VOLUME 2

Hydraulic Brakes
Cooling
Intake & Exhaust
Fuel System
Instrumentation
Dual Zone Multiplex System
Body Electrical
Chassis Electrical
Steering
Body Structure
Seating / Restraints / Handrails

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BLUE BIRD **VISION**

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SERVICE MANUAL

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The Blue Bird Vision complies with all applicable federal and state regulations. These include, but are not be limited to, Federal ADA as well as state accessibility, safety and security requirements.

The Blue Bird Vision meets all applicable Federal Motor Vehicle Safety Standards (FMVSS) rules and regulations.

In the event of any conflict between the requirements of this publication and any applicable legal requirement, the legal requirement prevails. Technical requirements that exceed the legal requirements are not considered to conflict.

Many of the components of Blue Bird buses are obtained from outside suppliers. Where maintenance and/or service information conflicts with the component manufacturer's documentation, the manufacturer's documentation prevails.

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Overview

Front and rear hydraulic disc brakes manufactured by ArvinMeritor are standard equipment. Two hydraulic systems come into play when the Vision's disc brakes are applied: The brake system, which is passive, and the power steering hydraulic system, which is pump driven. Although the two systems interact, they are separate closed circuits with separate fluid supplies. The component at which the two systems interact is the Bosch Hydro-MaxR™ master cylinder/booster assembly.

Under normal driving conditions with the engine running, the driver presses the brake pedal, actuating the HydroMaxR™ (mounted in the engine compartment against the driver-side firewall). The booster portion of the assembly receives hydraulic steering fluid and allows hydraulic pressure generated by the power steering pump to assist in actuating (boost) the master cylinder, which contains brake fluid.

A pressure switch mounted on the body of the brake booster monitors pressure in the hydraulic power steering system. If pressure is absent when brakes are applied (as when the engine is not running), the pressure switch activates an electric pump mounted on the underside of the brake booster body to provide brake boosting power. The BRAKES warning light on the driver's instrument panel is also activated.

When there is no boost pressure in the power steering hydraulic system, and no boost is being provided by the electric pump (as when the ignition switch is off), the hydraulic brakes still operate, but require significantly greater pressure at the pedal.

The master cylinder, power boosted by the power steering pump system, transfers hydraulic pressure to the Antilock Brake System (ABS) modulator, mounted on the frame cross member located just aft of the transmission above the front end of the driveline. The modulator distributes the pressure in the brake system to the master cylinders mounted on each wheel, according to control signals it receives from the ABS Electronic Control Unit (ECU), which is mounted inside the bracket which supports the transmission shift lever.

At each wheel, a wheel speed sensor detects the speed of the rotating wheel and sends a signal to the ECU. The ECU monitors these wheel speed signals and controls the modulator to adjust the braking pressure at each wheel individually, so as to maintain traction (avoid wheel lock) at all wheels.

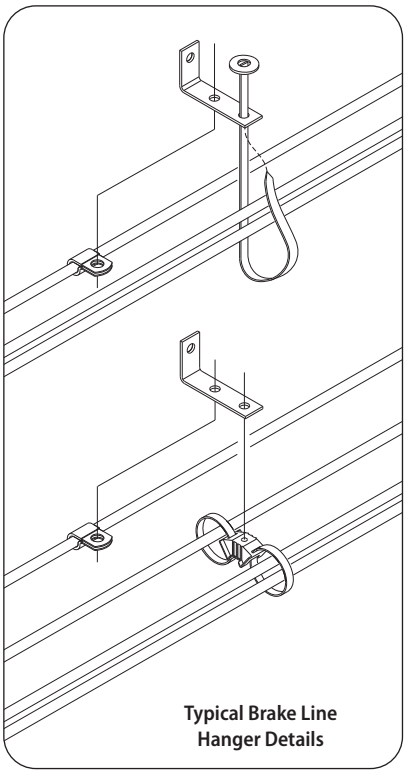
Blue Bird Visions equipped with standard hydraulic brakes employ a cable-actuated drum-type parking brake installed on the rear of the transmission. The parking brake is not to be used as a normal service brake, but can be used to help stop the bus in an emergency situation.

Appendixes In This Chapter

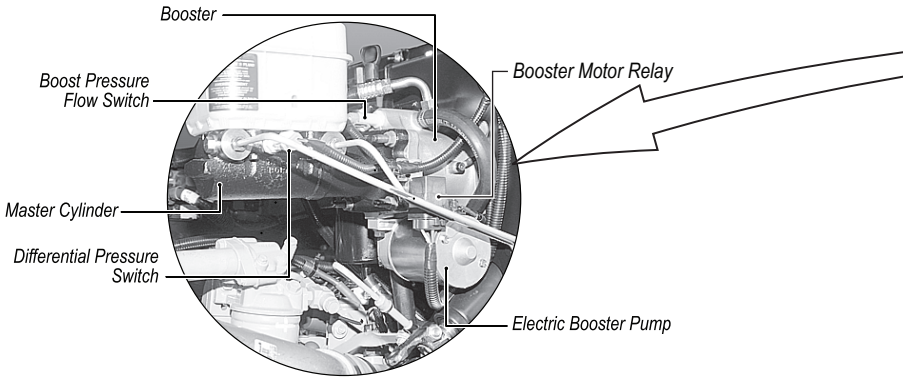
Appendix 1: Hydro-Max Hydraulic Brake Booster and Master Cylinder. This Bosch publication details the operation of the master cylinder & booster assembly, and includes troubleshooting information.

Appendix 2: Hydaulic ABS. Meritor Wabco Maintenance Manual 39. Detailed information on the ABS Module and other ABS components. Includes troubleshooting using blink codes and Meritor Wabco Toolbox diagnostic software.

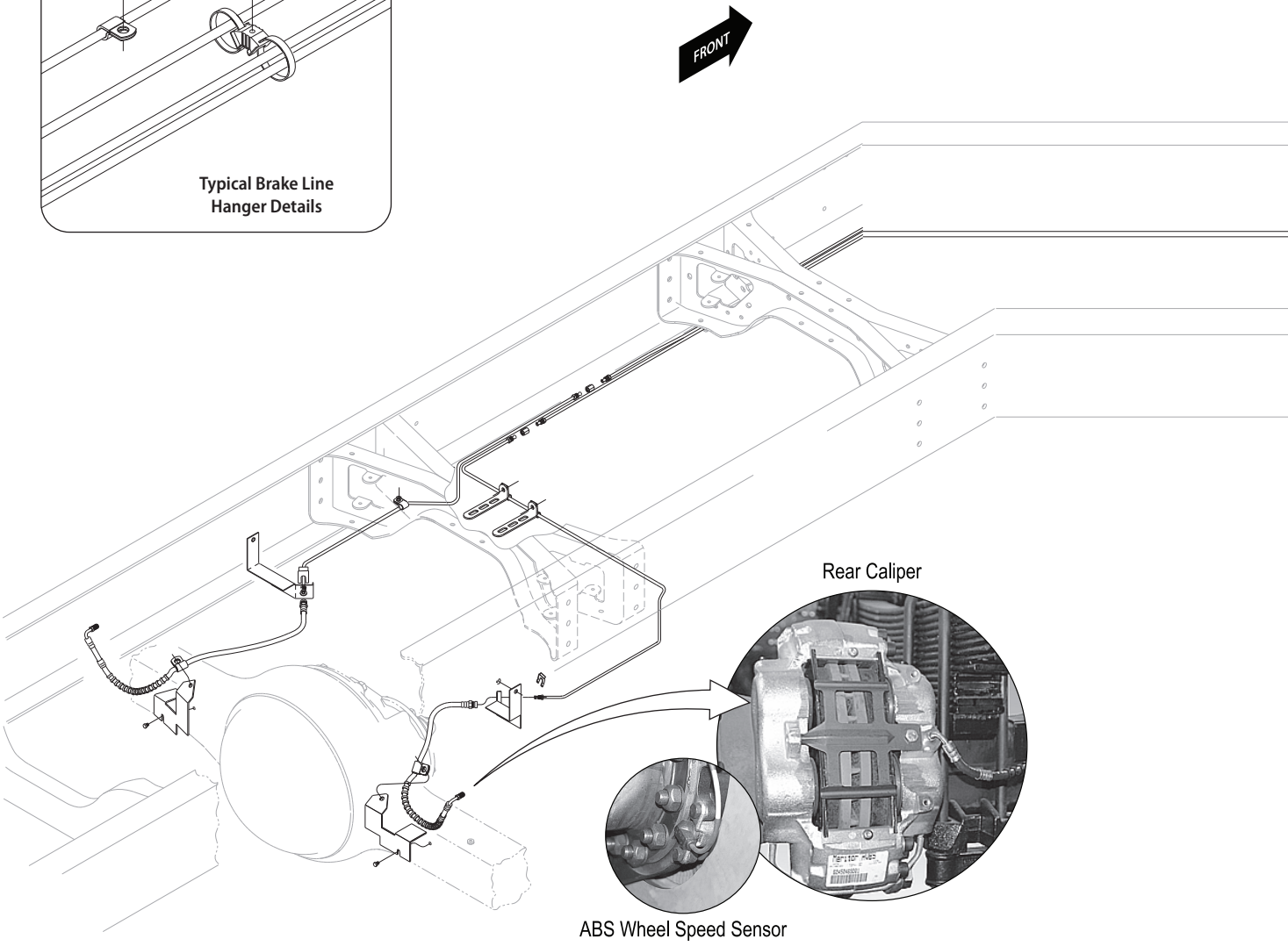
Appendix 3: Four Piston Quadraulic Disc Brake Caliper. Meritor MM-2075. Detailed information on disassembly, inspection, and reassembly of the brake calipers.

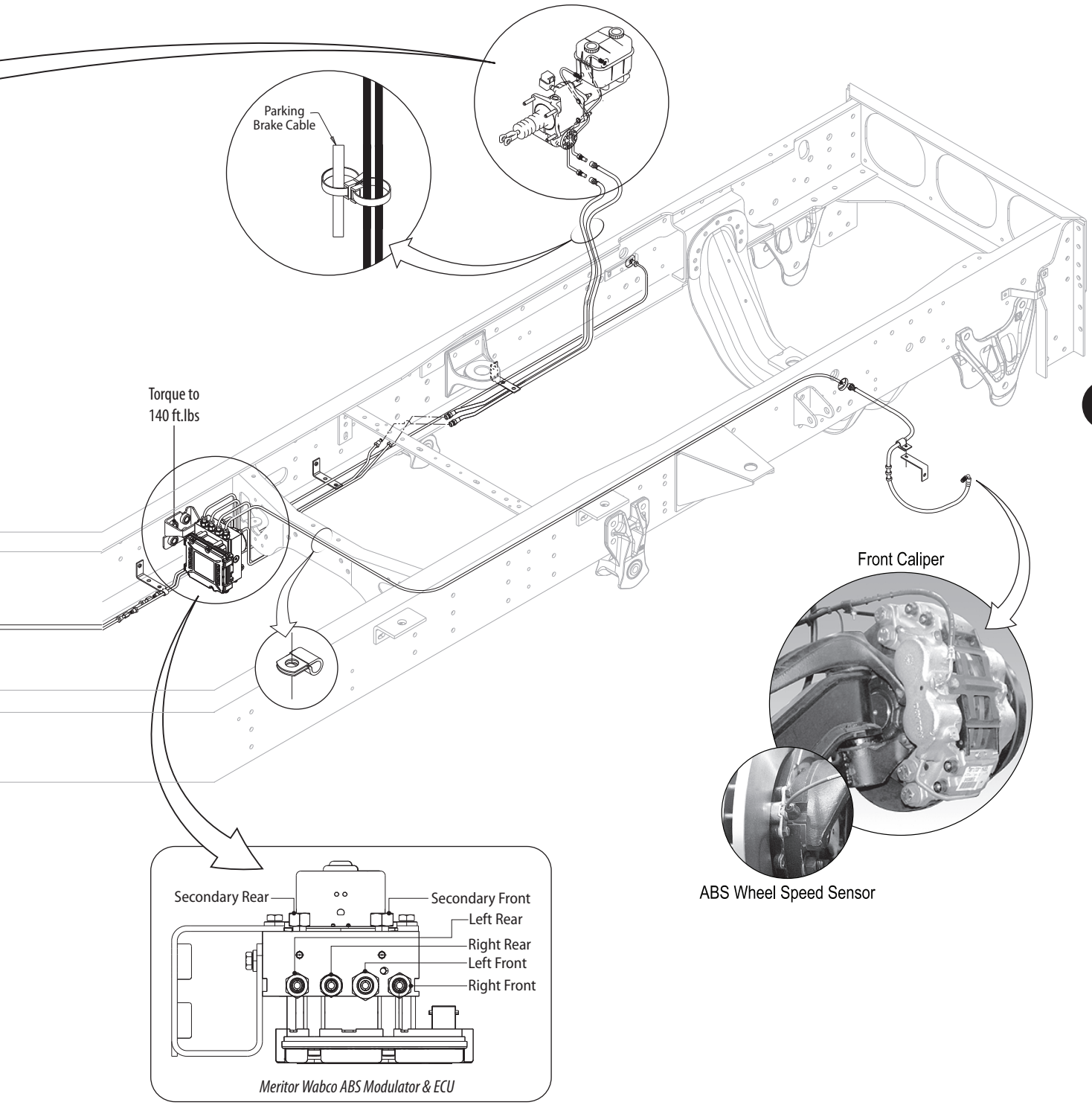


Typical Brake Line Hanger Details



Bendix Hydro-Max





Hydraulic Brakes *Major Components*

Maintenance

Servicing the hydraulic brake system involves procedures at several levels.

- Regularly scheduled maintenance tasks such as inspection, fluid replenishment, and linkage lubrication. See the Hydraulic Brakes Maintenance chart below (also included in the Brakes chart in the Specs & Maintenance Chapter).

- Replacement and/or servicing of normal wear parts, such as brake pads and rotor surfaces, as they approach their service life specifications. These procedures must be performed according to the manufacturers' specifications. References are provided in the various component sections that follow.

- More involved overhaul or rebuild procedures for major components; for example, replacement of seals in the caliper(s). These also must be performed according to manufacturers' procedures. Appropriate references are provided in the respective component descriptions below.

- When any part of the brake system's hydraulic fluid circuit is disassembled or loosened, the system must be bled before returning the bus to operation. This must be done according to procedure for the Meritor Wabco ABS system. See Hydraulic Brakes Appendix 2 (Meritor Wabco publication: Hydraulic ABS Maintenance Manual no. 39). Arvin Meritor also provides additional information online at www.arvinmeritor.com.

Hydraulic Brakes Maintenance

Interval: Months/1000 Miles
whichever occurs first

Operation	1 / 3,000	3 / 5,000	3 / 24,000	6 / 6,000	6 / 10,000	12 / 12,000	12 / 24,000	24 / 24,000	Notes
Hydraulic Brakes									
Check fluid level	•								*Use DOT-3 brake fluid.*
Inspect booster & master cylinder			•						*Inspect for signs of leakage or damage.*
Adjust park brake lever				•					*Adjust engagement pressure at the lever to 90-100 lbs.*
Hydraulic Brake Wheel Ends									
Inspect calipers				•					*Inspect for signs of leakage or damage.*
Lubricate calipers		•							*See Meritor documentation.*
Check pad thickness	weekly or as needed in severe applications								*Minimum ⅛ inch (3.175mm).*

Master Cylinder

The master cylinder assembly is mounted directly to the body of the hydraulic booster. These two components are mounted as a unit in the engine compartment on the driver-side firewall.

The fluid reservoir for the brake system is part of the master cylinder assembly, and contains DOT 3 brake fluid. When the brake is operated, pistons in the master cylinder drive brake fluid that it receives from the reservoir into the brake lines, transferring the mechanical force to the brake calipers at each wheel.

The master cylinder is internally divided into two hydraulic circuits; one for the front brakes, and one for the rear. The fluid reservoir is similarly divided, thus its two fill caps. Hydraulic leakage or complete failure in one system does not affect function of the other system.

An electric sending unit is mounted to the side of the master cylinder. If significant pressure difference is detected between the front and rear brake circuits, the sensor sounds a warning buzzer in the driver's area and turns on the BRAKES light on the instrument panel.

Troubleshooting

Symptoms that may indicate master cylinder failure include, but are not limited to:

- Brake fluid leakage from between the master cylinder and booster.
- Hard pedal. Excessive pressure is required at the pedal to apply brakes.
- Excessive pedal travel. Pedal goes to the floor.
- Actuated pedal does not return.
- Brake drag.

For a more detailed description the master cylinder's operation, as well as troubleshooting guidelines, see Hydraulic Brakes Appendix 1 (Bosch publication: HydroMax Hydraulic Brake Booster and Master Cylinder). If the master cylinder is determined to be malfunctioning, it must be replaced. Replacements are available from your Blue Bird Parts Distributor.

Removal

The master cylinder may be unbolted from the booster without removing the entire master cylinder/booster combination as a unit. However, it is possible that when the master cylinder is unbolted from the booster, the booster's internal spring may cause its o-ring seal to pop out, spilling hydraulic fluid. Thus, it is a good practice to take measures to catch the hydraulic fluid in case this occurs.

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. Disconnect the harness wire from the master cylinder's balance sending unit.

4. Position a suitable container under the master cylinder/booster assembly.

5. Disconnect the two hydraulic lines from the master cylinder.

6 Remove the four bolts and nuts which fasten the master cylinder to the booster and remove the master cylinder.

Reinstallation

Install the master cylinder by reversing the removal procedure.

1. Mount the master cylinder to the booster and tighten the four bolts to 25–30 ft. lbs. (33.9–40.7 Nm).

2. Reattach the brake fluid lines and tighten the nuts to 200 in. lbs. (22.5 Nm).

3. After installation, the brake system must be bled before operating the bus. This must be done according to procedure for the Meritor Wabco ABS system. See Brakes Appendix 2 (Meritor Wabco publication: Hydraulic ABS Maintenance Manual no. 39).

Booster

The brake booster is mounted directly to the front of the driver-side firewall in the engine compartment, and also serves as the support for the brake master cylinder.

During normal operation, fluid pumped by the hydraulic pump flows through the booster's inlet, throttle valve, and power piston, and then exits through the outlet port. When the brake pedal is applied, the booster's input rod activates the throttle valve, restricting flow through the power piston. The resulting pressure, acting upon the power piston, applies force to the master cylinder's primary piston, "boosting" the force applied to it by the driver.

The Booster assembly incorporates an electric motor/pump which provides braking boost whenever hydraulic flow ceases in the booster. A flow switch mounted at the top of the booster, next to the outlet port is held open by the normal flow of hydraulic fluid into the outlet. When pressure is absent, this switch closes, energizing a power relay, and thereby providing electrical power to the motor. The switch also causes a buzzer to sound in the driver's area and the BRAKES warning light to illuminate in the instrument panel. (See the Chassis Electrical chapter for schematic).

Troubleshooting

Symptoms which may indicate booster failure include, but are not limited to:

- Hydraulic steering fluid leakage between the master cylinder and booster.
- Hard pedal. Excessive pressure is required at the pedal to apply brakes.
- Actuated pedal does not return.
- Brake self apply May indicate self applied booster due to too high fluid flow.
- Brake drag. May indicate selfapplied booster due to too high fluid flow

For a more detailed description the booster's internal operation, as well as trouble-shooting guidelines, see Hydraulic Brakes Appendix 1 (Bosch publication: HydroMax Hydraulic Brake Booster and Master Cylinder). If the booster is determined to be malfunctioning, it must be replaced. Replacements are available from your Blue Bird Parts Distributor.

Removal

As described above, the booster supports the master cylinder. Although it is possible to remove the booster without removing the master cylinder, doing so will require devising means by which to support the weight of the master cylinder so as to avoid bending the brake lines. The following procedure therefore assumes that the master cylinder/brake booster assembly will be removed as a unit, and that the two components will be separated after removal. Note that this will require that the brake system be bled after reassembly.

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. The brake balance sensor and the booster pressure sensor lead to a single connector at the wire harness. Disconnect the connector. Disconnect the boost pump motor relay.

Caution

Do not apply the brakes after removal of the input hose unless the reserve boost system is disconnected. Reserve boost pressure will blow the inlet check valve out of the booster.

4. Loosen the hose clamp at the booster outlet, remove the hose and plug its end.

5. Remove the hose fitting at the booster inlet and plug its end, and/or support it vertically to prevent spillage.

6. Disconnect both output brake lines from the master cylinder.

7. Inside the bus, remove the cotter pin, washer and clevis pin which connect the booster push rod to the brake pedal lever.

8 Inside the bus, remove the four nuts which secure the booster's mounting studs to the driver's toe box. While doing this, have a helper support the master cylinder/booster assembly, or devise other means to support it while removing the nuts.

9. Remove the four bolts, nuts, and washers which fasten the master cylinder to the booster assembly.

Servicing

If found defective, the brake booster must be replaced. Contact your Blue Bird parts distributor for a replacement. Refer to Appendix 1 for more information.

Installation

Install the booster by reversing the removal procedure.

1. Assemble the master cylinder to the booster and tighten the four bolts to 25–30 ft. lbs. (33.9–40.7 Nm).

2. Mount the reassembled master cylinder/booster unit on the vehicle and tighten the four mounting nuts to 18–25 ft. lbs. (24.4–33.9 Nm).

3. Reattach the brake fluid lines to the master cylinder and tighten the nuts to 200 in. lbs. (22.5 Nm).

4. Inside the bus, attach the booster push rod to the brake pedal lever with the clevis pin and washer. Use a new cotter pin.

5. After installation, the brake system must be bled before operating the bus. This must be done according to procedure for the Meritor Wabco ABS system. See Appendix 2.

ABS Modulator

The ABS modulator is mounted in a bracket affixed to a frame crossmember, just above the forward end of the front most driveshaft. The modulator houses the ABS solenoid control valves (one inlet valve and one outlet valve per wheel), a pump motor, and two accumulators

Under normal braking conditions, the modulator unit receives brake fluid pressure from its two inlets (one for the front brakes; one for the rear) and distributes it evenly to the two brake calipers in each circuit. However, if a wheel starts to lock, a signal from the ECU cause a solenoid control valve to regulate the brake pressure to that wheel. During such an ABS stop, the solenoid valve is rapidly pulsed; opening and closing several times per second to control the brake pressure and prevent wheel lock. When this occurs, the driver may notice a pulsation of the brake pedal.

Troubleshooting

For troubleshooting and diagnosis of the modulator, see Appendix 2. The modulator should be replaced as a unit if found to be defective.

Removal

Removing the modulator involves three electrical plugs, six brake fluid tubes, and three mounting studs:

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. Disconnect the chassis wire harness's control plug and main ground plug from the modulator unit. Disconnect the pump's pigtail component from the chassis wire harness.

4. Mark the six brake lines for ease of installation. Place a container under the modulator assembly to catch leaking brake fluid. Disconnect the six brake lines.

5 The mounting holes of the bracket are slotted and open on the top. Loosen the mounting nuts on the modulator's three rubber isolator mounts and lift the modulator out.

Reinstallation

Reinstall the modulator in the reverse order of removal, being sure to tighten fittings to the appropriate torque values:

1. Place the modulator in its bracket, being sure the studs of the three rubber isolators seat in the bottom of the mounting slots. Tighten the mounting stud nuts to 132 in. lbs (15 Nm).

2. Connect the main ground plug and the control plug on the chassis wire harness to the unit. Connect the pump's pigtail connector into the wire harness.

3. Connect the two small brake lines and tighten to 108 in. lbs. (12 Nm).

4. Connect the four larger brake lines and tighten to 132 in. lbs. (15 Nm.).

5. After installation, the brake system must be bled before operating the bus. This must be done according to procedure for the Meritor Wabco ABS system. See Brakes Appendix 2 (Meritor Hydraulic ABS Maintenance Manual no. 39) for brake bleeding procedure.

Wheel Speed Sensors

A wheel speed sensor is mounted on the inboard side of each wheel assembly. As the wheel rotates, the flats of a notched casting in the wheel end assembly pass in close proximity to the sensor. The sensor responds to the passing notches magnetically and outputs a voltage, which increases with the speed of the wheel. This signal is then used by the ECU to determine when wheel lock is immanent.

Troubleshooting

Appendix 2 includes specific information on testing the output voltage and resistance of the wheel speed sensors. Sensors found out of range should be replaced.

Removal

The sensors are held in place by the friction fit of spring clip sleeves which are inserted into the mounting blocks with the sensors. To remove a sensor:

1. Apply the parking brake. Chock the tires to prevent vehicle movement.

2. Disconnect the sensor cable from the wire harness and remove the cable from any cable clamps or clips.

3. Pull the sensor straight out of its socket, using a twisting motion if required. Do not pull on the wires. On front wheels, removal of the sensor may be impeded by interference with the steering arm casting. If this occurs, removal may be more easily achieved by removing the two bolts which secure the sensor's mounting block.

4. The spring clip may remain in the socket, or may pull out with the sensor. Remove and inspect the spring clip. Replace any damaged spring clips with new ones.

Installation

The steps below assume the sensor has been removed without removing its mounting block. If removal of the sensor has required removal of its mounting block, install the new sensor into the mounting block according to the steps below and reinstall the mounting block using a thread locking compound on the threads of the two bolts and tighten the two mounting bolts to 16–18 ft. lbs. (21.7–24.4 Nm).

1. Connect the new sensor cable to the chassis harness.

2. Press the sensor spring clip into the socket until it stops. Make sure the tabs are on the inboard side.

3. Apply an appropriate lubricant to the shank of the sensor. Lube must be mineral oilbased and contain molydisulfide. It should have excellent anticorrosion and adhesion characteristics and be capable of continuous function in a temperature range of 40° to 300°F (40 to 150° C).

4. Push the sensor completely into the spring clip until it contacts the tooth wheel.

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

6. Secure the sensor cable with tie wraps every 12 inches. Properly bundle and store excess cable.

ECU (Electronic Control Unit)

The ECU is a rectangular black box mounted to the side of the modulator housing. The unit receives signals from the wheel speed sensors, processes them, and generates solenoid valve commands for the ABS modulator to reduce, maintain or reapply brake pressure.

When the ECU senses an error in the system, it activates the ABS light on the driver's instrument panel according to a set of blink codes, which can help diagnose the system. A description of the blink codes is contained in Appendix 2

The ECU also stores ABS errors which it has detected but which are not presently active. This information can be accessed and used to troubleshoot the ABS system using Meritor Wabco's PC-based diagnostic software. The PC is connected using an appropriate adapter to the 9 pin diagnostic tool port located in the upper right corner of the driver's toe box. Once connected, the diagnostic software can communicate with the ECU to display system faults and wheel speed data, test individual components, verify wiring, and more. The specific interface adapter needed will vary according to the specific PC setup being used. Meritor Wabco provides a tollfree number, 800/535-5560, for ordering the software and for assistance.

Removal

The ECU is mounted to the modulator assembly. It is not necessary to remove the entire assembly to replace the ECU. To remove:

1. Park the bus on a level surface with parking brake on.

2. Disconnect the negative terminal of the battery.

3. Open the latches on the 31 pin harness attached to the ECU and remove the connector.

4. Use a 4 mm allen wrench to loosen and remove the four mounting screws.

5. Carefully remove the ECU by lifting straight out.

Installation

Reinstall the ECU in reverse order of the removal steps. It is not necessary to bleed the system when only the ECU is replaced.

Calipers

The Blue Bird Vision with hydraulic brakes uses Meritor 70mm four piston Quadraulic disc brake calipers. The same model caliper is used on all four wheels, but left and right side housings are mirror versions. An installation includes four major components: the caliper itself, the caliper support assembly, hub/rotor assembly, and attaching hardware.

When brakes are applied, brake fluid pressure (as regulated by the ABS modulator) causes the caliper's pistons to extend, pressing the brake friction pads against the surfaces of the rotor. The brake fluid line from the modulator attaches directly to the inboard side of the caliper. A crossover tube supplies fluid to the outboard pistons.

Servicing

If a caliper assembly is leaking, has stuck piston(s), or is otherwise found damaged, it must be replaced or rebuilt according to manufacturer's instructions. Stepby step procedures for rebuilding the brake calipers are included in Appendix 3.

WARNING ***Do not rebuild a caliper with damaged piston bore(s). If the piston bore is corroded, galled or scratched, replace the caliper assembly. Replacing only the piston and seals will not correct the damage. Do not attempt to hone or rebore damaged piston bores. Piston sized for honed caliper bores are not available.***

Removal

The caliper housing is mounted to the caliper support assembly by four bolts on the inboard side of the caliper.

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.
2. Raise the wheel to be serviced and support the vehicle with safety stands.
3. Remove the tire and wheel assembly.
4. Remove the brake hose from the inboard side of the caliper.
5. Remove the four calipertosupport assembly bolts.

Installation

To install the caliper, reverse the removal process. Torque the caliper mounting bolts to 320–360 ft lb (434–488 Nm). Bleed the affected brake lines system and road test the vehicle before returning it to normal service.

Brake Pads

The brake pads on the front and rear of the Vision, and on the inside and outside of the calipers are identical (8 total). Whenever working on the brake system, avoid contamination of the brake pads by brake fluid or grease. Contaminated brake pads, even if new, must be replaced.

Inspection

Brake pads should be inspected for amount of wear at least every 3000 miles. When the friction pad material is worn to a thickness of 1/8 inch (3.2mm), the pads must be replaced. It is recommended that when one brake pad has reached its service limit, all brake pads should be replaced. If not, at least the brake pads on both sides of the same axle must be replaced at the same time.

Removal

Removal of the brake pads requires removal of the wheel, but not of the caliper. The brake pads are held in place by retainer spring plates, which are secured with one bolt.

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.

2. Raise the wheel to be serviced and support the vehicle with safety stands.

3. Remove the tire and wheel assembly.

4. Remove the master cylinder reservoir filler cap. Check the brake fluid level in the reservoir. If necessary, remove fluid to keep the reservoir from overflowing when the caliper pistons are compressed.

5. Remove the pad retainer spring bolt and remove the retainer spring.

6. Remove the two brake pads.

Installation

Because the pistons travel out from their bore during the wear of the pads, it is necessary to compress them back into their bores sufficiently to accommodate the thickness of the new pads.

1. Compress the caliper pistons. This can be done with a thin plate and cclamps as shown. Compress the two pistons slowly and equally so as to avoid cocking or wedging either piston in its bore.

2. When the pistons have been retracted enough to accommodate the new pad, insert the new pad. Be sure that the friction side is against the rotor.

3. Insert the tab of the retainer spring into its retaining hole on the outboard side of the caliper. Install the retainer spring bolt and tighten to 30 ft. lbs. (40 Nm).

Brake Rotors

Disc brake rotors are subject to temperature and stress extremes. As brake pads wear during normal operation, grooves or ridges may develop in the rotor surfaces as a result of road contaminants. The service life of the rotor surfaces may or may not correspond to that of the pads, depending upon operating conditions.

The front axle on the Blue Bird Vision with standard hydraulic brakes is a Hendrickson 60952 axle with Meritor brake components. The rear axle is a Meritor RS 21145NFB1012 with Meritor brake components. Removal procedures differ accordingly.

Inspection

Whenever replacing brake pads, inspect the rotors for scoring, warping, cracks, bluing, heat spots or other damage, and for minimum thickness. Repair or replace if necessary. Rotors may be resurfaced at an appropriate truck brake service shop. The thickness of the resurfaced rotor must always exceed the minimum thickness dimension stamped or cast into the rotor. Replace if necessary.

Check the rotor while it is assembled to the hub and mounted on the axle. The lateral runout of the rotor friction surfaces should not exceed .015 in. (.381 mm) total indicator reading (TIR). The thickness variation of the rotor should not exceed .0012 in. (.03 mm). If the lateral runout and/or the thickness variation exceed these values have the rotor resurfaced.

Removal, Front

Remove the front rotor as follows:

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.
2. Raise the wheel to be serviced and support the vehicle with safety stands.
3. Remove the tire and wheel assembly.
4. Remove the brake caliper assembly as described in the Calipers section.
5. Remove the ABS sensor.
6. Remove the drain plug from the oil lube hubcap. Drain the oil
7. Remove the six bolts which fasten the hubcap. Remove the hubcap and its gasket.

8. Flatten the tab of the bendable lock washer to allow removal of the wheel nut. Remove wheel nut and bendable lock washer.

9. Remove the pierced lock ring.

10. Remove the adjusting nut.

11. Remove the outer tapered cage bearing.

12. Slide the hub/rotor assembly off the axle. Note that the inner bearing and seal will slide off together with the hub. Take care to maintain alignment so as to avoid damaging the seal.

Installation, Front

Reinstall the front rotor by reversing the removal procedure:

1. Slide the hub/rotor assembly onto the axle. Take care to maintain alignment so as to avoid damaging the inner seal.

2. Prelube the outer wheel bearing and install.

3. Install adjusting nut with locking tab outboard. Torque to 100 ft lb (135.5 Nm). Back off nut. Torque to 20 ft lb (27 Nm). Then back nut off 1/3 turn. After proper adjustment, verify hub rotation.

4. Install pierced lock ring, verifying the engagement of the locking tab to the adjusting nut. Tighten nut if necessary for lock alignment.

5. Install a new bendable lock washer.

6. Install wheel nut and torque to 200–300 ft lb (271–407 Nm). Verify hub rotation.

7. Check bearing adjustment with a dial indicator and magnetic base. Bearing end play should not exceed .005 in. (.127 mm).

8. Install hub cap and gasket. Use a new gasket if the original was damaged during removal.

9. Reinstall caliper assembly. Torque mounting bolts to 320–360 ft lb (434–488 Nm).

10. Fill hubcap with appropriate oil for the buses climate. See

11. Install ABS sensor.

Removal/Installation, Rear

To remove the rear disc rotor:

1. Park the bus on a level surface with parking brake on. Block the wheels to prevent the vehicle from moving.

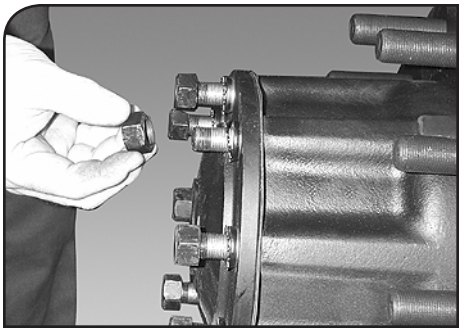
2. Raise the wheel to be serviced and support the vehicle with safety stands under the frame rails.

3. Remove the tire and wheel assembly.

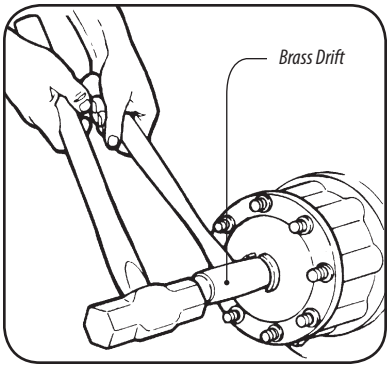
4. Remove the brake caliper assembly as described in the Calipers section, above.

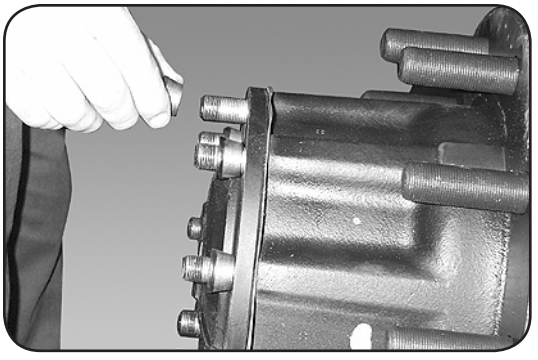
5. Place a drain pan under the end of the axle to catch brake axle lubricant.

6. Remove the 8 axle nuts and 8 star lock washers.



7. The axle end cap is centered by conical dowels on each of the 8 studs. It may be necessary to loosen the dowels, to allow removal. Hold a 1-1/2" diameter brass drift against the center of the axle end cap, inside the round driving lugs. Then strike the end of the drift with a large hammer. Remove the loosened dowels.





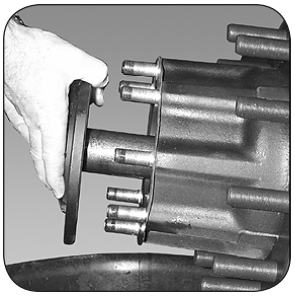
8. Remove the axle shaft and gasket.

9. Inside the rotor hub, the outer 4" adjusting nut is held in place by a tabbed retainer washer. Using a small hammer and punch, straighten the bent tabs of the lock washer.

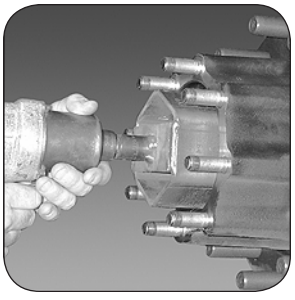
10. Remove the outer 4" adjusting nut, the tabbed washer, and the wheel bearing lock washer.

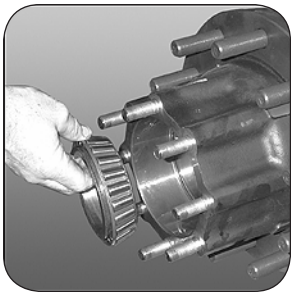
11. Remove the 4" adjusting nut and the outer wheel bearing.

The rotor can now be removed. Remove the rotor gently and as straightly as possible to avoid damage to the inner bearing rubber seal.



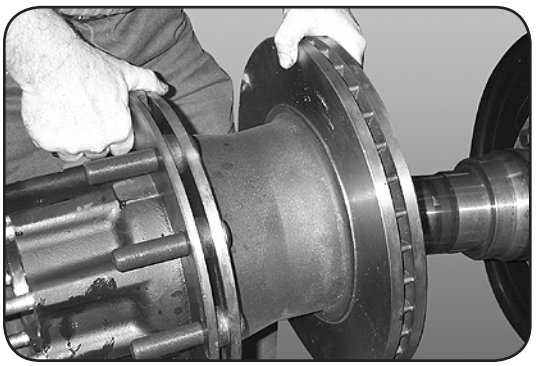




Installation, Rear

Reinstall the rear rotor and adjust the wheel bearing as follows:

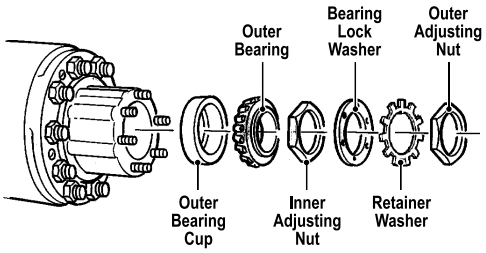


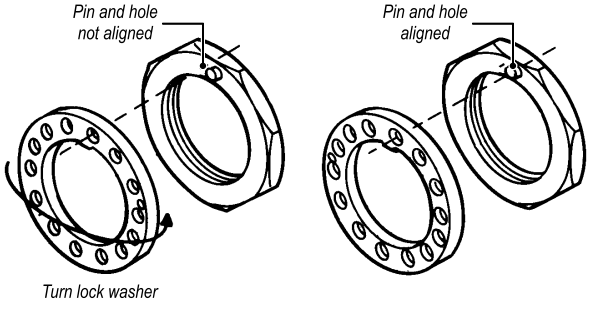
1. Slide the hub/rotor assembly onto the axle. Take care to maintain alignment so as to avoid damaging the inner seal.

2. Prelube the outer wheel bearing and install.

3. Install the 4" adjusting nut with locking pin facing outward. Torque to 100 ft lb (135.5 Nm). Back the nut off 1 turn. Torque to 50 ft lb (68 Nm). Then back nut off 1/3 turn.

4. Install the wheel bearing lock washer. If the hole in the washer is not aligned with the adjusting nut pin, remove the washer, turn it over, and reinstall. The pin should now be aligned. If not, slightly adjust the inner adjusting nut. Use whichever lock washer hole causes the least movement of the adjusting nut.





5. Install the tabbed retainer washer.

6. Install outer wheel bearing adjusting nut and torque to 100–200 ft lb (136–271 Nm). Verify hub rotation.

7. Bend two tabs of the retainer washer up against the flats of the adjusting nut.

8. Install axle shaft gasket. Use a new gasket if the original was damaged during removal.

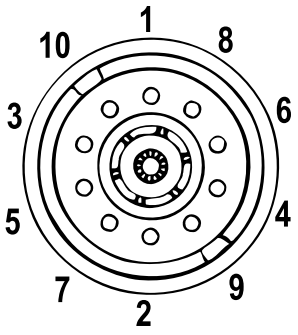
9. Install the axle shaft.

10. Insert a tapered dowel onto each of the axle shaft studs, narrow end first. Install the eight star washers and eight nuts. Working back and forth across the center of the axle, gradually tighten the eight nuts to 150–230 ft lb (203–312 Nm).

11. Reinstall caliper assembly. Torque the four mounting bolts to 320–360 ft lb (434–488 Nm).

12, Check bearing adjustment with a dial indicator and magnetic base. Bearing end play should not exceed .010 in. (.254 mm).

13. Install wheel, and wheel mounting nuts. Draw up the wheel nuts evenly, rotating the wheel a few turns to be sure to remove all free play in the mounting nuts. Then use a calibrated torque wrench to gradually tighten the wheel nuts to 450–500 ft. lbs. (610–678 Nm), working back and forth across the center of the wheel as in the pattern shown:



14. Lower bus. Chock all wheels and check axle fluid level and replenish if necessary.

Brake Interlock, Hydraulic

As a safety feature, Blue Bird Visions are equipped with hydraulic brakes and wheelchair lift doors incorporating a Mico 691 brake interlock system designed to automatically apply the front hydraulic service brakes when the lift door is open. The interlock system can also be activated by other options; entrance door, exit door etc. The main components of the interlock system include a motor driven hydraulic pump called the power unit, an actuator which operates similar to a master cylinder, and a solid-state control module with troubleshooting LED's. The Mico User Interface used on earlier Blue Bird buses and referenced in the Mico Appendix has been integrated into the Vision's electrical system.

The interlock system has its own separate hydraulic reservoir, and uses DOT 5 fluid. The interlock system's fluid supply is not shared by the service brake system, which uses DOT3 fluid.

WARNING ***The use of an incorrect fluid in the steering, brake or brake interlock system may result in a reduced function or failure of these systems resulting in a potential for bodily harm or death***

Several conditions must be met and communicated to the interlock system control module to initiate a brake interlock sequence. The logic (what conditions must be met) of the interlock system is managed by the Actia instrument panel and the Mico control module. The instrument panel receives several inputs; lift door open, bus below 3MPH etc., and provides an output signal to the interlock control module if the conditions meet required parameters. Reference the instrument panel chapter for brake interlock logic charts and system requirements.

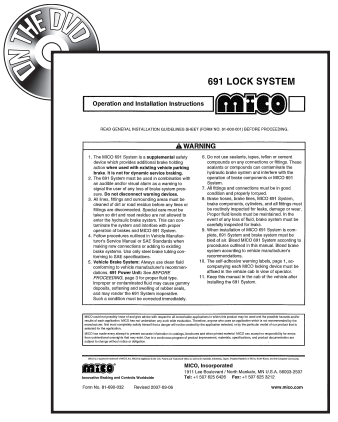
The interlock system control module provides an interface between system logic generated by the instrument panel, and the operating components of the brake interlock system. The control module starts the power unit pumping the Dot 5 fluid into the actuator. As the actuator becomes pressurized it isolates the master cylinder and pressurizes the front service brake circuit. When lock pressure is reached, the high pressure switch, located on the power unit, signals the control module to stop the pump. The control module also transmits signals back to the instrument panel to communicate interlock operating conditions to the driver. While the pump is stopped, locking pressure is held in the front brake system. If locking pressure drops, the high pressure switch signals the power unit to turn "on" and restore locking pressure.

When the interlock system is deactivated (usually by closing the door), the pump reverses and releases pressure on the actuator. The actuator releases pressure from the brake circuit and opens the port to the master cylinder. When lock pressure returns to zero psi a signal from the low-pressure switch, also located on the power unit, signals the control module to stop the pump.

More information on the **Mico 691 Lock System** can be found on the TechRef DVD.

CAUTION ***The Mico 691 performs as an operational holding brake only and is not intended to be used for prolonged parking.***

WARNING ***The Brake Interlock system is not a parking brake; it provides added security against the bus moving when it is activated. Do not rely on the Brake Interlock system as a substitute for the parking brake. To prevent the bus from moving during normal operation, always apply the parking brake. Failure to properly apply the parking brake to prevent the bus from moving may result in a potential for vehicle damage and/or a potential for bodily harm or death***



Mico 691 Lock System
Mico Publication 81-690-032

The Power Unit

The power unit incorporates two pressure switches, and is able to reverse flow to release locking pressure. The high pressure switch starts and stops the pump while pressurizing the system. The low pressure switch starts and stops the pump while releasing pressure from the system.

When locking pressure is reached, the high-pressure swithch signals the control module to stop the pump. While the pump is stopped, locking pressure is held. If locking pressure drops, the high pressure switch signals for the power unit to turn on and restore locking pressure.

When the interlock system is deactivated, the pump reverses, releasing pressure from the actuator. When pressure reaches zero psi, a signal from the low pressure switch stops the pump.

The Actuator

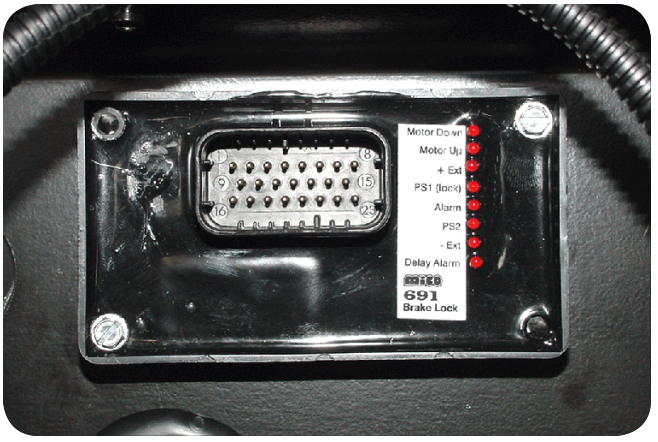
The actuator communicates the hydraulic pressure of the interlock system to that of the Vision's service brake system, while keeping the two systems' fluid circuits separate. (The two fluid circuits use different types of brake fluid, which must not be allowed to contaminate each other.)

The power unit's fluid pressure acts upon one side of a piston in the actuator. The opposite end of this piston is in contact with the fluid of the service brake system. When the power unit pumps pressure against the interlock system side of the piston, the piston moves toward the end of its bore, closing the port leading to the service brake master cylinder, and applying pressure to the fluid of the service brake circuit.

When the power unit's pump reverses, the actuator piston moves in the opposite direction, releaving pressure from the service brakes fluid circuit, and opening the port leading to the service brake master cylinder.

Control Module

In addition to acting as a solid-state starter solenoid for the interlock system's power unit motor, the interlock control module also incorporates an LED array which displays the current state of the interlock system. The LEDs indicate the following:



Mico Control Module

Motor Down On when system is releasing pressure. Remains on for three seconds after PS2 goes off.

Motor Up On when system has been activated (proper signal on +Ext or -Ext), until PS1 comes on.

+Ext On when positive signal is present on brown harness wire and/or green user interface wire.

PS1 (lock) On when system is locked at full pressure. Receives ground signal from pressure switch #1 on white wire.

Alarm On when power unit is pressurizing teh system. Controls user interface audible alarm.

PS2 On whenever any pressure is present in the system. REceives ground signal from pressure switch #2 on violet wire.

_Ext On when negative signal is present on gray harness wire.

Delay Alarm Comes on 9 seconds after activating the system if full system pressure has not been attained. Also comes on anytime the power unit runs to repressurize the system.

The input LEDs should be on when receiving their respective signal and off when not. Replace the 691 Control Module when this is not observed.

Control Module Troubleshooting

The following lists possible causes/solutions for particular observed situations:

- When the 691 System is activated, the brakes will not lock up and the power unit does not run.

  1. **No electric power.** Check the battery, fuse, and wiring connection.
  2. **High Pressure Switch is inoperative.** Activate the 691 system. If PS1 (lock) LED is on, unplug pressure switch 1. If pump runs, replace pressure switch 1 (high pressure switch), or check for a short to ground in the wiring.
  3. **The power unit or control module is inoperative.** Activate the 691 system. If the Motor Up LED is on, check for 12v DC at the power unit connector. Unplug the power unit and attach a voltmeter (+ to blue, - to green) to the connector leading to the control module. If 12v DC is present, replace the power unit. If 12v DC is not present, replace the control module.
  4. **The control module is not receiving an input signal.** Activate the 691 system. Check the +Ext and -Ext LEDs. If neither is on, check that a ground signal is present at the gray lead in the main wiring harness, or the green lead from the user interface; or that a positve signal is present on the brown wire in the main wiring harness. If not, determine the reason, and correct.

- When the 691 system is activated, the brakes will not lock up and the power unit continues to run.

  1. **The fluid level in the reservoir is low.** Deactivate the 691 system. Verify that the power unit is mounted level. Remove the reservoir breather/filler plug and fill the reservoir with proper fluid to within 1/4" of top. Reinstall breather/filler plug.
  2. **Hydraulic leak in either the 691 system or the service brake system.** Inspect all tubing and connections for leaks and tighten or replace as necessary.
  3. **The actuator is not functioning properly.** Activate the 691 system. Check the master cylinder reservoir for excessive fluid level. This condition indicates that the seals in the actuator are allowing 691 system fluid to leak into the vehicle service brake system. Replace the actuator and completely flush and refill the service brake fluid circuit.
  4. **The power unit is not properly building pressure.** Replace the power unit. (No test to troubleshoot this condition.)

- The 691 system will activate adn lock up the brakes, but the power unit keeps running.

  1. **High pressure switch is inoperative.** Activate the 691 system. If PS2 LED is off, replace pressure switch 1 (high pressure switch).

- The power unit does not operate to release the brakes when the 691 system is deactivated.

  1. **No electric power.** Check teh battery, fuse, and wiring connections.
  2. **Low pressure switch is inoperative.** Deactivate the 691 system. If the PS2 LED is off, replace pressure switch 2 (low pressure switch).
  3. **The power unit or control module is inoperative.** Deactivate the 691 system. If the Motor Down LED is on, check for 12v DC at power unit connector. Unplug power unit and attach a voltmeter (-to blue, + to green) to the connector leading to control module. If 12v DC is present, replace the power unit. If 12v DC is not present, replace control module.

- The brakes release, but the 691 power unit does not stop running.

  1. **Low pressure switch is inoperative.** Deactivate the 691 system. If the PS2 LED is on, replace pressure switch 2 (low pressure switch).
  2. **The control module is inoperative.** Deactivate the 691 system. If Motor Down LED is off, replace the control module.

- The 691 system and Motor Up LED come on unexpectedly without being activated.

  1. **The control module is receiving false signals.** Be sure stray signals are not being introduced into the external inputs. If the gray wire is not connected to an external input, ensure that it is capped off and not shorting to ground inadvertently. While deactivated, occasional operation of power unit and Motor Down LED is normal to relieve pressure caused by thermal expansion of fluid in the power unit.

- While the 691 system is activated, the power unit and horn activate intermittently.

1. **Change in temperature has caused the system to contract and reduce brake system pressure.** The power unit runs briefly to restore brake system pressure to the orignal lock up pressure. This is considered normal operation as fluid temperature changes.
2. **The service brake system or 691 system has air in it.** Bleed service brake and 691 system.
3. **Hydraulic leak in either the 691 system or service brake system.** Inspect all tubing and connectors for leaks and tighten or replace as necessary.
4. **The power unit is not functioning properly.** Replace the power unit. (No test to troubleshoot this condition.)

Bleeding Procedure

Because the interlock system has its own fluid circuit separate from that of the service brakes, the interlock system must also be bled separately.

1. Make sure the vehicle master cylinder reservoir (not the interlock reservior) is filled with DOT 3 brake fluid, and that the service brake system has been properly bled.
2. Activate the interlock system.
3. Open the bleeder valve on top of the power unit a quarter turn. Close the bleeder screw when a steady stream of fluid is present.

Mico 691 Wire-By-Wire Troubleshooting

With the harness unplugged from the control module, check for the following at the harness sockets.

Position	Color	Use	Check For
1	Red	12 Volt Power Input	+12 VDC
2	Black	Ground for PS2	Continuity with position 6 if system is pressurized at all, open if not.
3	Green	Motor Green	Motor - Connect ground here and +12 Vdc at position 4 to run pump to pressurize.*
4	Blue	Motor Blue	Motor - Connect ground here and +12 Vdc at position 3 to run pump to depressurize.*
5	White	PS1 Input	Continuity with position 10 if system is fully pressurized, open if not.
6	Violet	PS2 Input	Continuity with position 2 if system is pressurized at all, open if not.
7	Brown	Ext + Input	+12 Vdc if external controls/switches are calling for the 691 to be activated, open if not.
8	Gray	Ext - Input	Ground if external controls/switches are calling for the 691 to be activated, open if not.
9			
10	Black	Ground for PS1	Continuity with position 5 if system is fully pressurized, open if not.
11			
12			
13			
14	Green (UI cable)	Rocker Switch	Continuity with position 22 if rocker switch is in "Lock" position, open if not.
15	Black (UI cable)	Locked Output	Connecting ground here and +12 VDC at position 22 should light the locked lamp.*
16			
17	Black	Ground	Ground
18			
19			
20	Yellow	Delayed Alarm	Connecting ground here should sound vehicle horn.
21			
22	Red (UI cable)	Power for User Interface	Continuity with position 14 if rocker switch is in "Lock" position, open if not.
23	Whaite (UI cable)	Alarm	Connecting ground here and +12 VDC at position 22 should sound the beeper.*

**Note: If testing by connecting +12 VDC to harness, use properly sized wire and properly sized in-line fuse.*

Parking Brake

The parking brake is a dual shoe drum type brake, similar in configuration and operating principle to a normal drum brake on a passenger car. However, rather than being mounted at the wheel(s), the single drum unit is mounted on, and rotates with, a yoke on the forward end of the driveshaft. The brake shoe assembly is mounted to the rear housing of the transmission.

When the driver depresses the parking brake pedal, the inner cable of a conventional control cable assembly is pulled. This actuates a pivoting bellcrank linkage mounted at the opposite end of the cable, on the top of the transmission. The linkage rotates a cam situated between the two brake shoes, spreading them to force their friction linings against the drum, thereby preventing the drive shaft from turning when the bus is parked.

Adjustment

The parking brake should be adjusted so as to require between 130 and 150 pounds of force at the parking brake pedal. Units equipped with hand operated parking brake levers should be adjusted to require between 90 and 100 pounds of force just prior to breaking over center and latching in the applied position. Three cable adjustment locations are provided: On the right side of the transmission housing, the outer cable is clamped to a bracket, which has three sets of mounting holes. Any of the three sets of holes can be used to achieve the proper working range for the finer adjustments.

The clevis at the transmission end of the cable is threaded onto the swaged fitting of the inner cable. The effective cable play can be adjusted by:

1. Loosen the clevis lock nut.

2. Disconnect the clevis by removing its cotter pin and clevis pin.

3. Turn the clevis to adjust the cable length. Be sure to always leave at least a few threads of the cable end fitting showing inside the clevis.

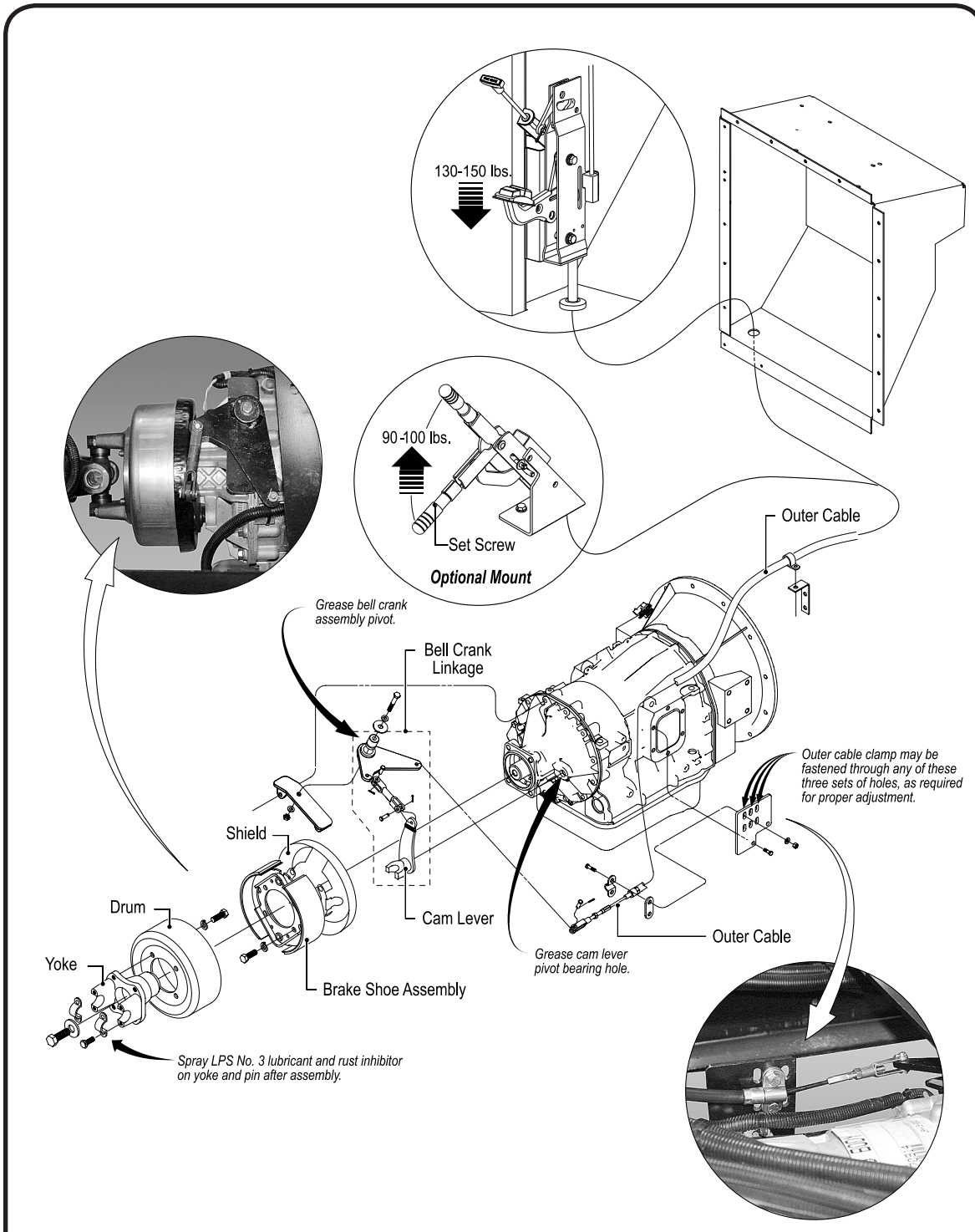
4. Reattach the clevis using a new cotter pin and tighten the lock nut.

The cable length can also be adjusted at the parking brake handle on units equipped with hand operated parking brake levers:

1. Remove the setscrew in the knurled end of the handle.

2. Rotate the knurled handle to adjust the tightness of the cable.

3. Replace the setscrew and tighten.



Park Brake *(on units with hydraulic brakes)*

Inspection

Parking brake service life will be dependent upon operating conditions and usage. Being designed for normal use with the bus stopped and parked, the drum and shoes of the parking brake are smaller and thinner units than would be used in drum type service brakes. Under normal usage brake lining wear should be minimal. However, the entire parking brake assembly should be disassembled and inspected after any use of it in an emergency stop situation.

Lubrication

A grease fitting is located on the bell crank pivot bushing. Grease should also be applied to the bearing hole on the transmission housing in which the knob of the cam lever pivots.

Removal & Disassembly

To remove the parking brake so as to inspect its brake shoes, drum and other components:

1. Park the bus on a level. Securely block the wheels to prevent the vehicle from moving in either direction.

2. Loosen, but do not remove, the bearing hanger bolts forward of the driveshaft slip joint. This is to allow some axial movement of the driveshaft when unbolting the front shaft from the transmission yoke.

3. Remove the two yoke clamps securing the front driveshaft pivot pin to the yoke.

4 Use a pry bar to carefully push the driveshaft rearward enough to clear the yoke clamps, and carefully lower the front of the drive shaft.

5. Apply the parking brake to prevent the transmission shaft from turning when loosening the yoke mounting bolt. Remove the yoke mounting bolt. Release the parking brake and remove the yoke & drum assembly.

6. To remove the drum from the yoke, mount the yoke in a bench vise with drum facing upward, and remove the four bolts from the inside of the drum.

7. Remove the four bolts which fasten the brake shoe assembly and parking brake shield to the transmission housing. The brake shoes can now be removed from the plate by hand on a workbench.

To remove the bell crank linkage:

8. Remove the cotter pin and clevis pin at the end of the inner cable's screwon clevis.

9. Remove the bell crank pivot bolt. The bell crank linkage can now be removed as an assembly.

Installation

1. Grease the socket hole on the transmission housing in which the cam lever pivots. Insert the pivot ball of the cam lever into the hole. Insert the pivot bolt through the bushing of the bell crank assembly, tightening it to 33 ft. lbs. (44.7 Nm). Connect the clevis end of the cable to the bell crank, using a new cotter pin on the clevis pin.

2. With the yoke mounted in a bench vise, assemble the drum to the yoke, tightening the four mounting bolts to 90 ft. lbs. (122 Nm).

3. Mount the parking brake shield and brake shoe assembly to the transmission housing. Check to ensure that the lugs of the cam lever properly engage the space between the ends of the brake shoes. tighten the four mounting bolts to 90 ft. lbs. (122 Nm).

4. Slip the assembled yoke and drum onto the transmission's splined output shaft. Insert the mounting bolt and handtighten. Apply the parking brake by pushing on the bell crank linkage, to prevent turning of the transmission shaft as the yoke mounting bolt is tightened. Tighten the yoke mounting bolt to 110 ft. lbs. (150 Nm).

5. Assemble the front driveshaft to the yoke using two new yoke straps. Tighten to 45–60 ft. lbs. (6181 Nm).

6. Tighten all driveshaft bearing hanger bolts to 29–33 ft. lbs. (39–45 Nm).

Hydro-Max™ Hydraulic Brake Booster and Master Cylinder



Technical Manual

BOSCH

BOSCH

Important Service Notes

The information in this publication was current at the time of printing. The information presented in this publication is subject to change without notice or liability.

The information contained in this publication is intended for use by properly trained and equipped professional technicians. It is NOT for the "Do It Yourselfer".

Failure to follow safety and repair procedures can result in personal injury, or damage to vehicles, components and equipment.

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Fax: 574-237-2210

August 2003

BOSCH

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BOSCH

General Description

The Hydro-Max™ is a hydraulically powered brake booster which provides power assist for applying hydraulic brakes. A booster combined with a master cylinder (refer to *Figure 1*) forms the hydraulic brake actuation unit. A typical assembly is shown in *Figure 1*. The booster reduces the pedal effort required to apply the brakes as compared to a non-power system.

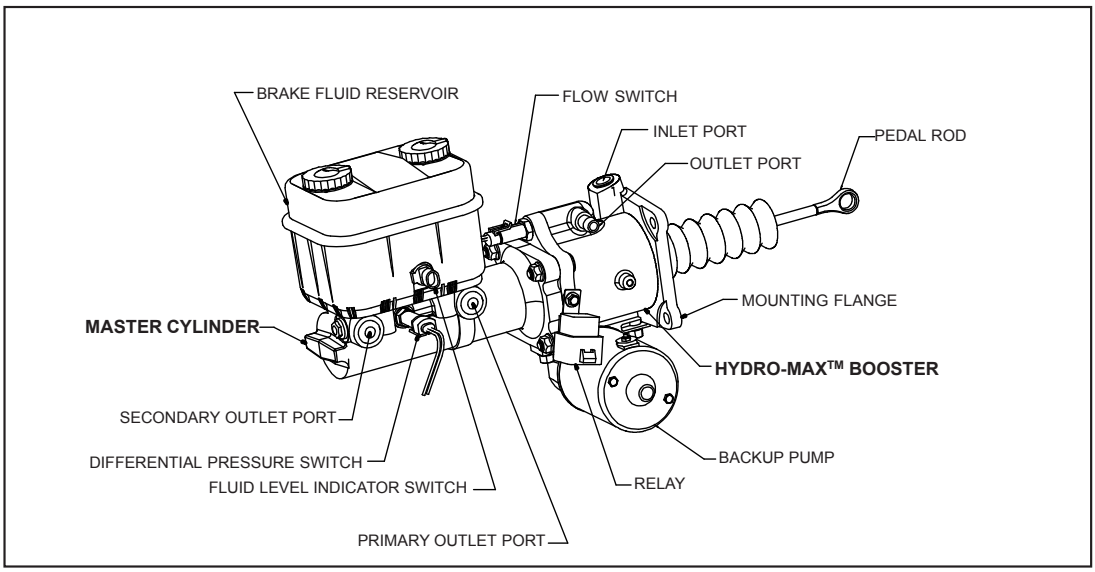


Figure 1 Hydro-Max™ Booster and Master Cylinder Assembly

Hydro-Max™ Booster

The hydraulic booster is comprised of an open center valve and reaction feedback mechanism, a power piston, a 12 and 24-volt backup pump and an integral flow switch. It is powered by either the power steering pump or other hydraulic source. The backup pump provides a secondary power source for the hydraulic booster and is controlled by the integral flow switch.

Master Cylinder

The master cylinder is a split system type with separate fluid chambers, pistons and outlet ports for the front and rear brake circuits. A differential pressure switch, fluid level indicator switch, and remote reservoir are also available.

A typical Hydro-Max™ booster and master cylinder assembly installation in a hydraulic braking system is shown in *Figure 2.*

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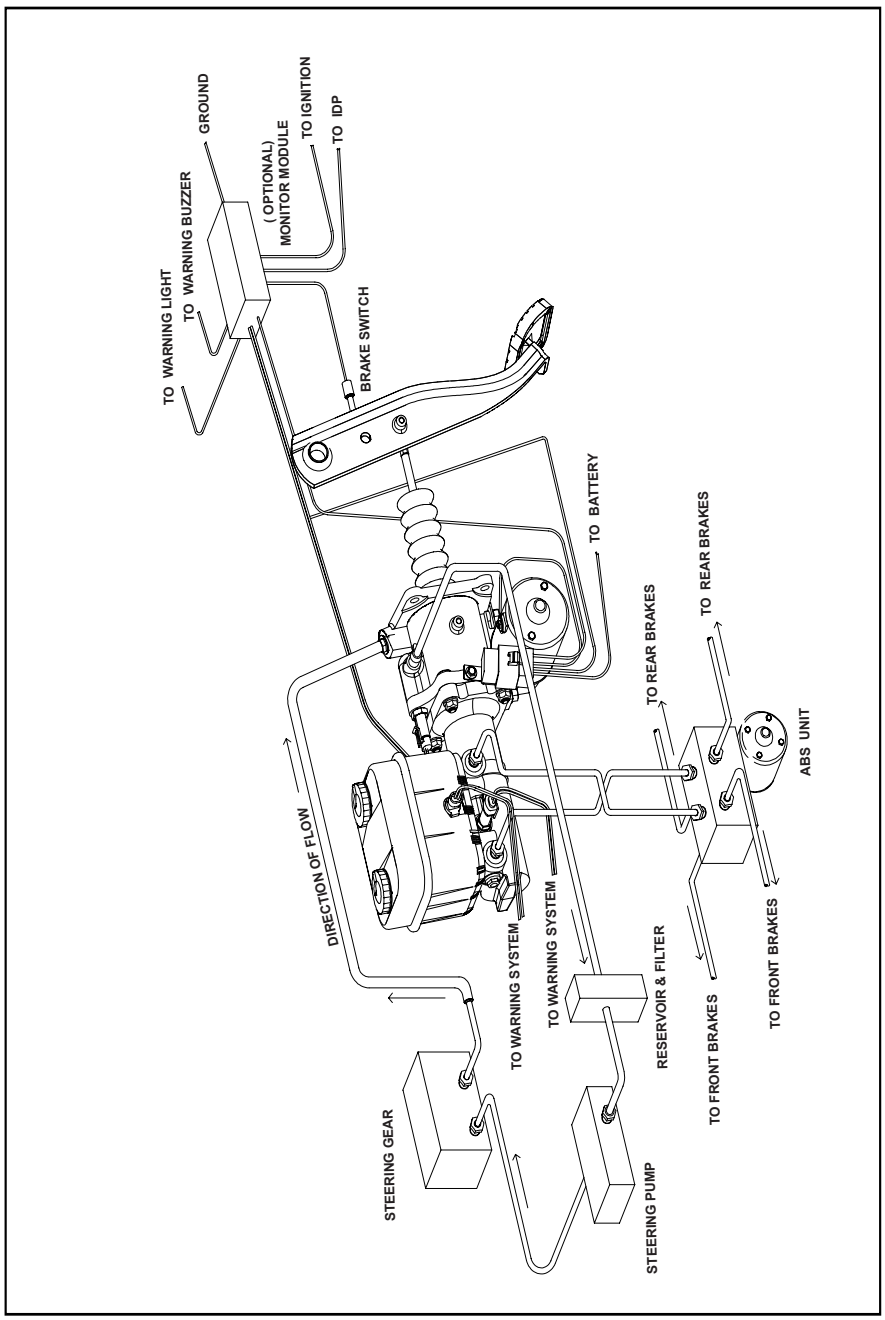


Figure 2 Typical Booster and Master Cylinder Assembly Installation in a Hydraulic Braking System

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Principle of Operation

Hydro-Max™ Booster

During normal system operation, (refer to *Figure 4*) fluid flow from a hydraulic power source (usually the power steering pump) enters the inlet port of the Hydro-Max™ booster, flows through the power piston, around the throttle valve and through the flow switch, exiting through the outlet port.

Force applied to the brake pedal by the vehicle operator is multiplied by the lever ratio of the pedal mechanism to move the pedal rod of the booster. This movement closes the throttle valve, which restricts flow. This restriction of flow, which results in a pressure increase acting on the power piston, applies an amplified force to the master cylinder primary piston. A reaction piston, inside the power piston subassembly, provides the driver "pedal feel" during an application of the brake pedal.

Fluid flow through the flow switch opens the backup pump electrical circuit during normal operation. A separate check valve in the backup pump prevents back-flow through the pump during normal power applications.

In the event normal flow from the power source is interrupted, the backup pump provides the power at a reduced rate for stopping. See *Figure 3* for performance curve. Upon flow interruption, the integral flow switch closes, energizing a relay, providing electrical power to the backup pump.

During backup operation, the pump re-circulates fluid within the booster assembly with pressure built on demand via the throttle valve. Fluid is retained within the booster by the inlet port check valve.

Figure 3 illustrates the typical relationship of master cylinder pressure and input force of the booster.

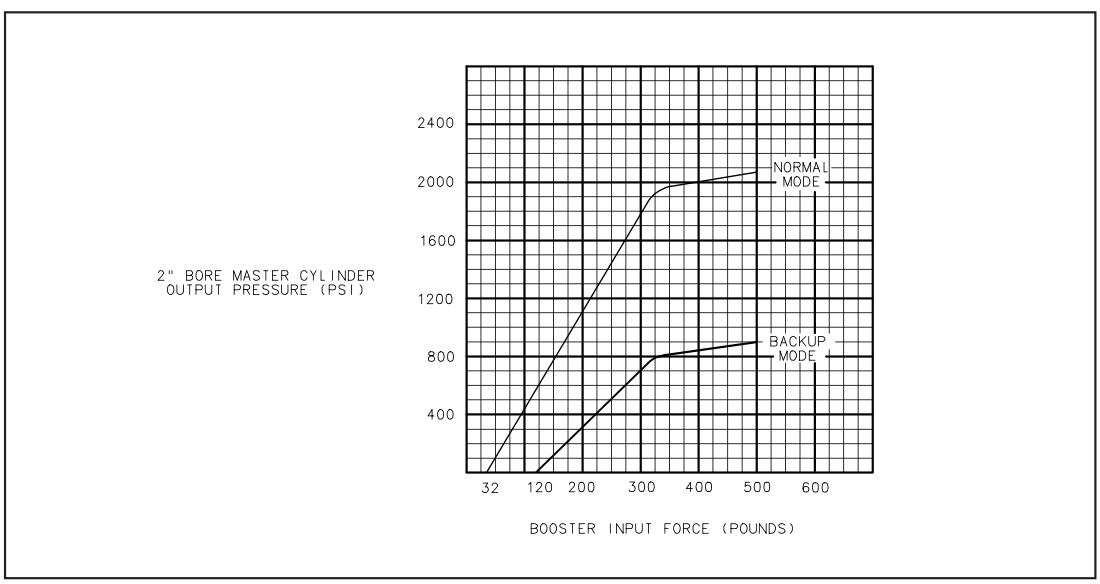


Figure 3 Typical Performance Curve

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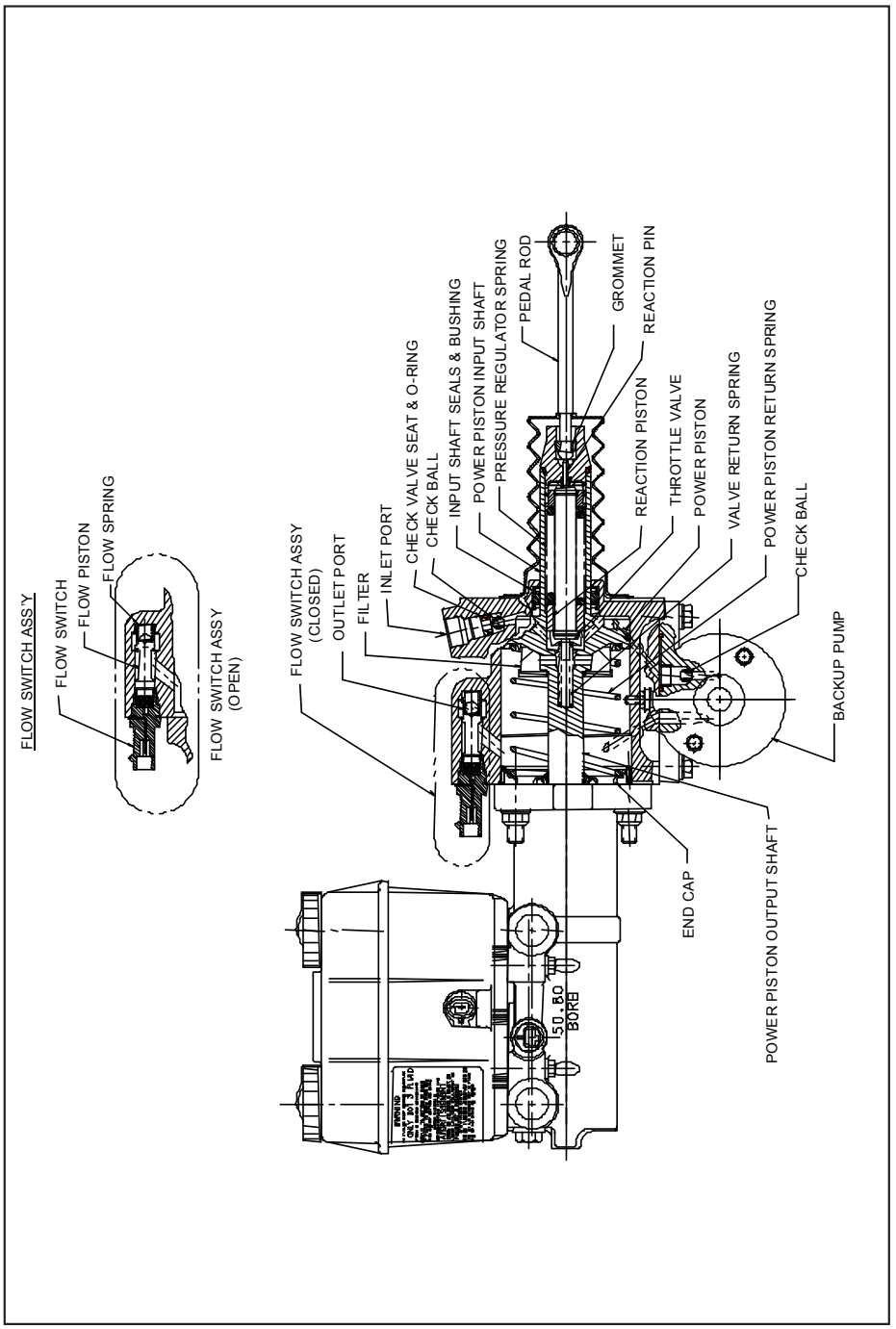


Figure 4 Hydro-Max™ Booster and Master Cylinder

BOSCH

Master Cylinder

In the released position, (refer to *Figure 5*) actuators of both the primary and secondary pistons are in with their respective compensating valve stems, which project into the cylinder bore. This contact tilts the valves to an open position, which allows hydraulic fluid in the reservoir sections to communicate with the primary and secondary pressure chambers. Each pressure chamber has a piston/actuator subassembly containing a preloaded (caged) spring and return spring.

Initial forward travel of the primary piston moves the primary actuator away from its compensating valve, permitting the valve to seat. Closure of this valve shuts off the passage between the primary pressure chamber and the reservoir section serving the primary chamber.

Further movement of the primary piston creates pressure in the primary pressure chamber, causing the secondary piston and actuator to move. As the secondary piston and actuator move, the secondary compensating valve closes, shutting off the passage between the secondary pressure chamber and the reservoir section serving the secondary chamber. Additional movement of the primary piston causes both chambers to build pressure.

When the load on the primary piston is removed, fluid pressure in each chamber, combined with return spring force, causes the primary and secondary pistons to return to their initial released positions. Each actuator opens its respective compensating valve, reopening the passage between the individual reservoir sections and its associated pressure chamber.

Should the rate of release be great enough to cause a partial vacuum in the chamber, the compensating valve will open to allow replenishment of fluid into the cylinder bore.

Any excess fluid remaining at the end of the stroke due to "pumping" and/or volume change due to temperature fluctuation is released to the reservoir as the compensating valves open.

The primary circuit is separated from the secondary hydraulic circuit. Hydraulic leakage in one circuit does not affect the function of the other circuit.

A fluid level indicator switch is available. It illuminates a light on the dash panel to warn of low brake fluid level in the master cylinder reservoir. A low fluid level can result from brake shoe lining wear, or it can occur if there is an external leak in the vehicle brake system.

A differential pressure switch is available. It illuminates a light on the dash panel to warn when there is a pressure differential between the primary and secondary brake circuits caused by a leak in one circuit. This may occur when one circuit leaks or is improperly bled.

A remote reservoir application is available where under-the-hood space constraints prohibit the use of a conventional booster and master cylinder assembly. In a remote application, the master cylinder reservoir is mounted separately from the master cylinder.

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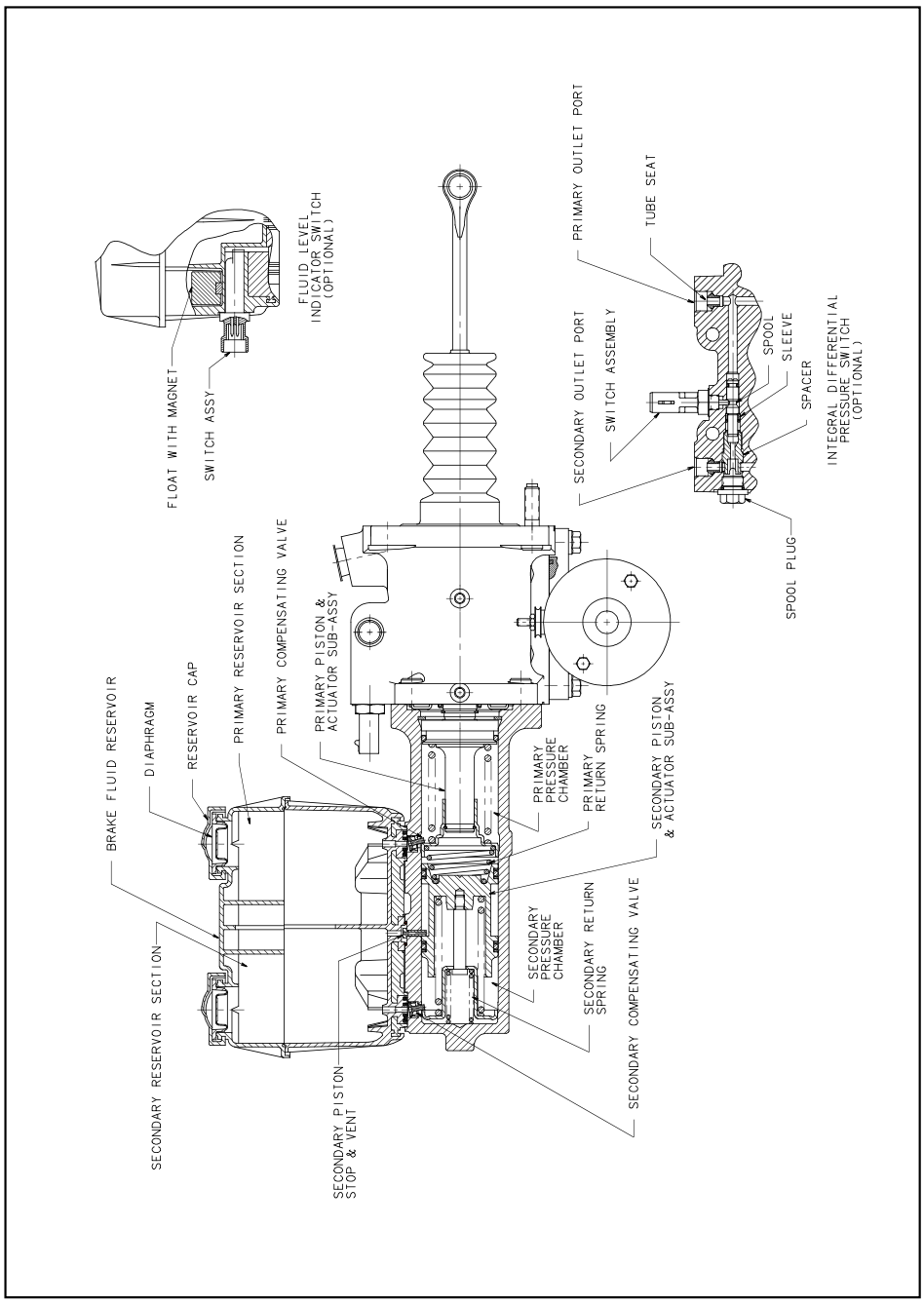


Figure 5 Master Cylinder

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Electrical Operating Systems

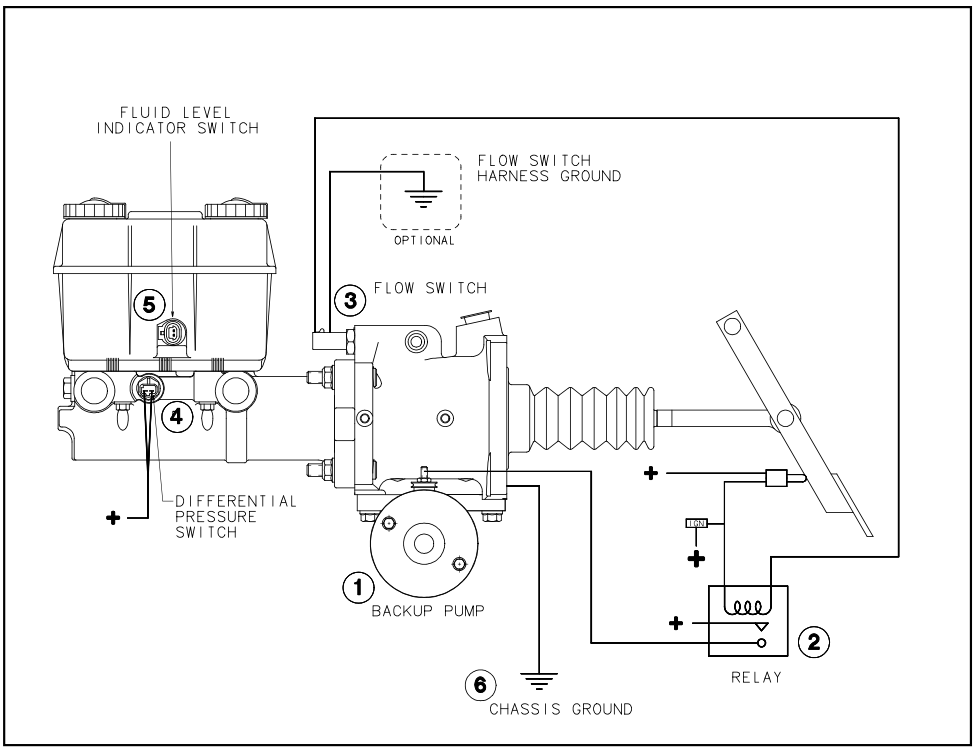


Figure 6 Schematic of Electrical Operating System

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Basic Operation of Hydro-Max™ Booster Assembly and Master Cylinder

Reference *Figure 6* for the following electrical components of the booster and master cylinder.

1. **Backup Pump**: The Hydro-Max™ hydraulic booster has a backup pump which will provide hydraulic boost at a reduced rate if the normal source of fluid is interrupted (refer to *Figure 3*). The signal for operation of the backup pump comes from the flow switch. If normal flow is interrupted, the flow switch will close and activate the relay, which will turn on the backup pump. The backup pump is available for 12 and 24-volt systems.

   The 12-volt backup pump can draw a steady state maximum of 55 amps at a power steering fluid temperature of 100° F. The 24-volt backup pump can have a steady state maximum draw of 27.5 amps at 100° F.

2. **Relay**: An optional relay is available for attachment to the booster. The relay connects to a sealed and mechanically latched wiring connector. The function of the relay is to provide current to the backup pump when triggered by the flow switch.

3. **Flow Switch**: The function of the flow switch is to activate the relay when normal hydraulic power source fluid flow is interrupted, turning on the backup pump. The flow switch has two terminals (A and B). A is positive. B is connected to the booster housing and can be used as an optional harness ground. The flow switch itself is grounded through the booster housing. A sealed and mechanically latched connector connects the flow switch to the backup pump relay circuitry.

4. **Differential Pressure Switch**: The differential pressure switch reacts to a loss of master cylinder hydraulic pressure in either side of the split hydraulic system and can illuminate a warning light at the instrument panel. When pressure is lost in either the primary or secondary circuit of the master cylinder, the switch closes. The electrical switch will remain closed until the malfunction is corrected. When both systems develop normal pressure, the switch will return to center and open the electrical switch circuit. A mechanically latched connector is attached to the switch. The switch has two tabs on a common terminal (positive) and is grounded through the master cylinder.

5. **Fluid Level Switch**: When the fluid reaches a predetermined level (low fluid level), the switch closes and can illuminate a warning light at the instrument panel. A sealed and mechanically latched connector is attached. The switch has two terminals, positive and negative, which are interchangeable.

6. **Chassis Ground**: The booster and master cylinder assembly must be provided with a ground path that will carry the maximum current of the backup pump.

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Electronic Monitor Modules (12-volt only)

Bosch recommends that a monitor module be included to monitor the electrical integrity of the backup system. Bosch offers two types with the following features and functions:

Monitor Module Type I

Features

1. Performs start-up self test for proper electrical signal to reserve backup pump.
2. Continuously test for an open circuit in backup pump.
3. Turns on vehicle warning light and buzzer if any of the above tests indicate a backup system electrical malfunction. The warnings are continuous until the malfunction is corrected or the power is shut off.
4. Conveys signal to provide electrical power to the backup pump via the relay.
5. Provides a centralized housing for diodes.
6. Includes an integral differential pressure switch light check at start up.

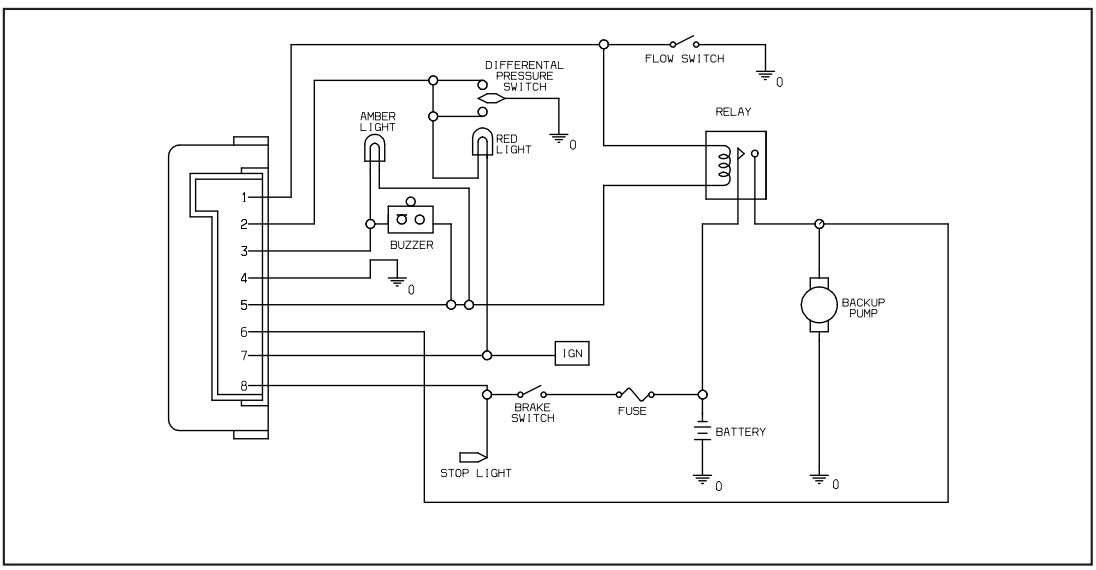


Figure 7 Schematic of Electronic Monitor Module Type I

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Pin Functions

Pin	Function
1	a) Provides path to flow switch to ground for pin 2 to allow test of red light during vehicle start up. b) Suppresses negative voltage transients into pin 5 from the relay coil.
2	Provides path to pin 1 to flow switch to vehicle ground to allow test of red light during vehicle start up. Note: Pin 1 and 2 are connected, with a diode in-between. With the key in the "on" position, the red dash panel light should illuminate anytime hydraulic flow (from the fluid power source) drops to a range of 0.5 to 1.1 gpm. (The range at which flow switch continuity occurs).
3	Open circuit when all is okay, but switches to ground (pin 4) during vehicle start or during a detected fault. Connection to ground turns on warning light and buzzer.
4	Connects monitor module to vehicle ground.
5	Supplies power from module to amber light, buzzer and relay coil. Current flow through this terminal must be limited to 300 mA.
6	a) Monitors for voltage to backup pump during startup. If none detected, pin 3 remains grounded (connected to pin 4). b) Monitors for continuity through the backup pump to vehicle ground during vehicle operation (engine on). Pin 3 switches to ground (pin 4) if continuity is lost.
7	Brings power into module from ignition switch.
8	Brings power into module from brake switch. Only needed when ignition switch is off. Enables backup pump to operate when ignition is off.

BOSCH

Monitor Module Type II (12 volt only)

Features

1. Performs start-up self test for proper electrical signal to backup pump.
2. Continuously tests for an open circuit in backup pump.
3. Tests for voltage during brake application in brake light circuit and backup pump relay coil circuit on vehicles equipped with dual brake switches.
4. Turns on warning light(s) and buzzer if any of the above tests indicate a backup pump system electrical malfunction. The warnings are continuous until the malfunction is corrected or the power is shut off.
5. Absence or malfunction of the module will not affect backup system operation.
6. Turns on light(s) and buzzer when integral differential pressure switch is activated.

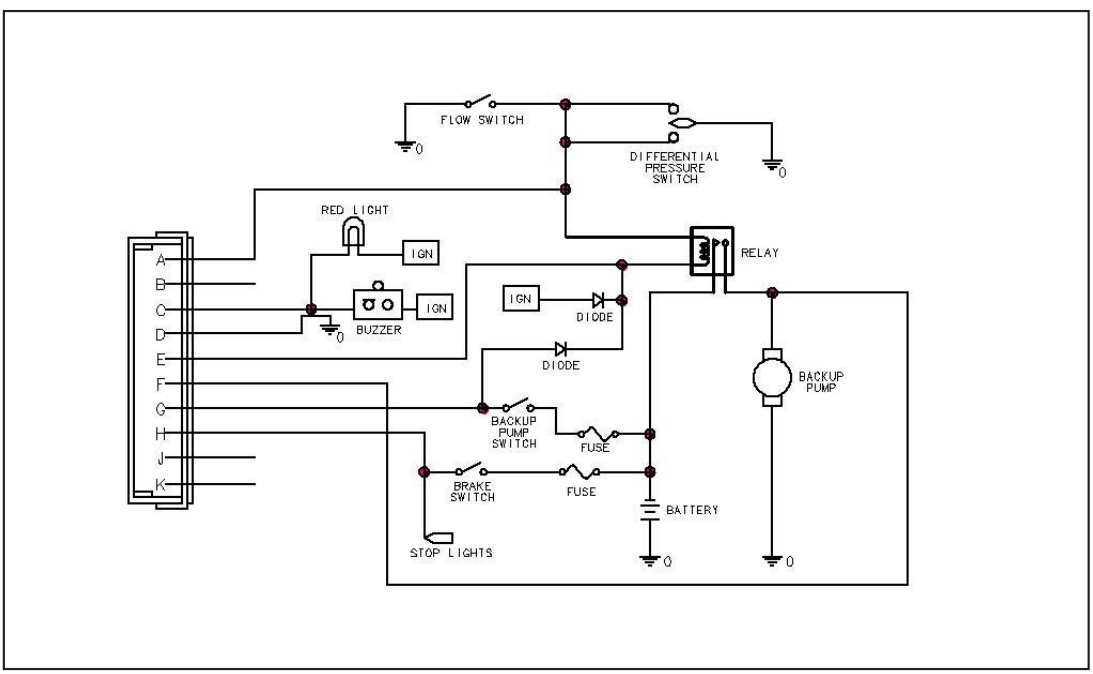


Figure 8 Schematic of Electronic Monitor Module Type II

BOSCH

Pin Functions

Pin	Function
A	Suppresses negative voltage transients into pin E from the relay coil.
B	Not used.
C	Open circuit when all is okay, but switches to ground (pin D) during vehicle startup or during a detected fault. Connection to ground switches on warning light and buzzer.
D	Connects monitor module to vehicle ground.
E	Power input to monitor module from ignition switch or Hydro-Max™ brake pedal switch.
F	1) Monitors for voltage to backup pump during vehicle startup. If none detected, pin C remains grounded (connected to pin D). 2) Monitors for continuity through backup pump to vehicle ground during vehicle operation (engine on). Pin C switches to ground (pin D) if continuity is lost.
G	Monitors output of the backup pump switch that turns on the backup pump, to allow comparison with pin H. If different for > 14±5 seconds, then pin C switches to ground (pin D) and latches.
H	Monitors output of stop light switch to allow comparison with pin G. If different for > 14±5 seconds, then pin C switches to ground (pin D) and latches.
J	Not used.
K	Not used.

BOSCH

Application Information

Hydraulic Fluids

The Hydro-Max™ booster uses power steering fluid as the medium of transmitting power.

The master cylinder uses DOT 3 brake fluid per SAE J1703, unless otherwise specified on the top of the reservoir. Service maintenance of motor vehicle brake fluid in motor vehicle brake actuating systems is covered in SAE J1707 information report.

⚠CAUTION

Before using any other type of fluid in the booster or in the master cylinder, contact the Bosch Hydraulic Actaution and Truck Brake Engineering Department. (See inside of front cover).

⚠CAUTION

The booster and the master cylinder use two (2) distinctly different incompatible hydraulic fluids. They must not be mixed. Using the incorrect fluid will permanently damage the seals and can cause the brakes to malfunction.

Brake Fluid Tubing, Hoses and Fittings

Brake fluid lines (tubing and flexible hose) transmit fluid under pressure between the master cylinder and the brakes. The hoses are the flexible links between wheels or axles and the frame or body. The hoses must withstand fluid pressure with minimal expansion and must be free to flex without damage during normal suspension deflection and wheel turns. The following SAE specifications, or their successors if appropriate, are recommended for consideration as a minimum requirement when outfitting a vehicle with brake fluid tubing, hoses and fittings. The hoses should conform to SAE J1401 Hydraulic Brake Hose - Automotive. The tubing should conform to SAE J1047 Tubing - Motor Vehicle Hydraulic Brake System. The fittings should conform to SAE J516a - Hydraulic Hose Fittings, or SAE J512 - Automotive Tube Fittings. Contact the vehicle manufacturer for specific requirements for individual applications.

BOSCH

Booster Fluid Tubing, Hoses and Fittings

The pressure line that supplies fluid to the booster must be a 1/2" diameter flexible or rigid pressure line conforming to SAE J188 and typically designed to run from the steering gear to the Hydro-Max™ inlet. The Hydro-Max™ inlet port utilizes a tube "O" arrangement as shown in *Figure 9* (not supplied by Bosch). For tube flare configuration see *Figure 10.*

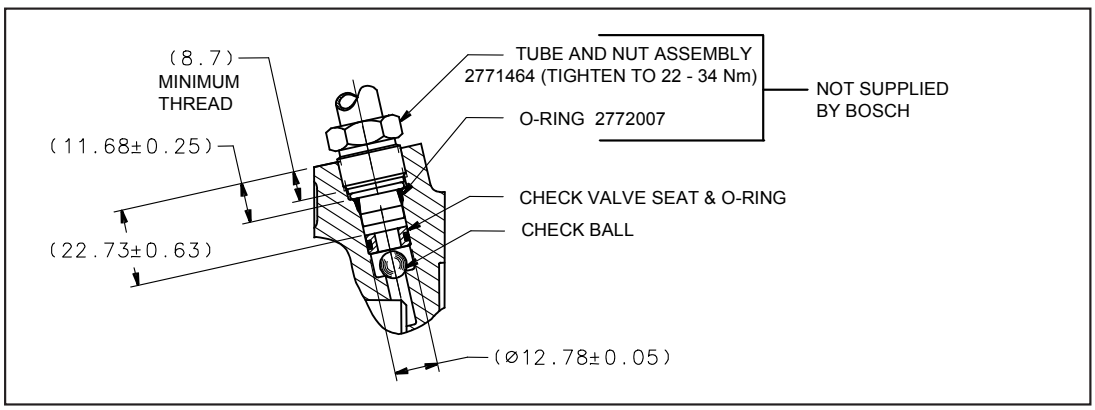


Figure 9 Tube"O" Fitting and O-ring Seal

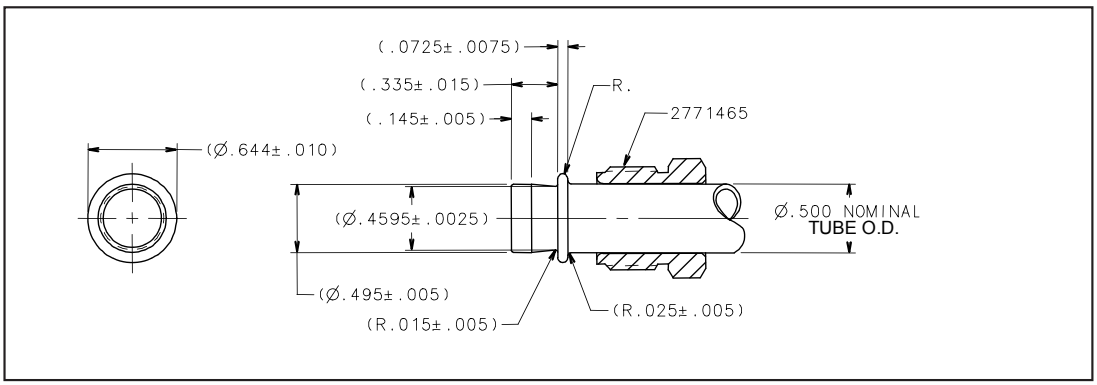


Figure 10 Tube Flare Configuration

The return line must be a 1/2" diameter hydraulic hose attached to the Hydro-Max™ outlet port (See *Figure 11*). The return line and clamp must be selected so that it will withstand worst case vehicle operating conditions, such as back pressures resulting from start up at extremely cold temperatures or from devices installed down stream of the booster.

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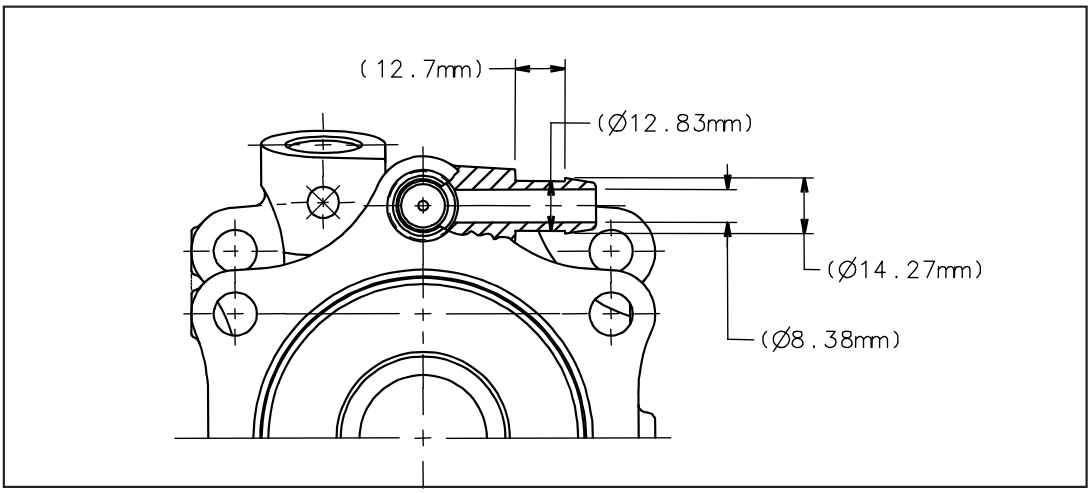


Figure 11 Outlet Port

Booster Fluid Source

The booster is designed to perform in a flow range of 3.2 to 5.0 gpm. Flow rate through the booster can impact vehicle stopping distance; therefore, the vehicle manufacturer must determine the required minimum flow rate. Flow rates below 3.2 gpm can cause slower response times when the booster is applied. Flow rates higher than 5.0 gpm may contribute to the booster self-applying, which will cause brake drag or fluid overheating.

The fluid power source must be capable of supplying 1,000 psi to the booster plus any additional pressure required by other devices in the system such as a power steering gear.

If a power steering gear is used, the steering gear must be "balanced" so that it can handle the pressures generated in the steering gear return line. It must also have an internal relief valve setting lower than the pump relief to allow the steering gear to relieve before the hydraulic pump does. It must also have an internal by-pass to allow manual steering during booster backup system operation. The manufacturer must adhere to the flow path illustrated in *Figure 2*.

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Installation Recommendations

The Hydro-Max™ booster is generally mounted to a vehicle's dash panel. If necessary, the Hydro-Max™ booster and master cylinder may be mounted remotely from the vehicle dash panel and actuated by appropriate linkage.

Four mounting holes are provided in the booster housing through which up to four studs can be pressed. Use of (Grade 5) 3/8-16 or M10 locknuts, having self-contained prevailing torque features that are frictionally resistant to rotation, are recommended.

See *Figure 12* for the three basic pedal rod designs offered. The threaded pedal rod screws into the customer supplied attachment to the brake pedal. The pin that attaches the pedal rod to the brake pedal must insert freely. The attachment mechanism of the pedal rod should be of sufficient strength to prevent linkage binding.

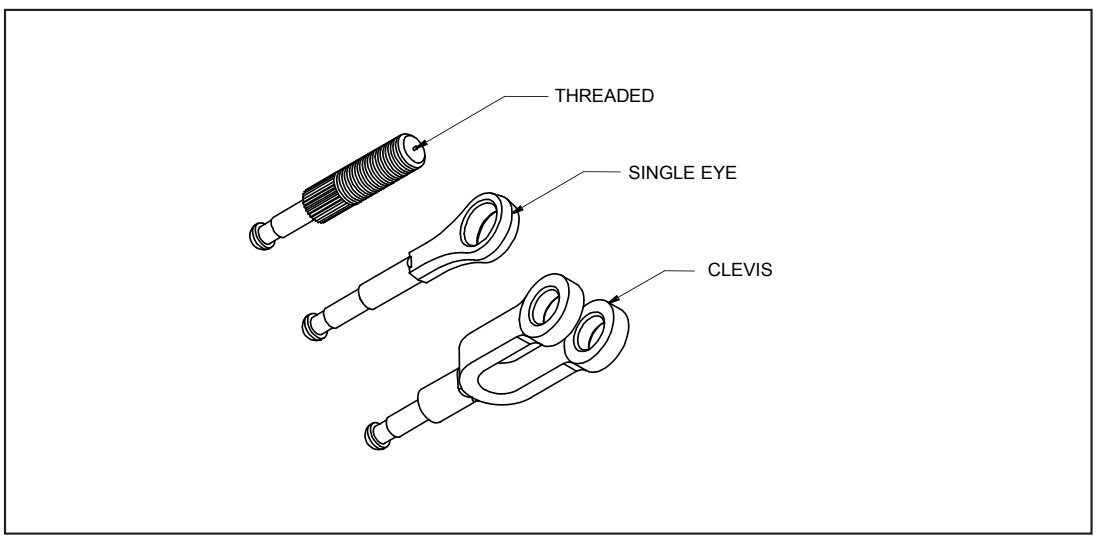


Figure 12 Basic Pedal Rod Designs

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ATTENTION

Regardless of mounting location, the following requirements **must** be followed:

a. Mount the unit such that the pedal rod, throughout full pedal travel, does not articulate more than plus or minus 5^{O} above or below booster centerline. The brake pedal lever must be aligned side to side with the booster centerline to prevent linkage binding.

b. The brake pedal and mechanical linkage **must** provide enough travel to fully stroke both booster and master cylinder, i.e., the brake pedal must not bottom on the floor of the vehicle. A pedal ratio of between 2.8:1and 3.3:1 is recommended to provide the desired "pedal feel".

c. The Hydro-Max^{TM} booster and master cylinder assembly **must** be mounted horizontally.

d. The reservoir of the master cylinder **must** be upright. The backup pump must always be at the bottom of the booster.

e. The unit **must** be protected from environmental and fluid temperatures over 250^{O}F.

General Safety Note

Unique usage or applications of the Hydro-Max^{TM} booster and master cylinder assembly requires input from Bosch and validation by the vehicle manufacturer.

Pedal Return Springs

Any vehicle application utilizing a Hydro-Max^{TM} booster and a brake pedal return spring must have:

1. A properly adjusted pedal stop

2. A limited spring load at the pedal released position.

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Pedal Stop and Proper Spring Load

The pedal stop must be adjusted such that when the brake pedal is fully released, there is no load on the grommet that retains the pedal rod to the Hydro-Max™ booster. When the brake pedal is fully released, the spring load must not be greater than that required to support the pedal weight.

The reason for a properly adjusted pedal stop and for the limitation on spring load is to prevent the spring from pulling on the grommet within the Hydro-Max™ booster and damaging the grommet. The grommet is not designed to be loaded in this manner.

Any adjustment of the brake switch and backup pump must not compromise the adjustment of the pedal stop.

⚠CAUTION

It is a commmon practice to stack vehicles on top of each other to deliver the vehicles. An air cylinder is typically used to apply the brake pedals in the towed vehicles. When installing such a cylinder, be sure that the backup pump turns off when the towing vehicle brake pedal is released.

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TROUBLE SHOOTING

Condition	Cause	Remedy
Hard Pedal	Binding pedal linkage	Contact dealer for service
	Pedal misaligment (side to side)	Contact dealer for service
	Low booster supply flow	Repair/replace power steering pump, check tension in belt
	Power steering pump flow control valve	Repair/replace power steering pump, check tension in belt
	Power steering pump relief valve setting too low	Replace power steering pump
	Fluid contamination	See vehicle service manual for type of fluid required. Drain, flush and refill system, replace booster or master cylinder as appropriate, and power steering reservoir filter as necessary
	Master cylinder	Replace master cylinder
	Booster	Replace booster
	Tube and hose passages are blocked shut	Replace parts containing blocked passages
Excessive pedal travel (pedal goes to the floor)	Improper pedal adjustment	See vehicle service manual for pedal rod adjustment (if system is adjustable)

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TROUBLE SHOOTING

Condition	Cause	Remedy
Excessive pedal travel (pedal goes to the floor)	External leak in brake fluid system	Check all fittings and connections for the master cylinder, calipers, hoses, and tubes, replace if necessary
(continued)	Internal master cylinder leak	Replace master cylinder
	Air in brake fluid system	Bleed system
	Brake linings	Inspect and adjust, or replace brake shoes, if necessary
Pulsating brake pedal	Master cylinder	Replace master cylinder
	Weak brake hoses that expand under pressure	Replace hoses
	Poor quality brake fluid (low boil point)	Drain the system, flush and refill with the recommended fluid.
	Brake self adjusting mechanism	See vehicle service manual (if brakes are adjustable)
Soft, spongy brakes	Air in hydraulic brake system	Bleed brake system
	Poor quality brake fluid (low boil point)	Drain the system, flush and refill with recommended fluid
	Weak brake hoses that expand under pressure	Replace defective hoses
Actuated pedal does not return	Binding pedal linkage	Contact dealer for service

BOSCH

TROUBLE SHOOTING

Condition	Cause	Remedy
Actuated pedal does not return *(continued)*	Fluid contamination	See vehicle service manual for type of fluid required. Drain, flush and refill system, replace booster or master cylinder as appropriate, and power steering reservoir filter as necessary
	Master cylinder	Replace master cylinder
	Binding booster	Replace booster
	Self applied booster (fluid flow too high)	Repair or replace power steering pump.
Pulsating brake pedal	ABS operation	See appropriate service manual
	Wheel bearings loose or worn	See appropriate service manual
	Excessive rotor hickness variation	See appropriate service manual
	Parking brake control valve (HR1) has internal leak	See appropriate service manual
Brake self apply	Self applied booster (fluid flow too high)	Repair or replace power steering pump
	Constricted master cylinder reservoir vent	Clean vent passage in reservoir cap
Dragging brake	Self applied booster (fluid flow too high)	Repair or replace power steering pump

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TROUBLE SHOOTING

Condition	Cause	Remedy
Dragging brake (*continued*)	Stuck or bound caliper pins or rails	See appropriate service manual
	Binding booster	Replace booster
	Binding pedal linkage	Contact dealer for service
	Master cylinder	Replace master cylinder
	Soft or swollen master cylinder seals due to brake fluid contamination	Flush out old brake fluid then replace master cylinder and add new brake fluid
	Tube and hose passages restricted	Replace the parts containing the restriction
Noise / Whistle	Inherent in some boosters (whistle)	None - Does not affect operation
Backup pump operates continuously	Brake switch	See vehicle service manual
	Monitor module	See vehicle service manual
	Relay	See vehicle service manual
	Flow switch	Remove switch components, clean, inspect for damage or contamination and replace if necessary
	Binding pedal linkage	Contact dealer for service

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TROUBLE SHOOTING

Condition	Cause	Remedy
Backup pump does not operate	Same as above	Repeat as above
	Electrical ground	See service manual
	Backup pump	Replace backup pump
Leakage	Master cylinder	Replace master cylinder
	Booster	Replace booster
	Master cylinder reservoir vent caps	Replace diaphragms and caps
	Fluid contamination	See vehicle service manual for type of fluid required. Drain, flush and refill system, replace booster or master cylinder as appropriate, and power steering reservoir filter as necessary
	Backup pump mounting seals	Replace seals
	Flow switch seal	Replace o-ring
	Hydraulic fittings and connections	See vehicle service manual, tighten and replace if necessary
Silicone floating in master cylinder	This material is an assembly lubricant	None - Does not affect operation

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TROUBLE SHOOTING

Condition	Cause	Remedy
Fluid level indicator light comes on	Low fluid level	Inspect brake pads, replace as necessary, add fluid as required
	Fluid level indicator switch	Replace master cylinder
	Brake pads worn out	Inspect brake pads, replace as necessary, add fluid as required
Brake indicator light and buzzer malfunction	Vehicle specific	See vehicle service manual

Correspondence concerning this manual should be addressed to:

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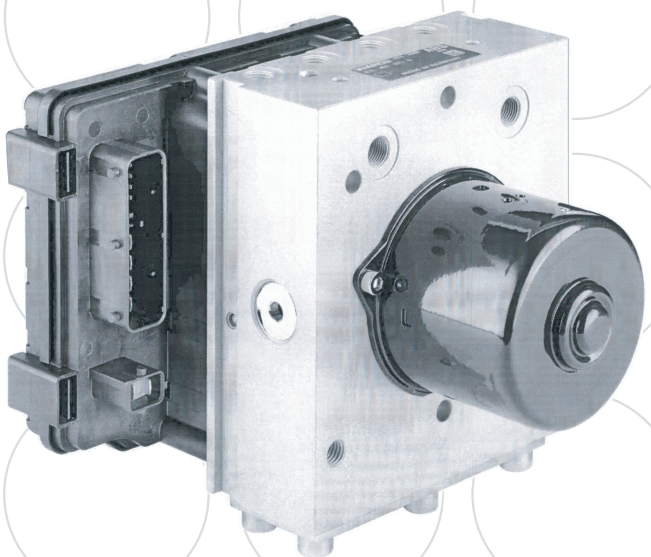
MERITOR WABCO

Maintenance Manual MM-0677

Hydraulic Anti-Lock Braking Systems (HABS) for Medium-Duty Trucks, Buses and Motor Home Chassis

For E Version Hydraulic ABS

Issued 09-07



Service Notes

About This Manual

This manual provides instructions for Meritor WABCO's E Version hydraulic anti-lock braking system (HABS) for medium-duty trucks, buses and motor home chassis.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at arvinmeritor.com to access and order product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components. Meritor WABCO publications are also available on our website: www.meritorwabco.com

Literature on Demand DVD (LODonDVD)

The LODonDVD contains product, service and warranty information for ArvinMeritor and Meritor WABCO products. To order the DVD, visit Literature on Demand at arvinmeritor.com and specify TP-0742.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

Information contained in this publication was in effect at the time the publication was approved for printing and is subject to change without notice or liability. Meritor WABCO reserves the right to revise the information presented or to discontinue the production of parts described at any time.

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Asbestos and Non-Asbestos Fibers

⚠ ASBESTOS FIBERS WARNING

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

Hazard Summary

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

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

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

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

3. Procedures for Servicing Brakes.

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

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

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

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

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

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

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

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

Regulatory Guidance

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

⚠ NON-ASBESTOS FIBERS WARNING

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

Hazard Summary

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

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

Recommended Work Practices

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

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

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

3. Procedures for Servicing Brakes.

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

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

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

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

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

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

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

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

Regulatory Guidance

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

1 Introduction

Maintenance

Manual Information

This manual contains service information for the Meritor WABCO **E Version** hydraulic ABS. For earlier versions of Meritor WABCO HABS, refer to:

- MM38 **C Version** HABS
- MM39 **D Version** HABS

Copies of these manuals are posted on our website:

meritorwabco.com.

Overview

Meritor WABCO Hydraulic Anti-lock Braking System (HABS) is an electronic wheel speed monitoring and control system used on medium-duty trucks, buses and motor home chassis equipped with a hydraulic brake system.

E Version HABS consists of an electronic control unit (ECU) mounted directly on a modulator valve. Typically, the modulator valve is mounted on the frame rail of the vehicle. Figure 1.1.

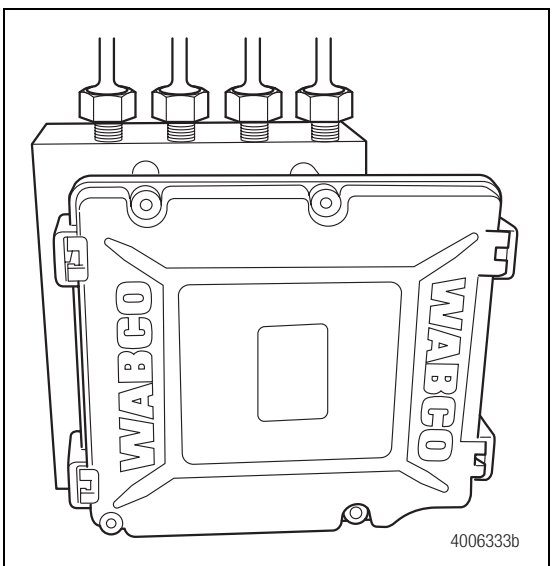


Figure 1.1

How Hydraulic ABS Works

ABS wheel sensors detect wheel speeds. The sensors generate signals that are transmitted to an ECU. If the wheels start to lock, the ECU signals the modulator assembly to regulate the brake pressure of each locking wheel.

During an ABS stop, a solenoid valve in the modulator assembly is rapidly pulsed; that is, it opens and closes several times per second to control the brake pressure. When this occurs, drivers may notice a pulsation of the brake pedal.

An ABS indicator lamp on the vehicle instrument panel alerts the driver to a possible system fault and provides blink code information to diagnose the system.

If the ABS indicator lamp comes on during normal vehicle operation, drivers may complete their trip, but are instructed to have their vehicle serviced as soon as possible.

In the unlikely event of an ABS system malfunction, the ABS in the affected wheel will be disabled and will return to normal braking. The other sensed wheels will retain their ABS function.

1 Introduction

System Layout

A typical Meritor WABCO E Version HABS installation is illustrated in Figure 1.2.

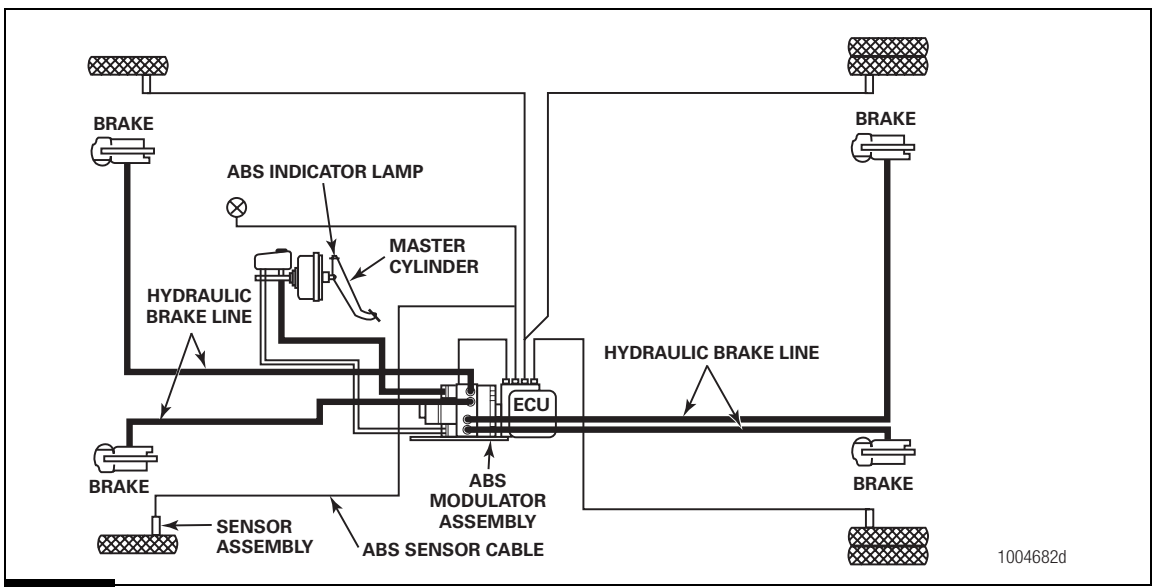


Figure 1.2

The ABS modulator assembly may be mounted in any orientation as long as the modulator is **below** the master cylinder and **above** the wheel cylinders.

System Components

The following components make up Meritor WABCO E Version HABS.

Electronic Control Unit (ECU)

The electronic control unit (ECU) processes sensor signals and generates solenoid valve commands to reduce, maintain or reapply brake pressure. Figure 1.3.

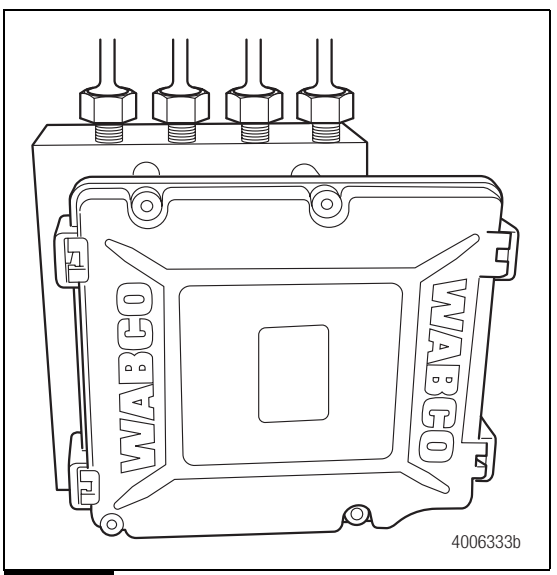


Figure 1.3

1 Introduction

Modulator Assembly

⚠ CAUTION

The modulator assembly contains brake fluid. Handle the modulator assembly with appropriate care. Do not expose the modulator assembly to impact loads or excessive vibrations. Do not blow compressed air into the hydraulic ports. Mishandling the modulator assembly may lead to component damage and system failure.

The modulator assembly houses the HABS solenoid control valves, one inlet valve and one outlet valve per wheel, a pump motor and two accumulators. Figure 1.4.

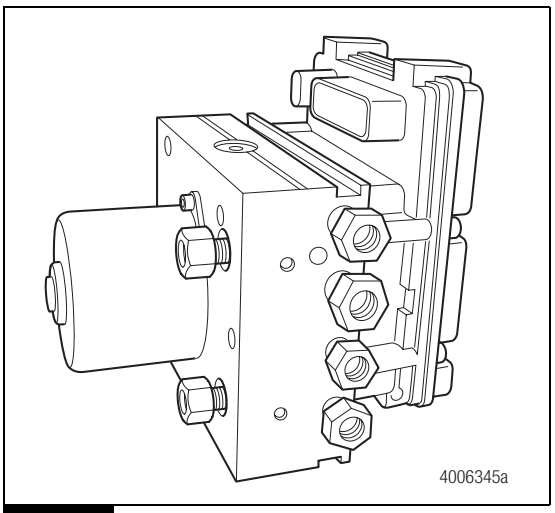


Figure 1.4

Sensors

Sensor with Molded Socket

- Measures the speed of a tooth wheel rotating with the vehicle wheel.
- Produces an output voltage proportional to wheel speed. Figure 1.5.

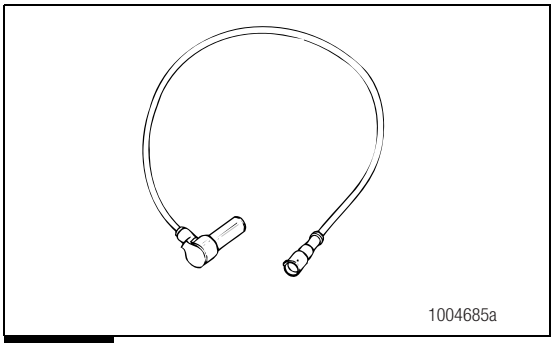


Figure 1.5

Sensor Spring Clip

- Holds the wheel speed sensor in close proximity to the tooth wheel. Figure 1.6.

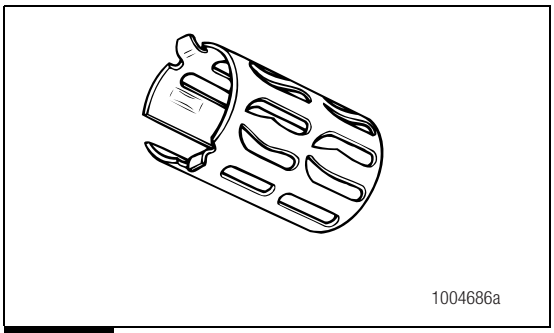


Figure 1.6

Tooth Wheel

- A machined or stamped ring mounted to a machined surface on the hub of each ABS-monitored wheel. Figure 1.7.

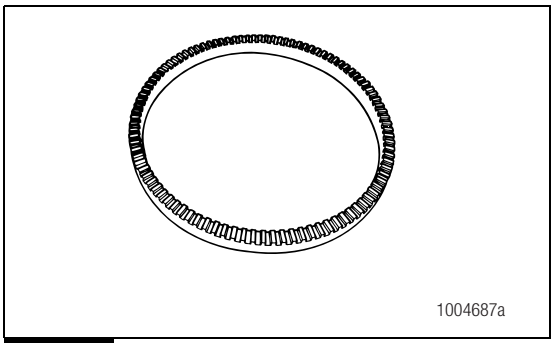


Figure 1.7

1 Introduction

Sensor Extension Cables

- Two-wire cable with molded-on connector. Figure 1.8.
- Connects the wheel speed sensor to the ECU.

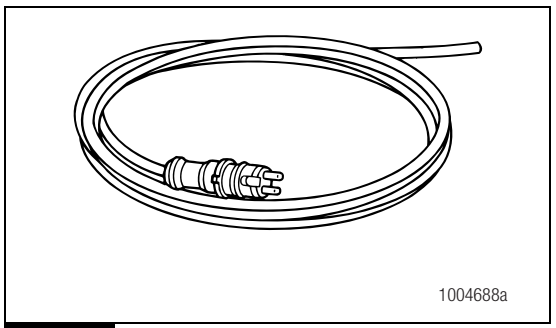


Figure 1.8

ABS Indicator Lamp

- Located on vehicle instrument panel. Figure 1.9.
- Alerts drivers to a possible system fault.
- Used by service personnel to display blink codes.
- ABS indicator lamp is not provided by Meritor WABCO.

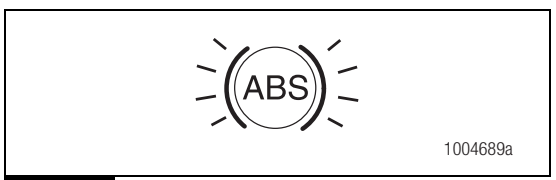


Figure 1.9

TOOLBOX™ Software

- A PC-based diagnostics program.
- Displays system faults and wheel speed data, tests individual components, verifies installation wiring and more.
- Runs in Windows® 98, ME, 2000, NT or XP. Figure 1.10.

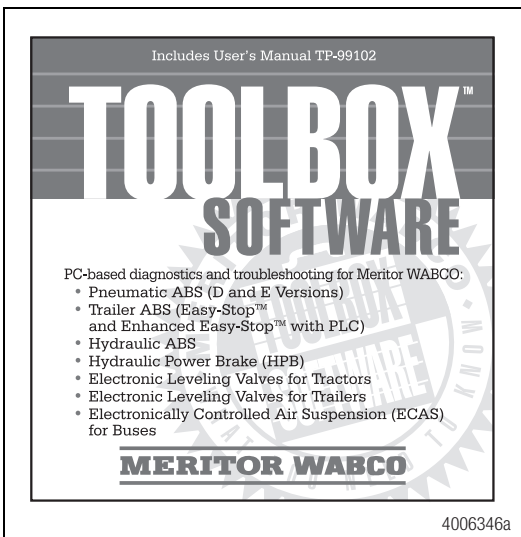


Figure 1.10

NOTE: An RS232 to J1708 converter box is required.

The program is available from SPX. Call 800-328-6657.

2 Troubleshooting and Testing

Maintenance

General Information

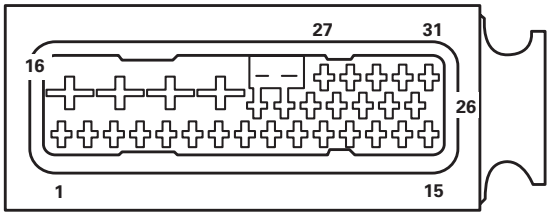
There is no regularly scheduled maintenance required for Meritor WABCO E Version Hydraulic ABS. However, ABS does not change current vehicle maintenance requirements. For example, it is important that the vehicle brake fluid level be correctly maintained.

Wiring Diagrams

System Wiring Information

Pin identification is shown in Figure 2.1. Wiring may vary according to the vehicle. Refer to the vehicle specifications for specific wiring diagrams. A typical Meritor WABCO Hydraulic ABS wiring diagram appears in Figure 2.2.

PIN IDENTIFICATION FOR HABS WIRE HARNESS CONNECTORS TO THE ECU



(9511)

Count from the pin number at the end of each row, identify pin assembly to measure. Connector view shows the back of the connector.

Pin #	Circuit Label
1	Ignition 12v
2	3rd Brake Relay (optional)
3	Not Used
4	Not Used
5	Not Used
6	Reference Ground
7	Not Used
8	Not Used
9	Not Used
10	Not Used
11	Not Used
12	Not Used
13	Not Used
14	J1939 + High – (optional)
15	J1939 – Low – (optional)

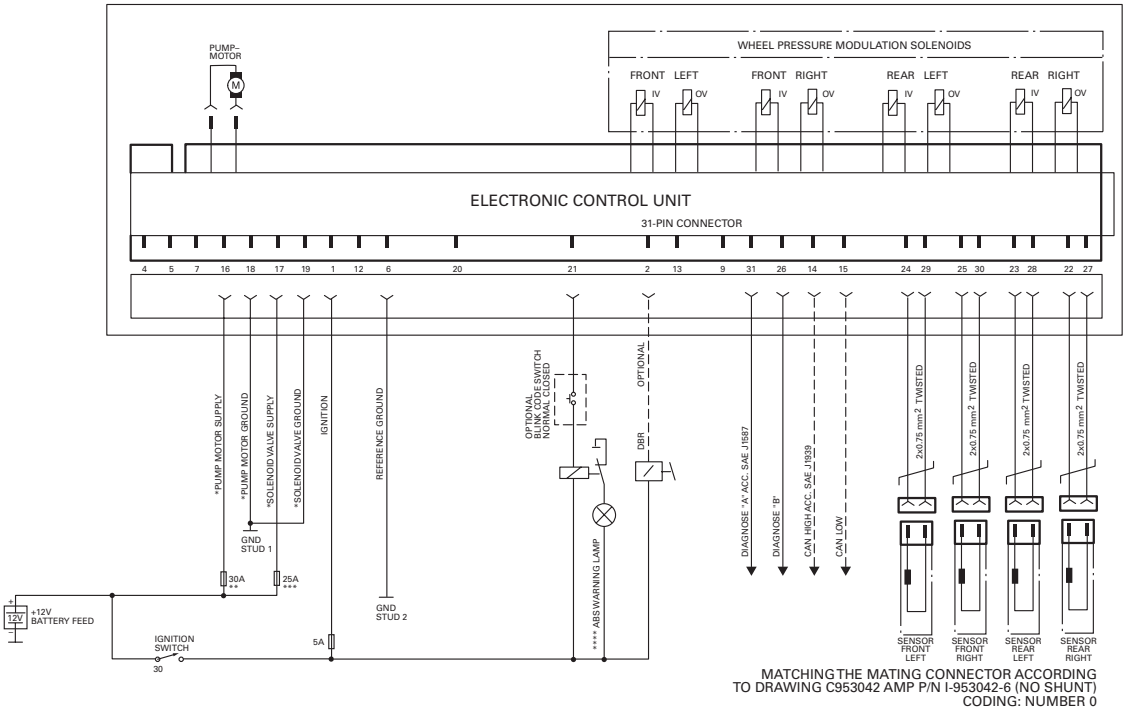
Pin #	Circuit Label
16	Pump Motor Supply 12v+
17	Solenoid Valve Supply 12v+
18	Pump Motor Ground –Gnd
19	Solenoid Valve Ground –Gnd
20	Not used
21	ABS Warning Lamp Relay
22	Rear Right Wheel Speed Sensor
23	Rear Left Wheel Speed Sensor
24	Front Left Wheel Speed Sensor
25	Front Right Wheel Speed Sensor
26	J1587 Diag. B + Low
27	Rear Right Wheel Speed Sensor
28	Rear Left Wheel Speed Sensor
29	Front Left Wheel Speed Sensor
30	Front Right Wheel Speed Sensor
31	J1587 Diag. A + High

4006172a

Figure 2.1

2 Troubleshooting and Testing

WIRING DIAGRAM
HYDRAULIC ABS E-VERSION HABS



NOTES:
Electric cables without marks:
AWG 18 (SAE J 1128 TYP: TXL-CABLE)
respectively 1 mm²
Blade type fuses corresponding to ISO/DIS 8820
Abbreviations: IV — Inlet Valve
OV — Outlet Valve

*** Wire size AWG 12 (SAE J 1128 TYP: GXL-CABLE)**
Respectively Min. 3 mm²:
Total resistance including crimp = 0.04 ohms.
Corresponds to an overall length of 6 meters.
**** According to SAE J 1284 or SAE J 1888.**
***** According to SAE J 1284.**
****** ABS lamp circuit (optional).**

4006173d

Figure 2.2

System Diagnostics

Use Meritor WABCO's PC-based diagnostic program, TOOLBOX™ Software, or standard blink codes to diagnose hydraulic ABS faults. Information for using standard blink codes appears in Table A in this section.

Meritor WABCO TOOLBOX™ Software

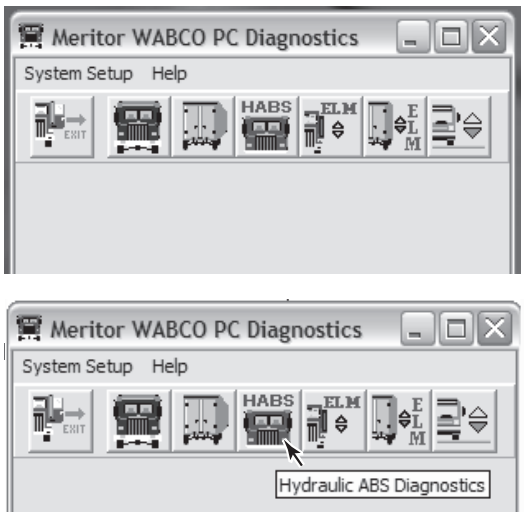
NOTE: For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800-535-5560 for information about TOOLBOX™ Software.

If you have TOOLBOX™ Software installed on your computer, use it to identify system faults. Then, follow the on-screen repair information to make the necessary repairs or replacements.

To display Hydraulic ABS faults, use the pull-down menu or the HABS icon, Figure 2.3, to select HABS (Hydraulic ABS) from the **Main Menu**. The **Hydraulic ABS Main Menu** will appear. Figure 2.4.

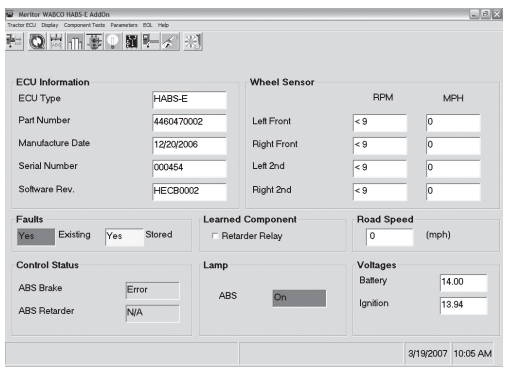
Select the View ECU Faults icon or select Display Faults to use the pull-down menu. Figure 2.5. This will display the **Fault Information** screen. Figure 2.6.

2 Troubleshooting and Testing



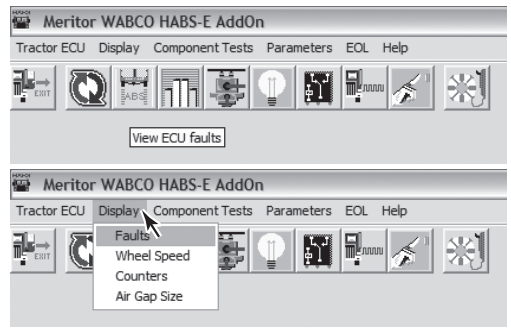
1004695b

Figure 2.3



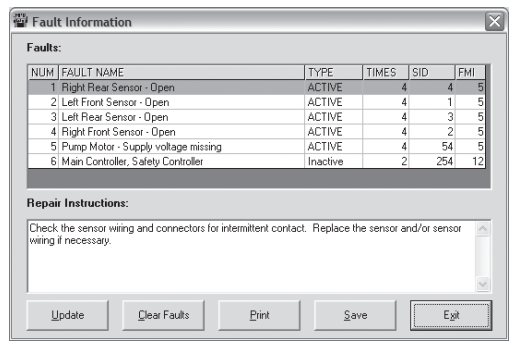
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Figure 2.4



1004697b

Figure 2.5



1004698b

Figure 2.6

The **Fault Information** screen contains a description of the fault. Repair instructions for each fault appear at the bottom of the screen.

Faults that occur after the screen is displayed will not appear until a screen update is requested. Use the ***Update*** button to refresh the fault information table.

After making the necessary repairs, use the ***Clear Faults*** button to clear the fault. Use the ***Update*** button to refresh the fault information table and display the new list of faults.

2 Troubleshooting and Testing

Blink Code Diagnostics

Definitions

ABS Indicator Lamp: This lamp, located on the vehicle instrument panel, serves two purposes:

1. Alerts drivers or service personnel to a possible fault in the hydraulic ABS, as follows:

   IF the ABS indicator lamp comes on briefly then goes OFF when the ignition is turned ON . . . . . there are no active or stored faults in the hydraulic ABS

   IF the ABS indicator lamp comes on and **stays on** AFTER the ignition is turned ON **and**

   The vehicle is driven in excess of four mph (6 km/h) . . . **There may be an active fault in the hydraulic ABS**

   IF the ABS indicator lamp comes on and stays on **and**

   Goes OFF after the vehicle is driven in excess of four mph (6 km/h) or illuminates intermittently during driving . . . **There may be a stored fault in the hydraulic ABS**

2. Displays diagnostic blink codes for easy servicing.

   Blink Code: A series of blinks or flashes that describe a particular ABS system condition. Refer to Table A and Table B in this section for blink code identification.

   Blink Code Diagnostics: The ability of the Meritor WABCO ECU to sense faults in the ABS system and to define these faults via blink codes.

   Blink Code Switch: A momentary switch that activates blink code diagnostic capabilities. Usually, it is mounted under the instrument panel or on the steering column. Refer to the vehicle specifications for type and location.

   Clearing Fault Codes: The process of erasing faults from the ECU memory bank. Refer to Table A in this section.

   Fault Code: An ABS condition (fault) detected and stored in memory by the Meritor WABCO ECU and displayed by blink code. System faults may be **Active** or **Stored**.

   Active Fault: A condition that currently exists in the ABS system; for example, a sensor circuit malfunction on the left front steering axle. An active fault **must be repaired before you can display additional faults.** Once an active fault has been repaired, it becomes a stored fault.

   Stored Fault: A condition that caused the system to register a fault, but **is not currently active.** For example, a loose wire that corrected itself. A stored fault can also be an active fault that has been corrected. Refer to Active Fault.

   Table A, in this section, describes the method of distinguishing between active and stored faults and explains how to clear them.

Using Blink Code Diagnostics

Follow the steps listed in Table A to use blink code diagnostics. Refer to Figure 2.7 and Figure 2.8 in this section for blink code illustrations.

2 Troubleshooting and Testing

Table A: Identifying E Version Hydraulic ABS Blink Codes

Troubleshooting with Blink Code Diagnostics			
Mode	**Procedure**	**System Response**	**Action**
Diagnostics	**Step I.** Turn ignition ON.	Possible responses:	
		1. ABS indicator lamp comes on momentarily then goes out, indicating System O.K.	No recognizable active faults in the ABS. No action required.
		2. ABS indicator lamp does not light, indicating possible wiring fault or burned-out bulb.	Inspect wiring. Inspect bulb. Make the necessary repairs.
		3. ABS indicator lamp stays on, indicating:	
		• Fault, or faults, in the system	Continue with blink code diagnostics. Go to Step II.
		• Sensor fault during last operation	Continue with blink code diagnostics. Go to Step II.
		• Faults cleared from ECU, but vehicle not driven.	Drive vehicle — lamp will go out when vehicle reaches four mph (6 km/h).
		• ECU disconnected.	Connect ECU.
	Step II. Press and hold Blink Code Switch for one second, then release.	ABS indicator lamp begins flashing two-digit blink code(s).	Determine if fault is active or stored: **Active Fault:** Lamp will repeatedly display one code. **Stored Fault:** Lamp will display code for each stored fault then stop blinking. Faults will be displayed **one time only**.
	Step III. Count the flashes to determine the blink code.	First Digit: 1-8 flashes, Pause (1-1/2 seconds). Second Digit: 1-8 flashes, Pause (4 seconds).	Find definition for blink code on blink code chart.
	Step IV. Turn ignition OFF. Repair and Record faults	Active Fault.	Make the necessary repairs.
		Stored Faults.	Record for future reference.
Clear	**Step V.** Turn ignition ON. Clear faults from memory: **Press and hold** blink code switch for at least three seconds, then release.	ABS indicator lamp flashes eight times.	All stored faults successfully cleared. Turn ignition OFF. Turn ignition ON. The indicator lamp will stay on. This is because the ECU is looking for wheel speed. Drive the vehicle at a speed of four mph (6 km/h). Once the ECU senses wheel speed, the lamp will go off.
		Eight flashes not received.	Active faults still exist, repeat Step I through Step V.

NOTE: If you receive a blink code that is not identified in this manual, contact the Customer Support Center at 800-535-5560.

2 Troubleshooting and Testing

Blink Codes Illustrated

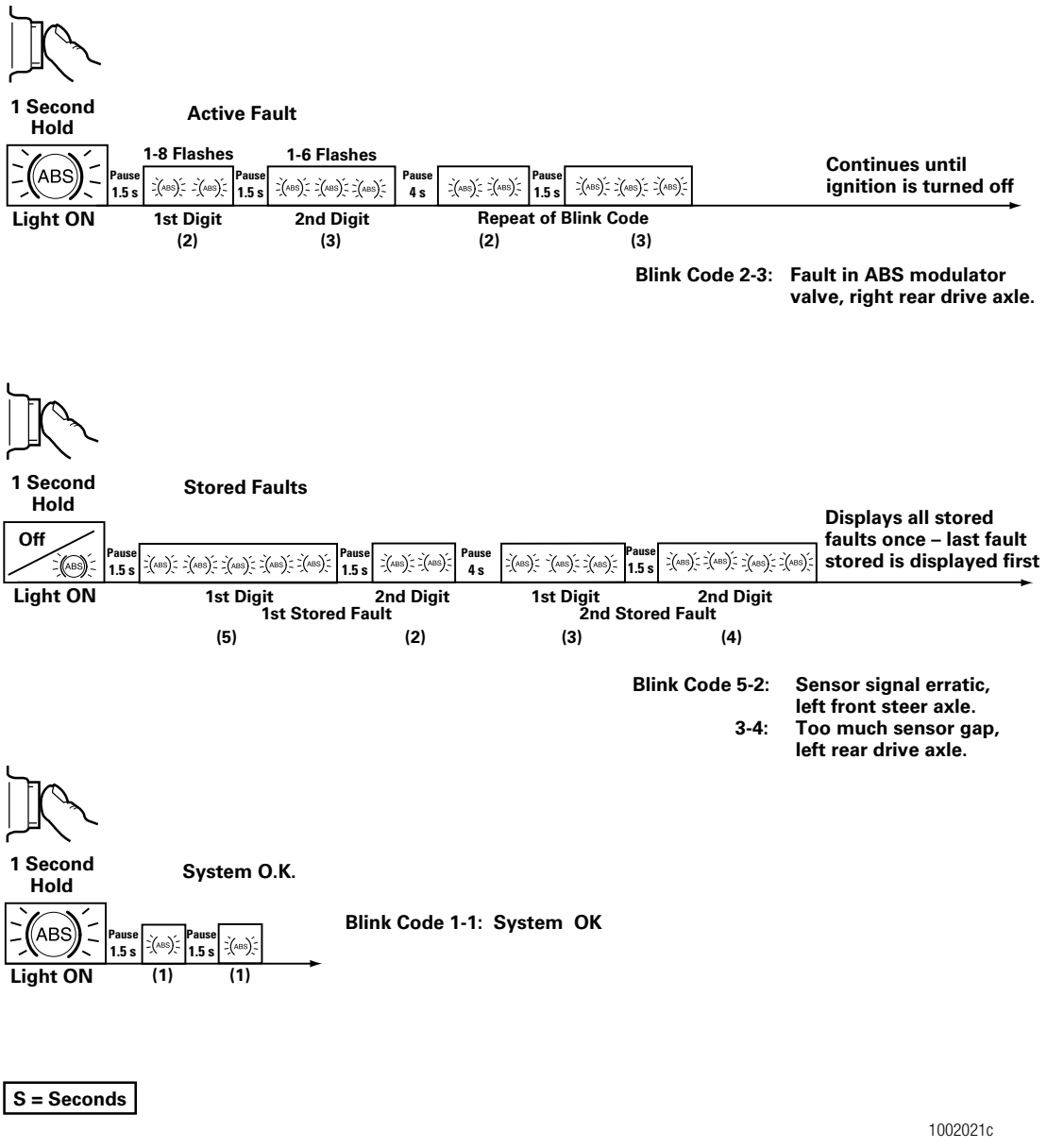


Figure 2.7

2 Troubleshooting and Testing

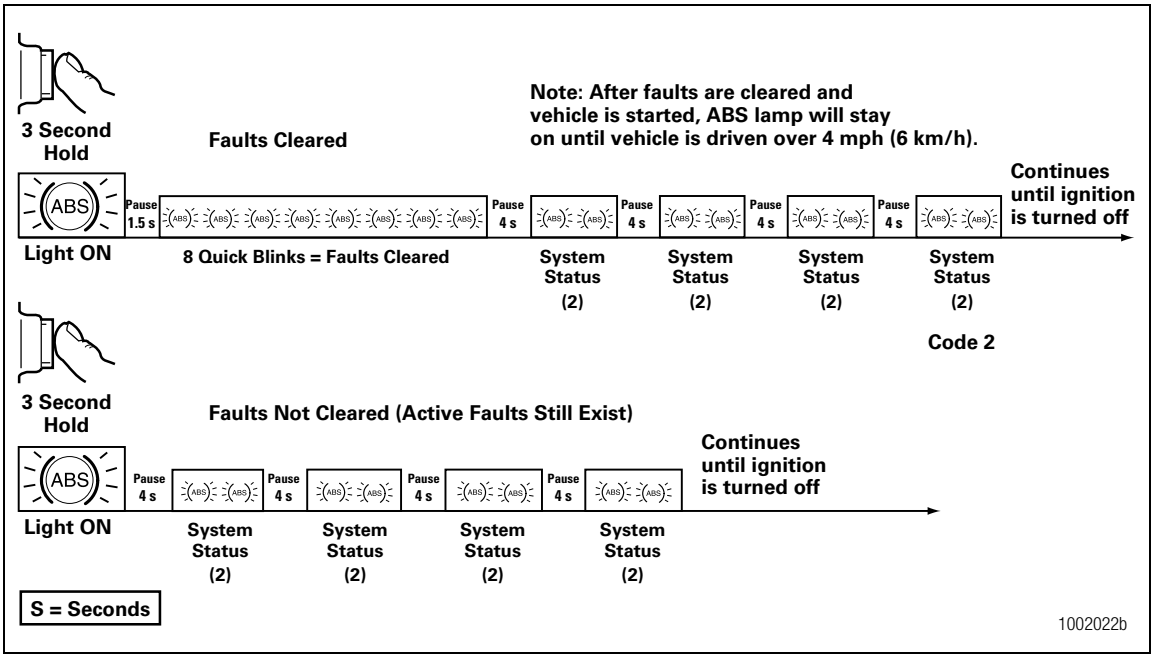


Figure 2.8

E Version Hydraulic ABS Blink Codes

Use the information in Table B to identify a fault, check for correct volt or ohm measurements and repair the fault.

1. Identify and record the blink code. Blink codes are identified in Column **1**.
2. Test the pins indicated. Pin locations to be tested are listed in Column **2**.
3. Compare the measurement received against the correct volt or ohm measurement listed in Column **3**.
4. Follow the instructions listed in Column **4**.

2 Troubleshooting and Testing

Table B: E Version Hydraulic ABS Blink Codes

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted)		
	Column 1	Column 2	Column 3	Column 4
Fault Code	Problem Area	Pins to be Tested	Correct Volt Ohm Meter Readings	Action
1-1	System OK			None required
2-1	**Right Front** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU	17 and 19	12 VDC Less than 1 ohm to chassis ground w/key-off	Check pin 17 for 12 volts. Check fuse. Check pin 19 for 1 ohm or less to chassis ground w/ key-off.
2-2	**Left Front** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU			
2-3	**Right Rear** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU			
2-4	**Left Rear** Solenoid valve (inlet or outlet valve) failure in modulator, wiring harness or inside ECU			
2-7	Reference to ground interrupted	6		Check HABS ground connections. Make necessary repairs. Check pin 6 for ≤1 ohm to chassis ground w/key-off.
3-1	**Right Front** sensor — Air gap	25 and 30	Greater than 0.2 volt AC at 30 rpm *(Rotate wheel 1/2 revolution per second)*	Check for sensor adjustment. Check for excessive wheel bearing end play. Repair or replace as needed.
3-2	**Left Front** sensor — Air gap	24 and 29		
3-3	**Right Rear** sensor — Air gap	22 and 27		
3-4	**Left Rear** sensor — Air gap	23 and 28		
4-1	**Right Front** sensor — Electrical fault	25 and 30	900-2000 ohms	Check electrical resistance of affected sensor and wiring at ECU connector and at harness plugs. Repair or replace as needed.
4-2	**Left Front** sensor — Electrical fault	24 and 29		
4-3	**Right Rear** sensor — Electrical fault	22 and 27		
4-4	**Left Rear** sensor — Electrical fault	23 and 28		
5-1	**Right Front** wheel — Erratic wheel speed			Check for tire size mismatch or tooth wheel difference. Check sensor, sensor cable and connector for intermittent contact. Repair or replace as needed. Check sensor mounting and alignment.
5-2	**Left Front** wheel — Erratic wheel speed			
5-3	**Right Rear** wheel — Erratic wheel speed			
5-4	**Left Rear** wheel — Erratic wheel speed			
7-4	ABS indicator lamp	21	10-200 ohms	Check bulb. Repair or replace as needed.

2 Troubleshooting and Testing

Table B: E Version Hydraulic ABS Blink Codes

Ignition Key ON to determine ABS blink code fault		Ignition Key OFF to test system (except where noted)		
	Column 1	Column 2	Column 3	Column 4
Fault Code	Problem Area	Pins to be Tested	Correct Volt Ohm Meter Readings	Action
7-7	Recirculation pump does not switch off. OR Recirculation pump does not switch on (low level with act). OR Recirculation pump motor locked.			Replace ECU.
7-8	Recirculation pump relay sticks.			
8-1	No voltage to ABS solenoid valves.	17 and 19	12 VDC	Check the valve relay, fuse and wiring. Repair or replace as needed.
8-2	Continuous supply to ECU with ignition off.			Check for correct wiring connections. Make necessary repairs. If problem persists, replace ECU.
8-3	Internal ECU Fault			Replace ECU.

Testing the System

This section of the manual contains information for testing the hydraulic ABS with TOOLBOX™ Software, as well as procedures for conducting standard air and electrical tests.

⚠ WARNING

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

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

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

Refer to, and follow, the vehicle manufacturer's Warnings, Cautions and Service Procedures.

When testing, set the parking brake and place the gear selector in NEUTRAL (manual transmission) or PARK (automatic transmission) unless otherwise directed.

Meritor WABCO TOOLBOX™ Software

Use TOOLBOX™ Software to verify the activation of various system components:

- Turn valves, pump and retarder relay on and off (Valve Activation Menu).
- Turn ABS indicator lamp on and off (Miscellaneous Output Activation Menu).

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

NOTE: For complete instructions for using this program, refer to the User's Manual, TP-99102. Contact Meritor WABCO at 800-535-5560 for information about TOOLBOX™ Software.

E Version Hydraulic ABS Menus and Toolbars

Select Hydraulic ABS from the TOOLBOX™ ***Main Menu***. TOOLBOX™ senses the type of ECU being used and displays the ***HABS Main Screen***.

2 Troubleshooting and Testing

Main Screen

This screen provides icons and pull-down menu task selections. It also provides information about the current status of Meritor WABCO HABS. Figure 2.9.

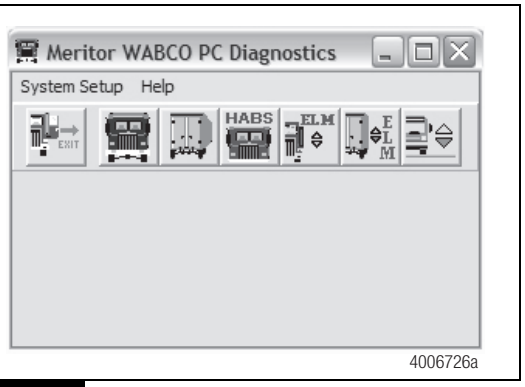


Figure 2.9

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

Display

Select ***Display*** from the HABS ***Main Screen***. A pull-down menu will appear. Figure 2.10.

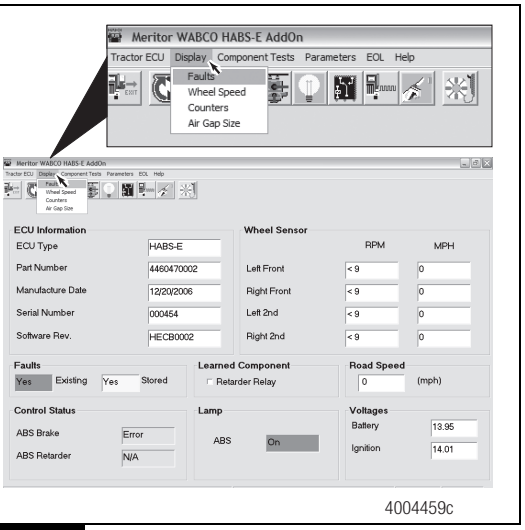


Figure 2.10

Faults

Select ***Faults*** to display the ***Fault Information*** screen. Figure 2.11.

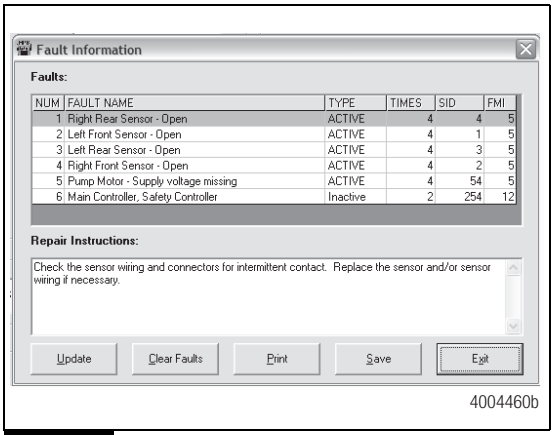


Figure 2.11

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

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

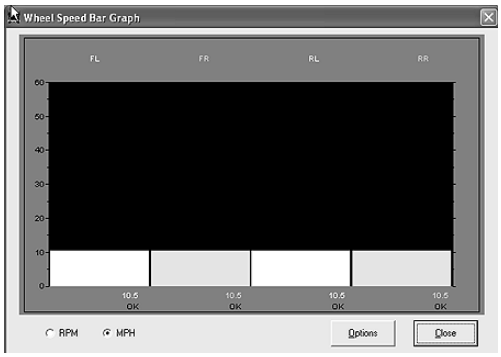
After making any required repairs, use the ***Clear Faults*** button to clear the fault. Clear each fault as it is repaired. Cycle the ignition after clearing the faults.

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

2 Troubleshooting and Testing

Wheel Speed

Select ***Wheel Speed*** to display the ***Wheel Speed*** screen. Figure 2.12.



4004461a

Figure 2.12

Use the ***Wheel Speed*** screen to verify that sensors are connected at each wheel. Speed at a sensed wheel (FL, FR, RL, RR) indicates sensors are installed, but does not verify correct sensor installation.

Counters

Select ***Counters*** to display the ***Counters*** screen. Figure 2.13.



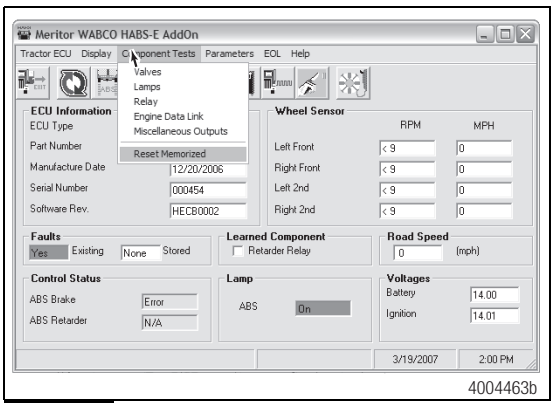
4004462b

Figure 2.13

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

Component Tests

Select ***Component Tests*** from the HABS ***Main Screen***. A pull-down menu will appear. Figure 2.14.



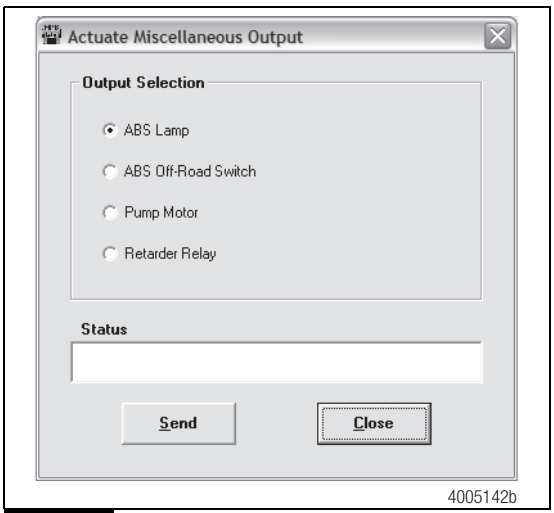
4004463b

Figure 2.14

Miscellaneous Outputs

Select ***Miscellaneous Outputs*** to display the ***Actuate Miscellaneous Outputs*** test screen. Figure 2.15.

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



4005142b

Figure 2.15

2 Troubleshooting and Testing

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

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

Valves

Select ***Valves*** to display the ***Valve Activation*** test screen. Figure 2.16.

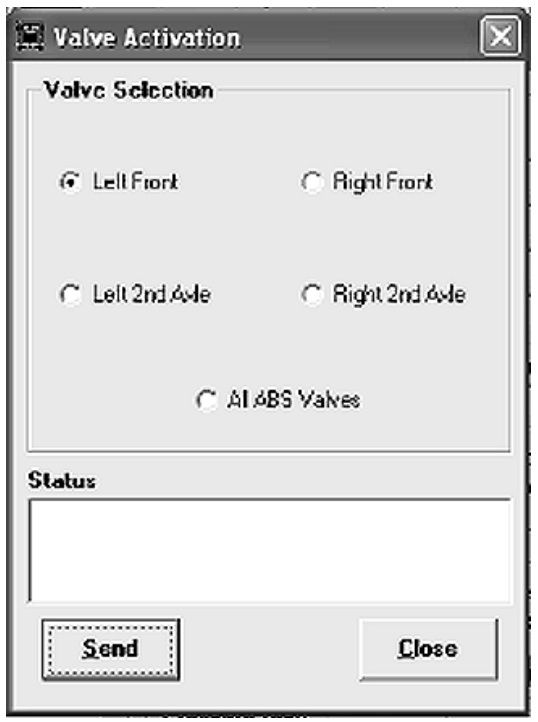


Figure 2.16

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

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

Lamps

Select ***Lamps*** to display the ***Lamp Test*** screen. Figure 2.17.

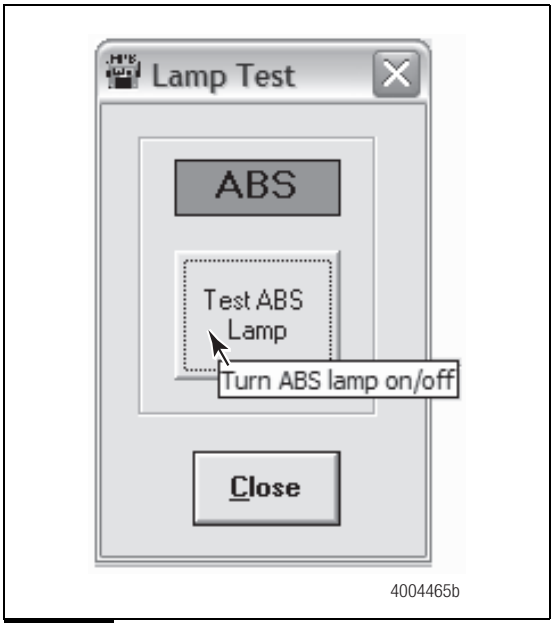


Figure 2.17

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

2 Troubleshooting and Testing

Relay

Select ***Relay*** to display the ***Activate Relay*** test screen. Figure 2.18.

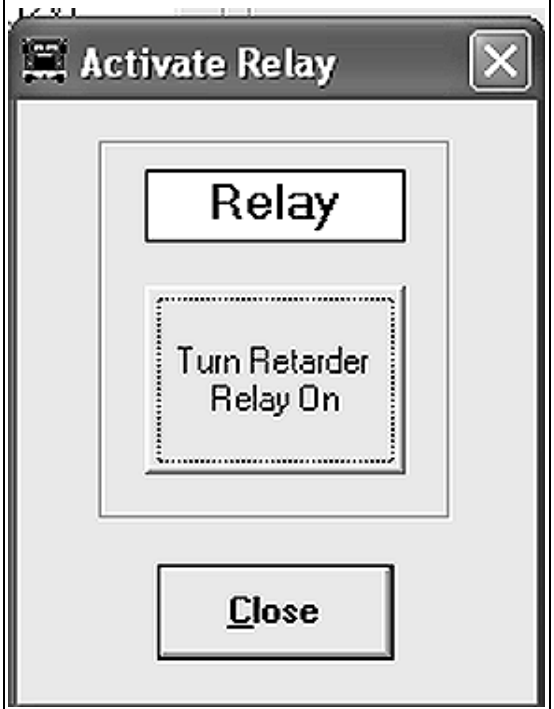


Figure 2.18

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

Engine Data Link

Select ***Engine Data Link*** to display the ***Data Link*** test screen. Figure 2.19.

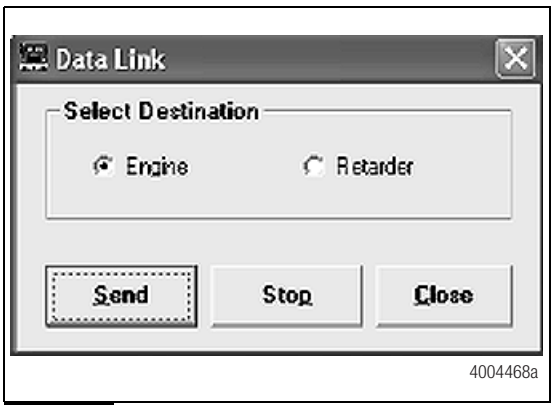


Figure 2.19

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

Select the data link destination (engine or retarder), then select ***Send*** to test. Use the ***Stop*** button to end testing. Select ***Close*** to exit this screen.

Reset Memorized

This is an automatic default and cannot be de-selected. It indicates the ECU has memorized the installed retarder relay. Once the ECU has seen a retarder, it expects to see it every time the vehicle is powered up. Figure 2.20.

Because there are times when an ECU is moved to another vehicle — or during diagnostic testing — you may want the ECU to disregard this learned component. Use the ***Reset Memorized*** command for this purpose.

Select ***Component Tests*** from the Hydraulic ABS ***Main Menu***. Then, select ***Reset Memorized*** from the pull-down menu to reset the ***Learned Component*** screen. Figure 2.21.

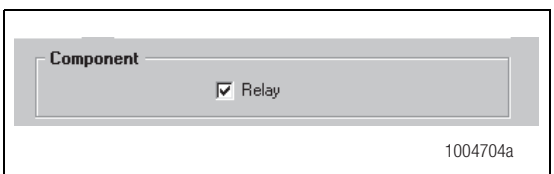


Figure 2.20

2 Troubleshooting and Testing

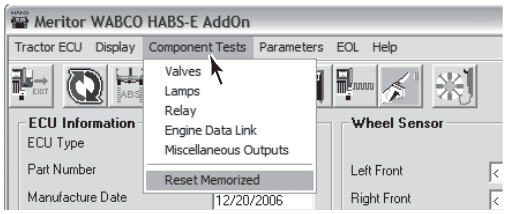


Figure 2.21

Standard Testing

Test Equipment: Volt-Ohm Meter (VOM)

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

System Requirements and Component Tests

Tire Size Range

For correct hydraulic ABS operation, front and rear tire sizes must be within 16% of each other.

Contact the Meritor WABCO Customer Support Center at 800-535-5560 if you plan a tire size difference greater than 8%.

Calculate the tire size with the following equation:

% Difference = (RPM Steer/RPM Drive)–1 x 100

RPM = tire revolutions per mile

⚠ CAUTION

When troubleshooting or testing the ABS system, do not damage the connector terminals. Damaged connector terminals may cause system malfunction.

Voltage Check

Voltage must be between 9.5 and 14 volts for the 12-volt hydraulic ABS to function correctly.

Check voltage as follows.

1. Turn ignition ON.
2. Check for the correct voltage.
   - Pins 16 to 18
   - Pins 17 to 19
   - Pins 1 to 6

Standard Component Testing

ABS Indicator Lamp

If the ABS indicator lamp does not come on after the ignition is turned on, or it comes on but does not go out after three seconds, check all ABS fuses or circuit breakers and replace if necessary. Check the wiring to the ABS diagnostic switch and the indicator lamp and repair or replace the wiring as required. When checking the indicator lamp, follow these steps:

1. Check voltage potential at the lamp socket.
2. Check continuity of the wires to the socket.
3. Replace the bulb.

NOTE: A complete wiring diagram for 4S/4M D Version hydraulic ABS appears in Figure 2.2 in this section.

ABS Blink Code Switch

When testing the ABS diagnostic switch, perform the following.

1. Check the resistance between the terminals while cycling the switch. A lack of continuity is an indication of a faulty switch.
2. Check the continuity of the wires to the switch:

   Pins 21 and 6 on the 31-pin harness

2 Troubleshooting and Testing

Sensor Adjustment

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

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

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

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

NOTE: No gap is allowable at installation. During normal operation, a gap not to exceed 0.04-inch is allowable.

Sensor Output Voltage Test

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

1. Turn ignition OFF.
2. Disconnect the ECU to measure voltage at the pins on the ECU connector. Refer to Table C.

⚠ WARNING

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

3. Place blocks under the front and rear tires to stop the vehicle from moving.
4. Raise the vehicle off the ground. Place safety stands under the axle.
5. Rotate the wheel by hand at 30 rpm (1/2 revolution per second).
6. Measure the voltage at the pins indicated in Table C. Voltage tolerance is ≥0.2 volts alternating current (VAC).

Table C: Sensor Check Pins

	HABS E Version ECU
Sensor	**31-Pin Harness**
Left Front	24 and 29
Right Front	25 and 30
Left Rear	23 and 28
Right Rear	22 and 27

Sensor Resistance

The sensor circuit resistance must be between 900 and 2000 ohms. Measure resistance at the sensor connector, or at the pins on the ECU connector, as follows.

1. Turn ignition OFF.
2. To measure resistance at the pins on ECU connector, disconnect the ECU connector from the ECU.

   To measure resistance at the sensor connector, disconnect the sensor from the sensor extension cable.
3. Measure output at the pins indicated in Table C.

   If measurement is not between 900 and 2000 ohms, replace the sensor.

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3 Component Replacement

Component Removal and Installation

Sensors

Sensor Lube Specification

Meritor WABCO specifications call for a sensor lubricant with the following characteristics.

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

Wheel Speed Sensor Replacement — Front Axle

Removal

⚠ WARNING

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

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

⚠ CAUTION

To avoid damage to the electrical system or HABS components, when welding on a HABS-equipped vehicle disconnect the power connector from the ECU.

1. Park the vehicle on a level surface. Apply the parking brakes. Block the rear tires to prevent the vehicle from moving.

   If necessary, raise the front tires off the ground. Place safety stands under the axle.
2. Disconnect the fasteners that hold the sensor cable to other components.
3. Disconnect the sensor cable from the chassis harness.
4. Remove the sensor from the sensor holder. Twist and pull the sensor to remove it from the sensor bracket. **Do not pull on the cable. Figure 3.1.**

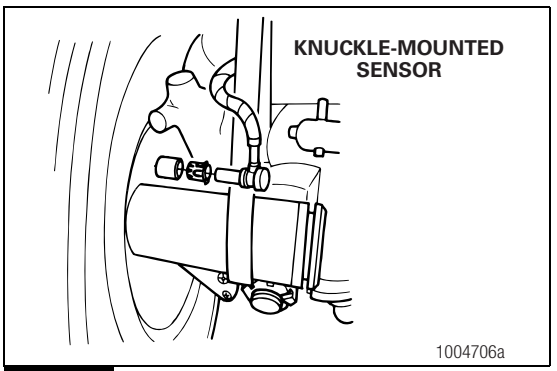


Figure 3.1

Installation

1. Connect the sensor cable to the chassis harness.
2. Install the fasteners used to hold the sensor cable in place.
3. Apply a Meritor WABCO-recommended lubricant to the sensor spring clip and sensor.
4. Install the sensor spring clip. Verify that the spring clip tabs are on the inboard side of the vehicle.
5. With the tabs on the inboard side, push the sensor spring clip into the bushing in the steering knuckle until the clip stops.
6. Push the sensor completely into the sensor spring clip until it contacts the tooth wheel.
7. Fasten the sensor cable every 12 inches. Correctly bundle and store any excess cable in the sub-frame. Figure 3.1.
8. Remove the blocks and safety stands.
9. Perform a voltage output check to ensure correct installation. Refer to Section 2.

Wheel Speed Sensor Replacement — Rear Axle

Removal

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

   Remove the wheel and tire assembly from the axle.

3 Component Replacement

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

Installation

1. Connect the new sensor cable to the chassis harness.
2. Press the sensor spring clip into the sensor bracket, located on the rear axle, until it stops. Verify that the tabs are on the inboard side.
3. Apply a Meritor WABCO-recommended lubricant to the sensor.
4. Push the sensor completely into the spring clip until it contacts the tooth wheel.
5. Reattach the sensor cable to the cable clamps or clips.
6. Fasten the sensor cable every 12 inches. Correctly bundle and store excess cable in the sub-frame. Figure 3.2.

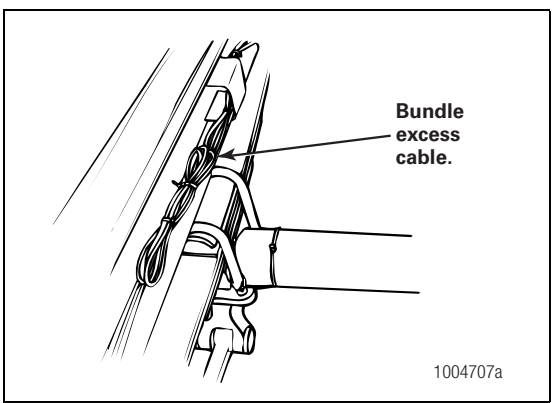


Figure 3.2

7. Replace the tire and remove the safety stands. Lower the vehicle and remove the blocks from the front tires.
8. Perform a voltage output check to ensure correct installation. Refer to Section 2.

Electronic Control Unit (ECU)

Removal

⚠ WARNING

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

⚠ CAUTION

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

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

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

- It is not necessary to remove the entire modulator to replace the Electronic Control Unit (ECU).
- When only the ECU is replaced, bleeding the system is not necessary.

1. Park the vehicle on a level surface. For vehicles with manual parking brakes, apply the parking brakes.
2. Block the front and rear tires to prevent vehicle movement.
3. Disconnect the battery.
4. Use a clean rag to carefully wipe the surface of the modulator and the surrounding area.
5. Open the latches on the 31-pin harness attached to the ECU. After the latch is released, remove the connectors from the ECU.
6. Use a 4 mm Allen wrench to loosen and remove the four mounting screws that attach the ECU module to the modulator valve.
7. Carefully remove the ECU by lifting straight out. To avoid damage, do not twist the ECU during removal. Determine the warranty status of the ECU. If the ECU is under warranty, return it to Meritor WABCO. If it is not under warranty, discard the used ECU.
8. Use a clean rag to carefully clean the area around the valves formerly covered by the ECU.

3 Component Replacement

Installation

⚠ CAUTION

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

1. Position the ECU onto the modulator valve. Apply gentle pressure to seat the ECU. Motor connectors must achieve full depth into the housing. The gap between the modulator and ECU must not exceed 0.08-inch (2 mm).
2. Use a 4 mm Allen wrench to tighten the four mounting screws that attach the ECU to the modulator. Tighten to 14 in-lb (1.5 N•m). Do not exceed this torque. The metal sleeves on the ECU housing must rest flat on the body of the modulator. T
3. When the ECU is correctly installed with the metal sleeves flat on the modulator, tighten the bolts to 21-30 in-lb (2.5-3.5 N•m). T

⚠ WARNING

Electrical connectors must be correctly installed with the latch pushed in to lock the connector. Failure to do so may allow the connectors to come loose or disconnect resulting in loss of ABS function.

4. Attach the 31-pin harness connector to the ECU.
5. Connect the battery.

Modulator Assembly

Removal

⚠ CAUTION

The modulator assembly contains hydraulic brake fluid, a caustic substance. Remove the valve carefully so that fluid does not leak and cause skin irritation or damage to components.

NOTE: If there is interference, the entire bracket and valve assembly can be removed.

1. Apply the parking brakes. Block the front and rear tires to prevent vehicle movement.
2. Place a container under the modulator assembly to catch leaking brake fluid.
3. Disconnect the electrical harness connectors from the modulator assembly.
4. Mark the six brake lines for ease of installation. Disconnect the lines from the modulator assembly.
5. Remove the three mounting capscrews and washers that attach the modulator assembly to the bracket.

   NOTE: Whenever any hydraulic system fitting is loosened or disconnected, the entire system must be bled to remove any air that may have entered. Refer to "Brake Bleeding Procedures" in this section.

6. Remove the modulator assembly.
7. Use a 4 mm Allen wrench to loosen and remove the four mounting screws that attach the ECU module to the modulator valve.
8. Carefully remove the ECU by lifting straight out. To avoid damage, do not twist the ECU during removal.

Installation

1. Position the old ECU onto the new modulator valve. Apply gentle pressure to seat the ECU. Motor connectors must achieve full depth onto the housing. The gap between the modulator and the ECU must not exceed 0.08-inch (2 mm).
2. Use a 4 mm Allen wrench to tighten the four mounting screws that attach the ECU to the modulator. Tighten to 14 in-lb (1.5 N•m). Do not exceed this torque. The metal sleeves on the ECU housing must rest flat on the body of the modulator. T
3. When the ECU is correctly installed with the metal sleeves flat on the modulator, tighten the bolts to 21-30 in-lb (2.5-3.5 N•m). T
4. Position the modulator assembly in place on the vehicle. Figure 3.3.

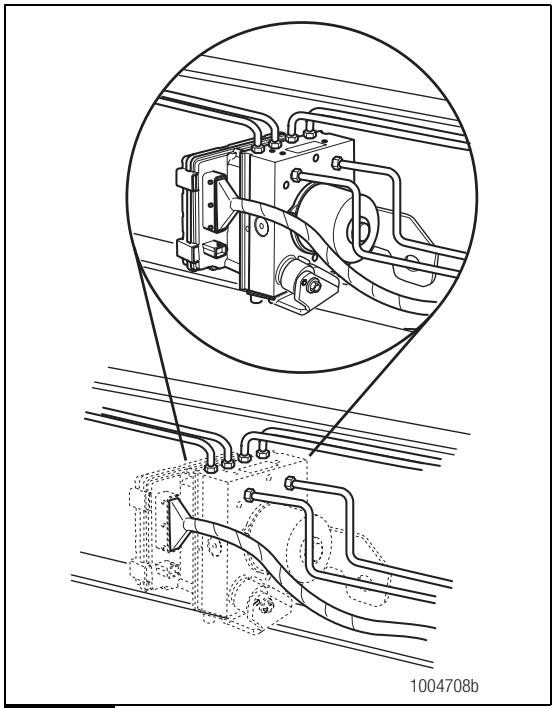


Figure 3.3

5. Tighten the three mounting nuts to 16 ft-lb (22 N•m).
6. Connect the electrical harnesses to the modulator assembly.
7. Connect and tighten the brake line connections.
8. Bleed the brake system, per the following instructions.

Brake Bleeding Procedures

General

The following brake bleeding methods explain how to bleed the hydraulic ABS modulator assembly during installation, or in the event of air in the brake system. There are instructions for both pressure and manual bleeding procedures.

These instructions include the procedure for bleeding both the master cylinder and the brake system. In some cases, for example, if you are replacing only the modulator assembly, it may not be necessary to bleed the master cylinder. If you have any questions, please contact the Meritor Service Center at 800-535-5560.

NOTE: The modulator assembly must be handled with appropriate care and should not be exposed to excessive impact or compressed air at the hydraulic ports prior to assembly.

⚠ WARNING

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

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

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

NOTE: Use DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.

⚠ CAUTION

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

Pressure Fill and Bleed

Pressure fill and bleed is the preferred method for bleeding the service brake system. It requires the use of a special pressure bleeder kit, consisting of a tank, pressure pump and valve, gauge, tubing and adapter. These kits are available from a number of manufacturers and include instructions for use. Figure 3.4.

3 Component Replacement

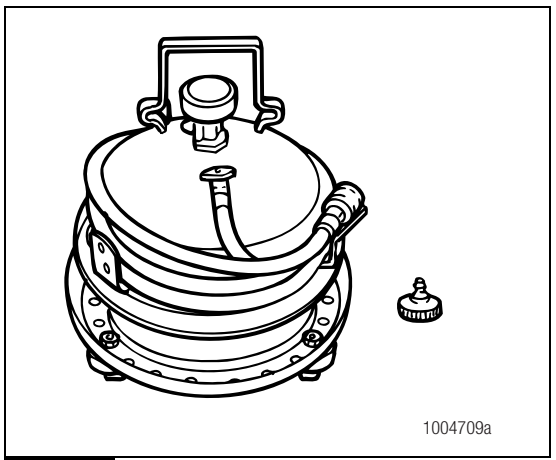


Figure 3.4

Pressure Fill and Bleed Procedure

⚠ CAUTION

Turn the ignition OFF for the entire bleed procedure. Do not energize the unit during the bleed procedure. Improper bleeding may result in system malfunction due to the presence of air in the closed hydraulic system.

1. Apply the parking brake and block the tires. Turn the ignition OFF and disconnect the battery terminals.
2. Fill the pressure bleeder with new DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.
3. Follow the manufacturer's instructions to connect the pressure bleeder to the brake master cylinder reservoir.
4. Set the filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
5. Turn on the bleed equipment until the fluid level in the reservoir reaches approximately 0.875-inches (20 mm).
6. Release pressure for three to five seconds. Apply pressure for five to 10 seconds.
7. Repeat Step 5 and Step 6 approximately 10 times. After releasing the pressure, air bubbles should rise up into the reservoir.

⚠ WARNING

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

8. Bleed the brake system:
   - Set the filling pressure to 20 to 30 psi (1.5 to 2.0 bar).
   - Place a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, typically the right rear, then attach a length of clear plastic tubing to the bleeder fitting. Verify that the tube fits snugly.

   NOTE: Both the tubing and container must be able to withstand the effects of hydraulic brake fluid. Tools used for bleeding the system should be brake fluid-safe.

9. Submerge the tubing in a container of clean hydraulic brake fluid. Figure 3.5.

   Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn). Let the hydraulic fluid flow out of the fitting until it is free of air bubbles.

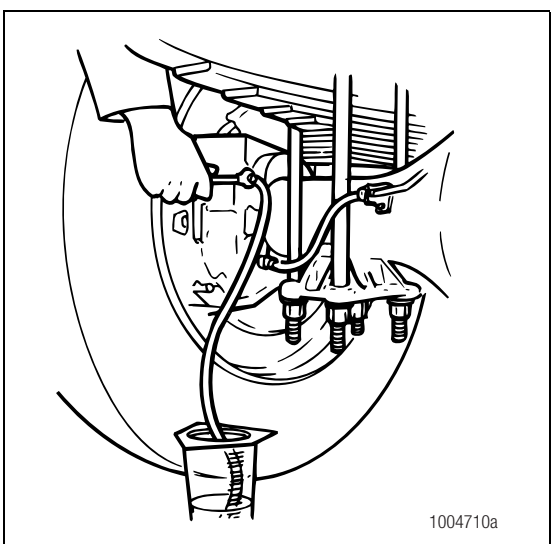


Figure 3.5

3 Component Replacement

10. Tighten firmly to secure the fitting.
11. Repeat Step 5 through Step 8 to bleed the remaining three brake actuators. Bleed in sequence of the longest to shortest circuit from the modulator assembly.
12. Turn off bleed equipment and remove pressure. Remove the bleed device and check the fluid level in the reservoir. Fill if required. Replace the reservoir cap and dispose of used brake fluid.
13. Remove the wheel blocks.

Manual Bleed Procedure

NOTE: The ignition must remain off for the entire bleed procedure; energizing the unit during bleeding must be impossible.

1. Apply the parking brake and block the tires. Turn the ignition OFF and disconnect the battery terminals.
2. Fill the reservoir with DOT 3 or DOT 4 hydraulic brake fluid. Refer to the vehicle specifications to determine which fluid to use.
3. Depress the brake pedal five times using the stroke between 1/3 travel and maximum travel in five seconds.
4. Release the pedal for five to 10 seconds. Air bubbles will rise into the reservoir while depressing and releasing the pedal.
5. Repeat Step 3 and Step 4 another three times, or until sufficient pedal resistance is felt.

⚠ WARNING

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

6. Bleed the brake system. Place a wrench on the brake actuator bleeder fitting. Start with the farthest from the modulator, (typically the right rear), then attach a length of clear plastic tubing to the bleeder fitting. Verify that the tube fits snugly.

   NOTE: Both the tubing and container must be able to withstand the effects of brake fluid. Tools used for bleeding the system should be brake fluid-safe.

7. Submerge the tubing in a container of clean brake fluid. Figure 3.5.
8. Depress the brake pedal 10 to 15 times, using the maximum available stroke.
9. Loosen the bleeder fitting until the fluid begins to flow (about 3/4 turn), while depressing the brake pedal through its maximum available stroke.
10. Tighten the fitting firmly prior to releasing the brake pedal.
11. Repeat Step 6 through Step 8 several times until the discharged fluid is free of air bubbles.
12. Repeat Step 3 through Step 9 to bleed the remaining three brake actuators. Bleed in sequence of the longest to the shortest circuit from the modulator.
13. Check the travel of the brake pedal. If a firm resistance is felt, the manual bleeding procedure is complete.
14. Check the fluid level in the reservoir and fill if required. Replace the reservoir cap and dispose of used brake fluid.
15. Remove the wheel blocks.

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MERITOR WABCO

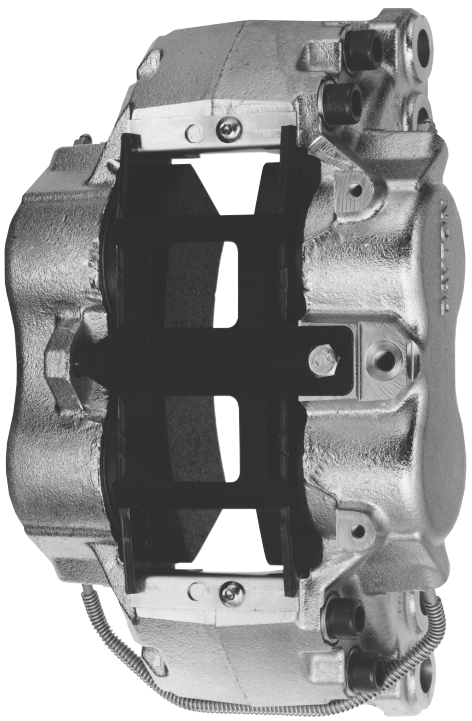
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Issued 01-01
$2.50

Four-Piston Quadraulic™ Disc Brake Caliper

Maintenance Manual MM-2075



Service Notes

MERITOR®

Before You Begin

This manual provides maintenance and service procedures for Meritor's four-piston quadraulic disc brake calipers. Before you begin procedures:

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Caution and Warning safety alerts that precede instructions or procedures you will perform. These alerts help to avoid damage to components, serious personal injury, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Safety Alerts, Torque Symbol and Notes

⚠ ***WARNING***	A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.
⚠ ***CAUTION***	A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components and possible serious injury.
T	A torque symbol alerts you to tighten fasteners to a specified torque value.
NOTE	A Note provides information or suggestions that help you correctly service a component.

Access Information on ArvinMeritor's Web Site

Additional maintenance and service information for ArvinMeritor's commercial vehicle systems component lineup is also available at www.arvinmeritor.com.

To access information, click on Products & Services/Tech Library Icon/HVS Publications. The screen will display an index of publications by type.

Additional Information

Call ArvinMeritor's Customer Service Center at 800-535-5560 to order the following item.

- *Drivetrain Plus™ by ArvinMeritor Technical Electronic Library* on CD. Features product and service information on most Meritor, ZF Meritor and Meritor WABCO products. $20. Order TP-9853.

MERITOR®

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Asbestos and Non-Asbestos Fibers

ASBESTOS FIBERS WARNING

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

Hazard Summary

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

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

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

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

3. Procedures for Servicing Brakes.

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

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

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

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

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

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

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

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

Regulatory Guidance

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

NON-ASBESTOS FIBERS WARNING

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

Hazard Summary

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

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

Recommended Work Practices

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

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

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

3. Procedures for Servicing Brakes.

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

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

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

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

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

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

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

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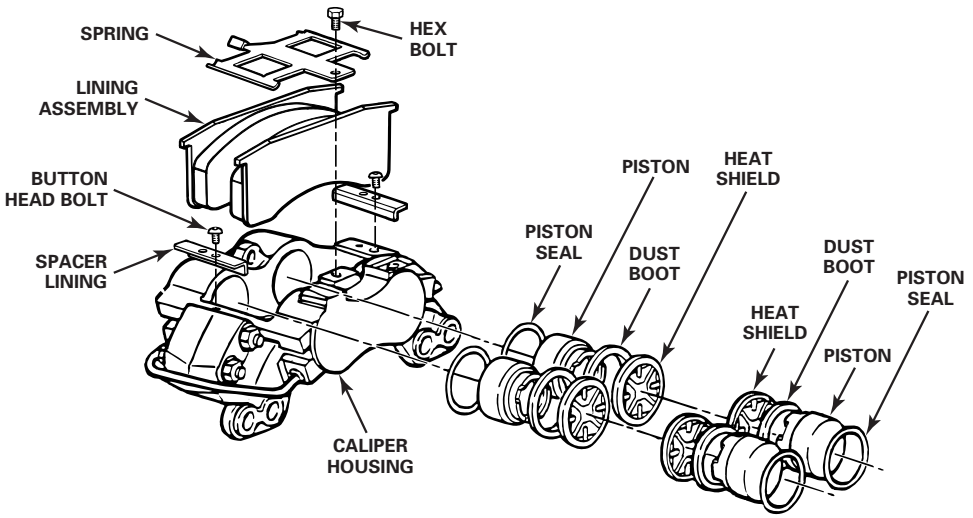
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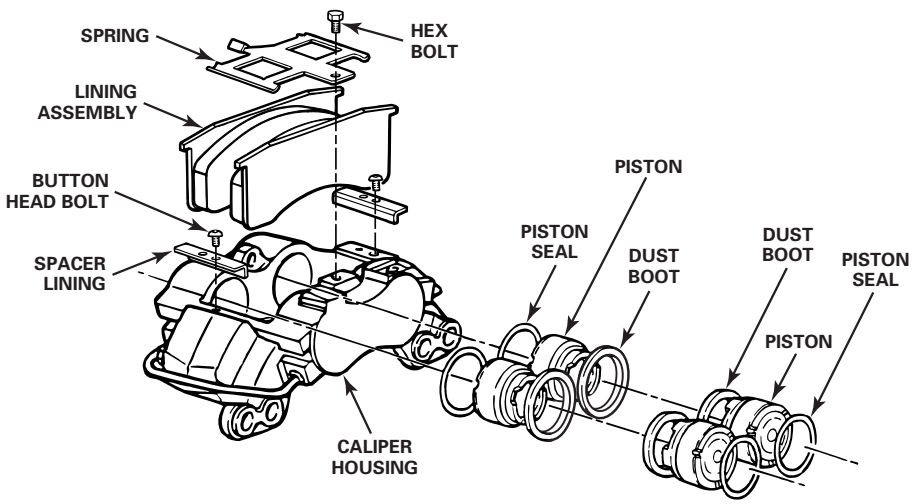
Section 1
Exploded Views

MERITOR®

Previous Style



Current Style



MERITOR®

Section 2 Introduction

Product Features

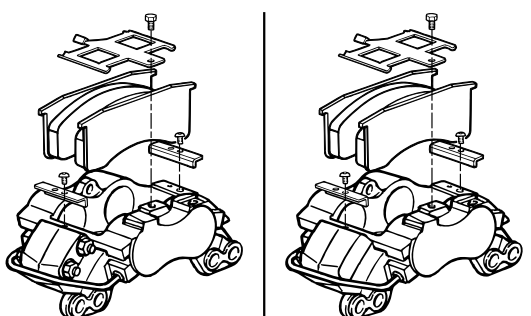
Four-Piston Quadraulic Disc Brake Caliper

Meritor's quadraulic disc brakes have a four-piston, fixed-mount caliper design for use on both front and rear drive axles. An installation includes four major components — the caliper assembly, support assembly, hub/rotor assembly and the attaching hardware.

The inboard pistons apply the inboard pads and the outboard pistons apply the outboard pads. Two sizes of calipers are used, 2.520-inch (64 mm) and 2.756-inch (70 mm).

Features of the caliper include:

- Designed for hydraulic brake systems.
- Hard-mounted to the anchor plate to eliminate caliper and anchor plate replacement.
- Designed with hardened stainless steel mounting surfaces, high temperature piston boot compound, sealed bleeder screws and full-coverage zinc plating.
- Compatible with anti-lock braking systems (ABS) and existing hydraulic systems.
- Helps to increase lining life.
- Can be adapted to fit most vehicles with a hydraulic system that supplies to 1,800 psi (12,402 kPa).
- Available in 33,000 lbs maximum GVWR (4 x 70 mm) and maximum 24,000 lbs GVWR (4 x 64 mm).



PREVIOUS STYLE CURRENT STYLE

Current Style	Previous Style
Metric caliper bolts	SAE caliper bolts
Caliper housing halves held together by bolts in blind holes in the bridge area.	Caliper housing halves held together by bolts and nuts in the bridge area.
Integral piston/heat shield	Separate piston and heat shield
Phenolic piston	Metal piston

Caliper

- The caliper assembly consists of two halves assembled with four bolts and washers.
- It includes four hydraulic piston bores, two brake pads, two stainless steel lining rail covers installed with button head bolts, a pad retainer spring and bolt, bleeder screw and crossover tube.
- The piston bores contain the pistons, piston seals and piston boots.
- The crossover tubes connect the two halves of the caliper piston to supply brake fluid to the outboard pistons.

How to Identify the Caliper

Check for an assembly number on the side of the caliper.

Support

The support assembly includes the ABS sensor bracket attached with two screws. It also has provisions to mount an optional splash shield to protect the rotor and brake assembly from road contamination. When the ABS system is not used or the sensor is mounted through the axle flange, the supports are not equipped with the sensor bracket.

Section 2
Introduction

MERITOR®

Hub/Rotor

- The hub and rotor assemblies consist of a hub and rotor, fitted with bearing cups and wheel attachment studs.
- There are two types of rotors used — a U-shaped rotor and a hat-shaped rotor.
- Some rotors are equipped with a cast-in ABS speed sensor tooth wheel, typically with 100 slots. Some rotors have separate ABS speed sensor tooth wheels attached to the rotor with bolts.
- Front hub/rotor assemblies can have various ABS speed sensor tooth wheels such as: a separate ring mounted to the inboard end of the hub, ABS teeth integral to the rotor, or a separate ABS ring attached to the rotor by bolts.
- There are various hub configurations offered to accept the 19.5-inch (495.3 mm) eight-hole wheels, as well as 22.5-inch (571.5 mm) 10-hole wheels with the hub piloted or stud piloted system.

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WARNING

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

Removal

Brake Pads

1. Visually inspect all brake pads. Replace pads when the remaining lining reaches 1/8-inch (3.175 mm) thickness.
   - **If you replace pads:** Replace all disc brake pads at the same time to maintain original brake balance.
   - **If a complete vehicle pad replacement is not necessary or desirable:** Replace the pads on both wheel ends on the same axle.

Replace Brake Pads

1. Raise and support the vehicle.
2. Remove the wheel and tire assembly according to manufacturer's recommendation.
3. Remove the master cylinder reservoir filler cap. Check the brake fluid level in the reservoir. If necessary, remove fluid to keep the reservoir from overflowing when compressing pistons into the caliper.
4. Remove the pad retainer spring bolt. **Figure 3.1**.
5. Compress the caliper pistons. **Figure 3.2**.
6. Remove the brake pads. **Figure 3.3**.

Figure 3.1

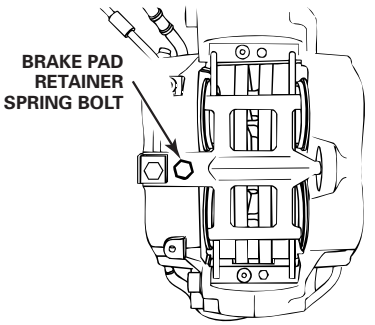


Figure 3.2

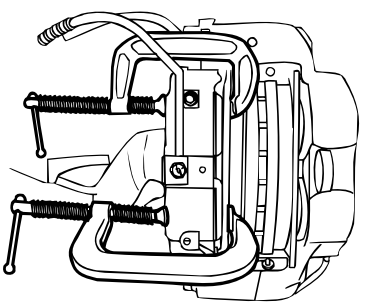
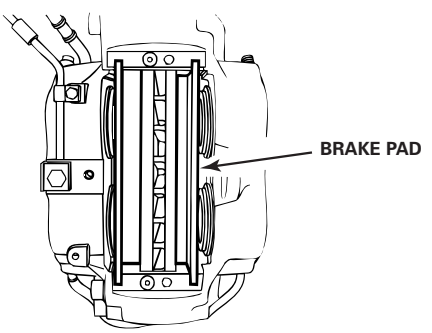


Figure 3.3



Section 3
Disassembly

MERITOR®

Brake Caliper

WARNING

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

1. Raise and support the vehicle.
2. Remove the tire and wheel assembly according to manufacturer's instructions.
3. Remove the brake hose hold down clamp bolt, if equipped. **Figure 3.4**.
4. Remove the brake hose/tube from the caliper. **Figure 3.5**.
5. Remove four caliper-to-support assembly bolts. **Figure 3.6. Do not disassemble the four bolts joining the two halves of the caliper.**

Figure 3.4

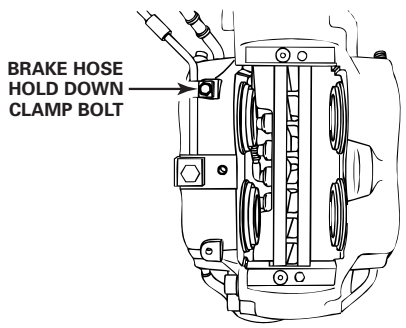


Figure 3.5

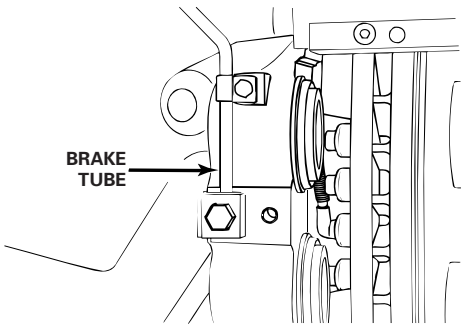
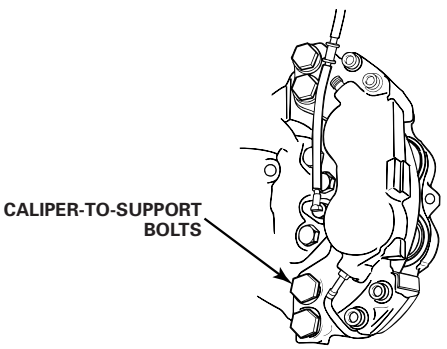


Figure 3.6

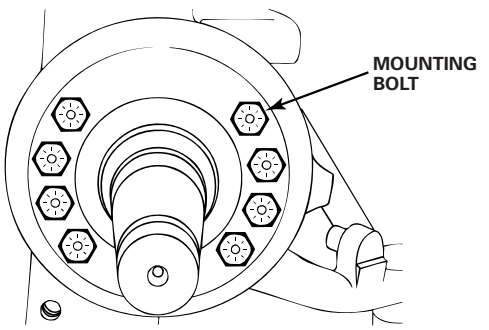


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Support

1. Remove the caliper from vehicle as described in Brake Caliper in this section.
2. Remove the splash shield if installed from the support.
3. Remove the hub and rotor assembly according to vehicle manufacturer's recommended service procedure.
4. Remove the ABS sensor.
5. Remove the support-to-axle mounting bolts. **Figure 3.7**.

Figure 3.7



Rotor

NOTE: The thickness of the resurfaced rotor must exceed the minimum thickness dimension stamped or cast into the rotor. Replace if necessary.

1. Check the rotor while assembled to the hub or spoke wheel and mounted on the axle spindle. The lateral runout of the rotor friction surfaces should not exceed 0.015-inches (0.381 mm) total indicator reading (TIR). The thickness variation of the rotor should not exceed 0.0012-inches (0.0300 mm).
   - **If the lateral runout and/or the thickness variation exceed the above values:** Resurface or replace the rotor.
2. Remove the caliper. Refer to Brake Caliper in this section.
3. Remove the hub/spoke wheel and rotor assembly from the axle according to vehicle manufacturer's recommendation.
4. Remove the hub-to-rotor attachment fasteners (hat-shaped rotor). For the U-shaped rotor, remove the studs holding the hub and rotor.

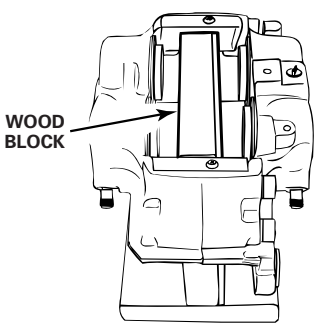
Disassemble and Overhaul the Brake Caliper

1. Remove the brake caliper. Refer to Brake Caliper in this section.
2. Drain all fluid from the caliper.
3. Push all four pistons to the bottom of their bores.
4. Remove the piston boots by prying the metal ring portion of the boot out of the bore with a screwdriver. Use care to avoid damage to the piston or bore. Discard the boots.

NOTE: The C-clamp must be between the pistons on the opposite side so they may move to the wood block without striking the C-clamp. Cover pistons with shop rag to prevent brake fluid spray.

5. Place a block of wood (7-5/8 x 3-1/2 x 2-9/16-inches thick) between the caliper pistons. **Figure 3.8**. Use a C-clamp to hold the block of wood against the pistons on one side of the caliper.

Figure 3.8



Section 3
Disassembly

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⚠ WARNING

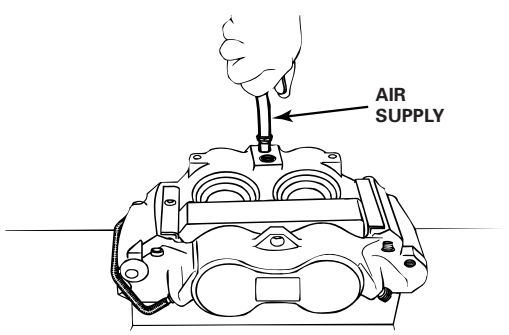
When you use compressed air to remove the pistons form the caliper bore, do not place your hands or fingers near the bore to catch or protect the pistons. Serious personal injury can result.

⚠ CAUTION

When you remove the pistons from the caliper bore, only direct enough compressed air into the caliper brake fluid inlet to ease the pistons out of the bore. Do not exceed 25 psi (172 kPa). Damage to components will result.

6. Apply low air pressure (no more than 25 psi [172 kPa]) to the fluid port in the caliper to move the caliper pistons out to the wood block. **Figure 3.9**.
7. With the pistons in contact with the wood block, there will be a small amount of seal engagement remaining. Remove the C-clamp and the wood block. The pistons may now be removed by hand.

Figure 3.9

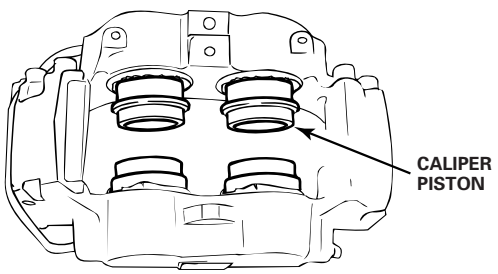


8. To remove the pistons from the other side of the caliper, place the block of wood now over the empty bores (from where the pistons have been removed) with a thick sheet of rubber (3/8-inch) between the wood and the caliper bores.

NOTE: Use the C-clamp to hold the block of wood in position against the empty bores. The C-clamp must be between the pistons on the opposite side so they may move out to the wood block without striking the C-clamp. Cover pistons with a shop rag to prevent brake fluid spray.

9. Apply low air pressure (no more than 25 psi [172 kPa]) to the fluid port in the caliper to move the caliper pistons out to the wood block.
10. With the pistons in contact with the wood block, there will be a small amount of seal engagement remaining. Remove the C-clamp and the wood block. The pistons may now be removed by hand. **Figure 3.10**.

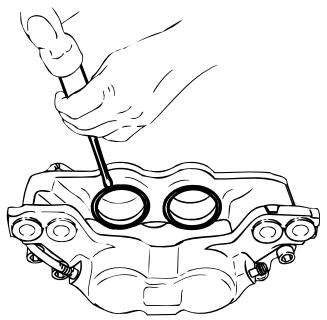
Figure 3.10



11. Remove the piston seals with a non-metallic device and discard them. **Figure 3.11**. Do not knick, scratch or otherwise scar piston bores or seal grooves.

NOTE: Do not hone the caliper bores. Pistons are not available for honed caliper bores. If the caliper bores are excessively scored or corroded, install a new caliper.

Figure 3.11



Section 4
Prepare Parts for Assembly

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WARNING

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

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, emulsion-type cleaners and petroleum-based cleaners. To avoid serious personal injury when you use solvent cleaners, you must carefully follow the manufacturer's instructions and these procedures:

- ***Wear safe eye protection.***
- ***Wear clothing that protects your skin.***
- ***Work in a well-ventilated area.***
- ***Do not use gasoline or solvents that contain gasoline. Gasoline can explode.***
- ***You must use hot solution tanks or alkaline solutions correctly. Carefully follow the manufacturer's instructions.***

Clean, Dry and Inspect Parts

Clean Parts

For Ground or Polished Metal Parts

CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts will result.

Use a cleaning solvent or kerosene or diesel fuel to clean ground or polished metal parts or surfaces.

For Rough Metal Parts

Use a cleaning solvent or a weak alkaline solution in a hot solution tank to clean rough metal parts. If you use a hot solution tank, follow the instructions below.

1. Leave the rough parts in the tank until they are completely cleaned and heated.
2. Remove the rough parts from the tank.
3. Wash the parts with water until you remove the alkaline solution.

Dry and Inspect Parts

1. Use soft, clean paper or cloth rags or compressed air to completely dry parts immediately after you clean them.
2. Carefully inspect all parts for wear or damage before you assemble them.
3. Repair or replace worn or damaged parts.

Apply Corrosion Protection

1. Apply a thin layer of brake grease to cleaned, dried parts. Be careful that you do not apply the grease to the linings or rotor.
2. If you will store the parts, apply a special material, which prevents corrosion and rust, to all surfaces. Store parts inside special paper or other material that prevents rust and corrosion.

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Section 5
Assembly and Installation

WARNING

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

Assembly

Brake Caliper

NOTE: When using compressed air, use air lines that are completely free of oil and moisture. All brake parts must be clean and completely dried of cleaning fluid. Use ONLY ArvinMeritor replacement parts to ensure proper caliper performance.

1. Clean caliper, caliper piston bores and fluid ports with solvent. Use compressed air to clean out and dry grooves and passages.
2. Dip new piston seals in new, clean DOT 3 hydraulic brake fluid and install in piston seal groove in caliper piston bores. Make sure that they are properly seated. Apply a thin film of silicon grease or brake fluid to the caliper bore seal land between the piston boot and seal groove. Apply the grease or brake fluid around the entire circumference of the caliper bore. **Figure 5.1**.
3. Apply DOT 3 hydraulic brake fluid to the outside of the caliper pistons and install them in caliper bores, making sure that they are square to the bore. **Figure 5.2**.
4. Be careful not to cock the caliper pistons and press them into the bores. **Figure 5.3**.

Figure 5.1

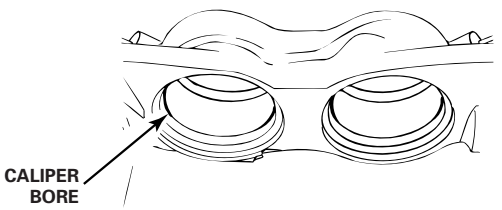


Figure 5.2

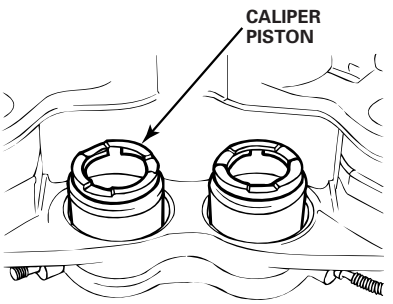
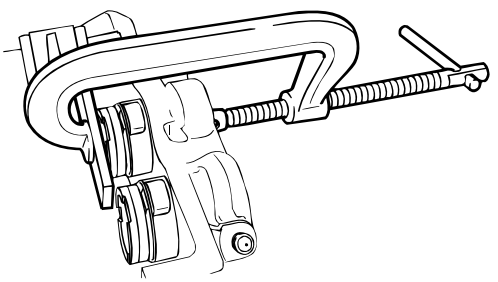


Figure 5.3



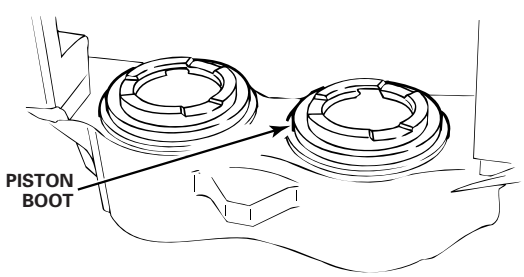
Section 5
Assembly and Installation

MERITOR®

5. Install the piston boots over the projecting ends of the pistons and press the ring side of the boots into the boot bore. **Figure 5.4**. An old bearing cup equal to the boot ring size helps install the boots. Make sure the piston boot bead is seated back against the shoulder of the projecting end of the piston. Boots for the 64 mm and 70 mm pistons are color-coded.
6. If required, replace the two stainless steel wear rails by removing the button head bolts.

NOTE: Inspect the caliper prior to reinstalling it onto the support. Pistons must be fully retracted into the caliper. Piston boots must be fully seated in the caliper boot grooves.

Figure 5.4



Installation

Rotor

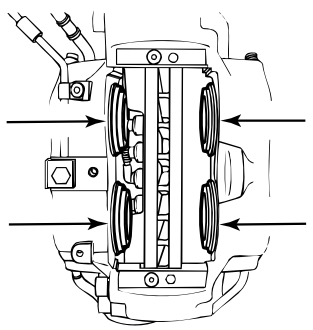
NOTE: Do not resurface a new replacement rotor.

1. To install, reverse the removal processes, making sure that the mating surfaces of the hub or spoke wheel and rotor are clean and free of rust build-up.
2. Check the rotor for lateral runout. If the lateral runout exceeds 0.015-inches (0.381 mm), the rotor may be rotated to a different mounting hole position on the hub or spoke wheel to reduce the value.

Caliper

1. Inspect the caliper for leakage, damage or defects to piston seals or pistons. If leakage, damage or defect is found, caliper disassembly may be required. **Figure 5.5**.
2. To install, reverse the removal process. **Figures 5.6 and 5.7.**
3. Bleed the brake system and road test the vehicle.

Figure 5.5



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Section 5
Assembly and Installation

Figure 5.6

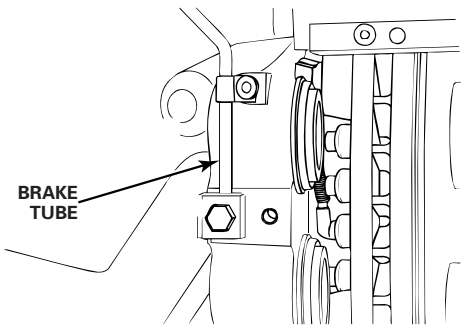
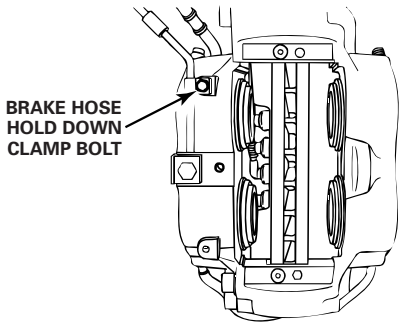


Figure 5.7



Brake Pads

1. Inspect the rotor for scoring, warping, cracks, bluing, heat spots or other damage or defects and minimum thickness. Repair or replace if necessary.
2. Inspect the disc brake calipers for leakage, damage or defects to piston boots, seals or pistons. Replace or repair the parts as required.
3. Clean and inspect the lining rail covers. If they are worn, they must be replaced.

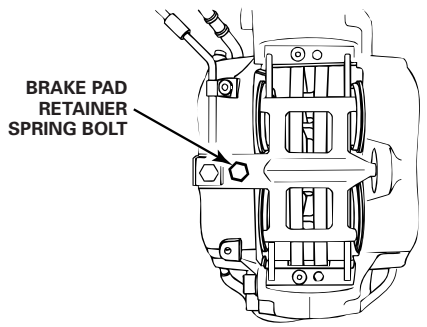
NOTE: The inboard and outboard brake pads are identical, except when they are equipped with a mechanical wear sensor.

4. Install the brake pads. Ensure that the friction surface is against the rotor. Install the pad retainer spring and tighten the bolt to 30 lb-ft (40 N•m) of torque. **Figure 5.8.** T

NOTE: Brake pad clearance adjustment is automatic.

5. Fill the master cylinder reservoir with new, clean, high-performance DOT 3 brake fluid or equivalent. Make several brake applications to move the brake pistons and linings out into contact with the brake rotors.
6. Recheck master cylinder reservoir and top off as necessary to manufacturer's recommended level.
7. Bleed the brake system.
8. Install the tire and wheel assembly according to the manufacturer's instructions.
9. Lower the vehicle and road test for correct operation.

Figure 5.8



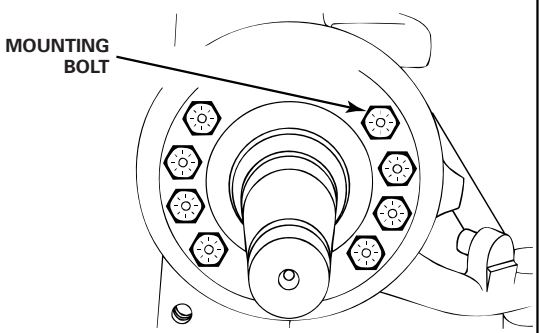
Section 5
Assembly and Installation

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Assemble the Support

1. Install the support mounting bolts. Tighten the bolts to the specified torque. Refer to Section 8. **Figure 5.9.** T

Figure 5.9



2. Install the ABS sensor. Tighten the bolt to 8 lb-ft (11 N•m). T
3. Install the hub and rotor assembly according to vehicle manufacturer's recommended service procedure.
4. Install the splash shield, if equipped.
5. Install the caliper as described in Caliper in this section.

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Section 6 Inspection

⚠ WARNING

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

Inspect Parts

Caliper

1. Clean the area around the brake hose. Use brake parts cleaner.
2. Inspect the heat shields (previous style only) for wear and damage. Replace worn or damaged shields.
3. Inspect the caliper lining spacers for wear and damage. Replace worn or damaged spacers.
4. Inspect the housing for cracks or damage. Replace a cracked or damaged housing.

⚠ CAUTION

The OUTSIDE diameter of the piston is the caliper's primary sealing surface and is manufactured to very close tolerances. Replace a piston if the OUTSIDE diameter is damaged. Do not refinish or use abrasives, including an emery cloth, on the piston. Damage to components can result.

5. Inspect the OUTSIDE diameter of the pistons for scoring, nicks, corrosion, wear and damage.
   - **If any of these conditions are evident:** Replace the pistons. Do not refinish or use abrasives.
6. Inspect the caliper bore for scoring, nicks, corrosion, wear and damage.
   - **If any of these conditions are evident:** Replace the caliper.

⚠ CAUTION

Use a crocus cloth to remove minor stains and corrosion from the caliper bore. Do not use abrasives, including an emery cloth. If you cannot remove minor stains and corrosion, replace the caliper bore to avoid damage to components.

7. Inspect the caliper bore for minor stains and corrosion.
   - **If these conditions are evident:** Use a crocus cloth to remove stains or corrosion. Clean the caliper bore after using a crocus cloth. Do not use abrasives, including an emery cloth.
   - **If you cannot remove stains and corrosion from the caliper bore:** Replace the caliper.

Caliper Mounting Plate

1. Inspect caliper mounting plate area for rust, corrosion. Replace a damaged or worn mounting plate.
2. Use a wire brush to clean the caliper mounting area.
3. Inspect the mounting plate for cracks or elongated bolt holes.
   - **If these conditions are evident:** Replace the mounting plate.

Brake System Bleeding Procedure

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

1. Check the master cylinder reservoir and fill, if necessary, with DOT 3 or DOT 4 brake fluid.
2. Bleed brakes in the following order: right rear, left rear, right front and left front.
3. Each four-piston caliper is equipped with two bleeder screws. Loosen the inner bleeder screw (which is always on the top) and purge the air. Tighten it loosely.
4. Open the outer bleeder screw and purge the air and tighten the bleeder screw to 9-12 lb-ft (12.2-16.3 N•m). T
5. Now again open the inner bleeder screw and purge the air and tighten the bleeder screw to 9-12 lb-ft (12.2-16.3 N•m). T
6. Repeat this procedure for all other brakes in the sequence specified in Step 2.
7. Test brakes prior to returning vehicle to service. A firm pedal should be felt during brake application.

Section 7
Troubleshooting

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Brakes

Conditions	Possible Causes	Correction
Excessive Pedal Effort	Pads worn below minimum thickness	Install new pads.
	Faded, overheated condition, glazed pads, "blued" or heat-checked rotors	Replace the rotor and/or reface pads if sufficient lining remains.
	Grease, oil and/or brake fluid on linings	Install new pads in axle sets.
	Seized or frozen pistons	Disassemble calipers and free pistons, or replace caliper.
Pedal Pulsation (Brake Roughness or Chatter)	Excessive lateral runout of brake rotor	Check with dial indicator. Install new rotor if runout exceeds the maximum specified.
	Excessive out-of-parallelism of brake rotor	Check the parallelism (rotor thickness variation) with micrometer and resurface the rotor, or install new rotor if the parallelism exceeds the maximum allowed.
	Loose or worn steering or suspension parts	Replace parts and realign.
	Excessive front bearing clearance	Readjust the bearing to specifications.
Vehicle Pulls to One Side	Brake fluid, oil and/or grease on linings	Install new pads in axle sets.
	Unmatched linings, uneven lining wear, distorted pads	Install new pads in axle sets.
	Rough rotor surfaces on one rotor	Resurface or replace rotor in axle sets.
	Seized or frozen pistons	Disassemble caliper and repair or replace.
	Loose caliper mounting bolts	Tighten to specifications.
	Uneven tire pressure, tread wear or size, right to left	Equalize to recommended pressures. Install correct size tires with good tread.
	Excessive rotor parallelism or runout	Resurface or replace rotor.
	Restricted hose or line	Examine the hoses and lines, and replace as necessary.
	Front end out of alignment	Reset alignment.
Leaky Caliper	Cylinder bore surface scored or corroded	Disassemble calipers, clean bore and replace seals and boots.
	Caliper piston seal damaged or worn	Disassemble calipers and install new seals and boots.
	Caliper piston damaged	Replace piston.

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Section 7 Troubleshooting

Brakes

Conditions	Possible Causes	Correction
No Braking Effect or Excessive Pedal Travel	Reservoir fluid level low	Check for causes of fluid leak, repair as required and refill the reservoir. Bleed system as needed.
	Air in the hydraulic system	Bleed the system.
	Bleeder screw loose or open	Bleed the system and tighten the bleeder screw.
	Caliper piston seal damaged	Disassemble the caliper and replace the piston seals. Replace piston if damaged.
	Excessive rotor runout or bent rotor	Check rotor with dial indicator. Install new rotor if runout exceeds maximum specified.
	Bad or excessively loose wheel bearings	Adjust or replace bearings as needed.
	Poor quality brake fluid	Drain and clean system. Replace with recommended brake fluid.
	Weak brake hose that expands under pressure	Replace defective hoses.
Brake Noise — Chatter	Excessive lateral runout of rotor	Check the runout with a dial indicator. Install new rotor if the runout exceeds the maximum specified.
	Lack of rotor parallelism	Check the parallelism with a micrometer. Resurface or install new rotor as required.
	Loose wheel bearing	Readjust the bearing to specified torque.
Brake Noise — Scraping	Rust or mud build-up on edges of rotor and on caliper housing	Clean or replace as necessary.
	Worn pad or pad installed backward	Replace pads in axle sets only with friction surface against the rotor.
	Faulty caliper alignment permitting rotor to scrape on housing	Correct the alignment.
Brake Noise — Groan	Pressure on the brake pedal too light	Slightly increase the pedal effort to eliminate noise.
Brake Noise — Rattle	Excessive clearance between the shoe and caliper	Install new pads.
	Pad retainer spring missing or not properly positioned	Install new pad retainer spring or position correctly.
Brake Noise — Squeal	Glazed pads	Resurface or replace pads in axle sets only.
	Weak pad retainer spring	Install new pad retainer spring.
	Pad wear indicator contacting rotor	Install new pads in axle sets only.
	Foreign material embedded in linings	Replace pads in axle sets only.

Section 8
Torque Specifications

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Description	Specification
ABS Sensor Bolts — 5/16-18	9-12 lb-ft (12.2-16.3 N•m)
Brake Hose Hold Down Clamp Bolt — 5/16-18	9-12 lb-ft (12.2-16.3 N•m)
Banjo Bolt	30-40 lb-ft (40.8-54.4 N•m)
Pad Retainer Spring Bolt — M10x1.5x16	28-32 lb-ft (38.1-43.5 N•m)
Caliper-to-Support Bolts — M20	320-360 lb-ft (435.2-489.6 N•m)
Cross Over Tube Nuts — 7/16-24	9-12 lb-ft (12.2-16.3 N•m)
Bleed Screw — 7/16-24	9-12 lb-ft (12.2-16.3 N•m)
Lining Rail Covers — M8x1.25x14	12-18 lb-ft (16.3-24.5 N•m)
Rotor to Hub Bolt (9/16-12 bolt)	100-125 lb-ft (136.0-170.0 N•m)
Rotor to Hub Bolt (9/16-18) with Lock Nuts	70-95 lb-ft (95.2-129.2 N•m)
Rotor to Hub Bolt (9/16-18) with Plain Nuts	130-165 lb-ft (176.8-224.4 N•m)
Support to Axle (5/8-18 bolt) (9/16-18 bolt)	 190-250 lb-ft (258.4-340.0 N•m) 130-165 lb-ft (176.8-224.4 N•m)

Description	Specification
Brake Pad — Thickness Above Metal (New) Minimum Thickness Above Metal (Discard)	 0.73" (18.5 mm) 0.125" (3.2 mm)
Brake Fluid — High-Performance Brake Fluid	DOT 3 or DOT 4
Rotor Diameter — Thickness (New) Thickness (Discard)	15.38" (390.7 mm) 1.54" (39.1 mm) 1.42" (36.1 mm)

ArvinMeritor™
Commercial Vehicle Systems

Drivetrain Plus™ by ArvinMeritor

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Issued 01-01
16579/24240

Overview

The cooling system on the Blue Bird Vision Propane is designed to maintain the temperature of the engine within the optimum operating range, throughout the conditions for which the vehicle is intended to function.

The down-flow radiator and transmission fluid cooler are fabricated together. The radiator is mounted at the front of the vehicle, behind the first cross-member and between the frame rails.

A nylon fan assists by pulling ambient air over the radiator. The operation of the fan is controlled by an automotive viscous type fan clutch. The fan clutch will automatically vary fan speed according to engine cooling requirements limiting power on the engine when cooling needs are low.

Power to drive the fan is supplied by a polly vee fan belt, driven directly by the engine. An automatic belt tensioner helps to keep the drive belt at the proper tension for maximum drive function and service life.

The water pump provides coolant flow within the cooling system, at a level sufficient to maintain pressure of less than 10 psi. Circulation of the coolant liquid is critical to maintaining proper operating temperature. Coolant absorbs heat generated by the combustion action of the engine and by friction generated by the moving parts. The heated coolant circulates through a system of pipes and hoses to the radiator, where heat is transferred to the atmosphere by the ambient air flowing over fins in the radiator.

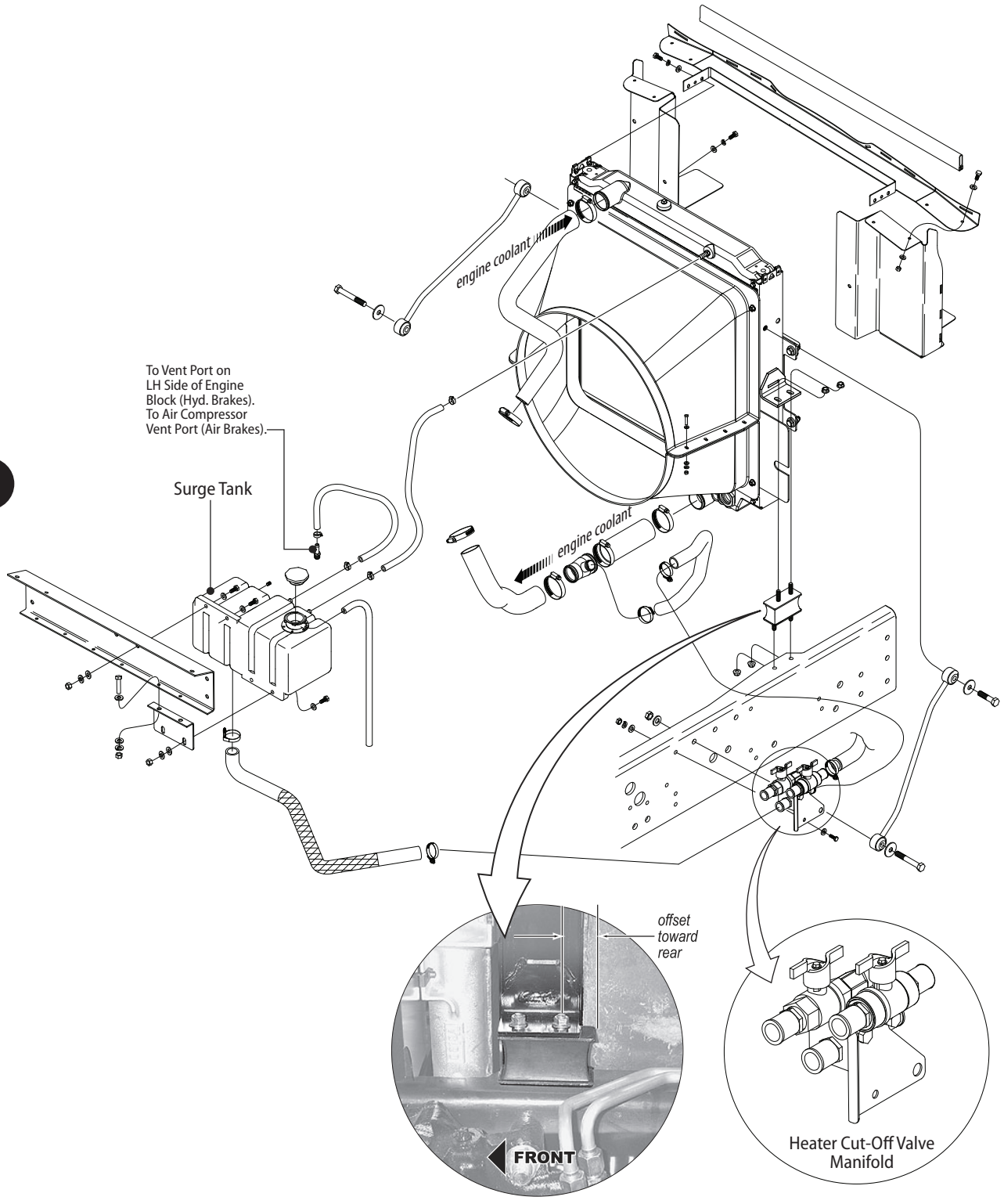
When excessively high operating temperature is observed, first check for proper fluid level in the coolant reservoir or "surge tank". If the fluid level is low and cannot be maintained without constant refill, inspect for leaks at pipe and hose connections. Also look for damaged hoses due to heat or chaffing from incorrect routing. During cold weather, the coach heater system may also be an area of leaks.

Debris accumulation in the radiator fins or bent fins restricting airflowmay also cause overheating.

The three main symptoms of trouble in the cooling system are overheating, overcooling, and loss of coolant. A cooling system should first be diagnosed by a thorough visual inspection. If this reveals no useful information, tools and test equipment will be needed to proceed.

In the case of overheating, the next step is to verify the proper operation of the thermostats. Refer to the appropriate GM 8.1L publication for instructions regarding the removal and testing of the thermostats.

WARNING ***The engine, coolant, and transmission fluid may be very hot (possibly above the boiling point at atmospheric pressure). Use caution when working with these components. Allow the system to cool to the point where you can comfortably lay your hand on the engine block and radiator before working on it. Refer to the Introduction section of this manual for advice on the environmental considerations required when working with these materials.***



Cooling System *Major Components*

Coolant

Havoline Extended Life Anti-Freeze/Coolant DEX-COOL is a concentrated coolant recommended for use in the Blue Bird Vision, GM 8.1L engine cooling system. For mixture of the coolant for ambient temperatures in which the bus will be operated, follow the coolant manufacturers recommendation. Optionally, Havoline Extended Life Prediluted 50/50 Anti-Freeze/Coolant DEX-COOL is available.

Havoline Extended Life Anti-Freeze/Coolant DEX-COOL is a single phase, ethylene glycol type universal automotive engine coolant based on Texaco's patented extended life carboxylate inhibitor system. Havoline Extended Life Prediluted 50/50 Anti-Freeze/Coolant DEX-COOL is a 50/50 mixture of Havoline Extended Life Anti-Freeze/Coolant DEX-COOL and deionized water. This coolant meets ASTM D 3306 for automotive service and GM6277M General Motors Specification.

Coolant Decals

On all bus models, Blue Bird installs a decal stating:

- The type of coolant installed at the factory.
- The coolant manufacturer's part number for one gallon quantity, suitable for regular top-off and refill.
- The coolant manufacturer's part number for one gallon quantity of the concentrate version of the installed coolant, suitable for formulating stronger glycol mixture ratio.

Blue Bird also installs a second decal containing radiator warnings. Both decals are mounted near the coolant fill neck.

Coolant Maintenance

Blue Bird advises strictly abiding by the following policy for all coolant maintenance for the life of the vehicle.

Never Mix Coolant Types

Routine coolant addition (top-off) must match the installed coolant type and brand. Do not mix coolants of different colors, types, or brands in the same engine.

Strictly Follow The Engine Manufacturer's Specifications

Each engine manufacturer publishes its own specific requirements for testing and maintaining coolant in their respective engines. Blue Bird recommends strictly abiding by the engine manufacturer's testing and maintenance schedules and draining, flushing, refilling procedures to maintain compliance with the engine warranty requirements. Blue Bird recommends that you maintain accurate vehicle-specific service records of all coolant system maintenance procedures performed.

Always Mix Concentrate With Premix Coolant, Not Water

If concentrated coolant is added in order to raise the glycol ratio, use only the concentrate version of the same premix coolant type and brand as installed. Do not mix the concentrate with water. Instead, mix the concentrate with the premix version of the same coolant.

Only Add Tap Water In Emergency Situations

A regularly-scheduled bus inspection and maintenance program should be followed to prevent coolant losses due to damaged or worn hoses, loose clamps, etc.

If coolant is lost while the bus is in use, and roadside emergency measures are called for, replenish the coolant with the same premix type and brand if possible. If the proper coolant is not available, and water must be used, use only de-ionized water if possible. Ordinary tap water should only be used if proper coolant or de-ionized water are not available.

Whenever tap water alone has been added, the bus should be taken to a service facility and the entire cooling system should be completely drained, flushed, and refilled with premix coolant.

Heater Cut Off Valves

The Blue Bird Vision is equipped with two cutoff valves which can be used isolate the heaters portion of the coolant circuit from the engine portion. These valves may be used to minimize spillage when performing maintenance tasks between coolant changes, such as replacing a damaged coolant hose. Both valves must be open when bleeding air from the heater circuit. See Cooling System Major Components.

Radiator

Removal

1. Support the hood and remove the hood support cables. *Note: Optionally, the hood may be removed from the bus by disconnecting the head light harness, supporting the hood for removal, then, removing the hood safety latch and six hood bolts*.

2. Remove all baffles surrounding the radiator.

3. Remove the upper and lower radiator hoses and the bleeder hoses.

4. Remove capscrews from the fan shroud assembly.

5. Disconnect the engine oil and power steering oil coolers mounting bracket from the radiator frame. Provide support for the cooler assembly and lay it forward.

6. Remove the transmission cooler hoses at the bottom of the radiator. Drain the fluid into a suitable container, observing all applicable local, state and federal laws concerning disposal of hazardous fluids. If the adapter fittings are removed from the bottom of the radiator, mark the orientation to aid at assembly.



Engine Oil & Power Steering Oil Mounting Bracket Fasteners

7. Close both heater circuit cut-off valves.

8. Using the petcock, drain the engine and radiator of coolant into a suitable container.

9. Pull the shroud as far rearward (over the fan) as possible, support the shroud. *Note: The fan shroud may be separated and removed.*

10. Remove the capscrew from the lower isolator blocks, right and left side. Note the orientation of the blocks. See Cooling System Major Components.

11. Support the radiator and remove the upper isolator support rods.

12. Carefully lift the radiator clear of the frame rails. Ensure the fins on the radiator and charge air are protected.

Reintallation

Both baffles must be in position and their respective seals in place for the cooling system to perform correctly.

When installing the radiator isolators, exercise care to orient the 20 mm edge distance toward the front of the bus. If the 35 mm edge is installed toward the front, there will not be space for the fan shroud.

1. Centering the assembly, carefully position the radiator onto the isolators at each frame rail. Torque new locknuts to 29–33 ft lb (39.32–44.74 Nm), at 4 places.

2. Position and install the radiator isolator rods. Torque all 4 fasteners to 70–80 ft lb (94.91–108.47 Nm). Use new Grade 8 locknuts at the frame rail.

3. Position and install the transmission fluid cooler hoses to the bottom of the radiator. Ensure the hoses are in the proper position. The left (driver's) side transmission hose connects to the driver's side of the radiator. Ensure that the protective loom is installed on the transmission lines. The threads in the bottom of the radiator are National Pipe Threads (NPT). These threads require the application of Loctite 557™ pipe sealant with Teflon™. Follow the directions and warnings on the package. Start the fitting 1 thread into the proper location, and then apply the sealant. Torque to 70–77 ft lb (94.91–104.40 Nm).

4. Position the shroud onto the radiator.

5. Turn the fan blades by hand. Ensure that the blades are centered in the shroud and do not touch at any point.

6. When the fan blades are centered in the shroud, torque the fasteners to 30–38 ft lb (40.67–51.52 Nm).

7. Install the bottom coolant hose. Torque clamps to 5 ft lb (6.8 Nm).

8. Install the upper coolant hose; torque the clamp to 5 ft lb (6.78 Nm). Ensure the protective loom is installed on the top radiator hose.

9. Install the coolant bleeder lines.

10. It is important that the baffles and their seals are properly positioned. Torque fasteners to 5–6 ft lb (6.78–8.13 Nm).

11. Install the hood, if removed, in the reverse order of its removal. Torque the hinge fasteners to 25–37 ft lb (33.90–50.17 Nm).

12. Install hood support cables.

13. Refill the cooling system with coolant, as prescribed in this chapter, in conjunction with ambient temperature in which the bus will be operated in.

14. Check transmission oil level and add as necessary.

15. Start the engine and operate at low idle.

16. Add coolant as needed to maintain coolant level at the full line on the reservoir.

17. Operate engine at high idle allowing ample time for thermostat to open.

18. Open the heater circuit cut-off valves and check for proper heater operation.

Intake System

Clean air is necessary for efficient fuel combustion and for normal engine life on an engine. Any opportunity for airborne contaminants to enter the intake flow represents a potential for serious damage to engine life. Therefore, careful inspection of the entire intake tract should be a part of regularly scheduled maintenance, and any signs of dust or debris entrace must be repaired immediately.

Fresh air enters the intake duct through vents built into the engine hood. The air enters a canister-type air filter mounted on top of the engine's right side. The filter element is of dry pleated fiber type and is easily accessible for replacement without tools, and without removal of any other chassis components or brackets. The element must be replaced when dirty, not cleaned and re-used.

After passing through the filter element, fresh air enters the manifold though the air intake duct extending from the left side of the filter cansiter to the manifold at the front of the engine. A pressure-sensing restriction indicator mounted on this duct provides a visual alert in the case of restriction of the air flow entering the intake manifold.

Air Restriction Indicator

The Air Restriction Indicator is visible from the right side of the bus when the engine compartment hood is raised. During engine operation, the indicator monitors vaccuum pressure inside the air filter elbow. As vaccuum increases, the indicator's red piston becomes visible through the clear portion of the housing indicating that air flow is being restricted by a clogged filter, debris, or other obstruction. The Air Restriction Indicator is variable until the monitored vaccuum increases to a measure of 25 inches H_2O. At that measure, the red piston fills the clear portion, and locks in its position. The indicator must then be manually reset by pressing the reset button after the restrictive condition has been corrected.



Air Restriction Indicator

Normal reading. Some fluctuation while the engine is running is acceptable.

At a vaccuum of 25 inches H_2O, the red piston locks, indicating that the air intake tract is too restricted.

CAUTION ***The Air Restriction Indicator activates only when an air flow restriction has occured. A normal reading (no red showing) must not be misunderstood as an indication that the air filter is clean, and does not preclude the need for other inspection and maintenance. For example, a leak in the intake will allow damaging debris to enter, but will not be indicated by the Air Restriction Indicator.***

Filter restriction and proper operation of the indicator may be verified by pressing the reset button on the top of the indicator. If restriction is occurring, the red indictor will move when the engine is under load. The indicator will lock in position if the monitored vaccuum increases to 25 inches H_2O.

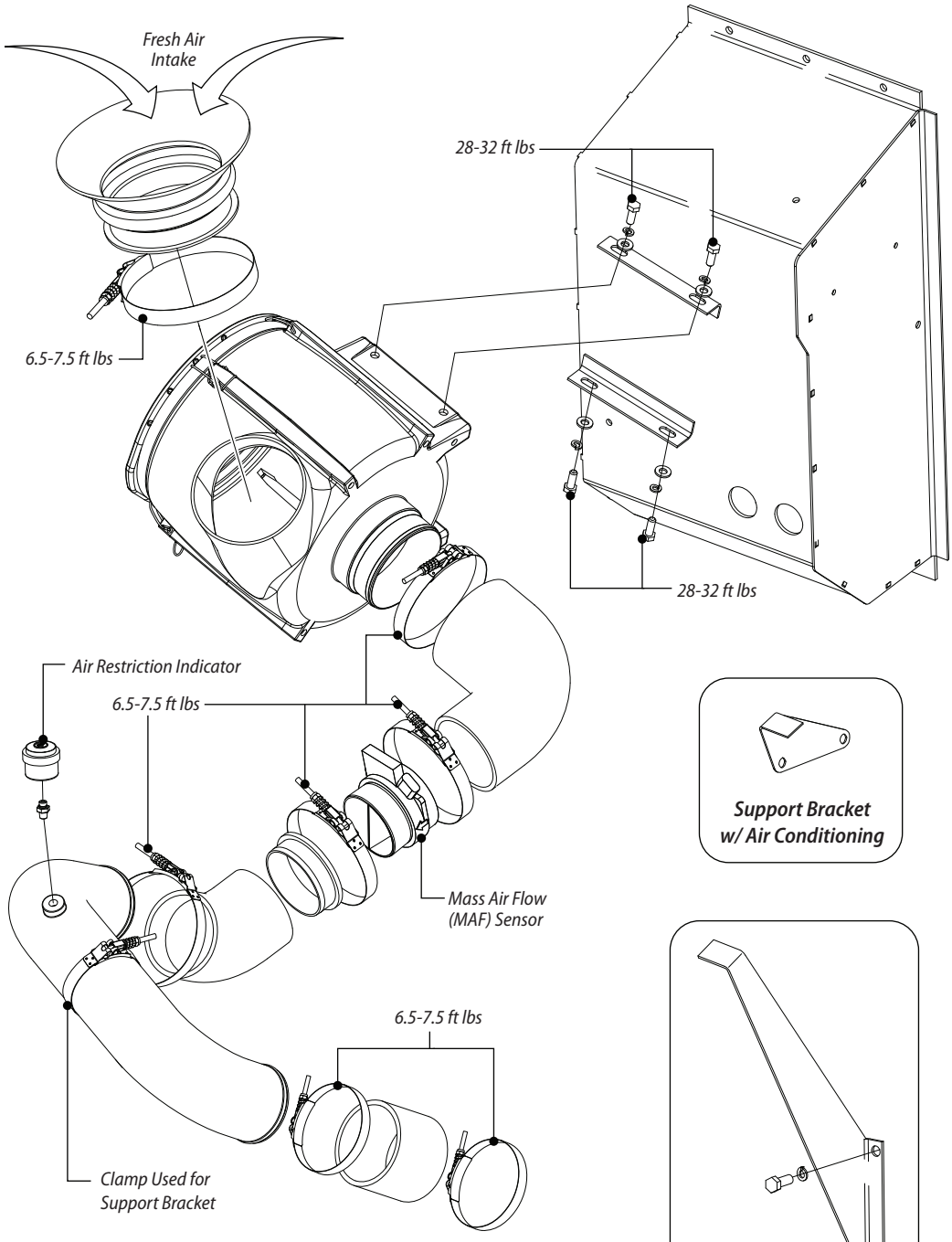
It is important to understand that the Air Restriction Indicator does not detect leaks, and will not properly indicate restrictions in a leaking intake system. Check for leaks in all inlet hoses, tubes and connections. If a leak is found, correct it immediately, using original replacement parts and torqing all clamps.

The Air Restriction Indicator can also be tested using a calibrated vacuum gauge and vacuum pump. Check the full range of the indicator, and verify that the red indicator locks into position at 25 inches H_2O. The Air Restriction Indicator is not repairable, and should be replaced if found to be operating incorrectly.

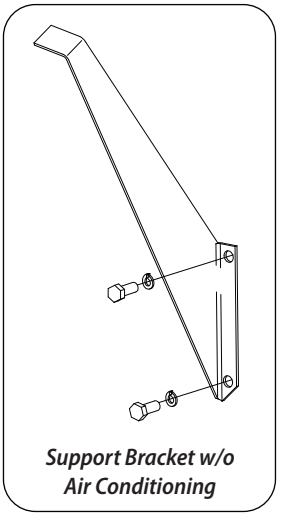
Intake System Maintenance

Although it is a simple system, dilligent maintenance and inspection of the air intake tract is critical to not only proper performance, but also to engine life and warranty compliance. Any leak along the various tubings and clamped joints of the intake tract is an opportunity for the engine to ingest abrasive dirt or contamination into the valves and combustion chambers under pressure. Never run the engine with the air cleaner or its filter element removed. Use only original replacement parts to avoid poor fit and consequent air leakage. Visually inspect the intake tract whenever working in the engine compartment. and follow the scheduled maintenance guidelines in the Specs & Maintenance chapter of this manual as a minimum.

CAUTION ***The intake system inspection and maintenance intervals indicated below are guidelines which assume normal operating conditions. Appropriate service intervals vary according to operating conditions. In dusty or high humidity environments, more frequent service may be required.***



Support Bracket w/ Air Conditioning



Support Bracket w/o Air Conditioning

Air Intake System

General Inspection

Under normal operating conditions, inspect the Air Restriction Indicator daily (more frequently in dusty high humidity conditions). Inspect the air intake system every 3 months or 5000 miles. Inspect the system for:

- Air Restriction Indicator. If red indicator is visible, replace the air cleaner element, and check the system for debris and other restrictions. Check Indicator operation by observing the red indicator movement while the engine is under load or use a calibrated vacuum gauge.
- Clamps. Tighten loose clamps and check for proper fit and seal. Replace if corroded, broken or otherwise damaged.
- Ducts and piping. Inspect for wear, damage, or abrasion.
- Air cleaner element. Replace if soiled, wet, torn, or otherwise damaged. Ensure proper installation and seal.
- Mounting brackets. Check for loose or damaged mounts.
- Air compressor inlet lines. Tighten. Check for wear or other damage.

Clamps should be tightened to the following specifications:

Spring-loaded clamps. ***Tighten to near full spring compression.***

T-Bolt clamps. ***Tighten to 50 in. lbs. (5.6 Nm).***

Worm gear clamps. ***Tighten to 38–42 in. lbs. (4.2–4.7 Nm).***

Hose clamps already in service. ***Tighten to 10 in. lbs. (1.1 Nm).***

Air Filter Element Replacement

Replace the air filter element at least once a year, and whenever the Air Restriction Indicator has been activated (shows red). Other indicators of a dirty air cleaner element include loss of power or excessive exhaust smoke. To replace the air cleaner element:

1. Unlatch the four quick release latch clamps holding the lid to the top of the air filter housing.

2. Remove the lid to expose the air cleaner element.

3. Pull the air cleaner element straight out of the filter housing. A rotating or rocking motion may help unseat the element.

4. Before replacing the element, inspect all clamps, hoses, piping and seals.

   - Inspect inside the manifold intake for signs of dust or debris finding its way into the system through leaks. Replace any damaged components allowing the leak, and clean the debris inside the ducts before installing a new element.

5. Install a new air cleaner element, fully seating its bottom seal.

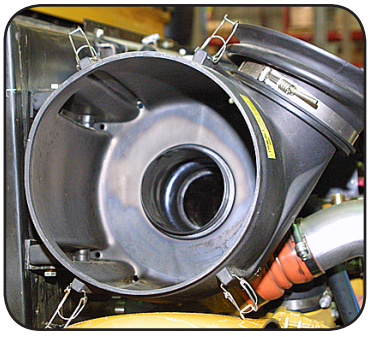
6 Re-latch the clamps for secure installation. If necessary, a clamp's tension may be tightened by using pliers to carefully shorten its curve.

7. Reset the Air Restriction Indicator by pushing the reset button. This will allow the indicator to monitor the newly installed components.



Air Cleaner Element

Unlatch the four clips and lift out the filter element. The lid is an integral part of the element.



The element fits snuggly around its bottom seal. A gentle rocking or rotating motion will help unseat it.

With the element removed, check the inside of the elbow for any sign of contamination due to leaks before replacing the element..

Exhaust Piping

The exhaust system beyond the muffler is designed to move hot exhaust gases from the engine, underneath the bus to be expelled at the rear, while preventing contamination of the passenger area. All pipes and connections must be inspected for leaks at least monthly to provide continued safe transport of passengers.

CAUTION ***Never work under a bus with the engine running. Never work under a bus until the wheels are chocked, to prevent movement in either direction.***

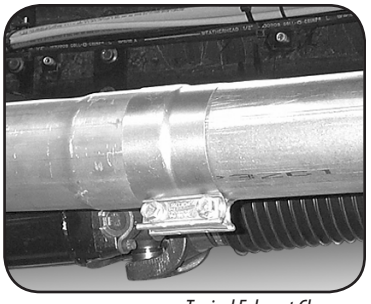
Although the exact configuration of exhaust pipe and tailpipe sections is dependent upon the wheelbase and body length of the particular bus, the pipe sections, joint clamps and suspension hangers from the muffler assembly are similar. As a general rule, to remove the exhaust system, or any part of it, start at the rear most hanger and work forward.

Muffler Removal

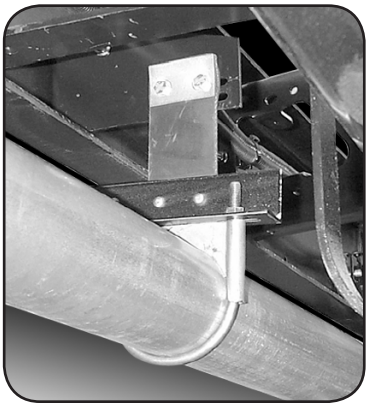
This general procedure applies to all wheelbases.

1. Start at the rear bumper and loosen all the sections forward until you reach the muffler.
2. Remove the clamp securing the tailpipe onto the muffler.
3. With the slack produced by loosening the section clamps rearward, remove the tailpipe section nearest the muffler.
4. On the lower exhaust pipe, forward of the muffler, locate and remove three nuts that secure the engine exhaust to the muffler.
5. Remove the clamp securing the upper engine exhaust pipe onto the muffler.
6. Support the muffler. Remove the cotter pins and hanger pins at the two muffler hangers. Lower the muffler.

If it is necessary to continue removing exhaust pipe sections, proceed from the muffler toward the engine as far as necessary.



Typical Exhaust Clamp



Typical Exhaust Hanger

Muffler Reinstallation

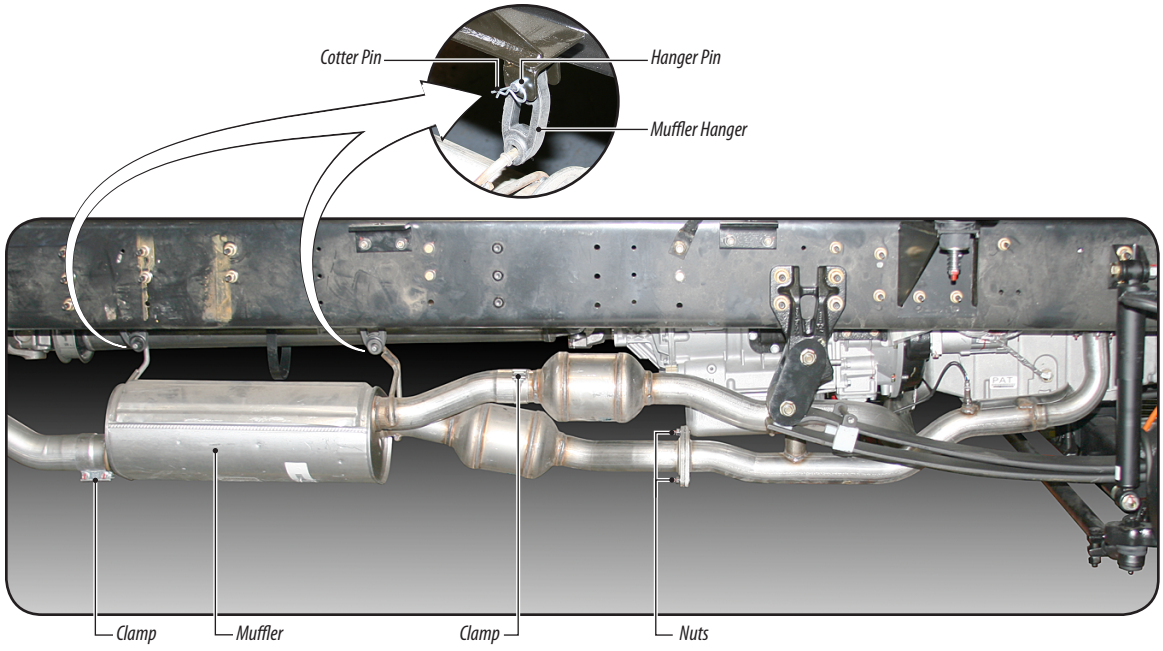
When assembling the exhaust system, start at the forward most section and work toward the rear of the bus. Always use new clamps and hardware.

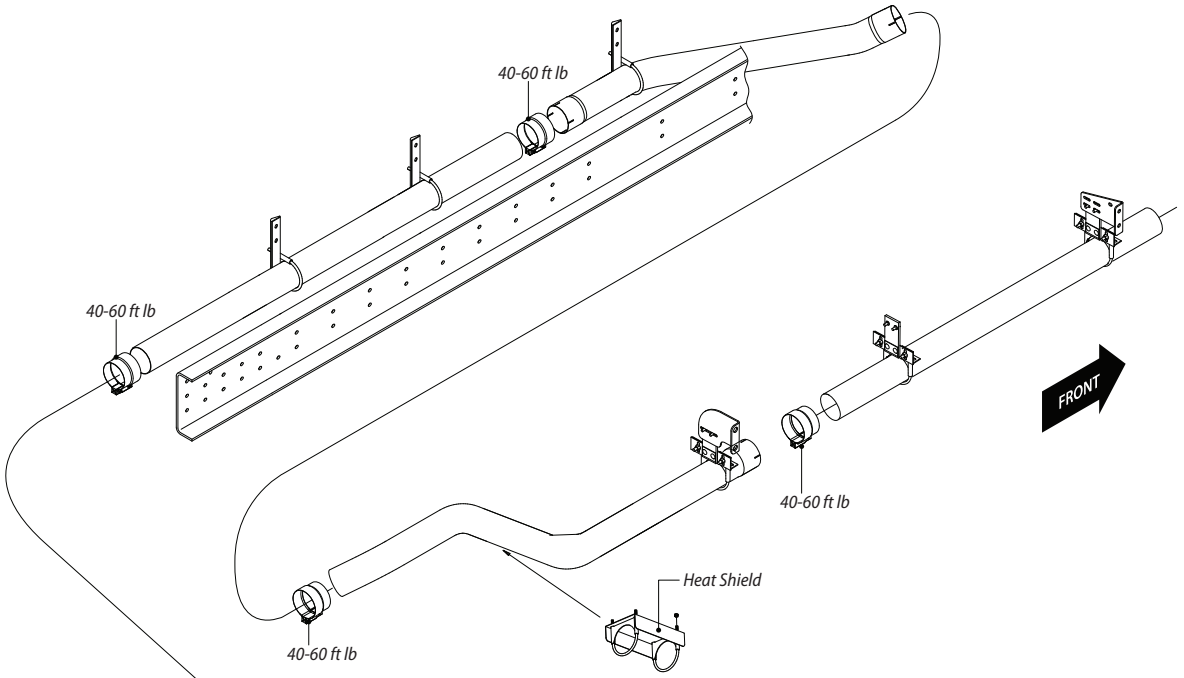
1. Assemble the exhaust pipe to the muffler. Leave all connectors loose for final adjustment.

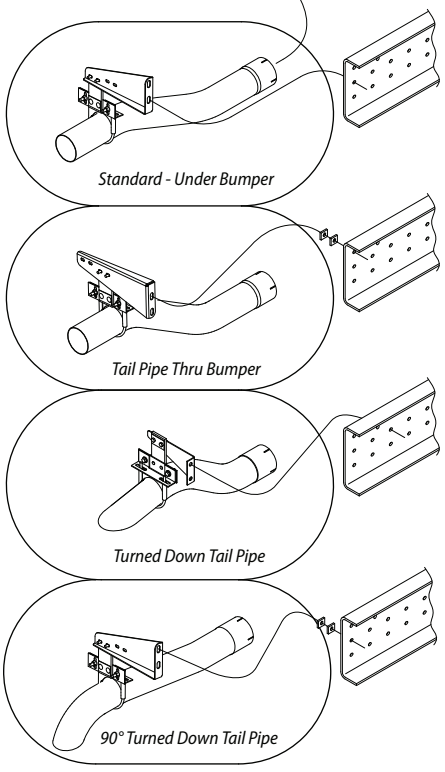
2 Use new wideband clamps and hardware.

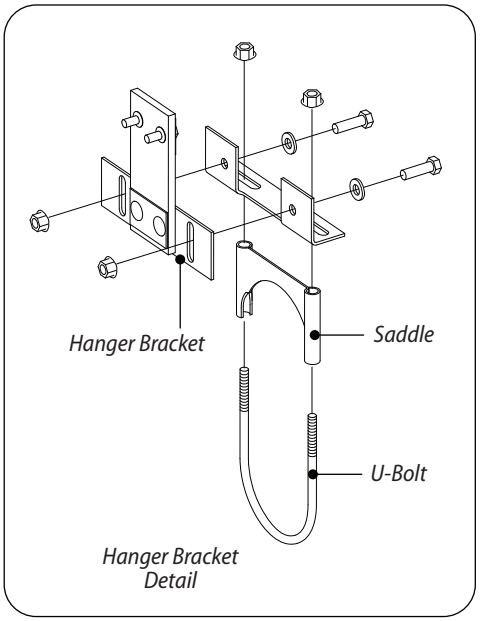
3. Insert the hanger pins and cotter pins at the muffler hangers.

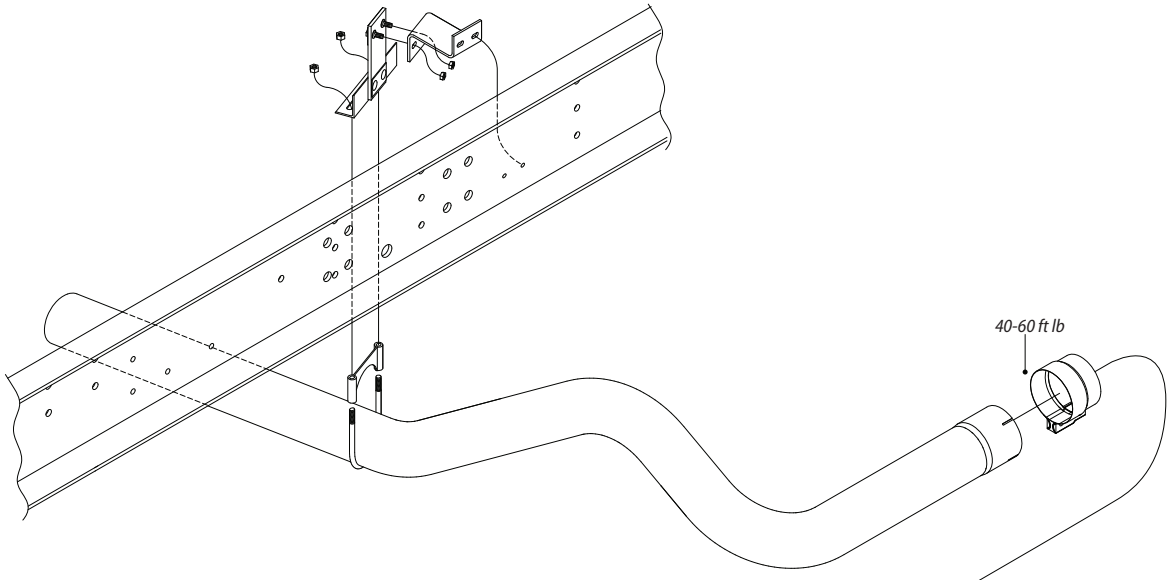
4. Continue working toward the rear of the vehicle. Leave all joints loose until the entire tailpipe assembly is in the correct position, and then tighten all the clamps.

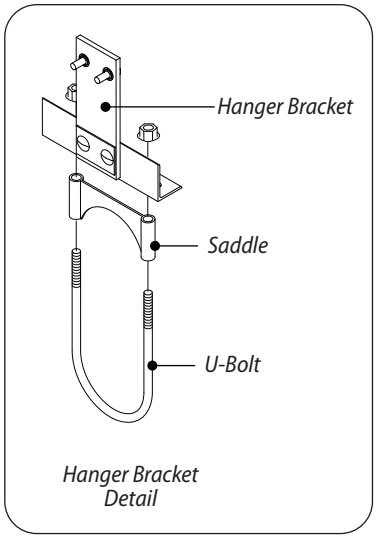



40-60 ft lb
40-60 ft lb
FRONT
40-60 ft lb
Heat Shield
40-60 ft lb

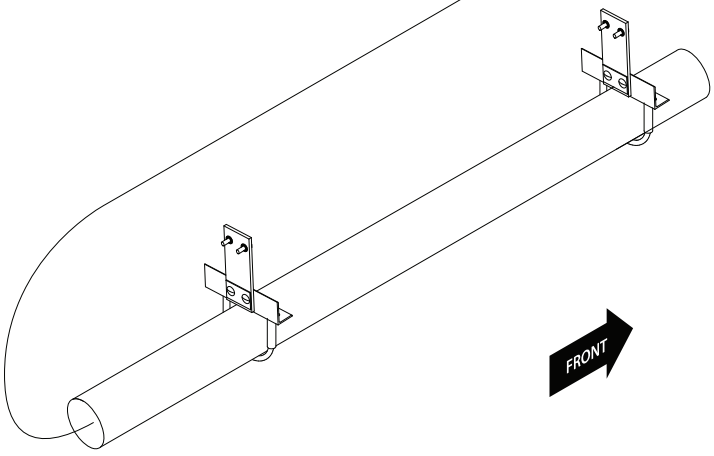

Standard - Under Bumper
Tail Pipe Thru Bumper
Turned Down Tail Pipe
90° Turned Down Tail Pipe


Hanger Bracket
Saddle
U-Bolt
Hanger Bracket Detail





Hanger Bracket Detail



Exhaust Piping

Overview

The introduction of the Propane powered Blue Bird Vision marks a new generation in alternative fuel powered school buses. The bus is powered by a General Motors, Vortec 8.1 Litre engine equipped with a Liquid Propane Injection (LPI®) fuel system. Unlike the traditional propane powered vehicle that supplies propane to the engine in a vapor phase, the LPI system delivers, meters and injects propane in a liquid phase into the engine.

Similar to a modern gasoline engine, the LPI® system stores liquid propane in the fuel tank. An electric in-tank fuel pump circulates the propane through fuel rails that supplies fuel sequentially to the fuel injectors. The injector's meter and inject liquid propane into each of the original eight inlet ports on the Vortec engine. Fuel that is not used by the injectors will return to the fuel tank through an in-line pressure regulator.

The operator should notice little difference in the operation of propane versus a diesel powered bus. Similar to the starting procedure of a diesel powered bus, there will be a wait to start indicator informing the operator when to start the propane powered engine. The propane wait-to-start procedure is similar to that of diesel, but must be performed during each start up regardless of ambient temperatures. The operator will also notice a drop in engine noise as the propane powered engine has a noise level similar to that of a gasoline engine versus a diesel engine.

Fueling a propane powered bus will be noticeably different than a conventional fueled vehicle. A propane fuel system is completely sealed and the major difference when fueling is a screw-on type fill connector. When fueling, turn connector clockwise to tighten ensuring a good seal. The tank can only be filled to 80%, leaving room for the fuel to expand/contract and the tank is equipped with an automatic stop fill device to prevent filling more than 80%. At 80% the dash gauge will read full. Fill time is only slightly longer than refueling a diesel powered bus.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

Propane

Propane, like diesel fuel, gasoline or natural gas, is a member of the hydrocarbon family and exists as a gas in its natural state. When stored under pressure, the propane turns into a liquid. Propane is a colorless, odorless and non-toxic gas. Ethyl mercaptan is added to propane during the manufacturing process to give it a distinct, recognizable odor. Propane is a by-product of refined petroleum and natural gas. Propane is commonly referred to as LPG or LP gas.

Like most liquids, liquid propane expands as its temperature increases. This is why propane tanks are only filled to 80% of its liquid capacity. Even with an 80% fill capacity, due to liquid propane's expansion ratio of 1:270 (liquid propane to a gas by volume) and its high BTU rating a large volume of energy can be stored in a relative small tank under relative low pressure.

Propane also has a very narrow range of flammability with a 2.15% threshold on the low side and a 9.6% threshold on the high side. This means that if the propane to oxygen mixture is lower than 2.15 % or higher than 9.6 % the mixture is noncombustible.

Propane is heavier than air; therefore, a leak in a propane fuel system can result in a gas accumulation in low places, such as sewers, drains or service pits. This can create a fire and health hazard as the propane will displace oxygen, potentially resulting in suffocation. For this reason, additional safety precautions should be observed when working on or around propane powered equipment or storage tanks.

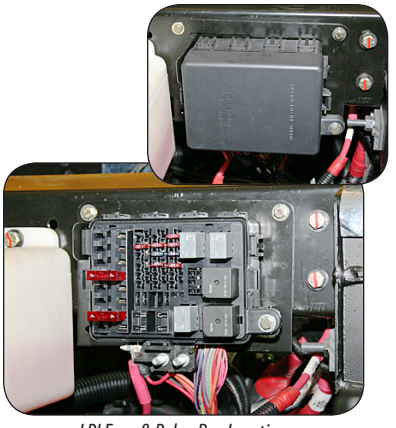
WARNING ***Blue Bird does not approve any additions to or modifications of Blue Bird fuel systems. Blue Bird fuel systems are designed and installed to meet federal standards and engine manufacturer's guidelines. The maintenance provider or modifier assumes all responsibility for the vehicle engine and fuel system if the fuel system is changed or modified. Some states require a special license to perform maintenance or work on propane powered vehicles. Check with local authorities or your state LP Gas Association for details. All fuel system components must be a minimum of 18 inches from any exhaust sytem component unless properly shielded. All service, maintenance and repairs performed on LP Gas systems must be done by an authorized LP Gas service technician..***

Fuel System Description and Operation

The General Motors Vortec. 8.1L engines fuel supply is controlled by the same PCM (Powertrain Control Module) as used on the GM medium duty truck; however the fuel control calibration has been changed to optimize the power and emissions for propane. The LPI system controls the purge cycle while the original PCM controls fuel flow to the injectors. The filling process is safeguarded against overfilling by an electronic 80% overfill protection device integral to the LPI® system.

The LPI system utilizes dual cylindrical tank assemblies manifold together to store the liquid propane under pressure. Internal to the tank is an electric fuel pump with a replaceable filter, a fuel level float device with rheostat, an auto stop pressure sensor, an 80% liquid level sensor, a fuel fill stop solenoid, a supply check valve assembly, a fill port check valve assembly, a return check valve assembly, and a wiring harness.

Due to the inherent qualities of Propane, a purge strategy must be employed during engine start up. Whenever the fuel pump is not activated, there is a potential for the liquid propane in the fuel rails to absorb heat from the engine or from ambient temperatures. This heat may cause the fuel to expand rapidly and create bubbles in the fuel rails. These bubbles, if not purged from the fuel rails, can cause lean fueling or a no start conditions.



LPI Fuse & Relay Box Location

PurgeCycle

During each engine start up the LPI fuel system will enter a two-stage purge cycle for a period of approximately 20 to 30 seconds. The purge process is controlled by the Fuel Control Unit (FCU). The FCU is an electronic module that controls the LPI fuel system and functions independently of the engines PCM (Power Train Control Module) during the purge cycle. The first stage of the purge cycle will begin when



Fuel Control Unit

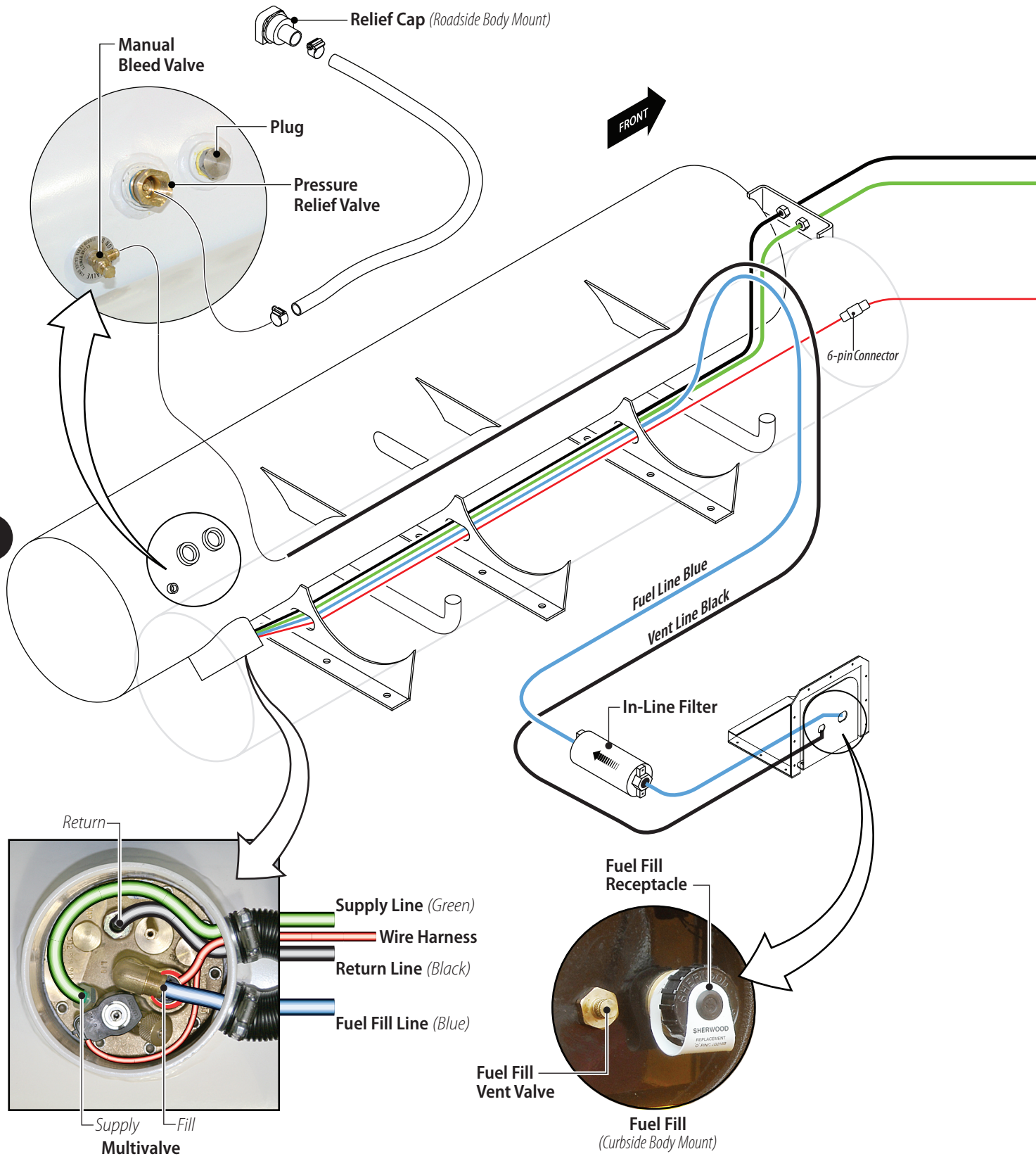
the operator turns the key to the Key On Engine Off (KOEO) position, a wait-to-start indicator in the instrument panel will illuminate for approximately 20 seconds. The FCU will then turn off the wait-to-start indicator marking the beginning of the second stage of the purge cycle. The operator should immediately start the engine. During the second stage of the purge cycle, the operator has approximately 10 seconds in which to start the engine. If the engine does not start or the operator waits too long (approximately 10 seconds) the wait-to-start indicator will begin blinking. This indicates that the purge cycle has been completed and has timed out at which time the FCU will de-energize the fuel pump and the engine will not start. The operator will have to repeat the purge cycle by turning the ignition key off and then back on to initiate a new purge cycle.

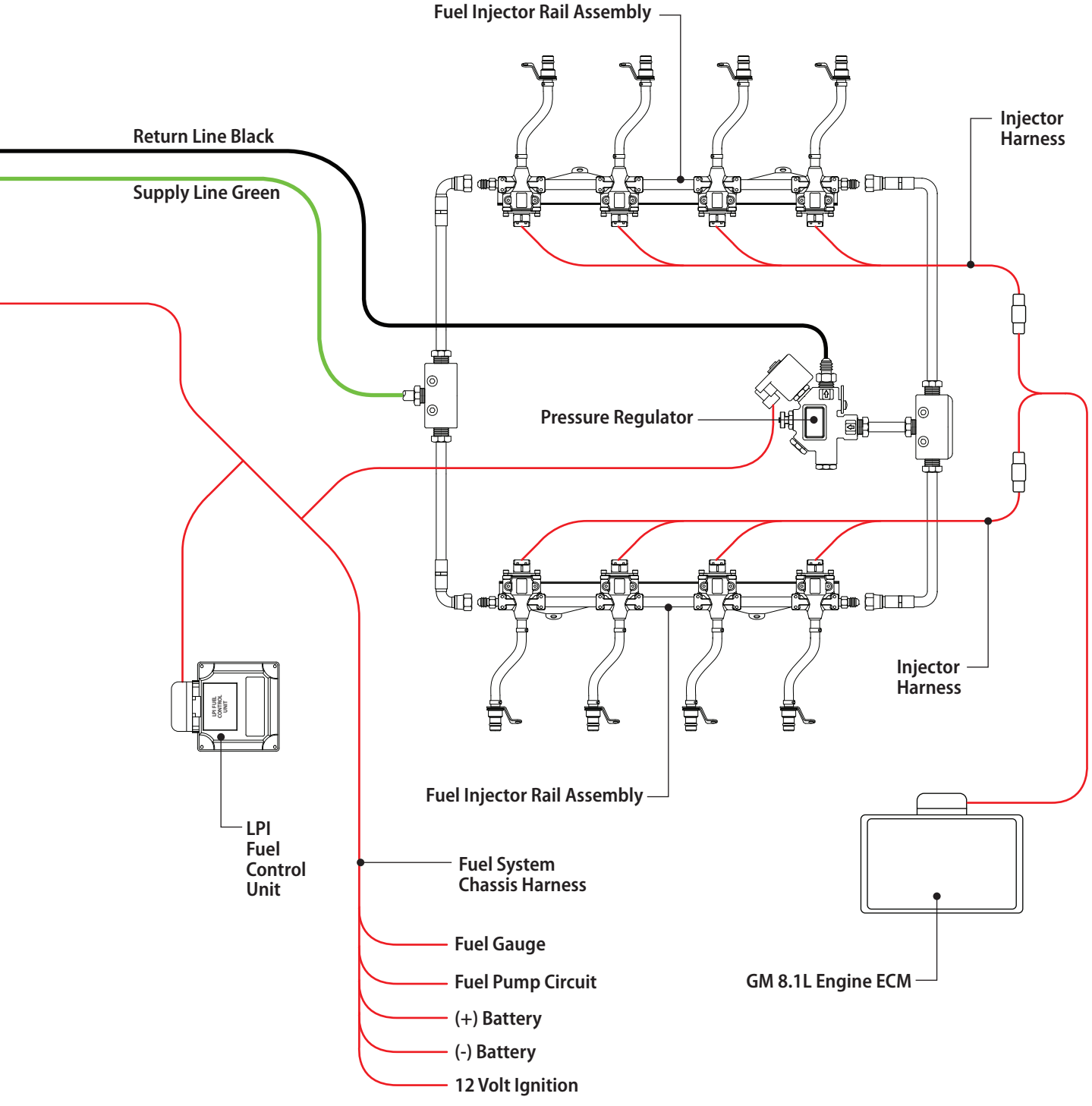
When the operator turns the key to the KOEO position the LPI Fuel Control Unit (FCU) supplies an electrical signal to the normally closed fuel supply solenoid (integrated into the multivalve), the normally closed fuel purge solenoid (integrated into the pressure regulator valve) and the fuel pump (located inside the fuel tank). Liquid propane will begin to flow through the green supply line, to the fuel rails and finally to the injectors. Fuel will flow back through the black return line to the pressure regulator, through the open purge solenoid valve and back to the fuel tank. This free flow circulation of liquid Propane will continue for approximately 20 seconds (stage one of the purge cycle) purging the fuel circuit of bubbles.

After the first stage of the purge cycle is completed, the FCU will turn the wait-to-start indicator and the purge solenoid off while keeping the fuel supply solenoid and the fuel pump energized for approximately 10 seconds. This 10 second period is stage two of the purge cycle. During stage two, propane will continue to flow through the fuel supply lines to the injectors. With the purge solenoid closed, fuel will no longer be able to bypass the fuel pressure regulator and return unrestricted to the fuel tank. Fuel flow will be regulated through the preset pressure regulator valve. By controlling the rate of fuel flow through the regulator, the necessary pressure for the fuel injectors to operate will be created and maintained by the fuel pressure regulator.

The Vortec engines, equipped with the LPI fuel systems, will have a unique calibration installed in the base engine PCM. Specific parameters and values have been slightly altered to optimize the base calibration to operate on Propane. By utilizing the base engine PCM, the LPI fuel system can utilize all the engine sensors and throttle control devices. The LPI fuel system controls the fuel pump and fuel flow to the injectors during the purge cycle and during normal operation fuel flow is controlled as required by the base engine PCM. The fuel injectors are specific to the LPI system, however, the electrical signals that control the injectors are provided solely by the engine PCM.

The LPI fuel system utilizes the base engine diagnostics to monitor the base engine fuel system and emission systems faults. This strategy allows the technicians to utilize the GM diagnostic tools and diagnostic charts when identifying base engine fuel and emission system faults. See Appendix 1. Symptoms Diagnostic Charts at the rear of this chapter.


Relief Cap (Roadside Body Mount)
Manual Bleed Valve
Plug
Pressure Relief Valve
FRONT
6-pin Connector
Fuel Line Blue
Vent Line Black
In-Line Filter
Return
Supply Line (Green)
Wire Harness
Return Line (Black)
Fuel Fill Line (Blue)
Supply
Fill
Multivalve
Fuel Fill Receptacle
Fuel Fill Vent Valve
Fuel Fill
(Curbside Body Mount)



Propane Fuel System GM 8.1L

General Propane Tank Filling Procedures

The most important procedure of filling any propane tank is safety. Understanding the properties & characteristics and safe handling practices of the fuel is required before conducting any propane tank filling efforts.

A propane powered vehicle is equipped with a propane tank built to and certified to the regulations of the American Society of Mechanical Engineers (ASME) These tanks have a data plate with pertinent information including the ASME stamp and the plate must be securely attached and legible or the tank should be taken out of service and replaced. There are no requirements for re-certifying ASME tanks however inspection is required and maintenance is recommended if there are signs of corrosion.

Propane tanks are filled to 80% capacity to allow for the liquid fuel to expand and contract depending on ambient or other influent temperatures. All tanks built for use on motor vehicles are equipped with overfilling prevention protection. The National Fire Protection Association (NFPA) have required motor vehicle propane tanks be equipped with a stop filling device to automatically prevent overfilling or filling the tank beyond the maximum recommended capacity of 80%. This automatic stop fill system provides the primary method of preventing overfill of the fuel tanks. This rule has been in effect since January 1, 1984.

As a secondary means of preventing an overfill condition of the fuel tanks and a means of verifying the accuracy of the automatic stop fill device, the tanks are equipped with an 80% fixed maximum liquid level outage valve (Manual bleeder valve). The valve would be used to verify when the liquid fuel reaches the 80% level at which point the fill process would be stopped. This valve can be used when filling and releases fuel in a vapor phase until the fuel reaches the 80% level at which time a stream of liquid will appear indicating the fuel level in the tank is 80%. Most propane fueling stations will want to open this bleeder valve however since the propane motor vehicle tank is equipped with an overfill prevention device it is not necessarily required and may be prohibited in certain municipalities where the release of hydrocarbons to the atmosphere is prohibited. The NFPA ruled that when the tank is equipped with an overfill prevention device the use of the 80% bleeder valve is not required.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

Propane Powered Motor Vehicle Filling Procedures

1. Entering the propane fueling station.
   a. Park the vehicle in close proximity to the motor fuel dispensing station.

      WARNING *NO SMOKING ALLOWED.*

2. Turn off and remove the vehicle ignition key.
3. Exit the vehicle and ask all passengers to step outside the vehicle.
   a. Some stations may ask all passengers to stand outside the area where the fill process is taking place.
   b. Some stations could be self-service and the driver would perform the filling process; however in this case the driver has to be trained and certified to obtain an authorized filling station dispenser access card.
4. The attendant may need to inspect the propane tank for corrosion, dents and verify the data plate displays the ASME stamp and other pertinent information is correct. An attendant can refuse to fill your propane tank if it does not pass this inspection. Regular inspection and maintenance of your tank will prevent refusal to fill the tank.
5. Verify the meter is set to zero.
   a. If the dispenser is an electronic dispenser it will set to zero automatically once the transaction has been initiated.
6. Connect the fuel nozzle to the vehicle fueling receptacle.
   a. The propane fueling nozzle has to be screwed on securely.
      i. Wear protective gloves while fueling a propane tank.
      ii. Remove the protective cap from the vehicle fueling receptacle.
      iii. Mate the nozzle coupling to the fueling receptacle.
      iv. Turn the nozzle coupling in a clockwise direction; two or three turns until secure. A soft rubber washer or o-ring seals the connection so over tightening is not required.
      v. Most nozzles for motor vehicle fueling are much like a gasoline type nozzle. The nozzles are also minimum bleed type for safety and to meet hydrocarbon release requirements in certain jurisdictions.
7. Turn on the propane dispenser/pump and begin the filling process.
   a. Open the nozzle to begin filling.
   b. Do not fill the tank based on a mechanical float gauge reading or the fuel level gauge on the dashboard.
   c. Pay attention and never walk away from the filling process.
   d. As a primary method of determining when the tanks are full (80% capacity) an 80% stop fill device will automatically stop the filling process when the liquid propane reaches an 80% liquid level capacity in the tanks.

WARNING ***For passenger safety, Blue Bird recommends all occupants disembark to a safety zone before fuel filling procedures take place.***

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

e. As a secondary method of determining when the tanks are full (80% capacity) an 80% fixed maximum liquid level outage valve (Manual bleeder valve) can be used.
   - Open the 80% fixed liquid level valve (located at the fill port)
   - Vapor will be vented from the valve during the filling process
   - When liquid propane begins to vent the from the valve the tanks have filled to 80% capacity
   - Immediately close the 80% fixed liquid level valve
   - Immediately close the filling nozzle

NOTE: The 80% fixed liquid level valve can be used to verify the accuracy of the automatic stop fill device.

8. Release or close the fueling nozzle.
   a. Turn off the fuel dispenser/pump.
   b. Carefully and slowly unscrew the fueling nozzle (unscrew counter clockwise).
      i. A minimum bleed nozzle should have released any pressure left in the space between the nozzle and the receptacle when closed and should not bleed any pressure when unscrewing the connection.
      ii. Some nozzles will have more pressure trapped between the nozzle and the receptacle so it is necessary to slowly unscrew the connection to allow pressure to bleed off before removing the nozzle completely. Some nozzles will be equipped with a small bleeder valve to release this trapped pressure before disconnecting the nozzle.
10. Replace the nozzle and fuel transfer hose on the dispenser.
11. Verify there are no leaks at the tank filling receptacle and replace the protective cap.
12. Document the amount of fuel received.
13. The fueling process is complete.

WARNING ***During a propane vehicle fueling process fuel may be emitted to the immediate area. There could be a combustible fuel mixture around this immediate area. The person performing the re-fueling process has total responsibility for safety in the immediate area.***

NOTES:

- It is unlawful to fill a non-compliant tank or a tank that posses a safety violation.
- Any person performing the re-fueling process must be trained and certified in the procedures of filling propane tanks and in the procedures of safe handling.

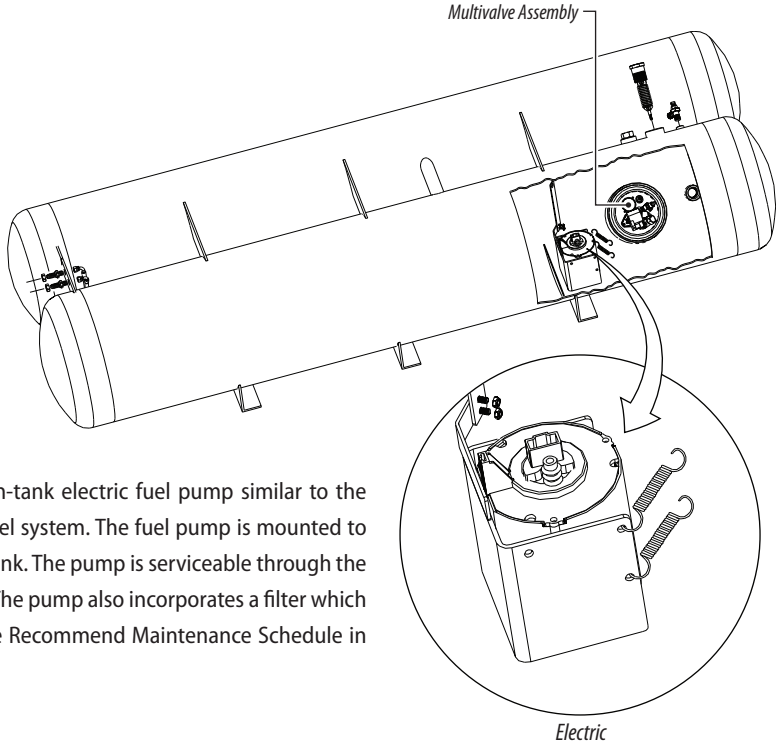
Propane Fuel Tanks

The LPI system utilizes a dual cylindrical manifold tank assembly to store the liquid propane. Only one of the tanks houses the LPI components which are mounted inside the tank or on the external surface of the tank. The other tank simply provides additional fuel volume. The two tanks are permanently connected by cross over tubes that create a single volume of fuel and therefore will be considered one fuel tank or tank assembly. The fuel tank is designed and certified to meet all applicable safety standards required for installation on a motor vehicle. The tank design utilizes integrated mounting brackets which are used for mounting the tank assembly between the frame rails. The tank assembly is secured to the chassis using specially coated and grade level fasteners.

The LPI fuel tank is fitted with a flange for mounting the Multivalve assembly on the bottom of the tank. In addition, a threaded coupling is fitted with a pressure safety valve that will open if tank pressure reaches 312 psi. The excessive pressure (propane vapor) is vented off and the integrity of the tank is protected. A second threaded coupling is fitted with a manual bleeder valve that is used for a maximum 80% liquid level indicator sometimes referred to as a bleeder valve, a fixed liquid level gauge or an outage gauge. The pressure safety valve and the manual bleeder valve are mounted on the top of the fuel tank near the multivalve assembly.

The following components are Inside the fuel tank; an electric fuel pump with a replaceable filter, a fuel level float device with rheostat, a fuel fill stop solenoid, an auto stop pressure sensor, an 80% liquid level sensor, a supply check valve assembly, a fill port check valve assembly, a return check valve assembly, and a wiring harness. The in tank components and their function will be discussed individually. All internal components are serviceable through the Multivalve flange opening in the bottom of the fuel tank.

CAUTION ***When servicing the tank or removing the tank from the vehicle be sure to reinstall the tank with the original fasteners or new like fasteners. Do not replace the fasteners with a lower grade of bolt than originally equipped as this may cause the tank to become dislodged from the vehicle and cause serious damage or injury.***



Electric In-Tank Fuel Pump

Electric In-Tank Pump

The LPI fuel system utilizes a 12 volt in-tank electric fuel pump similar to the fuel pump which is used with a gasoline fuel system. The fuel pump is mounted to brackets located in the bottom of the fuel tank. The pump is serviceable through the Multivalve flange opening in the fuel tank. The pump also incorporates a filter which is serviceable, for maintenance; refer to the Recommend Maintenance Schedule in this manual.

The in-tank pump receives a 12 volt supply when the ignition key is switched on and runs a purge cycle for approximately 20 seconds. The pump is provided with a constant ground signal. The LPI system utilizes the base vehicle fuel pump circuit which incorporates all the base vehicle safety features. To facilitate the purge cycle the LPI Fuel Control Unit (FCU) will override the PCM fuel pump circuit only for the 20 seconds during the purge cycle as the base PCM pump circuit has a much shorter time out strategy.

Fuel Gauge Driver

The tank is also fitted with an in-tank float and gauge driver which provides a standard linear signal with "0" ohms equaling an empty fuel tank and "90" ohms equaling a full tank (80% by liquid volume) of liquid Propane. The signal is routed to the instrument panel. The fuel gauge driver utilizes the base vehicle "anti-sloshing" signal condition originally programmed for a gasoline fuel system. The In-Tank Gauge Driver is serviceable through the multivalve flange opening.

Multivalve Assembly

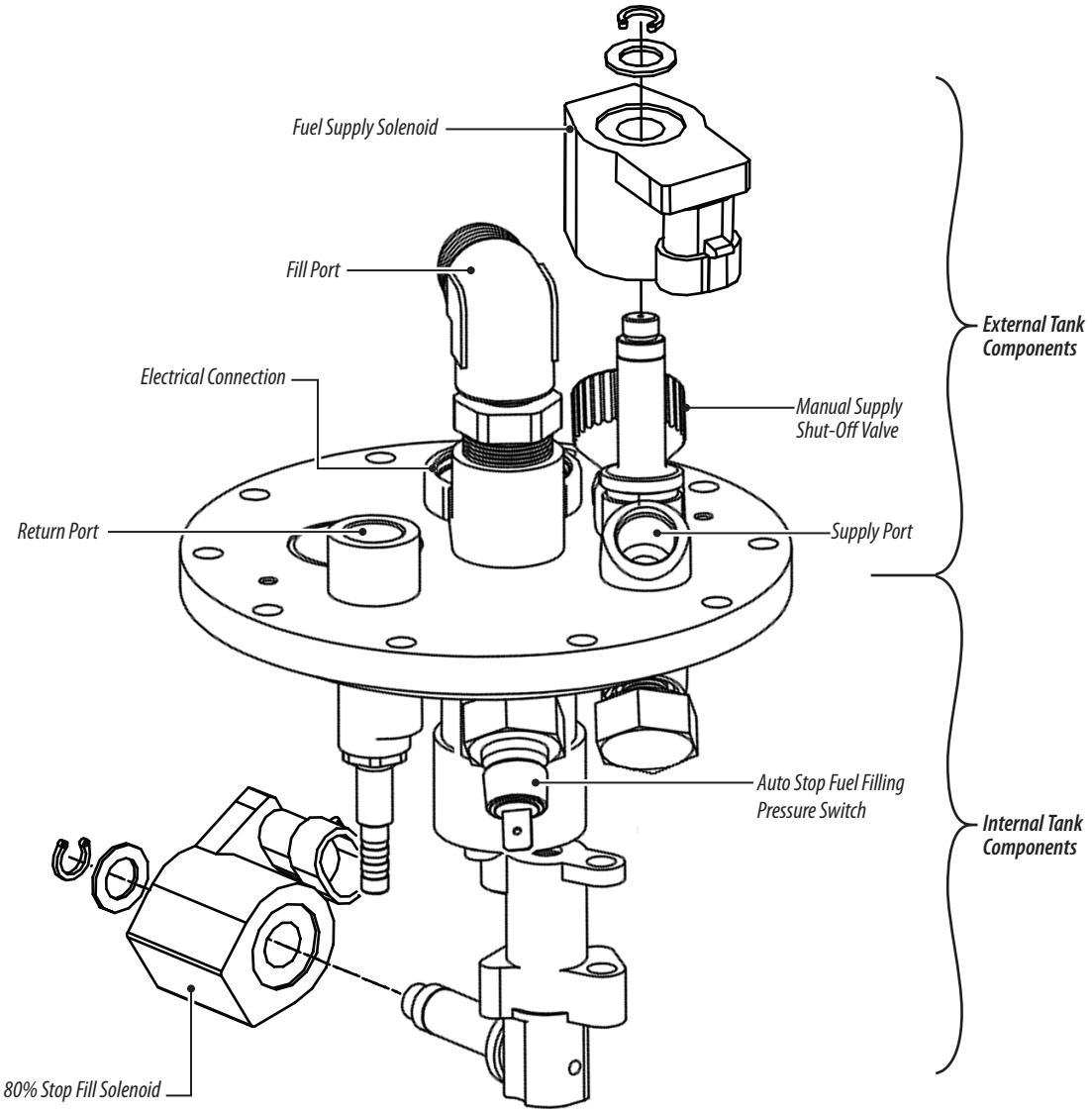
The LPI fuel system utilizes a unique Multivalve assembly that is flange mounted to the bottom area of the fuel tank. The valve assembly is attached to the tank with 10 fasteners and an o-ring seal that seals the valve to the flange. The Multivalve is a brass housing providing an integrated network of components mounted to the bottom and the top of the valve. The Multivalve assembly incorporates the following components:

Multivalve components, Bottom side (portion of the valve inside of the tank)

- An 80% Stop Fill Solenoid Valve Assembly
- An auto Stop fuel filling Pressure Switch
- A double back check fill valve assembly
- A double back check return valve assembly
- An wiring pass-through electrical connector

Multivalve components, Top side (portion of the valve outside of the tank)

- A Liquid Supply Solenoid valve assembly with electric and manual opening/ closing with excess flow protection.
- A fuel supply port
- A fuel return port
- A refueling port
- A wiring pass-through electrical connector



Multivalve Assembly

Refueling *(Automatic Stop Fill Cricuit)*

The 80% stop fill solenoid valve is an electrically actuated valve mounted to the bottom of Multivalve inside the fuel tank. The solenoid is a normally closed valve that prevents fuel flow through the fuel fill port (integrated into the Multivalve) when the solenoid is de-energized. When energized, the valve is equipped with a pressure differential sensor and will only open and allow propane to be pumped into the tank through the fill port if there is sufficient fueling station pump pressure, as described in more detail later in this section. As the tank reaches an 80% fill point by liquid volume, the solenoid valve will be de-energized, the valve will close and the fuel flow will be stopped. The 80% maximum capacity is to allow for the expansion of the liquid propane inside the fuel tank.

The 80% Stop Fill Solenoid is connected to a constant 12 volt positive signal. The solenoid will be energized or de-energized by switching the ground signal on and off. There are two requirements that must be satisfied before the solenoid receives a ground signal and allows fuel to be pumped into the fuel tank.

One of the requirements will be detected by the Auto stop fuel filling pressure switch. The switch is mounted to the bottom of the Multivalve and monitors the fuel fill port pressure during the refueling process. The sensor is a normally open switch and will close when it detects a differential pressure of 8.5 psi. The switch is connected to ground at it's mounting base and therefore provides a ground signal when closed. During the refueling process, liquid propane from the refueling station will be pumped into the fuel fill port (integrated in Multivalve). When the pressure switch detects a differential pressure of 8.5 psi between fuel tank pressure and the fill port pressure (created by the refueling station pump), the Auto Stop fuel filling Pressure Switch will close providing a ground signal to the Infra-Red 80% Liquid Level Sensor. This signal is one of the two requirements necessary to energize the 80% Stop Fill Solenoid and allow refueling of the fuel system.

The other requirement will be detected by the infra-red 80% liquid level sensor. The Sensor is mounted inside the fuel tank. The sensor monitors the liquid propane level in the fuel tank and is positioned to detect when the fuel reaches an 80% fill point by liquid volume. When the sensor detects a fuel level of 80% (wet sensor), it will open the electrical circuit to the 80% Stop Fill Solenoid. The solenoid will de-energized and remain closed preventing fuel flow into the fuel tank. When the sensor detects a fuel level below 80% (dry sensor) it will provide a ground to the Stop fill solenoid. The solenoid will open allowing the refueling process to take place. Keep in mind the 80% liquid level sensor receives its ground from the Auto Stop fuel filling Pressure Switch after its requirements has been satisfied.

The Auto Stop fuel filling Pressure Switch and the Infra-Red 80% Liquid Level Sensor are electrically connected in series to provide the stop fill solenoid with its ground signal.

Satisfying only one of the two requirements will not result in energizing the stop fill solenoid. It does not matter which of the two requirements are satisfied first, the fact is both requirements are necessary.

The Auto Stop fuel filling Pressure Switch must detect differential fill port pressure (created by refueling station pump) and send a ground to the Infra-red 80% liquid level sensor. The Infra-Red 80% Liquid Level Sensor must detect a liquid propane level in the fuel tank below 80% fill point. When these two requirements are satisfied, the 80% Stop Fill solenoid will be energize and the stop fill valve will open allowing the refueling process to take place. If one of the two requirements is not satisfied, the 80% Stop Fill Solenoid will be de-energized and the refueling process will be prevented.

Fuel Transfer Lines

The fuel transfer hoses utilized in the LPI fuel system are made of a unique material to provide long term protection and service. The hose end fittings may incorporate a swaged type fitting or a compression type fitting. The hoses are color coded to identify the supply, return and fill lines. Green fuel lines indicates supply from the pump to the fuel rail, black indicates return lines from the injectors back to the tank and blue indicates re-fuel lines. Fitting sizes are all metric, use the proper wrench size when removing and replacing the fittings or connectors.

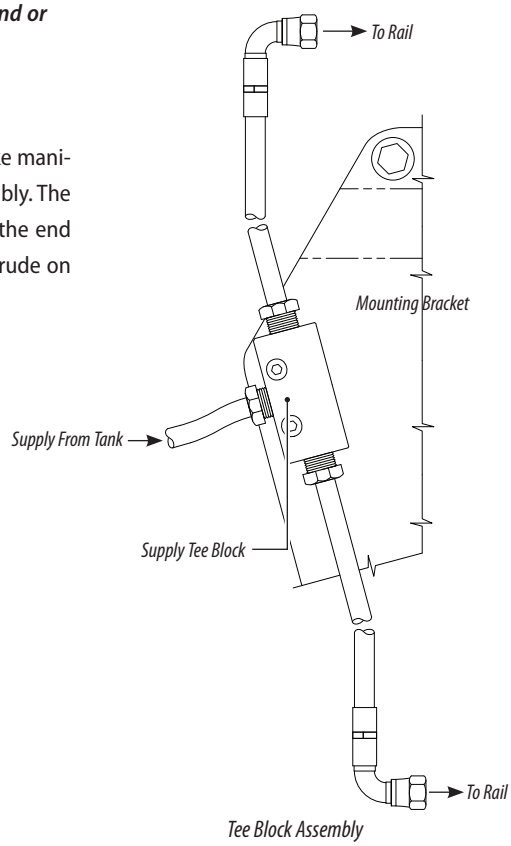
A special tool is required to properly install the compression fittings. This tool can be secured from Clean Fuels. Part No. 90700000 Compression Tool.

NOTE: When replacing hoses use hoses made of the same material, size and color. Some hoses contain an internal spring guard to prevent kinking and or collapsing. Always route and secure hoses as originally installed

Fuel Rail Tee Block Assembly

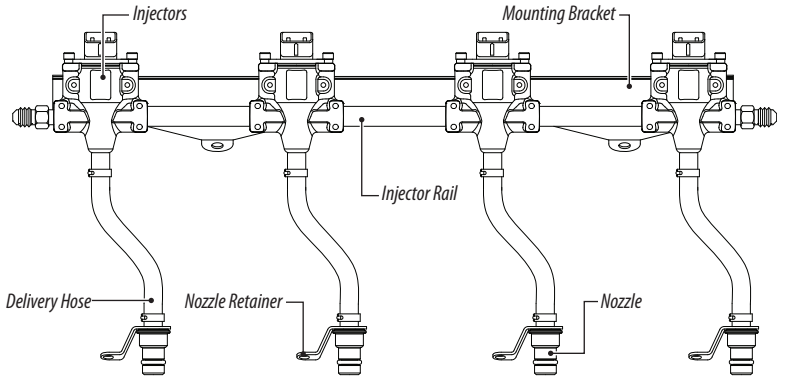
Fuel is delivered to each rail via the Tee block located at the rear of the intake manifold. The Tee assembly is used to distribute the fuel evenly to each rail assembly. The Green hose connectors are assembled using compression type fittings on the end and swaged 90º swivel fittings to allow for proper hose routing and not intrude on base vehicle parts.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***



Tee Block Assembly

Fuel Rail Assemblies



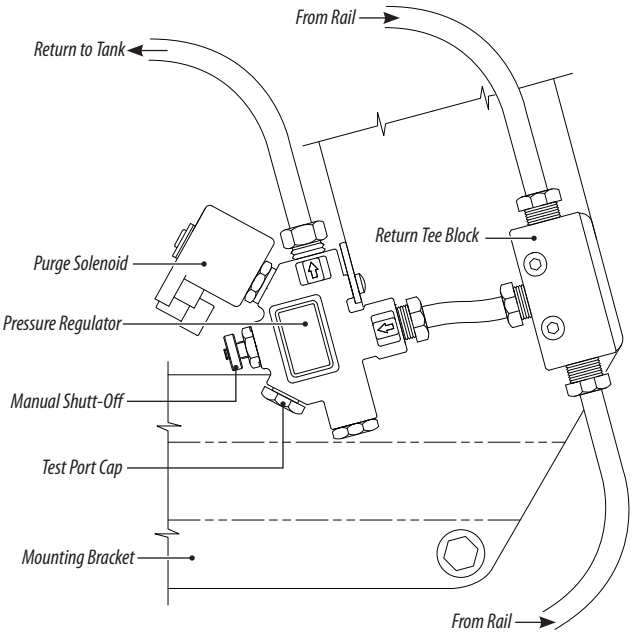
Injector Rail Assembly

Each fuel rail assembly is made up of four individual injectors fitted to the manifold by the means of a common mounting bracket. Each injector is mounted in a holder and each holder is connected via a brass tube connected with two securing pins at each holder The Fuel Rails are sealed to each holder with an o-ring. A flared fitting is installed at each end of the rail assembly to connect the fuel rails to the supply and return lines. The injector holder delivery hoses are fitted with a nozzle adapter and retainer. The nozzle is fitted to the manifold opening for each cylinder and is secured by the retainer to each manifold bolt.

The injectors are connected to the main harness with an Injector Harness assembly. Fuel delivery is accomplished the same as a gasoline injection system. A 12 volt power supply is delivered to each positive injector terminal and each individual injector negative terminal is connected to a pin at the engine PCM. Injectors are opened and closed by switching the ground internally in the PCM. Therefore fuel metering and fuel injection is controlled solely by the engines PCM. To diagnose electrical problems with the LPI fuel injectors refer to the Fuel Injector Diagnosis section of the GM Medium Duty Service Manual.

Fuel Pressure Regulator

The LPI fuel system pressure is regulated by an in-line pressure regulator mounted in the return line at the front of the engines intake manifold. Fuel is returned to the regulator via the Black return lines which are connected to a Tee block which is connected to the pressure regulator. The pressure regulator is preset at the factory and has been sealed to prevent infield alteration to the pressure setting. Fuel flow passing through the regulator has to overcome the flow resistance created by the regulator which increases fuel pressure. The regulator assembly is also fitted with a 12 volt purge solenoid which is opened during the purge cycle to allowing fuel to bypass the fuel pressure regulator valve during the purge cycle. The pressure regulator is also fitted with a test port which enables a test gauge to be installed to measure fuel system pressure.



Pressure Regulator Assembly

LPI Fuel Control Unit (FCU) and Electrical Harness

The Fuel Control Unit (FCU) is an electronic module that serves as a central control system for the LPI fuel system. The FCU controls the wait to start light, purge cycle and the automatic stop fill circuit. The FCU will interface with the engines electrical system and the buses electrical system. Although the FCU controls the fuel pump relay during the purge cycle thus providing fuel flow, the engine PCM provides the electrical signals to the injectors and therefore controls the fuel metering and injection of the liquid propane. The FCU provides control signals to the fuel supply solenoid, the purge solenoid, the fuel pump and purge cycle control systems.

The FCU is connected to the LPI system via the Main LPI Electrical harness. The LPI electrical harness also provides electrical interface between the LPI electrical system, the GM Vortec engine electrical system and the electrical system on the bus.

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Fuel System Pressure Release

During any fuel system maintenance or repair in which the fuel pressure must be released from the system use the following procedure.

WARNING ***LPG is under pressure, wear adequate eye protection. When LPG is discharged into the atmosphere the rapid change in pressure can cause a refrigerant condition in the fuel (quick cooling) and can harm your skin or cause serious burns much like frostbite, Always wear gloves.***

1. Close the manual supply valve on the multivalve (Turn Clockwise).See Multivalve Assembly.
2. Make sure the manual valve on the pressure regulator is fully closed.
3. Remove the test port cap located on the regulator. See Fuel Pressure Regulator.
4. Install the pressure test gauge tool with its manual valve closed and a drain hose attached (number CF-10001) to the test port on the pressure regulator.
5. Slowly open the manual valve on the pressure regulator.
6. Slowly open the manual valve on the pressure test gauge tool.
7. When the fuel flow stops at the discharge point on the drain hose the system pressure is released and you can safely work on the fuel supply/return lines, the injectors, the fuel pressure regulator or any associated external of the tank fuel system component. *DO NOTE REMOVE ANY PORTION OF THE MULTIVALVE OR ANY VALVE FROM THE TANK.* At this point all fuel pressure is isolated in the fuel tank.

WARNING ***When releasing the fuel pressure be sure to place the discharge point of the drain hose in a safe area free from any combustible material or ignition source. Be sure that no one is in the immediate area of the discharge hose.***

After fuel system service maintenance and/or repairs are complete, remove the pressure test gauge tool.

1. Close the manual valve on the pressure test gauge tool.
2. Close the manual valve on the pressure regulator.
3. Remove the test tool from the regulator.
4. Reinstall the test port cap and tighten.
5. Open the manual supply valve at the tank (Turn Counterclockwise).
6. Purge the fuel system *(Do Not Start the Engine)* Refer to Fuel System Purge Procedure below and repeat the procedure several times to fully purge the air out of the system.
7. Leak check the test port cap and all other connections loosened during the service procedure with an approved leak detection soap solution or electronic leak detector.

Fuel System Purge Procedure

After performing a Fuel System Pressure Release, air may enter the system through the open connections and/or ports. You will need to purge the fuel system a minimum of 3 purge cycles to expel all the air from the fuel rails and fuel lines. To purge the fuel system turn the ignition key to the Key On Engine Off (KOEO) position the wait-to-start light will illuminate for approximately 20 seconds (first stage of the purge cycle). See Fuel System Description and Operation at the beginning of this chapter for detailed operation of the purge cycle.

1. Make sure the battery is connected.
2. Check to make sure there is fuel in the tank.
3. Turn the key to the KOEO position.
4. Wait for the wait-to-start-light to go out.
5. Turn the key off and repeat steps 3 and 4 two additional times.
6. Turn the key back on (forth time), when the wait to start light goes out, start the engine; if the engine fails to start refer to the Fuel System Pressure Check procedure in this manual.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

Fuel Tank Draining and Evacuation Procedure

The fuel tank on an LPI fuel system utilizes an electric fuel pump to deliver fuel to the injector fuel rails during normal operations. If you are removing the tank, service the Multivalve or to service in-tank components you must follow the procedures listed below.

WARNING ***Draining the LPI tank should be performed by a trained technician only. When draining a fuel tank use all the following precautions to prevent serious bodily injury, death and/or property damage.***

- ***Wear protective eye wear, gloves and clothing***
- ***Perform the process in a well ventilated area only***
- ***Remove all potential ignition sources from the area***
- ***Use only the recommended processes***
- ***Use the required tools***
- ***Drain the tank on the vehicle into a tank of equivalent or larger capacity***

Using In-Tank Pump

Use of the in-tank pump to drain the tank is an acceptable method, however, most of the components in the fuel tank must be functioning in their normal operation, specifically the pump. *NOTE: This method will not completely drain the tank and a final process of venting the tank will still be required. In some areas it is not allowed or may not be safe to vent the fuel to the atmosphere. In this case, the fuel must be burned off.*

1. Move the vehicle to a well ventilated area free of any external ignition sources.
2. Place the tank in which the fuel is to be captured close to the tank to be drained.
3. Remove the pressure in the fuel system using the Fuel System Pressure Release process.
4. Remove the green fuel supply line from the supply port at the supply solenoid on the multivalve.
5. Connect the fuel transfer hose to the supply port on the Multivalve using tool number CF-10002-LPI.
6. Connect the other end of the fuel transfer hose to the receiving tank fill valve or appropriate valve.
7. Remove the fuel pump relay and connect a switch/jumper harness assembly with the switch in the off position between terminals 30 and 87.
8. Open the manual supply valve on the tank to be drained and the valve on the capture tank.
9. Turn the switch on the jumper harness to the ON position, you should here the pump in the fuel tank running and fuel will begin to transfer to the capture fuel tank.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

10. When the liquid propane level in the fuel tank drops below the fuel pumps pickup tube the pump will make a different sound. Turn the switch off to stop the pump.
11. The remaining fuel in the tank will now need to be evacuated through the liquid supply valve. In order to accomplish this, the electrical portion of the liquid supply valve will require disassembly.
12. Close the supply valve on the Multivalve and the supply valve on the capture tank.
13. Loosen the fuel transfer hose and bleed off the fuel pressure.

WARNING ***Fuel may be under pressure in the transfer line; use caution when disconnecting the fittings, slowly loosen the fittings and use gloves and protective eye wear.***

14. Disconnect the transfer hose from the receiving tank and place the other end of the transfer hose in a safe, well ventilated location away from any area where the fuel could create a volatile condition.
15. Remove the liquid supply valve solenoid, remove the valve stem tower, remove the plunger and spring and re-install the valve stem tower. This allows the liquid supply valve to be controlled manually during servicing/ evacuating the fuel tank.
16. Make sure the fuel line at the multivalve is tight.
17. Slowly open the liquid supply valve and allow the tank to vent until the pressure has been released completely from the tank. It may be required to set up a flare stand to burn off the remaining fuel in the tank. This would require approximately a 50 foot clearance from the vehicle, other vehicles, a building or any combustible materials. Slowly open the valve on the flare stand and light the escaping gas; open the valve little by little to increase the time to evacuate. Most liquid supply valves are rated to pass 2.3 to 3.3 gallons per minute before the excess flow rating is exceeded and could close. If the excess flow closes during this operation simply close the liquid supply valve and re-open it slowly.

CAUTION ***Some states and municipalities may have regulations preventing the release of LPG into the atmosphere. Check with your local fire marshal or your local LPG supplier prior to venting or burning off a tank.***

18. When the pressure in the tank has reduced to a point that it does not support the flame turn the liquid supply valve off and disconnect the hoses. Open the liquid supply valve and vent the remaining pressure to the atmosphere.

WARNING ***Do not have any sources of ignition within a minimum of 50 foot of the area.***

19. Do not close the liquid supply valve after the pressure is completely released because pressure will build up in a closed tank even if the tank is empty. The pressure that would build up if the valve was closed would affect removing of any tank valve or component.
20. After service of the tank is complete and all components are replaced/re-installed replace the plunger and spring back into the liquid service valve stem tower and replace the solenoid.

NOTE: If you have any questions or concerns or you feel unqualified to perform the process of venting the tank contact you local fuel system provider or Clean Fuels USA at (877)-234-1722.

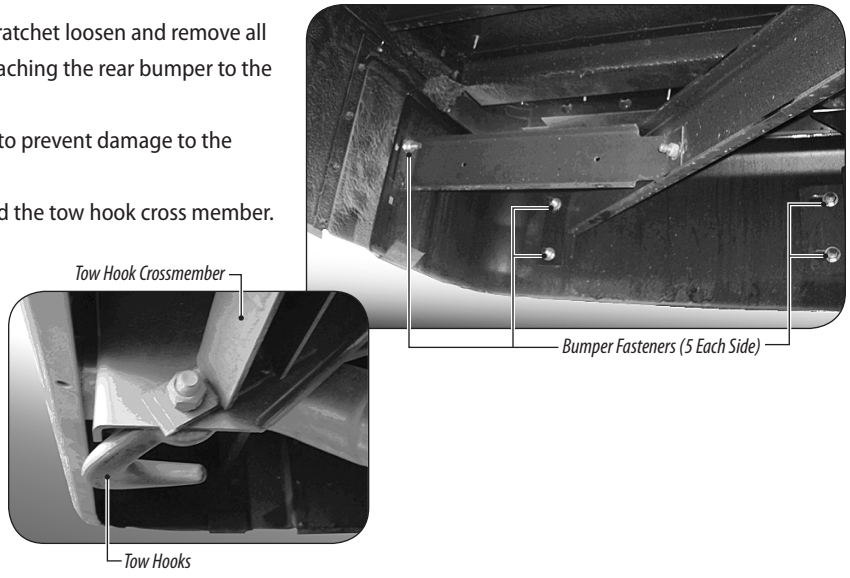
Fuel Tank Removal And Replacement

The cylindrical tank assembly for the LPI fuel system is mounted in the rear overhang between the frame rails parallel to the vehicle frame.

WARNING ***LPG Propane Gas is flammable. DO NOT vent propane in an enclosed area, or close to service pits, drainage ditches or low lying areas. DO NOT vent propane within 25 feet of any source of ignition, spark, open flame or heat. When venting propane liquid, it will vaporize at a very cold temperature (-44 F). Always wear safety goggles and gloves when handling systems venting gas. Always perform a complete system leak test after completing any service or maintenance.***

Removal

1. Be fully aware of the local regulations, NFPA codes and safety requirements for handling propane fuel prior to working on this unit.
2. Drain LPI fuel tank and purge of vapor in accordance with service manual safety instructions and warnings. See **Fuel Tank Draining & Evacuation Procedure**.
3. Leave supply valve, and 80% bleeder valve open for safety.
4. Carefully loosen the pressurized black and green lines located on the top front portion of the tank. Once the propane has been drained remove both lines. See **Propane Fuel System GM 8.1L**.
5. Remove black bleed hose from back of bleed valve on fuel filler assembly.
6. Remove the blue fill hose from back of the fill valve on the fuel filler assembly.
7. Using a wrench and/or socket ratchet loosen and remove all nuts and carriage fasteners attaching the rear bumper to the vehicle.
8. Carefully remove rear bumper to prevent damage to the vehicle.
9. Remove the rear tow hooks and the tow hook cross member.



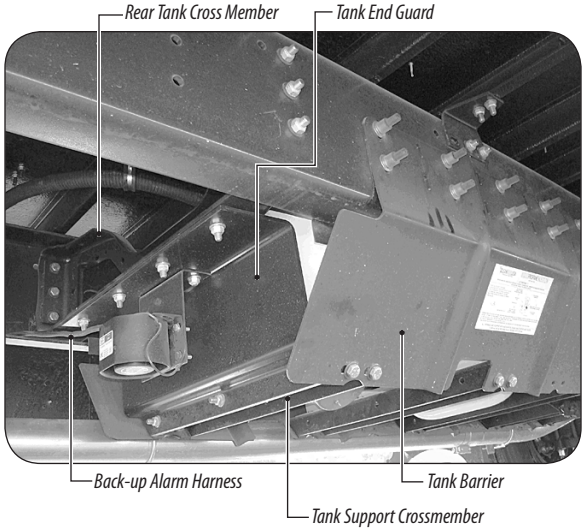
10. Detach back up alarm harness from vehicle frame and ensure it is safely out of the way.
11. Remove six fasteners attaching the rear tank cross member to the frame.
12. Remove four fasteners attaching the rear tank cross member to the tank end guard.
13. Remove three fasteners attaching the tank end guard to the tank support crossmember. Remove the tank end guard and rear tank cross member.
14. Unplug the tanks flat 6 pin connector from the vehicle harness located at the bottom center of the tank assembly. Cut any nylon ties that will prevent easy removal.
15. Remove 16 fasteners attaching the tank to the tank support cross members.
16. Remove every other nut and bolt attaching the tank support cross members to the right and left hand tank barriers.
17. Loosen but DO NOT remove remaining nuts and fasteners.
18. Using suitable lifting device (hydraulic table, transmission jack, etc) lift tank from tank support cross members approximately 1". *(Note: using 4x4 wooden blocks makes this much easier.)*

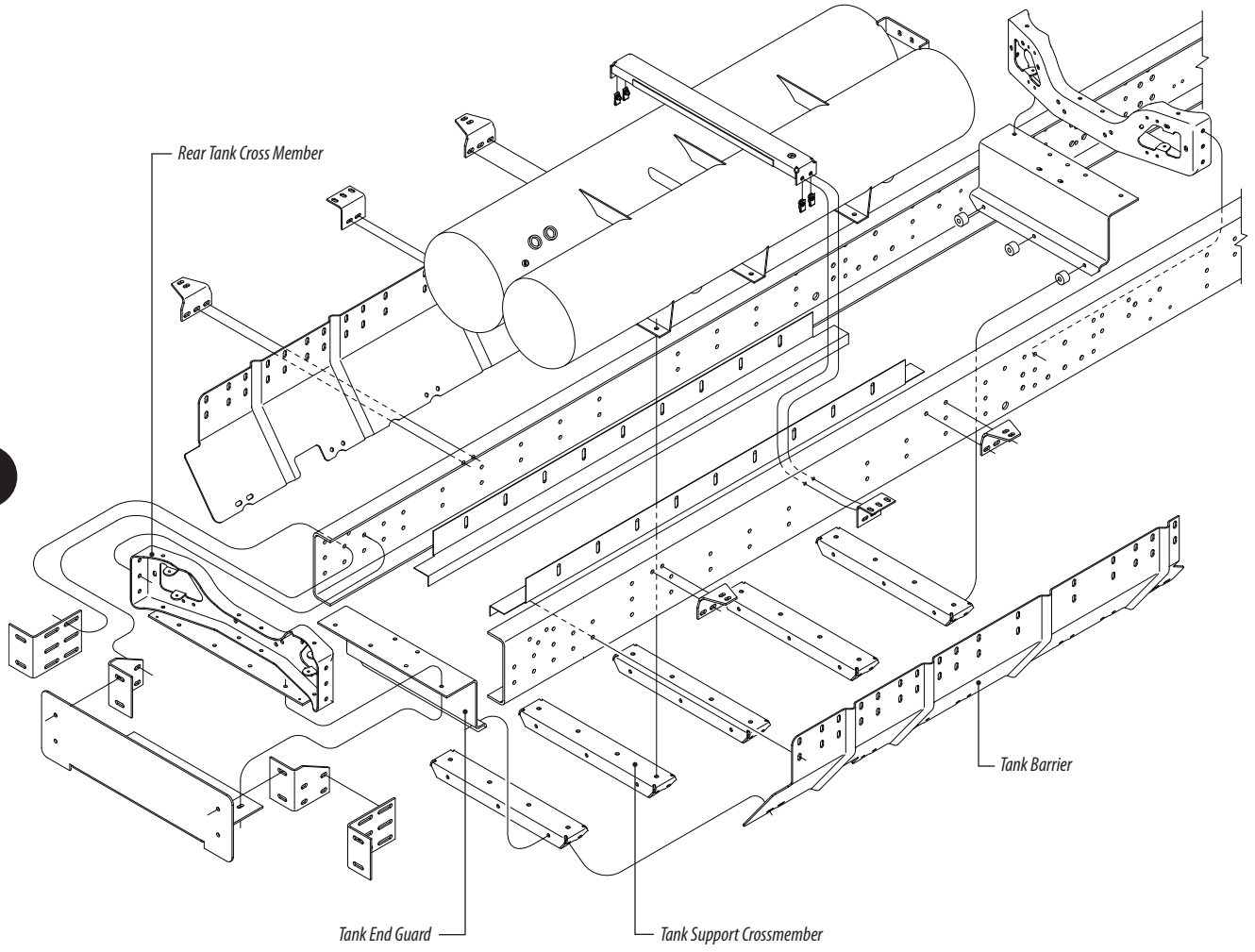
WARNING ***Ensure tank is securely fastened to lifting device to prevent accidental dropping.***

19. When tank is fully supported and stable on the lifting device, remove the four tank support cross members toward the rear of the vehicle. The forward most bracket doesn't need to be removed for this operation.
20. Center tank in the vehicle frame and roll lifting device toward rear of vehicle. Ensure the tank remains stable and centered as the lifting device is rolled rearward. Carefully feed the fill and bleed hoses over top of vehicle chassis into the middle of the chassis frame.

Replacement

Reverse the above procedure.





Fuel Tank & Barrier

Multivalve Removal and Replacement

CAUTION ***Be sure the tank has been completely drained before removing the multivalve from the tank. See Fuel Tank Draining Procedures.***

Service the tank or Multivalve in a well ventilated area and insure the tank is in a stable position prior to removing the Multivalve.

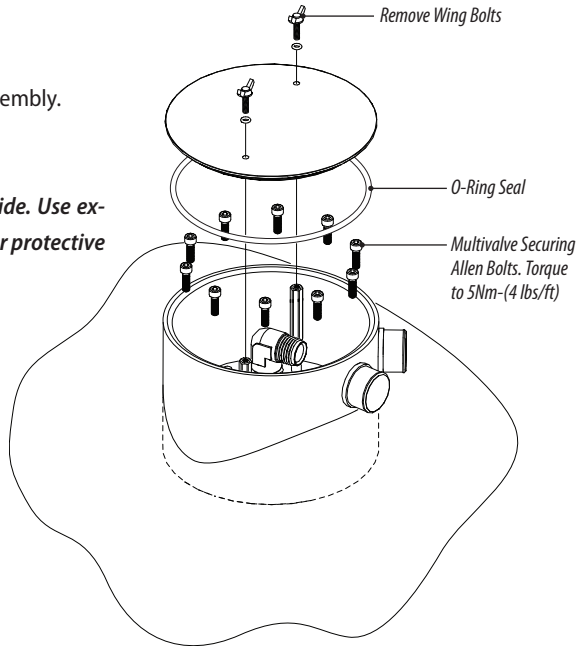
Removal

1. Disconnect the battery.
2. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
3. Disconnect the fuel supply line from the supply port at the Multivalve and move the line so it clears the fuel flange.
4. Disconnect the fuel fill line from the fill port at the Multivalve and move the line so it clears the fuel tank flange.
5. Disconnect the return line from the Multivalve and move the line so it clears the fuel tank flange.
6. Disconnect the LPI electrical harness connector, located at the bottom center of the fuel tanks and route the harness through the protective loom as far as possible.
7. Remove the ten (10) securing bolts from the Multivalve.
8. Lift the Multivalve from the tank. There will be several connections between in-tank components and the Multivalve restricting the distance the valve can be moved from the tank.
9. Feed as much of the LPI electrical harness back toward the Multivalve as possible, this will allow the Multivalve to clear the tank flange.
10. Disconnect the electrical connector at the pressure switch.
11. Disconnect the electrical connector at the 80% stop fill solenoid.
12. Disconnect the 80% liquid level sensor harness.
13. Disconnect the electrical connector for the rheostat and float assembly.
14. Disconnect the fuel pump supply hose from the Multivalve.

CAUTION ***The fuel pump hose will have liquid fuel trapped inside. Use extreme caution. Disconnect slowly allowing the pressure to exit. Wear protective gloves.***

15. Disconnect the electrical connector at the fuel pump.
16. Disconnect the fuel return line.
17. Remove the Multivalve.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***



Replacement

1. Using a light weight petroleum jelly or o-ring lube, lightly lubricate a new o-ring on the Multivalve.
2. Place the Multivalve near the tank opening.
3. Connect the electrical circuit to the 80% stop fill solenoid.
4. Connect the electrical connector to the pressure switch.
5. Reconnect the fuel pump hose to the Multivalve.
6. Position the Multivalve to the tank.
7. Install the ten (10) fasteners and tighten to specification; 5.0 Nm – (4 lbs ft).

80% Stop Fill Valve Service

Refer to Multivalve Assembly Diagram

Removal (Solenoid Only)

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Unplug the electrical connector.
4. Remove the Solenoid retaining nut.
5. Remove the Solenoid from the valve assembly stem.

Replacement (Solenoid Only)

1. Install the Solenoid to the valve assembly stem.
2. Install the nut and tighten until the nut is snug.
3. Connect the electrical connector, push the connector until it clicks, then pull on the connector to make sure it is locked. *NOTE: Solenoid will not be tight on the stem and is allowed to rotate freely.*
4. Reinstall the multivalve.

Removal (Valve Stem Only)

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Remove the solenoid retaining nut.
4. Remove the solenoid from the Valve Assembly Stem.
5. Remove the stem, valve spring and piston assembly.

Replacement (Valve Stem Only)

1. Lubricate the o-ring on the valve stem with a petroleum jelly.
2. Insert the piston into the 80% valve housing.
3. Insert the spring into the piston.
4. Insert the Valve Stem into the valve housing and tighten until snug.
5. Install the solenoid.
6. Install the solenoid retaining nut and tighten until snug.
7. Reinstall the multivalve.

Removal (Valve Assembly)

1. Remove the multivalve assembly from the tank refer to Multivalve Removal.
2. Remove the solenoid retaining nut.
3. Remove the solenoid from the Valve Assembly stem.
4. Remove the Stop Fill Valve Assembly retaining screw.
5. Remove the valve assembly, spring and piston from the multivalve.

Replacement (Valve Assembly)

1. Install the piston into the multivalve.
2. Install the spring into the piston.
3. Install the Valve Assembly to the multivalve and secure with the retaining screws, tighten until the screws are snug.
4. Install the solenoid.
5. Install the solenoid retaining nut and tighten until snug.
6. Reinstall the multivalve.

Fill Pressure Switch Replacement

Refer to Multivale Assembly Diagram.

Removal

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Remove the Pressure Sensor from the multivalve.
4. Disconnect the wire from the end of the sensor.

Replacement

1. Carefully install the sensor into the multivalve. *NOTE: Use caution when installing the pressure sensor as the threaded portion of the body is a plastic insert and can be damaged from cross threading or over tightening.*
2. Carefully tighten the sensor into the housing. Refer to pressure sensor replacement.
3. Reinstall the multivalve.

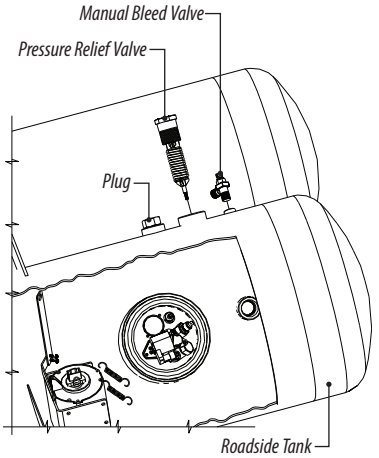
Fuel Pressure Relief Valve Replacement

Removal

1. Drain the fuel pressure, refer to Drain The Fuel Tank procedures.
2. Disconnect the Fuel Pressure Relief Valve hose.
3. Remove the Fuel Pressure Relief Valve.

Replacement

1. Install the Fuel Pressure Relief Valve into the threaded coupling and tighten. Use a pipe thread sealant suitable for liquid propane usage.
2. Reconnect the Fuel Pressure Relief Valve hose.



Fuel Return Line Valve Replacement

CAUTION ***Be sure the tank has been completely drained before removing the return line manual shut off valve from the tank.***

Removal (Return Valve Only)

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the Multivalve, refer to Multivalve removal procedure.
3. Remove the return hose from the return valve housings barb fitting.
4. Remove the return valve hose.
5. The return valve is a double back-check valve for redundancy & only one piston uses a spring, see photo insert.

Replacement (Return Valve Only)

1. Lubricate the valve seat with petroleum jelly.
2. Install the valve assembly and tighten until snug.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

Manual Shut Off Valve Replacement

CAUTION ***Be sure the tank has been completely drained before removing the manual shut off valve from the tank.***

Removal

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the Manual Valve from the multivalve.

Replacement

1. Lubricate the valve seat with petroleum jelly.
2. Install the Manual Valve assembly and tighten until snug.

Multivalve Supply Flow Check Valve Replacement

Removal (Check Valve)

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Disconnect the fuel pump supply hose.
4. Remove the hose nipple from the multivalve adapter.
5. Remove the orifice, Check Valve and spring.
6. Remove the multivalve adapter and o-ring from the multivalve.

Replacement (Check Valve)

1. Lubricate the adapter o-ring and install to the adapter. Use lubricant approved for use with propane.
2. Install the adapter to the multivalve and tighten until snug.
3. Install the spring, Check Valve and orifice.
4. Install the nipple fitting to the adapter and tighten until snug.
5. Reconnect the fuel pump supply hose.
6. Reinstall the multivalve.

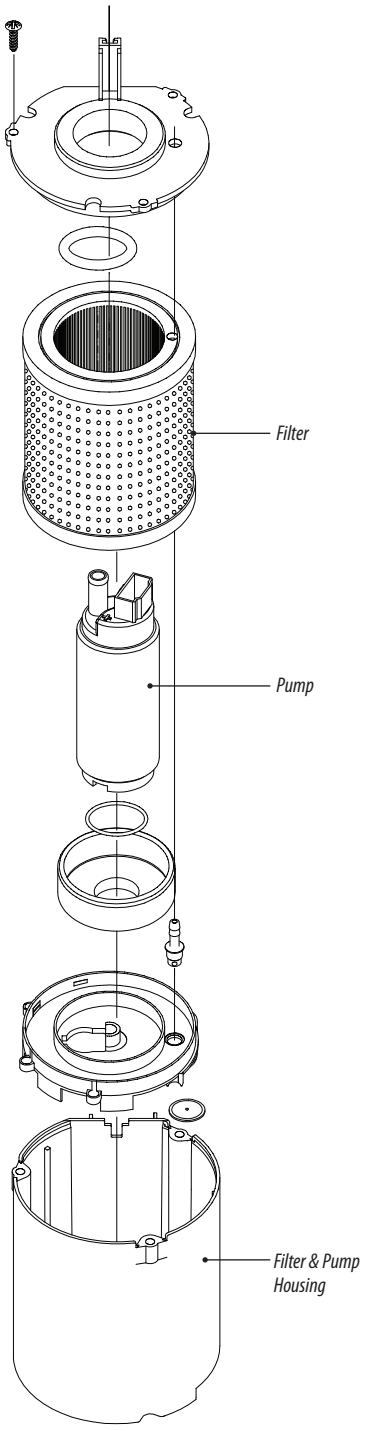
Fuel Pump/Filter Replacement *(In-Tank)*

Removal

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Reach into the tank and disconnect the Fuel Pump electrical connector.
4. Release the top spring retaining the Fuel Pump and holder.
5. Lift the plastic pump and holder from the tank.
6. Remove the three screws that hold the pump cover in place.
7. Slide the pump and filter assembly out of the plastic cup .
8. Remove the black plastic return tube from the brass nozzle on the bottom fuel pump plate.
9. Slide the filter off of the plastic return tube.

Replacement

1. Insert the black plastic tube through the hole in the new fuel filter and attach the tubing to the brass nozzle, if replacing the pump remove the black plastic spacer and ring from the intake port of the old fuel pump and place it on the intake port of the new pump. Install the new pump into a new filter.
2. Insert the filter and pump into the plastic pump holder and reinstall the three screws into the pump cover.
3. Install the Fuel Pump and holder into the tank in the pump mounting bracket.
4. Secure the pump holder using the spring.
5. Connect the fuel pump electrical connector.
6. Reinstall the multivalve.

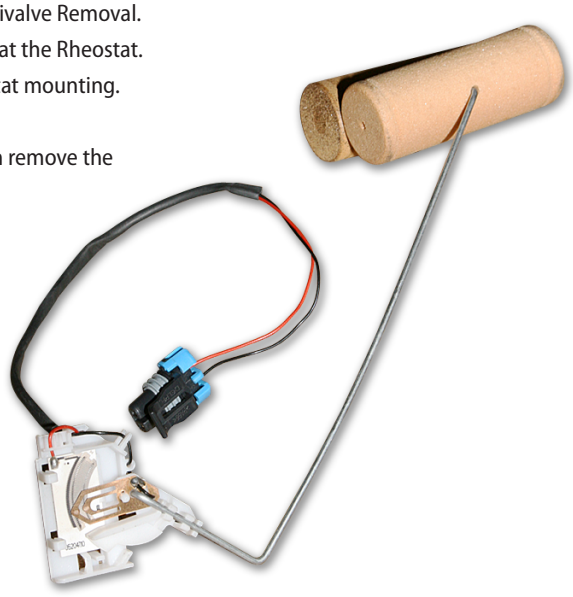


Fuel Punmp and Filter

Rheostat Replacement *(In-Tank)*

Removal

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Reach into the tank and disconnect the electrical connector at the Rheostat.
4. Remove the two (2) retaining nuts from the float and Rheostat mounting. bracket.
5. Remove the 80% sensor from the (2) retaining nuts and then remove the loat assembly and Rheostat.
6. Remove the plastic rheostat cover from the Rheostat.



Rheostat and Float Assembly

Replacement

1. Install the rheostat cover onto the new Reostat and bracket.
2. Install the new Rheostat onto the two mounting studs.
3. Install the float assembly onto the two mounting studs, reinstall the 80% sensor and and secure using the two (2) nuts.
4. Tighten nuts until snug.
5. Connect the Rheostat electrical connector.
6. Reinstall the multivalve.

Float Assembly Replacement *(In-Tank)*

Removal

1. Drain the fuel tank, refer to Fuel Tank Draining Procedure.
2. Remove the multivalve assembly from the tank refer to Multivalve Removal.
3. Reach into the tank and disconnect the Float Assembly electrical connector.
4. Remove the two (2) retaining nuts from the float and rheostat mounting bracket.
5. Remove the 80% sensor from the (2) retaining nuts and then remove the Float assembly.

Replacement

1. Install the Float assembly onto the two mounting stud then install the 80% sensor and secure using the two (2) nuts.
2. Tighten nuts until snug.
3. Connect the Float assembly electrical connector.
4. Reinstall the multivalve.

Remote Mounted Fuel Fill Valve Replacement

The LPI fuel system on this vehicle utilizes a remote mounted fill valve location. The fill valve is located on the curb side of the vehicle and is attached by a fuel fill hose to the multivalve. The following procedure must be done outside and 50 feet away from any source of ignition.

Removal

1. Disconnect the battery.
2. Drain the fill line by carefully loosing the blue fill hose that is connected to the back side of the filler Valve. Allow all of the LP to drain out before removing the blue filler hose from the fill valve.
3. Locate the remote mounted Fill valve.
4. Remove the Fill Valve from the remote mounted fixture.

Replacement

1. Install the Fill Valve to remote mounted fixture, install the large nut and lock washer. Tighten the nut and lock washer.
2. Reattach the blue filler hose to the rear of the fill valve and tighten.
3. Reconnect the battery. Fill tank and leak check the fitting using an approved leak detection soap solution or a electronic leak detector.

Remote Fuel Fill Line Replacement

This vehicle utilizes a remote fill device mounted in the curbside side panel. The fill valve will be mounted to a bracket and a fuel line will be connected from the fill valve to the tank multivalve. To replace the remote line use the following steps.

Removal

1. Disconnect the battery.
2. Remove any securing clamps or devices.
3. Slowly loosen the hose at the fill and drain the fill line. The tank fill valve is a double back check valve and only allows fuel flow in one direction. This allows the blue fill hose to be bleed without allowing any fuel from the tank to escape. It may take a minute or two to drain this hose.
4. Loosen the fill line at the Multivalve connector and remove the line.

Replacement

1. Install the remote fill line at the Multivalve and tighten until fully sealed. *NOTE: No sealant required on flare or compression fittings, ONLY on pipe threads where applicable.*
2. Connect the line at the fill valve and tighten until fully sealed.
3. Connect the fill valve to a fuel source and charge the line.
4. Leak check all fittings.
5. Secure the fuel line using the originally installed clamps.

Fuel Supply And Return Line Replacement

The fuel supply and return lines are made of special material and should only be replaced or repaired using original equipment parts. The fuel line can be removed using the following procedure.

Removal (Fuel Line)

1. Remove any securing clamps or ties from the hose(deletion).
2. Release the pressure in the system by using the Fuel System Pressure Release procedure.
3. Slowly loosen the fittings at each end of the hose.

WARNING ***LPG is under pressure, wear adequate eye protection. When LPG is discharged into the atmosphere the rapid change in pressure can cause a refrigerant condition in the fuel and can harm your skin or cause serious burns, always wear gloves.***

4. Remove the hose to be repaired.

Replacement (Fuel Line)

1. Reinstall the hose.
2. Tighten the hose ends until fully seated and tight.

Compression Fitting Replacement

Certain hoses are made with a fixed swaged hose connector at one end and a compression fitting at the opposite end. The compression fitting can be repaired or replaced using the following procedure. *NOTE: Certain hoses are installed with a spring guard to prevent kinking and collapsing of the hose. If you shorten the hose you may need to retain the spring guard and reinstall after shortening the hose.*

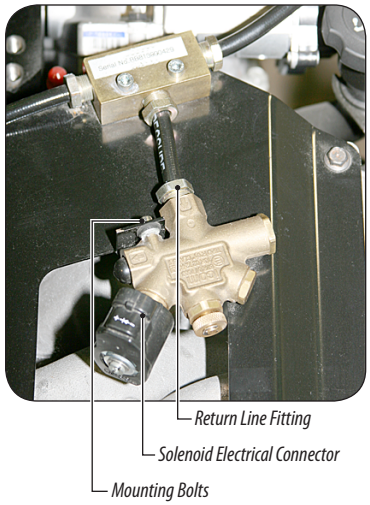
1. Using a hose cutting tool cut the hose end from the hose.
2. Discard the hose end.
3. Slide the compression nut onto the hose.
4. Slide the new Collet onto the hose. *NOTE: Make sure the long tapered edge is facing the nut.*
5. Install the Farrell onto the end of the hose until it is fully seated.
6. Slide the Collet down to the Farrell. Install the Compression tool over the hose so that the recessed edge of the clamping tool is against the tapered edge of the Collet.
7. Place the coned shaped end of the compressing screw into the end of the Farrell.
8. Start turning the Tee handle until the Collet is seated against the edge of the Farrell.
9. Remove the tool.
10. Reinstall the hose, refer to Fuel Supply and Return Line Replacement.

WARNING ***Technicians working with, or around, fuel systems should be properly trained to utilize extreme care and caution at all times. Failure to exercise extreme caution and care may lead to serious accidents which can result in property damage, personal injury and/or death.***

Fuel Pressure Regulator Replacement

When replacing the fuel pressure regulator use the following procedure.

Fuel Pressure Regulator



Removal

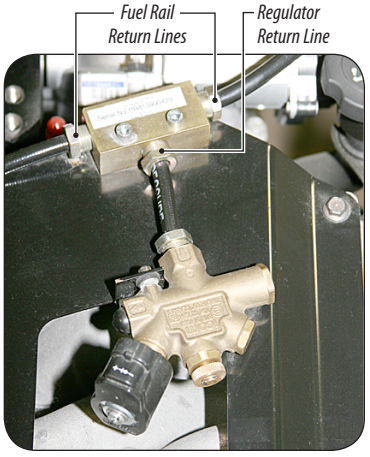
1. Close the manual supply valve at the multivalve.
2. Relieve the pressure in the system, refer to Fuel System Pressure Release.
3. Disconnect the purge solenoid electrical connector.
4. Disconnect the return line at the regulator fitting.
5. Loosen the return line hose from the Tee block to the regulator at the regulator.
6. Remove the two (2) regulator mounting bolts and retain.
7. Remove the one (1) regulator return line fitting and retain.

Replacement

1. Install in the new regulator and tighten until fully seated.
2. Install the regulator to the mounting bracket using the two (2) previously removed mounting screws.
3. Tighten fasteners until fully tight.
4. Install the return line hose from the Tee block to the regulator and tighten the nut until fully seated.
5. Connect the Return line to the regulator return line fitting and tighten until fully seated.
6. Connect the Purge Solenoid electrical connector. *NOTE: Push until you hear a click then pull to insure the connector is locked.*
7. Open the supply manual valve at the Multivalve until they are fully open.
8. Purge the fuel system by turning the key to the KOEO position and wait until the light in the dash goes out.
9. Repeat the purge process several times.
10. Leak check all fuel fittings using an approve leak detection soap solution or an electronic leak detector.

Injector Return Line Tee Block Replacement

When replacing the Injector Return Line Tee Block use the following procedure.



Return Tee Block

Removal

1. Close the manual supply valve at the multivalve.
2. Relieve the pressure in the system, refer to Fuel System Pressure Release.
3. Disconnect both the fuel rail return lines from the Tee block.
4. Loosen the return line hose from the Tee block to the regulator at the Tee block.
5. Remove the two (2) Injector Return Line Tee Block retaining bolts and nuts and retain.
6. Remove the Injector Return Line Tee Block.

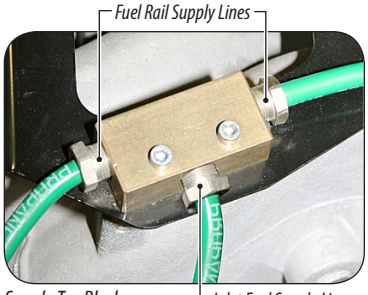
Replacement

NOTE: Do not use liquid pipe sealant on the compression fitting connections. Always check the compression fittings for damage before reinstalling.

1. Install the new Injector Return Line Tee Block to the bracket secure it using the two (2) retaining bolts and nuts.
2. Tighten until fully secured.
3. Install the return line hose from the Tee block to the regulator at the Tee block and tighten until fully seated.
4. Install both the fuel rail return lines to the Tee block tighten until fully seated.
5. Open the manual supply valve at the multivalve until they are fully open.
6. Purge the fuel system by turning the key to the KOEO position and wait until the light "Wait to Start" light on the dash goes out.
7. Repeat the purge process several times.
8. Leak check all fuel fittings using an approved leak detection soap solution or a electronic leak detector.

Fuel Supply Tee Block Replacement

When replacing the Forward Fuel Supply Tee Block use the following procedure.



Removal

1. Close the manual supply valve at the multivalve.
2. Relieve the pressure in the system, refer to Fuel System Pressure Release.
3. Disconnect both the fuel rail supply lines from the Tee block and cap both fittings.
4. Disconnect the inlet fuel supply line from the Tee block.
5. Remove the inlet fuel supply fitting from the Tee block.
6. Remove the two (2) Tee Block retaining bolts and nuts and retain.
7. Remove the Tee Block.

Replacement

NOTE: Do not use liquid pipe sealant on the compression fitting connections. Always check the compression fittings for damage before reinstalling.

1. Install the new Tee Block to the bracket secure the tee using the two (2) bolts and nuts.
2. Install the fitting into the Tee block and tighten until fully seated.
3. Connect the fuel supply line to the inlet fitting and tighten until fully seated.
4. Install both the fuel rail supply lines to the Tee block and tighten until fully seated.
5. Open the manual supply valve at the multivalve until they are fully open.
6. Purge the fuel system by turning the key to the KOEO position and wait until the "Wait to Start" light on the dash goes out.
7. Repeat the purge process several times.
8. Leak check all fuel fittings using an approved leak detection soap solution or a electronic leak detector.

Fuel Rail Replacement

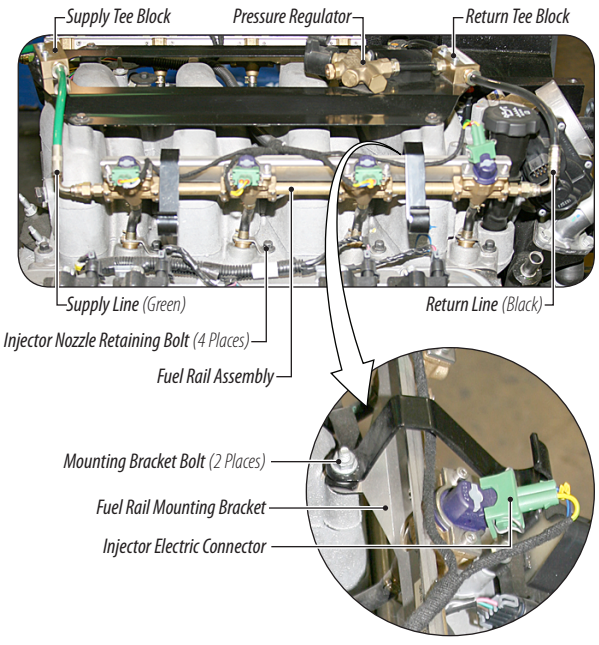
CAUTION ***When removing or replacing any fuel delivery components which include: Fuel Rails, Injectors, or Supply Lines, thoroughly clean the work area with solvents and compressed air to remove any debris or contaminants. Always insure your hands are clean when handling fuel injection components to prevent contaminating the fuel delivery systems.***

CAUTION ***Contamination may cause the injectors to stick, leak, or become damaged, delivering incorrect amounts of fuel and causing the fuel control system to be non-compliant. NOTE: Always cap any open ports after disconnecting fuel lines, removing injectors or the fuel rails to prevent contamination of the fuel delivery system.***

When removing the fuel rails use the following procedure.

Removal

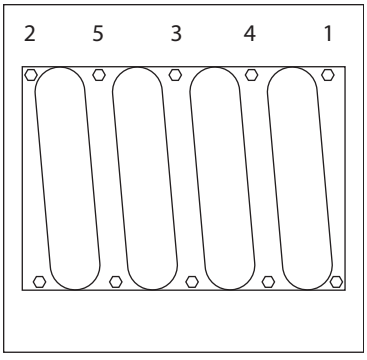
1. Close the manual supply valve at the multivalve.
2. Relieve the pressure in the system, refer to Fuel System Pressure Release. Using shop air carefully blow away any debris around the area where the injector nozzles are bolted into the intake manifold.
3. Disconnect both the fuel rail supply line and return line from the fuel rail fittings and cap both the fittings and the hose ends. *NOTE: Use a backup wrench on the fuel rail fitting when disconnecting the fuel supply and return line connections.*
4. Tag each injector connector to insure that the correct connector is re-installed properly.
5. Disconnect each of the injector electrical connectors.
6. Remove the two (2) fuel injector bracket retaining bolts at the manifold and retain.
7. Remove the four (4) fuel injector nozzle retaining bolts (Manifold Bolts) and retain.
8. Lift the Fuel Rail from the intake manifold and cap all nozzles and place protective covering over each of the open manifold holes.



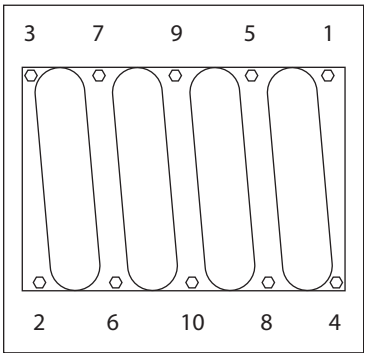
Curbside Fuel Rail

Replacement

1. Using a petroleum jelly or an o-ring lube lightly coat each nozzle o-ring.
2. Place the Fuel Rail assembly onto the intake manifold.
3. Starting at the rear remove the nozzle cap and the manifold plug and install the nozzle into the hole.
4. Rotate the nozzle retainer over the manifold bolt hole and install a manifold retaining bolt hand tighten the bolt.
5. Continue to install the balance of the nozzles into the manifold.
6. Tighten the Fuel Rail to specification; 15 Nm (11 lbs ft.), using the tightening sequence shown.
7. Position the Fuel Rail bracket onto the manifold and secure using the two (2) previously removed bolts.
8. Tighten the bolts until secured.
9. Check the electrical tag and connect each injector electrical connector to the proper injector.
10. Reinstall the fuel rail supply and return lines.

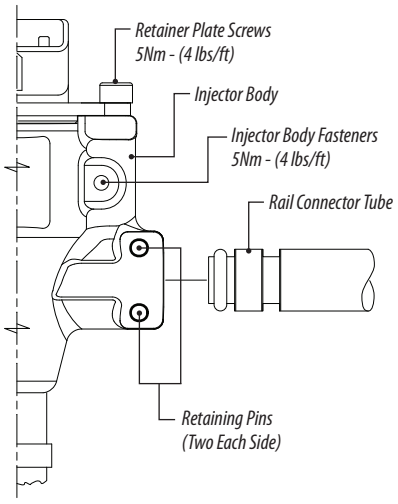


Single Rail Removal Tightenting Sequence



Both Rails Removed Tightenting Sequence

Fuel Injector Assembly Replacement



CAUTION ***When removing or replacing any fuel delivery components which include: Fuel Rails, Injectors, or Supply Lines, thoroughly clean the work area with solvents and compressed air to remove any debris or contaminants. Always insure your hands are clean when handling fuel injection components to prevent contaminating the fuel delivery systems.***

If a single injector must be replaced use the following procedure. *NOTE: The injector body itself is almost never disassembled, only the injector is replaced. To replace an injector you do not need to pull the complete rail assembly.*

Removal

1. Remove the injector rail assembly refer to Fuel Rail Replacement.
2. Remove the fuel rail bracket by removing the eight (8) retaining screws.
3. Place the fuel rail assembly on a clean work surface.
4. Place a small block of wood under the injector to be replaced.
5. Using a small hammer and punch, drive the four (4) retaining pins out of the injector body and retain the pins.
6. Pull the connector tubes from each side of the injector body.
7. Cap all open ports on the fuel rail and Injectors.

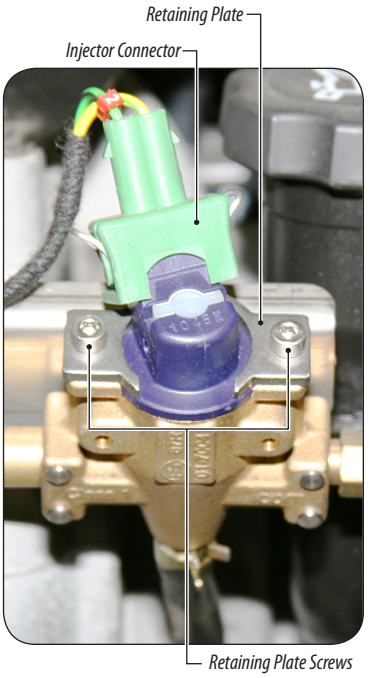
Replacement

NOTE: Before removing the injector assembly from the package, clean the work area and your hands. Do not remove the protective caps until it is necessary.

1. Remove the protective caps from one of the connector tubes and lightly lubricate the o-ring with a petroleum jelly or o-ring lube.
2. Remove the injector assembly from the plastic bag.
3. Position the injector assembly in the correct position (All injector wire connectors facing the same way).
4. Remove one protective cap and install the previously lubed connector tube into the injector body.
5. Press two (2) pins into the body.
6. Place the injector assembly on a small block of wood and drive the pin into place using a small hammer.
7. Drive the pin in until the head is against the injector housing.
8. Repeat steps 1, 3, 4, 5, 6 & 7.
9. Mount the injector rail to the rail mounting bracket using the eight (8) screws and tighten until fully seated.
10. Reinstall the fuel rail assembly refer to Fuel Rail Replacement.

Fuel Injector Replacement

NOTE: It is possible to service the injector on the vehicle. However clean the area thoroughly with an acceptable engine cleaner and blow the area clean with compressed air before starting.



CAUTION ***When removing or replacing any fuel delivery components which include: Fuel Rails, Injectors, or Supply Lines, thoroughly clean the work area with solvents and compressed air to remove any debris or contaminants. Always insure your hands are clean when handling fuel injection components to prevent contaminating the fuel delivery systems.***

CAUTION ***The Injector, Calibrator, and the Calibrator Holder are a matched set and must be replaced as a kit. If removing multiple injectors keep each set of injectors and calibrators together as a set and replace in the same injector body.***

If replacing one or more injectors use the following procedure.

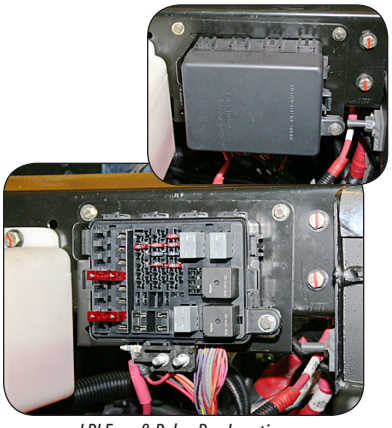
Removal

1. Close the manual supply valve at the Multivalve.
2. Relieve the pressure in the system, refer to Fuel System Pressure Release.
3. If replacing more than one injector, tag the injector connectors to insure the correct connectors are reinstalled.
4. Remove the two (2) injector retaining plate screws and retain.
5. Remove the retaining plate.
6. Using a small screw driver place it between the plastic edge of the injector and the brass body.
7. Rotate the screw driver slowly this will allow the injector to rise against the resistance of the sealing o-ring.
8. Slowly lift the injector out of the holder. *NOTE: The calibrator and holder may be attached to the injector when removing and could drop into the engine compartment.*
9. Using needle nose pliers or clamping forceps reach into the holder and remove the calibrator and holder.
10. Using a pick remove the calibrator seal from the body.
11. Using a lint free cloth and denatured alcohol clean the bore of the holder.

Replacement

NOTE: Before removing the injector assembly from the package, clean the work area and your hands. Do not remove the protective caps until it is necessary.

1. Place the calibrator seal into the bore of the holder and insure the seal is in place and fully seated.
2. Use a mirror to check the seal position.
3. Place the calibrator into the holder with the o-ring end of the calibrator facing up.
4. Using reverse locking ring pliers, clamp the holder and lower the holder and calibrator into the bore.
5. Using a mirror check to insure the calibrator and holder are properly positioned in the bore.
6. Remove the protective cap from the injector and lightly lubricate the upper and lower sealing o-rings.
7. Place the injector into the holder and press down.
8. Rotate the injector electrical connector into the proper position.
9. Install the retaining plate.
10. Install the two (2) retaining screws and draw the injector down until it is full seated and the injector screw are tight.
11. Connect the injector electrical connectors.
12. Open the manual supply valve at the multivalve.
13. Purge the fuel system.
14. Leak check the rail using an approved leak detection soap solution or electronic leak detector.



LPI Fuse & Relay Box Location

LPI Fuel Control Unit Replacement

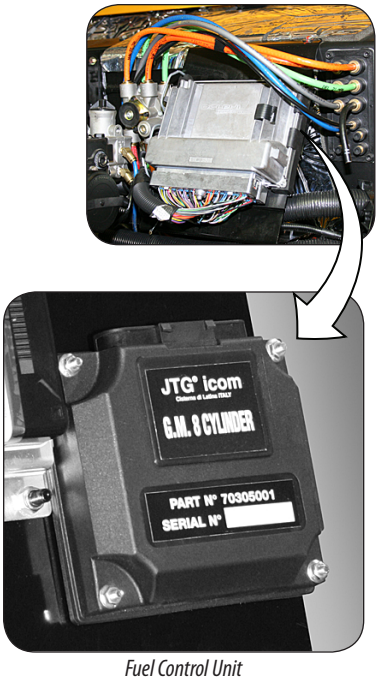
The LPI fuel system utilizes a Fuel Control Unit (FCU). It interrupts the ground signal to the original fuel pump control relay to control the purge timing and the wait to start indicator. It also controls the tank overfill prevention circuit. To replace the FCU use the following procedure.

Removal

1. Disconnect the main harness connector at the FCU.
2. Remove the four (4) mounting screws and nuts and retain.
3. Remove the FCU.

Replacement

1. Install the FCU to the mounting bracket using the four (4) screws and nuts and tighten until fully secured.
2. Reconnect the main harness connector to the FCU.
3. Push until you hear the click then pull on the connector to insure the connector is locked.



Fuel Control Unit

Fuel Pump Pressure Test Instructions

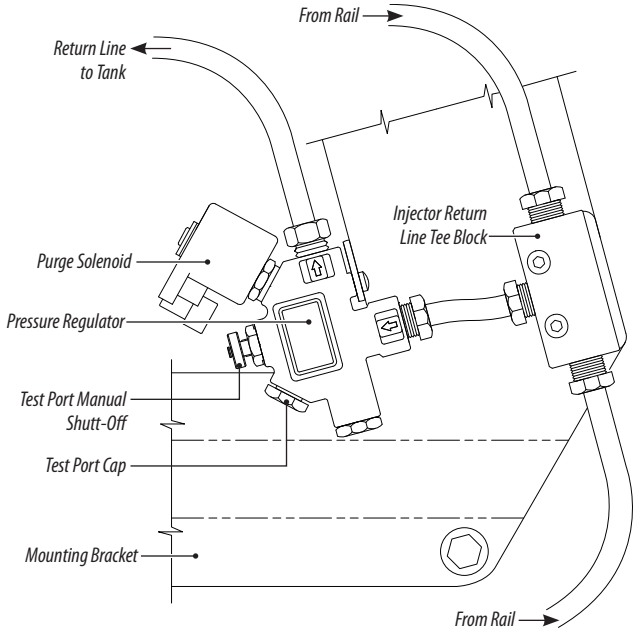
LPI Fuel System Properties

For proper engine performance the LPI fuel system must maintain a consistent liquid fuel supply in the fuel rails and at the injectors. While fuel demand varies widely between low- speed, low power operations and wide open throttle, full load operations, the liquid fuel volume and fuel pressure must remain constant. During the start mode the operator will move the key from the OFF position tothe Key On Engine Off (KOEO) position, with the key in this position the fuel system begins its "purge cycle".

The LPI fuel system is a liquid fuel injection system, LPG changes from a liquid to a vapor at -40º F. During normal operation there is sufficient fuel volume flowing in the fuel rails to prevent vaporization of the fuel in the rails. However when the engine is shut off the fuel solenoid is closed and the in-tank pump ceases operation. Thus any fuel trapped in the fuel lines is now subject to ambient temperature and the high temperature radiating from the hot engine and its components.

A prolonged exposure of this radiating heat on the fuel rails will cause the liquid fuel to vaporize and create "bubbles" in the fuel lines and fuel rails. If this vaporized fuel is not purge before restarting the engine the engine may not restart due to the extremely lean fuel condition. Therefore a "purge strategy" is employed to insure liquid fuel is flowing in the fuel rails prior to cranking the engine.

The purge strategy is engaged when the operator positions the key in the Key On Engine Off (KOEO) position. When the system is being purged a light in the dash will illuminate during the purge cycle. The duration of the purge cycle is approximately 20 seconds.



Pressure Regulator Assembly

Taking Line pressure reading:
Before proceeding, verify that the vehicle has a minimum of ¼ tank of fuel, and the manual shut off valve at the Multivalve is in the full OPEN position (counterclockwise).

1. Observe regulator assy as shown in Fig 1 (this located under the hood at the front of the intake manifold). Make sure the test port manual valve is in the closed position.
2. Using a 16MM wrench remove the test port cap.
3. Using your LPI system test gauge assembly carefully thread male end into test port until fully seated
4. Slowly open test port manual valve and check for leakage around gauge fitting, tighten if necessary to ensure gas tight seal.
5. Turn key to start purge cycle for 2 seconds, then turn key off and allow pressure reading to drop to lowest point. Document pressure gauge reading as this is tank pressure.
6. Turn key to start purge cycle and document highest pressure reading during 20 sec purge and document this reading as this is purge pressure. Turn key off after reading.
7. Turn Key on, complete 20 sec purge cycle then start engine, document gauge reading while running as this is true running pressure.

Now that all readings have been taken the LPI system requires 50 psi "boost pressure" over tank pressure when engine is running. Its not unusual to see 60 to 65 psi of boost with a new pump.

Once the pressure test is complete close the test port manual valve, open the LPI pressure test gauge drain port slowly and drain off the small amount of LP trapped between the regulator test port and the test gauge. Unscrew the LPI test gauge assembly from the pressure regulator and install the test port plug and tighten the pressure test is complete.

Fuel Injector Leak Down Testing

If the bus is hard to start it is possible that there has been an injector leak down. This is evident if the engine cranks longer than 7 seconds but eventually starts after long crank time.

The before proceeding make sure the following conditions are met:

- The battery is completely charged.
- The engine cranking speed is acceptable.
- There is adequate fuel in the fuel tank.

CAUTION ***Injector leak down testing should be done on a cold engine or damage to the intake manifold could occur.***

1. Crank the engine over normally for seven seconds, if the engine does not start normally within 7 seconds stop stop cranking.
2. Hold the accelerator pedal to the floor, this puts the engine in clear flood mode. Crank the engine for seven seconds. If the engine starts within the seven seconds this could indicate possible injector leakage.

CAUTION ***Do not loosen more than one intake bolt at a time, Loosening more than one bolt could result in a intake leak).***

3. Working from the front of the passengers side, remove the bolt that secures the oil filler tube in place. Remove the oil filler tube.
4. Spray a small amount of penetrating oil around the base of the injector nozzle, this will prevent the o-ring from tearing. Remove the 10 mm intake bolt, carefully remove the injector nozzle. Lay the injector nozzle on top of the intake manifold.
5. Spay the end of the nozzle with a liquid- leak detector. (Soapy water solution will work). Turn the key to the on position; **(DO NOT START THE ENGINE)** Let the system go through a regular purge cycle. This will charge the fuel rail with adequate pressure for testing the injector. Turn the key off.
6. Check the end of the injector nozzle for bubbles (See illustrations for acceptable injector leakage).
7. Use a permanent marker and put an X on the body of any injector that has unacceptable leakage. Before reinstalling the injector nozzles apply a small amount of engine petroleum jelly or O-ring lube to the nozzle o-ring, then replace the nozzle into the intake manifold. Torque the bolt to 130 inch pounds. Repeat the process on all 8 Injectors.
8. All the injectors that are marked with an X, now need to be replaced. Before proceeding the system will need to be depressurized. Refer to the **Fuel System Pressure Release** section of this manual.
9. With the fuel system depressurized, remove the injector electrical connector. Remove the two Allen head bolts and the injector hold down bracket.
10. Twist and pull up on the injector, this will help break the injector o-ring seal. When removing the old injector take care to make sure the injector calibrator does not come out with the injector. Remove the old injector.
11. Apply a small amount of petroleum jelly or O-ring lube to the o-rings of the new injector. Before inserting the new injector into the rail make sure the injector calibrator is still in the calibrator pocket. Insert the new injector into the rail and push it to its fully seated position. Reinstall the injector hold down and the two Allen bolts and tighten, reconnect the injector electrical connection.
12. Repeat this process on any remaining leaking injectors.
13. Complete two purge cycles before staring, this will remove any air in the rails. Start the bus and check the injectors with the soapy solution for leaks.



Unacceptable
Quick bubbling forming on the tip of the nozzle. This condition is unacceptable. Replace Injector..



Unacceptable
Moderate bubbling forming on the tip of the nozzle. This condition is unacceptable. Replace Injector..



Acceptable
Fine bubbling in capillary tube. This is an acceptable injector.

Fill Circuit Repair Procedure

The following procedures will need to be completed before proceeding with the fill circuit repair.

1. Fuel system pressure release procedure.
2. Fuel tank draining procedure.
3. Multi-valve removal procedure.
3. Fuel Pump Removal Procedure.

Fuel System Diagnostic Chart

Under the condition that the vehicle will not fill:

Step	Action	Value	Yes	No
1	Verify the dispenser is working correctly	100 pound pressure differential.	Go to step 2	Call fuel/fuel station provider
2	Verify power supply and ground to the tank fill circuit. Connect DVOM + probe to pin "A" the blue wire of the tank electrical harness connector and DVOM - probe to a known good ground connection.	12v +	Go to step 3	Go to step 3
3	Check the fill circuit ground by connecting a DVOM + probe to pin "A" blue wire and the DVOM - probe to pin "D" black wire on the tank electrical harness connector	12v +	The tank fill circuit inside of the tank will need to be inspected. Refer to the following sections, Fuel system pressure release, Fuel Tank Draining and Evacuation Procedure, Multi-valve Removal & Fill Circuit Repair sections.	Go to step 4
4	Check the LPI tank harness grounding lug connection located on the drivers side of the frame rail above the rear end. With the your DVOM to OHMS and connect one lead to pin "D" of the tank harness and the the other connector to the grounding lug.	Continuity	Repair ground lug connection or check for broken ground wire in the tank harness.	Go to step 5
5	Locate the LPI harness connection above the driver side transmission mount, disconnect the LPI harness. Check the Blue Bird supply harness for power and ground by connecting a DVOM + probe to pin "A" red wire and the DVOM - probe to pin "D" black wire of the harness connector	12v +	Check for pinched or broken wires in the LPI harness	Go to step 6
6	Check the ECM/Fuel pump 20A fuse located on the firewall fuse block.		Replace 20A fuse	Go to step 7
7	Check for open circuit in the Blue Bird power supply harness between fuse block and connector above the transmission mount			

Maintenance of the LPI Fuel System

This section covers the items in the LPI fuel system, which requires regularly scheduled maintenance. For maintenance of the base engine refer to the GM Medium Duty Service Manual or consult your GM dealer Service Department.

Fuel Tank Maintanance

The fuel tank equipped has been certified to ASME Tank and Pressure vessel requirements and the installation complies with all NFPA Pamphlet 58 Standards in affect at the time of certification. State and or local regulatory agencies may require a periodic inspection of the LPG tank. At a minimum of every 12 months the LPG tank should be inspected by a trained technician for the following items:

- Check for impact damage, dents, cuts or severe gouging or any tank deformation
- Check for rust and paint flaking
- Check for cracks in the welded seams or mounting brackets
- Check to insure the service valves or shut off valves are functioning and manually closes the valve
- Check to insure the pressure relief valve vent is clear of any obstructions and is properly orientated
- Check all electrical connections to insure they are properly seated and have not become corroded
- Check all mounting fasteners and brackets to insure the tank is properly fitted to the chassis
- Leak check all external fittings and connection

If during the tank inspection any or all the above have been observed you should have the tank repaired by a certified LPG Tank Repair Facility or replace the tank.

WARNING ***Never cut or weld on the LPG fuel tank. Repairs to the fuel tank should only be made by a certified LPG tank repair facility. Failure to observe this warning could result in serious bodily injury, death and/or serious property damage.***

Fuel Filter Maintenance

The LPG fuel pump is located inside the LPG tank. The pump is equipped with a filter which requires periodic service.

It is recommended that the fuel filter be replaced every 60,000 Miles (96,550km) or 24 months which ever occurs first Refer to the Fuel Filter Replacement procedure in this manual.

Fuel Supply And Return Line Maintenance

The fuel supply and return lines are made of special thermoplastic material. It is recommended that the fuel line connections be leak checked annually or anytime the lines have been removed. The routing of the lines should also be inspected annually to insure that the lines have not come into contact with any rotating devices, hot surfaces, or are located in a position in which they may be impacted by road debris.

Fuel Pressure Regulator

The fuel pressure regulator does not require any periodic adjustment. You should annually inspect the following items on the fuel pressure regulator:

- Check to make sure the mounting bracket is securely fastened and there is no cracking or breaking in the bracket
- Check to make sure the regulator is securely attached to the bracket
- Check to make sure the electrical lock-off connector is securely attached and that the wiring is secured
- Leak check the fuel line connector using an electronic leak detector or an approved leak detection soap solution

Fuel Rails And Injectors

The fuel rails and injectors require no periodic adjustment. You should annually inspect the following items on the fuel rails and injectors:

- Check to make sure the rail brackets are securely attached to the manifold
- Check to make sure the rail bracket have no cracking or breaking
- Check to make sure that each injector is securely attached to the rail bracket
- Leak check all the connections on the fuel rail at each injector connector and the inlet and outlet fitting at the rail using an electronic leak detector or an approved leak detection soap solution
- Check the injector delivery hose for any cracking, kinky, cuts, or deformation, replace if necessary
- With the engine running use an electronic leak detector or an approved leak detection soap solution to check the delivery nozzle to intake manifold and all hose connections for leaks

Electrical System Checks

The electrical system, wiring harness, fuel control unit (FCU) do not require any periodic adjustments. You should annually inspect the following items:

- Check the mounting bracket for the fuel control unit (FCU) for cracks or breaking
- Check the controller mounting bracket securing bolts to insure they are securely fastened
- Check the electrical connector and insure the connector is securely attached, locked and the secondary lock is in position
- Check the wire harness routing under the hood to insure the main harness and injector harness have not come into contact with any rotating devices, hot surfaces, or have come loose from their securing points and are hanging in an unsafe location.
- Check all electrical connectors by lightly pulling on each connector to insure the connector is fully locked and seated
- Check all wire ties used to secure the harness for cracking, splitting, or breakage, replace if necessary
- Check the harness routing to the fuel tank connector and insure the harness is securely attached to the frame and protected from any hot surfaces, rotating devices or road debris,repair any unsafe condition

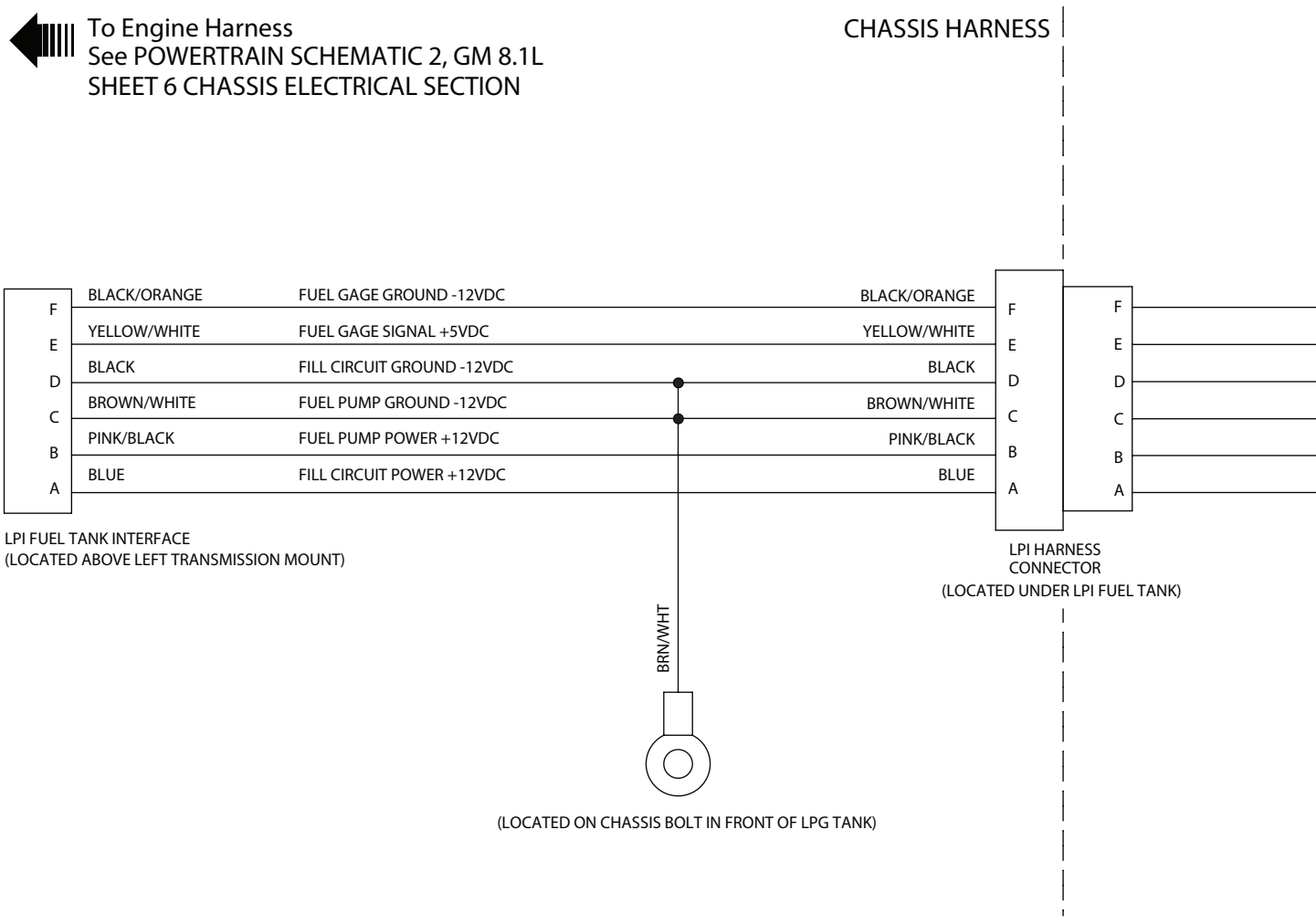
LPI Maintenance Schedule

LPI FUEL SYSTEM RECOMMENDED MAINTENANCE SCHEDULE

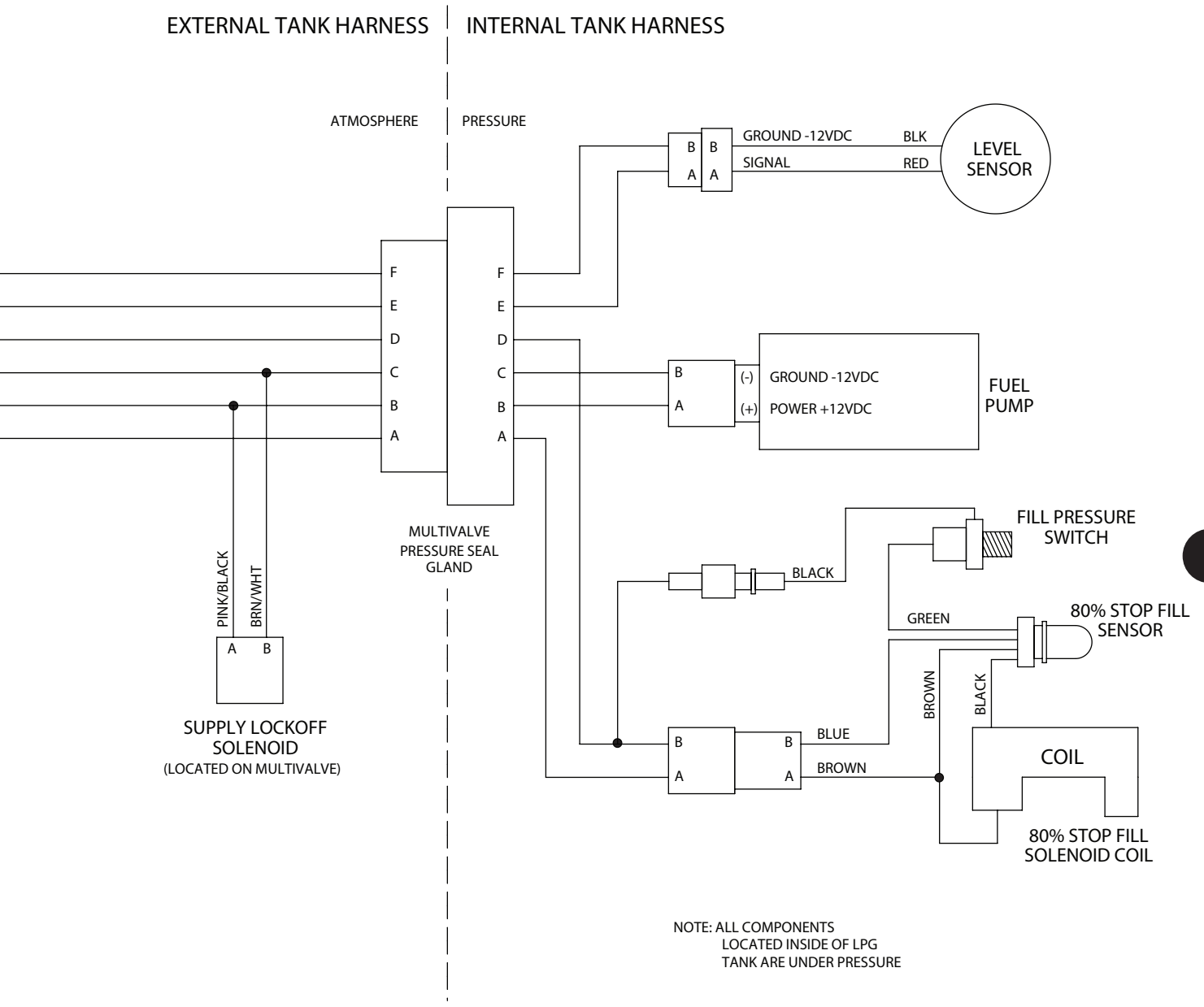
DESCRIPTION OF MAINTENANCE	FREQUENCY					
	ANNUALLY	OR	30,000 MILES	60,000 MILES	90,000 MILES	120,000 MILES
Fuel Tank Inspections						
Check for rust, dents, or external impact damage	X				X	
Leak check all tank fittings and connections	X		X	X	X	X
Check all tank retaining devices	X				X	
Fuel Filter replacement				X		X
Fuel Supply and Return Lines						
Check line routing check securing points	X				X	
Inspect lines for damage	X				X	
Fuel Pressure Regulator						
Mounting bracket securely attached	X				X	
Regulator securely attached to bracket	X				X	
Leak check all connections	X		X	X	X	X
Check electrical connectors	X				X	
Fuel Rail and Injectors						
Rail bracket securely attached	X				X	
Injectors securely attached to rail bracket	X				X	
External leak check injectors	X		X	X	X	X
Injector Hose inspection	X				X	
Electrical System Inspection						
Check controller mounting bracket	X				X	
Check controller for damage	X				X	
Check controller connection	X				X	
Check under hood wire harness routing	X				X	
Check under hood wire harness connections	X				X	
Check underbody wire harness routing	X				X	
Check fuel tank wire harness connections	X				X	
Spark Plugs and Wiring						
Check Spark plug gap and condition				X		
Check Spark Plug wiring				X		
Replace Spark Plugs					X	

This maintenance schedule represents Clean Fuels USA recommended maintenance intervals to insure safe & reliable operation of the *LPI* fuel system. Specific state and federal regulation may require vehicle operators to perform more comprehensive or frequent inspections. If you have any questions regarding the maintenance procedures and or question regarding the system please contact Clean Fuels USA.

LPI Wiring Schematic



LPI Wiring Schematic



NOTE: ALL COMPONENTS
LOCATED INSIDE OF LPG
TANK ARE UNDER PRESSURE

LIQUIDPROPANEINJECTION
SYMTOMS DIAGNOSTIC CHARTS

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8.1 Liter GM Medium Duty Dedicated LPG

CLEANFUELUSA
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LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Important Preliminary Checks

Checks	Action
Before Using This Section	Before using this section, you should have performed On Board Diagnostic Check and determined that: 1. The FCU (Flow Control Unit) and MIL (Malfunction Indicator Lamp) are operating correctly. 2. There are no Diagnostic Trouble Codes (DTCs) stored, or a DTC exists but without a MIL. Several of the following symptom procedures call for a careful visual and physical check. The visual and physical checks are very important. The checks can lead to correcting a problem without further checks that may save valuable time.
LPG Fuel System Check	1. Verify the customer complaint. 2. Locate the correct symptom table. 3. Check the items indicated under that symptom. 4. Operate the vehicle under the conditions the symptom occurs. Verify HEGO switching between lean and rich. **IMPORTANT!** **Normal HEGO switching indicates the LPG fuel system is in closed loop and operating correctly at that time.** 5. If a scan tool is available, **take a snapshot** under the condition that the symptom occurs. Go to *Engine Scan Tool Data* List to verify normal sensor values and parameters.
Visual and Physical Checks	• Check all PCM system fuses and circuit breakers. • Check the PCM ground for being clean, tight and in its proper location. • Check the vacuum hoses for splits, kinks and proper connections. • Check thoroughly for any type of leak or restriction. • Check for air leaks at all the mounting areas of the intake manifold sealing surfaces. • Check the ignition wires for the following conditions: – Cracking – Hardness – Proper routing – Carbon tracking • Check the wiring for the following items: – Proper connections, pinches or cuts. • The following symptom tables contain groups of possible causes for each symptom. The order of these procedures is not important. If the scan tool readings do not indicate the problems, then proceed in a logical order, easiest to check or most likely to cause first.

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Intermittent

Checks	Action
DEFINITION: The problem may or may not turn ON the Malfunction Indicator Lamp (MIL) or store a Diagnostic Trouble Code (DTC).	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Do not use the DTC tables. If a fault is an intermittent, the use of the DTC tables may result in the replacement of good parts.
Faulty Electrical Connections or Wiring	• Faulty electrical connections or wiring can cause most intermittent problems. • Check the suspected circuit for the following conditions: – Faulty fuse or circuit breaker – Connectors poorly mated – Terminals not fully seated in the connector (backed out) – Terminals not properly formed or damaged – Terminal to wires poorly connected – Terminal tension insufficient. • Carefully remove all the connector terminals in the problem circuit in order to ensure the proper contact tension. If necessary, replace all the connector terminals in the problem circuit in order to ensure the proper contact tension. • Checking for poor terminal to wire connections requires removing the terminal from the connector body.
Operational Test	If a visual and physical check does not locate the cause of the problem, drive the vehicle with a scan tool. When the problem occurs, an abnormal voltage or scan reading indicates the problem may be in that circuit.
Intermittent Malfunction Indicator Lamp (MIL)	The following components can cause intermittent MIL and no DTC(s): • A defective relay, Control Module driven solenoid, or a switch that can cause electrical system interference. Normally, the problem will occur when the faulty component is operating. • The improper installation of electrical devices, such as lights, 2-way radios, electric motors, etc. • The ignition secondary voltage shorted to a ground. • The Malfunction Indicator Lamp (MIL) circuit or the Diagnostic Test Terminal intermittently shorted to ground. • The Control Module grounds.
Loss of DTC Memory	To check for the loss of the DTC Memory: 1. Disconnect the MAF sensor. 2. Idle the engine until the Malfunction Indicator Lamp illuminates. The PCM should store a MAF DTC. The MAF DTC should remain in the memory when the ignition is turned OFF. If the MAF DTC does not store and remain, the PCM is faulty.
Additional Checks	.

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

No Start

Checks	Action
DEFINITION: The engine cranks OK but does not start.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check fuel level
Control Module Checks	• If a scan tool is available: • Check for proper communication with the PCM • Check the inline fuse in the PCM battery power circuit. Refer to *Engine Controls Schematics.* • Check battery power, ignition power and ground circuits to the PCM. Refer to *Engine Control Schematics.* Verify voltage and/or continuity for each circuit.
Sensor Checks	• Check the Magnetic pickup sensor (RPM). .
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create a no start condition. Verify the manual valve is open; has a c-clip on top of thumb wheel, if there is no c-clip the valve will not open or will only partially open and could cause decreased power. • Check the in tank fuel pump (activate the purge cycle and listen for the fuel pump) • Verify proper operation of the fuel supply valve solenoid at the tank. • Check the fuel system pressures. Refer to the *LPG Fuel System Diagnosis*.

Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions.
	• Check for proper primary ignition voltage
	• Check for the proper ignition voltage output with *J 26792* or the equivalent.
	• Verify that the spark plugs are correct for use with LPG
	• Check the spark plugs for the following conditions:
	  – Wet plugs
	  – Cracks
	  – Wear
	  – Improper gap
	  – Burned electrodes
	  – Heavy deposits
	• Check for bare or shorted ignition wires.
	• Check for loose ignition coil connections at the coil.

LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Checks	Action
Engine Mechanical Checks	**Important:** The LPG Fuel system operates in the same fashion as the gasoline fuel supply system. • Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes.
Exhaust System Checks	• Check the exhaust system for a possible restriction: – Inspect the exhaust system for damaged or collapsed pipes – Inspect the muffler for signs of heat distress or for possible internal failure. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis*

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Hard Start

Checks	Action
DEFINITION: The engine cranks OK, but does not start for a long time. The engine does eventually run, or may start but immediately dies.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Make sure the vehicle's operator is using the correct starting procedure. • Make sure the purge cycle is being activated • Check to make sure there is adequate fuel supply in the tank
Sensor Checks	• Check the Crankshaft Position (CKP) sensor. • Check the Throttle position (TPS) sensor.
Fuel System Checks	**Important**: A closed LPG manual fuel shut off valve will create an extended crank OR no start condition. • Check the fuel system pressures. Refer to the *Fuel System Diagnosis*. • Verify proper operation of the fuel supply valve solenoid. • Check for restrictions or kinks in the fuel supply line • Check Multivalve electrical connection at the fuel tank for loose connection and/or corrosion in the connectors • Refer to base manual symptom chart for further fuel system checks in the GM MD Service Manual..
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. • Check for proper primary ignition voltage • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check the spark plugs for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check for bare or shorted ignition wires. • Check for moisture in the distributor cap if applicable. • Check for loose ignition coil connections. **Important**: 1. If the engine starts but then immediately stalls, check the Crankshaft Position (CKP) sensor. 2. Check for improper gap, debris or faulty connections.

LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Checks	Action
Engine Mechanical Checks	• **Important:** The LPG Fuel system operates in the same fashion as the gasoline fuel supply system. • Check for the following: – Vacuum leaks – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes. Ref • Check the intake and exhaust manifolds for casting flash.
Exhaust System Checks	• Check the exhaust system for a possible restriction: – Inspect the exhaust system for damaged or collapsed pipes – Inspect the muffler for signs of heat distress or for possible internal failure. • Check for possible plugged catalytic converter. Refer to *Restricted Exhaust System Diagnosis* or *Exhaust System* in the GM MD Service Manual.
Additional Checks	•

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Cuts Out, Misses

Checks	Action
DEFINITION: A surging or jerking that follows engine speed, usually more pronounced as the engine load increases which is not normally felt above 1500 RPM. The exhaust has a steady spitting sound at idle, low speed, or hard acceleration for the fuel starvation that can cause the engine to cut-out.	
Preliminary Checks	• Refer to *Important Preliminary Checks*.

Ignition System Checks	• Start the engine.
	• Wet down the secondary ignition system with water from a spray bottle, and look/listen for arcing or misfiring as you apply water.
	• Check for proper ignition output voltage with spark tester J 26792.
	• Check for a cylinder misfire.
	• Verify that the spark plugs are correct for use with LPG
	• Remove the spark plugs in these cylinders and check for the following conditions:
	  • Insulation cracks
	  • Wear
	  • Improper gap
	  • Burned electrodes
	  • Heavy deposits
	  • Visually/Physically inspect the secondary ignition for the following:
	  • Ignition wires for arcing, cross-firing and proper routing
	  • Ignition coils for cracks or carbon tracking

Engine Mechanical Checks	• Perform a cylinder compression check.
	• Check the engine for the following:
	  – Improper valve timing
	  – Bent pushrods
	  – Worn rocker arms
	  – Worn camshaft lobes.
	  – Broken or weak valve springs.
	• Check the intake and exhaust manifold passages for casting flash.

Fuel System Checks	• Check the fuel system - plugged fuel filter, low fuel pressure, etc. Refer to *LPG Fuel System Diagnosis*. • Check the condition of the wiring to the low pressure lock-off solenoid.
Additional Check	Check for Electromagnetic Interference (EMI). • EMI on the reference circuit can cause a missing condition. • Monitoring the engine RPM with a scan tool can detect an EMI. • A sudden increase in the RPM with little change in the actual engine RPM, indicates EMI is present. • If the problem exists, check the routing of the secondary wires and the ground circuit.

LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Hesitation, Sag, Stumble

Checks	Action
DEFINITION: The vehicle has a momentary lack of response when depressing the accelerator. The condition can occur at any vehicle speed. The condition may cause the engine to stall if it's severe enough.	
Preliminary Checks	Refer to *Important Preliminary Checks*.
Fuel System Checks	• Check the fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for low fuel pressure during a moderate or full throttle acceleration. If the fuel pressure drops below specification, there is possibly a faulty low pressure regulator, a restriction in the fuel system, plugged fuel filter or a faulty fuel pump. • Check for excessively high or low fuel trim corrections. • Check fuel supply valve electric solenoid connections at the tank.
Ignition System Checks	Note: LPG being a gaseous fuel requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. If a problem is reported on LPG and not gasoline, do not discount the possibility of a LPG only ignition system failure and test the system accordingly. • Check for proper primary ignition voltage • Check for the proper ignition voltage output with *J 26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check for faulty spark plug wires • Check for fouled spark plugs.
Additional Check	• Check for manifold vacuum or air induction system leaks • Check the generator output voltage.

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Backfire

Checks	Action
DEFINITION: The fuel ignites in the intake manifold, or in the exhaust system, making a loud popping noise.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Ignition System Checks	**Important!** **LPG, being a gaseous fuel, requires higher secondary ignition system voltages for the equivalent gasoline operating conditions. The ignition system must be maintained in peak condition to prevent backfire.** • Check for proper primary ignition voltage • Check for the proper ignition coil output voltage using the spark tester *J26792* or the equivalent. • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires. • Check the connection at each ignition coil. • Check for deteriorated spark plug wire insulation. • Check the spark plugs are correct for LPG • Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits
Engine Mechanical Check	• Check the engine for the following: – Improper valve timing – Engine compression – Manifold vacuum leaks – Intake manifold gaskets – Sticking or leaking valves – Exhaust system leakage • Check the intake and exhaust system for casting flash or other restrictions.
Sensor Checks	• Check the Crankshaft Position (CKP) sensor. • Check the HEGO sensors
Fuel System Checks	• Perform a fuel system diagnosis. Refer to *LPG Fuel System Diagnosis*.

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Lack of Power, Sluggishness, or Sponginess

Checks	Action
DEFINITION: The engine delivers less than expected power. There is little or no increase in speed when partially applying the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks.* • Compare the customer's vehicle with a similar unit. Make sure the customer has an actual problem. • Remove the air filter and check for dirt or restriction. • Check the vehicle transmission Refer to the OEM transmission diagnostics.
Fuel System Checks	• Check the manual fuel supply valve, a restricted fuel filter, contaminated fuel, or improper fuel pressure. Refer to *LPG Fuel System Diagnosis*. • Check for the proper ignition output voltage with the spark tester *J 26792* or the equivalent. • Check all air inlet ducts for condition and proper installation. • Check for fuel leaks • Verify that the LPG tank manual shut-off valve is fully open, check for lost c-clip. • Check the fuel pump circuit for loose connection • Check the fuel supply and return lines for restrictions and or kinking and binding.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. • Check for proper operation of the TPS sensor.
Exhaust System Checks	• Check the exhaust system for a possible restriction: – Inspect the exhaust system for damaged or collapsed pipes – Inspect the muffler for signs of heat distress or for possible internal failure. – Check for possible plugged catalytic converter.
Engine Mechanical Check	Check the engine for the following: • Engine compression • Valve timing • Improper or worn camshaft. Refer to *Engine Mechanical* in the Service Manual.

LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Checks	Action
Additional Check	• Check the PCM grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • If all procedures have been completed and no malfunction has been found, review and inspect the following items: • Visually and physically, inspect all electrical connections within the suspected circuit and/or systems. • Check the scan tool data.

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Poor Fuel Economy

Checks	Action
DEFINITION: Fuel economy, as measured by refueling records, is noticeably lower than expected. Also, the economy is noticeably lower than it was on this vehicle at one time, as previously shown by an by refueling records.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Check the air cleaner element (filter) for dirt or being plugged. • Visually (Physically) check the vacuum hoses for splits, kinks, and proper connections. • Check the operators driving habits for the following items: – Is there excessive idling or stop and go driving? – Are the tires at the correct air pressure? – Are excessively heavy loads being carried? – Is their often rapid acceleration? • Suggest to the owner to fill the fuel tank and to recheck the fuel economy. • Suggest that a different operator use the equipment and record the results.
Fuel System Checks	• Check the fuel system pressure. Refer to *LPG Fuel System Diagnosis*. • Check the fuel system for leakage. • Check the fuel injector sealing rings to insure no leakage at the injector • Refer to *Fuel Injector Leakage tests*
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) for contamination and performance. Check for proper operation of the MAP sensor. • Check for proper operation of the TPS sensor.
Ignition System Checks	• Verify that the spark plugs are correct for use with LPG • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits • Check the ignition wires for the following items: – Cracking – Hardness – Proper connections
Cooling System Checks	• Check the engine thermostat for always being open or for the wrong heat range
Additional Check	• Check the transmission shift pattern. Refer to the OEM Transmission Controls section the Service Manual. • Check for dragging brakes.

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Rough, Unstable, or Incorrect Idle, Stalling

Checks	Action
DEFINITION: The engine runs unevenly at idle. If severe enough, the engine or vehicle may shake. The engine idle speed may vary in RPM. Either condition may be severe enough to stall the engine.	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Sensor Checks	• Check for silicon contamination from fuel or improperly used sealant. The HEGO sensor will have a white powdery coating. The sensor will result in a high but false signal voltage (rich exhaust indication). The PCM will reduce the amount of fuel delivered to the engine causing a severe driveability problem. • Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: • Check the Engine Coolant temperature sensor response and accuracy.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check for a Leaking Fuel Injector seal • Perform a cylinder compression test. Refer to *Engine Mechanical* in the Service Manual. • Check the fuel system pressure. Refer to the *LPG Fuel System Diagnosis*.
Ignition System Checks	• Check for proper primary ignition voltage • Check for the proper ignition output voltage using the spark tester *J26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Blistered insulators – Heavy deposits • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
Additional Checks	**Important:** The LPG Fuel system operates similar to the gasoline fuel supply system. • Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. • Check the PCM grounds for being clean, tight, and in their proper locations. • Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality..

LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Checks	Action
Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Surges/Chuggles

Checks	Action
DEFINITION: The engine has a power variation under a steady throttle or cruise. The vehicle feels as if it speeds up and slows down with no change in the accelerator pedal.	
Preliminary Checks	• Refer to *Important Preliminary Checks*. • Be sure the driver understands the Torque Converter Clutch operation.
Sensor Checks	• Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance.
Fuel System Checks	• Check for Rich or Lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check the fuel pressure while the condition exists. Refer to *LPG Fuel System Diagnosis.* • Check electrical connections at the Multivalve and electric lock off at the tank. • Verify that the LPG manual shut-off valve is fully open, check the c-clip.
Ignition System Checks	• Check for proper primary ignition voltage • Check for the proper ignition output voltage using the spark tester J26792 or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Heavy deposits.
Additional Check	• Check the PCM grounds for being clean, tight, and in their proper locations. • Check the generator output voltage. • Check the vacuum hoses for kinks or leaks. • Check Transmission
Sensor Checks	• Check the Crankshaft Position (CKP) sensor

LPI LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Excessively High Negative or Positive Fuel Correction

Checks	Action
DEFINITION: The scan tool indicates a excessively high negative fuel correction which would indicate the fuel is operating in a **Rich fueling condition** and the controller is trying to correct for the condition, The scan tool indicates a excessively high positive fuel correction which would indicate the fuel is operating in a **Lean fueling condition** and the controller is trying to correct for the condition	
Preliminary Check	• Refer to *Important Preliminary Checks*.
Sensor Checks	• Check for silicon contamination from fuel or improperly used sealant. The HEGO sensor will have a white powdery coating. The sensor will result in a high but false signal voltage (rich exhaust indication). The PCM will reduce the amount of fuel delivered to the engine causing a severe drivability problem. • Check the Heated Exhaust Gas Oxygen Sensor (HEGO) performance: • Check the Engine Coolant temperature sensor response and accuracy.
Fuel System Checks	• Check for rich or lean symptom that causes the condition. Drive the vehicle at the speed of the complaint. Monitoring the oxygen sensors will help identify the problem. • Check for a Leaking Fuel Injector seal • Perform a cylinder compression test. Refer to *Engine Mechanical* in the Service Manual. • Check the fuel system pressure. Refer to the *LPG Fuel System Diagnosis*.
Ignition System Checks	• Check for proper primary ignition voltage • Check for the proper ignition output voltage using the spark tester *J26792* or the equivalent. • Verify that the spark plugs are correct for use with LPG • Check the spark plugs. Remove the plugs and inspect them for the following conditions: – Wet plugs – Cracks – Wear – Improper gap – Burned electrodes – Blistered insulators – Heavy deposits • Check the spark plug wires by connecting an ohmmeter to the ends of each wire in question. If the meter reads over 30,000 ohms, replace the wires.
Additional Checks	**Important:** The LPG Fuel system operates similar to the gasoline fuel supply system. • Check for vacuum leaks. Vacuum leaks can cause a higher than normal idle and low throttle angle control command. • Check the PCM grounds for being clean, tight, and in their proper locations. • Check the battery cables and ground straps. They should be clean and secure. Erratic voltage may cause all sensor readings to be skewed resulting in poor idle quality.

LIQUIDPROPANEINJECTION

SYMTOMS DIAGNOSTIC CHARTS

Checks	Action
Engine Mechanical Check	• Check the engine for the following: – Broken motor mounts – Improper valve timing – Low compression – Bent pushrods – Worn rocker arms – Broken or weak valve springs – Worn camshaft lobes

Approximate Properties of LP-Gases

(Commercial Propane)

C_3H_8

Specific gravity of liquid (water = 1) at 60 degrees F.		0.504
Initial boiling point at 14.7 psia, (displayed in degrees F.)		- 44.0
Weight per gallon of liquid at 60 degrees F. (displayed in pounds)		4.24
Cubic ft. of vapor per gallon at 60 degrees F.		36.38
Cubic ft. of vapor per pound at 60 degrees F.		8.66
Specific gravity of vapor (air = 1) at 60 degrees F.		1.50
Ignition temperature in air, degrees F.		920 to 1120
Maximum flame temperature in air, degrees F.		3,595
Limits of flammability in air Percent of vapor in air/gas mixture:		
	Lower	2.15
	Upper	9.60
Air/Fuel ratio by volume		15.6: 1
Air/Fuel ratio by weight		24:1
Octane number as it relates to gasoline		98 to 102
Heating values:		
	BTU per cubic foot	2,488
	BTU per pound	21,548
	BTU per gallon	91,500
Chemical formula		C_3H_8
Vapor pressure in psig		
	70 degrees F	127
	100 degrees F	196
	105 degrees F	210

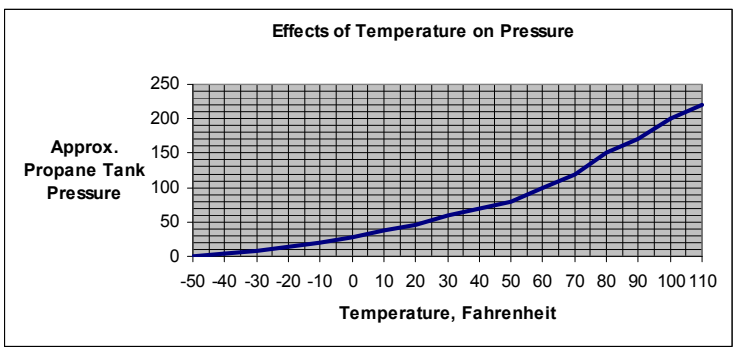
LIQUIDPROPANEINJECTION
SYMTOMS DIAGNOSTIC CHARTS

LPI® Fuel System

Fuel Pressure:
Fuel pressure should be measured at the fuel pressure test port commonly found on the fuel pressure regulator. The same as fuel injected gasoline vehicle the in-tank fuel pump provides an amount of fuel pressure and is required to maintain the necessary amount of fuel delivered during all driving conditions. The difference in checking fuel pressure of the LPI fuel system is propane is stored as a liquid under moderate pressure and the moderate pressure is different depending on temperature and the blend of hydrocarbons the fuel is refined with at the refinery. There are specifications which each refinery has to meet so the variance in this area of fuel is not much of an issue.

There are three considerations to document when measuring fuel pressure

1. Tank pressure: The amount of pressure in the tank at the time fuel pressure is measured
   a. Tank pressure varies, see chart below



2. Purging boost pressure: The amount of pressure measured when the purge cycle has been initiated by turning the ignition key to the "ON" position. Normally ranges from 15 to 30 P.S.I. and is always lower than operating boost pressure due to the purge solenoid is open to allow more volume of fuel flow.
3. Operating boost pressure: The amount of pressure measured when the engine is running. It is important to note that battery condition and charging system condition can affect the operating pressure so if low pressure is experienced verify that there is no failure in the charging system, battery or voltage supply to the fuel pump.

NOTE: Pump boost pressure is the amount of pressure added by the pump over actual internal tank pressure. Pump boost pressure ranges from 50 to 70 P.S.I. with a minimum acceptable boost of 40 P.S.I.

LIQUIDPROPANEINJECTION
SYMTOMS DIAGNOSTIC CHARTS

Reading & understanding data stream information from the scan tool

Scan tools have made a technician's life so much easier because information is easy to access and there is so much information to review to make your diagnosis quicker and easier. However, it is always recommended that replacement of good components is a risk if a clear understanding of what the data you read means and how the components of electronic engine control works; sensors, actuators and the control computer.

The following relates to the LPI fuel system diagnosis and may not be equal on a gasoline system. The LPI system works identical to the gasoline fuel injection system it replaced but some control data may differ slightly.

The very first piece of information to eliminate is fuel pressure. A good understanding of the LPI fuel flow control as described in the previous page is required and it is recommended if no trouble codes exist and there is a performance complaint that fuel pressure be verified first.

If there are any diagnostic trouble codes retrieved from the PCM (Power-train control module) take a close look at the codes and consider each one carefully. Some codes indicate a gross error with a sensor therefore you would want to investigate the condition of the sensor, it's electrical connector and sometimes the wiring going from the PCM to the sensor. You may also be able to perform a test on the sensor to verify fault or no fault.

After fuel pressure is considered within specifications the following data should be reviewed first.

Fuel Control

1. LTFT B1 (Long term fuel trim, bank one)
    a. Long Term means adjustment to fuel control over time. It may take a few hours or a few days to stabilize completely however once the Short Term values are stable around "0" the Long Term Fuel Trims should have learned enough to be stable.
    b. Values should range between -10 to +10 but not more than 10 points difference from Bank One to Bank Two
    c. The value is shown from -25 to +25 and 0 is the center of the range of fuel control.
        i. If the value is a negative number the fuel control is biased rich and the controller is subtracting fuel. Note: This does not mean the system is running rich but is controlling a rich fuel delivery and is subtracting some fuel to maintain the best overall control of emissions through fuel control.

ii. The air filter could be dirty causing a biased rich system. If the value is a positive number (if the value does not have the – negative mark in front of it, it is a positive value) the opposite applies, the fuel control is lean and the controller is adding fuel to maintain the best overall control of emissions through fuel control. The fuel filter could be getting clogged, fuel pressure could be low and etc…
iii. If fuel control reaches -25 or +25 the limit of fuel control is at the maximum control capacity and a diagnostic trouble code will be logged and if the condition continues a MIL (Malfunction Indicator Lamp/Check Engine Light) will illuminate to warn the driver of a failure and the need to take the vehicle in for service.

2. LTFT B2 (Long term fuel trim, bank two) See number one
3. STFT B1 (Short term fuel trim, bank one)
    a. Short term means current time adjustments to fuel control; until the long term fuel control has learned, short term will provide the range of fuel control as needed. Short term also has a range of -25 to +25 and 0 being the center of range of fuel control
    b. Short term will more commonly move around from a negative number to a positive number or actually toggle above and below zero as required to control fuel for best exhaust emissions. This movement is normal and the range could vary depending on where the long term fuel trims are.
4. STFT B2 (Short term fuel trim, bank two)
5. PW 1 (Pulse width, bank one)
6. PW 2 (Pulse width, bank two)
7. O2 B1S1 (Heated oxygen sensor, bank one, sensor one)

LPI Recommended Tools

99000010	Pressure test gauge with bleeder - no hoses
99000011	1 3/4" ACME to No 4 Flare Fuel Evacuation Adaptor
99000012	Evacuation Valve hose with 90 degree special fitting
99000013	30 foot Evacuation hose extension
99000014	Evacuation hose (pigtail) for fuel supply valve connection
99000015	Tank pressure gauge with bleeder - no hoses
99000016	Fuel system pressure testing hose for pressure test gauge with special adaptor for pressure regulator test port
99000017	Adaptor, No 4 flare to 3/8 male flare
99000025	Storage case
10:01-45-LPI tool kit	Complete Kit (all above parts)
90700002	Hose end assembly tool for 3/8" blue filler hoses
90700000	Hose end assembly tool for 3/16" green or black hoses
Other Recommended tools	**Purchase from GM and/or local tool man (Snap-On or Mac)**
	Diagnostic Scan Tool - GM Tech II or equivalent
	Digital Multi-meter
	Metric hand tools
	Tee-handle type Allen wrenches
	1/4" or 3/8" Torque wrench (inch lb or NM)
	GM Medium Duty Truck Service & Diagnostic Manuals

Overview

The Blue Bird Vision instrument cluster uses all electronic analog gauges with stepper motor technology coupled to a microcontroller that provides the necessary electrical control. In addition to gauges, this ACTIA® manufactured instrument cluster includes an LCD display panel known as a Message Display Center and gauge warning indicators which provide illuminated visual alerts to the Driver.

The instrument cluster receives both analog inputs from such components as the fuel tank sender and instrument panel dimmer switch; binary inputs from brake and directional signal switches; and digital signals from components such as the engine and transmission control modules, via the J1939 and J1587 data buses.

The instrument cluster comes with several modes of operation. The system is in Sleep Mode when the battery power is applied to the cluster with no other activity. In this mode the microprocessor deactivates the power maintain output resulting in low power draws of less than 3mA to support the clock. When the instrument cluster sences a change to an input signal such as turning the iginition key on or turning on the headlights, the cluster wakes up and then decides which mode to enter depending on which input is active. Limited Mode is a stand by mode entered when there is battery power available and the iginition is turned off, but other input signals are requiring the system to operate such as hazard warning lights or brake interlock request. Another mode of operation is the Start-Up Mode. This mode is entered when the iginition is turned on. When the start-up mode is initiated the cluster will go through a functional diagnostic test, if the self-test option is enabled (default). During this test you will see the gauge pointers drive to zero position (pause) then move to half scale (pause) and then move to full scale (pause) before returning to the zero position, and finaly going to the commanded position. During this time all warning lights will perform a lamp check by turning on for 5 seconds, and the three different audible tones will be checked by turning on for 1 second. During this start-up mode, the microprocessor also monitors all the inputs. If a problem is detected an error message will be displayed and the gauges will wag to flag the communication failure. The Ignition Mode is the normal operational mode of the system and is active as long as the ignition switch is on. When the ignition is turned off the microprocessor will zero all gauges, except the fuel gauge which will remain at its last command position. The Self-Diagnostic Mode is entered through a menu selection. The self-diagnostic tests include the gauges, LCD, warning lights, binary inputs, analog inputs and binary outputs. Detailed specifications can be found in the Message Display Center section of the appendix.

The backlighting on this instrument cluster is adjustable through an internal dimmer. This is done using the two buttons on the face of the cluster. The backlight color can also be changed through the setting and diagnostics menu accessed using the same two buttons on the face of the cluster. Backlight colors are blue, light blue, white, red and green. The white LCD and amber pointer backlights are not adjustable.

The cluster also uses its microprocessor to compute logic required for certain units to function. When the logic is satisfyied, an output is generated and sent to these units to satisfy their operational needs. Units requiring logic outputs include Speed Detect used in the brake interlock system, Seat Belt Logic used for alarms and Lift Authorization used to supply power to deploy the handicap wheelchair lift.

The instrument cluster is a sealed unit with no serviceable parts including gauges, lights and buzzers. If your cluster is found to be defective, it is replaced in whole as a unit.

Appendixes In This Chapter

Appendix 1. Blue Bird Corporate Cluster 2010 Common Functional Specification. This ACTIA publication was created especially for Blue Bird and details the operation of the instrument system including a detailed explanation of the Message Display Center's menus and diagnostic capabilities.

Instrument Cluster

The VISION'S instrument cluster is a single unit of all-electronic guages and warning lights, which receive both analog inputs from such components as the fuel tank sender, oil pressure sensor; and digital signals from components such as the engine and transmission control modules. A centrally-located Message Display Center displays the odometer reading, error alerts, and service technician diagnostic information. If the VISION is equipped with hydraulic brakes, the instrument cluster contains 5 gauges. Buses equipped with air brakes have two additional gauges indicating primary (front) and secondary (rear) air pressure.

1. **Speedometer.** Indicates vehicle speed in miles/hour or kilometers/hour.

2. **Tachometer.** Indicates engine speed in revolutions per minute times 1000.

3. **Message Display Center.** Displays additional information to the vehicle operator. See Message Display Center.

4. **Fuel Gauge.** Indicates fuel level in tank. Fuel gauge bank includes illuminated Low Fuel Indicator and Low Fuel Pressure Indicator.

5. **Coolant Temperature Gauge.** Indicates engine coolant temperature and includes an engine coolant temperature warning indicator.

6. **Oil Pressure Gauge.** Indicates engine oil pressure and includes an oil pressure warning indicator.

7. **Front Air Gauge.** Indicates air pressure in front brake reservoir and includes a low air warning indicator.

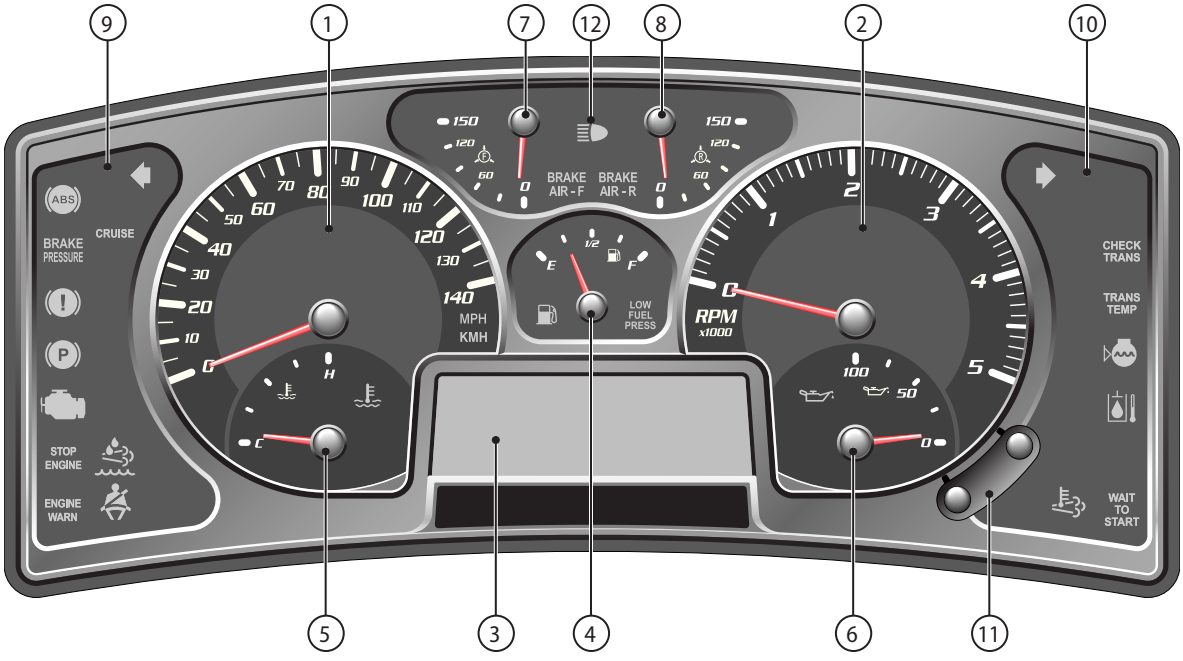
8. **Rear Air Gauge.** Indicates air pressure in rear brake reservoir and includes a low air warning indicator.

9. **Left Warning Bank.** Cluster of indicator lamps. See Warning Bank Indicators.

10. **Right Warning Bank.** Cluster of indicator lamps. See Warning Bank Indicators.

11. **Message Display Center Control Panel.** Two buttons which activate and toggle the menus of the Message Display Center. These buttons also serve as an Instrument Panel Dimmer, see *Dimmer Adjustment*.

12. **Headlight Highbeam Indicator.**

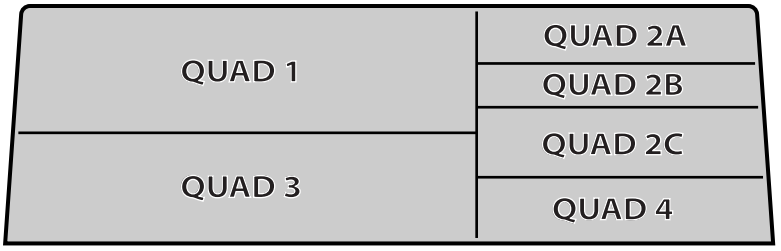


Message Display Center

The message display center provides additional information to the vehicle operator. It is a Liquid Crystal Display (LCD) screen located at the bottom center of the instrument panel and is divided into four quadrants. Each quadrant displays specific data relayed to the vehicle operator from vehicle systems. The message display center can also be used for diagnostic purposes by trained service technicians. The four quadrants of the display are selected and toggled by the two buttons on the message display control panel on the lower right side of the tachometer.


Message Display Control Panel

Quad 1. Displays the Odometer, Trip 1 Odometer and Trip 2 Odometer. The odometer registers the mileage on the vehicle and the trip odometers may be set to register mileage from destination to destination. On the message display control panel press



and release the top button to toggle between the odometer, and trip 1 and trip 2 odometer settings. Press and hold the top button to reset the trip odometer. After the bus has been turned off the odometer reading can be displayed by activating the headlights or by pressing either the top or bottom button. This quadrant also displays all general priority messages when triggered. In most cases, the priority message will flash between forward and reverse video. The priority messages can be acknowledged by pressing the bottom button or cycling the ignition. This will allow you to return Quad 1 to the previous display until the recurrence time-out, next ignition or the trigger logic is not satisfied. Any lamps associated with the acknowledged message will remain on until the fault is gone or the ignition is turned off. If multiple messages are present, they will cycle every two seconds.

Quad 2A. Displays Gear Selection. **P** - Park, **N** - Neutral, **R** - Reverse, and **D** - Drive.

Quad 2B. Displays alternator output voltage (in Volts) and depending on option, can display the amount of current being drawn by the vehicle electrical system (in Amps).

Quad 2C. Displays the transmission temperature. On buses equipped with and configured for air brakes the service brake pressures will be displayed, temporarily replacing the transmission temperature. This shows how much air pressure in psi (pounds per square inch) is being applied to the front and rear brakes when the brake pedal is pressed. On busses equipped and configured for hydraulic brakes, the transmission temperature will be temporarily replaced with the rear suspension air pressure when the service brakes are applied, if enabled. When the service brakes are not applied Quad 2C will return to Transmission Temperature.

Quad 3. Displays the diesel exhaust fluid (DEF) gauge. The DEF level is displayed as a percent of full tank (15 gallons) capacity.

Quad 4. Displays a clock. This clock can be displayed in either a 12 or 24 clock mode. This mode can be toggled by pressing and releasing the bottom button until Quad 4 is activated, then press and release both buttons simultaneously to highlight the quadrant in reverse video. Toggle between the two modes by pressing and releasing the top or bottom button. *Note: This quadrant configuration is for busses equipped with a 2010 emission compliant diesel engine (i.e. ISB10/ISC10). Busses equipped with an optional engine such as an export engine (i.e. ISB03/ISB05) may display information in alternate quadrants.*

Priority Messages

No Engine Communication
No Transmission Communication
No ABS Communication
Data Link Warning
Vehicle Speed Error
Engine Door Open
Brake Interlock Set
Brake Interlock Fail
Brake Interlock Requested
Retarder Applied
DEF Level Low
DEF Level Critical
DEF Level Derate
DEF Level Empty
DEF Speed Limit
DEF Fluid Type
* Stop Engine
* Engine Warning
* Hi Trans Temp
* Low Oil Pressure
* High Engine Temp
* Low Coolant Level
* Turn Signal On
* Voltage Error
* Water In Fuel
* Lift Not Stowed
* Regen Needed
* High Exhaust Temp
* Alternator Fail
* Headlights On
* ATC Active
* Range Inhibit
* Transmission Oil Life
* Trans Oil Filter
* Transmission Oil Service

** (Messages Shown with Icon)*

Warning Bank Indicators

Two arrangements of LED-illuminated warning lights provide feedback to the Driver about various systems. These are located to the right and left sides of the instrument panel. Indicator definitions are shown on the following page.

An audible speaker is incorporated into the back of the instrument cluster, and sounds to accompany the indicator light warnings. The audible alarm also serves to indicate turn signal blink and turn signal reminder.



Left Turn. Flashes with left turn signal.



ABS. Indicates fault in the anti-lock brakes system. Complete route then service as soon as possible.



Brake Pressure. Indicates brake failure. Stop vehicle and call for assistance.



Service Brakes. Indicates service brakes have been applied.



Park. Indicates parking brake is applied.



Maintenance Indicator Lamp. Indicates maintenance required.



Stop Engine. The engine ECU has detected a problem which can lead to engine damage. Stop the engine and call for assistance.

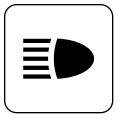


Engine Warn. The engine needs service.



Diesel Exhaust Fluid. DEF low level warning light.

.



High Beam. Headlights are in high beam.



Cruise. Cruise control has been activated.



Brake Air Front. Indicates front brake air pressure outside of normal operating range.



Brake Air Rear. Indicates rear brake air pressure outside of normal operating range.



Low Fuel. Indicates fuel level at 12 percent of maximum capacity.



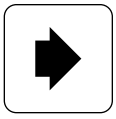
Low Fuel Pressure. Indicates low fuel pressure on compressed natural gas vehicles.



High Coolant Temp. Indicates coolant temperature out of normal operating range.



Seat Belt. Indicates driver seatbelt not engaged.



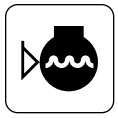
Right Turn. Flashes with right turn signal.



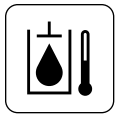
Check Trans. The transmission needs service.



Trans Temp. The transmission temperature is beyond normal operating range.



Coolant Level. Indicates low coolant level.



Hydraulic Fluid Temperature. The hydraulic fluid temperature is beyond normal operating range.



Wait to Start. Indicates engine preheating. Wait until indicator goes off before starting engine.



HEST. High Exhaust System Temperature. Indicates elevated exhaust temperature



Oil Pressure. Indicates low oil pressure.

Set the Clock

To set the clock, be sure the park brake is set then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move to the highlighted bar to menu item 6 – Set Clock. Press both buttons simultaneously to select "hours" then use the upper and lower buttons to increase or decrease the setting. Press both buttons simultaneously to set the hours. Repeat the process for the "minutes" setting. A lapse of ten seconds or more of inactivity will return the display to the previous screen automatically.



Message Display Control Panel

Dimmer Adjustment

Dimming or brightening the backlight in the instrument cluster can be accomplished two ways. The first is when the bus is stationary with park brake set. The second is in Drive Mode when the park brake is released and the headlight switch is in the "ON" position. In either case the new setting will be stored in memory.

When the bus is stationary and the park brake is set, dimming the instrument cluster is achieved through a menu in the drivers display in the cluster. Set the park brake then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move the highlighted bar to menu item 4 – Dimmer. Press both buttons simultaneously to select "dimmer" then use the upper and lower buttons to increase or decrease the backlight intensity. Press both buttons simultaneously to set the dimmer and exit the menu. A lapse of ten seconds or more of inactivity will return the display to the previous screen automatically.

If the bus is in drive mode by having the park brake released, the dimmer can be adjusted by pressing either the top or bottom buttons to brighten or dim the instrument cluster. The headlight switch must be in the "ON" position for this function to operate.

Contrast Adjustment

Set the park brake then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move the highlighted bar to menu item 3 – Contrast. Press both buttons simultaneously to select "contrast" then use the upper and lower buttons to increase or decrease the contrast. Press both buttons simultaneously to set. A lapse of ten seconds or more of inactivity while in this mode will return the display to the previous screen automatically.

Backlight Color Adjustment

The backlight color can be adjusted to illuminate in any of five different colors (Red, Green, Blue, Lt Blue, White). To change the backlight color set the park brake then press and hold the bottom button on the face of the instrument cluster for approximately 5 seconds. This will display the Settings and Diagnostics screen. Press either the top or bottom button to move the highlighted bar to menu item 5 – BL Color. Press both buttons simultaneously to select "BL Color" then use the upper or lower buttons to toggle between a list of preset colors. Press both buttons simultaneously to set the color and exit the menu. A lapse of ten seconds or more of inactivity while in this mode will return the display to the previous screen automatically.

Instrument Cluster Removal

The instrument cluster is designed for easy removal from its housing by means of screws around the perimeter of its face. The instrument cluster itself is not designed for disassembly and is removed as a unit.

1. Turn the iginition switch to the off position and remove the key. Lower the steering wheel to the bottom of its travel.

2. Remove the four screws from the corners of the instrument panel which houses the instrument cluster. This will allow access to the back of the instrument cluster for removal and installation.

3. Remove the seven machine screws from around the instrument cluster's perimeter. This will detach the cluster from the instrument panel.

4. Carefully rotate the instrument cluster and pull it away from the dash housing. Tilt the cluster face down to gain access to the back.

5. Disconnect the electrical connectors from the back of the instrument cluster and remove unit.

Instrument Cluster Installation

The installation of the instrument cluster is done in the reverse order of the removal. After it has been installed the Cluster must be configured or programmed to operate accurately for the bus it was installed. Failure to do this may result in inaccurate instrument readings.

1. Connect the electrical connectors to the back of the instrument cluster.

2. Carefully rotate the cluster and center it in the panel for attachment. Position the cluster so the mounting holes align. You will need to reach behind the panel to hold the cluster in position while securing the seven mounting screws.

3. Secure the panel by installing the four mounting screws located in each corner.

4. Enter the Configuration Menu to set-up specific features for your instrument cluster. To do this first be sure the ignition is in the off position. Press and hold the top and bottom buttons on the face of the cluster. While holding these buttons presses in, turn on the ignition. Release the buttons when a menu appears in the drivers information display. This display will allow you to set-up items in the configuration menu.

5. You can use the top and bottom buttons on the face of the cluster to scroll up or down. Press both buttons simultaneously to enter the configuration value. After entering the value the highlight bar will automatically move to the next item to be set –up. If the cluster has logged less than 25 miles all menu items can be changed. After 25 miles you will not be able to change some items, only user configurable items. See appendix 1 for more details. This menu will auto exit after 10 seconds with no activity.

Overview

Many of the Blue Bird Vision's electrical circuits communicate and interact with each other through an advanced Multiplex control system. This solid-state system provides significant advantages over traditional wiring:

- Multiplex simplifies the system by replacing multiple mechanical relays and switches with reliable solid-state components.

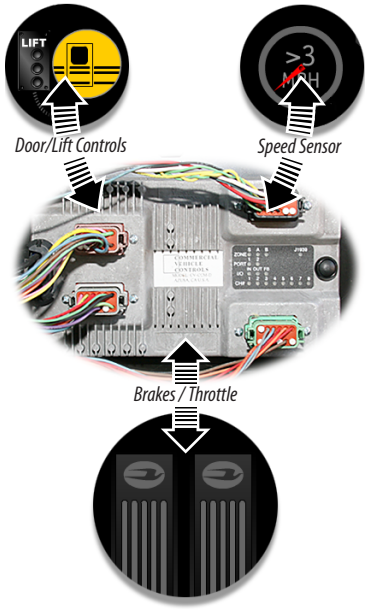
- Multiplex provides intelligent programmed (rather than mechanical) interaction between components. Multiple component signals are transmitted simultaneously along a common data bus, and are monitored and controlled by a digital microprocessor.

- The Multiplex system also serves as a centralized troubleshooting tool which simplifies the process of isolating causes of electrical malfunctions, without requiring special diagnostic hardware/software interfaces.

The Multiplex system may be thought of as similar in purpose and function to already-familiar electronic control devices such as the engine ECU, or the Weldon warning light control module. The main differences are that the programmable module of a multiplex system are programmed to control Blue Bird's chassis and body circuits, and provides information to the technician by means of a series of visible LED indicators rather than by means of special diagnostic interface tool.

The main components of the Multiplex system are the two control modules. The role of the modules are similar to that of a telephone switchboard which makes and breaks connections for multiple individual "calls" (between two components) and/or "conference calls" (between several components), simultaneously. Input signals from various circuits arrive at the modules input terminals. Inside the Module, the Inputs trigger Output signals which activate/deactivate other components or circuits. The programming of the main module determines which Input (or combination of Inputs) results in any particular Output being activated. Specific programming of the module is identified by the body number placed on the module after being programed at the factory.

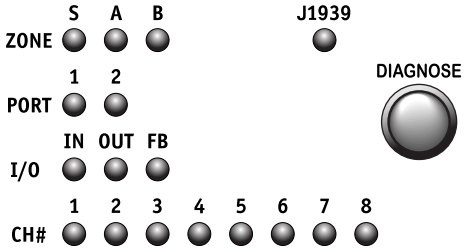
An array of Light Emitting Diodes (LEDs) provides the means by which a technician can visually monitor the individual Inputs, Outputs, and Feedbacks providing a quick means of diagnosing failures within the Multiplex systems. The technician uses a button to select which circuits to be monitored and the LED display indicates the status for that specific circuit. The system also generates a Feedback signal for each of its load circuits, and continually monitors the Feedback signals to verify the integrity of the circuits, much as a technician would use an Ohm meter to test continuity. To interpret the LEDs and better understand the logic (conditions required for the circuit to become active/functional) of a circuit, the technician refers primarily to two printed references presented later in this chapter: the Input/Output charts and the Ladder Logic Lines.



Multiplex System

The Brake & Throttle Interlock system is an example of how multiplexing handles simultaneous communications between seemingly unrelated components.

As with any new technology, troubleshooting and servicing a Multiplex system requires an initial familiarization, a firm conceptual understanding, and the acquisition of new skills (such as reading Ladder Logic Lines). However, Multiplexing does not supersede or invalidate what a qualified electrical technician already knows about troubleshooting and diagnosis. Rather, it provides a new and valuable tool to assist the qualified technician in narrowing down the source of a problem, thereby minimizing downtime and reducing operating costs.



CAUTION ***Failure to follow specific troubleshooting guidelines could result in damage to the multiplex system or other electrical systems on the bus.***

CAUTION ***Failure to confirm proper electrical component and system operation and failure to diagnose electrical problems and take immediate corrective action may result in electrical system damage and/or possible injury.***

Multiplex Terms:

Multiplex (MPX): A way of transmitting multiple lines of communications (signals) simultaneously on one data line. This is similar in principle to the J1939 data communication circuit which connects the engine, transmission, and ABS electronic modules together, providing multiple communications between their respective electronic control modules. The Vision's Multiplex system uses two modules containing microcomputer technology that allows the modules to communicate with one another electronically providing a modern method of electrical distribution, circuit control, and circuit protection.

Zone A: The portion of the Multiplex system controlling chassis circuits, Zone A consists of an electronic control module, Module A, and the surrounding area of circuits that interact with the module. Module A, the main MPX module, is located in the Power Distribution Unit (PDU).

Zone B: The portion of the Multiples system controlling body electrical circuits, Zone B consists of an electronic control module, Module B, and the surrounding area of circuits that interact with the module. Module B, the secondary module, is located in the Body Electrical Panel

Hard-wiring: A conventional method of designing an electrical circuit from the source to the load and back to the source using copper wire, switches, relays, circuit breakers, fuseable links, fuses and other non-electronic components.

MPX Input: Typically a ground or 12 volt signal supplied to the MPX module, a signal necessary for the MPX Module to produce an Output. An examle of an MPX Input is the hard wired signal from the turn signal switch that provides a ground to the MPX module when the turn signal is switched on. The programming of the MPX Module can require that a particular Input be either active (on) or inactive (off) in order to generate a particular Output.

Active Input:  An input which is in an "ON" state, A 12 volt potential or ground that exist at a specific input terminal on the MPX Module. The corresponding diagnostic LED should be ON.

Inactive Input:  An input which is in an "OFF" state, the absence of voltage potential or ground on a specific input terminal on the MPX Module. The corresponding diagnostic LED should be OFF.

Active Output:  An output which is in an "ON" state, A 12 volt potential or ground that exist on a specific output terminal on the MPX Module. The corresponding diagnostic LED should be ON.

Inactive Output:  An output which is in an "OFF" state, the absence of voltage potential or ground on a specific output terminal on the MPX Module. The corresponding diagnostic LED should be OFF.

Flags:  A Flag is an output that exits on the printed circuit board inside the Multiplex module. A Flag could be considered as part of the microprocessors logic or programing. Flags are generated when specific requirements have been satisfied much like a regular Multiplex output is generated. Each Flag will have its own logic line but will not be listed in the output table. A Flag will not have a connector, pin or output circuit associated with it. Therefore, a Flag by it's self is nonfunctional outside the Multiplex module. To become functional outside of the MPX module, a flag will be used as an input on a logic line that has a physical output.

A Flag may be thought of as similar to a shorthand way to refer to another logic line's function or set of commands. When a Flag is encountered somewhere along a logic line, its own logic line must be examined in turn to fully understand its function. Look at the description under the flag to the far right of each logic line to determine which line of logic you are searching for.

Logic Line: A graphical means of communicating the logic or the function of an electrical circuit that is controlled by the Multiplex system. It identifies the inputs, input status (active/on or inactive/off), the output, output status and other conditions required to activate a specific Multiplex output. Logic lines identify input and output LED addresses used in troubleshooting the system.

LED Addresses: An alpha-numerical code which denotes which arrangement of LEDs on the MPX Module A is associated with a particular Input or Output.

Timers. A Timer is an internal function generated by the Multiplex program. Activated by specific input(s), timers cycle the output of the logic line it is located on, on and off, according to a specific program. Example: turn signal, one second on, one second off.

Connector/Pin Addresses: An alpha-numerical code which denotes which physical connector pin on the MPX Module is associated with a particular Input or Output.

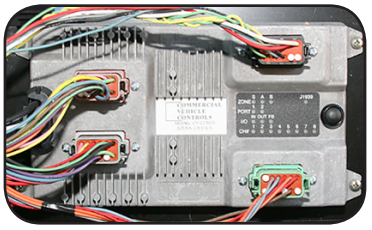
Dual Zone Multiplex (MPX) System

Blue Bird Visions manufactured on or after August 16, 2010, are manufactured with a Dual Zone multiplex system. The overall operation and functionality of the Dual Zone Multiplex system is very similar to the earlier system it replaces. The system involves electronic control modules that monitor specific circuit activity. When circuit activity corresponds with specific programming in the Multiplex microprocessors, an output command is issued and the MPX module provides an output to an electrical load. This basic functionality provides electrical distribution, circuit control and circuit protection for a large number of circuits in Blue Bird Vision electrical system.

The Dual Zone system also has the ability to simplify the troubleshooting process. An LED display continues to provide an at-a-glance account of input and output activity helping the technician locate difficulties in the electrical system. In fact, the expanded diagnostic capabilities of the Dual Zone MPX system represents a major improvement by monitoring chassis and body electrical circuits. All diagnostic LED's are located on Module A.

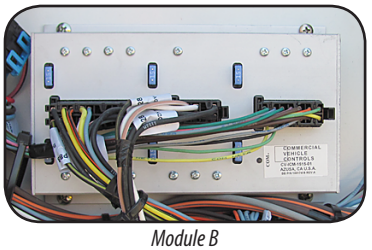
Although there are a number of similarities to the earlier MPX system it replaces, the Dual Zone system has some major enhancements that improve the overall operation and functionality of the system. The most noted changes of the Dual Zone Multiplex system are:

- The Multiplex Modules physical appearance.
- The Multiplex diagnostic button location on the module.
- The Multiplex system evolving into a two module system.
- The Multiplex systems ability to communicate electronically.



Module A

Located in the PDU to the right of the driver below the dash.



Module B

Located in the body electrical panel below the driver's side window.

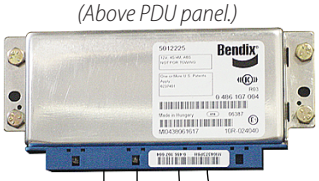
Although the physical appearances of the module does not enhance its ability to manage the electrical system, it is the most distinguishable feature of the Dual Zone system. The most noted change relating to appearances, one that does enhance the systems function, is the location of the diagnostic switch/button. The "Diagnose" button is located at the right edge of the MPX Module A inside the PDU. The function of the button is to initiate a diagnostic mode within the MPX system and to provide navigation to locate specific LED addresses. The Diagnose button and the LED display are located side by side on the same MPX module, adding convenience of operation but more importantly decreasing the chance of errors during diagnostic activity.

The most significant upgrade to the Dual Zone system is its evolution to a two module design. The electrical circuits managed by the Dual Zone system are divided into two specific ares of electrical distribution referred to as Zones. The portion of the multiplex system controlling chassis circuits is called Zone A. The portion of the multiplex system controlling body electrical circuits is called Zone B.

The method in which the MPX module communicates with other electrical systems on the bus has also evolved. For the first time the Multiplex system is connected to the J1939 data communication circuit. On buses built prior to August 16, 2010, the J1939 data circuit provides an electronic communication path between the engine ECM, the engine DCU, the transmission TCM, the Antilock Brake System ECU and the Blue Bird instrument panel. This data pathway forms a network of microprocessors that communicate large amounts of data electronically over two hard wired electrical circuits, referred to as the J1939 data communication circuit. The Dual Zone Multiplex system joins this network of data communication through a hard wired connection with Module A. The module has access to all of the data transmitted over the J1939 data network but is limited by its programing to interact with only three specific inputs; the Engine > 400 RPM, the Park Brake On and the Speed > 3 MPH. Similar electronic communications exist in a circuit between Module A and Module B. This circuit is not part of the J1939 data circuit but is considered a private data communications circuit. **See the J1939 Circuit Diagram on the following pages.**

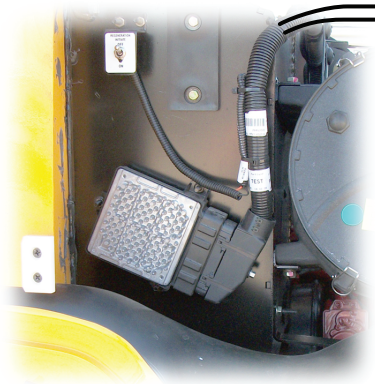
Module A and Module B operating and functional characteristics are very similar. The process of receiving and monitoring inputs using LED's and photo sensors are basically the same. A MOSFET, an electronic switching device that provides the electrical outputs for module A, is the same device that provides outputs for Module B. The major difference between the two modules is in the programming of the microprocessors within each module. Module A's microprocessor is programmed to compute circuit logic for each of the circuits the Dual Zone MPX system monitors. Both Modules are programmed to receive multiple inputs and provide specific outputs but only Module A has the specific programing that governs what conditions are required for a specific output to become active. Module B, operating as a secondary module relies on electronic communication between the two modules for vital operational commands. It relays input circuit status to Module A through the MPX Data Communication circuit. Depending on input circuit activity Module A transmits output commands back to Module B's microprocessor. Module B's microprocessor in turn activates a specific MOSFET that provides the actual output from the module to the electrical load.

ABS Electronic Control Module (Air)
(Above PDU panel.)

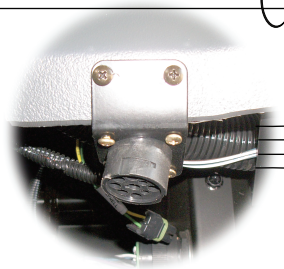


Note: *Hydraulic ABS Electronic Control Module is located inside the left frame rail mounted to the Hydraulic Modulator.*

J1587 Harness

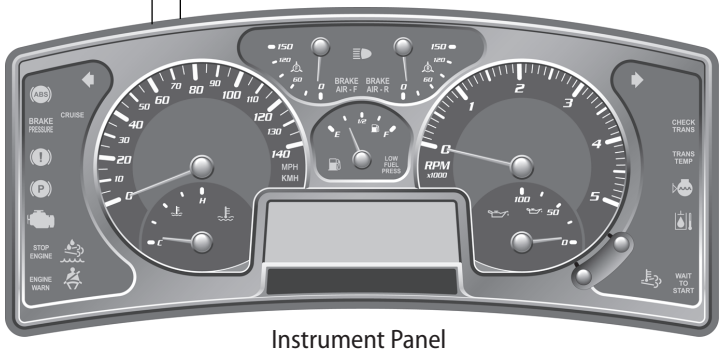


Transmission Control Module
(Right side , under hood, to rear of air cleaner, below regen switch.)

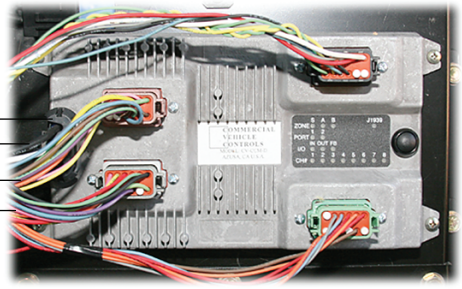


Diagnostic Interface Tool Port
(Under dash, between steering column and PDU.)

Original J1939 Harness



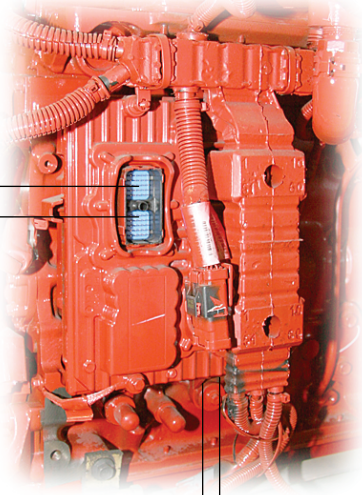
Instrument Panel



Chassis MPX Control Module Zone A
(Inside PDU panel.)

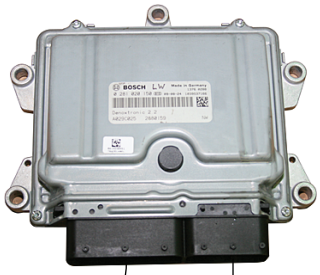
Terminating Resistor

Engine ECM
(Left side of engine block.)



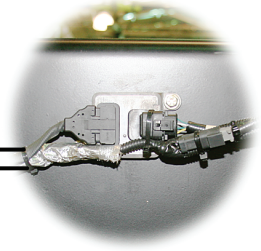
Terminating Resistor

Dosing Control Module
(Behind DEF tank, between frame rails.)



Private J1939 Harness

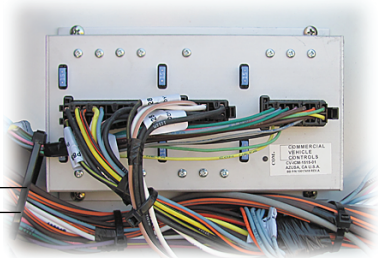
NOx Sensor & Module
(Outside surface right frame rail.)



2011 Visions with engines meeting 2007 emission standards.

2011 Visions with engines meeting 2010 emission standards.

Body MPX Control Module Zone B
(Inside body electrical panel.)

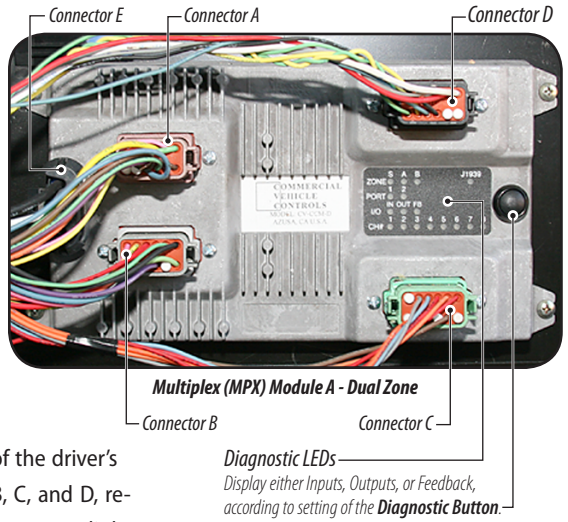


Private MPX Data Communication Circuit

2012 Visions manufactured on or after August 16, 2010.

Module A (Zone A)

Module A is the main control module in the Dual Zone Multiplex system and it only has one designation and part number. It's flexibility to manage and control the large number of variables in the chassis and body electrical systems comes from the flexibility of its microprocessor and programming. There are six specific programs available for Module A. The specific programming downloaded into the Module is related to the features (options) manufactured into the bus. Therefore the initial programming of the module is part of the manufacturing process. If a failure occurred with Module A, a new replacement module would be programmed by Blue Bird or a Blue Bird Dealer.



Multiplex (MPX) Module A - Dual Zone

The CV-CCM-D, A Module is mounted in the PDU to the right of the driver's area below the dash. Four connectors on the module labeled A, B, C, and D, receive Inputs from sensors and switches, and convey Outputs to actuators, lights, and other devices.

Four rows of LEDs indicate the status (active/on or inactive/off) of the circuits controlled by Zone A and Zone B:

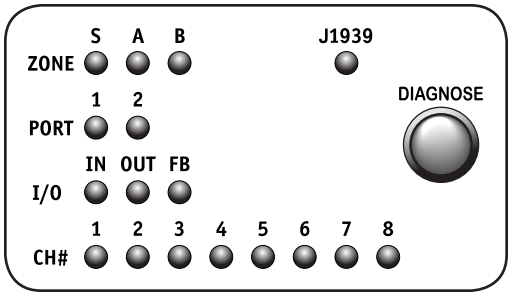
Zone: The top row consists of three LEDs, labeled S, A, and B. The Blue Bird Vision's Dual Zone Multiplex System is contained within Zone A and Zone B. (Note that all of the LED addresses shown in the Input and Output charts begin with "A" or "B".) When in the diagnostic mode, selecting Zone A by pressing the Diagnose Button, provides diagnostics for circuits controlled by Module A (chassis circuits) and selecting Zone B provides diagnostics for circuits controlled by the Module B (body circuits). Zone A and Zone B LEDs are the only functionally active LEDs for diagnostic purposes on the top row. The S LED indicates when the Multiplex System enters Sleep Mode by turning off and remains on during normal operation. When power is first applied to the system, all the LEDs come on momentarily, Zone A LED then blinks a number of times corresponding to the software programming installed in Module A. Finally, the Zone A and B LEDs go off and, the system is in its normal operating mode with only the S LED and the J1939 LED on. If the B LED is on while the MPX system is in a normal operating mode or flashing while in a diagnostic mode and Zone B is selected it indicates a communication failure between Module A and Module B.

Port: The two LEDs in this row correspond to internal ports (an interface between inputs/outputs and the circuit board) inside Module A or Module B. When in the diagnostic mode, these LEDs indicate which one of the internal ports is presently being monitored.

I/O: When in the diagnostic mode, the three LEDs in this row, labeled IN, OUT, and FB, indicate whether the row of eight CH# LEDs are monitoring Inputs or Outputs or Feedback. Note: The Feedback LED's are nonfunctional when zone B is selected.

CH#: When in the diagnostic mode, the bottom row of eight LEDs indicate the current state (active on or inactive off) of the specific Input or Output or Feedback circuit being monitored.

J1939 When the J1939 LED is on it indicates there is communication between Module A and the J1939 data communication circuit. During normal operation the J1939 LED may flash. When the J1939 LED is off and the ignition is on it indicates a communication failure between Module A and the J1939 data communication circuit.

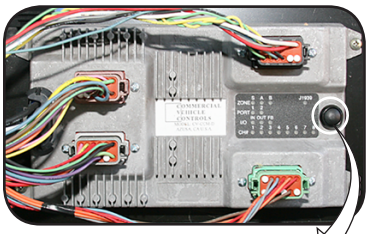


Diagnostic Mode

The LED's are used to simplify the troubleshooting process. The status of each input and output circuit can be monitored by using the "Diagnose" Button to select a specific LED address. In much in the same way a person delivering the US Mail would review a three or four line mailing address, to identify the specific area of the US, the state, the city and the specific mail box, to know where to deliver a specific piece of mail, a technician would review an LED address relating to the Zone, Port, I/O, and CH# to locate a specific LED. Each address references a specific LED that corresponds to a specific input or output that interacts with the Multiplex system. Once located, the LED will indicate the status active (on) or inactive (off) of the circuit in question.

Pressing the Diagnose Button one time activates the on board Multiplex diagnostics. This links the external LED's on Module A with the internal functional LED's located on the printed circuit board inside of Module A and Module B. This provides a means of monitoring any input or output interacting with MPX system. Selecting a specific LED address can be accomplished by pressing the Diagnose Button repeatedly until the address can be viewed. However, the diagnostic LED's will activate in a sequence relating to the number of times the diagnose button is pressed. Each subsequent press of the button cycles through the Zone, Ports, and I/O menu in the following order:

1st press:	**Puts the Module in Diagnostic Mode, displaying Zone A, Port 1 Inputs.**
2nd press:	**Zone A, Port 1 Outputs.**
3rd press:	**Zone A, Port 1 Feedbacks.**
4th press:	**Zone A, Port 2 Inputs.**
5th press:	**Zone A, Port 2 Outputs.**
6th press:	**Zone A, Port 2 Feedbacks.**
7th press:	**Zone B, Port 1 Inputs.**
8th press:	**Zone B, Port 1 Outputs.**
9th press:	**Zone B, Port 2 Inputs.**
10th press:	**Zone B, Port 2 Outputs.**
11th press:	**Ends Diagnostic Mode. Only the Sleep LED and the J1939 LED remains on.**
Note:	**Feedbacks are not supported by the B module.**

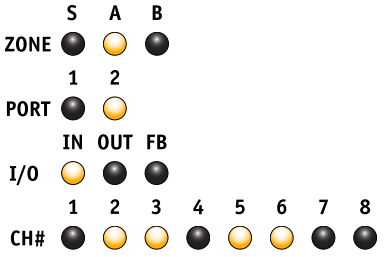


Diagnostic Mode Button
Cycles the MPX display through Ports, Inputs, Outputs, and Feedbacks.

Example

The following LED address, A2 - I05 is the input address for the Start Switch input circuit. Locating this address would require pressing the Diagnose button four times to access Zone A, Port number two, Input and the technician would observe the fifth CH# LED to see if it is active or inactive.

For a better understanding of applying LED Diagnostics and a general troubleshooting scenario involving an electrical failure diagnosed by the Multiplex system, review the Troubleshooting Example at the end of this chapter.



In this example, the LEDs are indicating the A2 Inputs. . .

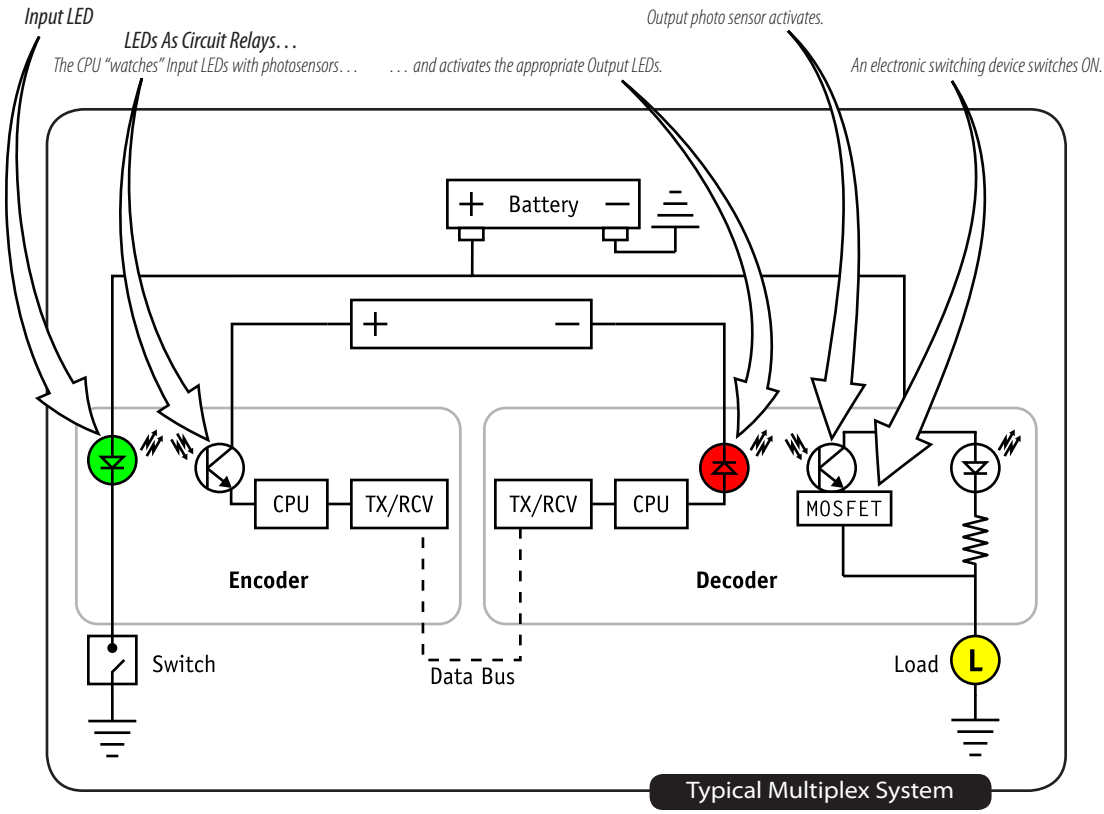
LED on
LED off

CAUTION ***Failure to confirm proper electrical component and system operation, failure to diagnose electrical problems and take immediate corrective action using industry guidelines and Blue Bird guidelines may result in electrical system damage and/or possible injury.***

Both Multiplex modules manage inputs and outputs using similar internal components and processes. The following illustration represents the basic functional processes that occur each time the MPX Module activates an output. Having an understanding of these internal processes should provide the technician an advantage when troubleshooting a circuit controlled by the MPX system. Except for the battery the input switch and the output load, the components illustrated are located on the printed circuit board inside the Multiplex Module.

All outputs generated by the Multiplex Modules are initiated by one or more inputs becoming active or inactive. The specific requirements necessary to produce an output is defined by circuit logic (reference specific ladder logic line) and controlled by the microprocessor inside the module.

Each input circuit connected to the MPX Module has its own dedicated LED that activates when the input circuit becomes active. Light generated by the LED is detected by a dedicated photo sensor that relays a signal to the MPX microprocessor or CPU. When one or more specific inputs are active, or inactive according to circuit logic, circuit logic has been satisfied and the MPX microprocessor will activate the appropriate output LED.



Typical Multiplex System

Light generated by the output LED is detected by a dedicated photo sensor. The photo sensor activates an electronic switching device called a MOSFET which supplies a 12 Volt output (some ouputs are Grounds) to the electrical load.

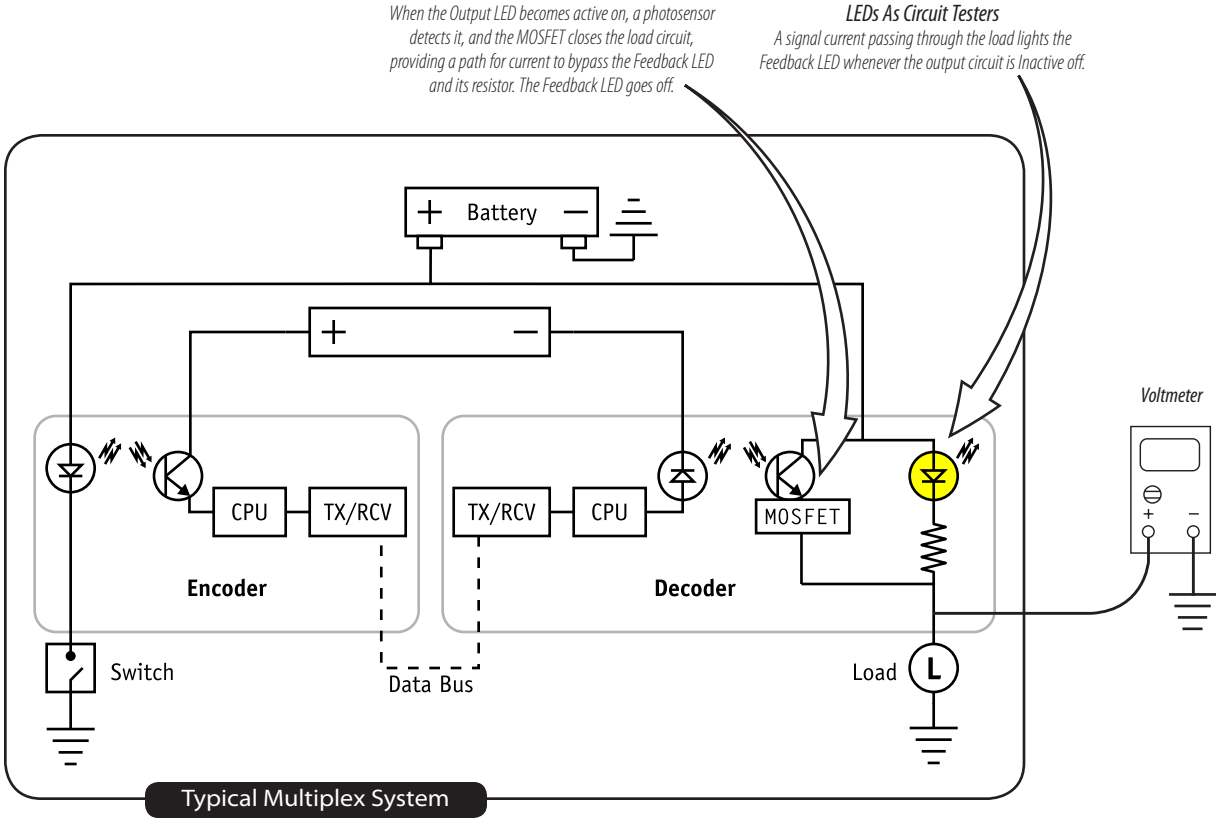
The air gap between the input and output LED's and it's matching photo sensors optically isolates the sensitive microprocessor inside the MPX Module from potential electrical noise in the bus electrical system.

Feedback Circuits (Module A Only)

Internal Feedback circuits in Module A are connected in parallel to the load side of Output circuits. A Feedback circuit conducts a faint current through the load, a resistor, and the Feedback LED. Thus, when the module is set, in a diagnostic mode, to display Feedbacks, each of the bottom row LEDs acts much like a conventional ohm meter, indicating the integrity (continuity) of the load side of the circuit it monitors.

When the load circuit is switched on, full working current is able to bypass the Feedback LED circuit. This removes the voltage differential across the LED and resistor, and the LED goes off.

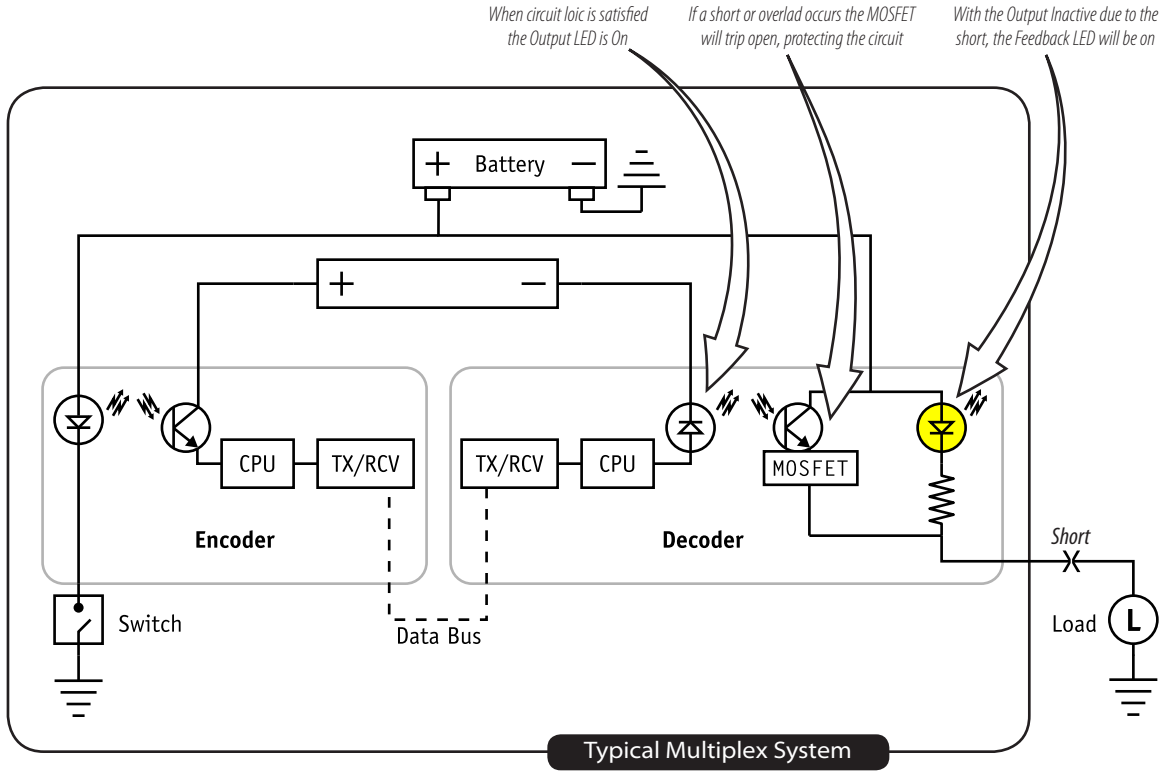
Thus, in a properly performing load circuit, the Feedback LED should be on (indicating that the circuit is ready) when the output circuit is Inactive; and should be off when the circuit is Active. If the Feedback LED is on while the circuit is Active, this is an indication of a short in the load side of the circuit or a failed MPX Module. *Note: Module B does not support Feedback monitoring for any of the output circuits it controls.*



Typical Multiplex System

Module A, Output and Circuit Protection

Module A has been designed to provide a specific output when input circuit logic has been satisfied. The specific pin and connector number for each output can be identified by referencing the output table for Module A. Each output circuit is activated and protected by an electronic device located inside of the module, called a MOSFET. A MOSFET is a metal oxide semiconductor field effect transistor or in simpler terms an electronic switching device with circuit protection capabilities. The MOSFET receives a signal from the microprocessor when input circuit logic has been satisfied. The MOSFET will activate (turn on) and supply 12 volts/ground (reference output table) to meet the electrical load requirements for that circuit. When the microprocessor deactivates the signal to the MOSFET, the MOSFET opens deactivating (turns off) the output circuit. In this function the MOSFET works similar to a regular transistor or relay, switching a circuit on or off electronically according to a signal from the microprocessor. In the event a fault occurs in the circuit, the circuit is overloaded or a short to ground occurs, the MOSFET reacts similar to a circuit breaker by deactivating the output and protecting the circuit. The MOSFET will continue to hold in the open mode as long as the electrical fault is active. When the fault has been corrected the MOSFET will revert back to its transistor mode activating and inactivating the output depending on the signal from the microprocessor. The circuit may have to be cycled on and off before the MOSFET will reset and operate as a transistor. The MOSFET is the only circuit protection device protecting the individual output circuits generated by Module A. Module B outputs are protected in a similar way but they also have a secondary protection device.



Typical Multiplex System

Module B (Zone B)

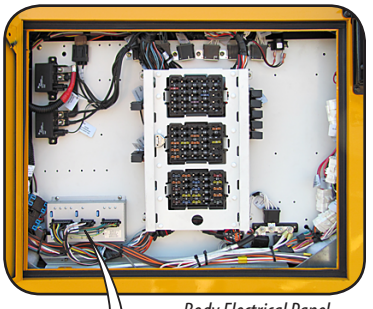
There are three specific body control modules available for the Blue Bird Vision. The particular module installed on a bus depends on the specific options the bus is manufactured with. The three modules are identified by the last digit of the model number.

BCM Model	Description/Application
CV-ICM-1515-01	Standard School bus application
CV-ICM-1515-02	School bus, warning light pilot (incandescent)
CV-ICM-1515-03	School bus, warning light pilot (LED)

For a more detailed explanation of the modules operating characteristics we will reference a standard school bus with a CV-ICM-1515-01 Module B installed in the body electrical panel, unless stated otherwise.

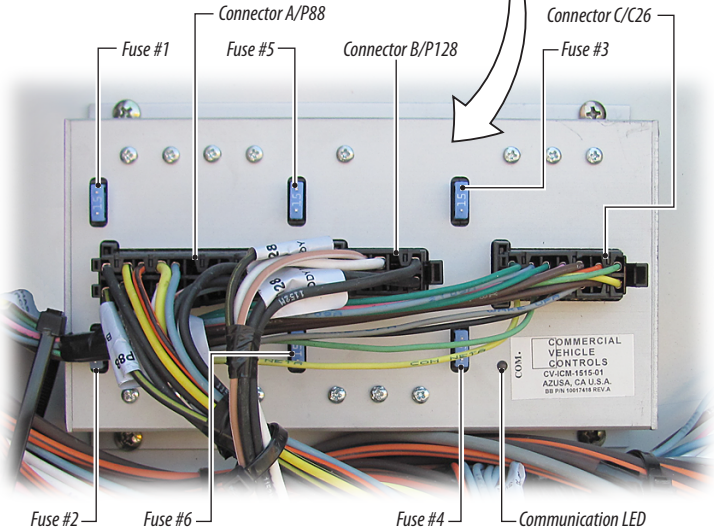
All MPX Module B's programmed and designated for standard school bus application will function identically and can be installed on any Blue Bird Vision manufactured on or after August 16, 2010 with a standard electrical system. There are no variations between modules with the same model number. Module B should never need reprogramming. If a module fails it would be replaced with a new module having the same programming and designation.

Module B, is located in the body electrical panel. The module is equipped with a 18 pin electrical connector A/P88, a 10 pin electrical connector B/P128 and a 14 pin electrical concector, C/C26 for interfacing with the bus electrical system. Note: Reference decal in body electrical panel and or Module B's input output tables.



Body Electrical Panel

Module B receives a 12 Volt and ground input from the bus electrical system to power its microprocessor and other internal electrical/electronic requirements. There are five other 12 Volt inputs connected to the module. They are designated to supply specific 12 Volt output requirements from the module. There are two other ground inputs that are designated to supply specific ground output requirements from the module (reference Zone B/Module B, Power & Communication Table). The remaining pins in connector A, B and C provide an interface for input and output signals relating to each of circuits manages/controlled by the module.



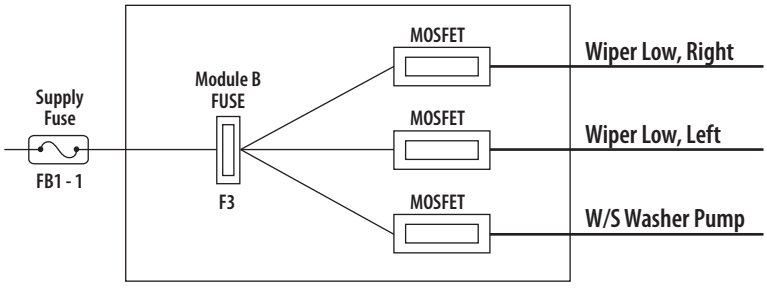
Multiplex Control Module B

Module B, Output and Circuit Protection

Module B has been designed to provide a specific output when input circuit logic has been satisfied. The specific pin and connector number for each output can be identified by referencing the output table for Module B. Each output circuit is activated and protected by an electronic device located inside of the module, called a MOSFET. A MOSFET is a metal oxide semiconductor field effect transistor or in simpler functional terms, its an electronic switching device with circuit protection capabilities. The MOSFET receives a signal from the microprocessor when input circuit logic has been satisfied. The MOSFET will activate (turn on) and supply 12 volts to meet the electrical load requirements for that circuit. When the microprocessor deactivates the signal to the MOSFET, the MOSFET opens deactivating the output circuit. In this function the MOSFET works similar to a regular transistor or relay, switching a circuit on or off electronically according to a signal from the microprocessor. In the event a fault occurs in the circuit, the circuit is overloaded or a short to ground occurs, the MOSFET reacts similar to a circuit breaker by deactivating the output and protecting the circuit. The MOSFET will continue to hold in the open mode as long as the electrical fault is active. When the fault has been corrected the MOSFET will revert back to its transistor mode activating and inactivating the output depending on the signal from the microprocessor. The circuit may have to be cycled on and off before the MOSFET will reset and operate as a transistor. The MOSFET is the primary device protecting the individual output circuits generated by Module B.

Six automotive style fuses are located on the front of Module B. Each fuse provides a function similar to a master fuse. They protect a designated group of output circuits but their main function is to protect internal components of the control module. If an electrical fault occurs, creating a spike (a very quick high current draw) within the circuit or if the total load of a specific group of circuits exceeds the rated amps, the fuse will blow protecting the circuits and the internal components of the module. The fuses provide a secondary protection device for circuits managed by Module B. The decal in the body electrical panel access door will identify each fuse, its rating, its location and the circuits each fuse protects. Module B's Output Table also references the fuse location on the front of the module.

As indicated in Module B's Current Flow illustration, electrical current will flow through three circuit protection devices for all circuits controlled by Module B; A **Supply Fuse** located in one of the three fuse blocks located in the body electrical panel; A Module **B Fuse** located on the front of the Module and the **MOSFET** located inside Module B.



Typical Module B Current Flow

Sleep Mode

To minimize battery draw while the bus is not in operation, modules A and B of the Multiplex system automatically go into a low current-draw Sleep Mode 30 minutes after ignition is turned off. The Modules awaken from Sleep Mode when either the ignition switch is turned on or one of a number of other circuits is used, i.e. headlights, stoplights, directional lights, park/tail lights, horn, or accessory switch. There is a slight delay while the system is awakening from Sleep Mode. This is evident by a two or three second delay in the instrument panel activating.

Multiplex Input & Output Tables

Two printed references are provided to assist the technician diagnosing issues with electrical circuits that are managed by the by the Multiplex system.

Input and Output Tables

The first step in troubleshooting an electrical problem on a Blue Bird Vision is to determine whether the affected or suspected circuit is part of the Multiplex system. The Input and Output Tables included in this chapter list the circuits with which the Multiplex system interacts. The Tables can be used as a quick reference to determine if the circuit in question is controlled by the Multiplex system, indicating the on board LED diagnostics should be used for troubleshooting the electrical failure. The Output table also provides a quick reference for the next step involved in the troubleshooting process. It identifies the specific ladder logic line relating to the electrical circuit that has failed.

Multiplex Input Table. The Inputs Table lists the circuits from which Module A and B receives on/off 12 volt/ground Input signals.

The second column (LED Address) shows the Input "LED address" of each Input circuit connected to the MPX Modules. These addresses relate to specific input LED locations, and are also indicated on the Ladder Logic Lines. For example, the Starter Switch input LED address is A2-I05 (Zone A, Port 2-Input number 05).

The third column (Connector/Pin number) shows the physical pin location of the circuits; which Pin of which Connector on the MPX Module to which the Input circuits are connected. For example, the Input circuit leading from the start terminal on the ignition switch is connected to Module A through pin number 8 connector A.

The fourth column (Circuit ID) list the circuit identification.

The fifth column (Wire Color) list the circuit color code.

The sixth column (Input) indicates whether the input signal is a 12 volt signal or a ground signal or if the signal is communicated electronically by the J1939 data communication circuit.

The last column (Wake Up) indicates which of the input circuits, when activated, will cause the A module to exit the sleep mode, wake up and become operational.

Multiplex Output Tables. The Outputs table lists the circuits for which Module A and Module B issues on/off 12 volt/ground Outputs. This list provides a Quick Reference to determining if an electrical failure is part of the Multiplex electrical system.

The second column (LL Line #) is the specific Ladder Logic Line which describes the requirements for the specific Output to become active. The second step in diagnosing a failure in an electrical circuit controlled by the MPX system is to locate the Logic Line specific to the Output that has failed. For example, to troubleshoot the Starter Relay Output, you would refer to the Ladder Logic line number 15 which describes the requirements for a Starter Relay Output (Note that the LED Address, Zone/Port-Output#, for the Starter Relay Output is the item at the right end of the Logic Line 15.

The third column (Connector / Pin Number) shows the physical pin location of the circuits; which Pin of which Connector on the MPX Module to which the Output circuits are connected. For example, the Starter Relay Output signal wire is connected to the A module through pin number 3 of the B connector.

The fourth column (Circuit ID) and fifth column (Wire Color) list the output circuit Identification and its color code.

Column number six (Output) indicates whether the Output is a ground or a 12 Volt signal when the Output is activated.

The seventh column (LED Address) shows the Output "LED address" of each Output circuit connected to the MPX Modules. These addresses relate to specific output LED locations, they are also indicated on the Ladder Logic diagrams. For example, the Starter Relay Output LED Address is A2-O06 (Zone A, Port 2-Output number 06).

The eighth column (Circuit Protection) indicates the Amp rating of the MOSFET protecting the circuit. Similar to a fuse or circuit breaker rating, the Circuit Protection indicates the electrical load that will cause the MOSFET to open, deactivating and protecting the circuit.

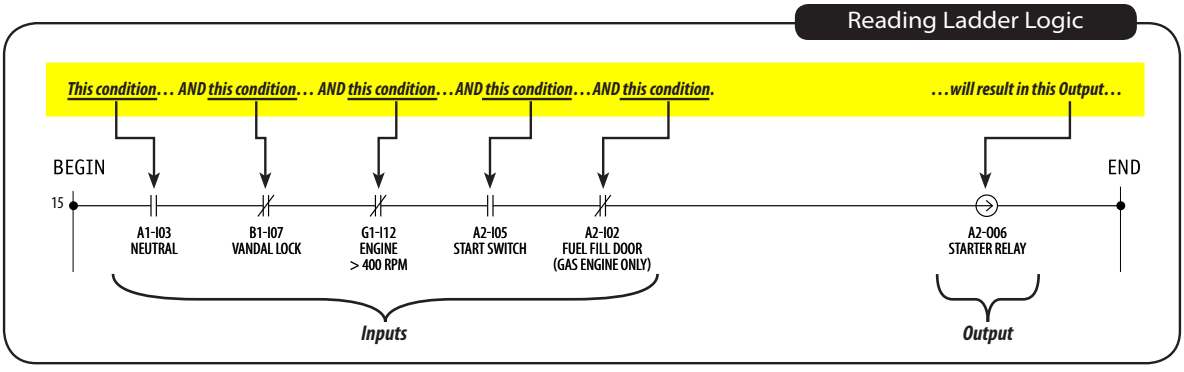
Zone B/Module B Output Tables have two additional columns. The ninth column (Module B Fuse) indicates which fuse, mounted on the front of Module B, provides circuit protection for a specific output circuit or a group of output circuits. The fuses actually provide internal component protection, for Module B, and a secondary circuit protection for outputs circuits.

The last column (Input Pin / Con.) indicates the specific input source pin and connector providing electrical power for a specific output or group of outputs.

Reading Ladder Logic Lines

The Ladder Logic Lines are not wiring schematics. They are lines of "logic," (conditions or rules) which the Multiplex program follows to determine which Input or set of inputs and/or other conditions results in a particular output becoming active. Each horizontal logic line graphically describes a set of requirements to activate the Output indicated at the right end of the line. The conditions required to activate the output will be indicated on the left of the logic line. A ladder logic line provides a means of communicating circuit logic and or circuit function. To understand and troubleshoot an electrical circuit a technician needs to know the purpose/function of the circuit and what conditions are necessary for the MPX system to activate the circuit. A specific logic line can be located by referencing the first column in the output table or by reviewing the output description indicated on the far right of the logic line. Each logic line is identified by it's output description and referenced with a number to the left of the logic line.

The logic lines located in this manual represents logic programing specifically for a "standard" school bus application. Buses manufactured with certain features will have some variations in the logic lines relating to that specific feature. If needed, your Blue Bird Dealer can provide the ladder logic lines specific to the body number of a particular bus.



Each logic line consists of a horizontal line with a description of all inputs and input status necessary to make the circuit function on the left and the output being activated on the far right. Each logic line will have one or more inputs but will only have one output. The description of each input and output is placed just below the horizontal line. A logic or status symbol is placed above each input and output description. This symbol indicates the state of each input or output, if they should be active (on) or inactive (off). Circuit logic may require some inputs on a logic line to be active while requiring other inputs on the same logic line to be inactive before the microprocessor in the module will activate a specific output. When all of the inputs on the logic line are set according to the logic symbols (active/on or inactive/off), it is said that, circuit logic has be satisfied and the microprocessor in the MPX Module will signal for the output to become active.

Each input and symbol on a logic line represents one particular requirement for the Output indicated at the right end of the line to become active. Reading a line from left to right, *all* of the requirements encountered along the path must be satisfied in order for the Output at the right end of the line to occur.

Thus, troubleshooting a circuit which interacts with the Multiplex system involves finding the Ladder Logic line or diagram for the desired Output; and then systematically verifying each of its requirements by comparing the chart to what is actually happening according to the diagnostic LEDs on the MPX Module. When a discrepancy is found, (When the symbol on the logic line indicates the LED should be ON but is found to be OFF) it is an indication that the problem exists "upstream" from that point, most likely one of the inputs has failed.

Ladder Logic Symbols

Following is a description of the symbols which appear on the Ladder Logic Lines:

Active Input: An input which is in an "ON" state, A 12 volt potential or ground that exist at a specific input terminal on the MPX Module. The corresponding diagnostic LED should be ON.

Inactive Input: An input which is in an "OFF" state, the absence of voltage potential or ground on a specific input terminal on the MPX Module. The corresponding diagnostic LED should be OFF.

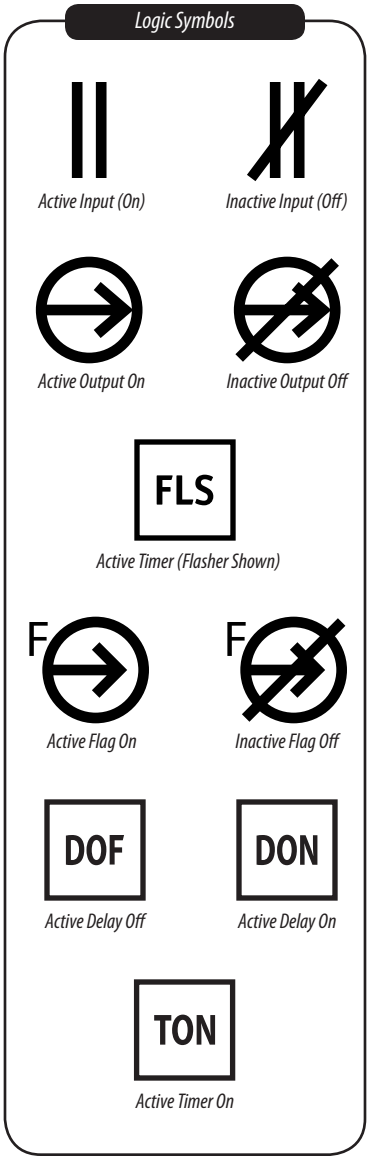
Active Output: An output which is in an "ON" state, A 12 volt potential or ground that exist on a specific output terminal on the MPX Module. The corresponding diagnostic LED should be ON.

Inactive Output: An output which is in an "OFF" state, the absence of voltage potential or ground on a specific output terminal on the MPX Module. The corresponding diagnostic LED should be OFF.

Timers. A Timer is an internal function generated by the Multiplex program. Activated by specific input (s), timers cycle the output of the logic line it is located on, on and off, according to a specific program (example: turn signal, one second on, one second off).

Flags. A Flag is an output that exits on the printed circuit board inside the Multiplex module. A Flag could be considered as part of the printed circuit boards logic or programing. Flags are generated when specific requirements have been satisfied much like a regular Multiplex output is generated. Each Flag will have its own logic line but will not be listed in the output table. A Flag will not have a connector, pin or output circuit associated with it, therefore a Flag, by it's self, is nonfunctional outside the Multiplex module (no physical output). To become functional outside of the MPX Module, a flag will be used as an input on a logic line that has a physical output.

A Flag may be thought of as similar to a shorthand way to refer to another logic line's function or set of commands. When a Flag is encountered somewhere along a logic line, its own logic line must be examined in turn to fully understand its function. Look at the description under the flag to the far right of each logic line to determine which line of logic you are searching for.



The following example, logic line number 27 is the Right Hand (RH) Wiper Low logic, further explains how a logic line communicates circuit logic and function. To simplify the example further we will assume the RH wiper low logic line only has one horizontal input line as indicated below.

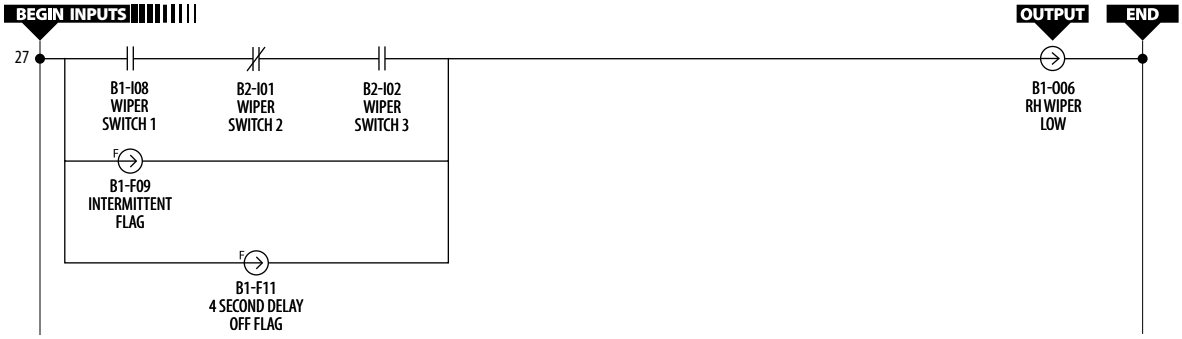


Reading and understanding a logic line is similar to reading a sentence from left to right. Reading the RH wiper, low logic line indicates Module B will activate (turn on) an output to the RH wiper motor when three conditions exist: (1) Module B receives an active input from wiper switch 1; (2) Module B senses an inactive input from wiper switch 2; (3) Module B receives an active input from wiper switch 3. To meet or satisfy circuit logic the microprocessor is programed to activate a RH wiper low output on pin number 5, connector C (reference output table) when all three of these conditions exist. It makes no difference in what order each input and input status is satisfied, Module B must see all three conditions. Although all three inputs in this example originate from the same switch, the wiper switch, they represent individual inputs into Module B and should be considered as such.

Reading the logic line from left to right provides all the necessary inputs, input status (active/on or inactive/off) and the specific output that will be activated when all the requirements are satisfied. If you think of a ladder logic line as a formula, it could be written as: inputs + input status = output.

Some Logic Lines provide alternate paths by which to reach the Output at the right end. These alternate paths may be thought of as logical "or" statements. If a requirement on one path is not met, the Output may still be achieved if all of the requirements of an alternate path are met.

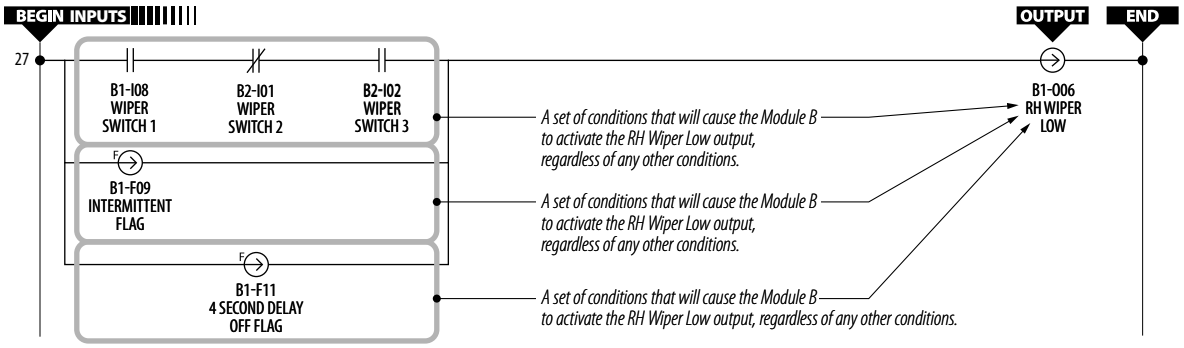
If there were only one horizontal input line on the RH wiper, low logic line, meeting the three conditions discussed in this example would be the only way to activate the RH wiper motor on low speed. However, there are three horizontal input lines for the RH wiper, low output logic line.



Each of the three horizontal input lines represents a separate logic path or set of conditions, if satisfied, would result in Module B activating an output to the RH wiper motor. The first set of conditions, the top line of inputs, has already been discussed. If Module B receives an active input from wiper switch 1 and senses an inactive input from wiper switch 2 and receives an active input from wiper switch 3, regardless of any other conditions, it will activate a RH wiper motor low output. The second set of conditions, the middle line with only one input, will activate the RH wiper motor output when the "Int Flag" (intermittent wipers) become active regardless of any other conditions. The third set of conditions, the bottom line, will activate the RH wiper motor output when the "4 Second Delay Off Flag" (provides 4 seconds of wiper operation after the washer pump is inactivated) becomes active regardless of any other conditions. The point to understand is: each individual set of inputs (top or middle or bottom) regardless of any other condition, represents a logic path that, if satisfied, would activate the RH wiper motor low output.

Logic lines having multiple input lines come in various configurations. Each horizontal input line represents a potential logic path. The vertical lines connecting the horizontal input lines also create a potential logic path. A logic line having multiple input lines provides multiple conditions or sets of conditions to activate the same output. Simply trace the multiple logic paths from begin (far left) to end (far right) one at a time in your mind, moving left to right, up and down without backing up. You will always start at the beginning on the top line and end up on the top line with the output. If there are three input lines, as in logic line 27, you should be able to trace three input logic paths from beginning to end. The inputs and input status encountered on each individual path would represent a unique set of conditions necessary to activate the output regardless of any other condition. During the tracing process some overlap of horizontal and vertical lines may occur, therefore, the same input(s) may be encountered on multiple logic paths.

If the RH wiper, low circuit were designed with the same logic but without using electronic controls it would consist of an interacting series of multiple relays and integrated hard wired circuits. By managing some of the body electrical circuits with the MPX system, Module B eliminates part of the dated electrical systems and simplifies body electrical logic and function.

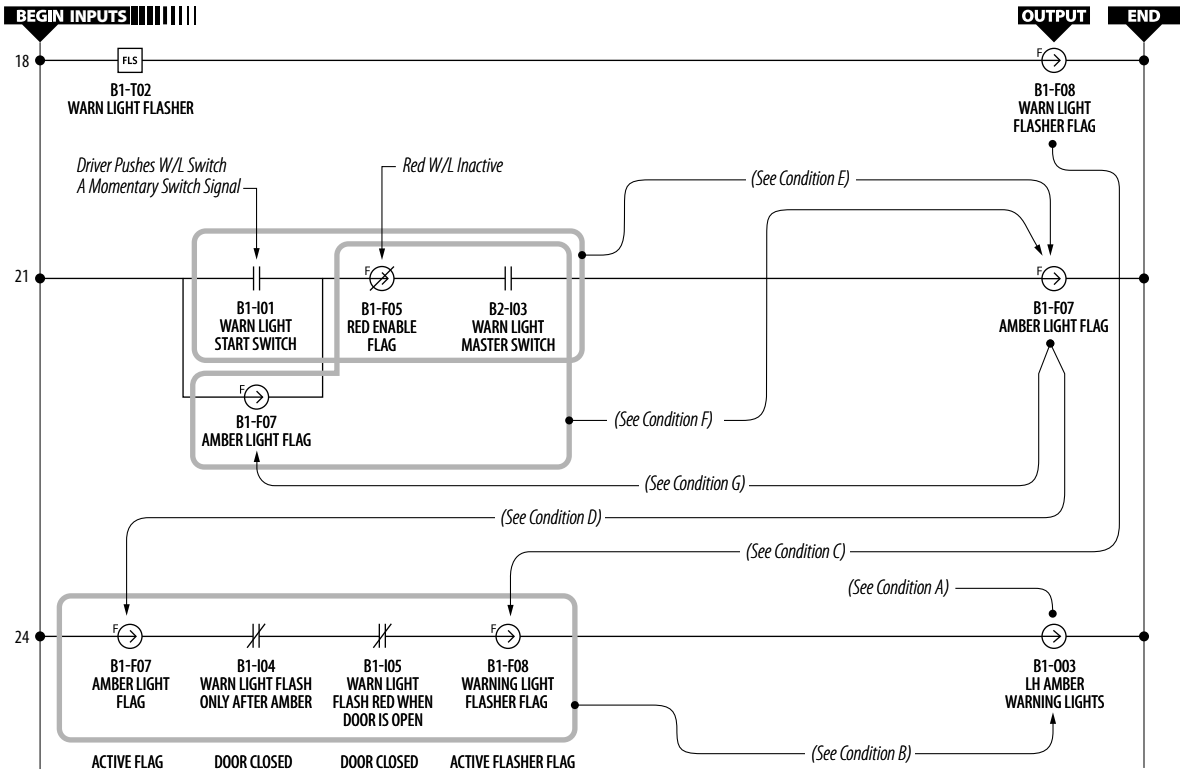


As indicated in logic line 27, some of the inputs required to generate a RH wiper low output are called Flags. The technical terms indicate a flag is an output that exits on the printed circuit board inside the Multiplex module. A Flag could be considered as part of the microprocessors logic or programing. Flags do not have external outputs and are not listed in the output table. They are generated in much the same way as a regular output (an output having a physical external output from the Module) is generated. Each flag requires specific inputs and correct input status to activate its output. All Flags have their own logic line to convey it's logic and function. A flag has a similar symbol as a regular output but with an "F" placed just outside of the circle (see Logic Symbols).

The symbol representing a flag can be encountered on both ends of a logic line. A flag symbol will be located on the far right of its own logic line indicating it is an output. When a Flag symbol is encountered on the left side of a logic line it is being used as an input, and represents a condition that must be satisfied to generate a specific output. To understand the logic or function of a flag when it is encountered as an input you would need to locate the logic line for that flag. Review the output description of each logic line until you locate the flag in question. The input(s) and input status(es) required to activate the flag would be located on the left. Read the logic line from left to right as you would a logic line having a regular output.

To further explain the function of a flag reference logic line 18, W/L (Warning Light) Flasher Flag. The only input required to generate a W/L Flasher Flag is an active W/L Flasher. The W/L Flasher input represents an electronic timer circuit generated inside Module B. When activated, this input will provide an alternating switch/on switch/off function. By itself, the W/L Flasher Flag is non-function outside of the of the Multiplex module. Flags do not have external output circuits. Only when the W/L Flasher Flag is placed on the input side of a logic line, that has an external output, will it become externally functional by cycling that output on and off. When the W/L Flasher Flag is placed on the LH Amber W/L logic line it becomes externally functional by cycling the LH Amber W/L output circuit on and off.

The following example will explain the inter action of multiple logic lines to produce one functional output. In this example we will assume there is a failure in the Left Hand Amber W/L circuit. Troubleshooting would start by identifying the Left Hand Amber W/L circuit is controlled by the Multiplex system and then locating the logic line specific to that output. The Left Hand Amber W/L output is located on logic line number 24 as indicate by the output table. The following example and conditions provide a logical sequence for troubleshooting the Left Hand Amber W/L failure.



Condition A: The Left Hand Amber W/L Output symbol represents an active signal to the LH Amber W/L MOSFET to activate and supply a 12 volt output to the LH Amber WL output circuit.

Condition B: A set of Inputs and input status (conditions), if satisfied, will cause Module B to activate the LH Amber W/L Output.

Condition C: The W/L Flasher Flag is an active output internal of the MPX Module, it is generated by the internal W/L Flasher which is a timer circuit controlled by the MPX microprocessor. When activated The W/L Flasher Flag will alternately activate (turn on) and inactivate (turn off) the output of the logic line it is located on. It is used in this example on logic line 24 to turn on and off the Left Hand Amber W/L output.

Flags are outputs generated and used inside the MPX Modules, they do not have external outputs and do not show up on the output table. For the W/L Flasher Flag to be functional external of Module B it must be used as an input on a logic line that has a physical output.

Condition D: The Amber Light Flag is an active output used internal of the MPX Module, it is generated by one or the other sets of conditions indicated on logic line 21. It is used as one of the inputs on logic line 24 to signal the microprocessor in Module B to activate a LH Amber W/L output (a physical output from the MPX Module) as long as one of the sets of conditions on logic line 21 stay satisfied. The basic logic for the Amber Light Flag is, the driver is requesting the Amber W/Ls to activate and stay active as long as the Red W/Ls are inactive.

Flags are outputs generated and used inside the MPX Modules, they do not have external outputs and do not show up on the output table. For the Amber Enable Flag to be functional external of the Module, it must be used as an input on a logic line that has a physical output.

Condition E: A set of Inputs and input status (conditions), if satisfied, will cause Module B to activate the Amber Enable Output Flag, regardless of any other conditions.

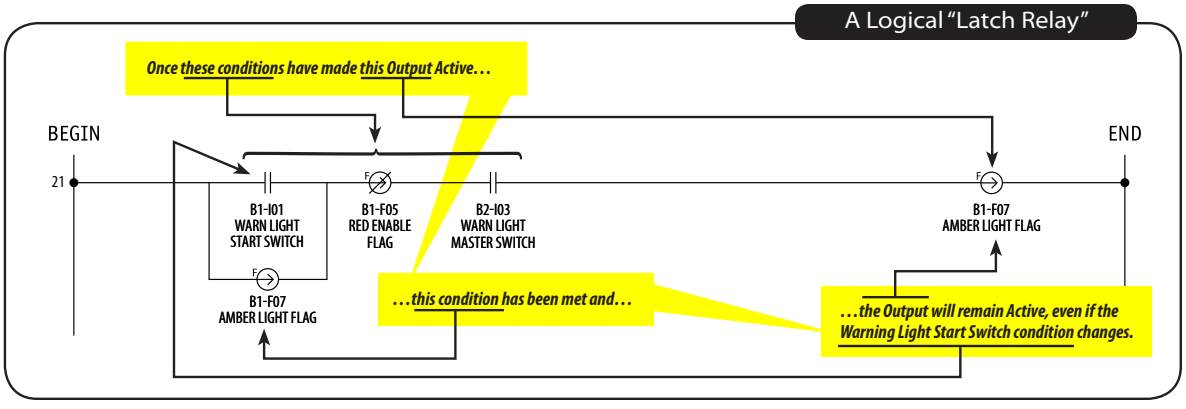
Condition F: Another set of Inputs and input status (conditions), if satisfied, will cause Module B to activate the Amber Enable Output Flag, regardless of any other conditions.

Condition G: Once activated the Amber Enable Flag can be used as an input on its own logic line to keep itself activated until the red W/Ls are activated.

Logical "Latch Relays"

Occasionally, a particular Output may appear to be a requirement for itself. In such situations, it is helpful to realize that the Multiplex program performs the horizontal lines of a Ladder in sequence, not all at once. If an initial set of conditions has made an Output true (active), that Output may then become a requirement in another set of conditions that will keep the Output true—even if one of the initial conditions changes. Logic line 21 is an example of this kind of Logic Line.

A Logical "Latch Relay"

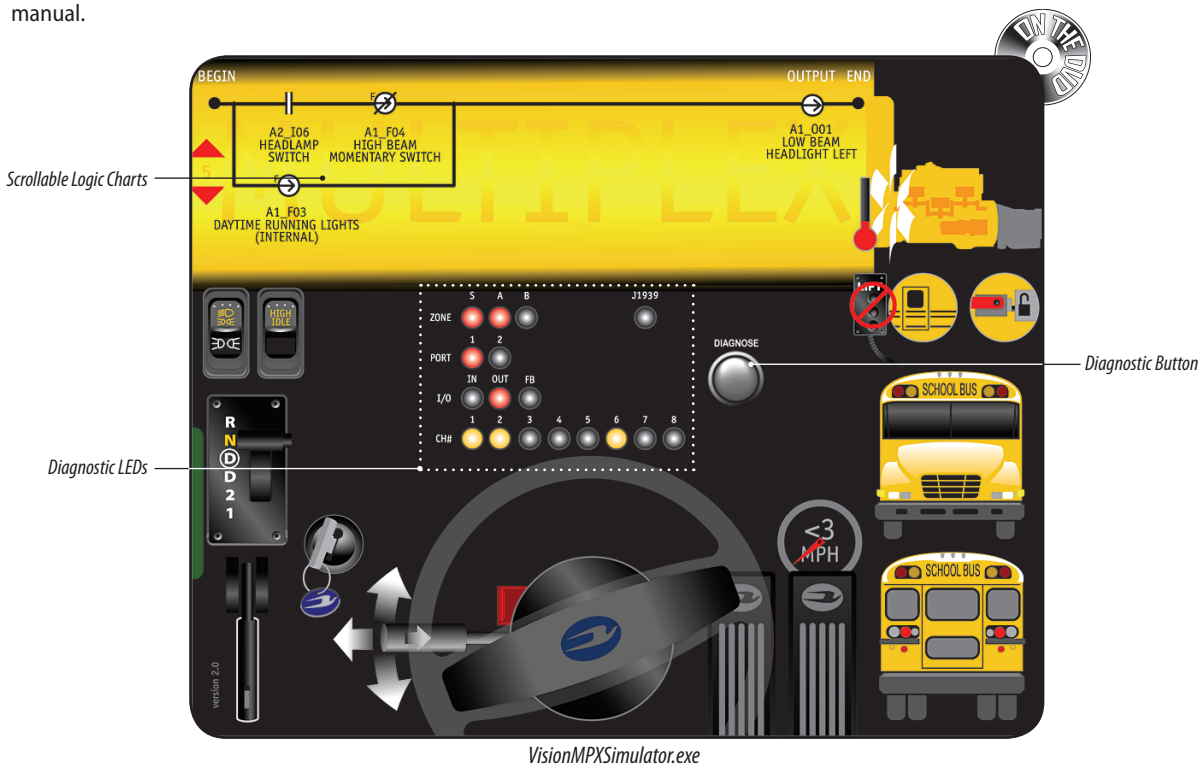


Vision MPX Simulator

Blue Bird has provided another reference tool to help technicians become more quickly acquainted with the Vision's Multiplex system. On the DVD that is delivered with each new bus there is a file named **VisionMPXSimulator.exe.** This is a small self-running Macromedia® Flash®-based application, suitable for use on most current Windows® computers.

CAUTION ***The Vision Multiplex Simulator is provided as a reference tool to help service technicians become more quickly familiar with the Blue Bird Vision's Multiplex system. It is intended for training/learning purposes only (not for actual troubleshooting). The software is only a SIMULATION of the Blue Bird Vision's Multiplex system. Although it imitates the behavior of the Vision's Multiplex Module, it does not contain the actual multiplex program. Because the actual program installed on buses is subject to change at the factory, the behavior of the Vision MPX Simulator may not exactly match that of your particular Vision unit(s).***

The Vision MPX Simulator operates upon a script which imitates the logic of the Ladder Logic diagrams of a 2012 Vision. Interactive on-screen controls represent the driver controls which generate Multiplex Inputs. Other animated graphic elements indicate the results of most Multiplex Outputs, as they are generated in response to the Inputs. An on-screen Diagnostic Switch allows the user to cycle the bank of "LEDs" to display Inputs, Outputs, or Feedbacks, simulating the behavior of the actual MPX Module. For reference while observing the behaviors of the LEDs, at the top of the screen is a scrolling list of the similar set of Ladder Logic charts printed in this manual.



VisionMPXSimulator.exe

Input Tables

Zone A / Module A Input Table

	Circuit Description	LED Address	Connector / Pin #	Circuit ID	Wire Color	Intput	Wake Up
1	Accessory Switch	A2 - I03	A - 2	*	YL	Ground	Yes
2	Brake Light Switch	A1 - I05	C - 6	*	RD	12 Volts	Yes
3	Engine > 400 RPM	G1 - I12	D - 1 - 2	*	YL/GN	J1939	
4	Fuel Door Switch	A2 - I02	C - 11	*	RD	12 Volts	
5	Headlight Switch	A2 - I01	C - 10	*	OR	Ground	Yes
6	High Beam Switch	A1 - I04	C - 5	*	OR	Ground	
7	Horn Button	A1 - I01	C - 2	*	GY	Ground	Yes
8	Ignition Switch	A2 - I04	A - 5	*	PK	Ground	Yes
9	Left Turn Switch	A2 - I07	B - 2	*	YL	Ground	Yes
10	Neutral Switch	A1 - I03	C - 4	*	RD	12 Volts	
11	Park Brake On	G1 - I10	D - 1 - 2	*	YL/GN	J1939	
12	Park & Tail Light Switch	A1 - I07	C - 8	*	BN	Ground	Yes
13	Reverse Signal	A1 - I02	C - 3	*	BL	Ground	
14	Right Turn Switch	A2 - I08	B - 5	*	GN	Ground	Yes
15	Speed > 3 MPH	G1 - I09	D - 1 - 2	*	YL/GN	J1939	
16	Start Switch	A2 - I05	A - 8	*	PU	Ground	

** Circuit ID same as Description*

Zone B / Module B Input Table

	Circuit Description	LED Address	Connector / Pin #	Circuit ID	Wire Color	Intput
1	Cross Arm Cancel	B1 - I06	A/P88 - 10	2425BB	----	12 Volts
2	Door Switch, Brake Interlock	B2 - I07	B/P128 - 7	1532C	YL/BK	Ground
3	Mirror Heat Switch	B2 - I06	B/P128 - 6	2105L	PU	Ground
4	Sleeping Child Check	B2 - I05	B/P128 - 3	2108A	TN/WH	12 Volts
5	Vandal Lock Switch	B1 - I07	A/P88 - 13	2601	----	Ground
6	W/L Flash Only After Amber, Seq	B1 - I04	A/P88 - 6	1221SS	LT / BL	Ground
7	W/L Flash Red, Door Open, N-Seq	B1 - I05	A/P88 - 9	1221TT	LT / BL	Ground
8	W/L Master Switch	B2 - I03	A/P88 - 14	1350D	RD / WH	12 Volts
9	W/L Start Switch	B1 - I01	A/P88 - 5	2410	OR / BK	Ground
10	Windshield Washer Switch	B2 - I04	C/C26 - 12	2102	BN	12 Volts
11	Wiper Park Left	B1 - I02	C/C26 - 3	2109A	BL	Ground
12	Wiper Park Right	B1 - I03	C/C26 - 7	2101A	PK	Ground
13	Wiper Switch 1	B1 - I08	C/C26 - 11	WRP1	OR	12 Volts
14	Wiper Switch 2	B2 - I01	C/C26 - 13	WRP2	LT / GN	12 Volts
15	Wiper Switch 3	B2 - I02	C/C26 - 14	WRP3	YL	12 Volts

Note: Circuit ID and Wire Color may vary depending on features.

Output Tables

Zone A / Module A Output Table

	Circuit Description	LL Line #	Connector / Pin #	Circuit ID	Wire Color	Output	LED Address	Circuit Protection
1	Back Up Alarm	9	B - 10	*	BL	12 Volts	A1 - 007	8 Amps
2	Brake Interlock	13	A - 10	*	BL	Ground	A2 - 003	1 Amp
3	High Beam Headlight Left	7	B - 7	*	GN	12 Volts	A1 - 005	8 Amps
4	High Beam Headlight Right	8	B - 9	*	PU	12 Volts	A1 - 006	8 Amps
5	Horn	17	B - 6	*	BK	12 Volts	A2 - 008	10 Amps
6	Ignition	10	B - 12	*	OR	12 Volts	A1 - 008	8 Amps
7	Ignition Dropout	14	B - 1	*	PK	12 Volts	A2 - 005	3.5 Amps
8	Left Turn Light	5	A - 4	*	YL	12 Volts	A1 - 003	10 Amps
9	Low Beam Headlight Left	3	A - 1	*	BN	12 Volts	A1 - 001	8 Amps
10	Low Beam Headlight Right	4	A - 3	*	OR	12 Volts	A1 - 002	8 Amps
11	Park Lights	11	A - 7	*	BN	12 Volts	A2 - 001	8 Amps
12	Right Turn Light	6	A - 6	*	GN	12 Volts	A1 - 004	10 Amps
13	Shift Inhibit Signal	12	A - 9	*	GN	Ground	A2 - 002	1 Amp
14	Starter Relay	15	B - 3	*	RD	12 Volts	A2 - 006	3.5 Amps
15	Stop Light Relay	16	B - 4	*	RD	12 Volts	A2 - 007	3.5 Amps

** Circuit ID same as Description*

Zone B / Module B Output Table

	Circuit Description	LL Line	Con./Pin #	Circuit ID	Wire Clr.	Output	LED Add.	Circ. Prot.	Mod. B Fuse	Input Pin / Con.
1	Accessory Power	44	B - 1	1106	----	12 Volts	B2 - 002	5 Amps	5	A - 17
2	Approach Light	48	B - 2	1221MM	----	12 Volts	B2 - 006	1 Amp	6	A - 18
3	Crossing Arm	49	A - 12	2426A	LT / BL	12 Volts	B2 - 005	4 Amps	6	A - 18
4	Left Hand Amber W/L	24	A - 2	2411A	BK / YL	12 Volts	B1 - 003	8 Amps	2	A - 1
5	Left Hand Red W/L	25	A - 4	2412A	BK	12 Volts	B1 - 004	8 Amps	2	A - 1
6	Left Hand Wiper Low	26	C - 1	2110A	DK / GN	12 Volts	B1 - 005	5 Amps	3	B - 9
7	Mirror Heater	29	B - 8	2105H	PU	12 Volts	B1 - 008	15 Amps	4	B - 10
8	Right Hand Amber W/L	19	A - 3	2413A	YL /BK	12 Volts	B1 - 001	8 Amps	1	A - 1
9	Right Hand Red W/L	22	A - 7	2414A	YL	12 Volts	B1 - 002	8 Amps	1	A - 1
10	Right Hand Wiper Low	27	C - 5	2111A	DK / GN	12 Volts	B1 - 006	5 Amps	3	B - 9
11	Stop Arm	46	A - 16	2425	LT / BL	12 Volts	B2 - 004	8 Amps	6	A - 18
12	Strobe Light With W/L	43	A - 15	2430E	----	12 Volts	B2 - 001	5 Amps	5	A - 17
13	W/L Monitor Pilot	45	A - 11	2417	----	12 Volts	B2 - 003	5 Amps	5	A - 17
14	Windshield Washer Pump	28	C - 9	WASH MTR	BN	12 Volts	B1 - 007	5 Amps	3	B - 9

Note: Circuit ID and Wire Color may vary depending on features.

Power & Communication Tables

Zone A / Module A

	Description	Connector & Pin
1	DNET A	D - 7
2	DNET B	D - 8
3	12 V MPX	D - 9
4	GND MPX	D - 10
5	CNET A	D - 11
6	CENT B	D - 12
7	J1939 H	D - 1
8	J1939 L	D - 2
9	J1939 S	D - 3
10	Wakeup Com	D - 4
11	SYS Power	D - 5
12	SYS GND	D - 6
13	Battery Power 1 (For Con - A)	E - 1
14	Battery GND	E - 2
15	Battery Power 2 (For Con - B)	E - 3

Zone B / Module B

	Description	Connector & Pin
1	Battery Ground 1	A - 8
2	Battery Ground 2	B - 5
3	DNET A, Send Com	C - 2
4	DNET B, Receive Com	C - 4
5	12 V MPX	C - 6
6	GND MPX	C - 8
7	Wakeup Com	C - 10
8	Input Power, Fuse 1 & 2	A - 1
9	Input Power, Fuse 3	B - 9
10	Input Power, Fuse 4	B - 10
11	Input Power, Fuse 5	A- 17
12	Input Power, Fuse 6	A - 18

Ladder Logic Lines

Symbols Key

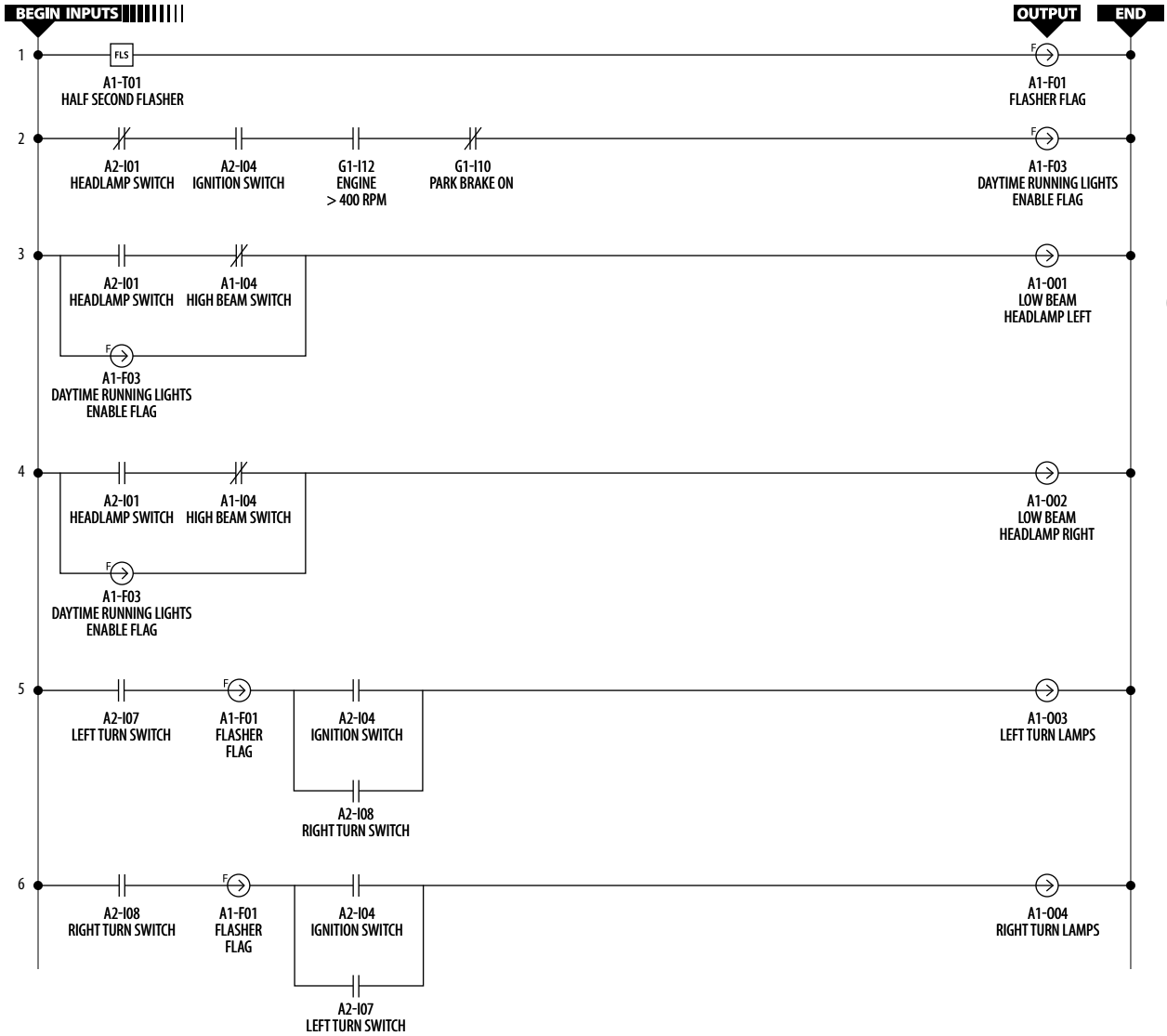


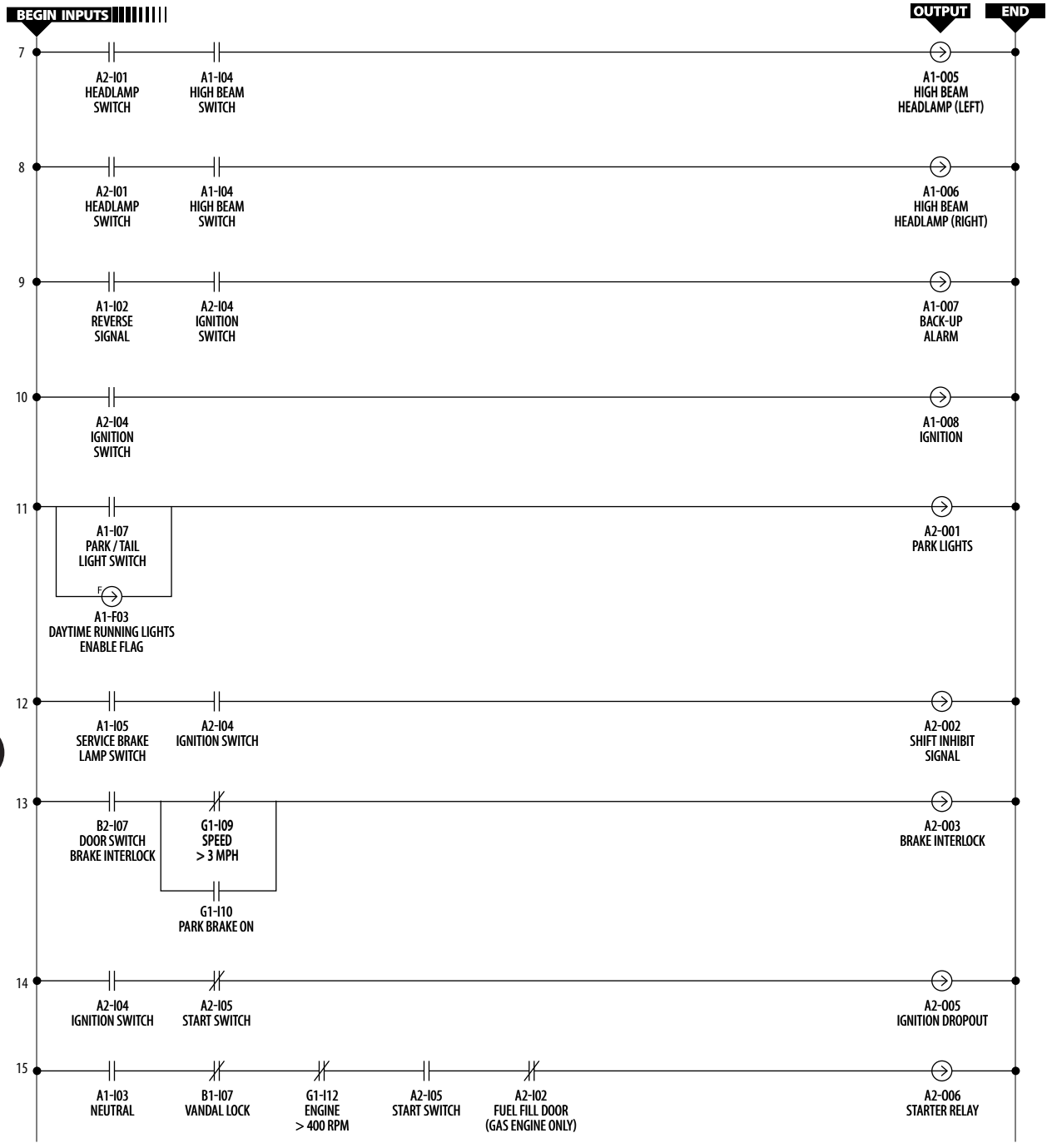
Active Input (LED ON) | *Inactive Input (LED OFF)* | *Active Output (LED ON)* | *Inactive Output (LED OFF)* | *Active Flag* | *Inactive Flag*

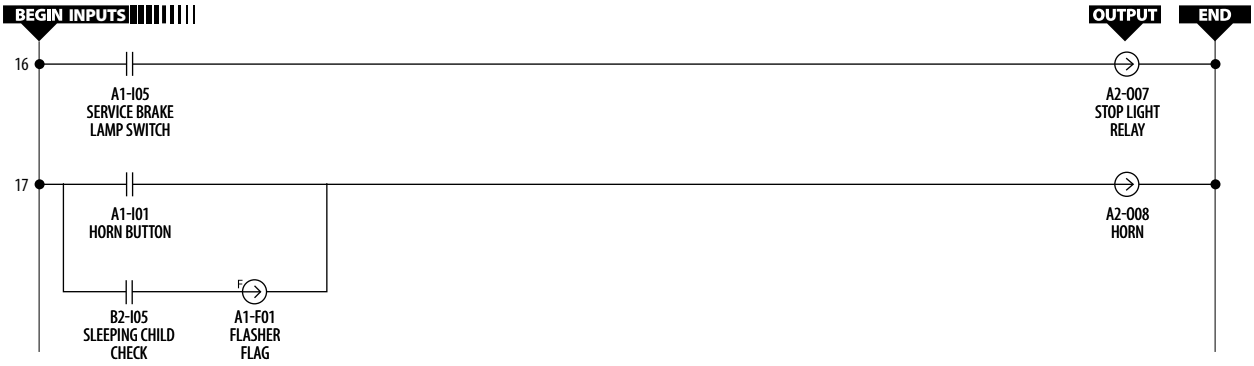


Active Delay Off | *Active Delay On* | *Active Timer On* | *Active Timer (Flasher Shown)*

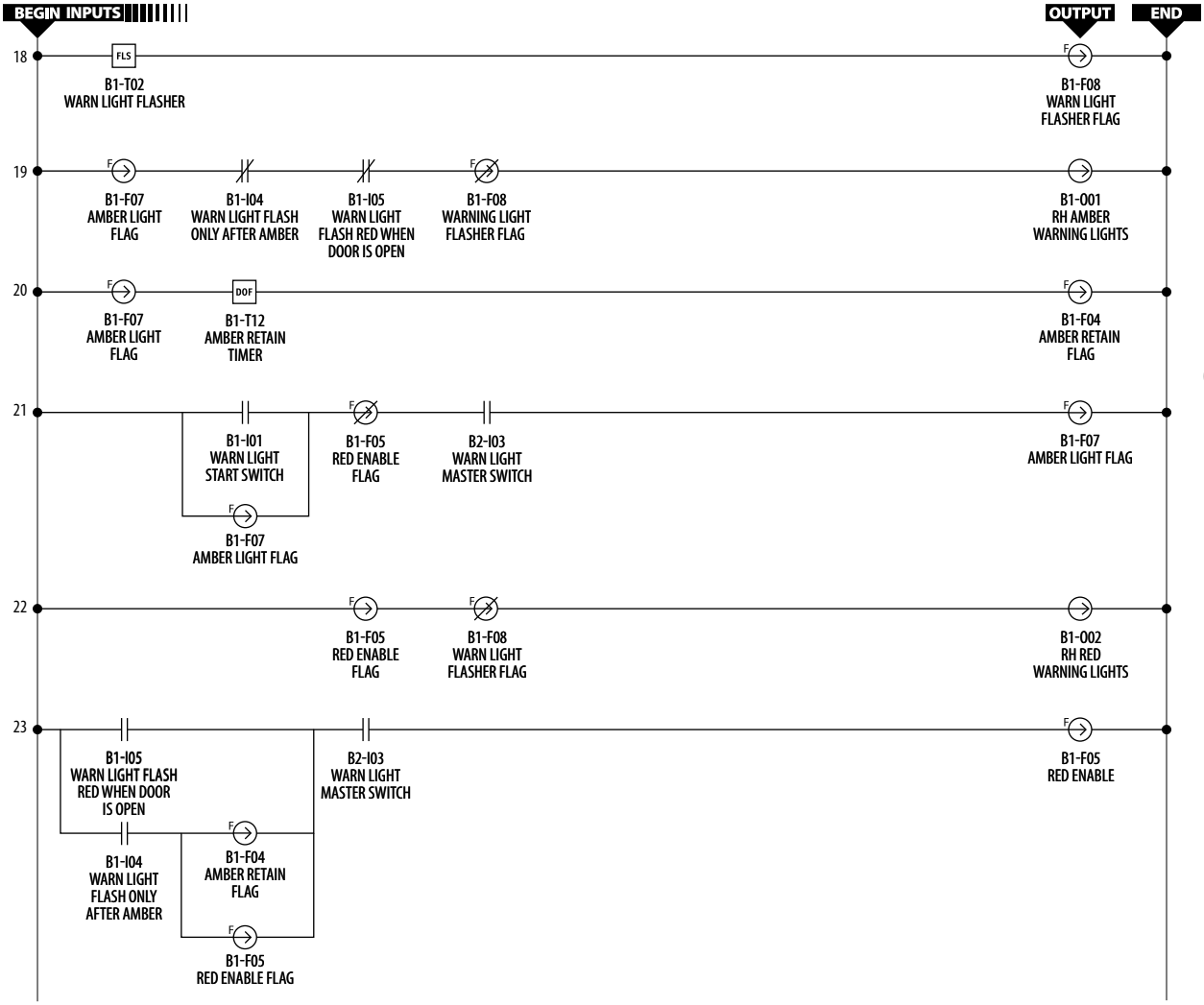
Zone A Logic Lines

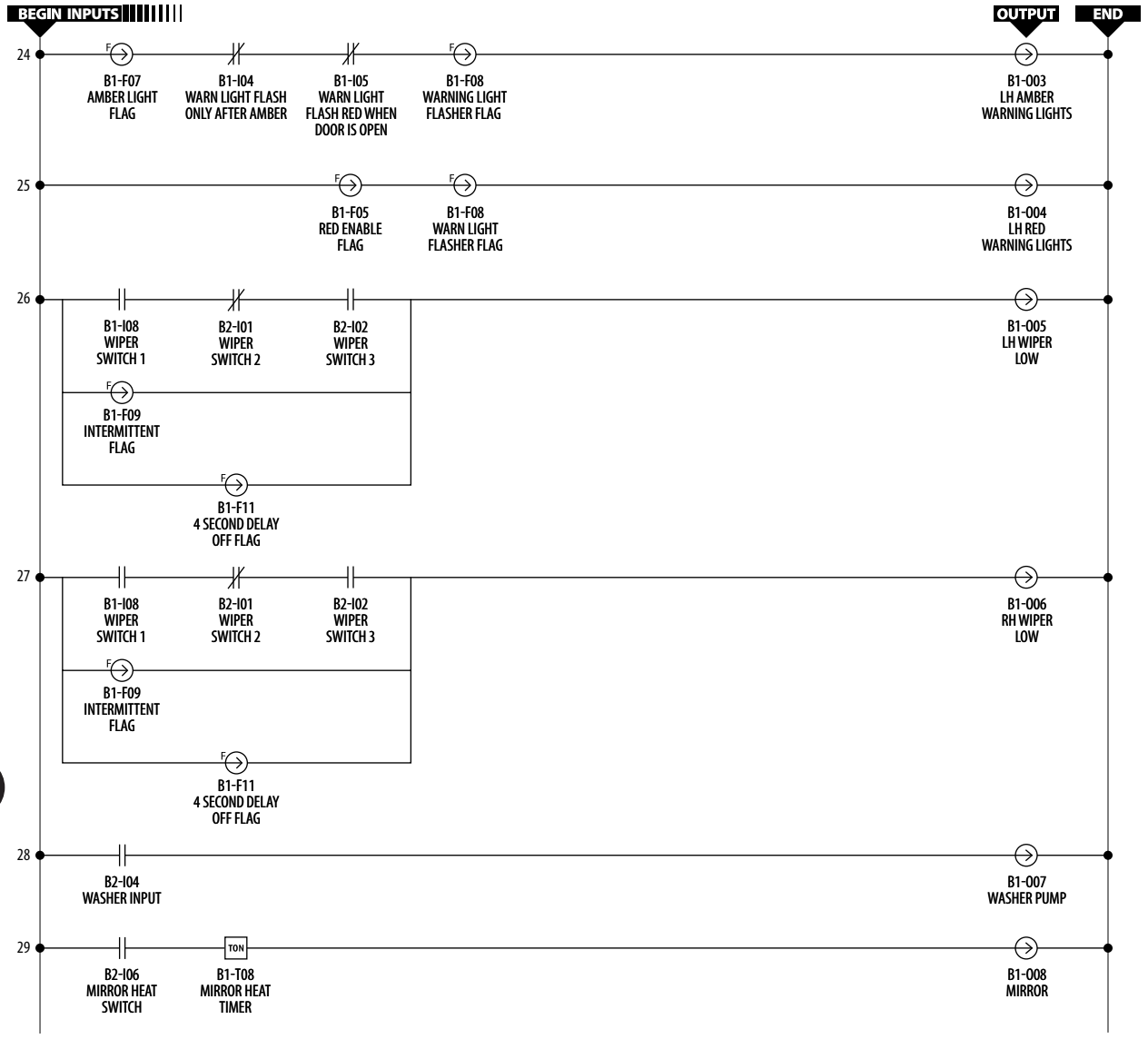


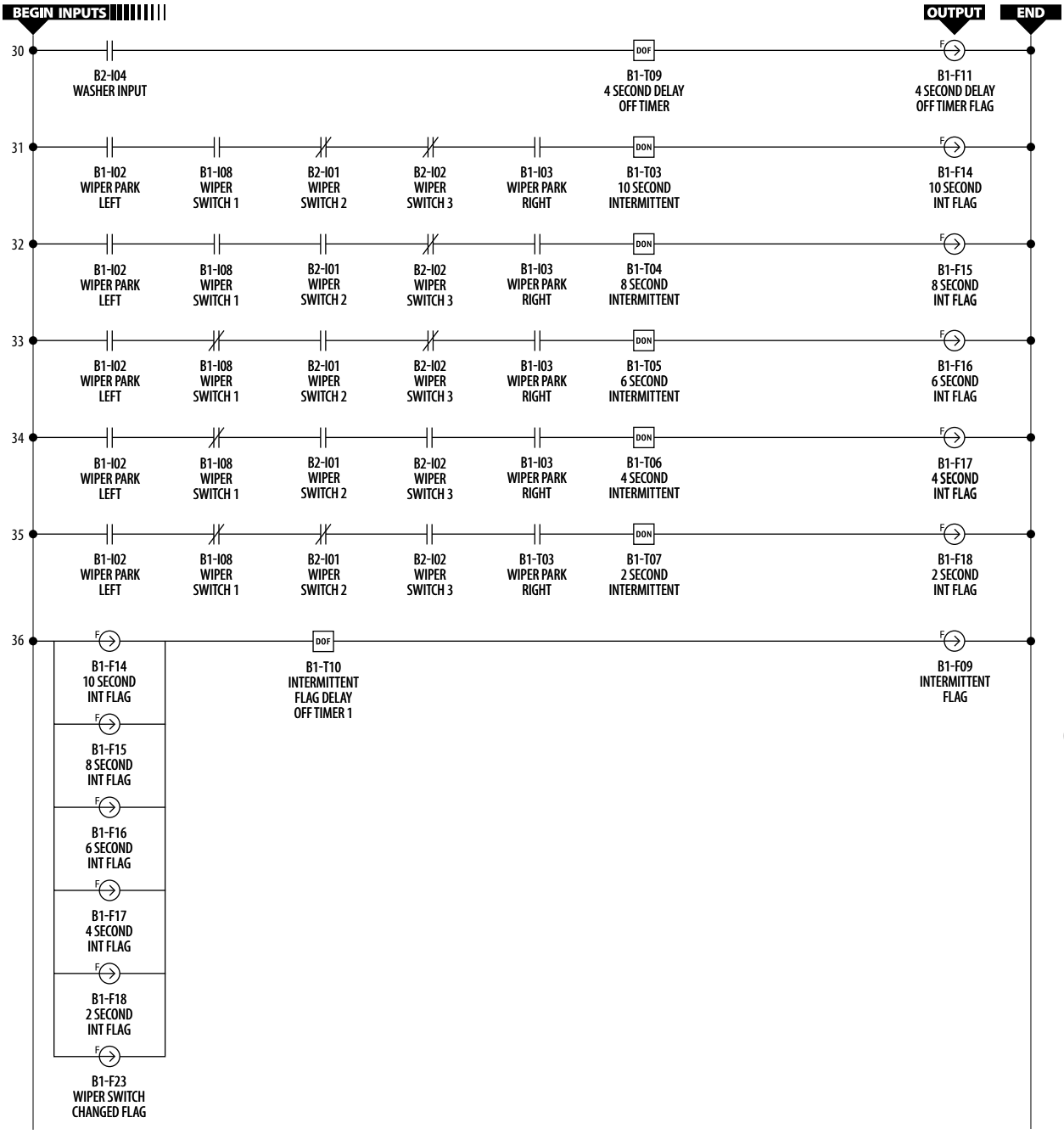

BEGIN INPUTS
OUTPUT
END
7
A2-I01 HEADLAMP SWITCH
A1-I04 HIGH BEAM SWITCH
A1-005 HIGH BEAM HEADLAMP (LEFT)
8
A2-I01 HEADLAMP SWITCH
A1-I04 HIGH BEAM SWITCH
A1-006 HIGH BEAM HEADLAMP (RIGHT)
9
A1-I02 REVERSE SIGNAL
A2-I04 IGNITION SWITCH
A1-007 BACK-UP ALARM
10
A2-I04 IGNITION SWITCH
A1-008 IGNITION
11
A1-I07 PARK / TAIL LIGHT SWITCH
A1-F03 DAYTIME RUNNING LIGHTS ENABLE FLAG
A2-001 PARK LIGHTS
12
A1-I05 SERVICE BRAKE LAMP SWITCH
A2-I04 IGNITION SWITCH
A2-002 SHIFT INHIBIT SIGNAL
13
B2-I07 DOOR SWITCH BRAKE INTERLOCK
G1-I09 SPEED > 3 MPH
G1-I10 PARK BRAKE ON
A2-003 BRAKE INTERLOCK
14
A2-I04 IGNITION SWITCH
A2-I05 START SWITCH
A2-005 IGNITION DROPOUT
15
A1-I03 NEUTRAL
B1-I07 VANDAL LOCK
G1-I12 ENGINE > 400 RPM
A2-I05 START SWITCH
A2-I02 FUEL FILL DOOR (GAS ENGINE ONLY)
A2-006 STARTER RELAY

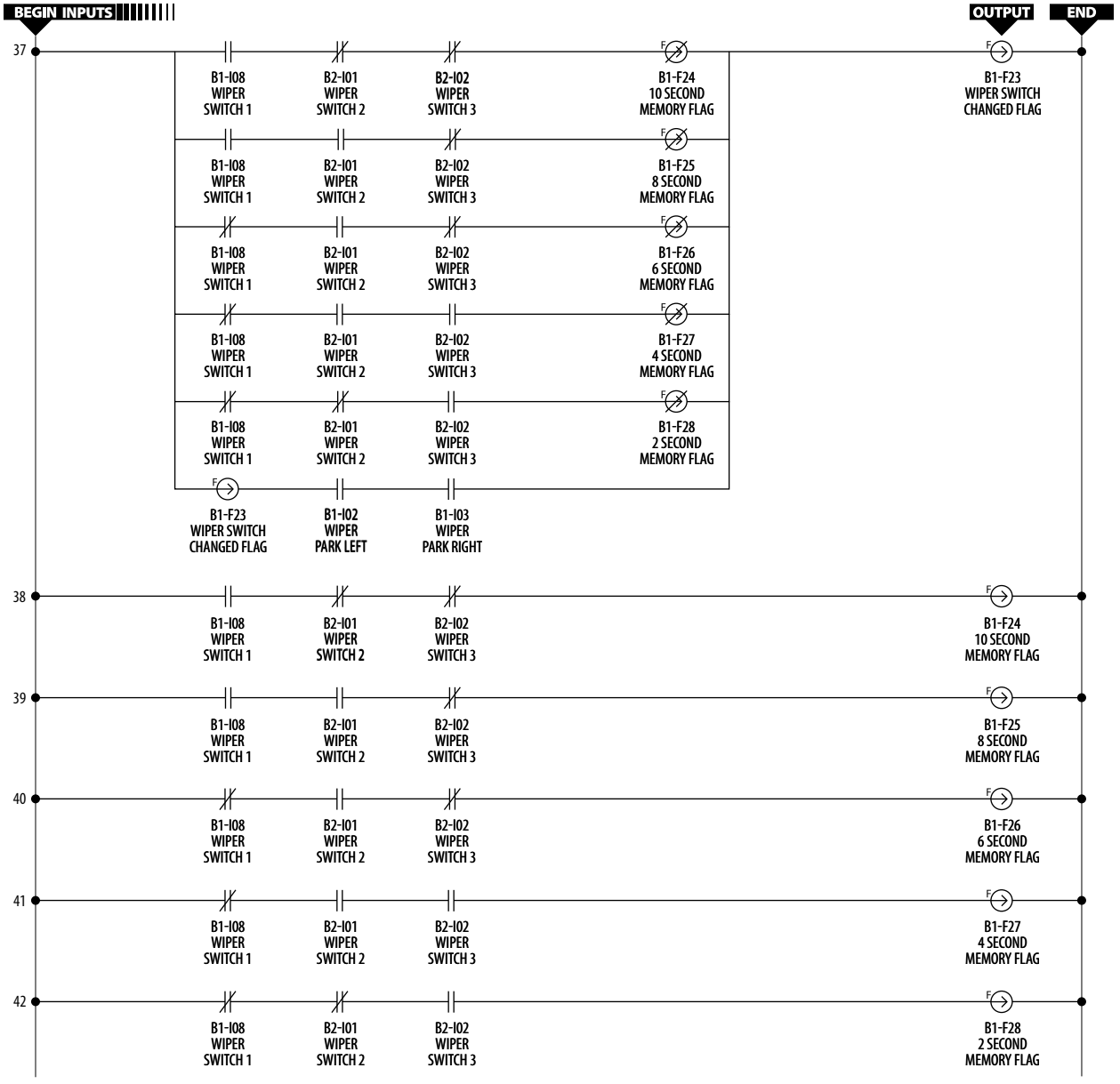


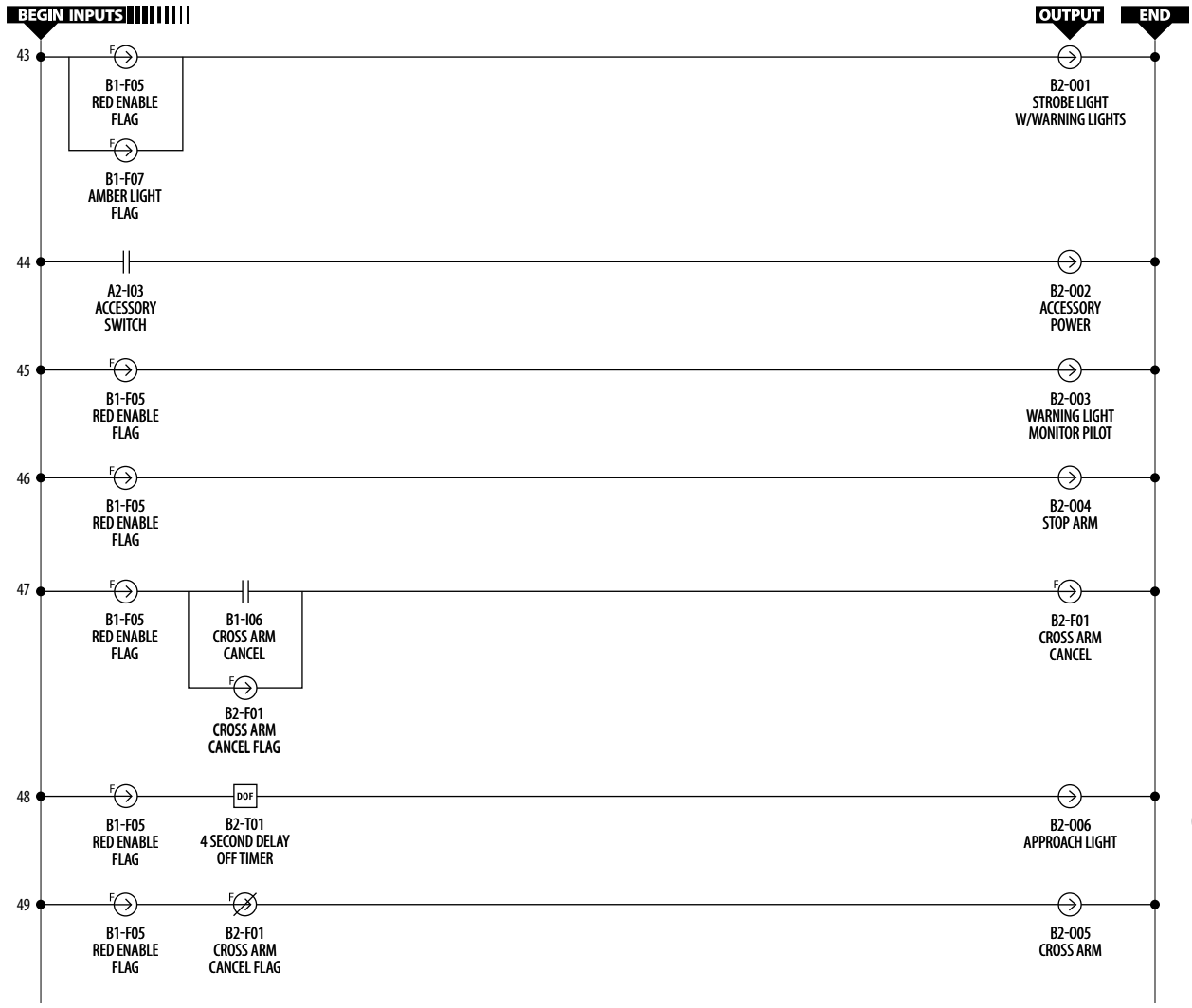
Zone B Logic Lines




BEGIN INPUTS
OUTPUT
END
24
B1-F07 AMBER LIGHT FLAG
B1-I04 WARN LIGHT FLASH ONLY AFTER AMBER
B1-I05 WARN LIGHT FLASH RED WHEN DOOR IS OPEN
B1-F08 WARNING LIGHT FLASHER FLAG
B1-O03 LH AMBER WARNING LIGHTS
25
B1-F05 RED ENABLE FLAG
B1-F08 WARN LIGHT FLASHER FLAG
B1-O04 LH RED WARNING LIGHTS
26
B1-I08 WIPER SWITCH 1
B2-I01 WIPER SWITCH 2
B2-I02 WIPER SWITCH 3
B1-O05 LH WIPER LOW
B1-F09 INTERMITTENT FLAG
B1-F11 4 SECOND DELAY OFF FLAG
27
B1-I08 WIPER SWITCH 1
B2-I01 WIPER SWITCH 2
B2-I02 WIPER SWITCH 3
B1-O06 RH WIPER LOW
B1-F09 INTERMITTENT FLAG
B1-F11 4 SECOND DELAY OFF FLAG
28
B2-I04 WASHER INPUT
B1-O07 WASHER PUMP
29
B2-I06 MIRROR HEAT SWITCH
TON
B1-T08 MIRROR HEAT TIMER
B1-O08 MIRROR


BEGIN INPUTS
OUTPUT
END
30
B2-I04 WASHER INPUT
DOF
B1-T09 4 SECOND DELAY OFF TIMER
F
B1-F11 4 SECOND DELAY OFF TIMER FLAG
31
B1-I02 WIPER PARK LEFT
B1-I08 WIPER SWITCH 1
B2-I01 WIPER SWITCH 2
B2-I02 WIPER SWITCH 3
B1-I03 WIPER PARK RIGHT
DON
B1-T03 10 SECOND INTERMITTENT
B1-F14 10 SECOND INT FLAG
32
B1-T04 8 SECOND INTERMITTENT
B1-F15 8 SECOND INT FLAG
33
B1-T05 6 SECOND INTERMITTENT
B1-F16 6 SECOND INT FLAG
34
B1-T06 4 SECOND INTERMITTENT
B1-F17 4 SECOND INT FLAG
35
B1-T07 2 SECOND INTERMITTENT
B1-F18 2 SECOND INT FLAG
36
B1-T10 INTERMITTENT FLAG DELAY OFF TIMER 1
B1-F09 INTERMITTENT FLAG
B1-F15 8 SECOND INT FLAG
B1-F16 6 SECOND INT FLAG
B1-F17 4 SECOND INT FLAG
B1-F18 2 SECOND INT FLAG
B1-F23 WIPER SWITCH CHANGED FLAG


BEGIN INPUTS
OUTPUT
END
37
B1-I08 WIPER SWITCH 1
B2-I01 WIPER SWITCH 2
B2-I02 WIPER SWITCH 3
B1-F24 10 SECOND MEMORY FLAG
B1-F23 WIPER SWITCH CHANGED FLAG
B1-F25 8 SECOND MEMORY FLAG
B1-F26 6 SECOND MEMORY FLAG
B1-F27 4 SECOND MEMORY FLAG
B1-F28 2 SECOND MEMORY FLAG
B1-I02 WIPER PARK LEFT
B1-I03 WIPER PARK RIGHT
38
39
40
41
42


BEGIN INPUTS
OUTPUT
END
43
B1-F05 RED ENABLE FLAG
B1-F07 AMBER LIGHT FLAG
B2-001 STROBE LIGHT W/WARNING LIGHTS
44
A2-I03 ACCESSORY SWITCH
B2-002 ACCESSORY POWER
45
B1-F05 RED ENABLE FLAG
B2-003 WARNING LIGHT MONITOR PILOT
46
B1-F05 RED ENABLE FLAG
B2-004 STOP ARM
47
B1-F05 RED ENABLE FLAG
B1-I06 CROSS ARM CANCEL
B2-F01 CROSS ARM CANCEL FLAG
B2-F01 CROSS ARM CANCEL
48
B1-F05 RED ENABLE FLAG
DOF
B2-T01 4 SECOND DELAY OFF TIMER
B2-006 APPROACH LIGHT
49
B1-F05 RED ENABLE FLAG
B2-F01 CROSS ARM CANCEL FLAG
B2-005 CROSS ARM

Troubleshooting In Diagnostic LED Mode

CAUTION ***Failure to confirm proper electrical component and system operation, failure to diagnose electrical problems and take immediate corrective action using industry guidelines and Blue Bird guidelines may result in electrical system damage and/or possible injury***

General Approach

A systematic approach to electrical troubleshooting of the Blue Bird Vision follows these general steps:

Note: See **Troubleshooting Tree** on the following pages.

1. **Check the Outputs Tables.** First determine if the affected circuit is one which interacts with or is controlled by the Multiplex system. If the circuit in question is listed in the Output Tables it is controlled by the Multiplex system and the onboard LED diagnostics should be used for troubleshooting the failure. Note the circuit's LED (logical) address (Zone-Port-Input/Output #) and its physical location (Connector / Port Pin). (If the issue is not with a Multiplex circuit, refer to the Electrical System chapter and appropriate wiring schematics to troubleshoot conventionally.)

2. **Check the Output.** Operate the appropriate bus controls or switches to set the conditions which are required for the circuit's Output to be Active. (Refer to the Ladder Logic Line to determine the required conditions). If the MPX Module is generating an Active Output signal, but the circuit is not operational, at least part of the problem exists "downstream" of the Multiplex module; probably in the Output's own load circuit. That is, since the Output signal is present, there is no reason at this point to suspect the "upstream" circuits of Inputs which are requirements of the desired Output. Troubleshooting efforts should be focussed upon the circuit beginning from the Output's Connector / Pin, through the load, and to ground.

3. **Check the Feedback.** To further verify that the problem exists in the load circuit, and to possibly gain additional information about its nature, create conditions (turn off switches, etc.) which should cause the Output to be Inactive. Then verify that the circuit's Output LED is off and its Feedback LED is on (the Feedback LED address is basically the same as the Output LED's address). If the Feedback LED is off when the Output is Inactive, an open is indicated in the load circuit, because the Feedback signal is not being conducted through

the load. If the Feedback LED of a malfunctioning load circuit is on when the Output is Inactive (as it is in a correctly functioning circuit), the Feedback signal is being conducted, and you at least have an indication of continuity. If the Feedback LED is on while the Output is Active, a short in the load circuit is indicated or a failed MPX Module is indicated. (It will be necessary to push the Diagnose Button one time to cycle the Diagnostic LED's from monitoring Outputs to monitoring Feedbacks to determine if this condition exist.) Locate and disconnect the output circuit in question from the MPX module. Test for a short circuit and make the necessary repairs. If a short circuit is not indicated, test for a failed MPX module. With the output circuit disconnected, create the conditions for an active output and confirm the output LED is on. Consult the Output Table and determine if the output should be 12 volts or ground, test the output terminal accordingly. If the output is not active, it indicates there may have been a failure in the MPX module. *Note: The most likely cause for a Feedback LED and an Output LED to be on with the same conditions active, is a short circuit not a failed MPX module. It is recommended that Blue Bird service personnel be consulted before replacing a Multiplex module.*

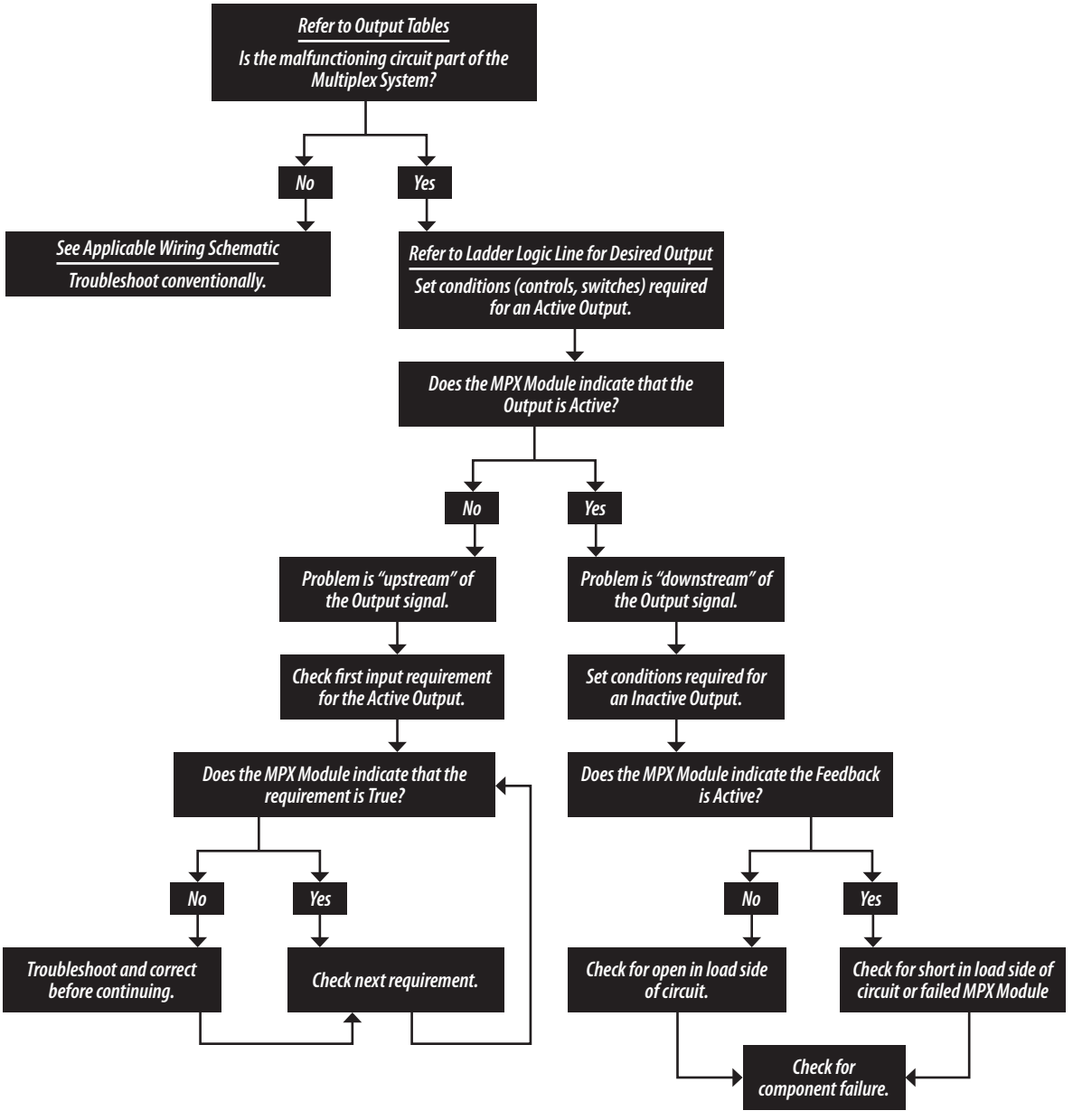
4. **Check Each Requirement.** If the desired Output is shown by the MPX Module to be Inactive when it should be Active, you would assume the problem to be "upstream" of the Output signal; at least one of the conditions (Inputs) required for an Active Output signal has failed. Referring to the Ladder Logic line, begin checking each requirement's LED to verify it is correctly Active (on) or Inactive (off) according to the symbol on the logic line. If a discrepancy is found, a malfunction is indicated "upstream" within that specific input circuit. Thus, comparing the states of the MPX Module's LEDs against the requirements of the Ladder Logic Lines enables the technician to quickly "narrow down" the source of the problem.

As you proceed, remember that:

- The Logic Line for a particular Active Output may require that certain Inputs are Active (LED on) while other Inputs are *In*active (LED off). It is helpful, therefore, to think of each item encountered on the Logic Line as a "statement" which is either *true* or *false* (This Input active=true; This Input inactive=false). You seek to find and correct the false "statements."

- The set of requirements for an Active Output may include requirements that other Outputs—which have their own Logic Lines—are either Active or Inactive. In such cases, the required Output states must also be investigated according to their own Logic Lines.

Troubleshooting Tree



Troubleshooting Principles:

About Flags

A Flag is an Output that is internally generated by the MPX Module. Just as with any other Output, a Flag is generated when a set of requirements (Inputs) are true. Being an internal signal, however, a Flag has neither a physical Output pin nor a voltage or ground signal associated with it that can be directly checked by the technician. A Flag therefore, can be thought of as an internal function, which may in turn be used as a requirement (Input) on a Logic Line.

The troubleshooting LEDs only indicate the active or inactive state of Outputs and Inputs. They do not display the state of Flags. Therefore, Flags are verified by a process of elimination. When troubleshooting a logic diagram that results in a Flag, the technician uses the troubleshooting LEDs to verify the required state of Inputs and Outputs required for the Flag to be active. When all of the Flag's requirements have been verified, the technician must assume that the Flag has been generated and that it is active.

If the Flag occurs as one of the requirements (Inputs) for a physical Output that can be verified by an LED, the troubleshooting LEDs can be used to confirm that all requirements *except* the Flag are satisfied. If all the verifiable Inputs are true, yet the desired Output does not occur, then the technician could logically assume the Flag is suspect. The technician would then look at the output of each Logic Line to locate the suspect Flags Logic Line. He would proceed to verify the requirements for that Flag to be active, and so on. If all the verifiable conditions check out correctly, and yet the desired output is not achieved, then the functioning of the MPX module would be suspect. Blue Bird recommends contacting your Blue Bird service source to confirm your troubleshooting before replacing a Multiples module.

Troubleshooting Example

CAUTION ***Failure to confirm proper electrical component and system operation, failure to diagnose electrical problems and take immediate corrective action using industry guidelines and Blue Bird guidelines may result in electrical system damage and/or possible injury.***

The following example steps through a typical examination of a Ladder Logic Line, using the Vision MPX Simulator for illustrative purposes. DoubleClick the VisionMPX-Simulator.exe icon to launch it.

The Problem. This example assumes a problem with starting the engine. It will walk through an investigation of the Multiplex logic which affects the starting circuit.

1. **Refer to Input/Output Tables.** The tables reveal that the Multiplex system does indeed contain logic affecting several circuits having to do with starting the engine. The MPX Module receives Inputs named Neutral, Vandal Lock, Engine > 400 RPM, Starter Switch and Fuel Fill Door (Gas Engine Only) . Outputs are generated by the MPX Module named Ignition, Ignition Dropout, and Starter Relay. Often, by merely considering these listings we can gain "hints" regarding how the Multiplex system comes into play: For example, it is easy to "guess" that the Engine > 400 RPM must be Inactive in order to start the bus.

Zone A / Module A Input Table

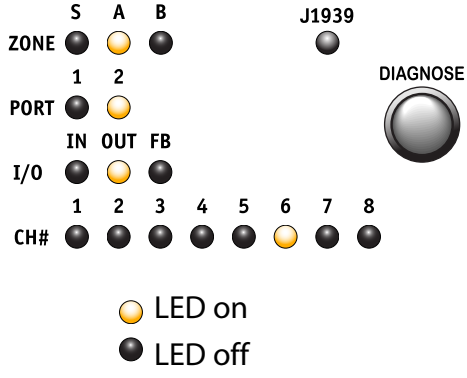
	Circuit Description	LED Address	Connector / Pin #
1	Accessory Switch	A2 - I03	A - 2
2	Brake Light Switch	A1 - I05	C - 6
3	Engine > 400 RPM	G1 - I12	D - 1 - 2 - 3
4	Fuel Door Switch	A2 - I02	C - 11
5	Headlight Switch	A2 - I01	C - 10
6	High Beam Switch	A1 - I04	C - 5
7	Horn Button	A1 - I01	C - 2
8	Ignition Switch	A2 - I04	A - 5
9	Left Turn Switch	A2 - I07	B - 2
10	Neutral Switch	A1 - I03	C - 4
11	Park Brake On	G1 - I10	D - 1 - 2 - 3
12	Park & Tail Light Switch	A1 - I07	C - 8
13	Reverse Signal	A1 - I02	C - 3
14	Right Turn Switch	A2 - I08	B - 5
15	Speed > 3 MPH	G1 - I09	D - 1 - 2 - 3
16	Start Switch	A2 - I05	A - 8

Zone A / Module A Output Table

	Circuit Description	LL Line #	Connector / Pin #	LED Address
1	Back Up Alarm	9	B - 10	A1 - 007
2	Brake Interlock	13	A - 10	A2 - 003
3	High Beam Headlight Left	7	B - 7	A1 - 005
4	High Beam Headlight Right	8	B - 9	A1 - 006
5	Horn	17	B - 6	A2 - 008
6	Ignition	10	B - 12	A1 - 008
7	Ignition Dropout	14	B - 1	A2 - 005
8	Left Turn Light	5	A - 4	A1 - 003
9	Low Beam Headlight Left	3	A - 1	A1 - 001
10	Low Beam Headlight Right	4	A - 3	A1 - 002
11	Park Lights	11	A - 7	A2 - 001
12	Right Turn Light	6	A - 6	A1 - 004
13	Shift Inhibit Signal	12	A - 9	A2 - 002
14	Starter Relay	15	B - 3	A2 - 006
15	Stop Light Relay	16	B - 4	A2 - 007

In this scenario, we'll assume the starter is not turning, and therefore begin our investigation with the Starter Relay Output. We note that the physical pin location for this Output is Zone A, Connector B, pin number 3. The Outputs Table lists the LED address of the Starter Relay Output as A2-O06 (Zone A, Port 2, Ouput number 6), and also shows that Output is on line 15 of the Ladder Logic diagrams.

2. **Check the Output.** To check the status of a desired Output, we must first put the MPX Module in Diagnostic Mode and cycle it to display Outputs for the appropriate Port. Press the Diagnose Switch repeatedly until Zone A LED (in the ZONE row)is on, Port 2 LED (in the PORT row) is on, and then until the Output LED (in the I/O row) is on. Set the conditions required for the MPX Module to activate the Starter Relay Output: Transmission is in neutral, Vandal lock is unlocked, Engine is not running, the fuel fill door is closed (gas engines only) and then turn the ignition switch to the start position and note whether the #6 LED (in the CH# row) comes on. By verifying an active output (LED address A2 - O06) first, you are in fact, verifying all input requirements are correct. If any one requirement does not match the logic line (active/on or inactive off) the MPX module will not activate the output. The specific LED addresses used for troubleshooting are referenced on the logic lines and/or the input and output tables.



3. **Check the Feedback.** If the A2-O06 LED lights when trying to start the engine, we know that the MPX Module is generating an Active Starter Relay Output. If the starter failed to operate despite the Output being Active, the cause would most likely be "downstream" of the multiplex system, in the load circuit itself (i.e.; Starter Relay, Solenoid, etc.) That is, there would be no reason at this point to suspect the various input circuits which are required for an Active Starter Relay Output, because the Output is Active. Even in such a case, though, further insight into the nature of a problem may be gained by checking the Feedback LED. Even though the A2-O06 LED comes on indicating the microprocessor in the MPX Module has determined circuit logic has been satisfied, it does not assure the electronic switching device (MOSFET) in the module is actively providing a physical 12 volt output on pin 3, connector B of the MPX A Module.

   Press the Diagnose Button once more to cycle the MPX Module to monitor the A2-F06 Feedback LEDs. (Note the Output and Feedback use the same LED address.) In our scenario, if the Starter Relay's Feedback LED were on and its Output is Active under the same conditions, it would, therefore, be reasonable to suspect a short to ground in the Output load circuit or a failed MPX Module.

The most likely cause for an Output LED and the Feedback LED being on while the same conditions exist is that a short to ground has been detected by the MPX Module. In that case, a MOSFET (the electronic switching device and circuit protector device inside the Module) will trip (open the circuit) and deactivate the Output, thus protecting the circuit from damage. The Output circuit connector should be removed and a conventional short to ground test with a voltmeter should be conducted. *Note: The Diagnose Button must be used to cycle from monitoring outputs to monitoring feedbacks.*

If a short to ground is not indicated by the above condition (an Output LED's being on while the Feedback LED is on), the MPX Module is suspect. A physical test at the output pin could be conducted. It is important to bear in mind that the MOSFET will not reset simply because the short has been removed or the connector containing the circuit in question has been removed from the MPX Module. If a short to ground has occurred, the Output will continue to be deactivated by the MOSFET in its tripped (open) state. It can be reset by turning the ignition switch off, or by turning off one of the inputs required for that circuit to be active. One could misdiagnose a correctly functioning MPX Module or even damage the Module by checking for voltage on an Output that has been shorted to ground without first performing these steps:

1. turn the ignition switch off.
2. Isolate the output circuit from the MPX module without disconnecting input circuits required to activate the output.
3. turn the ignition switch on.
4. verify that all requirements for an active Output are active (true).
5 verify that the output LED for the circuit in question is on
6. Refer to the output chart to see if the Output should be 12 volts or ground.
7. Measure the Output at the correct terminal for the correct condition with a voltmeter.

If the physical output is not found to be correct by conducting the above test, the MPX Module is suspect. Confirm proper voltage and grounds to the module with a voltmeter. Blue Bird recommends consulting with a Blue Bird service source to confirm your diagnosis before replacing the MPX Module.

If, as is normal, the Feedback LED is off while the Output is Active, then the circuit should be operative. If not, there is an open on the Output circuit. Thus, in cases where the desired Output is Active, but the circuit is still inoperative, the Feedback LED can help indicate whether the probable cause is an open or a short.

But what if a desired Output is Inactive? Even then it is still good practice to check the Feedback LED before proceeding to verify the presence of each requirement for an Active Output. In our example, we know that if the Starter Relay Output is Inactive, we should see its Feedback LED on, indicating that continuity exists in the Starter Relay circuit, and that it should become operational when the Output becomes Active. But if the Feedback LED were off while the Output is Inactive, then we would already have an indication of an open in the Starter Relay circuit, and that the Starter will not work even when the requirements for an Active Starter Relay Ouput are met.

4. **Check Each Requirement.** At this point in our example, we assume that the Starter Relay Output is Inactive, and that the Feedback LED is on, as it should be. It is now safe to assume that any starting problem must be "upstream" of the load circuit itself. We must begin to systematically ensure that each of the requirements for the Starter Relay Output to be active is satisfied. It is now time to refer back to the Logic Line.

   As indicated in the Output Table, Logic Line 15 is the one which leads to an Active Starter Relay Output. Click the yellow tab at the upper left of the Vision MPX Simulator to reveal a scrolling list of the Logic Diagrams. Click the red down arrow to scroll down to line 15.

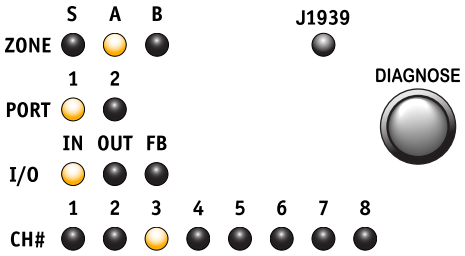
   Reading from left to right, we see that the requirements for an Active Starter Signal are:

   - The Neutral Signal Input LED address A1-I03 must be Active.
   - The Vandal Lock Input LED address B1-I07 must be Inactive.
   - The Engine > 400 RPM LED address G1-I12 must be Inactive.
   - The Start Switch Input LED address A2-I05 must be Active.

     The Fuel Fill Door LED (GAS ENGINES ONLY) address A2-I02 must be Inactive

   Our procedure, then, is to systematically set the controls which operate each of these input requirements and verify their Active or Inactive status to the Active or Inactive symbols on the logic line:

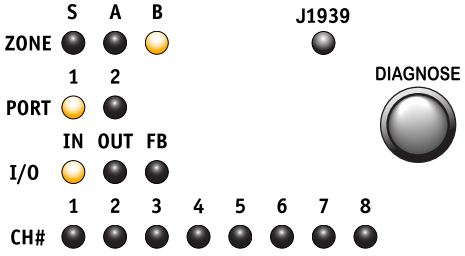
4.1 Verify that the transmission is in Neutral. Press the Diagnose Button enough times to cycle the MPX Module LEDs to display Zone A Port 1 Inputs. If the #3 LED on the CH# row were not on it would not match the correct status as indicated on the logic line, at least part of the problem would have already been isolated. In this case, you would then refer to the wiring schematic for the Neutral signal switch and troubleshoot that circuit. Locating a wiring schematic for a specific failure can be simplified by referring to the input chart. Locate the input that has failed (in this case, the Neutral Signal, Line 10 of the A Zone Input Table). The third column shows C - 4, indication the Neutral Signal circuit connects to the MPX Module through the C connector pin number 4. Go to the chassis electrical schematic index, reference the sheet number for Schematic, "WRG, Multiplex, A Zone, Port 1 and 2", for a cross reference of Input/Output Description, Connector, Pin Number and Signal (12 volt or ground). The Port 1 wiring schematic will indicate the Neutral Signal circuit connects to the MPX Module through the C connector pin number 4. Troubleshoot the Neutral signal input circuit with conventional troubleshooting procedures. We will now assume that the A1-I03 LED is on, the Input is Active as it should be, and we proceed to step 4.2.



The MPX Module is displaying A1 Inputs. Input #3 (Neutral Signal) is Active.

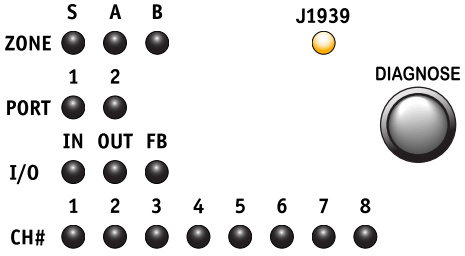
LED on
LED off

4.2 Make sure the Vandal Lock is not in the locked position. This is a B1 LED Input, so the MPX Module needs to be cycled to indicate addresses for B1 Inputs. However, now we are looking for an *In*active Input, not an Active one. Verify that the #7 Input LED is off. If the B1-I07 Input LED were to stay on while the Vandal Lock was unlocked, it might be suggestive of a stuck or shorted Vandal Lock signal switch. Again, you would refer to the appropriate wiring schematic and troubleshoot that circuit.



The MPX Module is displaying B1 Inputs. LED #7 (Vandal Lock Signal) is off—satisfying a requirement for an Inactive Input.

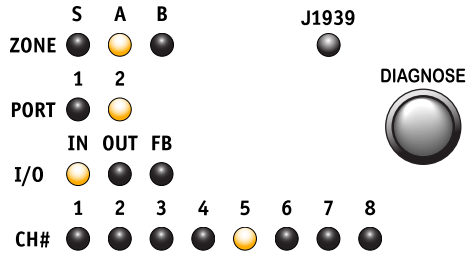
4.3 The third requirement is also for an Inactive Input; the Engine > 400 RPM. This input is generated by the engine ECU to prevent the starter from engaging if the engine is already running. Therefore, it is not an Input over which the Driver has direct control. He controls it indirectly by starting the engine. The Engine > 400 RPM input signal is communicated to the MPX Module through the J1939 data link circuit, therefore it does not have a dedicated LED indicating its status. However, the J1939 LED indicates if the data link is active (the J1939 LED will be on and may flash) and the assumption is, that if it is active, all signals communicated through the J1939 data link are good. If the J1939 LED is off, indicating a fault in the circuit, refer to specific J1939 troubleshooting instructions in the chassis electrical section for correct test procedures.



An Active J1939 LED indicates an Active Engine > 400 RPM Input.

4.4 The A2-I05 Start Switch Input must be Active. This is a signal from the ignition switch when it is turned to the Start position. Press the Diagnostic Switch enough times to cycle the MPX Module LEDs to display Zone A Port 2 Inputs, the #5 Input LED should be off. Press and hold the ignition switch and you will see that the #5 LED comes on while the switch is in the Start Position. If this did not occur, the ignition switch or its circuit would be suspect.

4.5 The A2-I02 Fuel Fill Door Input must be Inactive. This input only applies to Blue Bird Visions powered by a Propane engine. The procedures for verifying this input would be the same as in steps 4.1 through 4.4.



Still displaying A2 Inputs, LED #5 is on only when the ignition switch is in its momentary Start position.

LED on
LED off

At this point, you have verified the presence of a full set of conditions (Inputs) required for an Active Starter Signal Output, and the starting circuit should be functional. If you experiment with the MPX Simulator by changing any of the required conditions, you will see that when any of the requirements are not met, the A2-O06 Output will not be Active, and the engine will not start. This example has shown that the Multiplex Diagnostic Mode can be used to quickly isolate the location of an electrical system malfunction in a circuit with which the MPX Module interacts. (For example, consider how much time might be spent in determining that the cause of a starting problem is a damaged parking brake switch, without the benefit of multiplex.) Note that the use of Multiplex Diagnostics does not negate or invalidate traditional means of tracing and troubleshooting circuits, but serves to eliminate much of the preliminary guesswork in determining which circuit(s) to investigate.

In a real-case scenario, only after verifying all the required conditions, yet still finding the Output to be Inactive and/or the circuit inoperative, should there be reason to suspect a failure of the MPX Module itself. Remember that all Input and Outputs can be verified using a multimeter at the associated Connector and pin locations. In the unlikely case that you have thorougly investigated the Multiplex Logic and have come to suspect a defective MPX Module, Blue Bird recommends you contact your Blue Bird Distributor's service technicians for a second opinion verification of your troubleshooting.

To avoid confusion when reading Ladder Logic lines remember that the requirements shown on a Ladder Logic line are only requirements for the MPX Module to make the Output indicated at the end of the line Active. It is possible for other conditions to be required beyond the scope of the Multiplex system. (Example: Engine or Transmission ECU Logic.)

Overview

Electrical systems on the Blue Bird Vision falls into two categories: standard electrical circuits and optional or "feature driven" electrical circuits. Standard circuits consist of typical electrical systems found on every Blue Bird Vision, i.e, turn signal circuit, wiper circuit, etc. The optional circuits or feature driven circuits consist of electrical systems that are not standard on a Blue Bird Vision i.e, vandal lock circuit, heated mirrors etc. There are many options requiring electrical circuits available on the Blue Bird Vision. The number of options on any given bus depends on how the bus was ordered and manufactured. When determining if a circuit is optional, the bus application must be considered. In most cases the Blue Bird Vision will be used in a school bus application, therefore the optional eight light warning circuit would be considered a standard circuit for that application. Consideration should also be given to federal and state school bus requirements in determining if specific electrical systems are standard or optional for the bus to be operated in your area.

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Doran Warning Light Monitor

The Doran Monitor™ is a current sensing device. If current is flowing through one of the bus lamp circuits, the monitor senses it and illuminates the corresponding monitor light emitting diode (LED). When a lamp burns out, current flow through the circuit stops and the corresponding LED on the monitor does not illuminate, indicating the outside lamp is not functioning. The Doran™ Monitor is located in the bulkhead over the windshield and slightly to the left of the driver.

Warning lights are such an essential safety feature, it is important to know when they are not working properly. This is the function of the Doran monitor. Its display is a schematic of the lights as they appear outside the bus. It continuously monitors the current in each lamp. If current is flowing through a particular bus lamp circuit (i.e., the light is on), the monitor senses this and lights the corresponding monitor bulb. If the bus lamp burns out, current ceases and the corresponding monitor bulb goes out, indicating a fault. Once the defective lamp is replaced, and the warning lights are working normally again, this also should be shown by the monitor.

The Doran monitor is a reliable, long-life device, but as with most electrical instruments, it can be overheated and damaged if an overload occurs in a bus light. Such overloads can exist if a bus light circuit becomes shorted, forcing current through a coil in the monitor that exceeds the coil's rated capacity. Short circuits can occur if improper connections are made during installations, bus repairs, etc. If the monitor has an optional thermistor overload protection, the tail light circuits are overload-protected. (Thermistors are located on the bottom of the component side of the printed circuit board.)

Doran Troubleshooting

CAUTION ***Do not attempt to check a light emitting diode (LED) with an ohmmeter. Some digital voltmeters (DVM) have a diode checking position, which is acceptable for testing LEDs. Any repair of the Doran Warning Light Monitor™ should be referred to a qualified technician.***

If the Doran Warning Light Monitor™ does not display any indicator LEDs:

- An overload situation may have created an open circuit: Check the system fuses.
- An overload (due to addition of extra lights or other loads to the circuit) or physical damage may have burned or broken a conductor on the printed circuit board: Remove the extra load and replace the damaged printed circuit board.
- Excessive vibration or abuse has resulted in a damaged monitor. Replace the printed circuit board.

If a particular LED on the Doran Warning Light Monitor™ does not display, but the bus running lights are operating properly:

- The coil is burned due to an overload. Replace the coil kit.
- A solder joint has weakened (a cold solder joint). Flow new solder on the connection.
- The reed switch has failed, the reed has broken, or the contacts have failed. Replace the reed switch kit.
- The printed circuit board is broken or burned. Replace the printed circuit board.
- There is an open in the LED circuit. Replace the LED.

If a monitor LED indicator is on, but the bus running light indicated is not operating, or the bus running light switch is in the off position and the monitor indicates the running lights are operating:

- Replace the coil and reed switch kit.

If neither the bus running lights nor the Doran Warning Light Monitor™ operates properly:

- The running light bulb may be burned out. Replace the light bulb.
- The overload thermistor has protected the circuit from overload. Remove the overload condition (a short; incorrect light bulb(s); Extra lights, etc.) (i.e., trailer lights, etc.)

Calibration

To self calibrate the monitor, ALL monitored lights must be in working order. For faster calibration, the operator may turn on as many exterior lights as possible at the start of the procedure. The operator will be required to activate these lights during the calibration procedure. Operator may begin with the tail/head lights on, hazard lights (for the turn signals), and the amber warning lights flashing (door closed).

1. Turn on ignition and start engine – Engine is running to assure proper voltage for operation and calibration. The GREEN LED voltage indicator at the bottom center of the monitor MUST BE ILLUMINATED indicating the voltage is within limits for proper operation. Before beginning calibration, allow time for the voltage to stabilize to its normal running voltage. After cranking the engine the battery voltage may be lower than normal. Allow time for the battery to recharge.

2. When the ignition is turned on, all LED's on monitor will be enabled for a few seconds to verify that all LED's are working.

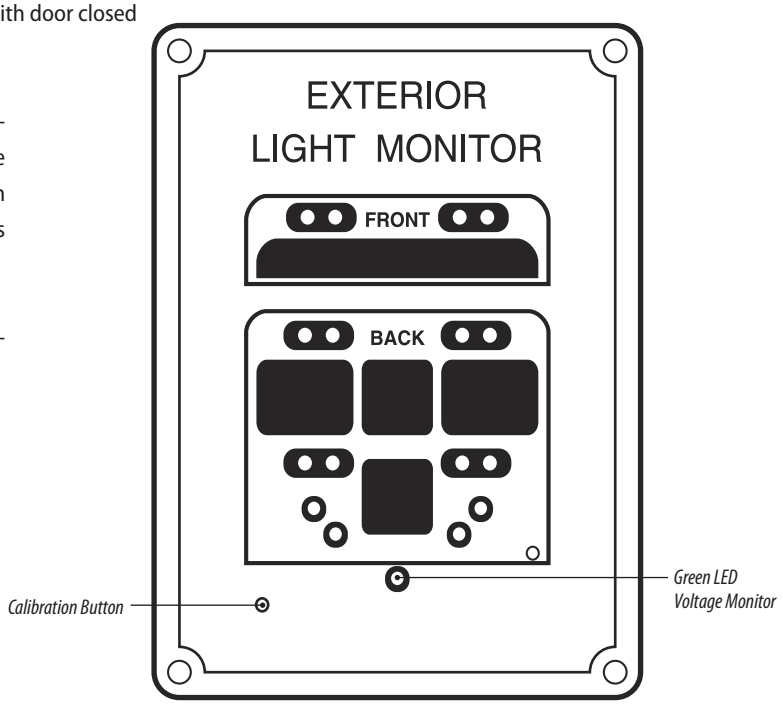
3. To enter the calibration mode, press and hold the calibrate button through the face plate hole for longer than two (2) seconds. This button/hole may be found located at the bottom left corner of the bus image on the monitor face plate. The first light to calibrate will begin flashing when the unit enters calibration mode. You may use an object such as an allen wrench or paper clip to activate the switch.

4. The unit will begin calibrating each light in a sequence. Each light tested must be active at the time of the calibration. As each light is calibrated, the matching monitor LED will flash. Operator shall activate (if not active) the bus light corresponding to the flashing LED. The sequence is as follows:

    a. Left turn signal – switch on
    b. Right turn signal – switch on
    c. Stop lights (left, then right side 7" will flash) – press brake pedal
    d. Tail light (left, then right side 4" will flash) – switch on (brakes off)
    e. Backup lights – press brake/clutch and engage reverse
    f. Each Amber warning light – switch on with door closed
    g. Each Red warning light – open door

5. Calibrated lights are indicated by the corresponding LED staying illuminated on the monitor. The unit continues to loop through the sequence flashing the un-calibrated lights until all lights are calibrated.

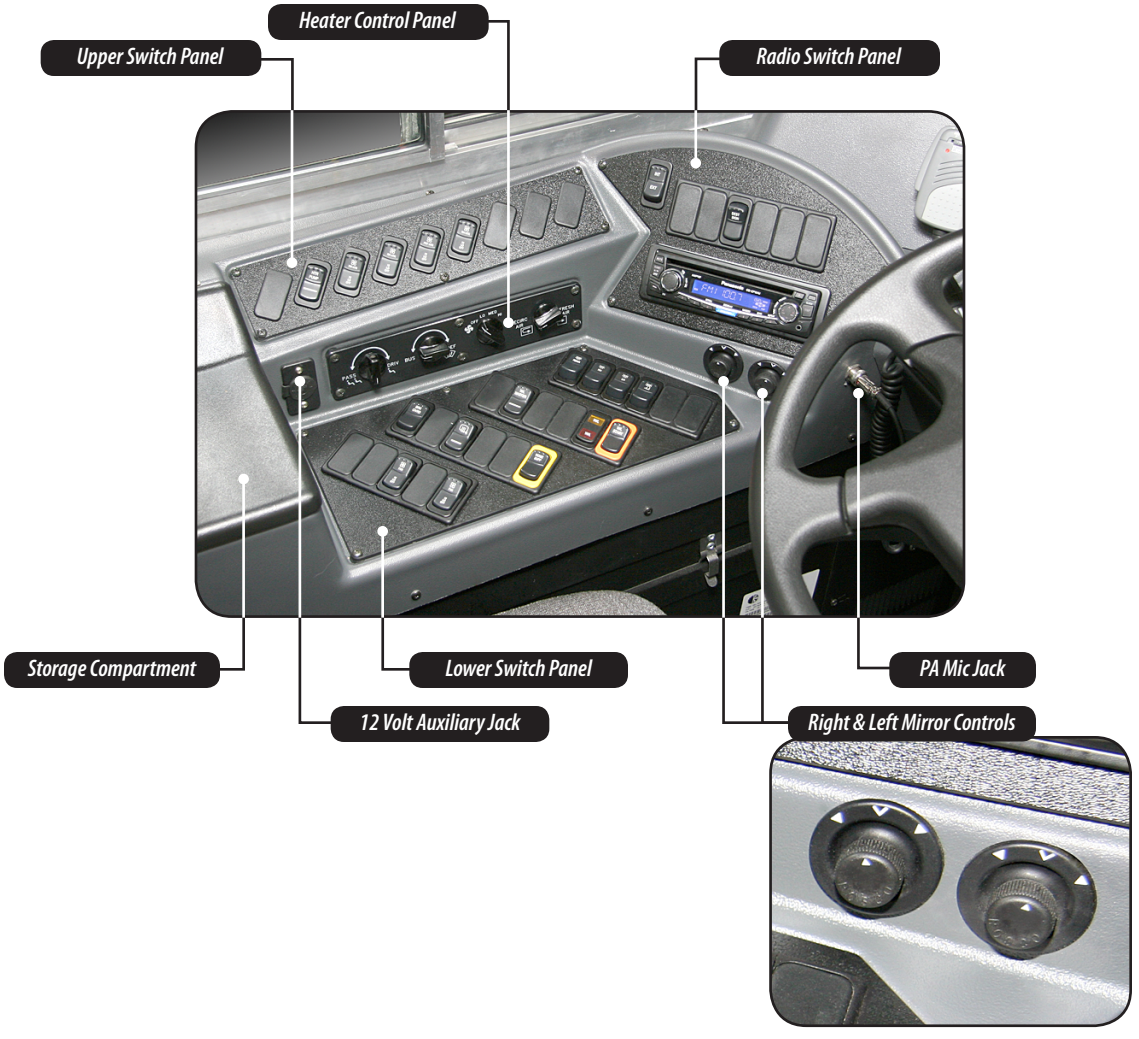
6. When all LED's are illuminated, turn off ignition to complete the calibration.



Left Switch Console

The left switch console under the driver's side window shown here consist of, the Radio Switch Panel, the Heater Control Panel, Right and left rearview mirror controls, upper and lower switch banks, a storage compartment, the optional PA mic jack and a 12 volt auxiliary jack as well.

The left switch console contains three switch panel banks. The exact arrangement of switches in all switch panels is somewhat dependent upon specific state specifications. (For example, some states require additional switches for red and amber Warning Light pilots.) Shown are the standard and most common configurations. If your bus differs from the diagarms shown, check with your local specifications and familiarize yourself with each switch function.

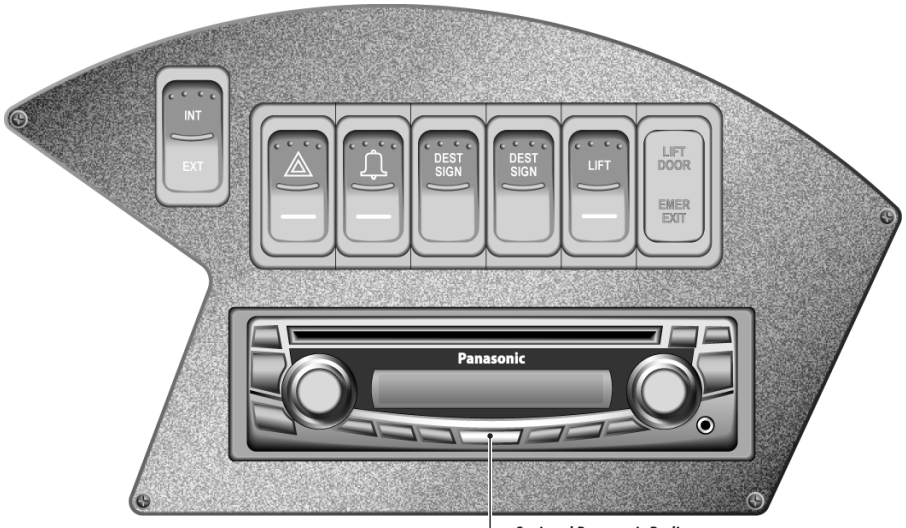


Radio Switch Panel

The radio console switch panel located to the left of the driver and shown below includes a Panasonic AM/FM stereo cassette or CD player with PA system, depending on option ordered. The panel contains switches for standard and optional equipment and will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. The following is a list of switches and indicators found in this panel and their descriptive icons.



PA Mic



Optional Panasonic Radio
With CD or Cassette and optional PA Mic.

INT / **EXT** — **Public Address.** Interior and exterior speakers.

Hazard Lights. This switch turns on / off the front and rear turn signals as blinking hazard flashers.

Chimes. Provides power for passenger compartment chime system.

DEST SIGN — **Destination Sign.**

LIFT — **Lift.** Provides power for lift operation.

LIFT DOOR — **Indicator Lights.** Lift door open and /or Emergency door open.

EMER EXIT

Upper Left Switch Panel

The upper left switch panel located directly below the driver's window and shown below includes switches that control the heater systems installed on your bus. The panel contains switches for standard and optional equipment heaters including front and rear heaters, the driver's heater, underseat heaters, and auxiliary heater pump. The panel will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. The following is a list of switches and their descriptive icons found in this panel.



Driver's Heater Fan. High, off and low positions.



Heater pump. Provides power to auxiliary heater pump, supplying heat to the passenger compartment.

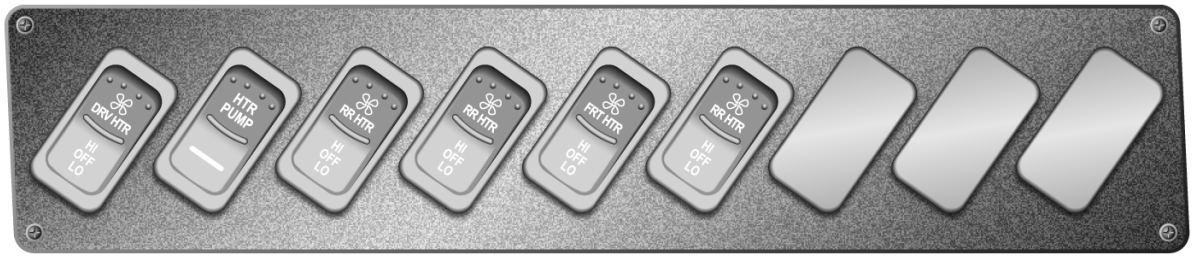


Underseat Heater Fan Switches. 3-position (High, Off, Low) . Additional 3-position heater switches may be located in the left console lower panel if the bus is equipped with optional passenger area heaters. These switches control the fan speed of underseat heaters.





Perimeter Convection Heater Switch. 2-position (On / Off). If the bus is equipped with optional perimeter convection heaters in the passenger area, a switch is provided to toggle these heaters on and off. This switch operates an electric valve which controls the flow of engine-heated water.



Heater Control Panel

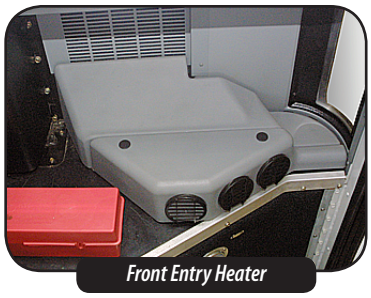
The Heater Control panel of the Side Console contains controls for the front heater unit which is housed immedately below the Side Console left of the Driver seat. Ducts from this unit also provide windshield defrosting.

Fresh / Recirculate. This knob controls the type air, which is circulated by the heater system and fan. By turning clockwise, air is circulated from the interior of the vehicle. This is desirable when trying to heat passenger compartment rapidly. By turning the control knob counterclockwise air from outside the bus is used in the system. This is helpful when trying to cool the vehicle.

Heater Fan. This knob adjusts the speed of the fan, which circulates the air in the system. In the counter clockwise position, the blower is off. By turning clockwise, 3 speeds can be achieved — low, medium and high..

Defrost / Bus. This knob adjusts the air flow balance between the vehicle passenger compartment and the windshield. By turning knob clockwise, a damper is moved and air is diverted toward the windshield for defrosting.

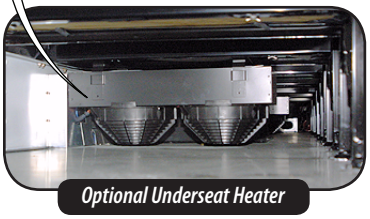
Driver / Passenger. This knob Adjusts air flow balance in two directions. By turning knob clockwise, a damper is moved and air is diverted toward the driver. By turning counterclockwise, the air is diverted toward passengers. The amount of air diverted is proportional to amount the knob is turned.



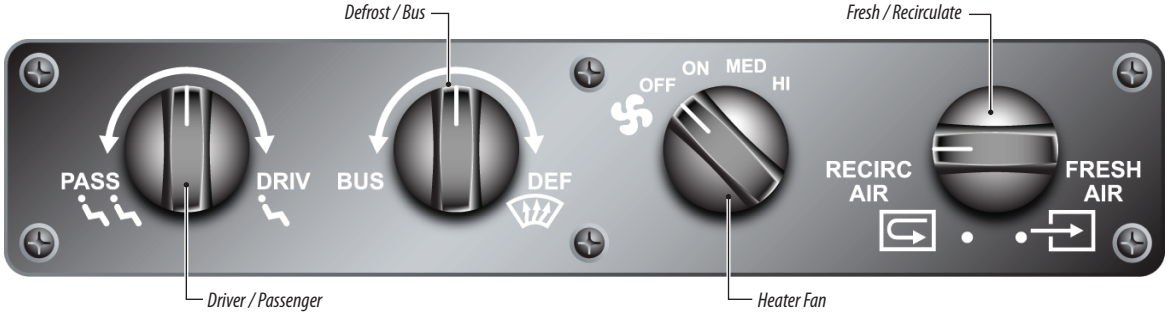
Front Entry Heater

Underseat Heater Switches





Optional Underseat Heater



Lower Left Switch Panel

The lower left switch panel located directly beside the driver consist of switches for standard and optional equipment. The panel will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. The following is a list of switches and indicators found in this panel and their descriptive icons.



Rear Dome Lghts. Turns on / off the overhead lights in the passenger area. Some Vision buses have two of these switches, one each for the dome lights in the front half and rear half or the right side and left side the bus.



Left Side Dome Lights.



Right Side Dome Lights.



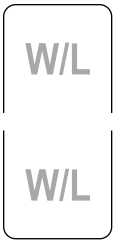
Driver's Dome Light. Turns on / off the overhead light in the Driver area.



Door Switch. Press and hold the top of this momentary rocker switch to open the entrance door. The door stops automatically when it reaches the end of its travel. Press and hold the bottom of the switch to close the door.



Warning Light Start. Switch with orange bezel. A momentary switch which initiates the Warning Light sequence. Press this switch upon approach to each school bus stop. In most Warning Light System configurations, this activates the amber warning light flashers. When the door is then opened, the red warning lights are activated and the stop arm and crossing arm extend. This also activates the Sleeping Child check system, as indicated on the Driver Information Display.



Warning Light Indicators. Red and yellow.



Warning Light Emergency. This momentary switch activates the red warning lights for use in the case of emergency, such as a roadside hazard.

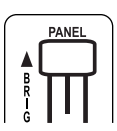


Warning Light Master. Enables entire warning light system. This switch must be on whenever the Warning Light System system is required. Specific requirements vary according to state specifications. Generally, the use of the Warning Light System is required whenever picking up and discharging students. The Master switch enables you to disable the Warning Light System when stopping for other purposes such as fueling stops.

CAUTION ***Be sure to turn the Warning Light Master Switch off when the bus is parked overnight. Whenever the Warning Light Master switch is on, the Vision's Multiplex System will not enter its sleep mode, even if the key is removed. This will lead to battery discharge.***

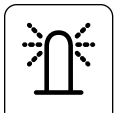


Stop Arm/Crossing Arm Cancel. Interupts stop arm and/or crossing arm sequence. Pressing this momentary switch retracts the Stop Arm and Crossing Arm if they are extended. Pressing it again extends them.

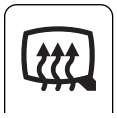


Noise Suppression. Includes yellow bezel. Momentary or on/off. When pressed and held, certain noisy devices such as auxilliary fans, heater blowers and radio are momentarily turned off to enable the Driver to better hear ambient sounds, such as railroad signals and gate intercoms or personnel, etc.

Console Panel Dimmer. Dims or brightens Console Panel switches.



Strobe Light. Controls the roof-mounted strobe light.



Mirror Defrost. Activates defrosting system for exterior rearview mirrors.



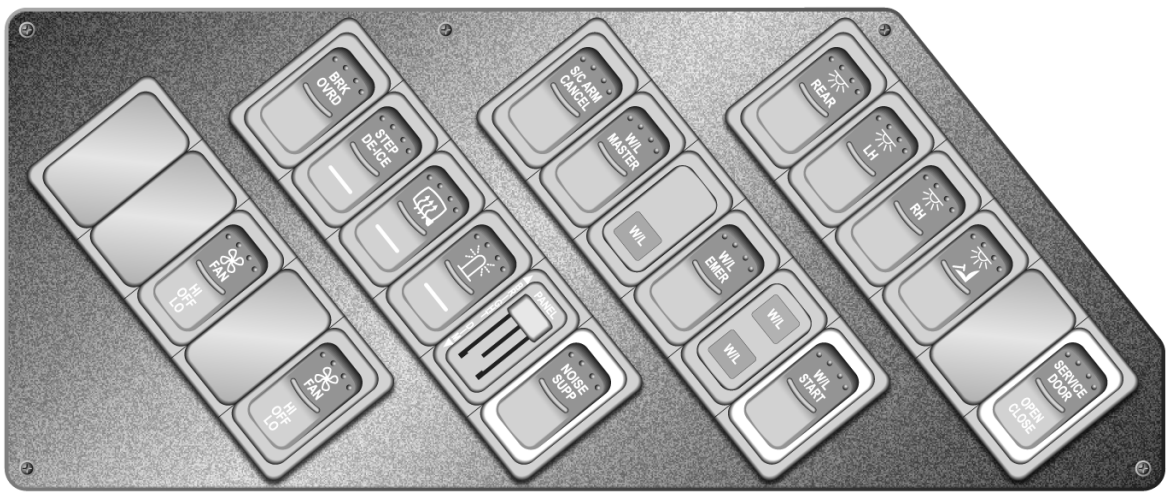
Step De-Ice. Activates de-icing system for entrance door steps.



Brake Interlock Overide. Momentary switch overides Brake Interlock system.

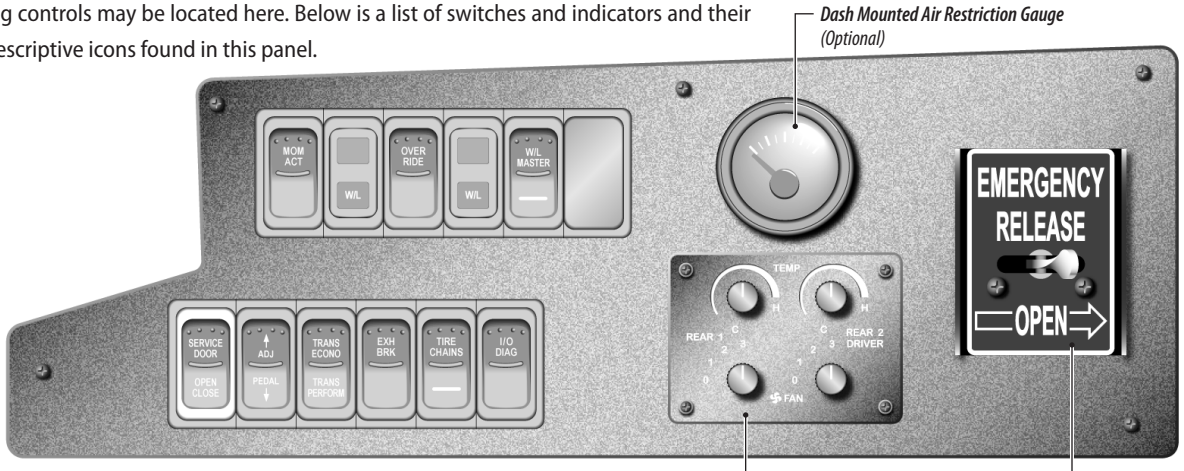


Fans. Left, center and right auxiliary fans. High, low, and off positions. Fans are provided for general air circulation, Driver comfort, and/or to help accellerate windshield de-fogging under certain conditions.



Right Console Switch Panel

The right switch panel located toward the center of the bus consist of switches for standard and optional equipment. The panel will be equipped only with switches for options that are included on your bus and therefore may differ from the panel shown here. Other options such as a dash mounted air restriction gauge, a relocated air door emergency release and a location for the standard or electronic air conditioning controls may be located here. Below is a list of switches and indicators and their descriptive icons found in this panel.



MOM ACT — **Warning Light Momentary.** Activates the warning light system.

OVER RIDE — **Override.** Switch enables an override of the sequencial locks. (Fearure Specific).

W/L MASTER — **Warning Light Master.** Enables entire warning light system. This switch must be on whenever the Warning Light System system is required. Specific requirements vary according to state specifications. Generally, the use of the Warning Light System is required whenever picking up and discharging students. The Master switch enables you to disable the Warning Light System when stopping for other purposes such as fueling stops.

W/L — **Warning Light Indicators.** Red and yellow.

SERVICE DOOR / **OPEN CLOSE** — **Electctric Entrance Door.** Switch with blue bezel. Press and hold the top of this momentary rocker switch to open the entrance door. The door stops automatically when it reaches the end of its travel. Press and hold the bottom of the switch to close the door.

ADJ / **PEDAL** — **Pedal Adjustment.** Allows forward and rearward movement of the accelerator and brake pedal. Provides a 3 inch range of movement.

TRANS ECONO — **Transmission Economy.** Puts transmission into an economy shift pattern. Can be used for long trips.

TRANS PERFORM — **Transmission Perform** puts transmission into a performance shift mode. This is the default mode for the tramsmission and can be used for short stop and go trips.

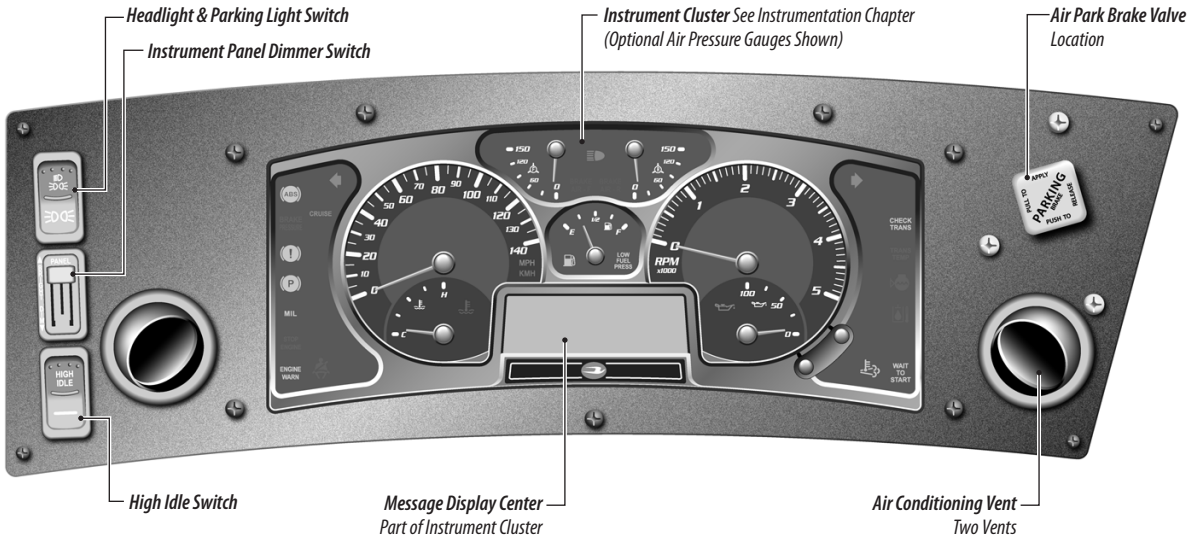
EXH BRK — **Exhaust Brake.** Activates the exhaust brake to help slow engine speed during deceleration.

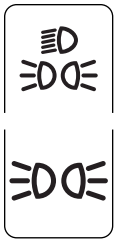
TIRE CHAINS — **Tire Chains.** Drops tire chains into position for icy conditions.

I/O DIAG — **Diagnostic Switch.** Provides diagnostic functions for the IO Control Multiplex system and the ABS system. For use by qualified personnel for diagnostic purposes only.

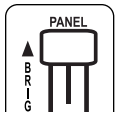
Driver's Instrument Panel

The driver's instrument panel behind the steering wheel and shown here consist of the instrument panel cluster, headlight switch, panel dimmer switch, high idle switch and air conditioning vents. If your bus is equipped with air brakes the parking brake valve is also located in this panel.





Headlights & Parking Lights. This switch turns headlights on and off, or turns on Parking Lights. Because daytime running lights are required, the headlights shine at a lower amperage during normal bus operation after the engine is running, even when this switch is in the bottom position.



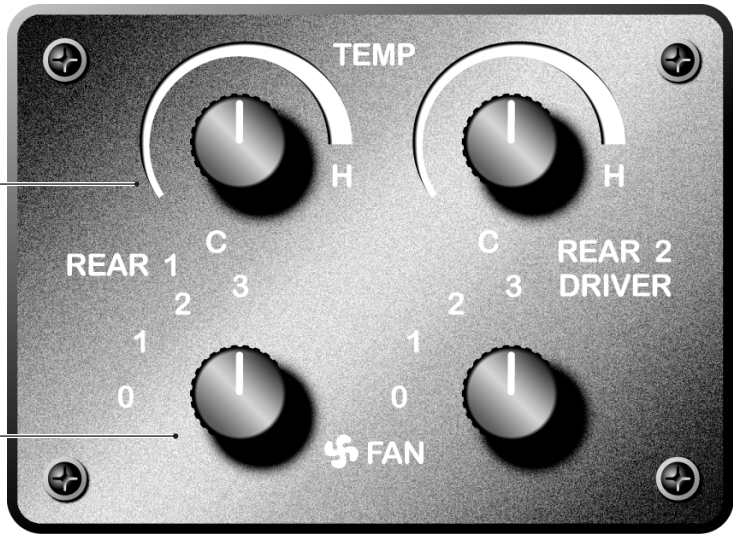
Instrument Dimmer. This slider switch is continuous, but has three detents. It adjusts the brightness of the instrument cluster and some of the backlighted switches.



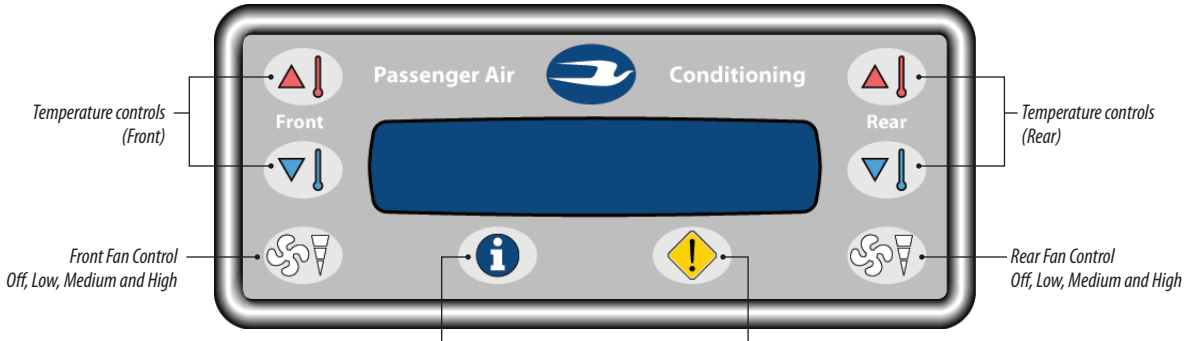
High Idle. This switch raises the engine idle RPM when in the on position. This may be used during engine / heater warmup and to increase alternator output in driving conditions which cause a high battery drain, such as very frequent stop / go while multiple accessories are on. This function is also useful when the bus is parked and left running for long periods of time or when electrical system demands are high such as running the AC or operating a wheelchair lift. Place the transmission in Neutral and set the Parking Brake before switching the engine to High Idle.

Heat and Air Controls

The optional heat and air control panels are defined below. For further explanation of heater switches and controls, see Upper Left Switch Panel and Heater Control Panel, under Left Console Switch Panel found in ths manual. For additional information on optional air conditioning, see your Comfort Aire publication supplied with your air conditioned bus.



Comfort Aire Manual Controls



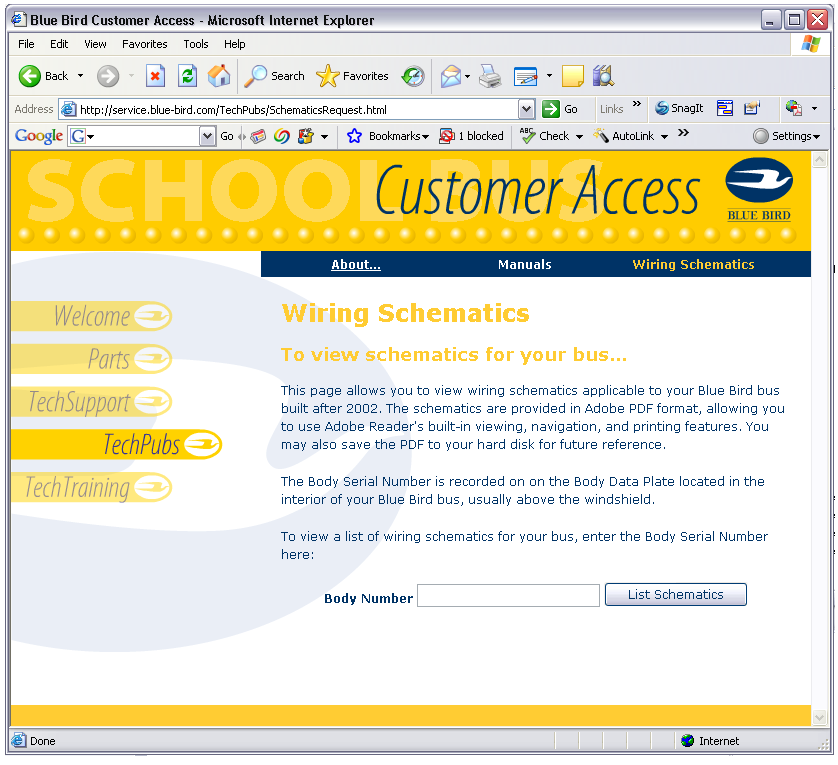
Comfort Aire Electronic Controls

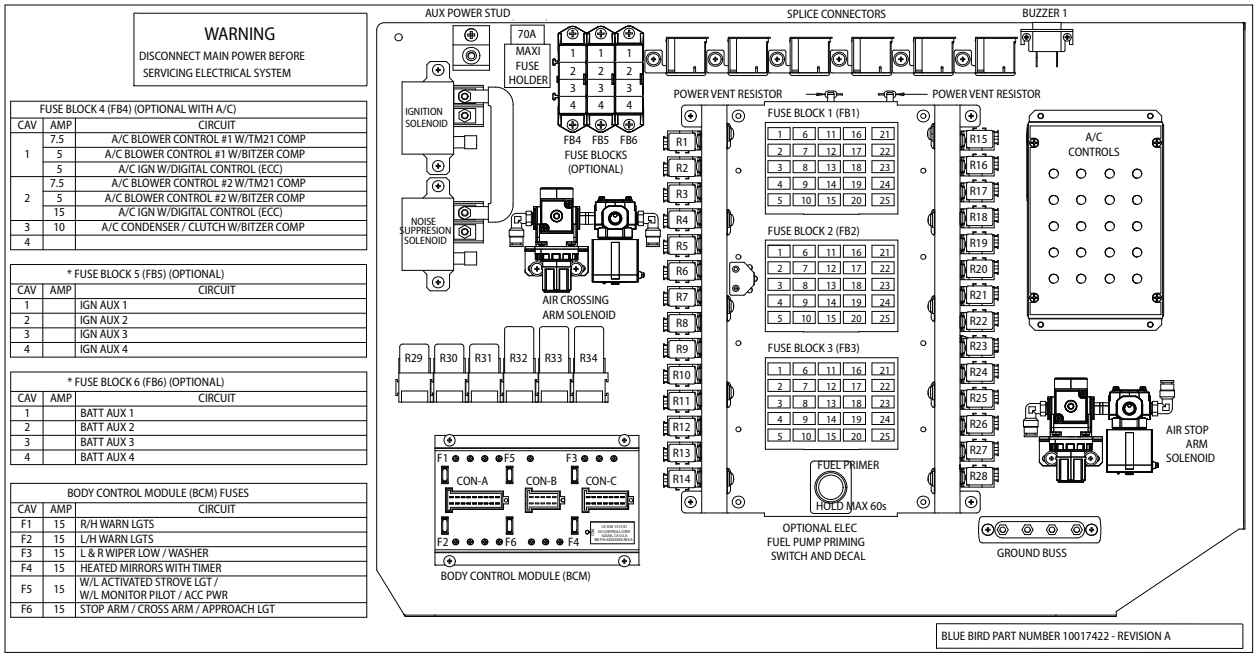
Body Wiring Schematics

Many customers select options which affect the wiring on a Blue Bird Vision. The drawings on the DVD are in resolution-independent vector format. This allows you to zoom them at will, without the images becomming jagged which occur with bit-map formats. This also means that you may print the drawing to your own office or desktop printer while maintaining legibility even at significant reductions.

For more information see; **About the TechReference DVD; Electrical Schematics** located in the **Introduction** section of **Volume 1**. Also see additional wiring schematics for your bus at the Customer Access web site:

http://service.blue-bird.com/wiringschematics





Decal, Electrical Panel, Layout

10017422A

748

FUSE BLOCK 1 (FB1)

CAV	AMP	CIRCUIT	CAV	AMP	CIRCUIT
1			14	3A	REMOTE CONTROL MIRRORS
2	10	MISC IGN	15		
3	15	2-WAY RADIO	16		
4	20	DEST SIGN	17	5	EXT LGT MONITOR
5	5	CONVECTION HTR	18	15	HEATED MIRRORS
6			19	15	EXT LOADING LGTS
7	5	EMER REL - AIR DOOR IGN	20		
8	5	EXIT DOOR	21		
9	5	NOISE SUPP W/P.A.	22	5	STEPWELL LGT (IGN)
10	10	ROOF STROBE LGT	23	10	VIEDO MONITOR PWR
11			24	15	ADJUSTABLE PEDAL
12	5	LIFT PILOT	25		
13	5	TIRE CHAINS			

FUSE BLOCK 2 (FB2)

CAV	AMP	CIRCUIT	CAV	AMP	CIRCUIT
1			14	5	SIDE EMERG DOOR VANDAL LOCK
2			15	10	BACK-UP LGTS W/R.E.D.
3	5	W/L EMER OVERRIDE SW	16		
4	5	FRONT STOP ARM PWR	17	20	STEP DE-ICER
5	5	REAR STOP ARM PWR	18	10	LUGG COMPARTMENT LGTS
6			19	10	LIFT LOADING LGTS
7	5	CROSS ARM MTR	20	25	ROOF LOADING LGTS
8	20	ACC PWR SOCKET	21	5	ENT DOOR PWR (AIR)
9	20	COMPRESSOR-AIR DRS SEAT / ELECT FUEL PRIMER		20	ENT DOOR PWR (ELEC)
			22	20	LH ENT DOOR
10	30	AUX HTR	23	20	DOME LGTS ACTIVATED
11	5	VCR MEMORY	24	5	REAR ALERT SIGN / WARN LGTS ON W/LIFT DR
12	5	SLEEPING CHILD CHECK	25		
13	5	RADIO MEMORY			

FUSE BLOCK 3 (FB3)

CAV	AMP	CIRCUIT	CAV	AMP	CIRCUIT
1	15	CLPS / MRK / ID LGTS	14	20	L/REAR HTR MTR 1
2	5	RADIO IGN PWR	15	20	L/REAR HTR MTR 2
3	7.5	AUX FAN - CENTER	16		
4	30	AUX FAN - DUCTED	17	15	R/FRT HTR MTR 1
5	7.5	AUX FAN - LEFT	18	15	R/FRT HTR MTR 2
6	5	STD WARN LGT SYS	19	20	R/REAR HTR MTR 1
	20	WHEELEN WARN LGT SYS			
7	7.5	AUX FAN - RIGHT	20	20	R/REAR HTR MTR 2
8	20	EXHAUST FAN	21	10	STD DOME / RIGHT DOME / FRONT DOME
9	20	FRT STEPWELL HTR	22	20	LEFT DOME / REAR DOME
10	15	HTR WATER PUMP	23	5	REAR SWITCHED DOME
11			24	5	DRIVERS DOME
12	15	L/FRT HTR MTR 1	25	35	MAIN HTR/DEFROSTER
13	15	L/FRT HTR MTR 2			

RELAYS/FLASHERS

LOCATION	TYPE	DESCRIPTION
R29	MINI	FRONT LOADING LGT / CRIME ALERT / LIFT DOOR ACTIVATE WARNING LIGHTS
R30	MINI	SPARE
R31	MINI	ADJ. PEDAL
R32	FLASHER	LIFT PILOT
R33	FLASHER	EXIT PILOT
R34	MINI	SPARE

* NOTE: OPTIONAL FUSE BLOCKS FB5 & FB6 PROVIDE IGNITION AND/OR BATTERY POWER @ 20 AMPS PER POSITION.
IT IS THE RESPONSIBILITY OF THE INSTALLER OF AUX CIRCUITS TO ENSURE SYSTEM AMPERAGE IS NOT EXCEEDED.

RELAY

LOCATION	TYPE	DESCRIPTION
R1	MICRO	SPARE
R2	MICRO	SPARE
R3	MICRO	SPARE
R4	MICRO	SPARE
R5	MICRO	MUX WAKE-UP
R6	MICRO	AUTO HIGH IDLE (PROPANE)
R7	MICRO	CLPS / MRK / ID LGTS
R8	MICRO	W/L SYSTEM
R9	MICRO	W/L SYSTEM
R10	MICRO	W/L SYSTEM
R11	MICRO	STOP ARM CONTROL
R12	MICRO	W/L PILOT
R13	MICRO	W/L OVERRIDE
R14	MICRO	STOP ARM CANCEL
R15	MICRO	DOME LGT ACTIVATED-1 RELAY
R16	MICRO	DOME LGT ACTIVATED-2 RELAY
R17	MICRO	DOME LGT ACTIVATED-3 RELAY
R18	MICRO	FRT STEPWELL HTR
R19	MICRO	LH REAR WALL HTR MTR 1
R20	MICRO	LH REAR WALL HTR MTR 2
R21	MICRO	RH REAR WALL HTR MTR 1
R22	MICRO	RH REAR WALL HTR MTR 2
R23	MICRO	STEP DE-ICER
R24	MICRO	DOME LIGHT ACTIVATION
R25	MICRO	DESTINATION SIGN
R26	MICRO	HEATED MIRROR TIMER RELAY
R27	MICRO	COMPRESSOR - AIR SEAT
R28	MICRO	BACK-UP LGTS ACTIVATED

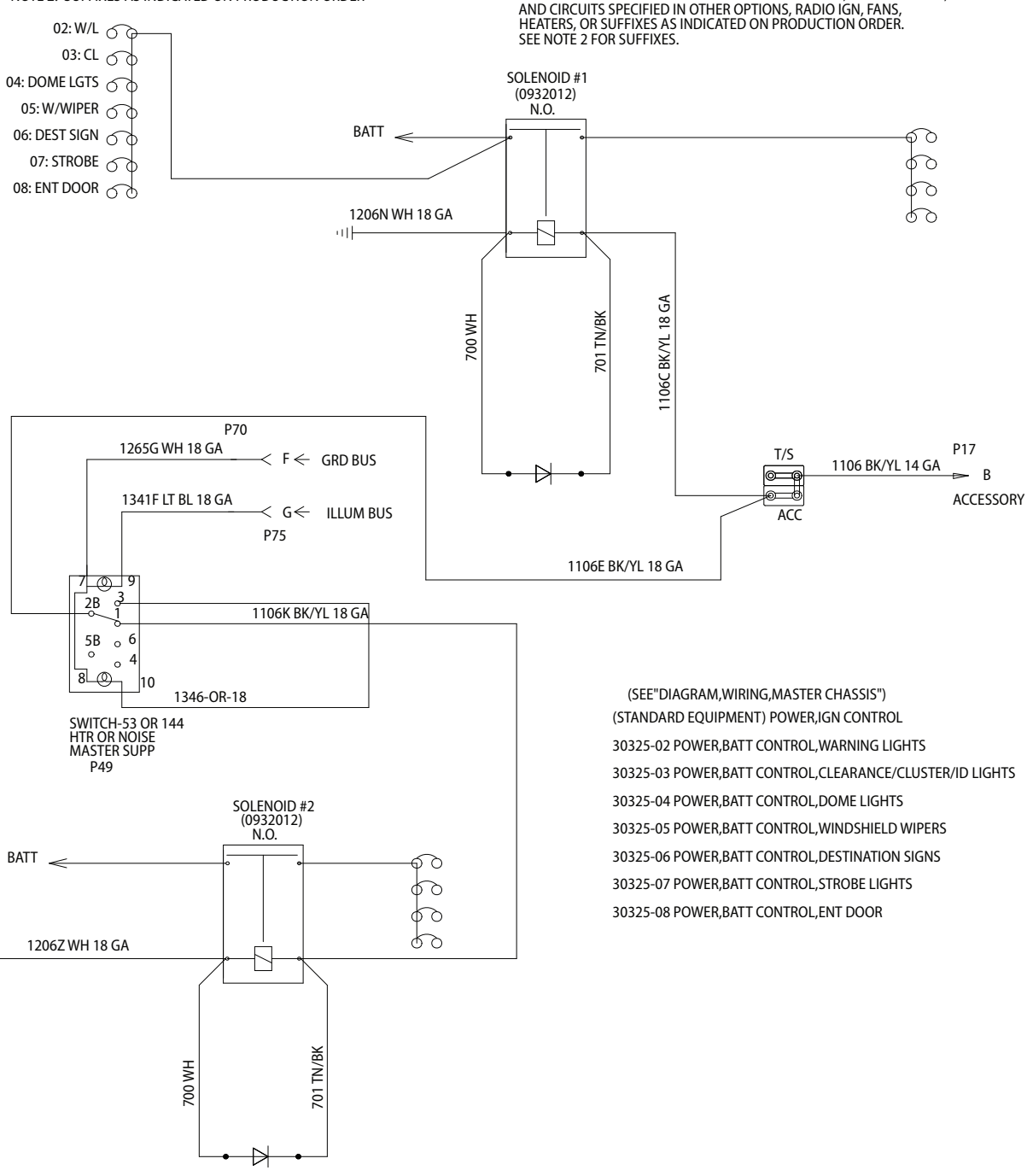
BLUE BIRD PART NUMBER 10017421 - REVISION D

Decal, Electrical Panel, Chart

10017421D

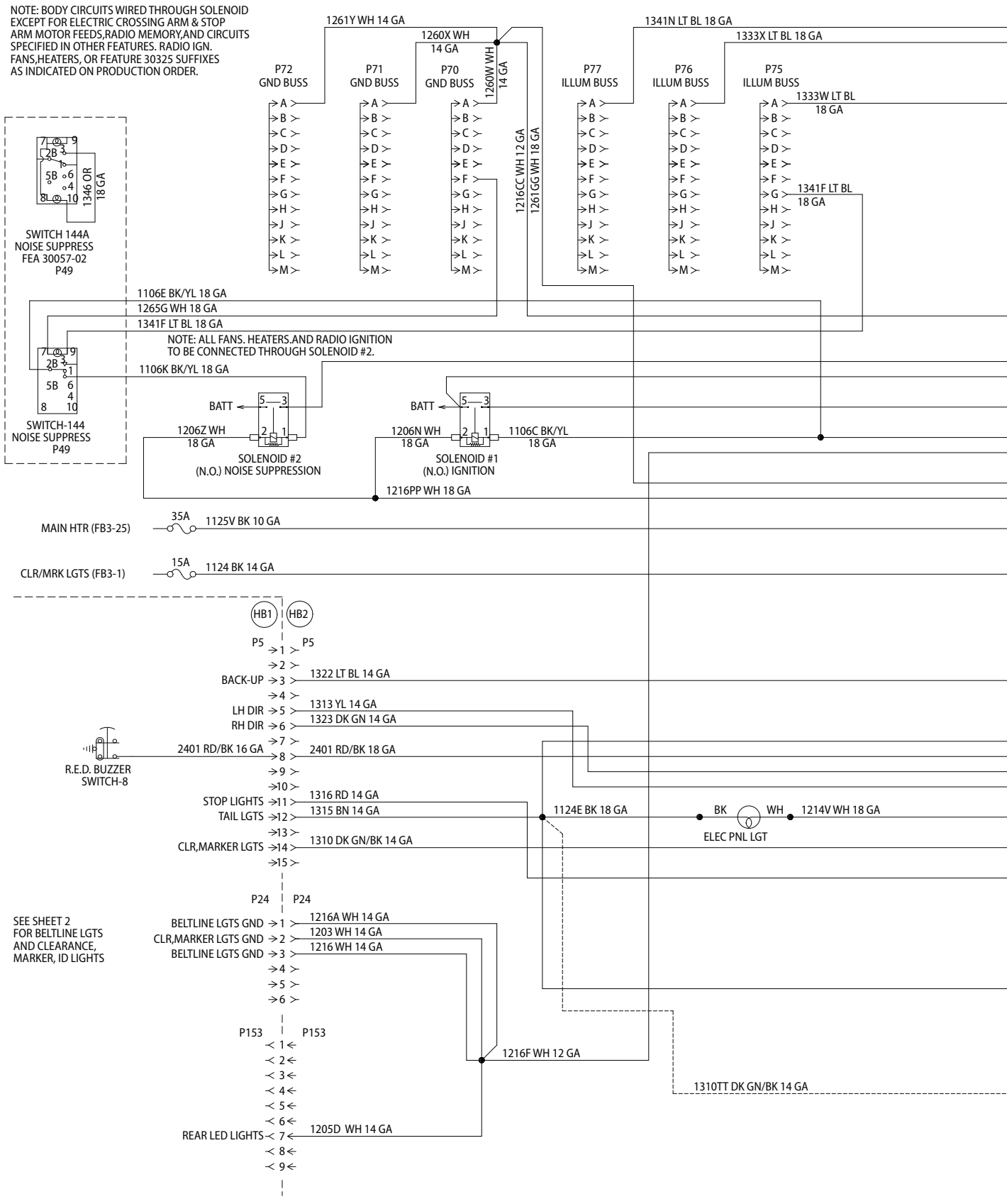
NOTE 2: SUFFIXES AS INDICATED ON PRODUCTION ORDER

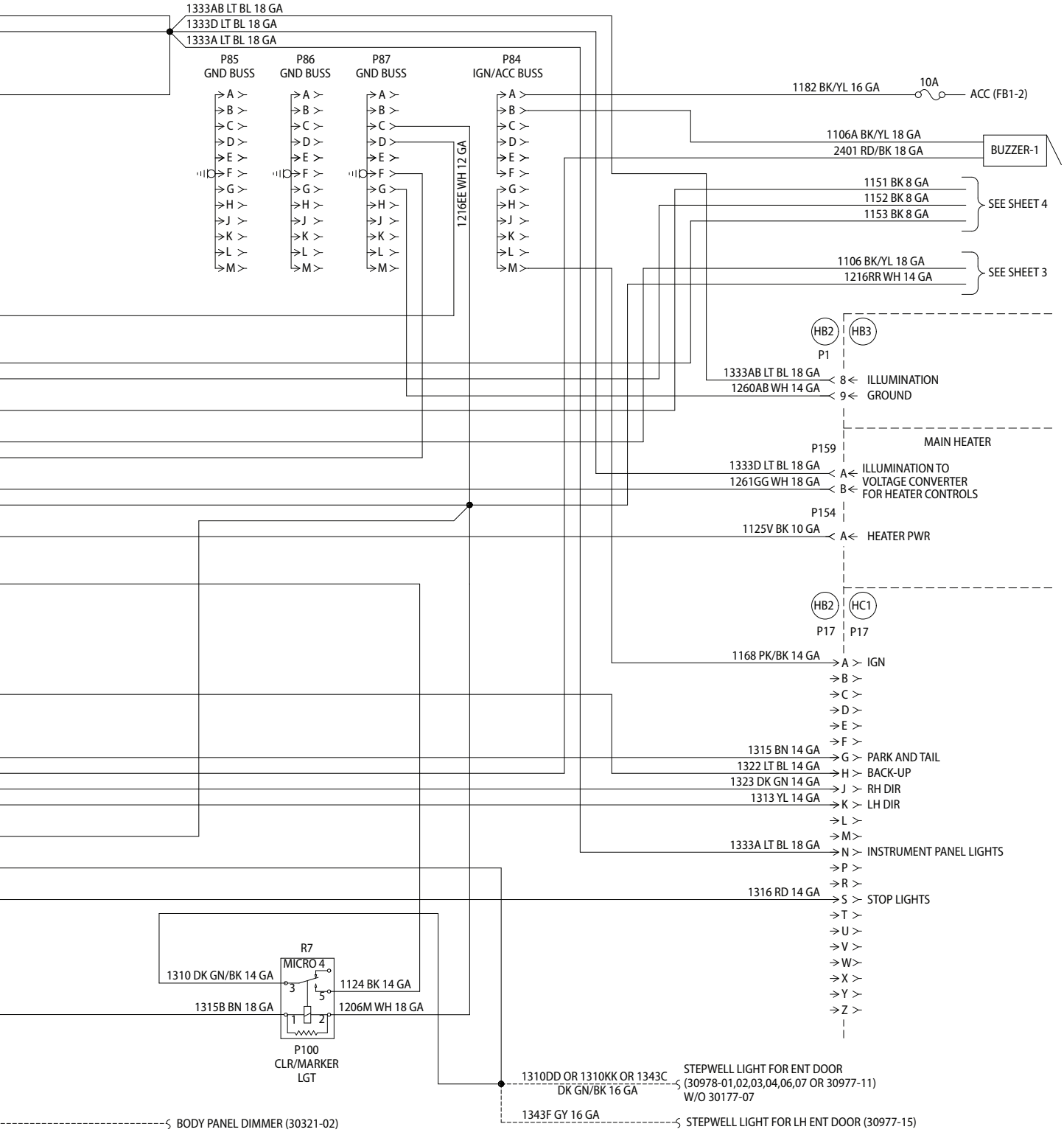
NOTE1: BODY CIRCUITS WIRED THROUGH SOLENOID EXCEPT FOR ELECTRIC CROSSING ARM & STOP ARM MOTOR FEEDS,RADIO MEMORY, AND CIRCUITS SPECIFIED IN OTHER OPTIONS, RADIO IGN, FANS, HEATERS, OR SUFFIXES AS INDICATED ON PRODUCTION ORDER. SEE NOTE 2 FOR SUFFIXES.



NOTE 3: ALL FANS. HEATERS. AND RADIO IGNITION TO BE CONNECTED THROUGH SECOND SOLENOID.

(SEE"DIAGRAM,WIRING,MASTER CHASSIS")
(STANDARD EQUIPMENT) POWER,IGN CONTROL
30325-02 POWER,BATT CONTROL,WARNING LIGHTS
30325-03 POWER,BATT CONTROL,CLEARANCE/CLUSTER/ID LIGHTS
30325-04 POWER,BATT CONTROL,DOME LIGHTS
30325-05 POWER,BATT CONTROL,WINDSHIELD WIPERS
30325-06 POWER,BATT CONTROL,DESTINATION SIGNS
30325-07 POWER,BATT CONTROL,STROBE LIGHTS
30325-08 POWER,BATT CONTROL,ENT DOOR


NOTE: BODY CIRCUITS WIRED THROUGH SOLENOID EXCEPT FOR ELECTRIC CROSSING ARM & STOP ARM MOTOR FEEDS,RADIO MEMORY,AND CIRCUITS SPECIFIED IN OTHER FEATURES. RADIO IGN. FANS,HEATERS, OR FEATURE 30325 SUFFIXES AS INDICATED ON PRODUCTION ORDER.
1261Y WH 14 GA
1260X WH 14 GA
1260W WH 14 GA
1341N LT BL 18 GA
1333X LT BL 18 GA
P72 GND BUSS
P71 GND BUSS
P70 GND BUSS
P77 ILLUM BUSS
P76 ILLUM BUSS
P75 ILLUM BUSS
1333W LT BL 18 GA
1341F LT BL 18 GA
1216CC WH 12 GA
1261GG WH 18 GA
1346 OR 18 GA
SWITCH 144A NOISE SUPPRESS FEA 30057-02 P49
1106E BK/YL 18 GA
1265G WH 18 GA
1341F LT BL 18 GA
NOTE: ALL FANS. HEATERS.AND RADIO IGNITION TO BE CONNECTED THROUGH SOLENOID #2.
1106K BK/YL 18 GA
SWITCH-144 NOISE SUPPRESS P49
BATT
1206Z WH 18 GA
SOLENOID #2 (N.O.) NOISE SUPPRESSION
1206N WH 18 GA
SOLENOID #1 (N.O.) IGNITION
1106C BK/YL 18 GA
1216PP WH 18 GA
MAIN HTR (FB3-25)
35A
1125V BK 10 GA
CLR/MRK LGTS (FB3-1)
15A
1124 BK 14 GA
HB1
HB2
P5
BACK-UP
1322 LT BL 14 GA
LH DIR
1313 YL 14 GA
RH DIR
1323 DK GN 14 GA
R.E.D. BUZZER SWITCH-8
2401 RD/BK 16 GA
2401 RD/BK 18 GA
STOP LIGHTS
1316 RD 14 GA
TAIL LGTS
1315 BN 14 GA
1124E BK 18 GA
BK
WH
1214V WH 18 GA
ELEC PNL LGT
CLR,MARKER LGTS
1310 DK GN/BK 14 GA
P24
SEE SHEET 2 FOR BELTLINE LGTS AND CLEARANCE, MARKER, ID LIGHTS
BELTLINE LGTS GND
1216A WH 14 GA
CLR,MARKER LGTS GND
1203 WH 14 GA
BELTLINE LGTS GND
1216 WH 14 GA
P153
1216F WH 12 GA
1310TT DK GN/BK 14 GA
REAR LED LIGHTS
1205D WH 14 GA

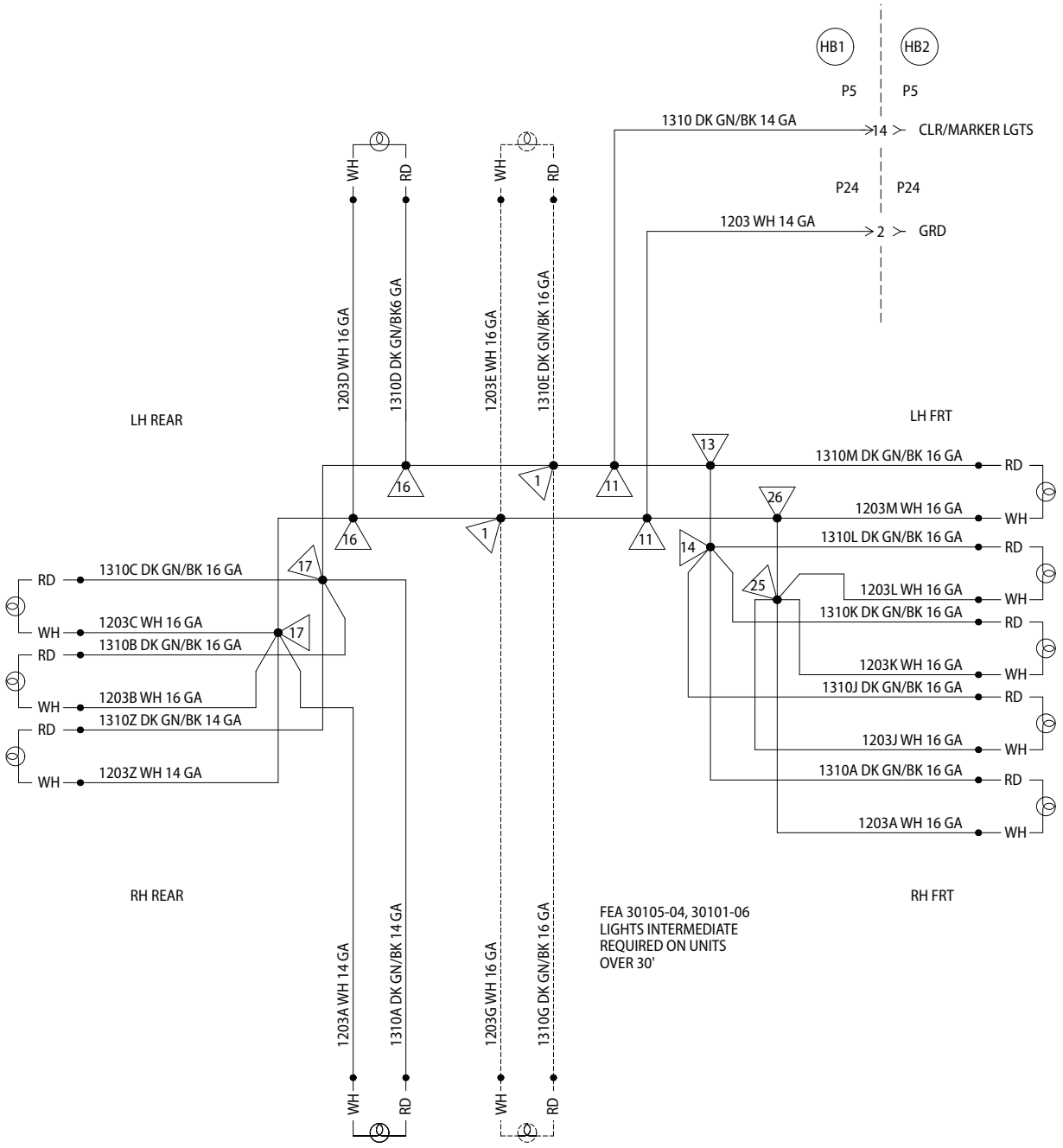


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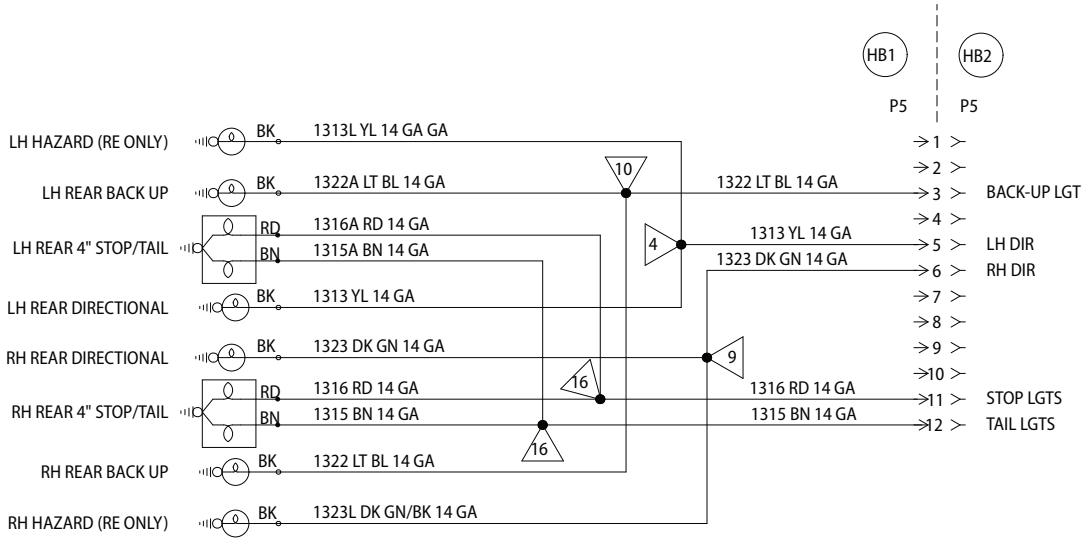
Sheet 1 of 4

D0005632A

DIAGRAM,WRG,STANDARD EQUIPMENT, with Dual Zone MPX



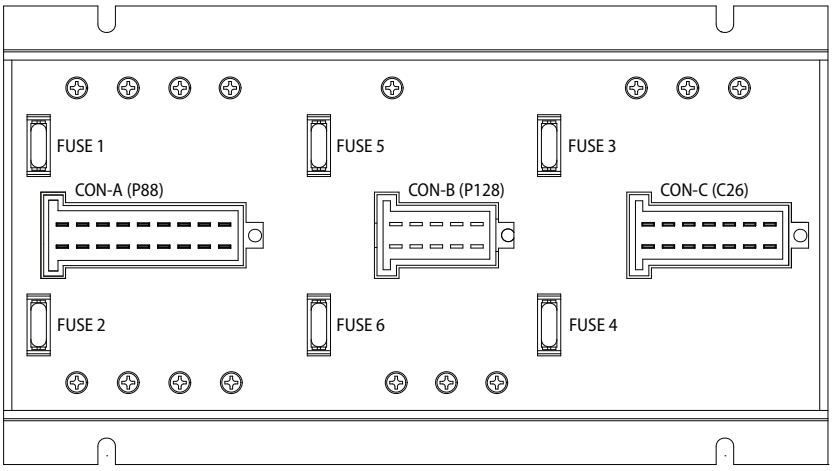
STANDARD
(CLEARANCE,MARKER,ID LIGHTS)
(FEAT 30101-03, 30102-04)
SEE SHEET 1



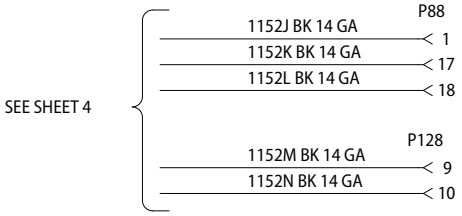
STANDARD
(BELTLINE LGTS)
SEE SHEET 1

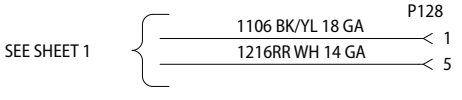
D0005632A

DIAGRAM,WRG,STANDARD EQUIPMENT, with Dual Zone MPX



FUSE #	LOAD CURRENT (A)	FUNCTION	DESCRIPTION
FUSE 1	15A	OUTPUT1	RH AMBER W/L
		OUTPUT2	RH RED W/L
FUSE 2	15A	OUTPUT3	LH AMBER W/L
		OUTPUT4	LH RED W/L
FUSE 3	15A	OUTPUT5	LH WIPER LOW
		OUTPUT6	RH WIPER LOW
		OUTPUT7	WASHER PUMP
FUSE 4	15A	OUTPUT8	MIRROR
FUSE 5	15A	OUTPUT9	STROBE LIGHT WITH W/L
		OUTPUT10	ACCESSORY POWER
		OUTPUT11	W/L MONITOR PILOTD
FUSE 6	15A	OUTPUT12	STOP ARM
		OUTPUT13	CROSS ARM
		OUTPUT14	APPROACH LIGHT
		OUTPUT15	SPARE





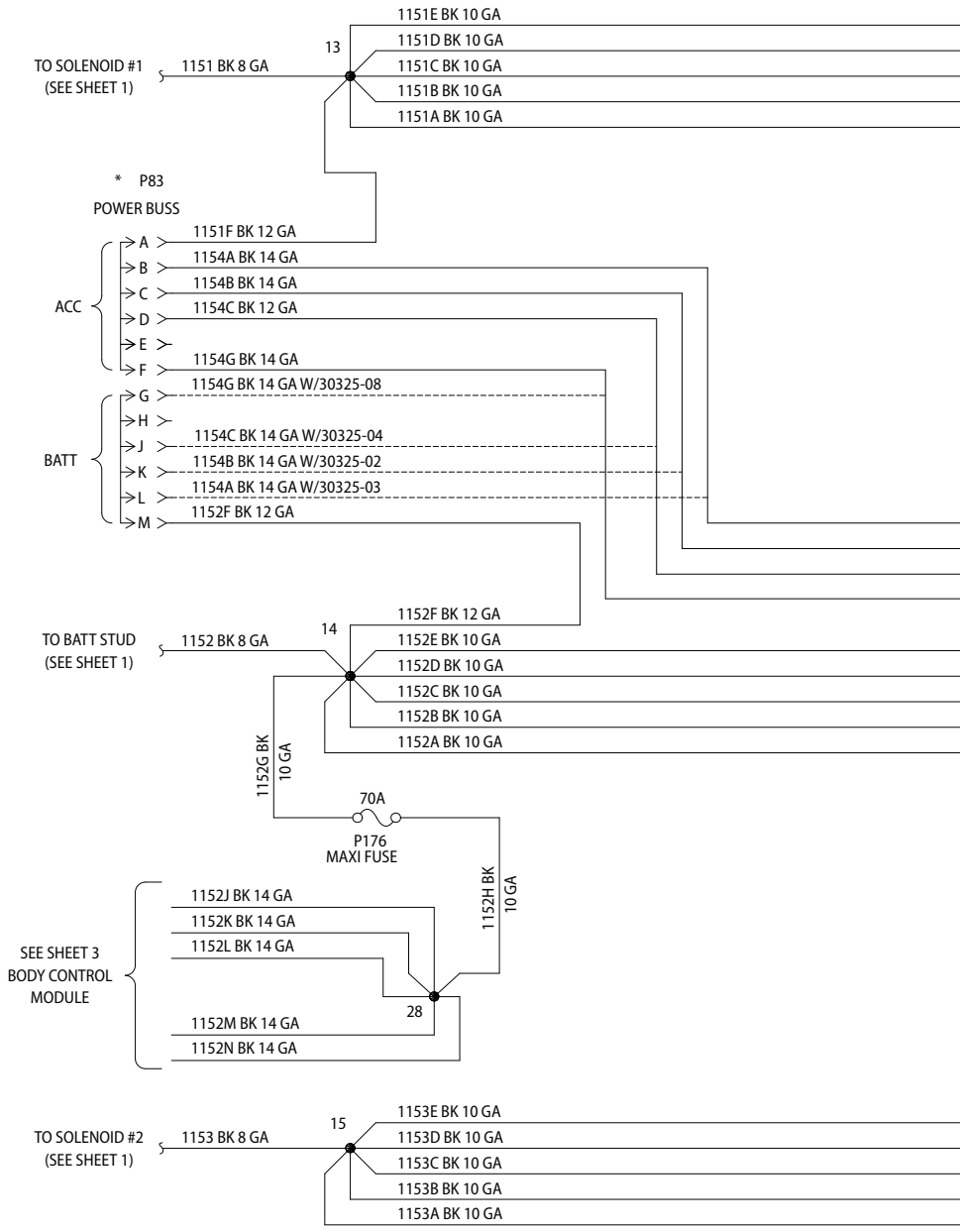
CON-A (P88) AMP 963357-2	
PIN	DESCRIPTION
1	INPUT PWR FOR FUSE 1 & 2
2	LH AMBER W/L
3	RH AMBER W/L
4	LH RED W/L
5	W/L START SWITCH
6	W/L FLASH ONLY AFTER AMBER
7	RH RED W/L
8	GROUND INPUT
9	W/L FLASH RED WHEN DOOR IS OPEN
10	CROSS ARM CANCEL
11	W/L MONITOR PILOT
12	CROSS AMR
13	VANDAL LOCK
14	W/L MASTER SWITCH
15	STROBE LIGHT WITH W/L
16	STOP ARM
17	INPUT PWR FOR FUSE 5
18	INPUT PWR FOR FUSE 6

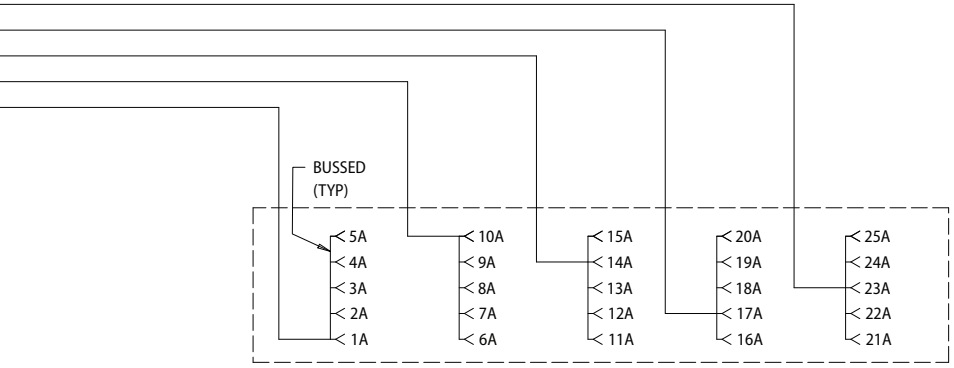
CON-B (P128) AMP 963357-4	
PIN	DESCRIPTION
1	ACCESSORY POWER
2	APPROACH LIGHT
3	SLEEPING CHILD CHECK
4	SPARE
5	GROUND INPUT
6	MIRROR HEAT SWITCH
7	BRAKE INTERLOCK DOOR SWITCH
8	MIRROR
9	INPUT PWR FOR FUSE 3
10	INPUT PWR FOR FUSE 4

CON-C (C26) AMP 963357-2	
PIN	DESCRIPTION
1	LH WIPER LOW
2	DNET A
3	WIPER PARK LEFT
4	DNET B
5	RH WIPER LOW
6	12V MPX
7	WIPER PARK RIGHT
8	GND MPX
9	WASHER PUMP
10	WAKEUP COM
11	WIPER SWITCH 1
12	WASHER INPUT
13	WIPER SWITCH 2
14	WIPER SWITCH 3

* CONNECTOR P83 ALLOWS SPECIFIED CIRCUITS TO BE ACCESSORY CONTROLLED OR BATTERY POWER CONTROLLED BASED ON OPTIONS. SEE CHART BELOW:

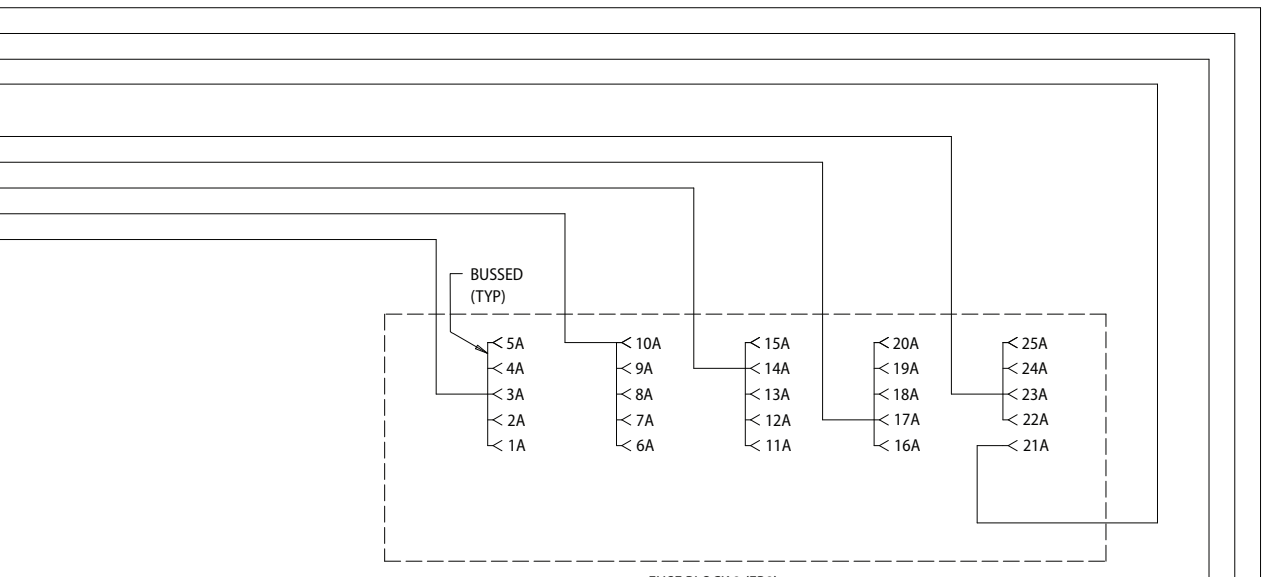
CIRCUIT	FUNCTION	FEATURE
1154A	CL/MR/ID LIGHTS	(30325-03)
1154B	WARNING LIGHT PWR	(30325-02)
1154C	DOME LIGHTS	(30325-04)
1154G	ENT DOOR PWR	(30325-08)



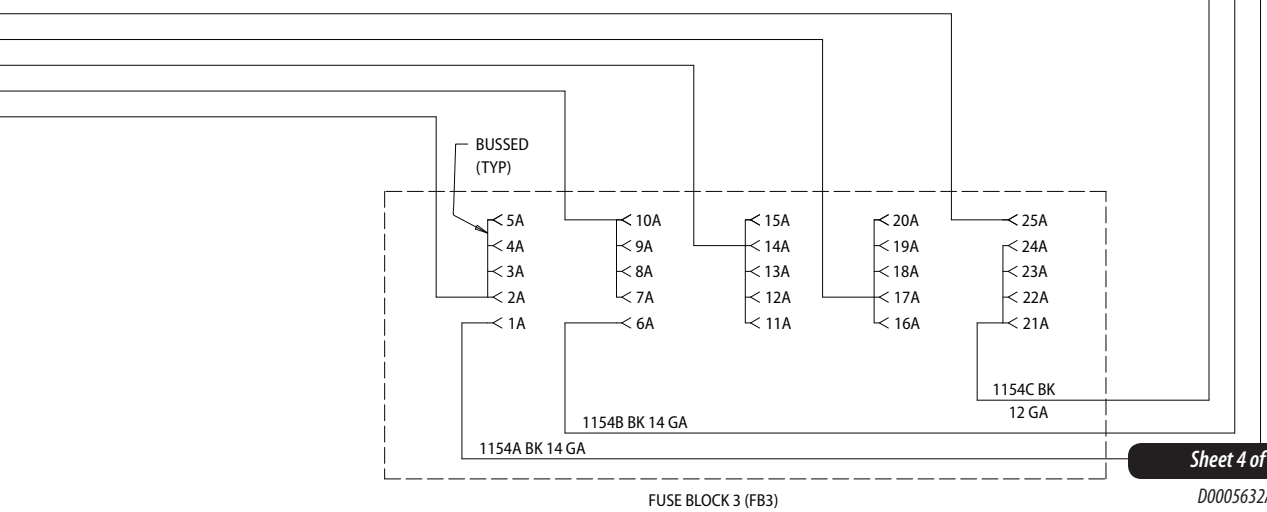


FUSE BLOCK 1 (FB1)

NOTE: THE NUMBERS LISTED IN THE DESIGNATED FUSE BLOCK LOCATIONS REPRESENT THE CONNECTOR POSITION FOR EACH CIRCUIT, NOT THE AMPERAGE RATINGS. EACH FUSE BLOCK HAS AN "A" POSITION AND "B" POSITION FOR EACH OF THE 25 FUSE/CIRCUIT BREAKER LOCATIONS. THE "A" POSITION IS ONLY SHOWN HERE TO REPRESENT THE PRIMARY/INPUT PORTION OF THE POWER DISTRIBUTION. THE SECONDARY/OUTPUT PORTION WILL BE SHOWN ON SHEET #1 OF THIS DRAWING AND ON OPTIONAL EQUIPMENT WIRING DIAGRAMS.



FUSE BLOCK 2 (FB2)



FUSE BLOCK 3 (FB3)

D0005632A

DIAGRAM,WRG,STANDARD EQUIPMENT, with Dual Zone MPX

Charging System

The charging system provides electrical current for the lights, radio, heater blower and the engine's electrical systems. It also maintains the batteries in a charged state, recharging them as necessary to provide cranking power.

The charging system has three main components, or component areas: the alternator, the voltage regulator, and the battery.

The alternator is driven by a belt from the engine crankshaft and produces the electrical power to operate the systems on the bus. It also recharges the battery.

The voltage regulator acts as a "control valve" for the alternator output. It senses the current load and maintains a constant voltage in the charging system, independent of the current load, up to its rated output. The Leece Neville™ alternator on the Blue Bird Vision has a "built in" voltage regulator. It is excited (started) by the ignition system.

The battery is the reservoir of chemical electrical power. Its primary purpose is to crank the engine. It also supplies power to the accessories for a short time when the demand is too high for the alternator alone (i.e., while the bus is at idle). Another key role of the battery is to act as a filter for the charging system.

The Blue Bird Vision has a 12-volt electrical system. The alternator is a 175-ampere, 12-volt device. Leece Neville model number A0014834LC is standard.

Maintenance

Clean the alternator and all connection points. Dirt buildup restricting air flow through to the alternator will cause excessive heat and premature failure. Corrosion at any connecting point will produce resistance to current flow, heat and diminished power for the starter and accessories.

Ensure that all the components in the charging system are mounted securely. Check the torque at all mounting bolts — both the bolts that hold the alternator in the mounting bracket and the bolts that secure the mounting brackets to the engine. The torque value for mounting bolts at the engine and at the alternator should be 70 – 80 ft lb (95 – 108 Nm)

Blue Bird Vision buses are equipped with an automatic belt tensioner. Ensure that all the grooves fit properly into the pulleys in the correct path. The drive belt should be inspected every 11,000 miles (17,700 km), 250 hours of service life, or every 3 months; whichever occurs first.

Also check:

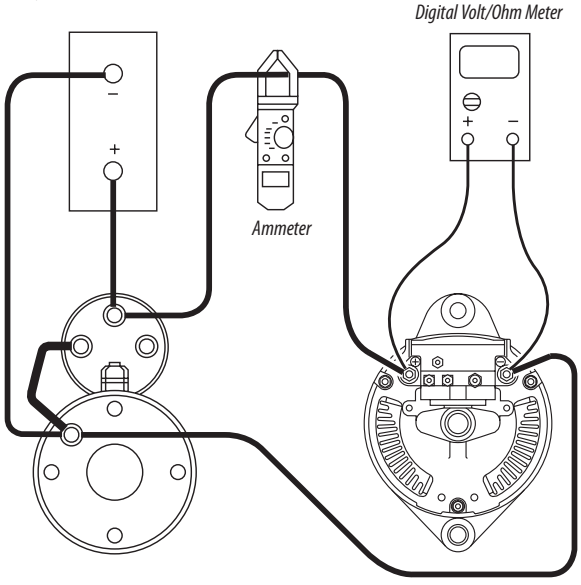
- Battery voltage
- Alternator output
- Starter current draw

Troubleshooting

Timely preventive maintenance of the charging system should keep it running smoothly. However, when a problem occurs, effective troubleshooting procedures will help locate and correct the problem quickly and economically.

WARNING ***Batteries emit an explosive gas. Never smoke while working on the charging system. Batteries can explode from a spark. Always remove the negative battery cable at the battery post before removing any other wires in the charging system. Be careful not to short the system while you are working on it. Do not wear jewelry.***

Before you begin to analyze the charging system, it is necessary that you ensure the battery is properly tested and charged to at least 75% of their rated capacity. Failure to confirm the condition of the battery will make the results of any diagnostic testing unreliable. Refer to the battery manufacturer's publications on battery maintenance and testing.



Alternator Performance Test

1. Connect a digital volt/ohmmeter (VOM) to the output terminals of the alternator.

   CAUTION ***Ensure that the test leads are connected properly. Observe the polarity and make secure connections.***

2. Connect an ammeter to the positive terminal of the alternator. Observe that the clamp on the ammeter is located at least 6 inches (15 cm) from the alternator to lessen the possibility of faulty readings due to spurious emissions.

3. Verify that the voltage output from the alternator is between 13.6 and 14.2 volts with the engine at operating RPM (1700 RPM minimum) and not idle.

4. Ensure that all "loads" are in the off position. The reading on the ammeter should be less than 20 amps.

   - If the amp reading is higher than 20 amps, ensure all accessories are turned off.

   - Ensure the battery is charged to at least 75% of their rated capacity.

5. Record the voltage. If the voltage is not within the specified range or the amperage is not within the specified range, the alternator is defective.

6. If the alternator is determined to be defective, repair or replace it in accordance with the instructions below. See Alternator Removal.

7. If the alternator is determined to be functioning properly, proceed as follows:

8. Continue to operate the engine at about 1700 RPM, and with the test equipment set up as illustrated.

9. Turn on vehicle loads (accessories) until the ammeter displays 132 amps, which is 75% of the rated capac-ity (175 amps). Record the voltage at this point.

10. Compare the voltage reading with the voltage reading observed in Step 3 above.

11. If the alternator voltage drops more than .5 (1/2) volt, the alternator is defective.

An alternate method of checking the alternator under load is to use a carbon pile load. Connect the carbon pile across the battery and adjust it until the ammeter reads 75% of the alternator rated capacity. Record the voltage at this point, shut off the engine, and compare the readings.

Alternator Cable Tests

To test the positive alternator cable:

1. Clamp the ammeter on the positive cable at least 6 inches (15 cm) from the alternator. See Figure 2.

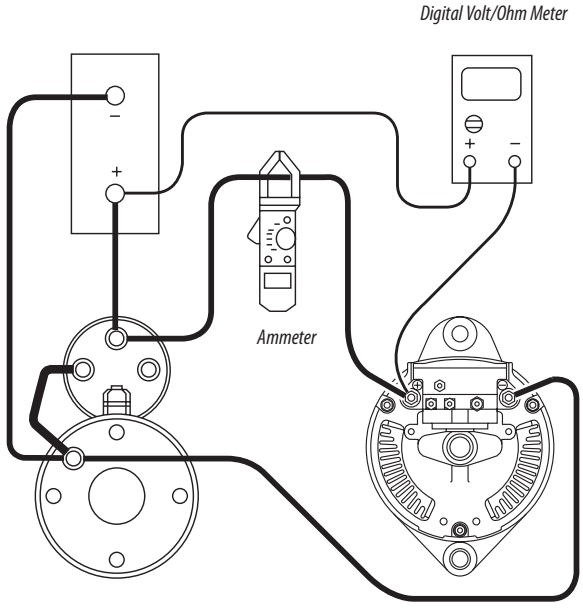
2. Connect the negative lead of the VOM to the positive post of the alternator.

3. Connect the positive lead of the VOM to the positive battery post.

4. Start the engine and let it run at about 1700 RPM.

5. Turn on accessories until the ammeter reads 132 amps, which is 75% of the rated alternator capacity (175 amps). Use a carbon pile if necessary to achieve the load.

6. Record the voltage reading on the VOM.



7. If the VOM reads more than -.25 volts, there is a problem with the positive cable.

   • Check and clean all the connections and the condition of all the cables/wires in the circuit.

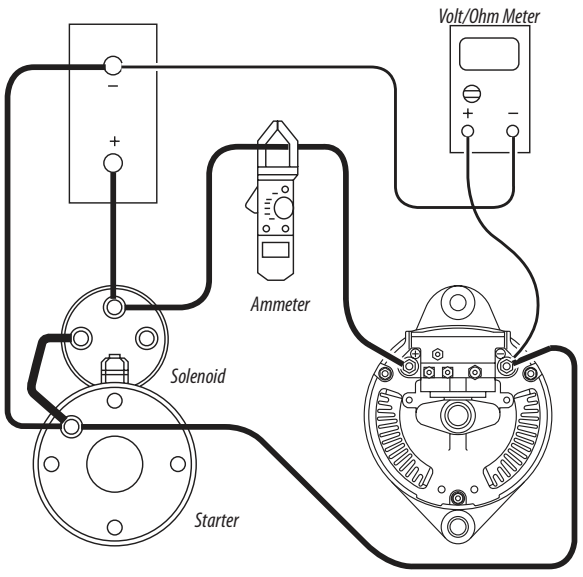
   • Re-test the circuit.

8. If the reading is less than -.25 volts, the cable and connections are good.

9. Connect the lead negative of the VOM to the negative terminal of the battery.

10. Connect the positive lead of the VOM to the negative terminal of the alternator.

11. Repeat Steps 4 through 8 for the negative cable.

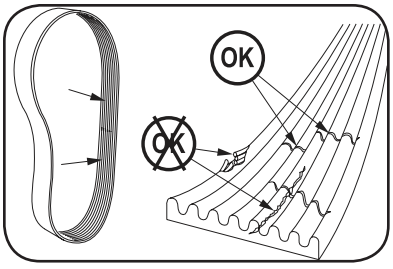


Bosch Alternator Removal

WARNING ***Always disconnect the negative (-) cable from the battery terminal first to avoid arcing, which could ignite explosive battery gases.***

1. Park the bus on a smooth, flat surface.
2. Chock the wheels in both directions.
3. Ensure the engine is not running, the ignition switch is in the "OFF" position and the key is removed.
4. Disconnect the negative (ground) cable from the battery post.
5. Lift the automatic belt tensioner to remove the drive belt from the alternator.
6. Remove the drive belt.
7. Inspect the drive belt; discard it if any signs of wear are present.

A few minor cracks across the belt are acceptable. Longitudinal cracks are NOT acceptable. Replace the drive belt when any crack is observed to be running lengthwise or with the belt, or when the belt appears frayed.



Belt Wear

WARNING ***Always disconnect the negative (-) battery cable at the battery before removing any wiring from the alternator.***

8. Remove the negative (-) cable from the alternator.
9. Remove the positive (+) cable from the alternator.
10. Remove the bottom mounting bolts.
11. Support the alternator and remove the top bolts.
12. Remove the alternator.

Alternator Reinstallation

Installation of the alternator is accomplished in the reverse order of the removal instructions above.

1. Position the alternator and install the top and bottom bolts. Torque bolts to 33-35 ft. lbs.

2. Install the positive cable on the positive (B+) post. Carefully tighten to avoid breaking or stripping the stud.

3. Install the negative cable on the negative (B -) post. Carefully tighten to avoid breaking or stripping the stud.

4. Using a square drive tool, position the automatic tensioner so that the drive belt can be installed. Inspect the drive belt carefully. Replace the belt if any signs of wear are present.

5. Install the drive belt. Ensure that the grooves in the belt fit into the proper places on all the pulleys.

6. Start the engine and test the alternator output.

Automatic Belt Tensioner

The automatic tensioner is spring loaded to provide the proper tension for the drive belt.

The automatic tensioner should travel at least 71°, and the torque to move the tensioner 25° from the "at rest" position must be 9 – 11 ft lb (12.4 – 15.8 Nm). Inspect the belt tensioner for any unusual noise, excessive looseness and shaking at the bearings.

Automatic Tensioner Removal

1. Remove the drive belt in accordance with the instruc-tions above.

2. Remove the capscrew (1) from the automatic ten-sioner. See Figure 8.

To install a new automatic tensioner, reverse the removal instructions. Torque the capscrew (1) to 28 – 42 ft lb (38 – 56 Nm).

Starter

There are 5 main components or component areas in the starting system: the ignition switch, a neutral safety switch, the starter solenoid, the starter motor and the batteries.

When the key is turned to the start position, electrical current flows to the starter solenoid from the batteries. The flow is interrupted if the transmission shift lever is not in the neutral position or if the neutral sensor switch is defective.

The starter solenoid is an electromagnetic switch mounted on the starter motor. When electric current energizes coils inside the solenoid, a magnetic field is induced which pulls a plunger. At one end of this plunger is a shift lever. The lever is connected to the drive pinion and clutch assembly of the starter motor. The plunger also connects the electrical power from the batteries to the starter motor as it engages the flywheel ring gear.

The starter motor is a relatively small electric motor, but it can deliver large amounts of torque for a short time.

When the operator releases the ignition switch it returns to the run position. The solenoid is disconnected from the batteries and the magnetic field collapses. This allows the spring in the solenoid to move the plunger in the opposite direction, disengaging the flywheel and removing electrical current from the starter motor.

The Blue Bird Vision has a 12-volt electrical system. The starter motor is Model 35261110, Presto-lite/Leece/Neville M100R series. The Starter motor is capable of 4kw cranking power for peak loads of no more than 30 seconds duration.

Preventative Maintenance

There are two preventative maintenance procedures that can greatly enhance the efficiency of the starting system. These two steps are also the first two steps taken when troubleshooting a malfunctioning starting system.

- An engine that needs a tune up will be difficult to crank; over cranking will lead to starter motor failure.
- Poor connections due to road dirt, grease, corrosion, loose connectors, or broken insulation at any connecting point rob the starting system of electrical power and cause it to over-crank.

Troubleshooting

Before beginning to troubleshoot the starting system, ensure the batteries are properly maintained and charged to at least 75% of their rated capacity. A drained battery will cause any further diagnostic tests to be inaccurate. Common causes of starting system malfunction include:

1. A battery that is low, poorly charged, or defective places high demands on the starting system; voltage at the battery should be 12.4 volts or greater to crank the engine. If the batteries aren't adequately charging, a problem in the charging system. Refer to the Alternator section of this Service Manual for information on the charging system.

2. A starter motor can be damaged by heat that is generated by excessive cranking. The starter should never be engaged for more than 30 seconds. It must "rest" (cool off) a minimum of 2 minutes between starting attempts.

3. Loose, dirty, or corroded connections in the starting system rob the system of the power needed to turn the engine. The case of the starter motor is the ground or "return" connection for the starter motor and solenoid.

4. A loose starter motor will allow vibration that can damage the motor. In addition, the ring gear could be damaged.

5. Improper or excessive use of starting fluid will cause extra stress on the starting system.

6. A defective solenoid will fail to engage the starter motor. A failed pull-up coil will cause the plunger to fail to pull in. A failed hold-in coil may cause the starter to fail to stay engaged, or may fail to switch the starter motor on. If the solinoid is suspect, test the wiring of the solenoid circuit before replacing the solenoid.

The starting circuit is among those incorporated into the Vision's Multiplex System. Therefore, Multiplex diagnostics procedure can help to quickly isolate the root cause of most starting problems, and thereby minimize downtime. Refer to the Multiplex chapter for full details on performing Multiplex diagnostics.

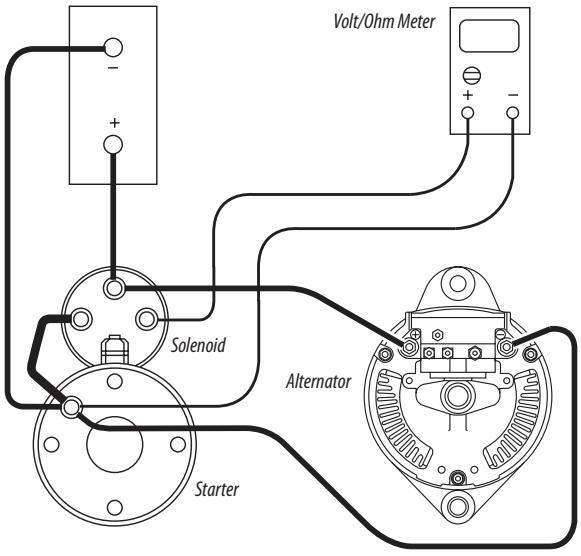
1. Refer to the Multiplex Output Table to find out which Port/Pin (B3-07) and which Output LED (B3-O02) pertain to the Starter Signal Output. The chart also shows which Ladder Logic Line (#20) describes the logic of the circuit.

2. Use the Diagnostic Switch to cycle the MPX Module to the appropriate Diagnostic Mode (Showing B3 Outputs). Check the LED to see if the Starter Signal Output (B3-O03) is Active. If the Output LED is Inactive, refer to Ladder Logic line #20 to systematically verify that each requirement for an Active Output is true.

3. Once the Output is Active, if the starter is still not operating, verify a ground at Pin B3-07 on the MPX Module. If the ground output is present, the problem exists "downstream" of the Multiplex system, and the starter itself is suspect.

Ignition/Run Test

Begin by determining whether the problem is with the ignition switch or the pilot relay, and their associated wiring; or if it is in the solenoid and/or starting motor. To begin with the ignition switch:



1. Connect the positive lead of a VOM to the ignition switch terminal on the solenoid.

2. Connect the negative lead of the VOM to the chassis ground.

3. While attempting to crank the engine, record the voltage displayed on the VOM. Observe the following:

   - No voltage
   - Low voltage
   - Normal voltage with slow cranking
   - Normal voltage with no cranking at all.

4. Connect a remote start switch to the positive battery post.

5. Connect the other end of the remote start switch to the ignition post of the solenoid.

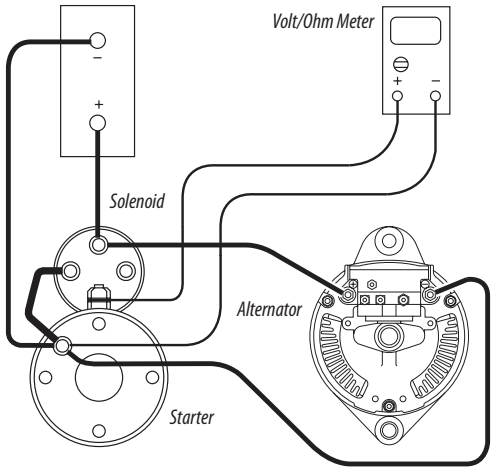
6. Attempt to crank the engine with the remote switch. Record the voltage displayed on the VOM. If there is less than 1 volt difference from the previous reading, the ignition switch is okay. If there is more than 1 volt difference, the switch is defective.

7. With the VOM negative lead connected to the chassis ground, move through the switch system one connection at a time. If your first voltage test has revealed low voltage, the starter motor may be shorted.

8. If the first voltage test indicated normal voltage, but there is slow cranking or no cranking at all, a problem with the batteries, battery cables, or a damaged starter motor is indicated.

Low Voltage Test

There are various reasons for low voltage but the troubleshooting methods are the same. If the solenoid clicks, it means that either current is flowing through the solenoid contacts but not through the main contacts; or that the current through the main contacts is insufficient due to low batteries.

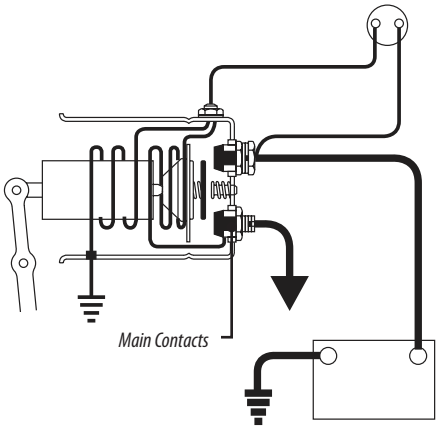


1. Connect the positive lead of the VOM to the starter motor terminal of the solenoid.

2. Connect the negative lead of the VOM to the chassis ground.

3. While attempting to crank the engine, if there is no voltage displayed on the VOM, the main contacts are not functioning properly.

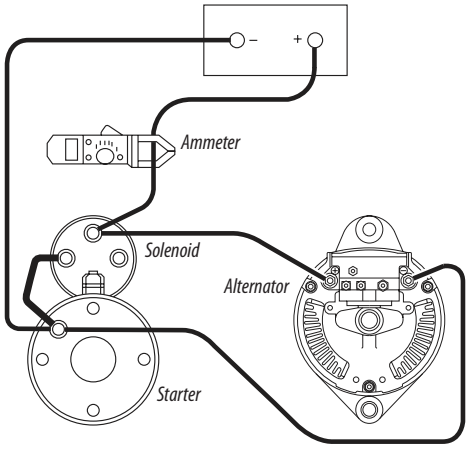
4. If there is voltage present at the solenoid terminal during Step 3, the problem is in the starter motor or its cabling.



5. If the first voltage check in Step 3 under Ignition/Run Test indicated normal voltage but slow or no cranking, the next step is to check the starter motor and its connections.

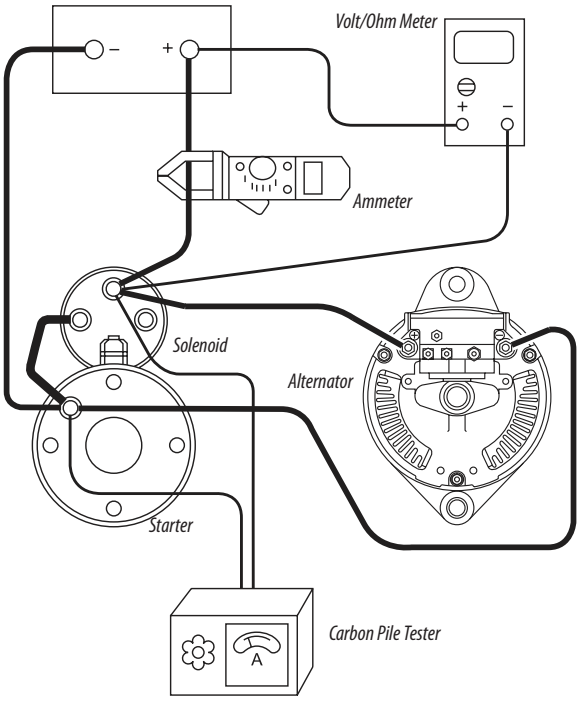
6. If the drive pinion jumps out of mesh with the flywheel ring gear, check for a broken or loose ground wire at the solenoid.

7. While attempting to crank the engine, place an ammeter on the positive battery cable. If the power drain is higher than the OEM specifications, the starter motor is defective. An exception would be if the engine was not properly tuned or is difficult to turn over; in which case, a new starter motor would be a temporary fix.



Slow Cranking

Sluggish cranking can be caused by a small amount of extra resistance in the cranking circuit. This extra resistance can come from loose or dirty (corroded) connections, or broken wires and/or cables. First check the positive cables and connections of the starter motor, then the negative circuit.



1. Connect the positive lead of a VOM to the positive battery terminal.
2. Position an ammeter between the solenoid and the positive terminal of the solenoid.
3. Connect the negative lead of the VOM to the positive terminal of the solenoid.
4. Connect the negative lead of the VOM to the negative battery post. This is the "unloaded" voltage. Record the reading; leave the VOM connected.
5. Connect one lead of a carbon pile tester to chassis ground.
6. Connect the other lead from the carbon pile tester to the positive terminal of the solenoid.
7. Adjust the carbon pile tester until the ammeter on the tester reads 500 amps.
8. Record the voltage display on the VOM; it should not be less than 0.4-volts less than the unloaded value.
9. Turn the carbon pile tester to the "OFF" position.
10. Connect the positive lead of the VOM to chassis ground.
11. Connect the negative lead of the VOM to the negative battery post. Record the reading; leave the VOM connected.
12. Position the ammeter in on the negative battery cable.
13. Turn on the carbon pile tester and adjust it to read 500 amps.
14. Record the voltage on the VOM; it should not drop more than 0.4-volts from the unloaded reading.
15. Turn the carbon pile tester to the OFF position.

16. If the voltage drop was more than 0.4-volts in step 8, the positive cabling is defective. Look for a broken cable or a loose or corroded connection.

17. If the voltage drop in step 14 is more than 0.4 volts, look for a problem in the negative cabling; look for broken or defective cables, and loose or corroded connections.

Final check at solenoid terminals.

1. Disconnect the carbon pile tester.

2. Disconnect the VOM.

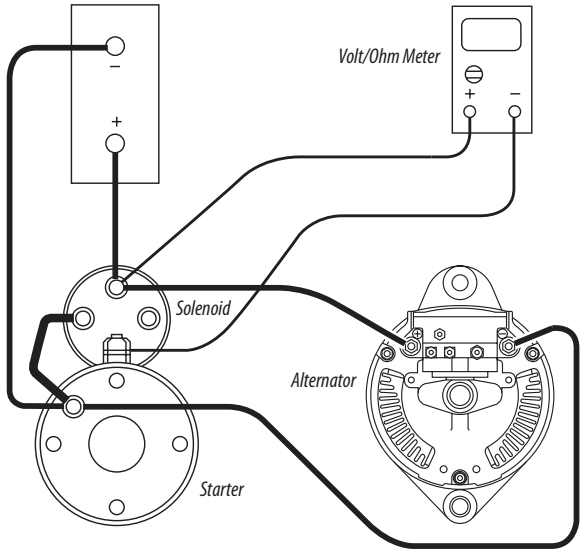
3. Remove the ammeter.

4. Connect the positive lead of the VOM to the positive (battery) terminal of the solenoid.

5. Set the VOM so that it can read the full battery volt-age; at least 14 volts.

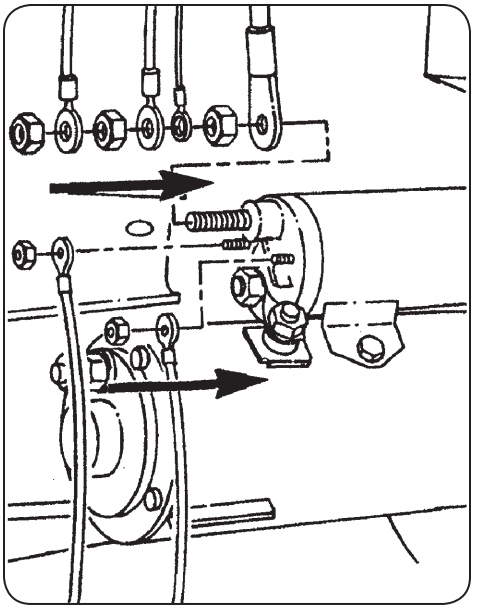
6. Connect the negative VOM lead to the starter motor terminal of the solenoid.

7. Crank the engine and record the voltage while cranking. There should be no more than 0.2 volts drop between the solenoid contacts while cranking.



8. The voltage reading in these last three tests (the positive cable check, the negative cable check and the solenoid test), should not total more than 1.0 volts. If the voltage drop is more than allowable, repeat the cable tests using a jumper cable. If the tests then indicate an acceptable drop, the cable(s) is (are) defective.

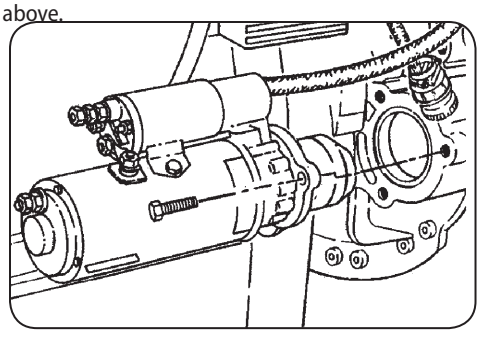
Starter Motor Removal



1. Disconnect the negative (ground) cable from the battery. Wrap it with tape or other suitable insulation to prevent shorts.
2. Disconnect positive cable from the battery. Wrap it with tape or other suitable insulation to prevent shorts.
3. Identify and tag each wire on the starter motor for reinstallation.
4. Remove all electrical connections from the starter motor. Be sure to identify and tag all electrical connection locations.
5. Remove 3 capscrews.
6. Remove starter motor from flywheel housing.

Starter Motor Installation

The starter motor is installed in the reverse order of the removal instructions above.



1. Carefully place the starter motor into position on the flywheel housing.
2. Install 3 capscrews (1). Torque to 32 ft lb (43 Nm). See Figure 8.
3. Being careful to observe the identification of the electrical wires, connect the wires to the appropriate terminal on the starter motor. See Figure 7.

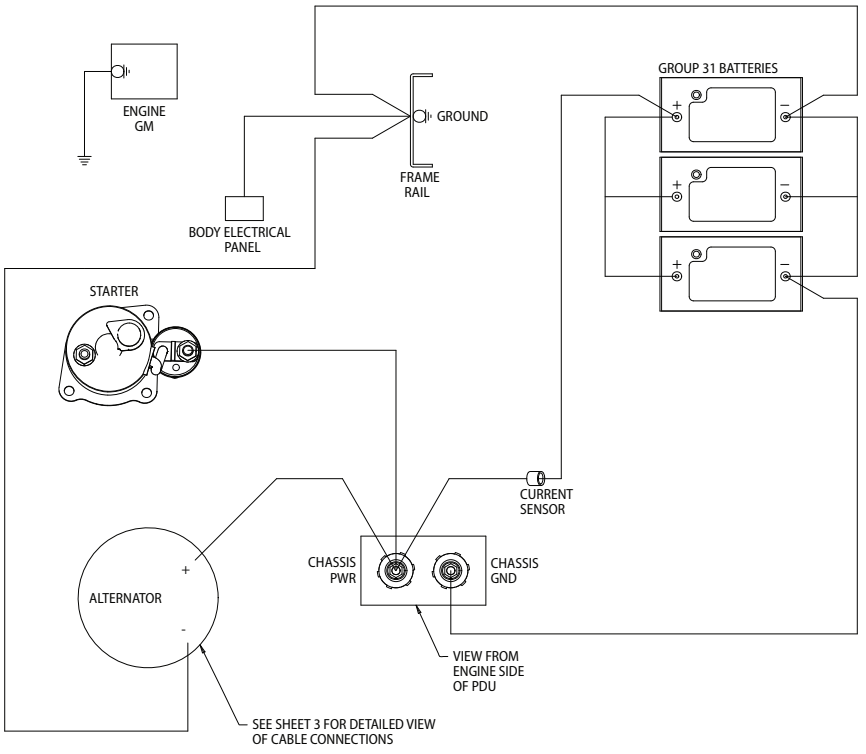
WARNING ***Always remove the negative (-) cable from the battery terminal first. Always connect the negative (-) cable to the battery terminal last to avoid arcing that could ignite explosive battery gases.***

4. Install the positive cable on the battery post.
5. Install the negative cable on the battery post.

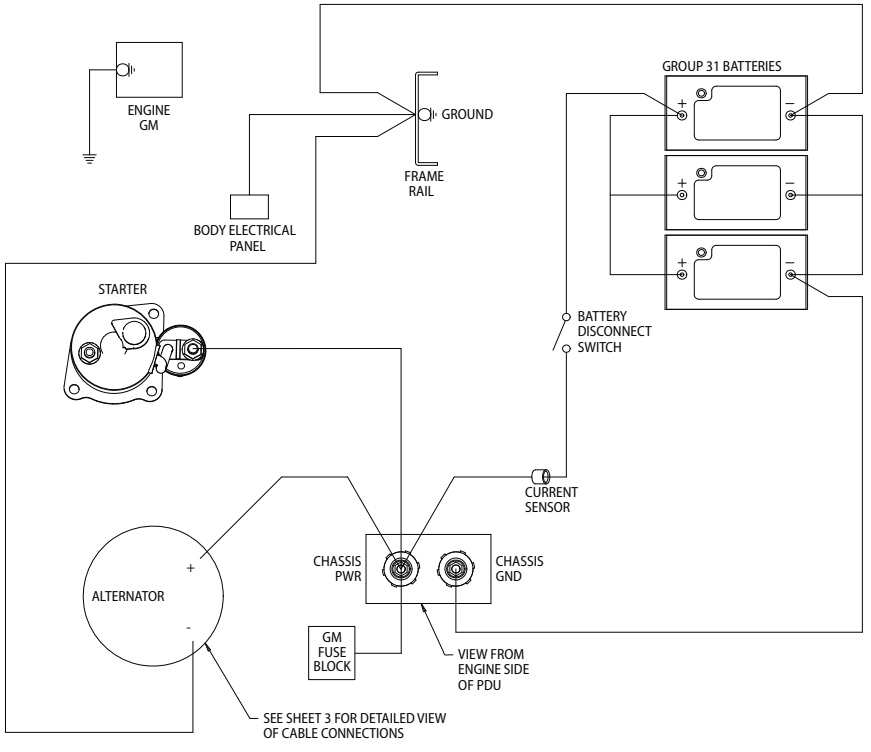
Chassis Harness Routing Diagrams

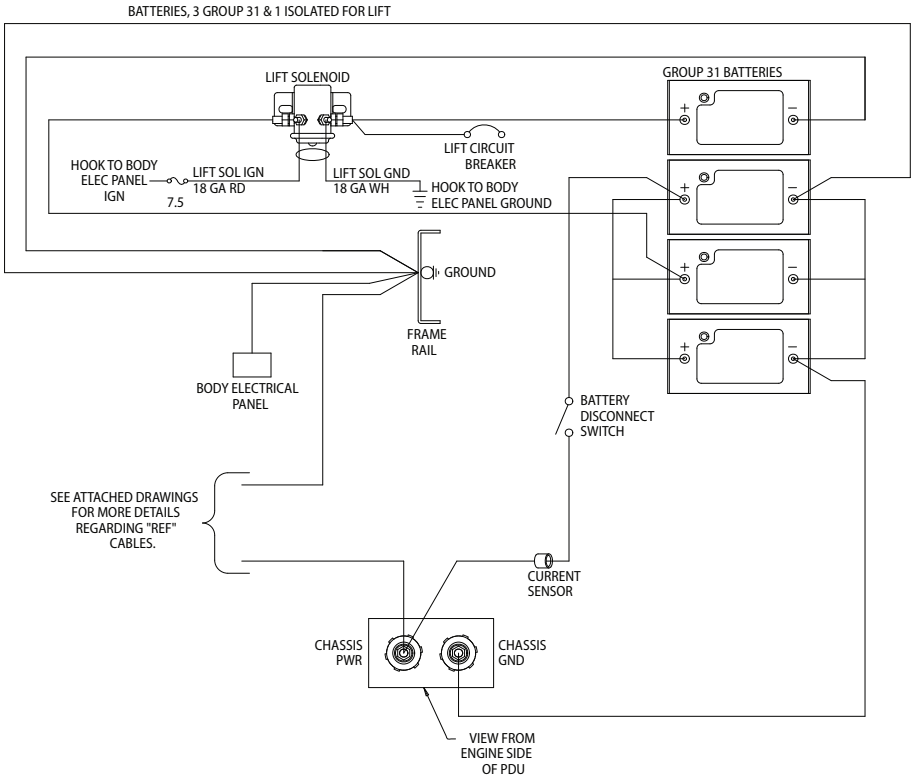
The following pages illustrate the routings of the main chassis wiring harnesses applicable to most Vision chassis.

CUMMINS ENGINE, GROUP 31 BATTERIES, NO BATTERY DISCONNECT SWITCH



CUMMINS ENGINE, GROUP 31 BATTERIES, WITH BATTERY DISCONNECT SWITCH





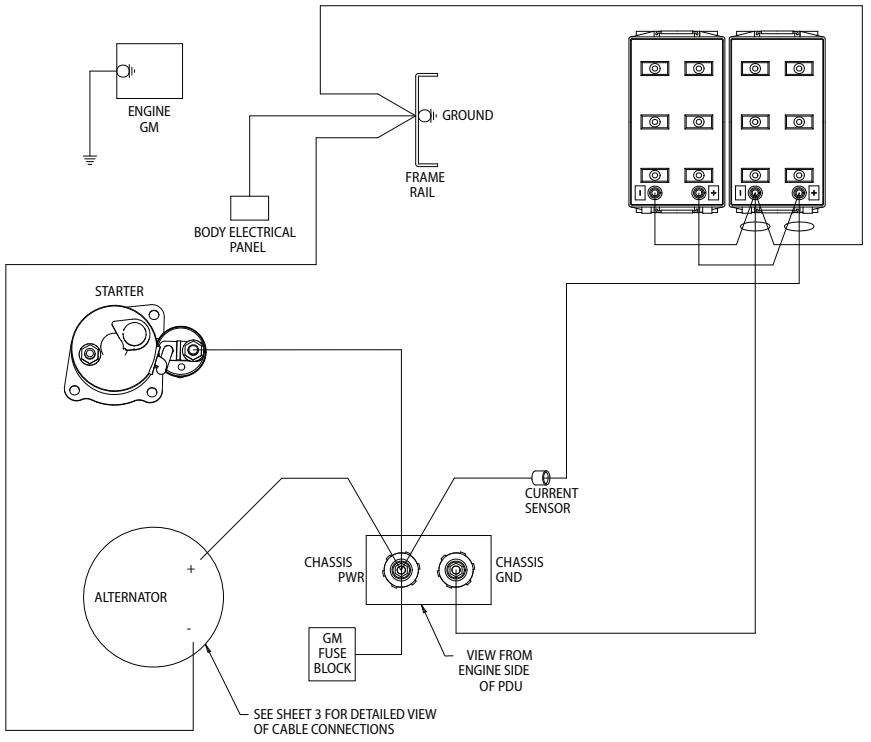
Battery Disconnect Switch

Some of the battery, starter, and charging system drawings illustrate an optional battery disconnect switch located at the battery box. The battery disconnect switch, when in the off position, isolates electrical power to the battery box by interrupting electrical current flow through the positive battery cable. The switch is sometimes called a quick disconnect switch because it provides a way to isolate battery power when servicing the bus, when the bus is parked or in an emergency situation.

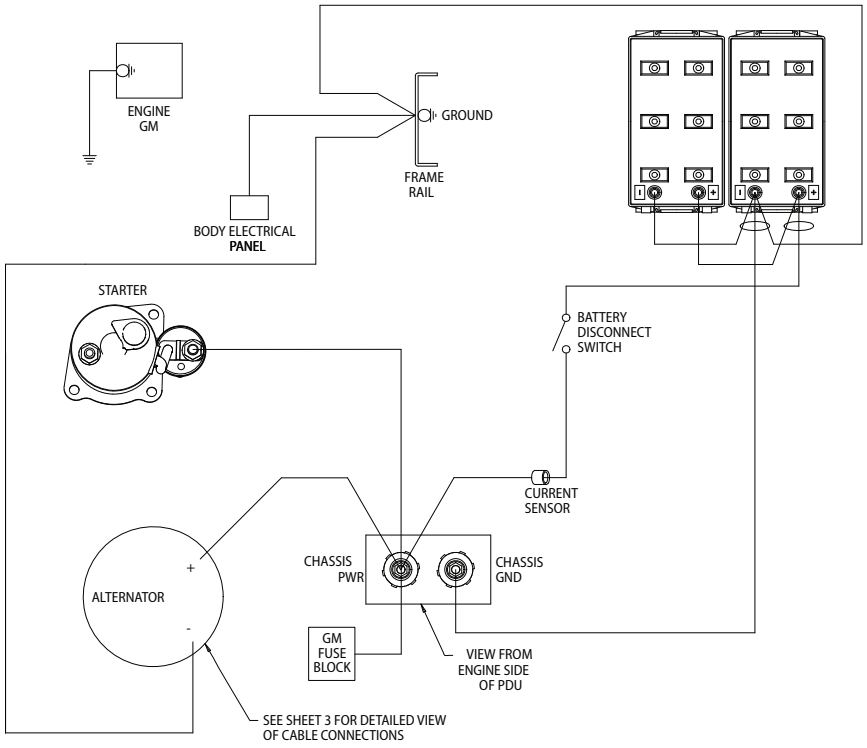
The battery disconnect switch is not intended to be a substitute for the ignition switch and/or other switches controlling the electrical systems throughout the bus. Some of the electronic systems on the bus will follow a systematic shutdown sequence similar to the shutdown sequence of a computer. For proper shutdown sequence to occur all individual circuit control switches, including the ignition switch, should be in the off position before placing the battery disconnect switch in the off position.

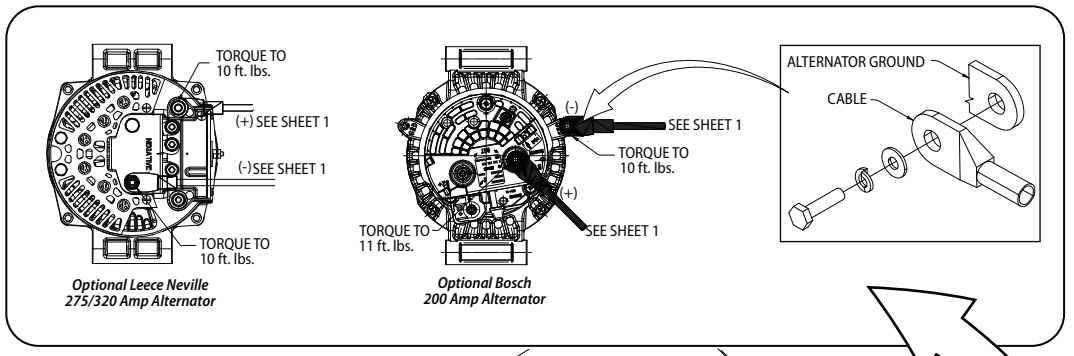
To comply with Cummins emissions systems requirements, a 60 seconds delay should occur after placing the ignition switch in the off position before placing the battery disconnect switch in the off position or disconnecting the batteries.

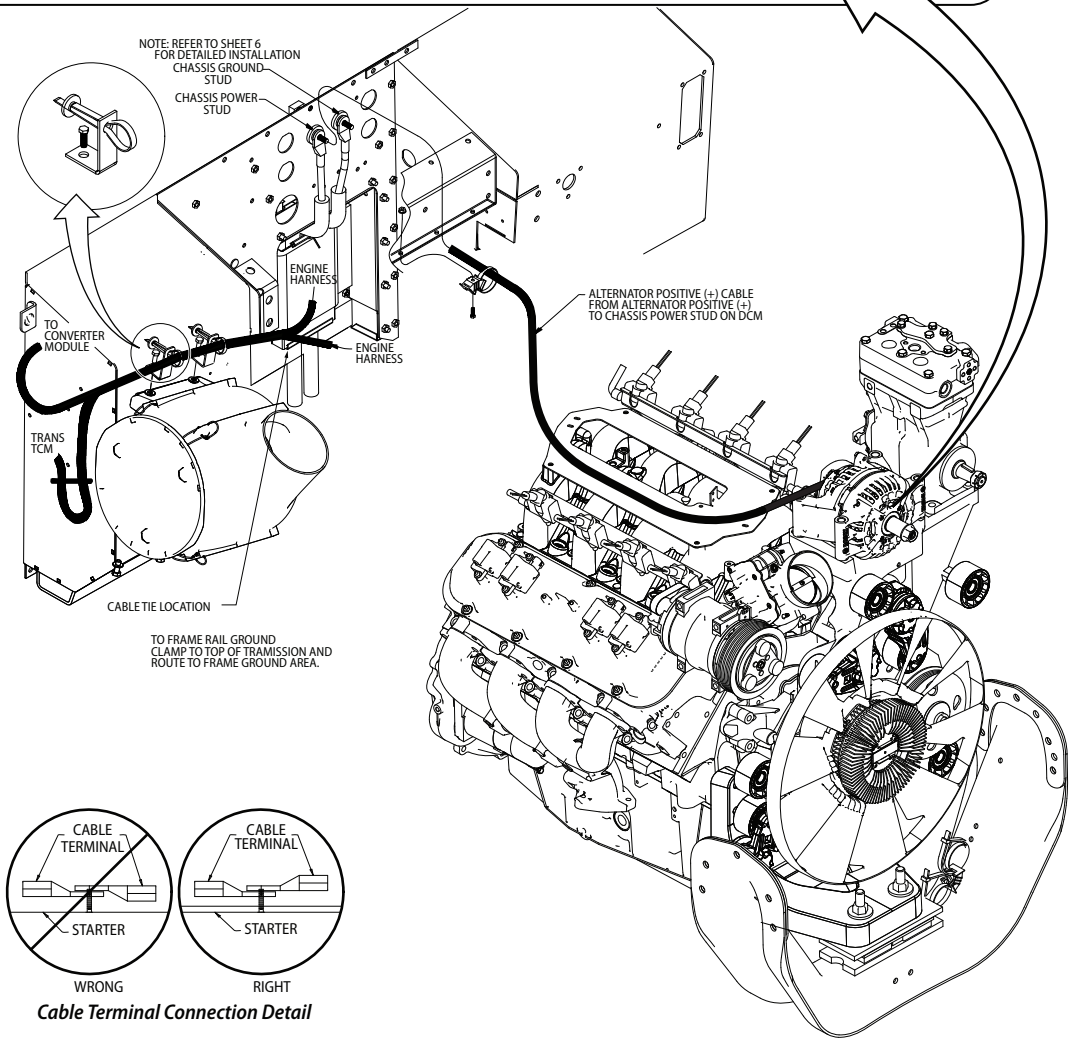
CUMMINS ENGINE, 8D BATTERIES, NO BATTERY DISCONNECT SWITCH



CUMMINS ENGINE, 8D BATTERIES, WITH BATTERY DISCONNECT SWITCH







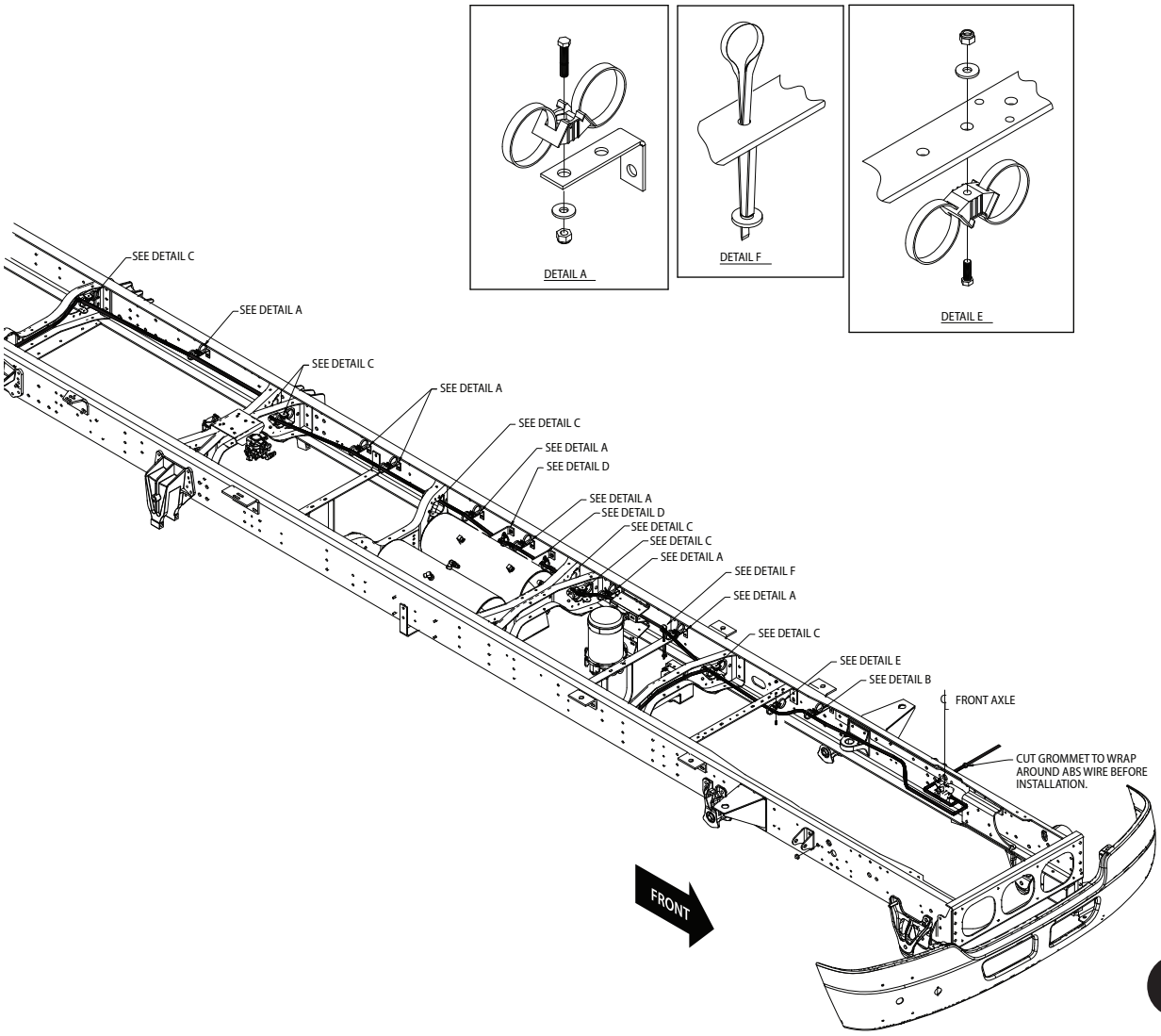
Cable Terminal Connection Detail

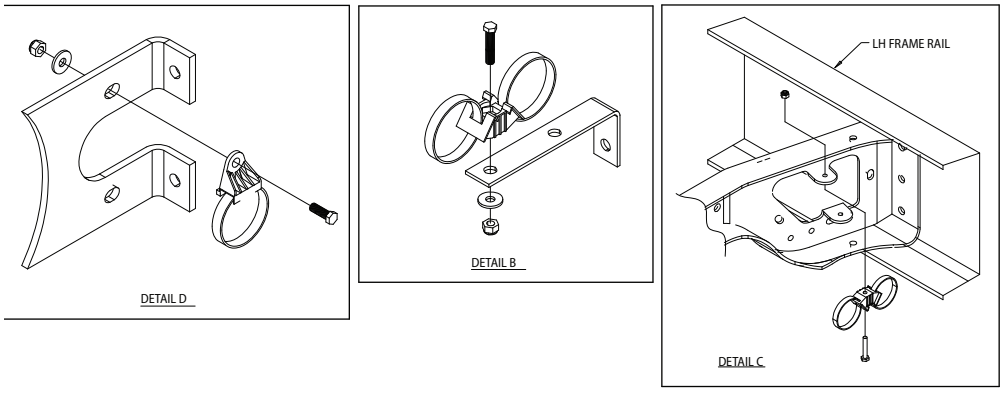
D0006303B

Chassis Harness Routing Sheet 3 of 9

D0006303b

HARNESS ROUTING, GM 8.1, NEW MPX



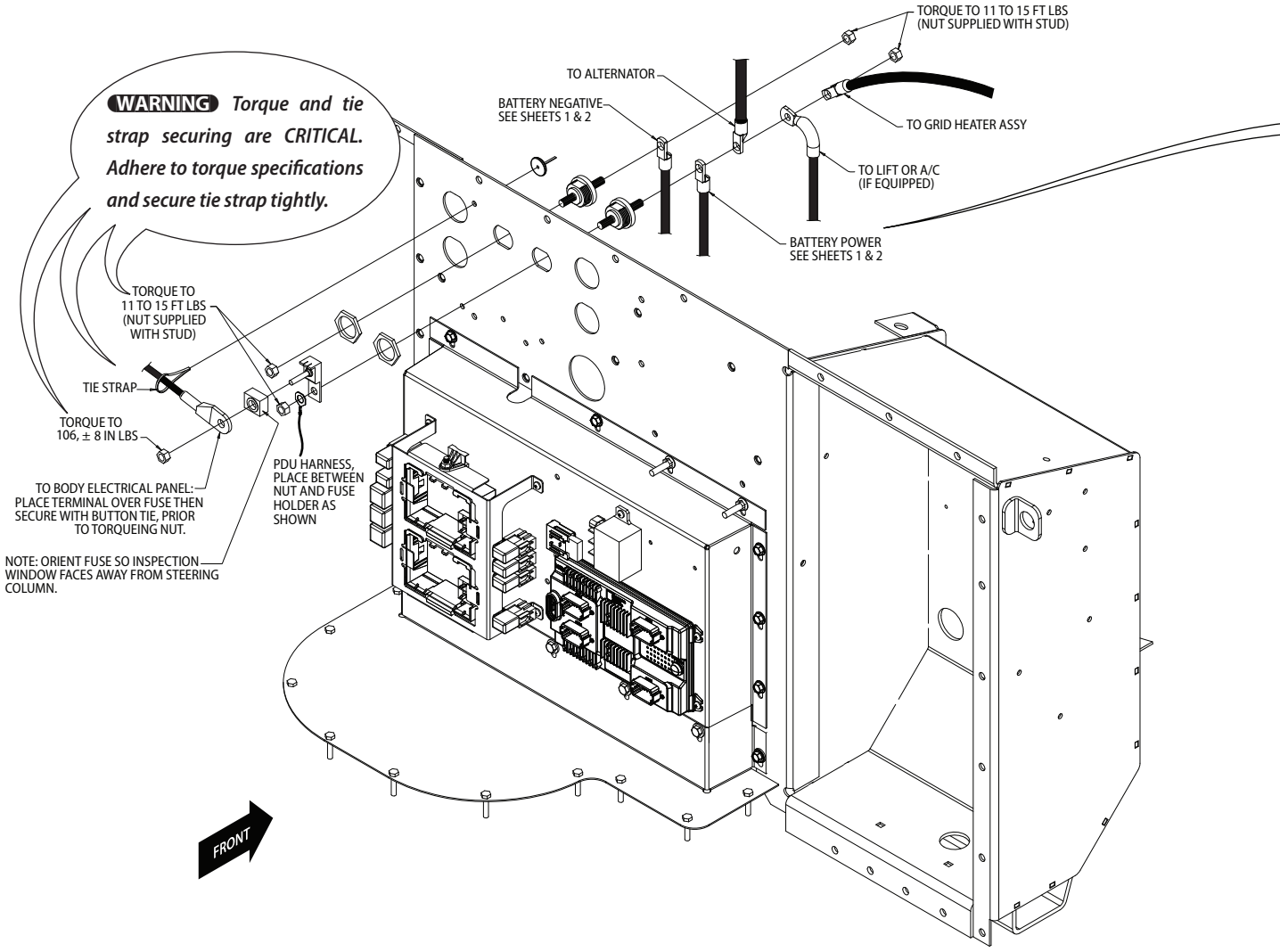


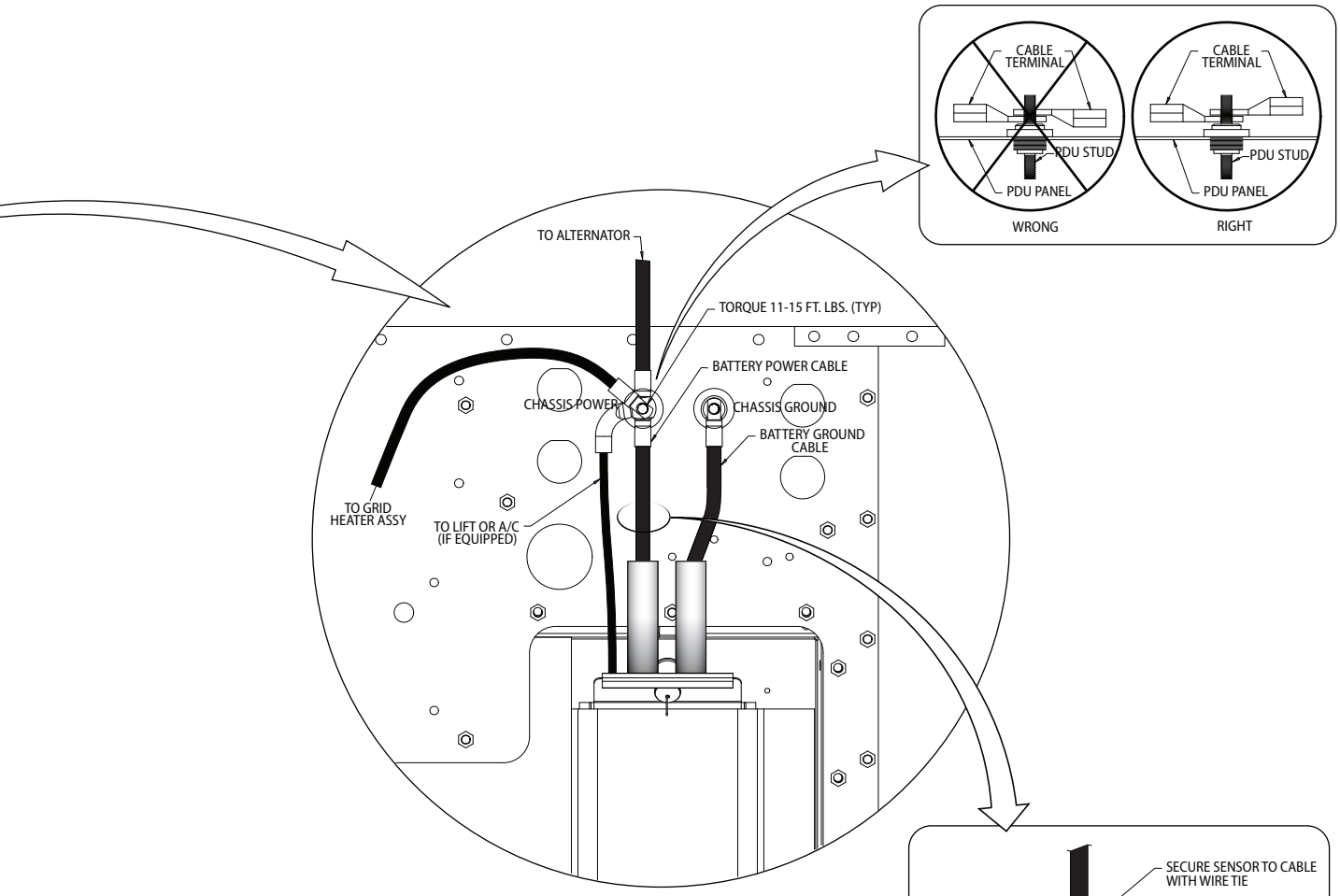
D0006303B

Chassis Harness Routing Sheet 5 of 9

D0006303b

HARNESS ROUTING, GM 8.1, NEW MPX


WARNING Torque and tie strap securing are CRITICAL. Adhere to torque specifications and secure tie strap tightly.
TORQUE TO 11 TO 15 FT LBS (NUT SUPPLIED WITH STUD)
TO ALTERNATOR
BATTERY NEGATIVE SEE SHEETS 1 & 2
TO GRID HEATER ASSY
TO LIFT OR A/C (IF EQUIPPED)
BATTERY POWER SEE SHEETS 1 & 2
TORQUE TO 11 TO 15 FT LBS (NUT SUPPLIED WITH STUD)
TIE STRAP
TORQUE TO 106, ± 8 IN LBS
TO BODY ELECTRICAL PANEL: PLACE TERMINAL OVER FUSE THEN SECURE WITH BUTTON TIE, PRIOR TO TORQUEING NUT.
NOTE: ORIENT FUSE SO INSPECTION WINDOW FACES AWAY FROM STEERING COLUMN.
PDU HARNESS, PLACE BETWEEN NUT AND FUSE HOLDER AS SHOWN
FRONT



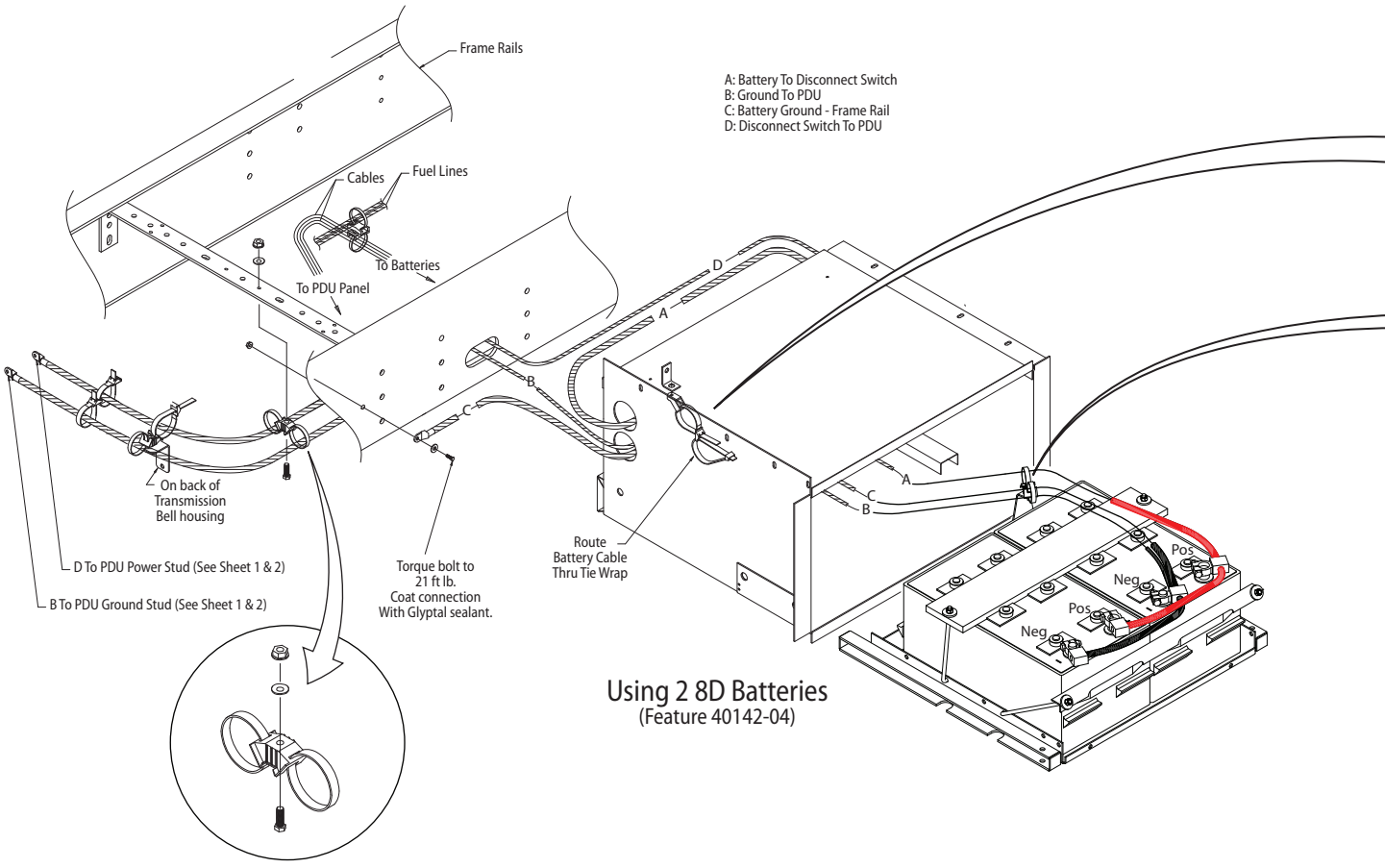
NOTES:
SEE SHEET 1 & 2 FOR CABLES.
USE SEALANT TO COMPLETELY COAT ALL EXPOSED ELECTRICAL CONNECTIONS.

D0006303B

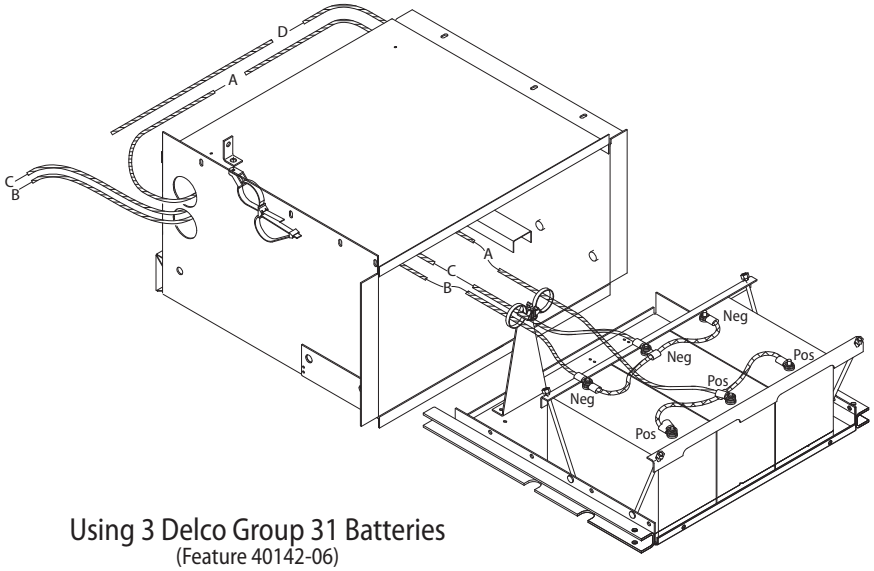
Chassis Harness Routing Sheet 6 of 9

D0006303b

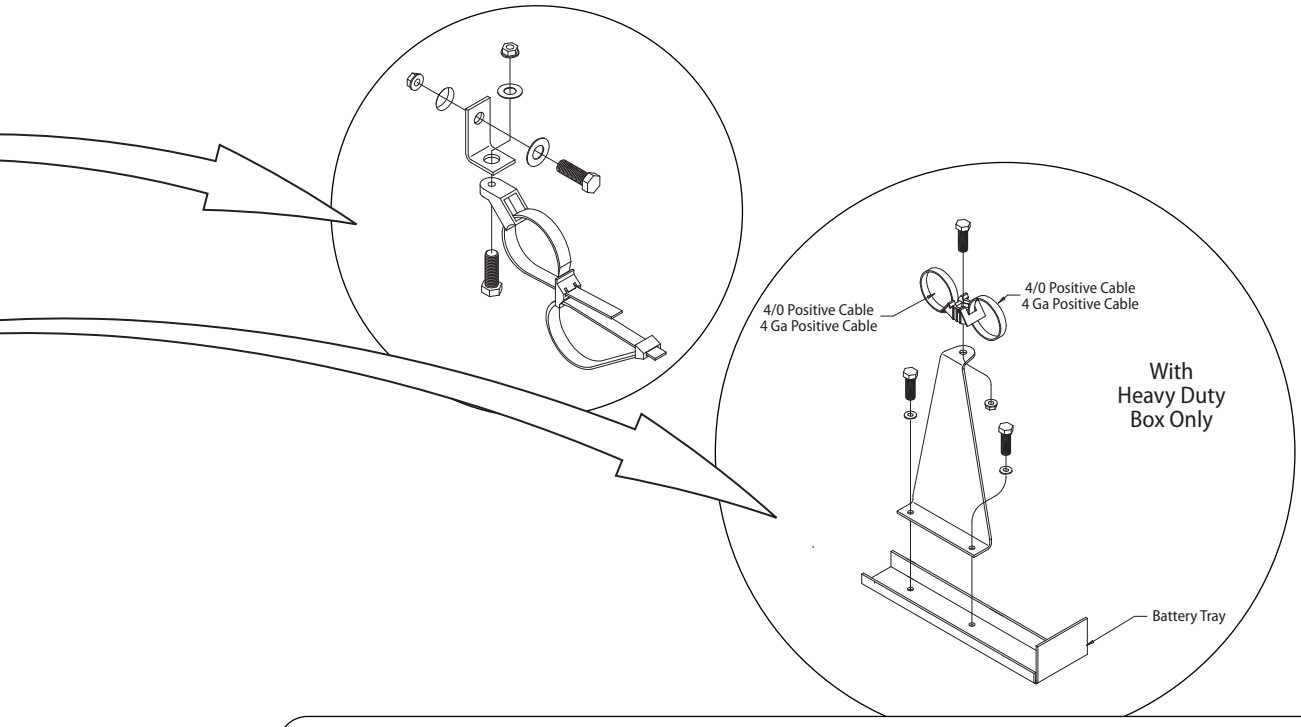
HARNESS ROUTING, GM 8.1, NEW MPX

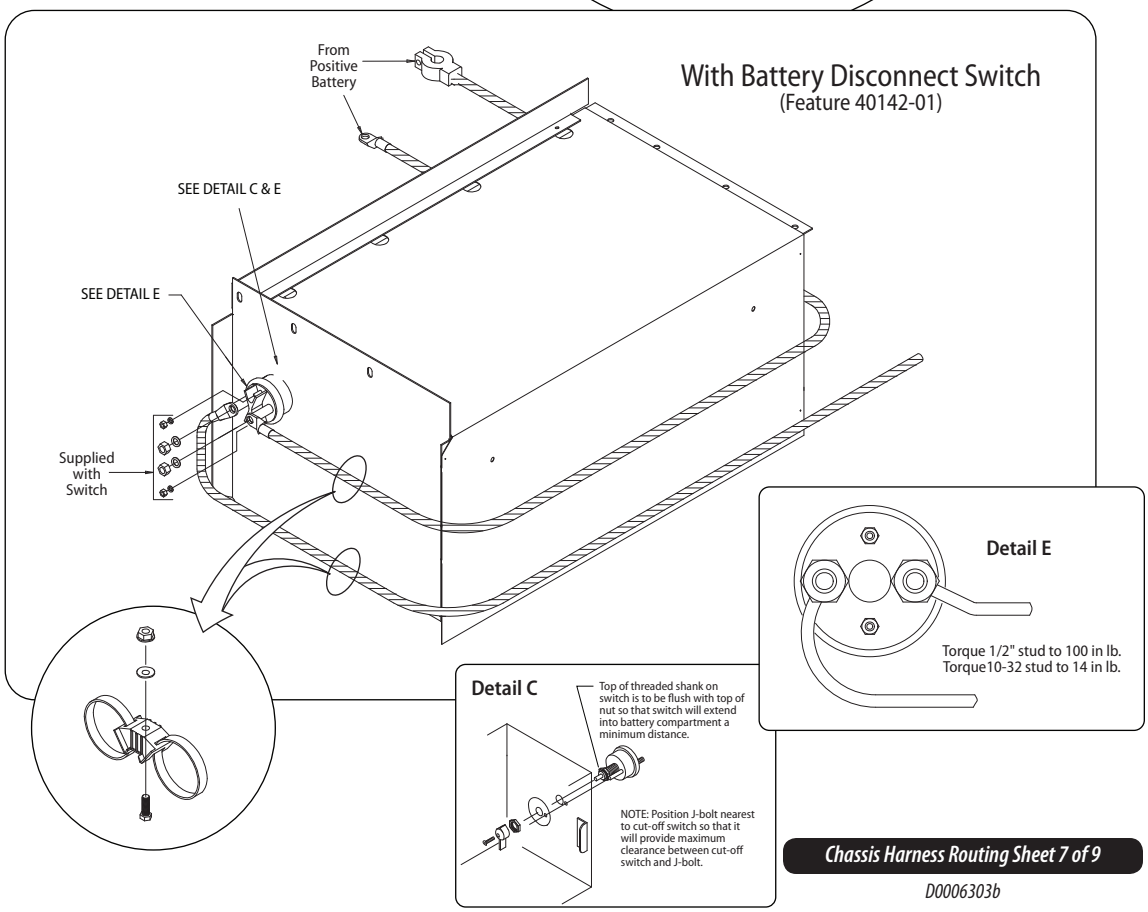


Using 2 8D Batteries
(Feature 40142-04)



Using 3 Delco Group 31 Batteries
(Feature 40142-06)



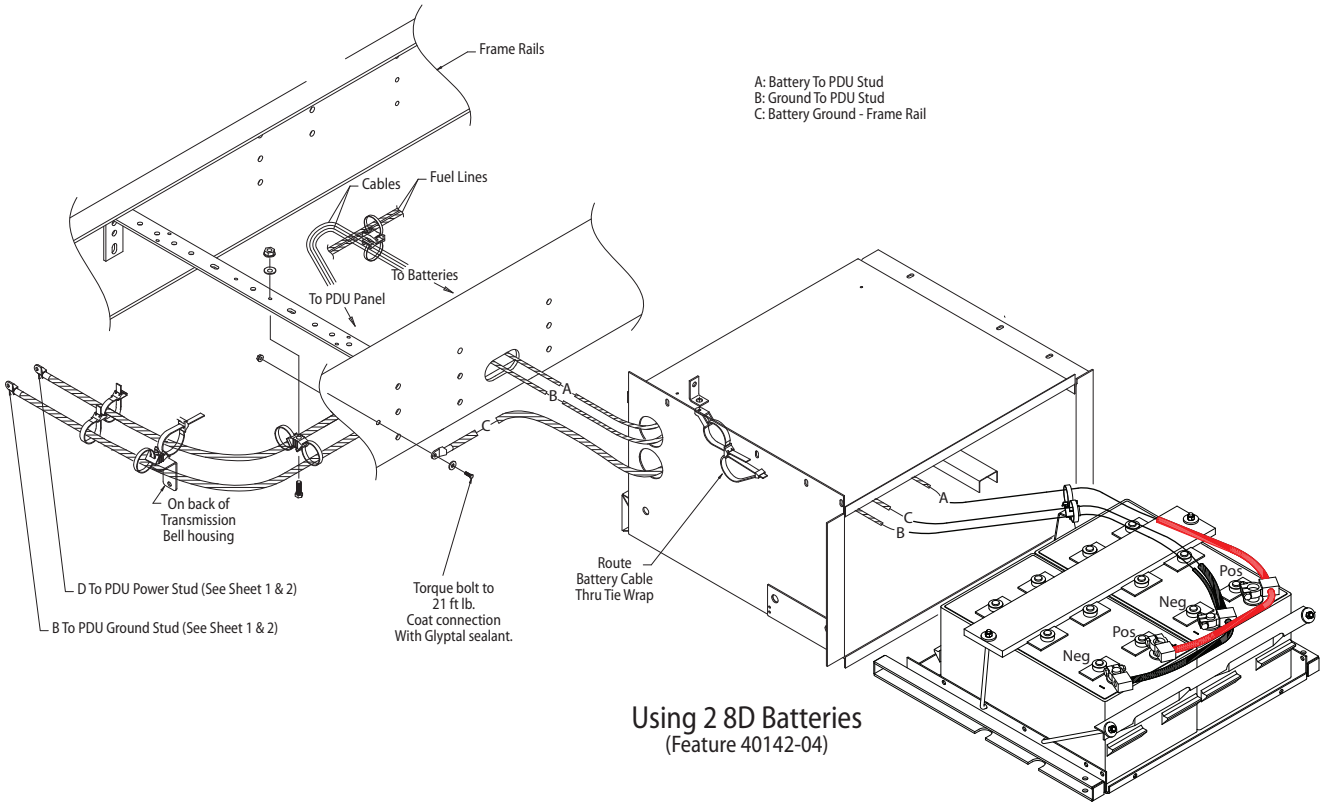


D0006303B

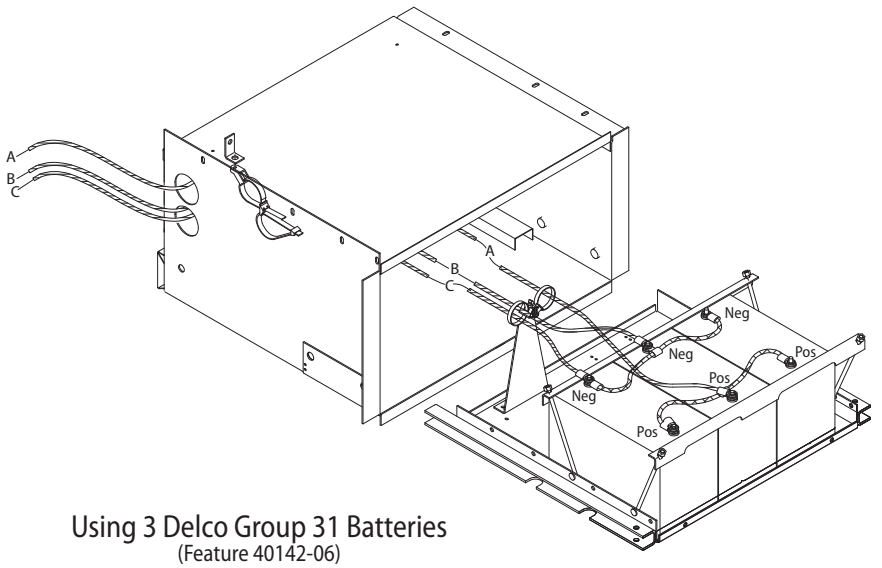
Chassis Harness Routing Sheet 7 of 9

D0006303b

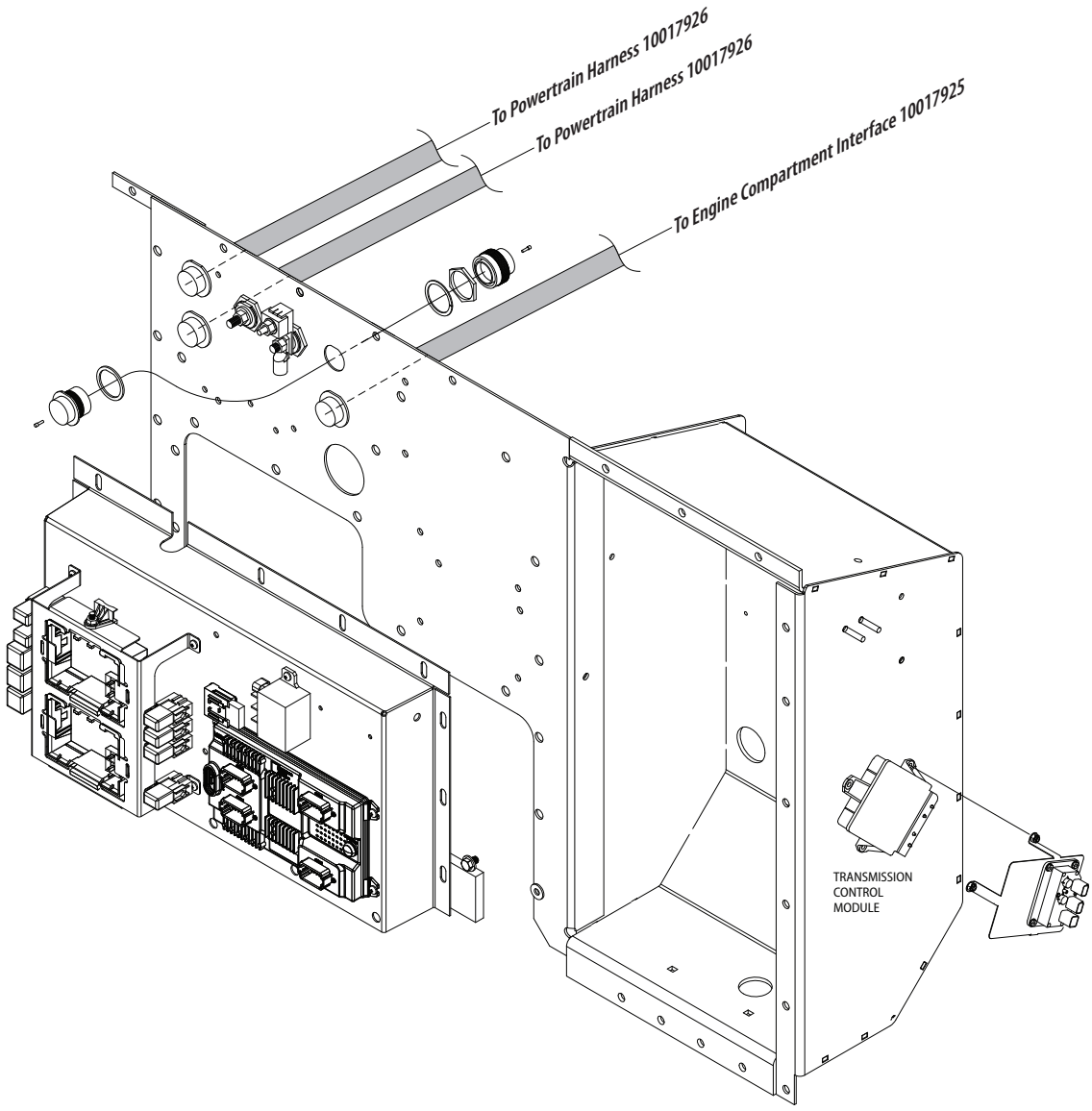
HARNESS ROUTING, GM 8.1, NEW MPX



Using 2 8D Batteries
(Feature 40142-04)



Using 3 Delco Group 31 Batteries
(Feature 40142-06)

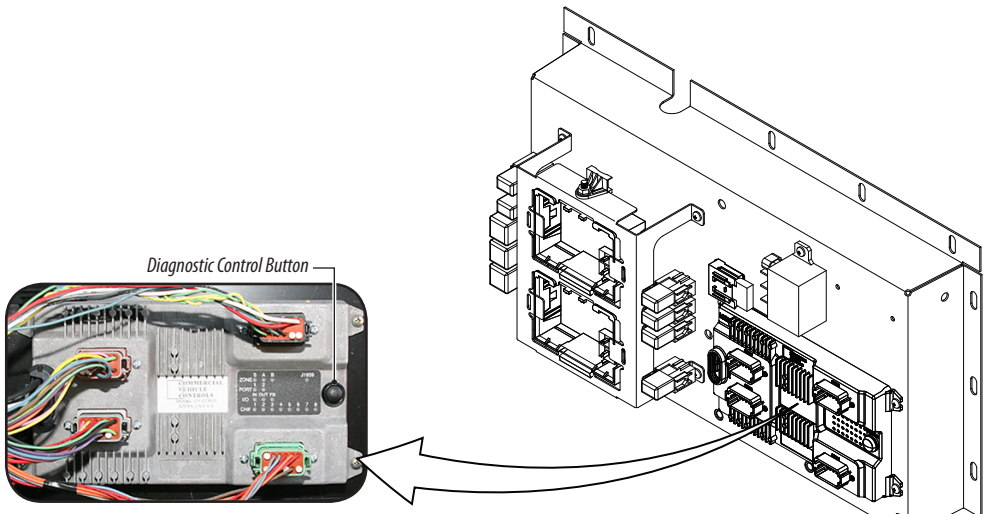


D0006303B

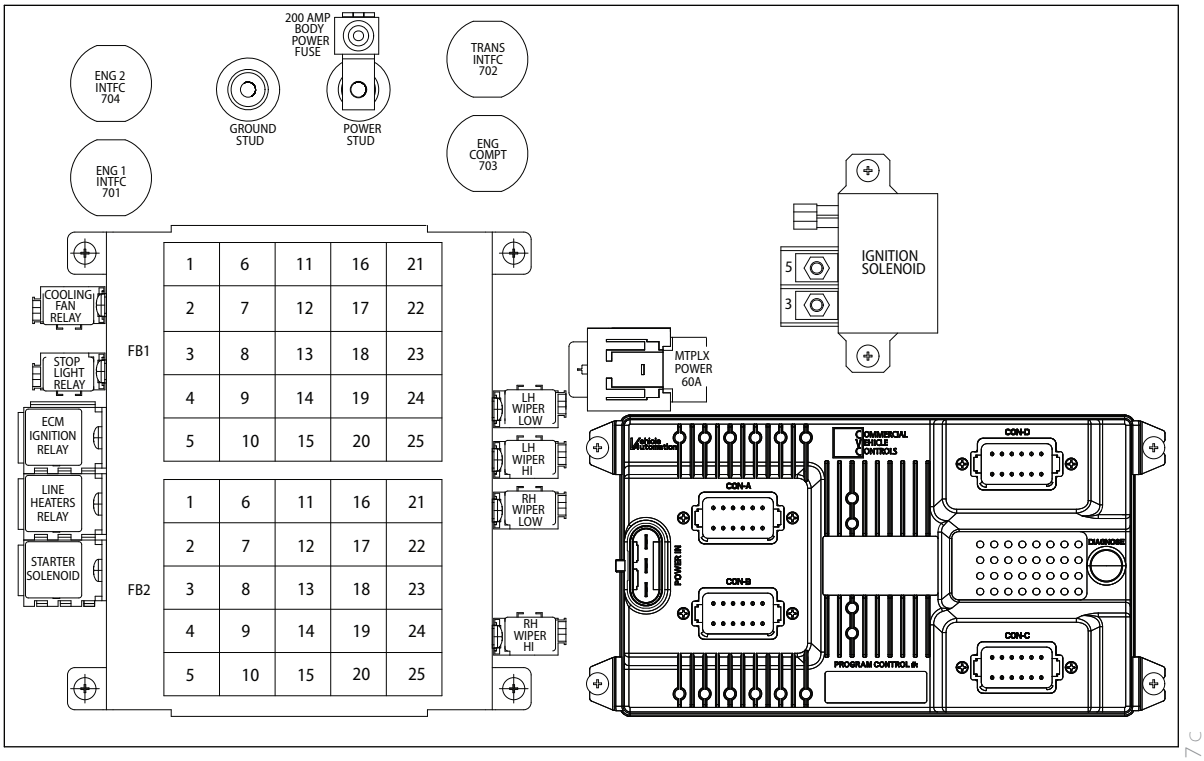
Chassis Harness Routing Sheet 9 of 9

D0006303b

HARNESS ROUTING, GM 8.1, NEW MPX



New Multiplex Module A



FB1 FUSE BLOCK

CB1	DIAGNOSTIC POWER	(10A)
F2	TRANSMISSION BATTERY	(10A)
F3	ENGINE ECM BATTERY	(30A)
CB4	MBC BATTERY	(10A)
5	SPARE	
F6	ABS BATTERY	(25A)
F7	DOSING CONTROL UNIT	(20A)
CB8	DASH BATTERY	(7.5A)
CB9	STOP LIGHT POWER	(15A)
10	SPARE	
F11	ENGINE KEY SWITCH	(5A)
F12	DOSING CONTROL UNIT IGNITION	(5A)
CB13	DEF TANK	(5A)
F14	ENGINE NOX SENSOR	(10A)
CB15	BODY IGNITION	(10A)
16-20	SPARES	
CB21	SENSOR IGNITION	(7.5A)
CB22	AIR DRYER POWER	(10A)
CB23	FAN (ENGINE) POWER	(10A)
CB24	WIPER RH	(20A)
CB25	WIPER LH	(20A)

FB2 FUSE BLOCK

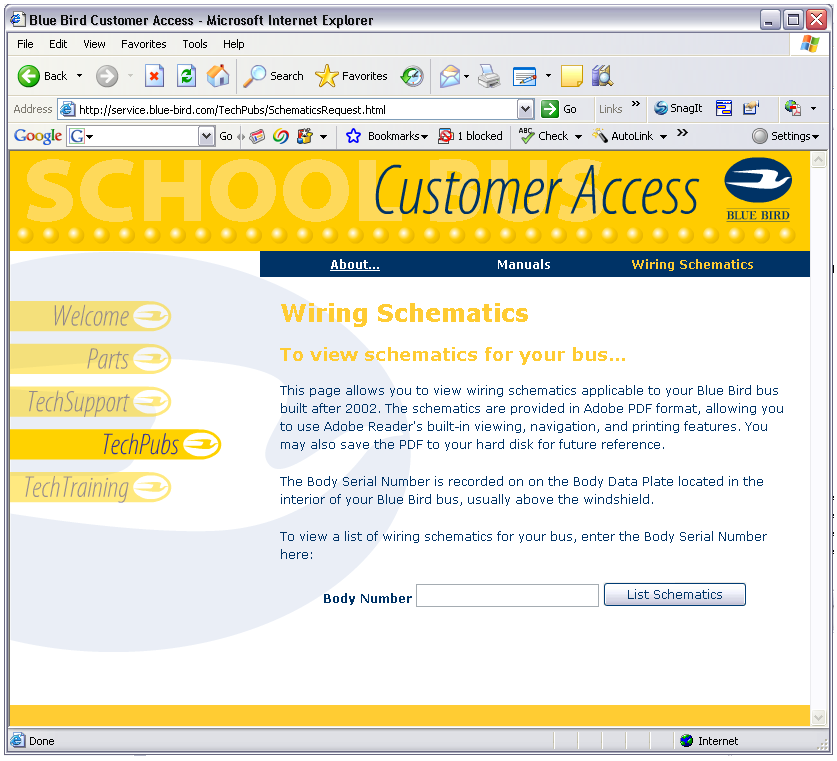
F1	HYD BRAKE BOOST BATT	(40A)	Units w/Hydraulic Brakes
1	SPARE		Units w/Air Brakes
CB2	HYD INTERLOCK POWER	(10A)	Units w/Hydraulic Brakes
CB2	INTERLOCK POWER	(10A)	Units w/Air Brakes
3-4	SPARES		
CB5	REVERSE SENSOR	(10A)	
CB6	DEF LINE HEATERS	(20A)	
7	SPARE		
CB8	ABS PUMP MOTOR	(30A)	Units w/Hydraulic Brakes
8	SPARE		Units w/Air Brakes
9-10	SPARES		
F11	TRANSMISSION IGNITION	(10A)	
F12	ABS IGNITION	(5A)	
CB13	DASH IGNITION	(10A)	
F14	SCR NOX SENSOR	(10A)	
15	SPARE		
CB16	HYD BRAKE WARNING	(7.5A)	Units w/Hydraulic Brakes
16	SPARE		Units w/Air Brakes
17-20	SPARES		
CB21	HEATED DRAIN VALVE	(20A)	
CB22	FUEL HEATER	(20A)	
23-24	SPARES		
CB25	WIPER SWITCH	(5A)	

Chassis Wiring Schematics

The following pages contain the main wiring schematics applicable to Blue Bird Vision Propane with 8.1L GM engine chassis.

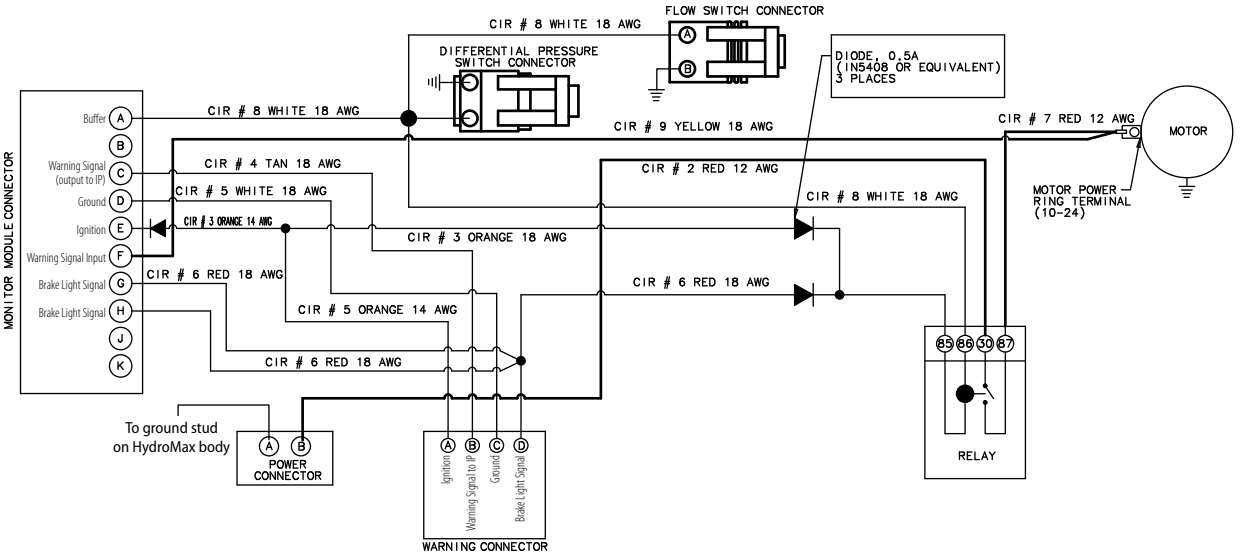
The schematics are provided for your convenience when you are limited to use of the print manual. Additional schematics specific to your bus may be viewed, printed, or downloaded in Adobe® PDF® format by pointing your web browser to the Customer Access website at:

http://service.blue-bird.com/TechPubs/SchematicsRequest.html



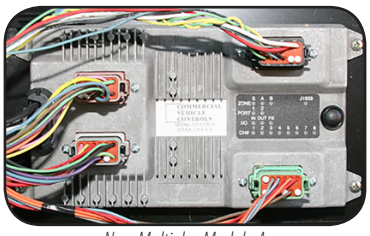
Hydraulic Brake Booster Harness

This schematic describes the wiring of the Bendix HydroMax brake master cylinder/ booster harness on Blue Bird Visions equipped with hydraulic brakes.

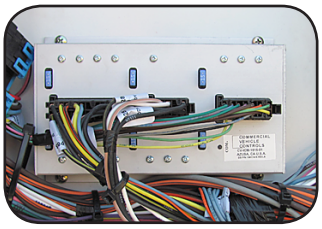


Electrical Diagrams for GM 8.1 w/Dual Zone Multiplex

A mid year update was made to the multiplex sytem of the 2011 model. The new multiplex system incorporates two modules, module A (chassis) and module B (body). The chassis module located behind the PDU cover has a different physical appearance and now incorporates the diagnostic control button. Units manufactured on or after August 16, 2010 are equipped with the new multiplex module.



New Multiplex Module A



New Multiplex Module B

Description	Sheet	Drawing Number
Starting And Charging, GM 8.1	3	D0006355B
Engine, Blue Bird Interface	4	D0006356A
Powertrain Schematic 1	5	D0006357A
Powertrain Schematic 2	6	D0006358A
Backlights	7	D0006359A
ABS - Bendix (air)	8	D0006360A
ABS - Wabco (hydraulic)	9	D0006361A
Multiplex, A Zone Port 1	10	D0006362A
Multiplex, A Zone Port 2	11	D0006363A
Mirror Heat / Exterior Speaker	13	D0006366A
Hydraulic Brake Boost	14	D0006366A
Frame Components	15	D0006367A
Crossing Arm	16	D0006368A
Instrument Cluster	17	D0006371A
Driver's Control Module - Air	18	D0006372A
Driver's Control Module - Hydraulic	19	D0006373A
A Zone Power & Ground	20	D0006374A
Body Interface	21	D0006375A
J1939 Datalink, Hydraulic	22	D0006376A
J1939 Datalink, Air	23	D0006377A
Wiper System	24	D0006378A

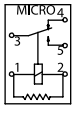
Wire Colors

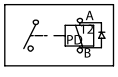
BL	BLUE	PK	PINK
BK	BLACK	OR	ORANGE
BR	BROWN	RD	RED
TN	TAN	GN	GREEN
WH	WHITE	PU	PURPLE
YL	YELLOW	GY	GRAY

Schematic Legend

PD	PDU PANEL
AC	AIR CLEANER BRACKET
IP	INSTRUMENT PANEL
FW	FIREWALL
SP	SHIFTER PANEL
DC	DCM

Electrical Component Index





Heavy Duty Relay



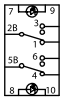
Fuse



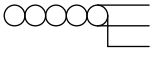
Voltage Stud



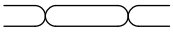
Shunt



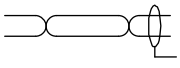
Switch Ngr Rocker (Non-typical)



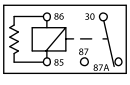
3 Wire Twisting



2 Wire Twisting



2 Wire Twisting with Shield



Mini Relay



Horn



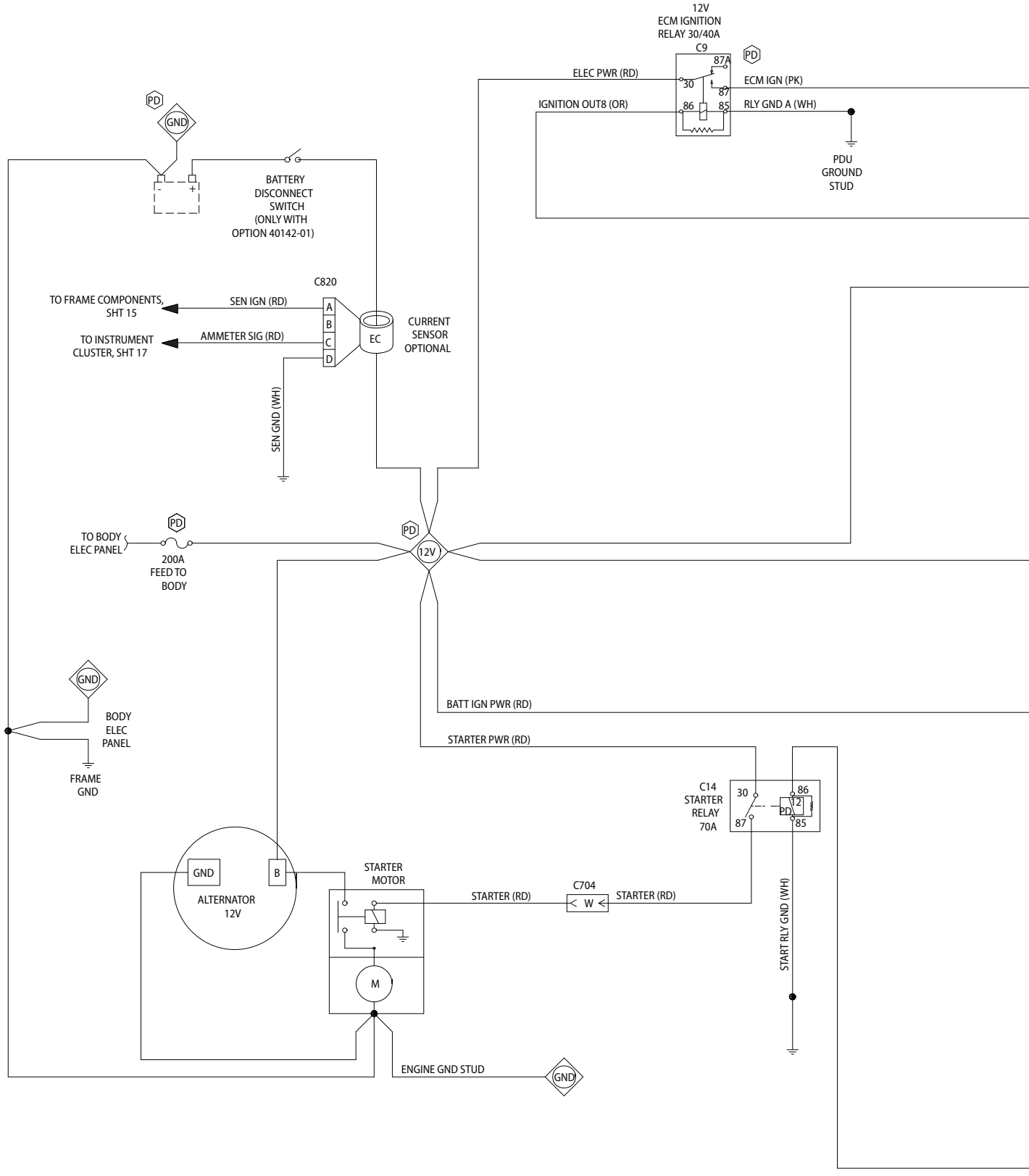
Speaker

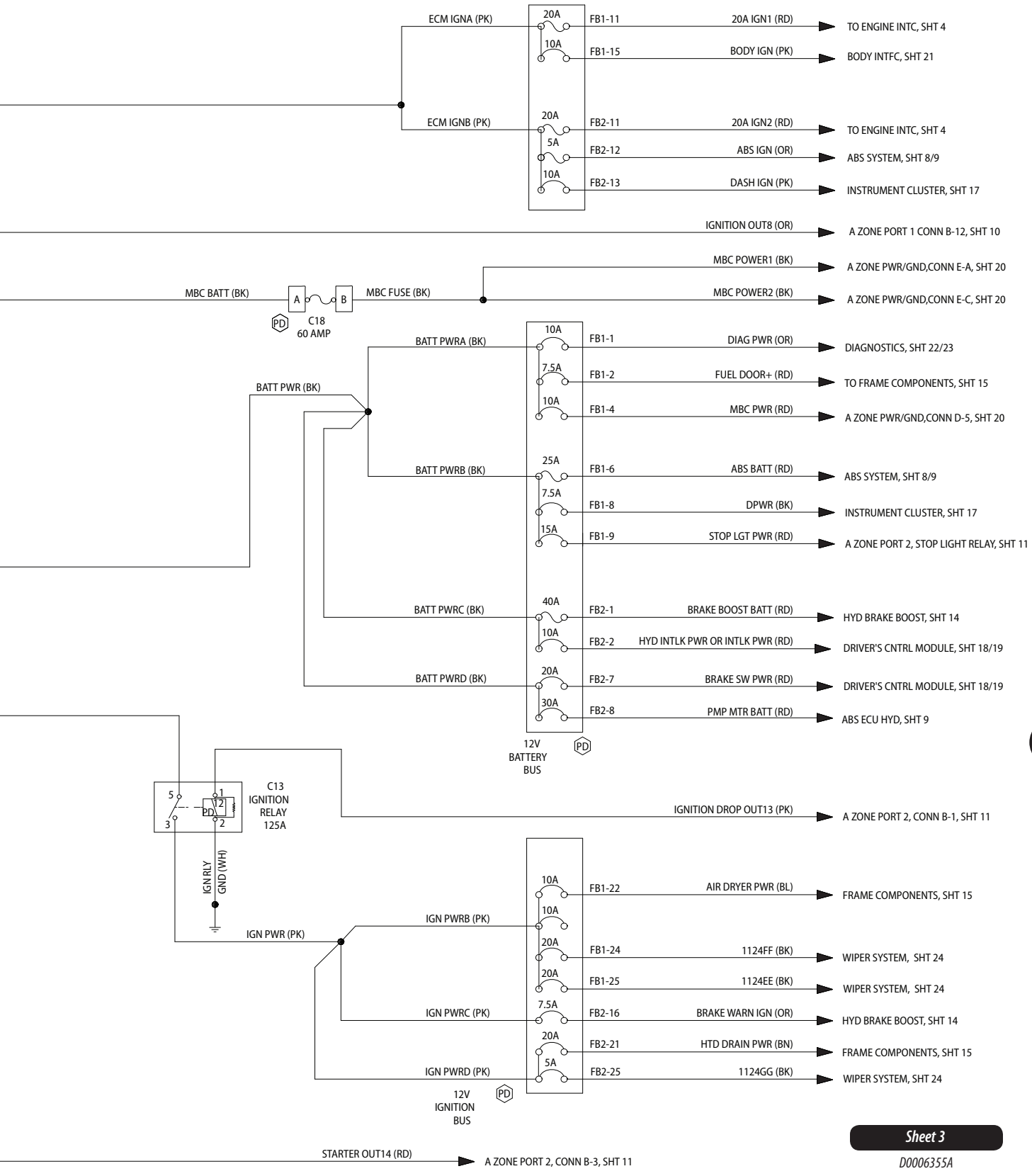


Light



Circuit Breaker


12V
ECM IGNITION
RELAY 30/40A
C9
87A
PD
ELEC PWR (RD)
30
ECM IGN (PK)
87
IGNITION OUT8 (OR)
86
85
RLY GND A (WH)
PDU
GROUND
STUD
PD
GND
BATTERY
DISCONNECT
SWITCH
(ONLY WITH
OPTION 40142-01)
C820
TO FRAME COMPONENTS,
SHT 15
SEN IGN (RD)
A
B
TO INSTRUMENT
CLUSTER, SHT 17
AMMETER SIG (RD)
C
D
EC
CURRENT
SENSOR
OPTIONAL
SEN GND (WH)
TO BODY
ELEC PANEL
PD
200A
FEED TO
BODY
PD
12V
GND
BODY
ELEC
PANEL
FRAME
GND
BATT IGN PWR (RD)
STARTER PWR (RD)
C14
STARTER
RELAY
70A
30
86
12
PD
87
85
GND
B
ALTERNATOR
12V
STARTER
MOTOR
STARTER (RD)
C704
W
STARTER (RD)
START RLY GND (WH)
M
ENGINE GND STUD
GND



Sheet 3

D0006355A

STARTING AND CHARGING, GM 8.1

INSTRUMENT CLUSTER, SHT 17 — WAIT START (LT GN)
INSTRUMENT CLUSTER, SHT 17 — SHUTTER SIG (GY)
DRIVER'S CONTROL MODULE, SHT 18/19 — THROT PWR 1 (LT BL)
DRIVER'S CONTROL MODULE, SHT 18/19 — THROT RET 1 (PK)
DRIVER'S CONTROL MODULE, SHT 18/19 — THROT SIG 1 (BN)
TO A ZONE PORT 1, SHT 10 — REVERSE IN2 (LT BL)
TO A ZONE PORT 1, SHT 10 — NEUTRAL IN3 (RD)

DRIVER'S CONTROL MODULE, SHT 18/19 — THROT SIG 2 (YL)
INSTRUMENT CLUSTER, SHT 17 — FUEL TANK SIG (BK)
TO A ZONE PORT 2, SHT 11 — SHIFT INHIBIT OUT10 (GN)
J1939 DATALINK,DIAGNOSTIC CONN, SHT 22/23 — CLASS 2 (GY)
DRIVER'S CONTROL MODULE, SHT 18/19 — THROT PWR 2 (BL)
TO STOP LIGHT RELAY A ZONE PORT 2, SHT 11 — TCC SW (RD)
DRIVER'S CONTROL MODULE, SHT 18/19 — THROT RET 2 (GN)
J1939 DATALINK,DIAGNOSTIC CONN, SHT 22/23 — GM LAN + (YL)
J1939 DATALINK,DIAGNOSTIC CONN, SHT 22/23 — GM LAN - (LT GN)
J1939 DATALINK, SHT 22/23 — EJ1939+ (YL)
J1939 DATALINK, SHT 22/23 — EJ1939- (LT GN)

START/CHARGE, SHT 3 — 20A IGN 1 (RD)
START/CHARGE, SHT 3 — 20A IGN 2 (RD)

BODY INTFC, SHT 21 — AC HI IDLE (LT GN)

TO A ZONE PORT 1, SHT 10 — ILLUM C (LT BL)

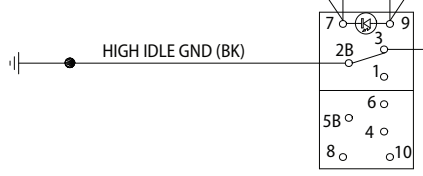
BACKLIGHTS, SHT 7 — ILLUM B (LT BL)

TO A ZONE PORT 1, SHT 10 — GND 2A (WH)

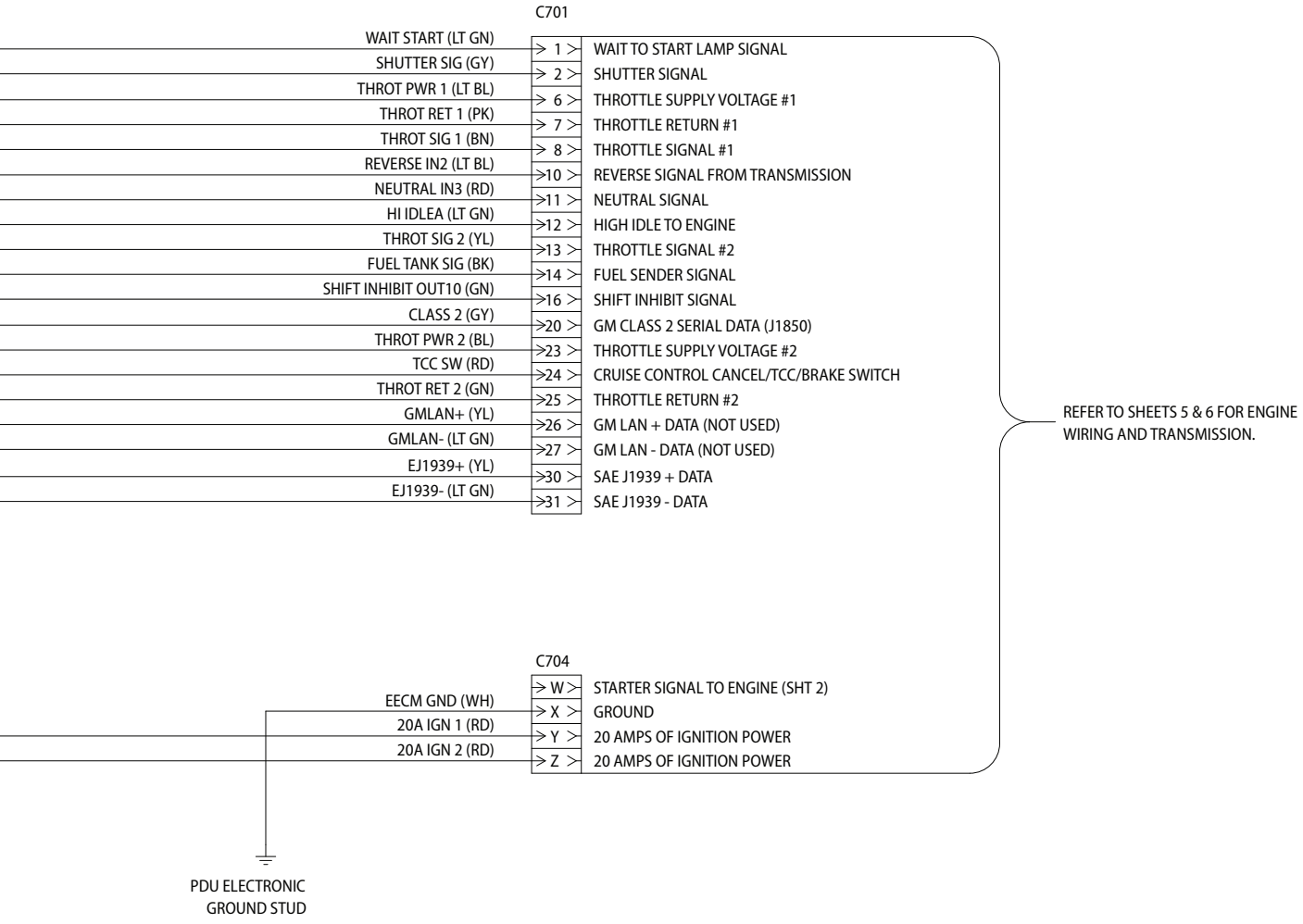
GND 2 (WH)

HIGH IDLE GND (BK)

HI IDLE (LT GN)



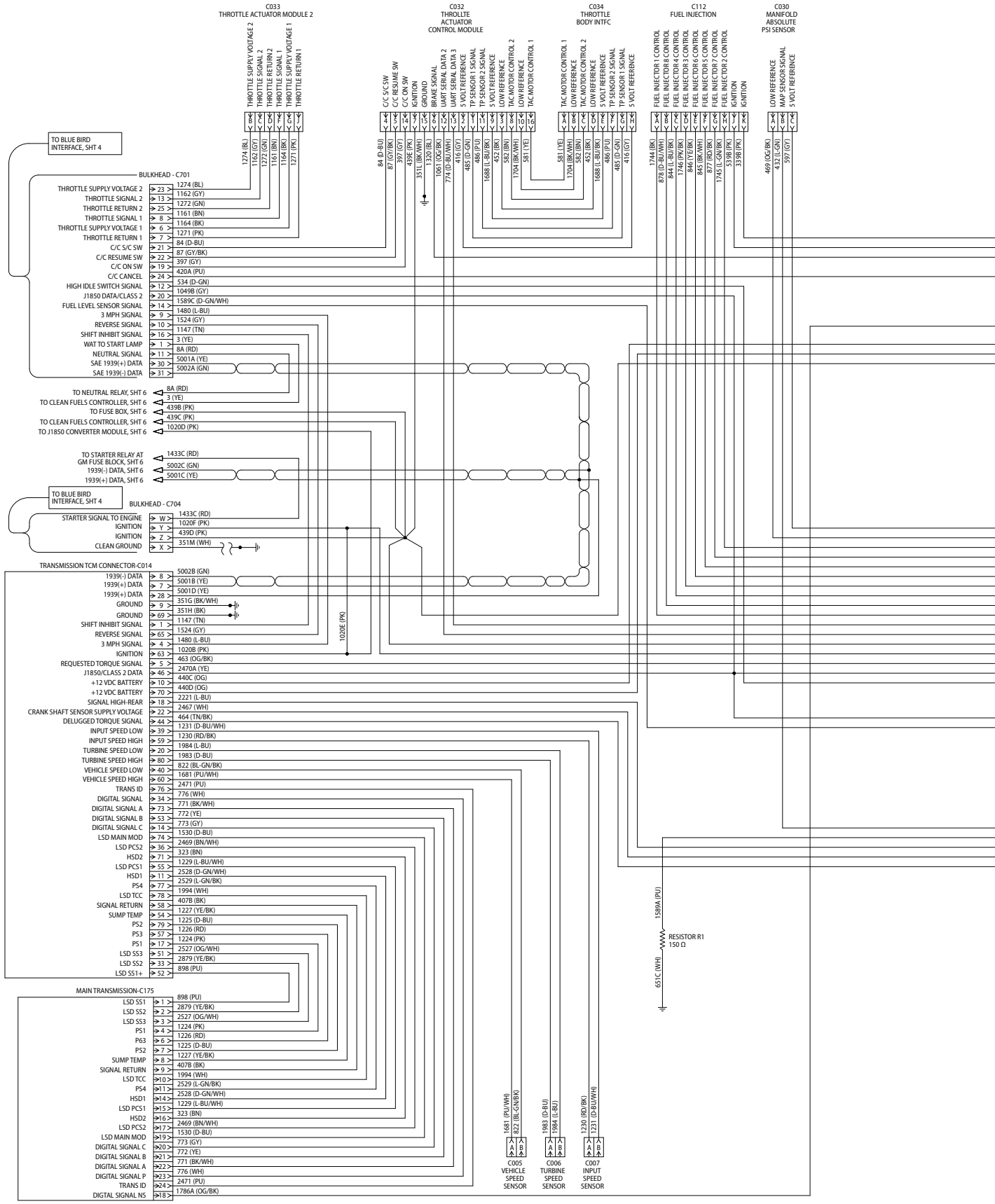
C425
HIGH IDLE SW

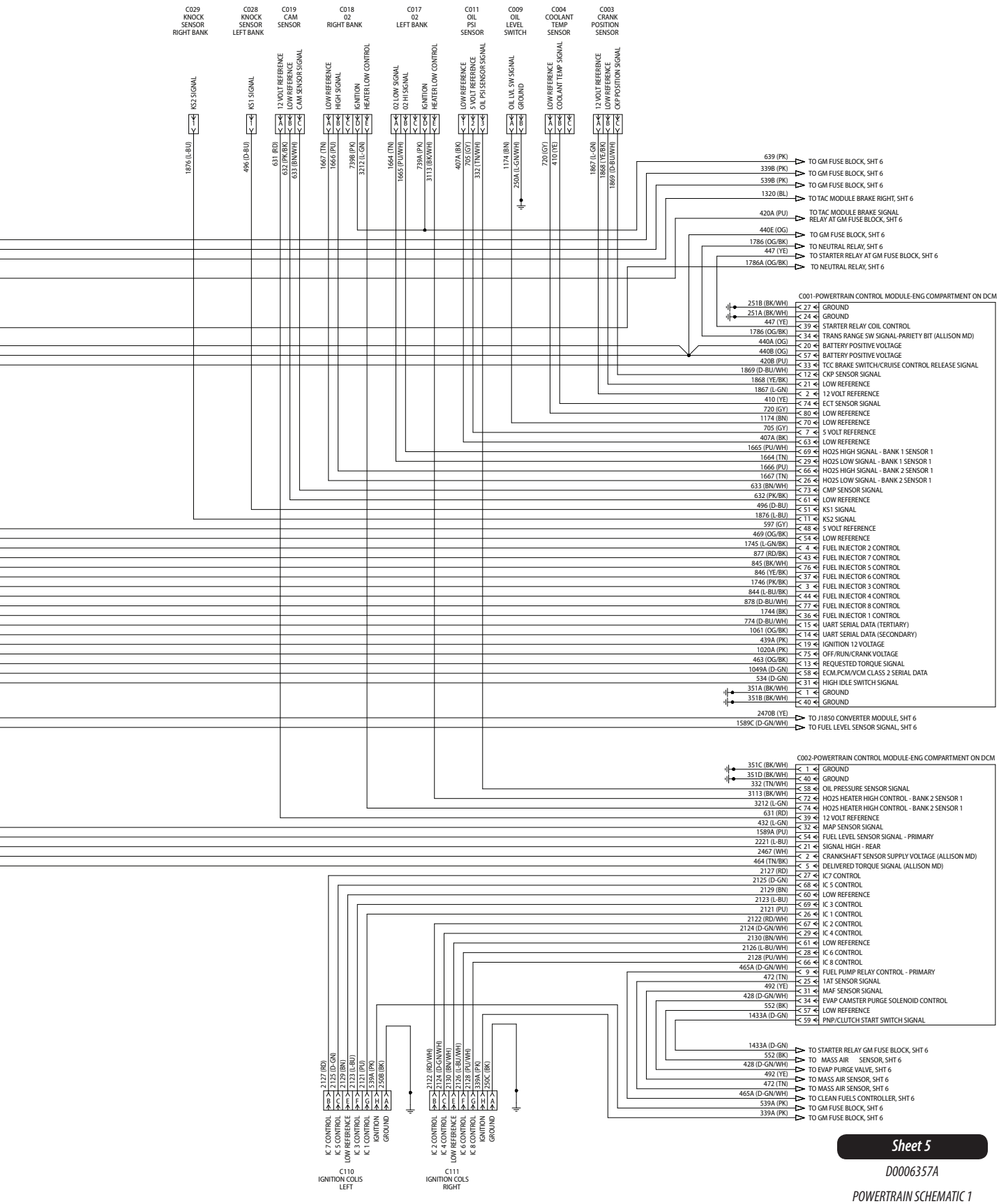


Sheet 4

D0006356A

ENGINE, BLUE BIRD INTERFACE, GM8.1

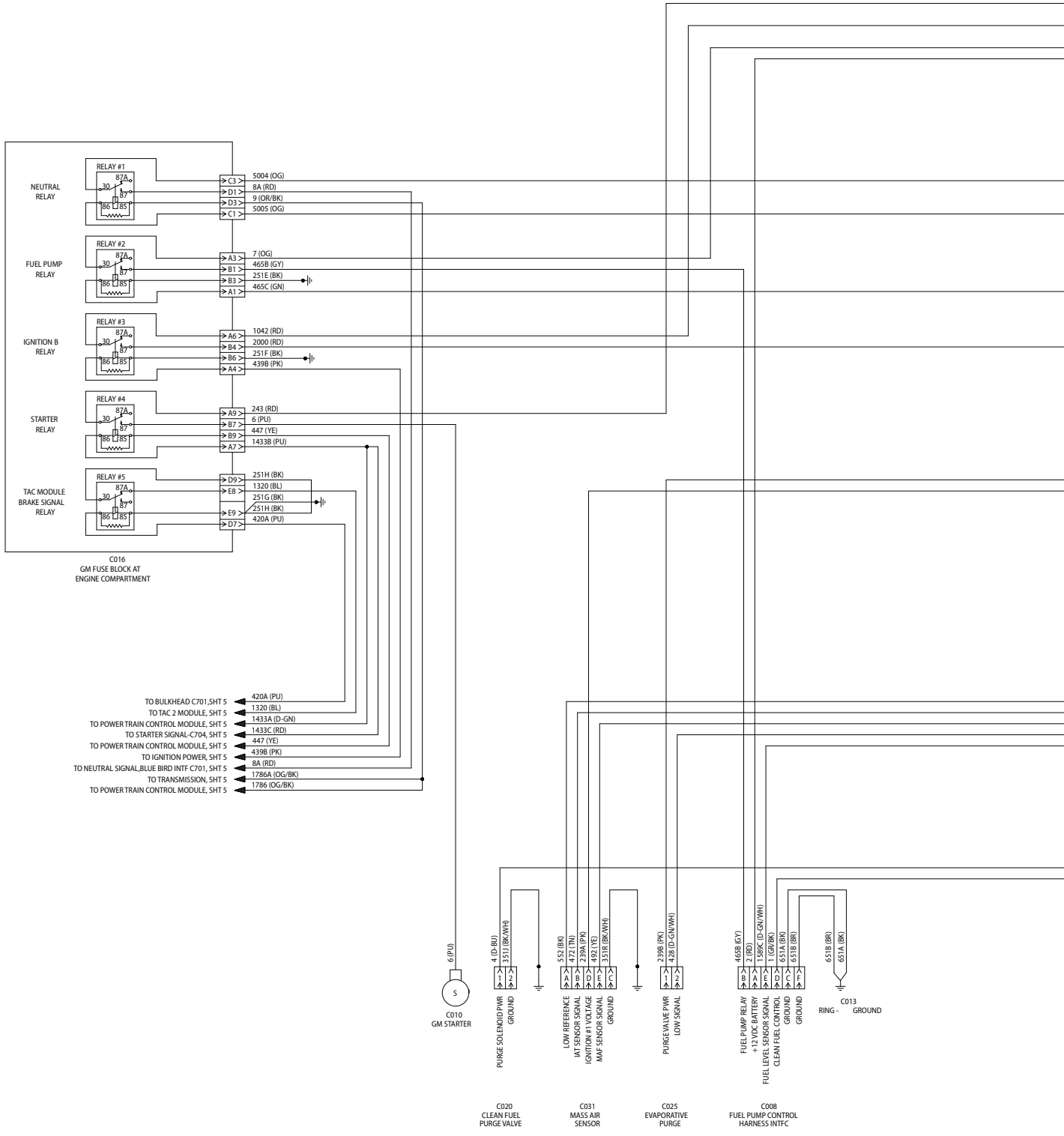

C033
THROTTLE ACTUATOR MODULE 2
C032
THROTTLE ACTUATOR CONTROL MODULE
C034
THROTTLE BODY INTFC
C112
FUEL INJECTION
C030
MANIFOLD ABSOLUTE PSI SENSOR
THROTTLE SUPPLY VOLTAGE 2
THROTTLE SIGNAL 2
THROTTLE RETURN 2
THROTTLE SIGNAL 1
THROTTLE SUPPLY VOLTAGE 1
THROTTLE RETURN 1
C/C S/C SW
C/C RESUME SW
C/C ON SW
IGNITION
GROUND
BRAKE SIGNAL
UART SERIAL DATA 2
UART SERIAL DATA 3
5 VOLT REFERENCE
TP SENSOR 1 SIGNAL
TP SENSOR 2 SIGNAL
5 VOLT REFERENCE
LOW REFERENCE
TAC MOTOR CONTROL 2
LOW REFERENCE
TAC MOTOR CONTROL 1
TAC MOTOR CONTROL 1
LOW REFERENCE
TAC MOTOR CONTROL 2
LOW REFERENCE
5 VOLT REFERENCE
TP SENSOR 2 SIGNAL
TP SENSOR 1 SIGNAL
5 VOLT REFERENCE
FUEL INJECTOR 1 CONTROL
FUEL INJECTOR 8 CONTROL
FUEL INJECTOR 4 CONTROL
FUEL INJECTOR 3 CONTROL
FUEL INJECTOR 6 CONTROL
FUEL INJECTOR 5 CONTROL
FUEL INJECTOR 7 CONTROL
FUEL INJECTOR 2 CONTROL
IGNITION
IGNITION
LOW REFERENCE
MAP SENSOR SIGNAL
5 VOLT REFERENCE
TO BLUE BIRD INTERFACE, SHT 4
BULKHEAD - C701
THROTTLE SUPPLY VOLTAGE 2
THROTTLE SIGNAL 2
THROTTLE RETURN 2
THROTTLE SIGNAL 1
THROTTLE SUPPLY VOLTAGE 1
THROTTLE RETURN 1
C/C S/C SW
C/C RESUME SW
C/C ON SW
C/C CANCEL
HIGH IDLE SWITCH SIGNAL
J1850 DATA/CLASS 2
FUEL LEVEL SENSOR SIGNAL
3 MPH SIGNAL
REVERSE SIGNAL
SHIFT INHIBIT SIGNAL
WAT TO START LAMP
NEUTRAL SIGNAL
SAE 1939(+) DATA
SAE 1939(-) DATA
TO NEUTRAL RELAY, SHT 6
TO CLEAN FUELS CONTROLLER, SHT 6
TO FUSE BOX, SHT 6
TO CLEAN FUELS CONTROLLER, SHT 6
TO J1850 CONVERTER MODULE, SHT 6
TO STARTER RELAY AT GM FUSE BLOCK, SHT 6
1939(-) DATA, SHT 6
1939(+) DATA, SHT 6
TO BLUE BIRD INTERFACE, SHT 4
BULKHEAD - C704
STARTER SIGNAL TO ENGINE
IGNITION
IGNITION
CLEAN GROUND
TRANSMISSION TCM CONNECTOR-C014
1939(-) DATA
1939(+) DATA
1939(+) DATA
GROUND
GROUND
SHIFT INHIBIT SIGNAL
REVERSE SIGNAL
3 MPH SIGNAL
IGNITION
REQUESTED TORQUE SIGNAL
J1850/CLASS 2 DATA
+12 VDC BATTERY
+12 VDC BATTERY
SIGNAL HIGH-REAR
CRANK SHAFT SENSOR SUPPLY VOLTAGE
DELUGGED TORQUE SIGNAL
INPUT SPEED LOW
INPUT SPEED HIGH
TURBINE SPEED LOW
TURBINE SPEED HIGH
VEHICLE SPEED LOW
VEHICLE SPEED HIGH
TRANS ID
DIGITAL SIGNAL
DIGITAL SIGNAL A
DIGITAL SIGNAL B
DIGITAL SIGNAL C
LSD MAIN MOD
LSD PCS2
HSD2
LSD PCS1
HSD1
PS4
LSD TCC
SIGNAL RETURN
SUMP TEMP
PS2
PS3
PS1
LSD SS3
LSD SS2
LSD SS1+
MAIN TRANSMISSION-C175
LSD SS1
LSD SS2
LSD SS3
PS1
P63
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
DIGTAL SIGNAL NS
1020E (PK)
RESISTOR R1
150 Ω
C005
VEHICLE SPEED SENSOR
C006
TURBINE SPEED SENSOR
C007
INPUT SPEED SENSOR

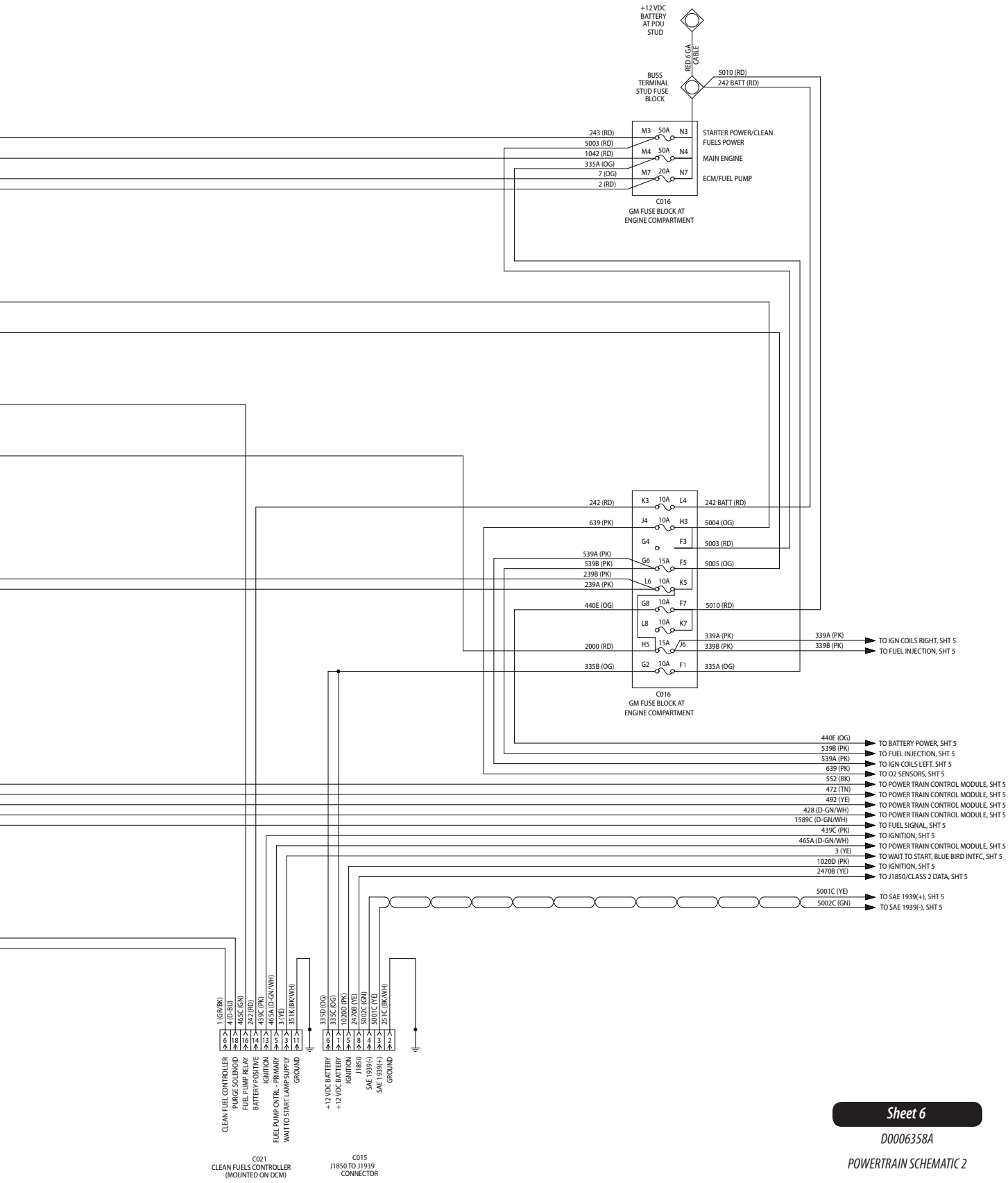


Sheet 5

D0006357A

POWERTRAIN SCHEMATIC 1

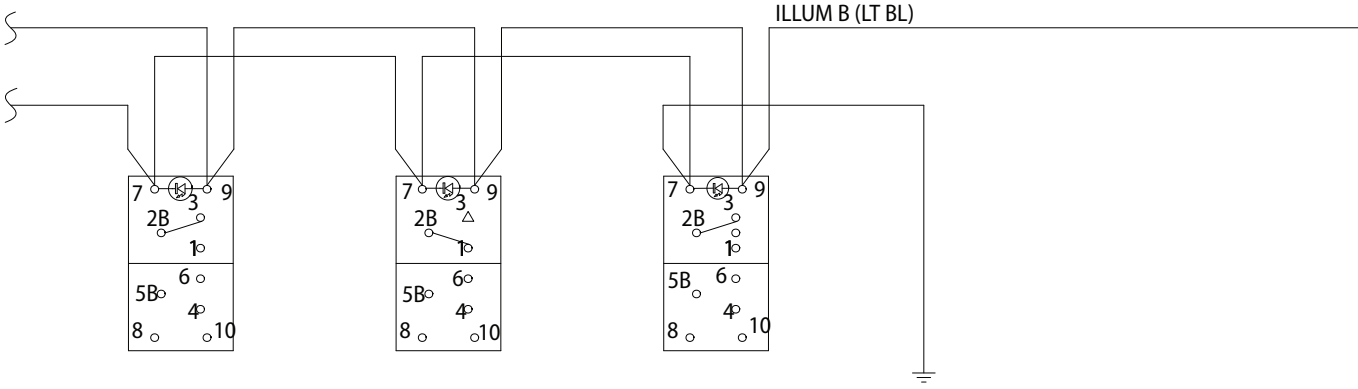

RELAY #1
NEUTRAL RELAY
C3 5004 (OG)
D1 8A (RD)
D3 9 (OR/BK)
C1 5005 (OG)
RELAY #2
FUEL PUMP RELAY
A3 7 (OG)
B1 465B (GY)
B3 251E (BK)
A1 465C (GN)
RELAY #3
IGNITION B RELAY
A6 1042 (RD)
B4 2000 (RD)
B6 251F (BK)
A4 439B (PK)
RELAY #4
STARTER RELAY
A9 243 (RD)
B7 6 (PU)
B9 447 (YE)
A7 1433B (PU)
RELAY #5
TAC MODULE BRAKE SIGNAL RELAY
D9 251H (BK)
E8 1320 (BL)
251G (BK)
E9 251H (BK)
D7 420A (PU)
C016
GM FUSE BLOCK AT ENGINE COMPARTMENT
TO BULKHEAD C701,SHT 5 420A (PU)
TO TAC 2 MODULE, SHT 5 1320 (BL)
TO POWER TRAIN CONTROL MODULE, SHT 5 1433A (D-GN)
TO STARTER SIGNAL-C704, SHT 5 1433C (RD)
TO POWER TRAIN CONTROL MODULE, SHT 5 447 (YE)
TO IGNITION POWER, SHT 5 439B (PK)
TO NEUTRAL SIGNAL,BLUE BIRD INTF C701, SHT 5 8A (RD)
TO TRANSMISSION, SHT 5 1786A (OG/BK)
TO POWER TRAIN CONTROL MODULE, SHT 5 1786 (OG/BK)
6 (PU)
S
C010
GM STARTER
4 (D-BU)
351J (BK/WH)
PURGE SOLENOID PWR
GROUND
C020
CLEAN FUEL PURGE VALVE
552 (BK)
472 (TN)
239A (PK)
492 (YE)
351R (BK/WH)
LOW REFERENCE
IAT SENSOR SIGNAL
IGNITION #1 VOLTAGE
MAF SENSOR SIGNAL
GROUND
C031
MASS AIR SENSOR
239B (PK)
428 (D-GN/WH)
PURGE VALVE PWR
LOW SIGNAL
C025
EVAPORATIVE PURGE
465B (GY)
2 (RD)
1589C (D-GN/WH)
1 (GR/BK)
651A (BK)
651B (BR)
FUEL PUMP RELAY
+12 VDC BATTERY
FUEL LEVEL SENSOR SIGNAL
CLEAN FUEL CONTROL
GROUND
GROUND
C008
FUEL PUMP CONTROL HARNESS INTFC
651B (BR)
651A (BK)
C013
RING -
GROUND



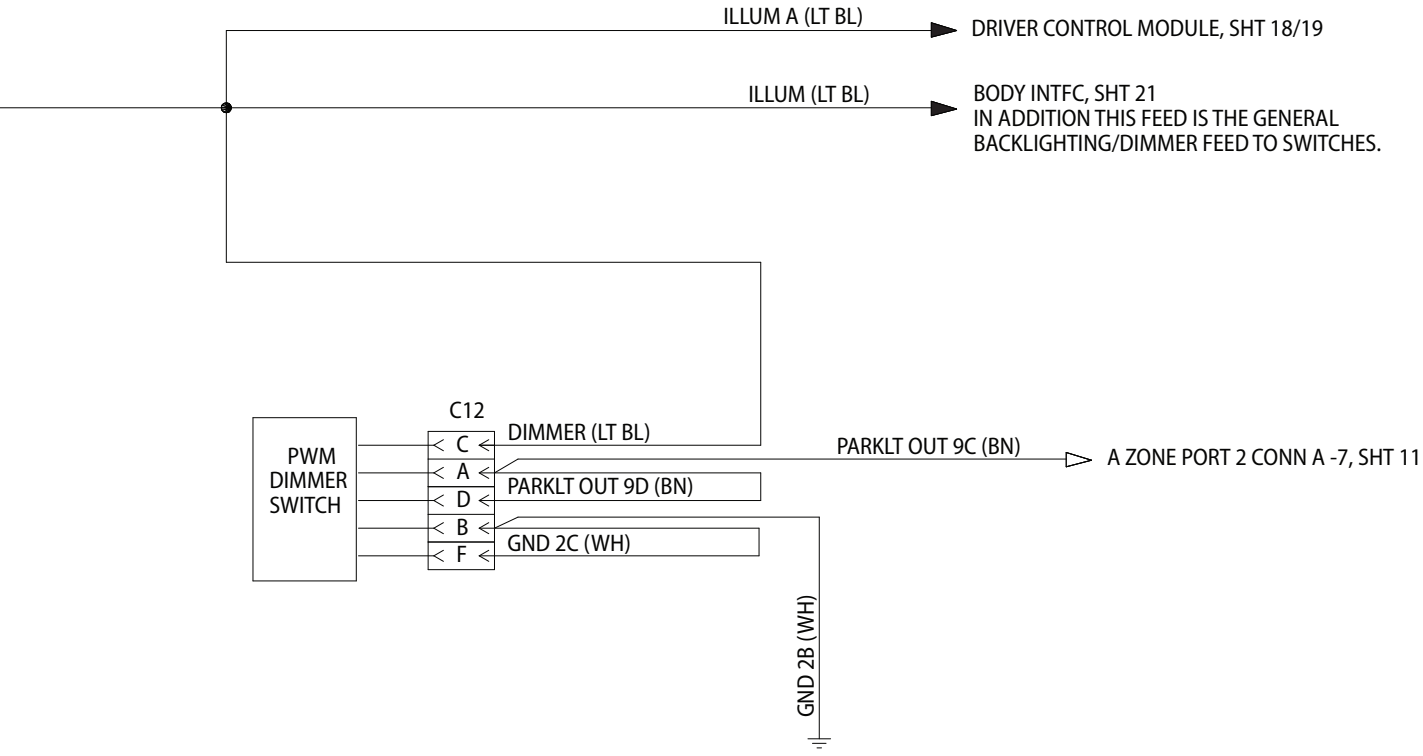
Sheet 6

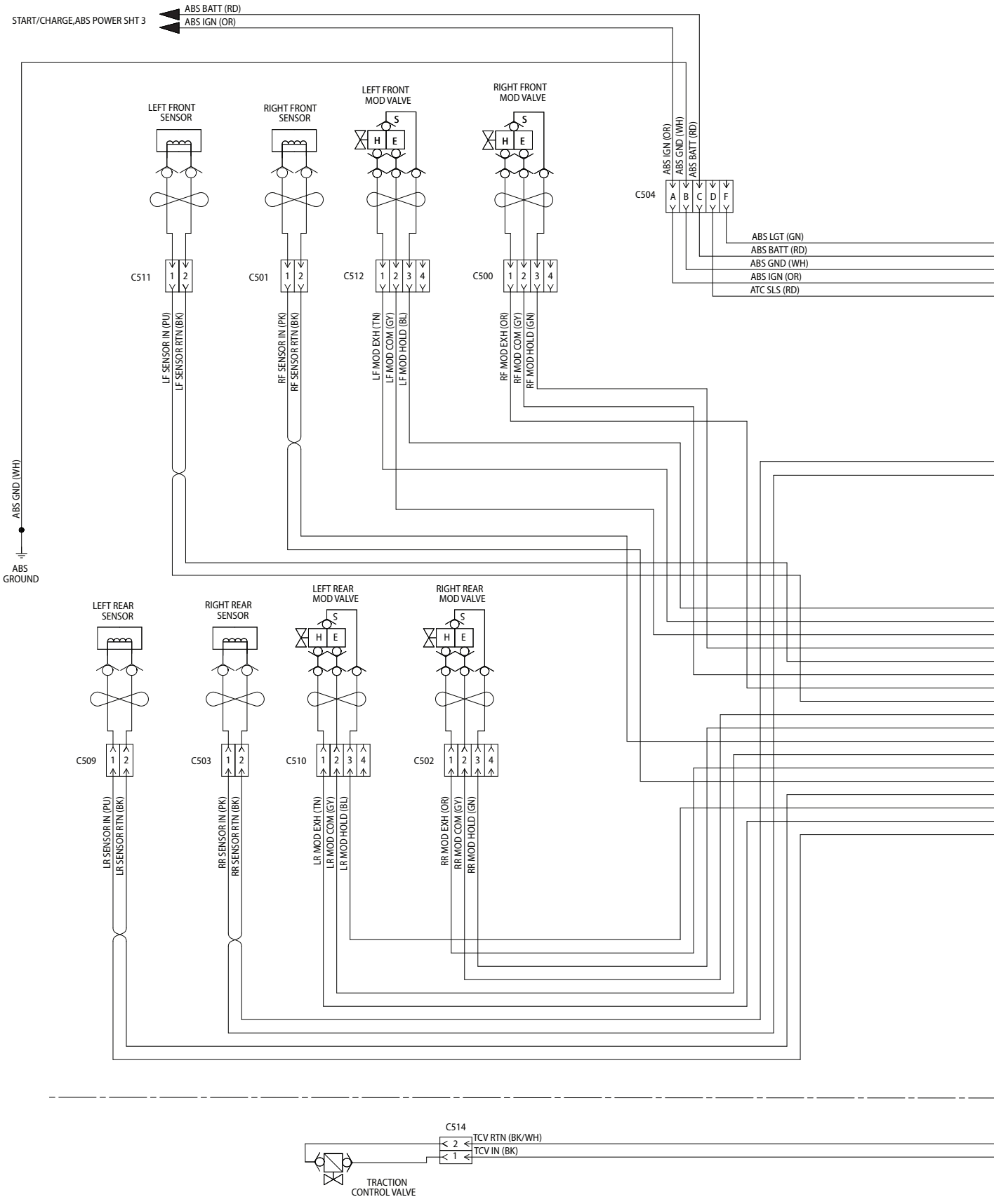
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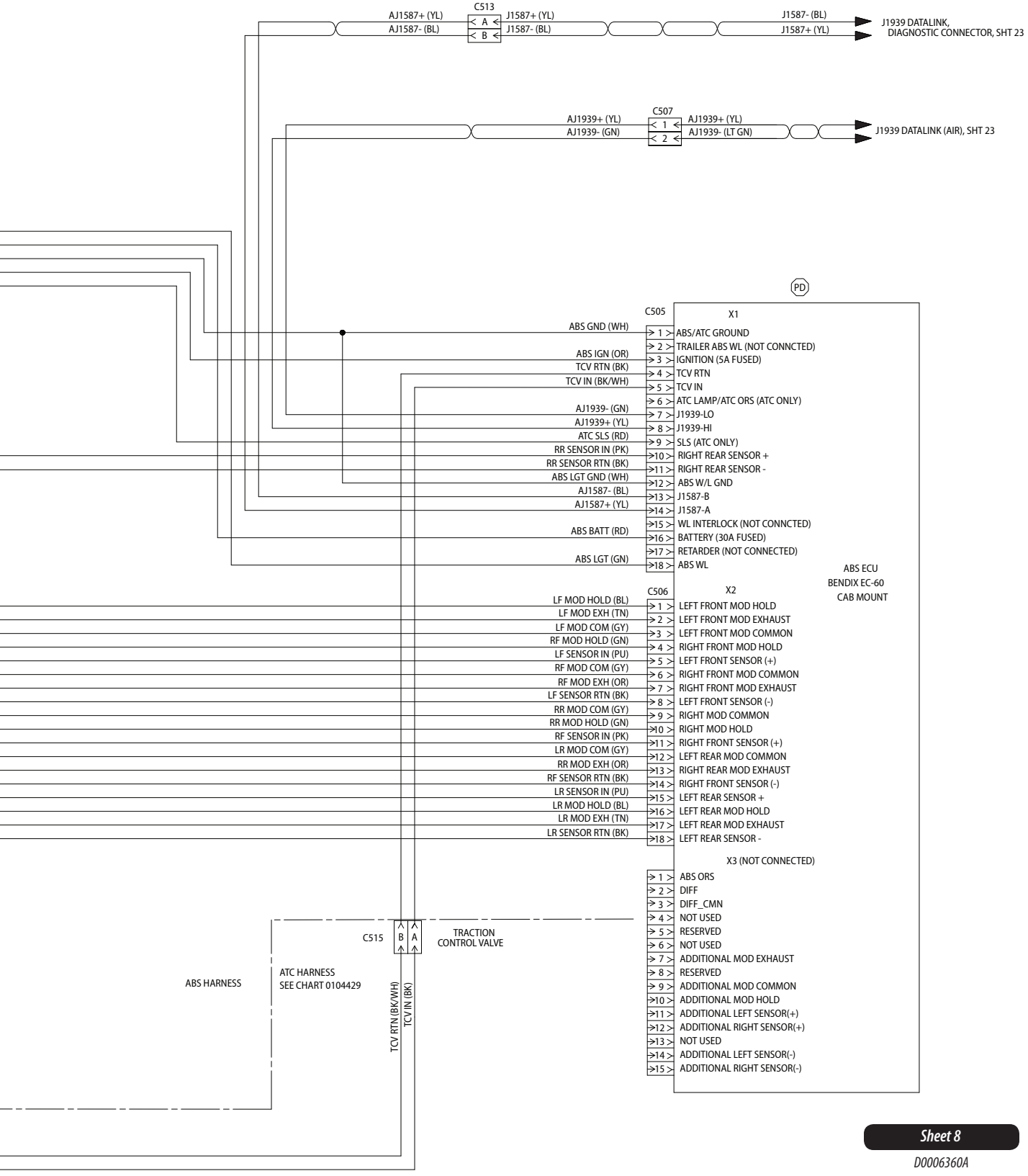
POWERTRAIN SCHEMATIC 2



TYPICAL DASH SWITCH BACKLIGHTING CIRCUITS.
POWER AND GROUNDS CONTINUE TO LOOP FROM SWITCH TO SWITCH.


ILLUM A (LT BL)
DRIVER CONTROL MODULE, SHT 18/19
ILLUM (LT BL)
BODY INTFC, SHT 21
IN ADDITION THIS FEED IS THE GENERAL
BACKLIGHTING/DIMMER FEED TO SWITCHES.
C12
PWM
DIMMER
SWITCH
C
A
D
B
F
DIMMER (LT BL)
PARKLT OUT 9C (BN)
A ZONE PORT 2 CONN A -7, SHT 11
PARKLT OUT 9D (BN)
GND 2C (WH)
GND 2B (WH)

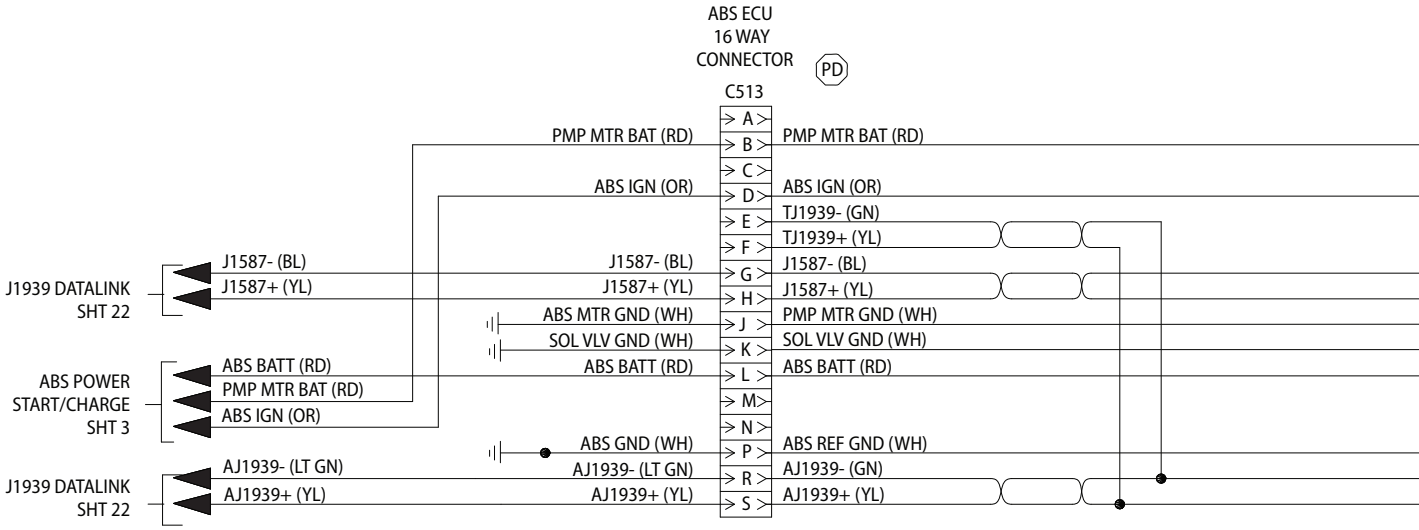

START/CHARGE,ABS POWER SHT 3
ABS BATT (RD)
ABS IGN (OR)
LEFT FRONT SENSOR
RIGHT FRONT SENSOR
LEFT FRONT MOD VALVE
RIGHT FRONT MOD VALVE
C504
ABS IGN (OR)
ABS GND (WH)
ABS BATT (RD)
A B C D F
ABS LGT (GN)
ABS BATT (RD)
ABS GND (WH)
ABS IGN (OR)
ATC SLS (RD)
C511
C501
C512
C500
LF SENSOR IN (PU)
LF SENSOR RTN (BK)
RF SENSOR IN (PK)
RF SENSOR RTN (BK)
LF MOD EXH (TN)
LF MOD COM (GY)
LF MOD HOLD (BL)
RF MOD EXH (OR)
RF MOD COM (GY)
RF MOD HOLD (GN)
ABS GND (WH)
ABS GROUND
LEFT REAR SENSOR
RIGHT REAR SENSOR
LEFT REAR MOD VALVE
RIGHT REAR MOD VALVE
C509
C503
C510
C502
LR SENSOR IN (PU)
LR SENSOR RTN (BK)
RR SENSOR IN (PK)
RR SENSOR RTN (BK)
LR MOD EXH (TN)
LR MOD COM (GY)
LR MOD HOLD (BL)
RR MOD EXH (OR)
RR MOD COM (GY)
RR MOD HOLD (GN)
C514
TCV RTN (BK/WH)
TCV IN (BK)
TRACTION CONTROL VALVE

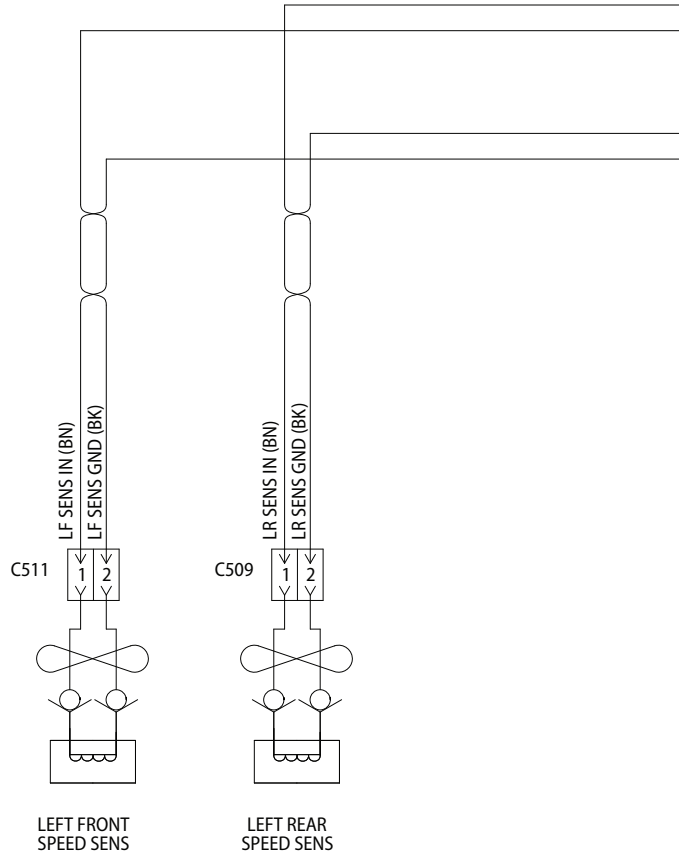


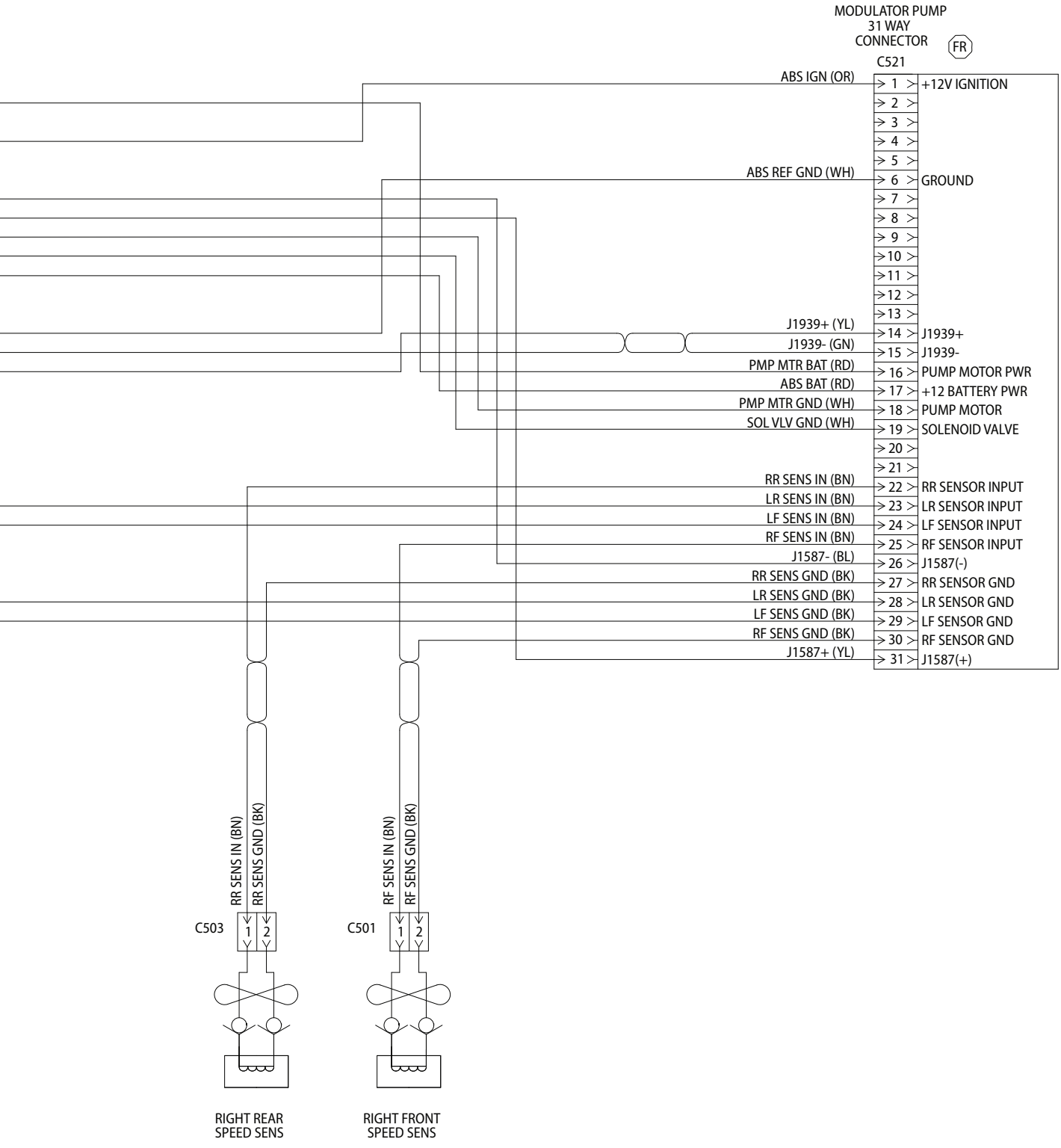
Sheet 8

D0006360A

ABS - BENDIX


ABS ECU
16 WAY
CONNECTOR
PD
C513
A
B
C
D
E
F
G
H
J
K
L
M
N
P
R
S
PMP MTR BAT (RD)
PMP MTR BAT (RD)
ABS IGN (OR)
ABS IGN (OR)
TJ1939- (GN)
TJ1939+ (YL)
J1587- (BL)
J1587+ (YL)
J1587- (BL)
J1587+ (YL)
ABS MTR GND (WH)
PMP MTR GND (WH)
SOL VLV GND (WH)
SOL VLV GND (WH)
ABS BATT (RD)
ABS BATT (RD)
ABS GND (WH)
ABS REF GND (WH)
AJ1939- (LT GN)
AJ1939- (GN)
AJ1939+ (YL)
AJ1939+ (YL)
J1939 DATALINK
SHT 22
J1587- (BL)
J1587+ (YL)
ABS POWER
START/CHARGE
SHT 3
ABS BATT (RD)
PMP MTR BAT (RD)
ABS IGN (OR)
J1939 DATALINK
SHT 22
AJ1939- (LT GN)
AJ1939+ (YL)

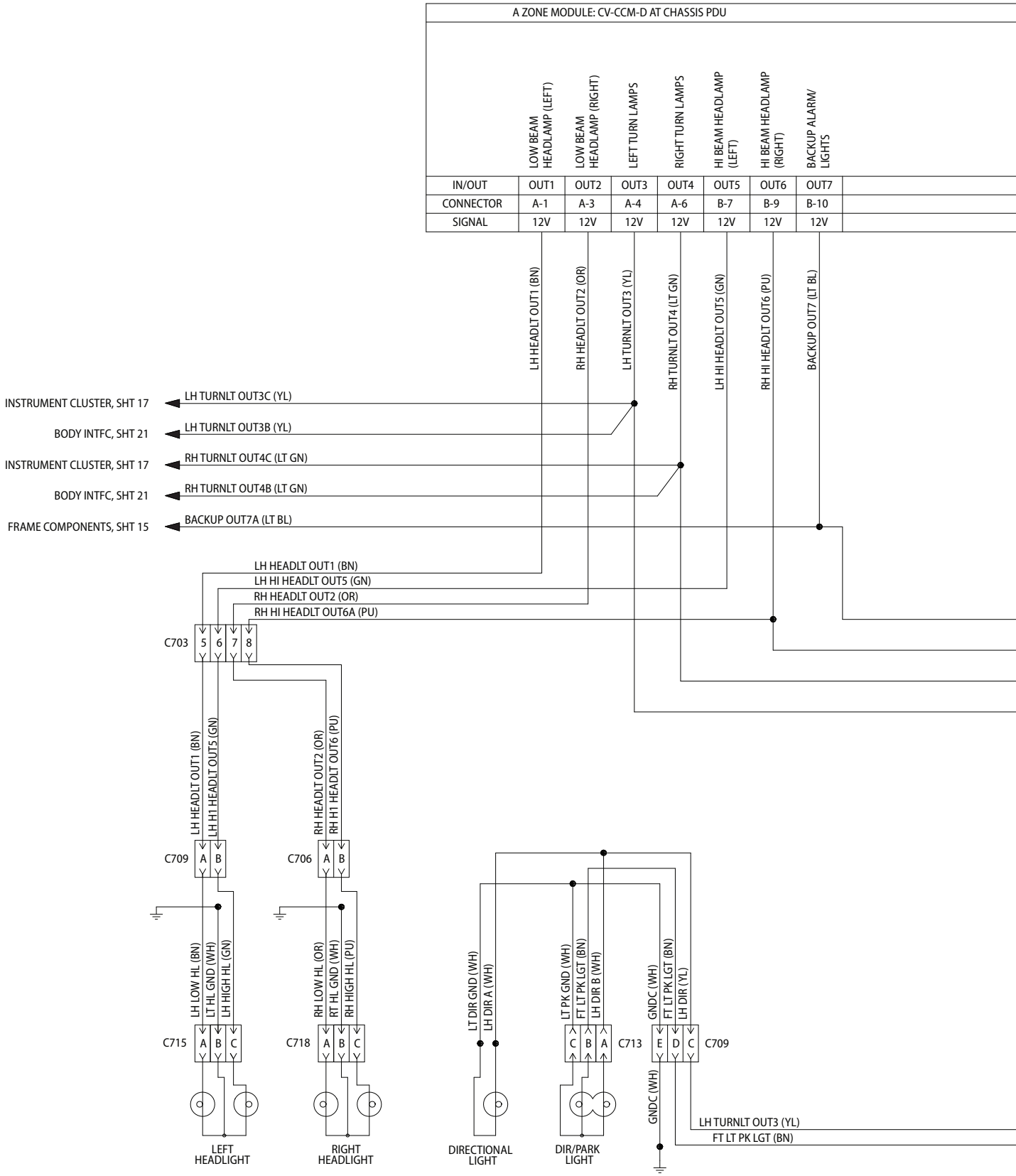

LF SENS IN (BN)
LF SENS GND (BK)
C511
1
2
LR SENS IN (BN)
LR SENS GND (BK)
C509
1
2
LEFT FRONT
SPEED SENS
LEFT REAR
SPEED SENS

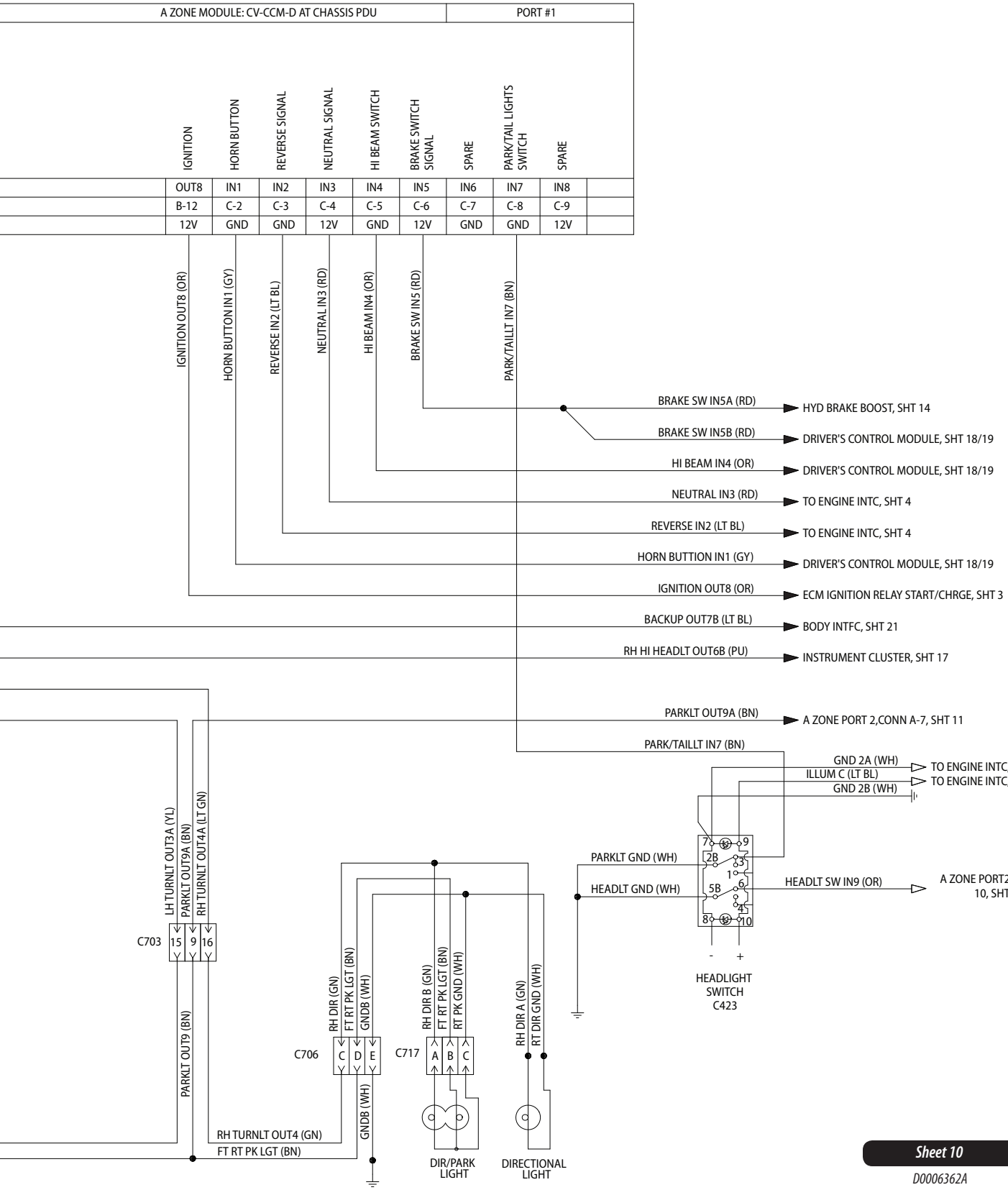


Sheet 9

D0006361A

ABS - HYDRAULIC


A ZONE MODULE: CV-CCM-D AT CHASSIS PDU
LOW BEAM HEADLAMP (LEFT)
LOW BEAM HEADLAMP (RIGHT)
LEFT TURN LAMPS
RIGHT TURN LAMPS
HI BEAM HEADLAMP (LEFT)
HI BEAM HEADLAMP (RIGHT)
BACKUP ALARM/ LIGHTS
IN/OUT OUT1 OUT2 OUT3 OUT4 OUT5 OUT6 OUT7
CONNECTOR A-1 A-3 A-4 A-6 B-7 B-9 B-10
SIGNAL 12V 12V 12V 12V 12V 12V 12V
LH HEADLT OUT1 (BN)
RH HEADLT OUT2 (OR)
LH TURNLT OUT3 (YL)
RH TURNLT OUT4 (LT GN)
LH HI HEADLT OUT5 (GN)
RH HI HEADLT OUT6 (PU)
BACKUP OUT7 (LT BL)
INSTRUMENT CLUSTER, SHT 17
LH TURNLT OUT3C (YL)
BODY INTFC, SHT 21
LH TURNLT OUT3B (YL)
INSTRUMENT CLUSTER, SHT 17
RH TURNLT OUT4C (LT GN)
BODY INTFC, SHT 21
RH TURNLT OUT4B (LT GN)
FRAME COMPONENTS, SHT 15
BACKUP OUT7A (LT BL)
LH HEADLT OUT1 (BN)
LH HI HEADLT OUT5 (GN)
RH HEADLT OUT2 (OR)
RH HI HEADLT OUT6A (PU)
C703 5 6 7 8
LH HEADLT OUT1 (BN)
LH H1 HEADLT OUT5 (GN)
RH HEADLT OUT2 (OR)
RH H1 HEADLT OUT6 (PU)
C709 A B
C706 A B
LH LOW HL (BN)
LT HL GND (WH)
LH HIGH HL (GN)
RH LOW HL (OR)
RT HL GND (WH)
RH HIGH HL (PU)
C715 A B C
C718 A B C
LEFT HEADLIGHT
RIGHT HEADLIGHT
LT DIR GND (WH)
LH DIR A (WH)
LT PK GND (WH)
FT LT PK LGT (BN)
LH DIR B (WH)
C713 C B A
DIRECTIONAL LIGHT
DIR/PARK LIGHT
GNDC (WH)
FT LT PK LGT (BN)
LH DIR (YL)
C709 E D C
GNDC (WH)
LH TURNLT OUT3 (YL)
FT LT PK LGT (BN)

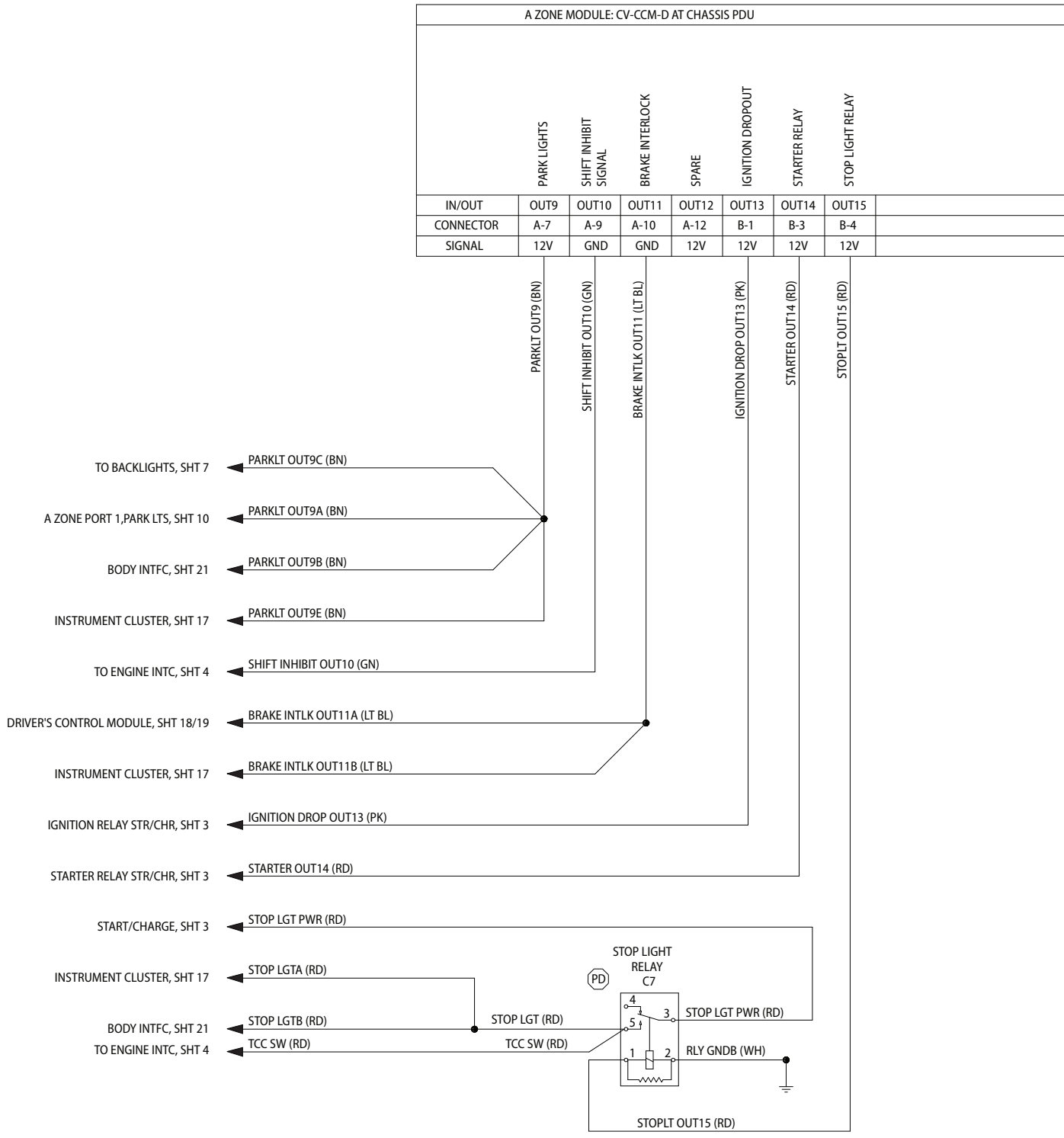


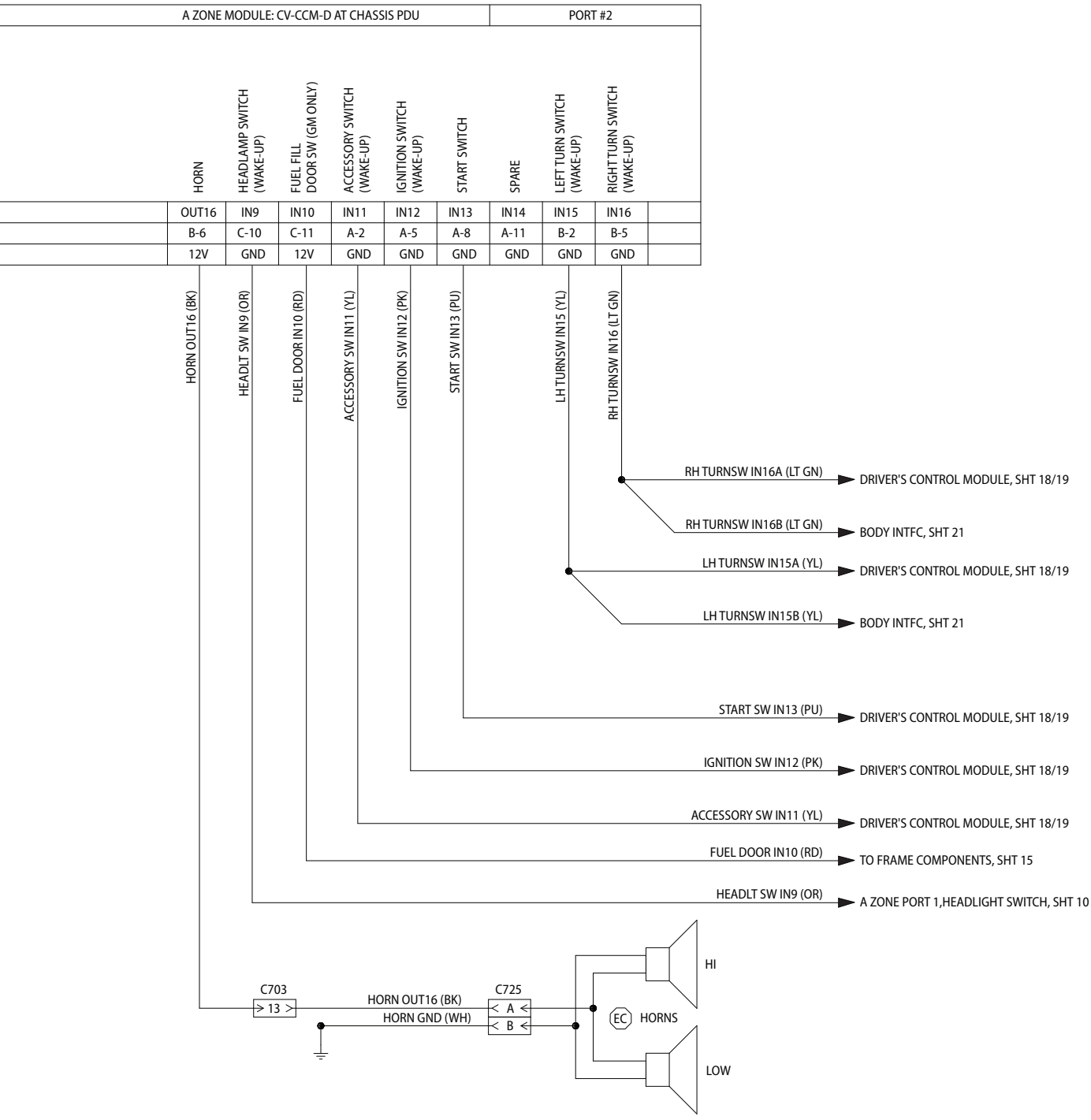
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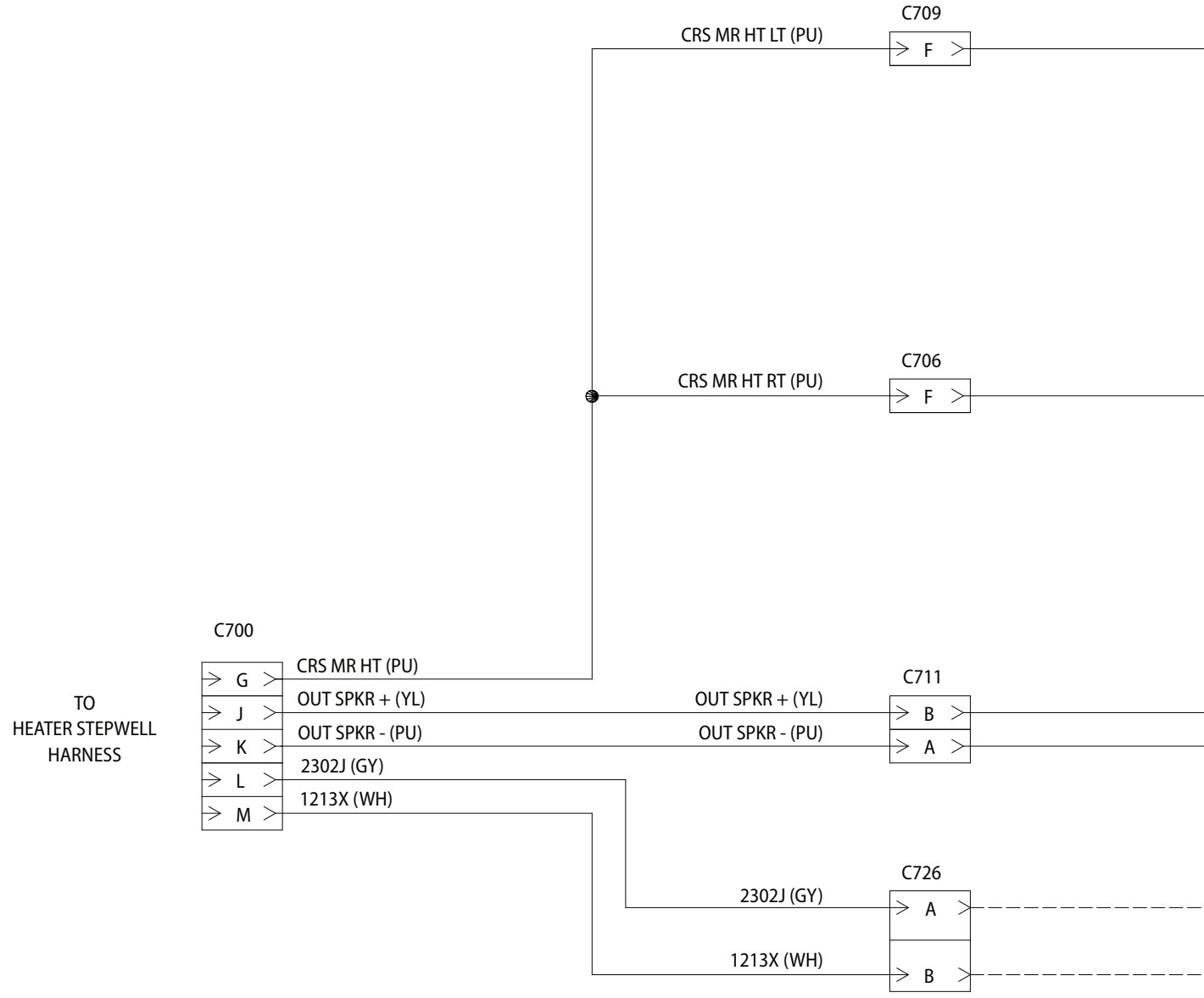
Sheet 10

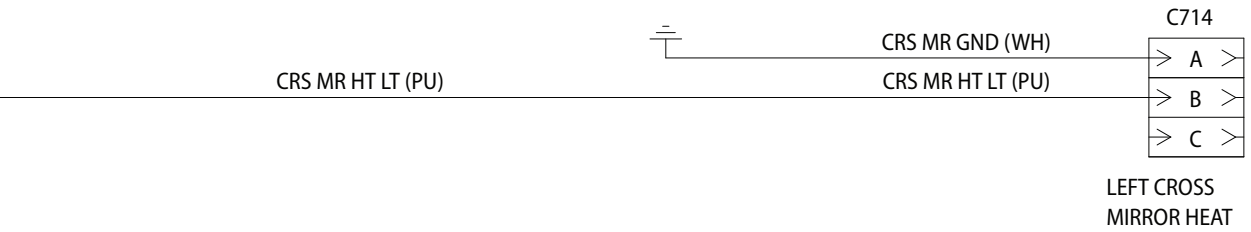
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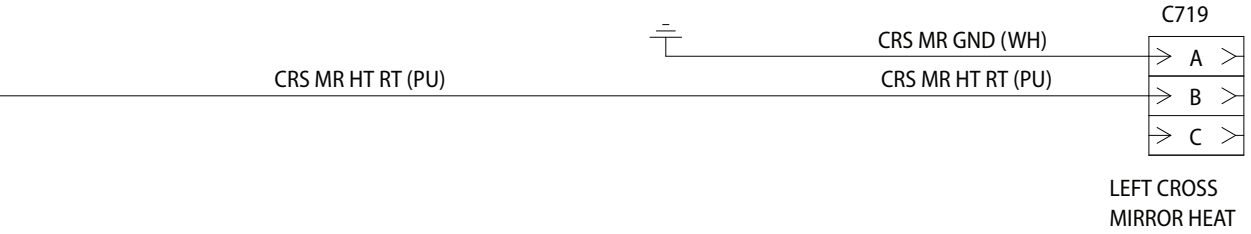
MULTIPLEX,A ZONE PORT 1

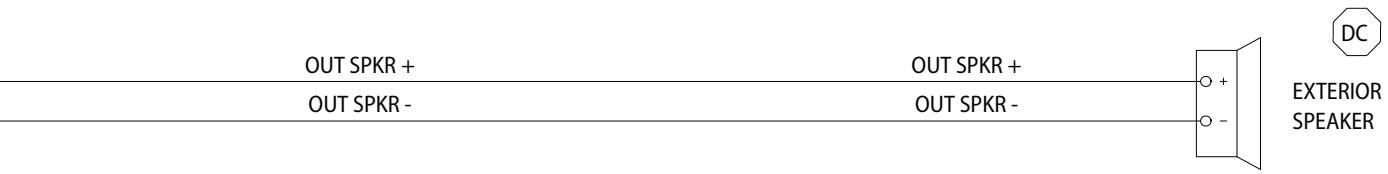

A ZONE MODULE: CV-CCM-D AT CHASSIS PDU
PARK LIGHTS
SHIFT INHIBIT SIGNAL
BRAKE INTERLOCK
SPARE
IGNITION DROPOUT
STARTER RELAY
STOP LIGHT RELAY
IN/OUT OUT9 OUT10 OUT11 OUT12 OUT13 OUT14 OUT15
CONNECTOR A-7 A-9 A-10 A-12 B-1 B-3 B-4
SIGNAL 12V GND GND 12V 12V 12V 12V
PARKLT OUT9 (BN)
SHIFT INHIBIT OUT10 (GN)
BRAKE INTLK OUT11 (LT BL)
IGNITION DROP OUT13 (PK)
STARTER OUT14 (RD)
STOPLT OUT15 (RD)
TO BACKLIGHTS, SHT 7
PARKLT OUT9C (BN)
A ZONE PORT 1,PARK LTS, SHT 10
PARKLT OUT9A (BN)
BODY INTFC, SHT 21
PARKLT OUT9B (BN)
INSTRUMENT CLUSTER, SHT 17
PARKLT OUT9E (BN)
TO ENGINE INTC, SHT 4
SHIFT INHIBIT OUT10 (GN)
DRIVER'S CONTROL MODULE, SHT 18/19
BRAKE INTLK OUT11A (LT BL)
INSTRUMENT CLUSTER, SHT 17
BRAKE INTLK OUT11B (LT BL)
IGNITION RELAY STR/CHR, SHT 3
STARTER RELAY STR/CHR, SHT 3
START/CHARGE, SHT 3
STOP LGT PWR (RD)
STOP LIGHT RELAY C7
PD
INSTRUMENT CLUSTER, SHT 17
STOP LGTA (RD)
BODY INTFC, SHT 21
STOP LGTB (RD)
TO ENGINE INTC, SHT 4
TCC SW (RD)
STOP LGT (RD)
TCC SW (RD)
4
1
3
5
1
2
STOP LGT PWR (RD)
RLY GNDB (WH)
STOPLT OUT15 (RD)

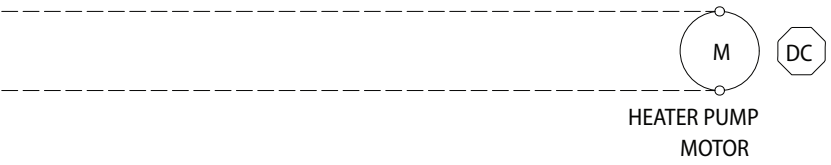

A ZONE MODULE: CV-CCM-D AT CHASSIS PDU
PORT #2
HORN
HEADLAMP SWITCH (WAKE-UP)
FUEL FILL DOOR SW (GM ONLY)
ACCESSORY SWITCH (WAKE-UP)
IGNITION SWITCH (WAKE-UP)
START SWITCH
SPARE
LEFT TURN SWITCH (WAKE-UP)
RIGHT TURN SWITCH (WAKE-UP)
OUT16 IN9 IN10 IN11 IN12 IN13 IN14 IN15 IN16
B-6 C-10 C-11 A-2 A-5 A-8 A-11 B-2 B-5
12V GND 12V GND GND GND GND GND GND
HORN OUT16 (BK)
HEADLT SW IN9 (OR)
FUEL DOOR IN10 (RD)
ACCESSORY SW IN11 (YL)
IGNITION SW IN12 (PK)
START SW IN13 (PU)
LH TURNSW IN15 (YL)
RH TURNSW IN16 (LT GN)
RH TURNSW IN16A (LT GN)
DRIVER'S CONTROL MODULE, SHT 18/19
RH TURNSW IN16B (LT GN)
BODY INTFC, SHT 21
LH TURNSW IN15A (YL)
DRIVER'S CONTROL MODULE, SHT 18/19
LH TURNSW IN15B (YL)
BODY INTFC, SHT 21
START SW IN13 (PU)
DRIVER'S CONTROL MODULE, SHT 18/19
IGNITION SW IN12 (PK)
DRIVER'S CONTROL MODULE, SHT 18/19
ACCESSORY SW IN11 (YL)
DRIVER'S CONTROL MODULE, SHT 18/19
FUEL DOOR IN10 (RD)
TO FRAME COMPONENTS, SHT 15
HEADLT SW IN9 (OR)
A ZONE PORT 1,HEADLIGHT SWITCH, SHT 10
C703
13
HORN OUT16 (BK)
HORN GND (WH)
C725
A
B
EC
HORNS
HI
LOW

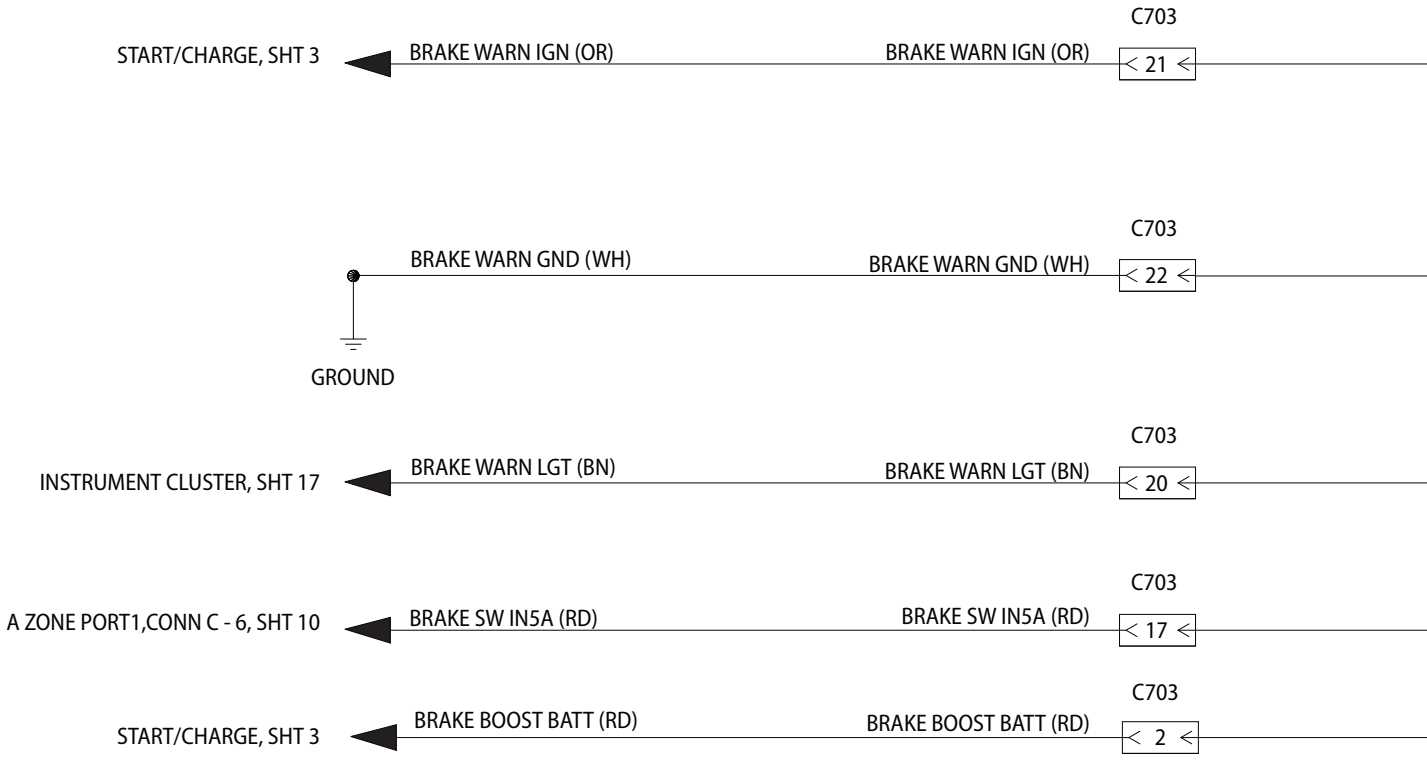

C709
CRS MR HT LT (PU)
F
C706
CRS MR HT RT (PU)
F
C700
G
J
K
L
M
CRS MR HT (PU)
OUT SPKR + (YL)
OUT SPKR - (PU)
2302J (GY)
1213X (WH)
C711
OUT SPKR + (YL)
OUT SPKR - (PU)
B
A
C726
2302J (GY)
1213X (WH)
A
B
TO
HEATER STEPWELL
HARNESS

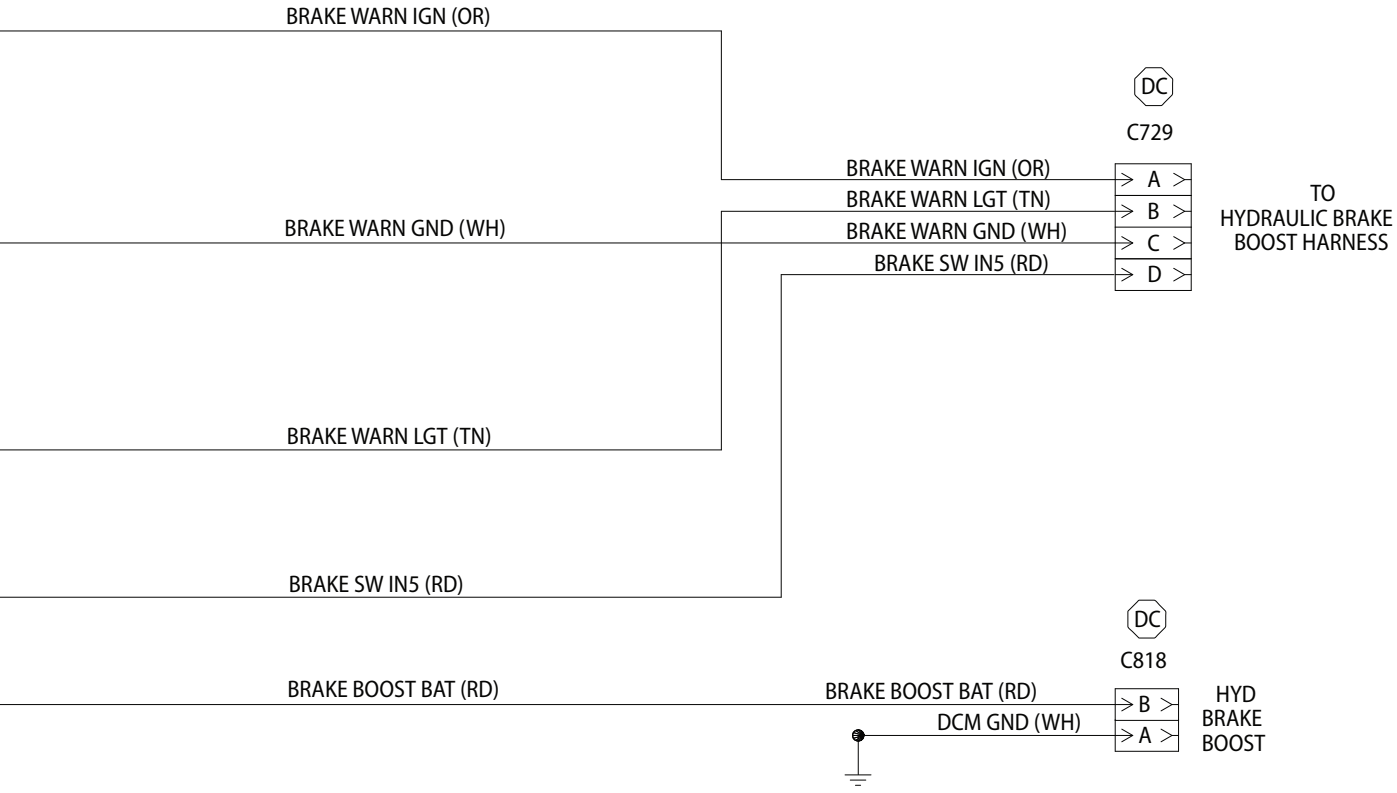

C714
CRS MR GND (WH)
CRS MR HT LT (PU)
CRS MR HT LT (PU)
A
B
C
LEFT CROSS
MIRROR HEAT


C719
CRS MR GND (WH)
CRS MR HT RT (PU)
CRS MR HT RT (PU)
A
B
C
LEFT CROSS
MIRROR HEAT


DC
OUT SPKR +
OUT SPKR -
OUT SPKR +
OUT SPKR -
+
–
EXTERIOR
SPEAKER


M
DC
HEATER PUMP
MOTOR


START/CHARGE, SHT 3
BRAKE WARN IGN (OR)
BRAKE WARN IGN (OR)
C703
21
BRAKE WARN GND (WH)
BRAKE WARN GND (WH)
C703
22
GROUND
INSTRUMENT CLUSTER, SHT 17
BRAKE WARN LGT (BN)
BRAKE WARN LGT (BN)
C703
20
A ZONE PORT1,CONN C - 6, SHT 10
BRAKE SW IN5A (RD)
BRAKE SW IN5A (RD)
C703
17
START/CHARGE, SHT 3
BRAKE BOOST BATT (RD)
BRAKE BOOST BATT (RD)
C703
2



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HYDRAULIC BRAKE BOOST

START/CHARGE,AMMETER IGNITION, SHT 3 ◄ SEN IGN (RD)

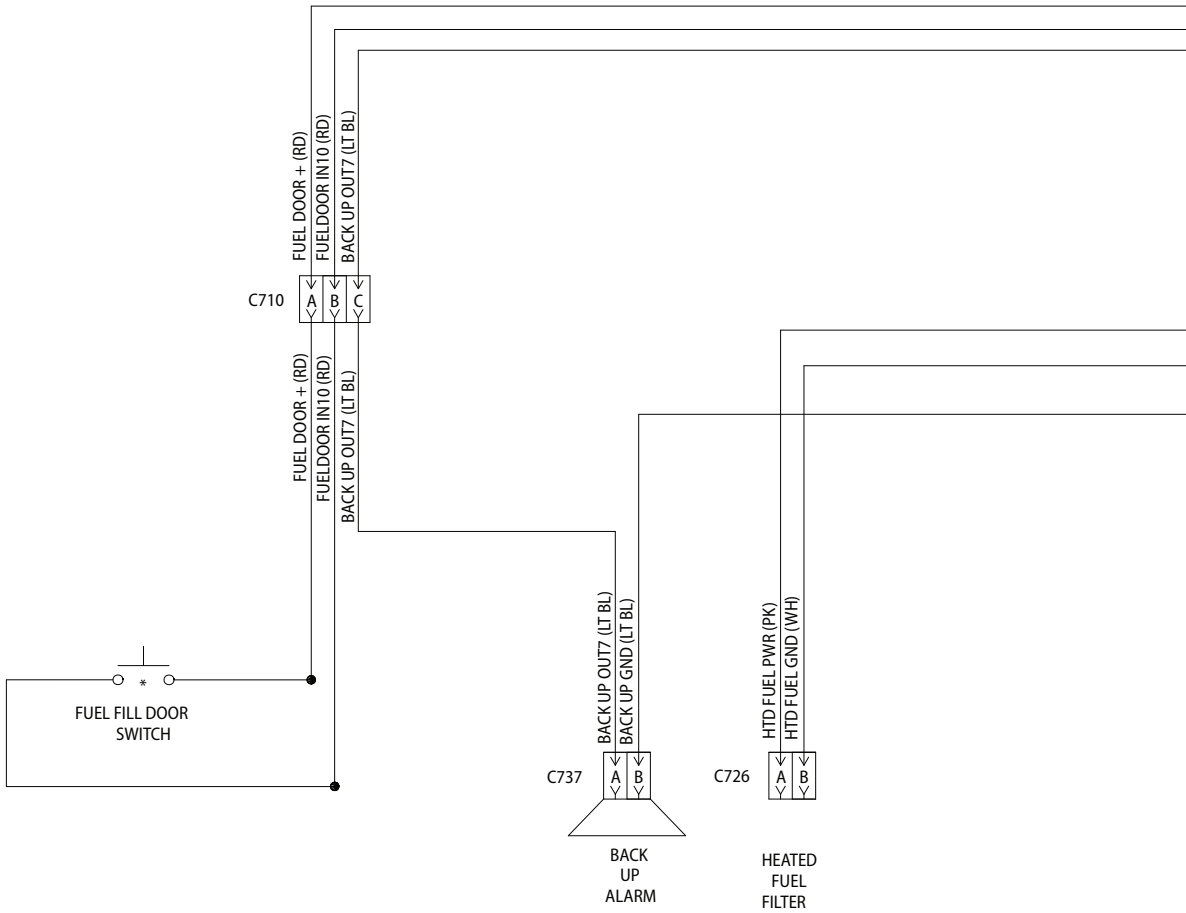
START/CHARGE,AIR DRYER POWER, SHT 3 ◄ AIR DRYER PWR (BL)

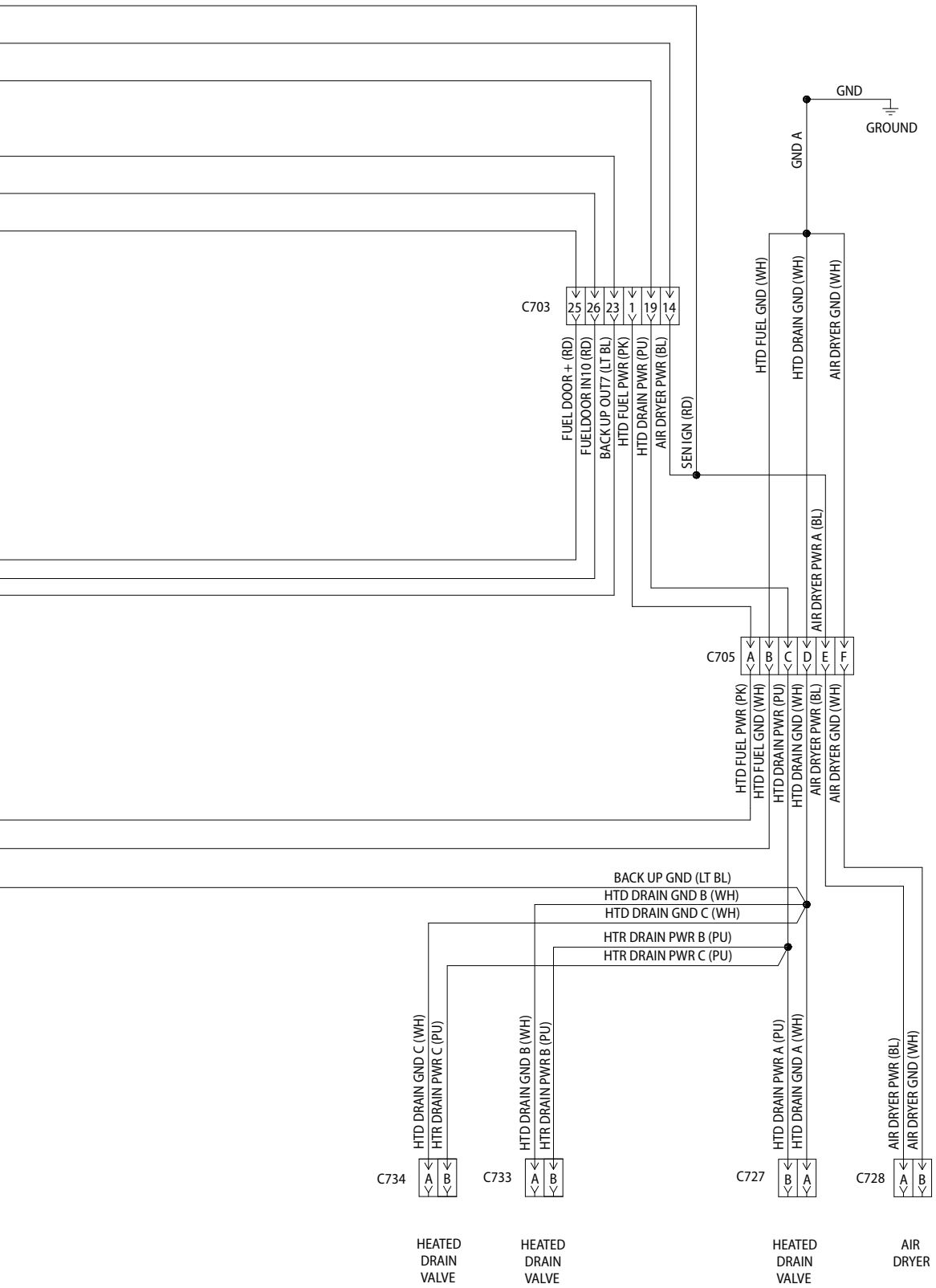
START/CHARGE,HEATED DRAIN POWER, SHT 3 ◄ HTD DRAIN PWR (BN)

A ZONE PORT 1,SHT 10 ◄ BACK UP OUT7A (LT BL)

A ZONE PORT 2,SHT 11 ◄ FUELDOOR IN10 (RD)

START/CHARGE,FUSE BOX, SHT 3 ◄ FUEL DOOR+ (RD)

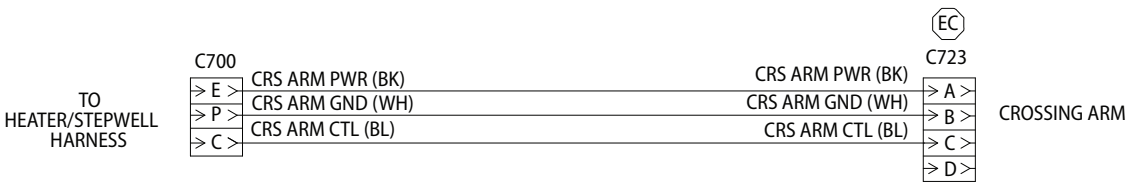




Sheet 15

D0006367A

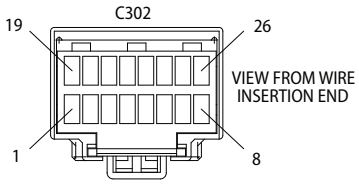
FRAME COMPONENTS



Sheet 16

D0006368A

CROSSING ARM



INSTRUMENT CLUSTER — C302

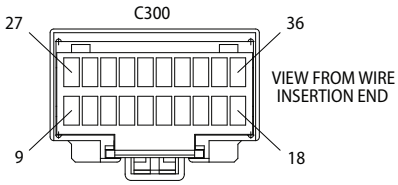
BATTERY +12V	> 1 >	DPWR (BK)
GROUND	> 2 >	DCHASS GND (WH)
SAE J1939+	> 3 >	J1939+ (YL)
SAE J1939-	> 4 >	J1939- (LT GN)
HEADLAMP REMINDER	> 19 >	PARKLT OUT9E (BN)
HI BEAM INDICATOR	> 20 >	RH HI HEADLT OUT6B (PU)
LEFT TURN INDICATOR	> 21 >	LH TURNLT OUT3C (YL)
PARK BRAKE	> 22 >	PBRAKE SW2 (GY)
RIGHT TURN INDICATOR	> 23 >	RH TURNLT OUT4C (LT GN)
BRAKE SIGNAL IN	> 24 >	STOP LGTA (RD)
BRAKE INTERLOCK REQUEST	> 26 >	BRAKE INTLK OUT11B (LT BL)

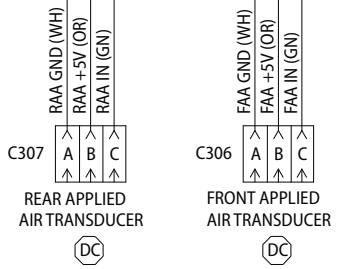
C300

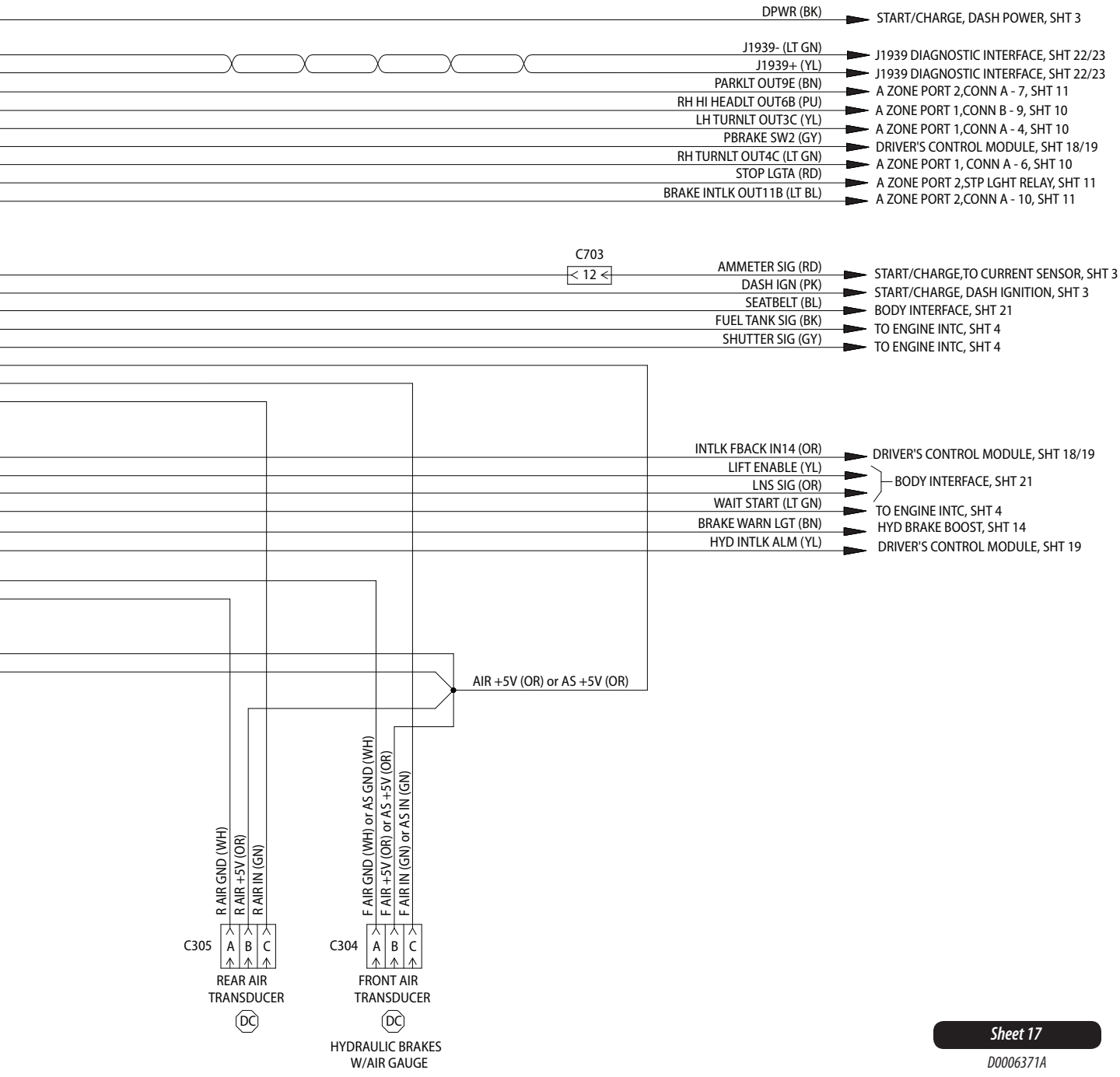
AMMETER IN	> 15 >	AMMETER SIG (RD)
IGNITION +12V	> 18 >	DASH IGN (PK)
SEAT BELT	> 32 >	SEATBELT (BL)
FUEL LEVEL SENDER	> 34 >	FUEL TANK SIG (BK)
SHUTTER SOLENOID	> 30 >	SHUTTER SIG (GY)
+5 VDC SENSOR POWER	> 9 >	AIR +5V (OR) or AS +5V (OR-HYD ONLY)
FRONT AIR PSI SENDER	> 11 >	F AIR IN (GN) or AS IN (GN-HYD ONLY)
REAR AIR PSI SENDER	> 12 >	R AIR IN (GN)
APPLILED FRONT AIR PSI SENSOR	> 13 >	FAA IN (GN)
APPLIED REAR AIR PSI SENSOR	> 14 >	RAA IN (GN)
INTERLOCK SET	> 35 >	INTLK FBACK IN14 (OR)
LIFT ENABLE OUT	> 29 >	LIFT ENABLE (YL)
LIFT NOT STOWED	> 33 >	LNS SIG (OR)
WAIT TO START LAMP SIGNAL	> 36 >	WAIT START (LT GN)
BRAKE WARN LGT	> 17 >	BRAKE WARN LGT (BN-HYD ONLY)
HYDRAULIC INTERLOCK ALARM	> 27 >	HYD INTLK ALM (YL-HYD ONLY)

THE INSTRUMENT CLUSTER TRANSMITS PARK BRAKE
AND SERVICE BRAKE (FOOT BRAKE) STATUS OVER THE SAE J1939 DATALINK
REFER TO CLUSTER SPECIFICATIONS FOR FULL DETAILS

GND 1G (WH)



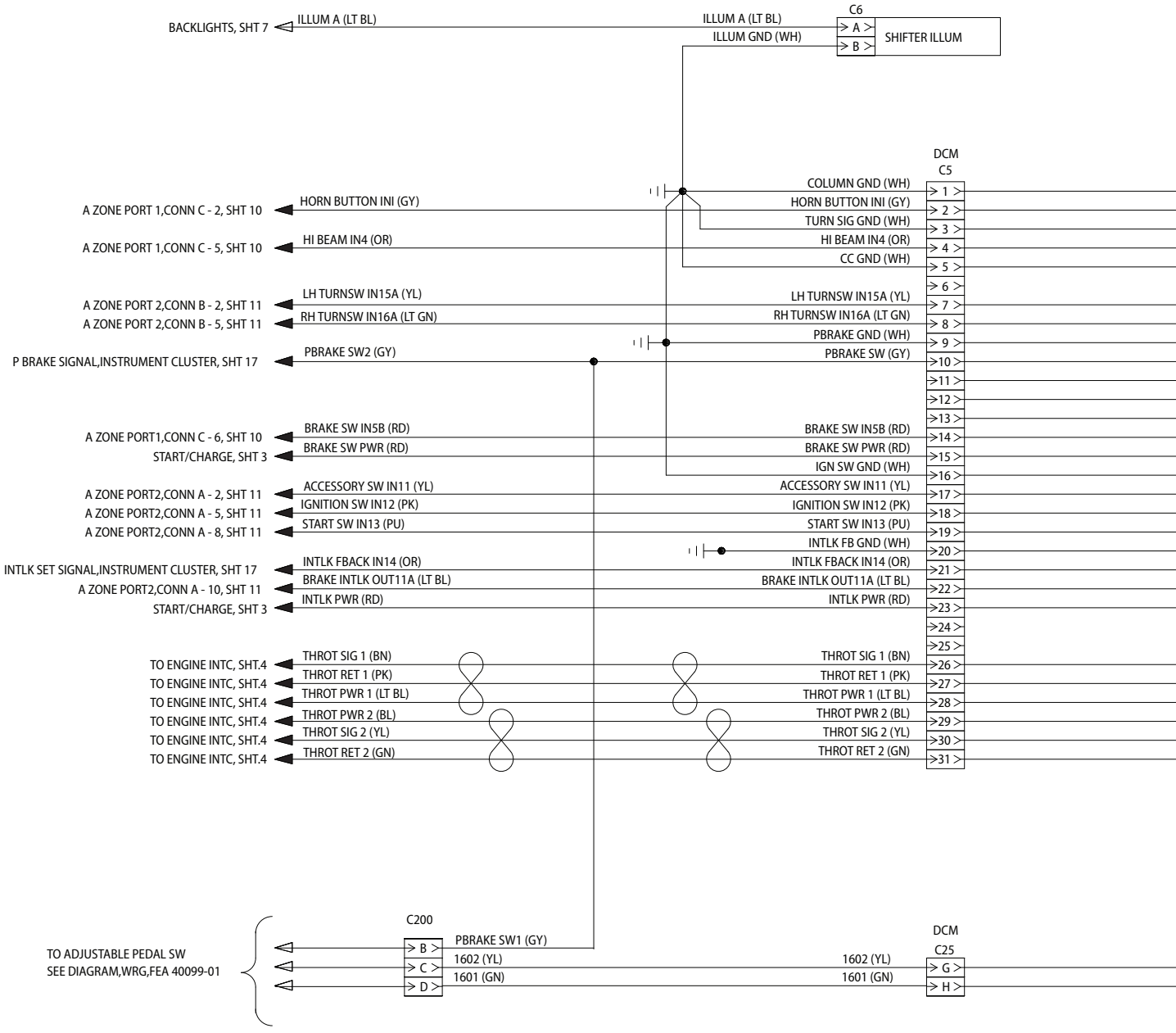


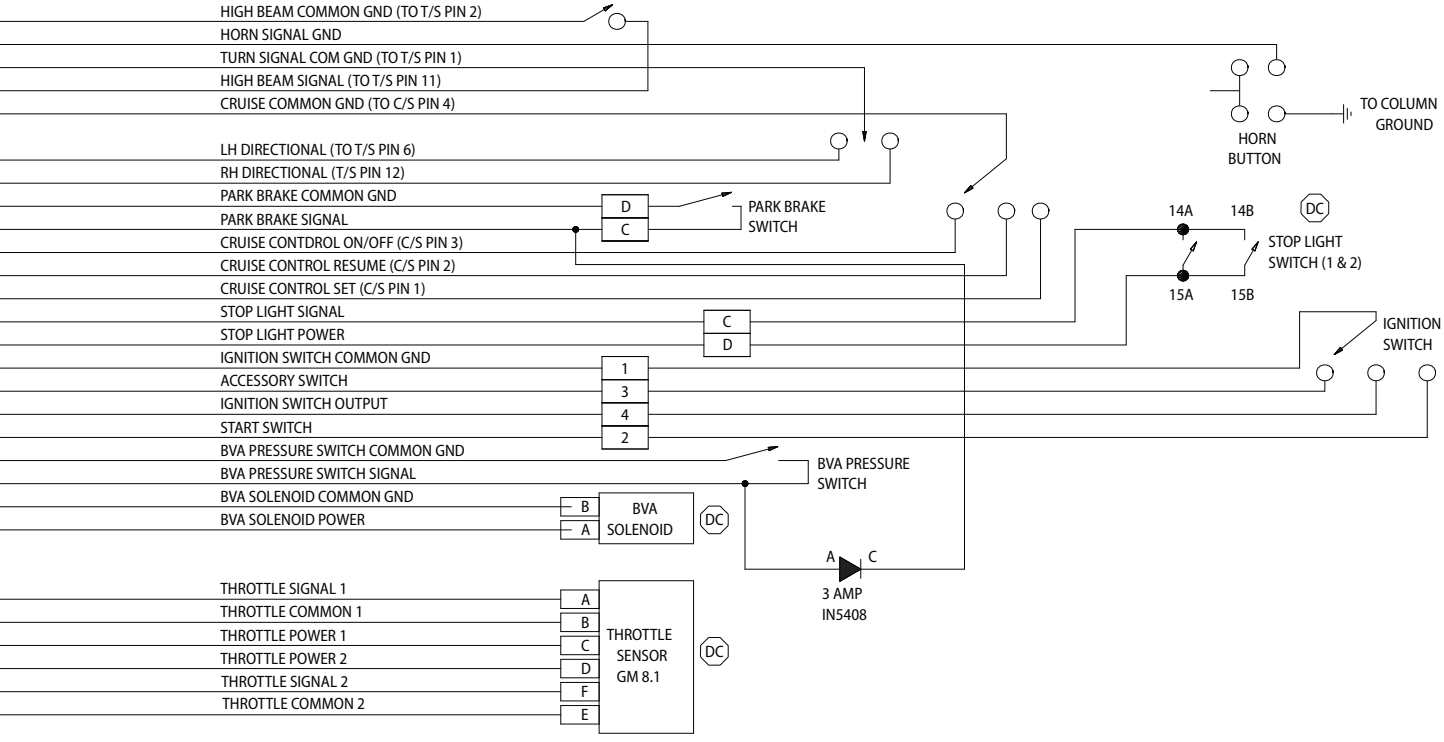


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INSTRUMENT CLUSTER

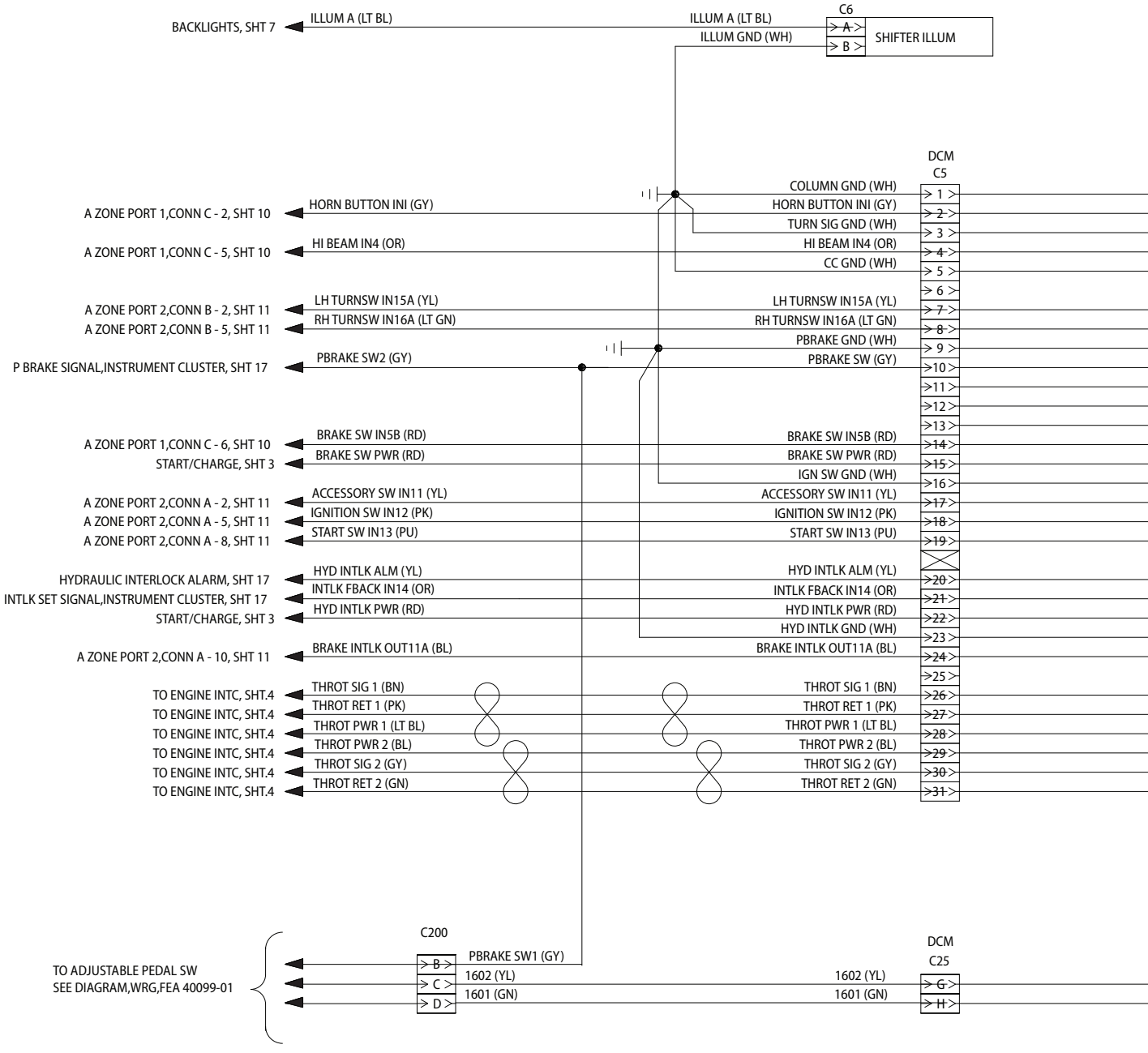

BACKLIGHTS, SHT 7
ILLUM A (LT BL)
ILLUM A (LT BL)
ILLUM GND (WH)
C6
A
B
SHIFTER ILLUM
DCM
C5
COLUMN GND (WH)
HORN BUTTON INI (GY)
TURN SIG GND (WH)
HI BEAM IN4 (OR)
CC GND (WH)
LH TURNSW IN15A (YL)
RH TURNSW IN16A (LT GN)
PBRAKE GND (WH)
PBRAKE SW (GY)
BRAKE SW IN5B (RD)
BRAKE SW PWR (RD)
IGN SW GND (WH)
ACCESSORY SW IN11 (YL)
IGNITION SW IN12 (PK)
START SW IN13 (PU)
INTLK FB GND (WH)
INTLK FBACK IN14 (OR)
BRAKE INTLK OUT11A (LT BL)
INTLK PWR (RD)
THROT SIG 1 (BN)
THROT RET 1 (PK)
THROT PWR 1 (LT BL)
THROT PWR 2 (BL)
THROT SIG 2 (YL)
THROT RET 2 (GN)
A ZONE PORT 1,CONN C - 2, SHT 10
A ZONE PORT 1,CONN C - 5, SHT 10
A ZONE PORT 2,CONN B - 2, SHT 11
A ZONE PORT 2,CONN B - 5, SHT 11
P BRAKE SIGNAL,INSTRUMENT CLUSTER, SHT 17
A ZONE PORT1,CONN C - 6, SHT 10
START/CHARGE, SHT 3
A ZONE PORT2,CONN A - 2, SHT 11
A ZONE PORT2,CONN A - 5, SHT 11
A ZONE PORT2,CONN A - 8, SHT 11
INTLK SET SIGNAL,INSTRUMENT CLUSTER, SHT 17
A ZONE PORT2,CONN A - 10, SHT 11
START/CHARGE, SHT 3
TO ENGINE INTC, SHT.4
TO ENGINE INTC, SHT.4
TO ENGINE INTC, SHT.4
TO ENGINE INTC, SHT.4
TO ENGINE INTC, SHT.4
TO ENGINE INTC, SHT.4
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
C200
B
C
D
PBRAKE SW1 (GY)
1602 (YL)
1601 (GN)
DCM
C25
G
H
1602 (YL)
1601 (GN)
TO ADJUSTABLE PEDAL SW
SEE DIAGRAM,WRG,FEA 40099-01

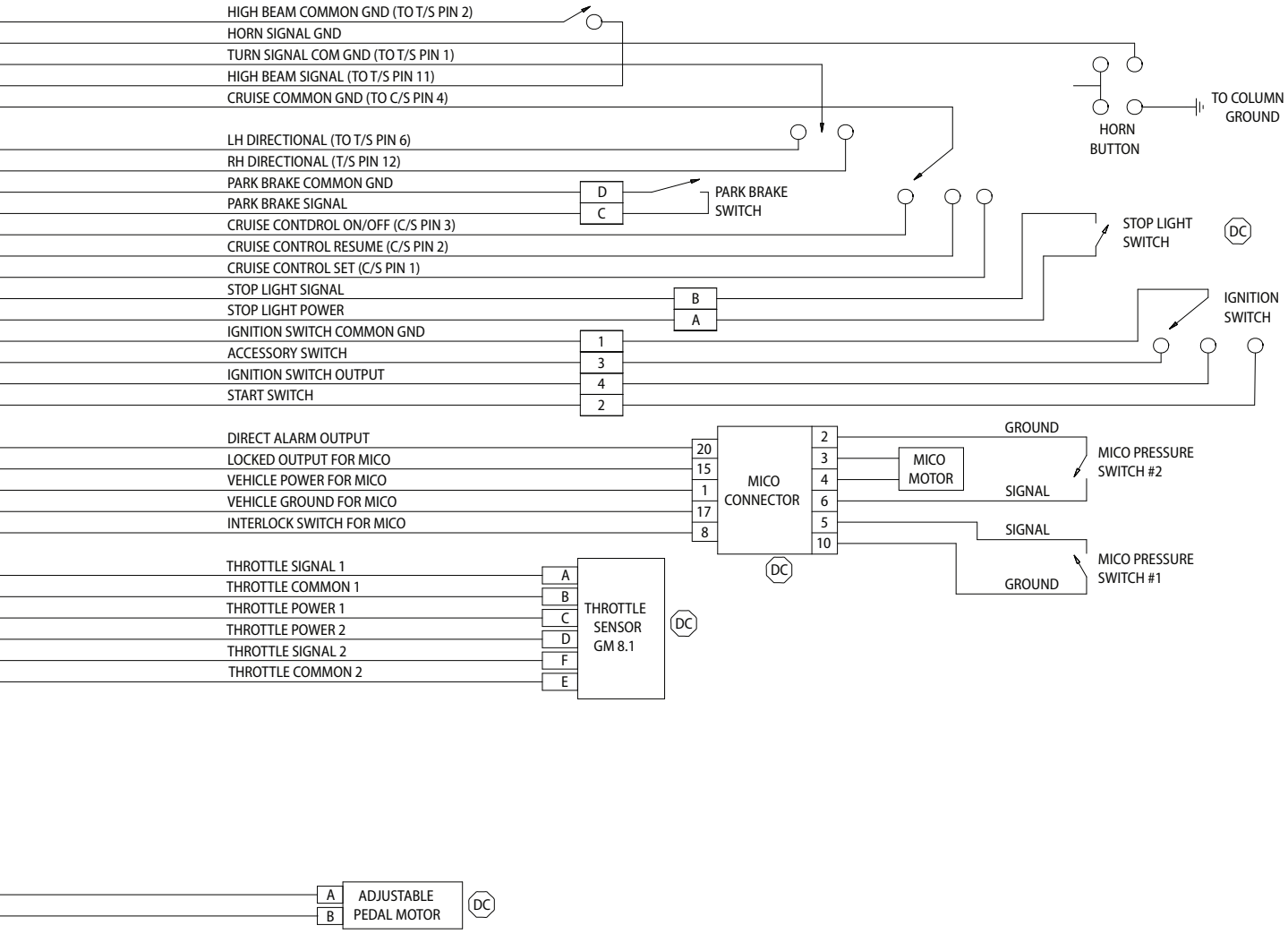


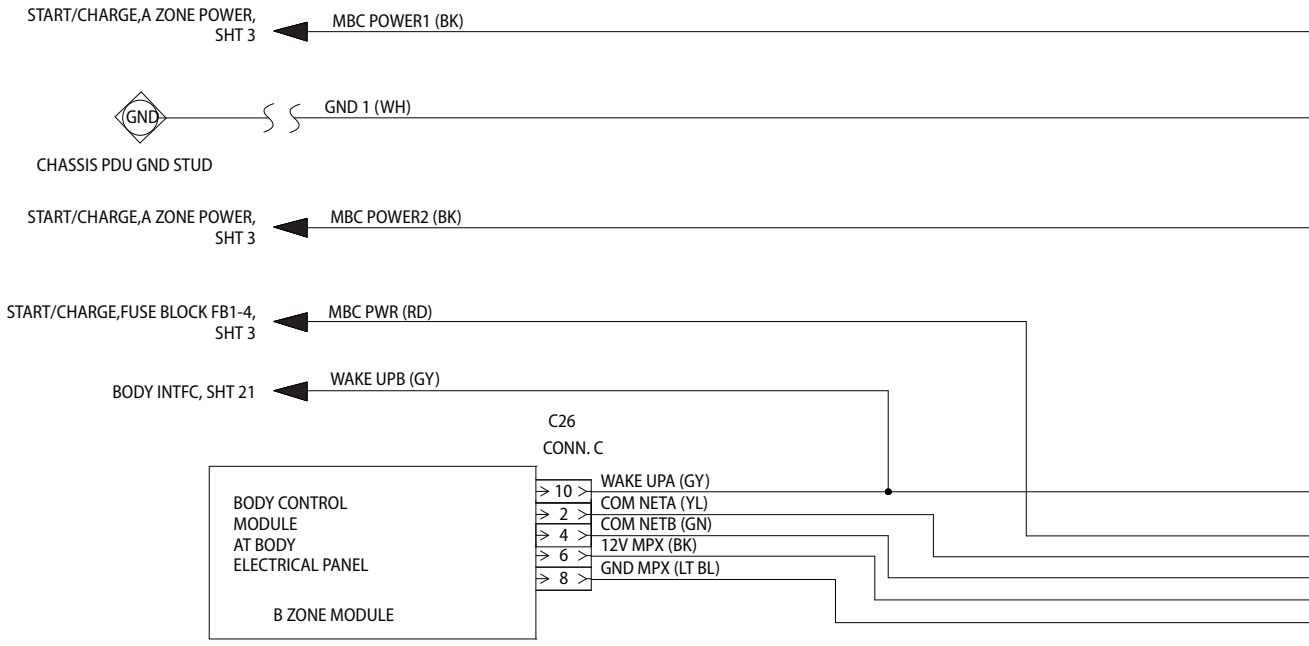
Sheet 18

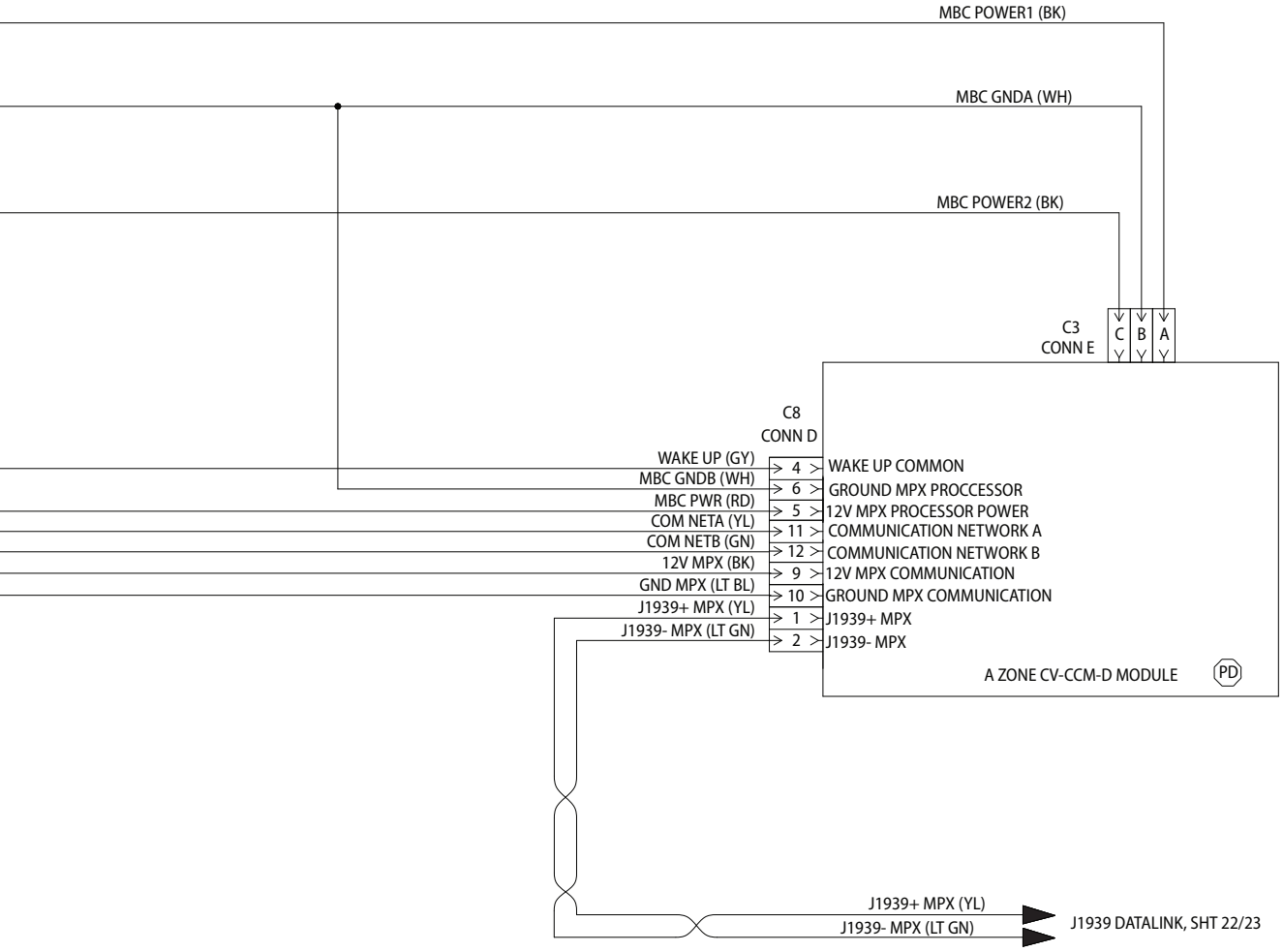
D0006372A

DRIVER'S CONTROL MODULE, AIR


BACKLIGHTS, SHT 7
ILLUM A (LT BL)
ILLUM A (LT BL)
ILLUM GND (WH)
C6
A
B
SHIFTER ILLUM
DCM
C5
A ZONE PORT 1,CONN C - 2, SHT 10
HORN BUTTON INI (GY)
COLUMN GND (WH)
HORN BUTTON INI (GY)
TURN SIG GND (WH)
A ZONE PORT 1,CONN C - 5, SHT 10
HI BEAM IN4 (OR)
HI BEAM IN4 (OR)
CC GND (WH)
A ZONE PORT 2,CONN B - 2, SHT 11
LH TURNSW IN15A (YL)
LH TURNSW IN15A (YL)
A ZONE PORT 2,CONN B - 5, SHT 11
RH TURNSW IN16A (LT GN)
RH TURNSW IN16A (LT GN)
PBRAKE GND (WH)
P BRAKE SIGNAL,INSTRUMENT CLUSTER, SHT 17
PBRAKE SW2 (GY)
PBRAKE SW (GY)
A ZONE PORT 1,CONN C - 6, SHT 10
BRAKE SW IN5B (RD)
BRAKE SW IN5B (RD)
START/CHARGE, SHT 3
BRAKE SW PWR (RD)
BRAKE SW PWR (RD)
IGN SW GND (WH)
A ZONE PORT 2,CONN A - 2, SHT 11
ACCESSORY SW IN11 (YL)
ACCESSORY SW IN11 (YL)
A ZONE PORT 2,CONN A - 5, SHT 11
IGNITION SW IN12 (PK)
IGNITION SW IN12 (PK)
A ZONE PORT 2,CONN A - 8, SHT 11
START SW IN13 (PU)
START SW IN13 (PU)
HYDRAULIC INTERLOCK ALARM, SHT 17
HYD INTLK ALM (YL)
HYD INTLK ALM (YL)
INTLK SET SIGNAL,INSTRUMENT CLUSTER, SHT 17
INTLK FBACK IN14 (OR)
INTLK FBACK IN14 (OR)
START/CHARGE, SHT 3
HYD INTLK PWR (RD)
HYD INTLK PWR (RD)
HYD INTLK GND (WH)
A ZONE PORT 2,CONN A - 10, SHT 11
BRAKE INTLK OUT11A (BL)
BRAKE INTLK OUT11A (BL)
TO ENGINE INTC, SHT.4
THROT SIG 1 (BN)
THROT SIG 1 (BN)
TO ENGINE INTC, SHT.4
THROT RET 1 (PK)
THROT RET 1 (PK)
TO ENGINE INTC, SHT.4
THROT PWR 1 (LT BL)
THROT PWR 1 (LT BL)
TO ENGINE INTC, SHT.4
THROT PWR 2 (BL)
THROT PWR 2 (BL)
TO ENGINE INTC, SHT.4
THROT SIG 2 (GY)
THROT SIG 2 (GY)
TO ENGINE INTC, SHT.4
THROT RET 2 (GN)
THROT RET 2 (GN)
C200
DCM
C25
TO ADJUSTABLE PEDAL SW
SEE DIAGRAM,WRG,FEA 40099-01
B
C
D
PBRAKE SW1 (GY)
1602 (YL)
1601 (GN)
1602 (YL)
1601 (GN)
G
H


HIGH BEAM COMMON GND (TO T/S PIN 2)
HORN SIGNAL GND
TURN SIGNAL COM GND (TO T/S PIN 1)
HIGH BEAM SIGNAL (TO T/S PIN 11)
CRUISE COMMON GND (TO C/S PIN 4)
LH DIRECTIONAL (TO T/S PIN 6)
RH DIRECTIONAL (T/S PIN 12)
PARK BRAKE COMMON GND
PARK BRAKE SIGNAL
CRUISE CONTDROL ON/OFF (C/S PIN 3)
CRUISE CONTROL RESUME (C/S PIN 2)
CRUISE CONTROL SET (C/S PIN 1)
STOP LIGHT SIGNAL
STOP LIGHT POWER
IGNITION SWITCH COMMON GND
ACCESSORY SWITCH
IGNITION SWITCH OUTPUT
START SWITCH
HORN BUTTON
TO COLUMN GROUND
D
C
PARK BRAKE SWITCH
STOP LIGHT SWITCH
DC
B
A
IGNITION SWITCH
1
3
4
2
DIRECT ALARM OUTPUT
LOCKED OUTPUT FOR MICO
VEHICLE POWER FOR MICO
VEHICLE GROUND FOR MICO
INTERLOCK SWITCH FOR MICO
20
15
1
17
8
MICO CONNECTOR
2
3
4
6
5
10
MICO MOTOR
GROUND
SIGNAL
MICO PRESSURE SWITCH #2
SIGNAL
GROUND
MICO PRESSURE SWITCH #1
DC
THROTTLE SIGNAL 1
THROTTLE COMMON 1
THROTTLE POWER 1
THROTTLE POWER 2
THROTTLE SIGNAL 2
THROTTLE COMMON 2
A
B
C
D
F
E
THROTTLE SENSOR GM 8.1
DC
A
B
ADJUSTABLE PEDAL MOTOR
DC

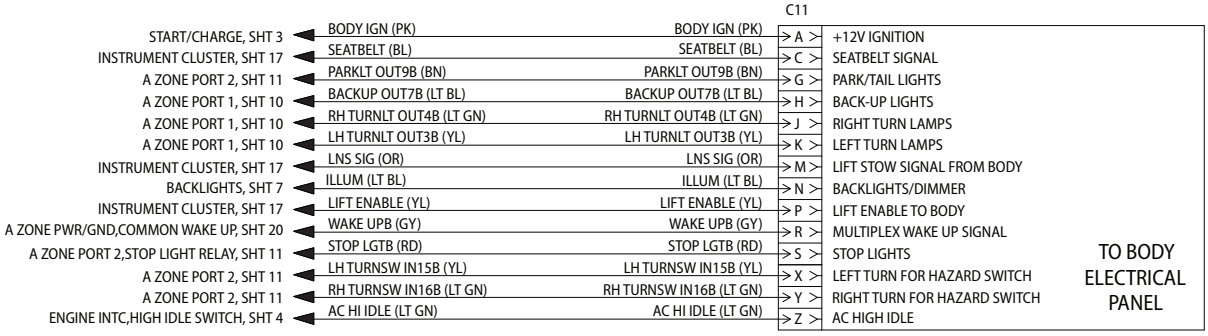

START/CHARGE,A ZONE POWER, SHT 3
MBC POWER1 (BK)
GND
GND 1 (WH)
CHASSIS PDU GND STUD
START/CHARGE,A ZONE POWER, SHT 3
MBC POWER2 (BK)
START/CHARGE,FUSE BLOCK FB1-4, SHT 3
MBC PWR (RD)
BODY INTFC, SHT 21
WAKE UPB (GY)
C26
CONN. C
BODY CONTROL MODULE AT BODY ELECTRICAL PANEL
B ZONE MODULE
10
WAKE UPA (GY)
2
COM NETA (YL)
4
COM NETB (GN)
6
12V MPX (BK)
8
GND MPX (LT BL)



Sheet 20

D0006374A

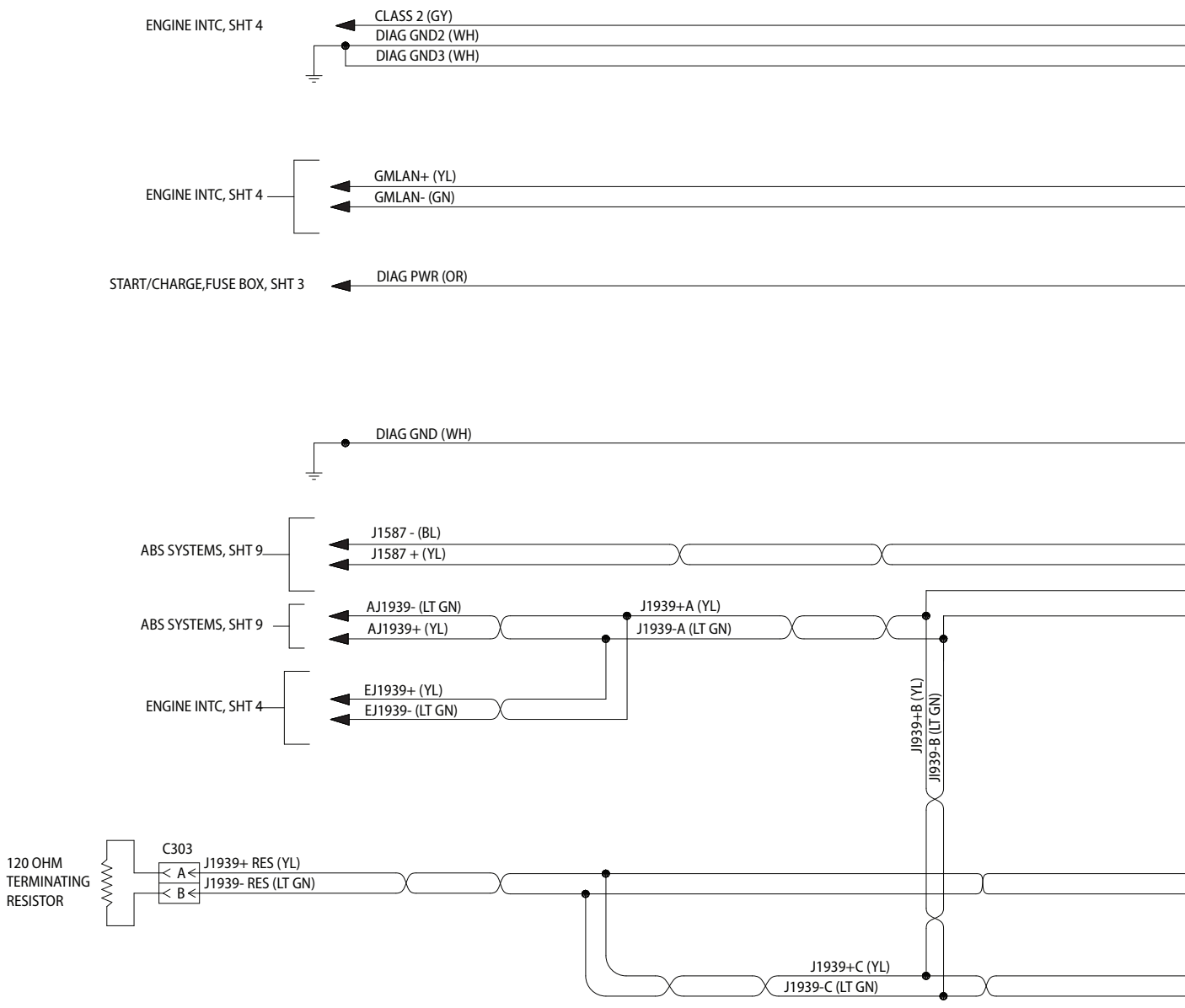
A ZONE, POWER AND GROUND

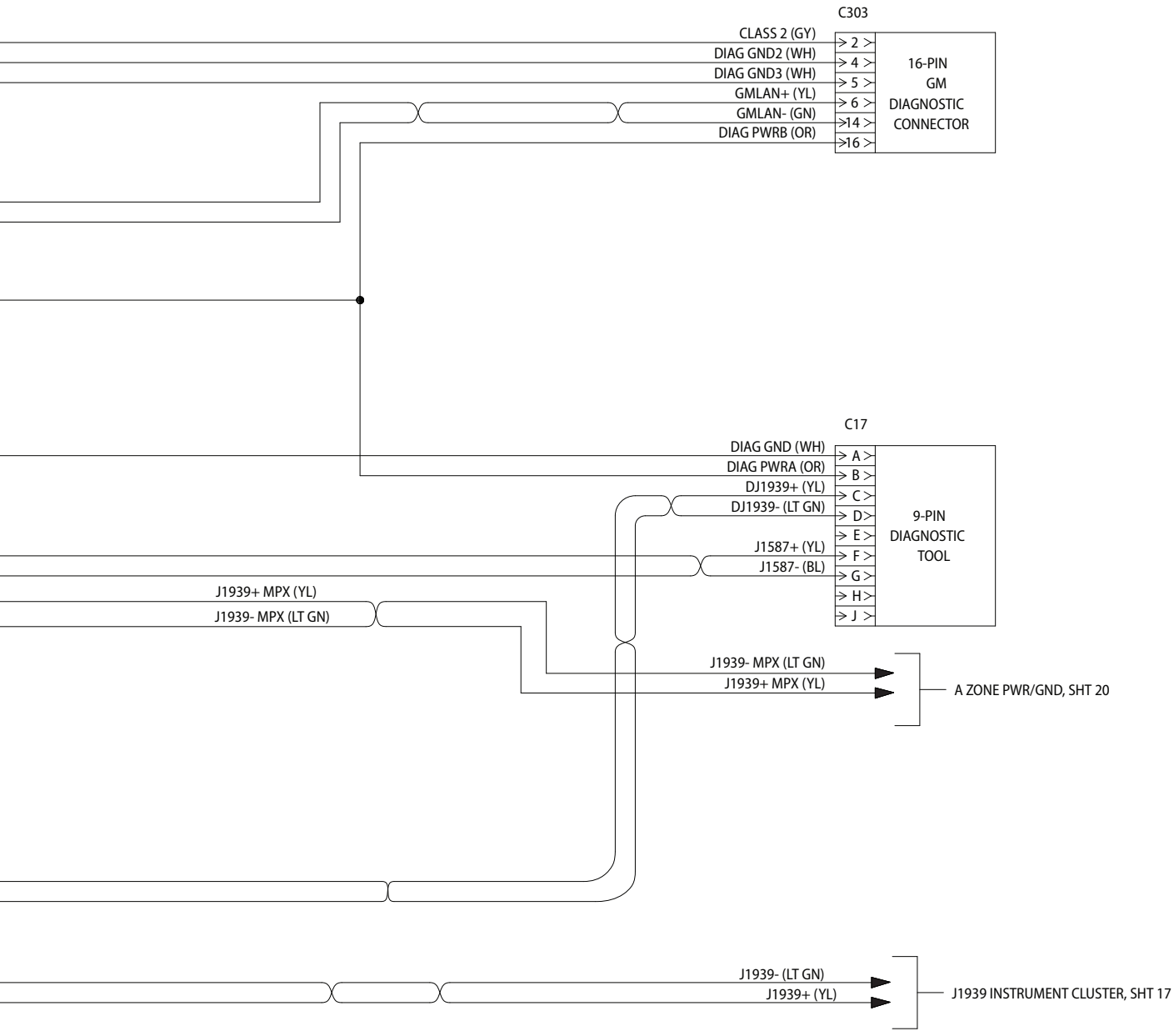


Sheet 21

D0006375A

BODY INTERFACE

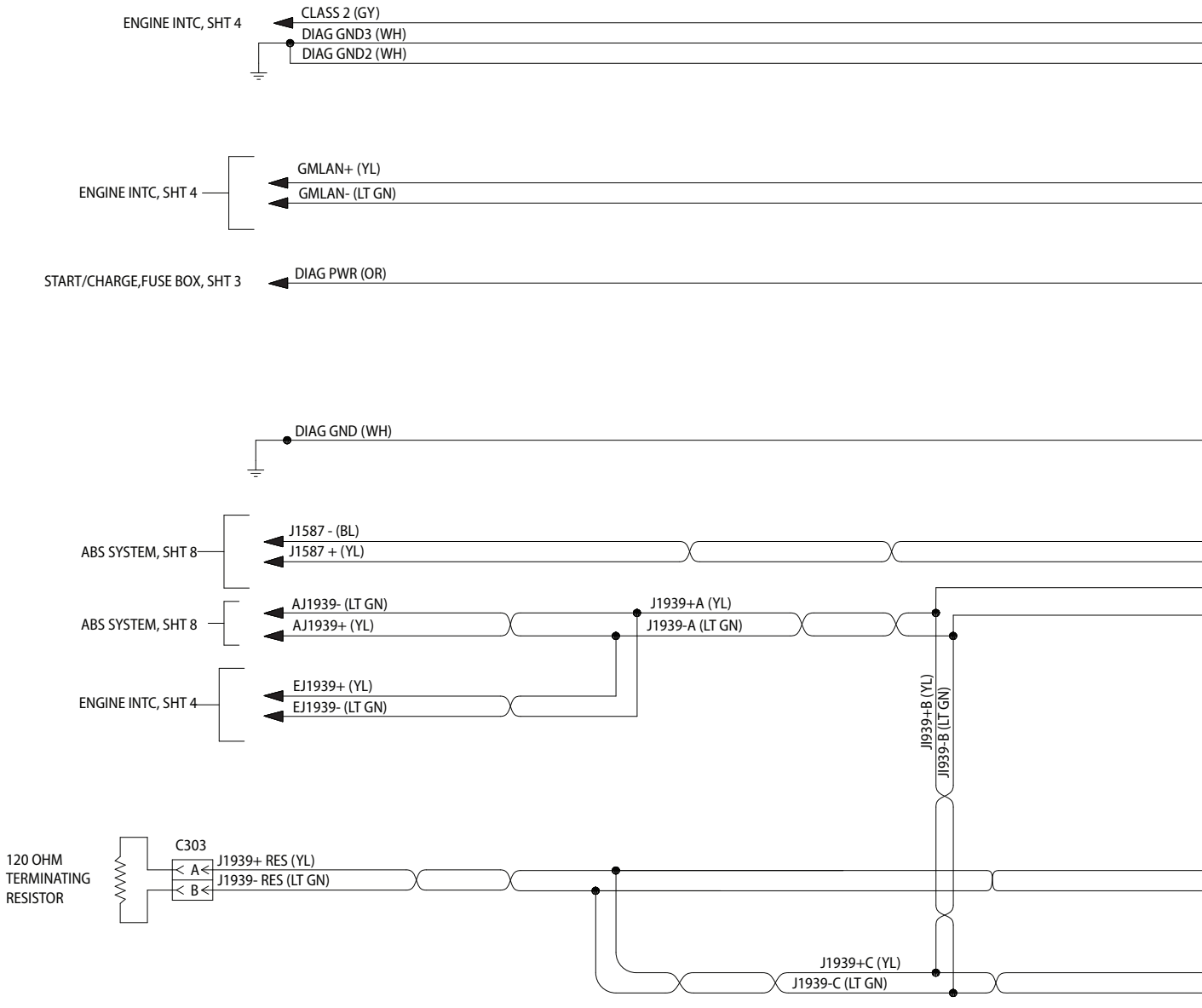

ENGINE INTC, SHT 4
CLASS 2 (GY)
DIAG GND2 (WH)
DIAG GND3 (WH)
ENGINE INTC, SHT 4
GMLAN+ (YL)
GMLAN- (GN)
START/CHARGE,FUSE BOX, SHT 3
DIAG PWR (OR)
DIAG GND (WH)
ABS SYSTEMS, SHT 9
J1587 - (BL)
J1587 + (YL)
ABS SYSTEMS, SHT 9
AJ1939- (LT GN)
AJ1939+ (YL)
J1939+A (YL)
J1939-A (LT GN)
ENGINE INTC, SHT 4
EJ1939+ (YL)
EJ1939- (LT GN)
JI939+B (YL)
JI939-B (LT GN)
120 OHM
TERMINATING
RESISTOR
C303
A
B
J1939+ RES (YL)
J1939- RES (LT GN)
J1939+C (YL)
J1939-C (LT GN)

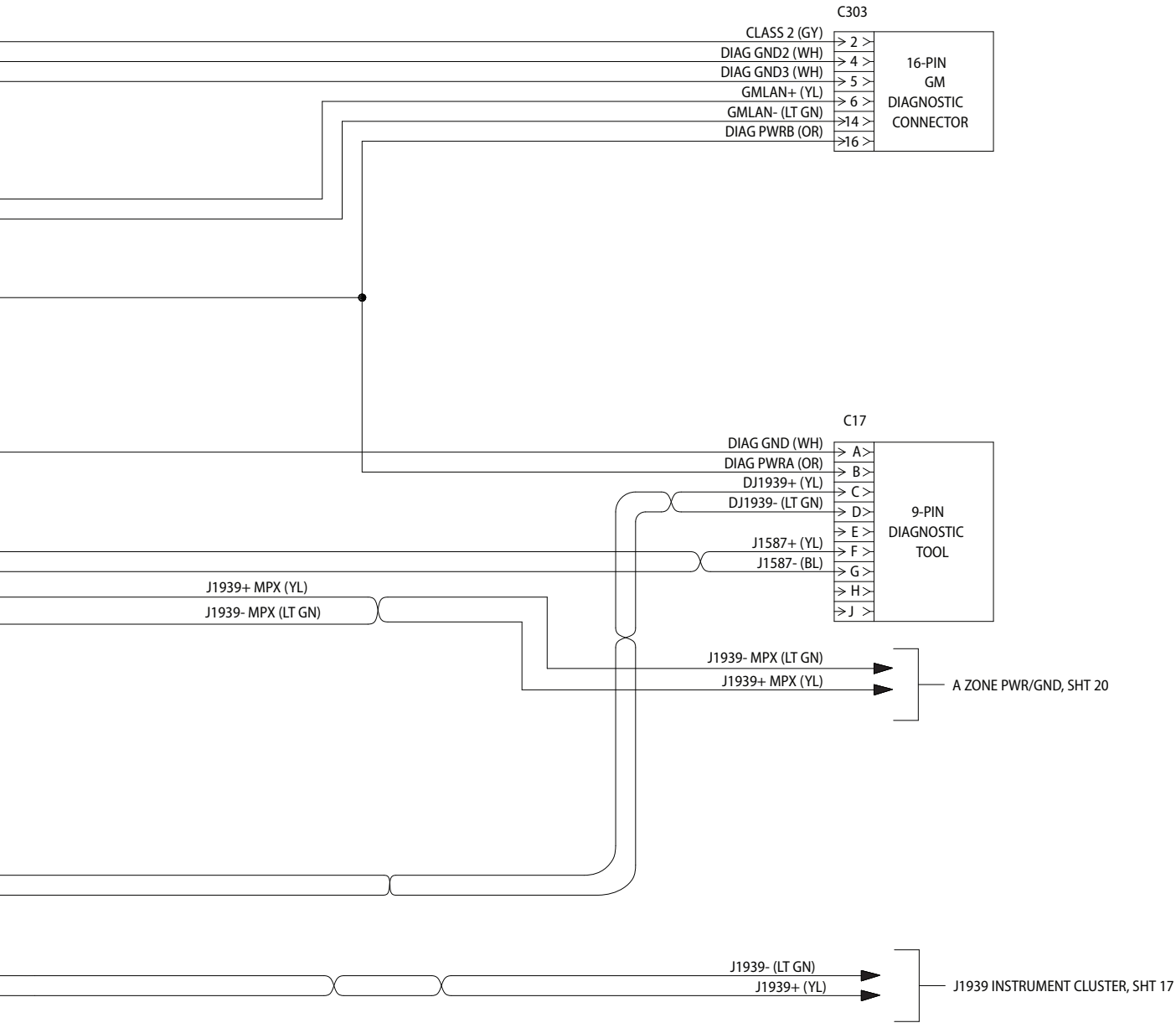


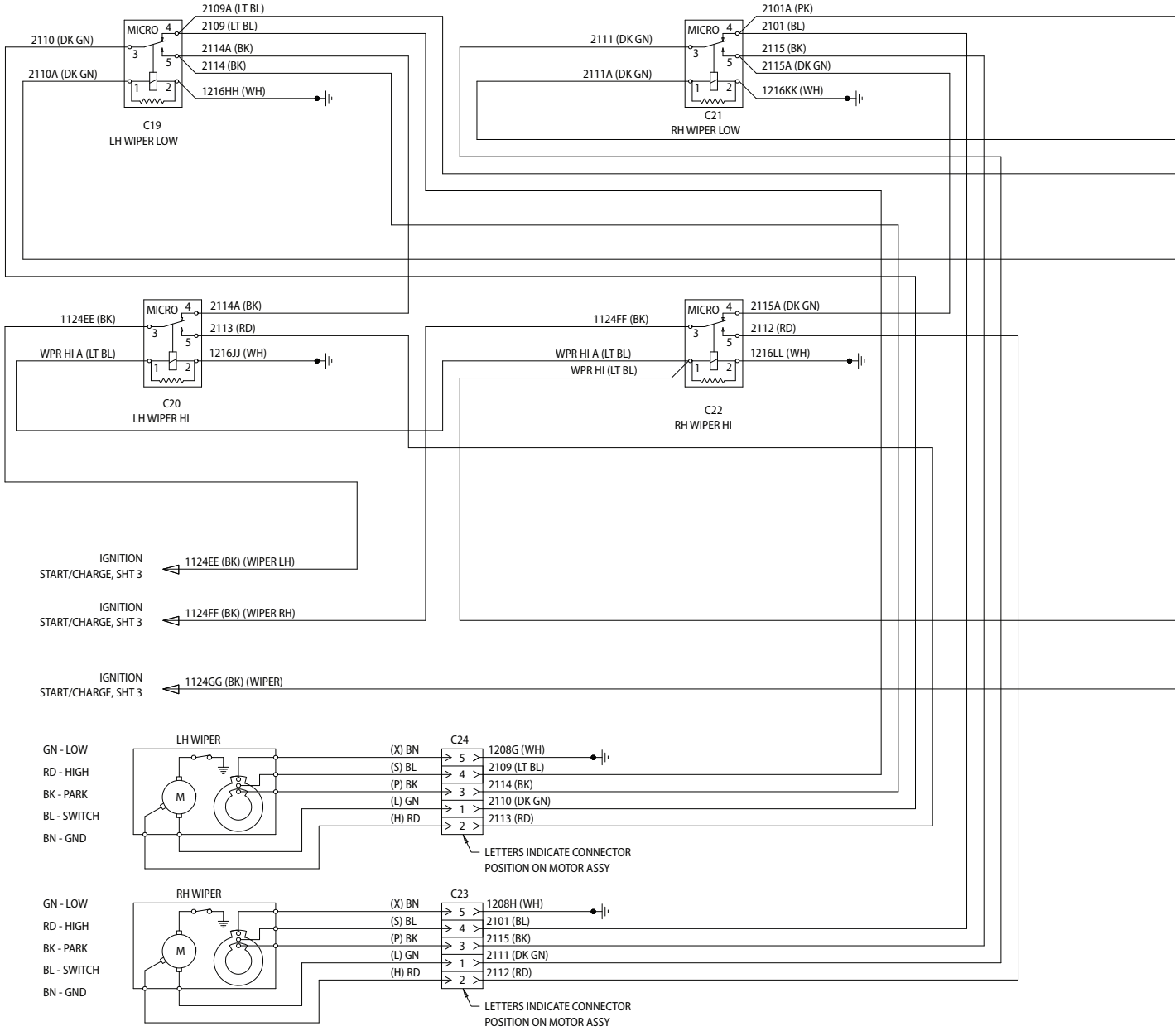
Sheet 22

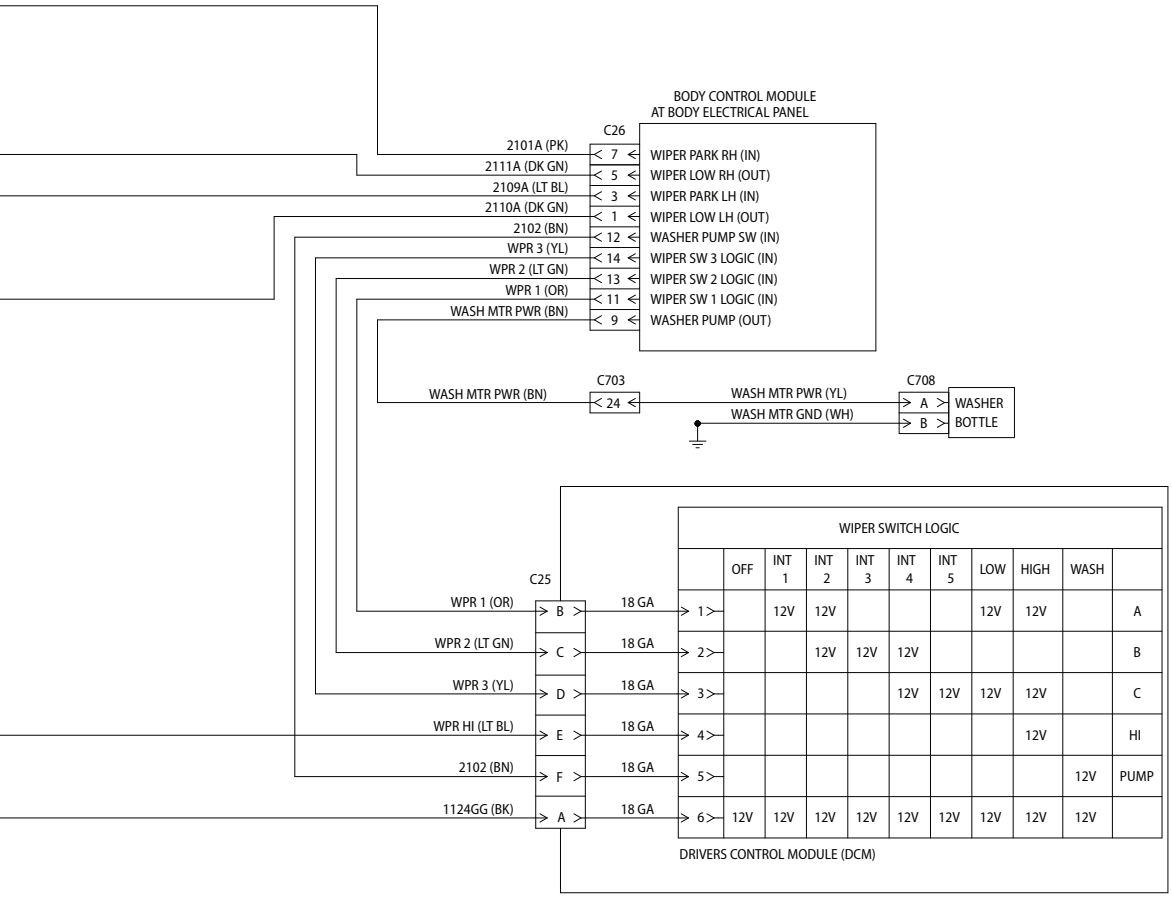
D0006376A

J1939 DATALINK, HYDRAULIC


ENGINE INTC, SHT 4
CLASS 2 (GY)
DIAG GND3 (WH)
DIAG GND2 (WH)
ENGINE INTC, SHT 4
GMLAN+ (YL)
GMLAN- (LT GN)
START/CHARGE,FUSE BOX, SHT 3
DIAG PWR (OR)
DIAG GND (WH)
ABS SYSTEM, SHT 8
J1587 - (BL)
J1587 + (YL)
ABS SYSTEM, SHT 8
AJ1939- (LT GN)
AJ1939+ (YL)
J1939+A (YL)
J1939-A (LT GN)
ENGINE INTC, SHT 4
EJ1939+ (YL)
EJ1939- (LT GN)
J939+B (YL)
J939-B (LT GN)
120 OHM
TERMINATING
RESISTOR
C303
A
B
J1939+ RES (YL)
J1939- RES (LT GN)
J1939+C (YL)
J1939-C (LT GN)


C303
CLASS 2 (GY)
DIAG GND2 (WH)
DIAG GND3 (WH)
GMLAN+ (YL)
GMLAN- (LT GN)
DIAG PWRB (OR)
> 2 >
> 4 >
> 5 >
> 6 >
>14 >
>16 >
16-PIN
GM
DIAGNOSTIC
CONNECTOR
C17
DIAG GND (WH)
DIAG PWRA (OR)
DJ1939+ (YL)
DJ1939- (LT GN)
J1587+ (YL)
J1587- (BL)
> A>
> B>
> C >
> D>
> E >
> F >
> G >
> H >
>J >
9-PIN
DIAGNOSTIC
TOOL
J1939+ MPX (YL)
J1939- MPX (LT GN)
J1939- MPX (LT GN)
J1939+ MPX (YL)
A ZONE PWR/GND, SHT 20
J1939- (LT GN)
J1939+ (YL)
J1939 INSTRUMENT CLUSTER, SHT 17


2109A (LT BL)
2109 (LT BL)
2110 (DK GN)
2114A (BK)
2110A (DK GN)
2114 (BK)
1216HH (WH)
MICRO
C19
LH WIPER LOW
2101A (PK)
2101 (BL)
2111 (DK GN)
2115 (BK)
2115A (DK GN)
2111A (DK GN)
1216KK (WH)
C21
RH WIPER LOW
2114A (BK)
1124EE (BK)
2113 (RD)
WPR HI A (LT BL)
1216JJ (WH)
C20
LH WIPER HI
2115A (DK GN)
1124FF (BK)
2112 (RD)
WPR HI A (LT BL)
WPR HI (LT BL)
1216LL (WH)
C22
RH WIPER HI
IGNITION
START/CHARGE, SHT 3
1124EE (BK) (WIPER LH)
1124FF (BK) (WIPER RH)
1124GG (BK) (WIPER)
LH WIPER
GN - LOW
RD - HIGH
BK - PARK
BL - SWITCH
BN - GND
M
C24
(X) BN
(S) BL
(P) BK
(L) GN
(H) RD
1208G (WH)
2109 (LT BL)
2114 (BK)
2110 (DK GN)
2113 (RD)
LETTERS INDICATE CONNECTOR
POSITION ON MOTOR ASSY
RH WIPER
C23
1208H (WH)
2101 (BL)
2115 (BK)
2111 (DK GN)
2112 (RD)



WIPER SWITCH LOGIC

	OFF	INT 1	INT 2	INT 3	INT 4	INT 5	LOW	HIGH	WASH	
1		12V	12V				12V	12V		A
2			12V	12V	12V					B
3					12V	12V	12V	12V		C
4								12V		HI
5									12V	PUMP
6	12V	12V	12V	12V	12V	12V	12V	12V	12V	

Overview

This section will address those parts of the steering system related to the:

- Steering wheel
- Steering column
- Power steering fluid requirements
- Steering gear (THP 60)
- Hydraulic steering pump

Appendixes In This Chapter

Appendix 1. TRW Flushing the Steering System. This two page exerpt from TRW's Steering System Maintenance Guidelines includes full details and instructions on flushing the steering system.

Appendix 2. TRW Air Bleeding the Steering System. This two page exerpt from TRW's Steering System Maintenance Guidelines includes full details and instructions on bleeding air from the steering system.

Appendix 3. TRW Steering Maintenance. This TRW publication, entitled *Chart Your Way To Easy Steering,* provides a solid overview of potential steering problems, their diagnosis and correction.

Appendix 4. THP Steering Gear Service Manual. This TRW Service Manual includes design features, fluid information, an exploded parts diagram, torque specifications, general information and on-vehicle service for the THP steering gear.

Appendix 5. Poppet Adjustment. This TRW publication explains what poppets are, how they work and readjustment procedures.

WARNING ***Hydraulic fluid must be handled, stored and disposed of in a manner consistent with all the applicable local, state, and federal guidelines concerning hazardous materials.***

The hydraulic pump for the power steering assist is flange mounted to the engine and gear driven. The configuration of hydraulic lines from the pump to the steering gear is dependent on whether the bus has a hydraulic brake or air brake system.

On Visions equipped with air brakes, the power steering fluid flows from the reservoir to the pump, then to the steering gear, and returns directly to the reservoir.

On Visions equipped with hydraulic brakes, the power steering fluid flows from the reservoir to the pump, to the power steering gear and then to the hydraulic brake power assist (booster). From there, the fluid returns to the reservoir.

WARNING ***The power steering fluid and the brake fluid are not the same. They must be kept separate. Use DOT–3 for the brake system and use Dexron III for the power steering fluid.***

There are a number of acceptable hydraulic fluids approved for use in the power steering system, the system must be drained and flushed to use a different type of fluid (See **Appendix 3. THP Steering Gear Service Manual** for approved hydraulic fluids). Do not mix oils or fluids if you change the fluid.

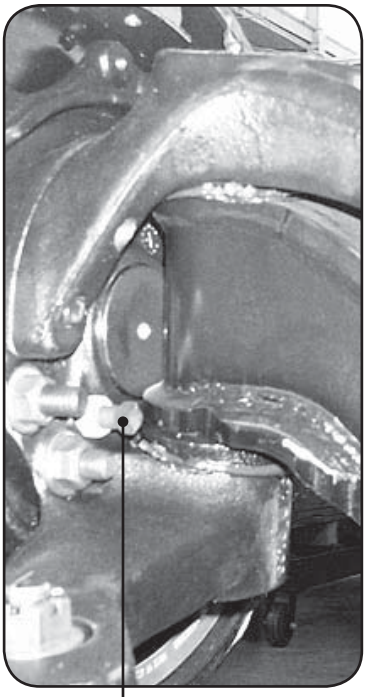
WARNING ***The hydraulic fluid for the steering system and the brake fluid used in the brake master cylinder are not compatible and could result in a loss of steering or a loss of braking if incorrect fluids are used in either system.***

Steering System Operation

The speed at which the driver can turn the steering wheel with power assist is dependent upon the rate of flow provided by the hydraulic pump. (Normal flow rate is 3.6 - 6.3 gpm, Minimum flow rate is 2.9 gpm.) As the driver turns the steering wheel faster or slower, more or less oil flow is required by the gear. The pressure of the hydraulic fluid is used to overcome the resistance in the system. The higher the pressure, the more work it can perform. (Maximum operating pressure is 2,682 psi.)

The steering wheel is connected to the steering column shaft. The steering column shaft is connected to the steering gear input shaft. When the driver turns the steering wheel, the input shaft and worm shaft rotate. The worm shaft is in turn connected to a rack piston through the recirculating ball mechanism. This rotational movement moves the rack piston axially in the gear housing cylinder bore. The rack piston turns the sector shaft, which is connected by linkage to the wheels on the front axle.

As resistance is encountered in the steering effort, pressure in the steering hydraulic system will increase proportionally to assist the movement of the rack piston thus reducing the effort needed to steer the bus. As the input shaft is turned the control valve spool mounted on the torsion shaft (the torsion shaft connects the input shaft to the worm shaft) shifts and redirects oil flow to either side of the rack piston. A relief valve mounted on the valve housing limits maximum pressure to protect the power steering system. This is the primary pressure relief valve for the steering system. A secondary pressure relief valve is located in the hydraulic pump assembly on Vision Forward Engine units.


Axle Stops

Objectionable kickback is prevented due to the geometry of the steering gear. If the wheels receive a shock load from hitting rough areas in the road it is transmitted back through the sector shaft, rack piston, and worm gears. This load is neutralized by the control valve, which sends oil flow to the correct side of the rack piston to resist the shock forces. By absorbing the shock forces hydraulically the steering gear prevents objectionable kickback at the steering wheel and driver.

The steering gear is equipped with two poppet valves, one on each end of the rack piston. The poppet valves are set specifically to the turning radius of each bus after the axle stop adjustment has been made. When the steering wheels are turned and approach the axle stop, one poppet valve (depending on the direction of turn) trips. The tripped poppet valve opens allowing oil flow to bypass the piston which reduces pressure in the gear and helps reduce heat buildup in the hydraulic system. At the same time, the valves also reduce forces on the steering linkage.

Careful preliminary checks should be done to identify a steering problem and its symptoms before deciding the steering gear has failed. In most cases, the steering gear should be the last component suspected as cause of a steering problem.

Refer to the Appendixes in this chapter for detailed step by step troubleshooting procedures.

Steering System Maintenance

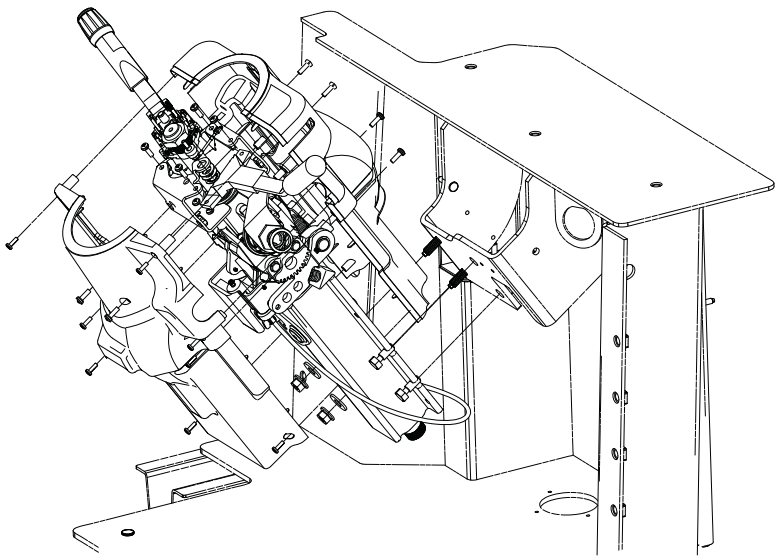
Before attempting to work on the steering gear, or any portion of the steering system, you must stabilize the vehicle. Read and understand the Warnings and Cautions in the General Maintenance chapter of this manual.

Regularly check the fluid level in the power steering reservoir. Change the fluid and replace the filter at the intervals specified in the Specs & Maintenance chapter. Clean around the reservoir filler cap before removing it. Dirt and other foreign matter can damage the hydraulic system.

Do not bend or straighten any steering component or linkage. Never attempt to weld any broken steering component. Do not use a torch to remove any steering component. Use only original equipment replacement parts.

Never use high pressure or steam to clean the power steering gear. Doing so can force contaminants inside the gear and lead to malfunction.

Proper alignment of the steering column is important to assure smooth steering. Correct the cause of any free play, rattle, or shimmy immediately to avoid damage to the steering system. Record and report any malfunctions or accidents which may have damaged steering components.



Steering Column Assembly

Setting the Steering Poppets

To adjust the steering poppets, refer to **Appendix 5 Steering Poppets** in this chapter.

Refer to the Front Axle Appendix located in the axle chapter of this manual for the following steering related adjustments and lubrication points:

Axle Stop Adjustment
Caster and Camber Adjustments
Toe-in Adjustment
King-Pin Lubrication
Te-Rod Lubrication

Steering Column & Steering Wheel

Steering Column

The Vision steering column offers a tilt/telescoping range of movement, allowing the steering wheel and stem controls to be placed with-in a comfort range of the driver. Adjustment of the steering wheel is accomplished by actuating a tile/telescoping control lever, located at the bottom center of the steering column, and moving the steering wheel into a new position. The control lever is actuated by pulling downward until the lever rolls over center and locks in the release position. With the control lever in the released position the steering wheel and column moves freely within its range of travel. When the steering wheel has been placed in the desired position push the control lever upward to lock the position. Actuating the control lever allows up and down movement of the steering wheel for tilt control and in and out movement of the steering column for telescopic control.

When the control lever is actuated a set of lock paws in the tilt locking mechanism is released allowing the steering wheel and upper steering column to be position up or down in one of 9 detents (positions). When the control lever arm is released the lock paws reengages the detent providing a positive lock in the position selected. At the same time the tilt lock paw is released the telescoping lock pad is released allowing the upper steering column to slide in and out of the lower steering column support. This function provides an almost infinite height control (within its range of travel) of the steering wheel and upper column. When the tilt/telescoping control is released a friction pad mounted on the lower stationary support column makes contact with the upper column providing a non-incremental positive lock of the telescoping mechanism

The steering column and its control mechanism is a self contained unit. Although the it provides tilt and telescoping adjustment of the steering wheel and column there are no adjustments to steering column control mechanism. The steering column requires no lubrication and is considered a non-serviceable component.

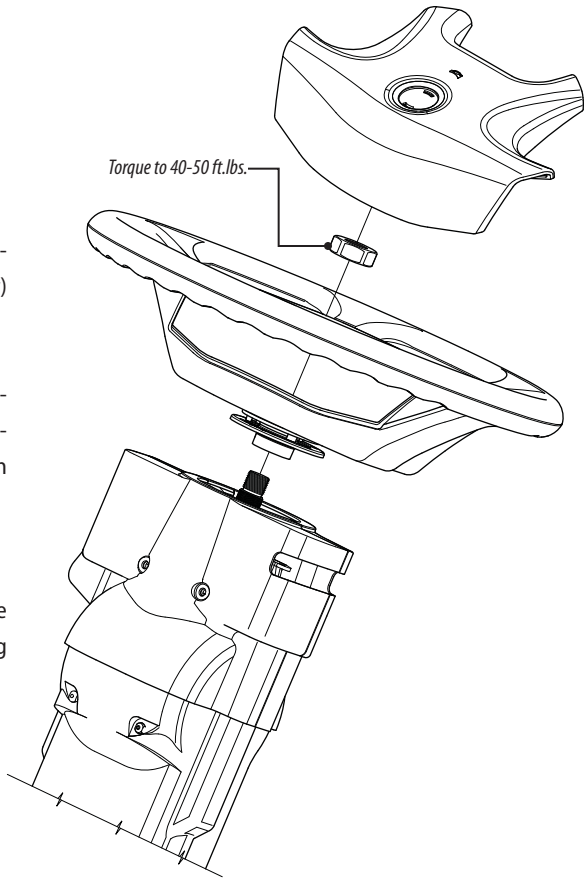
Some components attached to the steering column are serviceable i.e., turn signal switch, cruise control, ignition switch, and the horn brush contact.

Steering Wheel Removal.

1. Remove the screws retaining the steering wheel cover.
2. Lift the cover and disconnect any electrical circuits.
3. Check the alignment marks on the steering shaft and steering wheel flange (make new alignment marks if necessary) and remove the steering wheel nut.
4. Remove the steering wheel. The steering shaft and the mating flange on the steering wheel has splines but are not tapered. A rubber hammer may be required to provide enough force to loosen the connection.

Steering Wheel Reinstallation

To replace the steering wheel assembly, reverse the procedure above. Making sure the steering wheel is aligned with the steering shaft. Torque the steering wheel nut to 40 to 50 ft. lbs.



Steering Wheel Installation
(Stems Not Illustrated)

Steering Gear

The THP 60 is an integral hydraulic power steering unit. The steering gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder. The control valve senses steering requirement from the driver and directs oil flow to the appropriate cylinder cavity at the proper flow rate thus providing a smooth power assist steering.

The speed at which the driver can turn the steering wheel with power assist is dependent upon the rate of flow provided by the hydraulic pump. (Normal flow rate is 3.6 to 6.3 gpm, Minimum flow rate is 2.9 gpm.) As the driver turns the steering wheel faster or slower, more or less oil flow is required by the gear. The pressure of the hydraulic fluid is used to overcome the resistance in the system. The higher the pressure, the more work it can perform. (Maximum operating pressure is 2,682 psi.)

The steering wheel is connected to the steering gear input shaft. The input shaft is connected to a worm shaft. When the driver turns the steering wheel, the input shaft and worm shaft rotate. The worm shaft is in turn connected to a rack piston through the recirculating ball mechanism. This rotational movement moves the rack piston axially in the gear housing cylinder bore. The rack piston turns the sector shaft, which is connected by linkage to the wheels on the front axle.

As resistance is encountered in the steering effort, pressure in the steering hydraulic system will increase proportionally to assist the movement of the rack piston, thus reducing the effort needed to steer the bus. As the input shaft is turned, the control valve spool mounted on the torsion shaft (the torsion shaft connects the input shaft to the worm shaft) shifts and redirects oil flow to either side of the rack piston. A relief valve, mounted on the valve housing, limits maximum supply pressure to protect the power steering system. This is the primary pressure protection for the steering system. (A secondary pressure relief valve is located in the hydraulic pump assembly.)

Objectionable kickback is prevented due to the geometry of the steering gear. If the wheels receive a shock load, it is transmitted back through the sector shaft, rack piston, and worm gears. This load is neutralized by the control valve, which sends oil flow to the correct side of the rack piston to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents objectionable kickback at the steering wheel and driver.

The steering gear is equipped with two poppet valves, one on each end of the rack piston. The poppet valves are set specifically to the turning radius of each bus after the axle stop adjustment has been made. When the steering wheels are turned and approach the axle stop, one poppet valve (depending on the direction of turn) trips. The tripped poppet valve opens, allowing oil flow to bypass the piston, which reduces pressure in the gear and helps reduce heat buildup in the hydraulic system. At the same time, the valves also reduce forces on the steering linkage.

Careful preliminary checks should be done to identify a steering problem and its symptoms before deciding to tear down the steering gear. In most cases, the steering gear should be the last component suspected as cause of a steering problem.

Refer to Appendix 3, 4, and 5 in this chapter for detailed step by step troubleshooting procedures.

Steering Pump

The hydraulic steering pump on the Blue Bird Vision Forward Engine is a positive displacement pump with an integrated pressure relief valve and a flow regulator valve.

When troubleshooting, it is important to remember to always do the simple steps first. Look for obvious signs of leaking, component wear or damage, and hose problems, before removing the power steering pump. Special attention should be given to the supply hose for signs of clasping or routing issues creating kinks in the hose that could restrict oil flow to the pump.

Using a flow meter, determine whether the pump is providing the necessary flow for proper steering. The steering pump should provide a flow of approximately 3.6 to 6.3 (minimum 2.9) gallons per minute (GPM). It is recommended that you use a Power Steering System Analyzer (PSSA) to assist in the diagnosis of steering system problems.

For details on troubleshooting the steering system, see **Appendix 4, TRW Steering Maintenance** in this chapter.

Steering Pump Removal (Vision With Air Brakes)

1. Drain the system of fluid in a manner consistent with all local, state and federal laws. Wear protective gear when working with hydraulic fluids including eye protection.

2. Remove the supply hose .

3. Remove the pressure hose from the fitting at the output port of the pump.

4. Secure the pressure line safely out of the way.

5. Remove two capscrews from the hydraulic pump mounting flange.

6. Remove and discard the gasket.

Steering Pump Reinstallation (Vision With Air Brakes)

Installation is accomplished in the reverse order of the removal instructions. Always install a new hydraulic pump gasket. Also install a new split ring lock washer and torque the mounting capscrews to 53–58 ft. lbs. (71.86–78.64 Nm).

After filling the reservoir, start and run the engine at idle for 10 seconds then switch the ignition off, refill the reservoir, start the engine and run for another 20 seconds, repeat this process until the reservoir maintains a full oil level. With the front wheels off the floor, (refer to **Jacking Procedures in the Specs & Maintenance** section of this manual) lifting by the axle not the wheels, start the engine and turn the steering wheel one direction and then the other direction a couple of times; then stop the engine and refill the reservoir. Perform this cycle until the reservoir maintains a full oil level.

Test drive the bus and let the power steering fluid warm to operating temperature; then check the fluid level again. Check for leaks in the system.

Steering Pump Removal (Vision With Hydraulic Brakes)

1. Drain the system of fluid in a manner consistent with all local, state and federal laws. Wear protective gear when working with hydraulic fluids including eye protection.

2. Remove the supply hose.

3. Remove the pressure line from the fitting at the output port of the pump.

4. Secure the pressure line safely out of the way.

5. Remove two capscrews from the hydraulic pump mounting flange.

6. Remove and discard the o-ring.

Steering Pump Reinstallation (Vision With Hydraulic Brakes)
Install the pump in the reverse order of the removal. Ensure that a new o-ring is installed. Install a new split ring lock washer and torque the mounting capscrews to 53–58 ft. lbs. (33.32–44.74 Nm).

Pitman Arm

Pitman Arm Removal
Remove the Pitman arm end of the draglink and secure it safely out of the way. Then remove and discard the nut and bolt assembly from the upper end of the Pitman. Being very careful of the spline on the steering gear, remove the Pitman arm by pulling with a wheel puller.

Pitman Arm Installation

1. Position the Pitman arm so that the index mark aligns with the mark on the output spline of the steering gear.

2. The Pitman arm offset must be inward, and at the bottom.

3. Press the Pitman onto the output spline of the steering gear.

4. Install new hardware (¾–10 Grade 8), and torque to 250–282 ft. lbs. (339–382 Nm).

5. Attach the drag link to the Pitman arm. Position the drag link journal into the lower hole in the Pitman. Torque the castle nut to 110–125 ft. lbs. (149.14–169.48 Nm), then align a castle nut slot with the cotter pin hole. If necessary, tighten further just enough to align. Install a new cotter pin and bend each end at least 45° to hold it in position.

Drag Link

Drag Link Removal

1. Remove and discard the cotter pin from the castle nut on the each end of the drag link.

2. Remove the castle nut from the Pitman arm end and secure the drag link.

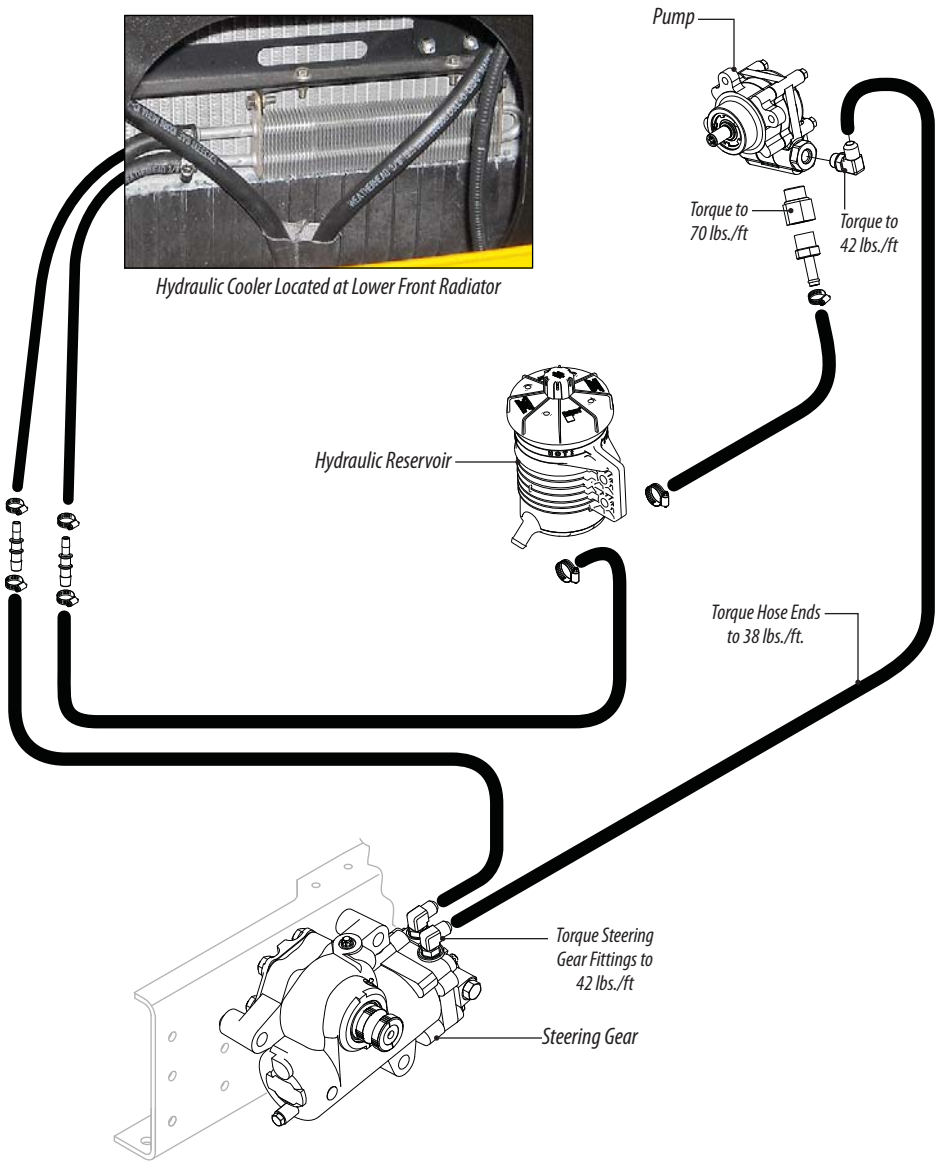
3. Remove the castle nut from the axle end of the drag link, and then remove the drag link journal from the Pitman arm. Be sure to wrap and protect the journal surfaces of the draglink.

Drag Link Reinstallation

Ensure the bend in the drag link is toward the front of the vehicle. Installation then becomes the reversal of the removal instructions, above. Torque each castle nut to 110–125 ft. lbs. (149.14–169.48 Nm), then align a castle nut slot with the cotter pin hole. Tighten further just enough to align if necessary. Install a new cotter pin and bend each end at least 45° to hold it in position.

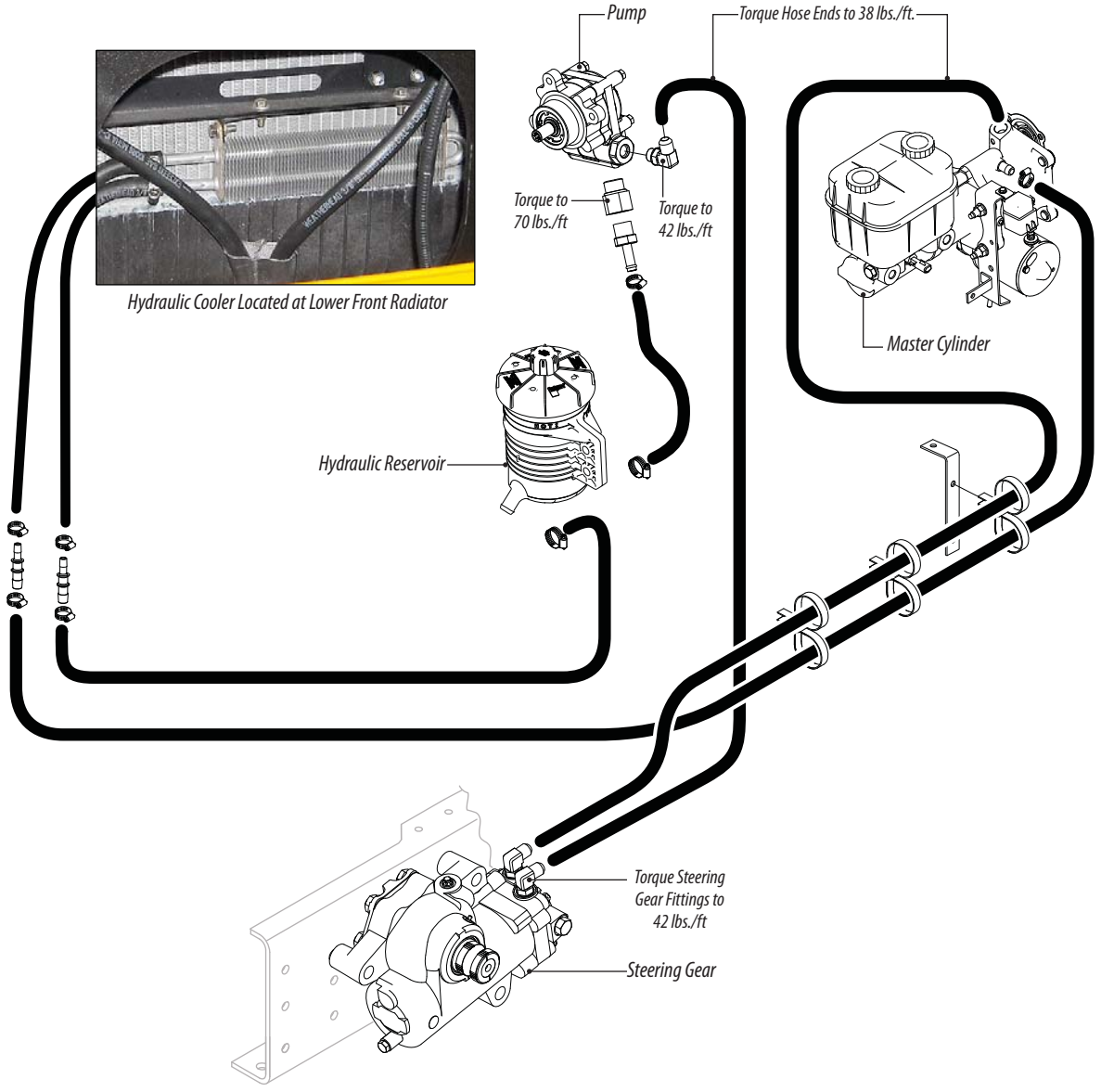
Refer to the Hendrickson™ SteerTek service manual included as an appendix to the Front Axle & Steering chapter for further information regarding removal and installation of steering axle suspension components. Additional information is available at Hendrickson's website at www.hendrickson-intl.com.

Hydraulic Cooler Located at Lower Front Radiator



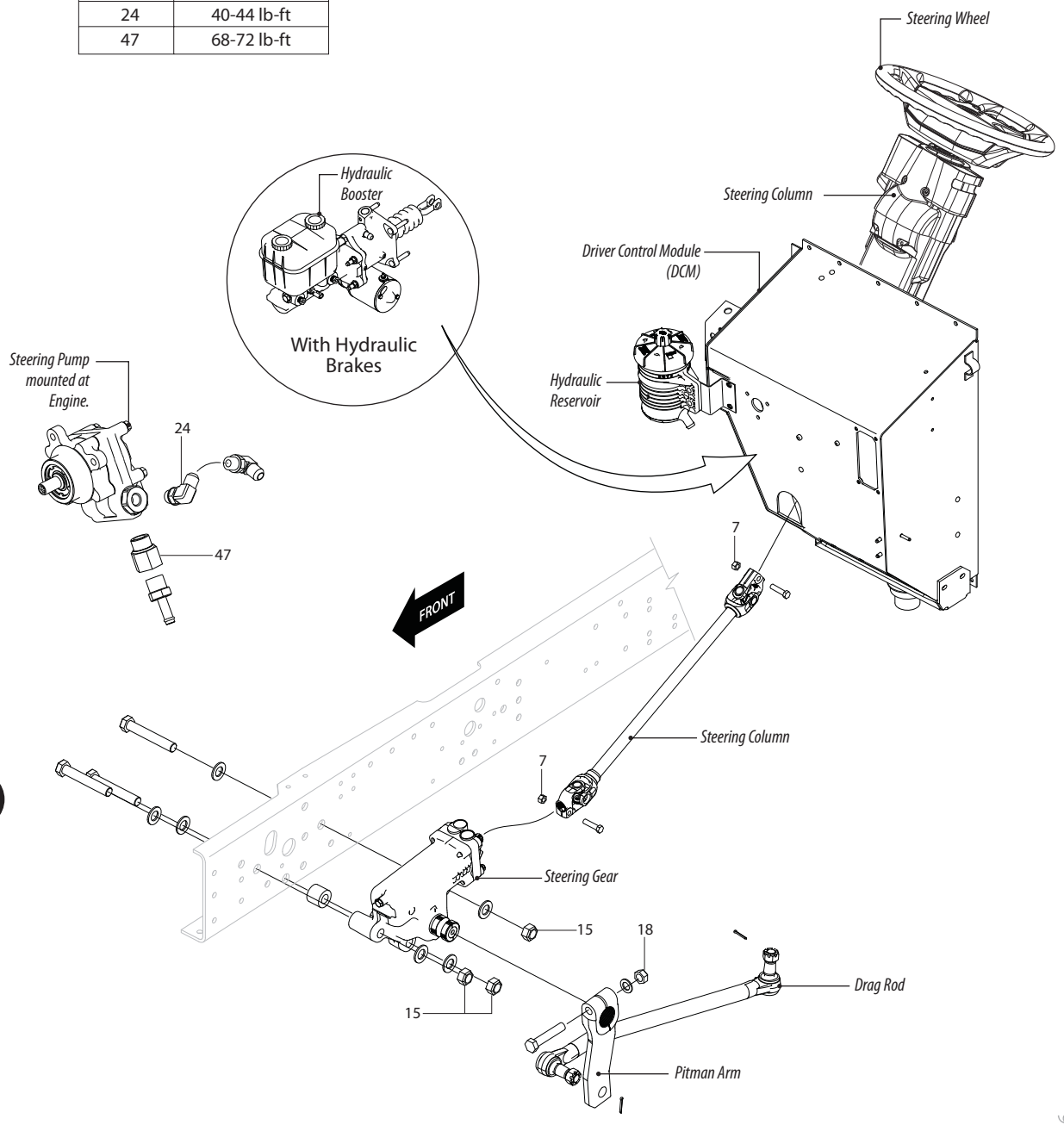
Steering Diagram with Air Brakes

Hydraulic Cooler Located at Lower Front Radiator



Steering Diagram with Hydraulic Brakes

Torque Chart	
7 Nut	40-44 lb-ft
15 Nut	270-300 lb-ft
18 Nut	170-180 lb-ft
24	40-44 lb-ft
47	68-72 lb-ft



Steering Components

D0002116

Flushing the Steering System

The steering system must be flushed every time a gear, pump, or reservoir gets replaced, regardless if the components are new or are remanufactured.

1. Set parking brake on vehicle and block rear wheels.
2. Raise the front end off the ground.
3. Take vehicle out of gear and put into neutral position.
4. Raise hood and wipe down area around the steering gear and the hydraulic lines related to the steering system.
5. Place a drip pan under the steering gear to catch the oil.
6. Remove both the pressure and return lines (Figure 1) from the steering gear and allow the oil to drain into the empty container.
7. Remove filter (Figure 2) from the power steering fluid reservoir and discard. Disconnect the supply line from the reservoir.
8. Rinse and clean the inside of the reservoir with an approved solvent, then air dry. Do not use a shop rag to wipe the inside of the reservoir and make sure that none of the solvent enters the rest of the steering system. If the reservoir is made from plastic inspect for cracks and damage. Replace if necessary.
9. Turn steering wheel from full left to full right 3-4 times. Collect the drained oil in the same container as in Step 6. This will purge the oil from the steering gear.
10. Reconnect pressure and return lines to the steering gear. Connect the supply line to the reservoir and then tighten all fittings.
11. Install new filter element into the reservoir.
12. Clean reservoir filler cap with an approved solvent. Inspect gasket and replace if necessary.
13. Inspect all hydraulic hoses (Figure 3) for cracks, soft or sweat spots and signs of local collapse (remove all covers/corrugated tubing from hoses to do this) and replace any that are found to be defective.
14. Check any banjo fittings and connectors for blockage. Clear any blockages using an appropriate method.
15. Filter contaminated oil through a coffee filter and examine for metal and foreign particles. Fine metal particles are evidence of normal wear and tear.



Figure 1



Figure 2



Figure 3

- Metal chips signify that the power steering pump needs to be replaced.
- If black rubber particles are present; the inner lining of the pressure, return or suction lines may be disintegrating. Replace all three hoses.

16. Fill reservoir with approved replacement fluid and reinstall the filler cap (Figure 5).

17. Start engine for 10 seconds, stop, and check reservoir fluid level and top off if necessary. You may need to repeat this procedure 3 or 4 times.

18. Upon completion of filling the reservoir, start the engine and let it idle. At engine idle, steer full right and full left (Figure 6) once and return to straight ahead. Stop engine and check power steering reservoir level and top off if required.



Figure 5



Figure 6

⚠ CAUTION

Do not hold steering wheel at full turn for longer than 10 seconds as this will cause system to overheat.

19. Restart engine and steer full turns each direction 3 or 4 times.

20. Stop engine and recheck reservoir fluid level and adjust to correct level, if needed.

21. Inspect system for leaks and correct if necessary.

22. Bleed air from the system, if required.

23. Remove drip pan and lower vehicle. Remove blocks from wheels and return vehicle for normal service.

TRW Automotive
Commercial Steering Systems
P.O. Box 60
Lafayette, Indiana 47902

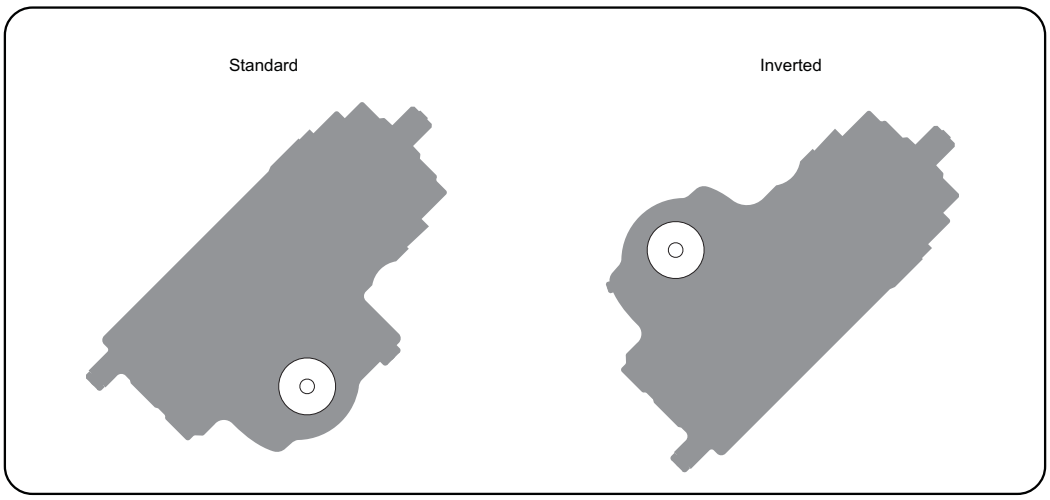
Tel 765.423.5377
Fax 765.429.1868
http://trucksteering.trw.com
http://www.trucksteering.com

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Air Bleeding the Steering System

Visual Identification

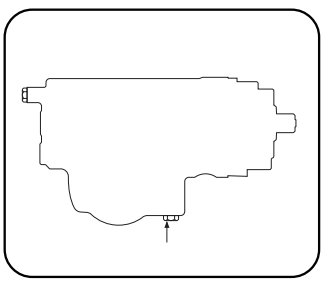
When you air bleed a steering system, you are simply allowing air trapped in the cavities of the steering gear to escape. As a general rule, if your steering gear is a “standard mount”, you should use the Automatic Bleed method. If your gear is an “inverted mount”, you will need to use the Manual Bleed method to purge the trapped air from the gear.



Gear Mounting Configurations

Automatic Bleed Gears

1. Fill the reservoir.
2. Start the engine, let it run for 10 seconds - without steering, then shut it off.
3. Check the reservoir, and refill if the fluid level has dropped.
4. Repeat at least three times, checking and refilling the reservoir each time if necessary.

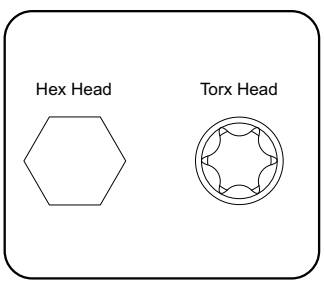


Auto Bleed Plug Location

NOTE

Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.

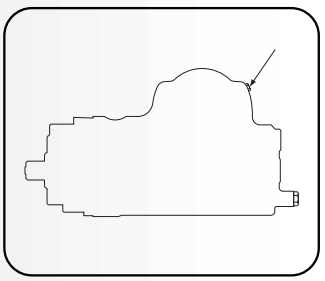
5. Start the engine and let it idle for 2 minutes - without steering. Shut off the engine and check the fluid level in the reservoir. Refill if required.
6. Start the engine again. Steer the vehicle from full left to full right several times. Automatic bleed systems should now be free from trapped air.
7. Finally, be sure to check the fluid level in the reservoir. Refill if necessary before returning the vehicle to service.



Auto Bleed Plug Styles

Manual Bleed Gears

1. Fill the reservoir.
2. Start the engine, let it run for 10 seconds - without steering, then shut it off.
3. Check the reservoir, and refill if the fluid level has dropped.
4. Repeat this process at least three times, checking and refilling the reservoir each time if necessary.



Manual Bleed Screw Location

NOTE

Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.

5. Start the engine and let it idle for 2 minutes - without steering. Shut off the engine and check the fluid level in the reservoir. Refill if required.
6. Start the engine again. Steer the vehicle from full left to full right several times.
7. Again, check the fluid level in the reservoir.
8. With the engine idling, steer from full left turn to full right turn several times. Stop steering with the wheels pointed straight ahead and loosen the manual bleed screw 2-3 turns.
9. Allow air and aerated fluid to “bleed out” until fluid appears without bubbles.
10. Close the bleed screw, refill the reservoir if required.
11. Repeat this process three or four times until all the air is discharged. Torque manual bleed screw to 45 in•lb.



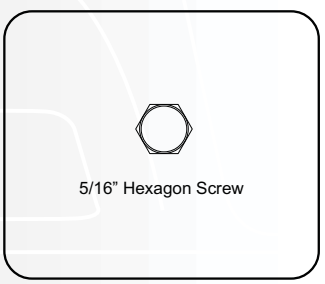
Figure 1

⚠CAUTION

Do not turn steering wheel with bleed screw loosened.



Figure 1



Manual Bleed Screw Style

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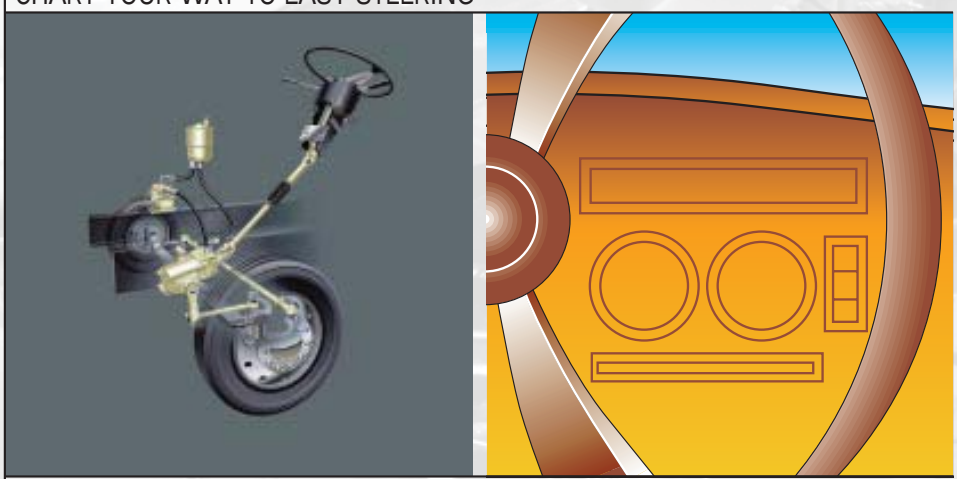
Tel 765.423.5377
Fax 765.429.1868
http://trucksteering.trw.com
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TRW Automotive
Commercial Steering Systems

Steering Diagnostics Service Manual

CHART YOUR WAY TO EASY STEERING



⚠ WARNING	**A warning describes hazards or unsafe practices which could result in severe personal injury or death.**
⚠ CAUTION	**A caution describes hazards or unsafe practices which could result in personal injury or product or property damage.**
NOTE	A note gives key information to make following a procedure easier or quicker.

Notice

This guide was prepared for the purpose of providing general advice concerning the diagnosis and correction of commercial vehicle steering related problems. This guide is intended for the use of properly trained, professional mechanics, NOT "Do-it-Yourselfers". Also, this guide should be used in conjunction with service manuals provided by both the vehicle and component manufacturers. Diagnosis and correction of commercial vehicle steering related problems should only be handled by properly trained, professional mechanics who have the proper equipment, tools, instructions and know-how to perform the work properly and safely.

Power Steering System Analyzer (PSSA) Gauge

Some of the tests in this manual require the use of a PSSA. This device is a combination flow meter, shut-off valve, and pressure gauge. This tool will allow you to measure flow and pressure, and provide a load on the pump through the hydraulic lines of the steering system. This tool is required to correctly analyze a steering system. TRW recommends that you **DO NOT BEGIN TROUBLESHOOTING A STEERING SYSTEM WITHOUT THE USE OF A PSSA.** If you are not sure how to use a PSSA, you may refer to the video available through our website at: *www.trucksteering.com*. This video compliments the tests in this book which require the use of the PSSA.

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⚠ WARNING
Throughout this troubleshooting guide, test procedures are recommended to help locate the cause of each complaint. While performing these tests, TRW advises that you TAKE NECESSARY PRECAUTIONS when working with internal vehicle components and hot hydraulic fluids.

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- Reduced Wheelcut
- Steering Wheel Kick
- Binding, Darting, and Oversteer
- Directional Pull
- Road Wander/Loose Steering
- Non-Recovery
- Shimmy
- Noise
- External Leakage

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Introduction

Understanding the Complaint

Steering systems for heavy duty trucks are made up of many components from the steering wheel to the road wheel. The purpose of the steering system is to give the driver directional control of the vehicle.

When a driver feels the steering control over his/her vehicle is not like it should be, it is up to you to determine if there is a problem, and if so, figure out what is causing it. It is always easier to fix something if you really understand the complaint. Some ways you could do this are:

- Talk to the driver and ask a lot of questions like "what, when, where, and how"
- Make sure you can feel or see the problem. Have the driver show you exactly what he/she means.
- Walk around the truck, looking for anything that may be an obvious cause of the problem.

To make your job easier and faster this manual has both the flow charts and test procedures/comments, each in their own section. Once you have a good understanding of what the complaint is, choose the flow chart that best matches the symptoms described to you. Because there are different ways to say the same thing, we have provided our definitions of the 10 most common complaints in this book. Use these to determine which section of the manual would be helpful to begin diagnosing the steering system.

Reading the flow charts:

Start the chart at the **BEGIN** box. Follow the lines to the next box answer the question or perform the test to verify the cause of the complaint, then proceed to the next step. These boxes are arranged in order of likelihood of being the cause of the driver's complaint. **It is important to complete the tests, in order, and follow the flow of the chart**. Locate correct test number in the TEST PROCEDURES section, and follow the test procedure. When you are done with the test, note the results and correct the root cause. If condition still exists, keep going through the chart (if necessary, to correct the problem). The results of some tests will need to be recorded. Use the TEST RESULTS section to record these values.

If you identify a problem through a test procedure it is important that you retest the vehicle to make sure the condition has been corrected.

Warranty

If you have identified that a steering component on your vehicle needs to be replaced, this does not always mean it is warrantable. Please read your manufacturer's warranty carefully before submitting a steering component for warranty consideration.

Definitions

1. Hard Steering

Hard Steering is when steering effort at the steering wheel is more than 200 inch pounds (typically 18-22 lbs at the rim of the steering wheel). Steering is still possible, but there is not enough power assist.

Common phrases used:

- Won't turn
- Locks-up
- Shuts-down
- Turns hard
- Hangs-up
- No assist
- Won't turn unless moving

2. Reduced Wheelcut

Common phrases used:

- Too great of turning radius required
- Wheelcut restricted
- Not enough turns lock to lock

3. Steering Wheel Kick

Steering Wheel Kick is when the road wheels hit a bump that the steering wheel reacts to. The kick is usually dampened out quickly.

Common phrases used:

- Kickback
- Backlash
- Bump steer

4. Binding, Darting and Oversteer

Binding is a change or increase in steering wheel effort. Binding will usually not require the effort levels described in Hard Steering, unless it is severe. Darting and oversteer are words that mean the driver suddenly gets more turning than he/she wants.

5. Directional Pull

Common phrases used:

- Steering pulls to the right (or left)
- Truck pulls to the right (or left)
- A constant force is required to keep the truck going straight

Definitions

6. Road Wander/Loose Steering

Common phrases used:

- Lash in steering
- Lost motion in steering
- Continual corrections are needed at the steering wheel to keep the vehicle from wandering

7. Non-Recovery

Common phrases used:

- Wheels don't return to straight ahead

8. Shimmy

A severe Shimmy condition can be felt at the steering wheel. Typically once something triggers a Shimmy condition to occur it is sustained until the driver does something (such as slow down) to dampen out the condition.

Common phrases used:

- Shake at steering wheel

9. Noise

Common phrases used:

- Steering is noisy
- Clicking or clunking sound is heard when steering

10. External Leakage

Common phrases used:

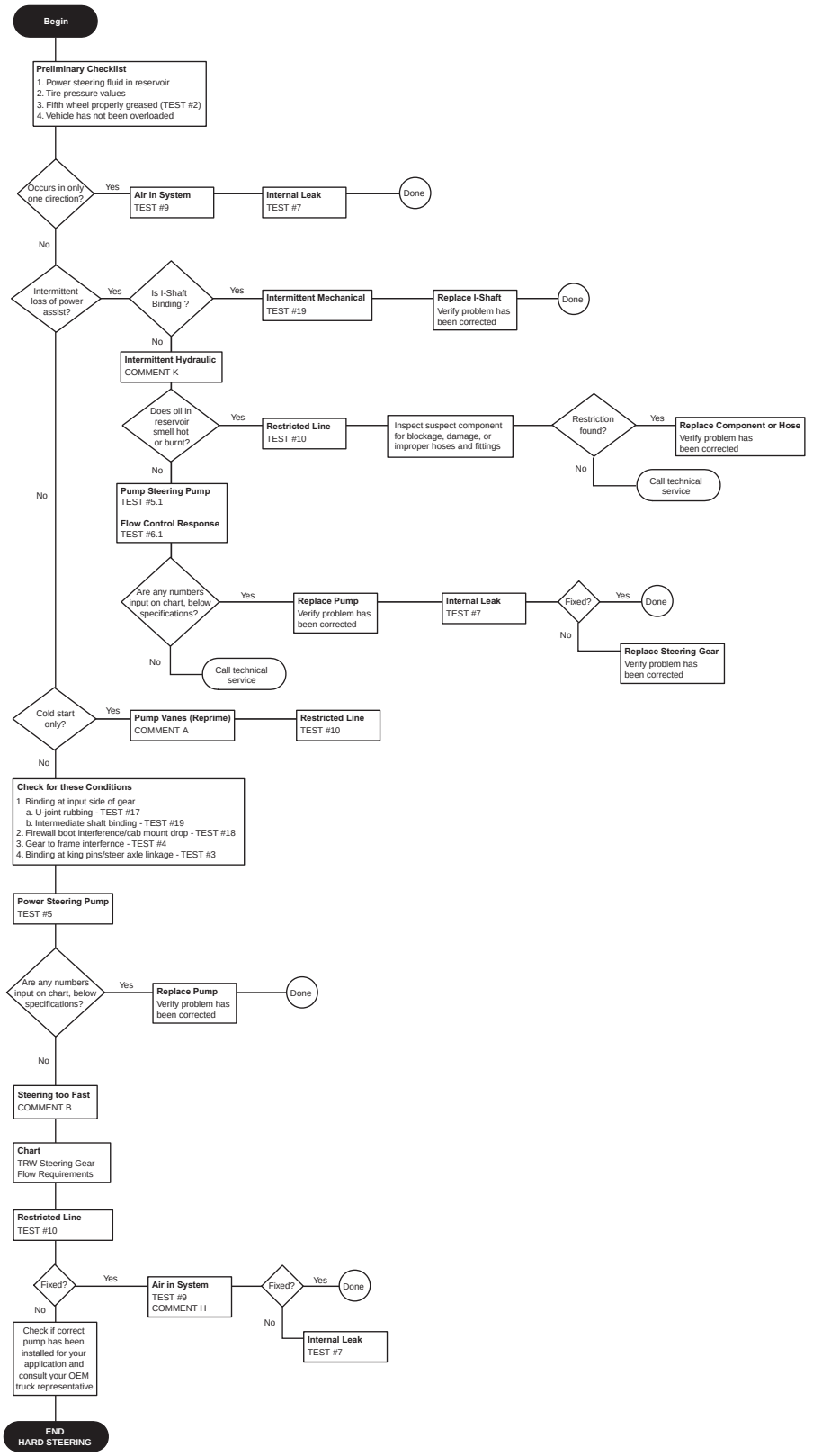
- Loss of steering fluid
- Continual adding of fluid in reservoir required

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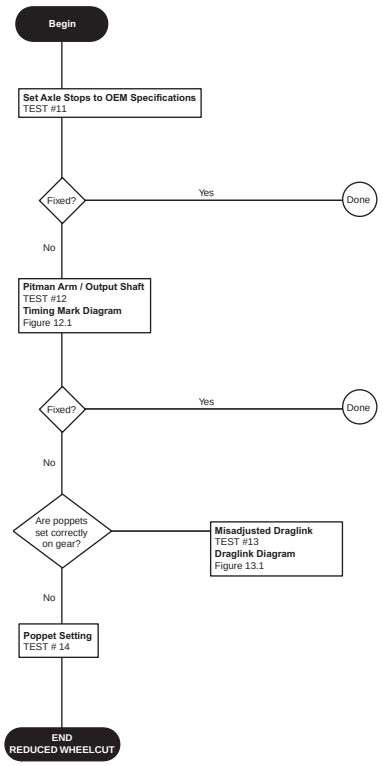
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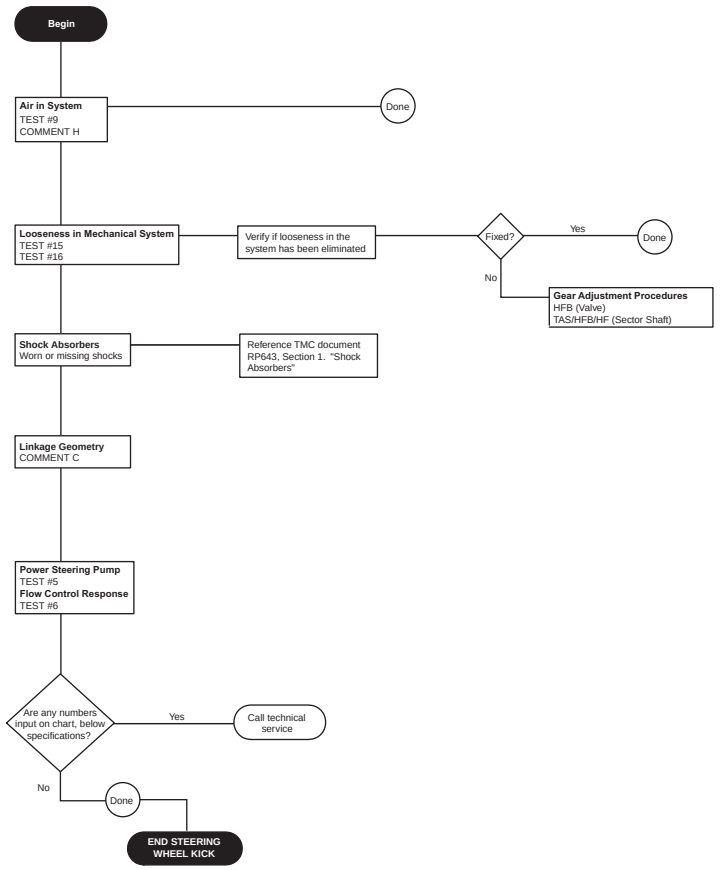
Hard Steering



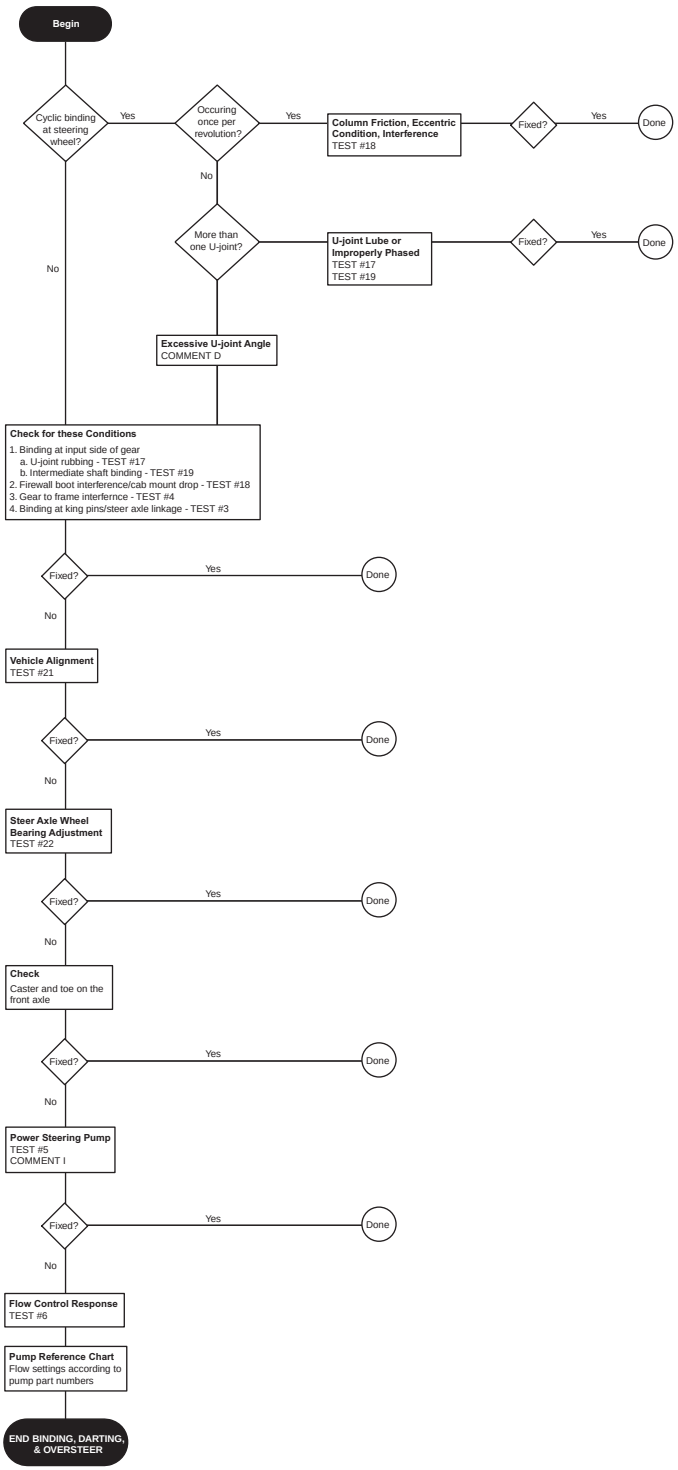
Reduced Wheelcut



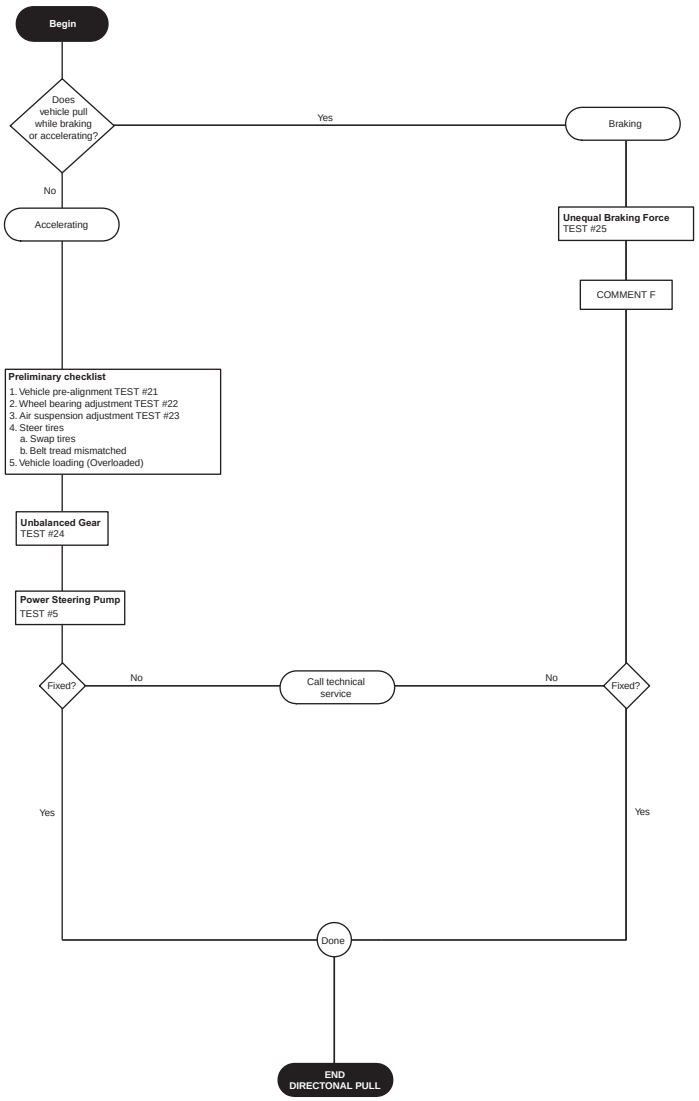
Steering Wheel Kick



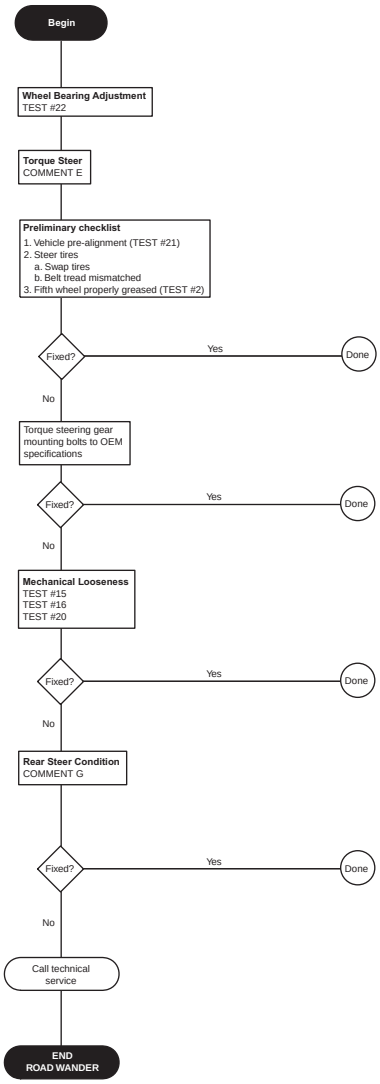
Binding, Darting, and Oversteer



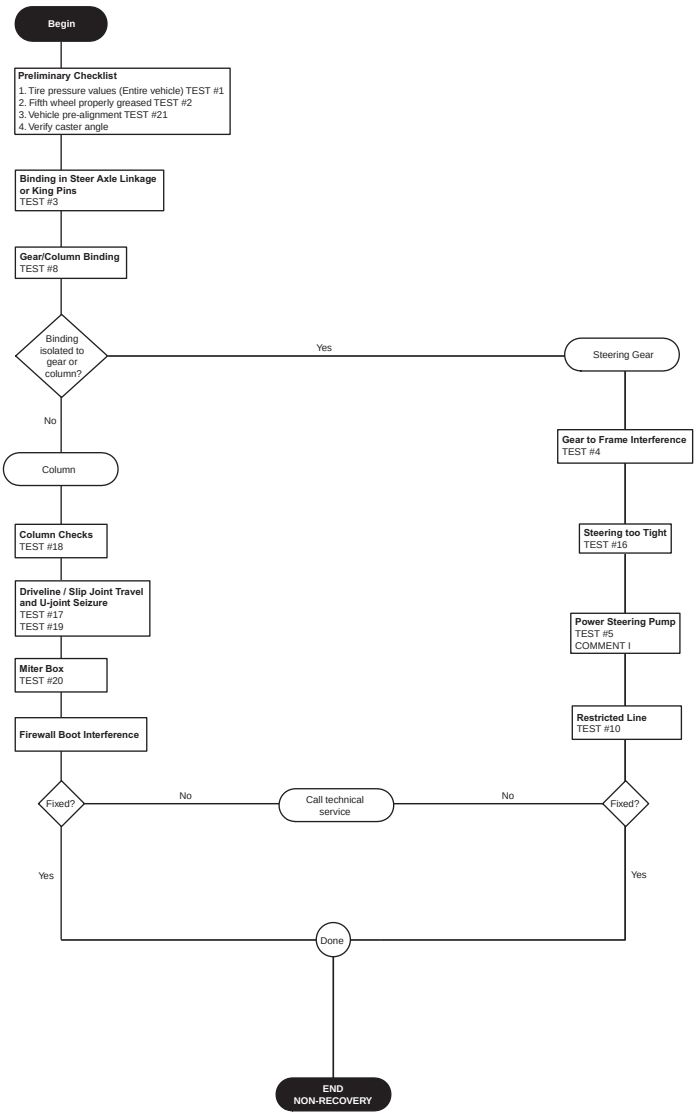
Directional Pull



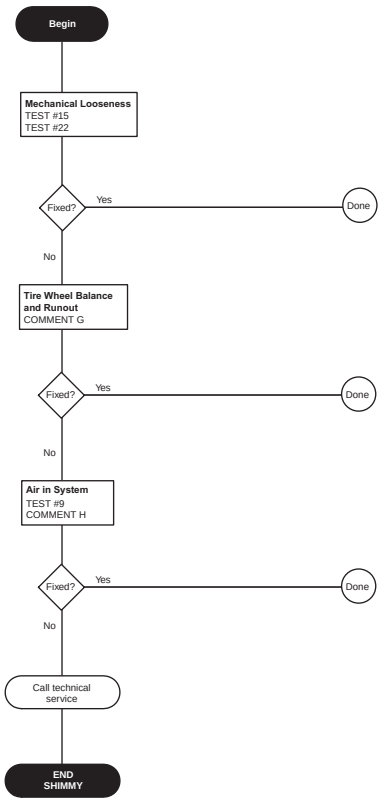
Road Wander/Loose Steering



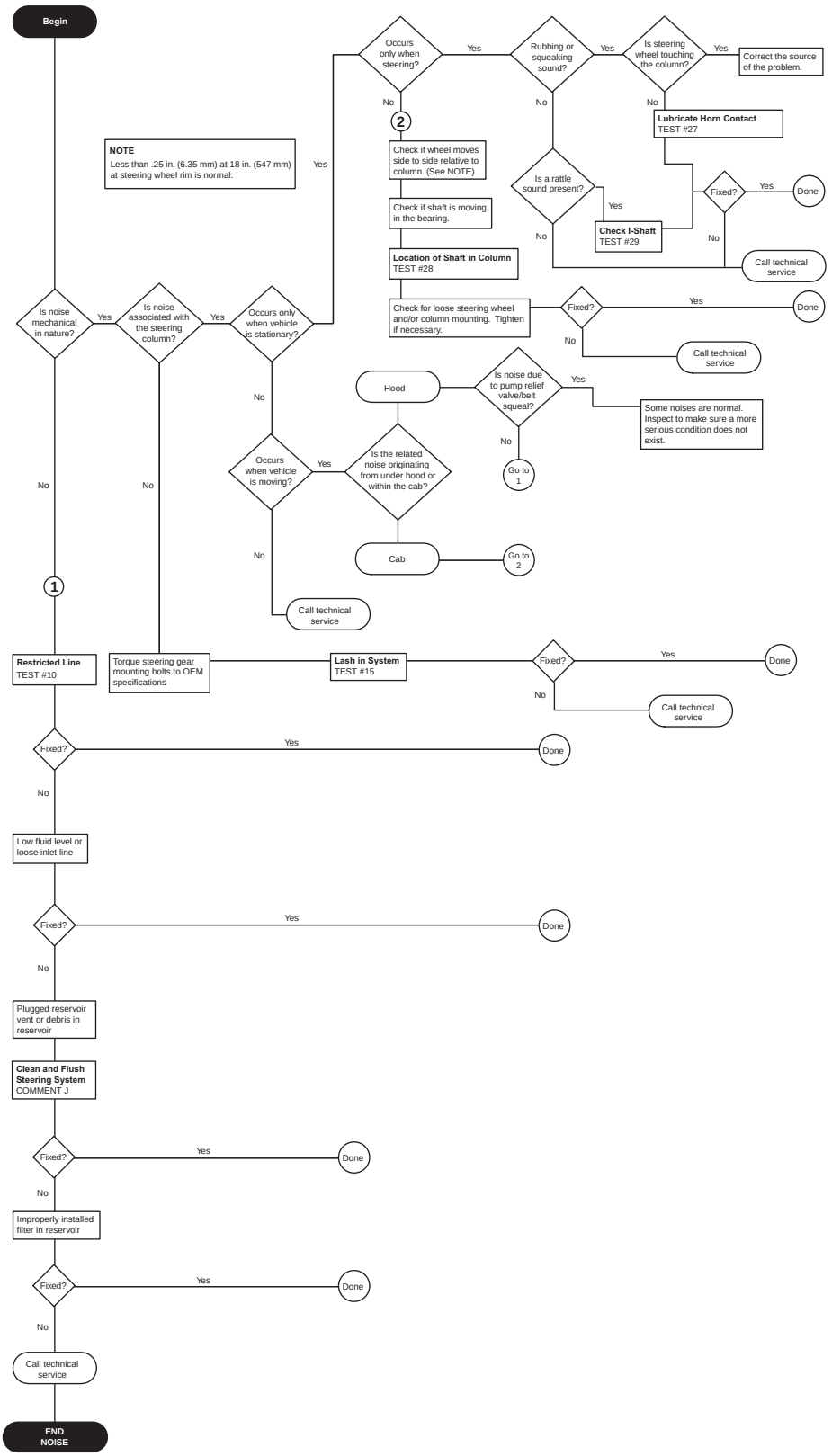
Non-Recovery



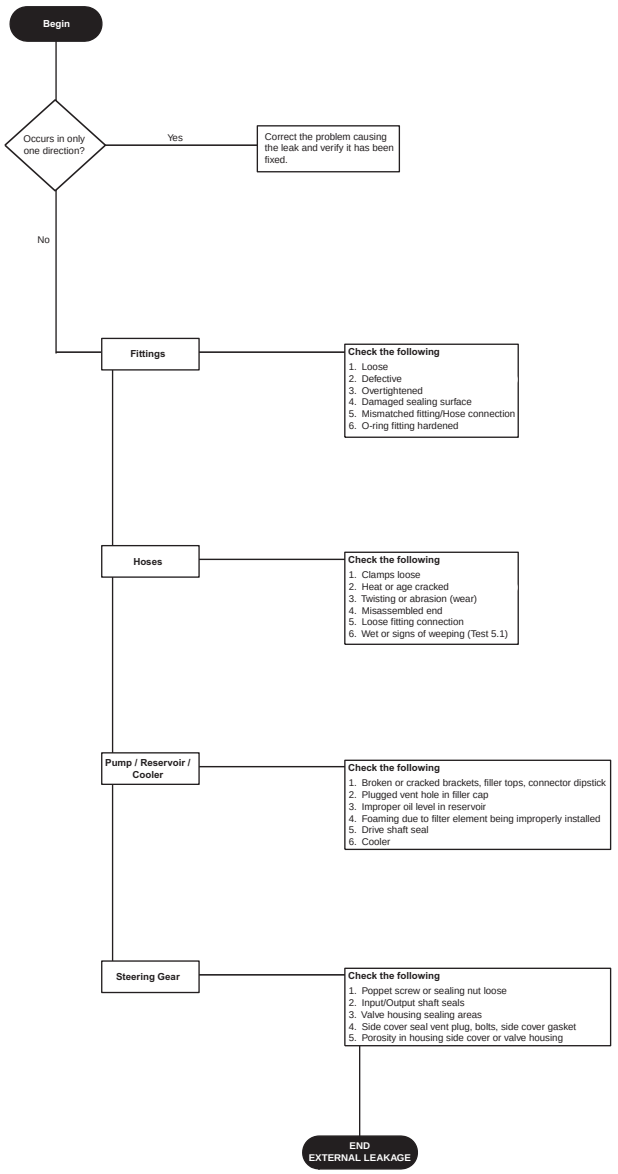
Shimmy


Begin
Mechanical Looseness
TEST #15
TEST #22
Fixed?
Yes
Done
No
Tire Wheel Balance and Runout
COMMENT G
Fixed?
Yes
Done
No
Air in System
TEST #9
COMMENT H
Fixed?
Yes
Done
No
Call technical service
END SHIMMY

Noise


Begin
Occurs only when steering?
Yes
Rubbing or squeaking sound?
Yes
Is steering wheel touching the column?
Yes
Correct the source of the problem.
No
No
No
2
Lubricate Horn Contact TEST #27
NOTE
Less than .25 in. (6.35 mm) at 18 in. (547 mm) at steering wheel rim is normal.
Yes
Check if wheel moves side to side relative to column. (See NOTE)
Is a rattle sound present?
Yes
Fixed?
Yes
Done
Check if shaft is moving in the bearing.
Check I-Shaft TEST #29
No
No
Location of Shaft in Column TEST #28
Call technical service
Is noise mechanical in nature?
Yes
Is noise associated with the steering column?
Yes
Occurs only when vehicle is stationary?
Check for loose steering wheel and/or column mounting. Tighten if necessary.
Fixed?
Yes
Done
No
Call technical service
Hood
Is noise due to pump relief valve/belt squeal?
Yes
Some noises are normal. Inspect to make sure a more serious condition does not exist.
No
No
No
Occurs when vehicle is moving?
Yes
Is the related noise originating from under hood or within the cab?
Go to 1
No
Cab
Go to 2
1
Call technical service
Restricted Line TEST #10
Torque steering gear mounting bolts to OEM specifications
Lash in System TEST #15
Fixed?
Yes
Done
No
Call technical service
Fixed?
Yes
Done
No
Low fluid level or loose inlet line
Fixed?
Yes
Done
No
Plugged reservoir vent or debris in reservoir
Clean and Flush Steering System COMMENT J
Fixed?
Yes
Done
No
Improperly installed filter in reservoir
Fixed?
Yes
Done
No
Call technical service
END NOISE

External Leakage



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Test #1
Steer Tire Check

1. Look for: Tire damage, Uneven or extreme tread wear, mismatched tires or other wear indicators that would cause the problem. *Figure 1.1.*

2. Check tire pressures on steer axle tires. *Figure 1.2.*


Figure 1.1


Figure 1.2

Test #2
Fifth Wheel and Trailer Plate

1. Look for dry fifth-wheel or trailer plate. *Figure 2.1.*

2. Look for damage to fifth-wheel or trailer plate. *Figure 2.2.*

3. Inspect fifth-wheel for looseness.

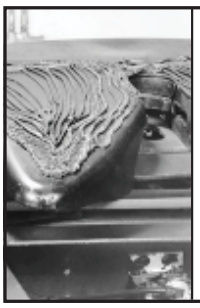

Figure 2.1


Figure 2.2

Test #3
Steer Axle and Linkage Binding

1. With vehicle steer tires on radius plates (turntables) or equivalent, disconnect the drag link or pitman arm from the steering gear, (and linkage from assist cylinder if there is one on the vehicle). *Figure 3.1.*

⚠ CAUTION **Do not steer the gear with linkage removed, as misadjustment of automatic poppets may result.**

2. By hand, pull the tire to one axle stop and release (engine off). The tire should self-return to near straight ahead. *Figure 3.2.*

3. Repeat the test in the opposite direction.

4. If tire does not self-return to near straight ahead, a problem is likely in steer axle king pin bushings/bearings or linkage.

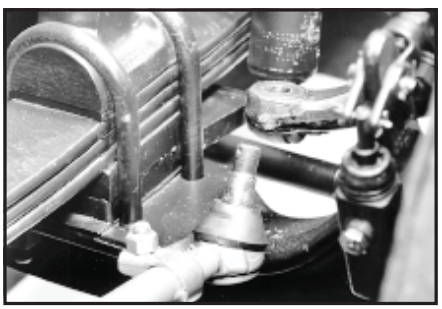

Figure 3.1


Figure 3.2

Test #4
Steering Gear Mounting

1. Look for anything between the steering gear and frame that could cause a binding problem. For example: hoses or brackets that have been routed, or are interfering between the steering gear and frame, frame flanges or spring mounting points. *Figure 4.1*. Mounting pads lower than steering gear housing, lack of clearance between frame and steering gear valve housing adapter, sector shaft adjusting screw and nut contact with access adjustment hole in frame. If interference is found, correct the problem.

2. If the steering gear has been mounted to the frame in a way that causes the gear to distort (not be flat), it may cause a steering problem. *Figure 4.2*. Checking to see if distortion is present on the vehicle may require the following test:

3. With vehicle parked and engine running, steer the wheel slowly checking for a binding-type of feel at the steering wheel. When binding is felt (stop engine loosen one mounting bolt restart engine) and steer the vehicle again. Continue to loosen one mounting bolt at a time, shutting off engine each time, and check for improvement in the binding condition. If improvement is made by loosening the bolts, determine by inspection the condition causing the gear to distort and correct the problem. Distortion of .030" (.80 mm) or less is acceptable. If greater than .030" (.80 mm) surface flatness, condition must be corrected.

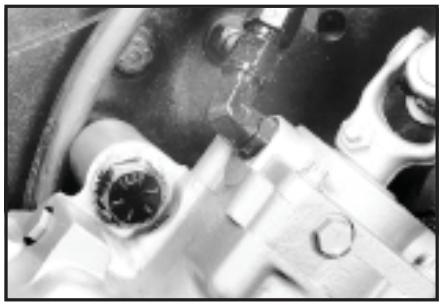


Figure 4.1

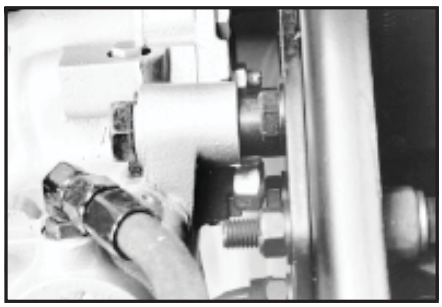


Figure 4.2

Test #5
Power Steering Pump Test

IMPORTANT: Read the following instructions below before completing **Table 5**, located in the "TEST RESULTS" section.

Verify Engine Idle speed per your OEM specifications.

1. Install temperature gauge in reservoir. *Figure 5.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 5.2.*

2. Run the engine at 1000 rpm.

⚠ CAUTION	**When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gauge. Do not allow the system to exceed 3000 psi (207 bar) for safety of personnel and to prevent damage to the vehicle.**

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build- up.**

3. Measure and record the following flow and pressure readings (see chart) by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. *Figures 5.3-5.7.*

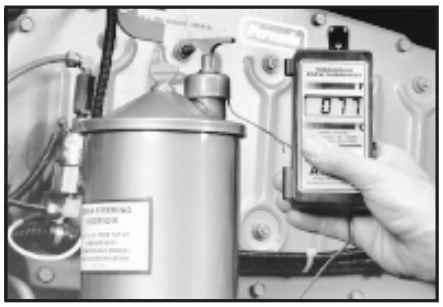
4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed.

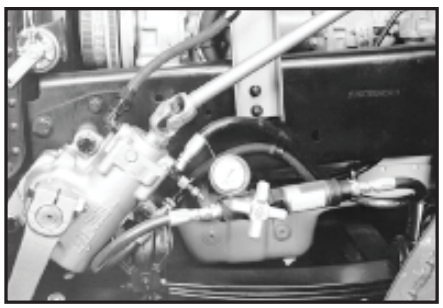
5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

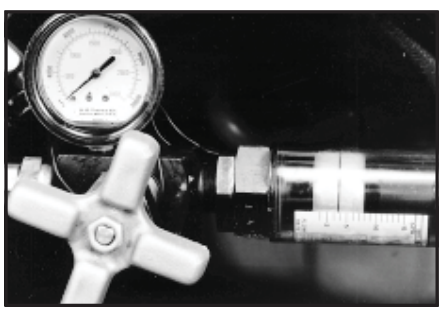
6. Compare the minimum and maximum flows (and the relief pressure you measured) to gear and pump specifications.

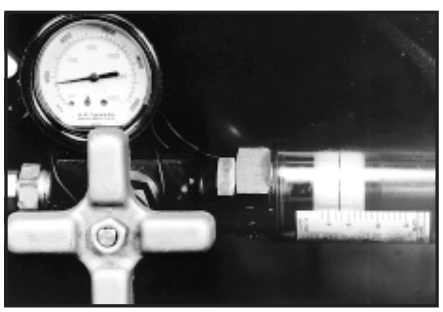
7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used (see **Steering Gear Flow Requirements** chart), the pump may not be putting out enough flow for an adequate steering speed. If the maximum system pressure is lower than that specified for the pump (check your manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

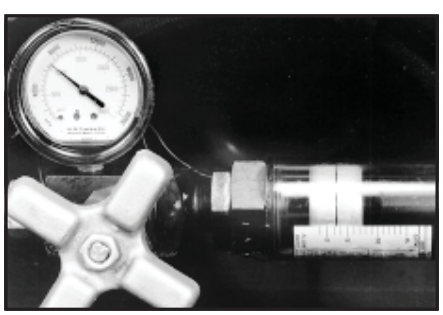
NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.


Figure 5.1


Figure 5.2


Figure 5.3


Figure 5.4


Figure 5.5

Test #5.1
40 Minute Power Steering Pump Test

IMPORTANT: Read the following instructions below before completing **Table 5.1** in the "Test Results" section.

Verify Engine Idle speed per your OEM specifications

1. Install temperature gauge in reservoir. *Figure 5.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 5.2.* Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30 and 40 minutes. Do not allow the temperature to exceed 250° F (121° C).

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

2. Run the engine at idle speed.

⚠ CAUTION	**When closing the PSSA shut off valve, do so slowly and keep an eye on the pressure gage. Do not allow the system to exceed 3000 psi (207 BAR) for safety of personnel and to prevent damage to the vehicle.**

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up.**

3. Measure and record the following flow and pressure readings (see chart) by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed. *Figures 5.3-5.7.*

4. Now with the load valve fully open, increase the engine speed to governed RPM and measure and record the following flow and pressure readings by adjusting the load valve while listening for any unusual noises as the valve is being opened and closed.

5. Determine the recommended flow range and maximum allowable system pressure for the steering system being used by referring to your service manual.

6. Compare the minimum and maximum flows, and the relief pressure you measured to gear and pump specifications.

7. If the minimum measured pump flow is less than the minimum recommended flow for the steering gear used (see **Steering Gear Flow Requirements** chart), the pump may not be putting out enough flow for an adequate steering speed. If the maximum

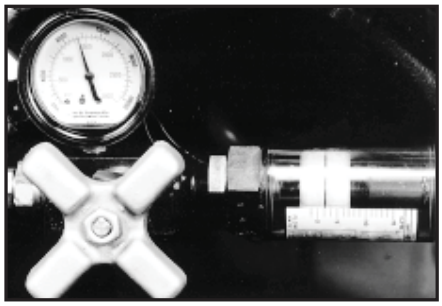


Figure 5.6

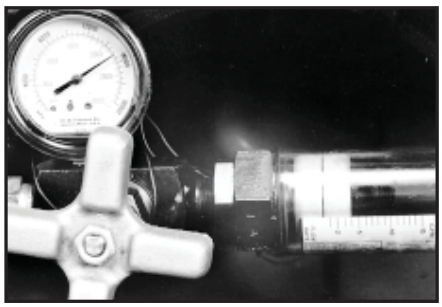


Figure 5.7

system pressure is lower than that specified for the pump (refer to your OEM service manual), it may not be developing enough pressure to steer. If either case exists, the pump needs to be repaired or replaced.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

Test #6
Pump Flow Control Response

IMPORTANT: Read the following instructions below before completing **Table 6**, in the "Test Results' section

1. Install temperature gauge in reservoir. *Figure 6.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 6.2.*

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up. (Do not allow the pressure to exceed 3000 psi (207 bar).**

2. With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test three times at idle and three times at 1500 RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

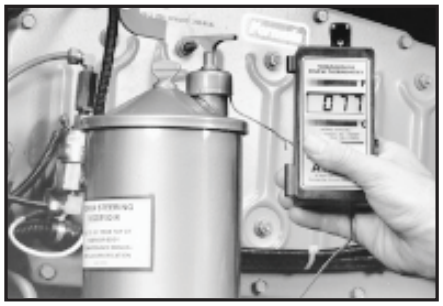


Figure 6.1

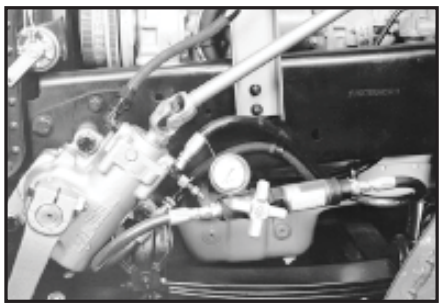


Figure 6.2

Test #6.1
40 Minute Pump Flow Control Response

Read the following instructions below before completing **Table 6.1** in the "Test Results' section

1. Install temperature gauge in reservoir. *Figure 6.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 6.2.* Park the vehicle outside. Record ambient temperature. Run the engine at governed RPM for 40 minutes to bring the fluid up to an elevated testing temperature. Measure and record the fluid temperature at the start and at 10, 20, 30, and 40 minutes. Do not allow the temperature to exceed 250° (121°C)

NOTE	If the temperature goes over 250° F (121° C) , or 150° F (66° C) above the surrounding temperature (ambient) at any time during the test, stop the test. This temperature level is considered extreme and steering system performance and life will be seriously affected. Damage to hoses, seals, and other components may result if operated at extreme temperature. If the steering system is operating above the recommended temperatures, the heat problem may be the root cause of the complaint.

⚠ CAUTION	**Do not keep the load valve closed for more than 5 seconds at a time because damage to the system may result from excessive heat build-up. (Do not allow the pressure to exceed 3000 psi (207 bar).**

2. With the engine at idle, note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading you noted above.

3. With the load valve open run the engine to governed speed and note the flow rate. Fully close the load valve until the flow drops to zero. Quickly open the load valve observing the flow meter. The flow rate must instantly return to the reading noted above.

4. Conduct this pump response test three times at idle and three times at 1500 RPM. If the flow rate does not return immediately, the pump is malfunctioning, which can result in momentary loss of power assist

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

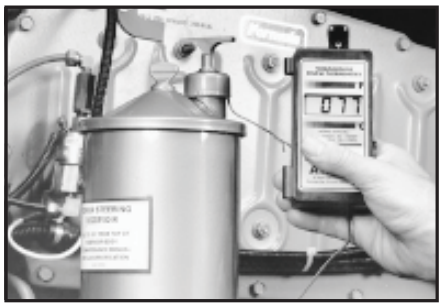


Figure 6.1

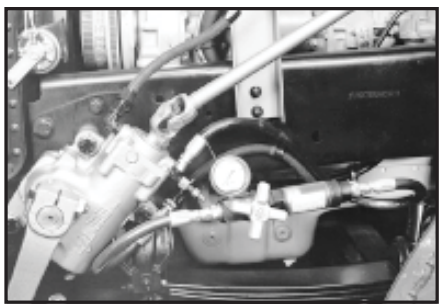


Figure 6.2

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Test #7
Measured Internal Leakage

1. Install temperature gauge in reservoir. *Figure 7.1.* Install PSSA in pressure line with shut-off valve fully open. *Figure 7.2.*

⚠ WARNING	**THIS TEST CAN BE DANGEROUS IF NOT PERFORMED CORRECTLY. KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.**

2. To test the steering gear for internal leakage, you must first prevent operation of the gear's internal unloading (poppet) valves or relief valve (or both, in some gears). This will allow full pump relief pressure to develop. To prevent operation of the poppets, place an unhardened steel spacer block, about one inch thick and long enough to keep your fingers clear between the axle stop at one wheel. *Figures 7.3-7.4.* To prevent operation of the relief valve, remove the relief valve cap, o-ring and two piece relief valve, if equipped, from valve housing. Install the relief valve plug, special tool number J37130 in its place.

NOTE	Be sure you reinstall the relief valve and valve cap with new o-ring, back onto the gear after leakage test.

⚠ CAUTION	**When running this test, do not hold the steering wheel in the full turn position for longer than 5 to 10 seconds at a time to avoid damaging the pump.**

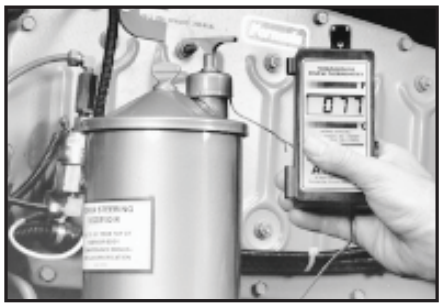
⚠ WARNING	**KEEP YOUR FINGERS CLEAR OF THE AXLE STOPS AND SPACER BLOCK DURING THIS TEST. MAKE SURE THAT THE SPACER BLOCK CONTACTS THE AXLE STOP SQUARELY. CONTACT THAT IS NOT SQUARE COULD BREAK THE AXLE STOPS OR DANGEROUSLY THROW OR EJECT THE SPACER BLOCK.**

3. With the fluid temperature between 125-135° F (52-57° C), turn the steering wheel until the axle stop bolt contacts the spacer block.

4. Apply 20 pounds of force to the rim of the steering wheel during this test to be sure that the steering gear control valve is fully closed. *Figure 7.5.* The pressure gauge should now read pump relief pressure, as noted during the Flow Control Response Test (Test #6). You can now read steering gear internal leakage on the flow meter.

5. Repeat this test for the opposite direction of turn.

6. If internal leakage is greater than 1 gpm (3.8 lpm) and there is no auxiliary hydraulic linear or rotary cylinder in the system, repair or replace the gear. If the internal leakage is greater than 2 gpm (7.6 lpm), and there is an auxiliary hydraulic linear or rotary cylinder in the system, controlled by the gear, isolate the auxiliary cylinder from the system by disconnecting the auxiliary cylinder hydraulic


Figure 7.1

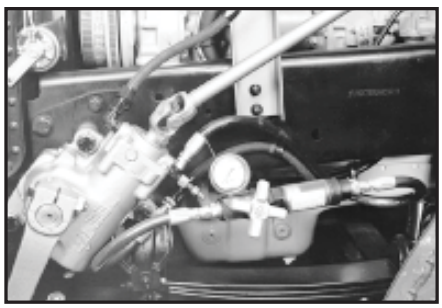

Figure 7.2


Figure 7.3

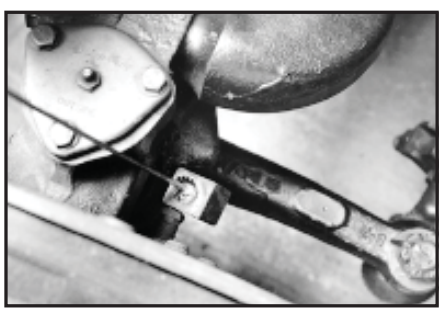

Figure 7.4


Figure 7.5

lines at the gear auxiliary ports. Plug the steering gear ports with suitable steel or high pressure plugs or caps.

In the event that a rotary cylinder is used in the system, connect the disconnected lines together with a suitable union fitting. In the case of a linear cylinder, first plug the disconnected lines and then disconnect the cylinder from the steering linkage, making sure it will clear the steered axle. *Figures 7.6-7.7.*

Repeat the internal leakage test. If the internal leakage is less than 1 gpm (3.8 lpm), repair or replace the auxiliary cylinder. If the internal leakage is greater than 1 gpm (3.8 lpm), repair or replace the gear.

NOTE	When hydraulic tests are completed and fluid lines are reconnected, check fluid level and bleed the air from the hydraulic system.

Test #8
Steering Column Binding

1. With the vehicle parked, the engine off, and the steer axle jacked-up, slowly steer the vehicle until the binding position is located.

2. With the steering gear at this position, remove the steering column assembly from the steering gear. Note the correct position of the column and steering gear for reassembly after test. *Figure 8.1*

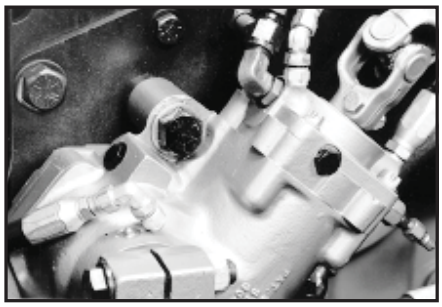
3. Rotate the steering gear input shaft no more than 1/4 turn each direction and check if binding is still present. *Figure 8.2* If binding is not felt, correct the steering column problem.

Test #9
Air in Hydraulic System

1. Inspect reservoir for foaming or air bubbles. *Figure 9.1* If foaming or bubbles are seen, air is being sucked into the system through cracks or loose fittings. Look for oil level changes engine off versus engine on, if fluid level increases when the vehicle is shut off, there is an air pocket trapped in the steering gear. The increase may not be noticeable, depending on the size of the pocket.

2. Bleed the steering gear (if there is a manual bleed screw at the top of the gear). With system at normal operating temperature and engine at proper idle speed and running, open the bleed screw and wait until clean, clear oil begins to flow from the gear. Close the bleed screw and steer the vehicle completely from stop to stop.

3. Repeat the bleeding operation three times, and recheck oil level in reservoir to make sure there is enough oil for the system to operate properly.


Figure 7.6

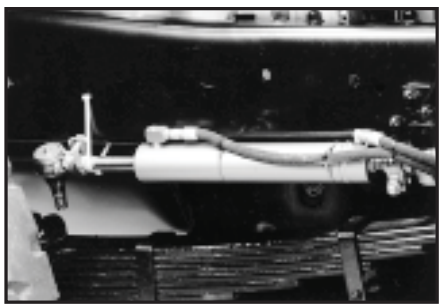

Figure 7.7


Figure 8.1

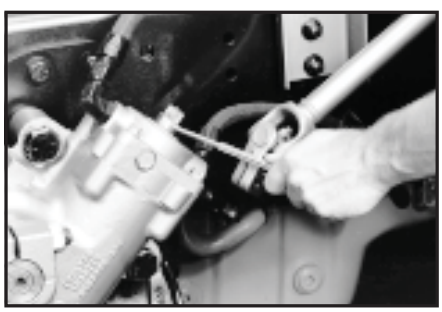

Figure 8.2


Figure 9.1

Test #10
Restricted Hydraulic Line

Read the following instructions below before completing **Table 10**, in the "Test Results' section

1. Look at the supply line that goes to the pump to check for kinking or any other obstructions or irregularities on the inside of the hose. *Figure 10.1.*

2. Install PSSA with load valve fully open. *Figures 10.2-10.3.* Insert temperature gauge into reservoir. With oil between 125-135 °F (52-57 °C), determine a test engine speed (RPM) that causes pump to deliver 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm) (whichever is easier) and note this speed.

3. Remove the PSSA and install a low pressure gauge (200-300 psi (14-21 bar)) maximum with approximately 10 psi (.70 bar) per division) in the pressure line to the steering gear at the pump end. Install a temperature gauge in the power steering reservoir.

⚠ CAUTION	**Do not allow system pressure to exceed the rating of the gauge during the following procedure or damage to the gauge will result. Extremely high restrictions may be indicated with the PSSA gauge as installed with load valve fully open.**

NOTE	Be sure that the steering gear input shaft is not being restrained from recentering because this will cause a false steering gear pressure drop. If there is any question, conduct this test with the steering column removed.

4. Bring the power steering fluid temperature to 125-135 °F (52-57 °C), at engine idle, with no steering force applied to the steering wheel. *Figure 10.4.*

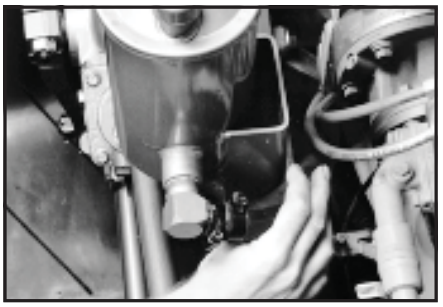
5. At the test engine speed selected from step 2 above, measure and record the gauge reading and shut off the engine. This measures total system pressure.

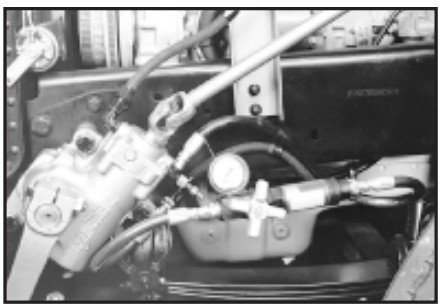
6. Remove the pressure and return lines from the steering gear and connect them together with a fitting that will not restrict the flow. *Figure 10.5.*

7. Start the engine, and run at the RPM identified in step 2 with the fluid temperature between 125-135 °F (52-57 °C).

8. Measure and record gauge reading and shut off engine. This is hydraulic line/reservoir pressure.

9. The difference between the total system pressure gauge reading and the hydraulic line/reservoir pressure gauge reading is the steering gear pressure drop. For a TRW steering gear, at a flow of 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm), the drop should not be greater than 30, 40, 55 or 70 psi (2.0, 2.8, 3.8, 4.8 bar) respectively. The line/reservoir pressure drop for a flow of 3, 4, 5 or 6 gpm (11, 15, 19, or 23 lpm) should not be greater than 20, 20, 25 or 25 psi (1.4, 1.4, 1.7, 1.7 bar) respectively.


Figure 10.1


Figure 10.2

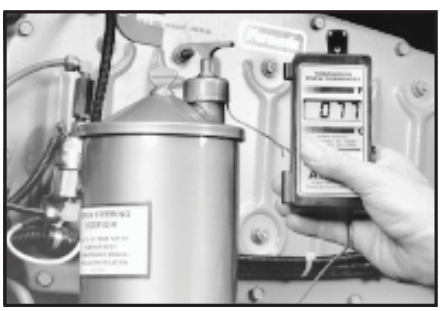
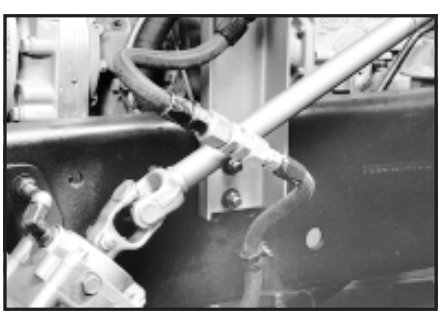

Figure 10.3

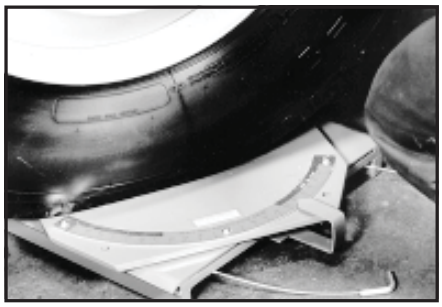


Figure 10.4


Figure 10.5

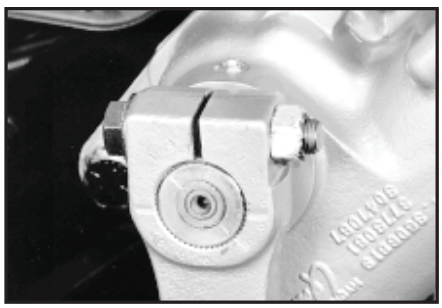
Test #11
Axle Stop Setting

Put vehicle steer tires on radius plates (turntables). Check to make sure axle stops are set to manufacturer's specifications. *Figure 11.1.*


Figure 11.1

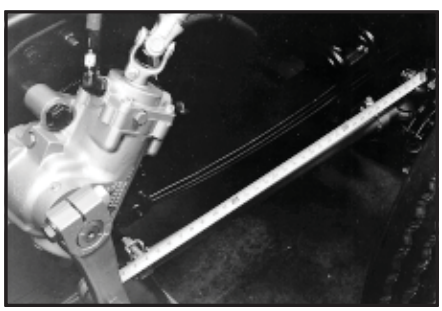
Test #12
Pitman Arm and Output Shaft Alignment

Look to make sure the output shaft timing mark is lined up with the pitman arm timing mark. Some pitman arms have more than one mark, so make sure the right one is used. *Figure 12.1.*


Figure 12.1

Test #13
Misadjusted Drag Link

The length of the drag link must be correct for the steering system. Check the length after you make sure the pitman arm/ shaft timing marks are aligned, the gear is at its center position, and the road wheels are straight ahead. *Figure 13.1.*


Figure 13.1

Test #14
Poppet Setting Procedure

1. If you are working on a newly-installed TAS steering gear, refer to the service manual to correctly set the poppets. If you are working on a steering gear, other than a TAS series, refer to the OEM's service manual for correct poppet setting instructions.

2. To set poppets on a TAS series gear using the adjustable service kit, refer to your steering gear service manual.

Test #15
Lash in Steering System

Two people are needed for this test. One person will slowly turn the steering wheel back and forth one-quarter turn each way from center with the engine idling. The other person should check for looseness at each of the following areas from steering wheel to road wheels: *Figures 15.1-15.5.*

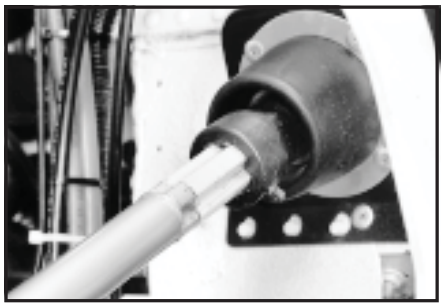
* Steering wheel to steering column
* U-joints, or slip-joint and/or miter boxes
* Steering column to steering gear input shaft
* Steering gear input shaft to steering gear output shaft
* Pitman arm to output shaft
* Drag link to pitman arm connection
* Drag link ends (sockets) and adjustable areas
* Axle arm to drag link connection
* King pin axle connections (bushings)
* Tie rod arms to tie rod connection
* Tie rod ends (sockets) and adjustable areas
* Steering spindle
* Wheel bearings
* Lug nuts
* Spring pin connectors
* Front axle u-bolts
* Spring hanger brackets/rear shackles

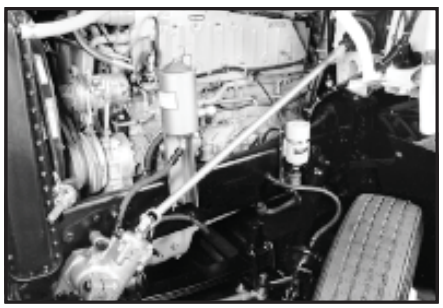
NOTE	Cracked or broken components can cause symptoms similar to loose components but may be more difficult to find.

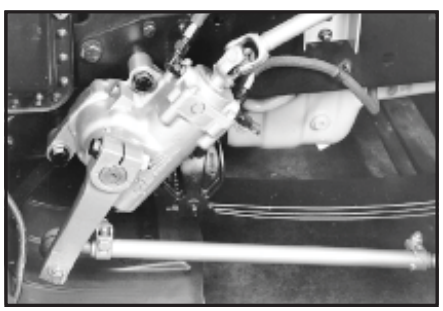
NOTE	Be sure to check rear drive axles for any looseness and inspect tires for signs of abnormal wear.

Test #16
Steering Gear Adjustment

Check and adjust according to the appropriate service manual for your steering gear if necessary


Figure 15.1


Figure 15.2


Figure 15.3

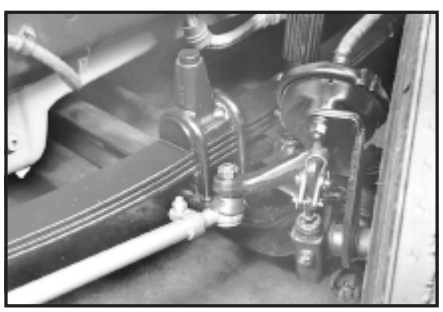

Figure 15.4


Figure 15.5

Test #17
U-Joint Phasing and Lubrication

1. Make sure u-joints are properly lubricated.

2. Steering column assemblies with more than one universal joint (cardan type) can cause a cyclic binding feel or torque variation at the steering wheel if the u-joints are not in phase with each other. *Figure 17.1-17.2*. If a steering column assembly with multiple u-joints is taken apart, it must be reinstalled with the timing marks for slip mechanisms aligned. This is true for both the cross-type and the splined-type two-piece intermediate shaft.

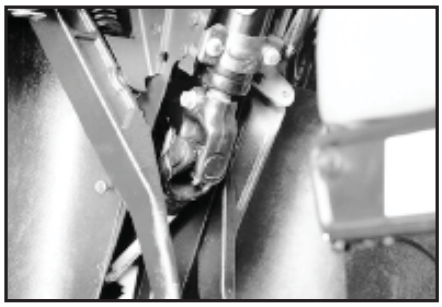


Figure 17.1

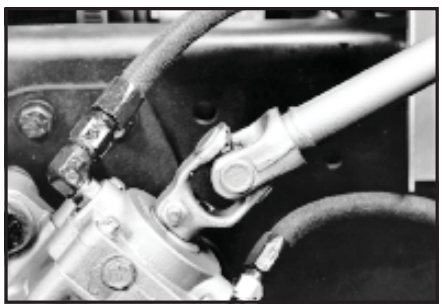


Figure 17.2

Test #18
Steering Column Interference

Position steering wheel at the location where steering wheel interference is noticed, and look for something interfering or rubbing on the rotating column assembly such as brackets, bolts, floorboard, boot, etc.

Test #19
Intermediate Column Interference

1. Check the slip column by looking to make sure there is proper travel allowance when in use. *Figure 19.1.*

2. Look for wear or galling. *Figure 19.2.*

3. Check slip column for too much slip force

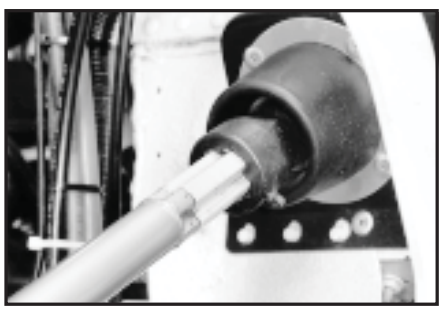


Figure 19.1

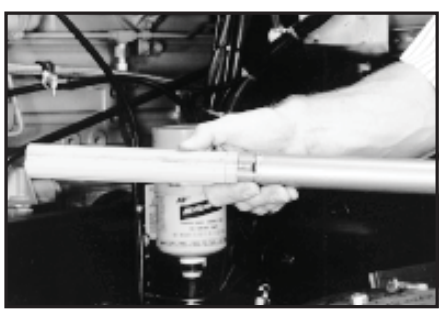


Figure 19.2

Test #20
Miter Box Misadjusted (if equipped)

Check and adjust per manufacturer's instructions. *Figure 20.1.*

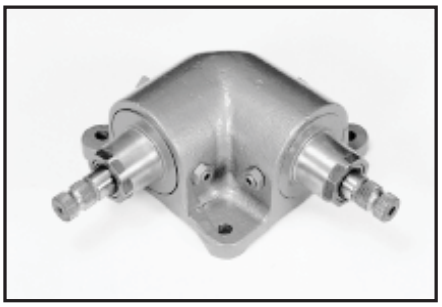


Figure 20.1

Test #21
Vehicle Alignment

Check alignment of steered axle and rear drive axles, and trailer axles (if problem only exists with trailer). *Figure 21.1.*

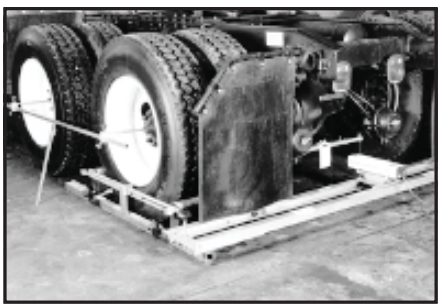


Figure 21.1

Test #22
Wheel Bearing Adjustment

Verify that adjustment is made according to manufacturer's specification. *Figure 22.1.*



Figure 22.1

Test #23
Air Suspension Adjustment

Check and set to manufacturer's specifications

Test #24
Gear Imbalance

1. Install a low pressure gauge (200-300 psi (14-21 bar) maximum with approximately 10 psi (.70 bar) per division) in the pressure line from pump to gear. *Figure 24.1.*

⚠ CAUTION **Do not allow system pressure to exceed the rating of the gauge in the following procedure or damage to the gauge will result.**

2. At engine idle, slightly turn the steering wheel one direction until a pressure rise is observed at the gauge. *Figure 24.2.*
3. Stop steering and gently allow the steering wheel to recenter.
4. Next slightly turn the steering wheel the opposite direction while observing the gauge and determine if pressure initially rises or falls with initiation of a turn.
5. Repeat test a few times in each direction.
6. If a consistent fall in pressure is associated with the initiation of a turn in one direction, the steering gear's control valve is unbalanced and needs to be replaced.

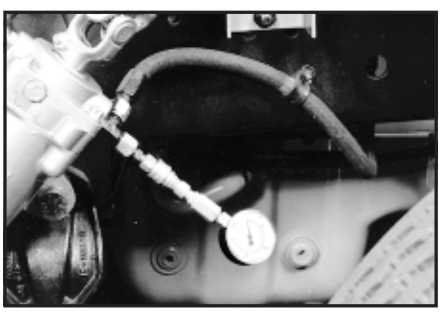


Figure 24.1

Test #25
Unequal Brake Force

Visually inspect brake assemblies for oil/grease on braking surfaces, and overall condition of brake surfaces. Adjust or replace brakes if necessary.



Figure 24.2

Test #26
Tire Balance / Runout

Have wheel assemblies balanced and checked for lateral and radial run out per manufacturer's specifications. Preferred method for checking balance is with wheels still on the vehicle. Balance includes total rotating assembly.

TEST #27
Steering Column Noise

If column does not include a clockspring, remove steering wheel and add dielectric grease to the horn contact. The grease TRW uses is Model No. K-5/X Semifluid CA, product code 134613, from Century Lubricants. If noise continues, check steering wheel and shroud (not applicable to columns with clockspring).

TEST #28
Steering Column Bearing

Check upper bearing gaskets. Gaskets should cover bearing.

TEST #29
Intermediate Column Lash

Check intermediate column (I-Shaft) for torsional lash in U-Joints of slip section. Replace intermediate column if necessary.

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Section 4 Comments

Comment A - H 36
Comment I - K 37

Comment A
Some power steering pumps have a temporary state during which the pumping element vanes do not extend. Usually increasing engine speed briefly will correct the problem.

Comment B
The maximum speed of steer with power assist for a power steering gear is limited by the pump flow and internal leakage. Example: Recommended minimum flow for a new TAS65 steering gear is 3.0 gpm (11.4 lpm), and is based on a maximum steering speed capability of 1.5 steering wheel turns per second.

Comment C
Vehicle linkages are designed to minimize the affect at the steering gear and steering wheel during normal steered axle/suspension movements. Be sure that linkage used is as specified by vehicle manufacturer.

Comment D
A single u-joint operating at an angle will cause a cyclic torque variation at the steering wheel. The amount of torque variation increases with the amount of operating angle. A secondary couple that side loads the input shaft also increases with increased u-joint angles. U-joint operating angles of 15 degrees or less will minimize the torque variation felt at the steering wheel.

Comment E
Deflections in the suspension and linkage, front and rear, due to high engine generated torque levels can cause a steering effect. This most often occurs at lower vehicle speeds while accelerating.

Comment F
The location of the axle arm ball center is important during spring wind-up conditions such as severe braking. A steering arm different from that specified by the manufacturer could cause a steering effect while braking.

Comment G
Soft or loosely supported rear suspensions may allow the rear driving axles to become non-square with the centerline of the chassis during load shifting or trailer roll which will tend to produce a steering effect.

Comment H
Power steering pump cavitation

Pump cavitation is defined as a "wining" or noisy power steering pump. Usually, pump cavitation is most noticed during engine start-up at low temperature extremes. However, other conditions can cause the power steering pump to continually cavitate and cause internal pump damage, and ultimately, failure. These conditions are:

1. Twisted, loose, or cracked inlet line
2. Inlet line blockage due to:
    a. Contamination - dirt and foreign material
    b. Damaged filters
    c. Reservoir components
    d. Inner hose liner separation
3. Displaced (improper or improperly installed) filters
4. Reservoir cap "vent" plugged

Comment I
Excessive Flow

TRW steering gears are rated for 8 gpm maximum power steering pump flow. Although the gears have the capability to handle this maximum flow, it is not always a system need or requirement. When using combinations of dual gears or a single gear with a hydraulic linear cylinder, supply flows for both components should be considered (See Steering Gear Flow Requirements). Single gear applications have a recommended flow at engine idle. For acceptable steering speed performance, again, refer to the Steering Gear Flow Requirements. Increasing the engine idle flow by more than 50% of the recommended flow can cause power steering system overheating, vehicle directional control problems (Darting), and steer axle returnability (Non-recovery). If you measure idle flows above the 50% limit, consult your OEM for guidance and recommendations.

Comment J
Flushing and Air Bleeding the System

IMPORTANT: Clean the area around the reservoir, steering gear and pump thoroughly before beginning this procedure.

1. Set parking brake on vehicle and block rear wheels.
2. Raise the front end off the ground
3. Take vehicle out of gear and put into neutral position
4. Raise hood and place a drip pan under the steering gear
5. Remove both the pressure and return lines from the steering gear
6. Remove filter from the power steering fluid reservoir and discard

IMPORTANT: Discard only the filter, other components may be required to hold filter element in place inside the reservoir.

7. Clean the inside of the reservoir
8. Turn steering wheel from full left to full right 3-4 times. This will purge the oil from the steering gear.
9. Reconnect pressure and return lines to the steering gear and tighten
10. Install new filter element into the reservoir
11. Clean reservoir filler cap with an approved solvent. Inspect gasket and replace if necessary.
12. Fill reservoir with approved replacement fluid and reinstall the filler cap
13. Start engine for 10 seconds, stop, and check reservoir fluid level and top off if necessary. You may need to repeat this procedure 3 or 4 times.
14. Upon completion of filling the reservoir, start the engine and let it idle. At engine idle, steer full right and full left once and return to straight ahead. Stop engine and check power steering reservoir level and top off if required.
15. Restart engine and steer full turns each direction 3 or 4 times.
16. Stop engine and recheck reservoir fluid level and adjust to correct level, if needed.
17. Inspect system for leaks and correct if necessary
18. Bleed air from the system if required (Refer to your steering gear service manual for recommended air bleeding procedures.)
19. Remove drip pan and lower vehicle. Remove blocks from wheels and release vehicle for normal service.

Comment K
Identifying “Burnt Oil”

Sometimes the power steering reservoir oil supply will become hotter than the normal operating temperature and overheat. This condition may result in an intermittent loss of power assist and also cause deterioration of the power steering hoses and component seals. TRW recommends that the power steering hoses be examined for deterioration due to overheated oil, which can be identified by wet hoses, and determine the condition of the reservoir fluid by looking for signs of “burnt oil.”

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Section 5 Test Results

Test 5 - Power Steering Pump Test 40
Test 5.1 - 40 Minute Power Steering Pump Test 40
Test 6 - Flow Control Response Test 41
Test 6.1 - 40 Minute Flow Control Response Test 41
Test 10 - Restricted Hydraulic Line Test 42
Steering Gear Flow Requirements 43
Pump Part Number Reference Guide 44

Test 5.0 - Power Steering Pump Test

Relief Pressure: _____ PSI/BAR

Engine(RPM)	No Load	1000PSI
Idle		
1500		

Table 5.0

Test 5.1 - 40 Minute Power Steering Pump Test

Ambient	
Start	
10 Minutes	
20 Minutes	
30 Minutes	
40 Minutes	
Unit of Measure	˚F or ˚C

Relief Pressure: _____ PSI/BAR

Engine(RPM)	No Load	1000PSI
Idle		
1500		

Table 5.1

Test 6.0 - Pump Flow Control Response Test

Unit of Measure	PSI or BAR
Pump Relief #1 (Idle)	
Pump Relief #2 (Idle)	
Pump Relief #3 (Idle)	

Unit of Measure	PSI or BAR
Pump Relief #1 (1500 RPM)	
Pump Relief #2 (1500 RPM)	
Pump Relief #3 (1500 RPM)	

Table 6.0

Test 6.1 - 40 Minute Pump Flow Control Response Test

Ambient	
Start	
10 Minutes	
20 Minutes	
30 Minutes	
40 Minutes	
Unit of Measure	°F or °C

Unit of Measure	PSI or BAR
Pump Relief #1 (Idle)	
Pump Relief #2 (Idle)	
Pump Relief #3 (Idle)	

Unit of Measure	PSI or BAR
Pump Relief #1 (1500 RPM)	
Pump Relief #2 (1500 RPM)	
Pump Relief #3 (1500 RPM)	

Table 6.1

Test 10.0 - Restricted Hydraulic Line Test

With PSSA @ 125 - 135 F (52 - 57 C)	RPM	GPM or LPM
With pressure gauge at pressure line to steering gear at pump end	RPM	GPM or LPM
Remove pressure and return lines and measure pressure with gauge at pump outlet	RPM	PSI or BAR

Table 10.0

Steering Gear Flow Requirements

Single Gear

Gear	GPM	LPM
TAS40, THP/PCF45, HFB52	2.2	8.3
TAS55, THP/PCF60	2.6	9.8
TAS65 or HFB64	3.0	11.4
TAS85 or HFB70	3.6	13.6
RCS40	2.2	8.3
RCS55	2.6	9.8
RCS65	3.0	11.4
RCS85	3.6	13.6

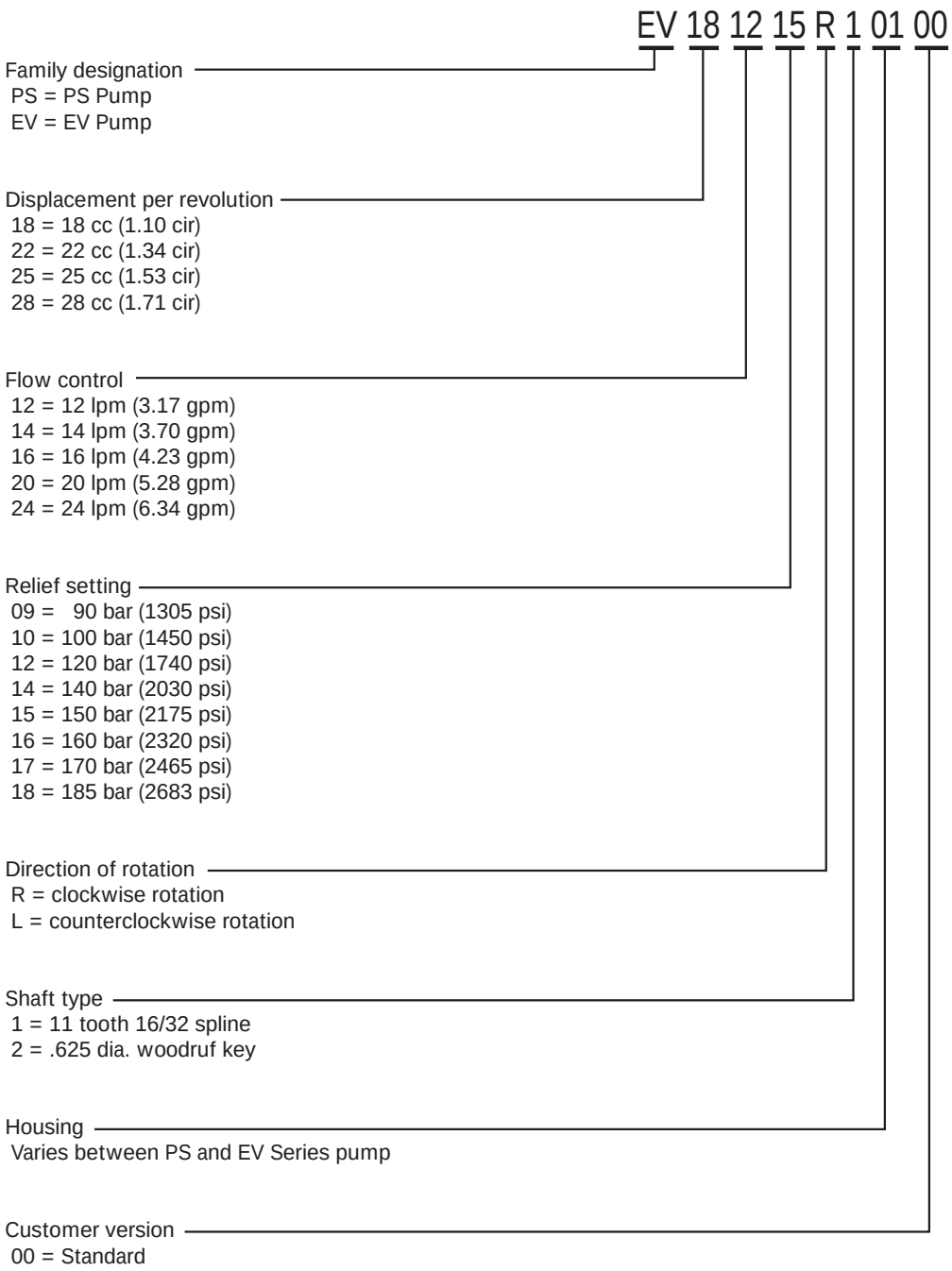
Dual Gear

Gear	GPM	LPM
TAS65 w/ RCS65	6.0	22.7
TAS65 w/ Linear Cylinder	6.5	24.6
TAS85 w/ RCS85	7.0	26.5
TAS85 w/ RCS65	6.5	24.6
TAS85 w/ Linear Cylinder	6.5	24.6
HFB70 w/ RCB70	7.0	26.5
HFB70 w/ RCB64	6.5	24.6
HFB70 w/ Linear Cylinder	6.5	24.6

Pump Part Number Reference Guide

Check the part number on your TRW power steering pump and note the pump relief setting shown in the example below. (See illustration on where to find the pump part number). If the values that you have recorded are within +/- 100 psi (+/- 7 bar) your pump is functioning properly. If the values recorded are below the negative tolerance, your pump is malfunctioning and should be replaced.

For TRW power steering pumps, the relief setting will be the 5th and 6th numbers in the pump part number.



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http://www.trucksteering.com
http://trucksteering.trw.com

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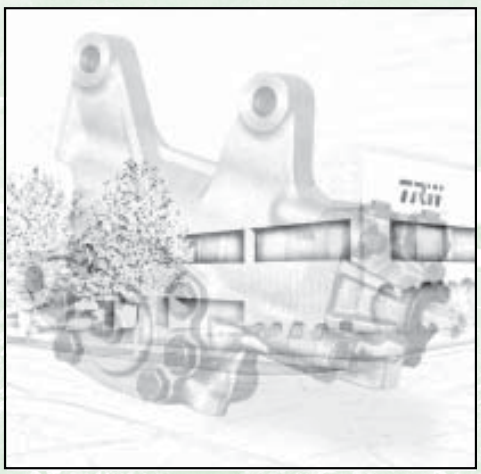
TRW1250 Rev. 4/02

TRW Automotive
Commercial Steering Systems

THP/PCF Steering Gear Service Manual

THP / PCF 4 5 AND 60 SERIES





Hazard Warning Definitions

⚠ WARNING	**A warning describes hazards or unsafe practices which could result in severe personal injury or death.**
⚠ CAUTION	**A caution describes hazards or unsafe practices which could result in personal injury or product or property damage.**
NOTE	A note gives key information to make following a procedure easier or quicker.

Disclaimer

This Service Manual has been prepared by TRW Commercial Steering Systems for reference and use by mechanics who have been trained to repair and service steering components and systems on heavy commercial vehicles. TRW Commercial Steering Systems has exercised reasonable care and diligence to present accurate, clear and complete information and instructions regarding the TRW Commercial Steering THP/PCF Series Integral Power Steering Gears. Since this is a general service manual, the photographs and illustrations may not look exactly like the steering gear being serviced. The procedures, therefore , must be carefully read and understood before servicing.

If inspection or testing reveals evidence of abnormal wear or damage to the THP/PCF steering gear or if you encounter circumstances not covered in the Manual, STOP - Consult the vehicle manufacturer's Service Manual and warranty. Do not try to repair or service a THP/PCF steering gear which has been damaged or includes any part that shows excessive wear unless the damaged and worn parts are replaced with original TRW replacement and service parts and the unit is restored to TRW's specifications for the THP/PCF steering gear.



It is the responsibility of the mechanic performing the maintenance, repairs or service on a particular THP/PCF steering gear to (a) inspect the steering gear for abnormal wear and damage, (b) choose a repair procedure which will not endanger his/her safety, the safety of others, the vehicle, or the safe operation of the vehicle, and (c) fully inspect and test the THP/PCF steering gear and the vehicle steering system to ensure that the repair or service of the steering gear has been properly performed and that the steering gear and system will function properly.

Patents

TRW Commercial Steering Systems THP/PCF power steering gears are covered by several United States and foreign patents, either issued or pending.

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Design Features

1 Size - Reduced package size for increased wheelcut

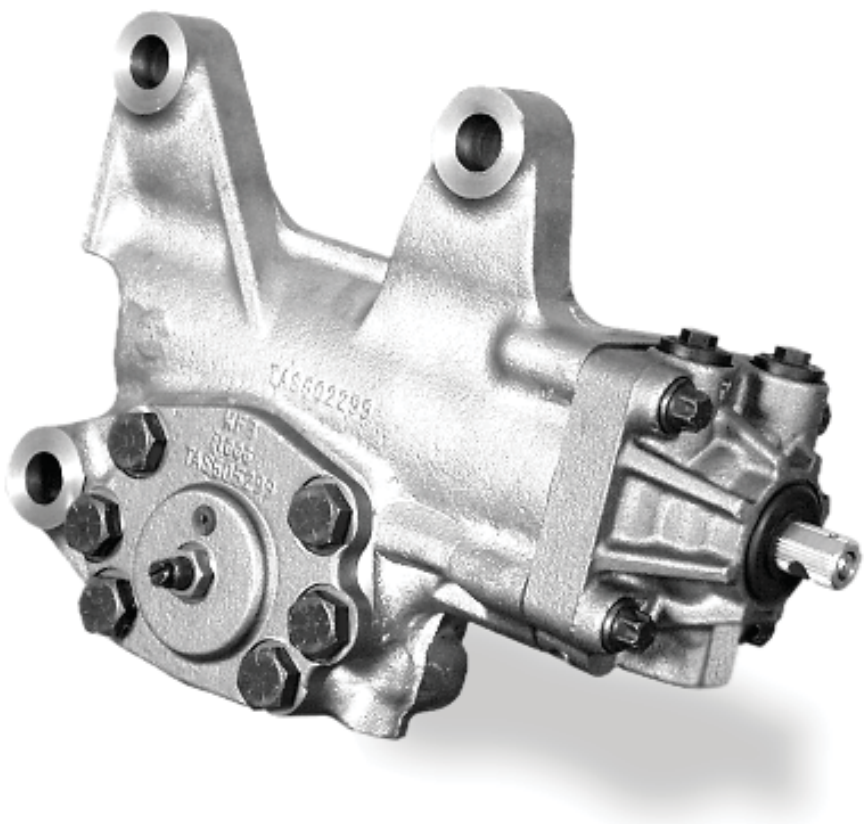
2 Weight - Reduced weight for improved vehicle efficiency.

3 Improved Steering Performance
- Faster steering ratio for improved handling and lower lock to lock turns
- Low internal friction for better return to center

4 High Pressure Capability - Provides for the smallest and lightest package

5 Positive Center Feel (Optional)
- Provides steering precision through improved straight ahead torque feedback (more stiffness) and improved position feedback control (less hysterisis)
- Allows separation of parking efforts from on-highway efforts
- Premium performance steering gear designed for line haul vehicles

6 Design - THP/PCF gear is based on the TAS model's proven steering gear technology plus:
- Improved side cover design that reduces weight, package size, more robust seal, and a roller bearing to reduce friction and wear
- Material and design changes made to operate at the higher pressure



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⚠ WARNING **All steering mechanisms are safety critical items. As such, it is imperative that the instructions in this booklet be followed to the letter. Failure to observe the procedures set forth in this pamphlet may result in a loss of steering.**

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Introduction

This THP/PCF Service Manual applies to all TRW THP45, PCF45, THP60 and PCF60 steering gears.

This service manual reflects TRW's commitment to provide easily usable material and highly recognizable hazard notices. Some of the updates are:

- Caution and warning definitions
- Torque, force, pressure and flow notations that provide metric equivalents
- Service manual divided into sections for easier reference.
- Uninterrupted resealing instructions. Reference to damage section allows you to repair or replace damaged parts and return to the resealing procedures easily.

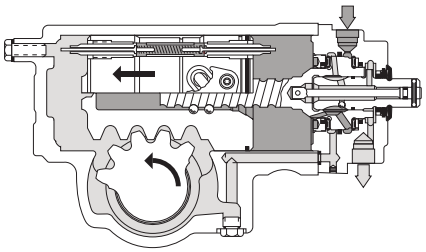
The three-column format used in the service manual will also help make it easy for you to service a steering gear. Column 1 illustrates the procedure with photographs, column 2 gives a brief key as well as tools to be used for each procedure, and column 3 explains in detail the procedure you should follow. **Pay special attention to the notes, cautions and warnings.**

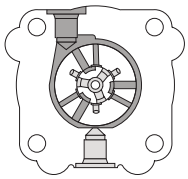
Item numbers on the exploded view correspond with item numbers in ( ), that are used throughout the service manual.

As you gain experience in servicing THP/PCF series steering gears, you may find that some information in this service manual could be clearer and more complete. If so, let us know about it. Don't try to second-guess the service manual; if you do not understand a procedure, or are stuck, contact our Field Service Department at 317.423.5377. Servicing THP/PCF series steering gears should be safe and productive.

Oil Flow Illustration

Left Hand Lead

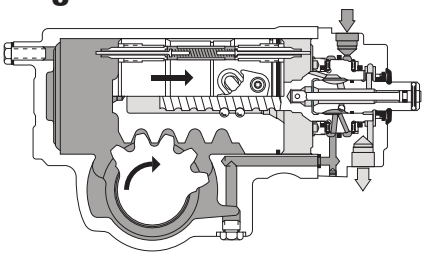


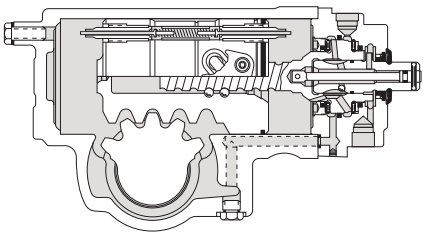


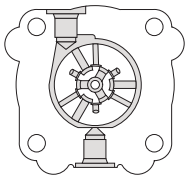
Right Hand Turn

Steering Wheel Input:
Clockwise Rotation

Right Hand Lead

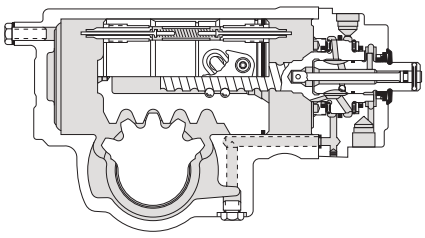


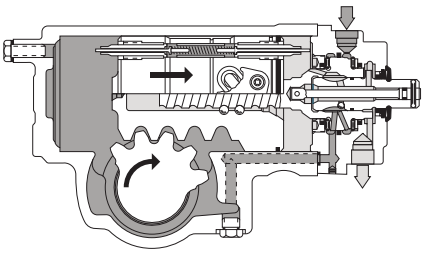


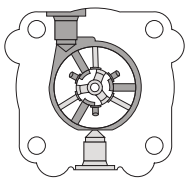


Straightline Running

No Steering Action

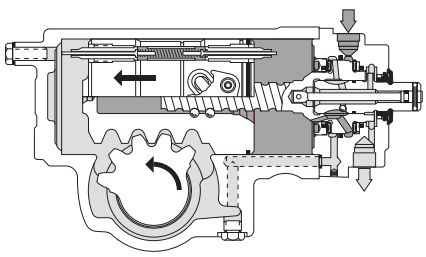






Left Hand Turn

Steering Wheel Input:
Counter-Clockwise Rotation



Supply Pressure

Return Pressure

909

General Design

Integral Power Steering

THP/PCF power steering gears are the latest design in the TRW Commercial Steering Systems' family of integral hydraulic power steering gears. Integral hydraulic power steering means that the gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder, all in a single, compact package.

Rotary Control Valve

The rotary control valve combines simplicity of construction with desirable performance characteristics. The speed at which the driver can turn the steering wheel with power assist is dependent upon the pump flow (measured in gallons per minute or liters per minute) directed to a cylinder cavity. The control valve controls flow through the steering gear.

The pressure (measured in pounds per square inch, or bar) required for the gear to steer the vehicle is created by the power steering pump to overcome resistance at the steered wheels. The control valve senses these requirements and directs fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder if it is a dual steering system) at the proper flow rate and pressure.

Pressure Means Work, Flow Means Speed

The higher pressure a steering gear can withstand, the more work it can perform. The maximum operating pressure for all THP/PCF gears is 2685 psi (185 bar), maximum flow rate for all THP/PCF gears is 6 gpm (22.7 lpm).

The THP/PCF series gears can steer a vehicle within its front-end weight rating through a turn at low speed and engine idle. As the driver turns the steering wheel faster or slower, more or less fluid will be required by the gear. THP/PCF series vehicle front-end weight ratings are as follows:

Gear	Front Axle Rating
THP/PCF45	9,000 lb (4,100 kg)
THP/PCF60	14,300 lb (6,500 kg)

The recommended minimum flow at 1½ steering wheel turns per second is as follows:

Gear	Minimum Flow Rate
THP/PCF45	2.2 gal/min (8.3 L/min)
THP/PCF60	2.6 gal/min (9.8 L/min)

If the steering gear valve is controlling an auxiliary cylinder, increased minimum flow is required (generally at least 75%) based on the size of the auxiliary cylinder and the vehicle's steering geometry.

Maximum internal leakage for all THP/PCF gears is 1.2 gpm (4.5 lpm)

General Operation

What Happens During a Steering Maneuver

When the driver turns the steering wheel, he transmits force from the steering wheel to the steering gear input shaft. A torsion bar, pinned at its one end to the input shaft and at its other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to this rotational force, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston axially through the gear housing cylinder bore.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is connected by linkage to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve, assists in moving the rack piston axially through the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

Shock Loads to the Gear

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston, and on to the worm shaft. The internal geometry of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents objectionable kickback at the steering wheel.

Unloading (Poppet) Valves

Most THP/PCF gears are equipped with two unloading valves, one at each end of the rack piston. One valve or the other, depending on the direction of turn, will trip as the steered wheels approach the axle stops (which must be set according to manufacturer's specification). The tripped valve reduces pressure in the gear and helps to reduce heat generated by the pump. At the same time, the valves also reduce forces on the steering linkage. These valves are automatically set to axle stops after installation in vehicle at first full right and left turn.

Relief Valve

Some THP/PCF gears, (with or without poppets), are supplied with a relief valve. The relief valve limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

Bleed Systems

Some THP/PCF gears which are mounted with the output shaft above the rack piston bore are equipped with either an automatic bleed system or a manual bleed screw.

The procedure for air bleeding the system is on page 16 of this manual. Replacement of damaged automatic bleed plugs, and manual bleed screws is described on page 61.

Approved Hydraulic Fluids

Automatic Transmission Fluid Dexron II
Automatic Transmission Fluid Type "E" or "F"
Chevron 10W-40
Chevron Custom 10W-40 Motor Oil
Chevron Torque 5 Fluid
Exxon Nuto H32 Hydraulic Fluid
Fleetrite PSF (Can #990625C2)
Ford Spec. M2C138CJ
Mack EO-K2 Engine Oil
Mobil ATF 210
Mobil Super 10W-40 Motor Oil
Premium Blue 2000 - SAE 15W-40
Texaco 10W-40
Texaco TL-1833 Power Steering Fluid
Union 10W-40
Union 15W-40
Unocal Guardol 15W-40 Motor Oil

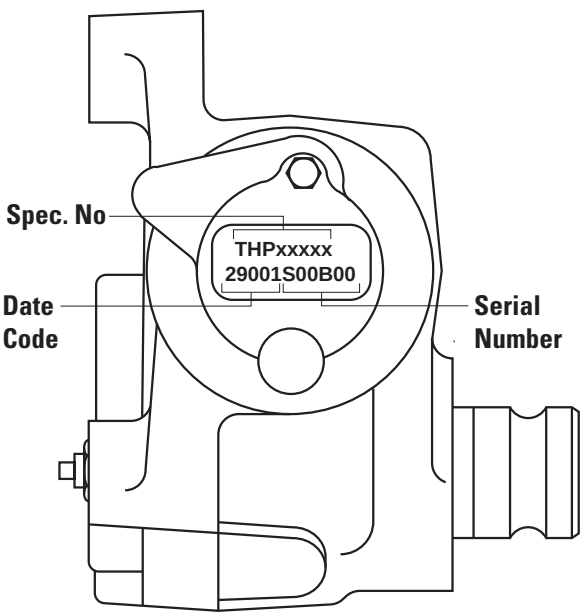
The steering system should be kept filled with one of the above fluids.

⚠ WARNING **Completely flush the steering system with one of the recommended fluids above only. Do not mix oil types. Any mixture or any unapproved oil could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

Approved Grease

Exxon Polyrex* EP2 (P/N 045422)

Gear Specification Numbers



The steering gear specification number and date code are stamped on a machined surface opposite the input shaft of every THP/PCF gear.

An example date code would be 29001; this means the gear was built on the 290th day of 2001.

A letter suffix at the end of the specification number indicates a design level for the gear.

*Trademark of Exxon Oil Corporation

Torque Chart

Part Name	Item #	Torque Range Dry	Torque Range Lubricated
Valve housing bolts	1		118-138 ft•lb (160-187 N•m)
Auxiliary port plug	7	25-35 ft•lb (34-48 N•m)	
Relief valve cap	10	25-35 ft•lb (34-48 N•m)	
Bearing adjuster	20		11-15 ft•lb (15-20 N•m)*
Locknut	21		101-122 ft•lb (137-165 N•m)**
Poppet sleeve assembly	27	16-20 ft•lb (22-27 N•m)	
Torx screw	33	14-22 ft•lb (19-29 N•m)	
Plug, auto bleed	37	38-58 ft•lb (52-79 N•m)	
Poppet fixed stop screw	38	38-42 ft•lb (52-57 N•m)	
Sector shaft adjusting screw jam nut	46	40-45 ft•lb (54-61 N•m)	
Side cover bolts	48		180-220 ft•lb (244-298 N•m)
Poppet sealing nut, service	n/s	33-37 ft•lb (45-50 N•m)	
Manual bleed screw	n/s	40-50 in•lb (3.1-3.7 N•m)	

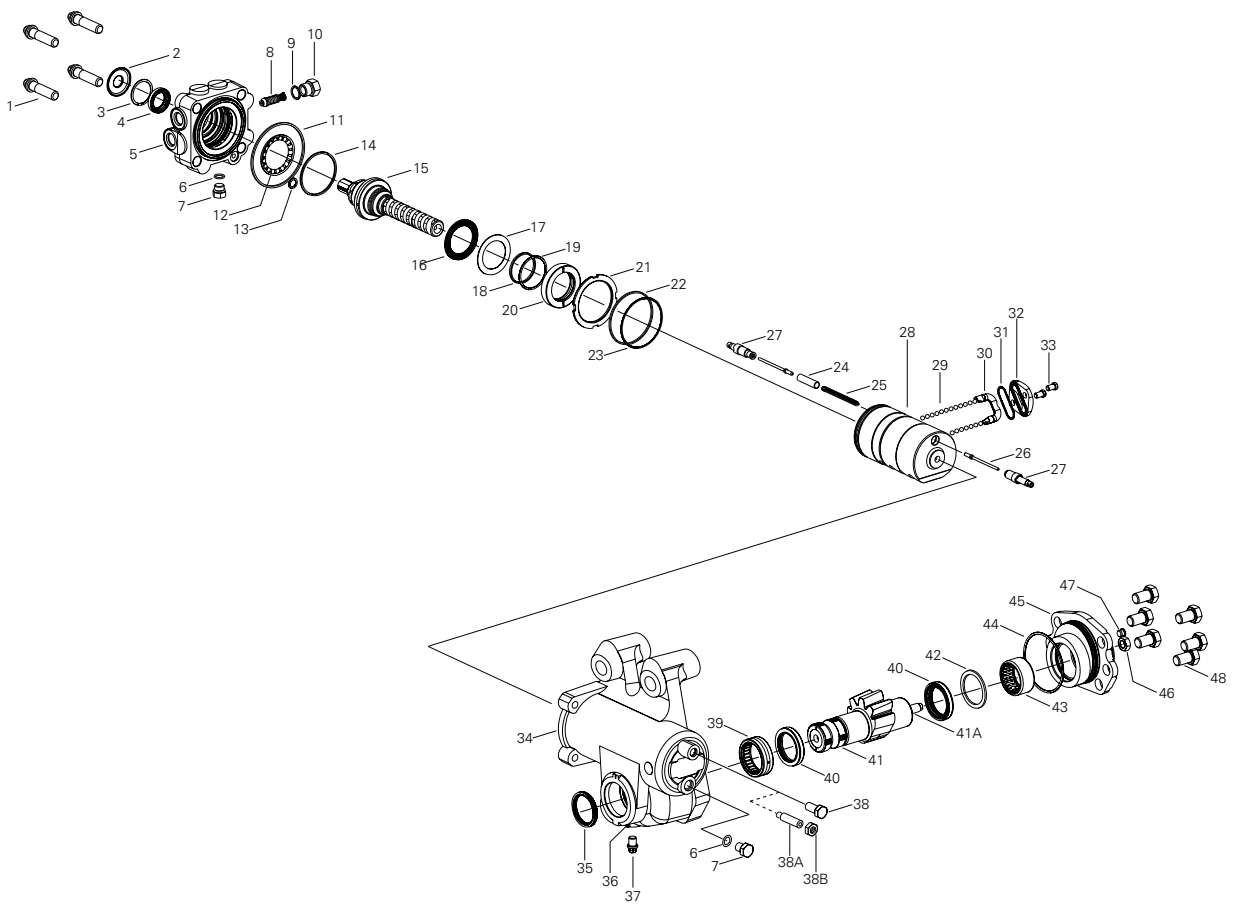
Item numbers referenced are shown on the exploded view located on page 8.

* After tightening to this torque value, the adjuster must be backed off ¼ to ½ of a turn as described in step 20 on page 57.

** Torque value indicated is using recommended tools.

Special tools can be purchased through:
SPX Corporation
Kent-Moore Tool Group
28635 Mound Road
Warren, MI 48092
1-800-328-6657

THP/PCF Exploded View



914

Item	Description	Item	Description	Item	Description
1	Valve Housing Bolts (4)	17	Thrust Washer	*35	Dirt and Water Seal (Trunnion)
*2	Dirt and Water Seal 13/16" Serr.	*18	Seal Ring	36	Grease Fitting
*2B	Dirt and Water Seal 7/8" Serr.	*19	O-ring	37	Plug (Auto Bleed)
*2C	Dirt and Water Seal 1" Serr.	20	Bearing Adjuster	38	Fixed Stop Screw (Poppet)
*3	Retaining Ring	*21	Lock Nut	38A	Poppet Adjusting Screw
*4	Seal (Input Shaft)	*22	O-ring	38B	Nut, Poppet Adjusting Screw
5	Valve Housing Assembly	*23	Seal Ring	39	Bearing, Roller
*6	Auxilliary Port O-ring (2)	24	Push Tube	*40	Seal (2-Output)
7	Auxilliary Port Plugs (2)	25	Poppet Spring	41	Sector Shaft Assembly
8	Relief Valve (2 Piece)	26	Poppet (2)	41A	Sector Shaft Adjusting Screw
*9	O-ring	27	Poppet Seat & Sleeve Assy. (2)	42	Washer
10	Relief Valve Cap	28	Rack Piston	43	Bearing, Roller
*11	O-ring (Valve Housing)	29	Balls	*44	Side Cover O-ring
12	Bearing Assembly	30	Ball Return Guide	45	Side Cover Assembly
*13	O-ring	*31	Seal (Cap)	46	Jam Nut
*14	Seal Ring	32	Ball Return Guide Cap	*47	Vent Plug (Side Cover)
15	Worm and Valve Assembly	*33	Torx Screw (2)	48	Bolts, Side Cover (6)
16	Thrust Bearing	34	Housing		

*These items are included in complete seal kits along with 045422 lubricant and a service bulletin.

THP/PCF Service Parts List

Common Parts

Item	Description	Part Number
1	Bolts (4-Valve Housing)	023037
2	Dirt and Water Seal 13/16" Serr.	478044
2B	Dirt and Water Seal 7/8" Serr.	478060
2C	Dirt and Water Seal 1" Ser	478050
3	Retaining Ring	401637
4	Seal (Input Shaft)	478076
6	O-ring (2-Aux. Port Plug)	032229
7	Auxiliary Port Plug (2)	415437-A1
9	O-ring (Relief Valve)	032200-153
10	Cap, Relief Valve	411061
11	Seal Ring	032829
12	Ball Bearing Assy.	400152-A1
13	Seal Ring (Valve Housing)	032823
14	Seal Ring (Valve Housing)	029128
16	Thrust Bearing	070027
17	Thrust Washer	400144
18	Seal Ring	029123
19	O-ring	032200-158
20	Bearing Adjuster	400149
21	Adjuster Locknut	027007
24	Push Tube	080154
25	Poppet Spring	401662
26	Poppet (2)	040248
27	Poppet Seat and Sleeve Assy. (2)	409118-A2
29	Balls	213684-X1
31	Cap, Seal	478042
32	Ball Return Guide Cap	400177
33	Torx Screws (2)	020228
36	Grease Fitting	037032
37	Plug, (Auto Bleed)	021397
37A	Screw, Manual Bleed	213705
38	Screw, Fixed Stop	021426
38A	Screw, Poppet Adjusting	
38B	Nut, Poppet Adjusting Screw	
44	O-ring, Sidecover	032856
46	Nut, Jam	025150
47	Plug, Vent (Side Cover)	036201
48	Bolts, Side Cover	021434

Parts Vary by Specification*

Item	Description
5	Valve Housing
8	Relief Valve
15	Input Shaft, Valve, Worm Assy.
28	Rack Piston
34	Housing
41	Sector Shaft (Includes 41A)
45	Side Cover Assembly (Includes 40, 42, 43)

*Contact Service/Sales for part numbers

Kits

Items	Description	Part Number
6 & 7	Port Plug & O-ring	415437-A1
9 & 10	Relief Valve Cap & O-ring	411061-A1
38A & 38B	Adj. Screw & Jam Nut	
	THP/PCF45 Kit	023045-X1
	THP/PCF60 Kit	021407-X1
2, 2B, 2C, 3, 4	Input Shaft Seal Kit	THP000001
	THP/PCF45 Seal Kit	THP450001
	THP/PCF60 Seal Kit	THP600001

Parts Vary by Gear Size

Item	Description	THP/PCF45	THP/PCF60
22	Rack Piston Seal Ring	032828	032830
23	Rack Piston O-ring	032827	032831
30	Ball Return Guide Halves (2) R.H.	400158	400172
	L.H.	400159	400173
35	Dirt and Water Seal (Trunnion)	478098	478095
39	Roller Bearing (Trunnion)	070030	071033
40	Output Seal (2)	478105	478104
42	Washer	028561	028557
43	Side Cover Roller Bearing	070031	071035
38	Fixed Stop Screw	023044	021426
38A	Poppet Adjusting Screw	023045	021407
38B	Poppet Adjusting Screw Nut	027018	025119

Section 2 Initial Installation

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Initial Poppet Setting 13
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Initial THP/PCF Installation

- Bolt steering gear to frame, torque bolts to vehicle manufacturer's recommendation.
- Connect return line to THP/PCF gear return port.
- Connect hydraulic line from pump to pressure port on THP/PCF unit.
- Connect steering column to input shaft, torque pinch bolt to vehicle manufacturer's recommendation.
- Install pitman arm on output shaft, torque bolt to vehicle manufacturer's recommendation.

Initial Poppet Setting

For this procedure to work correctly, you must have: A new gear received from TRW or your vehicle manufacturer's aftermarket system, **or** a used gear on which poppet seats have been replaced or reset during gear disassembly procedures. **ALSO:** A fixed stop screw installed in the housing, or a poppet adjusting screw installed so that it duplicates the fixed stop screw length.

⚠ CAUTION **The axle stops and all steering linkage must be set according to vehicle manufacturer's specifications, and the pitman arm must be correctly aligned on the sector shaft for poppets to be set correctly.**

Full turn in one direction

1. With the engine at idle and the vehicle unloaded, turn the steering wheel to full travel in one direction until axle stop contact is made. Maximum input torque to be applied during this procedure is 40 lb rim pull (178 N) on a 20 in. (508mm) diameter steering wheel.

NOTE If you encounter excess rim pull effort, allow the vehicle to roll forward or jack up the vehicle at the front axle.

Full turn in other direction

2. Follow the same procedure while turning the steering wheel in the other direction. The poppets are now positioned to trip and reduce pressure as the steered wheels approach the axle stops in either direction.

Maintenance Tips

Never high-pressure wash or steam clean a power steering gear while on or off the vehicle. Doing so could force contaminants inside the gear and cause it to malfunction.

Make sure vehicle wheel cut or clearances meet manufacturer's specifications, and make sure pitman arm timing marks are aligned properly to **prevent internal bottoming** of the steering gear.

Regularly check the fluid and the fluid level in the power steering reservoir.

Keep tires inflated to correct pressure.

Never use a torch to remove pitman arm.

Investigate and immediately **correct the cause of any play, rattle, or shimmy** in any part of the steering system.

Make sure the steering column is aligned properly.

Encourage drivers to report any malfunctions or accidents that could have damaged steering components.

Do not attempt to weld any broken steering component. Replace the component with original equipment only.

Do not cold straighten, hot straighten, or bend any steering system component.

Always **clean off around the reservoir filler cap** before you remove it. Prevent dirt or other foreign matter from entering the hydraulic system.

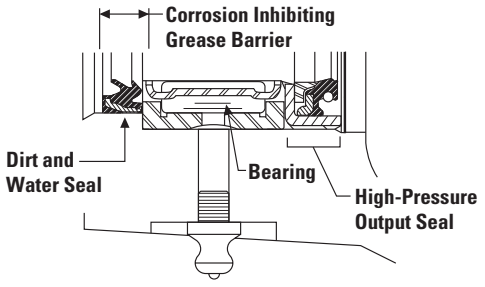
Investigate and correct any external leaks, no matter how minor.

Replace reservoir filters according to requirements.

If you feel the vehicle is developing excessively **high hydraulic fluid temperatures**, consult with your vehicle manufacturer for recommendations.

Maintain grease pack behind the output shaft dirt and water seal as a general maintenance procedure at least twice a year, in the Spring and Fall. Grease fitting is provided in housing trunnion. Use Exxon Polyrex EP2 (P/N 045422 or NLGI grade 2 or 3 multipurpose chassis lube, and use only a hand operated grease gun on fitting. Add grease until it begins to extrude past the sector shaft dirt and water seal.

THP/PCF Gear



Section 3 On-Vehicle Service

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Filling and Air Bleeding the System

Tools Required	Materials Required
5/16" Socket in•lb Torque wrench	Hydraulic fluid

⚠ CAUTION **Make sure poppets are set correctly before beginning this procedure.**

Run engine for 10 seconds, turn off and fill reservoir

Hydraulic fluid

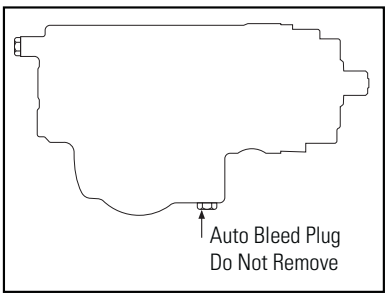
1. Fill the reservoir nearly full. Do not steer. Start and run the engine for 10 seconds, then shut it off. Check and refill the reservoir. Repeat at least three times, checking the reservoir each time.

⚠ CAUTION **Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.**

Run engine for 2 minutes, turn off and fill reservoir

Hydraulic fluid

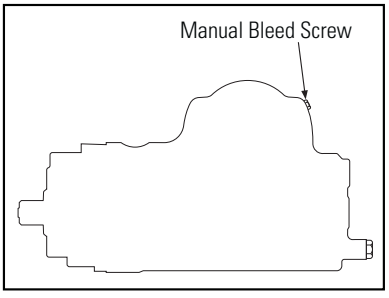
2. Start the engine and let it idle for 2 minutes. Do not steer. Shut off the engine and check the fluid level in the reservoir. Refill as required.



Steer vehicle

3. Start the engine again. Steer the vehicle from full left to full right several times. Add fluid, as necessary, to the full line on the dip stick.

   Automatic bleed systems should now be free from trapped air. **Manual bleed systems continue with step 4.**



Allow air to bleed out from bleed screw

in•lb Torque wrench
5/16" Socket

4. With engine idling, steer from full left turn to full right turn several times. Stop steering and loosen the manual bleed screw about one turn. Allow air and aerated fluid to "bleed out" until only clear fluid is seen. Close the bleed screw, refill the reservoir if required.

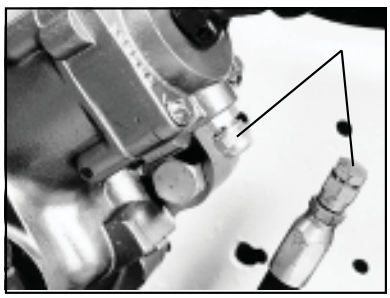
   Repeat step 4 three to four times until all the air is discharged. Torque manual bleed screw to **45 in•lb.**

⚠ CAUTION **Do not turn steering wheel with bleed screw loosened.**

Input Shaft Seal Replacement

Tools Required	Materials Required
Hammer J37073 Seal Driver Screwdriver	Clean cloth Drip pan High pressure fitting Hydraulic fluid Plug Shop towel

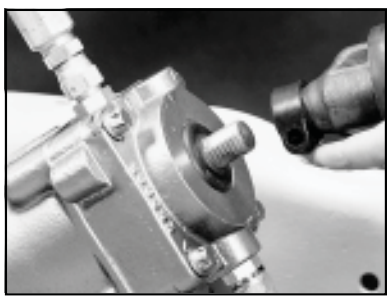
This procedure uses the vehicle's power steering pump to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1,500 psi available.



Disconnect return line

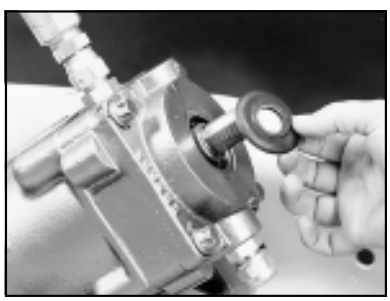
High pressure fitting
Plug

1. Disconnect return line from the steering gear and plug the line. Also cap the return port of the gear with a high pressure fitting.



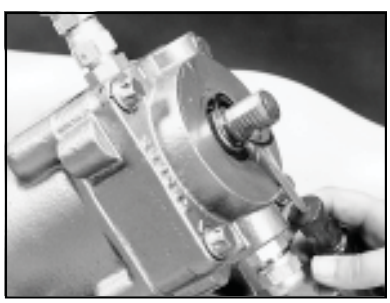
Disconnect column

2. Remove the steering column from the gear input shaft.



Remove dirt & water seal

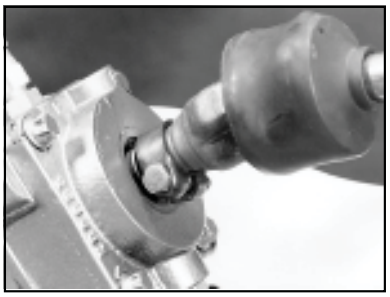
3. Remove the dirt and water seal from the steering gear. Save this seal to match the new seal to the correct size.



Remove retaining ring

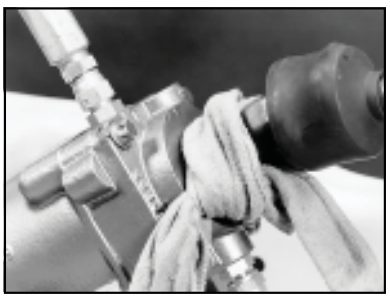
Clean cloth
Screwdriver

4. Wipe out the grease and then remove the spiral retaining ring. Use a screwdriver inserted into the notch formed in the end of the ring. Be careful not to scratch the bore with the screwdriver.



Replace column

5. Slip the steering column back onto the input shaft with the pinch bolt installed, but not tightened.



Wrap exposed area

Drip pan
Shop towel

6. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil.



Fill reservoir

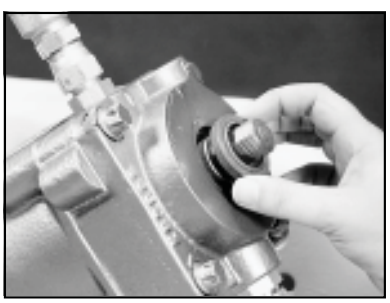
Hydraulic fluid

7. Add fluid as necessary, to the full line on the dip-stick. Do not mix fluid types.

⚠ WARNING **Any mixture of fluid types, or use of any unapproved fluid could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

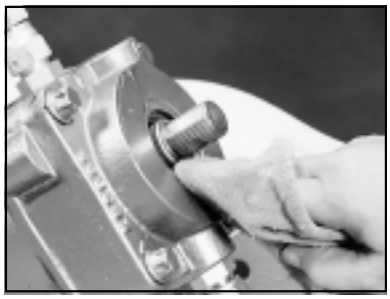
Force out the seal

8. With the vehicle in neutral, momentarily turn the starter (quickly turn off the engine if it starts).



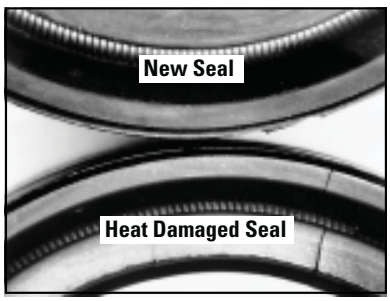
Remove input shaft seal

9. Remove the shop towel. Disconnect the steering column, and remove the input shaft seal.



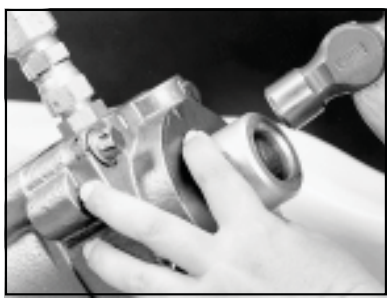
Inspect seal area

10. Check the seal area of the valve housing for any seal fragments. Remove any that are found.



Inspect old seal

11. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

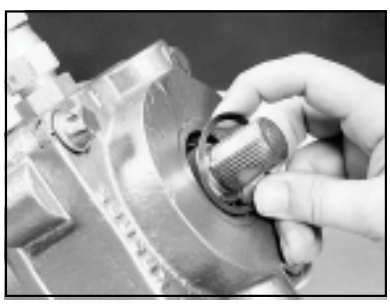


Install new seal

Hammer
J37073 Seal Driver

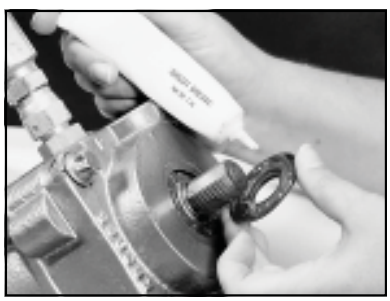
12. Put clean grease 045422 on the inside dia. of the new input shaft seal, and place it over the input shaft. With the small dia. of tool J37073 against the seal, tap the tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.

⚠ CAUTION **Do not use a socket to install this seal because you will not be able to control seal installation depth, possibly causing a leak.**



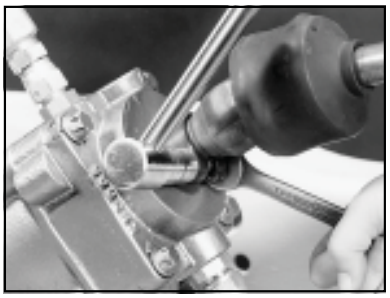
Install retaining ring

13. Insert new retaining ring into the groove.



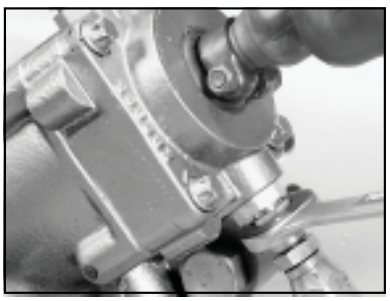
Install dirt & water seal

14. Pack the end of the valve housing bore around the input shaft with grease 045422. Choose the correct size dirt & water seal by comparing the choices to the old seal, or by measuring the major diameter of the input shaft serrations (see chart next page). Apply more grease 045422 to the new dirt & water seal and install it over the input shaft. Seat it in the groove behind the serrations and against the valve housing.



Reconnect column

15. Reconnect the steering column to the input shaft and tighten the pinch bolt to torque level specified.



Reconnect return line

16. Reconnect the return line to the steering gear return port.

Air bleed system

17. Air bleed the system using the procedure on pg. 16.

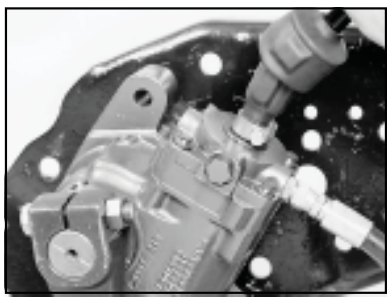
Seal Part No.	Serration Size	Major Serration Dia.
478044	13/16" x 36	0.807 / 0.799
478060	7/8 x 36	0.866 / 0.857
478050	1" x 36	0.987 / 0.977
478050	1" x 79	1.008 / 1.000

Sector Shaft Adjustment

Tools Required	Materials Required
Screwdriver ¾" Socket ¾" Open end wrench	

This adjustment can only be completed on the vehicle if the adjusting screw jam nut is accessible. This nut is located on the side cover.

Photos in this section were taken on a mock frame rail for clarity.



Center the sector shaft

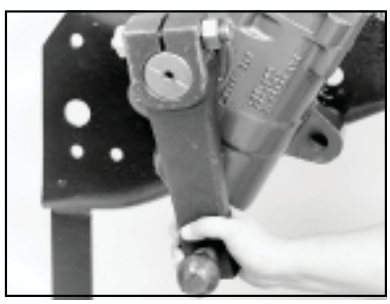
1. With the engine on, rotate the steering wheel (input shaft) until the timing mark on the sector shaft lines up with the mark on the housing. The line on the sector shaft should be at a 90° angle from the input shaft. The sector shaft is now on its "center of travel". Turn the vehicle off.



Remove the drag link

2. Remove the drag link from the pitman arm.

> **⚠ CAUTION** **To avoid resetting the poppets, do not rotate the input shaft more than 1½ turns from the "center of travel" position while the drag link is disconnected.**



Check for sector shaft lash

3. From the "center of travel" position, grasp the pitman arm and gently try to rotate it back and forth. If looseness or lash is felt at this point, the sector shaft is out of adjustment.

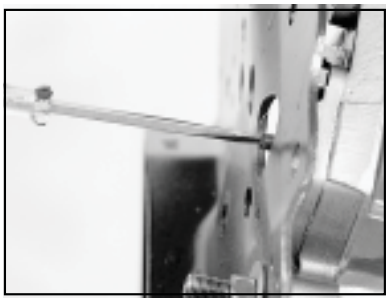


Loosen jam nut

¾" Socket

4. Loosen the jam nut.

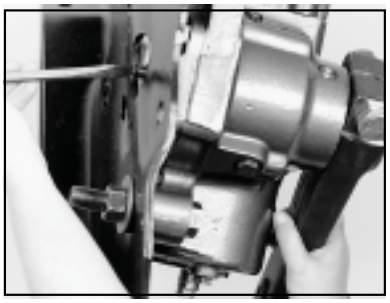
> **NOTE** If the gear is removed from the vehicle to adjust the lash:
> - Leave the pitman arm connected to the gear.
> - Best option is to follow the Final Adjustment procedure on page 62.
> - Alternate option is to continue with step 5 of this procedure.



Position adjusting screw

Screwdriver

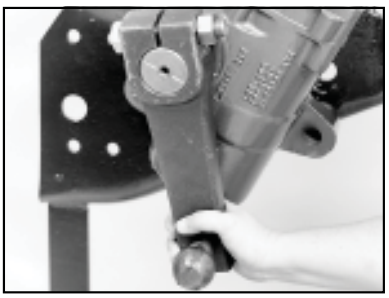
5. If no lash was detected in step 3, turn the shaft adjusting screw counterclockwise until you feel lash at the output shaft.



Adjust shaft

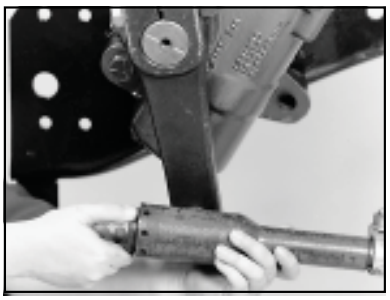
Screwdriver
¾" Open end wrench

6. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the output shaft without using more than **10 ft•lb** (14 N•m) of torque. From this position, turn the screw clockwise ⅛ to 3⁄16 of a turn more. Hold the adjusting screw in place, and tighten the jam nut. Final jam nut torque **43 ft•lb** (58 N•m).



Recheck for lash

7. Turn the steering wheel ¼ turn each side of center, then back to center and recheck the pitman arm for lash. You should feel no lash; if there is lash, repeat steps 4, 6 and 7.



Connect drag link

8. Reconnect the drag link to the pitman arm according to manufacturer's specifications.

⚠ CAUTION **Maintain grease in the sector shaft bearing through the grease fitting in the housing using only a hand operated grease gun. Add grease until it begins to extrude past the dirt and water seal. Do not use a power grease gun because it will supply grease too fast; this could adversely affect the high pressure seal and contaminate the hydraulic fluid.**

Poppet Readjustment - Single Gears

Tools Required

THP/PCF45
6mm Allen wrench
19mm Open end wrench
19mm Socket
18mm Open end wrench
THP/PCF60
7/32" Allen wrench
3/4" Open end wrench
3/4" Socket
5/8" Open end wrench
ft•lb Torque wrench

Materials Required

Hydraulic fluid
Jack

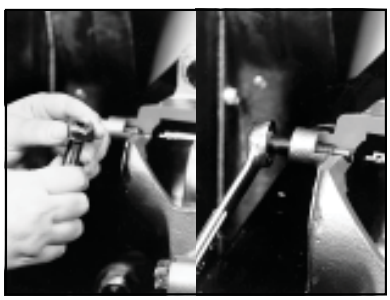
This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.



Set axle stops, warm-up system

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.



Assemble adjusting screw into nut

2. If a new poppet adjusting screw and nut are being used, turn the screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear will have either a fixed stop bolt or an adjusting screw. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

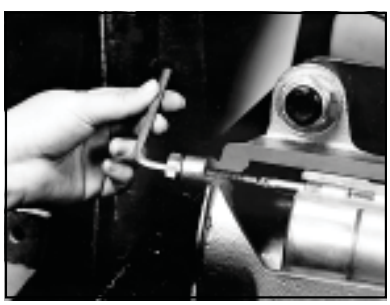


Remove poppet stop bolt

THP/PCF45
18mm Open end wrench
THP/PCF60
5/8" Open end wrench

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of the housing.

   If the unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.



Turn adjusting screw assembly into housing

THP/PCF45
6mm Allen wrench
19mm Wrench
THP/PCF60
7/32" Allen wrench
3/4" Wrench

4. Turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a 6mm (THP/PCF45) or 7/32" (THP/PCF60) Allen wrench. Tighten the sealing nut against the housing.

⚠ CAUTION **If the drive end of the screw is below the face of the nut, the poppet seat flange will break during step 7d.**

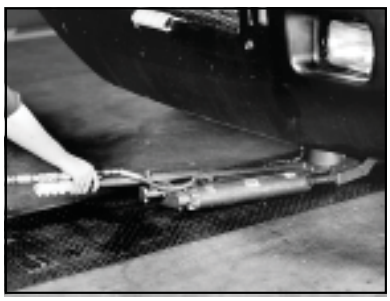


Refill reservoir

Hydraulic fluid

5. Refill the system reservoir with approved hydraulic fluid.

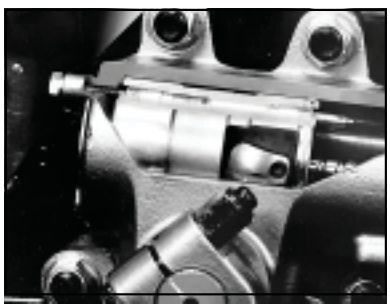
⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**



Jack up vehicle

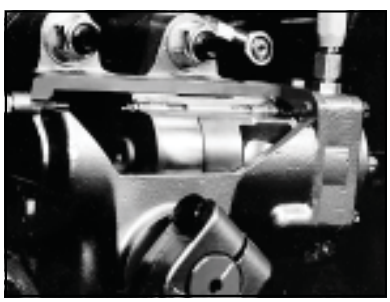
Jack

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.



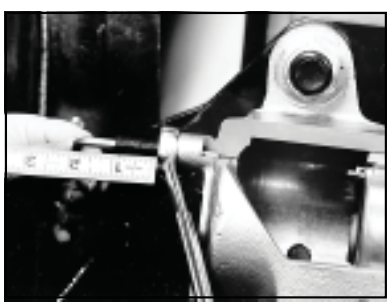
Push upper poppet out to prepare it for setting

7. **a)** Start the engine and let it run at idle speed.
   b) Note which output shaft timing mark is nearest the housing piston bore.
   c) Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.
   d) Pull hard on the steering wheel (put up to 40 lb rim pull on a 20" dia. steering wheel) after the axle stop is contacted.



Set upper poppet

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.
   b) Pull hard on the steering wheel (put up to 40 lb rim pull on a 20" dia. steering wheel).
   c) Release the steering wheel and shut off the engine.



Back out adjusting screw

THP/PCF45
6mm Allen wrench
19mm Wrench
THP/PCF60
7/32" Allen wrench
3/4" Wrench

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut. Tighten the sealing nut against the housing.

⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

928



Set lower poppet

10. **a)** Start the engine and let it idle.

b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

c) Hold the steering wheel in this position (with up to 40 lb rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 11.



Position adjusting screw

THP/PCF45
6mm Allen wrench
19mm Wrench
19mm Socket
THP/PCF60
7⁄32" Allen wrench
¾" Wrench
¾" Socket
ft•lb Torque wrench

11. **a)** With steering wheel held tightly at full turn loosen the jam nut and hold it in place with a wrench.

b) Turn the adjusting screw in (clockwise) using **finger-pressure only (don't use a ratchet)**, until the Allen wrench stops. Do not attempt to turn it in further. Pause the turning-in process each time the driver releases the steering wheel; continue turning only while the wheel is held at full turn.

c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque sealing nut to **35 ft•lb**. (48 N•m)

The procedure is complete

12. The poppets have now been completely reset. Lower the vehicle. Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1⁄16" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

929

Poppet Readjustment - Dual Gears

Mirror Image Systems and Reversed Image Systems

Before setting poppets on a dual gear system, you must determine whether the system has mirror image gears or reversed image gears. The procedures are slightly different for each type of system.

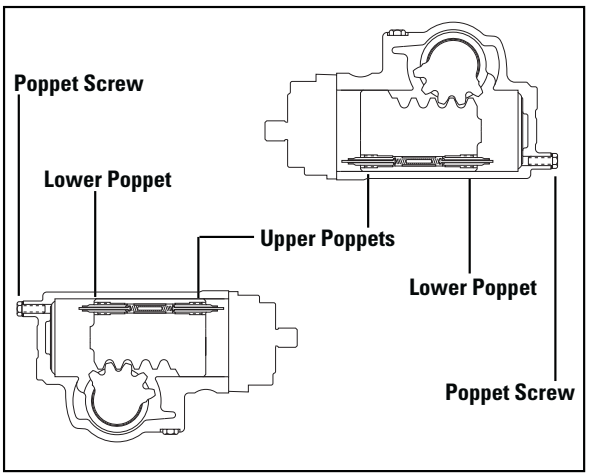
1. Park the vehicle with the wheels turned all the way to the axle stop in either direction. Turn the vehicle off.

2. Look at the output shaft timing mark nearest the housing piston bore on the master gear. Is this mark pointing toward the poppet screw or away from it?

3. Now check the same timing mark on the rotary cylinder. Does it point toward the poppet screw or away from it?

   If they point to opposite ends of the gears you have a mirror image system, see pg. 27.

   If they both point toward the poppet screws or both point toward the end opposite the poppet screws, you have a reversed image system, see pg 29.



Poppet Readjustment - Dual Gears - Mirror Image

Tools Required

THP/PCF45
6mm Allen wrench
19mm Open end wrench
19mm Socket
18mm Open end wrench
THP/PCF60
7/32" Allen wrench
3/4" Open end wrench
3/4" Socket
5/8" Open end wrench
ft•lb Torque wrench

Materials Required

Hydraulic fluid
Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.

2. If new poppet adjusting screws and nuts will be used, turn each screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear and rotary cylinder will both have either fixed stop bolts or adjusting screws. If the adjusting screw is already part of the gear or cylinder, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of housing on both the gear and the cylinder.

   If either unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

4. On both the master gear and the rotary cylinder, turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a 6mm (THP/PCF45) or 7/32" (THP/PCF60) allen wrench. Tighten the sealing nut against the housing.

5. Refill system reservoir with approved hydraulic fluid.

   ⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

7. **a)** Start the engine and let it run at idle speed.

   b) Turn the steering wheel in the direction that makes the timing mark on the master gear move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.

   c) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark on the master gear away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

9. Loosen the sealing nut and back out the adjusting screw on the master gear until 1" is past the nut. Tighten the sealing nut against the housing.

   ⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

10. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the original direction (end of timing mark on the gears toward adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (with 40 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing steps 11 & 12.

11. **a)** With steering wheel held at full turn, loosen the jam nut on the master gear and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 ft•lb.** (45-50 N•m)

    d) Release the steering wheel and shut off the engine.

12. Loosen the sealing nut and back out the adjusting screw on the rotary cylinder until 1" is past the nut. Tighten the sealing nut against the housing.

13. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the opposite direction (end of timing mark on master gear away from adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (put up to 40 lb. rim pull on a 20" dia. steering wheel) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 14

14. **a)** With steering wheel held at full turn, loosen the jam nut on the rotary cylinder and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 ft•lb.** (45-50 N•m)

    d) Release the steering wheel and shut off the engine.

15. The poppets have now been completely reset. Lower the vehicle . Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1/16" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

Poppet Readjustment - Dual Gears - Reversed Image

Tools Required

THP/PCF45
6mm Allen wrench
19mm Open end wrench
19mm Socket
18mm Open end wrench
THP/PCF60
7/32" Allen wrench
3/4" Open end wrench
3/4" Socket
5/8" Open end wrench
ft•lb Torque wrench

Materials Required

Hydraulic fluid
Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.

2. If new poppet adjusting screws and nuts are being used, turn the screws into the non-sealing end of the jam nuts until the drive end of screw is flush with the nut.

   Your steering gear and rotary cylinder will have either fixed stop bolts or adjusting screws. If the adjusting screw is already part of the steering gear or cylinder, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolts (if equipped) and washers (if equipped) from the lower end of housing on both the master gear and the rotary cylinder.

   If the unit has poppet adjusting screws and sealing nuts that need to be replaced, remove and discard them.

4. Turn the adjusting screws and sealing nut assemblies, without rotating the nut on the screw, into the housing until the nut is firmly against the housing, on both the master gear and the rotary cylinder, using a6mm (THP/PCF45) or 7/32" (THP/PCF60) allen wrench. Tighten the sealing nut against the housing.

5. Refill system reservoir with approved hydraulic fluid.

   ⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

7. **a)** Start the engine and let it run at idle speed.

   b) Note which output shaft timing mark is nearest the housing piston bore.

   c) Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screws just installed on both the gear and the cylinder. Turn in this direction until axle stop contact is made.

   d) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut on both the master gear and the rotary cylinder. Tighten the sealing nuts against both housings.

   ⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

10. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (with 40 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing steps 11 and 12, first on the master gear, then on the rotary cylinder.

11. **a)** With steering wheel held at full turn, loosen the jam nut on the master gear, and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque nut to **33-37 ft•lb.** (45-50 N•m)

12. **a)** With steering wheel held at full turn, loosen the jam nut on the rotary cylinder and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using **finger- pressure only** (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque nut to **33-37 ft•lb.** (45-50 N•m)

13. The poppets on both the master gear and rotary cylinder have now been completely reset. Lower the vehicle . Check the reservoir and fill if required.

⚠ WARNING **The length of the adjusting screw beyond the nut must be no more than 1 1/16" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

Section 4 Reseal & Repair

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Final Adjustments 63

Disassembly Preparation

Stop the vehicle with wheels pointed straight ahead.

Clean off all outside dirt from around fittings and hose connections before you remove the gear.

Remove input and output shaft connections per vehicle manufacturer's instructions.

⚠ WARNING **When using a chisel to spread a pinch bolt-type pitman arm boss for assembly or removal from the shaft, maintain a firm grip on the chisel at all times. Failure to do this may result in the chisel flying loose which could cause an injury. Never leave the chisel wedged in the pitman arm boss. If you cannot remove the pitman arm from the shaft with a chisel and your hands, remove the chisel from the arm boss and use a puller only to remove pitman arm.**

⚠ CAUTION **Do not use a hammer on the pitman arm to remove it from sector shaft as internal damage to steering gear could result. Be sure there is no spreading wedge left in the pitman arm boss before tightening pitman arm clamp bolt after assembly on sector shaft. Do not pound the universal joint or input shaft coupling on or off the input shaft as internal damage to the steering gear can result.**

⚠ CAUTION **Unless the poppet adjuster seat and sleeve assemblies (27) are to be removed and replaced or reset for automatic poppet adjustment, or a manual adjustment with a service poppet adjuster screw (38A) and nut (38B) is anticipated, do not allow the input shaft on a steering gear with the automatic poppet adjustment feature to rotate more than 1.5 input shaft revolutions from "straight ahead position" when the output shaft is disconnected from the vehicle steering linkage; this could disrupt the poppet setting achieved at initial installation. The steering gear is in the "straight ahead position" when the timing marks on the end of the housing trunnion and sector shaft are aligned.**

Remove the supply and return lines from the gear, and immediately plug all port holes and fluid lines.

⚠ WARNING **THP/PCF steering gears can weigh up to 70 pounds dry. Exercise caution when you remove, lift, carry, or fix in a bench vise.**

Remove the steering gear from the vehicle and take it to a clean work surface.

Clean and dry the gear before you start to disassemble it.

As you disassemble the gear, clean all parts in clean, OSHA approved solvent, and air blow-dry them only.

⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

⚠ WARNING **Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.**

⚠ CAUTION **Never steam clean or high-pressure wash hydraulic steering components. Do not force or abuse closely fitted parts. Use care that bearing and sealing surfaces are not damaged by the assembly and disassembly procedures.**

Keep each part separate to avoid nicks and burrs.

Discard all seals, o-rings, and gaskets removed from the gear. Replace them with new parts only.

The steering gear should be identified to the vehicle from which it was removed. The poppet adjuster seat and sleeve assemblies are set for that particular vehicle only.

Disassembly

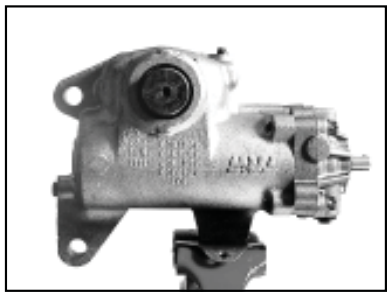
Tools Required

Allen wrenches
Pocket knife
Ratchet
Rolling head pry bar
Rubber mallet
Screwdriver
Sockets:
- •Standard
- •Torx

Vise

Materials Required

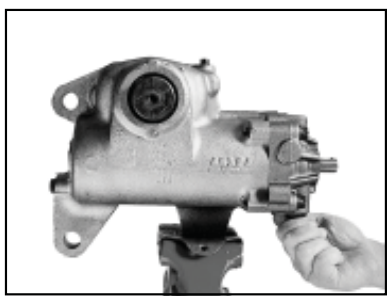
Emery cloth
Masking tape



Position gear in vise

1. Put the steering gear in a vise, clamping firmly against the housing mounting flange or boss. Input shaft should be horizontal; side cover and valve housing are accessible for disassembly.

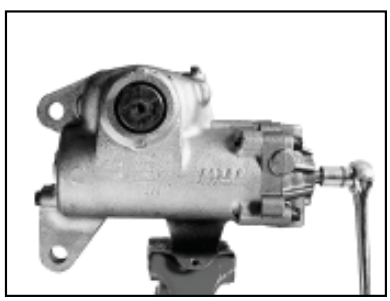
⚠ CAUTION **Do not clamp against body of housing. If mounting boss or flange is not accessible, fabricate and attach a mounting plate to the housing mounting bosses.**



Unplug ports

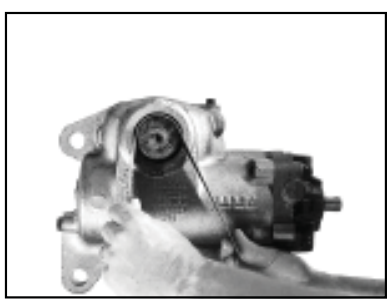
Appropriate size socket or open-end wrench

2. Prepare for fluid drainage and unplug hydraulic ports.



Position sector shaft

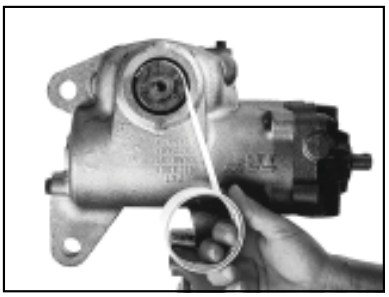
3. Rotate the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing. This will position the sector shaft for removal.



Clean sector shaft

Fine grade emery cloth

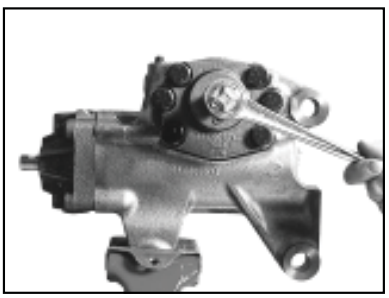
4. Remove any paint or corrosion from the exposed area of the sector shaft (41).



Tape sector shaft

Masking tape

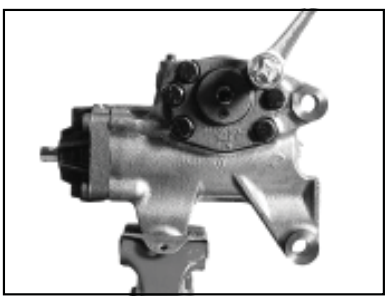
5. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape. The tape should not extend onto the sector shaft bearing diameter.



Remove jam nut

¾" Socket

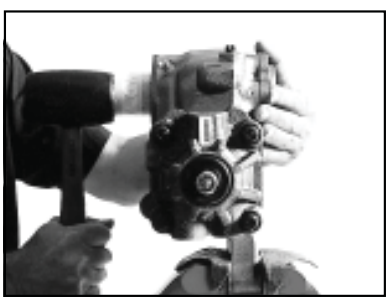
6. Remove the sector shaft adjusting screw jam nut (46).



Remove side cover bolts

15⁄16" Socket

7. Be prepared for more fluid drainage and remove the six bolts (48) from the side cover (45).



Remove side cover

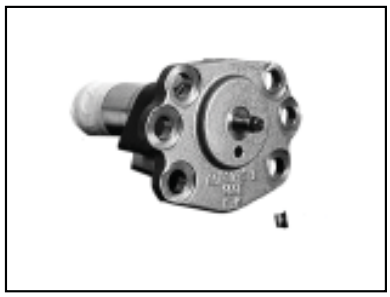
Soft mallet

8. Be prepared for more fluid drainage and remove the side cover and sector shaft assembly from the gear. You may start the shaft and cover assembly removal by tapping the end of the shaft lightly with a soft mallet or wooden hammer handle.



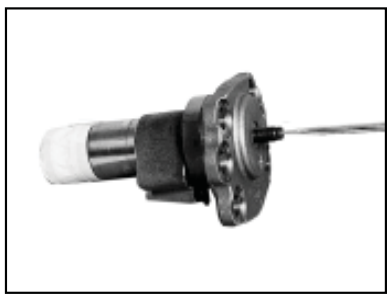
Discard O-ring

9. Remove and discard the side cover o-ring (44).



Remove vent plug

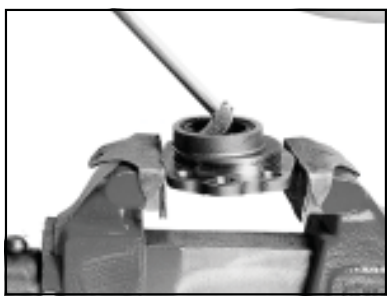
10. Remove and discard the vent plug (47).



Remove sector shaft from cover

Screwdriver

11. Turn sector shaft adjusting screw (41A) clockwise through the side cover and pull the sector shaft out of the side cover.



Remove side cover seal and washer

⅜" Drive socket
Rolling head pry bar

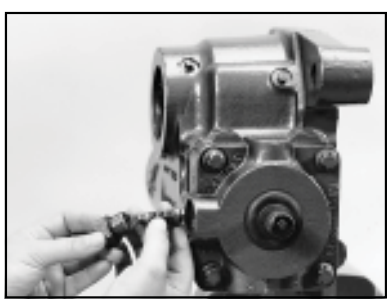
12. **⚠ CAUTION** **Don't damage the bore or bearing when removing the seal.**

Clamp the side cover in a vise. Place a standard ⅝" or 11⁄16" - ⅜ drive socket in the center of the side cover. Pry the seal (40) out with a rolling head pry bar, using the socket for support. Discard the seal and remove the socket. Remove washer (42).



Inspect adjusting screw and retainer

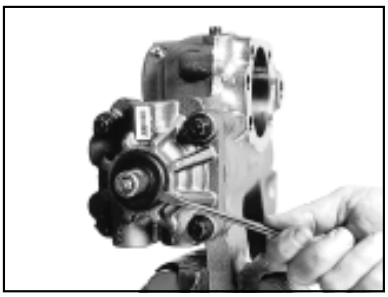
13. Inspect the sector shaft assembly for damaged adjusting screw threads. The retainer (41B, not shown) must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play (lash).



Remove relief valve components

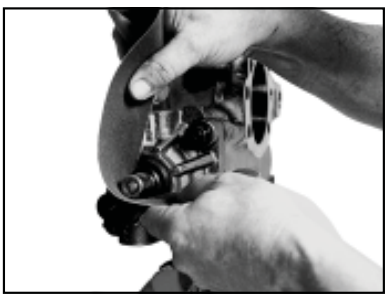
⅞" Socket

14. If equipped, remove relief valve cap (10), o-ring (9) and two-piece relief valve (8) from the valve housing. Discard the o-ring.



Remove dirt & water seal

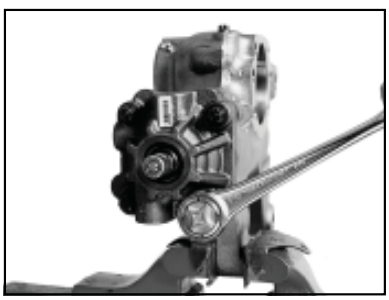
15. Remove and discard the dirt & water seal (2, 2B or 2C) from the input shaft worm and valve assembly. Save this seal for comparison with the new seal.



Clean input shaft

Fine grade emery cloth

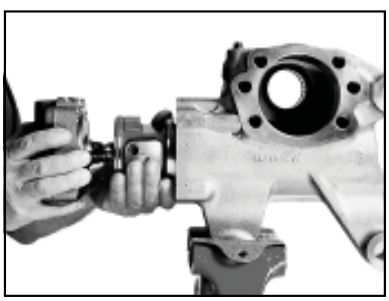
16. Clean any paint or corrosion from the exposed area of the input shaft.



Remove valve housing bolts

E-18 Torx socket

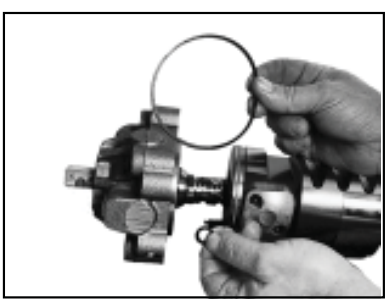
17. Remove the four torx head valve housing bolts (1).



Remove valve housing, worm and rack subassembly

18. Be prepared for more fluid drainage and remove the rack piston subassembly. Place the assembly on a clean cloth.

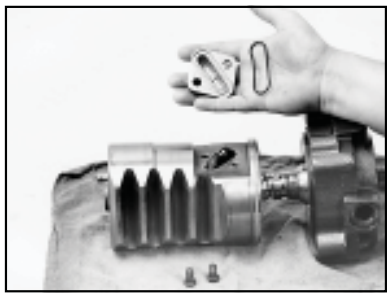
⚠ CAUTION **The set position of poppet seat and sleeve assemblies (27) must not be disturbed if the poppets are not going to be replaced or reset during disassembly.**



Remove seals

19. Remove and discard the valve housing seal rings (11& 13).

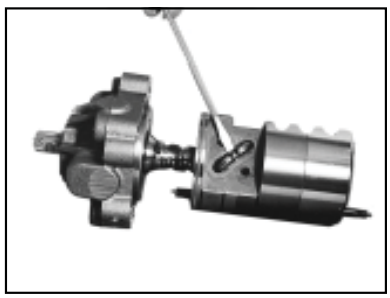
⚠ CAUTION **Do not remove the input shaft, valve worm assembly or balls from the rack piston until the ball return guides are removed as damage to the ball guides will occur.**



Remove ball return guide cap

T-30 Torx wrench

20. Remove and discard the two special sealing screws (33). Remove the ball return cap (32) and seal (31), discard the seal.

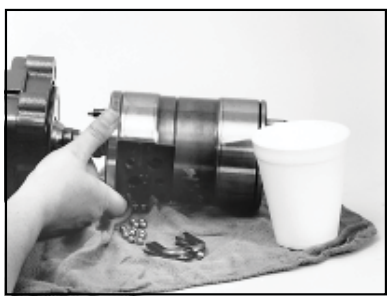


Remove ball return guides

Screwdriver

21. Make sure the rack piston is on a cloth so the steel balls that fall out won't roll very far. Remove ball return guide (30) by carefully inserting a screwdriver between the rack piston and guides.

NOTE Left hand ball return guide halves are plated with copper or zinc chromate for identification. Right hand guides are not plated. **Retain the guides for reassembly**.



Remove steel balls

22. Remove the steel balls (29) from the rack piston (28) by rotating the input shaft, valve worm assembly until the balls fall out. Place the balls and return guides in a cup or other container. Count the balls, and make sure all have been removed.

⚠ CAUTION **The steel balls are a matched set. If any are lost, the set must be replaced by service balls. Number of factory balls installed: THP/PCF45 - 29 balls, THP/PCF60 - 31 balls.**



Separate rack piston from worm subassembly

23. Remove the input, worm, and valve housing subassembly from the rack piston.



Remove seal ring and o-ring

Pocket knife

24. Cut and remove the Teflon seal ring (23) and o-ring (22) from the rack piston.



Inspect poppet assemblies

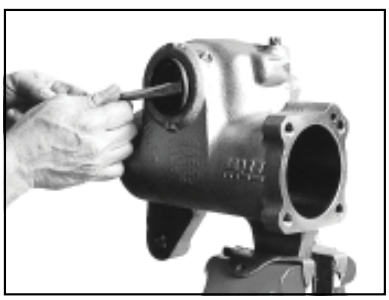
25. Push poppet stems, they should spring back. Push poppet seat, it should not move by hand. If components are bent or broken, poppet stems don't spring back, or poppet seat moves by hand, go to **Poppet Component Replacement** section on page 51. Otherwise, proceed to step 26.

NOTE TRW recommends the poppet adjuster seat and sleeve assemblies (27) not be removed unless replacement of poppet components is required.



Inspect valve housing and worm screw

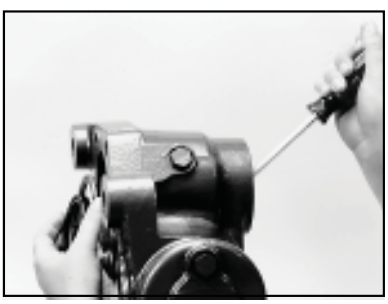
26. Inspect valve housing/worm screw subassembly for heat damage or bearing roughness. If these conditions are present, or if there was excessive internal leakage, or if preload adjustment is required, go to **Valve Housing/Worm Screw Disassembly** procedures on page 53. If not, proceed to step 27.



Remove dirt seal

Screwdriver

27. Remove and discard the dirt and water seal (40).

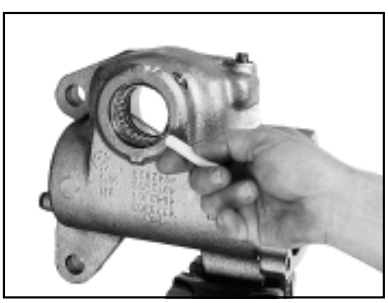


Remove pressure seal

Screwdriver

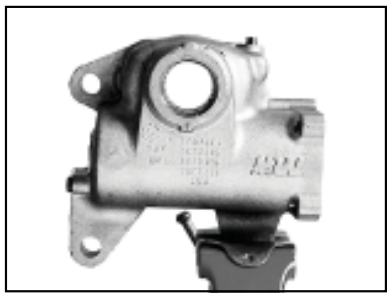
28. Insert a screwdriver through the trunnion opening, and carefully push the seal (40) out ***without damaging the sealing area of the bore***. Discard the seal.

NOTE A special hook groove has been machined into the bore to hold the seal in position. Clean out rubber from groove prior to installing new seal.



Inspect roller bearing

29. Inspect the roller bearing (39) for brinelling or spalling. If replacement is required, go to **Roller Bearing Replacement -** on page 60. If not, proceed to step 30.



Inspect housing screws, and plugs

30. Inspect the following for damage:

- Poppet fixed stop screw (38)
- Poppet adjusting screw (38A) and sealing nut (38B)
- Auto-bleed plug (37)
- Manual bleed screw (Not shown)
- Auxiliary port plugs (7) and o-rings (6)

If any are damaged, go to **Replace Housing Port Plugs and Screws** on page 61. If not, proceed to the Inspection Section.

Inspection

Make sure all sealing surfaces and seal cavities are free from nicks and corrosion. Any nicked or corroded surface requires part replacement to ensure proper sealing.

Wash all parts in clean, OSHA approved solvent. Air blow them dry only.

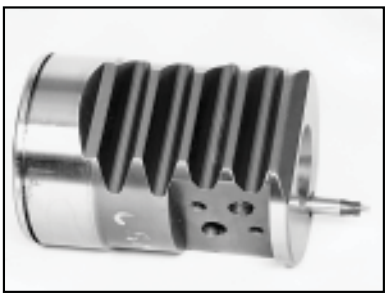
⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

⚠ WARNING **Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.**

⚠ WARNING **Any of the following conditions present in the steering gear indicates impact damage.**

Condition	Area
Brinelling	**• Ball track grooves of rack piston** **• Ball track grooves of worm screw** **• Bearing area of sector shaft** **• Thrust washer and bearing in valve housing** **• Ball cup and bearing in valve housing**
Cracks or Breaks	**• Bearing area of sector shaft** **• Sector shaft teeth** **• Rack piston teeth** **• Housing** **• Thrust washer and bearing in valve housing** **• Worm screw** **• Ball cup and bearing in valve housing**
Twisted serrations	**• Output shaft serrations**

If one of these conditions is found in one component, be sure to inspect all components carefully for signs of impact damage. Replace components noted in individual inspection steps below if you suspect impact damage. Failure to replace all damaged components could result in a serious vehicle accident.



Inspect rack piston teeth

1. Inspect the rack piston (28) teeth for cracks or obvious damage. If teeth are damaged, replace the rack piston, sector shaft (41) and set of balls (29).



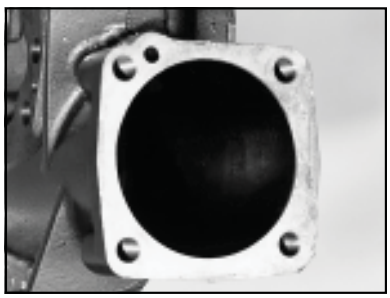
Inspect rack piston and worm ball track grooves

2. Inspect the rack piston (28) ball track grooves for brinelling or spalling. If either condition exists, replace the input shaft valve/worm assembly (15), valve housing (5), rack piston subassembly (28) and balls (29).



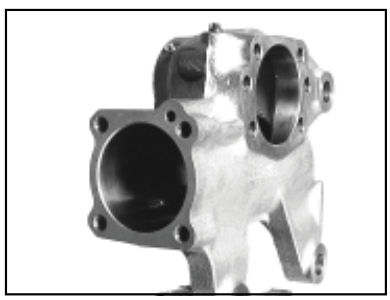
Inspect input shaft, valve/worm assembly sealing areas

3. Inspect the sealing area of input shaft and valve (15) for nicks, and damage. Inspect for discoloration from excess heat. Inspect input shaft ball-track grooves for brinelling or spalling. If any of these conditions exist, replace the input shaft, valve worm assembly, valve housing and balls. Also replace rack piston if brinelling or spalling is found.



Inspect housing cylinder bore

4. Inspect the housing (34) cylinder bore. some scoring marks are normal. If there was internal leakage greater than 1.2 gpm (4.5 lpm), make sure there are no damaged seals before replacing the housing.



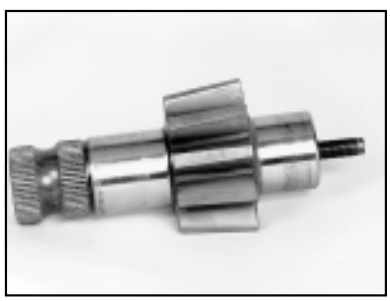
Inspect valve housing surface

5. Inspect the valve housing mating surface for nicks that would prevent proper sealing. Replace the gear housing if these nicks are present and cannot be easily removed with a fine-tooth flat file without changing the dimensional characteristics.



Inspect side cover bearing

6. Inspect roller bearing in side cover assembly (45) for brinelling or spalling. If either condition exists, replace the side cover and bearing assembly.



Inspect sector shaft assembly

7. Inspect the sector shaft (41) bearing and sealing areas and sector teeth contact surfaces for brinelling, spalling or cracks. Run your fingernail edge across these areas to detect steps. Remove masking tape from the shaft and inspect for twisted or otherwise damaged serrations. If any of these conditions exist, replace the sector shaft.

NOTE A service sector shaft will come assembled with the adjusting screw (41A) and retainer (Not shown).

Assembly Preparation

Wash all parts in clean, OSHA approved solvent. Air blow-dry them only.

⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

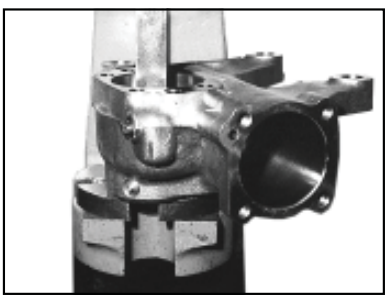
⚠ WARNING **Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.**

Replace all seals, seal rings, and gaskets with new ones each time you disassemble the gear.

TRW Commercial Steering Division makes complete seal kits available. These parts can be purchased through most OEM parts distributors. Contact your local dealer for availability.

Assembly

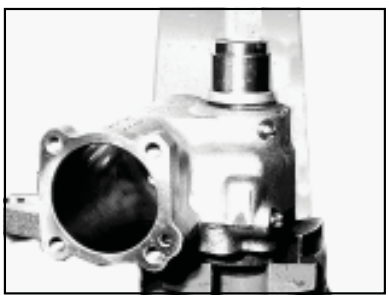
Tools Required		Materials Required	
Hammer	Screwdriver	ATF oil	Seal kit: THP450001
J37705 (THP/PCF45)	Sockets	Grease (Exxon Polyrex* EP2	THP600001
J37071 (THP/PCF60)	Torx sockets	Masking tape	
Press	Vise	14mm x 2.0mm All Thread	
Punch	Torque wrench		
Ratchet			



Press seal into housing

J37705
(THP/PCF45)
J37071
(THP/PCF60)

4. **All gears** - Assemble new seal (40) onto bearing and seal tool (short end) so the lip with the garter spring is toward the shoulder of the tool. Working from the side cover side of the housing, pilot the seal tool into the washer and bearing and press with a force of 100-800 lb (445-3,560 N) until the seal is seated firmly.

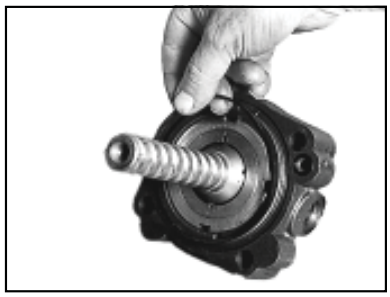


Install dirt & water seal

J37071
Press

6. Install the dirt & water seal (35) with the bearing and seal tool (long end), making sure it is not cocked. **Press the seal only until it seats against the bearing, don't push it in farther.**

Liberally pack the roller bearing and new seals with clean, high temperature industrial grease, Exxon Polyrex EP (P/N 045422).



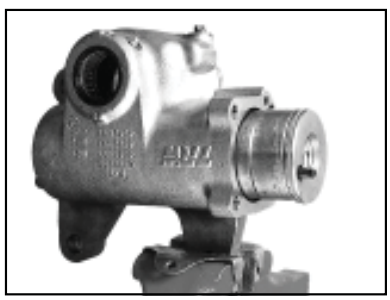
Assemble seal rings

3. Lightly oil new seal ring (11) and assemble in valve housing mounting face groove. Then, oil new seal ring (10) and assemble in valve housing (5) mounting face groove.



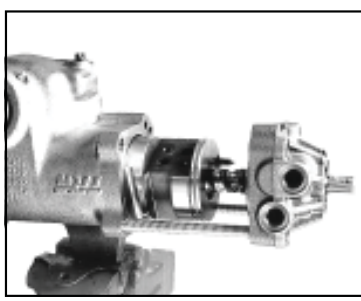
Install rack piston o-ring and seal ring

4. Install a new backup o-ring (22) and then a new Teflon seal ring (23) on rack piston (19). Do not over-stretch these rings as you install them. Do not allow the Teflon seal ring to be twisted.



Position rack piston in housing

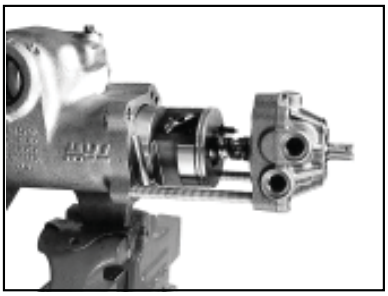
5. Apply clean oil to housing cylinder bore. Place the rack piston (28) in the housing piston bore with ball return guide holes up.



Insert worm and valve assembly into rack piston

14mm x 2.0mm
All Thread

6. Insert the worm screw into the rack piston close to maximum depth, without the valve housing making contact with the poppet stem. Insert two 14 mm x 2.0 mm All Threads through valve housing bolt holes and tighten into housing to support the worm screw. Line up rack piston ball guide holes with the worm ball track grooves by rotating the input shaft.



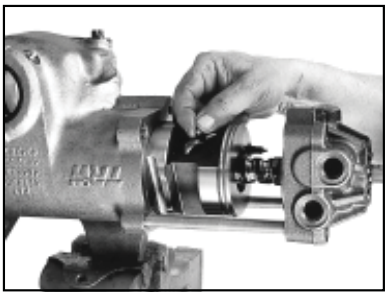
Assemble ball return guide halves

7. Assemble the ball return guide (30) into the rack piston until seated, rotate the input shaft slightly if necessary.

⚠ WARNING **Do not seat guides with a hammer. Damage to guides can result in subsequent lockup or loss of steering.**

⚠ CAUTION **If a new rack piston (28) or a new input shaft, valve, worm subassembly (15) is being assembled, the balls (29) removed from the unit must be discarded and a service ball kit utilized. The balls in a service ball kit are sized to function in the ball track guide path as altered by component replacement.**

⚠ CAUTION **When using the service ball kit, use the correct quantity of service balls: THP/PCF45 - 29 balls, THP/PCF60 - 31 balls.**



Assemble balls

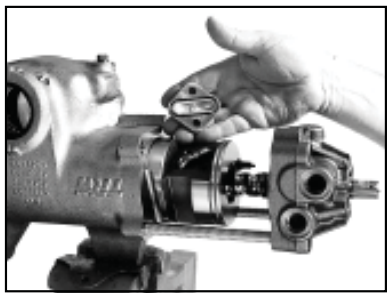
8. **Hold the ball return guide (30) firmly in place during this entire procedure.** Insert as many of the steel balls as you can through the hole in the top of the ball return guides. Rotate the input shaft to pull the balls down and around the ball track guide path. Continue until the correct number of balls are in the ball track guide path.

⚠ WARNING **Hold down the ball return guides until cap is reinstalled. Failure to hold the guides will result in a trapped ball or balls, which could cause a vehicle accident. If the ball guide becomes unseated (raises) at any time, repeat the procedure starting at step 7.**

⚠ WARNING **The correct number of balls are required for proper gear operation. Count the balls and insert each carefully as in step 7. Number required: THP/PCF45 - 29 balls, THP/PCF60 - 31 balls.**

⚠ CAUTION **Do not allow valve housing to contact the poppet stem or move more than 2½ inches (69.1 mm) from upper end of rack piston during these procedures. This could incorrectly reset the poppet, or back out worm beyond closed ball loop, trapping balls.**

⚠ CAUTION **Remove any fluid present in the two screw holes. Fluid in these holes could cause improper clamp load when torquing the cap.**

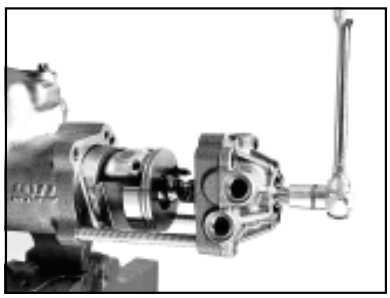


Assemble ball return guide cap

T-30 Torx socket
in•lb Torque wrench
Grease

9. Place a new ball return guide cap seal (31) in the seal groove of the cap (32). Make sure the seal makes full contact with the rack piston surface. Install two new Torx head screws (33) and torque each screw alternately until a final torque of **18 ft•lb** (24.5 N•m) is achieved.

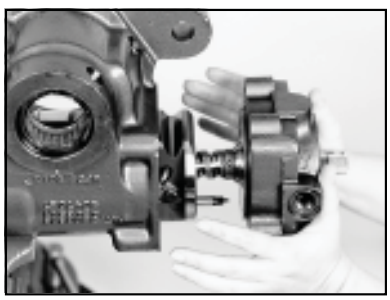
⚠ CAUTION **Ball cap seal is greased to hold seal in groove while assembling. Be sure not to trap the seal outside of the groove during reassembly.**



Rotate input shaft to check for proper installation of balls

10. Rotate the input shaft from one end of travel to the other without contacting the poppet stem to the valve housing, and without moving the valve housing face more than 2½" (69.1 mm) from input end (upper end) of rack piston. If you cannot rotate the input shaft, remove the balls and reassemble them.

⚠ WARNING **If you install a gear on a vehicle with the worm shaft unable to rotate, the gear will not function correctly. Steering and gear failure may result.**



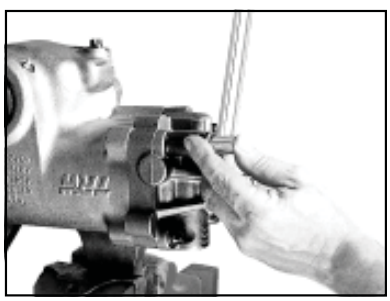
Install rack piston, worm, valve assembly

Oil

11. Apply clean oil to Teflon seal ring (23) on rack piston. Make sure there is a space of ⅜ - ½" (10.0-13.0 mm) between valve housing (5) and poppet stem to prevent poppet contact at either end. Remove the All Threads, and push the rack piston assembly into the housing with the rack piston teeth toward the sector shaft cavity. Line up the valve housing cylinder feed hole with the gear housing feed hole. Make sure both o-rings in the valve housing remain in position.

⚠ CAUTION **Do not damage the seal ring (23) while installing the rack piston into housing.**

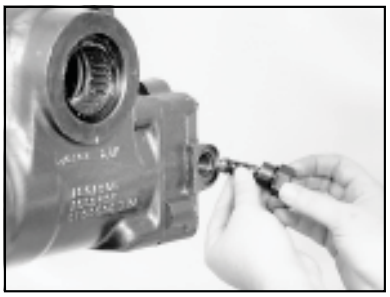
⚠ CAUTION **The poppet seat and sleeve assemblies (27) must not bottom against the internal poppet stops in the steering gear until the gear is installed on the vehicle and the poppet adjustment procedures are performed.**



Install valve housing bolts

E-18 Torx socket
ft•lb Torque wrench

12. Lubricate and install the four valve housing bolts (1) into the housing. Torque the bolts to **118-138 ft•lb** (160-187 N•m).



Install relief valve parts

⅞" Socket
ft•lb Torque wrench

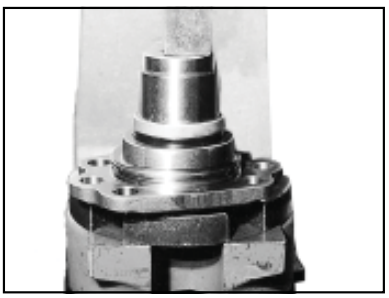
13. If the gear is equipped with a relief valve, assemble a new o-ring (9) on relief valve cap (10). Assemble the small end of tapered spring onto the pin on the relief valve cartridge and insert the assembly (8), (large end of tapered spring end first) into the relief valve cap cavity. Turn the relief valve cap as assembled into the valve housing and torque to **30 ft•lb** (41 N•m).



Lubricate side cover bearing

14. Apply a generous amount of Exxon Polyrex* EP2 (TRW P/N 045422, do not substitute another type of grease) to the caged bearing assembly inside the side cover. Next, install washer (42) on top of bearing before inserting the seal (40).

⚠ CAUTION **This bearing is sealed and will receive no lubrication from the hydraulic fluid in the gear. Failure to use the proper grease could result in premature bearing wear.**



Press seal in side cover

J37705
(THP/PCF45)
J37071
(THP/PCF60)
Press

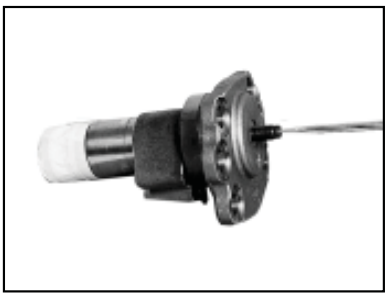
15. Grease and assemble new seal (40) onto installation tool so the side with the garter spring is against the shoulder of the tool. Pilot the tool into the side cover (45) with a force of 100-800 lb (445-3560 N) until it is seated against the bearing or bushing.

⚠ CAUTION **Make sure the OD of the seal, and the ID of the bore are free from grease and dust, for proper engagement of the seal.**



Lubricate sector shaft

16. Apply a generous amount of Exxon Polyrex EP2 (P/N 045422) to the short bearing area of the sector shaft.

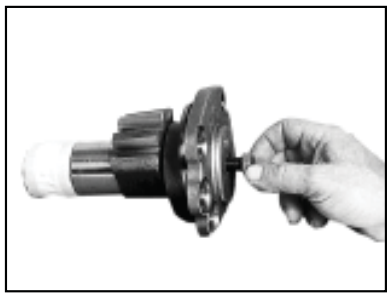


Install sector shaft into side cover

Screwdriver

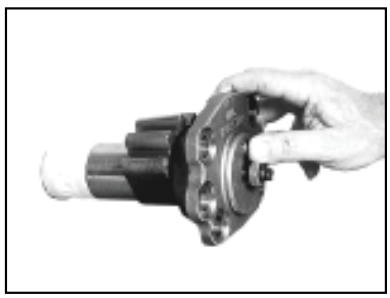
17. Insert the sector shaft (41) into the side cover subassembly (45), and turn the sector shaft adjusting screw (41A) counterclockwise into the side cover until the screw reaches solid height.

Rotate the adjusting screw clockwise one half turn so the side cover will rotate freely on the sector shaft.



Install jam nut

18. Install the sector shaft adjusting screw jam nut (46) onto the sector shaft adjusting screw (41A) a few threads. Final adjustment will be made later.



Assemble vent plug

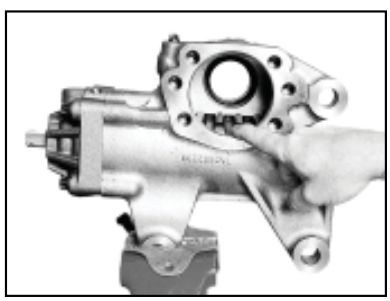
19. Press the new vent plug (47) into the hole provided in the side cover until the plug is bottomed.

⚠ WARNING **Do not weld or otherwise plug this hole in any permanent manner. This is a safety vent which functions only if the side cover seal fails. If the seal fails and the plug cannot vent, the steering gear may lock-up or otherwise malfunction.**



Install side cover o-ring

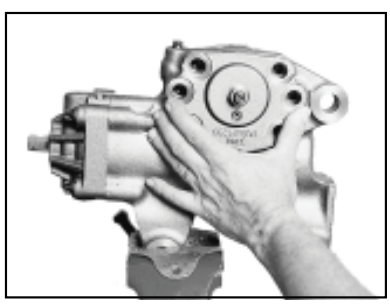
20. Apply clean oil to the new side cover o-ring (44) and assemble it onto the side cover (45).



Center rack piston

21. There are four teeth on the rack piston. Rotate input shaft to position the rack piston so the space between the second and third tooth is in the center of the sector shaft opening. This will center the rack piston for assembly of sector shaft.

⚠ WARNING **If the rack piston is not centered when sector shaft is installed, gear travel will be severely limited in one direction. This could result in an accident.**

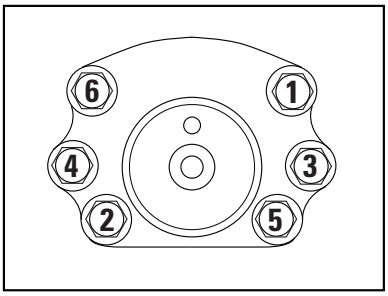


Install sector shaft and side cover into housing

Masking tape

22. Clean off any old tape on the serrations. Reapply one layer of masking tape. Install the sector shaft assembly into the housing. The center tooth of the sector shaft must engage the center space (between the second and third tooth) of the rack piston. Lightly tap on sidecover with a rubber hammer to seat cover against housing face.

⚠ CAUTION **If the serrations are not properly taped, they will damage the output seal (41) in housing, causing the seal to leak.**

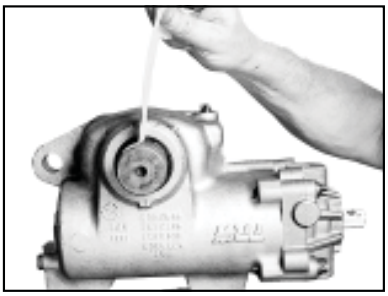


Install side cover bolts

15/16" Socket
Torque wrench

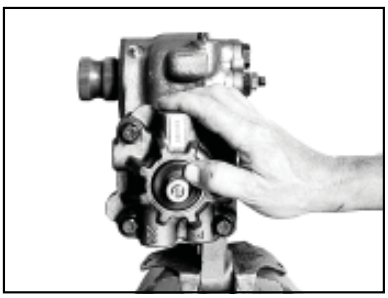
23. Install bolts in positions 3 and 4 first, by hand. Then, install the remaining side cover bolts (48) into the side cover and torque them in the sequence shown. If bolts must be replaced, use bolts of the same design, type and length as those you removed. **Do not use a substitute.**

    Lubricate side cover bolts and torque bolts to **180-220 ft•lb** (244-298 N•m).



Remove tape

24. Remove tape from the sector shaft (41).



Install dirt & water seal

Grease

25. Pack the end of the valve housing bore around the input shaft with clean, high temperature industrial grease, Exxon Polyrex EP2. (P/N 045422). Apply more of the grease to the inside of a new dirt and water seal (2, 2B or 2C) and install it over the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

    This step may have already been completed if you disassembled the valve housing and worm screw for repair.

Proceed to Final Adjustments on page 62

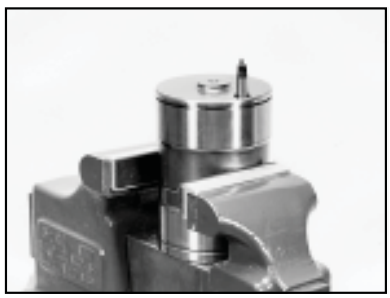
Poppet Component Replacement

Tools Required

2 lb Sledge
ft•lb Torque wrench
J36452-A
Press
3/8" x 6" drill rod
Ratchet
Soft-jawed vise

Materials Required

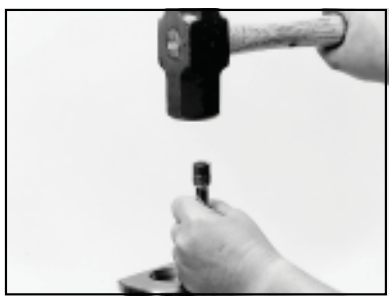
Locquic "T" primer
Loctite RC680



Place rack piston in vise

Soft-jawed vise

1. If the poppet assemblies are to be removed for replacement, place rack piston in a soft-jawed vise.



Loosen poppet adjuster seat

J36452-A
2 Lb Sledge

2. Slide special tool #J36452-A over the seat of poppet adjuster seat and sleeve assembly (27) and engage tool in the slots in the threaded sleeve. Hit the end of the tool firmly four or five times with a 2 lb sledge hammer to loosen Loctite.

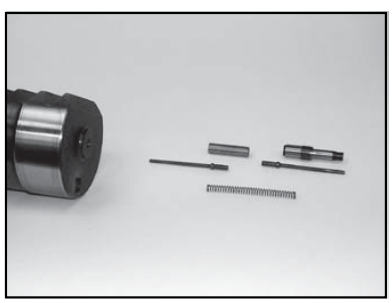
⚠ CAUTION **Poppet adjuster seat and sleeve assemblies (27) are retained by Loctite applied to the threads which makes the assemblies difficult to remove.**



Remove poppet adjuster seat

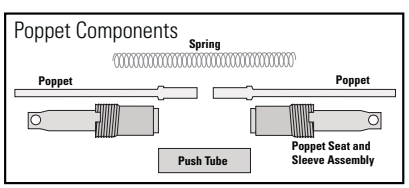
J36452-A

3. With a ratchet applied to the tool, turn one adjuster seat and sleeve assembly out of the rack piston. If the ratchet does not turn easily, strike the adjuster removal tool again with a hammer. If the engaging tangs won't stay in place while torquing, it might be necessary to hold in place with an arbor press while applying loosening torque. Discard poppet seat and sleeve assembly.



Remove poppet components

4. Remove the two poppets (26), spring (25), and push tube (24).



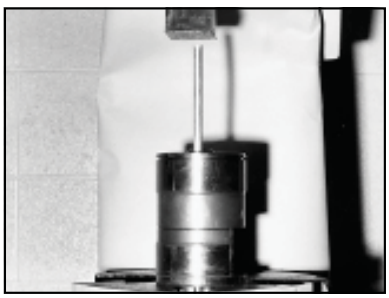
953



Remove other seat & sleeve if necessary

5. Remove and discard remaining poppet seat and sleeve assembly only if required.

NOTE It is possible to reset one poppet adjuster seat and sleeve assembly for automatic poppet adjustment while it is in the rack piston if one adjuster seat and sleeve assembly and the poppets, spring, spacer rod and push tube are removed.



Reset remaining poppet seat and sleeve assembly

Press
⅜" X 6" Drill rod

6. If one poppet seat and sleeve assy. (27) was left in rack piston, it can be reset for automatic poppet adjustment by inserting a ⅜" (9.52 mm) diameter X 6" (152.4 mm) drill rod down through the poppet seat hole at the opposite end of the rack piston and against the adjuster seat to press the seat in until it bottoms against the adjuster sleeve.



Apply Locquic "T" primer and Loctite RC680

Locquic "T" primer
Loctite RC680

7. Carefully apply Locquic "T" primer to the threads in poppet holes, and threads on the new seat and sleeve assemblies (27). Allow to dry for ten minutes; then carefully apply Loctite® RC680 to same threads.

⚠ CAUTION **Do not allow Loctite or Locquic to get on the adjuster seat component of the adjuster seat and sleeve assembly. The poppets will not function properly.**

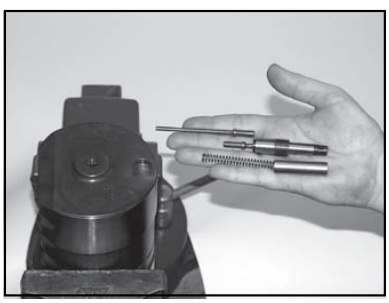


Install one poppet seat and sleeve assembly

Soft-jawed vise

8. **⚠ WARNING** **Wear eye protection while assembling poppets, as spring loaded poppets could eject and cause eye injury.**

Place rack piston (28) in a soft-jawed vise and turn one new poppet adjuster seat and sleeve assembly (27), (slotted end out) into the poppet hole in one end of rack piston.

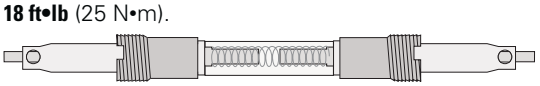


Install remaining poppet components

J36452-A
ft•lb Torque wrench

9. From the other end of the poppet hole in the rack piston, install: one poppet (26), poppet spring (25), push tube (24), other poppet (26), and the other new poppet adjuster seat and sleeve assembly (27). The new components will stack up as shown below.

Torque both poppet seat and sleeve assemblies to **18 ft•lb** (25 N•m).



Return to step 25, page 40.

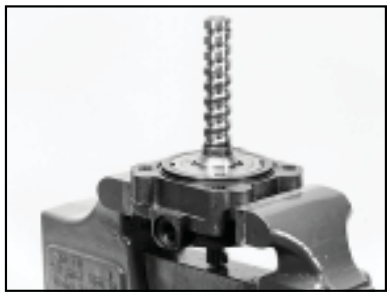
954

Valve Housing/Worm Screw Disassembly

Tools Required

Hammer
ft•lb Torque wrench
Punch, center
Punch, roll pin
in•lb. Torque wrench
J37464
J37070
J37073
Screwdriver
Small probe or pick
Sockets
12-point sockets

Materials Required



Place valve housing and valve assembly in vise

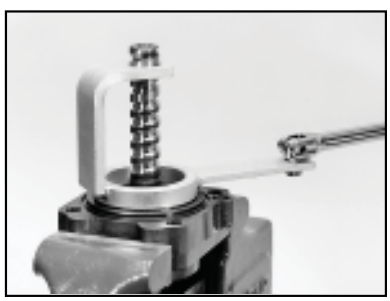
1. With worm vertical, place the valve housing (5), input shaft valve/worm assembly (15) in a vise.



Unstake adjuster locknut

Roll pin punch
Hammer

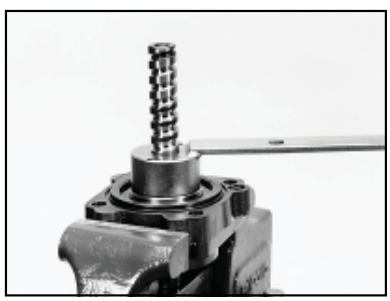
2. Unstake the valve housing (5) where it was upset into the adjuster locknut (21) slot. Also unstake adjuster nut from adjuster (20).



Remove bearing adjuster locknut

J37464

3. Turn bearing adjuster locknut (21) out of the valve housing.



Remove bearing adjuster

J37070

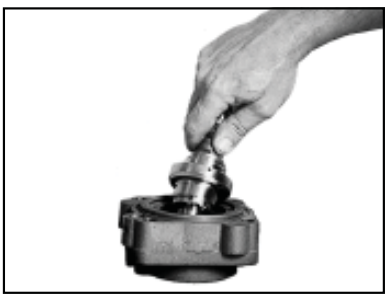
4. Turn bearing adjuster (20) out of the valve housing.



Remove seal ring and o-ring

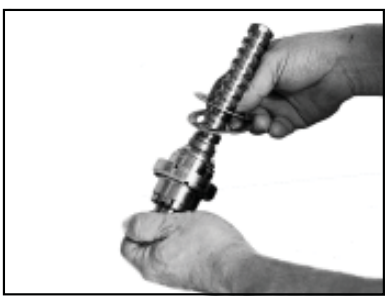
Small probe or pick

5. Remove and discard seal ring (18) and o-ring (19) from bearing adjuster.



Remove input shaft

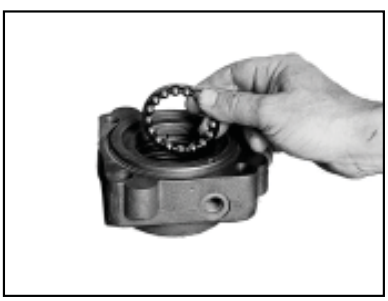
6. Remove the input shaft valve/worm assembly (15) from the valve housing (5).



Remove thin washer and bearing

7. Remove thin thrust washer (17) and thrust bearing (16) from input shaft (15).

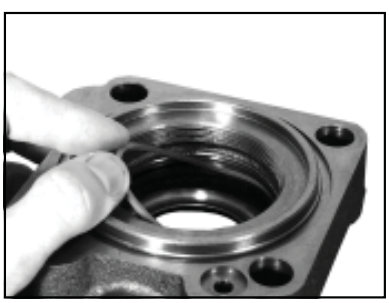
⚠ CAUTION **Input shaft, valve worm assembly must not be disassembled further. The components were a select fit at assembly and are available only as part of this subassembly. If disassembled further, the subassembly must be replaced.**



Remove ball bearing

8. Remove bearing (12) from valve housing.

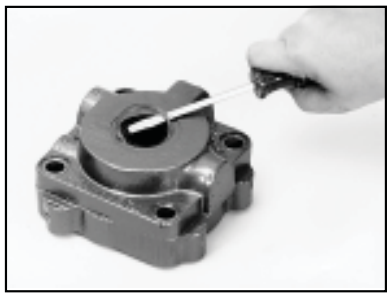
⚠ WARNING **Do not remove the ball cup that the bearing (12) rides on. Do not remove the special spacer seal behind the ball cup.**



Remove seal ring

Small probe or pick

9. Remove and discard seal ring (14) from valve housing (5).



Remove retaining ring

Screwdriver

10. Turn over valve housing and remove retaining ring (3).



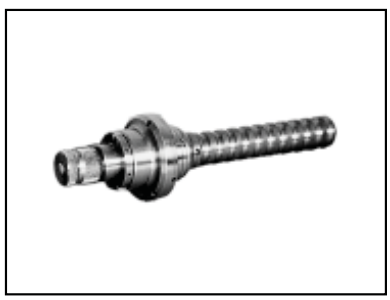
Remove seal

1⅛" Socket
Hammer

11. **⚠ CAUTION** **Exercise special care when removing seal (4) to prevent damaging the valve housing seal bore.**

Tap input shaft seal (4) out of valve housing. Discard seal.

NOTE The valve housing also utilizes a ball plug for manufacturing purposes that must not be removed.



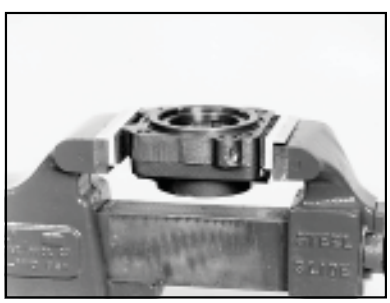
Inspect input shaft, valve worm assembly sealing areas

12. Inspect the sealing areas of input shaft and valve (15) for nicks and run your fingernail edge across the sealing surfaces to detect steps. Inspect for discoloration from excess heat. Inspect input shaft ball-track grooves for brinelling or spalling. If any of these conditions exist, you must replace the input shaft valve/worm assembly, valve housing and balls. Also replace rack piston if brinelling or spalling is found.



Inspect thrust washer and bearings

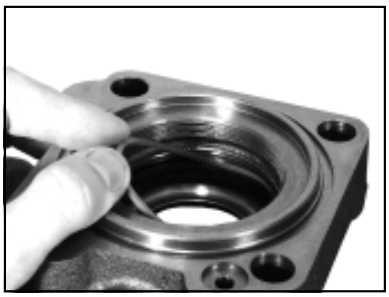
13. Inspect the thrust bearing (16) rollers and ball bearing (12) for any deterioration. Inspect thrust washer (17) and ball bearing race in the valve housing for brinelling, spalling, or cracks. Replace any part with these conditions.



Place valve housing in vise

14. Place valve housing (5) firmly in a vise so the input shaft, valve/worm assembly (15) can be assembled vertically with the worm end up.

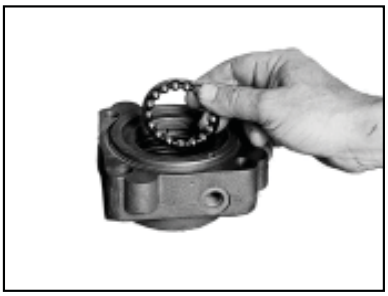
⚠ CAUTION **Do not clamp against threaded port hole or relief valve hole sealing faces when placing valve housing in vise.**



Assemble seal ring

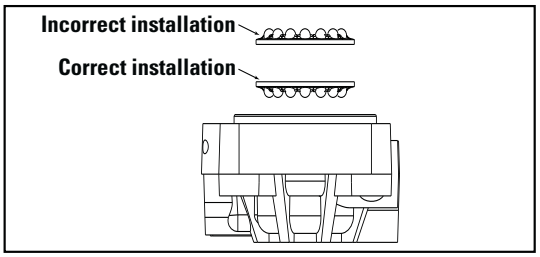
15. Lightly oil and assemble new seal ring (14) into the large diameter seal ring groove in valve housing, bending and working it in and smoothing it out as necessary.

NOTE The seal ring must be smoothed out or it may be damaged when the worm is installed.



Install ball bearing into valve housing

16. Install ball bearing (12) into valve housing (5).





Assemble input shaft, valve worm.

17. Dip the input end of the input shaft, valve, worm assembly (15) into oil up to the worm lead. Assemble the input shaft end of the assembly into the valve housing (5) until it is firmly seated.



Assemble bearing and thrust washer

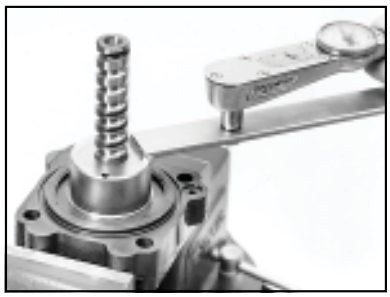
18. Apply oil and assemble the other thrust bearing (16) then the thin thrust washer (17) over the ball groove end of worm, and seat them against the shoulder of input shaft valve worm assembly (15).



Assemble seals in bearing adjuster

19. Lightly oil a new o-ring (19) and assemble into the seal groove in bearing adjuster (20). Oil and work a new seal ring (18) into the same groove and smooth it out.

NOTE Be sure the valve housing, adjuster locknut and bearing adjuster threads are clean and free of any staking burrs that would impede the locknut from turning freely on adjuster or the adjuster turning freely in valve housing.



Assemble bearing adjuster

J37070
ft•lb Torque wrench

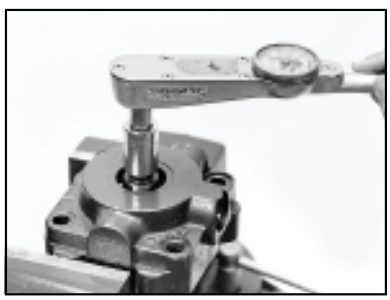
20. Lightly oil and assemble bearing adjuster (20) over worm and into valve housing. Torque adjuster to **13 ft•lb** (18 N•m) indicated torque using a torque wrench inserted in adjuster tool #J37070. This will seat the components. Back off adjuster ¼ to ½ of a turn.



Assemble new locknut

J37464

21. Lightly oil and assemble new locknut (21) onto bearing adjuster (20) with radius (slightly rounded) side down. Tighten slightly to keep the bearing adjuster in place.



Adjust to required input torque

¾" or 11⁄16" 12-point socket
in•lb Torque wrench

22. Reverse assembly in vise so the worm end is down. With an inch pound torque wrench on the input shaft, note torque required to rotate the input shaft 360° in each direction. Tighten the bearing adjuster to increase the maximum torque at the input shaft **5-10 in•lb** (.5-1.0 N•m) over that which was previously noted.



Torque locknut

J37070
J37464
ft•lb Torque wrench

23. Again reverse the assembly in vise. Torque locknut while holding bearing adjuster in position established in step 22 with appropriate adjuster tool. When using a torque wrench in locknut tool J37464, the torque wrench reading should be **112 ft•lb** (152 N•m).



Check input shaft torque

24. Recheck input shaft torque. It should match torque measured in step 22. Repeat steps 22 and 23 if necessary.

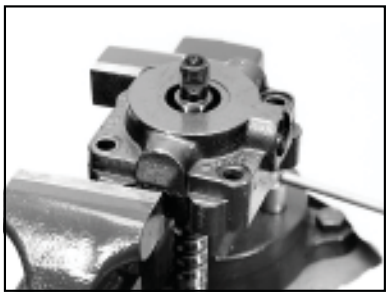


Stake valve housing and locknut

Center punch
Hammer
13/16" Socket
in•lb Torque wrench

25. Stake valve housing into the clockwise most corner of two opposing slots in lock nut (21). Stake the locknut into the adjuster (20) in two places (180° apart) at threaded area. Choose areas that have not been previously staked.

    After staking, torque required to rotate input shaft must be between **5-10 in•lb** (.5-1.0 N•m) **greater** than the torque noted in step 22. Torque value must **not exceed 22 in•lb** (2.5 N•m). Unstake and readjust if necessary.



Reposition subassembly in vise

26. Reposition worm screw/valve housing subassembly in soft-jawed vise, clamping tightly against valve housing, so the worm screw is pointing down.



Install input shaft seal

J37073
Hammer

27. Apply clean grease (Exxon Polyrex EP2, P/N 045422) to the outside and inside diameters (fill cavity between the lips) of the new input shaft seal (4) and assemble it, garter spring side first over the input shaft. Align seal in the valve housing seal bore.

    Place seal installer tool #J37073, small diameter end first, over the input shaft and against the seal. Tap the seal installer tool until the tool shoulder is squarely against the valve housing. This will correctly position the seal in the housing bore just beyond the retaining ring groove.

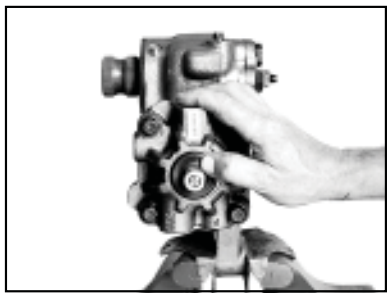
⚠ CAUTION **Remove any seal material that may have sheared off and is in seal bore and retaining ring groove.**

⚠ CAUTION **The input shaft seal must be square in the seal bore and installed to the correct depth.**



Insert retaining ring

28. Insert new retaining ring (3) into its groove in valve housing (5).



Install dirt & water seal

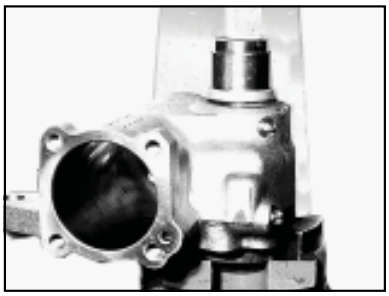
Grease

29. Pack the end of the valve housing bore around the input shaft with clean, high temperature industrial grease, Exxon Polyrex EP2 (P/N 045422). Apply more of the grease to the inside of a new dirt and water seal (2, 2B or 2C) and install it over the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

Return to step 26, page 40.

Roller Bearing Replacement

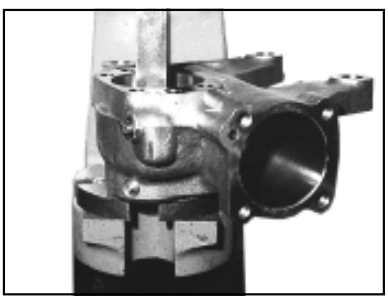
Tools Required	Materials Required
Press J37705 (THP/PCF45) J37071-A (THP/PCF60)	



Remove roller bearing if required

J37705
THP/PCF45
J37071-A
THP/PCF60
Press

1. If roller bearing (39) in housing needs to be replaced, place the bearing removal end (long end) of the bearing and seal tool against the trunnion end of the bearing and press it out of the side cover end of the bearing bore. Discard bearing.



Press in housing roller bearing

J37705
THP/PCF45
J37071-A
THP/PCF60
Press

2. Press the new roller bearing (39) into the housing from the side cover end of the bearing bore until it is seated against the step bore. Be sure the housing is square with the press base and the bearing is not cocked.

⚠ CAUTION **Use the bearing <u>installation end</u> of the tool (short end). If the bearing <u>removal end</u> of the bearing & seal tool is used to press in bearing, the cage on the new bearing may be damaged.**

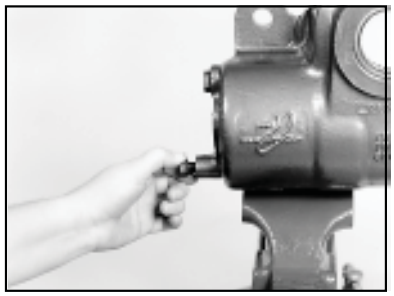
NOTE If the unmachined trunnion face is not square, use shims to square it before pressing in the bearing.

Return to step 29, page 40.

962

Replace Housing Port Plugs, Screws, and Fittings

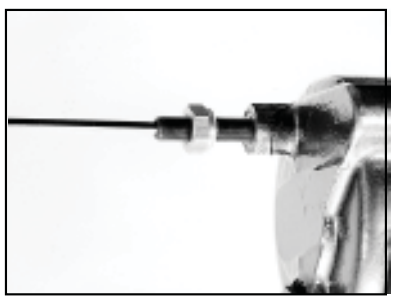
Tools Required	Materials Required
Allen wrench Torx sockets SAE/Metric sockets Open end wrench in•lb Torque wrench ft•lb Torque wrench	



Replace poppet fixed stop screw

THP/PCF45
18mm Socket
THP/PCF60
5/8" Socket
ft•lb Torque wrench

1. If damaged, remove and replace the poppet fixed stop screw (38) and washer (Not shown) if equipped. Replace with poppet fixed stop screw (38), discard the washer. Torque to **48 ft•lb** (65 N•m).

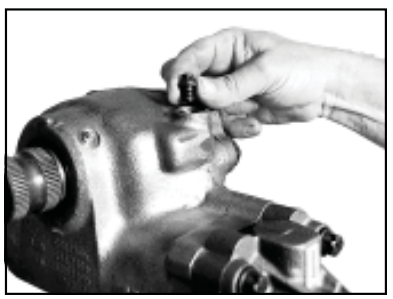


Replace poppet adjusting screw

THP/PCF45
6mm Allen wrench
18mm Socket
19mm Wrench
THP/PCF60
7/32" Allen wrench
5/8" Socket
3/4" Wrench
ft•lb Torque wrench

2. If damaged, remove poppet adjusting screw (38A) and sealing nut (38B) without allowing the nut to change its position on the screw.

   Assemble the new nut onto the new adjusting screw, matching its position to the nut and screw removed. Torque sealing nut to **35 ft•lb** (47 N•m).

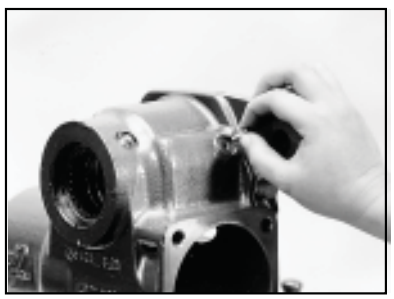


Replace automatic bleed screw, and aux. port plugs

E-14 Torx socket
ft•lb Torque wrench

3. If damaged, remove and replace automatic bleed plug (38). Torque to **48 ft•lb** (65 N•m).

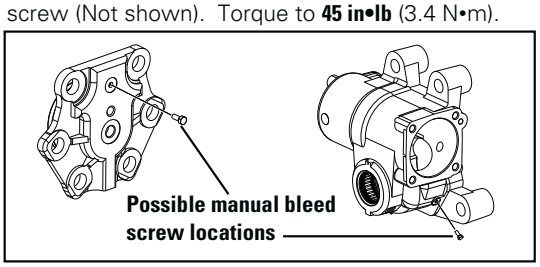
   If damaged, remove and replace permanent auxiliary port plugs (7) and o-rings (6). Assemble new o-rings on port plugs and torque to their respective ports in the housing or valve housing to **30 ft•lb** (41 N•m).



Replace manual bleed screw

5/16" Hex socket
in•lb Torque wrench

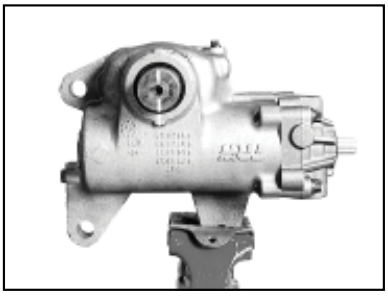
4. If damaged, remove and replace manual bleed screw (Not shown). Torque to **45 in•lb** (3.4 N•m).



Return to inspection section, page 42.

Final Adjustments

Tools Required		Materials Required
Box-end wrench ft•lb Torque wrench in•lb. Torque wrench	Screwdriver Sockets	



Center steering gear

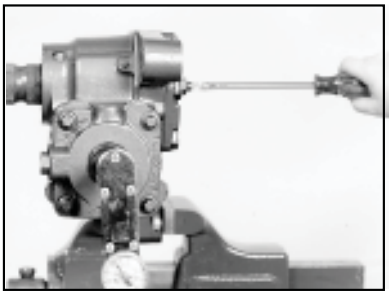
¾" and 11⁄16" Socket or box end wrench

1. To center the steering gear, rotate input shaft valve worm assembly (15) until the timing mark on the end of the sector shaft (41) is in line with the timing mark on the end of housing trunnion.

⚠ CAUTION **Do not rotate the input shaft more than 1.5 revolutions from center position until the steering gear is installed, during poppet setting procedure. Doing so could make the automatic poppets inoperative, which would require disassembly of steering gear to reposition poppet seat and sleeve assemblies.**

NOTE Initial poppet contact will occur at less than one input shaft rotation in one direction from steering gear center position, if new or reset poppet adjuster seat and sleeve assemblies are assembled in the unit.

NOTE Worm preload adjustment was set when input shaft, valve and worm were assembled into valve housing.

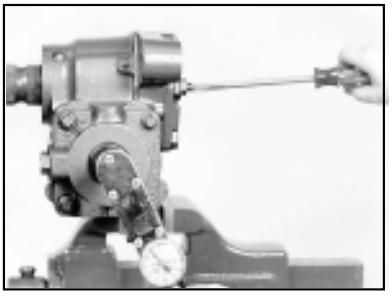


Tighten adjusting screw

in•lb Torque wrench
Screwdriver
11⁄16" or ¾" Socket

2 With adjusting screw jam nut (46) loose, turn sector shaft adjusting screw (41A) clockwise to provide **45-50 in•lb** (5-5.5 N•m) of torque required to rotate the input shaft valve/worm assembly (15) through one half turn (180°) each side of center.

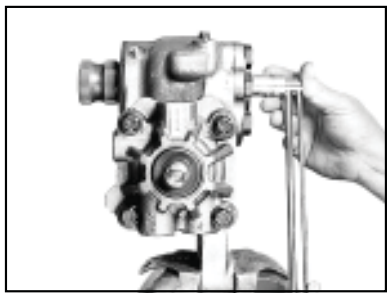
NOTE This procedure will properly mesh and seat the rack piston and sector shaft teeth for final adjustments.



Loosen adjusting screw and note torque

in•lb Torque wrench
Screwdriver
11⁄16" Socket

3. Turn sector shaft adjusting screw (41A) counter-clockwise one half turn and **note maximum torque** required to rotate the input shaft, valve/worm assembly through one half turn (180°) each side of center.



Adjust adjusting screw

¾" Socket
$^{11}/_{16}$" Socket
ft•lb Torque wrench
in•lb Torque wrench

4. Adjust sector shaft adjusting screw (41A) clockwise **to increase** maximum torque noted in step 3 by **7 in•lb** (.8 N•m). Tighten jam nut (47) firmly against side cover while holding the adjusting screw in position. Finally, torque jam nut to **43 ft•lb** (58 N•m) and check input shaft valve/worm assembly torque again. Readjust if input shaft torque exceeds **40 in•lb** (4.5 N•m).

Section 5 Reinstallation

Reinstallation 65
Poppet Resetting 65

Glossary 66

Reinstallation

- Verify that axle stops are set to manufacturer's wheelcut or clearance specifications.
- Bolt gear to frame, torque to vehicle manufacturer's recommendation.
- Connect return line to reservoir in THP/PCF return port.
- Connect hydraulic line from pump to pressure port in THP/PCF unit.
- Connect steering column to input shaft, torque pinch bolt to vehicle manufacturer's recommendation.
- Install pitman arm on output shaft, with timing marks aligned. Torque bolt to vehicle manufacturer's recommendation.
- Connect drag link to pitman arm.

Poppet Resetting

IF Poppets remain unchanged from when gear was removed from vehicle, and gear is being installed on the same vehicle with no change in axle stops or linkage.	After installation, check to make sure poppets relieve in both turns just before axle stop contact is made. If not, use resetting procedure beginning on page 23.
IF Poppets were replaced with new components or reset during gear disassembly, and are ready for automatic positioning.	Use poppet setting procedure on page 13.
IF Poppets may have been moved during disassembly or reassembly procedures, or gear is being installed on a different vehicle.	Use poppet resetting procedure beginning on page 23.

Glossary

Aerated Fluid
Fluid with air bubbles

Automatic Bleed Systems
Gears are mounted in such a way that trapped air can be forced out of the system "automatically" without loosening bleed screw.

Axial
In-out movement along an axis (imaginary straight line on which an object moves)

Brinelling
Dents

Date Code
Date the steering gear was built (Julian date)

Discoloration
Change in color

External Leakage
Fluid Leaking out of the system or steering gear

Full Turn
Hub contacts axle stop

Integral Power Steering
Steering gear has manual steering mechanism, hydraulic control valve, and hydraulic power cylinder all within gear housing.

Impact
The application of torques and forces to steering gear components during accidents or other similar events which exceed the hydraulic capacity of the steering gear

Internal Leakage
Fluid leaking inside the gear

Lash
Free play

Manual Bleed Systems
Gears are mounted in such a way that an air pocket could form in one end of the steering gear. The bleed screw is positioned so trapped air can be forced out when loosened.

OSHA
Occupational Safety and Health Administration

PCF
Positive Center Feel - option available on THP series steering gears.

Poppets
Unloading valves, reduce pressure in full turns.

Relief Valve
Limits maximum supply pressure

Return Line
Line that connects steering gear to reservoir to recirculate hydraulic fluid

Rotary Control Valve
Controls flow in internal cavities

Scoring
Scratch

Shock Load
Shake or jar

Spalling
Flaking or chipping

Subassembly
An assembled unit that fits into a larger unit

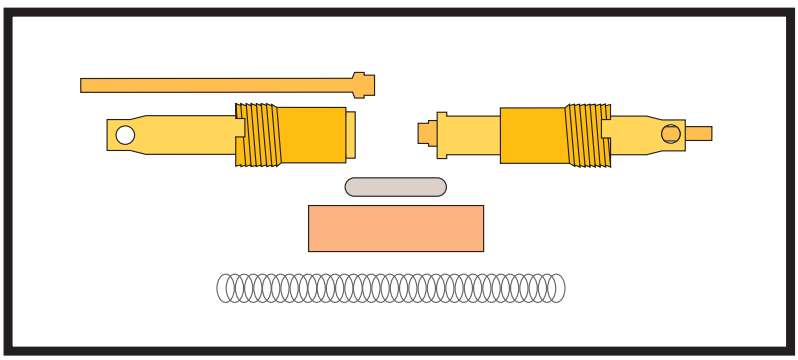
Supply Line
Line that connects pump to steering gear

Twisted Serrations
Output shaft serrations damaged by impact overload. Serrations can be twisted at the area between the large diameter of the shaft and the end of the serrations.

TRW Automotive
CommercialSteering Systems

TAS Poppets

A Workbook and Self-Test
to be used with the
TRW TAS Poppet SettingVideo



Follow all precautions and warnings in Service Manual when setting or resetting poppets

What Poppets Are:

Poppets reduce pressure in full right and left turns

- Reduces hydraulic system heat
- Reduces force on linkage components

Pressure and heat build up in the steering system during turning maneuvers.

High temperatures can deteriorate the hydraulic system over time.

High pressure could put a lot of stress on linkage components over time.

How Poppets Work:

Rotating input shaft causes rack piston to move

Lower poppet in rack piston contacts fixed stop bolt or adjusting screw

Upper poppet in rack piston contacts valve housing

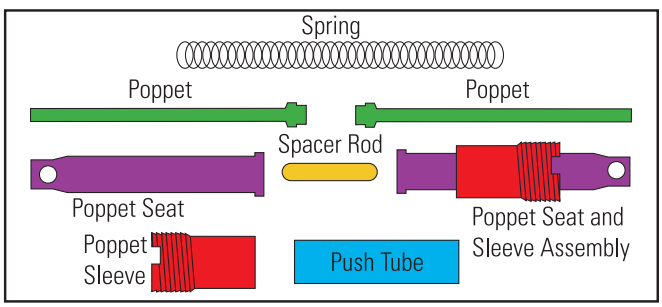
Contact of poppet and screw or valve housing pushes poppet away from it's seat.

Gap between poppet and seat allows fluid to pass through the rack piston, reducing pressure.

Poppet should contact screw or valve housing just before axle contacts axle stop.

TAS Poppet Components:

- Two Poppet Seat and Sleeve Assemblies
- Two Poppets
- Spring
- Nylon Spacer Rod
- Push Tube



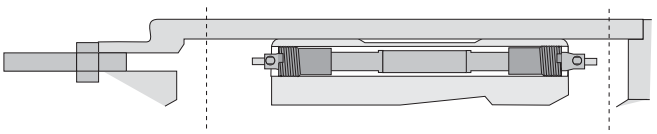
Setting poppets means pushing the poppet seat into the poppet sleeve. This backs off the poppet so it will contact the screw or valve housing just before axle contacts axle stop

TAS Factory Setting:
(or New Aftermarket Gear)

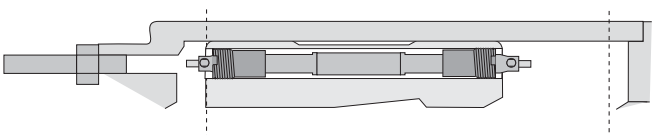
- Set axle stops
- Raise front axle
- Turn full right - engine on
- Turn full left - engine on

New steering gear poppet components look like this before setting. At this point, they are ready for automatic adjustment.

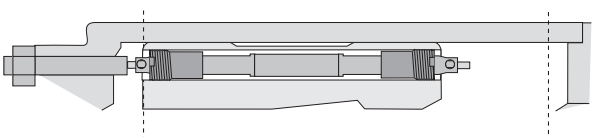
The amount of gear travel is determined on each vehicle by the axle stop settings. End of gear travel is marked in these diagrams by dotted lines The rack piston will stop when it reaches these points because the axle stops will not allow the road wheels to travel further.



On the first full turn after installation on a vehicle, the poppet seat will make contact internally, and be pushed into the sleeve. Since the rack piston has travelled to its farthest point for the vehicle, the poppet seat, in its new set position, has also reached its farthest point of travel.

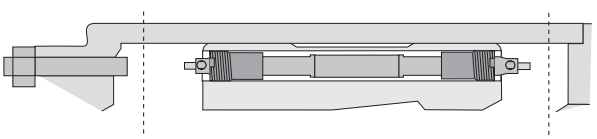


In the second full turn, the remaining poppet seat will be pushed in the amount required for that vehicle. Since the poppet seat and sleeve assemblies are a pressed fit, both poppet seats will now remain in this set position until they are reset using the procedure that follows.



Notice that the poppets were adjusted along with the poppet seat. In all subsequent turns, the poppet will be pushed off the seat to reduce pressure, and the poppet seat should never again make contact with the housing or the fixed stop screw.

When the poppet makes contact, pressure is reduced which also reduces the power assist felt at the steering wheel. Axle to axle stop contact can still be achieved, but with manual steering only.



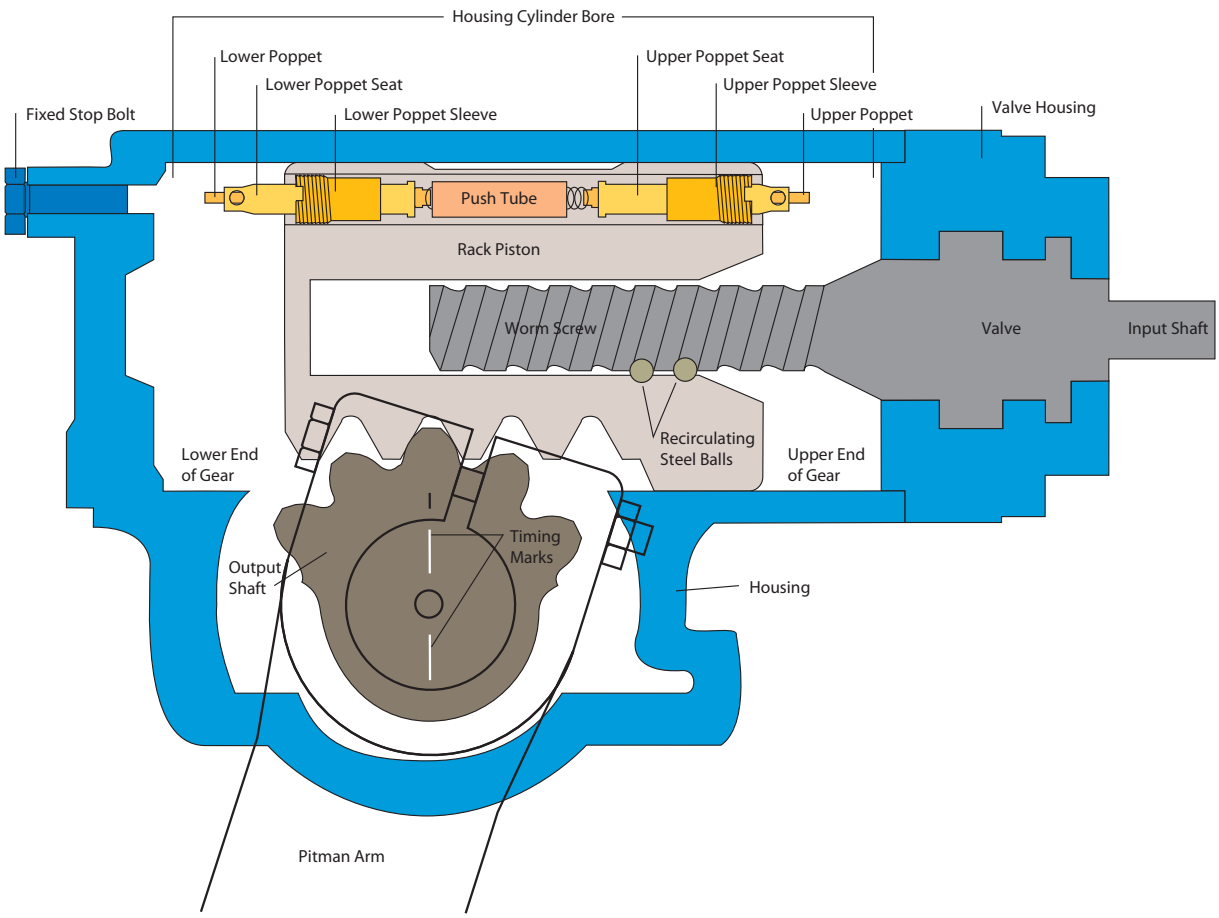
Reasons for Resetting Poppets:

- Changing to larger tires
- Reducing wheelcut for any reason
- If the steer axle u-bolts were bent or broken
- If the pitman arm was mistimed
- Axle stop bolts were damaged
- Steering gear is mounted on a different vehicle

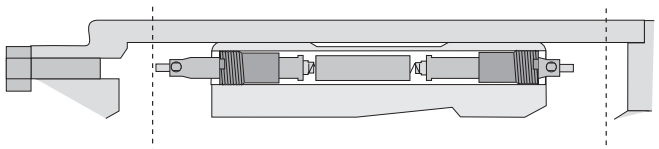
TAS Resetting:

- Set axle stops
- Install adjusting screw
- Raise Front Axle
- Start Engine
- Turn in the direction that moves the inner output shaft timing mark toward adjusting screw
- Pull hard on the steering wheel
- Turn in opposite direction, pull hard on the steering wheel
- Turn off engine
- Back out adjusting screw until 1" is past the nut
- Start engine
- Turn steering wheel in original direction, pull hard when axle stop contact is made
- Screw in adjusting screw until it stops
- Back out adjusting screw 3 1/4 turns
- Torque jam nut
- Turn off engine, lower vehicle

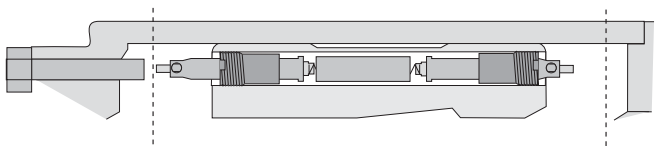
Introduction to Internal Components



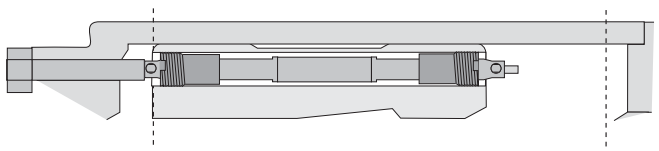
Axle stops have been reset in this diagram. They have been moved in, indicating that wheel cut has been reduced.



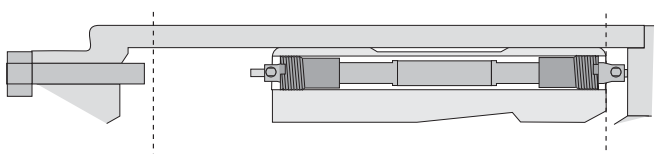
An adjusting screw is installed in the gear for the resetting process so the poppet components can be forced together to push on one another. Once the poppet components are pushed together, they will stay that way. The adjusting screw will also remain as part of the gear. Do not try to reuse the fixed stop screw after resetting poppets.



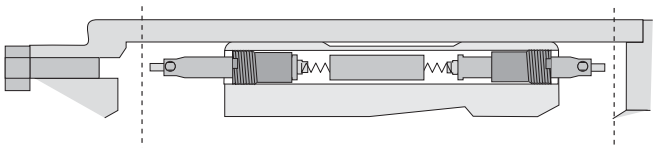
Turning in a direction that makes the rack piston move toward the lower end of the steering gear will force the lower poppet seat against the adjusting screw. The lower poppet seat then contacts the push tube and forces it against the upper poppet seat. This will force the upper poppet seat out so it can be set automatically on the next turn.



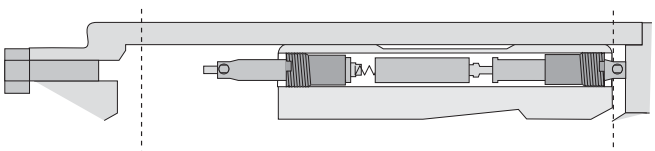
This turn sets the upper poppet seat in just the same way as it was set when the gear was new. Notice that since the poppet components are still forced together, the upper poppet seat is now forcing the push tube against the lower poppet seat to push it out.



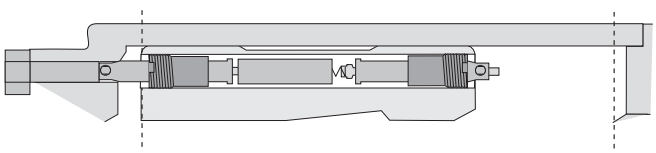
The adjusting screw is backed out of the way, so the poppet seat will not contact it on the next turn.



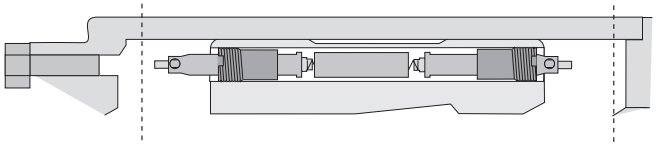
Holding the wheel at full turn places the poppet seat in the proper position for setting.



The adjusting screw is then turned in to meet the lower poppet seat and backed-out 3 1/4 turns.



The adjusting screw remains in this position, and acts as the contact point for the lower poppet until poppets need to be reset again.



Self-Test:

1. Poppets reduce system pressure:
   A. After full turn
   B. When axle stop contact is made
   C. Just before full turn

2. Reducing pressure lessens:
   A. Temperature in the hydraulic system
   B. Stress on the linkage
   C. Both

3. A good reason to reset poppets would be:
   A. Wheelcut has been reduced
   B. Loose Steering
   C. Wheel kick

4. Always set axle stops before setting poppets.
   A. True
   B. False

5. If the sector shaft timing mark points toward the upper poppet, you should set the lower poppet.
   A. True
   B. False

Glossary of Terms:

Gear Families - TAS Family = TAS40, TAS55, TAS65, TAS85 (RCS cylinders are TAS gears without worm and valve). HFB Family = HFB52, HFB64, HFB70 (RCB cylinders are HFB gears without worm and valve) HF Family = HF54, HF64

Linear Cylinder - A cylinder with a piston rod that provides in/out thrust.

Lower End - End of cylinder bore farthest from the input shaft.

Master Gear - Main steering gear, located on driver's side of vehicle.

Pressed Fit - The fitting of two components that allows a controlled movement between them, but will not allow them to move during normal operational actions.

Pump Relief Pressure - Maximum pressure of the power steering pump.

Rim Pull - Force used to turn the steering wheel, measured in pounds at the rim of the steering wheel.

Slave Gear - Auxiliary gear on passenger side of vehicle. Has no worm screw, ball-nut mechanism, or control valve.

Steering System - Includes mechanical and hydraulic components: steering wheel, column, u-joints, slip joints, miter box, steering gear, pump, reservoir, hoses and connections, pitman arm, drag link and sockets, axle arm, king pin, bushings, tie rod arms and ends, steering spindle, wheel bearings, springs and spring pin connectors, spring hanger brackets, front axle, u-bolts.

Steering Wheel Travel - Number of times the steering wheel can rotate between full turns.

Thread Engagement - The amount of contact between threads on screw and nut.

Timing Marks - Use the output shaft timing mark nearest the cylinder bore to judge which poppet to set.

Upper End - End of cylinder bore nearest the input shaft.

Answers to the Self-Test:

1. C
2. C
3. A
4. A
5. B

TAS Poppet Workbook

TRW Commercial Steering Systems
800 Heath Street
Lafayette, IN 47904
Phone: 765/423-5377
Fax: 765/423-4453

TRW1102
Electronic Version February 2001

Body Glass

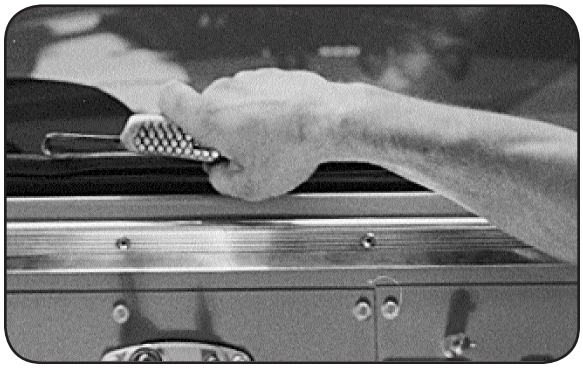
Glass replacement should meet standards in specification FMVSS 205 and 217.

WARNING ***When replacing broken or damaged glass, use extreme care at all times to prevent personal injury. Use proper replacement parts, tools and personal protective equip-ment, such as gloves and safety goggles.***

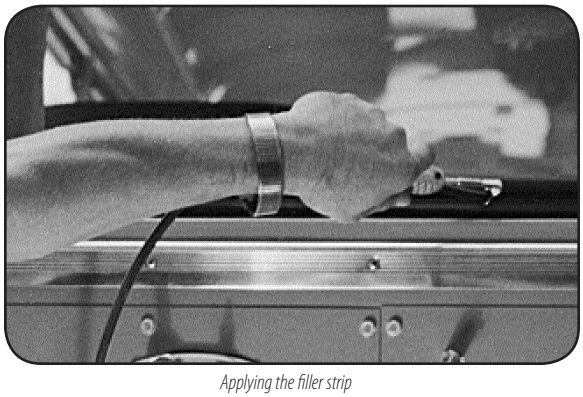
Windshield Glass Replacement

Remove vertical filler strip in glazing rubber on each side of broken glass. Remove horizontal filler strip in glazing rubber on top and bottom of broken glass. It will be necessary to cut the horizontal filler strip after it is pulled past the glass.

1. Starting at a corner, push glass free of glazing rubber from inside of bus outward and remove.
2. Position new glass in glazing rubber.
3. Using installation tool, work glass into glazing rubber.
4. Seal glass to glazing rubber from outside of the bus with an adhesive sealant, such as Silastic 732 RTV Adhesive/ Sealant.
5. Apply soapy solution to filler strip channel on glazing rubber to act as a lubricant for easier installation of filler strip.
6. Using filler strip tool, insert fillet strip into channel on glazing rubber.



Using glazing tool to help work gasket around windshield

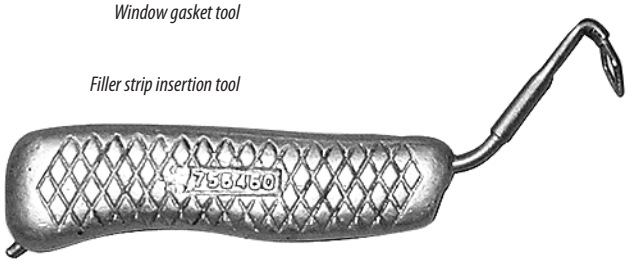


Applying the filler strip



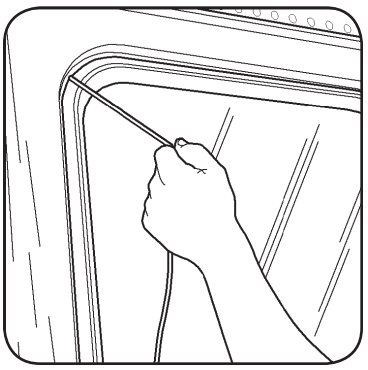
Window gasket tool

Filler strip insertion tool

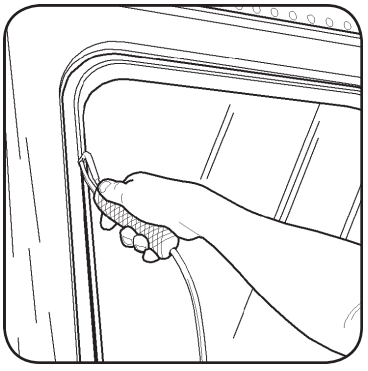


Rear Vision Glass Replacement

1. Remove filler strip from channel in glazing rubber.
2. Apply pressure against glass from the outside of the bus starting at a corner, push glass and glazing rubber off metal flange.
3. Remove glazing rubber from glass.
4. Put glazing rubber on new glass.
5. Apply a soapy solution to the flange on the bus body and to the filler strip channel on glazing rubber. This acts as a lubricant for easier installation.
6. Wrap a cord around the glazing rubber and rest the glass on the bottom window flange from the inside of the bus body. See Figure 6.
7. Apply pressure from the inside of the bus body to ensure glass is seated properly. Pull cord slowly and work glazing rubber onto the window flange.
8. Using a filler strip tool, insert the filler strip into the channel on the glazing rubber. The filler strip tool is available from your Dealer. See Figure 7.
9. Apply clear caulking around glass and window flange on the outside of bus body to ensure that no leaks occur.



Using a cord to help install gasket around glass



Applying Filler Strip

Transit Sliding Window Removal

1. Remove screws in outside aluminum extrusion.

2. Loosen sealer between window frame with putty knife.

CAUTION ***Do not pry window frame from body without loosening sealer. Unless sealer is loosened, window frame will be bent.***

3. Pry out using screwdriver.

4. Reverse procedure for installation.

Transit Window Glass Replacement

On push out windows, when hinge screws are removed and interior latch released, window sash may be removed from frame.

1. Release window lever (1) located inside the bus at the bottom of each push-out window.

2. Remove hinge screws (2) on outside of body.

3. Lift and pull window out of section.

4. To remove stationary transit sliding window, remove all screws between inner frame (4) and outer frame (5).

5. Lift and pull window out of section.

6. Remove four screws and take out vertical brace (6) located in the center of the window.

7. Remove two window stops (one on each side of the top of window).

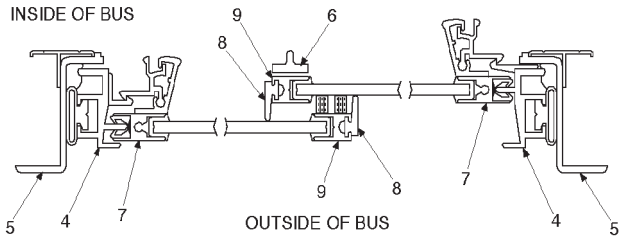
8. Slide glass to the center of the window. Spread apart the inner frame (4) just enough to lift glass frame (7) out.

9. To remove glass from frame, slide rubber seal (8) out of vertical rail (9) exposing two screws. Window glass is removable after screws are removed. Remove glass.

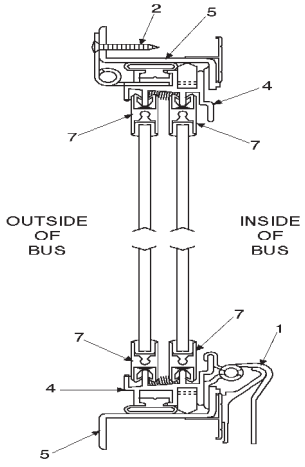
10. To replace glass, slip glazing vinyl seal around glass and slide into frame.

11. Reassemble by reversing procedure.

Transit Sliding Window

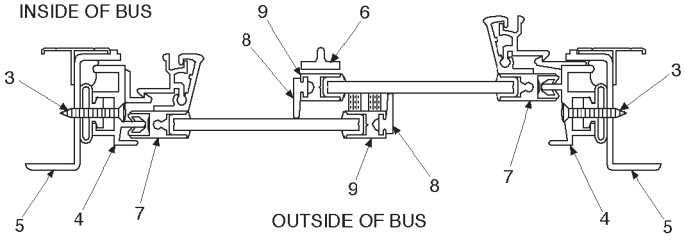


**HORIZONTAL SECTION THRU
TRANSIT SLIDING WINDOW PUSH OUT WINDOW**

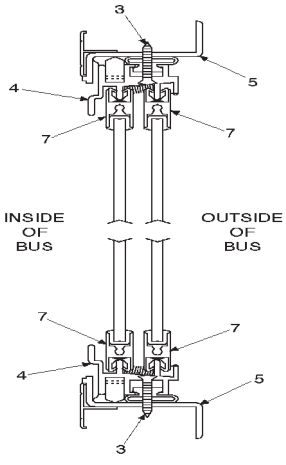


**VERTICAL SECTION THRU
TRANSIT SLIDING
PUSH OUT WINDOW**

Pushout Transit Sliding Window



**HORIZONTAL SECTION THRU
TRANSIT SLIDING WINDOW**



**VERTICAL SECTION
THRU TRANSIT
SLIDING WINDOW**

Outward Opening Entrance Door

The outward opening door panels are hung in a prefabricated framework before mounting into the body construction. The doors are suspended from sealed ball bearings located at the upper corners of the door. These components are accessible only from inside the body.

The bronze bearings at the lower corners of the door assembly are not weight bearing, but serve to hold the bottom of the assembly in position. These bronze bearing are permanently lubricated and should require little maintenance during the service life of the door assembly, which exceeds 300,000 cycles.

The interlink between the door panels is installed as a single assembly in the door header, and is adjustable for maintaining proper opening/closing tension.

Interlink Adjusment

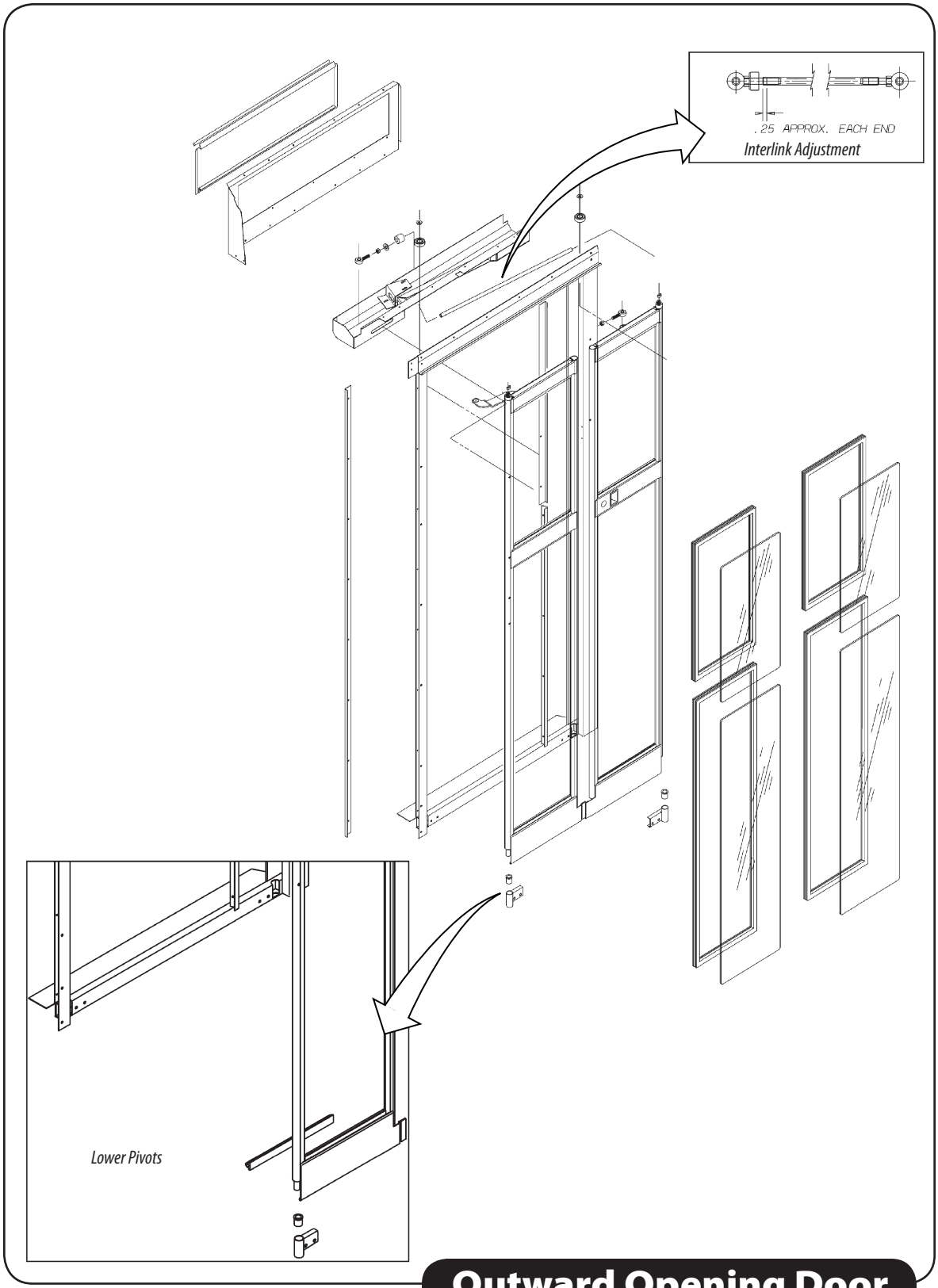
The mechanical link between the doors (the interlink rod) should be adjusted so that the rearward door closes and seats first. One of the spherical bearing, rod end connectors has a right-hand thread; the other has a left-hand thread. This allows for length adjustment by simply turning the interlink rod. The forward door panel then closes with an overlap to the rear of the bus, helping to reduce the intrusion of outside air while the bus is in motion. The forward door pivots across the centerline of a cam, thus locking the rear door panel in position.

When properly adjusted, the door should begin to require more energy to close as the trailing edge of the front door panel gets to within 2 or 3 inches of the closed position. When the mechanism is properly adjusted, you should only be able to push the door open by pressing on the forward door panel from the inside. The rearward panel should be locked into position and will not move until the forward panel moves.

1. With the doors open, loosen the jam nut at the forward end of the interlink rod. The jam nut on the rearward end of the interlink assembly is to hold the bumper in position and is located inside the access panel over the door.

2. Turn the interlink tube until, by trial and error, the door mechanism operates properly.

3. Tighten the jam nut securely.



Outward Opening Door

Manual Door Control

Manual Door Control Arm Removal

The manual door control rod does not need to be removed to adjust or remove the door panel assemblies. However, the clevis pin must be removed when removing the door panels.

1. Remove the cotter pin and clevis pin securing the control arm to the door.

2. If the control arm is in the way of your work, remove it by removing the pivot bolt, nut, and spacer from the handle.

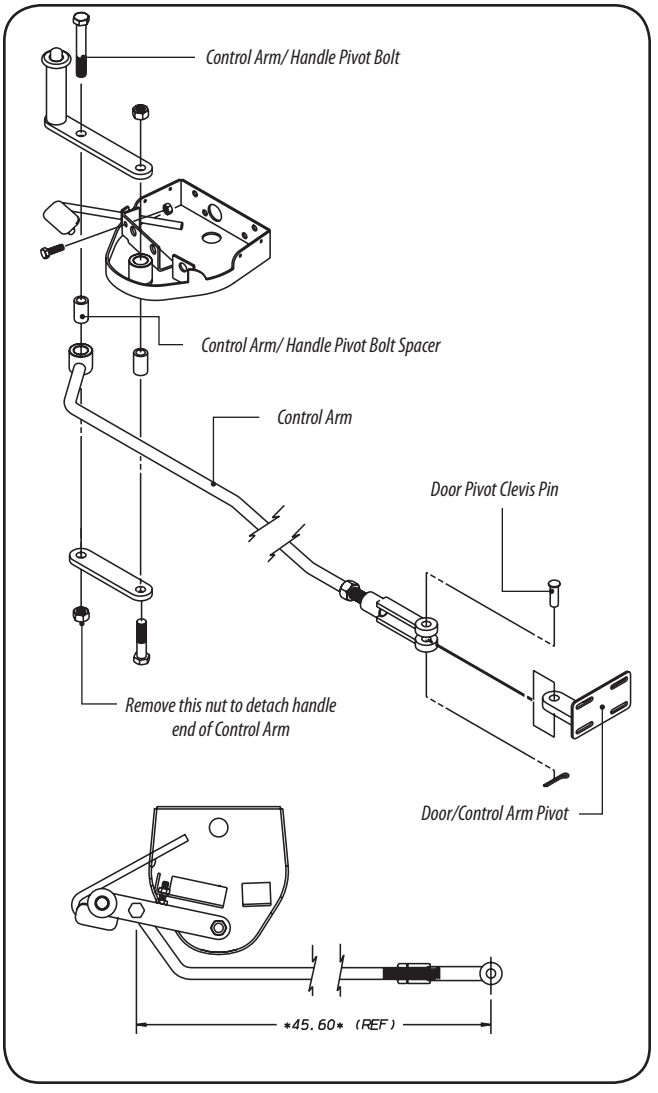
Manual Door Control Reinstallation

If the length of the manual control rod assembly is moved, the nominal length for outward opening doors should be set to 45.60 inches (115.82 cm). Then adjust to close with proper tension. When the door operates satisfactorily, tighten all hardware securely.

1. If necessary, install the door/control arm pivot. Snug up so it will not move. Do not tighten securely at this time.

2. With the doors in the closed position, pre-assemble the control arm to the approximate length required.

3. Attach the clevis to the door pivot and insert the clevis pin. Do not install the cotter pin at this time.



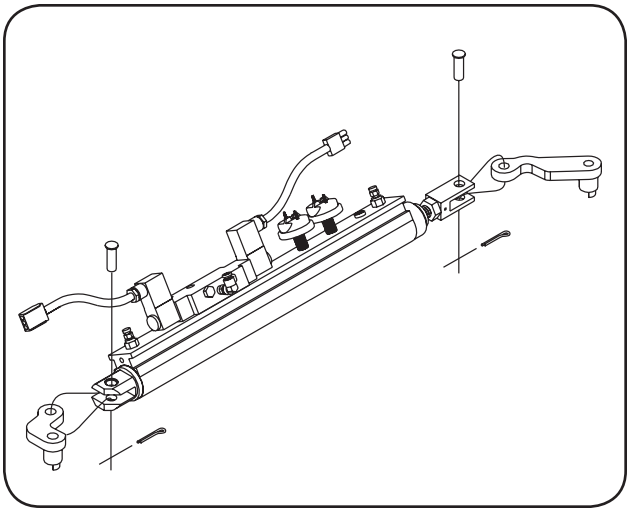
4. Assemble the opposite end of the control arm to the handle and tighten the locknut securely.

7. By trial and error, adjust the length of the rod assembly by removing the clevis pin and turning the clevis. Adjust the rod assembly length so that the control assembly handle passes through the center of the control assembly's cam action as the doors reach the fully open position.

8. When the door opening mechanism operates properly, tighten all hardware securely. Install the cotter pin into the clevis pin. Tighten the jam nut at the clevis in the rod assembly.

Pneumatic Door Opener

The pneumatically operated outward opening door operates similarly to the manual door described above but uses an air cylinder mechanism located inside the door header to actuate the door.



Pneumatic Door Opener Removal

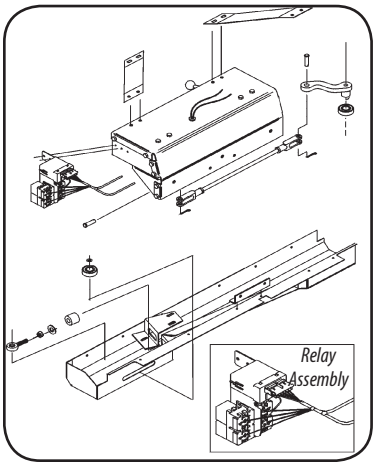
1. Remove the cotter pins and clevis pins from each end of the actuator.
2. Disconnect the electrical connectors.
3. Remove the pneumatic tubing. Identify the tubing as you remove it and replace it in the same positions.
4. Carefully remove the actuator from the compartment.

Pneumatic Door Opener Reinstallation

Installation of the pneumatic door actuator is accomplished in the reverse order of the removal instructions, above.

An air flow control valve located at each end of the actuator assembly allows adjustment of the speed of the door operation. Properly operating doors should cycle open or close in 3 seconds. If the doors do not operate properly, refer to "Adjustment of Outward Opening Door Mechanism", above.

Electric Door Opener



Electric Door Opener Removal

1. Remove hardware holding access panel over the door assembly.
2. Remove the nut and capscrew assembly from 10 places.
3. Disconnect electrical connectors at the relay assembly.
4. Remove the clevis pin from forward door lever.
5. Remove the clevis pin from rearward door lever.
6. Remove the actuator assembly.

Electric Door Opener Reinstallation

Install the electrically operated door actuator in the reverse order of the removal instructions above.

1. Pre-install the relay assembly on the actuator housing.
2. Preset the length of the actuator rod assembly to 18.50 inches (46.99 cm). Be sure the clevis pinholes are properly oriented.
3. Install the actuator assembly by installing bolt and locknut in 10 places. Tighten securely.
4. Install the actuator rod assembly clevis to the lever on the electrically operated actuator.
5. Install the actuator rod clevis to the forward door operating lever.
6. Check for proper operation of the actuator. It may be necessary to adjust the length of the actuator rod assembly so the door will stop before the motor crosses center.
7. If necessary, install the emergency release lever.
8. Move the open position stop to its rearmost position to prevent the motor driven actuator from rotating too far rearward.
9. After adjusting for proper operation, position cam on the rotating shaft to operate limit switch when the door is in the open position.

Door Panels

Door Panels Removal

If so equipped, optional safety equipment attached to the door panel's assembly must be disconnected and/or removed before continuing. Access to the door mechanism is provided over the door opening, inside the bus.

1. Remove the access panel cover or header.
2. If equipped with pneumatic door actuator, refer to Removal of Optional Pneumatic Door Opener above.
3. If equipped with electrically operated door actuator, disconnect the actuator rod clevis from the front door operating lever.
4. Remove Allen head machine screws and lock nuts from spherical bearing (at each end of the connector link).
5. Remove the connecting link.
6. Remove the nut, lock washer and flat washer from the bearing at the top outside corners of the door panels.
7. Support the door panels and remove two carriage bolts from the lower outside corner of each door panel.
8. Lift the door panel and slide the bottom, with bracket and bronze bushing attached, away from the stepwell. Some manipulation of the rearward door panel may be necessary to remove the door lever from the header.
9. Lower the door panel until it clears the header.
10. Set the door panel aside and remove the forward door panel in the same manner.
11. Remove the sealed ball bearings from the outside corners of the door header.
12. Remove the flanged bronze bearing and bracket from the bottom of each door panel.

Door Panels Reinstallation

Installation of the outward opening door panels is accomplished, in the reverse order of the removal instructions above.

1. Install the sealed ball bearings at two places in the header, at the outside corners.

2. Install the bronze bearings and brackets at the bottom outside corner of each door panel.

3. Install the rearmost door panel first. Some manipulation may be necessary to install the rear door panel control lever into the header.

4. Support the door panel and install the lower door pivot bracket and bronze bearing.

5. Install two carriage bolts to secure the pivot assembly in the stepwell.

6. Install the upper spacer.

7. Install the upper pivot through the upper support bearing. Install flat washer. Wipe pivot threads clean and coat the bottom 3 to 5 threads with Loctite™. Install lock washer and nut to hang door panel in frame. Torque to 30 ft-lbs (3.38 Nm).

8. Install forward door panel bronze bearing and bottom pivot bracket onto the door panel.

13. Install the upper pivot through the sealed ball bearing.

14. Lift and support the door panel while installing two carriage bolts to secure the bottom pivot to the stepwell. Install the flat washer. Wipe top pivot threads clean and apply Loctite™ to the bottom 3 to 5 threads. Install lock washer and nut. Torque to 30 ft-lbs (3.38 Nm).

Door Panel Glass Replacemement

With the old glass and the rubber gasket removed, clean the inside edges of the door panel opening. Using a new rubber gasket of the proper size:

1. Install a new rubber gasket onto the new glass.

2. Place a sash cord, or other suitable string, around the outside groove of the glass assembly.

3. Pull the string tight to make sure it seats fully into the groove. Leave the ends of the sash cord hanging down from bottom corners of new glass assembly. Do not lubricate the new gasket material.

4. Install the glass assembly into the door panel, from the inside, placing the bottom groove of the rubber gasket properly straddling the bottom of the opening in the door panel. Be sure the ends of the sash cord are on the outside of the door panel, protruding from the lower corners of the opening.

5. From the inside of the door assembly, press and hold the glass assembly securely into the hole.

6. From the outside of the door assembly, carefully pull the sash cord, causing the outer edge of the gasket to pop into place.

Stop Arms

Federal Motor Vehicle Safety Standard 131 requires all school buses in the United States to be equipped with a Stop Arm. The specific requirements for the blade, lights, lettering and reflectivity of the Stop Arms vary from state to state. Blue Bird provides Stop Arms as kits to match requirements for each state from which the school bus was ordered. Stop arms are available as either electric or air-operated.

Usually, the Stop Arm is located on the left side of the bus, at the front under the driver's window. In some cases, there is another Stop Arm on the left, toward the rear of the bus.

The driver most commonly controls Stop Arms manually via a switch. Some states require that Stop Arms be operated in concert with the Warning Lights when the bus is preparing to stop. Some states allow the lights to be on while the Stop Arm is retracted. In such case, the electronic controls are wired into the lighting system, and operation is automatic when the driver activates the warning light switch. In these cases, the driver will be alerted by an audible signal.

Air Operated Stop Arm

For pneumatically operated (air pressure) Stop Arms, the electric control switch operates an air valve solenoid which controls the flow of air to operate the Stop Arm. The air-operated system is dependant on the air brake system for pressure to operate.

The air stop arm may require periodic air pressure adjustment. The air regulator is accessible from the electrical panel located under the driver's window at the outside of the bus. To adjust the air pressure, remove the wire retaining clip and pull downward on the red lock ring. Turn the knob counterclockwise to decrease the airflow, and then slowly increase the air pressure until the Stop Arm is fully extended. Push the red lock ring upward and install the wire retaining clip.

Electric Stop Arm

Stop Arms may also be electrically operated. There may be a discrete switch for the driver, or the system may be wired into the warning light circuit.

Stop Arm Maintenance

Monthly, lubricate the breakaway hinge at the four pivot points using a high performance penetrating lubricant such as Triflow™ with Teflon.™ Ensure that the Stop Arm moves freely. Check all the fasteners for security and tighten as necessary. Quarterly, remove the covers (both front and rear) to inspect the security of the internal fasteners. Tighten as necessary.

Overview

The seating in your Blue Bird Vision bus is designed for your safety and comfort. The placement and installation of school bus passenger seats is governed by federal regulations. The bus seating meets or exceeds FMVSS222 School Bus Passenger Seating and Crash Protection.

WARNING ***Do not attempt to modify the location of the passenger seats in your Blue Bird Vision without reading the FMVSS222 specifications.***

Driver's Seat

Driver's Seat Adjustment

WARNING ***Do not attempt to adjust the driver's seat while vehicle is in motion. A sudden, unexpected adjustment to the driver's seat while vehicle is in motion could result in serious injury or death.***

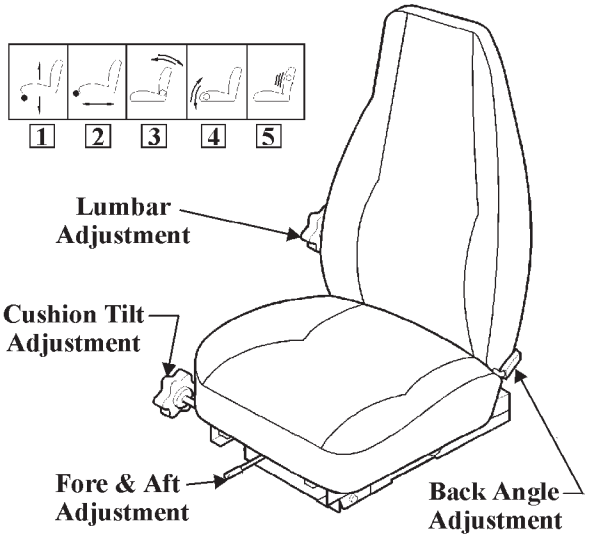
Weight and Height Adjustment. To adjust, push valve knob in to raise seat and pull out to lower seat. When properly adjusted, the seat should neither top nor bottom against the end limits of the vertical travel, under normal driving conditions. Adjustment position should also provide for driving visibility and vehicle control.

Fore and Aft Adjustment. Hold lever to the left to adjust seat position forward or backward.

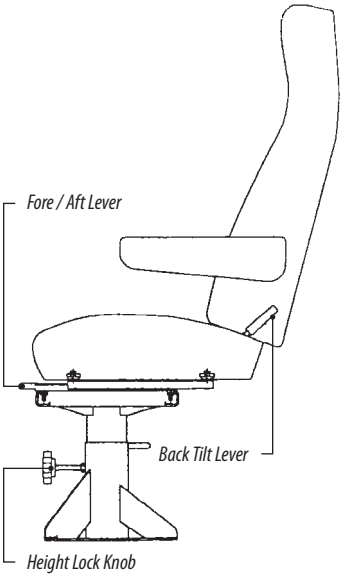
Back Angle Adjustment. Lean forward slightly to remove pressure from seat back. Hold the handle rearward to adjust to any position within the seat's range.

Cushion Tilt Adjustment. Rotate seat tilt knob to decrease or to increase seat tilt.

Lumbar Adjustment. Rotate knob forward to increase or rearward to decrease the support in the lumbar area.



Manually Operated Driver's Seat



Manually Operated Driver's Seat Adjustment

Fore and Aft Adjustment. Hold lever to the left to adjust seat position forward or backward.

Height Adjustment. Loosen height lock knob in front. Lift height adjust handle on side. Slowly sit or stand to position seat at desired height. Release height adjust handle before applying full weight. Tighten handle in front. Fasten and adjust seat belt.

Back Tilt Adjustment. Lean forward slightly to remove pressure from seat back. Hold the handle (Figure 2, C) rearward to adjust to any position within the seat's range.

Driver's Seat Lubrication

CAUTION ***Lubricants can damage vinyl. Use caution around upholstery.***
The moving parts of the driver's seat require occasional lubrication for ease of operation, and longevity of the seat. White lithium-based grease in an aerosol can is recommended. Motor oil 10W30 or 10W40 will provide adequate lubrication, although it may not be as easy to apply.

Seat Care and Cleaning Tips

Dirt and Soil. Most dirt and soil may be removed with soap and warm water solution. If a stain is persistent, a stiff bristle brush may be used. Fabric covered seats should be rinsed with clean water after stain is removed.

Paint, Tar and Asphalt. Paint, tar and asphalt stains may become permanent if not cleaned immediately. Remove stain immediately, using a damp cloth and kerosene. Rub the stain gently, using small strokes.

Nail Polish and Lacquer-based Stains. Immediately soak up as much as possible with a dry cloth. Any remaining stain may be removed with a non-flammable cleaning fluid, such as Tuff Stuff™ or Ar-morall™ cleanser. Rinse thoroughly with clean water.

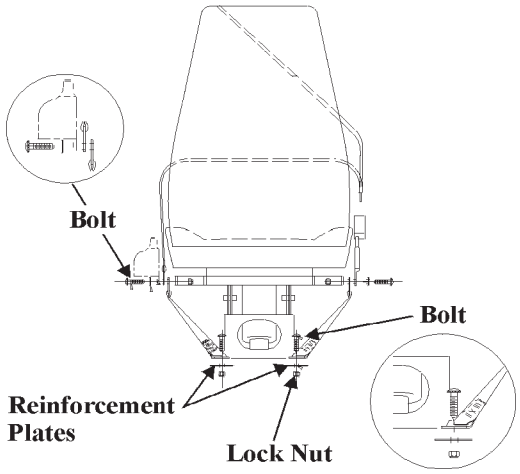
Gum, Grease and Shoe Polish. Immediately remove as much as possible. Shoe polish can permanently stain, if left unattended for a long period. Clean any remaining stain with a Tuff Stuff™ or Armorall™ cleanser.

Ink. Immediately remove stain using a damp cloth and alcohol.

Driver's Seat Removal

1. Remove two (2) bolts and washers from seat belt tether assembly, if equipped. See Figure 3—Driver's Seat Attachment Points.

2. Remove six (6) bolts from seat base mount and floor.



Driver's Seat Reinstallation

1. Clean the six (6) bolts, removing dirt and grease.

2. Apply Loctite™ 242 Blue to five or six threads.

3. Install six (6) bolts and washers into the driver's seat mount.

4. Torque the six (6) bolts 15 to 20 foot-pounds.

Driver's Seat Belt Tether Installation (Air Seat Only)

1. Install two (2) washers and two (2) bolts.

2. Hand-tighten two (2) bolts.

CAUTION ***If washers are not installed, belt will not function as designed.***

Passenger DOT Seats

Blue Bird seats are built to meet Federal Motor Vehicle Safety Standards. School bus seats are equipped with a special foam back pad. When the pad is damaged, replace with an approved replacement part.

Passenger DOT Seat Maintenance

- Inspect and retighten seat leg and wall side mounting bolts every 90 days.
- Inspect and retighten cushion attachments with a Phillips head screwdriver each week.
- Inspect upholstery for cuts and tears every 90 days. If torn, remove upholstery by removing the staples at the bottom front of seat back, or bottom of cushion.

WARNING ***If seat cushions are removed for maintenance, they must be reinstalled using the following instructions. Failure to comply with these instructions could result in injury from unattached seat cushions in the event of an accident.***

Passenger DOT Seat Cushion Removal

1. Loosen (do not remove) the two front swivel type clamps at the front underside of the cushion, with a Phillips tip screwdriver.
2. Rotate the swivel clamps to clear the front retaining channel frame.
3. Lift the forward edge of seat cushion 2 to 3 inches and pull cushion forward to remove.

Passenger DOT Seat Cushion Reinstallation

1. Place the rear edge of cushion down on the base portion of the seat frame, lifting the forward edge 2 to 3 inches.
2. Slide the cushion to the rear edge to engage the positive type clamp into the rear-retaining channel.
3. Lower the forward edge to the frame, making sure the swivel clamps are inside the frame and the posi-tive type clamps are secure on the rear-retaining channel.
4. Rotate the swivel clamp to engage the forward retaining channel frame.
5. Tighten with a Phillips tip screwdriver until clamps no longer rotate.

Track Mounted Passenger Seats

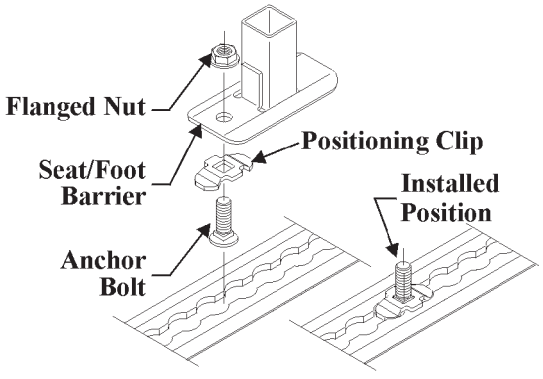
If your Blue Bird Vision bus is equipped with track mounted passenger seats and you relocate a row of seats to accommodate wheelchairs, you must observe rules of spacing and placement. See FMVSS222 School Bus Passenger Seating and Crash Protection.

Track-Mounted Passenger Seat Removal

1. Remove flange nut from the anchor bolt at the seat/barrier foot.
2. Lift seat frame up and off of the anchor bolt.

Track-Mounted Passenger Seat Reinstallation

1. Set seat/barrier down on the anchor bolt and positioning clip.
2. Torque flange nut 34 to 37 foot-pounds.



Seat Belts & Shoulder Harnesses

Seat Belt Inspection and Maintenance

The seat belts, buckles and their attachments must be inspected weekly basis to ensure proper condition, security and operation. If necessary, lubricate seat belt buckles with a graphite lubricant. If a seat belt buckle is found inoperable, replace immediately. If there are any defects in the webbing of the seat belt (i.e., torn or frayed), replace before use. Hand-wash seat belt webbing with warm water and a mild soap. Rinse thoroughly and dry in shaded area.

CAUTION ***Do not bleach or re-dye the seat belt webbing. Such processing may severely weaken the belt.***

Driver's Seat Belt Operation

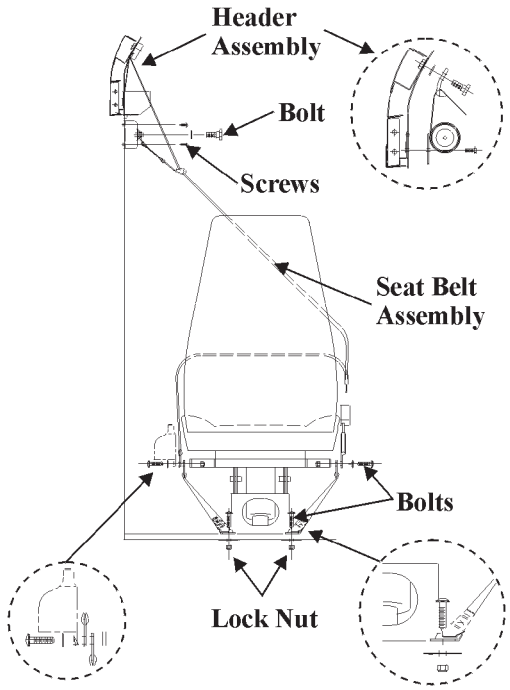
The driver's seat belt should be worn at all times when the vehicle is being driven. Blue Bird drivers' seat belts have automatic locking retractors and are self-adjusting. The seat belts also have an anti-cinch device to prevent the belt from tightening uncomfortably.

WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

The driver's seat belt shoulder harness is an emergency locking belt. The harness may be either emergency locking or automatic locking, depending on the seat belt option chosen. The emergency locking retractor used for all shoulder harness, and specified lap belts, is dual sensitive, engaging when the vehicle tips 15 degrees or if the belt speed exceeds a preset rate.

Automatic locking retractors for specified lap belts are self-adjusting. Adjust the shoulder belt bracket upward for taller drivers downward for shorter drivers, or until maximum comfort is achieved.

To use, withdraw an ample length of seat belt from retractor(s) to allow engagement of buckle halves. Engage buckle halves and allow retractor to draw belt to a snub, comfortable fit. The seat can be released by pushing button in center of buckle.



Driver's Seat Belt Removal

1. Remove one (1) capscrew and flat washer at seat belt retractor. See Figure 5—Driver's Seat Belt Attach Points.

2. Remove one (1) shoulder bolt and flat washer at the header assembly.

3. Remove two (2) screws at the header assembly.

4. Remove one (1) bolt from the mounting bracket. See Figure 5—Driver's Seat Belt Attach Points.

5.Remove two (2) bolts and washers from seat belt tether assembly. See Figure 5—Seat Belt Attach Points.

6. Remove one (1) lock nut, one (1) reinforcement plate and one (1) bolt from floor.

Driver's Seat Belt Reinstallation

1. Clean bolt, removing dirt and grease.

2. Apply Loctite™ 242 Blue to five (5) or six (6) threads.

3. Install one (1) bolt, one (1) reinforcement plate, lock nut and washer into floor.

4. Torque nut on bolt 15 to 20 foot-pounds.

5. Install two (2) bolts and washers at the rear of the driver's seat. See Figure 5—Driver's Seat Belt At-tach Points.

6. Install one (1) bolt at the mount bracket. See Fig-ure 5—Driver's Seat Belt Attach Points.

7. Install one (1) flat washer and one (1) shoulder bolt at the header assembly.

8. Install one (1) capscrew and flat washer at seat belt retractor. See Figure 5—Driver's Seat Belt Attach Points.

9. Install two (2) screws at the header assembly.

Passenger Seat Belts

Individual lap belts for passengers are retractable or non-retractable, depending upon the option chosen. Insert the catch into the buckle, test for assurance of latch fit and pull loose end of strap until belt fits snugly across the lower hips, and not the waist.

WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

The seat belt buckle can be released by pushing button in center of buckle. Turning the strap 90 degrees and pulling can move the adjustable end outward.

Passenger Seat Belt Removal

1. Remove ten screws from seat belt cover on cross bar at the rear of seat on the aisle side and wall side.

2. Remove one flange head screw from rear frame under seat on the aisle side and wall side.

Passenger Seat Belt Installation

1. Install one flange head screw to rear frame under seat on the aisle side and wall side.

2. Torque head screw 15 to 20 foot-pounds.

3. Install ten screws from seat belt cover on cross bar at the rear of seat on the aisle side and wall side. Screws are for the cover only, not the belt. Make sure they are in the plywood-tacking strip. Exposed screw points are not allowed inside back of seat.

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