VOLUME 2

Intake & Exhaust

Fuel System

Instrumentation

Body Electrical

Chassis Electrical

Steering

Body Structure

Body Interior

Body Finish

Specs & Maintenance

D3RE

2013

SERVICE MANUAL

APPLIES TO THESE MODELS

ALL AMERICAN REAR ENGINE
TX3 REAR ENGINE
GLOBAL TRANSIT REAR ENGINE

COUNT ON BLUE BIRD

BLUE BIRD

BLUE BIRD

D3RE

10026182
Edition A

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

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Intake Overview

Clean air is necessary for efficient fuel combustion and for normal engine life. If allowed to enter the engine, airborne contaminants combine with engine oil to form an abrasive compound which may drastically shorten engine life.

On the All American Rear Engine, a fresh air intake grille is located in the engine compartment on the upper left side of the bus. Air enters through louvers in the body panel into a screened duct leading to the air filter. The filter housing is mounted to the left of the engine above the frame rail. An optional precleaner (Feature 40170-01) is available on the All American Rear Engines which replaces the standard filter assembly.

Fresh air passes through ductwork leading to the air filter, where airborne dirt, dust and other foreign particles are trapped in the replaceable dry filter element.

Air from the air filter enters a duct leading to the intake side of the engine's turbocharger where it is compressed into the inlet tube of the Charge Air Cooler.

Compressing the air causes it to give off heat. The purpose of the Charge Air System is to remove this heat before the compressed air enters the engine intake manifold. The Charge Air Cooler is a radiator-like component mounted directly to the top of the engine coolant radiator. Although the two radiators are mounted as a unit, they are components of two separate circuits and do not share air or coolant. Ambient air is drawn by the radiator fan through the cooling fins of both coolers. The cooled intake air proceeds from the CAC to the intake manifold, where it enters the engine combustion chambers under compression. The Charge Air Cooler is illustrated in the Cooling System chapter.

Air Restriction Indicator

An air restriction indicator is mounted on the air cleaner housing. The restriction indicator is designed to provide a visual warning in the event of overly restricted air intake, as in the case of a clogged air filter element or the presence of debris.

During engine operation, the indicator monitors vacuum pressure immediately downstream of the air filter. As vacuum 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 vacuum 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

At a vacuum of 25 inches H2O, 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 bottom 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 vacuum 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 system. Check for leaks in all inlet hoses, tubes and connections. If a leak is found, correct it immediately, using original replacement parts and torquing 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. 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.

See the Specifications and Scheduled Maintenance chapter for recommended intake system inspection intervals.

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

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.
- 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.
- Charged air system piping. Tighten loose clamps. Check for wear spots and holes in the piping.
- Air compressor inlet lines. Tighten. Check for wear or other damage.

All clamps should be tightened to 6.5 - 7.5 ft. lbs.:

Air Filter 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 three quick release latch clamps holding the lid to the air filter housing.

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

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

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

   - Inspect inside the intake elbow 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 elbow and ducts before installing a new element.

   - If evidence of leaks is found, check the tube between the charged air cooler and the engine intake for contamination. If contamination is found, the charged air cooler should be replaced.

5. Install new air cleaner elements, fully seating the bottom seals.

6. Assemble removed parts in reverse order of disassembly.

7. Replace the filter housing lid. Ensure it is properly seated, and secure with the three quick release clamps. If necessary, a clamp's tension may be tightened by using pliers to carefully shorten its curve.

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

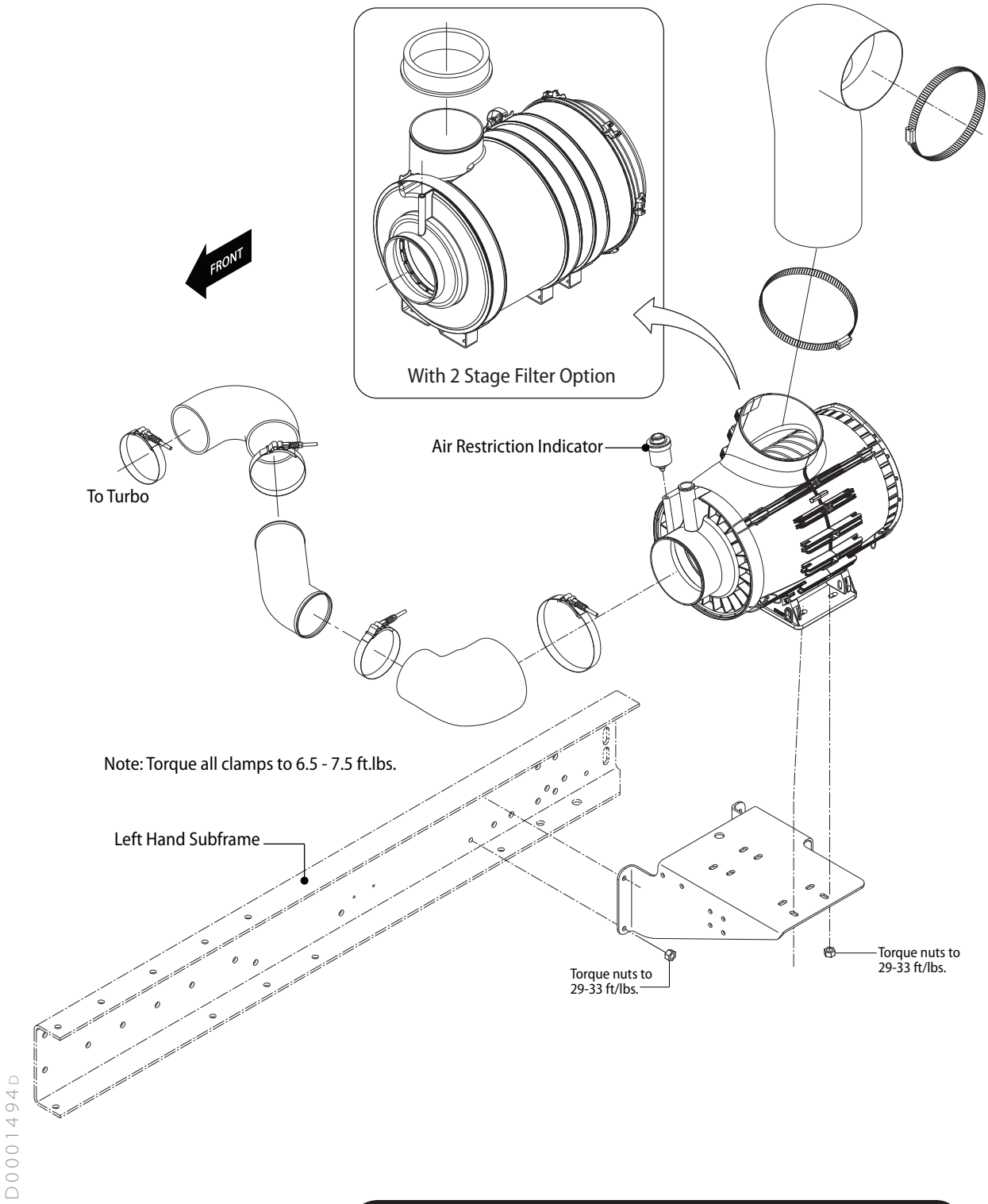
Unlatch three quick release clamps.

Remove air cleaner lid.

Note: On the two-stage Air Cleaner, when replacing the lid, ensure that the evacuation valve is pointing down.

Air Cleaner Element

Two-stage air cleaner shown.



Intake Tract

About 2010 Exhaust Emissions

In 2010, emissions requirements changed for all on-road vehicles equipped with a diesel engine. Both Nitrogen Oxide (NOx) and particulate matter are reduced by 90% from 2004 levels. Specifically, NOx was reduced to 0.2-g/hp-hr while the particulate standard was reduced to 0.01-g/hp-hr. The Environmental Protection Agency (EPA) allowed for NOx phase-in from 2007 through 2009. During this time 50% of the engines produced met the 0.2-g/hp-hr NOx standard, while 50% continued to meet the 2.5-g/hp-hr NOx+NMHC standard. Most engine manufacturers used the NOx phase-in provisions along with averaging to certify engines to a NOx value roughly halfway between 2.5-g/hp-hr NOx+NMHC and the 0.2-g/hp-hr NOx levels through 2009. This calculates to approximately 1.2-g/hp-hr NOx. Beginning in the 2010 emission compliant engines, 100% of the 0.2-g/hp-hr standard for NOx must be met.

The PM level was not phased in, and thus all engine produced were required to be at 0.01-g particulate matter beginning January 2007. In addition to the lower NOx and particulate matter levels, crankcase gases are also included in the emissions measurements. This requirement has driven closed crankcase systems in 2007 or ultra-low emissions from open systems. In open systems crankcase gases are vented into the atmosphere through a breather/filter tube arrangement. Closed systems reroute crankcase ventilation gases from the breather tube back into the engine intake airflow to be used for combustion.

On-Board Diagnostics (OBD)

Beginning in 2010, the California Air Resources Board (CARB) requires engine manufacturers to phase in On-Board Diagnostics (OBD) on their highest-volume heavy-duty engines. By 2013 all engines including the ISB and ISC produced will have to be OBD-compliant per CARB requirements. It is expected that the EPA will have the same OBD requirements as CARB beginning in 2013. The CARB is also requiring engine manufacturers to comply with a new Service Information Regulation (SIR). In essence, the SIR requires that engine manufacturers provide the necessary troubleshooting, maintenance and service information to third-party service centers as well as to their own service channel. This approach should allow customers to have access to proper diagnosis and repair of their engine to ensure that the engine remains in emissions compliance for the life of the engine.

The OBD system detects emissions-related malfunctions, alerts the operator of the bus to the detected malfunction, stores diagnostic records of the malfunction and supports off-board communications to a diagnostic service tool (e.g., scan tool) to allow the efficient service and maintenance of your bus. The Service Information Report makes it possible for the aftermarket service centers as well as the engine manufacturer's support centers to service and maintain the emissions control systems to their proper performance levels.

Fuel and Lubricating Oil Requirements

The EPA has lowered the limit for sulfur in diesel fuel from 500 parts per million (ppm) to 15 ppm. This fuel standard was phased in beginning October 1, 2006 (80% participation) through September 1, 2010 (100% participation). In 2010, all indications show that 15-ppm Ultra-Low Sulfur Diesel (ULSD) fuel is widely available. Use of ULSD fuel is critical for proper performance of exhaust aftertreatment systems. Beginning in 2007, all heavy-duty, mid-range and light-duty diesel engines are required to operate using ULSD fuel.

Biodiesel is growing in popularity which is why Cummins Engines are capable to operate on B20 biodiesel. Refer to the Cummins service literature or service center for more information.

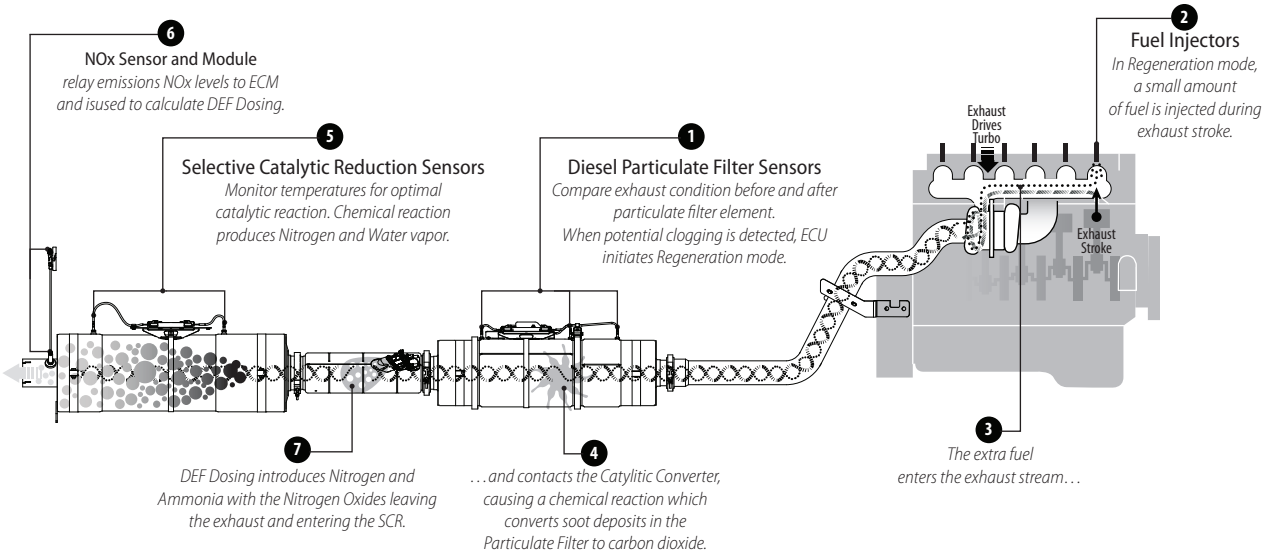
New specifications have been released for lubrication oil compatible with low-emissions engines for 2007-2010. The primary focus has been to make the oils compatible with exhaust aftertreatment devices (e.g., diesel particulate filter). In 2007 the requirement had been to reduce ash in the oil in order to enable extended maintenance intervals on the diesel particulate filter while maintaining the important lubricity capability of the lubricant. The low-ash oil classification (CJ-4) that was released for 2007 on-highway emission compliant engines must also be used in the 2010 emission compliant engines. A new oil classification is not required for 2010.

Integrated Cooled EGR

Cooled Exhaust Gas Recirculation (EGR) technology, introduced in 2002 to meet the 2.5-g/hp-hr NOx+NMHC standards, created the foundation for the EPA 2007 and EPA 2010 products. Cooled EGR is very effective at reducing NOx levels. The EGR system takes a measured quantity of exhaust gas, passes it through a cooler before mixing it with the incoming air charge to the cylinder. The EGR adds heat capacity and reduces oxygen concentration in the combustion chamber by diluting the incoming ambient air with cool exhaust gases. During combustion, EGR has the effect of reducing flame temperatures which, in turn, reduces NOx production since NOx is proportional to temperature. This allows the engine to be tuned for the best fuel economy and performance at lower NOx levels. EGR was used to attain the NOx levels introduced in 2007 and in current 2010 engines. In order to control both NOx and particulate emissions accurately, the amount of recirculated exhaust gas and air has to be precisely metered into the engine under all operating conditions.

This has driven the use of advanced Variable Geometry Turbochargers (VGT) that continuously vary the quantity of air delivered to the engine. The VGT features a one-piece sliding nozzle which moves continuously to vary the power of the turbine and the amount of air delivered to the engine. It is used in concert with an EGR control valve to accurately meter the EGR into the intake system

Cummins Regeneration



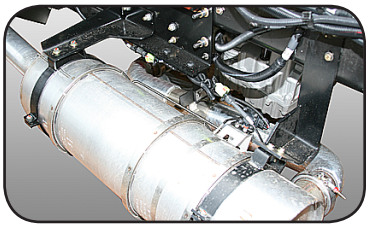
Exhaust System

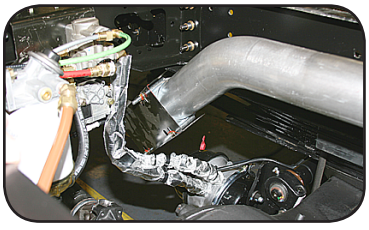
New federally mandated emission standards affect all buses equipped with 2010 emission standard engines. The exhaust systems for Cummins engines in Blue Bird buses are aftertreatment systems which incorporate a Diesel Particulate Filters (DPF), a Decomposition Reactor and a Selective Catalytic Reduction (SCR) system instead of ordinary mufflers. This sophisticated exhaust system reduces emissions by trapping particulate matter (soot) and reducing the level of NOx (nitrogen oxides) in the exhaust stream.

As the exhaust leaves the turbo on the engine it is first channeled through the DPF. The DPF contains a filter which traps the particulate matter in the exhaust stream. The rate at which the soot accumulates is dependent upon multiple conditions including the quality of the diesel fuel, type of engine oil, ambient temperature, engine load, and other factors. Over time, the trapped particulate matter accumulates in the DPF filter and must be removed through a process referred to as regeneration. Regeneration uses heat to convert most of the trapped particulate matter in the filter into carbon dioxide, and leaves behind a small amount of ash. Regeneration is conceptually similar to the cleaning mode of a self-cleaning oven in that heat removes the accumulated soot.

CAUTION ***In 2010 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications. In Cummins, use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.***

As the exhaust leaves the DPF it enters a decomposition reactor where a fine mist of Diesel Exhaust Fluid (DEF) is sprayed into the exhaust stream. The DEF vaporizes in the decomposition reactor converting it into Nitrogen and Ammonia. This exhaust mixture then leaves the decomposition reactor and enters the SCR catalyst which prompts a chemical reaction. The harmful NOx in the exhaust combines with the ammonia (NH_3) to form harmless nitrogen (N_2) and Water Vapor (H_2O). Because of the higher operating temperatures involved, the exhaust system components are insulated from other chassis components.





The exhaust systems of 2010 and newer engines incorporate engine-specific Diesel Particulate Filters, which operate at higher temperatures during their Regeneration cycles. The front exhaust pipes are insulated, and heat shields are installed at locations along the exhaust tubing.

Engine-Specific Technologies

Although the purpose and general principles of aftertreatment exhaust systems are similar among engine manufacturers, both the terminology and the mechanisms to perform "active" regeneration differ. Cummins has developed unique technologies for accomplishing and controlling the active regeneration process. The engine-specific ECMs which control the process are also different. Engine manufacturers differ in the construction of the DPF units, the exhaust flow paths, and other related components. It is for these reasons that the service technician must now regard that portion of the exhaust system from the engine to the outlet port of the SCR system as part of the engine package itself.

This chapter provides conceptual explanations of the Cummins systems. However, the service technician must refer to the engine manufacturer's operators' manual and service literature regarding service and maintenance of the 2010 exhaust system.

Exhaust Aftertreatment

2010 emissions standards-compliant Cummins engines incorporate an Aftertreatment System. The first part of the aftertreatment system is to trap particulate matter (soot) in the DPF filter. As the soot accumulates on the filter it must be cleaned to prevent backpressure. Cleaning is accomplished with heat created through regeneration. Regeneration occurs in three ways:

- Some regeneration occurs "naturally" whenever operating conditions (speed, engine load, etc.) result in exhaust system temperatures high enough to oxidize accumulated soot. Terminology differs between engine manufacturers, but this unassisted regeneration mode can generically be referred to as "passive" regeneration.
- Regeneration can be caused by raising the temperature of the exhaust system. A set of sensors mounted on the DPF assembly enable the Electronic Control Module (ECM) to monitor the buildup. The ECM then automatically activates and de-activates a system designed to increase exhaust temperature when the ECM senses that regeneration is needed, and when certain requirements, including a minimum travel speed, are met. This automatic "heat assisted" mode can be generically referred to as "active" regeneration.
- Regeneration can be manually activated by means of a switch. This procedure is generically referred to as "stationary" or "manual" regeneration, and should only be performed by or under the direction of a qualified service technician, and in a controlled environment to avoid the potential for human injury or fire hazards.

The ECM communicates the need for regeneration to the driver by a set of visual and audible signals in the instrument cluster. An additional alert, the High Exhaust System Temperature (HEST) indicator, notifies the driver whenever exhaust system temperature is high due to recent regeneration. Periodically, the normal ash accumulation which results from the regeneration process must be removed from the DPF using equipment designed for that purpose at qualified engine service facilities. Refer to the engine manufacturer's documentation for these service intervals.

Cummins Passive Regeneration

When driving at high speeds or with heavy loads, the exhaust system is hot enough to turn soot accumulation inside the DPF into carbon dioxide. Temperatures generated in this mode are comparable to those of pre-2007-standards engines.

At moderate and continuous speeds or engine load conditions, normal exhaust temperatures may be maintained at a high enough level for normal operation to prevent additional accumulation. At moderate-to-heavy operating conditions, normal exhaust heat may be high enough to reduce accumulated soot levels.

Cummins Active Regeneration

Accumulation occurs most at low speeds and relatively low temperatures. Frequent stop-and-go and continual low-speed operation typical of some school bus routes may not always generate sufficient heat to keep the particulate filter clear.

Sensors monitor the pressure differential before and after the DPF, and also monitor temperature. The pressure and temperature data is communicated to the ECM. When the pressure / temperature readings indicate that the particulate filter is beginning to become restricted, the ECM may signal the system to enter an Active Regeneration mode.

During Active Regeneration, a small amount of fuel is injected into the exhaust stream by the engine's fuel injector during the engine's exhaust stroke. This fuel reacts with the diesel oxidation catalyst in the DPF, raising the temperature of the exhaust flow sufficiently to remove the accumulation. This process activates and deactivates automatically as-needed during normal operation.

Active Regeneration begins only if DPF accumulation has reached a certain level and if the bus is moving above a preset speed threshold (approximately 40 mph). If the bus is operated above the speed threshold long enough, the soot accumulation on the filter clears and Active Regeneration mode stops automatically.

If the bus is slowed to below a certain speed threshold while in Active Regeneration mode, the Active Regeneration stops, even if the cleaning process has not completed. If the bus slows or stops while the exhaust system temperature is still high due to recent Active Regeneration, the High Exhaust System Temperature (HEST) indicator appears on the driver's instrument panel to notify the driver that the exhaust system temperature is elevated.

Cummins Stationary Regeneration

Active Regeneration removes the accumulation at an increased rate. However, each time the bus slows to below the speed threshold, and each time exhaust temperature drops to levels insufficient for soot to be cleared, accumulation may increase.

Depending upon the operating conditions, there may not be sufficient opportunity or duration for either Passive Regeneration (normal running) or Active Regeneration (ECM initiated) to keep the filter clear therefore a Stationary Regeneration must eventually be performed. Stationary Regeneration is initiated with the use of a manually activated switch

During Stationary Regeneration, temperatures inside the exhaust can exceed 1300°F. Stationary Regeneration must be performed in a controlled environment where precautions are taken to avoid any hazard that might result from the elevated temperatures. Blue Bird strongly recommends that Stationary Regeneration be performed only by, or under the supervision of a qualified service technician. Read carefully the section titled **Stationary Regeneration Precautions**.

Stationary Regeneration is initiated by means of a momentary toggle switch. Operating the switch starts a Stationary Regeneration only if certain conditions are met: The ECM must have indicated that Regeneration is needed (as indicated by the appearance of the DPF indicator). The bus must be stopped with the parking brake on, the engine must be running and the transmission must be in Neutral. During a Stationary Regeneration procedure, the process is monitored and controlled by the engine ECM. Depending on the severity of the restriction, the engine may raise its idle speed. The Regeneration process continues until the filter is clean, and then the process stops automatically. The bus may then be returned to normal service. (For more information, see **DPF Regeneration**.)

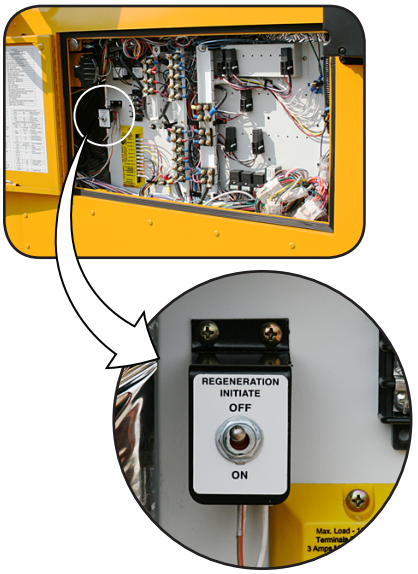
Cummins Exhaust Gas Recirculation

In the Cummins ISB engine, a portion of the exhaust is returned to the engine intake which adds an inert gas and reduces emissions. A device on the engine exhaust routes a small amount of the exhaust through a cooler, mixes it with fresh air, and re-introduces it into the intake stream. This helps lower the temperature during combustion, which reduces the formation of Nitrogen Oxides (NOx).

***WARNING** The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.*

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.



Regeneration switch for use by Service Technicians performing Stationary Regeneration only in a controlled, fire-hazard-free environment.

DPF Regeneration

As with most new mechanical processes, the introduction of more sophisticated exhaust systems in 2007 and 2010 emission standard-compliant engines, a higher degree of understanding is required to troubleshoot these systems. Engine manufacturers have designed their own methods to meet the EPA standards, and therefore describe the process in somewhat differing terms. The Cummins equipped Blue Bird bus system is not complicated, but both Drivers and service technicians should be familiar with the regeneration process.

As soot builds up in the DPF filter, the driver is notified in several stages by visual and audible alerts. As the need for regeneration becomes more severe, the alerts become increasingly imperative to act upon; and the penalty for postponing the needed regeneration also increases.

When the earliest alerts occur, there is ample time to complete a route and then have a Stationary Regeneration procedure performed at a proper facility. If early alerts are ignored, and the condition is allowed to worsen, the engine will eventually de-rate automatically, and performance will reduce noticeably. If the condition is allowed to become severe, a Stationary Regeneration may not be possible, and the DPF may require removal and cleaning with specialized equipment. Therefore, to minimize disruption of your bus operation, the regeneration-related alerts should be heeded and responded to at their early stages as a matter of routine.

Aftertreatment Terms

The following summarizes some of the terms associated with the exhaust systems of Blue Bird buses equipped with 2010 emission standards compliant engines. Both the driver and technician should become familiar with the following terms:

Aftertreatment. The process of filtering engine exhaust in order to reduce emissions, and purging the exhaust system of accumulated exhaust residue.

DPF (Diesel Particulate Filter). A component in the exhaust system which takes the place of a traditional muffler. A DPF contains a special dissimilar metals filter which traps particulate matter (soot), which is then converted to carbon dioxide by the aftertreatment process. The Cummins DPF also contains a DOC also known as a catalytic converter.

Regeneration. The process of cleaning accumulated soot from the filtering components inside the DPF. Regeneration occurs at high exhaust system temperatures to turn the soot into carbon dioxide gas. Regeneration can be thought of as conceptually similar to the clean cycle of a self-cleaning oven.

WARNING ***Postponing regeneration beyond the early indications may result in the engine being automatically de-rated, and reduction of power while driving.***

WARNING ***The aftertreatment regeneration process can cause extremely high exhaust gas temperatures hot enough to ignite or melt common materials, and to burn people.***

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other related engine manufacturer's literature) regarding safe operation when the HEST indicator is on.

Carefully read, understand, and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual (and other engine manufacturer's literature) regarding safety conditions when performing Stationary regeneration.

HEST Indicator (High Exhaust System Temperature). An instrument panel indicator which appears when the exhaust temperature is unusually high due to recent regeneration. This is a normal behavior of the aftertreatment system, intended to notify the driver and technician that the exhaust system temperature is high and that caution should be observed around the exhaust system.

DPF Indicator. An instrument panel indicator which displays when particulate accumulation has reached a preset level in the DPF, and regeneration is needed. The bus should either be operated with a more demanding duty cycle until the indicator goes off, or it should be scheduled for a Stationary Regeneration at a service facility.

DPF Regeneration Levels of Notification

Regeneration—the process which clears soot accumulation in the DPF—occurs automatically as the bus is operated, as long as certain operating conditions (such as minimum speed thresholds) are met. When bus operating conditions do not provide adequate opportunity for the regeneration system to keep the DPF clear, soot begins to accumulate. A system of driver alerts keeps the driver informed of when the exhaust system is in need of regeneration, and of high exhaust temperature associated with regeneration. Several levels of regeneration alerts occur in sequence, each indicating a more imperative warning.

High Exhaust Temperature Notification

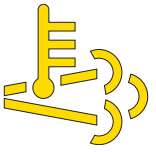
The High Exhaust System Temperature (HEST) indicator appears to alert the driver when exhaust temperature is unusually high and that prudent judgement should be applied regarding the proximity of people or combustibles to the exhaust system. For example, the bus should not be parked on a surface of grass or weeds.

The HEST indicator appears whenever the exhaust temperature is high (752°F or above), regardless of moving speed.

The driver should be familiar with and abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when the HEST indicator is on.

- The HEST alert appears in the instrument panel's warning bank.
- The audible alarm sounds one beep.

HEST Notification



The HEST alert appears in the instrument panel's warning bank.

The audible alert sounds one beep.

Level 1 Regeneration Notification: DPF Indicator Appears

In low-demand operating conditions, it is possible that the regeneration system does not have sufficient opportunity to prevent particulate build-up in the DPF. The ECM senses that accumulation is occurring and that regeneration is needed. When notified, Regeneration should be done as soon as possible. The driver is notified as follows:

- The DPF Regeneration alert activates.
- The audible alert sounds one beep.

The DPF Regeneration alert appears in the Message Display.

The audible alert sounds one beep.

The regeneration can be accomplished in either of two ways: If practical, the bus could simply be operated for a while at a speed above the automatic regeneration threshold; or the bus could be taken to a suitable location to have a Stationary Regeneration procedure performed.

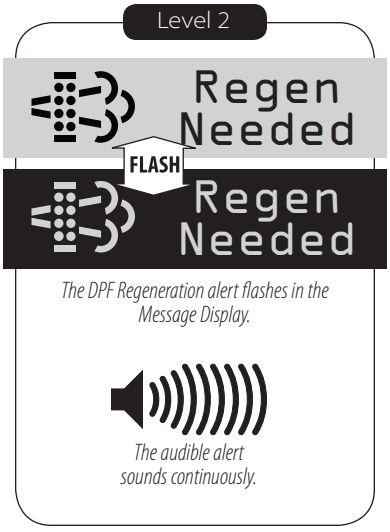
If the bus is operated at a minimum highway driving speed (40 mph Cummins), the automatic regeneration system will activate. If minimum speed is maintained long enough (usually 20-30 minutes), the automatic regeneration mode can likely reduce the soot sufficiently to cause the DPF Icon to go off.

Therefore, the first appearance of the DPF icon should be perceived by the driver as a normal notification of action that needs to be taken, but not as an emergency situation. Typically, even if the bus route does not afford immediate opportunity for higher-speed operation, there is sufficient time to finish the bus route and return to the bus maintenance shop before a higher level of notification occurs. Exactly how much time after the first appearance of the DPF indicator represents is dependant upon specific operating conditions. However, current data from Cummins suggest that, at this level of notification, the DPF needs to undergo regeneration within two to six hours of bus operation. If regeneration does not begin, the next level of notification will activate.

Level 2 Notification: DPF Indicator Blinks

If the bus continues to be operated without taking the measures indicated by a Level 1 Notification (described above), particulate accumulation continues, and a Level 2 notification occurs:

- The DPF Regeneration alert begins to flash.
- The audible alarm sounds continuously.
- The engine may be automatically de-rated.



The DPF Regeneration alert flashes in the Message Display.

The audible alert sounds continuously.

The above indications should be viewed with a higher degree of urgency and that the exhaust system is in need of regeneration soon. As soon as practical, the bus should be operated at or above the minimum speed needed to allow automatic regeneration to activate, or a Stationary Regeneration must be performed. Current data from Cummins suggest that at this level of notification, regeneration needs to be performed within the next one to two hours of bus operation. Otherwise, the third level of notification will occur.

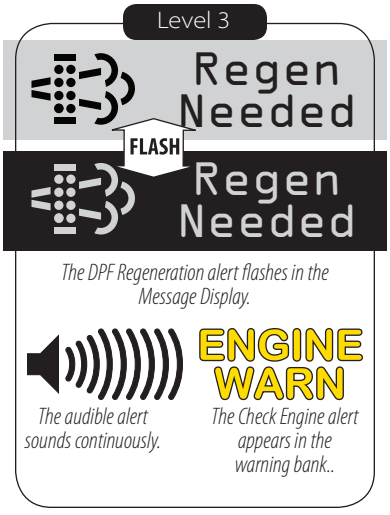
Level 3 Notification: Check Engine Indicator Appears

If the bus continues to be operated without taking the measures indicated by a Level 2 Notification, particulate accumulation will continue. These indicators are activated:

- The DPF Regeneration alert continues to flash.
- The audible alert sounds continuously.
- The engine is automatically de-rated.
- The Check Engine alert appears.

The above indicates that a Manual Regeneration must be performed as soon as possible. Because the engine is automatically de-rated it may not be possible to drive at sufficient speed to cause active regeneration to occur.

Depending upon the severity of the accumulation, the regeneration switch may not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.



Level 4 Notification: Stop Engine Indicator Appears

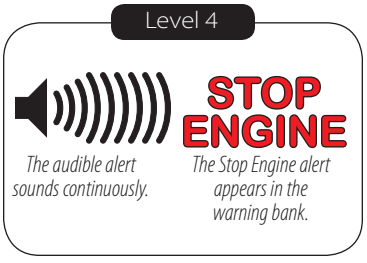
If the bus continues to be operated without taking the measures indicated by a Level 3 Notification, particulate accumulation reaches a critical level. Engine power is automatically de-rated *further* by the ECM. These indicators are activated:

- The DPF Regeneration alert deactivates.
- The audible alert sounds continuously.
- The engine is further de-rated.
- The Check Engine alert deactivates.
- The red Stop Engine alert appears.

The above indicates that accumulation has progressed to critical levels and the bus should be stopped with the engine off as soon as it is safe to do so. The bus should remain shut down until the aftertreatment system has been serviced.

The regeneration switch will not be allowed to initiate a regeneration without use of Cummins's PC-based diagnostic software, Insite.

Removal and cleaning of the DPF using specialized equipment may be required.



Stationary Regeneration Precautions

During active regeneration, the exhaust system can reach extremely high temperatures. Automatic active regeneration, which occurs while driving the bus, is programmed to occur only when the bus is moving at a minimum speed, and it stops when the vehicle slows or stops.

The HEST indicator appears whenever high temperature condition exists.

When performing a Stationary Regeneration, the entire process occurs for an extended period while the bus is stopped. It is therefore critical that prudent human safety and fire hazard precautions are followed. Those precautions include:

- Read, understand, and abide by all the precautions pertaining to regeneration procedures in the engine manufacturer's Operator's Manual.
- If at all possible, the Stationary Regeneration procedure should be conducted at a service facility by trained technicians.
- The Driver's first priority is the safety of the passengers. If a Stationary Regeneration must unavoidably be done by the Driver under a qualified technician's direction, alternate transportation should be arranged first, or passengers should be removed under proper supervision to a location away from the bus.
- Select an appropriate location to park the vehicle.
    - Choose a surface that will not burn or melt under high temperature, such as clean concrete or gravel, *not grass or asphalt*.
    - Ensure that nothing that can burn, melt, or explode (gasoline, wood, paper, plastics, fabric, compressed gas containers, hydraulic lines) is near the exhaust outlet. Abide by all instructions, warnings, and cautions in the engine manufacturer's operator's manual regarding safe operation when performing a Stationary Regeneration.
- Park the bus securely.
    - Set the parking brake. Put the transmission in Neutral. Chock the wheels.
- Secure the exhaust area.
    - If bystanders might enter the area, set up barriers to keep people safely away from the exhaust outlet.

- If the procedure is performed indoors at a service facility, attach an exhaust discharge pipe rated for at least 1500°F.

- Keep a fire extinguisher nearby.

- Check exhaust system surfaces to confirm that no tools, rags, grease, debris or any other objects are on or near the exhaust system.

- Start the engine.

- Operate the Regeneration Switch to begin the regeneration process.

- Monitor the process. If any unsafe condition occurs, shut off the engine immediately. During the regeneration process, the engine may change speed, and the turbocharger may whistle. When the process is complete, the engine will return to normal idle speed. Exhaust gas and exhaust surface temperatures will remain elevated until they have had time to cool to normal levels.

SCR Treatment

The Selective Catalytic Reduction (SCR) system uses diesel exhaust fluid (DEF) as a chemical reactant. The DEF converts to ammonia in the exhaust stream. The SCR catalyst is mounted in the exhaust stream and is similar in outward appearance to a muffler. It contains chemical compounds which, in the presence of ammonia, help transform nitrogen oxides into harmless nitrogen and water.

In an SCR system, the rate at which DEF is sprayed must be tightly controlled. If the rate is too high, not all of the ammonia will react with the NOx and some ammonia will "slip" through the catalyst. If the rate is too low, the desired NOx reduction will not be achieved. Both situations are undesirable and must be avoided.

The SCR system consumes DEF at a rate of approximately 2% of the amount of fuel used, depending on bus operation. Therefore a 15 gal tank of DEF will treat approximately 750 gallons of diesel fuel.

The DEF tank level indicator can be found in quadrant 3 of the message display center located in the instrument cluster. This display provides a constant reading indicating the percent of fluid in the tank. If a problem is identified with the amount of fluid or the quality of the fluid a priority message will appear in quadrant 1 of the message display center indicating the fault.

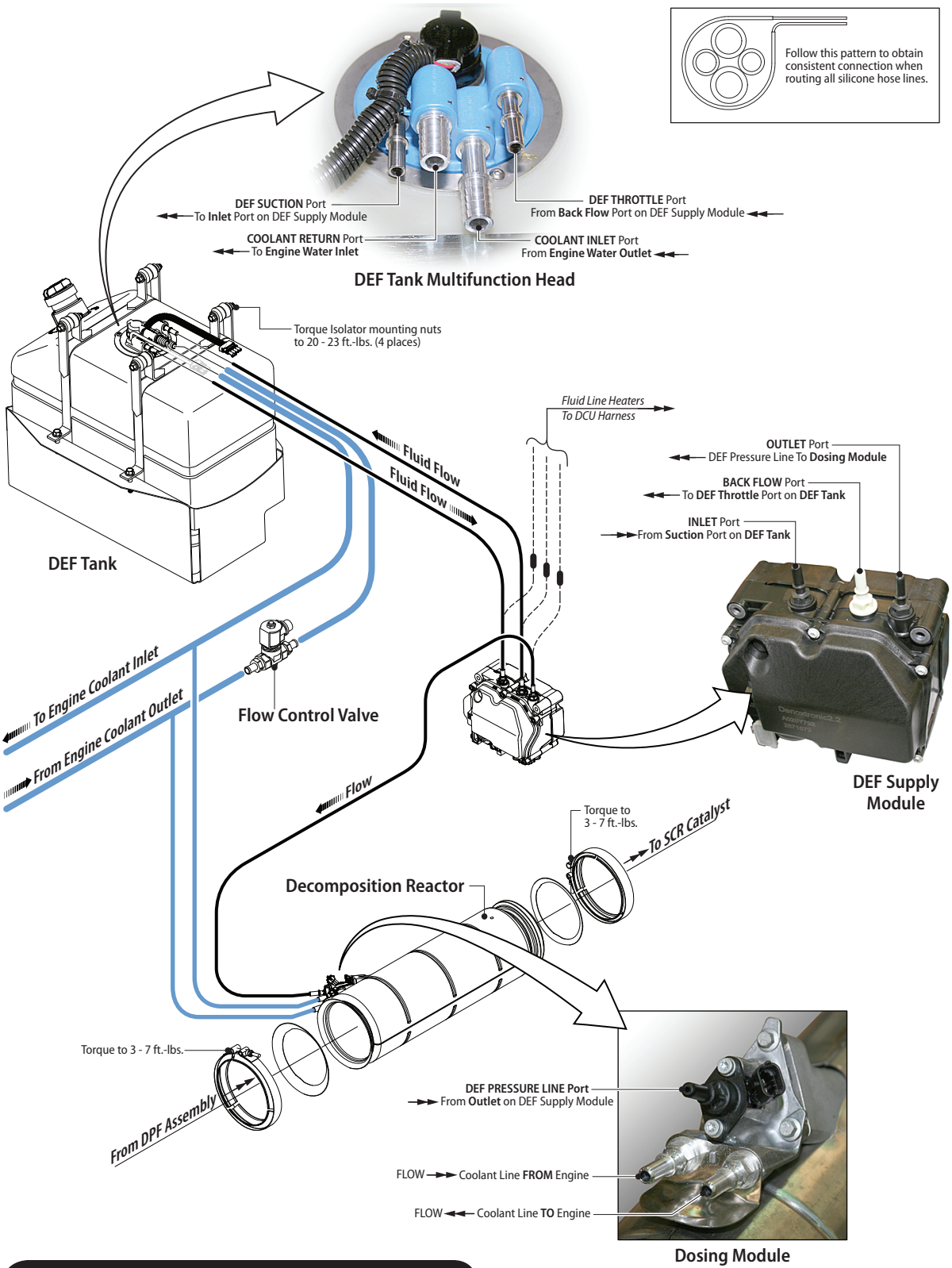
Keeping adequate levels of DEF in the tank is crucial to the operation of the SCR system. When low levels are indicated, refill the tank using only approved DEF solution. The DEF has its own tank and fill port with a blue cap. You will notice the fill port is smaller than the diesel fuel port. This is to prevent putting diesel fuel into the DEF tank. Conversely, care should be given not to put DEF in the diesel fuel tank. Read all decals carefully before refilling.

CAUTION ***DO NOT put diesel fuel in the DEF tank. DO NOT put DEF in the fuel tank of the bus.***

DEF Fill Door

DEF Fill located on curbside, forward of rear axle.

Diesel Fill



SCR System Plumbing

Selective Catalytic Reduction Components

Dosing Control Unit (DCU). The DCU is a computer, designed as the central control for the diesel exhaust fluid dosing system. This module handles the dosing activity by energizing and de-energizing the Dosing Module. It also monitors and adjusts the diesel exhaust fluid tank temperature by adjusting the engine coolant control valve. In cold temperatures it will also energize electrical line heaters on the diesel exhaust fluid lines to thaw and prevent freezing during operation. The diesel exhaust fluid tank level sensor information is also monitored by the DCU. The dosing control unit is in constant communication with the engine ECM through a data communications line. Before servicing this unit, the DCU must be disconnected from the battery before installing or removing the electrical connectors. The DCU is mounted on a bracket attached to the inside of the right frame rail near the diesel exhaust fluid tank.

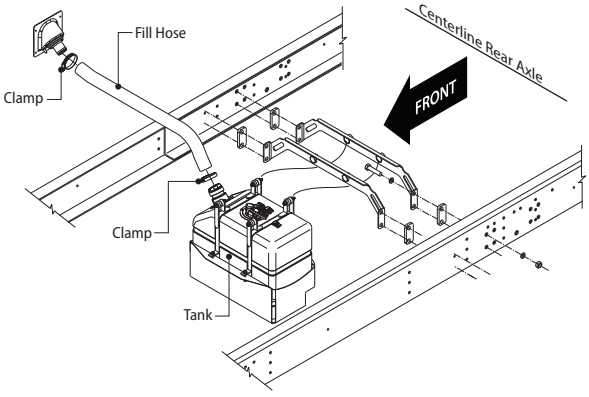
Dosing Control Unit

CAUTION ***Disconnect battery before removing or installing electrical connectors. DO NOT use battery disconnect switch.***

Diesel Exhaust Fluid (DEF) Tank. The DEF Tank is a 15 gallon medium-high density polyethylene tank. This tank is designed to hold 15 usable gallons of DEF. The usable amount of fluid in the tank is displayed in the instrument panel's driver information panel as a percent of DEF in the tank. The tank fill neck has a 19 mm diameter restrictor to prevent inserting a diesel fuel fill nozzle. The tank is also designed to prevent overfilling. When the tank is full there will be approximately 10% empty space at the top of the tank for fluid expansion due to temperature. If the fluid level in the tank drops to 10% the driver will be notified with a priority message in the instrument panel accompanied by a warning light (see *DEF Levels of Notification*). The feed line in the tank has a serviceable 100 micron filter. This filter is back-flushed each time the bus is turned off due to a purge cycle (see *Purge Cycle*). The tank also has a heater which uses engine coolant to regulate the temperature of the DEF. When the outside temperature is below 11°F the tank heater will maintain a minimum temperature of 21°F during operation. Above this temperature the DEF will be maintained at ambient temperature. The tank also houses a fluid temperature sensor and a fluid level sensor. A multifunction head provides access to the DEF feed line, return line, and coolant lines as well as electrical connections to the two sensors. The tank is supported by a metal housing which is attached to the frame rail out rigging with four isolators. The tank is located between the frame rails just forward of the rear axle with the fill port on the curb side of the bus.

DEF Fill Door

DEF Fill located on curbside, forward of rear axle.



Diesel Fill

Diesel Exhaust Fluid (DEF). Diesel Exhaust Fluid (DEF) is a nontoxic, nonpolluting, non-hazardous and nonflammable solution. It is stable, colorless, and meets accepted international standards for purity and composition. DEF is safe to handle and store and poses no serious risk to humans, animals, equipment or the environment when handled properly. Refer to MSDS sheets currently available. DEF is a solution of 32.5% high purity urea and 67.5% de-ionized water. This ratio is critical due to the fact that both the urea and water will freeze together at 11°F. At this temperature both the urea and water will not only freeze, but thaw at the same rate, ensuring that as it thaws the fluid does not become diluted or over concentrated. This ratio is the ideal solution as it provides the lowest freeze point for both the urea and water, preventing degradation of the solution. Also, the SCR system is calibrated to the 32.5% ratio for optimum NOx reduction during operation. The DEF you purchase should state and display the certification of the American Petroleum Institute, German Institute for Standardization DIN70700, the International Organization for Standardization ISO 22241-1 and meet AUS – 32 specifications. This will ensure the proper purity and concentration. For more information on these specifications, visit *www.iso.org*. DEF packages will also have a date code located somewhere on the product. The first digit of the date code represents the fluid batch number and the next six digits reflect the date that the batch was filled.

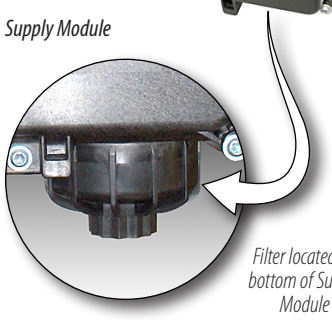
During bus operation, the SCR system is designed to provide heat for the tank and supply lines. If the DEF freezes during shut down, starting and normal operation of the bus will not be inhibited. The system is designed to quickly return the DEF to a liquid state and the operation of the bus will not be impacted.

CAUTION ***Anti-gelling or freeze point improvers or additives of any type are not approved for DEF. Any further blending or adjusting of the DEF mixture will impede its ability to perform correctly and may cause damage to the SCR components.***

DEF should be stored in a cool, dry, well-ventilated area, out of direct sun light. The shelf life is a function of ambient storage temperatures. DEF will degrade over time depending on temperature and exposure to sunlight. The optimum storage temperature is up to 77° F (25° C) where shelf life will be greater than two years. DEF stored between 10° and 90° F will have a shelf life greater than one year. DEF can be tested using a refractometer designed for this purpose.

Supply Module. The Supply Module is part of a high accuracy system for injecting diesel exhaust fluid into the exhaust aftertreatment system. It has a 12V electronically operated pump and metering system, controlled by the DCU, which delivers diesel exhaust fluid to the Dosing Module mounted in the exhaust system downstream of the diesel particulate filter. The Supply Module has two filters, a 100 micron inlet filter and a 10 micron main filter which is serviceable. The Supply Module and Dosing Module system is designed to deliver a precise amount of DEF solution by weight into the exhaust system according to capacity, which is calculated by an external algorithm. The Supply Module also houses a heater and temperature sensors to thaw and keep the DEF in a liquid state during cold temperatures, a pressure sensor to regulate the output pressure to 130 psi and a reverting valve that clears the fluid lines during shut down (see *Purge Cycle*). The Supply Module is attached to a bracket on the inside of the frame rail near the DEF tank.

Supply Module



Filter located on bottom of Supply Module

CAUTION ***When handling or storing the Supply Module, suitable precautions should be made to protect it from damage. If this component is dropped it should not be used.***

Dosing Module. The Dosing Module is mounted to the decomposition reactor and is used to add diesel exhaust fluid to the exhaust stream. DEF is supplied to the Dosing Module from the Supply Module through a pressure line with an operating pressure of 130 psi. When needed, the DCM will activate the Dosing Module which will introduce a fine mist of DEF to the exhaust stream. The DEF is supplied to the Dosing Module at an operating temperature between 23°F and 158°F. Because this is part of the exhaust system, temperatures can become extremely hot which would cause the DEF to vaporize. To prevent this from happening, engine coolant is continuously circulated through the module while in operation. Coolant supply and return lines (3/8" SAE J2044 quick connect fittings) are provided and supply a minimum of 0.17 GPM at idle to a maximum of 2.0 GPM during bus operation. Care should be taken not to break or damage the plastic DEF pressure line fitting (5/16" SAE J2044 quick disconnect).

Dosing Module

CAUTION ***Never use the Dosing Module as a carry handle when servicing the Decomposition Reactor. Suitable precautions should be used to protect the Dosing Module from damage when storing and handling. The protective caps provided with the module should not be removed until final installation of the fluid lines. If this component is dropped it should not be used.***

Decomposition Reactor. The Decomposition Reactor is located downstream to the DPF between the DPF and SCR unit. It measures 19 inches long and has a diameter of five inches with a half inch of insulation making the outside diameter six inches. The Decomposition Reactor has an integrated diesel exhaust fluid diffuser inside the housing designed so that the ammonia contained in the injected DEF can decompose and be adequately mixed with the exhaust stream before it reaches the SCR Catalyst. The Decomposition Reactor is supplied with a Dosing Module already mounted on the reactor flange. The decomposition reactor assembly must be clamped and properly torqued to the DPF and SCR units using gaskets and full Marmon joints with "vee" band clamps to minimize leakage and heat loss, which is critical to the process. Never use the Dosing Module as a handle when picking up the decomposition reactor assembly.

Selective Catalytic Reduction (SCR) Device. The SCR device is comprised of a canister which contains a selective catalytic reduction catalyst and two temperature sensors. The temperature sensors are used to determine when the SCR unit has reached the required temperature to support the chemical reactions and allow diesel exhaust fluid dosing. An oxygen sensor is also mounted to the outlet section of the canister. The SCR catalyst uses Ammonia (NH3), contained in the injected diesel exhaust fluid and formed in the decomposition reactor, to react with the NOx in the exhaust stream. The catalyst prompts a chemical reaction combining the ammonia and the nitrogen oxides ($4NH3 + 4NOx + O2 = 4N2 + 6H2O$) to form harmless Nitrogen (N2) and Water (H2O). This reaction is temperature dependent therefore it is important that all insulation is intact and all connections are leak free. On the bottom of the canister is a moisture drain hole in the outlet section. Hot exhaust gas will escape the drain hole with temperatures reaching 300° F three inches radially outward from the holes exit during normal active regeneration. Be careful not to plug this hole or cover it with the mounting straps. Caution should be observed while working in this area with the engine running. To avoid damage to the SCR device only ultra low sulfur diesel fuel with a maximum sulfur content of 15 ppm.

Nitrogen Oxide (NOx) Sensor/Module. The NOx sensor is part of an assembly which includes the NOx sensor probe and NOx sensor control module. A 12v sensor cable attaches these components to form an assembly. There are two cable lengths available, 24.2 inch (615mm) and 36 inch (915mm) to accommodate variations in the configuration of the system. The cable should be anchored to insure cable temperature does not exceed 392 deg F (200 deg C). The NOx sensor probe is located on the outlet tube of the SCR device and is connected to an electronic control module mounted to the frame rail. The NOx sensor communicates with the engine ECU on the J1939 data link and continually monitors the NOx level leaving the SCR device ensuring that the emissions are compliant with the EPA 2010 standard by meeting or exceeding NOx removal at 0.2-g/HP-HR.

Diesel Exhaust Fluid (DEF) Lines. The diesel exhaust fluid lines carry DEF from the supply tank to the supply module which pumps the fluid to the dosing module. There are three DEF lines involved in supplying the pump a steady flow of fluid and supplying it to the dosing module. The Supply line from the tank to the Supply Module is called the Inlet or Suction line and is a 3/8" line with SAE J2044 quick connect fittings. This line is designed sufficiently rigid to prevent collapse due to a vacuum of up to 8.9 in. Hg (300 mbar) created during the suction event. The second line is the Throttle line which is the backflow line from the supply module. This line is also a 3/8" line used to return unused DEF to the tank. The third line is a 5/16" Pressure line which connects the Supply Module to the Dosing Module with SAE J2044 quick disconnect fittings. The Supply Module provides a pressure head of 130psi to the pressure line providing DEF to the dosing module for injection into the exhaust stream. This is a flexible line made of polytetrafluoroethylene (PTFE) allowing movement between the Supply Module and the Dosing Module. The line also has high thermal resistance withstanding temperatures up to 248° F (120C). All three lines offer excellent chemical resistance and are heated electrically with a series resistant heating circuit wrapped around the lines with a protective thermoplastic jacket.

Purge Cycle

The parts of this system vulnerable to freezing in the winter are the external lines and fittings between the supply module and the dosing module. Exposed lines and fittings will freeze and prevent diesel exhaust fluid from flowing. The purge cycle is necessary to protect the dosing system from expansion of the DEF during a hard freeze which would damage the dosing system components. During a purge cycle the supply module pumps the diesel exhaust fluid inside the supply, pressure, and throttle lines back into the DEF tank. This is done through a reverting valve located inside the supply module. Purging begins when the ignition is switched to the "Key Off" position and is completed in 60 seconds. This allows adequate time for the DEF lines to empty, protecting the dosing system components from damage due to thermal expansion of the DEF as a result of deep freeze conditions. Battery power must remain on during this process until the purge process is complete.

CAUTION ***Power to the Supply Module must remain on for 60 seconds after ignition is switched off to complete the purge cycle.***

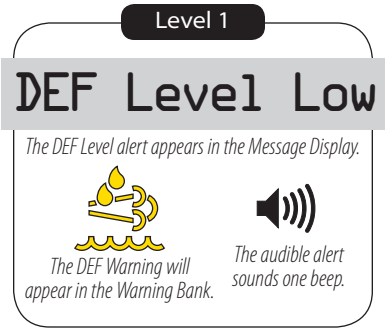
DEF Levels of Notification

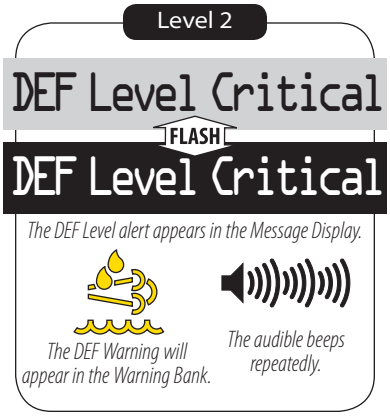
A system of driver alerts keeps the driver informed of when the DEF is in need of service. When fluid is low or contaminated, several levels of alerts occur in sequence, each indicating a more imperative warning. When priority warnings occur, they will appear in Quad 1 of the Message Display in lieu of the odometer reading while Quad 3 indicates fluid level in the DEF tank at all times. The notifications are as shown below.

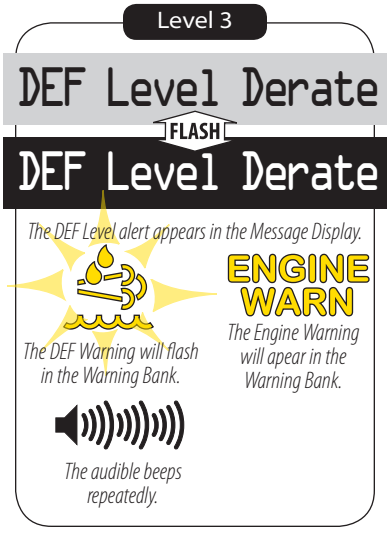
DEF Level 1. When the DEF level reaches 10% in the tank, a **DEF LEVEL LOW** warning will appear in Quad 1 of the Message Display at which point the amber DEF warning icon will appear in the lower left warning bank. This warning is accompanied with a single beep.

DEF Level 2. When the DEF level reaches 5% in the tank, a **DEF LEVEL CRITICAL** warning will appear in Quad 1 of the Message Display, this DEF LEVEL CRITICAL warning display will flash from positive to negative and the amber DEF Warning icon will remain in the lower left warning bank. This warning is accompanied with repeating beeps.

DEF Level 3. When the DEF level reaches 2.5% in the tank, a **DEF LEVEL DERATE** warning will appear in Quad 1 of the Message Display, this DEF LEVEL DERATE warning display will flash from positive to negative**.** The amber DEF Warning icon will commence flashing in the lower left warning bank and an addtional amber Engine Warning light will appear. At this point a 25% engine torque derating will occur.

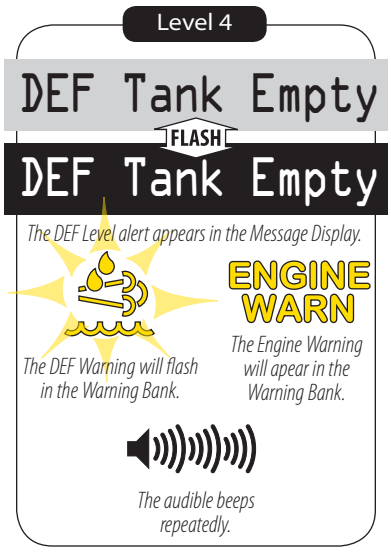


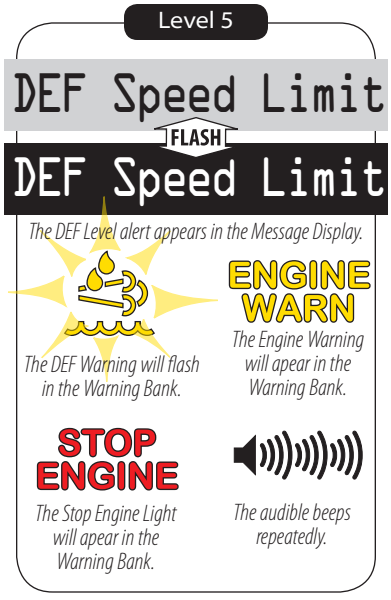




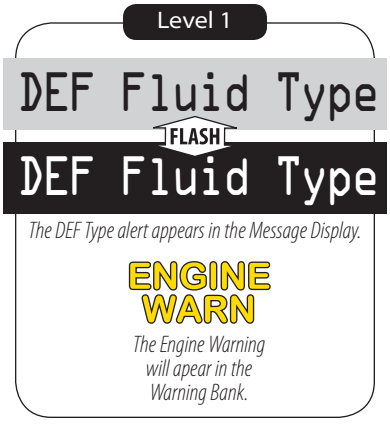
DEF Level 4. When the DEF level reaches 0% in the tank, a **DEF TANK EMPTY** warning will appear in Quad 1 of the Message Display, this DEF TANK EMPTY warning display will flash from positive to negative**.** The amber DEF Warning icon will continue flashing in the lower left warning bank and the amber Engine Warning light will be illuminated. Continued 25% engine torque derating.

DEF Level 5. When DEF sytem can no longer maintain pressure, a **DEF SPEED LIMIT** warning will appear in Quad 1 of the Message Display, this DEF SPEED LIMIT warning display will flash from positive to negative**.** The amber DEF Warning icon will continue flashing in the lower left warning bank. The amber Engine Warning light will remain illuminated and a red Stop Engine light will appear. At this point a 5 MPH speed limit will be introduced with the 25% engine torque derating.



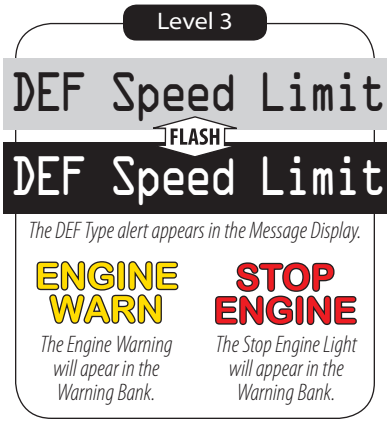


DEF Type Level 1. When incorrect fluid or mixture is introduced into the tank, a **DEF FLUID TYPE** warning will appear in Quad 1 of the Message Display, this DEF FLUID TYPE warning display will flash from positive to negative**.** The amber Engine Warning light will appear in the lower left warning bank. The integrity of the DEF solution needs to be checked using a refractometer. DEF system service should be attained within 10 hours or subsequent levels of derating will occur.



DEF Type Level 2. The **DEF FLUID TYPE** warning in Quad 1 of the Message Display continues to flash from positive to negative**.** The amber Engine Warning light will appear in the lower left warning bank. At this point a 25% engine torque derating will occur. DEF system service should be attained within 10 hours or subsequent levels of derating will occur.

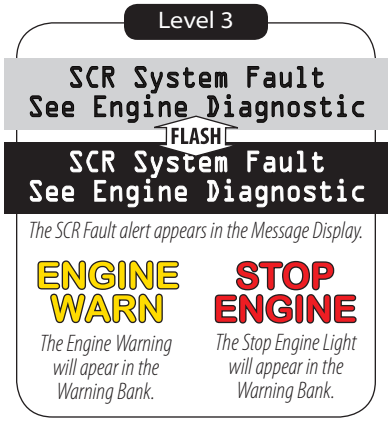
DEF Type Level 3. After 10 Hours at level 2, a **DEF SPEED LIMIT** warning will appear in Quad 1 of the Message Display, this DEF SPEED LIMIT warning display will flash from positive to negative**.** The amber Engine Warning light will remain illuminated and and a red Stop Engine light will appear. At this point a 5 MPH speed limit will be introduced with the 25% engine torque derating.

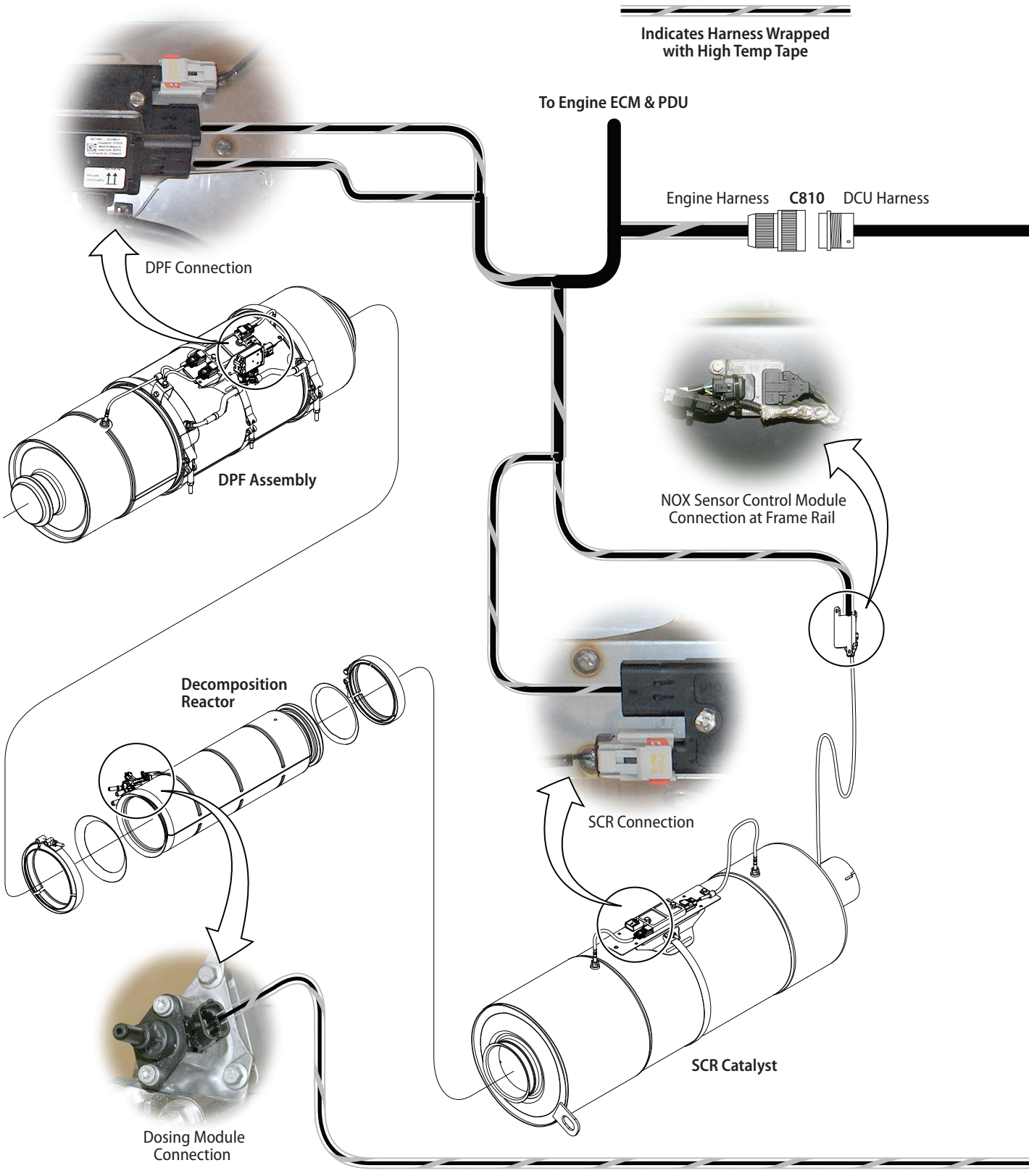


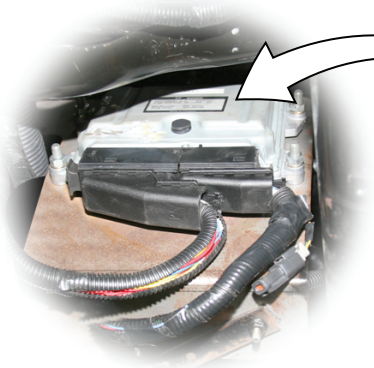
SCR Fault Level 1. When an SCR System Fault is detected, a **SCR SYSTEM FAULT SEE ENGINE DIAGNOSTIC** warning will appear in Quad 1 of the Message Display, this SCR SYSTEM FAULT SEE ENGINE DIAGNOSTIC will flash from positive to negative. The amber Engine Warning light will appear in the lower left warning bank. Engine diagnostic codes should be recorded and appropriate repairs should be made. DEF system service should be attained within 10 hours or subsequent levels of derating will occur.

SCR Fault Level 2. After 10 Hours at level 1 the amber Engine Warning light *WILL* be illuminated and a 25% engine torque derating will occur. DEF system service should be attained within 30 hours or subsequent levels of derating will occur.

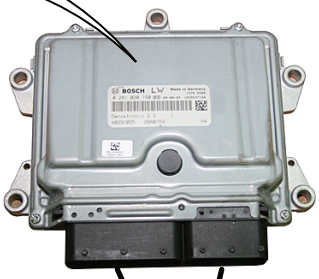
SCR Fault Level 3. After 30 Hours at level 2 the amber Engine Warning light and the Stop Engine light WILL be illuminated. At this point a 5 MPH speed limit will be introduced with a 25% engine torque derating.



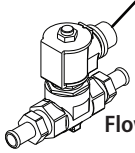

Indicates Harness Wrapped with High Temp Tape
To Engine ECM & PDU
Engine Harness
C810
DCU Harness
DPF Connection
DPF Assembly
NOX Sensor Control Module Connection at Frame Rail
Decomposition Reactor
SCR Connection
SCR Catalyst
Dosing Module Connection



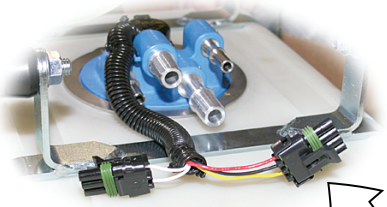
DCU Module Connection viewed from under bus



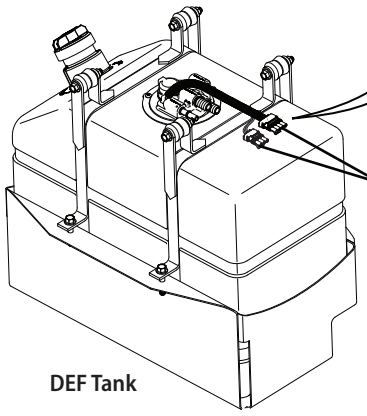
DCU Module



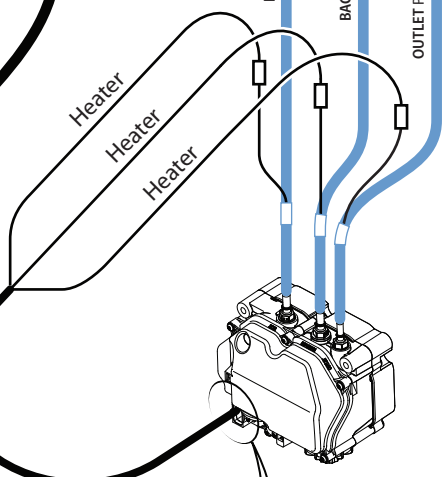
Flow Control Valve



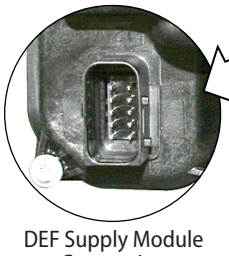
DEF Tank Harness Connection



DEF Tank



DEF Supply Module



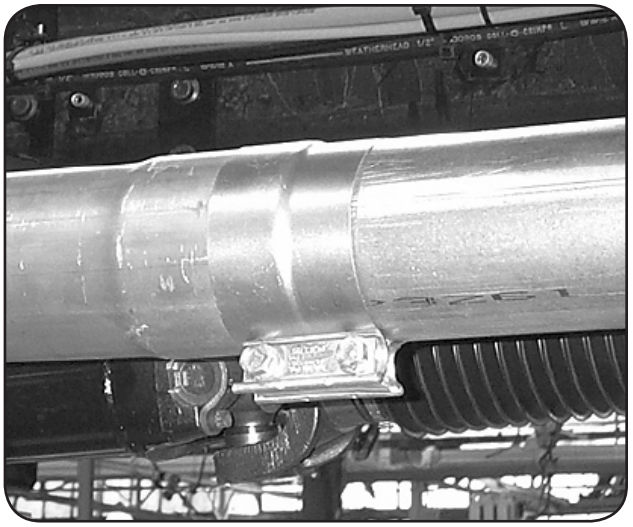
DEF Supply Module Connection

Exhaust, SCR Aftertreatment Harness

Exhaust Piping

The exhaust system is designed to move hot exhaust gases from the engine, underneath and toward the rear of the bus, 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.***



Typical Exhaust Clamp

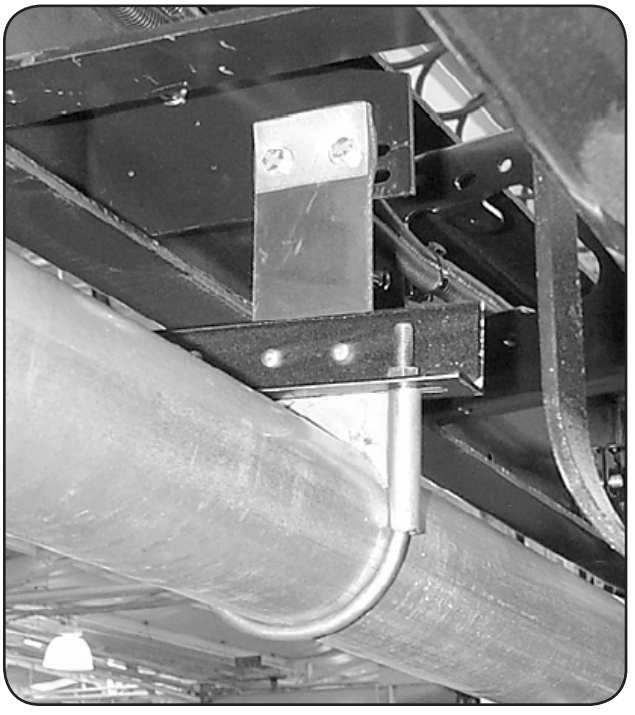
Although the exact configuration of exhaust pipe and tailpipe sections is dependent upon the wheelbase and body length of the particular bus, the pipe sections, joint clamps and suspension hangers are similar. As a general rule, to remove the exhaust system, or any part of it, start at the rear most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

SCR/DPF Assembly Removal

This general procedure applies to all wheelbases. See Exhaust illustrations at rear of this chapter.

1. Start at the rear bumper and loosen all the sections forward until you reach the SCR.
2. Remove the clamp securing the tailpipe onto the SCR.
3. With the slack produced by loosening the section clamps rearward, remove the tailpipe section nearest the SCR.
4. Disconnect all electrical harnesses from the SCR, Decomposition Reactor, and DPF. See *Exhaust, SCR Aftertreatment Harness*, next page.
4. Loosen the nuts at the straps securing the SCR.
5. Loosen the Vee-Band clamp which secures the SCR to the Decomposition Reactor.
6. Support the SCR and remove the strap from the hanger.

Typical Exhaust Hanger



If it is necessary to continue removing exhaust system sections, proceed from the SCR toward the engine as far as necessary. Proceed to remove DPF in same manner as SCR.

DPF/SCR Assembly Reinstallation

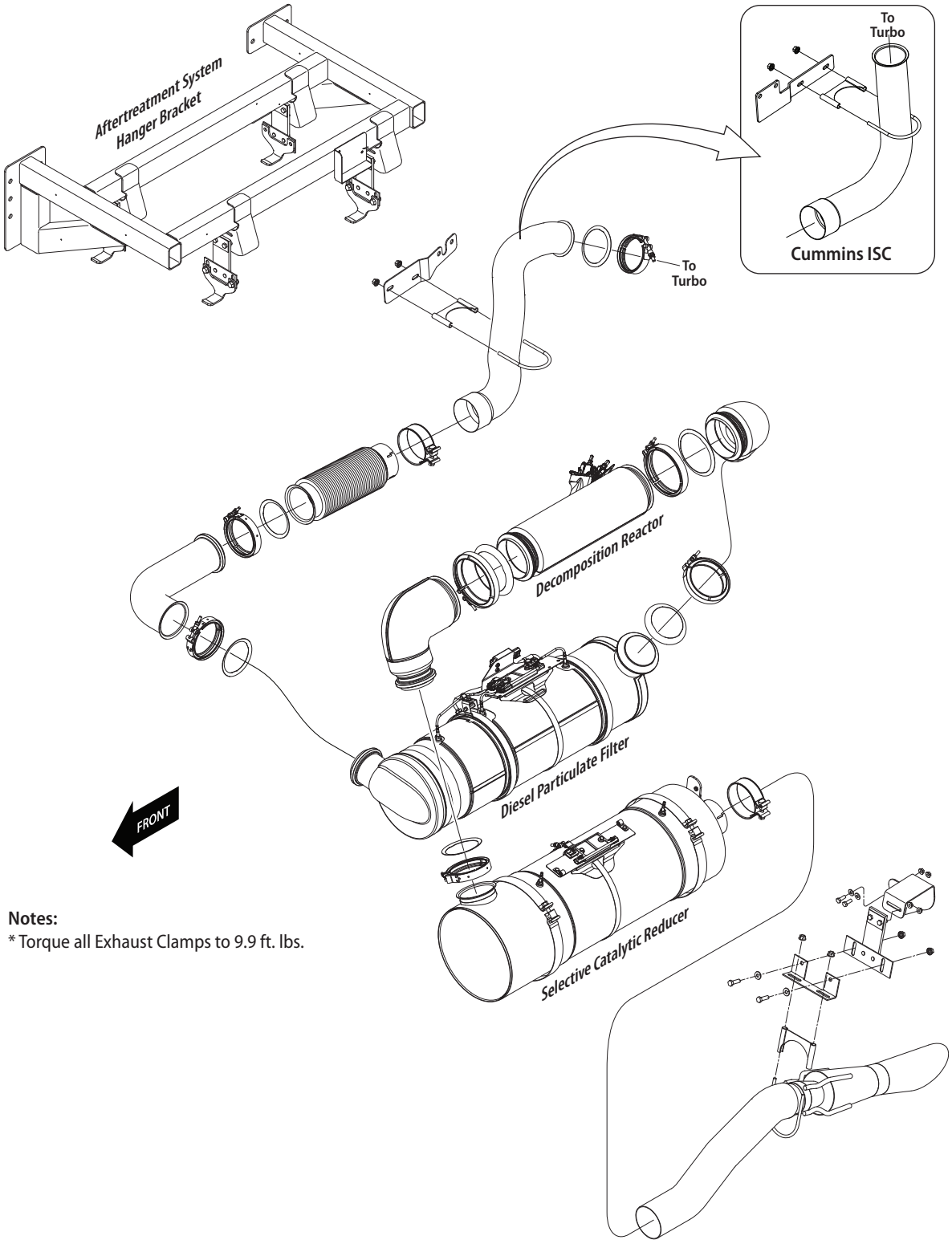
When assembling the exhaust system, start at the forward most section and work toward the rear of the bus. Always use new clamps and hardware.

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

2 Use new wideband clamps and hardware.

3. Tighten the strap holding the DPF.

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.

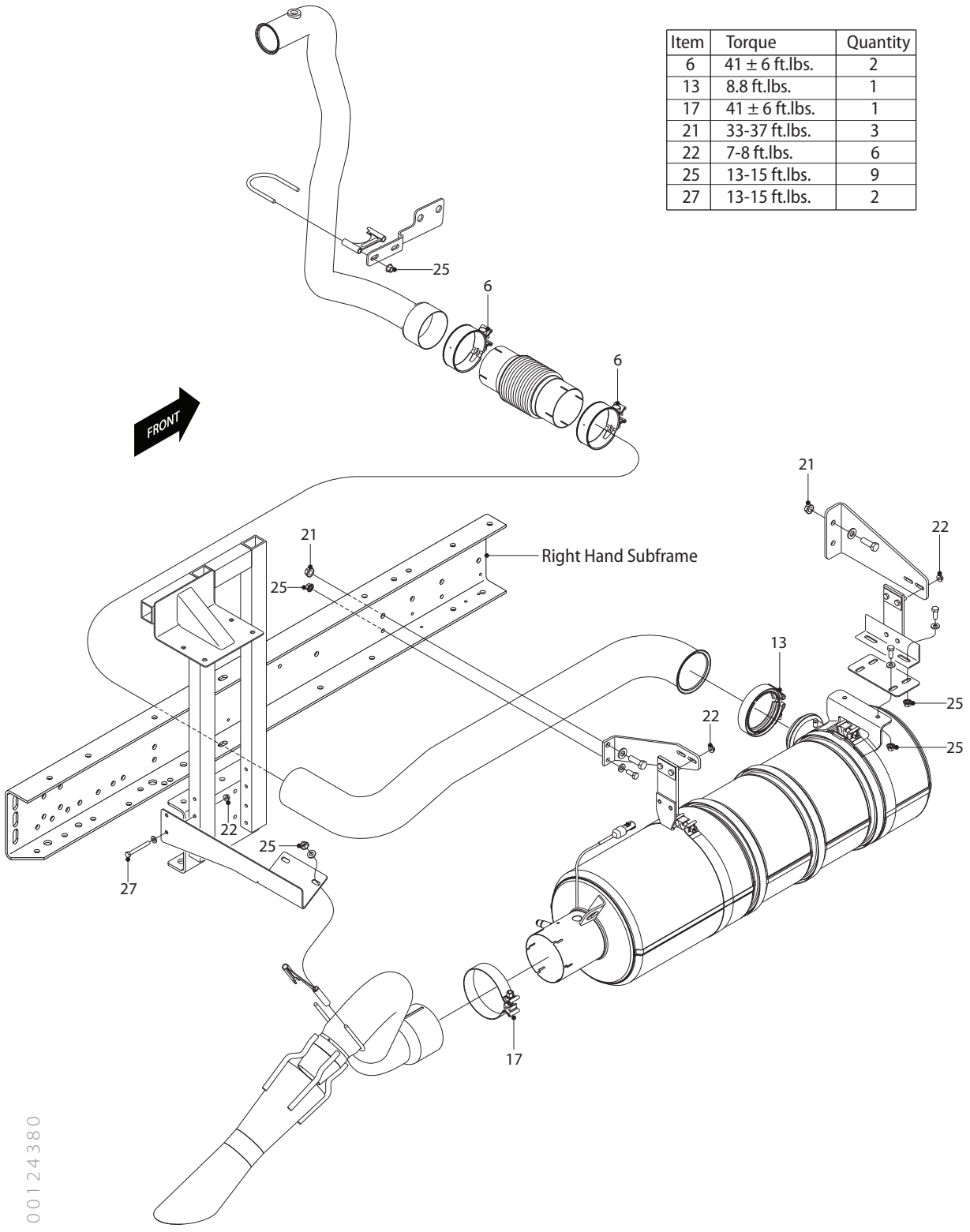


Notes:
* Torque all Exhaust Clamps to 9.9 ft. lbs.

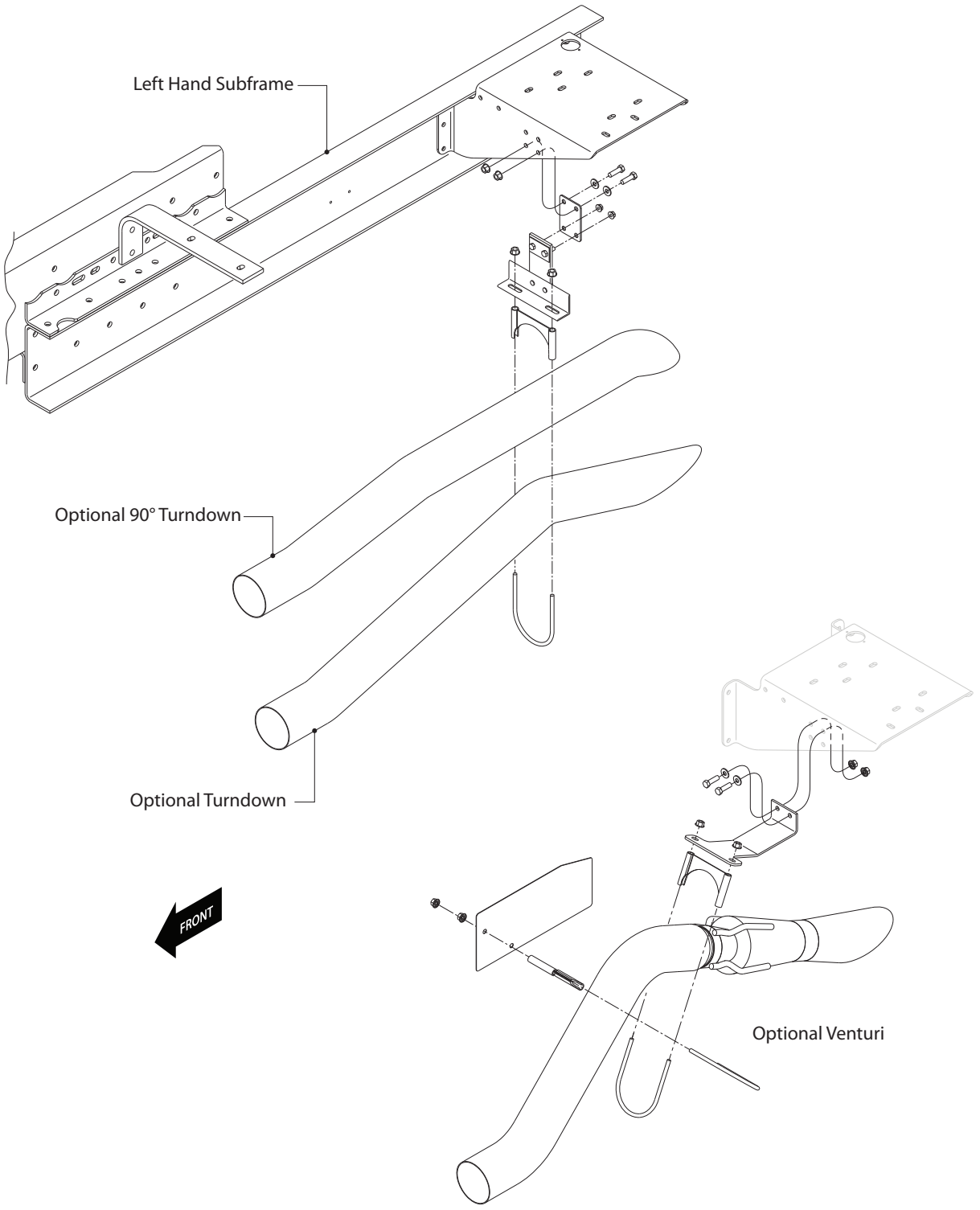
D0004193A & D0004192B

Exhaust: Cummins

Item	Torque	Quantity
6	41 ± 6 ft.lbs.	2
13	8.8 ft.lbs.	1
17	41 ± 6 ft.lbs.	1
21	33-37 ft.lbs.	3
22	7-8 ft.lbs.	6
25	13-15 ft.lbs.	9
27	13-15 ft.lbs.	2



Exhaust: Cummins ISL-G-07



Exhaust, Tailpipe Options

Fuel System

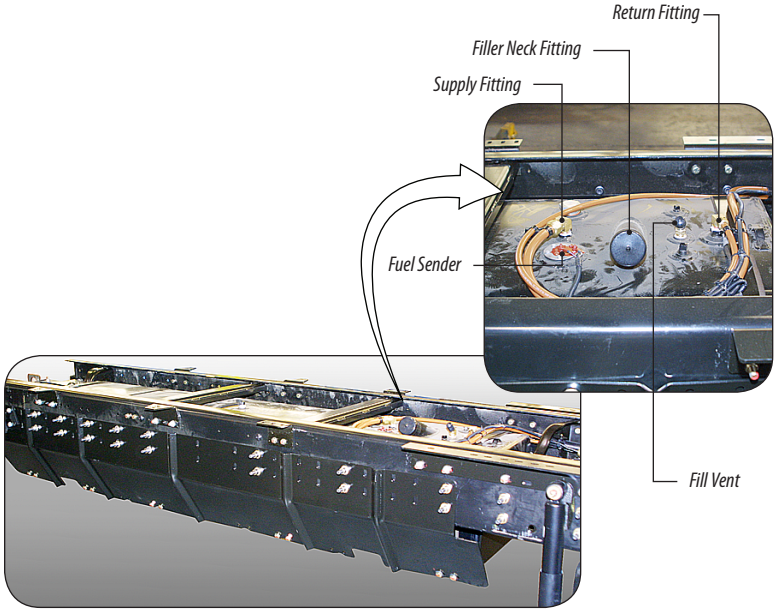
Fuel Storage

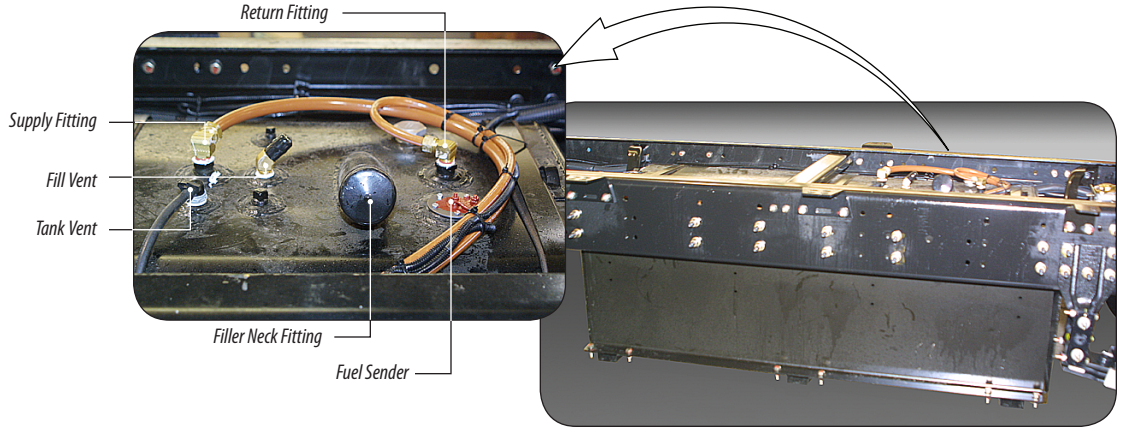
On most All American buses, the fuel tank is mounted between the frame rails and is surrounded for impact protection by a barrier system of steel panels and structural beams. On All American Rear Engine, the between-rails fuel tank is located rearward of the front axle.

Fuel tanks of several capacities are available. All are rectangular tanks secured by a set of steel straps which surround the tank and mount to the barrier and support members. All tube fittings, filler necks, and sending units are mounted on the top of the fuel tank. An inspection port on the floor of the passenger compartment provides access to the fuel sending unit.

WARNING ***Blue Bird Product Engineering does not approve or disapprove 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 upfitter or modifier assumes all responsibility for vehicle engine and fuel system if the fuel system is modified.***

CAUTION ***In 2007 diesel engines, use only diesel fuel labeled Ultra Low Sulfer, per the engine manufacturer's specifications. In Cummins, use oils meeting API CJ-4/SL and Cummins Engine Standard CES-20081. See Cummins Owners Manual ISB 6.7L CM2150 for details.***





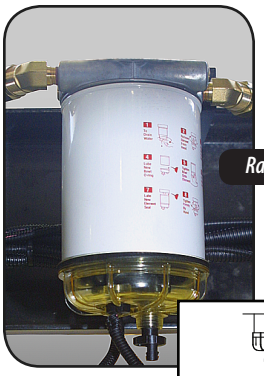
Fuel Filtration

It is critical to the high pressure fuel injection systems of modern diesel engines that fuel is free of contaminates and moisture. Diesel fuel serves to lubricate the injector pumps; any water in the fuel inhibits that lubrication and can lead to injector/pump failure. Therefore, diligent inspection and maintenance of the fuel system filters is essential to engine longevity and performance.

Diesel-fueled All Americans are equipped with two stages of fuel filtration; a primary filter and a secondary filter, each with its own replaceable element. The primary filter is mounted by Blue Bird between the tank and the engine along the inside of the left frame rail, and provides the first stage of filtration at a scale of approximately 10 microns. The second stage of filtration is provided by a much finer filter (2-5 microns, depending upon specific engine) mounted on the engine by the engine manufacturer. Water separation occurs at either or both filters, depending upon which engine is installed. A manually-operated drain is provided to allow collected moisture to be expelled. The moisture collection trap(s) are equipped with electric heater elements to prevent accumulated water from freezing. The moisture trap may also be equipped with an electric water sensor, which causes a yellow warning light in the Driver's instrument panel to illuminate when water in the trap rises to a level sufficient to complete the circuit between the sensor's contacts. This indicates it is time to drain the contaminant collection bowl. After the water has been drained from the bowl, the yellow warning light resets.

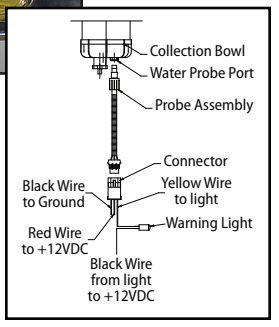
On All Americans equipped with Cummins ISC engines the primary filter is a Raycor filter/water separator unit with a spin-on element, a manually operated drain, an electric heater element and a moisture sensor.

The secondary filter is a Fleetguard unit mounted to the engine and does not have its own water-separation feature.



Raycor Primary Fuel Filter

Cummins ISC



Optional Water Level Sensor

Secondary Fuel Filter

Cummins ISC

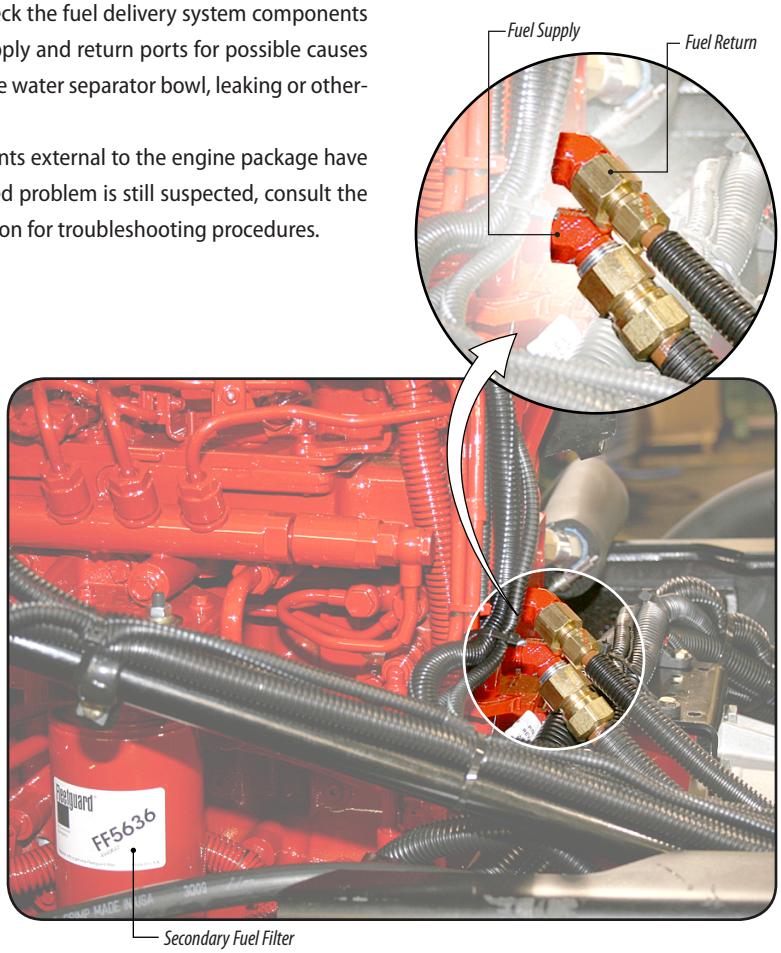
Fuel Delivery

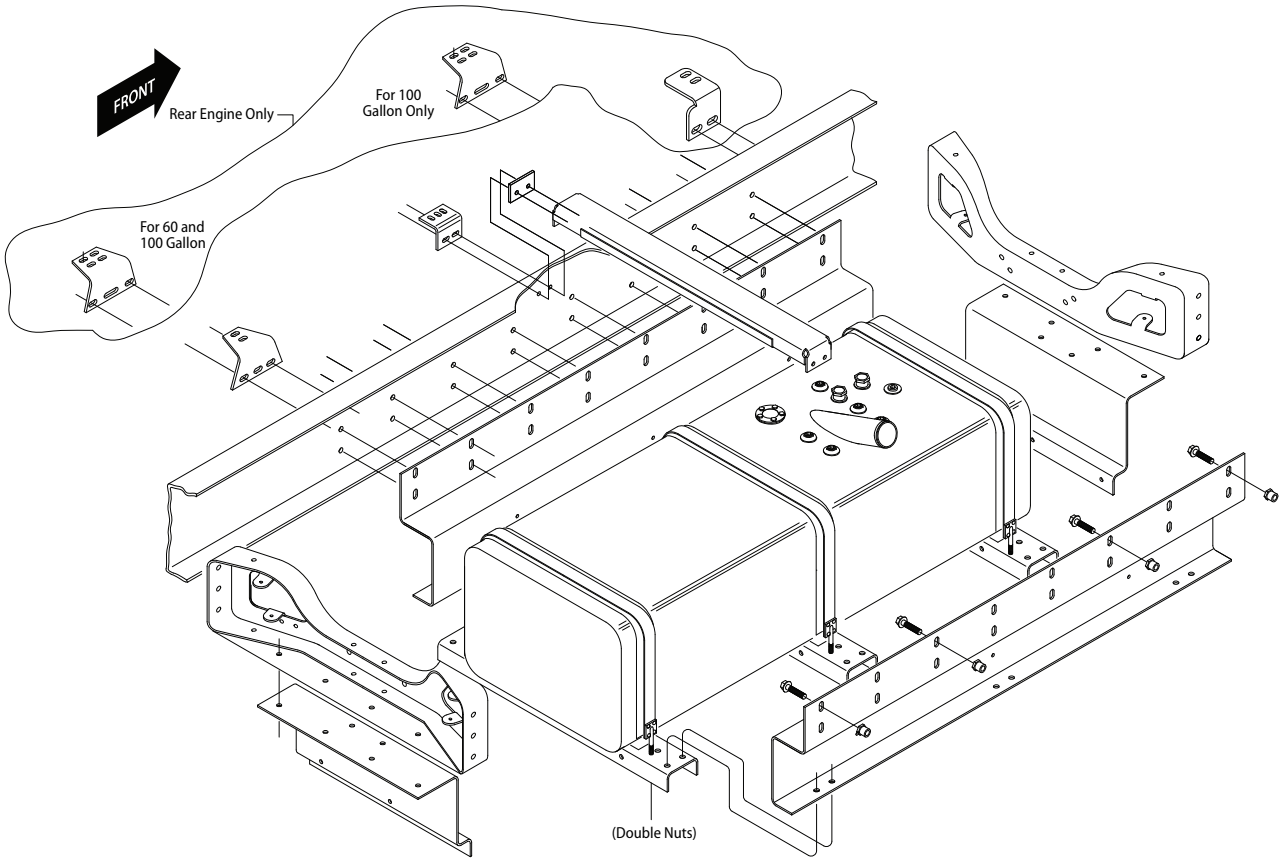
On Cummins engines, two pumps are employed: The "transfer pump" draws fuel from the tank, through the frame-mounted Raycor filter, and into the engine supply port. The fuel then passes through a cooling coil mounted between the engine ECM and the engine. Thus, fuel is used as a cooling agent to reduce the temperature of the Electronic Control Unit. Leaving the ECM cooler, the fuel passes through the engine-mounted secondary filter and then enters a second, high pressure pump. The high pressure pump delivers the fuel under increased pressure to the Cummins Common Rail fuel delivery system. The portion of the fuel flow not used by the injectors continues on its way back to the engine's fuel return port, where a 1/2" OD fuel line conveys it back toward and into the top of the fuel tank.

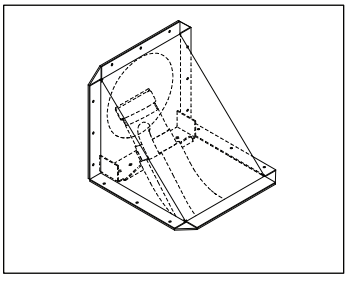
Fuel system delivery problems typically manifest themselves as symptoms such as failure to start, rough idling, rough running, etc. When a fuel-related problem is suspected, first check the Driver's dash panel warning lights for any light which would be generated by the ECM (Check Engine, Stop Engine, etc.) If any such lights are displayed, use the engine manufacturer's recommended electronic diagnostic tool(s) to obtain more detailed information about any stored error codes.

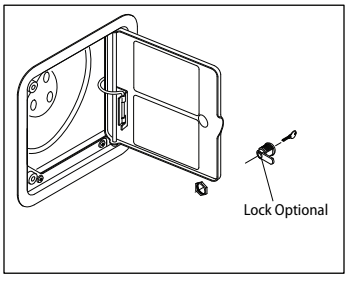
If no dash light errors are indicated, check the fuel delivery system components between the fuel tank and the engine's supply and return ports for possible causes such as clogged filters, water presence in the water separator bowl, leaking or otherwise damaged lines, etc.

If both filters and fuel system components external to the engine package have been eliminated as causes, but a fuel-related problem is still suspected, consult the engine manufacturer's service documentation for troubleshooting procedures.









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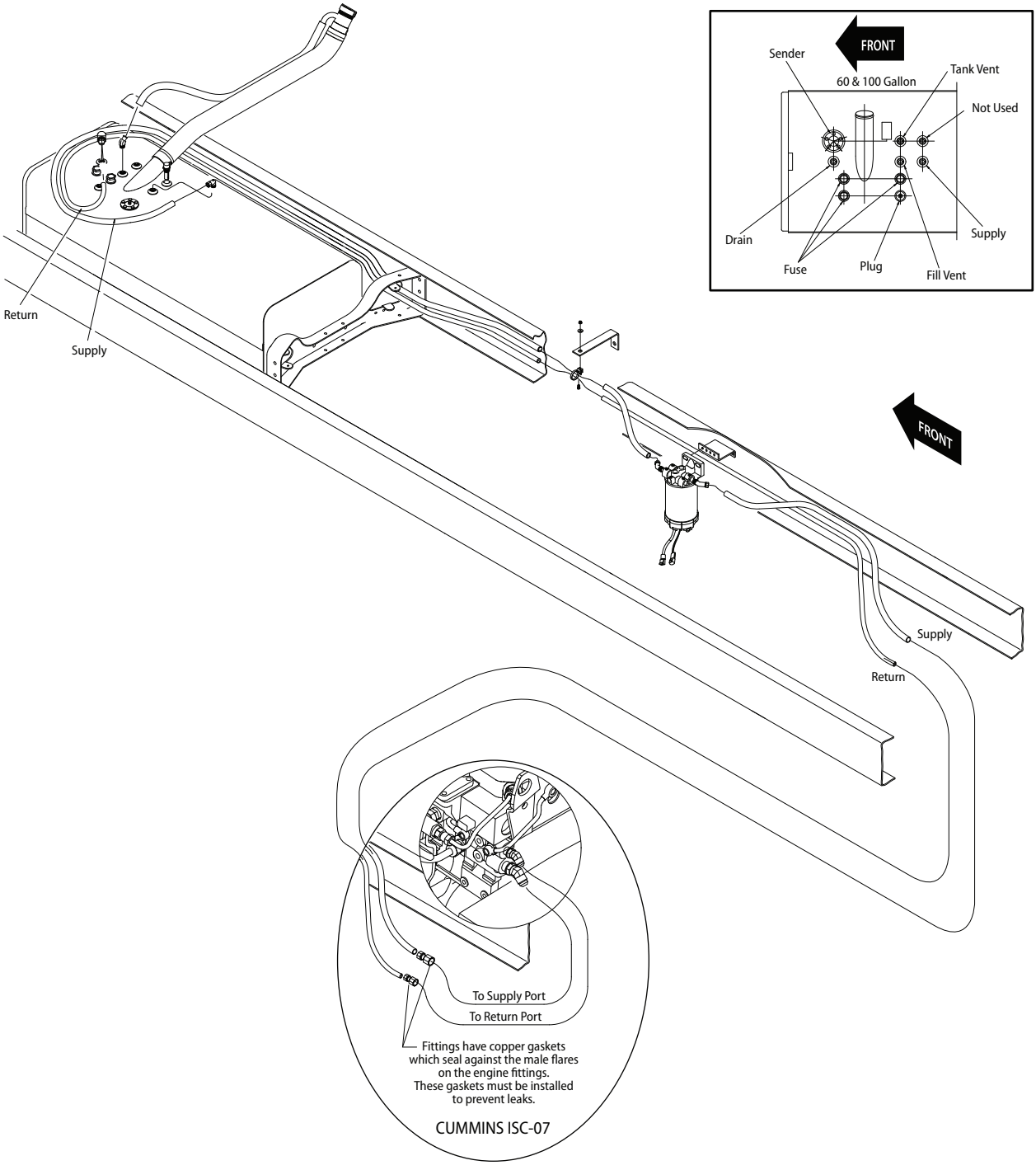
Fuel Tank & Barrier: D3RE



Fuel System: D3RE

Accelerator Control, Electronic

The All American's throttle control on a Cummins engine regulates engine speed not by direct mechanical linkage, but by electronically communicating the position of the pedal to the engine's Electronic Control Module (ECM). The ECM in turn controls the engine's fuel system to adjust engine speed.

When the pedal is pressed, its lever arm rotates a spring-loaded mechanism inside the throttle assembly's housing. Attached to the side of the housing is an electronic position sensor which varies a signal it sends to the engine ECM. The signal modulates according to the position of the rotating part of the pedal assembly.

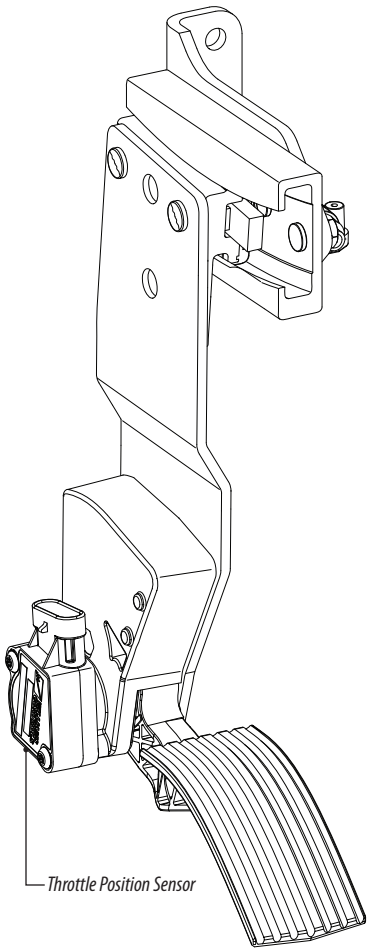
The accelerator pedal assembly is mounted entirely inside the bus, with no part of it extending through the firewall. The assembly is not rebuildable; therefore, it must be replaced as a unit if damaged or faulty. The Accelerator Pedal Position Sensor (APPS) requires no adjustment, and is not rebuildable.

Throttle Position Sensor

The APPS receives an +5 volt DC supply voltage from the engine ECM, drawing less than 40mA of current. It's electonic circuitry senses the accelerator pedal position, and generates an output signal which communicates the throttle position back to the ECM.

Testing And Troubleshooting (Cummins)

The Cummins accelerator pedal incorporates two Throttle Position Sensors to provide the required input to the engine ECM. These components are non serviceable and should not be removed from the accelerator assembly or you could risk voiding the warranty. Each component has three wires going through a weather-pak connector and can be tested individually for proper operation.



Accelerator Pedal Assembly

Throttle Position Sensor Coil Resistance

The Throttle Position Sensor provides the engine an analog signal instructing it to increase or decrease RPM based on the position of the accelerator. This is done with a three wire potentiometer. The sensor is provided a continuous 5V DC (pin B27) and a ground (pin B28) by the engine ECU. As the accelerator pedal is depressed, the throttle position sensor will relay its position to the engine (pin B35). The throttle position sensor can be tested by the following:

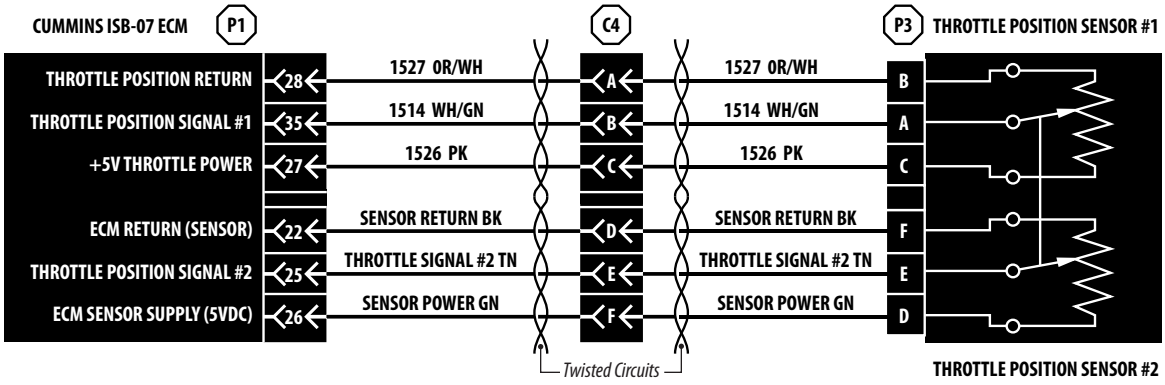
Disconnect sensor plug and meassure resistance on accelerator side of connector between:

- Pins C and A. (Supply and Return) Value should be between 2000 and 3000 ohms.
- Pins C and B. (Supply and Return) Released pedal value should be between 1500 and 3000 ohms.
- Pins C and B. (Supply and Return) Depressed pedal value should be between 200 and 1500 ohms.

Resistance should decrease proportionally as pedal is depressed. Released pedal resistance minus depressed pedal resistancemust be greater than 1000 ohms.

CAUTION ***Do not attempt to adjust or repair throttle position sensor or idle validation sensor. Warranty will be voided.***

Should the accelerator fail to meet specifications the entire pedal must be replaced.



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Overview

The Blue Bird All American instrument cluster uses all electronic analog guages 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.

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.

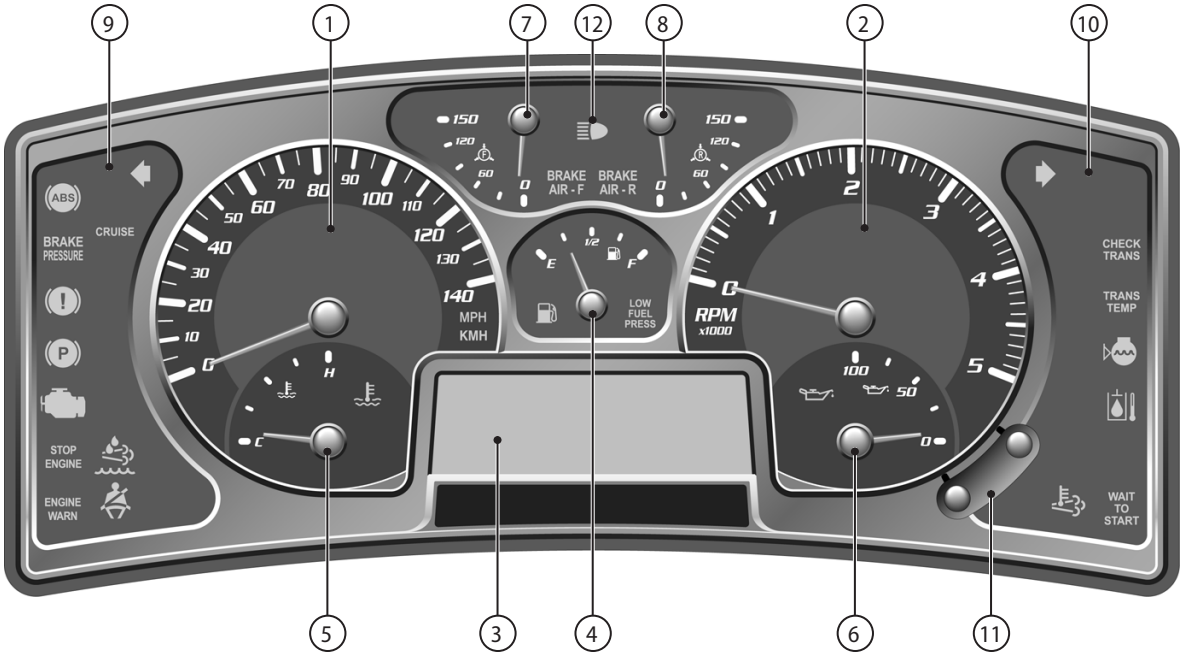
8. **Rear Air Gauge.** Indicates air pressure in rear brake reservoir and includes a low air warning indicator.

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.**

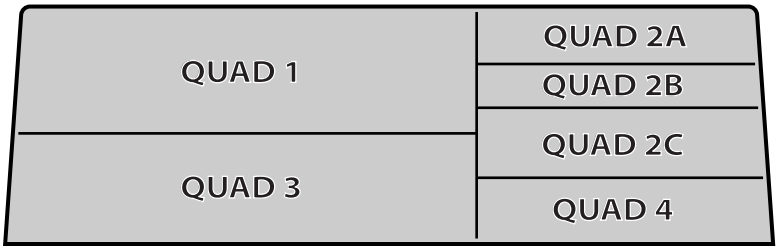


Message Display Center

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 igni-



tion 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.

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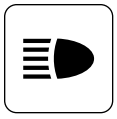


High Beam. Headlights are in high beam.

Cruise. Cruise control has been activated.

Brake Air Front. Indicates front brake air pressure outside of normal operating range.

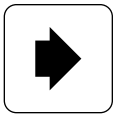
Brake Air Rear. Indicates rear brake air pressure outside of normal operating range.

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.

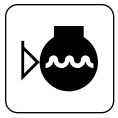
Seat Belt. Indicates driver seatbelt not engaged.



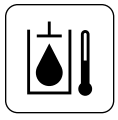
Right Turn. Flashes with right turn signal.

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 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 seven machine screws from around instrument panel's perimeter.

3. Carefully pull the instrument assembly away from the dash housing and tilt face down.

4. Disconnect the electrical connectors from the back of the instrument cluster and remove unit.

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Overview

Electrical systems on the All American may fall into two categories; standard electrical circuits and optional or "feature" electrical circuits. Standard circuits consist of typical electrical circuits and systems found on every All American, i.e; turn signal circuit, wiper circuit, heater circuit, etc. The optional circuits or feature driven circuits consist of electrical circuits and systems that may or may not be installed on the All American i.e; eight light warning circuit, vandal lock circuit, heated mirrors etc. There are hundreds of options with electrical circuit requirement available for the All American. The number of options on any given bus simply depends on how the bus was ordered and manufactured. When deciding if a circuit is optional, the bus application must be considered. In most cases the All American will be used in school bus application, therefore the 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 components and electrical systems are optional or required for the bus to be operated in your area.

The body electrical circuits can be divided into two groups: Conventional designed electrical circuits and circuits designed with built in electronics. With the introduction of the D3 All American, the body electrical system has been upgraded and simplified by the introduction of a Body Control Module (BCM). This is an electronic control module designed to manage a portion of the body electrical systems by serving as a central switching station, receiving inputs from various sources and providing outputs to various loads depending on circuit logic functionality. The module represents a modern means of power distribution, circuit control, and circuit protection using electronic switching devices as it manages the body electrical system by a pre-programed logic. The BCM serves a similar function for a portion of the body electrical system as an ECU serves for an engine, transmission or ABS system.

Technical Terms:

A review of the following terms and their definition should provide a better overall understanding of the body electrical systems covered in this chapter.

Body Control Module (BCM): An electronic device that manages a portion of the body electrical circuits. The module monitors inputs, computes circuit function and activates outputs to the electrical loads.

MOSFET: An electronic switching device inside the BCM with circuit protection capability.

BCM Circuit Logic: The designed in logic of a circuit that determines what conditions are necessary to activate a specific electrical circuit as indicated by a ladder logic line.

Ladder Logic Line: A means of communicating circuit logic, it identifies specific inputs necessary to activate a specific output.

Active Input: An input which is in an "ON" state, A 12 volt potential or ground that is measurable by a volt meter at a specific input terminal on the BCM.

Inactive Input: An input which is in an "OFF" state, the absence of voltage potential or ground on a specific input terminal on the BCM.

Active Output: An output which is in an "ON" state, A 12 volt potential that is measurable by a volt meter at a specific output terminal on the BCM.

Inactive Output: An output which is in an "OFF" state, the absence of voltage potential on a specific output terminal on the BCM.

Flag: An output generated by the BCM, they are used only as an input internal of the BCM module, flags do not have external output circuit.

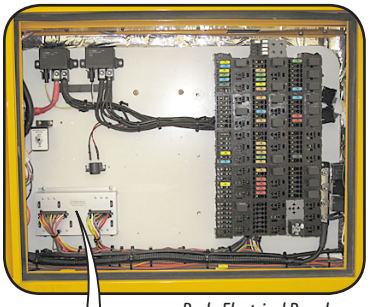
Hard Wired: A conventional method of routing current from an electrical source to a load and back to the source using copper wire, switches, relays, circuit breakers, fuseable link, fuses and other non-electronic components.

Electronic Control Unit (ECU): An electronic device that manages electrical circuits, typically used to control engines, transmissions, ABS systems, etc.

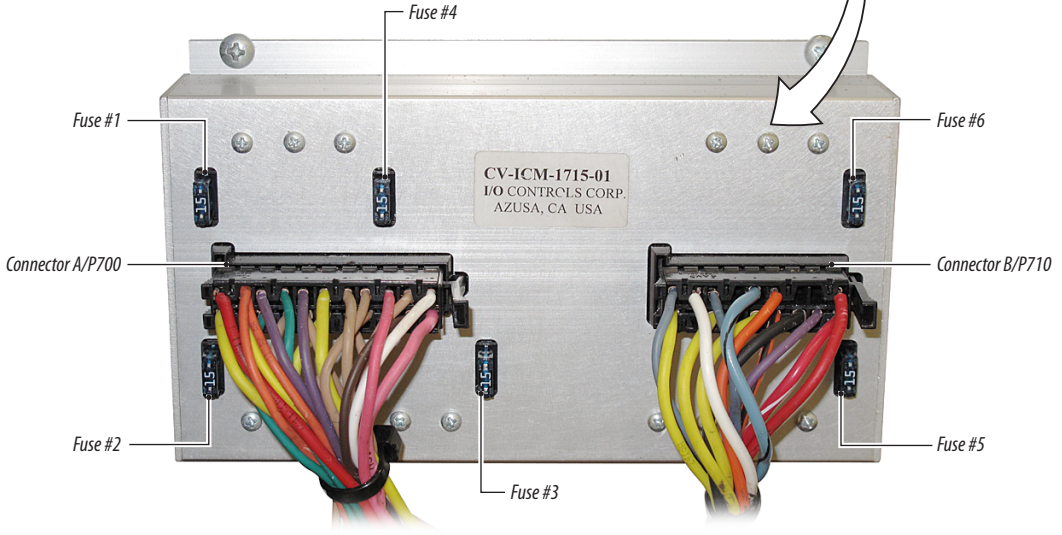
Body Control Module (BCM)

There are four specific body control modules available for the All American. The particular module installed on a bus depends on the bus application, (school bus or non-school bus) and specific options the bus is manufactured with. The four modules are identified by the last two digits of the model number located on the front of the module.

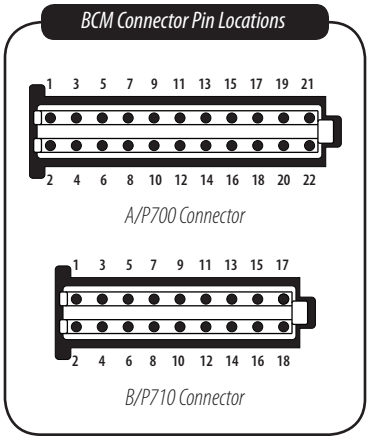
BCM Model	Description/Application
DV-ICM-1715-01	Standard School bus application
DV-ICM-1715-02	School bus, warning light pilot (incandescent)
DV-ICM-1715-03	School bus, warning light pilot (LED)
DV-ICM-1715-04	Non-school bus application with kneeling



Body Electrical Panel



Body Control Module (BCM)



For a more detailed explanation of the modules operating characteristics, unless stated otherwise, we will reference a standard school bus BCM. All body control modules programmed and designated for a standard school bus application will function identically and can be installed on any All American manufactured with a standard electrical system. There are no variations between modules programmed and designated with the same model number. The BCM should never need reprogramming for any reason. If a module fails it would be replaced with a new module having the same programming and designation.

The Body Control Module is located in the body electrical panel. The module is equipped with a 22 pin AMP connector (connector A / P700) and an 18 pin AMP connector (connector B / P710) for interfacing with the electrical system (see decal in body electrical panel access door). Each connector provides an avenue for inputs and outputs.

The module receives power from the bus electrical system through five power input pins and two ground pins. The remaining pins in connector A & B provide an interface for 17 input signals and 15 output signals (reference the input and output table). Each output represents a specific task or function that the BCM manages/ controls.

Six automotive style fuses are located on the front of the module. Each fuse serves 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. Each output circuit is protected individually by an electronic control devise called a MOSFET. In most cases the MOSFET will be the device protecting each individual output circuit from an overload or a short to ground but if an electrical fault occurs, creating a spike (a very quick high current draw) within the circuit or if the over all load of a specific group of circuits exceeds 15 amps, the fuse will blow protecting the circuits and the internal components of the module. The decal in the body electrical panel access door will identify each fuse, its rating, its location and the circuits each fuse protects.

Another characteristic of the BCM, typical to other electronic control modules, is its power down mode. When the ignition switch is turned off the module will immediately and systematically go into a sleep mode. The module will draw very low current (less than 1ma) and will not operate unless certain inputs become active. Input circuits not having wake up status will not function if the ignition switch is off. Input circuits having wake up status will function with the ignition switch off but when the input is deactivated the module will return to its sleep mode. Reference the BCM input table to identify the specific inputs that will cause the control module to wake up in a fully functional mode.

The BCM is designed to monitor full on or full off body circuit inputs and deliver an output according to a programed circuit logic. The BCM is programed to recognize when inputs are active (on) and or inactive (off), the module compares each input or a group of inputs with it's pre-programed logic and activates outputs accordingly. The body control module does not manage all body circuits. To determine which circuits are managed by the BCM see the BCM input and output table.

BCM Input and Output Table

One of the first steps in understanding a body electrical system on the D3 All American is to determine which circuits are controlled by the BCM. The BCM Input and Output Table can be used as a quick reference to identify which circuits are managed by the body control module.

The input table provides a description of each input circuit the BCM manages, it identifies the pin number and connector the circuit is connected to, the circuit number, the circuit color, whether the input is 12V or Ground and whether or not the input, if activated, would cause the module to wake up.

The output table provides similar information for each output the BCM manages plus other information that is specific to outputs. The table also indicates which input source feeds current to a specific output, which fuse protects a specific output or group of outputs, and the specific ladder logic line to use when troubleshooting a circuit by referencing each output to its specific logic line. Therefore the output table can be used as a quick reference to locate a specific ladder logic line.

BCM Input Table

	Circuit Description	Pin Number	Connector	Circuit Number	Circuit Color	Input	Wake-Up
1	Power 1	1	A / P700			12 Volts	
2	Power 2	22	A / P700			12 Volts	
3	Power 3	17	A / P700			12 Volts	
4	Ground	21	A / P700			Ground	
5	Headlight Switch	8	A / P700			12 Volts	Yes
6	High Beam Switch	3	A / P700			12 Volts	
7	Turn Signal, Right	7	A / P700			12 Volts	Yes
8	Turn Signal, Left	4	A / P700			12 Volts	Yes
9	Wiper Switch 1	15	A / P700			12 Volts	
10	Wiper Switch 2	16	A / P700			12 Volts	
11	Wiper Switch 3	19	A / P700			12 Volts	
12	Wiper Park Right	12	A / P700			Ground	
13	Wiper Park Left	11	A / P700			Ground	
14	Mirror Heat Switch	20	B / P710			Ground	
15	Ignition	11	B / P710			12 Volts	Yes
16	Power 4	18	B / P710			12 Volts	
17	Power 5	17	B / P710			12 Volts	
18	Ground	3	B / P710			12 Volts	
19	Daytime Running Lights Enable	16	B / P710			12 Volts	
20	Warning Light Start Switch	12	B / P710			12 Volts	
21	W/L Flash Only After Amber	1	B / P710			Ground	
22	W/L Flash Red When Door is Open	7	B / P710			Ground	
23	Stop Arm Cancel	4	B / P710			12 Volts	
24	Cross Arm Cancel	8	B / P710			12 Volts	
25	Children Check Alarm	15	B / P710			12 Volts	

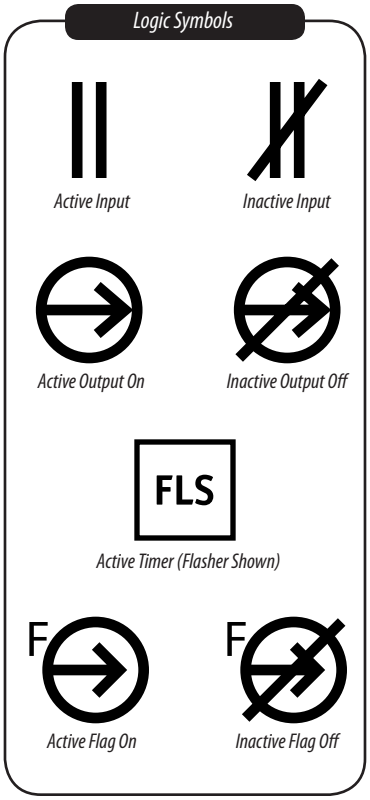
BCM Output Table

	Circuit Description	Pin Number	Connector	Input Source Pin	Fuse	Circuit Number	Circuit Color	Output	Ladder Logic Line
1	Headlight Low, Right	9	A / P700	1	1			12 Volts	3
2	Headlight Low, Left	5	A / P700	1	1			12 Volts	2
3	Turn Signal, Right	6	A / P700	1	2			12 Volts	5
4	Turn Signal, Left	2	A / P700	1	2			12 Volts	4
5	Wiper Low, Right	14	A / P700	2	3			12 Volts	14
6	Wiper Low, Left	10	A / P700	2	3			12 Volts	13
7	Strobe Light with Warning Light	18	A / P700	2	3			12 Volts	15
8	Mirror Heat	13	A / P700	3	4			12 Volts	17
9	Amber Warning Light, Right	2	B / P710	4	5			12 Volts	27
10	Amber Warning Light, Left	10	B / P710	4	5			12 Volts	28
11	Red Warning Light, Right	6	B / P710	4	5			12 Volts	30
12	Red Warning Light, Left	14	B / P710	4	5			12 Volts	31
13	Stop Arm	5	B / P710	5	6			12 Volts	33
14	Cross Arm	9	B / P710	5	6			12 Volts	35
15	W/L Pilot Lights	13	B / P710	5	6			12 Volts	--

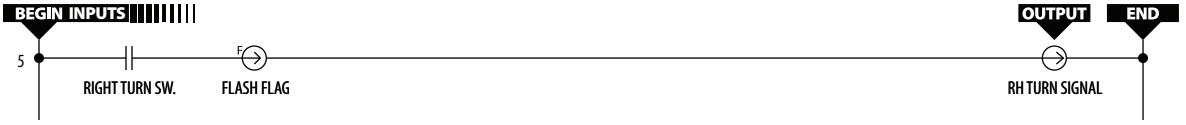
Ladder Logic Lines

As defined in the technical terms, a ladder logic line or diagram provides a means of communicating circuit logic, which inputs are necessary for the BCM to activate a specific output. To understand an electrical circuit a technician needs to know the function of the circuit and what conditions are necessary to activate the circuit. All outputs managed by the BCM will have their own logic line. Each logic line is identified by a reference number to the left of the line. A logic line relating to a specific output can be located by referencing the last column in the output table or simply reviewing the output description (located on the far right of the logic line) of each logic line until you locate the logic line in question.

Each logic line consists of a horizontal line with a description of all inputs 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 symbol is placed on the horizontal line above each input and output description. This symbol indicates if the inputs and output 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 BCM 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), input logic has been satisfied and the microprocessor in the BCM will signal for the output to be activated.



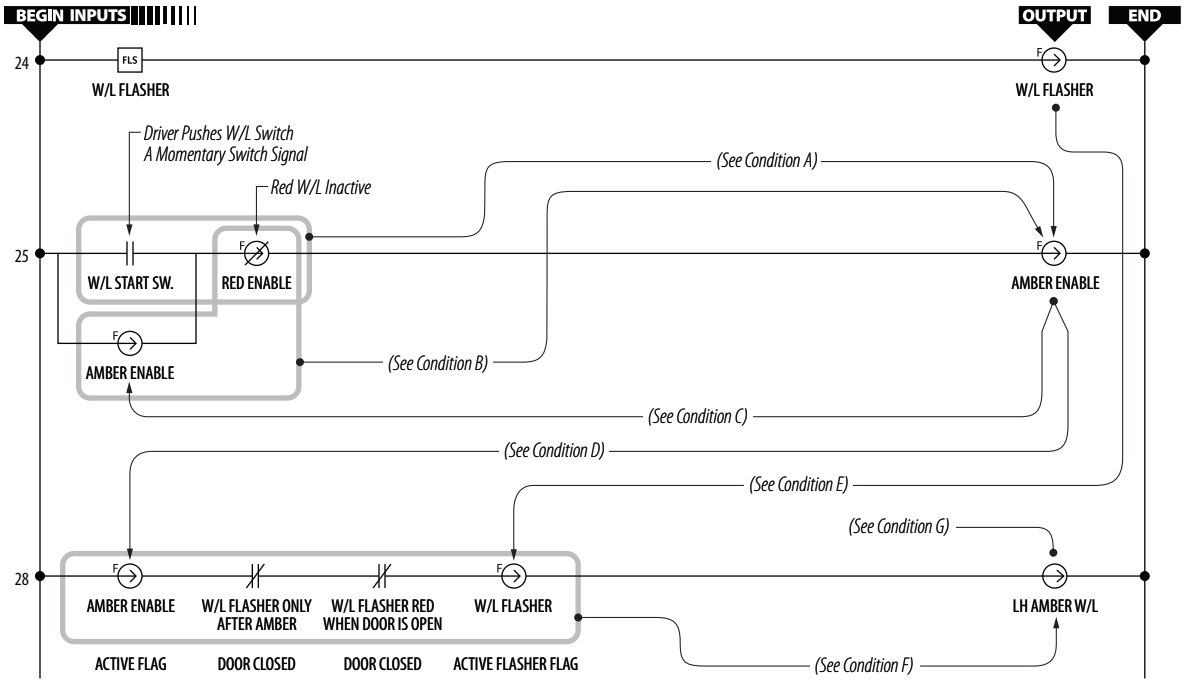
Using a logic line to understanding how a circuit works would require reading the line from left to right.



Example One: The right turn signal circuit logic can be located by referring to logic line number 5. The BCM will activate (turn on) an output to the right turn signal when it monitors a 12V input, coming from the turn signal switch, on pin number 7 connector A. In this simple example it only requires one external input to activate one output but that's not all the module is programed to do. The BCM manages each circuit, for the turn signal circuit to work something must turn the circuit on and off. The BCM handles the turn signal flasher function for the All American electrical system. This is indicated by the Flash Flag input (internal input) located on the left side of the turn signal logic line.

Reading the logic line from left to right provides all the necessary inputs, input logic (or input status, active/on or inactive/off) and the specific output that is activated if all the requirements are satisfied. If you think of a ladder logic line as a formula, it could be written as; inputs + input logic = output.

As noted in the example above, one of the inputs required for the right turn signal circuit to function is the Flash Flag (reference logic line number 5 and 1). The technical terms describes a flag as; an output generated by the BCM. They are used only as an input internal of the BCM module and flags do not have external output circuits. By not having an external output circuit, flags are not listed in the output table. A flag has a similar symbol as a regular output but with an "F" outside the circle and it is generated in much the same way as a regular output is generated. Each flag requires certain inputs to activate its output and each flag has its own ladder logic line that communicates its function and logic in the same way as a regular output logic line does. A flag symbol can be encountered in two different areas on a logic line. A flag symbol will be located on the far right of its own logic line indicating it is an output but to be functional, a flag must be used internal of the module as an input and would be located on the left of a logic lines. To fully understand the function of a flag when it is encountered as an input on a logic line, you would have to locate that particular flag's logic line. Review the output description (located on the right) of each logic line until you locate the flag in question. The inputs required to activate the flag would be located on the left. Read the logic line from left to right as you would with a logic line having an external output.



Ladder Logic Example

Condition A & B: A set of Input Logic conditions that will cause the BCM to activate the Amber Enable Output Flag, regardless of any other conditions.

Condition C: Once activated the Amber Enable flag can be used on its own logic line to keep itself activate until the red W/Ls are activated.

Condition D: Flags are outputs generated by the BCM, they are used internal of the module and they do not have external outputs, for the Amber Enable flag to be functional it must be used as an input on a logic line.

The Amber Enable flag indicates the driver is requesting the Amber W/L to activate as long as the Red W/Ls are inactive.

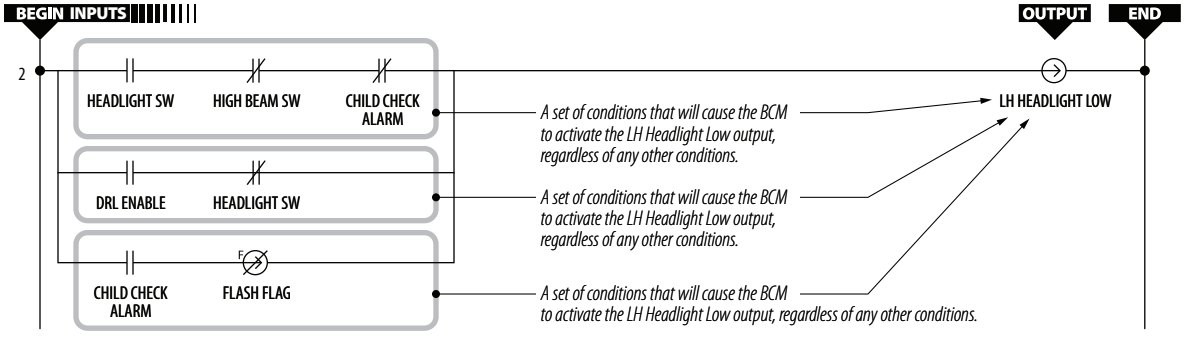
Condition E: Flags are outputs generated by the BCM, they are used internal of the module and they do not have external outputs, for the W/L Flasher Flag to be functional it must be used as an input on a logic line.

The W/L Flasher Flag indicates the W/L Flasher internal of the BCM has been activated and it will alternately activate and inactivate the output of the logic line it is located on.

Condition F: A set of Input Logic conditions that will cause the BCM to activate the Right Hand Amber W/L Output.

Condition G: The Left Hand Amber W/L Output symbol represents an actual 12 volt output from the BCM that will carry the full load of the Left Hand Amber Warning Lights.

Example three: The headlight circuit logic can be referenced by referring to logic line number 2. The BCM will activate the left hand headlight, low beam, (1) When the headlight switch is active and the high beam switch is inactive and the child check alarm is inactive, or (2) if the day time running light is active and the head light switch is inactive or, (3) if the child check alarm is active and the flash flag is inactive. In this example there are three sets of inputs for one logic line. Each set of inputs represents a logic path that could activate the left head light with only one set of inputs being satisfied. This represents multiple paths of logic to activate the same output. If the head light circuit were designed with the same logic but without using electronic controls it would consist of an interacting series of relays and integrated hard wired circuits. In short a more complex circuit. By managing body electrical circuits the BCM eliminates some of the dated electrical systems and simplifies body electrical logic and function.



Output MOSFET

When an output is activated, the BCM supplies12V directly to the load. The specific pin and connector number for each output can be identified by referencing the BCM output table. The fuses located on the front of the module protect groups of output circuits and components internal of the module. Each output circuit is also protected individually from an overload or a short to ground by an electronic device located inside 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 for the BCM microprocessor when input circuit logic has been satisfied. The MOSFET electronically closes (switches on) the specific output and carries the full load of the output circuit. When the microprocessor deactivates the signal to the MOSFET, the MOSFET opens deactivating the output circuit (switches off). In this function the MOSFET works similar to a regular transistor, switching a circuit on or off electronically according to a signal from the microprocessor. In the event a fault occurs on the circuit, if the circuit is over loaded (draws more current than it was designed to) or if a shorts to ground occurs, the MOSFET reacts similar to an automatic circuit breaker and opens (switches off) the output protecting the output circuit. The MOSFET will continue to hold in the open mode as long as the electrical fault is active on the circuit. When the fault is removed or corrected the MOSFET will revert back to its transistor mode activating and inactivating the output depending on the signal from the microprocessor. The MOSFET is the main device protecting the individual circuits.

Troubleshooting Body Electrical Circuits

CAUTION ***Failure to follow specific troubleshooting guidelines could result in damage to Body Control Module.***

Use a high impedance volt meter for circuit testing.

1. Determine if the failed circuit is managed by the Body Control Module.
   a. Review the circuit description column in the BCM Output Table.
   b. If the circuit is not in the list, it is not managed by the BCM.
      - Locate the circuit wiring diagram and use conventional electrical circuit troubleshooting to resolve the issue.
   c. If the circuit is in the list it is managed by the BCM.

2. Check the BCM for required output.
   a. Refer to the BCM output table for the connector and pin number of the failed circuit.
   b. Set all the conditions necessary for the specific output circuit to be active (on).
      - Locate the circuit in question on the BCM output table, refer to the last column for the applicable logic line (each logic line is referenced with a number to the left of the line), reference inputs and input logic, set inputs accordingly.
   c. Back probe the output circuit for 12 volts.
      - If the voltage is correct the test indicates the BCM and all inputs are functioning properly and the failure is downstream of the BCM. The failure could be in the output circuit, other downstream control devices, or the load its self may have failed. Refer to the output circuit electrical diagram and use conventional electrical circuit troubleshooting to indentify the fault.
      - If voltage is not detected on the output circuit the test indicates one of the following four conditions. (1) One or more of the power or grounds circuits supplying the BCM has failed. (2) One of the supply fuses has failed. (3) One or more of the inputs for that specific circuit has failed or (4) the BCM has failed.

3. Check power supply circuits for the BCM.
   a. Refer to the BCM input table and indentify the connector and pin numbers for all the input power circuits and ground circuits.
      - Use a volt meter to confirm all power and ground circuits are good.
      - Check the circuit fuses. Each input power circuit is protected with a fuse located on the fuse panel inside the body electrical panel (not the fuse on the BCM).
      - Use conventional electrical troubleshooting to determine failure of power circuits.

4. Check BCM Inputs.
   a. Locate the circuit in question on the BCM output table, refer to the last column for the applicable logic line. Each logic line is reference with a number to the left of the line.
   b. Systematically check input circuits as indicated on the logic line.
   c. Set conditions (active or inactive depending on each input logic symbol) for all inputs required to generate and active output for the circuit in question.
   d. Refer to the input table for the connector and pin number of each input.
   e. Back probe each input (keep in mind some of the inputs may be active and others inactive to satisfy circuit logic, refer to the logic symbol above each input).
   f. Locate the electrical diagram for the failed input and use conventional electrical troubleshooting to resolve the issue.
   g. If all of the inputs test good a failure may have occurred inside the BCM.

5. Confirm the Body Control Module has failed.
   a. Refer to the BCM output table and check specific BCM output.
   b. Refer to the BCM input tables and check for 12V on all power inputs.
   c. Check all BCM fuses.
   d. Refer to the input table and check all grounds (less than 10 ohm).
   e. Refer to the specific ladder logic line and check each input.
   f. Review all the troubleshooting steps (steps 1 – 5) that apply to the specific failure mode. If the cause of the failure has not been discovered by reviewing the troubleshooting steps a second time, failure may have occurred in the BCM.

The Body Control Module has been designed specifically for the All American and manufactured to provide long service life. The BCM has double protection supporting the integrity of the output circuits and internal components of the module. The BCMs are assembled using premium quality components that are designed for the loads and environment school buses operate in. Carefully review all troubleshooting procedures and call your Blue Bird Service Provider prior to replacing the BCM.

Body Wiring Schematics

Many customer selected options which affect wiring are available for the D3 All American. The drawings on the DVD are in resolution-independent vector format. This allows you to zoom them at will, without the images becomming jagged as occurs with bitmap formats. This also means that you may print the drawing to your own office or desktop printer while maintaining legibility even at significant reductions.

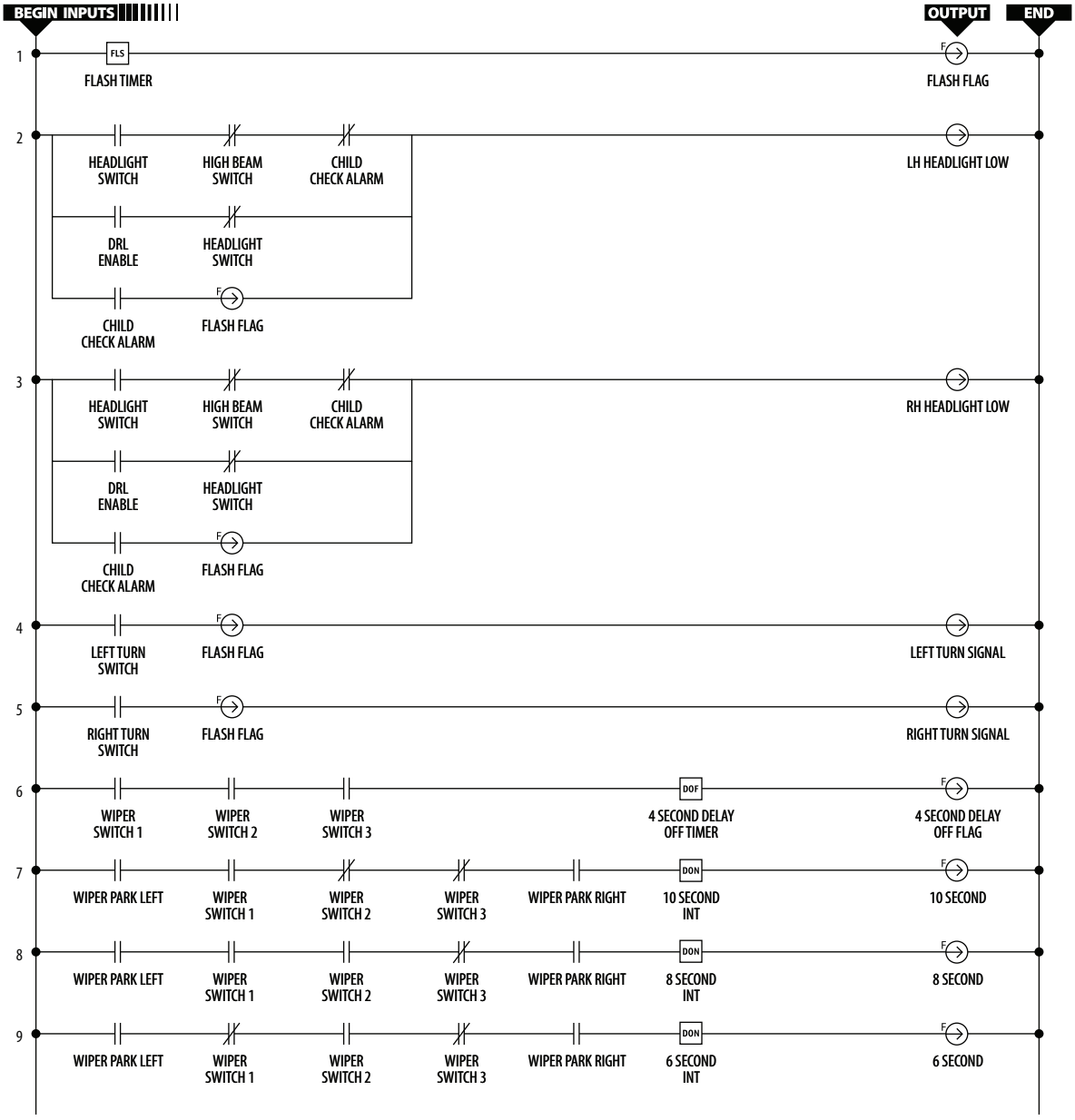
For more information see; **About the TechReference DVD; Electrical Schematics** located in the **Introduction** section of **Volume 1**. Also see additional wiring schematics for your bus at the Customer Access web site:

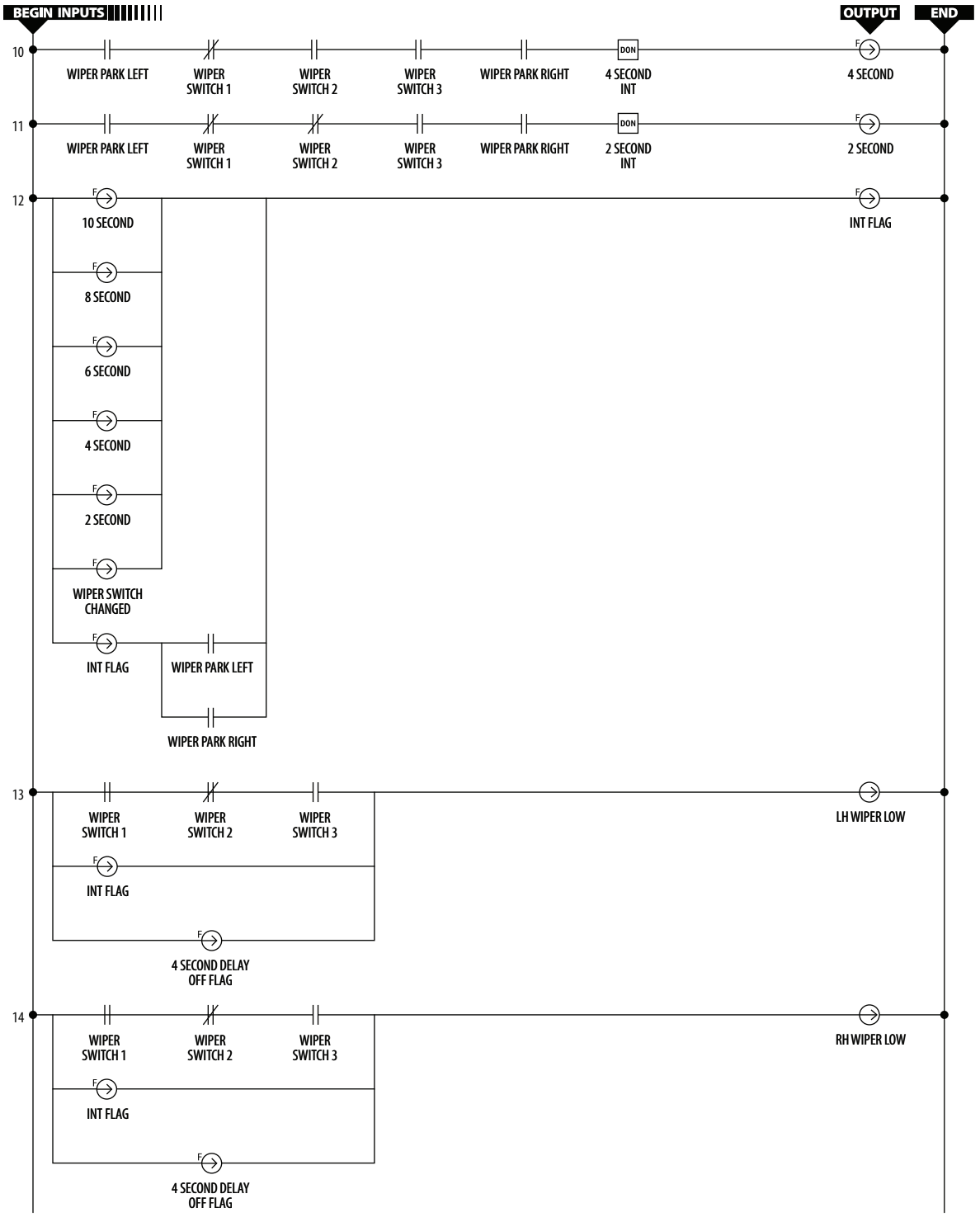
http://service.blue-bird.com

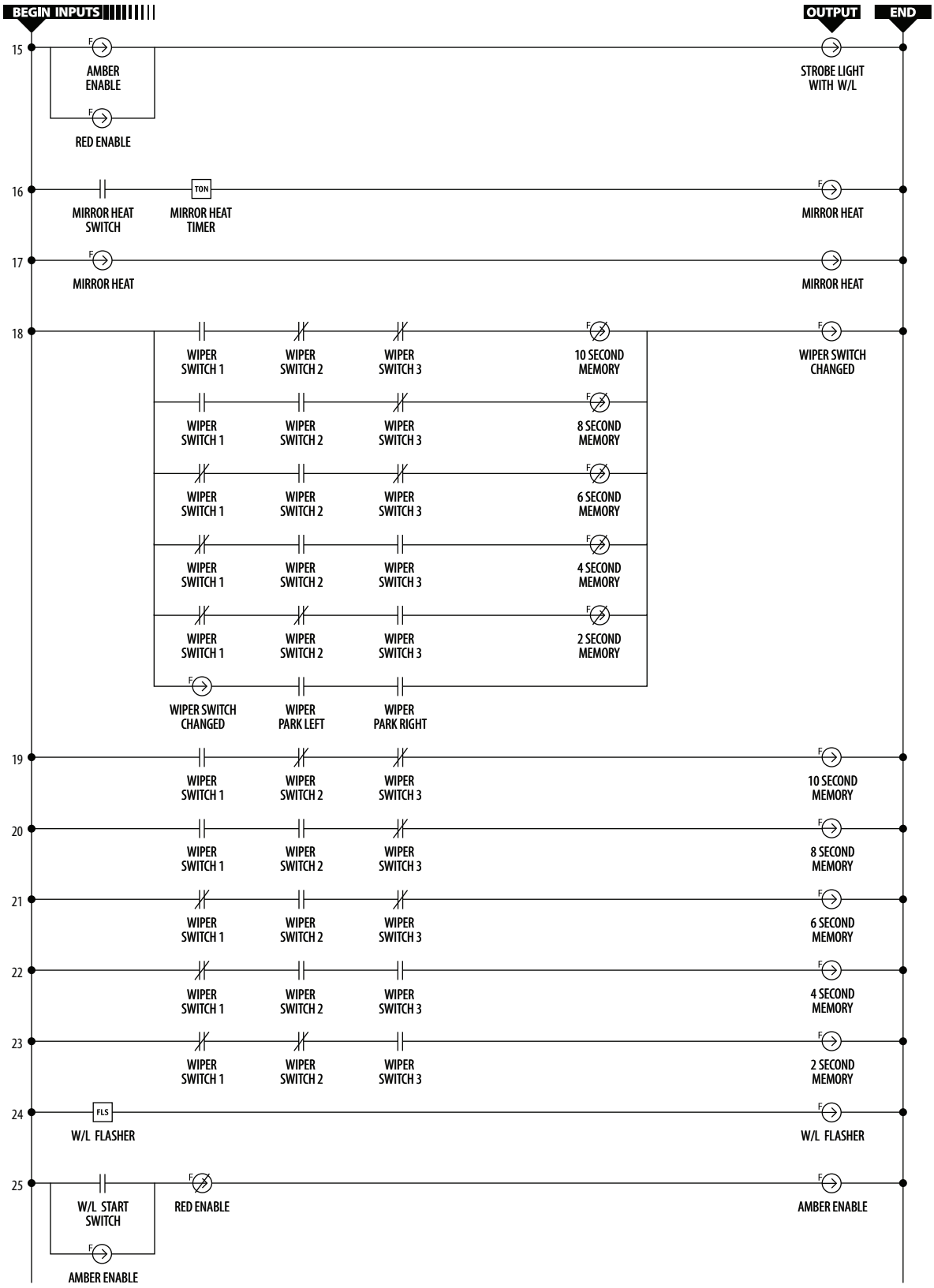
BCM Ladder Logic Diagrams

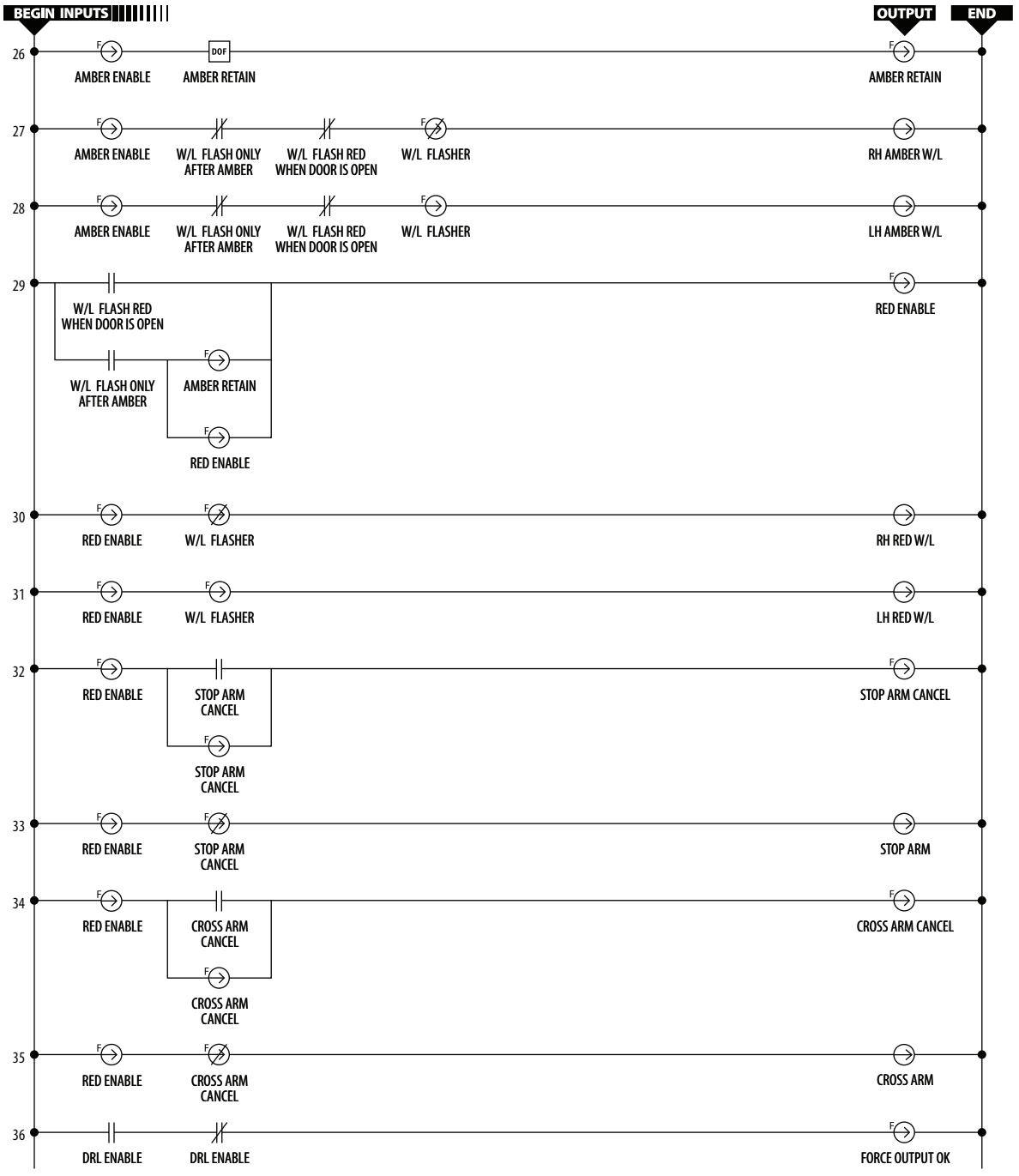
Logic Symbols Key

Active Input *Inactive Input* *Active Output* *Inactive Output* *Active Timer (Flasher Shown)* *Active Flag* *Inactive Flag*




BEGIN INPUTS
OUTPUT
END
10
WIPER PARK LEFT
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
WIPER PARK RIGHT
4 SECOND INT
4 SECOND
11
WIPER PARK LEFT
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
WIPER PARK RIGHT
2 SECOND INT
2 SECOND
12
10 SECOND
8 SECOND
6 SECOND
4 SECOND
2 SECOND
WIPER SWITCH CHANGED
INT FLAG
WIPER PARK LEFT
WIPER PARK RIGHT
INT FLAG
13
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
INT FLAG
4 SECOND DELAY OFF FLAG
LH WIPER LOW
14
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
INT FLAG
4 SECOND DELAY OFF FLAG
RH WIPER LOW


BEGIN INPUTS
OUTPUT
END
15
AMBER ENABLE
RED ENABLE
STROBE LIGHT WITH W/L
16
MIRROR HEAT SWITCH
TON
MIRROR HEAT TIMER
MIRROR HEAT
17
MIRROR HEAT
MIRROR HEAT
18
WIPER SWITCH 1
WIPER SWITCH 2
WIPER SWITCH 3
10 SECOND MEMORY
WIPER SWITCH CHANGED
8 SECOND MEMORY
6 SECOND MEMORY
4 SECOND MEMORY
2 SECOND MEMORY
WIPER PARK LEFT
WIPER PARK RIGHT
19
20
21
22
23
24
FLS
W/L FLASHER
25
W/L START SWITCH
AMBER ENABLE


BEGIN INPUTS
OUTPUT
END
26
AMBER ENABLE
DOF
AMBER RETAIN
AMBER RETAIN
27
AMBER ENABLE
W/L FLASH ONLY AFTER AMBER
W/L FLASH RED WHEN DOOR IS OPEN
W/L FLASHER
RH AMBER W/L
28
AMBER ENABLE
W/L FLASH ONLY AFTER AMBER
W/L FLASH RED WHEN DOOR IS OPEN
W/L FLASHER
LH AMBER W/L
29
W/L FLASH RED WHEN DOOR IS OPEN
W/L FLASH ONLY AFTER AMBER
AMBER RETAIN
RED ENABLE
RED ENABLE
30
RED ENABLE
W/L FLASHER
RH RED W/L
31
RED ENABLE
W/L FLASHER
LH RED W/L
32
RED ENABLE
STOP ARM CANCEL
STOP ARM CANCEL
STOP ARM CANCEL
33
RED ENABLE
STOP ARM CANCEL
STOP ARM
34
RED ENABLE
CROSS ARM CANCEL
CROSS ARM CANCEL
CROSS ARM CANCEL
35
RED ENABLE
CROSS ARM CANCEL
CROSS ARM
36
DRL ENABLE
DRL ENABLE
FORCE OUTPUT OK

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.)

Your bus may be equipped with optional LED tail lights. To monitor these lights a Doran UBM-00 monitor may have been installed. This monitor can be identified by a green power light on the face of the monitor. Complete instructions on set-up, operation and servicing can be found in the Tech Reference DVD.

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.

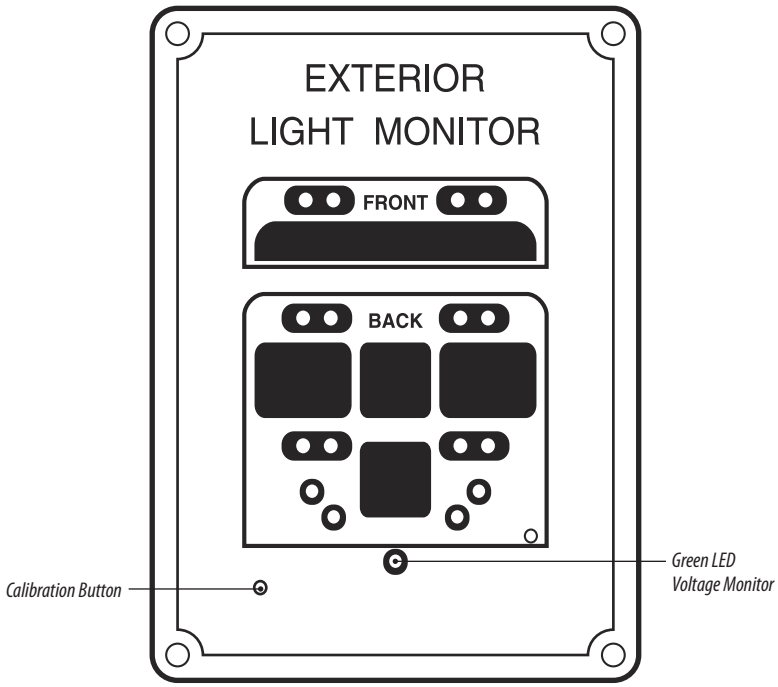
3. To enter the calibration mode, press and hold the calibrate button through the face plate hole for longer than two (2) seconds. This button/hole may be found located at the bottom left corner of the bus image on the monitor face plate. The first light to calibrate will begin flashing when the unit 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

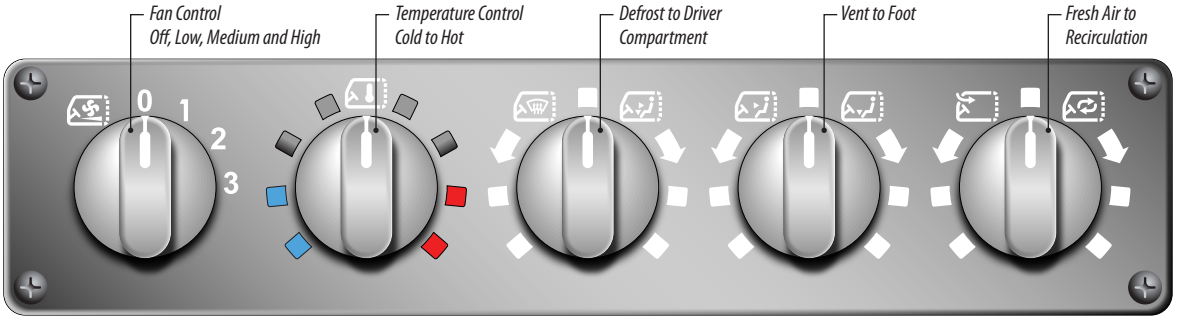
5. Calibrated lights are indicated by the corresponding LED staying illuminated on the monitor. The unit continues to loop through the sequence flashing the un-calibrated lights until all lights are calibrated.

6. When all LED's are illuminated, turn off ignition to complete the calibration.

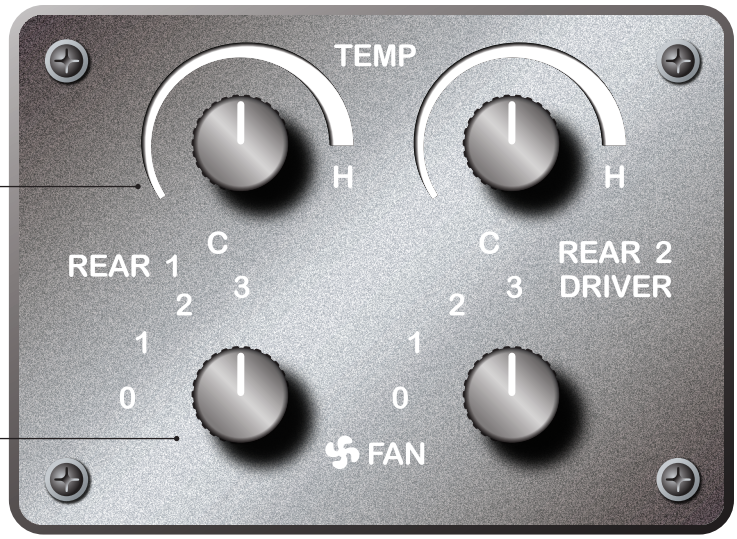


Heat and Air Control Panels

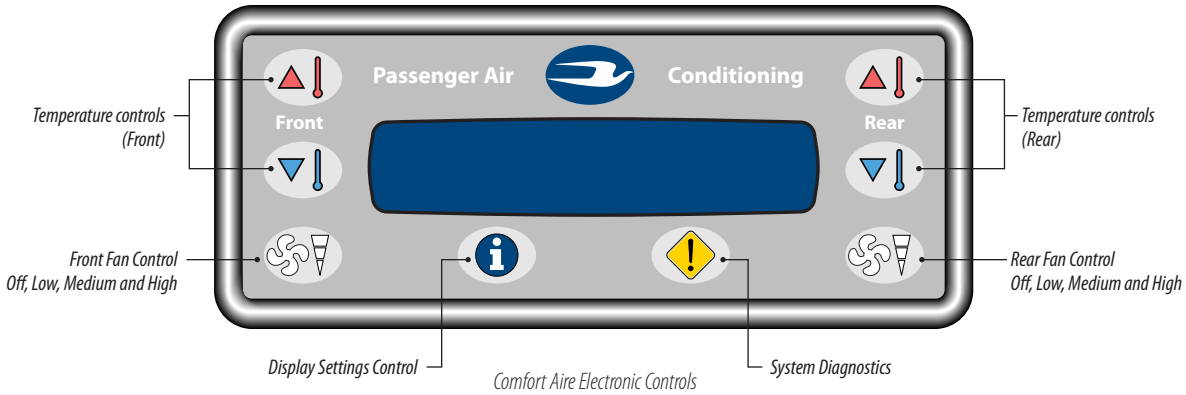
The heat and air control panels are defined below. For further explanation of heaters and heater controls, see Heaters, under Routine Operation found in the Drivers Handbook supplied with the bus. For additional information on optional air conditioning, see your Comfort Aire publication supplied with your air conditioned bus.



Blue Bird Heater Control Panel



Comfort Aire Manual Controls

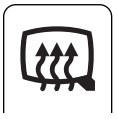


Comfort Aire Electronic Controls

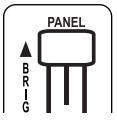
Left Switch Panel

The left switch panel located under the driver's side window and shown here consist of the exterior reaview mirror controls and switches for standard and optional equipment. The left switch 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 and their descriptive icons.

Right and left rearview mirror remote control.



Exterior rearview mirror defrost.



Interior panel dimmer.

Destination sign.

Brake interlock override. Momentary switch. Overrides brake interlock system.

Variable geometry turbo brake. Helps slow engine speed.

High idle. Engages high idle.

Tire chains.

Headlight and parking lights.

Park lights.

Left, center and right auxiliary fans. High, low, and off positions.

Open fuel door indicator light.

Noise suppression. Includes yellow bezel. Momentary or on/off. Turns off all heaters, fans and radio to allow the driver to hear sounds outside the bus; for instance, at a railroad crossing.

Driver's dome light.

Left side dome lights.

Right side dome lights.

REAR — Rear dome lghts.

LIFT — Lift. Provides power for lift operation.

LIFT DOOR — Lift door open indicator light.

EMER EXIT — Emergency door open indicator light.

Strobe light.

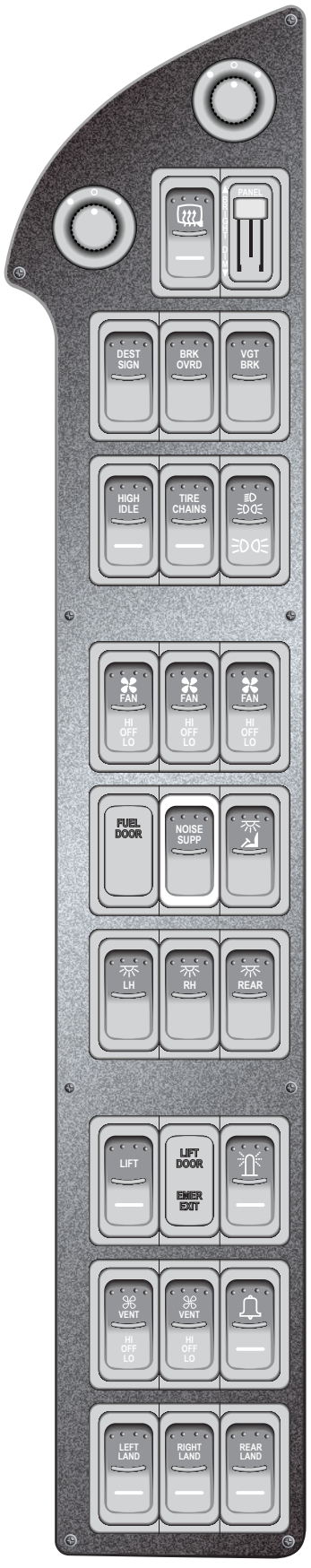
VENT — Roof vent fan. High, low, and off positions.

Chimes. Provides power for passenger compartment chime system.

LEFT LAND — Left side landing lights.

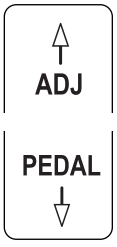
RIGHT LAND — Right side landing lights.

REAR LAND — Rear landing lights.

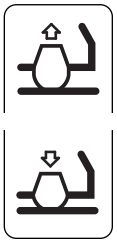


Right Switch Panel

The right switch panel as shown here consist of switches and controls for optional equipment installed on the bus. There are three banks of switches. The first bank of switches are for optional equipment that may be installed. The second bank of switches control heater options installed. Heater options are installed according to option priority, therefore, the switches in this bank may or may not appear in the positions shown. The third bank of switches control warning lights, these switches and indicators are also installed by option priority so, switch locations in this bank may vary also. If this unit is equipped with optional air conditioning the control panel will be located as shown on the upper right side of this panel. The following is a list of switches and indicators and their descriptive icons.



Pedal Adjustment. Allows forward and rearward movement of the accelerator and brake pedal. Provides a 3 inch range of movement.



Kneeling feature. Allows front of bus to be lowered and raised for passengers to embark or disembark more easily.

Kneel feature indicator light. Kneeling feature has been initiated.

Luggage door open indicator light

Driver's heater fan. High, off and low positions.

Heater pump. Provides supplemental heat to the passenger compartment.

Rear heater fans. High, off and low positions.

Front heater fans. High, off and low positions.

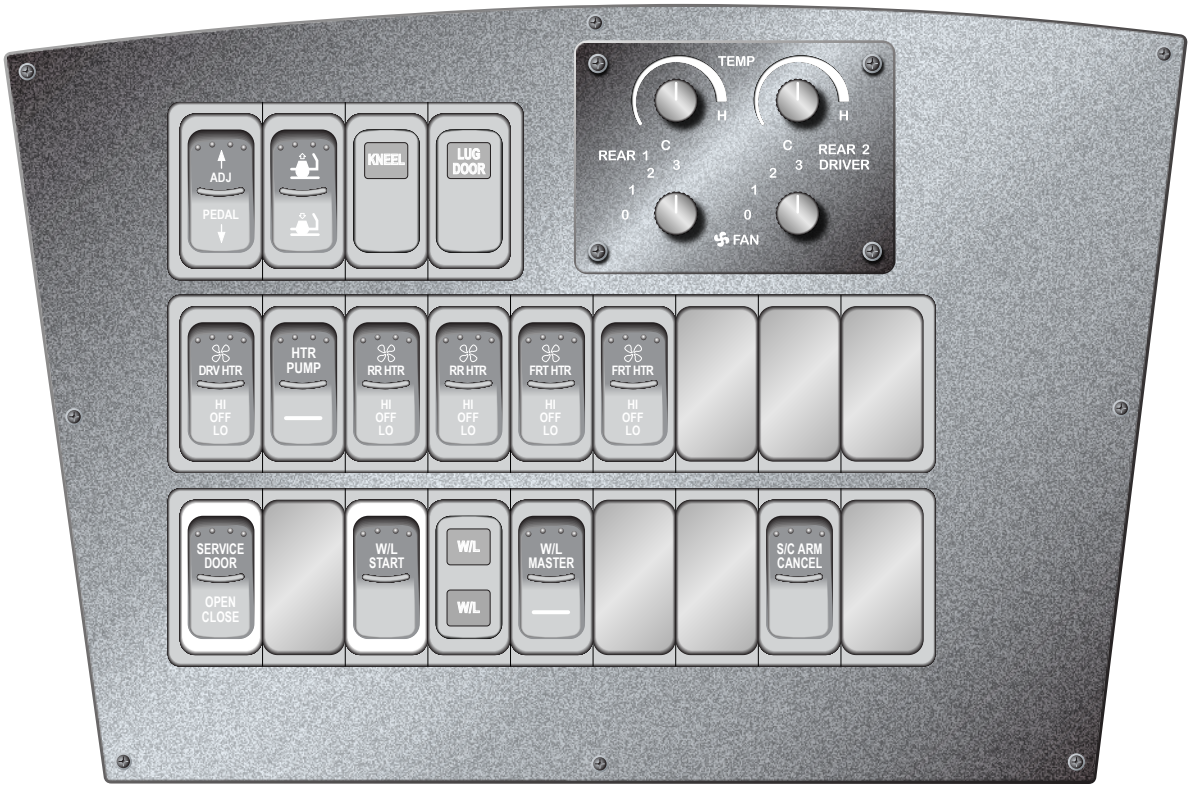
SERVICE DOOR Electctric entrance door switch with blue bezel.

W/L START Warning light start with orange bezel. Initiates warning light sequence

W/L MASTER Warning light master. Enables entire warning light system.

W/L Warning light indicators. Red and yellow.

S/C ARM CANCEL Stop arm and/or crossing arm cancel. Interupts stop arm and/or crossing arm sequesnce.



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 alternator on the Blue Bird All American 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 by providing clean "electronic power" for the electronic control systems; ECU, ECM, TCM, and gauges.

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 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 60 – 70 ft lb.

Blue Bird All American 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:

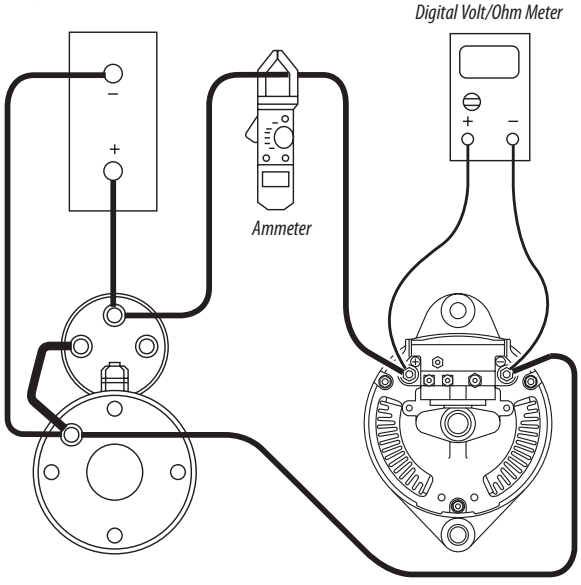
- Battery voltage
- Alternator output
- Starter current draw

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 13.8 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 amps, 75% of the rated capacity of the alternator. 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.

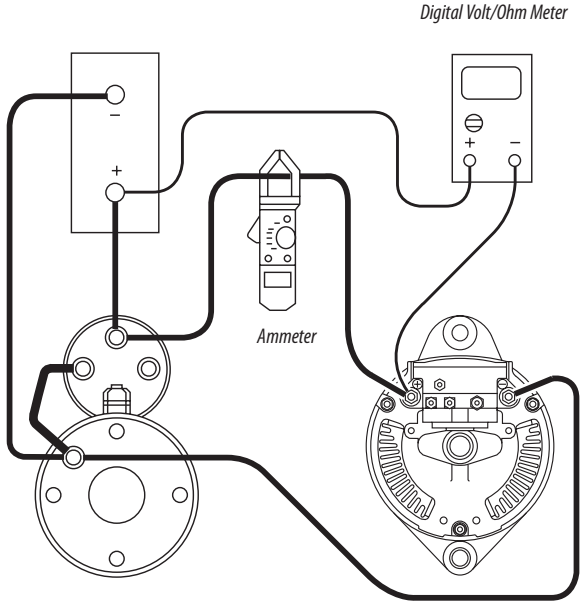
2. Connect the negative lead of the VOM to the positive post of the alternator.

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 amps, which is 75% of the rated alternator capacity, 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.

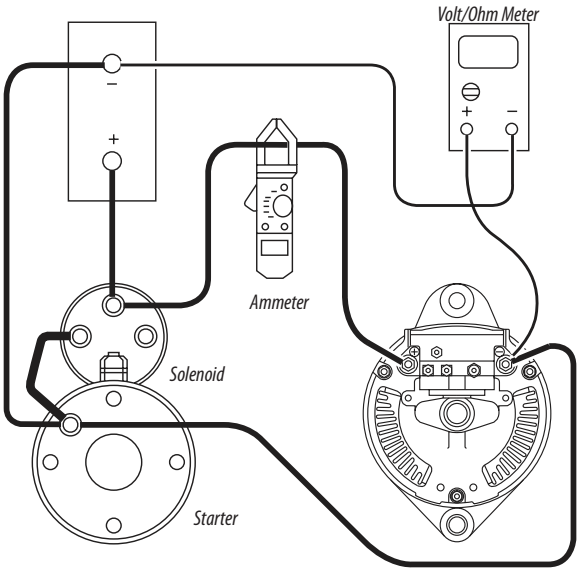
   • Re-test the circuit.

8. If the reading is less than -.25 volts, the cable and connections are good.

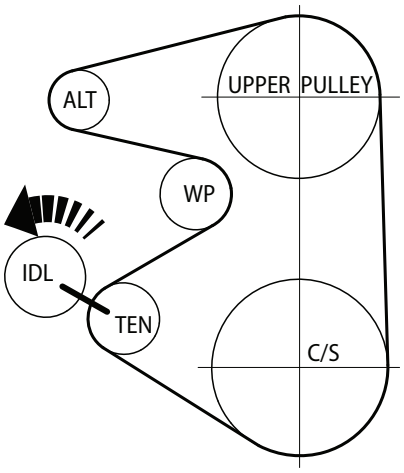
9. Connect the negative lead of the VOM to the negative terminal of the battery.

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.

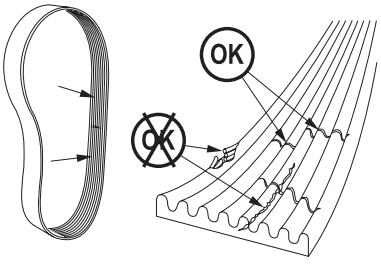


Alternator Removal



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. Using a square drive tool, position the automatic tensioner so that the drive belt can be removed.
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.

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. Support the alternator and remove the mounting bolts.
11. Remove the alternator.

Alternator Reinstallation

Installation of the alternator is accomplished in the reverse order of the removal instructions above.

1. Position the alternator to the saddle.
2. Install the alternator mounting bolts.
3. Torque bolts to 70 - 80 ft. lbs. for Leece Neville and 55 - 59 ft. lbs. for Bosch alternators.
4. Install the positive cable on the B+ post. Carefully tighten to avoid breaking or stripping the stud.
5. Install the negative cable on the B- post. Carefully tighten to avoid breaking or stripping the stud.
6. Before installing the drive belt, inspect it closely. Replace the belt if any signs of wear are present.
7. Using a square drive tool, position the automatic tensioner so that the drive belt can be installed. Install the belt and ensure that the grooves in the belt fit properly on all the pulleys.

Automatic Belt Tensioner

The automatic tensioner is spring loaded to provide the proper tension for the drive belt.

The automatic tensioner should travel freely within its full range of travel. Inspect the belt tensioner for any unusual noise, excessive loosenenss and shaking at the bearings.

Automatic Tensioner Removal

1. Remove the drive belt in accordance with the instructions above.
2. Remove the bolt from the automatic tensioner.

To install a new automatic tensioner, reverse the removal instructions.

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 lever. The lever is connected to the starter drive pinion of the starter motor. The plunger also connects the electrical power from the batteries to the starter motor as the drive pinion 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 drive pinion from the flywheel and removing electrical current from the starter motor.

The Blue Bird All American has a 12-volt electrical system.

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 12.5 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.

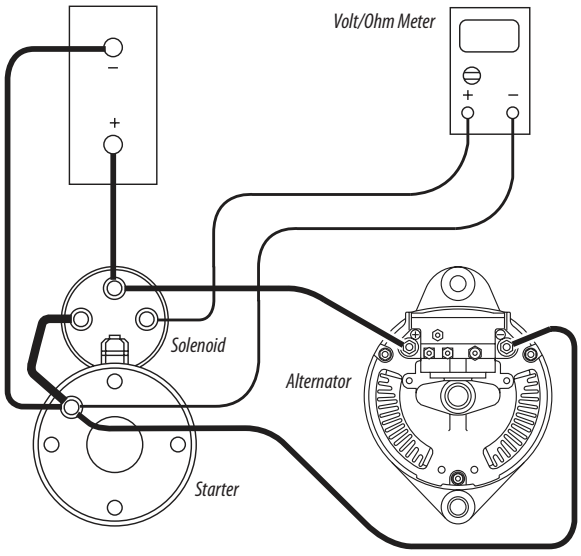
4. A loose starter motor will allow vibration that can damage the motor. In addition, the ring gear could be damaged.

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 drive pinion of the starter motor. A failed pull-in 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.

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.

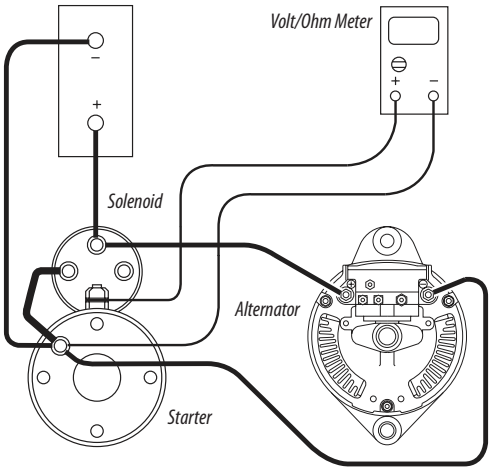
6. Attempt to crank the engine with the remote switch. Record the voltage displayed on the VOM. If there is less than 1 volt difference from the previous reading, the ignition switch is okay. If there is more than 1 volt difference, the switch is defective.

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.

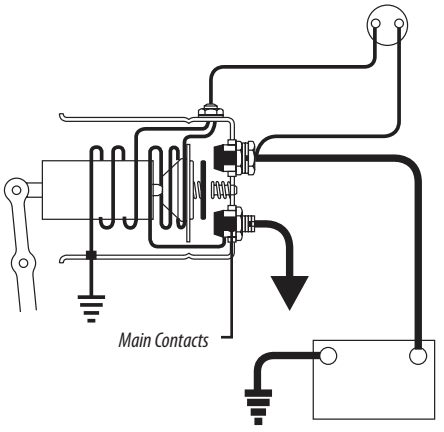


1. Connect the positive lead of the VOM to the starter motor terminal of the solenoid.

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.

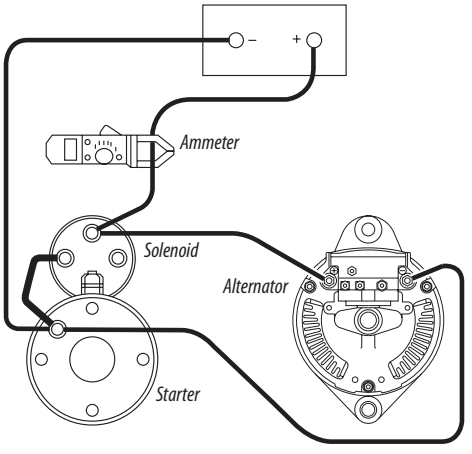
4. If there is voltage present at the solenoid terminal during Step 3, the problem is in the starter motor or its cabling.



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.

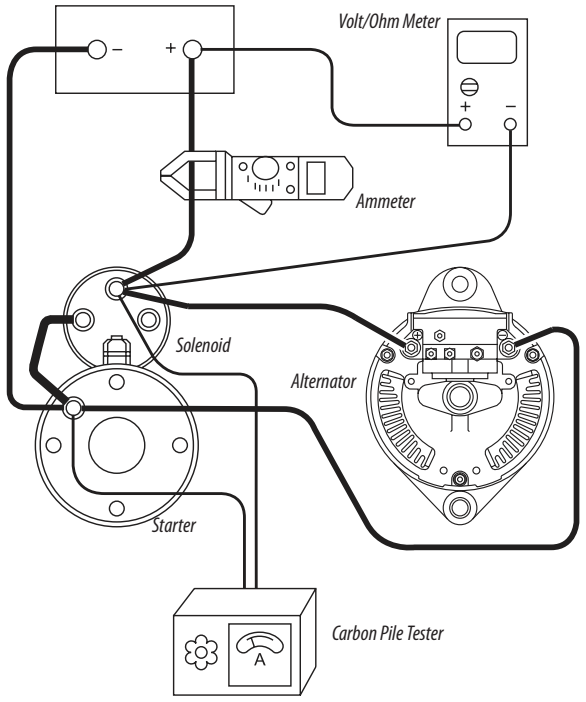
6. If the drive pinion jumps out of mesh with the flywheel ring gear, check for a broken or loose ground wire at the solenoid.

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 0.5-volts from the unloaded reading.
15. Turn the carbon pile tester to the OFF position.

16. If the voltage drop was more than 0.5-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.

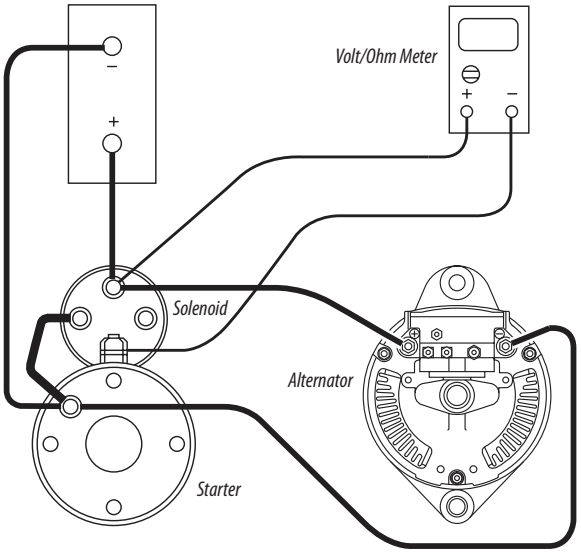
3. Remove the ammeter.

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.

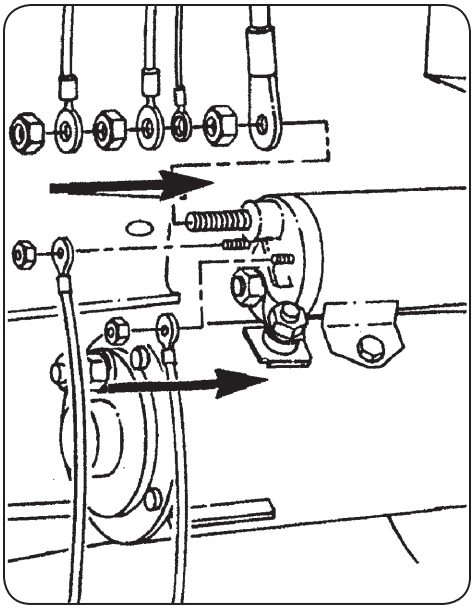
6. Connect the negative VOM lead to the starter motor terminal of the solenoid.

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.

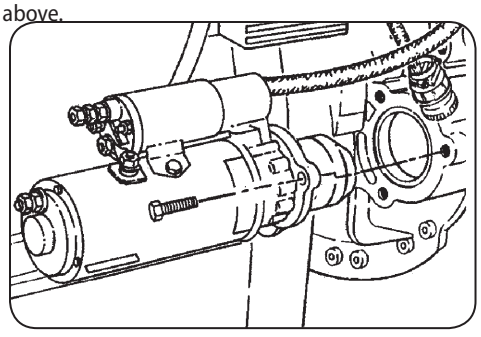
Starter Motor Removal



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.

J-1939 Harness Diagnostics

1. Disconnect battery or J-1939 connector from the engine, ABS, transmission and instrument panel.

2. Measure resistance between pin A and pin B. Reading should be 60 ohms +/-1% (0.6 ohms).

3. Meassure continuity between shield (pin C) and ground. Reading should be minimal resistance.

4. Meassure resistance between pin A and ground. Reading should be infinity (maximum resistance).

5. Meassure resistance between pin B and ground. Reading should be infinity.

6. If all readings are correct, and problem appears to be intermittent:

   6.1 Inspect each connector for positive lock connection.

   6.2 Inspect for corrosion.

   6.3 Inspect for damage to connectors.

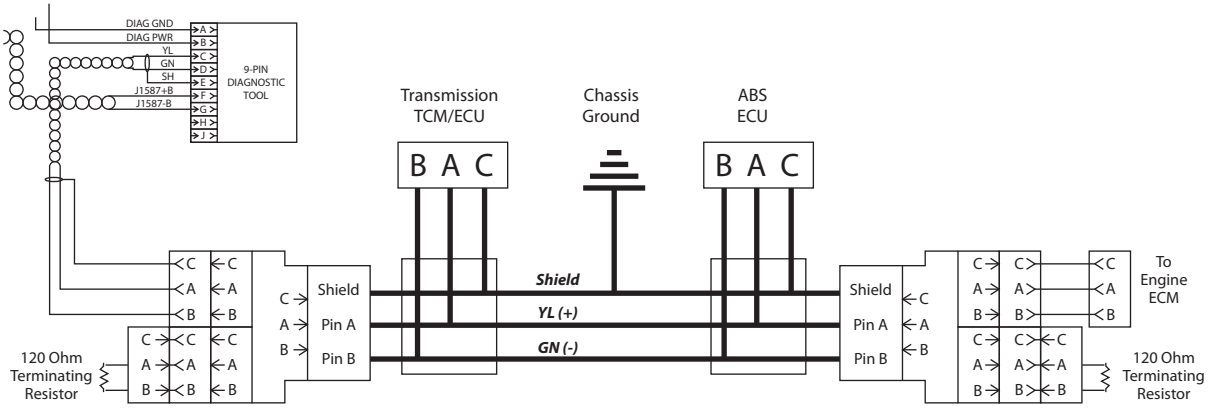
7. If resistance between pins A and B is 120 ohms, one of the terminating resistorsis missing or bad.

8. If reading between pins A and B is infinity:

   8.1 One of the connectors is unplugged.

   8.2 Both resistors are bad or missing.

   8.3 A connector is damaged



Chassis Wiring Schematics

The D3 All American electrical diagrams are formatted by electrical system, electrical circuit, or by options/features. They are also divided into two basic groups, body and chassis electrical systems. There are some over lapping circuits resulting in some body circuits existing on chassis diagrams and some chassis circuits existing on body diagrams.

Each circuit is represented on the diagram with its own line running from one connector to another connector or from a connector to an electrical source or electrical load. When a dot is encountered on a circuit line it indicates a soldered splice with all the circuits that intersect that point. Each circuit will be identified by a number or the description of the circuit, the color of the circuit and the gauge of the wire used in the circuit is also indicated on the diagram. In some cases the circuit will be identifed as positive (+) or negative (-). Most of the circuits interface the electrical system through electrical connectors. Each half of the connector will be identified with the letter "P" or "J" and a number. The two halves of the connector may or may not have the same number code but each half will be clearly marked on the print. Each pin in the connector will be indentified with a letter or number, the male and female side of the connector will be indicated and each circuit flowing through a connector will have a description. Information concerning the continuation of a circuit that exists on more than one diagram will also be provided, (example; See Diagram WRG: Power and Ground).

Some of the diagrams are subdivided by dotted lines that usually run through the center of a connector. The subdivisions represent the different electrical harnesses making up the circuits on a specific diagram. This provides the interaction between electrical circuits or harnesses and serves as a general locator for the electrical connectors.

The following subdivisions are identified on the drawings:

ELEC PANEL – Side (Body) Electrical Panel, located in the access panel below the driver's side window. It serves as the main power distribution point for the body electrical system. The Body Control Module (BCM) is also located in the side body electrical panel.

PDU – Power Distribution Unit, located in the lower skirt panel behind the rear axle on the entrance door side of the bus. It serves as the main power distribution point for the chassis electrical system. Power from the battery is routed through the PDU before being distributed to the upper electrical panel and throughout the bus.

DCM – Driver Control Module, represents the structural support for the dash, the steering column, left side of the fire wall, and the structure the driver seat is fastened to. With respect to electrical diagrams, this subdivision could represent any electrical circuit or device in and around the drivers area, including circuits routed to the steering column, heaters and etc. These circuits will interface with the PDU, the body electrical panel, the engine harness and the transmission harness.

ENGINE – This subdivision involves all electrical circuit interfaces between Blue Bird systems and the engine electrical system, mainly the engine ECU. This does not include the engine wiring harness supplied with the engine.

TRANSMISSION – This subdivision involves all electrical circuit interfaces between Blue Bird systems and the transmission electrical system.
IP – Instrument Panel, involves all electrical interfaces between the instrument panel and Blue Bird's electrical system.
FRAME – This subdivision involves the electrical circuits located on the frame and circuits not covered by other subdivisions.
BODY - This subdivision involves the electrical circuits located on the body and circuits not covered by other subdivisions.

For example, on diagram D0001451 - AIR ABS SYSTEM, even though the ABS system is for the most part a self contain electrical system the circuits between the ABS ECU/ Modulator and the other ABS components are routed through six separate electrical subdivisions indicated on the drawing. Starting at the top right corner and working around the print clockwise the PDU provides power to the ABS system. From the lower right corner across the bottom and up through the center of the diagram the diagram provides most of the electrical interface between the ABS components and the rest of the electrical system. Other electrical interfaces on the diagram include the Transmission, the DCM, Instrument Panel, and Electrical Panel along the left side of the diagram.

The following pages contain the main wiring schematics applicable to most All American chassis. These are provided for your convenience when you are limited to use of the print manual.

The drawings on the DVD are in resolution-independent vector format. This allows you to zoom them at will, without the images becomming jagged as occurs with bitmap 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

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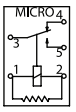
Wire Colors

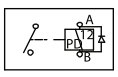
BL	BLUE
BK	BLACK
BN	BROWN
TN	TAN
WH	WHITE
YL	YELLOW
PK	PINK
OR	ORANGE
RD	RED
GN	GREEN
PU	PURPLE
GY	GRAY

Schematic Legend

PD	Power Distribution Unit (PANEL)
AC	AIR CLEANER BRACKET
IP	INSTRUMENT PANEL
FW	FIREWALL
SP	SHIFTER PANEL
DC	Driver Control Module (DCM)



Micro Relay

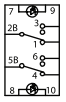


Heavy Duty Relay

Fuse

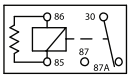
Circuit Breaker

Voltage Stud



Switch Ngr Rocker (Non-typical)

Twisted Wires



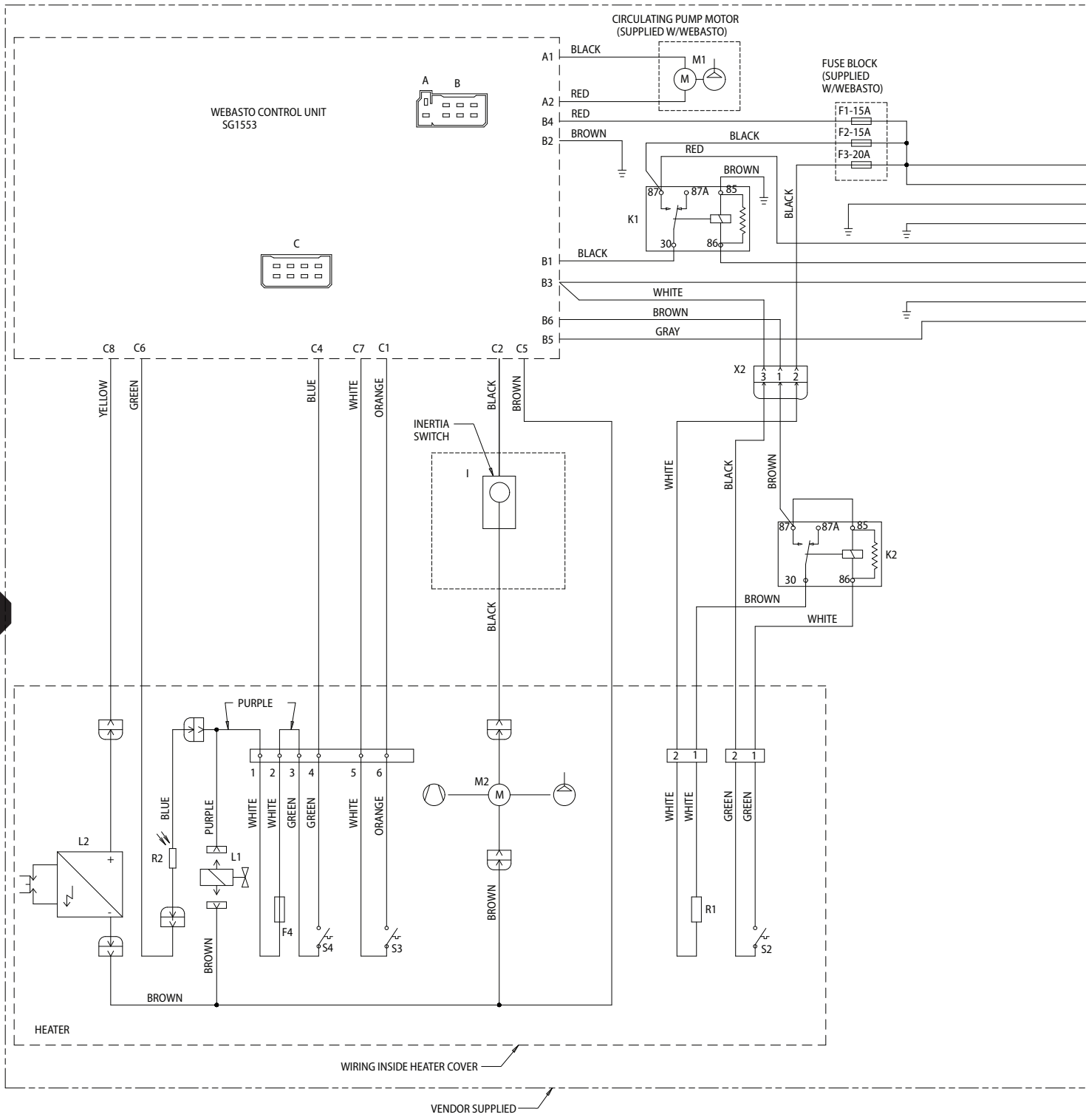
Mini Relay

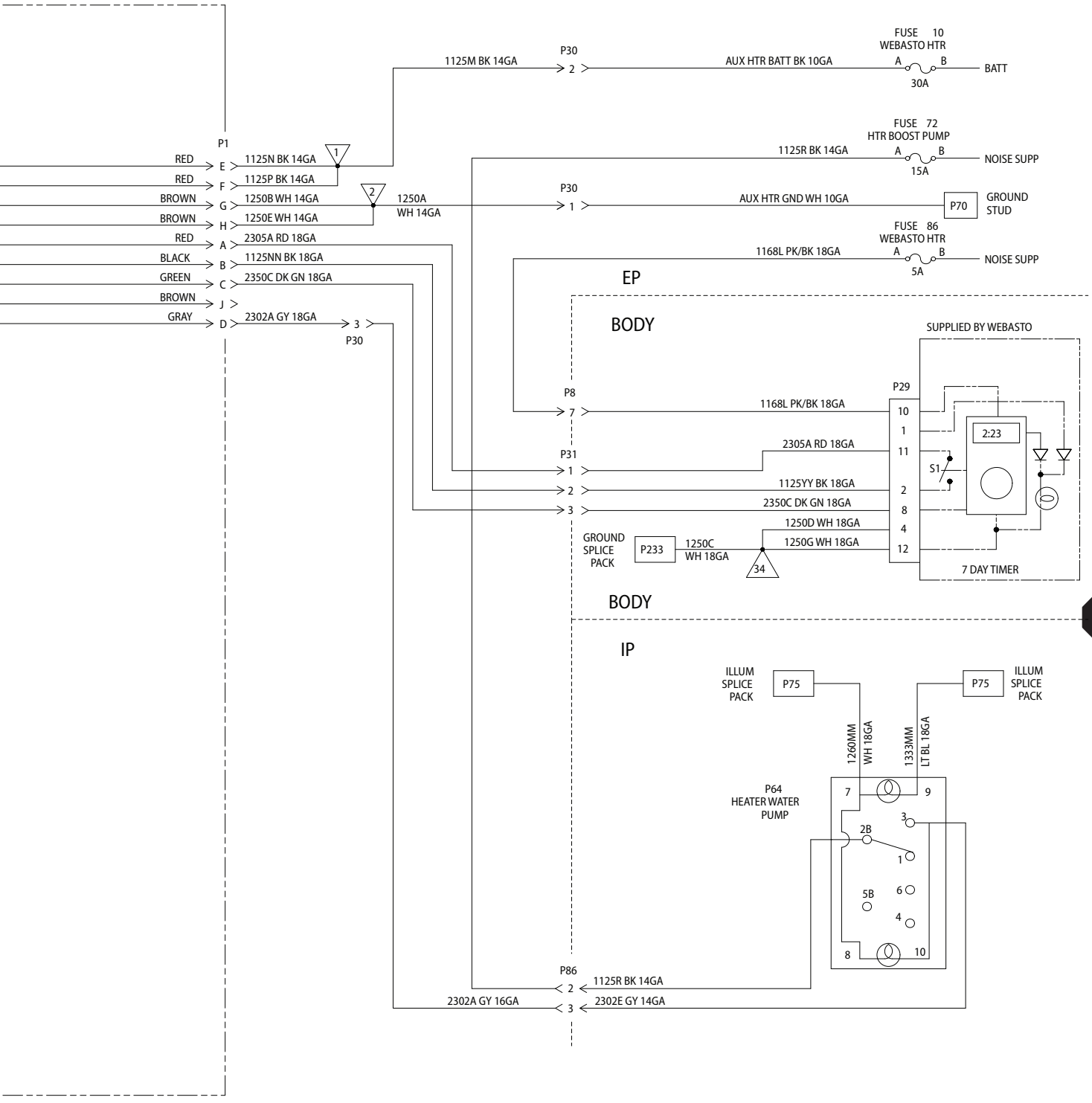
Horn

Speaker

Light

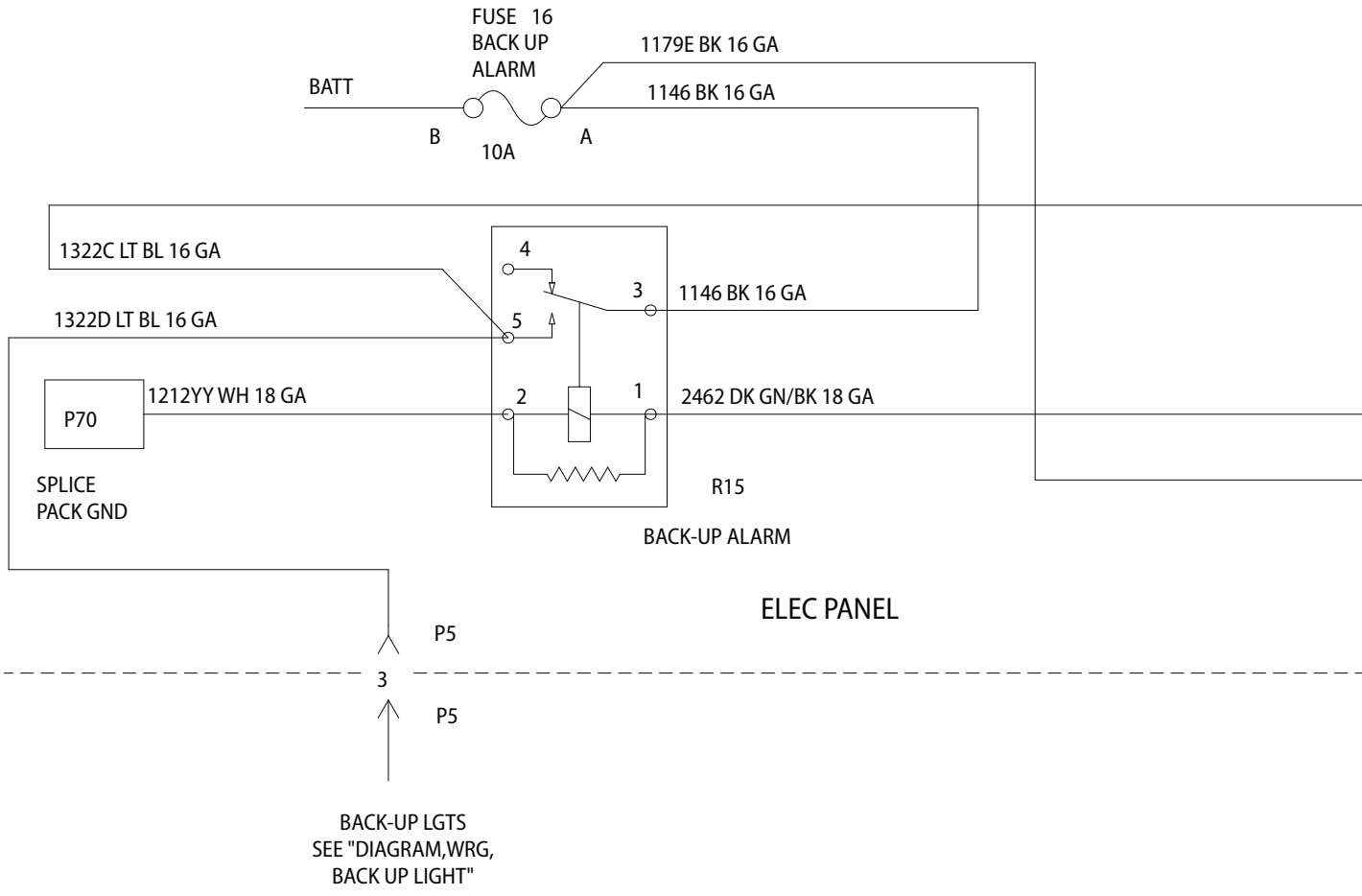
Shunt

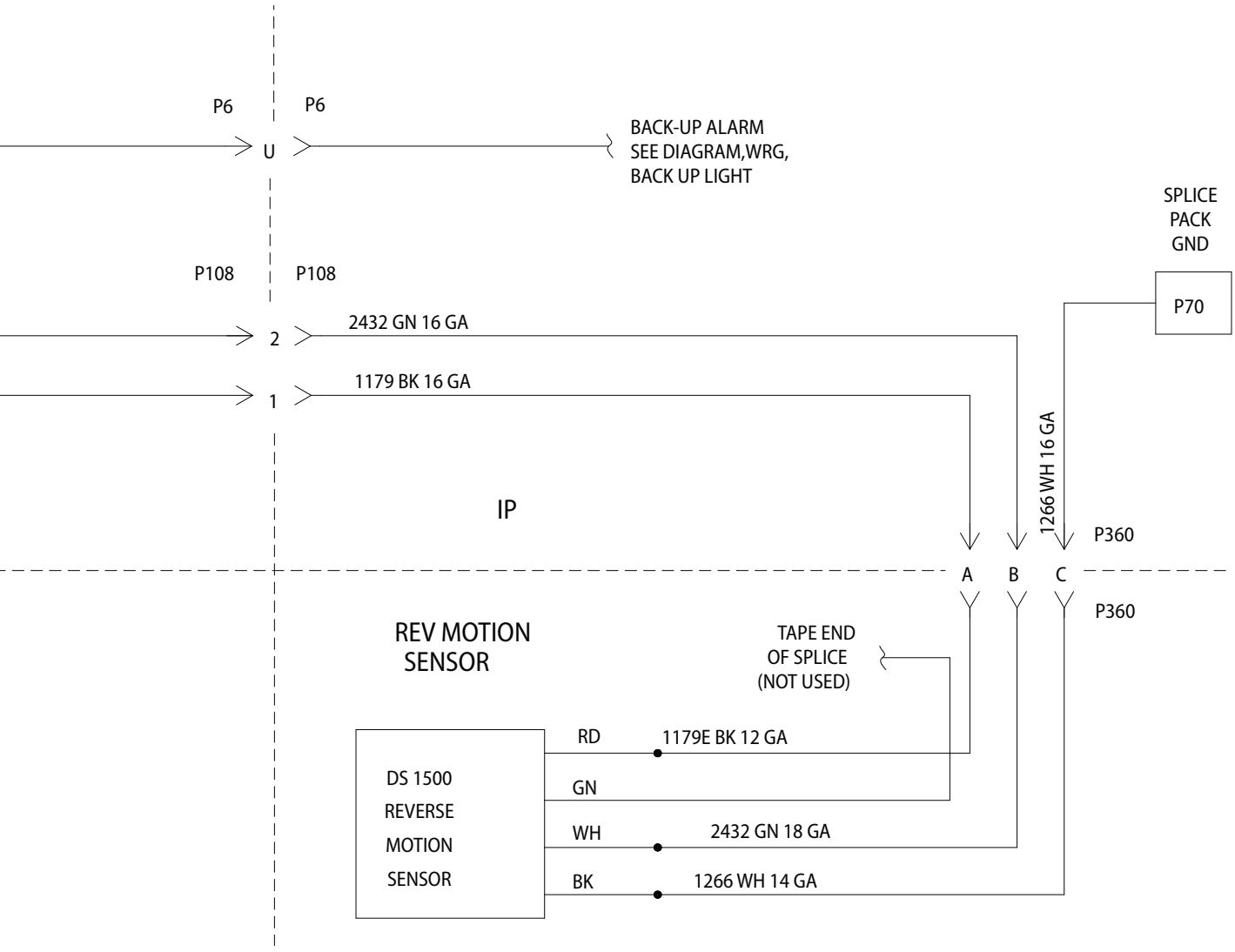

CIRCULATING PUMP MOTOR
(SUPPLIED W/WEBASTO)
FUSE BLOCK
(SUPPLIED
W/WEBASTO)
WEBASTO CONTROL UNIT
SG1553
A1 BLACK
A2 RED
B4 RED
B2 BROWN
B1 BLACK
B3 WHITE
B6 BROWN
B5 GRAY
M1
F1-15A
F2-15A
F3-20A
K1
K2
X2
C8 C6 C4 C7 C1 C2 C5
YELLOW
GREEN
BLUE
WHITE
ORANGE
BLACK
BROWN
INERTIA
SWITCH
PURPLE
M2
L1
L2
R1
R2
F4
S2
S3
S4
HEATER
WIRING INSIDE HEATER COVER
VENDOR SUPPLIED



Webasto Aux. Heater

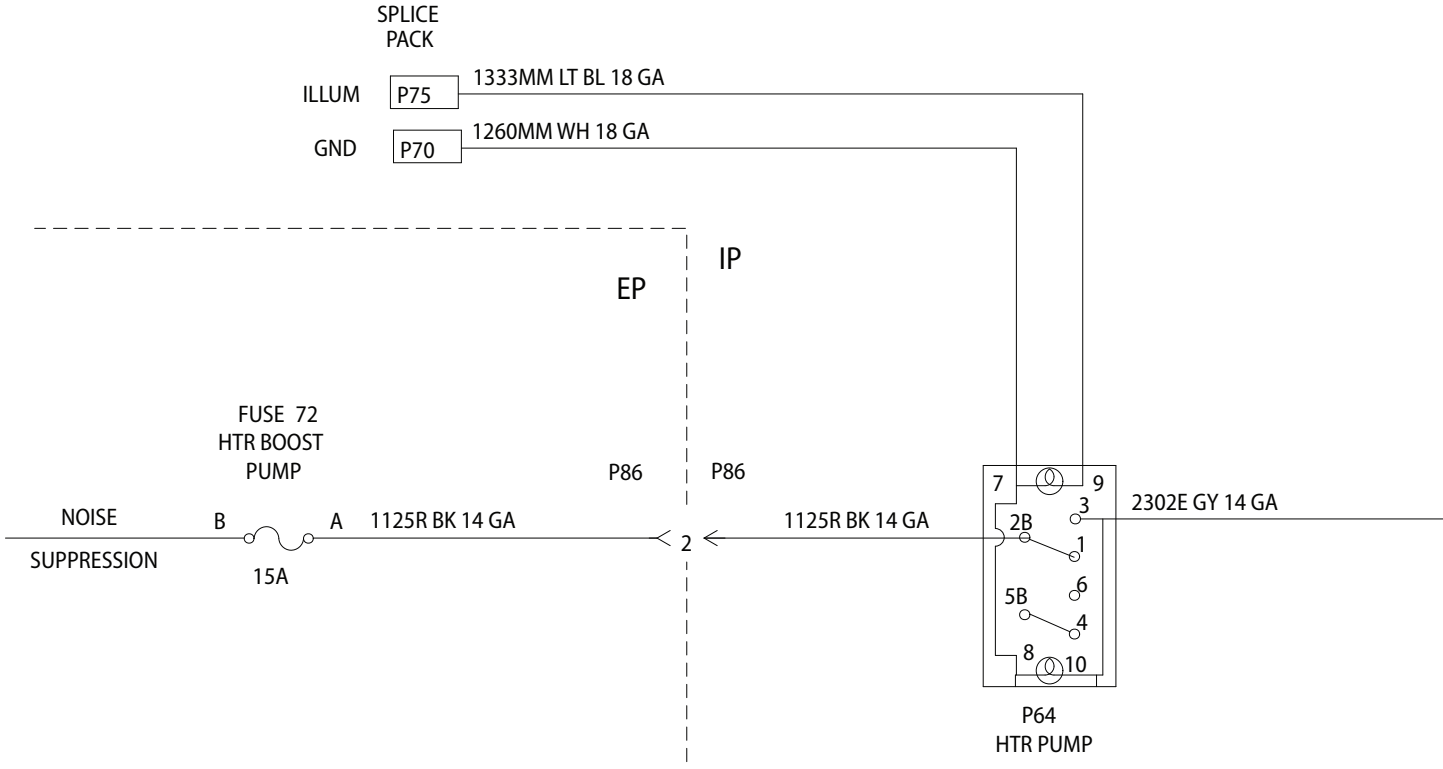
D0000809C

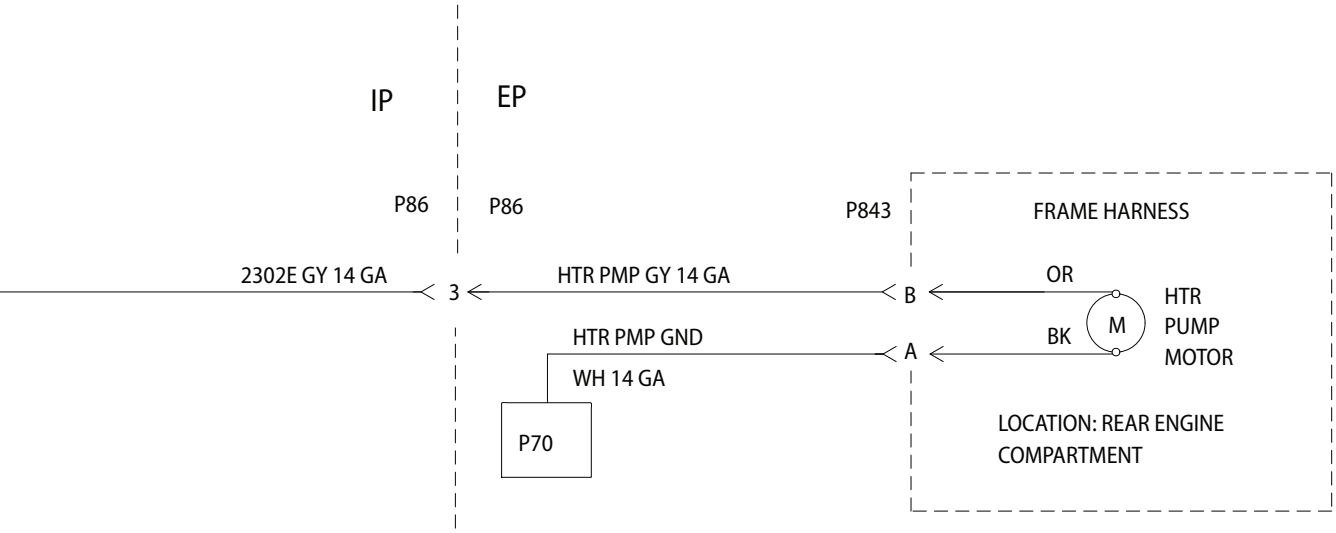

FUSE 16
BACK UP
ALARM
BATT
B
10A
A
1179E BK 16 GA
1146 BK 16 GA
1322C LT BL 16 GA
1322D LT BL 16 GA
4
3
5
1146 BK 16 GA
P70
1212YY WH 18 GA
2
1
2462 DK GN/BK 18 GA
SPLICE
PACK GND
R15
BACK-UP ALARM
ELEC PANEL
P5
3
P5
BACK-UP LGTS
SEE "DIAGRAM,WRG,
BACK UP LIGHT"



Louisiana Back-Up Alarm

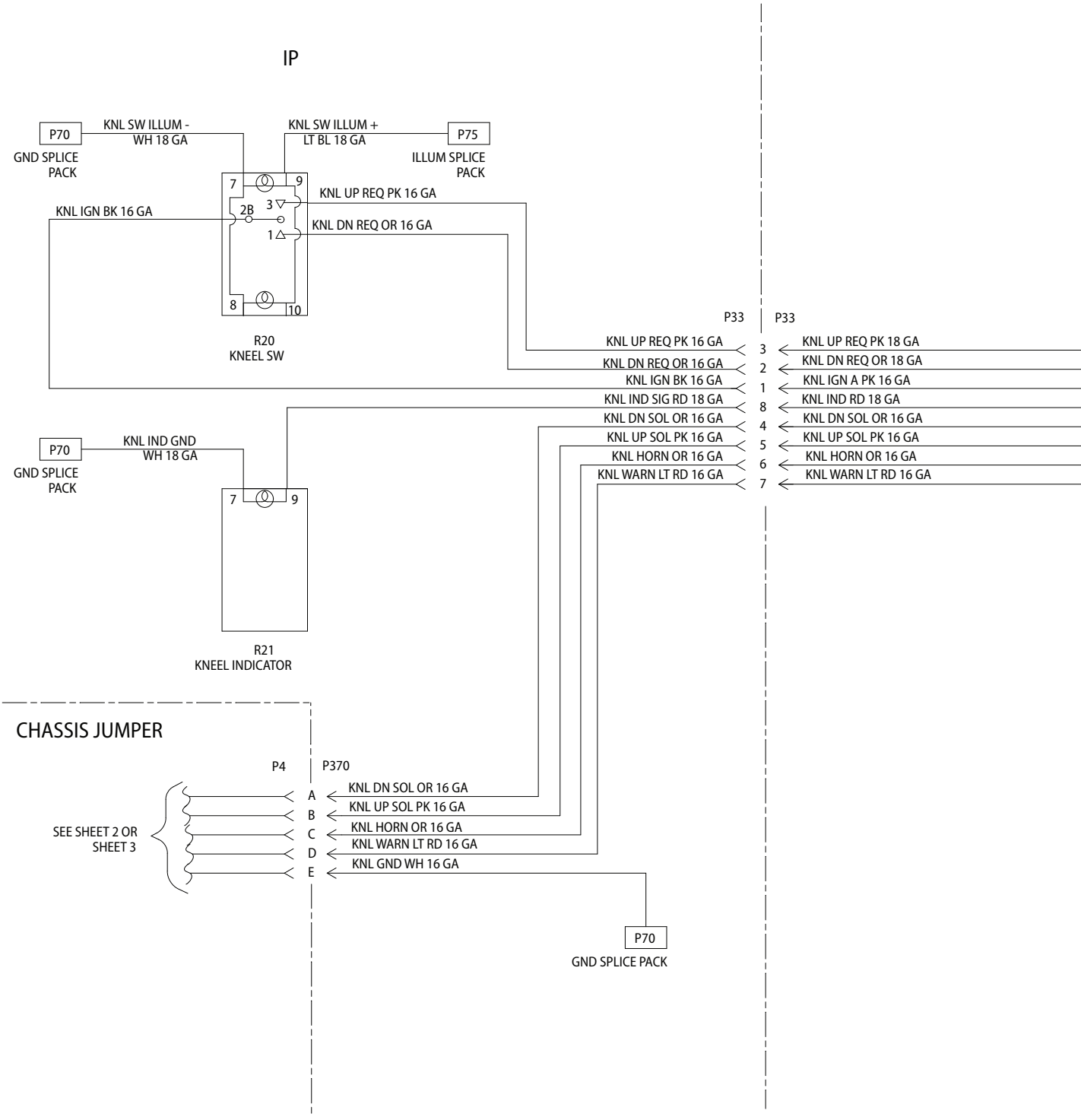
D0000811C


SPLICE
PACK
ILLUM
P75
1333MM LT BL 18 GA
GND
P70
1260MM WH 18 GA
IP
EP
FUSE 72
HTR BOOST
PUMP
P86
P86
NOISE
SUPPRESSION
B
A
1125R BK 14 GA
15A
2
1125R BK 14 GA
7
9
3
2302E GY 14 GA
2B
1
6
5B
4
8
10
P64
HTR PUMP

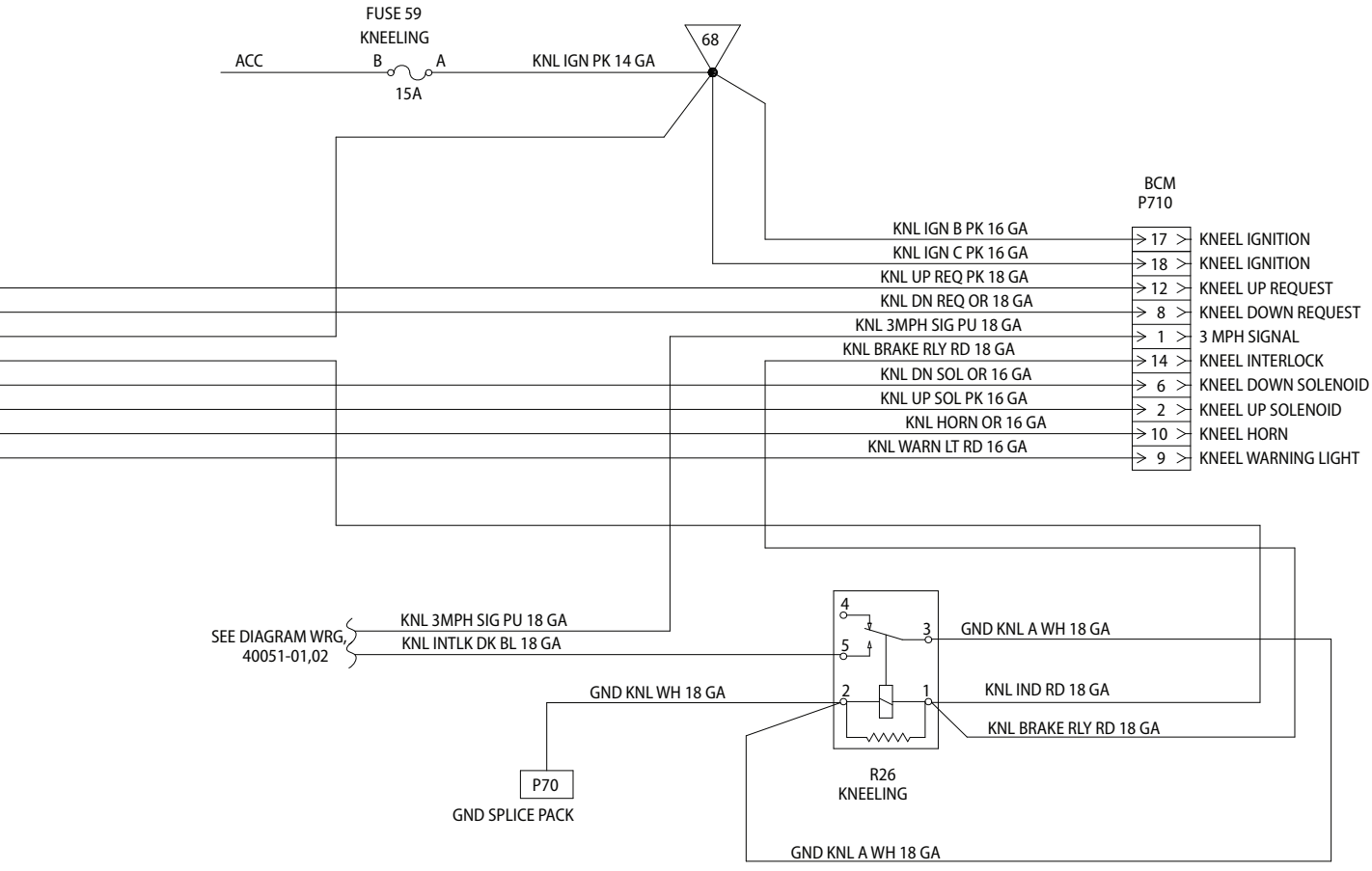


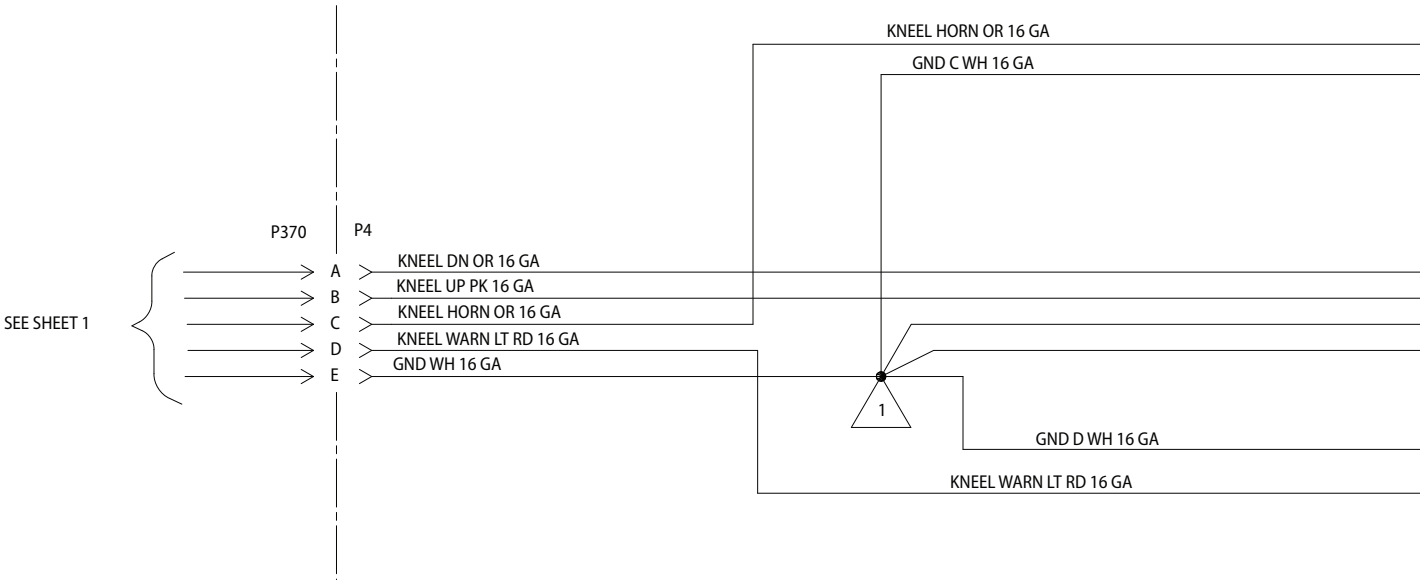
Heater Boost Pump

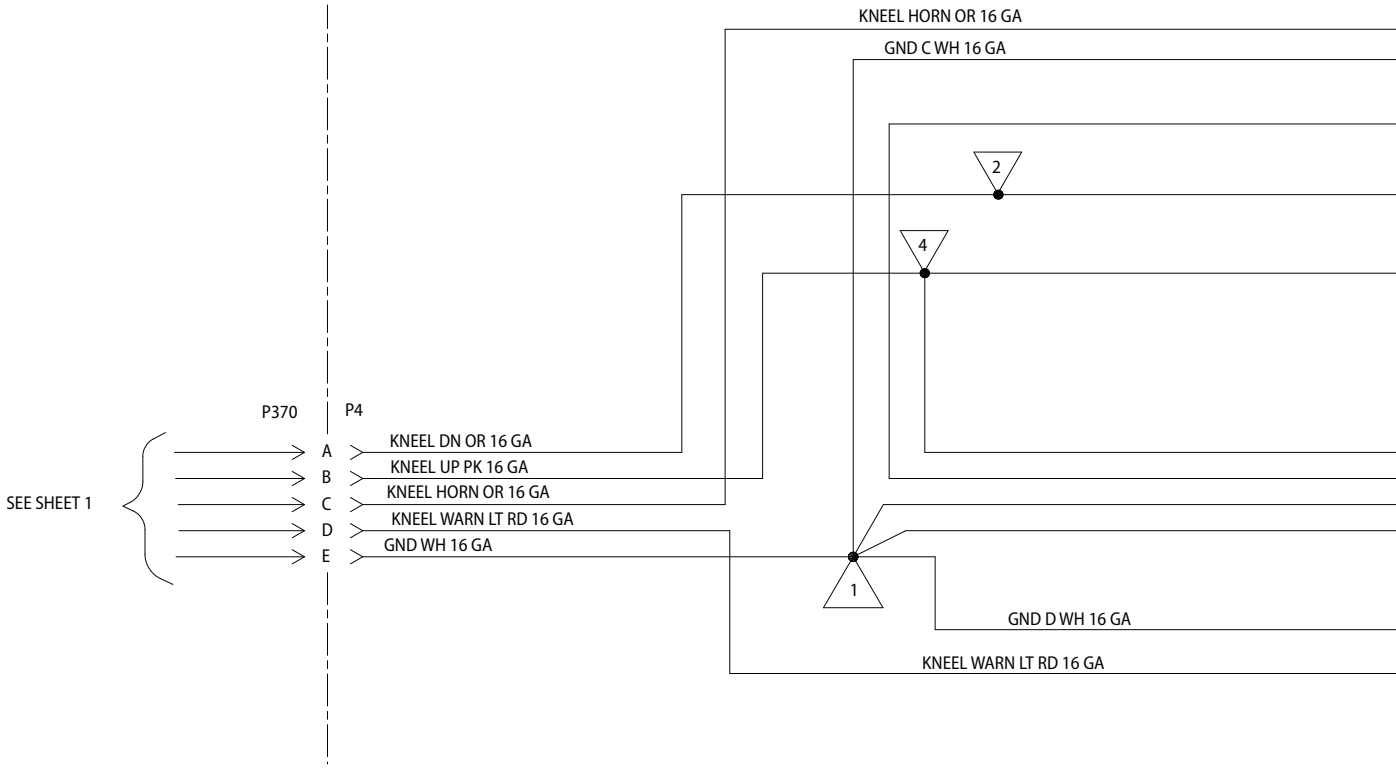
D0000826B

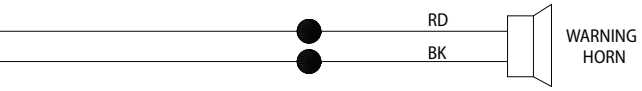

IP
P70
GND SPLICE PACK
KNL SW ILLUM - WH 18 GA
KNL SW ILLUM + LT BL 18 GA
P75
ILLUM SPLICE PACK
7
9
2B
3
1
8
10
KNL UP REQ PK 16 GA
KNL IGN BK 16 GA
KNL DN REQ OR 16 GA
R20
KNEEL SW
P33
P33
KNL UP REQ PK 16 GA
3
KNL UP REQ PK 18 GA
KNL DN REQ OR 16 GA
2
KNL DN REQ OR 18 GA
KNL IGN BK 16 GA
1
KNL IGN A PK 16 GA
KNL IND SIG RD 18 GA
8
KNL IND RD 18 GA
KNL DN SOL OR 16 GA
4
KNL DN SOL OR 16 GA
KNL UP SOL PK 16 GA
5
KNL UP SOL PK 16 GA
KNL HORN OR 16 GA
6
KNL HORN OR 16 GA
KNL WARN LT RD 16 GA
7
KNL WARN LT RD 16 GA
P70
GND SPLICE PACK
KNL IND GND WH 18 GA
7
9
R21
KNEEL INDICATOR
CHASSIS JUMPER
P4
P370
SEE SHEET 2 OR SHEET 3
A
KNL DN SOL OR 16 GA
B
KNL UP SOL PK 16 GA
C
KNL HORN OR 16 GA
D
KNL WARN LT RD 16 GA
E
KNL GND WH 16 GA
P70
GND SPLICE PACK

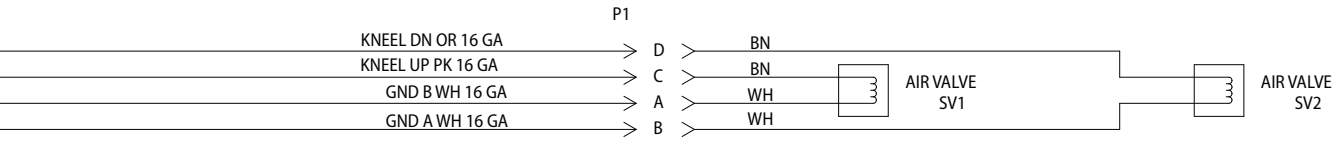
ELEC PANEL

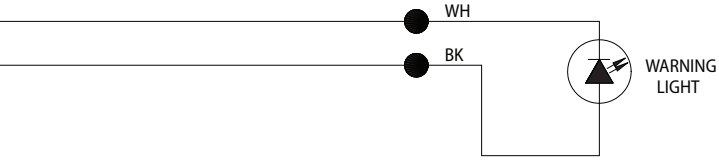

FUSE 59
KNEELING
ACC
B
A
15A
KNL IGN PK 14 GA
68
BCM
P710
KNL IGN B PK 16 GA
17
KNEEL IGNITION
KNL IGN C PK 16 GA
18
KNEEL IGNITION
KNL UP REQ PK 18 GA
12
KNEEL UP REQUEST
KNL DN REQ OR 18 GA
8
KNEEL DOWN REQUEST
KNL 3MPH SIG PU 18 GA
1
3 MPH SIGNAL
KNL BRAKE RLY RD 18 GA
14
KNEEL INTERLOCK
KNL DN SOL OR 16 GA
6
KNEEL DOWN SOLENOID
KNL UP SOL PK 16 GA
2
KNEEL UP SOLENOID
KNL HORN OR 16 GA
10
KNEEL HORN
KNL WARN LT RD 16 GA
9
KNEEL WARNING LIGHT
SEE DIAGRAM WRG,
40051-01,02
KNL 3MPH SIG PU 18 GA
KNL INTLK DK BL 18 GA
4
5
3
2
1
GND KNL A WH 18 GA
GND KNL WH 18 GA
KNL IND RD 18 GA
KNL BRAKE RLY RD 18 GA
P70
GND SPLICE PACK
R26
KNEELING
GND KNL A WH 18 GA


KNEEL HORN OR 16 GA
GND C WH 16 GA
P370
P4
SEE SHEET 1
A
B
C
D
E
KNEEL DN OR 16 GA
KNEEL UP PK 16 GA
KNEEL HORN OR 16 GA
KNEEL WARN LT RD 16 GA
GND WH 16 GA
1
GND D WH 16 GA
KNEEL WARN LT RD 16 GA


KNEEL HORN OR 16 GA
GND C WH 16 GA
2
4
P370
P4
SEE SHEET 1
A
B
C
D
E
KNEEL DN OR 16 GA
KNEEL UP PK 16 GA
KNEEL HORN OR 16 GA
KNEEL WARN LT RD 16 GA
GND WH 16 GA
1
GND D WH 16 GA
KNEEL WARN LT RD 16 GA



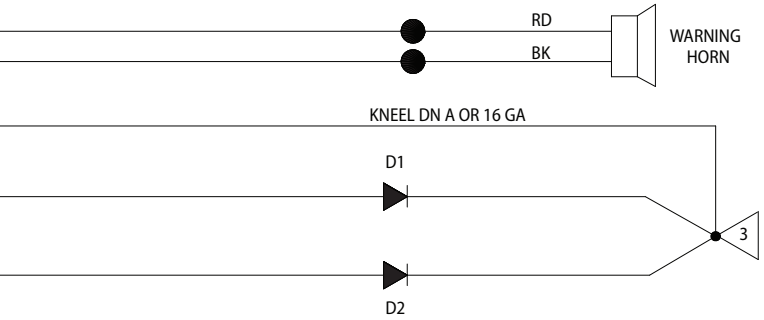


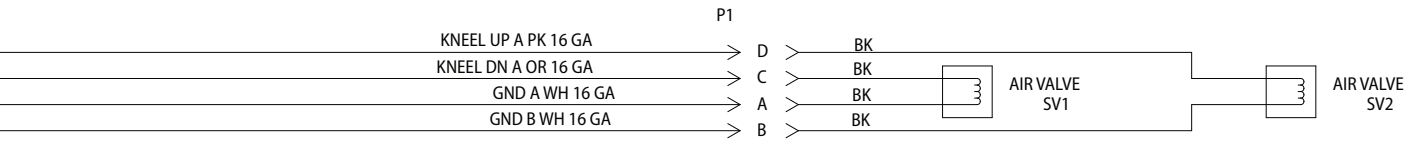


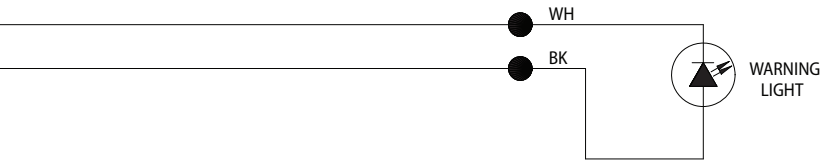
Kneeling System Front Susp

D0001452B

Sheet 2 of 3



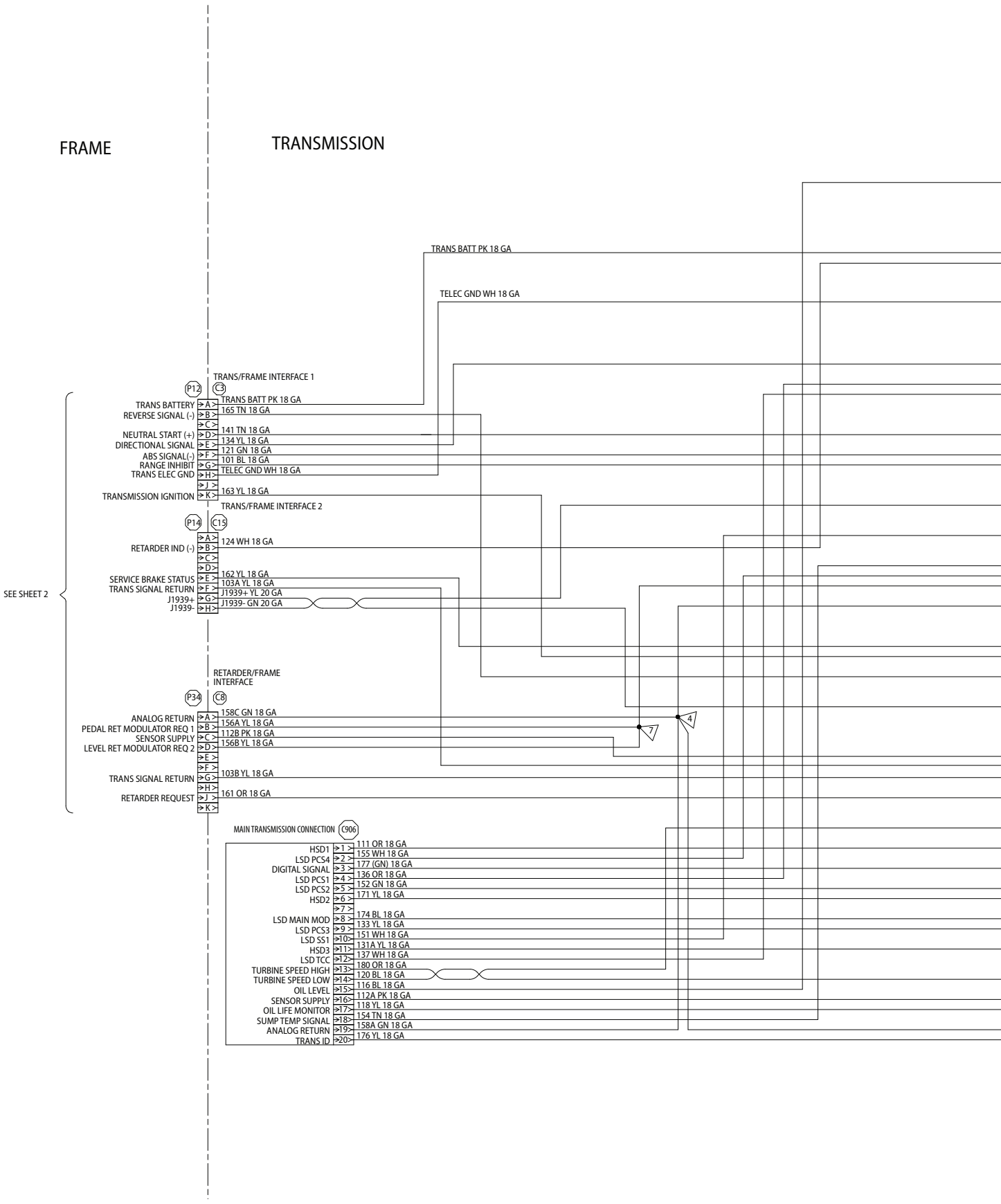


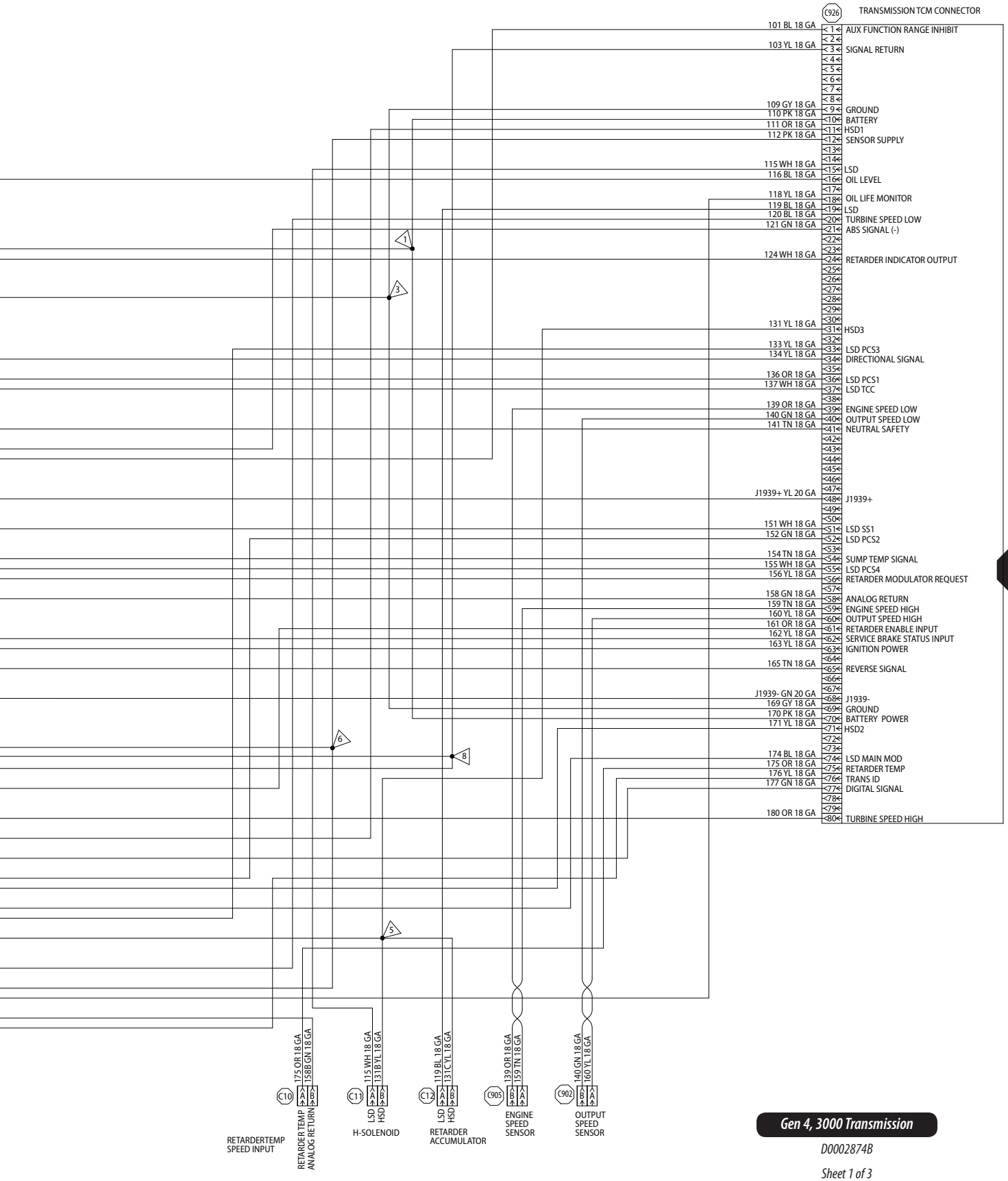


Kneeling System Front Susp.

D0001452B

Sheet 3 of 3

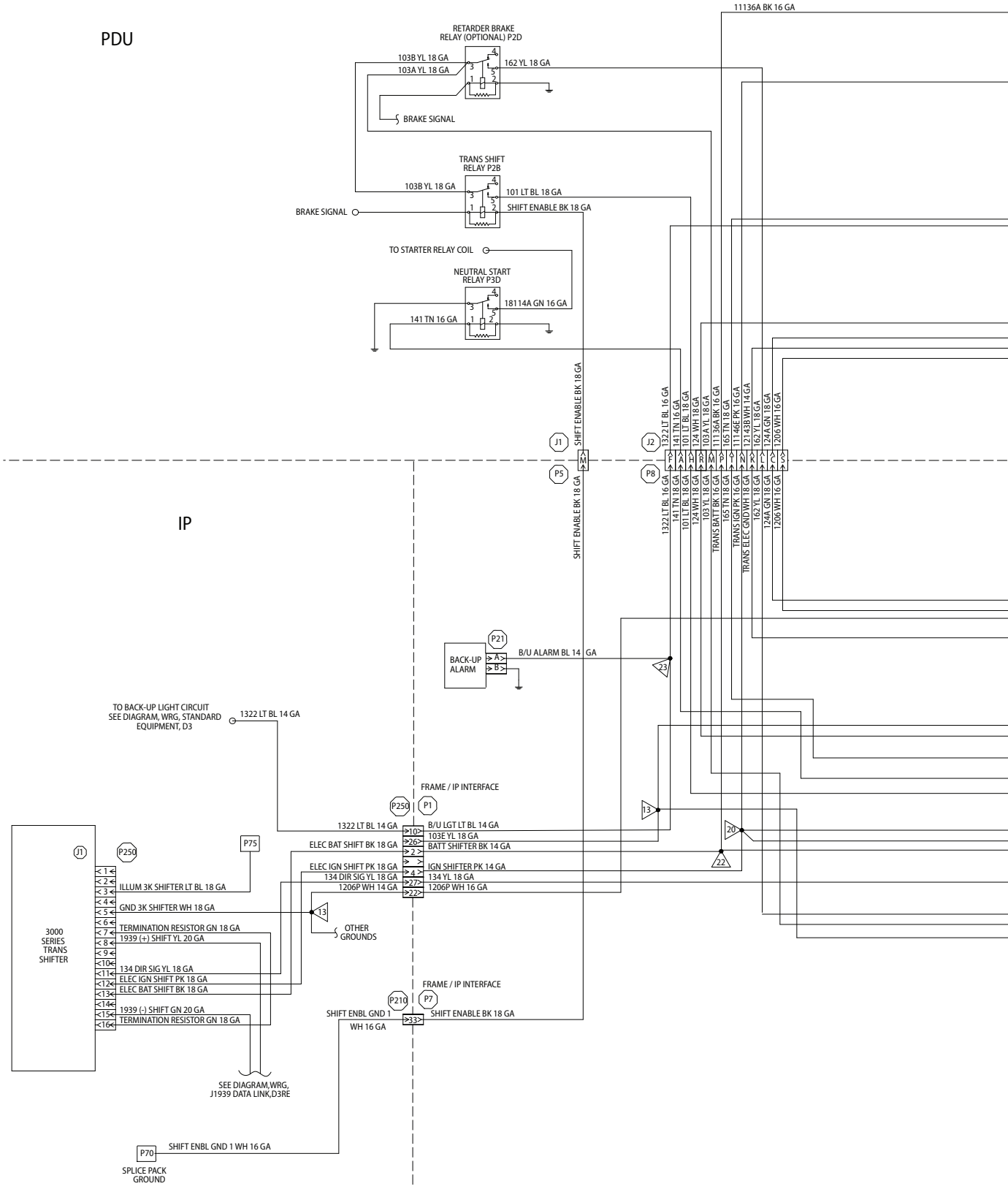

FRAME
TRANSMISSION
TRANS BATT PK 18 GA
TELEC GND WH 18 GA
TRANS/FRAME INTERFACE 1
P12
C3
TRANS BATTERY >A<
REVERSE SIGNAL (-) >B<
>C<
NEUTRAL START (+) >D<
DIRECTIONAL SIGNAL >E<
ABS SIGNAL(-) >F<
RANGE INHIBIT >G<
TRANS ELEC GND >H<
>J<
TRANSMISSION IGNITION >K<
TRANS BATT PK 18 GA
165 TN 18 GA
141 TN 18 GA
134 YL 18 GA
121 GN 18 GA
101 BL 18 GA
TELEC GND WH 18 GA
163 YL 18 GA
TRANS/FRAME INTERFACE 2
P14
C15
>A<
RETARDER IND (-) >B<
>C<
>D<
SERVICE BRAKE STATUS >E<
TRANS SIGNAL RETURN >F<
J1939+ >G<
J1939- >H<
124 WH 18 GA
162 YL 18 GA
103A YL 18 GA
J1939+ YL 20 GA
J1939- GN 20 GA
542
SEE SHEET 2
RETARDER/FRAME INTERFACE
P34
C8
ANALOG RETURN >A<
PEDAL RET MODULATOR REQ 1 >B<
SENSOR SUPPLY >C<
LEVEL RET MODULATOR REQ 2 >D<
>E<
>F<
TRANS SIGNAL RETURN >G<
>H<
RETARDER REQUEST >J<
>K<
158C GN 18 GA
156A YL 18 GA
112B PK 18 GA
156B YL 18 GA
103B YL 18 GA
161 OR 18 GA
7
4
MAIN TRANSMISSION CONNECTION C906
HSD1 >1<
LSD PCS4 >2<
DIGITAL SIGNAL >3<
LSD PCS1 >4<
LSD PCS2 >5<
HSD2 >6<
>7<
LSD MAIN MOD >8<
LSD PCS3 >9<
LSD SS1 >10<
HSD3 >11<
LSD TCC >12<
TURBINE SPEED HIGH >13<
TURBINE SPEED LOW >14<
OIL LEVEL >15<
SENSOR SUPPLY >16<
OIL LIFE MONITOR >17<
SUMP TEMP SIGNAL >18<
ANALOG RETURN >19<
TRANS ID >20<
111 OR 18 GA
155 WH 18 GA
177 (GN) 18 GA
136 OR 18 GA
152 GN 18 GA
171 YL 18 GA
174 BL 18 GA
133 YL 18 GA
151 WH 18 GA
131A YL 18 GA
137 WH 18 GA
180 OR 18 GA
120 BL 18 GA
116 BL 18 GA
112A PK 18 GA
118 YL 18 GA
154 TN 18 GA
158A GN 18 GA
176 YL 18 GA

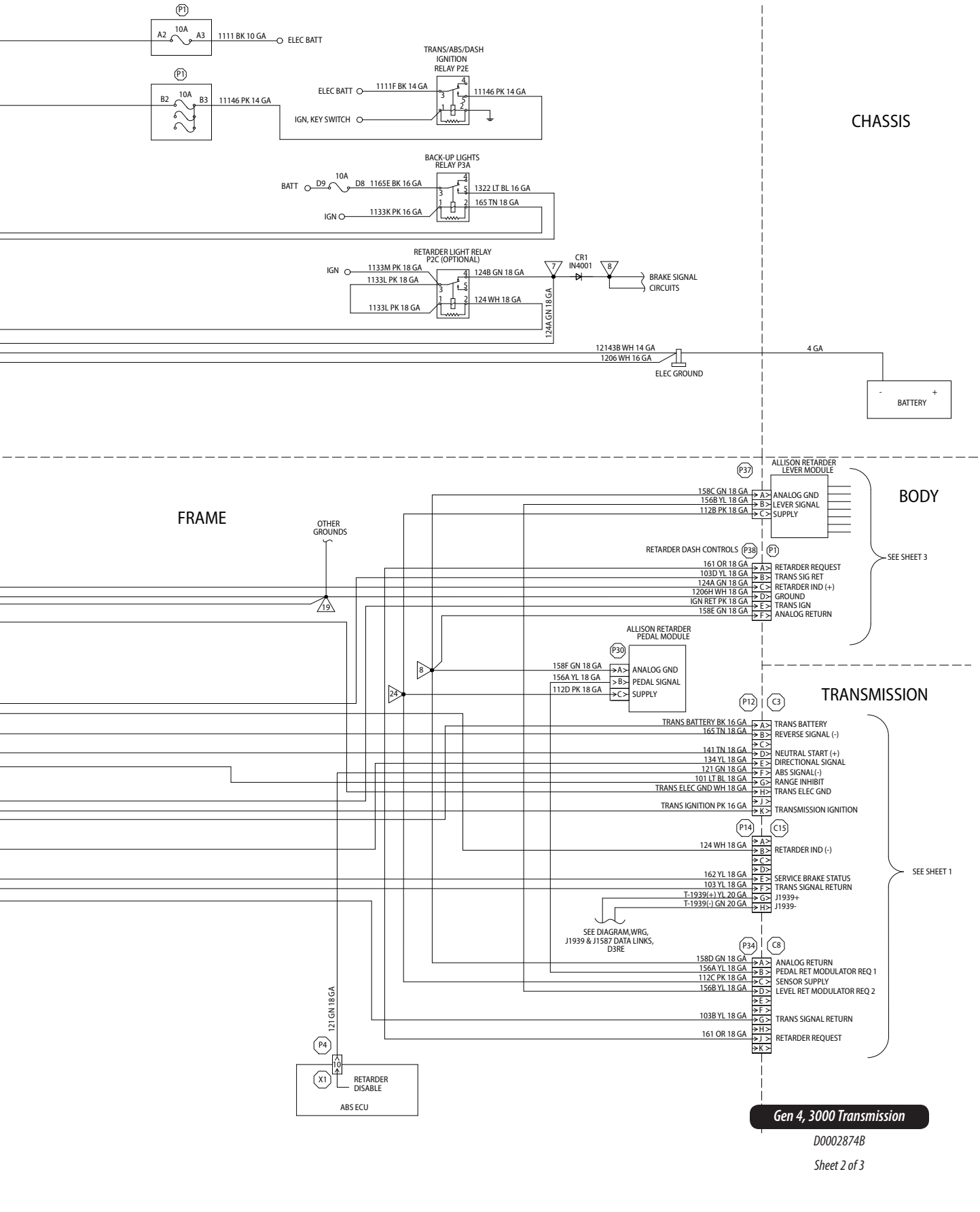


Gen 4, 3000 Transmission

D0002874B

Sheet 1 of 3

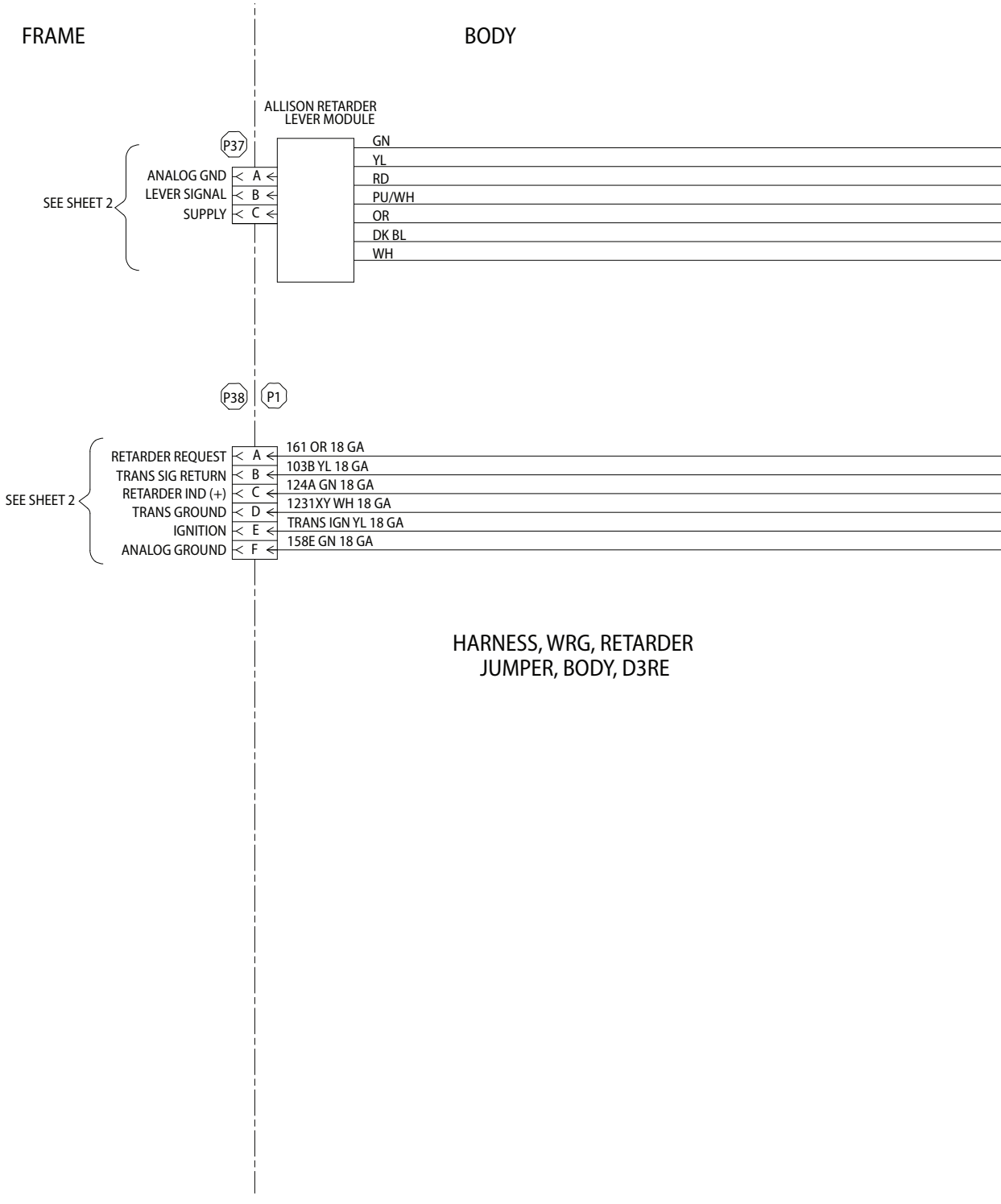

PDU
IP
RETARDER BRAKE RELAY (OPTIONAL) P2D
103B YL 18 GA
103A YL 18 GA
162 YL 18 GA
BRAKE SIGNAL
TRANS SHIFT RELAY P2B
103B YL 18 GA
101 LT BL 18 GA
BRAKE SIGNAL
SHIFT ENABLE BK 18 GA
TO STARTER RELAY COIL
NEUTRAL START RELAY P3D
18114A GN 16 GA
141 TN 16 GA
11136A BK 16 GA
SHIFT ENABLE BK 18 GA
J1
P5
J2
P8
1322 LT BL 16 GA
141 TN 16 GA
101 LT BL 18 GA
124 WH 18 GA
103A YL 18 GA
11136A BK 16 GA
165 TN 18 GA
11146E PK 16 GA
12143B WH 14 GA
162 YL 18 GA
124A GN 18 GA
1206 WH 16 GA
1322 LT BL 16 GA
141 TN 18 GA
101 LT BL 18 GA
124 WH 18 GA
103 YL 18 GA
TRANS BATT BK 16 GA
165 TN 18 GA
TRANS IGN PK 16 GA
TRANS ELEC GND WH 18 GA
162 YL 18 GA
124A GN 18 GA
1206 WH 16 GA
P21
BACK-UP ALARM
B/U ALARM BL 14 GA
23
TO BACK-UP LIGHT CIRCUIT SEE DIAGRAM, WRG, STANDARD EQUIPMENT, D3
1322 LT BL 14 GA
FRAME / IP INTERFACE
P250
P1
1322 LT BL 14 GA
B/U LGT LT BL 14 GA
103E YL 18 GA
ELEC BAT SHIFT BK 18 GA
BATT SHIFTER BK 14 GA
ELEC IGN SHIFT PK 18 GA
IGN SHIFTER PK 14 GA
134 DIR SIG YL 18 GA
134 YL 18 GA
1206P WH 14 GA
1206P WH 16 GA
13
20
22
J1
P250
P75
3000 SERIES TRANS SHIFTER
ILLUM 3K SHIFTER LT BL 18 GA
GND 3K SHIFTER WH 18 GA
TERMINATION RESISTOR GN 18 GA
1939 (+) SHIFT YL 20 GA
134 DIR SIG YL 18 GA
ELEC IGN SHIFT PK 18 GA
ELEC BAT SHIFT BK 18 GA
1939 (-) SHIFT GN 20 GA
TERMINATION RESISTOR GN 18 GA
OTHER GROUNDS
SEE DIAGRAM,WRG, J1939 DATA LINK,D3RE
FRAME / IP INTERFACE
P210
P7
SHIFT ENBL GND 1 WH 16 GA
SHIFT ENABLE BK 18 GA
P70
SHIFT ENBL GND 1 WH 16 GA
SPLICE PACK GROUND



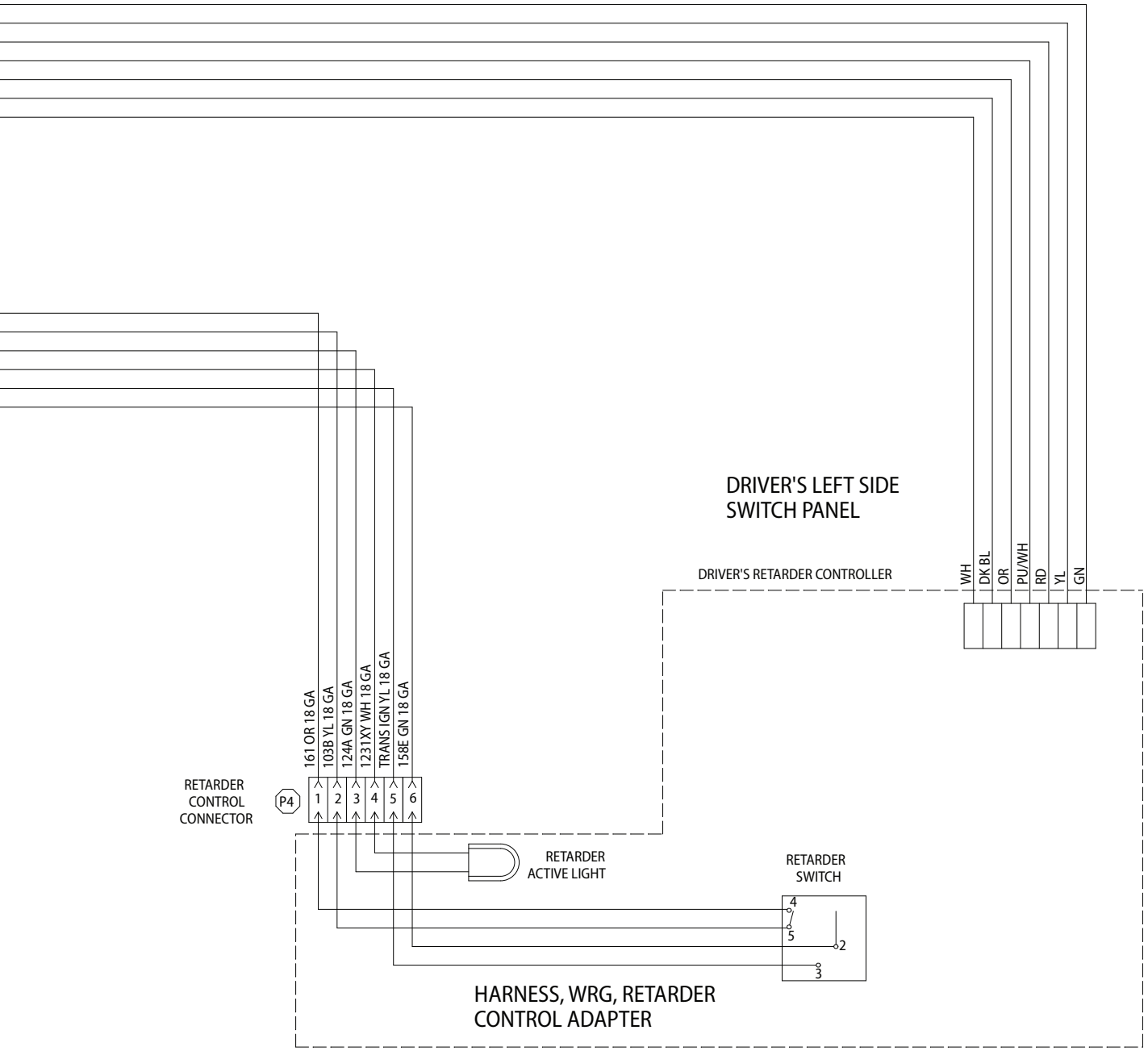
Gen 4, 3000 Transmission

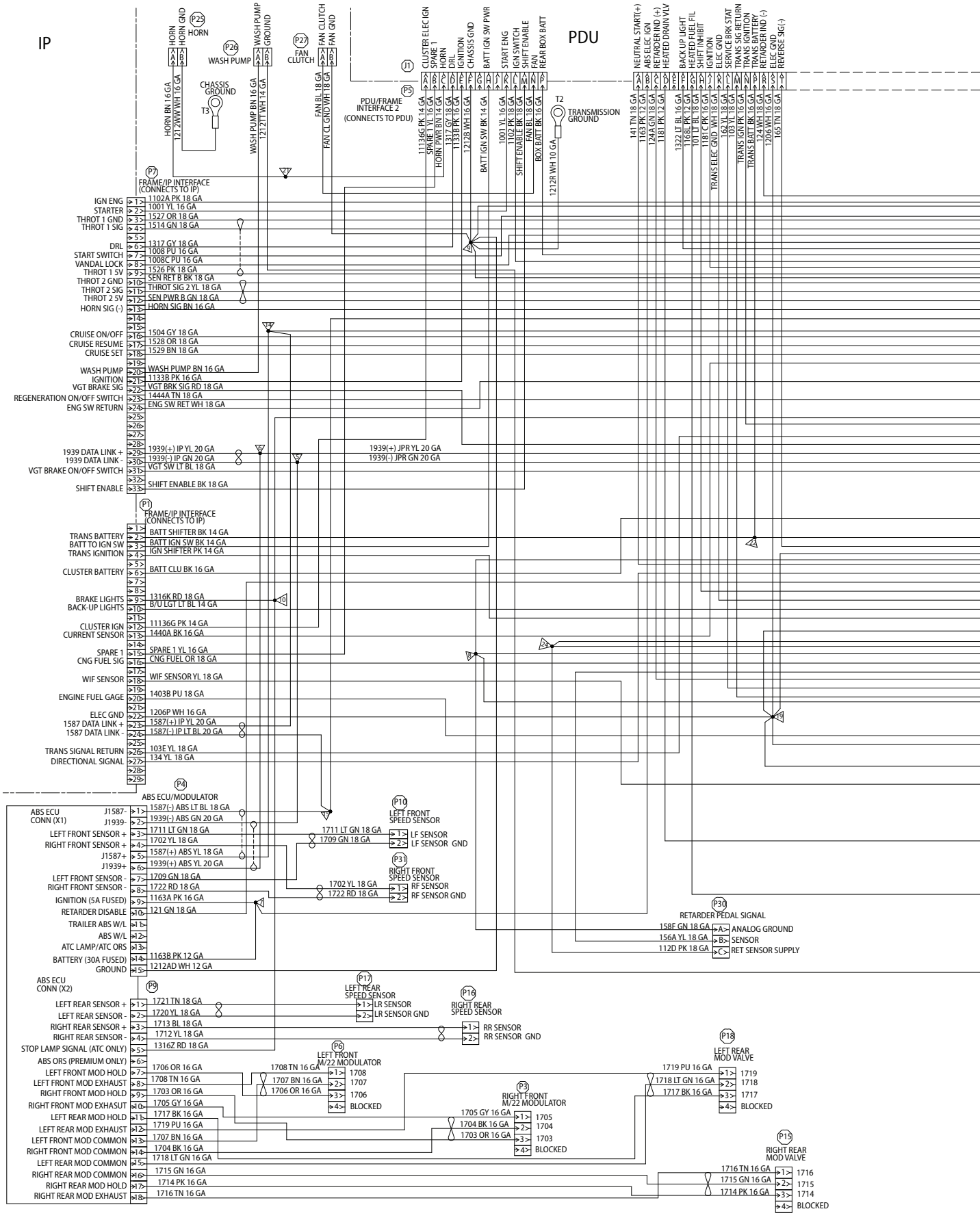
D0002874B

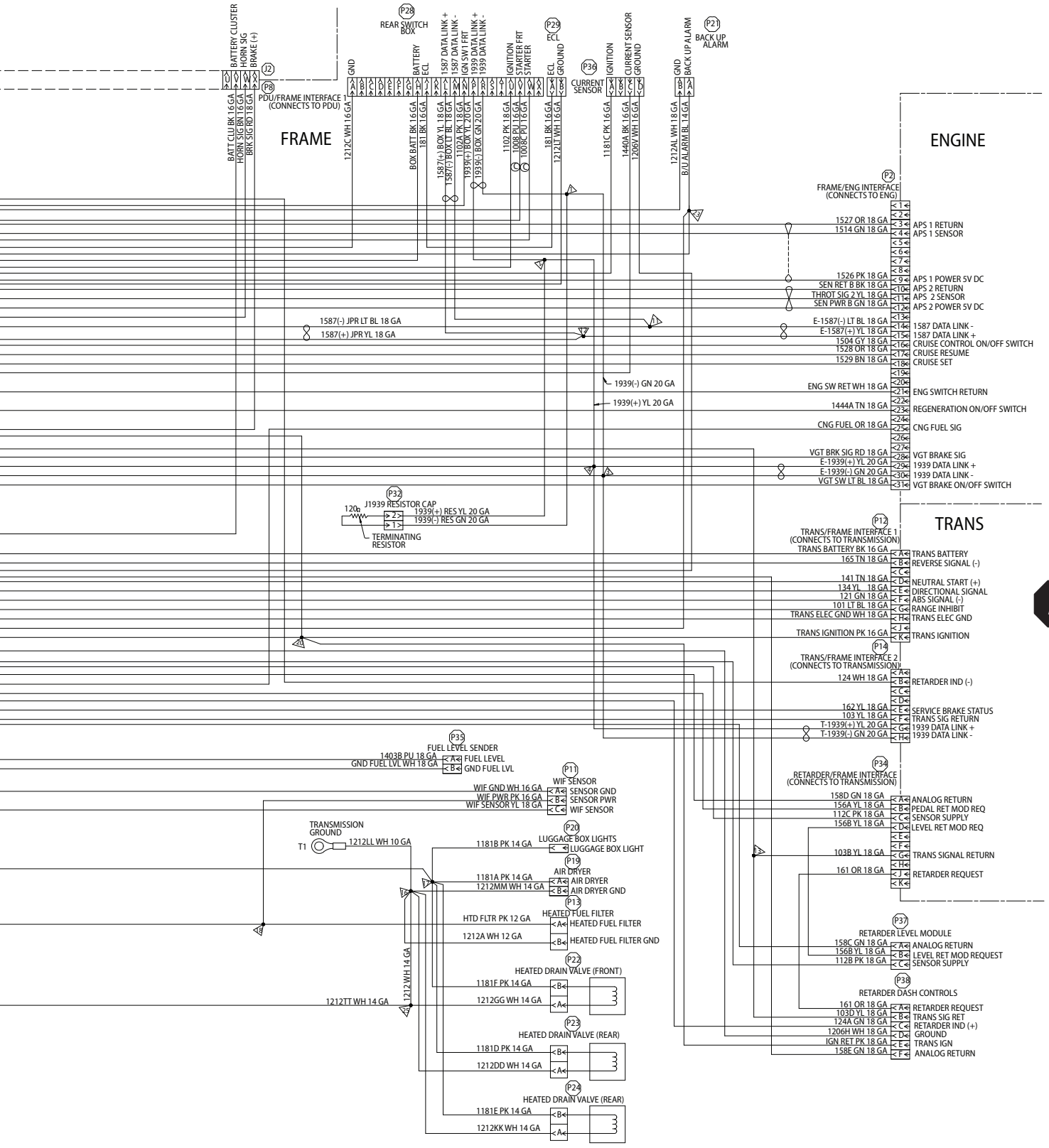
Sheet 2 of 3



HARNESS, WRG, RETARDER
JUMPER, BODY, D3RE


DRIVER'S LEFT SIDE
SWITCH PANEL
DRIVER'S RETARDER CONTROLLER
WH
DK BL
OR
PU/WH
RD
YL
GN
161 OR 18 GA
103B YL 18 GA
124A GN 18 GA
1231XY WH 18 GA
TRANS IGN YL 18 GA
158E GN 18 GA
RETARDER
CONTROL
CONNECTOR
P4
1
2
3
4
5
6
RETARDER
ACTIVE LIGHT
RETARDER
SWITCH
4
5
2
3
HARNESS, WRG, RETARDER
CONTROL ADAPTER

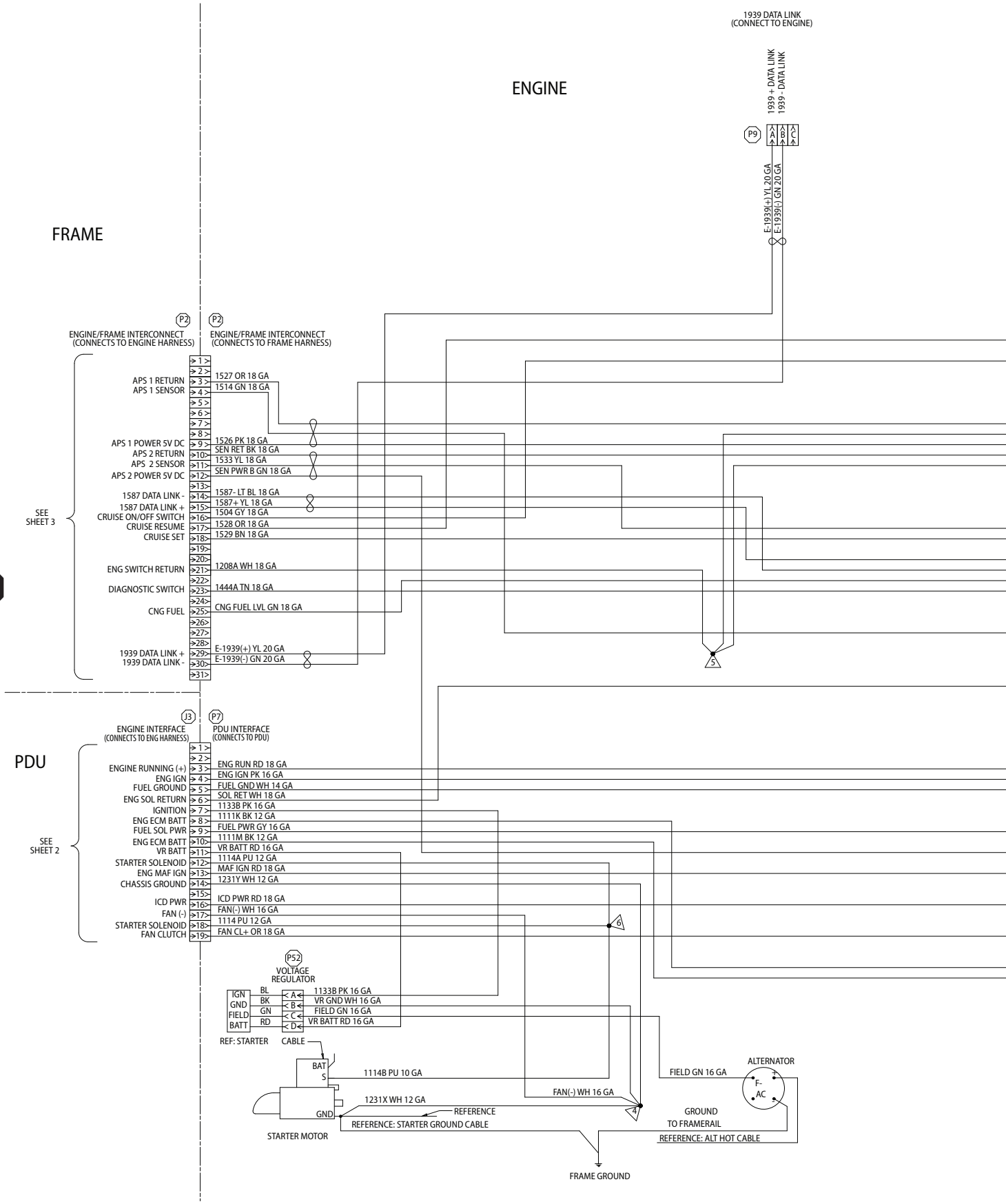

IP
PDU
P29 HORN
P26 WASH PUMP
P27 FAN CLUTCH
J1
P5
PDU/FRAME INTERFACE 2 (CONNECTS TO PDU)
T3 CHASSIS GROUND
T2 TRANSMISSION GROUND
P7 FRAME/IP INTERFACE (CONNECTS TO IP)
P1 FRAME/IP INTERFACE (CONNECTS TO IP)
P4 ABS ECU/MODULATOR
ABS ECU CONN (X1)
ABS ECU CONN (X2)
P9
P10 LEFT FRONT SPEED SENSOR
P31 RIGHT FRONT SPEED SENSOR
P30 RETARDER PEDAL SIGNAL
P17 LEFT REAR SPEED SENSOR
P16 RIGHT REAR SPEED SENSOR
P6 LEFT FRONT M/22 MODULATOR
P3 RIGHT FRONT M/22 MODULATOR
P18 LEFT REAR MOD VALVE
P15 RIGHT REAR MOD VALVE
IGN ENG
STARTER
THROT 1 GND
THROT 1 SIG
DRL
START SWITCH
VANDAL LOCK
THROT 1 5V
THROT 2 GND
THROT 2 SIG
THROT 2 5V
HORN SIG (-)
CRUISE ON/OFF
CRUISE RESUME
CRUISE SET
WASH PUMP
IGNITION
VGT BRAKE SIG
REGENERATION ON/OFF SWITCH
ENG SW RETURN
1939 DATA LINK +
1939 DATA LINK -
VGT BRAKE ON/OFF SWITCH
SHIFT ENABLE
TRANS BATTERY
BATT TO IGN SW
TRANS IGNITION
CLUSTER BATTERY
BRAKE LIGHTS
BACK-UP LIGHTS
CLUSTER IGN CURRENT SENSOR
SPARE 1
CNG FUEL SIG
WIF SENSOR
ENGINE FUEL GAGE
ELEC GND
1587 DATA LINK +
1587 DATA LINK -
TRANS SIGNAL RETURN
DIRECTIONAL SIGNAL
1939(+) JPR YL 20 GA
1939(-) JPR GN 20 GA
NEUTRAL START(+)
ABS ELEC IGN
RETARDER IND (+)
HEATED DRAIN VLV
BACK UP LIGHT
HEATED FUEL FIL
SHIFT INHIBIT
IGNITION
ELEC GND
SERVICE BRK STAT
TRANS SIG RETURN
TRANS IGNITION
TRANS BATTERY
RETARDER IND (-)
ELEC GND
REVERSE SIG(-)
CLUSTER ELEC IGN
SPARE 1
HORN
DRL
IGNITION
CHASSIS GND
BATT IGN SW PWR
START ENG
IGN SWITCH
SHIFT ENABLE
FAN
REAR BOX BATT
HORN BN 16 GA
1212WW WH 16 GA
WASH PUMP BN 16 GA
1212TT WH 14 GA
FAN BL 18 GA
FAN CL GND WH 18 GA
11136G PK 14 GA
SPARE 1 YL 16 GA
HORN PWR BN 14 GA
1317 GY 18 GA
1133B PK 16 GA
1212B WH 16 GA
BATT IGN SW BK 14 GA
1001 YL 16 GA
1102 PK 16 GA
SHIFT ENABLE BK 18 GA
FAN BL 18 GA
BOX BATT BK 16 GA
1212R WH 10 GA
141 TN 18 GA
1163 PK 12 GA
124A GN 18 GA
1181 PK 12 GA
1322 LT BL 16 GA
1168L PK 12 GA
101 LT BL 18 GA
1181C PK 16 GA
TRANS ELEC GND WH 18 GA
165 YL 18 GA
TRANS IGN PK 16 GA
TRANS BATT BK 16 GA
124 WH 18 GA
1206 WH 16 GA
165 TN 18 GA
1316K RD 18 GA
B/U LGT LT BL 14 GA
11136G PK 14 GA
1440A BK 16 GA
SPARE 1 YL 16 GA
CNG FUEL OR 18 GA
WIF SENSOR YL 18 GA
1403B PU 18 GA
1206P WH 16 GA
1587(+) IP YL 20 GA
1587(-) IP LT BL 20 GA
103E YL 18 GA
134 YL 18 GA
1939(+) IP YL 20 GA
1939(-) IP GN 20 GA
VGT SW LT BL 18 GA
SHIFT ENABLE BK 18 GA
BATT SHIFTER BK 14 GA
BATT IGN SW BK 14 GA
IGN SHIFTER PK 14 GA
BATT CLU BK 16 GA
1504 GY 18 GA
1528 OR 18 GA
1529 BN 18 GA
WASH PUMP BN 16 GA
1133B PK 16 GA
VGT BRK SIG RD 18 GA
1444A TN 18 GA
ENG SW RET WH 18 GA
SEN RET B BK 18 GA
THROT SIG 2 YL 18 GA
SEN PWR B GN 18 GA
HORN SIG BN 16 GA
1102A PK 18 GA
1001 YL 16 GA
1527 OR 18 GA
1514 GN 18 GA
1317 GY 18 GA
1008 PU 16 GA
1008C PU 16 GA
1526 PK 18 GA
1587(-) ABS LT BL 18 GA
1939(-) ABS GN 20 GA
1711 LT GN 18 GA
1702 YL 18 GA
1587(+) ABS YL 18 GA
1939(+) ABS YL 20 GA
1709 GN 18 GA
1722 RD 18 GA
1163A PK 16 GA
121 GN 18 GA
1163B PK 12 GA
1212AD WH 12 GA
1711 LT GN 18 GA
1709 GN 18 GA
LF SENSOR
LF SENSOR GND
1702 YL 18 GA
1722 RD 18 GA
RF SENSOR
RF SENSOR GND
158F GN 18 GA
156A YL 18 GA
112D PK 18 GA
ANALOG GROUND
SENSOR
RET SENSOR SUPPLY
1721 TN 18 GA
1720 YL 18 GA
1713 BL 18 GA
1712 YL 18 GA
1316Z RD 18 GA
LR SENSOR
LR SENSOR GND
RR SENSOR
RR SENSOR GND
1706 OR 16 GA
1708 TN 16 GA
1705 GY 16 GA
1717 BK 16 GA
1719 PU 16 GA
1707 BN 16 GA
1704 BK 16 GA
1718 LT GN 16 GA
1715 GN 16 GA
1714 PK 16 GA
1716 TN 16 GA
1708 TN 16 GA
1707 BN 16 GA
1706 OR 16 GA
1708
1707
1706
BLOCKED
1705 GY 16 GA
1704 BK 16 GA
1703 OR 16 GA
1705
1704
1703
BLOCKED
1719 PU 16 GA
1718 LT GN 16 GA
1717 BK 16 GA
1719
1718
1717
BLOCKED
1716 TN 16 GA
1715 GN 16 GA
1714 PK 16 GA
1716
1715
1714
BLOCKED

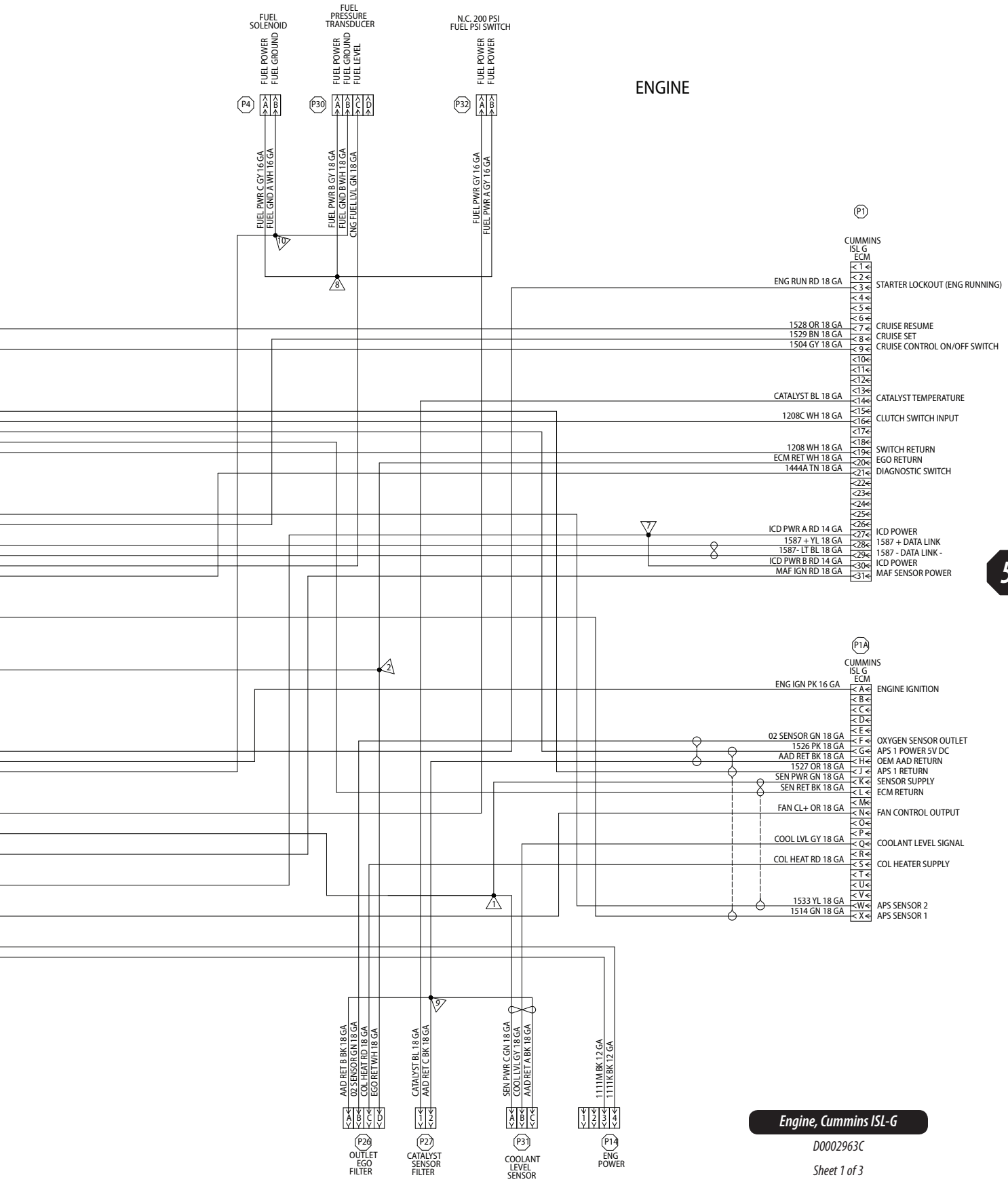


549

Frame

D0002958F


1939 DATA LINK
(CONNECT TO ENGINE)
ENGINE
1939 + DATA LINK
1939 - DATA LINK
P9
A
B
C
E-1939(+) YL 20 GA
E-1939(-) GN 20 GA
FRAME
P2
ENGINE/FRAME INTERCONNECT
(CONNECTS TO ENGINE HARNESS)
P2
ENGINE/FRAME INTERCONNECT
(CONNECTS TO FRAME HARNESS)
APS 1 RETURN
APS 1 SENSOR
1527 OR 18 GA
1514 GN 18 GA
APS 1 POWER 5V DC
APS 2 RETURN
APS 2 SENSOR
APS 2 POWER 5V DC
1526 PK 18 GA
SEN RET BK 18 GA
1533 YL 18 GA
SEN PWR B GN 18 GA
1587 DATA LINK -
1587 DATA LINK +
1587- LT BL 18 GA
1587+ YL 18 GA
SEE
SHEET 3
CRUISE ON/OFF SWITCH
CRUISE RESUME
CRUISE SET
1504 GY 18 GA
1528 OR 18 GA
1529 BN 18 GA
ENG SWITCH RETURN
1208A WH 18 GA
DIAGNOSTIC SWITCH
1444A TN 18 GA
CNG FUEL
CNG FUEL LVL GN 18 GA
1939 DATA LINK +
1939 DATA LINK -
E-1939(+) YL 20 GA
E-1939(-) GN 20 GA
5
PDU
J3
ENGINE INTERFACE
(CONNECTS TO ENG HARNESS)
P7
PDU INTERFACE
(CONNECTS TO PDU)
ENGINE RUNNING (+)
ENG IGN
FUEL GROUND
ENG SOL RETURN
IGNITION
ENG ECM BATT
FUEL SOL PWR
ENG ECM BATT
VR BATT
STARTER SOLENOID
ENG MAF IGN
CHASSIS GROUND
ICD PWR
FAN (-)
STARTER SOLENOID
FAN CLUTCH
ENG RUN RD 18 GA
ENG IGN PK 16 GA
FUEL GND WH 14 GA
SOL RET WH 18 GA
1133B PK 16 GA
1111K BK 12 GA
FUEL PWR GY 16 GA
1111M BK 12 GA
VR BATT RD 16 GA
1114A PU 12 GA
MAF IGN RD 18 GA
1231Y WH 12 GA
ICD PWR RD 18 GA
FAN(-) WH 16 GA
1114 PU 12 GA
FAN CL+ OR 18 GA
6
P52
VOLTAGE
REGULATOR
IGN
GND
FIELD
BATT
BL
BK
GN
RD
A
B
C
D
1133B PK 16 GA
VR GND WH 16 GA
FIELD GN 16 GA
VR BATT RD 16 GA
REF: STARTER
CABLE
BAT
S
GND
1114B PU 10 GA
1231X WH 12 GA
REFERENCE
REFERENCE: STARTER GROUND CABLE
STARTER MOTOR
FAN(-) WH 16 GA
4
ALTERNATOR
FIELD GN 16 GA
F-
AC
GROUND
TO FRAMERAIL
REFERENCE: ALT HOT CABLE
FRAME GROUND



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Engine, Cummins ISL-G

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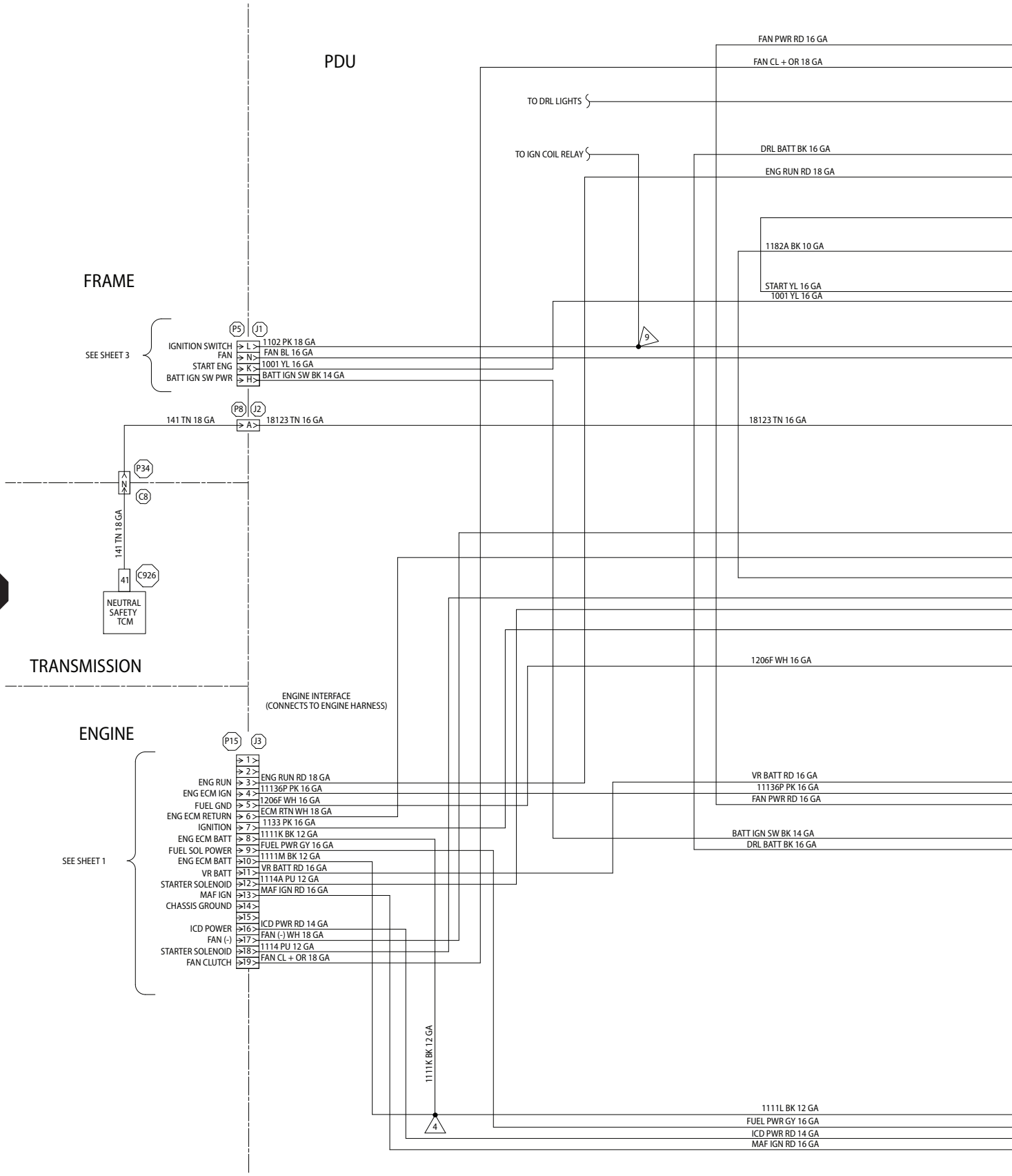
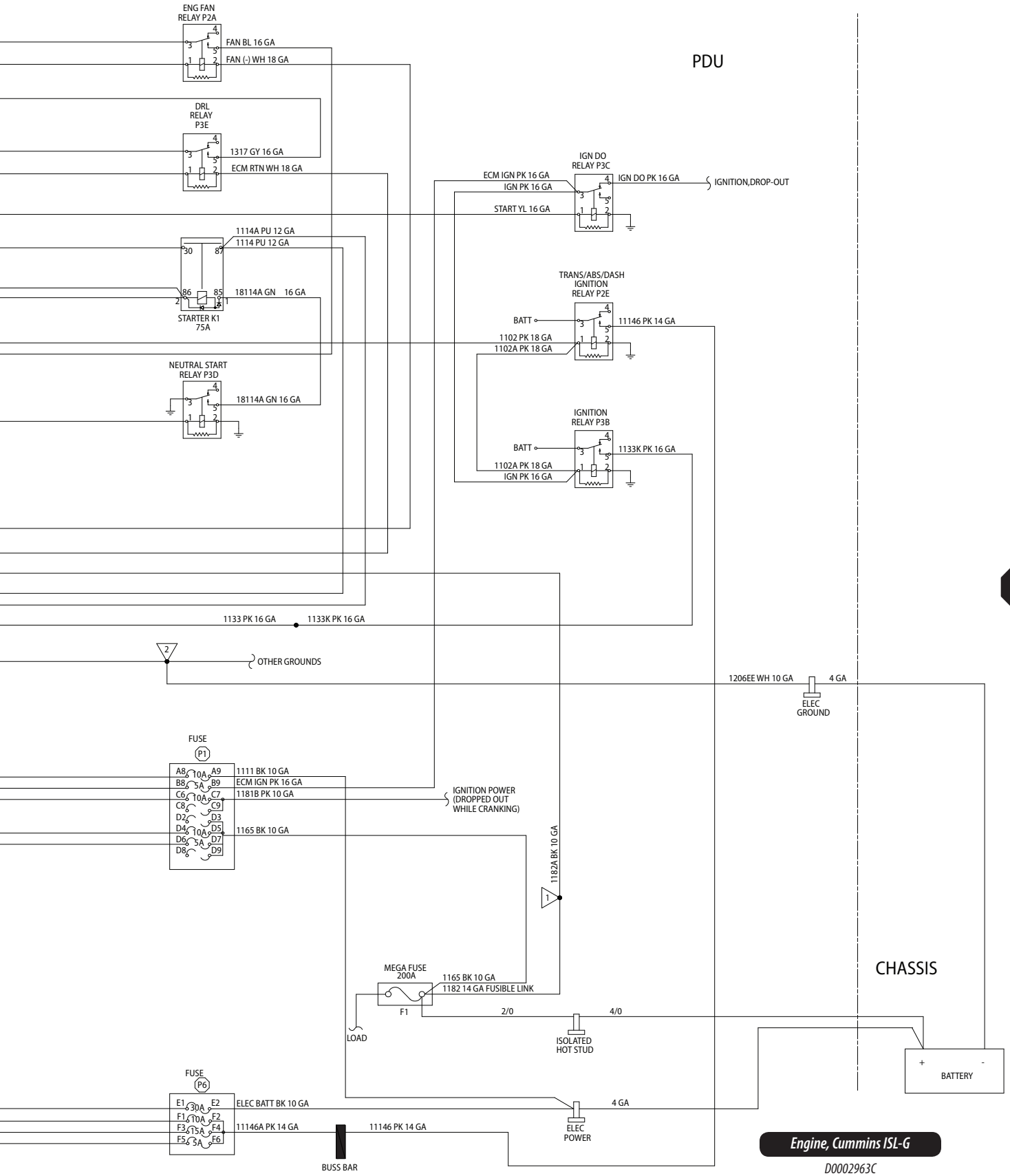
Sheet 1 of 3


PDU
FRAME
SEE SHEET 3
IGNITION SWITCH
FAN
START ENG
BATT IGN SW PWR
P5
J1
L
N
K
H
1102 PK 18 GA
FAN BL 16 GA
1001 YL 16 GA
BATT IGN SW BK 14 GA
P8
J2
A
141 TN 18 GA
18123 TN 16 GA
P34
N
C8
141 TN 18 GA
41
C926
NEUTRAL SAFETY TCM
TRANSMISSION
ENGINE INTERFACE (CONNECTS TO ENGINE HARNESS)
ENGINE
SEE SHEET 1
P15
J3
ENG RUN
ENG ECM IGN
FUEL GND
ENG ECM RETURN
IGNITION
ENG ECM BATT
FUEL SOL POWER
ENG ECM BATT
VR BATT
STARTER SOLENOID
MAF IGN
CHASSIS GROUND
ICD POWER
FAN (-)
STARTER SOLENOID
FAN CLUTCH
ENG RUN RD 18 GA
11136P PK 16 GA
1206F WH 16 GA
ECM RTN WH 18 GA
1133 PK 16 GA
1111K BK 12 GA
FUEL PWR GY 16 GA
1111M BK 12 GA
VR BATT RD 16 GA
1114A PU 12 GA
MAF IGN RD 16 GA
ICD PWR RD 14 GA
FAN (-) WH 18 GA
1114 PU 12 GA
FAN CL + OR 18 GA
1111K BK 12 GA
4
9
TO DRL LIGHTS
TO IGN COIL RELAY
FAN PWR RD 16 GA
FAN CL + OR 18 GA
DRL BATT BK 16 GA
ENG RUN RD 18 GA
1182A BK 10 GA
START YL 16 GA
1001 YL 16 GA
18123 TN 16 GA
1206F WH 16 GA
VR BATT RD 16 GA
11136P PK 16 GA
FAN PWR RD 16 GA
BATT IGN SW BK 14 GA
DRL BATT BK 16 GA
1111L BK 12 GA
FUEL PWR GY 16 GA
ICD PWR RD 14 GA
MAF IGN RD 16 GA



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Engine, Cummins ISL-G

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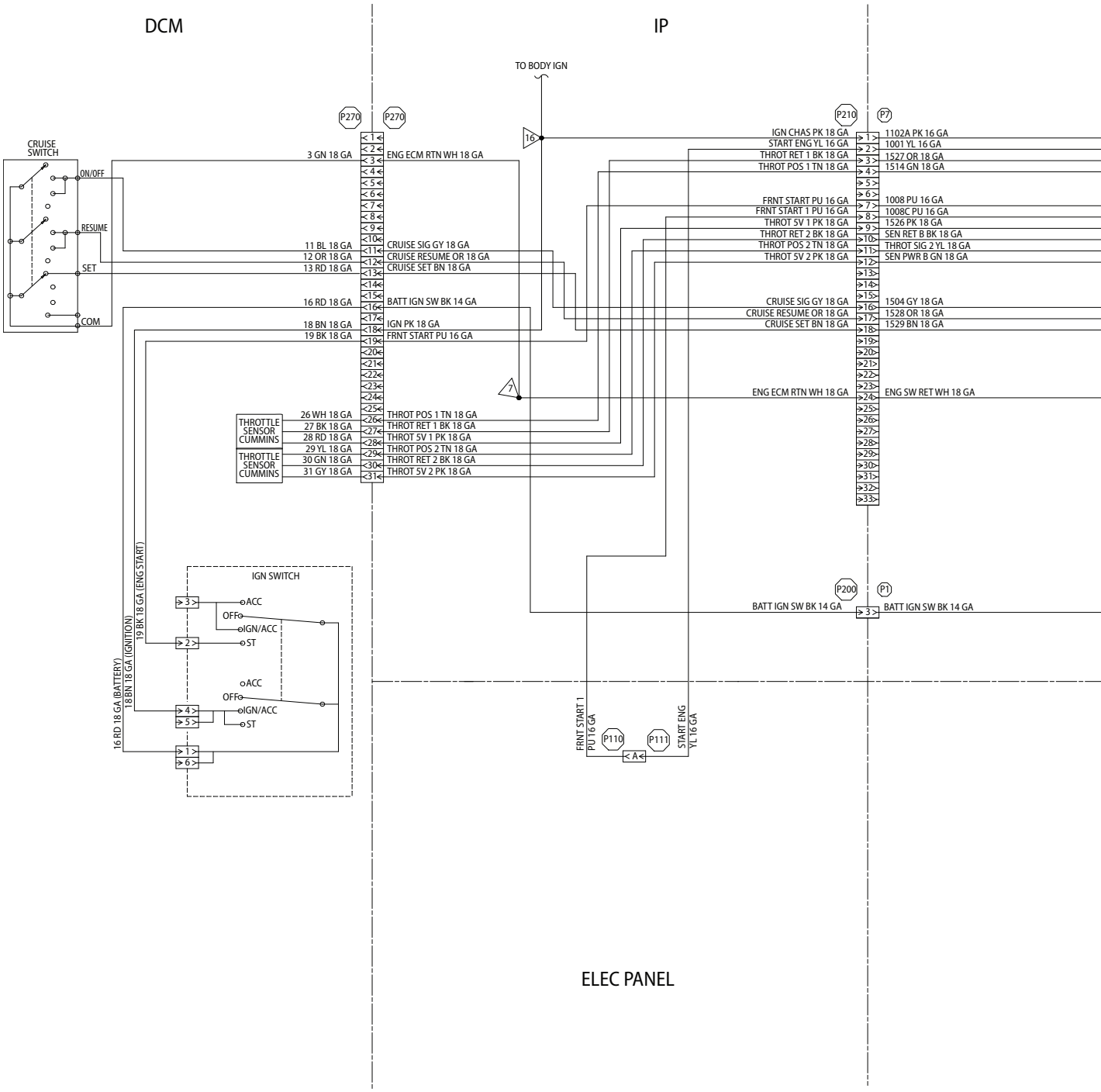
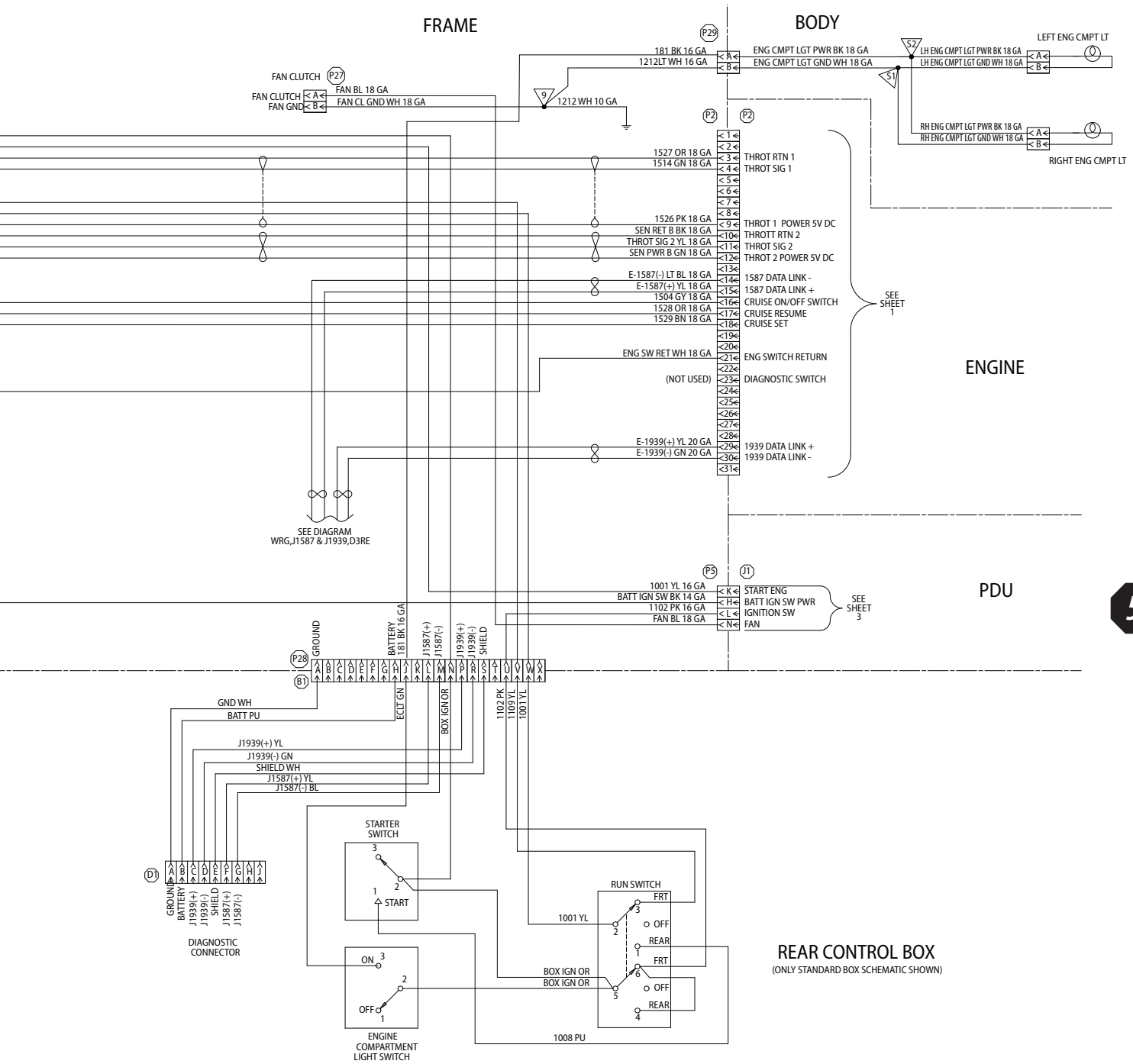
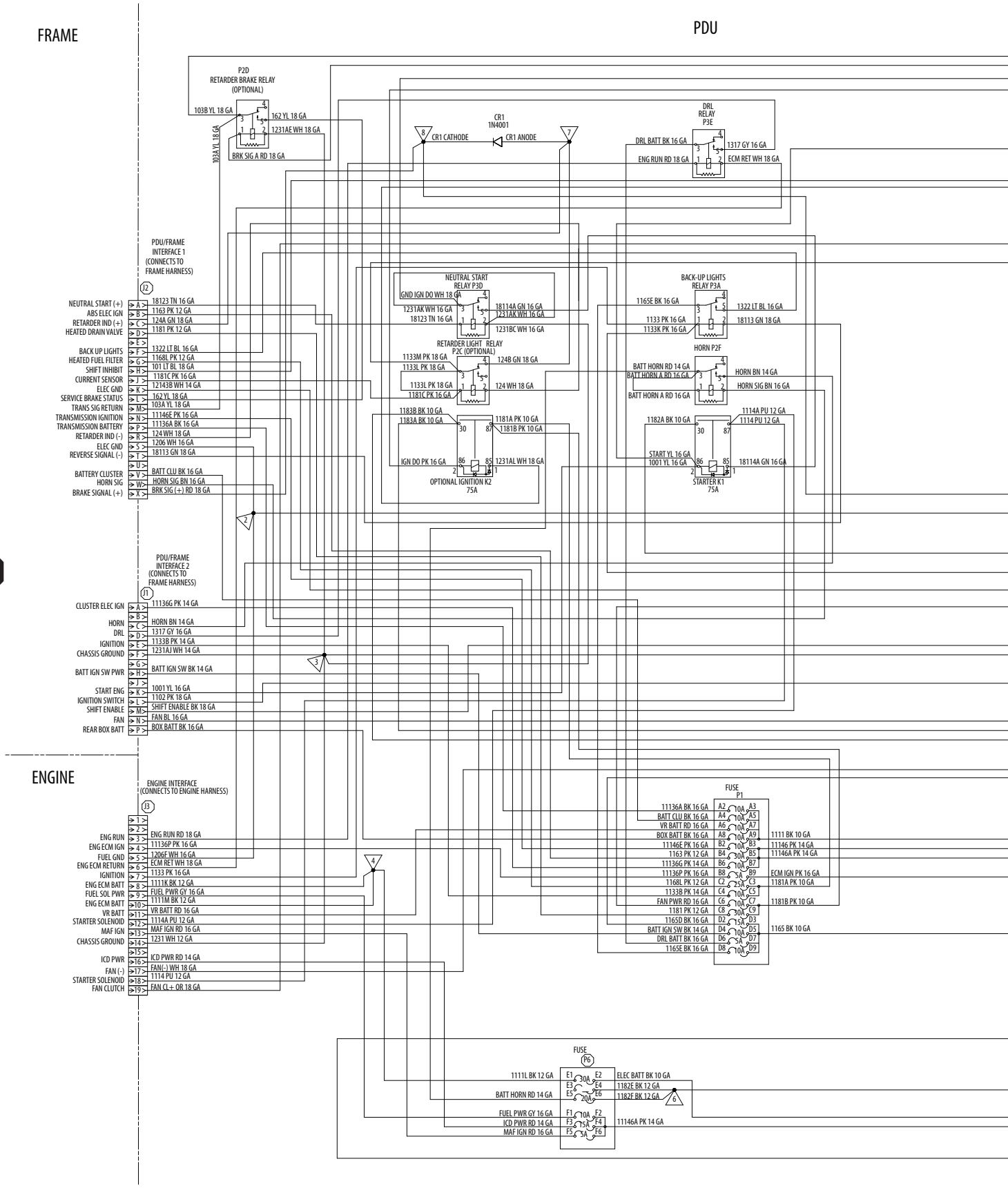
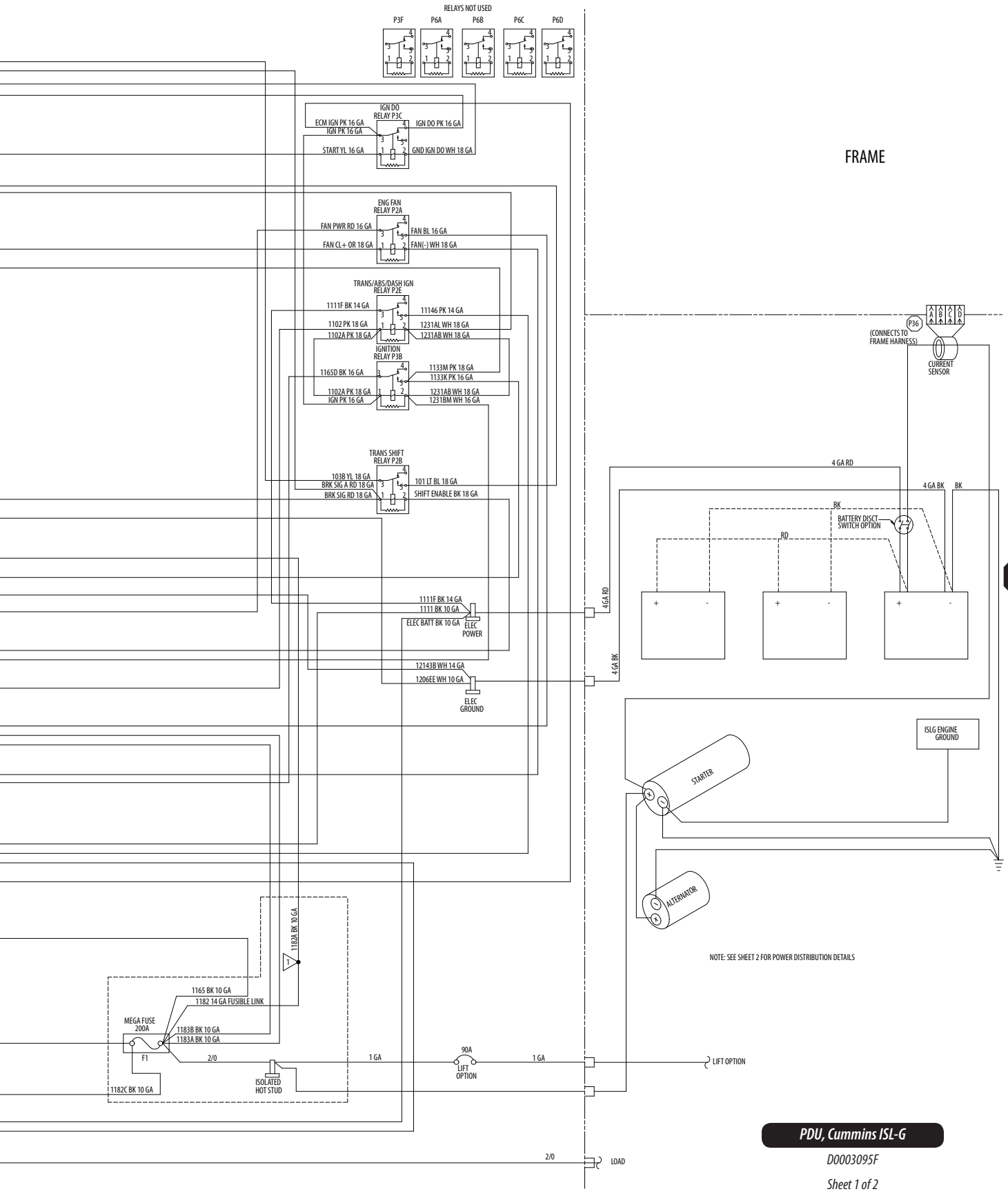
Sheet 2 of 3


DCM
IP
TO BODY IGN
CRUISE SWITCH
ON/OFF
RESUME
SET
COM
P270
P270
P210
P7
3 GN 18 GA
ENG ECM RTN WH 18 GA
11 BL 18 GA
CRUISE SIG GY 18 GA
12 OR 18 GA
CRUISE RESUME OR 18 GA
13 RD 18 GA
CRUISE SET BN 18 GA
16 RD 18 GA
BATT IGN SW BK 14 GA
18 BN 18 GA
IGN PK 18 GA
19 BK 18 GA
FRNT START PU 16 GA
THROTTLE SENSOR CUMMINS
26 WH 18 GA
THROT POS 1 TN 18 GA
27 BK 18 GA
THROT RET 1 BK 18 GA
28 RD 18 GA
THROT 5V 1 PK 18 GA
THROTTLE SENSOR CUMMINS
29 YL 18 GA
THROT POS 2 TN 18 GA
30 GN 18 GA
THROT RET 2 BK 18 GA
31 GY 18 GA
THROT 5V 2 PK 18 GA
IGN CHAS PK 18 GA
1102A PK 16 GA
START ENG YL 16 GA
1001 YL 16 GA
THROT RET 1 BK 18 GA
1527 OR 18 GA
THROT POS 1 TN 18 GA
1514 GN 18 GA
FRNT START PU 16 GA
1008 PU 16 GA
FRNT START 1 PU 16 GA
1008C PU 16 GA
THROT 5V 1 PK 18 GA
1526 PK 18 GA
THROT RET 2 BK 18 GA
SEN RET B BK 18 GA
THROT POS 2 TN 18 GA
THROT SIG 2 YL 18 GA
THROT 5V 2 PK 18 GA
SEN PWR B GN 18 GA
CRUISE SIG GY 18 GA
1504 GY 18 GA
CRUISE RESUME OR 18 GA
1528 OR 18 GA
CRUISE SET BN 18 GA
1529 BN 18 GA
ENG ECM RTN WH 18 GA
ENG SW RET WH 18 GA
IGN SWITCH
ACC
OFF
IGN/ACC
ST
19 BK 18 GA (ENG START)
18 BN 18 GA (IGNITION)
16 RD 18 GA (BATTERY)
P200
P1
BATT IGN SW BK 14 GA
BATT IGN SW BK 14 GA
FRNT START 1 PU 16 GA
P110
P111
START ENG YL 16 GA
ELEC PANEL


FRAME
BODY
ENGINE
PDU
REAR CONTROL BOX
(ONLY STANDARD BOX SCHEMATIC SHOWN)
P29
181 BK 16 GA
1212LT WH 16 GA
ENG CMPT LGT PWR BK 18 GA
ENG CMPT LGT GND WH 18 GA
S2
S1
LEFT ENG CMPT LT
LH ENG CMPT LGT PWR BK 18 GA
LH ENG CMPT LGT GND WH 18 GA
RH ENG CMPT LGT PWR BK 18 GA
RH ENG CMPT LGT GND WH 18 GA
RIGHT ENG CMPT LT
FAN CLUTCH
P27
FAN BL 18 GA
FAN CL GND WH 18 GA
9
1212 WH 10 GA
P2
1527 OR 18 GA
1514 GN 18 GA
THROT RTN 1
THROT SIG 1
1526 PK 18 GA
SEN RET B BK 18 GA
THROT SIG 2 YL 18 GA
SEN PWR B GN 18 GA
THROT 1 POWER 5V DC
THROTT RTN 2
THROT SIG 2
THROT 2 POWER 5V DC
E-1587(-) LT BL 18 GA
E-1587(+) YL 18 GA
1504 GY 18 GA
1528 OR 18 GA
1529 BN 18 GA
1587 DATA LINK -
1587 DATA LINK +
CRUISE ON/OFF SWITCH
CRUISE RESUME
CRUISE SET
SEE SHEET 1
ENG SW RET WH 18 GA
ENG SWITCH RETURN
(NOT USED)
DIAGNOSTIC SWITCH
E-1939(+) YL 20 GA
E-1939(-) GN 20 GA
1939 DATA LINK +
1939 DATA LINK -
SEE DIAGRAM WRG,J1587 & J1939,D3RE
P5
J1
1001 YL 16 GA
BATT IGN SW BK 14 GA
1102 PK 16 GA
FAN BL 18 GA
START ENG
BATT IGN SW PWR
IGNITION SW
FAN
SEE SHEET 3
P28
B1
GROUND
BATTERY 181 BK 16 GA
J1587(+)
J1587(-)
J1939(+)
J1939(-)
SHIELD
GND WH
BATT PU
ECLT GN
BOX IGN OR
1102 PK
1109 YL
1001 YL
J1939(+) YL
J1939(-) GN
SHIELD WH
J1587(+) YL
J1587(-) BL
D1
DIAGNOSTIC CONNECTOR
STARTER SWITCH
START
ON
OFF
ENGINE COMPARTMENT LIGHT SWITCH
RUN SWITCH
FRT
OFF
REAR
1001 YL
BOX IGN OR
BOX IGN OR
1008 PU


FRAME
PDU
P2D
RETARDER BRAKE RELAY
(OPTIONAL)
103B YL 18 GA
162 YL 18 GA
1231AE WH 18 GA
103A YL 18 GA
BRK SIG A RD 18 GA
CR1
1N4001
CR1 CATHODE
CR1 ANODE
DRL
RELAY
P3E
DRL BATT BK 16 GA
1317 GY 16 GA
ENG RUN RD 18 GA
ECM RET WH 18 GA
PDU/FRAME
INTERFACE 1
(CONNECTS TO
FRAME HARNESS)
J2
NEUTRAL START (+) 18123 TN 16 GA
ABS ELEC IGN 1163 PK 12 GA
RETARDER IND (+) 124A GN 18 GA
HEATED DRAIN VALVE 1181 PK 12 GA
BACK UP LIGHTS 1322 LT BL 16 GA
HEATED FUEL FILTER 1168L PK 12 GA
SHIFT INHIBIT 101 LT BL 18 GA
CURRENT SENSOR 1181C PK 16 GA
ELEC GND 12143B WH 14 GA
SERVICE BRAKE STATUS 162 YL 18 GA
TRANS SIG RETURN 103A YL 18 GA
TRANSMISSION IGNITION 11146E PK 16 GA
TRANSMISSION BATTERY 11136A BK 16 GA
RETARDER IND (-) 124 WH 18 GA
ELEC GND 1206 WH 16 GA
REVERSE SIGNAL (-) 18113 GN 18 GA
BATTERY CLUSTER BATT CLU BK 16 GA
HORN SIG HORN SIG BN 16 GA
BRAKE SIGNAL (+) BRK SIG (+) RD 18 GA
NEUTRAL START
RELAY P3D
GND IGN DO WH 18 GA
1231AK WH 16 GA
18123 TN 16 GA
18114A GN 16 GA
1231AK WH 16 GA
1231BC WH 16 GA
RETARDER LIGHT RELAY
P2C (OPTIONAL)
1133M PK 18 GA
1133L PK 18 GA
124B GN 18 GA
1133L PK 18 GA
1181C PK 16 GA
124 WH 18 GA
1183B BK 10 GA
1183A BK 10 GA
1181A PK 10 GA
1181B PK 10 GA
IGN DO PK 16 GA
1231AL WH 18 GA
OPTIONAL IGNITION K2
75A
BACK-UP LIGHTS
RELAY P3A
1165E BK 16 GA
1133 PK 16 GA
1133K PK 16 GA
1322 LT BL 16 GA
18113 GN 18 GA
HORN P2F
BATT HORN RD 14 GA
BATT HORN A RD 16 GA
HORN BN 14 GA
HORN SIG BN 16 GA
BATT HORN A RD 16 GA
1182A BK 10 GA
1114A PU 12 GA
1114 PU 12 GA
START YL 16 GA
1001 YL 16 GA
18114A GN 16 GA
STARTER K1
75A
556
PDU/FRAME
INTERFACE 2
(CONNECTS TO
FRAME HARNESS)
J1
CLUSTER ELEC IGN 11136G PK 14 GA
HORN HORN BN 14 GA
DRL 1317 GY 16 GA
IGNITION 1133B PK 14 GA
CHASSIS GROUND 1231AJ WH 14 GA
BATT IGN SW PWR BATT IGN SW BK 14 GA
START ENG 1001 YL 16 GA
IGNITION SWITCH 1102 PK 18 GA
SHIFT ENABLE SHIFT ENABLE BK 18 GA
FAN FAN BL 16 GA
REAR BOX BATT BOX BATT BK 16 GA
ENGINE
ENGINE INTERFACE
(CONNECTS TO ENGINE HARNESS)
J3
ENG RUN ENG RUN RD 18 GA
ENG ECM IGN 11136P PK 16 GA
FUEL GND 1206F WH 16 GA
ENG ECM RETURN ECM RET WH 18 GA
IGNITION 1133 PK 16 GA
ENG ECM BATT 1111K BK 12 GA
FUEL SOL PWR FUEL PWR GY 16 GA
ENG ECM BATT 1111M BK 12 GA
VR BATT VR BATT RD 16 GA
STARTER SOLENOID 1114A PU 12 GA
MAF IGN MAF IGN RD 16 GA
CHASSIS GROUND 1231 WH 12 GA
ICD PWR ICD PWR RD 14 GA
FAN (-) FAN(-) WH 18 GA
STARTER SOLENOID 1114 PU 12 GA
FAN CLUTCH FAN CL+ OR 18 GA
FUSE
P1
11136A BK 16 GA
BATT CLU BK 16 GA
VR BATT RD 16 GA
BOX BATT BK 16 GA
11146E PK 16 GA
1163 PK 12 GA
11136G PK 14 GA
11136P PK 16 GA
1168L PK 12 GA
1133B PK 14 GA
FAN PWR RD 16 GA
1181 PK 12 GA
1165D BK 16 GA
BATT IGN SW BK 14 GA
DRL BATT BK 16 GA
1165E BK 16 GA
1111 BK 10 GA
11146 PK 14 GA
11146A PK 14 GA
ECM IGN PK 16 GA
1181A PK 10 GA
1181B PK 10 GA
1165 BK 10 GA
FUSE
P6
1111L BK 12 GA
BATT HORN RD 14 GA
FUEL PWR GY 16 GA
ICD PWR RD 14 GA
MAF IGN RD 16 GA
ELEC BATT BK 10 GA
1182E BK 12 GA
1182F BK 12 GA
11146A PK 14 GA



PDU, Cummins ISL-G

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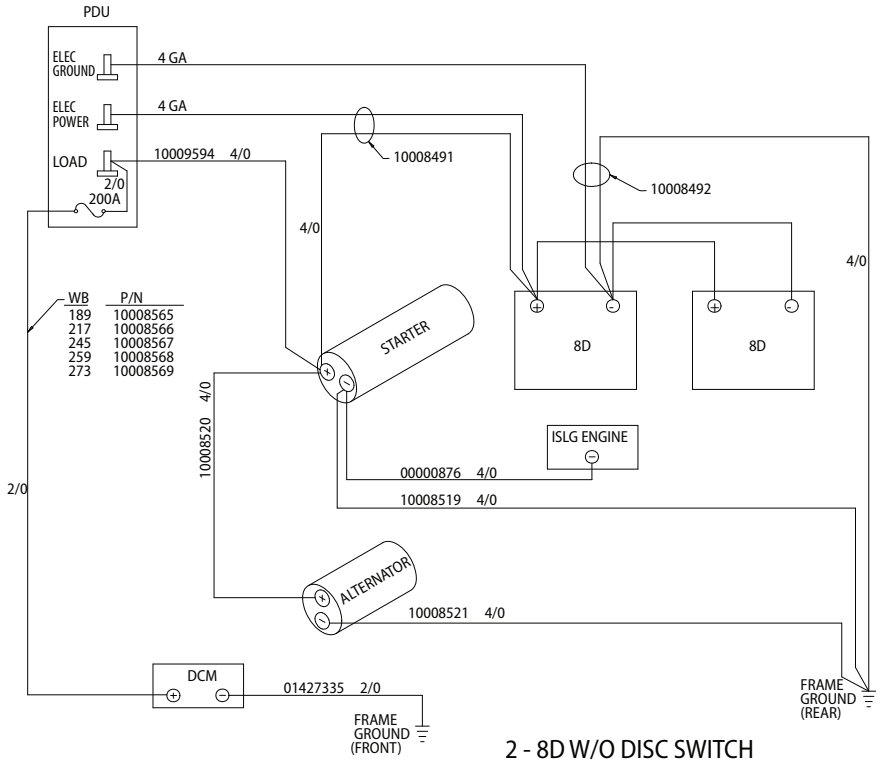
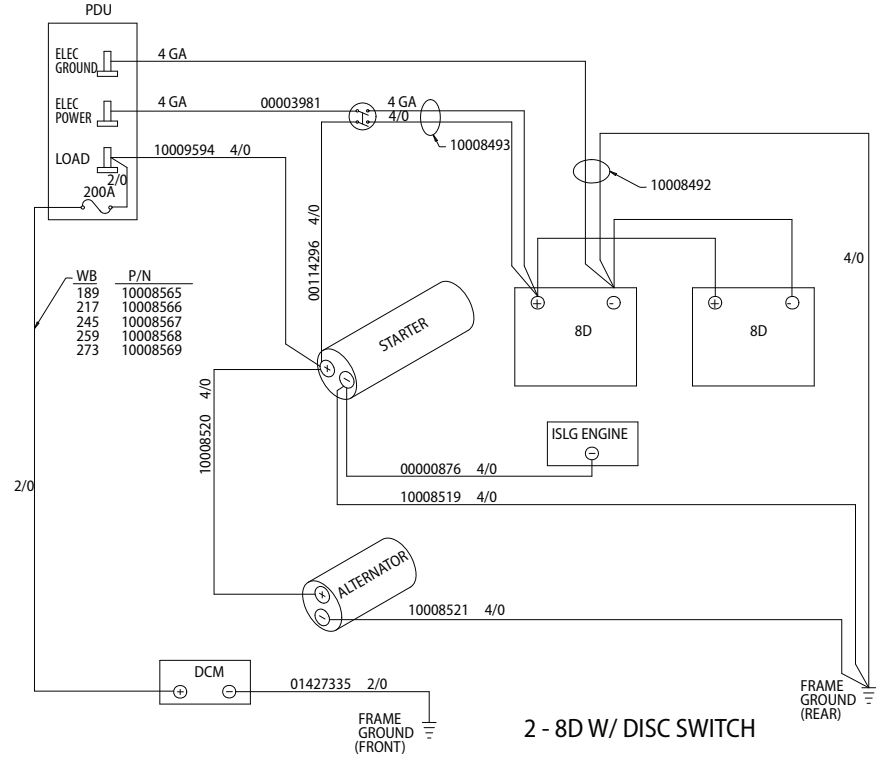
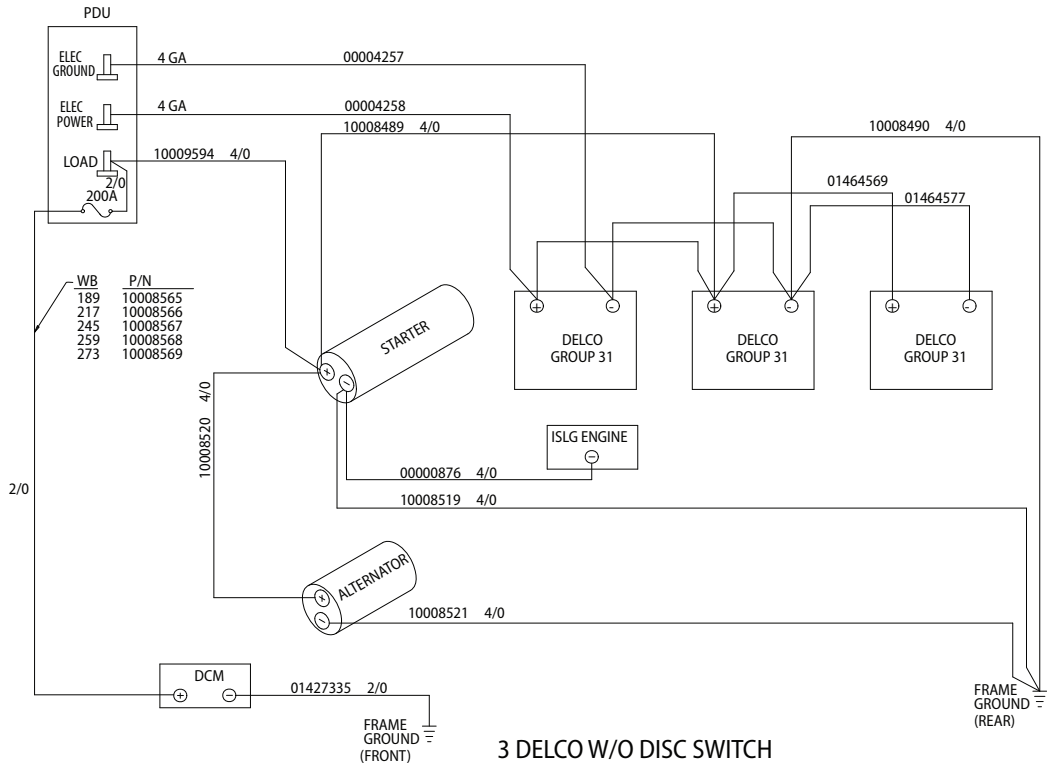
Sheet 1 of 2



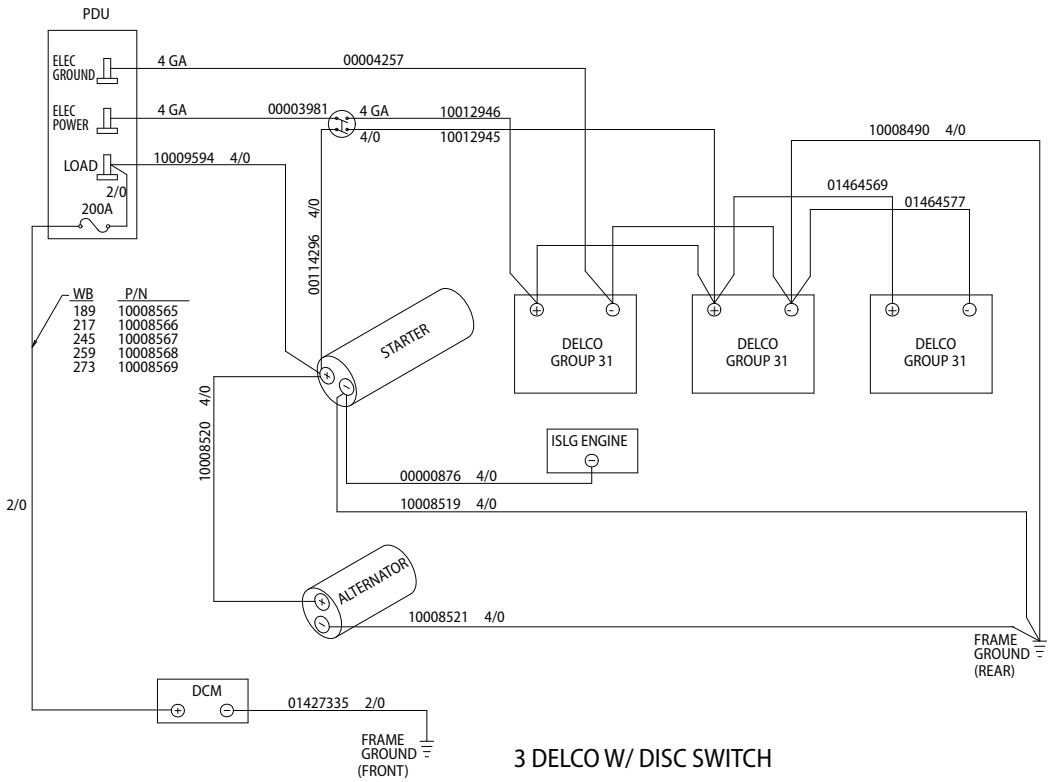
2 - 8D W/O DISC SWITCH



2 - 8D W/ DISC SWITCH



3 DELCO W/O DISC SWITCH



3 DELCO W/ DISC SWITCH

PDU, Cummins ISL-G

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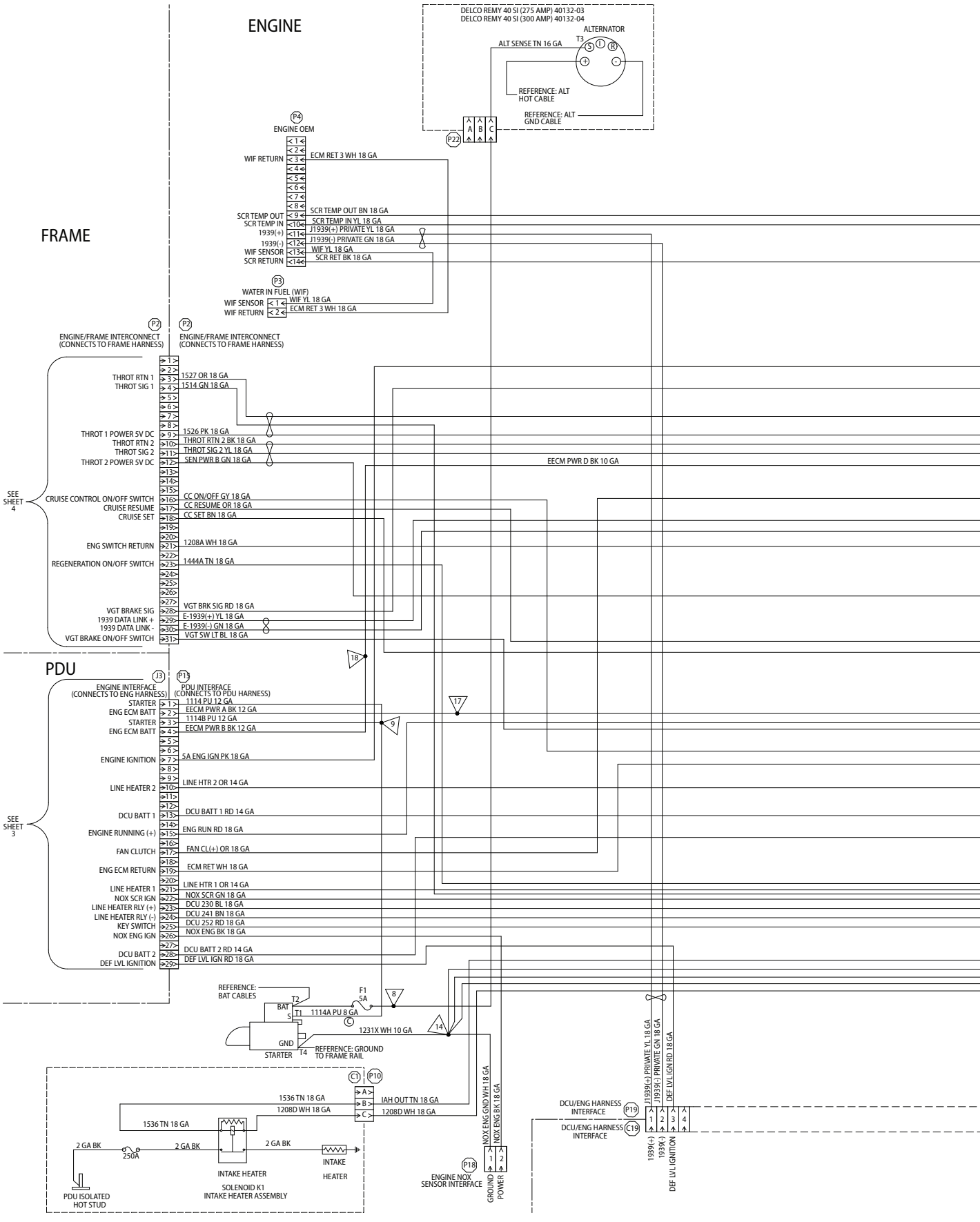
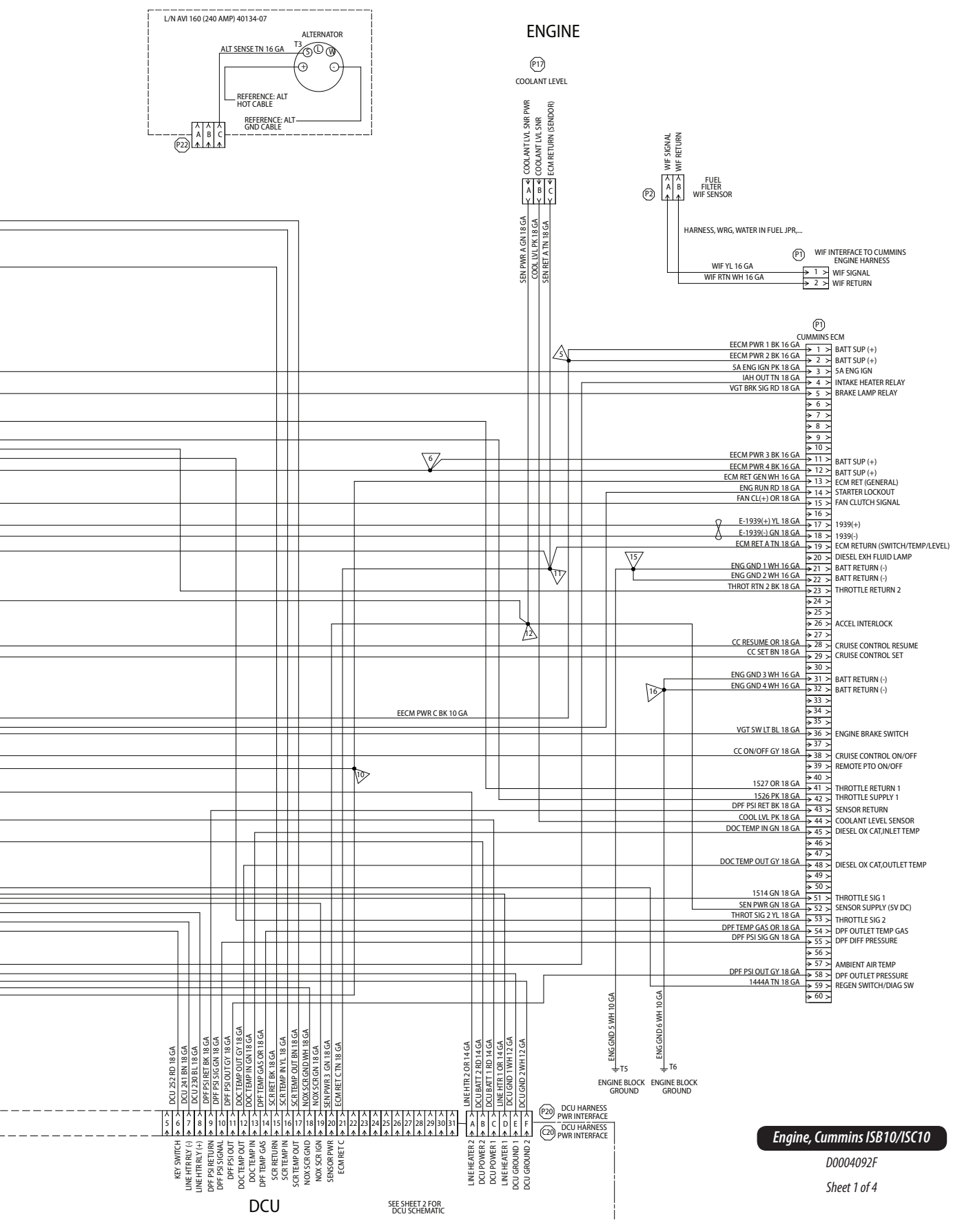

ENGINE
FRAME
PDU
DELCO REMY 40 SI (275 AMP) 40132-03
DELCO REMY 40 SI (300 AMP) 40132-04
ALTERNATOR
ALT SENSE TN 16 GA
REFERENCE: ALT HOT CABLE
REFERENCE: ALT GND CABLE
ENGINE OEM
WIF RETURN
ECM RET 3 WH 18 GA
SCR TEMP OUT
SCR TEMP IN
1939(+)
1939(-)
WIF SENSOR
SCR RETURN
SCR TEMP OUT BN 18 GA
SCR TEMP IN YL 18 GA
J1939(+) PRIVATE YL 18 GA
J1939(-) PRIVATE GN 18 GA
WIF YL 18 GA
SCR RET BK 18 GA
WATER IN FUEL (WIF)
WIF SENSOR
WIF RETURN
ENGINE/FRAME INTERCONNECT (CONNECTS TO FRAME HARNESS)
THROT RTN 1
THROT SIG 1
THROT 1 POWER 5V DC
THROT RTN 2
THROT SIG 2
THROT 2 POWER 5V DC
1527 OR 18 GA
1514 GN 18 GA
1526 PK 18 GA
THROT RTN 2 BK 18 GA
THROT SIG 2 YL 18 GA
SEN PWR B GN 18 GA
EECM PWR D BK 10 GA
SEE SHEET 4
CRUISE CONTROL ON/OFF SWITCH
CRUISE RESUME
CRUISE SET
CC ON/OFF GY 18 GA
CC RESUME OR 18 GA
CC SET BN 18 GA
ENG SWITCH RETURN
1208A WH 18 GA
REGENERATION ON/OFF SWITCH
1444A TN 18 GA
VGT BRAKE SIG
1939 DATA LINK +
1939 DATA LINK -
VGT BRAKE ON/OFF SWITCH
VGT BRK SIG RD 18 GA
E-1939(+) YL 18 GA
E-1939(-) GN 18 GA
VGT SW LT BL 18 GA
ENGINE INTERFACE (CONNECTS TO ENG HARNESS)
PDU INTERFACE (CONNECTS TO PDU HARNESS)
STARTER
ENG ECM BATT
STARTER
ENG ECM BATT
1114 PU 12 GA
EECM PWR A BK 12 GA
1114B PU 12 GA
EECM PWR B BK 12 GA
ENGINE IGNITION
5A ENG IGN PK 18 GA
LINE HEATER 2
LINE HTR 2 OR 14 GA
SEE SHEET 3
DCU BATT 1
ENGINE RUNNING (+)
DCU BATT 1 RD 14 GA
ENG RUN RD 18 GA
FAN CLUTCH
FAN CL(+) OR 18 GA
ENG ECM RETURN
ECM RET WH 18 GA
LINE HEATER 1
NOX SCR IGN
LINE HEATER RLY (+)
LINE HEATER RLY (-)
KEY SWITCH
NOX ENG IGN
LINE HTR 1 OR 14 GA
NOX SCR GN 18 GA
DCU 230 BL 18 GA
DCU 241 BN 18 GA
DCU 252 RD 18 GA
NOX ENG BK 18 GA
DCU BATT 2
DEF LVL IGNITION
DCU BATT 2 RD 14 GA
DEF LVL IGN RD 18 GA
REFERENCE: BAT CABLES
BAT
S
GND
STARTER
T1
T2
T4
1114A PU 8 GA
F1 5A
1231X WH 10 GA
REFERENCE: GROUND TO FRAME RAIL
1536 TN 18 GA
1208D WH 18 GA
IAH OUT TN 18 GA
1208D WH 18 GA
1536 TN 18 GA
2 GA BK
250A
2 GA BK
2 GA BK
INTAKE HEATER
INTAKE HEATER
SOLENOID K1
INTAKE HEATER ASSEMBLY
PDU ISOLATED HOT STUD
NOX ENG GND WH 18 GA
NOX ENG BK 18 GA
GROUND
POWER
ENGINE NOX SENSOR INTERFACE
DCU/ENG HARNESS INTERFACE
DCU/ENG HARNESS INTERFACE
1939(+)
1939(-)
DEF LVL IGNITION
J1939(+) PRIVATE YL 18 GA
J1939(-) PRIVATE GN 18 GA
DEF LVL IGN RD 18 GA



Engine, Cummins ISB10/ISC10

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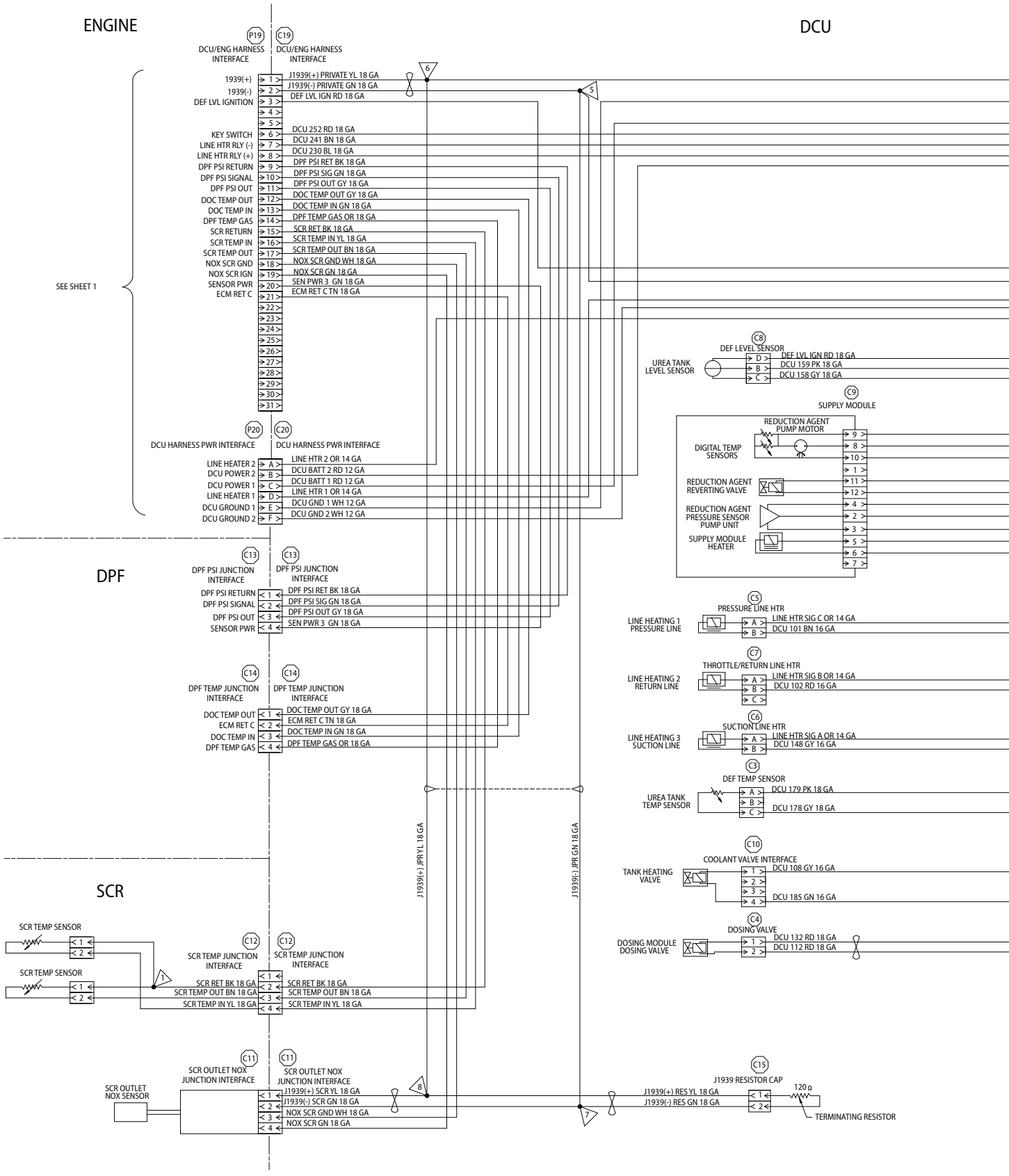
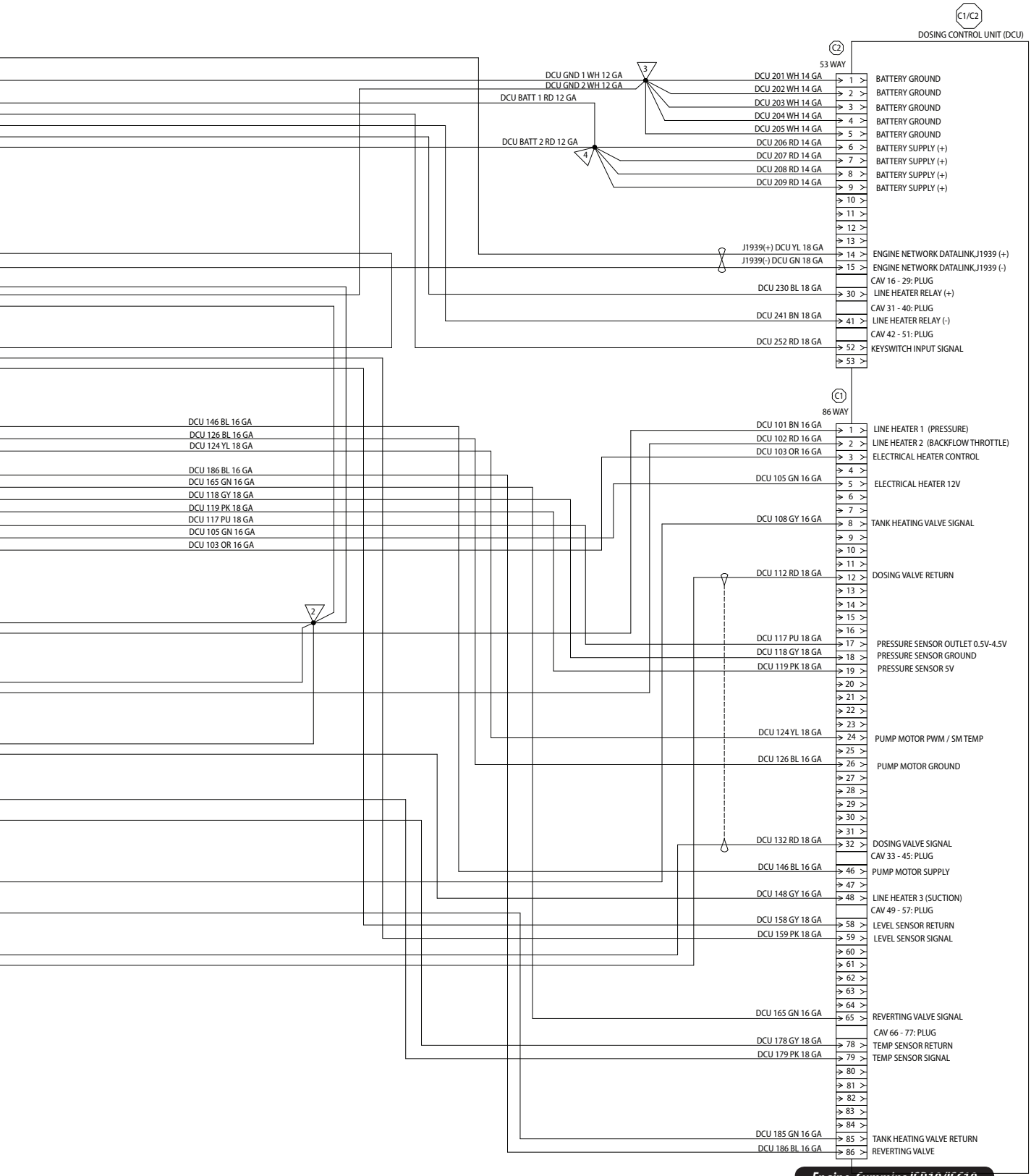
Sheet 1 of 4


ENGINE
DCU
DPF
SCR
P19
C19
DCU/ENG HARNESS INTERFACE
DCU/ENG HARNESS INTERFACE
1939(+)
1939(-)
DEF LVL IGNITION
KEY SWITCH
LINE HTR RLY (-)
LINE HTR RLY (+)
DPF PSI RETURN
DPF PSI SIGNAL
DPF PSI OUT
DOC TEMP OUT
DOC TEMP IN
DPF TEMP GAS
SCR RETURN
SCR TEMP IN
SCR TEMP OUT
NOX SCR GND
NOX SCR IGN
SENSOR PWR
ECM RET C
SEE SHEET 1
J1939(+) PRIVATE YL 18 GA
J1939(-) PRIVATE GN 18 GA
DEF LVL IGN RD 18 GA
DCU 252 RD 18 GA
DCU 241 BN 18 GA
DCU 230 BL 18 GA
DPF PSI RET BK 18 GA
DPF PSI SIG GN 18 GA
DPF PSI OUT GY 18 GA
DOC TEMP OUT GY 18 GA
DOC TEMP IN GN 18 GA
DPF TEMP GAS OR 18 GA
SCR RET BK 18 GA
SCR TEMP IN YL 18 GA
SCR TEMP OUT BN 18 GA
NOX SCR GND WH 18 GA
NOX SCR GN 18 GA
SEN PWR 3 GN 18 GA
ECM RET C TN 18 GA
P20
C20
DCU HARNESS PWR INTERFACE
DCU HARNESS PWR INTERFACE
LINE HEATER 2
DCU POWER 2
DCU POWER 1
LINE HEATER 1
DCU GROUND 1
DCU GROUND 2
LINE HTR 2 OR 14 GA
DCU BATT 2 RD 12 GA
DCU BATT 1 RD 12 GA
LINE HTR 1 OR 14 GA
DCU GND 1 WH 12 GA
DCU GND 2 WH 12 GA
C8
DEF LEVEL SENSOR
UREA TANK LEVEL SENSOR
DEF LVL IGN RD 18 GA
DCU 159 PK 18 GA
DCU 158 GY 18 GA
C9
SUPPLY MODULE
REDUCTION AGENT PUMP MOTOR
DIGITAL TEMP SENSORS
REDUCTION AGENT REVERTING VALVE
REDUCTION AGENT PRESSURE SENSOR PUMP UNIT
SUPPLY MODULE HEATER
C13
C13
DPF PSI JUNCTION INTERFACE
DPF PSI JUNCTION INTERFACE
DPF PSI RETURN
DPF PSI SIGNAL
DPF PSI OUT
SENSOR PWR
DPF PSI RET BK 18 GA
DPF PSI SIG GN 18 GA
DPF PSI OUT GY 18 GA
SEN PWR 3 GN 18 GA
C14
C14
DPF TEMP JUNCTION INTERFACE
DPF TEMP JUNCTION INTERFACE
DOC TEMP OUT
ECM RET C
DOC TEMP IN
DPF TEMP GAS
DOC TEMP OUT GY 18 GA
ECM RET C TN 18 GA
DOC TEMP IN GN 18 GA
DPF TEMP GAS OR 18 GA
C5
PRESSURE LINE HTR
LINE HEATING 1 PRESSURE LINE
LINE HTR SIG C OR 14 GA
DCU 101 BN 16 GA
C7
THROTTLE/RETURN LINE HTR
LINE HEATING 2 RETURN LINE
LINE HTR SIG B OR 14 GA
DCU 102 RD 16 GA
C6
SUCTION LINE HTR
LINE HEATING 3 SUCTION LINE
LINE HTR SIG A OR 14 GA
DCU 148 GY 16 GA
C3
DEF TEMP SENSOR
UREA TANK TEMP SENSOR
DCU 179 PK 18 GA
DCU 178 GY 18 GA
C10
COOLANT VALVE INTERFACE
TANK HEATING VALVE
DCU 108 GY 16 GA
DCU 185 GN 16 GA
C4
DOSING VALVE
DOSING MODULE DOSING VALVE
DCU 132 RD 18 GA
DCU 112 RD 18 GA
J1939(+) JPR YL 18 GA
J1939(-) JPR GN 18 GA
SCR TEMP SENSOR
SCR TEMP SENSOR
C12
C12
SCR TEMP JUNCTION INTERFACE
SCR TEMP JUNCTION INTERFACE
SCR RET BK 18 GA
SCR TEMP OUT BN 18 GA
SCR TEMP IN YL 18 GA
C11
C11
SCR OUTLET NOX JUNCTION INTERFACE
SCR OUTLET NOX JUNCTION INTERFACE
SCR OUTLET NOX SENSOR
J1939(+) SCR YL 18 GA
J1939(-) SCR GN 18 GA
NOX SCR GND WH 18 GA
NOX SCR GN 18 GA
C15
J1939 RESISTOR CAP
J1939(+) RES YL 18 GA
J1939(-) RES GN 18 GA
120 Ω
TERMINATING RESISTOR



Engine, Cummins ISB10/ISC10

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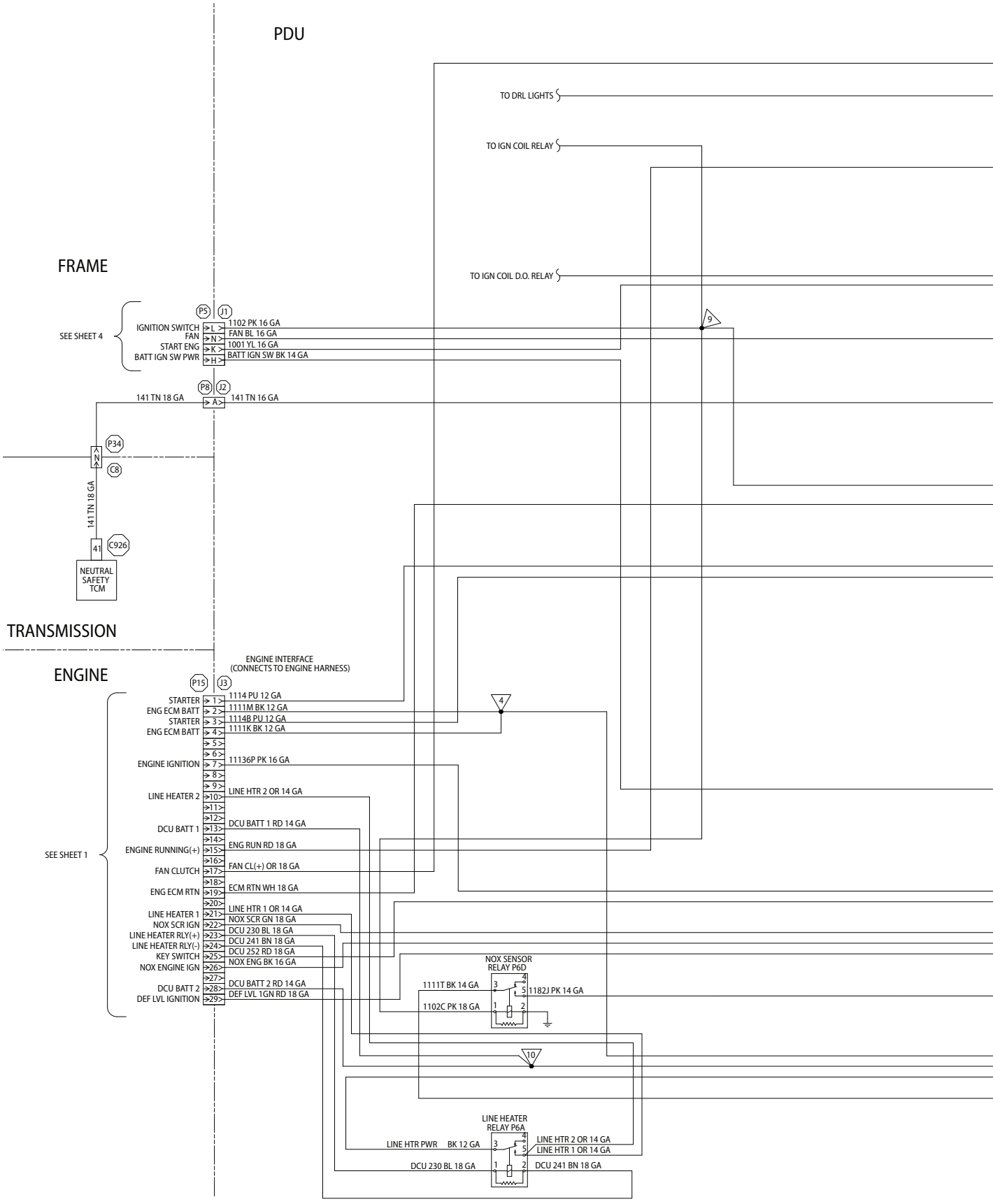
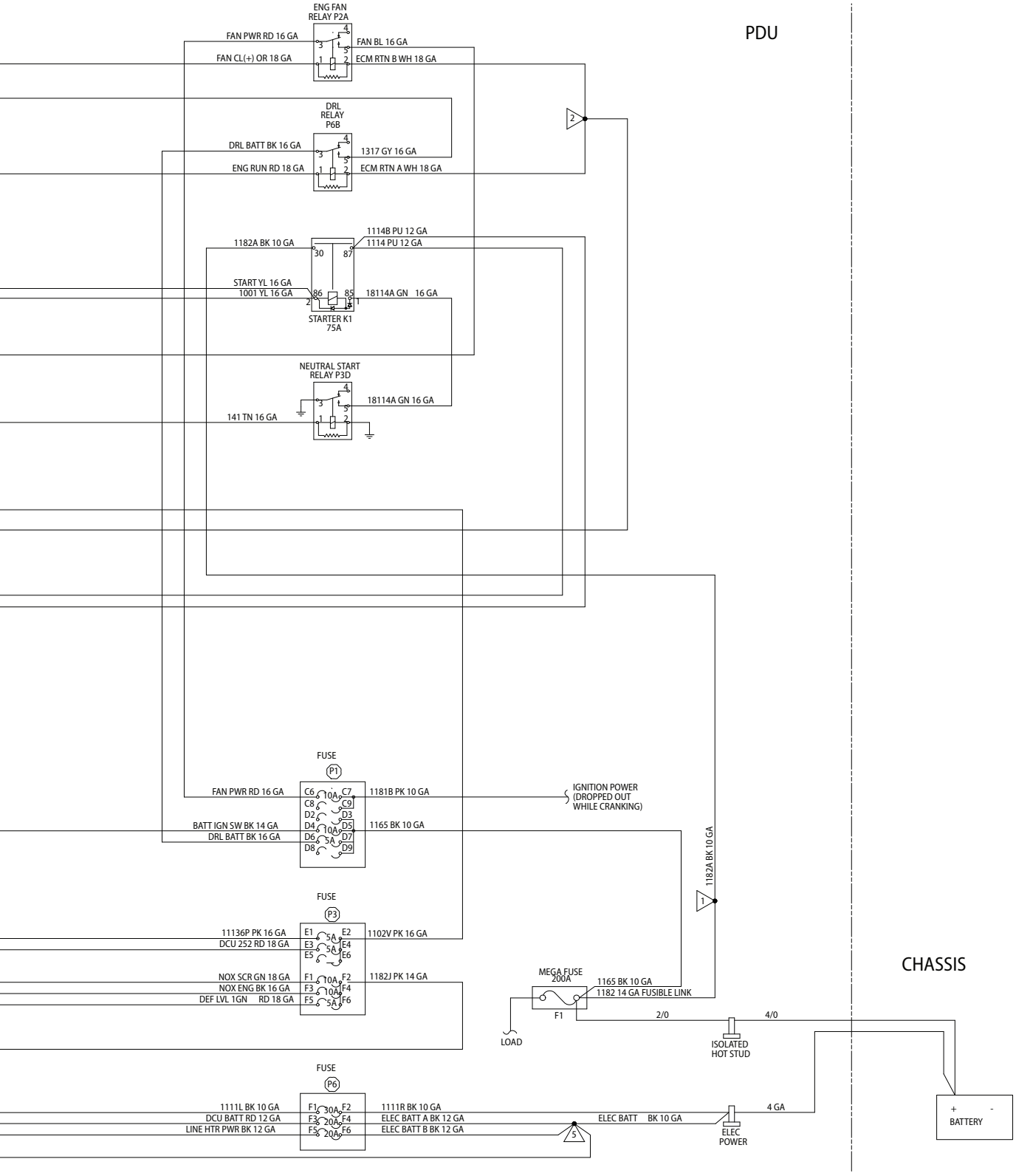
Sheet 2 of 4


PDU
TO DRL LIGHTS
TO IGN COIL RELAY
TO IGN COIL D.O. RELAY
FRAME
SEE SHEET 4
P5
J1
IGNITION SWITCH
FAN
START ENG
BATT IGN SW PWR
1102 PK 16 GA
FAN BL 16 GA
1001 YL 16 GA
BATT IGN SW BK 14 GA
P8
J2
141 TN 18 GA
141 TN 16 GA
P34
C8
141 TN 18 GA
41
C926
NEUTRAL SAFETY TCM
TRANSMISSION
ENGINE
ENGINE INTERFACE
(CONNECTS TO ENGINE HARNESS)
P15
J3
SEE SHEET 1
STARTER
ENG ECM BATT
STARTER
ENG ECM BATT
1114 PU 12 GA
1111M BK 12 GA
1114B PU 12 GA
1111K BK 12 GA
ENGINE IGNITION
11136P PK 16 GA
LINE HEATER 2
LINE HTR 2 OR 14 GA
DCU BATT 1
DCU BATT 1 RD 14 GA
ENGINE RUNNING(+)
ENG RUN RD 18 GA
FAN CLUTCH
FAN CL(+) OR 18 GA
ENG ECM RTN
ECM RTN WH 18 GA
LINE HEATER 1
NOX SCR IGN
LINE HEATER RLY(+)
LINE HEATER RLY(-)
KEY SWITCH
NOX ENGINE IGN
LINE HTR 1 OR 14 GA
NOX SCR GN 18 GA
DCU 230 BL 18 GA
DCU 241 BN 18 GA
DCU 252 RD 18 GA
NOX ENG BK 16 GA
DCU BATT 2
DEF LVL IGNITION
DCU BATT 2 RD 14 GA
DEF LVL 1GN RD 18 GA
NOX SENSOR RELAY P6D
1111T BK 14 GA
1182J PK 14 GA
1102C PK 18 GA
LINE HEATER RELAY P6A
LINE HTR PWR BK 12 GA
LINE HTR 2 OR 14 GA
LINE HTR 1 OR 14 GA
DCU 230 BL 18 GA
DCU 241 BN 18 GA



Engine, Cummins ISB10/ISC10

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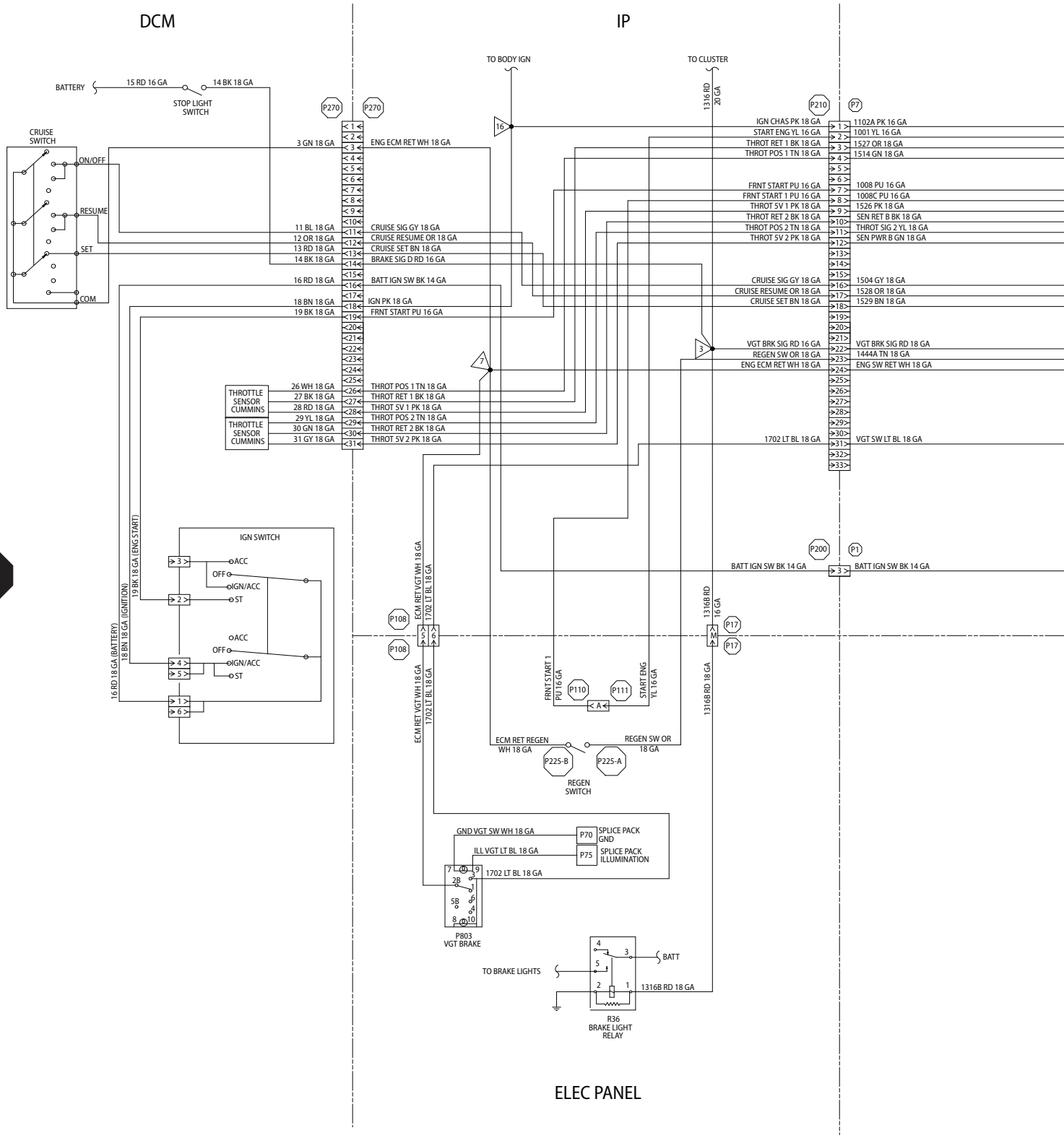
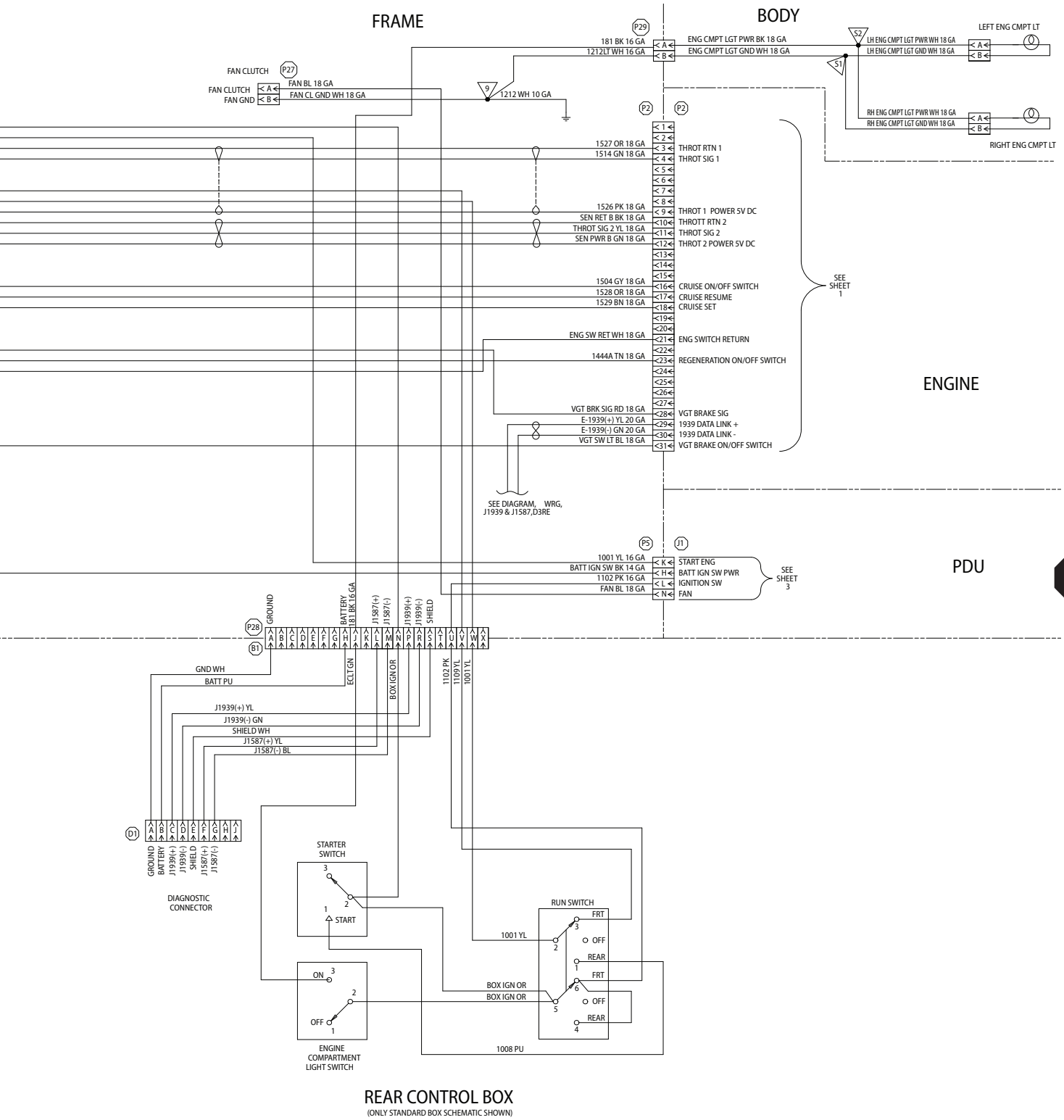
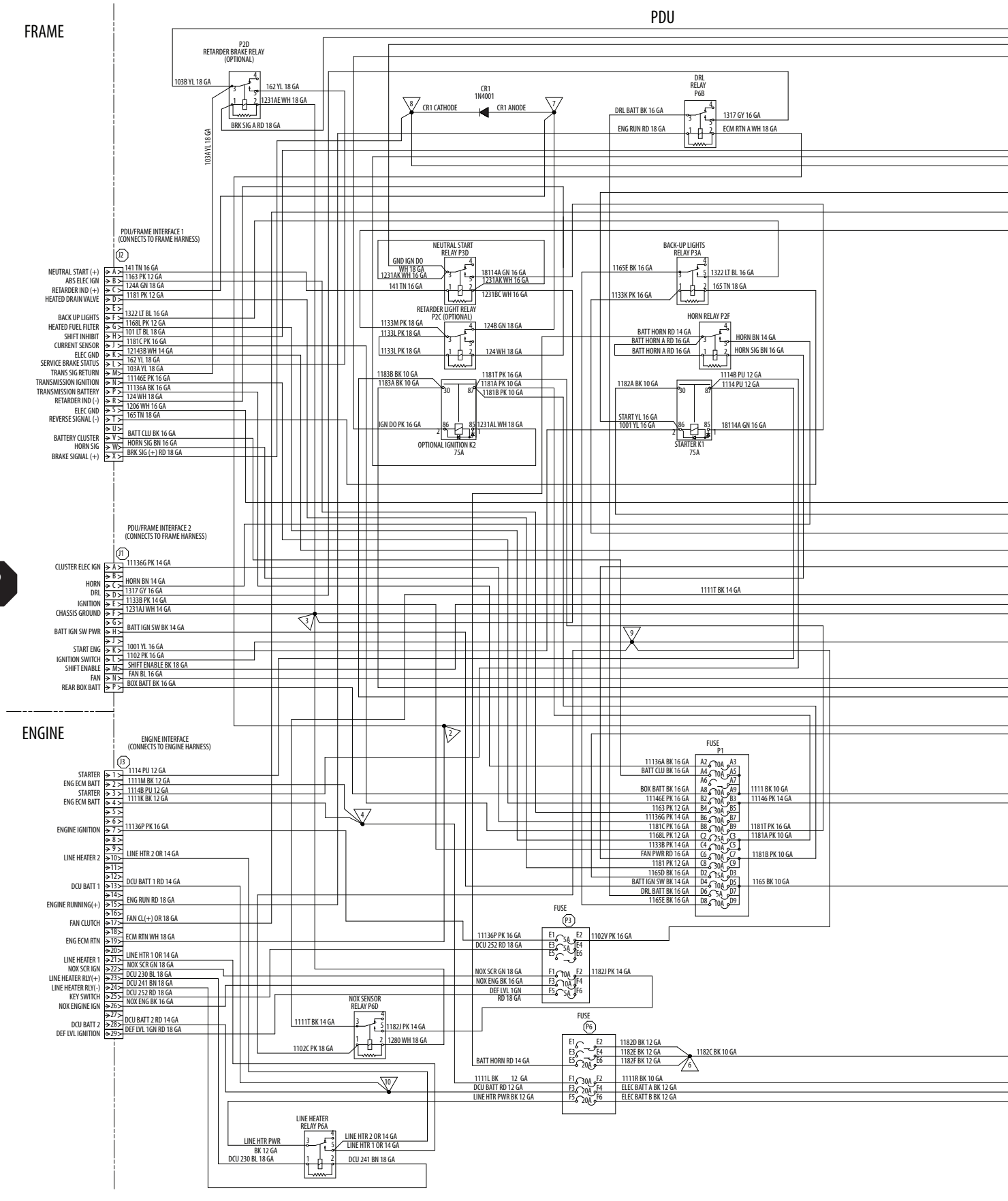
Sheet 3 of 4

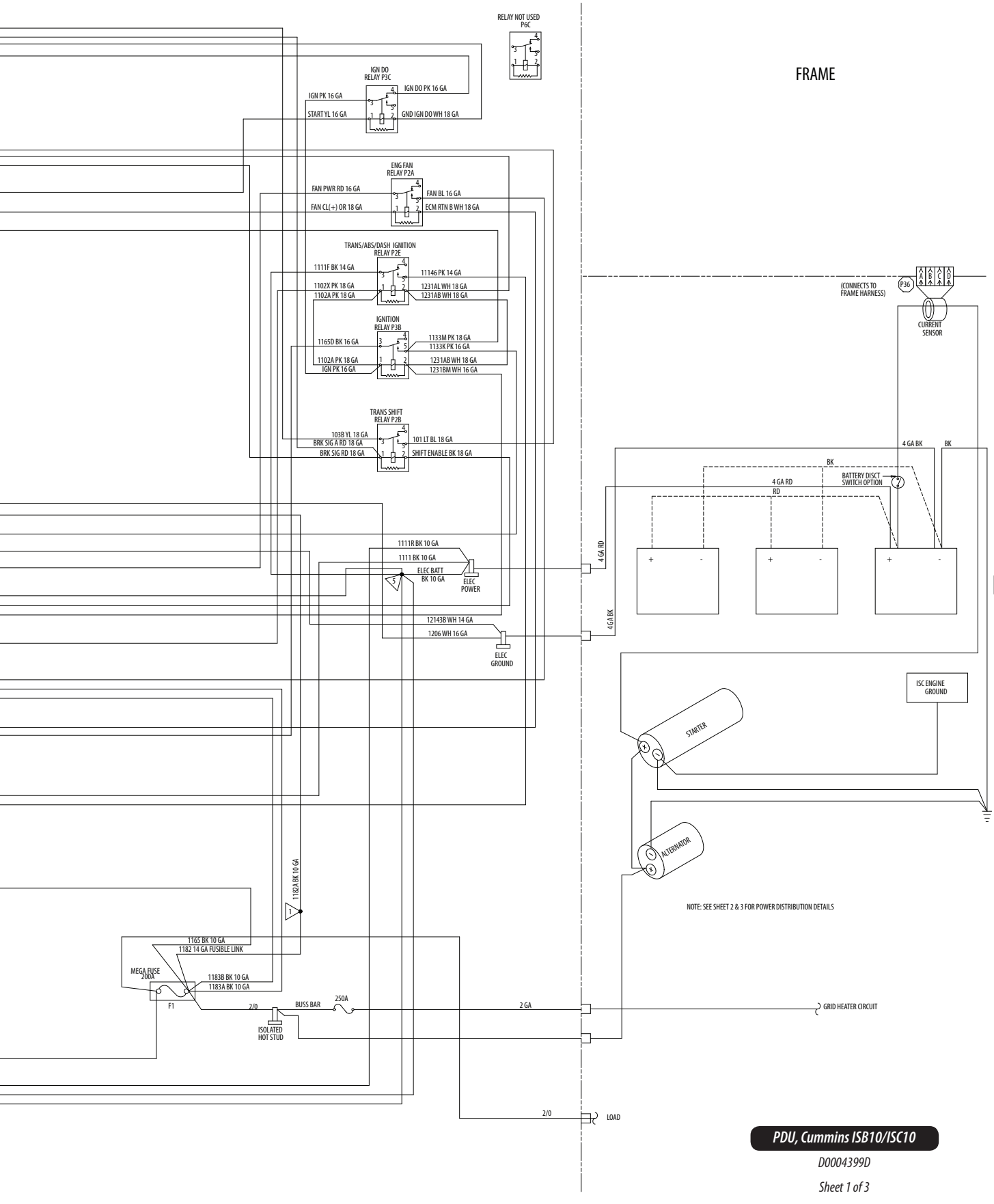

DCM
IP
TO BODY IGN
TO CLUSTER
BATTERY
15 RD 16 GA
14 BK 18 GA
STOP LIGHT SWITCH
CRUISE SWITCH
ON/OFF
RESUME
SET
COM
P270
P210
P7
3 GN 18 GA
ENG ECM RET WH 18 GA
11 BL 18 GA
CRUISE SIG GY 18 GA
12 OR 18 GA
CRUISE RESUME OR 18 GA
13 RD 18 GA
CRUISE SET BN 18 GA
14 BK 18 GA
BRAKE SIG D RD 16 GA
16 RD 18 GA
BATT IGN SW BK 14 GA
18 BN 18 GA
IGN PK 18 GA
19 BK 18 GA
FRNT START PU 16 GA
IGN CHAS PK 18 GA
1102A PK 16 GA
START ENG YL 16 GA
1001 YL 16 GA
THROT RET 1 BK 18 GA
1527 OR 18 GA
THROT POS 1 TN 18 GA
1514 GN 18 GA
FRNT START PU 16 GA
1008 PU 16 GA
FRNT START 1 PU 16 GA
1008C PU 16 GA
THROT 5V 1 PK 18 GA
1526 PK 18 GA
THROT RET 2 BK 18 GA
SEN RET B BK 18 GA
THROT POS 2 TN 18 GA
THROT SIG 2 YL 18 GA
THROT 5V 2 PK 18 GA
SEN PWR B GN 18 GA
CRUISE SIG GY 18 GA
1504 GY 18 GA
CRUISE RESUME OR 18 GA
1528 OR 18 GA
CRUISE SET BN 18 GA
1529 BN 18 GA
VGT BRK SIG RD 16 GA
VGT BRK SIG RD 18 GA
REGEN SW OR 18 GA
1444A TN 18 GA
ENG ECM RET WH 18 GA
ENG SW RET WH 18 GA
THROTTLE SENSOR CUMMINS
26 WH 18 GA
THROT POS 1 TN 18 GA
27 BK 18 GA
THROT RET 1 BK 18 GA
28 RD 18 GA
THROT 5V 1 PK 18 GA
29 YL 18 GA
THROT POS 2 TN 18 GA
THROTTLE SENSOR CUMMINS
30 GN 18 GA
THROT RET 2 BK 18 GA
31 GY 18 GA
THROT 5V 2 PK 18 GA
1702 LT BL 18 GA
VGT SW LT BL 18 GA
IGN SWITCH
ACC
OFF
IGN/ACC
ST
16 RD 18 GA (BATTERY)
18 BN 18 GA (IGNITION)
19 BK 18 GA (ENG START)
P200
P1
BATT IGN SW BK 14 GA
P108
ECM RET VGT WH 18 GA
1702 LT BL 18 GA
1316B RD 16 GA
P17
FRNT START 1 PU 16 GA
START ENG YL 16 GA
P110
P111
1316B RD 18 GA
ECM RET REGEN WH 18 GA
REGEN SW OR 18 GA
P225-B
P225-A
REGEN SWITCH
GND VGT SW WH 18 GA
P70
SPLICE PACK GND
ILL VGT LT BL 18 GA
P75
SPLICE PACK ILLUMINATION
1702 LT BL 18 GA
P803
VGT BRAKE
TO BRAKE LIGHTS
BATT
1316B RD 18 GA
R36
BRAKE LIGHT RELAY
ELEC PANEL



REAR CONTROL BOX

(ONLY STANDARD BOX SCHEMATIC SHOWN)


FRAME
PDU
ENGINE
P2D RETARDER BRAKE RELAY (OPTIONAL)
103B YL 18 GA
162 YL 18 GA
1231AE WH 18 GA
BRK SIG A RD 18 GA
103A YL 18 GA
CR1 1N4001
CR1 CATHODE
CR1 ANODE
DRL RELAY P6B
DRL BATT BK 16 GA
1317 GY 16 GA
ENG RUN RD 18 GA
ECM RTN A WH 18 GA
PDU/FRAME INTERFACE 1 (CONNECTS TO FRAME HARNESS)
J2
NEUTRAL START (+)
ABS ELEC IGN
RETARDER IND (+)
HEATED DRAIN VALVE
BACK UP LIGHTS
HEATED FUEL FILTER
SHIFT INHIBIT
CURRENT SENSOR
ELEC GND
SERVICE BRAKE STATUS
TRANS SIG RETURN
TRANSMISSION IGNITION
TRANSMISSION BATTERY
RETARDER IND (-)
ELEC GND
REVERSE SIGNAL (-)
BATTERY CLUSTER
HORN SIG
BRAKE SIGNAL (+)
141 TN 16 GA
1163 PK 12 GA
124A GN 18 GA
1181 PK 12 GA
1322 LT BL 16 GA
1168L PK 12 GA
101 LT BL 18 GA
1181C PK 16 GA
12143B WH 14 GA
162 YL 18 GA
103A YL 18 GA
11146E PK 16 GA
11136A BK 16 GA
124 WH 18 GA
1206 WH 16 GA
165 TN 18 GA
BATT CLU BK 16 GA
HORN SIG BN 16 GA
BRK SIG (+) RD 18 GA
NEUTRAL START RELAY P3D
GND IGN DO
WH 18 GA
1231AK WH 16 GA
141 TN 16 GA
18114A GN 16 GA
1231AK WH 16 GA
1231BC WH 16 GA
RETARDER LIGHT RELAY P2C (OPTIONAL)
1133M PK 18 GA
1133L PK 18 GA
124B GN 18 GA
124 WH 18 GA
1183B BK 10 GA
1183A BK 10 GA
1181T PK 16 GA
1181A PK 10 GA
1181B PK 10 GA
IGN DO PK 16 GA
1231AL WH 18 GA
OPTIONAL IGNITION K2 75A
BACK-UP LIGHTS RELAY P3A
1165E BK 16 GA
1322 LT BL 16 GA
1133K PK 16 GA
165 TN 18 GA
HORN RELAY P2F
BATT HORN RD 14 GA
BATT HORN A RD 16 GA
BATT HORN A RD 16 GA
HORN BN 14 GA
HORN SIG BN 16 GA
1114B PU 12 GA
1114 PU 12 GA
1182A BK 10 GA
START YL 16 GA
1001 YL 16 GA
18114A GN 16 GA
STARTER K1 75A
PDU/FRAME INTERFACE 2 (CONNECTS TO FRAME HARNESS)
J1
CLUSTER ELEC IGN
HORN
DRL
IGNITION
CHASSIS GROUND
BATT IGN SW PWR
START ENG
IGNITION SWITCH
SHIFT ENABLE
FAN
REAR BOX BATT
11136G PK 14 GA
HORN BN 14 GA
1317 GY 16 GA
1133B PK 14 GA
1231AJ WH 14 GA
BATT IGN SW BK 14 GA
1001 YL 16 GA
1102 PK 16 GA
SHIFT ENABLE BK 18 GA
FAN BL 16 GA
BOX BATT BK 16 GA
1111T BK 14 GA
ENGINE INTERFACE (CONNECTS TO ENGINE HARNESS)
J3
STARTER
ENG ECM BATT
STARTER
ENG ECM BATT
ENGINE IGNITION
LINE HEATER 2
DCU BATT 1
ENGINE RUNNING(+)
FAN CLUTCH
ENG ECM RTN
LINE HEATER 1
NOX SCR IGN
LINE HEATER RLY(+)
KEY SWITCH
NOX ENGINE IGN
DCU BATT 2
DEF LVL IGNITION
1114 PU 12 GA
1111M BK 12 GA
1114B PU 12 GA
1111K BK 12 GA
11136P PK 16 GA
LINE HTR 2 OR 14 GA
DCU BATT 1 RD 14 GA
ENG RUN RD 18 GA
FAN CL(+) OR 18 GA
ECM RTN WH 18 GA
LINE HTR 1 OR 14 GA
NOX SCR GN 18 GA
DCU 230 BL 18 GA
DCU 241 BN 18 GA
DCU 252 RD 18 GA
NOX ENG BK 16 GA
DCU BATT 2 RD 14 GA
DEF LVL 1GN RD 18 GA
FUSE P1
11136A BK 16 GA
BATT CLU BK 16 GA
BOX BATT BK 16 GA
11146E PK 16 GA
1163 PK 12 GA
11136G PK 14 GA
1181C PK 16 GA
1168L PK 12 GA
1133B PK 14 GA
FAN PWR RD 16 GA
1181 PK 12 GA
1165D BK 16 GA
BATT IGN SW BK 14 GA
DRL BATT BK 16 GA
1165E BK 16 GA
1111 BK 10 GA
11146 PK 14 GA
1181T PK 16 GA
1181A PK 10 GA
1181B PK 10 GA
1165 BK 10 GA
FUSE P3
11136P PK 16 GA
DCU 252 RD 18 GA
1102V PK 16 GA
NOX SCR GN 18 GA
NOX ENG BK 16 GA
DEF LVL 1GN RD 18 GA
1182J PK 14 GA
NOX SENSOR RELAY P6D
1111T BK 14 GA
1102C PK 18 GA
1182J PK 14 GA
1280 WH 18 GA
FUSE P6
BATT HORN RD 14 GA
1182D BK 12 GA
1182E BK 12 GA
1182F BK 12 GA
1182C BK 10 GA
1111L BK 12 GA
DCU BATT RD 12 GA
LINE HTR PWR BK 12 GA
1111R BK 10 GA
ELEC BATT A BK 12 GA
ELEC BATT B BK 12 GA
LINE HEATER RELAY P6A
LINE HTR PWR BK 12 GA
DCU 230 BL 18 GA
LINE HTR 2 OR 14 GA
LINE HTR 1 OR 14 GA
DCU 241 BN 18 GA



PDU, Cummins ISB10/ISC10

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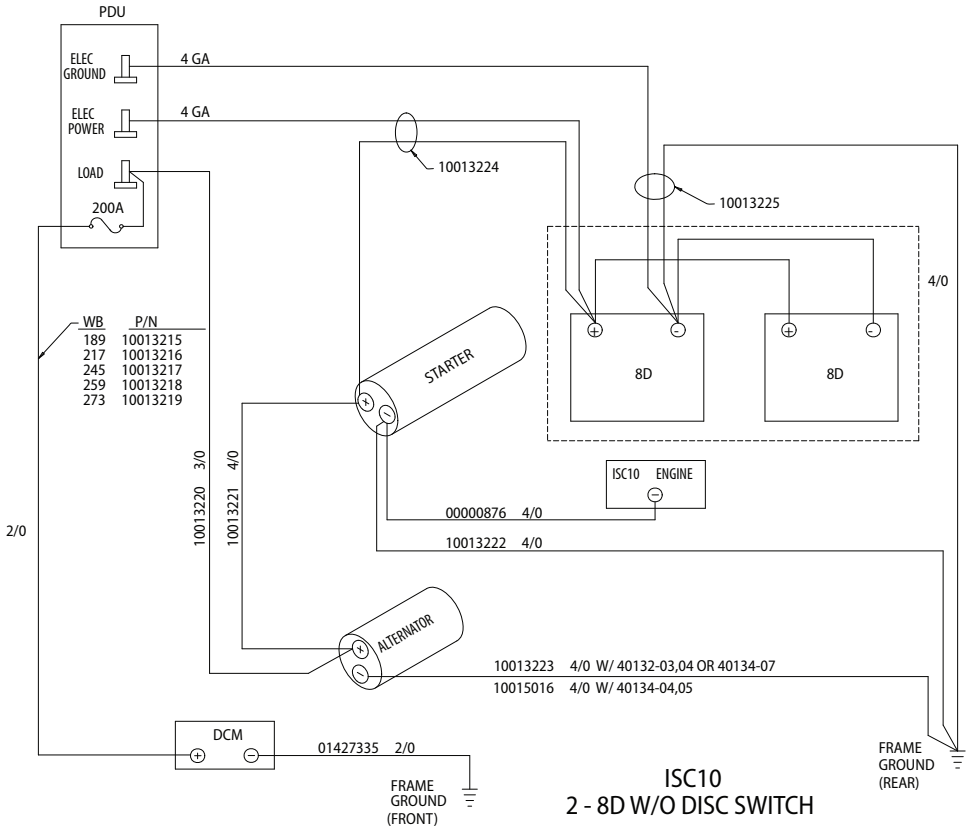
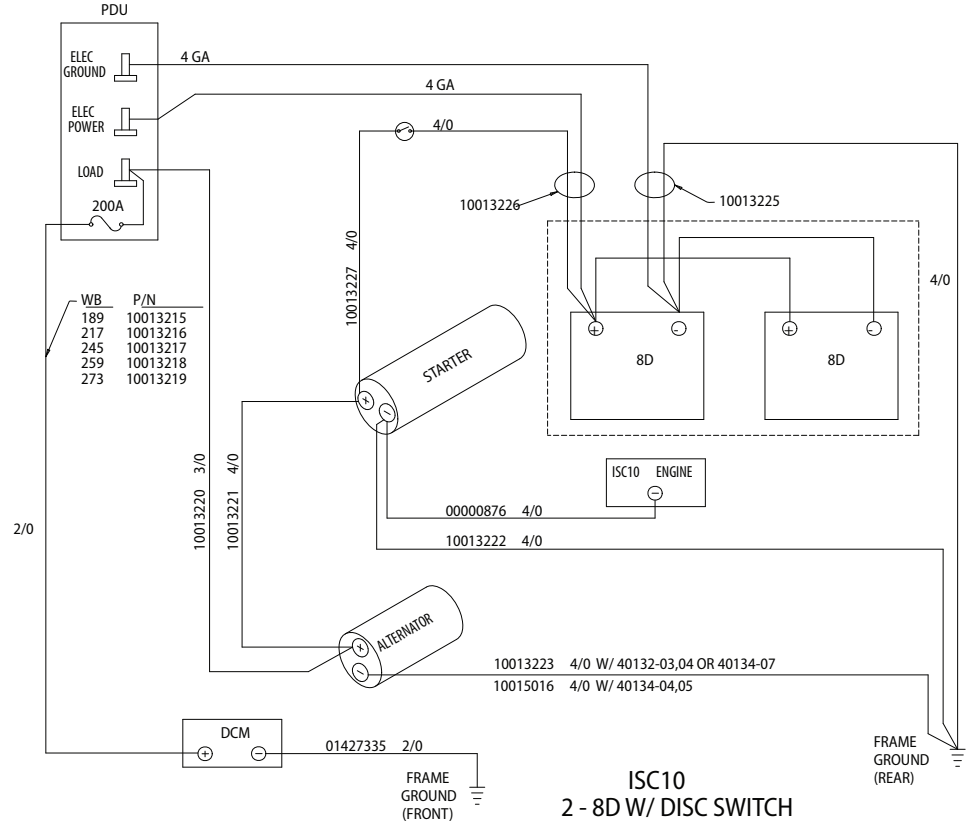
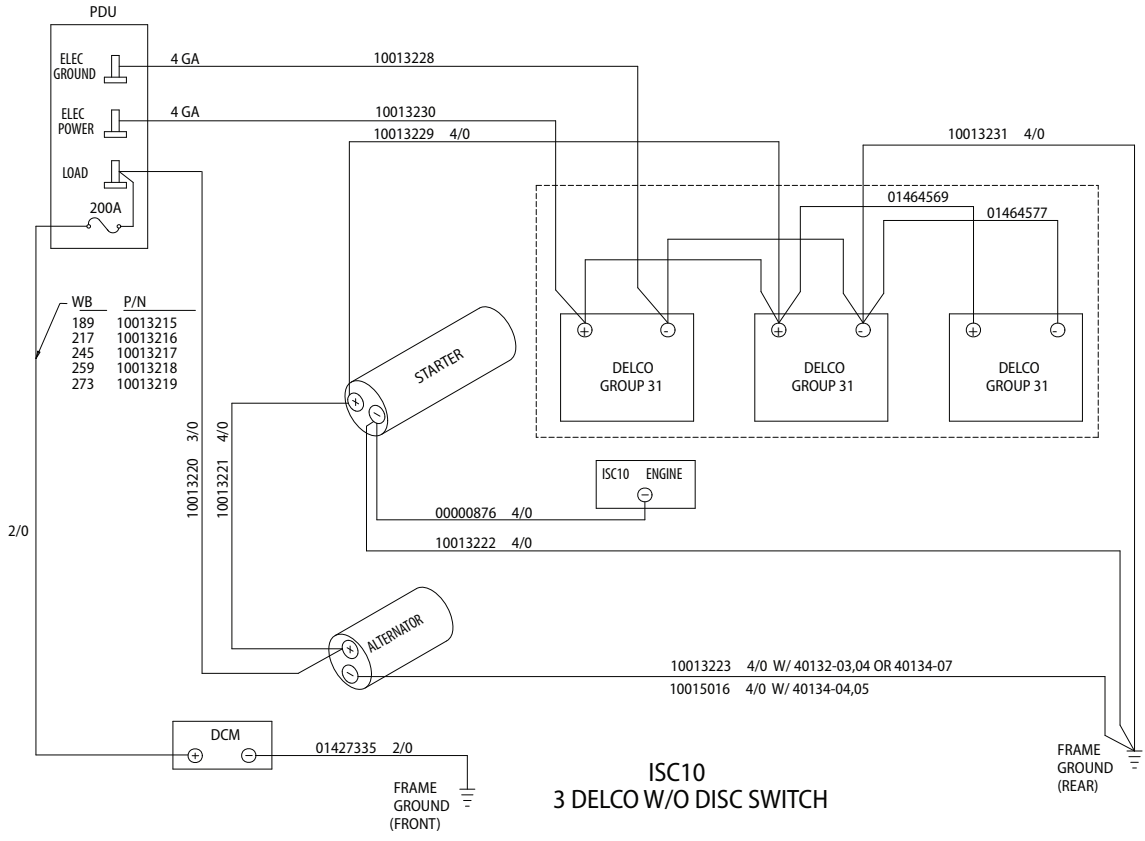
Sheet 1 of 3



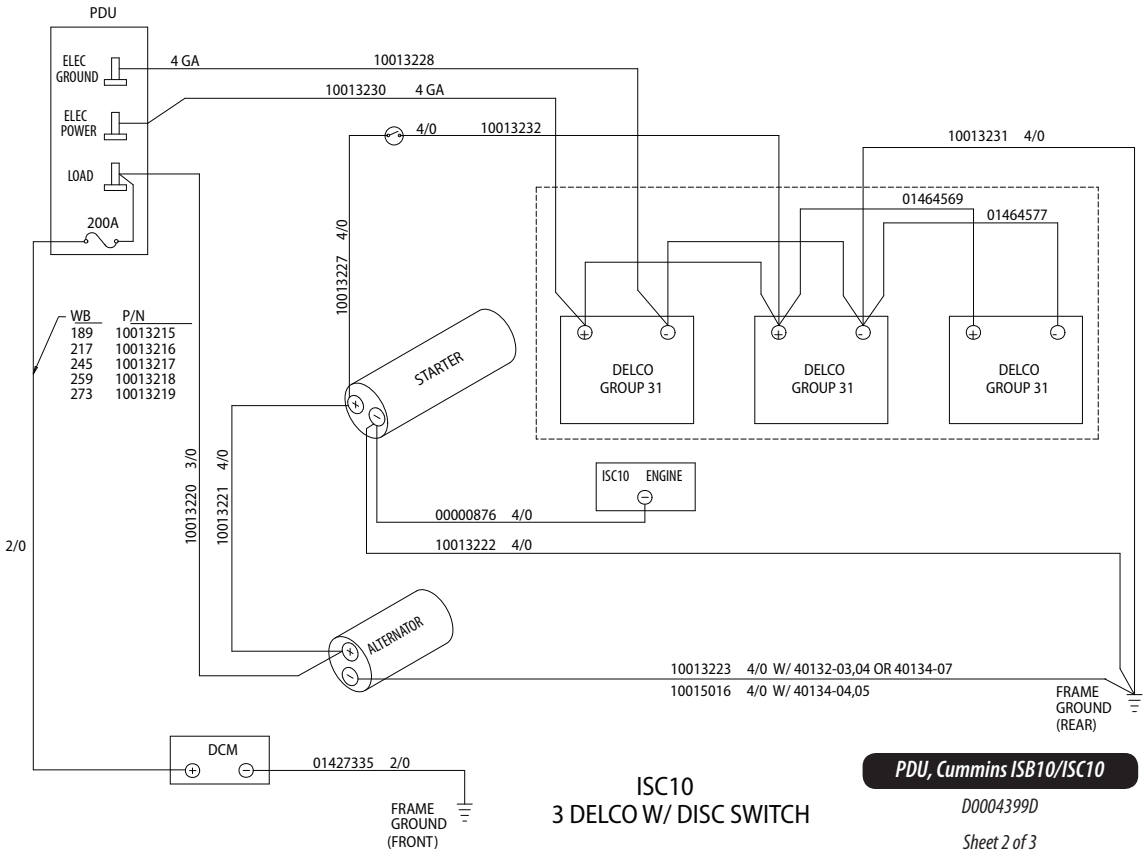
ISC10
2 - 8D W/O DISC SWITCH



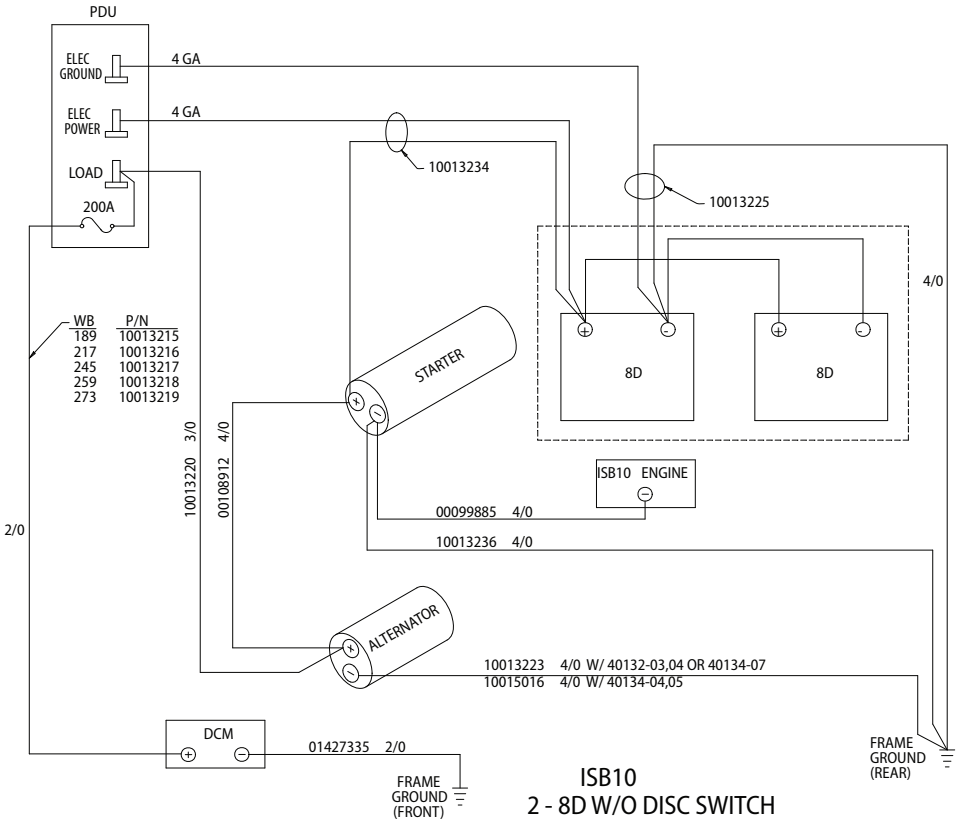
ISC10
2 - 8D W/ DISC SWITCH



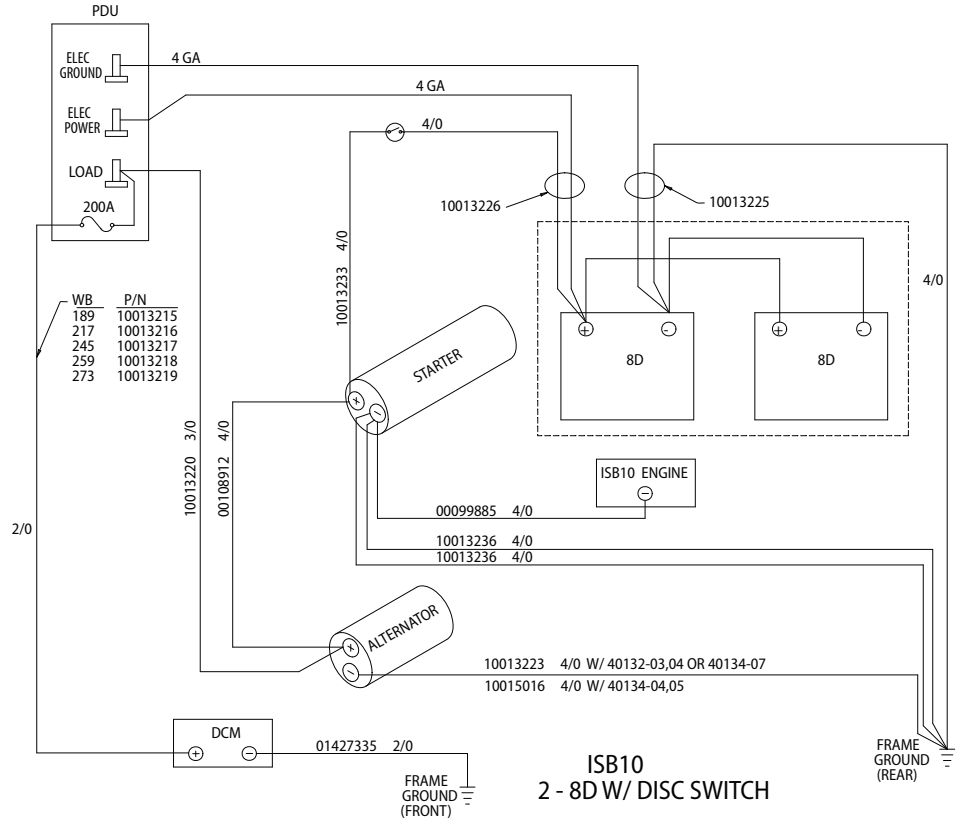
ISC10
3 DELCO W/O DISC SWITCH



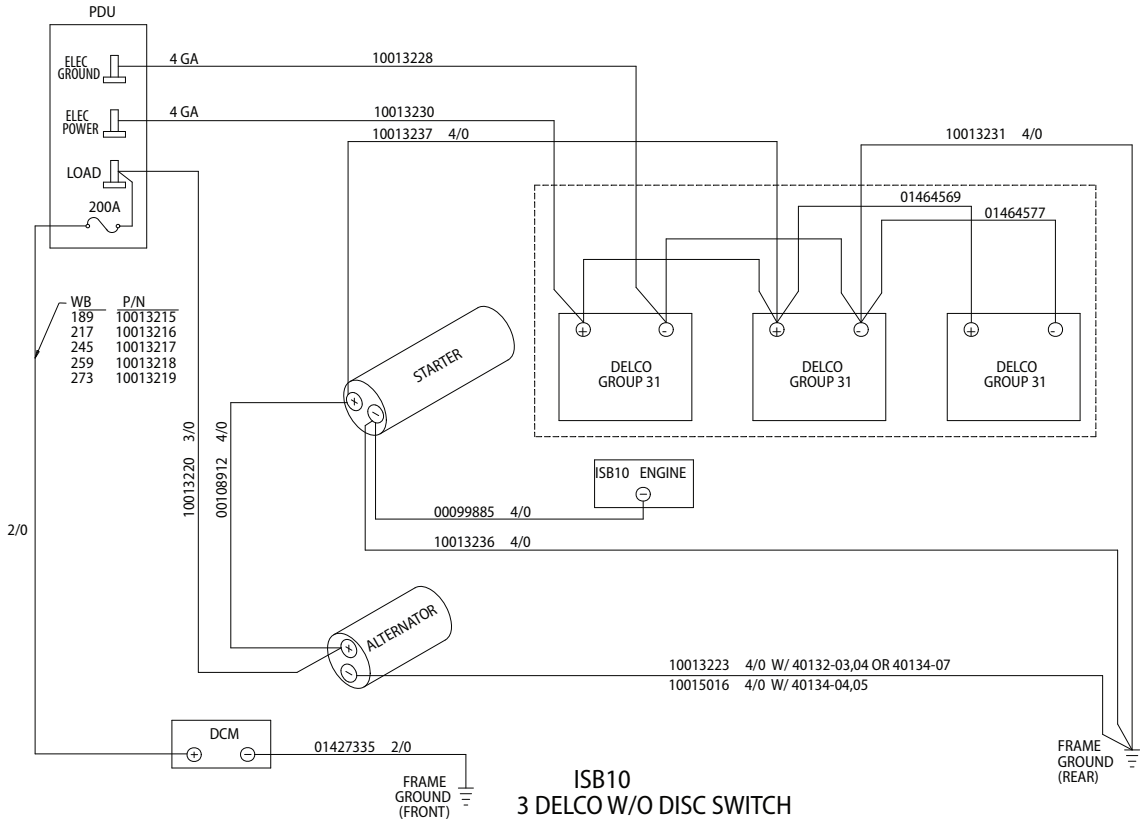
ISC10
3 DELCO W/ DISC SWITCH



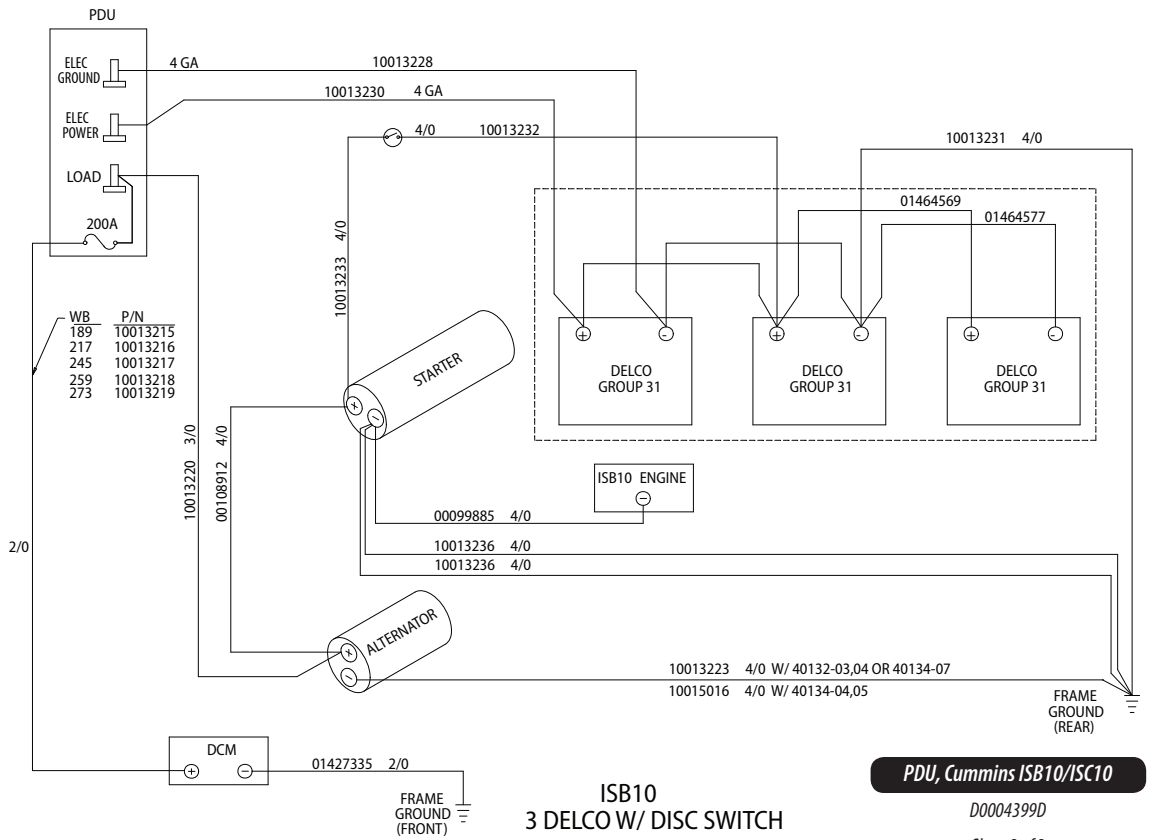
ISB10
2 - 8D W/O DISC SWITCH



ISB10
2 - 8D W/ DISC SWITCH



ISB10
3 DELCO W/O DISC SWITCH



ISB10
3 DELCO W/ DISC SWITCH

PDU, Cummins ISB10/ISC10

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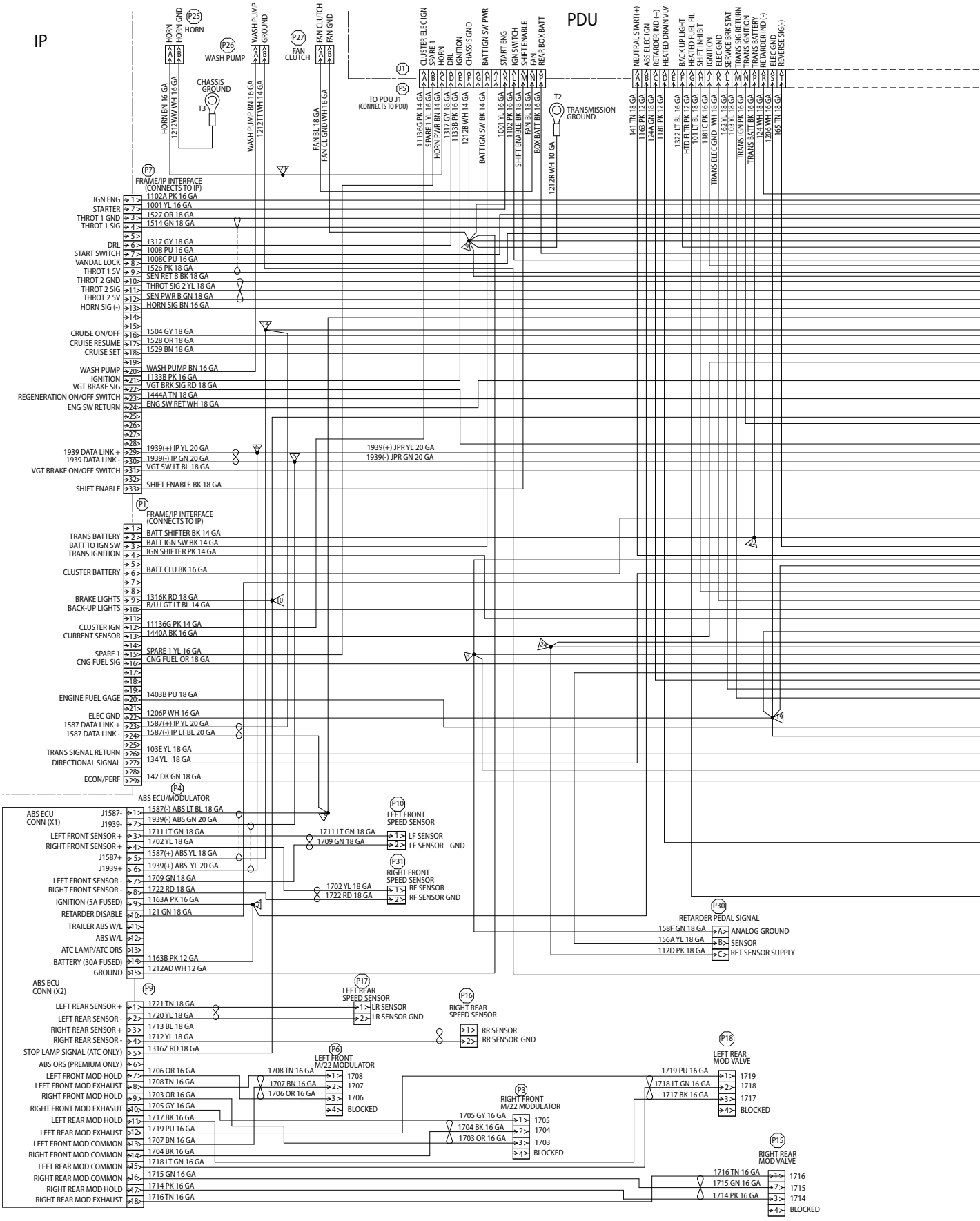
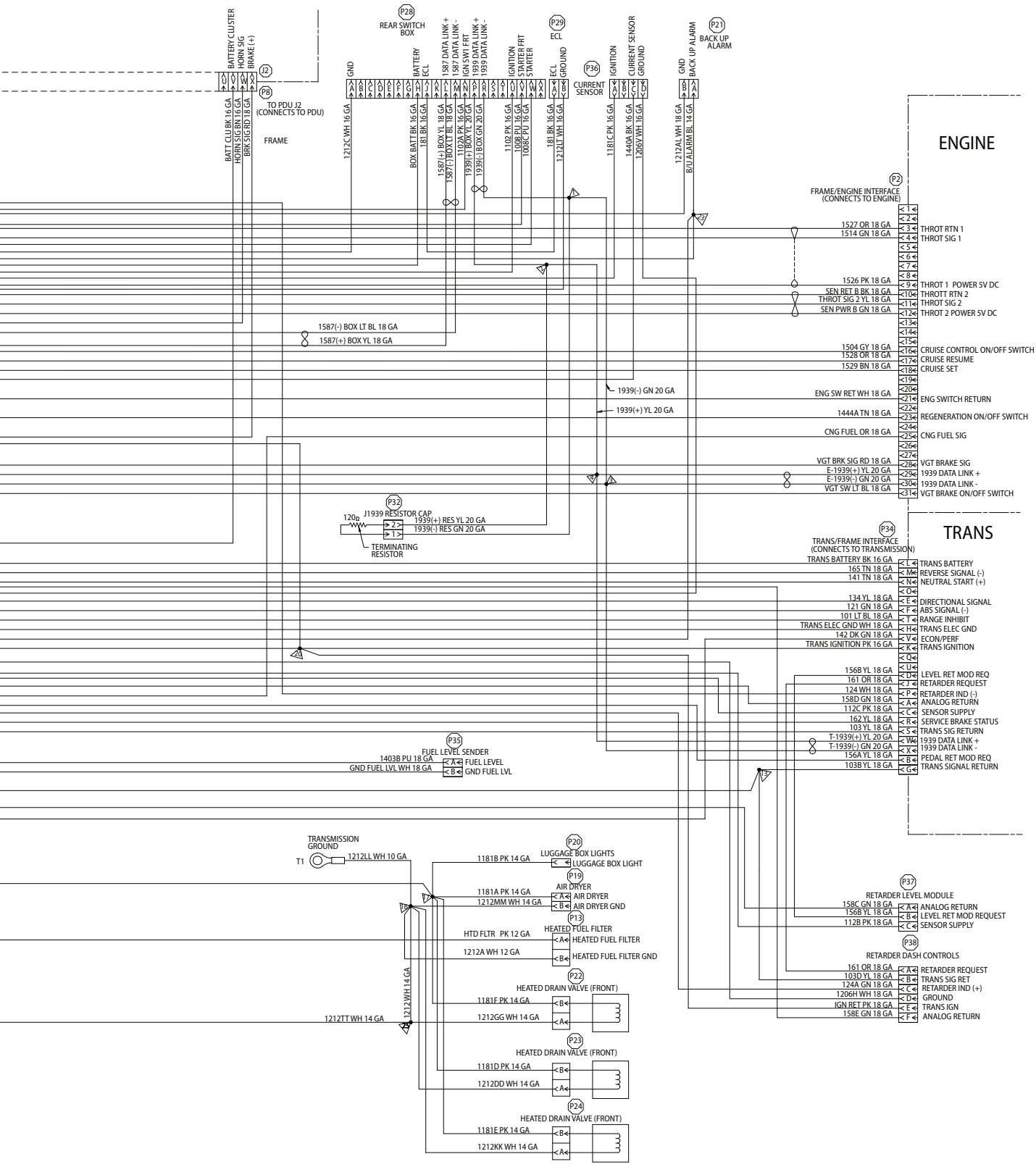
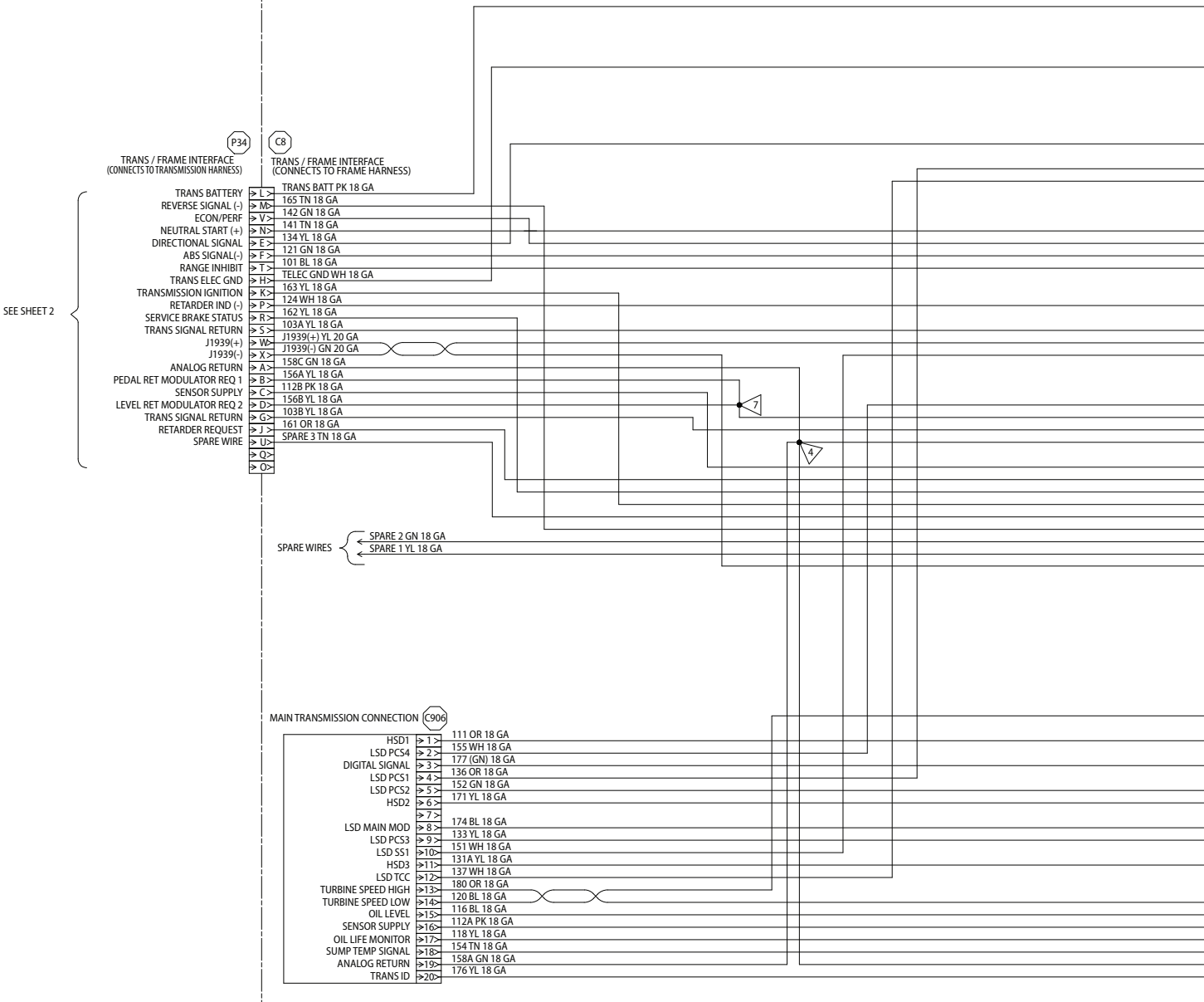
Sheet 3 of 3

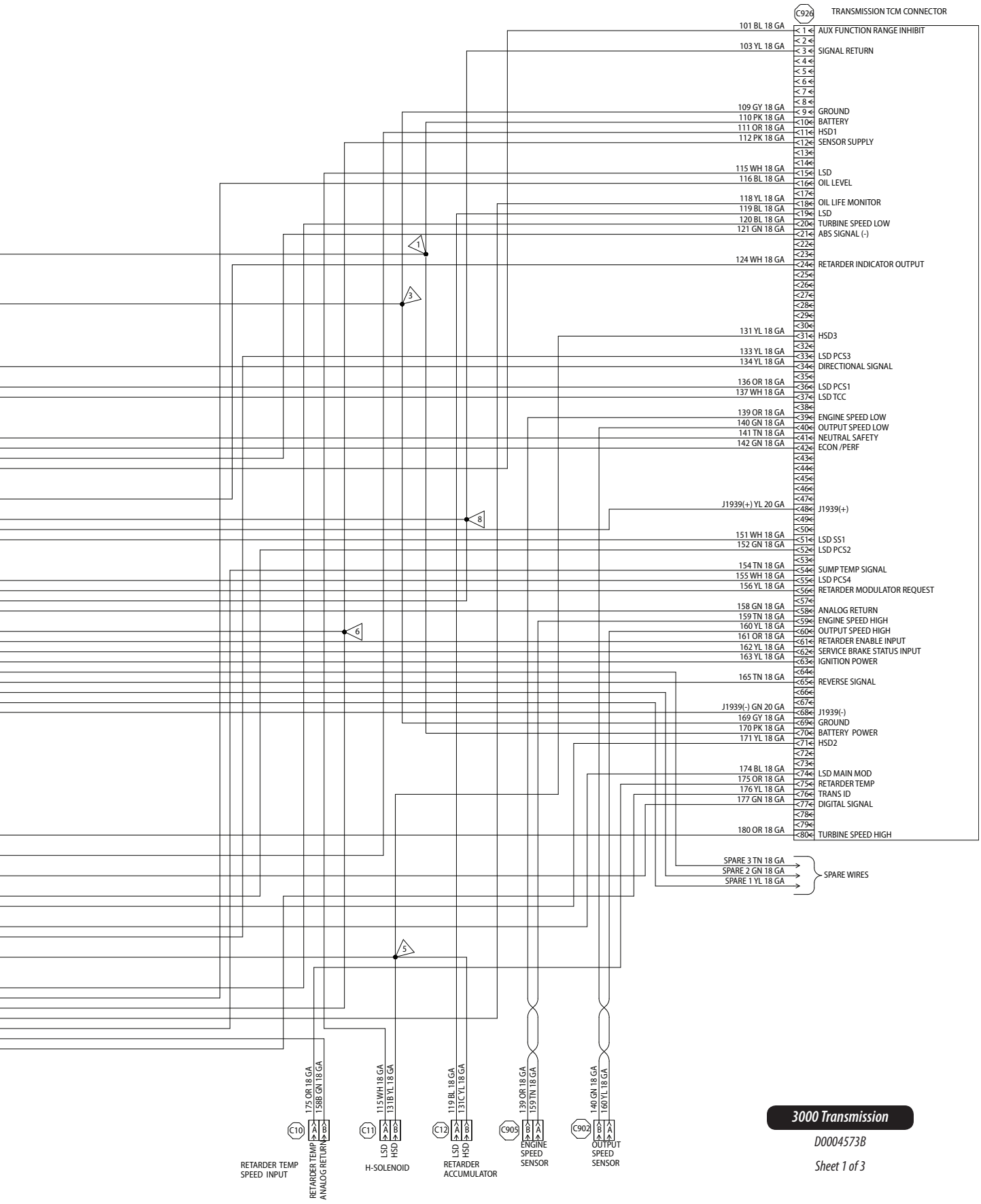

IP
PDU
HORN
HORN GND
WASH PUMP
WASH PUMP GROUND
FAN CLUTCH
FAN GND
CHASSIS GROUND
TO PDU J1 (CONNECTS TO PDU)
TRANSMISSION GROUND
FRAME/IP INTERFACE (CONNECTS TO IP)
IGN ENG
STARTER
THROT 1 GND
THROT 1 SIG
DRL
START SWITCH
VANDAL LOCK
THROT 1 5V
THROT 2 GND
THROT 2 SIG
THROT 2 5V
HORN SIG (-)
CRUISE ON/OFF
CRUISE RESUME
CRUISE SET
WASH PUMP
IGNITION
VGT BRAKE SIG
REGENERATION ON/OFF SWITCH
ENG SW RETURN
1939 DATA LINK +
1939 DATA LINK -
VGT BRAKE ON/OFF SWITCH
SHIFT ENABLE
FRAME/IP INTERFACE (CONNECTS TO IP)
TRANS BATTERY
BATT TO IGN SW
TRANS IGNITION
CLUSTER BATTERY
BRAKE LIGHTS
BACK-UP LIGHTS
CLUSTER IGN
CURRENT SENSOR
SPARE 1
CNG FUEL SIG
ENGINE FUEL GAGE
ELEC GND
1587 DATA LINK +
1587 DATA LINK -
TRANS SIGNAL RETURN
DIRECTIONAL SIGNAL
ECON/PERF
ABS ECU/MODULATOR
ABS ECU CONN (X1)
LEFT FRONT SENSOR +
RIGHT FRONT SENSOR +
LEFT FRONT SENSOR -
RIGHT FRONT SENSOR -
IGNITION (5A FUSED)
RETARDER DISABLE
TRAILER ABS W/L
ABS W/L
ATC LAMP/ATC ORS
BATTERY (30A FUSED)
GROUND
ABS ECU CONN (X2)
LEFT REAR SENSOR +
LEFT REAR SENSOR -
RIGHT REAR SENSOR +
RIGHT REAR SENSOR -
STOP LAMP SIGNAL (ATC ONLY)
ABS ORS (PREMIUM ONLY)
LEFT FRONT MOD HOLD
LEFT FRONT MOD EXHAUST
RIGHT FRONT MOD HOLD
RIGHT FRONT MOD EXHASUT
LEFT REAR MOD HOLD
LEFT REAR MOD EXHAUST
LEFT FRONT MOD COMMON
RIGHT FRONT MOD COMMON
LEFT REAR MOD COMMON
RIGHT REAR MOD COMMON
RIGHT REAR MOD HOLD
RIGHT REAR MOD EXHAUST
LEFT FRONT SPEED SENSOR
LF SENSOR
LF SENSOR GND
RIGHT FRONT SPEED SENSOR
RF SENSOR
RF SENSOR GND
LEFT REAR SPEED SENSOR
LR SENSOR
LR SENSOR GND
RIGHT REAR SPEED SENSOR
RR SENSOR
RR SENSOR GND
LEFT FRONT M/22 MODULATOR
RIGHT FRONT M/22 MODULATOR
RETARDER PEDAL SIGNAL
ANALOG GROUND
SENSOR
RET SENSOR SUPPLY
LEFT REAR MOD VALVE
RIGHT REAR MOD VALVE
BLOCKED


J2
P8
TO PDU J2 (CONNECTS TO PDU)
FRAME
BATTERY CLUSTER
HORN SIG
BRAKE (+)
BATT CLU BK 16 GA
HORN SIG BN 16 GA
BRK SIG RD 18 GA
P28
REAR SWITCH BOX
GND
BATTERY
ECL
1587 DATA LINK +
1587 DATA LINK -
IGN SW1 FRT
1939 DATA LINK +
1939 DATA LINK -
IGNITION
STARTER FRT
STARTER
P29
ECL
GROUND
P36
CURRENT SENSOR
IGNITION
CURRENT SENSOR GROUND
P21
BACK UP ALARM
GND
BACK UP ALARM
1212CWH 16 GA
BOX BATT BK 16 GA
181 BK 16 GA
1587(+) BOX YL 18 GA
1587(-) BOX LT BL 18 GA
1939(+) BOX YL 20 GA
1939(-) BOX GN 20 GA
1102 PK 16 GA
1008 PU 16 GA
1008C PU 16 GA
181 BK 16 GA
1212LT WH 16 GA
1181C PK 16 GA
1440A BK 16 GA
1206J WH 16 GA
1212AL WH 18 GA
B/U ALARM BL 14 GA
1587(-) BOX LT BL 18 GA
1587(+) BOX YL 18 GA
1939(-) GN 20 GA
1939(+) YL 20 GA
ENGINE
P2
FRAME/ENGINE INTERFACE (CONNECTS TO ENGINE)
1527 OR 18 GA
1514 GN 18 GA
THROT RTN 1
THROT SIG 1
1526 PK 18 GA
SEN RET B BK 18 GA
THROT SIG 2 YL 18 GA
SEN PWR B GN 18 GA
THROT 1 POWER 5V DC
THROTT RTN 2
THROT SIG 2
THROT 2 POWER 5V DC
1504 GY 18 GA
1528 OR 18 GA
1529 BN 18 GA
CRUISE CONTROL ON/OFF SWITCH
CRUISE RESUME
CRUISE SET
ENG SW RET WH 18 GA
ENG SWITCH RETURN
1444A TN 18 GA
REGENERATION ON/OFF SWITCH
CNG FUEL OR 18 GA
CNG FUEL SIG
VGT BRK SIG RD 18 GA
E-1939(+) YL 20 GA
E-1939(-) GN 20 GA
VGT SW LT BL 18 GA
VGT BRAKE SIG
1939 DATA LINK +
1939 DATA LINK -
VGT BRAKE ON/OFF SWITCH
P32
J1939 RESISTOR CAP
120Ω
1939(+) RES YL 20 GA
1939(-) RES GN 20 GA
TERMINATING RESISTOR
TRANS
P34
TRANS/FRAME INTERFACE (CONNECTS TO TRANSMISSION)
TRANS BATTERY BK 16 GA
165 TN 18 GA
141 TN 18 GA
134 YL 18 GA
121 GN 18 GA
101 LT BL 18 GA
TRANS ELEC GND WH 18 GA
142 DK GN 18 GA
TRANS IGNITION PK 16 GA
156B YL 18 GA
161 OR 18 GA
124 WH 18 GA
158D GN 18 GA
112C PK 18 GA
162 YL 18 GA
103 YL 18 GA
T-1939(+) YL 20 GA
T-1939(-) GN 20 GA
156A YL 18 GA
103B YL 18 GA
TRANS BATTERY
REVERSE SIGNAL (-)
NEUTRAL START (+)
DIRECTIONAL SIGNAL
ABS SIGNAL (-)
RANGE INHIBIT
TRANS ELEC GND
ECON/PERF
TRANS IGNITION
LEVEL RET MOD REQ
RETARDER REQUEST
RETARDER IND (-)
ANALOG RETURN
SENSOR SUPPLY
SERVICE BRAKE STATUS
TRANS SIG RETURN
1939 DATA LINK +
1939 DATA LINK -
PEDAL RET MOD REQ
TRANS SIGNAL RETURN
P35
FUEL LEVEL SENDER
1403B PU 18 GA
GND FUEL LVL WH 18 GA
FUEL LEVEL
GND FUEL LVL
TRANSMISSION GROUND
T1
1212LL WH 10 GA
P20
LUGGAGE BOX LIGHTS
1181B PK 14 GA
LUGGAGE BOX LIGHT
P19
AIR DRYER
1181A PK 14 GA
1212MM WH 14 GA
AIR DRYER
AIR DRYER GND
P13
HEATED FUEL FILTER
HTD FLTR PK 12 GA
1212A WH 12 GA
HEATED FUEL FILTER
HEATED FUEL FILTER GND
P22
HEATED DRAIN VALVE (FRONT)
1181F PK 14 GA
1212GG WH 14 GA
1212TT WH 14 GA
1212WH 14 GA
P23
HEATED DRAIN VALVE (FRONT)
1181D PK 14 GA
1212DD WH 14 GA
P24
HEATED DRAIN VALVE (FRONT)
1181E PK 14 GA
1212KK WH 14 GA
P37
RETARDER LEVEL MODULE
158C GN 18 GA
156B YL 18 GA
112B PK 18 GA
ANALOG RETURN
LEVEL RET MOD REQUEST
SENSOR SUPPLY
P38
RETARDER DASH CONTROLS
161 OR 18 GA
103D YL 18 GA
124A GN 18 GA
1206H WH 18 GA
IGN RET PK 18 GA
158E GN 18 GA
RETARDER REQUEST
TRANS SIG RET
RETARDER IND (+)
GROUND
TRANS IGN
ANALOG RETURN

FRAME

TRANSMISSION

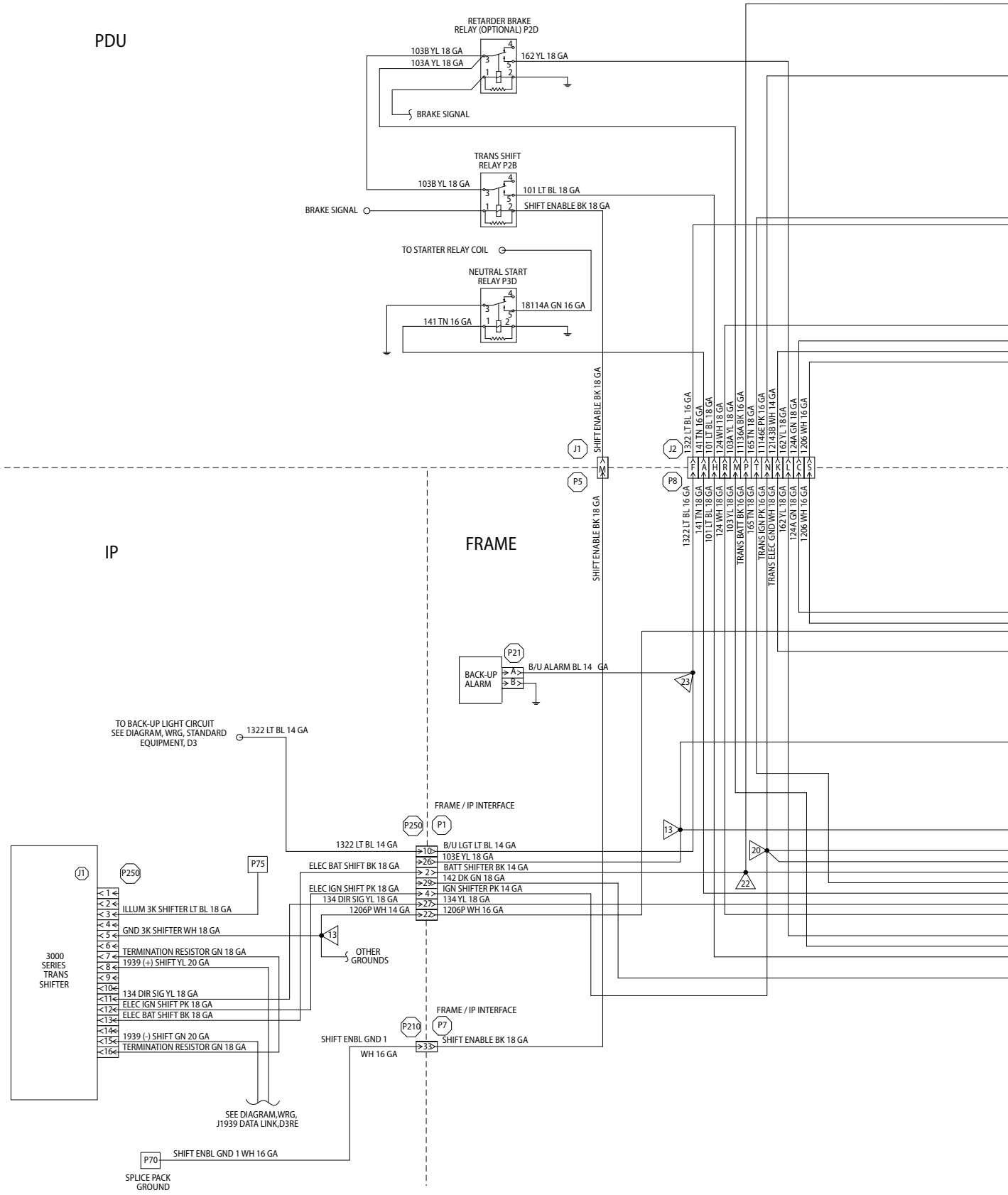


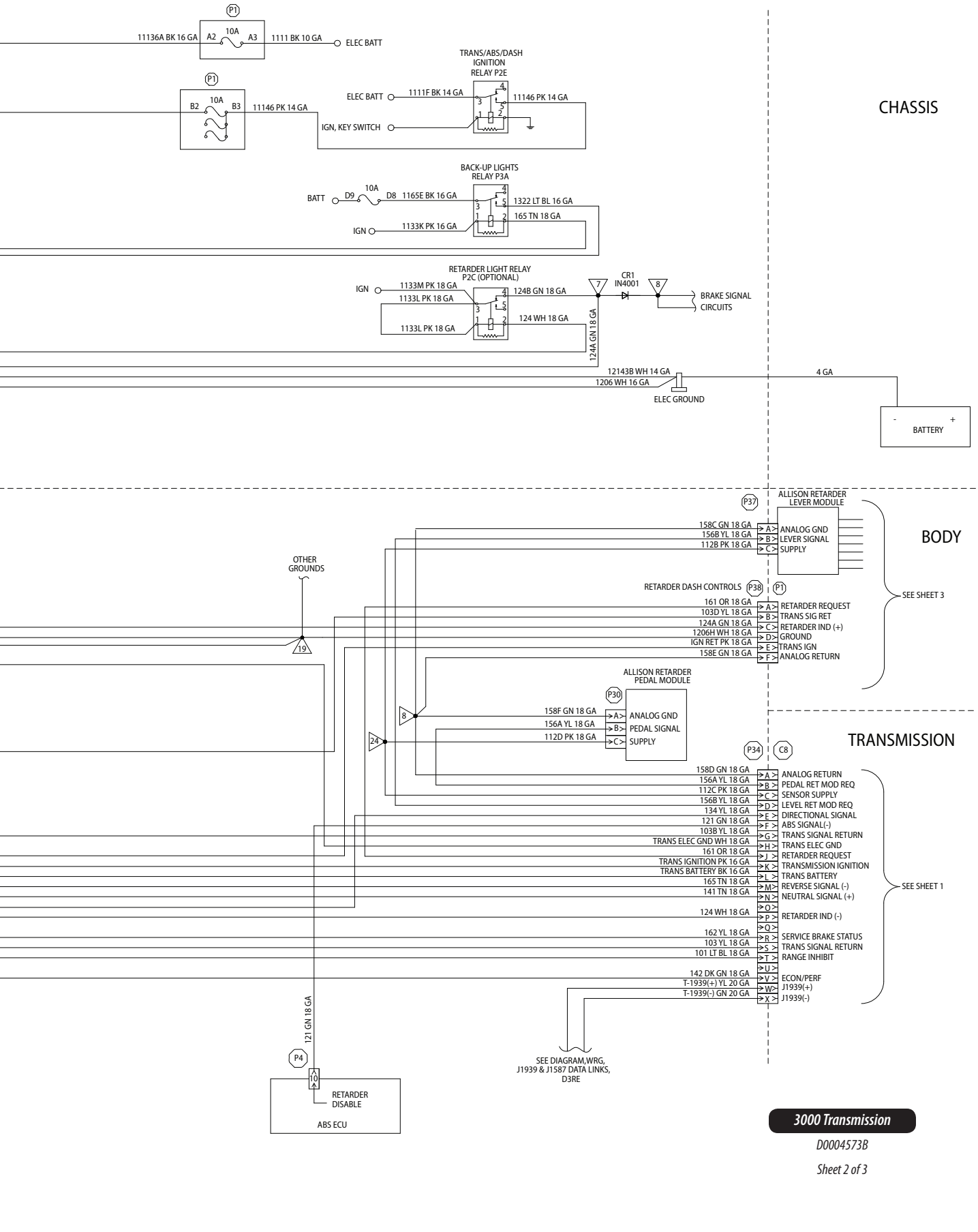


3000 Transmission

D0004573B

Sheet 1 of 3


PDU
RETARDER BRAKE RELAY (OPTIONAL) P2D
103B YL 18 GA
103A YL 18 GA
162 YL 18 GA
BRAKE SIGNAL
TRANS SHIFT RELAY P2B
103B YL 18 GA
101 LT BL 18 GA
BRAKE SIGNAL
SHIFT ENABLE BK 18 GA
TO STARTER RELAY COIL
NEUTRAL START RELAY P3D
18114A GN 16 GA
141 TN 16 GA
SHIFT ENABLE BK 18 GA
J1
P5
J2
P8
1322 LT BL 16 GA
141 TN 16 GA
101 LT BL 18 GA
124 WH 18 GA
103A YL 18 GA
1136A BK 16 GA
165 TN 18 GA
1146E PK 16 GA
1214B WH 14 GA
162 YL 18 GA
124A GN 18 GA
1206 WH 16 GA
IP
FRAME
P21
BACK-UP ALARM
B/U ALARM BL 14 GA
23
TO BACK-UP LIGHT CIRCUIT SEE DIAGRAM, WRG, STANDARD EQUIPMENT, D3
1322 LT BL 14 GA
FRAME / IP INTERFACE
P250
P1
13
20
22
P75
J1
P250
3000 SERIES TRANS SHIFTER
ILLUM 3K SHIFTER LT BL 18 GA
GND 3K SHIFTER WH 18 GA
TERMINATION RESISTOR GN 18 GA
1939 (+) SHIFT YL 20 GA
134 DIR SIG YL 18 GA
ELEC IGN SHIFT PK 18 GA
ELEC BAT SHIFT BK 18 GA
1939 (-) SHIFT GN 20 GA
TERMINATION RESISTOR GN 18 GA
1322 LT BL 14 GA
B/U LGT LT BL 14 GA
103E YL 18 GA
ELEC BAT SHIFT BK 18 GA
BATT SHIFTER BK 14 GA
142 DK GN 18 GA
ELEC IGN SHIFT PK 18 GA
IGN SHIFTER PK 14 GA
134 DIR SIG YL 18 GA
134 YL 18 GA
1206P WH 14 GA
1206P WH 16 GA
13
OTHER GROUNDS
SEE DIAGRAM,WRG, J1939 DATA LINK,D3RE
FRAME / IP INTERFACE
P210
P7
SHIFT ENBL GND 1 WH 16 GA
SHIFT ENABLE BK 18 GA
P70
SHIFT ENBL GND 1 WH 16 GA
SPLICE PACK GROUND



3000 Transmission

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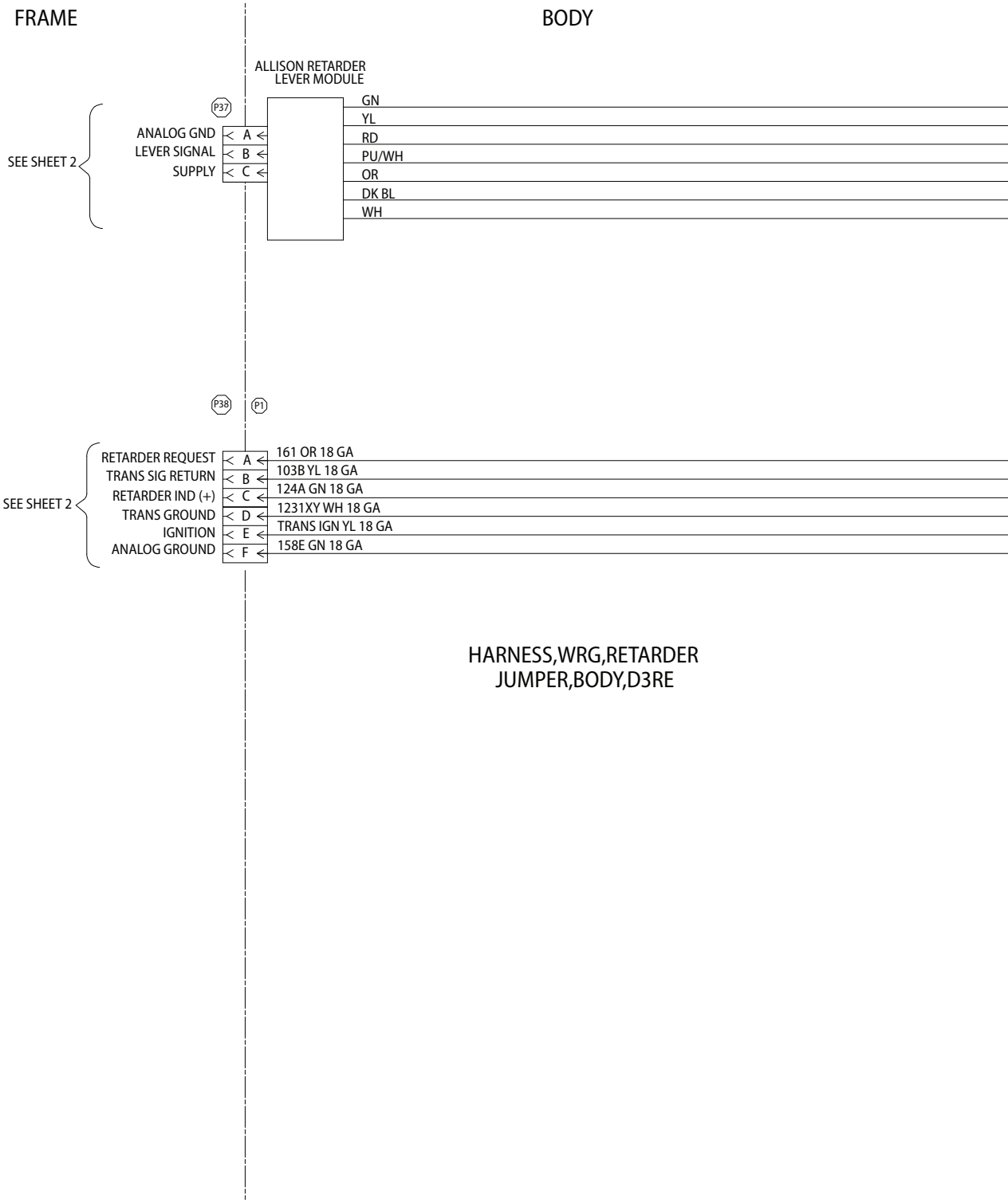
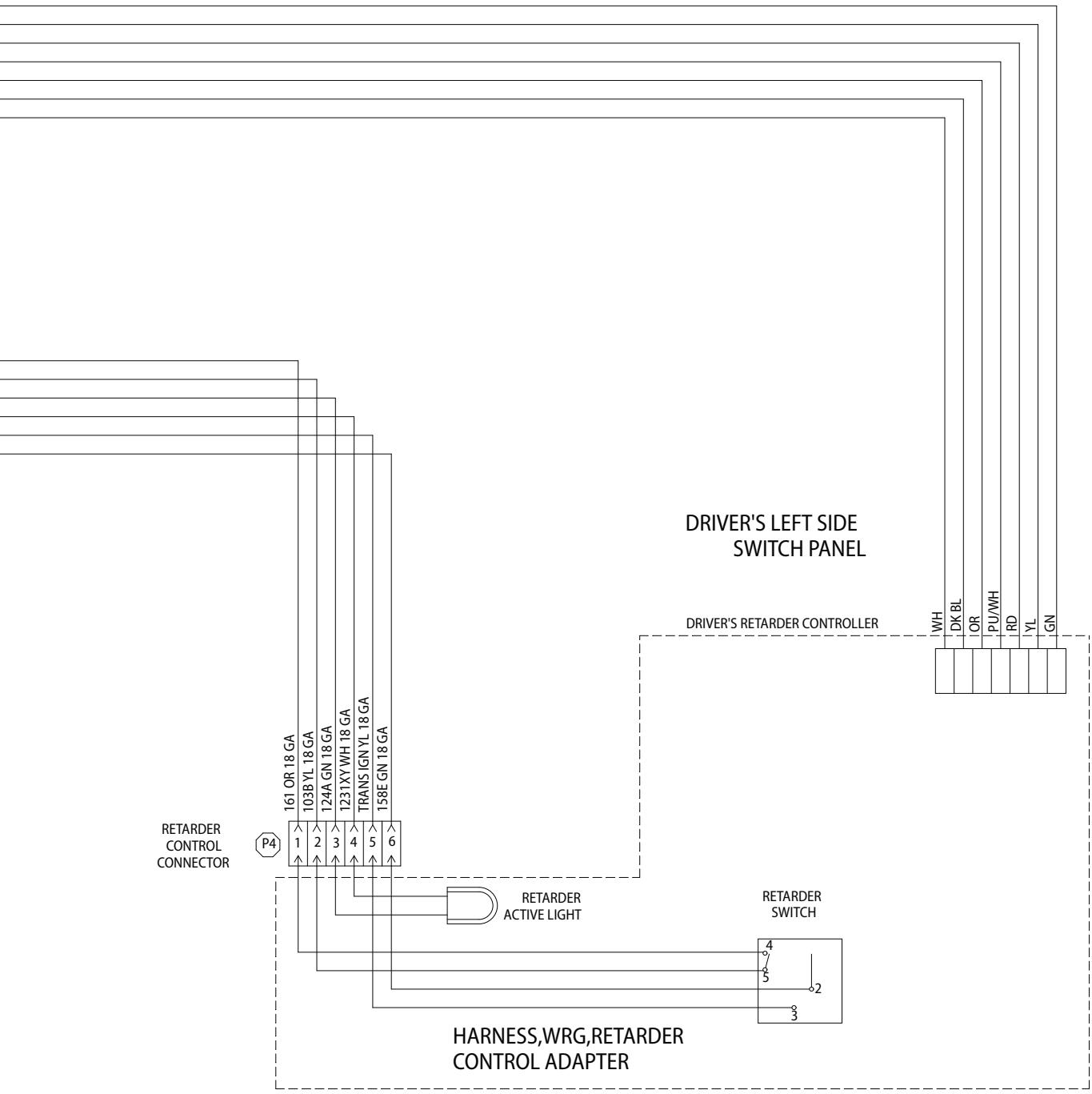
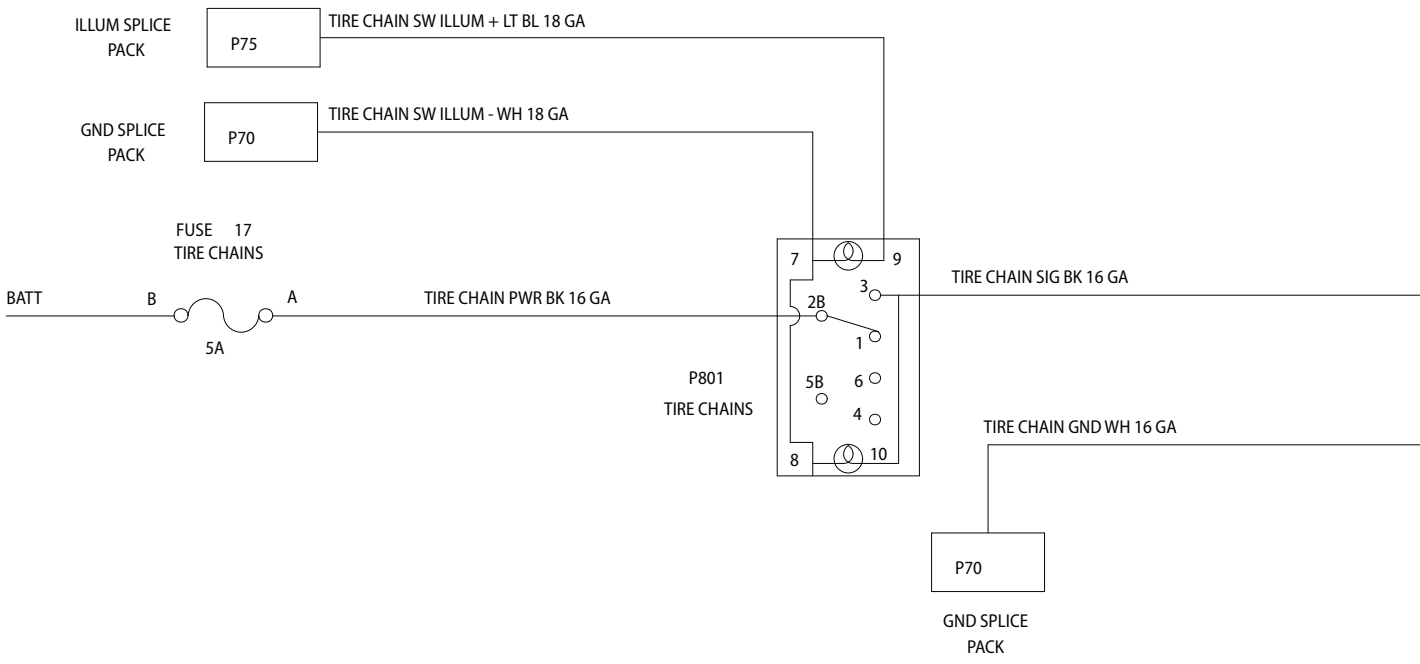
Sheet 2 of 3



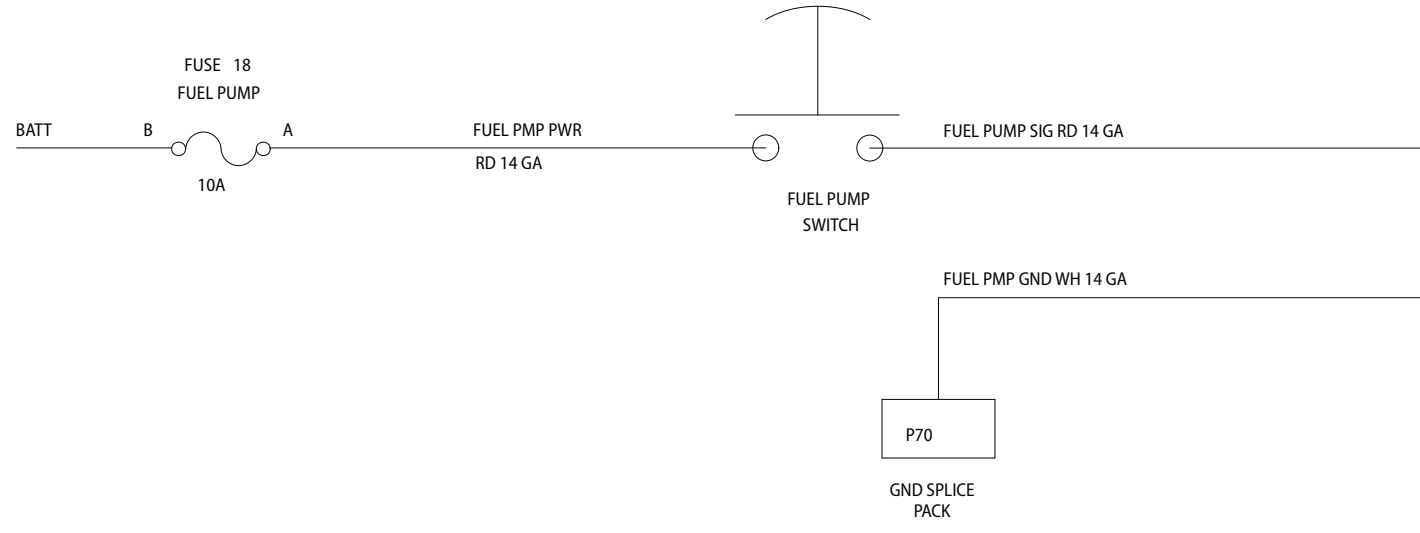
HARNESS,WRG,RETARDER
JUMPER,BODY,D3RE

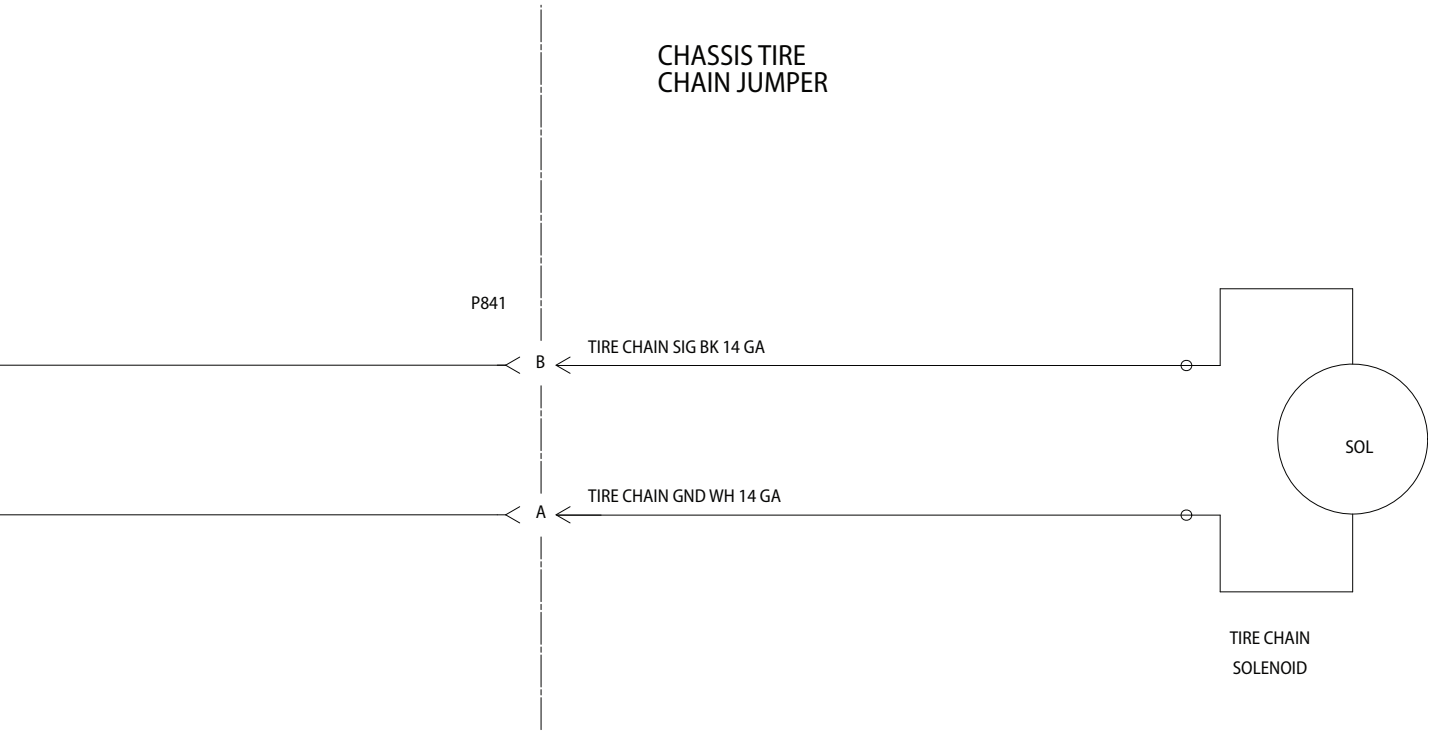

DRIVER'S LEFT SIDE
SWITCH PANEL
DRIVER'S RETARDER CONTROLLER
WH
DK BL
OR
PU/WH
RD
YL
GN
161 OR 18 GA
103B YL 18 GA
124A GN 18 GA
1231XY WH 18 GA
TRANS IGN YL 18 GA
158E GN 18 GA
RETARDER
CONTROL
CONNECTOR
P4
1
2
3
4
5
6
RETARDER
ACTIVE LIGHT
RETARDER
SWITCH
4
5
2
3
HARNESS,WRG,RETARDER
CONTROL ADAPTER

ELEC PANEL



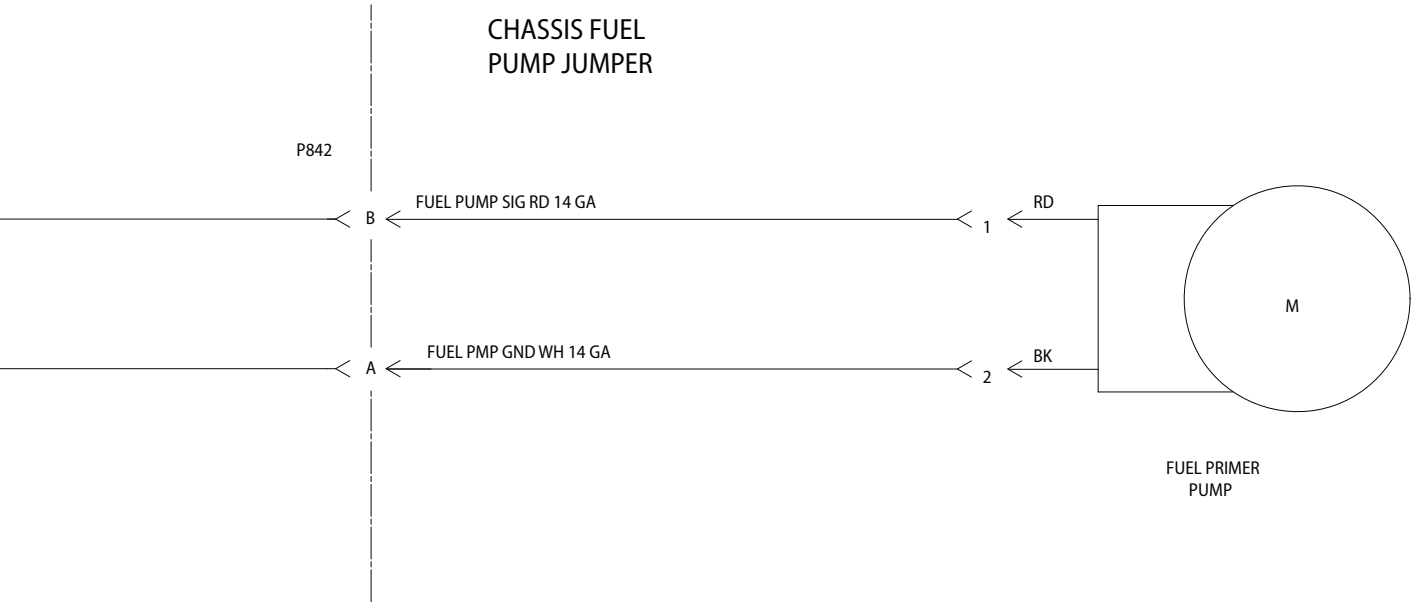
ELEC PANEL





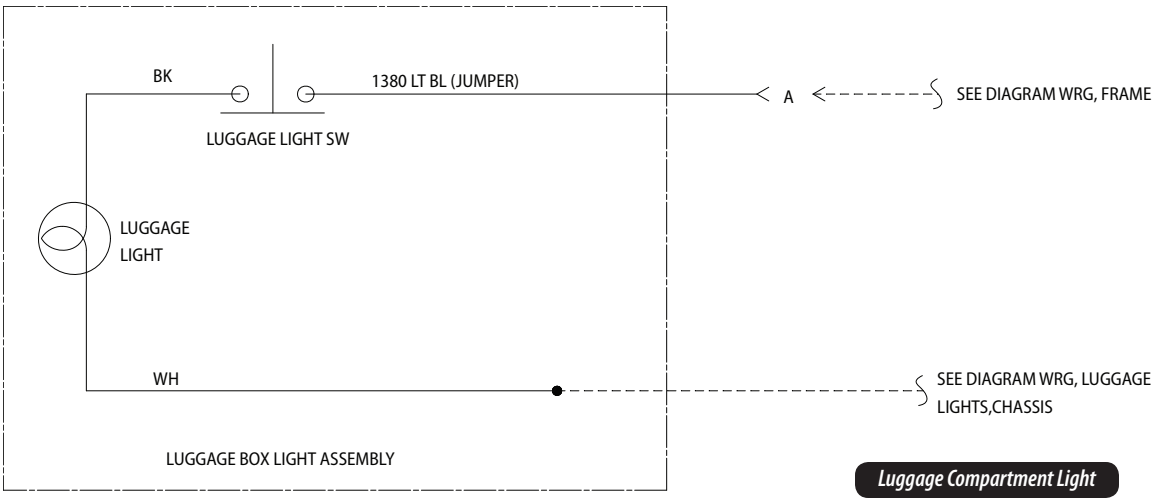
Tire Chains

D0005090B



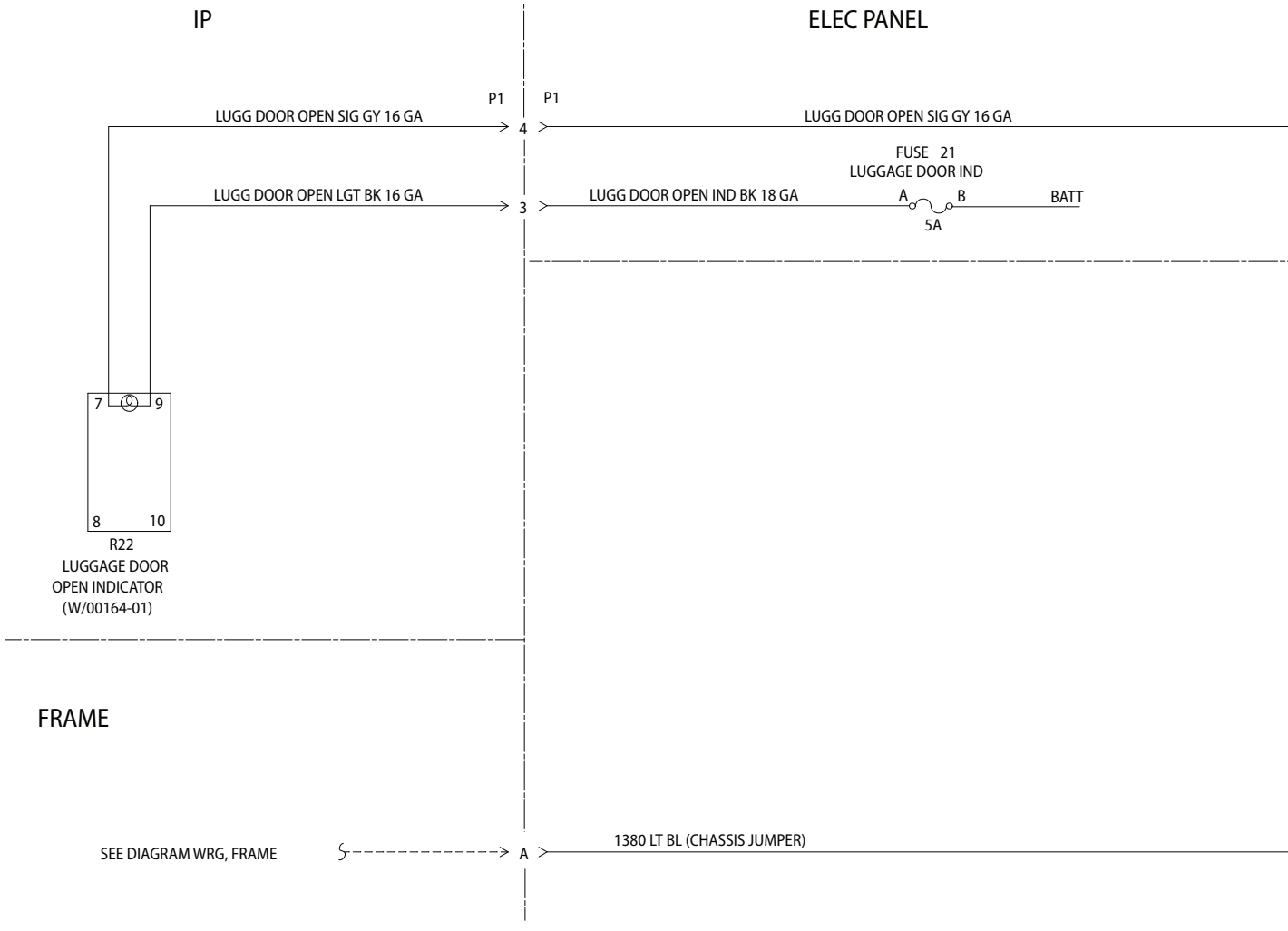
Fuel Filter/ Water Separator

D0005091B

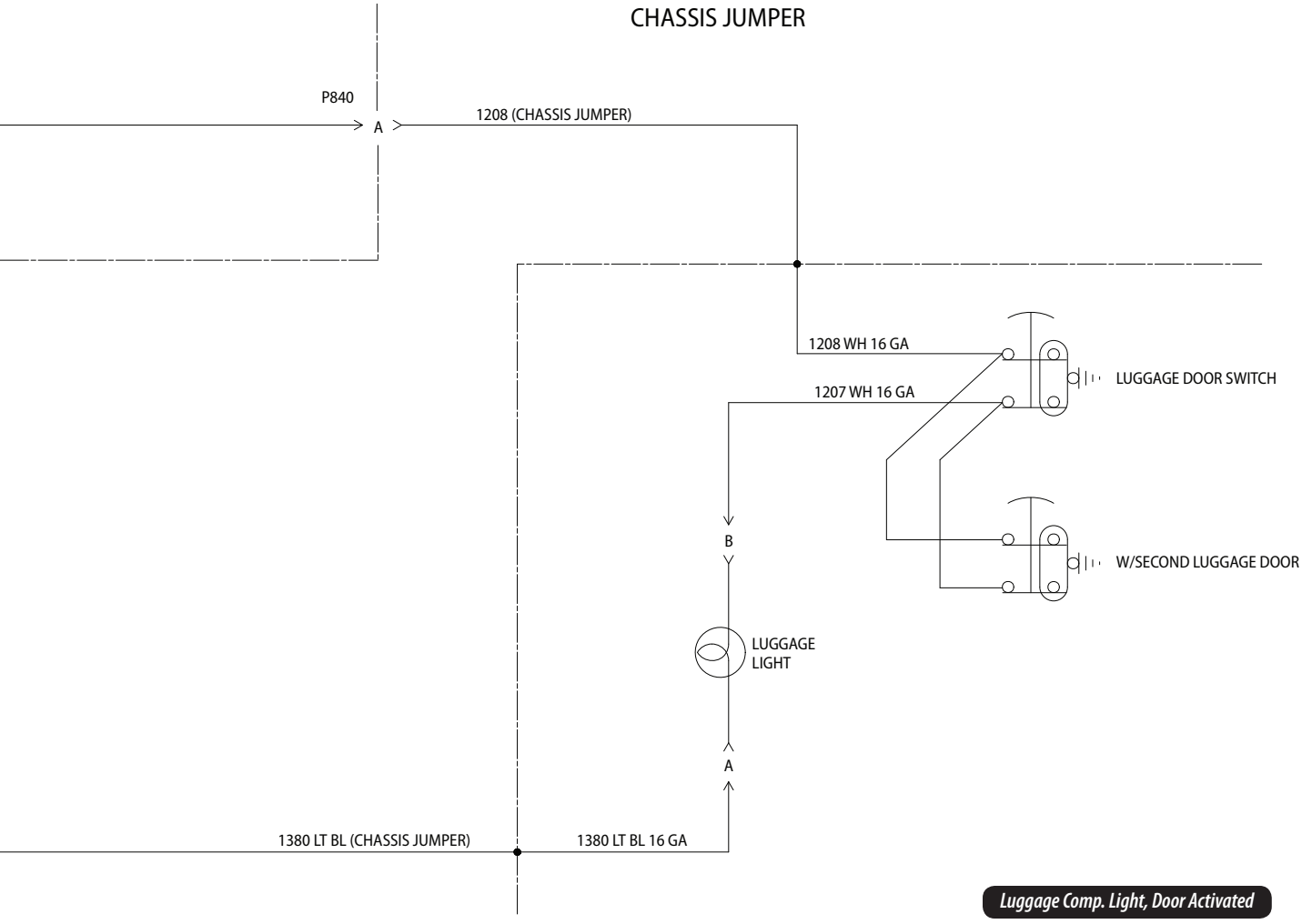


Luggage Compartment Light

D0005097A

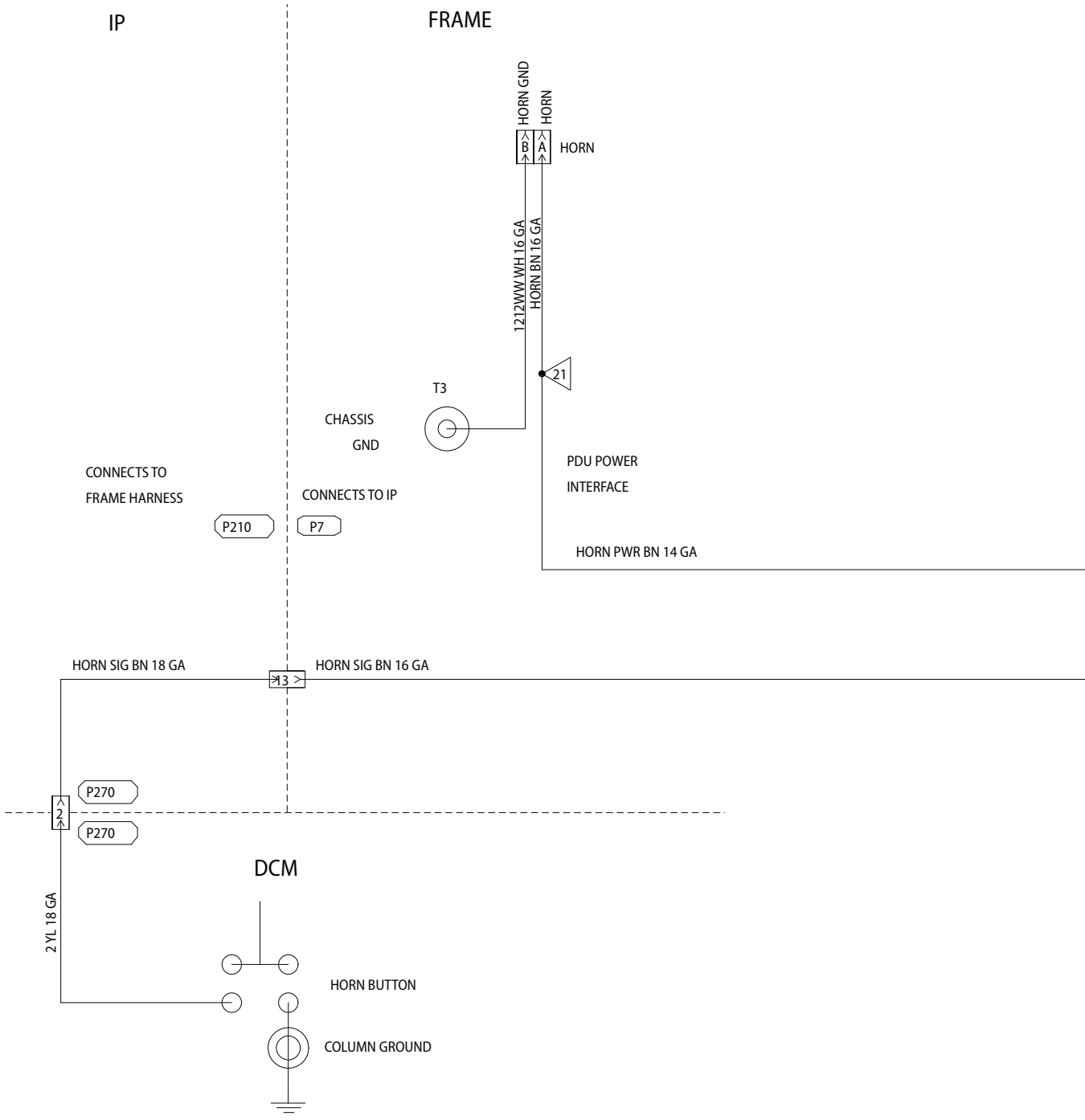


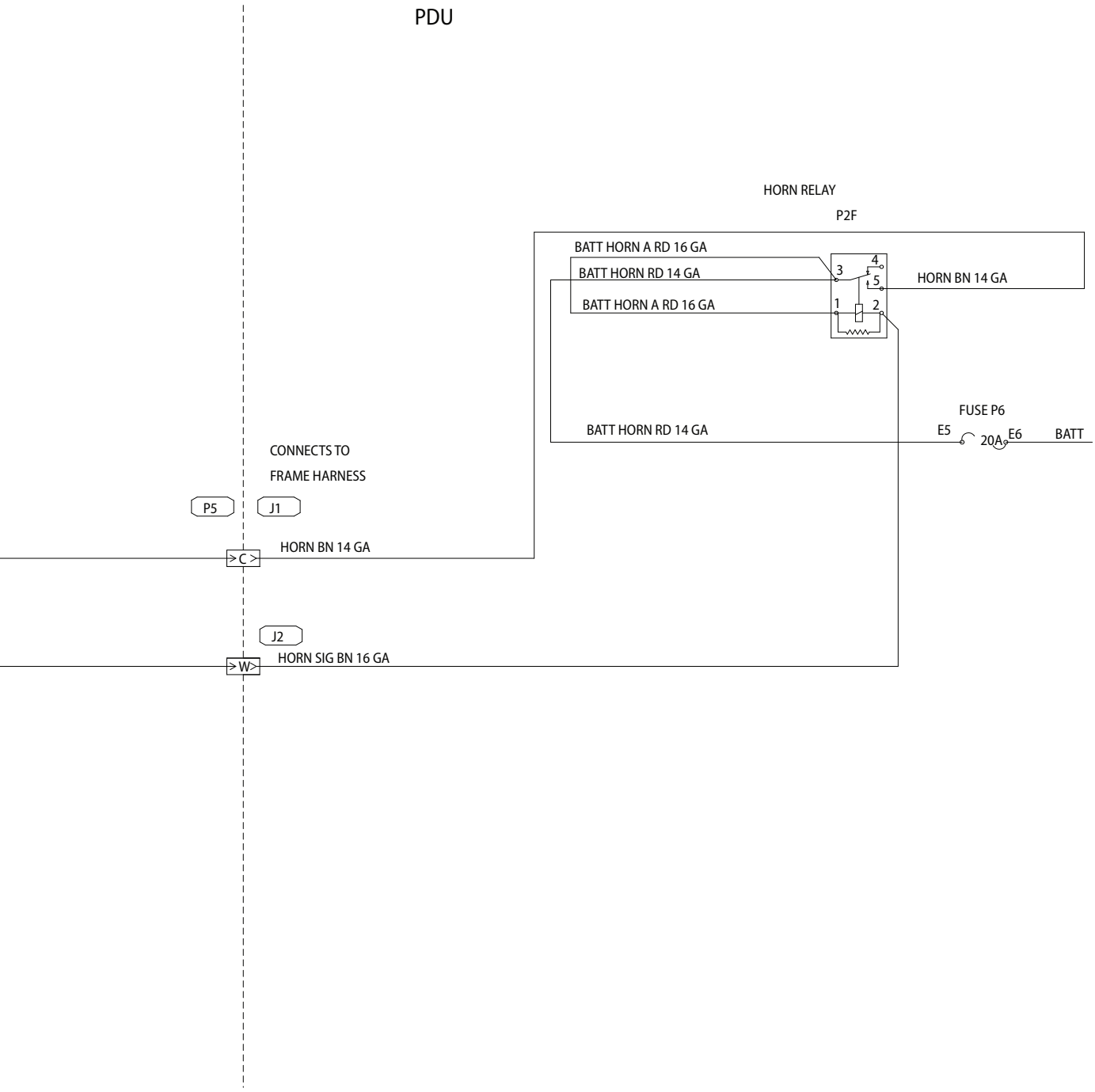
CHASSIS JUMPER



Luggage Comp. Light, Door Activated

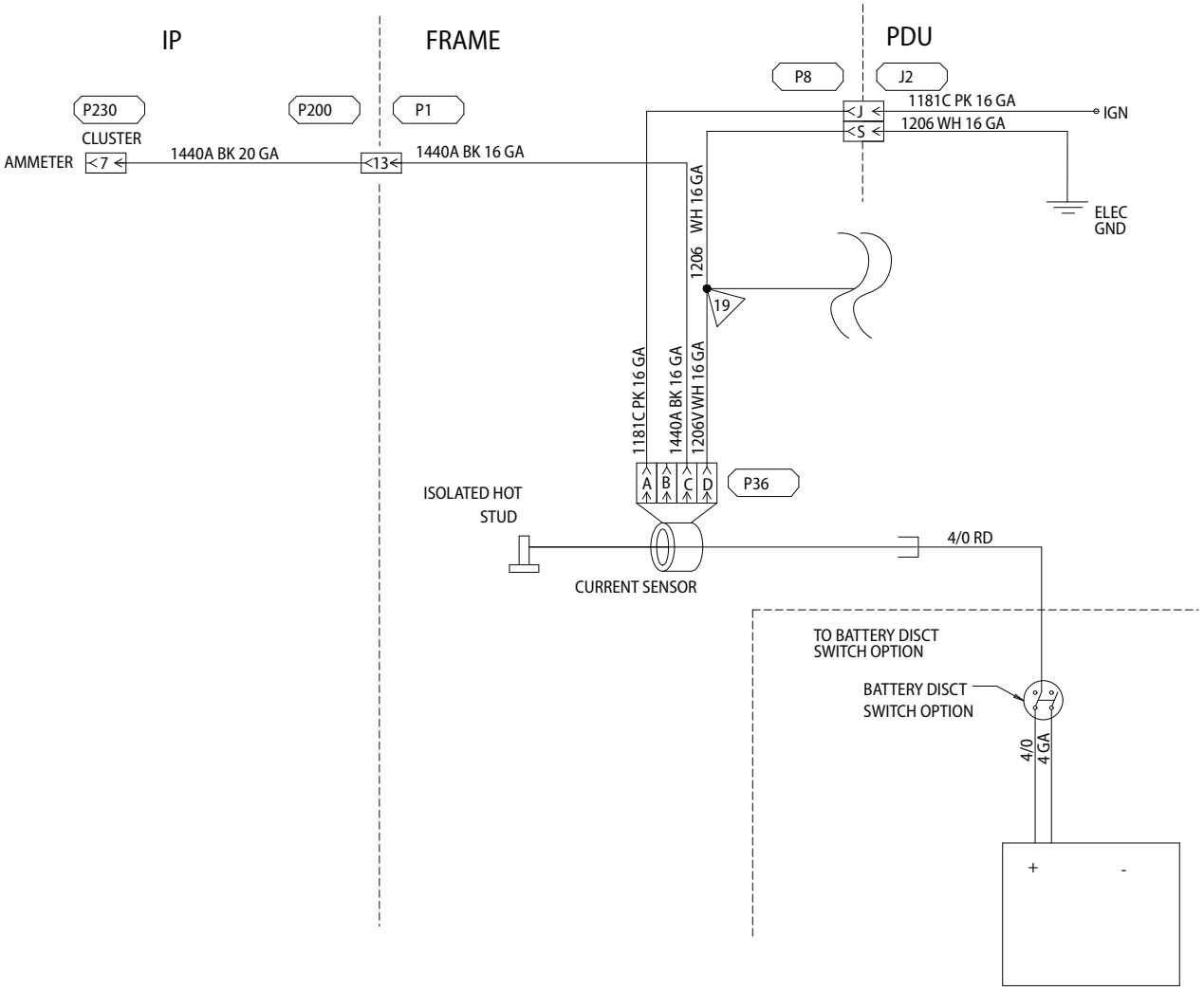
D0005102B


IP
FRAME
HORN GND
HORN
B
A
HORN
1212WW WH 16 GA
HORN BN 16 GA
21
T3
CHASSIS
GND
PDU POWER
INTERFACE
CONNECTS TO
FRAME HARNESS
CONNECTS TO IP
P210
P7
HORN PWR BN 14 GA
HORN SIG BN 18 GA
3
HORN SIG BN 16 GA
P270
2
P270
DCM
2 YL 18 GA
HORN BUTTON
COLUMN GROUND



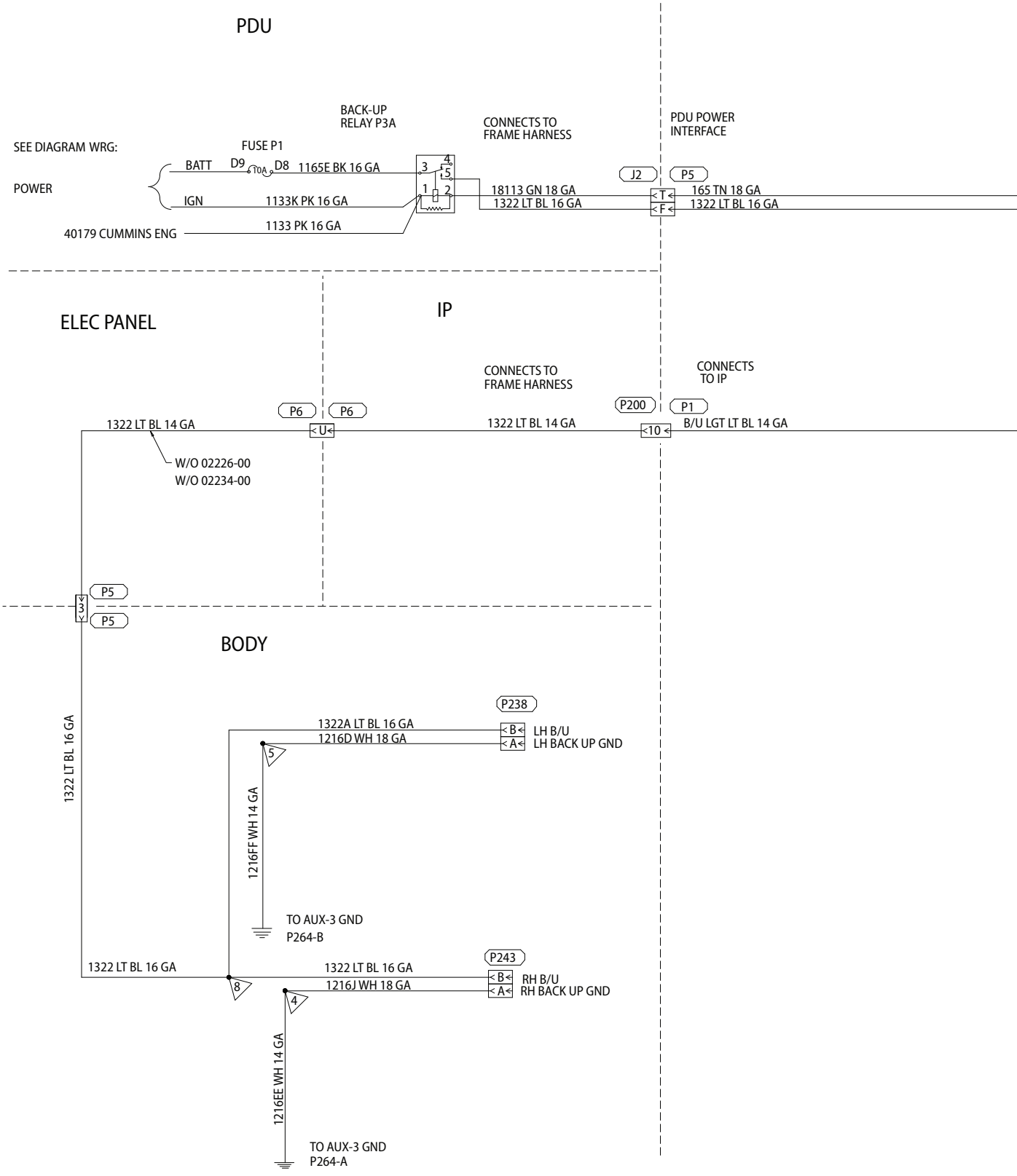
Horn

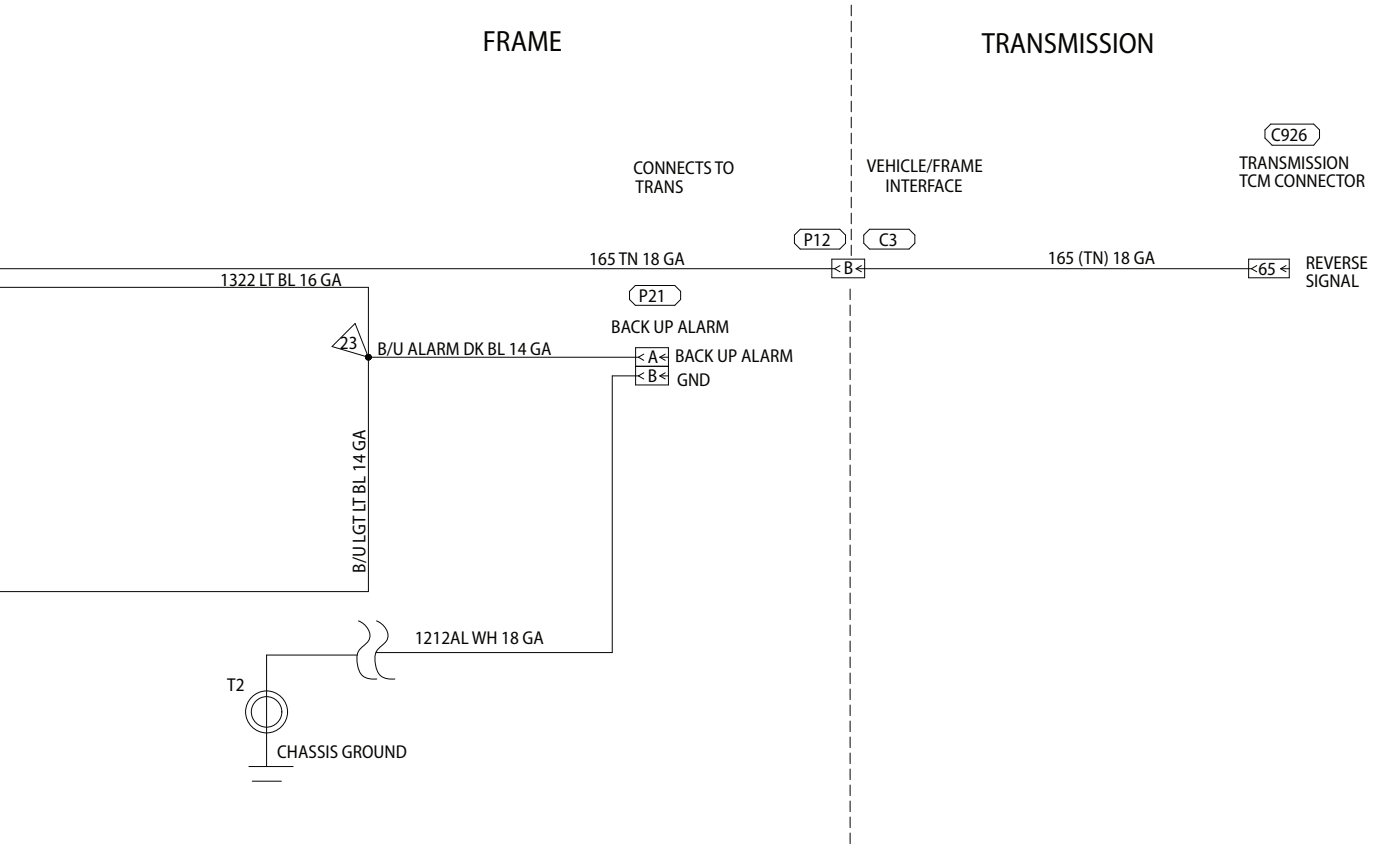
D0005830A



Ammeter

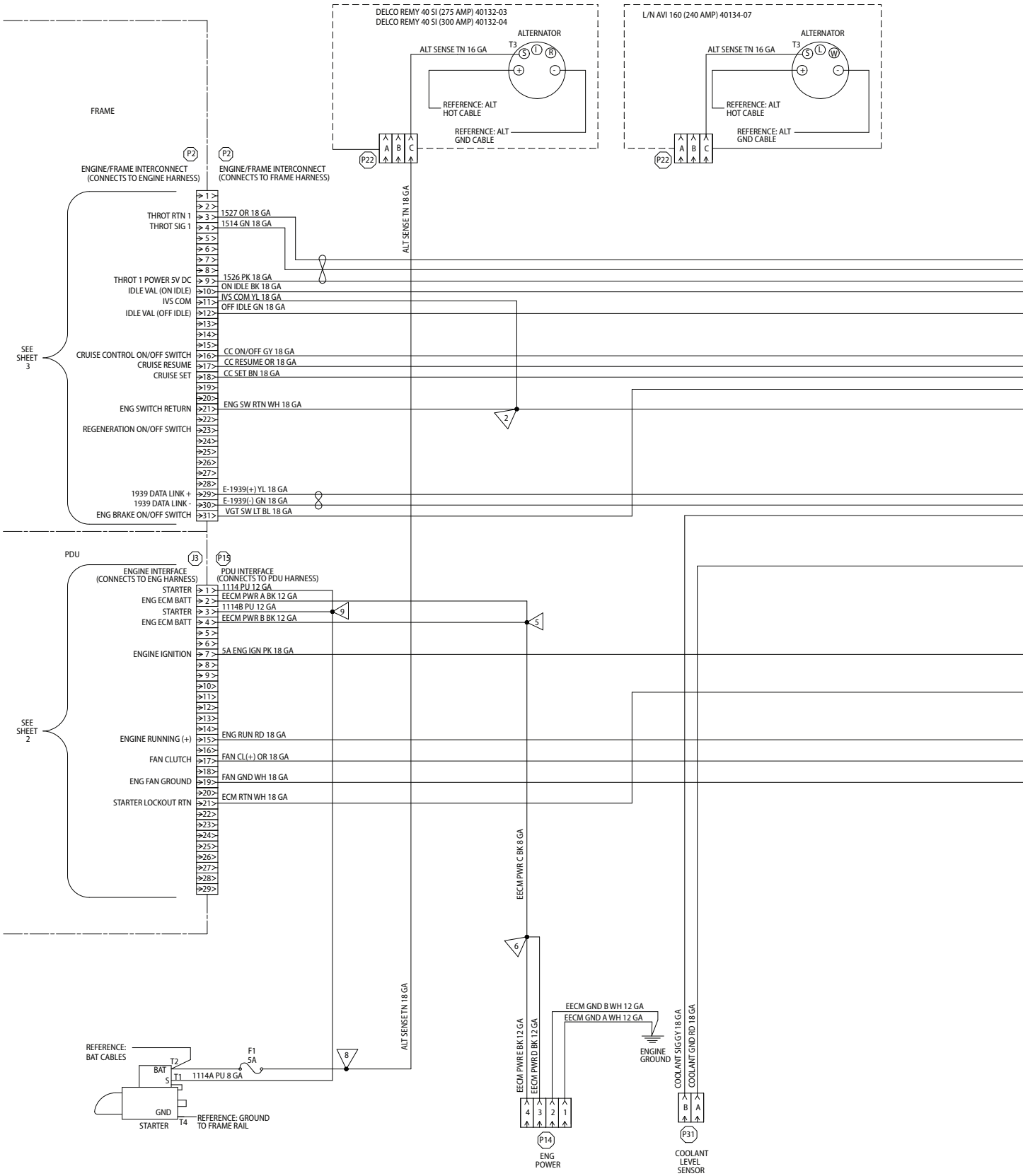
D0005831A

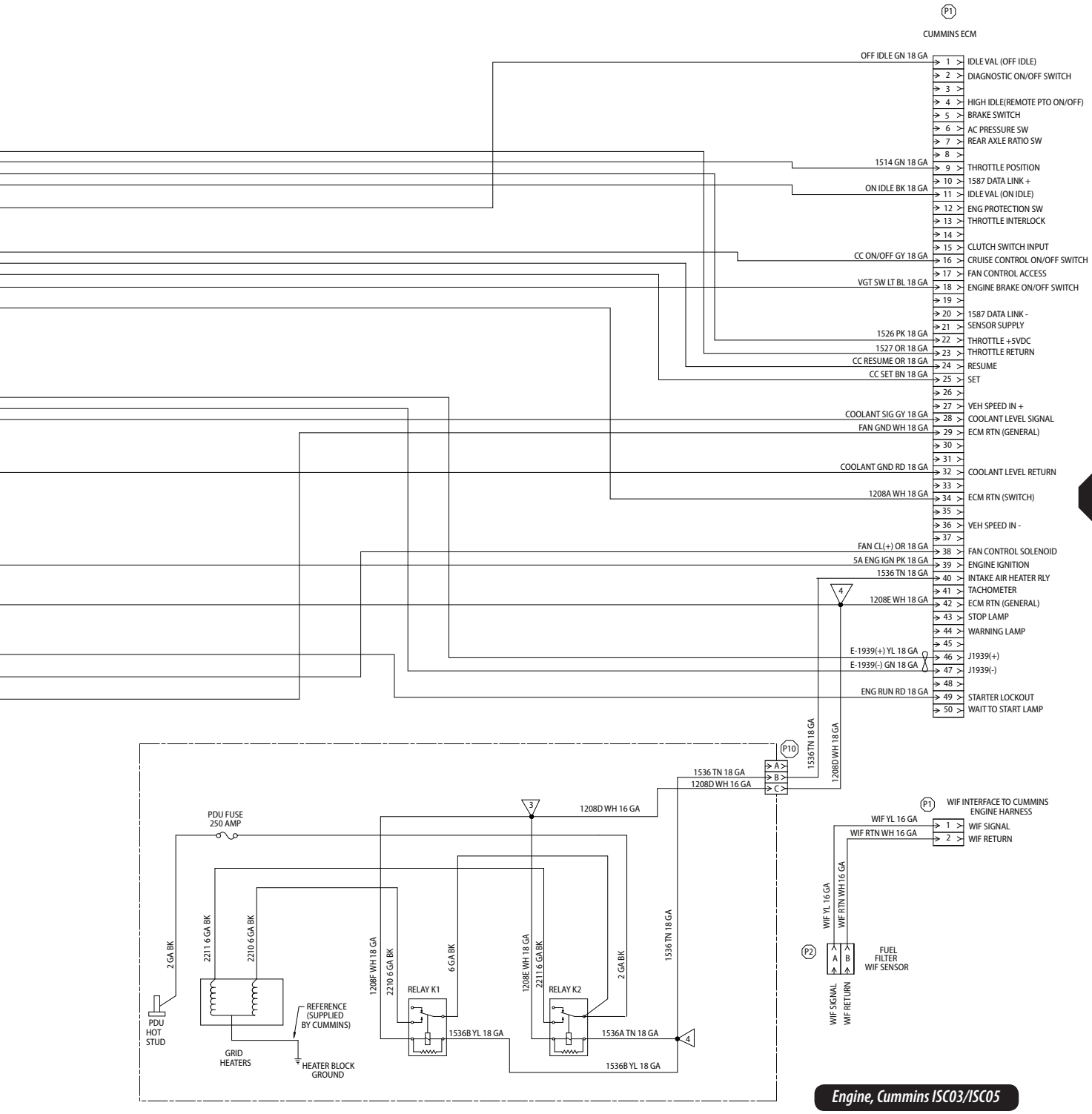

PDU
BACK-UP RELAY P3A
CONNECTS TO FRAME HARNESS
PDU POWER INTERFACE
SEE DIAGRAM WRG:
FUSE P1
BATT
D9
D8
1165E BK 16 GA
POWER
IGN
1133K PK 16 GA
40179 CUMMINS ENG
1133 PK 16 GA
18113 GN 18 GA
1322 LT BL 16 GA
J2
P5
165 TN 18 GA
1322 LT BL 16 GA
ELEC PANEL
IP
CONNECTS TO FRAME HARNESS
CONNECTS TO IP
P6
P6
P200
P1
1322 LT BL 14 GA
1322 LT BL 14 GA
B/U LGT LT BL 14 GA
W/O 02226-00
W/O 02234-00
P5
P5
BODY
P238
1322A LT BL 16 GA
1216D WH 18 GA
LH B/U
LH BACK UP GND
1322 LT BL 16 GA
1216FF WH 14 GA
TO AUX-3 GND
P264-B
P243
1322 LT BL 16 GA
1322 LT BL 16 GA
1216J WH 18 GA
RH B/U
RH BACK UP GND
1216EE WH 14 GA
TO AUX-3 GND
P264-A



Back-Up Light/Alarm

D0005832A

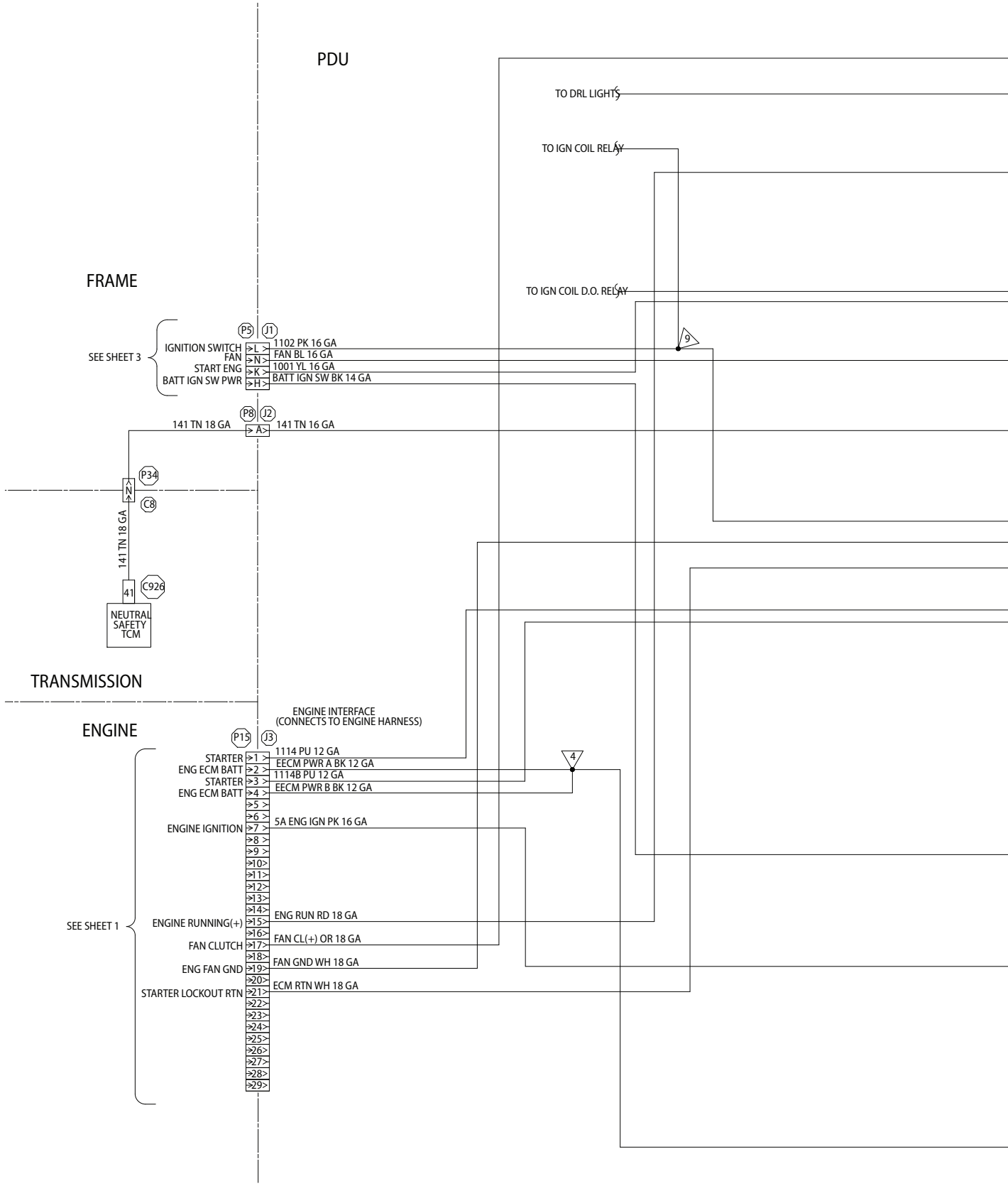

DELCO REMY 40 SI (275 AMP) 40132-03
DELCO REMY 40 SI (300 AMP) 40132-04
ALTERNATOR
ALT SENSE TN 16 GA
T3
REFERENCE: ALT HOT CABLE
REFERENCE: ALT GND CABLE
P22
L/N AVI 160 (240 AMP) 40134-07
FRAME
P2
ENGINE/FRAME INTERCONNECT (CONNECTS TO ENGINE HARNESS)
ENGINE/FRAME INTERCONNECT (CONNECTS TO FRAME HARNESS)
THROT RTN 1
THROT SIG 1
1527 OR 18 GA
1514 GN 18 GA
ALT SENSE TN 18 GA
THROT 1 POWER 5V DC
IDLE VAL (ON IDLE)
IVS COM
IDLE VAL (OFF IDLE)
1526 PK 18 GA
ON IDLE BK 18 GA
IVS COM YL 18 GA
OFF IDLE GN 18 GA
SEE SHEET 3
CRUISE CONTROL ON/OFF SWITCH
CRUISE RESUME
CRUISE SET
CC ON/OFF GY 18 GA
CC RESUME OR 18 GA
CC SET BN 18 GA
ENG SWITCH RETURN
ENG SW RTN WH 18 GA
REGENERATION ON/OFF SWITCH
1939 DATA LINK +
1939 DATA LINK -
ENG BRAKE ON/OFF SWITCH
E-1939(+) YL 18 GA
E-1939(-) GN 18 GA
VGT SW LT BL 18 GA
PDU
J3
P15
ENGINE INTERFACE (CONNECTS TO ENG HARNESS)
PDU INTERFACE (CONNECTS TO PDU HARNESS)
STARTER
ENG ECM BATT
1114 PU 12 GA
EECM PWR A BK 12 GA
1114B PU 12 GA
EECM PWR B BK 12 GA
ENGINE IGNITION
5A ENG IGN PK 18 GA
SEE SHEET 2
ENGINE RUNNING (+)
FAN CLUTCH
ENG FAN GROUND
STARTER LOCKOUT RTN
ENG RUN RD 18 GA
FAN CL(+) OR 18 GA
FAN GND WH 18 GA
ECM RTN WH 18 GA
EECM PWR C BK 8 GA
REFERENCE: BAT CABLES
BAT
S
GND
STARTER
T1
T2
T3
T4
F1
5A
1114A PU 8 GA
REFERENCE: GROUND TO FRAME RAIL
EECM PWR E BK 12 GA
EECM PWR D BK 12 GA
EECM GND B WH 12 GA
EECM GND A WH 12 GA
ENGINE GROUND
COOLANT SIG GY 18 GA
COOLANT GND RD 18 GA
P14
ENG POWER
P31
COOLANT LEVEL SENSOR

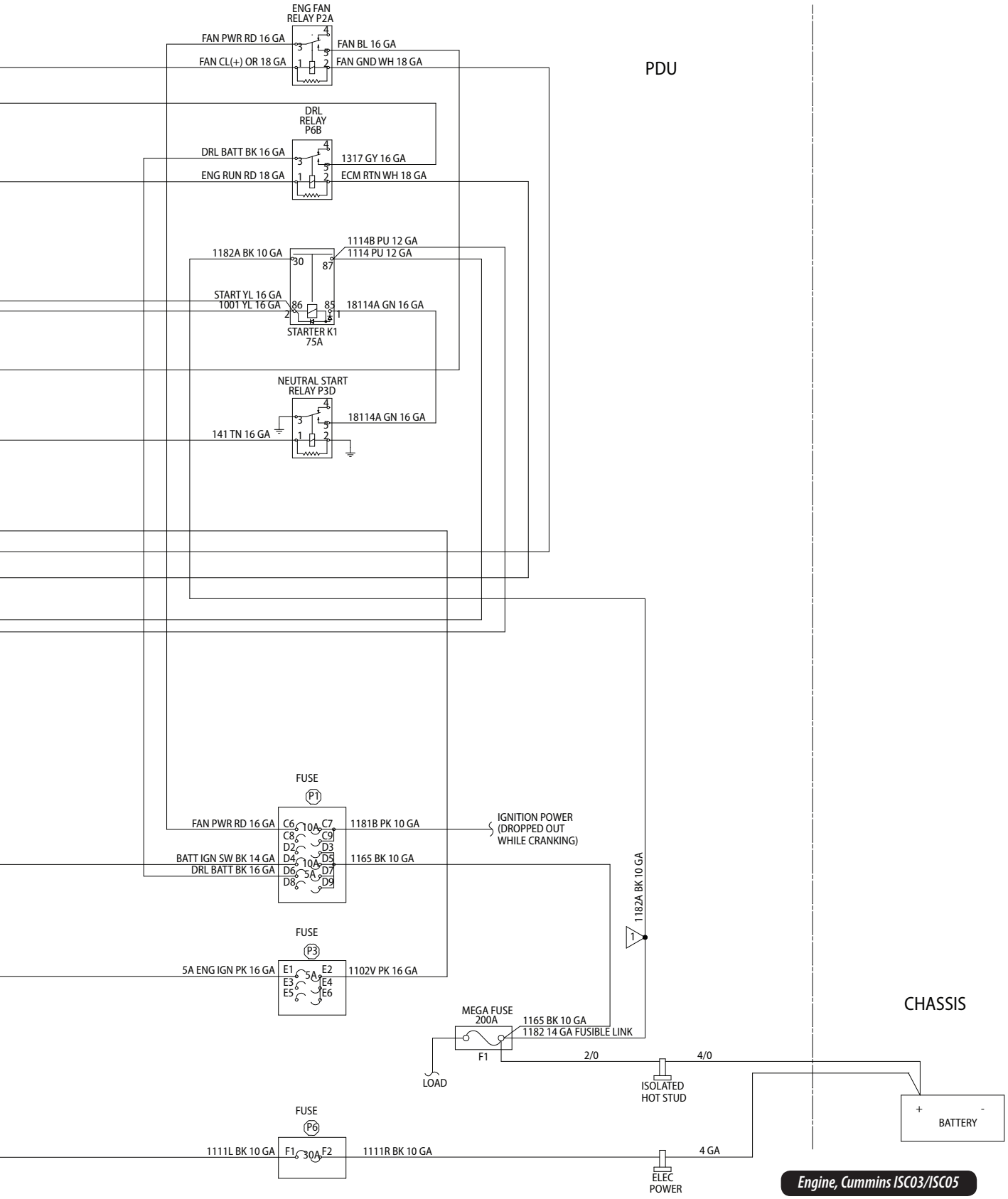


Engine, Cummins ISC03/ISC05

D0005873C

Sheet 1 of 3


PDU
TO DRL LIGHTS
TO IGN COIL RELAY
TO IGN COIL D.O. RELAY
FRAME
SEE SHEET 3
P5
J1
IGNITION SWITCH
FAN
START ENG
BATT IGN SW PWR
>L<
>N<
>K<
>H<
1102 PK 16 GA
FAN BL 16 GA
1001 YL 16 GA
BATT IGN SW BK 14 GA
9
P8
J2
141 TN 18 GA
>A<
141 TN 16 GA
P34
N
C8
141 TN 18 GA
41
C926
NEUTRAL SAFETY TCM
TRANSMISSION
ENGINE
ENGINE INTERFACE
(CONNECTS TO ENGINE HARNESS)
P15
J3
STARTER
ENG ECM BATT
STARTER
ENG ECM BATT
1114 PU 12 GA
EECM PWR A BK 12 GA
1114B PU 12 GA
EECM PWR B BK 12 GA
4
ENGINE IGNITION
5A ENG IGN PK 16 GA
SEE SHEET 1
ENGINE RUNNING(+)
FAN CLUTCH
ENG FAN GND
STARTER LOCKOUT RTN
ENG RUN RD 18 GA
FAN CL(+) OR 18 GA
FAN GND WH 18 GA
ECM RTN WH 18 GA



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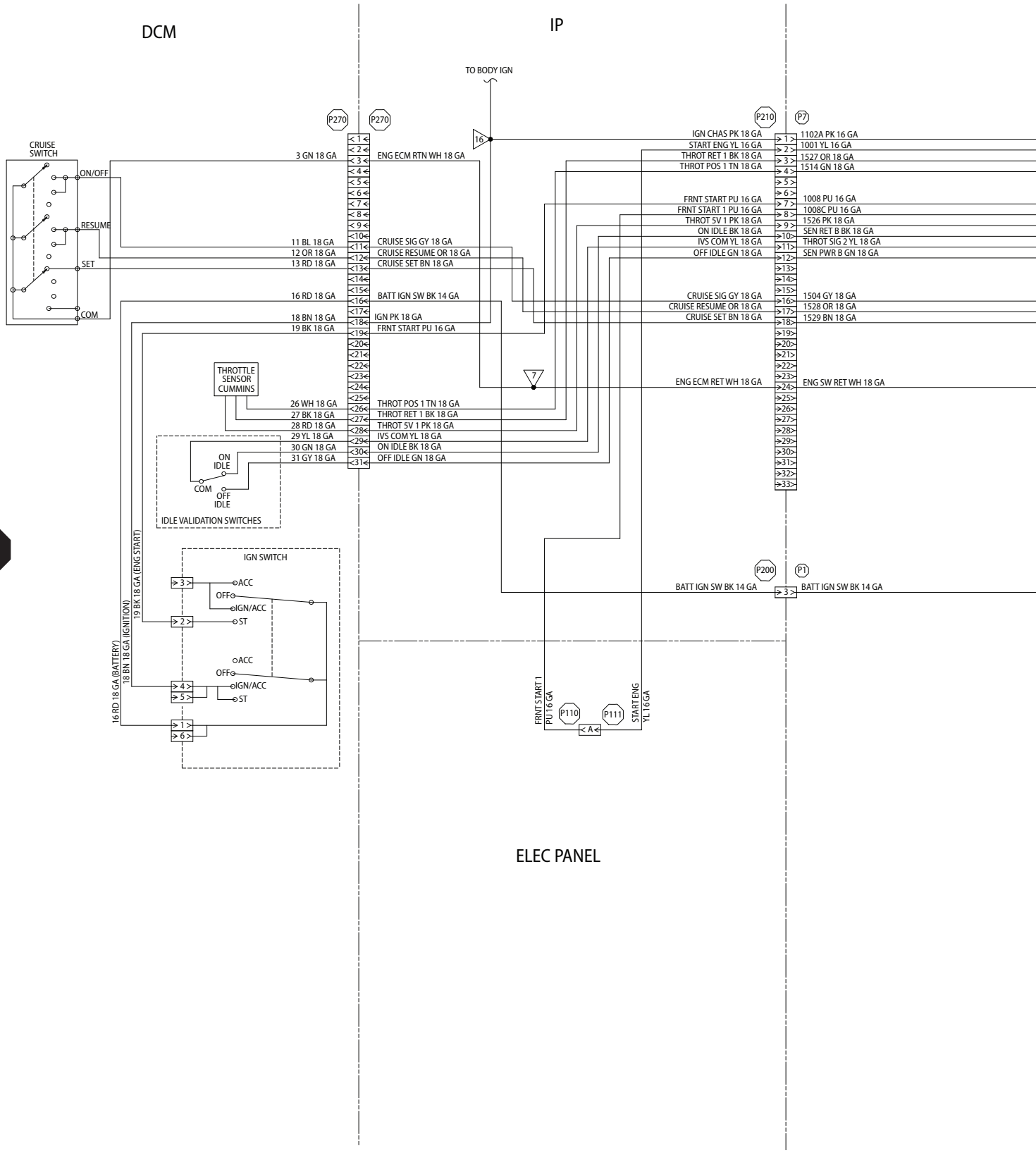
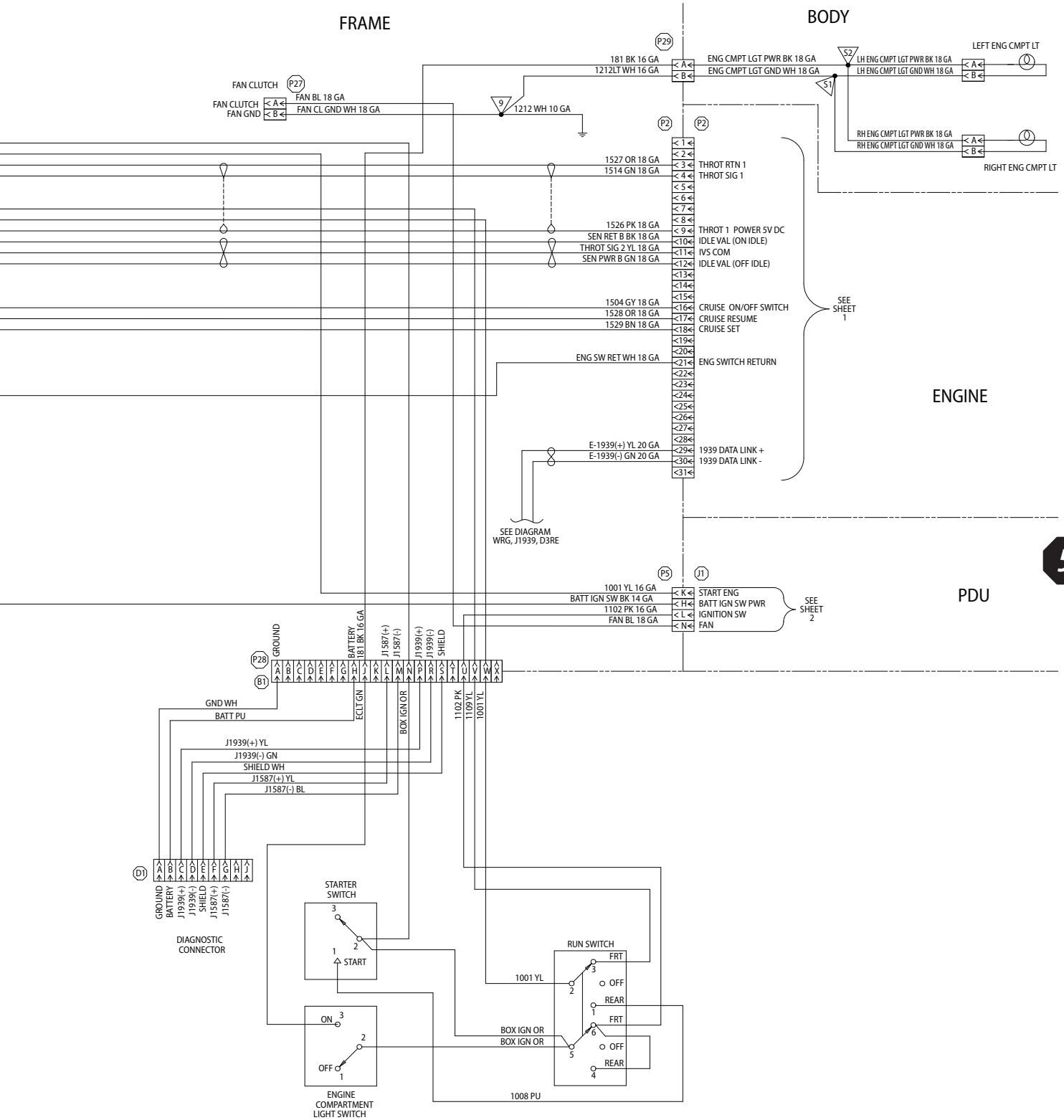
Engine, Cummins ISC03/ISC05

D0005873C

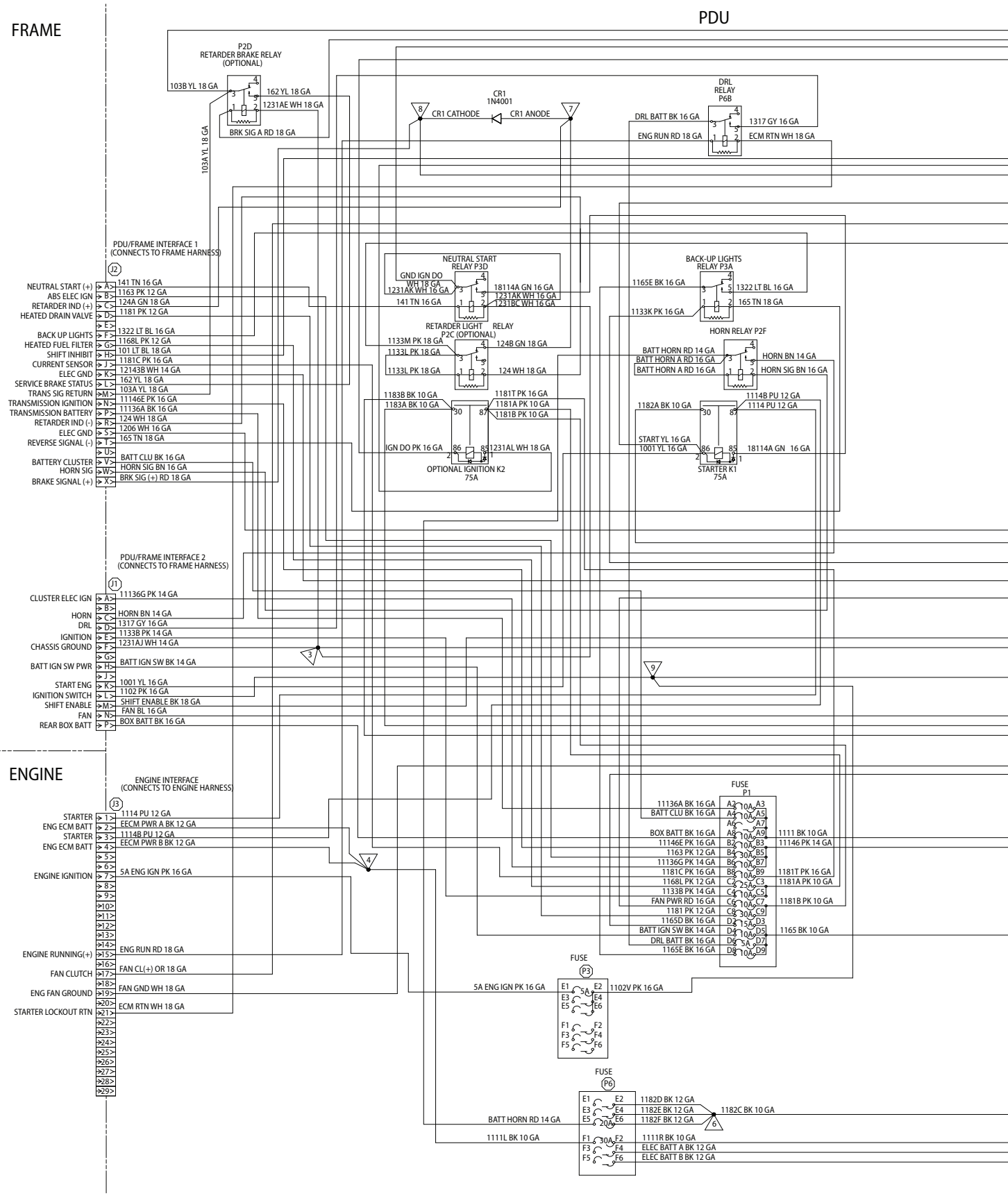
Sheet 2 of 3

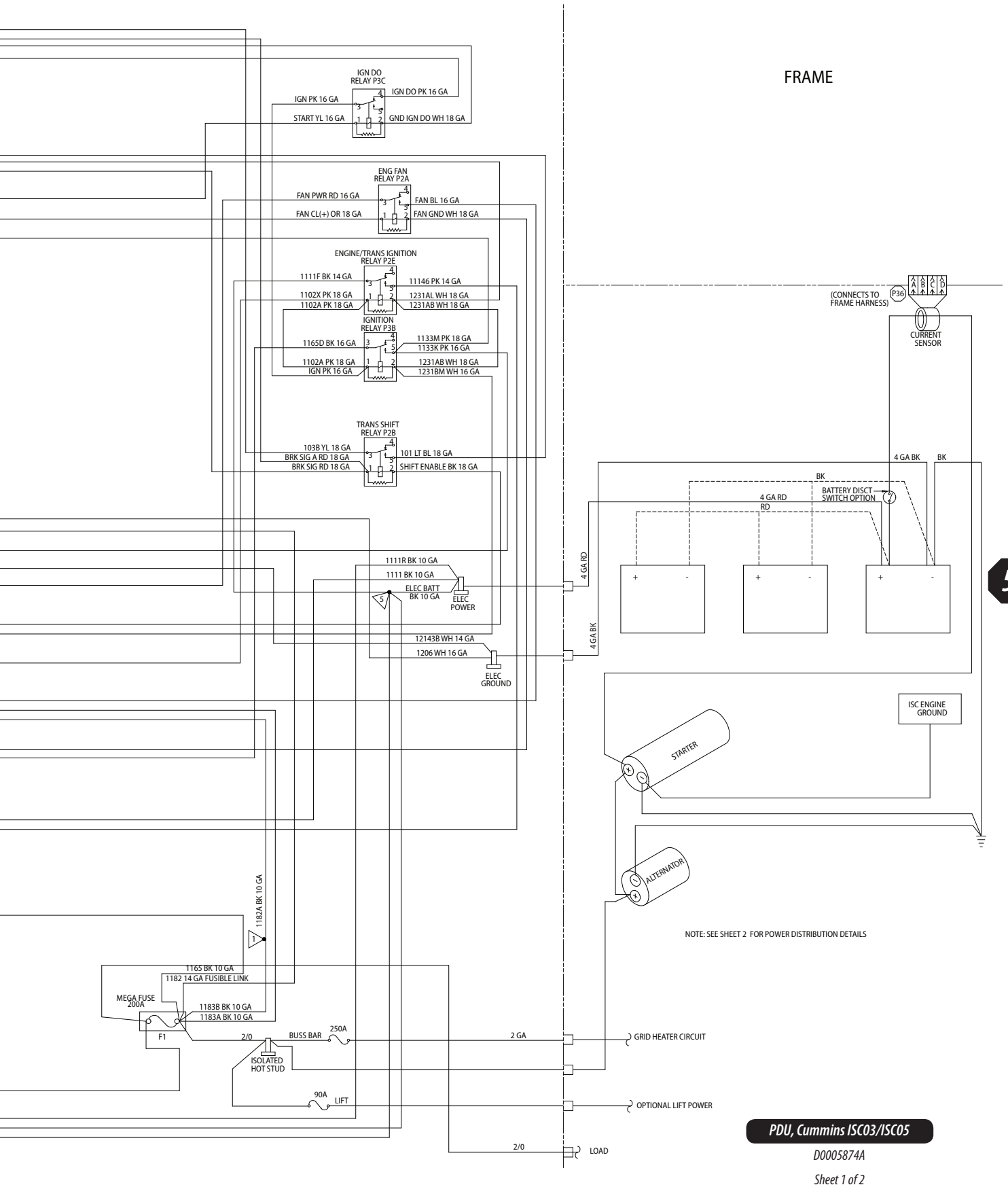

DCM
IP
TO BODY IGN
P270
P270
P210
P7
CRUISE SWITCH
ON/OFF
RESUME
SET
COM
3 GN 18 GA
ENG ECM RTN WH 18 GA
11 BL 18 GA
CRUISE SIG GY 18 GA
12 OR 18 GA
CRUISE RESUME OR 18 GA
13 RD 18 GA
CRUISE SET BN 18 GA
16 RD 18 GA
BATT IGN SW BK 14 GA
18 BN 18 GA
IGN PK 18 GA
19 BK 18 GA
FRNT START PU 16 GA
THROTTLE SENSOR CUMMINS
26 WH 18 GA
THROT POS 1 TN 18 GA
27 BK 18 GA
THROT RET 1 BK 18 GA
28 RD 18 GA
THROT 5V 1 PK 18 GA
29 YL 18 GA
IVS COM YL 18 GA
30 GN 18 GA
ON IDLE BK 18 GA
31 GY 18 GA
OFF IDLE GN 18 GA
ON IDLE
COM
OFF IDLE
IDLE VALIDATION SWITCHES
IGN SWITCH
ACC
OFF
IGN/ACC
ST
19 BK 18 GA (ENG START)
18 BN 18 GA (IGNITION)
16 RD 18 GA (BATTERY)
IGN CHAS PK 18 GA
1102A PK 16 GA
START ENG YL 16 GA
1001 YL 16 GA
THROT RET 1 BK 18 GA
1527 OR 18 GA
THROT POS 1 TN 18 GA
1514 GN 18 GA
FRNT START PU 16 GA
1008 PU 16 GA
FRNT START 1 PU 16 GA
1008C PU 16 GA
THROT 5V 1 PK 18 GA
1526 PK 18 GA
ON IDLE BK 18 GA
SEN RET B BK 18 GA
IVS COM YL 18 GA
THROT SIG 2 YL 18 GA
OFF IDLE GN 18 GA
SEN PWR B GN 18 GA
CRUISE SIG GY 18 GA
1504 GY 18 GA
CRUISE RESUME OR 18 GA
1528 OR 18 GA
CRUISE SET BN 18 GA
1529 BN 18 GA
ENG ECM RET WH 18 GA
ENG SW RET WH 18 GA
P200
P1
BATT IGN SW BK 14 GA
BATT IGN SW BK 14 GA
FRNT START 1 PU 16 GA
P110
P111
START ENG YL 16 GA
A
ELEC PANEL



REAR CONTROL BOX

(ONLY STANDARD BOX SCHEMATIC SHOWN)


FRAME
PDU
ENGINE
P2D
RETARDER BRAKE RELAY
(OPTIONAL)
103B YL 18 GA
162 YL 18 GA
1231AE WH 18 GA
BRK SIG A RD 18 GA
103A YL 18 GA
CR1
1N4001
CR1 CATHODE
CR1 ANODE
DRL
RELAY
P6B
DRL BATT BK 16 GA
1317 GY 16 GA
ENG RUN RD 18 GA
ECM RTN WH 18 GA
PDU/FRAME INTERFACE 1
(CONNECTS TO FRAME HARNESS)
J2
NEUTRAL START (+) 141 TN 16 GA
ABS ELEC IGN 1163 PK 12 GA
RETARDER IND (+) 124A GN 18 GA
HEATED DRAIN VALVE 1181 PK 12 GA
BACK UP LIGHTS 1322 LT BL 16 GA
HEATED FUEL FILTER 1168L PK 12 GA
SHIFT INHIBIT 101 LT BL 18 GA
CURRENT SENSOR 1181C PK 16 GA
ELEC GND 12143B WH 14 GA
SERVICE BRAKE STATUS 162 YL 18 GA
TRANS SIG RETURN 103A YL 18 GA
TRANSMISSION IGNITION 11146E PK 16 GA
TRANSMISSION BATTERY 11136A BK 16 GA
RETARDER IND (-) 124 WH 18 GA
ELEC GND 1206 WH 16 GA
REVERSE SIGNAL (-) 165 TN 18 GA
BATTERY CLUSTER BATT CLU BK 16 GA
HORN SIG HORN SIG BN 16 GA
BRAKE SIGNAL (+) BRK SIG (+) RD 18 GA
NEUTRAL START
RELAY P3D
GND IGN DO WH 18 GA
1231AK WH 16 GA
141 TN 16 GA
18114A GN 16 GA
1231AK WH 16 GA
1231BC WH 16 GA
RETARDER LIGHT RELAY
P2C (OPTIONAL)
1133M PK 18 GA
1133L PK 18 GA
124B GN 18 GA
1133L PK 18 GA
124 WH 18 GA
1183B BK 10 GA
1183A BK 10 GA
1181T PK 16 GA
1181A PK 10 GA
1181B PK 10 GA
IGN DO PK 16 GA
1231AL WH 18 GA
OPTIONAL IGNITION K2
75A
BACK-UP LIGHTS
RELAY P3A
1165E BK 16 GA
1322 LT BL 16 GA
1133K PK 16 GA
165 TN 18 GA
HORN RELAY P2F
BATT HORN RD 14 GA
BATT HORN A RD 16 GA
HORN BN 14 GA
BATT HORN A RD 16 GA
HORN SIG BN 16 GA
1114B PU 12 GA
1182A BK 10 GA
1114 PU 12 GA
START YL 16 GA
1001 YL 16 GA
18114A GN 16 GA
STARTER K1
75A
PDU/FRAME INTERFACE 2
(CONNECTS TO FRAME HARNESS)
J1
CLUSTER ELEC IGN 11136G PK 14 GA
HORN HORN BN 14 GA
DRL 1317 GY 16 GA
IGNITION 1133B PK 14 GA
CHASSIS GROUND 1231AJ WH 14 GA
BATT IGN SW PWR BATT IGN SW BK 14 GA
START ENG 1001 YL 16 GA
IGNITION SWITCH 1102 PK 16 GA
SHIFT ENABLE SHIFT ENABLE BK 18 GA
FAN FAN BL 16 GA
REAR BOX BATT BOX BATT BK 16 GA
ENGINE INTERFACE
(CONNECTS TO ENGINE HARNESS)
J3
STARTER 1114 PU 12 GA
ENG ECM BATT EECM PWR A BK 12 GA
STARTER 1114B PU 12 GA
ENG ECM BATT EECM PWR B BK 12 GA
ENGINE IGNITION 5A ENG IGN PK 16 GA
ENGINE RUNNING(+) ENG RUN RD 18 GA
FAN CLUTCH FAN CL(+) OR 18 GA
ENG FAN GROUND FAN GND WH 18 GA
STARTER LOCKOUT RTN ECM RTN WH 18 GA
FUSE
P1
11136A BK 16 GA
BATT CLU BK 16 GA
BOX BATT BK 16 GA
11146E PK 16 GA
1163 PK 12 GA
11136G PK 14 GA
1181C PK 16 GA
1168L PK 12 GA
1133B PK 14 GA
FAN PWR RD 16 GA
1181 PK 12 GA
1165D BK 16 GA
BATT IGN SW BK 14 GA
DRL BATT BK 16 GA
1165E BK 16 GA
1111 BK 10 GA
11146 PK 14 GA
1181T PK 16 GA
1181A PK 10 GA
1181B PK 10 GA
1165 BK 10 GA
FUSE
P3
5A ENG IGN PK 16 GA
1102V PK 16 GA
FUSE
P6
BATT HORN RD 14 GA
1111L BK 10 GA
1182D BK 12 GA
1182E BK 12 GA
1182F BK 12 GA
1182C BK 10 GA
1111R BK 10 GA
ELEC BATT A BK 12 GA
ELEC BATT B BK 12 GA



PDU, Cummins ISC03/ISC05

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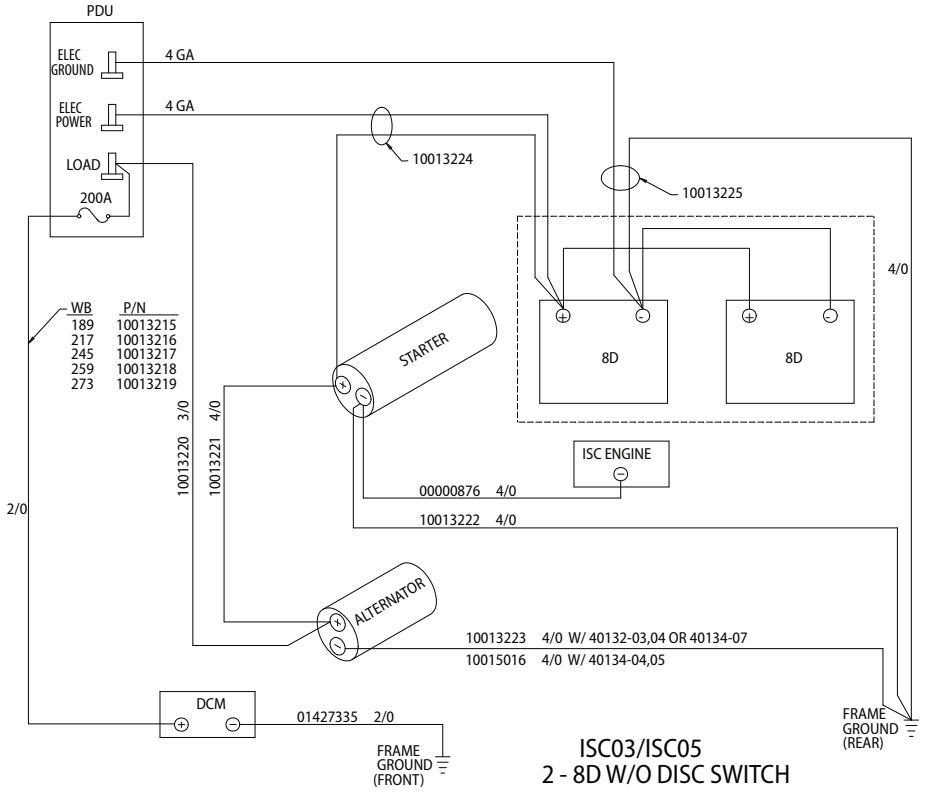
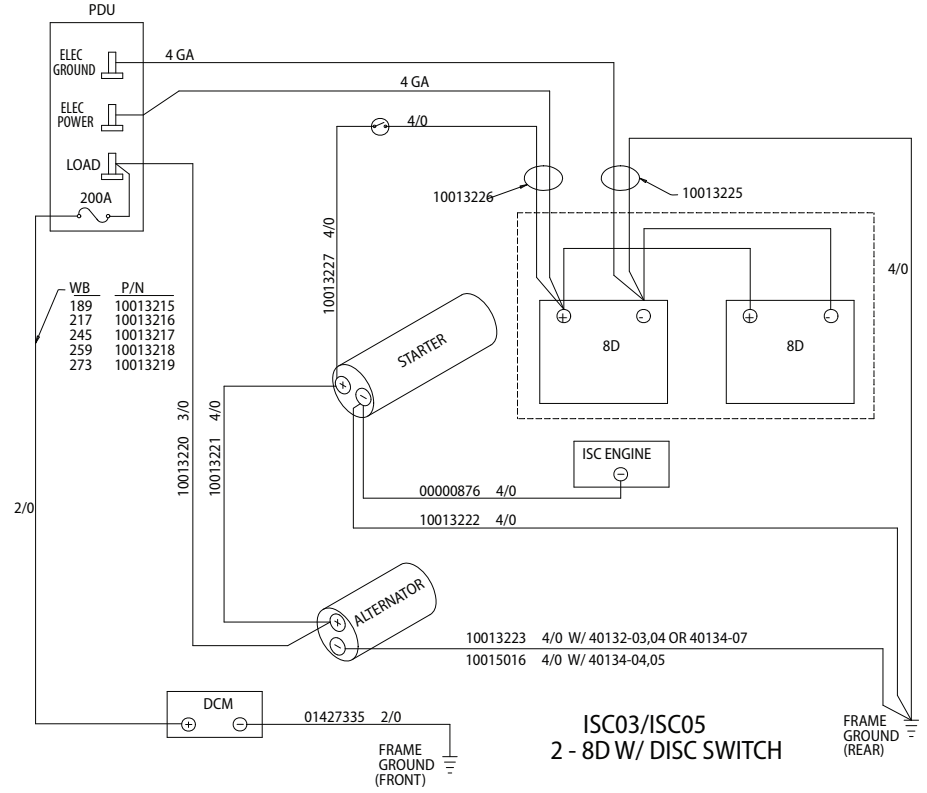
Sheet 1 of 2

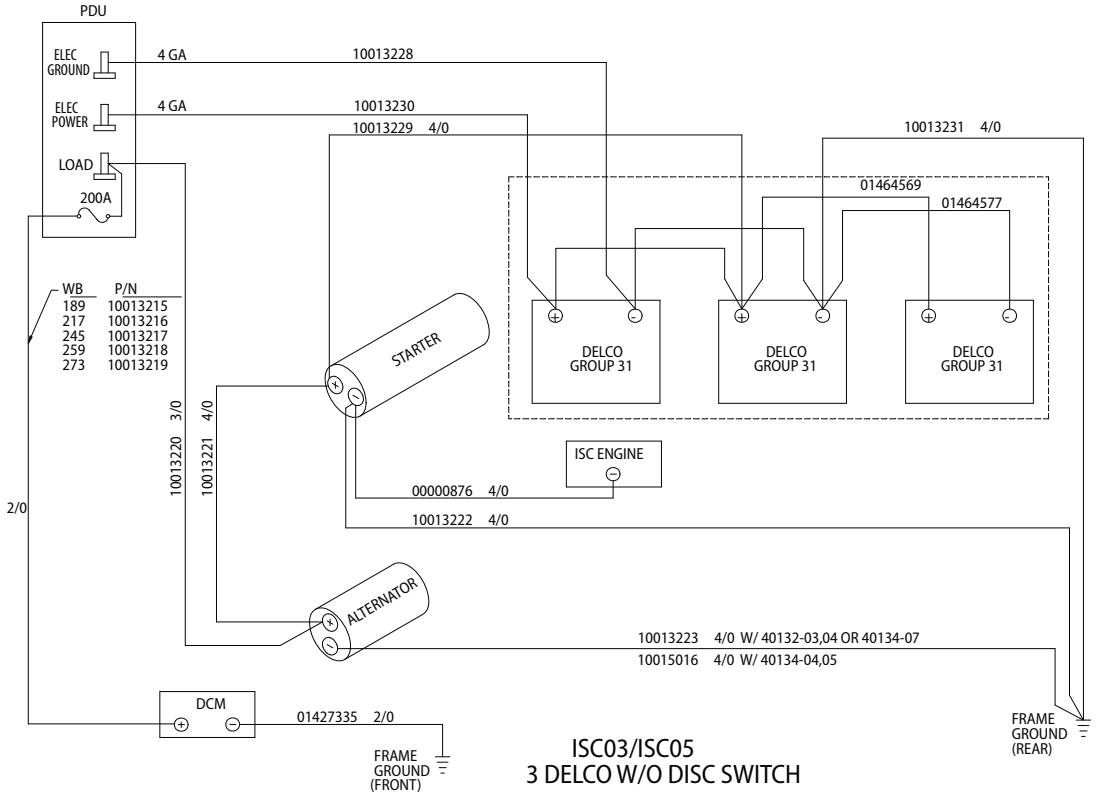


ISC03/ISC05
2 - 8D W/O DISC SWITCH

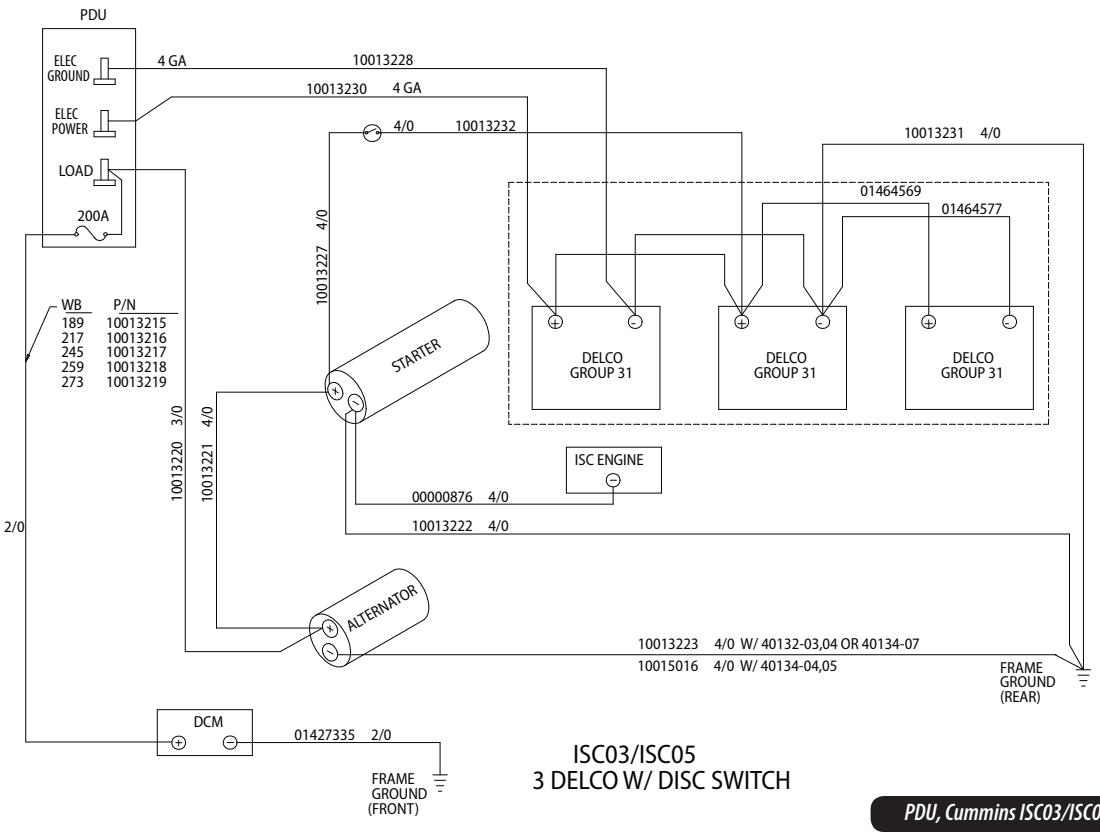
600



ISC03/ISC05
2 - 8D W/ DISC SWITCH



ISC03/ISC05
3 DELCO W/O DISC SWITCH



ISC03/ISC05
3 DELCO W/ DISC SWITCH

PDU, Cummins ISC03/ISC05

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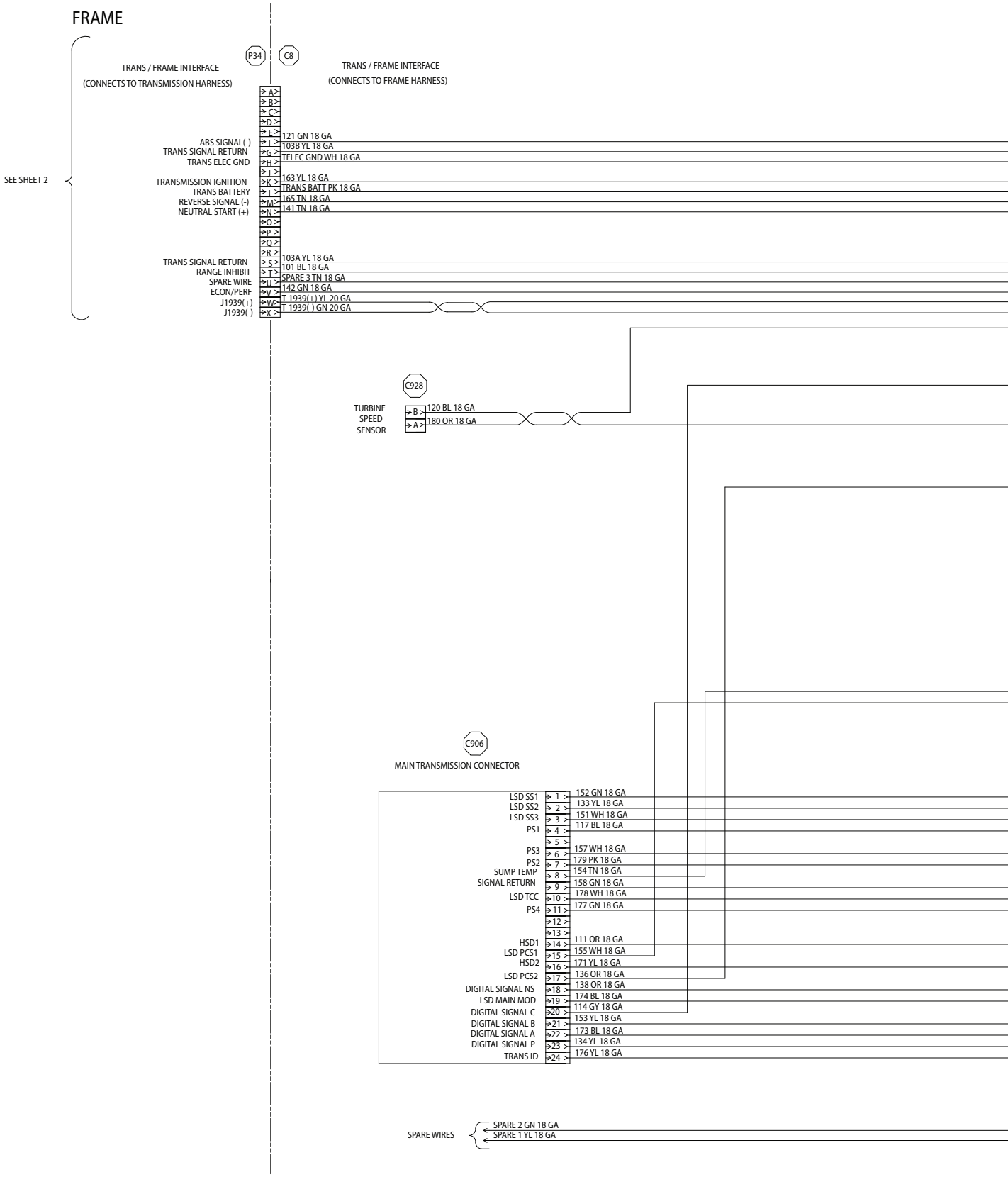
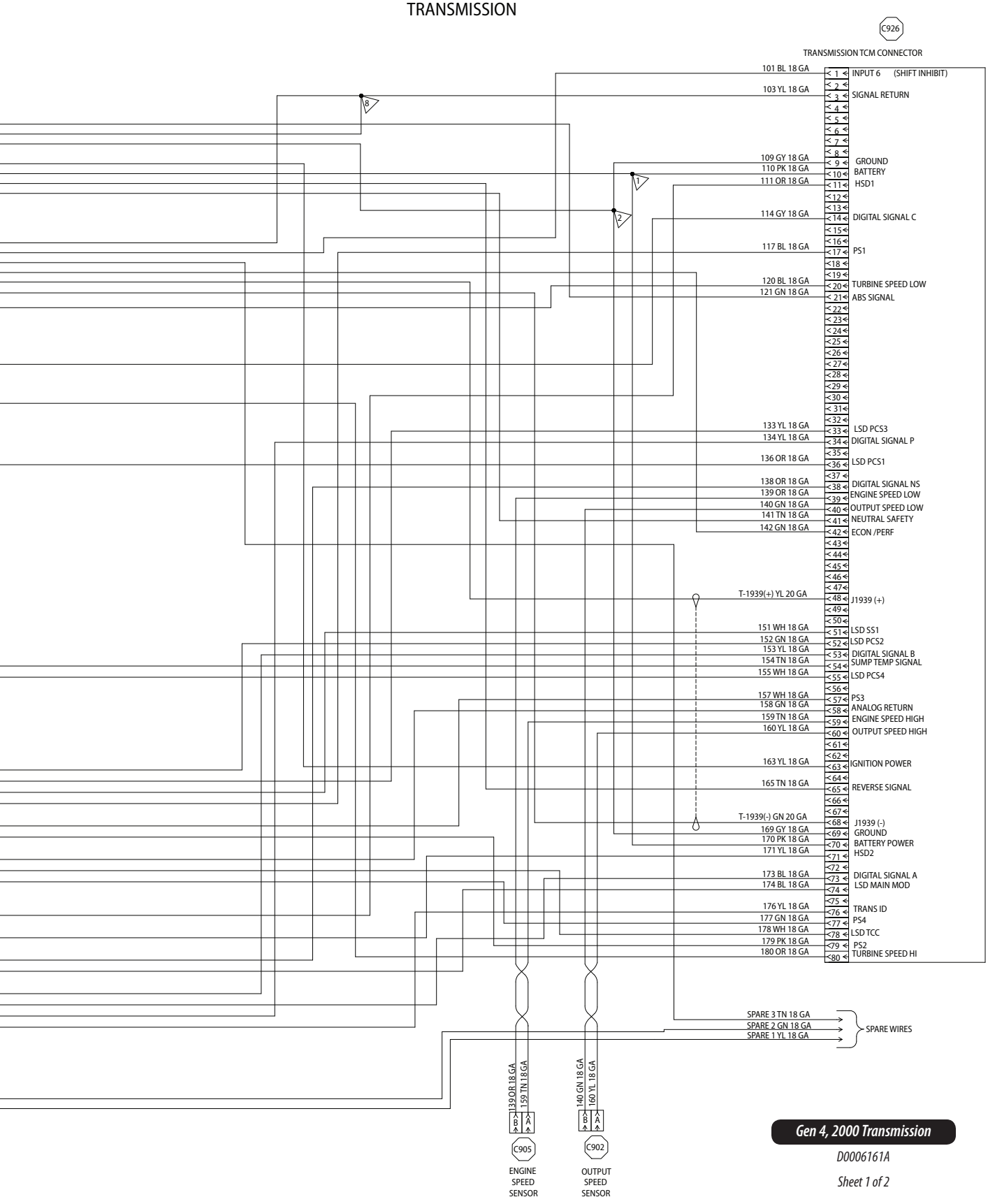
Sheet 2 of 2


FRAME
P34
C8
TRANS / FRAME INTERFACE
(CONNECTS TO TRANSMISSION HARNESS)
TRANS / FRAME INTERFACE
(CONNECTS TO FRAME HARNESS)
SEE SHEET 2
ABS SIGNAL(-)
TRANS SIGNAL RETURN
TRANS ELEC GND
TRANSMISSION IGNITION
TRANS BATTERY
REVERSE SIGNAL (-)
NEUTRAL START (+)
TRANS SIGNAL RETURN
RANGE INHIBIT
SPARE WIRE
ECON/PERF
J1939(+)
J1939(-)
121 GN 18 GA
103B YL 18 GA
TELEC GND WH 18 GA
163 YL 18 GA
TRANS BATT PK 18 GA
165 TN 18 GA
141 TN 18 GA
103A YL 18 GA
101 BL 18 GA
SPARE 3 TN 18 GA
142 GN 18 GA
T-1939(+) YL 20 GA
T-1939(-) GN 20 GA
C928
TURBINE SPEED SENSOR
120 BL 18 GA
180 OR 18 GA
C906
MAIN TRANSMISSION CONNECTOR
LSD SS1
LSD SS2
LSD SS3
PS1
PS3
PS2
SUMP TEMP
SIGNAL RETURN
LSD TCC
PS4
HSD1
LSD PCS1
HSD2
LSD PCS2
DIGITAL SIGNAL NS
LSD MAIN MOD
DIGITAL SIGNAL C
DIGITAL SIGNAL B
DIGITAL SIGNAL A
DIGITAL SIGNAL P
TRANS ID
152 GN 18 GA
133 YL 18 GA
151 WH 18 GA
117 BL 18 GA
157 WH 18 GA
179 PK 18 GA
154 TN 18 GA
158 GN 18 GA
178 WH 18 GA
177 GN 18 GA
111 OR 18 GA
155 WH 18 GA
171 YL 18 GA
136 OR 18 GA
138 OR 18 GA
174 BL 18 GA
114 GY 18 GA
153 YL 18 GA
173 BL 18 GA
134 YL 18 GA
176 YL 18 GA
SPARE WIRES
SPARE 2 GN 18 GA
SPARE 1 YL 18 GA

TRANSMISSION



Gen 4, 2000 Transmission

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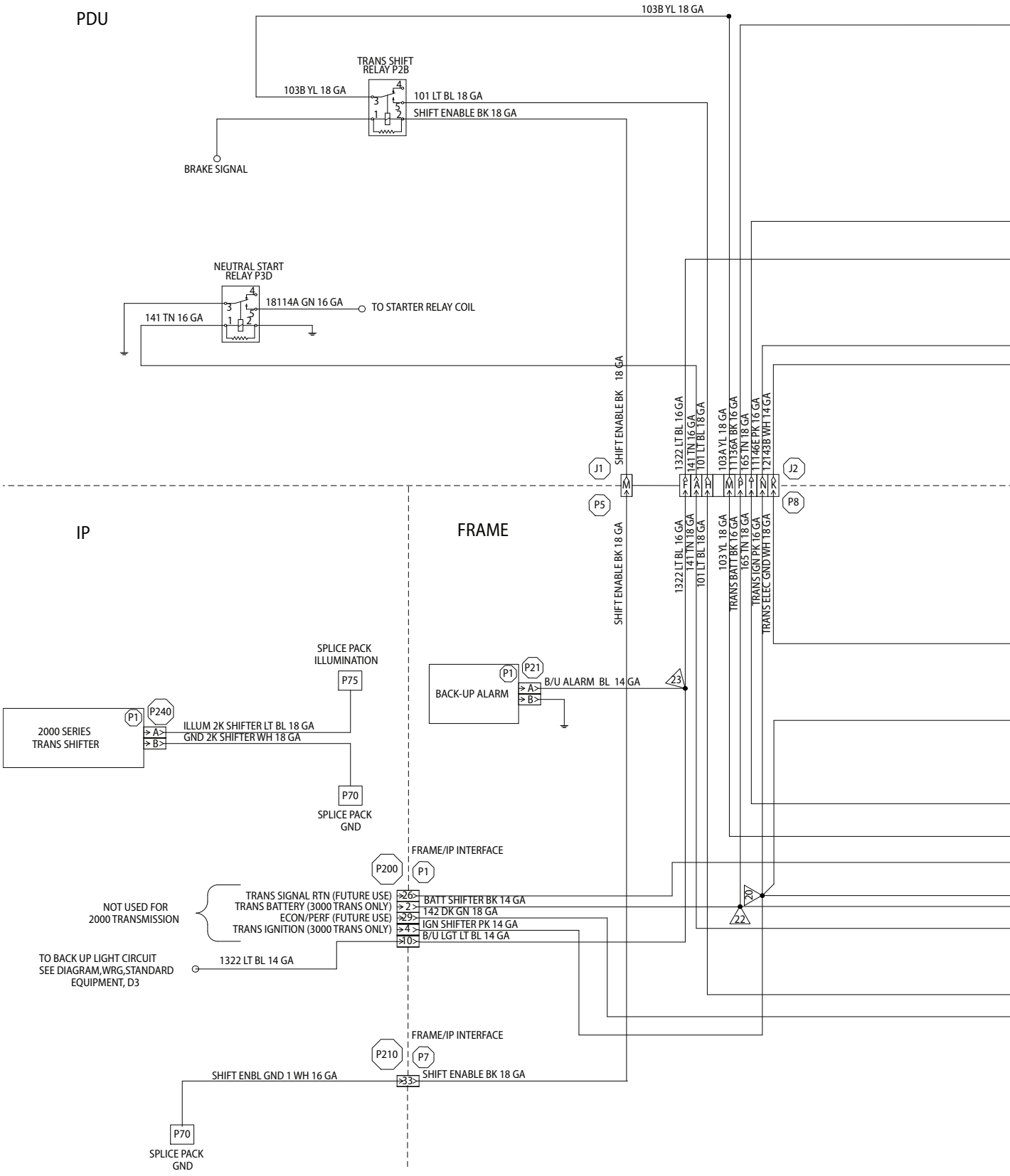
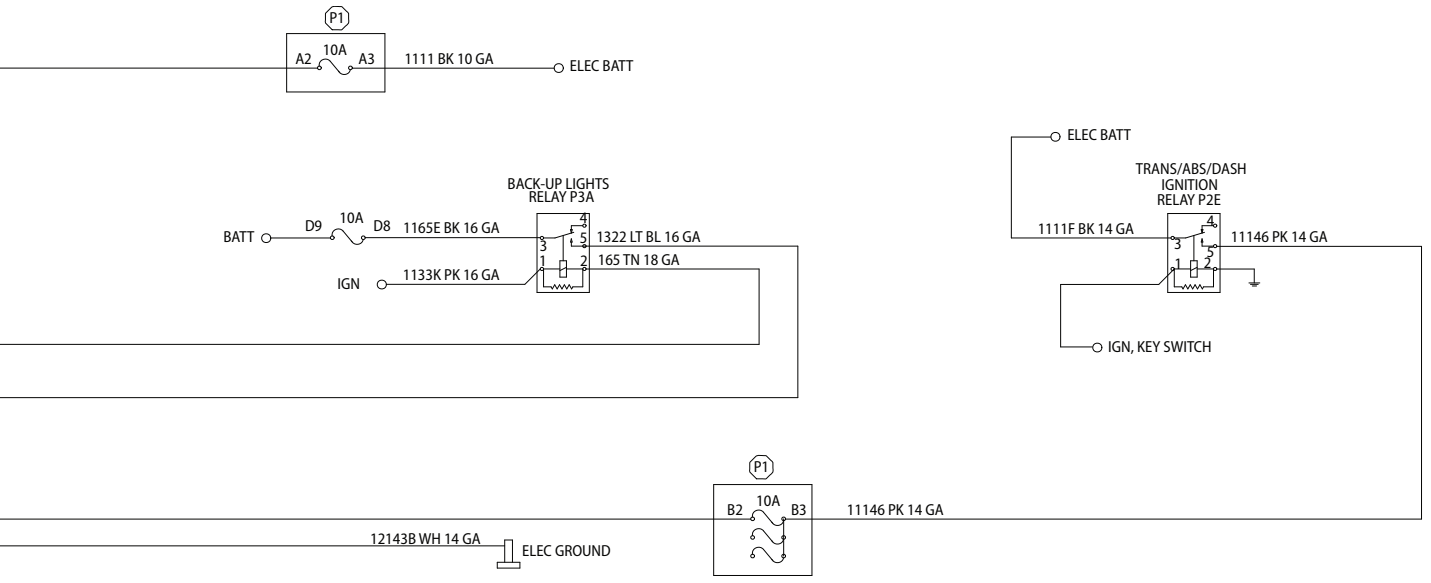
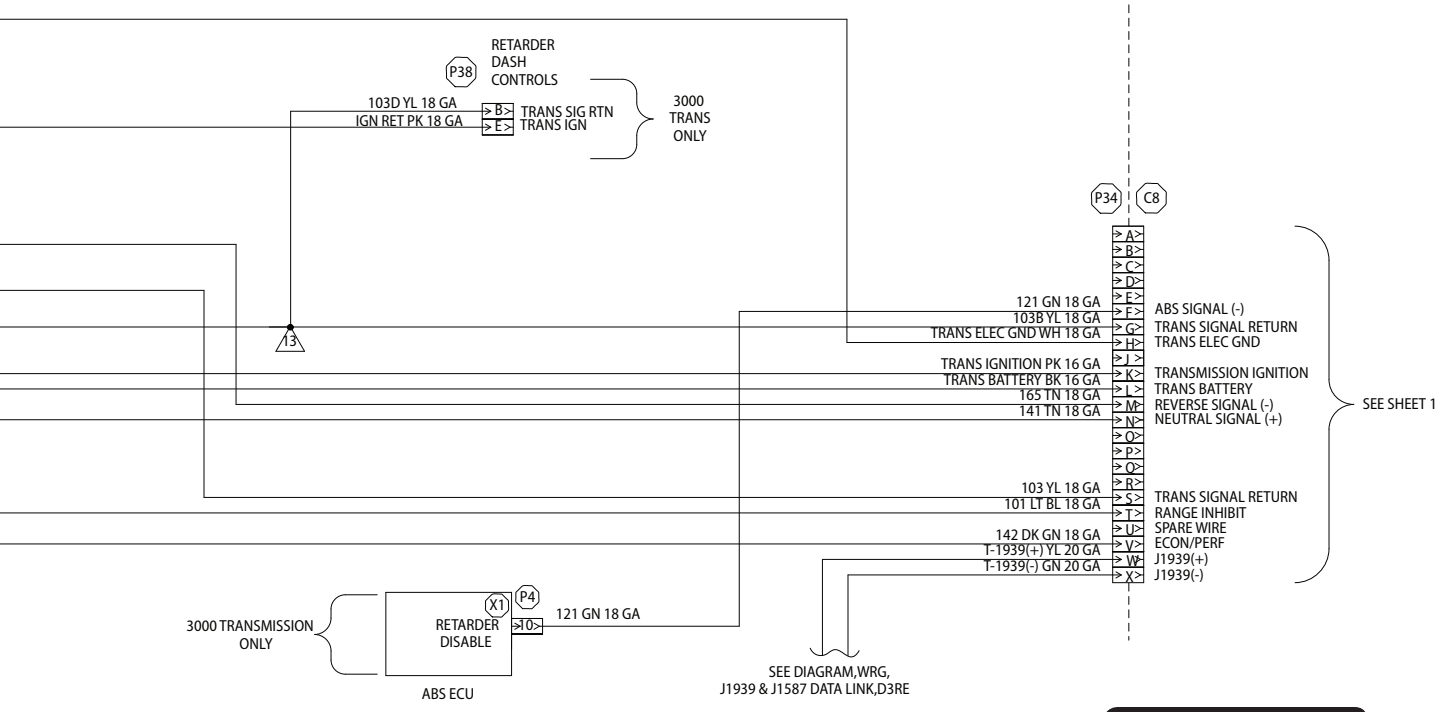
Sheet 1 of 2


PDU
103B YL 18 GA
TRANS SHIFT RELAY P2B
103B YL 18 GA
101 LT BL 18 GA
SHIFT ENABLE BK 18 GA
BRAKE SIGNAL
NEUTRAL START RELAY P3D
18114A GN 16 GA
TO STARTER RELAY COIL
141 TN 16 GA
SHIFT ENABLE BK 18 GA
1322 LT BL 16 GA
141 TN 16 GA
101 LT BL 18 GA
103A YL 18 GA
11136A BK 16 GA
165 TN 18 GA
11146E PK 16 GA
12143B WH 14 GA
J1
J2
P5
P8
IP
FRAME
SHIFT ENABLE BK 18 GA
1322 LT BL 16 GA
141 TN 18 GA
101 LT BL 18 GA
103 YL 18 GA
TRANS BATT BK 16 GA
165 TN 18 GA
TRANS IGN PK 16 GA
TRANS ELEC GND WH 18 GA
SPLICE PACK ILLUMINATION
P75
P1
P240
2000 SERIES TRANS SHIFTER
A
B
ILLUM 2K SHIFTER LT BL 18 GA
GND 2K SHIFTER WH 18 GA
P70
SPLICE PACK GND
P1
P21
BACK-UP ALARM
B/U ALARM BL 14 GA
23
FRAME/IP INTERFACE
P200
P1
NOT USED FOR 2000 TRANSMISSION
TRANS SIGNAL RTN (FUTURE USE)
TRANS BATTERY (3000 TRANS ONLY)
ECON/PERF (FUTURE USE)
TRANS IGNITION (3000 TRANS ONLY)
26
2
29
4
10
BATT SHIFTER BK 14 GA
142 DK GN 18 GA
IGN SHIFTER PK 14 GA
B/U LGT LT BL 14 GA
20
22
TO BACK UP LIGHT CIRCUIT SEE DIAGRAM,WRG,STANDARD EQUIPMENT, D3
1322 LT BL 14 GA
FRAME/IP INTERFACE
P210
P7
SHIFT ENBL GND 1 WH 16 GA
33
SHIFT ENABLE BK 18 GA
P70
SPLICE PACK GND





Gen 4, 2000 Transmission

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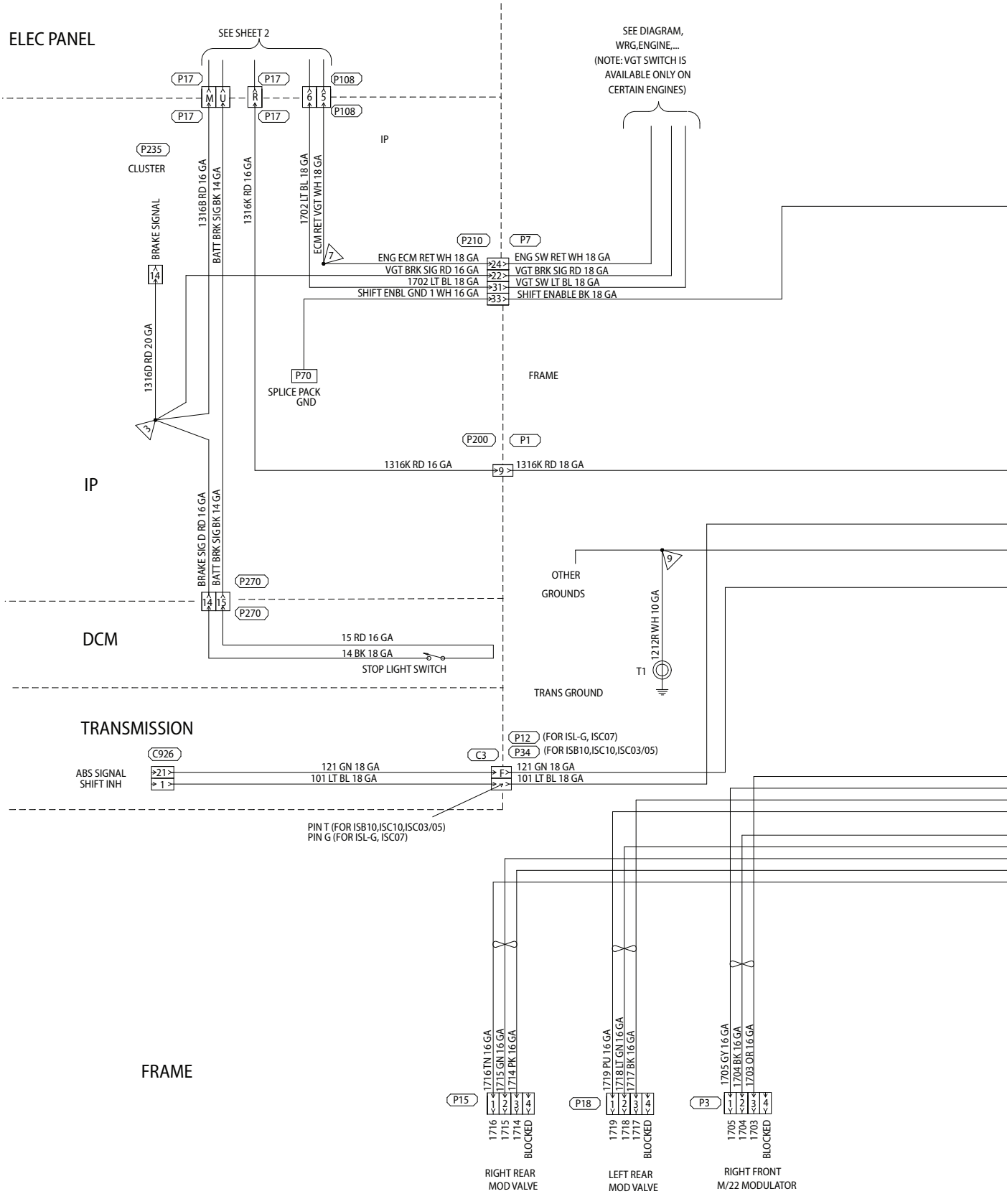
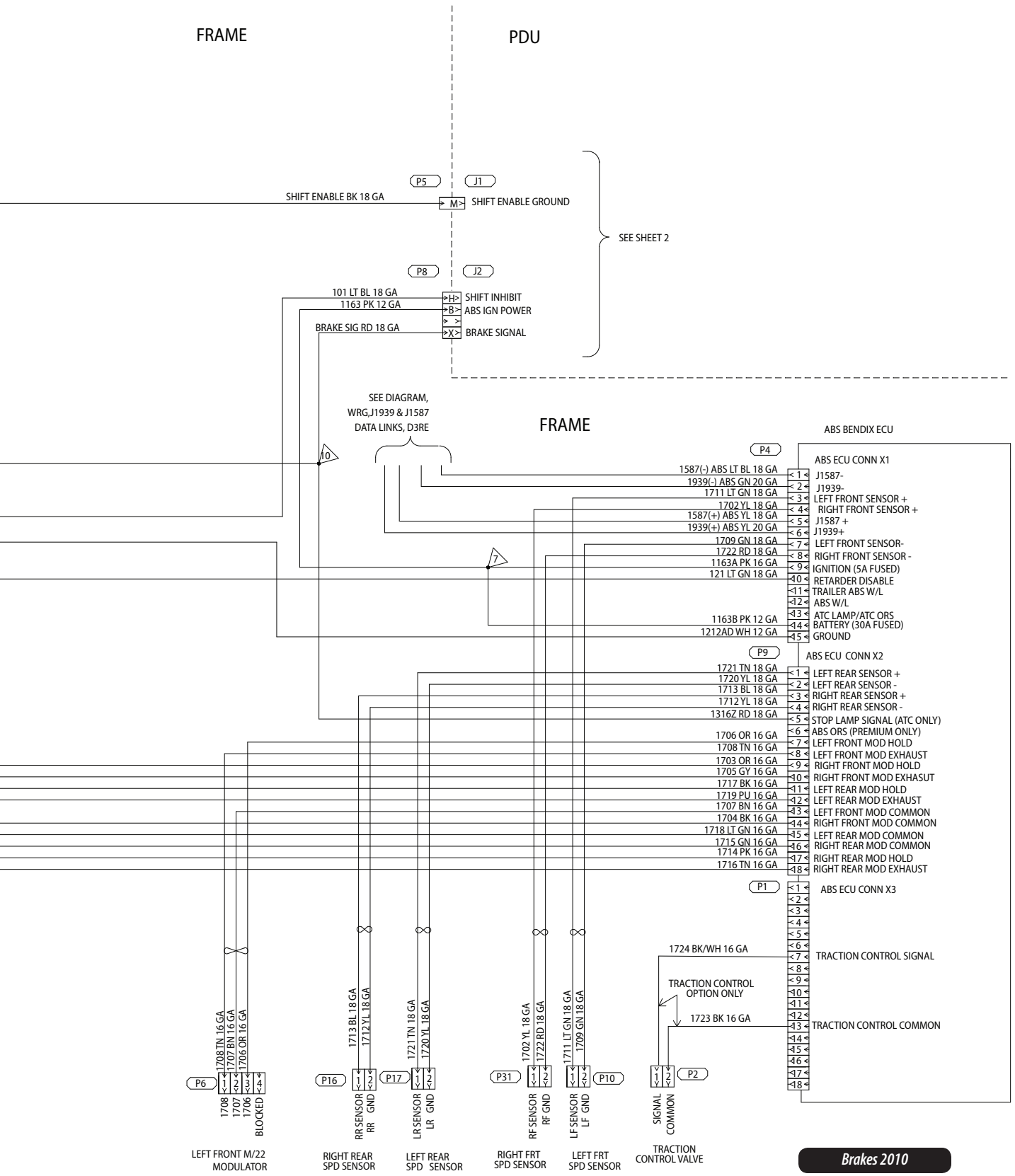
Sheet 2 of 2


ELEC PANEL
SEE SHEET 2
SEE DIAGRAM, WRG,ENGINE,... (NOTE: VGT SWITCH IS AVAILABLE ONLY ON CERTAIN ENGINES)
P17
P108
IP
P235
CLUSTER
BRAKE SIGNAL
1316B RD 16 GA
BATT BRK SIG BK 14 GA
1316K RD 16 GA
1702 LT BL 18 GA
ECM RET VGT WH 18 GA
P210
P7
ENG ECM RET WH 18 GA
VGT BRK SIG RD 16 GA
1702 LT BL 18 GA
SHIFT ENBL GND 1 WH 16 GA
ENG SW RET WH 18 GA
VGT BRK SIG RD 18 GA
VGT SW LT BL 18 GA
SHIFT ENABLE BK 18 GA
1316D RD 20 GA
P70
SPLICE PACK GND
FRAME
P200
P1
1316K RD 16 GA
1316K RD 18 GA
IP
BRAKE SIG D RD 16 GA
BATT BRK SIG BK 14 GA
P270
DCM
15 RD 16 GA
14 BK 18 GA
STOP LIGHT SWITCH
OTHER GROUNDS
1212R WH 10 GA
T1
TRANS GROUND
TRANSMISSION
C926
ABS SIGNAL SHIFT INH
121 GN 18 GA
101 LT BL 18 GA
C3
P12 (FOR ISL-G, ISC07)
P34 (FOR ISB10,ISC10,ISC03/05)
PIN T (FOR ISB10,ISC10,ISC03/05)
PIN G (FOR ISL-G, ISC07)
FRAME
P15
1716 TN 16 GA
1715 GN 16 GA
1714 PK 16 GA
1716
1715
1714
BLOCKED
RIGHT REAR MOD VALVE
P18
1719 PU 16 GA
1718 LT GN 16 GA
1717 BK 16 GA
1719
1718
1717
BLOCKED
LEFT REAR MOD VALVE
P3
1705 GY 16 GA
1704 BK 16 GA
1703 OR 16 GA
1705
1704
1703
BLOCKED
RIGHT FRONT M/22 MODULATOR



Brakes 2010

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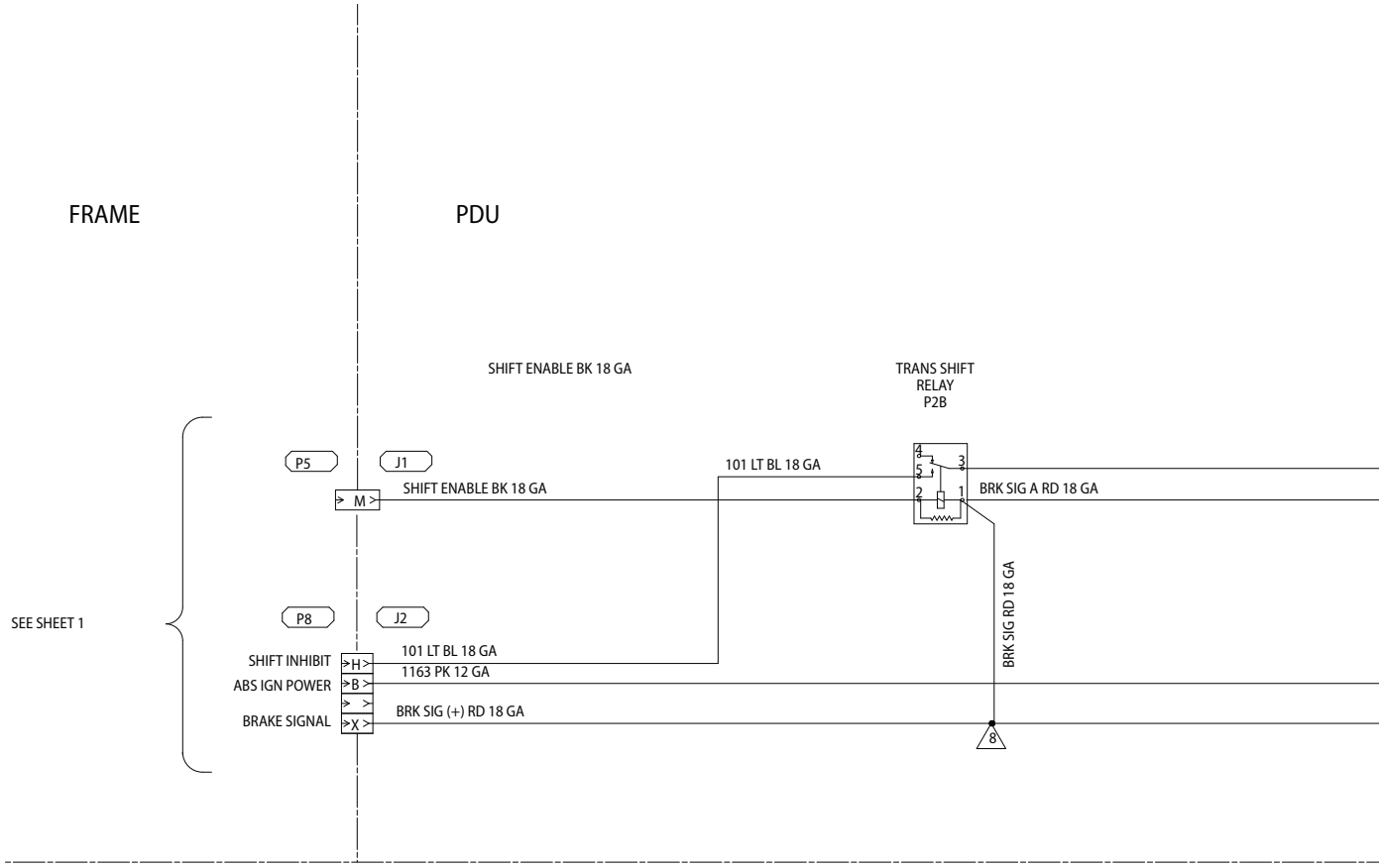
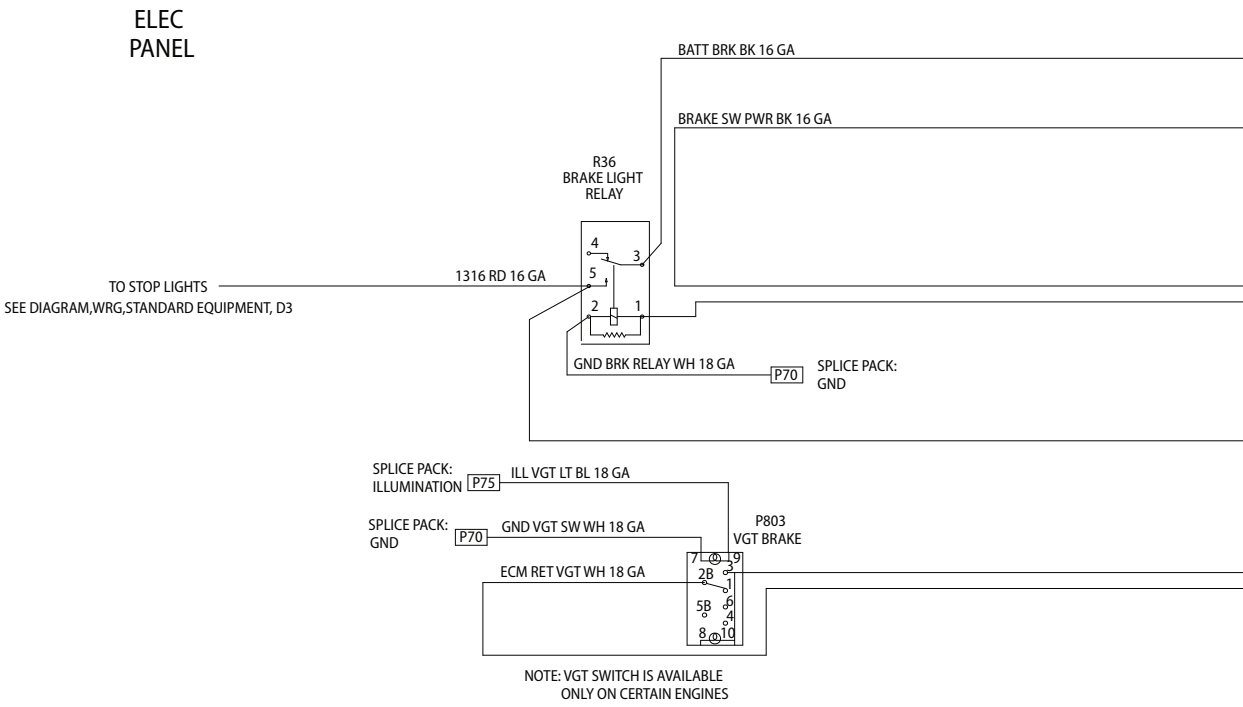
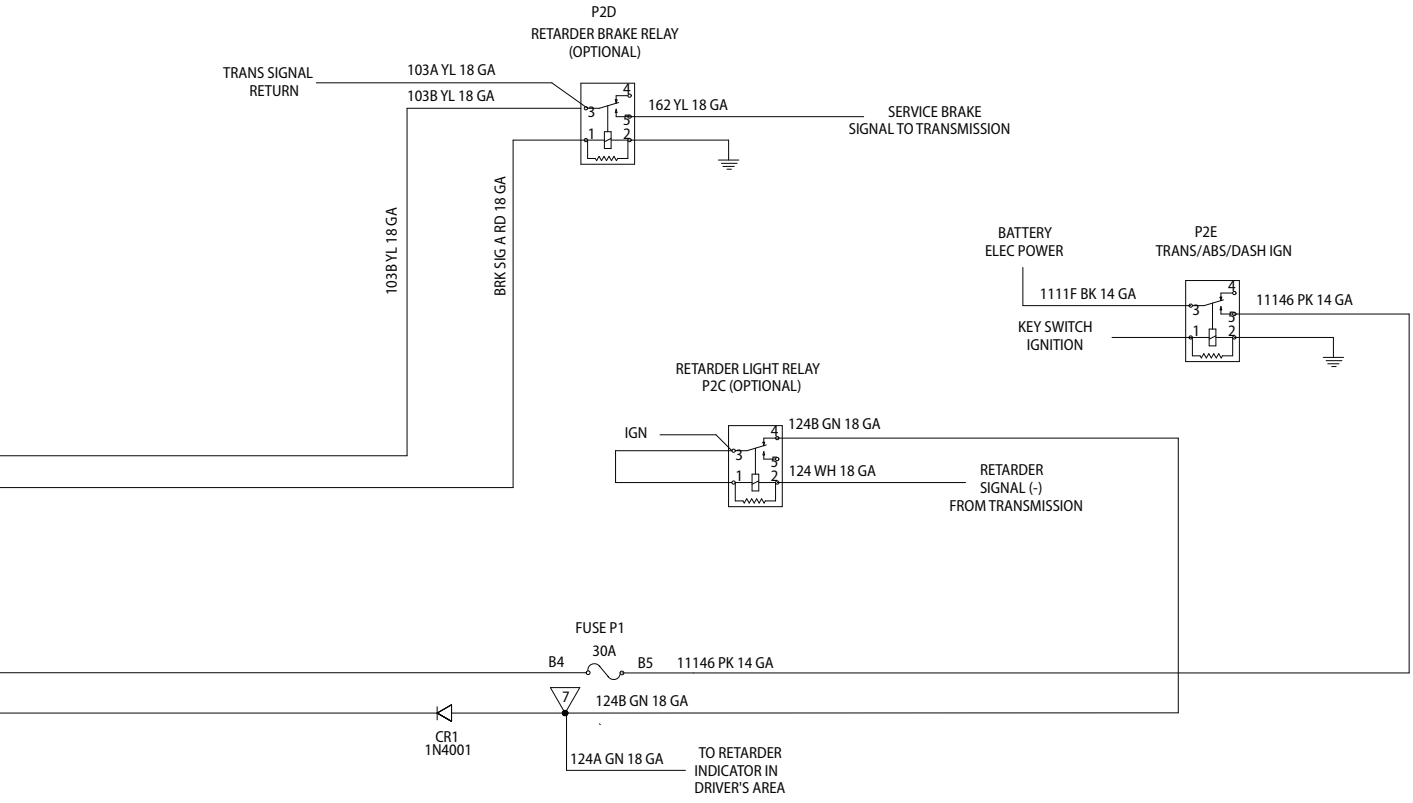
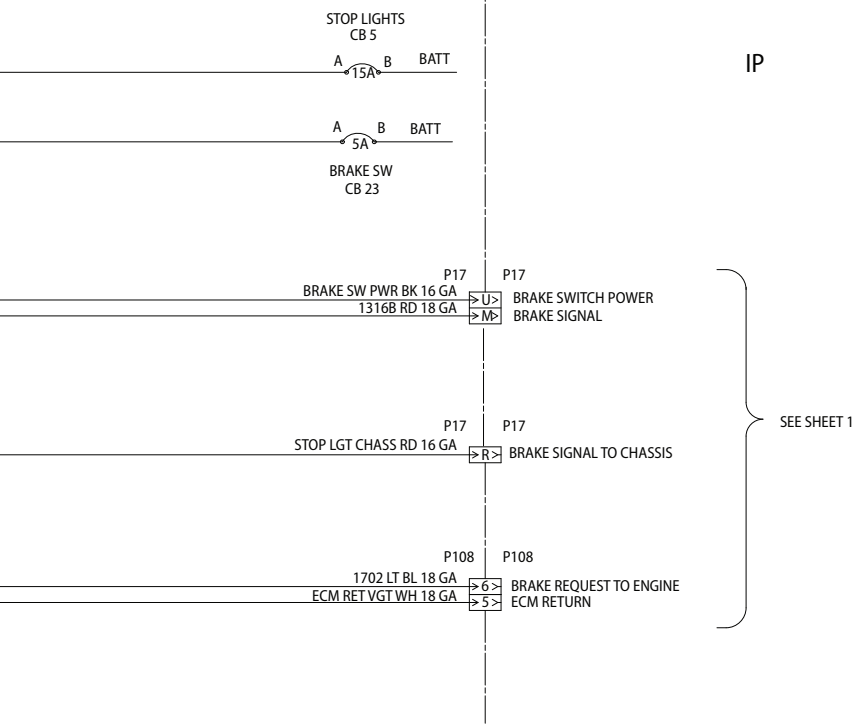
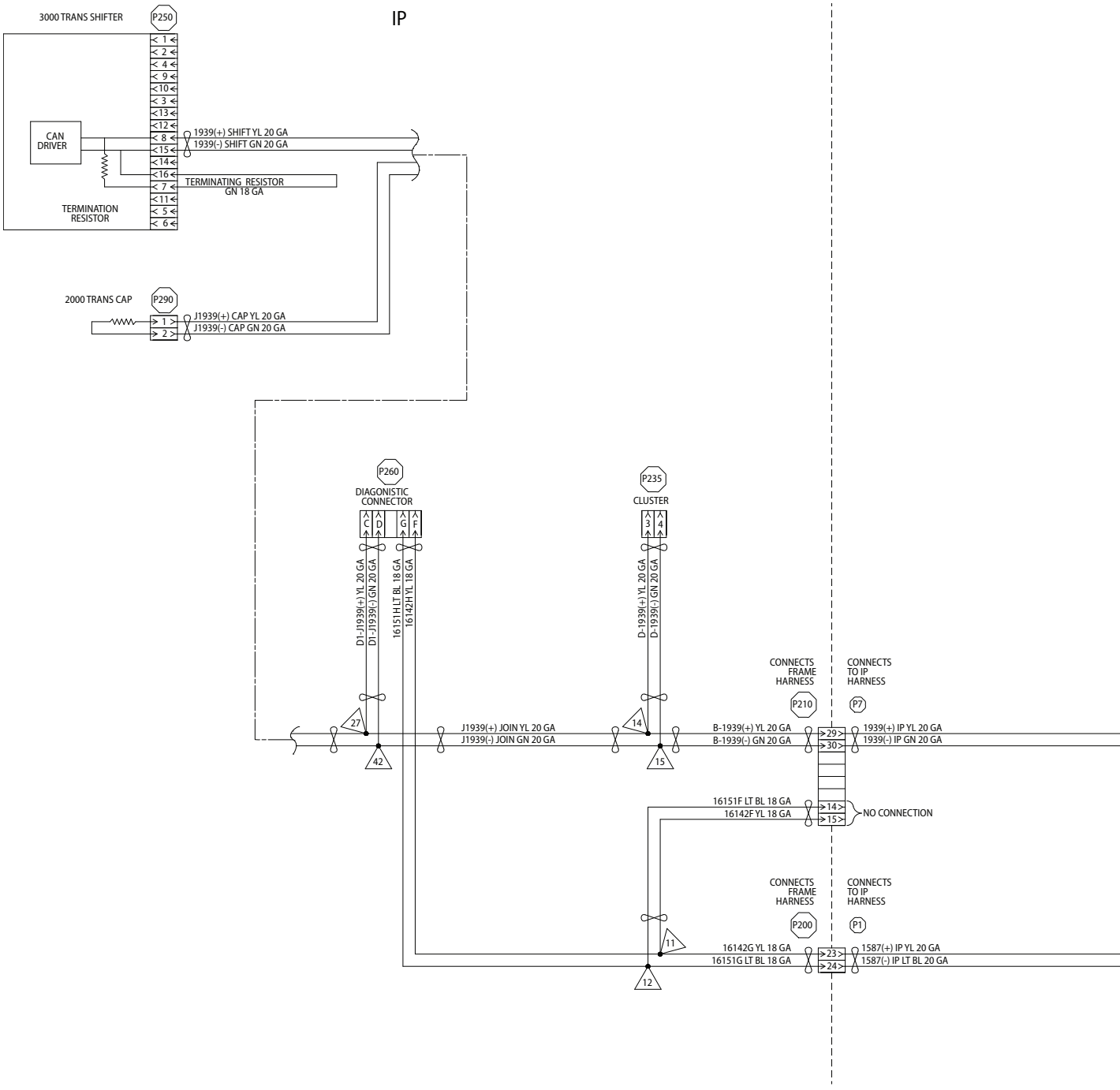
Sheet 1 of 2

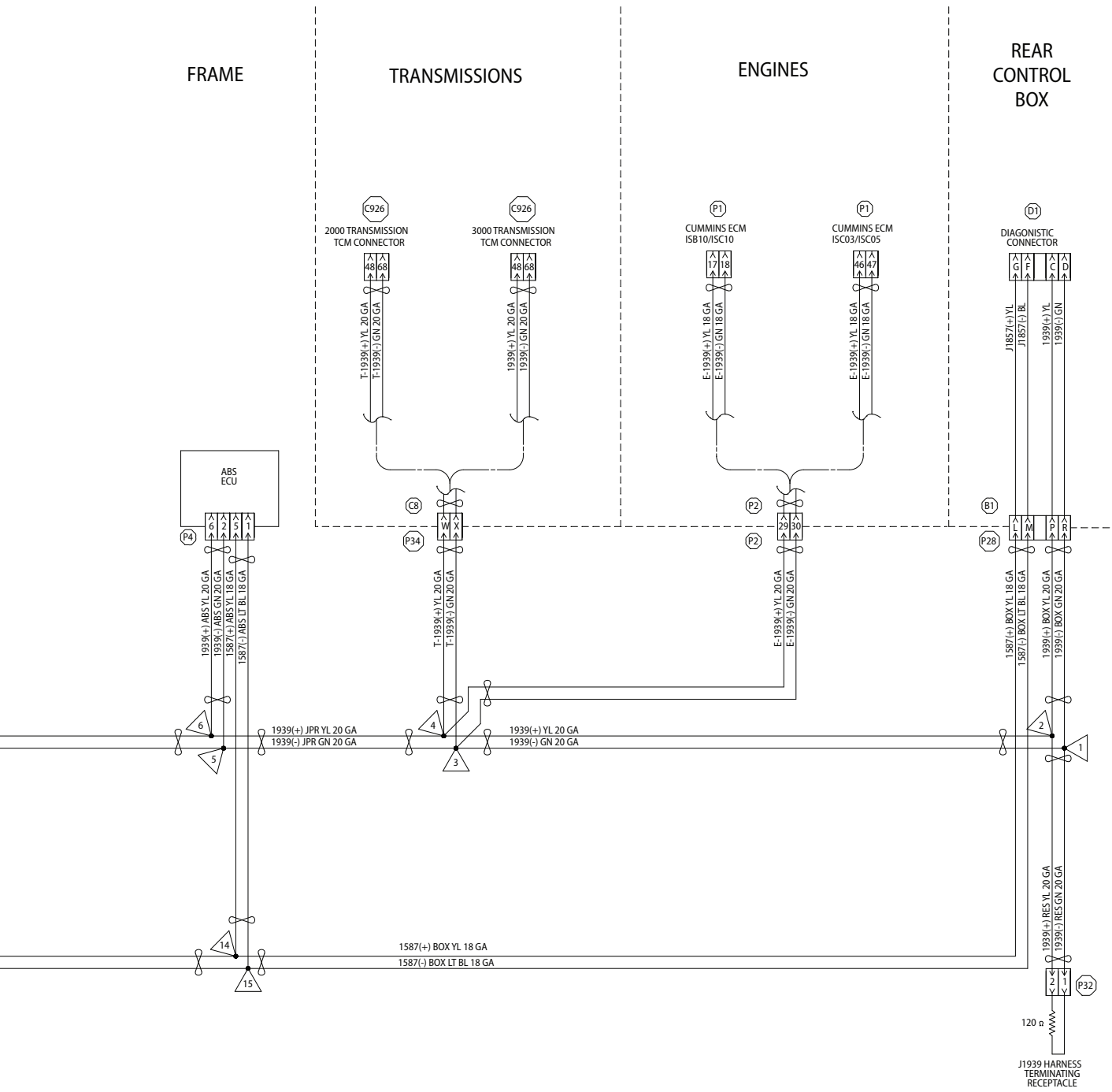

FRAME
PDU
SHIFT ENABLE BK 18 GA
TRANS SHIFT RELAY P2B
P5
J1
101 LT BL 18 GA
M
SHIFT ENABLE BK 18 GA
BRK SIG A RD 18 GA
SEE SHEET 1
P8
J2
BRK SIG RD 18 GA
SHIFT INHIBIT
H
101 LT BL 18 GA
ABS IGN POWER
B
1163 PK 12 GA
BRAKE SIGNAL
X
BRK SIG (+) RD 18 GA
8


ELEC PANEL
BATT BRK BK 16 GA
BRAKE SW PWR BK 16 GA
R36 BRAKE LIGHT RELAY
TO STOP LIGHTS
SEE DIAGRAM,WRG,STANDARD EQUIPMENT, D3
1316 RD 16 GA
GND BRK RELAY WH 18 GA
P70
SPLICE PACK: GND
SPLICE PACK: ILLUMINATION
P75
ILL VGT LT BL 18 GA
SPLICE PACK: GND
P70
GND VGT SW WH 18 GA
P803 VGT BRAKE
ECM RET VGT WH 18 GA
NOTE: VGT SWITCH IS AVAILABLE ONLY ON CERTAIN ENGINES


P2D
RETARDER BRAKE RELAY
(OPTIONAL)
TRANS SIGNAL
RETURN
103A YL 18 GA
103B YL 18 GA
162 YL 18 GA
SERVICE BRAKE
SIGNAL TO TRANSMISSION
103B YL 18 GA
BRK SIG A RD 18 GA
BATTERY
ELEC POWER
P2E
TRANS/ABS/DASH IGN
1111F BK 14 GA
11146 PK 14 GA
KEY SWITCH
IGNITION
RETARDER LIGHT RELAY
P2C (OPTIONAL)
IGN
124B GN 18 GA
124 WH 18 GA
RETARDER
SIGNAL (-)
FROM TRANSMISSION
FUSE P1
30A
B4
B5
11146 PK 14 GA
7
124B GN 18 GA
CR1
1N4001
124A GN 18 GA
TO RETARDER
INDICATOR IN
DRIVER'S AREA


STOP LIGHTS
CB 5
A
15A
B
BATT
A
5A
B
BATT
BRAKE SW
CB 23
IP
P17
P17
BRAKE SW PWR BK 16 GA
U
BRAKE SWITCH POWER
1316B RD 18 GA
M
BRAKE SIGNAL
P17
P17
STOP LGT CHASS RD 16 GA
R
BRAKE SIGNAL TO CHASSIS
P108
P108
1702 LT BL 18 GA
6
BRAKE REQUEST TO ENGINE
ECM RET VGT WH 18 GA
5
ECM RETURN
SEE SHEET 1


IP
3000 TRANS SHIFTER
P250
1
2
4
9
10
3
13
12
8
15
14
16
7
11
5
6
CAN DRIVER
1939(+) SHIFT YL 20 GA
1939(-) SHIFT GN 20 GA
TERMINATING RESISTOR GN 18 GA
TERMINATION RESISTOR
2000 TRANS CAP
P290
1
2
J1939(+) CAP YL 20 GA
J1939(-) CAP GN 20 GA
P260
DIAGONISTIC CONNECTOR
C
D
G
F
P235
CLUSTER
3
4
D1-J1939(+) YL 20 GA
D1-J1939(-) GN 20 GA
16151H LT BL 18 GA
16142H YL 18 GA
D-1939(+) YL 20 GA
D-1939(-) GN 20 GA
27
42
14
15
J1939(+) JOIN YL 20 GA
J1939(-) JOIN GN 20 GA
CONNECTS FRAME HARNESS
CONNECTS TO IP HARNESS
P210
P7
B-1939(+) YL 20 GA
B-1939(-) GN 20 GA
29
30
1939(+) IP YL 20 GA
1939(-) IP GN 20 GA
16151F LT BL 18 GA
16142F YL 18 GA
14
15
NO CONNECTION
CONNECTS FRAME HARNESS
CONNECTS TO IP HARNESS
P200
P1
11
12
16142G YL 18 GA
16151G LT BL 18 GA
23
24
1587(+) IP YL 20 GA
1587(-) IP LT BL 20 GA



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J1939 & J1587 Datalinks

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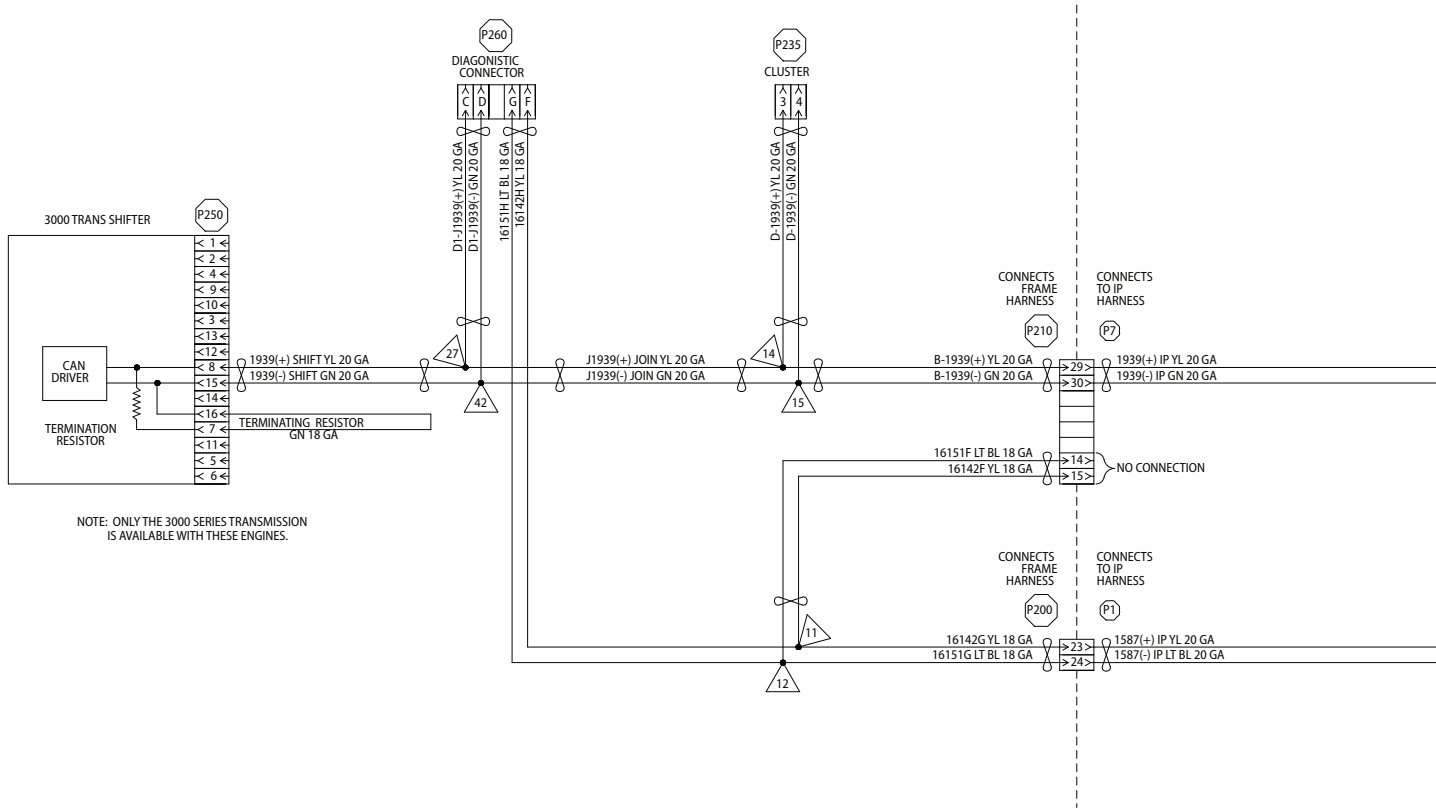
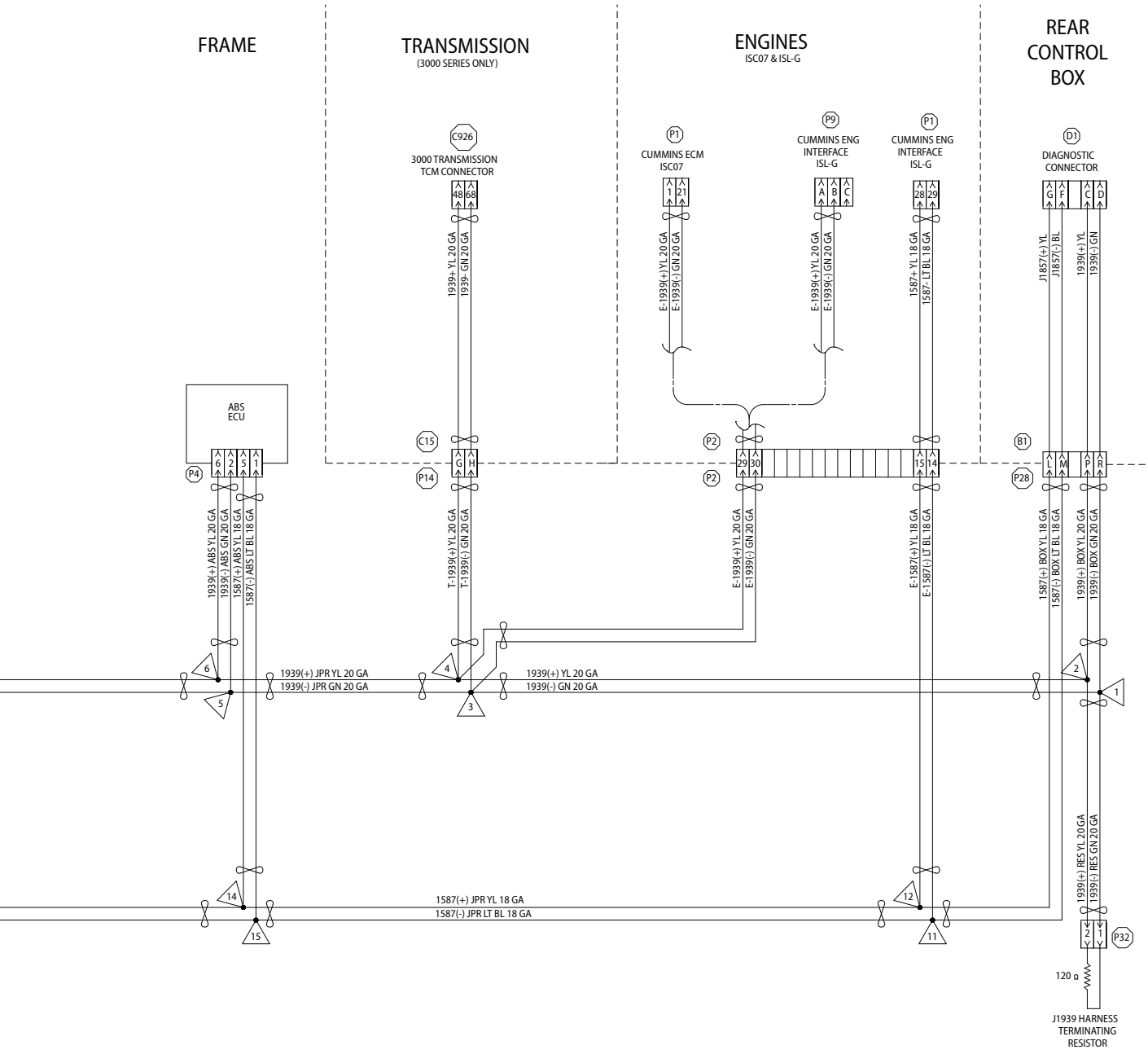
IP



NOTE: ONLY THE 3000 SERIES TRANSMISSION IS AVAILABLE WITH THESE ENGINES.



J1939 & J1587 Datalinks, ISC07, ISL-G

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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. 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 4. 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 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.

On All Americans 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.

CAUTION ***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.

The steering reservoir on an All American Rear Engine can be accessed by opening the engine compartment. The reservoir is located on the right hand side.

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

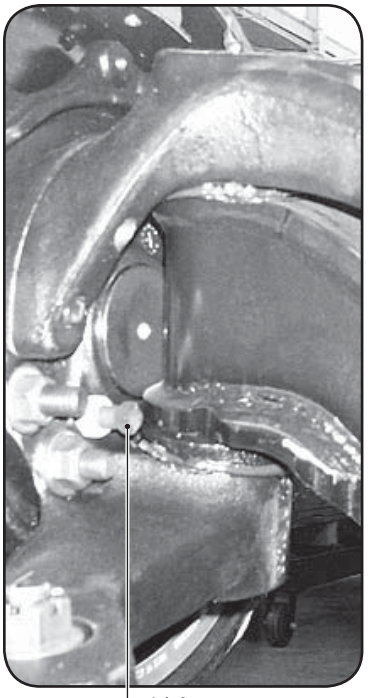
The speed at which the driver can turn the steering wheel with power assist is dependent upon the rate of flow provided by the hydraulic pump. (Normal flow rate is 3.6 - 6.3 gpm, Minimum flow rate is 2.9 gpm.) As the driver turns the steering wheel faster or slower, more or less oil flow is required 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 All American Forward Engine units.

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


Axle Stops

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

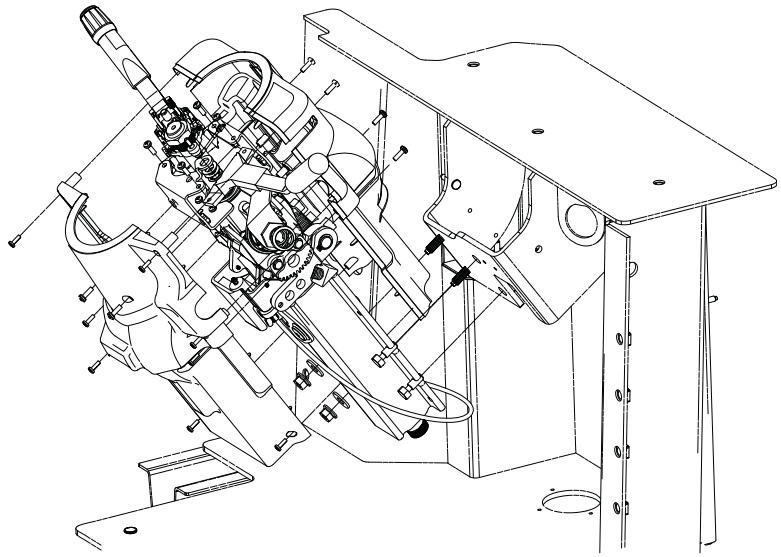
Before attempting to work on the steering gear, or any portion of the steering system, you must stabilize the vehicle. Read and understand the Warnings and Cautions in the General Maintenance chapter of this manual.

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 All American 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 tilt/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 pawls 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 pawls reengage the detent providing a positive lock in the position selected. At the same time the tilt lock pawl 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.

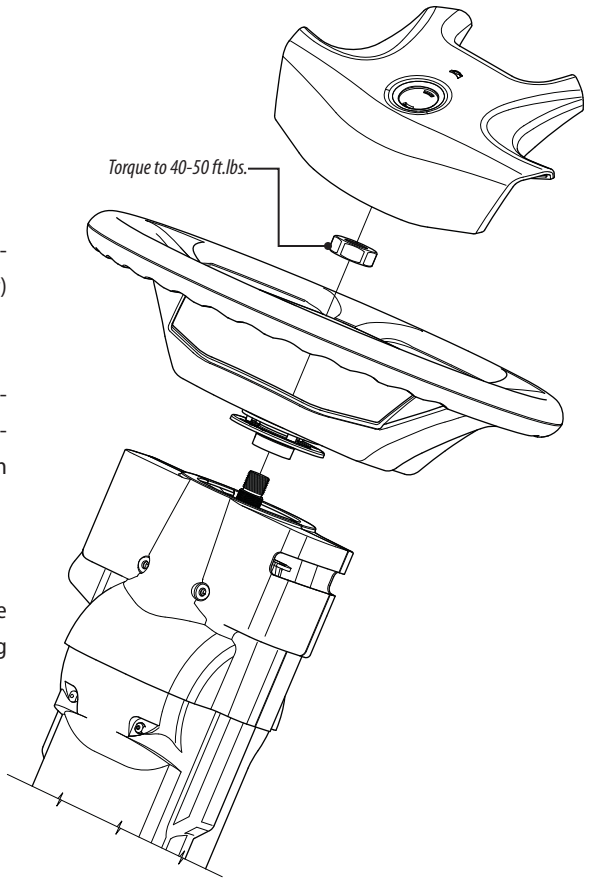
Some components attached to the steering column are serviceable i.e., turn signal switch, cruise control, ignition switch, and the horn brush contact. See details in the **Chassis Electrical** section of this manual.

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 All American Rear 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 4 (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 (All American 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.

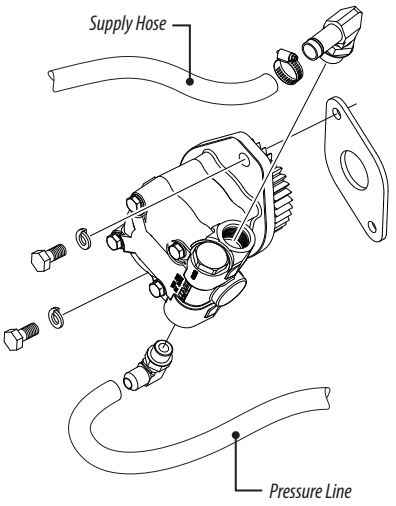
6. Remove and discard the gasket.

Steering Pump Reinstallation (All American With Air Brakes)

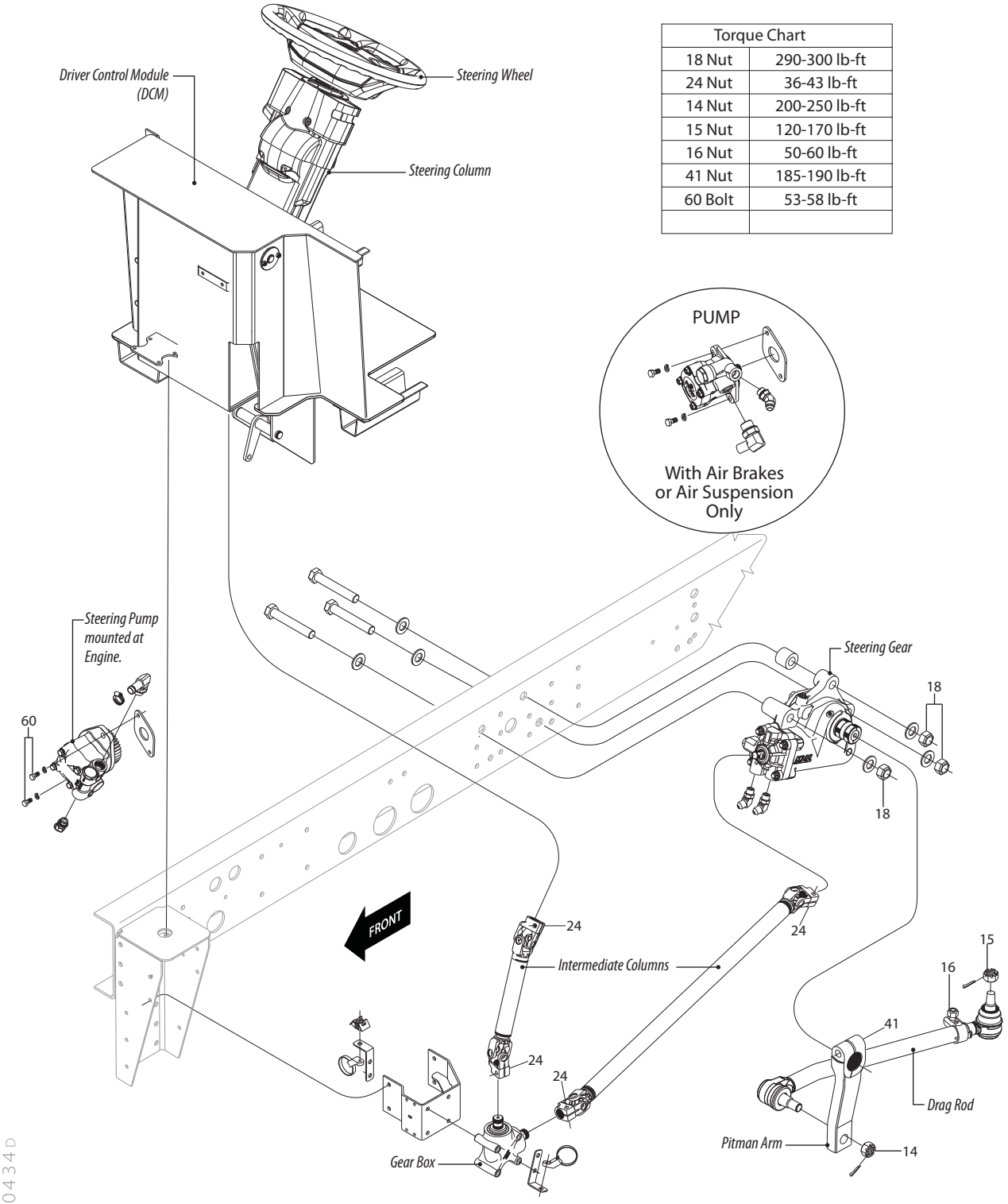
Installation is accomplished in the reverse order of the removal instructions. Always install a new hydraulic pump gasket. Also install a new split ring lock washer and torque the mounting capscrews to 53–58 ft. lbs. (71.86–78.64 Nm).

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.



Torque Chart	
18 Nut	290-300 lb-ft
24 Nut	36-43 lb-ft
14 Nut	200-250 lb-ft
15 Nut	120-170 lb-ft
16 Nut	50-60 lb-ft
41 Nut	185-190 lb-ft
60 Bolt	53-58 lb-ft



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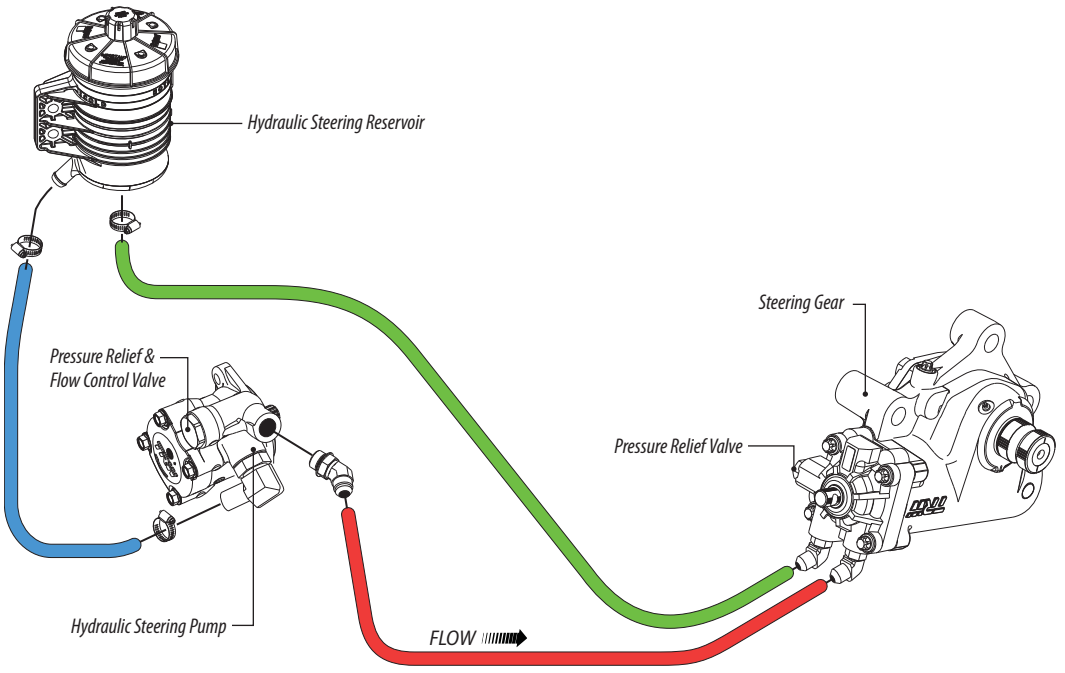
Steering Components

Steering Hydraulics with Air Brakes



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Steering Schematics

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

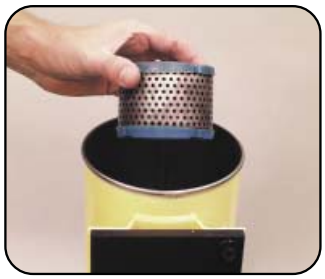

Figure 2

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.

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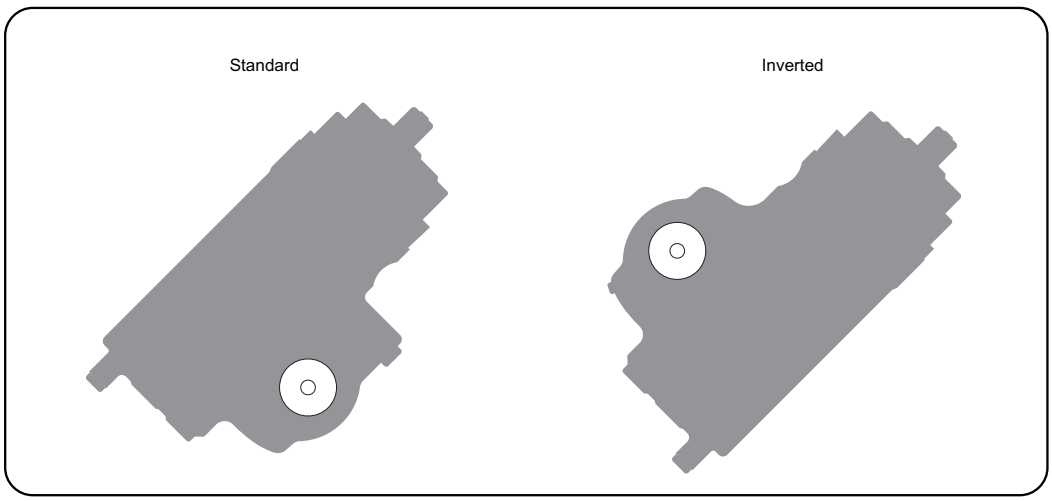
Air Bleeding the Steering System

Visual Identification

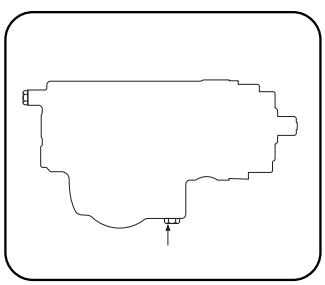
When you air bleed a steering system, you are simply allowing air trapped in the cavities of the steering gear to escape. As a general rule, if your steering gear is a “standard mount”, you should use the Automatic Bleed method. If your gear is an “inverted mount”, you will need to use the Manual Bleed 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.

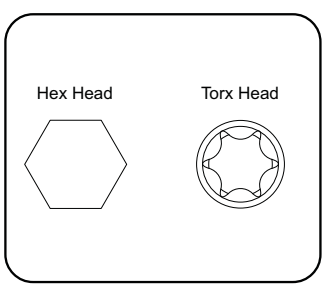


Auto Bleed Plug Location

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

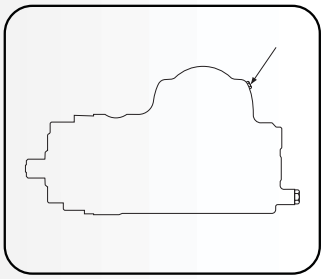
Manual Bleed Gears

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.

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.

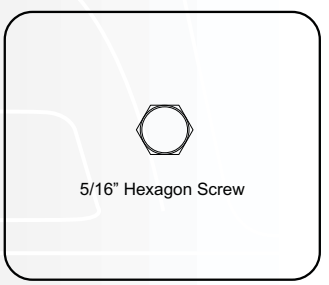
⚠CAUTION
Do not turn steering wheel with bleed screw loosened.



Manual Bleed Screw Location

Figure 1

Figure 1



Manual Bleed Screw Style

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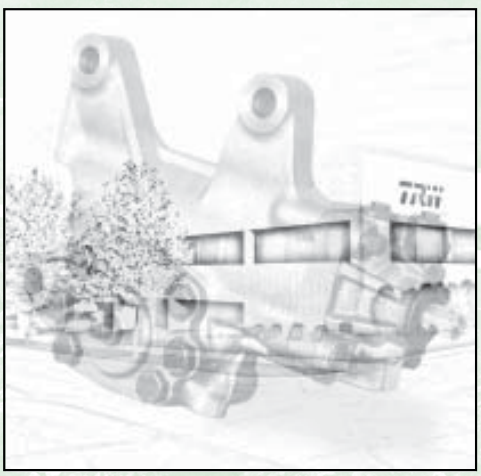
THP/PCF Steering Gear Service Manual

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

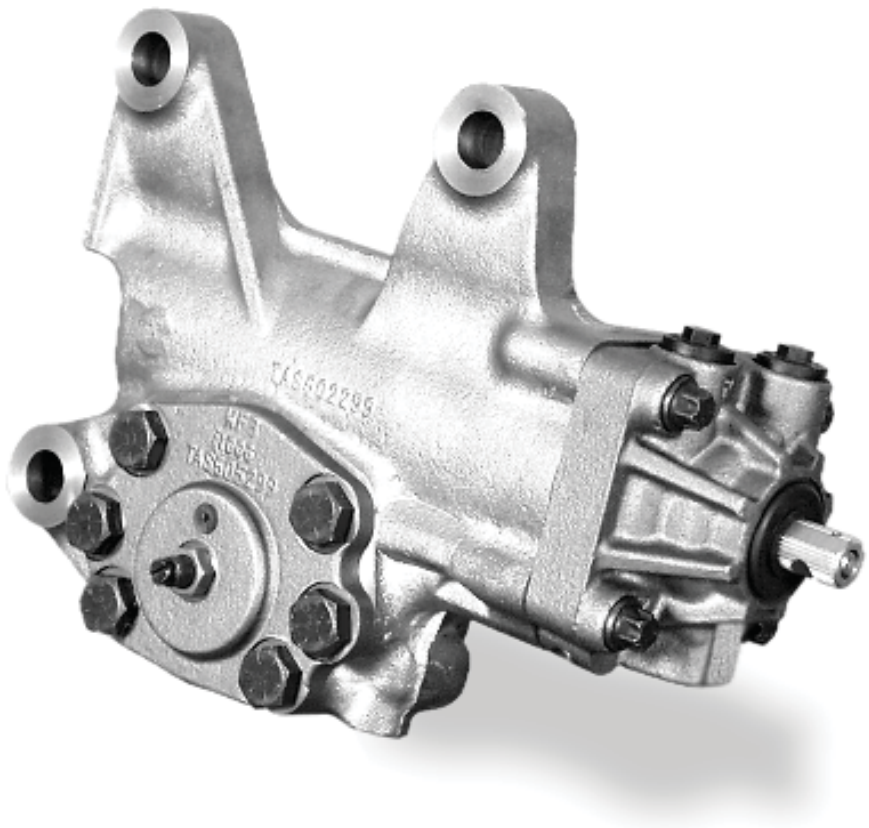
2 **Weight -** Reduced weight for improved vehicle efficiency.

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.

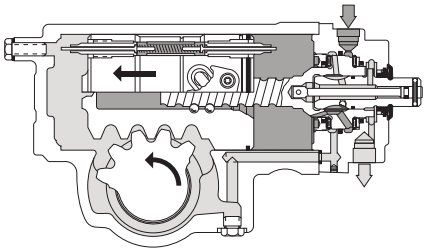
The three-column format used in the service manual will also help make it easy for you to service a steering gear. Column 1 illustrates the procedure with photographs, column 2 gives a brief key as well as tools to be used for each procedure, and column 3 explains in detail the procedure you should follow. **Pay special attention to the notes, cautions and warnings.**

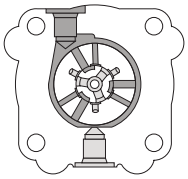
Item numbers on the exploded view correspond with item numbers in ( ), that are used throughout the service manual.

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

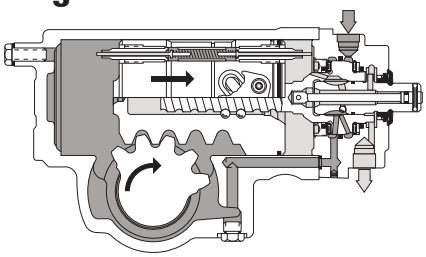


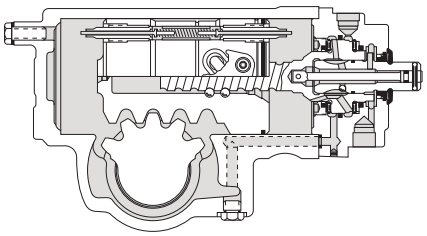


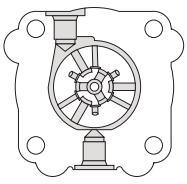
Right Hand Turn

Steering Wheel Input:
Clockwise Rotation

Right Hand Lead

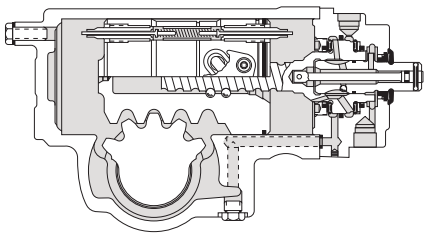


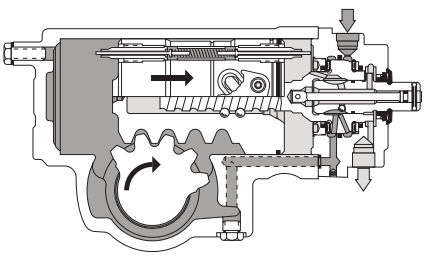


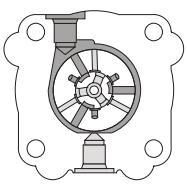


Straightline Running

No Steering Action

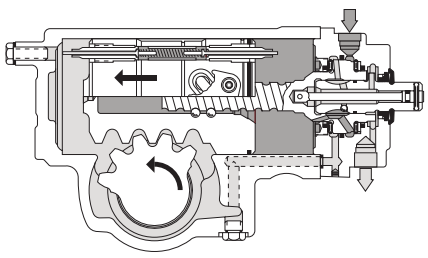






Left Hand Turn

Steering Wheel Input:
Counter-Clockwise Rotation



Supply Pressure

Return Pressure

635

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.

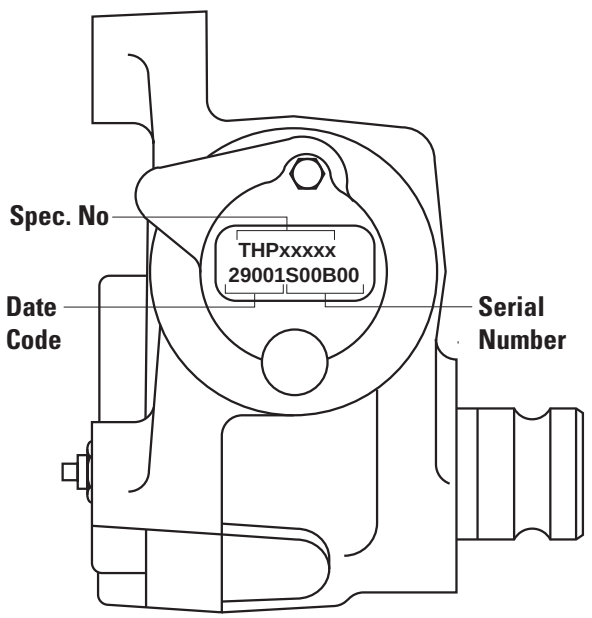
⚠ WARNING **Completely flush the steering system with one of the recommended fluids above only. Do not mix oil types. Any mixture or any unapproved oil could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

Approved Grease

Exxon Polyrex* EP2 (P/N 045422)

Gear Specification Numbers

638



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)	

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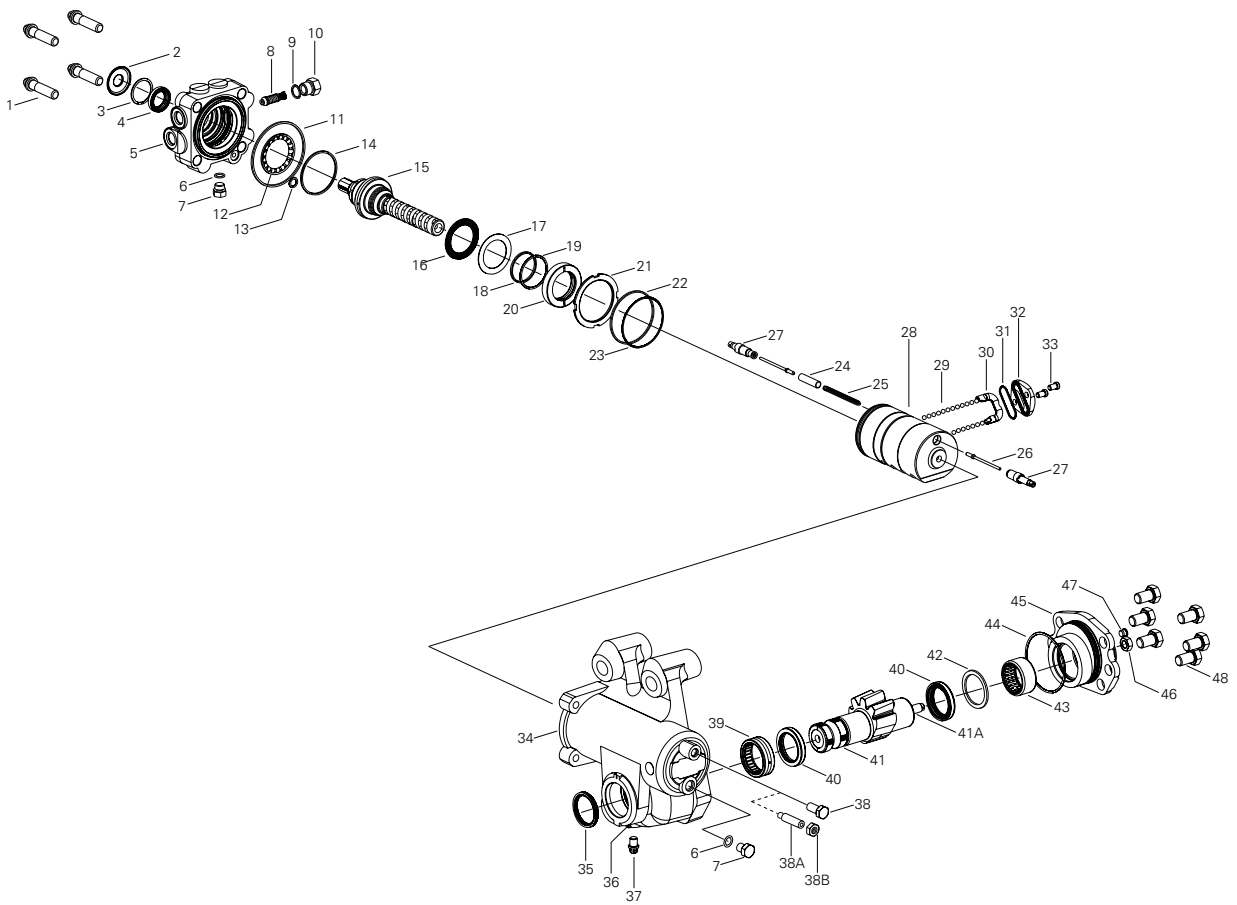
Item numbers referenced are shown on the exploded view located on page 8.

* 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



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

THP/PCF Installation 13
Initial Poppet Setting 13
Maintenance Tips 14

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.

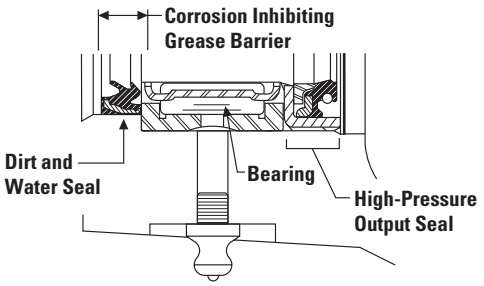
Investigate and correct any external leaks, no matter how minor.

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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Sector Shaft Adjustment 21
Poppet Readjustment
Single Gears 23
Dual Gears 26
Mirror Image 27
Reversed Image 29

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

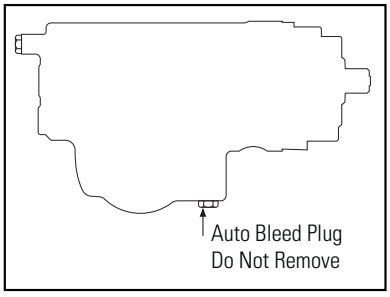
1. Fill the reservoir nearly full. Do not steer. Start and run the engine for 10 seconds, then shut it off. Check and refill the reservoir. Repeat at least three times, checking the reservoir each time.

⚠ 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

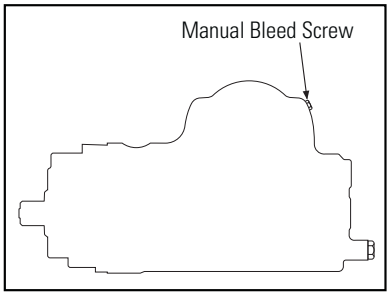
2. Start the engine and let it idle for 2 minutes. Do not steer. Shut off the engine and check the fluid level in the reservoir. Refill as required.



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.

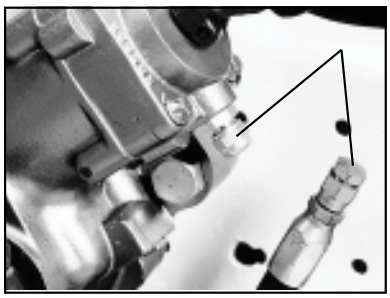
   Repeat step 4 three to four times until all the air is discharged. Torque manual bleed screw to **45 in•lb.**

⚠ CAUTION **Do not turn steering wheel with bleed screw loosened.**

Input Shaft Seal Replacement

Tools Required	Materials Required
Hammer	Clean cloth
J37073 Seal Driver	Drip pan
Screwdriver	High pressure fitting
	Hydraulic fluid
	Plug
	Shop towel

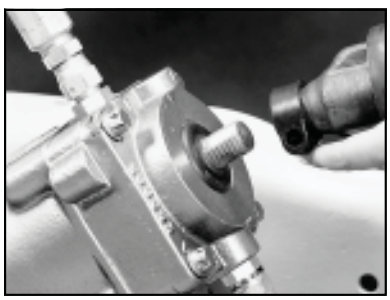
This procedure uses the vehicle's power steering pump to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1,500 psi available.



Disconnect return line

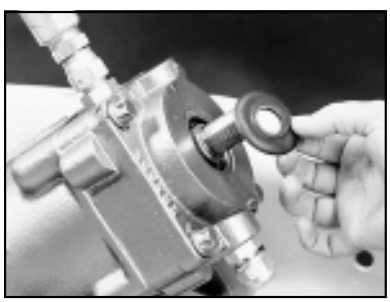
High pressure fitting
Plug

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.



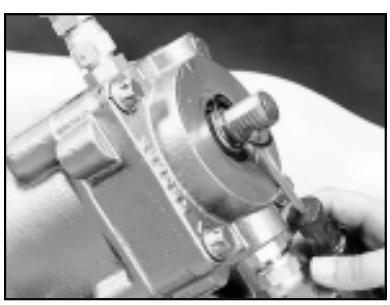
Disconnect column

2. Remove the steering column from the gear input shaft.



Remove dirt & water seal

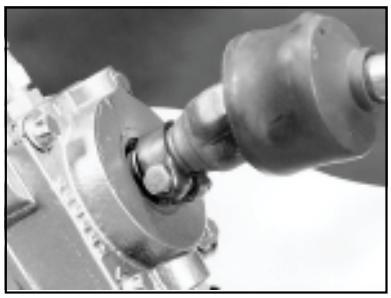
3. Remove the dirt and water seal from the steering gear. Save this seal to match the new seal to the correct size.



Remove retaining ring

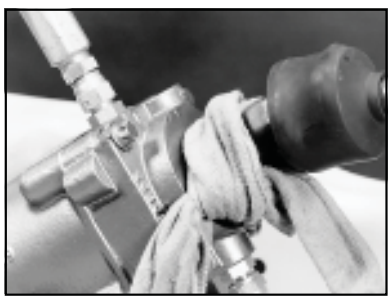
Clean cloth
Screwdriver

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

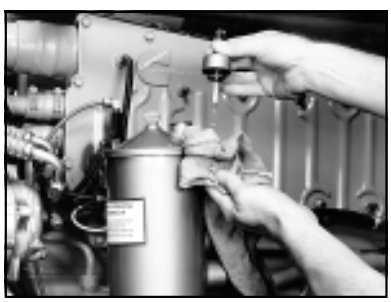
5. Slip the steering column back onto the input shaft with the pinch bolt installed, but not tightened.



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

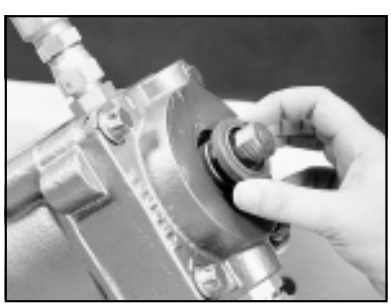
Hydraulic fluid

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.**

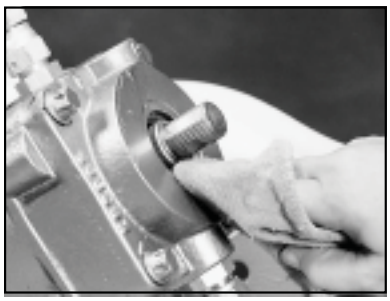
Force out the seal

8. With the vehicle in neutral, momentarily turn the starter (quickly turn off the engine if it starts).



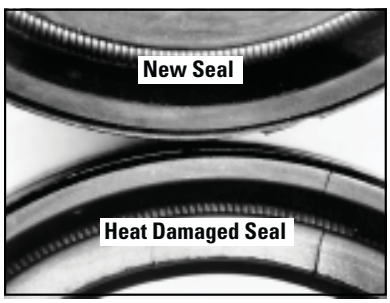
Remove input shaft seal

9. Remove the shop towel. Disconnect the steering column, and remove the input shaft seal.



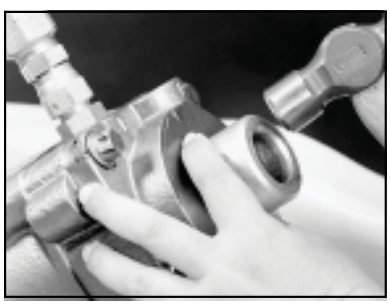
Inspect seal area

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.

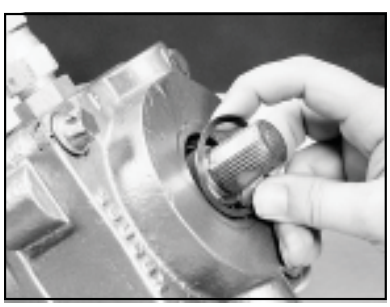


Install new seal

Hammer
J37073 Seal Driver

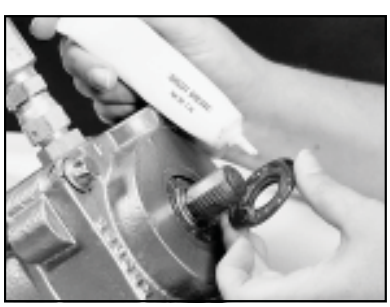
12. Put clean grease 045422 on the inside dia. of the new input shaft seal, and place it over the input shaft. With the small dia. of tool J37073 against the seal, tap the tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal 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.**



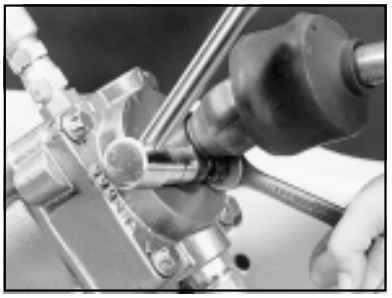
Install retaining ring

13. Insert new retaining ring into the groove.



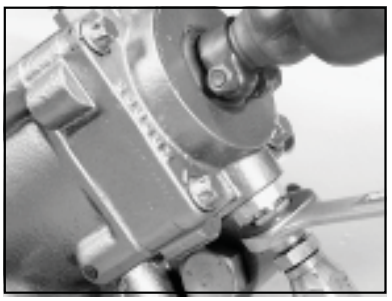
Install dirt & water seal

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.

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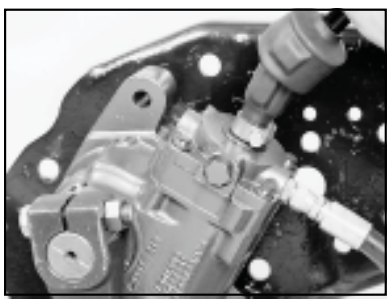
Seal Part No.	Serration Size	Major Serration Dia.
478044	13/16" x 36	0.807 / 0.799
478060	7/8 x 36	0.866 / 0.857
478050	1" x 36	0.987 / 0.977
478050	1" x 79	1.008 / 1.000

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.



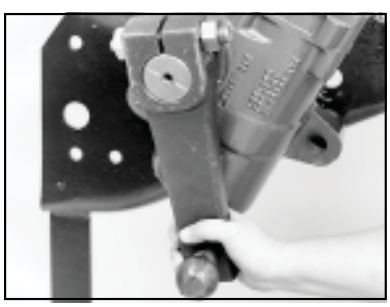
Center the sector shaft

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

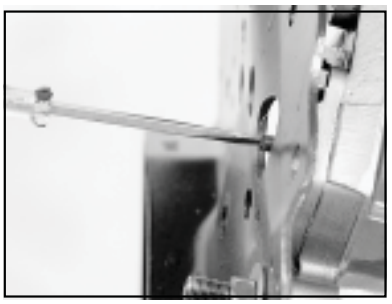
3. From the "center of travel" position, grasp the pitman arm and gently try to rotate it back and forth. If looseness or lash is felt at this point, the sector shaft is out of adjustment.

Loosen jam nut

¾" Socket

4. Loosen the jam nut.

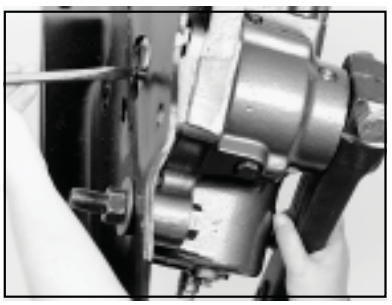
NOTE If the gear is removed from the vehicle to adjust the lash:
- Leave the pitman arm connected to the gear.
- Best option is to follow the Final Adjustment procedure on page 62.
- Alternate option is to continue with step 5 of this procedure.



Position adjusting screw

Screwdriver

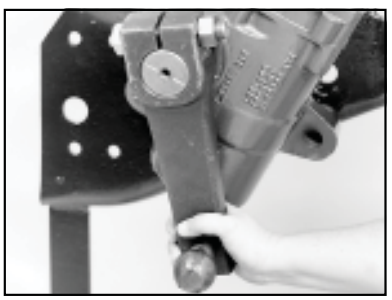
5. If no lash was detected in step 3, turn the shaft adjusting screw counterclockwise until you feel lash at the output shaft.



Adjust shaft

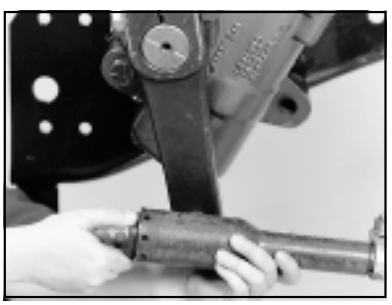
Screwdriver
¾" Open end wrench

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

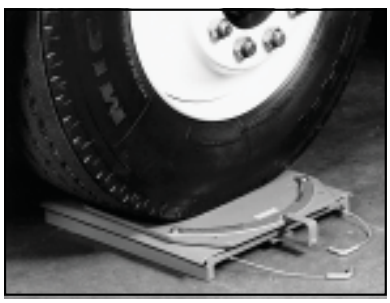
Tools Required

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

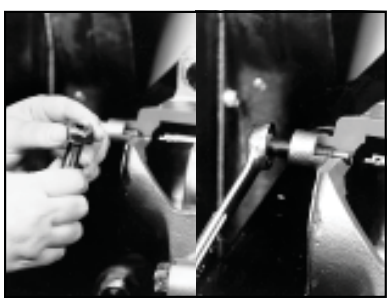
This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section 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.

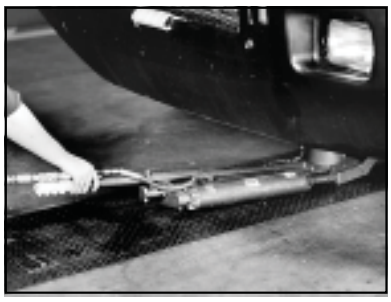
⚠ CAUTION **If the drive end of the screw is below the face of the nut, the poppet seat flange will break during step 7d.**

Refill reservoir

Hydraulic fluid

5. Refill the system reservoir with approved hydraulic fluid.

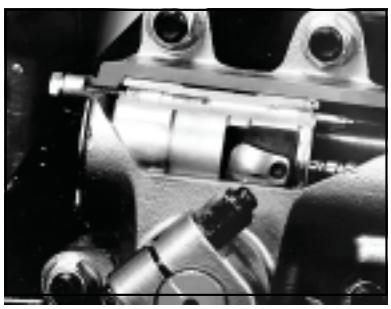
⚠ CAUTION **Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**



Jack up vehicle

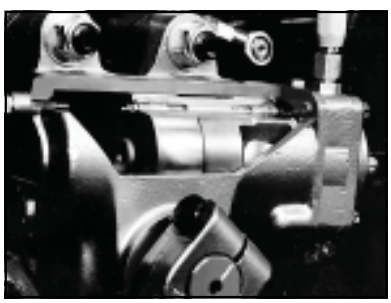
Jack

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.



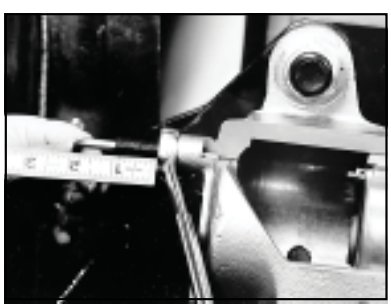
Push upper poppet out to prepare it for setting

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.**

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.

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.

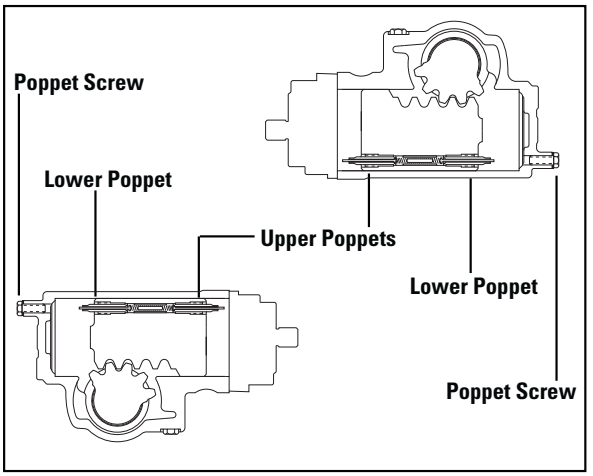
1. Park the vehicle with the wheels turned all the way to the axle stop in either direction. Turn the vehicle off.

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.



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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.

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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

Disassembly 34
Inspection 42
Assembly 44
Internal Damage Repair (by reference)
- Poppet Component Replacement 51
- Valve Housing Worm Screw Disassembly 53
- Roller Bearing or Retaining Ring Replacement 60
- Replace Housing Port Plugs, Screws, and Fittings .. 61

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.

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⚠ 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.**

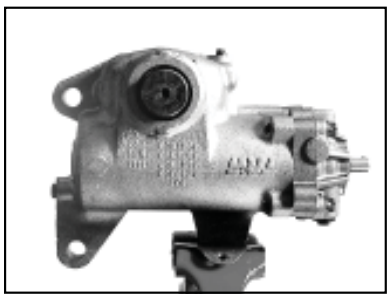
Keep each part separate to avoid nicks and burrs.

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

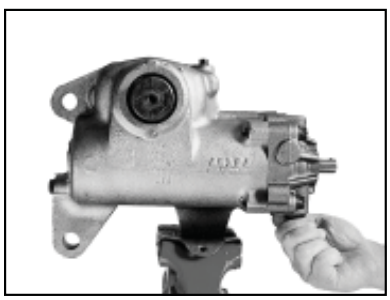
Tools Required		Materials Required
Allen wrenches Pocket knife Ratchet Rolling head pry bar Rubber mallet	Screwdriver Sockets: •Standard •Torx Vise	Emery cloth Masking tape



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.

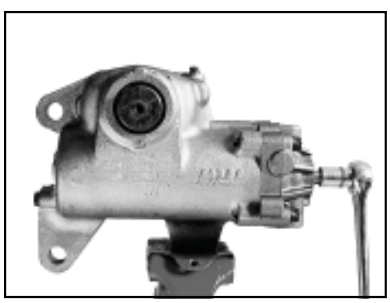
⚠ CAUTION **Do not clamp against body of housing. If mounting boss or flange is not accessible, fabricate and attach a mounting plate to the housing mounting bosses.**



Unplug ports

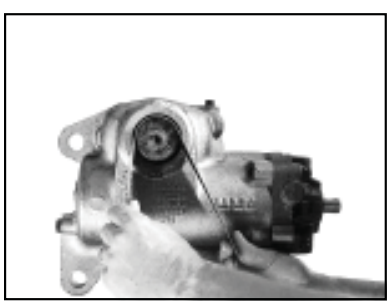
Appropriate size socket or open-end wrench

2. Prepare for fluid drainage and unplug hydraulic ports.



Position sector shaft

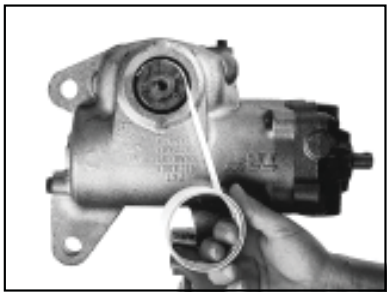
3. Rotate the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing. This will position the sector shaft for removal.



Clean sector shaft

Fine grade emery cloth

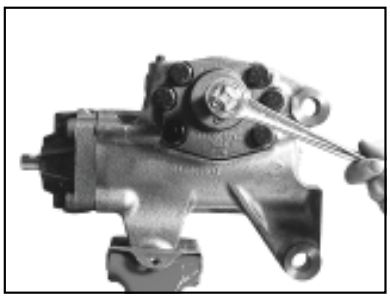
4. Remove any paint or corrosion from the exposed area of the sector shaft (41).



Tape sector shaft

Masking tape

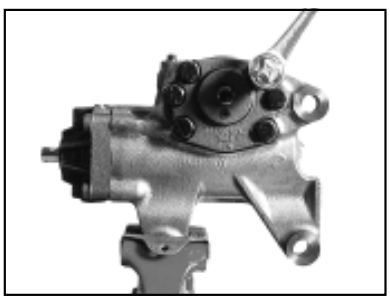
5. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape. The tape should not extend onto the sector shaft bearing diameter.



Remove jam nut

¾" Socket

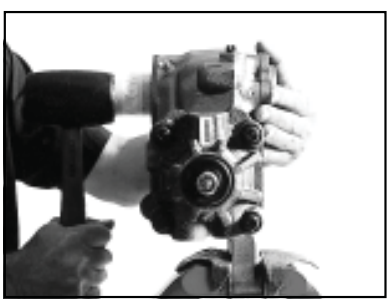
6. Remove the sector shaft adjusting screw jam nut (46).



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).



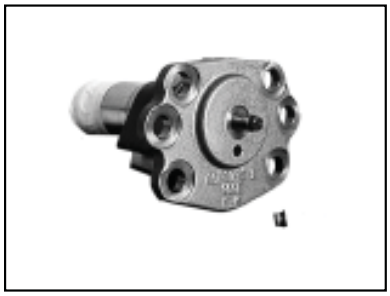
Remove side cover

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.

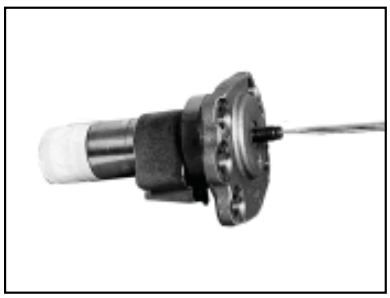
Discard O-ring

9. Remove and discard the side cover o-ring (44).



Remove vent plug

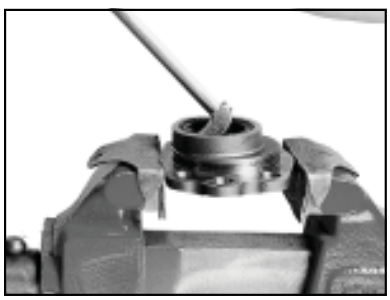
10. Remove and discard the vent plug (47).



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

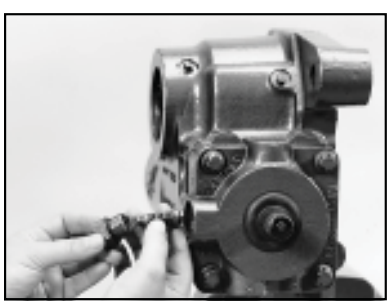
⅜" Drive socket
Rolling head pry bar

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

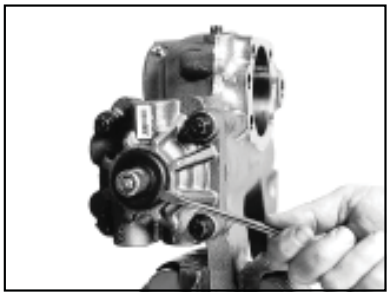
13. Inspect the sector shaft assembly for damaged adjusting screw threads. The retainer (41B, not shown) must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play (lash).



Remove relief valve components

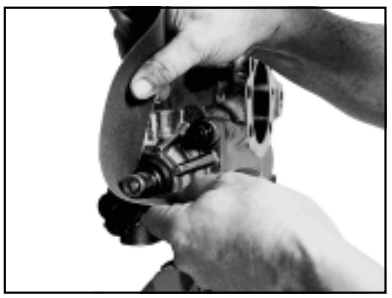
⅞" Socket

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

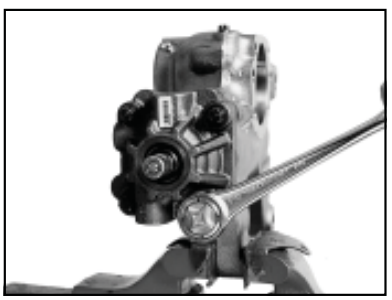
15. Remove and discard the dirt & water seal (2, 2B or 2C) from the input shaft worm and valve assembly. Save this seal for comparison with the new seal.



Clean input shaft

Fine grade emery cloth

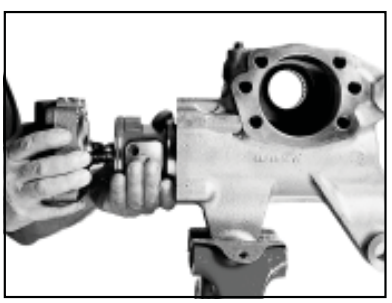
16. Clean any paint or corrosion from the exposed area of the input shaft.



Remove valve housing bolts

E-18 Torx socket

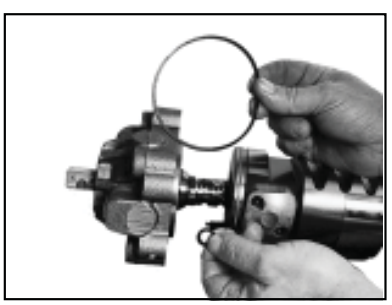
17. Remove the four torx head valve housing bolts (1).



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.

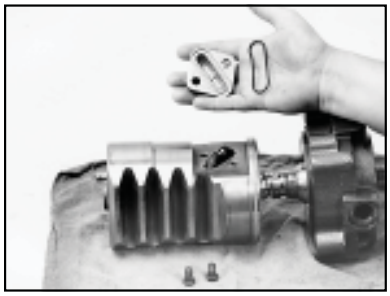
⚠ CAUTION **The set position of poppet seat and sleeve assemblies (27) must not be disturbed if the poppets are not going to be replaced or reset during disassembly.**



Remove seals

19. Remove and discard the valve housing seal rings (11& 13).

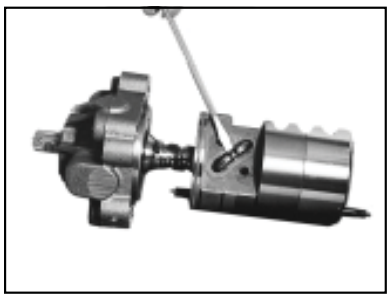
⚠ CAUTION **Do not remove the input shaft, valve worm assembly or balls from the rack piston until the ball return guides are removed as damage to the ball guides will occur.**



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.

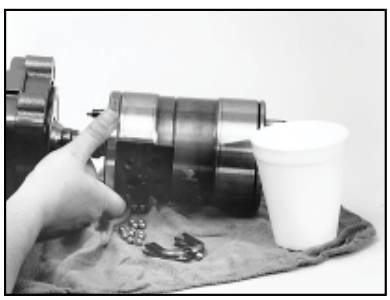


Remove ball return guides

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.

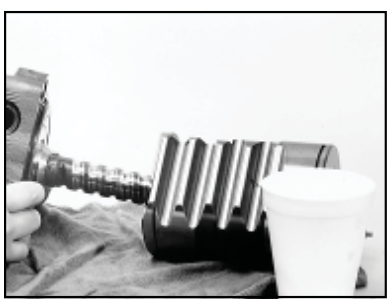
NOTE Left hand ball return guide halves are plated with copper or zinc chromate for identification. Right hand guides are not plated. **Retain the guides for reassembly**.



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.

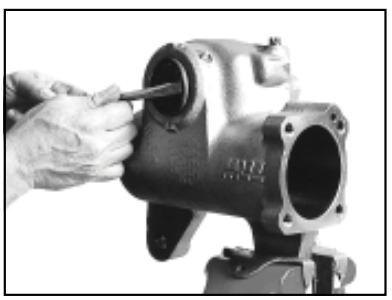
Inspect poppet assemblies

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).

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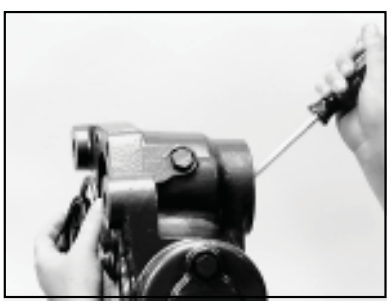
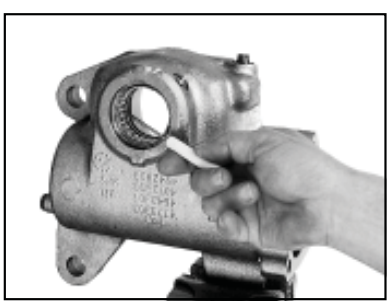


Remove pressure seal

Screwdriver

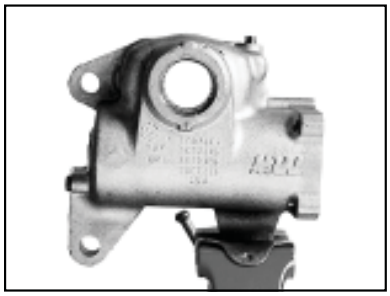
28. Insert a screwdriver through the trunnion opening, and carefully push the seal (40) out ***without damaging the sealing area of the bore***. Discard the seal.

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.

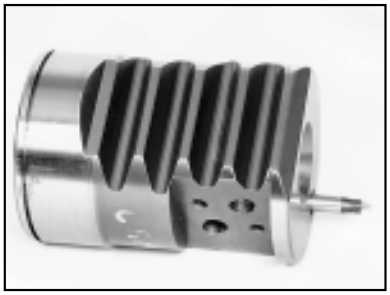
⚠ WARNING **Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.**

⚠ 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

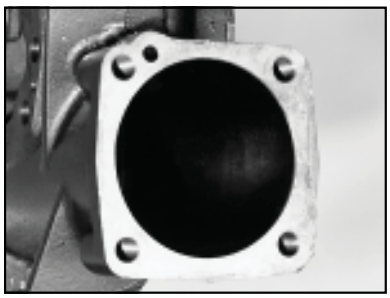
1. Inspect the rack piston (28) teeth for cracks or obvious damage. If teeth are damaged, replace the rack piston, sector shaft (41) and set of balls (29).

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).

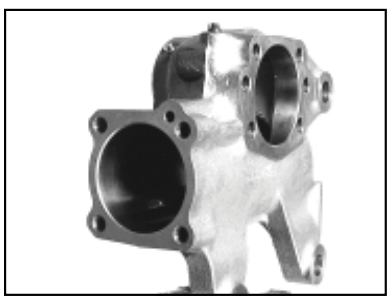
Inspect input shaft, valve/worm assembly sealing areas

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.

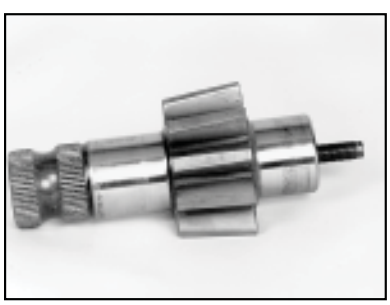


Inspect valve housing surface

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.

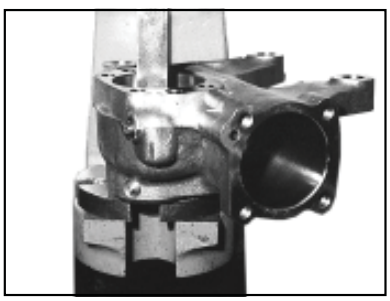
Assembly

Tools Required

Hammer
J37705 (THP/PCF45)
J37071 (THP/PCF60)
Press
Punch
Ratchet
Screwdriver
Sockets
Torx sockets
Vise
Torque wrench

Materials Required

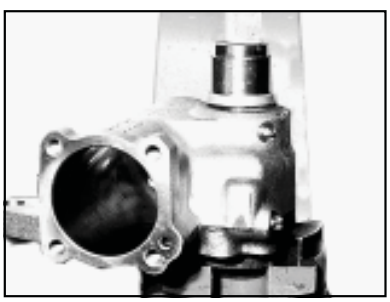
ATF oil
Grease (Exxon Polyrex* EP2
Masking tape
14mm x 2.0mm All Thread
Seal kit: THP450001
THP600001



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.

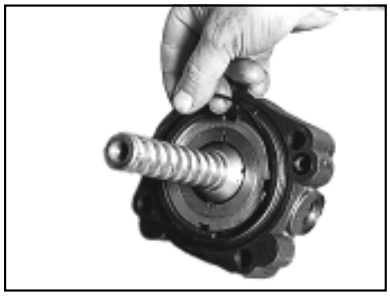


Install dirt & water seal

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).

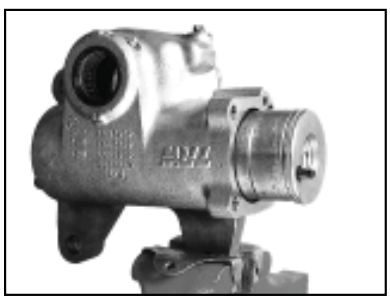


Assemble seal rings

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.

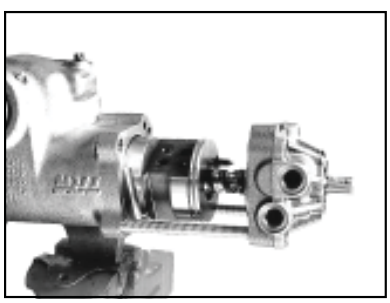
Install rack piston o-ring and seal ring

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

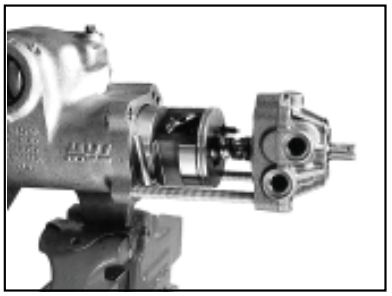
5. Apply clean oil to housing cylinder bore. Place the rack piston (28) in the housing piston bore with ball return guide holes up.



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.



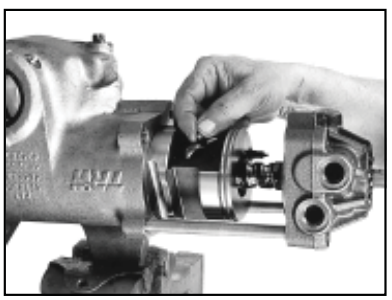
Assemble ball return guide halves

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

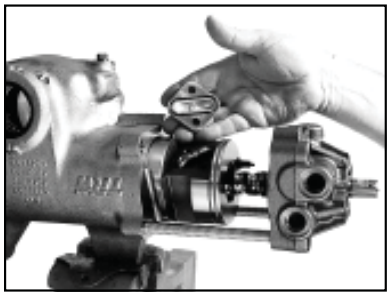
8. **Hold the ball return guide (30) firmly in place during this entire procedure.** Insert as many of the steel balls as you can through the hole in the top of the ball return guides. Rotate the input shaft to pull the balls down and around the ball track guide path. Continue until the correct number 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.**

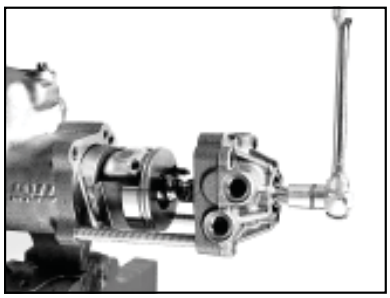


Assemble ball return guide cap

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.

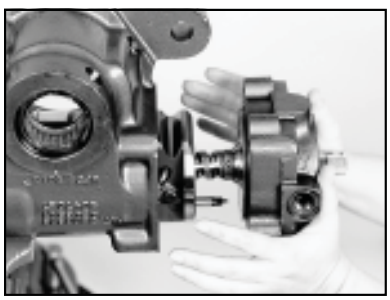
⚠ CAUTION **Ball cap seal is greased to hold seal in groove while assembling. Be sure not to trap the seal outside of the groove during reassembly.**



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.**



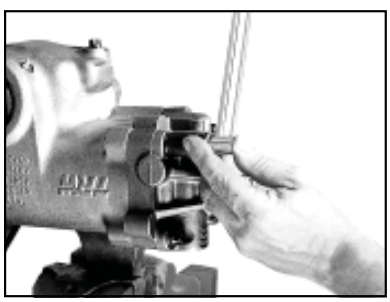
Install rack piston, worm, valve assembly

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.**

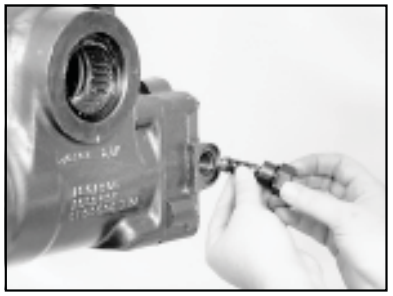
⚠ CAUTION **The poppet seat and sleeve assemblies (27) must not bottom against the internal poppet stops in the steering gear until the gear is installed on the vehicle and the poppet adjustment procedures are performed.**



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

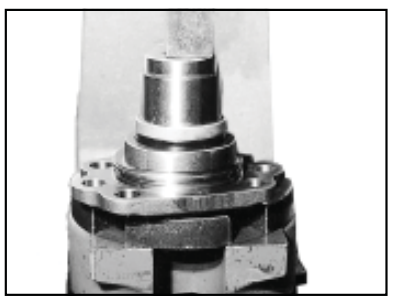
⅞" Socket
ft•lb Torque wrench

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

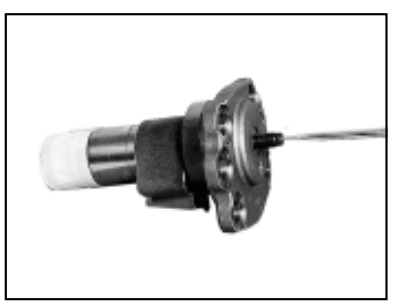
J37705
(THP/PCF45)
J37071
(THP/PCF60)
Press

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.

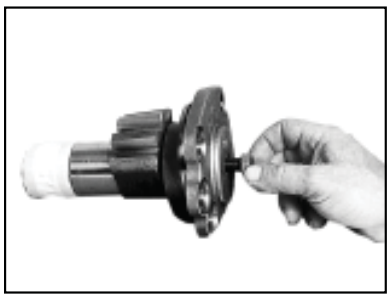


Install sector shaft into side cover

Screwdriver

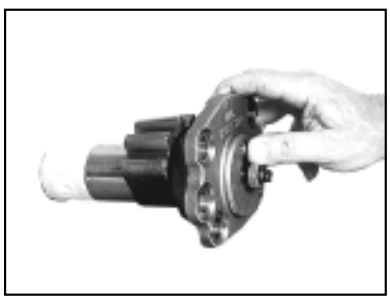
17. Insert the sector shaft (41) into the side cover subassembly (45), and turn the sector shaft adjusting screw (41A) counterclockwise into the side cover until the screw reaches solid height.

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.



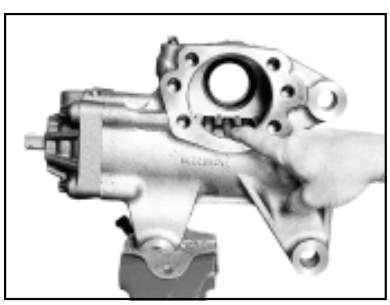
Assemble vent plug

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

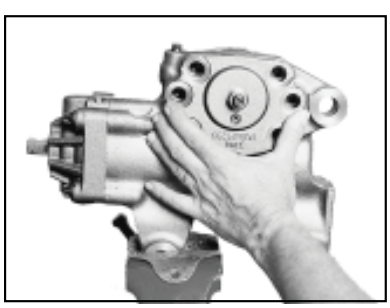
20. Apply clean oil to the new side cover o-ring (44) and assemble it onto the side cover (45).



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.**

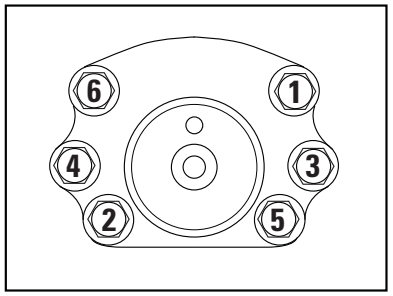


Install sector shaft and side cover into housing

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.**

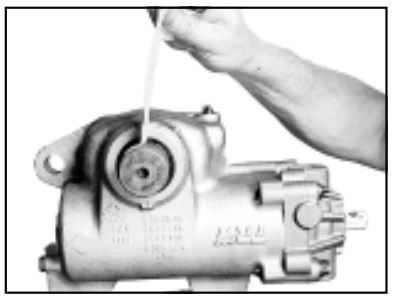


Install side cover bolts

15/16" Socket
Torque wrench

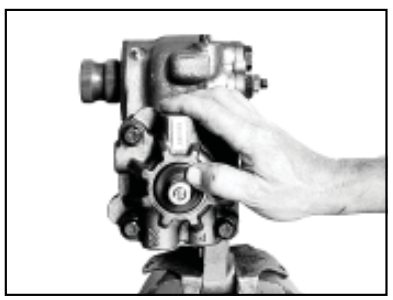
23. Install bolts in positions 3 and 4 first, by hand. Then, install the remaining side cover bolts (48) into the side cover and torque them in the sequence shown. If bolts must be replaced, use bolts of the same design, type and length as those you removed. **Do not use a substitute.**

    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

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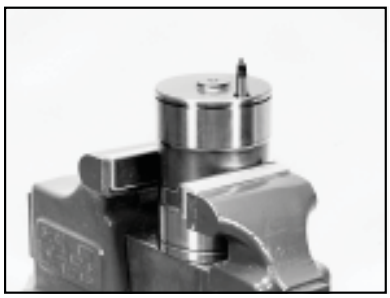
Poppet Component Replacement

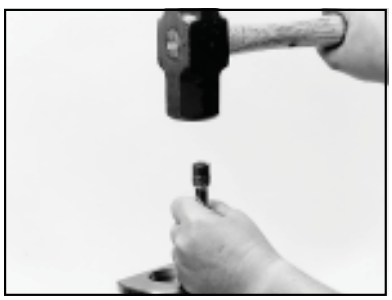
Tools Required		Materials Required
2 lb Sledge ft•lb Torque wrench J36452-A Press ⅜" x 6" drill rod	Ratchet Soft-jawed vise	Locquic "T" primer Loctite RC680



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.

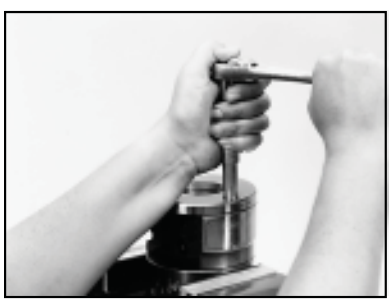


Loosen poppet adjuster seat

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.

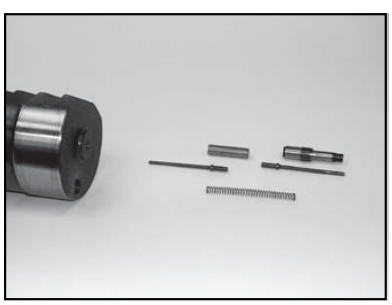
⚠ CAUTION **Poppet adjuster seat and sleeve assemblies (27) are retained by Loctite applied to the threads which makes the assemblies difficult to remove.**



Remove poppet adjuster seat

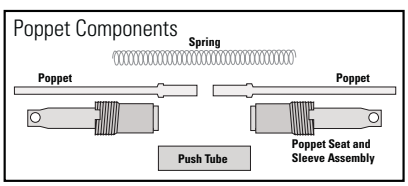
J36452-A

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

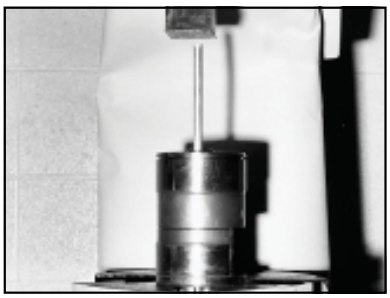
4. Remove the two poppets (26), spring (25), and push tube (24).



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.

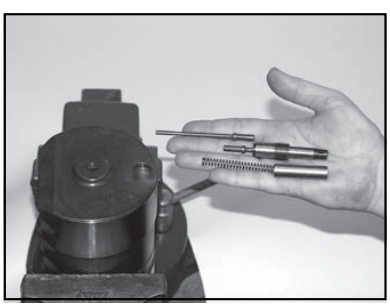
⚠ CAUTION **Do not allow Loctite or Locquic to get on the adjuster seat component of the adjuster seat and sleeve assembly. The poppets will not function properly.**

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.

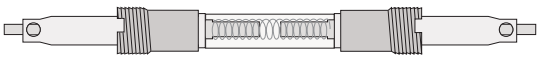


Install remaining poppet components

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.

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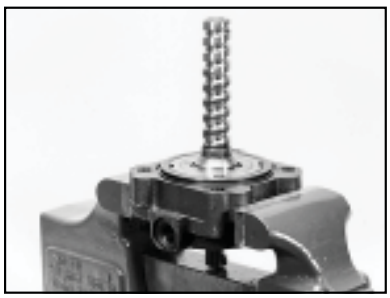
Valve Housing/Worm Screw Disassembly

Tools Required			Materials 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	



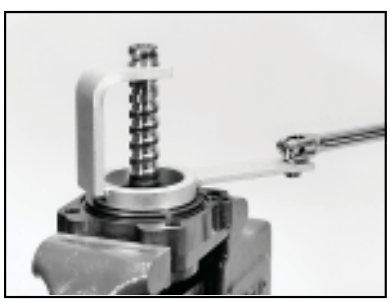
Place valve housing and valve assembly in vise

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

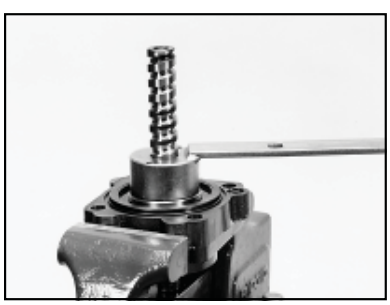
2. Unstake the valve housing (5) where it was upset into the adjuster locknut (21) slot. Also unstake adjuster nut from adjuster (20).



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.

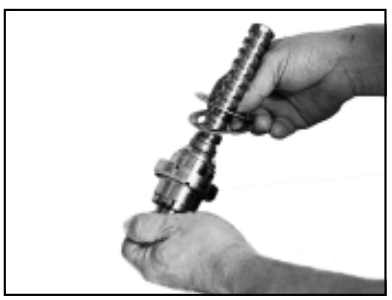
Remove seal ring and o-ring

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

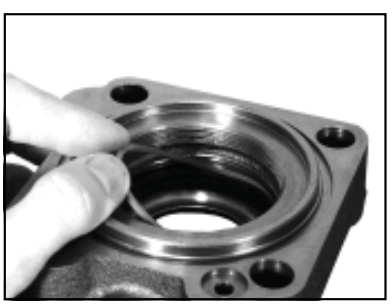
7. Remove thin thrust washer (17) and thrust bearing (16) from input shaft (15).

⚠ 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.

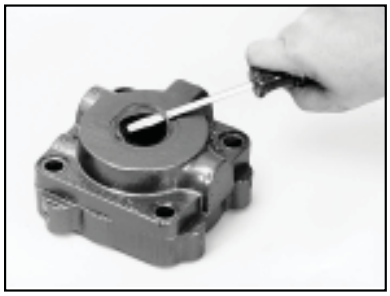
⚠ WARNING **Do not remove the ball cup that the bearing (12) rides on. Do not remove the special spacer seal behind the ball cup.**



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).

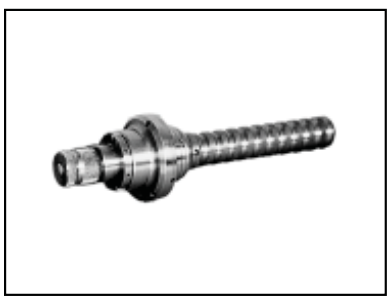
Remove seal

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.

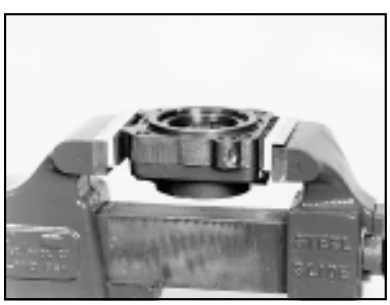


Inspect input shaft, valve worm assembly sealing areas

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

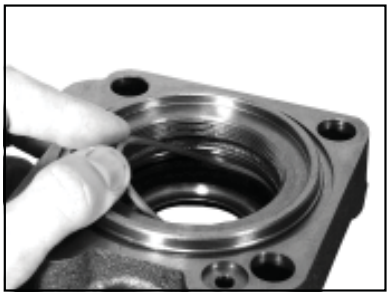
13. Inspect the thrust bearing (16) rollers and ball bearing (12) for any deterioration. Inspect thrust washer (17) and ball bearing race in the valve housing for brinelling, spalling, or cracks. Replace any part with these conditions.



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.

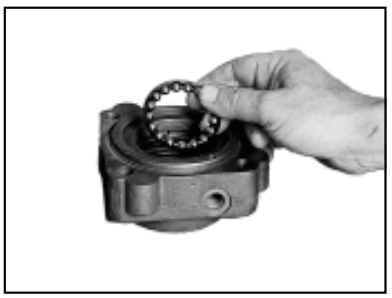
⚠ CAUTION **Do not clamp against threaded port hole or relief valve hole sealing faces when placing valve housing in vise.**



Assemble seal ring

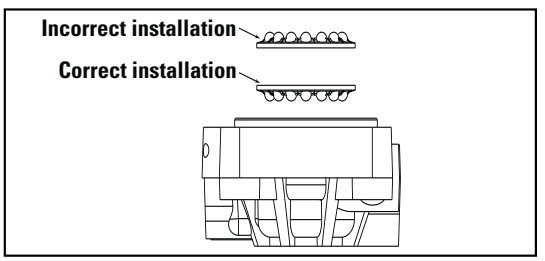
15. Lightly oil and assemble new seal ring (14) into the large diameter seal ring groove in valve housing, bending and working it in and smoothing it out as necessary.

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.

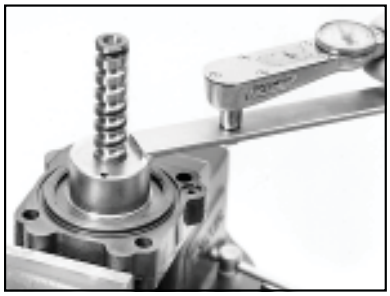
Assemble bearing and thrust washer

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

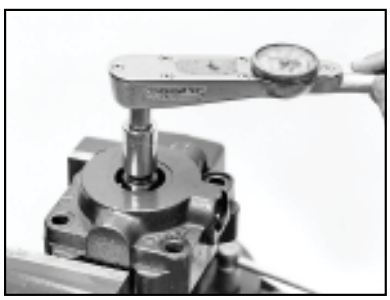
J37070 ft•lb Torque wrench

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

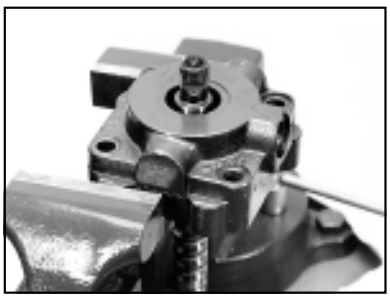
24. Recheck input shaft torque. It should match torque measured in step 22. Repeat steps 22 and 23 if necessary.

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.

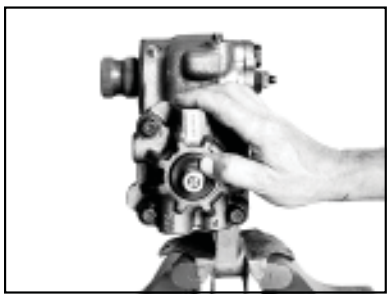
    Place seal installer tool #J37073, small diameter end first, over the input shaft and against the seal. Tap the seal installer tool until the tool shoulder is squarely against the valve housing. This will correctly position the seal in the housing bore just beyond the retaining ring groove.

⚠ 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

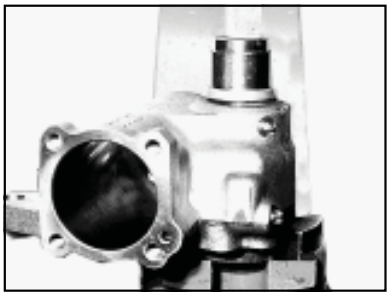
Grease

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

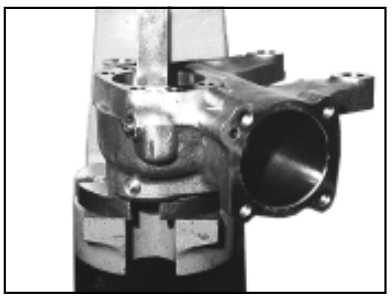
Tools Required	Materials Required
Press J37705 (THP/PCF45) J37071-A (THP/PCF60)	



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.

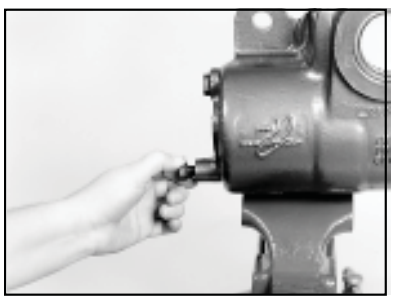
⚠ CAUTION **Use the bearing <u>installation end</u> of the tool (short end). If the bearing <u>removal end</u> of the bearing & seal tool is used to press in bearing, the cage on the new bearing may be damaged.**

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.

Replace Housing Port Plugs, Screws, and Fittings

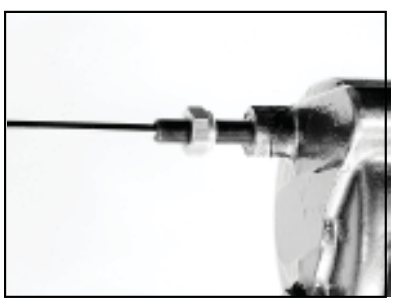
Tools Required	Materials Required
Allen wrench Torx sockets SAE/Metric sockets Open end wrench in•lb Torque wrench ft•lb Torque wrench	



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).

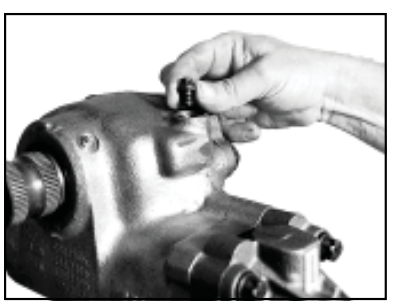


Replace poppet adjusting screw

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

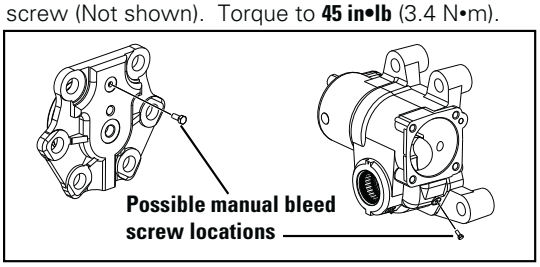
3. If damaged, remove and replace automatic bleed plug (38). Torque to **48 ft•lb** (65 N•m).

   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

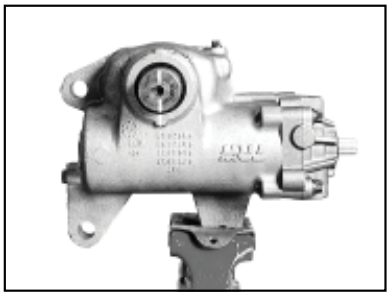
4. If damaged, remove and replace manual bleed screw (Not shown). Torque to **45 in•lb** (3.4 N•m).



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

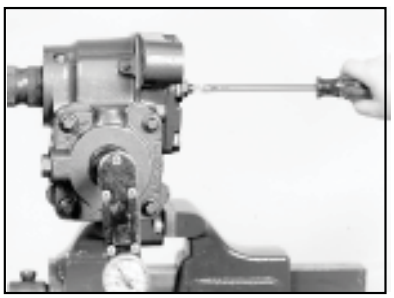
¾" and 11⁄16" Socket or box end wrench

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.

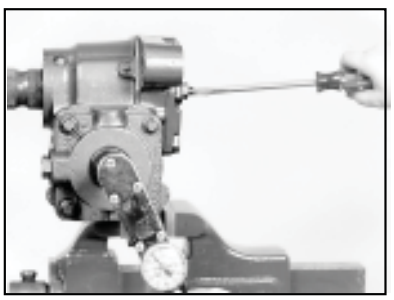


Tighten adjusting screw

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.

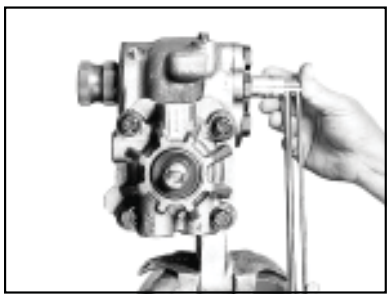
NOTE This procedure will properly mesh and seat the rack piston and sector shaft teeth for final adjustments.



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

Commercial Steering Systems

Steering Diagnostics Service Manual

CHART YOUR WAY TO EASY STEERING

BLUE BIRD

⚠ 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.

⚠ 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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- Reading the Flow Charts
- Warranty

Definitions 4-5
- Hard Steering
- 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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Section 2 Flow Chart Diagrams

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Reduced Wheelcut 9
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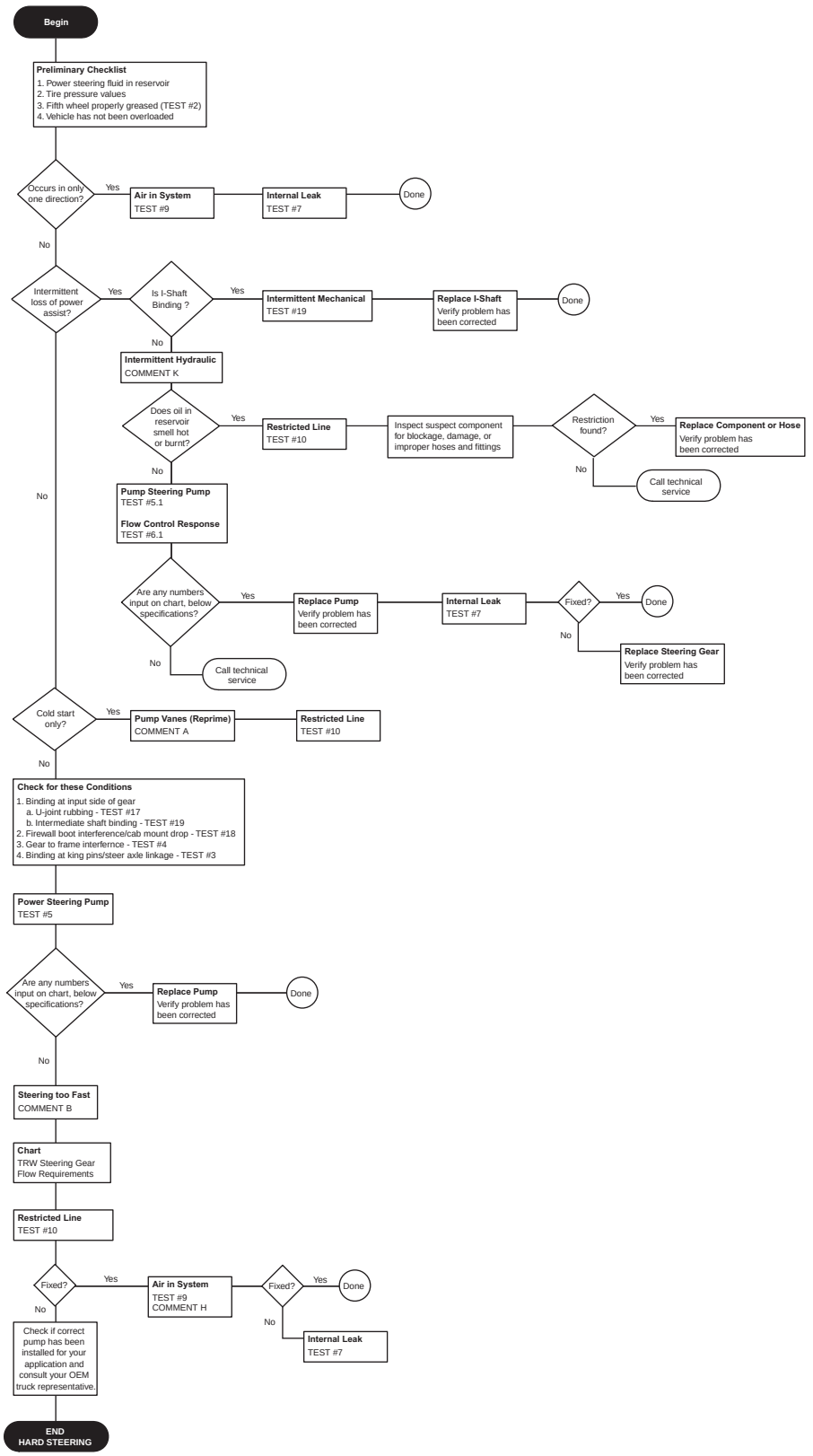
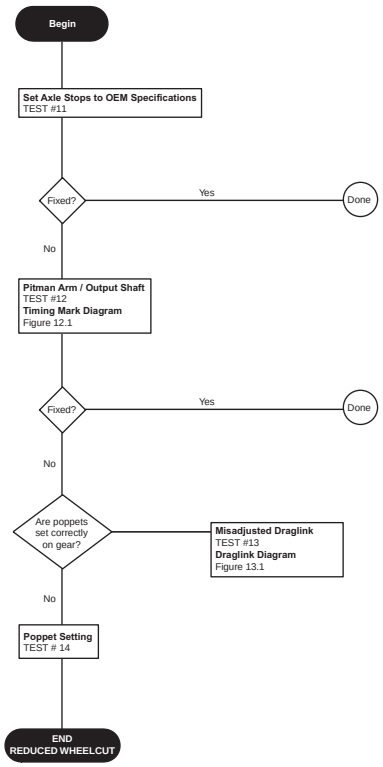
Binding, Darting, and Oversteer 11
Directional Pull 12
Road Wander/Loose Steering 13
Non-Recovery 14
Shimmy 15
Noise 16
External Leakage 17

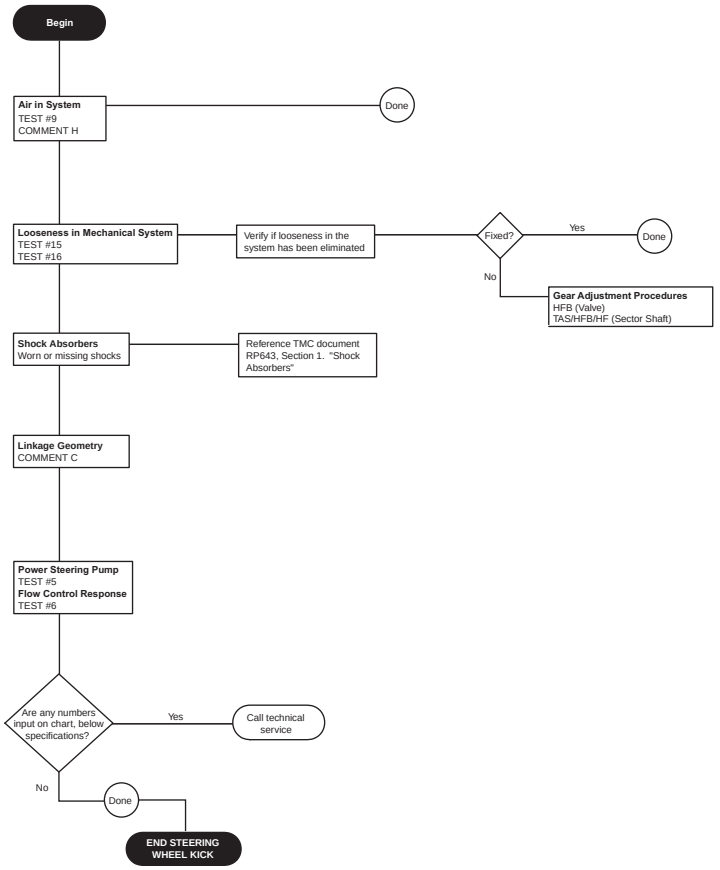
Hard Steering



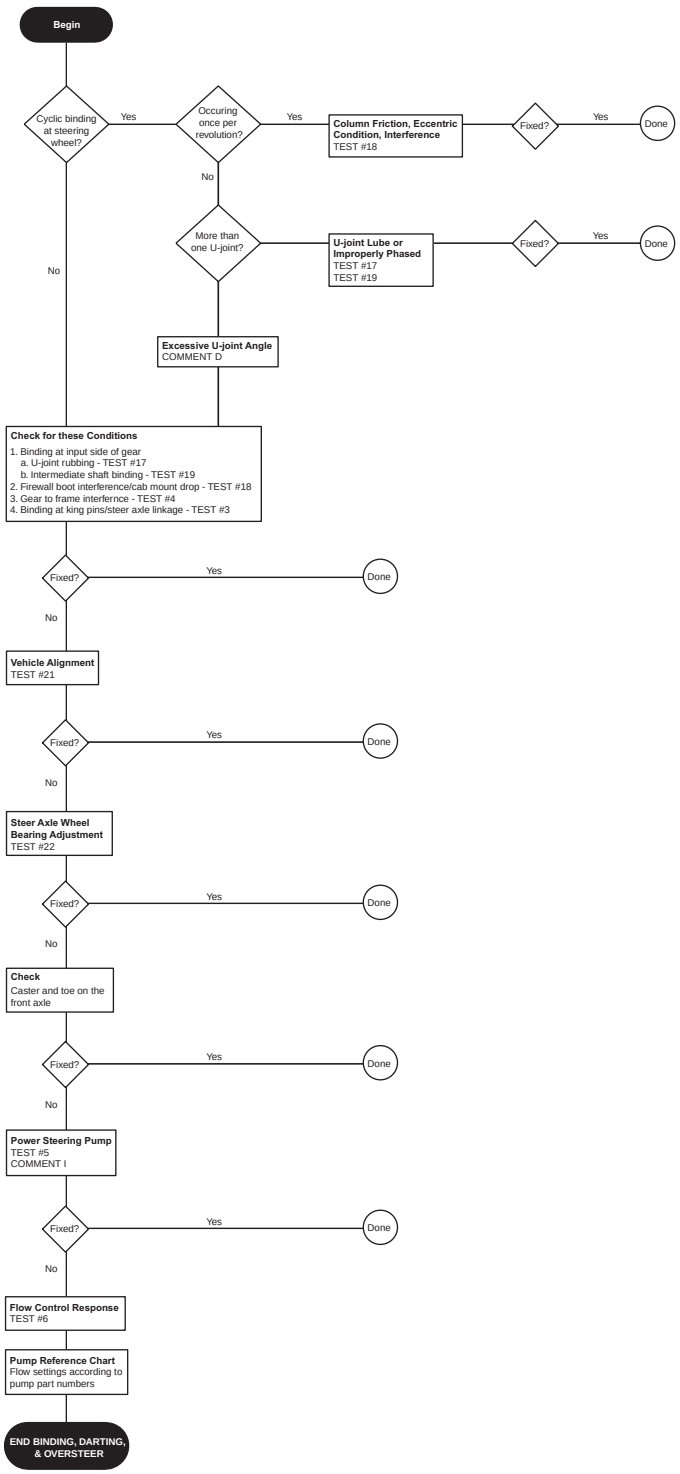
Reduced Wheelcut



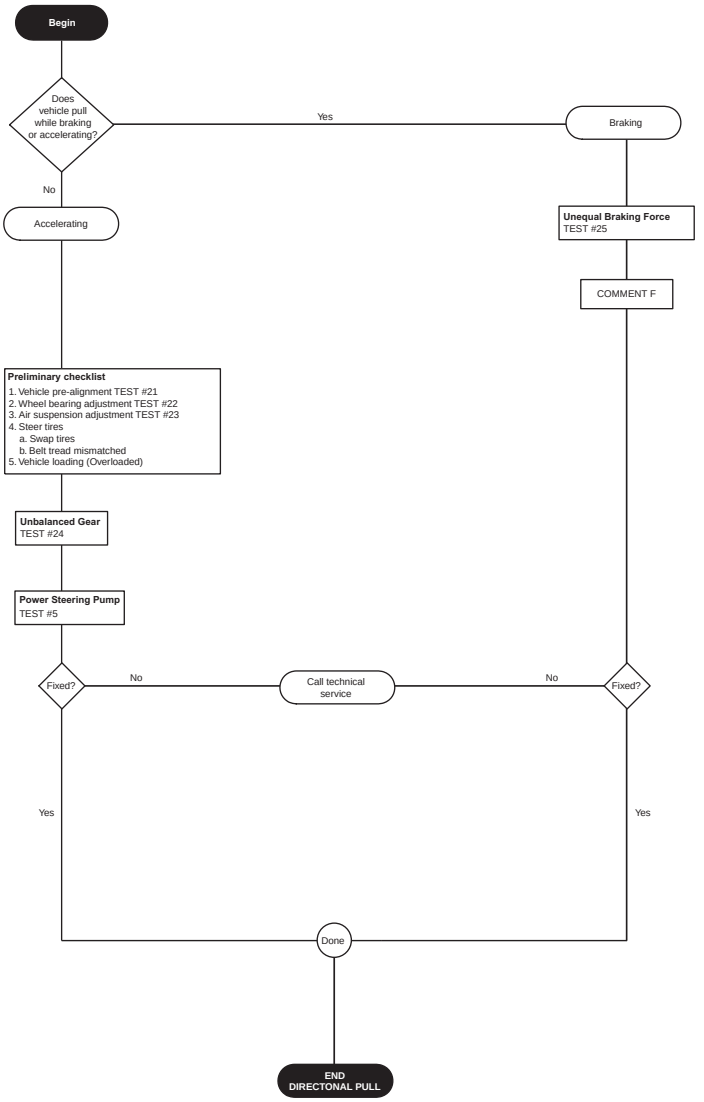
Steering Wheel Kick



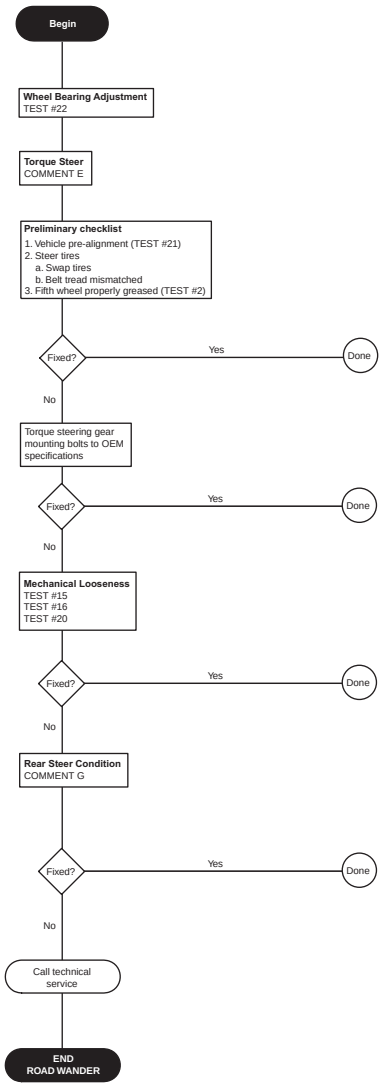
Binding, Darting, and Oversteer



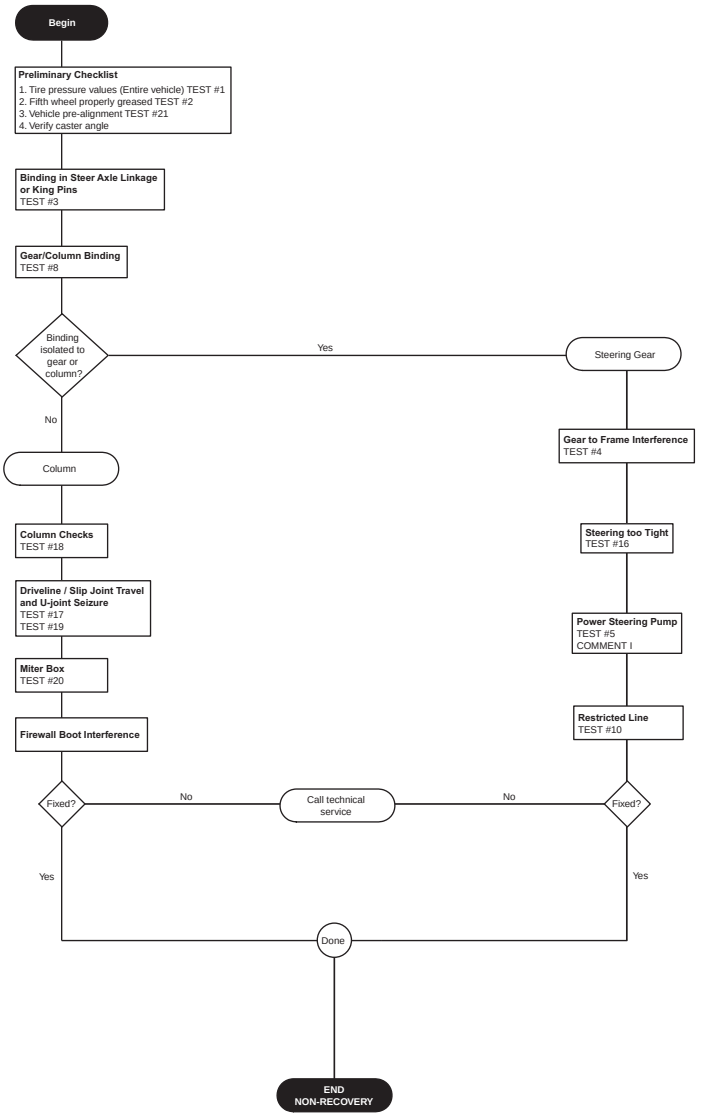
Directional Pull



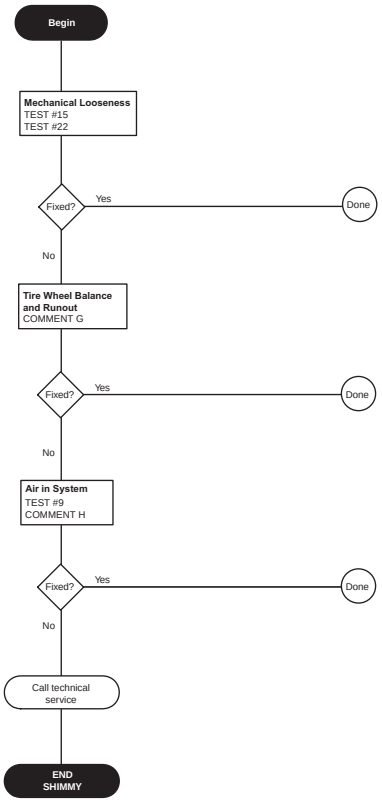
Road Wander/Loose Steering



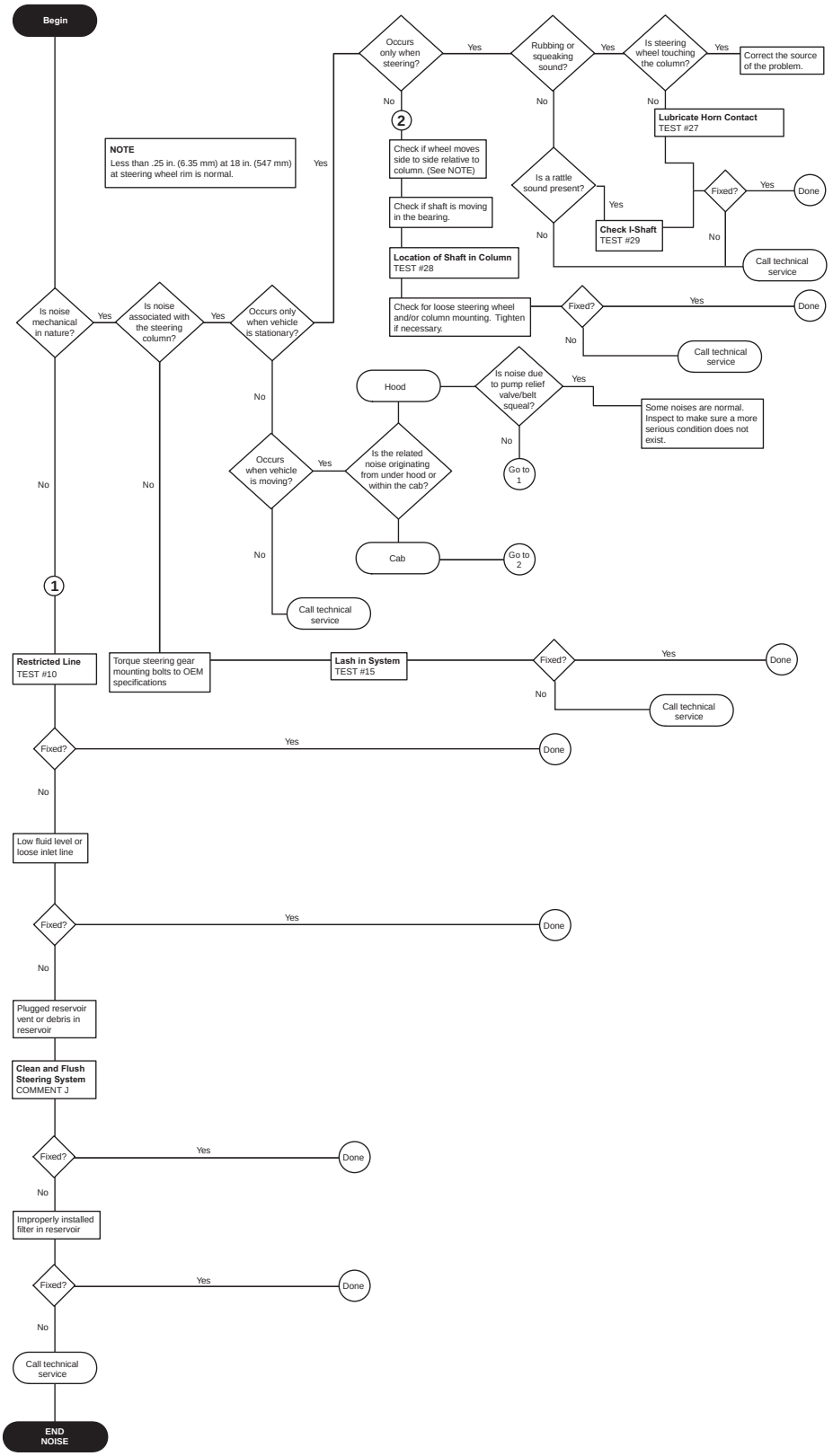
Non-Recovery



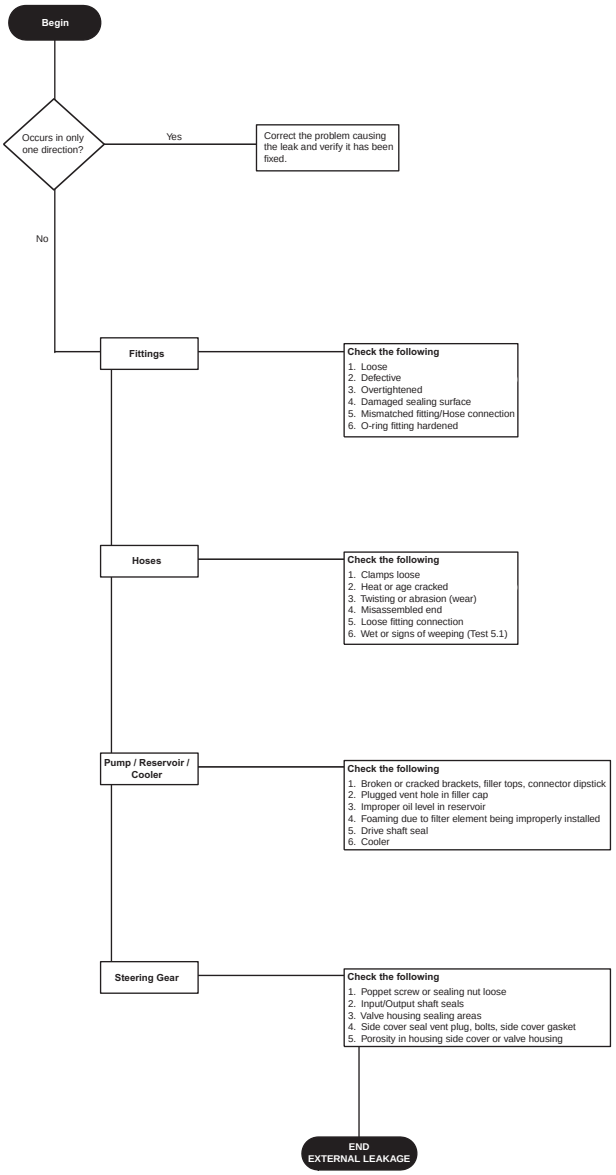
Shimmy


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
Occurs when vehicle is moving?
Yes
Is the related noise originating from under hood or within the cab?
Go to 1
No
No
Cab
Go to 2
1
No
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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Section 3 Test Procedures

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Test #4 21
Test #5 22
Test #5.1 23
Test #6 24
Test #6.1 25
Test #7 26
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Test #11 - #14 29
Test #15 - #16 30
Test #17 - #19 31
Test #20 - #25 32
Test #26 - #29 33

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.

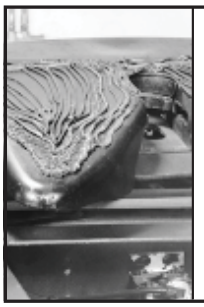
Figure 2.1

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.

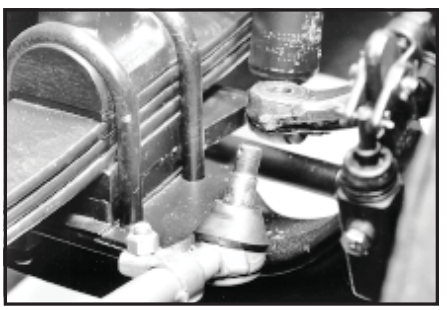
Figure 3.1

Figure 3.2

720

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.

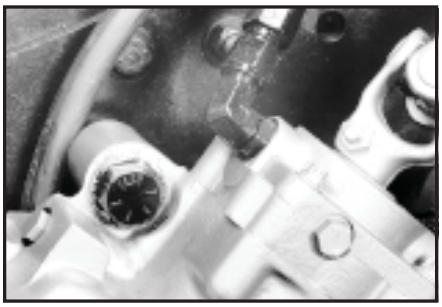

Figure 4.1

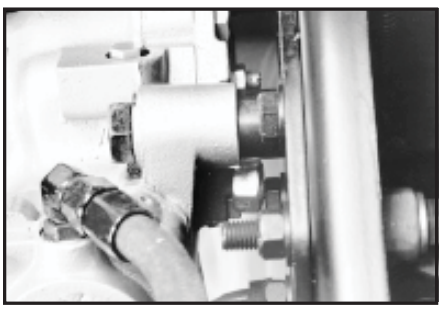

Figure 4.2

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.

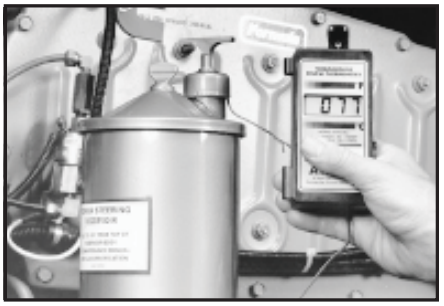
Figure 5.1

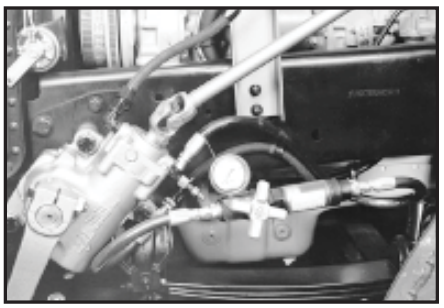
Figure 5.2

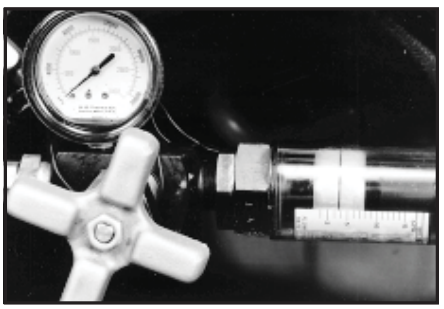
Figure 5.3

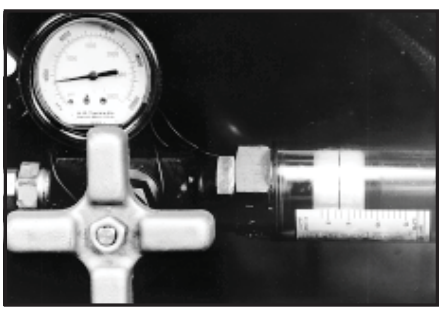
Figure 5.4

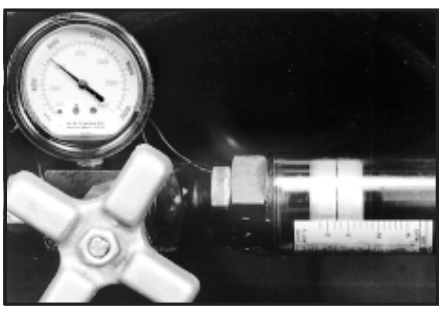
Figure 5.5

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

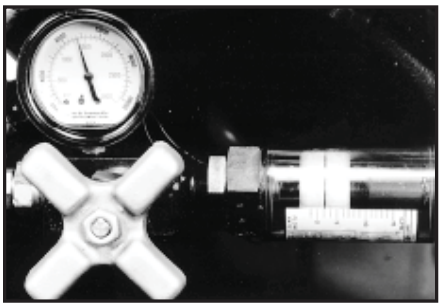

Figure 5.6

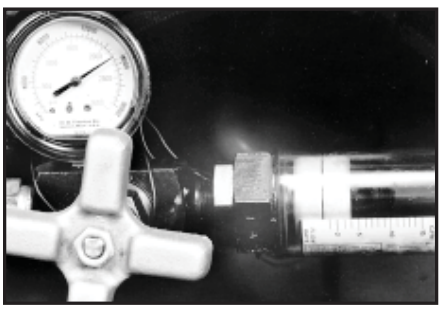

Figure 5.7

723

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.

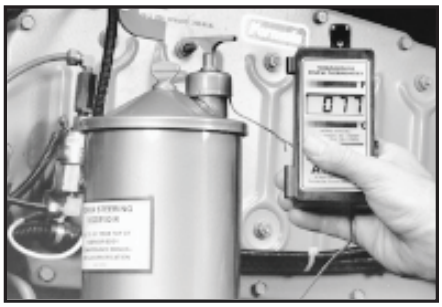

Figure 6.1

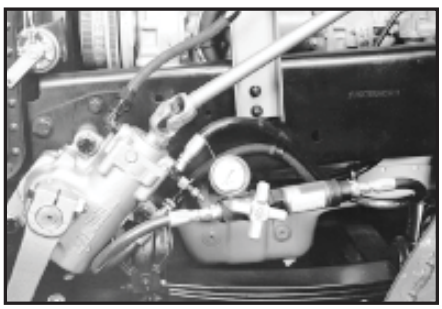

Figure 6.2

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.

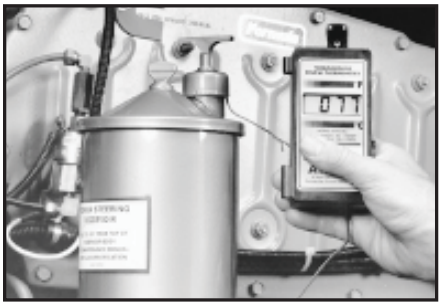

Figure 6.1

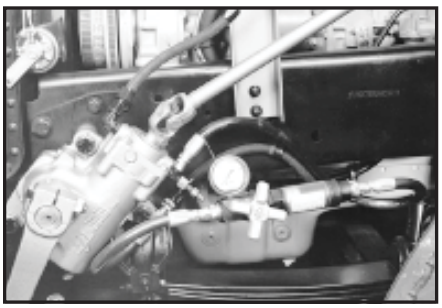

Figure 6.2

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

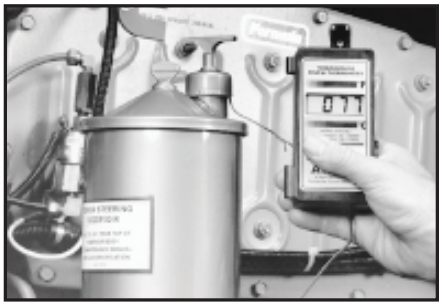
Figure 7.1

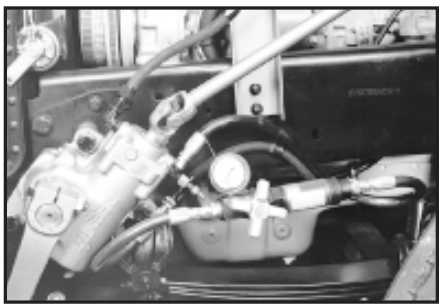
Figure 7.2

Figure 7.3

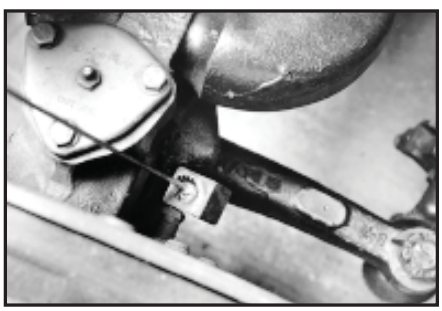
Figure 7.4

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.

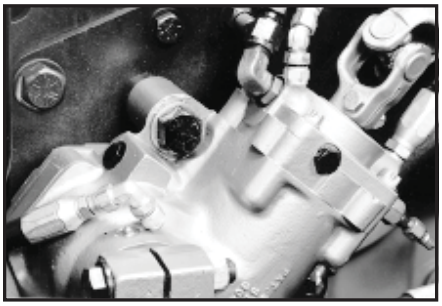
Figure 7.6

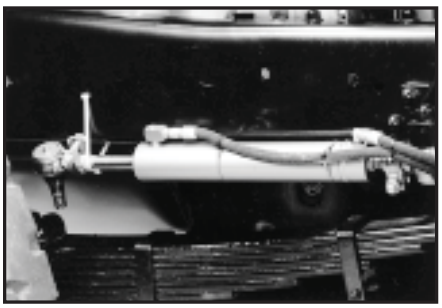
Figure 7.7

Figure 8.1

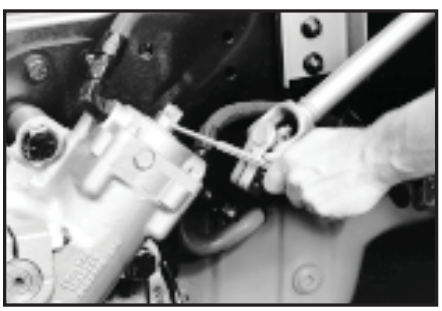
Figure 8.2

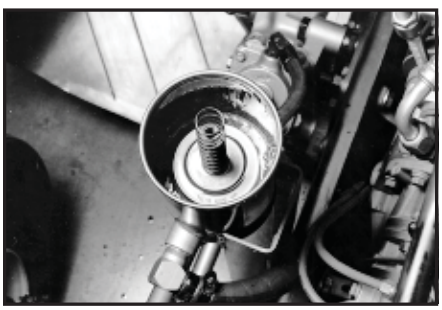
Figure 9.1

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.

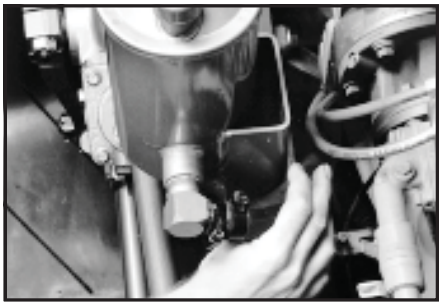
Figure 10.1

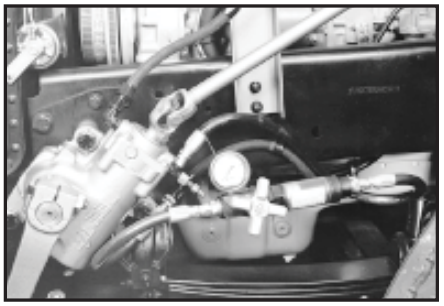
Figure 10.2

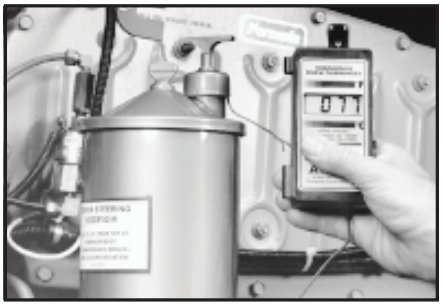
Figure 10.3

Figure 10.4

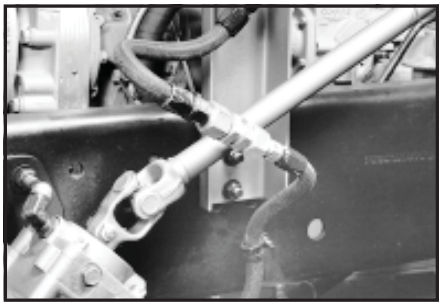
Figure 10.5

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.*

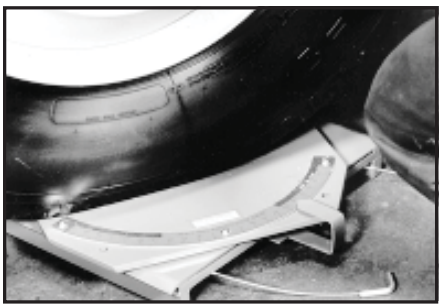

Figure 11.1

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.*

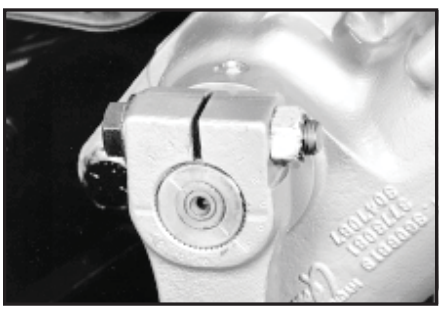

Figure 12.1

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.*

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.

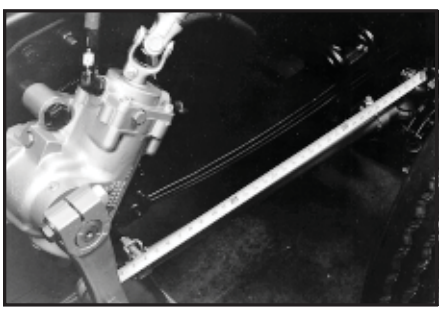

Figure 13.1

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.

730

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

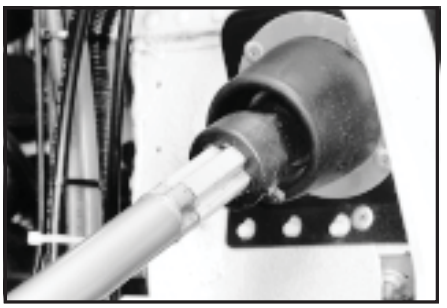
Figure 15.1

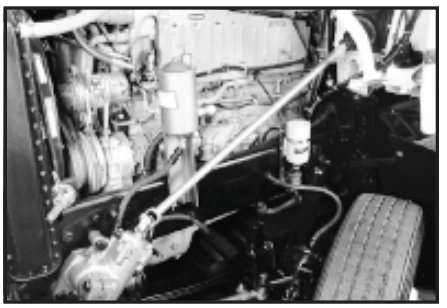
Figure 15.2

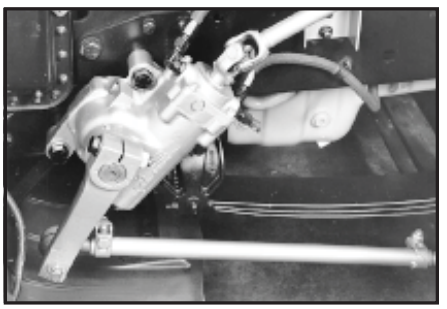
Figure 15.3

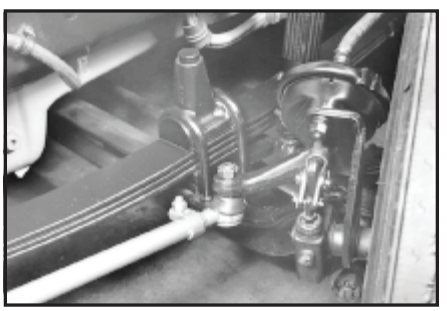
Figure 15.4

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.

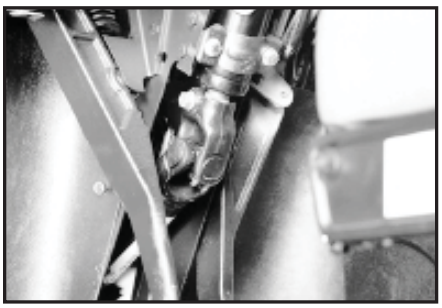

Figure 17.1

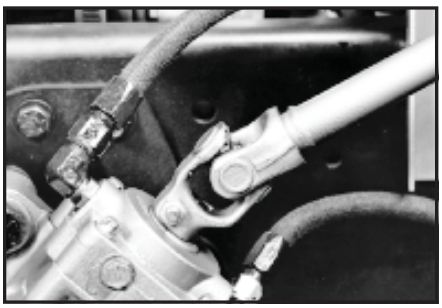

Figure 17.2

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

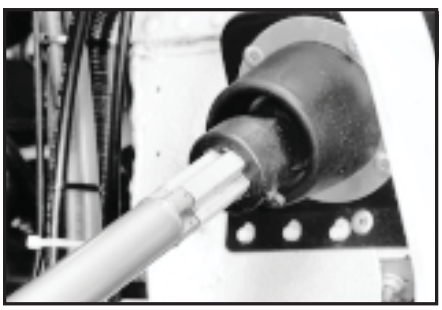

Figure 19.1

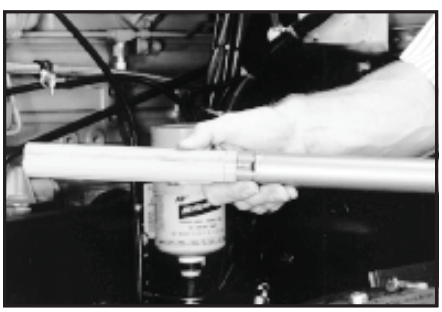

Figure 19.2

Test #20
Miter Box Misadjusted (if equipped)

Check and adjust per manufacturer's instructions. *Figure 20.1.*

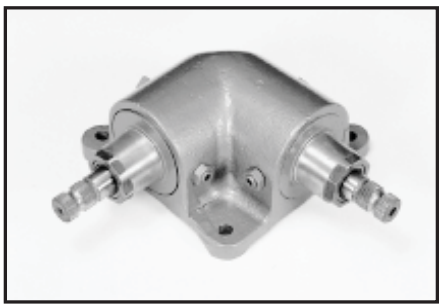

Figure 20.1

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.*

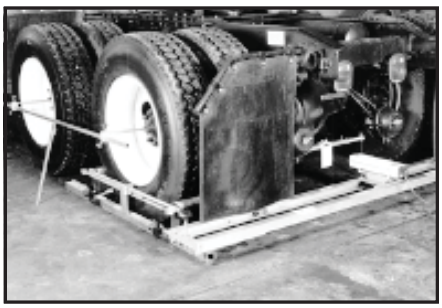

Figure 21.1

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.

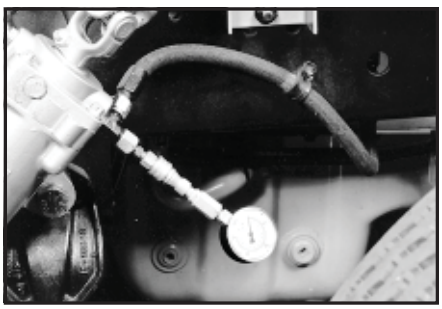

Figure 24.1

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	℉ or ℃

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

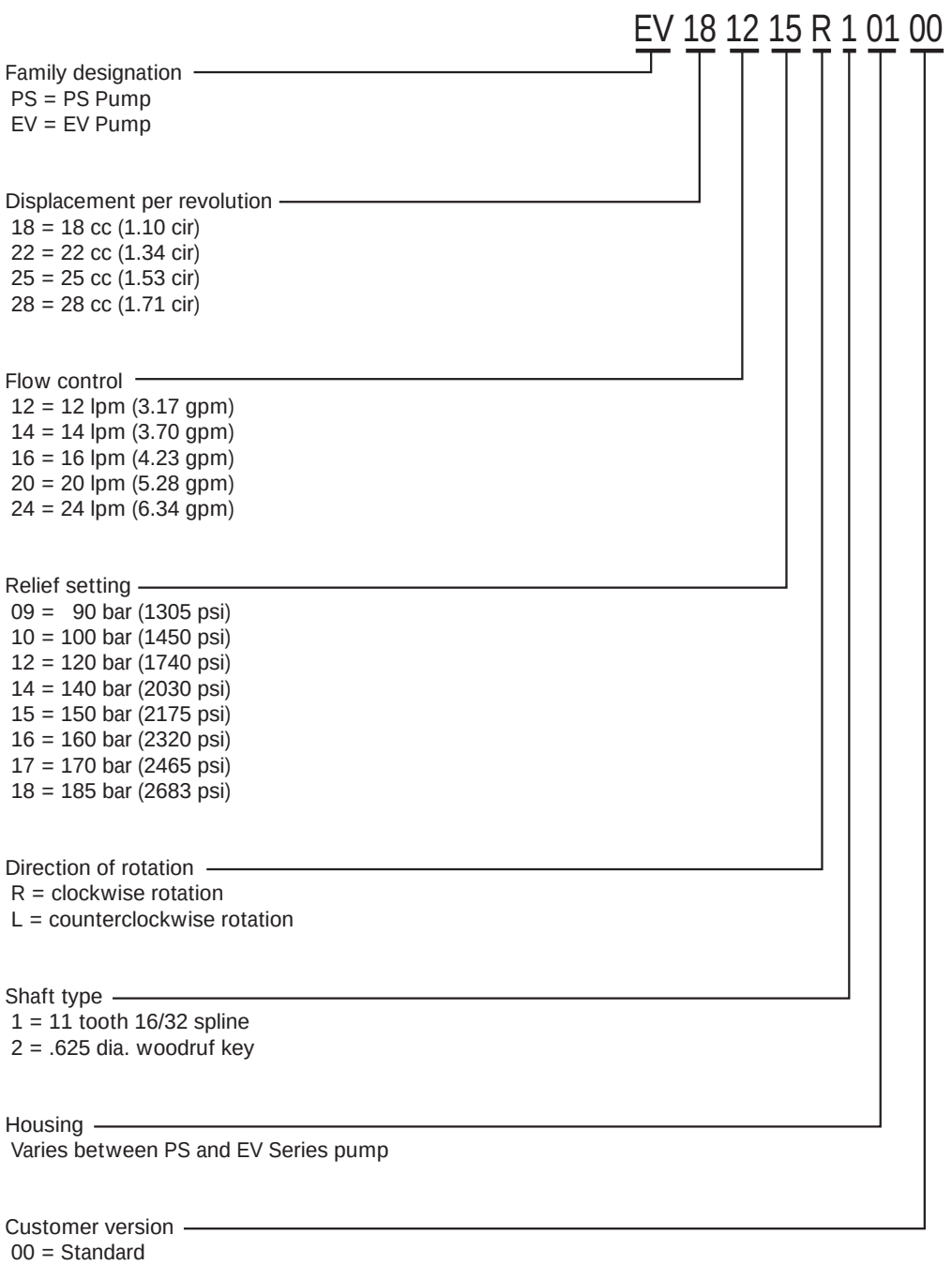
Dual Gear

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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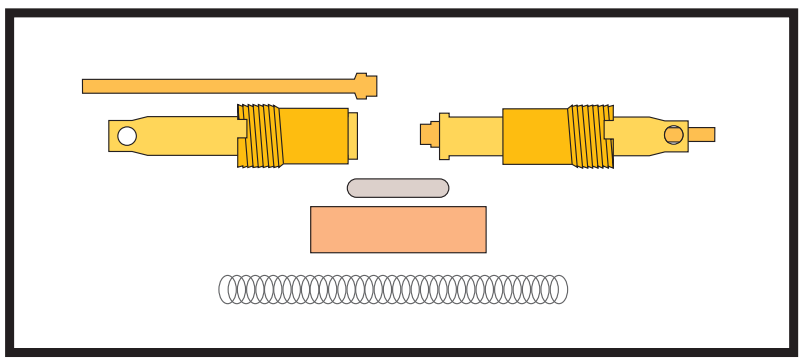
TRW1250 Rev. 4/02

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

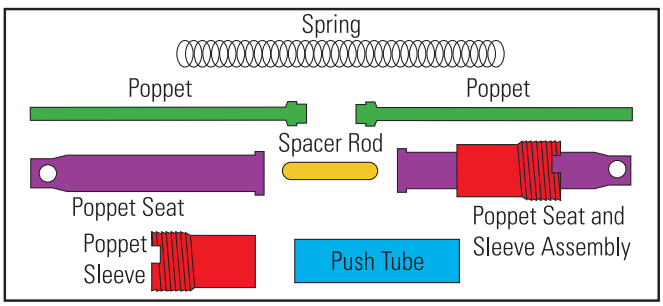
Contact of poppet and screw or valve housing pushes poppet away from it's seat.

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



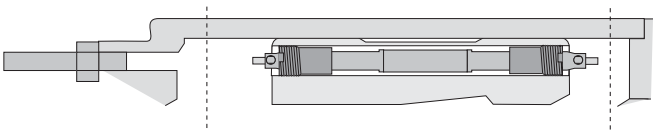
Setting poppets means pushing the poppet seat into the poppet sleeve. This backs off the poppet so it will contact the screw or valve housing just before axle contacts axle stop

TAS Factory Setting:
(or New Aftermarket Gear)

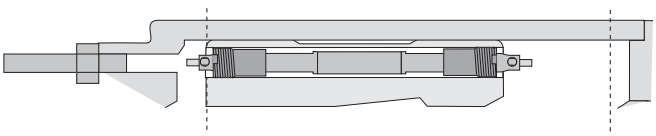
- Set axle stops
- Raise front axle
- Turn full right - engine on
- Turn full left - engine on

New steering gear poppet components look like this before setting. At this point, they are ready for automatic adjustment.

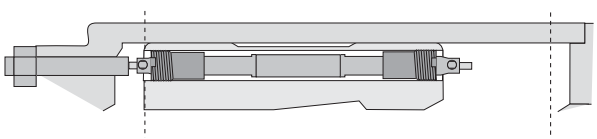
The amount of gear travel is determined on each vehicle by the axle stop settings. End of gear travel is marked in these diagrams by dotted lines The rack piston will stop when it reaches these points because the axle stops will not allow the road wheels to travel further.



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.

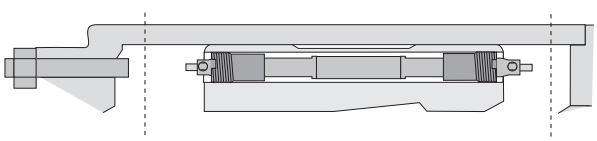


In the second full turn, the remaining poppet seat will be pushed in the amount required for that vehicle. Since the poppet seat and sleeve assemblies are a pressed fit, both poppet seats will now remain in this set position until they are reset using the procedure that follows.



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.



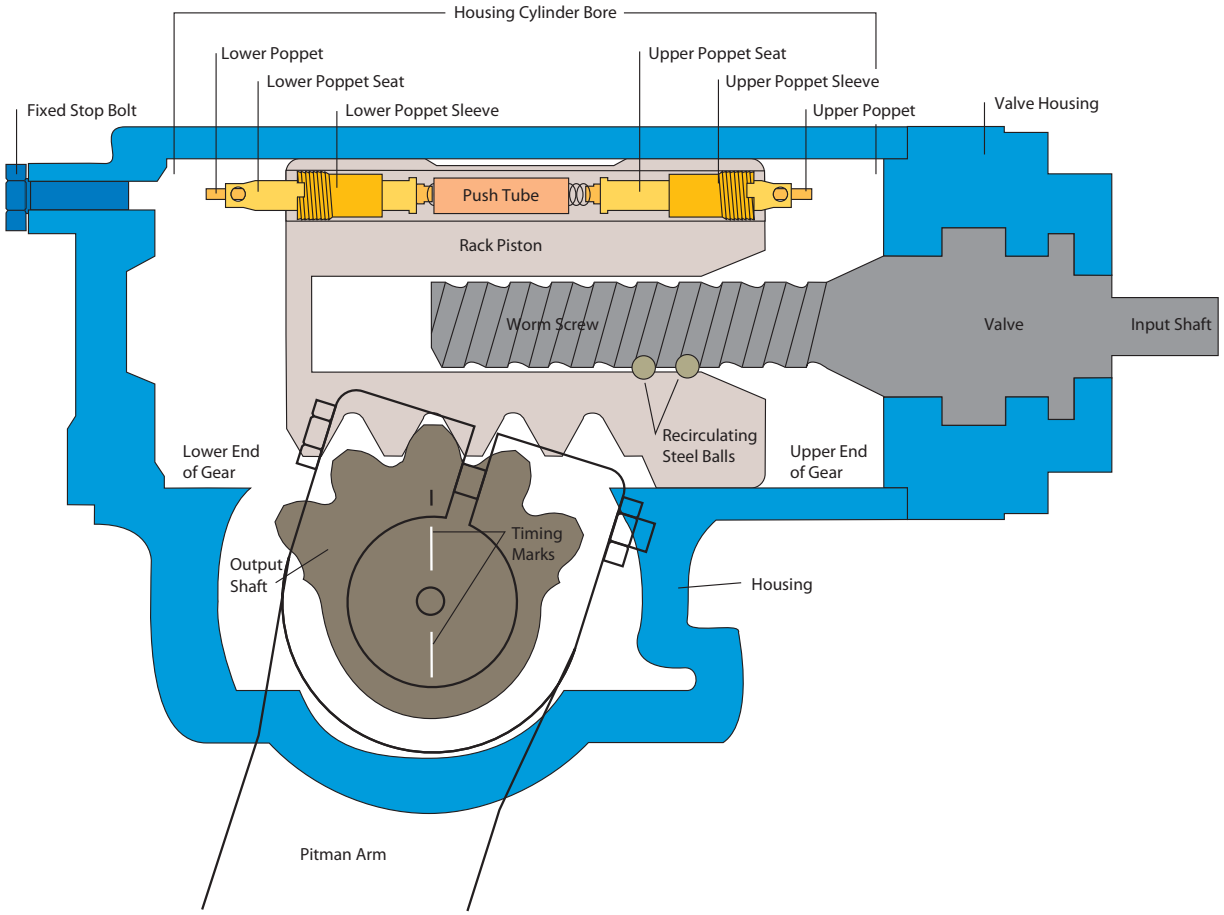
Reasons for Resetting Poppets:

- 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

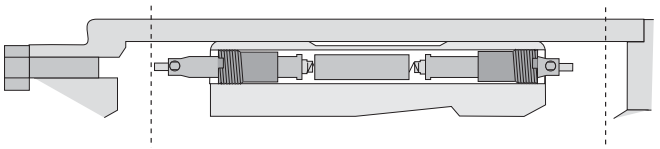
TAS Resetting:

- 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

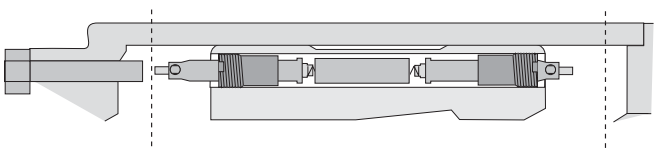
Introduction to Internal Components



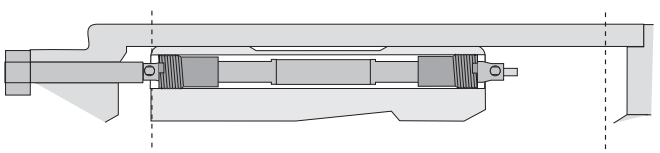
Axle stops have been reset in this diagram. They have been moved in, indicating that wheel cut has been reduced.



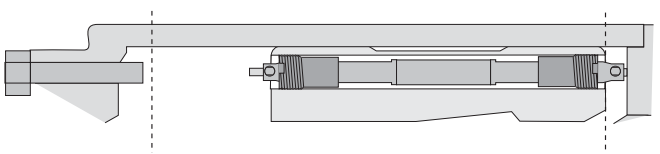
An adjusting screw is installed in the gear for the resetting process so the poppet components can be forced together to push on one another. Once the poppet components are pushed together, they will stay that way. The adjusting screw will also remain as part of the gear. Do not try to reuse the fixed stop screw after resetting poppets.



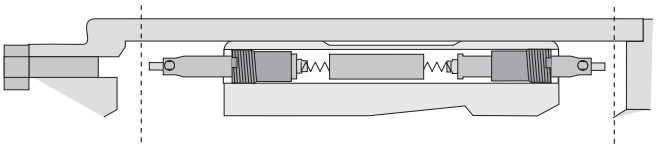
Turning in a direction that makes the rack piston move toward the lower end of the steering gear will force the lower poppet seat against the adjusting screw. The lower poppet seat then contacts the push tube and forces it against the upper poppet seat. This will force the upper poppet seat out so it can be set automatically on the next turn.



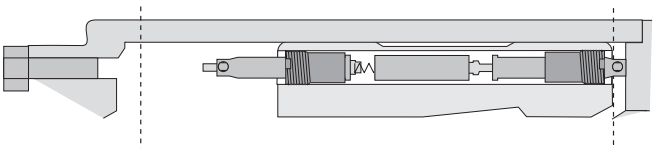
This turn sets the upper poppet seat in just the same way as it was set when the gear was new. Notice that since the poppet components are still forced together, the upper poppet seat is now forcing the push tube against the lower poppet seat to push it out.



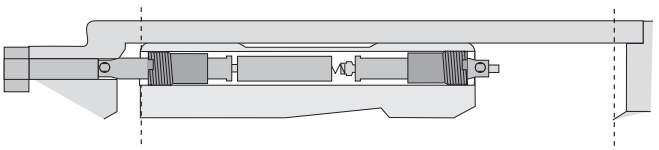
The adjusting screw is backed out of the way, so the poppet seat will not contact it on the next turn.



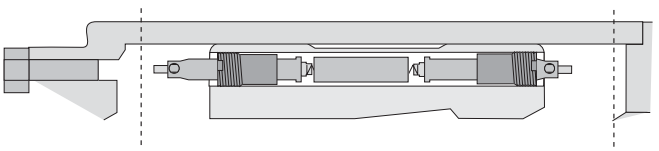
Holding the wheel at full turn places the poppet seat in the proper position for setting.



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

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TRW1102
Electronic Version February 2001

Overview

The Blue Bird All American's body structure consists of Blue Bird's one piece bow construction and body sections built in 28 and 35 inch increments that run the entire length of the bus. The roof has one piece roof sheets which extend from one side to the other. The body is insulated with mineral wool insulation and 16 gauge rubrails extending from front to rear help ensure structural integrity. Body joint structure is riveted with adhesive and meets all applicable state and Federal Motor Vehicle Safety Standards.

Appendixes In This Chapter

Appendix 1. Sika AGR Technician Training Manual 2008. This manual from Sika includes full details and technician training instructions on the replacement of bonded glass systems using the Sika line of products.

Body Glass

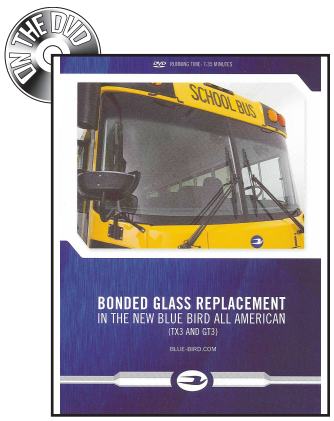
Glass replacement should meet standards in specification FMVSS 205 and 217.

> **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 equipment, such as gloves and safety goggles.***

Windshield Glass Replacement

The all new look of the 2010 D3 All American represents more than just a cosmetic facelift. One of the more noticeable differences is more glass on the front and rear of the bus. Not only does the windshield have 33 percent more glass area, the method of fastening the windshield to the bus is different. The windshield is bonded to the front structure of the bus with an adhesive retention system.

Fastening glass to the body of automobiles using adhesives has proven to be a very reliable time tested method of glass installation. The automotive industry has been using adhesive retention systems for installing windshields, rear glass and other glass components on automobiles for years.



Bonded Glass Replacement
In The New Blue Bird All American
(VIDEO)

Using adhesives to install glass has a number of advantages over other methods of retention. Most important, adhesive retention systems provide a positive means of fastening the windshield to the front structure of the bus. Raising the standard for safety, bonded windshields provide an increased resistance against forces that may be applied directly or indirectly to the glass depending on the environment or unforeseen conditions the bus may encounter. Although the windshield is not considered a component required for structural integrity, the 9mm thick laminated windshield is very rigid and when installed by Automotive Glass Replacement Safety Standards (AGRSS) standards using Sika brand retention products, the windshield becomes a part of the structure adding strength and integrity to the body.

D3 Bonded Glass Windshield

Other advantage of using a bonded retention system is its ability to not only act as a fastener but its ability to act as a sealer. Adhesives and sealants have similar characteristics but in very general terms adhesives do not require mechanical fasteners. A properly installed windshield by AGRSS standards using Sika retention products will provide a positive seal against wind noise and water leakage.

Using an adhesive retention system to install the windshield and rear glass provides an advantage from a cosmetic viewpoint, by adding to the aesthetic appearance of the bus.

Blue Bird engineering has selected Sika brand adhesive retention products for bonding the windshield and rear glass to the bus during the manufacturing process. Sika products have been used in the automotive industry for over 25 years and they are time tested proven reliable products. The following Sika products are used during the manufacturing process.

Sika Products

Product Name	Description
Sika® Aktivator UH-2 LUM	Adhesion Promoter
Sika® Primer – 206 G + P	Primer
Sikaflex® – 255FC	Direct Glazing Adhesive

Regardless of who installs the windshield on a D3 All American it is the responsibility of those who place the bus in operation to insure the vehicle is safe for over the road operation and most importantly the bus is safe for transporting passengers. With this in mind it becomes the responsibility of those who place the bus in operation to select who will replace bonded glass that has been damaged on the bus.

There are a numerous considerations that need specific attention when bonded glass needs replacing. One example, of many, is the purchase and storage of adhesive retention products. Like most adhesives, some of the Sika products have a shelf life that needs to be monitored and documented at the point of installation. If a windshield or other bonded glass is installed with adhesive products having an expired shelf life, even though the installation procedures may seem normal and successful, proper bonding of the glass to the bus body may not have occurred. This may result in the glass de-bonding in some areas causing wind noise and water leakage or the glass may separate from the bus body. All of the products used in the installation process and the technician conducting the installation of bonded glass on a D3 All American must comply with AGRSS and Federal Motor Vehicle Safety Standard (FMVSS) standards. *Contact your Blue Bird Dealer for assistance.*

CAUTION ***Blue Bird strongly recommends only Sika brand adhesive retention products be used when replacing the windshield or other bonded glass on the bus and the installation should be conducted by an AGRSS® certified installer following all AGRSS and FMVSS requirements. Failure to do so could result in the replaced glass de-bonding and separating from the bus.***

The **AGR Technician Training Manual 2008 Appendix 1** is provided as a reference for the certified installer to assure proper use of Sika brand adhesive retention products. Also see: **Bonded Glass Rplacement in the New Blue Bird All American** on the DVD.

Terms

ANSI/AGRSS 002-2002: American National Standards Institute/Auto Glass Replacement Safety Standard 002-2002

The AGRSS Council: The Automotive Glass Replacement Safety Standards Council Inc, AGRSS is a not-for-profit organization dedicated to the safe replacement of auto glass. AGRSS was founded and is supported by companies in the auto glass replacement industry that keep safe installation as their primary goal.

AGRSS: an accredited American National Standards Institute (ANSI) standards development organization. It has developed the North American's only auto glass replacement standard, the AGRSS standard (ANSI/AGRSS 002-2002 Automotive Glass Replacement Safety Standard). The AGRSS Standard addresses procedures, education and product performance.

IGA: Independent Glass Association

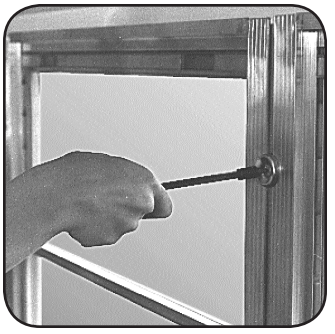
Rear Vision Glass Replacement

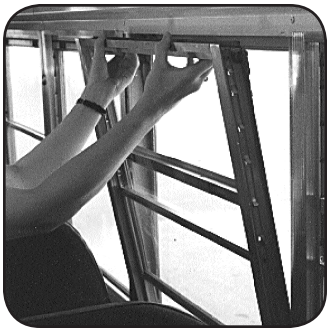
1. Remove filler strip from channel in glazing rubber.
2. Apply pressure against glass from the outside of the bus starting at a corner, push glass and glazing rubber off metal flange.
3. Remove glazing rubber from glass.
4. Put glazing rubber on new glass.
5. Apply a soapy solution to the flange on 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.
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.
9. Apply clear caulking around glass and window flange on the outside of bus body to ensure that no leaks occur.

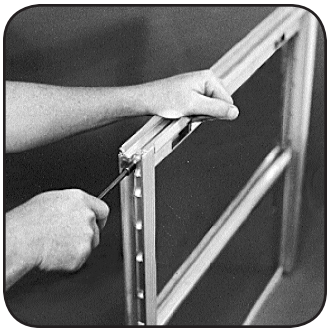
Split Sash Window and Glass Replacement

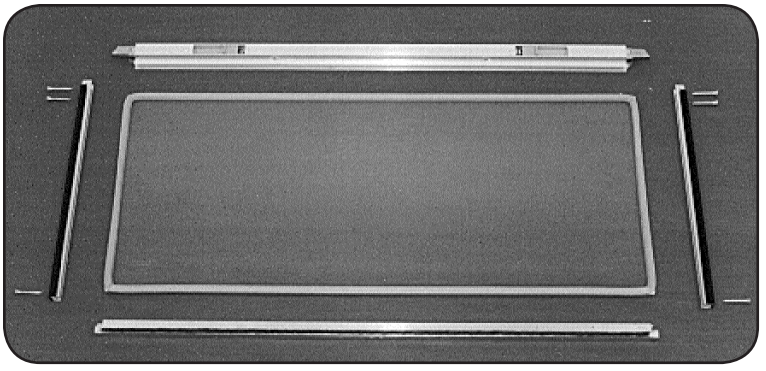
The glass used in the Blue Bird bus meets FMVSS 205 and 217. When a glass is broken, it should be replaced with identical glass.

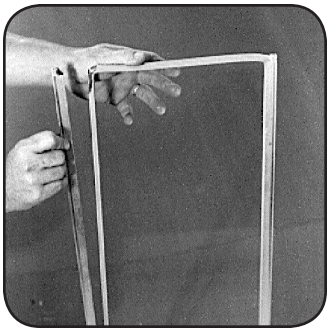
1. Remove four screws securing window frame to bow.
2. Pull window to inside of body and remove.
3. Remove six screws (three on each side of window) holding assembly together.
4. On bottom glass, simply pull aluminum channel off top and bottom of glass.
5. To remove glass from top part of window, remove 6 screws holding frame around glass.
6. Reassemble window by reversing above procedure.
7. Apply weather seal caulking around window frame to prevent leaking.











Window Latch Replacement

1. Remove screw and block located in side channel directly above stationary glass.

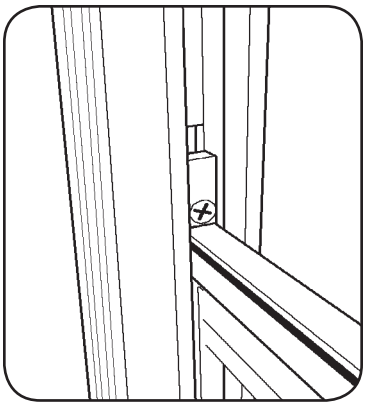
2. Lower sliding sash so that latch enters notch covered by block removed in Step 1.

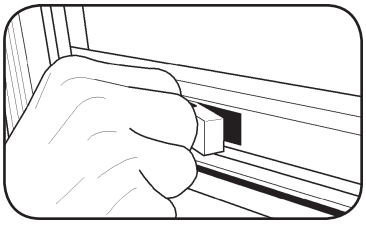
3. With latch in large notch, push finger holes outward until inside edge is exposed. Pull latch out of finger hole opening.

4. Finger latch is pried off attached metal latch with any tool that provides leverage. Latch may now be removed and replaced.

5. Reassemble by reversing procedure.

Lubricate latches and sliding seal of top window with silicon spray every 30 days. See decal on driver's window.





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).

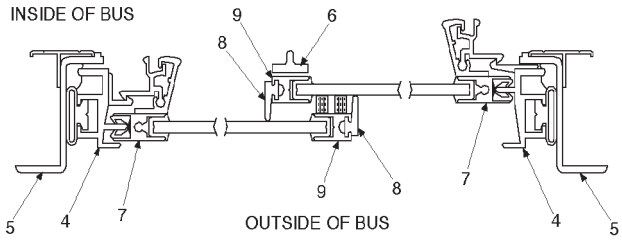
8. Slide glass to the center of the window. Spread apart the inner frame (4) just enough to lift glass frame (7) out.

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.

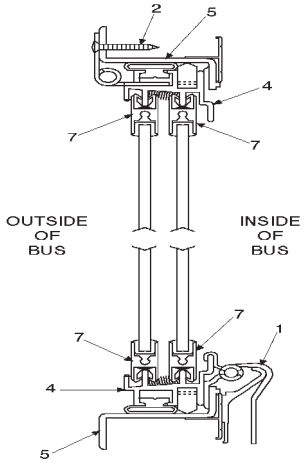
10. To replace glass, slip glazing vinyl seal around glass and slide into frame.

11. Reassemble by reversing procedure.

Transit Sliding Window

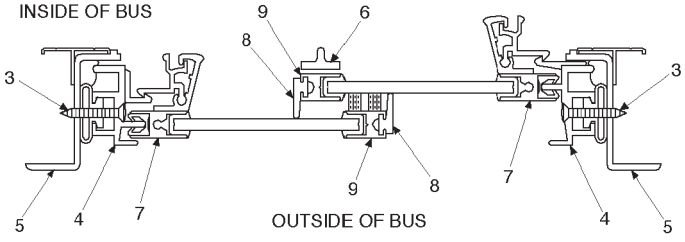


HORIZONTAL SECTION THRU TRANSIT SLIDING WINDOW PUSH OUT WINDOW

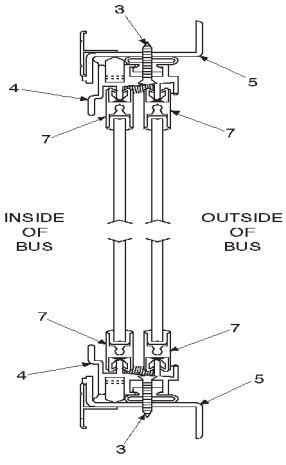


VERTICAL SECTION THRU TRANSIT SLIDING PUSH OUT WINDOW

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

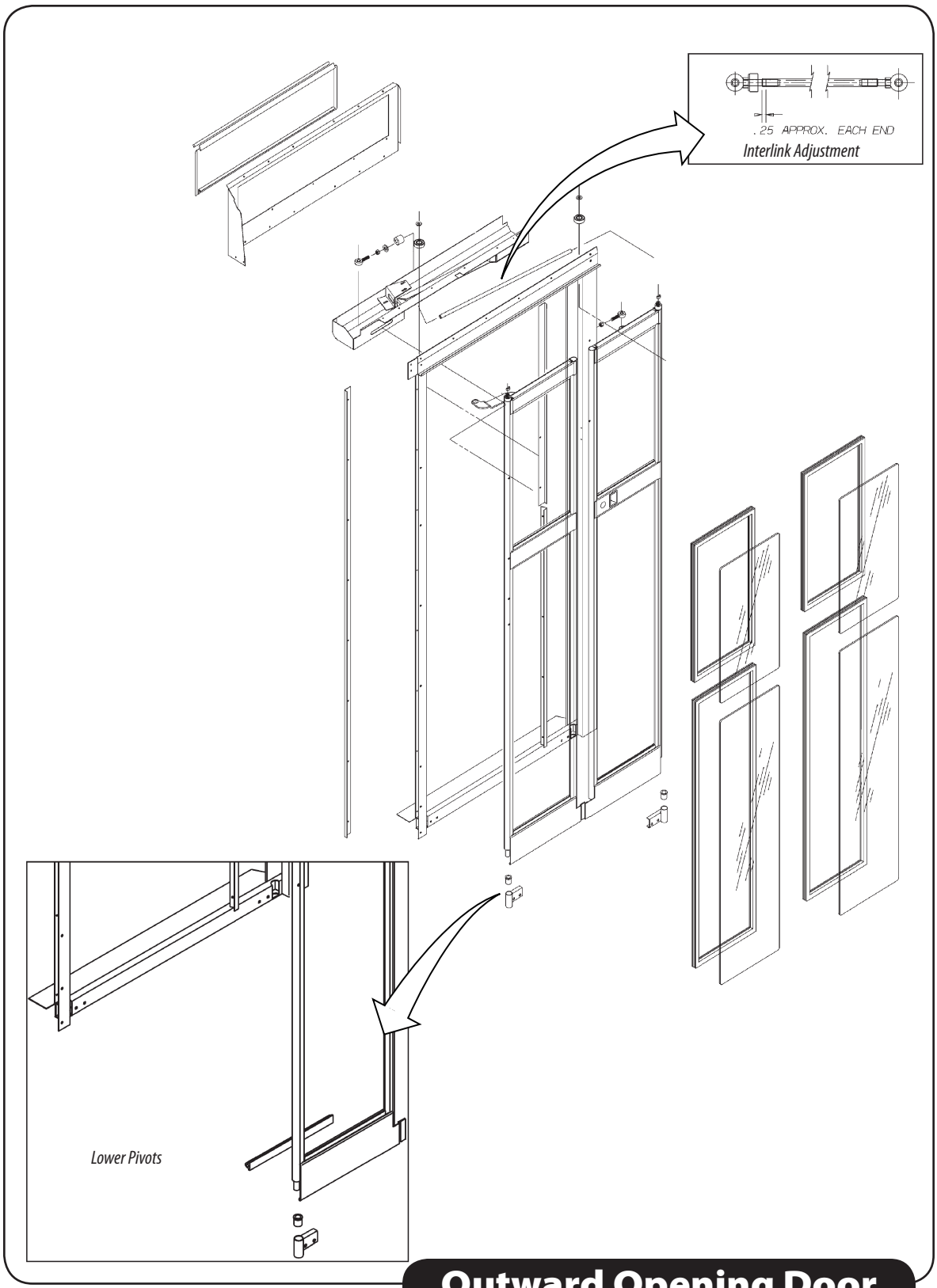
The mechanical link between the doors (the interlink rod) should be adjusted so that the rearward door closes and seats first. One of the spherical bearing, rod end connectors has a right-hand thread; the other has a left-hand thread. This allows for length adjustment by simply turning the interlink 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.

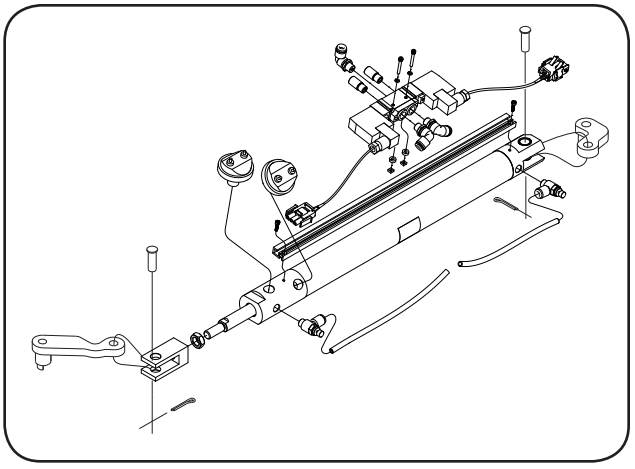


Outward Opening Door

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



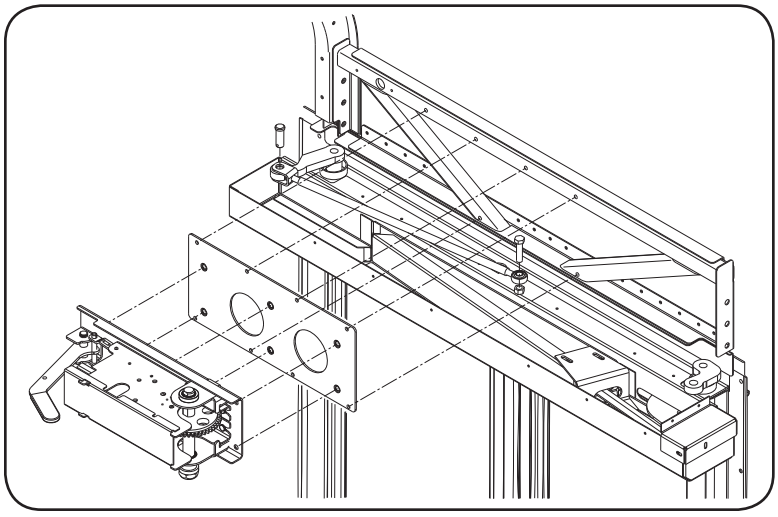
1. Remove the cotter pins and clevis pins from each end of the actuator.
2. Disconnect the electrical connectors.
3. Remove the pneumatic tubing. Identify the tubing as you remove it and replace it in the same positions.
4. Carefully remove the actuator from the compartment.

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 and 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.

AGR Technician Training Manual 2008

(Including Aktivator PRO Updates)

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1.0 Quality Installation Guidelines

Don't ever underestimate the importance of your job in protecting the welfare of your customer and the integrity of their car! Use of the wrong products and poor workmanship can and has resulted in fatal accidents that have cost the glass industry millions of dollars. Make sure to follow every step as prescribed by this manual as well as training that you will receive from Sika personnel. ***You participate in a very important profession in that the quality of your work could seriously affect both the people and the cars they drive.*** **Demonstrate your pride by delivering a safe and quality proven installation 100% of the time. Anything less may be fatal!**

TIP 1: MANAGE YOUR INVENTORY

All too often, technicians get carried away with the inventory they have open either in the shop or truck. It pays great dividends to have specific locations set aside to store product. This promotes a good system of opening only what products are needed, helps ensure that products are used prior to expiration and protects the packaging of the products.

TIP 2: ALWAYS START WITH THE GLASS

Never begin work on the vehicle prior to cleaning and inspecting the glass part that is to be installed. Inspect both the quality and the suitability of the selected glass part for installation on the vehicle you are working on. There have been occasions, especially in mobile work, where the glass part may have a small scratch or blemish that went undetected in the shop and was not discovered until after the new glass was installed on the vehicle. There have been other incidences when the technician didn't realize he had the wrong part; he prepared the glass and applied the adhesive, and only when he tried to install it on the vehicle, did he learn of his mistake. Pre-inspection and cleaning of the glass helps to avoid these two time-consuming errors.

TIP 3: VEHICLE PRE-INSPECTION

Before working on any vehicle, take a moment to inspect for pre-existing damage. While looking for damage, which might prevent the proper installation of the new glass, also inspect the vehicle and make notes as to any scratches or dents that exist in the areas that you will be working. This step can save thousand of dollars in pre-existing damage claims and is a professional courtesy that the insurance industry respects. *Section 3 of the AGRSS Standard requires that a vehicle is pre-inspected to determine if any condition exists that may jeopardize the retention system. Make sure to keep written records of all pre-inspections and notify the owner/operator of the vehicle if any pre-existing damage or condition is discovered.*

TIP 4: PROTECT VULNERABLE AREAS OF THE VEHICLE

It is advisable to use fender and hood covers as well as some form of seat covering before working on a vehicle. Taping vulnerable paint areas to protect them from becoming scratched is also a good idea. Never leave tools or equipment on painted surfaces, seats or dashboards. Such mistakes result in many needless damage claims. When removing cowls, wipers and other equipment from the vehicle, store in a safe area to eliminate the risk of damage from inadvertent contact.

TIP 5: POST-INSPECT ALL VEHICLES

After installation is complete, inspect and clean all areas affected by the performance of your work. Glass, carpets, seats, dashes and all painted surfaces around new glass parts must be cleaned and, or vacuumed. To avoid injury to the vehicle owner, defroster ducts must be blown out and cleared of any possible glass fragments. Blow out ducts by running the vehicle's defroster on high for at least one minute. Tapping on the dashboard while the defroster is running may also help loosen glass fragments from the ducts. The technician should also wear appropriate eye protection while clearing the defroster ducts to avoid injury. All airbags and safety belts must be in place and operative.

TIP 6: FOLLOW SAFE-DRIVE-AWAY-TIME (SDAT) PROCEDURE

Federal law requires that the strength of the adhesive system must be adequate to retain the windshield glass in the event of a mishap whenever the vehicle is operated. To allow adequate time for the adhesive to set up and secure the windshield, the adhesive manufacturer's installation procedures and prescribed SDATs must be followed at all times. The vehicle must remain out of service and NOT be operated until the appropriate SDAT has been reached**.** This is your legal obligation to help ensure the vehicle complies with all applicable FMVSS regulations.

TIP 7: FOLLOW ALL SAFETY AND HAZARD WARNING INSTRUCTIONS AND CAUTIONS

The most important part of any job is the need to work safely and carefully. Follow all manufacturer's instructions and warnings. Follow all advice for personal safety and hygiene. Always use common sense and decide before acting as to whether a particular action could cause unwanted consequences.

2.0 Glass Removal

Sika®-Slick

Sika has found that the removal of glass parts from vehicles is often the most difficult step in the replacement process. In the past, the only lubricant recommended for use during a cut out was water. While water is still an acceptable cut out lubricant, Sika has developed Sika®-Slick, an improved water based cut out lubricant for use in AGR applications. **Tests have shown that some glass cleaners can negatively affect the integrity of the urethane bond, therefore glass cleaner should never be used as a cut-out lubricant.** Sika®-Slick can significantly reduce the forces required to cut out a glass part and extend blade life. The following recommendations must be followed when using this product.

- Sika®-Slick is only designed for use with Sika's AGR adhesives. Alternative AGR urethane adhesive manufacturers will most likely view this product as incompatible with their adhesive systems.
- Sika®-Slick is best suited for use with reciprocating cutting motions, such as the cutting motion of a reciprocating power cut out tool or a long knife cutting a windshield's bottom bead.
- In some cases Sika®-Slick is capable of reducing forces associated with the use of a cold knife, specifically when the friction forces between the upper leg of the cold knife blade and the edge of the glass part or trim are high.
- Sika also recommends that the technician test the color-fastness of any interior component that Sika®-Slick may come into contact with during use. This is especially important if the interior components are aged or when contact with water may affect their appearance. To test color-fastness, apply a small drop of Sika®-Slick to an inconspicuous area of the interior component and allow it to dry. If any discoloration occurs, protect these interior components from any Sika®-Slick overspray or dripping.
- After the glass part has been completely removed, immediately clean up excess Sika®-Slick from any areas where it has come in contact with interior components of the vehicle, such as the dash board, to further avoid the possibility of staining. Cutting blades should be wiped clean with a wet towel and then dried to prevent corrosion.
- Prior to trimming the existing urethane bead, the pinchweld must be cleaned and dried to prevent dirt and debris from contaminating the bonding surface.
- If the Sika®-Slick comes in direct contact with the bonding surface (freshly trimmed existing urethane bead), then clean the bonding surface using the following method.
- **Dry wipe the trimmed existing urethane bead with a clean lint-free towel until all visible traces of Sika®-Slick have been removed.**
- **Apply Sika® Aktivator PRO from a 250 ml can to the trimmed existing urethane using a clean lint-free towel and the wipe-on wipe-off method.**
- **Allow Sika® Aktivator PRO 10 minutes to dry / react. Since Sika® Aktivator PRO is being applied to a freshly trimmed urethane, there are no temperature restrictions on this step and 10 minutes is sufficient down to 0°F.**
- If the Sika®-Slick does NOT come in contact with the bonding surface (freshly trimmed urethane), then no extra steps are required and you may proceed to the next step.
- Apply fresh Sika AGR urethane of choice and install glass part. Please be sure to adhere to all of Sika's AGR guidelines and SDAT recommendations for the specific product being used.

3.0 Pinchweld Preparation

Technicians must make an assessment of the pinchweld area of the vehicle once the windshield has been removed. If the pinchweld is exceptionally dirty and requires clean up, use a brush and or towels to clear away debris prior to trimming existing urethane. If additional cleaning is necessary, use water or oil free compressed air to clean the surface. Make sure the surface is dry prior to priming or urethane application. If after using the above methods, the pinchweld is still not completely clean and dry, then Sika® Aktivator PRO can be used as long as it is sufficiently wiped off and allowed to thoroughly dry prior to trimming the existing urethane bead. In this case, the solvent in Sika® Aktivator PRO acts as a drying agent. The condition of the old urethane and pinchweld will determine whether the ANSI approved full cut method can be used.

3.1 Full Cut Method:

A full cut method is trimming the existing bead of urethane down to a height of approximately 1 to 2mm (0.04”-0.08”) on the pinchweld when the residual bead and pinchweld are structurally sound. Use the full cut method when:

- The existing adhesive is urethane (i.e. – not butyl, silicone, etc.)
- The existing bead of urethane is well bonded to the pinchweld and is in excellent shape.
- The pinchweld is not corroded.
- Previous glass replacement procedures and products were correct and have the appropriate integrity to support the bond of new urethane, under the fullcut method.
- The pinchweld is undamaged and has not been repainted (For scratches and nicks see pages 25-26).

SPECIAL NOTICE: **Short cuts (lightly trimming existing urethane beads and using little new urethane) are wrong and potentially very DANGEROUS.** Short cutting a windshield will void all SDAT guidelines and can cause possible loss of glass adhesion and potential serious personal injury. Since too little space has been created to allow enough urethane to be applied between the new windshield and old bead of urethane, the application will not pass all applicable FMVSS regulations, and may fail during vehicle operation.

3.2 Corrosion of the Pinchweld:

Corrosion of the pinchweld is a very serious issue and must be corrected properly. Automotive OEMs have issued guidelines for addressing this issue and these guidelines have been incorporated into the recommendations that follow. To properly treat a pinchweld that is corroded it is important to first identify the type and the amount of corrosion that is present. The following will define these characteristics.

Type:
There are four levels of corrosion that have now been recognized by automotive OEMs.
1 = Light = Light metal discoloration; typically orange.
2 = Moderate = Moderate corrosion typically has some red spots.
3 = Severe = This can be identified by deep “pitting”, dark red spots and raised edges.
4 = Perforation = This level can vary from microscopic holes to loss of metal.

Amount:
In this manual, the amount of corrosion will be referred to in cumulative total area of corrosion in $inch^2$.

NOTE: Sika recommends that treatment of level 4 corrosion, or perforation, only be performed by a body shop that is trained in metal restoration. Also, for any amount of corrosion greater than a cumulative total of 24 inch^2 of the pinchweld, Sika recommends that this treatment only be performed by a body shop that is trained in metal restoration. Sika Corporation's opinion is that any corrosion amount greater than 24 inch^2 constitutes a very severe and potentially dangerous corrosion condition and should be addressed by a reputable body shop.

Example of Level 4 or Perforating Corrosion
MUST BE TREATED BY BODY SHOP

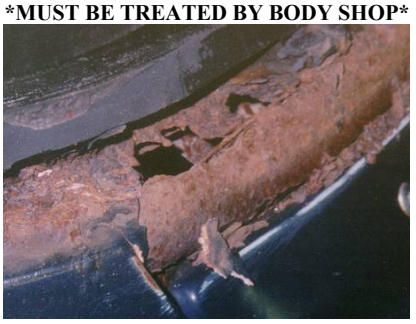


Photo courtesy of Visions autoglass, Byron Center, MI

After identifying the type and amount of corrosion, a technician should follow the recommendations outlined below for removal of the corrosion and treatment.

3.3 Corrosion Removal:

NOTE: Many of the following procedures involve actions that will require a technician to wear appropriate personal protective equipment (PPE) to avoid personal injury. Technicians performing these procedures should be sure to wear safety glasses or goggles, gloves (to protect hands from chemicals and other types of physical injury) and in some cases hearing protection, such as earplugs or ear muffs.

The first step in corrosion treatment will always be to remove the corrosion to obtain a bright, corrosion free, metal surface. Ideally, this should be done prior to trimming the remaining intact and well bonded adhesive bead. However, if this is not possible, then be sure to clean the freshly cut original urethane bead, using Sika® Aktivator PRO to ensure that the fresh urethane will be able to sufficiently bond to the original bead.

The method used to remove the corrosion will depend on the type of corrosion that is present. The guidelines on the next page are consistent with automotive OEM recommendations and should be followed for removing corrosion.

1 = Light = Remove corrosion with 80 grit sand paper or wire wheel.
2 = Moderate = Remove corrosion with wire wheel, media blast or chemical rust remover.
3 = Severe = Remove corrosion with media blast or chemical rust remover.
4 = Perforation = The panel must be replaced and treated by a body shop.

In addition to a wire wheel, corrosion of levels 1 and 2 can also be removed with a Dremel® and a grinding stone. The Dremel® Flex-Shaft attachment is also recommended because it makes precise corrosion removal easier. Care must be taken when using a Dremel or wire wheel so that the thickness of the metal is not significantly reduced. A spot sand blaster would be considered a media blast. Products that contain phosphoric acid, such as Dupont's Metal Conditioner #5717 or PPG's DX 579, would be considered chemical rust removers.

Prior to treating the areas where corrosion has been removed, make sure that these areas are smooth, uniform, and completely rust free. The remaining recommendations for corrosion treatment are shown on the next page.

3.4 Corrosion Treatment:

For treatment of **fresh scratches or bright metal rubs and scrapes** that are **1 inch^2** in area or less, Sika recommends that the technician cover these areas with Sika®Primer-206 G+P, from a 250 ml can or from the new Sika®Primer-206 Stix applicators, as directed in the procedures outlined in this manual under ~~the~~ Section 13.0 Priming (page 24).

Corroded areas of the pinchweld that are **less than 1 inch^2** can be treated by using the following procedure:

1. Remove the corrosion as outlined on the previous page.
2. Abrade the paint edges around the corroded area. This will ensure that the surrounding paint provides a sound bonding surface and will also improve the adhesion durability of the treatment system, helping to keep moisture from reaching the bare metal areas.
3. Wipe the debris away with a clean dry towel. Sika® Aktivator PRO may also be used to clean the area, although the installer must be sure to follow all Sika® Aktivator PRO procedures given in Section 6.0 (page 15) of this manual.
4. Apply a single coat of Sika® Primer-206 G+P as directed in the procedures outlined in this manual under Section 13.0 Priming (page 24).

The technician should use the procedure outlined below for treatment of the following scenarios.

- For **fresh rubs and scrapes** that are **greater than 1 inch^2** in area.
- For covering bright metal of the pinchweld that has been exposed following the corrosion removal recommendations that were previously outlined, as long as there is not significant metal loss or perforation of the metal and this area is **greater than 1 inch^2** but less than a cumulative total of **24 inch^2** of the pinchweld.

1. Remove the corrosion as outlined on the previous page.
2. Abrade (using Scotch-brite™ or Norton Bear-Tex® abrasive pads) the intact paint 1/8” from the paint edges surrounding the fresh bright metal area(s) where the corrosion was removed around the corroded area.
3. Wipe the bright metal with Sika® Aktivator PRO from a 250 ml can. Repeat this step as necessary until all contaminants (both chemical and particle) have been removed. Be sure to follow all Sika® Aktivator PRO procedures given in Section 6.0 (page 15).
4. If the adhesive bead was trimmed prior to removal of the corrosion, clean the contaminated areas of the trimmed original urethane bead by wiping with Sika® Aktivator PRO. NOTE: Be sure to follow all Sika® Aktivator PRO procedures given in Section 6.0 (page 15) of this manual.
5. Apply Sika® Primer-206 G+P, using a brush or a dauber, making sure that the primer overlaps onto the surrounding intact and paint by a minimum of 1/8”. Allow a minimum of 10 minutes for the primer to dry before proceeding to the next step. If this procedure is to be performed at temperatures below 40°F, then allow up to 25 minutes for primer to flash. A Sika® Primer-206 Stix applicator may be used for this application; but due to its limited coverage and the need for a second coat of primer in the following step, the Sika® Primer-206 Stix may be impractical for this application.

6. Apply a second coat of Sika®Primer-206 G+P over the first coat, using a brush or a dauber. Allow a minimum of 10 minutes for the primer to dry before proceeding to the next step. If this procedure is to be performed at temperatures below 40°F, then allow the primer to flash up to 25 minutes. To determine if the primer is completely dry, it may be touched 10 minutes after application, in areas that will not directly receive adhesive, using a clean nitrile glove. Before and after pictures are shown below. A Sika®Primer-206 Stix applicator may be used for this application, however, due to its limited coverage, the Sika®Primer-206 Stix may be impractical for this application.
7. Proceed with the remainder of the full cut method by trimming the original urethane bead and apply Sika AGR urethane adhesive as required.

(Level 2 – 3 corrosion of pinchweld)

(Same area treated using treatment process)

3.5 Complete Adhesive Removal:

If the technician discovers that either improper procedures or products (such as butyl or silicone) were used on previous glass replacements or that the existing pinchweld and urethane conditions would compromise the retention system, they are NOT to use the full cut method. Instead, it is recommended to fully correct any adverse glass installation related condition(s), providing a clean and sound substrate for bonding.

A complete adhesive removal requires the total removal of existing material down to the pinchweld. During a complete removal, the pinchweld must be cleaned of all products and materials other than the clean weld and the original paint. This method must be used when:

- The pinchweld has been repainted for any reason (i.e. body shop corrosion treatment)
- The pinchweld is damaged
- The existing urethane adhesive is loose or deteriorated.
- An improper product was previously used (i.e. – butyl, silicone, etc.)

After exposing the original paint, carefully scuff the paint on the pinchweld to remove the clear coat and or topcoat, exposing the OEM primer. Care must be taken so that the e-coat and phosphate coatings, which lie beneath the OEM primer, are not removed. The e-coat and phosphate coatings are essential part of the OEM corrosion inhibiting system and it is not possible to replace these in the after market. Apply Sika® Aktivator PRO according to the instructions given in Section 6.0 (page 15) of this manual. Paint a thin coat of Sika® Primer-206 G+P and allow it to dry for at least an additional ten minutes. Then set the windshield using the appropriate Sika adhesive for the vehicle type and required drive away time. In most instances, Sika® Primer-206 G+P from a 250ml will be the best option for this type of application, but a Sika® Primer-206 Stix applicator may also be used. However, please keep in mind that, due to the limited coverage of the Sika®Primer-206 Stix, a can of Sika® Primer-206 G+P will most likely be the more convenient option.

NOTE: See low temperature instructions, found in Section titled "Seasonal Concerns" for details on the use of primers and adhesives below 40°F.

3.6 Repaired, newly painted pinchwelds, and when OEM urethane has poor adhesion:

Perforation corrosion located in the windshield mounting area of a vehicle's pinchweld, just like perforation corrosion located in any structural area of a vehicle, requires replacement of the entire section of metal. Filling these types of areas with body filler is not acceptable. Furthermore, I-CAR has made recommendations that state, "do not use body filler on the pinchweld where glass urethane adhesive will be applied." This recommendation was taken from the March - April 2000 I-CAR Advantage and this document also states that, "small irregularities in the flange surface will be filled when the adhesive bead is applied." Keep in mind that the glass bonding area of a pinchweld does not require a "Class A" appearance and, if required, welded areas can be sanded smooth prior to primer application. Again, **do not apply body filler in areas where glass bonding adhesive will be applied.**

In the special case of a newly painted pinchweld, one of the following four options may be selected.

Option 1: Whenever possible, remove the windshield, by cutting the adhesive as close to the glass as possible, and leave the entire remaining urethane adhesive bead in place. Do not trim the adhesive bead until the vehicle has been painted and the new windshield is ready to be installed. In this case, it is not necessary to tape or otherwise protect the existing urethane. After the vehicle is repaired and painted, remove most of the existing urethane leaving 1-2 mm on the pinchweld and install the windshield.

Option 2: If the pinchweld area is to be repaired and painted by a body shop, remove the section of metal to be repaired, repair pinchweld and apply an epoxy or etch primer coat. Allow the primer to cure for at least as long as would be required prior to applying topcoat over the primer, following the paint manufacturer's recommendations. If topcoat is to be applied to remainder of the vehicle, mask off the bond area of the pinchweld with masking tape. Continue painting the vehicle as required. Remove the masking tape. If a forced drying process is to be used, remove the tape prior to baking the topcoat. Next, lightly abrade the primer with a Scotchbrite® or similar abrasive pad. Apply Sika® Aktivator PRO according to the instructions in this guide and allow it to cure according to the instructions given in Section 6.0 (page 15) of this manual. Paint a thin coat of Sika® Primer-206 G+P and then allow at least ten minutes for this product to dry. Then set the windshield using the appropriate Sika adhesive for the vehicle type and required drive away time.

Option 3: If a freshly primed pinchweld has already been color coated and Option 1 is not possible, then the topcoat, basecoat, and clear coat if used, must be removed to expose the primer coat. Once completed, follow instructions posted under Option 2. If the primer coat is removed during this procedure, exposing bare metal, then the body shop must re-apply the primer coat and allow this newly applied primer coating to fully cure, according to the paint manufacturer's recommendations, prior to application of any Sika product.

Option 4: If the vehicle's OEM urethane bead has poor adhesion and easily peels away from pinchweld to reveal unblemished original paint, begin by removing the clearcoat and or basecoat from the bond area with a Scotchbrite® or similar abrasive pad. If the clearcoat and basecoat pulled away from the vehicle with the original urethane bead then lightly abrade the exposed primer using a Scotchbrite® or similar abrasive pad. Apply Sika® Aktivator PRO according to the instructions in this guide. Paint on a thin coat of Sika®Primer-206 G+P and then allow at least ten minutes for this product to dry. Set the windshield using the appropriate Sika adhesive for the vehicle type and required drive away time.

IMPORTANT NOTE: Options 2, 3, and 4 above call for the use of current Sika® Aktivator PRO and Sika® Primer-206 G+P. If any of these procedures are to be performed at temperatures below 40°F, then please refer to the special low temperature precautions for these products, which can be found in the section of the manual on *Seasonal Concerns for Hot and Cold Weather.* Also, please note that when these recommendations call for Sika® Primer-206 G+P, a Sika®Primer-206 Stix applicator may be used. However, due to the limited coverage of the Sika® Primer-206 Stix, a can of Sika® Primer-206 G+P will most likely be the more convenient option.

3.7 Aluminum Pinchwelds and FRP Bonding Flanges:

On occasion an auto glass technician will come across vehicles that have aluminum pinchwelds or FRP (Fiber Reinforced Plastic) bonding flanges where a glass part is bonded with a urethane adhesive. Fiberglass is an example of an FRP. In these cases, if the technician finds that some of the original urethane bead is not properly adhered to the substrate, the following process should be followed to prepare the substrate for bonding.

1. Lightly abrade the area of the aluminum or FRP with a Scotchbrite® (or similar) abrasive pad.
2. Apply Sika® Aktivator PRO according to the instructions provided in Section 6.0 (page 15) of this manual.
3. Apply a thin coat of Sika® Primer-206 G+P, using a brush or dauber, and then allow at least ten minutes for this product to dry. Allow up to 25 minutes for the primer to dry if it is below 40°F. Please note that a Sika® Primer-206 Stix applicator may be used for this application, however, due to its limited coverage, a can of Sika® Primer-206 G+P will most likely be the more convenient option.
4. Set the glass part using the appropriate Sika adhesive for the vehicle type and needed drive away time. Generally, on aluminum pinchwelds a non-conductive urethane will be required. For additional information on non-conductive urethanes, please review the section on page 31.

NOTE: At this time, Sika has identified one exception to this recommendation and this is the Freightliner Century Class with an aluminum pinchweld. The recommendation for treating any exposed aluminum on the pinchweld of this vehicle is to prepare it with an appropriate aftermarket epoxy or etch primer. Allow the primer to cure for at least as long as would be required prior to applying topcoat over the primer, following the paint manufacturer's recommendations. Then lightly abrade the bond area surfaces of the primer and follow steps 2 through 4 above.

4.0 Glass Preparation

Each time you perform a windshield installation you are providing a vital component of the vehicle's retention system. An essential part of the retention system is the bond between the adhesive and the glass. This critical area can experience leaks and problems if there are contaminants between the adhesive and the glass. Cleaning the glass with Sika's recommended products is the most important step to safe and leak-free installations.

Most new cars have a frit band near or along the edge of the glass, which also needs to be cleaned. As you might expect, through the course of the manufacturing process and distribution of the windshield to your location, many people and items have come into contact with the edge of the glass, leaving behind solvents, grease, oily fingerprints, and other materials which can reduce the performance of the adhesives you will apply; possibly with serious consequences.

Sika® Aktivator PRO has been designed not only to remove these types of contaminants but also to ensure a strong, durable bond between the adhesive and the windshield. **Sika® Aktivator PRO must be used on every windshield before applying the adhesive.** Windshields installed without the use of Sika® Aktivator PRO may be subject to leaks, stress cracks and retention problems. The loss of windshield retention can cause serious injuries. Therefore, the use of Sika® Aktivator PRO cannot be over emphasized. After Sika® Aktivator PRO application, the windshield installation must be completed within 8 hours or Sika® Aktivator PRO must be re-applied. Please review the following section on Sika® Aktivator PRO, Section 6.0 (page 15), for more detailed instructions and precautions.

Used correctly, Sika® Aktivator PRO will remove the small particles of dust, oil and other contaminants, which could cause a bond to fail. Unlike some other glass primers, Sika® Aktivator PRO will not harm the topcoats of car finishes. Occasionally some windshields are supplied to the AGR market with contaminants that are difficult to remove using Sika's standard recommendations. Sika Cleaner S is designed to treat excessive contamination. More details of this product are available on page 13.

Occasionally, some windshields are supplied to the automotive aftermarket with a factory pre-applied black primer. Over a period of many years, Sika has thoroughly investigated many of these situations by performing adhesion tests in our laboratory using our adhesive systems. The results of these investigations have indicated that these windshields should be prepared using Sika's standard surface preparation recommendation of glass cleaner and Sika® Aktivator PRO, just as if the black primer was not present. Please keep in mind that all application recommendations for Sika® Aktivator PRO are still necessary and must be followed in accordance to instructions given on page 15 of this manual.

Additionally it should be noted that this recommendation is being made only after an extensive investigations that included laboratory adhesion testing and with consideration that the primer has been applied to the windshield in a controlled factory setting, ensuring both sufficient adhesion of the factory applied black primer to the glass part's bond area and consistent application from part to part. It is due to these factors that Sika can endorse the use of Sika® Aktivator PRO and Sika adhesives with the factory pre-applied primer that is found on these particular windshields. **In no other instance should a customer interchange primers, glass activators and/or adhesives from different adhesive suppliers.** If the installation technician is unable to determine if the primer has been applied by an automotive OEM, then Sika recommends that the part is not installed and is returned to the distributor.

5.0 Traditional and Non-Traditional Contamination

Sika approved glass cleaners work very well to remove traditional forms of contaminants that may be found on an auto glass part prior to the application of Sika® Aktivator PRO. The following is a list of what Sika considers to be the most common examples of these types of (traditional) contaminants:

- Dirt
- Dust
- Skin Oils

However, with the introduction of many new glass suppliers, installation technicians have witnessed increased occurrences of non-traditional contaminants (NTC) on windscreen frits that can greatly affect adhesion. It has been Sika's experience that the type and severity of non-traditional contamination can vary significantly. Generally, the source of non-traditional contamination is the manufacturing process, specifically from one of two processes, which Sika now uses to categorize NTCs:

1. Mold release agents (most common in the U.S. market)
   - Associated with encapsulated parts (where trim is bonded to part)
2. Silicone residue from a vacuum tube laminating process
   - Results from the use of silicone based vacuum tubes that remove air from between the inorganic glass lites and the inner PVB layer during the lamination process
   - Not applicable to tempered (non-laminated) auto glass parts

While many incidents of contamination are clearly visible to the naked eye, some NTCs are not as easy to observe without instituting additional procedures. To verify the existence of NTCs, Sika recommends that the auto glass Technician be trained to inspect the bond areas of each part for inconsistent areas of surface tension after glass cleaner has been applied to the frit and before the glass cleaner has been wiped off the part. The Technician should observe whether the glass cleaner migrates or changes appearance along the contaminated areas.

Recommended Treatment for all Types of Contamination:
Once it has been determined that the bond area of a glass part has been contaminated, Sika offers a UNIVERSAL treatment through the following recommended procedure:

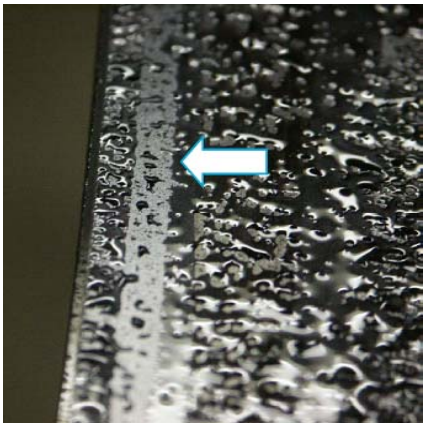
Sika® Cleaner S method – *Sika® Cleaner S is an organic solvent based cleaning agent specifically designed for use on heavily soiled surfaces.*

- Clean bonding surface with glass cleaner.
- Shake Sika® Cleaner S can for 10 seconds.
- Applying from a distance of approximately 2 inches, spray a light coat of Sika® Cleaner S around the entire perimeter of the glass part.
- Lightly "wet-scrub" the affected area with a fine weave abrasive pad (i.e.; Scotch-brite™ or Norton Bear-Tex®) using small circular motions.
- Remove the Sika® Cleaner S using a clean lint free towel.
- Re-clean the glass part as needed using glass cleaner.
- Allow the surface to completely dry before applying Sika® Aktivator PRO according to the instructions provided in Section 6.0 (page 15) of this manual.

Alternative Method for Removing VACUUM TUBE SILICONE Contamination ONLY:

Although the Sika® Cleaner S method given above will treat all KNOWN types of windscreen contamination, Sika also offers a procedure specifically designed for treating silicone oil residue derived from a vacuum tube lamination process. A NTC can be categorized as a silicone residue if the glass cleaner reveals an area of low surface tension in a relatively straight line that runs parallel to the edge of the glass (see photo below). If the glass cleaner migrates or changes appearance and the installation technician suspects silicone contamination, then the area can be treated using the Sika® Cleaner S method above or using the glass cleaner "wet scrub" methods given below. If the technician observes contamination but is unsure if it is silicone then the recommendation is to follow the Sika® Cleaner S method on page 13.

This photo is an example of an auto glass part contaminated with silicone residue resulting from the glass manufacturer's lamination process and after the application of a non-foaming glass cleaner. The area of contamination has a significantly lower surface energy than the surrounding non-contaminated areas and this affects the "wet out" of the glass cleaner in a way that allows one to observe a distinct lineal pattern of contamination. If this form of silicone contamination is not properly removed from the part, it can have a deleterious affect on adhesion.



Glass Cleaner Wet-Scrub method

- Apply glass cleaner to the frit and lightly "wet-scrub" the affected area with a fine weave abrasive pad (i.e.; 3M Scotch-brite™ or Norton Bear-Tex®) using small circular motions
- Care should be taken not to scratch the glass or frit
- After the "wet-scrub" has been completed, clean the frit area with glass cleaner and a clean paper towel
- Allow the surface to completely dry before applying Sika® Aktivator PRO
- IMPORTANT NOTE: This method is only recommended for removing silicone residue resulting from the glass manufacturer's laminating process and is NOT to be used to remove silicone contamination that originated from a glass manufacturer's encapsulation process

It must be restated that the glass cleaner "wet scrub" method given above is ONLY for silicone oil contamination and not mold release agents, which must be treated using Sika® Cleaner S.

6.0 Sika® Aktivator PRO; (orange cap)

First, thoroughly clean the glass. Any glass cleaner can be used, as long as it has been confirmed that it does NOT contain anti-static ingredients. Use another brand of cleaner if these kinds of ingredients are used. When cleaning the glass, make sure glass is fully cleaned and no moisture is left on the bonding surface.

- **Next apply Sika® Aktivator PRO**. Sika® Aktivator PRO is available in 250 ml cans and easy to use single application pads. With either product, ALWAYS use chemical resistant gloves and safety glasses. DO NOT SMOKE while applying Sika® Aktivator PRO. Read and follow all precautionary instructions and warnings on the product.
- **For the cans**, use a clean, lint-free towel. With Sika® Aktivator PRO wetting the towel, but not soaking it, drag the towel in one direction around the perimeter of the glass (on bonding area only*)*.
- **For Sika® Aktivator PRO use on pinchwelds, in cases where the pinchweld has been painted or repaired;** Use the above method when applying Sika® Aktivator PRO to a pinchweld.
- The towel should be continually turned to expose a clean surface to the Sika® Aktivator PRO can**.** When re-wetting the towel, turn a clean surface to the can to avoid dirt and other contaminants on the towel from mixing with the pure Sika® Aktivator PRO in the can.
- **For the single application pads**, take one (1) Sika® Aktivator PRO Pad from box, hold the pad directly against the bond area of the glass part, and with pad handle between thumb and forefinger, pinch to break the internal ampoule to release contents to the fabric pad. Holding the pad flat against the glass part, draw the pad around the perimeter (bond area) of the glass part in one direction. Dispose the Sika® Aktivator PRO Pad after each use.

- **With either application system,** apply Sika® Aktivator PRO at, or above 15°F and allow Sika® Aktivator PRO to cure a minimum of three (3) minutes (but not more than eight hours) before applying adhesive. If temperatures where glass installation is to occur are below 15°F, but above 0°F, then the flash-off / cure time needs to be increased to a minimum of ten (10) minutes.
- If the "Aktivated" surface becomes contaminated or the open time is missed, then Sika® Aktivator PRO can be re-applied to the glass part up to three additional times, or a total of four applications. After Sika® Aktivator PRO has been applied more than four times to the same glass part, the adhesion characteristics may be compromised and the glass part should be discarded.
- When Sika® Aktivator PRO is properly applied to "non-fritted" substrates, the "Aktivated" surface will be observed to have a thin prismatic film.

7.0 Removal and Replacement

Note: This procedure is not recommended for use with glass parts that have been previously installed with a non-urethane adhesive. Under these circumstances, the glass part should be discarded and, in most cases, the new glass part should be installed following the *Complete Adhesive Removal* method described in this manual. If the original urethane on the glass part does not have good adhesion around the entire perimeter of the part or was not originally adhered using urethane, then Sika does NOT recommend installation of the part.

Use the following guidelines in cases where a glass part is removed for later use as a replacement.

Remove the glass part using standard removal tools, taking care to avoid damaging the frit. Try to cut through the middle of the existing urethane bead. Set the glass aside until it is time to replace it.

Following removal of the part that is to be reinstalled, begin by cleaning the glass part with an appropriate glass cleaner. Next, using your preferred urethane-trimming tool, trim the existing bead of cured urethane and examine to confirm that the remaining urethane is sufficiently bonded to the glass. Generally, Sika recommends that the bead of urethane on these parts be trimmed just prior to reinstallation, but if this is not possible, the trimmed bead should be "cleaned" using Sika® Aktivator PRO according to the instructions given in Section 6.0 (page 15) of this manual. **One of the following two options MUST be followed when performing a removal and replacement:**

1. If the remaining layer of urethane adhesive has good adhesion to the entire perimeter of the glass part, it does not matter which adhesive company manufactured the remaining layer of adhesive, and this part can be installed using the standard procedures described in this manual.

2. If the original urethane on the glass part does not have good adhesion around the entire perimeter of the part then Sika does NOT recommend installation of the part.

8.0 Special Sets

8.1 Gasket Set Windshields

For vehicles that have windshields set with a gasket and require that the gasket be bonded to the pinchweld and to the glass with a urethane adhesive, Sika recommends the following procedure.

1. Use appropriate personal protective equipment when performing the following tasks.
2. Remove original windshield and gasket.
3. Use a new gasket if the original has been damaged.
4. Clean the glass with an approved glass cleaner as defined on page 15 of this manual.
5. Remove contaminants from the pinchweld and the inside of the gasket, where the pinchweld and glass will sit, using a clean towel and water. An approved glass cleaner may be used to clean these areas if necessary.
6. Allow water and glass cleaner to thoroughly dry before proceeding.
7. Prepare all areas of the glass that will sit in the gasket with Sika® Aktivator PRO as described on page 15 of this.
8. Apply Sika® Aktivator PRO to the pinchweld, where the gasket will sit, and to the inside of the channels of the gasket, as described on page 15 of this manual. Allow at least 15 minutes for the Sika® Aktivator PRO to cure on both the gasket and the pinchweld.
9. Set the windshield, making sure that the gasket is fully seated on the pinchweld, and be sure to apply the desired Sika AGR adhesive into the channels of the gasket at the appropriate time.
10. Clean up of uncured urethane can be performed using mineral spirits and a towel or Scrubs®.

8.2 PAAS

(PAAS on Saint Gobain FW02072 for New Beetle)

PAAS stands for Pre-Applied Adhesive System and an example of one of these types of parts is shown above. Modern PAAS glass parts are designed to act as a height-guide when installing fresh adhesive. However, a PAAS system can also get easily contaminated from shipping and handling. To prepare a PAAS windshield, wipe the bond area of the pre-applied adhesive with Sika® Aktivator PRO. In some cases, the pre-applied adhesive may need to be trimmed down to allow room for the new urethane adhesive. In these cases, it is not necessary to apply Sika® Aktivator PRO to the freshly cut bonding area exposed by the trimming of the pre-applied urethane adhesive.

8.3 Rear Sliders and PVC Encapsulated Glass Parts:

Most, if not all, aftermarket **rear sliders** for pickup trucks are manufactured using a painted aluminum extrusion frame. Follow the procedure detailed below in order to properly prepare this painted aluminum frame for installation.

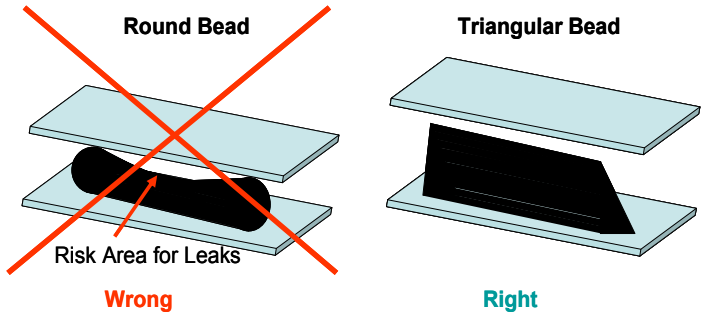
1. Lightly abrade the bond area of the painted aluminum extrusion with a Scotchbrite® (or similar) abrasive pad.
2. Apply Sika® Aktivator PRO according to the instructions in this guide and allow it to flash for at least three (3) minutes. If this operation is to be performed at temperatures below 15°F, but above 0°F, then the flash time must be increased to ten (10) minutes.
3. Apply a thin coat of Sika® Primer-206 G+P, using a brush or a dauber, and then allow at least ten minutes for this product to dry. Allow up to 25 minutes for the primer to dry if it is below 40°F. Please note that a Sika® Primer-206 Stix applicator may be used for this application, however, due to its limited coverage, a can of Sika® Primer-206 G+P will most likely be the more convenient option.
4. Set the glass part using the appropriate Sika adhesive for the vehicle type and required drive away time.

When preparing an **encapsulated** part that requires bonding urethane to PVC or for preparing a rear slider frame that has been confirmed to be made of PVC and NOT of a painted aluminum extrusion, the technician should follow the procedure detailed below

1. Make sure that the bond area of the glass part is clean and contaminant free. Clean the area with an approved glass cleaner if required and allow to completely dry.
2. Apply a thin coat of Sika® Primer-215 to the bond area of the glass part, using a brush or a dauber, and then allow at least ten minutes for this product to dry. If it is below 40°F, then allow at least 25 minutes for the primer to dry.
3. Set the glass part using the appropriate Sika adhesive for the vehicle type and required drive away time.

9.0 "V" Bead Applications

Sika adhesives are supplied with a pre-cut triangular "V" notched nozzle. This is the recommended nozzle tip that must be used in order to apply the proper bead size. A round bead can trap air in all four corners when compressed between the glass and pinchweld. A round bead is also more difficult to uniformly compress during windshield decking which may result in voids and leak points across the entire width of the bead (see figure). However, when a triangular shaped bead is compressed, no air is trapped and the bead squeezes down to a rectangular dimension.



Conventional, un-cut nozzles are also provided for backfilling use, sealing gaskets and other custom applications.

Make sure that the depth of the "V" notched nozzle is the same as the height between the pinchweld mounting surface and roof of the car. This can be checked by simply placing the nozzle on the pinchweld near the roofline and viewing to see that the top of the "V" matches the height of the roof. If it is short, simply cut a deeper and wider "V" in the nozzle. This step helps ensure that enough urethane is supplied to the pinchweld to prevent the glass from sagging below the roofline of the vehicle.

When applying Sika AGR urethanes it is imperative for the fresh adhesive to match or exceed the width of the trimmed OEM bead on the pinchweld. This will ensure that there is a sufficient amount of new adhesive available to meet FMVSS standards for safety. Sika's recommendation is that the fresh adhesive bead may be applied either to the trimmed OEM urethane bead located on the pinchweld of a vehicle or to the glass. Sika's only requirement with regard to the fresh adhesive bead placement location is that the installer ensures that the fresh adhesive bead makes good contact with both the trimmed bead and the glass part that has been prepared using Sika® Aktivator PRO, whether the adhesive is applied directly to the glass part or to the trimmed adhesive bead. When deciding the most appropriate location to apply the AGR adhesive bead for a specific installation Sika offers the following considerations:

- If the vehicle's OEM bead pattern is non-uniform and proper fresh adhesive bead placement / alignment will be difficult if applying to the glass, the better option may be to apply the adhesive to the vehicle's pinchweld.

- When the OEM bead pattern is uniform and the proper bead location on the glass can be easily identified, the better option may be to apply the fresh adhesive bead to the glass part. One reason is that applying the bead to the glass part is considered to be more ergonomically friendly. Also, this can make it easier for the installer to hold the application gun at the proper 90° angle when applying the adhesive to the entire perimeter of the part, which can result in more consistent and uniform bead dimensions.

Please note that pre-cut "V" notched nozzles come with a stem guide. This stem is to provide a guide for installers choosing to apply the urethane on the glass instead of the pinchweld. If you apply urethane to the pinchweld, simply clip the stem from the end of the nozzle and discard.

10.0 Seasonal Concerns

High Temperature Instructions:

When performing mobile glass replacements during the summer months, the technician must be concerned with the temperatures of the substrates that are to be bonded. In auto glass replacement (AGR) the substrates are the glass part and the pinchweld. If the temperature of these substrates is too high, the AGR urethane can cure / react too quickly and experience what is called "gassing." "Gassing" results when the urethane adhesive skins over and carbon dioxide is generated faster than it can be released. The carbon dioxide then builds up inside the adhesive bead and gives the adhesive a "Swiss cheese" appearance. If this phenomenon occurs in very small amounts there is little reason for concern. If it occurs significantly, then adhesion and long-term durability of the bonded system may be compromised. If temperatures are extremely high and or proper shade cannot be provided then Sika recommends the following maximum substrate temperatures, by product.

Sika AGR Adhesive	Maximum substrate temperature (°F)
Sikaflex® 220+	130
SikaTack®-COOL	170
SikaTack®-Ultrafast II	170
SikaTack®-ASAP	170
SikaTack®-MOVE^{IT}	170

Low Temperature Instructions

Sika® Aktivator PRO:

Above 15°F, Sika® Aktivator PRO has a flash-off time of 3 minutes, however, when the temperature is between 0° and 15°F, the recommendation is to allow the product to flash-off for 10 minutes.

Sika®Primer-206 G+P and 206 Stix:

There are no special low temperature requirements for Sika®Primer-206 G+P, either from a 250 ml can or from a 206 Stix applicator, that is being used, outside the bond area of the pinchweld, to cover fresh bright metal scratches or fresh bright metal rubs and scrapes that are less than 1 inch^2 in area. Extra dry time is required if Sika®Primer-206 G+P is used below 40°F in all other situations, such as to prepare the pinchweld as outlined in various sections of the *Pinchweld Preparation* section of this manual. Specific examples would be if Sika®Primer-206 G+P is being used below 40°F for a complete adhesive removal or the pinchweld is newly painted. Under these circumstances, the primer must be allowed to completely dry, which may require up to 25 minutes. To determine if the primer is completely dry, it may be touched 10 minutes after application, in areas that will not directly receive adhesive, using a clean nitrile glove. As an alternative, it is suggested that the vehicle be moved to an environment where the temperature exceeds 40°F.

SikaTack®-Ultrafast II (15° TO 40°F)
SikaTack®-ASAP (0° TO 40°F)

Due to the unique strength development characteristics of SikaTack®-Ultrafast II and SikaTack®-ASAP, these products can be used in low temperature situations but special care must be used when temperatures are below 40°F. These products develop extremely high green (initial set-up) strength within minutes of application.

For optimal results, be sure to set the glass within 5 minutes of beginning application of the adhesive. The glass can be set as long as 10 minutes after applications of adhesive, but positioning the glass will be difficult. Consider use of the following points to help ensure a problem free installation:

- Remove original windshield and clean the pinchweld thoroughly with a brush to remove all contaminants.
- Dry set glass and mark alignment points.
- Trim old adhesive to a height of 1 - 2 mm.
- Glass should be cleaned and prepared with Sika® Aktivator PRO before applying adhesive to either pinchweld or glass (see pages 12 – 15 for more details).
- Have enough adhesive heated and prepared to complete the job.
- Have second cartridge or unipac open with nozzle installed. Put it on car or in your pocket for quick changeover. If you have two guns, have one tube in each gun.
- Set the glass immediately after adhesive is applied.
- Position glass before pressing it into place.
- Refer to Sika's SDAT chart to determine the minimum hold time for the vehicle at the measured environmental conditions. **DO NOT RELEASE VEHICLE UNTIL HOLD TIME HAS LAPSED.**
- Use extra care while removing and replacing the cowl cover and trim pieces.

11.0 The Adhesive System

Glass shops can select a Sika AGR urethane to suit the specific SDAT needs of their customer. The speed with which a customer needs to return their vehicle to service will dictate the kind of adhesive to use for windshield replacement. Factors affecting drive away time include application temperature, humidity, and the presence of passenger side airbags on the vehicle. For every installation, please refer to the Sika SDAT chart for a complete listing of products and safe drive away times. *Section 5 of the AGRSS Standard requires that the vehicle owner / operator is advised of the minimum safe-drive-away time under the circumstances of the replacement.*

SPECIAL NOTES:

A. Heated products must be warmed for a minimum of one-hour in a Sika approved oven prior to use. These products can be heated a total of 10 hours (either consecutively or in shorter periods adding up to a total of 10 hours). After this total heating time without use, the product must be discarded.
B. Do not heat products in ovens that are designed to be dispensed at ambient temperature. Instead of speeding adhesion, the product will not properly perform.
C. In many cases, partial tubes can be reheated and reused.
D. It is recommended that urethanes are stored at temperatures under 75°F to maximize shelf life.
E. Use "V" notched nozzles when applying beads or adhesives for auto glass sets.
F. For every windshield installation, regardless of adhesive used, the installer MUST use Sika® Aktivator PRO to prepare all glass or fritted surfaces that will be in contact with the adhesive.
G. Certain installations will also require the use of Sika®Primer-206 G+P to prepare the glass and pinchweld for adhesive application. Some installations will require Sika®Primer-215 to prepare PVC and EPDM parts that will receive adhesive application. For rear sliders and PVC encapsulated glass parts, refer to page 18 of this manual. Be sure to also review the section on *Priming* in this manual for detailed instructions on application of Sika®Primer-206 G+P and Sika®Primer-215.

11.1 Unipacs:

In 2007, Sika Corporation began offering its customers the option of using Sikaflex®-220+, SikaTack®-COOL and SikaTack®-MOVE^{IT} in 600 ml unipacs. Because of the packaging and dispensing efficiency, this design allows for greater waste savings of adhesive material and will save the installation technician time by reducing the frequency of changing out 300 ml cartridge material.

Sika Corporation will also begin to offer SikaTack®-ASAP in 465 ml unipacs by the fourth quarter of 2008. At present, 465 ml SikaTack®-ASAP unipacs, being about 2" longer than cartridges, can only be heated in PURfect Heater ovens and Hydrotherm^{TM} ovens that have been modified with aluminum sleeves, developed specifically for use with this oven (see page 29 for more information).

NOTE: All Sika AGR unipacs require dispensing guns that have been equipped with unipac conversion kits. Please contact your local Sika Sales Representative for further details.

12.0 Date Codes

All Sika products have a shelf life or period after production within which the product must be used. After the expiration of the product shelf life without use, the product MUST be discarded. Expired product performance is not warranted and the product may not properly adhere, causing loss of glass retention and possible personal injury. Humidity, temperature and sunlight can affect the shelf life. It is important to keep the products stored correctly. Make sure you rotate your stock and use it on a "first in-first out" basis. This will ensure that you always use fresh material. If you ever have problems with the materials, the first thing you should check is the date code to determine if the product shelf life has expired. Date codes are located both on the shipping box and individual container. **IF THE SHELF LIFE HAS LAPSED, DO NOT USE THE PRODUCT.**

A. All Sika AGR adhesives have a 9 month shelf life, with the exception of SikaTack®-Sierra which has a 6 month shelf life, when stored below 75°F.
B. Sika® Primer-206 G+P in a 250 ml can has a 9 month shelf life. Sika® Primer-206 G+P packaged in the Sika® Primer-206 Stix format has a 13-month shelf life.
C. Sika® Aktivator PRO in 250 ml cans and Sika®Primer-215 in 30ml cans have a 12-month shelf life. Sika® Aktivator PRO packaged in a Sika® Aktivator PRO Pad has an 18 month shelf life.
D. Once Sika® Aktivator PRO and/or a Sika primer is opened, the shelf life is reduced, but not destroyed. With proper storage conditions, they will remain usable up to six months after opening, or until the expiration date, whichever comes first. Always tightly replace both the inner liner and outer cap after each use. If the product becomes thick or cloudy, discontinue use immediately.
E. The published shelf life of all Sika cleaners, primers and urethanes will be realized when the product is stored below 75°F. If properly stored in cool, dry conditions, the unopened adhesive cartridges or unipacs have a shelf life of 9 months (SikaTack®-Sierra is 6 months). Long-term storage of the product at higher temperatures will affect the handling characteristics and shorten the shelf life. Typically, chemical reactions double for every 18°F increase in ambient temperature. Therefore, product stored continuously at 93°F would be expected to have a shelf life of four-and-a-half months, while product stored at 111°F would have approximately 2 months left.. Short-term storage, say over a several day period in a hot vehicle, will have relatively very little affect on the shelf life of the adhesive. If the product is exposed to freezing conditions (<32°F) the product will not be damaged, but it will require additional time to acclimate to the optimal application temperature. For optimal application characteristics, SikaTack®-COOL and SikaTack®-MOVE^{IT} should be applied when the adhesive is between 50°F and 120°F and Sikaflex® 220+ when the product temperature is between 40°F and 110°F. Heated products (SikaTack®-Ultrafast II and SikaTack®-ASAP) will require additional heating time if the product is stored at or below freezing. For additional information on the optimal application temperature of the heated products, please review the section on *Hot Applied Adhesives* located on page 27 of this manual.
F. For products that have expiration dates, or “Best Before” dates, that are given only in month and year (without a specific day), please remember that these products can be used until the end of the month that is listed.

13.0 Priming

Sika® Primer-206 G+P: (black cap)

Sika® Primer-206 G+P is a moisture sensitive black liquid to be applied to glass or bare metal**.** Sika® Primer-206 G+P is packaged in 250 ml cans as well as in single-use applicators called, "Sika® Primer-206 Stix." Each Sika®Primer-206 Stix applicator contains 1.4ml of Sika®Primer-206 G+P and are best suited for covering bright metal scratches, rubs, and scrapes.

- Use Sika® Primer-206 G+P to cover bright metal scratches on the pinchweld in order to reduce corrosion**.** Fresh, bright, metal rubs and scrapes, up to 1 inch^2 in area, may be covered with one coat of Sika® Primer-206 G+P. Sika® Primer-206 Stix are designed specifically for these applications.
- In some cases, Sika® Primer-206 G+P can be used on glass to create a frit band appearance and/or provide supplemental UV protection for the ceramic frit found on present day windshields. The product IS NOT intended for use as the only protector against UV rays.
- Sika adhesives are designed to bond aggressively to the existing freshly trimmed urethane bead. For this reason, do **NOT** apply Sika® Primer-206 G+P to the existing trimmed urethane bead when performing a full cut.

IMPORTANT NOTE: Currently, there is no after-market coating available that can restore the automotive OEM corrosion protection system that todays vehicles are manufactured with. Therefore, care must be taken when removing glass parts so that little or no damage is incurred to the paint.

All pre-existing corrosion conditions on the pinchweld must be removed and prepared with Sika® Aktivator PRO before the area can be treated using two coats of Sika® Primer-206 G+P. Severe rust conditions, as defined in the section of this manual on *Corrosion of the Pinchweld*, must be brought to the customer's attention and possibly remedied by a body shop. Please review Sections 3.2 – 3.4 (pages 5 - 8) of this manual for a detailed explanation of how this issue should be addressed. NEVER apply Sika® Aktivator PRO or Sika® Primer-206 G+P over rust.

Sika® Primer-206 G+P and Sika®Primer-206 Stix Application Guidelines:

- Shake the bottle vigorously until you hear the mixing ball rattle and then continue shaking for an additional 10 seconds.
- Apply Sika® Primer-206 G+P from a can using a brush, dauber, or a cotton swab to cover any bare metal areas, that are within the limits defined above, trying not to get any primer on remaining bead of urethane (after a FULL-cut has been performed).
- If using the Sika® Primer-206 Stix, shake the applicator for a minimum of 30 seconds prior to use. To begin priming with the Sika®Primer-206 Stix, point the tip toward the ground and pinch tube just above the tip with the thumb and forefinger to break the internal vial and release the Sika® Primer-206 G+P into the tip. With the tip down, gently squeeze the Stix applicator to wet out the tip, being careful not to squeeze too hard creating a drip. When the tip is fully saturated, begin priming the pinchweld immediately. Allow gravity to feed the tip, but you may gently squeeze the Stix applicator if more primer is needed. After application, allow primer to dry for a minimum of 10 minutes before applying adhesive. The primer must be completely dry prior to adhesive application.
- For complete adhesive removals, at temperatures lower than 40°F, up to 25 minutes may be required for the primer to completely dry. To determine if the primer is completely dry, it may be touched 10 minutes after application, in areas that will not directly receive adhesive, using a clean nitrile glove. Please note that Sika® Primer-206 Stix applicator(s) may be used for these applications; but due to its limited coverage, a can of Sika® Primer-206 G+P will most likely be the more convenient option.
- Sika® Primer-206 G+P can be used to create a frit band appearance around the perimeter of the windshield, but it does not act as a primary UV protector for the urethane. If the windshield to be installed does not already have a frit band, first apply Sika® Aktivator PRO around perimeter of glass and allow to flash-off according to the procedures given in Section 6.0 (page 15) of this manual. Then apply Sika® Primer-206 G+P and let dry an additional 10 minutes. Generally, in these cases, the urethane is protected from UV rays by a trim molding. Please note that Sika® Primer-206 Stix applicator(s) may be used for these applications, however, due to its limited coverage, a can of Sika®Primer-206 G+P will most likely be the more convenient option.

There are no special low temperature requirements for Sika®Primer-206 G+P that is being used, outside the bond area of the pinchweld, to cover fresh bright metal scratches or fresh bright metal rubs and scrapes that are less than 1 inch^2 in area. Extra dry time is required if Sika®Primer-206 G+P is used below 40°F in all other situations, such as to prepare the pinchweld as outlined in Section 3.0 “Pinchweld Preparation” (page 5) of this manual. Specific examples would be if Sika®Primer-206 G+P is being used below 40°F for a complete adhesive removal or the pinchweld is newly painted. Under these circumstances, the primer must be allowed to completely dry, which may require up to 25 minutes. Again, as stated above, to determine if the primer is completely dry, it may be touched 10 minutes after application, in areas that will not directly receive adhesive, using a clean nitrile glove. As an alternative, it is suggested that the vehicle be moved to an environment where the temperature exceeds 40°F.

Always use chemical resistant gloves and safety glasses when applying Sika®Primer-206 G+P. DO NOT SMOKE during use. Follow all warnings and instructions on product container.

Sika® Primer-215: (white cap)

Sika® Primer-215 is used to prepare PVC and EPDM encapsulated parts, moldings and plastic door glass fasteners if these parts are to bonded using one of Sika's urethane adhesives. For additional information, please review Section 8.3 (page 18) in this manual. Also, be sure to follow all safety instructions on container.

Application Guidelines:

- Make sure that the bond area of the glass part or molding is clean and contaminant free. Clean the area with an approved glass cleaner if required and allow to completely dry. Sika® Aktivator PRO may also be used to clean the bond area of the glass part or molding prior to Sika® Primer-215 application, but, if this process is used, be sure to adhere to all Sika® Aktivator PRO applications guidelines given in Section 6.0 (page 15) of this manual.
- Use brush or dauber to apply a thin, continuous coat of Sika® Primer-215 to the surface area to be bonded.
- Allow a minimum of 10 minutes to dry prior to adhesive application. The primer must be completely dry prior to adhesive application.
- If below 40°F, the primer may take up to 25 minutes to dry. As with the Sika® Primer-206 G+P, to determine if the primer is completely dry, it may be touched 10 minutes after application, in areas that will not directly receive adhesive, using a clean nitrile glove.

14.0 Hot Applied Adhesives

Use of Ovens to Heat Sika Adhesives:

SikaTack®-Ultrafast II, SikaTack®-Sierra and SikaTack®-ASAP must be heated in a Sika approved oven for a minimum of one hour**.** One hour is necessary to ensure the product reaches a temperature range of 75°C - 90°C (167°F - 194°F) before it is used. These products can be heated a total of 10 hours (either consecutively or cumulatively for a total of 10 hours). After this total heating time without use, the product must be discarded. If not heated properly problems with gunnability, decking, and adhesion may occur.

You should ALWAYS wear protective gloves and safety glasses while handling the heated products. Product is HOT when applied and can cause burns. Exposure to urethanes may have health risks. See warnings on product container

Special Notes about Hot Applied Sika Adhesives:

- Only heat recommended Sika Adhesives. Never heat cold applied adhesives or other brands of products.
- Allow heated products at least one hour in oven to reach application temperature, 30 minutes if PRE-HEATED in a Hydrotherm ™ system. (See Section 14.3 for additional information).
- Use protective gloves when handling heated cartridges.
- Only use approved cartridge ovens referenced below. **NEVER** use a different heat source to heat Sika products. Over heating product can cause **PERSONAL INJURY.**

PRODUCT NOTE: The one hour heating requirement assumes urethane stored at 32°F or higher. Urethane stored below 32°F. (such as overnight in a mobile vehicle) will require additional oven time to reach the 167°F – 194°F range. Fifteen minutes of extra heating time is satisfactory.

EQUIPMENT NOTE: Only PURfect Heater, Intertech, and Pragmatech, Inc.'s Hydrotherm™ adhesive heaters (vehicle coolant system heaters) are recommended by Sika Corporation and of these only the PURfect Heater and the Hydrotherm Oven, outfitted with aluminum sleeves, are approved for heating SikaTack®-ASAP in 465 ml unipacs. For PURfect Heater, Intertech and Pragmatech ovens, please contact these manufacturers directly for heater warranties and usage instructions. Please also note that you can have your Aztech ovens refurbished through Intertech. The Vulkan oven has a one-year limited warranty, and if you have performance issues with these ovens please contact your local Sika Sales Representative or Sika's Customer Service Department at (800) 688 – 7452.

- **PURfect Heater by Mycon Industries, 10488 U.S. 12, Brooklyn, MI 49230, Phone (517) 467-6887**
- **Intertech Associates International, Inc., 120 Stryker Lane, Suite 209, Hillborough, New Jersey 08844, Phone (908) 284-9098, FAX (908) 284 – 9448, Website www.eintertech.com.**
- **Hydrotherm™ by Pragmatech, Inc., W4015 876th Ave., Spring Valley, WI 54767, Phone (715) 688 – 6177 or (877) 244-3961, FAX (267) 790 - 4884.**

IMPORTANT: Ovens are for use with SikaTack®-Ultrafast II and SikaTack®-ASAP adhesive only. Never place any other adhesive including any other Sika adhesive in an oven for any reason.

14.1 PURfect Heater – 4 hole (120 VAC) Oven (Part # COV00PH)

- Accepts 465 ml unipacs and 300 ml cartridges (cartridges work best with pedestals – see below)
- Solid State Thermostat is pre-programmed for accuracy and reliability
- Works well with mobile power inverters
- Operates equally well in the vertical or horizontal position
- Turn off heater at the end of every work day and remove urethane
- Keep heating chambers clean and free of debris

Cartridge Pedestals for PURfect Heater

- Pedestals are designed to fit into the PURfect Heater cylinders, properly positioning Sika cartridges for easy removal
- Sold separately from PURfect Heater oven (4 to a box)

14.2 Intertech 2-hole Dual Volt (12 VDC / 120VAC) Cartridge Oven (Part # COV0030)

- Make sure plug end is pushed all the way into lighter receptacle
- Operate engine during oven use to prevent drain on battery
- Remove plug at end of business day and turn off heater
- Keep debris away from operating heater
- Never pull on cord to remove plug end; grasp plug to remove from receptacle
- Keep heating chambers clean and free of debris

14.3 Pragmatech Hydrotherm™ - 4 hole - Oven (Part # COV00P1)

- Follow installation procedures carefully and without deviation.
- Load oven holes with cartridges or unipacs**.** Additional cartridges or unipacs may be pre-heated by placing them inside the cooler and around the perimeter of the heater.
- The engine is not required to be continually operated at the job site once sufficient product has been heated to the 167 – 194°F. range. The insulated container and residual heat will keep the adhesive hot. Engine coolant, which supplies heat to the heater, will remain hot for quite some time.
- Keep cooler lid closed at all times when oven is in operation.
- Since the urethane may only be heated for a total of 10 hours it is recommended to remove all urethane from the oven at the end of the day

Hydrotherm Oven Sleeves

- Aluminum sleeve converts your existing Hydrotherm Oven from 300 ml cartridge to 465 ml unipac capability
- Two lateral slots are designed for easy installation into the Hydrotherm™ oven holes
- Simply insert the aluminum sleeve, slotted end down, into the Hydrotherm™ oven cylinders and gently push down with the palm of your hand until the bottom of the sleeve is even with the bottom of the oven
- Care should be taken to not damage the top edge of the aluminum sleeve. Burrs and other imperfections may be snag points for the aluminum foil of the unipacs
- Sold separately from Hydrotherm™ Oven

APPLICATION TIP: Cartridges or unipacs set inside the Hydrotherm™ cooler, but outside of the oven, will be preheated. Urethane that's been preheated for a minimum of one hour, will only require 30 minutes within the heater cylinder to reach application temperature. To ensure a ready supply of heated product, remember to pre-heat additional tubes to reduce the required heater time.

15.0 "Wet" Adhesive Strength Properties

When a windshield has been recently installed using Sika products and is later removed, it is not unusual to find the center of the adhesive bead is wet. This situation is normal and does NOT affect the performance characteristics of the adhesive.

Some technicians have asked how a "fast-curing" adhesive can still be wet after several days. This is because all one-part adhesives cure from the outside to the inside, developing a partially cured skin that gradually thickens until the bead has reached full cure. The "doughnut" affect that this creates still represents enough cured material and strength throughout the bead to meet all strength retention requirements mandated by FMVSS regulation.

16.0 Traceability of AGR Super Kit Components

Since Sika introduced Auto Glass Replacement (AGR) Super Kits, traceablity of Sika® Aktivator PRO Pads and Sika® Primer-206 Stix has been achieved by adhering individual stickers to the insurance documentation. Now, the Lot Number which is located on the white Batch Code Sticker adhered on all AGR cartridges and unipacs, on separate sheets of sticker available in all AGR Super Kits, or on the white Corner Label located on the outside of the Super Kit Boxes, is sufficient to track all of the components within a Super Kit. This means that Sika customers do not need to place Sika® Aktivator PRO Pad and Sika® Primer-206 Stix stickers on their insurance documentation. The Sika® Aktivator PRO Pad and Sika® Primer-206 Stix stickers will continue to be available in each Super Kit for usage on documentation. If desired, the customer can decide to continue to use these stickers on their documentation, but if the required information is needed, our polyurethane Lot Number allows us to track all components of the specific Super Kit in question.

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Section 5 of the AGRSS Standard requires that all adhesive system components are traceable to each job.

Important Note: For the traceability system listed above to work effectively, it is imperative that the urethane, Sika® Aktivator PRO Pads and Sika® Primer-206 Stix contained within the same Super Kit are used on the same installations. Sika® Aktivator PRO Pads or Sika® Primer-206 Stix leftover from previous Super Kits would need to have their lot numbers recorded on all insurance documentation with the corresponding stickers that will still be provided.

17.0 Non-Conductive Urethanes

The subject of "conductivity" is not a new one in the field of polyurethane adhesives. Being non-conductive is an important part of successful urethane design and production because this quality resolves several problems of automotive design and manufacture. Not every brand of polyurethane adhesive is non-conductive. Sika makes several adhesives that are rated non-conductive to address certain problem applications.

Conductivity is a measure of the ability of a material to conduct electrical current. If a material is non-conductive, the material acts as an insulator preventing the flow of electricity, much like the plastic surrounding the exterior of a lamp cord. Due to the physical positioning of a urethane adhesive between two surfaces, in order to seal or bond them together, engineers and designers have found the urethane bead to be in an excellent location to prevent several potential electrical related problems.

PROBLEM 1: The prevention of electrical current flow between an exposed electrically charged wire and non-targeted area of the vehicle.
CONCERN: If such wiring is not insulated, the consequences could be electrical shorts, potential fire hazard and inoperative equipment due to disruption of power. Examples of this situation include heating/defrosting elements in front and rear glass. These electrically charged elements need to be isolated / insulated from the rest of the vehicle. The non-conductive urethane adhesive bead serves this need.

PROBLEM 2: To prevent signal loss as a result of induced current, which impairs the performance of aerial receivers located in the windshield glass.
CONCERN: Unblocked channels of electrical conductivity create static interference and weakened reception. A non-conductive adhesive isolates the windshield receiver from the rest of the vehicle.

PROBLEM 3: The prevention of electro-chemical or galvanic corrosion between two different types of metal that comes into contact through seal, bond or mechanical fasteners.
CONCERN: In the presence of moisture and air, galvanic corrosion will occur at the contact point of two different types of metals. The result will be oxidation of the metal and formation of rust. An insulator must be installed between the different metals to block the conductive exchange. Non-conductive polyurethane adhesive is a great insulator for this purpose.

PROBLEM 4: To prevent corrosion of aluminum in contact with the carbon black within the adhesive.
CONCERN: As the conductive component in some black polyurethane adhesives is carbon black, there is a possibility of galvanic corrosion leading to the destruction of the aluminum.

NOTE: SikaTack®-COOL, SikaTack®-MOVE^{IT}, SikaTack®-Ultrafast II and SikaTack®-ASAP are all rated non-conductive. The most recently published complete list of non-conductive applications is given in Sika Marketing Bulletin #X07-11, which is available from your Sika Sales Representative. Use any of these four products in ALL non-conductive urethane applications except when a "high modulus" adhesive is required. SikaTack®-COOL and SikaTack®-MOVE^{IT} are both Non-Conductive and recommended for High Modulus applications.

18.0 High Modulus Urethanes

Some automotive OEMs (Original Equipment Manufacturers) use windshield bonding urethane adhesives that have a slightly higher modulus, compared to that of conventional urethane adhesives. The modulus of an adhesive indicates how much joint movement is to be expected when a given amount of force is applied to the bonded joint. If the same amount and type of force is applied to two separate bonded joints, of the same dimensions, one being bonded with a high modulus (HM) urethane and the other with a conventional urethane, the HM bond will have less movement.

This characteristic of high modulus urethane adhesives has allowed some automotive OEMs to increase the overall stiffness of their vehicles simply by bonding the windshield with this type of adhesive. If a windshield that was originally installed with an HM urethane is replaced using a conventional urethane, the vehicle might not retain its original level of stiffness. In this case, it may also be possible for the windshield to move, during operation, beyond the limits of the window opening, causing the windshield to break. Conversely, if an HM urethane is used for a windshield replacement that does not require HM, stress cracking of the windshield may occur.

SikaTack®-COOL and SikaTack®-MOVE^{IT} are designed to be what Sika calls an "All-In-One" modulus adhesive. SikaTack®-COOL and SikaTack®-MOVE^{IT} have a shear modulus that is on the high-end of the range for conventional polyurethane adhesives as defined in the requirements outlined in the North American automobile manufacturer's direct glazing specifications. Extensive field testing performed by Sika in the United States, Europe, Australia, and Canada over a two and a half year period has shown that an adhesive with this level of shear modulus is suitable for replacement of all glass parts, even those that were originally installed in vehicles using a high modulus adhesive. When used for high modulus AGR applications, SikaTack®-COOL and SikaTack®-MOVE^{IT} will be able to maintain the vehicle's original level of stiffness.

Please remember that high modulus and non-conductive are not distinctly related. While many vehicles require non-conductive adhesives, very few legitimately require high modulus. At the time of this publication, Sika endorses the use of SikaTack®-COOL and SikaTack®-MOVE^{IT} on 1995 and later Audis, 1996 and later Volkswagen models, 2004 and later Mercedes models, and 2004 and later Porsche models. The most recently published complete list of applications can be found in Sika Marketing Bulletin #X07-10, which is available from your Sika Sales Representative. This "All-In-One" modulus adhesive provides a stiffer cured product, but it can be used for all auto glass replacement applications. If you run into a requirement for this type of product, SikaTack®-COOL and SikaTack®-MOVE^{IT} can be ordered through your local distributor.

19.0 FMVSS 111

Subject: Passenger and Commercial Vehicle Side and Rear View Mirror Replacements

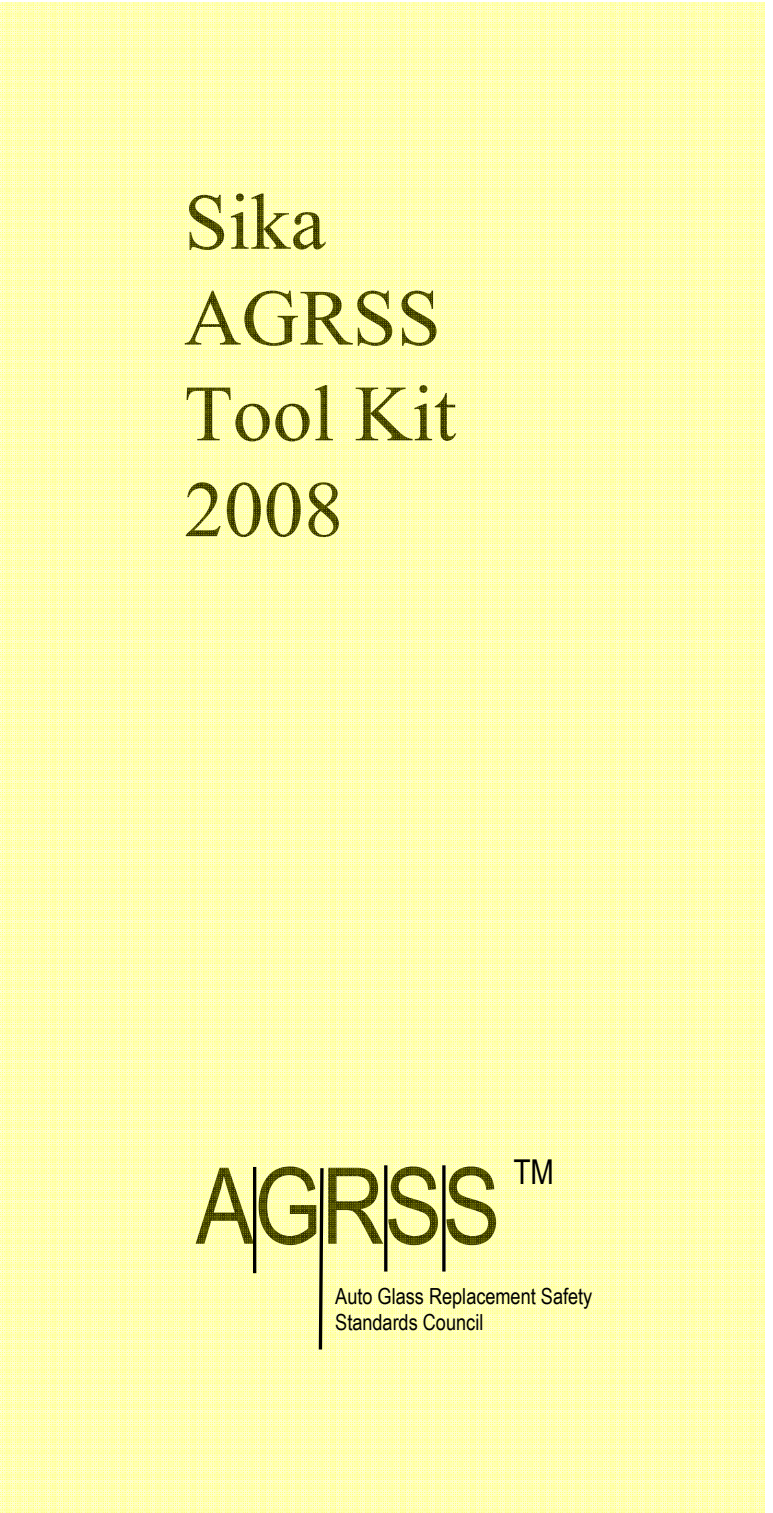
Auto glass replacement technicians, being trained and certified through Sika Corporation and in accordance to the current AGR Technician Training Manual, are required to follow this addendum instruction as it pertains to the proper replacement of side and rear view mirrors in both passenger and commercial vehicles:

1) Sika training personnel will refer to the FMVSS 111 specification in order to alert auto glass technicians to the importance of properly installing approved mirror products and how they must be installed. Below you will find the website address for the FMVSS 111 specification. It is critical that each technician fully comply with each section, namely S-1 through S-12 in that each defines all types of vehicles requiring special attention.
2) Sika can endorse the use of Sika non-conductive AGR urethanes for the installation of side view mirrors provided the mirrors pass FMVSS 111 and the bonding surface of the mirror has no exposed silvering or paint on the bonding surface. The integrity of such surfaces may be compromised if exposed to urethane systems and related cleaners and primers. The bonding surface of the mirror should be cleaned with an appropriate glass cleaner and then Sika® Aktivator PRO needs to be applied in accordance with the procedures given on page 15 of this manual. Next, use a brush or dauber to apply Sika® Primer-206 G+P according to the procedures provided on page 25 of this manual. The bonding surface of the mirror mounting bracket, contained inside the mirror housing, can be prepared with Sika® Aktivator PRO and Sika® Primer-206 G+P, following the guidelines provided in this manual. At this point any of Sika's non-conductive urethanes can be used for bonding in the mirror. Care should be taken that urethane does not contact the motor mount, impeding the ability of the motor to adjust the mirror.

Website Address to FMVSS 111:

http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi?TITLE=49&PART=571&SECTION=111&YEAR=1998&TYPE=TEXT

20.0 Sika AGRSS Tool Kit 2008



Sika Corporation

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Sika Corporation

AGRSS Tool Kit Instructions

Sika has assembled this AGRSS tool kit to assist in your awareness and compliance to the current AGRSS Standard. These documents are designed to assist you with completion of portions of five of the eight new self-assessment deliverable requirements for registration with AGRSS[1]. Sika recommends that you log onto www.agrss.com and read the AGRSS standards and registration requirements. Within the contents of this tool kit you will find:

A. AGRSS Declaration of Standard Conformance – Deliverable 4.01

To be copied and stapled to the DECLARATION CHECK-LIST- SHEET to cover Deliverable 4.01 of your self- assessment.

B. AGRSS Declaration of Standard Conformance – Deliverable 4.03

To be copied and stapled to the DECLARATION CHECK-LIST- SHEET to cover Deliverable 4.03 of your self- assessment.

C. AGRSS Declaration of Standard Conformance – Deliverable 4.04

To be copied and stapled to the DECLARATION CHECK-LIST- SHEET to cover Deliverable 4.04 of your self- assessment.

D. AGRSS Declaration of Standard Conformance – Deliverable 5.03

To be copied and stapled to the DECLARATION CHECK-LIST- SHEET, along with a copy of Sika's current safe-drive-away time chart, to cover Deliverable 5.03 of your self- assessment.

E. AGRSS Declaration of Standard Conformance – Deliverable 8.02

To be copied and stapled to the DECLARATION CHECK-LIST- SHEET, along with a copy of Sika's current certificate of training for at least one of your technicians, to cover Deliverable 8.02 of your self-assessment.

F. AGRSS Safety Bulletin – Corrosion Treatment

To be copied and provided to any customer that is experiencing corrosion damage in order that they understand what repair practices are permissible under the AGRSS Standard and that you must adhere to required safe auto glass installation practices to protect the integrity of the vehicle and occupant safety.

G. AGRSS Safety Bulletin – Removal and Replacement of Automobile Glass Parts

To be copied and provided to any customer or body shop requesting the removal and replacement of a stationary bonded glass part. This document defines what is permissible and what the auto glass technician, customer and body shop must do to remain compliant within section 7 of the AGRSS Standard.

H. AGRSS Safety Bulletin – Pinchweld Restoration Considerations

To be copied and provided to any body shop performing a pinchweld repair or repainting a vehicle that involves a glass replacement. This document defines what is permissible and what the auto glass technician and body shop must do to remain compliant within section 7 of the AGRSS Standard.

[1] The language contained in the response section to each of the declaration documents listed above is by way of example only and should not be used if it does not accurately depict the prospective registrant's conduct or practices. This AGRSS Tool Kit is intended as a guide only and is not a guarantee or warranty by Sika to prospective registrant of its successful registration with the Auto Glass Replacement Safety Standards Council, of compliance with AGRSS Standards, or of compliance with Sika handling use and application instructions or applicable local, state or federal law. Sika is not however responsible for nor does Sika guarantee any installation technician's compliance with Sika's guidelines for handling and use of its products or its training instructions. TRAINING BY SIKA AS WELL AS A CERTIFICATION OF TRAINING COMPLETION SHALL NOT CONSTITUTE A WARRANTY OF ANY KIND BY SIKA OF AN INSTALLATION TECHNICIAN'S WORKMANSHIP OR THE HANDLING, USE, STORAGE AND APPLICATION OF SIKA'S PRODUCTS. SIKA GIVES NO WARRANTY OR GUARANTEE OF ANY KIND EXPRESS OR IMPLIED WITH RESPECT TO THE INFORMATION AND/OR ANY GUIDANCE WHICH MAY BE PROVIDED HEREIN OR ITS USE. SIKA SHALL NOT UNDER ANY CIRCUMSTANCES BE RESPONSIBLE FOR CONSEQUENTIAL DAMAGES OF ANY KIND UNDER ANY LEGAL THEORY ARISING FROM THE USE OF OR RELIANCE UPON THE INFORMATION AND/OR GUIDANCE PROVIDED HEREIN.

Sika AGRSS Tool Kit:

- **Registration Values**
- **Registration Preparation**
- **Self-Assessment Preparation**
- **Sika Self-Assessment Assistance Program**

Registration Values:

The AGRSS Registration Program provides two distinct values for participating companies: first, the ability to differentiate oneself from the competition and, second, the ability to validate safe auto glass installation practices that leads to increased revenue and reduced liability risks, respectively.

Registration Preparation:

The following instructions need to be followed in order to properly be prepared for AGRSS registration:

A. Go to www.agrss.com to access forms.

B. Under the left tab, click on “REGISTRATION”.

C. Click on “Invitation Letter” and copy.

D. Close “Invitation Letter” and then click on “Application Documents”.

E. Once opened, download and copy the “Application”, “STANDARD part A”, and “Standard part B” (note that these forms are made available in either a Microsoft Word or Acrobat format).

F. You now should have 4 documents in your possession for review and use.

G. Now read the “Invitation Letter” that provides a cordial welcome, a brief outline of each of the remaining 3 documents, a 7-point instruction-step guideline and a random sampling chart to calculate how many store locations need to be assessed.

H. Next, review the Application in order to understand the contents of agreement, payment information, and how to submit the registration documents.

I. Make copies of “STANDARD part A” and circulate copies to every employee for their review. This part of the registration packet is the current AGRSS Standard.

AGRSS Self-Assessment Preparation:

When in receipt of the AGRSS Registration packet, you'll note within the instructions that a 90 day registration period is provided. The reason for this extended period of time is to allow for a thorough self-assessment of the required number of store locations of your company, and the ability to correct and re-assess any non-compliance issues.

What has proven beneficial, in terms of time efficiency and elimination of non-compliances, is the pre-work done prior to the conducting of your official self-assessment. To help ensure a smooth and hassle-free self-assessment, utilize the following instructions:

1 Understand that the square root of your total store location count must be assessed (look to the chart provided as part of the "Invitation Letter" to learn how many store locations, or functional units, are to be involved).
2 The element of "random sampling" means that the store locations to be assessed, if more than one is to be involved, must be selected randomly, such as drawing locations from a hat. Conduct some form of lottery to identify the store locations to be assessed.
3 "STANDARD part B" is the key document used for conducting the self-assessment. Understand that each of the store locations being assessed must have their own copy of "STANDARD part B" completed and submitted back to your management team for review. For example, if the company had 10 store locations, 3 would need to be assessed. The management team would be in receipt of 3 "STANDARD part B" forms that were fully completed.
4 There are 8 deliverables required as part of the self-assessment. These deliverables play an enormous role in validating conformance to the AGRSS Standard. Each store location completing their own STANDARD part B must also attach the 8 deliverables to the back "DELIVERABLE CHECK-LIST-SHEET".
5 Company management must review each of the completed STANDARD part B forms and deliverables making sure that each question is marked "Yes" and that 8 acceptable deliverables are attached. If this level of accuracy occurs, then management has validated that acceptable and consistent policies and procedures are in place to best ensure compliance to the AGRSS Standard. Management then is to complete one corporate registration packet that is to include one STANDARD part B with one set of deliverables, and one Application Form (along with proper payment, notarization and instructed submission of additional locations requiring website posting and certificates). While a copy should be maintained, the original set is to be mailed to the AGRSS Secretary as indicated on the Application Form. It may take up to 6 weeks for return registration approval.
6 If any store location has either indicated "No" on STANDARD part B, or fails to understand the question, management must assess those specific subjects, correct the situation and then reassess the situation as soon as possible. Note that only those specific questions not being adequately answered need to be re-assessed and only for those store locations having indicated such. Once all assessed locations are deemed to be in compliance, then final corporate registration forms are ready for completion and submission. Registration is by company, which is why only one properly completed registration packet is required.
7 On deliverables, note that 8 are required. If one form is being used to cover more than one deliverable, make sure to include the appropriate number of extra copies, highlighting the area on that document that pertains to the deliverable required.
8 From these instructions, it makes sense for management to make sure that all store locations conduct business in the same way, using the same policies, procedures and documents long before the self-assessment is completed. This practice eliminates much of the risk of discovering non-compliances, which add much additional work and time to the registration process.

Sika Self-Assessment Assistance Program:

Sika, as your preferred retention system provider, has taken great strides in assisting with your successful completion of becoming an AGRSS Registered company. Sika has been an "originator" and leader of many of the AGRSS related projects and, largely because, we believe AGRSS to be one of the greatest and most important subjects ever developed for the AGR Industry.

One such proof of our commitment to the AGRSS process has been the provision of Sika's AGRSS Tool Kit that provides 5 of the 8 required Deliverables that must be submitted with your properly completed registration packet. This Tool Kit is updated each year and provided to you as a Sika-trained and certified glass shop.

The basis of our new "Sika-Self-Assessment Assistance Program" is that one of our full-time, factory trained personnel will literally assist your management team in conducting your self-assessment process. Through our field trials of this new program, glass shop customers have found this support to be rewarding due to the expertise we bring to the process, the knowledge we have within many of the topics and deliverables measured, and the streamlined approach we have developed to ensure the best use of your time and effort in completing AGRSS registration.

Following are the steps that you need to take in order to utilize this new program:

1 Complete all steps outlined in the "Registration Preparation" box.
2 Read through and understand the self-assessment process outlined in the "Self-Assessment Preparation" box.
3 Representing the management of your company, create, what we refer to as, the "Model" STANDARD part B, which means type out each question and then write your preferred answer to each, understanding that "Yes" would be the expected box checked. This document becomes your company's targeted script and answer sheet that your Sika representative would use in assessing each of your assessed locations. Along with this document, include the 8 deliverable documents that are representative of what should be used by each technician when conducting business. Note that Sika provides 5 of the 8 deliverables through this Kit and that you will need to provide the documents used to record pre-inspection conditions, safe-driveaway time and traceability of lot numbers, DOT numbers and part numbers. Make sure to review this Model from with your Sika representative prior to assessing any locations.
4 Do your best to teach each technician and store location the policies, procedures and documents that are to be used in order to be compliant to AGRSS and do so prior to your scheduled time of assessment. This prevents much of the risk of having to conduct more than one assessment per location due to a non-compliance issue.
5 Once steps 1-4 are complete, call your local Sika Territory Account Manager to schedule time to conduct your self-assessment. Once the schedule is set, be sure that all pertinent locations and personnel are properly notified and committed to the schedule.
6 Sika personnel will complete one STANDARD part B for each store locations that they are able to assess (depending on schedules and number of locations, Sika personnel may only be available to complete a portion of the assessments while your people complete the balance). If any non-conformances are discovered, they will be reported on part B and discussed. It will be the responsibility of your management to correct and re-assess such issues in order for the non-compliant issue to be amended to "Yes".
7 Upon the successful completion of the self-assessment, it will be the responsibility of your management team to properly complete the Application Form, the corporate STANDARD part B and required attachments, then submit it for approval to AGRSS.

Sika Corporation

AGRSS Declaration of Standard Conformance

DELIVERABLE 4.01

Section 4.01 of ANSI/AGRSS 002-2002:

"Those engaged in automotive glass replacement shall use retention systems that are produced under documented quality assurance standards."

Sika Response:

Each of Sika's AGR adhesives and primers is manufactured according to our documented quality assurance procedures. These internal quality assurance procedures have been certified by a third party approved ISO registrar to meet the requirements of ISO 9001:2000.

ISO (International Organization for Standardization) is the world's largest developer of standards. For more information on ISO and this standard you can log onto its website using the following address.

www.iso.org

John King Vice President –
Aftermarket Sika Corporation

Sika Corporation

AGRSS Declaration of Standard Conformance

DELIVERABLE 4.03

Section 4.03 of ANSI/AGRSS 002-2002:

"Those engaged in automotive glass replacement must use either an OEM approved retention system or equivalent retention system as certified in writing by the equivalent retention system manufacturer directly or through a private labeler."

Sika Response:

Sika Automotive OEM direct glazing polyurethane adhesive systems are used by a number of automobile manufacturers, such as Audi, BMW, DaimlerChrysler, Volkswagen, and others. This fact validates Sika's ability to produce qualified adhesive systems that meet or exceed the stringent OEM specifications for quality and performance for automobiles produced in the United States as well as worldwide.

When used as directed, each of Sika's AGR adhesives meets or exceeds the strength requirements outlined in the direct glazing specifications of all automobile manufacturers.

John King Vice President –
Aftermarket Sika Corporation

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Sika Corporation

AGRSS Declaration of Standard Conformance

DELIVERABLE 4.04 Section 4.04 of ANSI/AGRSS 002-2002

"Those engaged in automotive glass replacement shall obtain and follow written comprehensive and current application instructions from the retention systems manufacturer or private labeler."

Registrant Response:

The attached diagram represents the current cover of the Sika Technician Training Manual and represents comprehensive application instructions covering all requirements stated within Section 4 of the AGRSS Standard. This manual is currently used by the registrant.

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AGRSS Declaration of Standard Conformance

DELIVERABLE 5.03

Section 5.03 of ANSI/AGRSS 002-2002:

"No automotive glass replacement shall be undertaken using an adhesive glass retention bonding system that would not achieve minimum drive-away strength by the time the vehicle may be reasonably expected to be operated."

Registrant Response:

Sika measures the strength build up rates of each AGR adhesive under varying weather conditions using proprietary Safe Drive Away Time (SDAT) determination test methods. The resulting SDATs are then validated under the supervision of a third party crash test facility using the FMVSS 212 standard in its most severe interpretation. This process provides a reliable means to establish SDAT charts for each of Sika's AGR adhesives. The information published in the SDAT chart for each AGR adhesive allows an auto glass technician to determine how long the vehicle must remain out of service prior to use. Such time allowances depend on which product is being used, temperature, humidity and the presence of a passenger side airbag.

The registrant has provided each of its installation technicians with the Sika SDAT charts for the Sika AGR adhesives that they use. The registrant has also provided training to each of its technicians to ensure that they are able to interpret this information properly and inform the vehicle owners of this information when necessary.

NOTE: See attached chart utilized for SDAT calculations.

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Safe Drive Away Time Charts – *The fastest, most reliable and cost effective adhesive system available.*

Based on temperature and humidity, these charts indicate when Sika polyurethanes reach FMVSS 212/208 windshield retention requirements for both dual airbag and non-dual airbag automobiles. Follow all product installation instructions and recommendations given in the Sika AGR Technician Training Manual.

Hot-Applied Adhesives

SikaTack®-ASAP (suitable for non-conductive)

Relative Humidity	Temperature					
	>0°F	>25°F	>35°F	>55°F	>72°F	>95°F <120°F
Without Airbag						
> 90%	30 min	30 min	30 min	30 min	30 min	30 min
> 70%	30 min	30 min	30 min	30 min	30 min	30 min
> 40%	30 min	30 min	30 min	30 min	30 min	30 min
> 20%	30 min	30 min	30 min	30 min	30 min	30 min
> 0%	30 min	30 min	30 min	30 min	30 min	30 min
With Passenger Airbag						
> 90%	45 min	45 min	1 hr	1 hr	1.25 hr	1.75 hr
> 70%	45 min	45 min	1 hr	1 hr	1.5 hr	1.75 hr
> 40%	45 min	45 min	1 hr	1 hr	1.75 hr	2 hr
> 20%	45 min	45 min	1 hr	1.5 hr	2 hr	2 hr
> 0%	45 min	45 min	1 hr	1.5 hr	2 hr	2 hr

SikaTack®-Ultrafast *II* (suitable for non-conductive)

Relative Humidity	Temperature					
	>15°F	>25°F	>35°F	>55°F	>72°F	>95°F <120°F
Without Airbag						
> 90%	30 min	30 min	30 min	30 min	30 min	2 hr
> 70%	30 min	30 min	30 min	30 min	30 min	2 hr
> 40%	30 min	30 min	30 min	30 min	30 min	2 hr
> 20%	30 min	30 min	30 min	30 min	30 min	2 hr
> 0%	2 hr	2 hr	2 hr	2 hr	2 hr	2 hr
With Passenger Airbag						
> 90%	2 hr	2 hr	2 hr	2 hr	2 hr	4 hr
> 70%	2 hr	2 hr	2 hr	2 hr	2 hr	4 hr
> 40%	2 hr	2 hr	2 hr	2 hr	2 hr	4 hr
> 20%	2 hr	2 hr	2 hr	2 hr	2 hr	4 hr
> 0%	4 hr	4 hr	4 hr	4 hr	4 hr	4 hr

SikaTack®-Sierra (suitable for non-conductive)

Relative Humidity	Temperature					
	>0°F	>25°F	>55°F	>72°F	>85°F	>95°F <120°F
Without Airbag						
> 75%	NR	NR	30 min	30 min	NR	NR
> 40%	NR	NR	30 min	30 min	30 min	NR
> 20%	NR	NR	30 min	30 min	30 min	30 min
> 10%	NR	NR	30 min	30 min	30 min	30 min
> 0%	NR	NR	30 min	30 min	30 min	30 min
With Passenger Airbag						
> 75%	NR	NR	1 hr	1 hr	NR	NR
> 40%	NR	NR	1 hr	1 hr	1 hr	NR
> 20%	NR	NR	1 hr	1 hr	1 hr	1 hr
> 10%	NR	NR	1 hr	1 hr	1 hr	1 hr
> 0%	NR	NR	1 hr	1 hr	1 hr	1 hr

NR = Not Recommended

Cold-Applied Adhesives

SikaTack®-MOVE^IT (suitable for non-conductive & high modulus)

Relative Humidity	Temperature					
	>0°F	>25°F	>35°F	>52°F	>72°F	>90°F <120°F
Without Airbag						
> 90%	30 min	30 min	30 min	30 min	30 min	30 min
> 70%	30 min	30 min	30 min	30 min	30 min	30 min
> 40%	30 min	30 min	30 min	30 min	30 min	30 min
> 10%	30 min	30 min	30 min	30 min	30 min	30 min
> 0%	30 min	30 min	30 min	30 min	30 min	30 min
With Passenger Airbag						
> 90%	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
> 70%	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
> 40%	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
> 20%	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
> 0%	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr

SikaTack®-COOL (suitable for non-conductive & high modulus)

Relative Humidity	Temperature					
	>0°F	>32°F	>40°F	>52°F	>72°F	>90°F <120°F
Without Airbag						
> 90%	NR	45 min	30 min	30 min	30 min	30 min
> 70%	NR	45 min	30 min	30 min	30 min	30 min
> 40%	NR	60 min	45 min	30 min	30 min	30 min
> 20%	NR	60 min	45 min	45 min	45 min	30 min
> 0%	NR	60 min	45 min	45 min	45 min	45 min
With Passenger Airbag						
> 90%	NR	4 hr	2 hr	2 hr	2 hr	2 hr
> 70%	NR	4 hr	2 hr	2 hr	2 hr	2 hr
> 40%	NR	6 hr	4 hr	2 hr	2 hr	2 hr
> 20%	NR	6 hr	4 hr	4 hr	4 hr	2 hr
> 0%	NR	6 hr	4 hr	4 hr	4 hr	4 hr

NR = Not Recommended

(Will transition to the name SikaTack®-Drive New by the end of 2007)

Sikaflex® 220+

Relative Humidity	Temperature					
	>15°F	>25°F	>40°F	>50°F	>72°F	>95°F <110°F
Without Airbag						
> 90%	24 hr	24 hr	4 hr	3 hr	2 hr	2 hr
> 70%	24 hr	24 hr	4 hr	3 hr	2 hr	2 hr
> 40%	NR	24 hr	24 hr	4 hr	2 hr	2 hr
> 10%	NR	NR	24 hr	24 hr	4 hr	2 hr
> 0%	NR	NR	NR	NR	4 hr	4 hr
With Passenger Airbag						
> 90%	NR	NR	16 hr	12 hr	8 hr	8 hr
> 70%	NR	NR	16 hr	12 hr	8 hr	8 hr
> 40%	NR	NR	NR	16 hr	8 hr	8 hr
> 10%	NR	NR	NR	NR	16 hr	8 hr
> 0%	NR	NR	NR	NR	NR	NR

NR = Not Recommended

Sika Corporation

AGRSS Declaration of Standard Conformance

DELIVERABLE 8.02

Section 8.0 of ANSI/AGRSS 002-2002:

"Technicians installing replacement automotive glass shall be fully qualified for the tasks they are required to perform. Such qualifications shall include, at a minimum, completion of a comprehensive training program with a final exam and a continuing education component. The program shall include, among other things: AGR safety issues, an understanding of OEM installation standards and procedures, relevant technical specifications, comprehensive retention system specific training and the opportunity to apply and demonstrate the skills technicians learn."

Registrant Response:

Sika offers training covering the proper use of Sika products when used as the retention system of any automobile. Such training includes the provision and study of the current Sika Auto Glass Replacement Technician Training Manual, skill development through Sika personnel's' observance of technician installations during the training session and a comprehensive test at the conclusion of the training to ascertain the technician's knowledge base of proper product usage. Each technician who successfully completes Sika training receives a certificate of training completion, along with an identification card to carry with them.

Attached to this document is a copy of our training completion certificate. We retain copies of the training completion certificates issued by Sika for our technicians who have successfully completed the course.

John King Vice President –
Aftermarket Sika Corporation

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AGR Authorization Form

Urethane Label

Batch No. _____

Exp. Date _____

Aktivator PRO Label

Batch No. _____

Exp. Date _____

Safe Drive Away Time

_____ **AM**
_____ **PM**

206 G+P Label

Batch No. _____

Exp. Date _____

215 Primer Label

Batch No. _____

Exp. Date _____

EXTERIOR

Mark all Damages as Followed:

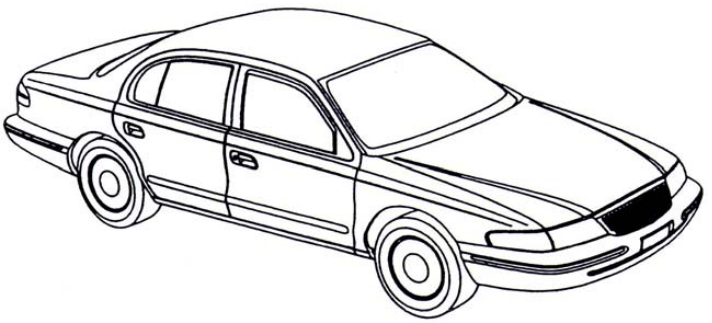
"S" = Scratched
"P" = Peeled Paint
"D" = Dented
"C" = Chipped
"M" = Missing Parts
"R" = Rusted Spots
"O" = Other: _____

INTERIOR

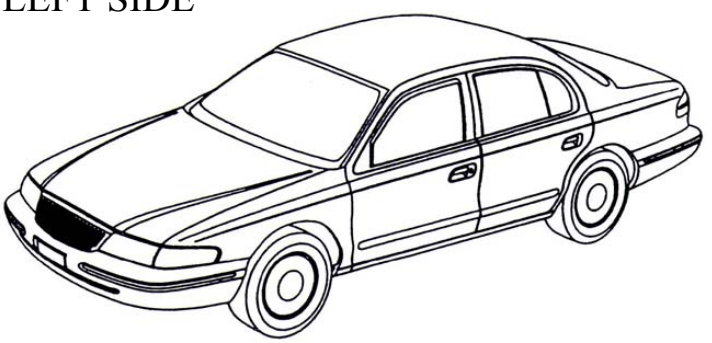
Mark all Damages as Followed:

	Tears	Stains	Area
Headliner:	_____	_____	_____
Seats:	_____	_____	_____
Dash:	_____	_____	_____
Door Panels:	_____	_____	_____
Floor-Front:	_____	_____	_____
Floor-Rear:	_____	_____	_____

RIGHT SIDE



LEFT SIDE



BEFORE RETURNING TO CUSTOMER

Circle the following that has been checked and or completed:

Vacuumed:	**yes/no**
Trim Secure:	**yes/no**
Glass Clean:	**yes/no**
Wipers ok:	**yes/no**
Air Condition Run:	**yes/no**
Radio:	**yes/no**

Customer Name: _____ **Date:** _____

Phone: _____ **Color Vehicle:** _____

Type Vehicle: _____ **VIN #:** _____

Glass DOT Number: _____ **Glass Part Number:** _____

Urethane System Used: _____ **Car Inspected By:** _____

I hereby have read the inspection sheet, authorization and agreement, before affixing my signature below, and warrant that I fully understand the contents thereof.

Customer Signature: _____ **Date:** _____

Sika Corporation

AGRSS Safety Bulletin

August 26, 2005 X05-25

Attention: Automobile Owner /Operator Subject: Corrosion Treatment; Section 3, ANSI/AGRSS Standard 002-2002

Section 3, *Vehicle Assessment Before Replacement,* of the American National Standards Institute/Auto Glass Replacement Safety Standard 002-2002 states that, "those engaged in automotive glass replacement shall not undertake or complete such installation when any related condition would compromise the retention system and the owner/operator shall be so notified." One condition which may exist within the mounting area of a glass part that fits this description is corrosion (rust). All auto glass technicians must abide by the specific instructions of the auto glass replacement adhesive supplier in evaluating the severity of corrosion and, its proper removal and pinchweld restoration.

When one of Sika Corporation's auto glass replacement adhesive systems is used as the glass replacement retention system, the following recommendations for corrosion treatment should be followed in order to be compliant with the ANSI/AGRSS Standard:

1 If any level of corrosion is found in or around the mounting area of the glass part, such corrosion must be fully removed down to bare metal and the bare metal must be properly primed prior to application of the adhesive in accordance with Sika's documented instructions set forth in Sika's Auto Glass Technician Training Manual available by calling 1-888-832-7452 or at www.sikaindustry.com[1].

2 In accordance with Sika's instructions, up to an accumulated maximum of 24 square inches of corrosion in the entire glass part mounting area can be properly restored by the auto glass technician, as long as there is no perforation (holes) in the mounting surface. If either of these parameters is not met, the vehicle must be restored by an authorized auto body repair facility.

If these practices are not followed, an auto glass replacement company may be in violation of the ANSI/AGRSS Standard 002-2002.

Recommendation: Since automotive glass parts are an integral part of a vehicle's overall passenger protection system, vehicle owners should only utilize the services of auto glass technicians who follow a comprehensive automotive glass replacement protocol which includes, but is not limited to, corrosion treatment procedures that comply with ANSI/AGRSS standards. Failure to comply with these recommendations may pose a risk to your personal safety.

Best regards,

Jeffry A. Woodford
Sr. Product Engineer
Sika Corporation

[1] The information and recommendations contained herein and any other advice given by Sika are provided in good faith based on Sika's current knowledge and experience of its products when properly stored, handled and applied within shelf life under normal conditions in accordance with Sika's instructions. **SIKA DOES NOT UNDER ANY CIRCUMSTANCES WARRANT OR ASSUME LIABILITY UNDER ANY LEGAL THEORY IN CONNECTION WITH THE USE OR APPLICATION OF ITS PRODUCTS BY ANY THIRD PARTY.**

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Sika Corporation

AGRSS Safety Bulletin

August 26, 2005 X05-24

Attention: Auto Body Repair Facility Subject: Pinchweld Restoration Considerations for Direct Glazing Applications Section 7, ANSI/AGRSS Standard 002-2002

Section 7 of the ANSI-AGRSS Standard 002-2002 states that "those engaged in automobile glass replacement shall not introduce any chemical agents, such as cleaners, solvents, lubricants, release agents, or utilize any installation practice, which will adversely affect the glass retention system." The ANSI/AGRSS standard can be obtained via the Internet by first logging on to www.agrss.com and then by clicking on "The Standard."

The aftermarket application of basecoat and or clearcoat to an automotive glass part's mounting area (commonly referred to as a vehicle's pinchweld in the auto glass replacement industry) prior to installation of a polyurethane direct-glazed stationary auto glass part is an installation practice that can adversely affect the glass retention system. When one of Sika Corporation's auto glass replacement adhesive systems is used as the glass retention system during a replacement, the recommendations that follow must be used in order to remain compliant with Section 7 of the ANSI/AGRSS Standard. More importantly, any glass part installation performed without following the procedures set forth below (as well as the comprehensive application instructions contained in Sika's Auto Glass Technician Training Manual) could cause possible loss of glass adhesion and potential serious personal injury.

Recommendation: Since automotive glass parts are an integral part of a vehicle's overall passenger protection system, vehicle repair businesses should only utilize the services of auto glass technicians that are aware of and follow pinchweld preparation procedures that comply with the ANSI/AGRSS Standard. Your customer, whether it is the vehicle owner or the insurance company, will expect you to meet these requirements and return the vehicle with all safety related features in an operable condition. Failure to comply with these recommendations may pose a risk to your customer's safety. The instructions that follow have been taken from Sika's Auto Glass Technician Training Manual available at www.sikaindustry.com or by calling 1-888-832-7452. Any body shop work that involves glass replacement using Sika's AGR urethane systems must be conducted in accordance with all of the instructions in the Auto Glass Technician Training Manual for Sika's warranty to apply[1]. Please take the time to familiarize yourself with and comply with Sika's Auto Glass Technician Training Manual as they pertain to the work you perform.
The following information has been taken from the Pinchweld Preparation Section of Sika's Auto Glass Technician Training Manual:

AGR / body shop instructions for repaired pinchwelds and vehicles to be repainted[2]

Perforation corrosion located in a glass part's mounting area of a vehicle's pinchweld, just like perforation corrosion located in any structural area of a vehicle, requires replacement of the entire section of metal. Filling these types of areas with body filler is not acceptable. Furthermore, I-CAR

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has made recommendations that state, “do not use body filler on the pinchweld where glass urethane adhesive will be applied.” This recommendation was taken from the March - April 2000 I-CAR Advantage and this document also states that, “small irregularities in the flange surface will be filled when the adhesive bead is applied.” Keep in mind that the glass bonding area of a pinchweld does not require a “Class A” appearance and, if required, welded areas can be sanded smooth prior to primer application. Again, **do not apply body filler in areas where glass bonding adhesive will be applied.**

For glass replacements involving a body shop repaired pinchweld or repainting of a vehicle, one of the following two options should be selected.

Option 1. Whenever possible, remove the glass part, by cutting the adhesive as close to the glass as possible, and leave the entire remaining urethane adhesive bead in place. Do not trim the adhesive bead until the vehicle has been painted and the new glass part is ready to be installed. In this case, it is not necessary to tape or otherwise protect the existing urethane. After the vehicle is repaired and painted, remove most of the existing urethane leaving 1-2 mm on the pinchweld and install the glass part (full cut method).

Option 2. If the pinchweld area is to be repaired and painted, remove the section of metal to be repaired, repair pinchweld and apply an epoxy or etch primer coat. Allow the primer to cure for at least as long as would be required prior to applying topcoat over the primer, following the paint manufacturer’s recommendations. If topcoat is to be applied to remainder of the vehicle, mask off the bond area of the pinchweld with masking tape. Continue painting the vehicle as required. Remove the masking tape. If a forced drying process is to be used, remove the tape prior to baking the topcoat. Next, lightly abrade the primer with a Scotchbrite® or similar abrasive pad. Apply Sika® -Aktivator according to the instructions in this guide and allow it to cure for at least ten minutes. Paint a thin coat of Sika® Primer-206 G+P and then allow at least ten minutes for this product to dry. Then set the glass part using the appropriate Sika adhesive for the vehicle type and required drive away time.

*IMPORTANT NOTE: Option 2 above calls for the use of Sika® -Aktivator and Sika® Primer-206 G+P. If any of these procedures are to be performed at temperatures below 40°F, then please refer to the special low temperature precautions for these products, which can be found in the “Seasonal Concerns” section of Sika’s Auto Glass Technician Training Manual. Also, please note that when these recommendations call for Sika® Primer-206 G+P, a Sika® Primer-206 Stix applicator may be used. However, due to the limited coverage of Sika® Primer-206 Stix, a can of Sika® Primer-206 G+P will most likely be the more convenient option.

Best regards,

Jeffry A. Woodford
Sr. Product Engineer
Sika Corporation

[1] Sika warrants its products for one year from date of installation to be free from manufacturing defect and to meet the technical properties on the current Technical Data Sheet(s) when used as directed within shelf life. User determines suitability of product for intended use and assumes all risks. Buyer’s sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor. **NO OTHER WARRANTY EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTIBILITY OR FITNESS FOR A PARTICULAR PURPOSE. SIKA SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSQUENTIAL DAMAGES. SIKA SHALL NOT BE RESPONSIBLE FOR THE USE OF THIS PRODUCT IN A MANNER TO INFRINGE ON ANY PATENT OR ANY INTELLECTUAL PROPERTY RIGHTS HELD BY OTHERS.**

[2] The information and recommendations contained herein and any other advice given by Sika are provided in good faith based on Sika’s current knowledge and experience of its products when properly stored, handled and applied within shelf life under normal conditions in accordance with Sika’s instructions. **SIKA DOES NOT UNDER ANY CIRCUMSTANCES WARRANT OR ASSUME LIABILITY UNDER ANY LEGAL THEORY IN CONNECTION WITH THE USE OR APPLICATION OF ITS PRODUCTS BY ANY THIRD PARTY.**

20.0 Questions & Answers

1. Can Sika adhesives be installed onto wet surfaces? *No. No urethane can be applied to a wet surface because the water causes the urethane to ball up and lift from the surface, compromising the adhesion. All surfaces must be dry.*

2. How do I install a gasket set windshield? *Clean the glass, gasket slots with Sika® Aktivator PRO. The gasket must then be bonded, with urethane, to the pinchweld and the glass must be bonded to gasket with urethane. Please refer to page 17 for additional information.*

3. How do I use your urethane on a "pre-applied adhesive system (PAAS)" windshield? *Modern PAAS systems are designed to act as a height-guide when installing fresh adhesive. However, a PAAS system can also get easily contaminated from shipping and handling. To prep a PAAS windshield, wipe the pre-applied adhesive with Sika® Aktivator PRO. Immediately wipe off and wait ten minutes. The windshield is now ready to be installed. Follow normal Sika guidelines for the remainder of the installation.*

4. Can I apply your heated products cold? *No, SikaTack®-Ultrafast II, SikaTack®-Sierra and SikaTack®-ASAP must be applied hot or else problems with gunnability, decking, and or adhesion may occur.*

5. Sometimes my push-in moldings do not stay down. What causes this and what would you recommend to address the problem? *SikaTack®-Ultrafast II, SikaTack®-Sierra and SikaTack®-ASAP stiffen rapidly and by the time you get to setting an old styled push-in molding, the foot of the molding may not penetrate the bead. IF this does happen, a great remedy is to simply slice through the surface of urethane with some form of narrow blade, and back fill with a small portion of fresh SikaTack®-Ultrafast II, SikaTack®-Sierra or SikaTack®-ASAP. You'll find this to be the best remedy and urethane to use in getting those moldings to stay down. Be reminded that a little Sika® Primer-215 is a great product to use when really needing to get urethane to stick to either PVC or EPDM rubber.*

6. What glass cleaner can I use? *Any type of glass cleaner is acceptable as long as the product doesn't contain any anti-static additives. Make sure that all cleaner is removed from the glass surface prior to applying Sika® Aktivator PRO.*

7. How long are primers and cleaners good for after they have been opened? *Sika® Aktivator PRO and Sika Primers have a limited shelf life when opened. With proper storage conditions, they will remain usable up to six months after opening, or until the expiration date, whichever comes first. Always tightly replace both the inner liner and outer cap after each use. If the product becomes thick or cloudy, discontinue use immediately.*

8. What risks do I take if I use a high modulus urethane on a vehicle that only requires non-conductive urethane? *The windshield could stress crack during vehicle operation. Please remember that the "All-In-One" modulus SikaTack®-COOL and SikaTack®-MOVE^{IT} is now recommended for high modulus applications and this product can be used for all applications without concern for stress cracking.*

9. What risks do I take if I don't use a high modulus or an "All-In-One" modulus urethane on a vehicle that does require it? *After the windshield is replaced, the vehicle might not have the its original level of stiffness and the windshield could break as a result of moving beyond the limits of the window opening during operation of the vehicle.*

10. I've always used a round bead and never had a problem. Why do you recommend a triangle bead? *When compressed, a triangle is the only dimension that will not trap air. Round beads tend to trap air in all four corners, creating air pockets that vibrate through the bead creating leaks. Triangle beads, when applied correctly, create less squeeze-out and clean up as well. Always remember to trowel all wet seams of urethane together, using a windshield stick or blade.*

11. Explain your oven kit program. *Retail glass shops can obtain free ovens by purchasing a kit through Sika distributors. Along with the free oven they purchase a specified number of cases of urethane, primer and cleaner that help offset the cost of the oven. Both Sika Corporation and Sika distributors share in the cost of the oven through reduced margins. While Sika Corporation picks up the largest portion of the oven cost, distributors sell the kits at a predetermined price and make a 20% gross margin. Kits are usually special ordered after the retail glass shop makes a commitment to the Sika line of products and determines which type of oven would best serve their business. Shops doing the math can determine that they are only paying for the urethane, primer and cleaner portion of the kit, which is a billable product to their customers.*

12. When uncertain of how to bond glass parts, is it best to always use a Sika adhesive system? *While urethane satisfies most vehicle needs for installing glass parts, there are some exceptions that may be encountered. Most notable is when the OE glass part utilizes a mechanical fastening system, which provides the required retention strength, and calls for a sealant to prevent water and sound penetration. When this is the case, it is always best to follow current OEM specifications for installing a replacement part. Where a model vehicle has been upgraded, it is recommended that only the most current specified retention system should be used. An example would be a vehicle model transitioning from a gasket set to a urethane set glass part.*

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21.0 2008 Sika Auto Glass Technician Test

_____
(Printed name of Technician)

_____ _____
(Technician Signature) **(Date)**

_____ _____
(Sika Trainer) **(Date)**

Technician Mailing Address:

_____

_____

_____

_____

TECHNICIAN TRAINING TEST

Section 1

Please determine if each statement is TRUE or FALSE

1. When preparing a glass part using Sika® Aktivator PRO (orange cap) at a temperature of 30°F, there are special low temperature precautions to be concerned with.
   A) TRUE
   B) FALSE
2. A complete adhesive removal is required if the bonded glass part was installed using a non-urethane adhesive.
   A) TRUE
   B) FALSE
3. There is no reason to worry about scratching the paint of a vehicle because Sika® Primer-206 G+P (black cap) can be used to restore the corrosion protection system back to the OEM level.
   A) TRUE
   B) FALSE
4. It is acceptable to apply Sika® Primer-206 G+P over rust.
   A) TRUE
   B) FALSE
5. Sika's hot applied (or heated) urethane adhesives must be heated, prior to use, in a Sika approved oven for a minimum of 1 hour, or 30 minutes if preheated in the cooler of a Pragmatech oven.
   A) TRUE
   B) FALSE
6. SikaTack®-COOL is rated non-conductive.
   A) TRUE
   B) FALSE
7. A bonded glass part that was previously installed with a silicone can be re-installed if properly prepared using Sika® Aktivator PRO.
   A) TRUE
   B) FALSE
8. A glass part that was prepared properly using Sika® Aktivator PRO (orange cap) can be installed 12 hours after the Aktivator PRO's application.
   A) TRUE
   B) FALSE
9. A high modulus urethane may be considered to be stiffer than a conventional urethane with a normal modulus.
   A) TRUE
   B) FALSE
10. If a 250 ml can of Sika® Aktivator PRO (orange cap) expires 8 months from today and you open this same can today, it can be used for the next 6 months or until it becomes "cloudy".
   A) TRUE
   B) FALSE

TECHNICIAN TRAINING TEST

Section 2

Please determine the BEST answer to each question

11. The "full-cut" method requires trimming the existing bead of urethane down to a height of

A) ¼ to ½ inch
B) 1 to 2 millimeters
C) 1 to 2 centimeters

12. The factors affecting safe-drive-away-time are

A) when the customer wants their car put back into service
B) temperature, humidity and presence of passenger side airbag
C) following the proper application procedures specified by the adhesive manufacturer

13. One reason to apply Sika® Primer-206 G+P (black cap) to the pinchweld of the vehicle is to

A) provide a UV barrier for the paint of the vehicle
B) provide coverage for bare metal in order to reduce future corrosion
C) to cover the existing urethane bead for improved adhesion

14. When installing a gasket set windshield the preparation of the gasket requires

A) removal of contaminants from within both slots of the gasket utilizing a towel and water. An approved glass cleaner may be used for additional cleaning power. After fully dry, apply Sika® Aktivator PRO to both slots and allow a minimum of 15 minutes before proceeding
B) removal of contaminants from within both slots of the gasket utilizing Sika® Primer-206 G+P and allow to dry for 10 minutes. Then apply Sika® Aktivator PRO per normal application procedures and allow to cure for 15 minutes
C) removal of contaminants from within both sides of the gasket utilizing compressed air. Do not apply any form of liquid due to rubber contamination

15. When applying Sika® Aktivator PRO (orange cap) to the windshield it is critical to

A) apply a thick, heavy layer to ensure a significant application of adhesion promoters
B) apply in one direction and then wait 3 minutes flash time for ambient temperatures above 15°F, 10 minutes when temperature is between 0°F and 15°F
C) apply in one direction, wait 10 minutes, and then wipe-off using a clean, lint-free towel

16. Any glass cleaner is acceptable to use as long as

A) there is no alcohol or ammonia contained within the product
B) the glass cleaner utilizes either a mint or winter fresh fragrance
C) the glass cleaner does not contain anti-static ingredients

17. Hot applied (or heated) Sika adhesives can be heated for a cumulative total period of

A) 1 hour
B) 10 hours
C) 9 months

18. Which of the following Sika urethane adhesives is **NOT** rated non-conductive?

A) SikaTack®-Ultrafast II
B) Sikaflex® 220+
C) SikaTack®-ASAP

19. The shelf life of Sika® Aktivator PRO (orange cap) and Sika® Primer-215 (white cap) is

A) 9 months
B) 12 months
C) 6 months

TECHNICIAN TRAINING TEST

Section 2 (continued)

Please determine the BEST answer to each question

20. The reason for applying adhesive using a "V" cut nozzle is

A) to prevent air from being trapped between the adhesive bead and the glass
B) to prevent the adhesive from "skinning over" too quickly
C) to provide an OEM appearance

21. The "short-cut" method of removing existing urethane is wrong because

A) it won't allow for enough time for the new urethane system to reach it's SDAT strength
B) it doesn't provide a bondable surface for the new urethane
C) it doesn't provide enough space for the proper amount of new urethane to be applied

22. The proper procedure for cleaning a dirty pinchweld is to

A) remove loose debris using a towel and water or oil-free compressed air if necessary. For heavy cleaning Sika Aktivator PRO can be used. Then trim the existing urethane bead.
B) blow out lose debris after trimming urethane to ensure all contaminants are removed. If additional cleaning is required, use alcohol or acetone
C) remove lose debris prior to trimming bead. After trimming the existing urethane bead, clean the opening with 3M adhesive cleaner

23. To properly prepare a rear slider, with a frame constructed of a painted aluminum extrusion, you must

A) abrade the bonding surface, apply Sika® Aktivtor PRO and then apply Sika® Primer-215, following the specific applications instructions of each product
B) abrade the bonding surface, apply Sika® Aktivtor PRO and then apply Sika® Primer-206 G+P, following the specific applications instructions of each product
C) apply Sika® Primer-215, following the specific applications instructions for the product

24. The procedure to use when installing a glass part with a "Pre-Applied-Adhesive-System" (PAAS) is to

A) apply Sika® Primer-215 to the bonding surfaces of the pre-applied adhesive following normal application procedures
B) apply Sika® Primer-206 G+P to the bonding surfaces of the pre-applied adhesive following normal application procedures
C) apply Sika® Aktivator PRO to the bonding surfaces of the pre-applied adhesive following normal application procedures

25. To maximize shelf life, Sika urethanes should be stored

A) at temperatures above 75°F
B) at temperatures below 75°F
C) it doesn't matter, Sika urethanes are usable for 9 months no matter what the storage condition

26. The special precaution for technicians to take when installing a glass part using SikaTack®-ASAP below 40°F is

A) to heat the adhesive for an additional 30 minutes to be sure that it will be at least 167°F
B) to apply the urethane and set glass part away from direct sunlight which will shorten the working time of the adhesive
C) to set the glass within five minutes of the adhesive application because at low temperatures repositioning the glass part will be difficult

27. The shelf life of Sika® Primer-206 G+P (black cap), packaged in 250 ml cans is

A) 9 months
B) 6 months
C) 13 months

TECHNICIAN TRAINING TEST

Section 2 (continued)

Please determine the BEST answer to each question

28. When applying Sika® Primer-206 G+P (black cap) at temperatures below 40°F

A) confirm dryness of the primer by touching a non-bonding area with a clean nitrile glove. It may take up to 25 minutes to dry
B) dry the primer with a heat gun and test with a nitrile glove to assure that it is dry
C) lightly spray wet primer surfaces with warm water to speed up the cross-linking of the urethane polymer that is in the primer

29. When applying the "V" bead to the pinchweld, the height of the bead should

A) exceed the roofline of the vehicle by ½ inch
B) not exceed the pre-cut dimensions of the provided Sika nozzle
C) match the height of the vehicle's roofline

30. When replacing a windshield in a vehicle that just had the pinchweld repaired and repainted by a body shop, which of the following is the proper procedure to prepare the fully cured etch primer (i.e; PPG DP-40) prior to adhesive application?

A) Lightly abrade and apply Sika® Aktivator PRO
B) Lightly abrade, apply Sika® Aktivator PRO and one coat of Sika® Primer-206 G+P
C) Lightly abrade and one coat of Sika® Primer-206 G+P

31. Preparation of the pinchweld for gasket set windshields requires

A) application of acetone to cut all foreign adhesive material and ensure a clean metal surface for bonding
B) application of Sika® Aktivator PRO, allowing 15 minutes flash-off / cure time, in order to clean and prepare the pinchweld for bonding
C) apply Sika® Primer-215, following the specific applications instructions for the product

32. It is acceptable to treat up to 24 in^2 of corrosion on the pinchweld using which of the following procedures, assuming that the corrosion has not perforated the metal?

A) Remove all corrosion, abrade the paint edges, apply Sika Aktivator PRO and then 1 coat of Sika® Primer-206 G+P according the recommended application procedures
B) Remove all corrosion, abrade the paint edges, apply Sika Aktivator PRO and then 1 coat of Sika® Primer-215 according the recommended application procedures
C) Remove all corrosion, abrade the paint edges, apply Sika Aktivator PRO and then 2 coats of Sika® Primer-206 G+P according the recommended application procedures

33. Under which of the following circumstances may a "removed" glass part be reinstalled using Sika's AGR adhesive systems?

A) The adhesive that remains on the glass part is a polyurethane and does not have good adhesion around the entire perimeter
B) The adhesive that remains on the glass part has good adhesion around the entire perimeter, but it cannot be confirmed to be a polyurethane
C) The adhesive that remains on the glass part is a polyurethane that has good adhesion around the entire perimeter

34. The reason for using a lint free paper towel and rotating to a clean side when re-applying Sika® Aktivator PRO from a 250 ml can is

A) to guarantee a good and professional appearance of the application
B) to avoid allowing contaminants from the towel to mix with the contents of the can
C) to make sure to lower costs per installation by not having to purchase extra daubers

35. Windshields that are supplied with a black primer can be installed

A) if prepared with an additional coat of Sika® Primer-206 G+P
B) by removing the primer down to the frit and applying Sika® Aktivator PRO
C) if the primer has been factory applied, is sound, and by preparing the bonding surface with Sika® Aktivator PRO

Overview

The seating in your Blue Bird All American 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 All American 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.***

To adjust seat position forward or backward, hold lever (A) to the left.
To adjust the height:

1. Loosen knob (B) in rear.
2. Lift height adjust handle (C) on side.
3. Slowly sit or stand to position seat at desired height.
4. Release height adjust handle prior to applying full weight.
5. Tighten knob in rear.
6. Fasten and adjust seat belt.

To adjust the back angle, lean forward slightly to remove pressure from seat back and turn adjustment knob at left side of seat cushion. For lumbar support adjust knob at right side of seat back. The arm rest can be raised out of the way or adjusted for comfort by raising and lowering.

Deluxe Driver's Seat

Deluxe Driver's Seat Controls

1. Weight and Height Adjustment—to adjust, push in valve knob to raise seat and pull out to lower. When adjusted properly, the seat will not rest against the top, or bottom, limits of vertical motion under normal driving conditions. Adjustment position should also provide for driving visibility and vehicle control.

2. Fore and Aft Adjustment—Hold lever to the left to adjust seat position forward or backward.

3. Back Angle Adjustment—Lean forward slightly to remove pressure from seat back. Hold handle rearward to adjust to any position within range.

4. Cushion Tilt Adjustment—Rotate seat tilt knob to decrease or to increase seat tilt.

5. Lumbar Adjustment—Rotate knob forward to increase, or rearward to decrease, the support in the lumbar area.

WARNING ***Do not attempt to adjust the driver's seat, while the vehicle is in motion. Do not adjust height while sitting in the driver's seat. Keep feet and other items away from height adjustment handles and pedals while vehicle is in motion.***

Driver's Seat Lubrication

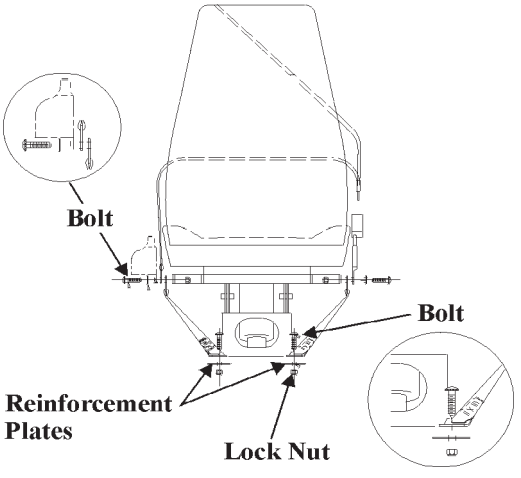
CAUTION ***Lubricants can damage vinyl. Use caution around upholstery.***

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.

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.***

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.

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 re-installed 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.

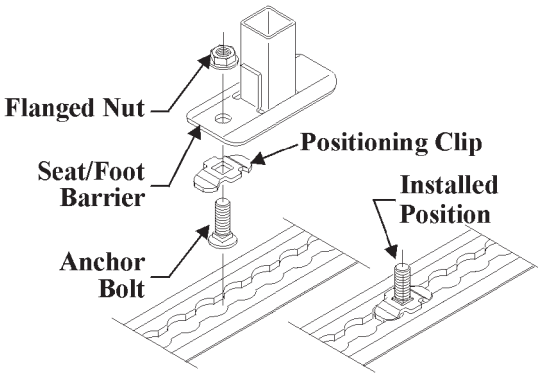
3. Lower the forward edge to the frame, making sure the swivel clamps are inside the frame and the posi-tive type clamps are secure on the rear-retaining channel.

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 All American 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.

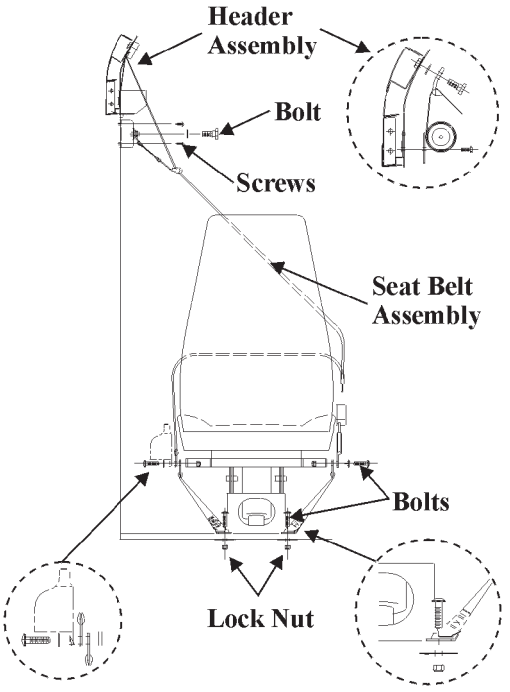
WARNING ***Be sure the lap belt is fitted snugly around the hips and not the waist. Failure to do so may increase the chance of injury in the event of a collision.***

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 Attach 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.

Exterior Paint

The Blue Bird All American exterior is finished with a heat cured polyurethane. All exterior surfaces are smooth and free of wrinkles and dents. Exterior painted surfaces are properly prepared as required by the paint system supplier, prior to application of paint to assure a proper bond between the basic surface and successive coats of original paint for the service life of the bus. Drilled holes and cutouts in exterior surfaces are made prior to cleaning, priming and painting to prevent corrosion. The bus is completely painted prior to installation of exterior lights, mirrors and other items, which are applied to the exterior of the bus.

Paint is applied smoothly and evenly with the finished surface free of dirt and the following other imperfections:

A. Blisters or bubbles appearing in the topcoat film.
B. Chips, scratches, or gouges of the surface finish.
C. Cracks in the paint film.
D. Craters where paint failed to cover due to surface contamination.
E. Over spray.
F. Peeling
G. Runs or sags from excessive flow and failure to adhere uniformly to the surface.
H. Chemical stains and water spots.

To the degree consistent with industry standards for commercial vehicle finishes, painted surfaces have gloss and orange peel minimized. All exterior finished surfaces are impervious to diesel fuel, gasoline and commercial cleaning agents. Finished surfaces resist damage by controlled applications of commonly used graffiti-removing chemicals. Colors and paint schemes shall be specified by Procuring Agency.

Interior Paint

Materials are selected on the basis of maintenance, durability, appearance, safety, flammability, and tactile qualities. Trim and attachment details are kept simple and unobtrusive. Materials are strong enough to resist everyday abuse and vandalism; they are resistant to scratches and markings. Interior trim is secured to avoid resonant vibrations under normal operational conditions.

Front End

The entire front end of the bus is constructed to minimize debris accumulation behind the dash and to prevent the operator's feet from kicking or fouling wiring and other equipment. Paneling across the front of the bus and any trim around the operator's compartment is formed metal, plastic, or composite material. Plastic dash panels are reinforced, as necessary, and replaceable. All colored, painted, and plated parts forward of the passenger seat barriers are finished with a dull matte surface to reduce glare. Color is coordinated to compliment the entire interior of the bus.

Rear End

The rear interior surfaces are constructed with steel. Color is coordinated to compliment the entire interior of the bus.

Interior side trims and panels are steel and aluminum. Panels are tamper-resistant and reinforced, as necessary, to resist vandalism and other rigors of school bus service. Individual trim panels and parts are interchangeable to the extent practicable. Untrimmed areas are painted and finished. Color is coordinated to compliment the entire interior of the bus.

Headlining

Standard ceiling panels are constructed of steel material. Headlining is supported to prevent buckling, drumming, or flexing and is secured without loose edges. Moldings and trim are aluminum, or plastic, colored to complement the interior of the bus.

Fastening

Interior panels are attached so that there are no exposed unfinished or rough edges or rough surfaces. Panels and fasteners are not easily removable by passengers. Interior trim fasteners are rivets or cross-recessed head screws.

Floor Covering

The floor covering is a non-skid walking surface that remains effective in all weather conditions and complies with all ADA requirements. RCA rubber flooring is also an available option. The floor covering, as well as transitions to the entrance area, are smooth and present no tripping hazards. Color/pattern is consistent throughout the floor covering.

The floor in the operator's compartment is easily cleaned and arranged to minimize debris accumulation. The driver's platform is raised two inches above the floor in the passenger area to prevent objects from rolling or sliding forward and interfering with the driver's operation of the bus.

The floor under the seats is covered with smooth surface flooring material. The floor covering closely fits the sidewall cove.

Undercoating

The body is undercoated with "Tectyl 355" and baked for durability before being mounted on the chassis. This ensures the most effective protection from road salt and other rust causing agents. "Tectyl 355" undercoating meets a rigorous 1000 hour salt spray test.

Additional undercoating may be applied over the existing undercoat provided a commercial grade undercoating material is used. Additional undercoating may be desireable in areas where corrosive chemicals are used for snow and ice removal.

Lettering/Decals

The standard lettering on the Blue Bird All Amrican displays "SCHOOL BUS" in 8 inch black vinyl lettering on the front and rear roof caps. Additional lettering is available. Contact your Blue Bird Dealer for available features.

"3M" diamond grade reflective vinyl is used as a safety feature to make the bus more visible in adverse or low light conditions. Reflective vinyl frames the words "SCHOOL BUS" on the front and rear roof caps. A 2 inch wide strip at the floor line extends the full length of the body on both sides. The rear of the bus is framed at the top, bottom and both sides using a 1.75 inch reflective strip. A one inch strip is used around all emergency exits. When replacing the reflective vinyl, use only that which meets federal, state and local regulations for school buses.

School Bus Lettering

Reflective Tape

Exterior Cleaning

Before cleaning and waxing your bus a few basic rules should be followed:

- Start your project with the bus out of direct sunlight.
- Make sure the paint is not warm to the touch before applying any cleaning product or wax.
- Spray your bus with ample amounts of water before washing. Use the water to spray off dirt and other contaminates that will scratch the surface.
- Wash and rinse in sections so the wash soap doesn't dry before being rinsed off.
- Drying your bus after washing is necessary to prevent water spots – mineral deposits that etch the outline of a drop of water into your vehicle's paint.
- Read the manufacturer's directions on all products used prior to use.

Wash

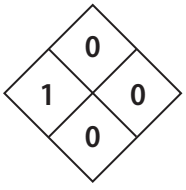
In order to preserve your vehicle's finish, Blue Bird requires protection of the finish by washing a minimum once every 3 months.

- Wash the vehicle in lukewarm or cold water.
- Use a lamb's-wool or paint-safe microfiber washing mitt to prevent scratching the surface.
- Do not use hot water or wash in the direct rays of the sun.
- Do not use strong soap or chemical detergents.

Only cleaners with an HMIS rating of 1,0,0,0 or less should be used to clean the buses. This HMIS rating is available on all product MSDS.

Hazard Rating (NFPA/HMIS)

Health = 1 Reactivity = 0
Fire = 0 Special = 0



Rating Scale

0 = Minimum 1 = Slight
2 = Moderate 3 = Serious
4 = Severe

To wash units, Blue Bird Corporation recommends Bird Bath™ Bus Wash & Wax Concentrate, available from authorized Blue Bird Dealers. Bus Wash & Wax is a concentrated vehicle wash (rated triple-zero) that is recommended to be mixed at up to a 20/1 ratio for new and reconditioned buses.

CAUTION ***Pressure washing may cause damage to finish. Pre-test pressure washer on a similar surface before applying pressure and chemicals to your vehicle. Pressure washers that re-circulate should filter the water to remove abrasive grit.***

Magnesium chloride, calcium chloride and other salts, ice melting agents, road oil and tar, tree sap, bird droppings, chemicals from industrial chimneys, and other foreign matter may damage vehicle finishes if allowed to remain on painted surfaces. Prompt washing may not completely remove all of these deposits. Additional cleaners may be needed. When using chemical cleaners developed for this purpose, be certain they are safe for use on painted surfaces.

Wax

Wax your bus a minimum of once a year with a nonabrasive wax. This is required to remove accumulated residue and eliminate any weathered appearance. It is essential that units are not waxed in direct sunlight.

Products labeled cleaner wax or polish should not be used as they are somewhat abrasive and can actually remove some paint from the surface of the vehicle. Care should be taken when choosing a wax to make sure that it does not contain abrasive materials i.e.; calcium carbonate, pumice, plastic beads, etc.

- Before waxing, thoroughly wash and dry the bus.
- Never wash or wax a bus in direct sunlight or if the paint is hot to the touch. The sun can soften the paint and make it more susceptible to scratching.
- Use a lamb's-wool mitt for washing and soft cotton rags or microfiber towels for waxing. Do not use rags for waxing; they can trap dirt and scratch the finish. Synthetic fabrics and brushes can also scratch the finish.
- Wash and wax in small sections. This saves time and if the wax stays on too long, it can be difficult to remove.

Approved Waxes

- Mequiars Gold Class Liquid Wax
- Mequiars NXT Generation® Tech Wax® 2.0 Paste or Liquid
- Black Magic Wet Shine Liquid Wax
- Turtle Wax Carnauba Car Wax T-6
- Turtle Wax 1 Step Wax & Dry T-9
- Nu Finish NFP-80

Bus Downtime Treatment

During periods of bus downtime, Blue Bird Corporation recommends the application of Bird Bath™ Bus Guard Protectant available from Blue Bird authorized dealers to protect exterior surfaces. Bus Guard is a triple-zero product that, when properly applied, protects against harmful UV rays and other damaging environmental conditions. For sufficient protection, see product instructions for the proper application requirement.

Owners should refer to the limited warranty statement supplied with the vehicle regarding their responsibilities for care and maintenance of the vehicle during the warranty period.

General Specification, Chassis

Specifications are for standard equipment, unless otherwise stated.

Alternator

All American RE Alternator Output @ Idle		
200 amp Bosch (standard)		
ENGINE	COLD (25C)	HOT (80C)
Cummins ISC-07	160 amps	138 amps
Cummins ISL-G	160 amps	138 amps
185 amp Leece Neville (optional)		
ENGINE	COLD (25C)	HOT (93C)
Cummins ISC-07	158 amps	135 amps
Cummins ISL-G	158 amps	135 amps
270 amp Leece Neville (optional)		
ENGINE	COLD (25C)	HOT (93C)
Cummins ISC-07	218 amps	175 amps
Cummins ISL-G	218 amps	175 amps
320 amp Leece Neville (optional)		
ENGINE	COLD (25C)	HOT (93C)
Cummins ISC-07	240 amps	205 amps
Cummins ISL-G	240 amps	205 amps
240 amp Leece Neville (standard)		
ENGINE	COLD (25C)	HOT (125C)
Cummins ISC-10	185 amps	158 amps
275 amp Delco Remy (optional)		
ENGINE	COLD (25C)	HOT (125C)
Cummins ISC-10	212 amps	178 amps
300 amp Delco Remy (optional)		
ENGINE	COLD (25C)	HOT (125C)
Cummins ISC-10	235 amps	192 amps

Axle, Front

Hendrickson Steertek. Synthetic lubed bearings. Hubcaps with window seal included. 13,200 lbs. capacity. Other models may be installed depending upon GVWR, suspension, and/or brakes options:

Hendrickson Model	GAWR	Details
SteerTek	13,200 lbs	4.25" drop. Standard.
SteerTek	13,200 lbs	5.36" drop.
SteerTek	14,600 lbs	4.25" drop.
SteerTek	14,600 lbs	5.36" drop.

Axle, Rear

Meritor single reduction speed with synthetic lubed bearings. Standard model is RS23-160; 23,000 lbs. capacity; 5.38 to 1 ratio. All American RE may be equipped with optional models depending upon GVWR and reduction ratio, suspension, and/or brakes options:

Meritor Model	GAWR	Details
RS19-144	19,000 lbs.	
RS21-145	21,000 lbs.	Standard.
RC23-160	23,000 lbs.	
RS23-160	23,000 lbs.	
RC23-161	23,000 lbs.	

Batteries

Three Group 31, 12V, 3375 Cold Cranking Amps (combined) 2/0 battery cables are standard. With Optional battery disconnect switch, 4/0 cables are std.

Braking System

Parking. 30 sq. in. spring brake system with treadle valve modulation. Instrument panel mounted valve provided for parking.

Service Brakes. Dual full air with Meritor - "S" cam 16.5 x 6" front and 16 .5 x 7" rear. Non-asbestos Q-Plus extended service linings. Dust shields are optional. Wider 8.62" or 10" brake linings are installed on some All American Rear Engine buses according to optional equipment and dependent upon GVWR. 24 sq. in. front and 30 sq. in. rear service brake chambers.

Air Tanks. One single compartment tank with 1760 cu. in. and one dual compartment tank with 1250 cu. in. in each. Total capacity of 4260 cu .in.

Air Compressor. Cummins/Wabco 18.7 cfm capacity @1250 rpm, compressor gear driven. Uses filtered and turbo charged clean engine air.

Automatic Slack Adjusters. Meritor.

Antilock (ABS). Air brakes include electronic control unit remote mounted to facilitate service.

Bumpers

Bumpers are die-formed, 12" high with 90° flanges, top and bottom.

Front. One-piece 3/16" thick steel plate with step holes for cleaning windshield.

Rear. One-piece 3/16" thick steel plate with 14" wraparound at corners and double "a" frame bracing.

Controls

Driver Controls. Electronic throttle, high idle switch, air brake pedal, parking brake valve, transmission selector, dimmer switch, self-canceling directional signal switch, hazard signal switch, headlamp switch and instrument panel with PWM dimmer controlled lighting. Key-type starter switch.

Engine compartment. Remote engine start switch, starter button, compartment light switch and tachometer.

Cooling system

The All American Rear Engine incorporates a cross-flow radiator with a charge air cooler mounted in tandem and located on the right side (curbside) of the bus. A nylon cooling fan is attached to an electrically actuated clutch. This assembly is belt driven through the use of a gearbox.

Transmission Cooling. Transmission fluid cooled by 2100 btu/min heat exchanger external to radiator.

Drive line

Spicer SPL 70, SPL 100 or SPL 140 with protective guard around shaft (1610 series - 273" wb).

Engine

Blue Bird All American Rear Engine buses are equipped with a Cummins ISB, ISC, (Diesel) or ISL-G (Compressed Natural Gas) engine.

> **CAUTION** ***Blue Bird diesel fuel systems are not compatible with biodiesel. Engine manufacturer's warranty regarding performance, emissions and durability can be affected by using biodiesel***

Cummins ISC-10. Cummins ISC-10 engines are certified for EPA and CARB and meets EPA standards. This engine includes a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF).

The ISC-10 engine protection system monitors key engine parameters, and logs diagnostic faults when an abnormal operating condition occurs. The engine de-rates available power and maximum vehicle speed when certain fluid parameters pass a limit threshold, or a maximum coolant temperature. The ECM keeps an electronic data log of time of occurrence, elapsed times, extreme pressures and extreme temperatures when the system detects an out-of-range condition.

Oil pressure and coolant level sensors mounted on the engine provide input to the engine protection system. Minimum pressure cap rating is 15 psi at sea level. Thermostats open at 180° F and fully open @ 200° F. Fan is fully on at 210° F engine coolant temperature.

Fuel/Water Separator supplied with engine.

All American Rear Engine Cummins ISC-07 Configurations				
Engine	**Horsepower @ RPM**	**Torque @ RPM**	**Transmission**	**Brakes**
Cummins ISC-7 8.3 L Turbo Diesel 260/660	260@2200 (250@2500 governed)	800 ft lb @1300	Allison PTS 3000	Air Brakes
Cummins ISC-7 Turbo Diesel 285/800	285@2000 (275@2200 governed)	800 ft lb @1300		
Cummins ISC-7 Turbo Diesel 300/860	260@2000 (285@2500 governed)	860 ft lb @1300		
All American Rear Engine Cummins ISC-10 Configurations				
Engine	**Horsepower @ RPM**	**Torque @ RPM**	**Transmission**	**Brakes**
Cummins ISC-10 Turbo Diesel 260/660	260@2200	660 ft lb @1300	Allison PTS 3000	Air Brakes
Cummins ISC-10 Turbo Diesel 270/800	270@2000	800 ft lb @1300		
Cummins ISC-10 Turbo Diesel 300/860	270@2000	860 ft lb @1400		
All American Rear Engine Cummins ISL-G Configurations				
Engine	**Horsepower @ RPM**	**Torque @ RPM**	**Transmission**	**Brakes**
Cummins ISL-G 8.9L Turbo	250/730@2200 (250@2200 governed)	730 ft lb @1300	Allison PTS 3000	Air Brakes
	260/660@2200 (250@2200 governed)	660 ft lb @1300		

Exhaust

4" O.D. 2 ply stainless steel bellow flex style piping from engine turbo charger to DPF. Heavy-duty stainless steel. 4" O.D. 16 gauge, aluminized steel tailpipe. Tail pipe arrangement is dependent on features ordered. Shields and heat wrap are provided in strategic locations along the exhaust system.

Frame

Main frame. Dual C-channels, 9.63" high with 3" flanges made of .25 thick, 50,000 psi steel, section modulus = 10.1 in.cu.

Insert. Liner across rear suspension is dual C-channels, 9 1/6" web with 2 3/4" flanges made of .25 thick, 50,000 psi steel. Insert section modulus = 9.5 in.cu. Total section modulus = 19.6 in. cu.

Sub-frame. dual C-channels, 50,000 psi steel. Sub-frame rails are turned with flanges outward and lowered 6" below main frame to best accommodate engine and related components. Section modulus = 7.80 in.cu. Sub-frame rails are 65" long and overlap main rail and insert 24" where joining is reinforced with dual 3" x 3', 1/4" thick angle.

Fasteners. All permanent fixtures on frame are attached with hi-tensile strength "huck-spin" fasteners with swaged lock nuts.

Fuel system

Tank. 100-gallon capacity aluminized steel, safety tank mounted between frame rails. Includes a sender inspection plate and right hand fill opening with spring loaded locking door.

Filter. Primary fuel filter/water separator is Racor 490r30 rated at 90 gph, 10 micron, with see-thru bowl and self-venting drain, 200 watt heater. Filter head includes integral check valve on inlet side. Secondary fuel filter is spin-on type mounted on engine and supplied by engine manufacturer.

Fuel pump. Mounted on engine.

Horn

Electrical dual with non-glare horn button emblem.

Backing Safety Horn. Activated whenever the bus is shifted into reverse. Sounds between 87 and 112 db automatically adjusting itself depending on the ambient noise level in the proximity of the alarm.

Instruments

Gauges. Speedometer with English major and metric minor; seven digit Odometer; resettable Trip Odometer; Tachometer; Oil Pressure; Voltmeter; Fuel Level; Coolant Temperature; Front Brake Pressure; Rear Brake Pressure; digital Clock; Panel Dimmer slide; Ammeter. Gauges have automatic self-test at power up. Needles sweep while display indicates "TEST".

LED Telltale Warnings / Indicators. Right and left directional (green); high beam indicator (blue); Service Brake Applied (red); Park Brake Applied (red); ABS Active (amber); Stop Engine (red); Service Engine Soon (amber); Check Transmission (Red); Low Coolant Level (Amber).

Steering

Steering Gear. Full power Ross THP-60 integral unit with 18.2 to 1 ratio; with gear driven hydraulic pump.

Column. Tilt telescoping steering column with 18" diameter, two-spoke, padded steering wheel.

Suspension, Front

Hendrickson SofTek Spring Suspension (Standard). 4" x 56", single stage, heavy duty 3-leaf springs with up-turned eyes, 1.25" diameter pins in graphite impregnated steel backed bronze bushings with urethane seals at each end. 7,300 lbs. Capacity each at ground. Monroe direct acting, 1.75 diameter bore double-action piston type shock absorbers with long life bonded bushings.

Hendrickson AirTek Suspension (Optional). 14,600 lb rated. Integrated front air suspension and steer axle that work together to form an integrated torsion system delivering superb ride stability and handling characteristics with reduced weight and maintenance.

Ridewell Model 227 Air Suspension (Optional). Parallelogram design with four air cushions carrying 100% of axle load. Long life maintenance free bushings and urethane thrust washers. Lateral motion controlled by transverse track rod. Vertical motion controlled by two adjustable heavy duty Koni shock absorbers. Ride height maintained at all loads by a single leveling valve. Caster adjustable via eccentric torque arm bolts.

Suspension, Rear

Hendrickson Softek Spring Suspension (Standard). 3" x 52" semi-elliptic, progressive, variable rate 14-leaf slipper springs, 11,500 lbs. Capacity each at the ground. Maintenance free, rubber bushed radius leaf permits axle adjustment for dog tracking. Oil slinger installed in wheel end to channel lube away from brake lining in the event of failed oil seal. Monroe direct acting, 1.75 diameter bore double-action piston type with long life bonded bushings.

Hendrickson Comfort Air Suspension (Optional). Trailing arm suspension with 2 heavy duty rolling lobe air springs mounted rearward of axle and steel springs forward of axle. Quick align axle dog tracking adjustment. Transverse track rod controls lateral motion. Vertical motion controlled by two 1⅜" bore Sachs shock absorbers. Single height control valve maintains suspension height at all loads.

Ridewell Model 227 Air Suspension (Optional). 4-bag parallelogram design. Long life maintenance free torque arm bushings. Urethane thrust washers. Lateral motion controlled by transverse track rod. Vertical motion controlled by adjustable heavy duty Koni shock absorbers. Two leveling valves, permitting leveling side to side and front to rear. Axle dog tracking adjustable via eccentric torque arm bolts.

Tires

Goodyear or Michelin 11r 22.5 h ply steel belted radial tires, xze highway tread. Aluminum or hub piloted steel 10 stud disc wheels, single front, dual rear, 22.5 x 8.25 rims.

Tow hooks

Two front and rear tow hooks are frame mounted.

Transmission

Allison 3000 PTS series transmission is standard. 6 forward speeds with 1 reverse. Synthetic transmission fluid is standard.

General Specification, Body

Access panels

Exterior. All access panels include keyed locked latches.

Front Access Panels. An inverted "L" shaped door at right front providing access to wiper motor and heater fresh air intake screen. Another door at left front providing access to windshield washer reservoir and wiper motor.

Body Electric Panel. A 28" x 22" hinged keyed lock door on exterior below driver's window providing access to the electrical junctions, circuit breakers and terminals for body wiring.

Chassis Electric Panel. A hinged door directly behind the rear axle on the curbside provides access to the Power Distribution Unit (PDU) which houses chassis terminals, circuit breakers and bus bars.

Compartments

Battery. Enclosed compartment 23.63" x 24.00" with rolling tray. Includes two retaining pins with cable to secure the tray in a closed position. Hinged door with recessed locking "paddle handle" latch. Located behind rear axle, right side. (holds 2-8 d batteries or 3-delphi freedom batteries)

Engine Compartment. A hinged, non-perforated door installed at the rear provides access to the engine for service. Two additional hinged doors on right and left sides, provide for access to radiator and air cleaner.

Doors

Outward Opening Entrance Door, Electric. Door consists of two separate door panels which open outward and close to seat against the outside edge of the lower step. Each panel is ball bearing suspended for ease of operation and wear resistance. A 4" wide header pad over the door opening inside bus is included. Openings for two glass panes with square corners are provided in each door panel. Includes a flush pull handle installed on the outside of the forward door panel, designed to provide a finger grip when opening the door from the outside of the bus. Door operates by a means of an Eberhard electric actuator controlled by a spring loaded "Open/Close" switch in the driver's area. The controls allow the driver to stop the doors in any position between open and closed, or to allow the doors to automatcally stop in open and closed positions after initial actuation. A manual emergency release is located above the door inside the bus to disengage the actuator and allow the doors to open freely. Control switch will be right hand located.

Outward Opening Entrance Door, Air. Door consists of two separate door panels which open outward and close to seal against outside edge of lower step. Includes laminated green tinted glass. Keyed security lock mechanism includes a deadbolt from the door panel to the header above the door. Ball bearing suspended for ease of operation and wear resistance. Doors are activated by a means of an air cylinder, with an electrically controlled valve assembly located over the door and a rocker-type switch accessible to a seated driver. Includes an emergency release valve in door header cover. An air pressure protection valve is also included. There is a 4" wide header pad covered with solid black fire-block upholstery over the door opening inside the bus and a stainless steel assist rail at the rear of the stepwell.

Emergency Door. Left side emergency door required-all are optional.

Electrical

Accessory Power Socket With Cap. Provides 12 volt power socket for connecting electrical accessories such as cellular phones, CB radios, etc. One per vehicle.

Fans

6" fan mounted to wire molding, located in the upper left, above driver's window. 6" fan mounted to windshield header, center of body.

Floor

Aisle. 3/16" thick ribbed gray rubber in aisles and at entrance aisle area. Aluminum aisle trim over joint in floor covering, full length of body.

Under seats. 1/8 inch thick smooth gray rubber. Cove molding at wall is galvanized steel.

Wheelhousing. Front and rear molded black smooth rubber. Galvanized steel wheelhouse trim

Subfloor. 5/8" AB marine grade plywood, attached with screws.

Headroom

Full 78", over 5/8" marine grade plywood and floor covering, measured at center aisle.

Heater / Defroster

Dual ball type heater cut-off valves isolate system from engine and radiator when necessary. Auxiliary pump with heavy duty motor seals, and housing. Mounted in the engine compartment. Goodyear hi-miler heater hose with constant torque clamps at all joints, including all heater hoses and hose clamps within the body heater system. Electrically controlled water regulating valve.

Front Heater/Defroster. 90,000 BTU with washable air filter. Driver selects air flow up to 100% for defrosting windshield, driver's window, and entrance door as conditions require.

Auxiliary. 12,000 btu, two speed heater under driver seat left side.

Insulation

Roof, sides, front and rear (including corners & bows) are insulated with 1 ½" thick material providing an R value of 5.75. Drivers left hand close-out panel is insulated inside and outside.

Lettering

3M Diamond Grade "SCHOOL BUS" 8" black vinyl letters on yellow reflective tape on roof caps, front and rear. BLBS lettering and bus #'s.

License panels

Two license plate embosses right and left rear on engine compartment door. Nylon nuts with slot head screws installed at emboss left side.

Lights

Back-Up. Two 5" clear right and left rear on engine compartment door.

Clearance. Two amber front and two red rear single with shields. Tail light switch operates clearance, cluster and side marker lights.

Cluster. Three amber front and three red rear with shields.

Daytime Running. Headlamps, tail, license plate, parking, clearance & marker lights activated when engine is running.

Directional. 7" front and rear, two plain amber front, two amber rear. Sealed shock mounted, side directional mounted at front belt line area.

Dome. Two rows equally spaced at center over aisle. Two switches, front and rear.

Driver's Dome Light. Activated with separate switch plus a separate switch to control last two dome lights (15 candlepower).

Engine Compartment. Two red lights, activated with the hazard lights, visible when door is open.

Headlights. Four rectangular, halogen single sealed-beam with alarm indication when ignition is off and head lamps are on.

Parking. 4" amber, right and left front.

Side Marker. Amber right and left intermediate side marker lights.

Stepwell. Wired to operate with ID lights with entrance door open (14 candlepower).

Stop / Tail. Two combination lights, 4" right and left rear license panel in combination with 7" stop & tail lights with clear red lens, on engine compartment door.
Warning Lights. Weldon 8-light sequential system with dual hoods.

Mirrors
Exterior. All exterior mirrors are heated. Heat is controlled by an on/off switch.
Crossview. A Rosco "Mini-Hawkeye" crossview mirror system is provided to allow a seated driver to view pedestrians while the bus is stopped. The crossview mirror system is comprised of a 10.8" x 12.5" elliptical mirror with tinted upper portion to reduce glare supported by a center mounting post with ball stud mounted, on both lh and rh sides of the bus. The mirror mounting posts are attached to the front cowls, and feature a breakaway pivot to reduce damage in the event of accidental contact. The crossview mirror system allows for viewing all areas along the front and sides of the bus which are not visible by direct view.
Rearview. The Rosco Avia rearview mirror system is designed to provide a view of the roadway to the rear, as well as a view of the ground along both sides of the bus. The rearview mirror system is comprised of 9" x 17" oval heads each containing 74 sq. in. flat and 38 sq. in. convex mirror, on both left and right sides. The right rearview mirrors are located to be visible through the wiped area of the windshield. The left rearview mirrors are located so as to be visible through the driver's window. The rearview mirrors on both right and left sides feature a spring breakaway pivot and are adjustable without tools.
Interior Rearview. 6" x 30" with 3/16" clear safety glass laminated to steel backing plate. Mirror has 1 3/4" radius rounded corners. Perimeter of mirror is padded for safety. The interior rearview mirror is installed above the seated driver on the front upper inner panel, and is designed to provide a clear view of the interior of the vehicle and of the roadway to the rear.

Mudguards & Flaps
Front. Metal guard forward of front axle; left side. Mudflaps to full length, installed behind front wheels. Fenders, black rubber.
Rear. 23 x 30" mudflaps; both sides (without logo and extended). Fenders, black rubber.

Paint
Exterior. National school bus yellow with black trim and black bumpers. OEM, heat cured polyurethane.
Interior. Astro white, hot sprayed-on baked enamel, except on aluminized inner side panels. Seat frames black, heaters and trim black, switch consoles and dash gray.
Rust Proofing. Body parts thoroughly rust-proofed after fabrication and before assembly.
Undercoat. Underside of body floor, skirt and wheelhousing thoroughly undercoated prior to body mount to ensure best coverage and maximum corrosion resistance. Undercoat material offers optimum corrosion protection.
Roof cap. A minimum area of 3" band of black background is inserted around front and rear warning lights.

Panels, Exterior

Body. 19 3/4" skirt. Outside side panels are constructed of 16-gauge smooth steel, includes window line, seat line, floor line, and skirt line rubrails. Side panels extend from below the side windows to a distance of 19 3/4" below the floor. Rear corner panels are constructed of 20-gauge steel. Front cowl panels are constructed of 16-gauge steel.

Roof. Front roof cap is formed from 16-gauge steel. Rear roof cap is formed from 20-gauge steel. Roof sheets are of 20-gauge steel and span the entire width of the bus (window header to window header). Roof sheets include an embossed rain visor over side windows.

Floor. Panels are constructed of 14-gauge steel and are reinforced with full width U-channel cross members. All floor joints are reinforced with matching "L" shaped bends which interlock and are held in place with welds.

Panels, Interior

A removable 18-gauge steel front upper inner panel is provided to allow access to the front roof cap area. Wire molding over window provides easy access to body wiring harness. Textured aluminized fully hemmed steel inside side panels are provided, extending from the window sill down to the floor gusset seat ledge, for the entire length of the body on both left and right sides. Perforated acoustic headlining panels, spanning the entire width of the bus (window header to window header), are constructed of 22-gauge steel and are double-hemmed to provide additional joint strength.

Radio

AM/FM/PA/DVD console mounted with 8 deluxe speaker system. Wiring for two way radio system. (Two way radio is not included.)

Reflectors

Standard reflectors include:

- Two 3" amber mounted on side of body near front.
- Two 3" red mounted on side of body near rear.
- Two 3" red mounted on rear of body.
- Two 3" amber right and left intermediate side reflectors on vehicles 30' and longer.

Reflective tape. 3M Diamond Grade. One-inch minimum width strip surrounds each emergency exit, 1 3/4" wide rear structure and 2" wide strip on each side of unit at approximately floor level. Front and rear roof cap, with black 8" "school bus" lettering.

Canada. 1" wide strip of yellow reflective vinyl on each side of the bus, above the Passenger windows. Also provides vertical 1" strips of yellow reflective vinyl at both the rear bow and front corner post, both sides of the bus.

Rubrails

Four double ribbed 16-gauge steel applied rubrails are installed along both sides of the body. The rub rails are installed as follows: one below side windows; one at seat (passenger) level; one near the floor level; one at the bottom of the skirt. The window rail extends from the front bow on the right side or the front cowl post on the left side to the rear corner radius. The seat rail extends from the front bow, both right and left to the rear corner radius. The floor rail extends from the front bow, both right and left, to the rear side access doors. The skirt rail extends from the front bow on the right side, or the front cowl post on the left side, to the rear side access doors (interrupted by wheelhousing cutouts).

Safety Equipment

Triangular warning device floor mounted.

Seats

Driver's. Bostrom Routemaster. Black vinyl with gray fabric insert. High back pedestal type with seven inch fore and aft travel and five inch vertical adjustment. Seat belt is three-point, floor mounted anti-cinch emergency locking retractor. Adjustable pillar loop provides approximately 7 1/2" vertical adjustment at the shoulder belt top mount. Driver's armrest to left of driver on rear portion of switch panel.

Passenger. All passenger seats are optional and are upholstered in fire block vinyl, solid gray.

Stepwell

Straight- 3 step, 24 3/4" depth stainless steel. Step treads with white abrasive stripe inserted and bonded into a recessed area. 3" white rubber abrasive wear plate is located at the floor level step of the entrance door.

Stop Arm

A Specialty solid state electric operated high intensity reflective octagonal stop arm, red with a white border and 6" high lettering. "STOP" or "ARRETT" on both sides. Includes red led cluster lights over and under the word "stop" visible from both sides.

Sun visor

Transparent dark green tint 6.5" x 30" smooth edge plastic. Located in front of driver. Adjustable vertically on two arms pivoted at ends of visor and at anchor points on windshield header.

Switch Panel

Mounted left of driver with rocker-type self illuminated switches for electrical equipment. Brightness of illumination is controlled by a separate dimmer switch located in the left switch panel.

Ventilation

Air Intake. Heater intake on right front below windshield level is electrically controlled. Manual driver's fresh air vent on left by driver's feet. Static non-closing vent in front roof.

Windows

Driver's. Double sliding aluminum sash with security fastener for locking both sashes, laminated green tinted glass.

Rear Emergency. Large, push-out, tempered dark tinted window assisted by self-contained air spring that holds in open position. Lettering "EMERGENCY EXIT", and/or "SORTIE DE SECOURS". Two-inch black double-faced decals on inside above glass. Includes a plug lock cylinder to prevent movement of locked handle.

Side. 12" split sash tempered tinted glass in aluminum frame provides clear opening when lowered.

Windshield. The windshield consists of four separate pieces of flat shaded safety plate glass. To facilitate cleaning of the windshield from the outside, there are non-glare black, grip handles above the windshield glass on each side of the vehicle, with assist steps in bumper.

Windshield Wipers

Electric, intermittent single switch, parallelogram type, bottom mounted with remote control, non-glare arms and blades. Electric windshield washer with hard plastic one-gallon capacity reservoir located behind driver's side front access panel, washer outlets installed on wiper arms.

Wiring

Color and number coded in molding on top of side windows for access to harness without removing windows. Body wiring protected by automatic resetting circuit breakers, located in easy access exterior wire terminal junction under driver window.

Dimensions, Rear Engine

The dimensions shown exclude exterior mirrors, marker and signal lights, bumpers, fender skirts, washers, wipers, and frames and rub rail; and are taken under static conditions at design height. Overall maximum height varies from 123″ to 126″ depending upon choice of tires, suspension system, and body model. Add 3″ for roof vents. Rear bumper adds 1.25″ to overall body length. Front bumper adds 2″ to overall body length.

Width:	**96″**
Interior Width:	**90 ¾″**
Height:	**123″- 126″**
Height, with Air Conditioning:	**Add 16″**
Front Overhang:	**94.48″**
Rear Overhang:	**121.75″**
Skirt Length:	**19 ¾″**
Interior Headroom:	**78″**
Front Door:	**32″ wide, 81″ high**
Wheel Cut:	**50° (nominal)**
Tire Size:	**Goodyear 11R 22.5 G ply tubeless XZE Highway Tread.**

RE Dimensions & Payload Weight (standard equipment)

WHEELBASE	BODY MODEL	CAPACITY	PAYLOAD	CURB WEIGHT	TOTAL WEIGHT	OVERALL LENGTH	TURN RADIUS
189″	D3RE3204	66	8070	20,700	28,770	395.76	29.9′
217″	D3RE3408	72	8790	20,900	29,690	423.76	34.2′
245″	D3RE3700	78	9510	21,700	31,210	451.76	38.4′
273″	D3RE3904	84	10,230	22,500	32,730	479.76	42.6′

Pupil weight @ 120 lb each. Driver @ 150 lb.
Approximate curb & total weights are based on standard equipment units. Optional equipment may significantly increase these estimated weights.

Fastener Grades

The following information defines chassis fastener grades to be used for the installation of various items on the Blue Bird chassis. The fastener grades shown are minimums, and the information applies to Blue Bird installed fasteners only. It does not apply to vendor supplied or installed fasteners, except where noted. Chassis fasteners not specified below must be grade 2 at a minimum. The grade of the hexnut used must be equal to the grade of the bolt to which it is assembled.

General Torque Procedure

Grade 8 and Grade 5 fasteners must be tightened to the recommended torque values listed in the Designated Fastener table. When the washer is on the threaded (hex nut) side, hold the bolt head and tighten the hex nut while reading the torque. Observe the torque to ensure it is in the specified range. It is usual practice to always torque the nut and not the bolt wherever possible. When there are washers on both sides of the bolt (capscrew), or it is assembled into a threaded hole, torque the bolt head to the specified value. Do not lubricate the components when applying torque.

Designated Fasteners Torque Chart (Plated Fasteners) U.S. Standards						
	SAE GRADE 2 (FT-LBS)		SAE GRADE 5 (FT-LBS)		SAE GRADE 8 (FT-LBS)	
SIZE	Min	Max	Min	Max	Min	Max
1/4"–20	3	4	5	6	8	9
1/4"–28	4	5	6	7	9	10
5/16"–18	7	8	12	13	16	18
5/16"–24	8	13	17	19	24	27
3/8"–16	13	15	17	19	24	27
3/8 "–24	15	17	23	26	33	37
7/16 "–14	21	24	33	37	46	52
7/16 "–20	24	27	37	41	52	58
1/2"–13	33	37	50	57	70	80
1/2 "–20	37	41	57	64	80	90
9/16"–12	47	53	73	82	101	115
9/16 "–18	53	59	82	91	115	129
5/8 "–11	63	73	106	112	138	159
5/8 "–18	73	83	112	128	159	180
3/4 "–10	116	129	177	200	250	282
3/4 "–16	129	144	200	223	282	315
7/8 "–9	112	125	289	322	407	454
7/8"–14	125	138	322	355	454	501
1"–8		188	437	483	618	682
1"–12	188	205	483	529	682	746
1"–14	205	210	529	541	746	764

Designated Metric Class 10.9		
	TORQUE (FT-LBS)	
SIZE	Min	Max
M4	2.6	2.9
M5	5	6
M6	9	10
M8	22	25
M10	53	58
M12	75	83
M14	1210	133
M16	176	196
M20	302	336
M24	598	664

Non Designated Fasteners Torque Chart (Plated Fasteners) U.S. Standards						
	SAE GRADE 2 (FT-LBS)		SAE GRADE 5 (FT-LBS)		SAE GRADE 8 (FT-LBS)	
SIZE	Min	Max	Min	Max	Min	Max
1/4"–20	2	4	4	6	6	9
1/4"–28	3	5	5	7	7	10
5/16"–18	6	8	9	13	12	18
5/16"–24	7	9	10	14	14	20
3/8"–16	10	15	16	23	23	33
3/8"–24	12	17	18	26	26	37
7/16"–14	17	24	25	37	46	52
7/16"–20	19	27	28	41	52	58
1/2"–13	25	37	40	57	70	80
1/2"–20	28	41	44	64	70	90
9/16"–12	47	53	73	82	101	115
9/16"–18	53	59	82	91	115	129
5/8"–11	63	73	106	112	138	159
5/8"–18	73	83	112	128	159	180
3/4"–10	116	129	177	200	250	282
3/4"–16	129	144	200	223	282	315
7/8"–9	112	125	289	322	407	454
7/8"–14	125	138	322	355	454	501
1"–8		188	437	483	618	682
1"–12	188	205	483	529	682	746
1"–14	205	210	529	541	746	764

Non Designated Metric Class 10.9		
	TORQUE (FT-LBS)	
SIZE	Min	Max
M4	2.0	2.9
M5	4.2	6
M6	7	10
M8	17	25
M10	33	58
M12	58	83
M14	93	133
M16	137	196
M20	235	336
M24	465	664

Service Precautions

This section proscribes safe working practices which must be followed in order to minimize the risk of personal injury and/or damage to the vehicle. Additional Warnings and Cautions appear throughout this manual.

Also follow all warnings and cautions printed in the various manuals from component manufacturers, included in this manual as chapter Appendixes.

Whenever Working Under the Bus:

Never move under a bus supported only by a hydraulic jack. Use only proper jackstands or lifts. Always check lifting equipment thoroughly to verify proper working condition before each use. Ensure that the lifting equipment is rated for lifting the weight of the bus. Ensure that the surface under all jacks, stands, or lifts is hard, level, and secure enough to support the weight of the bus concentrated on the footprint of the jack. Chock all wheels to prevent rolling in either direction. Disconnect battery cables to ensure the vehicle cannot be started.

About Modifications:

School buses are built in conformance to several levels of stringent governmental regulations. Any user-performed modification of the bus may potentially result in a non-conformance. For this reason, it is Blue Bird's policy that end users should not perform any equipment modifications to the bus. Contact your Athorized Blue Bird Dealer for advice and consultation before adding any electrical accessories or non-standard mechanical equipment.

Whenever Working Around Moving Parts:

Use extreme caution to avoid accidental entaglement. Do not wear loose clothing. Remove all jewelry including watches and rings. Securely cover long hair. Wear eye, hearing, and respiratory protection.

Whenever Working Inside the Engine Compartment:

Disconnect batteries to prevent accidental engine starting. Exercise extreme caution around hot components, and wear sufficiently protective clothing. Whenever possible, allow components to cool completely before working. Be mindful of any system which operates under pressure, and ensure that pressure is released before working on that system.

When closed system components (such as those associated with the fuel system, cooling system, or charge air system) have been removed, always take appropriate measures to prevent contamination of the system by dust, dirt, or debris.

Replacing Fasteners

Do not re-use fasteners in high-torque locations. Replace with new fasteners of appropriate hardness grade.

Performing Structural Repairs:

Welding. Modern school buses are equipped with sensitive electronic equipment such as the multiplex system and the ECUs of engine, transmission, and ABS brakes. Such components can be permanently damaged by current fluctuations. In addition to the welding precautions you would normally take to isolate components which may be damaged by heat, the repair technician must also bear in mind the potential for expensive damage to electronic systems. It is highly recommended that the multiplex Main Bus Controller and other such electronic control units be disconnected before performing any welding anywhere on the body or chassis.

Whenever Rendering Roadside Assistance:

Take measures to ensure the safety of passengers first. Move passengers away from the disabled bus to a safe location in an organized fashion. Use the roadside emergency markers to clearly warn traffic of the hazard. Call for help and alternate passenger pick-up immediately. If at all possible, avoid performing service procedures roadside, and instead have the bus towed to a proper and safe service facility.

Hazardous Materials

Vehicle fluids, including engine coolant, transmission fluid, engine oil and power steering fluid, are hazardous to the environment and to the individual performing maintenance and repair on the vehicle. The handling, storage, and disposal of these fluids are subject to government regulation. Read and strictly follow the warnings and instructions on the labels of all fluids and compounds.

The anti-freeze in engine coolant is Ethylene Glycol. This is a skin, eye and respiratory irritant, and is toxic to humans and animals.

Certain other materials, such as plastics, rubber compounds, solvents and paints, are also considered environmental hazards. Always exercise caution to protect your health and the environment when working with, or disposing of, any chemically active material or compound, including cleaning materials.

Protective Gear

Always wear proper eye protection and other required personal protective equipment to help prevent personal injury when performing vehicle maintenance, repair, or service. These include, but are not limited to:

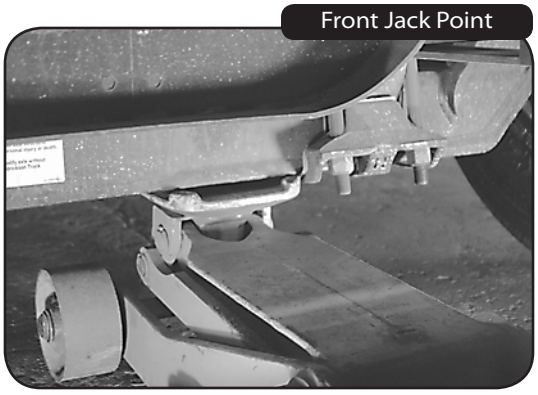
- **Skin protection.** Long sleeves, appropriate gloves, an appropriate apron, etc.
- **Eye protection:** Safety glasses, a facemask, serviceable eye wash equipment, etc.
- **Respiratory protection:** A filter mask appropriate for the material being used, properly ventilated work area, emergency breathing aids, etc.
- **Hearing protection:** Earplugs, earmuffs, etc.

Jacking and Towing

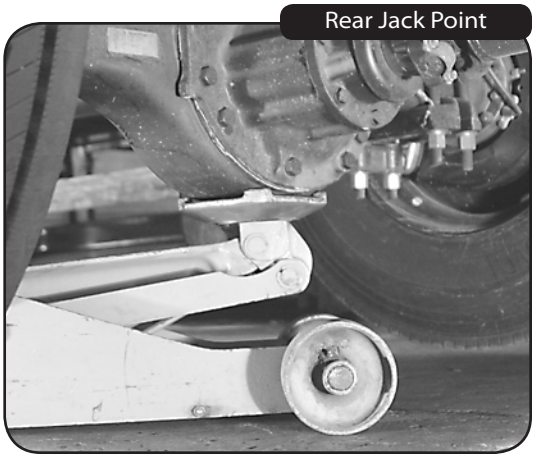
Jack Points

WARNING ***Proper jacking procedures and basic safety measures must be observed to ensure the safety of personnel while working under the bus. Always check the serviceability of any lifting equipment prior to use. Ensure that the lifting device is of sufficient strength to handle the bus, and that the surface provides the necessary firmness to support the weight of the bus concentrated on the footprint of the jack. Never move under a bus supported only by a hydraulic jack.***

Front Jack Point



Rear Jack Point



1. Park the bus on a flat, level surface of sufficient firmness to support the jack.
2. Chock the wheels in both directions.
3. Use only jacks and jack stands of sufficient capacity to support the bus. Following the jack manufacturer's recommendations, place the jack securely under the axle at the spring or suspension beam, nearest the tire/wheel to be repaired.
4. Jack the bus only to the height necessary to service.
5. Support the bus with blocks or jack stands under the frame rails.

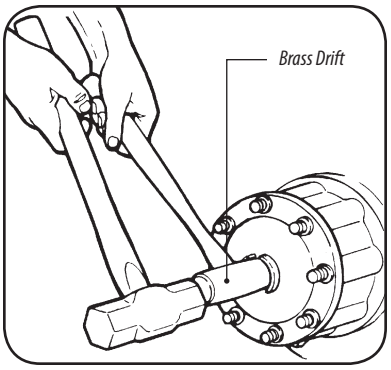
Towing

If the bus is towed with the rear wheels on the road, the driveshaft must be prevented from turning in order to avoid possible damage to the automatic transmission. This is accomplished by removing the rear axle shafts, and covering their openings with caps to prevent rear axle lubricant spillage.

Also, on All American's equipped with air brakes, if full normal air pressure is not present in the air system, the spring brakes must be mechanically caged to prevent their engagement.

1. Apply the parking brake and chock the wheels while preparing the vehicle for towing.
2. Remove the stud nuts and washers from the center hub.

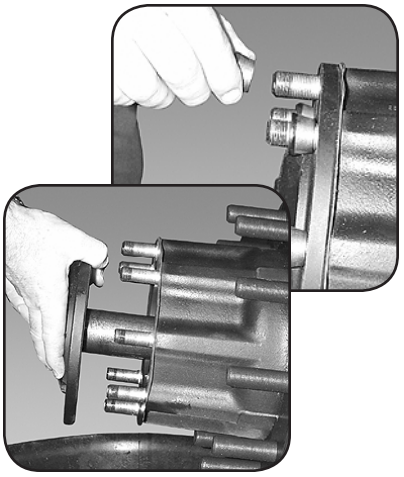
3. To loosen the tapered dowels which surround each stud, use a 1.5" diameter brass drift and 5-6 lb hammer. Hold the brass drift against the center of the axle shaft flange, inside the round driving lugs. Firmly striking the end of the brass drift with the hammer will dislodge the tapered dowels.



CAUTION ***Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Doing so can damage the axle shaft, gasket, seal, or axle hub.***

4. Mark the axle shaft so that it can easily be identified for reinstallation on the side of the axle from which it is removed. Carefully remove the axle shaft, taking measures to catch the axle lubricant which may spill. Install a cover plate over the open end of the hub to prevent dirt contamination and lubricant spillage during towing.

5. Repeat the above procedure to remove the other axle shaft.



6. If the bus is equipped with air brakes, and if full working air pressure is not present in the system, the spring brakes must be mechanically caged before the vehicle can be towed. Proceed as follows:

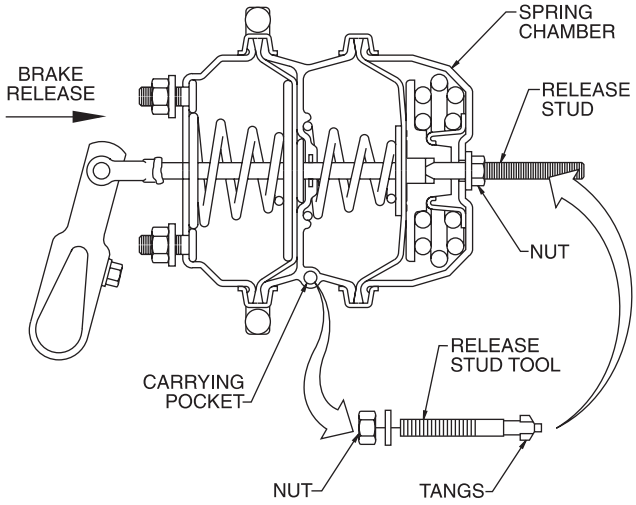
WARNING ***Caging the spring brakes disables the parking brake. Ensure that the bus is completely secured against rolling by wheel chocks before caging the spring brakes.***

6.1 On each of the rear combination brake chambers, a special release stud tool is carried in a storage socket cast into the body of the chamber. Remove the nut and washer from the end of the release stud tool, and remove the tool from its socket.

6.2 Remove the rubber dust cap from the access hole in the upper end of the spring brake chamber. Insert the toggle end of the release stud tool into the access hole. Be sure that the tapered end of the tool has entered the hole in the piston inside the chamber. Insert the tool until it bottoms.

6.3 Rotate the release stud tool a quarter turn clockwise and pull outward, to engage the toggle end with the piston. While holding the bolt in its engaged position, install the washer and nut onto the end of the tool. Turn the nut down against the flat washer until finger tight.

6.4 Using a 3/4" hand wrench, (do not use an impact-type wrench), turn the release nut clockwise until the internal spring is fully caged.

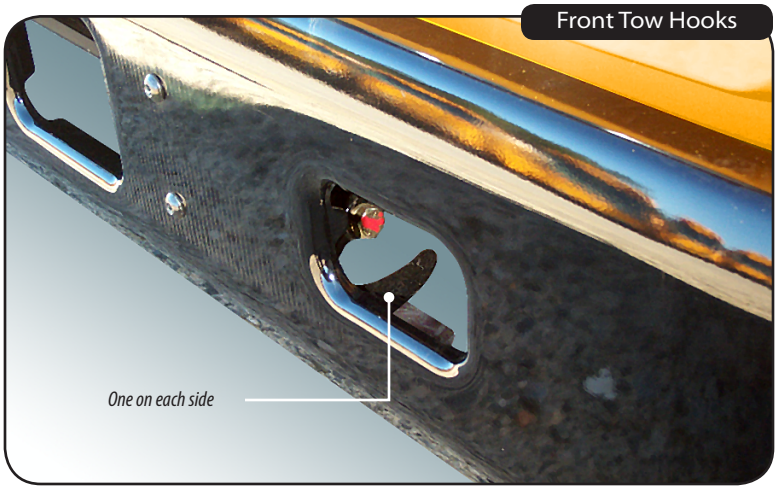


6.5 Repeat the procedure for the spring brake chamber on the opposite side of the bus. The spring brakes are now released, having their springs compressed by the release bolts.

7. With the axle shafts removed and air spring brakes caged, the bus is prepared for towing. The All American may be equipped with optional tow hooks, located just inside the access openings of the front and/or rear bumper. Appendix 1 of the Front Axle & Suspension chapter contains additional information about towing procedure.

WARNING ***The tow hooks are designed for horizontal pulling only; not for lifting. Never attempt to lift the bus by the tow hooks.***

Front Tow Hooks



Fluids & Filters

Fluids & Filters, Rear Engine				
Fluid	Type	Capacity	Filter	Comments
Engine, Cummins ISC				
*Engine Oil	High-Quality SAE 15W-40 heavy duty engine oil, such as Mobil Delvac 1300 15W-40 or equivalent	25.2 Quarts (including filter)	Fleetguard LF9009	*See your Cummins ISC Owner's Manual for more details.*
*Engine Coolant	Cummins Fleetguard ES Compleat 50/50 premix (standard only)	66.5 to 68.8 Quarts (Dependent upon wheelbase)	BB 0064641 Wix 24070	*Cummins equipped buses may have optional extended-life coolant installed. Never mix different coolant colors, types, or brands. See Engine Cooling System chapter for details.*
Fuel Filter			Fleetguard BFF5488	
Water Separator Filter			Fleetguard FS1003	
Engine, Cummins ISL-G				
*Engine Oil	High-Quality SAE 15W-40 heavy duty engine oil, such as Mobil Delvac 1300 15W-40 or equivalent	28.2 Quarts (including filter)	Fleetguard LF9009	*See your Cummins ISL-G Owner's Manual for more details.*
*Engine Coolant	Cummins Fleetguard ES Compleat 50/50 premix (standard only)	13.1 quarts (engine only)	BB 0064641 Wix 24070	*Cummins equipped buses may have optional extended-life coolant installed. Never mix different coolant colors, types, or brands. See Engine Cooling System chapter for details.*
Fuel Filter			Cummins NG0590000	*Supplied with Engine*
Fill Point Filter			BB 01649375 Racor FFC-116N	
Regulator Filter			BB 01808187 Racor FFC-112	

**All fluid capacities should be re-checked to full level after initial fill, bleeding, or changing.*

Fluids & Filters, Rear Engine				
Fluid	Type	Capacity	Filter	Comments
Transmission				
*Transmission Fluid	Transynd™	7.4 Quarts (7 liters)	BB 0033381	*Transmission refill capacity is substantially less than the initial fill because some fluid remains in the transmission cavities after draining.*
Rear Axle				
Axle Oil (RS19-144)	Hypoid Gear Oil	33.3 pints (15.2 liters)		*See Rear Axle Viscosity Chart for appropriate viscosity.*
Axle Oil (RS21-145)		33.3 pints (15.2 liters)		
Axle Oil (RS23-160)		39.5 pints (18.7 liters)		
Front Axle				
Front Axle Grease	Chevron Dura Lith Grease EP NLGI 2	2.1 pounds		
Front Axle Oil (FF944) (FF966) (FF967)	Chevron RPM Synthetic Transmission Fluid SAE 50	4 pints (1.9 liters)		
Front Axle Oil (FG941)	Chevron RPM Synthetic Transmission Fluid SAE 50			
Hydraulic System				
Hydraulic Steering	Dexron III™	3 quarts (approximate)		
Pneumatic System				
AD-9 Air Dryer Element			BB 0020138	*On units with air brakes.*
AD-IP Air Dryer Element			BB 0066221	*On units with air brakes.*
		Fuel System		
Fuel Filter / Water Separator			BB 1967009	
		Other		
Windshield Washer Fluid		1.05 gallons		

**All fluid capacities should be re-checked to full level after initial fill, bleeding, or changing.*

Rear Axle Viscosity /Temperature Chart				
Meritor Lubricant Specification	Description	Cross Reference	Minimum Outside Temperature	Maximum Outside Temperature
0-76-A	Hypoid Gear Oil	GL-5, S.A.E. 85W/140	+10° F (-12.2° C)	*
0-76-B	Hypoid Gear Oil	GL-5, S.A.E. 80W/140	-15° F (-26.1° C)	*
0-76-D	Hypoid Gear Oil	GL-5, S.A.E. 80W/90	-15° F (-26.1° C)	*
0-76-E	Hypoid Gear Oil	GL-5, S.A.E. 75W/90	-40° F (-40° C)	*
0-76-J	Hypoid Gear Oil	GL-5, S.A.E. 75W	-40° F (-40° C)	+35° F (+1.6° C)
0-76-L	Hypoid Gear Oil	GL-5, S.A.E. 75W/140	-40° F (-40° C)	*
** No upper limit on these temperatures. However, axle sump temperature must never exceed + 250° F (121° C).*				

General Maintenance Schedules

The following charts list maintenance procedures which should be performed with regularity. For convenience, some of these tables are also duplicated in their respective areas throughout the manual.

About Service Intervals

The charts show recommended minimum service intervals. More frequent service intervals should be considered if the vehicle is operated in extreme conditions such as high humidity and/or dusty environments. Time intervals are shown in terms of months or mileage. The correct interval is whichever is the first to occur.

Some components should be regularly inspected, but do not lend themselves to universal intervals, because their normal service life is highly dependent upon local conditions. For these components, any estimated interval would result in overservicing in some locales and underservicing in others. Such intervals are left to the judgement of the local technican, and the service interval indicated is *As Required*. It is important to understand that this designation should not be taken as an optional inspection. Every item in the following tables should be considered mandatory, and an As Required interval should be viewed as emphasizing the importance of the local service operation first determining, and then strictly adhering to, an appropriate interval. Regardless of the interval determined appropriate, the operation must not be overlooked.

Vendor-Supplied Maintenance Guidelines

The technician should bear in mind that many of the components which are installed on a bus, are neither manufactured nor serviced by the bus manufacturer. Service and Maintenance information more detailed than that presented in this manual may be available from the component manufacturer, or may be included in the chapter appendixes. Wherever practical and available, component-specific material from our vendors has been included on the DVD which accompanies this manual, and references to those documents are given in the maintenance charts.

Please be aware that these supplemental documents are provided as a courtesy, and are reproduced in their entirity. Therefore, they may also include information on other component models offered by the vendor, but not specifically applicable to the Blue Bird bus. When referring to the appendixes documents, always check the model of the component and be certain that you are using the applicable portions of the appendix documents.

Also, some of the manufacturer-supplied component manuals contain rebuild procedures. As a general rule, Blue Bird does not recommend rebuilding of components, especially in safety-critical systems such as air or hydraulic control valves. Blue Bird strongly recommends component replacement over rebuild.

Maintenance Task Schedule

Ensure that the Safety information, warnings and instructions are read and understood before operation or maintenance procedures are performed. Use whichever interval listed (time, mileage, engine hours) occurs first. Engines operated in severe operating conditions may require more frequent maintenance. See engine manufacturer's specifications for more information.

As Specified by Engine Manufacturer	
Cooling System	
Replace Coolant	See your Engine Operator's Manual. Use only premixed coolant(s) approved by the engine manufacturer. Never mix different types or brands of coolant.
Engine	
Replace Oil & Filter	See Engine operators manual for oil and filter specifications and maintenance interval.
Adjust Valves	See Engine manufacturer's Service Manual for interval.

As Specified by Transmission Manufacturer	
Transmission	
Adjust Transmission Shift Cable	See Transmission Chapter.

First 100 Hours Then Every 6 Months or 2500 Engine Hours	
Cooling System	
Flush and refill Mechanical Fan Drive	Drain out initial oil, flush gear case with an approved non-flammable, non-toxic solvent, such as Whitmore's Flushing Oil (#06802030) or Medallion ™ Flushing Oil Kosher (#06812010), and refill. Replenish with Synthetic 75W-90 Gear Oil meeting API GL-5 / MT-1 specifications.

First 100 Miles Then Every 12,000 Miles	
Tires & Wheels	
Inspect & Tighten Lug Nuts	Torque to 450-500 ft lb with calibrated torque wrench. Do not over-tighten. Do not lubricate nuts or studs. Operating conditions may require more frequent checks.

First 1000 Miles Then Every 3 Months or 6000 Miles	
Frame	
Inspect & Tighten Body Tie Downs Body Tie Down Clamps	Inspect for missing, damaged rubber pads. Tighten clamps to 37–41 ft lb.
Inspect & Tighten Body Tie Downs Rear Tie Down Bolts	Inspect for missing, damaged rubber pads. Tighten clamps to 37–41 ft lb.
Inspect Front Rubber Isolators	Replace any worn isolators. Tighten bolts to 52-56 ft lb.

First 1000 Miles Then Every 6 Months or 6000 Miles	
Axle & Suspension, Rear	
Inspect Comfort Air Suspension Ride Height	Shock length, eye-to-eye: 22.68" +/- 0.25"

First 1000 Miles Then Every 12 Months or 12,000 Miles	
Heaters & Defrosters	
Inspect Front Heater Hoses & Clamps	Inspect for evidence of leaks or deterioration. Replace with proper parts.

First 5000 Miles Then Every 12 Months or 24,000 Miles
Transmission
Replace Transmission Sump Filter

First 5000 Miles Then Every 24 Months or 24,000 Miles
Transmission
Replace Transmission Main Fluid Filter

First 6000 Miles Then Every 6 Months or 25,000 Miles	
Axle & Suspension, Front	
Inspect & Torque Ridewell Air Suspension Curved T'Beam Bolts	Torque to 1000 ft lb.
Inspect & Torque Ridewell Air Suspension Shock Eye Bolts	Torque to 460 ft lb.
Inspect & Torque Ridewell Air Suspension Straight T'Beam Bolts	Torque to 1000 ft lb.
Inspect & Torque Ridewell Air Suspension Sway Bar	Torque to 460 ft lb.
Inspect & Torque Ridewell Air Suspension Top Inside and Bottom Air Spring Attachment Bolts	Torque to 50 ft lb.
Inspect & Torque Ridewell Air Suspension Top Outside Air Spring Attachment Bolts	Torque to 25 ft lb.
Inspect & Torque Ridewell Air Suspension U-Bolts	Torque U-Bolts to 340-360 ft lb.
Axle & Suspension, Rear	
Inspect & Torque Ridewell Air Suspension Shock Absorber Nuts	Torque until a dimension of 1.75" between washers is attained.
Inspect & Torque Ridewell Air Suspension Transverse Torsion Rod to Axle Bracket	Torque to 460 ft lb.

First 11,000 Miles Then Every 3 Months or 5000 Miles or 250 Engine Hours	
Engine	
Inspect All Belts	Inspect condition and tension of belts.

First 11,000 Miles Then Every 6 Months or 5000 Miles	
Cooling System	
Inspect Charge Air Cooler	Inspect for clogging debris.

First Month Then Every 3 Months or 3000 Miles	
Cooling System	
Inspect & Tighten Hose Clamps	Tighten radiator hose clamps to 90 in lb. Tighten heater hose clamps to 45 in lb.

Every Day	
Doors	
Test Wheelchair Lift	Follow the manufacturers recommendations.
Emergency Equipment	
Inspect Fire Extinguisher Charge	Ensure that Extinguisher Charge is not expired.
Inspect Fire Extinguisher Mounting Bracket	Ensure that Extinguisher bracket is secure and operates correctly.
Inspect First Aid Kit Contents	Ensure that kit supplies are fully replenished, clean, and not expired.
Inspect First Aid Kit Mounting Bracket	Ensure that mounting bracket is secure and operates correctly.
Emergency Exits	
Inspect All Emergency Exits	Test all emergency exits for proper operation, including warning buzzer.
Warning Devices & Signs	
Test Stop Arms & Crossing Arms	
Windows	
Inspect All Mirrors	Clean, adjust mirrors.
Inspect All Windows	Clean windshield, door glass, driver's window, rear vision windows, rear door windows.
Brakes	
Inspect Air Brakes Air Lines & Fittings	Inspect for leaks or physical damage.
Drain Air Brakes Air Tanks	Drain daily in cold weather; weekly in warm weather.
Inspect Air Brakes Brake Chambers	See Air Brakes Chapter for inspection criteria.
Inspect Air Brakes Brake Shoes	Wear depends upon application environment. See Meritor Cam Brakes Appendix in Air Brakes Chapter of Service Manual for guidelines.

Cooling System	
Inspect Coolant Level	Adjust to proper level with premixed coolant of same type as installed. Never mix coolants of different colors, types, or brands. See engine Operator's Manual for details. See decal on vehicle showing original equipment.
Inspect Entire Cooling System	Visually inspect for any signs of leakage.
Inspect Mechanical Fan Drive	Inspect for signs of leakage or physical damage.
Electrical	
Inspect All Lights	Check all running, stop, marker, hazard, and warning lights for proper operation.
Engine	
Inspect Oil Level	See engine operators manual for oil specifications.
Fuel System	
Inspect Fuel Cap	
Inspect Water Separator Petcock Drain	Check for water contamination.
Intake System	
Inspect Intake Tract Duct & Elbow	Visually inspect for proper fit and sealing, cuts, abrasions, signs of dirt contamination.
Inspect Intake Tract Restriction Indicator	Replace primary filter element when gauge on Filter Minder goes into the red area, regardless of time or mileage. If filter has secondary or safety filter, replace at minimum every 2nd primary filter replacement.
Steering	
Inspect Power Steering Fluid Level	Replenish to full mark. Dexron III or approved equal.
Tires & Wheels	
Inspect All Tires & Wheels	Check air pressure. Visually inspect tires, tread wear, lug nuts, including spare.
Transmission	
Inspect Transmission Fluid Level	Check production order for proper type of fluid to be added.

Every Week	
Seats	
Inspect & Tighten Passenger Seats Cusion Screws	Inspect for loose cushions clips.
Inspect Passenger Seats Seat Belts	Lubricate buckles, clean webbing as required. Replace any damaged webbing straps.
Inspect Passenger Seats Upholstery	Inspect for cuts, tears, wear and soiled areas.
Cooling System	
Inspect Mechanical Fan Drive	Check oil level.

Every 60,000 Miles
Fuel System
Replace Fuel Filter

Every Month or 3000 Miles	
Doors	
Adjust Outward Opening Door Control Rod	
Adjust Outward Opening Door Control Rod Bracket	Adjust for full and secure closure without binding.
Adjust & Lubricate Outward Opening Door Linkage	Adjust linkage for firm closure, and to ensure rear panel closes first.
Lubricate Outward Opening Door Pivots	Lubricate pivot pins with LPS #1.
Adjust Outward Opening Door Roller Bracket	Adjust for full and secure closure without binding.
Lubricate Wheelchair Lift Lube Points	See model-specific literature provided with lift.
Emergency Exits	
Lubricate All Emergency Exits Hinges	LPS #1
Lubricate Rear Emergency Door Hold-Open	Apply ASTM D4950 GC-LB Grade 2
Lubricate Roof Hatch Seal and Latch	Use silicone lubricant to prevent sticking of rubber seal. Spray silicone lubricant into latch mechanism.
Floor	
Inspect Floor Drains	Check drain hole in each body section under window for debris or obstruction.
Seats	
Lubricate Driver's Seat	Lubricate per manufacturers recommendation.
Inspect & Tighten Passenger Seats Mountings	Use standard torque for bolt size, thread type and grade.
Warning Devices & Signs	
Lubricate Stop Arm, Electric 4-Point Pivot	Lubricate four hinge pivot points with Try-Flow lubricant
Inspect & Tighten Stop Arm, Electric Fasteners	Check interior and exterior fasteners for loosening.

Windows	
Lubricate Passenger Windows Latches & Slides	Use silicone lubricant.

Doors	
Lubricate All Doors Vandal Locks	Apply spray lubricant into key locks. Use LPS #1 for sliding bolt locks.

Electrical	
Inspect Battery Electrolyte Level	Replenish with distilled water.

Every Month or 5000 Miles

Warning Devices & Signs	
Inspect Stop Arm, Air Pressure	Adjust for full deployment and retraction.

Every Month or 12,000 Miles

Axle & Suspension, Rear	
Inspect Rear Axle Lubricant Level	If low, refill to bottom of filler opening. Use same lubricant type as already installed.

Every 3 Months

Exterior Structure	
Wash Body	Wash the vehicle in lukewarm or cold water. Do not use hot water or wash in the direct sunlight. Only cleaners with an HMIS rating of 1,0,0,0 or less should be used to clean the buses. See Exterior Cleaning section of Driver's Handbook for further information.

Every 3 Months or 3000 Miles

Emergency Exits	
Lubricate Rear Emergency Door Hinges	LPS #1

Cooling System	
Inspect Radiator Fins	Clean debris from fins.
Inspect Water Pump Belt	Inspect condition and tension of belt.

Every 3 Months or 5000 Miles	
Brakes	
Lubricate Air Brakes S-Cam	See Meritor Cam Brakes Appendix in Air Brakes Chapter of Service Manual for guidelines.
Cooling System	
Inspect Intake Tract Charged Air Tubing	Inspect for signs of contaminate infiltration, loose clamps, wear spots, holes in piping.
Inspect & Tighten Intake Tract Hose Clamps	Tighten to 5 ft lb.
Electrical	
Inspect Alternator Connections	Inspect for loose wires, damaged terminals, damaged insulators.
Inspect Battery Connections	Check for solid connection, tight fasteners and absence of corrosion.
Fuel System	
Inspect Fuel Lines	Inspect for leaks or signs of abrasion.
Inspect Fuel Tank Vent	Inspect for obstruction.
Intake System	
Inspect Air Cleaner Filter Element	Inspect for proper seating, secure lid. Replace if soiled, wet, or damaged.
Inspect Intake Duct and All Fasteners	Inspect for signs of contaminate infiltration, loose clamps, wear spots, holes in piping
Inspect & Tighten Intake Tract T-Bolt Clamps	Tighten to 7 ft lb.
Inspect & Tighten Intake Tract Worm Gear Clamps	Tighten to 38–42 in lb.
Steering	
Lubricate Axle Steering Linkage Drag Link	NLGI #2 EP multipurpose grease rated GC-LB or equivalent.
Lubricate Axle Steering Linkage King Pins	NLGI #2 EP multipurpose grease rated GC-LB or equivalent.
Lubricate Axle Steering Linkage Tie Rod Ends	NLGI #2 EP multipurpose grease rated GC-LB or equivalent.
Lubricate Intermediate Steering Shaft Slip Joint	NLGI #2 EP multipurpose grease rated GC-LB or equivalent

Every 3 Months or 24,000 Miles	
Brakes	
Inspect Air Brakes Air Dryer	See Bendix appendix for specific model in Air Brakes Chapter of Service Manual.

Every 6 Months or 5000 Miles	
Warning Devices & Signs	
Lubricate Destination Sign Hinges	
Lubricate Destination Sign Roller Gears	Lightweight grease such as White Lube.

Every 6 Months or 6000 Miles	
Brakes	
Clean Air Brakes Check Valves	
Clean & Lubricate Air Brakes Treadle Valve	See Bendix Treadle Valve Appendix in Air Brakes Chapter of Service Manual.
Clean Air Compressor Governor	
Cooling System	
Replace Coolant Filter	
Lubricate Shutters Pivots	Use Never Seize spray lubricant.
Electrical	
Inspect Battery Posts	Clean and apply anti corrosion agent.
Exhaust System	
Inspect Exhaust Pipe Joints	Inspect for loose clamps, leaks, damage.
Fuel System	
Replace Fuel Filter Filter Element	
Clean Fuel Filter Inlet Screen	Clean. Replace if damaged.
Steering	
Lubricate Steering Gear Pitman Arm Pivot	NLGI #2 EP multipurpose grease rated GC-LB or equivalent. Use hand-operated grease gun.

Every 6 Months or 12,000 Miles	
Brakes	
Lubricate Air Brakes Cam Shaft Housing	NLGI #2 EP multipurpose grease rated GC-LB or equivalent. Use hand-operated grease gun.
Lubricate Air Brakes Haldex Slack Adjusters	See Haldex lubricant specs in Air Brakes chapter of Service Manual.
Lubricate Air Brakes Meritor Slack Adjusters	See Meritor lubricant specs in Air Brakes chapter of Service Manual.

Every 6 Months or 25,000 Miles	
Axle & Suspension, Front	
Inspect & Torque AirTek Suspension Air Spring to Air Spring Bracket	Torque to 20-30 ft lb.
Inspect & Torque AirTek Suspension Air Spring to Top Pad	Torque to 20-30 ft lb.
Inspect & Torque AirTek Suspension Clamp Group Hardware	Torque to 285-305 ft lb.
Inspect & Torque AirTek Suspension Front Frame Hanger to Front Leaf Spring Eye	Torque to 290-310 ft lb.
Inspect & Torque AirTek Suspension HVC Linkage to HVC Arm	Torque to 10-12 ft lb.
Inspect & Torque AirTek Suspension Rear Shackle Bracket to Shackle Plate	Torque to 290-310 ft lb.
Inspect & Torque AirTek Suspension Rear Shackle Bracket to Spring Eye	Torque to 290-310 ft lb.
Inspect & Torque AirTek Suspension Shackle Bracket Lock Nuts	Torque to 114-126 ft lb.
Inspect & Torque AirTek Suspension Shocks Eye Bolts	Torque to 125-135 ft lb.
Inspect & Torque SofTek Spring Suspension Axle Clamp Group Nuts	Torque to 285-305 ft lb.
Inspect & Torque SofTek Spring Suspension Front Frame Hanger to Front Leaf Spring Eye	Torque to 290-310 ft lb.
Inspect & Torque SofTek Spring Suspension Rear Shackle Bracket to Shackle Plate	Torque to 290-310 ft lb.
Inspect & Torque SofTek Spring Suspension Rear Shackle Bracket to Spring Eye	Torque to 290-310 ft lb.
Inspect & Torque SofTek Spring Suspension Shackle Bracket Lock Nuts	Torque to 114-126 ft lb.

Inspect & Torque SofTek Spring Suspension Shocks Eye Bolts	Torque to 125-135 ft lb.

Axle & Suspension, Rear

Inspect & Torque Comfort Air Suspension Air Spring to Cross Channel	Torque to 20–30 ft lb.
Inspect & Torque Comfort Air Suspension Cross Channel to Main Support Member	Torque to 260-320 ft lb.
Inspect & Torque Comfort Air Suspension HCV Linkage to Height Control Valve Arm	Torque to 80–90 in lb.
Inspect & Torque Comfort Air Suspension Height Control Valve to Frame Bracket	Torque to 40–50in lb.
Inspect & Torque Comfort Air Suspension Linkage Rod Assembly Locknut	Torque to 80-90 in lb.
Inspect & Torque Comfort Air Suspension Quick Align Bolts	Torque to 525–575 ft lb.
Inspect & Torque Comfort Air Suspension Shock Absorbers	Inspect for leakage or damage. Torque mount bolts to 160–180 ft lb.
Inspect & Torque Comfort Air Suspension Suspension Hanger	Torque to 155-210 ft lb.
Inspect & Torque Comfort Air Suspension Transverse Torsion Rod to Axle Bracket	Torque to 90-122 ft lb.
Inspect & Torque Comfort Air Suspension Transverse Torsion Rod to Frame	Torque to 90-122 ft lb.
Inspect & Torque Comfort Air Suspension U-Bolts	Torque 7/8" U-Bolts to 400–450 ft lb.
Inspect Comfort Air Suspension Whole Assmebly	Visually inspect for damage.

Driveline	
Inspect & Torque SPL 100 & 70 Driveshafts U-Joint Bolts	Inspect for wear and damage every time vehicle is serviced. Torque to 45–50 ft lb.
Lubricate SPL 140 Driveshafts U-Joint Bolts	Grease meeting NLGI Grade #2 grease specifications.
Inspect & Torque SPL140 & 170 Driveshafts U-Joint Bolts	Inspect for wear and damage every time vehicle is serviced. Torque to 115-135 ft lb.

Every 12 Months

Exterior Structure	
Wax Body	Use of a nonabrasive wax is recommended to remove accumulated residue and eliminate any "weathered appearance". It is essential that units are not waxed in direct sunlight. See Exterior Cleaning section of Driver's Handbook for further information and approved waxes.

Intake System	
Test Intake Tract Restriction Indicator	Test indicator with vacuum gauge and pump.

Every 12 Months or 12,000 Miles	
Heaters & Defrosters	
Tighten Front Heater Fasteners	All fasteners holding such heaters in place in unit. For details on fasteners check installation prints.
Inspect, clean and replace Front Heater Filter & Screen	Wash filter and screen. If filter cannot be washed or is damaged, the filter MUST be replaced immediately. If a screen cannot be cleaned, a new screen must be installed immediately.
Inspect and clean Front Heater Heater Cores	Clean carefully with compressed dry air or vacuum and a soft bristle brush. Damaged fins should be straightened with a fin comb.
Inspect and clean Heater Cores	The core should be cleaned carefully with compressed dry air or vacuum and a soft bristle brush. Damaged fins should be straightened with a fin comb to prevent airflow restrictions.
Bleed Heater System	Bleed air from heater circulation system. This procedure is done to keep system operating correctly.
Inspect, clean or replace Heater System Filter	The filter and screen are washable. If a filter cannot be washed or is damaged, the filter MUST be replaced immediately. If the screen cannot be cleaned, a new screen must be installed immediately. Filter may need to be cleaned or replaced more frequently in extreme dusty and dirty environments.
Clean Underseat Heaters Filter Elements	Clean dust from cores.
Axle & Suspension, Front	
Inspect & Adjust AirTek Suspension Ride Height	Shock Length, eye-to-eye: 17.47" +/- 0.25".
Axle & Suspension, Rear	
Inspect & Adjust Ridewell Air Suspension Ride Height	Shock Length, eye-to-eye: 17.53" +/- 0.25".
Inspect & Torque Spring Suspension Shock Absorbers	Inspect for signs of leakage, wear, or damage. Torque locknuts to 75–100 ft lb.
Inspect & Torque Spring Suspension U-Bolts	Torque u-bolt nuts to 280–310 ft lb.

Cooling System	
Test Entire Cooling System	Pressure Test Cooling system.
Clean Radiator Fins	Clean as required.
Engine	
Test Engine Starting Aid Block Heater	
Steering	
Inspect Hydraulic Pump Body & Seals	Inspect for leaks.
Inspect Steering Gear Body & Seals	Inspect for leaks.

Every 12 Months or 24,000 Miles	
Brakes	
Clean Air Brakes Pop Off Valves	
Steering	
Replace Hydraulic Reservoir Filter Element	Replace element and fluid. Replace more frequently in severe operating conditions. Dexron III or approved equal.
Transmission	
Replace Transmission Fluid	Use TransSynd fluid.
Inspect Transmission Shift Cable	
Inspect Transmission Vent	Clear vent of debris or obstruction.

Every 12 Months or 50,000 Miles	
Axle & Suspension, Rear	
Replace Rear Axle Petroleum Based Lubricant	Hypoid Gear Oil. Viscosity depends upon operating climate. See Viscosity/Temperature chart.

Every 12 Months or 90,000 Miles	
Axle & Suspension, Rear	
Replace Rear Axle Synthetic Lubricant	Viscosity depends upon operating climate. See Viscosity/Temperature chart.

Every 24 Months or 24,000 Miles	
Brakes	
Clean Air Brakes Parking Brake Valve	See Bendix Appendixes in Air Brakes Chapter.
Clean Air Brakes Quick Release Valves	See Bendix Appendixes in Air Brakes Chapter.
Clean Air Brakes Relay Valves	See Bendix Appendixes in Air Brakes Chapter.
Clean Air Brakes Spring Brake Valve	See Bendix Appendixes in Air Brakes Chapter.
Intake System	
Replace Air Cleaner Filter Element	

Every 24 Months or 225,000 Miles
Exhaust System
Replace DEF Supply Module Filter
Replace DEF Tank Head Unit Filter

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For GENUINE BLUE BIRD replacements parts, contact your Blue Bird Authorized Dealer

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