DIAGNOSTIC TROUBLESHOOTING MANUAL

H2.0-3.0XT (H40-60XT) [A380]

HYSTER

PART NO. 4150998

9000 SRM 2004

SAFETY PRECAUTIONS
TROUBLESHOOTING PROCEDURES

- The Service Manuals are updated on a regular basis, but may not reflect recent design changes to the product. Updated technical service information may be available from your local authorized Hyster® dealer. Service Manuals provide general guidelines for maintenance and service and are intended for use by trained and experienced technicians. Failure to properly maintain equipment or to follow instructions contained in the Service Manual could result in damage to the products, personal injury, property damage or death.
- When lifting parts or assemblies, make sure all slings, chains, or cables are correctly fastened, and that the load being lifted is balanced. Make sure the crane, cables, and chains have the capacity to support the weight of the load.
- Do not lift heavy parts by hand, use a lifting mechanism.
- Wear safety glasses.
- DISCONNECT THE BATTERY CONNECTOR before doing any maintenance or repair on electric lift trucks. Disconnect the battery ground cable on internal combustion lift trucks.
- Always use correct blocks to prevent the unit from rolling or falling. See HOW TO PUT THE LIFT TRUCK ON BLOCKS in the **Operating Manual** or the **Periodic Maintenance** section.
- Keep the unit clean and the working area clean and orderly.
- Use the correct tools for the job.
- Keep the tools clean and in good condition.
- Always use **HYSTER APPROVED** parts when making repairs. Replacement parts must meet or exceed the specifications of the original equipment manufacturer.
- Make sure all nuts, bolts, snap rings, and other fastening devices are removed before using force to remove parts.
- Always fasten a DO NOT OPERATE tag to the controls of the unit when making repairs, or if the unit needs repairs.
- Be sure to follow the **WARNING** and **CAUTION** notes in the instructions.
- Gasoline, Liquid Petroleum Gas (LPG), Compressed Natural Gas (CNG), and Diesel fuel are flammable. Be sure to follow the necessary safety precautions when handling these fuels and when working on these fuel systems.
- Batteries generate flammable gas when they are being charged. Keep fire and sparks away from the area. Make sure the area is well ventilated.

NOTE: The following symbols and words indicate safety information in this manual:

WARNING

Indicates a condition that can cause immediate death or injury!

CAUTION

Indicates a condition that can cause property damage!

On the lift truck, the WARNING symbol and word are on orange background. The CAUTION symbol and word are on yellow background.

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This section is for the following models:

H2.0-3.0XT (H40-60XT) [A380]

How To Use This Troubleshooting Manual

GENERAL INSTRUCTIONS AND SAFETY INFORMATION

WARNING

DO NOT add to or modify the lift truck. Any modification that affects the safe operation of the truck cannot be undertaken without written authorization of the Hyster company.

Any change to the lift truck, the tires, or its equipment can change the lifting capacity. The lift truck must be rated as equipped and the nameplate must show the new rating capacity.

WARNING

The technician must be aware of, and follow, all general safety precautions that are published in the Operating Manual and that are posted as Safety Decals on and in the lift truck.

Before starting, the technician should be familiar with certain policies, requirements, and instructions used in the troubleshooting procedures. Using the troubleshooting procedures correctly helps the technician to perform the procedure safely and prevents damage to the machine and support equipment.

HOW TO USE DIAGNOSTIC TROUBLESHOOTING MANUAL

Manual Layout:

Sections: The manual is divided into nine sections, each representing a major system, functional area, or specific operation on the lift truck.

- 9010 – Operational Diagnostic Procedures
- 9020 – Engine
- 9030 – Electrical System
- 9040 – Drive Train
- 9050 – Hydraulic System
- 9060 – Operators Station
- 9070 – Front End (Mast) and Chassis
- 9080 – Supplementary Data

Groups: The sections of the manual are further subdivided into groups, where applicable, that identify specific functions, operating criteria, or maintenance tasks.

- 01 – Introduction to the Troubleshooting Manual
- 03 – General Maintenance/Diagnostic Data
- 05 – Operational Checkout
- 10 – Principles of Operation
- 20 – Diagnostic Trouble Codes
- 30 – Observed Symptoms
- 40 – Test and Adjustments

NOTE: Not all groups will appear in all sections.

Supplementary Data: The supplementary data section of the manual includes information and data that apply to many sections or groups and is stored here for access by all users of the manual. This data includes, but is not limited to:

- Abbreviations and Acronyms
- Special Tools List
- Fault Mode Indication Reference Table
- Supplier Specification Data

GENERAL INSTRUCTIONS

1. Become familiar with the content, layout, and access provisions of data in this manual. This will improve your efficiency and decrease the time required to resolve the problems.
2. Use all sections of the manual for relevant information on the subject system.
3. Once you begin a troubleshooting procedure, do not skip steps.
4. If you reach the end of a procedure without resolving the problem and you are not directed to another procedure contact Resident Service Engineering through the Contact Management System.
5. Do not limit yourself, remember to apply your own experience and knowledge to assist in resolving the problems, but do not compromise safety in doing so.
6. Most of the cross-reference data in the manual will be electronically linked for rapid and easy access. Use the links wherever the cursor highlights an item as a linkable option.
   As an example of this linking option:

   > Assume that during a procedure or test, it is necessary to refer to a different section of manual, in this case, the Light Circuit Check in the Operational Checkout part of this manual.
   >
   > The instruction would read, "refer to, or see" followed by text identifying what the reference is (for hard-copy, paper manual use). When the cursor is placed over the text, it will then indicate that it is active, and left-clicking will direct the system to take you directly to that reference.

Service Manual Lookup

The following service manuals may be referenced throughout this manual or may be useful in diagnosing, removing, or repairing components not fully discussed in this manual.

- **Frame** 0100SRM1984
- **Operator's Cab** 0100SRM1985
- **PSI 2.4L Engine** 0600SRM1755
- **Yanmar Diesel Engines** 0600SRM1205
- **Cooling System** 0700SRM1986
- **Fuel System PSI 2.4L** 0900SRM1987
- **Transmission Repair** 1300SRM1988
- **Drive Axle Repair** 1400SRM1989
- **Steering Axle** 1600SRM1990
- **Brake System** 1800SRM1991
- **Hydraulic Gear Pump** 1900SRM1992
- **Main Control Valve** 2000SRM1993
- **Cylinder Repair** 2100SRM1994
- **User Interface** 2200SRM1996
- **Electrical System** 2200SRM1997
- **Electrical System PSI 2.4L** 2200SRM1998

SECTION 9010

OPERATIONAL DIAGNOSTIC PROCEDURES

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Group 05

Operational Checkout

Operational Checkout Procedures

WARNING

Be sure to read the warnings prior to performing the checkout procedures.

WARNING

Before operating the lift truck, FASTEN YOUR SEAT BELT.

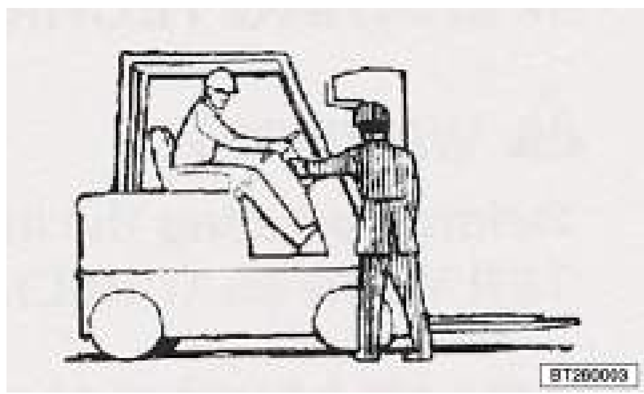
There are a number of operations, if not performed carefully, that can cause the lift truck to tip. If you have not read the WARNING page in front of the Operating Manual, do so NOW. As you study the following information about how to properly operate a lift truck, remember the Warnings.

WARNING

Mast parts are heavy and can move. Distances between parts are small. Serious injury or death can result if part of the body is hit by parts of the mast or the carriage.

- **Never put any part of the body into or under the mast or carriage unless all parts are completely lowered or a safety chain is installed. Also make sure the power is OFF and the key is removed. Fasten a DO NOT OPERATE tag in the operator's compartment.**
- **Be careful of the forks. When the mast is raised, the forks can be at a height that may cause an injury.**
- **DO NOT climb on the mast or lift truck at any time. Use a ladder or personnel lift to work on the mast.**
- **DO NOT use blocks to support the mast weldments nor to restrain their movement.**
- **Mast repairs require disassembly and removal of parts and can require removal of the mast or carriage. Follow the repair procedures in the correct Service Manual for the mast.**

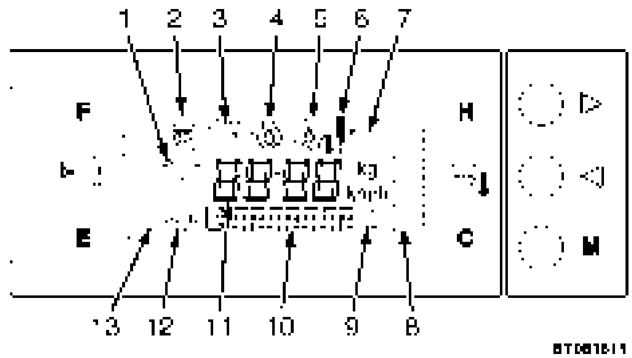
Before performing the operational checkout, complete the INSPECTION BEFORE OPERATION in the **Operating Manual**.

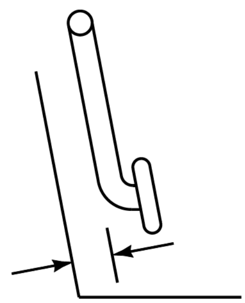


All DTCs must be corrected or cleared before starting this checkout. Before starting operational checkout, talk to the operator and check Diagnostic Trouble Codes (DTC).

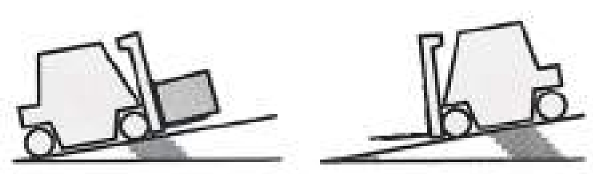
When a problem is found, stop operational checkout and correct it before going to the next check. Repeat check after repair to confirm repair was successful before proceeding with the remaining checks.

CHECK	PROCEDURE	ACTION
DTC Check	1. Turn key switch to **ON** position or press power ON/OFF button. 2. Check for DTCs. ***Are any DTCs displayed?***	**YES:** Refer to the appropriate troubleshooting procedure. **NO:** Go to next check.
Horn Circuit Check	Press horn button. ***Does horn sound?***	**YES:** Go to next check. **NO:** Refer to Horn Failure.
Light Circuit Check	1. Turn key switch to **ON** position or press power ON/OFF button. 2. Turn front and rear work light switches ON. ***Do lights turn on?***	**YES:** Lights are OK. Go to next check. **NO:** Check fuse. If OK, check display to see if light switch is turned ON. Check bulbs, see Electrical Functions Do Not Operate.
Windshield Washer Wiper Check (If equipped)	**NOTE:** Do not operate windshield wipers on a dry windshield. 1. Turn key switch to **ON** position or press power ON/OFF button. 2. Press windshield washer switch. ***Does washer fluid spray on front and rear windshields while wipers operate?***	**YES:** Go to next check. **NO:** Check windshield washer fluid level and refer to Observed Symptom, Electrical Functions Do Not Operate.
	3. With wipers operating, press and hold front wiper switch for greater than 1 second. 4. On the display, use the up arrow key to set the front wiper delay to approximately 10 seconds, (5 or 6 segments displayed). ***Do the front wipers now operate with a delay of approximately 10 seconds?***	**YES:** Continue with this procedure. **NO:** Refer to Observed Symptom, Electrical Functions Do Not Operate.
	Continue: 5. With wipers operating, press and hold rear wiper switch for greater than 1 second. 6. On the display, use the up arrow key to set the rear wiper delay to approximately 10 seconds, (5 or 6 segments displayed). ***Do the rear wipers now operate with a delay of approximately 10 seconds?***	**YES:** Go to next check. **NO:** Refer to Observed Symptom, Electrical Functions Do Not Operate.

Malfunction Indicator Check	1. Start engine. 2. Check display for warning indicator lights. ***Are any warning lights ON?***	**YES:** Go to appropriate . **NO:** Engine indicators are OK. Resume operation.
Indicator Light Power Check Errd006, Errd007, Errd008, Errd009, Errd010	 1. SEDIMENTER (DIESEL ONLY) 2. GLOW LAMP 3. BATTERY CHARGE 4. ENGINE OIL PRESSURE 5. AUTOMATIC TRANSMISSION FLUID TEMPERATURE (IF EQUIPPED) 6. WARNING DISPLAY 7. MAINTENANCE REQUIRED 8. COOLANT TEMP 9. ALARM DISPLAY 10. HOUR, MESSAGE, CALENDAR, ERROR DISPLAY 11. CLOCK, SPEED, LOAD, MESSAGE, PASSWORD, MENU DISPLAY 12. SEAT BELT 13. FUEL LEVEL Turn key switch to **ON** position or press power ON/OFF button with park brake applied. ***Do the lights turn ON?*** **NOTE:** Fasten seat belt light will turn off after 10 seconds. *Continue:*	**YES:** Continue with this procedure. **NO:** Go to Vehicle Does Not Power On.
	Are the following items on LCD screen? • ***Clock and Hourmeter.***	**YES:** Go to next check. **NO:** Refer to Observed Symptom, Electrical Functions Do Not Operate.

Cold Start Check (Diesel Engines Only)	**NOTE:** Engine must be cold to properly check the cold start circuit. • Turn key switch to **ON** position or press power ON/OFF button. ***Does cold start indicator illuminate?***	**YES:** Go to next check. **NO:** Continue with this procedure.
Brake Pedal Check 1-7 Ton Only	 BT260022 1. Measure pedal distance from floor plate as shown in the illustration (this is taken from bottom of brake pedal bracket to floor plate). **NOTE:** It is normal for trucks equipped with MONOTROL® to increase engine speed as park brake is released. ***Does brake pedal remain at least 25 mm (1 in.) off floor plate?***	**YES:** Go to next check. **NO:** Adjust brakes. Refer to appropriate **Brake System** manual, depending on lift truck model.
Backup Alarm Check (If equipped)	1. Start engine and apply service brake. 2. Release park brake. 3. Shift transmission to reverse. ***Does backup alarm sound?***	**YES:** Go to next check. **NO:** Check wiring connections first. If connections are OK, check display for SPN 522755 or PSI code and troubleshoot per procedure. See the appropriate Diagnostic Trouble Codes.

Operator Presence System Check	**NOTE:** This procedure requires Service Password. **NOTE:** Operator presence sensor requires a minimum of 45.4 kg (100 lb) to actuate. **NOTE:** Hydraulic Interlock message will result if operator is not detected in seat or mini-levers not mechanically or electronically in neutral position when power **ON**. 1. While operator in seat, power truck **ON**. 2. At the display, Enter Main Menu, scroll to Diagnostics, **Enter**, scroll to General Data Display. 3. Scroll display until seat sensor appears. Read display. ***Does display show 1.4 volts or greater?***	**YES:** Continue with this procedure. **NO:** Check display for SPN 524245 and troubleshoot per procedure. See the appropriate Diagnostic Trouble Codes.
	Continue: While operator is out of seat, power truck **ON**. ***Does display show less than 0.8 volts?*** **NOTE:** BEFORE PROCEEDING TO NEXT CHECK, RETURN TO SEAT AND FASTEN SEAT BELT.	**YES:** Operator presence sensor is OK. Go to next check. **NO:** Operator presence sensor has failed. Replace seat sensor. Refer to appropriate **Electrical System** manual, depending on lift truck model.
Hydraulic Interlock Check	**NOTE:** Hydraulic Interlock message will result if operator not detected in seat or mini-levers not mechanically or electronically in the neutral position when power **ON**. While operator in seat, power truck **ON**. ***Does display show "Hydraulic Interlock?"***	**YES:** Be sure Operational Checkout Procedures has been performed and passed, then continue. **NO:** Hydraulic Interlock is OK.
	Continue: While operator in seat and not touching MLM, power truck **ON**. ***Does display show "Hydraulic Interlock?"***	**YES:** Refer to appropriate **Electrical System** manual and perform **TEST, Mini-Levers**. **NO:** Hydraulic Interlock is OK.

Brake and Inching Pedal Check	1. With engine running, fully depress inching pedal. 2. Release park brake. 3. Shift to forward and increase engine to governed speed. ***Does engine increase smoothly to governed speed?***	**YES:** Inching function is OK. Go to next check. **NO:** Operate truck to 10 full stops in each direction while fully pressing inch/brake pedal each time.
Park Brake Sensor Check	1. With engine running, release park brake. 2. Slowly apply park brake and note when park brake light comes ON. ***Does light come on before park brake reaches first click of engagement?***	**YES:** Park brake sensor is OK. Go to next check. **NO:** Adjust park brake sensor. Refer to appropriate **Brake System** manual, depending on lift truck model.
Park Brake Check	 BT260002 **WARNING** **Ensure load is secured so it will not move when mast is tilted fully forward.** 1. Stop lift truck in an uphill direction with rated load on 15% grade or less, and apply park brake. 2. Stop engine and note if machine remains static. 3. Start engine and remove rated load. 4. Position lift truck with No Load in a downhill direction, on 15% grade or less, and apply park brake. 5. Stop engine and note if machine remains static. ***Does machine remain static on grade in both directions?***	**YES:** Go to next check. **NO:** Adjust park brake. Refer to appropriate **Brake System** manual, depending on lift truck model.

Engine Power Check	1. Ensure lift truck transmission and engine are at operating temperature, fully warmed transmission temperature 90 °C (194 °F). **WARNING** **Ensure load is secured so it will not move when mast is tilted fully forward.** 2. Put capacity secured load on forks. 3. Position forks against an immovable object, like a loading dock. 4. Scroll the display to display engine rpm. 5. Shift to forward and operate engine at governed speed. Record the highest rpm achieved with transmission engaged after 10 seconds, then disengage transmission for 10 second and release accelerator pedal. Repeat test three times to get highest stall speeding reading. ***Does engine stall speed meet stall speed specifications? For lift truck stall speed specifications, refer to Torque Converter Stall Test.*** **NOTE:** If engine speed is low, check if air filter restriction light is ON. A plugged air filter will lower stall speeds.	**YES:** Engine power is OK. Go to next check. **NO:** To diagnose this problem, go to Torque Converter Stall Test.
Transmission Check	**NOTE:** Make sure you have clear driving area for this check. 1. Drive lift truck at governed speed for a short distance. 2. Decelerate and shift to opposite direction. Observe lift truck direction changes. 3. Repeat above steps three times and observe engine rpm and tire engagement during direction changes. ***Does truck make smooth direction changes without excessive delay or engine surges?***	**YES:** Transmission shift program is OK. Go to next check. **NO:** Install PC Service Tool and check program. Refer to appropriate **Calibration Procedures** manual, depending on lift truck model.

Brake and Axle Drag Check	**NOTE:** Move truck to level surface before performing the following steps. 1. Raise lift truck until drive tires are off ground. Support lift truck using suitable shop standard. (See "How to Raise Drive Tire" procedure in **Operating Manual**.) 2. Stop engine and release park brake. 3. Back off park brake adjustment on handle. 4. Check brakes for dragging. ***Are the brakes dragging?***	**YES:** Repair brakes. Refer to appropriate **Brake System** manual, depending on lift truck model. **NO:** Brakes are OK. Continue with this procedure.
	Continue: Manually turn one tire by hand. ***Does the tire turn with moderate force and does the other tire turn in the opposite direction?***	**YES:** Axle is OK. Go to next check. **NO:** Adjust park brake back to correct setting. Refer to appropriate **Brake System** manual, depending on lift truck model. If opposite wheel does not turn, differential is damaged. If equipped, remove differential cover and inspect. Refer to appropriate **Drive Axle** manual, depending on lift truck model.
Hydraulic Pump Flow Check	**WARNING** **Ensure load is secured so it will not move when mast is tilted fully forward.** 1. Put secured capacity load on forks. 2. With engine running at slow idle, raise forks approximately 1 m (3 ft) off floor. ***Does load raise at low idle speed?***	**YES:** Hydraulic pump output is OK. Go to next check. **NO:** If load raises only at increased governed speed, pump flow is low. Go to Hydraulic Pump Flow Test.

<table>
<tr>
<td>Priority Flow Divider Valve Check</td>
<td>
NOTE: Observe the movement of lift carriage frame (1) during the following two operations:


1. With engine running at slow idle, turn steering wheel to right axle stop and then back to left axle stop in one continuous cycle while raising lift carriage.
Does carriage lift speed decrease while steering?
</td>
<td>YES: Continue with this procedure.
NO: If no steering, flow divider spool is stuck. Remove, clean, and inspect spool. Refer to appropriate Main Control Valve manual, depending on lift truck model.</td>
</tr>
<tr>
<td></td>
<td>
2. Continue:
3. Release steering wheel.
Does carriage lift speed increase when not steering?
</td>
<td>YES: Flow divider is OK. Go to next check.
NO: Inspect and clean steering priority flow divider spool. Refer to appropriate Hydraulic Gear Pump manual, depending on lift truck model.</td>
</tr>
<tr>
<td>Steering Relief Valve Low Pressure Check</td>
<td>
1. With engine running at slow idle.
2. Position steer axle wheels straight to start check.
3. Turn steering wheel stop-to-stop in both directions.
Does steer axle wheels turn stop-to-stop without stopping?
</td>
<td>YES: Relief pressure is OK. Go to next check.
NO: If steer axle wheels do not turn stop-to-stop, pressure is too low. Adjust steering relief pressure. Go to Steering Relief Pressure Test and Adjustment.</td>
</tr>
</table>

Steering Relief Valve High Pressure Check	1. With engine running, turn steering wheel to stop. Then, jerk wheel against the stop and continue to turn with moderate force. 2. Observe reaction of steering wheel as tilt function is held over relief. Repeat several times. ***Does steering wheel jerk each time tilt function is held over relief?*** **NOTE:** *Continue:* It is normal for steering wheel to jerk when tilt function is held over relief because the secondary relief valve is set higher than the steering relief.	**YES:** Steering relief valve high pressure setting is OK. Continue with this procedure. **NO:** If steering wheel does not jerk and moves faster when tilt is held over relief, relief pressure is set too high. Adjust steering relief pressure. Go to Steering Relief Pressure Test and Adjustment.
	Does engine rpm drop when tilt function goes over relief?	**YES:** Secondary relief is working. Go to next check. **NO:** Do Secondary Relief Valve Test and Adjustment.
Control Valve Load Check Valve (Manual Valve)	**WARNING** **Ensure load is secured so it will not move when mast is tilted fully forward.** 1. Put secured capacity load on forks and raise forks approximately 1 m (3 ft) and tilt slightly forward. 2. Stop engine. 3. Move lift lever to raise forks and observe movement. 4. Move tilt lever to tilt back position and observe movement. ***Did the forks drop or tilt forward?***	**YES:** Repair upper load check valves in the function that moved. Refer to appropriate **Main Control Valve** manual, depending on lift truck model. **NO:** Load check valves are OK. Go to next check.

Lift E-Valve Check

Lift Check (E-Valve)	**NOTE:** The air bleed procedure is necessary if the carriage moves slightly when the engine is started without activating the lift control lever. Cycling of the lift control lever is intended to bleed the air from the poppets (internal in the valve). 1. Activate the lift control lever from neutral to full and then back to neutral at a rate of one or two times per second. Repeat until the lift control lever functions are operating smoothly and there is no mast movement upon engine start. ***Does symptoms still exist?***	**YES:** Repeat until the lift control lever functions are operating smoothly. **NO:** Lift E-Valves are OK. Go to next check.
Tilt Function Counterbalance Check	**WARNING** **Ensure load is secured so it will not move when mast is tilted fully forward.** 1. Put secured capacity load on forks and raise forks approximately 1 m (3 ft). 2. Run engine at low idle speed and tilt load back to tilt stop. 3. Move tilt lever to tilt forks forward full stroke and observe speed. ***Can tilt speed be controlled?***	**YES:** Counterbalance is OK. Go to next check. **NO:** Repair counterbalance valve in tilt spool. Refer to appropriate **Main Control Valve** manual, depending on lift truck model.

Lift Drift Check	Ensure the following before starting procedure: • Truck operating on flat surface. • Hydraulic oil at operating temperature. **WARNING** **Ensure load is secured so it will not move when mast is tilted fully forward.** • Secured capacity load on forks. 1. Install angle meter on mast and position mast at approximately 90° angle to ground. 2. Raise mast until approximately 75 mm (3 in.) of main lift cylinder rods are exposed on mast. Record this measurement. 3. Stop engine. 4. After 5 minutes, measure mast main lift cylinder drop. ***Does main lift cylinder rod retract more than 50 mm (2 in.)?***	**YES:** Go to **Lift Cylinder Leakage Test** to isolate if problem is in cylinder or control valve. **NO:** Main cylinder drift is OK. Continue with this procedure.
	Continue: 5. Raise free lift cylinder approximately 75 mm (3 in.) and mark cylinder rod to record movement. 6. After 5 minutes, measure free lift cylinder drop. ***Does free lift drop more than 50 mm (2 in.)?***	**YES:** Go to **Lift Cylinder Leakage Test** to isolate if problem is in cylinder or control valve. **NO:** Free lift drift is OK. Go to next check.

SECTION 9020

ENGINE

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Group 10

Principles of Operation

Engine Basics

GENERAL TERMINOLOGY

NOTE: Engine Basics may not be applicable to your lift truck configuration. For specific engine Principles of Operation.

There are basically 3 requirements for engine combustion. They are: Fuel-Air, Compression, and Ignition source.

Fuel-Air is a combination of a combustible material such as petroleum and oxygen. The fuel in a Spark Ignited engine must be vaporized prior to reaching the combustion chamber. Fuel and air are typically mixed prior to the combustion chamber.

Compression takes place within the cylinder of an engine. Compression of the fuel air mixture is accomplished by the piston and increases the energy output of the ignited fuel.

Ignition Source for Combustion converts the compressed fuel air mixture to mechanical energy.

COMBUSTION THEORY

The German physicist who developed the four-stroke engine in the 19th century was Nikolaus August Otto. The four-stroke engine, even today, is sometimes referred to as the Otto' Engine.

A four-stroke engine is comprised, basically, of one or more cylinders in which a piston moves up and down. The piston is attached to a crankshaft by connecting rods so that when the piston moves, the crank' of the crankshaft causes it to rotate. This is how up and down movement is converted to circular motion.

Two valves are located near the top of the cylinder. The intake valve opens to admit the combustible mixture into the cylinder and the exhaust valve opens to expel the exhaust gases out.

The valves are spring-loaded closed and they are opened by the action of the camshaft. The camshaft is driven by a timing gear (or in some cases by a belt or a chain) attached to the crankshaft.

The camshaft gear is twice the diameter of the crankshaft gear, so that the camshaft rotates at exactly half the speed of the crankshaft. The lobes or cams of the camshaft are arranged so that they open the valves at the correct time during the engine's operational sequence.

The physical arrangement of the valves and camshaft depends on the design of the engine. The valves of an overhead valve engine are located above the combustion chamber. The stem of each valve extends upward and rides against a rocker arm.

Each trip that the piston takes from one end of the cylinder to the other is called a stroke. Four complete strokes of the piston completes one cycle; the cylinder is then ready to begin another cycle. As previously stated, the crankshaft completes two revolutions during one cycle.

Each stroke of the piston is given a name according to what happens within the cylinder during that interval. They are intake, compression, power, and exhaust.

Intake Stroke. The first stroke is the Intake Stroke. The intake stroke is the interval during which the combustible mixture is drawn into the cylinder. The stroke begins with the piston at the top of the cylinder and the intake valve begins to open. The exhaust valve is closed. As the piston moves downward, a partial vacuum is produced within the cylinder. The intake valve opens a passage through the intake manifold to the carburetor, or throttle body, where fuel and air are mixed in the intake manifold. The fuel-charged air, called the fuel-air mixture, is drawn into the cylinder by the partial vacuum created. As the piston approaches the bottom of the cylinder, the intake valve closes, completely containing the fuel-air mixture within the cylinder.

Compression Stroke. The next stroke is the Compression Stroke. Now that the cylinder is charged with a fuel-air mixture and both valves are closed, the piston begins to travel back to the top of the cylinder. The piston squeezes or compresses the fuel-air mixture into a very small space. The temperature, as well as, the pressure of the mixture is greatly increased. By compressing the fuel-air, the expansion force produced when it is ignited is significantly increased.

A common engine measurement is its Compression Ratio.' Compression ratio is the relationship between the greatest available volume of the cylinder when the piston is at the bottom of the stroke, and the smallest available volume, when the piston is at the top of the stroke. (For example, if an engine has a compression ratio of 8 to 1, the air-fuel mixture is compressed into a space 1/8th its original volume.) At the end of the compression stroke, the crankshaft has made one complete revolution.

Power Stroke. The third stroke is the Power Stroke. With both valves closed, the piston approaches the top of the cylinder and compresses the air-fuel mixture into the smallest space possible. Near the point of the greatest compression, a high-voltage electrical spark jumps across the gap of the spark plug; that is, the spark fires.' The spark ignites the fuel-air mixture and the combustion that results causes a rapid expansion of gases. The expanding gases exert equally against the walls of the cylinder and the top of the piston. Since the piston is the only moveable element, it is forced down the cylinder like a projectile fired from a gun. The descending piston drives the crankshaft another half-turn as it travels to the bottom of the cylinder. The power stroke is the only stroke that performs work.

Exhaust Stroke. The fourth stroke is the Exhaust Stroke. As the piston approaches the bottom of the cylinder at the end of the power stroke, the exhaust valve opens. As the piston travels upward, it acts like a pump to force the exhaust gases past the open exhaust valve to the exhaust system and into the atmosphere. When the piston is near the top of the cylinder, the exhaust valve closes and the intake valve opens so the four strokes can be repeated over and over again.

There are two more topics to discuss; Power Overlap and Valve Timing.

Power Overlap. A flywheel is bolted to the crankshaft to keep the crankshaft coasting' and to help smooth out the power output of the engine by absorbing power during the power stroke and releasing it during the other 3 strokes. Remember, the impulse energy from each cylinder's power stroke is only transmitted to the crankshaft for about 1/3 of one revolution yet it takes 2 complete revolutions of the crankshaft to complete a cycle.

In a multiple cylinder engine, there are more power impulses. An engine must have at least six cylinders to provide a continuous force to the crankshaft. If more than one cylinder fires during each third of crankshaft rotation, this condition is termed Power Overlap.' As power overlap is increased by the number of engine cylinders, the mass of the flywheel can be reduced. The camshaft revolves at half the crankshaft speed. Anything driven by the camshaft, (for example, the fuel pump, distributor, etc.…), are turning at half-engine speed while items driven by the crankshaft, like the rods, pistons, flywheel, etc., are turning at engine speed.

Valve Timing. When discussing valve timing, the first things to define are the terms "top dead center" referred to often as TDC and "bottom dead center," referred to as BDC. These two terms refer to the upper and lower most limits of piston travel within the cylinder, respectively. In actual engine operation, the intake valve opens "before top dead center" and closes after "bottom dead center" of the intake stroke. Also the exhaust valve opens before "bottom dead center" and closes after "top dead center" of the exhaust stroke.

During a portion of an engine cycle, both the intake and exhaust valves are open. This is Valve Overlap.' Valve overlap provides three benefits.

1. Keeping the intake valve open longer allows a greater charge of fuel-air mixture into the cylinder.
2. Keeping the exhaust valve open during the initial portion of the intake stroke allows the incoming fuel-air mixture to help force the exhaust gases out of the cylinder, and the flow of the fuel-air mixture past the exhaust valve helps to cool the engine.
3. The combination of better engine cooling, more complete purging of the exhaust, and greater volume of fuel-air mixture that results from valve overlap increases the power output of the engine.

ENGINE COMPONENTS – CYLINDER BLOCK

The cylinder block is made from cast iron or cast aluminum. The block is usually cast as one piece. It contains the bearings that support the crankshaft and the cylinders within which each piston moves. It is typically liquid cooled through a water jacket. Components of the block include the crankshaft, piston and rod assemblies, bearings and seals, and the timing set. The camshaft is in the block unless it is an overhead cam engine.

The crankshaft converts the reciprocating motion of the pistons and rods into rotating motion. The crankshaft is located near the bottom of the block assembly. Because it is mounted in bearings, the crankshaft can rotate freely within the block.

The piston and rod assembly absorbs the power released when the fuel-air mixture is ignited. The piston is usually made of aluminum alloy and is machined so that it fits the cylinder properly when it reaches operating temperature.

A piston usually contains three rings. The bottom ring controls oil flow to the cylinder wall, the other two rings seal the combustion chamber during engine operation. The connecting rod assembly, usually made from forged steel, connects the piston to the crankshaft and transmits the energy created by the burning of the fuel-air mixture, to the crankshaft. The small' end of the connecting rod is connected to the piston by a piston pin or wrist pin. The lower end, or large end, of the connecting rod contains the rod bearing. This bearing allows the rod to be fastened to the crankshaft while still allowing it to rotate.

CAMSHAFT AND TIMING SET

The camshaft operates the engine's intake and exhaust valves. These valves channel the fuel-air mixture into the cylinders and remove the exhaust products from the cylinder. The camshaft is often responsible for other functions. For example, in a diesel engine, the camshaft operates the fuel, oil and vacuum pumps.

Either a chain, belt or gears drive the camshaft at one-half the speed of the crankshaft. The chain and its sprockets, the gears, or the belt and its sprockets are referred to as the timing set'. A timing set includes all the components used to drive the camshaft.

CYLINDER HEAD ASSEMBLY

Cylinder heads are made from cast iron or cast aluminum. An engine has one or two cylinder heads, depending on how many cylinders of the engine. The cylinder heads are located on top of the cylinder block. The cylinder heads have one intake valve and one exhaust valve for each cylinder. In spark ignited engines, the heads contain some of the ignition system parts. In many engines, a large portion of the valve train is located in the cylinder head. Many of the cooling system components may also be located in and around the cylinder head, such as the outlet housing, thermostat, and water jacket.

VALVE TRAIN ASSEMBLY

The valve train assembly is responsible for transmitting the valve signals from the camshaft to the engine valves. In some engine designs, the entire valve train is located in the block assembly. In other designs, the entire valve train is located in the cylinder head. Some of the components included in the valve train are: valve lifters (tappets), push rods, rocker arms, rocker shafts or stud valves and valve keepers, valve seats, valve springs, and other attachment parts.

MANIFOLDS

There are two types of manifolds connected to an engine: an intake manifold to take air into the cylinders and an exhaust manifold to discharge the exhaust gas. The purpose of the intake manifold is to distribute the air or fuel-air mixture uniformly to each of the engine cylinders.

To maximize volumetric efficiency, some engines have tuned intake manifolds, in which the port cross-sectional area and length are adjusted to a size that fills the cylinders most efficiently. A leaking intake system may allow unfiltered air to reach the cylinders. A leak can cause detonation, misfire, and exhaust-emission problems during engine operation and evaporative hydrocarbon emissions when the engine is not operating. Leakage of air into the fuel-air mixture unbalances the engine by producing lean mixtures and upsetting the calibration of the fuel metering system.

Many exhaust manifolds are made from cast iron or nodular iron. Some manifolds are made from stainless steel or heavy gauge steel. The exhaust manifold contains an exhaust port for each exhaust port in the cylinder head, and a flat machined surface on the manifold fits against a matching surface on the exhaust port area of the cylinder head. Some manifolds have a gasket between the manifold and the cylinder head.

The engine exhaust manifold is a casting or assembly of passages through which the products of combustion leave the exhaust-valve ports in the cylinder head or cylinder block and enter the exhaust piping system. The purpose of the exhaust manifold is to collect and carry the exhaust gases away from the cylinders with a minimum of back pressure.

The entire exhaust system, including the exhaust manifold, catalytic converter, muffler, and piping affects the efficiency of combustive gas evacuation from the engine cylinders. Exhaust back pressure, when present; represents a direct loss of engine power. Exhaust manifolds operate at high temperatures and may be subject to erosive or corrosive attack.

The exhaust pipe is connected from the exhaust manifold to the catalytic converter or muffler. On V-type engines, the exhaust pipe is connected to each manifold flange and these two pipes are connected into a single pipe under the rear of the engine. This single pipe is then attached to a catalytic converter, if included in the exhaust system. Most exhaust pipes are made from stainless steel or aluminized steel. Some pipes are double walled.

A catalytic converter reduces the levels of carbon monoxide (CO), nitrogen oxides (NOx), and hydrocarbons (HC) (unburned fuel from the exhaust gases). Many lift trucks include a catalytic converter in the exhaust system. The catalytic converter will be discussed further within this section.

The muffler directs exhaust gases through a series of tubes, baffles, and chambers to reduce noise. The tail pipe dispenses water vapor and exhaust gases into the atmosphere. Another common component in the exhaust system is the oxygen (O_2) sensor. The sensor constantly makes comparisons between the oxygen content inside the exhaust manifold and the air outside the engine. If a rich or lean air/fuel mixture is sensed in the exhaust, the sensor provides a signal to the engine control unit (ECU). The ECU will then make an adjustment to the fuel-air mixture. If equipped, an additional (O_2) sensor is after (Post) the catalytic converter. The Post (O_2) sensor is used to determine the efficiency of the catalytic converter.

AIR CLEANER/FILTER

The air cleaner/filter is common to all LPG- engine systems. The air cleaner utilizes a cyclone-type dust separator, forcing dust to circulate around the blades. Dust, separated from the fresh air by the centrifugal force, accumulates in the dust pan. A special paper filter element is used to trap dust not separated by the cyclone action.

ELECTRONIC FUEL INJECTION (EFI)

The function of an Electronic Fuel Injection (EFI) system is to deliver the correct amount of fuel to the engine under all operating conditions. Engine conditions including speed, manifold pressure, engine coolant temperature, and throttle position are used to determine the engine mode of operation and the required fuel metering.

Port fuel injection delivers metered fuel directly prior to the intake valve. There is one port injector for each cylinder of the engine.

The benefits of an injected fuel system over a standard carbureted system are:

- Better fuel atomization.
- More control of fuel delivery.
- Better fuel efficiency.
- Increased engine performance.
- Improved emission control.

Electronic adjustment of fuel delivery is based on engine temperature, engine load, and atmospheric pressure.

POSITIVE CRANKCASE VENTILATION (PCV)

The Positive Crankcase Ventilation (PCV) system is designed to remove harmful vapors from the engine and to prevent those vapors from being expelled into the atmosphere. The PCV system does this by using manifold vacuum to draw vapors from the crankcase into the intake manifold. This vapor is then carried with the fuel-air mixture into the combustion chambers where it is burned. The flow or circulation within this system is controlled by the PCV Valve. The PCV valve is effective as both a crankcase ventilation system and as a pollution control device.

The closed PCV system draws fresh air from the air filter housing. The oil filler cap in this system is NOT vented. Consequently, excessive vapor will be carried to the intake manifold. The closed system prevents vapor, whether normal or excessive, from reaching the open atmosphere.

The most critical part in the PCV system is the flow control valve, commonly referred to as the PCV Valve. The purpose of this valve is to meter the flow of the vapor from the crankcase to the intake manifold. This is necessary in order to provide for proper ventilation for the crankcase, while not upsetting the fuel-air mixture for combustion.

Blow-by gases and vapor should be removed at about the same rate they enter the crankcase. Since blow-by is minimal at idle and increases during high speed operation, the PCV valve must control the flow of vapor accordingly. The valve is operated by manifold vacuum which increases or decreases as engine speeds change. At low or idle engine speeds, manifold vacuum is high. This pulls the plunger inside the valve to a position which reduces vapor flow to a minimum. This low rate is adequate for ventilation purposes and does not upset the fuel-air mixture ratio.

At high speeds, manifold vacuum is decreased. The plunger is only drawn about halfway within the valve and allows maximum vapor flow. Since the engine needs more fuel-air mixture at higher speeds, the introduction of more vapor does not affect performance. A neglected PCV system can fail to function and result in maintenance troubles. If the crankcase is not adequately ventilated, the engine oil can be contaminated and heavy sludge accumulations will begin to form. Water and acids can become trapped within the crankcase and cause rust or corrosion of internal engine parts.

Engine Electrical

INTRODUCTION

The Engine Electrical System includes the battery, starting, charging, ignition system, and instrumentation systems.

BATTERY CONSTRUCTION

The battery stores energy for the complete truck electrical system. On demand, the battery produces a flow of direct current for the devices connected to its terminals. After a period of use, the battery becomes discharged and no longer produces a flow of current. It can, however, be recharged by making an outside direct current flow through it in the opposite way from that which the current normally flows.

The battery is made up of a number of individual cells in a case. Each cell within the battery contains a group of positive and negative plates. There is always one more negative than positive plate within each cell group. Separators are between plates to prevent the plates from physically contacting each other and allow a free flow of electrolyte around each plate. The plates hold the active materials in flat grids. Charged negative plates contain spongy lead (Pb). Charged positive plates contain lead peroxide (Pb 02). Plate groups of opposite polarity are interlaced so the negative and positive plates alternate. Negative plate groups normally have one more plate than positive groups. This keeps negative plates exposed on both sides of the interlaced group.

The main battery terminals are the positive (+) and negative (−) posts. The positive (+) terminal is larger to prevent the danger of connecting the battery in reverse polarity. Reversing the polarity may damage some components and wiring in the system. A red cable is connected to the positive (+) battery terminal and a black cable is connected to the negative (−) terminal. The negative (−) cable is typically connected to the frame or engine block. The positive post cable is connected to the starter solenoid.

WARNING

Whenever disconnecting or reconnecting a battery, always disconnect the negative post cable first and connect it last. If you don't do this, dangerous sparking could occur. You should never connect the battery with the key switch in the ON position or the engine running. Never lay metal tools or any other objects across the battery which could potentially cause a short circuit.

A standard battery has one vent cap for each cell. The caps serve two purposes: First, they close the opening in the cell cover through which the electrolyte level is checked and water added, and second, they provide a vent for the escape of gases formed when the battery is charging. Each cell within the battery has a potential voltage of approximately 2 volts. A 12-volt battery will have six cells connected in series.

CONVENTIONAL STANDARD BATTERY

A conventional standard battery, when new, contains fully-charged elements and is filled with electrolyte at the factory. It will not maintain its charged condition during storage and must be recharged periodically. A standard battery requires periodic measurement and adjustment of the electrolyte levels. Access the electrolyte within each cell through the battery vent caps. The electrolyte level should be checked daily. The electrolyte should be 6.35 to 12.7 mm (1/4 to 1/2 in.) above the plate separators, so that the tops of the battery plates are covered. The battery should be filled with distilled water and never overfilled. Do not add electrolyte to the battery unless it has been lost by spillage.

Always wait until after checking battery specific gravity before adding distilled water to the battery. This will ensure a true reading. If the electrolyte level is too low to check specific gravity, add distilled water, operate in circuit for a few minutes to mix the distilled water and electrolyte, then check the specific gravity. Specific gravity testing procedures are covered later.

Standard batteries that are stored for long periods of time without recharging form lead sulfate crystals on the wires of the positive plates and could cause permanent damage. In some instances, if the sulfation is not too severe, a slow charge rate for a longer than normal period could restore the battery to normal operating condition.

MAINTENANCE-FREE BATTERY

A Maintenance-Free battery operates similarly to a conventional standard battery. The use of lead-calcium plates instead of lead-antimony in their construction increases the ability of the battery to accept an overcharge, thus greatly reducing bubbling and gassing of the electrolyte. Less fluid is lost, eliminating the need to add water. Venting of gases from a maintenance-free battery is done through a vent.' Most maintenance-free batteries do not have typical vent caps.' These batteries are ready for service when they leave the factory. They have a very low rate of discharge and thus, have a longer shelf life than a conventional standard battery.

BATTERY CHARGING

WARNING

Safety is very important while charging batteries. Always wear safety goggles, protective clothing, and rubber gloves when charging a battery. Keep sparks and flames away from the battery. Make sure the work area is well-ventilated. When charging and discharging, a lead acid storage battery generates harmful fumes and gases. This gas is very explosive.

The amount of electrical current a battery can produce is limited by the amount of chemical reaction which can take place within it. When the chemical reaction in the battery has ended, either through defect or long use, it can no longer produce a flow of electrical current. In most instances, if the battery is not defective, it can be recharged.

The battery charge is maintained by the truck charging system. If a component in the charging system fails or if a truck system is drawing current while the truck is not running, the battery charge may be depleted. In these circumstances, external charging of the battery may be required. Batteries are charged by reversing their flow of current. Batteries can be recharged in two ways, either Fast Charging or Slow Charging.

A battery that is in satisfactory condition but requires recharging will accept a large amount of charging current without undesirable effects. This type of battery may be charged quickly at a high rate with a battery fast charger.' The reaction of the battery itself to fast charging will indicate the amount of charging current it can accept without damage. NEVER allow the battery electrolyte to heat above 49°C (120°F).

A battery that becomes sulfated will not accept a high rate of charging current without possible damage. Its sulfated condition provides increased resistance to current flow within the battery. Flow of high current through this kind of resistance creates heat. Damage that may occur includes plate warping, boiling of the electrolyte, and possible damage of the separators. Also, the cell caps, covers, and battery case may be damaged or distorted. A battery that has become sulfated must be charged over a long period of time at a low rate of charge.

BATTERY FAST CHARGING

WARNING

Safety is very important while charging batteries. Always wear safety goggles, protective clothing, and rubber gloves when charging a battery. Keep sparks and flames away from the battery. Make sure the work area is well-ventilated. When charging and discharging, a lead acid storage battery generates harmful fumes and gases. This gas is very explosive.

To fast charge the battery, perform the following steps:

1. Disconnect the truck negative (−) and then positive (+) lead. Check, and if necessary, fill the cells with distilled water to the level recommended.
2. Connect the battery to the charger following manufacturer's recommendations. Set the charger to 15-30 amps for a 12-volt battery.
3. Start the charger at a slow or low charging rate.
4. Increase the charging rate one selection' at a time.
5. Observe the charger ammeter after one minute at each selection for a 10-amp' charging rate. If necessary, select boost.
6. After the battery has charged for 3 minutes, monitor the electrolyte and look for signs of excessive gassing.
7. Reduce the charging rate until the electrolyte produces comparatively few bubbles, but basing has not stopped entirely.

The maximum charging time at the boost selection is 10 minutes for a conventional battery and 20 minutes for a maintenance-free battery. Cold temperatures can increase the time required to charge the battery. Check the charger instructions for additional details. If the battery is not accepting the required 10-ampere charging rate by the specified time, replace the battery.

The charging rate for conventional batteries may require 2 to 4 hours. The charging rate for maintenance-free batteries may require 4 to 8 hours. Once the battery is charged, check the electrolyte specific gravity after the battery has cooled for 30 minutes. The specific gravity should be between 1.230 and 1.265.

BATTERY SLOW CHARGING

WARNING

Safety is very important while charging batteries. Always wear safety goggles, protective clothing, and rubber gloves when charging a battery. Keep sparks and flames away from the battery. Make sure the work area is well-ventilated. When charging and discharging, a lead acid storage battery generates harmful fumes and gases. This gas is very explosive.

To slow charge the battery, perform the following steps:

1. Disconnect the truck negative (−) and then positive (+) lead. Check, and if necessary, fill the cells with distilled water to the level recommended.
2. Charge the battery at a low rate (7% of the battery amp-hour rating or less) for an extended period of time until the battery is fully charged.
3. Take three consecutive hydrometer readings an hour apart, until it shows no rise in the specific gravity. The battery is now considered fully charged.

The normal slow-charging period is from 12 to 24 hours. If the battery's specific gravity has not reached the normal full-charge range (1.225 to 1.280) within 48 hours of slow charging, replace the battery. Badly sulfated batteries, however, could take between 60 to 100 hours to recharge completely.

STARTING SYSTEM PRINCIPLES OF OPERATION

The starting circuit converts electrical energy from the battery into mechanical energy at the starter motor to crank the engine.

The basic components of a starting system are:

- **Battery** - supplies energy for the circuit.
- **Starter Switch** - activates the circuit.
- **Solenoid-Operated Motor Switch** - engages the starter motor drive.
- **Starter Motor** - drives the flywheel to crank the engine.

When the starter switch is activated by the operator, a small amount of electrical energy flows from the battery to the starter solenoid and back to the battery through the ground circuit. As the starter solenoid gets this power from the battery, it moves the solenoid plunger against spring pressure, and engages the pinion gear with the flywheel ring gear. The plunger also closes the switch inside the solenoid between the battery and the starting motor, completing the circuit, and allowing a large amount of electrical energy to flow into the starting motor. The starter takes the electrical energy from the battery and converts it into rotary mechanical energy to crank the engine.

STARTING SYSTEM COMPONENTS - IGNITION SWITCH

The ignition switch is activated by the vehicle operator. It typically has three positions: **OFF**, **START**, and **RUN**. In the **OFF** position all truck circuits are de-energized. In the **START** position, system circuitry is activated to allow the starter to rotate and ignition systems to be energized. In the **RUN** position, the starter system is de-energized but the truck auxiliary systems and ignition remain powered.

STARTING SYSTEM COMPONENTS - STARTER SOLENOID

The primary purpose of the starter solenoid is to engage the starter pinion gear. The starter solenoid is a magnetic switch, but in addition to closing a circuit, the solenoid provides a mechanical means of shifting the starter motor pinion. The solenoid switch can be either contained within the starter motor unit or a separate component.

A typical solenoid switch has two coils of wire wound in the same direction. The pull-in' winding is made up of heavy wire connected to the motor terminal of the solenoid and through the motor to ground. The hold-in' winding has an equal number of turns of fine wire with one end connected to ground. These coils are energized directly from the battery through the start' position of the ignition switch. They work together to pull-in and hold-in the pinion gear positioning plunger against spring pressure, engaging the pinion gear with the flywheel.

When the ignition switch is released to the run position, the pull-in and hold-in windings within the starter solenoid are energized in opposing directions. This causes the magnetic field controlling the plunger to collapse. Spring tension then acts on the plunger, moving it and disengaging the pinion gear from the flywheel.

STARTING SYSTEM COMPONENTS - FLYWHEEL AND RING GEAR

The flywheel is connected to the engine crankshaft. During engine starting, the starter, through the starter pinion gear, rotates the flywheel and the crankshaft. A ring gear is installed around the outer edge of the flywheel. This ring gear is engaged by the starter pinion gear during the engine start cranking process.

STARTING SYSTEM COMPONENTS - STARTER MOTOR AND DRIVE

The starter motor does the actual job of cranking the engine. It is a special electrical motor designed to operate for short intervals under great overload. It also produces very high horsepower for its size. The starter motor is a series-wound, direct-current electric motor designed to provide high power for a short time using current from a storage battery. Most starting motors have two, four, or six field poles with windings; a wound armature with a commutator; and two, four, or six brushes. The basic parts of a starter motor are the solenoid, a field frame assembly, an armature, and a drive mechanism.

After electrical power is transmitted from the battery through a switch to the starting motor, some type of connection is needed to put this energy to work. The last link in the starting circuit is the starting motor drive. The drive makes it possible to use the mechanical energy produced by the starter motor. The starter motor armature revolves at a relatively high speed. Since the speed required to start the engine is comparatively slow, the starter motor is equipped with a small drive pinion which meshes with the teeth of the flywheel ring gear.

The gear ratio between the drive pinion and the flywheel are typically in the range of 20 to 1. This permits the starter motor to develop high armature speeds and considerable power while turning the engine over at a lower speed. After combustion has occurred and the engine speeds up to idle, the starter must be disengaged to prevent damage as the flywheel RPM increases. A starter drive on the end of the armature shaft meshes the drive pinion with the ring gear on the flywheel, and prevents the starter motor from overspeeding after the engine is started.

There are two basic ways in which starter drives are engaged. They are either Inertia Drives or Electromagnetic Drives. On an inertia drive, the pinion gear is weighted on one side to aid in its initial rotating motion. An inertia drive starter does not contain a starter solenoid. When not rotating, the inertia drive is out of mesh and separated from the flywheel ring gear. The drive relies upon inertia of a counterweight pinion and acceleration of the armature to move the pinion into mesh with the flywheel. As the starter armature shaft accelerates rapidly, the pinion gear, due to inertia created by the counterweight, runs forward on a revolving screw sleeve until it meets and meshes with the flywheel. When the engine starts, the flywheel rotates faster than the starter shaft, causing the pinion to turn in the opposite direction on the screw and it spins itself out of mesh.

Electromagnetic drives are shifted in or out of mesh by the magnetic field of a switch. The Overrunning Clutch, Dyer Drive, and Sprag Clutch Drive are all electromagnetic type drives.

- **Overrunning Clutch Type Drive** - uses a shift lever to actuate the drive pinion. The pinion, together with the overrunning clutch mechanism, is moved endwise along the armature shaft and into, or out of, mesh with the flywheel.
- **Dyer Drive** - is a special drive mechanism that provides positive meshing of the drive pinion with the flywheel, before the cranking of the starter motor armature begins. This action eliminates the clashing of pinion teeth with flywheel teeth, as well as, the possibility of broken or burred teeth on either gear.

- **Sprag Clutch Drive** - is constructed and operated similar to the overrunning clutch drive, except that a series of sprags replace the rollers between the shell and sleeve. The sprag clutch drive is used primarily on larger starting motors to carry the high torque required to turn over high-compression engines.

CHARGING SYSTEM - GENERAL

AC charging circuits have an alternator and a regulator. Most regulators are internal to the alternator. The alternator is really an AC generator. The generator produces AC current and then rectifies it to DC current through the use of diodes. Alternators are generally more compact than generators of equal output, and supply a higher current output at low engine speeds.

CHARGING SYSTEM - REGULATOR

The regulator in an AC generation circuit limits the alternator voltage to a safe, preset value. Transistorized models are used in many charging circuits.

CHARGING SYSTEM - THEORY

All charging circuits operate in three stages:

- **Starting** – the battery supplies all load current.
- **Peak Operation** – the battery helps the generator supply current.
- **Normal Operation** – the generator supplies all current and recharges the battery.

In a typical charging circuit, the battery starts the circuit when it supplies the spark to start the engine. The engine then drives the generator or alternator, which produces current to take over the operation of the ignition, lights, and truck accessory loads within the electrical system. It is important to remember that once the engine is started, the generator or alternator is the work horse’ which gives current to the ignition and accessory circuits.

Most lift trucks incorporate an AC charging circuit, comprised of an alternator and voltage regulator. The alternator is the heart of the charging circuit. Basically, like a generator, the alternator converts mechanical energy into electrical energy. The initial energy produced is alternating current. The AC current is electronically converted to direct current using diodes.

As the engine operates, the alternator is rotated by a belt. A voltage is produced within the alternator by moving a charged field across a stationary conductor, thereby inducing voltage. With each revolution alternating current is produced. The alternator is either ON or OFF. It generates maximum current when it is ON and no current when it is OFF. The regulator switches the alternator between ON and OFF to get the average current needed to charge the battery. Alternator output is directly changed by engine speed and rotor field current.

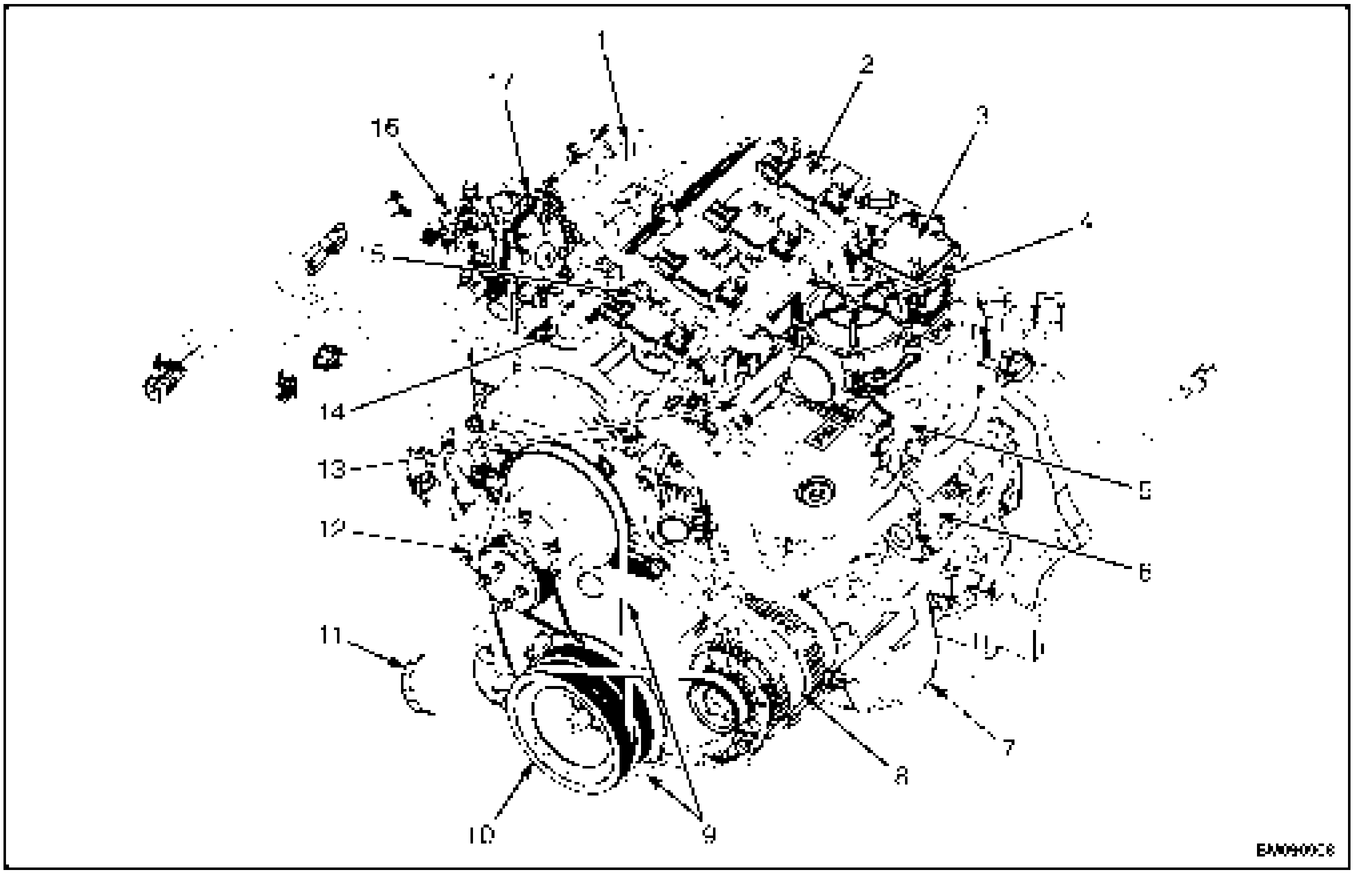
A diode is an electrical device that will allow current to flow through itself in only one direction. When a diode is connected to an alternating current, it only allows the alternating current to flow through it in one direction, thereby rectifying it to direct current. The diode provides what is termed half wave’ rectification of the alternating current. If the circuit only has one diode, the DC generation would be very limited. A diode bridge within the alternator is designed to extract maximum DC current from the produced alternating current.

Direct current from the diodes of the diode bridge flows to the alternator output terminal, sometimes called the BAT terminal. A capacitor between the BAT terminal and the electrical ground removes any remaining alternating current from the produced direct current. The capacitor also protects the diodes from high voltages.

The voltage regulator controls the alternator to charge the battery. The voltage is set by the manufacturer and is not adjustable. Battery voltage decreases as the starting circuit and other circuits use power from it. When the ignition switch is in the start position, the voltage regulator is energized. The regulator senses battery voltage and increases alternator output to charge the battery during various operating states of the electrical system.

PSI 2.0L / 2.4L Engine

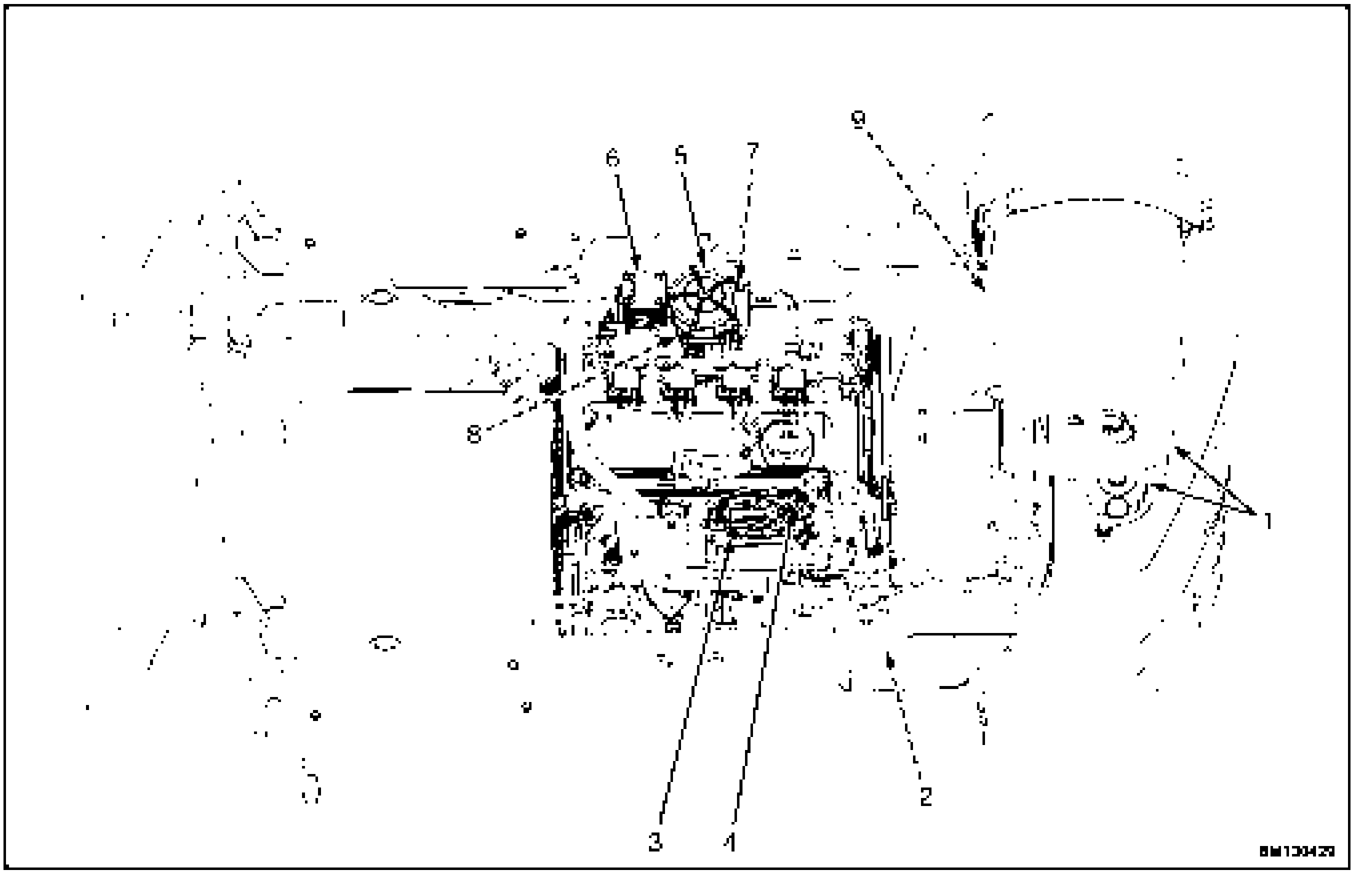
The PSI 2.4L and 2.0L engines are available in LPG and dual fuel configurations.



1. DIPSTICK (ENGINE OIL)
2. IGNITION COILS AND PLUGS
3. DIRECT ELECTRONIC PRESSURE REGULATOR (DEPR)
4. AIR FUEL MIXER
5. ELECTRONIC THROTTLE CONTROL
6. STARTER
7. DRAIN PLUG
8. ALTERNATOR
9. DRIVE BELTS
10. CRANKSHAFT PULLEY
11. OIL FILTER
12. WATER PUMP
13. OIL FILL CAP
14. FUEL RAIL/FUEL INJECTORS/FUEL LINE
15. PCV HOSE
16. LOCK-OFF VALVE
17. (OSR) DUAL STAGE REGULATOR

Figure 9020-10-1. PSI 2.4L Engine

LPG System



1. TANK
2. FUEL FILTER
3. VAPORIZER
4. LOCK-OFF SOLENOID
5. FUEL MIXER
6. DIRECT ELECTRONIC PRESSURE REGULATOR (DEPR)
7. ELECTRONIC THROTTLE
8. ENGINE CONTROLLER
9. EXHAUST SYSTEM

Figure 9020-10-2. Key Components of LPG Fuel System, (PSI 2.0L Engine)

Principles of Operation

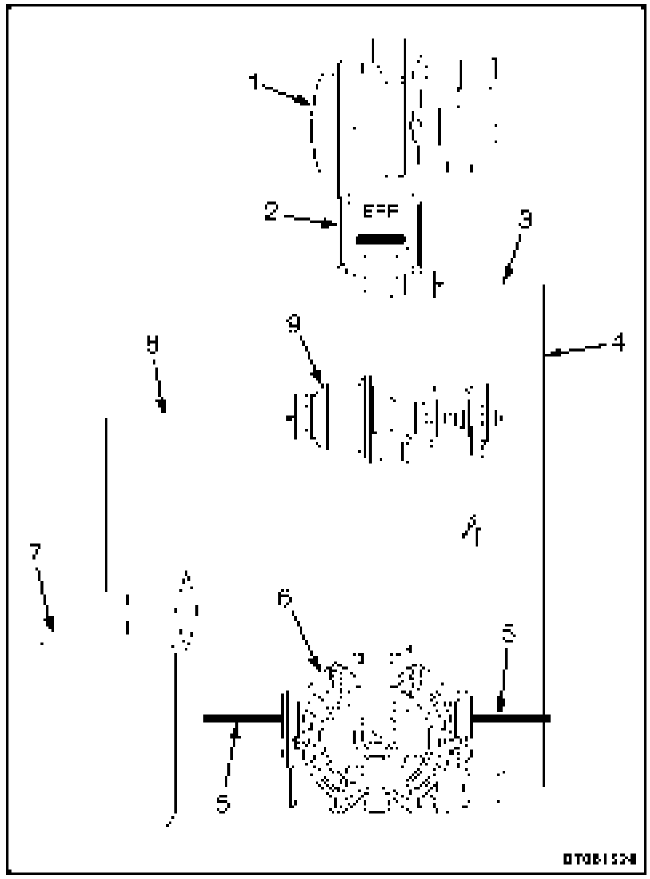
Propane is compressed in the tank in a liquid form. With the tank valve open, liquid propane flows from the tank to the lock-off valve through a fuel filter in the lock-off valve. As the pilot opens, pressure builds in the outlet side of the lock-off valve as pressure begins to equalize the main valve fully opens.

When the lock-off valve is open, liquid propane flows into the vaporizer where heat from the engine coolant is used to convert the liquid fuel to vapor. The vaporizer consists of primary and secondary pressure sides.

The vapor hose supplies fuel from the vaporizer to the propane line. The propane line feeds fuel directly into the Direct Electronic Pressure Regulator (DEPR). The DEPR is a stand alone module controlled by the engine controller over the CANbus. The DEPR consists of a control module, pressure and temperature sensor, and solenoid valve. The DEPR controls fuel inlet into the mixer.

The mixer is an air-fuel metering device. The mixer is an air valve design, utilizing a pressure drop to draw fuel into the mixer. The mixer is mounted in the air stream, ahead of the electronic throttle body.

Air is supplied to the electronic throttle body through the mixer's air outlet. Fuel is supplied to the fuel delivery pipe by the mixer's fuel outlet hose. The engine controller controls the fuel injector based on inputs from the camshaft position (CMP) sensor, the crankshaft position (CKP) sensor which measures RPM, oxygen (O_2) sensor, temperature manifold absolute pressure (TMAP) sensor, and coolant temperature sensor (CTS).



1. MIXER
2. DIRECT ELECTRONIC PRESSURE REGULATOR (DEPR)
3. GASEOUS PROPANE LINE
4. VAPOR HOSE
5. COOLANT INLET / OUTLET HOSE
6. VAPORIZER
7. LPG TANK / MANUAL VALVE
8. LIQUID PROPANE LINE
9. LOCK-OFF VALVE

Figure 9020-10-3. LPG System Component Location

Lock-Off Valve

The LPG lock-off valve is a 12 volt, normally closed valve. When energized, the solenoid opens the pilot valve which uses the tank pressure, to open the valve. The valve is open when the key is ON. The lock-off supply voltage is controlled by the ignition feed. The lock-off valve ground is at the controller.

Vaporizer

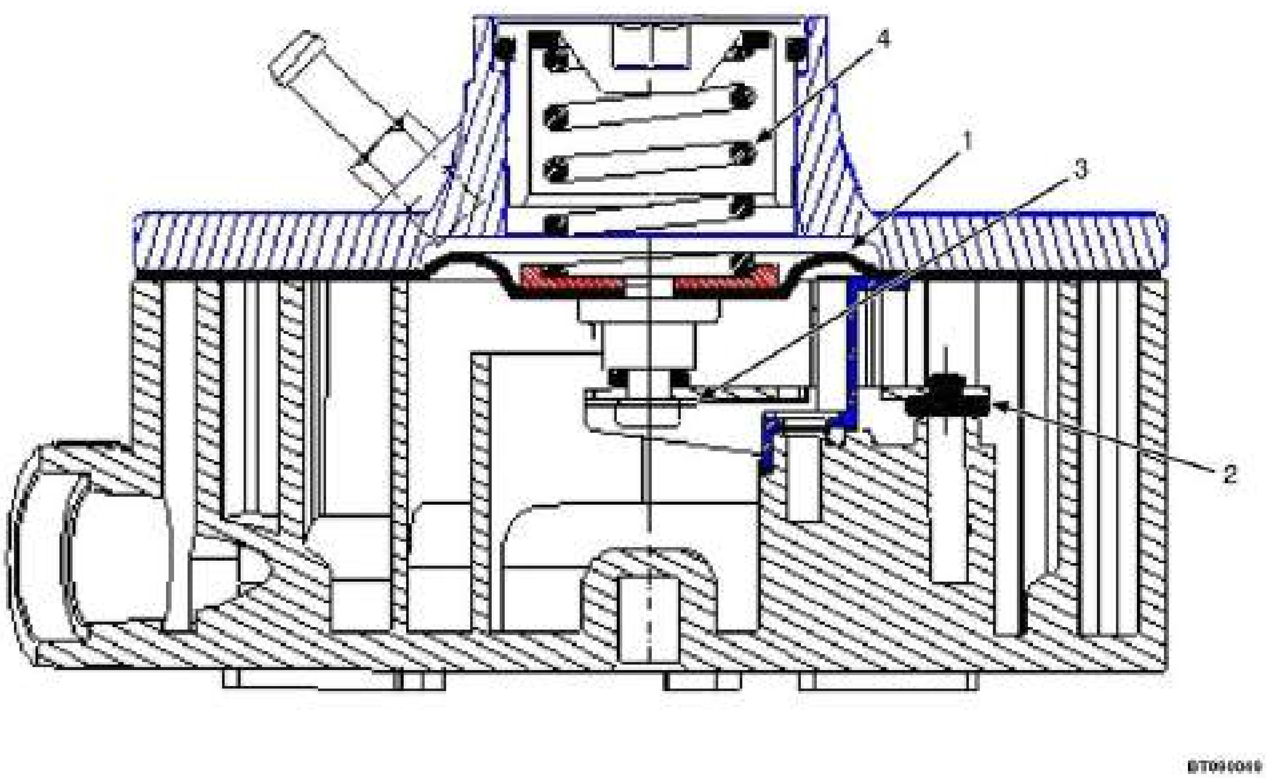
The vaporizer receives a liquid fuel at tank pressure from the filter fuel lock-off and reduces that pressure in two stages to slightly less than atmospheric.

When the engine is cranking or running, a partial vacuum is created in the fuel line to the mixer, which opens the regulator, permitting fuel to flow to the mixer.

The LPG expands as it vaporizes, and the pressure drops from approximately 1.24 MPa (180 psi), cooling the surrounding components.

To compensate for the cooling effect and to assist in vaporization, water from the engine cooling system is circulated through a heat exchanger.

The fuel flow is sealed off when the engine is stopped.



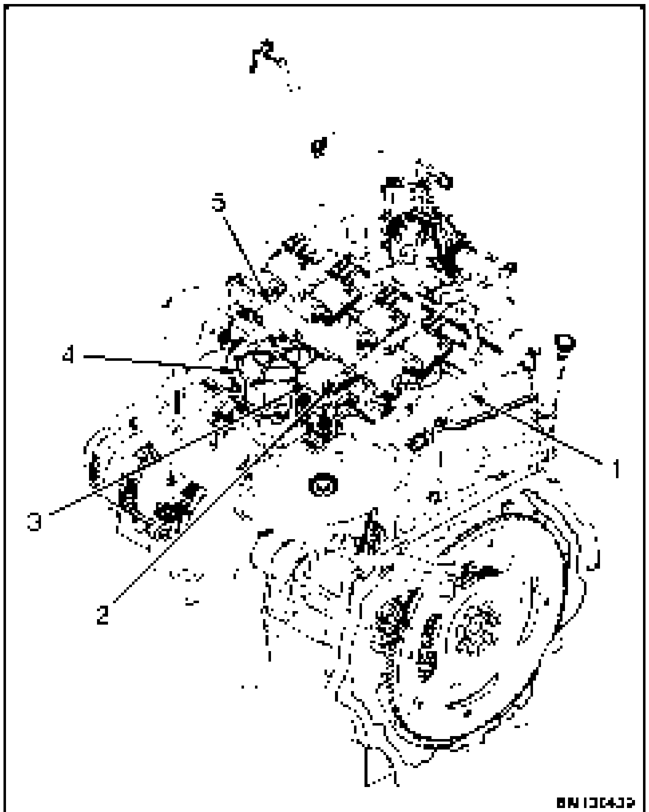
1. MEMBRANE
2. VALVE
3. LEVER
4. SPRING

Figure 9020-10-4. Vaporizer Cross-Sectional View

Direct Electronic Pressure Regulator (DEPR)

The Direct Electronic Pressure Regulator (DEPR) is the primary fuel control device, used to control both performance and emissions. The DEPR contains a computer which communicates to the engine controller via the CANbus connection.

The DEPR precisely controls the fuel flow required to ensure Stoichiometric (correct air / fuel mixture for complete burn) fuel delivery to the engine combustion chambers. The DEPR also contains fuel pressure and temperature sensors, which provide input via the CANbus, to the engine controller, for fuel calculation. The engine controller uses this information to command changes back via the CANbus, to the DEPR to adjust fueling.



1. FUEL VAPOR HOSE
2. DEPR CONNECTOR
3. DIRECT ELECTRONIC PRESSURE REGULATOR (DEPR)
4. FUEL MIXER
5. REAR PCV HOSE

Figure 9020-10-5. Fuel Mixer and DEPR Components

Mixer

The mixer uses a piston with a sealing ring in place of a diaphragm. Cranking the engine lowers pressure under the mixer piston causing the engine piston to descend. The reduced pressure lowers the mixer piston against the metering spring.

Approximately 1.4 kPa (0.2 psi) of pressure is required to lower the air valve off its seat. Approximately 3.4 kPa (0.5 psi) lowers the valve to the bottom of its travel in full open position.

Pressure varies with engine speed and position of throttle valve opening. The air valve assembly measures the air flow into the engine by moving precisely in response to the demands of the engine and throttle valve position.

The controlled pressure drop of 1.4 kPa (0.2 psi) to 3.4 kPa (0.5 psi) caused by the metering spring provides the force necessary to draw fuel into the air stream. The gas metering valve attached to the air valve assembly is shaped to admit the correct amount of fuel from the gas jet to mix with incoming air at any opening of the air valve.

The gas metering valve is designed to produce lean mixtures at heavier loads and higher engine speeds.

Gasoline Fuel System

The primary components of the Gasoline Multi Point Fuel Injection (MPFI) fuel system are the gasoline fuel tank, electric fuel pump, fuel pressure and temperature sensor manifold, fuel filter and fuel rail.

Principle of Operation

An in-tank fuel pump assembly provides fuel from the tank through an in-line fuel filter to the fuel rail. The fuel pressure in the rail is controlled with a pressure regulator. The regulator maintains the pressure difference between the fuel in the rail and the air within the intake manifold. Excess fuel that passes the regulator is returned to the tank through the fuel return line, while regulated fuel is sent to the injectors.

The injector is a pulse width modulated controlled device which opens and closes, injecting fuel into the engine combustion chamber.

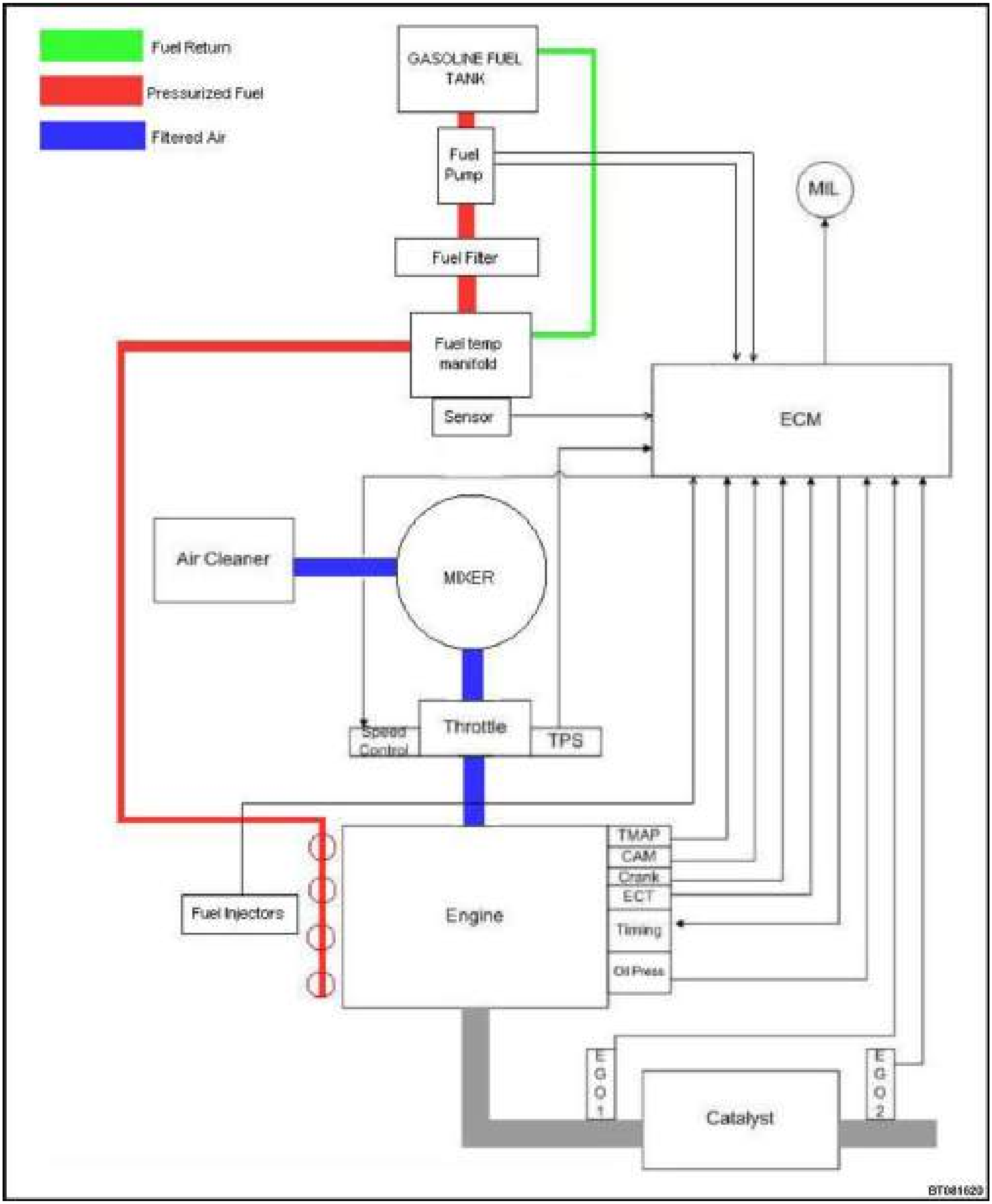
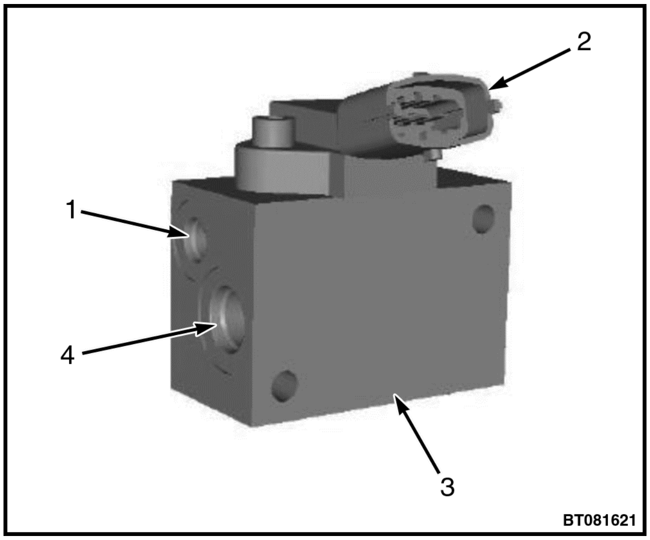


Figure 9020-10-6. Gasoline Fuel System Schematic

Fuel Pump

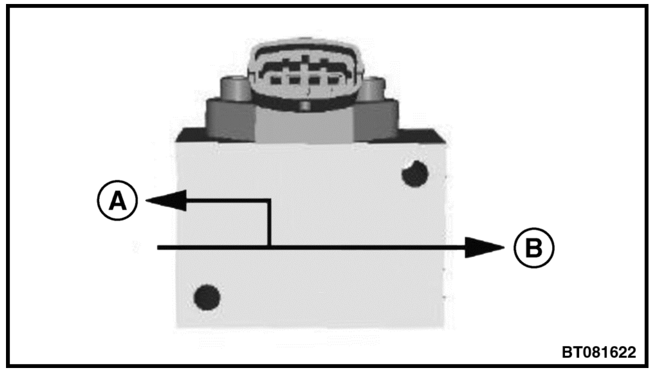
The Gasoline is stored as a liquid in the fuel tank and in drawn into the fuel system by a 12 volt electric fuel pump. Depending on the vehicle application the fuel pump may be mounted in the fuel tank or as a stand alone component. In either case the fuel pump will receive a signal from the ECM at Key On to prime the fuel system for approximately 2 seconds prior to start. Priming of the fuel system provides for a quicker start, when the engine begins to crank.

Pressure and Temperature Sensor Manifold



1. RETURN / BLEED PORT
2. ELECTRICAL CONNECTOR
3. PRESSURE / TEMPERATURE SENSOR MANIFOLD
4. FUEL FEED PORT

Figure 9020-10-7. Pressure and Temperature Sensor Manifold



A. BLEED / RETURN CIRCUIT
B. FUEL FEED CIRCUIT

Figure 9020-10-8. Manifold Flow

This engine is equipped with a fuel injector rail that does not have a pressure regulator or a return circuit to the fuel tank. Fuel pressure for this engine is regulated by the engine's ECM. The ECM receives fuel pressure and temperature feedback from the gasoline fuel sensor manifold and uses this information to control the ground side of the fuel pump. Fuel pressure is regulated by the ECM pulse width modulating (PWM) the fuel pump. The fuel pressure and temperature sensor manifold has a return or "bleed" circuit that connects back to the equipment fuel tank. This circuit is used to bleed off any vapor that develops in the line and returns a small amount of fuel to the tank. The fuel comes from the fuel tank and passes through the fuel pump. Fuel exits the fuel pump, passes through the filter and then enters the fuel pressure and temperature manifold assembly. Fuel flows through the feed circuit and is delivered to the fuel injector rail. Fuel that enters the bleed circuits through the by-pass valve in the manifold is returned to the fuel tank.

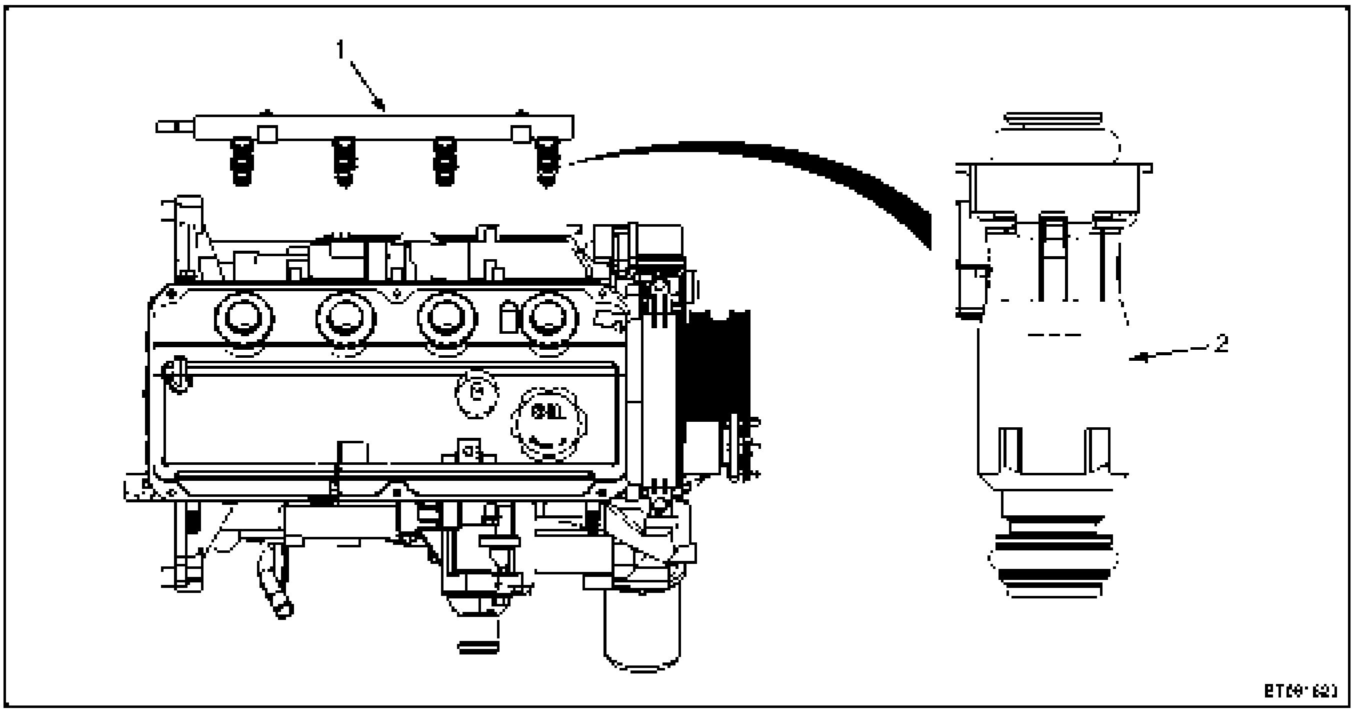
Fuel Filter

After the fuel is drawn into the fuel pump, the fuel flows through the gasoline fuel filter. The fuel filter will trap small particles. The fuel passes through the filter to remove debris which prevents the fuel pressure and temperature manifold and fuel injectors from becoming damaged. Maintenance of the fuel filter is required as indicated in the Recommended Maintenance Schedule. A more frequent replacement of the filter may be required if the equipment operates in a dusty or dirty environment.

Fuel Rail and Fuel Injector

The fuel flows from the fuel pressure and temperature manifold assembly to the fuel rails where the fuel is delivered to the fuel injectors.

The fuel supply is maintained on the top of the injector from the injector rail. The injector is fed a “pulse” ground signal through the wire harness which causes the injector to open. During regular operating conditions the ECM controls the opening and duration of opening of the injector. During lower RPM operation the injector signals or “pulses” are less frequent then when the engine is operating at higher RPMs. The certified engine has been calibrated to deliver the precise amount of fuel for optimum performance and emission control.



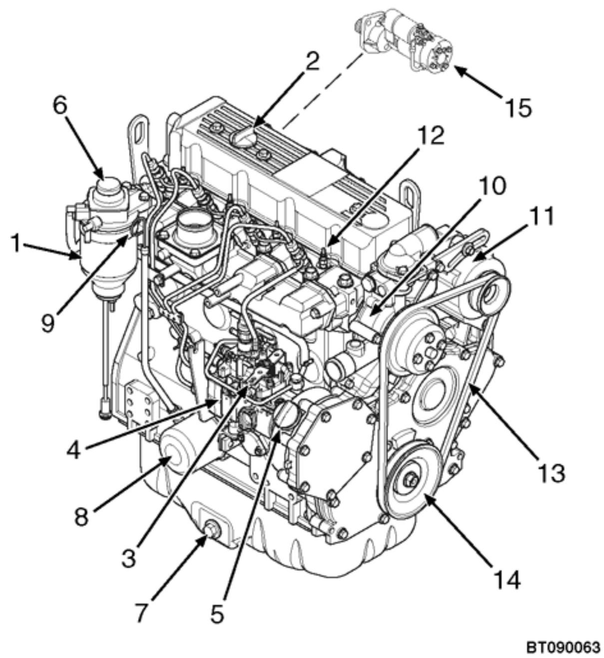
1. FUEL INJECTOR RAIL
2. FUEL INJECTOR

Figure 9020-10-9. Fuel Rail and Injectors

Yanmar (Diesel) Engine

DESCRIPTION

The Yanmar diesel engine is a naturally aspirated, liquid cooled, indirect injection system that has an in-line four configuration. The key components of the Yanmar diesel engine are shown in Figure 9020-10-10.



1. FUEL FILTER/WATER SEPARATOR AND STRAINER
2. OIL FILL PORT (TOP)
3. GOVERNOR LEVER
4. FUEL INJECTION PUMP
5. OIL FILL PORT (SIDE)
6. FUEL PRIMING PUMP
7. OIL DRAIN PLUG
8. OIL FILTER
9. DIPSTICK
10. ENGINE COOLANT PUMP
11. ALTERNATOR
12. GLOW PLUG
13. V-BELT
14. CRANKSHAFT V-PULLEY
15. STARTER MOTOR

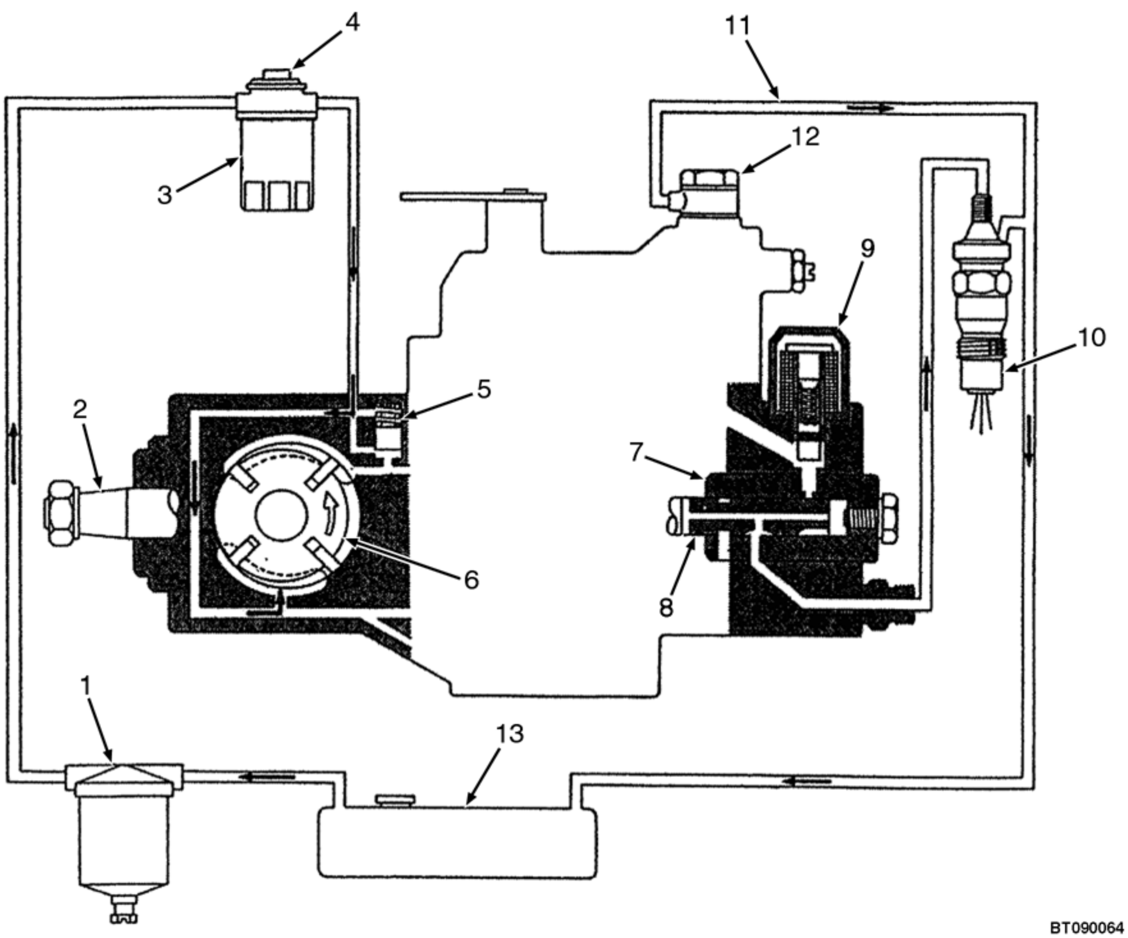
Figure 9020-10-10. Yanmar Diesel Engine Components

DIESEL FUEL SYSTEM

Principles of Operation

The diesel fuel system is summarized as follows:

Fuel is fed from the fuel tank through an external fuel filter to the fuel filter/water separator and strainer and then to the inlet port of the injection pump. This flow is accomplished by the feed pump, which is an internal component of the fuel injection pump. The fuel filter/water separator and strainer functions to remove contaminants, sediments and water from the diesel fuel. The fuel pressure created by the feed pump in the pump chamber is proportional to the pump RPM. Excess fuel is returned to the suction side by the regulating valve. Fuel is directed to the plunger via a fuel path within the distributor head. The plunger increases the fuel pressure, allowing the fuel to be fed to the fuel injectors. An overflow tube at each injector allows excess fuel to flow back to the fuel tank. See Figure 9020-10-11.



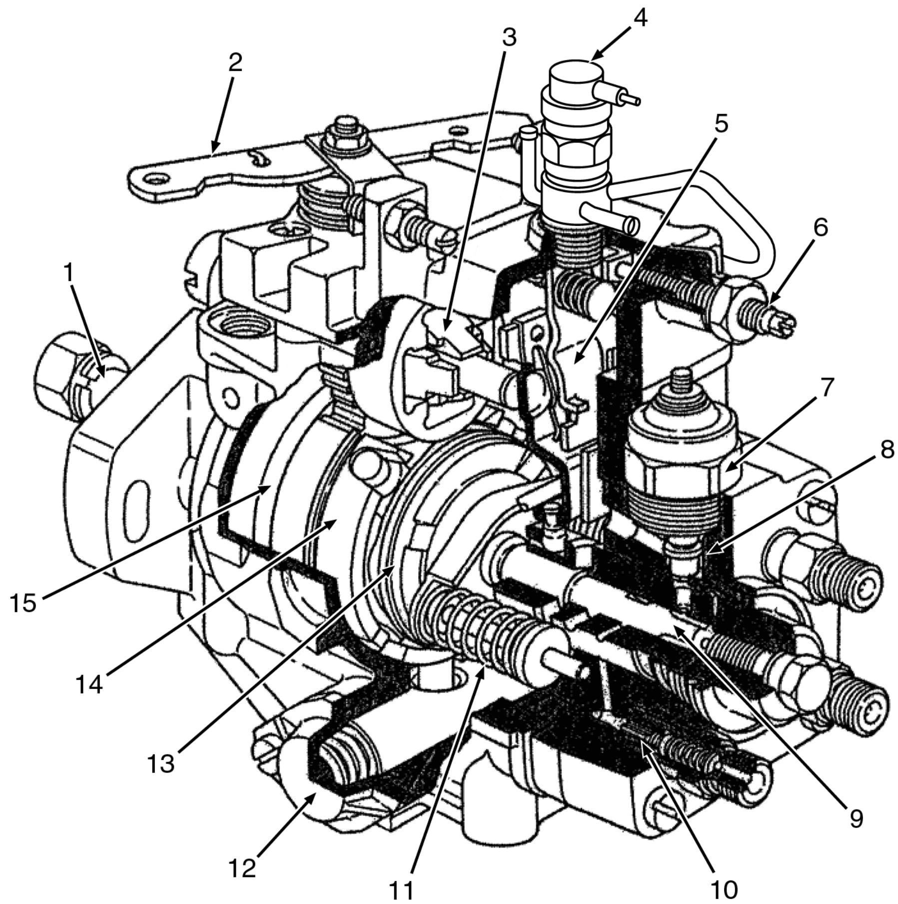
1. WATER SEPARATOR
2. DRIVE SHAFT
3. FUEL FILTER
4. PRIMING PUMP
5. REGULATING VALVE
6. FEED PUMP
7. PLUNGER BARREL
8. PLUNGER
9. ENGINE STOP SOLENOID
10. FUEL INJECTOR NOZZLE
11. OVERFLOW PIPE
12. OVERFLOW VALVE
13. FUEL TANK

Figure 9020-10-11. Diesel Control System Diagram

FUEL INJECTION PUMP AND GOVERNOR

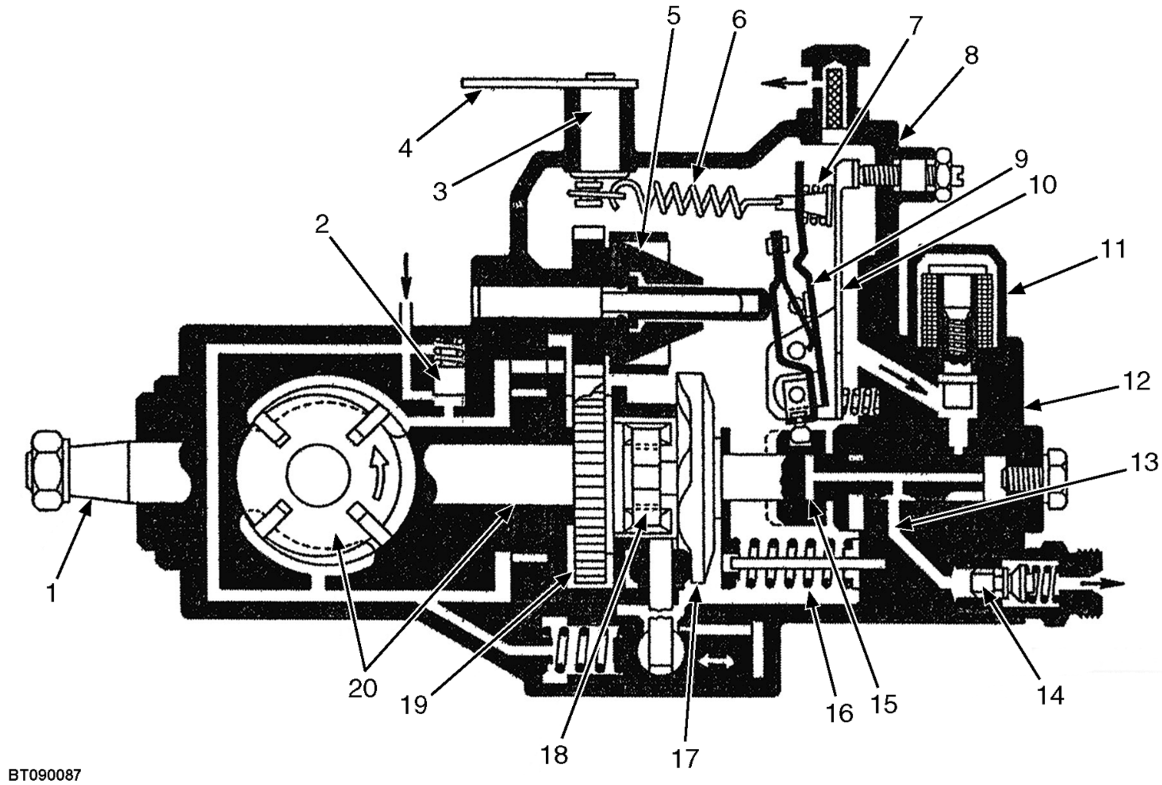
Description

The fuel injection pump and governor consist of the following components. See Figure 9020-10-12 and Figure 9020-10-13.



1. DRIVE SHAFT
2. CONTROL LEVER
3. FLYWHEEL
4. COLD START SOLENOID
5. GOVERNOR LEVER
6. FULL LOAD ADJUSTING SCREW
7. ENGINE STOP SOLENOID (MAGNETIC VALVE)
8. DISTRIBUTOR HEAD
9. PLUNGER
10. DELIVERY VALVE
11. PLUNGER SPRING
12. TIMER
13. CAM DISC
14. ROLLER HOLDER
15. FEED PUMP

Figure 9020-10-12. Fuel Injection Pump and Governor Components



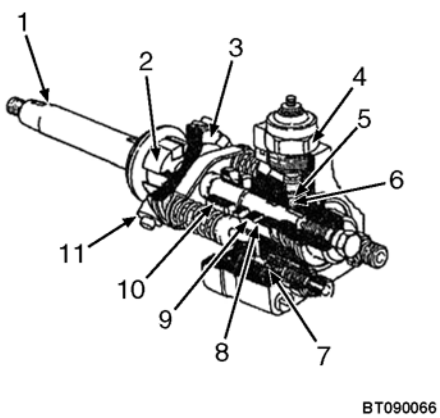
1. DRIVE SHAFT
2. REGULATING VALVE
3. CONTROL LEVER SHAFT
4. CONTROL LEVER
5. FLYWHEEL
6. GOVERNOR SPRING
7. IDLE SPRING
8. FULL LOAD ADJUSTING SCREW
9. TENSION LEVER
10. GOVERNOR LEVER ASSEMBLY
11. MAGNET VALVE
12. PLUNGER
13. OUTLET PORT
14. DELIVERY VALVE
15. CONTROL SLEEVE
16. PLUNGER SPRING
17. CAM DISC
18. CROSS COUPLING
19. DRIVE GEAR
20. FEED PUMP

Figure 9020-10-13. Structure and Operation of Fuel Injection Pump

Check the Service Manual section in Hypass Online for possible updates and check pertinent Grams

Principles of Operation

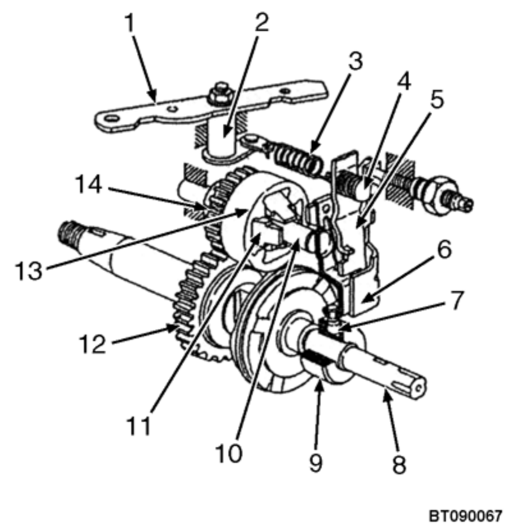
Injection Pump: The injection pump drive shaft directly receives engine rotation via the timing gear and transfers it to the cam disc. The plunger revolves by means of the drive shaft and reciprocates by means of the cam disc. The plunger operates at the same speed as the cam disc. On the outside of the plunger are two return springs. When the fuel is pressurized by the plunger, the fuel travels through the outlet port and the delivery valve opens to inject the fuel into the engine combustion chamber via the nozzle and nozzle holder. See Figure 9020-10-14 and Figure 9020-10-19.



1. DRIVE SHAFT
2. CROSS COUPLING
3. CAM DISC
4. ENGINE STOP SOLENOID
5. DISTRIBUTOR HEAD
6. INLET PORT
7. DELIVERY VALVE
8. OUTLET PORT
9. PLUNGER BARREL
10. CONTROL SLEEVE
11. ROLLER

Figure 9020-10-14. Injection Pump Operation

Governor: The governor is located above the injection pump chamber and consists of a flyweight holder and governor lever assembly. The flyweight holder consists of four flyweights and governor sleeves, and is supported by the governor shaft. The drive gear engages with the flyweight holder gear to turn the flyweight holder assembly. The governor lever assembly is secured by a pivot bolt on the pump housing. The ball pin at the bottom of the governor lever assembly is inserted into the control sleeve which slides on the outer periphery of the plunger. The governor spring at the top of the assembly is connected to the tension lever by the retaining pin. The end of the governor spring is connected to the control lever via the control lever shaft. The control lever is used to change the set force of the governor spring according to the inclined angle. The difference between the governor spring set force and the flyweight centrifugal force determines the moving distance of the control sleeve, thereby increasing or decreasing the fuel injection volume. See Figure 9020-10-15.

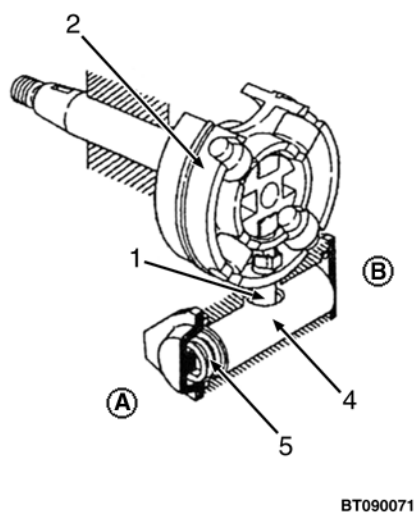


1. CONTROL LEVER
2. CONTROL LEVER SHAFT
3. GOVERNOR SPRING
4. RETAINING PIN
5. TENSION LEVER
6. GOVERNOR LEVER ASSEMBLY
7. BALL PIN
8. PLUNGER
9. CONTROL SLEEVE
10. GOVERNOR SLEEVE
11. FLYWEIGHT
12. DRIVE GEAR
13. FLYWEIGHT HOLDER
14. FLYWEIGHT HOLDER GEAR

Figure 9020-10-15. Governor Operation

Timer

At the bottom of the injection pump is the built-in timer. A timer spring having a set force is installed on the low pressure side of the timer piston. The fuel pressure in the pump chamber is directly applied to the high pressure side of the timer piston. The position of the timer piston changes according to the balance between the fuel pressure and the timer spring force to turn the roller holder via the roller holder pin. When the piston moves in the direction to compress the timer spring, the roller holder moves in the advance direction (opposite direction of driveshaft rotation) to advance the injection timing. Thus, the timer controls the fuel injection timing according to the fuel pressure in the pump chamber. See Figure 9020-10-16.



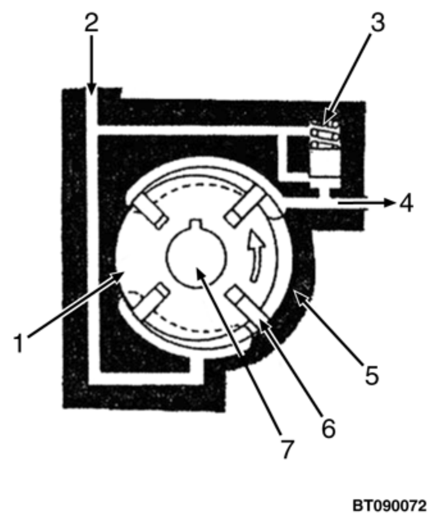
A. LOW PRESSURE SIDE
B. HIGH PRESSURE SIDE

1. ROLLER HOLDER PIN
2. ROLLER HOLDER
3. TIMER PISTON
4. TIMER SPRING

Figure 9020-10-16. Injection Pump Timer

Feed Pump (Vane Type)

The feed pump functions to feed fuel from the fuel tank to the pump chamber. The feed pump consists of the rotor, blade (vane) and liner. The shaft drives the slotted rotor. The rotor is fitted with blades that can move in and out of the slots. This assembly is offset mounted inside a circular ring. As the shaft and rotor are turned, the vanes are forced against the outer ring by centrifugal force. As the assembly rotates the cavity formed by the liner, rotor and vanes will get increasingly larger on the inlet side of the pump. Fuel from the inlet will fill this void. Fuel is carried to the outlet side where the cavity gets increasingly smaller. This forces fuel out the outlet passage. See Figure 9020-10-17.

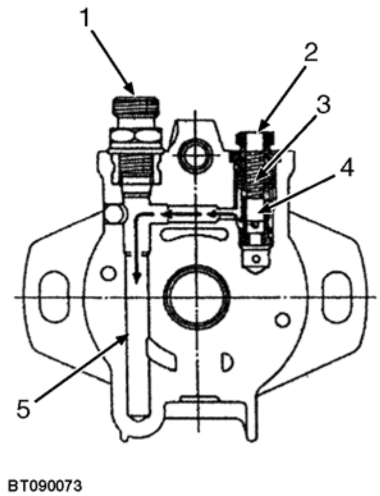


1. ROTOR
2. FROM FUEL FILTER
3. REGULATING VALVE
4. TO PUMP CHAMBER
5. LINER
6. BLADE
7. DRIVE SHAFT

Figure 9020-10-17. Feed Pump Operation

Regulating Valve

The regulating valve regulates the feed pump fuel pressure so that the fuel pressure in the pump chamber is maintained within the specified pressure range. When the feed pump fuel pressure increases, the fuel compresses the regulating valve spring to lift the piston. The fuel is then returned to the suction side as shown by the arrows in Figure 9020-10-18. It is possible to regulate the pump chamber pressure by changing the set force of the regulating valve spring.



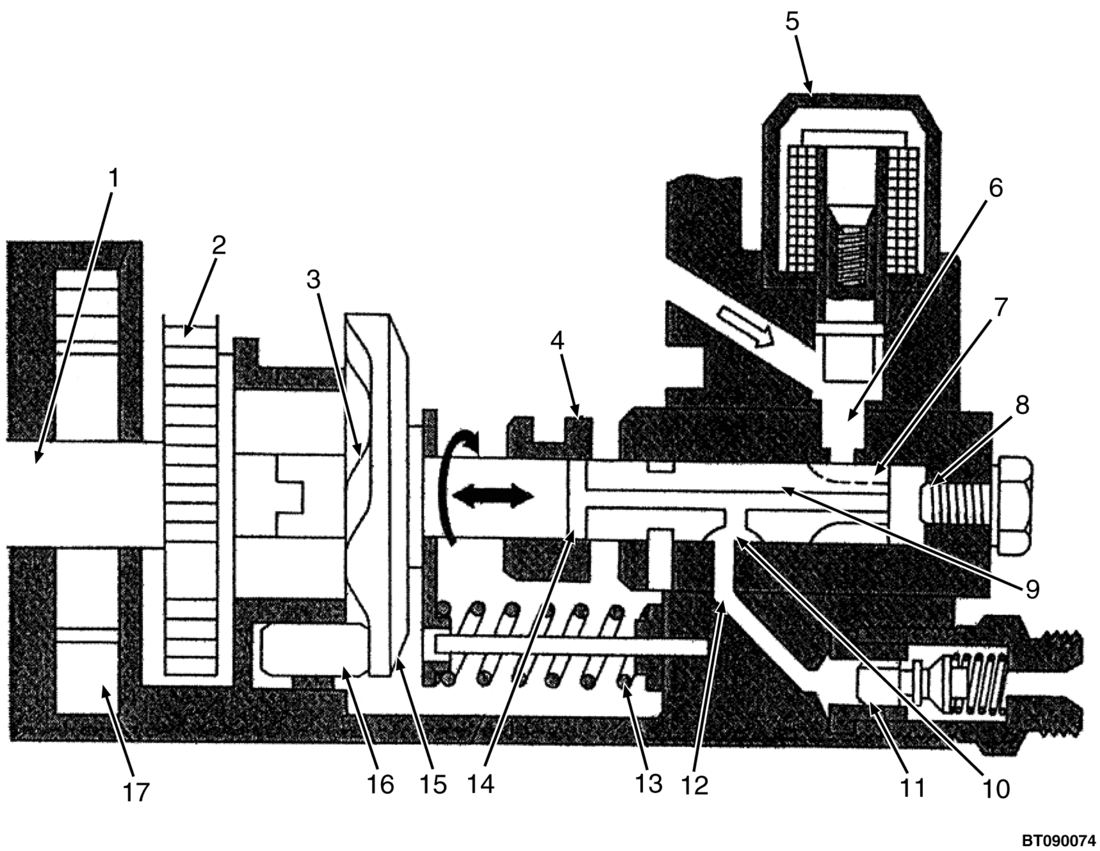
1. FUEL INLET
2. REGULATING VALVE
3. SPRING
4. PISTON
5. SUCTION SIDE OF PUMP

Figure 9020-10-18. Regulating Valve Functionality

Injection Pump Plunger

The drive shaft drives the fuel feed pump, cam disc and plunger. The plunger spring presses the plunger and cam disc onto the roller. When the cam disc turns, the face cam moves on the roller causing the plunger to reciprocate. When the inlet port of the plunger barrel and the inlet slit of the plunger overlap, the plunger draws in fuel under feed pump pressure.

As the plunger rotates, the inlet and outlet slits are sealed off and the plunger reciprocates to pressurize the fuel. When the outlet port of the plunger barrel and the outlet slit of the plunger align, the high-pressure fuel opens the delivery valve to allow fuel to be injected into the engine combustion chamber via the fuel injection nozzle. When the cutoff port reaches the edge of the cutoff sleeve, pressure feeding from the plunger is terminated. See Figure 9020-10-19.

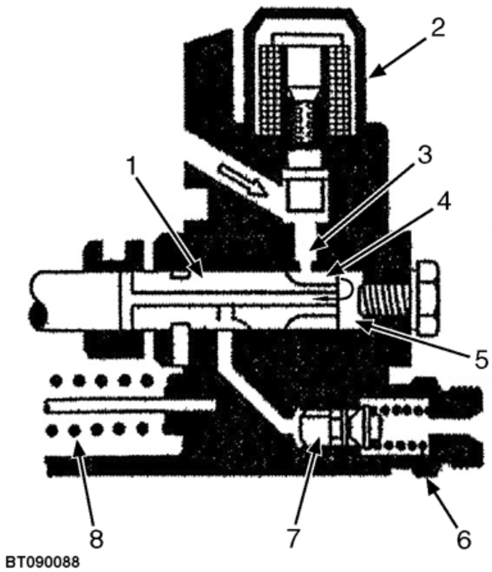


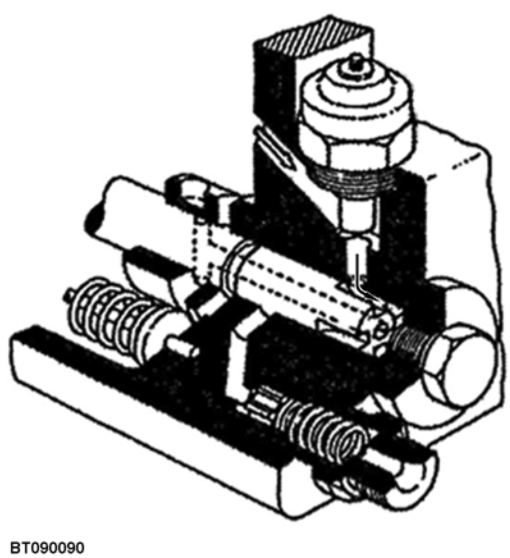
1. DRIVE SHAFT
2. DRIVE GEAR
3. FACE CAM
4. CONTROL SLEEVE
5. MAGNETIC VALVE
6. INLET PORT
7. INLET SLIT
8. PLUNGER BARREL
9. PLUNGER
10. OUTLET SLIT
11. DELIVERY VALVE
12. OUTLET PORT
13. PLUNGER SPRING
14. CUTOFF PORT
15. CAM DISC
16. ROLLER
17. FEED PUMP

Figure 9020-10-19. Plunger Operation

Suction Process

When the inlet port of the plunger barrel overlaps the inlet slit of the plunger during the lowering process of the plunger, the fuel in the pump chamber is drawn into the plunger. See Figure 9020-10-20.



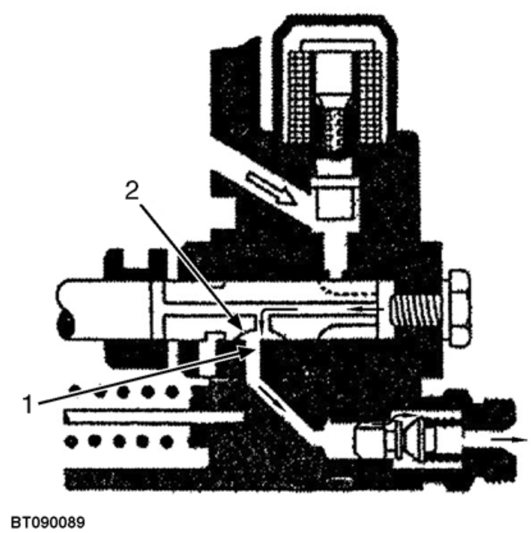


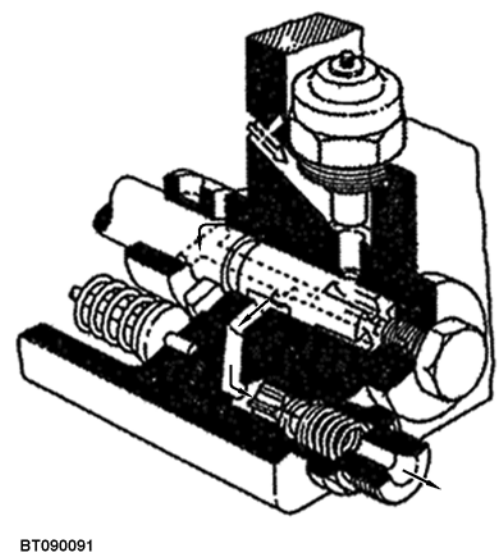
1. PLUNGER
2. MAGNETIC VALVE
3. INLET PORT
4. INLET SLIT
5. PRESSURIZING CHAMBER
6. DELIVERY VALVE SPRING
7. DELIVERY VALVE
8. PLUNGER SPRING

Figure 9020-10-20. Suction Process

Injection Process

The plunger begins rotating at the same time the lifting process of the cam disc begins. When the inlet port of the plunger barrel is covered by the plunger, pressure feeding of fuel is initiated. At the same time, the highly pressurized fuel opens the delivery valve when the outlet slit of the plunger meets the outlet port of the plunger barrel. The fuel is then injected into the engine combustion chamber via the nozzle and nozzle holder. See Figure 9020-10-21.



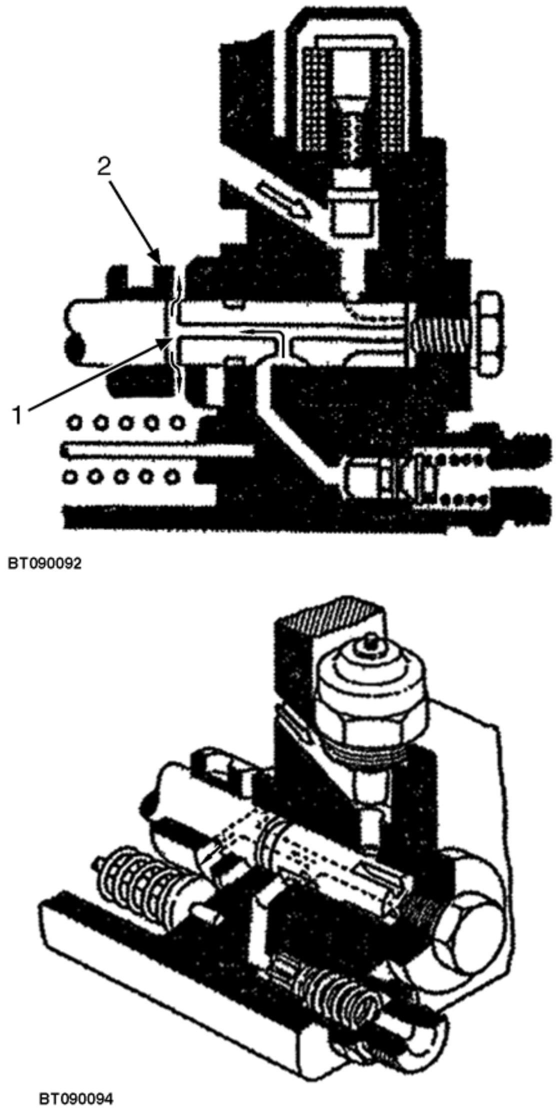


1. OUTLET PORT
2. OUTLET SLIT

Figure 9020-10-21. Injection Process

End of Injection

When the plunger reaches the point where the cutoff port just overruns the control sleeve, the high-pressure fuel in the plunger high-pressure chamber returns to the pump chamber through the cutoff port. As a result, the fuel pressure in the plunger becomes lower than the set force of the delivery valve spring, so, the delivery valve closes to terminate pressure feeding of fuel. See Figure 9020-10-22.

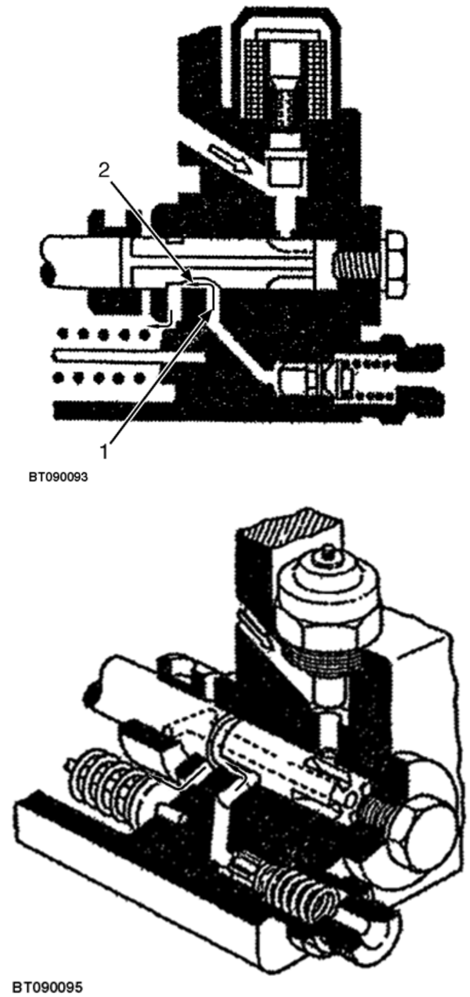


1. CUTOFF PORT
2. CONTROL SLEEVE

Figure 9020-10-22. End of Injection

Uniform Pressure Process

When the plunger turns 180° after the end of fuel injection, the uniform pressure slit of the plunger meets the outlet port of the plunger barrel. As a result, the pump chamber is connected to the outlet port, thereby making the pressure in the chamber and outlet port equal. After the uniform pressure process, the pressure in the outlet port becomes uniform, ensuring stable fuel injection. The suction process through the uniform pressure process are carried out for each cylinder during every injection cycle. See Figure 9020-10-23.

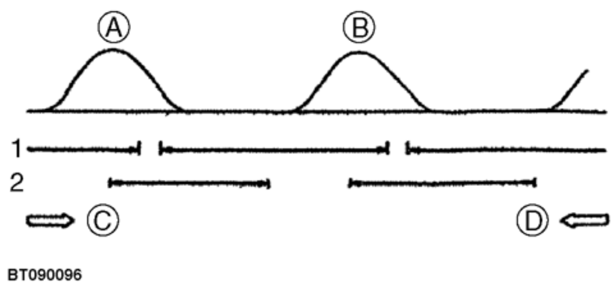


1. OUTLET PORT
2. UNIFORM PRESSURE SLIT

Figure 9020-10-23. Uniform Pressure Process

Reverse Rotation Prevention Mechanism

While the plunger is rotating in the correct direction, the fuel is sufficiently drawn into the plunger since the inlet port of the plunger barrel opens during the plunger lowering process. The inlet port closes during the lifting process to inject the fuel. On the contrary, the inlet port of the plunger barrel does not close during the plunger lifting process if the engine rotates in the reverse direction. So, the fuel is not pressurized, resulting in non-injection state. See Figure 9020-10-24.



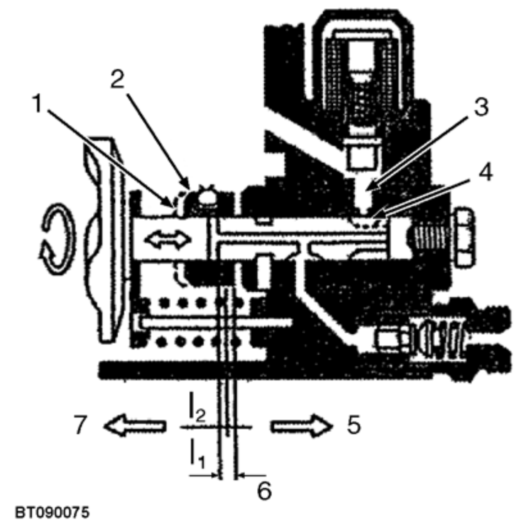
A. CYLINDER A
B. CYLINDER B
C. CORRECT DIRECTION
D. REVERSE DIRECTION

1. PERIOD THE OUTLET PORT IS OPEN
2. PERIOD THE INLET PORT IS OPEN

Figure 9020-10-24. Reverse Rotation Prevention

Fuel Injection Volume Adjustment Mechanism

The fuel injection volume is adjusted by changing the control sleeve position, resulting in change of the plunger's effective stroke. The effective stroke represents the plunger's stroke from the time the inlet port and inlet slit close until the cutoff port overruns the control sleeve, which is proportional to the fuel injection volume. When the control sleeve moves to the left as shown in the figure below, the effective stroke decreases. When the control sleeve moves to the right, the effective stroke increases to increase the fuel injection volume. The control sleeve position is determined according to the governor control. See Figure 9020-10-25.

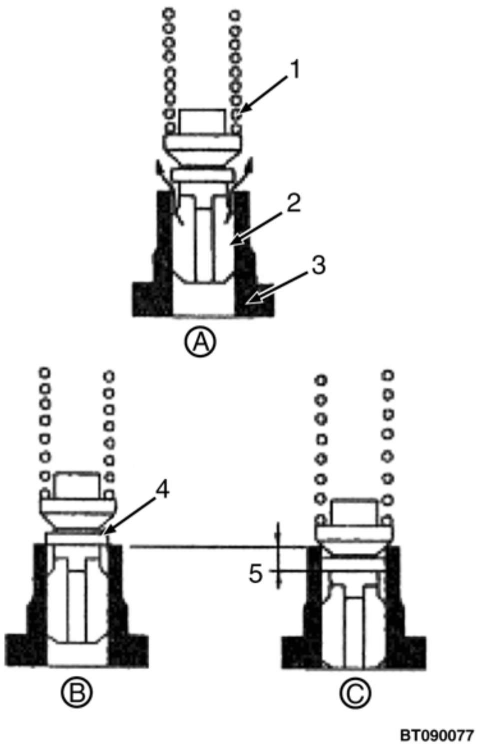


1. CUTOFF PORT
2. CONTROL SLEEVE
3. INLET PORT
4. INLET SLIT
5. INCREASING INJECTION VOLUME
6. EFFECTIVE STROKE
7. DECREASING INJECTION VOLUME

Figure 9020-10-25. Control Sleeve Adjustment

Delivery Valve Assembly

The delivery valve assembly consists of the delivery valve and valve seat. When the high-pressure fuel being fed from the plunger exceeds the force of the delivery valve spring, the delivery valve opens to feed fuel to the injection nozzle and nozzle holder via the injection pipe. After injection, a certain degree of remaining pressure exists in the injection pipe ready for the next injection. The delivery valve prevents this fuel from returning to the plunger. The delivery valve also functions to improve fuel cutoff of the nozzle by drawing back the fuel in the pipe by the amount equal to the draw back stroke of the piston. See Figure 9020-10-26.



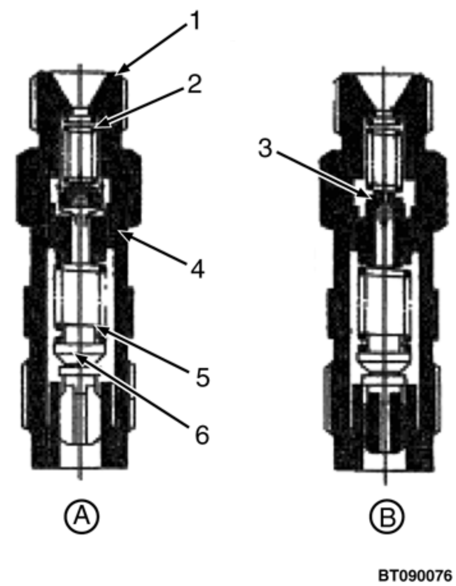
A. DURING PRESSURE FEEDING
B. START OF DRAW BACK
C. END OF DRAW BACK

1. DELIVERY VALVE SPRING
2. DELIVERY VALVE
3. VALVE SEAT
4. PISTON
5. DRAW BACK STROKE

Figure 9020-10-26. Delivery Valve Operation

Delivery Valve Holder with Damping Valve

The delivery valve holder with damping valve functions to prevent cavitation erosion in the pipe at high speed, unstable fuel injection and secondary injection. When high-pressure fuel is fed from the plunger, it is mainly sent to the nozzle through the outer periphery of the damping valve. Since the damping valve also opens at the same time as the delivery valve upon completion of each injection cycle, the only fuel path left is the small orifice of the damping valve. This permits slow closing of the delivery valve. Thus, rapid pressure decrease in the pipe is prevented and transfer of the reflection wave in the pipe suppressed to ensure stable injection. See Figure 9020-10-27.

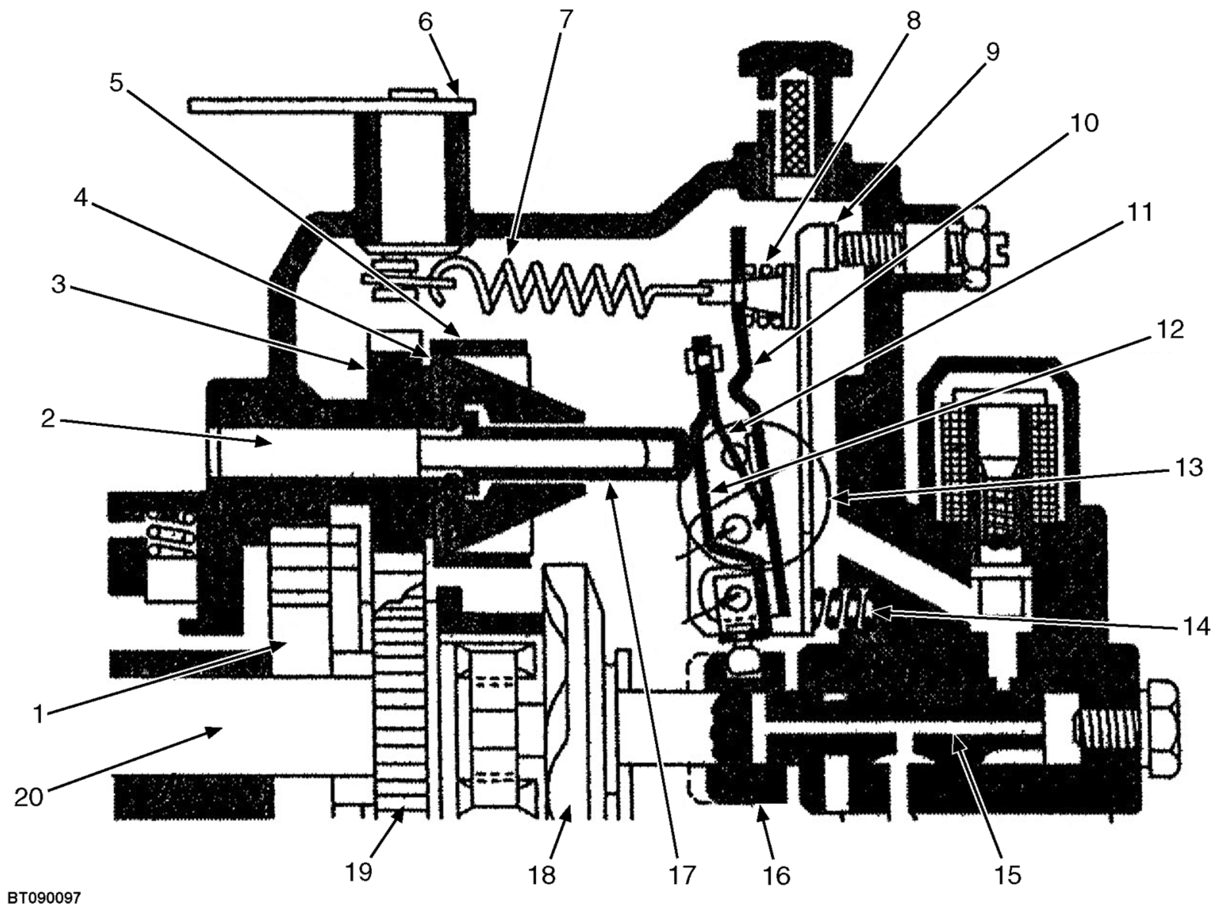


A. DURING PRESSURE FEEDING
B. END OF PRESSURE FEEDING

1. DELIVERY VALVE HOLDER
2. DAMPING VALVE SPRING
3. ORIFICE
4. DAMPING VALVE
5. DELIVERY VALVE SPRING
6. DELIVERY VALVE

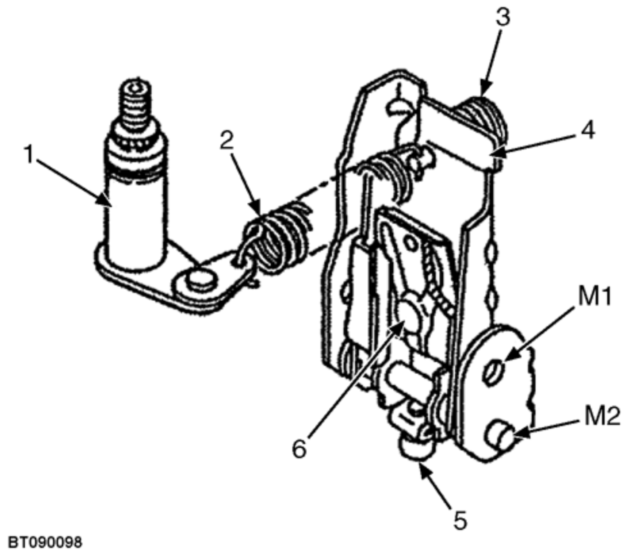
Figure 9020-10-27. Pressure Feeding

All - Speed Governor



1. FEED PUMP
2. GOVERNOR SHAFT
3. FLYWEIGHT HOLDER GEAR
4. FLYWEIGHT
5. FLYWEIGHT HOLDER
6. CONTROL LEVER
7. GOVERNOR SPRING
8. IDLE SPRING
9. CORRECTOR LEVER
10. TENSION LEVER
11. START SPRING
12. START LEVER
13. GOVERNOR LEVER ASSEMBLY
14. SPRING
15. PLUNGER
16. CONTROL SLEEVE
17. GOVERNOR SLEEVE
18. CAM DISC
19. DRIVE GEAR
20. DRIVE SHAFT

Figure 9020-10-28. All - Speed Governor



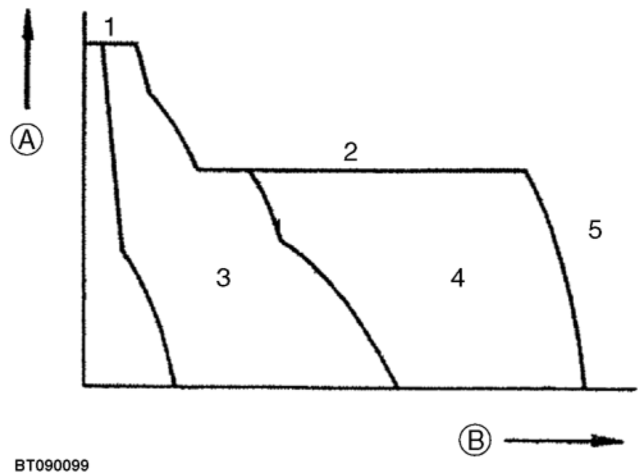
1. CONTROL LEVER SHAFT
2. GOVERNOR SPRING
3. IDLE SPRING
4. TENSION LEVER
5. BALL PIN
6. START LEVER

Figure 9020-10-29. All-Speed Governor Operation

Figure 9020-10-28 shows the composition of the all-speed governor. Revolution of the shaft is transferred to the flyweight holder acceleration gear via the drive gear to turn the flyweight holder. The flyweight holder is supported by the governor shaft. There are four fly-weights in the holder which are installed in such a way that they open outwardly by means of centrifugal force. The flyweight movement presses the governor sleeve and presses the governor lever assembly to the right. The governor lever assembly mainly consists of the corrector lever, tension lever and start lever. Corrector lever fulcrum M1 is fixed by the pivot bolt of the pump housing. Furthermore, the corrector lever cannot move since it is pressed both by the spring at the bottom and the full load adjusting screw at the top. The tension and start levers move around shaft M2 as the fulcrum fixed on the corrector lever. See Figure 9020-10-29.

The start spring presses the start lever into the governor sleeve at engine start. The start lever turns counterclockwise around fulcrum M2 to move the control sleeve to the start offset position.

The start and tension levers contact each other and move together during engine operation. Above the tension lever is the governor spring which is connected to the control lever. Movement of the control lever is capable of changing the set force of the governor spring. On the upper back of the tension lever is the idle spring. The governor is controlled at all speeds by means of the start, governor and idle springs.

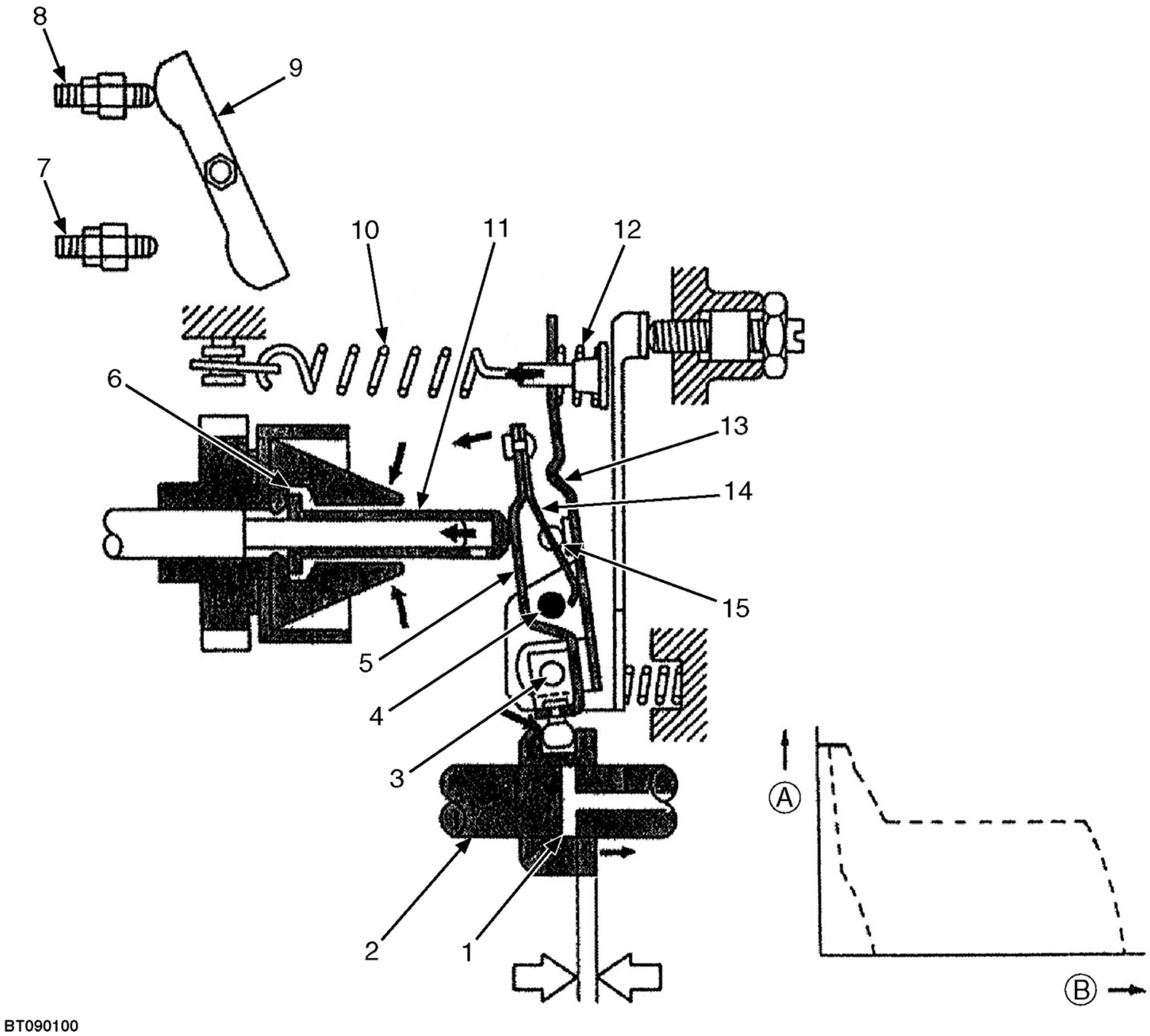


A. CONTROL SLEEVE POSITION (INJECTION VOLUME)
B. PUMP RPM

1. AT START
2. AT FULL LOAD
3. AT IDLE
4. AT PARTIAL LOAD
5. AT MAXIMUM SPEED CONTROL

Figure 9020-10-30. Injection Volume Control Characteristics

At Start of Engine



A. INJECTION VOLUME

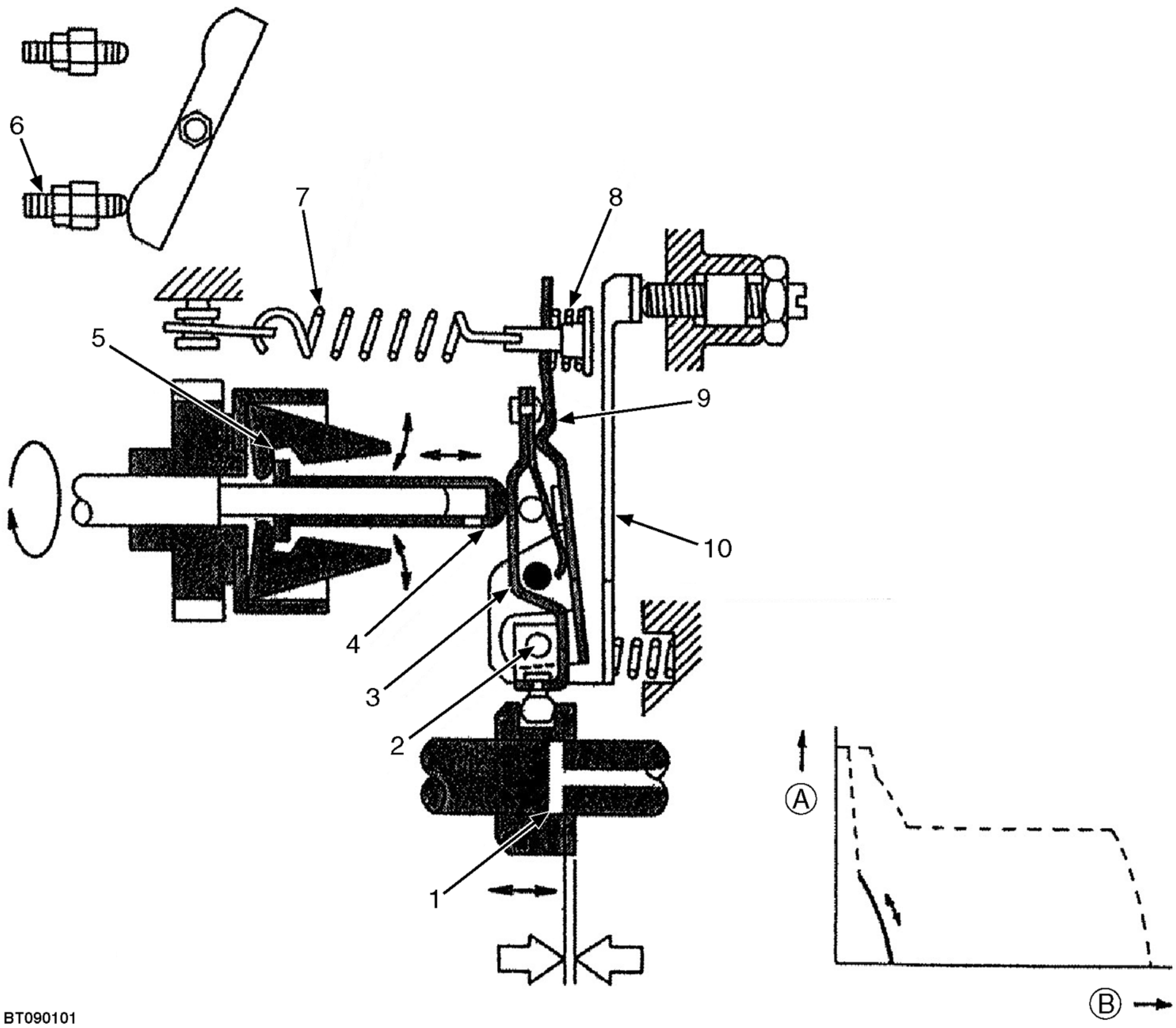
B. PUMP RPM

1. CONTROL SLEEVE
2. PLUNGER
3. M2 (FULCRUM)
4. M1 (FIXED)
5. START LEVER
6. FLYWEIGHT
7. IDLING STOPPER BOLT
8. MAXIMUM SPEED STOPPER BOLT
9. CONTROL LEVER
10. GOVERNOR SPRING
11. GOVERNOR SLEEVE
12. IDLING SPRING
13. POINT A
14. START SPRING
15. M3 (PRESS-IN PIN)

Figure 9020-10-31. Injection Volume at Engine Start

It is necessary to increase the injection volume in order to improve the starting characteristics at engine start. When the accelerator pedal is pressed while the engine is stopped, the tension lever is pulled until it comes into contact with press-in pin M3 by governor spring force. At the same time, the start lever is released from the tension lever by the start spring force pressing the governor sleeve to the left. The flyweight then closes completely and the start lever moves the control sleeve to the start increasing position (to the right) with M2 being the fulcrum. Thus, the engine can be started easily by lightly pressing down on the accelerator pedal.

During Idle



A. INJECTION VOLUME

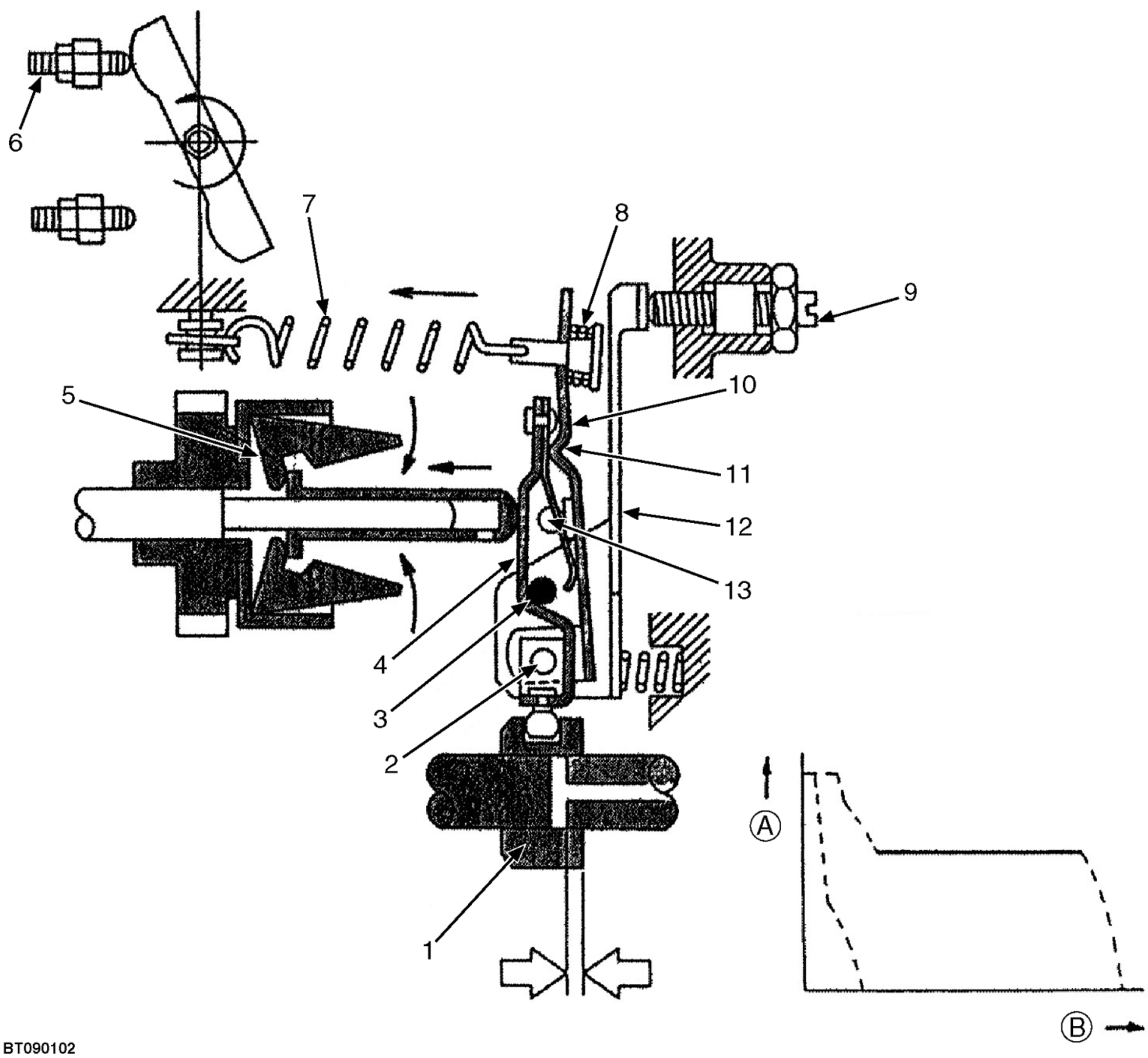
B. PUMP RPM

1. CONTROL SLEEVE
2. M2 (FULCRUM)
3. START LEVER
4. GOVERNOR SLEEVE
5. FLYWEIGHT
6. IDLING STOPPER BOLT
7. GOVERNING SPRING
8. IDLE SPRING
9. TENSION LEVER
10. CORRECTOR LEVER

Figure 9020-10-32. Injection Volume During Idling

When the engine starts and the accelerator pedal is released, the control lever returns to the idle position and the tension of the governor spring becomes zero. Therefore, the flyweight opens outwardly even at low revolutions to move the governor sleeve to the right. This makes the start lever turn clockwise with M2 being the fulcrum to move the control sleeve in the direction to reduce the fuel volume. The governor sleeve stops at a point where the flyweight centrifugal and idle spring force are balanced to ensure stable idling.

At Full - Load Maximum Speed Control



A. INJECTION VOLUME

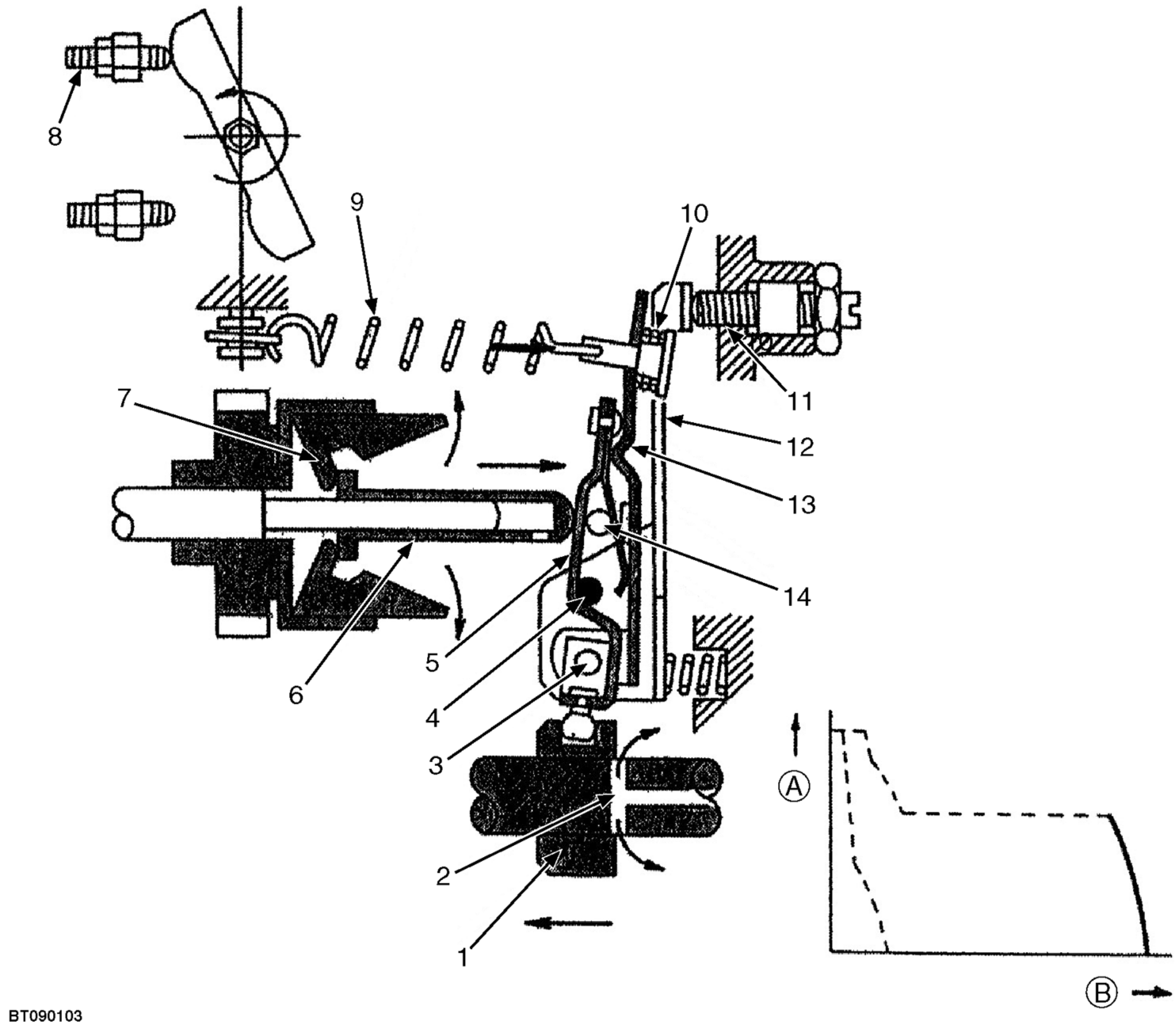
B. PUMP RPM

1. CONTROL SLEEVE
2. M2 (FULCRUM)
3. M1 (FIXED)
4. START LEVER
5. FLYWEIGHT
6. MAXIMUM SPEED STOPPER BOLT
7. GOVERNOR SLEEVE
8. IDLE SPRING
9. FULL - LOAD ADJUSTING SCREW
10. TENSION LEVER
11. POINT A
12. CORRECTOR LEVER
13. M3 (PRESS-IN PIN)

Figure 9020-10-33. Injection Volume at Full - Load Maximum Speed Control

When the accelerator pedal is pressed down all the way and the control lever comes into contact with the maximum speed stopper bolt, the tension of the governor spring becomes maximum. At this time, the tension lever is fixed at the position where is contacts pin M3 being pressed into the pump housing. The idle spring is completely compressed to connect the start lever and the tension lever at point A, thereby holding the control sleeve at the full-load position. At this time, the flyweight is pressed by the governor sleeve and is in the completely closed state.

At No-Load Maximum Speed Control



A. INJECTION VOLUME

B. PUMP RPM

1. CONTROL SLEEVE
2. CUTOFF PORT
3. M2 (FULCRUM)
4. M1 (FIXED)
5. START LEVER
6. GOVERNOR SPRING
7. FLYWEIGHT
8. MAXIMUM SPEED STOPPER BOLT
9. GOVERNOR SPRING
10. IDLE SPRING
11. FULL-LOAD ADJUSTING SCREW
12. CORRECTOR LEVER
13. TENSION LEVER
14. M3 (PRESS-IN PIN)

Figure 9020-10-34. Injection Volume At No Load Maximum Speed

When the engine revolutions increase and the fly-weight centrifugal force exceeds the governor spring set force, the governor sleeve moves making the governor lever assembly turn clockwise with fulcrum M2. As a result, the control sleeve moves in the direction of no-injection (to the left) for controlling speed so as not to exceed the full-load maximum speed. When the accelerator pedal is not pressed down fully, the set force of the governor spring changes accordingly in order to achieve governor control based on the governor spring set force during partial load operation.

Full-Load Position Adjustment Mechanism

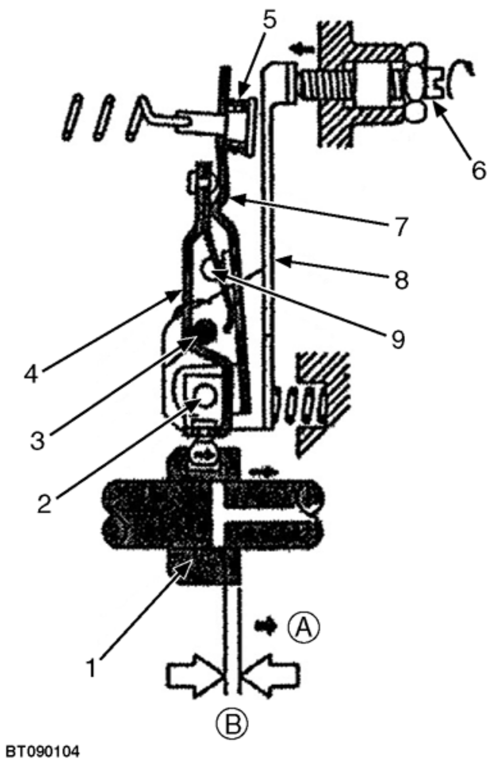


Figure 9020-10-35. Full-Load Adjustment

Legend for Figure 9020-10-35

A. FUEL INCREASE DIRECTION
B. EFFECTIVE STROKE

1. CONTROL SLEEVE
2. M2 (FULCRUM)
3. M1 (FIXED)
4. START LEVER
5. IDLE SPRING
6. FULL LOAD ADJUSTING SCREW
7. TENSION LEVER
8. CORRECTOR LEVER
9. M3

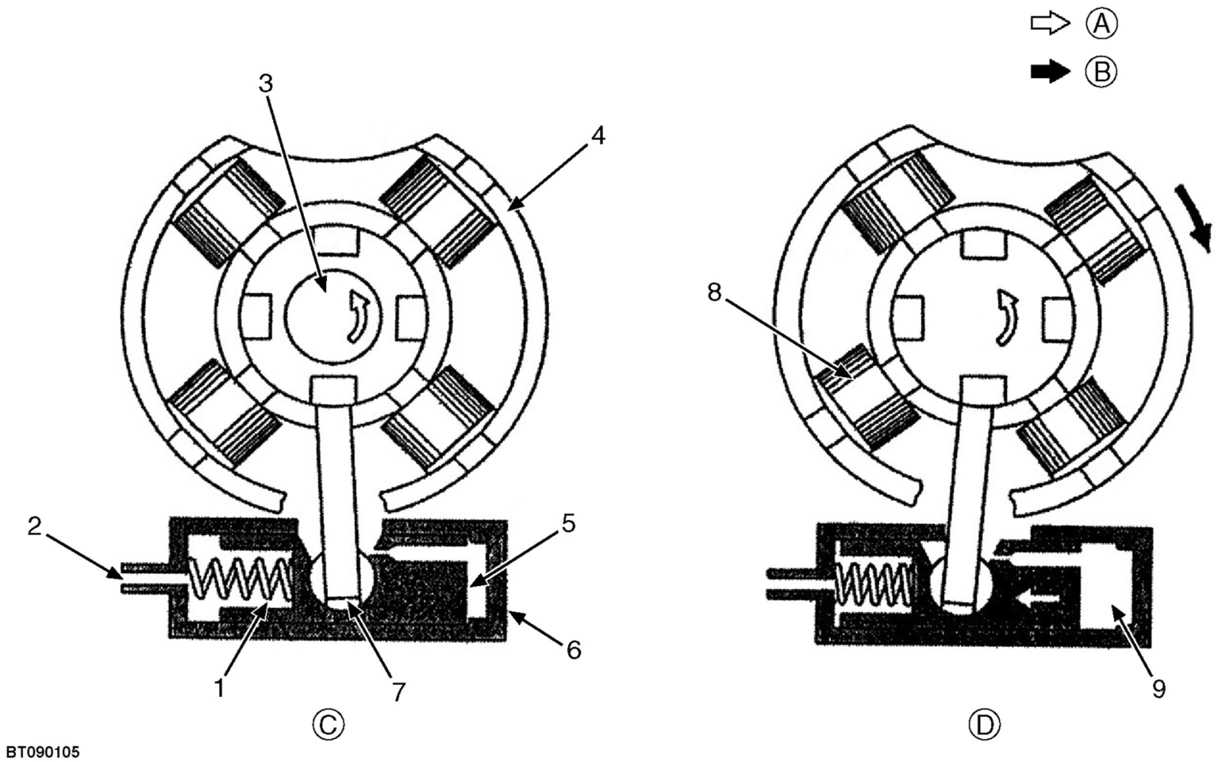
The full-load position is determined by the amount the full-load adjusting screw is driven. When the screw is driven, the corrector lever turns counterclockwise with M1 being the fulcrum to move the control sleeve to the fuel increase direction. When the screw is loosened, the control sleeve moves to the fuel decrease direction.

STRUCTURE AND OPERATION OF TIMER

The ignition period which occurs in the combustion process of a diesel engine tends to increase as the speed becomes higher. Consequently, the timer is installed under the injection pump in order to correct the ignition delay period by shortening the injection timing of the injection pump. See Figure 9020-10-36.

Standard Type Automatic Timer

As shown in Figure 9020-10-36, the inside of the timer housing is separated into low and high pressure sides, the latter directly receiving the pump chamber pressure. A timer spring having a set force is installed in the low pressure side. The timer piston slides horizontally based on the balance between the spring force and changes in the pump chamber pressure. The movement of the timer piston turns the roller holder assembly via the pin. When pump revolutions increase and the pump chamber pressure exceeds the set force of the timer spring, the timer piston moves in the direction to compress the spring. This turns the roller holder assembly in the reverse direction of pump revolution via the pin. This causes the crest of the cam disc to approach the roller position of the roller holder, advancing the injection timing. When pump revolutions decrease and the timer spring force exceeds the pump chamber pressure, the timer piston moves in the direction to delay the timing.



A. DIRECTION OF DRIVE SHAFT ROTATION
B. DIRECTION OF ROLLER HOLDER ROTATION
C. WHEN TIMER IS INACTIVE
D. WHEN TIMER IS ACTIVE

1. TIMER SPRING
2. LOW PRESSURE SIDE
3. DRIVE SHAFT
4. ROLLER HOLDER ASSEMBLY
5. TIMER PISTON
6. HIGH PRESSURE SIDE
7. PIN
8. ROLLER
9. HIGH PRESSURE CHAMBER

Figure 9020-10-36. Timer Operation

YANMAR ENGINE CONTROLS

The components of the system are shown in Figure 9020-10-37.

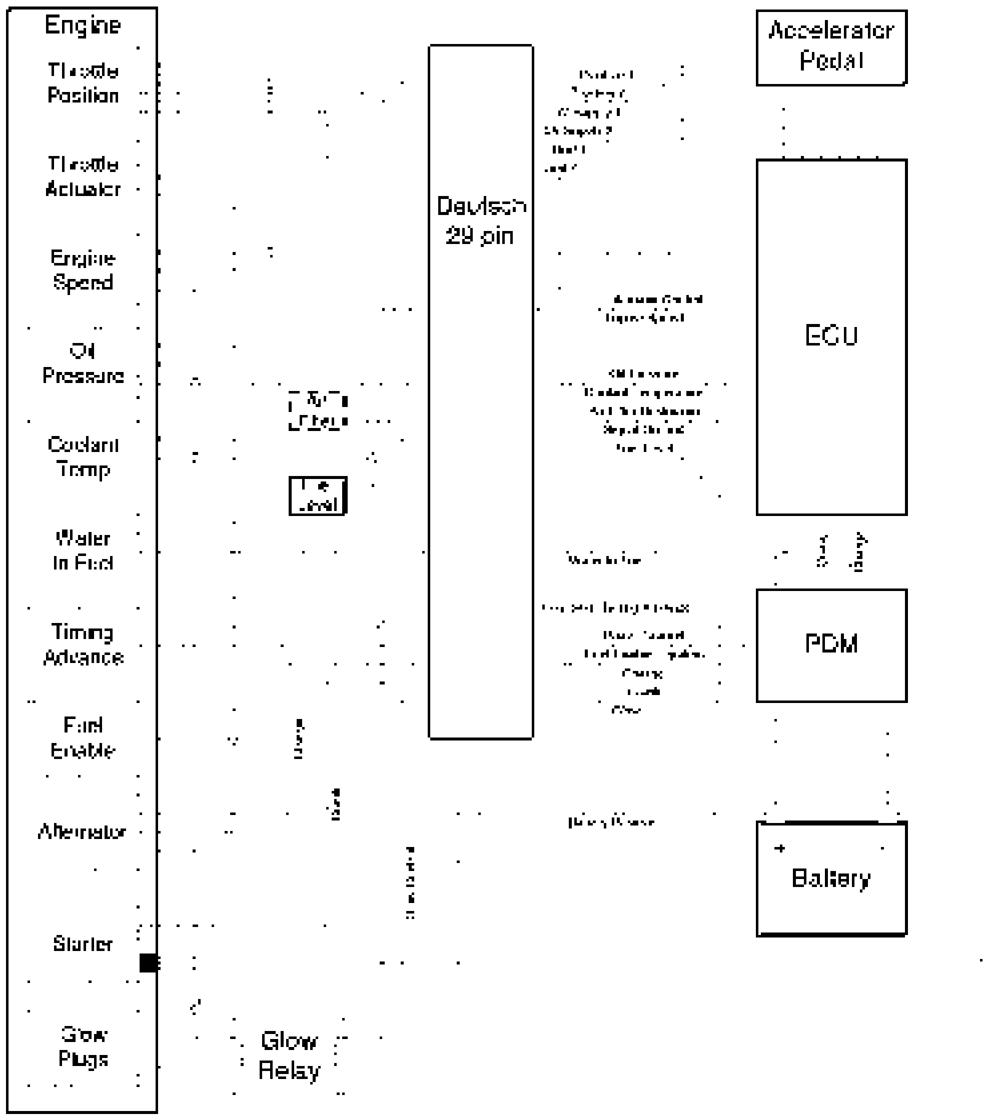
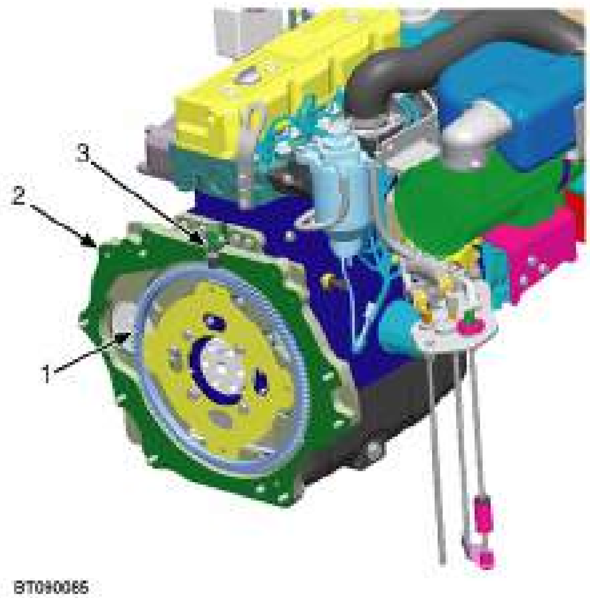


Figure 9020-10-37. Control System Components

Engine Speed (RPM) Sensor

The Engine Speed (RPM) sensor is mounted in the flywheel housing and senses the gear teeth on the flywheel. The Engine Speed (RPM) sensor uses Hall Effect Sensor Technology to sense rotational speed of the engine. This technology uses the presence and absence of gear teeth to change the strength of the magnetic field and therefore cause a variable voltage that is used to operate a transistor switch. The RPM sensor sends an electrical pulse every time a gear tooth passes it. It does not sense direction of gear rotation.

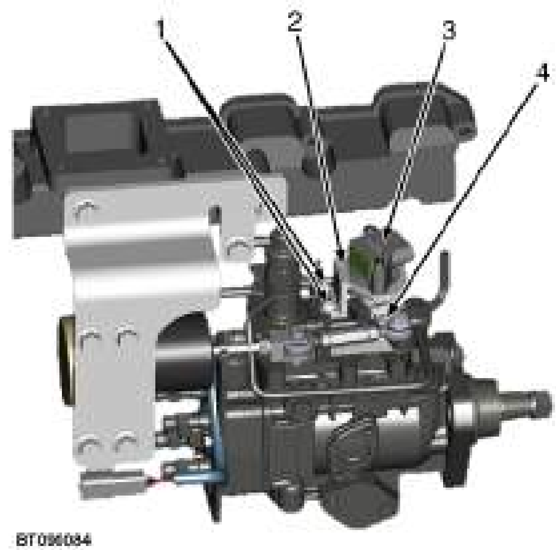


1. FLYWHEEL
2. FLYWHEEL HOUSING
3. ENGINE SPEED (RPM) SENSOR

Figure 9020-10-38. Engine Speed (RPM) Sensor

Throttle Position Sensor

The Throttle Position Sensor (TPS) is located above the fuel injection pump lever. The lever has a unique "D-shape" design that interlocks with the TPS sensor. The sensor uses Hall Effect Sensor Technology to sense the position of the throttle. This technology uses a sensor that can detect the strength of a magnetic field and provide an output signal that is proportional to the strength of the field. Moving the magnet closer or further away from the sensor varies the output voltage. The position sensor for the throttle on Yanmar engines contain dual sensors for redundancy. The ECU delivers separate 5 Vdc supplies and independent grounds for these dual applications.

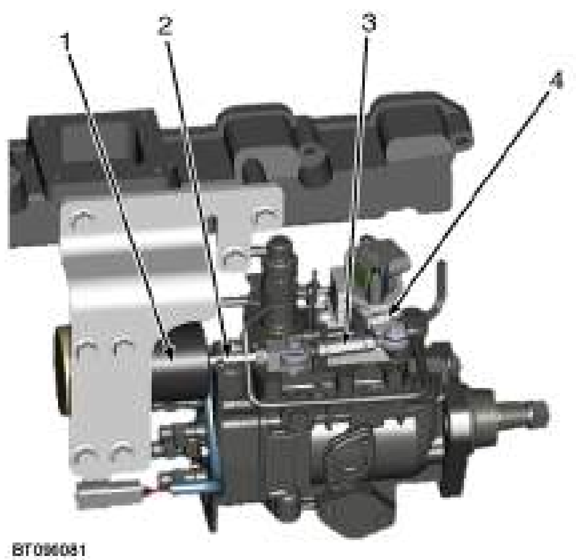


1. MOUNTING SCREWS
2. THROTTLE POSITION SENSOR BRACKET
3. THROTTLE POSITION SENSOR
4. INJECTION PUMP CONTROL LEVER

Figure 9020-10-39. Throttle Position Sensor

Electronic Throttle Actuator

The electronic throttle actuator is a pull type linear proportional actuator. The ECU monitors the electronic throttle actuator through the throttle position sensor. The actuator's output shaft is linked to the fuel injection pump control lever via an adjustable turn buckle. The actuator receives a pulse width modulated (PWM) 12 volt signal from the ECU. The actuator converts this signal to an output shaft position, proportional to the amount of current supplied by the ECU. See Figure 9020-10-40.



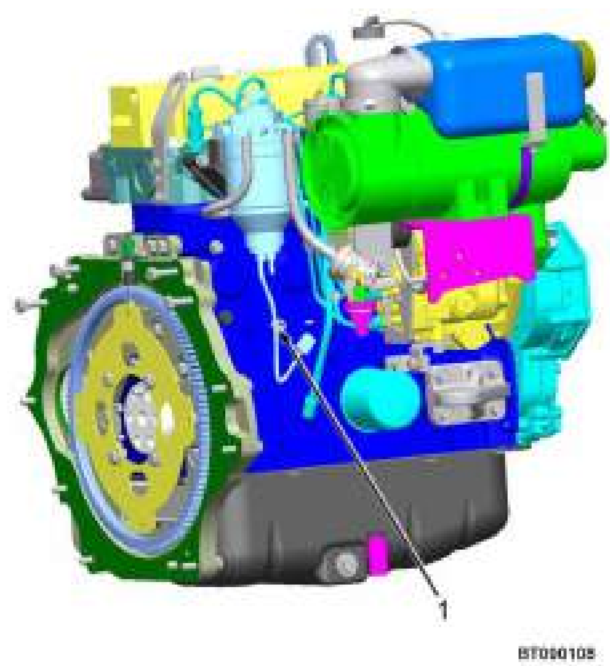
1. LINEAR ACTUATOR
2. OUTPUT SHAFT
3. ADJUSTABLE TURN BUCKLE
4. INJECTION PUMP CONTROL LEVER

Figure 9020-10-40. E-Throttle Actuator

Engine Oil Pressure Sensor

The engine has an internal oil pump which creates oil pressure once the engine is rotating. An oil pressure sensor monitors the pressure created by this oil pump. See Figure 9020-10-41. The sensor is a gauge pressure sensor which is powered by the ECU's 5-volt supply and reads out a signal ranging from 0.5 to 4.5 volts on the signal wire. This sensor reads 0 kPa (0 psi) (0.5 volts) when the engine is not rotating. The ECU continuously monitors the oil pressure to determine if the shutdown sequence will be initiated.

The normal voltage output limits for this sensor are 0.5 volts to 4.5 volts.

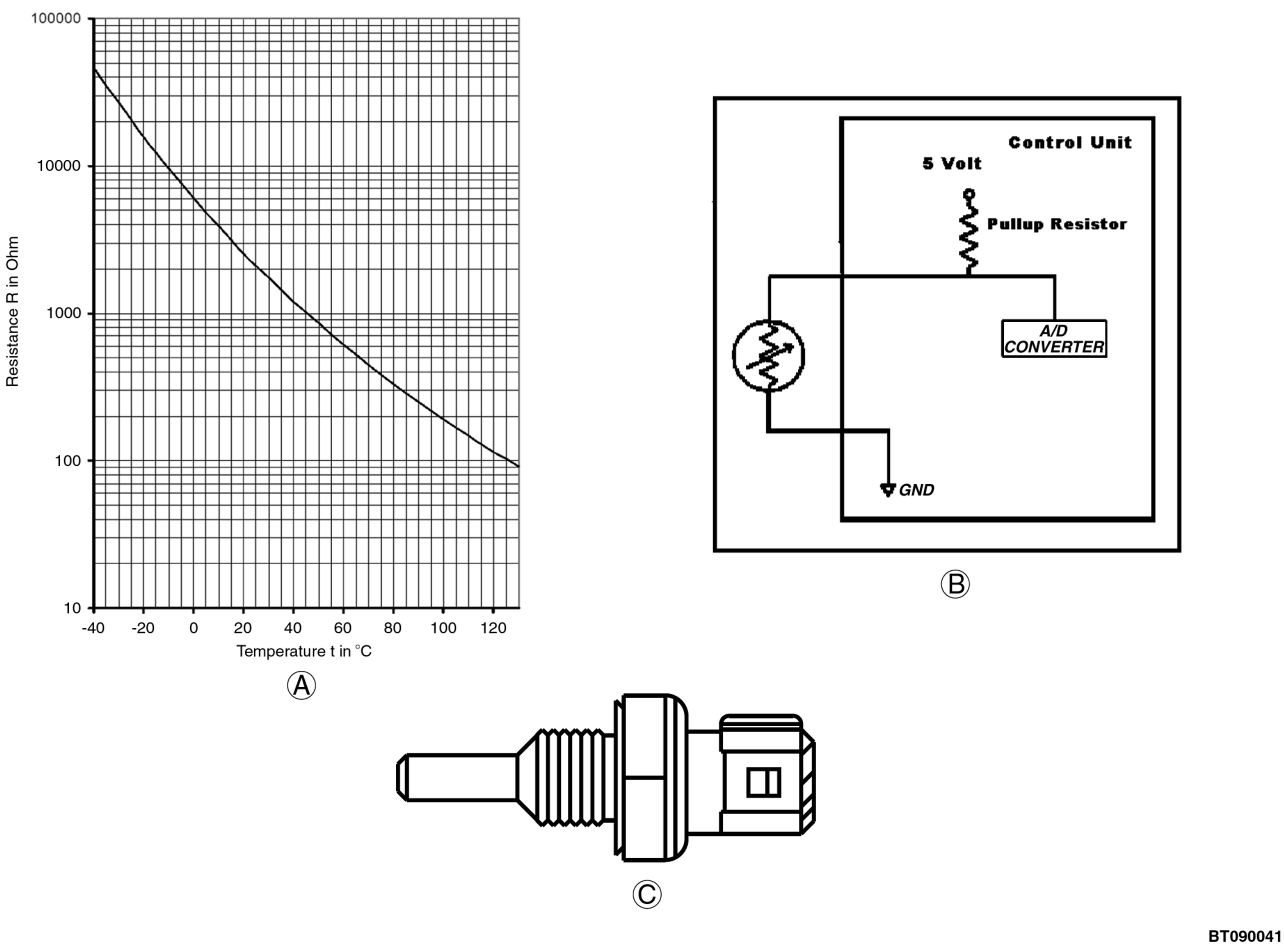


1. OIL PRESSURE SENSOR

Figure 9020-10-41. Oil Pressure Sensor Location

Coolant Temperature Sensor

The Coolant Temperature Sensor is located in the engine coolant pump thermostat housing. The sensor is a Negative Coefficient (as the temperature rises, the resistance drops) sensor. The ECU uses the reading to determine temperature related operating condition requirements for the engine. 5 volts is applied across the sensor and voltage drop is measured to determine the temperature. See Figure 9020-10-42.



A. RESISTANCE VS COOLANT TEMPERATURE GRAPH
B. COOLANT TEMPERATURE SENSOR WIRING
C. COOLANT TEMPERATURE SENSOR

Figure 9020-10-42. Coolant Temperature Sensor

Air Filter Restriction Switch

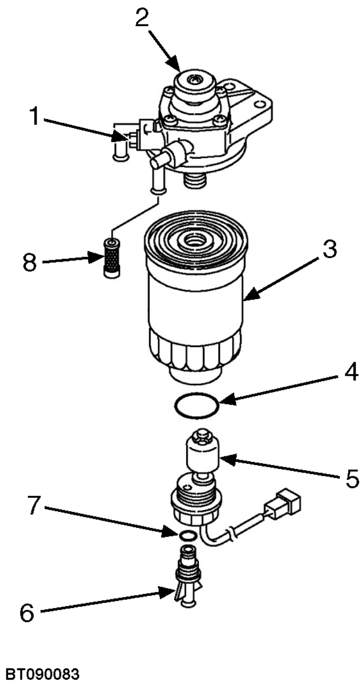
The air filter restriction switch is mounted on the air cleaner housing near the output tube. The main purpose of the switch is to alert the operator when the air filter is dirty or clogged and needs to be replaced. The switch works on air pressure and switches at a predetermined pressure value. Restriction of the air flow to the air filter will cause this switch to trigger. This switch closes the circuit to send a signal to an indicator on the display to alert the operator.

Fuel Filter/Water Separator and Strainer

The fuel filter/water separator removes contaminants, sediments and water from diesel fuel going to the fuel filter. This is a required component of the fuel system. The separator is installed between the fuel tank and the fuel pump. Water is drained from the fuel filter/ water separator using the drain cock at the bottom of the separator. The separator contains a float switch to detect the presence of water and contaminants. This float switch closes the circuit to send a signal to an indicator on the display to alert the operator. See Figure 9020-10-43.

Fuel Level Sensor

The fuel level sensor has float with an embedded magnet. As the fuel level changes the float moves past a series of reed switches. As each one is activated, it changes the value of a series resistance ladder, which results in a varying voltage being read at the ECU.



1. BLEED PLUG
2. HAND PRIMER PUMP
3. FUEL FILTER
4. O-RING
5. SENSOR
6. DRAIN PLUG
7. O-RING
8. IN-LINE FUEL FILTER

Figure 9020-10-43. Fuel Filter/Water Separator and Strainer

ENGINE ELECTRICAL SYSTEM

Magnetic Valve (Engine Stop Solenoid)

The Magnetic Valve (Engine Stop Solenoid) is either energized or de-energized as the key switch or push ON/OFF button of the vehicle is operated. The solenoid actuates a valve which opens or closes the fuel path connected to the inlet port of the plunger barrel. When the key switch is turned to the ON position, power is supplied to the magnetic valve solenoid to lift the armature, thus opening the fuel path. When the key switch is turned to the OFF position, the armature is lowered by spring force to close the fuel path. As a result, no fuel is fed to the plunger, stopping the engine. See Figure 9020-10-44.

Alternator

When the engine is running, the alternator produces electric power to run various electrical devices. The alternator also charges the lift truck battery.

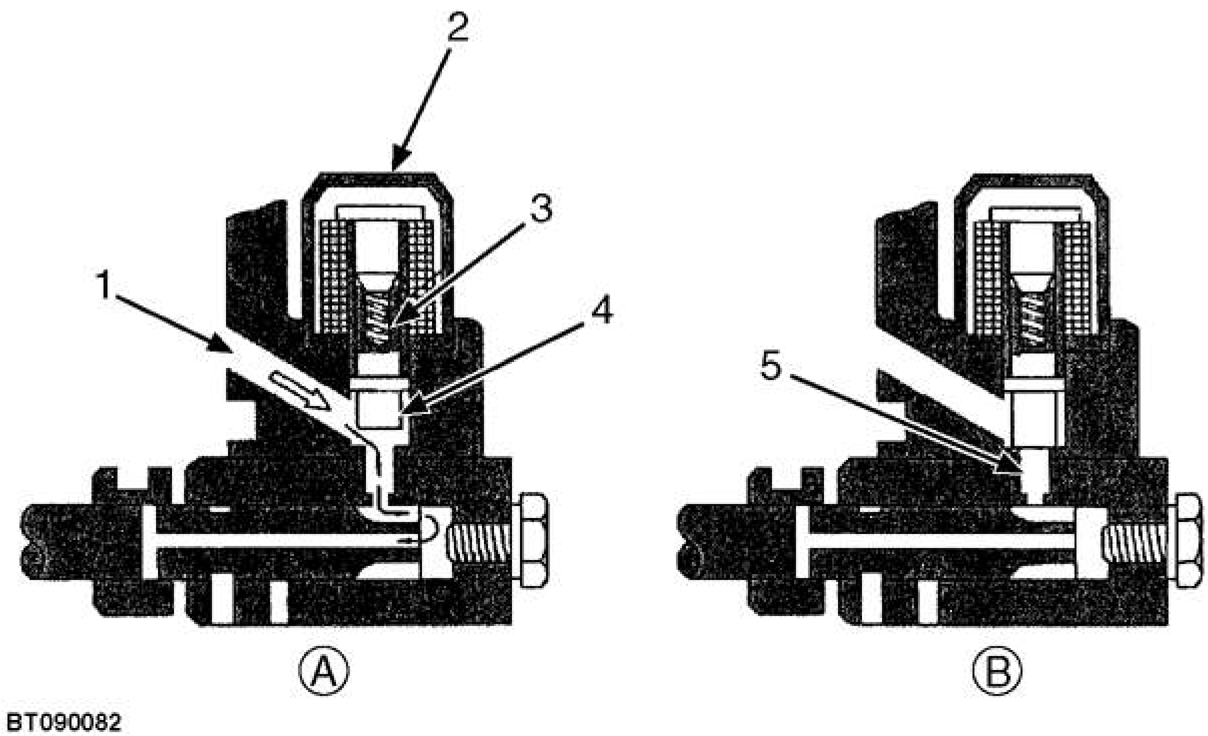
The alternator generates alternating current at the stator coil when the rotor is rotated by the engine. The diode then rectifies the AC voltage into DC voltage. The voltage generated by the alternator varies depending on the engine speed. The alternator has a regulator that maintains constant voltage.

Glow Plugs

The glow plugs are located in the cylinder head (swirl) chamber to assist in cold-weather starting. There is one glow plug per cylinder. When activated during engine start, the glow plugs heat to approximately 850°C (1562°F). The ECU utilizes engine coolant temperature to determine if glow plugs are needed.

Cold Start Timing Advance (Fuel Injection Pump)

The cold start timing advance consists of an electric actuator that adjusts the fuel timing based on engine coolant temperature. The electric actuator is controlled by the ECU.



A. WHEN MAGNETIC VALVE IS ON

B. WHEN MAGNETIC VALVE IS OFF

1. FUEL PATH
2. MAGNETIC VALVE
3. SPRING
4. ARMATURE
5. INLET PORT

Figure 9020-10-44. Magnetic Valve

NOTES

Group 40

Tests and Adjustments

Fuel System Pressure Test (Gasoline Engines Only)

This test is performed to check the fuel pump pressure and pressure regulator operation.

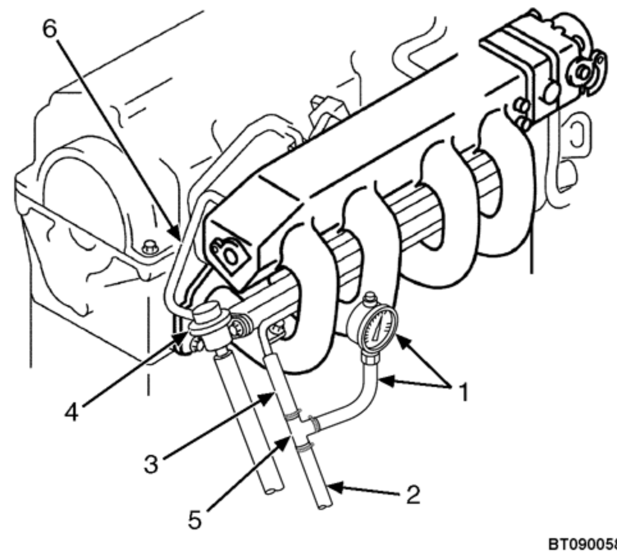
The Intake Air Fuel Module (IAFM) incorporates the air intake manifold and fuel delivery into one system. See Figure 9020-40-46.

Table 9020-40-1. Test Specifications

Fuel Pressure with Vacuum Hose ON	200 - 240 kPa (29 - 35 psi) at Low Idle
Fuel Pressure Increase With Vacuum Hose OFF	34 - 103 kPa (5 - 15 psi) at Low Idle Speed
Minimum Fuel Pressure After 5 Minutes	130 kPa (20 psi) with Engine **OFF**

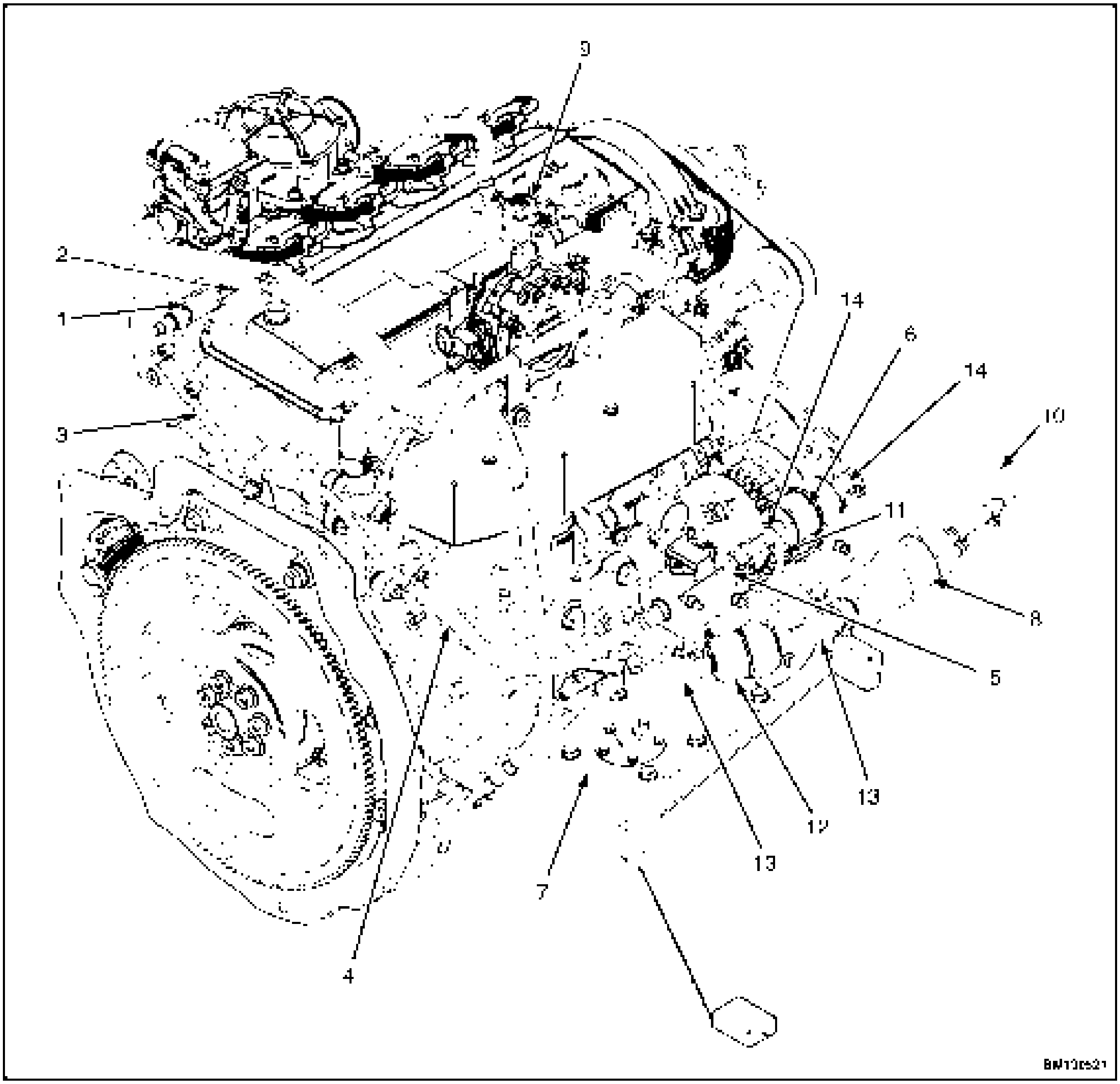
WARNING

Fuel line spills and leakage are dangerous. Fuel can ignite and cause serious injuries or death. Fuel can also irritate skin and eyes. Always perform the following procedure with the engine stopped.



1. TEST GAUGE AND HOSE
2. FUEL HOSE FROM PUMP
3. ADAPTOR HOSE TO FUEL RAIL
4. PRESSURE REGULATOR
5. TEST TEE FITTING
6. VACUUM HOSE

Figure 9020-40-45. Fuel System Pressure Test Gauge Setup



1. FUEL RAIL
2. FUEL INJECTOR
3. FUEL SUPPLY TUBE
4. FUEL SUPPLY HOSE
5. FUEL PRESSURE / TEMPERATURE SENSOR MANIFOLD
6. FUEL FILTER
7. FUEL SENDING UNIT
8. FUEL PUMP
9. LOCK OFF VALVE
10. FUEL SUPPLY TUBE
11. FUEL RETURN TUBE
12. FUEL FILTER INLINE STRAINER
13. HOSE
14. HOSE

Figure 9020-40-46. PSI Engine Fuel Components

NOTE: If engine will not start, perform Fuel Line Pressure Check. Refer to the appropriate **Gasoline Fuel System Engine** SRM .

1. Remove battery ground cable.
2. Install test gauge into test port on fuel line next to fuel filter.
3. Install battery ground cable.
4. Start engine, run at low idle, and record fuel pressure after 2 minutes. Compare test results to specifications.
   - If pressure is above specifications, replace pressure regulator. Refer to the appropriate **Gasoline Fuel System Engine** SRM .
   - If fuel pressure is below specifications, replace fuel filter and retest. Refer to the appropriate **Gasoline Fuel System Engine** SRM .
   - If pressure is still low and does not meet specification, stop engine and perform Fuel Line Pressure Check. Refer to the appropriate **Gasoline Fuel System Engine** SRM .
5. Slowly close return flow shutoff valve on fuel tank, pressure should increase as flow is restricted and go above specifications. Do not completely close this shutoff valve unless pressure does not increase.

   If pressure does not increase, replace fuel pump. Refer to the appropriate **Electrical System** SRM .
6. Fully open return fuel shutoff valve.

NOTE: If pressure regulator is operating correctly, the fuel pressure should increase when vacuum hose is removed.

7. Remove vacuum hose and record fuel pressure. Reinstall vacuum hose.

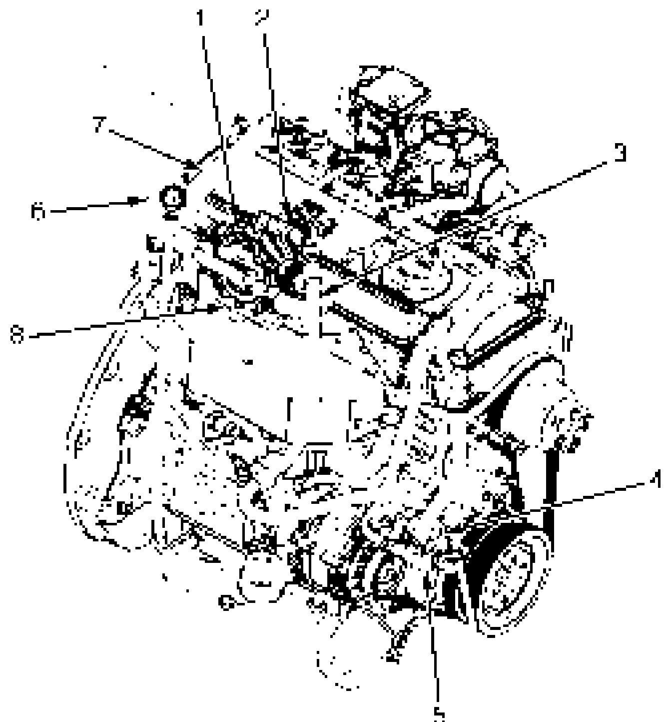
   If pressure does not increase when vacuum hose is removed, replace pressure regulator. Refer to the appropriate **Gasoline Fuel System Engine** SRM .

   If pressure is above specifications, replace pressure regulator. Refer to the appropriate **Gasoline Fuel System Engine** SRM .
8. Stop engine and observe the pressure gauge and record pressure drop after 5 minutes.

   If fuel system does not hold pressure inspect for leakage, if no external leakage, the check valve in fuel pump in leaking. Replace fuel pump. Refer to the appropriate **Electrical System** SRM .

Fuel System Pressure Test (LPG Engines Only)

ENGINE DESCRIPTION

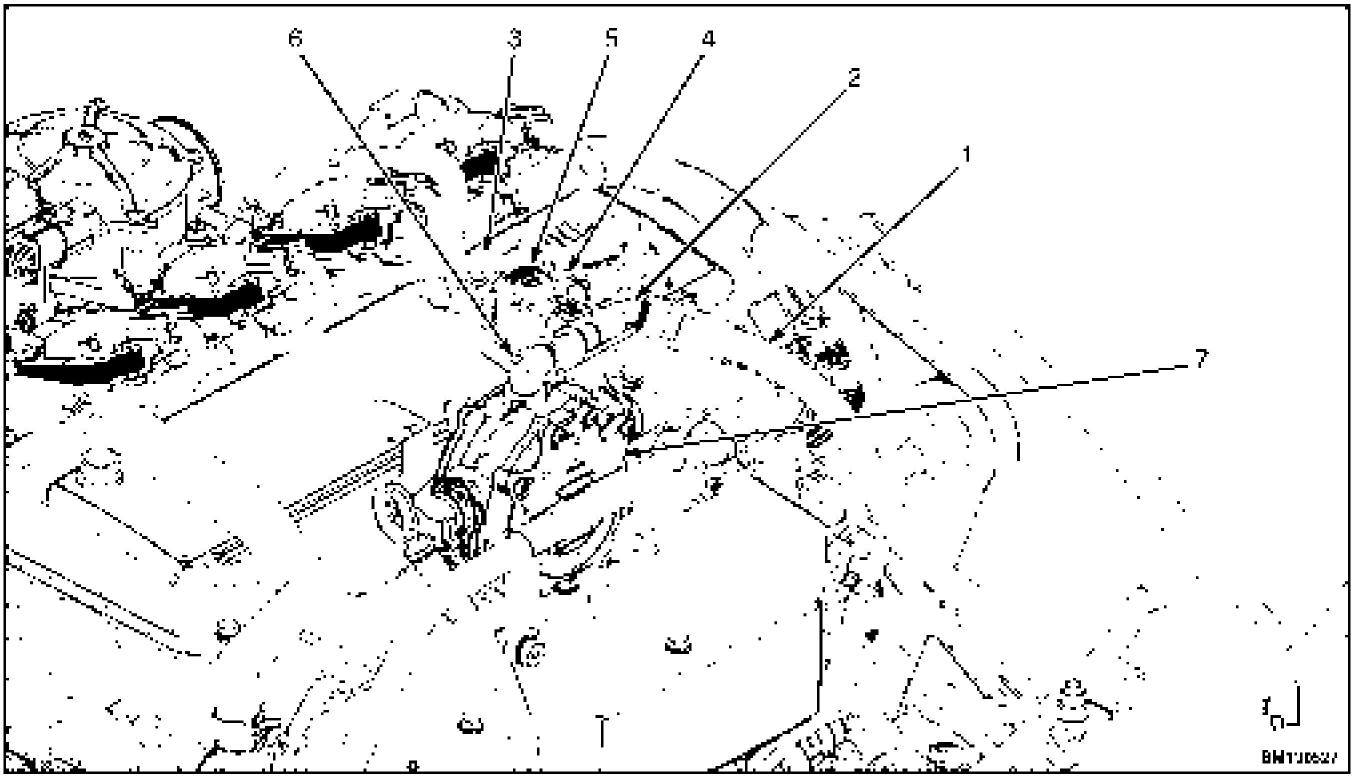


1. LPG CONVERTER
2. LPG LOCK-OFF VALVE
3. LPG FUEL SUPPLY HOSE
4. LPG FUEL FILTER
5. LPG LOW PRESSURE SWITCH
6. COOLANT HOSES
7. LPG FUEL VAPOR HOSE
8. LPG CONVERTER MOUNTING

Figure 9020-40-47. LPG Engine Fuel Components

The Engine Control Unit (ECU) receives information from various engine sensors in order to control the operation of the Electronic Pressure Regulator (EPR) and Lock-Off valve. The Lock-Off valve solenoid prevents fuel flow unless the engine is cranking or running. LPG is stored in the tank as a liquid and delivered under pressure of up to 21.5 bar (312 psi). During cranking and normal engine operation, LPG flows from the fuel tank through fuel hoses to the fuel filter and LPG lock-off valve to the EPR. Inside of the EPR, fuel is vaporized and reduced in pressure in two stages. The first stage reduces the tank pressure to approximately 20.68 kPa (3.0 psi). The second stage then reduces the pressure to approximately -38.1 mm H_2O (-1.5 in. H_2O) when vacuum from the engine draws in fuel.

The fuel is then drawn in from the secondary chamber of the EPR by the vacuum generated by air flowing through the carburetor. This vacuum also generates lift for the carburetor air valve and is commonly referred to as air valve vacuum. Once in the carburetor, the fuel is combined with air and is drawn into the engine for combustion.



NOTE: VIEW IS FROM LEFT SIDE OF LIFT TRUCK, FACING FRONT OF LPG CONVERTER AND LOCK-OFF ASSEMBLY.

NOTE: SEVERAL COMPONENTS PARTS OF ENGINE, FUEL SYSTEM, AND FRAME OMITTED FOR CLARITY.

1. FUEL SUPPLY HOSE
2. FITTING (LPG LOCK-OFF)
3. WIRE HARNESS
4. ELECTRICAL CONNECTOR
5. LPG LOCK-OFF VALVE ASSEMBLY
6. ELBOW FITTING (LPG CONVERTER)
7. LPG CONVERTER

Figure 9020-40-48. LPG Lock-Off Valve Assembly

Table 9020-40-2. Service Tools

NOTE: Fuel System Test Kit 1674479 includes all below tools except primary port test hoses, hose clamps, and PC Service Tool		
Pressure Gauge	0 to 69 kPa (0 to 10 psi)	1650625
Water Column Gauge (Manometer)	0 to 254 mm H_2O (0 to 10 in. H_2O)	8525266
Test Port Adapters	Primary	1450629 (Straight) 1358232 (90° elbow)
	Secondary	1650628
Test Port Hose	Primary	1 m (3 ft) length of: Hose 181761 (for straight adapter) 338694 (for 90° elbow adapter)
	Secondary	1650626
Hose Clamps	Primary & Secondary	Appropriately sized hose clamps
PC Service Tool		1595697

1. DIAGNOSTIC AIDS

This procedure is intended to diagnose a vehicle operating on LPG. Before starting this procedure, complete the following tasks to verify that liquid fuel is being delivered to the EPR:

- Inspect the fuel system for leaks using soapy solution or electron leak detector
- Inspect fuel tank to verify it has a sufficient amount of fuel
- Verify manual shut off valve on the LPG tank is fully opened
- Verify that the excess flow valve has not been activated
- Inspect fuel tank to ensure it is properly mounted and rotated to the correct position
- Inspect the hoses leading from the tank ensuring they are properly connected and do not have any kinks or damage.

EPR PRIMARY PRESSURE TEST

WARNING

Always disconnect the cables at the battery before you make repairs to the engine. Disconnect the cable at the negative terminal first.

WARNING

LPG can cause an explosion. DO NOT cause sparks or permit flammable material near the LPG system. LPG fuel systems can be disconnected indoors only if the lift truck is at least 8 m (26 ft) from any open flame, motor vehicles, electrical equipments, or ignition source.

1. Close the shutoff valve on the LPG tank and run the engine until it is out of fuel and stops running.
2. Attempt to start engine 2 to 5 times to ensure all fuel has been removed from EPR.
3. Disconnect battery negative cable.
4. Connect a 0 to 69 kPa (0 to 10 psi) pressure gauge to the EPR using the Primary Pressure test port adapter, appropriate test hose and hose clamps.
5. Install battery negative cable.
6. Fully open LPG tank shutoff valve and start engine.
7. EPR Primary Pressure should be 13.8 to 27.6 kPa (2.0 to 4.0 psi) during all engine operating conditions (including cranking).
8. If pressure is not within specified range verify LPG lock-off valve is operating properly and fuel filter is not restricted.
9. If LPG lock-off valve and fuel filter are functioning properly replace the EPR.

EPR SECONDARY PRESSURE TEST

WARNING

Always disconnect the cables at the battery before you make repairs to the engine. Disconnect the cable at the negative terminal first.

WARNING

LPG can cause an explosion. DO NOT cause sparks or permit flammable material near the LPG system. LPG fuel systems can be disconnected indoors only if the lift truck is at least 8 m (26 ft) from any open flame, motor vehicles, electrical equipments, or ignition source.

1. Close the shutoff valve on the LPG tank and run the engine until it is out of fuel and stops running.
2. Attempt to start engine 2 to 5 times to ensure all fuel has been removed from EPR.
3. Disconnect battery negative cable.
4. Remove the LPG Fuel Temperature sensor from the EPR (keep sensor connected to wire harness). Secure the sensor away from the fan.
5. Connect a 0 to 254 mm H_2O (0 to 10 in. H_2O) water column gauge or manometer to the EPR using the Secondary Pressure test port adapter, retention clip, appropriate test hose and hose clamps. Secure the test hose away from the fan.
6. Install battery negative cable.
7. Fully open LPG tank shutoff valve and start engine.
8. Allow engine to warm up to operating temperature.
9. Use PC Service Tool to view the Actual Gaseous Fuel Pressure data. Compare the water column gauge or manometer's measured value to PC Service Tool's value. The pressures should be within ± 19 mm H_2O (75 in. H_2O) of each other during all engine operating conditions.

NOTE: The action in the following step will cause a fault code to be set and the MIL will illuminate.

10. If pressures are not within the specified range turn the engine off and disconnect the EPR's main electrical connector. Secure the connector away from the fan
11. Start the engine and let it idle. Observe the pressure reading on the water column gauge or manometer. If the pressure reading is NOT within the range of -25 to -76 mm H_2O (-1.0 to -3.0 in. H_2O) repair or replace the EPR.

Fuel Injection Nozzle Test (Yanmar Diesel)

This test is performed to check the operation of the fuel injection nozzle.

Table 9020-40-3. Test Specifications

Fuel Pressure at which injector will start spraying	11.8 - 13.2 MPa (1711 - 1914 psi)
Pressure change per 0.1 mm (0.004 in.)shim	1.2 - 2.2 MPa (174 - 319 psi)

Table 9020-40-4. Service Tools

Fuel Injection Nozzle Tester

1. Prior to connecting the fuel injector to the nozzle tester, visually inspect the fuel injectors and nozzle protectors for deposits or damage. Clean, repair or replace as necessary.

NOTE: Use clean, filtered fuel or F.I.E. calibration fluid for this test.

2. Using the correct adaptor, connect the fuel injector to the high-pressure pipe of the nozzle tester. Aim the fuel injector into a suitable container to catch the fuel spray. See Figure 9020-40-49.

WARNING

Never inject fuel towards you. Fuel injected at high pressure from the nozzle may penetrate the skin, resulting in injury.

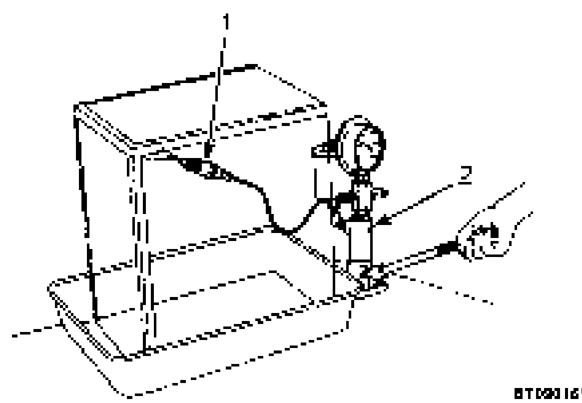
Never inject fuel towards a fire source. Atomized fuel is highly flammable and may cause a fire or skin burns.

3. Pump the operating lever of the tester slowly, observing the pressure reading at the point where the fuel injector begins spraying fuel. The fuel injectors for these engines should begin spraying fuel at test specifications. The opening pressure may be adjusted by adding or subtracting internal fuel injector shims.

4. Add or remove shims as required. Refer to appropriate engine manual.

5. Repeat test until injector performs to test specification. Replace injector if test specification cannot be achieved.

6. To check injection nozzle for leakage, pump the operating lever slowly to hold the pressure steady at a point just below the “pop off” pressure point. Observe the injector to see that it is sealing properly and is not “dripping”. Replace injector as necessary.



1. INJECTION NOZZLE 2. NOZZLE TESTER

Figure 9020-40-49. Fuel Injection Nozzle Test Setup

Group 30

Observed Symptoms

Engine Does Not Crank

POSSIBLE CAUSE

A. STARTER INTERLOCK ENGAGED.
B. IF EQUIPPED, BATTERY DISCONNECT SWITCH IN "OFF" POSITION.
C. FAULTY CABLE CONNECTIONS.
D. BATTERY STATE (DISCHARGED OR FAULTY).
E. FAULTY KEY SWITCH OR START BUTTON.
F. BLOWN STARTER FUSE.
G. FAULTY STARTER RELAY.
H. FAULTY STARTER.
I. SEIZED ENGINE.

CAUSE A - STARTER INTERLOCK ENGAGED.

PROCEDURE OR ACTION:

1. Check for messages displayed.
   Are any messaged displayed on the display?
   YES: Follow directions on the display. For example, apply parking brake, place transmission in neutral.
   NO: Go to Cause B.

CAUSE B - IF EQUIPPED, BATTERY DISCONNECT SWITCH IN "OFF" POSITION.

PROCEDURE OR ACTION:

1. Check that battery disconnect switch is in the "ON" position.
   Is battery disconnect switch in "OFF" position?
   YES: Turn switch to "ON" position. See **Operating Manual** for operation of battery disconnect.
   NO: Go to Cause C.

CAUSE C - FAULTY CABLE CONNECTIONS.

PROCEDURE OR ACTION:

1. Check for proper cable connections at battery terminals, starter, engine block ground, and starter solenoid. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
   Are cable connections loose or corroded?
   YES: Clean or tighten cable connections. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
   NO: Go to Cause D.

CAUSE D - BATTERY STATE (DISCHARGED OR FAULTY).

PROCEDURE OR ACTION:

1. Check battery for low voltage.
   Is the battery discharged?
   YES: If battery case is cracked or leaking fluid, replace battery. Refer to appropriate **Electrical System** manual, depending on lift truck model. If battery case is OK, go to Step 2.
   NO: Go to Cause E.
2. Charge and inspect visual hydrometer indicator on battery and perform battery load test.
   Does battery pass load test?
   YES: Charge battery and check charging system. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Replace battery.

CAUSE E - FAULTY KEY SWITCH OR START BUTTON.

PROCEDURE OR ACTION:

1. Check to see that ignition switch is closed. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   Is ignition switch open?
   YES: Replace ignition switch. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause F.

CAUSE F - BLOWN STARTER FUSE.

PROCEDURE OR ACTION:

1. Check for blown starter fuse.
   Is starter fuse (located in PDM) blown?
   YES: Replace starter fuse. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
   NO: Go to Cause G.

CAUSE G - FAULTY STARTER RELAY.

PROCEDURE OR ACTION:

1. Check for faulty starter relay. Perform similar relay troubleshooting as found in Cause A of Diagnostic Trouble Codes, Page 9030-20-52.
   Is starter relay (located in PDM) faulty?
   YES: Replace starter relay. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
   NO: Go to Cause H.

CAUSE H - FAULTY STARTER.

PROCEDURE OR ACTION:

1. Check that starter operates properly. Ensure all cables are clean and secure. Ensure no resistance is present in starting circuit. Measure voltage at starter solenoid when attempting to crank engine.
   Does starter motor operate properly / voltage present at starter solenoid?
   YES: Go to Cause I.
   NO: Replace faulty starter.

CAUSE I - SEIZED ENGINE.

PROCEDURE OR ACTION:

1. Check for seized drive plate or flywheel. Remove spark plugs from engine and manually rotate engine. If engine will not rotate, check for:
   - Seized drive plate
   - Seized valve train
   - Crankshaft, connecting rod, or piston damage

   Is drive plate or flywheel seized, or engine parts damaged?
   YES: Replace drive plate, flywheel, or damaged engine parts. Refer to appropriate manual.
   NO: Resume operation.

END SYMPTOM

NOTES

SECTION 9030

ELECTRICAL SYSTEM

TABLE OF CONTENTS

Group 03

General Maintenance and Diagnostic Data

Troubleshooting Guidelines and Procedures

TROUBLESHOOTING GUIDELINES

The troubleshooting procedures that will be encountered in this manual require that the individual be familiar with certain policies, requirements, and instructions before starting any of the procedures. These are included to assure the safety of the technician performing the tasks, simplify the procedures, and prevent damage to the machine and supporting equipment.

WARNING

All safety precautions for working on and around powered vehicles must be observed and maintained. (Refer to Operating or Repair Manual.)

1. Initial conditions will be with the vehicle power OFF and park brake set, unless directed otherwise.
2. The Diagnostic Trouble Code (DTC) Table will indicate:
   - Suspect Parameter Number (SPN)
   - Fault Mode Indication (FMI) number (FMI code definitions can be found in Fault Mode Indicator Reference, Page 9080-70-1)
   - A brief description of the fault/symptom

   This number is the number displayed in the Liquid Crystal Display (LCD) section of the display. In addition to active faults that will be displayed on the LCD, the system is capable of displaying fault history data that is stored in the ECU and other controller units, if equipped.
   - Engine Fault Log
   - XMSN Fault Log
   - HYDR Fault Log

   These fault history logs are accessible to service level technicians.
3. Abbreviations and Acronyms will be defined when first used in a procedure. They are also listed and defined in Abbreviations and Acronyms, Page 9080-50-1 that accompanies this document.

NOTE: When troubleshooting the electrical wiring harness for your lift truck, the wire connectors may be different but the pin numbers for the connectors are the same between the different connectors.

4. Most procedures will require the use of a Digital MultiMeter (DMM) and associated probes. The service technician should be familiar with the operation, range scales, polarity selection, and measurement techniques.
   - **a.** Unless otherwise directed, the **RED** probe of the DMM will always be connected to the point indicated as **(+)** and the **BLACK** probe will always be connected to the point indicated as **(-)**.
   - **b.** When performing a continuity check, all signal circuits should be equal or less than 0.5 ohms. At the start of troubleshooting procedures, verify that the DMM will display 0 ohms when the resistance scale is selected and the probes are shorted together. If the DMM display indicates a value less than 1 ohm and that value is consistently repeated, it may be considered as the zero value. Resistance readings during testing will require correction by this small value. If the DMM display is not correct or is greater than 1 ohm, have the meter calibrated/serviced.
   - **c.** In some improved DMMs, when the test probes are shorted together, a momentary push-button switch will re-zero the meter scale and maintain that zero position as a reference until the meter is turned off. If this feature is available, be sure to re-zero each time meter power is cycled.

d. Probing the back of connectors for obtaining in-line voltage measurements requires a special probe extension for the meter probes. Failure to use this tool can result in damage to the integrity of the connector seal and may cause a failure in the harness/connector assembly. Refer to Probing Deutsch Connectors,.

5. Most electrical problems will be harness related:

- Connectors not fully engaged and locked
- Connector pins not fully inserted
- Circuit repairs incorrectly wired at connectors
- Damaged connector pins

6. Major component service tips:

a. Power Distribution Module (PDM):

- Blown fuses can be easily checked without removal from PDM. Fuses have slots at each end for meter probe connection.
- All relays are socketed
- Transient suppressor and alternator excite resistor are socketed
- Internal component locator on inside cover

7. When troubleshooting electrical/electronic faults and symptoms:

a. Verify that battery voltage level is adequate to provide at least 6.2 volts during the cranking cycle. Before starting the engine, enter the Service Menu. Go to Diagnostics/Battery Voltage. Monitor Battery Voltage during cranking. If battery drops below 6.2 volts, check specific gravity of battery. Charge or replace battery(s), as needed.

b. Verify that the connector is properly engaged and that connector security clips, tabs, and other locking devices are properly attached.

c. Visually examine the connectors and harness termination points for “pushed” or “recessed” pins or sockets.

d. Frame or chassis “ground” is not a valid test point for “common return” or as a “low” (-) when measuring voltages. Grounds for these truck systems are isolated and identified as control ground, signal ground, and CAN ground. Use frame ground for measurement only when directed by procedures.

e. Before opening any connector or removing any wires from their termination point, disconnect the negative (-) cable from the battery. If the truck is equipped with the Battery Disconnect Switch, pull the “T” handle on the dash to disconnect the battery.

NOTE: The Electrical System Schematic referenced in this manual will be supplied in the appropriate circuit diagram book. Verify that this data is current and the revisions are up to date before making any changes or alterations to the truck wiring.

Prior to making any corrections or changes to the wiring, verify that the wire number and color coincide with the information on the referenced schematics, wiring diagrams, or special instructions, if any.

NOTE: There may be customer options and equipment installed on the lift trucks by third-party services that do not comply with the standard wiring specifications and standards. Suppliers are encouraged to follow these standards for circuits that connect to Hyster® circuits when possible.

8. The chassis wiring used in these vehicles conforms to the electrical circuit identification standard ES-1359 and in addition to surface marked ID circuit numbers, generally utilizes the colors that are indicated below. Also refer to Wiring Reference Data.

a. Red = Battery level power circuits and 5-volt supply circuits

b. Black = Heavy current grounds

c. Green = Signal Grounds

d. White = Other circuits

e. Twisted Pair (Yellow/Green) = Controller Area Network (CANbus)

- Yellow = CANbus Hi (+)
- Green = CANbus Lo (-)

9. Connectors used on schematics and reference drawings are identified as follows: See Figure 9030-03-1 in this section.

a. **CPSXXX** -- **Connector Plug Socket (CPS)**, with **XXX** being the identity number.

b. **CRPXXX** -- **Connector Receptacle Pin (CRP)**, with **XXX** being the identity number.

10. At the completion of a Troubleshooting Procedure, verify the following:

a. All components removed for replacement, test or access purposes have been correctly reinstalled.

b. All electrical connections are restored.

c. If operational test or checkout is to be performed, make sure operating area is free of personnel, obstructions, and ground hazards.

d. Vehicle is in proper location and configuration for safe operation.

e. Support equipment and tools are removed and properly stored.

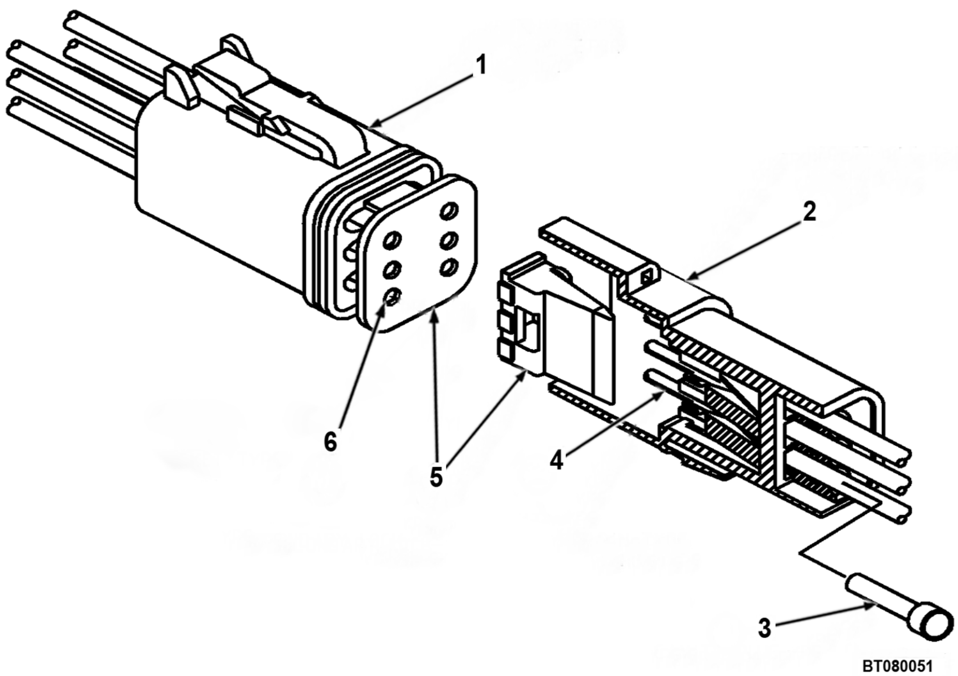
f. If operation is complete and the lift truck is to be stored or shut down, verify:

(1) Mast/Carriage/Forks are properly positioned.

(2) If LPG powered, Fuel shutoff is secured.

(3) Electrical power is turned **OFF**.

(4) Cab (if equipped) is closed and secured.



1. PLUG TYPE CONNECTOR BODY
2. RECEPTACLE TYPE CONNECTOR BODY
3. CAVITY PLUG
4. PIN-TYPE TERMINAL
5. SECONDARY LOCK
6. SOCKET TYPE TERMINAL

Figure 9030-03-1. Typical DT Series Connector

TROUBLESHOOTING PROCEDURES

This section describes the general process of identification, location, structure, and performance of the troubleshooting procedures that are included in this manual.

Troubleshooting Procedures, Identification

The various procedures are identified by an assigned number. For the engine when you use diagnostic tools are in accordance with SAE Specification J1939-73. This number is referred to as a Diagnostic Trouble Code (DTC) and is comprised of:

- Suspect Parameter Number (SPN) which may be contain up to six characters and identifies the item, device, parameter, or data value that is at fault.
- Fault Mode Indicator (FMI) which may display 0 through 31 to indicate the type of failure; (i.e. Data Incorrect, Voltage Out Of Range, Current Below Normal, etc.).

Troubleshooting Procedures, Location

These two numbers, the SPN and the FMI, combine to form the Diagnostic Trouble Code (DTC) number that will be displayed in the Liquid Crystal Display (LCD) portion of the display. Once this number has been displayed, indicating a fault has been detected, the operator/service technician can review the DTC Table in this section to determine where the appropriate troubleshooting procedure is located.

The reported DTCs are listed in numerical order, along with the DTC title description of the detected fault. The reported FMI number is also included in the list with the applicable DTC to fully identify the correct troubleshooting procedure to use. DTCs are also stored in the Fault Logs, where a history of repeat failures is maintained, until cleared by an authorized service technician.

When working from an Integrated Electronic Technical Manual (IETM) format, clicking on the DTC index number, or the page in the Table of Contents, will link you to the applicable procedure in section 9030-20. If working from a hardcopy (paper) manual, this capability is not available.

Fault Logs store a history of DTCs within a specific controller file. These fault logs are accessible via the service mode main menu using the following procedure:

- Turn key switch **OFF**.
- Hold **<**, **>**, and **M** and turn key switch **OFF**.
- Enter service password, if enabled.
- Press **>** until **mAnT-CErTIFY** is displayed.
- Press **<** to navigate sub menus.

  Engine Fault Log, press ENTER

  XMSN Fault Log, press ENTER

  HYDR Fault Log, press ENTER

- After acquiring the Fault Log display, use the scroll arrows to view stored faults that will be listed numerically in the log. The displayed data will show the following:

Troubleshooting Procedures, Structure

The structure or makeup of the troubleshooting procedures is generally the same for all entries. Minor differences in the beginning of a procedure are determined by whether the procedure has:

- A single fault code with a single schematic diagram
- A single fault code with multiple schematic diagrams
  In this instance, the technician will have to select the appropriate schematic based on the DTC and the lift truck/engine configuration.
- Multiple fault codes with a single or multiple schematic diagram(s)
- A single fault code with no schematic diagrams, used when only the operational check and replacement procedures are employed in the procedure.

In each case, the opening page of a procedure will identify the following at the top of the page:

- **DTC** number
- Codetype, (i.e. **Pressure Sensor** Out-Of-Range-Low (**OORL**)
- Trigger or condition that enabled the fault (i.e. Signal reading above allowable threshold) if available

The next identifiable element of the procedure will be the **CODES** if this is a multiple code type. The codes will be listed here in numerical order, along with a brief code title and specific application, if any. If a single fault DTC, this data appears at the top of the page.

The next identifiable element of the procedure will be the **POSSIBLE CAUSE**. One or more possible causes will be listed here in the order of most probable to the least probable. Each of the possible causes is internally linked to that portion of the procedure and subsequent links are embedded in these causes, where applicable.

The next identifiable element of the procedure will be the **OPERATIONAL CHECK**. This is a very important part of the procedure and should not be skipped. This operational check is installed at this point in the procedure to permit the user accomplish the following:

- Verify truck serial number matches the key components. If these numbers do not match, the data reported for the fault codes may not be accurate.
- Verify the DTC is still a valid fault. If the DTC is cleared during the power cycling, it may not have been a hard failure and if it does not reoccur on the display, there is no method of identifying or troubleshooting the problem.
  If this situation occurs randomly or reoccurs frequently with the same DTC, access and review the fault history log for that group to determine the frequency of failure and the last reported time it occurred. This information can be helpful in isolating intermittent problems when known conditions under which it occurred can be repeated.
- The operational check will also direct the technician to the proper cause in the procedure, based on truck/system configuration, other symptoms, and advise the user if any special conditions are required (i.e. Operate the truck until it has reached normal temperature, recharge the battery before proceeding etc.).
- The operational check is also performed to verify that the problem has been corrected and that the components and devices have been restored to an operating condition.

The next item that appears in the procedure is the **CAUSE A**. This introduces the troubleshooter to the first sequence of tests or measurements to follow. Continuing through the procedure in the step-by-step directions will lead the user to:

- Additional possible causes
- Replacement/repair instructions
- Correction of the fault
- Operational check of the repaired/replaced device

Following through the procedure, the next items are the **DIAGRAMS** that support the troubleshooting and provide relevant data for wiring, connectors, power, signal and other reference data. These will enable the troubleshooter to measure, verify, and make critical decisions leading to the root cause. The diagrams may include:

- A mini-schematic of the suspect circuit
- Wire identification and circuit function
- Connector pin-out locators
- Special reference data for device or component

Troubleshooting Procedures, Performance

It is important to remember the basics of troubleshooting when checking the electronically reported faults. Prior to starting any of the listed procedures, it is recommended that the items listed below be reviewed. These may help to isolate the problem, eliminate some steps or enforce the procedure that has been identified. These items are:

- **LOOK** — Are there any observable symptoms, visual evidence or obvious conditions that could result in, or contribute to, the reported fault.
- **LISTEN** — If the lift truck can be operated with the reported problem, are there any unusual noises or vibrations that could result in, or contribute to, the reported fault.
- **TOUCH OR SMELL** — High operating temperatures and excessive wear can sometimes produce an odor or visual evidence that can be linked to other faults or conditions.
- In general, let your senses and your experience assist you in resolving the problem in the most efficient manner. Ask yourself:
  - What is required for this device or operation to function correctly?
  - Where are the devices/parts located?
  - Has this problem been reported before? If so, how frequently? Use the fault history logs to help identify repeated problems. This can be very helpful in analyzing faults of an intermittent nature which may be difficult to duplicate.
  - Has repair work, disassembly or other maintenance work been performed on suspect device or system recently?
- Once these questions have been considered, proceed with the DTC resolution as per the procedure, using any additional information to assist in resolving the discrepancy.

Wiring Reference Data

NOTE: When troubleshooting the electrical wiring harness for your lift truck, the wire connectors may be different but the pin numbers for the connectors are the same between the different connectors.

Function/Circuit Identification — A standard numbering and color-coding system is used in the lift truck wiring. This system will simplify repairs. The Electrical Circuit Identification Specification is ES-1359. The ID data is described in the Function/Group table that follows:

— Each circuit Function ID has a number from 1 through 999, as indicated in the Table 9030-03-1.

- A circuit labeled with a single numerical Function ID shall be electrically equivalent throughout the harness (physically connected through splices or connectors).
- Wires which are connected only through an internal connection in a controller shall have separate Function ID numbers.
- Wire Function ID numbers will be stamped at 50mm intervals along the wire length.
- Harness wires which serve different functions depending on the truck options shall include both Function IDs, separated by a “/”.
  For example, a wire which serves as a Lift Switch circuit on one option and a Tilt Up Switch circuit on another would be marked “26 / 42”. If a Computer Aided Drawing (CAD) or wire printing restriction does not allow the character “/”, it may be replaced with “-”. As in the previous example referring to the Lift and Tilt Switches, this wire would now be identified as "26-42."
- The Function IDs are assigned into groups as shown in the table. Unless noted otherwise, specific functions are to be preassigned to unique Function IDs.

If a circuit function does not meet one of the preassigned numbers, and its function is unique within the truck series and option, then a number from the “Non-Standard Functions” range may be used.

Table 9030-03-1. Circuit Group Identification

Circuit Type	Circuit ID
Grounds (IDs not preassigned within this range)	101-149
Current sense ground	150-199
Switched B+ (IDs not preassigned within this range)	200-239
Fused B+ (IDs not preassigned within this range)	240-249
Regulated Power 5V (IDs not preassigned within this range)	250-279
Regulated Power 12V	280-299
Analog Inputs – hydraulics / mast	300-319
Analog Inputs – chassis	320-339
Analog Inputs – powertrain	340-399
Analog Inputs – CAB / OHG	400-419
Reserved for additional analog inputs	420-499
Digital inputs – hydraulics / mast	500-509
Digital inputs – chassis	510-539
Digital inputs – powertrain	540-559
Digital inputs – CAB / OHG	560-569
Encoder inputs	570-599
Reserved for additional digital inputs	600-699
Digital outputs – hydraulics / mast	700-719
Digital outputs – chassis	720-749
Digital outputs – powertrain	750-779
Digital outputs – CAB /OHG	780-799
PWM outputs – hydraulics / mast	800-829
PWM outputs – chassis	830-839
PWM outputs – powertrain	840-889
PWM outputs – CAB / OHG	890-899
Communications (eg., CANbus)	900-909
Non-Standard functions	910-999

Wiring Color Codes — The colors used to identify the lift truck wiring, in addition to the surface marked circuit ID data, are identified in Table 9030-03-2. Diagrams and Schematics in this book can be viewed and printed in color. If not printed or viewed in color refer to the electrical circuit identification located on schematic circuits. When viewing a color version of the diagrams and schematics, the white chassis wires are seen as yellow. Other wires are shown in colors similar to actual colors, i.e., tan shows as yellow. Use circuit identification for true wire color. MONOTROL®, Foot Directional Control, engine harnesses, wiring to sensors and other applications vary with respect to wire colors.

Table 9030-03-2. Hyster Wiring Color Codes

Color	Use/Function
Red	Battery-level power circuits and 5 Volt supply circuits
Black	Heavy current grounds
Green	Signal grounds
White	Other circuits
Twisted Pair (Yellow/Green) Yellow Green	**CANbus** CAN-Hi CAN-Lo

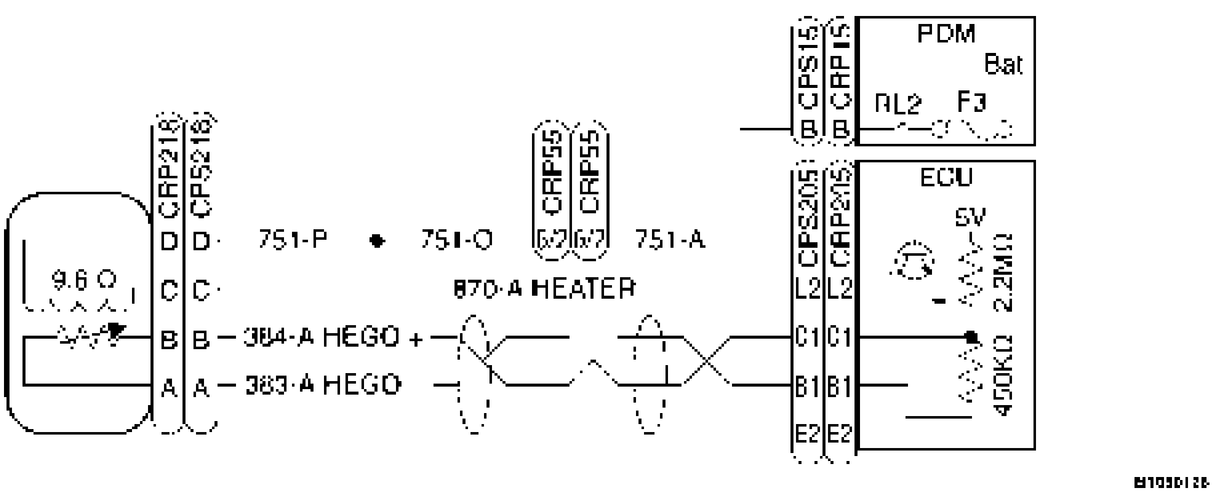
Symbol Definitions

Type "S", Identifies information for UL Safety rated trucks. Applicable trucks are rated for GS, LPS, DS depending upon fuel type.

Arrow Symbols, Go to specified page of schematic. Page number is located in the “hexagon symbol” on schematic.

---x, Go to specified sheet of diagram. Sheet number is located in lower right corner of figure.

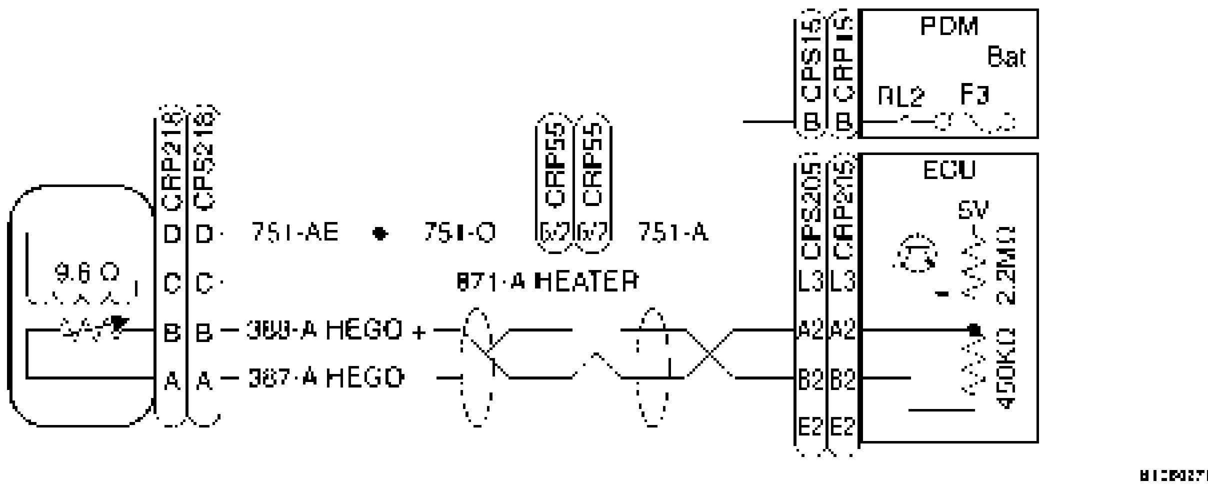
Circuit Identification — All circuits are assigned a number for identification. See Circuit Group Identification. Most circuits also have an alpha suffix to help determine position. For example:



WIRE # 751 (RED), SEGMENTED, SUFFIX LETTERS A, O, P
WIRE # 870 (WHITE), NON-SEGMENTED, SUFFIX LETTER A

WIRE #S 383, 384 (WHITE), NON-SEGMENTED, TWISTED PAIR, SUFFIX LETTER A (SHOWN WITH SHIELD THAT TERMINATES AT PIN B2)

Figure 9030-03-2. Single Wiring Sample Circuit



WIRE # 751 (RED), SEGMENTED, SUFFIX LETTERS A, O, P
WIRE # 870, 871 (WHITE), NON-SEGMENTED, SUFFIX LETTER A

WIRE #S 383, 384, 387, AND 388 (WHITE), NON-SEGMENTED, TWISTED PAIR, SUFFIX LETTER A (SHOWN WITH SHIELD THAT TERMINATES AT PIN B2)

Figure 9030-03-3. Dual Wiring Sample Circuit

Harness Assembly Data

NOTE: When troubleshooting the electrical wiring harness for your lift truck, the wire connectors may be different but the pin numbers for the connectors are the same between the different connectors.

This section depicts the lift truck harness assemblies with their respective connector identifications. The harnesses are arranged as follows:

- 4-Function E-Hydraulic Harness Assembly Figure 9030-03-5
- 3-Function E-Hydraulic Harness Assembly Figure 9030-03-6
- Mast Harness Assembly Figure 9030-03-8

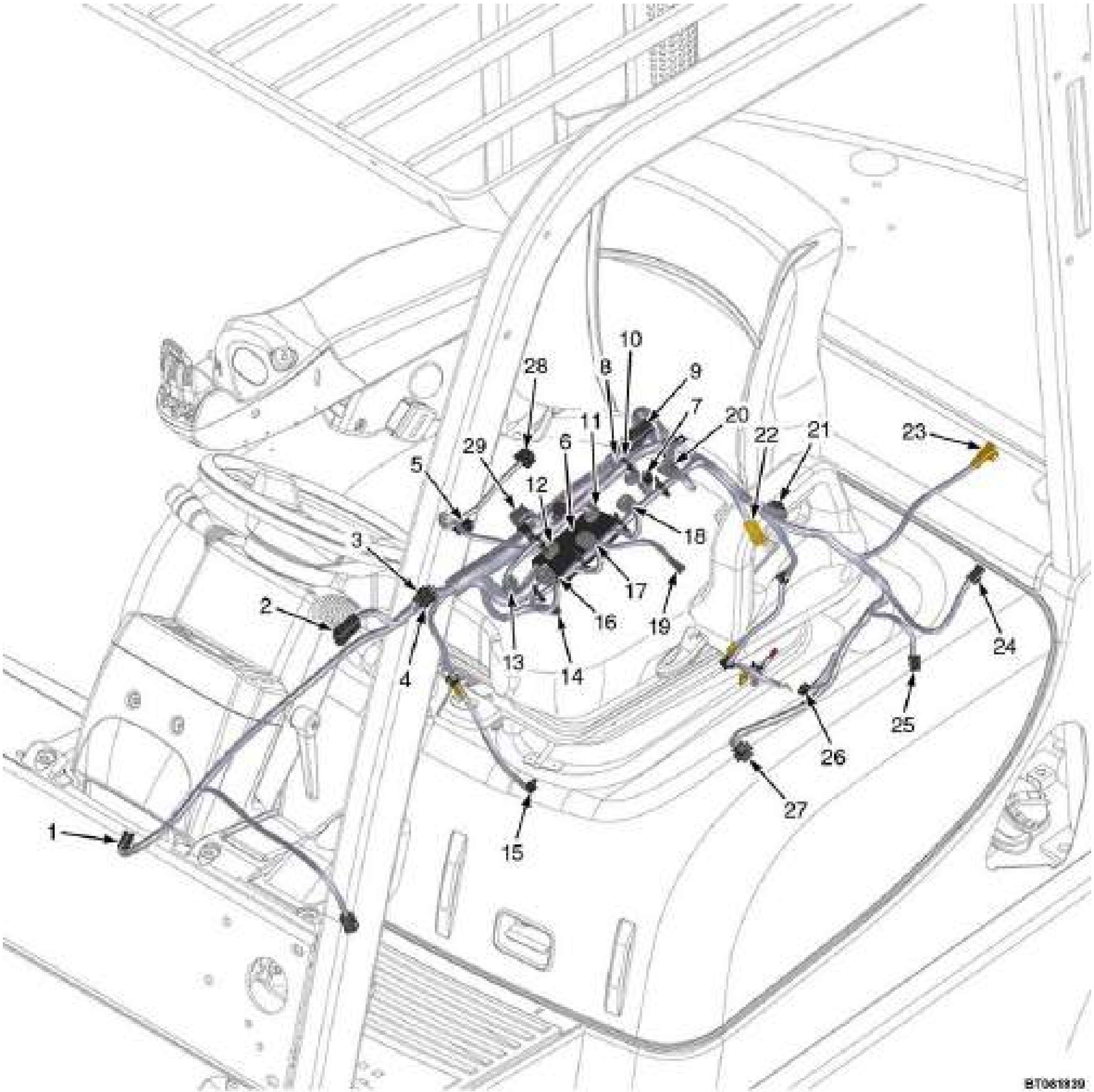


Figure 9030-03-4. Engine Harness Assembly (PSI 2.4L Bi-Fuel)

Legend for Figure 9030-03-4

1. HARNES, TO APP CPS27
2. CRP55, FRAME HARNESS CONNECTOR
3. 10A FUEL PUMP FUSE
4. 5A VSW FUSE
5. T263 B(-) CABLE
6. CPS202, ECU CONNECTOR
7. CPS232, ECT CONNECTOR
8. CPS218, EGO1 CONNECTOR
9. CPS229, DIAGNOSTIC CONNECTOR
10. CPS208, INJECTOR
11. CPS209, INJECTOR
12. CPS210, INJECTOR
13. CPS211, INJECTOR
14. CPS212, TMAP CONNECTOR
15. CPS225, CRANKSHAFT POSITION SENSOR CONNECTOR
16. CPS268, IGNITION COIL
17. CPS267, IGNITION COIL
18. CPS266, IGNITION COIL
19. CPS275, LOCK-OFF CONNECTOR
20. CPS265, IGNITION COIL
21. CPS219, CAMSHAFT POSITION SENSOR CONNECTOR
22. T201, OIL PRESSURE
23. CPS298, BUZZER
24. CPS207, FUEL PUMP
25. CPS70, LPG SWITCH
26. CPS252, EGO 2
27. CPS254, FUEL PRESSURE MANIFOLD
28. CPS230, THROTTLE CONNECTOR
29. CPS269, DEPR

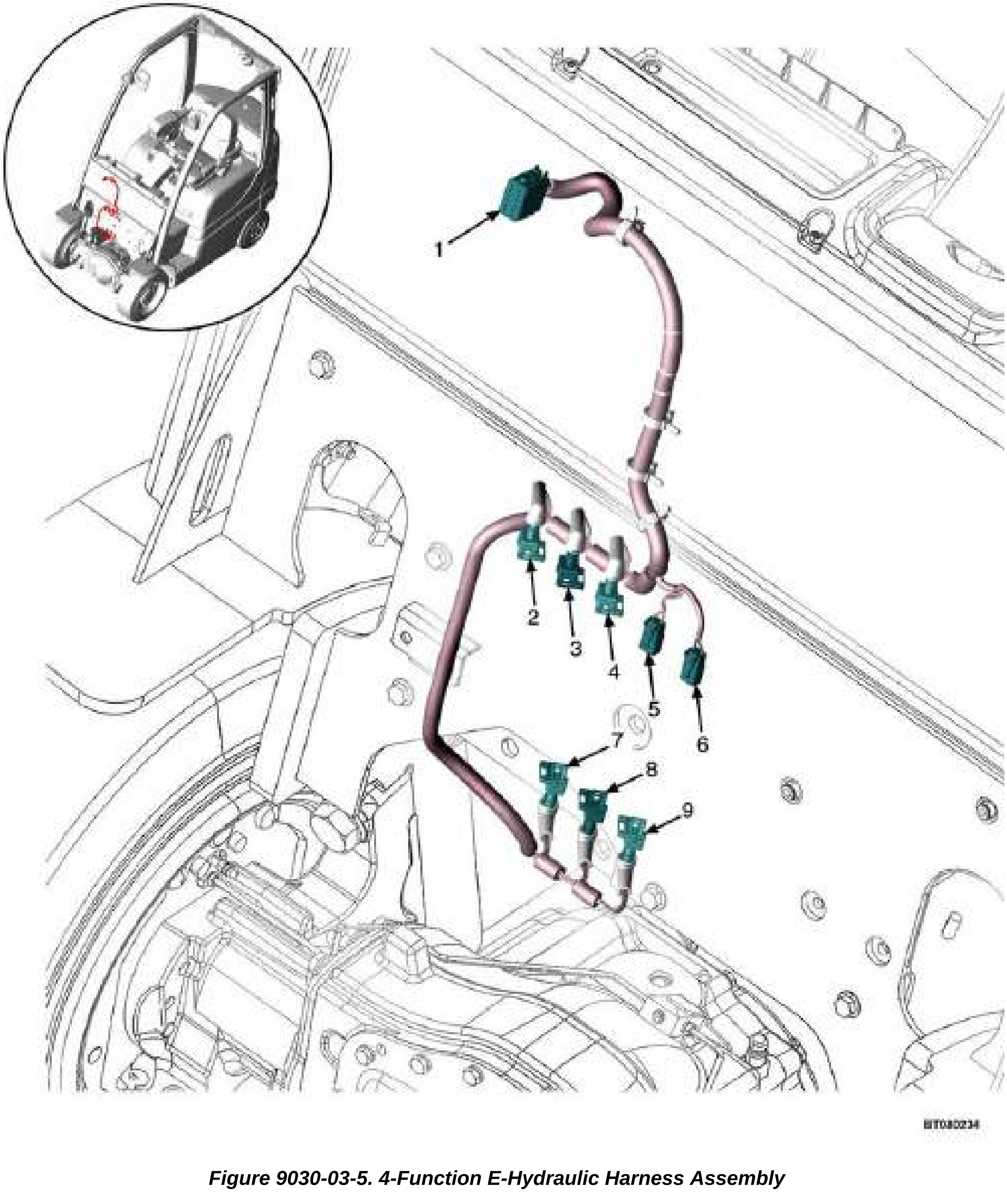


Figure 9030-03-5. 4-Function E-Hydraulic Harness Assembly

Legend for Figure 9030-03-5

1. CPS 2, VEHICLE SYSTEM MANAGER CONNECTOR
2. CRS 105, 4A (AUX 2) CONNECTOR
3. CRS 03, 3A (AUX 1) CONNECTOR
4. CRS 101, 2A (TILT) CONNECTOR
5. CPS 100, LOWER CONNECTOR
6. CPS 99, LIFT CONNECTOR
7. CRS 106, 4B (AUX 2) CONNECTOR
8. CRS 104, 3B (AUX 1) CONNECTOR
9. CRS 102, 2B (TILT) CONNECTOR

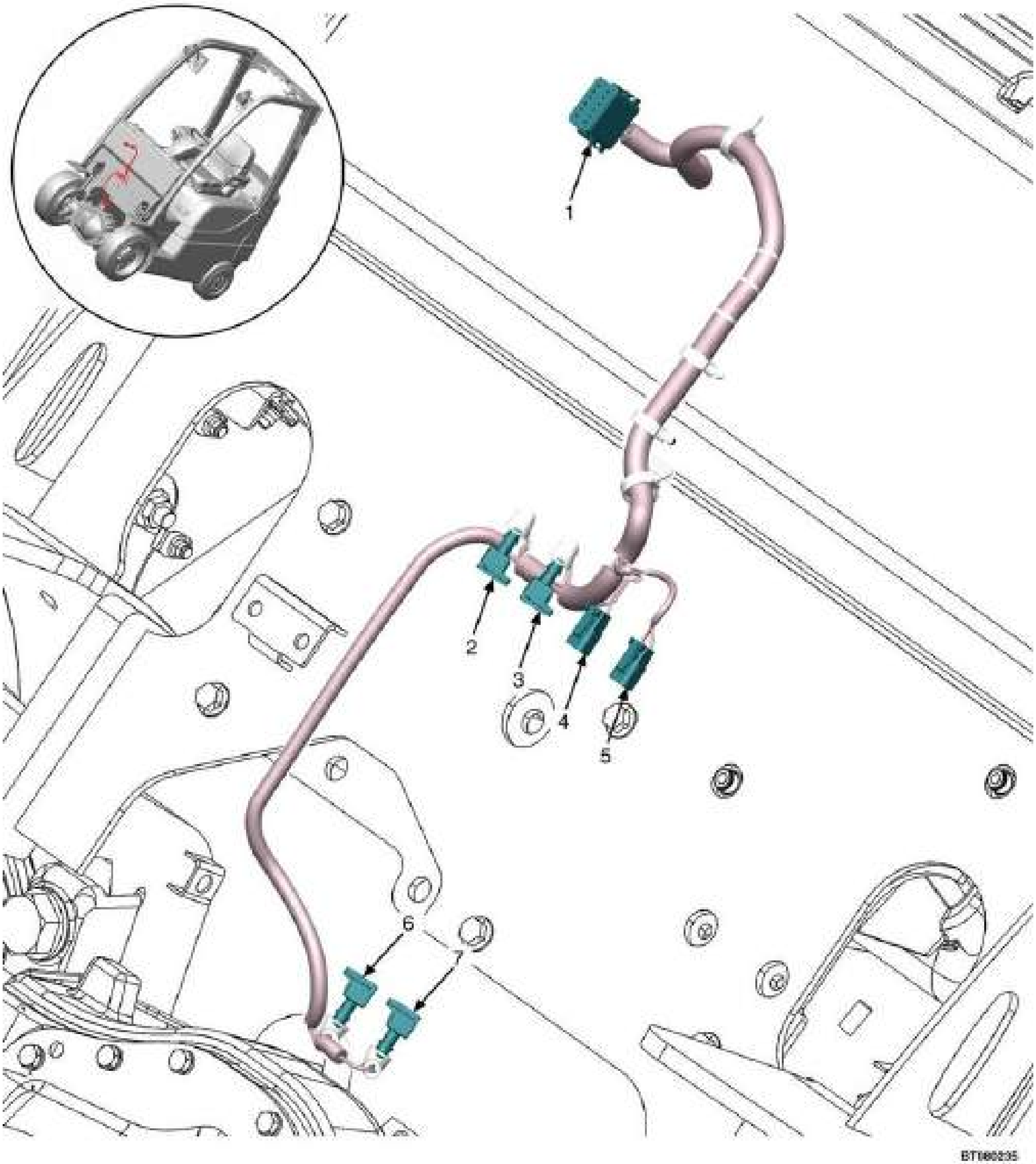


Figure 9030-03-6. 3-Function E-Hydraulic Harness Assembly

Legend for Figure 9030-03-6

1. CRS 103, 3A (AUX 1) CONNECTOR
2. CPS 2, VEHICLE SYSTEM MANAGER CONNECTOR
3. CRS 101, 2A (TILT) CONNECTOR
4. CPS 100, LOWER CONNECTOR
5. CPS 99, LIFT CONNECTOR
6. CRS 104, 3B (AUX 1) CONNECTOR
7. CRS 102, 2B (TILT) CONNECTOR

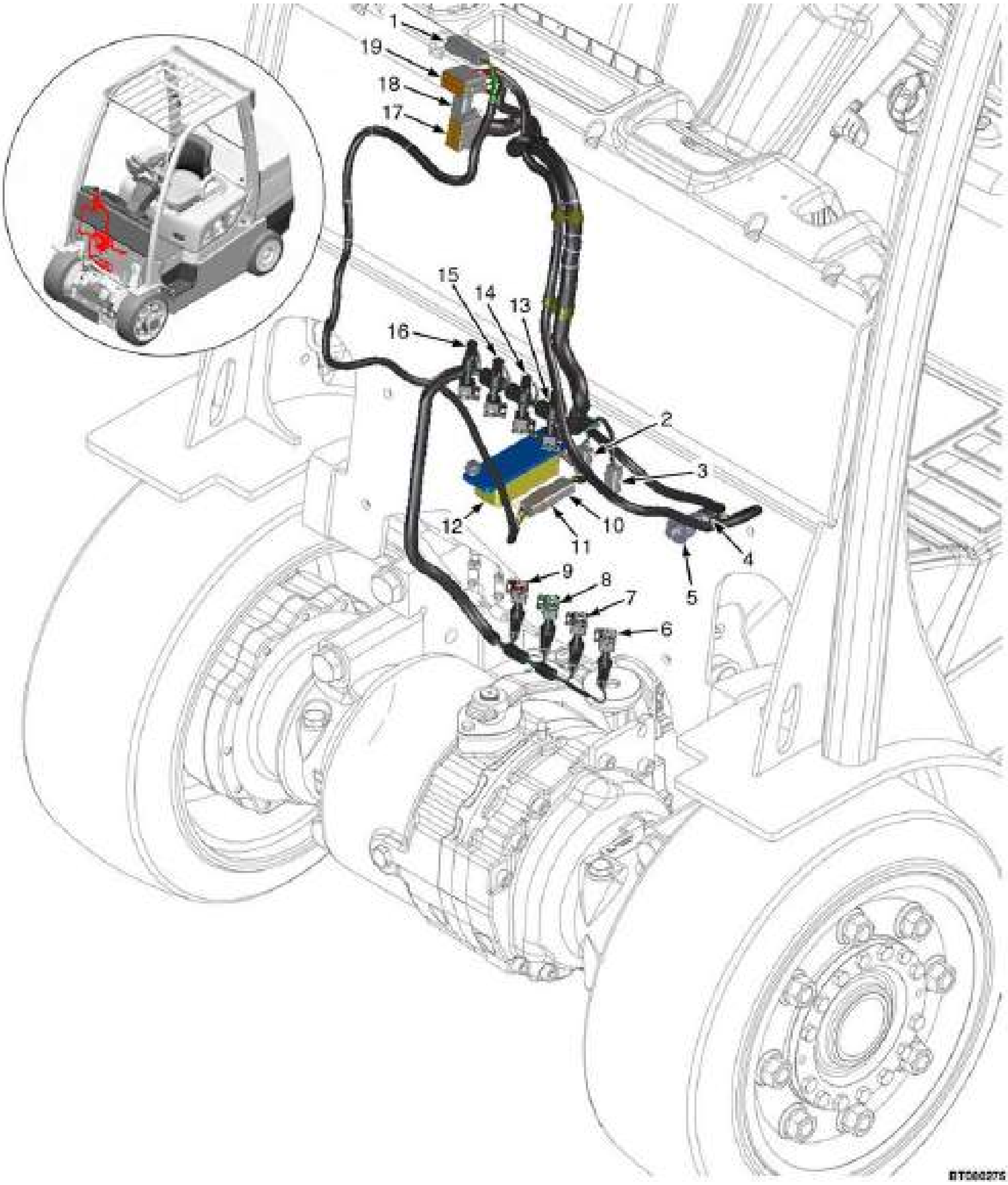
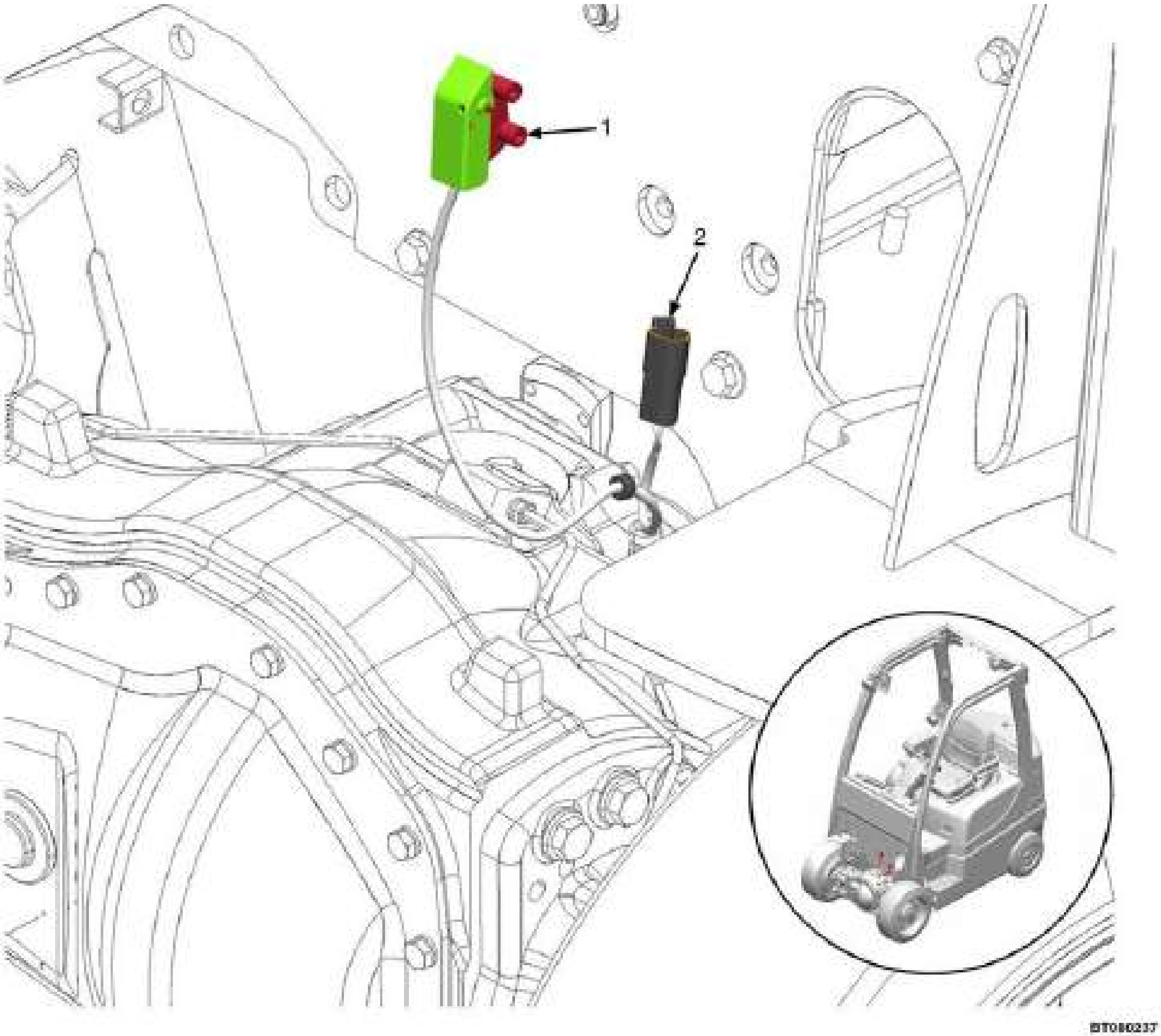


Figure 9030-03-7. 5-Function Hydraulic Harness Assembly With Impact and Load Weight Sensor

Legend for Figure 9030-03-7

1. CRP 73, COWL HARNESS CONNECTOR
2. CPS 100, LOWER CONNECTOR
3. CPS 99, LIFT CONNECTOR
4. CPS 149, LOAD WEIGHT SENSOR CONNECTOR
5. LOAD WEIGHT SENSOR
6. CRS 108, 5B (AUX 3) CONNECTOR
7. CRS 106, 4B (AUX 2) CONNECTOR
8. CRS 104, 3B (AUX 1) CONNECTOR
9. CRS 102, 2B (TILT) CONNECTOR
10. CRP 148, IMPACT SENSOR CONNECTOR
11. CPS 148, IMPACT SENSOR CONNECTOR
12. IMPACT SENSOR
13. CRS 107, 5A (AUX 3) CONNECTOR
14. CRS 105, 4A (AUX 2) CONNECTOR
15. CRS 103, 3A (AUX 2) CONNECTOR
16. CRS 101, 2A (TILT) CONNECTOR
17. CPS 2, VEHICLE SYSTEM MANAGER CONNECTOR
18. CPS 72, CHASSIS HARNESS CONNECTOR
19. CPS 3, VEHICLE SYSTEM MANAGER CONNECTOR



1. CRS 116, RETURN TO SET TILT CONNECTOR
2. CRP 53, COWL HARNESS CONNECTOR

Figure 9030-03-8. Mast Harness Assembly

Group 10

Principles of Operation

Electrical System

GENERAL DESCRIPTION

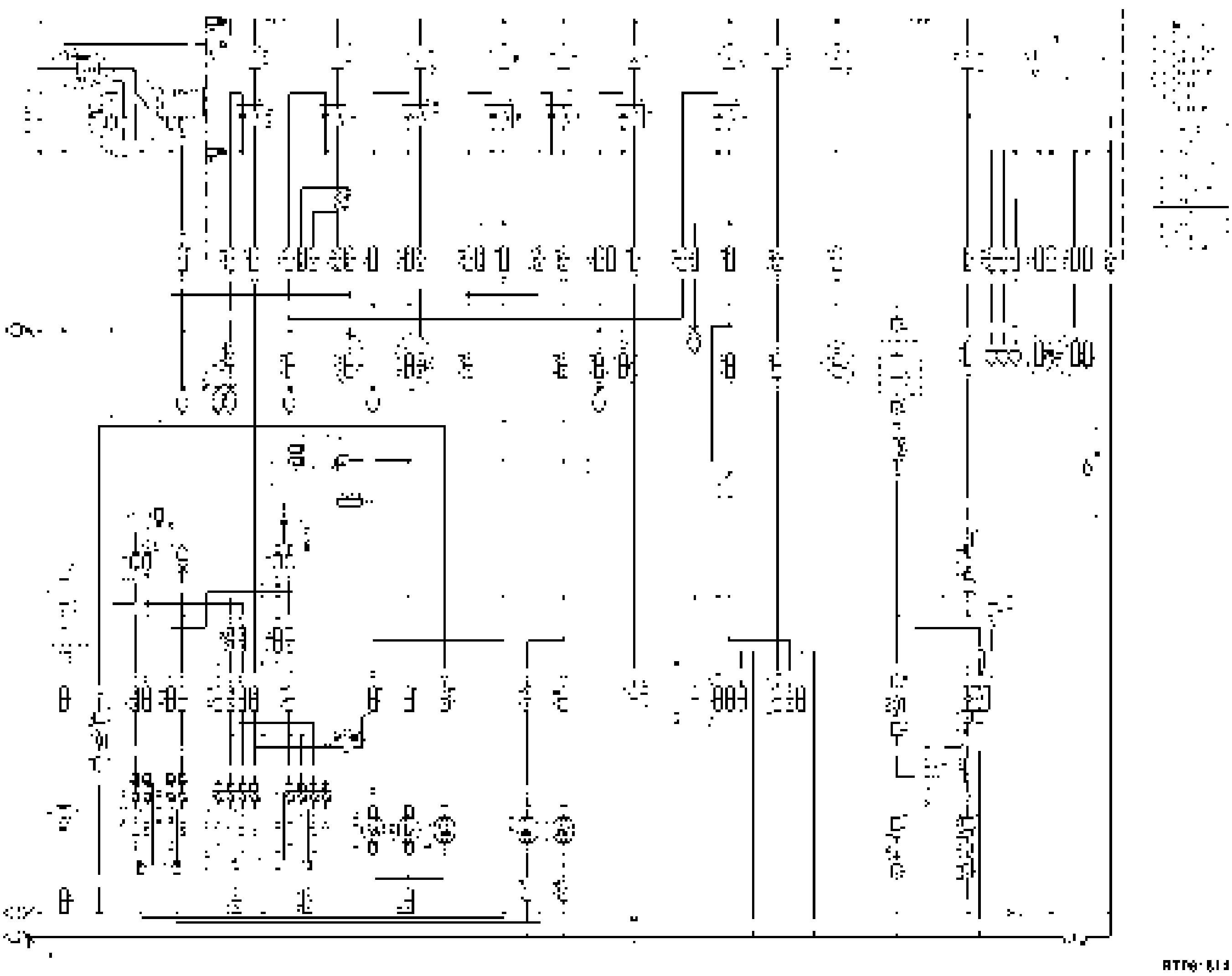


Figure 9030-10-9. Power Distribution Schematic

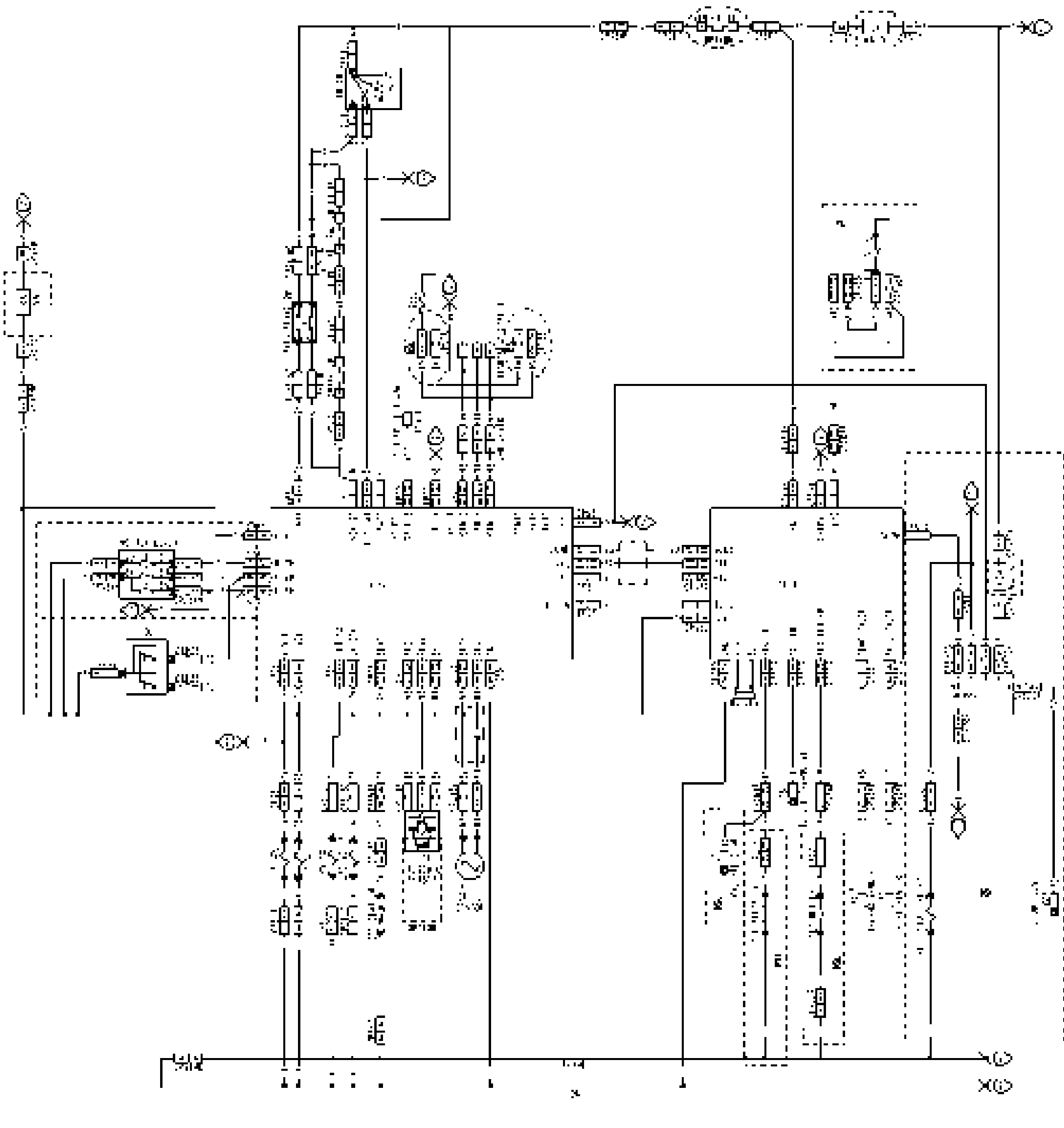


Figure 9030-10-10. ECU and Display Schematic

The truck electrical system follows conventional 12-volt automotive design in using basic automotive building blocks:

1. Power Source
   a. Battery
   b. Alternator
2. Power Distribution and Circuit Protection
   a. Power Distribution Module
      (1) Fuses
      (2) Relays
      (3) Wire Harnesses
3. Operator Interface
   a. Control Switches
   b. Display
      (1) Gauges
      (2) Warning Lights
      (3) Audible Alarms
4. System Inputs
   a. Sensors
   b. Switches
5. System Controlled Outputs
   a. Lighting
   b. Engine
      (1) Start
      (2) Emissions

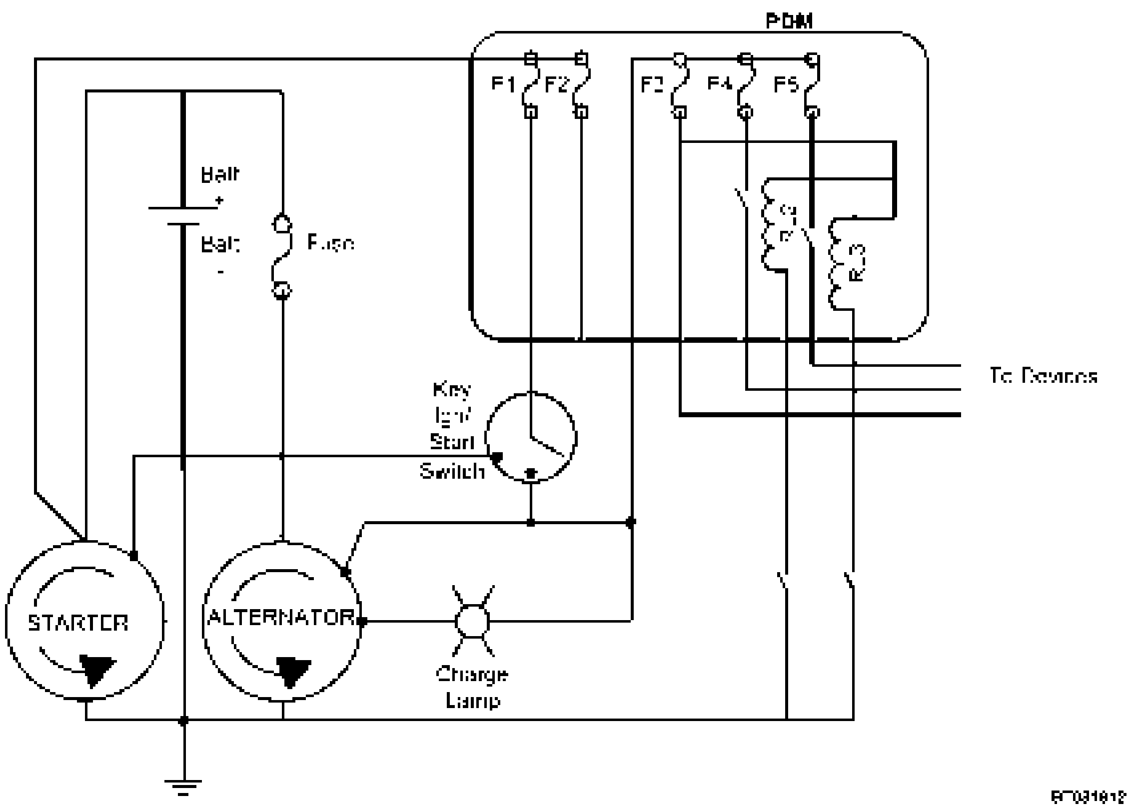
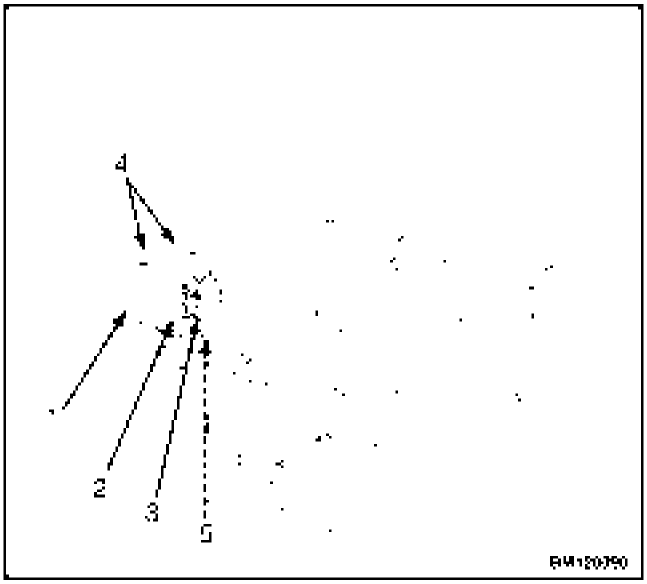


Figure 9030-10-11. Conventional Truck Power Block Diagram

DESCRIPTION

The following paragraphs discuss the basic operation of the electrical system components that are depicted in Figure 9030-10-13.



1. BATTERY
2. BATTERY TRAY
3. PDM
4. BATTERY LOCKDOWN BAR
5. GROUND STRAP

Figure 9030-10-12. Truck Electrical System Components

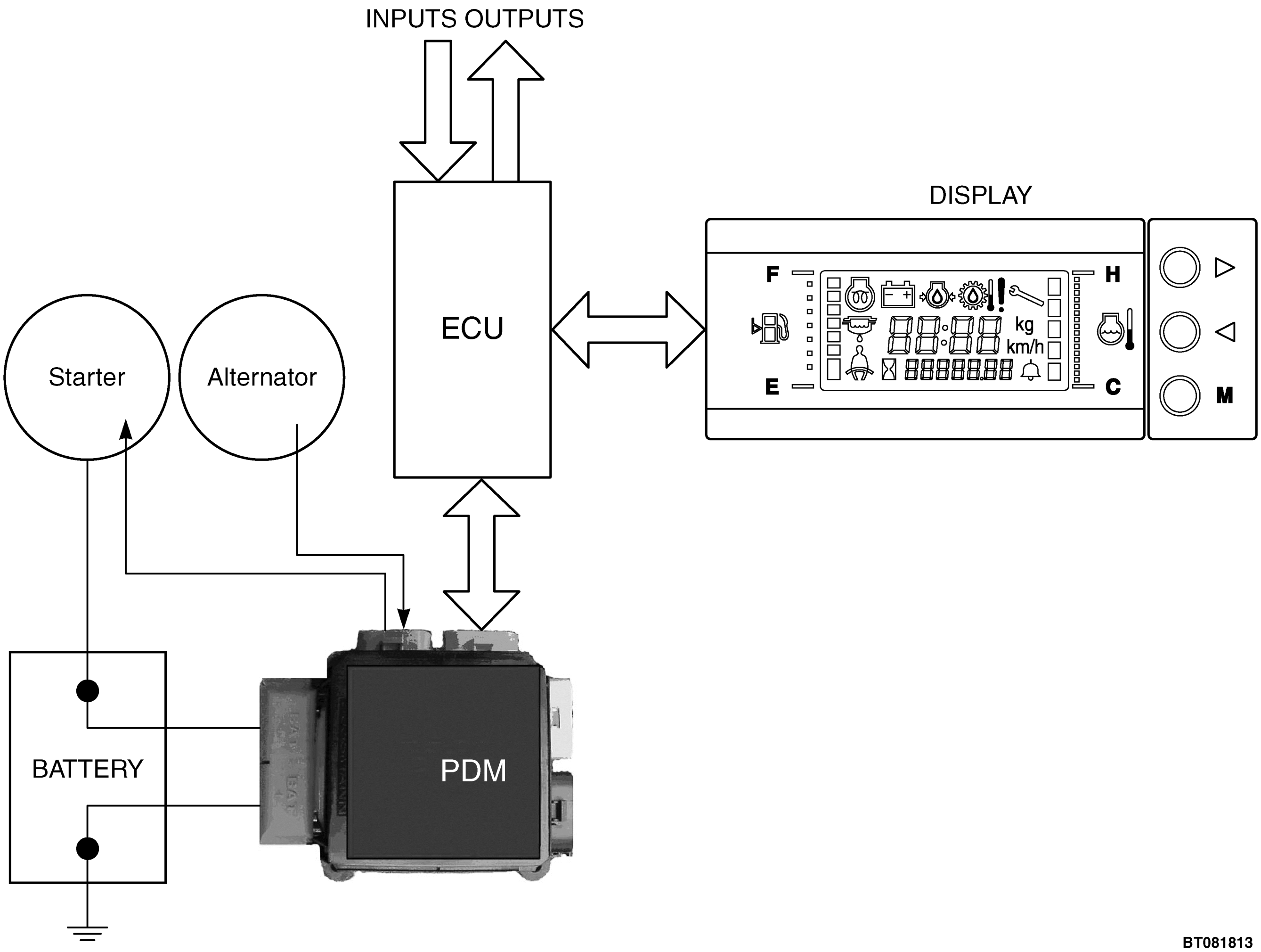
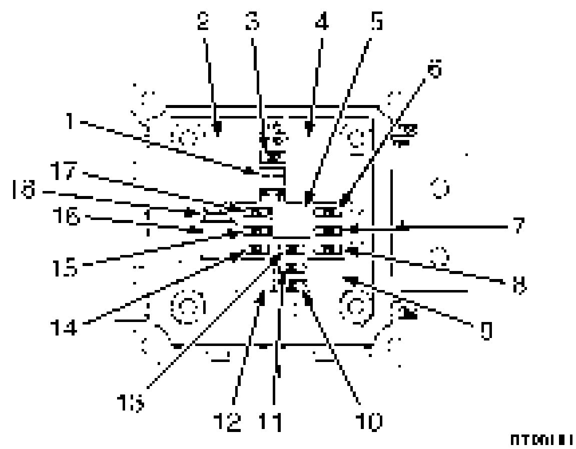


Figure 9030-10-13. Electrical System Basic Operation Diagram

1. **BATTERY —** The battery is a 12-volt battery rated at 475 cold cranking amps. The battery provides the main startup power source and is located beneath the engine hood, on the right side of the truck. It is mounted in a tray and secured with a hold down fixture. The battery is a sealed unit that requires no service or maintenance.

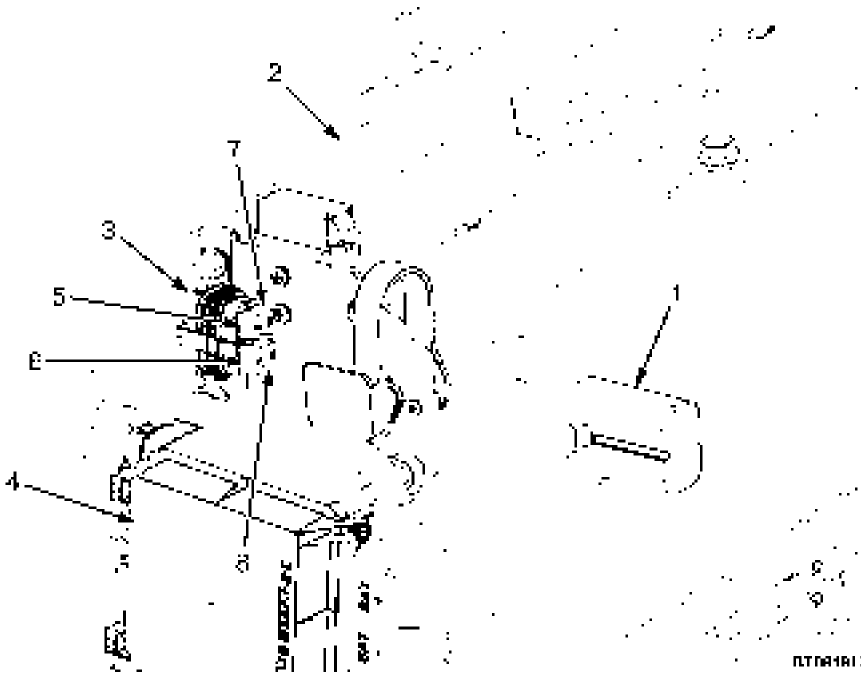
2. **ALTERNATOR —** The alternator charges the battery with a DC voltage output. The crankshaft and a belt drive the alternator.

3. **POWER DISTRIBUTION MODULE (PDM) —** The PDM distributes switched and unswitched power to the rest of the truck system. Where equipped, power will also be supplied to the Engine Control Unit (ECU), Governor Control Unit (GCU), and Transmission Control Unit (TCU). All PDM distributed circuits are fused. The PDM (see Figure 9030-10-14) contains fuses, relays, and devices that suppress transients. It is mounted directly forward of the battery and is attached to the frame with a mounting plate. It is connected to the battery with short unfused cables. A battery disconnect switch is added for the optional safety truck configuration. The components in the PDM are plug-in socketed devices and automotive blade-type fuses for ease of maintenance.



1. RESISTOR (68Ω)
2. START RELAY
3. STARTER (30 AMP)
4. IGNITION 3 RELAY
5. BACKUP RELAY
6. BACKUP (20 AMP)
7. IGNITION (30 AMP)
8. SPARE FUEL PUMP (20 AMP)
9. SPARE FUEL PUMP RELAY
10. BATTERY (20 AMP)
11. FRONT WORK LIGHT (20 AMP)
12. FRONT / REAR WORK LIGHT RELAY
13. BATTERY (25 AMP)
14. REAR WORK LIGHT (20 AMP)
15. IGNITION 1 (20 AMP)
16. IGNITION 1 RELAY
17. BATTERY (25 AMP)
18. TRANSZORB

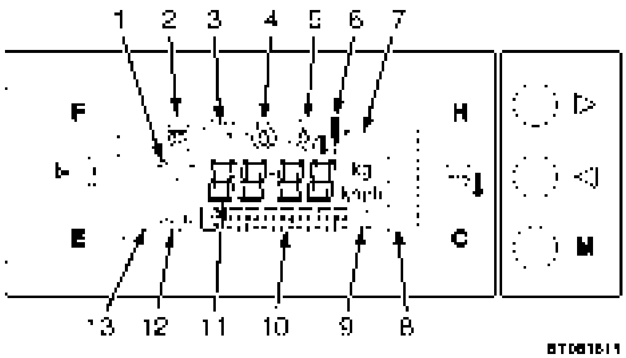
Figure 9030-10-14. Power Distribution Module (PDM)



1. FUSE COVER
2. BATTERY
3. FUSE HOLDER
4. PDM
5. MAIN (5 AMP)
6. HORN/STOP (5 AMP)
7. ACC 12 VOLT (15 AMP)
8. IGNITION (10 AMP)

Figure 9030-10-15. Fuses

4. **DISPLAY** The display combines all the display and operator control functions into one unit. It is mounted on the steering column. The display is the main operator interface providing operator input through the levers and push buttons and outputs to operator through messages and warning icons.



1. SEDIMENTER
2. GLOW LAMP
3. BATTERY CHARGE
4. ENGINE OIL PRESSURE
5. ATF TEMPERATURE (AUTO ONLY)
6. WARNING DISPLAY
7. MAINTENANCE REQUIRED
8. COOLANT TEMPERATURE
9. ALARM DISPLAY
10. HOUR, MESSAGE, CALENDAR, ERROR DISPLAY
11. CLOCK, SPEED, LOAD MESSAGE, PASSWORD MENU
12. SEAT BELT
13. FUEL LEVEL

Figure 9030-10-16. Display

5. **WIRING HARNESS ASSEMBLIES —** Fundamental to the operation of the truck, the wire harnesses have been designed to ensure trouble free, reliable electrical operation and ease of service. This has been achieved through the following:

   - Sealed, locking connectors (90% Deutsch)
   - No ring terminals except for heavy current connections
   - No spade terminals
   - Standardized harness routing
   - Color Coded Keyed connectors
   - Correctly gauged wire for each application

   All engine and transmission connections to the main truck harness are made through single independent connectors for each function.

NOTE: No other CAN devices are to be connected to the CANbus without approval from Hyster .

All of the controllers on the truck are joined by a communication link called a CANbus (Controlled Area Network bus). This is similar to the links used to connect computers in an office, often referred to as a Local Area Network or LAN. The CANbus conforms to the SAE (Society of Automotive Engineers) J1939 standards and consists of a twisted pair of wires that are contained in its own jacket. Multiple pieces of information can be sent on this bus, an operation commonly referred to as multiplexing. This CANbus system is also used on the AC electric trucks and while the electrical hardware is the same, a different communication language is used.

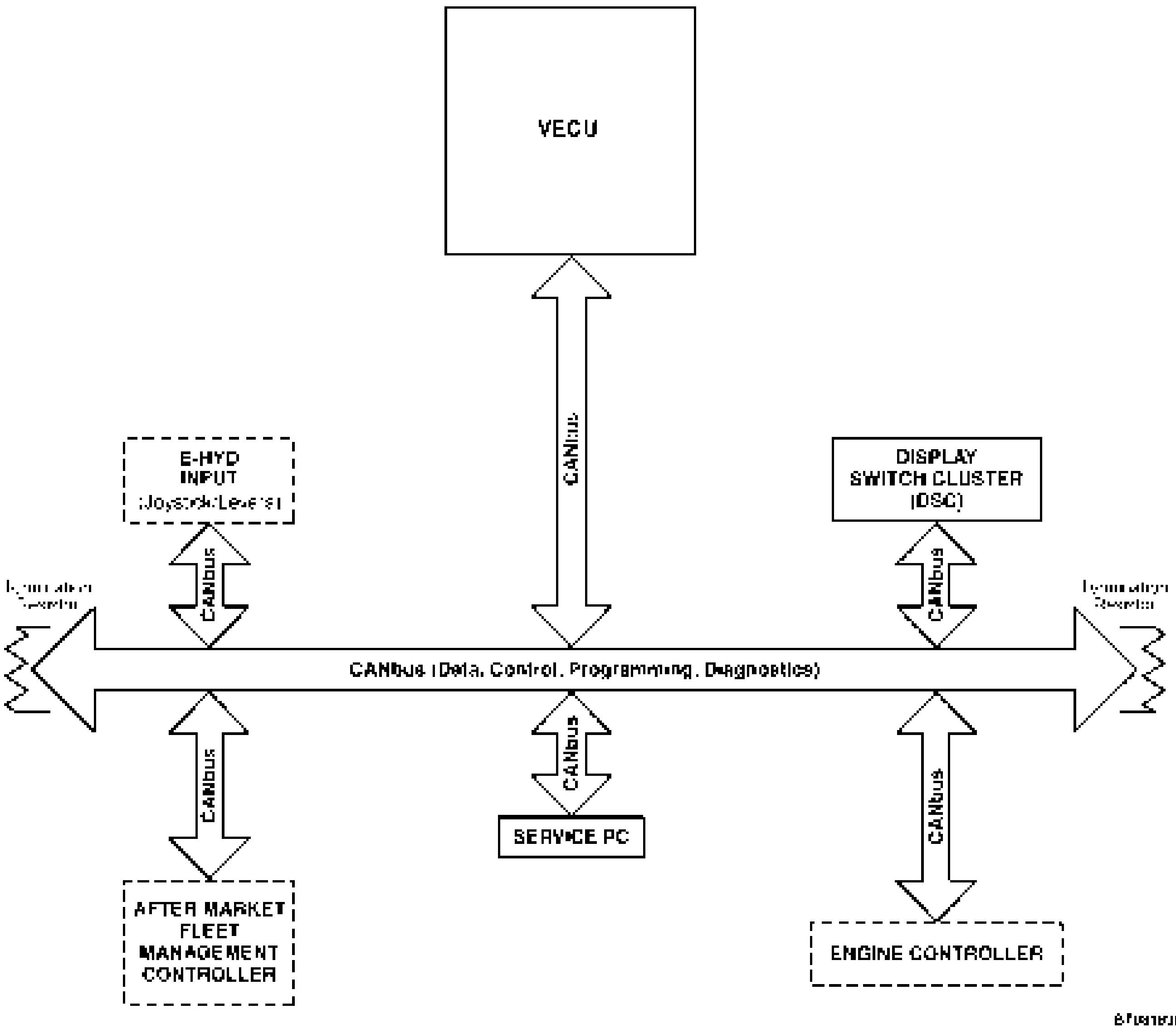


Figure 9030-10-17. Typical CANbus Distribution

Each of the twisted wires is uniquely color-coded. For correct operation, the extreme ends of the CANbus wiring must be terminated with 120 ohm resistors.

Yellow = CAN Hi

Green = CAN Lo

Typical characteristics of data on the CANbus are:

- Each wire broadcasts a mirror image of the other to insure signal integrity.
- Each CAN connected device receives and broadcasts messages.
- The message data, if viewed with an oscilloscope, would look like the signal trace depicted in Figure 9030-10-18.

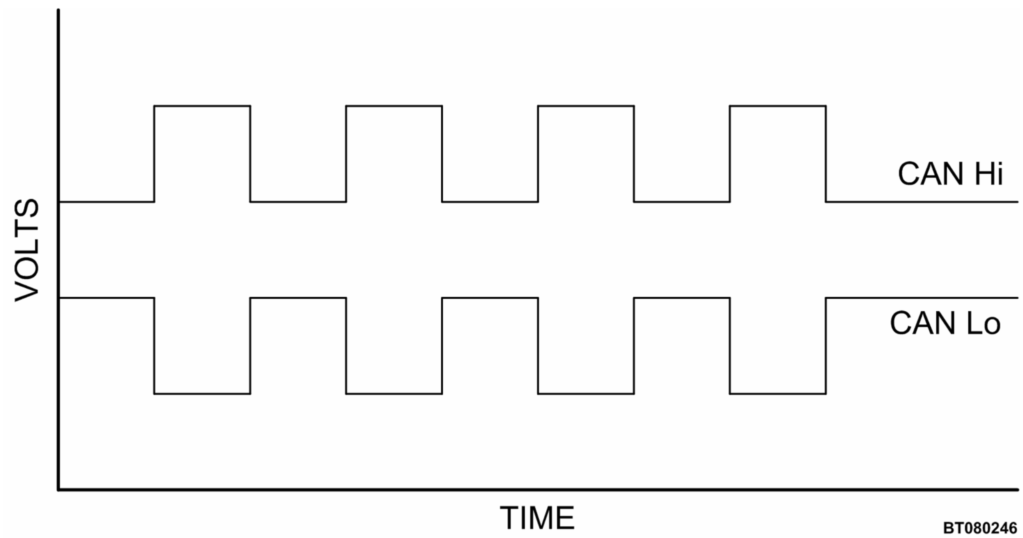


Figure 9030-10-18. Typical CANbus Signal Trace

Group 20

Diagnostic Trouble Codes

CODES

DTC Errd011 - Switch 1 (► Button) Error
DTC Errd012 - Switch 2 (◄ Button) Error
DTC Errd013 - Switch 3 (M Button) Error
DTC ErrC023 - Display / Setting Does Not Change
DTC ErrC026 - Load Meter Display Fault

POSSIBLE CAUSE

A. FAULTY DISPLAY

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

Errors are set when either the M, ◄, or ► button has been turned ON continuously.

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - FAULTY DISPLAY

PROCEDURE OR ACTION:

1. Inspect display for physical damage or cause of stuck buttons.
   Is damage present to the display?
   YES: Clean or repair display buttons and retest system.
   NO: Replace faulty display. Make sure to indicate the error code(s) on the warranty claim to include an accurate problem description leading to controller replacement.

END POSSIBLE CAUSES

END FAULT

CODES

DTC Errd001 - Communication Data Fault
DTC Errd002 - EEPROM Readout Fault
DTC Errd003 - EEPROM Writing Fault (Hour Meter)
DTC Errd004 - EEPROM Writing Fault (Controller Instructions)
DTC Errd005 - EEPROM Readout Fault (Controller Instructions)
DTC Errd110 - Hour Meter Reading Not Copied in Serviceman Mode
DTC Errd111 - Hour Meter Data Copy Error
DTC Errd112 - Truck Setting Data Copy Error
DTC Errd113 - Travel Hour Meter Data Copy Error
DTC Errd114 - Mileage Data Copy Error
DTC Errd115 - Batch Copy Hour Meter Related Data Error
DTC Errd116 - Batch Copy Travel Related Data Error
DTC ErrC060 - Maintenance Data Error
DTC ErrC061 / ErrC062 - EEPROM Data Not Written
DTC ErrC063 - Password Not Allowed
DTC ErrC064 / ErrC065 - Optional Function Not Operating
DTC ErrC069 - Mileage Data Not Updating
DTC ErrC120 / ErrC121 / ErrC123 / ErrC124 / ErrC125 / ErrC126 - Hour Meter Not Copied in Serviceman Mode

POSSIBLE CAUSE

A. CANBUS COMMUNICATION FAULT

B. DISPLAY WIRING FAULT

C. FAULTY DISPLAY

NOTE

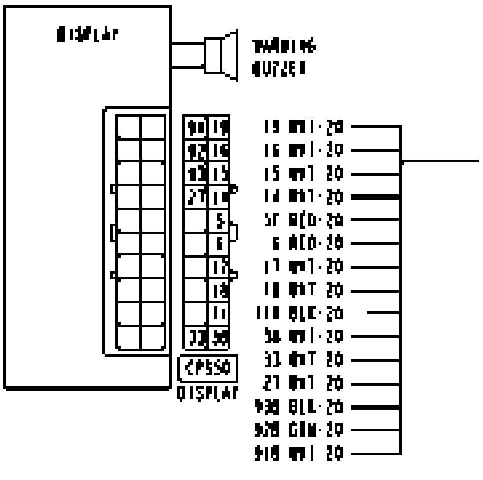
Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The display receives constant battery power and ground. When the key is in the ON position, ignition voltage is provided to the display and communication occurs over the CANbus. If Errd110 code is set, check operator's manual to ensure proper hour meter application is being used.

(Cont)



1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

(Cont)

CAUSE A - CANBUS COMMUNICATION FAULT

PROCEDURE OR ACTION:

NOTE: Perform Step 1 and Step 2 with key in ON position.

1. Disconnect the display connector CPS50 and measure voltage between socket 20 and B(-).
   Is CAN HI voltage approximately 2.5 Vdc?
   YES: Proceed to Step 2.
   NO: Inspect CAN HI circuit for open or short. If voltage is 0 volts, the CAN HI circuit is shorted to ground or open. If voltage is above 5 volts, the CAN HI circuit is shorted to power.
2. Measure voltage between the display connector CPS50, socket 15 and B(-).
   Is CAN LO voltage approximately 2.5 Vdc?
   YES: Disconnect battery and proceed to Step 3.
   NO: Inspect CAN LO circuit for open or short. If voltage is 0 volts, the CAN LO circuit is shorted to ground or open. If voltage is above 5 volts, the CAN LO circuit is shorted to power.
3. Measure resistance between the display connector CPS50, socket 20 and socket 15.
   Is resistance 60 ± 6 ohms?
   YES: No communication faults are present, connect battery and proceed to Cause B.
   NO: If resistance is 120 ohms, the CANbus has an open circuit or a missing or damaged termination resistor. If resistance is 0 ohms, the CANbus circuits are shorted together.

CAUSE B - DISPLAY WIRING FAULT

PROCEDURE OR ACTION:

1. Measure voltage between the display connector CPS50, socket 5 and B(-).
   Is battery voltage present?
   YES: Proceed to Step 2.
   NO: Inspect battery voltage circuit for open or short.
2. Measure voltage between the display connector CPS50, socket 2 and socket 5.
   Is battery voltage present?
   YES: Proceed to Cause C.
   NO: Inspect ground circuit for open or short.

CAUSE C - FAULTY DISPLAY

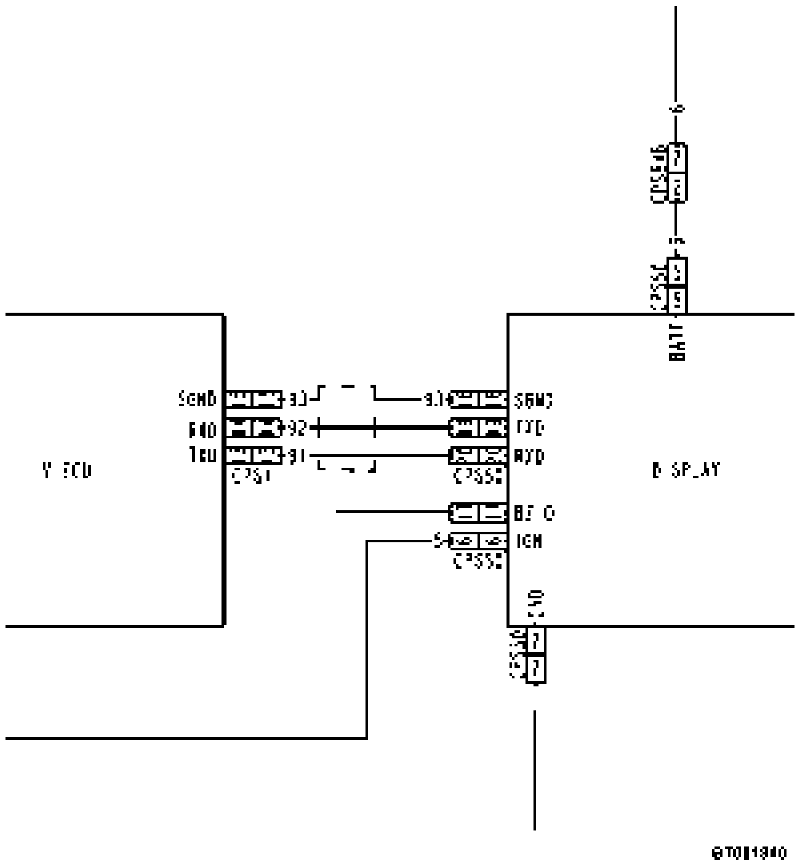
PROCEDURE OR ACTION:

1. Replace faulty display. Make sure to indicate the DTC code(s) on the warranty claim to include an accurate problem description leading to controller replacement.

END POSSIBLE CAUSES

(Cont)

DTC ERRD001 COMMUNICATION DATA FAULT DIAGRAMS



Troubleshooting Scene

END FAULT

System Battery Voltage OOR

System Voltage To ECU Below Acceptable Threshold.

CODES

DTC ErrE615 (168-0) - Battery Voltage OORH
DTC ErrE616 (168-1) - Battery Voltage OORL
DTC ErrC027 - Engine Does Not Start

POSSIBLE CAUSE

A. BATTERY FAILURE

B. ALTERNATOR FAILURE

C. OPERATION CYCLE TOO SHORT TO CHARGE BATTERY

D. QUIESCENT CURRENT DRAW TOO HIGH DURING TRUCK OFF TIME

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

NOTE: The following procedures may not work if the battery voltage is too low. The battery will need to be charged if this is a problem.

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A. If alternator Icon is displayed on the display, go to Cause B.

CAUSE A - BATTERY FAILURE

PROCEDURE OR ACTION:

1. Verify that the battery is the correct type and capacity.
2. Ensure battery terminals are clean and tight.
3. Using DMM set to volts scale, measure voltage across battery terminals after charging.
   Is voltage less than 9 Vdc?
   YES: Replace battery.
   NO: Go to Cause C.

System Battery Voltage OOR (Cont)

CAUSE B - ALTERNATOR FAILURE

PROCEDURE OR ACTION:

1. Test and Replace faulty alternator.

CAUSE C - OPERATION CYCLE TOO SHORT TO CHARGE BATTERY

PROCEDURE OR ACTION:

1. Observe cycle time when engine is above low idle.
   Is cycle less than 10 minutes with engine running above low idle?
   YES: Consult with Hyster® Service for alternator/alternator pulley size alternatives.
   NO: Go to Cause D.

CAUSE D - QUIESCENT CURRENT DRAW TOO HIGH DURING TRUCK OFF TIME

PROCEDURE OR ACTION:

1. Truck power **OFF**, disconnect battery (+) terminal cable.
2. Using a DMM set to amp scale (DMM must be capable of measuring up to 10 amps), measure current between battery (+) terminal and battery cable.
   Is the current reading greater than 30 mA?
   YES: Refer to Electrical Schematic. Refer to the appropriate **Diagrams and Schematics** SRM . While monitoring current reading, locate the source of the current draw by sequentially disconnecting all devices connected to unswitched battery. If disconnecting a device reduces the current to less than or equal to 30 mA, repair or replace device.
   NO: Go to Step 3.
3. Ensure battery is fully charged and has been disconnected from the truck.

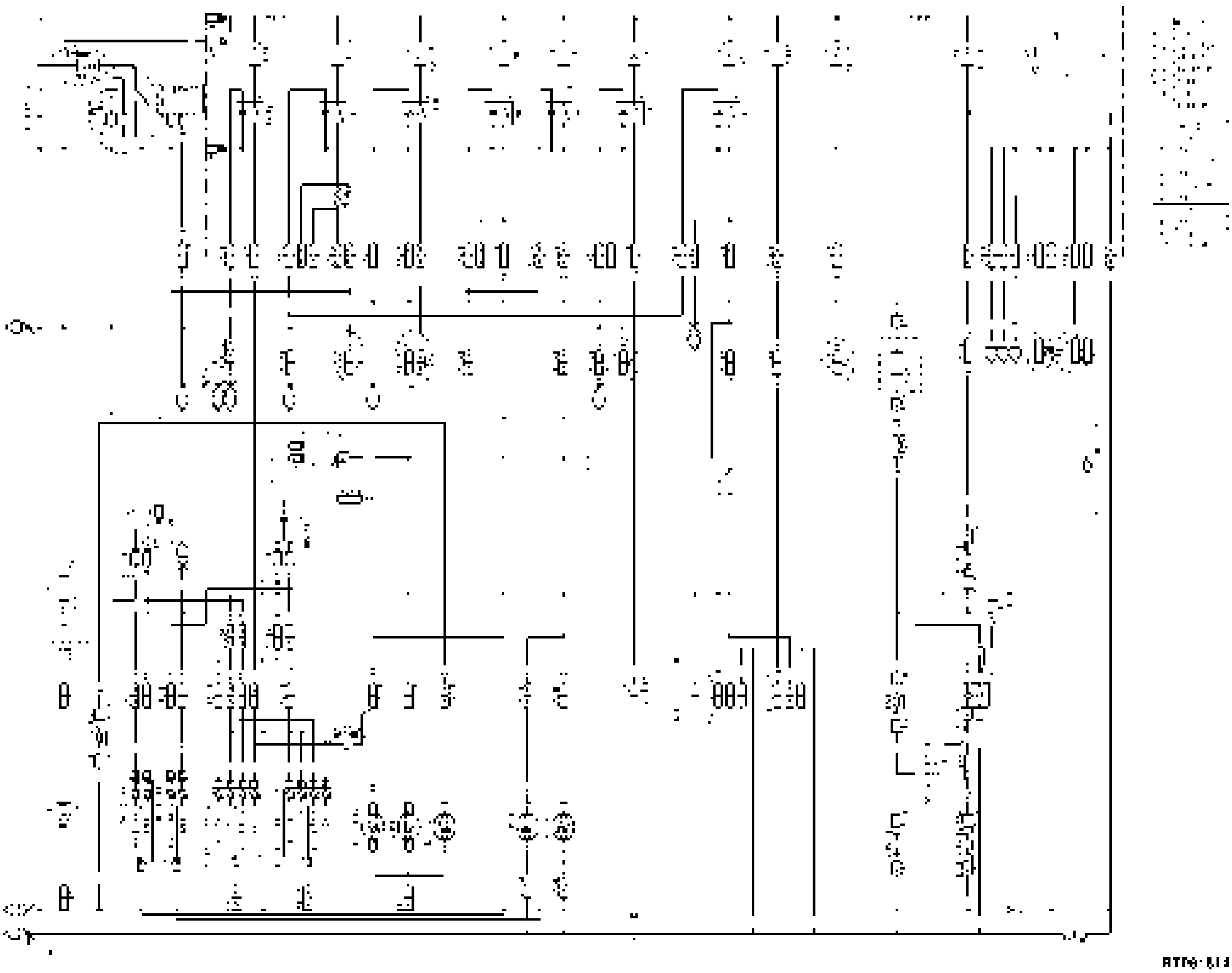
NOTE: A battery can have an internal short whose resistance will cause the battery to discharge within an 8-hour period.

4. Using a DMM set to volts scale, measure and record voltage reading 1 hour after charging is completed. Leave battery disconnected for 8 hours.
5. Check battery voltage after 8 hours and compare to the first reading.
   Has the voltage dropped by more than 1 volt?
   YES: Replace Battery.
   NO: Battery OK. Reconnect battery and resume operation.

END POSSIBLE CAUSES

System Battery Voltage OOR (Cont)

DIAGRAMS



Power Distribution

END FAULT

Manifold Absolute Pressure (MAP) signal to ECU outside of allowable threshold

CODES

DTC ErrE600 (106-3) - Manifold Absolute Pressure (MAP) Sensor OORH
DTC ErrE601 (106-4) - Manifold Absolute Pressure (MAP) Sensor OORL
DTC ErrE614 (108-1) - Barometric Pressure Below Acceptable Limit

POSSIBLE CAUSE

A. MAP SENSOR WIRING FAULT

B. MAP SENSOR SIGNAL FAULT

C. MAP SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The TMAP Sensor is provided 5 volt power and ground via the ECU. The TMAP provides ECU input data regarding intake air temperature and manifold atmospheric pressure on dedicated circuits. MAP data is provided via circuit 379-A.

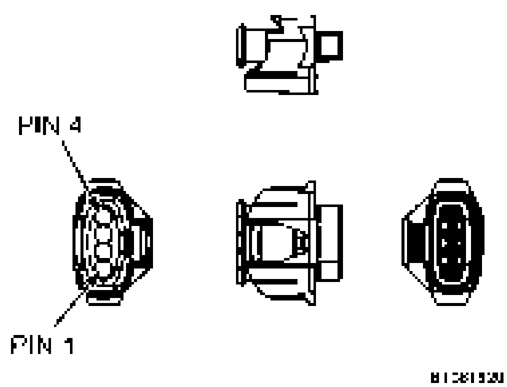


Figure 9030-20-19. TMAP Connector

(Cont)

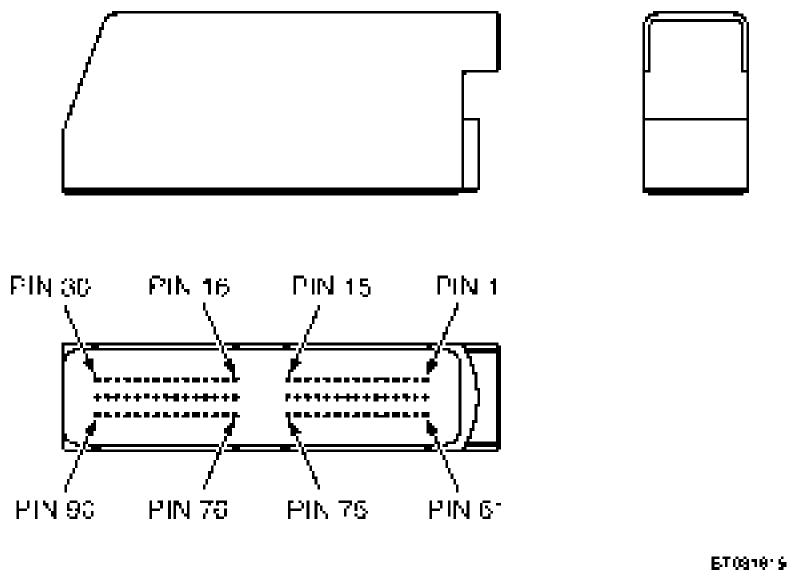


Figure 9030-20-20. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - MAP SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the MAP connector CPS212 and measure voltage between socket 3 and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Go to Step 2.
   NO: Inspect supply circuit 261-a and 261-D for open or short.
2. Measure voltage between the MAP connector CPS212, socket 3 and socket 1.
   Is voltage 5 ± 0.5 Vdc?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect MAP ground circuit 115-A and 115-C for open or source of excessive resistance. If circuit 115-A fault is present, engine coolant temp, throttle, oil pressure, and other sensors may be inoperative.

(Cont)

CAUSE B - MAP SENSOR SIGNAL FAULT

PROCEDURE OR ACTION:

1. Disconnect ECU connector CRS202. Measure resistance between MAP sensor connector CPS212, socket 4 and ECU connector CRS202, socket 7.
   Is resistance ≤1 ohm?
   YES: No signal circuit faults present, proceed to Cause C.
   NO: Inspect signal circuit 379-A for open, short, or source of excessive resistance.

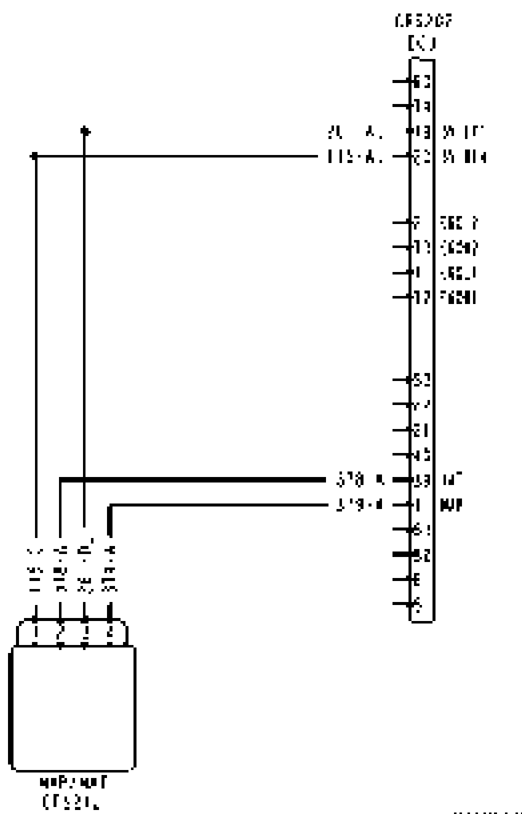
CAUSE C - MAP SENSOR FAULT

PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty MAP sensor, clear DTC and retest system.

END POSSIBLE CAUSES

DTC ERRE600 (106-3) MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR OORH DIAGRAMS



Troubleshooting Scene

END FAULT

CODES

DTC ErrE602 (94-0) - Primary Fuel Pressure Higher Than Expected
DTC ErrE603 (94-1) - Primary Fuel Pressure Lower Than Expected
DTC ErrE604 (94-3) - Primary Fuel Pressure Circuit Voltage OORH
DTC ErrE605 (94-4) - Primary Fuel Pressure Circuit Voltage OORL

POSSIBLE CAUSE

A. FUEL PRESSURE SENSOR WIRING FAULT

B. FUEL PRESSURE FAULT

C. FAULTY CONTROLLER

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

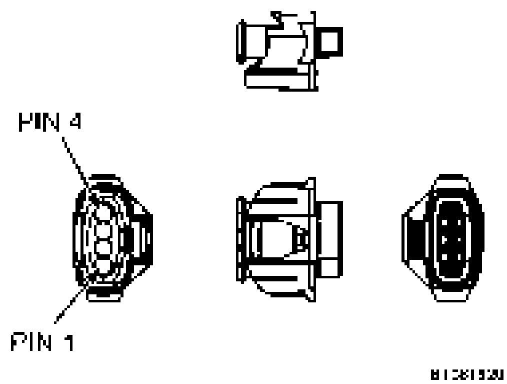


Figure 9030-20-21. Fuel Pressure Manifold Connector

(Cont)

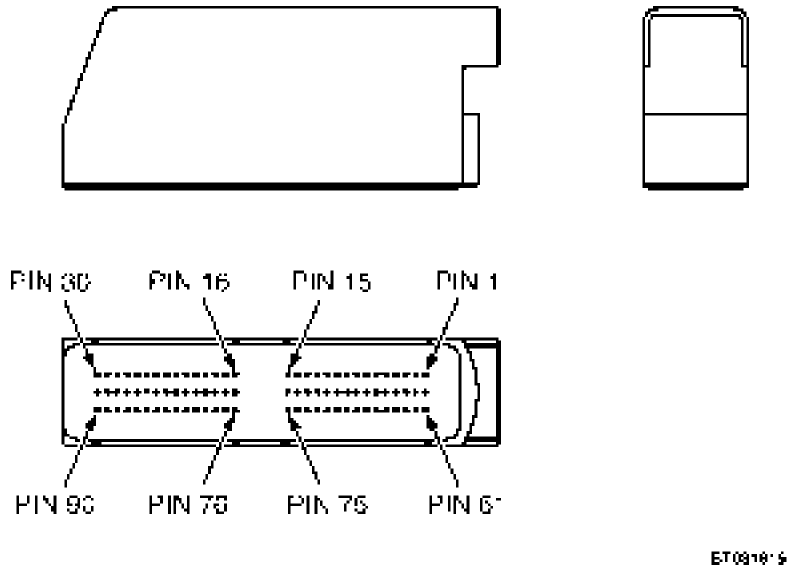


Figure 9030-20-22. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly). See Harness Assembly Data.
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

(Cont)

CAUSE A - FUEL PRESSURE SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the fuel pressure manifold connector CPS254 and measure voltage between socket C and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Proceed to Step 2.
   NO: Inspect five volt signal circuit for open or short.
2. Measure voltage between the fuel pressure manifold connector CPS254, socket A and socket C.
   Is voltage 5 ± 0.5 Vdc?
   YES: Disconnect battery, ECU connector CRS202, and proceed to Step 3.
   NO: Inspect ground circuit for open or short.
3. Measure resistance between the following:
   - ECU connector CRS202, socket 48 and fuel pressure manifold connector CPS254, socket B.
   - ECU connector CRS202, socket 54 and fuel pressure manifold connector CPS254, socket D.

   Is resistance <1 ohm?
   YES: Connect battery and connectors, proceed to Cause B.
   NO: Inspect appropriate circuit for open, short, or source of excessive resistance.

CAUSE B - FUEL PRESSURE FAULT

PROCEDURE OR ACTION:

1. Using the PC Service Tool, locate and observe manifold fuel pressure value.
   Is fuel pressure between 40 and 90 PSI?
   YES: No fuel pressure faults at this time, proceed to Cause C.
   NO: Replace faulty fuel pressure sensor.

CAUSE C - FAULTY CONTROLLER

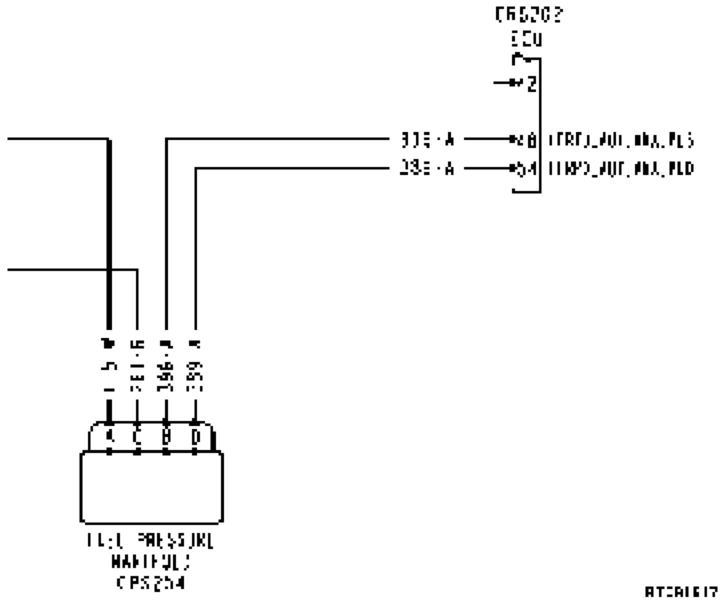
PROCEDURE OR ACTION:

1. If no faults are evident and fault code remains, suspect faulty controller.

END POSSIBLE CAUSES

(Cont)

DIAGRAMS



Troubleshooting Scene

END FAULT

This DTC is set when a coolant temperature sensor circuit fault is detected or the sensor is faulty.

CODES

DTC ErrE609 (110-3) - ECT Sensor OORH or Open Circuit (>4.9 volts)
DTC ErrE610 (110-4) - ECT Sensor Voltage OORL (<0.10 volts)

POSSIBLE CAUSE

A. COOLANT TEMPERATURE SENSOR WIRING FAULT

B. COOLANT TEMPERATURE SENSOR FAULT

C. ECU FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The Coolant Temperature Sensor (ETC) is provided 5 volt supply circuit and ground from the ECU. The sensor provides the ECU with a return signal.

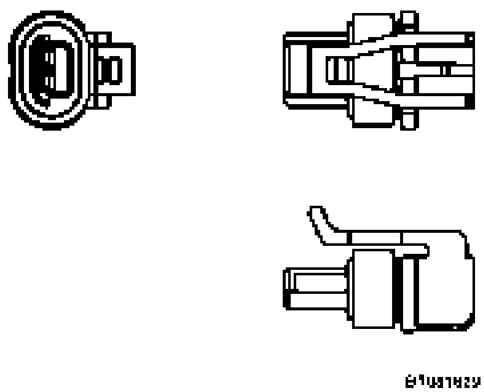


Figure 9030-20-23. ECT Sensor Connector

(Cont)

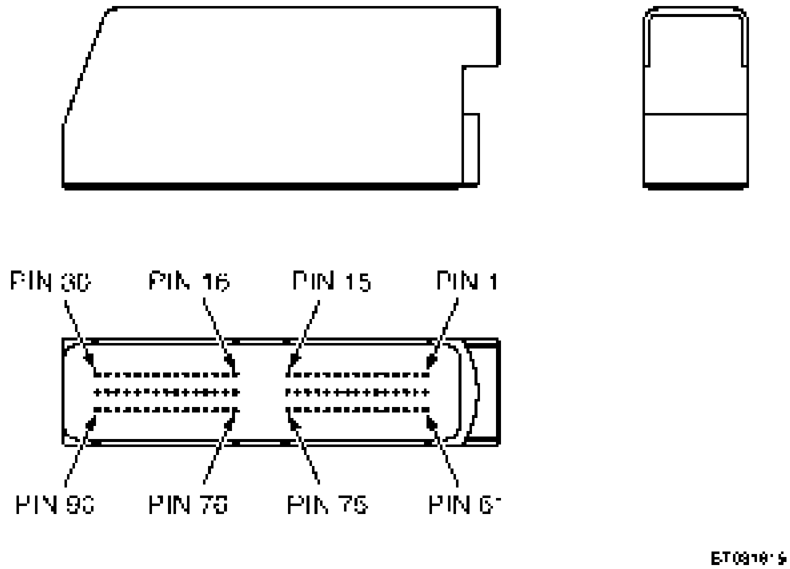


Figure 9030-20-24. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

(Cont)

CAUSE A - COOLANT TEMPERATURE SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the coolant temp sensor connector CPS232 and measure voltage between pin A and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Disconnect battery and proceed to Step 2.
   NO: Inspect circuit 374-A for open or short.
2. Disconnect ECU connector CRS202 and measure resistance between socket 40 and the coolant temp sensor connector CRS232, socket A.
   Is resistance < 1 ohm?
   YES: Proceed to Cause B.
   NO: Inspect circuit 115-D for open, short, or source of excessive resistance.

CAUSE B - COOLANT TEMPERATURE SENSOR FAULT

PROCEDURE OR ACTION:

1. Measure resistance between the coolant temperature sensor, pin A and pin B.
   - 20°C(68°F) Approx 2.5kΩ
   - 40°C(104°F) Approx 1.2kΩ
   - 60°C(140°F) Approx 0.58kΩ
   - 80°C(176°F) Approx 0.32kΩ
   - 100°C(212°F) Approx 0.18kΩ

   Is resistance within specifications?
   YES: Proceed to Cause C.
   NO: Replace faulty coolant temperature sensor.

CAUSE C - ECU FAULT

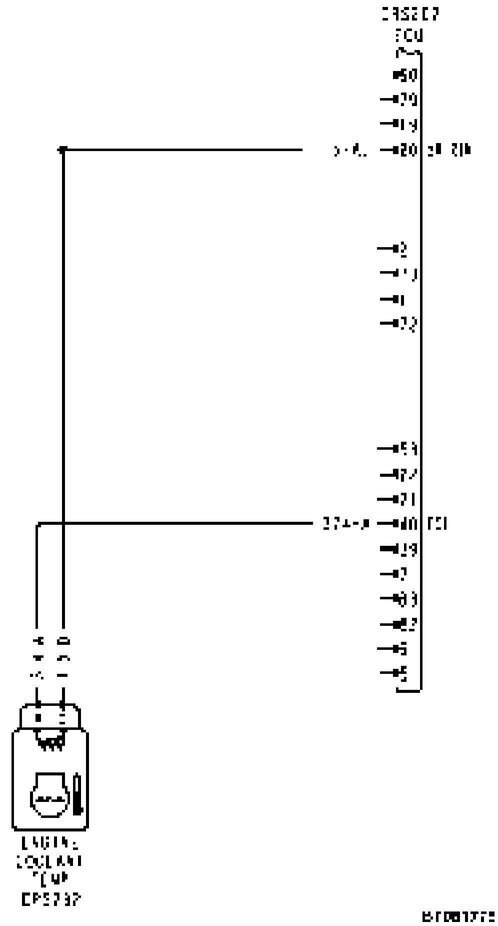
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty ECU, clear DTC and retest system.

END POSSIBLE CAUSES

(Cont)

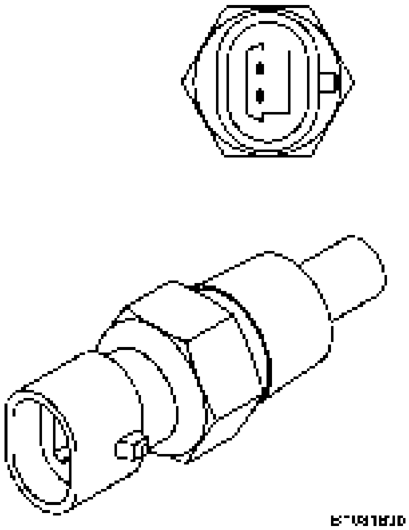
DIAGRAMS



Troubleshooting Scenes

(Cont)

CONNECTOR(S)



ECT Sensor

END FAULT

Intake Air Temperature (IAT) signal to ECU outside of allowable threshold

CODES

DTC ErrE611 (105-3) - IAT Sensor Voltage OORH (>4.90 volts)
DTC ErrE612 (105-4) - IAT Sensor Voltage OORL (<0.10 volts)
DTC ErrE613 (105-16) - Intake Air Temperature Higher than Expected

POSSIBLE CAUSE

A. MAT SENSOR WIRING FAULT

B. MAT SENSOR SIGNAL FAULT

C. MAT SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The TMAP Sensor is provided 5 volt power and ground via the ECU. The TMAP provides ECU input data regarding intake air temperature and manifold atmospheric pressure on dedicated circuits. The IAT signal is provided over circuit 378-A.

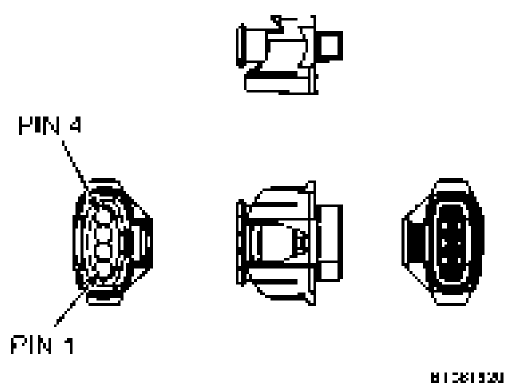


Figure 9030-20-25. TMAP/IAT Connector

(Cont)

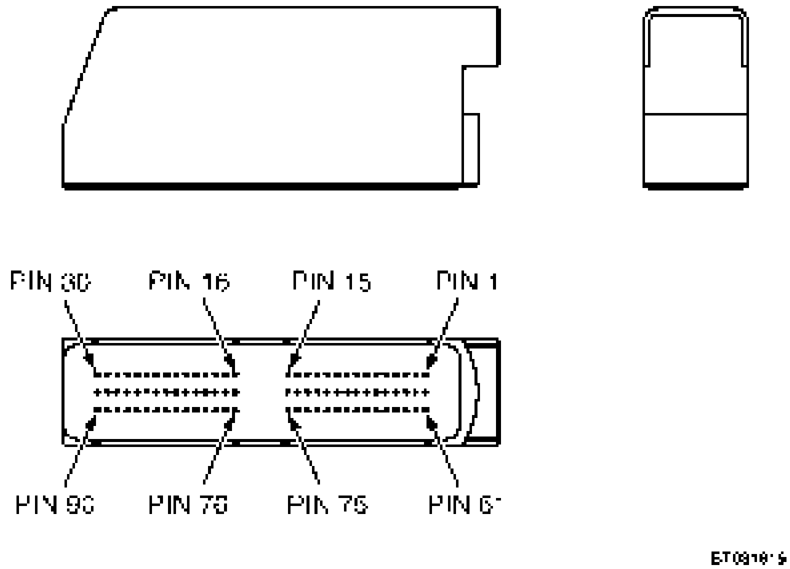


Figure 9030-20-26. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - MAT SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the TMAP connector CPS212 and measure voltage between socket 3 and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Go to Step 2.
   NO: Inspect supply circuit 261-a and 261-D for open or short.
2. Measure voltage between the TMAP connector CPS212, socket 3 and socket 1.
   Is voltage 5 ± 0.5 Vdc?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect MAT ground circuit 115-A and 115-C for open or source of excessive resistance. If circuit 115-A fault is present, engine coolant temp, throttle, oil pressure, and other sensors may be inoperative.

(Cont)

CAUSE B - MAT SENSOR SIGNAL FAULT

PROCEDURE OR ACTION:

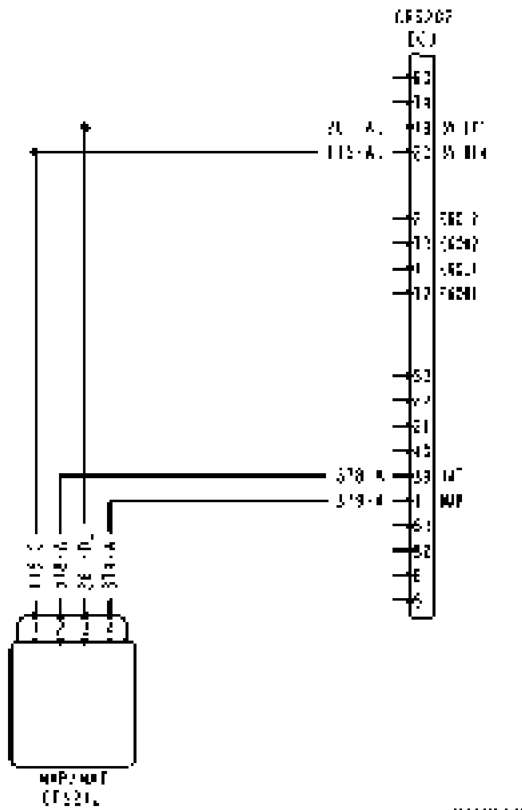
1. Disconnect ECU connector CRS202. Measure resistance between TMAP sensor connector CPS212, socket 2 and ECU connector CRS202, socket 39.
   Is resistance ≤1 ohm?
   YES: No signal circuit faults present, proceed to Cause C.
   NO: Inspect signal circuit 378-A for open, short, or source of excessive resistance.

CAUSE C - MAT SENSOR FAULT

PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty MAT sensor, clear DTC and retest system.

END POSSIBLE CAUSES



END FAULT

5 Volt Supply

Fault will set when an open or short is detected an either 5 volt supply circuit. Additionally, if both supply circuits are faulty, the ECU may set a simultaneous out of range DTC.

CODES

DTC ErrE617 (524261-3) - 5VE1 Sensor Supply Voltage OORH
DTC ErrE618 (524261-4) - 5VE2 Sensor Supply Voltage OORL
DTC ErrE619 (524260-3) - 5VE1 Sensor Supply Voltage OORH
DTC ErrE620 (524260-4) - 5VE2 Sensor Supply Voltage OORL
DTC ErrE621 (1079-31) - 5 Volt Supply 5VE1 and 5VE2 Simultaneous OOR

POSSIBLE CAUSE

A. 5 VOLT SUPPLY (5VE1) WIRING FAULT

B. 5 VOLT SUPPLY (5VE2) WIRING FAULT

C. ECU 5 VOLT SUPPLY FAULT (5VE1 AND 5VE2)

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

NOTE: The ECU provides the appropriate sensors with 5 volt supply. ECU connector CRS202, pin 19 (5VE1) and pin 49 (5VE2) provide voltage to numerous sensors.

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - 5 VOLT SUPPLY (5VE1) WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Using current circuit diagram information, determine which sensors the supply fault may be affecting. This will isolate the section of wiring to be inspected. Additionally sensor faults may be present at this time. 5VE1 faults may cause issues with camshaft, oil pressure, and throttle functions. 5VE2 may cause faults with the accelerator pedal sensor.

1. Disconnect the throttle connector CPS230 and measure voltage between socket 3 and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Reconnect throttle connector CPS230 and proceed to Step 2.
   NO: I
2. Disconnect intermediate harness connector CPS83 and measure voltage between socket 3 and B(-). Ensure voltage reading is on ECU harness side and not accelerator pedal sensor harness side.
   Is voltage 5 ± 0.5 Vdc?

5 Volt Supply (Cont)

YES: Proceed to Cause B.
NO: Inspect circuits 261-B and 261-A for open or short. It may be necessary to measure voltage at the camshaft sensor (CPS219, socket 3) and oil pressure sensor (CPS201, socket 2) to isolate 5VE1 circuit fault location. If not faults are present, proceed to Cause C.

CAUSE B - 5 VOLT SUPPLY (5VE2) WIRING FAULT

PROCEDURE OR ACTION:

1. Measure voltage between the intermediate harness connector CPS83, socket 4 and B(-). Ensure voltage reading is on ECU harness side and not accelerator pedal sensor harness side.
   Is voltage 5 ± 0.5 Vdc?
   YES: Connect intermediate harness connector CPS83 and proceed to Step 2.
   NO: Inspect supply circuit 262-0 for open or short.
2. Disconnect accelerator pedal sensor connector CPS27 and measure voltage between socket D and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: No 5 volt supply circuit faults evident at this time.
   NO: Inspect circuits 262-A for open or short. If not circuit faults are evident, connect pedal sensor connector CPS27 and proceed to Cause C.

CAUSE C - ECU 5 VOLT SUPPLY FAULT (5VE1 AND 5VE2)

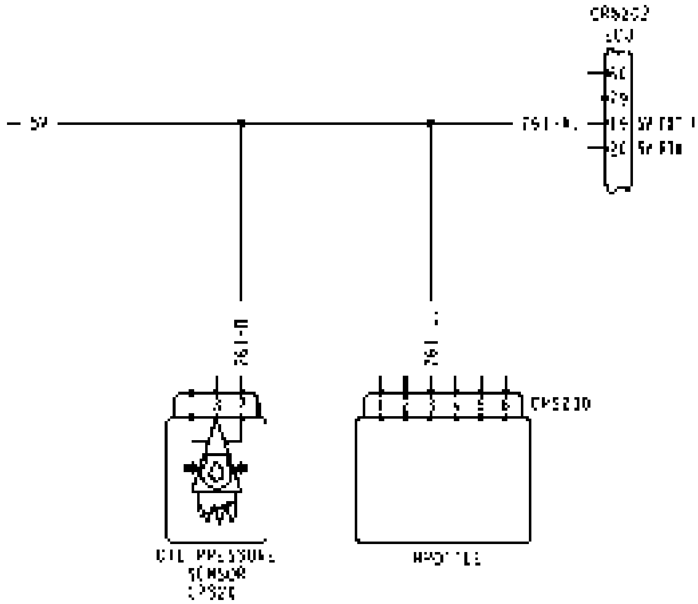
PROCEDURE OR ACTION:

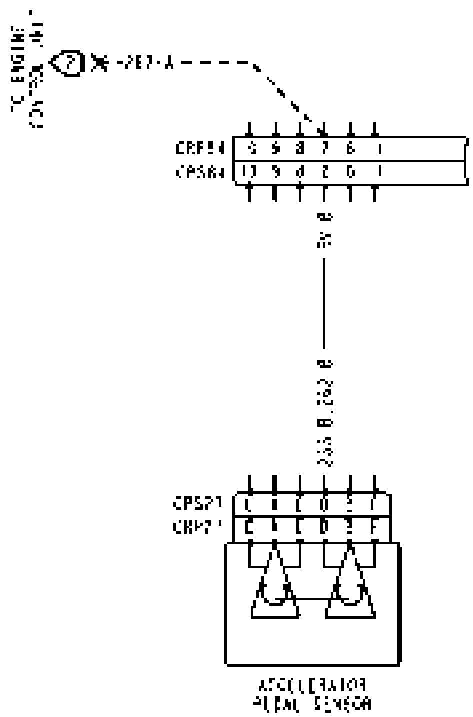
1. Disconnect ECU connector CRS202 and measure voltage between the following:
   - CRS202, socket 19 and socket 81
   - CRS202, socket 49 and socket 81

   Is voltage 5 ± 0.5 Vdc?
   YES: No faults evident at this time. Inspect ECU connector CRS202 for loose, damaged, or corroded terminals.
   NO: Replace faulty ECU.

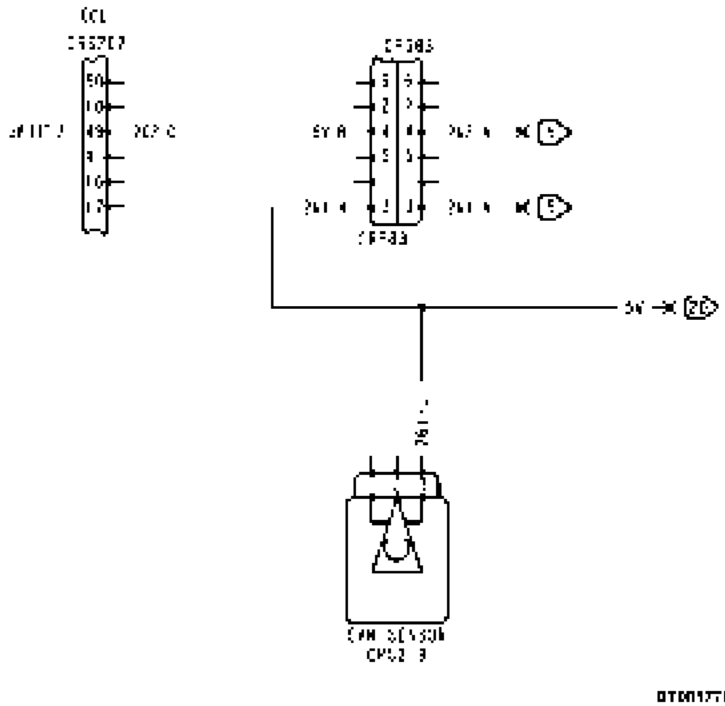
END POSSIBLE CAUSES

5 Volt Supply (Cont)





5 Volt Supply (Cont)



END FAULT

This DTC is set when throttle position voltage is above or below threshold values or the throttle does not respond to command.

CODES

DTC ErrE622 (522710-3) - TPS 1 Voltage OORH
DTC ErrE623 (522710-4) - TPS 1 Voltage OORL
DTC ErrE624 (522711-3) - TPS 2 Voltage OORH
DTC ErrE625 (522711-4) - TPS 2 Voltage OORL
DTC ErrE626 (51-2) - TPS 1 Position < TPS 2 Position
DTC ErrE627 (51-7) - Unable to Reach Commanded TPS
DTC ErrE628 (51-31) - TPS1 and TPS2 Voltage Simultaneous OOR

POSSIBLE CAUSE

A. THROTTLE WIRING FAULT

B. THROTTLE SIGNAL FAULT

C. THROTTLE MOTOR WIRING FAULT

D. THROTTLE ASSEMBLY FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The throttle is provided 5 volt supply and ground from the ECU. An ECU driven motor actuates the throttle plate according to accelerator pedal sensor input request. The throttle then provides the ECU with throttle plate position input signal.

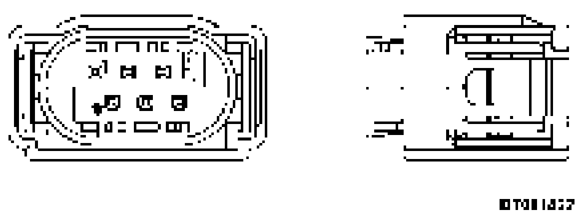


Figure 9030-20-27. Throttle Connector

(Cont)

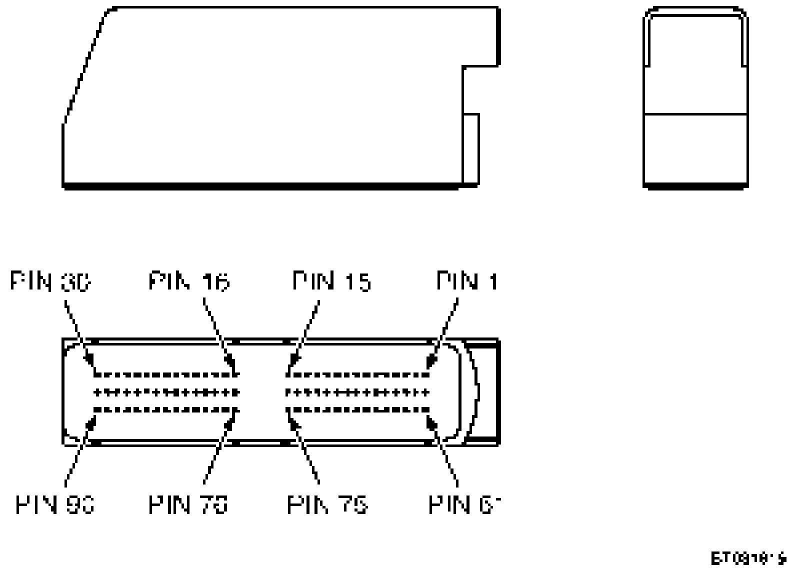


Figure 9030-20-28. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

(Cont)

CAUSE A - THROTTLE WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect throttle connector CPS230, and measure voltage between socket 3 and B(-).
   Is voltage 5 ± 0.5 vdc?
   YES: Proceed to Step 2.
   NO: Inspect supply circuit 261-L and 261-A for open or short.

NOTE: Key in ON position.

2. Measure voltage between the throttle connector CPS230, socket 3 and socket 2.
   Is voltage 5 ± 0.5 vdc?
   YES: Disconnect battery, ECU connector CRS202, and proceed to Cause B.
   NO: Inspect ground circuit 115-L and 115-A for open or short.

CAUSE B - THROTTLE SIGNAL FAULT

PROCEDURE OR ACTION:

1. Measure resistance between the following:
   - Throttle connector CPS230, socket 6 and ECU connector CRS202, socket 5.
   - Throttle connector CPS230, socket 5 and ECU connector CRS202, socket 6.

   Is resistance < 1 ohm?
   YES: Connect ECU connector CRS202, battery, and proceed to Cause C.
   NO: Inspect appropriate signal circuits for open, short, or source of excessive resistance.

CAUSE C - THROTTLE MOTOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Measure voltage between the throttle connector CPS230, socket 4 and B(-).
   Is voltage 5 ± 0.5 vdc?
   YES: Proceed to Step 2.
   NO: Inspect motor power circuit 848-A for open or short.
2. Measure voltage between the throttle connector CPS230, socket 4 and socket 1.
   Is voltage 5 ± 0.5 vdc?
   YES: Proceed to Cause D.
   NO: Inspect motor ground circuit 847-A for open or short.

CAUSE D - THROTTLE ASSEMBLY FAULT

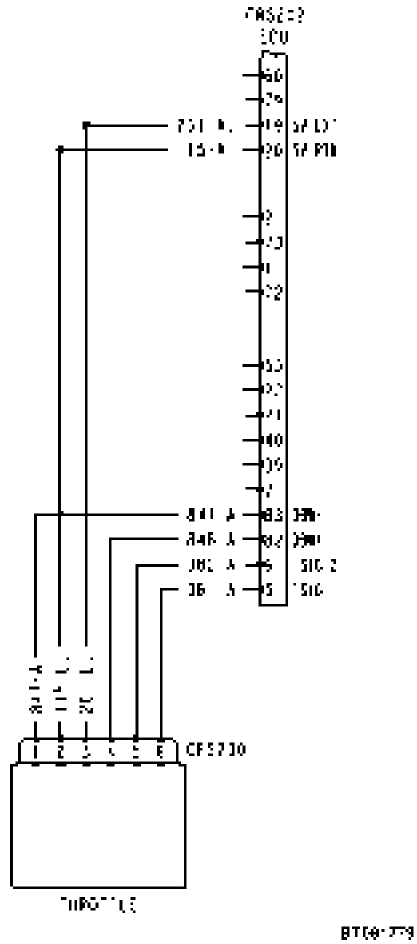
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty throttle assembly, clear DTC and retest system.

END POSSIBLE CAUSES

(Cont)

DIAGRAMS



Troubleshooting Scenes

END FAULT

This DTC is set when pedal position voltage is above or below threshold values.

CODES

DTC ErrE629 (522712-3) - APP 1 Voltage OORH
DTC ErrE630 (522712-4) - APP 1 Voltage OORL
DTC ErrE631 (522713-3) - APP 2 Voltage OORH
DTC ErrE632 (522713-4) - APP 2 Voltage OORL
DTC ErrE633 (91-2) - APP 1 Position 1 < 2

POSSIBLE CAUSE

A. APP SENSOR WIRING FAULT

B. APP SENSOR SIGNAL FAULT

C. APP SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The ECU provides the APP 5 volt signal and ground. The APP will provide a voltage return signal back to the ECU depending on accelerator pedal position.

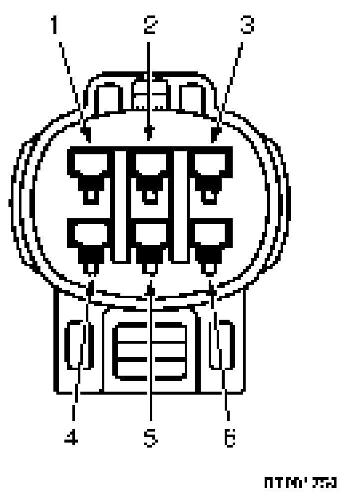


Figure 9030-20-29. APP Sensor Connector

(Cont)

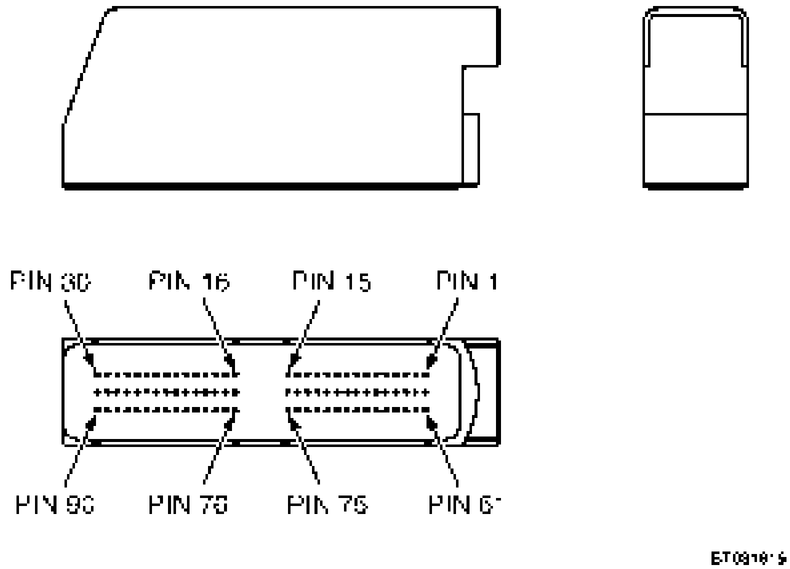


Figure 9030-20-30. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

(Cont)

CAUSE A - APP SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Using the PC Service Tool, locate and observe the ***Accelerator Position*** and ***Accelerator Position Sensor 1 Output Voltage***. Actuate accelerator pedal position fully close and fully open.
   - 0% APP, output voltage <1.35 volts
   - 100% APP, output voltage >4.0 volts

   Is voltage within specifications?
   YES: Clear DTC and retest system. If DTC returns, proceed to Cause C.
   NO: Proceed to Step 2.

NOTE: Key in ON position.

2. Disconnect the APP sensor connector CPS27 and measure voltage between sockets C / D and B(-).
   Is voltage 5 ± 0.5 vdc?
   YES: Proceed to Step 3.
   NO: Inspect supply circuits 261-H and 262-O for open or short.
3. Measure voltage between the APP sensor connector CPS27, sockets C / D and sockets B / E.
   Is voltage 5 ± 0.5 vdc?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect signal ground circuits 116-O and 385-A for open or short.

CAUSE B - APP SENSOR SIGNAL FAULT

PROCEDURE OR ACTION:

1. Disconnect ECU connector CRS202 and measure resistance between the following:
   - ECU connector CRS202, socket 10 and the APP connector CRP27, socket F.
   - ECU connector CRS202, socket 9 and the APP connector CRP27, socket A.

   Is resistance < 1 ohm?
   YES: Proceed to Cause C.
   NO: Inspect signal circuits 371-O and 370-O for open, short, or excessive resistance. Inspect connectors for loose, damaged, or corroded terminals.

CAUSE C - APP SENSOR FAULT

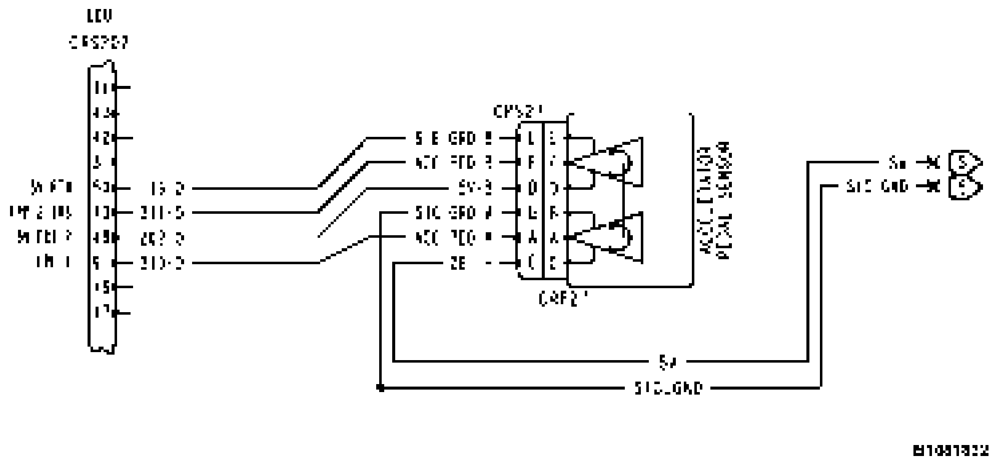
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty APP sensor, clear DTC and retest system.

END POSSIBLE CAUSES

(Cont)

DIAGRAMS



Troubleshooting Scene

END FAULT

This DTC is set when oil pressure voltage exceeds or drops below the target value.

CODES

DTC ErrE636 (100-3) - Engine Oil Pressure Sensor Voltage OORH
DTC ErrE637 (100-4) - Engine Oil Pressure Sensor Voltage OORL

POSSIBLE CAUSE

A. OIL PRESSURE SENSOR WIRING FAULT

B. OIL PRESSURE SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The oil pressure sensor provides resistance value to the ECU via circuit 353-A.

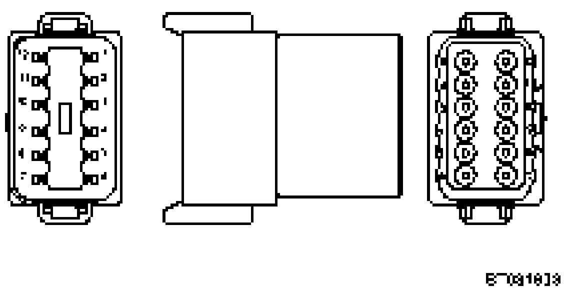


Figure 9030-20-31. Frame Harness Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

(Cont)

CAUSE A - OIL PRESSURE SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in OFF position.

1. Disconnect the frame harness connector CPS55 and oil pressure sensor terminal. Measure resistance between frame harness connector CPS55, socket 12 and oil pressure sensor terminal.
   Is resistance ≤ 1 ohm?
   YES: Proceed to Cause B.
   NO: Inspect signal circuit 353-A for open, short, or source of excessive resistance. Inspect frame harness for loose, damaged, or corroded terminals.

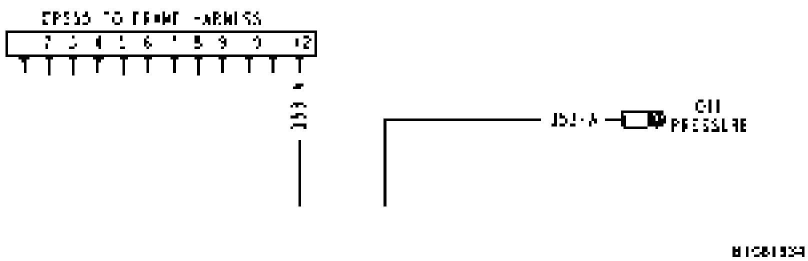
CAUSE B - OIL PRESSURE SENSOR FAULT

PROCEDURE OR ACTION:

1. If no wiring faults are present, replace faulty oil pressure sensor, clear DTC and retest system.

END POSSIBLE CAUSES

DIAGRAMS



Troubleshooting Scene

END FAULT

Fuel Trim

CODES

DTC ErrE638 (522663-1) - Adaptive Learning (Gasoline) Long Term Fuel Trim High (Bank 1)
DTC ErrE639 (522663-0) - Adaptive Learning (Gasoline) Long Term Fuel Trim Low (Bank 2)
DTC ErrE640 (522660-1) - Adaptive Learning (LPG) Long Term Fuel Trim High
DTC ErrE641 (522660-0) - Adaptive Learning (LPG) Long Term Fuel Trim Low
DTC ErrE642 (520203-0) - Adaptive Learn (CNG) Long Term Fuel Trim High
DTC ErrE643 (520203-1) - Adaptive Learn (CNG) Long Term Fuel Trim Low
DTC ErrE644 (522662-1) - Closed Loop Feedback (Gasoline) Short Term Fuel Trim High on Bank 1
DTC ErrE645 (522662-0) - Closed Loop Feedback (Gasoline) Short Term Fuel Trim Low on Bank 1
DTC ErrE646 (522655-1) - Closed Loop Feedback (LPG) Short Term Fuel Trim High
DTC ErrE647 (522655-0) - Closed Loop Feedback (LPG) Short Term Fuel Trim Low

POSSIBLE CAUSE

A. FUEL SYSTEM FAULT

B. EXHAUST SYSTEM FAULT

C. AIR INDUCTION SYSTEM FAULT

D. MIXER / REGULATOR FAULT

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly). See Harness Assembly Data.
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

CAUSE A - FUEL SYSTEM FAULT

PROCEDURE OR ACTION:

1. Verify fuel quality. Inspect gasoline for contaminants or verify LP is certified HD-5 or HD-10 and there are no known fuel issues.
   Is fuel contaminated?
   YES: Replace with correct / certified LP. Drain gasoline, flush system, and use new fuel source.
   NO: Proceed to Step 2.
2. Inspect fuel delivery system for leaks or damage. Inspect storage tank, delivery lines, rails, and other fuel components.
   Is fuel system damage evident?
   YES: Repair fuel system / component, clear DTC and retest system.
   NO: Proceed to Cause C.

Fuel Trim (Cont)

CAUSE B - EXHAUST SYSTEM FAULT

PROCEDURE OR ACTION:

1. Inspect exhaust system components for damage. Ensure no restrictions or leaks are present.
   Is an exhaust fault present?
   YES: Repair or replace exhaust system, clear DTC and retest system.
   NO: Proceed to Cause C.

CAUSE C - AIR INDUCTION SYSTEM FAULT

PROCEDURE OR ACTION:

1. Inspect air filter and air induction system. Ensure no damage or restrictions are present.
   Is an air restriction present?
   YES: Repair or replace faulty air induction component.
   NO: Proceed to Cause D.

CAUSE D - MIXER / REGULATOR FAULT

PROCEDURE OR ACTION:

1. If no faults are evident and fault code remains, replace faulty mixer or fuel regulator.

END POSSIBLE CAUSES

END FAULT

Oxygen Sensor Fault

Oxygen (O_2) Sensor circuit fault has been detected.

CODES

DTC ErrE648 (522737-10) - O2 Sensor 1 (Pre-Catalyst) Bank 1 Lazy
DTC ErrE649 (522606-10) - O2 Sensor 1 (Post-Catalyst) Bank 1 Lazy
DTC ErrE650 (522598-4) - EGOH4 Open / Short to Ground
DTC ErrE651 (522598-3) - EGOH4 Short to Power

POSSIBLE CAUSE

A. OXYGEN SENSOR HEATER WIRING FAULT

B. OXYGEN SENSOR 5 VOLT SUPPLY WIRING FAULT

C. OXYGEN SENSOR SIGNAL WIRING FAULT

D. OXYGEN SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The O_2 sensors are provided heater power and ground from the ECU. The ECU also provides a 5 volt reference signal and receives a return signal representing oxygen levels in the appropriate exhaust section (post-catalyst / pre-catalyst).

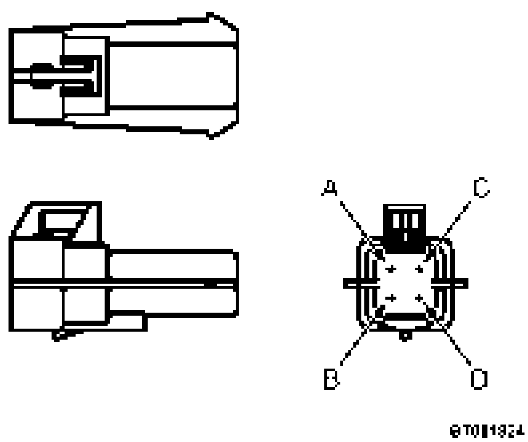


Figure 9030-20-32. Oxygen Sensor Connector

Oxygen Sensor Fault (Cont)

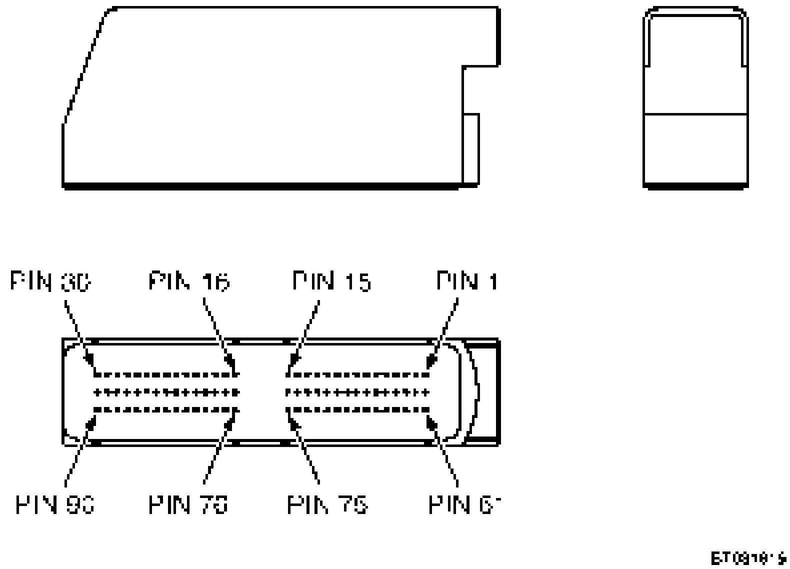


Figure 9030-20-33. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.
3. Using the PC Service Tool, observe O_2 Sensor data, both cold (open loop), and heated (closed loop). It is important to note that the downstream (post-catalyst) sensor will not switch as rapidly as the upstream (pre-catalyst) sensor.
   Do both upstream and downstream sensors respond normally?
   YES: Clear DTC and retest system.
   NO: Proceed to Cause A.

Oxygen Sensor Fault (Cont)

CAUSE A - OXYGEN SENSOR HEATER WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the appropriate oxygen sensor and measure voltage between CPS252 or CPS218, socket C and B(-).
   Is battery voltage present?
   YES: Go to Step 2.
   NO: Inspect 751-D or 751-A for open or short. Verify fuel/run relay located in the PDM.
2. Measure voltage between the appropriate oxygen sensor connector CPS252 or CPS218, socket C and socket D.
   Is battery voltage present?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect heater ground circuit 870-A or 871-A for open or short.

CAUSE B - OXYGEN SENSOR 5 VOLT SUPPLY WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Measure voltage between the appropriate oxygen sensor connector CPS252 or CPS218, socket B and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: ECU is providing supply voltage to sensor. Disconnect battery and proceed to Cause C.
   NO: Inspect 5 volt supply circuit 384-A or 388-A for open or short.

CAUSE C - OXYGEN SENSOR SIGNAL WIRING FAULT

PROCEDURE OR ACTION:

1. Disconnect ECU connector CRS202 and measure resistance between the following:
   - ECU CRS202, socket 2 and EGO 2 connector CPS252, socket A.
   - ECU CRS202, socket 1 and EGO 1 connector CPS252, socket B.

   Is resistance ≤ 1 ohm?
   YES: Proceed to Cause D.
   NO: Inspect appropriate oxygen sensor ground signal circuit 115-B or 115-F for open, short, or source of excessive resistance.

CAUSE D - OXYGEN SENSOR FAULT

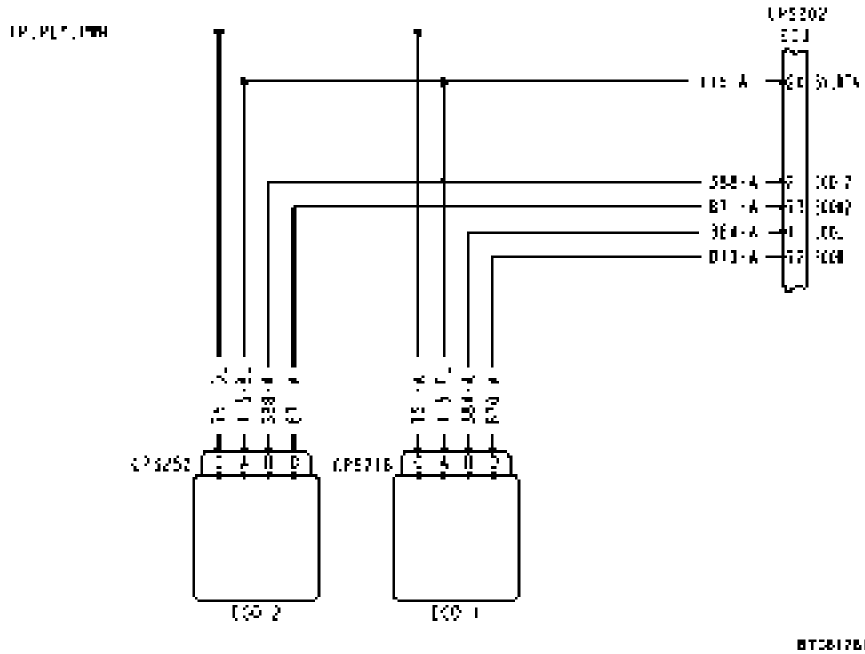
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace appropriate oxygen sensor, clear DTC and retest system.

END POSSIBLE CAUSES

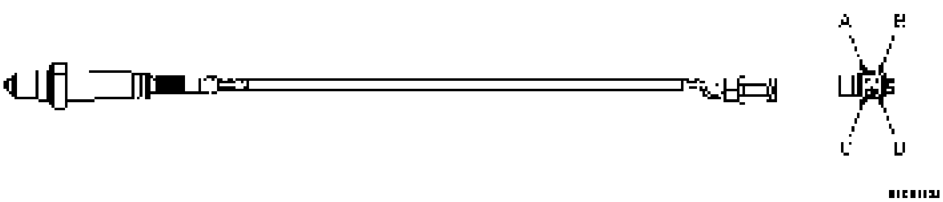
Oxygen Sensor Fault (Cont)

DTC ERRE648 (522737-10) O2 SENSOR 1 (PRE-CATALYST) BANK 1 LAZY DIAGRAMS



Troubleshooting Scene

CONNECTOR(S)



Oxygen Sensor Harness

END FAULT

This DTC is set when an injector circuit fault or injector fault has been detected.

CODES

DTC ErrE652 (522599-4) - Cylinder #1 Fuel Injector Coil Open Circuit or Shorted to Ground
DTC ErrE653 (522601-4) - Cylinder #2 Fuel Injector Coil Open Circuit or Shorted to Ground
DTC ErrE654 (522602-4) - Cylinder #3 Fuel Injector Coil Open Circuit or Shorted to Ground
DTC ErrE655 (522600-4) - Cylinder #4 Fuel Injector Coil Open Circuit or Shorted to Ground
DTC ErrE656 (522599-3) - Cylinder #1 Fuel Injector Coil Shorted to Power
DTC ErrE657 (522601-3) - Cylinder #2 Fuel Injector Coil Shorted to Power
DTC ErrE658 (599602-3) - Cylinder #3 Fuel Injector Coil Shorted to Power
DTC ErrE659 (522600-3) - Cylinder #4 Fuel Injector Coil Shorted to Power

POSSIBLE CAUSE

A. INJECTOR WIRING FAULT

B. INJECTOR FAULT

C. ECU FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The fuel injector is provided common ground from the ECU. When the injector is operated, the ECU provides high voltage on the supply circuit.

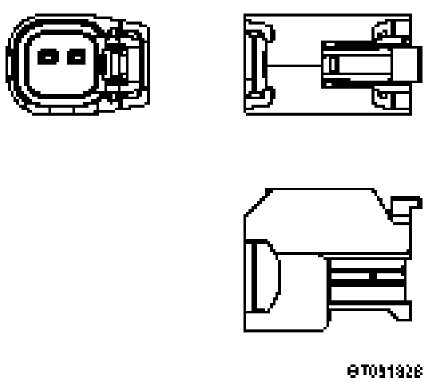


Figure 9030-20-34. Fuel Injector Coil Connector

(Cont)

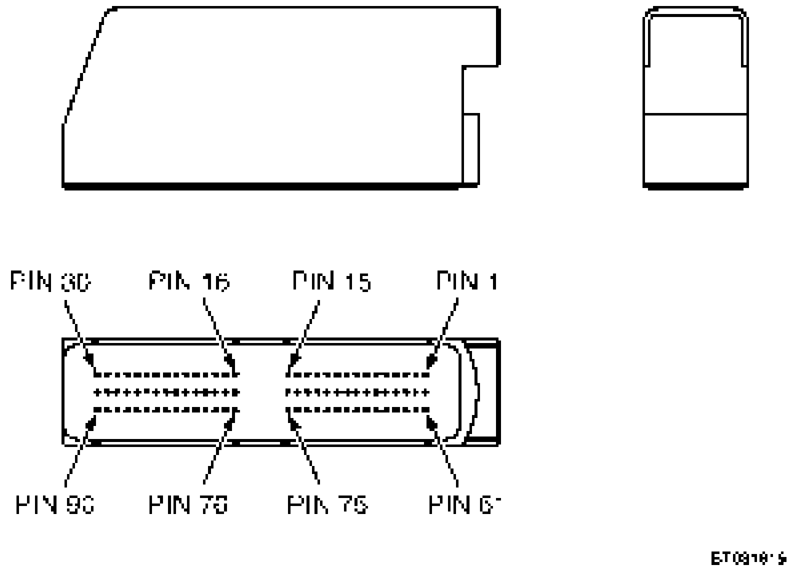


Figure 9030-20-35. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

(Cont)

CAUSE A - INJECTOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the appropriate fuel injector connector and measure voltage between socket 1 and B(-)
   Is battery voltage present?
   YES: Disconnect battery and proceed to Step 2.
   NO: Inspect appropriate battery voltage supply circuit for open or short.
2. Disconnect ECU connector CRS202 and measure resistance between the following:
   - ECU CRS202, socket 61 and injector connector CRS208, socket 2.
   - ECU CRS202, socket 62 and injector connector CRS209, socket 2.
   - ECU CRS202, socket 63 and injector connector CRS210, socket 2.
   - ECU CRS202, socket 64 and injector connector CRS211, socket 2.

   Is resistance < 1 ohm?
   YES: Connect battery and proceed to Cause B.
   NO: Inspect appropriate control circuit for open, short, or source of excessive resistance.

CAUSE B - INJECTOR FAULT

PROCEDURE OR ACTION:

1. Using a insulation resistance tester (megohmmeter tester) measure resistance between injector pins 1 and 2.
   Is resistance ≥ 10 MΩ
   YES: Proceed to Cause C.
   NO: Replace faulty injector.

CAUSE C - ECU FAULT

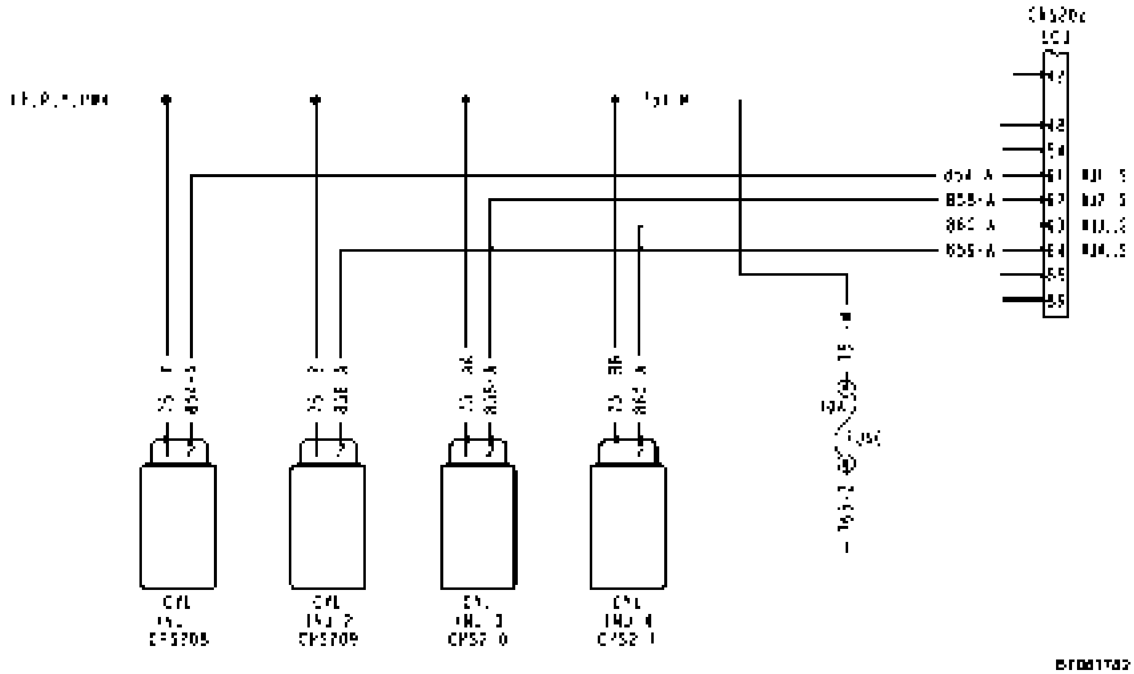
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty ECU, clear DTC and retest system.

END POSSIBLE CAUSES

(Cont)

DIAGRAMS



Troubleshooting Scenes

END FAULT

Fuel / Run Relay

CODES

DTC ErrE674 (1348-3) - Fuel Pump Relay Shorted to B(+)
DTC ErrE672 (1348-4) - Fuel Pump Relay Shorted to B(-)
DTC ErrE673 (1348-5) - Fuel Pump Relay Open Circuit

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

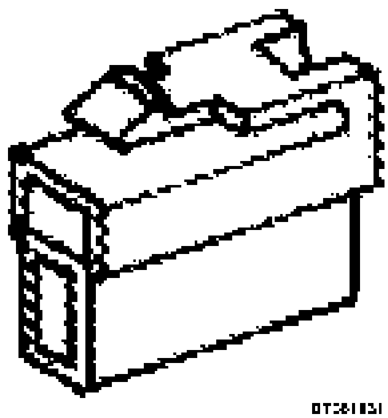


Figure 9030-20-36. Fuel Pump Connector

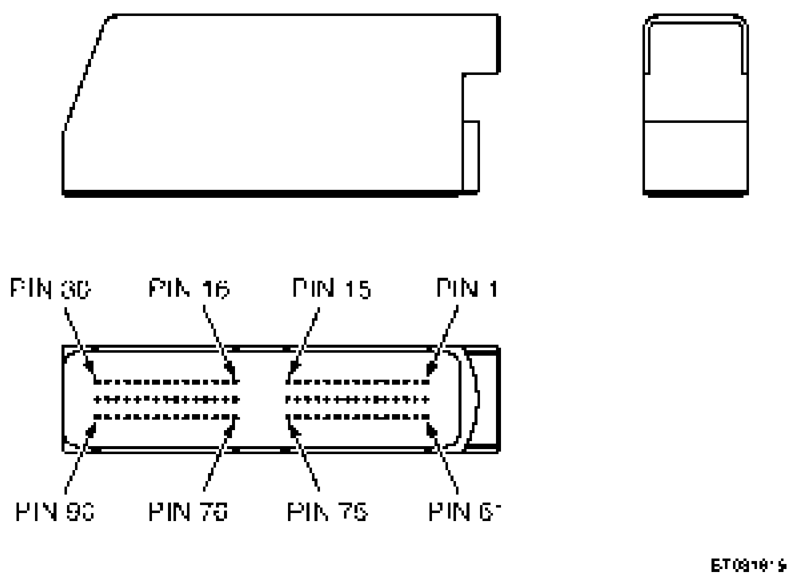


Figure 9030-20-37. ECU Connector

Fuel / Run Relay (Cont)

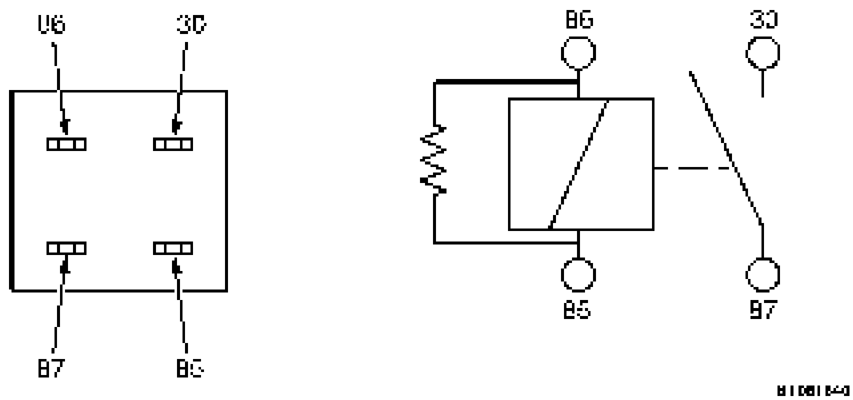


Figure 9030-20-38. Fuel / Run Relay

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - FUEL PUMP CIRCUIT FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect fuel pump connector CPS207 and measure voltage between socket C and B(-).
   Is battery voltage present?
   YES: Proceed to Step 2.
   NO: Inspect circuit 765-C for open or short. Inspect 10A fuel pump fuse.
2. Measure voltage between the fuel pump connector CPS207, socket C and socket A.
   Is battery voltage present?
   YES: Proceed to Cause B.
   NO: Inspect ground circuit 136-A for open, short, or source of excessive resistance.

Fuel / Run Relay (Cont)

CAUSE B - FUEL / RUN RELAY WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Remove Fuel / Run Relay RL2 located in PDM. Measure voltage between the RL2 relay socket 30 of PDM and B(-).
   Is battery voltage present?
   YES: Go to Step 2.
   NO: Inspect Fuel / Run 20A Fuse F3. Inspect PDM connections.

NOTE: Key in ON position.

2. Measure voltage between the RL2 relay socket 86 of PDM and B(-).
   Is battery voltage present?
   YES: Proceed to Step 3.
   NO: Inspect battery supply circuit 760-A for open or short. Inspect PDM connector for loose, damaged, or corroded terminals.

NOTE: Key in ON position.

3. Measure voltage between RL2 relay socket 86 and socket 87 of PDM.
   Is battery voltage present?
   YES: Proceed to Cause C.
   NO: Inspect relay coil ground circuit 759-A and 759-O for open or short. Inspect ECU202 connector, pin 71 (ground control) for loose, damaged, or corroded terminals. Inspect PDM connector CRP15 for loose, damaged, or corroded terminals.

CAUSE C - FUEL / RUN RELAY OUTPUT FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Using a jumper wire, bypass Fuel / Run Relay by installing jumper between the PDM socket 30 and socket 87.
   Does system operate correctly?
   YES: Proceed to Cause D.
   NO: Inspect relay's output voltage circuit 751-A and 751-C for open or short.

CAUSE D - FUEL / RUN RELAY FAULT

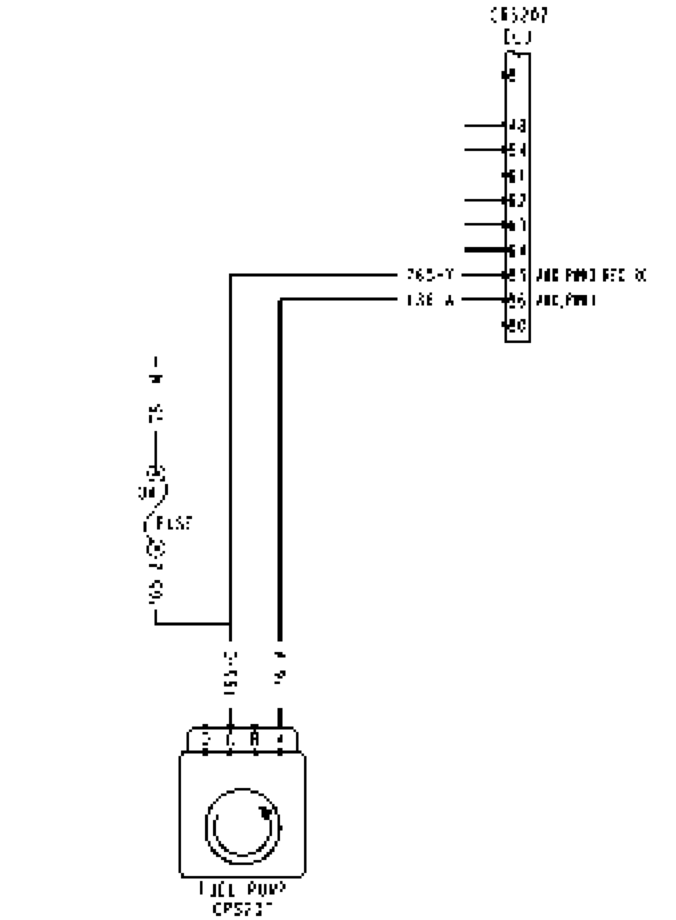
PROCEDURE OR ACTION:

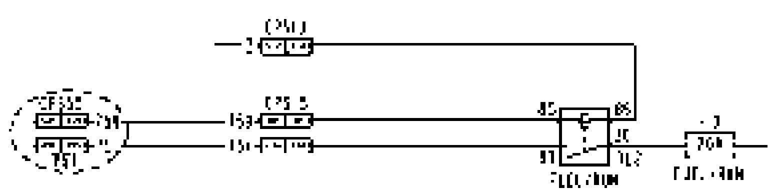
1. If no wiring faults are present, replace faulty relay, clear DTC and retest system.

END POSSIBLE CAUSES

Fuel / Run Relay (Cont)

DTC ERRE674 (1348-3) FUEL PUMP RELAY SHORTED TO B(+) DIAGRAMS





Troubleshooting Scene

END FAULT

Main Relay

CODES

DTC ErrE677 (522604-3) - Main Relay Shorted to B(+)
DTC ErrE675 (522604-4) - Main Relay Shorted to B(-)
DTC ErrE676 (522604-5) - Main Relay Open Circuit

POSSIBLE CAUSE

A. MAIN RELAY WIRING FAULT

B. MAIN RELAY OUTPUT FAULT

C. MAIN RELAY FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

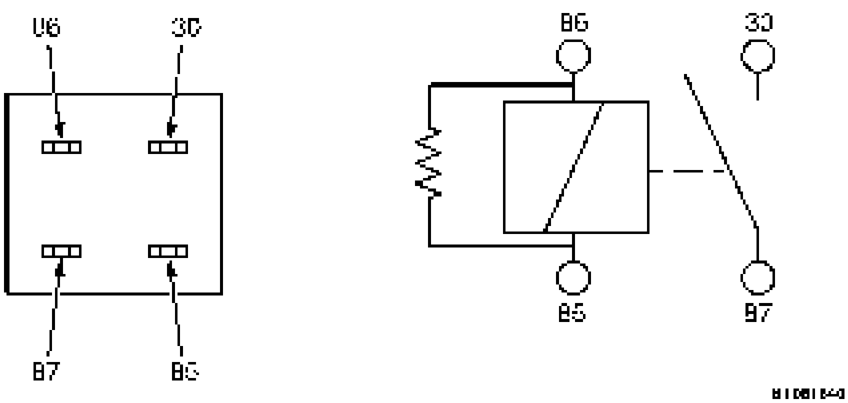


Figure 9030-20-39. Main Start Relay

NOTE: The Main Relay RL5 terminal 30 is provided constant fused battery voltage and terminal 86 is provided switched battery voltage. The ECU provides ground circuit to relay coil to activate. When activated, the switch closes providing battery voltage to starter motor.

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

Main Relay (Cont)

CAUSE A - MAIN RELAY WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Remove Main Relay RL5 located in PDM. Measure voltage between the RL5 relay socket 30 of PDM and B(-).
   Is battery voltage present?
   YES: Go to Step 2.
   NO: Inspect Main 30A Fuse F3. Inspect PDM connections.

NOTE: Key in ON position.

2. Measure voltage between the RL5 relay socket 86 of PDM and B(-).
   Is battery voltage present?
   YES: Proceed to Step 3.
   NO: Inspect battery supply circuit 761-A for open or short. Inspect PDM connector CRP13 for loose, damaged, or corroded terminals.

NOTE: Key in ON position.

3. Measure voltage between RL5 relay socket 86 and socket 87 of PDM.
   Is battery voltage present?
   YES: Proceed to Cause B.
   NO: Inspect relay coil ground circuit 126-A and 126-F for open or short. Inspect CRS202 connector, pin 81 (ground control) for loose, damaged, or corroded terminals. Inspect PDM connector CRP14 for loose, damaged, or corroded terminals.

CAUSE B - MAIN RELAY OUTPUT FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Using a jumper wire, bypass Main Relay by installing jumper between the PDM socket 30 and socket 87.
   Does system operate correctly?
   YES: Proceed to Cause C.
   NO: Inspect relay's output voltage circuit 750-A and 750-B for open or short.

CAUSE C - MAIN RELAY FAULT

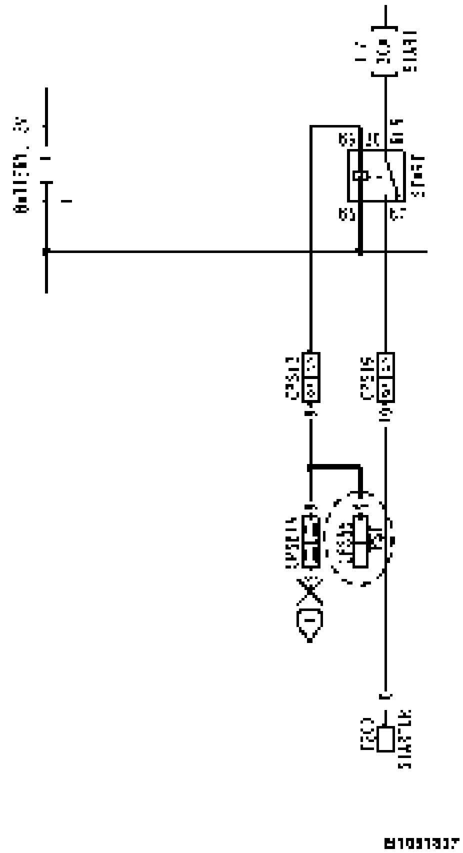
PROCEDURE OR ACTION:

1. If no wiring faults are present, replace faulty relay, clear DTC and retest system.

END POSSIBLE CAUSES

Main Relay (Cont)

DTC ERRE677 (522604-3) MAIN RELAY SHORTED TO B(+) DIAGRAMS



Troubleshooting Scene

END FAULT

Fuel Delivery (DEPR)

CODES

DTC ErrE678 (522592-0) - Fuel Pressure at DEPR Higher Than Expected
DTC ErrE679 (522592-1) - Fuel Pressure DEPR Lower Than Expected
DTC ErrE680 (522593-12) - Electronic Pressure Regulator (EPR) Communication Loss
DTC ErrE681 (522595-12) - Electronic Pressure Regulator (EPR) Actuator Problem
DTC ErrE682 (522596-12) - Electronic Pressure Regulator (EPR) Internal Circuit Problem

POSSIBLE CAUSE

A. DEPR WIRING FAULT

B. DEPR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

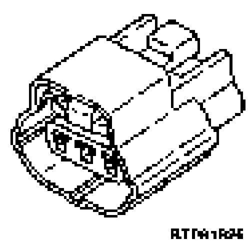


Figure 9030-20-40. DEPR Connector

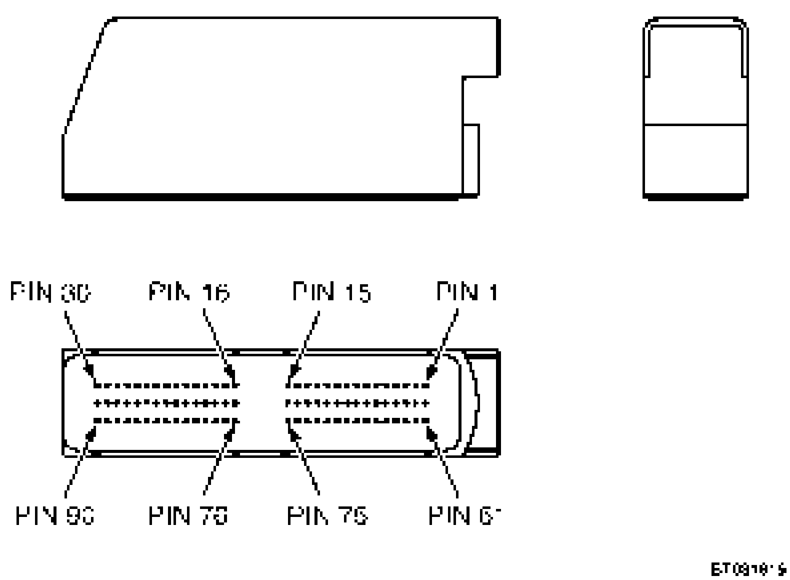


Figure 9030-20-41. ECU Connector

Fuel Delivery (DEPR) (Cont)

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly). See Harness Assembly Data.
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

CAUSE A - DEPR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the DEPR connector CPS269 and measure voltage between socket 6 and B(-).
   Is battery voltage present?
   YES: Proceed to Step 2.
   NO: Inspect 20A Fuse F6 and battery voltage input circuit for open or short. Inspect connectors CPS160 and CRP15 for loose, damaged, or corroded terminals.

NOTE: Key in ON position.

2. Measure voltage between the DEPR connector CPS269, socket 4 and B(-).
   Is ignition voltage present?
   YES: Proceed to Step 3.
   NO: Inspect 30A Start Fuse F7 and start switch for faults. Inspect ignition voltage circuit for open or short. Inspect connectors CPS55 and CRP14 for loose, damaged, or corroded terminals.

NOTE: Key in ON position.

3. Measure voltage between the DEPR connector CPS269, socket 5 and B(-).
   Is CAN HI voltage approximately 2.5 Vdc?
   YES: Proceed to Step 4.
   NO: Inspect CAN HI circuit for open or short. if voltage is 0 volts, the CAN HI circuit is shorted to ground or open. If voltage is above 5 volts, the CAN HI circuit is shorted to power.

NOTE: Key in ON position.

4. Measure voltage between the DEPR connector COS269, socket 1 or 2 and B(-).
   Is CAN LO voltage approximately 2.5 Vdc?
   YES: Disconnect battery and proceed to Step 5.
   NO: Inspect CAN LO circuit for open or short. if voltage is 0 volts, the CAN HI circuit is shorted to ground or open. If voltage is above 5 volts, the CAN HI circuit is shorted to power.
5. Measure resistance between the DEPR connector CPS269, socket 5 and socket 1 or 2.
   Is resistance 60 ± 6 ohms?
   YES: No communication faults are present, connect battery and proceed to Cause B.
   NO: If resistance is 120 ohms, the CANbus has an open circuit or a missing or damaged termination resistor. If resistance is 0 ohms, the CANbus circuits are shorted together.

Fuel Delivery (DEPR) (Cont)

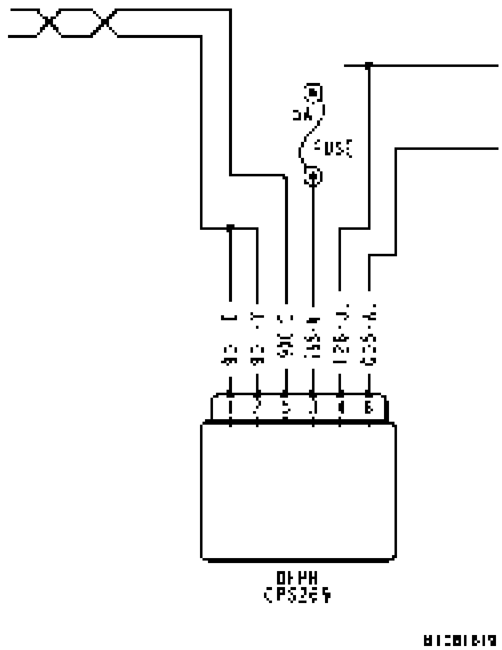
CAUSE B - DEPR FAULT

PROCEDURE OR ACTION:

1. Replace faulty DEPR.

END POSSIBLE CAUSES

DIAGRAMS



Troubleshooting Scene

END FAULT

This DTC is set when a fault has been detected on the camshaft position sensor circuit, the sensor is dirty, or the camshaft position sensor is faulty.

CODES

DTC ErrE683 (522752-4) - Camshaft Position Sensor Loss of Pulse
DTC ErrE685 (522752-2) - Camshaft Position Sensor Pulse Abnormality
DTC ErrE688 (520800-7) - Camshaft Position Sensor Error

POSSIBLE CAUSE

A. CAMSHAFT POSITION SENSOR WIRING FAULT

B. CAMSHAFT POSITION SENSOR SIGNAL CIRCUIT FAULT

C. CAMSHAFT POSITION SENSOR DAMAGED

D. CAMSHAFT POSITION SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The camshaft position sensor is provided a 5 volt supply and ground circuits from ECU. The sensor provides camshaft speed data to the ECU via a signal circuit.

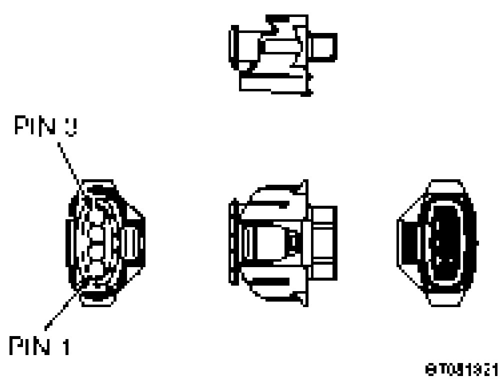


Figure 9030-20-42. Camshaft Position Sensor Connector

(Cont)

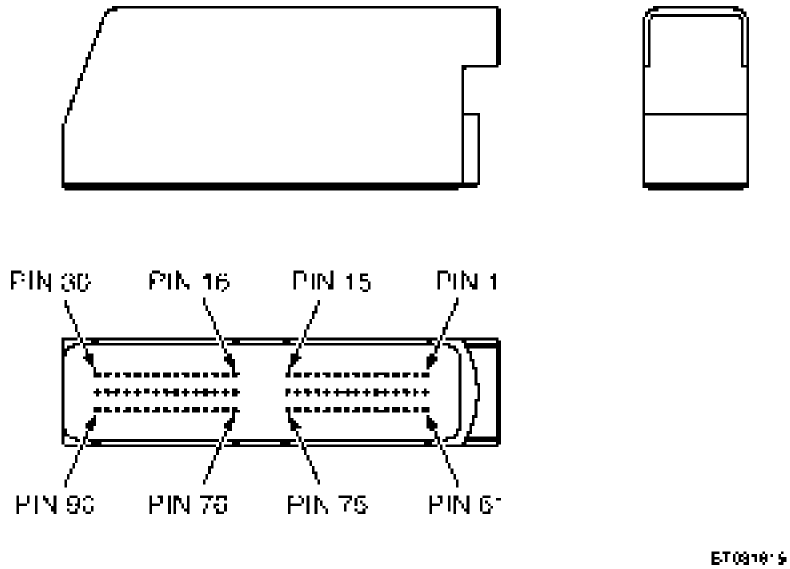


Figure 9030-20-43. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

CAUSE A - CAMSHAFT POSITION SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect camshaft sensor connector CRS219 and measure voltage between socket 3 and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Proceed to Step 2.
   NO: Inspect supply voltage circuit 266-B and 266-A for open or short.
2. Measure voltage between the crank sensor connector CRS219, socket 3 and socket 2.
   Is voltage 5 ± 0.5 Vdc?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect ground circuit 130-B and 130-A for open or short.

(Cont)

CAUSE B - CAMSHAFT POSITION SENSOR SIGNAL CIRCUIT FAULT

PROCEDURE OR ACTION:

1. Disconnect ECU connector CRS204 and measure resistance between CRS204, socket 8 and the camshaft position sensor connector CRS219, socket 1.
   Is resistance <1 ohm?
   YES: Proceed to Cause C.
   NO: Inspect signal circuit 385-B and 385-A for open, short, or source of excessive resistance.

CAUSE C - CAMSHAFT POSITION SENSOR DAMAGED

PROCEDURE OR ACTION:

1. Remove crank position sensor and inspect sensor for damage. Inspect for excessive metal buildup on sensor face.
   Is sensor damaged?
   YES: Replace faulty sensor.
   NO: Proceed to Cause D.

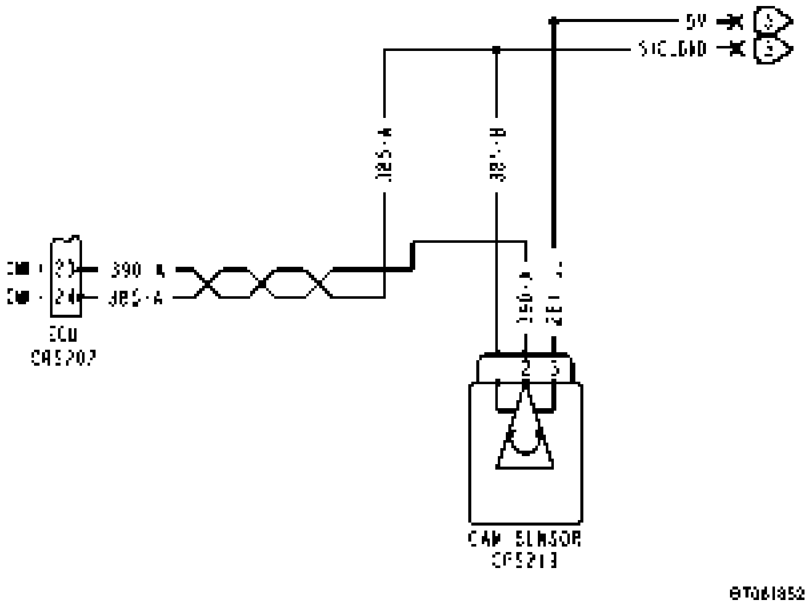
CAUSE D - CAMSHAFT POSITION SENSOR FAULT

PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty camshaft position sensor, clear DTC and re-test system.

END POSSIBLE CAUSES

DIAGRAMS



Troubleshooting Scenes

END FAULT

This DTC is set when a fault has been detected on the crank position sensor circuit or the crank position sensor is faulty.

CODES

DTC ErrE684 (190-4) - Crank Position Sensor Loss of Pulse
DTC ErrE686 (190-2) - Crank Position Sensor Pulse Count Abnormal
DTC ErrE687 (190-8) - Crank Position Sensor No Pulse On Start

POSSIBLE CAUSE

A. CRANK POSITION SENSOR WIRING FAULT

B. CRANK POSITION SENSOR SIGNAL CIRCUIT FAULT

C. CRANK POSITION SENSOR DAMAGED

D. CRANK POSITION SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

The crank position sensor is provided a 5 volt supply and ground circuits from ECU. The crank position sensor provides crank speed data to the ECU via a signal circuit.

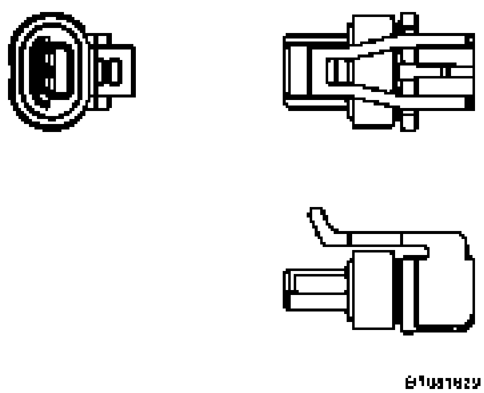


Figure 9030-20-44. Crankshaft Position Sensor Connector

(Cont)

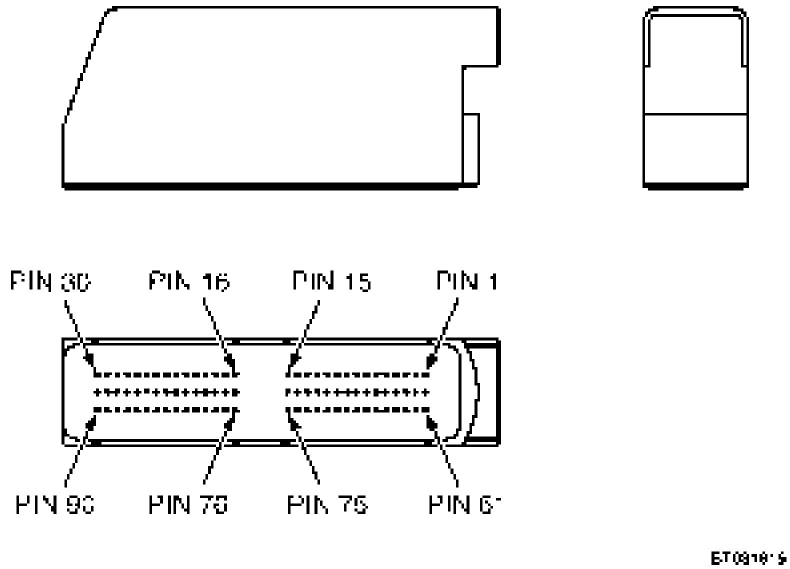


Figure 9030-20-45. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

CAUSE A - CRANK POSITION SENSOR WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect crank sensor connector CRS225 and measure voltage between socket 3 and B(-).
   Is voltage 5 ± 0.5 Vdc?
   YES: Proceed to Step 2.
   NO: Inspect supply voltage circuit 267-D and 267-A for open or short.
2. Measure voltage between the crank sensor connector CRS225, socket 3 and socket 2.
   Is voltage 5 ± 0.5 Vdc?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect ground circuit 375-D, 375-A, and 375-B for open or short.

(Cont)

CAUSE B - CRANK POSITION SENSOR SIGNAL CIRCUIT FAULT

PROCEDURE OR ACTION:

1. Disconnect ECU connector CRS204 and measure resistance between CRS204, socket 29 and the crank position sensor connector CRS225, socket 1.
   Is resistance <1 ohm?
   YES: Proceed to Cause C.
   NO: Inspect signal circuit 376-A and 376-B for open, short, or source of excessive resistance.

CAUSE C - CRANK POSITION SENSOR DAMAGED

PROCEDURE OR ACTION:

1. Remove crank position sensor and inspect sensor for damage. Inspect for excessive metal buildup on sensor face.
   Is sensor damaged?
   YES: Replace faulty sensor.
   NO: Proceed to Cause D.

CAUSE D - CRANK POSITION SENSOR FAULT

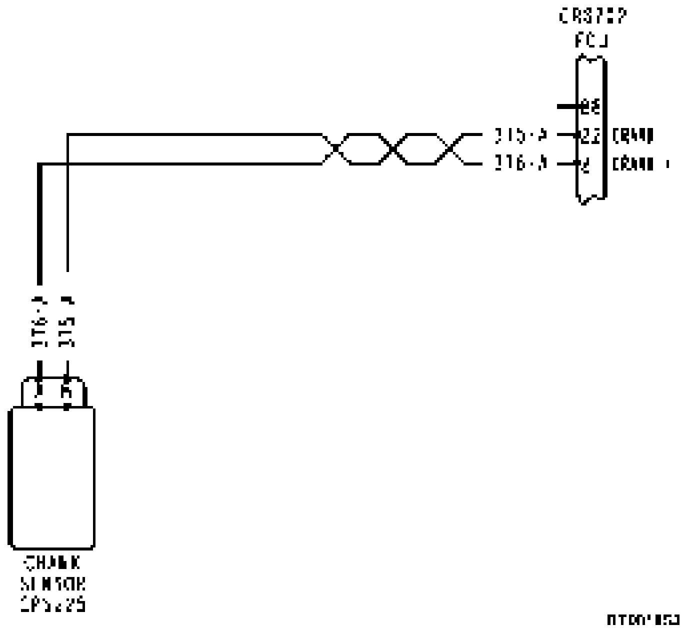
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty crank position sensor, clear DTC and retest system.

END POSSIBLE CAUSES

(Cont)

DIAGRAMS



Troubleshooting Scene

END FAULT

This DTC is set when controller fails a random access memory test or communication with controller on CANbus has been lost.

CODES

DTC ErrE689 (522697-12) - Engine Controller Hardware Failure
DTC ErrE690 (1634-2) - Engine Controller Hardware ID Failure
DTC ErrE691 (1634-13) - ECM Calibration Error
DTC ErrE694 (1231-12) - CAN Tx or Rx Failure
DTC ErrE694 (2000-12) - CAN Tx or Rx Failure
DTC ErrE694 (2000-14) - CAN Address Conflict
DTC ErrE695 (1231-14) - CAN Address Conflict

POSSIBLE CAUSE

A. ECU WIRING FAULT

B. ECU CANBUS COMMUNICATION FAULT

C. ECU FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

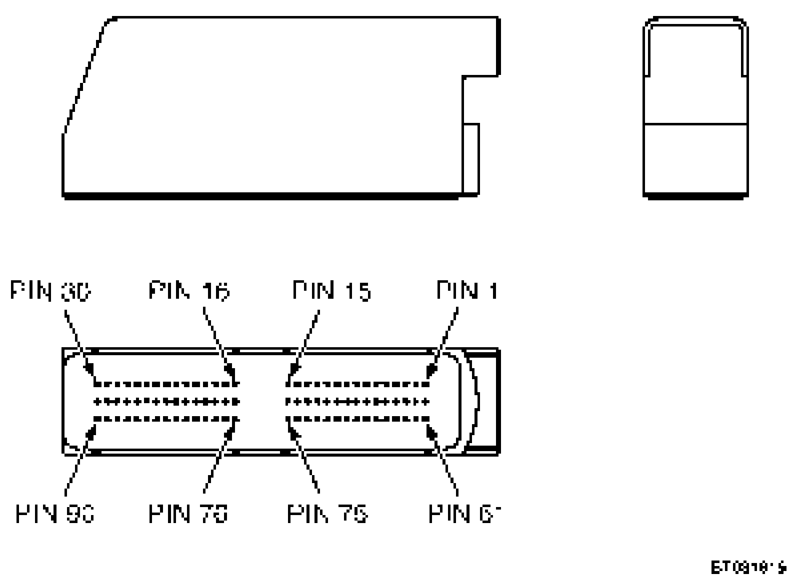


Figure 9030-20-46. ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.

(Cont)

2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code. Make sure electrical connection is a good physical connection (i.e. sockets and pins are seated correctly; connector "clicks" indicating locking tab works correctly).
   Are any of the connectors/wiring damaged?
   YES: Repair/replace connector or wiring associated with faults found. Refer to appropriate **Electrical System** manual, depending on lift truck model.
   NO: Go to Cause A.

CAUSE A - ECU WIRING FAULT

PROCEDURE OR ACTION:

1. Disconnect ECU connector CRS202 and measure voltage between socket 60 or 79 and B(-).
   Is battery voltage present?
   YES: Disconnect battery and proceed to Step 2.
   NO: Inspect ECU power circuits 005-A and 005-B for open or short.
2. Measure resistance between CRS202, socket 81 and B(-).
   Is resistance ≤ 1 ohm?
   YES: Connect battery and proceed to Cause B.
   NO: Inspect ground circuit 126-Z and 126-E for open, short, or source of excessive resistance.

CAUSE B - ECU CANBUS COMMUNICATION FAULT

PROCEDURE OR ACTION:

1. Measure voltage between the ECU connector CRS202, socket 14 and B(-).
   Is CAN HI voltage approximately 2.5 Vdc?
   YES: Proceed to Step 2.
   NO: Inspect CAN HI circuit for open or short. If voltage is 0 volts, the CAN HI circuit is shorted to ground or open. If voltage is above 5 volts, the CAN HI circuit is shorted to power.
2. Measure voltage between the ECU connector CRS202, socket 15 and B(-).
   Is CAN LO voltage approximately 2.5 Vdc?
   YES: Disconnect battery and proceed to Step 3.
   NO: Inspect CAN LO circuit for open or short. If voltage is 0 volts, the CAN LO circuit is shorted to ground or open. If voltage is above 5 volts, the CAN LO circuit is shorted to power.
3. Measure resistance between the ECU connector CRS202, socket 14 and socket 15.
   Is resistance 60 ± 6 ohms?
   YES: No communication faults are present, connect battery and proceed to Cause C.
   NO: If resistance is 120 ohms, the CANbus has an open circuit or a missing or damaged termination resistor. If resistance is 0 ohms, the CANbus circuits are shorted together.

CAUSE C - ECU FAULT

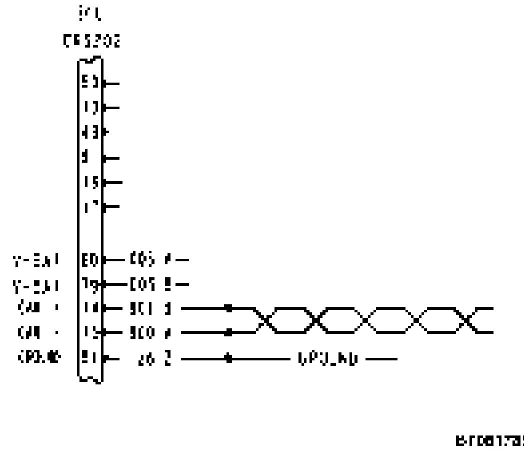
PROCEDURE OR ACTION:

1. If no wiring or communication faults are present, replace faulty ECU, clear DTC and retest system.

END POSSIBLE CAUSES

(Cont)

DIAGRAMS



Troubleshooting Scene

END FAULT

CODES

DTC ErrC008 - Truck Can Not Travel
DTC ErrC009 - Truck Does Not Start
DTC ErrC021 / ErrC022 - Operation Management Data Not Updated
DTC ErrC024 - External Option Does Not Work
DTC ErrC066 - Controller Error Not Stored
DTC ErrC067 - Controller Error Not Stored
DTC ErrC068 - Operation Management Fault

POSSIBLE CAUSE

A. CANBUS COMMUNICATION FAULT

B. DISPLAY WIRING FAULT

C. FAULTY DISPLAY

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

NOTE: Ensure proper calibration before performing the following procedures.

PROCEDURE OR ACTION:

The vehicle ECU controls various truck input and outputs: Solenoids, forward / reverse shift lever, transmission functions, and forward / reverse solenoids. These components are capable of setting dedicated error codes that will isolate the V-ECU fault. In addition, the V-ECU may set internal failure errors. The following procedures provides troubleshooting procedures for individual components as well as V-ECU faults.

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

(Cont)

CAUSE A - CANBUS COMMUNICATION FAULT

PROCEDURE OR ACTION:

NOTE: Perform Step 1 and Step 2 with key in ON position.

1. Disconnect the display connector CPS50 and measure voltage between socket 20 and B(-).
   Is CAN HI voltage approximately 2.5 Vdc?
   YES: Proceed to Step 2.
   NO: Inspect CAN HI circuit for open or short. If voltage is 0 volts, the CAN HI circuit is shorted to ground or open. If voltage is above 5 volts, the CAN HI circuit is shorted to power.
2. Measure voltage between the display connector CPS50, socket 15 and B(-).
   Is CAN LO voltage approximately 2.5 Vdc?
   YES: Disconnect battery and proceed to Step 3.
   NO: Inspect CAN LO circuit for open or short. If voltage is 0 volts, the CAN LO circuit is shorted to ground or open. If voltage is above 5 volts, the CAN LO circuit is shorted to power.
3. Measure resistance between the display connector CPS50, socket 20 and socket 15.
   Is resistance 60 ± 6 ohms?
   YES: No communication faults are present, connect battery and proceed to Cause B.
   NO: If resistance is 120 ohms, the CANbus has an open circuit or a missing or damaged termination resistor. If resistance is 0 ohms, the CANbus circuits are shorted together.

CAUSE B - DISPLAY WIRING FAULT

PROCEDURE OR ACTION:

1. Measure voltage between the display connector CPS50, socket 5 and B(-).
   Is battery voltage present?
   YES: Proceed to Step 2.
   NO: Inspect battery voltage circuit for open or short.
2. Measure voltage between the display connector CPS50, socket 2 and socket 5.
   Is battery voltage present?
   YES: Proceed to Cause C.
   NO: Inspect ground circuit for open or short.

CAUSE C - FAULTY DISPLAY

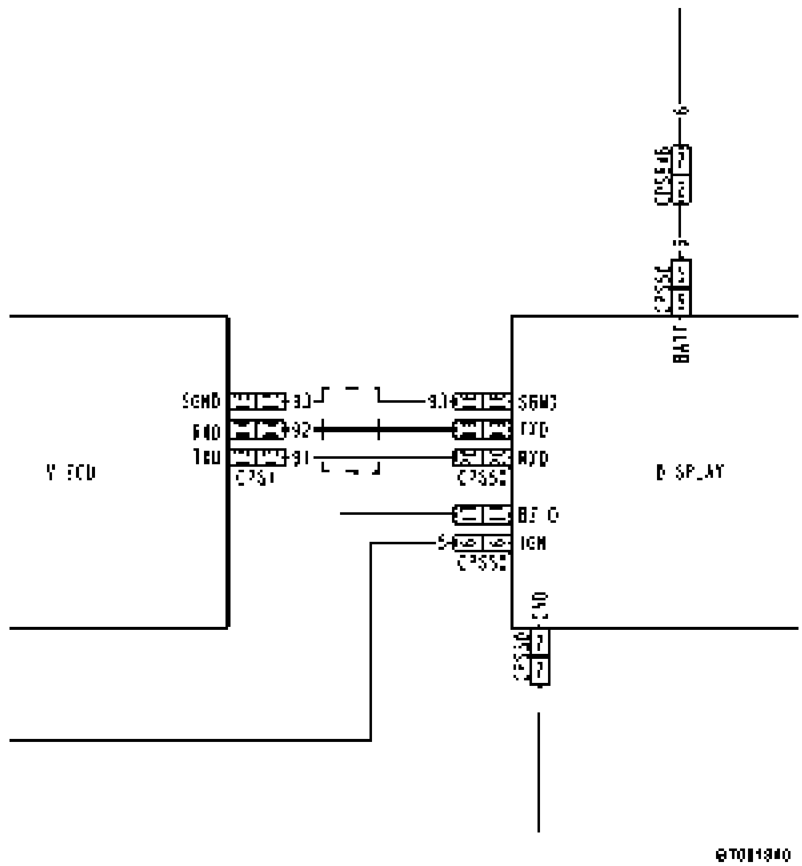
PROCEDURE OR ACTION:

1. Replace faulty display. Make sure to indicate the DTC code(s) on the warranty claim to include an accurate problem description leading to controller replacement.

END POSSIBLE CAUSES

(Cont)

DTC ERRC008 TRUCK CAN NOT TRAVEL DIAGRAMS



Troubleshooting Scene

END FAULT

DTC ErrC020
Forward / Reverse Lever

POSSIBLE CAUSE

A. FORWARD / REVERSE LEVER BATTERY VOLTAGE FAULT
B. FORWARD / REVERSE LEVER FAULT
C. FAULTY V-ECU

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

NOTE: Ensure proper calibration before performing any troubleshooting procedures.

PROCEDURE OR ACTION:

The vehicle ECU controls various truck input and outputs: Solenoids, forward / reverse shift lever, transmission functions, and forward / reverse solenoids. These components are capable of setting dedicated error codes that will isolate the V-ECU fault. In addition, the V-ECU may set internal failure errors. The following procedure provides diagnostics for specific V-ECU controlled components.

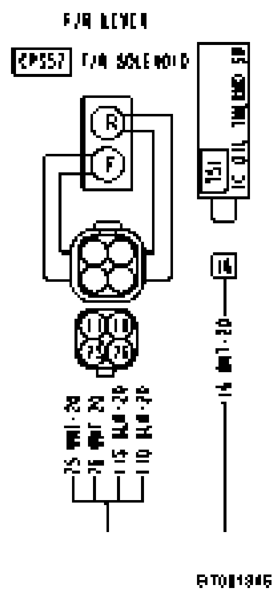


Figure 9030-20-47. Forward Solenoid Connector

DTC ErrC020 (Cont)
Forward / Reverse Lever

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - FORWARD / REVERSE LEVER BATTERY VOLTAGE FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect the forward / reverse lever connector CPS349 and measure voltage between socket 3 and socket 4.
   Is battery voltage present?
   YES: Reconnect connector CPS349 and proceed to Cause B.
   NO: Inspect voltage input circuits for open or short.

CAUSE B - FORWARD / REVERSE LEVER FAULT

PROCEDURE OR ACTION:

NOTE: Key in ON position.

1. Disconnect V-ECU connector CPS5 and measure voltage between the following while operating lever:
   - V-ECU connector, socket 22 and B(-) with lever in neutral position.
   - V-ECU connector, socket 8 and B(-) with lever in forward position.
   - V-ECU connector, socket 9 and B(-) with lever in reverse position.

   Is battery voltage present when lever operated?
   YES: Proceed to Cause C.
   NO: Replace faulty lever.

CAUSE C - FAULTY V-ECU

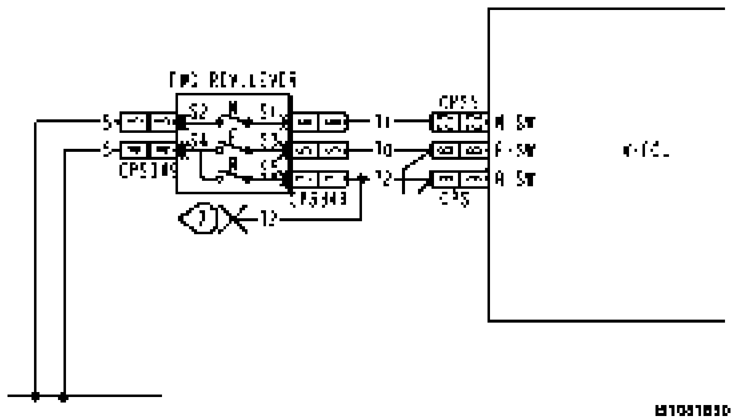
PROCEDURE OR ACTION:

1. Replace faulty V-ECU. Make sure to indicate the DTC code(s) on the warranty claim to include an accurate problem description leading to controller replacement.

END POSSIBLE CAUSES

DTC ErrC020 (Cont)
Forward / Reverse Lever

DTC ERRC020 FORWARD / REVERSE LEVER DIAGRAMS



Troubleshooting Scene

END FAULT

CODES

DTC ErrC000 - Forward Solenoid
DTC ErrC003 - Reverse Solenoid

POSSIBLE CAUSE

A. FORWARD / REVERSE SOLENOID WIRING FAULT

B. FORWARD / REVERSE SOLENOID FAULT

C. FAULTY V-ECU

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

NOTE: Ensure proper calibration before performing any troubleshooting procedures.

PROCEDURE OR ACTION:

The vehicle ECU controls various truck input and outputs: Solenoids, forward / reverse shift lever, transmission functions, and forward / reverse solenoids. These components are capable of setting dedicated error codes that will isolate the V-ECU fault. In addition, the V-ECU may set internal failure errors. The following procedure provides diagnostics for specific V-ECU controlled components.

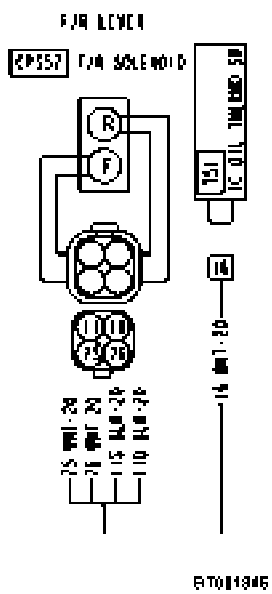


Figure 9030-20-48. Forward Solenoid Connector

(Cont)

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - FORWARD / REVERSE SOLENOID WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Perform Step 1 and Step 2 with key in ON position.

1. Disconnect the forward or reverse solenoid connector CPS57 and measure voltage between the following:
   - Forward Solenoid - socket 2 and B(-).
   - Reverse Solenoid - socket 1 and B(-).

   Is battery voltage present?
   YES: Proceed to Step 2.
   NO: Inspect power circuit 75 or circuit 76 for open or short between V-ECU and solenoid terminal.
2. Measure voltage between the forward solenoid connector CPS57, and the following:
   - Forward Solenoid - socket 2 and socket 4.
   - Reverse Solenoid - socket 1 and socket 3.

   Is battery voltage present?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect ground circuit 11 for open, short, or source of excessive resistance.

CAUSE B - FORWARD / REVERSE SOLENOID FAULT

PROCEDURE OR ACTION:

1. Measure resistance between forward solenoid terminals.
   Is resistance approximately 5Ω?
   YES: Proceed to Cause C.
   NO: Replace faulty solenoid.

CAUSE C - FAULTY V-ECU

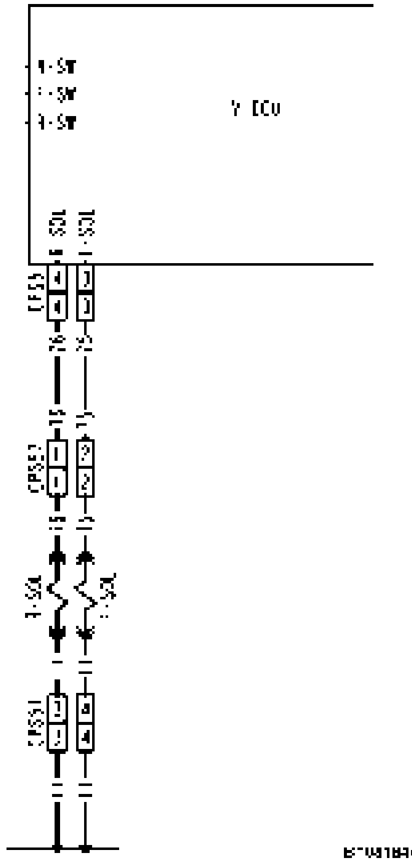
PROCEDURE OR ACTION:

1. Replace faulty V-ECU. Make sure to indicate the DTC code(s) on the warranty claim to include an accurate problem description leading to controller replacement.

END POSSIBLE CAUSES

(Cont)

DTC ERRC000 FORWARD SOLENOID DIAGRAMS



Troubleshooting Scene

END FAULT

CODES

DTC ErrC0012 / ErrC0013 - Speed Sensor
DTC ErrC330 - Limited Engine Speed
DTC ErrC332 - Limited Engine Speed
DTC ErrC358 - Limited Engine Speed
DTC ErrC359 - Limited Engine Speed

POSSIBLE CAUSE

A. SPEED SENSOR WIRING FAULT

B. SPEED SENSOR FAULT

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

NOTE: Ensure proper calibration before performing any troubleshooting procedures.

PROCEDURE OR ACTION:

The vehicle ECU controls various truck input and outputs: Solenoids, forward / reverse shift lever, transmission functions, and forward / reverse solenoids. These components are capable of setting dedicated error codes that will isolate the V-ECU fault. In addition, the V-ECU may set internal failure errors. The following procedure provides diagnostics for specific V-ECU controlled components.

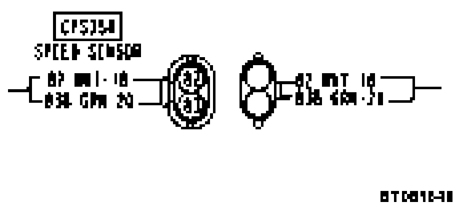


Figure 9030-20-49. Speed Sensor Connector

(Cont)

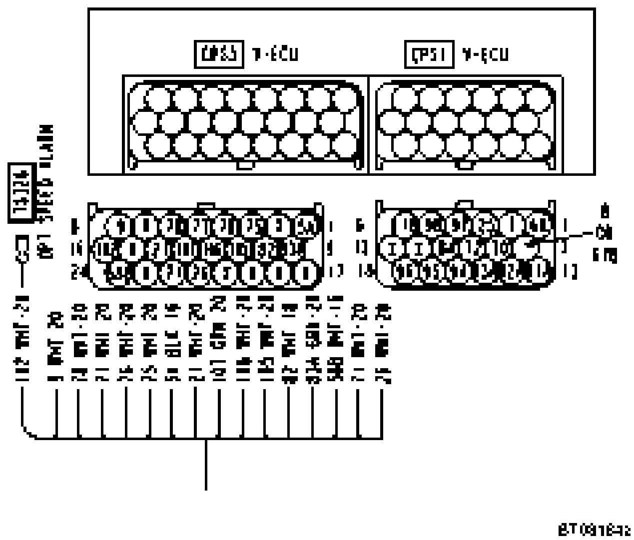


Figure 9030-20-50. V-ECU Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

CAUSE A - SPEED SENSOR WIRING FAULT

PROCEDURE OR ACTION:

1. Disconnect the speed sensor and measure resistance between the following:
   - V-ECU Connector CPS1, socket 10 and speed sensor connector CPS354, socket 1.
   - V-ECU Connector CPS1, socket 9 and speed sensor connector CPS354, socket 2.

   Is resistance ≤ 1 ohm?
   YES: Proceed to Cause B.
   NO: Inspect appropriate circuit for short, open, or source of excessive resistance.

CAUSE B - SPEED SENSOR FAULT

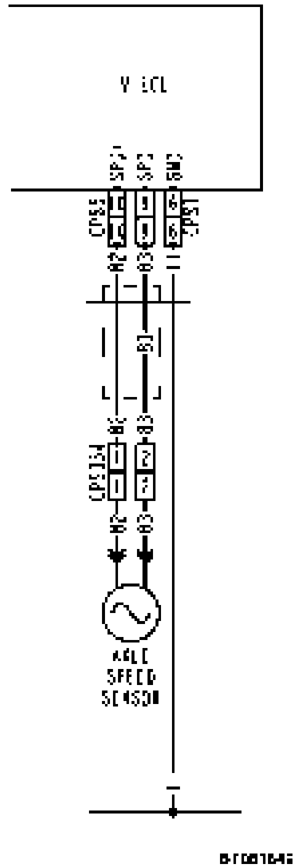
PROCEDURE OR ACTION:

Replace faulty speed sensor.

END POSSIBLE CAUSES

(Cont)

DTC ERRC0012 / ERRC0013 SPEED SENSOR DIAGRAMS



Troubleshooting Scene

END FAULT

CODES

DTC ErrC004 - Lift Solenoid
DTC ErrC005 - Lower Solenoid
DTC ErrC007 - Unload Solenoid

POSSIBLE CAUSE

A. LIFT / LOWER SOLENOID WIRING FAULT

B. LIFT / LOWER SOLENOID FAULT

C. FAULTY V-ECU

NOTE

Please refer to the end of this procedure for supporting diagrams.

COMPONENT OPERATIONAL CHECK

NOTE: Ensure proper calibration before performing any troubleshooting procedures.

PROCEDURE OR ACTION:

The vehicle ECU controls various truck input and outputs: Solenoids, forward / reverse shift lever, transmission functions, and forward / reverse solenoids as well as lift / lower solenoids. These components are capable of setting dedicated error codes that will isolate the V-ECU fault. In addition, the V-ECU may set internal failure errors. The following procedure provides diagnostics for specific V-ECU controlled components.

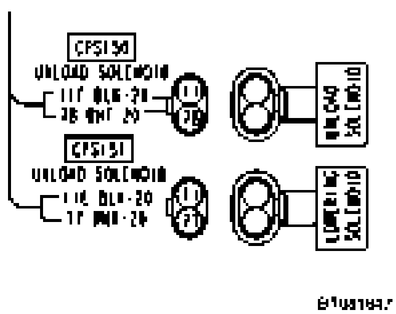


Figure 9030-20-51. Lift / Lower and Unload Solenoid Connector

1. Turn power to **OFF** for no less than 30 seconds, and then to **ON** to clear displayed DTC.
   Does reported DTC reoccur?
   YES: Go to Step 2.
   NO: Problem not verified. Resume operation.
2. Conduct a quick visual inspection of all connectors/wiring associated with the displayed fault code.
   Are any faults detected/observed?
   YES: Repair/replace connector or wiring associated with faults found. Refer to the appropriate **Electrical System** SRM .
   NO: Go to Cause A.

(Cont)

CAUSE A - LIFT / LOWER SOLENOID WIRING FAULT

PROCEDURE OR ACTION:

NOTE: Perform Step 1 and Step 2 with key in ON position.

1. Disconnect the appropriate solenoid connector CPS150/151 and measure voltage between socket 1 and B(-).
   Is battery voltage present?
   YES: Proceed to Step 2.
   NO: Inspect power circuit for open or short between V-ECU and solenoid terminal.
2. Measure voltage between the forward solenoid connector CPS150/151, socket 1 and socket 2.
   Is battery voltage present?
   YES: Disconnect battery and proceed to Cause B.
   NO: Inspect ground circuit for open, short, or source of excessive resistance.

CAUSE B - LIFT / LOWER SOLENOID FAULT

PROCEDURE OR ACTION:

1. Measure resistance between the appropriate solenoid terminals.
   Is resistance approximately 9Ω?
   YES: Proceed to Cause C.
   NO: Replace faulty solenoid.

CAUSE C - FAULTY V-ECU

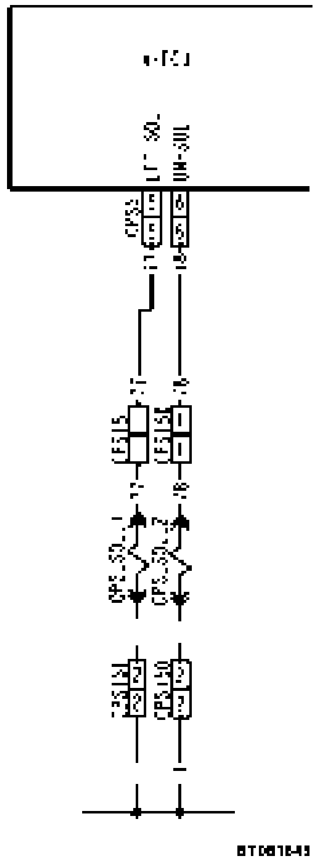
PROCEDURE OR ACTION:

1. Replace faulty V-ECU. Make sure to indicate the DTC code(s) on the warranty claim to include an accurate problem description leading to controller replacement.

END POSSIBLE CAUSES

(Cont)

DTC ERRC004 LIFT SOLENOID DIAGRAMS



Troubleshooting Scene

END FAULT

Group 30

Observed Symptoms

Electrical Functions Do Not Operate

POSSIBLE CAUSE

A. FUSE BLOWN/SHORT CIRCUIT IN POWER CONNECTION
B. RELAY CONTACTS DO NOT CLOSE WHEN COIL IS ENERGIZED
C. OPEN CIRCUIT IN HARNESS

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

1. Using the display, locate DIAGNOSTICS and observe truck DATA DISPLAY.
2. Operate input of appropriate faulty component.
   Does display show Switch operating correctly?
   YES: Go to Cause B.
   NO: Refer to appropriate Electrical System manual for display operation and replacment procedures.

CAUSE A - FUSE BLOWN/SHORT CIRCUIT IN POWER CONNECTION

PROCEDURE OR ACTION:

1. Locate device fuse.
   Is fuse value correct?
   YES: Go to Step 2.
   NO: Replace with correct value fuse and check device for correct operation. Refer to Figure 9030-10-14.
2. Disconnect harness connector at device. Turn power **ON**. Actuate device push button.
3. Using a DMM, measure for voltage across harness connector pins.
   Is battery voltage present?
   YES: Replace device and check circuit operation.
   NO: Go to Cause C.

CAUSE B - RELAY CONTACTS DO NOT CLOSE WHEN COIL IS ENERGIZED

PROCEDURE OR ACTION:

1. Disconnect PDM connector for relevant circuit. Using a DMM, connect negative probe to battery ground terminal. Turn power **ON** and actuate the device push button. Measure voltage at PDM socket pin as indicate in circuit schematic. Refer to Figure 9030-10-14 and Figure 9030-10-9.
   Is battery voltage present?
   YES: Relay is OK. Go to Cause D.
   NO: Relay may be cause of failure.

CAUSE C - OPEN CIRCUIT IN HARNESS

PROCEDURE OR ACTION:

1. Disconnect harness at device and PDM. Using a DMM, measure resistance across each wiring lead. (See circuit schematic.)
   Is resistance less than 0.5 ohms?
   YES: Replace PDM.
   NO: Repair or replace wiring harness.

END SYMPTOM

Electrical Function Does Not Turn Off

POSSIBLE CAUSE

A. **SHORT TO SWITCHED OR UNSWITCHED BATTERY IN HARNESS**
B. **FUSED RELAY CIRCUIT**
C. **POWER DISTRIBUTION MODULE SHORT**

COMPONENT OPERATIONAL CHECK

PROCEDURE OR ACTION:

1. Using the display, locate DIAGNOSTICS and observe truck DATA DISPLAY.
2. Operate input of appropriate faulty component.
   Does display show Switch Operating Correctly?
   YES: Go to Cause B.
   NO: Replace display.

CAUSE A - SHORT TO SWITCHED OR UNSWITCHED BATTERY IN HARNESS

PROCEDURE OR ACTION:

NOTE: Refer to the overall Electrical System Schematics.

1. Turn power **OFF**. Disconnect relevant wiring harness connector from the PDM, refer to Figure 9030-10-9. Turn power **ON**.
   Does device continue to operate?
   YES: Go to Step 2.
   NO: Go to Cause C.
2. Turn power **OFF**. Inspect harness for short to battery.
   Is harness shorted to battery?
   YES: Repair or Replace harness.
   NO: Go to Cause C.

CAUSE B - FUSED RELAY CIRCUIT

PROCEDURE OR ACTION:

1. Reconnect PDM connector and remove relevant relay. Refer to Figure 9030-10-14.
   Does device continue to operate?
   YES: Go to Cause D.
   NO: Go to Step 2.
2. Using a DMM, check for a short circuit by measuring resistance across relay contacts.
   Are relay contacts shorted?
   YES: Replace relay and check circuit operation.
   NO: Go to Cause D.

CAUSE C - POWER DISTRIBUTION MODULE SHORT

PROCEDURE OR ACTION:

1. Remove relevant circuit fuse and relay, refer to Figure 9030-10-14. Using a multimeter, connect negative probe to Battery Ground terminal. Measure for battery voltage on each terminal of fuse socket.
   Is voltage present on both ends?
   YES: PDM shorted to battery between fuse socket and relay socket. Replace PDM.
   NO: Go to Step 2.
2. Remove relevant circuit relay. Using a multimeter, connect negative probe to Battery Ground terminal. Measure for battery voltage on the device side of relay contacts.
   Is voltage present at relay socket?
   YES: PDM shorted to battery between relay socket and connector. Replace PDM.
   NO: Reinstall all removed components and repeat component operational check.

END SYMPTOM

Vehicle Does Not Power On

No Display Activity or Diagnostic Trouble Code (DTC)

POSSIBLE CAUSE

A. **LOW VOLTAGE**
B. **OPEN CONNECTION IN POWER CIRCUIT. (CONNECTOR PINS, SOCKETS, BROKEN WIRES)**
C. **SHORTED TRANSIENT SUPPRESSOR TRANSZORB**

CAUSE A - LOW VOLTAGE

PROCEDURE OR ACTION:

1. Open engine cover to gain access to battery and Power Distribution Module (PDM). See **Operating Manual**.
2. Examine connections between battery and PDM, refer to Figure 9030-10-12.
   Are connections correct and secure?
   YES: Go to Step 1.
   NO: Connect cables, as required.

PROCEDURE OR ACTION:

3. Using a DMM, measure voltage across the PDM terminals (B+) and (B-) beneath red safety cover.
   Is voltage at least 9 Vdc?
   YES: Go to Step 1.
   NO: Charge or replace battery.

PROCEDURE OR ACTION:

4. At the PDM, open access cover.
5. Measure voltage on both sides of fuse F3 (+) with respect to ground (-). Refer to Figure 9030-10-9.
   Is voltage on one side of fuse less than 0.5 Vdc?
   YES: Test circuit for short to ground, repair if necessary. Replace fuse and retest system.
   NO: Fuse F3 is OK. Go to Cause B.

CAUSE B - OPEN CONNECTION IN POWER CIRCUIT. (CONNECTOR PINS, SOCKETS, BROKEN WIRES)

PROCEDURE OR ACTION:

1. Disconnect display connector CPS50 and ECU connector CPS1.
2. Measure voltage between the following:
   - Display connector CPS50, socket 5
   - ECU connector CPS1, socket 1

   Is battery voltage present?
   YES: Replace faulty display or ECU.
   NO: Inspect appropriate battery supply circuits for open or short. Inspect appropriate connectors for loose, damaged, or corroded terminals. If no faults are present, proceed to Cause C.

CAUSE C - SHORTED TRANSIENT SUPPRESSOR TRANSZORB

PROCEDURE OR ACTION:

1. Remove transient suppressor TRANSZORB (A) from PDM. See Figure 9030-10-14.
2. Using a DMM, set to ohms. Test TRANSZORB suppressor for short circuit across terminals. Reverse DMM probes and repeat short circuit test.
   Is either resistance reading <0.5 ohms?
   YES: Replace TRANSORB suppressor.
   - Close PDM cover.
   - Connect ground (-) cable to battery.
   - Resume operation.

   NO: Go to Step 3.
3. Inspect fuse F3.
   Is fuse F8 open?
   YES: Replace TRANSZORB suppressor and fuse F3.
   - Close PDM cover.
   - Connect ground (-) cable to battery.
   - Resume operation.

   NO: Replace PDM.

END SYMPTOM

SECTION 9040

DRIVE TRAIN

TABLE OF CONTENTS

Group 40 - Tests and Adjustments

Group 10

Principles of Operation

Mechanical Overview

The Drive Train power flow includes the following components:

1. Engine
2. Torque Converter
3. Transmission
4. Clutch Assemblies
5. Output Gear and Yoke
6. Driveshaft, Differential, and Drive Axle
7. Brakes

These components make up a mechanical system that transfers power from the engine to the ground. The Pump PTO, although it does not transfer power to the ground, does drive the transmission charge pump and hydraulic system pump. Therefore, the Pump PTO is included as part of the drive train.

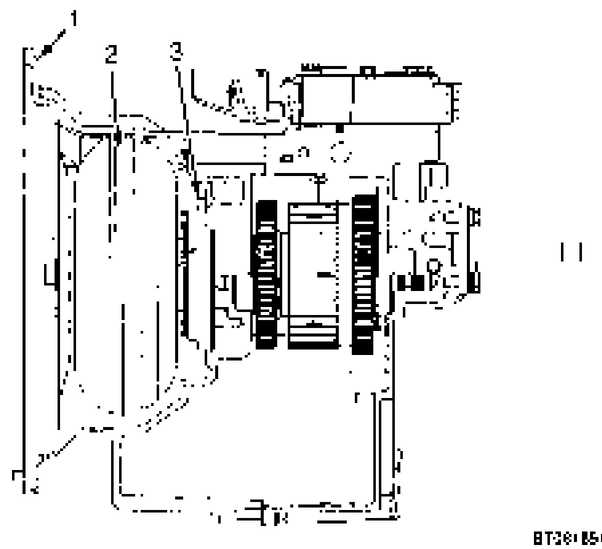
Torque Converter

DESCRIPTION

The torque converter hydraulically connects the engine to the transmission. It acts as a fluid coupling. There is no direct mechanical connection between the engine and the transmission. See Figure 9040-10-1. The torque converter has an impeller, a turbine, and a stator with a stator clutch. The impeller is fastened to the flywheel/flexplate and has a set of curved blades. The turbine also has blades, and is connected to the input shaft (forward clutch housing) of the transmission by splines. The stator is between the turbine and the impeller. The stator clutch is a single-direction clutch that permits the stator to turn freely in the direction of engine rotation, but locks to prevent rotation in the opposite direction of engine rotation. When the turbine is rotating at the same speed as the impeller, the stator clutch permits the stator to rotate as a unit with the impeller and turbine.

The torque converter has two main functions. It operates as a fluid clutch to smoothly transfer power from the engine to the transmission. The torque converter will also multiply the torque from the engine. When the engine works against a load, the torque converter can multiply the torque from the engine to the transmission. The maximum torque multiplication is available just before the torque converter stalls. If the need for torque multiplication is not required, the torque converter operates as a fluid coupling.

The impeller has a set of curved blades that accelerate the oil from the center of the impeller when the impeller turns. The volume of the impeller decreases toward the outer circumference. This decreasing volume increases the speed and energy of the oil as it leaves the impeller and flows into the outer circumference of the turbine. The force from the high-speed oil hitting the blades in the turbine transfers most of the energy to the turbine and causes it to move in the direction of engine rotation. The oil then flows from the outer circumference toward the center of the turbine. The turbine blades change the direction of the oil flow so that the oil leaving the center of the turbine is going in the direction opposite of engine rotation. This oil now has a lower velocity because it has given most of its energy to rotate the turbine.



1. TORQUE CONVERTER HOUSING
2. TORQUE CONVERTER ASSEMBLY
3. CHARGE PUMP

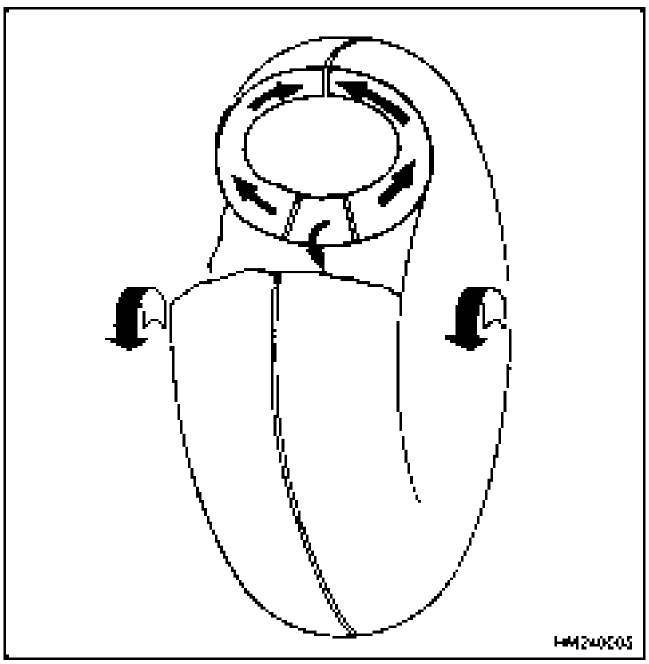
Figure 9040-10-1. Torque Converter

Stator

The stator is between the turbine and impeller in the center of the torque converter. When the oil hits the stator blades, the stator clutch prevents the stator from turning in the direction opposite of engine rotation. The blades of the stator change the direction of the oil so that the oil enters the impeller in the direction of engine rotation. The energy that remains in the oil flow as it leaves the stator is added to the new energy being added to the impeller by the engine. This use of energy, controlled by the stator, permits the torque converter to multiply the torque of the engine.

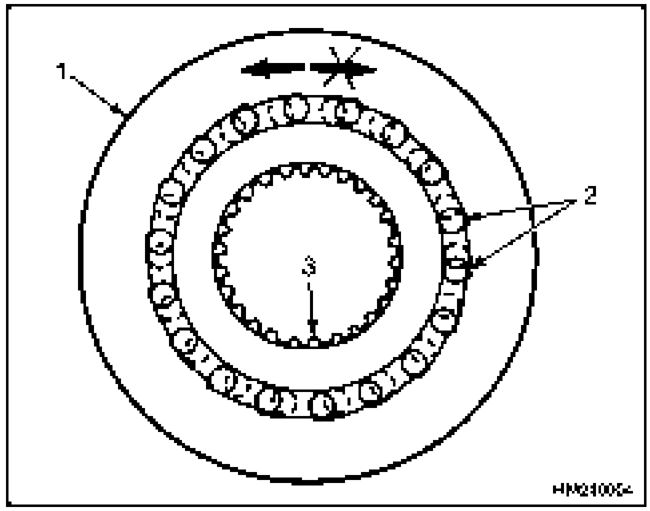
Turbine

Resistance to the flow of oil in the turbine, because of centrifugal force, increases as the speed of the turbine increases. This resistance decreases the energy and amount of oil flow to the impeller from the stator. When the flow to the impeller decreases, the additional force added to the impeller decreases. Less torque is generated when less torque is needed. When the lift truck is traveling at a constant speed on level ground, the turbine and impeller rotate at approximately the same speed. See Figure 9040-10-2. The centrifugal force of the oil is the same for both the impeller and turbine. The oil does not flow through the stator, and torque is not multiplied. The rotating oil hits the back of the stator blades and turns the stator in the direction of engine rotation. The stator clutch permits the stator to turn with engine rotation. The impeller, turbine, stator, and oil rotate as a unit when torque multiplication is not required. See Figure 9040-10-3.



NOTE: LIFT TRUCK TURBINE AT CONSTANT SPEED, NO TORQUE MULTIPLICATION IN EFFECT.

Figure 9040-10-2. Turbine



1. OUTER RACE
2. SPRAG
3. SPLINES ON INNER RACE

Figure 9040-10-3. Stator Clutch

When the lift truck begins to travel up a ramp, the resistance to turning the turbine increases. The centrifugal force of the oil in the turbine decreases. When the speed of the turbine is less than the speed of the impeller, the stator locks in place. Torque is multiplied only when the stator is held by the stator clutch. The oil flows from the impeller, through the turbine and stator, and enters the impeller to multiply the torque. The torque converter again increases the torque when more torque is needed.

Engine

DESCRIPTION

The engine is the prime mover. Engine torque is multiplied by the torque converter. For further description and Principles of Operation of the engine, see **Engine Basics**.

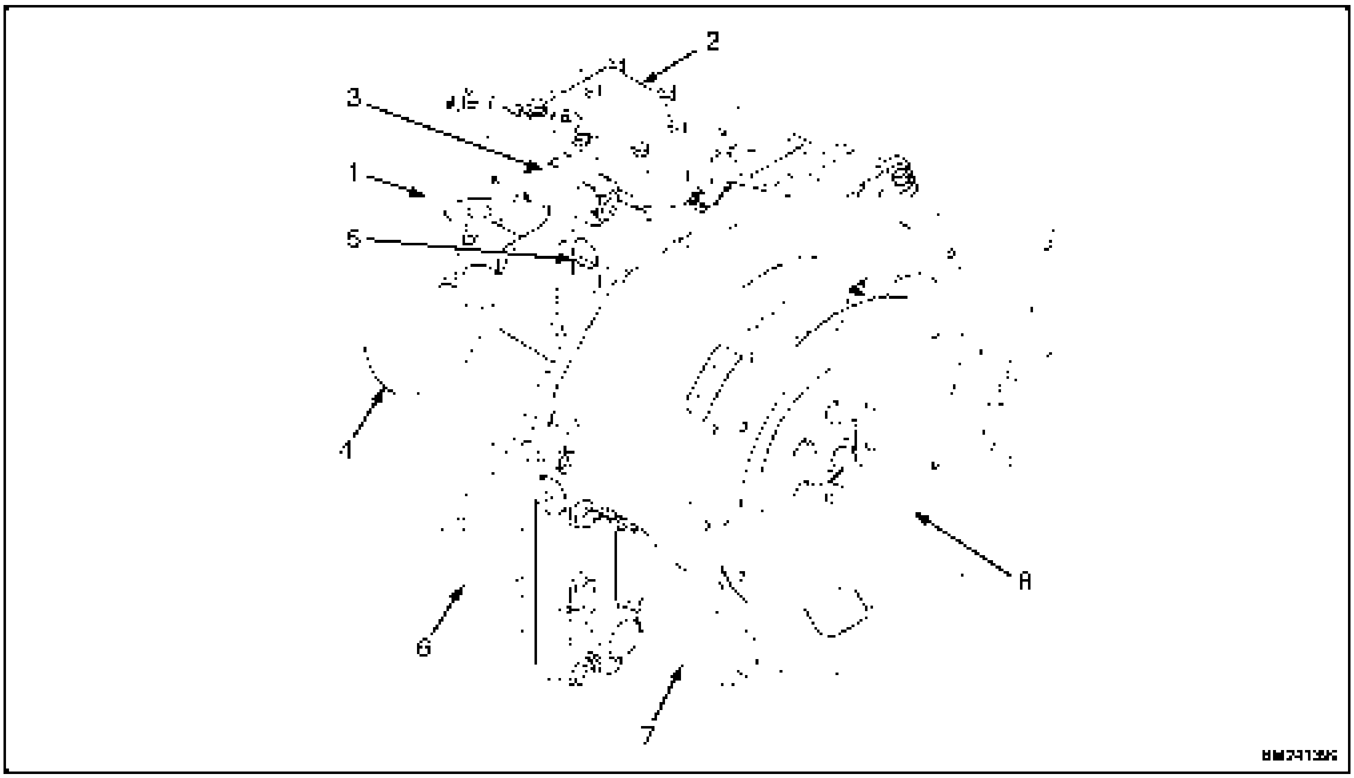
Transmission

DESCRIPTION

The transmission is mounted directly to the engine block. Engine power is transmitted through a torque converter to hydraulic clutch packs. Engagement of clutch packs is controlled by either proportional valves or solenoid valves, depending on transmission type.

LIFT TRUCK TRANSMISSIONS

The single-speed transmission is a constant mesh counter shaft transmission that has one forward and one reverse speed. The transmission has two clutches, an Input (Forward 1) and Counter (Reverse 1) clutch, which are applied hydraulically and released by spring force.



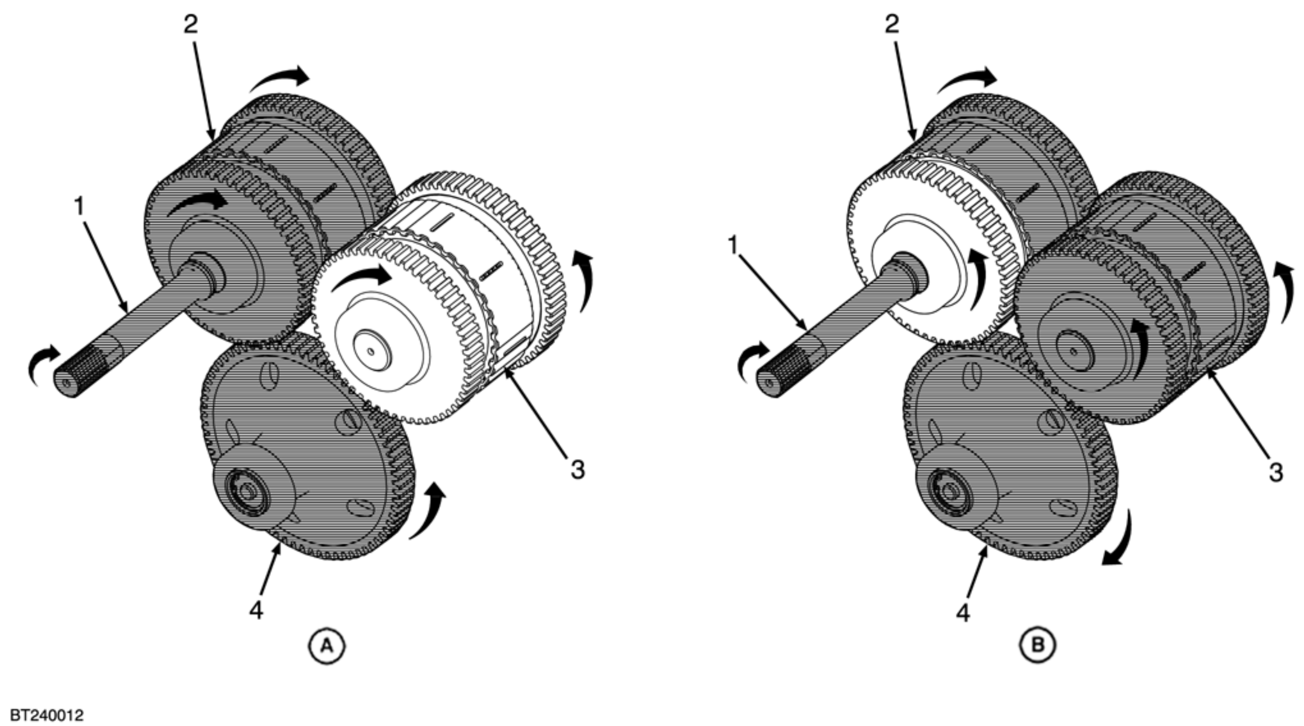
1. TRANSMISSION MOUNTING BRACKET
2. CONTROL VAVLE
3. SOLENOID VALVE
4. OIL FILTER
5. DIPSTICK
6. TRANSMISSION HOUSING
7. TORQUE CONVERTER HOUSING
8. TORQUE CONVERTER

Figure 9040-10-4. Single-Speed Powershift Transmission

Power Flow

Forward Operation: When the Input (Forward 1) clutch is applied, the power from the engine is sent through the Input (Forward 1) clutch assembly to the output gear. The flow of power is from the input shaft (part of the Forward 1 clutch housing) through the applied clutch to the Forward 1 hub. The gear on the hub of the Input (Forward 1) clutch is engaged with the output gear. The power flows from the applied clutch in the transmission through the drive shaft to the drive axle. The gear on the outside of the Input (Forward 1) clutch housing is engaged with the gear on the outside of the Counter (Reverse 1) clutch housing. The gear on the Counter (Reverse 1) clutch hub is engaged with the output gear on the pinion. These gears are always engaged so that they rotate, but when the Counter (Reverse 1) clutch is released, they do not transfer power.

Reverse Operation: When the Counter (Reverse 1) clutch is applied, the Input (Forward 1) clutch is released. The flow of power is from the input shaft (Forward 1 clutch housing) to the Counter (Reverse 1) clutch housing. The power is transferred through the pplied Counter (Reverse 1) clutch to the hub. The hub gear transfers the power to the output gear. The output gear will rotate in the opposite direction as it did when the Input (Forward 1) clutch was applied. See .



NOTE: ARROWS SHOW COMPONENT ROTATION. SHADING SHOWS POWER TRANSFER WHEN CLUTCH PACKS ARE PRESSURIZED.

A. FORWARD 1 CLUTCH PACK ENGAGED

B. REVERSE 1 CLUTCH PACK ENGAGED

1. INPUT SHAFT
2. FORWARD 1 CLUTCH
3. REVERSE 1 CLUTCH
4. TRANSMISSION OUTPUT GEAR

Figure 9040-10-5. Power Transfer Through Clutch Assemblies

Transmission Control System Overview

TRANSMISSION CONTROL SYSTEM

The system consists of operator and transmission.

The operator inputs include the following:

- Directional Control Lever
- MONOTROL® Pedal
- Accelerator Pedal
- Inch/brake Pedal
- Parking Brake Lever

The V-ECU outputs to the transmission include:

- FWD (Forward) Clutch Pack Pressure control current
- REV (Reverse) Clutch Pack Pressure control current

Transmission Control Hardware

CONTROL VALVE AND SENSORS

Description

The control valve includes a manual spool valve for inching; an electric solenoid valve to feed the forward, reverse clutch packs, or dump to tank for neutral. The assembly is installed on the top of the transmission. See Figure 9040-10-6.

Torque Converter Regulator receives oil flow through an orifice in the bore of the clutch pressure regulator. The torque converter pressure regulator stays closed until pressure to the torque converter increases to 758 - 793 kPa (110 - 115 psi). When the pressure regulator for the torque converter opens, the oil that is not directed to the torque converter flows directly to sump. The oil that flows to the torque converter goes through the oil cooler before entering the passage to cool and lubricate the clutches.

Principles of Operation

The transmission control valve controls clutch pack engagement.

The clutch packs receive regulated pressure oil through the solenoid valve spool. The proportional valves control the pressure in forward and reverse clutch packs. Inputs from the park brake lever position and seat occupied sensor are used to enable transmission control.

1. TRANSMISSION WIRING HARNESS
2. TRANSMISSION WIRING HARNESS CONNECTOR (TO CONTROL VALVE)
3. CONTROL VALVE CONNECTOR
4. CONTROL VALVE
5. SOLENOID VALVE
6. TRANSMISSION WIRING HARNESS CONNECTOR (TO TRANSMISSION)

Figure 9040-10-6. Control Hardware Components

DIRECTIONAL CONTROL LEVER

Principles of Operation

The directional control lever has three detent positions. The forward position corresponds to the selected forward direction of travel, the middle position corresponds to neutral, and the aft position corresponds to the selected reverse direction of travel.

The direction control lever is mounted on the display. It controls a Hall effect sensor which directs the transmission control circuit to send signals to the transmission proportional valves to engage for transmission movement.

Before the lift truck will move the following conditions must be met:

- Operator must be present in seat
- Directional control lever must be in the neutral position prior to starting the engine
- Engine running and not cranking (starting)

WARNING

The park brake lever is not required to be released. It is possible to drive the transmission against the park brake on a directional lever equipped truck.

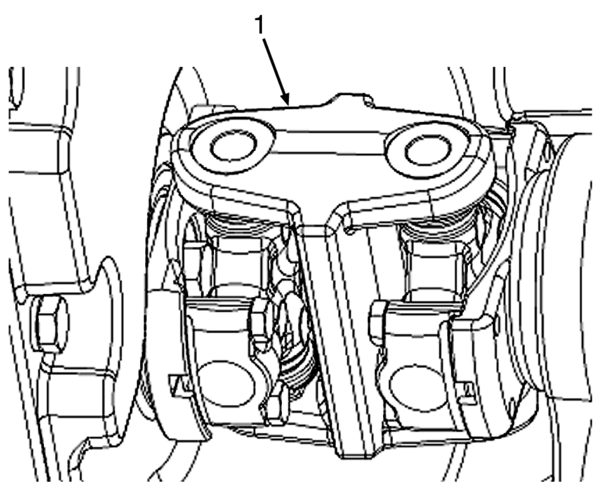
When any one of the following conditions occur, the transmission shifts to neutral regardless of lever position.

- Operator not present in seat
- Some diagnostic faults cause the transmission to shift to neutral
- When the engine is not running transmission control pressure is lost and the transmission is effectively in neutral

Driveshaft, Differential, Drive Axle, and Brakes (Dry Brake Only)

DRIVESHAFT

The driveshaft transfers power between the transmission and the drive axle. The driveshaft also allows the transmission and engine to be isolated from the frame. If the transmission and engine were mounted directly to the axle, their vibrations would be passed to the frame and the noise and vibration levels would be much higher. See Figure 9040-10-7.



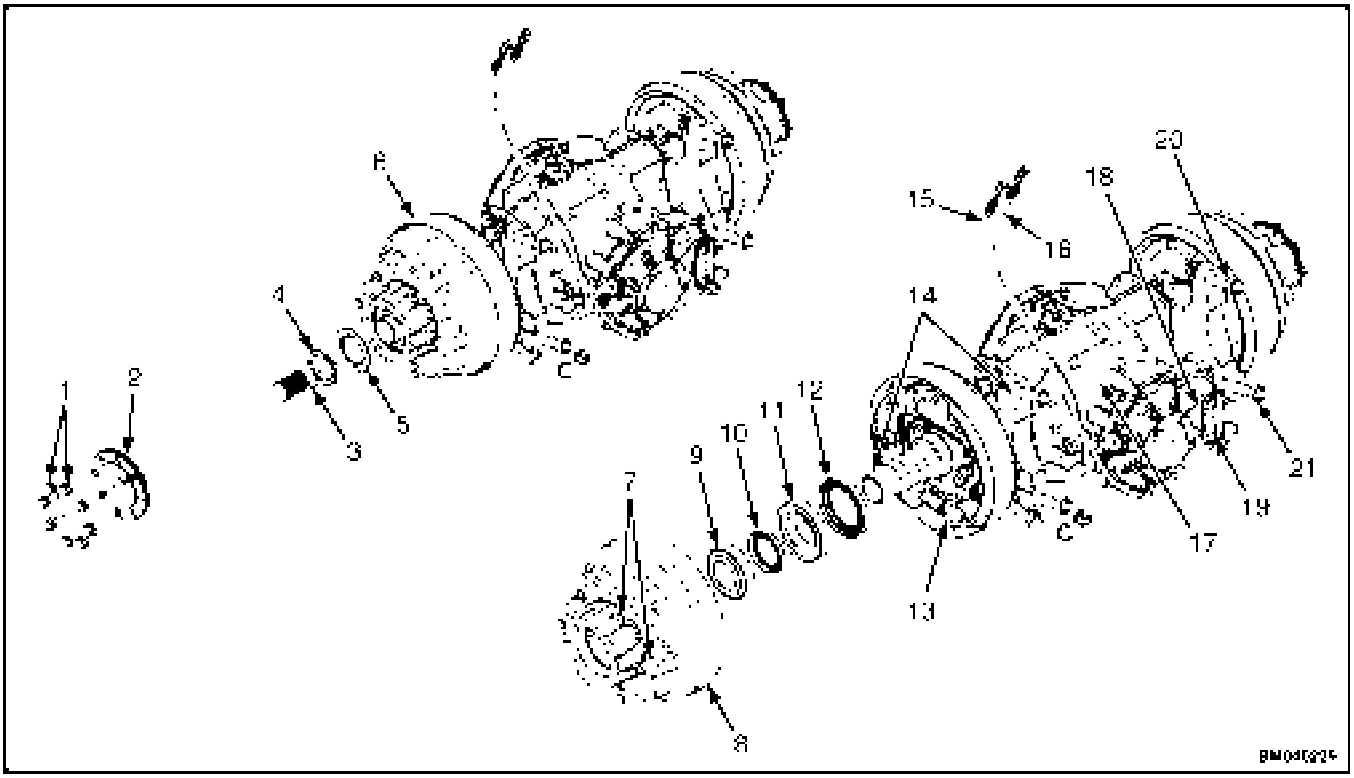
1. DRIVESHAFT ASSEMBLY

Figure 9040-10-7. Driveshaft Assembly

DIFFERENTIAL AND DRIVE AXLE

The differential receives power from the transmission via a short driveshaft connected to the input yoke. Power is sent through a drop box reduction gear to the pinion shaft. The ring and pinion is also a gear reduction which increases the torque to the drive wheels. The differential assembly permits the drive wheels to turn at different speeds when the lift truck is turning a corner. The ring and pinion gears are held in position in the differential housing. The axle shaft side gears are meshed to a spider gear assembly that is turned by the ring gear. See Figure 9040-10-8.

The drive axle is held to the lift truck by axle mounts. These axle mounts are fastened to the frame of the lift truck by four bolts. The differential mounts solidly to the frame. The outer ends of the spindles are the mounts for the wheel bearings. The wheel bearings are tapered roller bearings with the cups pressed into the hub/brake drum. The nut on the end of the spindle holds and adjusts the wheel bearings. The axle shafts are fastened to the hubs by cap screws. The back plate and brake assembly are fastened to the axle housing mounts. The axle housing provides the J-hook hangers for the mast. The outer wheel bearing is lubricated with gear oil from the differential housing. The inner wheel bearing is lubricated with wheel bearing grease.



1. CAPSCREW
2. DRIVE AXLE SHAFT
3. SET SCREW
4. LOCKNUT
5. LOCKWASHER
6. HUB/BRAKE ASSEMBLY
7. HUB BOLT
8. HUB
9. ROLLER BEARING
10. OUTER SEAL
11. INNER BEARING
12. INNER SEAL
13. BRAKE ASSEMBLY
14. SPINDLE/HANGER ASSEMBLY
15. LEFT BRAKE LINE
16. RIGHT BRAKE LINE
17. CENTER COVER
18. DUST COVER
19. INPUT SHAFT (YOKE)
20. DRIVE AXLE MOUNTING CAPSCREW
21. DRIVE AXLE MOUNTING NUT

Figure 9040-10-8. Differential and Drive Axle Components

BRAKE SYSTEM

Description

The brake system includes the following parts: master cylinder, brake shoes, wheel cylinders, and parking brake system.

Service Brakes

A service brake assembly is installed on the mounts at each end of the drive axle. See Figure 9040-10-9. When the brake pedal is pushed, fluid pressure from the master cylinder causes the pistons in the wheel cylinder to extend. The pistons expand the brake shoes against the drums. The clearance between the brake shoes and the brake drum is adjusted automatically. An adjuster linkage turns the adjuster wheel to adjust the clearance. When the lift truck moves in the reverse direction and the brakes are applied, the rear brake shoe and the adjuster links move with the drum. This linkage moves the adjuster lever to rotate the adjuster wheel. The adjuster wheel can turn only when there is clearance between the lining of the brake shoe and the brake drum. The adjuster wheel can also be turned with a tool. A slot in the back plate gives access to the adjuster wheel.

Master Cylinder

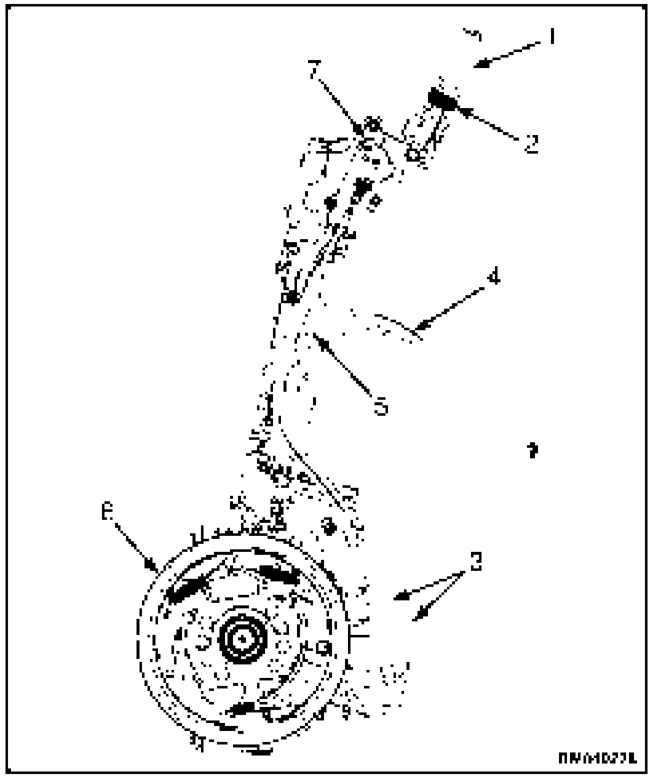
The master cylinder is designed for a single-circuit system. The master cylinder has a piston that operates in the bore of the master cylinder. See Figure 9040-10-10.

NOTE: The reservoir is located to the right of the park brake and is attached to the cowl.

The reservoir is equipped with an indicator for low fluid level. A float in the reservoir moves up and down with the fluid level. When the fluid level is low, a magnet on the float activates a switch in the bottom of the reservoir. This switch signals the display, which illuminates a light on the display.

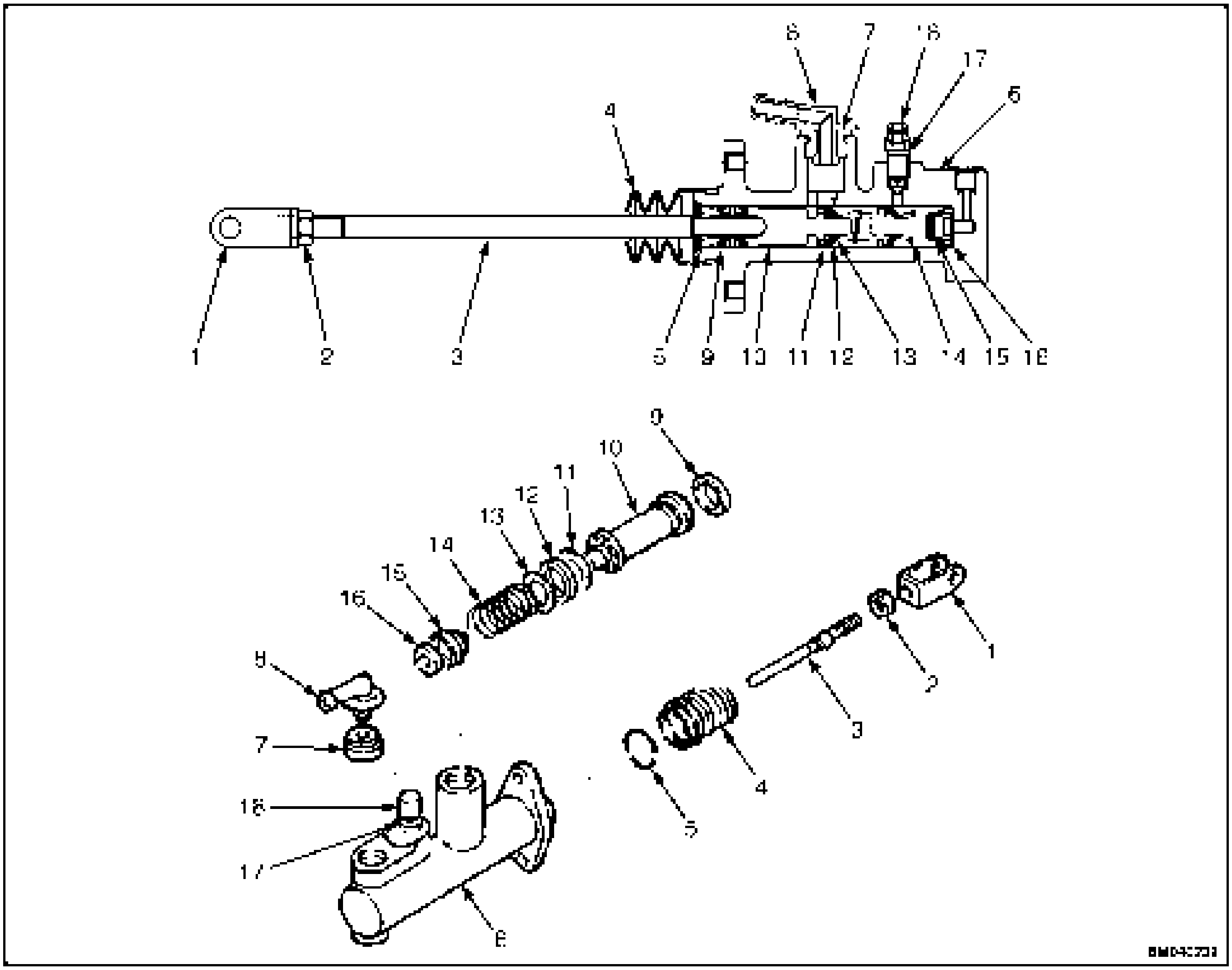
Parking Brake

The parking brake system uses the service brake shoes. Additional linkage activates the parking brake system. When the lever is moved to apply the parking brake, the cables and linkage expand the brake shoes against the drums. The design of the parking brake linkage adjusts each cable so that the tension is the same when the lever is moved to apply the parking brake. The park brake sensor is located on the right side of the park brake handle.



1. PARK BRAKE LEVER
2. ADJUSTMENT KNOB
3. PARK BRAKE CABLES
4. INCHING/BRAKE PEDAL
5. MASTER CYLINDER
6. BRAKE ASSEMBLY
7. PARK BRAKE SENSOR

Figure 9040-10-9. Brake System



1. YOKE
2. NUT
3. PUSH ROD
4. BOOT
5. SNAP RING
6. CYLINDER HOUSING
7. SEAL
8. FITTING
9. PISTON SEAL
10. PISTON
11. SPACER
12. PISTON CUP
13. RETAINER
14. SPRING
15. CHECK VALVE
16. VALVE SEAT
17. BLEEDER VALVE
18. CAP

Figure 9040-10-10. Master Cylinder

NOTES

Group 30

Observed Symptoms

Overheating Brakes (Dry Brake Axle Only)

POSSIBLE CAUSE

A. PARKING BRAKE IS NOT RELEASED.
B. PARKING BRAKE LEVER IS OUT OF ADJUSTMENT.
C. BRAKE SHOES OUT OF ADJUSTMENT.
D. MASTER CYLINDER IS DAMAGED.

CAUSE A - PARKING BRAKE IS NOT RELEASED.

PROCEDURE OR ACTION:

1. Release parking brake.
2. Inspect parking brake lever mechanism for interference.
   Does parking brake lever mechanism have interference?
   YES: Loosen parking brake lever and remove interference of lever mechanism. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause B.

CAUSE B - PARKING BRAKE LEVER IS OUT OF ADJUSTMENT.

PROCEDURE OR ACTION:

1. Check parking brake lever tension.
   Is parking brake lever tension too tight?
   YES: Loosen parking brake lever tension. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause C.

CAUSE C - BRAKE SHOES OUT OF ADJUSTMENT.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Rotate tires and check for correct brake shoe adjustment.
   Are brake shoes adjusted incorrectly?
   YES: Adjust brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause D.

CAUSE D - MASTER CYLINDER IS DAMAGED.

PROCEDURE OR ACTION:

1. Remove floor mat and plate.
2. Verify that linkage from brake pedals to master cylinder is connected.
3. Inspect master cylinder for leaks, binding, or damage.
   Is master cylinder leaking, binding, or damaged?
   YES: Repair or replace master cylinder. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of leakage, binding, or damage and correct as necessary.
   NO: Perform brake system operational check. See Operational Checkout Procedures.

END SYMPTOM

Poor Brake Performance (Dry Brake Axle Only)

POSSIBLE CAUSE

A. LOW BRAKE FLUID IN RESERVOIR.
B. AIR IS PRESENT IN BRAKE SYSTEM.
C. BRAKES OUT OF ADJUSTMENT.
D. BRAKE SHOES ARE WORN OR DAMAGED.
E. MASTER CYLINDER IS DAMAGED.
F. WHEEL CYLINDER LEAKING OR NOT OPERATING PROPERLY.
G. BRAKE DRUM IS CRACKED.
H. BACK PLATE IS DAMAGED.

CAUSE A - LOW BRAKE FLUID IN RESERVOIR.

PROCEDURE OR ACTION:

1. Inspect reservoir and master cylinder assembly for leaks. Verify that all brake system fittings are tight. Correct cause of brake fluid leakage as necessary.
2. Check brake fluid reservoir for proper fluid level.
   Is brake fluid below minimum mark in reservoir?
   YES: Fill reservoir with brake fluid. See **Operating Manual**.
   NO: Go to Cause B.

CAUSE B - AIR IS PRESENT IN BRAKE SYSTEM.

PROCEDURE OR ACTION:

1. Verify that reservoir and master cylinder assembly are not leaking and all brake system fittings are tight. Correct cause of leakage as necessary.
2. Press brake pedal several times. Free brake pedal travel is 10 - 12 mm (0.393 - 0.472 in.).
   Does brake pedal travel more than 10 - 12 mm (0.393 - 0.472 in.)?
   YES: Bleed air from brake lines. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of oil or brake fluid leaks and correct as necessary.
   NO: Go to Cause C.

CAUSE C - BRAKES OUT OF ADJUSTMENT.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Rotate tires and check for correct brake tension.
3. Check that brake adjustor is visible and brakes are correctly adjusted. Adjustment is 0.026 mm (0.001 in.) diameter per one notch of star wheel. With a minimum drum radius of 155 mm (6.10 in.), properly adjusted brake shoe clearance is 0.1 - 0.35 mm (0.004 - 0.014 in.) at maximum point of shoe width.
   Is brake shoes and brake drum clearance out of adjustment?
   YES: Replace brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of oil or brake fluid leaks and correct as necessary.
   NO: Go to Cause D.

CAUSE D - BRAKE SHOES ARE WORN OR DAMAGED.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Remove wheels and brake drums.
3. Inspect brake shoes for wear, damage, or glazing.
   Are brake shoes worn, damaged, or glazed?
   YES: Replace brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause E.

CAUSE E - MASTER CYLINDER IS DAMAGED.

PROCEDURE OR ACTION:

1. Remove floor mat and plate.
2. Verify that linkage from brake pedals to master cylinder is connected.
3. Inspect master cylinder for leaks, binding, or damage.
   Is master cylinder leaking, binding, or damaged?
   YES: Repair or replace master cylinder. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause F.

CAUSE F - WHEEL CYLINDER LEAKING OR NOT OPERATING PROPERLY.

PROCEDURE OR ACTION:

1. Inspect for oil or brake fluid around tire and wheel assemblies.
   Is oil or brake fluid present around tire or wheel assemblies?
   YES: Repair or replace wheel cylinder. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of wheel cylinder damage and correct as necessary.
   NO: Go to Cause G.

CAUSE G - BRAKE DRUM IS CRACKED.

PROCEDURE OR ACTION:

1. Remove wheel and tire assembly.
2. Inspect brake drum for cracks or damage.
   Is brake drum cracked or damaged?
   YES: Replace brake drum and adjust as necessary. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of brake drum damage and correct as necessary.
   NO: Go to Cause H.

CAUSE H - BACK PLATE IS DAMAGED.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Inspect back plate for damage.
   Is back plate damaged?
   YES: Replace back plate. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of back plate damage and correct as necessary.
   NO: Perform brake system operational check. See Operational Checkout Procedures.

END SYMPTOM

Brakes Make Too Much Noise (Dry Brake Axle Only)

POSSIBLE CAUSE

A. OIL OR BRAKE FLUID ON BRAKE SHOES.
B. BRAKE SHOES ARE WORN OR DAMAGED.
C. BRAKE DRUM IS DAMAGED.

CAUSE A - OIL OR BRAKE FLUID ON BRAKE SHOES.

PROCEDURE OR ACTION:

1. Inspect for oil or brake fluid around tire and wheel assemblies.
   Is oil or brake fluid present around tire or wheel assemblies?
   YES: Clean or replace brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of oil or brake fluid leaks and correct as necessary.
   NO: Go to Cause B.

CAUSE B - BRAKE SHOES ARE WORN OR DAMAGED.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Rotate tires and check for scrubbing sound or metal on metal contact.
   Is scrubbing sound or metal on metal contact detected?
   YES: Replace brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause C.

CAUSE C - BRAKE DRUM IS DAMAGED.

PROCEDURE OR ACTION:

1. Remove wheel and tire assembly.
2. Inspect brake drum for cracks or damage.
   Is brake drum cracked or damaged?
   YES: Replace brake drum. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of brake drum damage and correct as necessary.
   NO: Perform brake system operational check. See Operational Checkout Procedures.

END SYMPTOM

Brakes Pull To One Side (Dry Brake Axle Only)

POSSIBLE CAUSE

- **A. PARKING BRAKE LEVER IS OUT OF ADJUSTMENT.**
- **B. PARKING BRAKE CABLES ARE DAMAGED.**
- **C. BRAKE SHOES ADJUSTED TOO TIGHT.**
- **D. BRAKE SHOES OR SPRINGS ARE NOT INSTALLED CORRECTLY.**
- **E. DAMAGED OR CONTAMINATED BRAKE SHOES.**
- **F. WHEEL CYLINDER IS LEAKING.**
- **G. BRAKE DRUM IS DISTORTED.**
- **H. BACK PLATE IS DAMAGED.**
- **I. BRAKE LINES HAVE A RESTRICTION OR DAMAGED.**

CAUSE A - PARKING BRAKE LEVER IS OUT OF ADJUSTMENT.

PROCEDURE OR ACTION:

1. Check parking brake lever tension.
   Is parking brake lever tension too tight?
   YES: Loosen parking brake lever tension. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause B.

CAUSE B - PARKING BRAKE CABLES ARE DAMAGED.

PROCEDURE OR ACTION:

1. Remove floor mat and plate.
2. Visually inspect parking brake cables for damage.
   Are parking brake cables damaged?
   YES: Replace parking brake cables. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of parking brake cable damage and correct as necessary.
   NO: Go to Cause C.

CAUSE C - BRAKE SHOES ADJUSTED TOO TIGHT.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Rotate tires and check for correct brake shoe adjustment. Refer to appropriate **Brake System** manual, depending on lift truck model.
   Is brake shoes and brake drum clearance out of adjustment?
   YES: Adjust brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause D.

CAUSE D - BRAKE SHOES OR SPRINGS ARE NOT INSTALLED CORRECTLY.

PROCEDURE OR ACTION:

1. Check that brake adjustor is visible and brakes are correctly adjusted. Adjustment is 0.026 mm (0.001 in.) diameter per one notch of star wheel. With a minimum drum radius of 155 mm (6.10 in.), properly adjusted brake shoe clearance is 0.1 - 0.35 mm (0.004 - 0.014 in.) at maximum point of shoe width.
   Is brake shoes and brake drum clearance out of adjustment?
   YES: Inspect brake shoe installation and adjustment. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause E.

CAUSE E - DAMAGED OR CONTAMINATED BRAKE SHOES.

PROCEDURE OR ACTION:

1. Inspect brake shoes for contamination or damage.
   Is brake shoes contaminated or damaged?
   YES: Replace brake shoes as necessary. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause F.

CAUSE F - WHEEL CYLINDER IS LEAKING.

PROCEDURE OR ACTION:

1. Inspect for oil or brake fluid around tire and wheel assemblies.
   Is oil or brake fluid present around tire or wheel assemblies?
   YES: Repair or replace wheel cylinder. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of wheel cylinder leakage and correct as necessary. Inspect brake shoes for contamination, replace as necessary.
   NO: Go to Cause G.

CAUSE G - BRAKE DRUM IS DISTORTED.

PROCEDURE OR ACTION:

1. Inspect brake drum for distortion.
   Is brake drum distorted?
   YES: Repair or replace brake drum. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause H.

CAUSE H - BACK PLATE IS DAMAGED.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Inspect back plate for damage.
   Is back plate damaged?
   YES: Replace back plate. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause I.

CAUSE I - BRAKE LINES HAVE A RESTRICTION OR DAMAGED.

PROCEDURE OR ACTION:

1. Inspect brake lines for restrictions.
   Are any brake lines restricted?
   YES: Replace brake lines that are restricted. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of restriction and correct as necessary.
   NO: Perform brake system operational check. See Operational Checkout Procedures.

END SYMPTOM

Parking Brake Will Not Release

POSSIBLE CAUSE

A. PARKING BRAKE HAND LEVER IS ADJUSTED TOO TIGHTLY.
B. BRAKE SHOES OR SPRINGS ARE NOT INSTALLED CORRECTLY. (DRY BRAKE ONLY)
C. PARKING BRAKE CABLES ARE DAMAGED.
D. RETURN SPRINGS ARE DAMAGED.

CAUSE A - PARKING BRAKE HAND LEVER IS ADJUSTED TOO TIGHTLY.

PROCEDURE OR ACTION:

1. Check parking brake lever tension.
   Is parking brake hand lever tension too tight?
   YES: Loosen parking brake hand lever and check for interference of hand lever mechanism. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause B.

CAUSE B - BRAKE SHOES OR SPRINGS ARE NOT INSTALLED CORRECTLY. (DRY BRAKE ONLY)

PROCEDURE OR ACTION:

1. Check that brake adjustor is visible and brakes are correctly adjusted. Adjustment is 0.026 mm (0.001 in.) diameter per one notch of star wheel. With a minimum drum radius of 155 mm (6.10 in.), properly adjusted brake shoe clearance is 0.1 - 0.35 mm (0.004 - 0.014 in.) at maximum point of shoe width.
   Is brake shoes and brake drum clearance out of adjustment?
   YES: Inspect brake shoe installation and adjustment. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause C.

CAUSE C - PARKING BRAKE CABLES ARE DAMAGED.

PROCEDURE OR ACTION:

1. Inspect parking brake cables for damage.
   Are parking brake cables damaged?
   YES: Replace parking brake cables. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause D.

CAUSE D - RETURN SPRINGS ARE DAMAGED.

PROCEDURE OR ACTION:

1. Inspect return springs for damage.
   Are return springs damaged?
   YES: Replace damaged return spring. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Perform parking brake hand lever operational check. See Operational Checkout Procedures.

END SYMPTOM

Parking Brake Will Not Hold Lift Truck (Dry Brake Axle Only)

POSSIBLE CAUSE

A. PARKING BRAKE LEVER IS OUT OF ADJUSTMENT.
B. PARKING BRAKE CABLES ARE DAMAGED.
C. OIL OR BRAKE FLUID ON BRAKE SHOES.

CAUSE A - PARKING BRAKE LEVER IS OUT OF ADJUSTMENT.

PROCEDURE OR ACTION:

1. Check parking brake lever tension.
   Is parking brake lever tension too loose?
   YES: Tighten parking brake lever tension. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause B.

CAUSE B - PARKING BRAKE CABLES ARE DAMAGED.

PROCEDURE OR ACTION:

1. Remove floor mat and plate.
2. Visually inspect parking brake cables for damage.
   Are parking brake cables damaged?
   YES: Replace parking brake cables. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause C.

CAUSE C - OIL OR BRAKE FLUID ON BRAKE SHOES.

PROCEDURE OR ACTION:

1. Inspect for oil or brake fluid around tire and wheel assemblies.
   Is oil or brake fluid present around tire or wheel assemblies?
   YES: Clean or replace brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model. Inspect for cause of oil or brake fluid leaks and correct as necessary.
   NO: Perform parking brake lever operational check. See Operational Checkout Procedures.

END SYMPTOM

Abnormal Drive Axle Noise

POSSIBLE CAUSE

A. CHECK FOR MISSING OR LOOSE WHEEL NUTS.
B. DRIVE AXLE OIL LEVEL IS LOW.
C. DRIVE AXLE MOUNTING CAPSCREWS ARE LOOSE.
D. BRAKE ASSEMBLY IS DAMAGED.
E. DRIVE AXLE UNIVERSAL JOINT DAMAGE OR FAILURE.
F. DRIVE AXLE BEARINGS ARE DAMAGED.
G. DAMAGED DIFFERENTIAL ASSEMBLY.
H. RING AND PINION GEAR SET FAILURE.
I. REDUCTION GEAR FAILURE.

CAUSE A - CHECK FOR MISSING OR LOOSE WHEEL NUTS.

PROCEDURE OR ACTION:

1. Inspect for missing wheel nuts.
   Are wheel nuts missing?
   YES: Replace and torque wheel nuts. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
   NO: Go to Step 1.

PROCEDURE OR ACTION:

2. Inspect for loose wheel nuts.
   Are wheel nuts loose?
   YES: Torque wheel nuts. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
   NO: Go to Cause B.

CAUSE B - DRIVE AXLE OIL LEVEL IS LOW.

PROCEDURE OR ACTION:

1. Check drive axle oil level.
   Is drive axle oil level too low?
   YES: Fill drive axle to proper oil level. See **Operating Manual**.
   NO: Go to Cause C.

CAUSE C - DRIVE AXLE MOUNTING CAPSCREWS ARE LOOSE.

PROCEDURE OR ACTION:

1. Inspect drive axle mounting capscrews to see if they are loose.
   Are drive axle mounting capscrews loose?
   YES: Tighten drive axle mounting capscrews. Refer to appropriate **Capacities and Specifications** manual, depending on lift truck model.
   NO: Go to Cause D.

CAUSE D - BRAKE ASSEMBLY IS DAMAGED.

PROCEDURE OR ACTION:

1. Inspect brake assembly for damage.
   Is brake assembly damaged?
   YES: Repair brake assembly. Refer to appropriate **Brake System** or **Drive Axle** manual.
   NO: Go to Cause E.

CAUSE E - DRIVE AXLE UNIVERSAL JOINT DAMAGE OR FAILURE.

PROCEDURE OR ACTION:

1. Inspect drive axle universal joints for damage or failure.
   Is a drive axle universal joint damaged or has it failed?
   YES: Replace universal joint. Refer to appropriate **Brake System** or **Drive Axle** manual.
   NO: Go to Cause F.

CAUSE F - DRIVE AXLE BEARINGS ARE DAMAGED.

PROCEDURE OR ACTION:

1. Inspect drive axle bearings for damage. Refer to appropriate **Brake System** or **Drive Axle** manual.
   Are drive axle bearings damaged?
   YES: Replace drive axle bearings. Refer to appropriate **Brake System** or **Drive Axle** manual.
   NO: Go to Cause G.

CAUSE G - DAMAGED DIFFERENTIAL ASSEMBLY.

PROCEDURE OR ACTION:

1. If equipped, remove differential cover.
2. Inspect differential assembly for damage.
   Is differential assembly damaged?
   YES: Replace or repair differential assembly. Refer to appropriate **Brake System** or **Drive Axle** manual.
   NO: Go to Cause H.

CAUSE H - RING AND PINION GEAR SET FAILURE.

PROCEDURE OR ACTION:

1. Inspect ring and pinion gear set.
   Is ring and pinion gear set damaged or has it failed?
   YES: Replace ring and pinion gear set. Refer to appropriate **Brake System** or **Drive Axle** manual.
   NO: Go to Cause I.

CAUSE I - REDUCTION GEAR FAILURE.

PROCEDURE OR ACTION:

1. Inspect reduction gears for damage or failure.
   Are reduction gears damaged or has it failed?
   YES: Replace reduction gears.Refer to appropriate **Brake System** or **Drive Axle** manual.
   NO: Resume lift truck operation to verify if noise is coming from drive axle.

END SYMPTOM

Discolored Drive Axle Oil

POSSIBLE CAUSE

A. DRIVE AXLE OIL IS CONTAMINATED.
B. DRIVE AXLE OIL HAS NOT BEEN PROPERLY MAINTAINED.
C. WRONG DRIVE AXLE OIL IN THE DRIVE AXLE SYSTEM.
D. OVERHEATED DRIVE AXLE OIL IN THE DRIVE AXLE SYSTEM.

CAUSE A - DRIVE AXLE OIL IS CONTAMINATED.

PROCEDURE OR ACTION:

1. Take Oil Sample for analysis before changing the oil. Refer to the **Drive Axle Manual**.
2. Replace drive axle oil. See **Operating Manual**.

CAUSE B - DRIVE AXLE OIL HAS NOT BEEN PROPERLY MAINTAINED.

PROCEDURE OR ACTION:

1. Take Oil Sample for analysis before changing the oil. Refer to the **Drive Axle Manual**.
2. Replace drive axle oil. See **Operating Manual**.

CAUSE C - WRONG DRIVE AXLE OIL IN THE DRIVE AXLE SYSTEM.

PROCEDURE OR ACTION:

1. Drain drive axle oil. Refer to the **Drive Axle Manual**.
2. Fill drive axle with correct oil. See **Operating Manual**.

CAUSE D - OVERHEATED DRIVE AXLE OIL IN THE DRIVE AXLE SYSTEM.

PROCEDURE OR ACTION:

NOTE: Overheated oil can be caused by driving the lift truck at high speeds for long periods of time, using lift truck to push heavy loads, or excessive braking on grades.

1. Take Oil Sample for analysis before changing the oil. Refer to the **Drive Axle Manual**.
2. Replace drive axle oil. See **Operating Manual**.

END SYMPTOM

Lift Truck Does Not Move (Drive Axle)

POSSIBLE CAUSE

A. **DRIVE AXLE UNIVERSAL JOINT DAMAGE OR FAILURE.**
B. **BROKEN SPIDER GEARS.**
C. **RING AND PINION GEAR SET FAILURE.**
D. **LOCKED, BROKEN, OR DAMAGED AXLE SHAFTS.**
E. **DAMAGED PLANETARY SECTION.**

CAUSE A - DRIVE AXLE UNIVERSAL JOINT DAMAGE OR FAILURE.

PROCEDURE OR ACTION:

1. Inspect drive axle universal joints for damage or failure.
   Is a drive axle universal joint damaged or has it failed?
   YES: Replace universal joint. Refer to the **Drive Axle and Differential Assembly Repair** manual.
   NO: Go to Cause B.

CAUSE B - BROKEN SPIDER GEARS.

PROCEDURE OR ACTION:

1. If equipped, remove differential cover.
2. Inspect spider gears.
   Are spider gears damaged or have failed?
   YES: Replace spider gears. Refer to the **Drive Axle and Differential Assembly Repair** manual.
   NO: Go to Cause C.

CAUSE C - RING AND PINION GEAR SET FAILURE.

PROCEDURE OR ACTION:

1. If equipped, remove differential cover.
2. Inspect ring and pinion gear set.
   Is ring and pinion gear set damaged or has it failed?
   YES: Replace ring and pinion gear set. Refer to the **Drive Axle and Differential Assembly Repair** manual.
   NO: Go to Cause D.

CAUSE D - LOCKED, BROKEN, OR DAMAGED AXLE SHAFTS.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model.
2. Check axle drag by turning one wheel by hand.
   Does opposite wheel turn freely in opposite direction?
   YES: Go to Cause E.
   NO: Remove both axle shafts, inspect for damage, and repair drive axles as necessary. Refer to the **Drive Axle and Differential Assembly Repair** manual.

CAUSE E - DAMAGED PLANETARY SECTION.

PROCEDURE OR ACTION:

1. Disassemble drive axle and inspect planetary section for damage.
   Is planetary section damaged?
   YES: Replace or repair planetary section. Refer to the **Drive Axle and Differential Assembly Repair** manual.
   NO: Drive axle and differential are OK. Possible transmission clutch failure. Refer to the **Transmission Manual.**

END SYMPTOM

Abnormal Transmission Noise

POSSIBLE CAUSE

A. TRANSMISSION OIL LEVEL IS LOW.
B. DAMAGED OR PLUGGED TRANSMISSION FILTER
C. FLEXPLATE DAMAGED OR HAS LOOSE HARDWARE.
D. SUCTION SCREEN RESTRICTED OR CLOGGED.
E. AIR LEAK IN SUCTION SIDE OF CHARGE PUMP/CHARGE PUMP FAILURE.
F. MISSING TRANSMISSION SUMP BAFFLE (IF EQUIPPED)
G. REGULATING SPOOL CHATTER
H. BEARING/GEAR DAMAGE OR FAILURE.

CAUSE A - TRANSMISSION OIL LEVEL IS LOW.

PROCEDURE OR ACTION:

NOTE: Cavitation of transmission pump will cause noise due to air in oil. The pump suction screen must be below surface of oil and unrestricted to pump.

1. Check transmission oil level.
   Is transmission oil level low?
   YES: Fill transmission to correct oil level. See **Operating Manual**.
   NO: Go to Cause B.

CAUSE B - DAMAGED OR PLUGGED TRANSMISSION FILTER

PROCEDURE OR ACTION:

1. Replace transmission filter. See **Operating Manual**.
   Does transmission noise stop after replacing filter?
   YES: Problem solved.
   NO: Go to Cause C.

CAUSE C - FLEXPLATE DAMAGED OR HAS LOOSE HARDWARE.

PROCEDURE OR ACTION:

1. Remove flywheel inspection plate and inspect flexplate.
   Is flexplate damaged or does it have loose hardware?
   YES: Replace flexplate or torque flexplate hardware. Refer to the **Transmission** manual.
   NO: Take Oil Sample for analysis to better understand possible source of failure. Go to Cause D.

CAUSE D - SUCTION SCREEN RESTRICTED OR CLOGGED.

PROCEDURE OR ACTION:

CAUTION

Excess contamination in oil will increase component wear. If excess debris is found in screen, an oil sample should be taken for further analysis of problem.

1. Remove transmission suction screen and inspect for contamination or debris.
   Does the suction screen contain excess debris?
   YES: Clean suction screen. Refer to the **Transmission** manual.
   NO: Go to Cause E.

CAUSE E - AIR LEAK IN SUCTION SIDE OF CHARGE PUMP/CHARGE PUMP FAILURE.

PROCEDURE OR ACTION:

1. If equipped, remove the Main Hydraulic Pump. Remove and inspect charge pump and gasket. Refer to appropriate **Single Speed Powershift, Aluminum Transmission** manual, depending on lift truck model.
   Is charge pump or gasket worn or damaged?
   YES: Replace gasket and if necessary, replace charge pump. Refer to the **Transmission** manual.
   NO: Go to Cause G.

CAUSE F - MISSING TRANSMISSION SUMP BAFFLE (IF EQUIPPED)

PROCEDURE OR ACTION:

1. Verify that transmission sump baffle is present and properly secured.
   Is the transmission sump baffle missing or loose?
   YES: Remove transmission from lift truck and repair or replace sump baffle. Refer to the **Transmission** manual.
   NO: Go to Cause G.

CAUSE G - REGULATING SPOOL CHATTER

PROCEDURE OR ACTION:

1. Check transmission pressures. See Transmission Pressure Test.
   Are transmission pressures within test specification?
   YES: Go to Cause H.
   NO: Inspect regulating spools, springs, and repair/replace as necessary. Refer to the **Transmission** manual.

CAUSE H - BEARING/GEAR DAMAGE OR FAILURE.

PROCEDURE OR ACTION:

1. Inspect bearings and gears for damage or wear.
   Are bearings and gears worn or damaged?
   YES: Remove and repair transmission as necessary. Refer to the **Transmission** manual.
   NO: Based on oil sample analysis taken earlier, remove and repair transmission as necessary. Refer to the **Transmission** manual.

END SYMPTOM

Bubbles or Foaming In Transmission Dipstick Tube

POSSIBLE CAUSE

A. TRANSMISSION OIL LEVEL IS LOW OR HIGH.
B. VENT PLUMBING CLOGGED OR RESTRICTED.
C. SUCTION SCREEN RESTRICTED OR CLOGGED.
D. AIR LEAK IN SUCTION SIDE OF CHARGE PUMP.
E. TRANSMISSION OIL IS CONTAMINATED.

CAUSE A - TRANSMISSION OIL LEVEL IS LOW OR HIGH.

PROCEDURE OR ACTION:

NOTE: Cavitation of transmission pump will cause noise due to air in oil. The pump suction screen must be below surface of oil and unrestricted to pump.

1. Check transmission oil level.
   Is transmission oil level low or high?
   YES: If low, fill transmission to correct oil level. If high, drain to correct level. See **Operating Manual**.
   NO: Go to Cause B.

CAUSE B - VENT PLUMBING CLOGGED OR RESTRICTED.

PROCEDURE OR ACTION:

1. Remove and inspect vent air breather and plumbing.
   Is vent circuit clogged or restricted?
   YES: Clean plumbing in housing and replace air breather. Refer to the **Transmission** manual.
   NO: Take Oil Sample for analysis before changing transmission oil. Go to Cause C.

CAUSE C - SUCTION SCREEN RESTRICTED OR CLOGGED.

PROCEDURE OR ACTION:

CAUTION

Excess contamination in oil will increase component wear. If excess debris is found in screen, an oil sample should be taken for further analysis of problem.

1. Remove transmission suction screen and inspect for contamination or debris.
   Does the suction screen contain excess debris?
   YES: Clean suction screen. Refer to the **Transmission** manual.
   NO: Go to Cause D.

CAUSE D - AIR LEAK IN SUCTION SIDE OF CHARGE PUMP.

PROCEDURE OR ACTION:

1. If equipped, remove the Main Hydraulic Pump. Remove and inspect charge pump and gasket. Refer to the **Transmission** manual.
   Is charge pump gasket worn or damaged?
   YES: Replace gasket and if necessary, replace charge pump. Refer to the **Transmission** manual.
   NO: Go to Cause E.

CAUSE E - TRANSMISSION OIL IS CONTAMINATED.

PROCEDURE OR ACTION:

1. Take Oil Sample for analysis before changing transmission oil. Refer to the **Transmission** manual.
2. Replace transmission and drive axle oil and filter. See **Operating Manual**.

END SYMPTOM

Inching Operation Is Not Smooth or Chatters

POSSIBLE CAUSE

A. INCH BRAKE OUT OF ADJUSTMENT.
B. BRAKES ARE NOT ADJUSTED CORRECTLY.
C. CONTROL VALVE HAS INTERNAL LEAKAGE.
D. INCORRECT TRANSMISSION OIL.

CAUSE A - INCH BRAKE OUT OF ADJUSTMENT.

NOTE: The following can be observed when the inch brake system is out of adjustment:

- Inching control is poor.
- Inching control has very little pressure modulation.
- Acceleration while exiting inching mode at high engine speed is abrupt.
- Inch/brake pedal has very little "free-pedal" at the top of the stroke.
- Inch/brake pedal is very firm.
- Low Power.

PROCEDURE OR ACTION:

1. Monitor the inch/brake pedal during operation.
   Does inch/brake pedal characteristics resemble any of the observations listed above?
   YES: Check and adjust brake / inching pedal. Refer to **Brake System** manual.
   NO: Go to Cause B.

CAUSE B - BRAKES ARE NOT ADJUSTED CORRECTLY.

PROCEDURE OR ACTION:

WARNING
Touching brake components can cause serious burns. Do not use hands to check temperature of wheel components.

1. Check brakes for overheating using a paint stick or infrared heat sensor.
   Do the brakes smell burnt and show signs of overheating?
   YES: Inspect and adjust brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause C.

CAUSE C - CONTROL VALVE HAS INTERNAL LEAKAGE.

PROCEDURE OR ACTION:

1. Test transmission pressure. See Transmission Pressure Test.
   Is pressure out of specification?
   YES: Remove control valve and replace gaskets. Refer to the **Transmission** manual.
   NO: Go to Cause D.

CAUSE D - INCORRECT TRANSMISSION OIL.

PROCEDURE OR ACTION:

NOTE: It is possible for clutch plates to absorb the wrong oil and may need to be replace with new friction plates.

1. Check transmission oil type.
   Is transmission oil the wrong type?
   YES: Flush transmission and drive axle and add the correct type oil to proper level. See **Operating Manual**.
   NO: Resume operation.

END SYMPTOM

Lift Truck Does Not Move In One or Both Directions (Transmission)

POSSIBLE CAUSE

A. **TRANSMISSION IS NOT ENGAGED (DISPLAY DIRECTIONAL CONTROL LEVER / MLM DIRECTIONAL CONTROL SWITCH EQUIPPED TRUCKS).**
B. **BRAKES OR DRIVE AXLE IS LOCKED UP.**
C. **TRANSMISSION OIL LEVEL IS LOW.**
D. **TRANSMISSION ENABLE VALVE FAILURE.**
E. **CONTROL VALVE HAS INTERNAL LEAKAGE OR DAMAGED.**
F. **TRANSMISSION PUMP DAMAGED OR RESTRICTED**
G. **TORQUE CONVERTER IS DAMAGED.**
H. **CLUTCH PACK FAILURE**

CAUSE A - TRANSMISSION IS NOT ENGAGED (DISPLAY DIRECTIONAL CONTROL LEVER / MLM DIRECTIONAL CONTROL SWITCH EQUIPPED TRUCKS).

PROCEDURE OR ACTION:

1. Check the direction arrows on the display.
   Do direction arrows light up when directional control lever / switch is moved to forward or reverse positions?
   YES: Electronic directional signal is OK. Check display for DTCs. See the appropriate troubleshooting code. If no DTCs appear on display, go to Cause B.
   NO: If lights do not light up, replace directional control lever switch. Refer to appropriate **Electrical System** manual, depending on lift truck model.

CAUSE B - BRAKES OR DRIVE AXLE IS LOCKED UP.

NOTE: Only applicable if lift truck does not move in both directions.

PROCEDURE OR ACTION:

1. Raise front axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model. Check drive axle drag by turning one wheel by hand.
   Does opposite wheel turn freely in opposite direction?
   YES: Go to Cause C.
   NO: Inspect and repair drive axle. Refer to the **Drive Axle** manual, depending on lift truck model.

CAUSE C - TRANSMISSION OIL LEVEL IS LOW.

NOTE: Only applicable if lift truck does not move in both directions.

PROCEDURE OR ACTION:

1. Check transmission oil level.
   Is transmission oil level low?
   YES: Fill transmission to correct oil level. See **Operating Manual**.
   NO: Go to Cause D.

CAUSE D - TRANSMISSION ENABLE VALVE FAILURE.

NOTE: Only applicable if lift truck does not move in both directions.

PROCEDURE OR ACTION:

1. Remove enable valve and apply 12-volt power to check operation.
   Does the solenoid click when power is applied and does spool move?
   YES: Enable valve is OK, reinstall it. Problem is electrical. Check for DTC and repair. If no DTC, check if harness is delivering the correct current. Refer to appropriate **Diagrams and Schematics** and **Wire Harness Repair** manual, depending on lift truck model. Go to Cause E.
   NO: Replace valve. Refer to the **Transmission** manual.

CAUSE E - CONTROL VALVE HAS INTERNAL LEAKAGE OR DAMAGED.

PROCEDURE OR ACTION:

1. Test transmission pressures. See Transmission Pressure Test.
   Is the charge pump, torque converter, or clutch pack pressures out of test specifications?
   YES: If charge pump pressure is out of specification, go to Cause F. If torque converter or clutch pack pressure is out of specification, inspect and replace regulator spools, springs, valve body (if applicable), and gasket as necessary. Refer to the **Transmission** manual.
   NO: Go to Cause G.

CAUSE F - TRANSMISSION PUMP DAMAGED OR RESTRICTED

PROCEDURE OR ACTION:

1. Remove and inspect transmission pump and suction screen.
   Is transmission pump damaged or suction screen clogged?
   YES: Clean screen and replace transmission pump. Refer to the **Transmission** manual.
   NO: Go to Cause G.

CAUSE G - TORQUE CONVERTER IS DAMAGED.

PROCEDURE OR ACTION:

1. Check torque converter stall speeds. See Torque Converter Stall Test.
   Do stall speeds meet test specifications?
   YES: Go to Step 2.
   NO: If stall speeds are high, clutch packs may be slipping. See Cause H.
2. Check display for transmission Diagnostic Trouble Codes (DTC).
   Do transmission DTCs appear on display?
   YES: Replace valve body (if applicable). Refer to the **Transmission** manual.
   NO: Go to Cause H.

CAUSE H - CLUTCH PACK FAILURE

PROCEDURE OR ACTION:

1. Remove transmission. Refer to appropriate **Frame** manual, depending on lift truck model. Inspect clutch packs for one of following failures:
   - Worn friction or separator plates.
   - Damaged friction or separator plates or improper assembly.
   - Leaking piston seals or shaft seals.
   - Disc hanging up and not engaging.
   - Damaged clutch pack springs.

   Has clutch pack failed?
   YES: Repair or replace clutch pack. Refer to the **Transmission** manual.
   NO: Perform transmission operation check. See Operational Checkout Procedures.

END SYMPTOM

Loss of Power/Drivetrain Performance

POSSIBLE CAUSE

A. **LOAD IS GREATER THAN TRUCK CAPACITY.**
B. **BRAKES ARE DRAGGING.**
C. **ENGINE NOT RUNNING CORRECTLY.**
D. **CONTROL VALVE HAS INTERNAL LEAKAGE OR DAMAGED.**
E. **TRANSMISSION PUMP DAMAGED OR RESTRICTED**
F. **TORQUE CONVERTER FAILURE.**
G. **EXCESSIVE DRIVE AXLE DRAG.**
H. **INCH BRAKE OUT OF ADJUSTMENT**

CAUSE A - LOAD IS GREATER THAN TRUCK CAPACITY.

PROCEDURE OR ACTION:

1. Check load weight and compare to truck capacity. See **Operating Manual**.
   Is load greater than truck capacity?
   YES: Reduce load.
   NO: Go to Cause B.

CAUSE B - BRAKES ARE DRAGGING.

PROCEDURE OR ACTION:

WARNING

Touching brake components can cause serious burns. Do not use hands to check temperature of wheel components.

1. Check brakes for overheating using paint stick or infrared heat sensor.
   Do the brakes smell burnt and show signs of overheating?
   YES: For dry brake axles, inspect and adjust brake shoes. Refer to the **Drive Axle** manual.
   NO: Go to Cause C.

CAUSE C - ENGINE NOT RUNNING CORRECTLY.

PROCEDURE OR ACTION:

1. Check torque converter stall speeds. See Torque Converter Stall Test.
   Are stall speeds low?
   YES: Go to Operational Checkout, Page 9010-05-7.
   NO: Go to Cause F.

CAUSE D - CONTROL VALVE HAS INTERNAL LEAKAGE OR DAMAGED.

PROCEDURE OR ACTION:

1. Test transmission pressures. See Transmission Pressure Test.
   Is the charge pump, torque converter, or clutch pack pressures out of test specifications?
   YES: If charge pump pressure is out of specification, go to Cause E. If torque converter or clutch pack pressure is out of specification, inspect and replace regulator spools, springs, valve body (if applicable), and gasket as necessary. Refer to the **Transmission** manual.
   NO: Go to Cause F.

CAUSE E - TRANSMISSION PUMP DAMAGED OR RESTRICTED

PROCEDURE OR ACTION:

1. Remove and inspect transmission pump and suction screen.
   Is transmission pump damaged or suction screen clogged?
   YES: Clean screen and replace transmission pump. Refer to the **Transmission** manual.
   NO: Go to Cause F.

CAUSE F - TORQUE CONVERTER FAILURE.

PROCEDURE OR ACTION:

1. Check torque converter pressures. See Transmission Pressure Test.
   Is pressure at test specifications and does it pass transmission clutch check?
   YES: Replace torque converter. Refer to the **Transmission** manual.
   NO: Go to Cause G.

CAUSE G - EXCESSIVE DRIVE AXLE DRAG.

PROCEDURE OR ACTION:

1. Raise front drive axle so both wheels are off ground. Secure lift truck. Refer to appropriate **Periodic Maintenance** manual, depending on lift truck model. Check drive axle drag by turning one wheel by hand.
   Does opposite wheel have excessive drag?
   YES: Inspect and repair drive axle. Refer to the**Drive Axle** manual, depending on lift truck model.
   NO: Go to Cause H.

CAUSE H - INCH BRAKE OUT OF ADJUSTMENT

NOTE: The following can be observed when the inch brake system is out of adjustment:

- Inching control is poor.
- Inching control has very little pressure modulation.
- Acceleration while exiting inching mode at high engine speed is abrupt.
- Inch/brake pedal has very little "free-pedal" at the top of the stroke.
- Inch/brake pedal is very firm.
- Low Power.

PROCEDURE OR ACTION:

1. Monitor the inch/brake pedal during operation.
   Does inch/brake pedal characteristics resemble any of the observations listed above?
   YES: Perform the following:
   - Shorten the brake master cylinder actuator push rod by releasing the lock nut and turning rod ½ turn CCW. Retighten lock nut.
   - Test the inching performance.
   - Adjust the inch/brake pedal overlap setting in the user menu.
   - Repeat if symptom has improved but is still unsatisfactory.

   NO: Resume Operation.

END SYMPTOM

Transmission Is Too Hot

POSSIBLE CAUSE

A. INCHING AND OPERATING THE LIFT TRUCK WITH LOADS GREATER THAN CAPACITY RATING.
B. TRANSMISSION OIL LEVEL IS INCORRECT OR WRONG TYPE.
C. OIL COOLER CIRCUIT EXTERNALLY DAMAGED.
D. BRAKES ARE DRAGGING.
E. OIL COOLER CIRCUIT RESTRICTED.
F. TORQUE CONVERTER IS DAMAGED.
G. INCH BRAKE OUT OF ADJUSTMENT

CAUSE A - INCHING AND OPERATING THE LIFT TRUCK WITH LOADS GREATER THAN CAPACITY RATING.

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

1. Check load weight and compare to lift truck capacity rating.
   Is load weight greater than lift truck capacity?
   YES: Decrease load weight.
   NO: Go to Cause B.

CAUSE B - TRANSMISSION OIL LEVEL IS INCORRECT OR WRONG TYPE.

PROCEDURE OR ACTION:

NOTE: Transmission oil level too low can cause overheating. Maintain oil at correct level.

1. Check transmission oil level and oil type. Verify the transmission temperature with thermal couple in dipstick tube.
   Is transmission oil level low and the wrong type?
   YES: Flush transmission and add the correct type oil to proper level. See **Operating Manual**.
   NO: Go to Cause C.

CAUSE C - OIL COOLER CIRCUIT EXTERNALLY DAMAGED.

PROCEDURE OR ACTION:

1. Inspect oil cooler and lines for debris or external damage.
   Is oil cooler and lines damaged or clogged with debris?
   YES: Clean oil cooler to remove external debris and improve air flow for cooling. Repair or replace damaged oil cooler and lines.
   NO: Go to Cause D.

CAUSE D - BRAKES ARE DRAGGING.

PROCEDURE OR ACTION:

WARNING

Touching brake components can cause serious burns. Do not use hands to check temperature of wheel components.

1. Check brakes for overheating using paint stick or infrared heat sensor.
   Do the brakes smell burnt and show signs of overheating?
   YES: Inspect and adjust brake shoes. Refer to appropriate **Brake System** manual, depending on lift truck model.
   NO: Go to Cause C.

CAUSE E - OIL COOLER CIRCUIT RESTRICTED.

PROCEDURE OR ACTION:

1. Check oil cooler and lines for a restriction. Perform Transmission Pressure Test.
   Is converter pressure out of specification?
   YES: Back flush the oil cooler and lines to remove internal debris. Replace oil cooler and lines as necessary. Refer to appropriate manual.
   NO: Go to Cause F.

CAUSE F - TORQUE CONVERTER IS DAMAGED.

PROCEDURE OR ACTION:

1. Check torque converter stall speeds. See Torque Converter Stall Test.
   Do stall speeds meet test specifications?
   YES: Go to Cause G.
   NO: If stall speeds are high, clutch packs may be slipping.
2. Test transmission pressure. PerformTransmission Pressure Test.
   Is pressure at test specifications and does it pass transmission clutch check?
   YES: Replace torque converter. Refer to appropriate manual.
   NO: Go to Cause G.

CAUSE G - INCH BRAKE OUT OF ADJUSTMENT

NOTE: The following can be observed when the inch brake system is out of adjustment:

- Inching control is poor
- Inching control has very little pressure modulation
- Acceleration while exiting inching mode at high engine speed is abrupt
- Inch/brake pedal has very little "free-pedal" at the top of the stroke
- Inch/brake pedal is very firm
- Low Power

PROCEDURE OR ACTION:

1. Monitor the inch/brake pedal during operation.
   Does inch/brake pedal characteristics resemble any of the observations listed above?
   YES: Perform the following:
   - Shorten the brake master cylinder actuator push rod by releasing the lock nut and turning rod ½ turn CCW. Retighten lock nut.
   - Test the inching performance
   - Adjust the inch/brake pedal overlap setting in the user menu.
   - Repeat if symptom has improved but is still unsatisfactory.

   NO: Resume Operation.

END SYMPTOM

Group 40

Tests and Adjustments

Transmission Warm-up Procedure

Use this procedure to get the transmission oil temperature to test specification. Install the test equipment on lift truck before starting this procedure to prevent handling of hot component or oil.

Table 9040-40-1. Test Specifications

Engine Speed	Gear Selection	Oil Temperature
2,700 RPM	NEUTRAL / FWD / REV	90°C (194 °F)

WARNING

Hot transmission oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure transmission oil has cooled to safe temperature before removing test equipment.

1. Install test equipment as called out in test.

2. Put a capacity load on the forks to prevent the wheels from turning. Start engine and operate engine at fast idle speed.

CAUTION

Do not hold the throttle open for more than 15 seconds at a time. Permit the engine to operate at idle speed for 30 seconds between tests. Release the accelerator immediately if the engine speed increases to the speed limit of the governor.

NOTE: Do not apply the inching/brake pedal or the parking brake. These controls will release the clutches in the transmission.

3. Put the lift truck against an object that cannot move. Put the transmission in FORWARD, and slowly push the accelerator pedal to full throttle. Stall the torque converter for 15 seconds. Return direction control to neutral for 30 seconds to allow oil to circulate and torque converter to cool.

4. Read temperature on display and compare to temperature specifications of test to be performed.

5. Repeat Step 2 and Step 3 until oil temperature is at test specifications.

6. When temperature is at test specifications, proceed with test.

Transmission Pressure Test

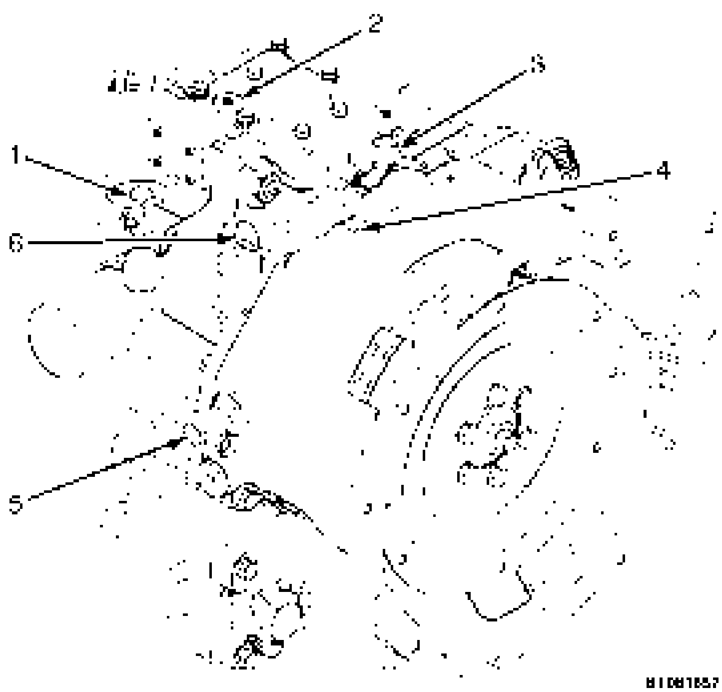
Do the following before performing the transmission pressure test:

- Resolve engine DTC's and performance issues.
- Make sure that all transmission observed symptoms have been checked. See Observed Symptoms.
- Make sure that transmission is filled to correct oil level. See **Operating Manual**.
- Make sure that all transmission filters are cleaned or replaced.
- Connect a tachometer to the engine. Engine RPM can also be read from the display.

Service Tools

NOTE: Use a pressure gauge suitable for use with transmission oils with a pressure range of 0 - 3450 kPa (0 - 500 psi).

- For port locations, see Figure 9040-40-11.
- Operate machine until transmission oil temperature is at test specification. See Transmission Warm-up Procedure.
- Raise front axle so both wheels are off the ground. Secure lift truck using proper shop standards.



1. T/C INPUT FROM RADIATOR
2. CLUTCH PRESSURE CHECK PORT
3. T/C INLET PRESSURE CHECK PORT
4. T/C OUTLET TO RADIATOR
5. PUMP PRESSURE CHECK POINT
6. DIPSTICK

Figure 9040-40-11. Transmission Pressure Test Ports

Regulators are not adjustable. If the correct pressure for a regulator cannot be obtained, replace regulator spring. For further description of transmission control valve, see Transmission Control Hardware.

TRANSMISSION CHARGE PUMP PRESSURE TEST

WARNING

Hot transmission oil can cause serious burns to skin. Do not touch components or oil during test. Make sure oil has cooled to safe temperature before removing test equipment.

1. Make sure that test gauge is properly installed to charge pump pressure port.
2. Operate the transmission until the oil temperature is at test specifications. See Transmission Warm-up Procedure.
3. Operate engine at test speed and record pressure reading.
4. Compare to specifications. If pressure is not correct, repair or replace charge pump relief valve or charge pump. Refer to the **Transmission** manual.
5. Remove test equipment.

CLUTCH PACK PRESSURE TEST

Table 9040-40-2. Test Specifications

INPUT SPEED	GEAR SELECTION	OIL TEMPERATURE	CLUTCH SELECTION	T/C INLET PRESSURE	PUMP PRESSURE
2,700 RPM	NEUTRAL	90°C (194°F)	0.680 to 0.79 MPa (99 to 115 psi)	0.29 to 0.69 MPa (42 to 100 psi)	1.47 MPa (213 psi)
2,700 RPM	FORWARD	90°C (194°F)	0.61 to 0.74 MPa (89 to 107 psi)	0.28 to 0.68 MPa (41 to 99 psi)	1.47 MPa (213 psi)
2,700 RPM	REVERSE	90°C (194°F)	0.63 to 0.76 MPa (92 to 110 psi)	0.28 to 0.68 MPa (41 to 99 psi)	1.47 MPa (213 psi)

1. Operate the transmission until the oil temperature is at test specifications. See Transmission Warm-up Procedure.
2. At the display, enter the DIAGNOSTICS display from the MAIN MENU.
3. Use the SCROLL ARROW to view the XMSN/BRAKE data display and press ENTER.

4. Use the DOWN SCROLL ARROW to view XMSN FORWARD, REVERSE PRESSURE or NEUTRAL transmission readouts.

5. Make sure that test gauges are properly installed to the forward and reverse pressure test ports.

6. Operate engine at test speed.

7. Shift transmission in all gears; Forward and Reverse.

8. Compare readings to test specifications. If pressure is not correct, check calibration. Refer to appropriate **Calibration Procedures** manual, depending on lift truck model. If pressure is still not to test specifications, replace proportional solenoid valves. Refer to the **Transmission** manual.

9. Repeat Step 1 through Step 7 for one additional cycle.

10. Remove test equipment.

TORQUE CONVERTER PRESSURE TEST

Refer to Table 9040-40-2.

1. Make sure that test gauge is properly installed to torque converter pressure port. See Figure 9040-40-11 for port location.

2. Operate the transmission until the oil temperature is at test specifications. See Transmission Warm-up Procedure.

3. Operate engine at test speed and record pressure reading.

4. Compare to specifications. If pressure is not correct, repair or replace transmission control valve or torque converter. Refer to the **Transmission** manual.

5. Remove test equipment.

LUBRICATION PRESSURE TEST

Refer to Table 9040-40-2.

1. Make sure that test gauge is properly installed to lubrication pressure port. See Figure 9040-40-11 for port location.

2. Operate the transmission until the oil temperature is at test specifications. See Transmission Warm-up Procedure.

3. Operate engine at test speed and shift transmission Forward and then Reverse. Record pressure reading.

4. Compare to specifications. If pressure is not correct, repair or replace oil cooler or torque converter. Refer to the **Transmission** manual.

5. Remove test equipment.

Torque Converter Stall Test

The torque converter stall test checks engine output, transmission clutches, torque converter, and torque converter stator clutch. Under test conditions, an engine speed lower than specified may indicate either low engine power or a malfunctioning torque converter stator clutch. Conversely, an engine speed higher than specified may indicate slippage in either the transmission clutches or the torque converter.

1. Place secured capacity load on forks to prevent wheel spin during this test.
2. Position the lift truck against an immovable object, like a loading dock.
3. Check transmission temperature. If not within specifications 90°C (194°F), See Transmission Warm-up Procedure.
4. Scroll Display to display engine speed (rpm).
5. With engine running, place transmission in the **Forward** gear selection.

NOTE: The wheels must not turn during the torque converter stall test.

6. Slowly push the accelerator pedal to full throttle while observing engine speed. Release throttle and place transmission in neutral between tests. Compare results against Table 9040-40-3.
   - If stall speed is 50 to 200 rpm below stall speed specification, the engine is not running at full power. Check the ignition timing, air filter, fuel system, and engine compression.
   - If engine speed is 250 to 500 rpm below stall speed specification, the torque converter stator clutch is worn or damaged. Replace torque converter. Refer to appropriate manual, depending on lift truck model.
   - If stall speed is greater than stall speed specifications, either the transmission clutch or the torque converter is slipping. Go to Step 7.
7. Turn the lift truck around and position against immovable object. Place transmission into **Reverse** gear selection.
8. Slowly push the accelerator pedal to full throttle while observing engine speed. Compare results against Table 9040-40-3.
   - If the engine rpm is greater than stall speed specification in either forward or reverse directions, perform Transmission Pressure Test.
   - If transmission clutches and pressures are within stall speed specification as a result of the test and checks performed above, the torque converter has failed. Replace torque converter. Refer to the **Transmission** manual.

Table 9040-40-3. Stall Speeds

ENGINE	Torque Converter Stall Test ±100 RPM					
	New Engine	Broken-In Engine	New Engine	Broken-In Engine	New Engine	Broken-In Engine
PSI 2.4L	1950 RPM	2053 RPM	N/A	N/A	[1]	[1]
Yanmar Diesel	1752 RPM	1845 RPM	N/A	N/A	N/A	N/A
NOTE: [1] = Stall Test Not Applicable Due to V-ECU Control of Engine Power Output.						

NOTES

SECTION 9050

HYDRAULIC SYSTEM

TABLE OF CONTENTS

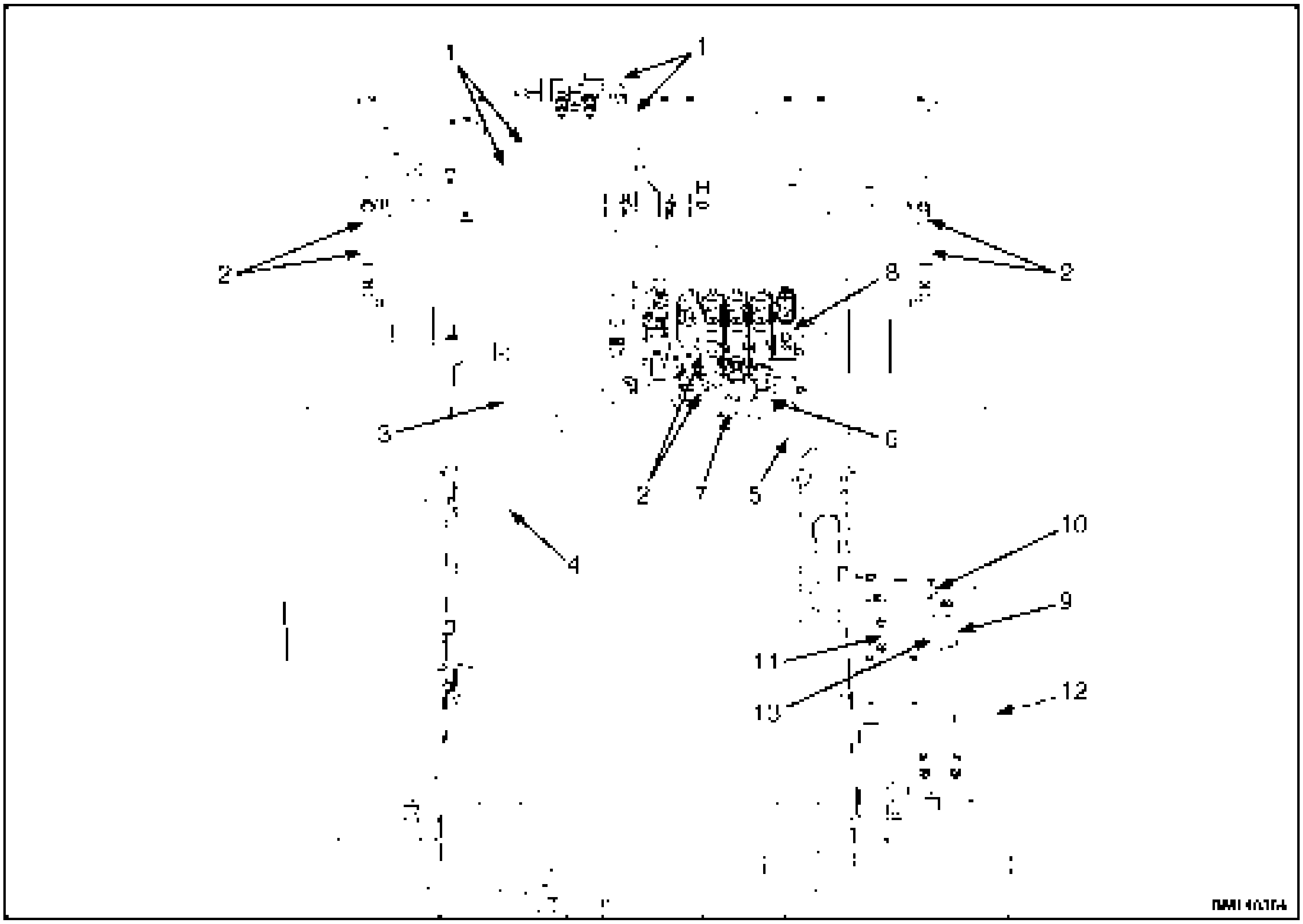
Group 10

Principles of Operation

Main Hydraulic System

DESCRIPTION

The hydraulic system consists of the following components: hydraulic tank, pump assembly, steering control unit, main control valve (manual or electric), lift cylinders, tilt cylinders, steering cylinder, filter assembly, suction screen, and breather. The steering control unit and main control valve are assembled together and utilize a common hydraulic supply. The hydraulic tank is integral to the right side of the frame channel. The hydraulic filter assembly is mounted to the top of the tank. See Figure 9050-10-1.



1. STEERING SYSTEM HOSES
2. TILT HOSES
3. LIFT HOSES
4. HYDRAULIC SUCTION HOSE
5. RETURN HOSE
6. FOURTH FUNCTION HOSE
7. THIRD FUNCTION HOSE
8. MAIN CONTROL VALVE
9. HYDRAULIC FILLER NECK
10. DIPSTICK
11. HYDRAULIC TANK PLATE
12. HYDRAULIC FILTERS (INSIDE TANK)

Figure 9050-10-1. Hydraulic Component Locator

PRINCIPLES OF OPERATION

A gear-type pump is mounted on the frame (LPG) or engine (diesel). This pump which provides flow for the hydraulic system, is driven by driveshaft (LPG) or Power Take Off (diesel). The gear pump receives oil from the hydraulic tank through either a single or dual screen at the outlet of the tank. See Figure 9050-10-1. The SCU is a load-sensing device and receives priority flow from the hydraulic valve upon steer demand. This flow is available to operate the hydraulic functions. The valve controls the flow of oil to the Lift, Tilt, and Auxiliary functions. Relief valves limit the pressure in the hydraulic system. Test ports permit checking the relief pressures of each system. Oil returning from the main control valve flows through the filter in the return circuit to the hydraulic tank.

HYDRAULIC SCHEMATICS

Manual and E-Hydraulic Control Valve Schematics

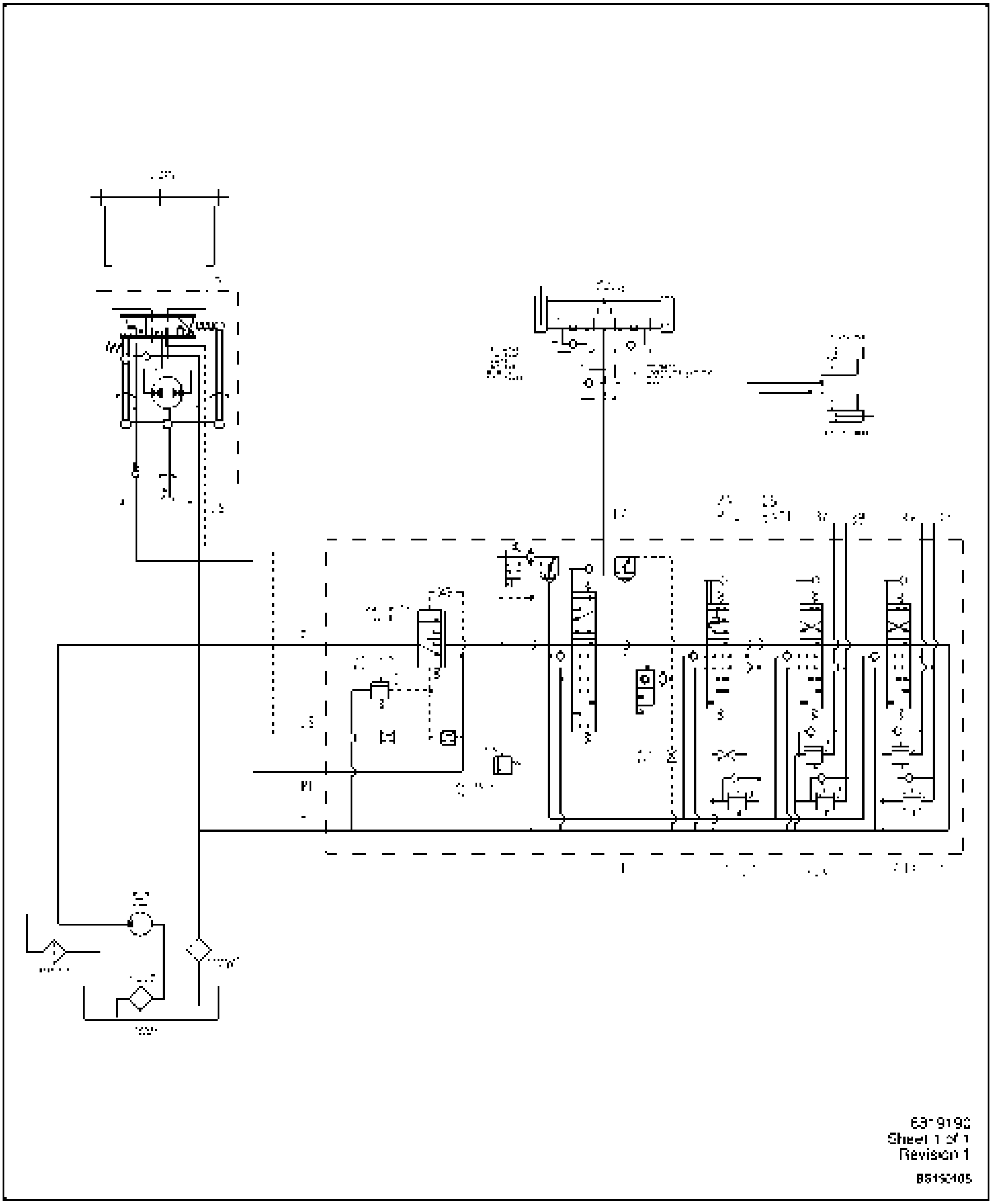


Figure 9050-10-2. Hydraulic Schematic (Manual Hydraulic Control valve)

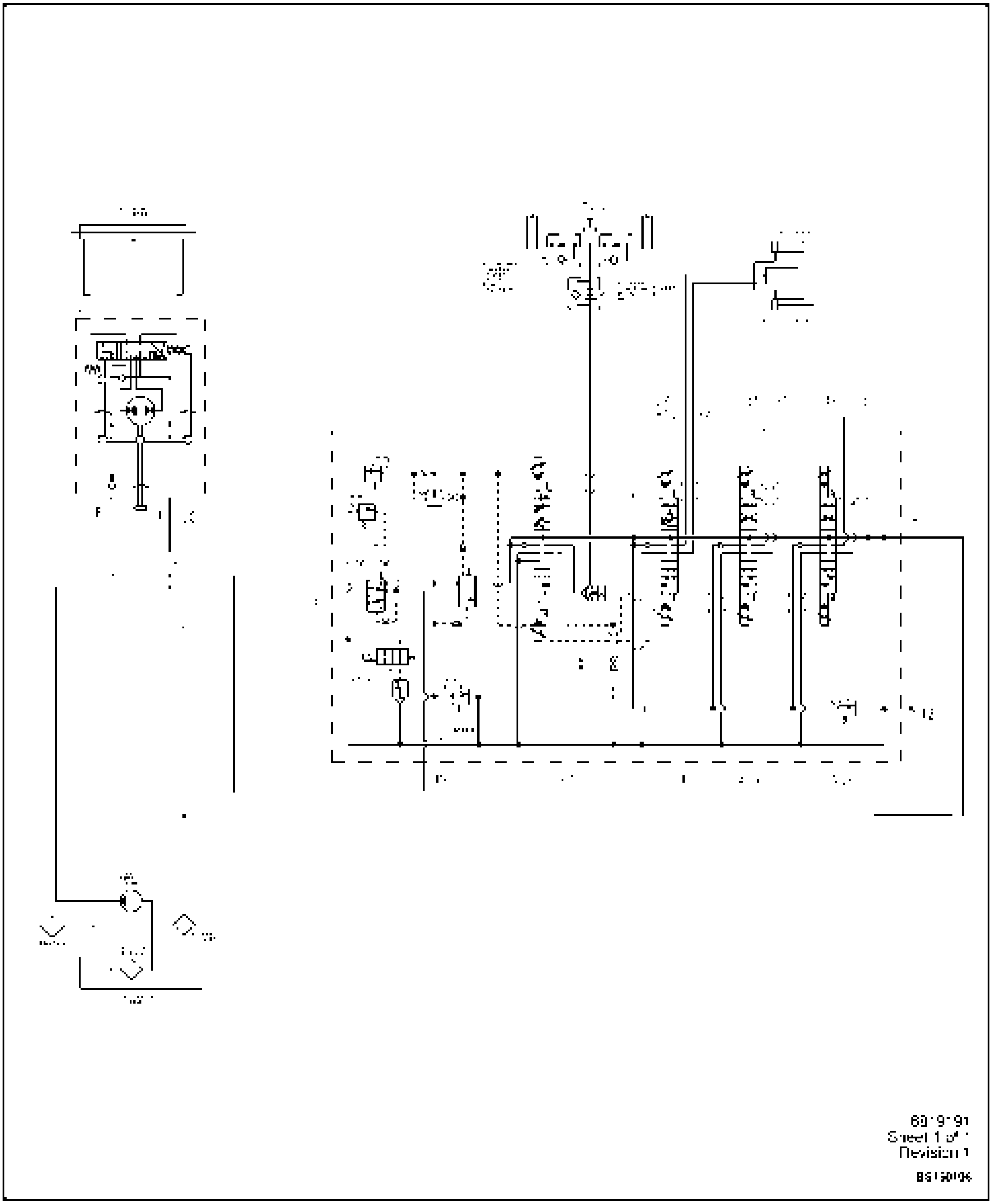
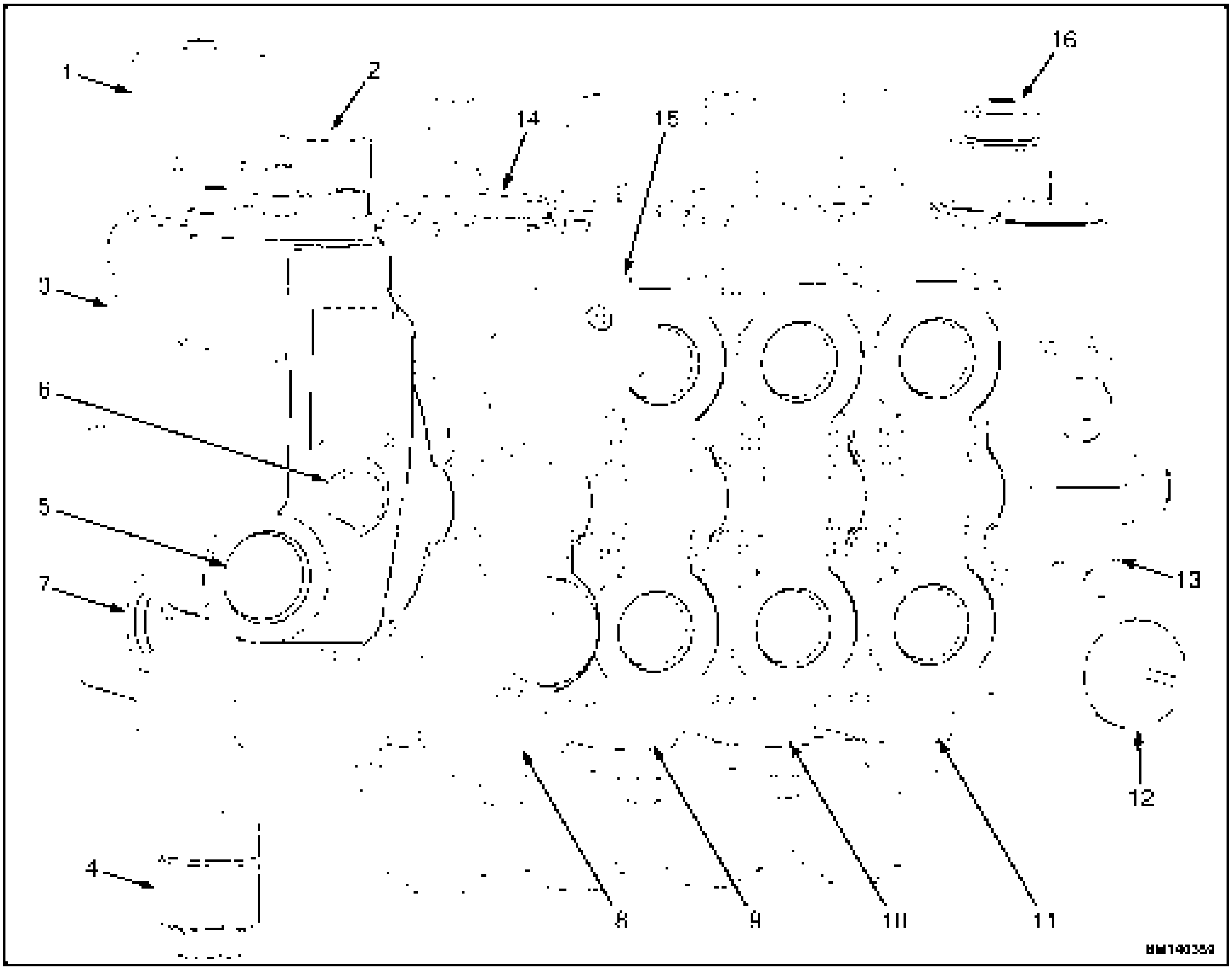


Figure 9050-10-3. Hydraulic Schematic (E-Hydraulic Control valve)

Manual Hydraulic Control Valve

DESCRIPTION

The Manual Hydraulic Control Valve controls the operation of the Lift, Tilt, and Auxiliary functions of the fork lift truck. The valve consists of a inlet, lift, tilt, two auxiliary sections and the outlet section. The oil from the pump flows directly to the hydraulic valve. See Figure 9050-10-4. The sections are held together with 3 tie-rod bolts. The main relief valve is located in the inlet section and the secondary relief valve is located in the outlet section.

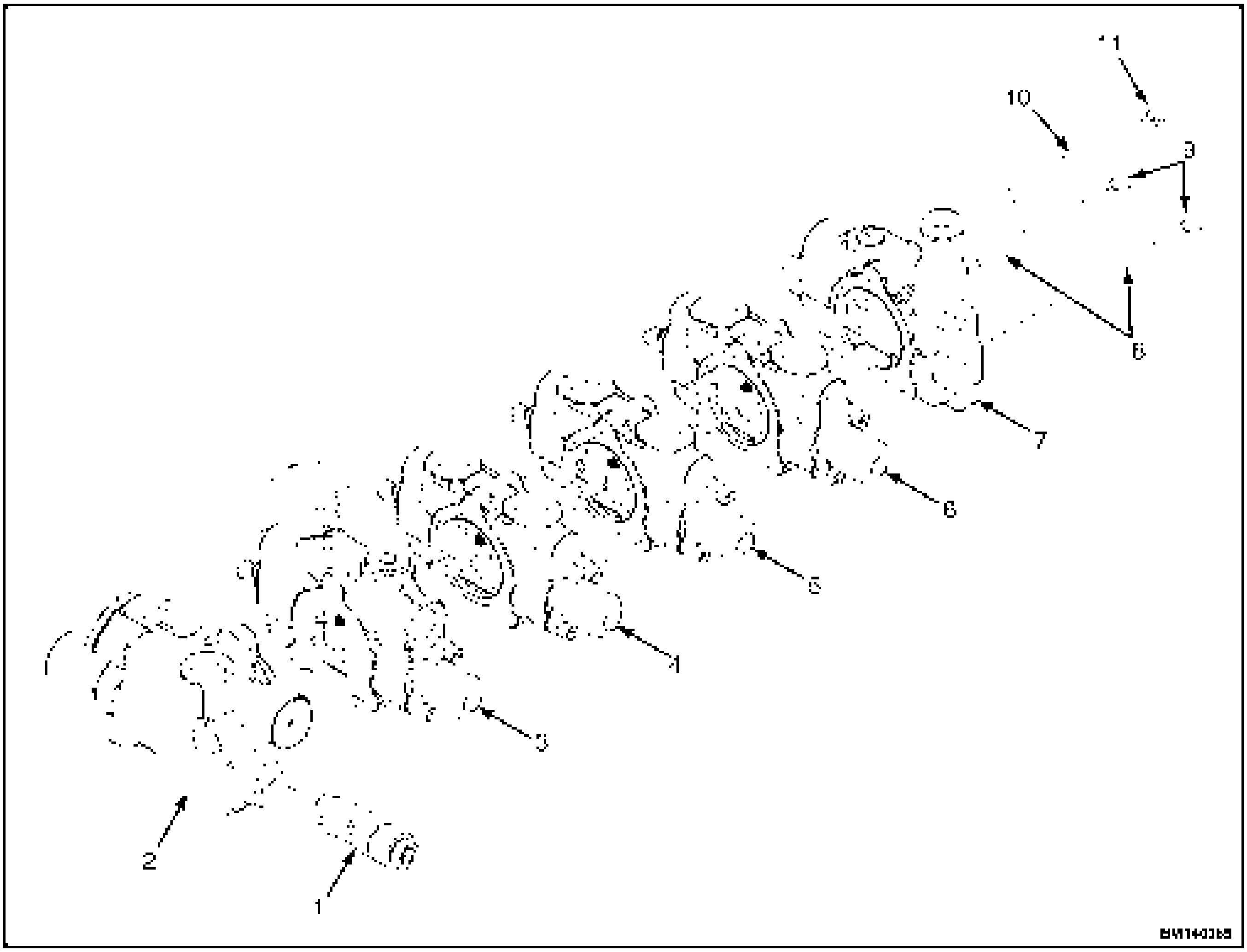


1. UNLOADER SOLENOID VALVE
2. LOAD SENSE (LS) PORT
3. INLET SECTION
4. PRIMARY RELIEF VALVE
5. VALVE INLET
6. GAUGE PORT (GP1)
7. PROPORTIONAL FLOW (PF) PORT
8. LIFT SECTION
9. TILT SECTION
10. AUXILIARY I SECTION
11. AUXILIARY II SECTION
12. VALVE OUTLET
13. OUTLET SECTION
14. EMERGENCY LOWERING VALVE
15. LOWERING LOCKOUT SOLENOID VALVE
16. SECONDARY RELIEF VALVE
17. SECTIONAL SPOOL ASSEMBLIES

Figure 9050-10-4. Manual Hydraulic Control valve

The manual control valve is an open center valve which utilizes parallel hydraulic circuitry. The valve is used with a fixed displacement pump. The hydraulic circuitry incorporates dual pressure reliefs. The Lift function operates on the main relief pressure setting. The Tilt and Auxiliary functions operate on the lower secondary relief pressure setting. If the Lift function is operated simultaneously with the Tilt and/or Auxiliary function, the maximum lift pressure is limited to the secondary relief valve pressure setting. For example, if the tilt and lift functions are operated simultaneously, then the lift function will be limited to 17.6 MPa (2,550 psi) instead of the main relief pressure of 21.4 MPa (3,103 psi).

Oil enters the valve from the inlet port. The priority flow divider delivers flow to the SCU upon demand. All excess flow is then available to work functions.



1. PRIMARY RELIEF VALVE
2. INLET SECTION
3. LIFT SECTION
4. TILT SECTION
5. AUXILIARY I SECTION
6. AUXILIARY II SECTION
7. OUTLET SECTION
8. TIE RODS
9. NUTS (M8)
10. TIE ROD
11. NUT (M10)

Figure 9050-10-5. Manual Main Control Valve Sections

PRINCIPLES OF OPERATION

Inlet Section

Lift Operation

When the lift valve is operated, the push rod pushes the shuttle, balancing the pressure within the chamber. The spool slides to the left until chamber pressures equal the force of the spring. The flow from the pump port goes through the road-check poppet and the bridge passage towards the cylinder port. See Figure 9050-10-6.

Maximum pressure of the lift port is limited by the main relief valve in the inlet section.

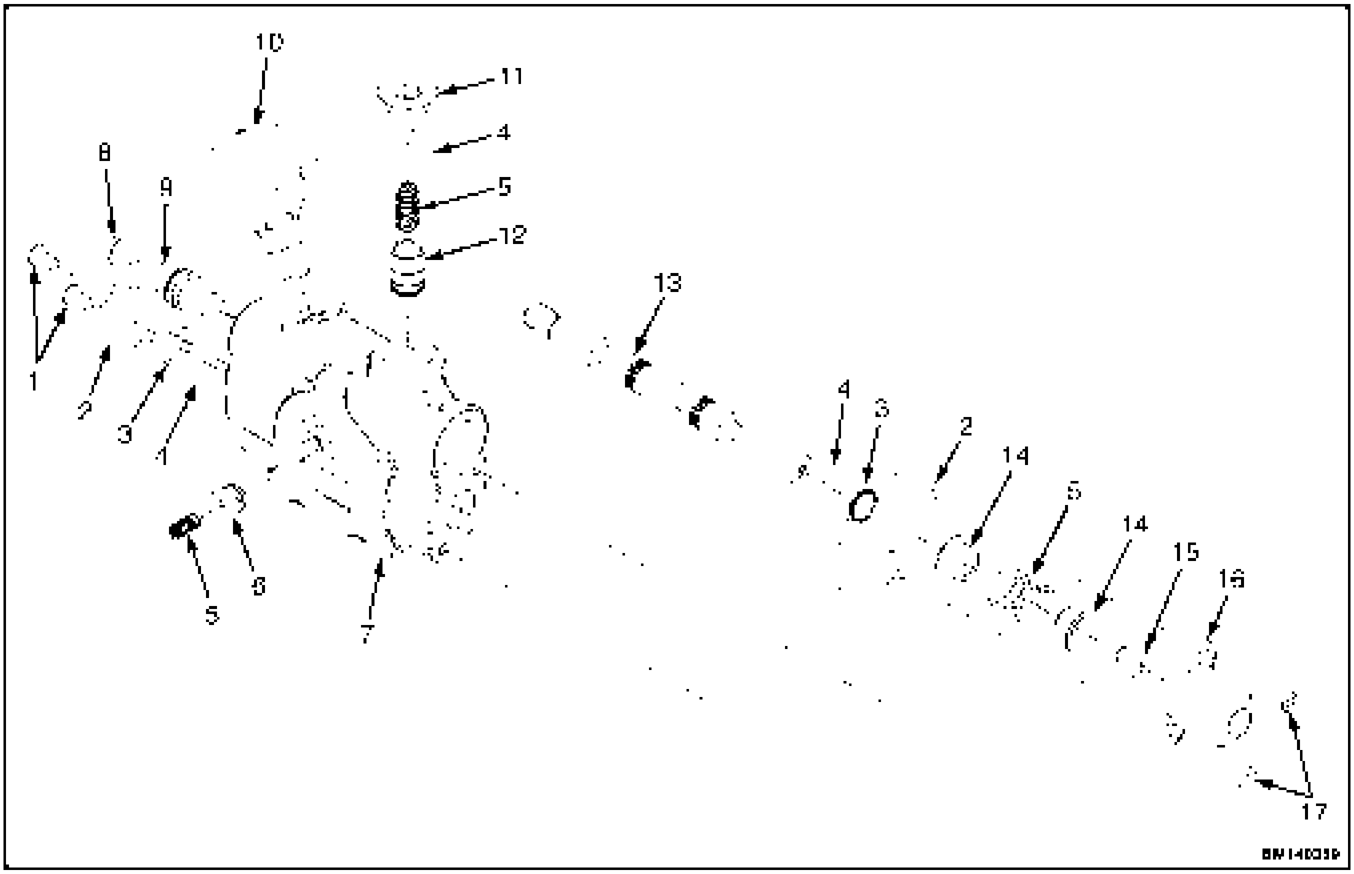
NOTE: Figure 9050-10-6 is an internal valve passage shown external only to illustrate the operation of the spool.

The maximum pressure of the lift function is controlled by the primary relief pressure setting unless a Tilt and/or Auxiliary function is actuated simultaneously. In that case, the maximum pressure of the Lift function is limited by the secondary relief pressure setting.

Lower Operation

When the lift spool is actuated to the lower position, the push rod pushes the shuttle and balances the chamber pressures. The spool slides to the right side until the pressure of the chamber equals the force of the spring. Pilot pressure of the chamber goes into the head chamber valve through the passage. Valve moves to the right side against the force of the spring and opens a path between the chambers. The pressure of the chamber is opened to the tank though the valve and then the lift-lock poppet is lifted up. The spool path opens a path to the tank passage.

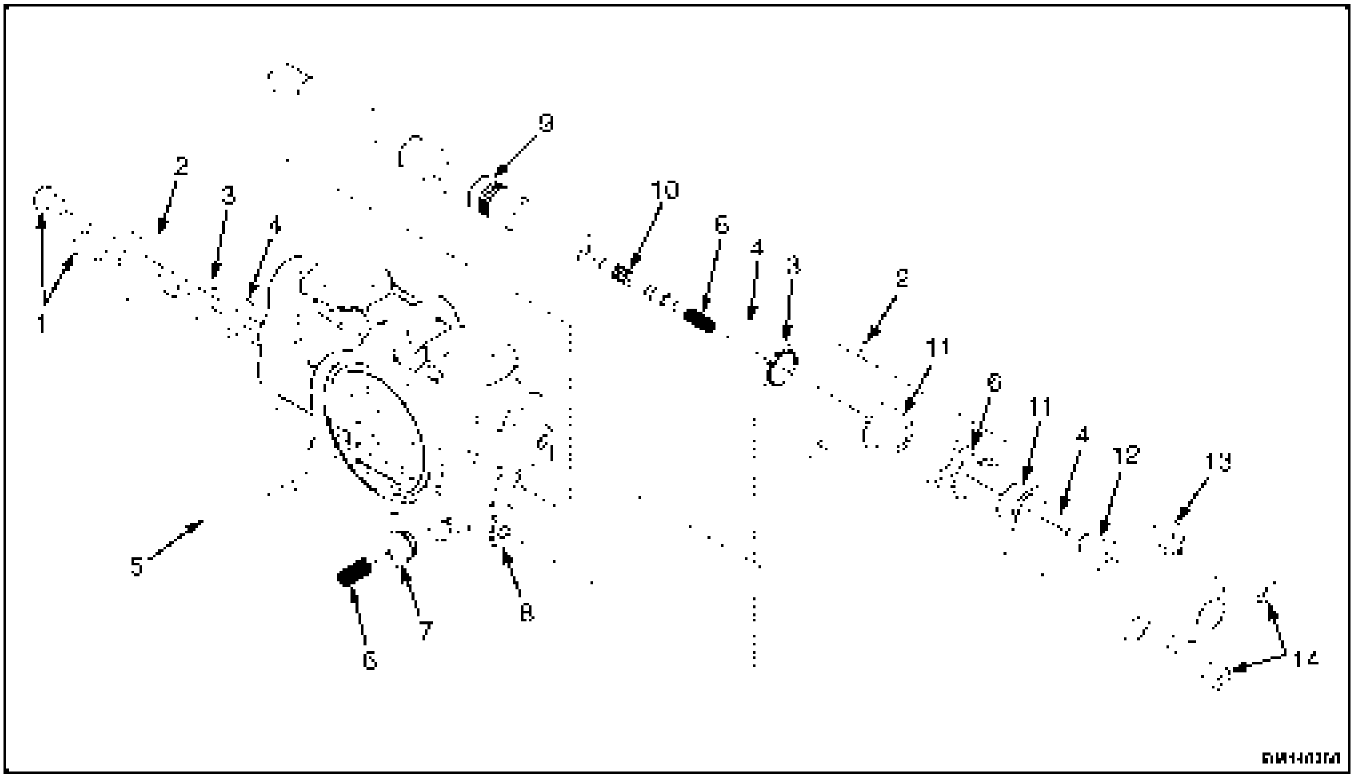
If the pilot pressure is lost, the valve will return to the neutral position and the path for the oil return is closed. The lift-lock poppet closes the path for return oil and to stop lowering.



1. CAPSCREW
2. SEAL PLATE
3. WIPER
4. O-RING
5. SPRING
6. POPPET
7. LIFT / LOWER CONTROL VALVE SECTION
8. HEX NUT (EMERGENCY LOWERING VALVE)
9. EMERGENCY LOWERING VALVE
10. LIFT / LOWERING LOCK-OUT SOLENOID VALVE
11. PLUG
12. POPPET
13. LIFT / LOWER SPOOL
14. SPRING SEAT
15. SPOOL END FASTENER
16. END CAP
17. SOCKET HEAD CAPSCREWS

Figure 9050-10-6. Lift and Lower Section

Tilt Section



1. CAPSCREW
2. SEAL PLATE
3. WIPER
4. O-RING
5. O-RING
6. SPRING
7. POPPET
8. TILT CONTROL VALVE SECTION
9. SPOOL
10. VALVE
11. SPRING SEAT
12. SPOOL END FASTENER
13. END CAP
14. SOCKET HEAD CAPSCREW

Figure 9050-10-7. Tilt Section

Tilt Backward

When the tilt spool is actuated to the tilt back position, the open center flow path is blocked off and forces the oil through the upper load check valve to the high pressure bridge core. From the high pressure bridge core the oil is metered or restricted across metering notches in the spool before flowing out the work port 2B to the rod end of the tilt cylinders. This metering limits the flow out to the tilt cylinders and thus limits the speed at which they move. The upper load check valve prevents back flow from the tilt cylinder under heavy load conditions. If the upper load check valve was absent, under a heavy load condition the mast could drift forward until the pressure builds to a sufficient level to move the mast backward. The oil from the base end of the tilt cylinders returns to the opposite work port 2A and then to the tank passage.

The maximum pressure of the tilt backward function is limited to the secondary relief valve pressure setting.

Tilt Forward

The tilt spool contains a tilt piston that operates when the tilt spool is actuated to the tilt forward position. The tilt lock piston insures positive control of tilting forward by preventing the load from "overrunning" the flow to the tilt cylinders. The tilt lock also prevents any unwanted tilt forwarding when the pump is not running.

When the tilt spool is actuated to the tilt forward position, the open center flow path is blocked off and forces the oil through the load check valve to the high pressure bridge core. From the high pressure bridge core the oil is directed out the work port to the base end of the tilt cylinders. The oil from the rod end of the tilt cylinders returns to the opposite work port and is metered back to the tank passage through orifices spool/tilt lock piston. This metering limits the flow out to the tilt cylinders and thus limits the speed at which they move.

Oil cannot pass through the tilt lock piston until a minimum 7.23 MPa (80 psi) is achieved at the secondary relief bridge passage. If the 7.23 MPa (80 psi)is not present, the tilt lock piston remains closed and will prevent backflow from the tilt cylinder under heavy load condition the mast could drift backward until the pressure builds to a sufficient level to move the mast forward. The maximum pressure of the tilt forward function is limited to the secondary relief valve pressure setting. .

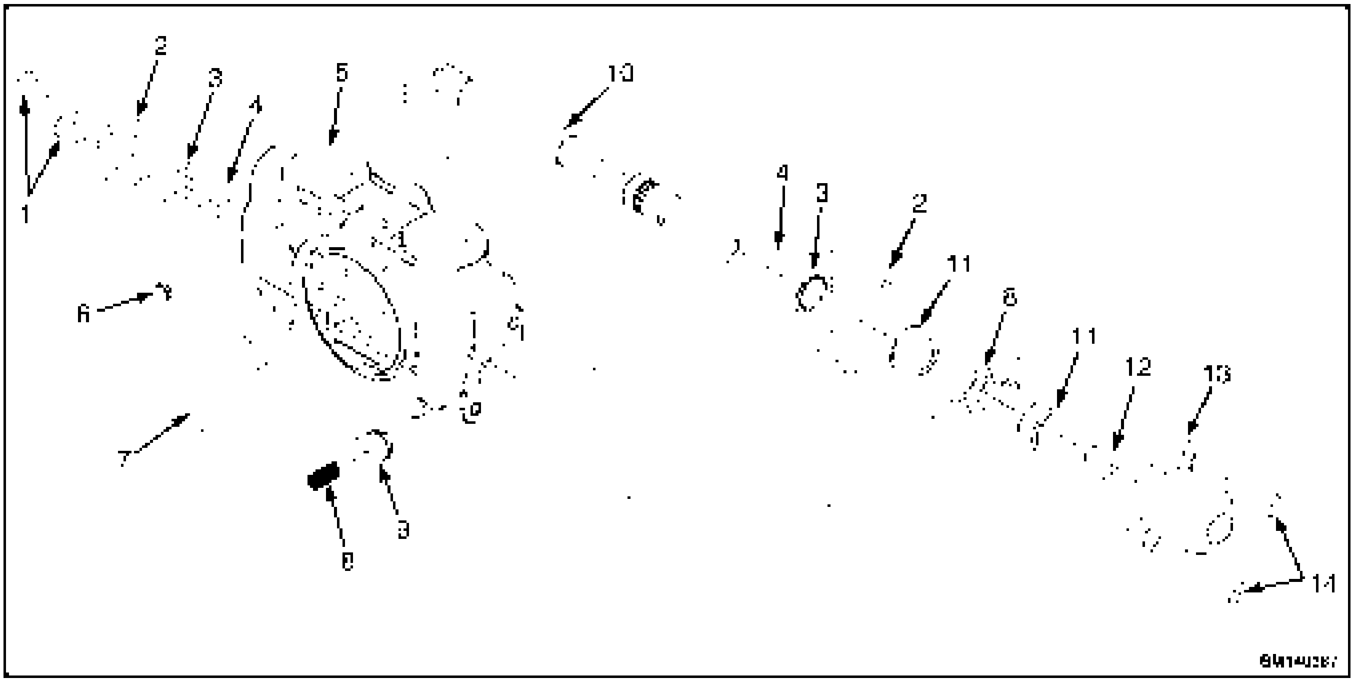
The lower load check valve prevents back flow from the secondary relief valve passage.

Auxiliary Section

The auxiliary section(s) is used to control various attachments that can be installed on the fork lift truck.

When the spool is actuated in or out, the open center flow path is blocked off and forces the oil through the upper load check valve to the high pressure bridge core. From the high pressure bridge core, the oil is directed out the selected work port (3A or 3B for three-function valve, 4A or 4B for four-function valve) to the auxiliary attachment. Oil returns from the auxiliary to the opposite work port and is directed to the tank passage. The upper load check valve prevents back flow from the auxiliary attachment under heavy load conditions. If the upper load check valve was absent, under a heavy load condition the attachment function could drift, when the auxiliary valve is actuated, until the pressure builds to a sufficient level to move the attachment. The maximum pressure of the auxiliary functions is limited to the secondary relief valve pressure setting. See Figure 9050-10-8.

The lower check valve prevents back flow from the secondary relief valve passage.



1. CAPSCREWS
2. SEAL PLATE
3. WIPER
4. O-RING
5. AUXILIARY CONTROL VALVE SECTION
6. PLATE
7. O-RING
8. SPRING
9. POPPET
10. SPOOL
11. SPRING SEAT
12. SPOOL END FASTENER
13. END CAP
14. SOCKET HEAD CAPSCREW

Figure 9050-10-8. Auxiliary I and II Sections

Relief Valves

Main Relief Valve

The Main Relief Valve (MRV) limits the maximum pressure of the lift function. If the lift function is actuated simultaneously with the tilt and/or auxiliary function, the maximum pressure of the lift function is limited by the secondary relief pressure setting.

The MRV is a direct acting differential area type relief valve. The relief valve consists of a poppet on a seat with a spring and adjustment screw.

Typically the main relief valve would not require any field adjustment. If adjustment is necessary, refer to Main Relief Valve Test and Adjustment.

Secondary Relief Valve

NOTE: The secondary relief valve is the same one used in the electro-hydraulic control valve.

The secondary relief valve limits the maximum pressure to the tilt and auxiliary functions. The valve is a direct acting differential area type relief valve. The relief valve consists of a poppet on a seat with a spring and adjustment screw. On occasions, the secondary relief valve may require pressure adjustment due to different types of attachments. If adjustment is necessary, refer to Steering Relief Pressure Test and Adjustment.

Emergency Lowering Valve

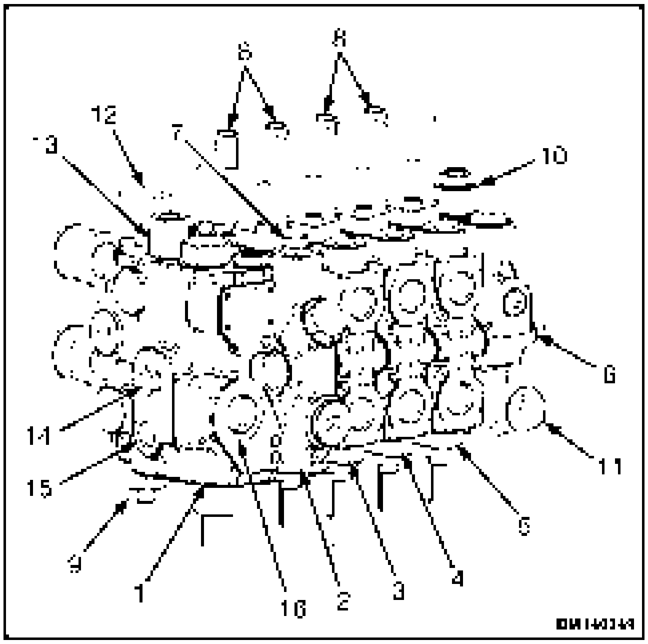
The emergency lowering valve is used to lower the load (including forks, carriage, and mast) in the event of an electrical power failure. The emergency lowering valve is located on the control valve and is equipped with a external hex head. When the emergency lowering valve is turned counterclockwise, the needle valve is unseated, opening a path to tank for the lift cylinder oil. The needle valve is turned clockwise to close off the path to tank.

NOTE: Open needle valve slowly. Needle valve must be completely seated (closed) during normal truck operation or pressure will leak to tank, causing loss of hydraulic lift function.

Electro-Hydraulic Control Valve

DESCRIPTION

The E-Valve is an electronically-controlled, open center valve. The sections are held together by tie-rod bolts. It uses an unloading solenoid to determine when flow can be delivered to the valve. Operating multiple functions simultaneously will result in the lowest pressure function receiving a greater supply of flow. A fixed displacement pump is used with the pressure regulator and unload solenoid valve to supply flow. The hydraulic circuitry will incorporate a dual pressure relief logic. Lift function is on main relief pressure setting. Tilt and Auxiliary functions are on secondary relief pressure setting. See Figure 9050-10-9.



1. INLET SECTION
2. LIFT / LOWER SECTION
3. TILT SECTION
4. AUXILIARY I SECTION
5. AUXILIARY II SECTION
6. OUTLET SECTION
7. EMERGENCY LOWERING VALVE
8. PROPORTIONAL SOLENOID VALVE (PSV)
9. PRIMARY RELIEF VALVE (ADJUSTABLE)
10. SECONDARY RELIEF VALVE (ADJUSTABLE)
11. RETURN TO HYDRAULIC TANK PORT
12. UNLOADER SOLENOID VALVE
13. LOAD SENSE (LS) PORT
14. GAUGE PORT (GP1)
15. PROPORTIONAL FLOW (PF) PORT
16. INLET VALVE

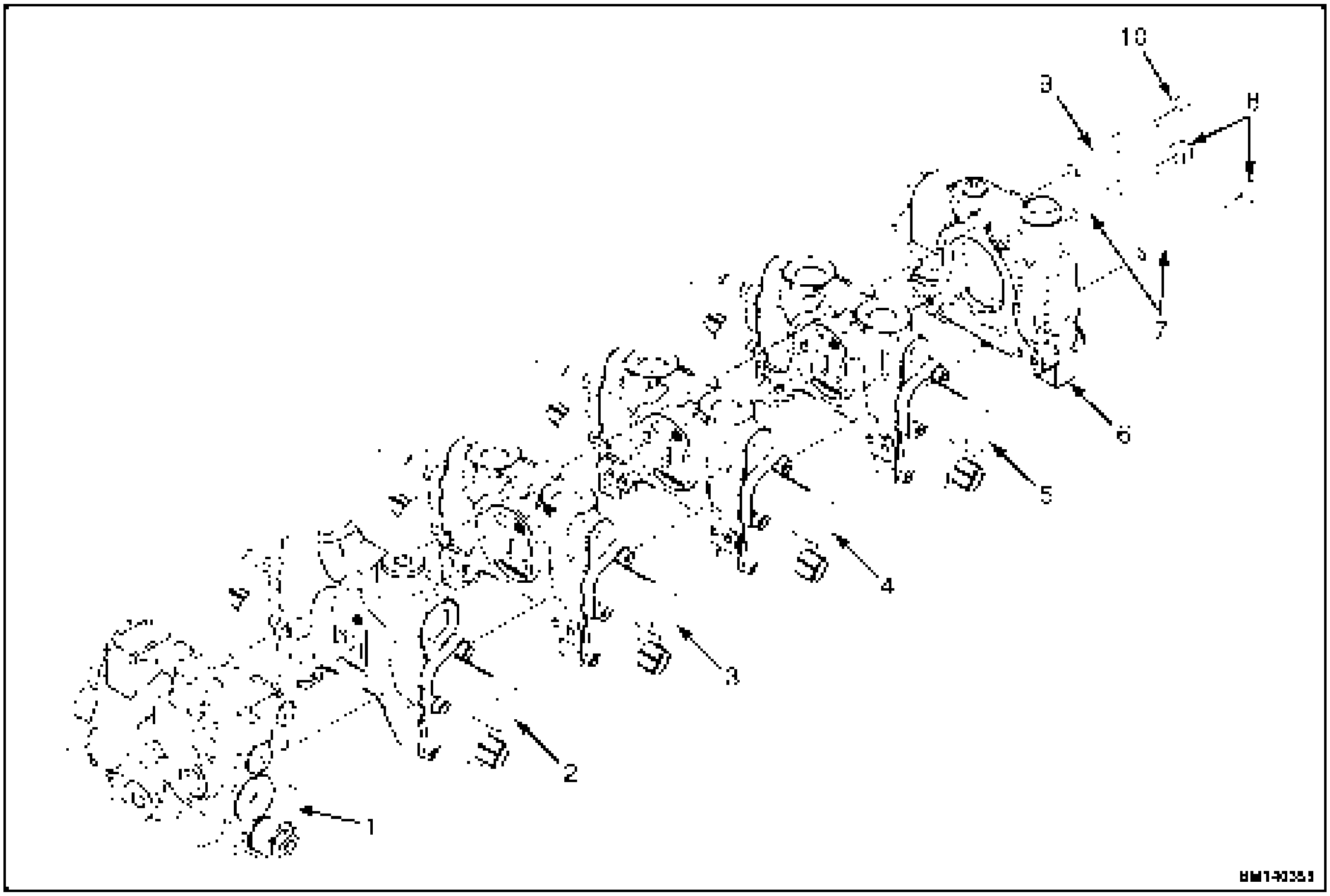
Figure 9050-10-9. Electronic Hydraulic Control valve

The electronic main control valve incorporates an emergency (manual) lowering valve. This valve allows the operator or service technician to lower the lift truck's mast assembly if the electrical signal to the electronic main control valve is disrupted.

The electronic main control valve is equipped with an unloader solenoid valve. This valve will disable each proportional solenoid valve for each hydraulic function when the controller is no longer sending a signal to the hydraulic functions because the operator is no longer in the seat. The unloader solenoid valve dumps excess hydraulic flow back into the hydraulic tank.

PRINCIPLES OF OPERATION

Electro-Hydraulic Control Valve Sections



1. INLET SECTION
2. LIFT / LOWER SECTION
3. TILT SECTION
4. AUXILIARY I SECTION
5. AUXILIARY II SECTION
6. OUTLET SECTION
7. TIE ROD
8. NUT (M8)
9. TIE ROD
10. NUT

Figure 9050-10-10. Control Valve Sections

Refer to Table 9050-10-1 for detailed information regarding main control valve specifications.

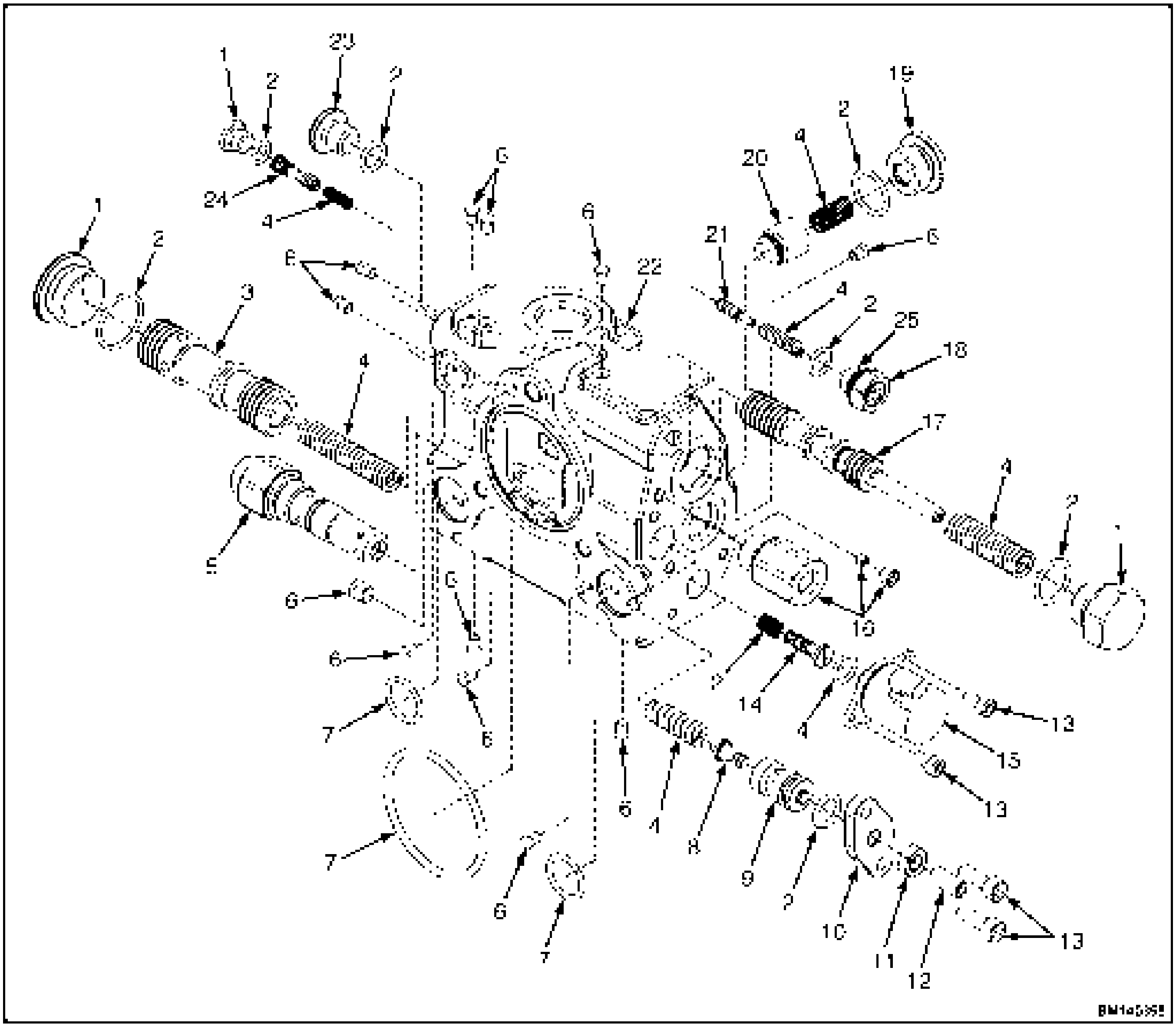
Inlet Pressure

NOTE: All standby pressures are different depending on your lift truck and are approximate measurements.

See for proper kPa (psi) for your lift truck. Refer to Table 9050-10-1.

Table 9050-10-1. E-Hydraulic Main Control Valve Specifications

MAXIMUM FLOW RATE	MAXIMUM OIL PRESSURE	PRIMARY RELIEF VALVE SETTING	SECONDARY RELIEF VALVE SETTING	OIL TEMPERATURE RANGE	FLOW PRIORITY VALVE SPECIFICATIONS (STEERING)
74.4 liter (19.6 gal) per minute	21.4 kPa (3105 psi)	21.4 kPa (3105 psi) at 67 liter (17.7 gal)	17.6 kPa (2553 psi) at 67 liter (17.7 gal)	50 to 65°C (122 to 149°F)	10.3 ±0.3 MPa (1494 ±43.5 psi) at 25 liter (6.6 gal) per minute



1. PLUG
2. O-RING
3. SPOOL ASSEMBLY
4. SPRING
5. PRIMARY RELIEF VALVE
6. PLUG
7. O-RING
8. POPPET
9. HOUSING
10. PLATE
11. NUT
12. SCREW
13. SOCKET HEAD CAPSCREW
14. SHUTTLE
15. UNLOADER SOLENOID VALVE ASSEMBLY
16. PLUG ASSEMBLY
17. SPOOL
18. LOCKNUT
19. PLUG
20. POPPET
21. PISTON
22. INLET HOUSING SECTION
23. PLUG
24. VALVE
25. ADJUSTING NUT

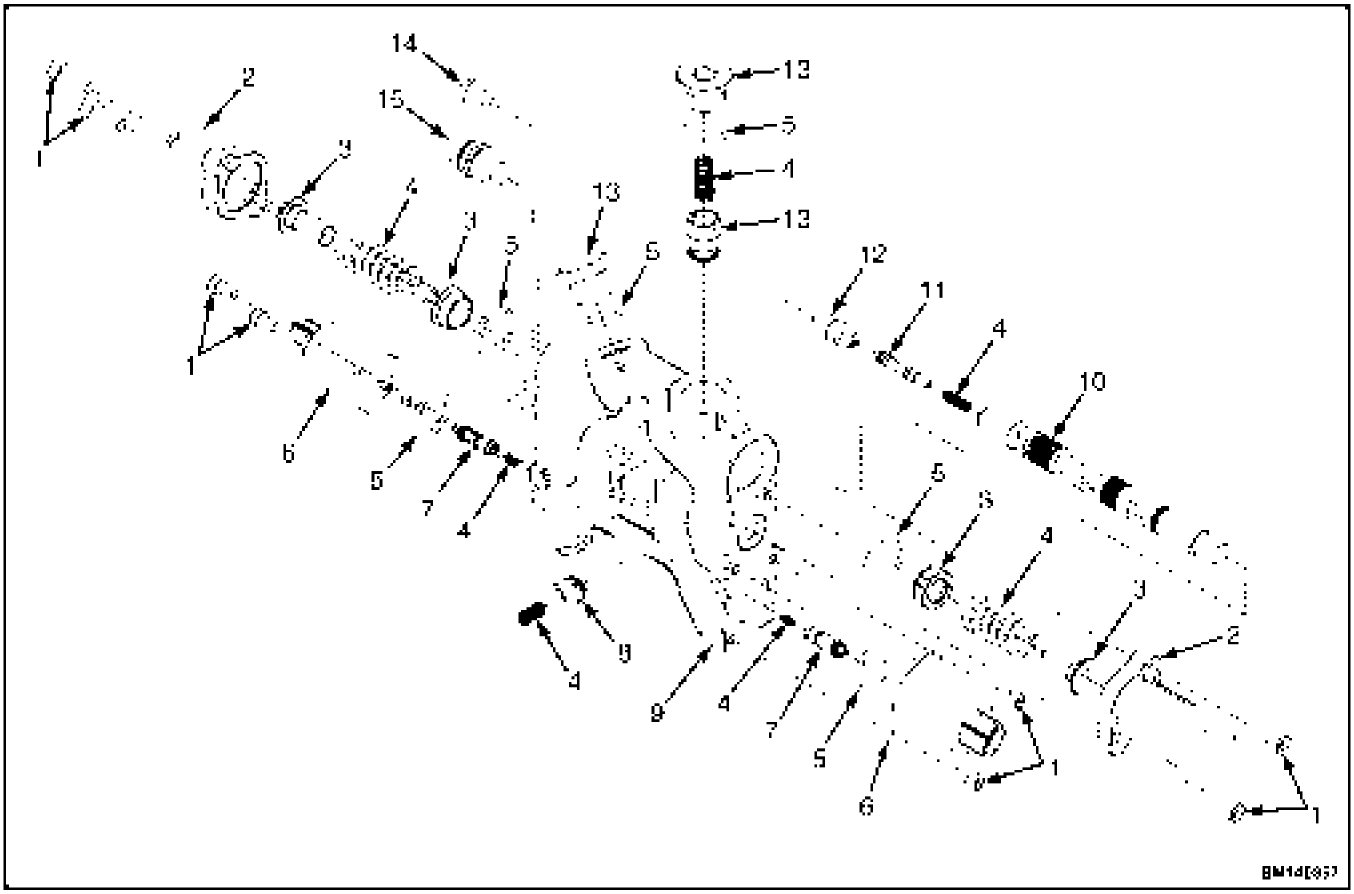
Figure 9050-10-11. Inlet Control Valve Section

Oil from the pump enters the inlet valve through a passage in the inlet section. Oil then flows through the flow priority chamber. At steering valve, spool slides to right side depending on steering demand. Excessive flow go through a paralleled chamber. Steering oil flow to outlet PF-Port. When steering wheel is not used, the flow priority spool keeps a neutral position and standby fluid goes to steering circuit.

When solenoid valve is not actuated, poppet remains neutral. Poppet chamber is connected with the tank through the solenoid valve to unload pump pressure. Once activated, the poppet chamber is closed disconnecting tank and keeping minimum pressure for solenoid operation.

Lift/Lower

Lifting and lowering are handled by a single-acting cylinder. This means there is only one work port for this function, so oil either comes into or leaves the cylinder through the same line. The Lift and Lower functions are controlled by electro-hydraulic poppet valves. These valves are poppets on seats and act as variable orifices. As the user inputs current to either the lift or lower coil, the poppet comes off its seat and allows more area for the oil to flow through.



1. SOCKET HEAD CAPSCREWS
2. CAP
3. SPRING SEAT
4. SPRING
5. O-RING
6. PROPORTIONAL SOLENOID VALVE
7. SPOOL
8. POPPET
9. LIFT / LOWER SECTION HOUSING
10. SPOOL
11. VALVE
12. SPOOL HEAD
13. SOCKET HEAD PLUG
14. BOLT
15. EMERGENCY LOWERING VALVE

Figure 9050-10-12. Lift / Lowering Control Valve

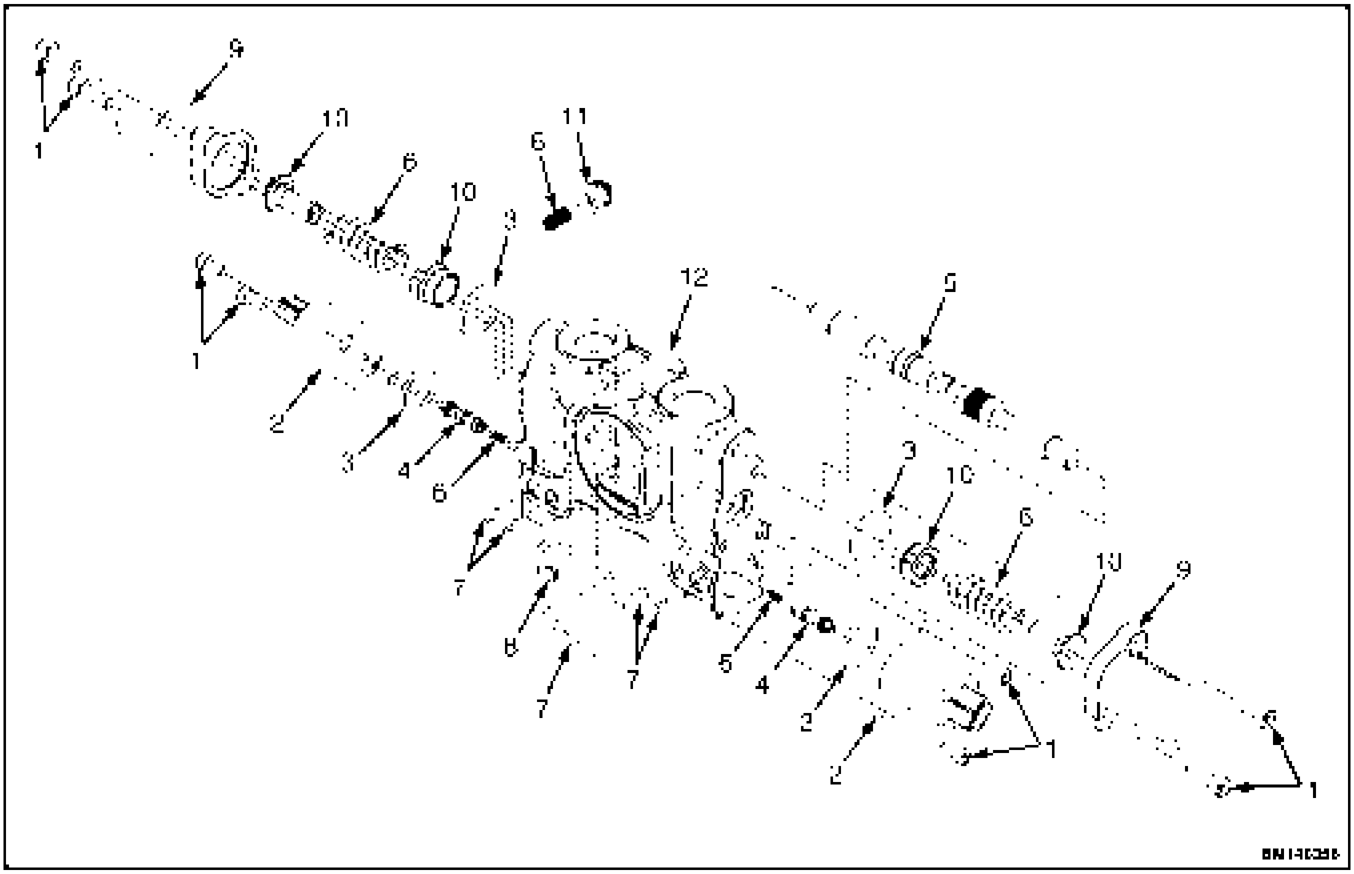
For the Lift function, the passage is connected to the work port, with oil first passing through the lift load-sense chamber and passing the low leak load check valve poppet. Oil then flows from the passage into the lift cylinder. Because the unloader maintains the pressure at Standby Pressure above the lift load-sense signal, the lift flow is compensated. This means lift speed will be the same no matter how much load is on the forks, since the pressure differential is constant.

For the Lower function, the work port is connected directly to the tank. Nothing but the lowering poppet is in this circuit. The gravitational forces on the forks force the oil in the cylinder back through the work port and to the tank passage. Because this is a single-acting cylinder, the pump is not pumping any oil into the other side of the cylinder. For this reason, the lowering flow is not compensated. The speed at which the forks lower will be directly proportional to the load.

Auxiliary Spool Functions

The tilt and auxiliary functions are electro-hydraulic pilot operated functions. That is, the user inputs a current to the Proportional Pressure Reducing Valve (PPRV), which outputs a pilot pressure to the end of the spool. This pressure moves the spool against a spring force on the other side of the spool. The spool, in turn, opens up an area from the (EF) passage to the work port of the valve, allowing the oil to flow.

NOTE: More current results in more flow. Less current results in less flow.



1. SOCKET HEAD CAPSCREW
2. PROPORTIONAL SOLENOID VALVE
3. O-RING
4. SPOOL
5. SPOOL
6. SPRING
7. O-RING
8. PLATE
9. CAP
10. SPRING SEAT
11. POPPET
12. AUXILIARY SECTION HOUSING

Figure 9050-10-13. Auxiliary I and II Control Valve Sections

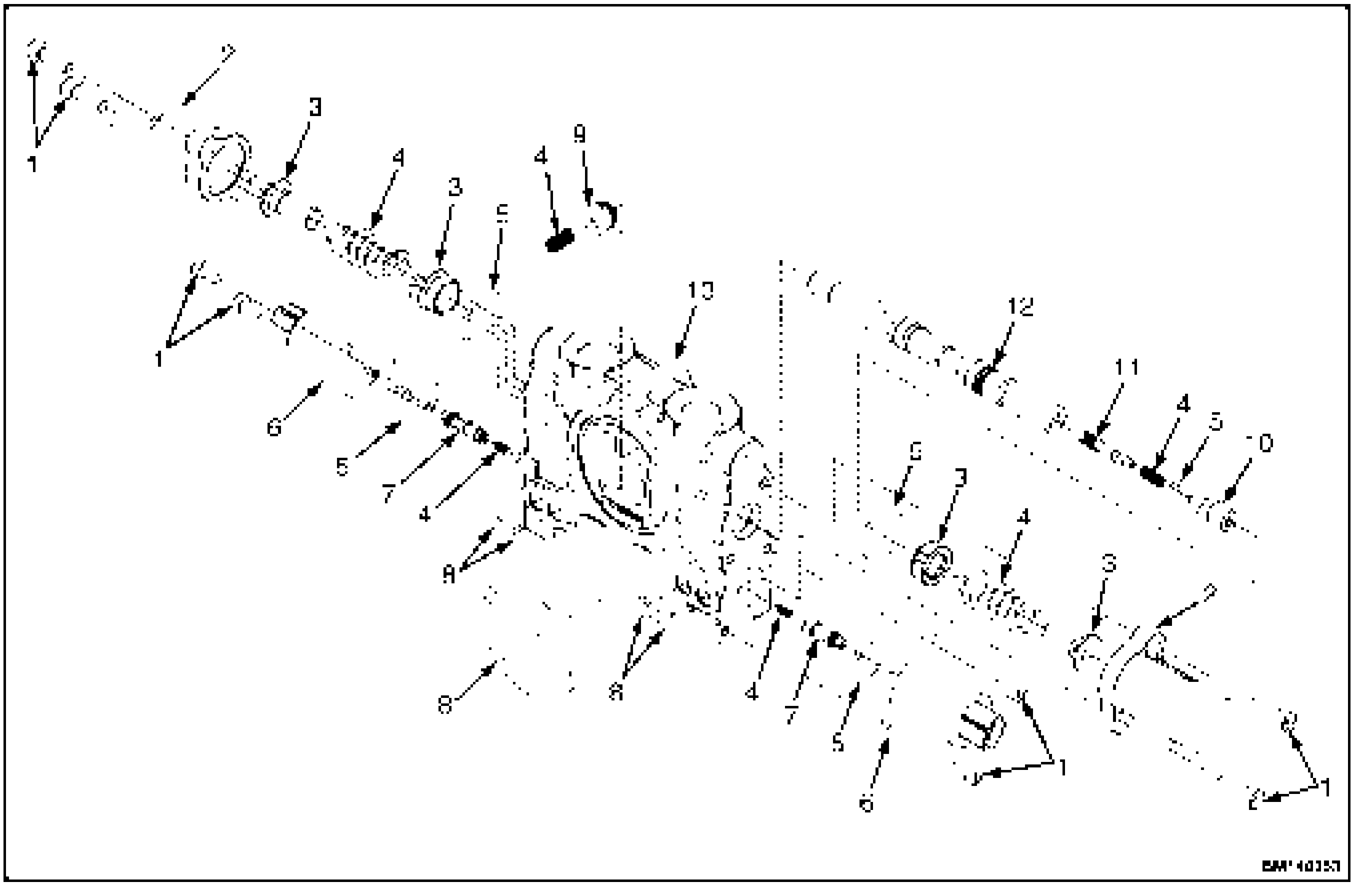
There are two load check valves in each spool sections. When the spool moves and the (EF) passage is opened up, the flow must push through this upper load check valve before it can get into the “bridge” (arch-shaped passage) and out to the work port. The function of this upper load check valve is to prevent “droop” when actuating a function. Before a function is actuated, the passage is at Standby Pressure, because there is no LS signal yet. When there is a large load on a work port and the spool is moved, the system must build up enough pressure to move the load. The upper load check valve is in place to prevent back flow before the system builds up pressure. If this upper load check valve was not present and a heavy loaded function was actuated, the function would briefly move backward before moving forward.

The load-sense load check valve allows the section bridge pressure to be applied down the secondary load-sense passage. With the two or more sections in parallel, this allows the highest pressure to be applied to the unloader and secondary relief valve without any back flow into the other sections. The secondary relief valve and its function will be explained later in this section.

The spool functions are all connected to double-acting cylinders, which means there are two lines connected to the cylinder. One line is connected to the “base” side, and one to the “rod” side. Hence, there are two work ports for these functions, with one being connected to each side of the cylinder. When flow comes out one work port and into the cylinder, the oil on the other side of the cylinder flows back through the spool to the tank.

Tilt Control Valve Section

The tilt spool contains a tilt piston that operates when the tilt spool is actuated to the tilt forward position. The tilt lock piston insures positive control of tilting forward by preventing the load from "overrunning" the flow to the tilt cylinders. The tilt lock also prevents any unwanted tilt forwarding when the pump is not running.



1. SOCKET HEAD CAPSCREWS
2. CAP
3. SPRING SEAT
4. SPRING
5. O-RING
6. PROPORTIONAL SOLENOID VALVE
7. SPOOL
8. O-RING
9. POPPET
10. SPOOL HEAD
11. VALVE
12. SPOOL
13. TILT SECTION HOUSING

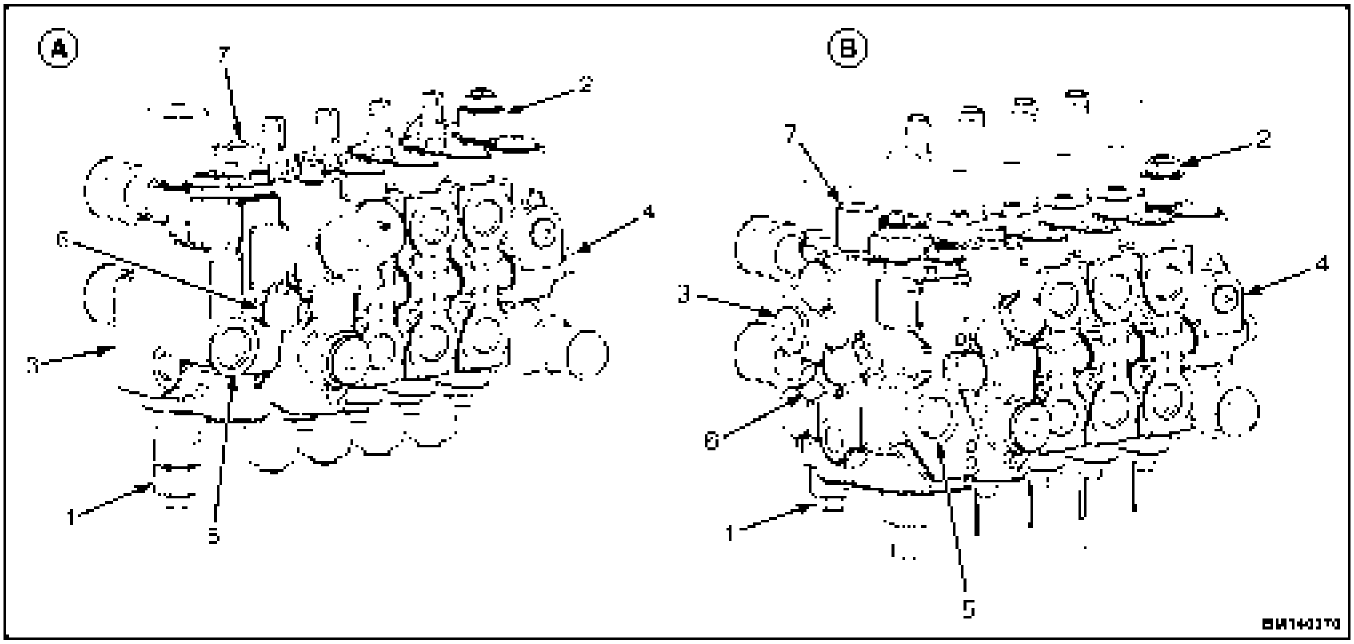
Figure 9050-10-14. Tilt Control Valve Section

When the tilt spool is actuated to the tilt forward position, the open center flow path is blocked off and forces the oil through the load check valve to the high pressure bridge core. From the high pressure bridge core the oil is directed out the work port to the base end of the tilt cylinders. The oil from the rod end of the tilt cylinders returns to the opposite work port and is metered back to the tank passage through orifices spool/tilt lock piston. This metering limits the flow out to the tilt cylinders and thus limits the speed at which they move.

The lower load check valve prevents back flow from the secondary relief valve passage.

NOTE: If the tilt control valve was not there, the heavy load would both push the rod side oil to tank quickly and draw the flow out from the (EF) passage. This would cause the load to overrun the pump and demand more flow than it could supply.

Pressure Relief Valves



A. MANUAL MAIN CONTROL VALVE

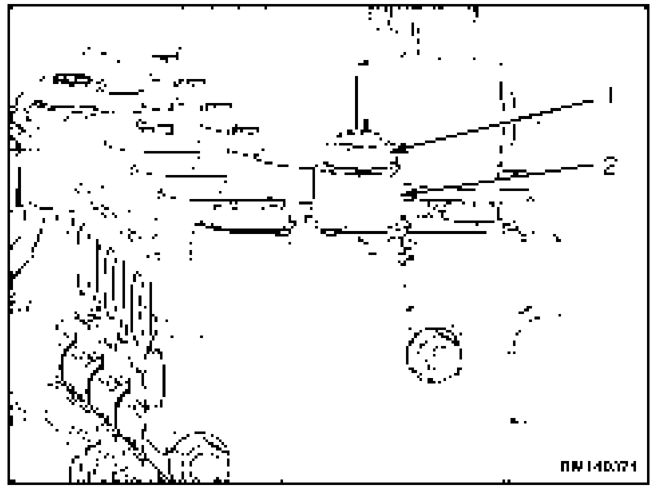
B. E-HYDRAULIC MAIN CONTROL VALVE

1. PRIMARY RELIEF VALVE
2. SECONDARY RELIEF VALVE
3. INLET CONTROL VALVE SECTION
4. OUTLET CONTROL VALVE SECTION
5. PRESSURE (P) PORT
6. GAUGE PORT (GP1 OR TEST PORT)
7. LOAD SENSE (LS) PORT

Figure 9050-10-15. Primary and Secondary Relief Valves Location

Both main control valves have two relief valves: a primary relief valve and a secondary relief valve. The primary relief valve is in the inlet section of the control valve. The secondary relief valve is in the outlet section of the control valve.

The Main Relief Valve (MRV) limits the pressure at which the entire hydraulic system can operate. The MRV contains a small poppet with a spring behind it, and an adjustment screw used to vary the preload on the spring. The screw is adjusted until the poppet will come off the seat at the desired pressure. A jam nut secures the adjustment screw in place. The nose of the MRV is subjected to the LS pressure, and the side exits to tank. The secondary functions (tilt and any auxiliary) have their own relief valve which is set lower than the main relief valve, the functionality of the MRV only applies to the Lift function unless the secondary relief valve is stuck closed. The MRV is situated at the LS end of the unloader spool, where it limits the maximum LS pressure. This, in turn, limits the maximum (EF) pressure, since **EF = LS + Standby Pressure**. The main relief valve itself has very low flow, but by decreasing the LS pressure, it causes the unloader spool to move. This allows the bulk of the flow to exit the valve to tank.



NOTE: SECONDARY RELIEF VALVE ON AN E-HYDRAULIC CONTROL VALVE SHOWN. ADJUSTING NUT ON SECONDARY RELIEF VALVE ON A MANUAL CONTROL VALVE IS THE SAME. ADJUSTING NUT ON PRIMARY RELIEF VALVE ON BOTH E-HYDRAULIC AND MANUAL CONTROL VALVES IS THE SAME.

1. ADJUSTING NUT
2. JAM NUT

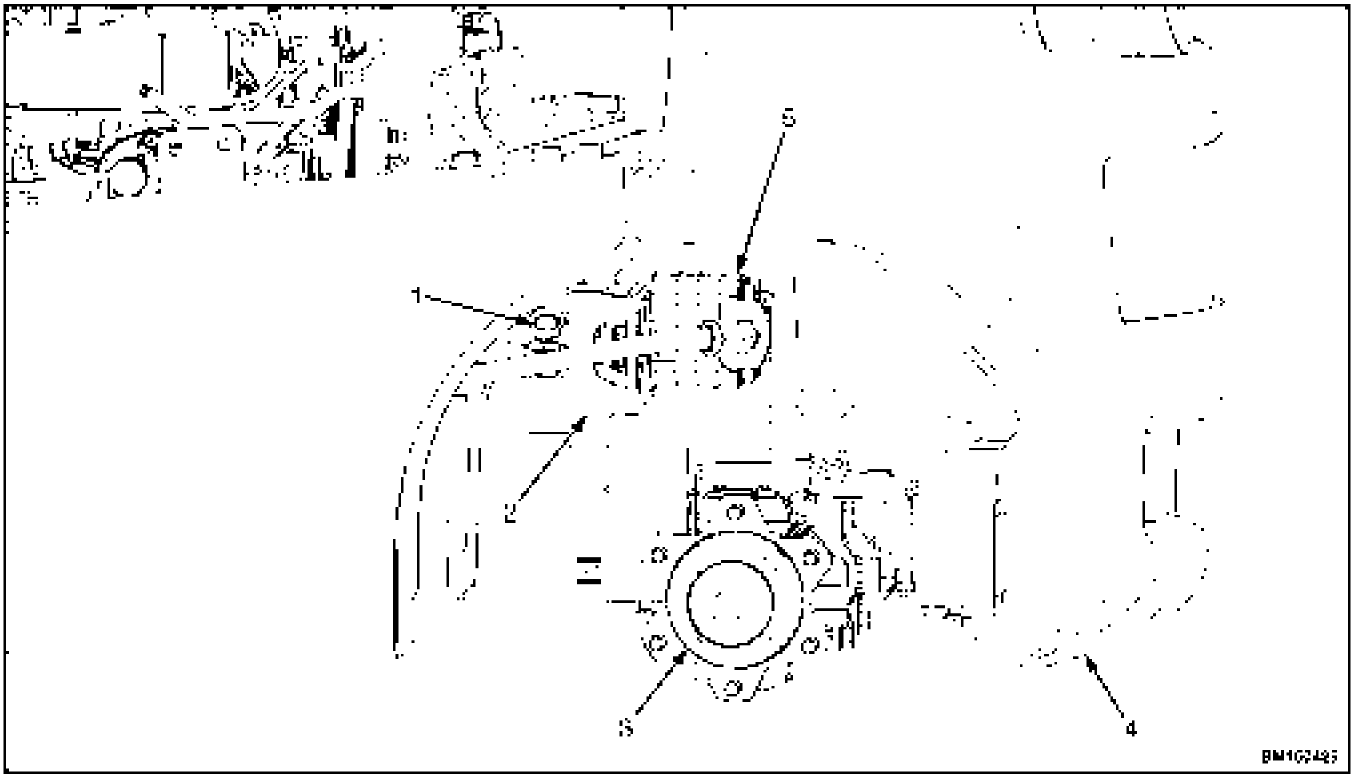
Figure 9050-10-16. Relief Valves Adjusting Nut Location

Steering System

COMPONENT LOCATIONS

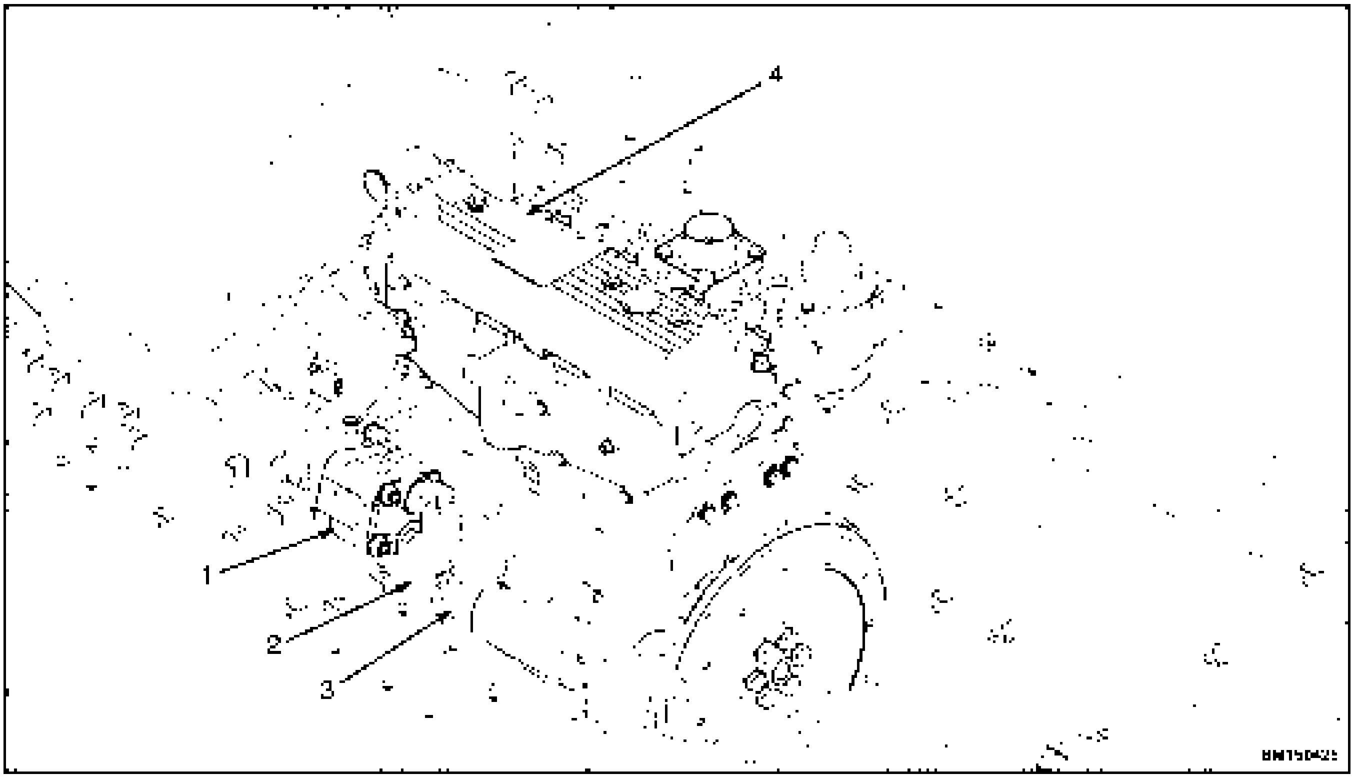
Description

The components of the steering system are shown in Figure 9050-10-19. The steering hoses route hydraulic oil from the Steering Control Unit (SCU) to the steering cylinder. The steering axle assembly controls the position of the wheels. All hydraulic circuits use a common hydraulic tank, hydraulic gear pump, return filter assembly, and breather.



1. PUMP DRIVE SHAFT
2. MOUNTING BRACKET
3. STEERING AXLE
4. COUNTERWEIGHT
5. HYDRAULIC GEAR PUMP

Figure 9050-10-17. Hydraulic Gear Pump (PSI 2.4L Engine and 27.8 cc/rev Gear Pump



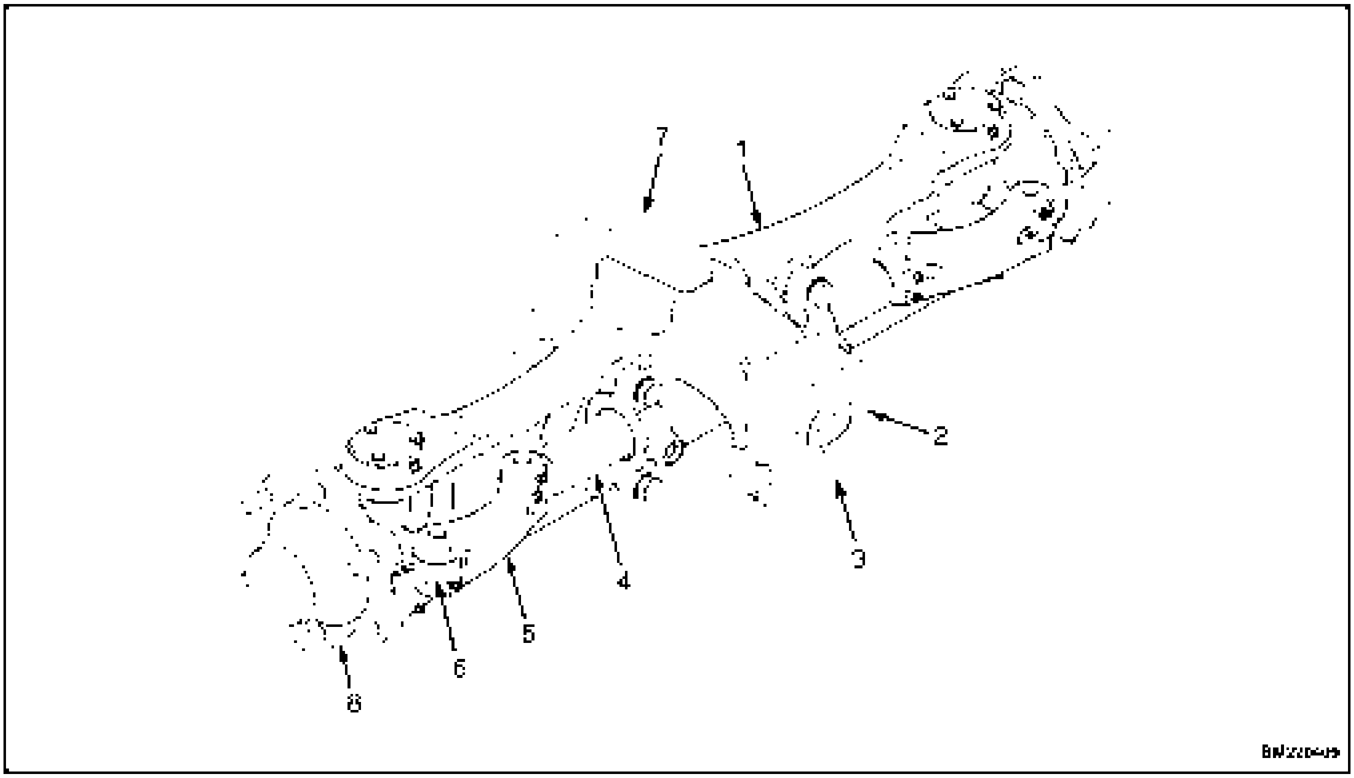
1. HYDRAULIC GEAR PUMP
2. SUCTION HOSE
3. PRESSURE HOSE / FITTING
4. YANMAR DIESEL ENGINE

Figure 9050-10-18. Hydraulic Gear Pump Location (Yanmar Diesel Engine and 24.0 cc/rev Gear Pump)

Steering Axle Assembly

The steering axle assembly consists of an axle frame, steering cylinder, spindle/hub assemblies, attaching brackets, top rubber cushions, and center pivot mounts. The two center pivot mounts isolate the axle from the frame and permit the steering axle to articulate as the lift truck travels over rough surfaces.

There is no mechanical linkage between the SCU and steering axle. The SCU has a gear pump and check valve. If hydraulic flow is lost, the check valve seals the circuit. The gear pump at the base of the SCU acts as a hydraulic pump as the steering wheel is manually turned. This hydraulic pressure and flow to the steering cylinder controls the steering axle wheel position.



1. AXLE FRAME
2. MOUNT
3. BRACKET
4. STEERING CYLINDER
5. TIE ROD
6. SPINDLE
7. MOUNT
8. HUB ASSEMBLIES

Figure 9050-10-19. Steering Axle

Steering Control Unit

The SCU is a closed-center valve. An internal load-sense (LS) oil pressure circuit is used to control the operation of priority flow divider valve spool located in the inlet section of the hydraulic control valve.

The SCU relief valve is located in the inlet section of the control valve, lower than the hydraulic control valve secondary relief setting. Steering relief oil flow is returned to the thank through a hose.

STEERING SCHEMATIC

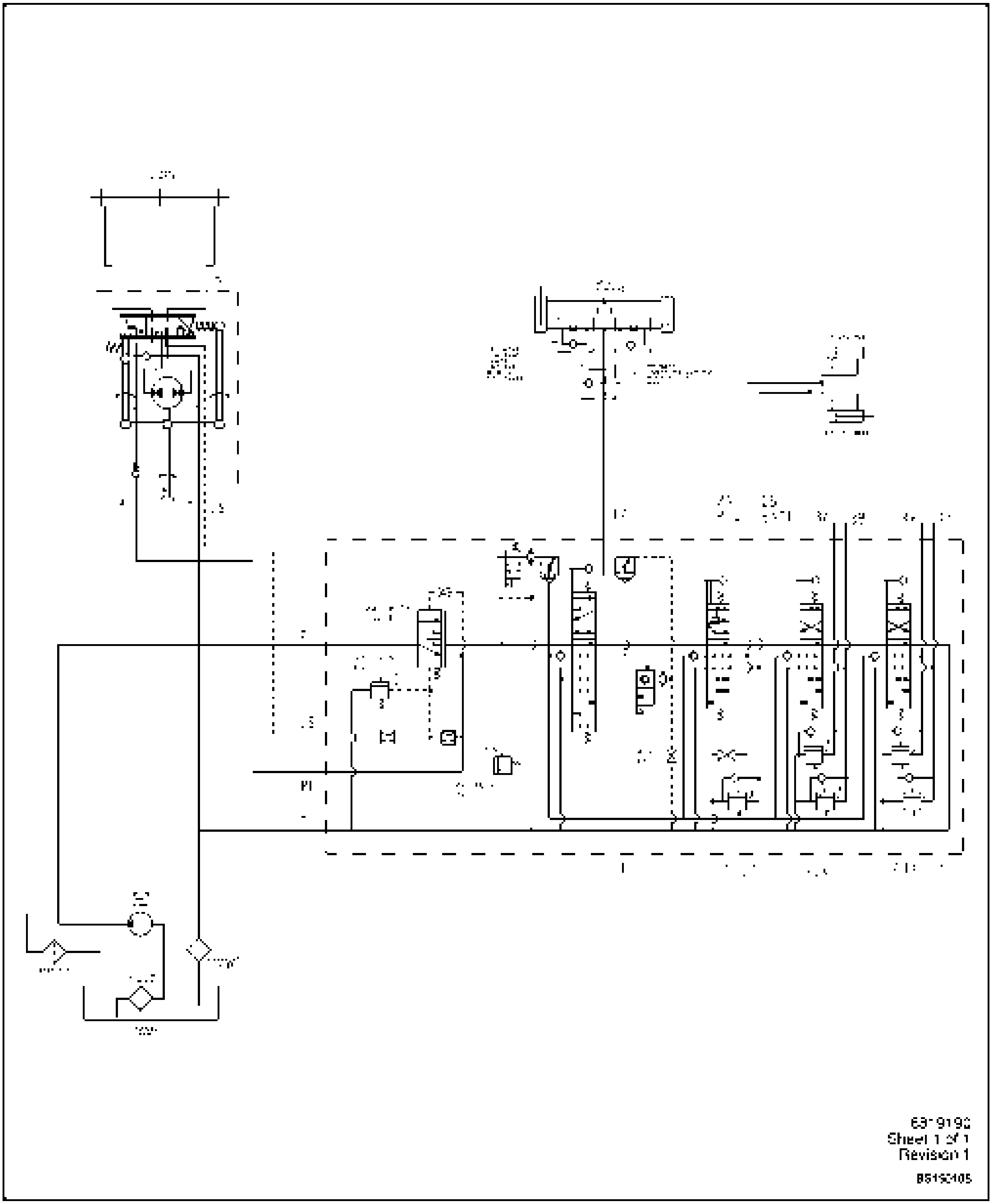


Figure 9050-10-20. Steering Schematic (Manual Hydraulic Control Valve)

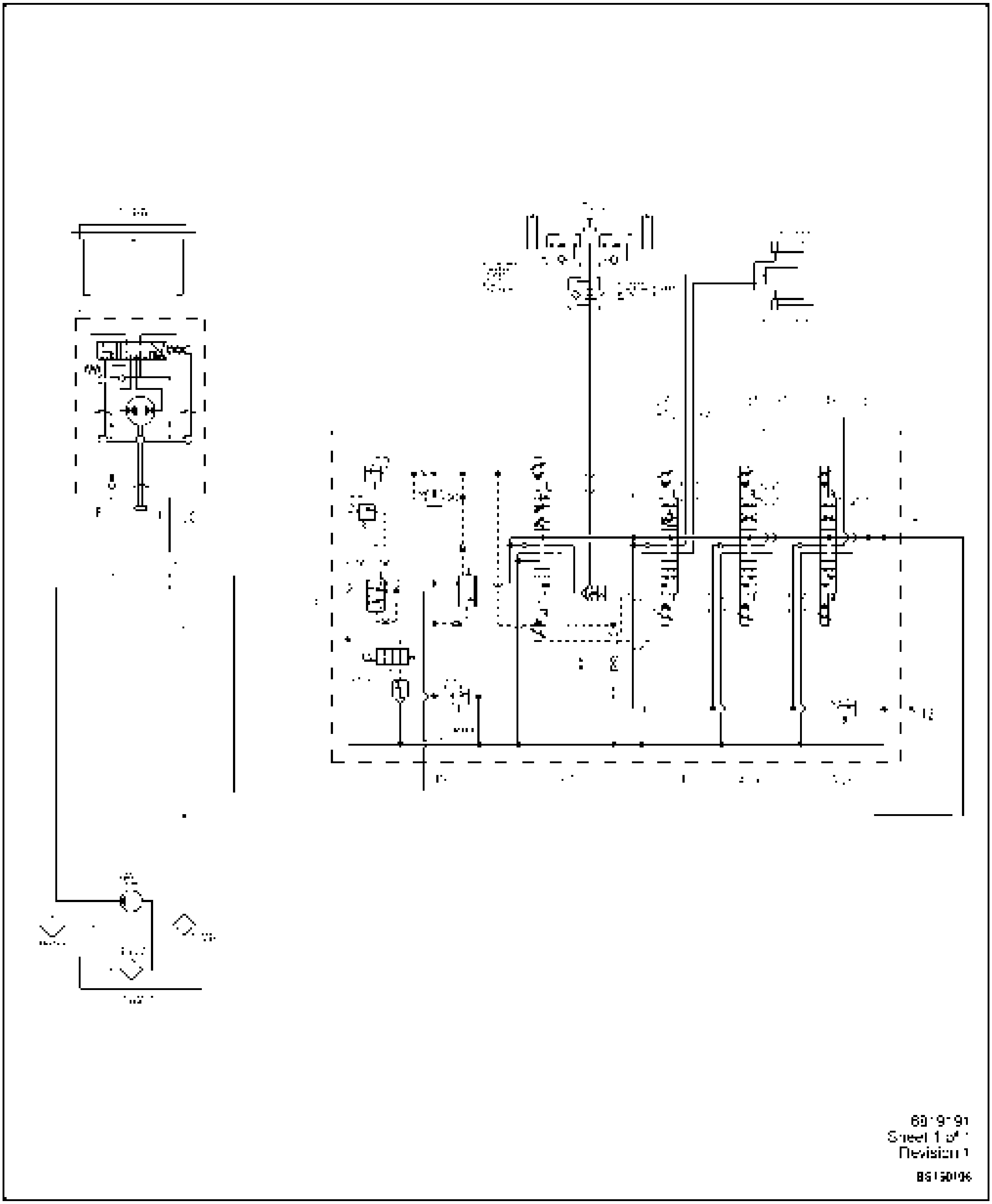


Figure 9050-10-21. Steering Schematic (E-Hydraulic Control Valve)

Principles of Operation

The steering system is a hydrostatic, closed-center, load-sensing type system. There are no mechanical linkages between the Steering Control Unit (SCU) and axle. The steer tires are controlled by oil pressure in the hydraulic circuit. Fixed displacement pump supplies oil flow to the valve. The internal priority flow divider valve provides priority flow to the steering cylinder upon demand (as the operator turns the steering wheel). Any excess flow is directed to the downstream functions in the control valve. If no steering flow is demanded (no rotation of steering wheel by operator), all pump flow is diverted to the control valve. Oil flow in the control valve is used to operate the Lift, Tilt, and Auxiliary functions. All flow is eventually returned to the hydraulic tank through an in-tank mounted hydraulic return filter. An internal bypass circuit protects the hydraulic return filter.

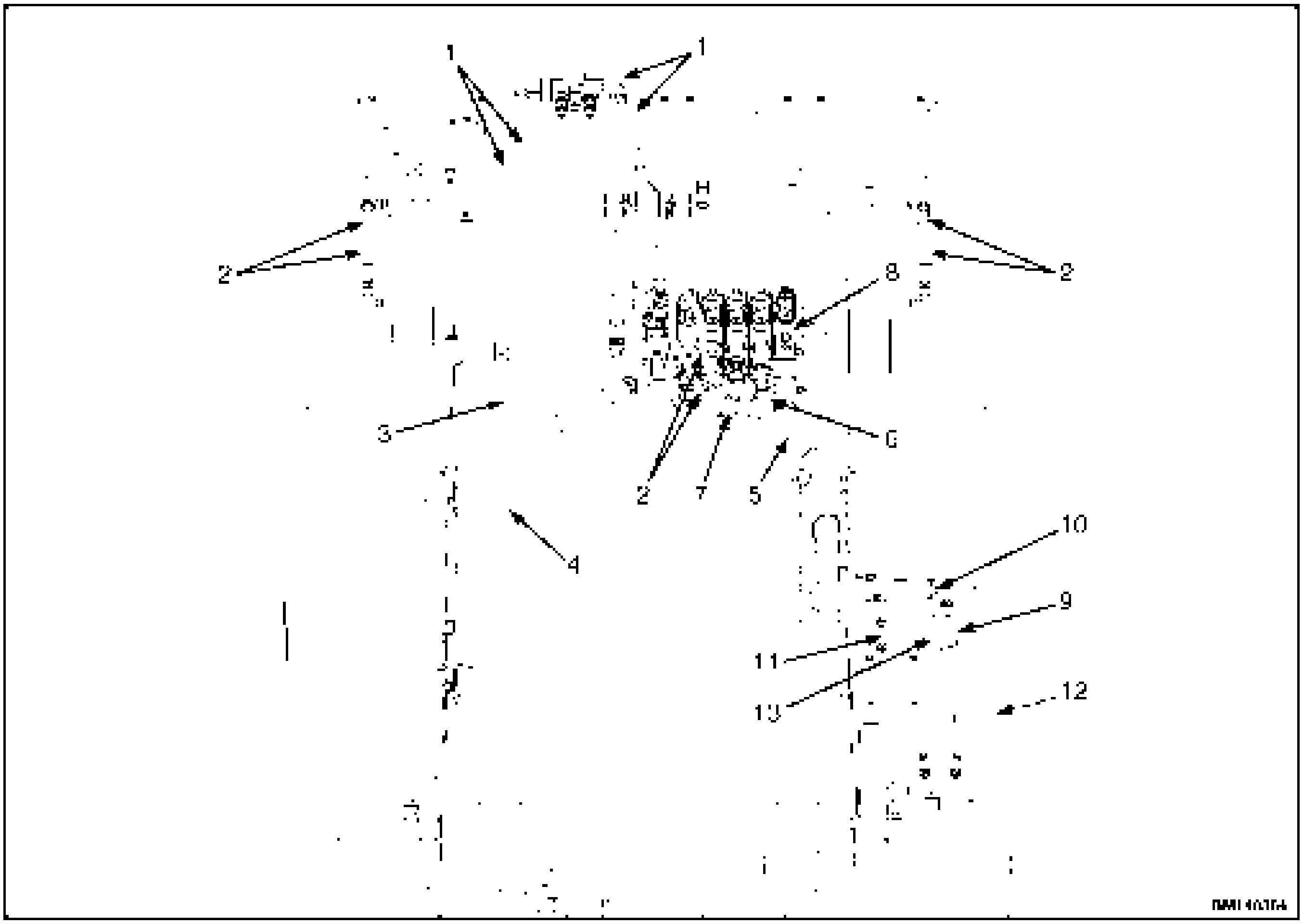
Steering Control Unit

The Steering Control Unit (SCU) is a load-sensing hydrostatic device. The steering wheel controls the SCU. Flow from fixed displacement pump enters the priority flow divider valve (located in the inlet section of the control valve) past the spool to internal anti-kickback check valve. Hydraulic pressure forces anti-kickback check valve to open allowing oil flow to steering valve spool and sleeve set. Flow is also directed through the Load-Sense circuit to the spool and sleeve set.

When the engine is running and the steering wheel is not being turned, the steering valve spool and sleeve set are aligned (neutral position). Oil flow through the valve is blocked from entering the left or right steering ports. Pressure at the pilot side of the priority flow divider valve spool builds forcing the spool to move against the spring on the opposite side. This movement allows full pump flow to be routed to the downstream functions in the control valve. In this neutral position, a small amount of oil is constantly bled through the LS circuit and through the spool and sleeve set, then back to the hydraulic tank. This dynamic flow prevents initial hard spot when steering is turned rapidly or abruptly.

When the engine is running and the steering wheel is being turned, the steering valve spool and sleeve set rotates. A passage opens for oil to flow to the internal gear pump on the SCU. The oil flow causes the gear pump to rotate. Oil flows back into the steering valve spool and sleeve set and out to the left or right steering ports depending on the direction of steering wheel rotation. At the same time, the LS circuit is blocked from returning to the hydraulic tank and is connected to the steering work port to sense pressure required to turn the steering wheels. As the pressure required increases or decreases in the LS circuit, the priority flow divider valve spool shifts to meet the flow and pressure required to rotate the tires. When the steering cylinder reaches the end of its stroke, relief valve in the steering circuit relieves the LS pressure to the hydraulic tank. The priority flow divider valve spool shifts, sending pump flow to the downstream functions in the control valve.

When the engine is not running and the steering wheel is being turned, the priority flow divider valve spool is pushed against the end stop by spring force. In this position, oil flow is open to the spool and sleeve set and closed to the valve work ports. As the steering wheel turns, a vacuum is created in the supply line between the priority flow divider valve and the steering valve spool and sleeve set. As the spool and sleeve set rotate, a passage opens for oil to flow to the internal gear set on the SCU. Trapped oil from the steering port pumps across manual steering check valve to the opposite side of the steering cylinder, allows steering during dead engine.



1. STEERING SYSTEM HOSES
2. TILT HOSES
3. LIFT HOSES
4. HYDRAULIC SUCTION HOSE
5. RETURN HOSE
6. FOURTH FUNCTION HOSE
7. THIRD FUNCTION HOSE
8. MAIN CONTROL VALVE
9. HYDRAULIC FILLER NECK
10. DIPSTICK
11. HYDRAULIC TANK PLATE
12. HYDRAULIC FILTERS (INSIDE TANK)

Figure 9050-10-22. Hydraulic / Steering Hoses

Group 30

Observed Symptoms

OPERATIONAL CHECK

Prior to troubleshooting any Observed Symptom fault, refer to the appropriate diagnostic troubleshooting code.

NOTES

Group 33

Observed Symptoms-Gear Pump

Abnormal Hydraulic Noise and/or Vibration

POSSIBLE CAUSE

A. LOW OIL LEVEL IN TANK.
B. AIR TRAPPED IN CIRCUIT.
C. SUCTION SIDE OF HYDRAULIC PUMP IS RESTRICTED.
D. HYDRAULIC PUMP LEAK AT THE INLET SUCTION HOSES.
E. HYDRAULIC PUMP IS WORN.
F. VIBRATION WITH TILT FUNCTION ONLY.
G. UNSTABLE MAIN RELIEF VALVE.
H. UNSTABLE SECONDARY RELIEF VALVE.
I. HYDRAULIC SYSTEM OVERHEATING.
J. UNSTABLE UNLOADER SPOOL.
K. UNSTABLE PRIORITY VALVE IN SCU.

CAUSE A - LOW OIL LEVEL IN TANK.

PROCEDURE OR ACTION:

NOTE: Cavitation of a hydraulic pump will cause noise and it is caused by air in the hydraulic oil. The hydraulic pump suction oil must be free of air and unrestricted to pump.

1. Check hydraulic oil level in tank.
   Is oil at correct level?
   YES: Go to Cause B.
   NO: Add oil to correct level. See **Operating Manual**.

CAUSE B - AIR TRAPPED IN CIRCUIT.

PROCEDURE OR ACTION:

1. Remove air from circuit by cycling function at one second intervals, for E-Valve hoist and lower only. All other functions, cycle fully for 5 - 10 times. If symptom is still present, go to Cause C.

CAUSE C - SUCTION SIDE OF HYDRAULIC PUMP IS RESTRICTED.

PROCEDURE OR ACTION:

1. Check for restricted inlet screen.
   Is inlet screen restricted?
   YES: Clean or replace inlet screen.
   NO: Go to Step 2.
2. Check for collapsed suction hose.
   Is suction hose collapsed?
   YES: Replace suction hose.
   NO: Go to Cause D.

CAUSE D - HYDRAULIC PUMP LEAK AT THE INLET SUCTION HOSES.

PROCEDURE OR ACTION:

1. Look at Steering System component location drawing to identify suction hose. See Steering System.
   - Inspect suction hoses between tank and pump. Check for loose hose clamps and oil seepage.

   Is oil leaking from suction side of hydraulic pump?
   YES: Check and tighten suction hose clamps.
   NO: Go to Cause E.
2. Inspect hydraulic oil. Check for foaming or aeration of oil.
   Is oil foaming or aerated?
   YES: Repair suction side air leak and test oil for contamination.
   NO: Go to Cause E.

CAUSE E - HYDRAULIC PUMP IS WORN.

PROCEDURE OR ACTION:

1. Check hydraulic pump flow. See Hydraulic Pump Flow Test in this section.
   Is hydraulic pump flow out of specifications?
   YES: Replace hydraulic pump.
   NO: Go to Cause F.

CAUSE F - VIBRATION WITH TILT FUNCTION ONLY.

PROCEDURE OR ACTION:

1. Inspect tilt spool and orifices for contamination or damage.
   Is counterbalance bridge pressure orifice plugged?
   YES: Clean or replace valve section.
   NO: Go to Cause G.

CAUSE G - UNSTABLE MAIN RELIEF VALVE.

PROCEDURE OR ACTION:

1. Install pressure gauge in hydraulic control valve. See Main Relief Valve Test and Adjustment.
2. Operate the hoist function while observing pressure gauge.
   Does pressure fluctuate during hoist function.
   YES: Go to Cause B.
   NO: Go to Step 3.
3. Hold hoist function over relief.
   Does relief pressure meet test specifications?
   YES: Go to Cause H.
   NO: Replace relief valve.

CAUSE H - UNSTABLE SECONDARY RELIEF VALVE.

PROCEDURE OR ACTION:

1. Install pressure gauge in hydraulic control valve. See Secondary Relief Valve Test and Adjustment.
2. Operate a secondary function while observing pressure gauge.
   Does pressure fluctuate during secondary function.
   YES: Go to Cause B.
   NO: Go to Step 3.
3. Hold secondary function over relief.
   Does relief pressure meet test specifications?
   YES: Go to Cause I.
   NO: Replace relief valve.

CAUSE I - HYDRAULIC SYSTEM OVERHEATING.

PROCEDURE OR ACTION:

1. See Observed Symptoms-Gear Pump, Page 9050-33-4Observed Symptoms-Gear Pump, Page 9050-33-4. If symptom is still present, go to Cause J.

CAUSE J - UNSTABLE UNLOADER SPOOL.

PROCEDURE OR ACTION:

1. Inspect unloader valve for damage or contamination.
   Is unloader valve free of contamination and in good condition?
   YES: Go to Cause K.
   NO: Clean or replace unloader valve.

CAUSE K - UNSTABLE PRIORITY VALVE IN SCU.

PROCEDURE OR ACTION:

1. Perform Priority Flow Divided Valve Check.
   Does priority flow divider valve pass the check?
   YES: Priority flow divider valve is OK.
   NO:
   - Cannot turn steering wheel, wheel locks up. See Observed Symptoms, Page 9050-30-1.
   - Steering wheel turns but fails Priority Valve Flow Divider Valve Check, remove and clean flow divider spool.

END SYMPTOM

Abnormal Smell/Discoloration/Foaming of Oil

POSSIBLE CAUSE

A. HYDRAULIC SYSTEM HAS BEEN OVERHEATED.
B. HYDRAULIC FLUID CONTAMINATED OR WRONG TYPE.
C. AIR LEAK ON SUCTION SIDE OF HYDRAULIC PUMP.

CAUSE A - HYDRAULIC SYSTEM HAS BEEN OVERHEATED.

PROCEDURE OR ACTION:

1. Inspect for the following:
   - Level and condition of hydraulic oil in tank
   - Valve stuck causing system to run at relief
   - Excessive duty cycle. Add hydraulic cooler field kit

   Are any of the above symptoms present?
   YES: Drain and refill hydraulic tank.
   NO: Go to Cause B.

CAUSE B - HYDRAULIC FLUID CONTAMINATED OR WRONG TYPE.

PROCEDURE OR ACTION:

1. Check hydraulic oil for contamination and correct type.
   Is hydraulic oil contaminated or incorrect type used?
   YES: Drain and refill hydraulic tank.
   NO: Go to Cause C.

CAUSE C - AIR LEAK ON SUCTION SIDE OF HYDRAULIC PUMP.

PROCEDURE OR ACTION:

1. Inspect condition of hydraulic oil.
   Is the hydraulic oil foaming or aerated?
   YES: Repair leak on suction side of hydraulic pump.
   NO: Check service record of lift truck to see if it requires periodic maintenance.

END SYMPTOM

Abnormal Steer Axle Noise

POSSIBLE CAUSE

A. WHEEL IS LOOSE.
B. STEER WHEEL CONTACTING STEERING AXLE OR CHASSIS.
C. TIE ROD AND/OR BUSHINGS ARE WORN.
D. WHEEL OR SPINDLE BEARING LUBRICATION IS INADEQUATE.
E. WHEEL OR SPINDLE BEARING FAILURE.
F. STEERING AXLE BUSHINGS WORN.
G. STEERING AXLE DAMAGED.

CAUSE A - WHEEL IS LOOSE.

PROCEDURE OR ACTION:

1. Inspect wheels, lug nuts and studs for damage.
   Are wheels, lug nuts and studs damaged or loose?
   YES: If loose, tighten wheel lugs. Repair or replace damaged parts. Refer to **Periodic Maintenance** 8000SRM2000 .
   NO: Go to Cause B.

CAUSE B - STEER WHEEL CONTACTING STEERING AXLE OR CHASSIS.

PROCEDURE OR ACTION:

1. Inspect steer wheels, steering axle, and chassis.
   Are wheels contacting steering axle or chassis?
   YES: Repair or replace steer wheel or steering axle, or repair chassis. **Steering Axle** 1600SRM1990 .
   NO: Go to Cause C.

CAUSE C - TIE ROD AND/OR BUSHINGS ARE WORN.

PROCEDURE OR ACTION:

1. Inspect tie rod and bushing.
   Are tie rods and bushing in good condition?
   YES: Go to Cause D.
   NO: Repair or adjust tie rods or bushings.

CAUSE D - WHEEL OR SPINDLE BEARING LUBRICATION IS INADEQUATE.

NOTE: See **Operating Manual** for lubrication procedures.

PROCEDURE OR ACTION:

1. Lubricate wheel and spindle bearings.
   Did the bearings lack lubrication?
   YES: Service lift truck per **Operating Manual** instructions.
   NO: Go to Cause E.

CAUSE E - WHEEL OR SPINDLE BEARING FAILURE.

PROCEDURE OR ACTION:

1. Inspect bearings and spindle.
   Are the bearings and spindle in good condition?
   YES: If bearings are OK, go to Cause F.
   NO: Replace bearings and/or spindle.

CAUSE F - STEERING AXLE BUSHINGS WORN.

PROCEDURE OR ACTION:

1. Inspect steering axle bushings for wear.
   Are the steering axle bushings in good condition?
   YES: Go to Cause G.
   NO: Replace bushings.

CAUSE G - STEERING AXLE DAMAGED.

PROCEDURE OR ACTION:

1. Inspect steering axle for damage.
   Is steering axle in good condition?
   YES: Resume operation while monitoring systems to locate source of noise.
   NO: Repair as required.

END SYMPTOM

Abnormal Steering Wheel Vibration

POSSIBLE CAUSE

A. WORN TIRES.
B. LOW OIL LEVEL IN TANK.
C. AIR WAS NOT REMOVED AFTER REPAIR TO THE HYDRAULIC SYSTEM.
D. STEERING AXLE COMPONENTS WORN.

CAUSE A - WORN TIRES.

PROCEDURE OR ACTION:

1. Inspect tires.
   Are tires worn?
   YES: Replace tires.
   NO: Go to Cause B.

CAUSE B - LOW OIL LEVEL IN TANK.

PROCEDURE OR ACTION:

NOTE: Cavitation of a hydraulic pump will cause noise and it is caused by air in the hydraulic oil. The hydraulic pump suction oil must be free of air and unrestricted to pump.

1. Check hydraulic oil level in tank.
   Is oil at correct level?
   YES: Go to Cause C.
   NO: Add oil to correct level. See **Operating Manual**.

CAUSE C - AIR WAS NOT REMOVED AFTER REPAIR TO THE HYDRAULIC SYSTEM.

PROCEDURE OR ACTION:

1. Check service record of lift truck.
   Was hydraulic system repaired recently?
   YES: Check the repaired hose connections. Remove air from system by cycling function full stroke of steering cylinder in each direction.
   NO: Go to Cause D.

CAUSE D - STEERING AXLE COMPONENTS WORN.

PROCEDURE OR ACTION:

1. Operate truck to determine if vibration is hydraulic or mechanical.
   Is the vibration caused by hydraulics?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-1.
   NO: Repair or replace worn or damaged steer axle components.

END SYMPTOM

Actuation Exhibits Slight Movement in Opposite Direction Before Moving (Manual Valve)

POSSIBLE CAUSE

A. AIR WAS NOT REMOVED AFTER REPAIR TO THE HYDRAULIC SYSTEM.
B. UPPER LOAD CHECK IS LEAKING, DAMAGED, OR CONTAMINATED.
C. EXCESSIVE CONTROL VALVE SPOOL OR CYLINDER LEAKAGE.

CAUSE A - AIR WAS NOT REMOVED AFTER REPAIR TO THE HYDRAULIC SYSTEM.

PROCEDURE OR ACTION:

1. Check service record of lift truck.
   Was hydraulic system repaired recently?
   YES: Check the repaired hose connections and remove air from system by cycling function full stroke of steering cylinder in each direction.
   NO: Go to Cause B.

CAUSE B - UPPER LOAD CHECK IS LEAKING, DAMAGED, OR CONTAMINATED.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Perform the Lift Load Check.
   Does lift load check pass test?
   YES: Go to Cause C.
   NO: Clean or repair lift load check.

CAUSE C - EXCESSIVE CONTROL VALVE SPOOL OR CYLINDER LEAKAGE.

PROCEDURE OR ACTION:

1. Identify if problem is in lift cylinder or control valve. Do **Lift Cylinder Leakage Test** .
   Does lift cylinder pass leakage test.
   YES: Problem is in control valve. Clean and repair.
   NO: Repair or replace lift cylinder.

END SYMPTOM

Actuation Functions With Armrest Up (E-Valve)

POSSIBLE CAUSE

A. ARMREST SWITCH IS STUCK CLOSED.
B. SHORT IN WIRING HARNESS.

CAUSE A - ARMREST SWITCH IS STUCK CLOSED.

PROCEDURE OR ACTION:

WARNING

Serious injury or death can occur if hydraulic functions are activated when operator is out of seat. Actuate control only while in the operator's seat and armrest in locked-down position. These safety devices are for your protection, do not disarm them.

1. Check armrest switch.
   Is armrest switch stuck closed?
   YES: Replace switch.
   NO: Go to Cause B.

CAUSE B - SHORT IN WIRING HARNESS.

PROCEDURE OR ACTION:

1. Inspect and repair harness. See **Wire Harness Repair**.

END SYMPTOM

Actuations Do Not Act Simultaneously

POSSIBLE CAUSE

A. LOW PUMP FLOW.
B. SECONDARY RELIEF VALVE SET TOO LOW.

CAUSE A - LOW PUMP FLOW.

PROCEDURE OR ACTION:

1. Check cycle times of lift function.
   Is lift function speed ok?
   YES: Go to Cause B.
   NO: Go to Observed Symptoms-Gear Pump, Page 9050-33-1.

CAUSE B - SECONDARY RELIEF VALVE SET TOO LOW.

PROCEDURE OR ACTION:

1. Test and adjust secondary relief pressure. See Secondary Relief Valve Test and Adjustment.

END SYMPTOM

Auxiliary Function is Slow or Does Not Function (Manual Valve)

POSSIBLE CAUSE

A. PUMP NOT GENERATING ENOUGH FLOW.
B. LOAD IS GREATER THAN TRUCK CAPACITY.
C. SPOOL IS NOT FULLY ACTUATED.
D. SECONDARY RELIEF VALVE IS SET TOO LOW.
E. SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.
F. MAIN RELIEF VALVE SET TOO LOW, DAMAGED, OR STUCK OPEN.
G. MAST/ATTACHMENT IS BINDING.
H. ENGINE HIGH IDLE SETTING NOT CORRECT.
I. EXCESSIVE INTERNAL SPOOL LEAKAGE.

CAUSE A - PUMP NOT GENERATING ENOUGH FLOW.

PROCEDURE OR ACTION:

1. Do hydraulic pump flow check. See Observed Symptoms, Page 9050-30-1.
   Does pump pass check?
   YES: Pump is OK. Go to Cause B.
   NO: Do Hydraulic Pump Flow Test before replacing pump.

CAUSE B - LOAD IS GREATER THAN TRUCK CAPACITY.

NOTE: See Serial Number plate or for lift capacity.

PROCEDURE OR ACTION:

1. Check load weight and compare to truck capacity rating.

CAUSE C - SPOOL IS NOT FULLY ACTUATED.

PROCEDURE OR ACTION:

1. Inspect linkage.
   Does linkage prematurely contact dash?
   YES: Repair or replace linkage.
   NO: Go to Cause D.

CAUSE D - SECONDARY RELIEF VALVE IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause E.
   NO: Adjust pressure to test specifications.

CAUSE E - SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect relief valve.
   Is relief valve damaged or stuck open?
   YES: Install new relief valve.
   NO: Go to Cause F.

CAUSE F - MAIN RELIEF VALVE SET TOO LOW, DAMAGED, OR STUCK OPEN.

PROCEDURE OR ACTION:

NOTE: This symptom only affects auxiliary functions when hoist function is activated.

1. Test and adjust pressure. See Main Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause G.
   NO: Adjust pressure to test specifications and retest. If problem is still present, replace relief valve.

CAUSE G - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair mast or attachment.
   NO: Go to Cause H.

CAUSE H - ENGINE HIGH IDLE SETTING NOT CORRECT.

PROCEDURE OR ACTION:

1. Check for correct engine high idle setting.
   Is engine high idle set correctly?
   YES: Go to Cause I.
   NO: Adjust engine high idle setting. Go to Engine Repair.

CAUSE I - EXCESSIVE INTERNAL SPOOL LEAKAGE.

PROCEDURE OR ACTION:

1. Replace spool or complete control valve.

END SYMPTOM

Back Lash/Kick Back in Steering Wheel

POSSIBLE CAUSE

A. LOOSE STEERING AXLE COMPONENTS.
B. SPLINES OR STEERING SHAFT UNIVERSAL JOINT IN STEERING COLUMN WORN OR BROKEN.
C. STEERING RELIEF PRESSURE IS NOT SET CORRECTLY.
D. FAILED CENTERING SPRINGS IN SCU.
E. STEERING CONTROL UNIT IS ASSEMBLED INCORRECTLY OR IS DAMAGED.
F. ANTI-KICKBACK CHECK VALVE NOT WORKING PROPERLY

CAUSE A - LOOSE STEERING AXLE COMPONENTS.

PROCEDURE OR ACTION:

1. Turn steering wheel back and forth while observing steer axle wheels at slow idle.
   Do the tires respond directly to steering wheel movement?
   YES: Go to Cause B.
   NO: Inspect wheel studs and steering axle components for damage. Repair as required.

CAUSE B - SPLINES OR STEERING SHAFT UNIVERSAL JOINT IN STEERING COLUMN WORN OR BROKEN.

PROCEDURE OR ACTION:

1. Turn steering wheel back and forth while observing steer axle wheels at slow idle.
   Does the steer axle wheels movement match steering wheel movement in both directions?
   YES: Go to Cause C.
   NO: Inspect and repair steering column.

CAUSE C - STEERING RELIEF PRESSURE IS NOT SET CORRECTLY.

PROCEDURE OR ACTION:

1. Verify steering relief pressure specification.
   Is steering relief pressure set to specification?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause D.

CAUSE D - FAILED CENTERING SPRINGS IN SCU.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Are the centering springs in good condition?
   YES: Springs are OK. Go to Cause E.
   NO: Replace centering springs.

CAUSE E - STEERING CONTROL UNIT IS ASSEMBLED INCORRECTLY OR IS DAMAGED.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Is SCU properly assembled and clean?
   YES: Go to Cause F.
   NO: Clean steering valve.

CAUSE F - ANTI-KICKBACK CHECK VALVE NOT WORKING PROPERLY

PROCEDURE OR ACTION:

1. Replace SCU.

END SYMPTOM

Cycle Times Too Fast - Fast Actuation

POSSIBLE CAUSE

A. ENGINE HIGH IDLE SETTING NOT CORRECT.
B. ORIFICES MISSING OR INSTALLED WRONG IN CYLINDER PORTS (ON AFTERMARKET CYLINDERS).
C. FAULTY MLCV FOR LOWERING FUNCTION ONLY.

CAUSE A - ENGINE HIGH IDLE SETTING NOT CORRECT.

PROCEDURE OR ACTION:

1. Check for correct engine high idle setting.
   Is engine high idle set correctly?
   YES: Go to Cause B.
   NO: Check engine idle speed.

CAUSE B - ORIFICES MISSING OR INSTALLED WRONG IN CYLINDER PORTS (ON AFTERMARKET CYLINDERS).

PROCEDURE OR ACTION:

1. Check cycle times. See aftermarket specifications.
   Do cycle times meet specifications?
   YES: Go to Cause C.
   NO: Inspect and repair orifices in cylinder ports. See aftermarket service manuals.

CAUSE C - FAULTY MLCV FOR LOWERING FUNCTION ONLY.

PROCEDURE OR ACTION:

1. Check the lowering cycle times.
   Are the lowering cycle times too fast?
   YES: Repair or replace Mast Lowering Control Valve (MLCV).
   NO: No faults evident at this time.

END SYMPTOM

Cycle Times Too Fast - Fast Actuation (E-Valve)

POSSIBLE CAUSE

A. **MAX FUNCTION SPEED SETTING TOO HIGH.**
B. **RAMP SETTING TOO HIGH FOR FUNCTION.**
C. **ORIFICES MISSING OR INSTALLED WRONG IN CYLINDER PORTS (ON AFTERMARKET CYLINDERS).**
D. **FAULTY MLCV FOR LOWERING FUNCTION ONLY.**
E. **UNLOADER VALVE PRODUCING TOO MUCH MARGIN PRESSURE.**

CAUSE A - MAX FUNCTION SPEED SETTING TOO HIGH.

PROCEDURE OR ACTION:

1. Adjust function speed setting on Display Panel. If problem is still present, go to Cause B.

CAUSE B - RAMP SETTING TOO HIGH FOR FUNCTION.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on Display Panel. If problem is still present, go to Cause C.

CAUSE C - ORIFICES MISSING OR INSTALLED WRONG IN CYLINDER PORTS (ON AFTERMARKET CYLINDERS).

PROCEDURE OR ACTION:

1. Check cycle times. See aftermarket specifications.
   Do cycle times meet specifications?
   YES: Go to Cause D.
   NO: Inspect and repair orifices in cylinder ports. See aftermarket Service Manuals.

CAUSE D - FAULTY MLCV FOR LOWERING FUNCTION ONLY.

PROCEDURE OR ACTION:

1. Check the lowering cycle times.
   Are the lowering cycle times too fast?
   YES: Repair or replace Mast Lowering Control Valve (MLCV).
   NO: Go to Cause E.

CAUSE E - UNLOADER VALVE PRODUCING TOO MUCH MARGIN PRESSURE.

PROCEDURE OR ACTION:

1. Test unloader valve.
   Is margin pressure too high?
   YES: Replace unloader valve spool spring.
   NO: Perform operational check.

END SYMPTOM

Cycle Times Too Fast - Fast Actuation (Manual Valve)

POSSIBLE CAUSE

A. ORIFICES MISSING OR INSTALLED IN WRONG CYLINDER PORTS (ON AFTERMARKET CYLINDERS).
B. ENGINE HIGH IDLE SETTING NOT CORRECT.
C. FAULTY MAST LOWERING CONTROL VALVE (MLCV) FOR LOWERING FUNCTION ONLY.

CAUSE A - ORIFICES MISSING OR INSTALLED IN WRONG CYLINDER PORTS (ON AFTERMARKET CYLINDERS).

PROCEDURE OR ACTION:

1. Check cycle times. See aftermarket specifications.
   Are cycle times to specifications?
   YES: Go to Cause B.
   NO: Inspect and repair orifices in cylinder ports. Go to aftermarket service manuals.

CAUSE B - ENGINE HIGH IDLE SETTING NOT CORRECT.

PROCEDURE OR ACTION:

1. Check for correct engine high idle setting.
   Is engine high idle set correctly?
   YES: Go to Cause C.
   NO: Go to Engine Idle Speed Incorrect.

CAUSE C - FAULTY MAST LOWERING CONTROL VALVE (MLCV) FOR LOWERING FUNCTION ONLY.

PROCEDURE OR ACTION:

1. Check the lowering cycle times.
   Are the lowering cycle times too fast?
   YES: Repair or replace MLCV.
   NO: Repeat lowering cycle times to make sure they are not too fast.

END SYMPTOM

Forks Drop Slightly Before Lifting (E-Valve)

POSSIBLE CAUSE

A. EXCESSIVE LEAKAGE IN LOAD CHECK VALVE.

CAUSE A - EXCESSIVE LEAKAGE IN LOAD CHECK VALVE.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Check for contamination or damage to load check valve. Depending on your left truck see, **Main Control Valve** 2000SRM1993 .
   Is load check valve in good condition?
   YES: Clean lift low leak valve.
   NO: Replace lift low leak valve.

END SYMPTOM

Forks Lower Without Command (E-Valve)

POSSIBLE CAUSE

A. MLM CONTROL MALFUNCTION.
B. EMERGENCY LOWER VALVE IS PARTIALLY OPEN.
C. EXCESSIVE LIFT CYLINDER LEAKAGE.

CAUSE A - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Ensure power is **OFF**. Operate lift/lower lever in both directions.
   Does lever exhibit any binding/stickiness or not return to center position?
   YES: Remove and replace lever. **Note:** Inspect cassette rotary mechanism for dirt contamination.
   NO: Go to Step 2.
2. Turn Power **ON**.
3. Go to the Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
4. Move lever(s) to full stroke position and allow to snap back to the center position.
   Does Display value = 0%?
   YES: Go to Cause B.
   NO: Go to Step 5.
5. Power **OFF**. Replace lift/lower lever.
6. Retest. Turn power **ON**.
7. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
8. Move lever(s) to full stroke position and allow to snap back to the center position.
   Does Display value = 0%?
   YES: Go to Cause B.
   NO: Replace MLM PCB Cassette.
9. Retest. Turn power **ON**.
10. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
11. Move lever(s) to full stroke position and allow to snap back to the center position.
    Display value = 0%?
    YES: Repair Complete. Resume operation.
    NO: Go to Cause B.

CAUSE B - EMERGENCY LOWER VALVE IS PARTIALLY OPEN.

PROCEDURE OR ACTION:

NOTE: Emergency lower valve has tee handle located on control valve. See **Operating Manual** for location and correct use.

1. Check and close valve. If problem is still present, go to Cause C.

CAUSE C - EXCESSIVE LIFT CYLINDER LEAKAGE.

PROCEDURE OR ACTION:

1. Do lift cylinder leakage test. See **Lift Cylinder Leakage Test** .
   Is there leakage in the lift cylinder?
   YES: Repair or replace lift cylinder.
   NO: Resume operation.

END SYMPTOM

Forks Raise or Actuate Without Command (E-Valve)

POSSIBLE CAUSE

A. MLM CONTROL MALFUNCTION.
B. AIR TRAPPED IN CIRCUIT.

CAUSE A - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Ensure power is **OFF**. Operate lift/lower lever in both directions.
   Does lever exhibit any binding/stickiness or not return to center position?
   YES: Remove and replace lever. See **Electrical System** 2200SRM1997 or **Electrical System PSI 2.4L** 2200SRM1998 . **Note:** Inspect cassette rotary mechanism for dirt contamination.
   NO: Go to Step 2.
2. Turn Power **ON**.
3. Go to the Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
4. Move lever(s) to full stroke position and allow to snap back to the center position.
   Does Display value = 0%?
   YES: Go to Cause B.
   NO: Go to Step 5.
5. Power **OFF**. Replace lift/lower lever.
6. Retest. Turn power **ON**.
7. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
8. Move lever(s) to full stroke position and allow to snap back to the center position.
   Does Display value = 0%?
   YES: Go to Cause B.
   NO: Replace MLM PCB Cassette.
9. Retest. Turn power **ON**.
10. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
11. Move lever(s) to full stroke position and allow to snap back to the center position.
    Does Display value = 0%?
    YES: Repair Complete. Resume Operation.
    NO: Go to Cause B.

CAUSE B - AIR TRAPPED IN CIRCUIT.

PROCEDURE OR ACTION:

1. Remove air from circuit by cycling function at one-second intervals, for E-Valve hoist and lower only. All other functions, cycle fully for 5 - 10 times.

END SYMPTOM

Forks Tilt Forward Without Command (E-Valve)

POSSIBLE CAUSE

A. MLM CONTROL MALFUNCTION.
B. PPRV GETTING STRAY SIGNAL.
C. EXCESSIVE TILT CYLINDER LEAKAGE.
D. EXCESSIVE SPOOL LEAKAGE.
E. PISTON STUCK.
F. TILT CONTROL SPOOL DAMAGED OR LEAKING EXCESSIVELY.

CAUSE A - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Ensure power is **OFF**. Operate tilt lever in both directions.
   Does lever exhibit any binding/stickiness or not return to center position?
   YES: Remove and replace lever. **Note:** Inspect cassette rotary mechanism for dirt contamination.
   NO: Go to Step 2.
2. Turn power **ON**.
3. Go to the Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
4. Move lever(s) to full stroke position and allow to snap back to the center position.
   Does Display value = 0%?
   YES: Go to Cause B.
   NO: Go to Step 5.
5. Power **OFF**. Replace tilt lever.
6. Retest. Turn power **ON**.
7. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
8. Move lever(s) to full stroke position and allow to snap back to the center position. Observe value. Move the lever(s) to the full stroke position and hold. Observe value.
   Does Display value = 0% at the center position and 92 to 100% at the full stroke position?
   YES: Go to Cause B.
   NO: Replace MLM PCB Cassette.
9. Retest. Turn power **ON**.
10. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
11. Move lever(s) to full stroke position and allow to snap back to the center position.
    Does Display value = 0%?
    YES: Repair Complete. Resume operation.
    NO: Go to Cause B.

CAUSE B - PPRV GETTING STRAY SIGNAL.

PROCEDURE OR ACTION:

1. Check for proper harness installation.
   Is valve harness installed wrong?
   YES: Install valve harness properly.
   NO: Go to Step 2.
2. Check for shorts in valve harness.
   Does valve harness have shorts?
   YES: Repair or replace valve harness.
   NO: Go to Cause C.

CAUSE C - EXCESSIVE TILT CYLINDER LEAKAGE.

PROCEDURE OR ACTION:

1. Do tilt cylinder leakage test. See **Lift Cylinder Leakage Test** .
   Is there leakage in the tilt cylinder?
   YES: Repair or replace tilt cylinder.
   NO: Go to Cause D.

CAUSE D - EXCESSIVE SPOOL LEAKAGE.

PROCEDURE OR ACTION:

1. Check spool for:
   - Damage
   - Free movement
   - Debris or contamination

   Is spool and mating bore in good condition?
   YES: Go to Cause E.
   NO: Replace damaged parts.

CAUSE E - PISTON STUCK.

PROCEDURE OR ACTION:

1. Inspect tilt control piston.
   Does piston move freely in bore?
   YES: Go to Cause F.
   NO: Clean piston or replace valve section.

CAUSE F - TILT CONTROL SPOOL DAMAGED OR LEAKING EXCESSIVELY.

PROCEDURE OR ACTION:

1. Inspect valve section.
   Is spool in good condition?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-22Observed Symptoms-Gear Pump, Page 9050-33-22.
   NO: Clean or replace spool.

END SYMPTOM

Intermittent Activation (E-Valve) While Commanding Function

POSSIBLE CAUSE

A. LOOSE WIRES OR CONNECTORS ON VALVE HARNESS.
B. ARMREST SWITCH FAILING INTERMITTENTLY.
C. OPEN IN ARMREST SWITCH WIRING HARNESS.
D. MAST/ATTACHMENT IS BINDING.
E. CONTAMINATION IN HYDRAULIC CONTROL VALVE.

CAUSE A - LOOSE WIRES OR CONNECTORS ON VALVE HARNESS.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Go to Step 2.
2. Check wire connection. See . If problem is still present, go to Cause B.

CAUSE B - ARMREST SWITCH FAILING INTERMITTENTLY.

PROCEDURE OR ACTION:

1. Check the display for "armrest down switch-hydraulic interlock" DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Replace armrest switch. See . If problem is still present, go to Cause C.

CAUSE C - OPEN IN ARMREST SWITCH WIRING HARNESS.

PROCEDURE OR ACTION:

WARNING

Serious injury or death can occur if hydraulic functions are activated when operator is out of seat. Actuate control only while in the operator's seat and armrest in locked down position. These safety devices are for your protection, do not disarm them.

1. Check the display for "armrest down switch-hydraulic interlock" DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Go to Step 2.
2. Check for open in armrest switch wiring harness.
   Is there an open in armrest switch wiring harness?
   YES: Repair or replace wiring harness. See .
   NO: Go to Cause D.

CAUSE D - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair mast or attachment.
   NO: Go to Cause E.

CAUSE E - CONTAMINATION IN HYDRAULIC CONTROL VALVE.

PROCEDURE OR ACTION:

1. Inspect and clean control valve. See **Main Control Valve** 2000SRM1993 .

END SYMPTOM

Jump/Delay In Lift or Lower Activation After Moving MLM (E-Valve)

POSSIBLE CAUSE

A. RAMP RATE NOT SET TO DESIRED LEVEL.
B. COIL NOT ATTACHED TO SOLENOID CORRECTLY.
C. AIR TRAPPED IN CIRCUIT.
D. OUTPUT THRESHOLD IS SET TOO HIGH.
E. ELECTRO-HYDRAULIC POPPET VALVE (EHPV) PILOT PIN ADJUSTMENT INCORRECT.
F. MAST/ATTACHMENT IS BINDING.
G. STICKING POPPET VALVE.
H. STICKING ELECTRO-HYDRAULIC POPPET VALVE (EHPV) PILOT PIN ASSEMBLY.
I. STICKING UNLOADER SPOOL.

CAUSE A - RAMP RATE NOT SET TO DESIRED LEVEL.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on display. If problem is still present, go to Cause B.

CAUSE B - COIL NOT ATTACHED TO SOLENOID CORRECTLY.

PROCEDURE OR ACTION:

1. Inspect coil installation.
   Is coil installed correctly to solenoid?
   YES: Go to Cause C.
   NO: Replace coil or solenoid. Coil cannot be repaired.

CAUSE C - AIR TRAPPED IN CIRCUIT.

PROCEDURE OR ACTION:

1. Remove air from circuit by cycling function at one second intervals, for E-Valve hoist and lower only. All other functions, cycle fully for 5 - 10 times. If symptom is still present go to Cause D.

CAUSE D - OUTPUT THRESHOLD IS SET TOO HIGH.

PROCEDURE OR ACTION:

1. Check current at Electro-Hydraulic Poppet Valve (EHPV).
   Is setting at valve correct?
   YES: Go to Cause E.
   NO: Decrease setting to specification or until operation is acceptable to operator.

CAUSE E - ELECTRO-HYDRAULIC POPPET VALVE (EHPV) PILOT PIN ADJUSTMENT INCORRECT.

PROCEDURE OR ACTION:

1. Check for EHPV servicing.
   Has EHPV been serviced recently?
   YES: Adjust EHPV.
   NO: Go to Cause F.

CAUSE F - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair mast or attachment.
   NO: Go to Cause G.

CAUSE G - STICKING POPPET VALVE.

PROCEDURE OR ACTION:

1. Locate which function has delay and remove poppet.
   Does poppet valve move freely in valve bore and not damaged?
   YES: Poppet is OK. Go to Cause H.
   NO: Replace poppet valve.

CAUSE H - STICKING ELECTRO-HYDRAULIC POPPET VALVE (EHPV) PILOT PIN ASSEMBLY.

PROCEDURE OR ACTION:

1. Check EHPV pilot pin assembly for contamination or bent pin.
   Is EHPV pilot pin assembly contaminated or is pin bent?
   YES: Repair or replace EHPV pilot pin assembly.
   NO: Go to Cause I.

CAUSE I - STICKING UNLOADER SPOOL.

PROCEDURE OR ACTION:

1. Inspect unloader valve for damage or contamination.
   Is unloader free of contamination and in good condition?
   YES: No fault at this time .
   NO: Clean or replace unloader valve.

END SYMPTOM

Jump/Delay In Secondary Function Actuation After Moving MLM (E-Valve)

POSSIBLE CAUSE

A. RAMP RATE NOT SET TO DESIRED LEVEL.
B. AIR TRAPPED IN CIRCUIT.
C. OUTPUT THRESHOLD IS SET TOO HIGH.
D. MAST/ATTACHMENT IS BINDING.
E. PILOT PRESSURE NOT BEING PRODUCED FAST ENOUGH.
F. STICKING VALVE SPOOL.
G. STICKING UNLOADER SPOOL.
H. VALVE SPOOL END SPRINGS TOO SOFT.

CAUSE A - RAMP RATE NOT SET TO DESIRED LEVEL.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on display. If problem is still present, go to Cause B.

CAUSE B - AIR TRAPPED IN CIRCUIT.

PROCEDURE OR ACTION:

1. Remove air from circuit by cycling function full stroke of hydraulic hoist cylinder at one second intervals. If symptom is still present, go to Cause C.

CAUSE C - OUTPUT THRESHOLD IS SET TOO HIGH.

PROCEDURE OR ACTION:

1. Check current at PPRV.
   Is setting at valve correct?
   YES: Go to Cause D.
   NO: Decrease setting to specification or until operation is acceptable to operator.

CAUSE D - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair mast or attachment.
   NO: Go to Cause E.

CAUSE E - PILOT PRESSURE NOT BEING PRODUCED FAST ENOUGH.

PROCEDURE OR ACTION:

1. Remove Proportional Pressure Reducing Valve (PPRV) and inspect filter.
   Is filter clean and in good condition?
   YES: Go to Step 2.
   NO: Clean or replace filter.
2. Check to see if PPRV is sticking. See PPRV Pilot Pressure Test.
   Is PPRV sticking?
   YES: Replace PPRV.
   NO: Go to Cause F.

CAUSE F - STICKING VALVE SPOOL.

PROCEDURE OR ACTION:

1. Inspect spool.
   Is spool clean and in good condition?
   YES: Go to Cause G.
   NO: Clean or replace spool.

CAUSE G - STICKING UNLOADER SPOOL.

PROCEDURE OR ACTION:

1. Inspect unloader valve for damage or contamination.
   Is unloader free of contamination and in good condition?
   YES: Go to Cause H.
   NO: Clean or replace unloader valve.

CAUSE H - VALVE SPOOL END SPRINGS TOO SOFT.

PROCEDURE OR ACTION:

1. Replace springs. If problem is still present, see Observed Symptoms-Gear Pump, Page 9050-33-56.

END SYMPTOM

Jump/Delay In Tilt Forward Actuation (E-Valve)

POSSIBLE CAUSE

A. RAMP RATE NOT SET TO DESIRED LEVEL.
B. AIR TRAPPED IN CIRCUIT.
C. OUTPUT THRESHOLD IS SET TOO HIGH.
D. COUNTERBALANCE BRIDGE PRESSURE ORIFICE PARTIALLY PLUGGED.
E. COUNTERBALANCE EXHAUST HOLES PARTIALLY PLUGGED IN VALVE.
F. COUNTERBALANCE PISTON STICKING.

CAUSE A - RAMP RATE NOT SET TO DESIRED LEVEL.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on display. If problem is still present, go to Cause B.

CAUSE B - AIR TRAPPED IN CIRCUIT.

PROCEDURE OR ACTION:

1. Remove air from circuit by cycling function full stroke of hydraulic hoist cylinder at one second intervals. If symptom is still present, go to Cause C.

CAUSE C - OUTPUT THRESHOLD IS SET TOO HIGH.

PROCEDURE OR ACTION:

1. Check current at EHPV.
   Is setting at valve correct?
   YES: Go to Cause D.
   NO: Decrease setting to specification or until operation is acceptable to operator.

CAUSE D - COUNTERBALANCE BRIDGE PRESSURE ORIFICE PARTIALLY PLUGGED.

PROCEDURE OR ACTION:

1. Inspect orifice.
   Is bridge pressure orifice open?
   YES: Go to Cause E.
   NO: Clean orifice or replace valve section.

CAUSE E - COUNTERBALANCE EXHAUST HOLES PARTIALLY PLUGGED IN VALVE.

PROCEDURE OR ACTION:

1. Inspect valve section.
   Are exhaust holes open?
   YES: Go to Cause F.
   NO: Clean or replace valve section.

CAUSE F - COUNTERBALANCE PISTON STICKING.

PROCEDURE OR ACTION:

1. Inspect piston.
   Does piston move freely in bore?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-56.
   NO: Clean piston or replace valve section.

END SYMPTOM

Lift Function Is Slow or Does Not Function (Manual Valve)

POSSIBLE CAUSE

A. **OPERATOR PRESENCE SENSOR HAS HYDRAULIC FUNCTION LOCKED OUT.**
B. **PUMP NOT GENERATING ENOUGH FLOW.**
C. **LOAD IS GREATER THAN TRUCK CAPACITY.**
D. **EMERGENCY LOWER VALVE IS PARTIALLY OPEN.**
E. **LIFT SPOOL IS NOT FULLY ACTUATED.**
F. **MAIN RELIEF VALVE IS SET TOO LOW.**
G. **MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.**
H. **SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.**
I. **MAST/ATTACHMENT IS BINDING.**
J. **EXCESSIVE INTERNAL SPOOL LEAKAGE.**
K. **MAST LOWERING CONTROL VALVE BLOCKING FLOW.**

CAUSE A - OPERATOR PRESENCE SENSOR HAS HYDRAULIC FUNCTION LOCKED OUT.

PROCEDURE OR ACTION:

1. Power **ON** and operator in seat. Operate lift/lower lever.
   Is a hydraulic interlock message displayed?
   YES: Go to Display Menu/Diagnostics/Seat (Operator Presence), then go to Step 2.
   NO: Go to Cause B.
2. Observe value.
   Is Operator Presence sensor value greater than 1.8 volts?
   YES: Go to Cause B.
   NO: Go to Cause C.

CAUSE B - PUMP NOT GENERATING ENOUGH FLOW.

PROCEDURE OR ACTION:

1. Do hydraulic pump flow check.
   Does pump pass check?
   YES: Pump is OK. Go to Cause C.
   NO: Do Hydraulic Pump Flow Test before replacing pump.

CAUSE C - LOAD IS GREATER THAN TRUCK CAPACITY.

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

1. Check load weight and compare to truck capacity rating. Adjust as necessary. If problem is still present, go to Cause D.

CAUSE D - EMERGENCY LOWER VALVE IS PARTIALLY OPEN.

PROCEDURE OR ACTION:

NOTE: Emergency lower valve has tee handle located on control valve. See **Operating Manual** for location and correct use.

1. Check and close valve. If problem is still present, go to Cause E.

CAUSE E - LIFT SPOOL IS NOT FULLY ACTUATED.

PROCEDURE OR ACTION:

1. Inspect linkage.
   Does linkage prematurely contact dash?
   YES: Repair or replace linkage.
   NO: Go to Cause F.

CAUSE F - MAIN RELIEF VALVE IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Test and adjust pressure.
   Is relief set at specifications?
   YES: Go to Cause G.
   NO: Adjust pressure to test specifications.

CAUSE G - MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect relief valve.
   Is relief valve damaged or stuck open?
   YES: Install new relief valve.
   NO: Go to Cause H.

CAUSE H - SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause I.
   NO: Adjust pressure to test specifications.

CAUSE I - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair mast or attachment.
   NO: Go to Cause J.

CAUSE J - EXCESSIVE INTERNAL SPOOL LEAKAGE.

PROCEDURE OR ACTION:

1. Replace spool or complete control valve.

CAUSE K - MAST LOWERING CONTROL VALVE BLOCKING FLOW.

PROCEDURE OR ACTION:

1. Inspect mast lowering control valve for blockage.
   Is mast lowering control valve blocking flow?
   YES: Repair or replace mast lowering control valve.
   NO: Perform operational check.

END SYMPTOM

Lift/Lower Continues To Move For Awhile After MLM Is Released (E-Valve) ErrCA004, ErrCA006, ErrCA008, ErrCA010, ErrCA012, ErrCA014, ErrCA016, ErrCA018, ErrCA020

POSSIBLE CAUSE

A. RAMP RATE NOT SET CORRECTLY.
B. ELECTRO-HYDRAULIC POPPET VALVE (EHPV) POPPET VALVE STICKING.
C. EHPV PILOT PIN ASSEMBLY STICKING.

CAUSE A - RAMP RATE NOT SET CORRECTLY.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust setting using display until operation is acceptable to operator. If symptom is still present, go to Cause B.

CAUSE B - ELECTRO-HYDRAULIC POPPET VALVE (EHPV) POPPET VALVE STICKING.

PROCEDURE OR ACTION:

1. Remove and inspect poppet valve.
   Is the poppet undamaged and moves freely in bore?
   YES: Go to Cause C.
   NO: Replace poppet valve.

CAUSE C - EHPV PILOT PIN ASSEMBLY STICKING.

PROCEDURE OR ACTION:

1. Remove and inspect pilot pin assembly for excessive debris or bent pin.
   Is pilot pin assembly dirty or is pin bent?
   YES: Clean or replace pilot pin assembly.
   NO: See Lower Function Will Not Move With MLM Movement (E-Valve) ErrCA006, ErrCA007.

END SYMPTOM

Lift/Lower Function Maximum Speed Too Slow (E-Valve)

POSSIBLE CAUSE

A. MAX FUNCTION SPEED SETTING TOO LOW.
B. RAMP SETTING TOO LOW FOR FUNCTION.
C. OUTPUT THRESHOLD IS SET TOO LOW.
D. MAST/ATTACHMENT IS BINDING.
E. MLM CONTROL MALFUNCTION.
F. MAIN RELIEF VALVE DAMAGED OR STUCK OPEN (LIFT FUNCTION ONLY).
G. EXCESSIVE PUMP LEAKAGE (LIFT FUNCTION ONLY).
H. UNLOADER NOT PRODUCING ENOUGH MARGIN PRESSURE (LIFT FUNCTION ONLY).
I. MAIN CONTROL VALVE LS (LOAD SENSE) LEAKAGE (LIFT FUNCTION ONLY).
J. FAULTY MAST LOWERING CONTROL VALVE.

CAUSE A - MAX FUNCTION SPEED SETTING TOO LOW.

PROCEDURE OR ACTION:

1. Adjust function speed setting on Display Panel. If problem is still present, go to Cause B.

CAUSE B - RAMP SETTING TOO LOW FOR FUNCTION.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on Display Panel. If problem is still present, go to Cause C.

CAUSE C - OUTPUT THRESHOLD IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Check current at Display Panel.
   Is setting at valve correct?
   YES: Go to Cause D.
   NO: Increase setting to specification or until operation is acceptable to operator.

CAUSE D - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair mast or attachment.
   NO: Go to Cause E.

CAUSE E - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Turn power **ON**.
2. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
3. Move lever to full stroke position – both directions.
   Is Display value >=92%?
   YES: Go to Cause F.
   NO: Go to Step 4.
4. Power **OFF**. Replace lift/lower Lever(s).
5. Retest. Turn power **ON**.
6. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
7. Move lever to full stroke position – both directions.
   Is Display value >=92%?
   YES: Go to Cause F.
   NO: Replace MLM PCB Cassette.

CAUSE F - MAIN RELIEF VALVE DAMAGED OR STUCK OPEN (LIFT FUNCTION ONLY).

PROCEDURE OR ACTION:

1. Install pressure gauge in hydraulic control valve. See Primary Relief Valve Test and Adjustment.
2. Hold lift function over relief.
   Does relief pressure meet test specifications?
   YES: Go to Cause G.
   NO: Replace relief valve.

CAUSE G - EXCESSIVE PUMP LEAKAGE (LIFT FUNCTION ONLY).

PROCEDURE OR ACTION:

1. Test hydraulic pump for excessive leakage. See Hydraulic Pump Flow Test.
   Does hydraulic pump have excessive leakage?
   YES: Repair or replace pump.
   NO: Go to Cause H.

CAUSE H - UNLOADER NOT PRODUCING ENOUGH MARGIN PRESSURE (LIFT FUNCTION ONLY).

PROCEDURE OR ACTION:

1. Test unloader spool spring. See Main Control Valve Unloader Margin Test.
   Does unloader valve pressure meet test specifications?
   YES: Go to Cause I.
   NO: Replace spring.

CAUSE I - MAIN CONTROL VALVE LS (LOAD SENSE) LEAKAGE (LIFT FUNCTION ONLY).

PROCEDURE OR ACTION:

1. Check LS pressure.
   Does LS pressure meet test specifications?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-43.
   NO: Clean or replace main relief valve.

CAUSE J - FAULTY MAST LOWERING CONTROL VALVE.

PROCEDURE OR ACTION:

1. Inspect mast lowering control valve for blockage.
   Is mast lowering control valve blocking flow?
   YES: Repair or replace mast lowering control valve.
   NO: Resume operation.

END SYMPTOM

Lift/Lower Function Suddenly Jumps In Middle of Stroke (E-Valve)

POSSIBLE CAUSE

A. STICKING POPPET VALVE
B. STICKING PPRV OR EHPV PILOT PIN ASSEMBLY.

CAUSE A - STICKING POPPET VALVE

PROCEDURE OR ACTION:

1. Locate which function has delay and remove poppet.
   Does poppet valve move freely in valve bore and not damaged?
   YES: Poppet OK. Go to Cause B.
   NO: Replace poppet valve.

CAUSE B - STICKING PPRV OR EHPV PILOT PIN ASSEMBLY.

PROCEDURE OR ACTION:

1. Remove PPRV or EHPV pilot pin assembly and clean.
2. Perform a PPRV pressure test. See PPRV Pilot Pressure Test.

END SYMPTOM

Secondary Function Suddenly Jumps In Middle of Stroke (E-Valve)

POSSIBLE CAUSE

A. STICKING VALVE SPOOL.
B. STICKING PPRV OR EHPV PILOT PIN ASSEMBLY.
C. VALVE SPOOL END SPRINGS TOO SOFT.

CAUSE A - STICKING VALVE SPOOL.

PROCEDURE OR ACTION:

1. Remove and inspect spool.
   Is the spool undamaged and moves freely in bore?
   YES: Proceed to Cause B.
   NO: Clean or replace valve spool.

CAUSE B - STICKING PPRV OR EHPV PILOT PIN ASSEMBLY.

PROCEDURE OR ACTION:

1. Remove PPRV or EHPV pilot pin assembly and clean.
2. Perform a PPRV pressure test. See PPRV Pilot Pressure Test.

CAUSE C - VALVE SPOOL END SPRINGS TOO SOFT.

PROCEDURE OR ACTION:

1. Replace springs.

END SYMPTOM

Load Drops Slightly When Metering Lift Function (Manual Valve)

POSSIBLE CAUSE

A. LIFT LOAD CHECK VALVE IS LEAKING OR DAMAGED.

CAUSE A - LIFT LOAD CHECK VALVE IS LEAKING OR DAMAGED.

PROCEDURE OR ACTION:

1. Clean or replace top lift load check valve. Go to **Main Control Valve** 2000SRM1993 .

END SYMPTOM

Lower Function Will Not Move With MLM Movement (E-Valve) ErrCA006, ErrCA007

POSSIBLE CAUSE

A. **JOYSTICK OR MLM CONTROL MALFUNCTION.**
B. **COIL NOT ATTACHED TO SOLENOID CORRECTLY.**
C. **ELECTRO-HYDRAULIC POPPET VALVE (EHPV) NOT GETTING SIGNAL.**
D. **EHPV PILOT PIN ADJUSTMENT INCORRECT.**
E. **LOWER POPPET VALVE STUCK CLOSED.**

CAUSE A - JOYSTICK OR MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See **User Interface** 2200SRM1996 . Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever. See the appropriate **Electrical System** manual.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - COIL NOT ATTACHED TO SOLENOID CORRECTLY.

PROCEDURE OR ACTION:

1. Inspect coil installation. See **Main Control Valve** 2000SRM1993 .
   Is coil installed correctly to solenoid?
   YES: Go to Cause C.
   NO: Repair or replace coil or solenoid.

CAUSE C - ELECTRO-HYDRAULIC POPPET VALVE (EHPV) NOT GETTING SIGNAL.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Go to Step 2.
2. Check wire connection to EHPV. See **Wire Harness Repair** manual. If problem is still present, go to Cause D.

CAUSE D - EHPV PILOT PIN ADJUSTMENT INCORRECT.

PROCEDURE OR ACTION:

1. Check for EHPV servicing.
   Has EHPV been serviced recently?
   YES: Adjust EHPV.
   NO: Go to Cause E.

CAUSE E - LOWER POPPET VALVE STUCK CLOSED.

PROCEDURE OR ACTION:

1. Remove, disassemble, and inspect poppet valve.
   Is the poppet undamaged and moves freely in bore?
   YES: Inspect lift cylinder lower valve for damage.
   NO: Replace poppet valve.

END SYMPTOM

No Steering (All Other Hydraulic Functions OK)

POSSIBLE CAUSE

A. HYDRAULIC HOSES ARE NOT CONNECTED OR DAMAGED.
B. STEERING RELIEF VALVE IS SET TOO LOW.
C. STEERING AXLE IS BINDING.
D. PRIORITY FLOW DIVIDER VALVE IS CONTAMINATED.
E. STEERING CYLINDER PISTON SEALS ARE WORN OR DAMAGED.
F. LEAKING SHOCK VALVES.
G. SLEEVE AND SPOOL IN THE CONTROL UNIT WILL NOT MOVE.
H. STEERING CONTROL UNIT IS DAMAGED.

CAUSE A - HYDRAULIC HOSES ARE NOT CONNECTED OR DAMAGED.

PROCEDURE OR ACTION:

1. Look at Steering System component location drawing to identify steering hoses. See Steering System. Inspect hoses for wear, damage, and correct installation.
   Are steering hoses in good condition and installed correctly?
   YES: Go to Cause B.
   NO: Install new components as necessary.

CAUSE B - STEERING RELIEF VALVE IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Perform Steering Relief Pressure Test and Adjustment.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause C.

CAUSE C - STEERING AXLE IS BINDING.

PROCEDURE OR ACTION:

1. Inspect steering axle for binding.
   Is steering axle binding?
   YES: Repair or replace steering axle.
   NO: Go to Cause D.

CAUSE D - PRIORITY FLOW DIVIDER VALVE IS CONTAMINATED.

PROCEDURE OR ACTION:

1. Perform Priority Flow Divider Valve Check in the appropriate Steering Axle manual.
   Does priority flow divider valve pass the check?
   YES: Priority flow divider valve is OK. Go to Cause E.
   NO:
   - Cannot turn steering wheel, wheel locks up. Go to Cause G.
   - Steering wheel turns but fails Priority Valve Flow Divider Valve Check. Remove and clean flow divider spool.

CAUSE E - STEERING CYLINDER PISTON SEALS ARE WORN OR DAMAGED.

PROCEDURE OR ACTION:

1. Do Steering Cylinder Leakage Test.
   Does steering cylinder pass leakage test?
   YES: Cylinder is OK. Go to Cause F.
   NO: Remove and repair steering cylinder.

CAUSE F - LEAKING SHOCK VALVES.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Are the shock valves in good condition?
   YES: Shock valves are ok. Go to Cause G.
   NO: Replace shock valves.

CAUSE G - SLEEVE AND SPOOL IN THE CONTROL UNIT WILL NOT MOVE.

PROCEDURE OR ACTION:

1. Turn steering wheel with engine running.
   Does steering wheel move?
   YES: Sleeve and spool are not seized. Go to Cause H.
   NO: Remove and clean steering valve.

CAUSE H - STEERING CONTROL UNIT IS DAMAGED.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Is steering control unit damaged?
   YES: Install new SCU.
   NO: Clean and repair steering valve. Replace components as required.

END SYMPTOM

Oil Leaking/Component Life Too Short

POSSIBLE CAUSE

A. **HYDRAULIC OIL TANK IS OVERFILLED.**
B. **LOOSE OR DAMAGED HARDWARE.**
C. **DAMAGED O-RING/ROD SEAL.**
D. **HYDRAULIC RELIEF PRESSURES SET TOO HIGH.**
E. **HYDRAULIC FLUID CONTAMINATED OR WRONG TYPE.**
F. **EXCESSIVE DEBRIS IN HYDRAULIC CIRCUIT.**
G. **HYDRAULIC OIL TANK OPEN TO ATMOSPHERE.**
H. **HYDRAULICS OPERATING ABOVE RECOMMENDED TEMPERATURE RANGE.**
I. **WARPED COMPONENT SECTION OF HYDRAULIC CONTROL VALVE.**

CAUSE A - HYDRAULIC OIL TANK IS OVERFILLED.

PROCEDURE OR ACTION:

1. Check to see if hydraulic oil tank is overfilled.
   Is hydraulic oil tank overfilled?
   YES: Drain hydraulic oil to proper level.
   NO: Go to Cause B.

CAUSE B - LOOSE OR DAMAGED HARDWARE.

PROCEDURE OR ACTION:

1. Locate source of oil leak by checking the following items.
   - Check torque on fittings.
   - Check torque on tie rod at valve outlet housing.
   - Check torque on hardware between SCU and valve.

   Did leak stop after checking hardware?
   YES: Problem solved.
   NO: Go to Cause C.

CAUSE C - DAMAGED O-RING/ROD SEAL.

PROCEDURE OR ACTION:

1. Replace damaged O-ring or rod seal.
   Is problem fixed?
   YES: Problem solved.
   NO: Go to Cause D.

CAUSE D - HYDRAULIC RELIEF PRESSURES SET TOO HIGH.

PROCEDURE OR ACTION:

1. Check main and secondary relief pressures. Go to Main Relief Valve Test and Adjustment.
   Does relief pressure meet specifications?
   YES: Go to Cause E.
   NO: Adjust or replace relief valve.

CAUSE E - HYDRAULIC FLUID CONTAMINATED OR WRONG TYPE.

PROCEDURE OR ACTION:

1. Check hydraulic oil for contamination and correct type.
   Is hydraulic oil contaminated or incorrect type used?
   YES: Drain and refill hydraulic tank.
   NO: Go to Cause F.

CAUSE F - EXCESSIVE DEBRIS IN HYDRAULIC CIRCUIT.

PROCEDURE OR ACTION:

1. Check for plugged and bypassing hydraulic oil filter.
   Is hydraulic oil filter plugged and bypassing?
   YES: Clean or replace hydraulic oil filter.
   NO: Go to Step 2.
2. Check for contaminated oil.
   Is hydraulic oil contaminated?
   YES: Drain and refill hydraulic tank.
   NO: Go to Cause G.

CAUSE G - HYDRAULIC OIL TANK OPEN TO ATMOSPHERE.

PROCEDURE OR ACTION:

1. Check hydraulic oil tank for missing breather or missing dipstick.
   Is breather or dipstick missing from hydraulic oil tank?
   YES: Replace breather or dipstick.
   NO: Go to Cause H.

CAUSE H - HYDRAULICS OPERATING ABOVE RECOMMENDED TEMPERATURE RANGE.

PROCEDURE OR ACTION:

1. Inspect hydraulic components and oil for signs of excessive heat.
   Do components and oil show signs of overheating?
   YES: Replace damaged components and service hydraulic system.
   NO: Go to Cause I.

CAUSE I - WARPED COMPONENT SECTION OF HYDRAULIC CONTROL VALVE.

PROCEDURE OR ACTION:

1. Check hydraulic control valve for warped component section.
   Does hydraulic control valve have warped component section?
   YES: Replace hydraulic control valve.
   NO: Problem solved. Resume operation.

END SYMPTOM

Poor Metering on Lift or Lower Functions (E-Valve)

POSSIBLE CAUSE

A. AIR TRAPPED IN CIRCUIT.
B. RAMP SETTING TOO HIGH FOR FUNCTION.
C. OUTPUT THRESHOLD IS SET TOO HIGH.
D. MAST/ATTACHMENT IS BINDING.
E. MLM CONTROL MALFUNCTION.
F. MAST LOWERING CONTROL VALVE IS STICKING.
G. STICKING UNLOADER SPOOL (LIFT FUNCTION ONLY).
H. MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.

CAUSE A - AIR TRAPPED IN CIRCUIT.

PROCEDURE OR ACTION:

1. Remove air from circuit by cycling function full stroke of hydraulic hoist cylinder at one second intervals. If symptom is still present, go to Cause B.

CAUSE B - RAMP SETTING TOO HIGH FOR FUNCTION.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on Display Panel. If problem is still present, go to Cause C.

CAUSE C - OUTPUT THRESHOLD IS SET TOO HIGH.

PROCEDURE OR ACTION:

1. Check current at E-Hydraulic Valve.
   Is setting at valve correct?
   YES: Go to Cause D.
   NO: Decrease setting to specification or until operation is acceptable to operator.

CAUSE D - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Repair or lubricate mast or attachment.
   NO: Go to Cause E.

CAUSE E - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Ensure power is **OFF**. Operate lift/lower lever in both directions.
   Does lever exhibit any binding/stickiness or not return to center position?
   YES: Remove and replace lever. **Note:** Inspect cassette rotary mechanism for dirt contamination.
   NO: Go to Step 2.
2. Turn Power **ON**.
3. Go to the Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
4. Move lever(s) to full stroke position and allow to snap back to the center position.
   Does Display value = 0%?
   YES: Go to Cause F.
   NO: Go to Step 5.
5. Power **OFF**. Replace lift/lower lever.
6. Retest. Turn power **ON**.
7. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
8. Move lever(s) to full stroke position and allow to snap back to the center position. Observe value. Move the lever(s) to the full stroke position and hold. Observe value.
   Does Display value = 0% at the center position and 92 to 100% at the full stroke position?
   YES: Go to Cause F.
   NO: Replace MLM PCB Cassette.
9. Retest.

CAUSE F - MAST LOWERING CONTROL VALVE IS STICKING.

PROCEDURE OR ACTION:

1. Inspect mast lowering control valve for proper operation.
   Is mast lowering control valve sticking?
   YES: Repair or replace mast lowering control valve.
   NO: Go to Cause G.

CAUSE G - STICKING UNLOADER SPOOL (LIFT FUNCTION ONLY).

PROCEDURE OR ACTION:

1. Inspect unloader valve for damage or contamination.
   Is unloader free of contamination and in good condition?
   YES: Go to Cause H.
   NO: Clean or replace unloader valve.

CAUSE H - MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.

PROCEDURE OR ACTION:

1. Check LS pressure.
   Does LS pressure meet test specifications?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-43.
   NO: Clean or replace main relief valve.

END SYMPTOM

Secondary Function Continues to Move for Awhile After MLM Is Released (E-Valve)

POSSIBLE CAUSE

A. RAMP SETTING TOO LOW FOR FUNCTION.
B. STICKING VALVE SPOOL.
C. STICKING PPRV.

CAUSE A - RAMP SETTING TOO LOW FOR FUNCTION.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on display. If problem is still present, go to Cause B.

CAUSE B - STICKING VALVE SPOOL.

PROCEDURE OR ACTION:

1. Remove and inspect spool.
   Is the spool undamaged and moves freely in bore?
   YES: Go to Cause C.
   NO: Clean or replace valve spool.

CAUSE C - STICKING PPRV.

PROCEDURE OR ACTION:

1. Test PPRV pressure. See PPRV Pilot Pressure Test.
   Is PPRV pressure test to specifications?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-59.
   NO: Remove PPRV and clean.

END SYMPTOM

Secondary Function Exhibits Slight Movement in Opposite Direction Before Moving (E-Valve)

POSSIBLE CAUSE

A. TOP LOAD CHECK VALVE IS LEAKING OR DAMAGED.

CAUSE A - TOP LOAD CHECK VALVE IS LEAKING OR DAMAGED.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Clean or replace top load check valve. See **Main Control Valve** 2000SRM1993 .

END SYMPTOM

Secondary Function Maximum Speed Too Slow (E-Valve)

POSSIBLE CAUSE

A. MAX FUNCTION SPEED SETTING TOO LOW.
B. RAMP SETTING TOO LOW FOR FUNCTION.
C. OUTPUT THRESHOLD IS SET TOO LOW.
D. MAST/ATTACHMENT IS BINDING.
E. JOYSTICK OR MLM CONTROL MALFUNCTION.
F. ORIFICES INSTALLED IN CIRCUIT TOO SMALL (ON AFTERMARKET CYLINDERS).
G. ENGINE HIGH IDLE SETTING NOT CORRECT.
H. MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.
I. SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.
J. PROPORTIONAL PRESSURE REDUCING VALVE TOO LOW.
K. STICKING SPOOL.
L. UNLOADER NOT PRODUCING ENOUGH MARGIN PRESSURE.
M. MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.

CAUSE A - MAX FUNCTION SPEED SETTING TOO LOW.

PROCEDURE OR ACTION:

1. Adjust function speed setting on display. If problem is still present, go to Cause B.

CAUSE B - RAMP SETTING TOO LOW FOR FUNCTION.

PROCEDURE OR ACTION:

1. Adjust function ramp setting on display. If problem is still present, go to Cause C.

CAUSE C - OUTPUT THRESHOLD IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Check current at Electro-Hydraulic Poppet Valve (EHPV).
   Is setting at valve correct?
   YES: Go to Cause D.
   NO: Increase setting until operation is acceptable to operator.

CAUSE D - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Lubricate or repair mast or attachment.
   NO: Go to Cause E.

CAUSE E - JOYSTICK OR MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See Appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause F.
   NO: Replace lever.

CAUSE F - ORIFICES INSTALLED IN CIRCUIT TOO SMALL (ON AFTERMARKET CYLINDERS).

PROCEDURE OR ACTION:

1. Check cycle times. See aftermarket specifications.
   Do cycle times meet specifications?
   YES: Go to Cause G.
   NO: Inspect and replace orifices in cylinder ports. See aftermarket service manuals.

CAUSE G - ENGINE HIGH IDLE SETTING NOT CORRECT.

PROCEDURE OR ACTION:

1. Check engine high idle setting.
   Is engine high idle set correctly?
   YES: Problem solved.
   NO: Go to Cause H.

CAUSE H - MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Install pressure gauge in hydraulic control valve. See Main Relief Valve Test and Adjustment.
2. Hold lift function over relief.
   Does relief pressure meet test specifications?
   YES: Go to Cause I.
   NO: Replace relief valve.

CAUSE I - SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause J.
   NO: Adjust pressure to test specifications.

CAUSE J - PROPORTIONAL PRESSURE REDUCING VALVE TOO LOW.

PROCEDURE OR ACTION:

1. Test Proportional Pressure Reducing Valve (PPRV) pressure. See PPRV Pilot Pressure Test.
   Is PPRV pressure at specifications?
   YES: Go to Cause K.
   NO: Clean screen on PPRV. If problem is still present, replace PPRV.

CAUSE K - STICKING SPOOL.

PROCEDURE OR ACTION:

1. Inspect spool.
   Is spool clean and in good condition?
   YES: Go to Cause L.
   NO: Clean or replace spool.

CAUSE L - UNLOADER NOT PRODUCING ENOUGH MARGIN PRESSURE.

PROCEDURE OR ACTION:

1. Test unloader spool spring.
   Does unloader valve pressure meet test specifications?
   YES: Go to Cause M.
   NO: Replace spring.

CAUSE M - MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.

PROCEDURE OR ACTION:

1. Check LS pressure.
   Does LS pressure meet test specifications?
   YES: Check for DTCs.
   NO: Clean or replace main relief valve.

END SYMPTOM

Secondary Function and Tilt Back Will Not Move With MLM Movement (E-Valve) ErrCA012-020, ErrCA008

POSSIBLE CAUSE

- **A. PUMP NOT GENERATING ENOUGH FLOW.**
- **B. LOAD IS GREATER THAN TRUCK CAPACITY.**
- **C. MLM CONTROL MALFUNCTION.**
- **D. COIL NOT ATTACHED TO SOLENOID CORRECTLY.**
- **E. PPRV GETTING STRAY SIGNAL.**
- **F. SECONDARY RELIEF VALVE IS SET TOO LOW.**
- **G. MAST/ATTACHMENT IS BINDING.**
- **H. STUCK SPOOL IN CONTROL VALVE.**
- **I. PROPORTIONAL PRESSURE REDUCING VALVE TOO LOW.**
- **J. SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.**
- **K. MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.**
- **L. UNLOADER VALVE STUCK OPEN.**
- **M. MAIN RELIEF LS (LOAD SENSE) STUCK OPEN.**
- **N. MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.**

CAUSE A - PUMP NOT GENERATING ENOUGH FLOW.

PROCEDURE OR ACTION:

1. Do hydraulic pump flow check.
   Does pump pass check?
   YES: Pump is OK. Go to Cause B.
   NO: Perform Hydraulic Pump Flow Test before replacing pump.

CAUSE B - LOAD IS GREATER THAN TRUCK CAPACITY.

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

1. Check load weight and compare to truck capacity rating. Adjust as necessary. If problem is still present, go to Cause C.

CAUSE C - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause D.

NO: Replace lever.

CAUSE D - COIL NOT ATTACHED TO SOLENOID CORRECTLY.

PROCEDURE OR ACTION:

1. Inspect coil installation.
   Is coil installed correctly to solenoid?
   YES: Cause E.
   NO: Repair or replace coil or solenoid.

CAUSE E - PPRV GETTING STRAY SIGNAL.

PROCEDURE OR ACTION:

1. Check for proper harness installation.
   Is valve harness installed wrong?
   YES: Install valve harness properly.
   NO: Go to Step 2.
2. Check for shorts in valve harness.
   Does valve harness have shorts?
   YES: Repair or replace valve harness.
   NO: Go to Cause F.

CAUSE F - SECONDARY RELIEF VALVE IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause G.
   NO: Adjust pressure to test specifications.

CAUSE G - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Lubricate or repair mast or attachment.
   NO: Go to Cause H.

CAUSE H - STUCK SPOOL IN CONTROL VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect spool.
   Does the spool move freely in bore and in good condition?
   YES: Go to Cause I.
   NO: Repair or replace valve spool or section.

CAUSE I - PROPORTIONAL PRESSURE REDUCING VALVE TOO LOW.

PROCEDURE OR ACTION:

1. Test Proportional Pressure Reducing Valve (PPRV) pressure. See PPRV Pilot Pressure Test.
   Is PPRV pressure at specifications?
   YES: Go to Cause J.
   NO: Clean screen on PPRV. If problem is still present, replace PPRV.

CAUSE J - SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

NOTE: This only affects hoist circuit when a secondary function is activated.

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause K.
   NO: Adjust pressure to test specifications.

CAUSE K - MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect relief valve.
   Is relief valve damaged or stuck open?
   YES: Install new relief valve.
   NO: Go to Cause L.

CAUSE L - UNLOADER VALVE STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect unloader spool.
   Does unloader spool move freely in bore and in good condition?
   YES: Go to Cause M.
   NO: Repair or replace unloader spool.

CAUSE M - MAIN RELIEF LS (LOAD SENSE) STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect main relief valve.
   Is the LS relief clean and spring OK?
   YES: Go to Cause N.
   NO: Check for contamination. Clean or replace relief valve.

CAUSE N - MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.

PROCEDURE OR ACTION:

1. Check LS pressure.
   Does LS pressure meet test specifications?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-77.
   NO: Clean or replace main relief valve.

END SYMPTOM

Secondary Function or Tilt Back Moves Without Command (E-Valve)

POSSIBLE CAUSE

A. MLM CONTROL MALFUNCTION.
B. PPRV GETTING STRAY SIGNAL.
C. EXCESSIVE SPOOL LEAKAGE.

CAUSE A - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check seat sensor. See Operator Presence System Check (9010-05). If seat sensor is OK then check to see that function returns to neutral (0%). Use display or install the Service Tool to monitor functions. Continue with Step 2.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See the appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
   Is each lever input = 0%?
   YES: Go to Step 5.
   NO: Replace lever.
5. Operate each lever to full stroke forward and slowly release (1-2 seconds from full stroke). Read input when fully released.
   Is lever Input = 0%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke back and slowly release (1-2 seconds from full stroke). Read input when fully released.
   Is lever Input = 0%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - PPRV GETTING STRAY SIGNAL.

PROCEDURE OR ACTION:

1. Check for proper harness installation.
   Is harness installed wrong?
   YES: Install valve harness properly.
   NO: Go to Step 2.
2. Check for shorts in valve harness.
   Does valve harness have shorts?
   YES: Repair or replace valve harness.
   NO: Go to Cause C.

CAUSE C - EXCESSIVE SPOOL LEAKAGE.

PROCEDURE OR ACTION:

1. Check spool for:
   - Damage
   - Free movement
   - Debris or contamination

   Is spool and mating bore in good condition?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-51.
   NO: Replace damaged parts.

END SYMPTOM

Steering Is Slow or Difficult

POSSIBLE CAUSE

A. LOW PUMP FLOW.
B. STEERING RELIEF PRESSURE IS SET TOO LOW.
C. PRIORITY FLOW DIVIDER VALVE IS CONTAMINATED.
D. HYDRAULIC LINES ARE RESTRICTED.
E. SEAL IN THE STEERING CYLINDER LEAKS.
F. STEERING AXLE COMPONENTS ARE DAMAGED AND/OR BINDING.
G. SCU IS WORN, NOT ASSEMBLED CORRECTLY, OR DAMAGED.

CAUSE A - LOW PUMP FLOW.

PROCEDURE OR ACTION:

1. Do Hydraulic Pump Flow Test.
   Are other hydraulic functions OK?
   YES: Hydraulic pump output is OK. Go to Cause B.
   NO: Test hydraulic system relief pressure. See Main Relief Valve Test and Adjustment.

CAUSE B - STEERING RELIEF PRESSURE IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Perform Steering Relief Pressure check.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause C.

CAUSE C - PRIORITY FLOW DIVIDER VALVE IS CONTAMINATED.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Does priority flow divider valve pass check?
   YES: Priority flow divider valve is OK. Go to Cause D.
   NO:
   - Flow divider valve spool is stuck. Remove and clean flow divider spool.
   - LS signal pressure is leaking away. See Steering Control Unit LS Pressure Test.

CAUSE D - HYDRAULIC LINES ARE RESTRICTED.

PROCEDURE OR ACTION:

1. Look at Steering System component location drawing to identify steering hoses. See Steering System. Inspect hoses for wear, damage, and correct installation.
   Are steering hoses in good condition and correctly installed?
   YES: Go to Cause E.
   NO: Install new hoses as necessary.

CAUSE E - SEAL IN THE STEERING CYLINDER LEAKS.

PROCEDURE OR ACTION:

1. Perform Steering Cylinder Leakage Test.
   Does steering cylinder pass leakage test?
   YES: Cylinder is OK. Go to Cause F.
   NO: Remove and repair steering cylinder.

CAUSE F - STEERING AXLE COMPONENTS ARE DAMAGED AND/OR BINDING.

PROCEDURE OR ACTION:

1. Turn steering wheel stop to stop in both directions while observing tires.
   Do tires shake or make noise while turning?
   YES: Inspect and repair damage steering axle components.
   NO: Go to Cause G.

CAUSE G - SCU IS WORN, NOT ASSEMBLED CORRECTLY, OR DAMAGED.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Is steering control unit damaged?
   YES: Install new SCU.
   NO: See Observed Symptoms-Gear Pump, Page 9050-33-63.

END SYMPTOM

Steering Operation Is Not Smooth

POSSIBLE CAUSE

A. AIR WAS NOT REMOVED AFTER REPAIR TO THE HYDRAULIC SYSTEM.
B. STEERING RELIEF PRESSURE SET TOO LOW.
C. BINDING IN STEERING COLUMN.
D. LOW PUMP FLOW.
E. FAILED CENTERING SPRINGS IN SCU.
F. STEERING CONTROL UNIT IS ASSEMBLED INCORRECTLY, DAMAGED, OR CONTAMINATED.

CAUSE A - AIR WAS NOT REMOVED AFTER REPAIR TO THE HYDRAULIC SYSTEM.

PROCEDURE OR ACTION:

1. Check service record of lift truck.
   Was hydraulic system repaired recently?
   YES: Check the repaired hose connections and remove air from system by cycling of steering cylinder full stroke in each direction.
   NO: Go to Cause B.

CAUSE B - STEERING RELIEF PRESSURE SET TOO LOW.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause C.

CAUSE C - BINDING IN STEERING COLUMN.

PROCEDURE OR ACTION:

1. Turn steering wheel stop to stop with engine running at slow idle.
   Is steering shaft binding in steering column?
   YES: Inspect and repair steering column.
   NO: Go to Cause D.

CAUSE D - LOW PUMP FLOW.

PROCEDURE OR ACTION:

1. Do Hydraulic Pump Flow Test.
   Are other hydraulic functions OK?
   YES: Hydraulic pump output is OK. Go to Cause E.
   NO: Test hydraulic system relief pressure. See Main Relief Valve Test and Adjustment.

CAUSE E - FAILED CENTERING SPRINGS IN SCU.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Are the centering springs in good condition?
   YES: Springs are OK. Go to Cause F.
   NO: Replace centering springs.

CAUSE F - STEERING CONTROL UNIT IS ASSEMBLED INCORRECTLY, DAMAGED, OR CONTAMINATED.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Is SCU properly assembled and clean?
   YES: Install new steering control unit.
   NO: Clean steering valve.

END SYMPTOM

Steering Wheel End Lock Position Cannot Be Felt by Operator

POSSIBLE CAUSE

A. ANTI-KICKBACK VALVES ARE SAME PRESSURE SETTING AS RELIEF VALVE.
B. CONTAMINATION CAUSING IMPROPER SHOCK VALVE OPERATION.

CAUSE A - ANTI-KICKBACK VALVES ARE SAME PRESSURE SETTING AS RELIEF VALVE.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Are the anti-kickback valves in good condition?
   YES: Anti-kickback valves OK. Go to Cause B.
   NO: Replace anti-kickback valves. See **Main Control Valve** 2000SRM1993

CAUSE B - CONTAMINATION CAUSING IMPROPER SHOCK VALVE OPERATION.

PROCEDURE OR ACTION:

1. Inspect assembly of SCU.
   Is SCU properly assembled and clean?
   YES: Install new steering control unit.
   NO: Clean steering valve.

END SYMPTOM

Steering Wheel Turns By Itself or Does Not Return To Neutral

POSSIBLE CAUSE

A. OIL CONTAMINATION
B. STEERING RELIEF PRESSURE SET TOO LOW.
C. BINDING IN STEERING COLUMN OR NO RESISTANCE.
D. FAILED CENTERING SPRINGS IN SCU.
E. DEFLECTION OF SPOOL AND SLEEVE CAUSED BY HIGH SYSTEM PRESSURE.
F. STEERING CONTROL UNIT IS ASSEMBLED INCORRECTLY OR IS DAMAGED.

CAUSE A - OIL CONTAMINATION

PROCEDURE OR ACTION:

Inspect oil for contamination prior to performing the following procedures.

CAUSE B - STEERING RELIEF PRESSURE SET TOO LOW.

PROCEDURE OR ACTION:

1. Perform Steering Relief Pressure check.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause C.

CAUSE C - BINDING IN STEERING COLUMN OR NO RESISTANCE.

PROCEDURE OR ACTION:

1. Turn steering wheel stop to stop with engine running at slow idle.
   Is linkage binding in steering column?
   YES: Inspect and repair steering column.
   NO: Go to Cause D.

CAUSE D - FAILED CENTERING SPRINGS IN SCU.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Are the centering springs in good condition?
   YES: Springs are OK. Go to Cause E.
   NO: Replace centering springs.

CAUSE E - DEFLECTION OF SPOOL AND SLEEVE CAUSED BY HIGH SYSTEM PRESSURE.

PROCEDURE OR ACTION:

1. Perform Steering Relief Pressure Test and Adjustment.
   Does steering relief pass check?
   YES: Go to Cause F.
   NO: Adjust relief pressure. See Steering Relief Pressure Test and Adjustment.

CAUSE F - STEERING CONTROL UNIT IS ASSEMBLED INCORRECTLY OR IS DAMAGED.

PROCEDURE OR ACTION:

1. Inspect SCU.
   Is SCU properly assembled and clean?
   YES: Install new steering control unit.
   NO: Clean steering valve.

END SYMPTOM

Steering Wheel Turns the Tires in the Wrong Direction

POSSIBLE CAUSE

A. HYDRAULIC HOSES ARE NOT CONNECTED CORRECTLY AT THE STEERING CYLINDER OR AT THE SCU.

CAUSE A - HYDRAULIC HOSES ARE NOT CONNECTED CORRECTLY AT THE STEERING CYLINDER OR AT THE SCU.

PROCEDURE OR ACTION:

1. Look at Steering System component location. See Steering System to identify steering hoses.
   Are hoses correctly installed?
   YES: Problem is in SCU. Repair or replace SCU.
   NO: Correct steering hose routing at valve or steering cylinder.

END SYMPTOM

Tilt Back Function Will Not Operate (Manual Valve)

POSSIBLE CAUSE

A. CONTROL VALVE PISTON IS STUCK IN OPEN POSITION.

CAUSE A - CONTROL VALVE PISTON IS STUCK IN OPEN POSITION.

PROCEDURE OR ACTION:

1. Inspect control valve piston and exhaust orifices.
   Does the valve move freely and are exhaust orifices open?
   YES: Valve is OK. See ***Auxiliary Function is Slow or Does Not Function (Manual Valve)***.
   NO: Replace control valve piston.

END SYMPTOM

Tilt Forward Function Continues to Move for Awhile When MLM Is Released (E-Valve) ErCd000, ErCd001, ErCd002, ErCd003, ErCd006, ErCd007, ErCd008

POSSIBLE CAUSE

A. RAMP SETTING TOO LOW FOR FUNCTION.
B. STICKING VALVE SPOOL.
C. STICKING TILT CONTROL PISTON IN TILT SPOOL.
D. STICKING PPRV.

CAUSE A - RAMP SETTING TOO LOW FOR FUNCTION.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Adjust function ramp setting on display. If problem is still present, go to Cause B.

CAUSE B - STICKING VALVE SPOOL.

PROCEDURE OR ACTION:

1. Remove and inspect spool.
   Is the spool undamaged and moves freely in bore?
   YES: Go to Cause C.
   NO: Clean or replace valve spool.

CAUSE C - STICKING TILT CONTROL PISTON IN TILT SPOOL.

PROCEDURE OR ACTION:

1. Inspect piston.
   Does piston move freely in bore?
   YES: Go to Cause D.
   NO: Clean piston or replace valve section.

CAUSE D - STICKING PPRV.

PROCEDURE OR ACTION:

1. Test PPRV pressure. See PPRV Pilot Pressure Test.
   Is PPRV pressure test to specifications?
   YES: See Observed Symptoms-Gear Pump, Page 9050-33-51.
   NO: Remove PPRV and clean.

END SYMPTOM

Tilt Forward Functions When Spool is Activated Forward With Engine Off (Manual Valve)

POSSIBLE CAUSE

A. TILT CONTROL VALVE IS STUCK IN OPEN POSITION.

CAUSE A - TILT CONTROL VALVE IS STUCK IN OPEN POSITION.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Inspect tilt control valve. See **Main Control Valve** 2000SRM1993 .
   Is the valve stuck open?
   YES: Clean or replace control valve.
   NO: Control valve has excessive leakage. Replace piston.

END SYMPTOM

Tilt Forward Will Not Function When Activated (Manual Valve)

POSSIBLE CAUSE

A. TILT CONTROL VALVE IS STUCK IN CLOSED POSITION.
B. TILT CONTROL VALVE EXHAUST HOLES PLUGGED IN VALVE.

CAUSE A - TILT CONTROL VALVE IS STUCK IN CLOSED POSITION.

PROCEDURE OR ACTION:

1. Inspect tilt control valve and exhaust orifices.
   Does the control valve piston move freely and are exhaust orifices open?
   YES: Go to Cause B.
   NO: Clean or replace tilt control valve spool.

CAUSE B - TILT CONTROL VALVE EXHAUST HOLES PLUGGED IN VALVE.

PROCEDURE OR ACTION:

1. Inspect valve section.
   Are exhaust holes open?
   YES: Valve is OK. See ***Auxiliary Function is Slow or Does Not Function (Manual Valve)***.
   NO: Clean or replace valve.

END SYMPTOM

Auxiliary Function, Tilt Back and/or Tilt Forward Will Not Move With MLM Movement (E-Valve) ErrCA008-019

POSSIBLE CAUSE

A. **PUMP NOT GENERATING ENOUGH FLOW.**
B. **LOAD IS GREATER THAN TRUCK CAPACITY.**
C. **MLM CONTROL MALFUNCTION.**
D. **HYDRAULIC FUNCTION SPEED IS SET AT 0%.**
E. **SECONDARY RELIEF VALVE IS SET TOO LOW.**
F. **MAST/ATTACHMENT IS BINDING.**
G. **STUCK SPOOL IN CONTROL VALVE.**
H. **PROPORTIONAL PRESSURE REDUCING VALVE TOO LOW.**
I. **SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.**
J. **MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.**
K. **UNLOADER VALVE STUCK OPEN.**
L. **MAIN RELIEF LS (LOAD SENSE) STUCK OPEN.**
M. **MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.**

CAUSE A - PUMP NOT GENERATING ENOUGH FLOW.

PROCEDURE OR ACTION:

1. Do hydraulic pump flow check.
   Does pump pass check?
   YES: Pump is OK. Go to Cause B.
   NO: Perform Hydraulic Pump Flow Test before replacing pump.

CAUSE B - LOAD IS GREATER THAN TRUCK CAPACITY.

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

1. Check load weight and compare to truck capacity rating. Adjust as necessary. If problem is still present, go to Cause C.

CAUSE C - MLM CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Power **ON** and operator in seat. Operate lever/s.
   Is a hydraulic interlock message displayed?
   YES: Go to Display Menu/Diagnostics/Seat (Operator Presence), then go to Step 2.
   NO: Go to Cause D.
2. Observe value.
   Is Operator Presence sensor value greater than 1.8 volts?
   YES: Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values, then go to Step 3.
   NO: Refer to Operator Section.
3. Operate lever/s in both directions.
   Does lever exhibit any binding/stickiness or not return to center position?
   YES: Remove and replace lever. **Note:** Inspect cassette rotary mechanism for dirt contamination.
   NO: Go to Next Step.
4. Move lever(s) to full stroke position and allow to snap back to the center position. Observe Value. Move the lever(s) to the full stroke position and hold. Observe Value.
   Does Display value = 0% at the center position and 92 to 100% at the full stroke position?
   YES: Go to Cause D.
   NO: Go to Step 5.
5. Power **OFF**. Replace lever(s).
6. Retest. Turn power **ON**.
7. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
8. Move lever(s) to full stroke position and allow to snap back to the center position. Observe value. Move the lever(s) to the full stroke position and hold. Observe value.
   Does Display value = 0% at the center position and 92 to 100% at the full stroke position?
   YES: Repair complete. Resume operation.
   NO: Replace MLM PCB Cassette.
9. Retest. Turn power **ON**.
10. Go to Display Menu/Diagnostics/Hydraulics Inputs/Lever Input values.
11. Move lever(s) to full stroke position and allow to snap back to the center position. Observe value. Move the lever(s) to the full stroke position and hold. Observe value.
    Does Display value = 0%? at the center position and 92 to 100% at the full stroke position?
    YES: Repair complete. Resume operation.
    NO: Go to Cause D.

CAUSE D - HYDRAULIC FUNCTION SPEED IS SET AT 0%.

PROCEDURE OR ACTION:

1. Check current setting of tilt hydraulic function. Go to Display Menu/Truck Set-Up/Hydraulic Function.
   Is Hydraulic Function set at 0%?
   YES: Reset hydraulic function to appropriate level.
   NO: Go to Cause E.

CAUSE E - SECONDARY RELIEF VALVE IS SET TOO LOW.

PROCEDURE OR ACTION:

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause F.
   NO: Adjust pressure to test specifications.

CAUSE F - MAST/ATTACHMENT IS BINDING.

PROCEDURE OR ACTION:

1. Check for mast or attachment binding.
   Is mast or attachment binding?
   YES: Lubricate or repair mast or attachment.
   NO: Go to Cause G.

CAUSE G - STUCK SPOOL IN CONTROL VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect spool.
   Does the spool move freely in bore and in good condition?
   YES: Go to Cause H.
   NO: Repair or replace valve spool or section.

CAUSE H - PROPORTIONAL PRESSURE REDUCING VALVE TOO LOW.

PROCEDURE OR ACTION:

1. Test Proportional Pressure Reducing Valve (PPRV) pressure.
   Is PPRV pressure at specifications?
   YES: Go to Cause I.
   NO: Clean screen on PPRV. If problem is still present, replace PPRV.

CAUSE I - SECONDARY RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

NOTE: This only affects hoist circuit when a auxiliary function is activated.

1. Test and adjust pressure. See Secondary Relief Valve Test and Adjustment.
   Is relief set at specifications?
   YES: Go to Cause J.
   NO: Adjust pressure to test specifications.

CAUSE J - MAIN RELIEF VALVE DAMAGED OR STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect relief valve.
   Is relief valve damaged or stuck open?
   YES: Install new relief valve.
   NO: Go to Cause K.

CAUSE K - UNLOADER VALVE STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect unloader spool.
   Does unloader spool move freely in bore and in good condition?
   YES: Go to Cause L.
   NO: Repair or replace unloader spool.

CAUSE L - MAIN RELIEF LS (LOAD SENSE) STUCK OPEN.

PROCEDURE OR ACTION:

1. Remove and inspect main relief valve.
   Is the LS relief clean and spring OK?
   YES: Go to Cause M.
   NO: Check for contamination. Clean or replace relief valve.

CAUSE M - MAIN CONTROL VALVE LS (LOAD SENSE) RELIEF LEAKAGE.

PROCEDURE OR ACTION:

1. Check LS pressure.
   Does LS pressure meet test specifications?
   YES: No faults evident at this time.
   NO: Clean or replace main relief valve.

END SYMPTOM

Too Much MLM Movement (Deadband) to Start Function Moving (E-Valve)

POSSIBLE CAUSE

A. EHPV PILOT PIN ADJUSTMENT INCORRECT (LIFT AND LOWER FUNCTION ONLY).
B. OUTPUT THRESHOLD IS SET TOO HIGH.

CAUSE A - EHPV PILOT PIN ADJUSTMENT INCORRECT (LIFT AND LOWER FUNCTION ONLY).

PROCEDURE OR ACTION:

1. Check for EHPV (Electro-Hydraulic Poppet Valve) servicing.
   Has EHPV been serviced recently?
   YES: Adjust EHPV.
   NO: Go to Cause B.

CAUSE B - OUTPUT THRESHOLD IS SET TOO HIGH.

PROCEDURE OR ACTION:

1. Check threshold at display.
   Is setting at valve correct?
   YES:
   - For hoist/lower functions, see Observed Symptoms-Gear Pump, Page 9050-33-27.
   - For secondary functions, see Observed Symptoms-Gear Pump, Page 9050-33-29.
   - For tilt forward function, see Observed Symptoms-Gear Pump, Page 9050-33-31.

   NO: Decrease setting to specification or until operation is acceptable to operator.

END SYMPTOM

Wrong Actuation Operates or Actuation is Backward (E-Valve)

POSSIBLE CAUSE

A. WIRING HARNESS INSTALLED WRONG.
B. HYDRAULIC HOSES INSTALLED WRONG.
C. WIRING HARNESS HAS FAILED.
D. MLM ASSEMBLED INCORRECTLY.

CAUSE A - WIRING HARNESS INSTALLED WRONG.

PROCEDURE OR ACTION:

WARNING

Unexpected movement of hydraulic function can cause injury or death. Do not operate the lift truck until problem has been repaired.

1. Inspect wiring harness.
   Is harness installed correctly?
   YES: Go to Cause B.
   NO: Adjust or repair harness.

CAUSE B - HYDRAULIC HOSES INSTALLED WRONG.

PROCEDURE OR ACTION:

1. Inspect hydraulic hose routing and correct as required. For proper hose routing, see Main Hydraulic System. If problem is still present, go to Cause C.

CAUSE C - WIRING HARNESS HAS FAILED.

PROCEDURE OR ACTION:

1. Inspect harness for shorts.
   Does harness have a short?
   YES: Repair wiring harness.
   NO: Go to Cause D.

CAUSE D - MLM ASSEMBLED INCORRECTLY.

PROCEDURE OR ACTION:

1. Check MLM for:
   - Lever rotated 180 degrees
   - Lever leads not connected to correct connector

   Is MLM assembled incorrectly?
   YES: Assemble MLM components correctly.
   NO: Perform operational check.

END SYMPTOM

Group 30

Observed Symptoms

No Steering (All other hydraulic functions are okay)

POSSIBLE CAUSE

A. STEERING RELIEF PRESSURE IS TOO LOW.
B. PRIORITY FLOW DIVIDER VALVE IS MALFUNCTIONING.
C. STEERING CONTROL UNIT (SCU) IS INTERNALLY CONTAMINATED.

CAUSE A - STEERING RELIEF PRESSURE IS TOO LOW.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause B.

CAUSE B - PRIORITY FLOW DIVIDER VALVE IS MALFUNCTIONING.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Does priority flow divider valve pass check?
   YES: Priority flow divider valve is OK. Go to Cause C.
   NO: Flow divider valve spool is stuck.

CAUSE C - STEERING CONTROL UNIT (SCU) IS INTERNALLY CONTAMINATED.

PROCEDURE OR ACTION:

1. Inspect SCU for contamination and damaged or broken components.
   Is SCU contaminated or have damaged or broken components?
   YES: Inspect and Clean SCU. **Resident Service Approval Required prior to Steering Control Unit (SCU) replacement for Trucks under warranty.** Make sure to indicate an accurate problem description leading to the SCU replacement.
   NO: Resume operation.

END SYMPTOM

Steering Effort is Too High (All other hydraulic functions are okay)

POSSIBLE CAUSE

A. **STEERING RELIEF PRESSURE IS TOO LOW.**
B. **PRIORITY FLOW DIVIDER VALVE IS MALFUNCTIONING.**
C. **STEERING CONTROL UNIT (SCU) IS INTERNALLY CONTAMINATED.**
D. **BINDING IN STEERING COLUMN.**

CAUSE A - STEERING RELIEF PRESSURE IS TOO LOW.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause B.

CAUSE B - PRIORITY FLOW DIVIDER VALVE IS MALFUNCTIONING.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Does priority flow divider valve pass check?
   YES: Priority flow divider valve is OK. Go to Cause C.
   NO: Flow divider valve spool is stuck. Remove and clean flow divider spool.

CAUSE C - STEERING CONTROL UNIT (SCU) IS INTERNALLY CONTAMINATED.

PROCEDURE OR ACTION:

1. Inspect SCU for contamination and damaged or broken components.
   Is SCU contaminated or have damaged or broken components?
   YES: Inspect and Clean SCU.
   Resident Service Approval Required prior to Steering Control Unit (SCU) replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the SCU replacement.
   NO: Go to Cause D.

CAUSE D - BINDING IN STEERING COLUMN.

PROCEDURE OR ACTION:

1. Perform steering column binding test. See .
   Does Dimension "A" meet the minimum dimension specification?
   YES: Resume operation.
   NO: Go to Step 2.
2. Inspect the hydraulic control valve isolator mount.
   Does Dimension "B" meet the isolator thickness specification?
   YES: Resume operation.
   NO: Replace worn or damaged isolator mounts.
   Resident Service Approval Required prior to Steering Control Unit (SCU) replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the SCU replacement.

END SYMPTOM

Steer Cylinder Does Not Reach End Of Stroke (All other hydraulic functions are okay)

POSSIBLE CAUSE

A. STEERING RELIEF PRESSURE IS TOO LOW.
B. STEERING CYLINDER PISTON SEALS ARE WORN OR DAMAGED.

CAUSE A - STEERING RELIEF PRESSURE IS TOO LOW.

PROCEDURE OR ACTION:

1. Perform Operational Check.
   Is steering relief pressure set too low?
   YES: Adjust steering relief pressure. See Steering Relief Pressure Test and Adjustment.
   NO: Go to Cause B.

CAUSE B - STEERING CYLINDER PISTON SEALS ARE WORN OR DAMAGED.

PROCEDURE OR ACTION:

1. Perform steering cylinder leakage test, see **Lift Cylinder Leakage Test** .
   Does steering cylinder pass leakage test?
   YES: Resume operation.
   NO: Remove and repair steering cylinder.

END SYMPTOM

No Hydraulic Functions (Lift, Tilt, and Aux) ErrCA004, ErrCA006, ErrCA007, ErrCA008, ErrCA009, ErrCA010, ErrCA011, ErrCA012, ErrCA013, ErrCA014, ErrCA015, ErrCA016, ErrCA017, ErrCA018, ErrCA019, ErrCA020, ErrCA021

POSSIBLE CAUSE

A. MLM/JOYSTICK CONTROL MALFUNCTION.
B. SYSTEM PRESSURE IS TOO LOW.
C. PUMP NOT GENERATING ENOUGH FLOW.

CAUSE A - MLM/JOYSTICK CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Are codes ErrCA004/006 through 021 displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - SYSTEM PRESSURE IS TOO LOW.

PROCEDURE OR ACTION:

1. Perform pressure compensator test.
   Does system pressure meet specifications for your lift truck?
   YES: Go to Cause C.
   NO: Adjust pressure compensator.

CAUSE C - PUMP NOT GENERATING ENOUGH FLOW.

PROCEDURE OR ACTION:

1. Perform flow compensator margin test.
   Does flow compensator margin pressure meet specifications for your lift truck?
   YES: Resume operation.
   NO: Adjust flow compensator.
   Resident Service Approval Required prior to Compensator Valve Assembly or Variable Displacement Pump (VDP) replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the Compensator Valve Assembly or VDP replacement.

END SYMPTOM

No Lift Function (Steering and All other hydraulic functions okay) ErrCA004, ErrCA006, ErrCA007

POSSIBLE CAUSE

A. MLM/JOYSTICK CONTROL MALFUNCTION.
B. CALIBRATION OF OUTPUT THRESHOLD IS TOO HIGH.
C. EMERGENCY LOWER VALVE OPEN.
D. SYSTEM PRESSURE IS TOO LOW.
E. PUMP NOT GENERATING ENOUGH FLOW.
F. NOT ENOUGH PILOT PRESSURE BEING PRODUCED BY PPRV.
G. STUCK SPOOL IN CONTROL VALVE.

CAUSE A - MLM/JOYSTICK CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Are codes ErrCA004, ErrCA006, or ErrCA007 displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - CALIBRATION OF OUTPUT THRESHOLD IS TOO HIGH.

PROCEDURE OR ACTION:

1. Check calibration threshold at display.
   Does setting meet specifications for your lift truck?
   YES: Go to Cause C.
   NO: Decrease setting to specification or until operation is acceptable to operator.

CAUSE C - EMERGENCY LOWER VALVE OPEN.

PROCEDURE OR ACTION:

1. Emergency lower valve has tee handle located on control valve. See **Operating Manual** for location and correct use.
   Is emergency lowering valve closed?
   YES: Go to Cause D.
   NO: Close emergency lowering valve.

CAUSE D - SYSTEM PRESSURE IS TOO LOW.

PROCEDURE OR ACTION:

1. Perform pressure compensator test.
   Does system pressure meet specifications for your lift truck?
   YES: Go to Cause E.
   NO: Adjust pressure compensator.

CAUSE E - PUMP NOT GENERATING ENOUGH FLOW.

PROCEDURE OR ACTION:

1. Perform flow compensator margin test.
   Does flow compensator margin pressure meet specifications for your lift truck?
   YES: Go to Cause F.
   NO: Adjust flow compensator.
   Resident Service Approval Required prior to Compensator Valve Assembly or Variable Displacement Pump (VDP) replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the Compensator Valve Assembly or VDP replacement.

CAUSE F - NOT ENOUGH PILOT PRESSURE BEING PRODUCED BY PPRV.

PROCEDURE OR ACTION:

1. Perform pilot pressure test. See PPRV Pilot Pressure Test.
   Does pilot pressure meet specifications for your lift truck?
   YES: Go to Cause G.
   NO: Clean screen on PPRV. If problem still persists, replace PPRV.

CAUSE G - STUCK SPOOL IN CONTROL VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect spool for contamination and damaged or broken components.
   Is the spool clean, undamaged, and moves freely in bore?
   YES: Resume operation.
   NO: Clean contaminated spool or replace lift section.
   Resident Service Approval Required prior to control valve assembly replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the control valve assembly replacement.

END SYMPTOM

Forks Raise Without Command ErrCA004

POSSIBLE CAUSE

A. **MLM/JOYSTICK CONTROL MALFUNCTION.**
B. **PPRV STUCK OPEN.**
C. **STUCK SPOOL IN CONTROL VALVE.**

CAUSE A - MLM/JOYSTICK CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the DSC for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use DSC or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - PPRV STUCK OPEN.

PROCEDURE OR ACTION:

1. Perform pilot pressure test. See PPRV Pilot Pressure Test.
   Does pilot pressure meet specifications for your lift truck?
   YES: Go to Cause C.
   NO: Remove and clean PPRV.

CAUSE C - STUCK SPOOL IN CONTROL VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect spool for contamination and damaged or broken components.
   Is the spool clean, undamaged, and moves freely in bore?
   YES: Resume operation.
   NO: Clean contaminated spool or replace lift section.
   Resident Service Approval Required prior to control valve assembly replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the control valve assembly replacement.

END SYMPTOM

No Lower Function (Steering, lift, tilt, and Aux functions okay) ErrCA004, ErrCA006, ErrCA007

POSSIBLE CAUSE

A. MLM/JOYSTICK CONTROL MALFUNCTION.
B. CALIBRATION OF OUTPUT THRESHOLD IS TOO LOW.
C. STUCK SPOOL IN CONTROL VALVE.
D. FAULTY MAST LOWERING CONTROL VALVE (MLCV).
E. NOT ENOUGH PILOT PRESSURE BEING PRODUCED BY PPRV.

CAUSE A - MLM/JOYSTICK CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the DSC for DTC.
   Are codes ErrCA004, ErrCA006, or ErrCA007 displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use DSC or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - CALIBRATION OF OUTPUT THRESHOLD IS TOO LOW.

PROCEDURE OR ACTION:

1. Check calibration threshold at DSC.
   Does setting meet specifications for your lift truck?
   YES: Go to Cause C.
   NO: Increase setting to specification or until operation is acceptable to operator.

CAUSE C - STUCK SPOOL IN CONTROL VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect spool for contamination and damaged or broken components.
   Is the spool clean, undamaged, and moves freely in bore?
   YES: Go to Cause D.
   NO: Clean contaminated spool or replace lift section.
   Resident Service Approval Required prior to control valve assembly replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the control valve assembly replacement.

CAUSE D - FAULTY MAST LOWERING CONTROL VALVE (MLCV).

PROCEDURE OR ACTION:

1. Inspect mast lowering control valve for blockage.
   Is mast lowering control valve blocking flow?
   YES: Repair or replace Mast Lowering Control Valve (MLCV).
   NO: Go to Cause E.

CAUSE E - NOT ENOUGH PILOT PRESSURE BEING PRODUCED BY PPRV.

PROCEDURE OR ACTION:

1. Perform pilot pressure test. See PPRV Pilot Pressure Test.
   Does pilot pressure meet specifications for your lift truck?
   YES: Resume operation.
   NO: Clean screen on PPRV. If problem still persists, replace PPRV.

END SYMPTOM

Forks Lower Without Command ErrCA006

POSSIBLE CAUSE

A. MLM/JOYSTICK CONTROL MALFUNCTION.
B. EMERGENCY LOWER VALVE IS PARTIALLY OPEN.
C. PPRV STUCK OPEN.
D. EXCESSIVE LEAKAGE IN LOAD CHECK POPPET VALVE.
E. EXCESSIVE LIFT CYLINDER LEAKAGE.
F. FAULTY MAST LOWERING CONTROL VALVE (MLCV).

CAUSE A - MLM/JOYSTICK CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - EMERGENCY LOWER VALVE IS PARTIALLY OPEN.

PROCEDURE OR ACTION:

1. Emergency lower valve has tee handle located on control valve. See **Operating Manual** for location and correct use.
   Is emergency lowering valve closed?
   YES: Go to Cause C.
   NO: Close emergency lowering valve.

CAUSE C - PPRV STUCK OPEN.

PROCEDURE OR ACTION:

1. Perform pilot pressure test. See PPRV Pilot Pressure Test.
   Does pilot pressure meet specifications for your lift truck?
   YES: Go to Cause D.
   NO: Remove and clean PPRV.

CAUSE D - EXCESSIVE LEAKAGE IN LOAD CHECK POPPET VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect load check valve for contamination and damaged or broken components.
   Is load check valve contaminated or have damaged or broken components?
   YES: Replace load check valve.
   NO: Go to Cause E.

CAUSE E - EXCESSIVE LIFT CYLINDER LEAKAGE.

PROCEDURE OR ACTION:

1. Do lift cylinder leakage test. See **Lift Cylinder Leakage Test** .
   Is there leakage in the lift cylinder?
   YES: Repair or replace lift cylinder.
   NO: Go to Cause F.

CAUSE F - FAULTY MAST LOWERING CONTROL VALVE (MLCV).

PROCEDURE OR ACTION:

1. Inspect mast lowering control valve for blockage.
   Is mast lowering control valve blocking flow?
   YES: Repair or replace Mast Lowering Control Valve (MLCV).
   NO: Resume operation.

END SYMPTOM

No Secondary Function (Tilt or Aux) ErrCA008-019

POSSIBLE CAUSE

A. MLM/JOYSTICK CONTROL MALFUNCTION.
B. CALIBRATION OF OUTPUT THRESHOLD IS TOO HIGH.
C. STUCK SPOOL IN CONTROL VALVE.
D. SECONDARY RELIEF PRESSURE TOO LOW.
E. NOT ENOUGH PILOT PRESSURE BEING PRODUCED BY PPRV.
F. TILT CONTROL SPOOL PISTON STICKING (TILT FORWARD ONLY).

CAUSE A - MLM/JOYSTICK CONTROL MALFUNCTION.

PROCEDURE OR ACTION:

1. Check the display for DTC.
   Is a DTC displayed?
   YES: Go to DTC diagnostic procedure.
   NO: Check for full stroke of lever. Use display or install the Service Tool to monitor functions.
2. Stroke each lever to full stroke and allow to snap back to center.
3. **(Do not start.)** Turn key switch to **ON** position or press power ON/OFF button.
4. See appropriate User Interface manual. Follow instructions to view Lever Input Value. With Service Password, view Diagnostics – Hydraulic Data Display – Hydraulic Input.
5. Operate each lever to full stroke forward and read input.
   Is lever Input = - 92%?
   YES: Go to Step 6.
   NO: Replace lever.
6. Operate each lever to full stroke backward and read input.
   Is lever Input = + 92%?
   YES: Go to Cause B.
   NO: Replace lever.

CAUSE B - CALIBRATION OF OUTPUT THRESHOLD IS TOO HIGH.

PROCEDURE OR ACTION:

1. Check calibration threshold at display.
   Does setting meet specifications for your lift truck?
   YES: Go to Cause C.
   NO: Decrease setting to specification or until operation is acceptable to operator.

CAUSE C - STUCK SPOOL IN CONTROL VALVE.

PROCEDURE OR ACTION:

1. Remove and inspect spool for contamination and damaged or broken components.
   Is the spool clean, undamaged, and moves freely in bore?
   YES: Go to Cause D.
   NO: Clean contaminated spool or replace Tilt or Auxiliary section.
   Resident Service Approval Required prior to control valve assembly replacement for Trucks under warranty. Make sure to indicate an accurate problem description leading to the control valve assembly replacement.

CAUSE D - SECONDARY RELIEF PRESSURE TOO LOW.

PROCEDURE OR ACTION:

1. Perform secondary relief pressure test. See Secondary Relief Valve Test and Adjustment.
   Does secondary relief pressure meet specifications for your lift truck?
   YES: Go to Cause E.
   NO: Adjust pressure to test specification. See Secondary Relief Valve Test and Adjustment.

CAUSE E - NOT ENOUGH PILOT PRESSURE BEING PRODUCED BY PPRV.

PROCEDURE OR ACTION:

1. Perform pilot pressure test. See PPRV Pilot Pressure Test.
   Does pilot pressure meet specifications for your lift truck?
   YES: Resume operation.
   NO: Clean screen on PPRV. If problem still persists, replace PPRV.

CAUSE F - TILT CONTROL SPOOL PISTON STICKING (TILT FORWARD ONLY).

PROCEDURE OR ACTION:

1. Inspect tilt control piston.
   Does piston move freely in bore and are the tilt spool orifices clean?
   YES: Resume operation.
   NO: Clean piston and spool or replace tilt section.

END SYMPTOM

Group 43

Tests and Adjustments-Gear Pump

Hydraulic Warm-up Procedure

Use this procedure to get the hydraulic oil temperature to test specification. Install the test equipment on lift truck before starting this procedure to reduce handling of hot component or oil.

Table 9050-43-2. Test Specifications

Engine Speed	Governed Speed
Oil Temperature	50 to 65°C (122 to 150 °F)

Table 9050-43-3. Service Tools

Temperature Reader - Thermocouple

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing or installing test equipment.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

1. Install test equipment as called out in test.
2. Install thermocouple on outside surface of hydraulic oil tank.
3. Start engine and operate engine at fast idle speed.
4. Tilt the mast back and hold over relief for 20 seconds, then release lever. Cycle both tilt and lift cylinders to circulate oil and equalize temperature in system.
5. Read temperature and compare to temperature specifications of test to be performed.
6. Repeat Step 4 and Step 5 until oil temperature is at test specifications.

NOTES

Group 40

Tests and Adjustments

E-Hydraulic Offset Adjustment

DESCRIPTION

E-Hydraulic valve currents can be adjusted using the PC Service Tool. Adjusting the cracking current can be done by changing offset current to improve hydraulic response.

1. Connect PC Service Tool.
2. View *Truck Setup* and select *Hydraulics*.
3. Adjust the appropriate hydraulic function offset to increase/decrease cracking current in milliamps.

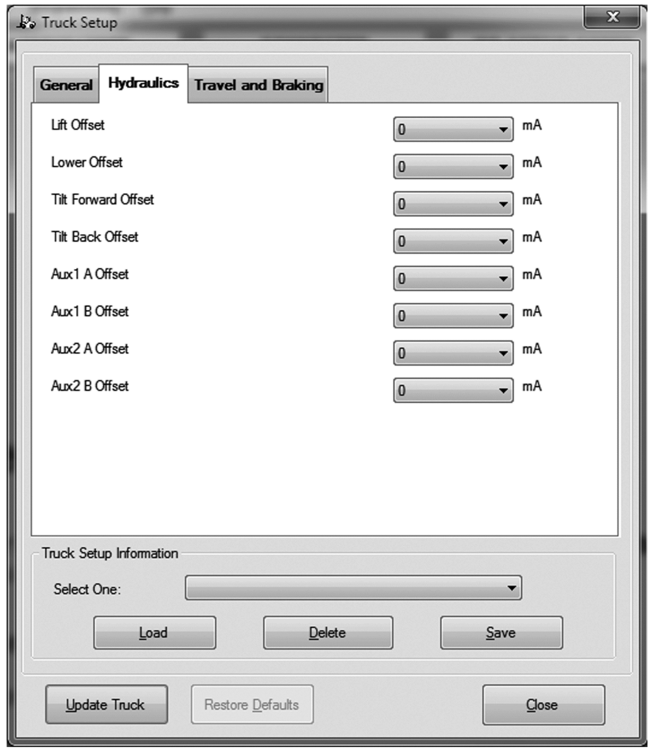


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Figure 9050-40-23. E-Hydraulic Cracking Adjustments

NOTES

Group 43

Tests and Adjustments-Gear Pump

Hydraulic Pump Flow Test

This test is done to accurately check the hydraulic pump output. This will isolate if performance problems are in hydraulic pump or elsewhere in hydraulic circuit.

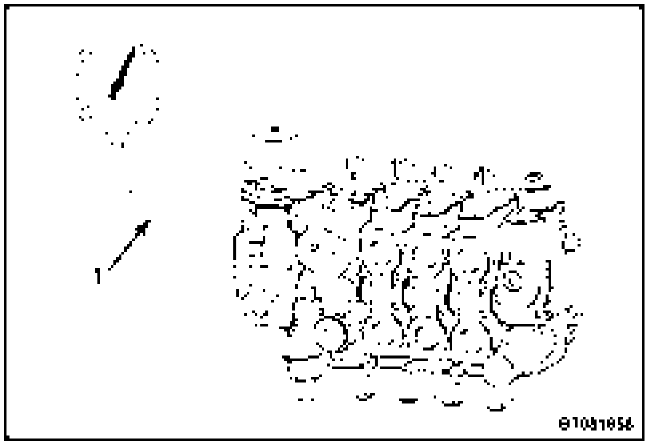
NOTE: If a flowmeter is not available, use lift speed charts to determine pump output. If lift raise times with capacity load on forks is more than 25% greater than specifications, the pump should be replaced.

Table 9050-43-4. Test Specifications

Engine Speed	Governed Speed
Oil Temperature	50 to 65°C (122 to 150 °F)
Minimum Pump Output	PSI 2.4L LPG Bi-Fuel 72.7 liter/min (19.2 gal/min) Yanmar 2.6L and 3.3L 74.6 liter/min (19.7 gal/min)
GP1 Test Pressure	Tilt Function Over Relief (Secondary Relief Valve Setting)

Table 9050-43-5. Service Tools

125 liter/min (33 gal/min) Flowmeter, rated at 24.0 MPa (3500 psi)	
0 - 35.0 MPa (0 - 5000 psi) Pressure Gauge	
GP1 Test Port Plug Size	SAE #4 O-ring Port (7/16-20 UNF)
Steering Control Valve Inlet Port Size	SAE #12 O-ring Port (1-1/16-12 UNF)



NOTE: CONNECT FLOW METER BETWEEN CONTROL VAVLE AND PUMP ASSEMBLY.

1. GP1 TEST PORT WITH GAUGE

Figure 9050-43-24. Manual Hydraulic Valve Shown

1. Lower forks to ground and stop engine. Apply park brake.

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

2. Remove front floor panel. Remove inlet hose to steering valve and install flowmeter. Install pressure gauge to the inlet port of flowmeter if it does not have internal gauge. See Figure 9050-43-24.

CAUTION

Hydraulic pump will be damaged if flowmeter gate valve is closed when engine is started. Open the gate valve all the way open (counterclockwise) on the flowmeter before starting engine.

3. Operate the hydraulic system until the oil temperature is to test specifications. See Hydraulic Warm-up Procedure.

4. Operate the engine at governed speed.

5. Tilt mast back and hold over relief, record pump flow. Compare pump flow to specifications.

6. Return forks to ground level and then stop engine.

NOTE: A collapsed suction hose or plugged suction screen in hydraulic tank could affect pump flow. Be sure to check these components before replacing pump.

7. If the flow is less than the specifications, inspect suction hoses to pump and suction screen in hydraulic tank. If they are OK then replace pump.

8. Remove test equipment, reinstall hoses and floor panel.

9. Check oil level in hydraulic tank. Add oil, as required.

Main Relief Valve Test and Adjustment

CAUTION

Typically, the Main Relief Valve (MRV) should NOT be adjusted in the field for general purposes. Increasing the setting of the MRV past its specified setting may damage truck.

Table 9050-43-6. Test Specifications

Engine Speed	Governed Speed
Oil Temperature	50 to 65°C (122 to 150 °F)
Main Relief Pressure	**For 2 to 3 Ton Lift Trucks:** 21.3 ±0.5 MPa (3100 ±70 psi) **For 3.5 Ton Lift Trucks:** 23.4 ±0.5 MPa (3400 ±70 psi)

Table 9050-43-7. Service Tools

0 - 35.0 MPa (0 - 5000 psi) Pressure Gauge	
GP1 Test Plug Port Size	SAE #4 O-ring Port (7/16-20 UNF)

1. GP1 TEST PORT WITH GAUGE
2. SECONDARY RELIEF VALVE LOCATION
3. MAIN RELIEF VALVE LOCATION

Figure 9050-43-25. Manual Valve Shown

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing test plugs from valve.

1. Lower forks to ground and stop engine. Apply park brake.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

2. Remove panels that cover MRV. Install pressure gauge in control valve GP1 test port. See Figure 9050-43-25.

3. Operate the hydraulic system until the oil temperature is at test specifications. See Hydraulic Warm-up Procedure.

WARNING

Forks contacting overhead electrical wires or fixtures can cause serious injury or death. Make sure area is clear of hazards before raising forks to maximum height.

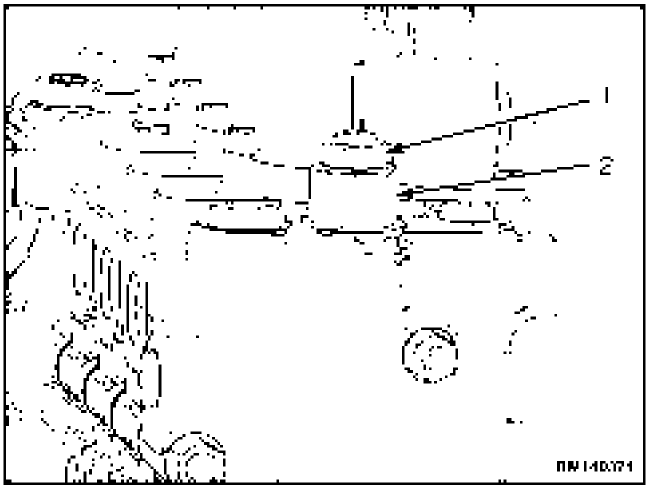
4. Raise the mast until it stops. Hold the lever and check the reading of the gauge when the relief valve opens. Compare to specifications.

CAUTION

Setting the relief valve above specification can cause damage to hydraulic and mechanical components of lift truck. Do not increase pressure above specifications.

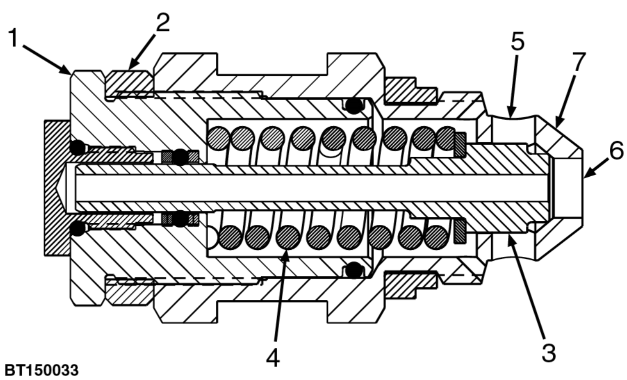
5. Adjust main relief valve, if not within specification, as follows:

- **Manual Control Valve:** If pressure is not within specifications, loosen the jam nut on relief valve. While holding lift hydraulics over relief, slowly turn the adjusting screw, in (clockwise) to increase pressure, out (counterclockwise) to reduce pressure.



1. ADJUSTING NUT 2. JAM NUT

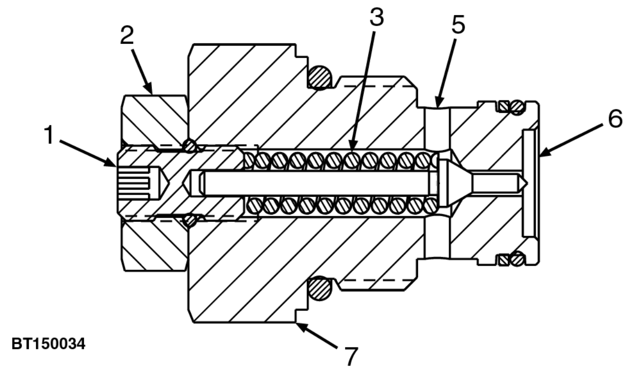
Figure 9050-43-26. Adjusting Nut Location



1. AJUSTMENT SCREW
2. JAM NUT
3. POPPET
4. SPRING
5. TO TANK
6. SECONDARY LOAD-SENSE
7. VALVE BODY

Figure 9050-43-27. Main Relief Valve

- **Electro-Hydraulic Control Valve (E-Valve):**
  If pressure is not within specifications, loosen the jam nut on relief valve. While holding lift hydraulics over relief, slowly turn the adjusting screw, in (clockwise) to increase pressure, out (counterclockwise) to reduce pressure.



1. ADJUSTMENT SCREW
2. JAM NUT
3. SPRING
4. POPPET
5. TO TANK
6. LOAD-SENSE PRESSURE
7. VALVE BODY

Figure 9050-43-28. Main Relief Valve (Electro-Hydraulic Control Valve)

NOTE: Cycling the lift function over relief after adjustment gives the relief valve spring opportunity to reposition itself inside the valve. This must be done after each adjustment until pressure is repeatable on gauge.

6. Cycle the lift control lever on and off against the relief three times to see if pressure is repeatable.

NOTE: Tightening the jam nut can sometimes take the adjustment screw with it and increase pressure setting. You may have to account for this change in your adjustment in Step 5.

7. Tighten the jam nut. Cycle lever over relief a few more times to verify the setting is still correct. If setting does not stabilize, clean or replace relief valve.

8. Remove test equipment and reinstall test port plugs.

PPRV Pilot Pressure Test

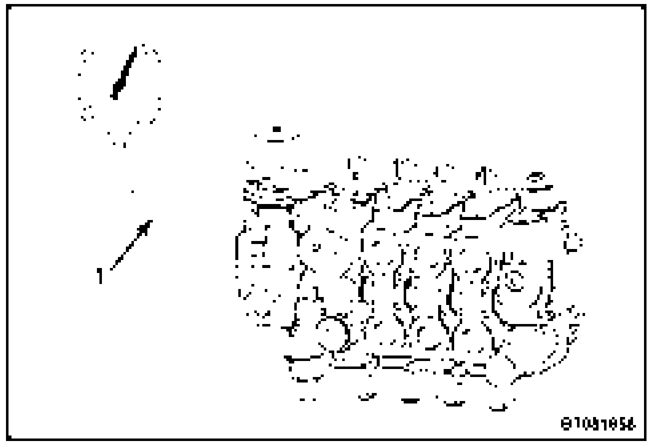
This test is to determine if Proportional Pressure Reducing Valve (PPRV) is hydraulically supplying pressure to move the valve spool in E-Valve. This test should be done after confirming that the PPRV solenoid is getting correct current and that Secondary Relief Pressure Test and Adjustment has been checked.

Table 9050-43-8. Test Specifications

Engine Speed	Governed Speed
Oil Temperature	50 to 65°C (122 to 150 °F)
Minimum Pilot Pressure 1.5 amps at 12 volts	2000 kPa (290 psi)

Table 9050-43-9. Service Tools

Pilot Pressure Test Plug	Order From Service Tools
Pilot Pressure Test Gauge	0 to 7.0 MPa (0 to 1000 psi) Pressure Gauge
GP1 Pressure Test Gauge	0 to 35.0 MPa (0 to 5000 psi) Pressure Gauge
GP1 Test Plug Port Size	SAE #4 O-ring Port (7/16-20 UNF)



1. GP1 TEST PORT WITH GAUGE

Figure 9050-43-29. Pilot Pressure Test Setup

NOTE: The solenoid valve will make a clicking sound when current is applied. This clicking can also be felt but solenoids may be too hot to touch if truck has been operating.

1. Check actuating current at solenoid by using display. If no reading, display will display a Diagnostic Trouble Code (DTC).

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing test plugs from valve.

2. Lower forks to ground and stop engine. Apply park brake.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

NOTE: The EF Pressure gauge is shown as an additional gauge to use if pilot pressure is low.

3. Remove covers. Install pilot pressure test plug in circuit to be tested and install pilot pressure test gauge. See Pilot Pressure Test Setup.
4. Operate the engine at governed speed.
5. Operate the hydraulic system until the oil temperature is at test specifications. See Hydraulic Warm-up Procedure.
6. Operate test function and hold over relief. Check the reading of the gauge when the relief valve is open. Measure the current flow to solenoid, using display. Compare to specifications.

NOTE: The PPRV is not repairable except for cleaning and replacing the solenoid.

7. If pressure is not within specifications, check pressure reading on EF Test Port gauge and compare to Secondary Relief Valve Test and Adjustment. The secondary relief pressure must be tested before removing PPRV.

   If Secondary Relief pressure is OK, remove PPRV and inspect for the following:

   - Plugged inlet screen in PPRV.
   - Failed sealing ring on PPRV.
   - Sticking valve.

8. Stop engine, remove test equipment, and reinstall original port plugs.

Secondary Relief Valve Test and Adjustment

It may be necessary to adjust the setting of the Secondary Relief Valve (SRV) depending on what attachments are used for the auxiliary function. Excess Flow (EF) port secondary relief pressure is measured to do this test.

NOTE: The Relief Pressure (EF) setting is the working range that the secondary relief can be set to meet requirements of attachments.

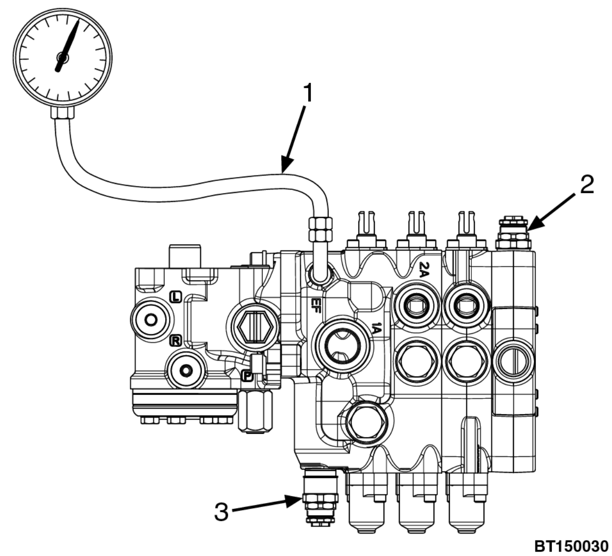
The Factory Default setting is the pressure that the secondary relief is set at the factory.

Table 9050-43-10. Test Specifications

Engine Speed	Governed Speed
Oil Temperature	50 to 65°C (122 to 150 °F)
GP1	13.8 to 17.9 MPa (2000 to 2596 psi)
Factory Default Setting	17.5 to 18.5 MPa (2538 to 2683 psi)

Table 9050-43-11. Service Tools

0 to 35.0 MPa (0 to 5000 psi) Pressure Gauge	
GP1Test Port Plug Size	SAE #4 O-ring Port (7/16-20 UNF)



1. EXCESS FLOW (EF) TEST PORT WITH GAUGE
2. SECONDARY RELIEF VALVE LOCATION
3. MAIN RELIEF VALVE LOCATION

Figure 9050-43-30. Manual Control Valve Shown

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing test plugs from valve.

1. Lower forks to ground and stop engine. Apply park brake.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

2. Remove covers. Install pressure gauge in control valve Excess Flow (EF) test port. See Manual Control Valve Shown.

CAUTION

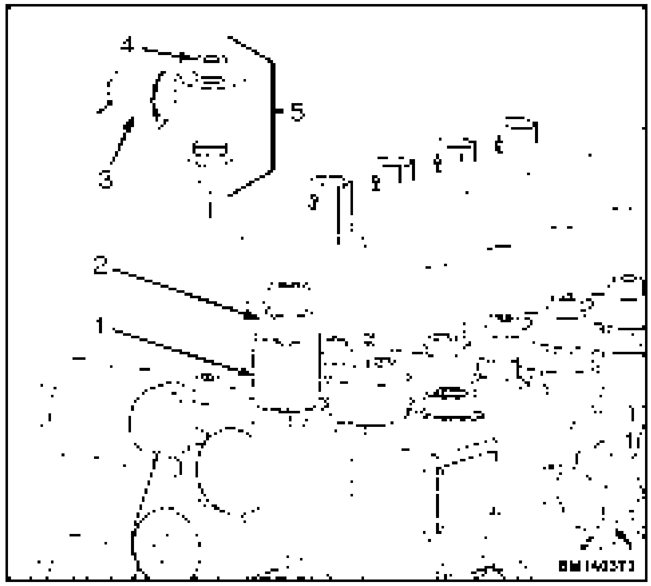
Setting relief valve above specification can cause damage to hydraulic and mechanical components of lift truck. Do not increase pressure above specifications.

3. Operate the hydraulic system until the oil temperature is at test specifications. See Hydraulic Warm-up Procedure.

4. Tilt the mast back until it stops. Hold the lever and check the reading of the gauge when the relief valve opens. Compare to test specifications.

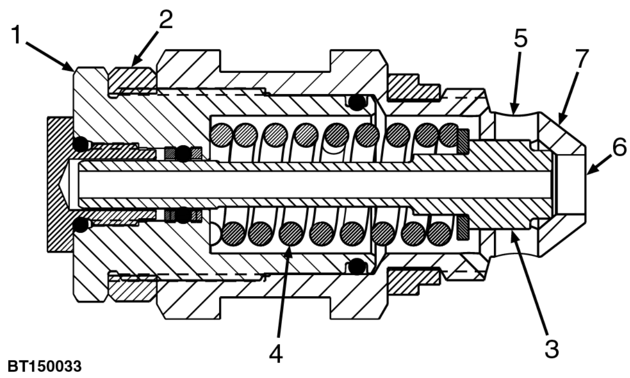
NOTE: Cycling the tilt function over relief after adjustment gives the relief valve spring opportunity to reposition itself inside the valve. This must be done after each adjustment until pressure is repeatable on gauge.

5. If pressure is not within specifications, loosen the jam nut on relief valve. While holding tilt hydraulics over relief, slowly turn the adjusting screw, in (clockwise) to increase pressure, out (counterclockwise) to reduce pressure. Cycle the tilt control lever on and off against the relief three times to see if pressure is repeatable.



1. LOAD SENSE (LS) PORT
2. FITTING
3. CAP (PRESSURE GAUGE)
4. PORT (STEER HOSE)
5. SERVICE TEE ASSEMBLY

Figure 9050-43-31. Steering Relief Check Service Tee



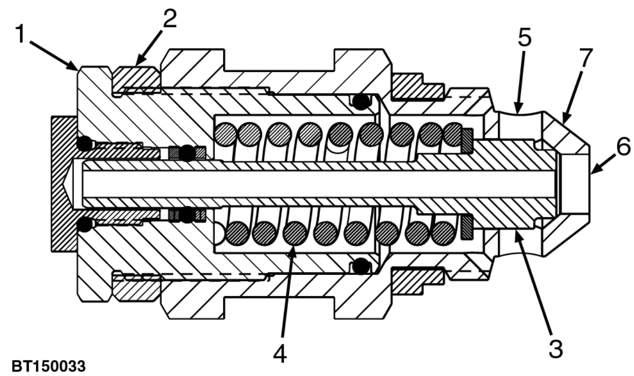
1. ADJUSTMENT SCREW
2. JAM NUT
3. POPPET
4. SPRING
5. TO TANK
6. SECONDARY LOAD-SENSE
7. VALVE BODY

Figure 9050-43-32. Secondary Relief Valve

NOTE: Tightening the jam nut can sometimes take the adjustment screw with it and increase pressure setting. You may have to account for this change in your adjustment in Step 5.

6. Tighten the jam nut. Cycle lever over relief a few more times to verify the setting is still correct. If setting does not stabilize, clean or replace relief valve.

7. Remove test equipment and reinstall test EF port plug.



1. ADJUSTMENT SCREW
2. JAM NUT
3. POPPET
4. SPRING
5. TO TANK
6. SECONDARY LOAD-SENSE
7. VALVE BODY

Figure 9050-43-33. Main Relief Valve (Manual Control Valve)

Steering Control Unit LS Pressure Test

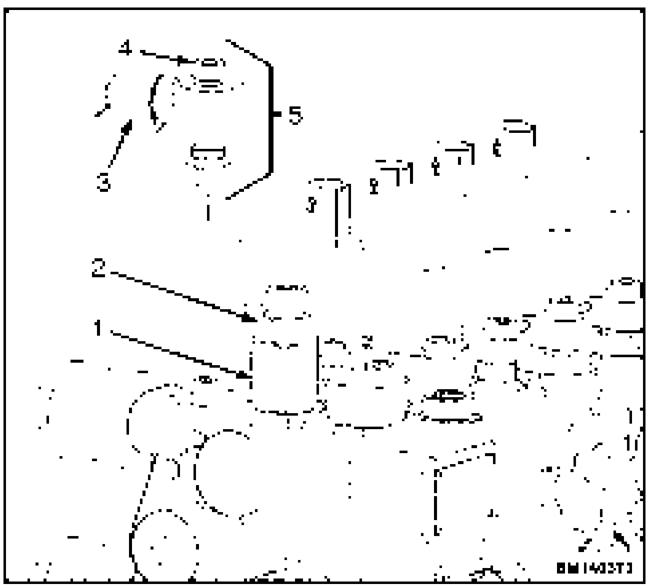
This test checks if LS (Load-Sense) pressure is correct to operate the flow divider spool functions of the Steering Control Unit (SCU). This LS pressure differential is required to control flow divider spool movement, which controls priority oil to steering and Excess Flow (EF) to the hydraulic control valve.

Table 9050-43-12. Test Specifications

Engine Speed	Low Idle
Oil Temperature	50 to 65°C (122 to 150 °F)
Minimum LS Pressure	Steering Relief Pressure minus 400 kPa (58 psi)

Table 9050-43-13. Service Tools

Pressure differential gauge or switching block	
0 to 35.0 MPa (0 to 5000 psi) Pressure Gauge	
Steering Control Unit (SCU) "P" & "LS" Test Port Size	SAE #4 O-ring Port (7/16-20 UNF)
Service Tee	LS (PN 4165707)



1. LOAD SENSE (LS PORT)
2. FITTING
3. CAP (PRESSURE GAUGE)
4. PORT (STEER HOSE)
5. SERVICE TEE ASSEMBLY

Figure 9050-43-34. SCU LS Pressure Test

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing test plugs from valve.

1. Lower forks to ground and stop engine. Apply park brake.

2. Remove panel that covers Steering Control Unit (SCU).

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

3. Install one test hose in LS port and the other test hose in (P) main pressure port of the SCU.

NOTE: Test gauges must be calibrated. Gauge accuracy is very important for this test. A pressure differential gauge or switching block should be used so both readings are on same gauge. If you do not have this equipment, you will need to switch gauges to verify gauge readings.

4. Operate engine at low idle speed.

5. Check hydraulic temperature. If not within specifications, see Hydraulic Warm-up Procedure.

6. Hold steering over relief and measure relief pressure, then LS pressure and compare to specifications.

7. If LS pressure is not within specifications, remove SCU. Inspect and clean LS orifices.

8. Remove test equipment and reinstall test plugs.

Steering Cylinder Leakage Test

Cylinder leakage causes heat and poor performance in a steering system. This test is done to determine if the leakage is in the steering cylinder or the steering control unit. For steering circuit schematic, see Steering System.

Table 9050-43-14. Test Specifications

Engine Speed	Low Idle
Oil Temperature	21 to 43°C (70 to 110 °F)
Maximum Leakage	10 ml (0.35 oz) Per Minute

Table 9050-43-15. Service Tools

Container	
Left and Right Work Port Size	SAE #8 O-ring Port (3/4-16 UNF)

1. Lower forks to ground and turn steering wheel until steer axle is against right axle stop. Stop engine and apply park brake.

2. Remove covers of Steering Control Unit (SCU) to expose steering cylinder hose connections.

3. Check hydraulic temperature. If not within specifications, see Hydraulic Warm-up Procedure.

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing hoses from cylinders.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

4. Slowly loosen left steering hose fitting that goes into SCU top left port marked (L). Remove left steering hose and keep it elevated so oil is not lost. Install O-ring Face Seal (ORFS) high pressure cap on left port fitting of SCU to seal valve against high pressure leakage when steering wheel is turned.

NOTE: Turning the steering wheel by hand with engine off will generate hydraulic pressure in cylinder. If leakage is noted at this lower pressure, cylinder has excessive leakage.

5. Attempt to turn the steering wheel by hand. If oil flows out of hose at noticeable rate (approximately 50% of test specification), steering cylinder needs repair. Stop test and repair steering. If no oil flow, go to Step 6.

WARNING

A open steering port can expel hydraulic oil under pressure and it can be injected into skin. Seal SCU port with high pressure ORFS cap before starting engine.

6. Start engine and hold steering against right axle stop and hold. Measure oil after it starts to flow from end of removed steering hose for 1 minute.

7. Stop engine and compare measured oil to test specifications.

- If leakage is below specifications, the steering cylinder is OK.
- If leakage is more than specifications, remove and repair steering cylinder.

8. Remove caps and reinstall hose and valve covers.

Steering Relief Pressure Test and Adjustment

Table 9050-43-16. Test Specifications

Engine Speed	Idle Speed
Oil Temperature	50 to 65°C (122 to 150 °F)
Steering Relief Pressure	

Table 9050-43-17. Service Tools

0 to 35.0 MPa (0 to 5000 psi) Pressure Gauge
6 mm Hex wrench

1. Lower forks to ground and stop engine. Apply park brake.

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing test plugs from valve.

2. Remove front console covers, side covers, and floor panel.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

3. Connect pressure gauge to inlet pressure test port of Steering Control Unit (SCU).

4. Operate engine at test specifications.

5. Operate hydraulic system until the oil temperature is at test specifications. See Hydraulic Warm-up Procedure.

6. Turn steering wheel to stop. Apply turning effort against stop, causing steering system pressure to go over relief.

7. Check pressure gauge reading. Compare reading to specifications.

NOTE: Steering relief adjuster is very sensitive. Make changes in 1/8 turn increments to avoid over pressurizing system.

8. If pressure is less than specifications, remove plug, install hex wrench (1), and turn relief valve adjuster clockwise. If pressure is higher than specification, turn adjuster counterclockwise.

9. Repeat Step 7 and Step 8. If pressure is to specifications, remove test equipment. Install test port and adjustor plug.

Primary Relief Valve Test and Adjustment

CAUTION

Typically, the Main Relief Valve (MRV) should NOT be adjusted in the field for general purposes. Increasing the setting of the MRV past its specified setting may damage truck.

WARNING

Hot hydraulic oil can cause serious burns to skin. Do not touch hydraulic components or oil during test. Make sure hydraulic oil has cooled to safe temperature before installing or removing test equipment.

WARNING

Hydraulic oil under pressure can be injected into skin. Lower forks to ground and relieve all circuit pressure before removing test plugs from valve.

1. Lower forks to ground and turn **OFF** key. Apply park brake.

CAUTION

Do not permit dirt or other contaminants to enter the hydraulic system. Disconnected hoses, tubes, open valves, cylinder fittings, and ports should be protected with clean caps or plugs.

2. Remove panels that cover MRV. Remove cover from diagnostic port and install pressure gauge.
3. Operate the hydraulic system until the oil temperature is at test specifications. See Hydraulic Warm-up Procedure.

WARNING

Forks contacting overhead electrical wires or fixtures can cause serious injury or death. Make sure area is clear of hazards before raising forks to maximum height.

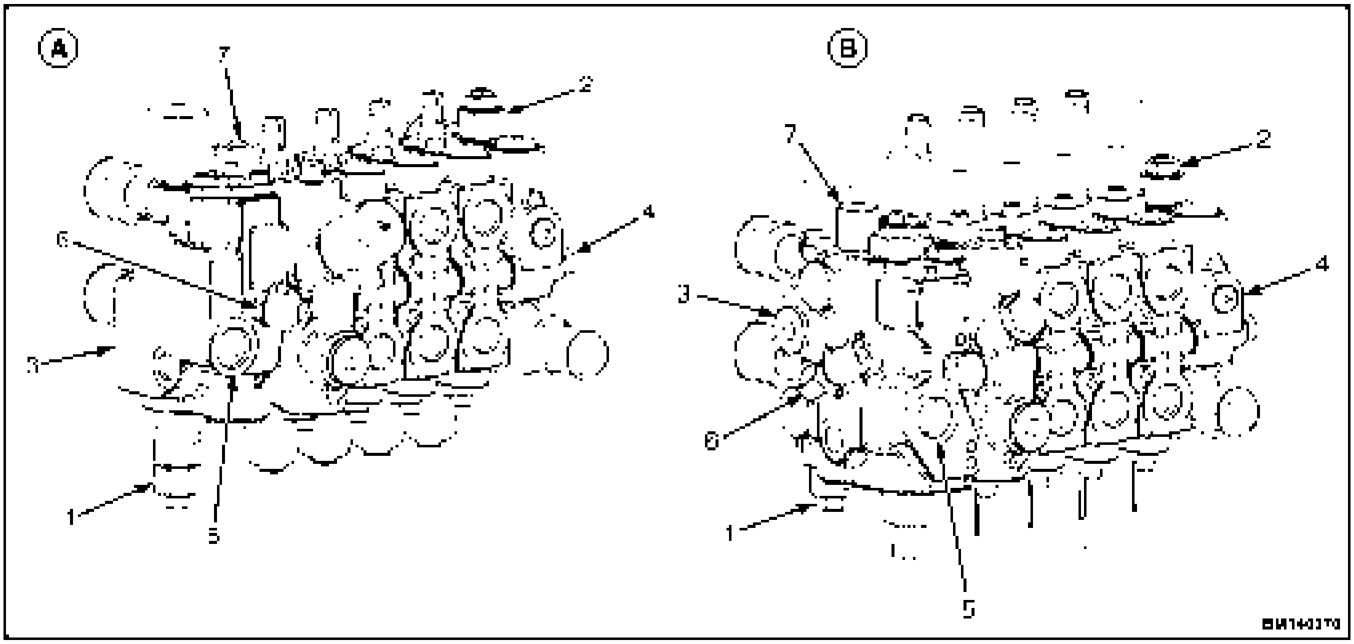
4. Raise the mast until it stops. Hold the lever and check the reading of the gauge when the relief valve opens. Compare to specifications.
5. Replace primary relief valve, if not within specification, by unscrewing the relief cartridge from the inlet section and installing a new relief cartridge.
6. Cycle lever over relief to verify the setting is within specification.
7. Remove test equipment and reinstall cap onto diagnostic port.

Table 9050-43-18. Service Tools

275 - 345 MPa (4000 - 5000 psi) Pressure Gauge	
GP1 Test Plug Port Size	SAE #4 O-ring Port (7/16-20 UNF)

Table 9050-43-19. Test Specifications

Capacity	Main Relief Pressure	Pump Flow
2.0 Tons	17.9 MPa (2596 psi)	63.6 liter/min (16.8 gal/min)
2.2-2.75 Tons	21.9 MPa (3176 psi)	81.4 liter/min (21.5 gal/min)
3.0 Tons	23.9 MPa (3466 psi)	81.4 liter/min (21.5 gal/min)



A. MANUAL MAIN CONTROL VALVE **B.** E-HYDRAULIC MAIN CONTROL VALVE

1. MAIN RELIEF VALVE
2. SECONDARY RELIEF VALVE
3. INLET CONTROL VALVE SECTION
4. OUTLET CONTROL VALVE
5. VALVE INLET PORT
6. GAUGE PORT (GP1 OR TEST PORT) WITH DIAGNOSTIC FITTING
7. LOAD SENSE (LS) PORT

Figure 9050-43-35. Main and Secondary Relief Valves Location

SECTION 9060

OPERATORS STATION

TABLE OF CONTENTS

Group 10

Principles of Operation

Operator Station General Description and Principles of Operation

GENERAL DESCRIPTION AND LOCATION

The components include multiple options which are customer determined. These options are explained in greater detail in the appropriate sections of this manual. The indicated devices are used for various control inputs and operation of the lift truck systems.

1. **Display** provides:
    - Power **ON/OFF** selection
    - Start control
    - Lighting control; Work Lights, Turn Lights, and Marker/Tail Lights
    - Forward/Neutral/Reverse Selection (if equipped)
    - Display and Input for menu-driven data entry, navigation, and readout
2. **Manual Hydraulic Levers** (if equipped) provides control of lift/lower, tilt, and other auxiliary functions.
3. **Vehicle System Manager (VSM):**
    - Controls or monitors most electrical operations of the lift truck
    - Monitoring includes engine, transmission, hydraulic, drive, and lighting systems
    - Provides safe shutdown for critical faults and limp-home mode capability
    - Manages operator inputs and stores operational/fault data history
4. **Hyster MONOTROL ® Foot Pedal Control** (if equipped)
    - Provides foot pedal input control for FWD or REV travel
    - Accelerator function for normal speed control
5. **Standard Accelerator** provides normal accelerator function on trucks equipped with FWD/NEUTRAL/REV directional control on display.
6. **Mini Lever Module (MLM)** (if equipped) provides fingertip control of lift/lower, tilt, and other auxiliary functions.
7. **Joystick Module** (if equipped) provides single multi-axis lever control of lift/lower, tilt, and other auxiliary functions.
8. **Inch Brake/Service Brake** provides normal braking operation and inch/braking for fine position control during load operations.
9. **Parking Brake** provides positive brake retention of wheels and is interlocked with seat occupancy, transmission, E-Hydraulic, and engine start operation.

Dash Display

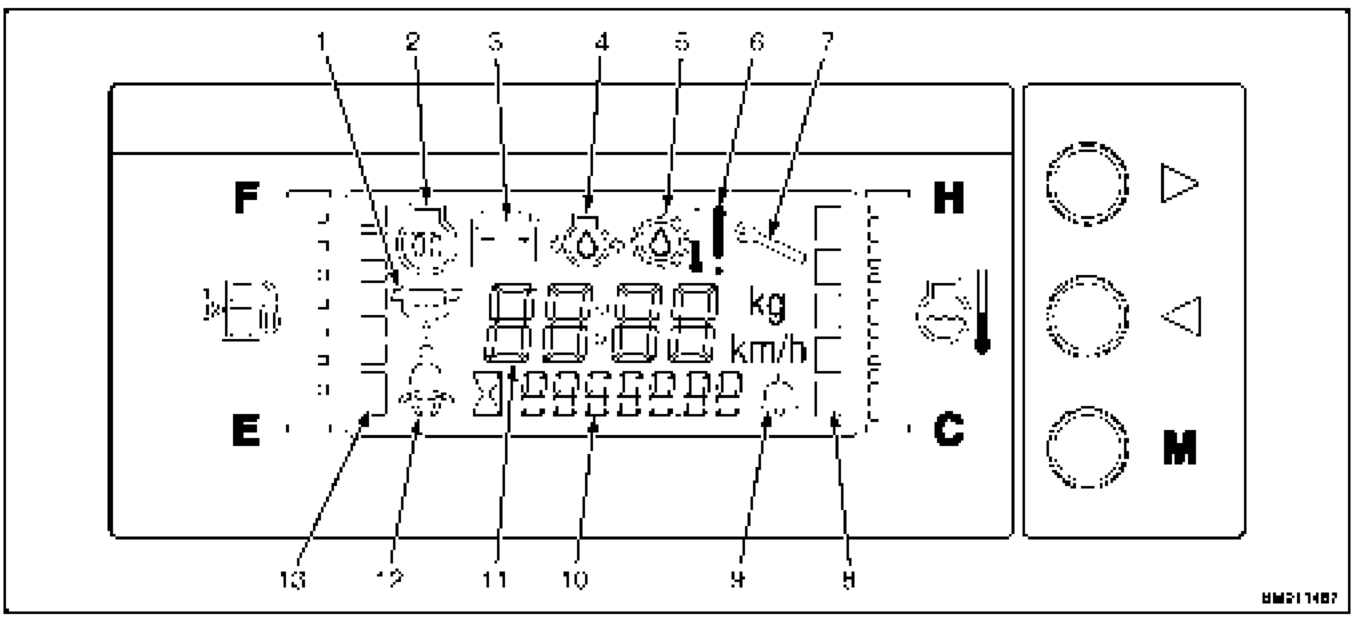
DETAILED DESCRIPTION

This section contains information on accessing the additional service technician functions of the dash display. With a proper service technician password, the service technician can access menu items not visible to persons with operator or supervisor password level access. Access to display panel functions is through the Mode Change button (M) and Didplay Change buttons (> or <) on the right side of the instrument panel. Passwords can be stored for a maximum of 10 users. When lift truck is operated by use of password, it is possible to store and display the total hour reading, travel distance and travel hours on a user-by-user basis.

The display works in conjunction with the ECU to operate the truck. The display communicates with the ECU via the CANbus.

The LCD in the center of the display is used to view information regarding normal truck operations, interlocks, diagnostics, and configuration menus.

The major components of the display are shown in Figure 9060-10-1.

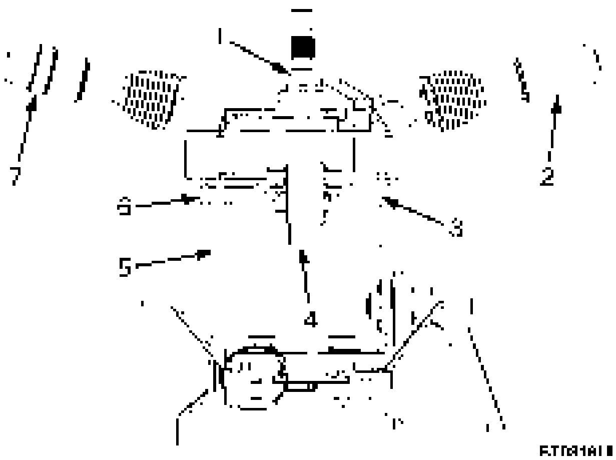


1. SEDIMENTER
2. GLOW LAMP
3. BATTERY CHARGE
4. ENGINE OIL PRESSURE
5. ATF TEMPERATURE (AUTO ONLY)
6. WARNING DISPLAY
7. MAINTENANCE REQUIRED
8. COOLANT TEMPERATURE
9. ALARM DISPLAY
10. HOUR, MESSAGE, CALENDAR, ERROR DISPLAY
11. DIGITAL CLOCK, SPEED, LOAD, MESSAGE, PASSWORD, MENU DISPLAY
12. SEAT BELT
13. FUEL LEVEL

Figure 9060-10-1. Display Switch Cluster Components

INPUTS

The directional lever and turn signal lever inputs are located on the sides of the steering column shaft assembly. Refer to the appropriate **Electrical System** manual for lever removal and replacement.



1. STEERING COLUMN SHAFT
2. LIGHTS/TURN SIGNAL LEVER
3. LIGHTS/TURN SIGNAL LEVER CONNECTION
4. HORN CONNECTION
5. STEERING COLUMN
6. DIRECTION CONTROL LEVER CONNECTION
7. DIRECTION CONTROL LEVER

Figure 9060-10-2. Steering Column Controls

For additional details on the operation of these elements, see the **Operating Manual**.

STANDARD DISPLAY

After successful entry of your password, you will be directed to the Main Menu. Using the Display Change buttons (▸ and ◂) , scroll through the menu choices until you see the selection you want to access. Press the display change (▸) button to access the selection.

The ◂ and ▸ button are used to make selections within the menu. The mode change button (**M**) allows you to move from menu to menu.

Each menu (except the Main Menu) will have a *Back One Level* option within the menu options at that level. Use the ◂ and ▸ buttons to access this option. Press the **M** button to select this option and return to the previous menu.

Any time an optional value is changed within a menu, pressing the **M** button will take you to the Exit Options menu where you will have the opportunity to return to the previous menu, exit the menu system without saving any changes, or save your changes and exit the menu system.

Some menus may contain several optional values that can be adjusted. It is not necessary to exit the menu after each adjustment and re-enter the menu to make multiple changes within a menu. After making a change to an optional value, use the **M** button to re-enter the menu, scroll to the next option to be adjusted, and make the change. After all adjustments have been made, press the **M** button to access the Exit Menu and save your changes.

Table 9060-10-1. Exit Options Menu

Main Menu Save and Exit	Press **M** Button	Save All Changes and Exit Menu - Yes	Press **M** Button to Save Changes and Return to Menu
↑ SCROLL ↓		↑ SCROLL ↓	
Main Menu Exit Without Saving		Cancel Save Return to Menu	Press **M** Button to Exit and Return to Menu

MAIN MENU

NOTE: Depending how your lift truck is equipped, some of the functions described in this section may not be included in the on-board menu structure for a particular lift truck.

After entering the Main Menu from the password entry screen, the following menu functions are visible:

- Password Settings
- Digital Clock / Alarm
- Speedometer / Hour Meter / Odometer / Calendar
- Controller Settings
- Memory Clear
- Load Meter

PASSWORDS

Service level password access is required to add, delete, or edit Service Level Passwords and the first installation of a Supervisor level password. Anyone with Service Level access can add, delete, or edit Operator or Supervisor passwords using the Instrument Panel Display.

The default Service Level password installed at the factory. Use this password when installing the lift truck at the customer location to set up customer passwords in the display. When initial installation is complete, choose a new personal password and enter it into the instrument panel display. When you have entered your personal service technician password in the dash display, the default password can no longer be used to access the service technician function of the instrument panel display. If a Service Technician password is lost, the password can be reset using the instrument panel display.

NOTE:

- The Service Technician must install the first Supervisor password into the instrument panel display. Once an initial Supervisor password is installed, then that password access can add additional Supervisor passwords to the instrument panel display.
- The Vehicle System Manager can hold up to 10 passwords. This can be in any combination of user, supervisor, or service passwords.

LCD DISPLAY

The LCD located in the top center of the display provides message information in text and numerical formats to indicate inputs, operating conditions, status, and faults. It is the primary means of communication between the operator and the V-ECU and can provide messages. Presented messages are dependent upon the user access level selected.

When a fault has been detected by the ECU, the Diagnostic Trouble Code (DTC) will be displayed on the LCD.

In the event that more than one DTC is broadcast, they will be displayed in sequence, last generated will be displayed. The scroll push buttons can be used to view the other DTCs.

HOURMETER

This function allows the service technician access to the various hourmeter readings available on the lift truck. When this menu is accessed, you can view the accumulated engine hours, calendar, odometer travel distance and accumulated travel hours.

During lift truck operation, whenever the display change button (◂) is pressed, the display alternates between the above mentioned display screens.

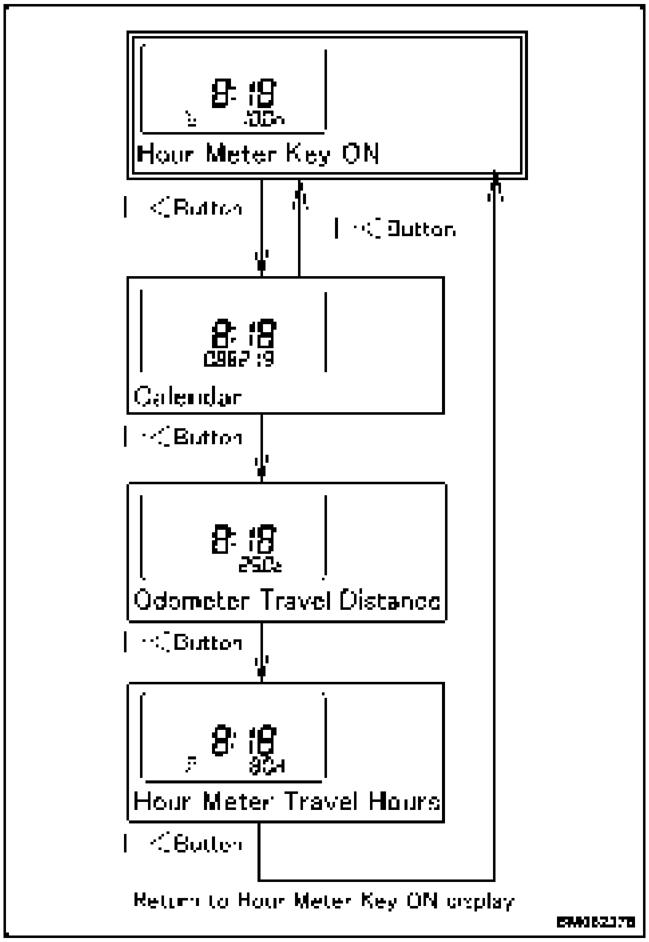


Figure 9060-10-3. Hourmeter, Odometer, and Calendar Display

INSTRUMENT PANEL DISPLAY FUNCTIONS

Upon entering the instrument panel display, the following menu functions are visible to the supervisor:

- Digital Clock / Alarm
- Engine Controller (if equipped)
- Transmission (Xmsn) Controller (if equipped)
- Load Meter

Use the display change buttons (◂ or ▸) and mode change button (**M**) to move to the desired function and access.

DIGITAL CLOCK

Whenever the key switch is in the **ON** position, the digital clock appears under normal display mode. The clock continues to operate after key switch is turned **OFF**, but the display will not be visible. If the battery is disconnected the digital clock will display 2005.01.01 and will need to be reset. Set clock using the following procedure.

1. Turn key switch to **ON** position and access normal display mode on the instrument panel display.
2. Press display change buttons ▸ and ◂ at the same time for 2 or more seconds to enable change display features. When the change display screen appears, it will be accompanied by a confirmation tone.
3. Push display change button ▸ to navigate from one display feature to the next. Navigation between features will be in sequence; Year → Month → Day → Hour → Minute → Year.
4. Push display change button ◂ to input correct value within display feature. If display feature is already correct, a long press of the display change button ◂ will act as a fast forward feature.
5. After all display features have been set to correct date and time, press change mode (**M**) button. A confirmation tone will sound and the instrument panel display will return to normal.

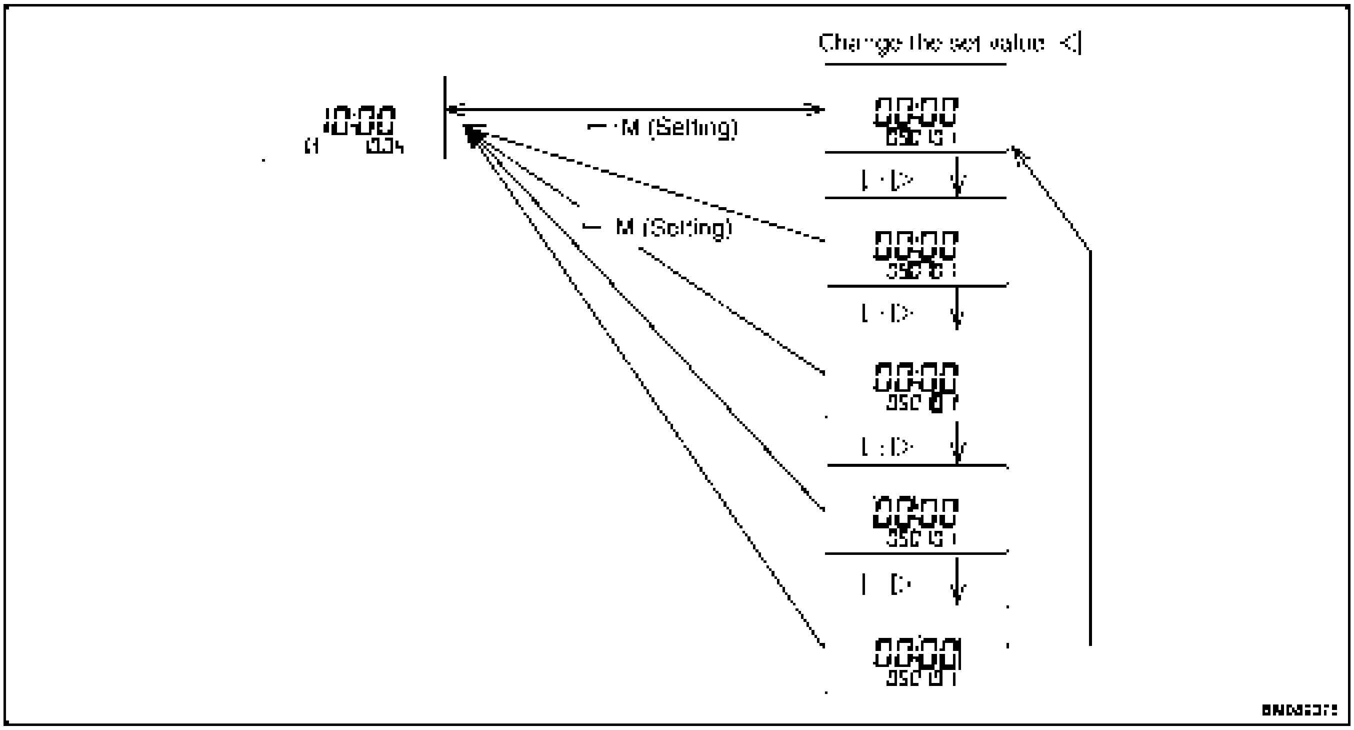


Figure 9060-10-4. Digital Clock Set

Alarm Function

The digital clock is equipped with an optional alarm clock. When the time reaches a preset time, an alarm tone sounds for ten seconds and the alarm display blinks. If the battery is disconnected the alarm will need to be reset. Set alarm using the following procedure.

1. Turn key switch to **ON** position and access normal display mode on the instrument panel display.
2. Press display change buttons ▸ and mode change button (**M**) at the same time for 2 or more seconds to enable change display features. When the change display screen appears, it will be accompanied by a confirmation tone.
3. Push display change button ▸ to navigate from one display feature to the next. Navigation between features will be in sequence; Hour → Minute → Presence of Alarm → Presence of Hour Tone → Hour.
4. Push display change button ◂ to input correct value within display feature. When setting the display feature for presence of alarm and hour tone, the options are **ON** and **OFF** that appear alternately on the hour meter display. A long push of the display change button ◂ will establish an automatic addition function.
5. After all display features have been set to correct date and time, press change mode (**M**) button. A confirmation tone will sound and the instrument panel display will return to normal.

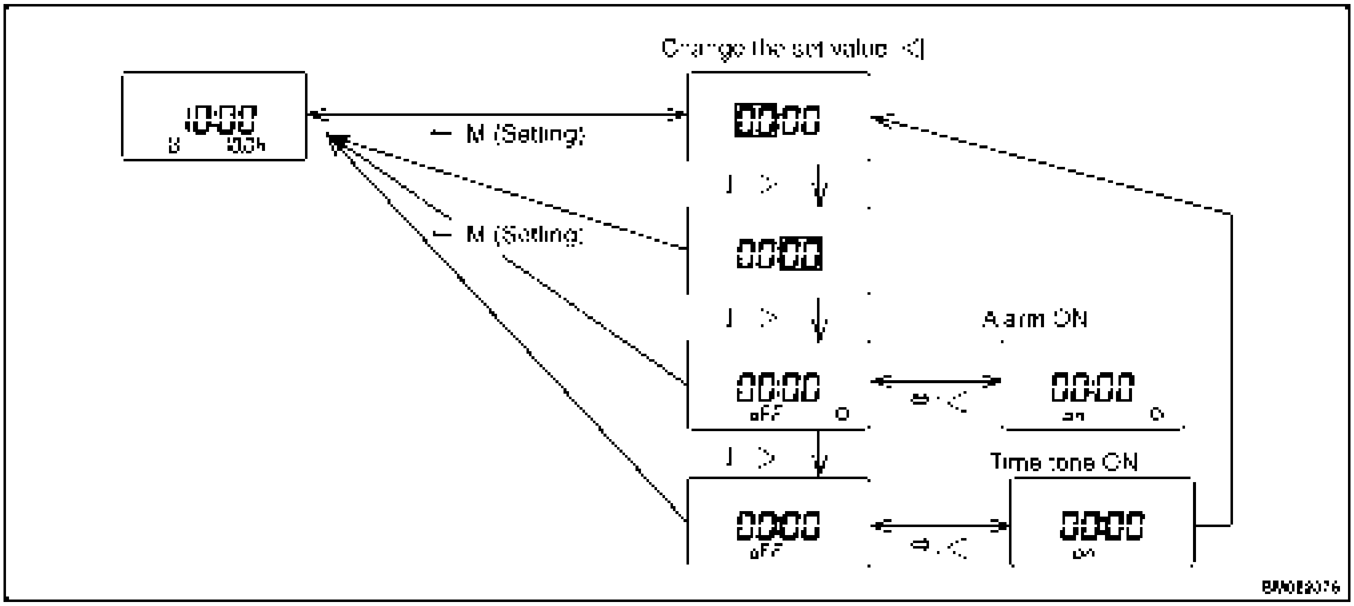
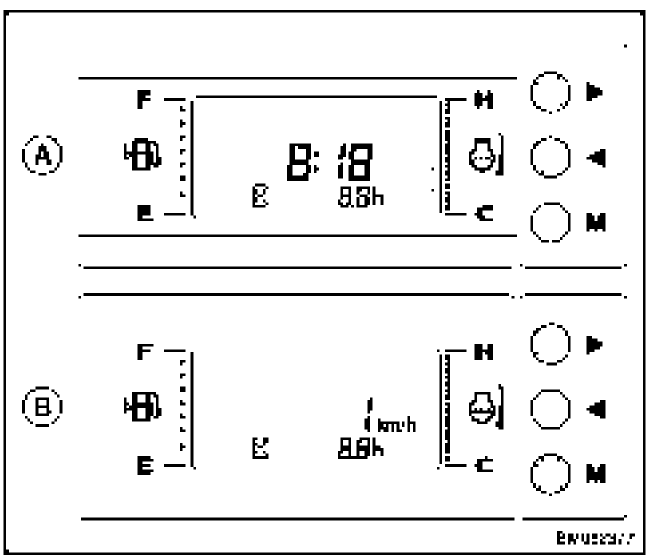


Figure 9060-10-5. Alarm Set

SPEEDOMETER

The speedometer display alternates between real time clock display and speedometer display when lift starts moving. After lift truck stops moving, the display defaults to real time clock display.



A. REAL TIME CLOCK DISPLAY
B. SPEEDOMETER DISPLAY

Figure 9060-10-6. Speedometer Display

LIFT TRUCK CONTROLLER

This lift truck is equipped with a single controller that receives input from multiple operating systems. Those inputs are then evaluated by the controller and appropriate data will be displayed on the instrument panel display.

There are multiple controller set codes for the different operating systems on the lift truck. Refer to **Calibration Procedures** 8000SRM2003 for list of set codes for lift truck systems.

The controller comes set from the factory. If it becomes necessary to reset or replace the controller, access Serviceman Mode.

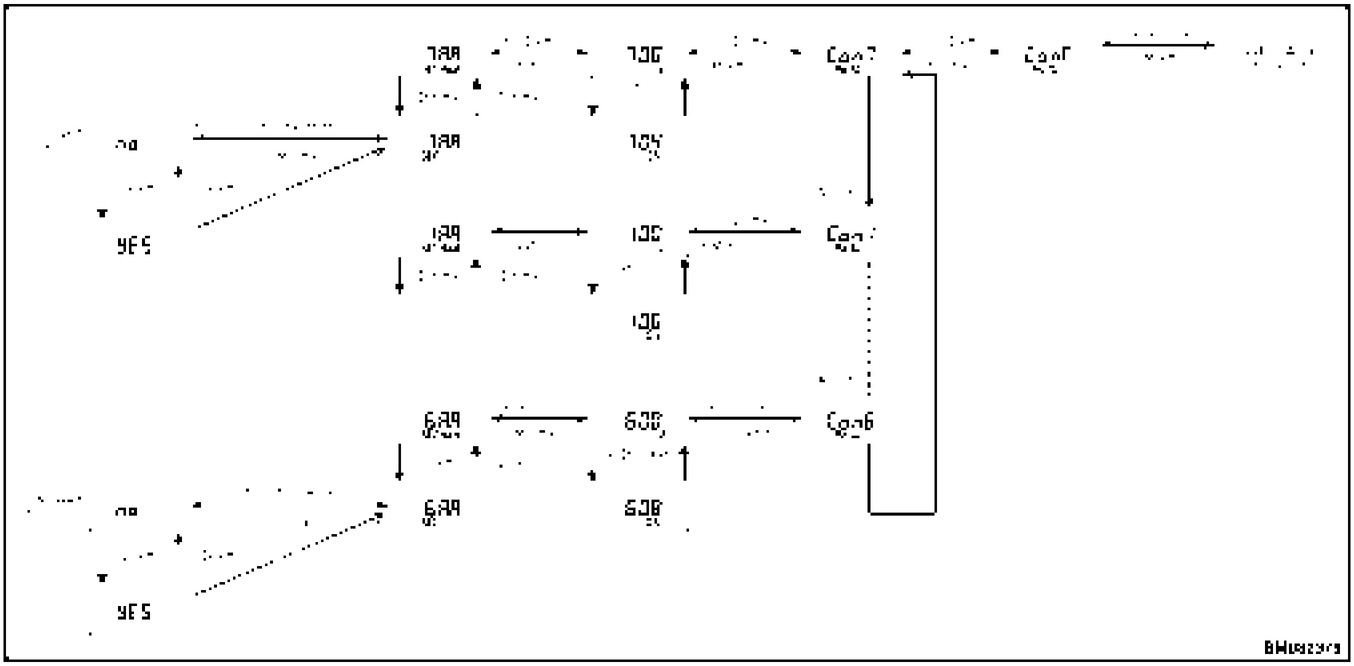


Figure 9060-10-7. Controller Setting and Adjustment

TRANSMISSION (XMSN) CONTROLLER

This lift truck model is not equipped with a separate transmission controller. All transmission inputs are processed through the lift truck controller. If the transmission code for your lift truck needs to be updated.

LOAD METER

Your lift truck may be equipped with an optional load meter. The load meter calculates mast pressure and coverts that pressure into a load value (weight) that will be displayed by pressing the mode change button (**M**) with lift truck stopped.

If the carriage and/or forks are replaced the load meter needs to be reset. To set the load meter function use the following procedure.

1. After turning key switch to **ON** position, press mode change button (**M**) for two or more seconds.
2. Press display change button (◂) one time to select "0 kg" set menu.
3. With a load on the forks, place mast assembly in vertical position. It is recommended that mast and forks are in a 90° (±1°) for set procedure.
4. Press display change button (▸) to begin "0 kg" set mode. With a second push of the display change button (▸) the pressure reading data will begin.
5. Rev engine and lift load 30 to 50 cm (11.8 to 19.7 in.) from floor.
6. After several seconds " 'Lo 0' kg "Set XXX" " will appear "0 kg" set is complete.
7. To exit "0 kg" set mode, press mode change button (**M**) or turn key switch to **OFF** position.

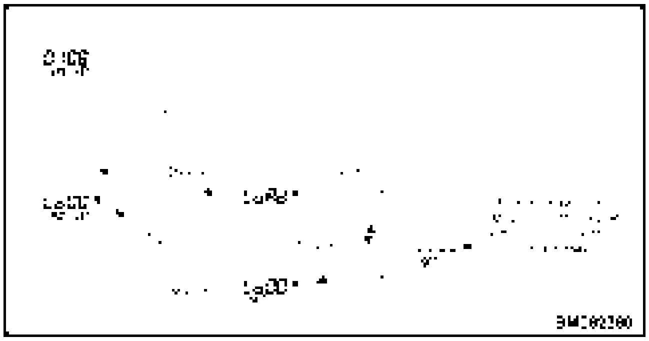


Figure 9060-10-8. Load Meter Set

TRUCK CONFIGURATION

This function allows the service technician to view the codes for lift truck configuration. Access Serviceman Mode and enter appropriate codes for necessary updates and changes.

DIAGNOSTICS

When an error is detected through the controller an error code is displayed on the instrument panel display. A warning symbol ("!") will be displayed followed by an error code (ErrC***) or (Errd***)

For a complete description of the error codes accessible through the instrument panel display.

VIEW FAULT LOG

This function will allow the error codes stored in the controller and displayed on the instrument panel display to be viewed. When the controller error codes are displayed, only the last 10 will be available for viewing. In the case of error codes displayed on the instrument panel display, only the last five cases will be available with date and hour meter readings.

Controller Error Code

Enter Serviceman Mode to access error codes for controller. When a controller error does occur (ErrC***) , the instrument panel display will show error code, order of occurrence (No 0-10), hour meter time when error occurred, and time and date when error occurred.

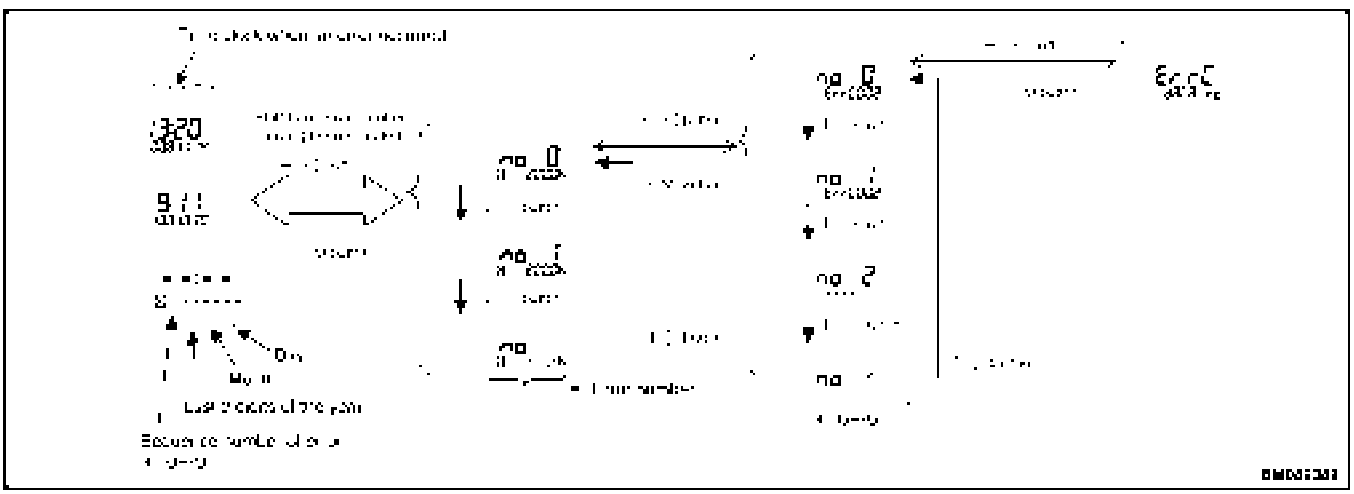


Figure 9060-10-9. Controller Error Code

Display Error Code

Enter Serviceman Mode to access error codes for display. When a display error does occur (Errd***), the instrument panel display will show error code, order of occurrence (No 0-5), hour meter when error occurred, and date and time when error occurred.

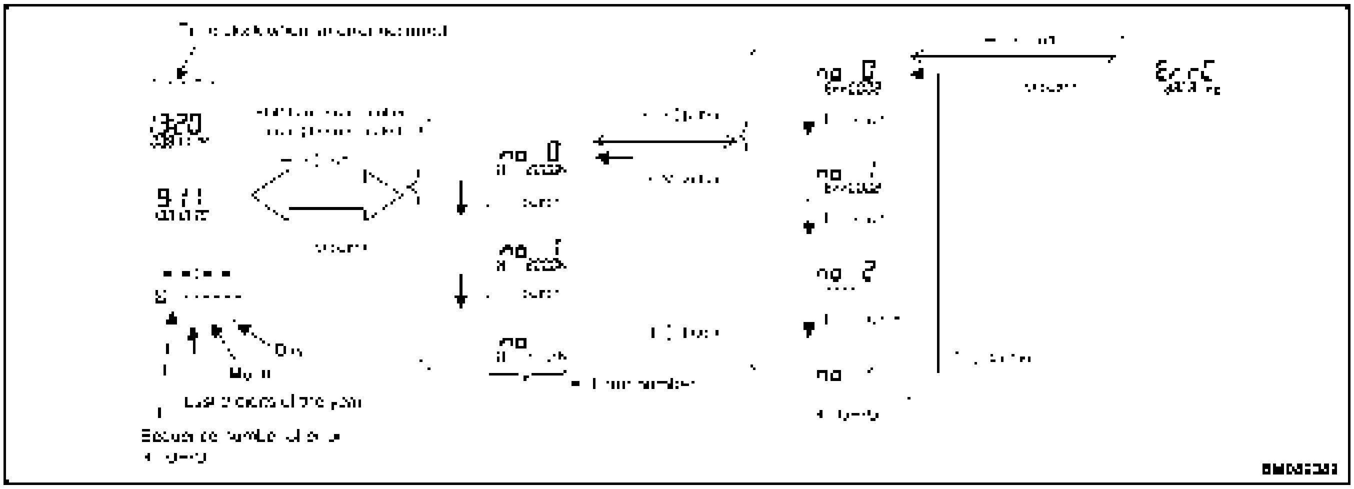


Figure 9060-10-10. Display Error Code

Clear Error Codes

After performing necessary repairs and documentation, clear error history from controller. Enter Serviceman Mode to access memory clear function. After accessing error reset function through instrument panel display, there are three reset screen options.

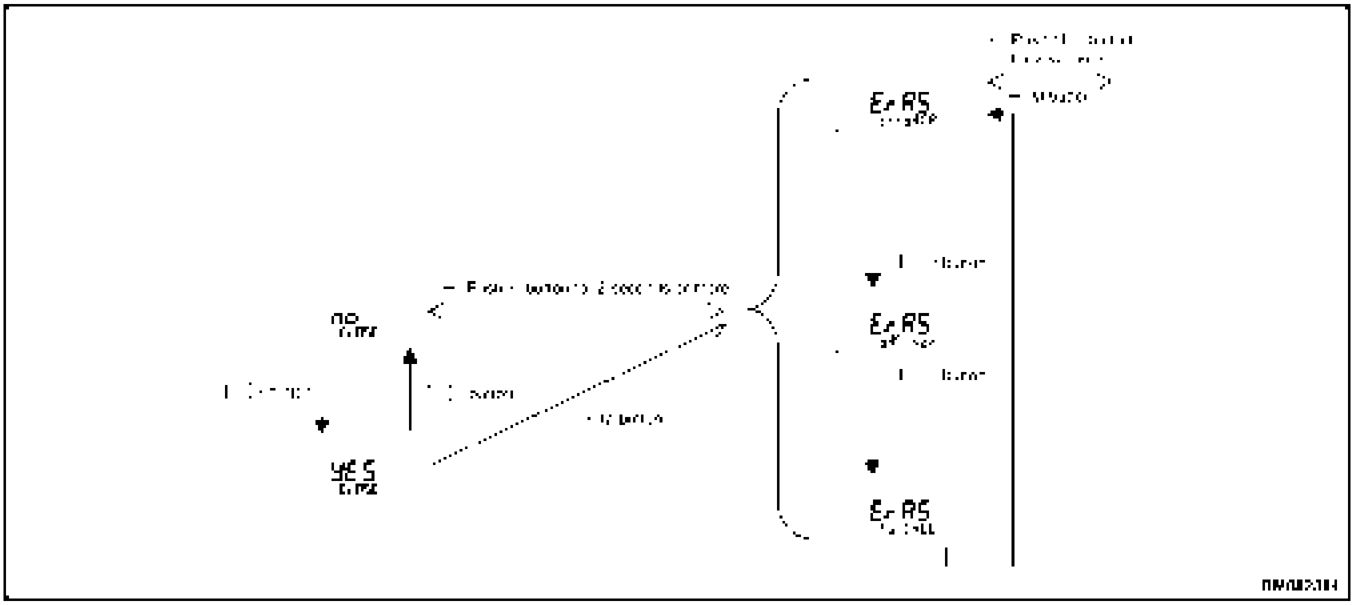


Figure 9060-10-11. Clear Error Codes

E-HYDRAULIC ERROR CODES

Enter Serviceman Mode to access error codes for display. When a an error does occur (ErrC*** or Errd***), the instrument panel display will show error code, order of occurrence (No 0-5), hour meter when error occurred, and time when error occurred.

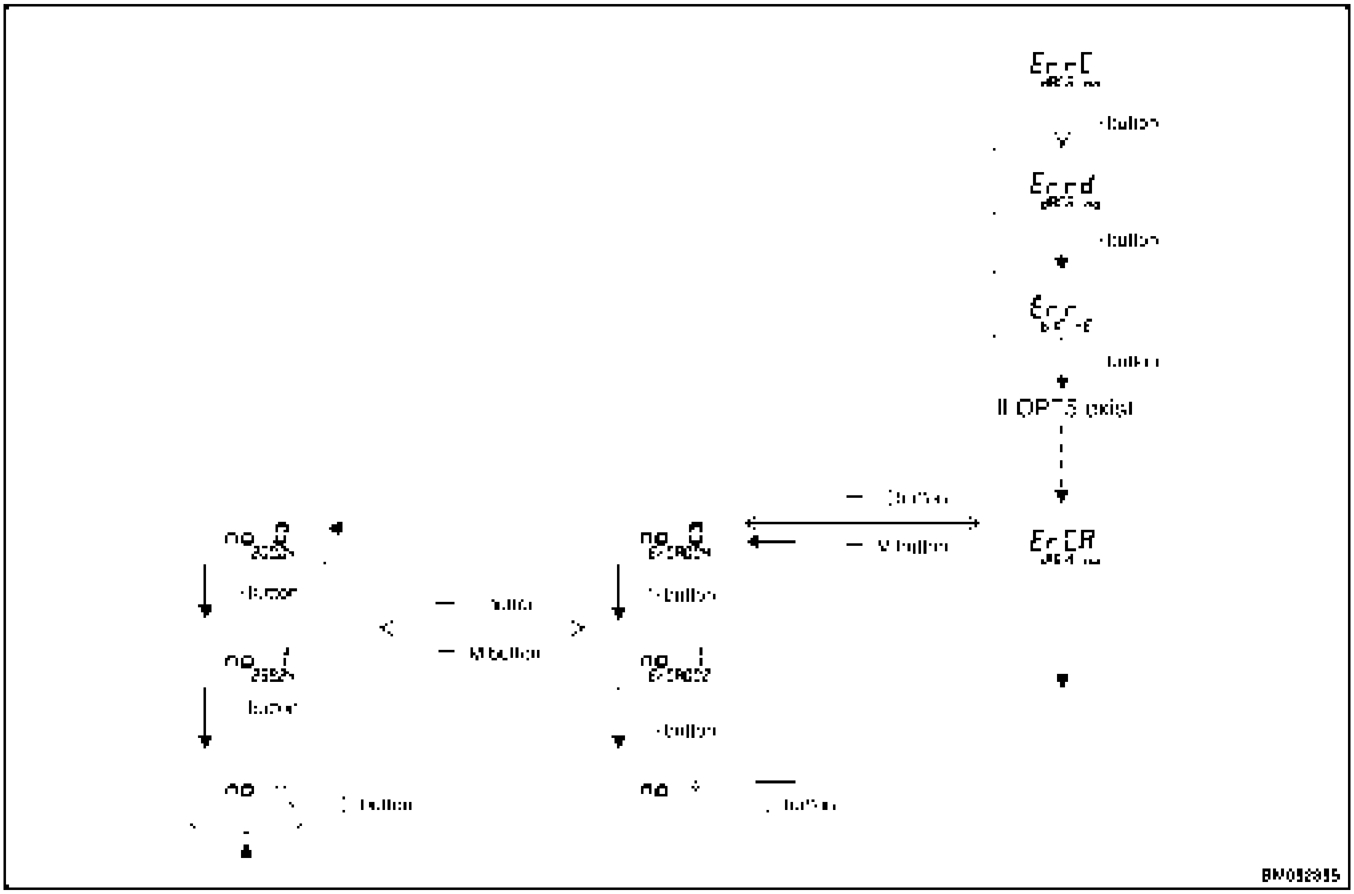


Figure 9060-10-12. E-Hydraulic Error Code

Transmission Control and Braking

DESCRIPTION

This section contains descriptions of transmission control and braking features.

Vehicle System Manager (VSM)

The VSM is the transmission controller. In response to the operator inputs, it:

- Sets the directional control logic conditions
- Turns on the transmission enable valve
- Sends proportional control signals to the appropriate pressure control valve to execute the operator command
- Monitors and adjusts pack pressure(s) to compensate for load, speed, braking conditions, and priority demands
- Provides indications to the display unit of direction or neutral status, fault detection, transmission oil temperature, and pack pressures (on demand)

Display Switch Cluster

The display has the display indicators for FWD - NEUTRAL - REV that are driven by the ECU in response to operator selection. These signals are sent to the display over the CANbus and will display the selected condition from either the Directional Control Lever or the foot pedal inputs. The transmission direction/neutral status is interlocked with other operating conditions on the truck to provide additional safety.

Interlock and Switching Features

- The direction control lever on the display must be in Neutral and the parking brake set or service brake applied to start the truck
- If transmission was in FWD or REV when the parking brake was applied, the transmission will return to Neutral until the brake is released
- When the parking brake is released, the transmission will return to the previously selected direction
- When the transmission is operated in reverse, the backup lights will be on and the audible backup alarm, if equipped will be activated.

Directional Control

CAUTION

For standard transmissions, the drive train can be damaged if the lift truck is traveling too fast when the controls are changed to the opposite direction of travel.

The foot pedal direction control is configured with switches that input the direction command to the VSM. Pressing on the right side of the pedal selects the REV direction with corresponding backup lights and backup alarm activated. Pressing the left side of the pedal selects the FWD direction. The selection is latched in the VSM logic so it will remain in that direction until the opposite direction is commanded or the parking brake is set. The foot pedal is also the accelerator pedal so pushing it further will increase the speed of the truck in the applied direction.

Inch Brake/Service Brake Pedal

Depending upon inch brake/service brake pedal configuration, there may be one combined pedal or a two-pedal configuration. With the two-pedal configuration, the left pedal controls both the inch brake and service brake function (similar to the single-pedal configuration) while the right pedal controls service brake function only. The operation of the inch brake or service brake pedal will provide two levels of control. Full depression of the pedal will disengage the transmission and apply the wheel brakes to stop the truck. During lifting/loading operations, the inch brake function can be used to provide a slow travel speed while maintaining a high engine speed to maintain high hydraulic flow for faster control of the lift mechanism.

WARNING

Inching requires coordinated movement of the inch brake pedal and the accelerator pedal. New operators must practice this procedure before attempting to handle loads.

When the inch brake/service brake pedal is initially applied, the clutch in the transmission is partially disengaged and the movement of the truck is slow. Use the foot pedal/accelerator to maintain engine RPM while inching.

The standard braking function is applied when the inch brake/service brake pedal is pushed down further than the inching position. This will cause the transmission to disengage and permit normal braking operation to the wheels. Inch/brake overlap calibration is performed automatically.

Parking Brake

The parking brake lever is a hand lever on the left side of the cowl and is used to activate the mechanical wheel brakes. Pull the lever toward the seat to apply the brake. To release the brake, press the release button on the top of the lever with your thumb, and ease the lever forward.

If the operator leaves the seat with the parking brake off, an audible alarm will sound for 10 seconds.

Manual Hydraulic Control Levers

GENERAL DESCRIPTION

The Manual Control Levers (if installed) are used to control hydraulic operation of the mast lift/lower, tilt, and auxiliary functions as in traditional lever-based trucks.

SYSTEM COMPONENTS

The operator input device is a set of control levers located to the right of the steering column. See Figure 9060-10-13.

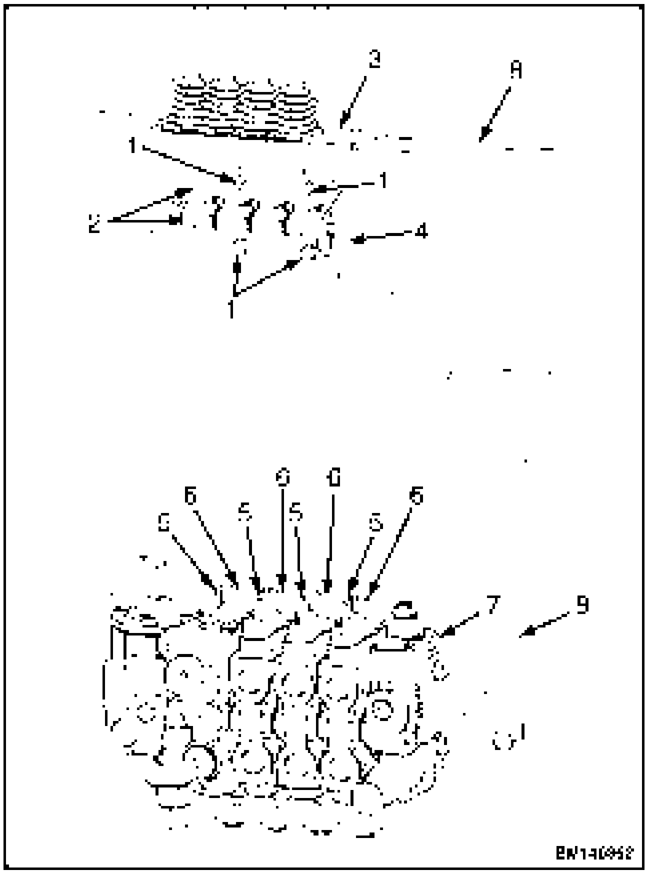


Figure 9060-10-13. Manual Hydraulic Control Components

Legend for Figure 9060-10-13

1. CAPSCREW
2. HYDRAULIC LEVER ASSEMBLY
3. RETAINING PLATE
4. MOUNTING BRACKET
5. LOCKING RING COTTER PINS
6. ROD END PINS
7. MANUAL CONTROL VALVE
8. COWL

Lift/Lower

This is the most used function in the hydraulic system. The lift/lower control is used to lift/lower the forks of the truck.

Tilt

Tilt control is used to tilt the angle of the forks of the truck.

Auxiliary 1

Auxiliary 1 function is assigned in line with traditional manual hydraulic levers.

Auxiliary 2

Auxiliary 2 function is assigned in line with traditional manual hydraulic levers.

E-Hydraulic System Interface

GENERAL DESCRIPTION

The Electro-Hydraulic (E-Hydraulic) system lift trucks controls hydraulic operation of the mast lift/lower, tilt, and auxiliary functions. This E-Hydraulic option replaces the manual control levers with simple, single-handed integrated electronic controls, either a joystick or a finger-operated lever module, located on the right-hand armrest. The E-Hydraulic system is controlled by the V-ECU that provides drive commands to the hydraulic valves based on the operator inputs. This system automatically adjusts the flow control based on conditions such as engine speed, load, and functions activated, etc., to provide better ergonomics, controllability, and flexibility. The V-ECU also monitors the performance of the system and reports faults to the operator via the display.

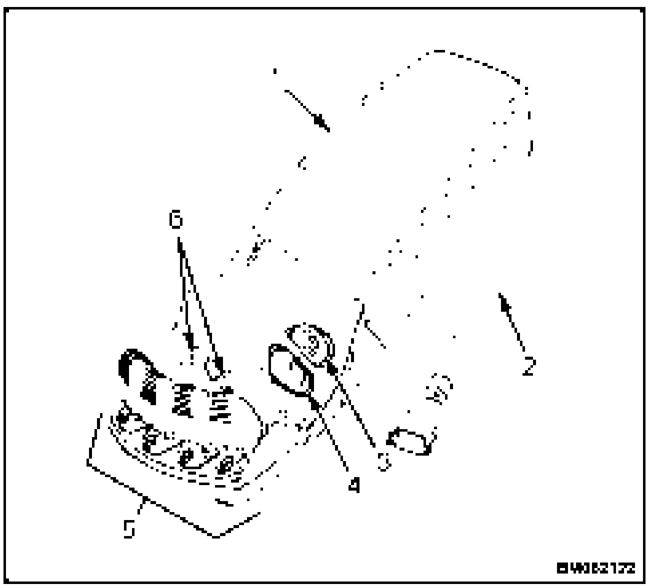
SYSTEM COMPONENTS

For the E-Hydraulic system to operate, certain conditions must exist. Mini-levers must be both mechanically and electronically in neutral position at power **ON**. If equipped, the raisable armrest must be locked down. The armrest latch release is located on the outboard of the armrest. The armrest also has a release handle at the aft outboard end that allows the armrest to be moved fore and aft in relation to the seat position.

The MLM commands are sent to the V-ECU via the CANbus. The V-ECU supplies proportional commands to drive the electro-hydraulic valves. The V-ECU monitors the input and output signals, armrest position, engine parameters, and hydraulic response, and adjusts the system performance as required. Faults or interlock conflicts are detected by the V-ECU which sends the error messages (fault codes) to the display for operator awareness and correction.

Mini-Lever Module (MLM)

The MLM has four proportional levers. Up to three push button switches may be included to support optional features such as Return-To-Set-Tilt (RTST), clamp interlock, and a third auxiliary (on 4.5 ton trucks only). The operator controls for the E-Hydraulics system on the 1.0-9.0 ton series lift truck are shown in Figure 9060-10-14.



1. ARMREST
2. WIRE HARNESS
3. HORN BUTTON
4. DIRECTION CONTROL SWITCH
5. MINI-LEVERS
6. MOMENTARY SWITCHES

NOTE: THE MOMENTARY SWITCHES ARE NUMBERED 1 THROUGH 4, LEFT TO RIGHT, WHEN VIEWED FROM THE OPERATOR'S SEAT.

Figure 9060-10-14. E-Hydraulic Controls

Lever 1

Lever 1 controls the carriage lift/lower function. Pushing the lever forward lowers the carriage. Pulling the lever back raises the carriage.

Lever 2

Lever 2 controls the tilt forward/backward function. Pushing the lever forward tilts the mast forward. Pulling the lever back tilts the mast back.

Optional: Return-To-Set-Tilt (RTST) — The RTST option assists the operator in positioning the mast at a predetermined set point. Note that the RTST function does not provide for "hands free" activation of the tilt valve. The operator must manually control both tilt speed and direction of the mast toward the set point. When the mast is far away from the stop point, the operator is allowed to tilt at the maximum tilt flow rate. When the mast is close to the set point, the maximum tilt flow rate is limited.

<u>The RTST override button is not depressed before pushing the tilt lever.</u>

The RTST control soft stops the mast at the set point and disables the tilt valve even if the operator command is not at neutral. Once stopped the system waits for one of three options:

1. Return the tilt control lever back to neutral position, which places the tilt control to neutral.
2. Depress the RTST override button, which will override the RTST control and allow the tilt control to function. If the delay time is set to "continuous", the operator MUST press the override button to resume tilt control past the set point.
3. Waits for the RTST time delay of 0.1 to 3 seconds to time out, at which time the tilt control will be enabled and the mast will continue to tilt in the direction the control lever is pushed.

<u>The RTST override button is depressed before pushing the tilt lever.</u>

If the RTST override button is depressed for 1/20th of a second and the tilt lever is moved out of neutral within three seconds of the button being released, the RTST control will not stop the mast at the set point.

Once the lever is returned to neutral the override command will be cancelled and the RTST control will become active.

NOTE: The following time delay adjustments are available:

- Disable RTST
- 8 increments of time delay from 0.1 to 3.0 seconds
- "Continuous" time delay. If the time delay is set to continuous the operator MUST press the override button to resume tilt control.

A service technician may adjust the time delay.

Lever 3

Lever 3 is normally configured for left and right sideshift. This is also an SEF that can be configured to customer requirements.

Lever 4

Lever 4 is not presently configured.

Optional: Unclamp Enable

<u>Clamp Function</u> — The lever is moved in the aft direction to operate the clamp function. The clamp function is allowed regardless of whether the clamp interlock button is in the depressed or released position.

<u>Unclamp Function</u> — In order to operate the unclamp function, the system must be "enabled" before moving the lever in the forward direction. The system is enabled by depressing the clamp interlock button for a minimum of 1/20th of a second while the lever is in neutral. The unclamp function will remain enabled for three seconds from the time the lever was moved. If the unclamp function is not initiated before this three second time period expires, the system will revert to the interlocked state.

If the unclamp function is initiated after enabling the system, then it will remain enabled as long as the lever is forward of the neutral position, regardless of whether the clamp interlock button is depressed or released.

The unclamp function is disabled immediately when the lever is returned to neutral regardless of whether the clamp interlock button is depressed or released. If the lever is returned to neutral from either the forward or aft direction with the clamp interlock button pressed, then the button must be released before the unclamp function can be enabled again.

SYSTEM MODES

The E-Hydraulic system operation for the mast components is defined in the following modes:

- Hydraulic Interlock Mode
- Fault Mode
- Engine Off Mode
- Normal Operation Mode

Hydraulic Interlock Mode

The electrical power of the E-Hydraulic system is on, but any one of the hydraulic interlock checks failed.

Fault Mode

If a fault condition has been detected on a specific operation, this operation may be suspended.

Engine Off Mode

The electrical power to the system is on, the engine is not running, and the system passes the hydraulic interlock check. The system only allows lowering control.

NORMAL OPERATION

Normal Operation Mode

The electrical power to the system is on, the engine is running, and the system passed the hydraulic interlock checks. The hydraulic functions operate per factory calibrations.

Lifting Control

- Speed for lifting is proportional to the operator’s command
- Provides fine control resolutions at low lifting speeds with or without load
- Lifting operation has priority over other functions, and will not be stopped by other functions operated simultaneously
- Maximum lifting speed can be configured by service technicians

Lowering Control

- Lowering speed is proportional to the operator’s command
- Provides fine control resolutions at low lowering speeds
- Maximum lowering speed can be configured by service technicians

Tilt Control (Forward and Backward)

- Tilting forward and backward speeds are proportional to the operator’s command
- Provides fine control at low tilting speeds
- Maximum speeds of tilting forward and backward can be configured differently and independently

Auxiliary Control

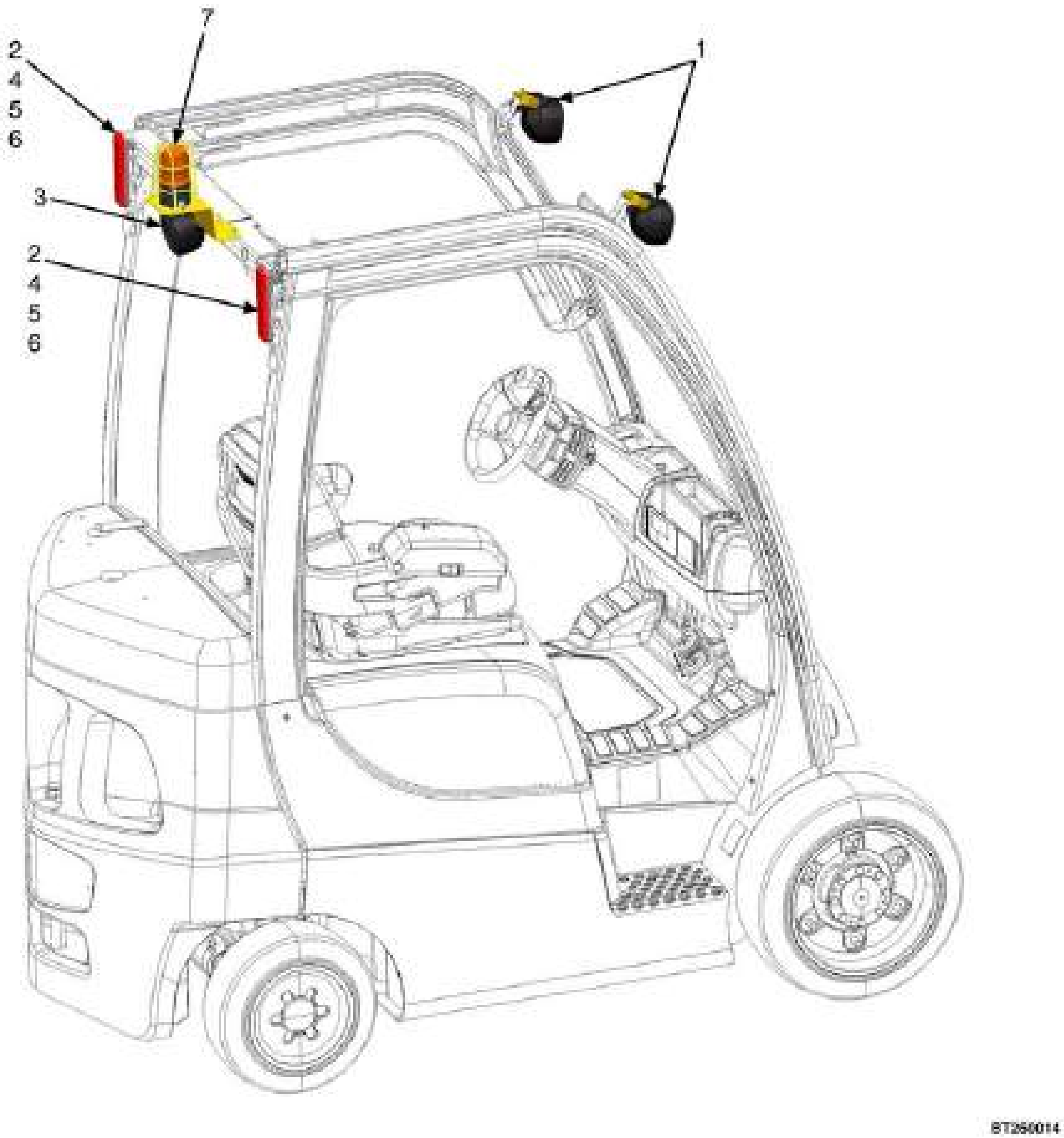
- Auxiliary valve operation is proportional to the operator’s command
- Up to three bidirectional proportional auxiliary functions are available in addition to the lift/lower and tilt functions
- Maximum speed of each auxiliary function can be configured differently and independently
- Second and third auxiliary functions use a common lever

NOTE: Some lift truck attachments have a clamping function. To prevent a clamp release unexpectedly, regulations require an operator make a second enabling action, such as pushing a button to control unclamping. The system supports each auxiliary function that is required to be interlocked with an additional on-off input.

Lighting Control

DESCRIPTION

The truck in the Non-Cab configuration can be equipped with lights as shown in Figure 9060-10-15. As described below, some of the truck lights are operator activated while the other lights operate in response to truck activities. The operation of the lights are dependent on the selected software option.



1. FRONT WORK LIGHTS
2. REAR TAIL/MARKER LIGHTS
3. REAR WORK LIGHT
4. REAR TURN LIGHTS
5. REAR BACKUP LIGHTS
6. REAR STOP LIGHTS
7. STROBE LIGHTS

Figure 9060-10-15. Lights, Non Cab Configuration

Front Work Lights

The front work lights switch is part of the turn signal level, located on the steering column assembly. The front work lights can be operated whether the truck system power is **ON** or **OFF**. If the System Power is **OFF** and the work lights are operating, they will automatically turn off after a service configured time.

Front Marker Lights (if equipped)

The front marker lights operate in conjunction with the front work lights.

Front/Rear Turn Signal Lights

The front/rear turn lights operate according to the position of the turn lever. The lever is momentary in its operation, returning to center rest position when released. The activated signal light will continue to operate until cancelled by momentary action of the lever in the opposite direction or until system power is turned off.

Rear Tail/Marker Lights

The rear tail/marker light operate in conjunction with the operation of the front work lights.

Rear Work Light

The rear work light switch is located on the right side of the display. The Rear work lights can only be operated when the truck system power is **ON**. If the System Power is turned **OFF** and the work lights are operating, they will automatically turn off after a service configured time.

Rear Backup Lights

The rear backup lights operate whenever Reverse direction is selected.

Rear Stop Lights

The rear stop lights operate whenever the brake pedal is pressed.

Strobe Light(s)

The strobe light(s) operate(s) whenever the truck power is **ON** or when a programmed function is selected.

Spot Light (if equipped)

If the truck is equipped with a spot light, the operator controls its operation with the switch on the spot light.

SECTION 9070

FRONT END (MAST) AND CHASSIS

TABLE OF CONTENTS

Group 10

Principles of Operation

Front End, Mast

DESCRIPTION

This section has the Description and Principles of Operation of the front end components.

The mast is used to lift a load vertically. The mast has two movements controlled by hydraulic cylinders: forward and backward tilt, and the lifting and lowering of the mast and carriage. The outer mast tilts on the pivot pins at the mast mounts. The operation of the tilt cylinders causes the mast to tilt forward and backward. The tilt cylinders are fastened between the frame of the lift truck and the outer mast. Hydraulic lift cylinders are installed vertically in the mast. The lift cylinders raise and lower the intermediate/inner masts and the carriage.

There are four types of masts available:

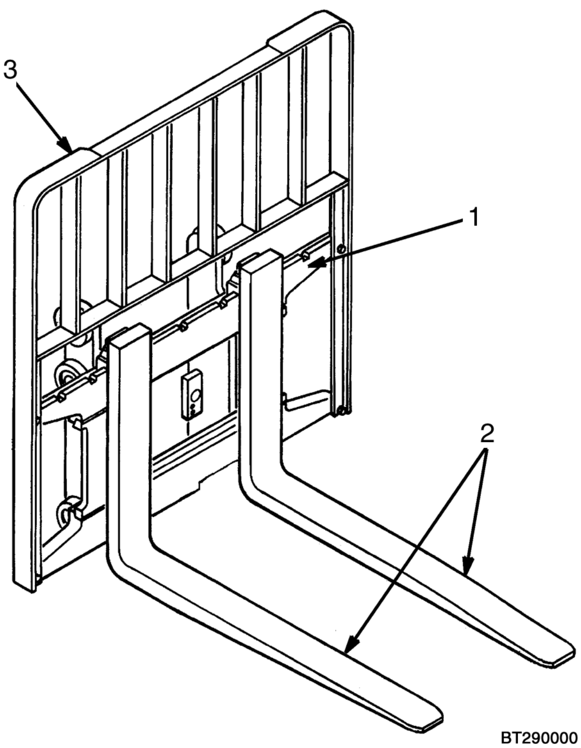
- Two-Stage Limited Free-Lift
- Two-Stage Full Free-Lift
- Three-Stage Full Free-Lift
-

Each type of mast is described separately in this section.

Carriages

DESCRIPTION

The carriage is a part of the mast assembly and moves within the vertical channels of the inner weldment. Load rollers, attached to the carriage, travel in the channels of the inner weldment. Forks or other types of load handling equipment are attached to the carriage. A load backrest extension is attached to the carriage and adds support for a load that has multiple pieces. See Figure 9070-10-1.



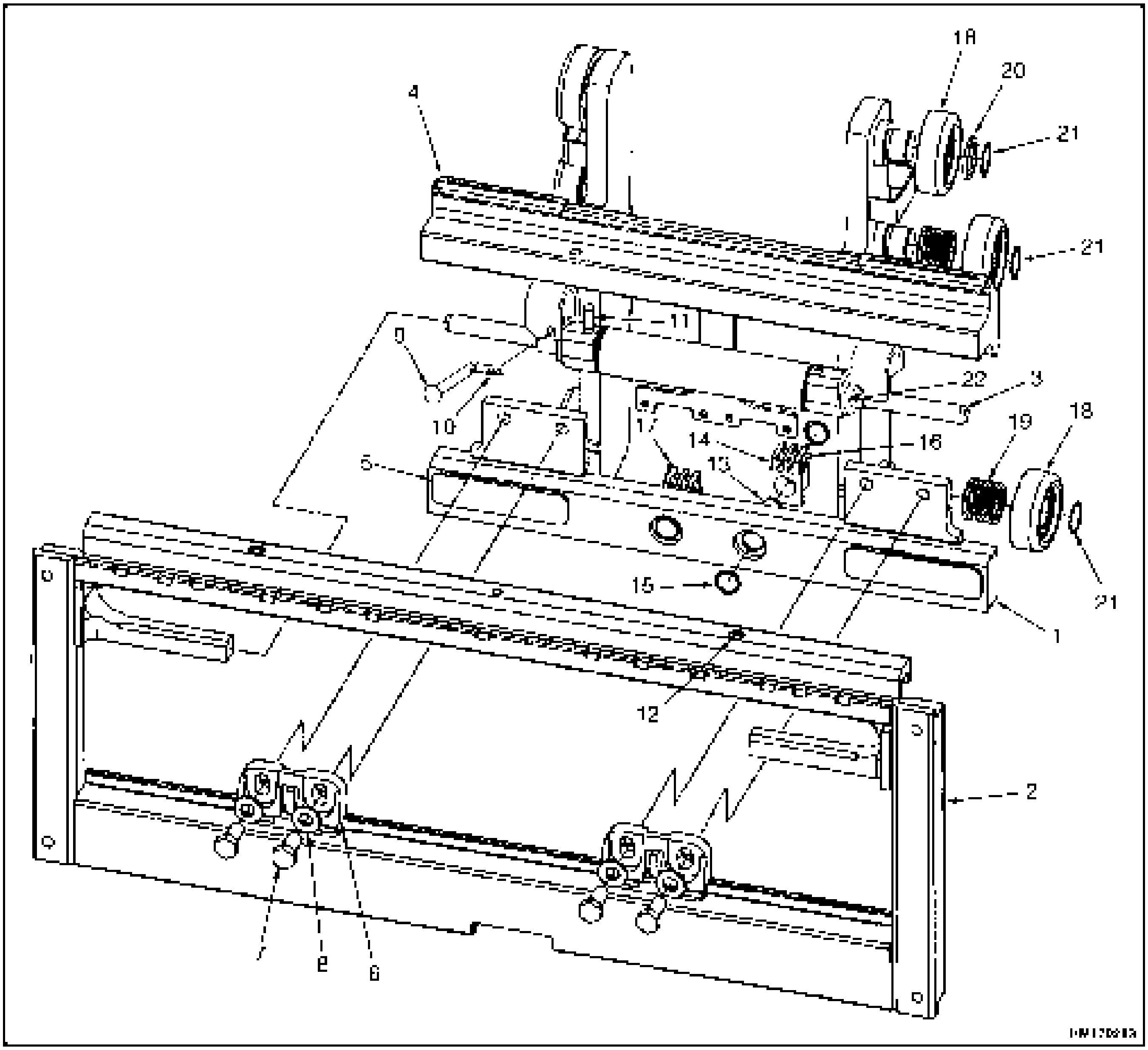
1. STANDARD CARRIAGE
2. FORKS
3. LOAD BACKREST EXTENSION

Figure 9070-10-1. Carriage

PRINCIPLES OF OPERATION

Integral Sideshift Carriage

The integral sideshift carriage lets the operator move the forks and load from side to side. This function makes it easier for the operator to align the forks with a load or align the load with a stack. The integral sideshift carriage is a complete inner carriage and outer frame assembly. The sideshift cylinder moves the outer frame assembly on the inner carriage. The fork spread control lever is the fourth manual lever. **PUSH** the lever **FORWARD** to move the forks apart. **PULL** the lever **BACKWARD** toward the operator to move the forks together. See Figure 9070-10-2.



1. INNER CARRIAGE
2. OUTER FRAME
3. SIDESHIFT CYLINDER
4. UPPER BEARING
5. LOWER BEARING
6. LOWER HOOK
7. CAPSCREW
8. WASHER
9. CLEVIS PIN
10. HAIRPIN
11. PIN
12. LUBE FITTING
13. PIN
14. CHAIN ANCHOR
15. SNAP RING
16. PIN
17. COTTER PIN
18. LOAD ROLLER
19. SHIMS
20. SPACER
21. SNAP RING
22. SPACER

Figure 9070-10-2. Integral Sideshift Carriage (1.0 - 3.5 Ton Truck shown)

Mast Mounts

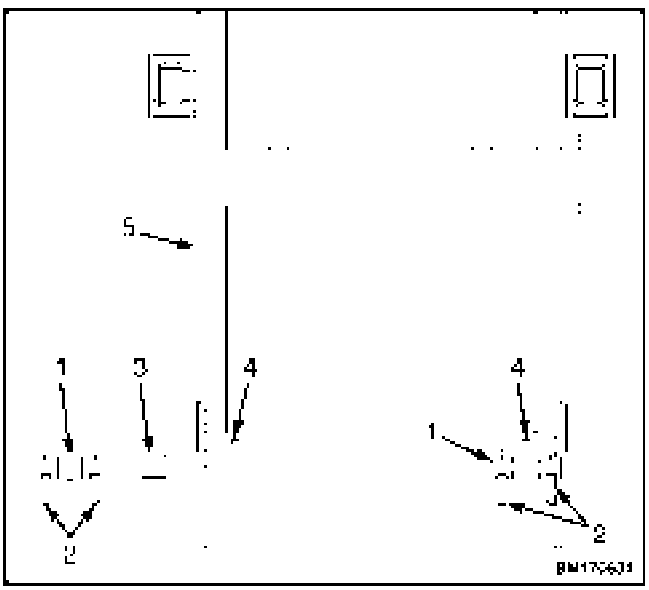
DESCRIPTION

The lower crossmember of the outer mast has castings to mount the mast pivot pins. The pivot pins are installed in the castings and the mast is hung on the hangers of the drive axle housing. Capscrews secure the mast pivot pins to the drive axle housing. For the Pin - Style see Figure 9070-10-3.

The mast tilt cylinders are attached to the mast upper attachment castings using rod end fittings. Pins attach the rod end fittings to the casting and are secured with anchor pins and capscrews.

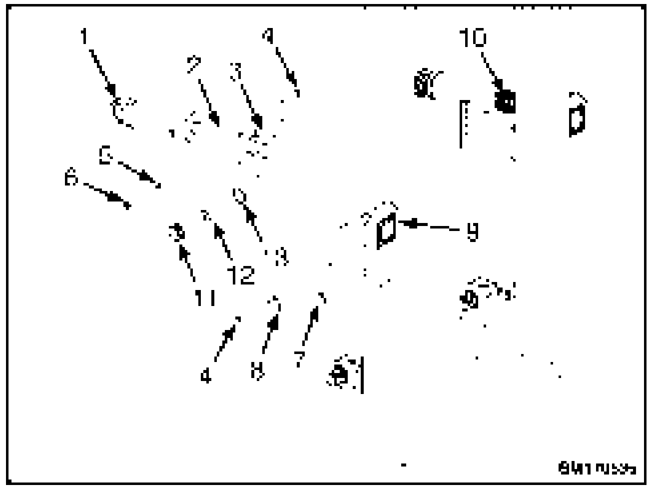
PRINCIPLES OF OPERATION

The mast and attached forks can tilt forward and backward. Tilt cylinders are fastened between the lift truck frame and the outer mast upper attachment points. The operator uses the Joystick or the Mini Lever Module controls to extend or retract the tilt cylinders, changing the angle of the mast that pivots on the pins mounted on the drive axle housing.



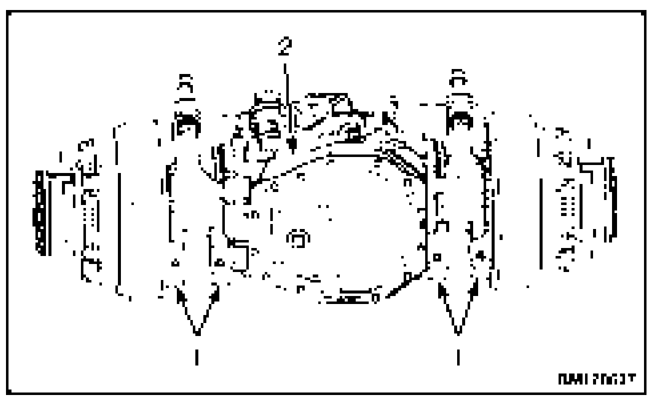
1. MAST PIVOT PIN
2. CAPSCREW
3. BUSHING (BRONZE)
4. LUBE FITTING
5. OUTER MAST

Figure 9070-10-3. Mast Mounts



1. ROD END (TRUCK)
2. TILT CYLINDER
3. ROD END (MAST)
4. CAPSCREW
5. WASHER
6. NUT
7. PIVOT PIN
8. RETAINING PLATE
9. TILT CYLINDER ANCHOR
10. BOOT (OPTIONAL)
11. BUSHING
12. BALL BUSHING
13. SNAP RING

Figure 9070-10-4. Tilt Cylinder Mounted to Mast



1. HANGER MOUNTS
2. DRIVE AXLE

Figure 9070-10-5. Mast Mounts, Drive Axle

Two-Stage Limited Free-Lift (LFL) Mast

DESCRIPTION

The Two-Stage Limited Free-Lift Mast has an outer mast, an inner mast, and two lift cylinders. See Figure 9070-10-6. At the base of the inner mast there is one load roller on each side. These load rollers travel along the flanges inside the outer mast channel. At the top of the outer mast there is also one load roller on each side. These load rollers travel along the flanges on the outside of the inner mast. The angle of the load rollers permits them to control the forces from the front, back, and sides of the mast. The strip bearings are installed at the top of the outer mast. The strip bearings can be adjusted by shims to help keep the correct clearance between the outer mast and the inner mast.

The two single-stage lift cylinders are installed at the back of the outer mast. The base of each lift cylinder sits in a mount on the bottom crossmember of the outer mast. The top of each lift cylinder rod fits into a guide on the top crossmember of the inner mast. Operation of the lift cylinders extends and retracts the inner mast. See Figure 9070-10-7.

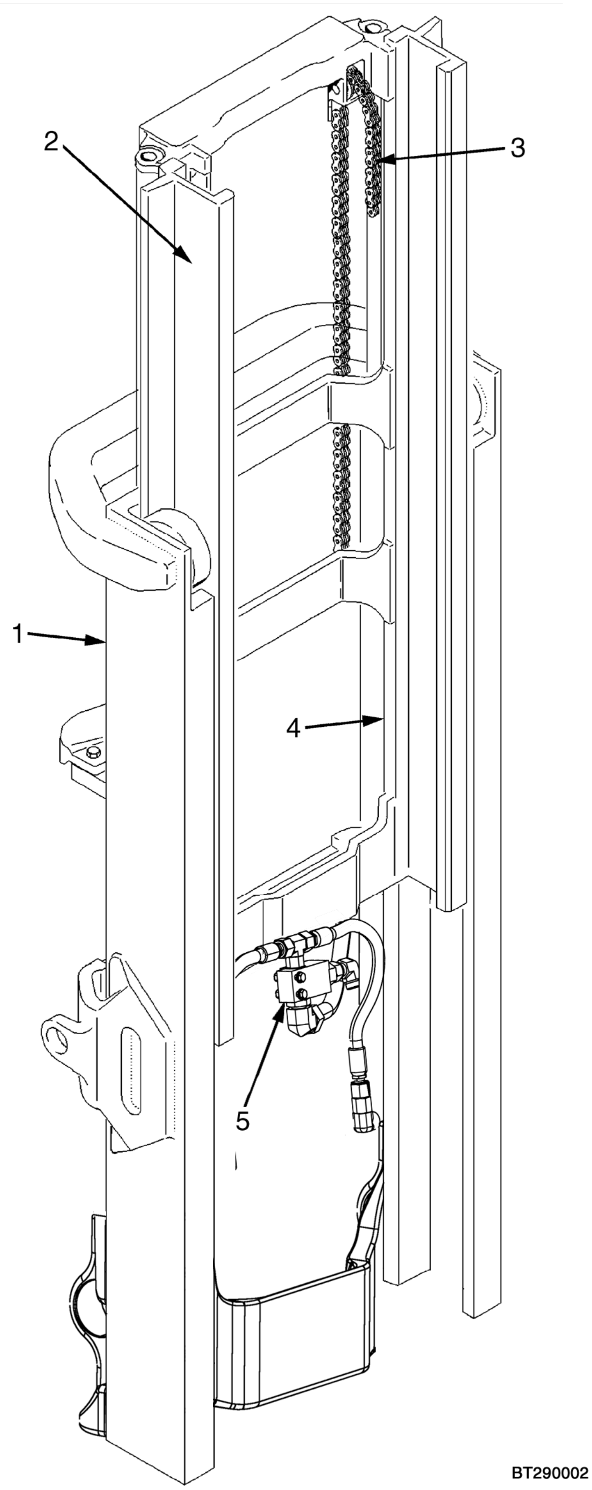


Figure 9070-10-6. Two-Stage (LFL) Mast

Legend for Figure 9070-10-6

NOTE: TYPICAL MAST ASSEMBLY IS SHOWN HERE.

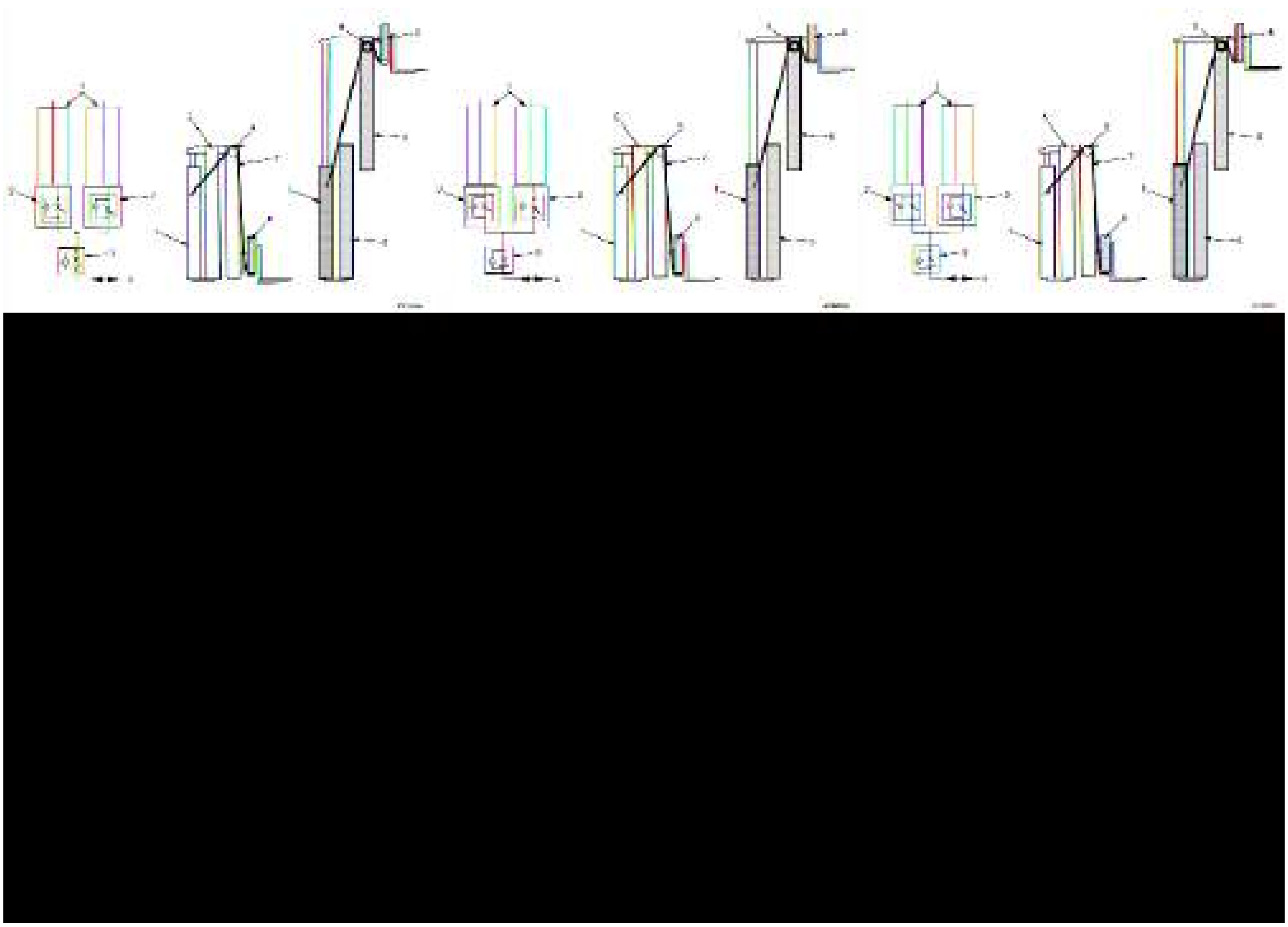
1. OUTER MAST
2. INNER MAST
3. LIFT CHAIN(S)
4. LIFT CYLINDER(S)
5. LOWERING CONTROL VALVE (EXTERNAL)

PRINCIPLES OF OPERATION

Two lift chains move the carriage. The chains fasten to mounts that are near the top of the lift cylinder shells as shown in Figure 9070-10-7. The chains go up and over the chain sheaves and connect to the carriage. The chain sheaves are installed at the top crossmember of the inner mast. When the lift cylinders extend, the lift chains transfer the force from the lift cylinders to the carriage. The inner mast and carriage raise a small amount before the overall height of the mast increases. During lifting, the inner mast moves at the same speed as the lift cylinders. The carriage moves at twice the speed of the inner mast/ lift cylinders.

When the lift cylinders retract, the weight of the load, carriage, forks, load backrest extension and attachment, and inner mast pushes the oil from the lift cylinders. The oil flows from the lowering control valves in the lift cylinders, through the external lowering control valve to the hydraulic tank.

Each cylinder has a check valve in the bottom of the rod assembly. When the cylinder is fully extended, any oil above the piston is forced through the check valve.



1. LIFT CYLINDER
2. LOWERING CONTROL VALVE (INTERNAL)
3. LOWERING CONTROL VALVE (EXTERNAL)
4. TO/FROM MAIN CONTROL VALVE
5. OUTER MAST
6. INNER MAST
7. LIFT CHAINS
8. CARRIAGE
9. CHAIN SHEAVES

Figure 9070-10-7. Operation of Two-Stage (LFL) Mast

Three-Stage Full Free-Lift (FFL) Mast

DESCRIPTION

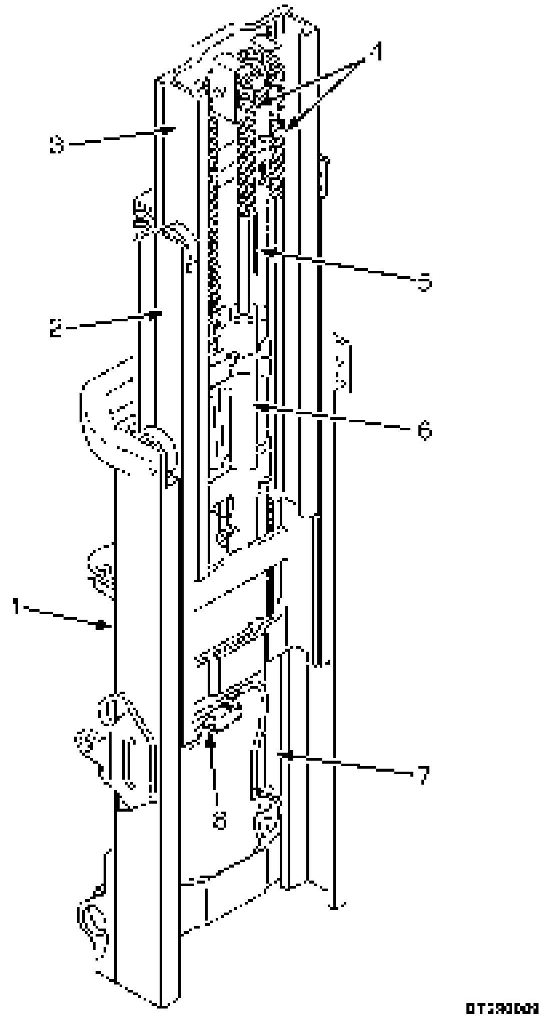
The Three-Stage Full Free-Lift Mast has three masts: outer, intermediate, and inner. See Figure 9070-10-8. Two single-stage main lift cylinders and a free-lift cylinder are used to raise the carriage and extend the intermediate and inner mast. It is called a full free-lift mast because the carriage can travel to the top of the inner mast without extending the inner mast. The masts are telescopic and have the load roller and strip bearing arrangements similar to the two-stage mast.

The load rollers are installed at the top of the outer and intermediate masts. Load rollers are also used at the bottom of the intermediate and inner masts. These load rollers travel along the flanges of the mast channels. The angle of the load rollers permits them to control the forces from the front, back, and sides of the mast. The strip bearings are installed at the top of the outer and intermediate masts and help keep the correct clearance between the masts. The load rollers and strip bearings are adjustable with shims.

The two main lift cylinders are installed at the back of the outer mast. The base of each main lift cylinder sits in a mount on the bottom crossmember of the outer mast. The top of each main lift cylinder rod fits into a guide in the top crossmember of the intermediate mast. The free-lift cylinder is installed to the inner mast. Each lift cylinder has an internal lowering control valve. A single external lowering control valve is connected by tubing and hoses to all of the lift cylinders.

The two main lift chains are connected to mounts that are welded near the top of the main lift cylinder shells. The lift chains go over sheaves at the top of the intermediate mast and fasten at the bottom of the inner mast.

The free-lift chains connect at one end to the mid-crossmember of the inner mast. Two chain sheaves are installed on a crosshead on the cylinder rod of the free-lift cylinder. The chains go over sheaves on the crosshead and connect to the carriage.



NOTE: TYPICAL MAST ASSEMBLY IS SHOWN HERE.

1. OUTER MAST
2. INTERMEDIATE MAST
3. INNER MAST
4. FREE-LIFT CHAIN
5. MAIN LIFT CHAIN(S)
6. FREE-LIFT CYLINDER
7. MAIN LIFT CYLINDER(S)
8. LOWERING CONTROL VALVE (EXTERNAL)

Figure 9070-10-8. Three-Stage (FFL) Mast

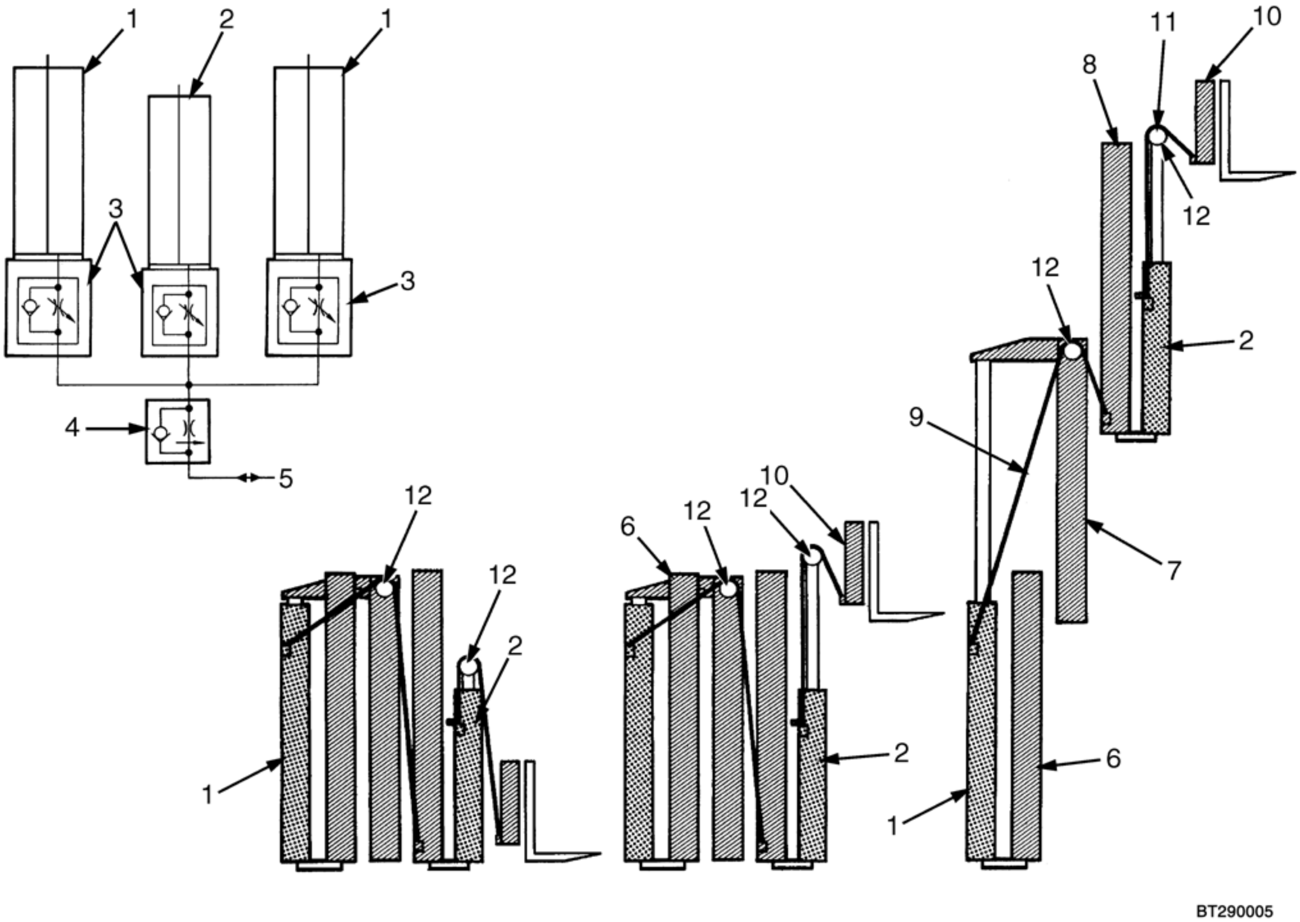
PRINCIPLES OF OPERATION

The three hydraulic cylinders are connected by hoses and tubing as shown in Figure 9070-10-9. When the mast is extended, oil from the main control valve flows to all cylinders at the same time. The free-lift cylinder extends first because it lifts the least amount of weight and has a lower operating pressure. The free-lift cylinder raises only the carriage. After the free-lift cylinder reaches the end of its stroke, the main lift cylinders begin to extend. As the main lift cylinders extend, the intermediate mast is raised by the main lift cylinders and the inner mast is raised by the main lift chains.

During lowering, the main lift cylinders lower first because they have a greater load and higher operating pressure. After the main lift cylinders have retracted, the free-lift cylinder lowers. All oil from the lift cylinders flows through the lowering control valves to the hydraulic tank.

The free-lift cylinder must have 150 cc (5 oz) of oil above the piston. This oil provides a hydraulic cushion when the cylinder reaches the top of its stroke. An orifice system in the piston provides the hydraulic cushioning. When the cylinder is fully extended, any excess oil above the piston is forced through the check valve.

Each main lift cylinder has an orifice system and a check valve in the bottom of the rod assembly. When the cylinder is fully extended, any oil between the rod end and the gland is forced through the check valve. The orifice system provides a hydraulic cushion when the cylinder reaches the bottom of its stroke.



1. LIFT CYLINDER
2. FREE-LIFT CYLINDER
3. LOWERING CONTROL VALVE (INTERNAL)
4. LOWERING CONTROL VALVE (EXTERNAL)
5. TO/FROM MAIN CONTROL VALVE
6. OUTER MAST
7. INTERMEDIATE MAST
8. INNER MAST
9. MAIN LIFT CHAINS
10. CARRIAGE
11. FREE-LIFT CHAINS
12. CHAIN SHEAVES

Figure 9070-10-9. Operation of Three-Stage (FFL) Mast

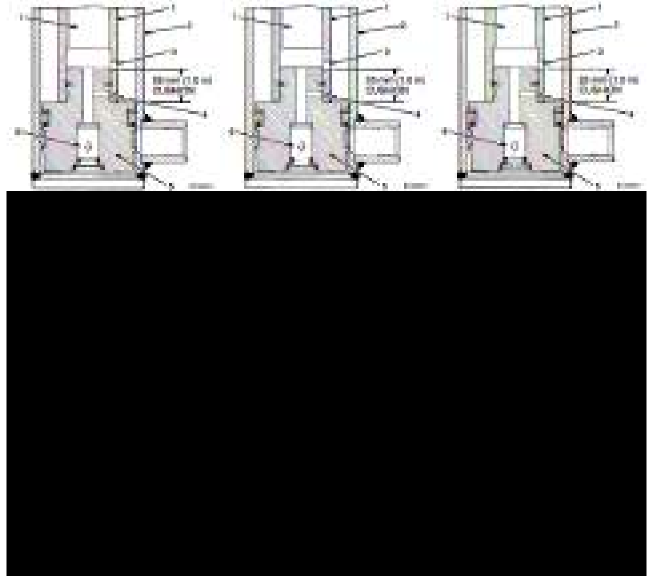
Cylinder Cushion During Lifting Sequence

DESCRIPTION

The hydraulic action at the end of the free-lift stroke provides a cushion effect for the free-lift cylinder and a smooth transition between the free-lift phase and the mast extension phase (main cylinder extension). All masts with a free-lift cylinder in this section use this design.

PRINCIPLES OF OPERATION

There is hydraulic oil on the rod side of the piston of the free-lift cylinder. When the cylinder rod extends to the last 25 mm (1.0 in.) of its stroke, the gland at the top of the cylinder closes the larger hole. During this part of the cylinder stroke, the hydraulic oil must flow through the orifice to the air cavity. This action increases the hydraulic pressure so the main lift cylinders begin to extend. See Figure 9070-10-10.



1. CYLINDER ROD
2. CYLINDER SHELL
3. LARGE ORIFICE
4. SMALL ORIFICE
5. PISTON
6. INTERNAL CHECK VALVE
7. AIR CAVITY

Figure 9070-10-10. Free-Lift Cylinder Operation

Cylinder Cushion During Lowering Sequence

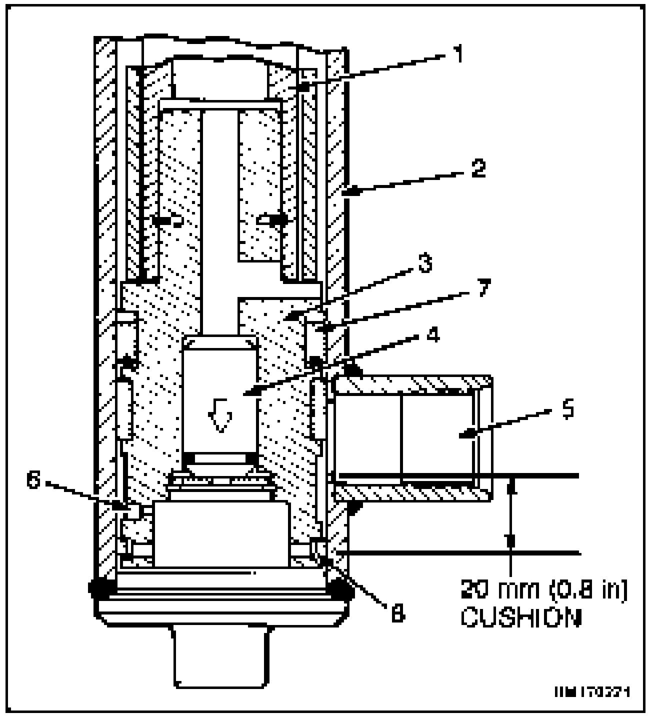
DESCRIPTION

This cushion effect prevents a sudden stop of the main cylinders, which causes smoother operation during lowering. All masts in this section, except Two-Stage Limited Free-Lift Masts, use this design in the main lift cylinders.

PRINCIPLES OF OPERATION

NOTE: An internal check valve is not used on the Two-Stage Full Free-Lift Mast.

When the main lift cylinders retract, the hydraulic oil flows out of the cylinder through the hydraulic port until the cushion ring moves past the hydraulic port. During the last 20 mm (0.79 in.) of the retraction stroke, the hydraulic oil must flow through the orifice. See Figure 9070-10-11. This action causes the cylinder rod to move much more slowly at the end of the retraction stroke.



NOTE: LEFT-HAND LIFT CYLINDER SHOWN.

1. CYLINDER ROD
2. CYLINDER SHELL
3. PISTON
4. INTERNAL CHECK VALVE
5. HYDRAULIC PORT
6. ORIFICE
7. PISTON SEAL
8. CUSHION RING

Figure 9070-10-11. Main Lift Cylinder Operation

Tilt and Sideshift Cylinders

DESCRIPTION

Tilt Cylinder

The tilt cylinders are used to move the mast forward and backward. To extend the cylinder rod (tilt forward), oil enters the tilt cylinder port behind the piston. The oil pressure pushes the cylinder rod out of the cylinder. Oil in front of the piston returns to the hydraulic tank. To retract the cylinder rod (tilt backward), the oil enters the port in front of the piston. The oil pressure pushes the cylinder rod into the tilt cylinder. The oil behind the piston returns to the hydraulic tank.

Sideshift Cylinder

The sideshift cylinder is removable for service. It is a double-acting, non-differential, piston-type cylinder, which allows the sideshift to attain the same speed moving either left or right. The cylinder also has flow restricting orifices in the ports.

Lowering Control Valves

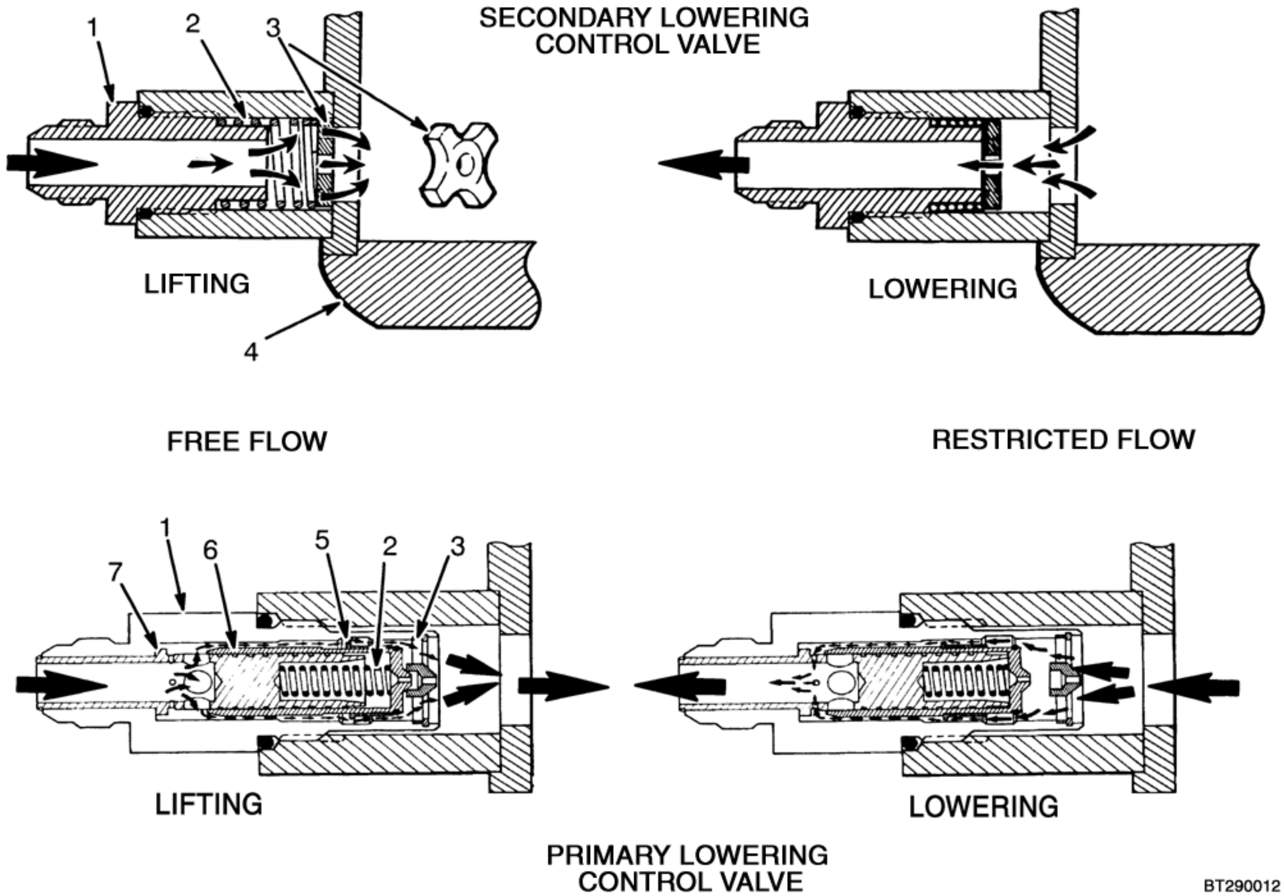
DESCRIPTION

The lowering control system permits easy entry of hydraulic oil into the cylinder during lifting, but restricts flow when rod is retracted to limit the speed at which a load maybe lowered. A pressure-compensated lowering control valve regulates the lowering speed to a more uniform value over the entire capacity range. The two types of lowering control valves used are designated as primary and secondary.

PRINCIPLES OF OPERATION

See Figure 9070-10-12. The Primary lowering control valve limits the lowering speed of the mast to a maximum controlled rate over the full range of loads. This valve is mounted externally on the middle crossmember of the outer mast. This type of lowering control valve uses these basic parts: (1) valve body, (2) spring, (3) special washer, (5) orifice sleeve, (6) plunger, and (7) main sleeve. The orifice sleeve position is controlled completely by oil flow. The plunger position is controlled by oil pressure and spring tension. During lifting, oil entering the lift cylinder goes through the center of the main sleeve to the large holes. The oil flow through the plunger and bore moves the orifice sleeve to the end of the plunger. The flange of the orifice sleeve is then aligned with the large part of the bore in the body. This alignment lets the oil flow past the orifice sleeve to the cylinder. During lowering, oil from the lift cylinder moves the orifice sleeve. The orifice sleeve moves away from the larger inner diameter area of the bore in the valve body. This movement makes a restriction to the oil flow. As the pressure increases, the plunger begins to move against the spring. The movement begins to close the openings of the large holes in the main sleeve. Additional pressure will push the plunger against the main sleeve to close the large holes completely. All the oil must then go through the small holes to the center of the main sleeve. This restriction permits the piston rod to lower only at a maximum controlled speed.

The Secondary lowering control valve is installed in each cylinder and is used only for emergency lowering. In the event an hydraulic line ruptures, this valve will lower the mast at a controlled rate. This type of lowering control valve uses these parts: (1) a special fitting for the valve body, (2) a spring, and (3) a special washer. There is a variation in the shapes of the special washer. The volume of the hydraulic oil flowing through the inlet port controls the shape of the special washer. When the piston rod is lowered, the oil flow pushes against the special washer and spring. When the oil flow reaches the limit, the special washer is moved against the special fitting. The oil then flows only through the hole in the center of the special washer. This restriction permits the piston rod to lower only at a maximum controlled speed.



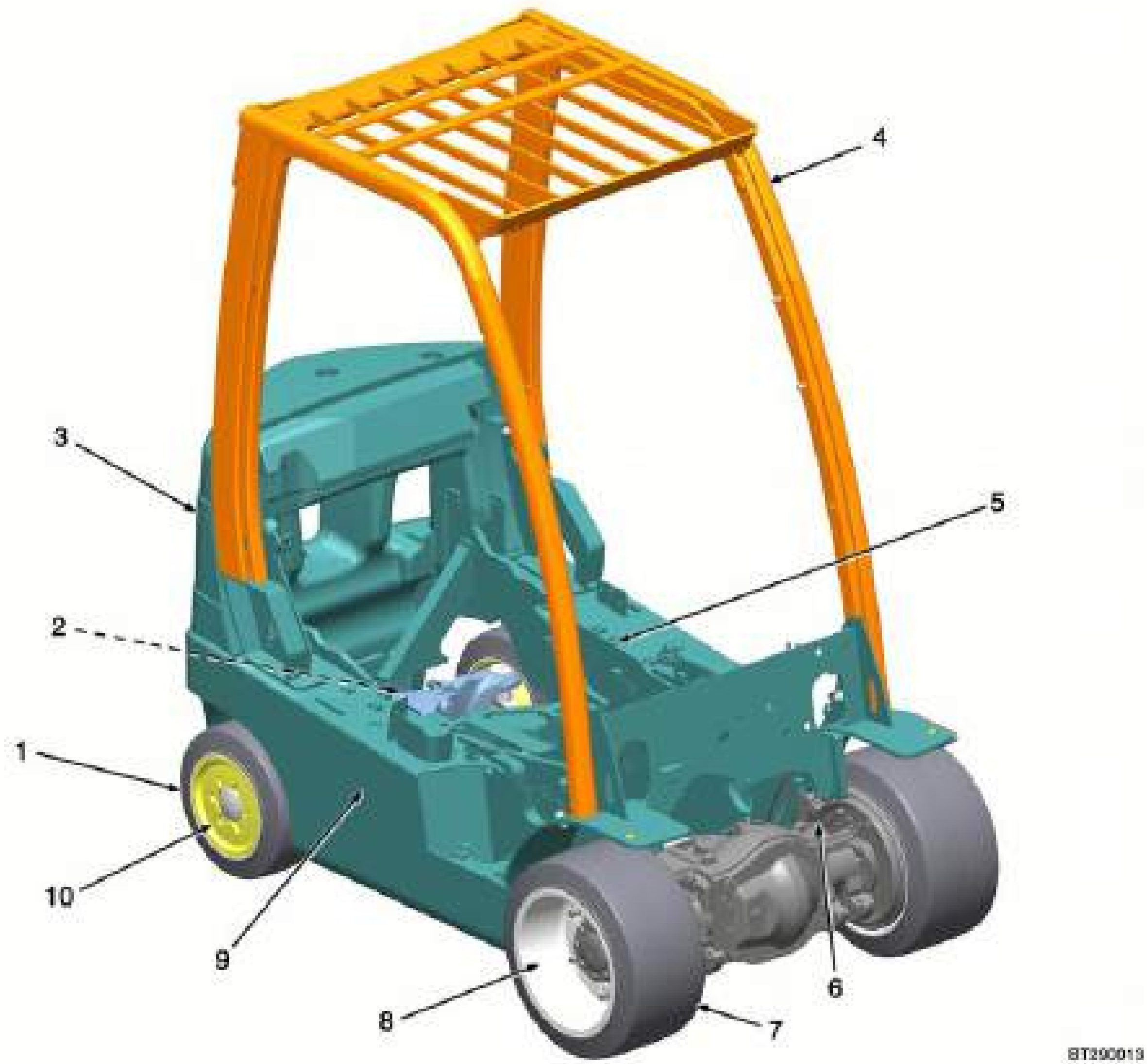
1. SPECIAL FITTING OR VALVE BODY
2. SPRING
3. SPECIAL WASHER
4. CYLINDER (SECONDARY ONLY)
5. ORIFICE SLEEVE
6. PLUNGER
7. MAIN SLEEVE

Figure 9070-10-12. Lowering Control Valve (Spring/Star-Washer Shown)

Chassis

DESCRIPTION

The chassis consists of the following components as shown in Figure 9070-10-13. The frame is one weldment which includes the hydraulic tank and fuel tank for gasoline or diesel fuel. The engine and transmission are isolated from the frame by rubber mounts. The counterweight is attached to the frame and varies in weight depending on truck capacity. The muffler is fastened to the frame inside of the counterweight.



1. TIRE (STEER AXLE CUSHION)
2. STEERING AXLE MOUNTS
3. COUNTERWEIGHT
4. OVERHEAD GUARD
5. FRAME
6. FRONT AXLE MOUNTS
7. TIRE (FRONT AXLE CUSHION)
8. WHEEL (DRIVE AXLE)
9. HYDRAULIC TANK
10. WHEEL (STEER AXLE)

Figure 9070-10-13. Chassis Component Location (Typical Cushion-Tire Truck Shown)

NOTES

Group 30

Observed Symptoms

Abnormal Channel Wear

POSSIBLE CAUSE

A. **MAST DAMAGED**
B. **MAST CHANNELS LACK LUBRICATION**
C. **CHAINS ARE LOOSE OR NOT EQUAL**
D. **MAST IS SHIMMED INCORRECTLY**
E. **LOAD ROLLERS ARE NOT ROTATING FREELY WITHIN CHANNEL**
F. **DAMAGED OR WORN LOAD ROLLERS OR STRIP BEARINGS**
G. **LIFT CYLINDER BINDING**

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - MAST CHANNELS LACK LUBRICATION

PROCEDURE OR ACTION:

1. Inspect grease on mast channels.
   Is a thin coat of grease spread evenly on channels?
   YES: Go to Cause C.
   NO: Apply grease to mast sliding surfaces.

CAUSE C - CHAINS ARE LOOSE OR NOT EQUAL

PROCEDURE OR ACTION:

1. Inspect lift chains.
   Are chains adjusted correctly and in good condition?
   YES: Go to Cause D.
   NO: Adjust or repair chains.

CAUSE D - MAST IS SHIMMED INCORRECTLY

PROCEDURE OR ACTION:

NOTE: A mast that is shimmed too loose will cause the rollers to ride up on the flange edge and produce a flaring wear pattern.

1. Inspect mast and carriage shimming.
   Is mast shimmed correctly?
   YES: Go to Cause E.
   NO: Adjust or repair as required.

CAUSE E - LOAD ROLLERS ARE NOT ROTATING FREELY WITHIN CHANNEL

PROCEDURE OR ACTION:

1. Inspect mast channel rollers.
   Do the rollers rotate freely?
   YES: Go to Cause F.
   NO: Replace load rollers.

CAUSE F - DAMAGED OR WORN LOAD ROLLERS OR STRIP BEARINGS

PROCEDURE OR ACTION:

1. Inspect load rollers and strip bearings.
   Are the load rollers and strip bearings in good condition?
   YES: Go to Cause G.
   NO: Adjust, repair, or replace load rollers and strip bearings as required.

CAUSE G - LIFT CYLINDER BINDING

PROCEDURE OR ACTION:

1. Remove cylinder.
2. Manually extend cylinder exterior.
   Does cylinder extend freely?
   YES: Mast is loose. See Observed Symptoms, Page 9070-30-24.
   NO: Service or replace cylinder.

END SYMPTOM

Abnormal Hose Wear

POSSIBLE CAUSE

A. MAST DAMAGED
B. HOSES RUBBING ON COMPONENTS
C. IMPROPER HOSE ROUTING
D. HYDRAULIC RELIEF PRESSURE SET TOO HIGH
E. TOO HIGH/LOW HYDRAULIC OIL TEMPERATURE

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause D.
   NO: Repair or replace damaged components.

CAUSE B - HOSES RUBBING ON COMPONENTS

PROCEDURE OR ACTION:

1. Inspect hoses for wear and tension.
   Is hose tension correct?
   YES: Go to Cause C.
   NO: Adjust or replace hoses or sheaves as required.

CAUSE C - IMPROPER HOSE ROUTING

PROCEDURE OR ACTION:

1. Inspect and adjust lift cylinder hoses.
   Are the hoses in good condition and adjusted correctly?
   YES: Go to Cause D.
   NO: Adjust or replace hoses as required.

CAUSE D - HYDRAULIC RELIEF PRESSURE SET TOO HIGH

PROCEDURE OR ACTION:

1. Test hydraulic relief pressure. See Main System Relief Test and Adjustment.
   Is pressure within test specifications?
   YES: Go to Cause E.
   NO: Adjust pressure to test specifications. See Main Relief Valve Test and Adjustment.

CAUSE E - TOO HIGH/LOW HYDRAULIC OIL TEMPERATURE

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Insure that hydraulic oil temperature is within the recommended operating range for the lift truck.

END SYMPTOM

Abnormal Mast Noise

POSSIBLE CAUSE

A. MAST DAMAGED
B. LOOSE OR MISSING MAST MOUNTING HARDWARE
C. LOOSE FORK FIT TO CARRIAGE
D. DAMAGED CHAIN SHEAVES
E. AIR IN HYDRAULIC SYSTEM
F. MAST CHANNELS LACK LUBRICATION
G. MAST MOUNTING BUSHINGS LACK LUBRICATION OR DAMAGED
H. MAST TILT BUSHINGS LACK LUBRICATION OR DAMAGED
I. CHAINS LOOSE OR NOT EQUAL
J. WORN LOAD ROLLERS OR STRIP BEARINGS
K. MAST CHANNELS ARE WORN
L. NOISY LIFT CYLINDER SEALS

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - LOOSE OR MISSING MAST MOUNTING HARDWARE

PROCEDURE OR ACTION:

1. Inspect mast mounting hardware.
   Is hardware in good condition and torqued correctly?
   YES: Go to Cause C.
   NO: Replace mast mounting hardware.

CAUSE C - LOOSE FORK FIT TO CARRIAGE

PROCEDURE OR ACTION:

1. Inspect carriage bar and fork hooks for wear.
   Do forks fit correctly and in good condition?
   YES: Go Cause D.
   NO: Replace carriage or forks if worn.

CAUSE D - DAMAGED CHAIN SHEAVES

PROCEDURE OR ACTION:

1. Inspect chain sheaves.
   Do chain sheaves rotate freely without noise?
   YES: Go to Cause E.
   NO: Replace chain sheaves.

CAUSE E - AIR IN HYDRAULIC SYSTEM

PROCEDURE OR ACTION:

1. Inspect oil condition and level in hydraulic tank.
   Is the hydraulic oil level in the operating range and in good condition?
   YES: Cause F.
   NO: If oil level is low, add oil. If hydraulic oil is aerated, locate source of suction side leak and repair.

CAUSE F - MAST CHANNELS LACK LUBRICATION

PROCEDURE OR ACTION:

1. Inspect grease on mast channels.
   Is a thin coat of grease spread evenly on channels?
   YES: Go to Cause G.
   NO: Apply grease to mast sliding surfaces.

CAUSE G - MAST MOUNTING BUSHINGS LACK LUBRICATION OR DAMAGED

PROCEDURE OR ACTION:

1. Inspect mast bushings.
   Are the mast bushings greased and in good condition?
   YES: Go Cause H.
   NO: Lubricate mast bushings.

CAUSE H - MAST TILT BUSHINGS LACK LUBRICATION OR DAMAGED

PROCEDURE OR ACTION:

1. Inspect mast tilt bushings.
   Are the mast tilt bushings greased and in good condition?
   YES: Go to Cause I.
   NO: Lubricate mast tilt bushings. Replace as required.

CAUSE I - CHAINS LOOSE OR NOT EQUAL

PROCEDURE OR ACTION:

1. Inspect chains.
   Are chains adjusted correctly and in good condition?
   YES: Go to Cause J.
   NO: Adjust or repair chains.

CAUSE J - WORN LOAD ROLLERS OR STRIP BEARINGS

PROCEDURE OR ACTION:

1. Inspect load rollers and strip bearings.
   Are the load rollers and strip bearings in good condition?
   YES: Go to Cause K.
   NO: Adjust, repair, or replace load rollers and strip bearings as required.

CAUSE K - MAST CHANNELS ARE WORN

PROCEDURE OR ACTION:

1. Inspect mast channels for wear or damage.
   Are the mast channels in good condition?
   YES: Go to Cause L.
   NO: Repair or replace worn mast components.

CAUSE L - NOISY LIFT CYLINDER SEALS

NOTE: Confirm that correct hydraulic oil is being used, see **Operating Manual**.

PROCEDURE OR ACTION:

1. On 2-Stage LFL, 3-Stage FFL, and 4-Stage FFL, apply thin film of hydraulic oil on cylinder rods.
   Does the noise stop?
   YES: Remove gland and add hydraulic oil.
   NO: Install new cylinder seal.

END SYMPTOM

Body Panels Making Noise

POSSIBLE CAUSE

A. ATTACHING HARDWARE IS LOOSE
B. FAILED LATCHES OR HINGES

CAUSE A - ATTACHING HARDWARE IS LOOSE

PROCEDURE OR ACTION:

1. Visually inspect mounting points for damage and loose or missing hardware.
   Are body panels and attaching hardware in good condition?
   YES: Inspect and repair hinges and latches. Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - FAILED LATCHES OR HINGES

PROCEDURE OR ACTION:

1. Inspect hinges and latches for correct operation.
   Are the hinges and latches in good condition?
   YES: Operating lift truck too fast on rough surface, reduce speed.
   NO: Adjust or repair latches and hinges as required.

END SYMPTOM

External Leakage From Free-Lift or Main Lift Cylinders

POSSIBLE CAUSE

A. MAST DAMAGED
B. CYLINDER HOSES OR FITTINGS LOOSE OR DAMAGED
C. CYLINDER SEAL DAMAGE OR INCORRECT INSTALLATION
D. CYLINDER ROD DAMAGE

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - CYLINDER HOSES OR FITTINGS LOOSE OR DAMAGED

PROCEDURE OR ACTION:

1. Inspect hoses and fittings for damage and proper torque.
   Are hose and fittings in good condition and torqued correctly?
   YES: Go to Cause C.
   NO: Adjust or replace hoses or fittings as required.

CAUSE C - CYLINDER SEAL DAMAGE OR INCORRECT INSTALLATION

PROCEDURE OR ACTION:

1. Inspect lift cylinder seals.
   Are the seals in good condition and installed correctly?
   YES: Go to Cause D.
   NO: Adjust or replace seals as required.

CAUSE D - CYLINDER ROD DAMAGE

PROCEDURE OR ACTION:

1. Inspect cylinder rod for damage.
   Is cylinder rod in good condition?
   YES: Problem solved. Resume operations.
   NO: Replace cylinder rod or cylinder.

END SYMPTOM

FFL Mast Banging During Phasing

POSSIBLE CAUSE

A. **MAST DAMAGED**
B. **FREE-LIFT CYLINDER TOP STROKE CUSHIONING NOT OPERATING**
C. **MAIN CYLINDER CUSHION NOT OPERATING WHEN FULLY LOWERED**
D. **CARRIAGE BINDING IN INNER MAST**
E. **CARRIAGE CONTACTS STOP AT TOP OF INNER MAST**

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - FREE-LIFT CYLINDER TOP STROKE CUSHIONING NOT OPERATING

PROCEDURE OR ACTION:

1. Confirm that cushioning oil is on top side of cylinder piston.
   Is cushioning oil level correct?
   YES: Go to Cause C.
   NO: Add oil.

CAUSE C - MAIN CYLINDER CUSHION NOT OPERATING WHEN FULLY LOWERED

PROCEDURE OR ACTION:

1. Operate lift lower and note speed as cylinder reached end of stroke.
   Does cylinder speed slow during final 25 mm (1.0 in.) of cylinder stroke?
   YES: Go to Cause D.
   NO: Repair or replace cylinder.

CAUSE D - CARRIAGE BINDING IN INNER MAST

PROCEDURE OR ACTION:

1. Observe carriage travels to the end of free lift cylinder stroke.
   Does the carriage go to end of free lift cylinder stroke?
   YES: Go to Cause E.
   NO: Shim carriage rollers.

CAUSE E - CARRIAGE CONTACTS STOP AT TOP OF INNER MAST

PROCEDURE OR ACTION:

1. Inspect free lift chains.
   Can lift chains be adjusted?
   YES: Adjust chains.
   NO: Replace free lift chains.

END SYMPTOM

High Tire Wear - Drive Axle

POSSIBLE CAUSE

A. RUNNING OVER OIL/SOLVENTS AND DEBRIS
B. LOW PNEUMATIC TIRE INFLATION
C. HIGH PNEUMATIC TIRE INFLATION
D. EXCESSIVE SPEED ON TURNS AND STOPS
E. EXCESSIVE LOADS
F. SPINNING TIRES DURING STARTS AND STOPS
G. FAILED WHEEL BEARINGS

CAUSE A - RUNNING OVER OIL/SOLVENTS AND DEBRIS

PROCEDURE OR ACTION:

1. Visually inspect work area for contaminates and debris.

CAUSE B - LOW PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE C - HIGH PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE D - EXCESSIVE SPEED ON TURNS AND STOPS

PROCEDURE OR ACTION:

1. Reduce speed and spinning of wheels.

CAUSE E - EXCESSIVE LOADS

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

1. Check load weight and compare to truck capacity rating.

CAUSE F - SPINNING TIRES DURING STARTS AND STOPS

PROCEDURE OR ACTION:

1. Check transmission operation. See Driving Checks, Operational Checkout Procedures.
   Does transmission pass operational check?
   YES: Reduce acceleration during starts and stops.
   NO: Check transmission calibration.

CAUSE G - FAILED WHEEL BEARINGS

PROCEDURE OR ACTION:

1. Inspect wheel bearings.
   Are bearing in good condition?
   YES: Tires are defective, See tire manufacture for warranty.
   NO: Replace wheel bearing.

END SYMPTOM

High Tire Wear - Steer Axle

POSSIBLE CAUSE

A. RUNNING OVER OIL/SOLVENTS AND DEBRIS
B. EXCESSIVE SPEED ON TURNS AND STOPS
C. TURNING WITH MACHINE STOPPED OR NO LOAD ON FORKS
D. LOW PNEUMATIC TIRE INFLATION
E. HIGH PNEUMATIC TIRE INFLATION
F. FAILED WHEEL BEARINGS
G. LOOSE TIE RODS

CAUSE A - RUNNING OVER OIL/SOLVENTS AND DEBRIS

PROCEDURE OR ACTION:

1. Visually inspect work area for contaminates and debris.

CAUSE B - EXCESSIVE SPEED ON TURNS AND STOPS

PROCEDURE OR ACTION:

1. Reduce speed and spinning of wheels.

CAUSE C - TURNING WITH MACHINE STOPPED OR NO LOAD ON FORKS

PROCEDURE OR ACTION:

NOTE: Steering without load on forks puts the highest load on steer axle because of counterweight. Avoid steering wheels when not moving to reduce tire wear.

1. Steer while moving whenever possible.

CAUSE D - LOW PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE E - HIGH PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE F - FAILED WHEEL BEARINGS

PROCEDURE OR ACTION:

1. Inspect wheel bearings.
   Are bearing in good condition?
   YES: Tires are defective. See tire manufacture for warranty.
   NO: Replace wheel bearing.

CAUSE G - LOOSE TIE RODS

PROCEDURE OR ACTION:

1. Inspect joint where tie rods are attached to pinion assembly.
   Is the tie rod tight in bore?
   YES: See Observed Symptoms, Page 9070-30-39.
   NO: Replace tie rod.

END SYMPTOM

Hoses Not Tracking Correctly

POSSIBLE CAUSE

A. MAST DAMAGED
B. IMPROPER HOSE TENSION
C. IMPROPER HOSE ROUTING
D. HOSES WORN

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - IMPROPER HOSE TENSION

PROCEDURE OR ACTION:

1. Check hose tension.
   Is hose tension correct?
   YES: Go to Cause C.
   NO: Adjust hose tension.

CAUSE C - IMPROPER HOSE ROUTING

PROCEDURE OR ACTION:

1. Inspect lift cylinder hoses.
   Are the hoses in good condition and adjusted correctly?
   YES: Go to Cause D.
   NO: Adjust or replace hoses as required.

CAUSE D - HOSES WORN

PROCEDURE OR ACTION:

1. Inspect hoses for uneven or excessive wear.
   Are hoses wearing evenly?
   YES: Locate cause of hoses wear. See Observed Symptoms, Page 9070-30-3.
   NO: Adjust or replace hoses as required.

END SYMPTOM

Integral Sideshift Moving Too Fast

POSSIBLE CAUSE

A. ORIFICES IN SIDESHIFT CYLINDER MISSING OR INSTALLED BACKWARD
B. ELECTRO-HYDRAULIC CONTROL VALVE OUT OF CALIBRATION

CAUSE A - ORIFICES IN SIDESHIFT CYLINDER MISSING OR INSTALLED BACKWARD

PROCEDURE OR ACTION:

CAUTION

Cylinder orifices are made from soft metal and can be easily damaged. Do not alter cylinder orifice size while cleaning.

1. Inspect cylinder port orifices.
   Are the orifices clean and installed correctly?
   YES: Reduce engine speed or control lever speed of movement to slow function. See **Parts Manual** to see if smaller size orifices are available.
   NO: Adjust or install orifices.

CAUSE B - ELECTRO-HYDRAULIC CONTROL VALVE OUT OF CALIBRATION

PROCEDURE OR ACTION:

1. Check electro-hydraulic control valve calibration. Install Service Tool.
   Is valve calibration correct?
   YES: Calibrate valve to operator's preference or reduce engine speed to slow function.
   NO: Calibrate valve to operator's preference.

END SYMPTOM

Integral Sideshift Not Moving or Slow

POSSIBLE CAUSE

A. NO OIL OR NOT ENOUGH OIL IN HYDRAULIC TANK
B. LINKAGE TO CONTROL VALVE DISCONNECTED OR DAMAGED (MANUAL CONTROL VALVE)
C. HYDRAULIC CONTROL VALVE CALIBRATED WRONG (E-VALVE)
D. WIRING CONNECTOR LOOSE OR DISCONNECTED ON CONTROL VALVE (E-VALVE)
E. INTEGRAL SIDESHIFT CARRIAGE DAMAGED
F. CLAMP BLOCKS TOO TIGHT
G. CONTAMINATION OR LACK OF LUBRICATION IS BINDING BEARINGS
H. DAMAGED CARRIAGE BEARINGS
I. HOSES NOT INSTALLED CORRECTLY
J. NO OIL FLOW TO SIDESHIFT CYLINDER
K. INCORRECT HYDRAULIC RELIEF PRESSURE SETTING
L. INSUFFICIENT OIL FLOW TO CYLINDER
M. DEFECTIVE SIDESHIFT CYLINDER

CAUSE A - NO OIL OR NOT ENOUGH OIL IN HYDRAULIC TANK

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Check hydraulic tank oil level and adjust as required.

CAUSE B - LINKAGE TO CONTROL VALVE DISCONNECTED OR DAMAGED (MANUAL CONTROL VALVE)

PROCEDURE OR ACTION:

1. Inspect valve linkage.
   Is the linkage moving the valve spool full travel?
   YES: Go to Cause E.
   NO: Repair or adjust linkage.

CAUSE C - HYDRAULIC CONTROL VALVE CALIBRATED WRONG (E-VALVE)

PROCEDURE OR ACTION:

1. Check electro-hydraulic control valve calibration. Install Service Tool.
   Is valve calibration correct?
   YES: Calibrate valve to operator's preference or reduce engine speed to slow function.
   NO: Calibrate valve to operator's preference.

CAUSE D - WIRING CONNECTOR LOOSE OR DISCONNECTED ON CONTROL VALVE (E-VALVE)

PROCEDURE OR ACTION:

1. Inspect wiring connections at valve and joystick/MLM controller.
   Are the connectors in good condition and installed correctly?
   YES: Go to Cause E.
   NO: Repair or replace wiring connectors.

CAUSE E - INTEGRAL SIDESHIFT CARRIAGE DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect carriage for damage.
   Is the carriage in good condition?
   YES: Go to Cause F.
   NO: Repair or replace damaged components.

CAUSE F - CLAMP BLOCKS TOO TIGHT

PROCEDURE OR ACTION:

1. Adjust clamp blocks.

CAUSE G - CONTAMINATION OR LACK OF LUBRICATION IS BINDING BEARINGS

PROCEDURE OR ACTION:

1. Inspect bearings.
   Are bearings worn or need lubrication?
   YES: Lubricate or replace bearings.
   NO: Go to Cause H.

CAUSE H - DAMAGED CARRIAGE BEARINGS

PROCEDURE OR ACTION:

1. Disassemble outer frame.
   Are bearings in good condition?
   YES: Go to Cause I.
   NO: Service or replace bearings.

CAUSE I - HOSES NOT INSTALLED CORRECTLY

NOTE: Check maintenance records to determine last repairs done to truck.

PROCEDURE OR ACTION:

1. Inspect hose routing and connections.
   Are hoses adjusted correctly and in good condition?
   YES: Go to Cause J.
   NO: Adjust or repair hoses.

CAUSE J - NO OIL FLOW TO SIDESHIFT CYLINDER

PROCEDURE OR ACTION:

1. Remove pin from rod end of cylinder.
2. Slowly operate sideshift cylinder control and observe cylinder rod movement.
   Does the cylinder rod move when controls are activated?
   YES: Install cylinder rod pin. Go to Cause K.
   NO: Determine if problem is in cylinder or control valve. Go to Cause L.

CAUSE K - INCORRECT HYDRAULIC RELIEF PRESSURE SETTING

PROCEDURE OR ACTION:

1. Test secondary relief valve pressure.
   Is the secondary relief pressure at specifications?
   YES: Go to Cause L.
   NO: Adjust or replace secondary relief valve.

CAUSE L - INSUFFICIENT OIL FLOW TO CYLINDER

PROCEDURE OR ACTION:

1. Perform Cycle Times.
   Is the sideshift the only hydraulic function that is slow.
   YES: Go to Step 2.
   NO: Problem is in hydraulic pump circuit. See Hydraulic Pump Flow Test.
2. Check electro-hydraulic control valve calibration. Install Service Tool.
   Is valve calibration correct?
   YES: Go to Cause M.
   NO: Calibrate valve to operator's preference.

CAUSE M - DEFECTIVE SIDESHIFT CYLINDER

PROCEDURE OR ACTION:

CAUTION

Cylinder orifices are made from soft metal and can be easily damaged. Do not alter cylinder orifice size while cleaning.

1. Inspect and clean cylinder port orifices.
   Are the orifices clean and installed correctly?
   YES: Remove and repair cylinder.
   NO: Adjust or replace orifices.

END SYMPTOM

LP Tank Bracket Disengages

POSSIBLE CAUSE

A. ATTACHING HARDWARE IS LOOSE
B. FAILED LATCHES OR HINGES

CAUSE A - ATTACHING HARDWARE IS LOOSE

PROCEDURE OR ACTION:

1. Visually inspect mounting points for damage and loose or missing hardware.
   Are brackets and attaching hardware in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - FAILED LATCHES OR HINGES

PROCEDURE OR ACTION:

1. Inspect hinges and latches for correct operation.
   Are the hinges and latches in good condition?
   YES: Ensure LP tank is secure and resume operation.
   NO: Adjust or repair latches and hinges as required.

END SYMPTOM

LP Tank Rattles and Does Not Stay Latched

POSSIBLE CAUSE

A. LATCH TRIPPED OR LATCH SPRING FAILED
B. ATTACHING HARDWARE IS LOOSE
C. FAILED LATCHES OR HINGES

CAUSE A - LATCH TRIPPED OR LATCH SPRING FAILED

PROCEDURE OR ACTION:

1. Inspect latch to make sure it has not been manually tripped before closing.
   Was the latch manually closed?
   YES: Trip latch to open latch, then close bracket to lock in place.
   NO: Spring has failed, replace latch.

CAUSE B - ATTACHING HARDWARE IS LOOSE

PROCEDURE OR ACTION:

1. Visually inspect mounting points for damage and loose or missing hardware.
   Are brackets and attaching hardware in good condition?
   YES: Go to Cause C.
   NO: Repair or replace damaged components.

CAUSE C - FAILED LATCHES OR HINGES

PROCEDURE OR ACTION:

1. Inspect hinges and latches for correct operation.
   Are the hinges and latches in good condition?
   YES: Ensure LP tank is secure and resume operation.
   NO: Adjust or repair latches and hinges as required.

END SYMPTOM

Fork Positioner Not Moving or Slow

POSSIBLE CAUSE

A. NO OIL OR NOT ENOUGH OIL IN HYDRAULIC TANK
B. LINKAGE TO CONTROL VALVE DISCONNECTED OR DAMAGED (MANUAL CONTROL VALVE)
C. HYDRAULIC CONTROL VALVE CALIBRATED WRONG (E-VALVE)
D. WIRING CONNECTOR LOOSE OR DISCONNECTED ON CONTROL VALVE (E-VALVE)
E. SIDESHIFT CARRIAGE DAMAGED
F. CONTAMINATION OR LACK OF LUBRICATION IS BINDING BEARINGS
G. DAMAGED CARRIAGE BEARINGS
H. HOSES NOT INSTALLED CORRECTLY
I. NO OIL FLOW TO FORK POSITIONER CYLINDER
J. INCORRECT HYDRAULIC RELIEF PRESSURE SETTING
K. INSUFFICIENT OIL FLOW TO CYLINDER
L. DEFECTIVE FORK POSITIONER CYLINDER

CAUSE A - NO OIL OR NOT ENOUGH OIL IN HYDRAULIC TANK

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Check hydraulic tank oil level and adjust as required.

CAUSE B - LINKAGE TO CONTROL VALVE DISCONNECTED OR DAMAGED (MANUAL CONTROL VALVE)

PROCEDURE OR ACTION:

1. Inspect valve linkage.
   Is the linkage moving the valve spool full travel?
   YES: Go to Cause E.
   NO: Repair or adjust linkage. Refer to the appropriate **Main Control Valve** SRM .

CAUSE C - HYDRAULIC CONTROL VALVE CALIBRATED WRONG (E-VALVE)

PROCEDURE OR ACTION:

1. Check electro-hydraulic control valve calibration. Install Service Tool.
   Is valve calibration correct?
   YES: Calibrate valve to operator's preference or reduce engine speed to slow function.
   NO: Calibrate valve to operator's preference. Refer to the appropriate **Calibration Procedures** SRM .

CAUSE D - WIRING CONNECTOR LOOSE OR DISCONNECTED ON CONTROL VALVE (E-VALVE)

PROCEDURE OR ACTION:

1. Inspect wiring connections at valve and joystick/MLM controller.
   Are the connectors in good condition and installed correctly?
   YES: Go to Cause E.
   NO: Repair or replace wiring connectors. Refer to the appropriate **Wire Harness Repair** SRM .

CAUSE E - SIDESHIFT CARRIAGE DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect carriage for damage.
   Is the carriage in good condition?
   YES: Go to Cause F.
   NO: Repair or replace damaged components. Refer to the appropriate **Mast Repair** SRM .

CAUSE F - CONTAMINATION OR LACK OF LUBRICATION IS BINDING BEARINGS

PROCEDURE OR ACTION:

1. Inspect bearings. Refer to the appropriate **Mast Repair** SRM .
   Are bearings worn or need lubrication?
   YES: Lubricate or replace bearings.
   NO: Go to Cause G.

CAUSE G - DAMAGED CARRIAGE BEARINGS

PROCEDURE OR ACTION:

1. Disassemble outer frame. Refer to the appropriate **Mast Repair** SRM .
   Are bearings in good condition?
   YES: Go to Cause H.
   NO: Service or replace bearings.

CAUSE H - HOSES NOT INSTALLED CORRECTLY

NOTE: Check maintenance records to determine last repairs done to truck.

PROCEDURE OR ACTION:

1. Inspect hose routing and connections. Refer to the appropriate **Mast Repair** SRM .
   Are hoses adjusted correctly and in good condition?
   YES: Go to Cause I.
   NO: Adjust or repair hoses.

CAUSE I - NO OIL FLOW TO FORK POSITIONER CYLINDER

PROCEDURE OR ACTION:

1. Remove pin from rod end of cylinder. Refer to the appropriate **Mast Repair** SRM .
2. Slowly operate sideshift cylinder control and observe cylinder rod movement.
   Does the cylinder rod move when controls are activated?
   YES: Install cylinder rod pin. Go to Cause J.
   NO: Determine if problem is in cylinder or control valve. Go to Cause H.

CAUSE J - INCORRECT HYDRAULIC RELIEF PRESSURE SETTING

PROCEDURE OR ACTION:

1. Test secondary relief valve pressure. Refer to the appropriate **Main Control Valve** SRM .
   Is the secondary relief pressure at specifications?
   YES: Go to Cause K.
   NO: Adjust or replace secondary relief valve.

CAUSE K - INSUFFICIENT OIL FLOW TO CYLINDER

PROCEDURE OR ACTION:

1. Perform Cycle Times. Refer to the appropriate **Capacities and Specifications** SRM .
   Is the sideshift the only hydraulic function that is slow.
   YES: Go to Step 2.
   NO: Problem is in hydraulic pump circuit. See Hydraulic Pump Flow Test.
2. Check electro-hydraulic control valve calibration. Install Service Tool.
   Is valve calibration correct?
   YES: Go to Cause L.
   NO: Calibrate valve to operator's preference. Refer to the appropriate **Calibration Procedures** SRM .

CAUSE L - DEFECTIVE FORK POSITIONER CYLINDER

PROCEDURE OR ACTION:

CAUTION

Cylinder orifices are made from soft metal and can be easily damaged. Do not alter cylinder orifice size while cleaning.

1. Inspect and clean cylinder port orifices. Refer to the appropriate **Cylinder Repair** SRM .
   Are the orifices clean and installed correctly?
   YES: Remove and repair cylinder.
   NO: Adjust or replace orifices.

END SYMPTOM

Mast is Loose

POSSIBLE CAUSE

A. MAST DAMAGED
B. LOOSE OR MISSING MAST MOUNTING HARDWARE
C. MAST NOT SHIMMED CORRECTLY
D. DAMAGED LOAD ROLLERS OR WORN STRIP BEARINGS
E. CHANNELS WORN

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - LOOSE OR MISSING MAST MOUNTING HARDWARE

PROCEDURE OR ACTION:

1. Inspect mast mounting hardware.
   Is mounting hardware in good condition and torqued correctly?
   YES: Go to Cause C.
   NO: Replace mast mounting hardware.

CAUSE C - MAST NOT SHIMMED CORRECTLY

PROCEDURE OR ACTION:

1. Inspect mast shimming.
   Is the mast shimmed correctly?
   YES: Go to Cause D.
   NO: Shim or adjust as required.

CAUSE D - DAMAGED LOAD ROLLERS OR WORN STRIP BEARINGS

PROCEDURE OR ACTION:

1. Inspect load rollers and strip bearings.
   Are the load rollers and strip bearings in good condition?
   YES: Go to Cause E.
   NO: Adjust, repair, or replace load rollers and strip bearings as required.

CAUSE E - CHANNELS WORN

PROCEDURE OR ACTION:

1. Repair or replace mast components.

END SYMPTOM

Mast Lift Chains Are Loose

POSSIBLE CAUSE

A. **MAST DAMAGED**
B. **DAMAGED CHAIN SHEAVES**
C. **INCORRECT CHAIN ADJUSTMENT**

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause C.
   NO: Repair or replace damaged components.

CAUSE B - DAMAGED CHAIN SHEAVES

PROCEDURE OR ACTION:

1. Inspect chain sheaves.
   Do chain sheaves rotate freely without noise?
   YES: Go to Cause C.
   NO: Replace chain sheaves.

CAUSE C - INCORRECT CHAIN ADJUSTMENT

PROCEDURE OR ACTION:

1. Inspect lift chains.
   Are the chains in good condition and adjusted correctly?
   YES: See Observed Symptoms, Page 9070-30-26.
   NO: Adjust or replace chain.

END SYMPTOM

Mast or Carriage Binding

POSSIBLE CAUSE

A. MAST OR CARRIAGE DAMAGED
B. MAST CHANNELS LACK LUBRICATION
C. MAST NOT SHIMMED CORRECTLY
D. CHAINS ARE LOOSE OR NOT EQUAL
E. CONTAMINATION IN CHANNELS IS BINDING LOAD ROLLERS
F. DAMAGED OR WORN LOAD ROLLERS OR STRIP BEARINGS
G. LIFT CYLINDER BINDING

CAUSE A - MAST OR CARRIAGE DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast and carriage for damage.
   Are components in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - MAST CHANNELS LACK LUBRICATION

PROCEDURE OR ACTION:

1. Inspect grease on mast channels.
   Is a thin coat of grease spread evenly on channels?
   YES: Go to Cause C.
   NO: Apply grease to mast sliding surfaces.

CAUSE C - MAST NOT SHIMMED CORRECTLY

PROCEDURE OR ACTION:

1. Inspect mast shimming.
   Is the mast shimmed correctly?
   YES: Go to Cause E.
   NO: Shim or adjust as required.

CAUSE D - CHAINS ARE LOOSE OR NOT EQUAL

PROCEDURE OR ACTION:

1. Inspect lift chains.
   Are chains adjusted correctly and in good condition?
   YES: Go to Cause E.
   NO: Adjust or repair chains.

CAUSE E - CONTAINMINATION IN CHANNELS IS BINDING LOAD ROLLERS

PROCEDURE OR ACTION:

1. Inspect mast channels.
   Do the rollers rotate freely?
   YES: Go to Cause F.
   NO: Replace load rollers.

CAUSE F - DAMAGED OR WORN LOAD ROLLERS OR STRIP BEARINGS

PROCEDURE OR ACTION:

1. Inspect load rollers and strip bearings.
   Are the load rollers and strip bearings in good condition?
   YES: Go to Cause G.
   NO: Adjust, repair, or replace load rollers and strip bearings as required.

CAUSE G - LIFT CYLINDER BINDING

PROCEDURE OR ACTION:

1. Remove cylinder.
2. Manually extend cylinder exterior.
   Does cylinder extend freely?
   YES: Mast is loose. See Observed Symptoms, Page 9070-30-24.
   NO: Service or replace cylinder.

END SYMPTOM

Mast/Carriage Bounces or is Spongy

POSSIBLE CAUSE

A. **MAST DAMAGED**
B. **AIR IN HYDRAULIC SYSTEM**
C. **TRAPPED AIR IN LIFT CYLINDER(S)**
D. **TWO-STAGE FFL MAST MAIN CYLINDERS NOT BLED OF AIR**

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - AIR IN HYDRAULIC SYSTEM

PROCEDURE OR ACTION:

1. Inspect oil condition and level in hydraulic tank.
   Is the hydraulic oil level in the operating range and in good condition?
   YES: Go to Cause C.
   NO:
   - If oil level is low, add oil.
   - If hydraulic oil is aerated, locate source of suction side leak and repair.

CAUSE C - TRAPPED AIR IN LIFT CYLINDER(S)

PROCEDURE OR ACTION:

1. Fully extend and lower the mast several times.
   Does the mast raise and lower without hesitation?
   YES: Go to Cause D.
   NO: Go to Step 2.
2. Open mast, lower valve, and operate all hydraulic functions in both directions.
3. Close mast lower valve.
4. Repeat Step 1 to see if problem has been solved.

CAUSE D - TWO-STAGE FFL MAST MAIN CYLINDERS NOT BLED OF AIR

PROCEDURE OR ACTION:

1. Bleed air from cylinders.

END SYMPTOM

Misphasing of Full Free-Lift Mast

POSSIBLE CAUSE

A. MAST DAMAGED
B. COLD OPERATING CONDITIONS
C. CARRIAGE IS BINDING
D. HYDRAULIC RESTRICTION TO FREE-LIFT CYLINDER
E. EXCESSIVE OIL ON TOP SIDE OF FREE-LIFT CYLINDER PISTON

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - COLD OPERATING CONDITIONS

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Confirm that oil is at correct operating temperature. See Hydraulic Warm-up Procedure.
   Does mast misphase after oil is at operating temperature?
   YES: Go to Cause C.
   NO: Incorrect hydraulic oil is being used. Consult **Operating Manual** for correct grade of hydraulic oil for your operating conditions.

CAUSE C - CARRIAGE IS BINDING

PROCEDURE OR ACTION:

1. Check carriage shimming.
   Is carriage shimmed correctly?
   YES: Go to Cause D.
   NO: Adjust or repair carriage.

CAUSE D - HYDRAULIC RESTRICTION TO FREE-LIFT CYLINDER

PROCEDURE OR ACTION:

1. Visually inspect hoses and fittings for damage
   Are hoses and fitting in good condition?
   YES: Go to Cause E.
   NO: Replace damaged hoses and fittings.

CAUSE E - EXCESSIVE OIL ON TOP SIDE OF FREE-LIFT CYLINDER PISTON

PROCEDURE OR ACTION:

1. Raise mast to full lift height without load and hold at relief pressure for 5 seconds.
2. Recheck for misphasing.
   Does the mast still misphase?
   YES: Remove cylinder, check piston seal and check valve.
   NO: Problem solved.

END SYMPTOM

Overhead Guard Loose or Damaged

POSSIBLE CAUSE

A. OVERHEARD GUARD DAMAGED
B. ATTACHING HARDWARE IS LOOSE
C. OPERATING TOO FAST OVER ROUGH FLOORS

CAUSE A - OVERHEARD GUARD DAMAGED

PROCEDURE OR ACTION:

WARNING

Death or injury can occur from falling objects. Do not operate lift truck with a damaged overhead guard.

1. Inspect overhead guard.
   Is the overhead guard in good condition?
   YES: Go to Cause B.
   NO: Replace overhead guard.

CAUSE B - ATTACHING HARDWARE IS LOOSE

PROCEDURE OR ACTION:

1. Visually inspect mounting points for damage and loose or missing hardware.
   Is overhead guard and attaching hardware in good condition?
   YES: Go to Cause C.
   NO: Repair or replace damaged components.

CAUSE C - OPERATING TOO FAST OVER ROUGH FLOORS

PROCEDURE OR ACTION:

1. Reduce speed and listen for noise.
   Does noise reduce with reduction in ground speed?
   YES: Reduce speed or install softer tires.
   NO: Refer to the appropriate **Frame Manual**.

END SYMPTOM

Racking During Lift

POSSIBLE CAUSE

A. MAST DAMAGED
B. MAIN LIFT CYLINDER NOT SHIMMED CORRECTLY
C. MAIN LIFT CYLINDER CHAINS LOOSE OR UNEQUAL
D. UNEQUAL MAIN LIFT CYLINDER ROD STROKE
E. LIFT CYLINDER BINDING

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - MAIN LIFT CYLINDER NOT SHIMMED CORRECTLY

PROCEDURE OR ACTION:

1. Check cylinder shimming.
   Is cylinder shimmed correctly?
   YES: Go to Cause C.
   NO: Adjust or repair cylinder.

CAUSE C - MAIN LIFT CYLINDER CHAINS LOOSE OR UNEQUAL

PROCEDURE OR ACTION:

1. Check chains.
   Are the chains adjusted correctly?
   YES: Go to Cause D.
   NO: Adjust or replace chains.

CAUSE D - UNEQUAL MAIN LIFT CYLINDER ROD STROKE

PROCEDURE OR ACTION:

1. Operate lift and compare each cylinder rod stroke.
   Are the cylinder rod strokes equal?
   YES: Go to Cause E.
   NO: Replace cylinder or cylinders spacers (if equipped).

CAUSE E - LIFT CYLINDER BINDING

PROCEDURE OR ACTION:

1. Remove cylinder.
2. Manually extend cylinder.
   Does cylinder extend freely?
   YES: Cylinder is OK. See Observed Symptoms, Page 9070-30-24.
   NO: Repair or replace cylinder.

END SYMPTOM

Racking During Tilt

POSSIBLE CAUSE

A. MAST DAMAGED
B. TILT ROD OUT OF ADJUSTMENT
C. UNEQUAL LENGTH OF BACK TILT SPACERS

CAUSE A - MAST DAMAGED

NOTE: See **Operating Manual**.

PROCEDURE OR ACTION:

1. Visually inspect mast for damage.
   Is the mast in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - TILT ROD OUT OF ADJUSTMENT

PROCEDURE OR ACTION:

1. Inspect tilt rod.
   Is tilt rod adjusted correctly?
   YES: Go to Cause C.
   NO: Adjust tilt rod.

CAUSE C - UNEQUAL LENGTH OF BACK TILT SPACERS

PROCEDURE OR ACTION:

1. Inspect length of spacers.
   Are back tilt spacers equal?
   YES: Mast is too loose. See Observed Symptoms, Page 9070-30-24.
   NO: Adjust or replace spacers.

END SYMPTOM

Truck Feels Unstable

POSSIBLE CAUSE

A. **OPERATING WITH TOO LARGE A LOAD**
B. **LOW PNEUMATIC TIRE INFLATION**
C. **LOAD IS BEING CARRIED TOO HIGH**
D. **AXLE MOUNTS ARE LOOSE**
E. **OPERATING AT TOO HIGH A SPEED**
F. **FAILED WHEEL BEARINGS**
G. **LOOSE TIE RODS**
H. **OPERATING OFF HARD SURFACES**
I. **MAST IS TOO LOOSE**

CAUSE A - OPERATING WITH TOO LARGE A LOAD

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

NOTE: Carrying a load that exceeds truck capacity will cause the steer axle wheels to loose contact with ground and negatively affect control of truck.

1. Check load weight and compare to truck capacity rating.

CAUSE B - LOW PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE C - LOAD IS BEING CARRIED TOO HIGH

PROCEDURE OR ACTION:

1. Carry load as low as possible to lower center of gravity and improve stability.

CAUSE D - AXLE MOUNTS ARE LOOSE

PROCEDURE OR ACTION:

1. Inspect axle bearing and rubber mounts.

CAUSE E - OPERATING AT TOO HIGH A SPEED

PROCEDURE OR ACTION:

1. See **Operating Manual** for correct operating speeds.

CAUSE F - FAILED WHEEL BEARINGS

PROCEDURE OR ACTION:

1. Inspect wheel bearings.
   Are bearings in good condition?
   YES: Go to Cause G.
   NO: Replace wheel bearing.

CAUSE G - LOOSE TIE RODS

PROCEDURE OR ACTION:

1. Inspect joint where tie rods are attached to pinion assembly.
   Is the tie rod tight in bore?
   YES: See Observed Symptoms, Page 9070-30-39.
   NO: Replace tie rod.

CAUSE H - OPERATING OFF HARD SURFACES

PROCEDURE OR ACTION:

1. Operate truck only on hard surfaces.

CAUSE I - MAST IS TOO LOOSE

PROCEDURE OR ACTION:

1. See Observed Symptoms, Page 9070-30-24.

END SYMPTOM

Truck Wanders, Does Not Track Straight or Steer Well

POSSIBLE CAUSE

A. EXCESSIVE LOADS.
B. LOW PNEUMATIC TIRE INFLATION
C. HIGH PNEUMATIC TIRE INFLATION.
D. FAILED WHEEL BEARINGS
E. LOOSE TIE RODS
F. DAMAGED UPPER AXLE MOUNTING EAR
G. STEERING VALVE PROBLEM

CAUSE A - EXCESSIVE LOADS.

NOTE: See Serial Number plate or **Operating Manual** for lift capacity.

PROCEDURE OR ACTION:

NOTE: Carrying a load that exceeds truck capacity will cause the steer axle wheels to loose contact with ground and negatively affect control of truck.

1. Check load weight and compare to truck capacity rating.

CAUSE B - LOW PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE C - HIGH PNEUMATIC TIRE INFLATION.

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE D - FAILED WHEEL BEARINGS

PROCEDURE OR ACTION:

1. Inspect wheel bearings.
   Are bearings in good condition?
   YES: Go to Cause E.
   NO: Replace wheel bearing.

CAUSE E - LOOSE TIE RODS

PROCEDURE OR ACTION:

1. Inspect joint where tie rods are attached to pinion assembly.
   Is the tie rod tight in bore?
   YES: See Observed Symptoms, Page 9070-30-39.
   NO: Replace tie rod.

CAUSE F - DAMAGED UPPER AXLE MOUNTING EAR

PROCEDURE OR ACTION:

NOTE: The upper axle ear can be bent if lift truck suddenly drops its load while rear steer axle wheels are off the ground.

1. Inspect axle pinion bearings vertical movement.
   Does pinion bearings have excessive endplay?
   YES: Replace axle.
   NO: Go to Cause G.

CAUSE G - STEERING VALVE PROBLEM

PROCEDURE OR ACTION:

1. Check steering hydraulics. Perform Steering Control Unit LS Pressure Test.

END SYMPTOM

Wheels Appear Tipped or Misaligned

POSSIBLE CAUSE

A. LOW PNEUMATIC TIRE INFLATION
B. FAILED WHEEL BEARINGS
C. LOOSE TIE RODS
D. DAMAGED UPPER AXLE MOUNTING EAR
E. WHEEL RIM BENT

CAUSE A - LOW PNEUMATIC TIRE INFLATION

PROCEDURE OR ACTION:

1. Check and adjust tire inflation. See **Operating Manual**.

CAUSE B - FAILED WHEEL BEARINGS

PROCEDURE OR ACTION:

1. Inspect wheel bearings.
   Are bearings in good condition?
   YES: Go to Cause C.
   NO: Replace wheel bearing.

CAUSE C - LOOSE TIE RODS

PROCEDURE OR ACTION:

1. Inspect joint where tie rods are attached to pinion assembly.
   Is the tie rod tight in bore?
   YES: Go to Cause D.
   NO: Replace tie rod.

CAUSE D - DAMAGED UPPER AXLE MOUNTING EAR

PROCEDURE OR ACTION:

NOTE: The upper axle ear can be bent if lift truck suddenly drops its load while rear steer axle wheels are off the ground.

1. Inspect axle pinion bearings vertical movement.
   Does pinion bearings have excessive endplay?
   YES: Replace axle.
   NO: Cause E.

CAUSE E - WHEEL RIM BENT

PROCEDURE OR ACTION:

1. Inspect wheel rims for damage. Replace as required.

END SYMPTOM

Wheels Spinning On Uneven Floors

POSSIBLE CAUSE

A. FAILED STEERING AXLE RUBBER MOUNTS

CAUSE A - FAILED STEERING AXLE RUBBER MOUNTS

PROCEDURE OR ACTION:

NOTE: When running empty, failed rubber mount will cause the frame to be rigid because of the counterweight on the steer axle. When one drive wheel encounters a uneven floor or object it will raise the other drive wheel off ground loosing traction to move truck.

1. Inspect and repair rubber mounts.

END SYMPTOM

Wheel Studs Breaking

POSSIBLE CAUSE

A. ATTACHING HARDWARE IS LOOSE
B. WHEEL STUDS ARE OVER TORQUED

CAUSE A - ATTACHING HARDWARE IS LOOSE

PROCEDURE OR ACTION:

1. Visually inspect wheel studs for damage and loose or missing hardware.
   Do wheels and attaching hardware appear to be in good condition?
   YES: Go to Cause B.
   NO: Repair or replace damaged components.

CAUSE B - WHEEL STUDS ARE OVER TORQUED

PROCEDURE OR ACTION:

1. Check wheel stud torque.
   Are the wheels studs at correct torque?
   YES: Check maintenance records to see what repairs were made that may have caused problem.
   NO: Replace all studs and torque correctly.

END SYMPTOM

NOTES

SECTION 9080

SUPPLEMENTARY DATA

TABLE OF CONTENTS

Group 50

Abbreviations and Acronyms

ABBREVIATIONS AND ACRONYMS

Table 9080-50-1. Abbreviations and Acronyms

Term	Definition or Description
AC	Alternating Current
ACC	Accessory
A/D	Analog to Digital
ACK	Acknowledged
Activated	A feature whose functionality may be turned on or off by the technician (parameters or selectable SEFs) and is currently set to be functional
ADC	Analog to Digital Converter
ADS	Auto Deceleration System
APPS	Accelerator Pedal Position Sensor
AROC	Abnormal Rate of Change
AUX	Auxiliary
BATT	Battery
Baud	A line’s signaling rate, the switching speed, or number of voltage or frequency changes made per second
BIT	Smallest element of binary data storage
BDC	Bottom Dead Center
bit	Smallest element of binary data storage
BTDC	Before Top Dead Center
Byte	The common unit of binary data storage. It is made up of eight bits.
C	Celsius
CA	Crank Angle
Calibration	Adjustment to accommodate truck-to-truck variations. Typical usage in system specifications applies to software processes to “learn” and store sensor baseline or extreme values. Calibration procedures may require repeating when controllers are replaced or if a specific sensor or mounting mechanism is replaced.
CANbus	CANbus is SAE J1939 Controller Area Network bus
CBB	Conventional Battery Box
CBDC	Counter Balanced Development Center
CD or CD-ROM	Compact Disc Read-Only Memory - a compact disc format used to hold text, graphics and hi-fi stereo sound in excess of 650MB of data, which is equivalent to about 250,000 pages of text

Table 9080-50-1. Abbreviations and Acronyms (Continued)

Term	Definition or Description
CDF	Configuration Data File (previously known as Cal Data) - factory-created file defining truck configuration details, dependent on truck model and option permutations (considered unique for a given truck). Not modified by service technicians, but a replacement file (with alternate options) may be factory-generated and loaded into a truck's controller by a service technician
CO	Carbon Monoxide
COP	Computer Operating Properly
CMP	Cam Position Sensor
CPS	Connector Plug Socket
CPU	Central Processing Unit
CRC	Cyclic Redundancy Checksum
CRP	Connector Receptacle Pin
CRS	Connector Receptacle Socket
DA	Destination Address
D/A	Digital to Analog Converter
DBB	Drop Battery Box
DBP	Drawbar Pull
DC	Direct Current
DCN	Document Control Number
Deactivated	A feature which is not currently Activated
Defaults	The set of factory values for all truck parameters. A setup menu function can restore the default values of all parameters.
De-Rated Mode	Operational mode with reduced performance (typically reduced speed) and/or disabled functionality in response to faults detected or operator checklist answers
Disabled	A Software Enabled Feature which is NOT present on a given truck
DIS	Distributorless Ignition System
DM	Diagnostic Message
DMM	Digital Multimeter
DTC	Diagnostic Trouble Code
DTM	Diagnostic Troubleshooting Manual
ECT	Engine Coolant Temperature
ECU	Engine Control Unit
EDBP	Extended Drawbar Pull
EEPROM	Electronically Erasable Programmable Read Only Memory
EF	Excess Flow
EFI	Electronic Fuel Injection
EGI	Electronic Gasoline Injection
EGO	Exhaust Gas Oxygen

Table 9080-50-1. Abbreviations and Acronyms (Continued)

Term	Definition or Description
EGP	Exhaust Gas Pressure
EGR	Exhaust Gas Recirculator
EGT	Exhaust Gas Temperature
EHP	Electro-Hydraulic Pilot
EHPV	Electro-Hydraulic Poppet Valve
E-Hyd	Electro-Hydraulic - hydraulic option utilizing electronic inputs and electrically-driven valves to actuate hydraulic functions, as opposed to manual hydraulics using mechanical levers
Embedded	Software that is installed on Lift Truck control system
EMI	Electro-Magnetic Interference
Enabled	A Software Enabled Feature which is present on a given truck, but not necessarily Activated (i.e., purchased but not necessarily in use)
EPA	Environmental Protection Agency
EPR	Electronic Pressure Regulator
ERPM	Engine (speed in) RPM
ESD	ElectroStatic Discharge
EST	Electronic Spark Timing
ETC	Electronic Throttle Control
FFL	Full-Free Lift
FMI	Fault Mode Indicator
FOSI	Format Output Specification Instances - an instance of the Output Specification (OS) that assigns values to the style characteristics for a particular document type declaration. The FOSI uses the syntax of an SGML/XML document instance and is designed to format documents for paper delivery.
FWD	Forward travel direction command signal to system
FWD1	Forward 1 gear (pack)
GB	Gigabyte - equal to 1024 Megabytes
GCU	Governor Control Unit
H	Henry - Unit of measurement of electrical inductance
HC	Hydro Carbons
HEGO	Heated Exhaust Gas Oxygen sensor
HO_2S	Heated Oxygen Sensor
HPCR	High-Pressure Common Rail
HPP	High Pressure Pump
HYDR	Hydraulic
Hz	Basic unit of frequency measurement, 1 Hz = 1 periodic interval in one second
IAC	Idle Air Control
IAFM	Intake Air Fuel Module

Table 9080-50-1. Abbreviations and Acronyms (Continued)

Term	Definition or Description
IAT	Intake Air Temperature
IBPP	Inching/Brake Pedal Position
ICE	Internal Combustion Engine
IGN	Ignition
ISR	Interrupt Service Routine
Joystick	Armrest-mounted module incorporating a single 2-axis control handle for Electro-Hydraulics. May include additional analog or digital inputs on control handle. Also includes additional inputs from sensors and/or switches in the seat area, to be broadcast over CAN
kBps	KiloBytes per second
kHz	KiloHertz - common frequency measurement of Hertz X 1000
kilobit	1,000 bits
kilobyte	A standard quantity measurement for disk and diskette storage. One kilobyte of memory equals 1024 bytes (8-bit characters) of computer memory.
kg	Kilogram, equal to 1000 grams
kPa	Kilo-Paschals, metric unit of pressure measurement X 1000
kph	Kilometers per Hour
L	Liter
LAN	Local Area Network
lbf ft	Foot Pounds
lbf in	Inch Pounds
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LFL	Limited Free Lift
Limp-Home Mode	See De-Rated Mode
LP (G)	Liquefied Petroleum (Gas)
LS	Load Sense
LSB	Least Significant Bit
LTFT	Long Term Fuel Trim
MAF	Mass Air Flow
MAP	Manifold Absolute Pressure
MAT	Manifold Air Temperature
MB	Megabyte - 1,048,576 bytes, equal to 1,024 kilobytes. The basic unit of measurement of mass storage
MHz	Megahertz - a unit of frequency equal to 1024 kilohertz. A common method for describing the speed of a computer CPU
MIL	Malfunction Indicator Lamp
MLM	Mini Lever Module

Table 9080-50-1. Abbreviations and Acronyms (Continued)

Term	Definition or Description
mH	Milli-Henry, 1 one thousandth of a Henry
Modem	Modulator-Demodulator - a device that adapts a terminal or computer to a telephone line converting the computer's digital pulses into audio frequencies (analog) for the telephone system and converts the frequencies back into digital pulses at the receiving side
MOR	Manufacturer Of Record
MPH	Miles Per Hour
MRV	Main Relief Valve
ms	Milli-second, 1 one thousandth of a second
MSB	Most Significant Bit
NACK	Not Acknowledged
NEU	Neutral travel direction command signal to system
N•m	Newton Meters
NOR	Normal
NOx	Nitrogen Oxide
OBD	On Board Diagnostics
OC	Open Circuit - indicates an open connection or break in an electrical path
OORH	Out-Of-Range High
OORL	Out-Of-Range Low
ORFS	O-Ring Face Seal
OS	Operating System - the embedded system of instructions and applications that control the operation of the processor
Parameter	A system characteristic which may be adjusted by a technician, e.g., Auto-Deceleration, which may be set on a scale of from 1 to 10. Each parameter will also have a default value.
Pb	Lead
PbO_2	Lead Peroxide
PC	Personal Computer
PC Tool	Any software that is installed on a PC that is used to service the lift truck control system
PCB	Printed Circuit Board
PCV	Positive Crankcase Ventilation
PDA	Personal Digital Assistant
PDM	Power Distribution Module
PDU	Protocol Data Unit
PGN	Parameter Group Number
PPAP	Production Part Approval Process
PPRV	Proportional Pressure Reducing Valve
PRD	Product Requirements Document

Table 9080-50-1. Abbreviations and Acronyms (Continued)

Term	Definition or Description
PWM	Pulse Width Modulation
RAM	Random Access Memory - the computer's primary workspace where the contents of each byte can be accessed directly without regard to the bytes before or after it
REV	Reverse travel direction command signal to system
Rev.	Revision - the issue control or version number of an item
RL	Relay
ROM	Read Only Memory
RPM	Revolutions Per Minute
RTST	Return to Set Tilt
SA	Source Address
SAE	Society of Automotive Engineers
Scroll Repeat	The repeating, incrementing, or decrementing of a displayed value when continuously pressing the scroll buttons
Scroll Wrap-around	In the setup menu, if wrap-around is specified, when extreme-adjustment values are reached while scrolling, the value shall change to the other extreme of adjustment. I.e., scrolling down to lowest point on menu shall jump back to the top of the menu.
SCU	Steering Control Unit
SCV	Suction Control Valve
SEF	Software Enabled Function - options which are Enabled by software (either entirely or in combination with additional hardware). For all SEFs, enabling the function requires a new CDF. An SEF may be Selectable, allowing it to be Activated or Deactivated by the technician once it has been enabled, or it may be non-selectable, such that it cannot be deactivated after being enabled.
Selectable	See Software Enabled Function (SEF)
Service Pack	Software update provided by a software manufacturer to fix an error and/or improve quality
SGT	Surrounded Gate Transistor
SLOT	Scaling, Lookup, Offset, Transform function
SMS	Severity Mitigating Software
SPED	Special Products Engineering Department - responsible for options not in the standard price book, but available by special order

Table 9080-50-1. Abbreviations and Acronyms (Continued)

Term	Definition or Description
SPI	Serial Peripheral Interface
SPN	Suspect Parameter Number
SRM	Service Reference Manual
SRV	Secondary Relief Valve
STB	Short-To-Battery - indicates a short to a battery level voltage source
STFT	Short Term Fuel Trim
STG	Short-To-Ground - indicates a short to a ground or frame connection
STS	Short-To-Supply - indicates a short to a supply voltage source other than battery level
TBC	To Be Continued
TBD	To Be Determined
TBI	Throttle Body Injection
TC	Torque Converter
TCU	Transmission Control Unit
TDC	Top Dead Center
TISS	Transmission Input Shaft Speed - refers to a sensor utilized for measuring the rotational speed of the transmission input shaft (output of the torque converter)
TMAP	Combined sensor inputs of Manifold Temperature and Pressure
TOSS	Transmission Output Shaft Speed - refers to a sensor utilized for measuring the rotational speed of the transmission output shaft (which is directly related to the ground speed of the truck). The TOSS sensor detects speed and direction of the shaft.
TPS	Throttle Position Sensor (on engine)
Truck Settings	The specific adjustments of the various parameters on a given truck. They may be saved to a data file through the Service PC software and copied to additional similar trucks.
TSP	Troubleshooting Procedure
USB	Universal Serial Bus - serial 4-wire connection that has advanced features over a serial port. Normally found on computers as a slotted connector configuration
VSM	Vehicle System Manager - the master controller of the vehicle integrated control system
WOT	Wide Open Throttle
XMSN	Transmission

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Group 60

Special Tools List

SPECIAL TOOLS LIST

Table 9080-60-2. Special Tools

Description	Part Number
TOOL - TERMINAL REMOVAL, SIZE 16	866400
PIN TERMINAL	866401
TOOL - TERMINAL REMOVAL, SIZE 12	866402
STORAGE BOX - FLAMBEAU	866403
TOOL - WEDGELOCK REMOVAL, DT	866404
SPLICE, SIZE 12	866405
SPLICE, SIZE 16	866406
KIT - DEUTSCH CONNECTOR	866410
WIRE STRIPPER	866411
WIRE STOP	866412
TOOL - TERMINAL REMOVAL, SIZE 12	866413
TOOL - TERMINAL REMOVAL, SIZE 16	866414
TOOL - TERMINAL REMOVAL, SIZE 16	866415
DEUTSCH TESTING TOOL	866416
SPLICE - HEAT SHRINKABLE TUBING	866417
SPLICE - HEAT SHRINKABLE TUBING	866418
SPLICE - HEAT SHRINKABLE TUBING	866419
TOOL - METRI-PACK CONNECTOR REMOVAL	866420
TOOL - WEATHER-PACK CONNECTOR REMOVAL	866421
TOOL - ECM CONNECTOR TERMINAL REMOVAL	866422
KIT - LUBE COOLER LEAK TEST	866436
KIT - COMBUSTION GAS LEAK TEST	866449
GEAR - ENGINE BARRING	866456
BRUSH - INJECTOR BORE	866460
GAUGE - CAPSCREW LENGTH	866461
DEUTSCH CRIMPING TOOL	867888
DEUTSCH CRIMPING TOOL	867889
KIT - DEUTSCH CONNECTOR	867892

Table 9080-60-2. Special Tools (Continued)

Description	Part Number
SOFTWARE PC SERVICE TOOL	1595697 See Software Section of Hypass Online
SOFTWARE IFAK DRIVERS FOR PC TO TRUCK INTERFACE	1595698 See Software Section of Hypass Online
FLEX HORN	1599906
INJECTOR PULLER	1651232
MAGNETIC BASE INDICATOR HOLDER	1651233
FILTER CUTTER	1651234
FUEL PUMP TIMING KIT	1651235
PRESSURE GAUGE (90 TO 160 PSI)	1651236
DIGITAL MULTIMETER	1651237
INJECTOR NOZZLE CLEANING KIT	1651240
TACHOMETER	1651241
INJECTOR NOZZLE TESTER	1651242
MANOMETER	1651246
PRESSURE GAUGE	1651247

Table 9080-60-3. Special Tools

Description	Part Number	1.0-2.0 Ton	2.0-3.5 Ton	4.0-5.5 Ton	6.0-7.0 Ton	8.0-9.0 Ton
Terminal Removal Tool Size 16	866400	X	X	X	X	
Pin Terminal	866401	X	X	X	X	
Terminal Removal Tool Size 12	866402	X	X	X	X	
Storage Box - Flambeau	866403	X	X	X	X	
Wedgelock Removal Tool, DT	866404	X	X	X	X	
Splice, Size12	866405	X	X	X	X	
Splice, Size 16	866406	X	X	X	X	
Deutsch Connector Kit	866410	X	X	X	X	
Deutsch Connector/Crimp/ Stripper Kit	867892	X	X	X	X	
Deutsch Crimp Tool	867888	X	X	X	X	
Deutsch Crimp Tool	867889	X	X	X	X	

Table 9080-60-3. Special Tools (Continued)

Description	Part Number	1.0-2.0 Ton	2.0-3.5 Ton	4.0-5.5 Ton	6.0-7.0 Ton	8.0-9.0 Ton
Wire Stripper	866411	X	X	X	X	
Wire Stop for Stripper	866412	X	X	X	X	
Deutsch Extracting Tool 12-14 AWG Thin Wall	866413	X	X	X	X	
Deutsch Extracting Tool 20-22 AWG	866415	X	X	X	X	
Deutsch Extracting Tool 16-18 AWG Thin Wall	866414	X	X	X	X	
150 series Metri-pack Connector Remover Tool	866420	X	X	X	X	
Weather-pack Connector Remover Tool	866421	X	X	X	X	
ECU Connector Terminal Remover Tool	866422	X	X	X	X	
Del City Heat Shrink Butt Connector 12-10 Gauge	866417	X	X	X	X	
Del City Heat Shrink Butt Connector 16-14 Gauge	866418	X	X	X	X	
Del City Heat Shrink Butt Connector 20-18 Gauge	866419	X	X	X	X	
Deutsch Crimp Test Tool	866416	X	X	X	X	
Pilot Pressure Plug	1585471	X	X	X	X	
LIFT EHPV SHUT-OFF PLUG ASSEMBLY	1585472	X	X	X	X	
LOWER EHPV SHUT-OFF PLUG ASSEMBLY	1585473	X	X	X	X	
LOWER EHPV CAGE SHUT-OFF PLUG	1585474	X	X	X	X	
EHPV REMOVAL/INSTALLATION TOOL	1585481	X	X	X	X	
SOFTWARE PC SERVICE TOOL	1595697 See Software Section of Hypass Online	X	X	X	X	
SOFTWARE IFAK DRIVERS FOR PC TO TRUCK INTERFACE	1595698 See Software Section of Hypass Online	X	X	X	X	

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Fault Mode Indicator Reference

FAULT MODE INDICATOR (FMI) REFERENCE LIST

There are additional FMI codes that define characteristics of other failures but are not listed here because they are not used in the lift truck systems. For a complete listing of these FMI codes, refer to SAE Specification J1939-73.

Table 9080-70-4. FMI

FMI #	Description
0	Data Valid but Above Normal Operational Range - Most Severe Level
1	Data Valid but Below Normal Operational Range - Most Severe Level
2	Data Erratic, Intermittent or Incorrect
3	Voltage Above Normal or Shorted to High Source (OORH)
4	Voltage Below Normal or Shorted to Low Source (OORL)
5	Current Below Normal or Open Circuit (OC)
6	Current Above Normal or Grounded Circuit
7	Mechanical System not Responding or Out of Adjustment
8	Abnormal Frequency or Pulse Width or Period
9	Abnormal Update Rate
10	Abnormal Rate of Change (AROC)
11	Root Cause Not Known
12	Bad Intelligent Device or Component
13	Out of Calibration
14	Special Instructions

NOTES

Group 80

Supplier Specification Data

TSP REFERENCE TABLES

Table 9080-80-5. Resistor-Temperature Characteristics

Temperature °C (°F)	Resistance				Temperature Accuracy ±°C (°F)
	Nominal (Ω)	Tolerance (±%)	Max (Ω)	Min (Ω)	
−40 (−40)	100,865	4.87	105,777.1	95,952.9	0.7 (1.26)
−35 (−31)	72,437	4.64	75,708.1	69,075.9	0.7 (1.26)
−30 (−22)	52,594	4.43	54,923.9	50,264.1	0.7 (1.26)
−25 (−13)	38,583	4.21	40,207.3	36,958.7	0.7 (1.26)
−20 (−4)	28,582	4.00	29,725.3	27,438.7	0.7 (1.26)
−15 (5)	21,371	3.80	22,183.1	20,558.9	0.7 (1.26)
−10 (14)	16,120	3.60	16,700.3	15,539.7	0.6 (1.08)
−5 (23)	12,261	3.40	12,677.9	11,844.1	0.6 (1.08)
0 (32)	9,399	3.21	9,700.7	9,097.3	0.6 (1.08)
5 (41)	7,263	3.06	7,485.2	7,040.8	0.6 (1.08)
10 (50)	5,658	2.92	5,823.2	5,492.8	0.6 (1.08)
15 (59)	4,441	2.78	4,564.5	4,317.5	0.6 (1.08)
20 (68)	3,511	2.64	3,603.7	3,418.3	0.6 (1.08)
25 (77)	2,795	2.50	2,864.9	2,725.1	0.6 (1.08)
30 (86)	2,240	2.45	2,294.9	2,185.1	0.6 (1.08)
35 (95)	1,806	2.40	1,849.3	1,762.7	0.6 (1.08)
40 (104)	1,465	2.36	1,499.6	1,430.4	0.6 (1.08)
45 (113)	1,195	2.31	1,222.6	1,167.4	0.6 (1.08)
50 (122)	980	2.27	1,002.2	957.8	0.6 (1.08)
55 (131)	809	2.23	827.0	791.0	0.6 (1.08)
60 (140)	671	2.19	685.7	656.3	0.6 (1.08)
65 (149)	559	2.15	571.0	547.0	0.6 (1.08)
70 (158)	469	2.11	478.9	459.1	0.6 (1.08)
75 (167)	395	2.07	403.2	386.8	0.6 (1.08)
80 (176)	334	2.04	340.8	327.2	0.6 (1.08)
85 (185)	283	2.00	288.7	277.3	0.6 (1.08)
90 (194)	241.8	2.10	246.9	236.7	0.7 (1.26)
95 (203)	207.1	2.21	211.7	202.5	0.7 (1.26)

Table 9080-80-5. Resistor-Temperature Characteristics (Continued)

Temperature °C (°F)	Resistance				Temperature Accuracy ±°C (°F)
	Nominal (Ω)	Tolerance (±%)	Max (Ω)	Min (Ω)	
100 (212)	178.0	2.31	182.1	173.9	0.8 (1.44)
105 (221)	153.6	2.42	157.3	149.9	0.8 (1.44)
110 (230)	133.1	2.52	136.5	129.7	0.9 (1.62)
115 (239)	115.7	2.61	118.7	112.7	0.9 (1.62)
120 (248)	100.9	2.68	103.6	98.2	1.0 (1.80)
125 (257)	88.3	2.75	90.7	85.9	1.0 (1.80)
130 (266)	77.5	2.80	79.7	75.3	1.1 (1.98)
135 (275)	68.3	2.84	70.2	66.4	1.1 (1.98)
140 (284)	60.3	2.87	62.0	58.6	1.2 (2.16)
145 (293)	53.4	2.89	54.9	51.9	1.2 (2.16)
150 (302)	47.5	2.90	48.9	46.1	1.2 (2.16)