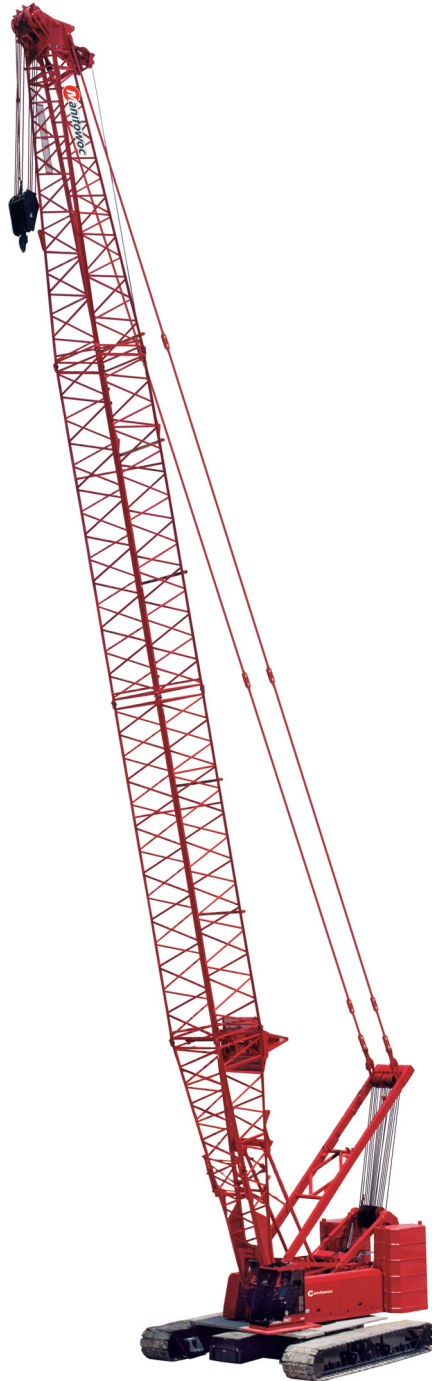


Manitowoc 999

Service/Maintenance Manual





SERVICE/MAINTENANCE MANUAL

This manual has been prepared for and is considered part of -

999

Crane Model Number

9991Ref

Crane Serial Number

This manual is divided into the following sections:

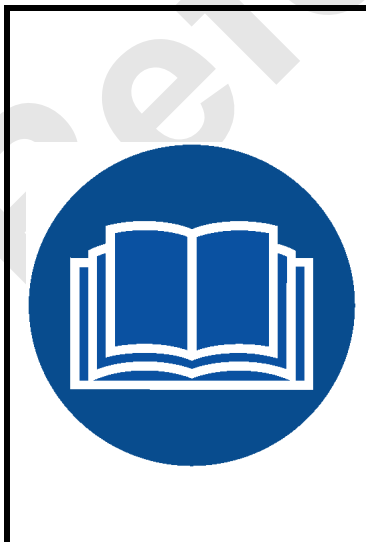
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SECTION 3	ELECTRIC SYSTEM
SECTION 4	BOOM
SECTION 5	HOISTS
SECTION 6	SWING
SECTION 7	POWER TRAIN
SECTION 8	UNDER CARRIAGE
SECTION 9	LUBRICATION
SECTION 10	TROUBLESHOOTING

NOTICE

The serial number of the crane and applicable attachments (luffing jib) is the only method your Manitowoc dealer or the Manitowoc Crane Care Lattice Team has of providing you with correct parts and service information.

The serial number is located on a crane identification plate attached to the operator's cab and each attachment. Refer to the Nameplate and Decal Assembly drawing in Section 2 of this manual for the exact location of the crane identification plate.

Always furnish serial number of crane and its attachments when ordering parts or discussing service problems with your Manitowoc dealer or the Manitowoc Crane Care Lattice Team.



! WARNING

To prevent death or serious injury:

- Avoid unsafe operation and maintenance.
Crane and attachments must be operated and maintained by trained and experienced personnel. Manitowoc is not responsible for qualifying these personnel.
- Do not operate or work on crane or attachments without first reading and understanding instructions contained in Operator Information Manual and Service Manual supplied with crane and applicable attachments.
- Store Operator Information Manual and Service Manual in operator's cab.
If Operator Information Manual or Service Manual is missing from cab, contact your Manitowoc dealer for a new one.

THE ORIGINAL LANGUAGE OF THIS PUBLICATION IS ENGLISH

See end of this manual for Alphabetical Index

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SECTION 1

INTRODUCTION

WARNING

California Proposition 65

Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information go to www.P65warnings.ca.gov/diesel.

Battery posts, terminals, and related accessories contain chemical lead and lead compounds, chemicals known to the State of California to cause cancer, birth defects, and other reproductive harm. Wash hands after handling.

California Spark Arrestor

Operation of this equipment may create sparks that can start fires around dry vegetation. A spark arrestor may be required. The owner/operator should contact local fire agencies for laws or regulations relating to fire prevention requirements.

CONTINUOUS INNOVATION

Due to continuing product innovation, the information in this manual is subject to change without notice. If you are in doubt about any procedure, contact your Manitowoc dealer or the Manitowoc Crane Care Lattice Team.

SAFETY MESSAGES

The importance of safe operation and maintenance cannot be over emphasized. Carelessness or neglect on the part of operators, job supervisors and planners, rigging personnel, and job site workers can result in their death or injury and costly damage to the crane and property.

To alert personnel to hazardous operating practices and maintenance procedures, safety messages are used throughout the manual. Each safety message contains a safety alert symbol and a signal word to identify the hazard's degree of seriousness.

Safety Alert Symbol



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. **Obey all safety messages that follow this symbol to avoid possible death or injury.**

Signal Words



DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.



CAUTION

Used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

CAUTION

Without the safety alert symbol, identifies potential hazards that could result in property damage.

NOTE: Highlights operation or maintenance procedures.

SAFE MAINTENANCE PRACTICES

WARNING

Importance of safe maintenance cannot be over emphasized. Carelessness and neglect on part of maintenance personnel can result in their death or injury and costly damage to the crane or property.

Safety information in this publication is intended only as a guide to assist qualified maintenance personnel in safe maintenance. Manitowoc cannot foresee all hazards that will arise in field; therefore, **safety remains responsibility of maintenance personnel and crane owner.**

Maintenance Instructions

To ensure safe and proper operation of Manitowoc cranes, they must be maintained according to the instructions contained in this manual and the 999 Operator Manual provided with the crane.

Crane maintenance and repair must be performed by personnel who by reason of training and experience are thoroughly familiar with the crane's operation and required maintenance. These personnel must **read the 999 Operator Manual and 999 Service/Maintenance Manual before attempting any maintenance procedure.** If there is any question regarding maintenance procedures or specifications, contact your Manitowoc dealer for assistance.

Training/qualification of maintenance personnel is responsibility of crane owner.

Safe Maintenance Practices

1. Perform following steps (as applicable) before starting a maintenance procedure:
 - a. Park crane where it will not interfere with other equipment or operations.
 - b. Lower all loads to ground or otherwise secure them against movement.
 - c. Lower boom onto blocking at ground level, if possible, or otherwise secure boom against dropping.
 - d. Move all controls to off and secure all functions against movement by applying or engaging all brakes, pawls, or other locking devices.
 - e. Stop engine and render starting means inoperative.
 - f. Place a warning sign at start controls alerting other personnel that crane is being serviced and engine must not be started. Do not remove sign until it is safe to return crane to service.
 2. Do not attempt to maintain or repair any part of crane while engine is running, unless absolutely necessary.

If engine must be run, keep your clothing and all parts of your body away from moving parts. **Maintain constant verbal communication between person at controls and person performing maintenance or repair procedure.**
 3. Wear clothing that is relatively tight and belted.
 4. Wear appropriate eye protection and approved hard hat.
 5. Never climb onto or off a moving crane. **Climb onto and off crane only when it is parked and only with 999 Operator permission.**

Use both hands and handrails, steps and ladders provided to climb onto and off crane.
- NOTE:** Safety harness and tether line must be worn when working on top of enclosure.
- Lift tools and other equipment which cannot be carried in pockets or tool belts onto and off crane with hand lines or hoists.
6. Boom and gantry are not intended as ladders. Do not attempt to climb lattice work of boom or gantry to get to maintenance points. If boom or gantry is not equipped with an approved ladder, lower them before performing maintenance or repair procedures.
 7. Do not remove cylinders until working unit has been securely restrained against movement.
 8. Pinch points are impossible to eliminate; watch for them closely.
 9. Pressurized air, coolant, and hydraulic oil can cause serious injury. Make sure all air, coolant, and hydraulic lines, fittings, and components are tight and serviceable.

Do not use your hands to check for air and hydraulic oil leaks:

 - Use a soap and water solution to check for air leaks (apply to fittings and lines and watch for bubbles).
 - Use a piece of cardboard or wood to check for coolant and hydraulic oil leaks.
 10. Relieve pressure before disconnecting air, coolant, and hydraulic lines and fittings.
 11. Do not remove radiator cap while coolant is hot or under pressure. Stop engine, wait until pressure drops and coolant cools, then slowly remove cap.
 12. Avoid battery explosion: do not smoke while performing battery maintenance, do not short across battery terminals to check its charge.
 13. Read safety information in battery manufacturer's instructions before attempting to charge a battery.

14. Avoid battery acid contact with skin and eyes. If contact occurs, flush area with water and immediately consult a doctor.
15. Stop engine before refueling crane.
16. Do not smoke or allow open flames in refueling area.
17. Use a safety-type can with an automatic closing cap and flame arrestor for refueling.
18. Hydraulic oil can also be flammable. Do not smoke or allow open flames in area when filling hydraulic tanks.
19. Never handle wire rope with bare hands. Always wear heavy-duty gloves to prevent being cut by broken wires.
20. Use extreme care when handling coiled pendants. Stored energy can cause coiled pendants to uncoil quickly with considerable force.
21. When inflating tires, use a tire cage, a clip-on inflater, and an extension hose which permits standing well away from tire.
22. Only use cleaning solvents which are non-volatile and non-flammable.
23. Do not attempt to lift heavy components by hand. Use a hoist, jacks, or blocking to lift components.
24. Use care while welding or burning on crane. Cover all hoses and components with non-flammable shields or blankets to prevent a fire or other damage.
25. To prevent damage to crane parts (bearings, cylinders, swivels, slewing ring, computers, etc.), perform following steps **before welding on crane**:
 - Disconnect all cables from batteries.
 - Disconnect output cables at engine junction box.
 - Attach ground cable from welder directly to part being welded and as close to weld as possible.

Do not weld on engine or engine mounted parts (per engine manufacturer).
26. Disconnect and lock power supply switch before attempting to service high voltage electrical components and before entering tight areas (such as carbody openings) containing high voltage components.
27. When assembling and disassembling booms, jibs, or masts on ground (with or without support of boom rigging pendants or straps), securely block each section to provide adequate support and alignment.
28. Unless authorized in writing by Manitowoc, do not alter crane in any way that affects crane's performance (to include welding, cutting, or burning of structural members or changing pressures and flows of air/hydraulic components). Doing so will invalidate all warranties and capacity charts and make crane owner/user liable for any resultant accidents.
29. **Keep crane clean.** Accumulations of dirt, grease, oil, rags, paper, and other waste will not only interfere with safe operation and maintenance but also create a fire hazard.
30. Store tools, oil cans, spare parts, and other necessary equipment in tool boxes. Do not allow these items to lie around loose in 999 Operator cab or on walkways and stairs.
31. Do not store flammable materials on crane.
32. Do not return crane to service at completion of maintenance or repair procedures until all guards and covers have been reinstalled, trapped air has been bled from hydraulic systems, safety devices have been reactivated, and all maintenance equipment has been removed.
33. Perform a function check to ensure proper operation at completion of maintenance or repair.

ENVIRONMENTAL PROTECTION

Dispose of waste properly! Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Manitowoc cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

Handle and dispose of waste according to local, state, and federal environmental regulations.

When filling and draining crane components: do not pour waste fluids onto the ground, down any drain, or into any source of water.

- Always drain waste fluids into leak proof containers that are clearly marked with what they contain.
- Always fill or add fluids with a funnel or a filling pump.
- Immediately wipe up any spills.

Do not go under boom, jib, or mast sections while connecting bolts or pins are being removed.

CRANE OPERATION

999CSM1-100

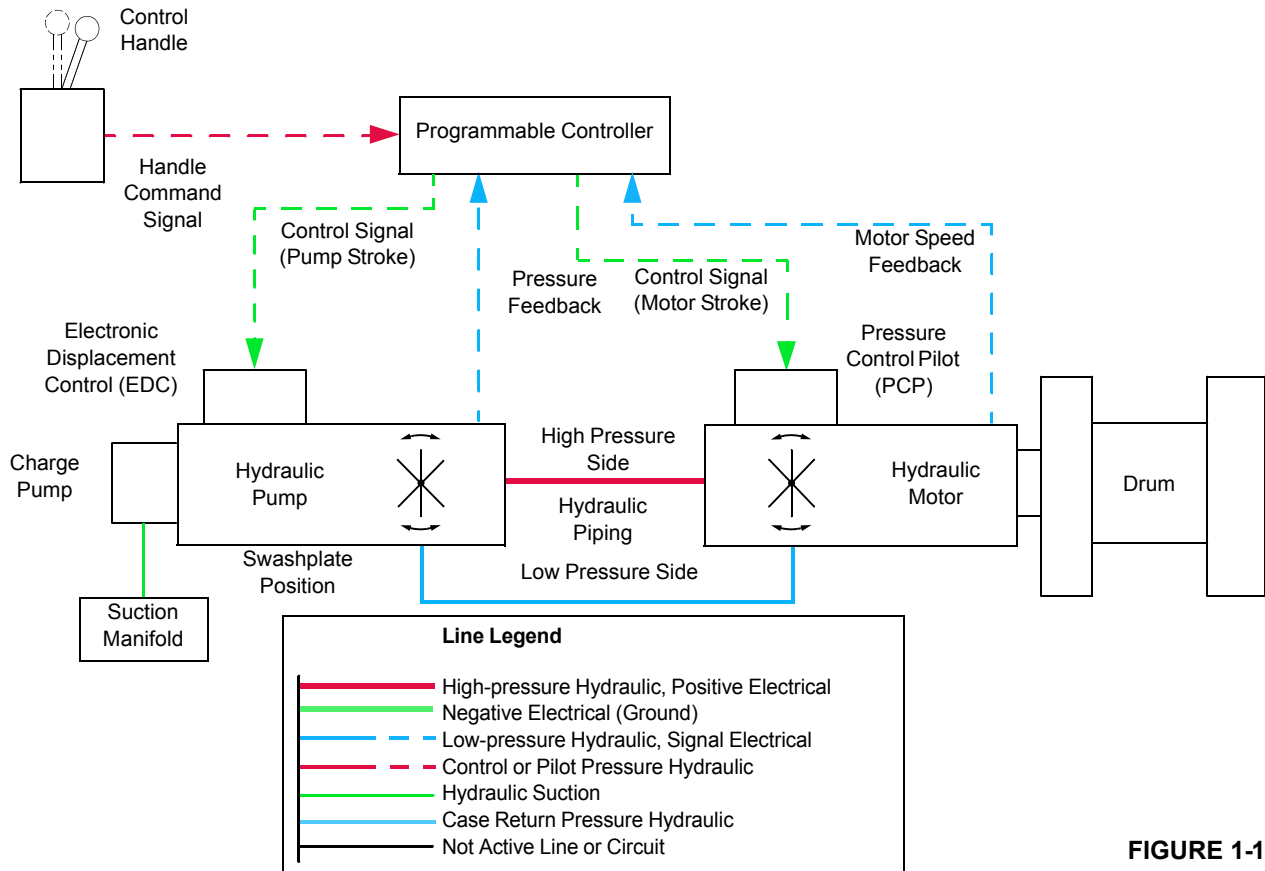


FIGURE 1-1

Operating System

See [Figure 1-1](#)

The Model 999 operating system is an EPIC® (Electrical Processed Independent Control). With this PC (Programmable Controller) the independently powered pumps and motors are controlled through operator commands and control handles. The PC compares control handle commands with monitored information from system sensors. Crane information is displayed on a digital display screen in operator's cab.

A diesel engine provides power to drive system pumps through a gearbox.

In a closed-loop hydraulic system, high-pressure hydraulic fluid from the system pump drives a hydraulic motor. Pressure develops within the closed-loop system while resistance of the load on motor is overcome. When movement begins, pump volume displacement maintains motor speed. Low-pressure side hydraulic fluid from motor returns directly to pump input. The crane closed loop systems are swing, right travel, left travel, boom hoist, front drum, rear drum, and auxiliary drum.

NOTE: In this manual, a hydraulic system that is “open” means fluid can flow in the circuit. In this manual, each hydraulic solenoid valve is assigned an HS (hydraulic solenoid) number. The HS numbers identify actual hydraulic solenoid valves on the crane for training purposes only.

Hydraulic Components

See Hydraulic Schematic drawing at end of Section 2.

Hydraulic Tank

Hydraulic tank has a fill cap, separate breather, suction filter, diffuser filter, high and low level sight gauges, vacuum, temperature, and level sensors.

The tank has two sections: a suction section and a return section. The suction section 100-mesh (150 micron) strainer has a 3 psi (0.2 bar) bypass that allows flow around it if it becomes plugged. A diffuser filter inside tank return line reduces turbulence created by fluid returning to tank.

Tank hydraulic filters remove contaminants from fluid.

NOTE: System filtration does not transform deteriorated fluid into purified quality fluid. Factors affecting service life of hydraulic fluid include high operating

temperatures, exposure to moisture or dust in work area, high contaminants in the fluid, or adding fluid of unlike viscosity or chemical composition. A program to test or replace hydraulic fluid at scheduled times must be established for efficient operation of all hydraulic systems.

NOTE: See Section 9 Lubrication Guide for recommended replacement of hydraulic system fluid.

Digital display screen displays hydraulic fluid temperature in the reservoir.

Hydraulic fluid vacuum is a pressure between 7 and 18 psia (0,5 and 1,2 bar absolute) depending on engine speed, ambient temperature, and filter condition. A system fault exists for suction pressure, but there is not a displayed pressure.

Shut-off Valve

A hydraulic shut-off valve is located between tank and tank suction manifold. Close this shut-off valve when performing maintenance on hydraulic systems. **Before starting engine, always check that the hydraulic tank shut-off valve is open.**

Supercharge Filter Manifold

Supercharge filter manifold supplies fluid to all system pumps except the auxiliary drum pump. When shut-off valve is open, fluid flows from tank to supercharge pump through tank suction manifold. Supercharge pump supplies hydraulic fluid to supercharge filter manifold. Filters must be changed when system fault alerts are enabled and digital display screen indicates that filters need to be serviced.

Return Manifolds

Return fluid from closed-loop auxiliary brake valve, motor servos, and pump case drains is routed through main return manifold and cooler before entering hydraulic tank. Main return manifold has a 25 psi (1,7 bar) bypass that allows fluid to bypass cooler if it becomes plugged. Return fluid from closed-loop relief valves, brake valves, drum pawls, and counterbalance pin cylinders returns to other return manifold, bypassing cooler before entering hydraulic tank.

Thermal Bypass Valve

Connected to the lower right side of the radiator is a thermostatically controlled valve. At 140°F (60°C), the valve begins to open, allowing return oil to flow to the cooler.

Hydraulic Pumps

See Figures [1-2](#) or [1-3](#)

NOTE: See hydraulic pump and motor manufacturer's manual for complete information on hydraulic pumps and motors.

Supercharge pump is a fixed displacement gear pump that draws hydraulic fluid from suction manifold and supplies make-up hydraulic fluid to supercharge filter manifold. Each closed-loop system, except the auxiliary drum, draws hydraulic fluid from supercharge filter manifold as needed. Auxiliary drum system draws hydraulic fluid directly from suction manifold.

Variable displacement, axial piston pumps are used in all closed-loop systems. Each pump operates in a bi-directional closed-loop system. Each pump has a charge pump, EDC (Electrical Displacement Control), cylinder block where pistons are positioned axially around a drive shaft, a charge pressure relief valve, and two multifunction valves.

Each system pump has a gerotor type gear charge pump that is internally mounted on the end of each pump system drive shaft. Charge pressure fluid provides cooling, positive pressure in low-pressure side of the closed loop, control pressure for pump servo, and make-up fluid for internal leakage. System charge pump draws fluid directly from supercharge filter manifold and delivers it to closed-loop system at a charge pressure of approximately 350 psi (24 bar). Charge pressure depends on engine load/speed and pressure relief valve settings. Rear drum pump supplies system flow to operate upper and lower accessory valves in Crane Setup mode and its charge pump supplies pressurized flow for low pressure accessories during normal operation.

When a system control handle is moved, the PC input voltage polarity to pump EDC is either negative or positive as required for operation command direction. Pump EDC tilts swashplate to stroke pump to perform the operation command. Hydraulic fluid displaced by motor pistons, returns to system pump through non-pressurized side of closed-loop system.

Pump pistons reciprocate within cylinder block as the block rotates. Lengthening stroke of each piston draws low-pressure return fluid from motor into the cylinder block. As the stroke shortens, fluid is pushed out of pump piston cylinder into high-pressure line to motor. Swashplate tilt angle determines the volume of fluid that can be pumped to motor. Increasing swashplate tilt angle increases piston stroke length, causing more fluid to be pumped to motor.

Each pump has two multifunction valves that consist of system relief valve and charge flow make-up check valve. Load drum pumps have a pressure limiting relief valve and a flow restrictor across high-pressure side and low-pressure side. Pump system multifunction valves control maximum system pressure and protect each pump system from damage by limiting pressure spikes in each operating direction. When preset loop system pressure is reached, multifunction valves limit system pressure by de-stroking pump or transferring fluid from high-pressure side to low-pressure side. Pressure settings of multifunction valves for each pump is listed in [Table 1-1](#). Limits should not be reached unless there is a failure in the system.

Table 1-1 System Pressure Settings

SYSTEM	LOAD DRUMS		BOOM HOIST		SWING	TRAVEL
	Hoist (Port A)	Lower (Port B)	Up	Down	Left/Right	Fwd./Rev.
FUNCTION						
PRESSURE psi (bar)	6,090 (420)	3,770 (260)	6,090 (420)	3,770 (260)	6,090 (420)	6,090 (420)

Charge Pressure

Diagnostic screens contain system charge pressure information. When a drum, swing or track system control handle is in neutral, the system diagnostic screen provides charge pressure information.

Charge pressure in each closed-loop system is preset at 350 psi (24 bar) with a relief valve in charge pump. Charge pressure must be at preset value as lower pressures can cause a slowing or stopping of operation.

If charge pressure drops in any system the brakes begin to spring-apply. Brakes are fully spring-applied at 200 psi (14 bar) or more, depending on system. System pump does not de-stroke when minimum charge pressure is reached, except the accessory system (rear drum) pump. The accessory pump de-strokes if the suction side pressure drops below 160 psi (11 bar).

Hydraulic Motors

Variable displacement low torque/high speed, bent axis piston motors are used in hydrostatic transmissions of the travel, boom hoist, and load drum systems. Swing system motor is a hydrostatic transmission, fixed displacement, low torque/high speed, axial piston motor. Each variable displacement motor contains a cylinder block, pistons, output shaft, and external flushing valve. Boom hoist drum and load drums have a PCP (Pressure Control Pilot) valve that controls output speed/torque of the motor.

Motor cylinder block axis is tilted at an angle to output shaft with pistons fitted axially around its axis. The internal end of output shaft has a large flange face similar to pump swashplate. Motor piston ends are retained to output flange face and do not ride around the axis of rotating flange face like the pump pistons.

Hydraulic fluid entering motor puts a force against pistons. The retained piston ends put a thrust against output flange with a rotational torque that turns output shaft. This also rotates the cylinder block on bent axis, while tilt angle to flange face reciprocates the pistons as they rotate. Hydraulic fluid displaced by the pistons, returns to system pump through non-pressure side of closed-loop system.

Main Pressure Monitoring

Diagnostics monitor each closed-loop system pressure. Drum, swing, or track diagnostics screen displays the monitored pressure information. System pressure value is maintained at or greater than preset value, depending on

engine RPM. System pressure can also be checked at pressure sender diagnostic gauge coupler with a 10,000 psi (689 bar) high pressure gauge, when pump is stroked.

Accessory System Pressure

Diagnostics monitor the accessory system pressure. The rear drum pump is the source of pressure for the accessory system items. When an accessory valve is enabled, the PC enables the rear drum pump to pressurize the low-pressure side of rear drum system. Each solenoid valve of the accessory system are open circuit type (return fluid is not ported back to high-pressure side of pump). The PC monitors the high-pressure side of the closed-loop. When pressure on the high-pressure side of the closed-loop drops off, the PC reduces the pump flow so the charge pumps can keep up. To increase flow, a check valve is piped from the charge pressure port on front drum pump to the high-pressure side of rear drum closed-loop.

Basic Operation

See Figures [1-2](#) or [1-3](#)

When a control handle is moved from neutral, the PC sends a positive or negative output signal to system pump external EDC. This current signal magnetizes armature (5, [Figure 1-2](#)) and starts to block orifice port (6) or (7), depending on current polarity. Blockage of flow at exhaust side of orifice port (6) in this example causes a pressure difference across spool (8). This pressure difference overcomes the resistance of spring (9) and moves the spool proportionally to pressurize servo control cylinder (10).

The other servo control cylinder (11) fluid is routed to tank. This tilts the swashplate (12), stroking the pump. As swashplate tilts, chamber spring (13) is pulled in the opposite direction of spool with linkage (14). This centers and maintains spool in a neutral position until the 16 psi (1 bar) chamber spring pressure is reached.

In travel pumps, the pressure relief and pressure-limiting sections of multifunction valve responds when relief pressure is reached. The pressure limiting function of travel pumps is set not to exceed 6090 psi (420 bar). If travel pump pressure exceeds preset pressure limit, pumps de-stroke to prevent overheating of system fluid. Hydraulic fluid pressure overcomes spring resistance in pressure limiting relief valve (17, [Figure 1-3](#)), shifting spool to open a path for fluid. Servo check valves (18) are spring loaded with an opening pressure of 750 psi (52 bar).

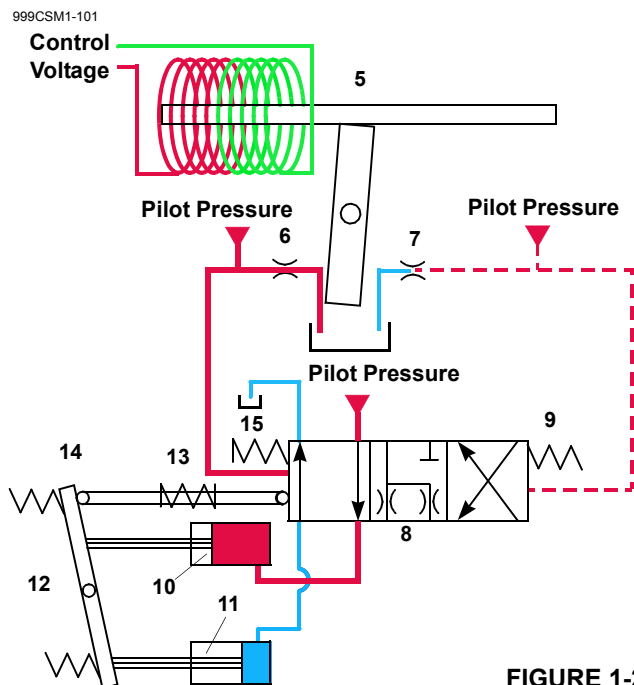


FIGURE 1-2

Exhaust hydraulic fluid from valve (17) flows through exhaust port of displacement control valve (19). Exhaust port of displacement control valve has a restricted orifice that develops back-pressure for servo control cylinder (1) to pressurize and de-stroke pump to limit system pressure. When rapid loading produces pressure spikes, system relief valve (16) shifts, allowing high pressure fluid to return to tank through charge pump relief valve (3) or transfers fluid to low-pressure side of closed-loop system through charge flow make-up check valves (4).

In other system pumps, pressure limiting is controlled through relief valve section of multifunction valves only. Flow control orifice (20) is removed from pump EDC. Servo check valves (18) are removed from pump and paths to servo control cylinders are plugged. These changes permit pump to react quicker to PC commands.

Also, pressure limiting valves (17) serve as pilot valves to open system relief valves (16) when desired relief pressure setting is reached. For example, if a pressure imbalance

occurs on both sides of flow restrictor (21), pressure limiting valve opens and system relief valve relieves system pressure. Hydraulic fluid is directed to tank through relief valve (3) or the flow is transferred to low-pressure side of system through make-up check valves (4).

NOTE: Servo check valves (18) are only used in the travel pump circuit. In other system pumps, these valves are removed and the paths to the servo control cylinders are plugged as shown with (X).

Pump displacement depends on engine driven pump speed through pump drive and swashplate tilt angle. The engine provides power for work, while the swashplate tilt angle provides speed control. Engine speed is set and controlled with hand or foot engine throttle.

Each variable displacement motor, except travel, begins operation at maximum displacement (high torque, low speed) and shifts to minimum displacement (low torque, high speed) if torque requirement is low. The motor remains in maximum displacement until servo PC valve (23) receives a command from PCP valve (25) to direct system pressure and flow from shuttle valve (22) to minimum displacement side of servo cylinder (24) that shifts motor. As PCP valve opens in proportion to the positive output signal received from the PC, pilot line pressure is directed to shift servo PC valve. After overcoming adjustable valve spring (26) and valve spring (27), servo PC valve shifts and directs fluid to stroke motor into minimum displacement output. If the load at the motor shaft increases, force on adjustable valve spring (26) increases. This shifts servo PC valve to de-stroke the motor to maximum displacement for safe load handling.

The load drums and boom hoist motors also have a PCOR (Pressure Compensating Over-Ride) valve (28) that is enabled when system pressure of 4,930 psi (340 bar) is reached (3770 psi [270 bar] for travel system). When system pressure exceeds the PCOR setting, the valve shifts to direct flow from shuttle valve (22) into maximum displacement side of servo cylinder (24). The PCOR valve over-rides the command from servo PC valve (23), increasing motor displacement and output torque and reducing output speed. When PCOR valve closes, control of the motor returns to servo PC valve.

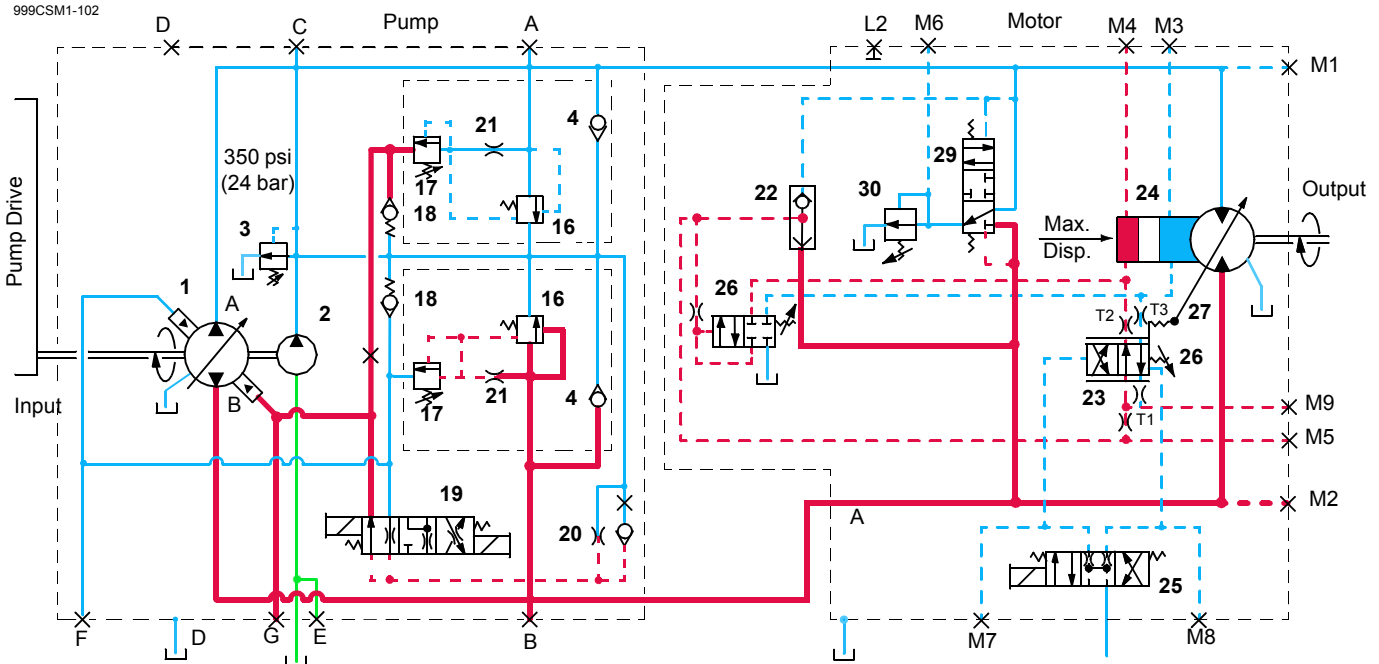


FIGURE 1-3

The travel motor servo is opposite of other system motors. Travel variable displacement motors begin operation at minimum displacement (low torque, high speed) and shifts to maximum displacement (high torque, low speed) when starting torque is required and back to minimum displacement when in motion if load is below a preset pressure. Depending on motor system, servo uses internally or externally supplied pressure to perform the shifting operation. Servo control fluid is supplied from high-pressure line of motor port "A" or "B" and shifts shuttle valve (22) and servo control valve (23) before entering servo cylinder (24).

Continuous changing of closed-loop fluid occurs through leakage in pumps, motors, and loop flushing valves. Motor case fluid drainage lubricates the motor and provides a re-circulation of hydraulic fluid to control heat in closed-loop system.

Motors also have an internal loop flushing (purge) system that consists of control valve (29) and relief valve (30). Loop flushing allows 6 GPM (23 L/min) of fluid at 350 psi (24 bar) to be removed from main hydraulic circuit for added cooling and purification.

Engine Controls

See engine manufacturer's manual for instructions.

The engine is started and stopped with engine key switch.

Use engine stop push button to stop engine in an emergency only as all brakes spring-apply and any functions stop abruptly.

Engine rpm is controlled with either the hand or foot throttle and monitored with an AC magnetic sensor.

The PC and engine throttle interface controls and processes engine information and displays the information on digital display screen.

Crane speed depends on engine speed and control handle movement in either direction from neutral.

Engine clutch lever must be manually engaged for normal operation.

Three engine indicator lights: engine warning, engine diagnostic, and engine maintenance are mounted on front console.

Engine maintenance clear switch is provided to clear an engine fault after fault is corrected.

EPIC® PROGRAMMABLE CONTROLLER

See [Figure 1-4](#)

The 999 crane's pumps, motors, control handles, sensors, limit switches, selectors, solenoid valves, brakes, pawls, clutches and alarms are controlled with the EPIC (Electrical Processed Independent Control) system. This simplifies the crane's electrical control system by avoiding mechanical control switches and relays. Standard or custom programming allows the PC (Programmable Controller) to adjust to each operational mode's acceleration rate and speed, apply brakes, retract pawls, and engage clutches-if equipped.

The PC receives and sends both analog and digital input/output signals that are AC or DC voltages or currents in a pulse train. Digital input/output signals are 12-volt nominal voltages that are either off 0 or on 1.

The PC uses the binary system. The binary system is based on binary multiples of 2, and only recognizes 0 for off or 1 for on voltages. Basic counts of this system are exponents of the number 2. These exponents are formed in words, called bytes, of eight numbers each. The eight numbers are 1, 2, 4, 8, 16, 32, 64, and 128 for an 8-bit controller or a combination of up to 255 bytes. These bytes represent electrical inputs to the controller. The controller processes this information by comparing it to programming requirements and data information. The PC then provides appropriate output commands to crane control devices.

Digital display screen shows operating conditions, operating limits, and system faults monitored by the PC. Access information by scrolling to the desired display screen with scroll switch. System messages are shown in Tables 1, 2, and 3 of the Digital Display Readings in Operator Manual.

Switches, limits, selectors or control handles send input voltage command signals to the PC. The PC compares these input voltages with feedback voltages received from system monitoring sensors, memory information, and directives entered into programming. Monitoring sensors includes; limit switches, pressure senders, speed encoders, engine RPM indicator, hydraulic fluid and temperature probes, and boom/mast/jib angle sensors. The PC then sends an output signal to pump EDC (Electrical Displacement Control) and digital outputs to solenoid valves to control system operation rates and direction. Digital outputs to solenoid valves operate brakes, pawls, and clutches that correspond with controls or control handle commands.

Pressure senders measure system pressures and supply the PC with input voltages that are stored in pressure memory. Pressure senders provide information on the required pressure to hold the load drum or boom hoist and prevent them from lowering after releasing drum brake. Pressure senders include: front drum, rear drum, auxiliary drum, boom hoist, right travel, left travel, swing right, swing left, and accessory system (low-pressure side of rear drum).

Drum speed encoders detect speed and direction of drum movement. The PC receives this information as two out-of-phase square wave voltages that are converted to "counts". The PC compares control handle voltage with pump output to determine when to vary pump stroke. Speed encoders include front drum shaft, rear drum shaft, boom hoist drum shaft, and auxiliary drum flange.

Universal boom top junction box monitors boom, luffing jib, or fixed jib components and transmits information to the PC. See RIN (Remote Input Node) Display Readings in 999 Operator Manual.

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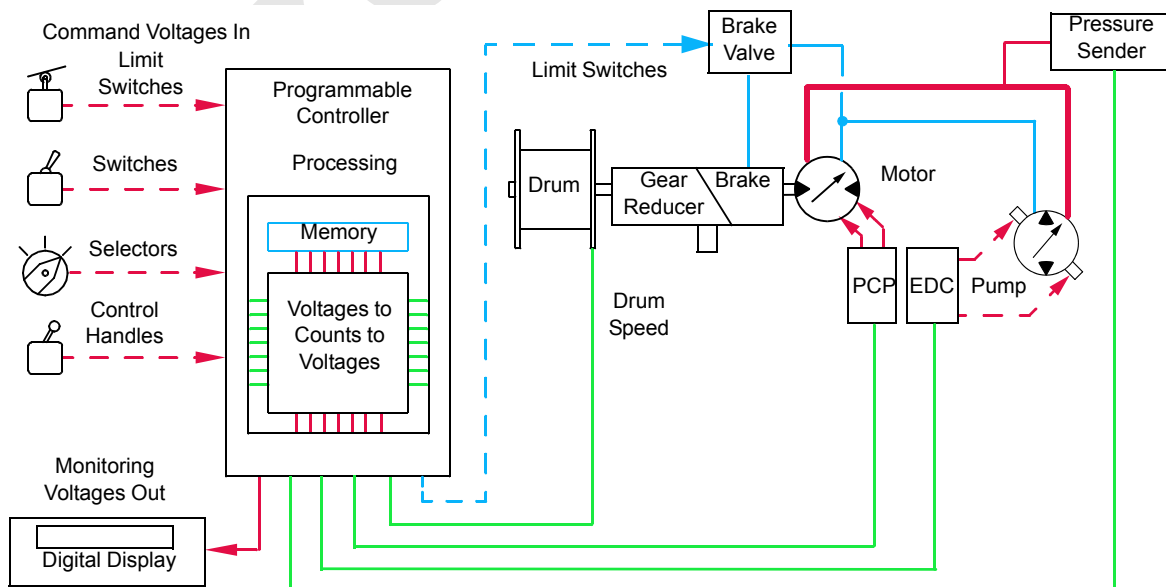


FIGURE 1-4

Boom, luffing jib, and fixed jib monitored components include component angles, minimum/maximum angle limits, block-up limits, and load sensors. The mast angle related to transport position is also monitored.

NOTE: RCL (Rated Capacity Indicator/Limiter) system has its own PC and is part of the EPIC system. For complete information on the RCL, see separate RCL Operation Manual.

Standard Mode

Hoisting or lowering are performed with front drum, rear drum, and auxiliary drum. Raising or lowering the boom is performed with boom hoist. Control handle commands for these operations are up or down.

When an up or down command is received from a control handle in full power, the PC compares the input command signal with sensor information to control braking and pump output. Before releasing system brake, the PC sends a positive voltage signal to pump EDC to stroke pump in up direction until pressure memory is met. Enough system pressure must be available to hold the load before the PC sends an output signal to release brake. This prevents momentary lowering of the load. The PC then responds to control handle command.

The PC sends required negative or positive output voltage command to load drum pump EDC. Pump EDC tilts swashplate to stroke pump in control handle command direction. The PC program provides precise pump control needed for initial control handle movement. Fluid then flows from pump to motor. The higher the command voltage, the more the pump EDC tilts swashplate.

As selected control handle is moved back to neutral position,

the PC sends an output signal to pump EDC to decrease pump output flow. When control handle is moved to neutral position and motion is stopped, the PC sends an output signal to apply system brake. A switch in control handle opens circuit when control handle is in neutral position.

Other Crane Modes

The PC applies brakes and pawls, verifies brake and pawl application, controls pump speeds, and selects control handle operation depending on other crane operation modes.

- The Standard mode is for all normal load-handling operations. Load drums can be operated in full power or free fall (optional).
 - In drum 1 free fall mode, the front drum is allowed to operate in free fall (optional).
 - In drum 2 free fall mode, the rear drum is allowed to operate in free fall (optional).
- In Clamshell mode, the front drum operates as the closing line and rear drum operates as the holding line. Power down and closing features are turned on. Closing line can be operated in free fall (optional).
- In Dragline mode, the front drum operates dragline and rear drum operates the hoist line. Drums can be operated in full power or free fall (optional).
- In Luffing Jib mode, the rear drum operates as luffing hoist and must be rigged accordingly.
- In Crane Setup mode, the PC allows operation of gantry cylinders, mast raising cylinders, boom hinge pin cylinders, counterweight pins, and carbody jacks.

Electrical Power to 999 Operator Cab

See [Figure 1-5](#)

Voltage is available to operate dome light switch (1), horn switch (2), when key-operated engine switch (3) is in stop position. After key-operated engine switch is placed in run

position, power is available to the EPIC programmable computer, air conditioning relay (ACR), power relay (K1), engine control module relay (ECM), and start relay (MS1). When power relay K1 is enabled, power is available to operate crane controls and accessory controls (see Electrical Schematic drawings in Section 3).

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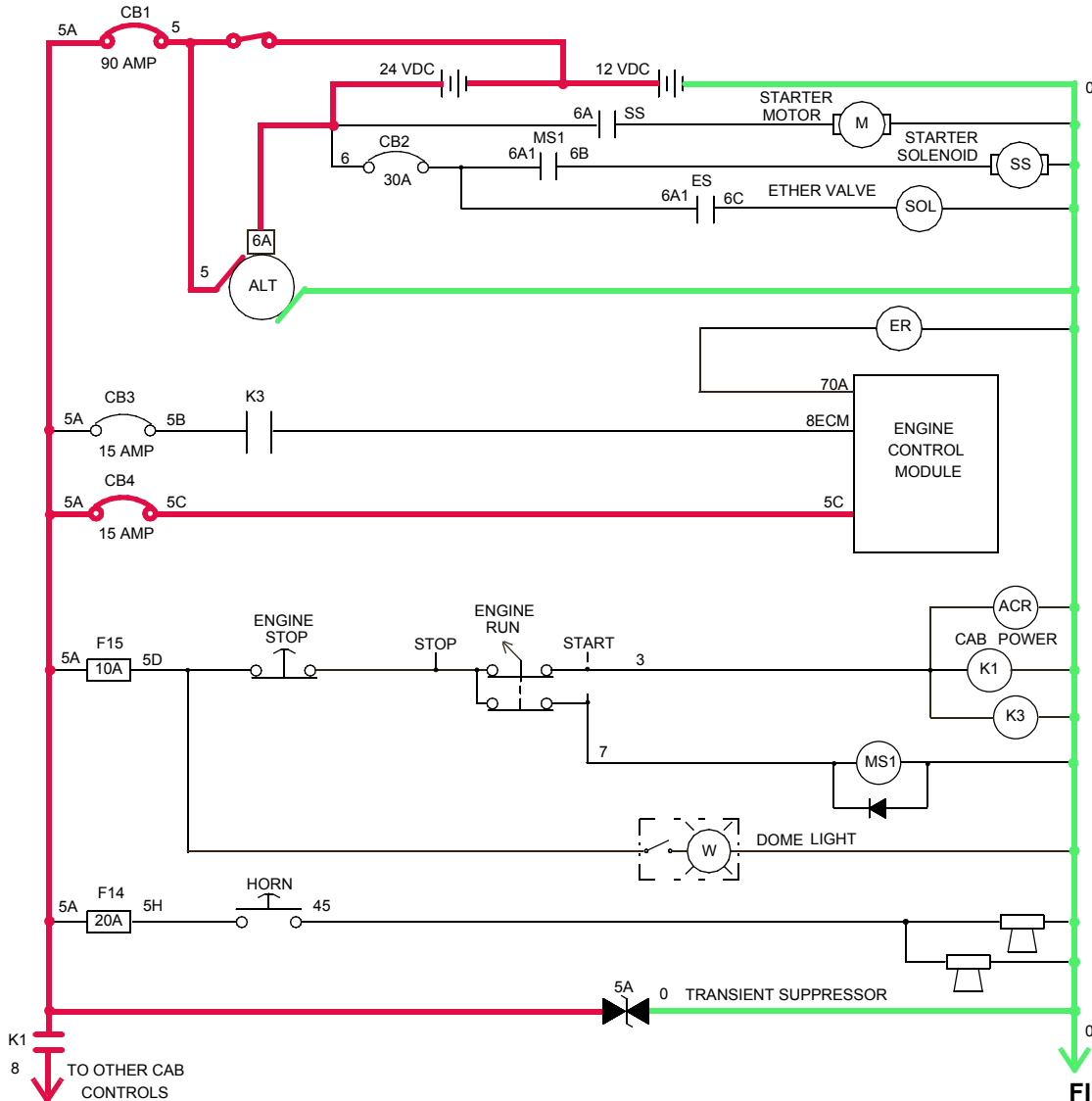


FIGURE 1-5

Pressure Senders and Encoders

See [Figure 1-6](#)

Voltage is also available to hydraulic pressure senders and electrical speed encoders. Hydraulic pressure senders monitor front and rear drum system pressure, accessory

system pressure, boom hoist system pressure, right/left travel system pressure, swing right/left system pressure and auxiliary drum system pressure. Electrical speed encoders monitor front and rear drum shaft, boom hoist drum shaft, and auxiliary drum flange rotation.

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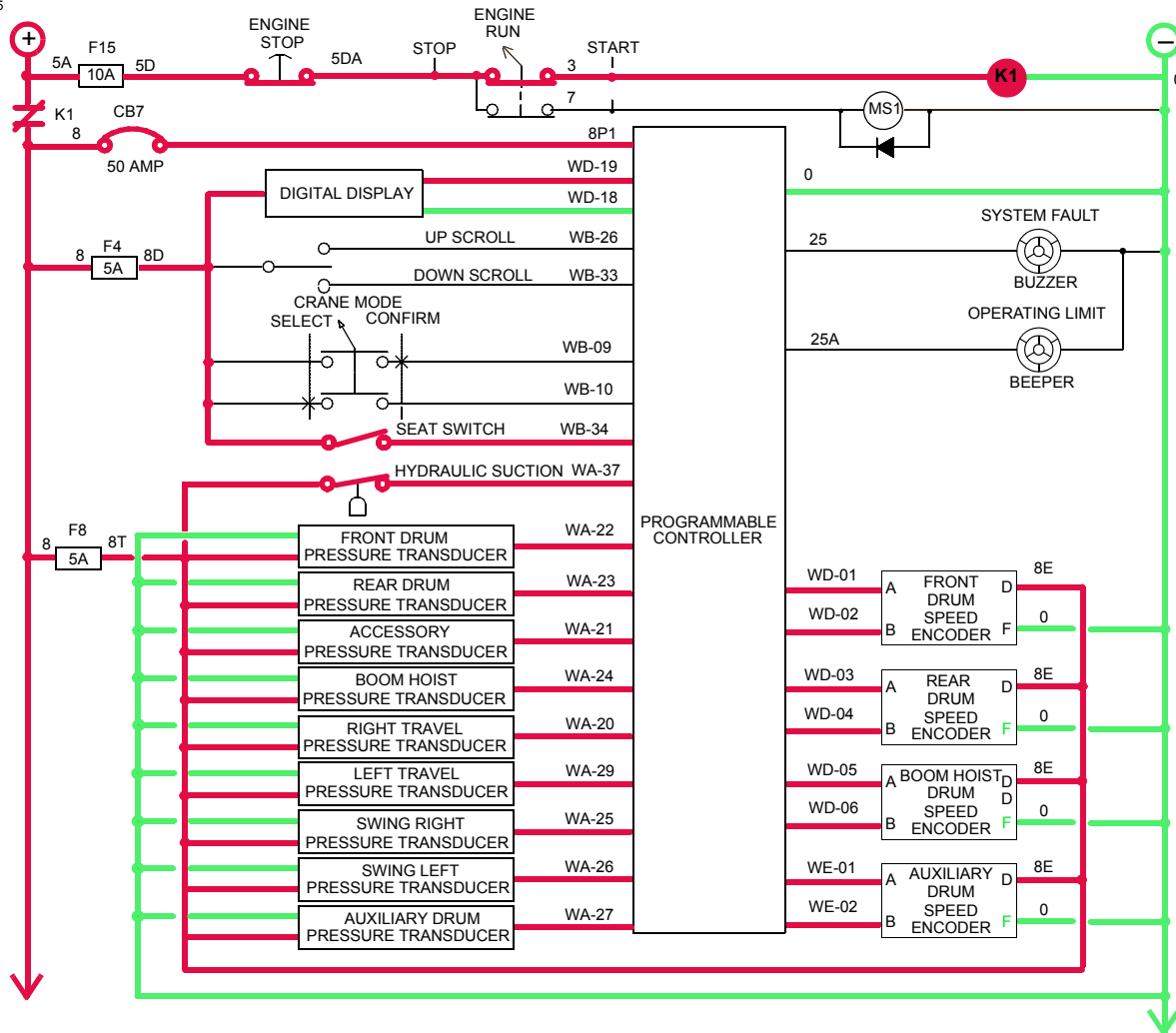


FIGURE 1-6

System Faults

See [Figure 1-7](#)

The PC monitors and enables a red system fault light and buzzer if any system fault is detected. System fault display screen displays faults and automatically scrolls through faults, stopping for three seconds at each fault. When fault is corrected, the display clears the fault from the screen after scrolling through fault screen twice. When a system fault is enabled, the PC displays the following messages:

HYD TANK FLUID TEMP – Hydraulic tank fluid temperature is above 180°F (82°C).

HYD TANK FLUID LEVEL – Hydraulic tank fluid at low level; fill tank.

ENGINE OIL PRESSURE – Engine oil pressure is below 15 psi (1,0 bar).

ENGINE TEMPERATURE – Engine coolant temperature is above 205°F (96°C).

MAIN CHARGE FILTER – Main charge filter is plugged, replace filter. Opens at 75 psi (5,2 bar).

AUX DRUM CHR G FILTER – Auxiliary drum charge filter is plugged, replace filter.

HYD SUCTION FILTER – Remove blockage from suction side of hydraulic tank or pumps will be damaged.

BOOM ANGLE SENDER – Boom angle sender output voltage is 0 volts or above 9.7 volts.

LUFF JIB SENDER – Luffing jib angle sender output voltage is 0 volts or above 9.7 volts.

MAST SYSTEM – Stop operating mast system and find cause of fault and correct.

BATTERY VOLTAGE LOW – Battery voltage is less than 10 volts.

FFALL FILTER – Free fall filter is plugged, replace filter.

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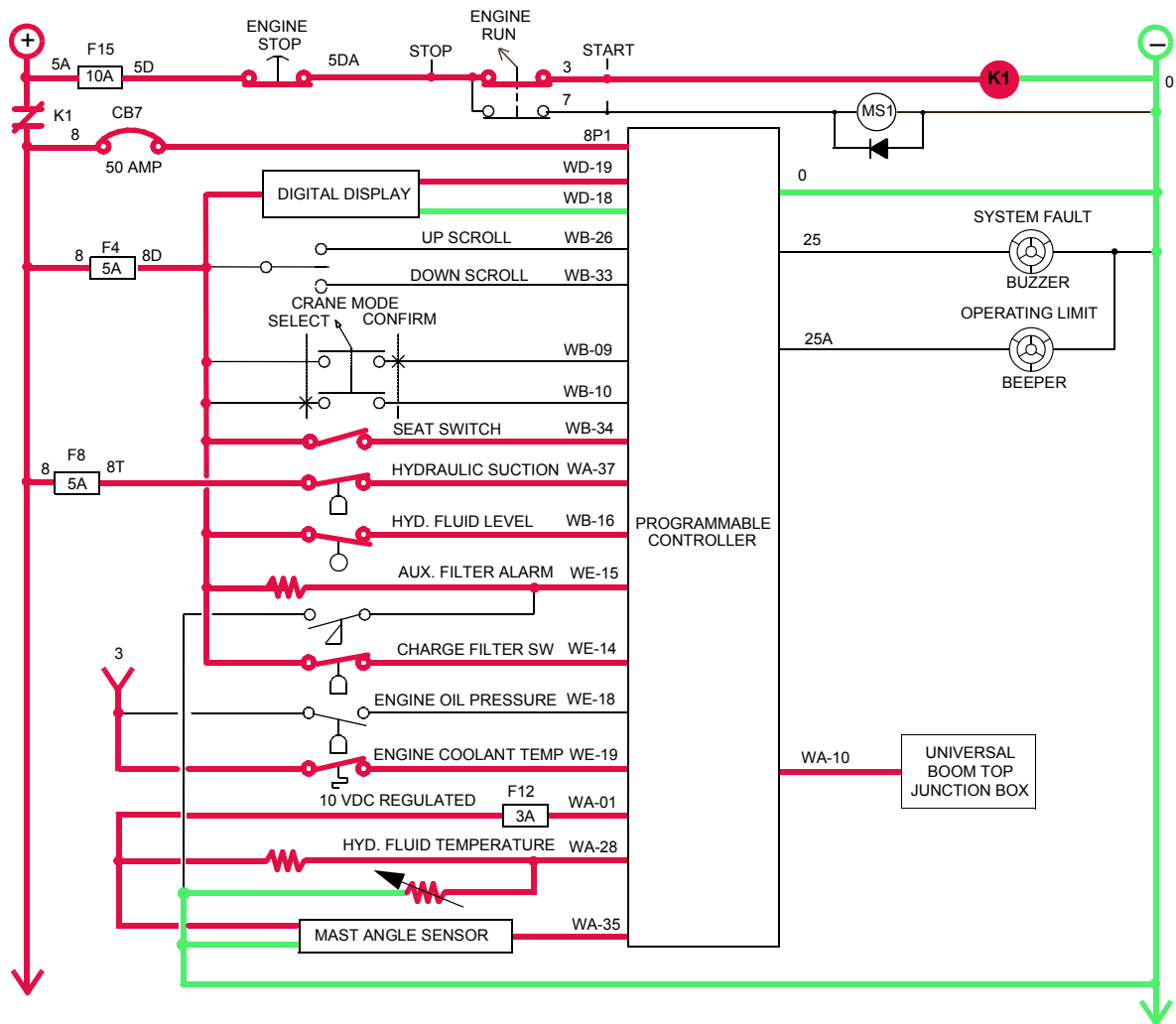


FIGURE 1-7

NOTE: The boom angle sender and luffing jib sender (optional) system faults are part of the boom top electrical system. Inputs from the boom top electrical system are sent to the PC and are internal to the PC program. See RIN (Remote Input Node) Display Readings in 999 Operator Manual for boom top electrical system instructions.

Operating Faults and Limit Switches

See [Figure 1-8](#)

When operating, all limit switches are closed, sending input signals to the PC. If a limit switch is tripped, the PC sends an output signal to pump EDC and brake solenoid. The pump de-strokes and brake solenoid valve shifts to spring-apply brake. Move control in the opposite direction away from limit to correct the problem.

Limit bypass key switch (1) allows crane to be operated beyond the limits for crane setup or maintenance only. See Bypassable Limit Identification, Table 3-1 in Section 3 of 999 Operator Manual.

The PC monitors crane systems and enables an alert (3) if any limit switch is open or any programmed limit is reached. To identify and display operating limit, use digital display screen and scroll switch (4) to scroll display up or down. When an operating limit is enabled, the PC displays one or more of the following messages:

BLOCK UP – Load drums stops hoisting and boom/luffing jib hoist stops lowering.

MAXIMUM DOWN – Stops boom from lowering; limit usually set at 0°. Stops luffing jib from lowering when boom-to-luffing jib angle is 60°.

MAX UP-1 – Stops boom at 83° or if equipped with luffing jib at 88°. Stops luffing jib when boom-to-luffing jib angle is 168°.

MAX UP-2 – Stops luffing jib when boom-to-luffing jib angle is 170°. Limit can be bypassed only when boom is below 50°.

CONFIRM MODE – All functions inoperable until an operating mode is selected and confirmed.

MAX BAIL – Stops load drum when a preset length of wire rope is spooled onto drum.

MIN BAIL – Stops load drum when there are 3 to 4 wraps of wire rope remaining on drum.

GANTRY DOWN – Boom hoist inoperable in both directions if gantry is down when mast angle is 120° or more.

JIB BELOW HORIZONTAL – Luffing jib operable. See Capacity Chart Manual for luffing jib minimum operating angles.

RATED CAPACITY – All load drums stop hoisting and boom/luffing jib stop lowering.

MAST TOO FAR FWD – Boom hoist inoperable in lowering direction (occurs if mast is below 175°).

MAST SYSTEM – Boom hoist inoperable in both directions.

FUNCTION IS PARKED – Function inoperable because it is parked.

NOTE: The block up, maximum down, maximum up-1, maximum up-2, and jib below horizontal (optional) limits are part of the boom top electrical system. Inputs from the boom top electrical system are sent to the PC and are internal to the PC program. See RIN (Remote Input Node) Display Readings in 999 Operator Manual for instructions on boom top electrical system.

Brake and Drum Pawl Application/Release

The load drums brakes and boom hoist drum brakes are spring-applied and hydraulically released. The operator enables brake/pawl operation by placing selected brake switch in off - park position. The load drum pawl or boom hoist drum pawl is disengage.

The PC controls release of selected brake with control handle movement. When PC enables the selected brake release solenoid, the brake valve shifts to block tank port and supplies pressurized fluid to hydraulically release brake.

With a up command, the PC does not release drum brake until pressure memory holding pressure is reached to hold the load, as determined by pressure senders. In a down command, the PC sends an output signal to pump EDC to tilt swashplate momentarily in up direction, opposite to the selected load drum handle command. The PC then sends an output signal to release brake when pressure memory holding pressure is reached.

As selected drum control handle nears neutral position, the PC compensates for hydraulic system leakage from changing load weight or changing engine speed. The PC sends an output signal to adjust swashplate in the up direction until load is supported and pressure memory is stored.

When drum control handle command is off for a preset time, the PC sends a output signal to disable the selected brake release solenoid, brake release solenoid valve shifts to block pressurized flow to brake. This opens a line to tank for brake hydraulic fluid and brake spring-applies. Placing selected brake switch in on - park position disables brake/pawl operation.

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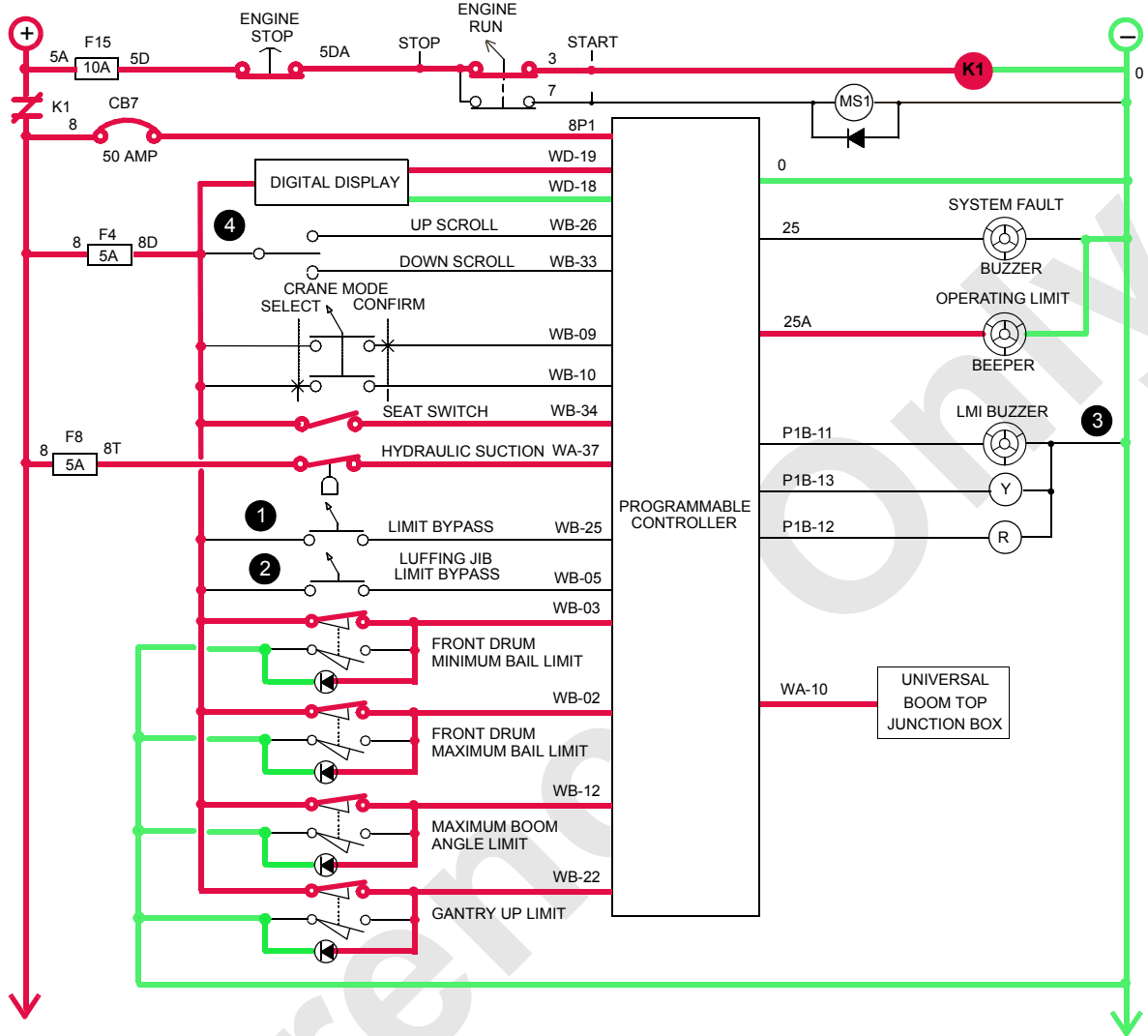


FIGURE 1-8

SWING SYSTEM OPERATION

See Figures 1-9 and 1-10

Swing handle (1) is inoperable when swing brake (2) is applied and the swing lock (3) is engaged. The rotating bed is free to coast if swing lock is disengaged, swing brake is released, and swing handle is in neutral position. Swing speed and swing torque can be selected for type of work being performed. See Swing Speed/Swing Torque diagnostic screen on digital display in 999 Operator Manual.

For swing brake and swing lock operation, charge pressure from rear drum pump must be above 200 psi (14 bar) for full release of swing brake and swing lock. If swing charge pressure is below above pressure, swing brake could be partially spring-applied and damage the swing brake. Swing pressure senders (6) monitor the pressure on swing left and swing right sides of swing closed loop system. This information is sent to the PC to control the coasting effect.

The PC does not control the fixed displacement swing motor (9). The swing motor is controlled directly by the output fluid volume of the swing pump. An orifice (7), across swing motor ports A and B allow smoother fluid flow when shifting swing directions.

Swing Brake and Swing Lock

After start-up, place swing brake switch (8) in off - park position. The swing lock engage solenoid HS-9 opens. The swing lock disengage solenoid HS-10 closes, disengaging locking pins from slots in shaft locking flange. Swing brake release solenoid HS-8 shifts to block tank port and supplies hydraulic charge pressure from rear drum pump to hydraulically release brake. If brake pressure or electrical power is lost when operating, brakes spring-apply.

Before shutdown, place swing brake switch in on - park position. Swing brake release solenoid HS-8 opens to exhaust fluid back to tank and swing brake spring-apply. Circuit to swing lock disengage solenoid HS-10 opens. Circuit to swing lock engage solenoid HS-9 closes to engaging locking pins into slots in shaft locking flange.

Swing Right or Left

When swing handle is moved to the left an input voltage of 5 volts or more is sent to the PC. The PC sends a negative output voltage to swing pump EDC (4). Swing pump swashplate tilts relative to control handle movement. Fluid flows from swing pump port B to swing motor port B, moving rotating bed to the left.

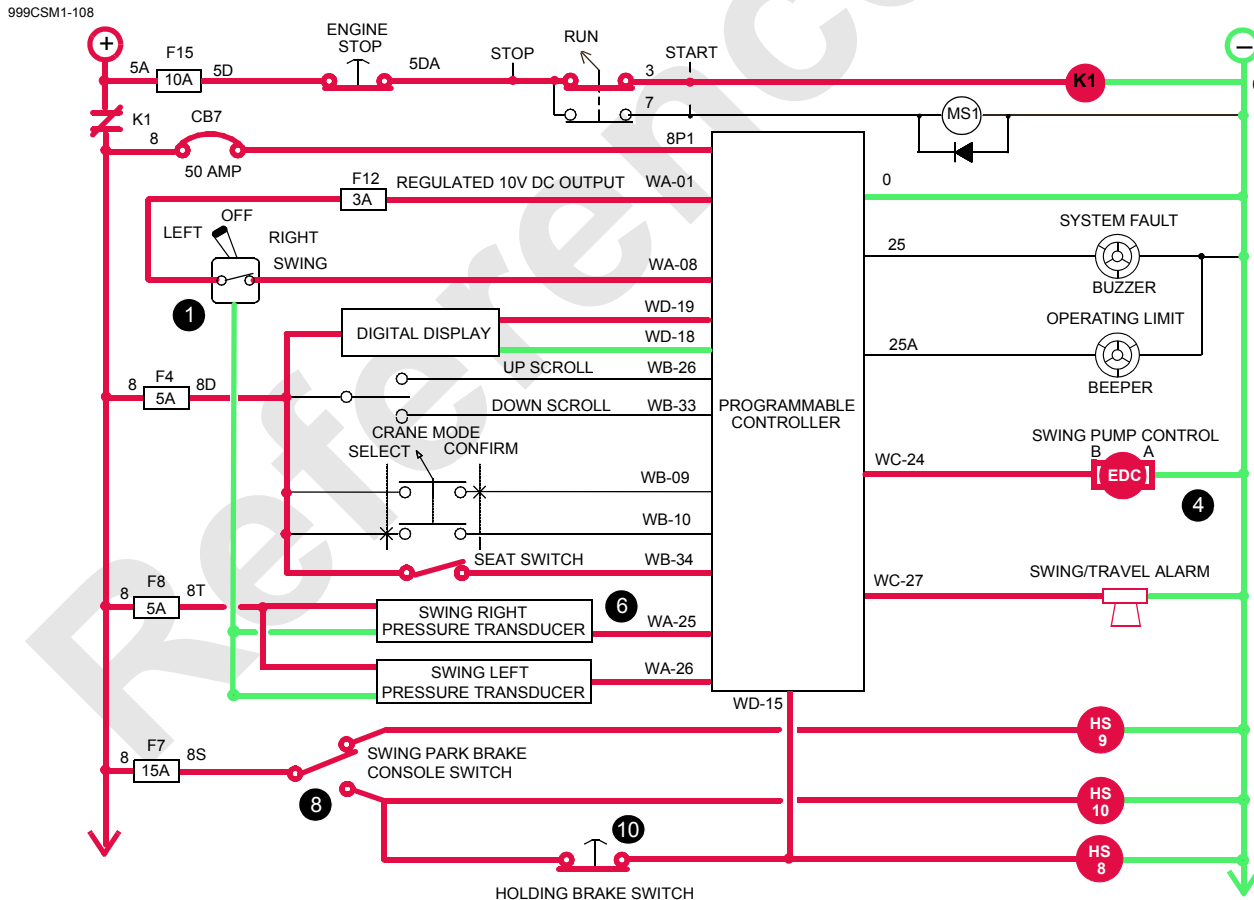


FIGURE 1-9

When swing handle is moved to right, an input voltage of 5 volts or less is sent to the PC. The PC sends a positive output voltage to swing pump EDC. Swing pump swashplate tilts relative to swing handle movement. Fluid flows from swing pump port A to swing motor port A, moving rotating bed to the right.

As swing handle is moved to neutral position, the PC sends an output signal to adjust swashplate to centered position. When in a swinging motion, the preferred way to stop or slow crane is to move swing handle beyond center in the opposite direction. This allows rotating bed to gradually stop.

Swing Holding Brake Switch

Swing holding brake switch (10) on side of swing handle, holds rotating bed in position (applies swing park brake) for short periods when operating. To prevent damage to swing system, swing holding brake switch must only be applied when crane is at a standstill.

When swing holding brake switch is pressed in and held, circuit to swing brake release solenoid HS-8 is opened, allowing fluid to exhaust to tank and brake spring-applies. Crane rotating bed is stopped while switch is held. When swing holding brake switch is released, circuit to swing brake release solenoid HS-8 is closed, allowing charge pressure to hydraulically release spring-applied park brake.

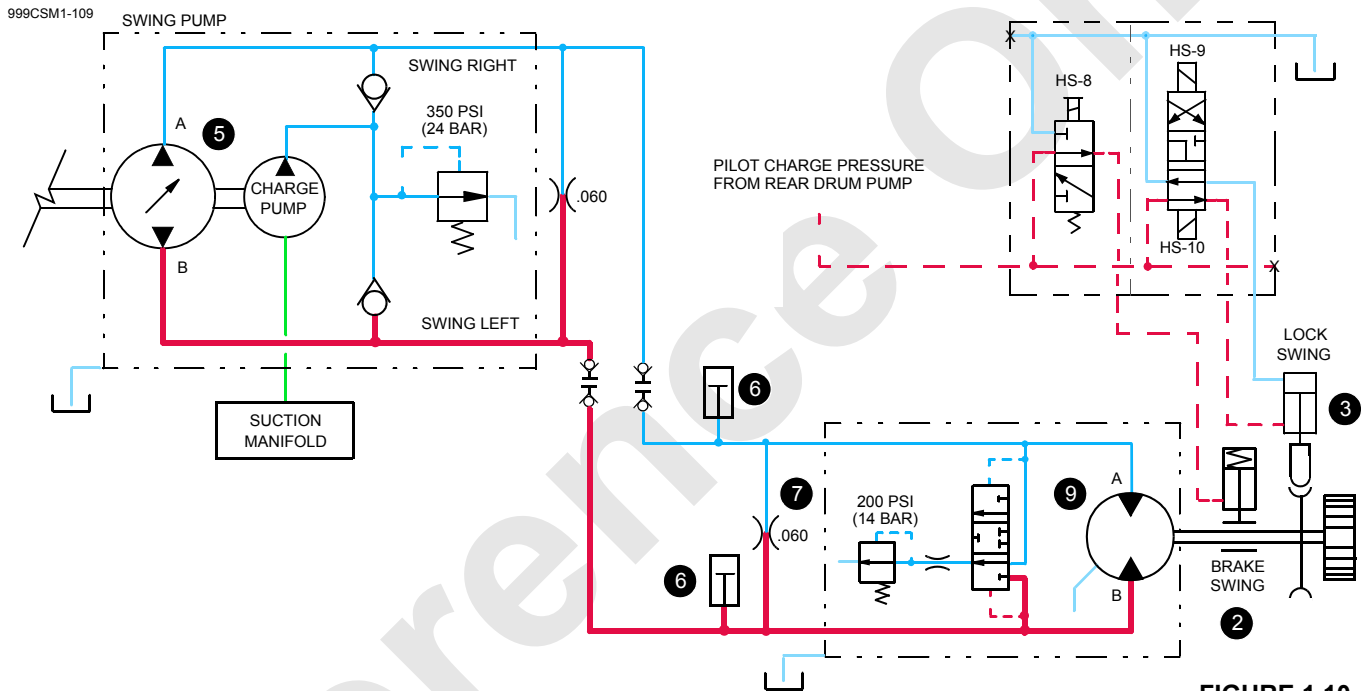


FIGURE 1-10

TRAVEL SYSTEM OPERATION

See Figures [1-11](#) and [1-12](#)

Travel handles (1) or foot pedals (2) are inoperable when travel brakes (3) are spring-applied, and there is no PC output signal to right travel pump EDC (4) or left travel pump (5) EDC. When travel brakes are released, travel handles or foot pedals are operable.

For travel operation, charge pressure from rear drum pump must be above 200 psi (14 bar) for travel spring brakes to fully release. If travel charge pressure is below above pressure, travel brake could be partially spring-applied and damage the brake. The left travel charge pump (14) supplies pilot charge pressure for enabling boom hoist, front drum, and rear drum motor servo operation.

To ensure crane travels in a straight forward or reverse direction, both travel hydraulic drive systems have shuttle valves (6) and pressure senders (7) that monitor the pressure to both closed-loop systems. When traveling, the PC monitors signals from pressure senders and adjusts displacement of the travel pumps (8) to maintain equal pressure in each travel drive system. This allows crane to track in a controlled straight direction.

Continuous changing of closed-loop fluid occurs through leakage in motors (9) and loop flushing valves (10) that allow 6 GPM (23 L/min) of fluid to return to tank when system pressure is above 350 psi (24 bar).

Travel Brakes

When travel brake switch (11) is in on - park position, both right and left travel brakes are spring-applied to hold crane in position. Travel brake release solenoid HS-11 is open to exhaust hydraulic fluid back to tank and travel brake is spring-applied.

When travel brake switch is in off - park position, travel command sends an input signal to the PC. The PC prepares crane travel system for operation. Travel brakes remain spring-applied until a travel handle or pedal is moved from neutral position. When a travel handle or pedal is moved, travel brake release solenoid HS-11 shifts to block tank port and supplies hydraulic charge pressure from rear drum pump to hydraulically release both spring brakes. If brake pressure or electrical power is lost when operating, brakes spring-apply.

Travel Forward and Reverse

Both right and left travel forward closed-loop systems operate the same, except fluid flows from left travel pump port A to left travel motor port A and from right travel pump port A to right travel motor port B.

When left or right travel handle or pedal is moved in forward direction, an input voltage of 5 volts or more is sent to the PC. The PC sends a positive output signal to selected travel pump EDC and enables travel brake release solenoid HS-11. Travel brake release solenoid HS-11 shifts to release left and right travel brake with charge pressure from rear drum pump, before selected travel pump strokes.

Selected travel pump EDC tilts swashplate in forward direction. Fluid flows from selected travel pump through swivel to travel motor. The PC controls input voltage to selected travel pump EDC, controlling travel speed relative to selected travel handle or pedal movement.

When left or right travel handle or pedal is moved in reverse direction, an input voltage of 5 volts or less is sent to the PC. The PC sends a negative output signal to selected travel pump EDC and enables travel brake release solenoid HS-11. Travel brake release solenoid HS-11 shifts to release left and right travel brake with charge pressure from rear drum pump, before selected travel pump strokes.

Selected travel pump EDC tilts swashplate in reverse direction. Fluid flows from selected travel pump through swivel to travel motor. The PC controls input voltage to selected travel pump EDC, controlling travel speed relative to selected travel handle or pedal movement.

As left or right travel handle or pedal nears neutral position, the PC compensates for hydraulic system leakage or changing engine speed. The PC sends an output signal to adjust swashplate to centered position. When travel handle or pedal command is off for a preset time, the PC sends an output signal to disable travel brake release solenoid HS-11. Travel brake release solenoid valve shifts to block charge pressure to brakes. This opens a line to tank for brake hydraulic fluid and brakes spring-apply.

Travel Speed-High/Low Operation

Travel motors are variable displacement and shift internally with an adjustable spring in each motor P/C (Pressure Compensator) valve, preset at 3,915 psi (270 bar). Travel speed switch (13) allows operator to select **LOW** when smoother starts and precise control over the load is required or high when maximum available travel speed is required.

When travel speed switch is in low position, the PC sends an output signal to enable 2-speed travel solenoid HS-12, shifting valve and directing pilot charge pressure to end of the P/C valve. The P/C valve shifts PCOR spool placing travel motor in maximum displacement (high torque, low speed) position. Travel motors remain in this position until travel speed switch is placed in high position and engine speed is more than 1500 rpm.

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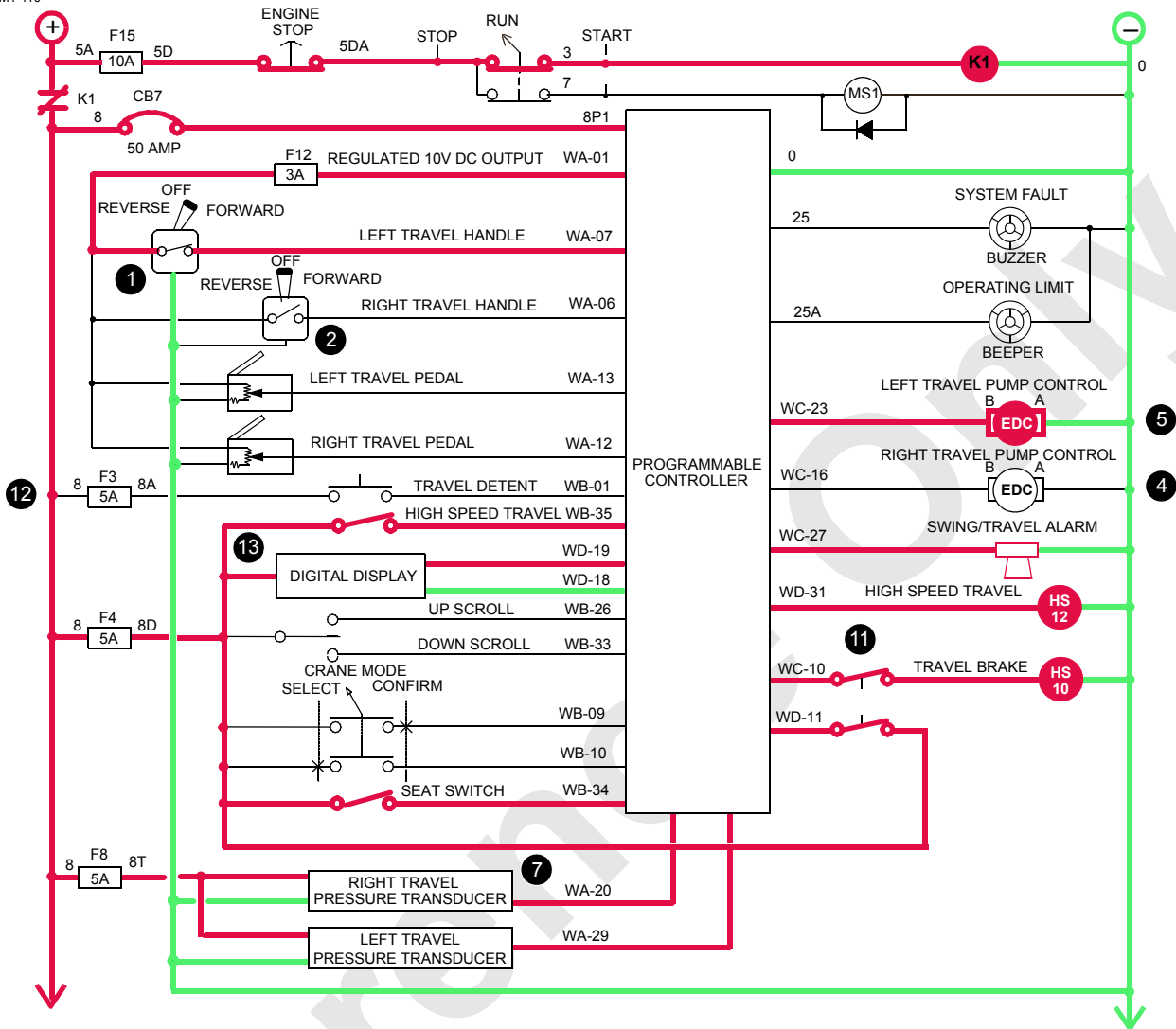


FIGURE 1-11

When travel speed switch is in high position, travel motors remain in minimum displacement (low torque, high-speed) position when starting. When crawler begins to move, a high system pressure shifts the PCOR spool placing travel motor in maximum displacement (high torque, low speed) position for breakaway torque. Travel motors shift back to minimum displacement automatically if engine speed is above 1500 rpm and system pressure is below 3,915 psi (270 bar). If engine is below 1500 rpm, 2-speed travel solenoid HS-12 is enabled even if travel speed switch in the high position. Two-speed travel solenoid HS-12 is disabled, shifting valve and removing pilot charge pressure to end of P/C valve, allowing motor to operate in PCOR mode.

Travel Detent Selector

Travel detent selector (12) on right travel handle locks-in any travel command. This allows crawler track to operate in

either direction at a selected speed without manually moving travel handles. When moving at desired speed and direction, lift up travel detent selector on right travel handle dome. The PC locks-in the travel information. When travel handle is moved back to neutral position, travel speed and direction is maintained.

Lifting travel detent selector again or moving either travel handle or pedal in opposite direction from neutral, opens travel detent circuit and returns control of travel system to the operator.

Travel detent selector also serves as a brake function. Lift the travel detent selector when travel handles are in neutral position. This locks-in off condition with brakes spring-applied and disables travel handles until travel detent selector is released.

999CSM1-111

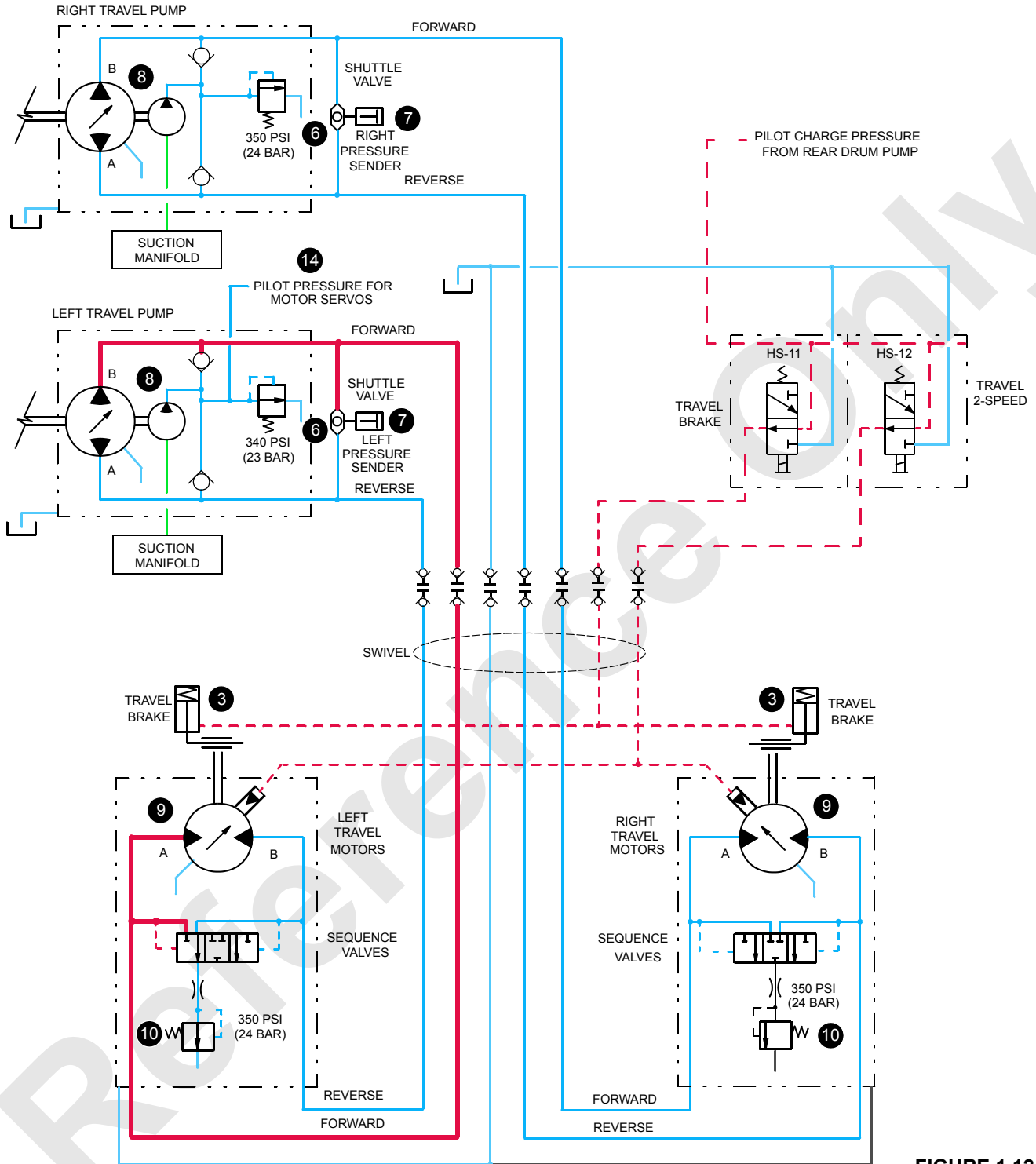


FIGURE 1-12

BOOM HOIST SYSTEM OPERATION

See Figures 1-13 and 1-14

Boom hoist handle (1) is inoperable when boom hoist brake (2) is applied. There is no output signal to boom hoist pump EDC (3) and boom hoist pump (4) does not stroke.

The left travel charge pump supplies pilot pressure to the boom hoist motor servo (5). Hydraulic charge pressure from rear drum charge pump must be above 200 psi (14 bar) to operate boom hoist drum pawl. Hydraulic pressure to operate boom hoist brake is from low-pressure side of boom hoist system. Pressure sender (6) in high-pressure side of boom hoist closed-loop system provides system pressure information to the PC.

When boom hoist drum rotates, boom hoist drum speed encoder (7) sends an input signal to the PC. The PC sends an output signal that enables rotation indicator (8) in boom hoist handle. Rotation indicator on top of control handle pulsates with a varying frequency that indicates rotational

speed of boom hoist drum. As drum rotates faster, the indicator pulsates faster.

Continuous changing of closed-loop fluid occurs through leakage in pump, motor, and external sequence/flow valve (9). Sequence/flow valve opens at 200 psi (14 bar) and removes 6 GPM (23 L/min) of hot fluid from system by dumping the fluid into the motor case where fluid returns to tank through tank cooler.

An orifice (10), across motor ports A and B allows for smoother fluid flow.

Boom Hoist Brake and Pawl Switch

When boom hoist brake switch (2) is in on - park position, boom hoist brake release solenoid HS-13 is disabled so brake is spring-applied to drum. Boom hoist drum pawl in solenoid HS-14 is enabled to keep pawl applied to boom hoist drum. Boom hoist pump does not stroke in response to boom hoist handle movement.

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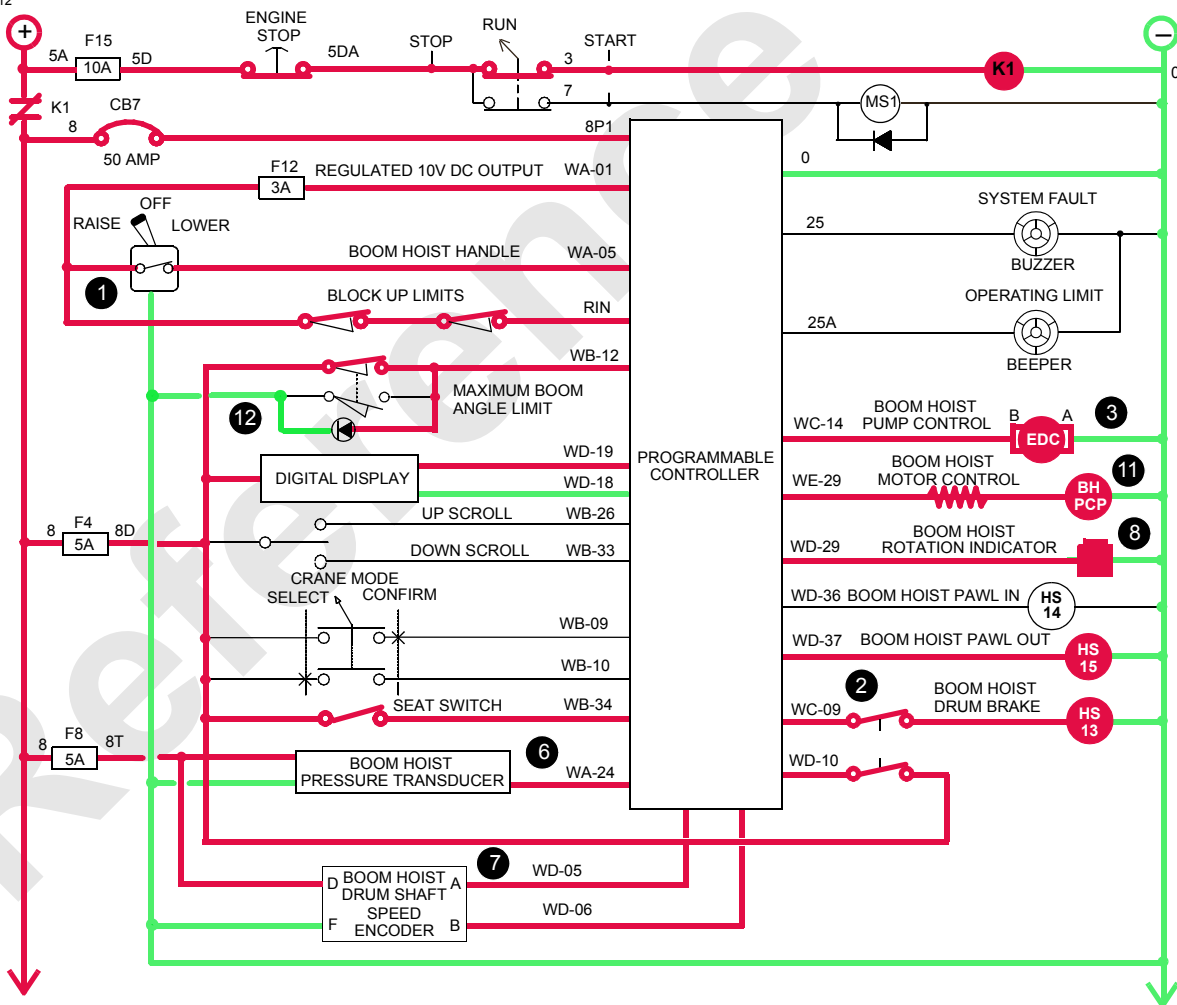


FIGURE 1-13

999CSM1-113

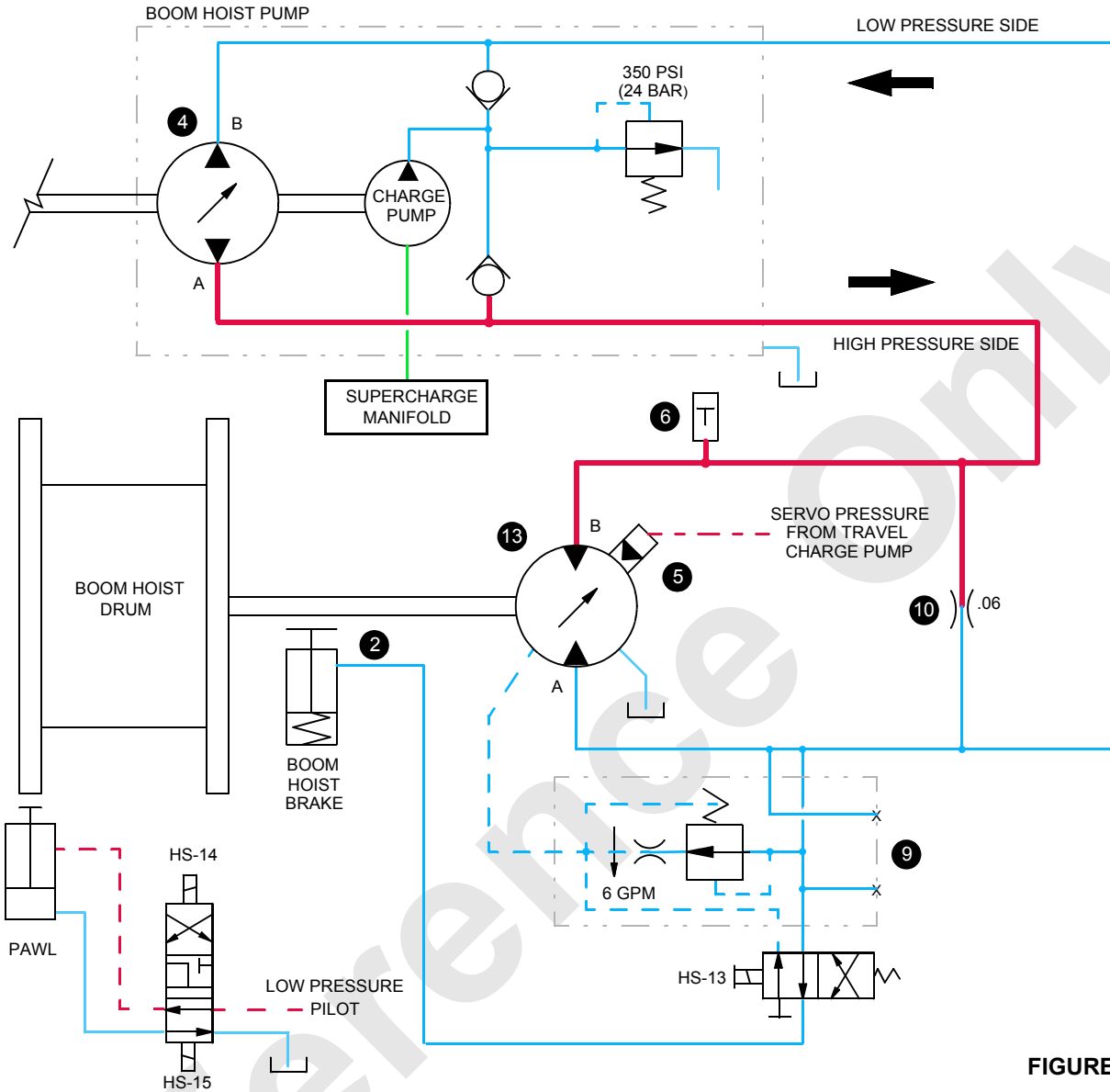


FIGURE 1-14

When boom hoist brake switch is placed in off - park position, boom hoist brake remains spring-applied to boom hoist drum until the PC releases the brake. Boom hoist drum pawl out solenoid HS-15 is enabled to disengage pawl from boom hoist drum. Boom control handle circuit to PC remains open.

Boom Hoist Raise

When boom hoist handle (1) is moved back for booming up, the handle neutral switch closes, sending an input voltage of 5 volts or more to PC. The PC sends a positive output voltage to boom hoist system pump EDC (3) and a positive output voltage to motor PCP (11). Boom up limit switch (12) must closed and with no hydraulic system faults present.

The PC requires that boom hoist pump strokes in up direction to satisfy pressure memory. The PC compares

boom hoist-holding pressure to value stored in pressure memory. When system pressure is high enough, the PC sends a positive output signal to enable brake release solenoid HS-13. Brake release solenoid HS-13 shifts to block tank port and open port from low-pressure-side of closed-loop system to release spring-applied brake.

The PC sends a positive output voltage to enable boom hoist pump EDC that tilts pump swashplate to stroke pump in the up direction. Hydraulic fluid flows from hoist pump port A to port B of hoist motor (13). Fluid from motor port A, returns to boom hoist pump port B.

The PC controls raising speed by varying the voltage to pump EDC and motor PCP in relation to handle movement. As boom hoist handle is moved back, the PC sends a signal to increase the boom hoist pump swashplate angle. The PC

also sends a signal to reduce the displacement of the motor. The PC is continuously balancing the system pressure and the motor displacement angle so the motor displacement goes to minimum when handle is all the way back, if the torque on the motor is not too high. Knowing the displacement of the motor, the PC may then control the speed that the motor turns by regulating the flow through the pump.

When boom hoist handle is moved to neutral position, the PC sends an output signal to boom hoist pump EDC to decrease swashplate angle, reducing oil flow output. This shifts the motor back to maximum displacement for slower output speed to slow the drum rotation. The PC stores the load holding pressure in pressure memory. After control handle neutral switch opens, the PC sends an output signal to disable brake release solenoid HS-13 to spring-apply brake before boom hoist pump de-strokes.

Boom Stop Cylinders

If boom is raised to 81°, springs in boom-stop cylinders slow the boom opposite movement. At approximately 90° boom-stop springs bottom out and boom physically stops. If boom is raised to maximum boom up stop angle of 83° above horizontal or 88° above horizontal with luffing jib, the boom up limit switch (12) opens the circuit. Boom hoist pump de-strokes and boom hoist brake spring-applies. Operating limit (MAX UP 1) is displayed as limit switch is tripped. Lower the boom to correct problem.

Boom Hoist Lower

See Figures 1-15 and 1-16

When boom hoist handle (1) is moved forward to move boom down, handle neutral switch closes, sending an input voltage of 5 volts or less to PC. The PC sends a negative output voltage to boom hoist system pump EDC (3) and a positive voltage to motor PCP (11).

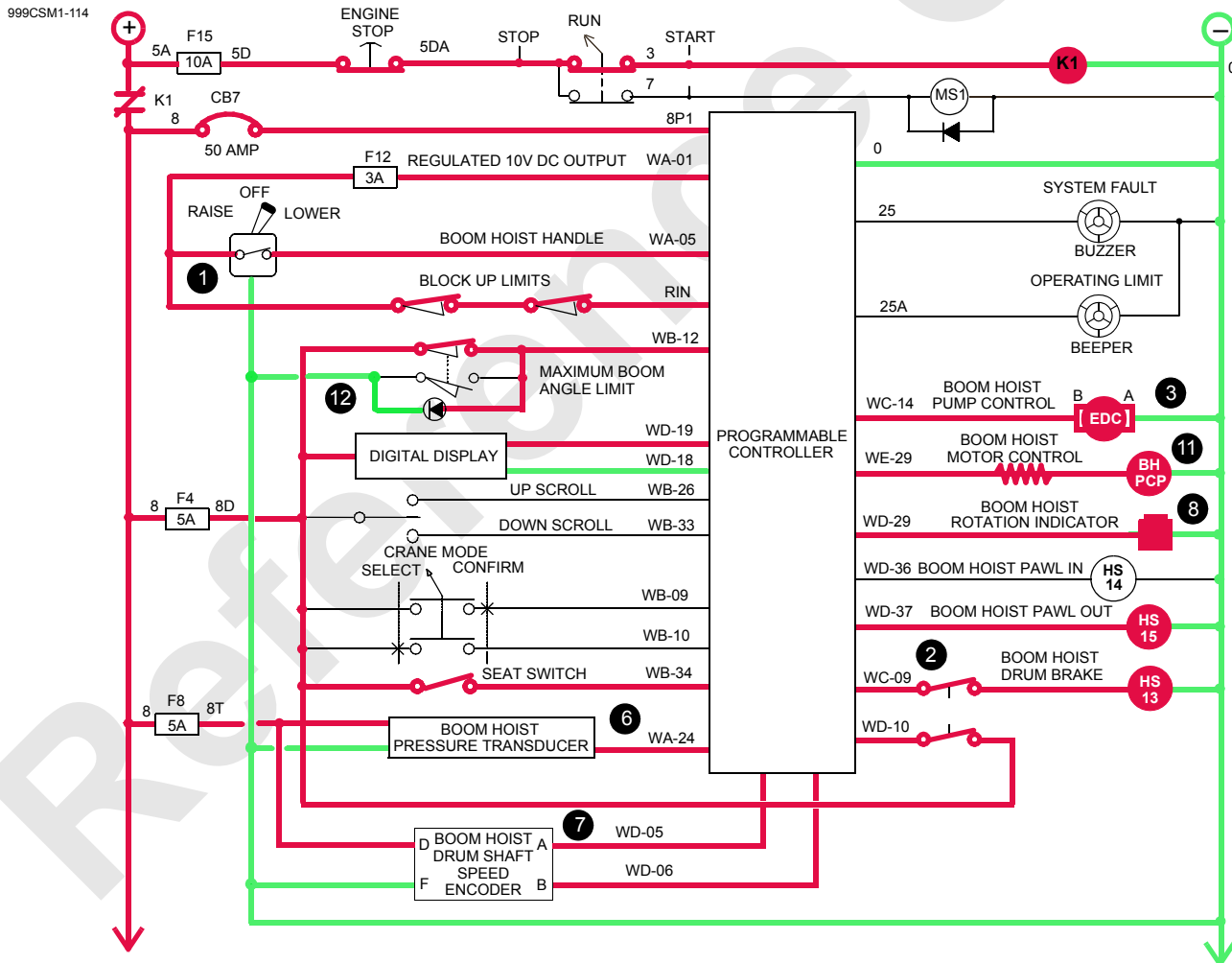


FIGURE 1-15

The PC sends a positive output signal to stroke the boom hoist pump momentarily in the up direction to satisfy pressure memory. The PC compares boom hoist-holding pressure to value stored in pressure memory. When system pressure is high enough, the PC sends a positive output signal to enable brake release solenoid HS-13. Brake release solenoid HS-13 shifts, to block tank port and open port from low pressure side of closed-loop to boom hoist brake cylinder spring, releasing brake (2).

The PC sends a negative output signal to enable boom hoist pump EDC that tilts pump swashplate to stroke pump in the down direction. Hydraulic fluid flows from hoist pump port B to port A of hoist motor (13). Fluid from motor port B returns to boom hoist pump port A.

The PC controls lowering speed by varying the voltage to pump EDC and motor PCP in relation to handle movement.

As boom hoist handle is pushed forward, the PC sends a signal to increase the boom hoist pump swashplate angle. The PC also sends a signal to reduce the displacement of the motor. The PC is continuously balancing the system pressure and the motor displacement angle so the motor displacement goes to minimum when handle is all the way back, if the torque on the motor is not too high. Knowing the displacement of the motor, the PC may then control the motor speed by regulating the flow through the pump.

The weight of boom attempts to drive motor faster than return fluid can return to low-pressure side of pump. System charge pump maintains fluid supply at a positive pressure to motor. Pump swashplate position restricts the returning fluid flow. Pressure builds on fluid return side of closed-loop, acting as a hydraulic brake to control lowering speed.

999CSM1-115

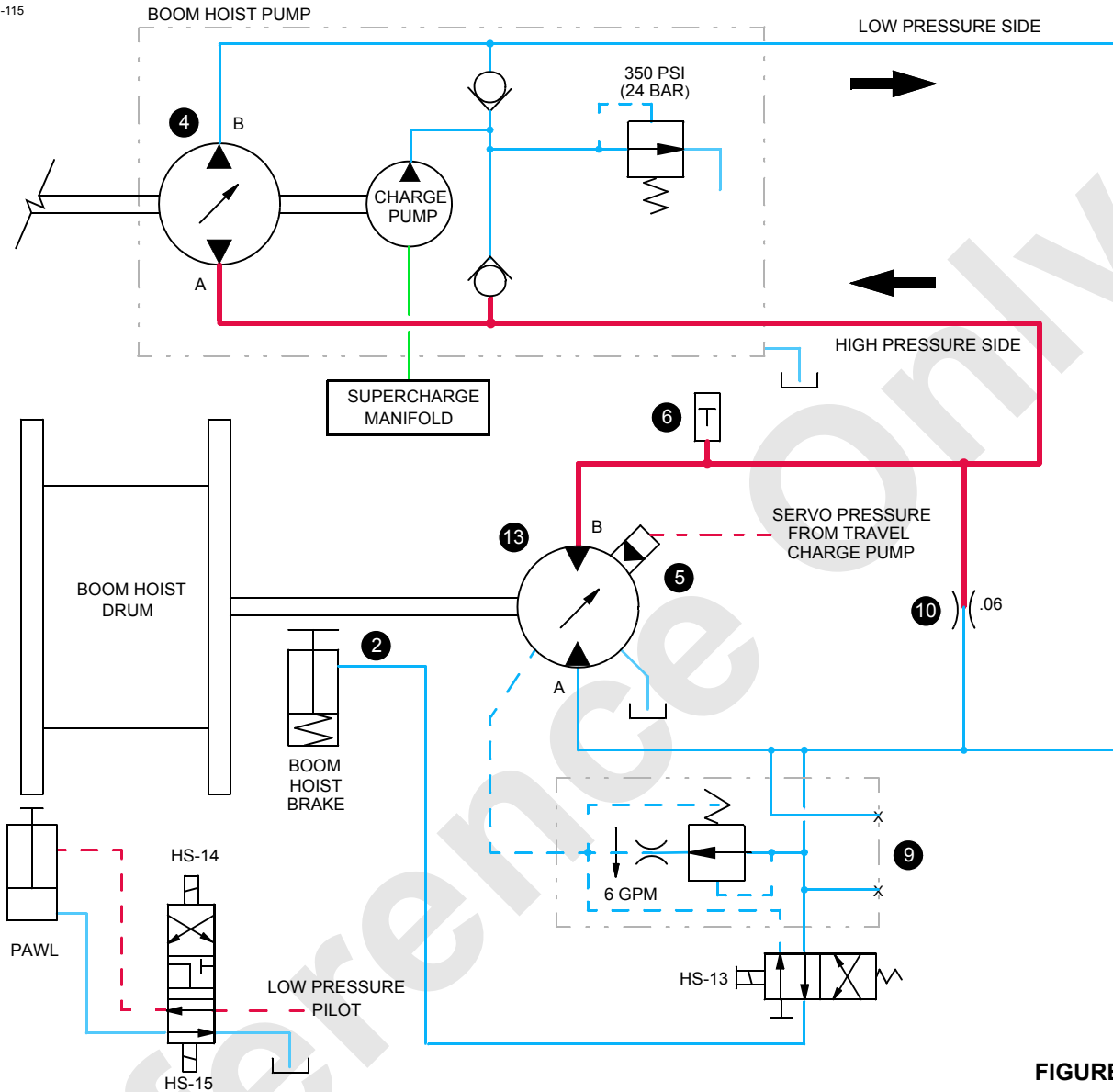


FIGURE 1-16

When boom hoist handle is moved to neutral position, the PC sends an output signal to boom hoist pump EDC to decrease swashplate angle, reducing flow output. The PC also shifts the motor back to maximum displacement for slower output speed to slow the drum rotation. The PC shifts the pump swashplate through neutral until the EDC has a slightly positive signal. This shifts the swashplate in the

positive direction and builds pressure on high-pressure side of closed-loop. The PC stores load-holding pressure in pressure memory. After control handle neutral switch opens, the PC sends an output signal to disable brake release solenoid HS-13 to spring-apply brake before boom hoist pump de-strokes.

FRONT/REAR DRUM SYSTEM

See Figures 1-17 and 1-18

The left drum handle (1) operates front drum while right drum handle (2) operates rear drum. Hydraulic connections between front or rear drum pump and motor form a closed-loop system. For load drum operation, system low-pressure side hydraulic fluid releases load drum brake (3) and drum pawl (4).

The left travel charge pump supplies pilot pressure for front and rear motor servo (5) operation. Pressure senders (6) in high and low-pressure side of rear drum (high-pressure side of front drum) provides system pressure information to the PC.

Continuous changing of closed-loop fluid occurs through leakage in motor and external sequence/flow valve (7). Sequence/flow valve opens at 200 psi (14 bar) and removes 6 GPM (23 L/min) of hot fluid from system by dumping fluid in the motor case where fluid returns to tank through cooler.

When a front or rear load drum rotates, speed encoder (8) sends an input signal to the PC. The PC sends an output signal that enables rotation indicator (9) in selected load drum control handle. Rotation indicator on top of each control handle pulsates with a varying frequency that indicates rotational speed of load drum. As drum rotates faster, the indicator pulsates faster.

999CSM1-116

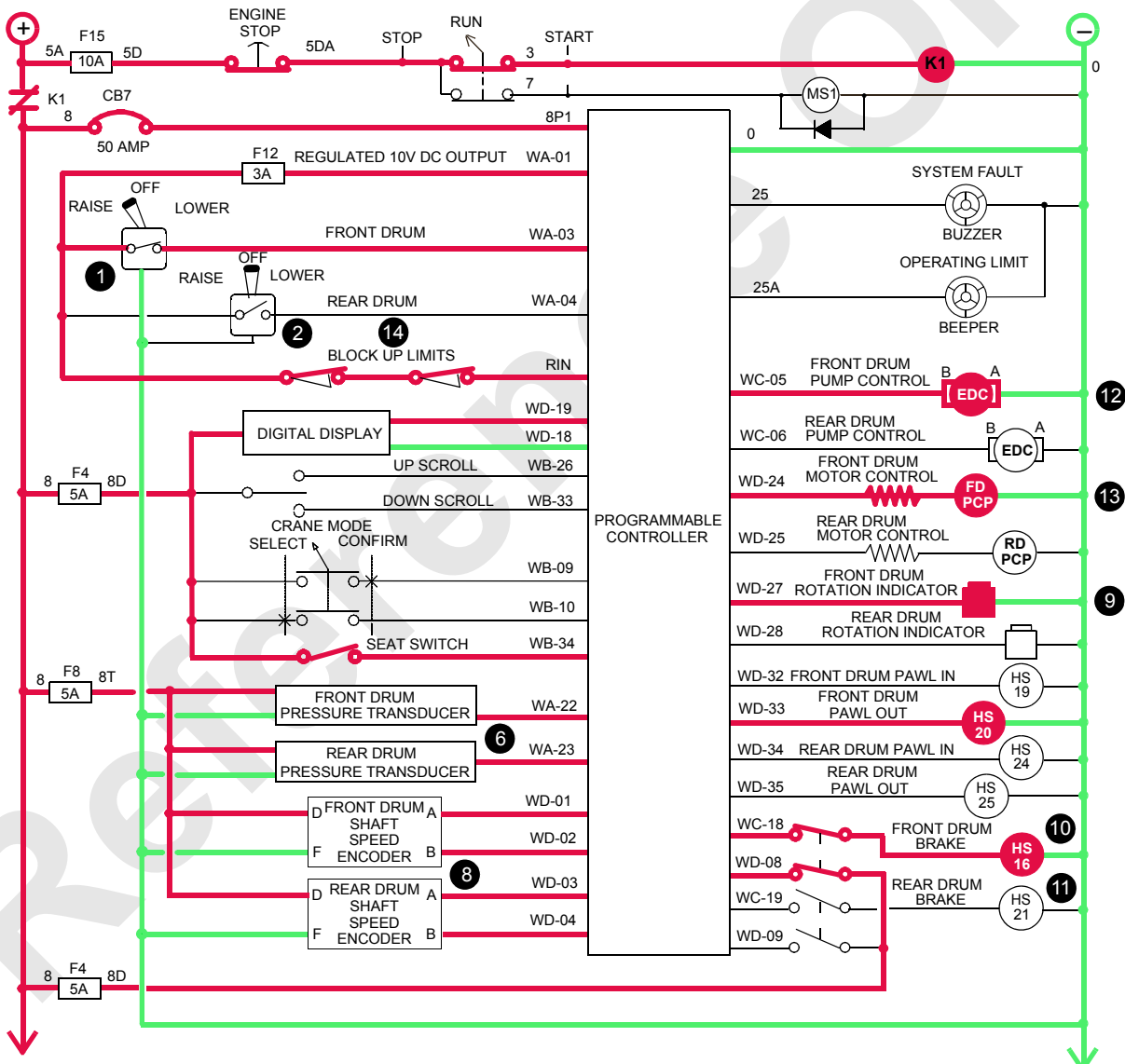


FIGURE 1-17

A high speed option is available for front/rear drums. This option allows increased fluid to two motors on tandem drive shafts for driving the drum. Electrical control of motors is similar to standard configuration.

Load Drum Brake and Pawl Switch

When selected front drum (10) or rear drum (11) brake switch is in on - park position, front drum hoist brake release solenoid HS-16 or rear drum hoist brake release solenoid HS-21 is disabled so brake is spring-applied to drum. Front drum pawl in solenoid HS-19 or rear drum pawl in solenoid HS-24 is enabled and pawl is engaged. Selected load pump does not stroke in response to control handle movement.

When selected front drum or rear drum brake switch is placed in off - park position, front and rear drum brakes remain spring-applied to selected load drum until the PC releases the brake. The PC sends an output signal to enable front drum pawl out solenoid HS-20 or rear drum pawl out solenoid HS-25. The pawl is disengaged from drum. Load drum control handle circuit to PC remains open.

Load Drum Hoisting

See Figures [1-17](#) and [1-18](#)

The following description of operation is for front drum while operating in full power. Operation of other load drums is the same, except for different drum, brake, and pawl.

When front drum handle (1) is moved back for drum hoist, handle neutral switch closes, sending an input voltage of 5 volts or more to PC. The PC sends a positive output voltage to front drum pump EDC (12) and a positive output voltage to motor PCP (13). The PC checks that front drum block-up limit switches (14) are closed with no hydraulic system faults present.

The PC requires that front drum pump strokes in hoist direction to satisfy pressure memory. The PC compares front drum holding pressure to value stored in pressure memory. When system pressure is high enough, the PC sends a positive output signal to enable brake release solenoid HS-16. Brake release solenoid HS-16 shifts, to block tank port and open port from low-pressure side of closed-loop system to release front drum spring brake.

The PC sends a positive output voltage to enable front drum pump EDC that tilts pump swashplate to stroke pump in the hoist direction. Hydraulic fluid flows from front drum pump port A to port A of front drum motor. Fluid from motor port B returns to front drum pump port B.

The PC controls raising speed by varying the voltage to pump EDC and motor PCP in relation to handle movement. As front drum handle is moved back, the PC sends a signal to increase the front drum pump swashplate angle. The PC also sends a signal to reduce the displacement of the motor. The PC is continuously balancing the system pressure and the motor displacement angle so the motor displacement goes to minimum when handle is all the way back, if the torque on the motor is not too high. Knowing the displacement of the motor, the PC may then control the speed that the motor turns by regulating the flow through the pump.

When front drum handle is moved to neutral position, the PC sends an output signal to front drum pump EDC to decrease swashplate angle, reducing oil flow output. This shifts the motor back to maximum displacement for slower output speed to slow the drum rotation. The PC stores the load holding pressure in pressure memory. After control handle neutral switch opens, the PC sends an output signal to disable brake release solenoid HS-16 to spring-apply brake before load pump de-strokes.

999CSM1-117

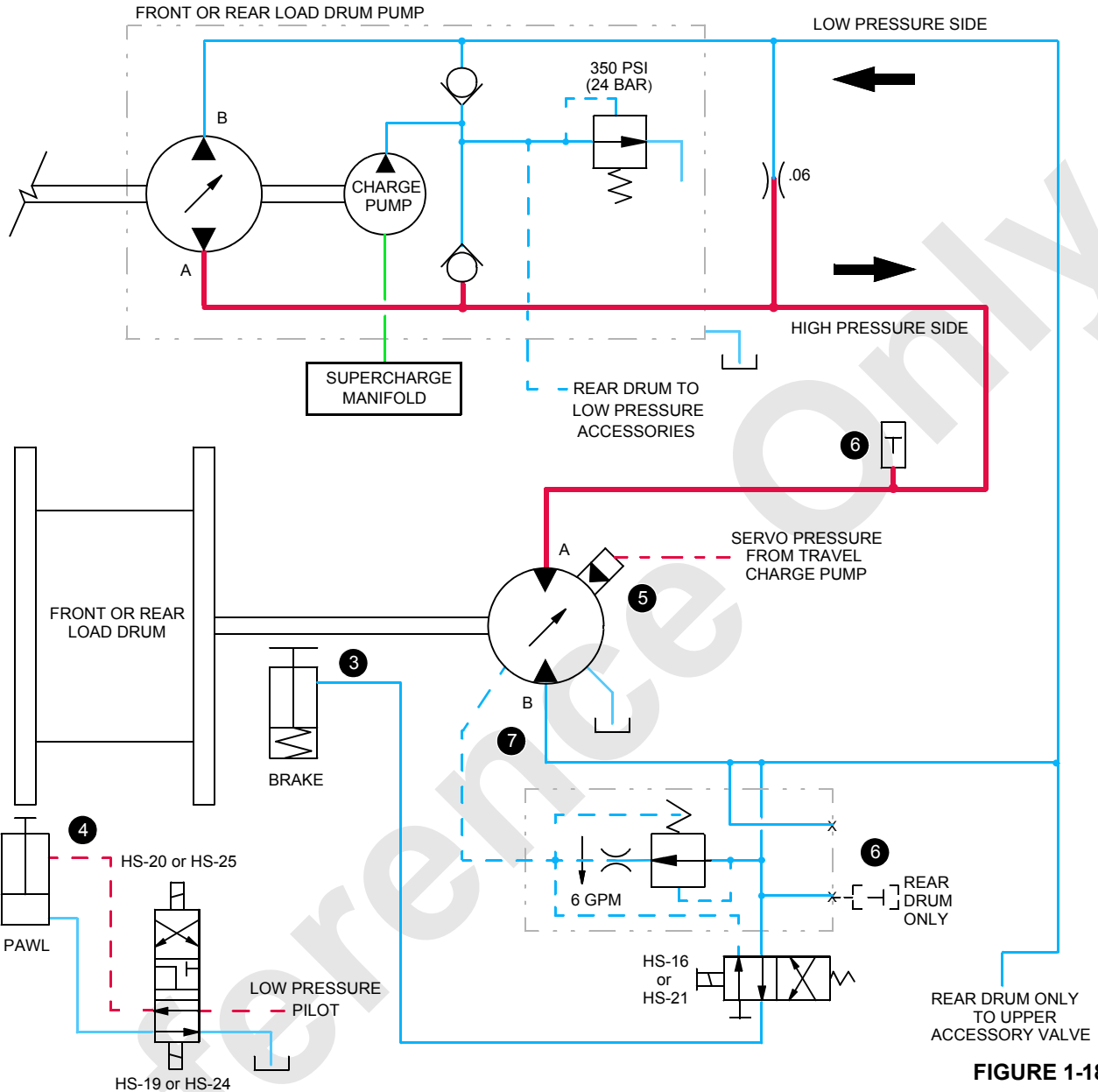


FIGURE 1-18

Load Drum Lowering

See Figures 1-19 and 1-20

When the front drum handle (1) is moved forward to lower, handle neutral switch closes, sending an input voltage of 5 volts or less to PC. The PC sends a negative output voltage to load drum system pump EDC (12) and motor PCP (13).

The PC sends a positive output signal to stroke the front drum pump momentarily in the up direction to satisfy pressure memory. The PC compares front drum holding pressure to value stored in pressure memory. When system

pressure is high enough, the PC sends a positive output signal to enable brake release solenoid HS-16. Front drum brake release solenoid HS-16 shifts, to block tank port and open port from low-pressure side of closed-loop to brake cylinder spring, releasing brake.

The PC sends a negative output signal to enable front drum pump EDC that tilts pump swashplate to stroke pump in the down direction. Hydraulic fluid flows from front drum pump port B to port B of front drum motor. Fluid from motor port A, returns to load drum pump port A.

999CSM1-118

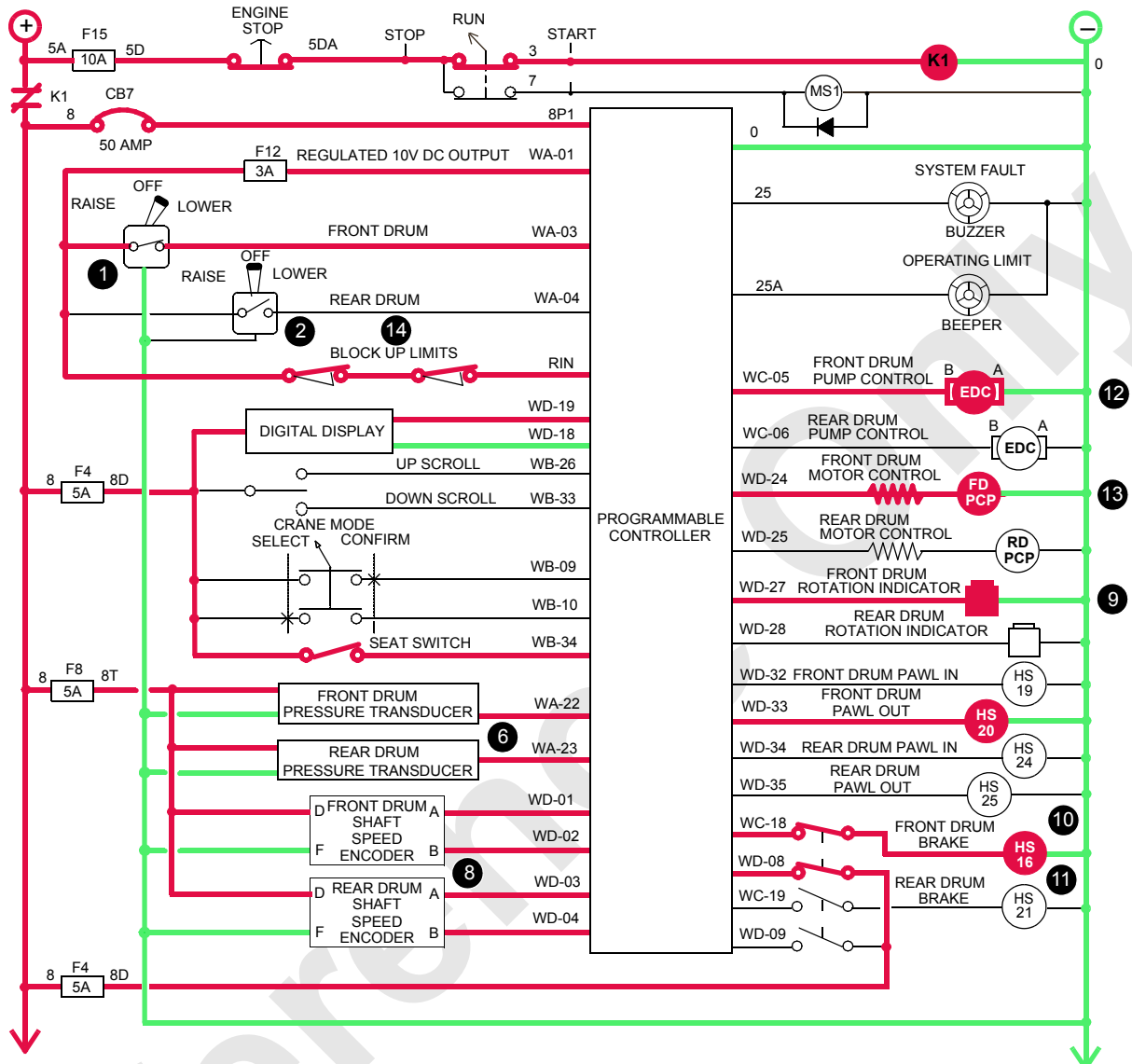


FIGURE 1-19

The PC controls lowering speed by varying the voltage to pump EDC and motor PCP in relation to handle movement. As front drum handle is pushed forward, the PC sends a signal to increase the front drum pump swashplate angle. The PC also sends a signal to reduce the displacement of the motor. The PC is continuously balancing the system pressure and the motor displacement angle so the motor displacement goes to minimum when handle is all the way back, if the torque on the motor is not too high. Knowing the displacement of the motor, the PC may then control the speed that the motor turns by regulating the flow through the pump.

The load weight attempts to drive motor faster than return fluid can return to low-pressure side of pump. System charge pump maintains fluid supply at a positive pressure to motor.

Pump swashplate position restricts returning fluid flow. Pressure builds on fluid return side of closed-loop, acting as a motor brake to control lowering speed.

When front drum handle is moved to neutral position, the PC sends an output signal to front drum pump EDC to decrease swashplate angle, reducing flow output. The PC also shifts the motor back to maximum displacement for slower output speed to slow the drum rotation. The PC shifts the pump swashplate through neutral until the EDC has a slightly positive signal. This shifts the swashplate in the positive direction and builds pressure on high-pressure side of closed-loop. The PC stores load-holding pressure in pressure memory. After control handle neutral switch opens, the PC sends an output signal to disable brake release

solenoid HS-16 to spring-apply brake before front drum pump de-strokes.

Luffing Jib Operation (Optional)

See Figures 1-17, 1-18, 1-19, and 1-20

Luffing jib hoist is operated with rear drum handle (2) with front drum as the main load line. Rear drum load handling operation in luffing mode is identical to front drum while performing crane operations in full power mode.

When rear drum brake switch is placed in on - park, auxiliary drum pawl in solenoid HS-24 is enabled and pawl is

engaged. Drum brake release solenoid HS-21 is spring-applied to auxiliary drum. When rear drum brake switch is placed in off - park position, drum pawl out solenoid HS-25 is enabled and pawl is disengaged. Rear drum brake remains spring-applied to drum and is controlled automatically by the PC with movement of control handle.

If a block up limit or LMI operating fault occurs while luffing, the PC sends a command to stop the rear drum. Corrective action for these operating faults is to raise the jib. In full power mode, corrective action requires lowering load with the rear drum.

999CSM1-119

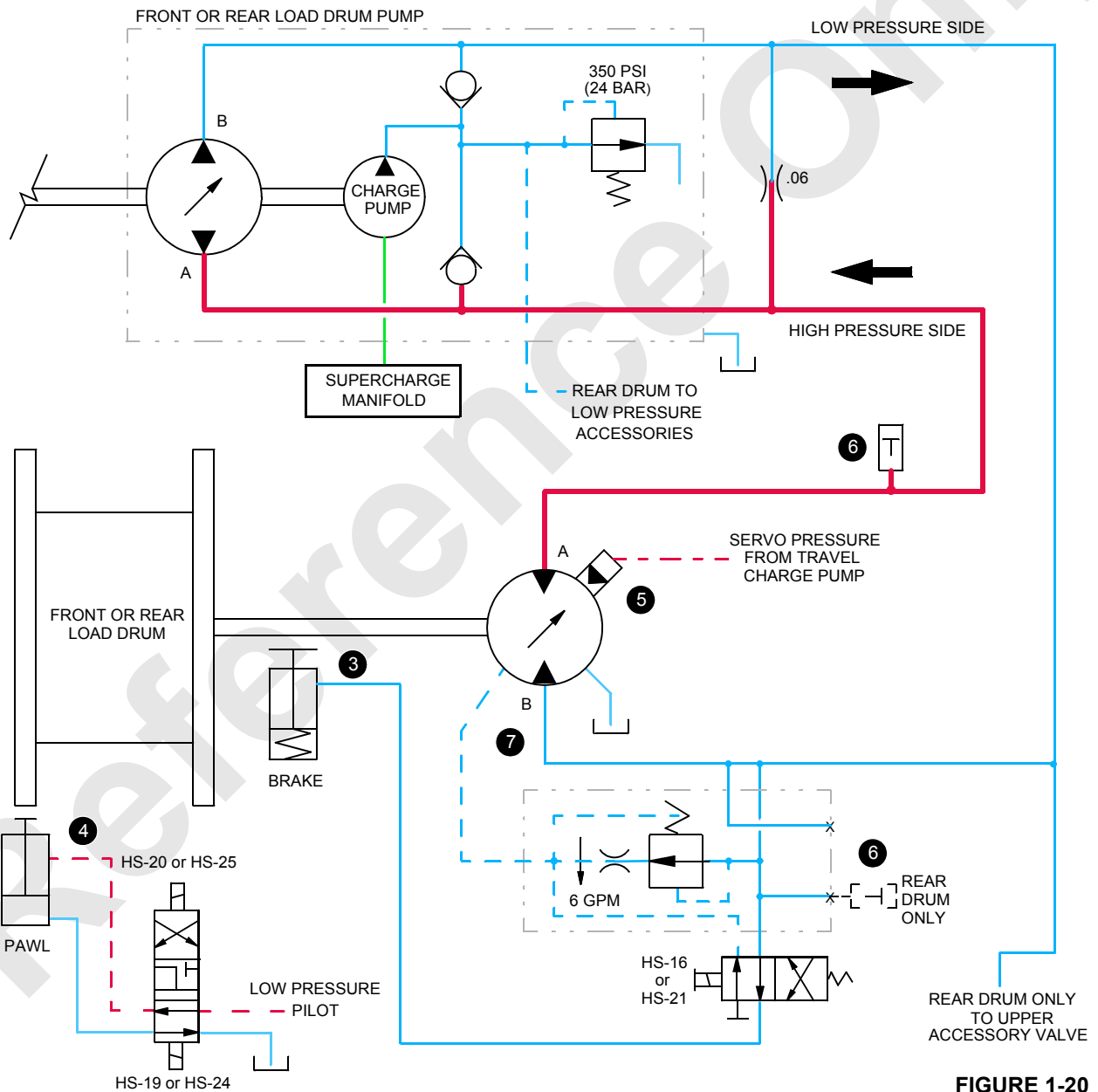


FIGURE 1-20

FREE FALL MODE (OPTIONAL)

See Figures [1-21](#), [1-22](#), and [1-23](#)

The front drum, rear drum or both drums can be equipped with free fall option. In Standard mode - free fall, left brake/clutch pedal operates front drum while right brake/clutch pedal operates rear drum when lowering the load. When hoisting in free fall, front drum handle or rear drum handle operates the same as in full power mode.

The PC will not allow a selected drum to be switched to free fall until following steps are performed:

- Bring selected load drum to complete stop.
- Press down selected drum brake/clutch pedal fully until latched.
- Turn Crane Mode switch clockwise and hold until Drum 1 FFall (front drum) or Drum 2 FFall (rear drum) appears on digital display screen.
- Turn crane mode switch counterclockwise to confirm selected free fall drum.
- Drum FFall On appears on digital display screen and yellow free fall light is on for selected drum.

The following description is for front load drum while operating in free fall. Operation of rear drum is the same, except for different drum, brake, pawl and brake/clutch.

Hydraulic connections between drum pump and motor form a closed-loop system. Load drum brake (1) and drum pawl (2) are released with low-pressure side hydraulic fluid. Left travel charge pump supplies pilot flow to shift drum motor servo (3). A pressure sender (4) in high-pressure side of each load drum circuit provides system pressure information to the PC.

Changing of closed-loop fluid occurs through leakage in motor and external sequence/flow valve (5). Sequence/flow valve opens at 200 psi (14 bar) and removes 6 GPM (23 L/min) of hot fluid from system by dumping fluid in the motor case.

Drum pump and motor case drains are connected together and routed to system drum brake/clutch housing. Case drain cooling fluid enters the center of brake/clutch housing and exits at top of housing. From brake/clutch-housing outlet the cooling fluid enters a filter assembly (16) before returning to tank.

When front load drum rotates, the speed encoder (6) sends an input signal to the PC. The PC sends an output signal that enables rotation indicator (7) in on top of control handle. As drum rotates faster, rotation indicator pulsates faster indicating rotational speed of drum.

Drum Brake and Pawl Switch

When front drum (8) brake switch is in on - park position, front drum hoist brake release solenoid HS-16 is disabled so brake is spring-applied to drum. Front drum pawl in solenoid HS-19 is enabled and pawl is engaged. Front drum pump does not stroke in response to control handle (9) or brake/clutch pedal (10) movement.

When front drum brake switch is placed in off - park position, front drum brake remains spring-applied to load drum until the PC releases the brake. The PC sends an output signal to enable front drum pawl out solenoid HS-20. The pawl is disengaged from drum. Load drum control handle circuit to the PC remains open.

Free Fall Brake/Clutch Operation

See Figures [1-21](#), [1-22](#), and [1-23](#)

An engine mounted auxiliary fixed displacement, two-output pump (11) supplies hydraulic fluid at 3,000 psi (207 bar) to inlet ports of brake/clutch valve manifold (12). Hydraulic fluid flows through front drum free fall enable solenoid HS-18 of brake/clutch valve to tank when free fall is disabled. Hydraulic fluid is returning to tank at 6 gpm (23 L/min). System pressure is not high enough to release spring-applied brake/clutch (13).

When solenoid HS-18 is enabled, hydraulic fluid is ported to front drum brake proportional valve HS-17. HS-17 receives a variable voltage signal from the PC from brake/clutch pedal. It uses this variable voltage to control the pressure being applied to the brake/clutch.

A pressure sender (15) in brake/clutch valve manifold provides system pressure information to the PC. Free fall manifold relief valve (14) is set to 3,000 psi (207 bars).

When brake/clutch is spring-applied, the shaft is engaged with drum planetary gears. In full power, the drum is powered from the motor shaft through planetary gears to rotate the drum. Free fall brake/clutch shaft, attached to third planet gear carrier, does not rotate when raising load.

When springs are hydraulically released, brake/clutch shaft and planet gear carrier are free to rotate, allowing drum to free fall. Brake/clutch pedal pressure controls drum speed as the PC controls releasing spring pressure to friction discs and outer plates.

NOTE: Brake/clutch pedal can remain applied during full power mode as brake/clutch pedal is disabled until the PC selects free fall.

Free Fall Hoisting

See Figures 1-21, 1-22, and 1-23

The following description is for the front drum while operating in free fall. Operation of rear drum is the same, except for different drum, brake, pawl and brake/clutch. Front drum hoisting in free fall operates the same as full power hoisting.

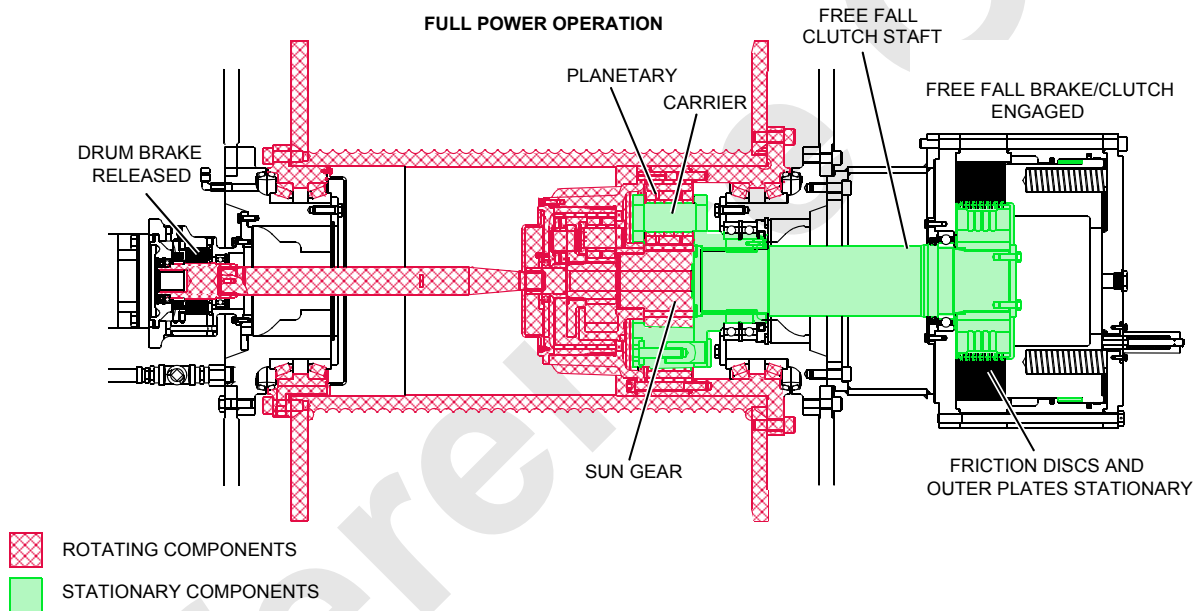
! WARNING
Falling Load Hazard!

When operating in free fall, load will lower uncontrolled if front drum brake/clutch pedal is not applied.

Be ready to apply front drum brake/clutch pedal so lowering speed can be controlled and load can be stopped immediately, when necessary.

Apply front drum brake/clutch pedal as front drum handle is moved to neutral position. After control handle neutral switch opens the PC sends an output signal to disable brake release solenoid HS-16 to spring-apply drum brake, before front drum pump de-strokes.

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999CSM1-121

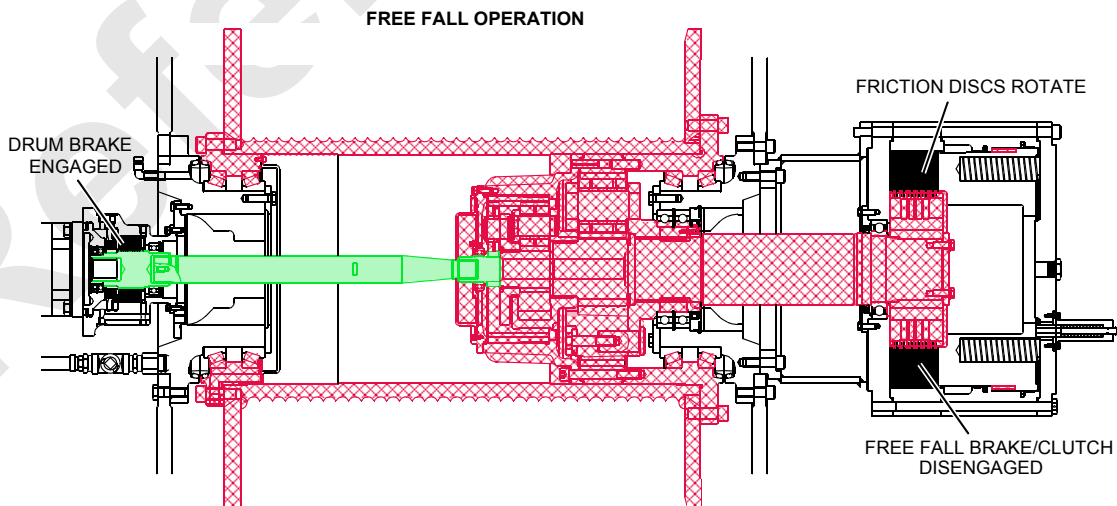


FIGURE 1-21

Free Fall Lowering

See Figures 1-21, 1-22, and 1-25

The percent of free fall drum slip to brake/clutch pedal movement is calibrated on the free fall diagnostic display screen.

WARNING Falling Load Hazard!

When operating in free fall, load will lower uncontrolled if front drum brake/clutch pedal is not applied.

Be ready to apply front drum brake/clutch pedal so lowering speed can be controlled and load can be stopped immediately, when necessary.

999CSM1-122

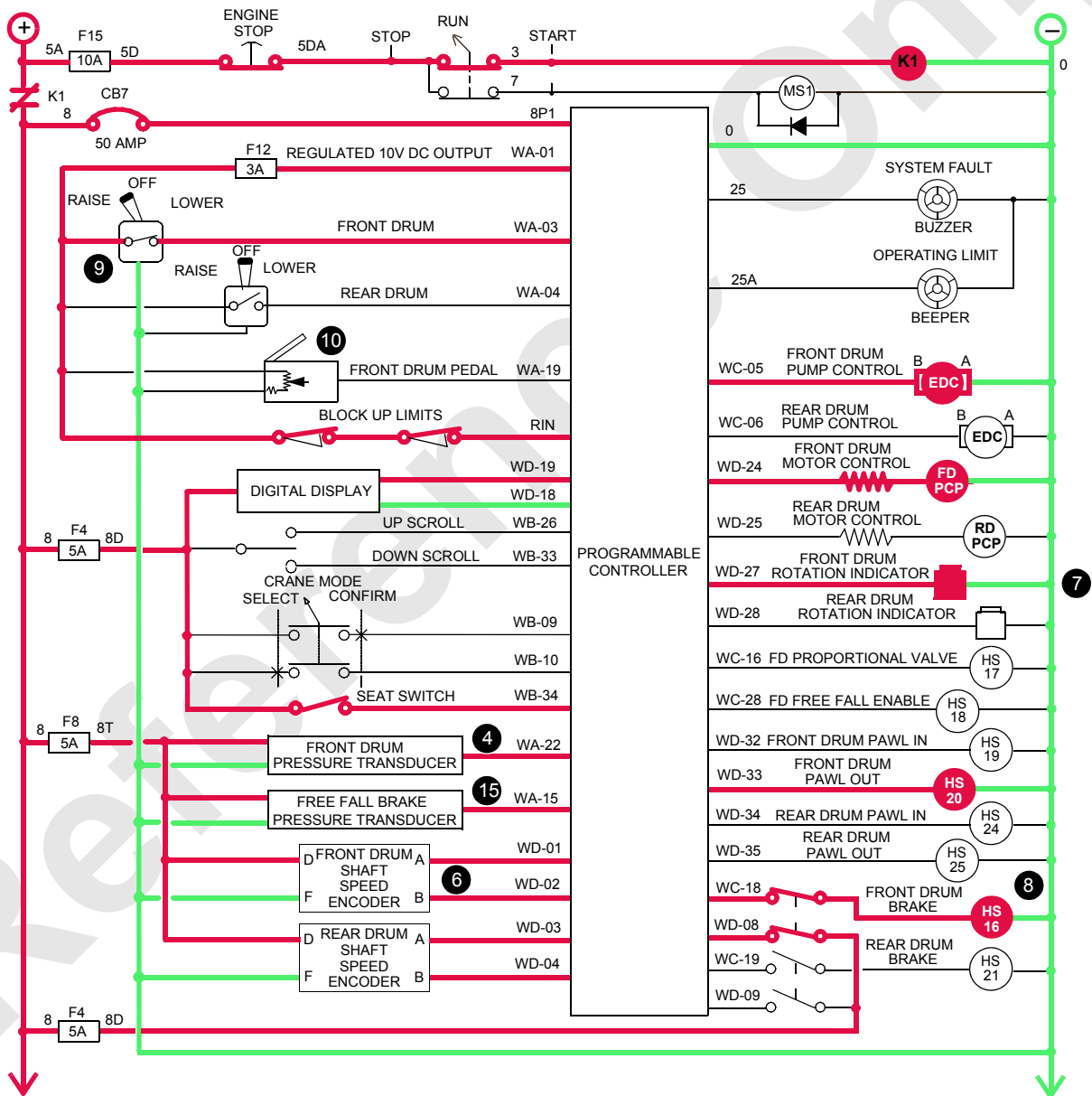


FIGURE 1-22

When front drum handle (9) is moved to neutral after raising load, the PC disables front drum brake solenoid HS-16, spring-applying front drum brake. When front drum brake is spring-applied, the PC sends an output signal to shift free fall enable solenoid valve HS-18 of brake/clutch valve manifold (12), blocking flow to tank. As front drum brake/clutch pedal is released, up to 3,000 psi (207 bar) hydraulic pressure pushes against piston to start compressing brake/clutch springs to release the brake/clutch. Hydraulic pressure to piston is in direct proportion to brake/clutch pedal movement as controlled by the PC. Front drum brake proportional valve HS-17 pulsates on/off between brake and tank, depending on PC command or back-pressure. Moving brake/clutch pedal fully applies brake/clutch without slipping.

CAUTION

Brake/Clutch/Motor Damage!

Do not move a drum handle in either direction from neutral while a load is free falling. Damage to brake/clutch and/or motor drive system could occur. Stop the load with drum brake/clutch pedal before moving drum control handle in either direction.

Do not turn free fall off or turn off drum brake while a load is free falling. Stop loads with brake/clutch pedal, then turn free fall off or turn off drum brake.

999CSM1-123

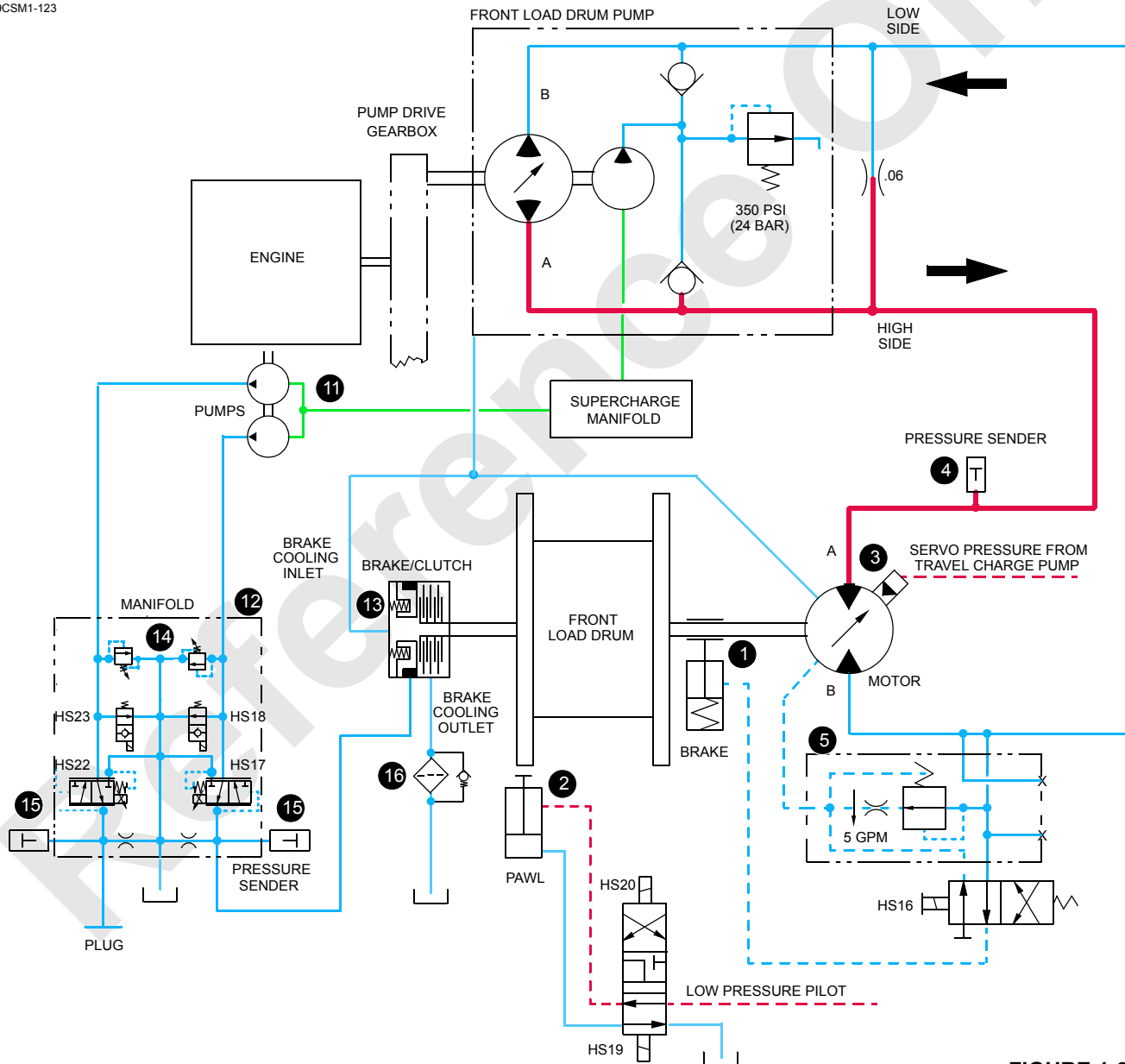


FIGURE 1-23

999CSM1-124

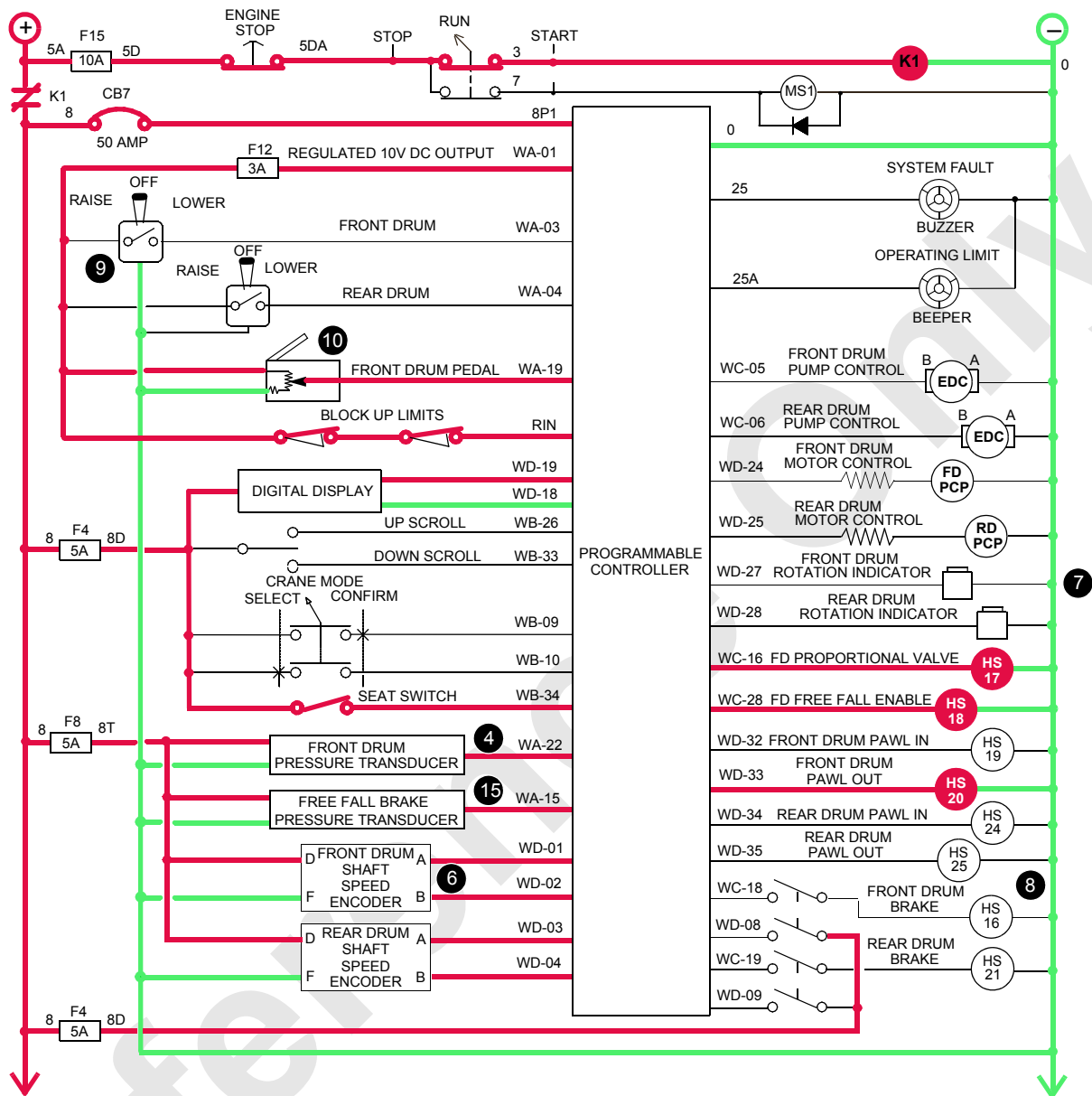


FIGURE 1-24

999CSM1-125

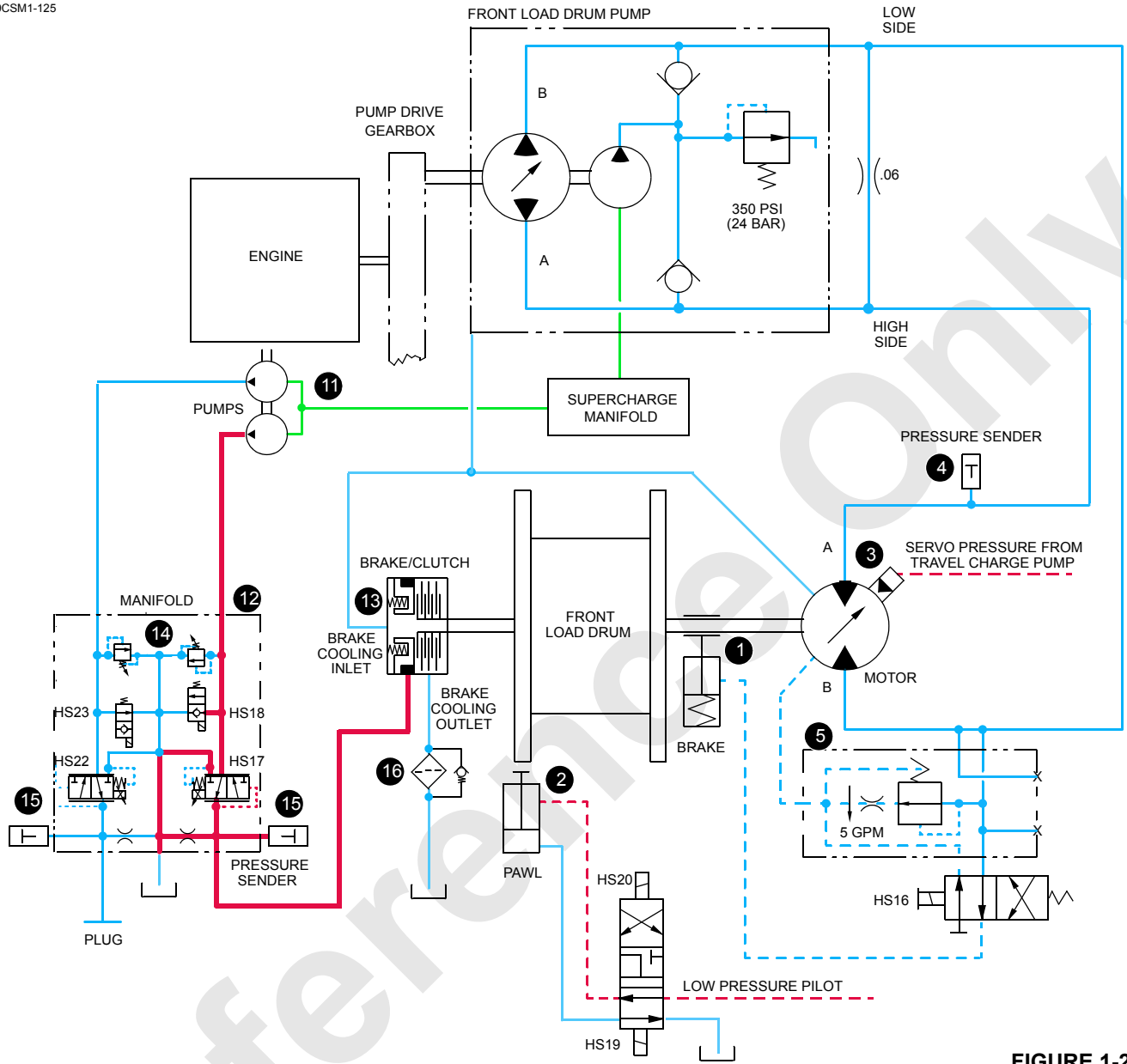


FIGURE 1-25

AUXILIARY DRUM SYSTEM (OPTIONAL)

See Figures 1-26 and 1-27

The auxiliary drum is located in boom butt and is operated with auxiliary drum handle (1) in operator's cab. The auxiliary drum system is similar to other load drums. Auxiliary drum pump is mounted on the engine driven pump drive. Unlike other system pumps, EDC valve (2) operates with positive current only rather than reversing polarity to control auxiliary pump displacement.

Hydraulic connection between auxiliary drum pump (3) and auxiliary drum motor (4) forms a closed-loop system. Make-up fluid from auxiliary drum charge pump (5) replaces fluid in the system that is displaced by internal leakage of the pump and motor.

When auxiliary drum handle is in neutral position, the PC receives no voltage from control handle, and the PC opens the circuits to auxiliary drum pump EDC (2), and brake release solenoid HS-26. Because these circuits are open, auxiliary drum pump does not stroke, auxiliary drum motor remains at low speed, and auxiliary drum brake (7) remains spring-applied to prevent the auxiliary drum from turning.

When auxiliary drum rotates, speed encoder (8) sends an input signal to the PC. The PC sends an output signal that enables rotation indicator (9) in auxiliary drum handle. Rotation indicator on top of control handle pulsates with a varying frequency that indicates rotational speed of load drum. As drum rotates faster, the indicator pulsates faster.

A pressure sender (10) in high-pressure side of auxiliary drum closed-loop system provides system pressure information to the PC.

999CSM1-126

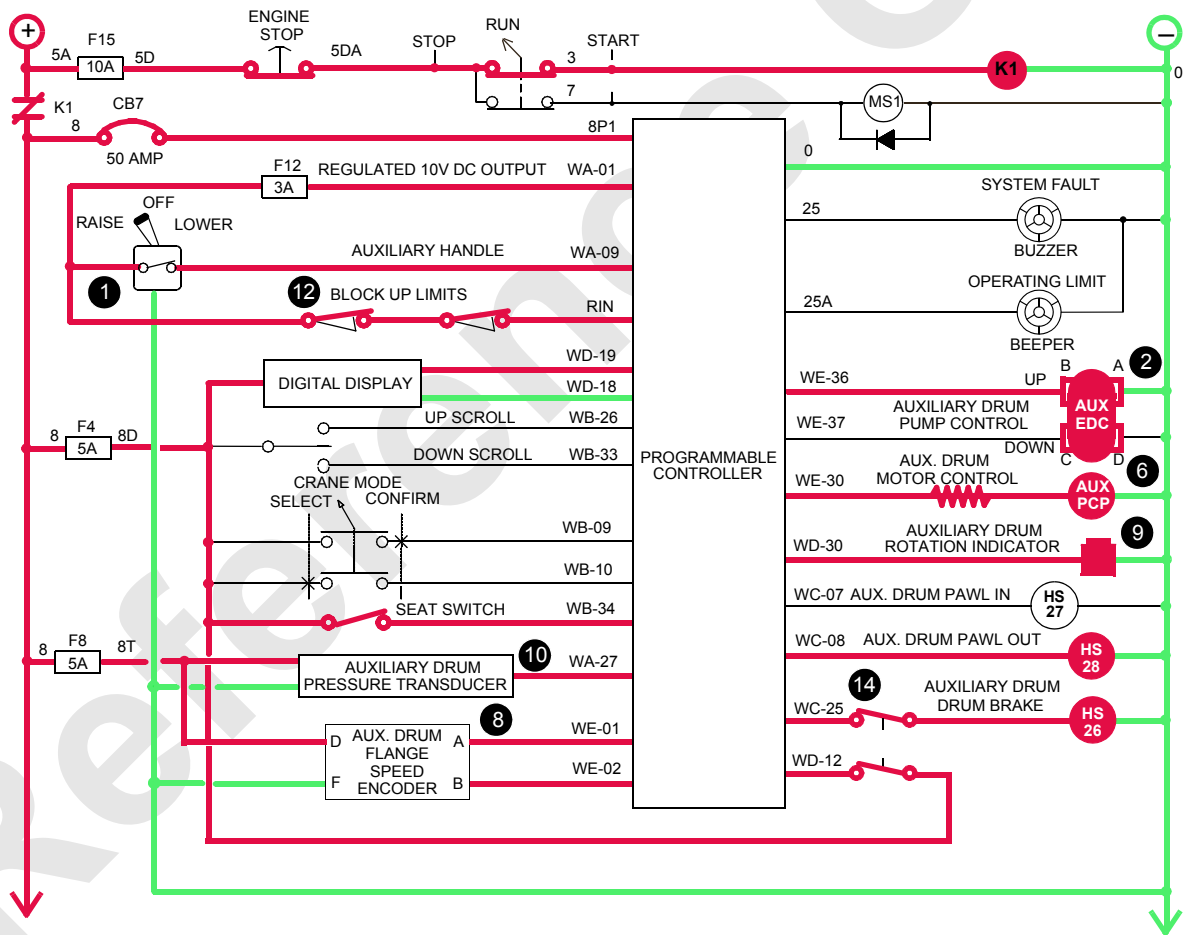


FIGURE 1-26

Auxiliary Drum Brake and Pawl Switch

When auxiliary drum brake switch (14) is in on - park position auxiliary drum pawl in solenoid HS-27 is enabled and pawl (11) is engaged. Auxiliary drum brake release solenoid HS-26 is spring-applied to auxiliary drum.

When auxiliary drum brake switch is placed in off - park position, auxiliary drum pawl out solenoid HS-28 is enabled and pawl is disengaged from drum. Auxiliary drum brake remains spring-applied to auxiliary drum and is controlled automatically by the PC with movement of auxiliary drum handle.

Release of auxiliary drum brake is from 350 psi (25 bar) charge pressure supplied from auxiliary charge pump. If

charge pressure drops below 200 psi (14 bar), brakes spring-apply.

Auxiliary Drum Raise

See Figures 1-26 and 1-27

When auxiliary drum handle (1) is moved back for drum hoist, handle neutral switch closes, sending an input voltage of 5 volts or more to PC. The PC sends a positive output voltage to auxiliary load drum pump EDC (2) and to motor PCP (6). The PC checks that drum block-up limit switches (12) are closed with no hydraulic system faults present.

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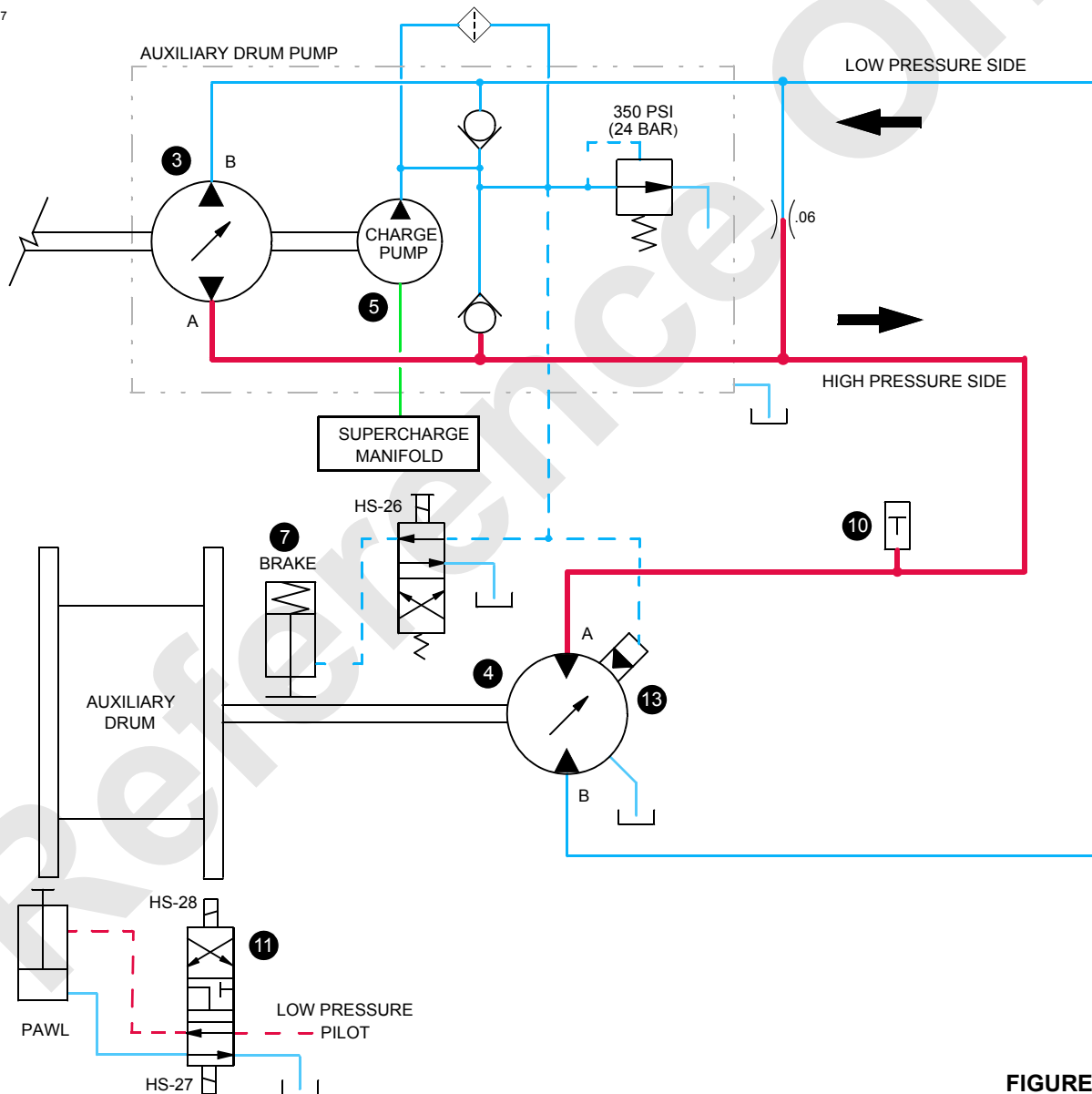


FIGURE 1-27

The PC requires that auxiliary drum pump strokes in hoist direction to satisfy pressure memory. The PC compares auxiliary drum holding pressure to value stored in pressure memory.

When system pressure is high enough, the PC sends a positive output signal to enable brake release solenoid HS-26. Brake release solenoid HS-26 shifts, to block tank port and open port from low-pressure side of closed-loop to auxiliary drum brake cylinder spring, releasing auxiliary drum brake (7).

The PC sends a positive output voltage to enable auxiliary drum pump EDC that tilts pump swashplate to stroke pump in the hoist direction. Hydraulic fluid flows from auxiliary drum pump port A to port A of auxiliary drum motor. Fluid from motor port B returns to drum pump port B.

The PC controls raising speed by varying the voltage to pump EDC and motor PCP in relation to auxiliary drum handle movement. As handle is moved back, the PC sends a signal to increase the pump swashplate angle. The PC also sends a signal to reduce the displacement of the motor.

The PC is continuously balancing the system pressure and the motor displacement angle so the motor displacement goes to minimum when handle is all the way back, if the torque on the motor is not too high. Knowing the displacement of the motor, the PC may then control the speed that the motor turns by regulating the flow through the pump.

When auxiliary drum handle is moved to neutral position, the PC sends an output signal to auxiliary drum pump EDC to decrease the swashplate angle, reducing oil flow output. This shifts the motor back to maximum displacement for slower output speed to slow the drum rotation.

The PC stores the load holding pressure in pressure memory. After control handle neutral switch opens, the PC sends an output signal to disable brake release solenoid HS-26 to spring-apply brake before auxiliary drum pump de-strokes.

Auxiliary Drum Lower

See Figures [1-28](#) and [1-29](#)

When auxiliary drum handle (1) is moved forward to lower, handle neutral switch closes, sending an input voltage of 5 volts or less to PC. The PC sends a positive output voltage to auxiliary load drum system pump EDC (2) and a positive voltage to motor PCP (6). The PC checks that drum block-up limit switches (12) are closed with no hydraulic system faults present.

The PC sends a positive output signal to stroke the auxiliary drum pump momentarily in the up direction to satisfy pressure memory. The PC compares auxiliary drum holding pressure to value stored in pressure memory.

When system pressure is high enough, the PC sends a positive output signal to enable brake release solenoid HS-26. Brake release solenoid HS-26 shifts, to block tank port and open port from low-pressure side of closed-loop to auxiliary drum brake cylinder spring, releasing brake (7).

The PC sends a positive output signal to enable auxiliary drum pump EDC that tilts pump swashplate to stroke pump in the lowering direction. Hydraulic fluid flows from pump port B to port B of motor. Fluid from motor port A, returns to load drum pump port A.

The PC controls lowering speed by varying the voltage to pump EDC and motor PCP in relation to auxiliary drum handle movement.

As handle is pushed forward, the PC sends a signal to increase the pump swashplate angle. The PC also sends a signal to reduce the displacement of the motor.

The PC is continuously balancing the system pressure and the motor displacement angle so the motor displacement goes to minimum when handle is all the way back, if the torque on the motor is not too high. Knowing the displacement of the motor, the PC may then control the speed that the motor turns by regulating the flow through the pump.

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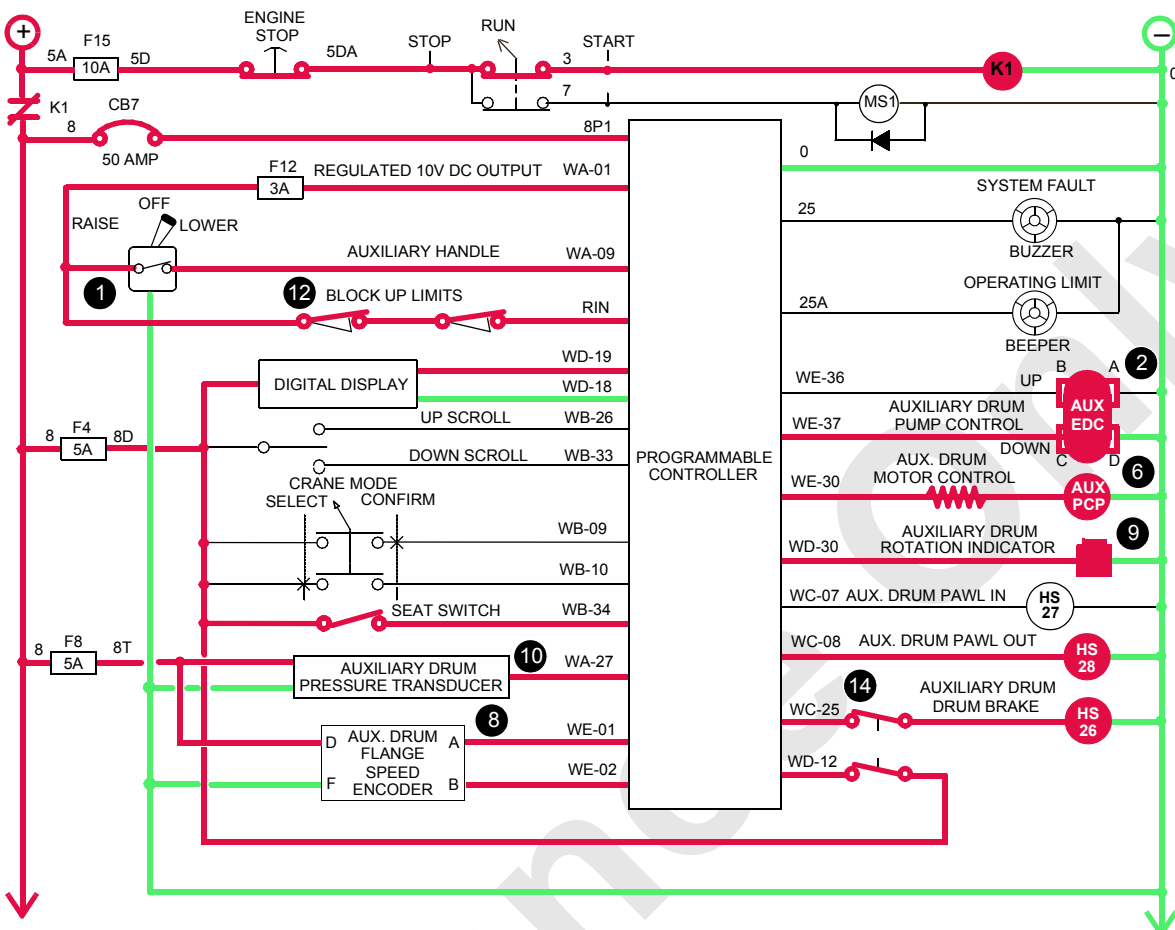


FIGURE 1-28

The load weight attempts to drive motor faster than return fluid can return to low-pressure side of pump. Auxiliary drum charge pump maintains the fluid supply at a positive pressure to auxiliary drum motor. The position of the pump swashplate restricts returning fluid and pressure builds on the return side of closed-loop system, acting as a brake against auxiliary drum motor to control the lowering speed.

When auxiliary drum handle is moved to neutral position, the PC sends an output signal to pump EDC to decrease swashplate angle, reducing flow output. The PC also shifts

the motor back to maximum displacement for slower output speed to slow the drum rotation. The PC shifts the pump swashplate through neutral until the EDC has a slightly positive signal. This shifts the swashplate in the positive direction and builds pressure on high-pressure side of closed-loop. The PC stores load-holding pressure in pressure memory. After control handle neutral switch opens, the PC sends an output signal to disable brake release solenoid HS-26 to spring-apply brake before auxiliary drum pump de-strokes.

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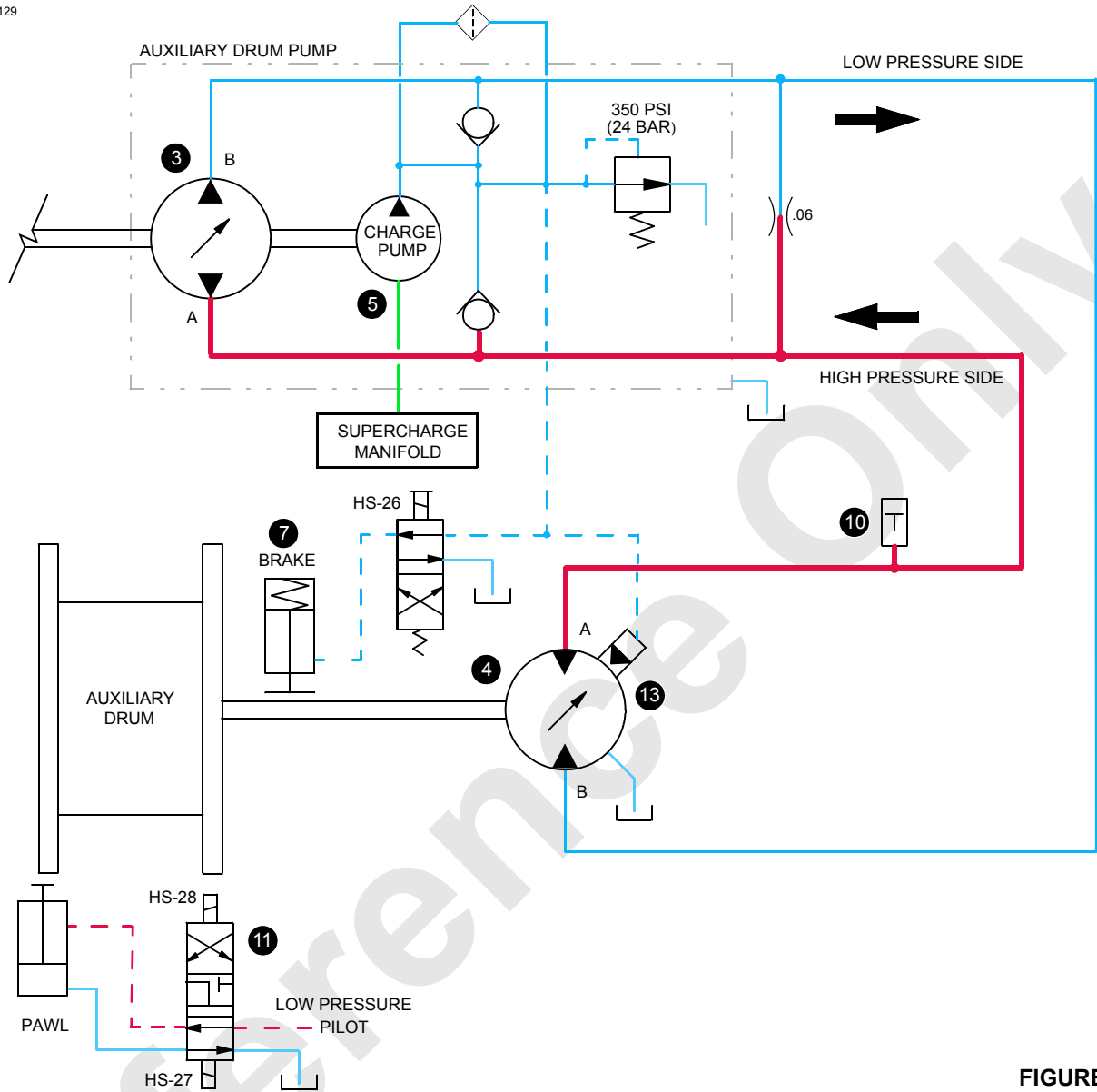


FIGURE 1-29

CRANE SETUP SYSTEMS

See Figure [1-31](#)

CAUTION

The boom must not be operated in Crane Setup mode for normal operation. The PC assumes that crane is in mast raising procedure and boom performance is unpredictable. Select and confirm Full Power mode after crane set-up is complete.

Place and hold crane mode switch in select position until the crane setup mode is displayed. Next, turn crane mode switch to confirm position to select and lock-in crane setup mode. The PC locks-out other mode selections and enables the boom hoist system, rear drum system, upperworks accessory valve system, and the lowerworks accessory valve system.

CAUTION

Mast bypass valve (1), in right side enclosure, must be turned to ON position during crane setup (assembly and disassembly). Mast bypass valve must be turned to OFF position during normal operation to prevent mast arms from raising and contacting mast.

When an accessory valve is enabled, the low-pressure side of the rear drum pump (5) is the pressure source to operate upperworks accessory valve manifold (3) and lowerworks accessory valve manifold(4).

Upperworks accessory valve manifold contains three solenoid valves and a mast bypass valve (1). The solenoid valves are piped in parallel but can be controlled independently for simultaneous accessory operation. The crane has direct-acting solenoids and do not require the

reducing valve to supply pilot pressure for shifting the spools. Upperworks accessory valve system includes boom pin pusher cylinder (7), gantry cylinders (8), and mast raising cylinders (9) that are electrically enabled. When an upperworks accessory valve is electrically enabled, an output signal is sent from the PC to the solenoid valve for the selected component, shifting its main spool. The PC sends a negative output voltage to stroke low-pressure side of rear drum pump to enable the selected accessory valve component.

Low-pressure side of rear hoist drum motor pressure sender (14) monitors accessory system pressure. The PC looks at the accessory system pressure sender and holds the system to required accessory pressure (see [Figure 1-30](#)) by controlling pump stroke. The rear hoist pump's multifunction valve of the low pressure side, port "B", is the accessory system safety delta pressure across the pump of 3770 (260 BAR).

The lowerworks accessory valve system includes crawler pin pusher cylinders (10) and carbody jack cylinders (11) that are enabled by return-to-center hand levers. Output flow from the lowerworks accessory system passes through control levers when all of the levers are centered. An orifice (13) restricts the flow, building pressure in the line that closes the accessory pressure switch (12). The PC then knows that none of the lowerworks accessory levers are enabled. When a lever is manually enabled, the flow is diverted from the switch to the desired accessory system. The pressure at the switch bleeds away through the orifice and the accessory pressure switch opens. The PC then sends a negative voltage to the rear drum to increase the pressure to the selected accessory system component. Accessory pressure switch trips at 120 psi (8,3 bar). The PC monitors lowerworks accessory system pressure and holds the system to 3000 psi (207 BAR) by controlling pump stroke.

Item	Accessory System Pressure Requirement	PSI	BAR
1	Raising Mast With Gantry Cylinders	1550	107
2	Lowering Mast With Gantry Cylinders	3500	241
3	Raising Counterweight With Gantry Cylinders	3800	262
4	Lowering Counterweight With Gantry Cylinders	3000	207
5	Raising Mast With Mast Cylinders	3000	207
6	Lowering Mast With Mast Cylinders	700	48
7	Extend Mast Arms Only	2000	138
8	Retract Mast Arms Only	2500	172
9	Boom Hinge Pin (Extend and Retract)	3000	207
10	Counterweight Pins	350	24

FIGURE 1-30

Gantry System

See Figures [1-32](#) and [1-33](#)

The PC controls the gantry and mast raising sequence. When in crane setup mode and the mast angle is less than 25°, the PC sends an output signal to boom hoist brake release solenoid HS-13 and boom hoist drum pawl out solenoid HS-15. This permits boom hoist drum to haul in or pay out wire rope to reeving between gantry and mast sheaves as the gantry is raised or lowered.

When raising gantry, boom hoist system hydraulic pressure is monitored by the PC with boom hoist pressure sender (12) and controlled by the PC to maintain a minimum rope tension on the boom hoist drum.

The gantry switch (2) on remote setup control should only be used for raising/lowering gantry without wire rope or installing/removing counter weights with mast laying forward. Power is available to setup remote control when cable is plugged into valve junction box on left side of rotating frame and engine is running. Pressing power button (3) completes power supply circuit to setup remote control switches.

A gantry operating limit message GANTRY DOWN appears on the digital display screen when gantry and the mast angle is 22° or more. The PC detects this fault when the mast angle sensor (4) monitors the mast position at 22° and gantry up limit switch (5) circuit to the PC is closed. The operator should raise gantry with the gantry switch in raise position.

Each gantry cylinder (6) has a counterbalance valve (7) at each cylinder port. These valves ensure smooth control when raising or lowering gantry and locks the cylinder in place when gantry is at a desired position or if a hydraulic line fails.

Gantry accessory valve is "motor spool" where both cylinder ports and tank port of valve spool section are connected in center position. This type of spool prevents premature opening of load equalizing valves (8).

Gantry Cylinders Raise

See Figures [1-32](#) and [1-33](#)

Place boom hoist brake switch (9) in off - park position. Boom hoist brake remains spring-applied to boom hoist drum until the PC releases the brake. Boom hoist drum pawl out solenoid HS-15 is enabled to disengage pawl from boom hoist drum. Boom control handle circuit to the PC remains open.

NOTE: Always confirm hydraulic and electrical schematics by serial number of crane.

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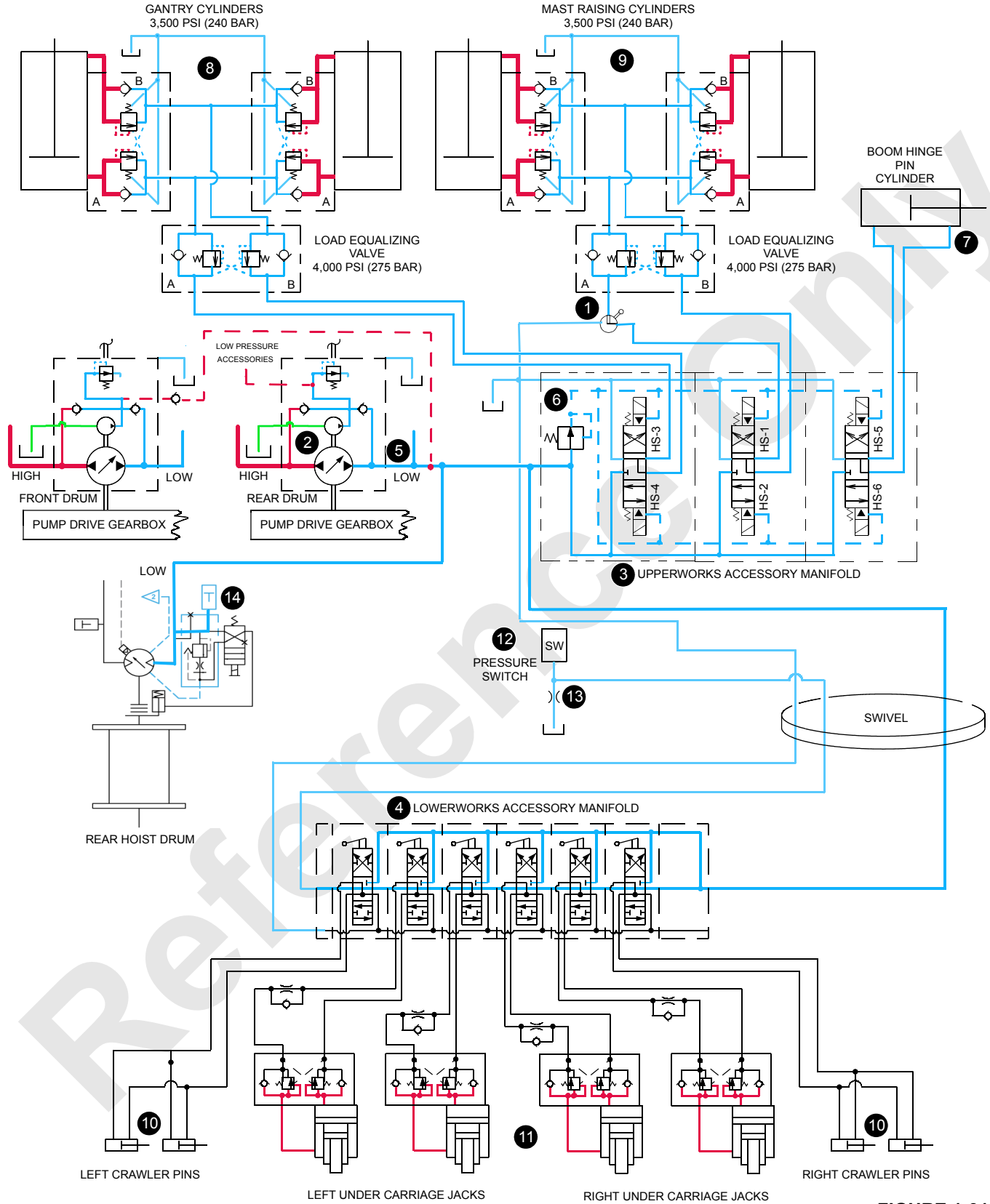


FIGURE 1-31

To raise gantry in Crane Setup mode after rigging is installed, move boom hoist handle (1) all the way forward. The handle neutral switch closes, sending an input voltage of 5 volts or less to PC. The PC sends a positive output signal brake release solenoid HS-13. Brake release solenoid valve shifts,

to block tank port and open port from low-pressure side of closed-loop to boom hoist brake cylinder spring, releasing brake. The PC sends a negative output signal to enable boom hoist pump EDC (11) that tilts pump swashplate to stroke boom hoist pump in the lower direction.

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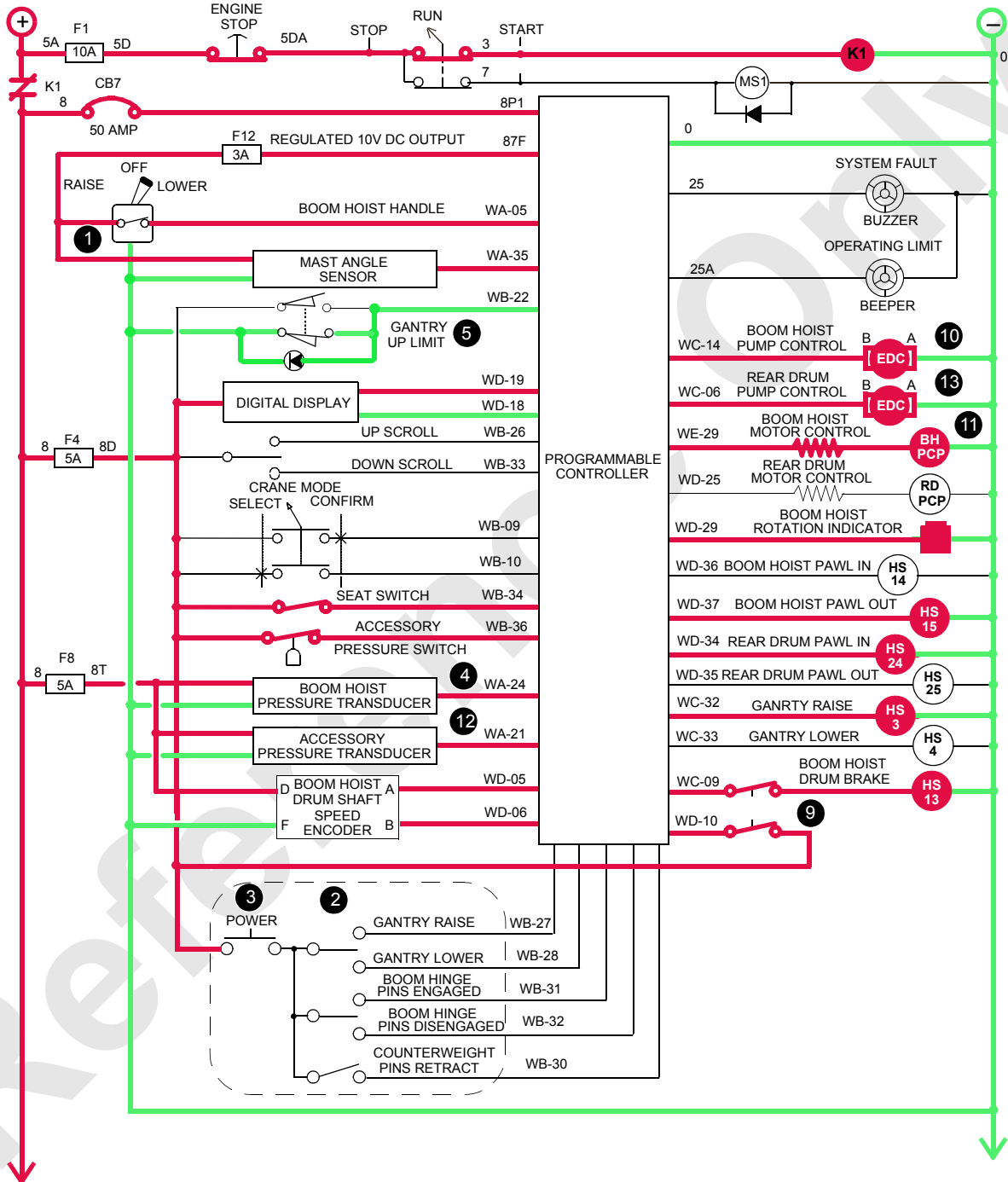


FIGURE 1-32

The PC sends a negative output voltage to rear drum pump EDC (13) that tilts rear drum pump swashplate to stroke pump in the low-pressure side direction. Low-pressure side hydraulic fluid flows to gantry extend cylinder solenoid HS-3 of upperworks accessory valve and through free flow check valve sections on side "A" of load equalizing valve (8). From the equalizing valve, fluid enters counterbalance valves (7) and piston end of gantry cylinders (6), extending cylinder rods to raise the gantry. As gantry raises, boom hoist drum pays out wire rope.

The PC monitors rear drum pressure senders to control gantry cylinder raising speed rate.

The free-flow check valve sections on side "B" of counterbalance valves block fluid exhausting from rod end of gantry cylinders. Fluid passes through flow restrain sections of counterbalance valve that have a relief setting of 3,500 psi (240 bar). Counterbalance valves act as a deceleration control and operate with a 5:1 pilot ratio of the relief valve pressure, permitting the valves to open when pressure in the piston end of cylinders is approximately 700 psi (48 bar).

Exhaust fluid from side "B" of both counterbalance valves combines and fluid passes through non-restrictive portion of load equalizing valve before entering accessory system valve. Hydraulic fluid exits the accessory system valve and returns to tank.

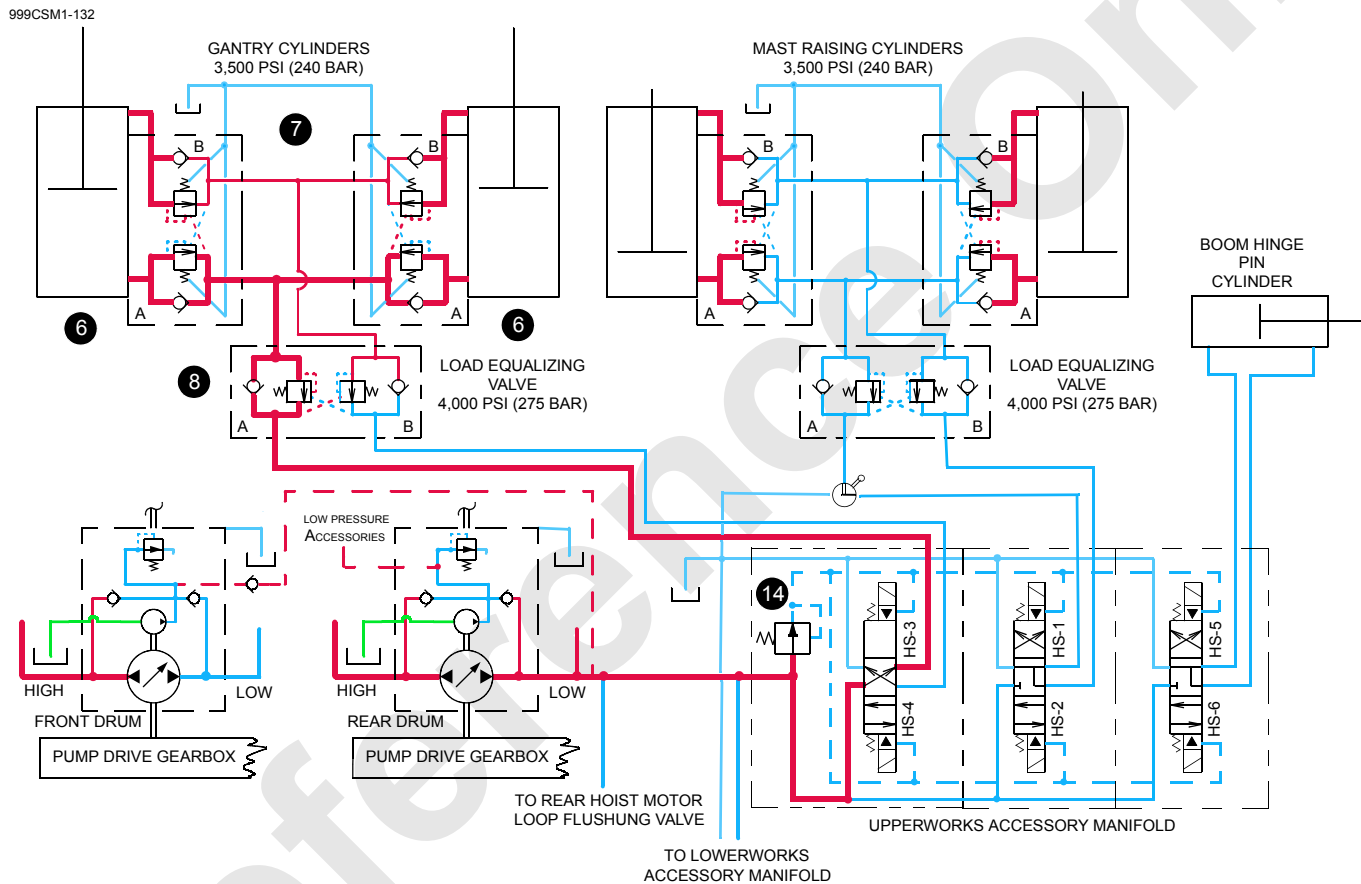


FIGURE 1-33

The free-flow check valve sections on side "B" of load equalizing valve block the flow. Hydraulic fluid then passes through flow restrain section of valve that is preset at 4,000 psi (275 bar).

Load equalizing valve operates with a 1.5:1 pilot ratio of the relief valve pressure, permitting valve to open when hydraulic pressure from the setup pump (rear drum) on side "A" of the valve is approximately 2,670 psi (185 bar). Restraining section on side "B" of load equalizing valve

opens, controlling fluid out of both cylinders and ensuring cylinder actuation is balanced.

When gantry is fully raised, gantry up limit switch closes sending an input signal to PC. The PC sends an output signal to de-stroke rear drum pump. The PC also sends an output signal to shift gantry extend cylinder solenoid HS-3 back to center position. The PC goes to next sequence step of raising mast.

Gantry Cylinders Lower

See Figures [1-34](#) and [1-35](#)

Place boom hoist brake switch (9) in off - park position. Boom hoist brake HS-13 remains spring-applied to boom hoist drum until the PC releases the brake. Boom hoist drum pawl out solenoid HS-15 is enabled to disengage pawl from boom hoist drum. Boom control handle circuit to the PC remains open.

To lower gantry in Crane Setup mode when rigging is installed, move boom hoist handle (1) all the way back. Handle neutral switch closes, sending an input voltage of 5 volts or more to PC. The PC sends a positive output signal to brake release solenoid HS-13. Brake release solenoid valve shifts, to block tank port and open port from low-pressure side of closed-loop to boom hoist brake cylinder spring,

releasing brake. The PC sends a negative output signal to enable boom hoist pump EDC that tilts pump swashplate to stroke boom hoist pump in the raise direction.

The PC sends a negative output voltage to rear drum pump EDC (13) that tilts rear drum pump swashplate to stroke pump in the low-pressure side direction.

Low-pressure side hydraulic fluid flows to gantry retract cylinder solenoid HS-4 of accessory valve and through free flow check valve sections on side "B" of load equalizing valve (8).

From equalizing valve, fluid enters counterbalance valves (7) and rod end of gantry cylinders (6), retracting cylinder rod to lower the gantry. As gantry raises, boom hoist drum hauls in wire rope. The PC monitors rear drum pressure senders to control gantry cylinder lowering speed rate.

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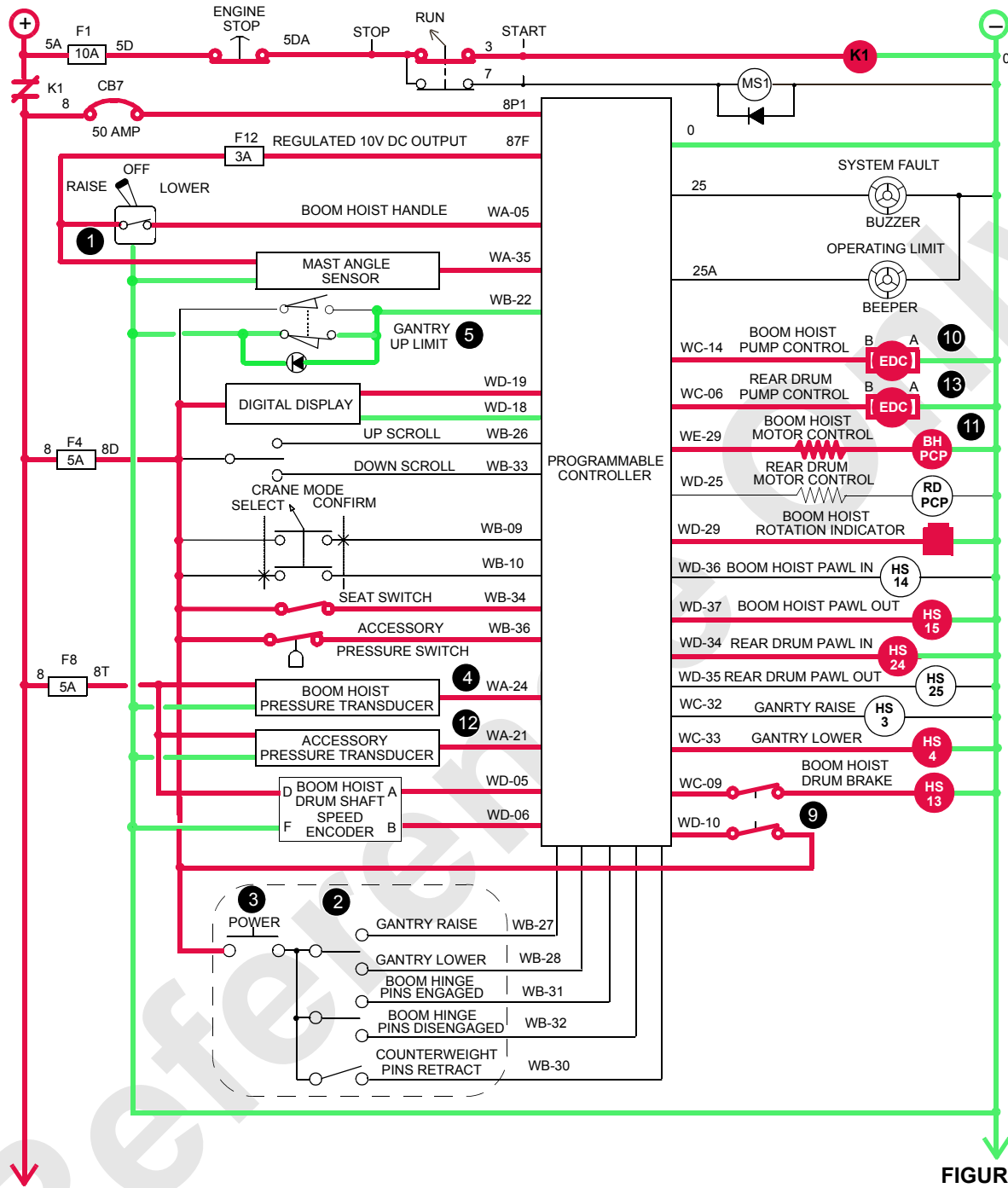


FIGURE 1-34

The free-flow check valve sections on side “A” of counterbalance valves block fluid exhausting from piston end of gantry cylinders.

Fluid passes through flow restrain sections of counterbalance valve that has a relief setting of 3,500 psi (240 bar). Counterbalance valves operate with a 5:1 pilot ratio of the relief valve pressure, permitting valve to open when hydraulic pressure in rod end of the cylinders is

approximately 700 psi (48 bar). Exhaust fluid from side “A” of counterbalance valves combines and free flow check valve section on side “A” of load equalizing valve blocks the flow. Hydraulic fluid then passes through flow restrain section of valve that is preset at 4,000 psi (275 bar).

Load equalizing valve operates with a 1.5:1 pilot ratio of the relief valve pressure. This permits valve to open when the hydraulic pressure (from the setup pump) on side “B” of load

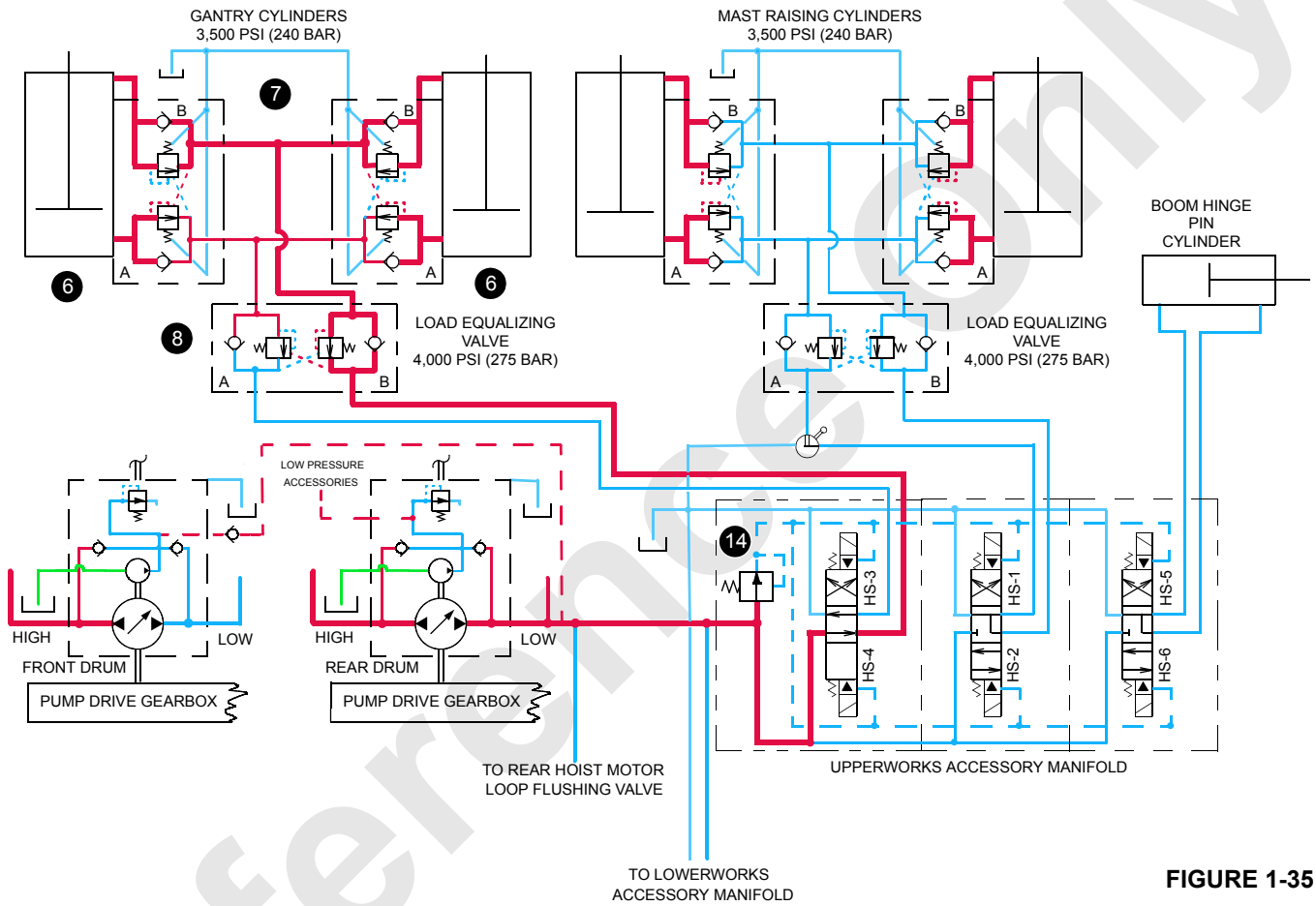
equalizing valves is approximately 2,670 psi (185 bar). Restraining section on side "A" of load equalizing valve opens, controlling fluid out of both cylinders and ensuring cylinder actuation is balanced. Hydraulic fluid exits the accessory system valve through gantry valve section and returns to tank.

When gantry is fully lowered, boom hoist handle is moved to neutral position to stop hauling in wire rope to drum. After

control handle neutral switch opens, the PC sends an output signal to disable brake release solenoid HS-13 to spring-apply brake before hoist pump de-strokes.

The PC sends an output signal to de-stroke rear drum pump and boom hoist pump. The PC also sends an output signal to shift gantry lower cylinder solenoid HS-4 back to center position.

999CSM1-134



Mast System

See Figures [1-36](#) and [1-37](#)

When in Crane Setup mode, mast-raising sequence is controlled by the PC. Mast raising and lowering rate is controlled by engine speed, as it regulates pay out and haul in of the cable reeving between gantry and mast sheaves. Mast raising cylinders also provide assistance to lift and lower mast during reeving of the mast and gantry sheaves.

A mast operating limit message MAST TOO FAR FWD appears on the digital display screen when the mast is lowered to 175°. The PC detects this fault when mast angle indicator monitors the mast position at 175° and overrides boom down command to automatically stop the boom from lowering. It is not possible for the operator to boom down at this time, and boom should be raised to correct this fault.

CAUTION

Mast bypass valve (5), in right side enclosure, must be turned to ON position during crane setup (assembly and disassembly). Mast bypass valve must be turned to OFF position during normal operation to prevent mast arms from raising and contacting mast.

Mast switch (2), on front console, should only be used for raising/lowering mast cylinders without wire rope rigging. When top of mast switch is pressed and held in the raise position, the PC sends an output signal to mast cylinders raise solenoid HS-1. When bottom of mast switch is pressed and held in the lower position, the PC sends an output signal to mast cylinders lower solenoid HS-2.

Mast accessory valve is “motor spool” where both cylinder ports and tank port of the valve spool section are connected in center position. This type of spool prevents premature opening of equalizing valves (8). Hydraulic pressure for mast cylinder solenoids HS-1 and HS-2 is from rear drum low-pressure side closed-loop system.

When raising the mast, the PC monitors boom hoist drum speed with the boom hoist drum encoder (3). The PC maintains a speed that is proportional to accessory system hydraulic pressure applied to the mast cylinders. The desired accessory system pressure builds with the actual pressure between a minimum of 500 psi (34 bar) at the beginning and 3000 psi (207 bar) after the mast starts moving.

When lowering the mast, the PC monitors boom hoist hydraulic system with boom hoist pressure sender (12). The PC maintains a minimum rope tension on boom hoist drum. The PC maintains this tension by controlling boom hoist pump to create an average system pressure of approximately 1100 psi (76 bar). The accessory system hydraulic system is maintaining a minimal hydraulic pressure by taking advantage of the boom hoist rope tension and the weight of the mast to retract the cylinders.

Each mast raising cylinder (6) has a counterbalance valve (7) at each cylinder port. These valves ensure smooth control when raising or lowering gantry and locks the cylinder in place when gantry is at a desired position or if a hydraulic line fails.

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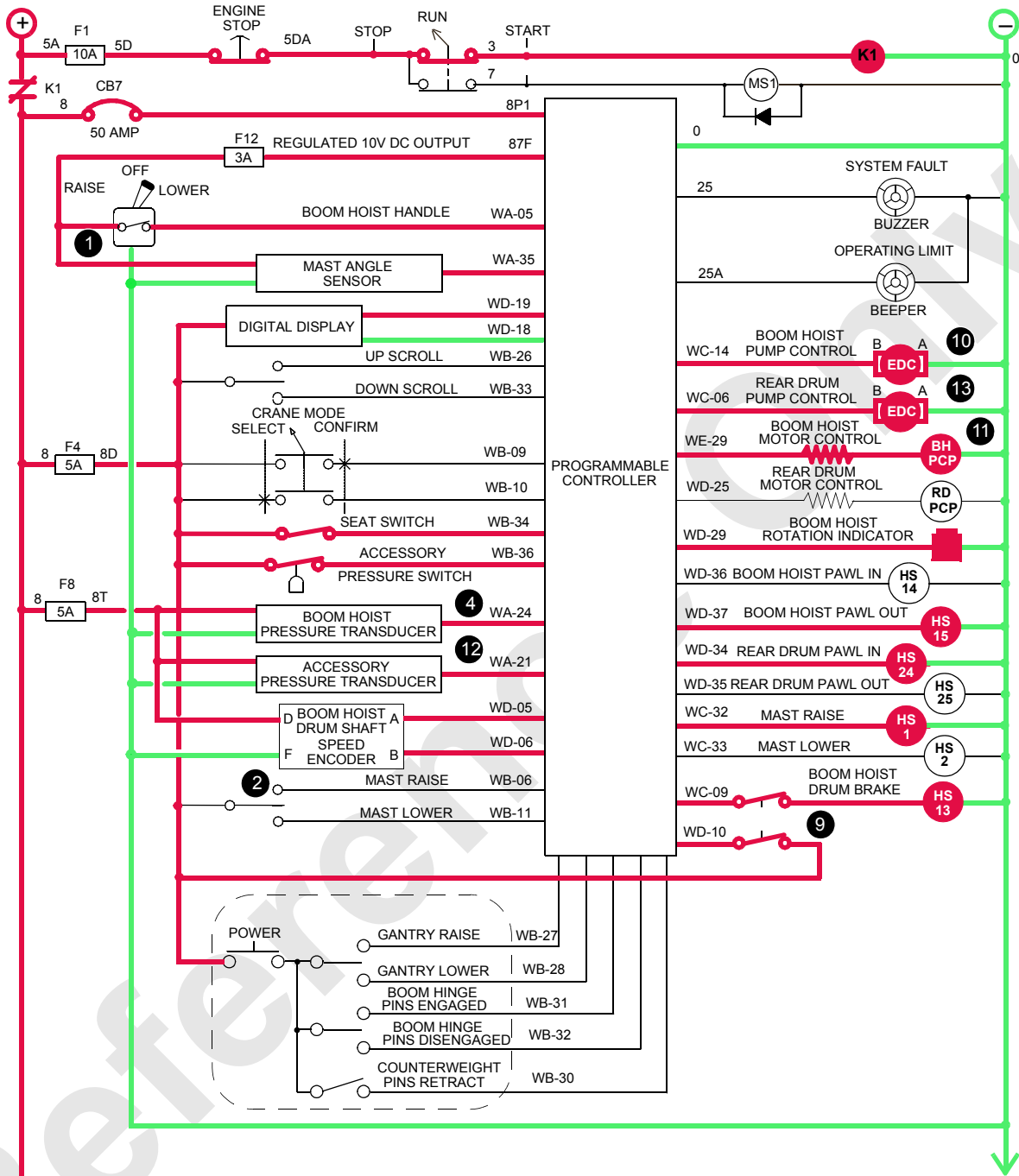


FIGURE 1-36

Mast Cylinders Raise

See Figures 1-36 and 1-37

Place boom hoist brake switch (9) in off - park position. Boom hoist brake remains spring-applied to boom hoist drum until the PC releases the brake. Boom hoist drum pawl out solenoid HS-15 is enabled to disengage pawl from boom hoist drum. Boom control handle circuit to the PC remains open.

After gantry support cylinders are fully extended, move boom hoist handle all the way forward to extend mast cylinders and push the mast upward. Handle neutral switch closes, sending an input voltage of 5 volts or less to the PC.

The PC sends a positive output signal brake release solenoid HS-13. Brake release solenoid valve shifts, to block tank port and open port from low-pressure side of closed-loop to boom hoist brake cylinder spring, releasing brake. The PC sends a negative output signal to enable boom hoist pump EDC that tilts pump swashplate to stroke pump in the lower direction.

When boom hoist brake is released, an input signal is sent to PC. The PC sends a negative output voltage to rear drum pump EDC (13) that tilts rear drum pump swashplate to stroke pump in the low-pressure side direction. Low-pressure side hydraulic fluid flows to mast extend cylinder solenoid HS-1 of accessory valve and through free flow check valve sections on side "A" of load equalizing valve (8).

From equalizing valve, fluid enters counterbalance valves (7) and piston end of mast raising cylinders (6), extending cylinder rods to raise the mast assembly. As mast raises boom hoist drum pays out wire rope between gantry and mast sheaves. The PC monitors rear drum pressure senders to control mast cylinder raising speed rate.

Fluid from rod end of mast raising cylinders is blocked by free flow check valve sections on side "B" of counterbalance valves and flows through valve flow restrain sections preset for a relief pressure of 3,500 psi (240 bar). Counterbalance valves operate with a 5:1 pilot ratio of the relief valve pressure, permitting valve to open when pressure in piston end of the cylinders is approximately 700 psi (48 bar).

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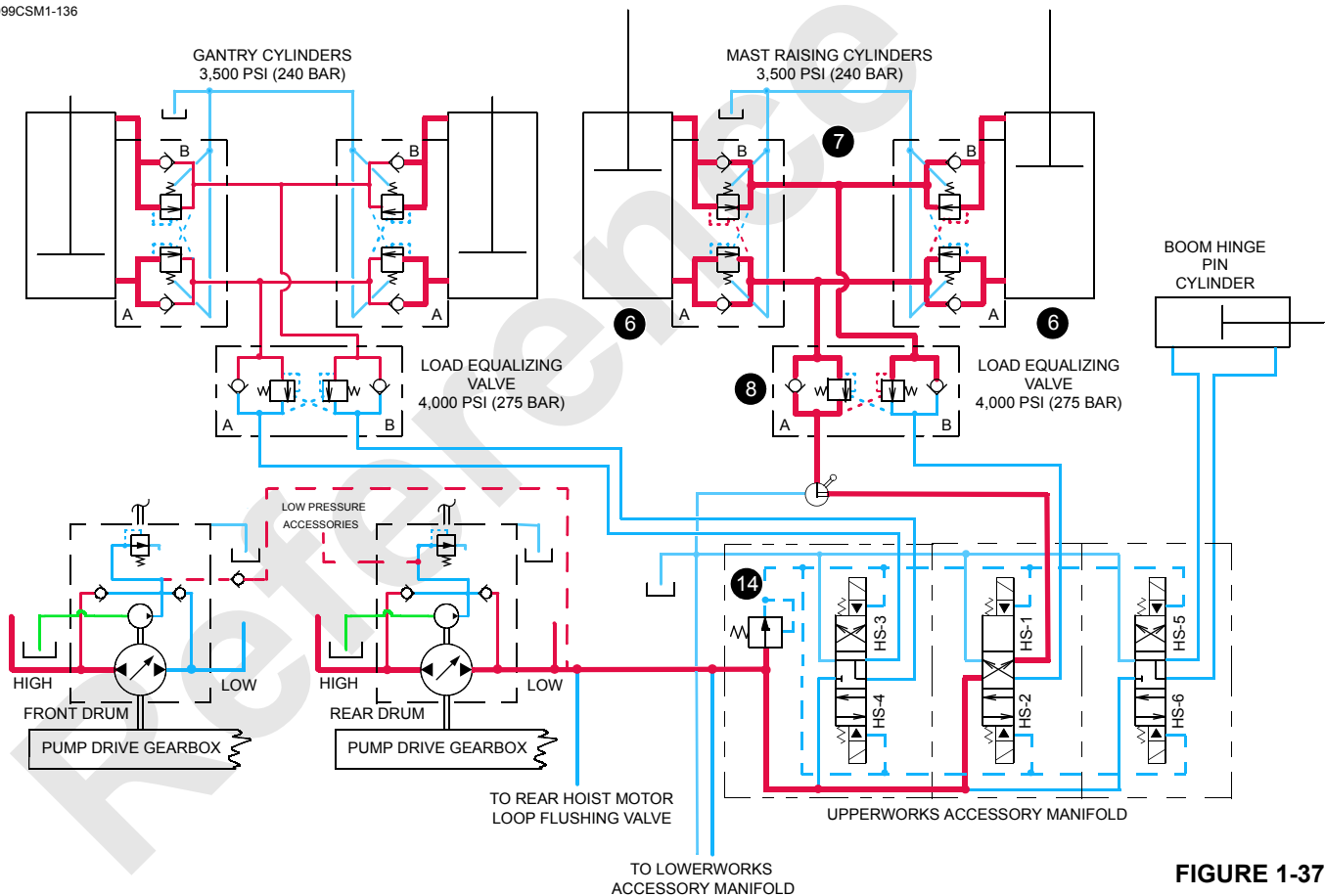


FIGURE 1-37

Load equalizing valve ensures mast-raising cylinders operate in unison, protecting mast from structural damage caused by twisting. Load equalizing valve also provides support resistance against mast to ensure control of the unit while rotating it 120° at time of assembly.

Exhaust fluid from side “B” sections of both counterbalance valves combines, and the free flow check valve section on side “B” of load equalizing valve blocks the flow. The fluid then passes through valve flow restrain section preset at 4,000 psi (275 bar).

Load equalizing valve operates with a 1.5:1 pilot ratio of the relief valve pressure, permitting valve to open when the hydraulic pressure (from the setup pump) on side “A” of the load-equalizing valve is approximately 2,670 psi (185 bar). Restraining section on side “B” of load equalizing valve opens, controlling flow of fluid out of the cylinders and ensuring cylinder operation is balanced.

The fluid then passes through non-restrictive portion of flow control valve and enters accessory system valve. Hydraulic fluid exits the accessory system valve through control valve section before returning to tank.

When mast raises over 90°, and starts to move away from mast assist arms, the PC sends an output signal to de-stroke

rear drum pump. The PC also sends an output signal to shift mast extend cylinder solenoid HS-1 back to center position.

Mast Cylinders Lower

See Figures [1-38](#) and [1-39](#)

To lower mast in Crane Setup mode, move boom hoist handle (1) all the way back. Handle neutral switch closes, sending an input voltage of 5 volts or more to PC. The PC sends a positive output signal brake release solenoid HS-13. Brake release solenoid valve shifts, to block tank port and open port from low-pressure side of closed-loop to boom hoist brake cylinder spring, releasing brake.

The PC tilts boom hoist pump swashplate to stroke pump in the raise direction. As mast lowers, boom hoist drum hauls in wire rope. The mast cylinders provide supportive resistance against mast while lowering to down position.

When lowering mast with computer programming, the mast cylinders retract solenoid HS-2 is enabled. Gravitational force from mast weight and boom hoist line pull helps retract the mast cylinder rods.

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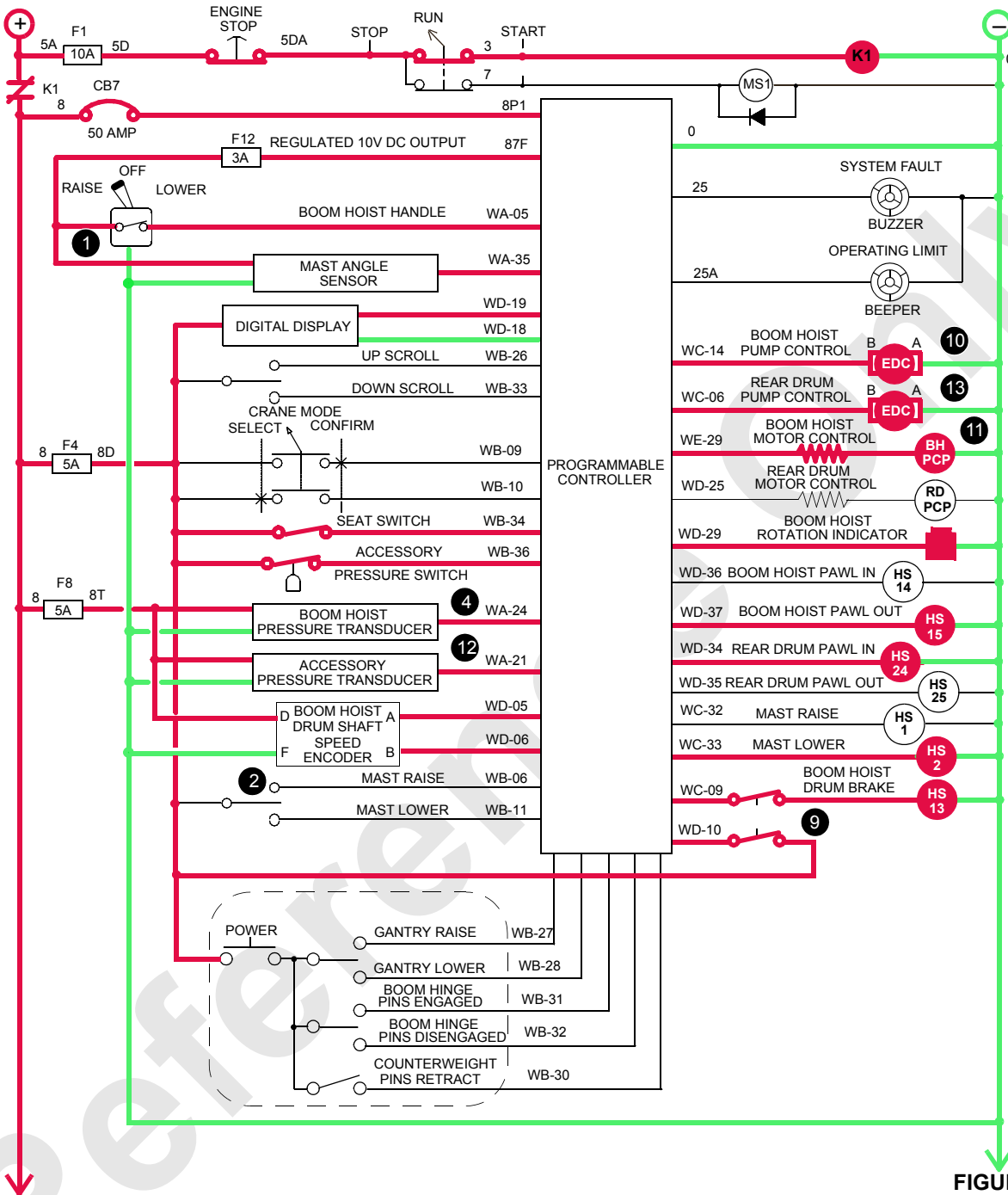


FIGURE 1-38

When cylinder rods retract, fluid exhausting from piston end of the cylinders is blocked by the free-flow check valve section on side "A" of counterbalance valves and passes through the valves' flow restrain sections preset for a relief pressure of 3,500 psi (240 bar).

Exhaust fluid from side "A" sections of both counterbalance valves combines, and flow is blocked by the free flow check valve section on side "A" of load equalizing valve where it passes through valve's flow restrain section preset at 4,000 psi (275 bar). Restraining section on side "A" of load equalizing valve opens, controlling flow of fluid out of both cylinders and ensuring cylinder actuation is balanced.

The fluid exiting side “A” of load equalizing valve enters and passes through control valve section of accessory system valve and into check valve (8) that has a cracking pressure of 65 psi (4,5 bar).

Mast cylinders lower hydraulic solenoid HS-2 does not enable when lowering the mast. Both cylinder ports are interconnected with tank port while valve spool is in the inactivated position. Both cylinder ports and tank port of valve encounter a common 65 psi (4,5 bar) resistance.

Mast cylinder exhaust fluid returns to tank. Mast cylinder exhaust fluid can also flow through check valve at 65 psi (4,5 bar) to replenish fluid on side “B” of the mast raising cylinders during retraction of the rods. Hydraulic fluid through free flow check valve sections on side “B” of counterbalance valves and enters into rod end of the mast lowering cylinders.

To continue lowering mast, the gantry must be lowered. When lowering gantry support cylinders to fully retracted position, boom hoist hydraulic system is monitored by the PC through boom hoist system pressure sender (12) and controlled by the PC to maintain a minimum rope tension on the boom hoist drum. The PC maintains this tension by controlling boom hoist pump to create an average system pressure of approximately 1100 psi (76 bar), while mast and gantry lower with the gantry support cylinders.

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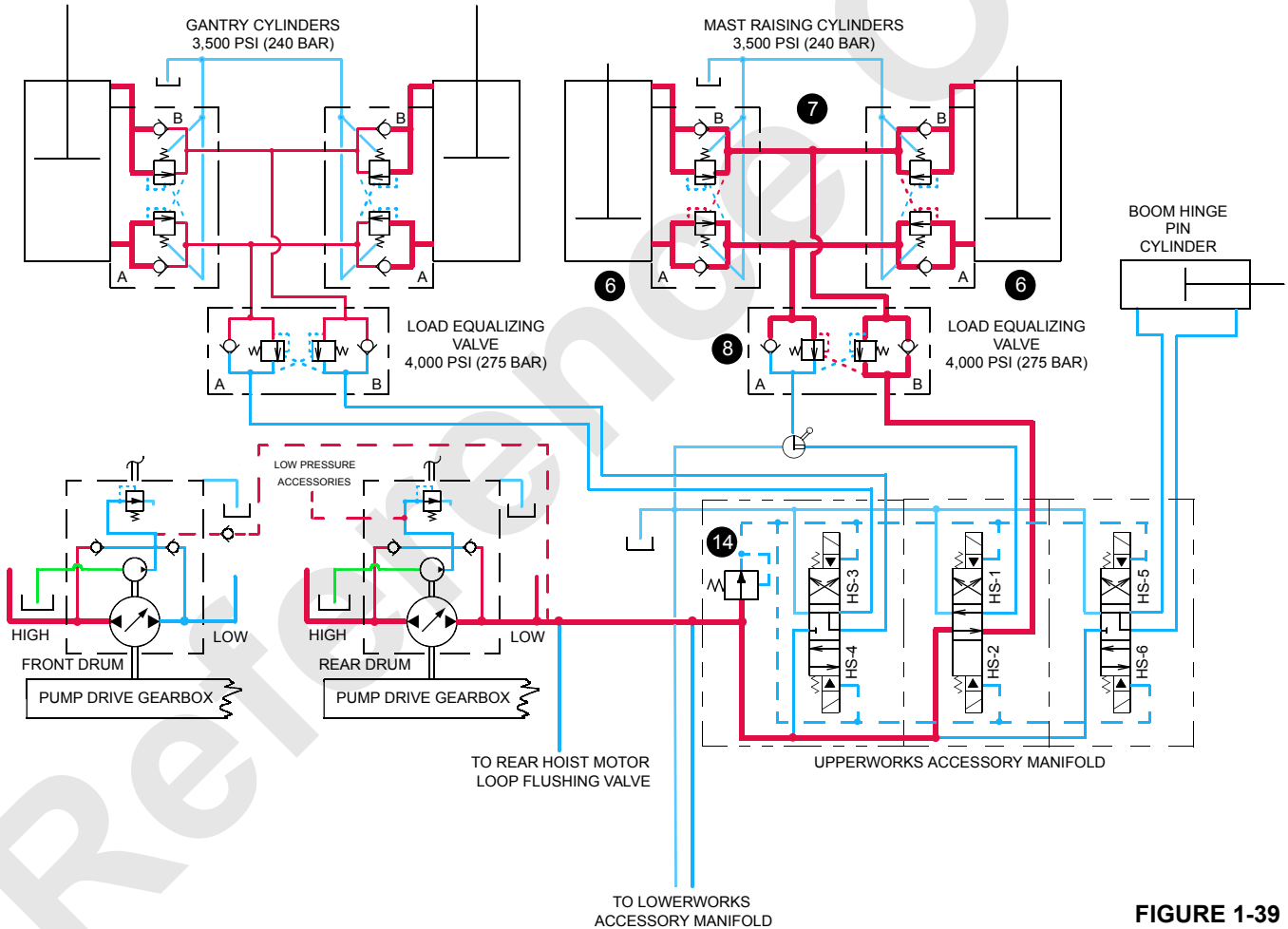


FIGURE 1-39

Boom Hinge Pins

See Figures 1-40 and 1-41

Power is available to setup remote control when cable is plugged into valve junction box on left side of rotating frame and engine is running. Pressing power button (3) completes power supply circuit to setup remote control switches.

When power button is pressed and boom hinge pins switch (2) is placed in engage position and held, the PC sends an output signal to boom hinge pins cylinder engage hydraulic solenoid HS-5. When HS-5 is enabled, the PC sends a negative output voltage to rear drum pump EDC (13) that tilts rear drum pump swashplate to stroke pump in the low-pressure side direction.

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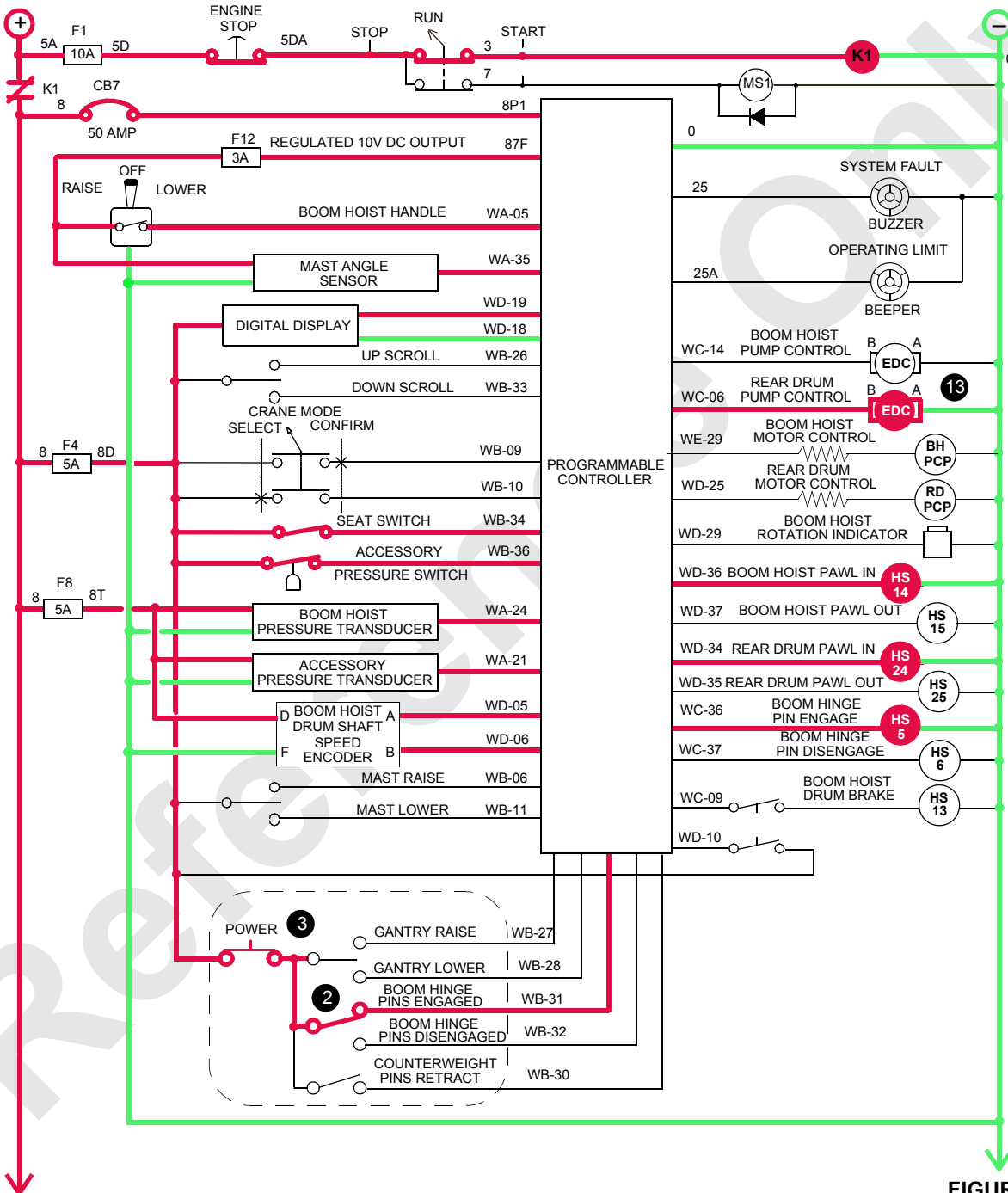


FIGURE 1-40

Low-pressure side hydraulic fluid flows to boom hinge pins engage solenoid HS-5 of accessory valve. Hydraulic fluid leaves the accessory valve and enters piston end of boom pin cylinder (6), extending cylinder rod to engage the boom hinge pins. Exhaust fluid from rod end of boom pin cylinder leaves accessory system valve and returns to tank.

output voltage to rear drum pump EDC (13) that tilts rear drum pump swashplate to stroke pump in the low-pressure side direction.

When power button is pressed and boom hinge pins switch is placed in disengage position and held the PC sends a positive output signal to boom hinge pins disengage solenoid HS-6. When HS-6 is enabled, the PC sends a negative

Low-pressure side hydraulic fluid flows to boom hinge pins disengage solenoid HS-6 of accessory valve. Hydraulic fluid leaves the accessory valve and enters rod end of boom pin cylinder (6), retracting cylinder rod to disengage the hinge pins. Exhaust fluid from piston end of boom pin cylinder leaves accessory system valve and returns to tank.

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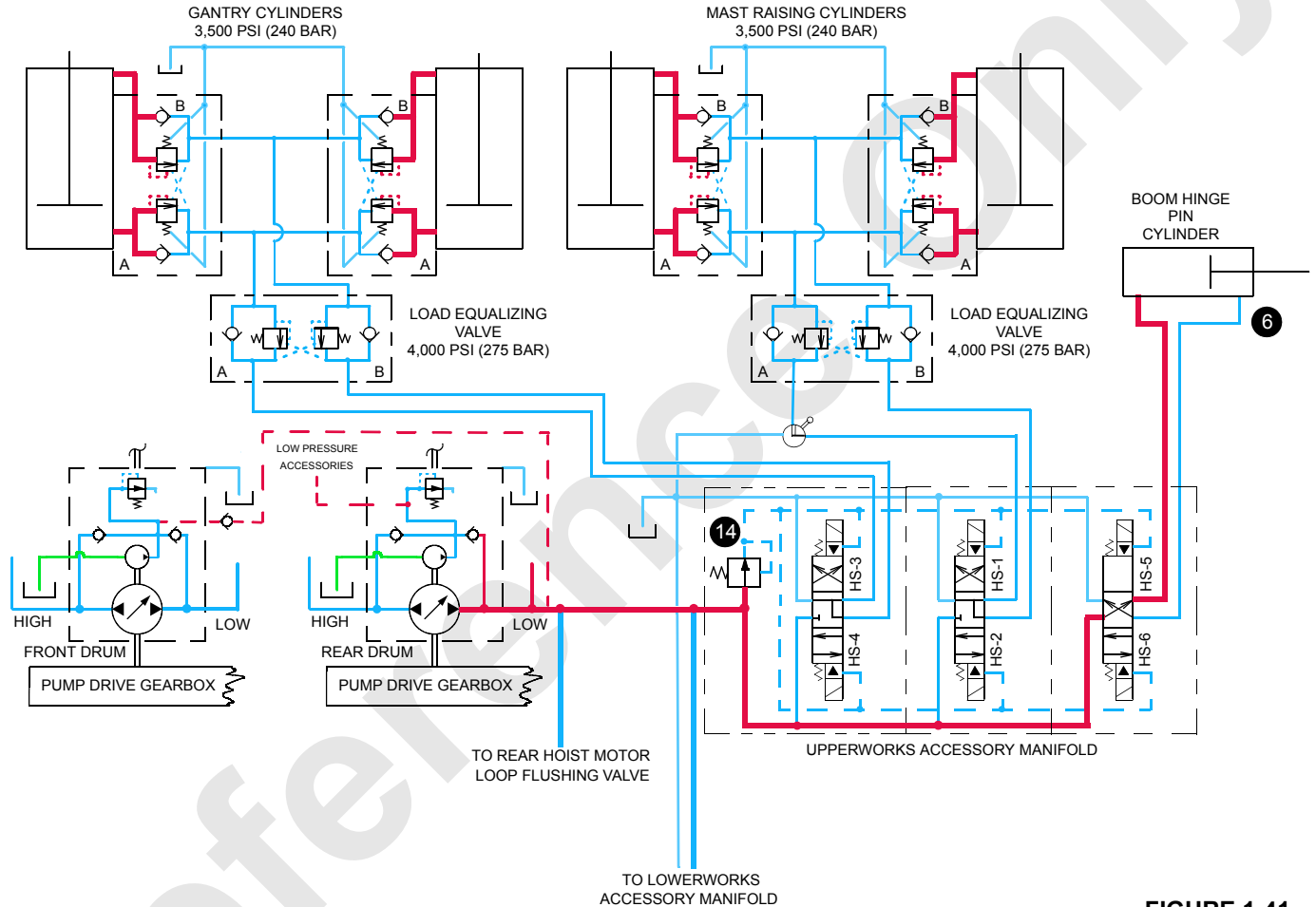


FIGURE 1-41

Carbody Jacking System

See [Figure 1-42](#)

The two-stage telescopic type jacking cylinders are mounted on each corner of carbody. Jacking cylinder operation is controlled with hydraulic valve handles on the carbody and PC programming. Operation of all four jacking cylinders is the same. The following description of operation is for a single jacking cylinder.

! WARNING
Collapsing Hazard!

Keep rotating frame as level as possible while jacking. Operating jacking cylinder with rotating frame more than 3° out of level can cause structural damage to jacking cylinders and possible collapse of rotating frame.

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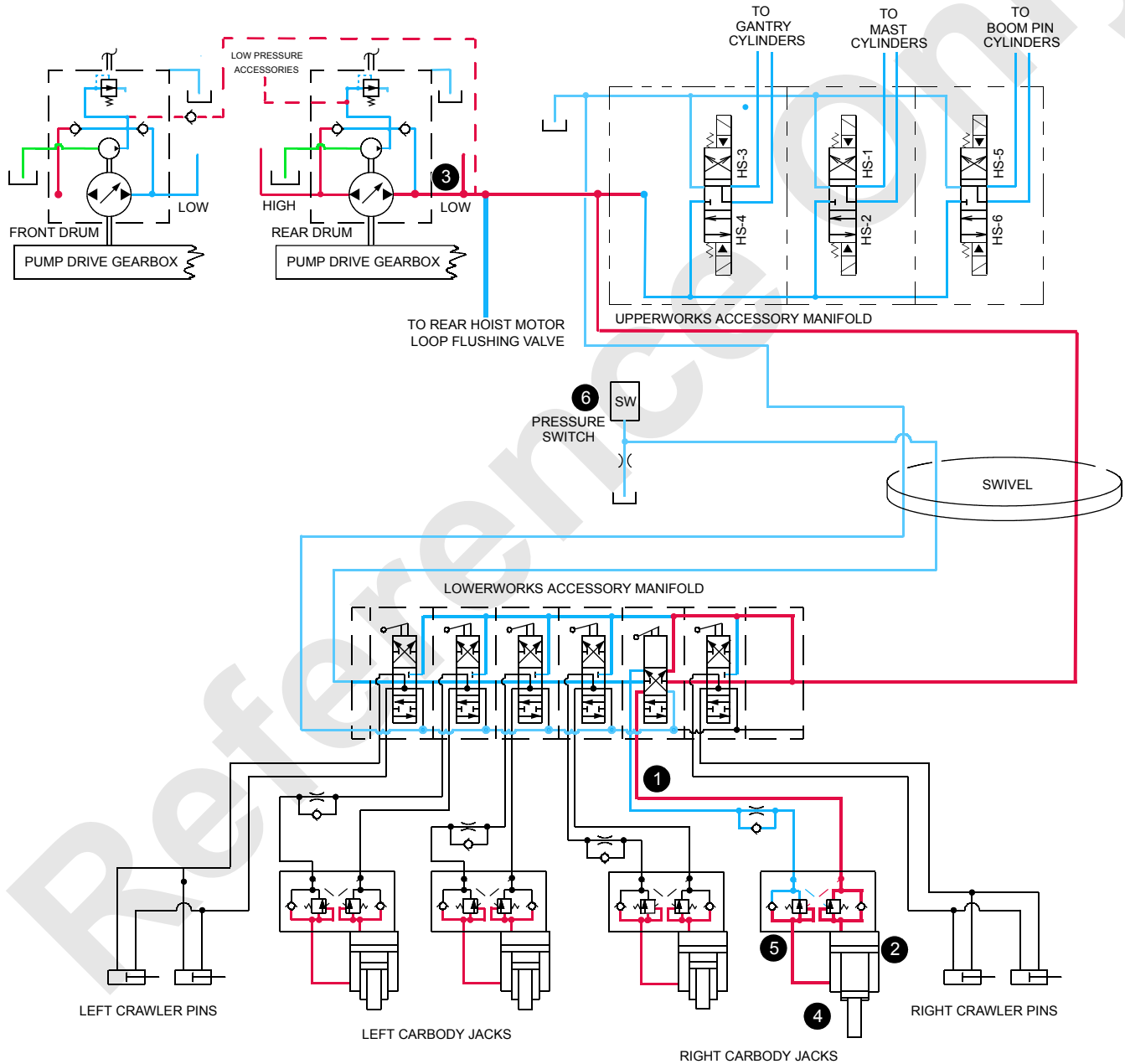


FIGURE 1-42

Each carbody-jacking cylinder (1) has a counterbalance valve (2) at the cylinder ports. Counterbalance valves ensure smooth control when raising or lowering the crane. Counterbalance valves lock the carbody jacking cylinders in place if there is a hydraulic line breakage or accidental operation of control valve when the crane's power is shut down. Also, counterbalance valves provide relief protection for the cylinders and shields them from mechanical overloading.

When a carbody jacking cylinder control valve handle is not enabled, it assumes a neutral position and hydraulic fluid passage to carbody jacking cylinder is blocked. In neutral, both valve section cylinder ports are connected to tank. This prevents in-line pressure from opening counterbalance valve, holding carbody load in position by the counterbalance valve.

Carbody Jacking Cylinder Raise

See [Figure 1-42](#)

Move desired carbody lever back to **raise** position to raise carbody-jacking cylinder. This shifts the selected carbody lower accessory valve to block charge pressure to accessory pressure switch (6). The accessory pressure switch trips when the system pressure drops to 120 psi (8,3 bar), sending an input signal to the PC. The PC sends a negative output voltage to rear drum pump EDC that tilts rear drum pump swashplate to stroke pump (3) in the low-pressure side direction.

Low-pressure side hydraulic fluid flows through high-pressure carry-over of accessory system valve where system pressure is 3,000 psi (207 bar). Hydraulic fluid exits valve section of lower accessory valve into counterbalance valve. Hydraulic fluid then enters piston end of carbody jacking cylinder (4), extending cylinder to raise the carbody. The PC monitors accessory system pressure sender to control jacking cylinder raising speed rate.

Hydraulic fluid returning to tank from rod end of the carbody jacking cylinder is blocked by the free flow check valve section of counterbalance valve and flows through flow restraining section that has a relief setting of 3,500 psi (240 bar).

The counterbalance valve acts as a deceleration control and functions with a 3:1 pilot ratio of the relief pressure. This permits the valve to open when the pressure in rod end of the cylinder is approximately 1,170 psi (81 bar). Restraining section of counterbalance valve opens, controlling the fluid out of the carbody-jacking cylinder.

Hydraulic fluid then flows through free-flow check valve (5) section of flow control valve before entering lower accessory valve. Hydraulic fluid leaving the lower accessory valve is returned to tank.

Carbody Jacking Cylinder Lower

See [Figure 1-43](#)

Move desired carbody lever forward to lower position to lower carbody jacking cylinder. Selected lower accessory valve shifts to block charge pressure to accessory pressure switch (6). The accessory pressure switch trips when the system pressure drops to 120 psi (8,3 bar), sending an input signal to the PC. The PC sends a negative output voltage to rear drum pump EDC that tilts rear drum pump swashplate to stroke pump (3) in the low-pressure side direction.

Low-pressure side hydraulic fluid flows through high-pressure carry-over of accessory system valve where the system pressure is 3,000 psi (207 bar). Hydraulic fluid exits the valve section of lower accessory valve and flows through the restraining section of flow control valve.

Restraining section controls the rate of speed for the cylinder to retract by limiting the velocity of fluid before passing through free flow check valve (5) section of counterbalance valve. Hydraulic fluid then proceeds into rod end of carbody jacking cylinder (4). Hydraulic pressure entrapped by the cylinder counterbalance valve at piston end of the carbody-jacking cylinder supports the weight and gravitational force of the carbody. The PC monitors accessory system pressure sender to control jacking cylinder lowering speed rate.

Hydraulic fluid exhausting from piston end of the carbody jacking cylinder is blocked by free flow check valve section of counterbalance valve and flows through the flow restraining section that has a relief setting of 3,500 psi (240 bar). The counterbalance valve serves as a deceleration control and functions with a 3:1 pilot ratio of the relief pressure, permitting the valve to open when the pressure in piston end of the cylinder is approximately 1,170 psi (81 bar). The restraining section of counterbalance valve opens that controls fluid out of the carbody-jacking cylinder to lower accessory valve. Hydraulic fluid leaving the lower accessory valve is returned to tank.

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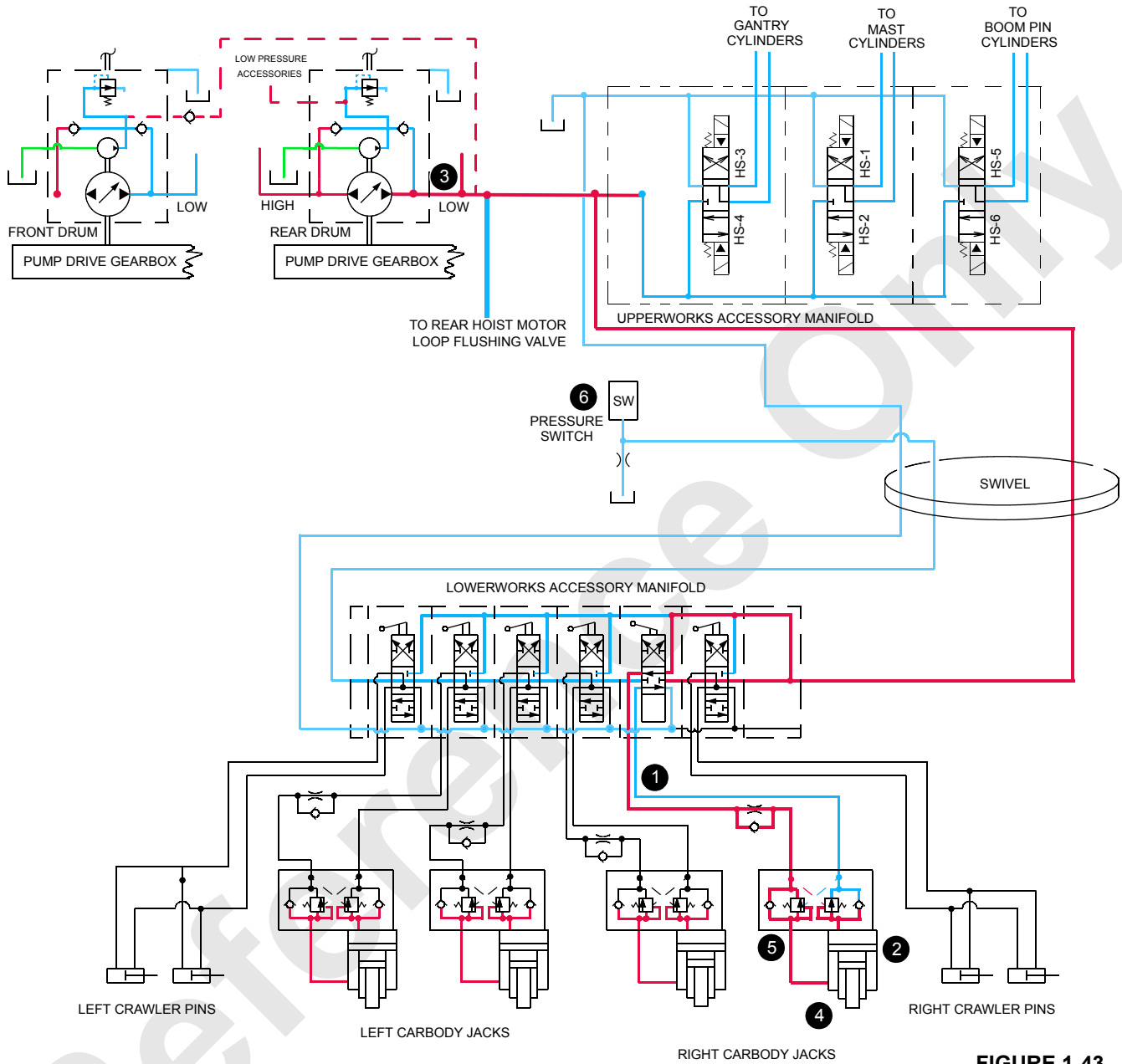


FIGURE 1-43

Left and Right Crawler Pin-Pusher Cylinders

Crawler pin pusher cylinder operation is controlled with hydraulic valve handles on the carbody and PC programming. The following description of operation is for right side set of crawler pin pusher cylinders. Operation of both sets of pin cylinders is the same.

Right Crawler Pin-Pusher Cylinders Engage

See [Figure 1-44](#)

Move right crawler pins lever (1) back to engage position to extend crawler pin pusher cylinders (2) into crawler track frame. This shifts selected carbody lower accessory valve to block charge pressure to accessory pressure switch (4).

The accessory pressure switch trips when the system pressure drops to 120 psi (8,3 bar), sending an input signal to the PC. The PC sends a negative output voltage to rear drum pump EDC that tilts rear drum pump swashplate to stroke pump (3) in the low-pressure side direction. Low-pressure side hydraulic fluid flows through the high-pressure carry-over of accessory system valve where the system pressure is 3,000 psi (207 bar). Hydraulic fluid enters piston end of both crawler pin pusher cylinders, extending each cylinder rod, rotating each assembly lever to secure crawler frame to carbody.

Hydraulic fluid exhausting from rod end of both crawler pin pusher cylinders returns to lower accessory valve and is returned to tank.

Right Crawler Pin-Pusher Cylinders Disengage

Move right crawler pins lever (1) forward to disengage position to retract crawler pin pusher cylinders (2) from crawler track frame. This shifts selected carbody lower accessory valve to block charge pressure to accessory pressure switch (4).

The accessory pressure switch trips when the system pressure drops to 120 psi (8,3 bar), sending an input signal to the PC. The PC sends a negative output voltage to rear drum pump EDC that tilts rear drum pump swashplate to stroke pump (3) in the low-pressure side direction. Low-pressure side hydraulic fluid flows through the high-pressure carry-over of accessory system valve where the system pressure is 3,000 psi (207 bar). Hydraulic fluid enters rod end of both crawler pin cylinders, retracting each cylinder rod, releasing crawler track frame from carbody.

Hydraulic fluid exhausting from piston end of both crawler pin cylinders returns to lower accessory valve and is returned to tank.

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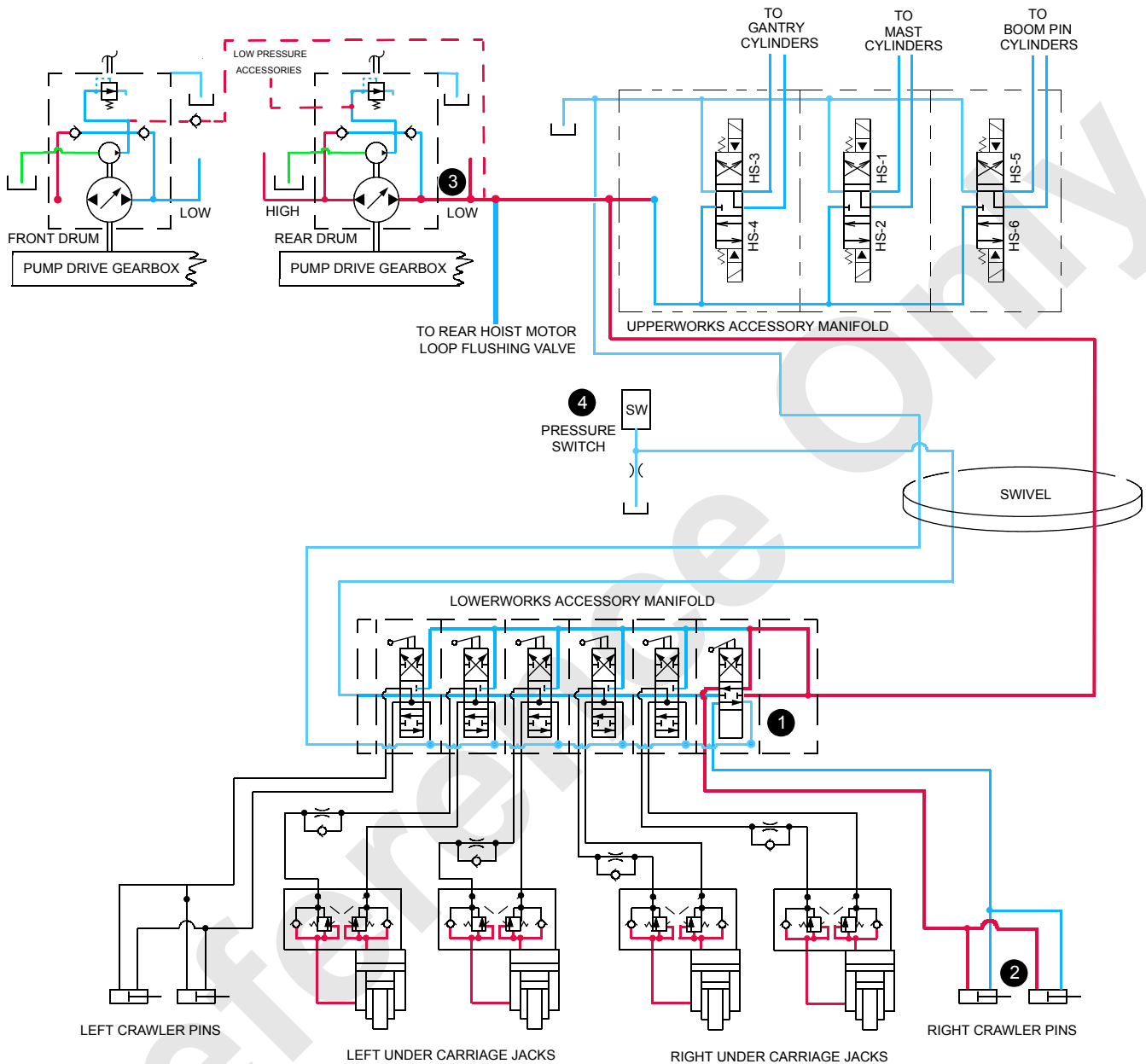


FIGURE 1-44

Counterweight Pins

See Figures 1-45 and 1-46

Counterweight pin switch (2) is spring-returned to engage position. In this position, counterweight pins are extended. Fluid flows through counterweight pins engage solenoid HS-7 to piston end of pin cylinder (3). Cylinder pins are engaged while fluid from rod end of cylinder flows to tank.

When setup remote power push button (3) is pressed and counterweight pins switch, is held in the disengage position, counterweight pins disengage solenoid HS-7 is enabled, to retract the pins. Fluid from rear drum low-pressure accessory line flows through the solenoid to rod end of counterweight pin cylinders. Cylinders then retract to move pins out of engagement while fluid from piston end of cylinder flows to tank. When counterweight pins switch is released, it returns to the engage position.

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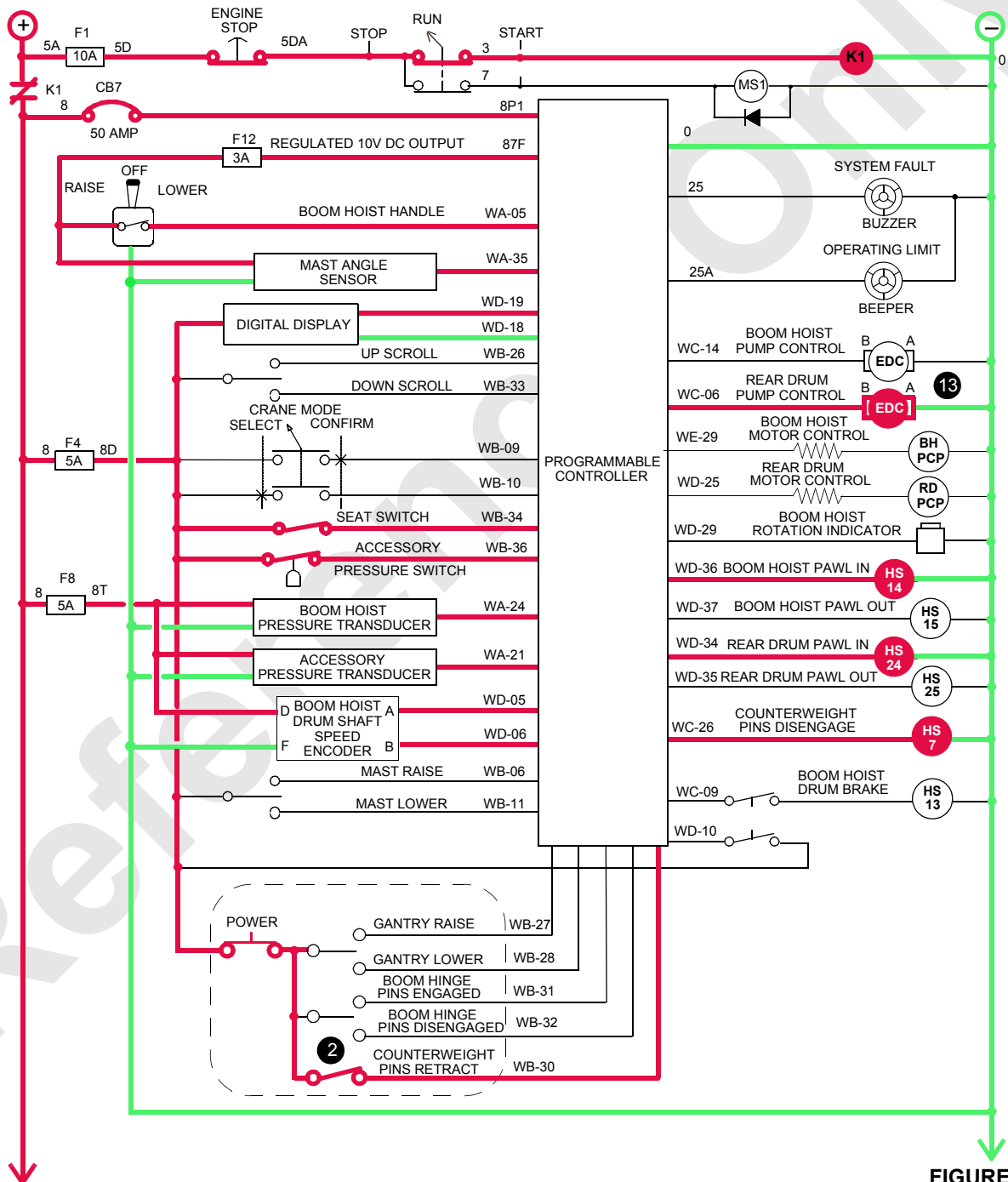


FIGURE 1-45

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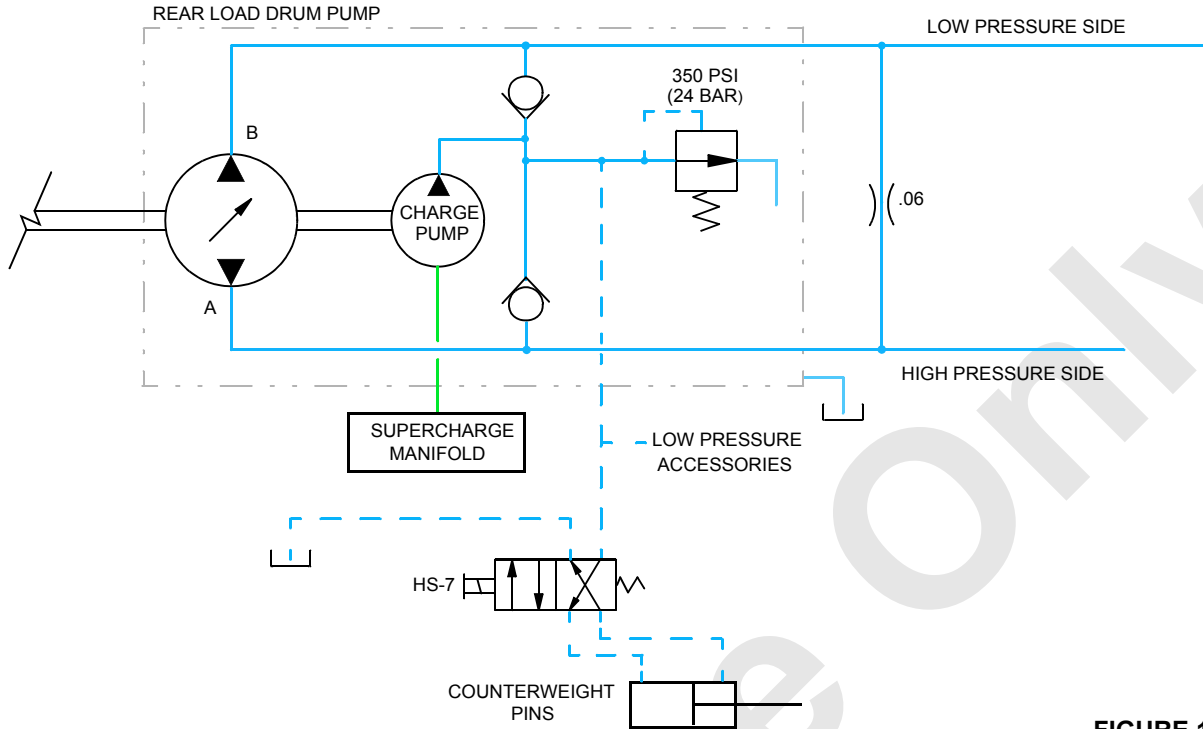


FIGURE 1-46

HYDRAULIC SOLENOID VALVE IDENTIFICATION

Each hydraulic solenoid valve is assigned an HS number. The HS numbers are for training purposes only and do not identify actual hydraulic solenoids on the crane.

HS-1	Mast Cylinders Raise
HS-2	Mast Cylinders Lower
HS-3	Gantry Cylinders Raise
HS-4	Gantry Cylinders Lower
HS-5	Boom Hinge Pins Engage
HS-6	Boom Hinge Pins Disengage
HS-7	Counterweight Pins Disengage
HS-8	Swing Brake Release
HS-9	Swing Lock Engage
HS-10	Swing Lock Disengage
HS-11	Travel Brake Release
HS-12	Two-speed Travel
HS-13	Boom Hoist Drum Brake Release
HS-14	Boom Hoist Pawl In
HS-15	Boom Hoist Pawl Out
HS-16	Front Drum Brake Release
HS-17	Front Drum Brake Proportional Valve
HS-18	Front Drum Free Fall Enable
HS-19	Front Drum Pawl In
HS-20	Front Drum Pawl Out
HS-21	Rear Drum Brake Release
HS-22	Rear Drum Brake Proportional Valve
HS-23	Rear Drum Free Fall Enable
HS-24	Rear Drum Pawl In
HS-25	Rear Drum Pawl Out
HS-26	Auxiliary Drum Brake Release
HS-27	Auxiliary Drum Pawl In
HS-28	Auxiliary Drum Pawl Out

ABBREVIATIONS

A	Amber Light
ACR	Air Conditioning Relay
AH	Auxiliary Hoist
ALT	Alternator
AUX	Auxiliary
BH	Boom Hoist
EDC	Electrical Displacement Control (Pump)
ED	Ether Disable
EFC	Electronic Fuel Control
ER	Ether Relay
EV	Ether Valve
DPF	Diesel Particulate Filter
FH	Front Hoist
FS	Fuel Solenoid
FSR	Fuel Solenoid Relay
G	Green Light
HDC	Hydraulic Displacement Control
HS	Hydraulic Solenoid
K1	Cab Power Relay
K3	Engine Power Relay
LD	Load Drum
LH	Luffing Hoist
LT	Left Travel
M	Starter Motor
M/C	Motor Control
MS1	Start Solenoid Relay
PC	Programmable Controller
P/C	Pump Control
PCOR	Pressure Compensated Over Ride
PCP	Pressure Control Pilot
PCR	Pressure Compensated Regulator
PCV	Pressure Control Valve
R	Red Light
RH	Rear Hoist
RT	Right Travel
S	Swing
SOL	Solenoid
SS	Starter Solenoid
VDC	Volts Direct Current

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Reference Only

SECTION 2 HYDRAULIC SYSTEM

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SECTION 2 HYDRAULIC SYSTEM

This section contains hydraulic system maintenance, adjustment, calibration and test procedures for the hydraulic system and related components on the Model 999.

Experienced technicians, trained in the operation of this crane and its hydraulic system, shall perform the procedures described in this section. The technicians shall read, understand, and comply with the instructions in this section and to the display screen instructions in Section 3 of the 999 Operator Manual.

Contact your Manitowoc dealer for an explanation of any procedure not fully understood.

The adjustment, calibration, and test procedures described in this section were made to the crane before it was shipped from the factory. These procedures must be performed by field personnel only when parts are replaced or when instructed by a Manitowoc dealer.

NOTE: Applicable hydraulic schematics are included at the end of this section.

CAUTION

Do not alter hydraulic system specifications given in this section without approval of your Manitowoc dealer.

Damage to hydraulic components and improper operation of crane can occur if specifications are altered.

INSPECTING HYDRAULIC HOSES



CAUTION

Burn Hazard!

Oil in hydraulic tank may be under pressure and extremely hot. Ensure that the hydraulic hose is depressurized before loosening any connections.

Every Month or 200 Hours

1. Visually inspect all hydraulic hose assemblies every month or at 200 hours of service life for the following:
 - Leaks at hose fittings or in hose
 - Damaged, cut, or abraded cover
 - Exposed reinforcement
 - Kinked, crushed, flattened, or twisted hose
 - Hard, stiff, heat cracked, or charred hose
 - Blistered, soft, degraded, or loose cover
 - Cracked, damaged, or badly corroded fittings

- Fitting slippage on hose
- Other signs of significant deterioration

If any of these conditions exist, evaluate the hose assemblies for correction or replacement.

2. At the same service interval, visually inspect all other hydraulic components and valves for the following:

- Leaking ports
- Leaking valve sections or manifolds and valves installed into cylinders or onto motors
- Damaged or missing hose clamps, guards, or shields
- Excessive dirt and debris around hose assemblies

If any of these conditions exist, address them appropriately.

Degradation Due to Extreme Environment

Table 2-1. Climate Zone Classification:

Zone	Description
A	Tropical Moist: All months average above 65°F (18°C). Latitude: 15° - 25° N & S
B	Dry or Arid: Deficient precipitation most of the year. Latitude: 20° - 35° N & S
C	Moist Mid-Latitude: Temperate with mild winters. Latitude: 30° - 50° N & S
D	Moist Mid-Latitude: Cold winters. Latitude 50° - 70° N & S
E	Polar: Extremely cold winters and summers. Latitude: 60° - 75° N & S

Salt Environment

Hydraulic hose assemblies operating in salt water climates could see a significant reduction in service life. Regularly inspect hydraulic hose assemblies per Step 1.

Zone A and B

After 4,000 to 5,000 hours of service life, replace hydraulic hose assemblies operating in these climate zones with high ambient temperatures and high duty circuits. These hoses could experience a service life reduced 40% to 50%.

High duty circuits can include, but are not limited to hoist(s), boom lift, swing, travel, pump suction and discharge to directional valves, and directional valve return to reservoir.

Zone C

After 8,000 hours of service life, replace hydraulic hose assemblies operating in this climate zone.

Zone D and E

Inspect hydraulic hose assemblies per Step 1. Cold temperatures will negatively impact service life of hose assemblies operating in these climate zones.

HYDRAULIC SYSTEM MAINTENANCE

Safety

Lower or securely block hydraulically operated attachments and loads before servicing. Do not rely on controls to support attachments or loads.

Stop engine and relieve hydraulic pressure to zero before servicing or disconnecting any part of hydraulic system. After stopping engine, operate controls in both directions to relieve pressure.

Before servicing hydraulic system, attach warning sign to engine start controls to warn other personnel not to start engine.

Do not perform hydraulic system maintenance, adjustment or repair procedures unless authorized to do so. And then, make sure all applicable instructions have been read and are thoroughly understood.

Do not alter specified pressure settings. Higher than specified pressures can cause structural or hydraulic failure. Lower than specified pressures can cause loss of control.

Never check for hydraulic leaks with hands. Oil under pressure can penetrate skin, causing serious injury. Oil escaping from a small hole can be nearly invisible; therefore, check for leaks with a piece of cardboard or wood.

Storing and Handling Oil

- Store oil drums in clean, cool, dry location. **Avoid outdoor storage.**
- Store oil drums on their side and cover them to prevent water and dirt from collecting on them.
- When handling drums and transfer containers, use care to avoid damage which can cause leaks and entry of dirt or water into oil.
- Before opening a drum, carefully clean top of it. Also clean faucet or pump to remove oil from drum.
- Only use clean transfer containers.
- Do not take oil from storage until oil is needed. If oil cannot be used immediately, keep transfer container tightly covered.

Storing and Handling Parts

- Store new parts (valves, pumps, motors, hoses, tubes) in clean, dry indoor location.

- Do not unpack parts or remove port plugs until parts are needed.
- Once unpacked, carefully inspect each part for damage that may have occurred during shipping. Remove all shipping material from ports of parts before installing them.
- Fittings, hoses, and tubes that are not equipped with shipping caps or plugs must be carefully cleaned before they are used. Flush fittings, hoses, and tubes with clean hydraulic oil. Then seal all openings until use at assembly.
- Do not use rags to plug openings. Use clean plastic shipping plugs and caps.

Inspecting System

The damaging effects of dirt, heat, air, and water in the hydraulic system can only be prevented by regular, thorough inspection of the system. The frequency of inspection depends on operating conditions and experience with the system; however, the more often the system is inspected and deficiencies corrected, the less likely the system will malfunction.

A good inspection program will include the following checks:

1. Keep accurate records so future maintenance needs can be projected.
2. Only use approved hydraulic oil in system (see Lubrication Guide in Section 9).
3. Check oil level in tank daily. Carefully clean area around fill cap before removing it to add oil. When adding oil to tank, filter oil through 10-micron filter.
4. Clean exterior of system often; do not let dirt accumulate on or around any part of system.
5. Check for external leaks. Leaks are not only unsafe; they also attract dirt and in some cases allow air and water to enter system. Do not return leakage oil back to hydraulic tank.

Remember not to use your hands to check for leaks.

- Look for oil leaking from fittings and from between parts that are bolted together. Tighten loose fittings and attaching bolts to proper torque, and do not over tighten.

If leakage persists at these points, replace seals or gaskets.

- Look for oil leaking from pump and motor shaft ends, from valve spool ends, and from cylinder shaft ends. Replace seal if leakage is found at any of these points.

- Replace tubes that are cracked, kinked, or bent.
- Replace hoses that are cracked, split, or abraded.
- Listen to pumps and motors for unusual noises; a high pitched whine or scream can indicate that air is being drawn in.

An air leak can be pinpointed by flooding inlet fitting, hose, or tube with oil. If there is an air leak, the oil will cause a noticeable reduction in noise. Correct cause for any air leak, or pump/motor will be ruined.

NOTE: A high-pitched whine or scream from the pump can also indicate cavitation (pump being starved of oil). This condition is caused by the following problems:

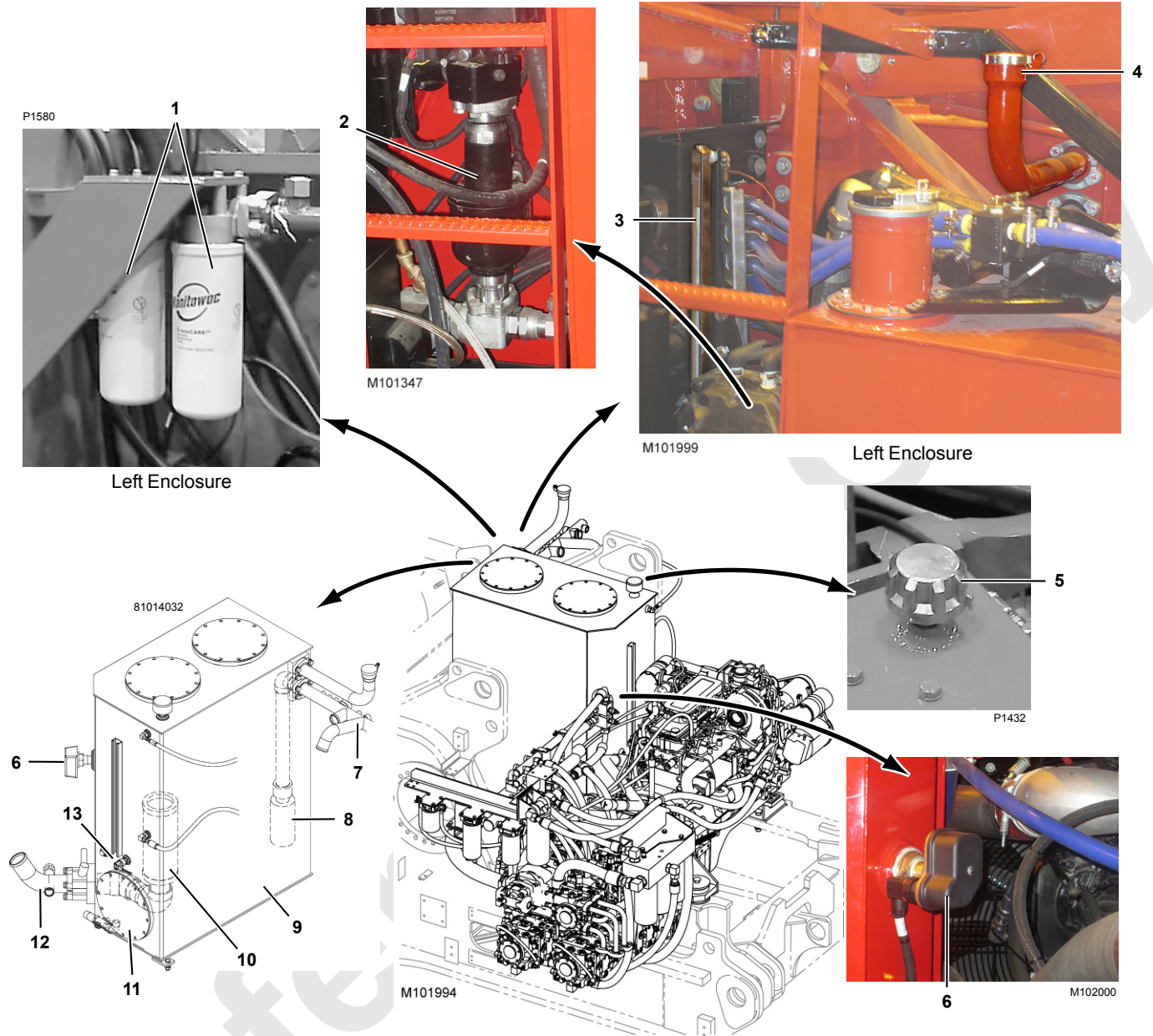
- Plugged suction filter
- Collapsed or plugged suction line

- Wrong oil (viscosity too high)

6. Look for signs of overheating: heat peeled parts, burned and scorched oil odor, and darkening and thickening of oil. Maximum temperature of oil in tank must not exceed 180°F (82°C).
7. Have hydraulic oil analyzed at regular intervals to determine condition of oil and extent of system contamination.

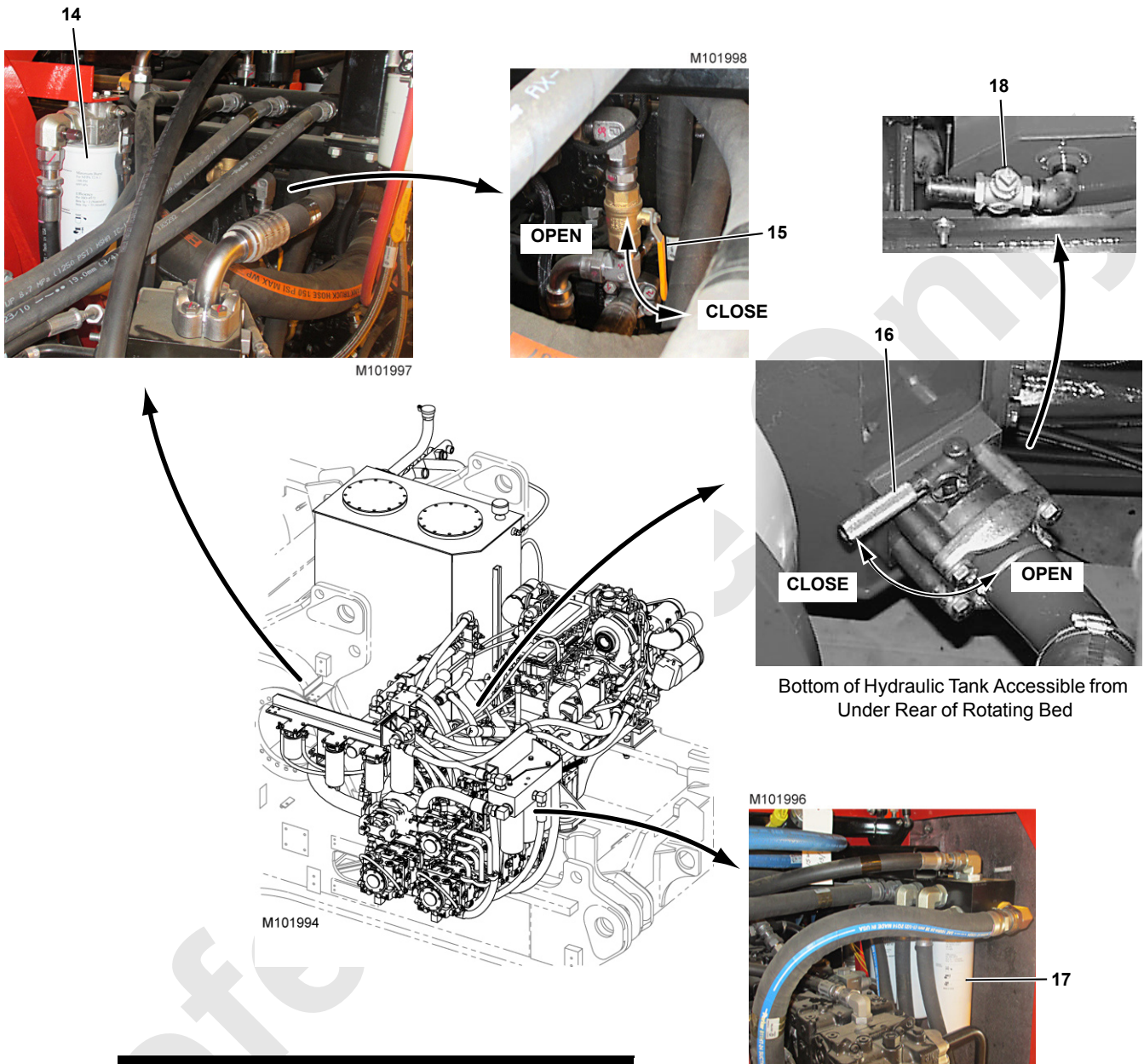
By having the oil analyzed on a regular basis, an oil change interval meeting your operating conditions can be established.

NOTE: Contact your oil supplier for the availability of oil analysis services and the steps that should be taken to obtain these services.



Item	Description	Item	Description
1	Free Fall Hydraulic Return Oil Filter (1 or 2)	8	Return Oil Diffuser
2	Thermal Bypass Valve	9	Hydraulic Tank
3	Hydraulic Tank Sight Gauge	10	Suction Filter
4	Hydraulic Tank Fill Cap	11	Hydraulic Tank Access Cover (3)
5	Hydraulic Tank Breather	12	Suction Tube (to pumps)
6	Hydraulic Tank Level Switch	13	Oil Temperature Switch
7	Hydraulic Oil Return Manifold		

FIGURE 2-1



Item	Description
14	Auxiliary Drum Hydraulic Oil Filter
15	Charge Filter Shut-Off Valve
16	Hydraulic Tank Shut-Off Valve (suction tube)
17	Hydraulic Oil Charge Filters (3)
18	Hydraulic Tank Drain Valve

FIGURE 2-1 continued

Replacing Filter Elements

This crane is equipped with up to five hydraulic oil filters (see table below):

- Free fall (1) filter for each optional free fall drum filters the return oil to tank.
- Suction filter (10), which is a mesh screen, filters the oil to the charge pumps.
- Charge filter (14) filters charging oil to the optional auxiliary drum charge pump.
- Main charge filters (17) filter charging oil to all of the pumps (except auxiliary).

The system fault alert will come on in the operator's cab when any of these filters plugs with dirt (see Digital Display Readings in 999 Operator Manual). The alert indicates which filter element needs replacing, as follows:

Filter (Figure 2-1)	Digital Display Reading
1	FFALL FILTER
10	HYD SUCTION FILTER
14	AUX DRUM CHRNG FILTER
17	MAIN CHARGE FILTER

It is normal for the alert to come on at start-up when the oil is cold. If the filters are not plugged, the alert will turn off after the hydraulic oil warms up.

The following procedure is for filters (1, 14, and 17).

To clean or replace filter (10), the hydraulic tank must be drained (see [Changing Oil](#) procedure to clean or replace this filter).

1. Stop engine.
2. For filters (1, 14, and 17), close filter shut-off valve (15).
3. Place a container below filter element to be replaced.
4. Clean outside of filter element and area around base.
5. Using filter wrench, loosen filter element.
6. Turn element off. Place filter element in container.
7. Lubricate gasket on new element with clean hydraulic oil. **Do not use grease.**
8. Make sure gasket is securely attached to element.
9. **Do not fill new element with oil.**
10. Screw new element onto filter housing until gasket contact is snug against base.
11. Tighten element by hand 1/2 turn more so that gasket is properly seated and filter element does not leak.

12. Start engine and allow hydraulic system to return to operating pressure. Check filter element for leaks. Tighten element as required to stop leakage.

13. For filters (1, 14, and 17), open filter shut-off valve (15).

Changing Oil

Drain and refill hydraulic system every 1,000 hours or semiannually, whichever occurs first, unless an alternate interval is established through an oil analysis program.

CAUTION

Equipment Damage!

Be sure to drain oil from and add oil to hydraulic tank, not fuel tank. The two tanks are next to each other on right side of crane. Hydraulic tank is to rear of fuel tank.

See [Figure 2-1](#) for the following procedure.

1. Operate crane until hydraulic oil is at normal operating temperature. This will help prevent impurities from settling in system.
2. Stop engine.
3. Attach a rubber hose to the pipe on drain valve (18) and insert the hose in a suitable container to catch hydraulic oil. Tank capacity is 120 gallons (454 liters) to full (cold (gantry up) mark on sight gauge.
4. Open drain valve (18) to drain tank.
5. Clean all dirt off access cover (11) on bottom of tank and two covers (11) on top of tank. Then remove covers from tank. Take precautions to prevent dust and wind-blown dirt from entering tank while covers are off.
6. Flush out any sediment inside tank.
7. Clean/replace suction filter (10):
 - a. Using a wrench, remove suction filter from inside tank.
 - b. Soak filter in clean, nonflammable solvent. Brush off outer surface, and flush from inside out. Replace if damaged.
 - c. Reinstall suction filter.
8. Use new seals and securely fasten access covers to tank.
9. Clean breather (5):
 - a. Remove breather.
 - b. Soak breather in clean, nonflammable solvent. Blow out with compressed air to clean. Replace if damaged.
 - c. Securely reinstall breather with thread sealant.

10. Replace all filter elements (1, 14 and 17).
11. Fully close drain valve (18) and remove rubber hose.
12. Fill hydraulic tank to proper full (cold) level on tank sight gauge (3). Use proper hydraulic oil (see Lubrication Guide supplied with crane). Filter oil with 10-micron element as oil is added to tank.
13. Make sure shutoff valves (15 and 16) are fully opened.
14. At engine, check that engine clutch is engaged.
15. Start and run engine at low idle for 10 to 15 minutes to fill all lines with oil and to bleed any air from system.
16. Stop engine and fill hydraulic tank to proper level as indicated on sight gauge.

NOTE: If hydraulic system is extremely dirty (gum or lacquer formation on parts indicated by erratic, jerky, or sluggish operation) repeat [Changing Oil](#) procedure after 48 hours of operation.

Tightening Hydraulic Connections

- Make sure fittings and O-rings being used are proper size and style.
- Flush sealing surfaces with clean hydraulic oil to remove any dirt.
- Carefully inspect threads and sealing surfaces for nicks, gouges, and other damage. Do not use damaged parts; they will leak.
- Carefully inspect O-rings for cuts and other damage. Do not use damaged O-rings; they will leak.
- Always lubricate O-rings when assembling them to fittings.
- Be careful not to cut O-rings when assembling them to fittings. Use thimble as shown in [Figure 2-2](#) when assembling O-ring over threads.

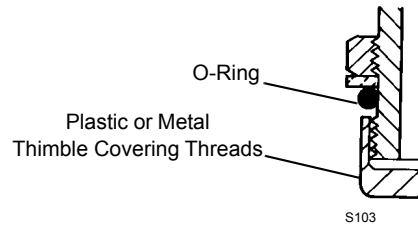


FIGURE 2-2

Pipe Thread Connection

1. Apply sealant (Loctite® 92 or equivalent) to male threads, never to female threads. Do not apply sealant to first two male threads.

CAUTION

Hydraulic System Damage!

Do not use PTFE (Teflon®) tape to seal threads. Pieces of tape will enter hydraulic system and cause damage.

2. Tighten fittings about 4-1/2 turns by hand and then 3 additional turns with a wrench.

Table 2-2. Pipe Thread Leakages

Causes	Cures
Fitting loose.	Tighten.
Fitting too tight causing thread distortion.	Replace damaged parts.
Threads on fitting or in port wrong size.	Use proper size threads.
Threads dirty, galled or nicked.	Clean or replace parts.
Straight thread used instead of tapered thread.	Use proper type and size thread.
Female threads expanded from heat.	Tighten when hot.
Fitting loosened by vibration.	Re-tighten.

SAE Straight Thread Connection

This type connection leaks most often because the jam nut and washer are not backed up before assembly.

When the jam nut and washer are not backed up, there is not enough room for the O-ring when the squeeze takes place and the washer cannot seat properly as shown in [Figure 2-3](#), View A. The compressed rubber between the washer and the spot face will cold flow out of compression, causing the fitting to loosen and leak as shown in [Figure 2-3](#), View B.

Tighten SAE straight thread connections, as follows:

1. Back up jam nut and washer to end of smooth portion on fitting as shown in [Figure 2-4](#), View A.
 2. Lubricate O-ring with clean oil; this is very important.
 3. Thread fitting into port until washer bottoms against spot face as shown in [Figure 2-4](#), View B.
- NOTE:** If an elbow is being used, back it out as necessary to align it with hose.
4. Tighten jam nut. When fitting is properly installed, O-ring will completely fill seal cavity and washer will be tight against spot face as shown in [Figure 2-4](#), View B.

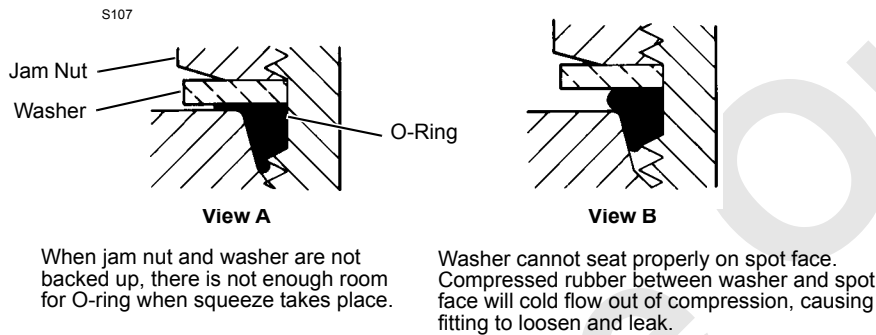


FIGURE 2-3

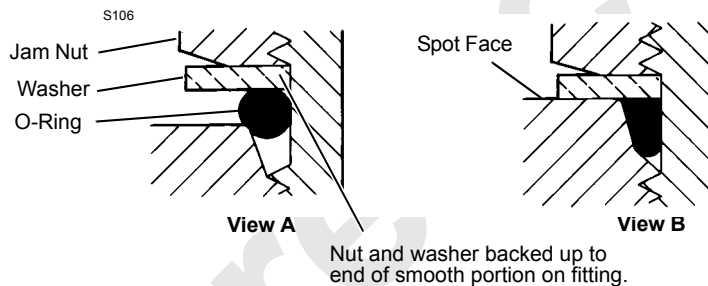


FIGURE 2-4

Table 2-3. Straight Thread Leakage

Causes	Cures
Jam nut and washer not backed up, causing O-ring to be pinched.	Replace O-ring and tighten fitting properly.
O-ring cut.	Replace.
O-ring wrong size.	Replace with proper size.
Sealing surfaces gouged or scratched.	Repair if possible or replace damaged parts.
Sealing surfaces dirty.	Clean and lubricate.

ORS Connection

- Lubricate and install O-ring in adapter groove (Figure 2-5).
- Lubricate threads.
- Tighten nut to torque value given in Table 2-4.

S105

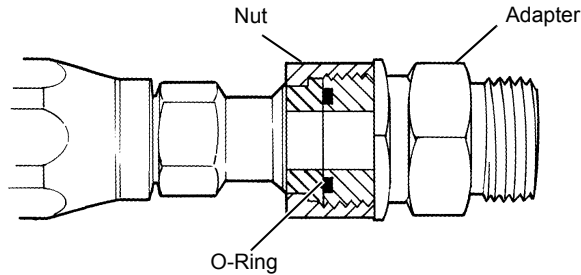


FIGURE 2-5

Table 2-5. ORS Leakage

Causes	Cures
Nut Loose.	Tighten to proper torque.
O-ring cut.	Replace.
O-ring wrong size.	Replace with proper size.
Sealing surfaces gouged or scratched.	Repair if possible or replace damaged parts.
Sealing surfaces dirty.	Clean and lubricate.

Table 2-4. ORS Assembly Torque

Nut Size inch across flats	Fitting Size	Torque	
		In-Lb	N•m
5/8	-04	120 – 145	14 – 16
13/16	-06	203 – 245	23 – 28
15/16	-08	380 – 470	43 – 53
1-1/8	-10	550 – 680	62 – 77
1-3/8	-12	763 – 945	86 – 107
1-5/8	-16	1110 – 1260	125 – 142
1-7/8	-20	1500 – 1680	170 – 190

2

Split Flange Connection

Lubricate and install O-ring in shoulder groove (see [Figure 2-6](#)).

1. Align shoulder with port and assemble flanges over shoulder.
2. Bolts used must be grade-5 or better. Grade-5 bolt has three dashes in head.
3. Snug bolts in a diagonal manner (see [Figure 2-6](#)) to 1/3 of torque given in [Table 2-6](#).
4. Repeat [step 3](#) to 2/3 of final torque. Repeat [step 3](#) to final torque.

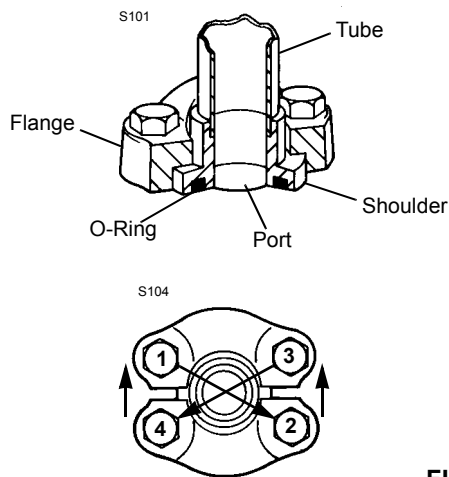


FIGURE 2-6

Table 2-6. Split Flange Assembly Torque

"A" Dimension (inch)	Flange Size	Torque	
		in-lb	N•m
Standard Pressure Series			
1-1/2	-08	175 – 225	20 – 25
1-7/8	-12	225 – 350	25 – 40
2-1/16	-16	325 – 425	37 – 48
2-5/16	-20	425 – 550	48 – 62
2-3/4	-24	550 – 700	62 – 79
3-1/16	-32	650 – 800	73 – 90
High Pressure Series			
1-9/16	-08	175 – 225	20 – 25
2	-12	300 – 400	34 – 45
2-1/4	-16	500 – 600	57 – 68
2-5/8	-20	750 – 900	85 – 102
3-1/8	-24	1400 – 1600	158 – 181
3-13/16	-32	2400 – 2600	271 – 294

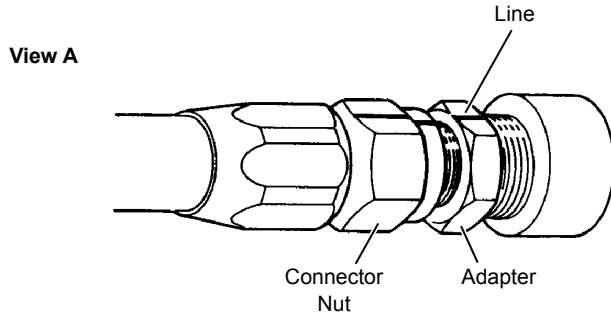
Table 2-7. Split Flange Leakage

Causes	Cures
Flanges not tight.	Tighten bolts evenly to proper torque.
Flanges tightened unevenly causing extrusion of O-ring.	Replace O-rings. Tighten bolts evenly to proper torque.
O-ring cut.	Replace.
O-ring wrong size.	Replace with proper size.
Sealing surfaces not smooth; scratched or gouged.	Repair if possible or replace parts.
Sealing surfaces dirty.	Clean.
Flanges keep getting loose in service.	Use SAE grade 5 bolts or better. Retighten bolts after system is hot.

SAE Flare Connection

1. Tighten nut finger tight until sealing surfaces touch.
2. Mark a line (use felt pen or marker) on adapter and extend it onto connector nut (Figure 2-7, View A).

S108



3. Using wrenches, tighten connector nut the number of flats shown in Table 2-8. (Figure 2-7, View B).
4. Misalignment of marks will show how much nut has been tightened, and that it has been tightened.

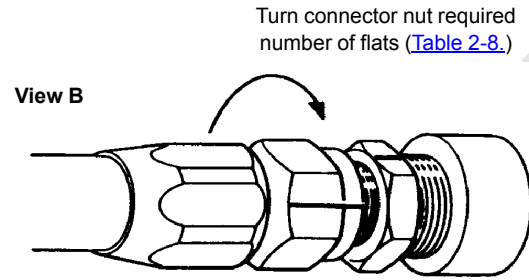


FIGURE 2-7

Table 2-8. SAE 37° Flare Tightening

Connector Nut Size inch across flats	Fitting Size	Adapter Flats to Rotate
9/16	-04	2-1/2
5/8	-05	2-1/2
11/16	-06	2
7/8	-08	2
1	-10	1-1/2 – 2
1-1/4	-12	1
1-1/2	-16	3/4 – 1
2	-20	3/4 – 1
2-1/4	-24	1/2 – 3/4

Table 2-9. SAE 37° Flare Leakage

Causes	Cures
Joint loose.	Tighten properly.
Sealing surfaces dirty.	Clean.
Sealing surfaces not smooth; scratched or gouged.	Replace faulty parts.
Sealing surfaces cracked.	Replace faulty parts.
SAE 45° parts used with SAE 37° parts.	Use only SAE 37° parts.

HYDRAULIC SYSTEM CALIBRATION

To ensure proper operation of the crane functions, the charge pressures, pressure senders, pump control system, and pump pressures must be properly calibrated. Calibration screens are provided to assist in the calibration process.

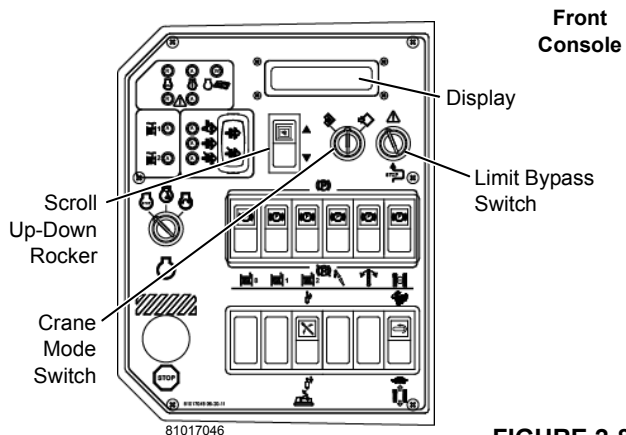


FIGURE 2-8

Accessing Calibration Screens



WARNING

Moving Load Hazard!

With engine running, crane functions (drums, boom hoist, swing, travel) can operate unexpectedly while system components are being calibrated.

To prevent crane functions from moving:

- Turn **park on** for all crane functions.

To access calibration screens, proceed as follows. See [Figure 2-8](#) for location of controls.

1. Select and confirm Setup mode to activate calibration program.
2. Turn limit bypass switch clockwise and hold and scroll up to access diagnostic screens.
3. Scroll up or down to HYD SYSTEM CHECK in display.
4. Turn crane mode switch CLOCKWISE to SELECT position. A cursor (*) will appear next to item being calibrated.
5. Scroll up or down to desired calibration screen.
6. Turn crane mode switch COUNTERCLOCKWISE to CONFIRM position to start calibration of selected item.
7. Once selected item is calibrated, repeat steps 3 – 6 for next item.

8. Once all items are calibrated, turn crane mode switch CLOCKWISE to SELECT position to turn off calibration sequence. Cursor (*) will disappear from screen.

Each calibration item is assigned a number in the binary system (power of two). After running a calibration check, outputs that are **on** (active) for any item, are added together. To identify the active items, find the binary number displayed on the screen in the first column of [Table 2-10](#).

All shaded boxes to the right of the number indicate active items (items that failed calibration). Troubleshoot the particular system to determine the cause of the fault.

If the number displayed on the screen is 0, there are no active items (all items passed calibration).

Calibration Procedures

Pressure Sender

The pressure sender screen ([Figure 2-9](#)) indicates if each system's pressure sender null (0) is within 0.65 – 1.35 volts.

The pressure senders must be calibrated at the following intervals:

- When a new programmable controller is installed
- When a new CPU board is installed
- When a new controller chip is installed
- When a pump is replaced
- When a pump control (EDC or PCP) is replaced
- When a pressure sender is replaced
- When displayed pressure is not correct

Be aware that if there is any residual pressure in the system during the calibration process, the display pressure reading in the cab may not reflect actual system pressure. See Note on [page 2-13](#).

- Every 6 months

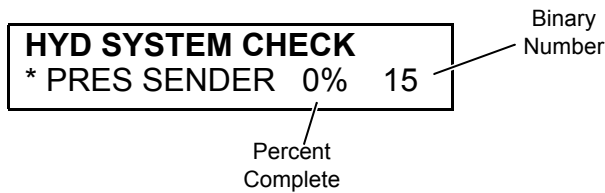
To calibrate the pressure senders, proceed as follows:

1. Stop engine and turn ignition switch to RUN position.
2. Access calibration screen (see [Accessing Calibration Screens](#)).
3. Stop engine (leave ignition and cab power switches on). It is normal for yellow operating limits light to come on during this procedure.

NOTE: Calibration will not start if engine is running or will stop if engine is started during calibration.

4. When calibration starts, percent (%) of completion is displayed on screen.
5. Check binary number in screen when calibration is done:

- a. If 0 appears, all items have passed.
- b. If any number other than 0 appears, use [Table 2-10](#) to determine which items have failed.



Binary Number	Calibration Item	Binary Number	Calibration Item
1	Front Drum	16	Swing Left
2	Rear Drum	32	Travel Right
4	Boom Hoist	64	Travel Left
8	Swing Right	128	Accessory System

FIGURE 2-9

NOTE: The cause of a failed calibration or faulty display pressure reading in the cab may not be the pressure sender. The cause of the fault could be trapped air or hydraulic pressure in the system.

Before replacing a pressure sender, do the following:

- Perform pressure sender calibration steps.
- Attach an accurate hydraulic pressure gauge to the quick-coupler at the suspect pressure transducer.
- If pressure appears on the gauge, bleed the corresponding system so the gauge reads zero pressure.
- Repeat calibration steps and check pressure on the display in the cab with the engine running at idle — the display reading and the gauge reading should be the same.
- Before replacing a pressure sender, check the signal voltage at the sender. It should be 1.0 volt against ground at 0 psi.

Charge Pressure

The charge pressure screen ([Figure 2-10](#)) indicates if each system’s charge pressure is within 275 – 400 psi (19 – 27 bar), as monitored by the computer.

Charge pressure should be checked at the following intervals:

- When a new programmable controller is installed
- When a new CPU board is installed
- When a new controller chip is installed
- When a pump is replaced
- When a pump control (EDC or PCP) is replaced
- Every 6 months

To check charge pressure, proceed as follows:

1. Start engine and run at **low idle**.
2. Access calibration screen (see [Accessing Calibration Screens](#)).
3. Screen indicates state of charge pressure:
 - a. If 0 appears, charge pressure is okay for all items.
 - b. If any number other than 0 appears, use [Table 2-10](#) to determine which items are not within specified charge pressure.



Binary Number	Calibration Item	Binary Number	Calibration Item
1	Front Drum	16	Swing Left ¹
2	Rear Drum	32	Travel Right
4	Boom Hoist	64	Travel Left
8	Swing Right	128	Accessory System

¹ Same Pump as Swing Right

FIGURE 2-10

Control System

The control system calibration screen (Figure 2-11) indicates whether the pump center is within the allowable range for each pump’s Electric Displacement Control (EDC). The allowable range is 5 – 25% pump command signal for hoist pumps, and 2.5 – 20% in each direction for swing.

Control system calibration must be performed at the following intervals:

- When a new programmable controller is installed
- When a new CPU board is installed
- When a new controller chip is installed
- When a pump is replaced
- When a pump control (EDC or PCP) is replaced
- When there is a noticeable time increase to engage a crane function when handle is moved from off
- Every 6 months

To check control system calibration, proceed as follows:

1. Access calibration screen (see [Accessing Calibration Screens](#)).
2. Turn PARK ON for all crane functions (drums, boom hoist, swing, travel).
3. Start engine and run at **high idle**. It is normal for yellow operating limits light to come on during this procedure.

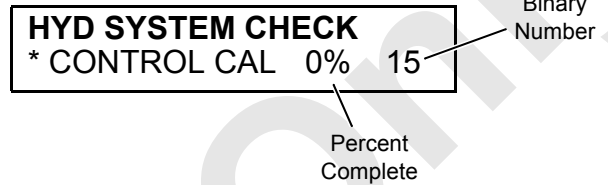
Calibration will not start if engine is not running at high idle. Calibration will stop if engine speed is decreased during calibration.

4. When calibration starts, percent (%) of completion is displayed on screen.

NOTE: It takes approximately 2 minutes to complete check.

5. Check binary number in screen when calibration is done:

- If 0 appears, all items have passed.
- If any number other than 0 appears, use [Table 2-10](#) to determine which items have failed.



Binary Number	Calibration Item
1	Swing Right
2	Swing Left ¹
4	Front Drum
8	Rear Drum
16	Boom Hoist
32	Auxiliary Drum (in butt)
¹ Same Pump as Swing Right	

FIGURE 2-11

Pump Pressure

The pump pressure screen ([Figure 2-12](#)) cycles through the hoist pumps to make sure each pump is capable of producing 6,000 psi (414 bar).

CAUTION: Only perform this high pressure test when absolutely necessary and by a qualified service technician.



WARNING
High Pressure Hazard!

This test generates maximum pressure in the main hydraulic circuits. Defective brakes may allow unintended motion during test. Move the crane to an area where such motion is not a hazard.

Use a signal person to monitor functions operator cannot see.

Be prepared to stop engine if unintended motion occurs.

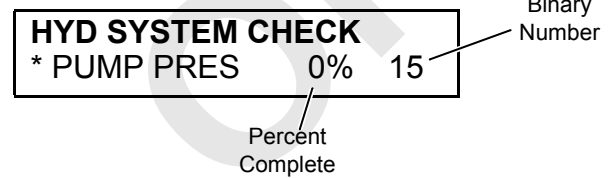
To check pump pressure calibration, proceed as follows:

1. Access calibration screen (see [Accessing Calibration Screens](#)).
2. Turn PARK ON for all crane functions (drums, boom hoist, swing, travel).
3. Start engine and run at:
 - HIGH IDLE, *field personnel*.
 - 1,500 rpm, *MCC assembly personnel* when checking out a new crane.

Testing will not start if engine is not running faster than 900 rpm.

NOTE: Pump pressure test will not start if engine is not running. Testing will stop if engine speed is decreased during procedure.

4. When testing starts, the percent (%) of completion is displayed on screen.
5. Check binary number in screen when calibration is done:
 - a. If 0 appears, all items have passed.
 - b. If any number other than 0 appears, use [Table 2-10](#) to determine which items have failed.



Binary Number	Calibration Item
1	Front Drum
2	Rear Drum
4	Boom Hoist
8	Auxiliary Drum
16	Travel Right
32	Travel Left

FIGURE 2-12

Table 2-10. Binary System

	1	2	4	8	16	32	64	128
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Table 2-10. Binary System (continued)

	1	2	4	8	16	32	64	128
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	1	2	4	8	16	32	64	128
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PRESSURE SENDER REPLACEMENT



WARNING

High Pressure Oil Hazard!

Do not attempt to remove a pressure sender unless following steps are performed. High pressure oil will exhaust from pressure sender port.

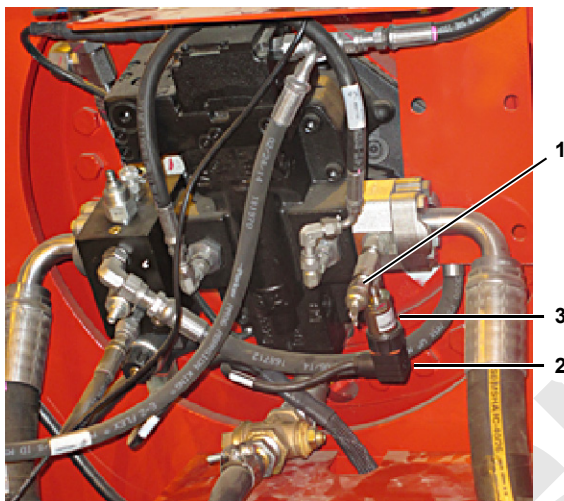
See [Figure 2-13](#) for identification of the pressure senders.

1. Lower all loads to ground.
2. Move all control handles to off and park all crane functions.

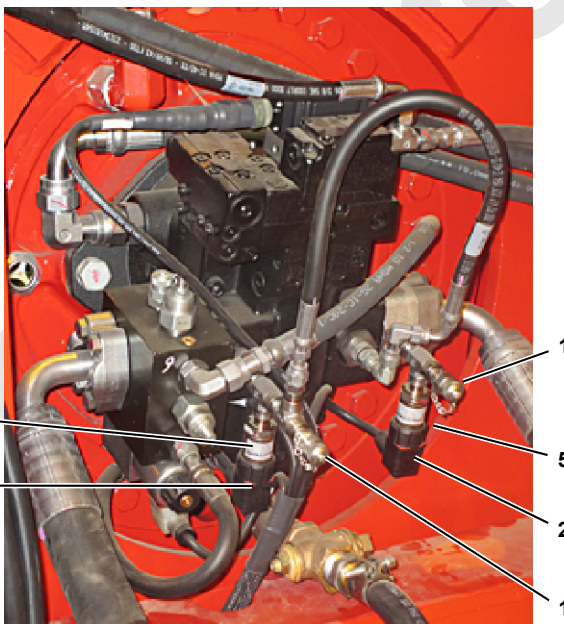
3. **Stop engine.**
4. Place a suitable container under pressure sender to catch oil leakage.
5. Disconnect electric plug from pressure sender.
6. **Slowly loosen** pressure sender only enough to allow any remaining pressure to exhaust.
7. Remove pressure sender.
8. Install new pressure sender and connect electric plug.

NOTE: Pressure senders have pipe threads. Be sure to install thread sealant.

9. Calibrate pressure senders (see [Hydraulic System Calibration](#) in this Section).



M102002

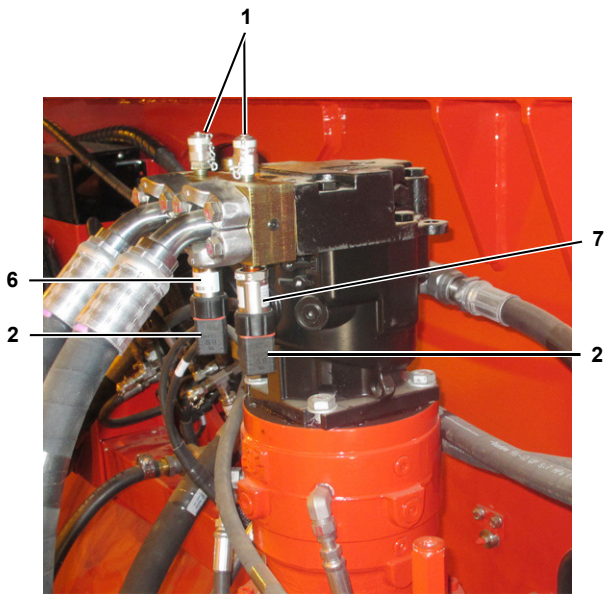


M102001

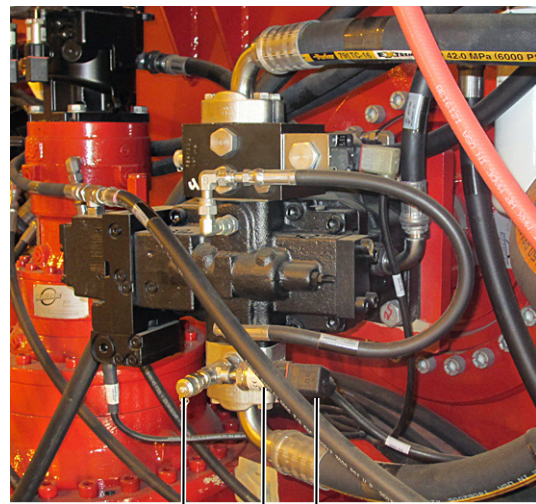
Item	Description
1	Gauge Coupler (typical)
2	Electric Plug (typical)
3	Front Drum Raising Pressure Sender
4	Rear Drum Lowering and Accessory System Pressure Sender
5	Rear Drum Raising Pressure Sender
6	Swing Right Pressure Sender
7	Swing Left Pressure Sender
8	Boom Hoist Raising Pressure Sender
9	Left Crawler Traveling Pressure Sender
10	Right Crawler Traveling Pressure Sender
11	Auxiliary Drum Raising Pressure Sender

Figure Continued on Next Page

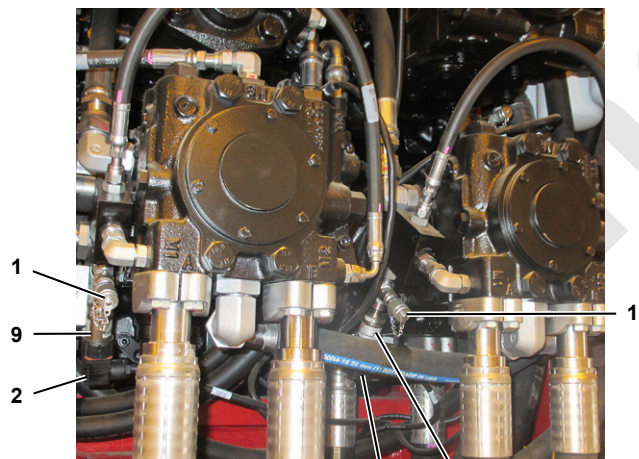
FIGURE 2-13



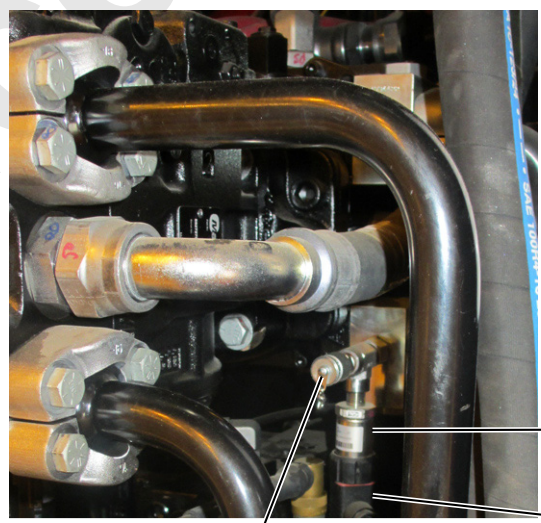
M102003



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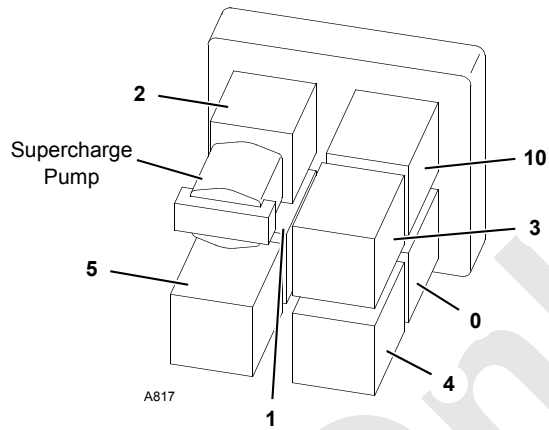


M102006

FIGURE 2-13 continued

Pump Identification

Item	Description
0	Front Load Drum
1	Rear Load Drum or Luffing Hoist
2	Boom Hoist
3	Swing
4	Right Crawler
5	Left Crawler
10	Auxiliary Load Drum



Pump Components

Item	Description
1	EDC (Electronic Displacement Control)
2	Manual Override Control
3	Case Drain Port (Note 1)
4	Charge Pressure Relief Valve
5	Filter Adapter (Note 2)
6	Multi-Function Valve (Note 3)
7	Charge Pressure Gauge Port
8	Charge Pump Inlet Port
9	Pump Port B
10	Pump Port B Gauge Port
11	Pump Port A
12	Pump Port A Gauge Port
13	Neutral Adjusting Screw

- NOTE 1** Both Sides of Pump
- NOTE 2** Auxiliary Drum Pump Only
- NOTE 3** Valve is Directly Opposite Port it Protects.

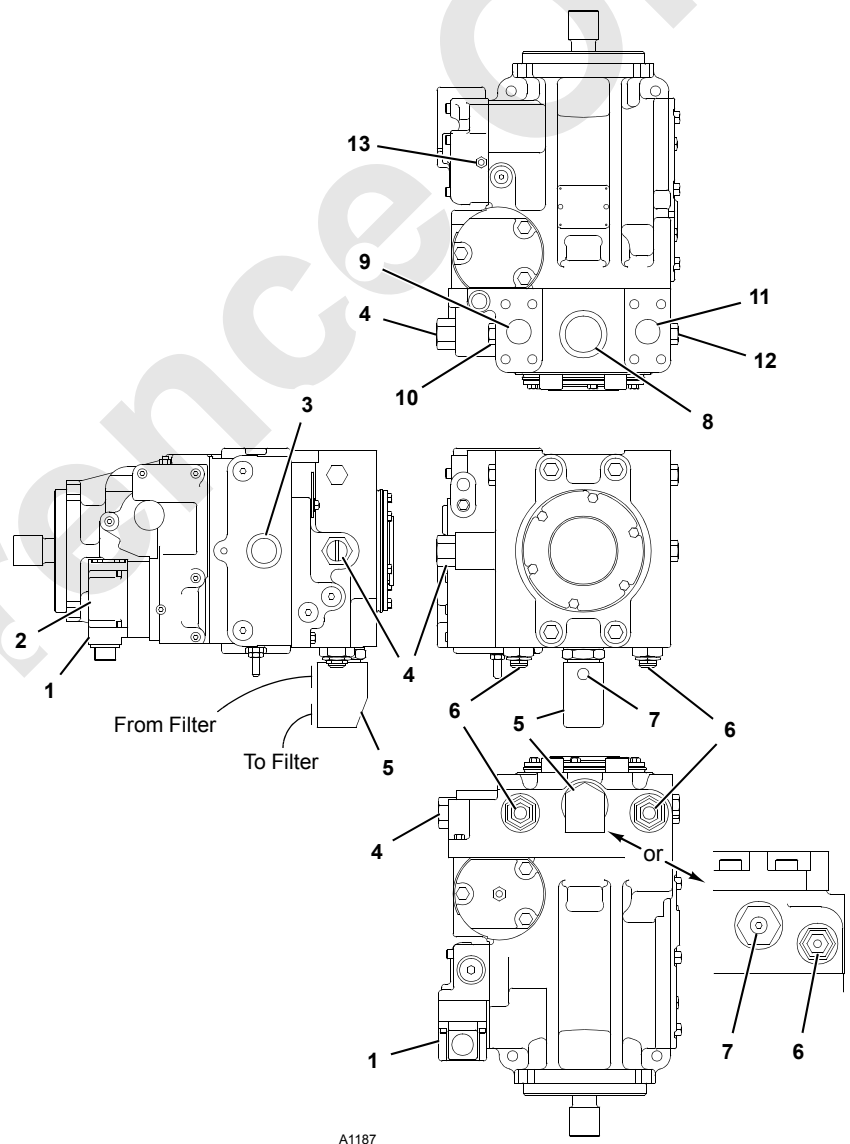


FIGURE 2-14

Pump and Motor Port Identification

System	Oil Flow From Pump Ports		Oil Flow to Motor Ports	
	A	B	A	B
Front Load Drum	Raise	Lower	Raise	Lower
Rear load Drum	Raise	Lower	Raise	Lower
Boom Hoist	Raise	Lower	Lower	Raise
Swing	Right	Left	Right	Left
Left Crawler	Forward	Reverse	Forward	Reverse
Right Crawler	Forward	Reverse	Reverse	Forward
Auxiliary Load Drum	Raise	Lower	Raise	Lower

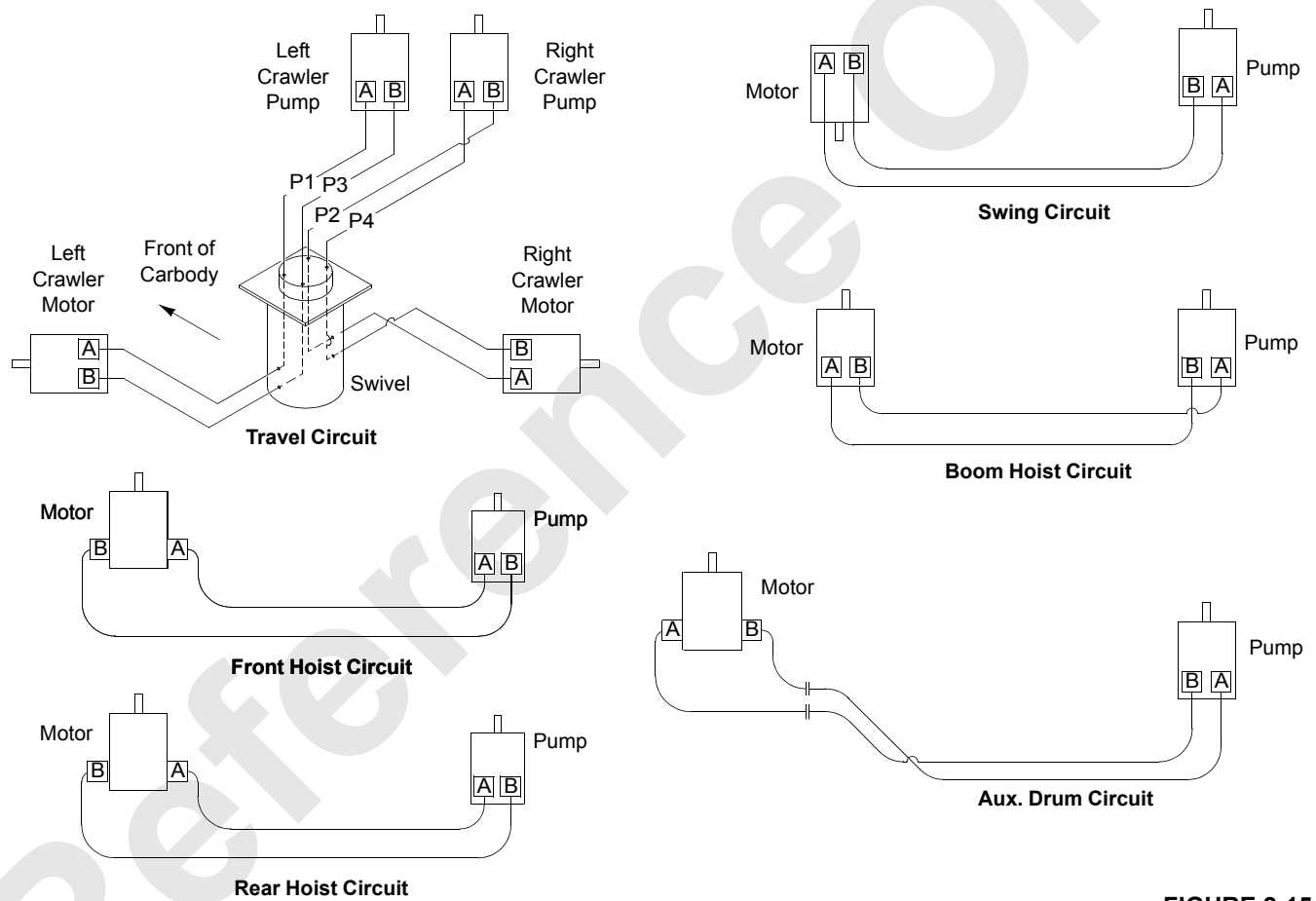


FIGURE 2-15

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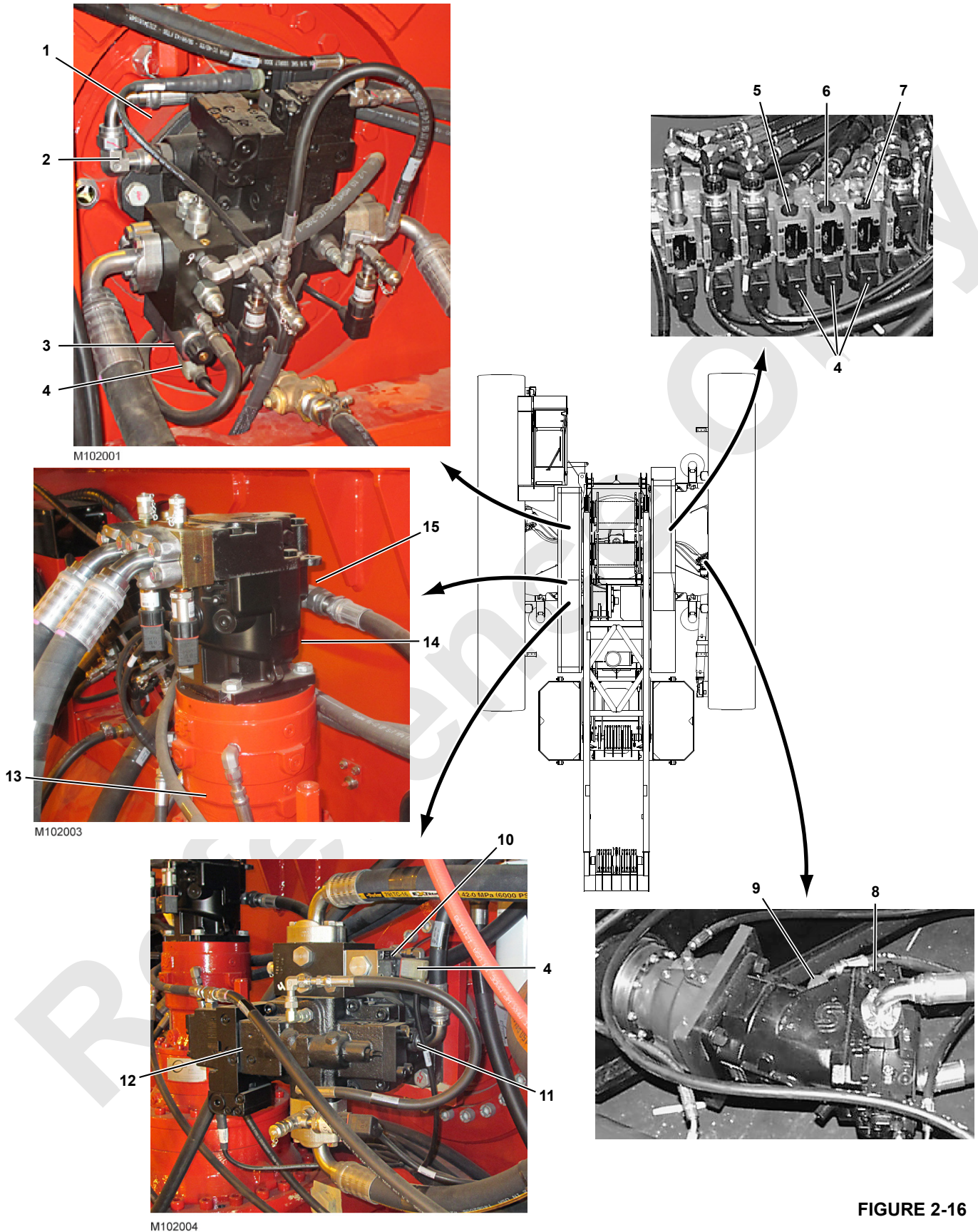


FIGURE 2-16

Legend for [Figure 2-16](#)

Item	Description
1	Load Drum Disc Brake (inside gearbox) (typical front and rear drums)
2	Load Drum Motor Case Drain Port (typical front and rear drums)
3	Load Drum Brake Solenoid Valve
4	Solenoid Valve Electrical Plug (typical front and rear drums)
5	Swing Brake Solenoid Valve
6	Travel 2-Speed Solenoid Valve
7	Travel Brake Solenoid Valve (controls both travel brakes)
8	Travel Motor (2 places)
9	Travel Motor Case Drain Port (typical both travel motors)
10	Boom Hoist Brake Solenoid Valve
11	Boom Hoist Motor Case Drain Port
12	Boom Hoist Motor
13	Swing Brake
14	Swing Motor
15	Swing Motor Case Drain Port

DISC BRAKE OPERATIONAL TEST

There is no physical way to check the disc brakes for travel, boom hoist, front and rear drums, and swing; therefore, an operational test of each brake must be performed weekly. [Figure 2-16](#) shows brake and brake solenoid valve locations.

Operational Test

NOTE: For all pumps except swing, system pressure is preset at 6,000 psi (414 bar). For swing pump, system pressure is preset at 5,000 psi (345 bar).

Electrical plugs at brake solenoid valves must be disconnected to stall crane functions during tests.

1. Start engine and allow it to idle at 1,000 rpm.
2. Select and confirm Standard mode.

NOTE: For either load drum, make sure crane is in full power mode (free fall **off**). The disc brake will remain applied.

3. Disconnect electrical plug for brake being checked.
4. Scroll to corresponding diagnostics screen for brake being checked. Monitor “pump pressure” and “pump command” while moving control handles.
5. For all functions, move control handle in both directions, one at a time, to check brake operation in both directions.

CAUTION

Overheat Hazard!

Do not hold any function on stall for more than 5 seconds. Damage to system components may occur.

6. Slowly move handle for function being checked. Specified system pressure must be reached before 50% pump command is reached and **brake must not slip**.



WARNING

Falling Load/Moving Crane Hazard!

If any disc brake slips when operational test is performed, repair or replace corresponding brake before placing crane back into service. Loads could fall or crane could move if brakes are not operating properly.

For load drums with a disc brake on both ends of drum, repair or replace both disc brakes.

See planetary manufacturer’s manual for disc brake repair instructions.

7. Reconnect electrical plugs at all brake solenoid valves at completion of operational test.

If disc brakes were repaired or replaced, retest brakes before operating with a load.

SHOP PROCEDURES

This topic covers initial oil fill and hydraulic adjustments for the hydraulic system and related components on the crane. (See Figures [2-14](#) and [2-15](#).)

Experienced technicians, trained in the operation of this crane and its hydraulic system, shall perform the shop procedures. These technicians shall read, understand, and comply with the instructions in this section.

Contact the Manitowoc Crane Care Lattice Team for a detailed explanation of any procedure not fully understood.

All adjustments identified in this section were made to the crane before it was shipped from the factory. Adjustments by field personnel are required only when parts are replaced or when instructed by the Manitowoc Crane Care Lattice Team.

Comply with the pressure and flow settings specified in this section. Altering settings without the approval of the Manitowoc Crane Care Lattice Team can damage crane components or cause the crane to operate improperly. Correct procedures for connecting hydraulic fittings are in the [Hydraulic System Maintenance](#) topic in this Section.

Initial Oil Fill

1. Check that hydraulic oil flow between auxiliary drum pump and auxiliary drum filter is correct as shown in [Figure 2-17](#).

CAUTION

Equipment Damage!

Filters and fittings incorrectly installed will damage pumps and motors.

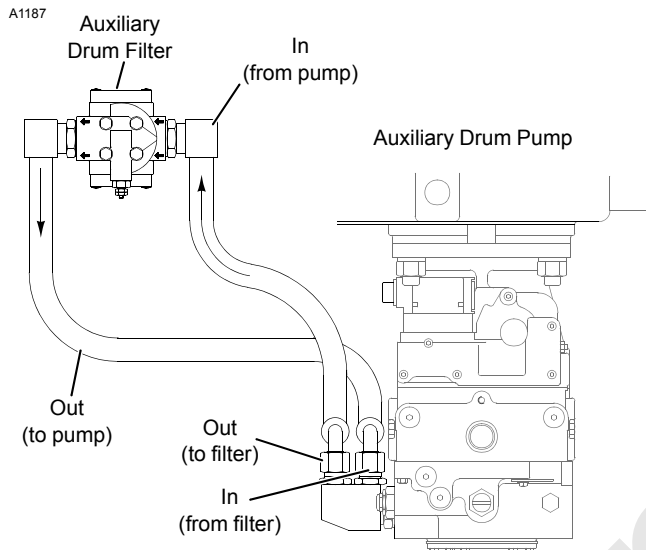
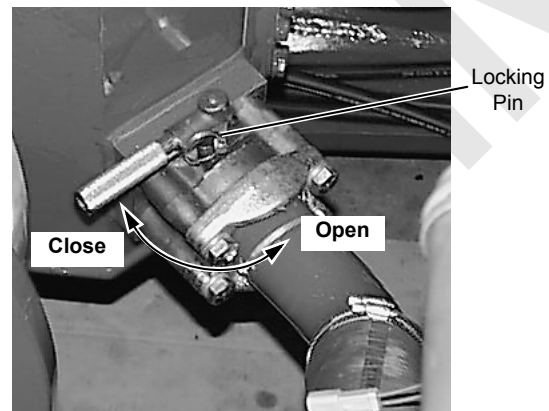


FIGURE 2-17

2. Fill all motor cases with oil ([Figure 2-16](#)).
 - a. Disconnect fittings at case drain ports.
 - b. Fill each motor case to level of case drain port. **Use new hydraulic oil which has been filtered through a 10-micron filter.**
 - c. Reconnect fittings.
3. Make sure hydraulic tank shut-off valve is fully open ([Figure 2-18](#)).
4. At engine, check that engine clutch is engaged ([Figure 2-19](#)).
5. Open charge filter shut-off valve ([Figure 2-20](#)).

6. Remove bleed cap from outlet fitting of auxiliary drum filter ([Figure 2-20](#)).
7. Remove bleed plug from top of tee in suction tube ([Figure 2-20](#)).
8. Remove pressure gauge fitting from top of charge filter manifold ([Figure 2-20](#)).

Hydraulic Tank Shut-Off Valve
(accessible from under rear of rotating bed)



P1074a

FIGURE 2-18

Engine Disconnect Lever
(above pumps in left rear enclosure)

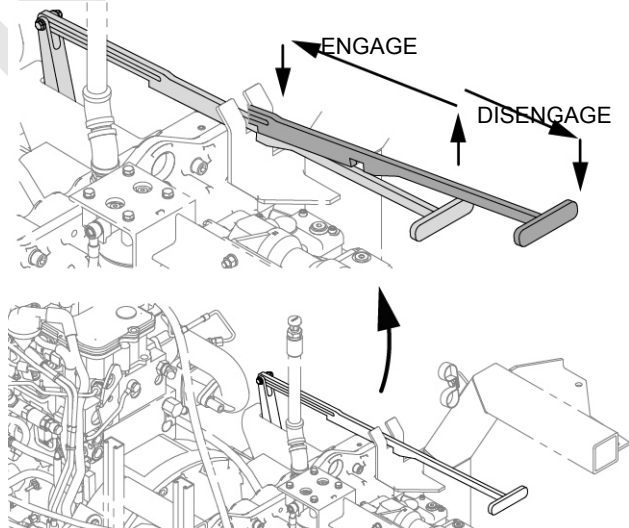


FIGURE 2-19

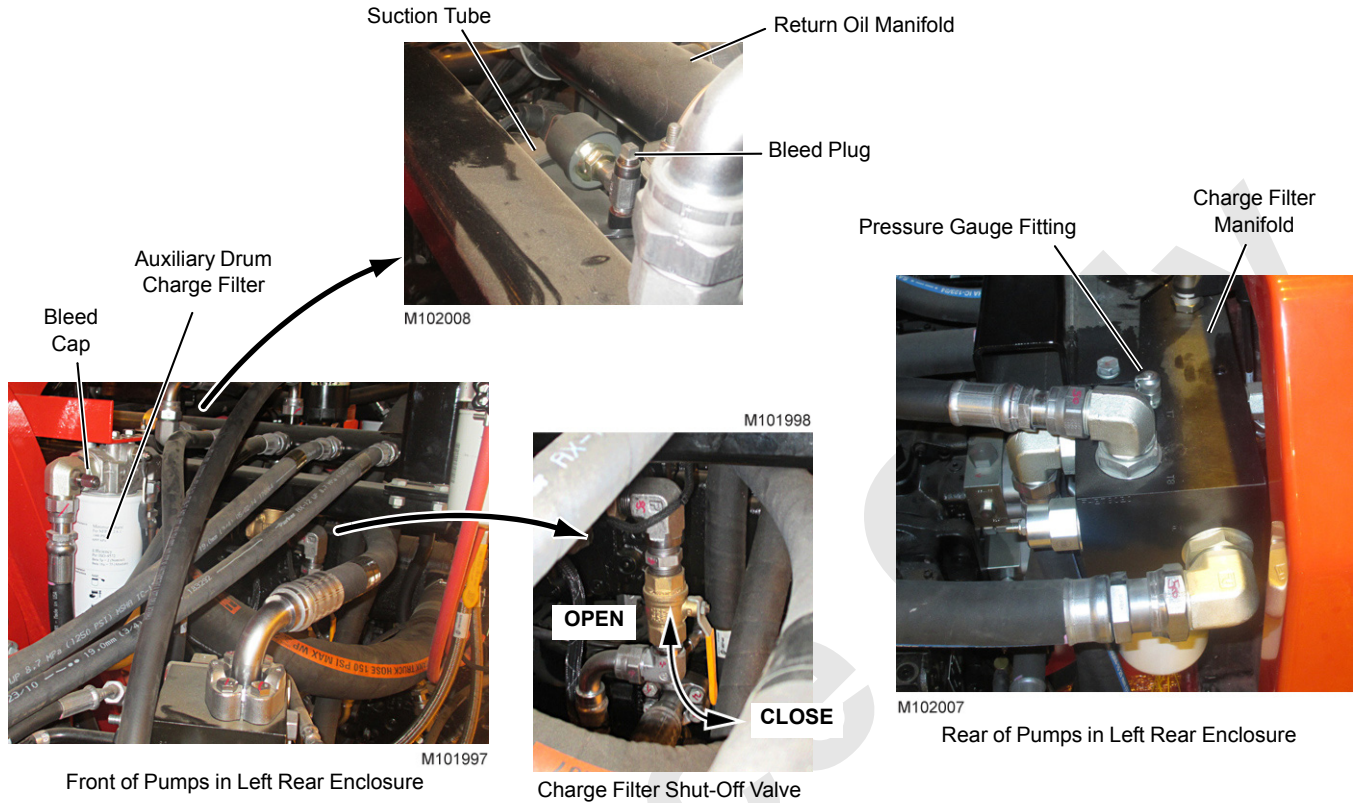


FIGURE 2-20

9. Fill hydraulic tank to FULL HOT level mark on sight gauge (Figure 2-21).
10. Bleed hydraulic tank sight gauge hose:
 - a. Disconnect hose at bottom of gauge.
 - b. Allow hose to hang straight down into a container.
 - c. Allow oil to flow freely from hose until oil is clear (no air bubbles in oil).
 - d. Reconnect hose to gauge.
11. As tank is filling, monitor bleed port on top of suction tube (Figure 2-20). When clear oil appears, install plug using Loctite sealant with Teflon.
12. Monitor pressure gauge port on top of charge filter manifold (Figure 2-20). Oil will flow by gravity from hydraulic tank to filter manifold. Install pressure gauge fitting when clear oil appears.
13. Check for oil at auxiliary drum charge filter. Observe open bleed port at outlet fitting while cranking engine momentarily — **do not start engine**. Continue to bump engine starter until oil appears at bleed port. Install bleed port fitting cap.

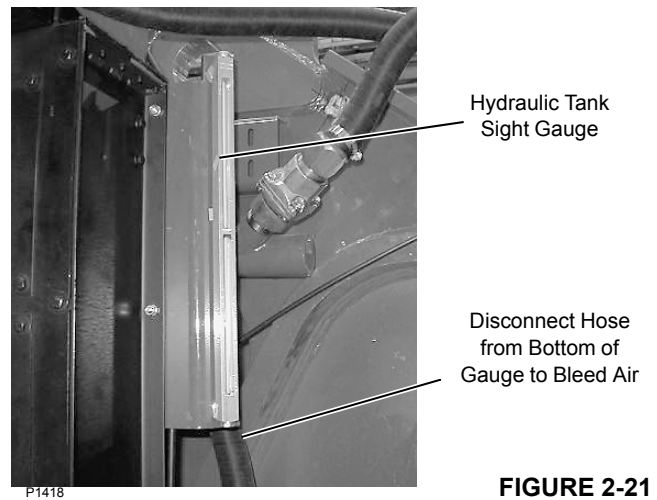


FIGURE 2-21

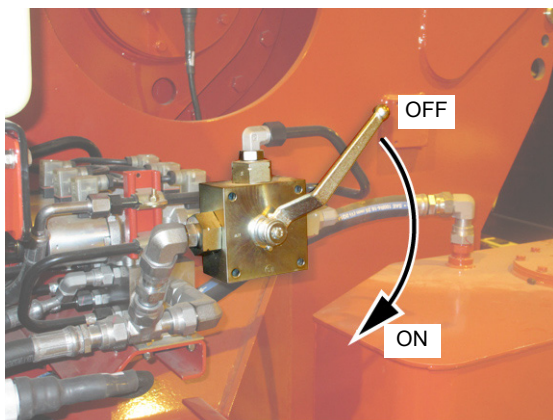
Accessory System Checks and Adjustments

High Pressure Accessory Systems

The high-pressure side of the rear drum system is the source for upper and lower accessory systems. The high-pressure upper accessory system includes mast assist cylinders, gantry cylinders, and boom pin pusher cylinder. The high-pressure lower accessory system includes crawler pin pusher cylinders and carbody jack cylinders.

For mast, gantry, and boom pin cylinders select and confirm Setup mode.

1. Mast cylinders:
 - a. Mast bypass valve ([Figure 2-22](#)) must be turned to **on** position during crane assembly and disassembly.
 - b. Press top and bottom of mast control to **raise** and **lower** mast cylinders several times to remove air from system.
 - c. Scroll to accessory screen on diagnostic display to verify that 3,000 psi (207 bar) is present when cylinders are extended.
 - d. Mast bypass valve ([Figure 2-22](#)) must be turned to **off** position during normal crane operation.



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View in Right Side Enclosure

FIGURE 2-22

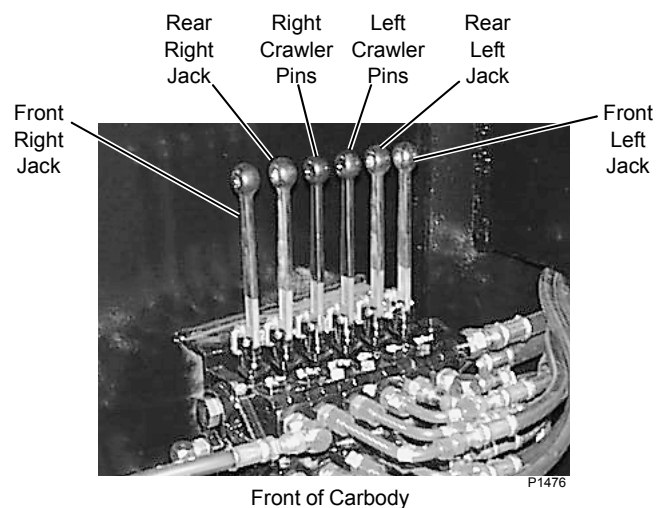
CAUTION

Damage to Gantry!

When raising gantry for first time or after maintenance of gantry cylinder, raise gantry slowly and check that both cylinders are raising gantry evenly. Gantry could twist if one cylinder is not working correctly.

2. Gantry cylinders:
 - a. Access setup remote control in left side enclosure.

- b. Use gantry toggle to **raise** and **lower** gantry several times to remove air from system.
 - c. Scroll to accessory screen on diagnostic display to verify that 3,000 psi (241 bar) is present when gantry is extended.
3. Boom pin pusher cylinder:
 - a. Access setup remote control in left side enclosure.
 - b. Use boom hinge pins switch on remote control to **engage** and **disengage** cylinders several times to remove air from system.
 - c. Verify that 3,000 psi (241 bar) is present when cylinder is extended.
4. Crawler pin pusher cylinder:
 - a. With handle on lower accessory valve, **engage** and **disengage** both crawler pin pusher cylinders several times to remove air from system.
 - b. Verify that 3,000 psi (241 bar) is present when cylinder is extended.
5. Carbody valves ([Figure 2-23](#)):
 - a. With handle on lower accessory valve, fully **retract** the carbody jacks if they are not already retracted.
 - b. Extend carbody jacks to full **extend** position.
 - c. Verify that 3,000 psi (241 bar) is present when each jack is extended.
 - d. When retracting jacks, the carbody must lower slowly and smoothly.



Front of Carbody

P1476

FIGURE 2-23

Low Pressure Accessory Manifold

The rear drum charge pump is the low-pressure source for the accessory manifold, at a pressure of 350 psi (24 bar). The low-pressure system includes drum pawls,

counterweight pins, swing lock, swing brake, travel brakes, and travel 2-speed. Reconnect all electrical connections (DIN plugs) that were disconnected for hydraulic system checks.

1. Drum pawls:
 - a. Place each drum park switch in on – park and off – park positions.
 - b. Observe that each drum pawl engages and disengages correctly.
2. Counterweight pins:
 - a. Access setup remote control in left side enclosure.
 - b. Use counterweight pins switch on remote control to **engage** and **disengage** cylinders several times to remove air from system.
3. Swing brake and swing lock:
 - a. Scroll to swing diagnostic screen.
 - b. With swing park brake and swing lock **off**, attempt to swing the crane by moving control handle in both directions.
 - c. Crane must respond and indicate on swing screen that swing park brake and swing lock are released.
4. Travel brakes:
 - a. Scroll to travel diagnostic screen.
 - b. With travel park brake **off**, attempt to travel the crane by moving control handles in both directions.
 - c. Crane must respond and indicate on travel screen that travel park brake is released.
 - d. Travel 2-speed is checked in test area when travel speed is checked.

Travel Handle and Speed Check

Verify that travel movement responds correctly to handle commands. You must count number of revolutions crawler rotates in one minute to determine travel speed.

NOTE: Final evaluation of travel system is completed in test area.

1. Put a timing mark on either front roller ([Figure 2-24](#)).
2. Start engine and set speed at **high idle**.
3. Push both crawler control handles fully forward to travel crane **forward** at full speed.

4. Have an assistant count number of revolutions timing mark makes.
5. Number should be 8-1/2 – 9 revolutions in one minute (tumbler or idler) or as indicated on Final Checkout/ Assembly and Test form.
6. If count does not fall within this range, **determine cause of problem and take corrective action**.

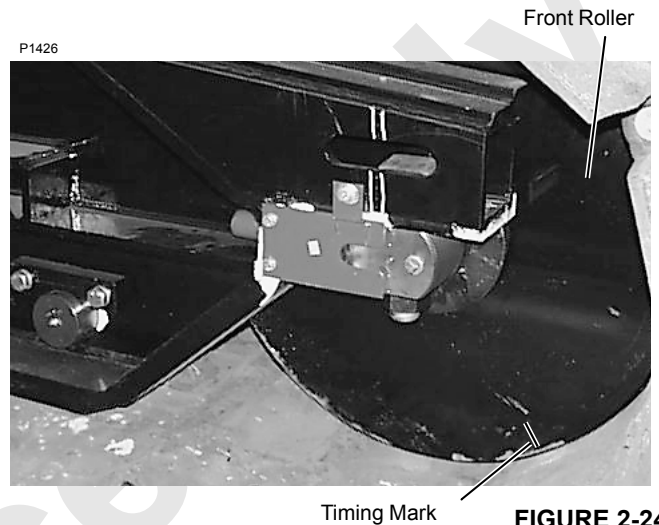


FIGURE 2-24

Operating Drum Speed Checks

Check operating speeds for functions listed below with engine running at high idle and control handles moved fully forward and back. Read speeds on digital display screen.

If proper speeds are not indicated, **determine cause of problem and take corrective action**.

Item	Speed Up (rpm)	Speed Down (rpm)
Boom Hoist	39 – 43	34 – 41
Front Drum	43 – 48	38 – 46
Front Drum (high line speed)	68 – 75	60 – 71
Rear Drum	43 – 48	38 – 46
Rear Drum (high line speed)	68 – 75	60 – 71
Auxiliary Drum	64 – 71	57 – 67

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SECTION 3 ELECTRIC SYSTEM

INSPECT ELECTRICAL COMPONENTS



DANGER

Electric Shock Hazard

Ensure that the battery cables are disconnected from the batteries before loosing any electrical connections.

Every Month or 200 Hours

1. Visually inspect all electrical harnesses and cables every month or at 200 hours of service life for the following:
 - Damaged, cut, or deteriorated harness loom covering
 - Damaged, cut, or abraded individual wires or cable insulation
 - Exposed bare copper conductors
 - Kinked, crushed, flattened harnesses or cables
 - Blistered, soft, degraded wires and cables
 - Cracked, damaged, or badly corroded battery terminal connections
 - Inspect all machine ground connections for damaged terminals or excessive corrosion
 - Other signs of significant deterioration

If any of these conditions exist, evaluate the harness for repair or replacement.
2. At the same service interval, visually inspect all Controller Area Network (CAN) nodes and electrical junction boxes for the following:
 - Damaged or loose connectors
 - Damaged or missing electrical clamps or tie straps

- Excessive corrosion or dirt on the junction boxes
- Loose junction box mounting hardware

If any of these conditions exist, address them appropriately.

Degradation Due to Severe Environment

Table 3-1 Climate Zone Classification

Zone	Description
A	Tropical Moist: All months average above 66°F (18°C). Latitude: 15° - 25° N & S
B	Dry or Arid: Deficient precipitation most of the year. Latitude: 20° - 35° N & S
C	Moist Mid-Latitude: Temperate with mild winters. Latitude: 30° - 50° N & S
D	Moist Mid-Latitude: Cold winters. Latitude 50° - 70° N & S
E	Polar: Extremely cold winters and summers. Latitude: 60° - 75° N & S

Zone A and B

Replace harnesses and battery cables operating in climate **zone A and B** after 8,000 hours of service life. Their electrical service life is reduced by 25% to 40%.

Zone C

Replace harnesses and battery cables operating in climate **zone C** after 10,000 hours of service life.

Zone D and E

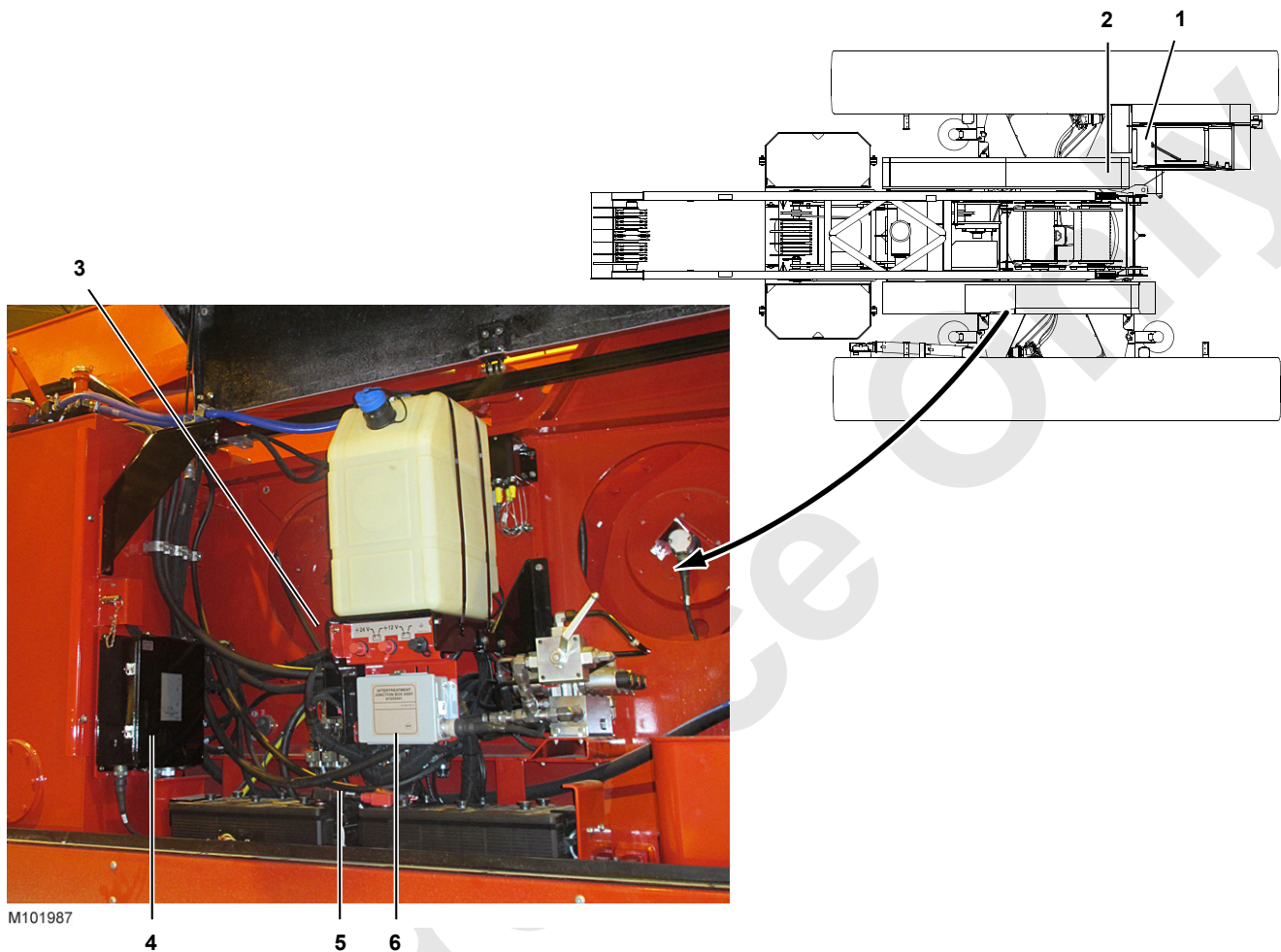
Inspect electrical harnesses and cable assemblies per Step 1. Cold temperatures will negatively impact service life.

Salt Environment

Harness and cable assemblies operating in salt water climates could see a significant reduction in service life. Regularly inspect electrical harnesses and cable assemblies per Step 1.

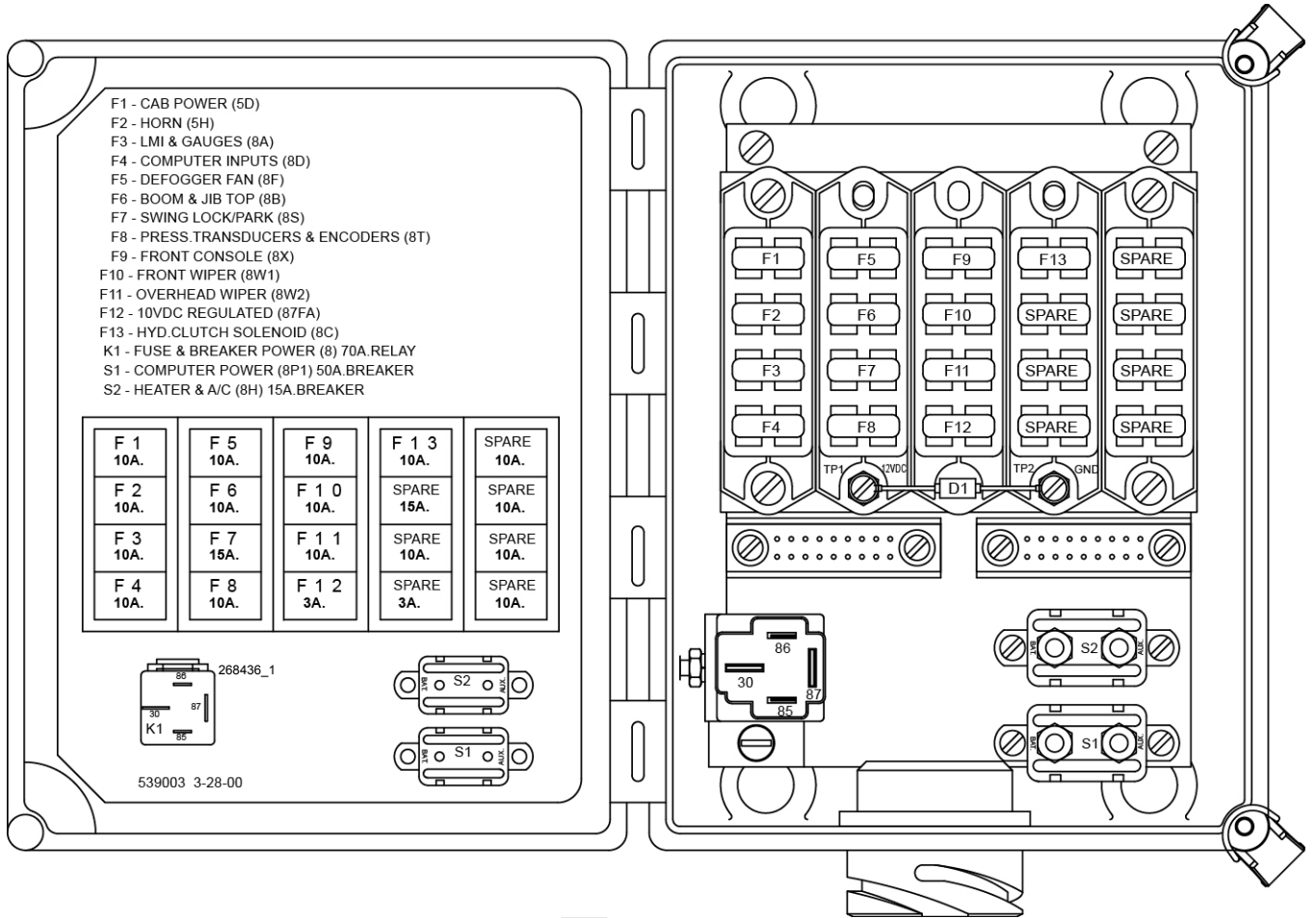
CIRCUIT BREAKER AND FUSE ID

Refer to [Figure 3-1](#) for the location and identification of the fuses and circuit breakers on this crane.



Item	Description	See
1	Fuse Junction Box in Operator's Cab	page 3-3
2	Cold Weather Circuit Breaker Load Center	page 3-4
3	Battery and Alternator Fuses	page 3-4
4	Engine Node	page 3-5
5	CraneStar TCU Fuses	page 3-6
6	Exhaust Aftertreatment Junction Box	page 3-6

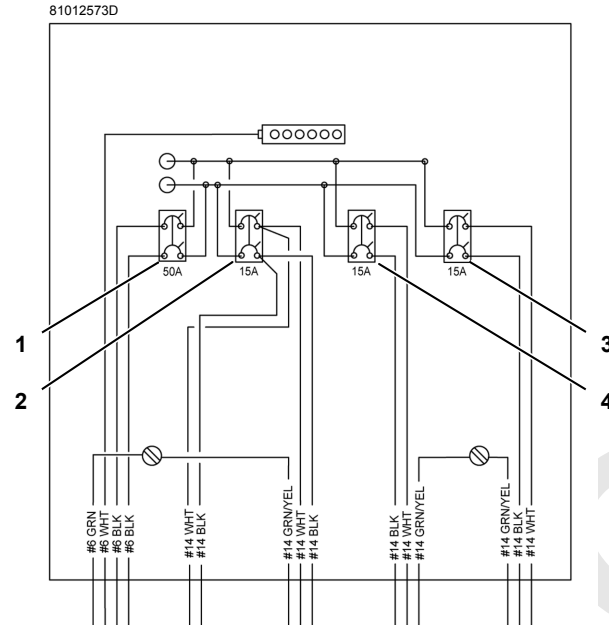
FIGURE 3-1



Fuse Junction Box in Operator's Cab

Fuse or Relay	Amps	Wire No.	Description of Items Protected
D1			Transient Suppressor Diode
F1	10	5D	Cab Power
F2	10	5H	Horn
F3	10	8A	LMI & Gauges
F4	10	8D	Computer Inputs
F5	10	8F	Defogger Fan
F6	10	8B	Boom & Jib Top
F7	15	8S	Swing Lock / Park
F8	10	8T	Pressure Transducers & Encoders
F9	10	8X	Front Console
F10	10	8W1	Front Wiper
F11	10	8W2	Overhead Wiper
F12	3	87FA	10VDC Regulated
F13	10	8C	Hydraulic Clutch Solenoid
K1	70	8	Fuse & Breaker Power (Relay)
S1	50	8P	Computer Power (CB7)
S2	15	8H	Heater & Air Conditioner (CB6)

FIGURE 3-2



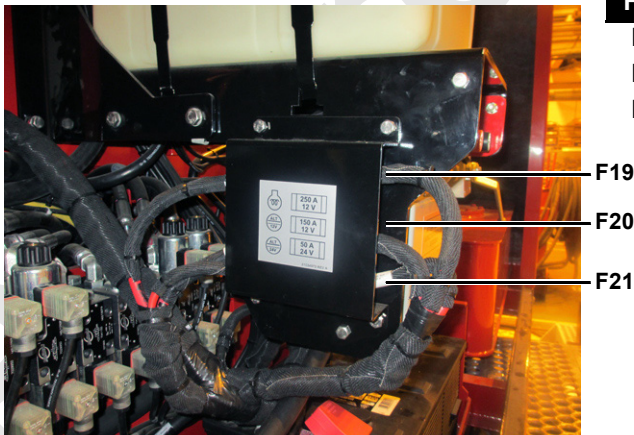
Cold Weather Circuit Breaker Load Center

Circuit Breaker	Amps	Description of Items Protected
1	50	Main Load Center Circuit Breaker
2	15	Hydraulic Reservoir Heaters (2), Cab Console Heater
3	15	Engine Coolant Heater, Engine Oil Heater
4	15	Battery Pad Heaters (2)

FIGURE 3-3

Battery and Alternator Fuses

Fuse	Amps	Description of Item Protected
F19	250	Air Intake Heater
F20	150	Alternator 12V
F21	50	Alternator 24V



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FIGURE 3-4

Engine Node

Item	Amps	Wire No.	Description of Item	Item	Amps	Wire No.	Description of Item
Circuit Breakers				Relays			
CB-1	120	5	Main System	ECM	—		ECM Power
CB-2	8	5C3	Engine ECM	AL1	—		Auto Lube 1
CB-3	10	5C2	Engine Diagnostics	AL2	—		Auto Lube 2
CB-4	30	5C1	Engine ECM	AL3	—		Auto Lube 3
CB-5	15	6A3	CAN Bus Power	CAN PWR	—		CANBUS Power
CB-6	15	6A4	Auto Lube and Engine Start	AC CLUTCH	—		Air Conditioner Clutch
CB-6	15	8H	Heater and A/C	KEY SWITCH	—		Engine Start
CB-7	30	6A1	Starter Solenoid	MS1	50		Start Solenoid
CB-8	30	58	A/C Clutch	MS2			NOT USED
				Eng Clutch	10		Cylinder Direction
				Eng Clutch	10		Cylinder Speed

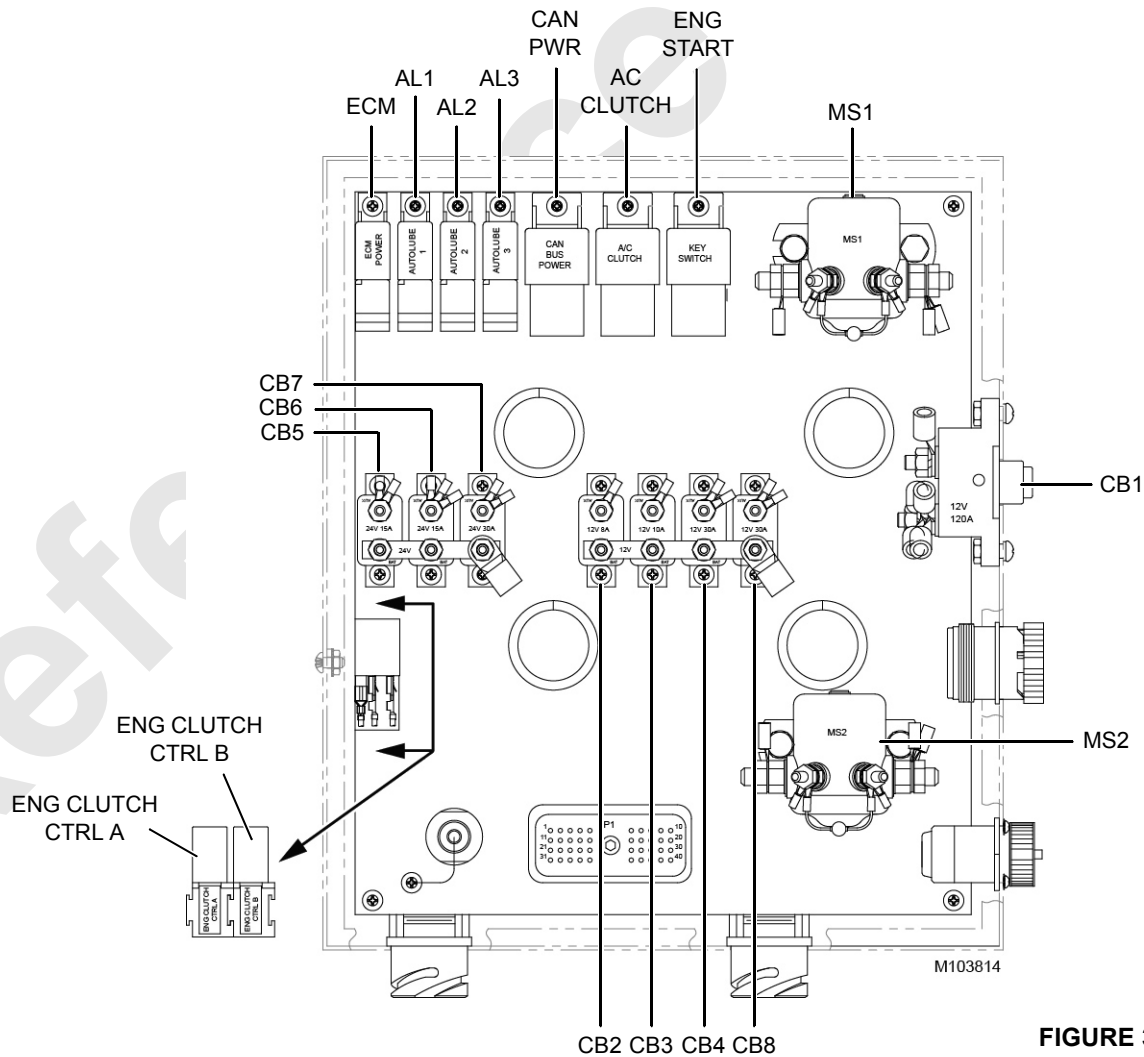
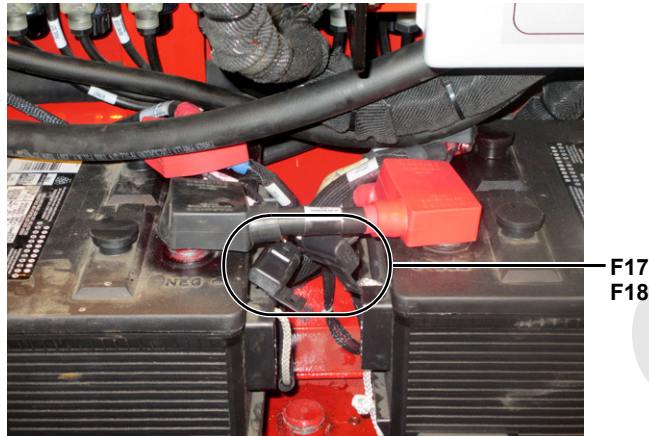


FIGURE 3-5

CraneStar TCU Fuses

Fuse	Amps	Wire No.	Description of Item Protected
F17	5	6	24VDC Power Bus
F18	10	6C	System 24VDC Fused Power

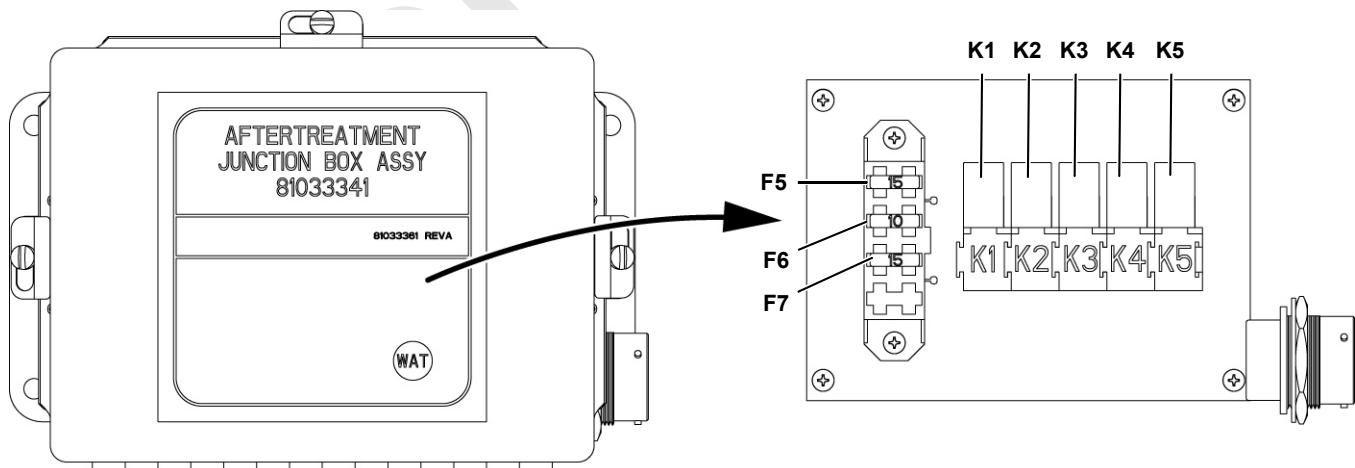


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FIGURE 3-6

Engine Exhaust Aftertreatment Junction Box

Fuse	Amps	Description of Item Protected
F5	15	DEF Supply Module
F6	10	Aftertreatment Sensors
F7	15	DEF Heaters
K1	10	DEF Pressure Hose Heater
K2	10	DEF Return Hose Heater
K3	10	DEF Suction Hose Heater
K4	10	DEF Supply Module
K5	10	Aftertreatment Sensors



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FIGURE 3-7

Reference Only

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TEST VOLTAGES

This section contains test voltages sorted into four categories:

- Pin Identification [page 3-9](#)
- Wire Identification [page 3-13](#)
- Description Identification [page 3-17](#)
- Controller Board Identification [page 3-21](#)

NOTE: Unused pin connections are not shown.

Controller Board Layout

The board locations in the programmable controller are shown below.

Test Voltage Abbreviations

The following abbreviations are used in this section:

I/O	=	Input/Output
AI	=	Analog Input
AO	=	Analog Output
Press.	=	Pressure
psi	=	Pounds per Square Inch
DI	=	Digital Input
DO	=	Digital Output
NC	=	No Connection
CHA or CHB	=	Channel A or B
COMM	=	Communication
CPU	=	Central Processing Unit

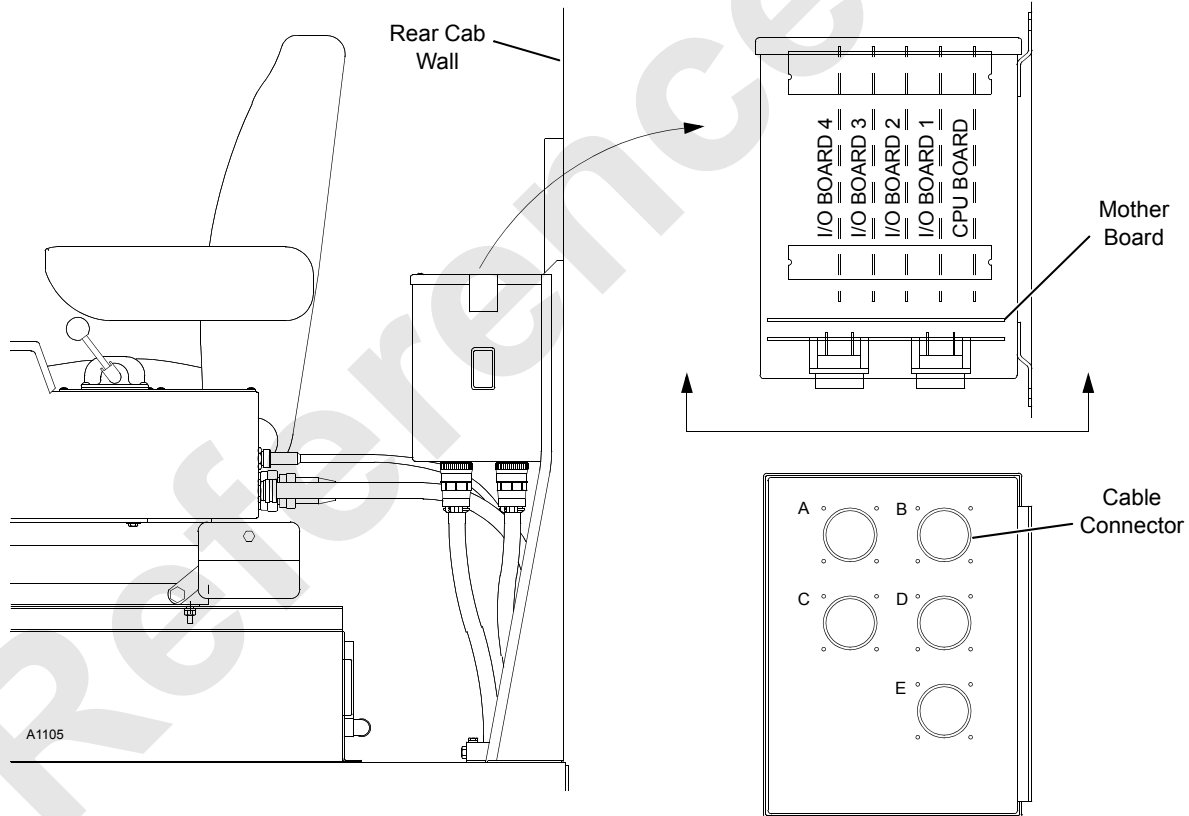


FIGURE 3-8

Pin Identification

Pin	Wire	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
A-01	87F	10 VDC Regulated Bus	10 Volts	CPU J1-01
A-03	80P	Front Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-50 (AI)
A-04	81P	Rear Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-52 (AI)
A-05	82P	Boom Hoist Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-54 (AI)
A-06	83P	Right Track Handle	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 1 J5-56 (AI)
A-07	84P	Left Track Handle	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 1 J5-58 (AI)
A-08	85P	Swing Handle	0 Volts Neutral; 1.4 to 5 Volts Right; 5 to 8.3 Volts Left	I/O 1 J5-60 (AI)
A-09	86P	Auxiliary Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-62 (AI)
A-10	101	Remote Input Node Communication		I/O 1 J5-64 (AI)
A-12	83PF	Right Track Pedal	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 2 J7-50 (AI)
A-13	84PF	Left Track Pedal	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 2 J7-52 (AI)
A-14	81QF	Rear Drum Free Fall Brake Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	I/O 2 J7-54 (AI)
A-15	80Qf	Front Drum Free Fall Brake Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	I/O 2 J7-56 (AI)
A-16	81EP	Rear Drum Brake Pedal	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 2 J7-58 (AI)
A-17	68K	Engine Throttle Lever	Power On: .064 to 10.05 Engine Running: .101 to 10.09	I/O 2 J7-60 (AI)
A-18	68KA	Engine Throttle Pedal	Power On: .280 to 10.05 Engine Running: .092 to 10.03	I/O 2 J7-62 (AI)
A-19	80EP	Front Drum Brake Pedal	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 2 J7-64 (AI)
A-20	83Q	Right Track Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-49 (AI)
A-21	81QA	Accessory System Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-51 (AI)
A-22	80QS	Front Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-53 (AI)
A-23	81QS	Rear Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-55 (AI)
A-24	82QS	Boom Hoist Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-57 (AI)
A-25	85QR	Swing Right Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-59 (AI)
A-26	85QL	Swing Left Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-61 (AI)
A-27	86QS	Auxiliary Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-63 (AI)
A-28	42	Hydraulic Fluid Temperature Switch	12 Volts Nominal	CPU J3-50 (AI)
A-29	84Q	Left Track Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-52 (AI)
A-30	90E	Backhitch Load Sensor	1.5 Volts at No Load; 9.5 Volts at Maximum Load	CPU J3-54 (AI)
A-35	88MA	Mast Angle Sensor	5 VDC Mast at Vertical	CPU J3-58 (AI)
A-37	89D4	Hydraulic Suction Switch	12 Volts Nominal	CPU J3-62 (AI)
B-01	89X	Travel Detent	12 Volts Nominal	I/O 1 J6-07 (DI)
B-02	89V	Front Drum Maximum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-08 (DI)
B-03	89T	Front Drum Minimum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-09 (DI)
B-04	89EC	Engine Clutch Disconnect Switch	12 Volts Nominal	I/O 1 (DI)

Pin	Wire	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
B-05	89ZZ	Boom/Jib Maximum Angle Bypass	12 Volts Nominal	I/O 1 J6-11 (DI)
B-06	89J5	Mast Raise Switch	12 Volts Nominal	I/O 1 J6-12 (DI)
B-07	89U	Rear Drum Maximum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-13 (DI)
B-08	89S	Rear Drum Minimum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-14 (DI)
B-09	89S2	Crane Mode Select Switch	12 Volts Nominal	I/O 1 J6-15 (DI)
B-10	89T2	Crane Mode Confirm Switch	12 Volts Nominal	I/O 1 J6-16 (DI)
B-11	89K5	Mast Lower Switch	12 Volts Nominal	I/O 1 J6-17 (DI)
B-12	89R	Boom Maximum Up Limit Switch	12 Volts Nominal	I/O 1 J6-18 (DI)
B-13	39	Remote Output Node Feedback		I/O 1 J6-19 (DI)
B-16	89R3	Hydraulic Fluid Level	12 Volts Nominal	I/O 2 J8-08 (DI)
B-22	89W3	Gantry Up Limit	12 Volts Nominal	I/O 2 J8-14 (DI)
B-24	89P	Rated Capacity Indicator/Limiter	12 Volts Nominal	I/O 2 J8-16 (DI)
B-25	89L	Limit Bypass Switch	12 Volts Nominal	I/O 2 J8-17 (DI)
B-26	89J	Display Scroll Up Switch	12 Volts Nominal	I/O 2 J8-18 (DI)
B-27	89A5	Gantry Raise Switch	12 Volts Nominal	I/O 2 J8-19 (DI)
B-28	89B5	Gantry Lower Switch	12 Volts Nominal	I/O 2 J8-20 (DI)
B-30	89D5	Counterweight Pins Retract Switch	12 Volts Nominal	I/O 3 J10-08 (DI)
B-31	89E5	Boom Hinge Pins Extend Switch	12 Volts Nominal	I/O 3 J10-09 (DI)
B-32	89F5	Boom Hinge Pins Retract Switch	12 Volts Nominal	I/O 3 J10-10 (DI)
B-33	89K	Display Scroll Down Switch	12 Volts Nominal	I/O 3 J10-11 (DI)
B-34	89Q3	Seat Switch	12 Volts Nominal	I/O 3 J10-12 (DI)
B-35	89L1	High Speed Travel Switch	12 Volts Nominal	I/O 3 J10-13 (DI)
B-36	89G5	Accessory Pressure Switch	12 Volts Nominal	I/O 3 J10-14 (DI)
C-01	8P1	Computer Bus	12 Volts DC	
C-02	0	Main System Ground Bus	0 Volts	
C-03	8P1	Computer Bus	12 Volts DC	
C-04	0	Main System Ground Bus	0 Volts	
C-05	80A	Front Drum Pump Control (Servo Driver 1)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 1 J6-41 (AO)
C-06	81A	Rear Drum Pump Control (Servo Driver 2)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 1 J6-42 (AO)
C-07	86R	Auxiliary Drum Pawl Enabled Solenoid	12 Volts Nominal	I/O 1 J6-21-22 (DO)
C-08	86RA	Auxiliary Drum Pawl Disabled Solenoid	12 Volts Nominal	I/O 1 J6-23-24 (DO)
C-09	82E	Boom Hoist Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-25-26 (DO)
C-10	84E	Travel Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-27-28 (DO)
C-11	68CA	Engine Clutch Cylinder Direction	0 Volts Off; 12 Volts On	I/O 1 (DI)
C-12	8P1	Computer Bus	12 Volts DC	
C-13	0	Main System Ground Bus	0 Volts	
C-14	82A	Boom Drum Pump Control (Servo Driver 3)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 2 J8-41 (AO)
C-15	83A	Right Track Pump Control (Servo Driver 4)	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward	I/O 2 J8-42 (AO)
C-16	80F	Front Drum Hydraulic Clutch Solenoid	12 Volts Nominal	I/O 1 J6-31-32 (DO)
C-17	81F	Rear Drum Hydraulic Clutch Solenoid	12 Volts Nominal	I/O 1 J6-33-34 (DO)
C-18	80E	Front Drum Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-35-36 (DO)
C-19	81E	Rear Drum Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-37-38 (DO)

Pin	Wire	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
C-20	68CB	Engine Clutch Cylinder Speed	Variable 0-12 Volts	I/O 1 (DO)
C-21	8P1	Computer Bus	12 Volts DC	
C-22	0	Main System Ground Bus	0 Volts	
C-23	84A	Left Track Pump Control (Servo Driver 5)	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward	I/O 3 J10-41 (AO)
C-24	85A	Swing Pump Control (Servo Driver 6)	0 to 2.8 ± 10% (110 mA) Volts Right; 0 to -2.8 ± 10% (-110 mA) Volts Left	I/O 3 J10-42 (AO)
C-25	86E	Auxiliary Drum Park Brake Solenoid	12 Volts Nominal	I/O 2 J8-21-22 (DO)
C-26	52B	Boom Hinge Pins Retract Solenoid	12 Volts Nominal	I/O 2 J8-23-24 (DO)
C-27	25X	Motion Alarm	12 Volts Nominal	I/O 2 J8-25-26 (DO)
C-28	80FS	Front Drum Spring Clutch Solenoid	12 Volts Nominal	I/O 2 J8-27-28 (DO)
C-29	81FS	Rear Drum Spring Clutch Solenoid	12 Volts Nominal	I/O 2 J8-29-30 (DO)
C-30	8P1	Computer Bus	12 Volts DC	
C-31	0	Main System Ground Bus	0 Volts	
C-32	43	Gantry Cylinder Extend Solenoid	12 Volts Nominal	I/O 2 J8-31-32 (DO)
C-33	44	Gantry Cylinder Retract Solenoid	12 Volts Nominal	I/O 2 J8-33-34 (DO)
C-34	55D	Mast Cylinder Extend Solenoid	12 Volts Nominal	I/O 2 J8-35-36 (DO)
C-35	55C	Mast Cylinder Retract Solenoid	12 Volts Nominal	I/O 2 J8-37-38 (DO)
C-36	52A	Boom Hinge Pins Extend Solenoid	12 Volts Nominal	I/O 2 J8-39-40 (DO)
D-01	80MA	Front Drum Flange Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-01 (DI)
D-02	80MB	Front Drum Flange Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-02 (DI)
D-03	81MA	Rear Drum Flange Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-03 (DI)
D-04	81MB	Rear Drum Flange Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-04 (DI)
D-05	82MA	Boom Hoist Shaft Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 2 J8-01 (DI)
D-06	82MB	Boom Hoist Shaft Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 2 J8-02 (DI)
D-07	24	Engine RPM Magnetic Pick-Up	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-05 (DI)
D-08	89Y3	Front Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-15 (DI)
D-09	89X3	Rear Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-16 (DI)
D-10	89T4	Boom Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-17 (DI)
D-11	89B4	Travel Park Brake Switch	12 Volts Nominal	I/O 3 J10-18 (DI)
D-12	89S4	Auxiliary Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-19 (DI)
D-13	89R1	Auxiliary Drum Minimum Bail Limit Switch	12 Volts Nominal	I/O 3 J10-20 (DI)
D-15	85EA	Swing Park Brake Switch	12 Volts Nominal	I/O 4 J12-08 (DI)
D-16	37	RS232 (Receive from Laptop)		CPU J4-02 (COMM)
D-17	36	RS232 (Transmit to Laptop)		CPU J4-01 (COMM)
D-19	31	RS232 To Display - White		CPU J4-05 (COMM)
D-20	30	RS232 To Display - Black (Ground)	0 Volts	CPU J4-07-08 (COMM)
D-21	35	RS232 Receive from LMI		CPU J4-10 (COMM)
D-22	34	RS232 Transmit to LMI		CPU J4-09 (COMM)

Pin	Wire	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
D-24	80MC	Front Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion	I/O 1 J6-06 (AO)
D-25	81MC	Rear Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion	I/O 2 J8-06 (AO)
D-26	56A	Counterweight Pins Retract Solenoid	12 Volts Nominal	I/O 3 J10-23 (DO)
D-27	80N	Front Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-23-24 (DO)
D-28	81N	Rear Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-25-26 (DO)
D-29	82N	Boom Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-27-28 (DO)
D-30	86N	Auxiliary Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-29-30 (DO)
D-31	84R	High Speed Travel Solenoid	12 Volts Nominal	I/O 3 J10-31-32 (DO)
D-32	80R	Front Drum Pawl Enable Solenoid	12 Volts Nominal	I/O 3 J10-33-34 (DO)
D-33	80RA	Front Drum Pawl Disable Solenoid	12 Volts Nominal	I/O 3 J10-35-36 (DO)
D-34	81R	Rear Drum Pawl Enable Solenoid	12 Volts Nominal	I/O 3 J10-37-38 (DO)
D-35	81RA	Rear Drum Pawl Disable Solenoid	12 Volts Nominal	I/O 3 J10-39-40 (DO)
D-36	82R	Boom Drum Pawl Enable Solenoid	12 Volts Nominal	I/O 4 J12-21-22 (DO)
D-37	82RA	Boom Drum Pawl Disable Solenoid	12 Volts Nominal	I/O 4 J12-23-24 (DO)
E-01	86MA	Auxiliary Drum Flange Encoder CH A	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving	I/O 2 J8-03 (DI)
E-02	86MB	Auxiliary Drum Flange Encoder CH B	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving	I/O 2 J8-04 (DI)
E-14	89E4	Main Charge Filter Pressure Switch	12 Volts Nominal	I/O 4 J12-10 (DI)
E-15	89N4	Auxiliary Drum Charge Filter Pressure Switch	12 Volts Nominal	I/O 4 J12-11 (DI)
E-17	89H5	Free Fall Filter Alarm	12 Volts Nominal	I/O 4 J12-13 (DI)
E-18	89T3	Engine Oil Pressure Switch	12 Volts Nominal	I/O 4 J12-14 (DI)
E-19	89U3	Engine Coolant Temperature Switch	0 Volts	I/O 4 J12-15 (DI)
E-29	82MC	Boom Hoist Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion	I/O 3 J10-06 (AO)
E-30	86MC	Auxiliary Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion	I/O 4 J12-06 (AO)
E-33	80G	Rotating Bed Auto-Lube Relay	12 Volts Nominal	I/O 4 J12-25-26 (DO)
E-34	85G	Swing Auto-Lube Relay	12 Volts Nominal	I/O 4 J12-27-28 (DO)
E-35	84G	Tracks Auto-Lube Relay	12 Volts Nominal	I/O 4 J12-29 30 (DO)
E-36	86A	Auxiliary Drum Pump Control Up	0 to 2.8 ± 10% (110 mA) Volts	I/O 4 J12-31-32 (DO)
E-37	86B	Auxiliary Drum Pump Control down	0 to 2.8 ± 10% (110 mA) Volts	I/O 4 J12-33-34 (DO)

Wire Identification

Wire	Pin	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
0	C-02	Main System Ground Bus	0 Volts	
0	C-04	Main System Ground Bus	0 Volts	
0	C-13	Main System Ground Bus	0 Volts	
0	C-22	Main System Ground Bus	0 Volts	
0	C-31	Main System Ground Bus	0 Volts	
24	D-07	Engine RPM Magnetic Pick-Up	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-05 (DI)
25X	C-27	Motion Alarm	12 Volts Nominal	I/O 2 J8-25-26 (DO)
30	D-20	RS232 To Display – Black (Ground)	0 Volts	CPU J4-07-08 (COMM)
31	D-19	RS232 To Display - White		CPU J4-05 (COMM)
34	D-22	RS232 Transmit to LMI		CPU J4-09 (COMM)
35	D-21	RS232 Receive from LMI		CPU J4-10 (COMM)
36	D-17	RS232 (Transmit to Laptop)		CPU J4-01 (COMM)
37	D-16	RS232 (Receive from Laptop)		CPU J4-02 (COMM)
38	C-11	Remote Output Node Communication		I/O 1 J6-29-30
39	B-13	Remote Output Node Feedback		I/O 1 J6-19 (DI)
42	A-28	Hydraulic Fluid Temperature Switch	12 Volts Nominal	CPU J3-50 (AI)
43	C-32	Gantry Cylinder Extend Solenoid	12 Volts Nominal	I/O 2 J8-31-32 (DO)
44	C-33	Gantry Cylinder Retract Solenoid	12 Volts Nominal	I/O 2 J8-33-34 (DO)
52A	C-36	Boom Hinge Pins Extend Solenoid	12 Volts Nominal	I/O 2 J8-39-40 (DO)
52B	C-26	Boom Hinge Pins Retract Solenoid	12 Volts Nominal	I/O 2 J8-23-24 (DO)
55C	C-35	Mast Cylinder Retract Solenoid	12 Volts Nominal	I/O 2 J8-37-38 (DO)
55D	C-34	Mast Cylinder Extend Solenoid	12 Volts Nominal	I/O 2 J8-35-36 (DO)
56A	D-26	Counterweight Pins Retract Solenoid	12 Volts Nominal	I/O 3 J10-23 (DO)
68CA	C-11	Engine Clutch Cylinder Direction	0 Volts Off; 12 Volts On	I/O 1 (DO)
68CB	C-20	Engine Clutch Cylinder Speed	Variable 0-12 Volts	I/O 1 (DO)
68K	A-17	Engine Throttle Lever	Power On: .064 to 10.05 Engine Running: .101 to 10.09	I/O 2 J7-60 (AI)
68KA	A-18	Engine Throttle Pedal	Power On: .280 to 10.05 Engine Running: .092 to 10.03	I/O 2 J7-62 (AI)
68KB	C-20	Engine Throttle Control	Power On: 2.76 to 8.84 Engine Running: 2.64 to 8.74	I/O 1 J6-39-40 (DO)
8P1	C-01	Computer Bus	12 Volts DC	
8P1	C-03	Computer Bus	12 Volts DC	
8P1	C-12	Computer Bus	12 Volts DC	
8P1	C-21	Computer Bus	12 Volts DC	
8P1	C-30	Computer Bus	12 Volts DC	
80A	C-05	Front Drum Pump Control (Servo Driver 1)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2. 8 ± 10% (-110 mA) Volts Up	I/O 1 J6-41 (AO)
80E	C-18	Front Drum Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-35-36 (DO)
80EP	A-19	Front Drum Brake Pedal	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 2 J7-64 (AI)
80F	C-16	Front Drum Hydraulic Clutch Solenoid	12 Volts Nominal	I/O 1 J6-31-32 (DO)
80FS	C-28	Front Drum Spring Clutch Solenoid	12 Volts Nominal	I/O 2 J8-27-28 (DO)
80G	E-33	Rotating Bed Auto-Lube Relay	12 Volts Nominal	I/O 4 J12-25-26 (DO)

Wire	Pin	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
80MA	D-01	Front Drum Flange Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-01 (DI)
80MB	D-02	Front Drum Flange Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-02 (DI)
80MC	D-24	Front Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion	I/O 1 J6-06 (AO)
80N	D-27	Front Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-23-24 (DO)
80P	A-03	Front Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-50 (AI)
80QF	A-15	Front Drum Free Fall Brake Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	I/O 2 J7-56 (AI)
80QS	A-22	Front Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-53 (AI)
80R	D-32	Front Drum Pawl Enable Solenoid	12 Volts Nominal	I/O 3 J10-33-34 (DO)
80RA	D-33	Front Drum Pawl Disable Solenoid	12 Volts Nominal	I/O 3 J10-35-36 (DO)
81A	C-06	Rear Drum Pump Control (Servo Driver 2)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 1 J6-42 (AO)
81E	C-19	Rear Drum Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-37-38 (DO)
81EP	A-16	Rear Drum Brake Pedal	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 2 J7-58 (AI)
81F	C-17	Rear Drum Hydraulic Clutch Solenoid	12 Volts Nominal	I/O 1 J6-33-34 (DO)
81FS	C-29	Rear Drum Spring Clutch Solenoid	12 Volts Nominal	I/O 2 J8-29-30 (DO)
81MA	D-03	Rear Drum Flange Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-03 (DI)
81MB	D-04	Rear Drum Flange Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-04 (DI)
81MC	D-25	Rear Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion	I/O 2 J8-06 (AO)
81N	D-28	Rear Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-25-26 (DO)
81P	A-04	Rear Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-52 (AI)
81QA	A-21	Accessory System Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-51 (AI)
81QS	A-23	Rear Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-55 (AI)
81QF	A-14	Rear Drum Free Fall Brake Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	I/O 2 J7-54 (AI)
81R	D-34	Rear Drum Pawl Enable Solenoid	12 Volts Nominal	I/O 3 J10-37-38 (DO)
81RA	D-35	Rear Drum Pawl Disable Solenoid	12 Volts Nominal	I/O 3 J10-39-40 (DO)
82A	C-14	Boom Drum Pump Control (Servo Driver 3)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 2 J8-41 (AO)
82E	C-09	Boom Hoist Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-25-26 (DO)
82MA	D-05	Boom Hoist Shaft Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 2 J8-01 (DI)
82MB	D-06	Boom Hoist Shaft Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 2 J8-02 (DI)
82MC	E-29	Boom Hoist Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion	I/O 3 J10-06 (AO)
82N	D-29	Boom Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-27-28 (DO)
82P	A-05	Boom Hoist Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-54 (AI)
82QS	A-24	Boom Hoist Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-57 (AI)
82R	D-36	Boom Drum Pawl Enable Solenoid	12 Volts Nominal	I/O 4 J12-21-22 (DO)
82RA	D-37	Boom Drum Pawl Disable Solenoid	12 Volts Nominal	I/O 4 J12-23-24 (DO)

Wire	Pin	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
83A	C-15	Right Track Pump Control (Servo Driver 4)	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward	I/O 2 J8-42 (AO)
83P	A-06	Right Track Handle	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 1 J5-56 (AI)
83PF	A-12	Right Track Pedal	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 2 J7-50 (AI)
83Q	A-20	Right Track Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-49 (AI)
84A	C-23	Left Track Pump Control (Servo Driver 5)	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward	I/O 3 J10-41 (AO)
84E	C-10	Travel Park Brake Solenoid	12 Volts Nominal	I/O 1 J6-27-28 (DO)
84G	E-35	Tracks Auto-Lube Relay	12 Volts Nominal	I/O 4 J12-29 30 (DO)
84P	A-07	Left Track Handle	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 1 J5-58 (AI)
84PF	A-13	Left Track Pedal	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 2 J7-52 (AI)
84Q	A-29	Left Track Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-52 (AI)
84R	D-31	High Speed Travel Solenoid	12 Volts Nominal	I/O 3 J10-31-32 (DO)
85A	C-24	Swing Pump Control (Servo Driver 6)	0 to 2.8 ± 10% (110 mA) Volts Right; 0 to -2.8 ± 10% (-110 mA) Volts Left	I/O 3 J10-42 (AO)
85EA	D-15	Swing Park Brake Switch	12 Volts Nominal	I/O 4 J12-08 (DI)
85G	E-34	Swing Auto-Lube Relay	12 Volts Nominal	I/O 4 J12-27-28 (DO)
85P	A-08	Swing Handle	0 Volts Neutral; 1.7 to 5 Volts Right; 5 to 8.3 Volts left	I/O 1 J5-60 (AI)
85QL	A-26	Swing Left Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-61 (AI)
85QR	A-25	Swing Right Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-59 (AI)
86A	E-36	Auxiliary Drum Pump Control Up	0 to 2.8 ± 10% (110 mA) Volts	I/O 4 J12-31-32 (DO)
86B	E-37	Auxiliary Drum Pump Control down	0 to 2.8 ± 10% (110 mA) Volts	I/O 4 J12-33-34 (DO)
86E	C-25	Auxiliary Drum Park Brake Solenoid	12 Volts Nominal	I/O 2 J8-21-22 (DO)
86MA	E-01	Auxiliary Drum Flange Encoder CH A	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving	I/O 2 J8-03 (DI)
86MB	E-02	Auxiliary Drum Flange Encoder CH B	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving	I/O 2 J8-04 (DI)
86MC	E-30	Auxiliary Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion	I/O 4 J12-06 (AO)
86N	D-30	Auxiliary Drum Rotation Indicator	12 Volts Nominal	I/O 3 J10-29-30 (DO)
86P	A-09	Auxiliary Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-62 (AI)
86QS	A-27	Auxiliary Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-63 (AI)
86R	C-07	Auxiliary Drum Pawl Enabled Solenoid	12 Volts Nominal	I/O 1 J6-21-22 (DO)
86RA	C-08	Auxiliary Drum Pawl Disabled Solenoid	12 Volts Nominal	I/O 1 J6-23-24 (DO)
87F	A-01	10 Volts DC Regulated Bus	10 Volts	CPU J1-01
88MA	A-35	Mast Angle Sensor	5 VDC Mast at Vertical	CPU J3-58 (AI)
89A5	B-27	Gantry Raise Switch	12 Volts Nominal	I/O 2 J8-19 (DI)
89B4	D-11	Travel Park Brake Switch	12 Volts Nominal	I/O 3 J10-18 (DI)
89B5	B-28	Gantry Lower Switch	12 Volts Nominal	I/O 2 J8-20 (DI)
89D4	A-37	Hydraulic Suction Switch	12 Volts Nominal	CPU J3-62 (AI)
89D5	B-30	Counterweight Pins Retract Switch	12 Volts Nominal	I/O 3 J10-08 (DI)
89E4	E-14	Main Charge Filter Pressure Switch	12 Volts Nominal	I/O 4 J12-10 (DI)

Wire	Pin	Description	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
89E5	B-31	Boom Hinge Pins Extend Switch	12 Volts Nominal	I/O 3 J10-09 (DI)
89EC	B-04	Engine Clutch Disconnect Switch	12 Volts Nominal	I/O 1 (DO)
89F5	B-32	Boom Hinge Pins Retract Switch	12 Volts Nominal	I/O 3 J10-10 (DI)
89G5	B-36	Accessory Pressure Switch	12 Volts Nominal	I/O 3 J10-14 (DI)
89H5	E-17	Free Fall Filter Alarm	12 Volts Nominal	I/O 4 J12-13 (DI)
89J	B-26	Display Scroll Up Switch	12 Volts Nominal	I/O 2 J8-18 (DI)
89J5	B-06	Mast Raise Switch	12 Volts Nominal	I/O 1 J6-12 (DI)
89K	B-33	Display Scroll Down Switch	12 Volts Nominal	I/O 3 J10-11 (DI)
89K5	B-11	Mast Lower Switch	12 Volts Nominal	I/O 1 J6-17 (DI)
89L	B-25	Limit Bypass Switch	12 Volts Nominal	I/O 2 J8-17 (DI)
89L1	B-35	High Speed Travel Switch	12 Volts Nominal	I/O 3 J10-13 (DI)
89N4	E-15	Auxiliary Drum Charge Filter Pressure Switch	12 Volts Nominal	I/O 4 J12-11 (DI)
89P	B-24	Rated Capacity Indicator/Limiter	12 Volts Nominal	I/O 2 J8-16 (DI)
89Q3	B-34	Seat Switch	12 Volts Nominal	I/O 3 J10-12 (DI)
89R	B-12	Boom Maximum Up Limit Switch	12 Volts Nominal	I/O 1 J6-18 (DI)
89R1	D-13	Auxiliary Drum Minimum Bail Limit Switch	12 Volts Nominal	I/O 3 J10-20 (DI)
89R3	B-16	Hydraulic Fluid Level	12 Volts Nominal	I/O 2 J8-08 (DI)
89S	B-08	Rear Drum Minimum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-14 (DI)
89S2	B-09	Crane Mode Select Switch	12 Volts Nominal	I/O 1 J6-15 (DI)
89S4	D-12	Auxiliary Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-19 (DI)
89T	B-03	Front Drum Minimum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-09 (DI)
89T2	B-10	Crane Mode Confirm Switch	12 Volts Nominal	I/O 1 J6-16 (DI)
89T3	E-18	Engine Oil Pressure Switch	12 Volts Nominal	I/O 4 J12-14 (DI)
89T4	D-10	Boom Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-17 (DI)
89U	B-07	Rear Drum Maximum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-13 (DI)
89U3	E-19	Engine Coolant Temperature Switch	0 Volts	I/O 4 J12-15 (DI)
89V	B-02	Front Drum Maximum Bail Limit Switch	12 Volts Nominal	I/O 1 J6-08 (DI)
89W3	B-22	Gantry Up Limit	12 Volts Nominal	I/O 2 J8-14 (DI)
89X	B-01	Travel Detent	12 Volts Nominal	I/O 1 J6-07 (DI)
89X3	D-09	Rear Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-16 (DI)
89Y3	D-08	Front Drum Park Brake Switch	12 Volts Nominal	I/O 3 J10-15 (DI)
89ZZ	B-05	Boom/Jib Maximum Angle Bypass	12 Volts Nominal	I/O 1 J6-11 (DI)
90E	A-30	Backhitch Load Sensor	1.5 Volts at No Load 9.5 Volts at Maximum Load	CPU J3-54 (AI)
101	A-10	Remote Input Node Communication		I/O 1 J5-64 (AI)

Description Identification

Description	Pin	Wire	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
10 VDC Regulated Bus	A-01	87F	10 Volts	CPU J1-01
Accessory Pressure Switch	B-36	89G5	12 Volts Nominal	I/O 3 J10-14 (DI)
Accessory System Hydraulic Pressure	A-21	81QA	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-51 (AI)
Auxiliary Drum Charge Filter Pressure Switch	E-15	89N4	12 Volts Nominal	I/O 4 J12-11 (DI)
Auxiliary Drum Flange Encoder CH A	E-01	86MA	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving	I/O 2 J8-03 (DI)
Auxiliary Drum Flange Encoder CH B	E-02	86MB	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving	I/O 2 J8-04 (DI)
Auxiliary Drum Handle	A-09	86P	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-62 (AI)
Auxiliary Drum Hydraulic Pressure	A-27	86QS	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-63 (AI)
Auxiliary Drum Minimum Bail Limit Switch	D-13	89R1	12 Volts Nominal	I/O 3 J10-20 (DI)
Auxiliary Drum Motor Control	E-30	86MC	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion	I/O 4 J12-06 (AO)
Auxiliary Drum Park Brake Solenoid	C-25	86E	12 Volts Nominal	I/O 2 J8-21-22 (DO)
Auxiliary Drum Park Brake Switch	D-12	89S4	12 Volts Nominal	I/O 3 J10-19 (DI)
Auxiliary Drum Pawl Disabled Solenoid	C-08	86RA	12 Volts Nominal	I/O 1 J6-23-24 (DO)
Auxiliary Drum Pawl Enabled Solenoid	C-07	86R	12 Volts Nominal	I/O 1 J6-21-22 (DO)
Auxiliary Drum Pump Control Down	E-37	86B	0 to $2.8 \pm 10\%$ (110 mA) Volts	I/O 4 J12-33-34 (DO)
Auxiliary Drum Pump Control Up	E-36	86A	0 to $2.8 \pm 10\%$ (110 mA) Volts	I/O 4 J12-31-32 (DO)
Auxiliary Drum Rotation Indicator	E-30	86N	12 Volts Nominal	I/O 3 J10-29-30 (DO)
Backhitch Load Sensor	A-30	90E	1.5 Volts at No Load 9.5 Volts at Maximum Load	CPU J3-54 (AI)
Boom Drum Park Brake Switch	D-10	89T4	12 Volts Nominal	I/O 3 J10-17 (DI)
Boom Drum Pawl Disable Solenoid	D-37	82RA	12 Volts Nominal	I/O 4 J12-23-24 (DO)
Boom Drum Pawl Enable Solenoid	D-36	82R	12 Volts Nominal	I/O 4 J12-21-22 (DO)
Boom Drum Pump Control (Servo Driver 3)	C-14	82A	0 to $2.8 \pm 10\%$ (110 mA) Volts Down; 0 to $-2.8 \pm 10\%$ (-110 mA) Volts Up	I/O 2 J8-41 (AO)
Boom Drum Rotation Indicator	D-29	82N	12 Volts Nominal	I/O 3 J10-27-28 (DO)
Boom Hinge Pins Extend Solenoid	C-36	52A	12 Volts Nominal	I/O 2 J8-39-40 (DO)
Boom Hinge Pins Extend Switch	B-31	89E5	12 Volts Nominal	I/O 3 J10-09 (DI)
Boom Hinge Pins Retract Solenoid	C-26	52B	12 Volts Nominal	I/O 2 J8-23-24 (DO)
Boom Hinge Pins Retract Switch	B-32	89F5	12 Volts Nominal	I/O 3 J10-10 (DI)
Boom Hoist Drum Handle	A-05	82P	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-54 (AI)
Boom Hoist Drum Hydraulic Pressure	A-24	82QS	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-57 (AI)
Boom Hoist Drum Motor Control	E-29	82MC	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion	I/O 3 J10-06 (AO)
Boom Hoist Park Brake Solenoid	C-09	82E	12 Volts Nominal	I/O 1 J6-25-26 (DO)
Boom Hoist Shaft Encoder CH A	D-05	82MA	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 2 J8-01 (DI)
Boom Hoist Shaft Encoder CH B	D-06	82MB	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 2 J8-02 (DI)
Boom/Jib Maximum Angle Bypass	B-05	89ZZ	12 Volts Nominal	I/O 1 J6-11 (DI)
Boom Maximum Up Limit Switch	B-12	89R	12 Volts Nominal	I/O 1 J6-18 (DI)
Computer Bus	C-01	8P1	12 Volts DC	

Description	Pin	Wire	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
Computer Bus	C-03	8P1	12 Volts DC	
Computer Bus	C-12	8P1	12 Volts DC	
Computer Bus	C-21	8P1	12 Volts DC	
Computer Bus	C-30	8P1	12 Volts DC	
Counterweight Pins Retract Solenoid	D-26	56A	12 Volts Nominal	I/O 3 J10-23 (DO)
Counterweight Pins Retract Switch	B-30	89D5	12 Volts Nominal	I/O 3 J10-08 (DI)
Crane Mode Confirm Switch	B-10	89T2	12 Volts Nominal	I/O 1 J6-16 (DI)
Crane Mode Select Switch	B-09	89S2	12 Volts Nominal	I/O 1 J6-15 (DI)
Display Scroll Down Switch	B-33	89K	12 Volts Nominal	I/O 3 J10-11 (DI)
Display Scroll Up Switch	B-26	89J	12 Volts Nominal	I/O 2 J8-18 (DI)
Engine Clutch Cylinder Direction	C-11	68CA	0 Volts Off; 12 Volts On	I/O 1 (D1)
Engine Clutch Cylinder Speed	C-20	68CB	Variable 0-12 Volts	I/O 1 (D1)
Engine Clutch Disconnect Switch	B-04	89EC	12 Volts Nominal	I/O 1 (D1)
Engine Coolant Temperature Switch	E-19	89U3	0 Volts	I/O 4 J12-15 (DI)
Engine Oil Pressure Switch	E-18	89T3	12 Volts Nominal	I/O 4 J12-14 (DI)
Engine RPM Magnetic Pick-Up	D-07	24	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-05 (DI)
Engine Throttle Control	C-20	68KB	Power On: 2.76 to 8.84 Engine Running: 2.64 to 8.74	I/O 1 J6-39-40 (DO)
Engine Throttle Lever	A-17	68K	Power On: .064 to 10.05 Engine Running: .101 to 10.09	I/O 1 J6-39-40 (DO)
Engine Throttle Pedal	A-18	68KA	Power On: .280 to 10.05 Engine Running: .092 to 10.03	I/O 2 J7-62 (AI)
Free Fall Filter Alarm	E-17	89H5	12 Volts Nominal	I/O 4 J12-13 (DI)
Front Drum Brake Pedal	A-19	80EP	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 2 J7-64 (AI)
Front Drum Flange Encoder CH A	D-01	80MA	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-01 (DI)
Front Drum Flange Encoder CH B	D-02	80MB	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-02 (DI)
Front Drum Free Fall Brake Pressure	A-15	80QF	1.2 Volts at 300 psi; 1 Volt at 0 psi	I/O 2 J7-56 (AI)
Front Drum Handle	A-03	80P	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-50 (AI)
Front Drum Hydraulic Clutch Solenoid	C-16	80F	12 Volts Nominal	I/O 1 J6-31-32 (DO)
Front Drum Hydraulic Pressure	A-22	80QS	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-53 (AI)
Front Drum Maximum Bail Limit Switch	B-02	89V	12 Volts Nominal	I/O 1 J6-08 (DI)
Front Drum Minimum Bail Limit Switch	B-03	89T	12 Volts Nominal	I/O 1 J6-09 (DI)
Front Drum Motor Control	D-24	80MC	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion	I/O 1 J6-06 (AO)
Front Drum Park Brake Solenoid	C-18	80E	12 Volts Nominal	I/O 1 J6-35-36 (DO)
Front Drum Park Brake Switch	D-08	89Y3	12 Volts Nominal	I/O 3 J10-15 (DI)
Front Drum Pawl Disable Solenoid	D-33	80RA	12 Volts Nominal	I/O 3 J10-35-36 (DO)
Front Drum Pawl Enable Solenoid	D-32	80R	12 Volts Nominal	I/O 3 J10-33-34 (DO)
Front Drum Pump Control (Servo Driver 1)	C-05	80A	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 1 J6-41 (AO)
Front Drum Rotation Indicator	D-27	80N	12 Volts Nominal	I/O 3 J10-23-24 (DO)
Front Drum Spring Clutch Solenoid	C-28	80FS	12 Volts Nominal	I/O 2 J8-27-28 (DO)

Description	Pin	Wire	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
Gantry Cylinder Extend Solenoid	C-32	43	12 Volts Nominal	I/O 2 J8-31-32 (DO)
Gantry Cylinder Retract Solenoid	C-33	44	12 Volts Nominal	I/O 2 J8-33-34 (DO)
Gantry Lower Switch	B-28	89B5	12 Volts Nominal	I/O 2 J8-20 (DI)
Gantry Raise Switch	B-27	89A5	12 Volts Nominal	I/O 2 J8-19 (DI)
Gantry Up Limit	B-22	89W3	12 Volts Nominal	I/O 2 J8-14 (DI)
High Speed Travel Solenoid	D-31	84R	12 Volts Nominal	I/O 3 J10-31-32 (DO)
High Speed Travel Switch	B-35	89L1	12 Volts Nominal	I/O 3 J10-13 (DI)
Hydraulic Fluid Level	B-16	89R3	12 Volts Nominal	I/O 2 J8-08 (DI)
Hydraulic Fluid Temperature Switch	A-28	42	12 Volts Nominal	CPU J3-50 (AI)
Hydraulic Suction Switch	A-37	89D4	12 Volts Nominal	CPU J3-62 (AI)
Left Track Handle	A-07	84P	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 1 J5-58 (AI)
Left Track Hydraulic Pressure	A-29	84Q	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-52 (AI)
Left Track Pedal	A-13	84PF	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 2 J7-52 (AI)
Left Track Pump Control (Servo Driver 5)	C-23	84A	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward	I/O 3 J10-41 (AO)
Limit Bypass Switch	B-25	89L	12 Volts Nominal	I/O 2 J8-17 (DI)
Rated Capacity Indicator/Limiter	B-24	89P	12 Volts Nominal	I/O 2 J8-16 (DI)
Main Charge Filter Pressure Switch	E-14	89E4	12 Volts Nominal	I/O 4 J12-10 (DI)
Main System Ground Bus	C-02	0	0 Volts	
Main System Ground Bus	C-04	0	0 Volts	
Main System Ground Bus	C-13	0	0 Volts	
Main System Ground Bus	C-22	0	0 Volts	
Main System Ground Bus	C-31	0	0 Volts	
Mast Angle Sensor	A-35	88MA	5 VDC Mast at Vertical	CPU J3-58 (AI)
Mast Cylinder Extend Solenoid	C-34	55D	12 Volts Nominal	I/O 2 J8-35-36 (DO)
Mast Cylinder Retract Solenoid	C-35	55C	12 Volts Nominal	I/O 2 J8-37-38 (DO)
Mast Lower Switch	B-11	89K5	12 Volts Nominal	I/O 1 J6-17 (DI)
Mast Raise Switch	B-06	89J5	12 Volts Nominal	I/O 1 J6-12 (DI)
Motion Alarm	C-27	25X	12 Volts Nominal	I/O 2 J8-25-26 (DO)
Rear Drum Brake Pedal	A-16	81EP	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 2 J7-58 (AI)
Rear Drum Flange Encoder CH A	D-03	81MA	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-03 (DI)
Rear Drum Flange Encoder CH B	D-04	81MB	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving	I/O 1 J6-04 (DI)
Rear Drum Free Fall Brake Pressure	A-14	81QF	1.2 Volts at 300 psi; 1 Volt at 0 psi	I/O 2 J7-54 (AI)
Rear Drum Handle	A-04	81P	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise	I/O 1 J5-52 (AI)
Rear Drum Hydraulic Clutch Solenoid	C-17	81F	12 Volts Nominal	I/O 1 J6-33-34 (DO)
Rear Drum Hydraulic Pressure	A-23	81QS	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-55 (AI)
Rear Drum Maximum Bail Limit Switch	B-07	89U	12 Volts Nominal	I/O 1 J6-13 (DI)
Rear Drum Minimum Bail Limit Switch	B-08	89S	12 Volts Nominal	I/O 1 J6-14 (DI)
Rear Drum Motor Control	D-25	81MC	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion	I/O 2 J8-06 (AO)
Rear Drum Park Brake Solenoid	C-19	81E	12 Volts Nominal	I/O 1 J6-37-38 (DO)

Description	Pin	Wire	Test Voltage (DC unless otherwise specified)	Board (Signal Type)
Rear Drum Park Brake Switch	D-09	89X3	12 Volts Nominal	I/O 3 J10-16 (DI)
Rear Drum Pawl Disable Solenoid	D-35	81RA	12 Volts Nominal	I/O 3 J10-39-40 (DO)
Rear Drum Pawl Enable Solenoid	D-34	81R	12 Volts Nominal	I/O 3 J10-37-38 (DO)
Rear Drum Pump Control (Servo Driver 2)	C-06	81A	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up	I/O 1 J6-42 (AO)
Rear Drum Rotation Indicator	D-28	81N	12 Volts Nominal	I/O 3 J10-25-26 (DO)
Rear Drum Spring Clutch Solenoid	C-29	81FS	12 Volts Nominal	I/O 2 J8-29-30 (DO)
Remote Input Node Communication	A-10	101		I/O 1 J5-64 (AI)
Remote Output Node Communication	C-11	38		I/O 1 J6-29-30 (DO)
Remote Output Node Feedback	B-13	39		I/O 1 J6-19 (DI)
Right Track Handle	A-06	83P	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 1 J5-56 (AI)
Right Track Hydraulic Pressure	A-20	83Q	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-49 (AI)
Right Track Pedal	A-12	83PF	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward	I/O 2 J7-50 (AI)
Right Track Pump Control (Servo Driver 4)	C-15	83A	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward	I/O 2 J8-42 (AO)
Rotating Bed Auto-Lube Relay	E-33	80G	12 Volts Nominal	I/O 4 J12-25-26 (DO)
RS232 - Receive from Laptop	D-16	37		CPU J4-02 (COMM)
RS232 - Receive from LMI	D-21	35		CPU J4-10 (COMM)
RS232 - To Display – Black (Ground)	D-20	30	0 Volts	CPU J4-07-08 (COMM)
RS232 - To Display - White	D-19	31		CPU J4-05 (COMM)
RS232 - Transmit to Laptop	D-17	36		CPU J4-01 (COMM)
RS232 - Transmit to LMI	D-22	34		CPU J4-09 (COMM)
Seat Switch	B-34	89Q3	12 Volts Nominal	I/O 3 J10-12 (DI)
Swing Auto-Lube Relay	E-34	85G	12 Volts Nominal	I/O 4 J12-27-28 (DO)
Swing Handle	A-08	85P	0 Volts Neutral; 1.7 to 5 Volts Right; 5 to 8.3 Volts Left	I/O 1 J5-60 (AI)
Swing Left Hydraulic Pressure	A-26	85QL	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-61 (AI)
Swing Park Brake Switch	D-15	85EA	12 Volts Nominal	I/O 4 J12-08 (DI)
Swing Pump Control (Servo Driver 6)	C-24	85A	0 to 2.8 ± 10% (110 mA) Volts Right; 0 to -2.8 ± 10% (-110 mA) Volts Left	I/O 3 J10-42 (AO)
Swing Right Hydraulic Pressure	A-25	85QR	1.2 Volts at 300 psi; 1 Volt at 0 psi	CPU J3-59 (AI)
Tracks Auto-Lube Relay	E-35	84G	12 Volts Nominal	I/O 4 J12-29 30 (DO)
Travel Detent	B-01	89X	12 Volts Nominal	I/O 1 J6-07 (DI)
Travel Park Brake Solenoid	C-10	84E	12 Volts Nominal	I/O 1 J6-27-28 (DO)
Travel Park Brake Switch	D-11	89B4	12 Volts Nominal	I/O 3 J10-18 (DI)

Controller Board Identification

Board (Signal Type)	Pin	Wire	Description	Test Voltage (DC unless otherwise specified)
CPU J1-01	A-01	87F	10 VDC Regulated Bus	10 Volts
CPU J3-49 (AI)	A-20	83Q	Right Track Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-50 (AI)	A-28	42	Hydraulic Fluid Temperature Switch	12 Volts Nominal
CPU J3-51 (AI)	A-21	81QA	Accessory System Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-52 (AI)	A-29	84Q	Left Track Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-53 (AI)	A-22	80QS	Front Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-54 (AI)	A-30	90E	Backhitch Load Sensor	1.5 Volts at No Load 9.5 Volts at Maximum Load
CPU J3-55 (AI)	A-23	81QS	Rear Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-56 (AI)	A-34		Spare	
CPU J3-57 (AI)	A-24	82QS	Boom Hoist Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-58 (AI)	A-35	88MA	Mast Angle Sensor	5 VDC Mast at Vertical
CPU J3-59 (AI)	A-25	85QR	Swing Right Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-60 (AI)	A-36		Spare	
CPU J3-61 (AI)	A-26	85QL	Swing Left Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-62 (AI)	A-37	89D4	Hydraulic Suction Switch	12 Volts Nominal
CPU J3-63 (AI)	A-27	86QS	Auxiliary Drum Hydraulic Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
CPU J3-64 (AI)	A-02		Spare	
CPU J4-01 (COMM)	D-17	36	RS232 (Transmit to Laptop)	
CPU J4-02 (COMM)	D-16	37	RS232 (Receive from Laptop)	
CPU J4-03-04 (COMM)	D-18		Spare	
CPU J4-05 (COMM)	D-19	31	RS232 To Display – White	
CPU J4-07-08 (COMM)	D-20	30	RS232 To Display – Black (Ground)	0 Volts
CPU J4-09 (COMM)	D-22	34	RS232 Transmit to LMI	
CPU J4-10 (COMM)	D-21	35	RS232 Receive from LMI	
I/O 1 J5-50 (AI)	A-03	80P	Front Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise
I/O 1 J5-52 (AI)	A-04	81P	Rear Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise
I/O 1 J5-54 (AI)	A-05	82P	Boom Hoist Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise
I/O 1 J5-56 (AI)	A-06	83P	Right Track Handle	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward
I/O 1 J5-58 (AI)	A-07	84P	Left Track Handle	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward
I/O 1 J5-60 (AI)	A-08	85P	Swing Handle	0 Volts Neutral; 1.7 to 5 Volts Right; 5 to 8.3 Volts Left
I/O 1 J5-62 (AI)	A-09	86P	Auxiliary Drum Handle	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise
I/O 1 J5-64 (AI)	A-10	101	Remote Input Node Communication	
I/O 1 J6-01 (DI)	D-01	80MA	Front Drum Flange Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving
I/O 1 J6-02 (DI)	D-02	80MB	Front Drum Flange Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving
I/O 1 J6-03 (DI)	D-03	81MA	Rear Drum Flange Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving

Board (Signal Type)	Pin	Wire	Description	Test Voltage (DC unless otherwise specified)
I/O 1 J6-04 (DI)	D-04	81MB	Rear Drum Flange Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving
I/O 1 J6-05 (DI)	D-07	24	Engine RPM Magnetic Pick-Up	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving
I/O 1 J6-06 (AO)	D-24	80MC	Front Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion
I/O 1 J6-07 (DI)	B-01	89X	Travel Detent	12 Volts Nominal
I/O 1 J6-08 (DI)	B-02	89V	Front Drum Maximum Bail Limit Switch	12 Volts Nominal
I/O 1 J6-09 (DI)	B-03	89T	Front Drum Minimum Bail Limit Switch	12 Volts Nominal
I/O 1 J6-10 (DI)	B-04		Spare	
I/O 1 J6-11 (DI)	B-05	89ZZ	Boom/Jib Maximum Angle Bypass	12 Volts Nominal
I/O 1 J6-12 (DI)	B-06	89J5	Mast Raise Switch	12 Volts Nominal
I/O 1 J6-13 (DI)	B-07	89U	Rear Drum Maximum Bail Limit Switch	12 Volts Nominal
I/O 1 J6-14 (DI)	B-08	89S	Rear Drum Minimum Bail Limit Switch	12 Volts Nominal
I/O 1 J6-15 (DI)	B-09	89S2	Crane Mode Select Switch	12 Volts Nominal
I/O 1 J6-16 (DI)	B-10	89T2	Crane Mode Confirm Switch	12 Volts Nominal
I/O 1 J6-17 (DI)	B-11	89K5	Mast Lower Switch	12 Volts Nominal
I/O 1 J6-18 (DI)	B-12	89R	Boom Maximum Up Limit Switch	12 Volts Nominal
I/O 1 J6-19 (DI)	B-13	39	Remote Output Node Feedback	
I/O 1 J6-20 (DI)	B-14		Spare	
I/O 1 J6-21-22 (DO)	C-07	86R	Auxiliary Drum Pawl Enabled Solenoid	12 Volts Nominal
I/O 1 J6-23-24 (DO)	C-08	86RA	Auxiliary Drum Pawl Disabled Solenoid	12 Volts Nominal
I/O 1 J6-25-26 (DO)	C-09	82E	Boom Hoist Park Brake Solenoid	12 Volts Nominal
I/O 1 J6-27-28 (DO)	C-10	84E	Travel Park Brake Solenoid	12 Volts Nominal
I/O 1 J6-29-30 (DO)	C-11	38	Remote Output Node Communication	
I/O 1 J6-31-32 (DO)	C-16	80F	Front Drum Hydraulic Clutch Solenoid	12 Volts Nominal
I/O 1 J6-33-34 (DO)	C-17	81F	Rear Drum Hydraulic Clutch Solenoid	12 Volts Nominal
I/O 1 J6-35-36 (DO)	C-18	80E	Front Drum Park Brake Solenoid	12 Volts Nominal
I/O 1 J6-37-38 (DO)	C-19	81E	Rear Drum Park Brake Solenoid	12 Volts Nominal
I/O 1 J6-39-40 (DO)	C-20	68KB	Engine Throttle Control	Power On: 2.76 to 8.74 Engine Running: 2.64 to 8.74
I/O 1 J6-41 (AO)	C-05	80A	Front Drum Pump Control (Servo Driver 1)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up
I/O 1 J6-42 (AO)	C-06	81A	Rear Drum Pump Control (Servo Driver 2)	0 to 2.8 ± 10% (110 mA) Volts Down; 0 to -2.8 ± 10% (-110 mA) Volts Up
I/O 2 J7-50 (AI)	A-12	83PF	Right Track Pedal	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward
I/O 2 J7-52 (AI)	A-13	84PF	Left Track Pedal	0 Volts Neutral; 1.4 to 5 Volts Reverse; 5 to 8.6 Volts Forward
I/O 2 J7-54 (AI)	A-14	81QF	Rear Drum Free Fall Brake Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
I/O 2 J7-56 (AI)	A-15	80QF	Front Drum Free Fall Brake Pressure	1.2 Volts at 300 psi; 1 Volt at 0 psi
I/O 2 J7-58 (AI)	A-16	81EP	Rear Drum Brake Pedal	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise
I/O 2 J7-60 (AI)	A-17	68K	Engine Throttle Lever	Power On: .064 to 10.05 Engine Running: .101 to 10.09
I/O 2 J7-62 (AI)	A-18	68KA	Engine Throttle Pedal	Power On: .280 to 10.05 Engine Running: .092 to 10.03

Board (Signal Type)	Pin	Wire	Description	Test Voltage (DC unless otherwise specified)
I/O 2 J7-64 (AI)	A-19	80EP	Front Drum Brake Pedal	0 Volts Neutral; 1.4 to 5 Volts Lower; 5 to 8.6 Volts Raise
I/O 2 J8-01 (DI)	D-05	82MA	Boom Hoist Shaft Encoder CH A	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving
I/O 2 J8-02 (DI)	D-06	82MB	Boom Hoist Shaft Encoder CH B	7.5 Volts or 0 Volts Not Moving 3.5 Volts Moving
I/O 2 J8-03 (DI)	E-01	86MA	Auxiliary Drum Flange Encoder CH A	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving
I/O 2 J8-04 (DI)	E-02	86MB	Auxiliary Drum Flange Encoder CH B	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving
I/O 2 J8-05 (DI)	E-07		Spare	
I/O 2 J8-06 (AO)	D-25	81MC	Rear Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 to Full Handle Motion
I/O 2 J8-07 (DI)	B-15		Spare	
I/O 2 J8-08 (DI)	B-16	89R3	Hydraulic Fluid Level	12 Volts Nominal
I/O 2 J8-09 (DI)	B-17		Spare	
I/O 2 J8-10 (DI)	B-18		Spare	
I/O 2 J8-11 (DI)	B-19		Spare	
I/O 2 J8-12 (DI)	B-20		Spare	
I/O 2 J8-13 (DI)	B-21		Spare	
I/O 2 J8-14 (DI)	B-22	89W3	Gantry Up Limit	12 Volts Nominal
I/O 2 J8-15 (DI)	B-23		Spare	
I/O 2 J8-16 (DI)	B-24	89P	Rated Capacity Indicator/Limiter	12 Volts Nominal
I/O 2 J8-17 (DI)	B-25	89L	Limit Bypass Switch	12 Volts Nominal
I/O 2 J8-18 (DI)	B-26	89J	Display Scroll Up Switch	12 Volts Nominal
I/O 2 J8-19 (DI)	B-27	89A5	Gantry Raise Switch	12 Volts Nominal
I/O 2 J8-20 (DI)	B-28	89B5	Gantry Lower Switch	12 Volts Nominal
I/O 2 J8-21-22 (DO)	C-25	86E	Auxiliary Drum Park Brake Solenoid	12 Volts Nominal
I/O 2 J8-23-24 (DO)	C-26	52B	Boom Hinge Pins Retract Solenoid	12 Volts Nominal
I/O 2 J8-25-26 (DO)	C-27	25X	Motion Alarm	12 Volts Nominal
I/O 2 J8-27-28 (DO)	C-28	80FS	Front Drum Spring Clutch Solenoid	12 Volts Nominal
I/O 2 J8-29-30 (DO)	C-29	81FS	Rear Drum Spring Clutch Solenoid	12 Volts Nominal
I/O 2 J8-31-32 (DO)	C-32	43	Gantry Cylinder Extend Solenoid	12 Volts Nominal
I/O 2 J8-33-34 (DO)	C-33	44	Gantry Cylinder Retract Solenoid	12 Volts Nominal
I/O 2 J8-35-36 (DO)	C-34	55D	Mast Cylinder Extend Solenoid	12 Volts Nominal
I/O 2 J8-37-38 (DO)	C-35	55C	Mast Cylinder Retract Solenoid	12 Volts Nominal
I/O 2 J8-39-40 (DO)	C-36	52A	Boom Hinge Pins Extend Solenoid	12 Volts Nominal
I/O 2 J8-41 (AO)	C-14	82A	Boom Drum Pump Control (Servo Driver 3)	0 to $2.8 \pm 10\%$ (110 mA) Volts Down; 0 to $-2.8 \pm 10\%$ (-110 mA) Volts Up
I/O 2 J8-42 (AO)	C-15	83A	Right Track Pump Control (Servo Driver 4)	0 to $2.8 \pm 10\%$ (110 mA) Volts Reverse; 0 to $-2.8 \pm 10\%$ (-110 mA) Volts Forward
I/O 2 J9-56 (AI)	E-08		Spare	
I/O 2 J9-58 (AI)	E-09		Spare	
I/O 2 J9-60 (AI)	E-10		Spare	
I/O 2 J9-62 (AI)	E-11		Spare	
I/O 2 J9-64 (AI)	E-12		Spare	
I/O 3 J9-50 (AI)	A-31		Spare	

Board (Signal Type)	Pin	Wire	Description	Test Voltage (DC unless otherwise specified)
I/O 3 J9-52 (AI)	A-32		Spare	
I/O 3 J9-54 (AI)	A-33		Spare	
I/O 3 J10-01 (DI)	E-03		Spare Encoder CH 5A	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving
I/O 3 J10-02 (DI)	E-04		Spare Encoder CH 5B	Above 7.5 Volts or 0 Volts Not Moving; 3.5 Volts Moving
I/O 3 J10-03 (DI)	E-05		Spare	
I/O 3 J10-04 (DI)	E-06		Spare	
I/O 3 J10-06 (AO)	E-29	82MC	Boom Hoist Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion
I/O 3 J10-07 (DI)	B-29		Spare	
I/O 3 J10-08 (DI)	B-30	89D5	Counterweight Pins Retract Switch	12 Volts Nominal
I/O 3 J10-09 (DI)	B-31	89E5	Boom Hinge Pins Extend Switch	12 Volts Nominal
I/O 3 J10-10 (DI)	B-32	89F5	Boom Hinge Pins Retract Switch	12 Volts Nominal
I/O 3 J10-11 (DI)	B-33	89K	Display Scroll Down Switch	12 Volts Nominal
I/O 3 J10-12 (DI)	B-34	89Q3	Seat Switch	12 Volts Nominal
I/O 3 J10-13 (DI)	B-35	89L1	High Speed Travel Switch	12 Volts Nominal
I/O 3 J10-14 (DI)	B-36	89G5	Accessory Pressure Switch	12 Volts Nominal
I/O 3 J10-15 (DI)	D-08	89Y3	Front Drum Park Brake Switch	12 Volts Nominal
I/O 3 J10-16 (DI)	D-09	89X3	Rear Drum Park Brake Switch	12 Volts Nominal
I/O 3 J10-17 (DI)	D-10	89T4	Boom Drum Park Brake Switch	12 Volts Nominal
I/O 3 J10-18 (DI)	D-11	89B4	Travel Park Brake Switch	12 Volts Nominal
I/O 3 J10-19 (DI)	D-12	89S4	Auxiliary Drum Park Brake Switch	12 Volts Nominal
I/O 3 J10-20 (DI)	D-13	89R1	Auxiliary Drum Minimum Bail Limit Switch	12 Volts Nominal
I/O 3 J10-23 (DO)	D-26	56A	Counterweight Pins Retract Solenoid	12 Volts Nominal
I/O 3 J10-23-24 (DO)	D-27	80N	Front Drum Rotation Indicator	12 Volts Nominal
I/O 3 J10-25-26 (DO)	D-28	81N	Rear Drum Rotation Indicator	12 Volts Nominal
I/O 3 J10-27-28 (DO)	D-29	82N	Boom Drum Rotation Indicator	12 Volts Nominal
I/O 3 J10-29-30 (DO)	D-30	86N	Auxiliary Drum Rotation Indicator	12 Volts Nominal
I/O 3 J10-31-32 (DO)	D-31	84R	High Speed Travel Solenoid	12 Volts Nominal
I/O 3 J10-33-34 (DO)	D-32	80R	Front Drum Pawl Enable Solenoid	12 Volts Nominal
I/O 3 J10-35-36 (DO)	D-33	80RA	Front Drum Pawl Disable Solenoid	12 Volts Nominal
I/O 3 J10-37-38 (DO)	D-34	81R	Rear Drum Pawl Enable Solenoid	12 Volts Nominal
I/O 3 J10-39-40 (DO)	D-35	81RA	Rear Drum Pawl Disable Solenoid	12 Volts Nominal
I/O 3 J10-41 (AO)	C-23	84A	Left Track Pump Control (Servo Driver 5)	0 to 2.8 ± 10% (110 mA) Volts Reverse; 0 to -2.8 ± 10% (-110 mA) Volts Forward
I/O 3 J10-42 (AO)	C-24	85A	Swing Pump Control (Servo Driver 6)	0 to 2.8 ± 10% (110 mA) Volts Right; 0 to -2.8 ± 10% (-110 mA) Volts Left
I/O 4 J12-01 (DI)	E-25		Spare	
I/O 4 J12-02 (DI)	E-26		Spare	
I/O 4 J12-03 (DI)	E-27		Spare	
I/O 4 J12-04 (DI)	E-28		Spare	
I/O 4 J12-06 (AO)	E-30	86MC	Auxiliary Drum Motor Control	0 Volts to 1/3 Handle Motion 0.96 to 2.19 Volts 1/3 Full Handle Motion
I/O 4 J12-07 (DI)	D-14		Spare	
I/O 4 J12-08 (DI)	D-15	85EA	Swing Park Brake Switch	12 Volts Nominal

Board (Signal Type)	Pin	Wire	Description	Test Voltage (DC unless otherwise specified)
I/O 4 J12-09 (DI)	E-13		Spare	
I/O 4 J12-10 (DI)	E-14	89E4	Main Charge Filter Pressure Switch	12 Volts Nominal
I/O 4 J12-11 (DI)	E-15	89N4	Auxiliary Drum Charge Filter Pressure Switch	12 Volts Nominal
I/O 4 J12-12 (DI)	E-16		Spare	
I/O 4 J12-13 (DI)	E-17	89H5	Free Fall Filter Alarm	12 Volts Nominal
I/O 4 J12-14 (DI)	E-18	89T3	Engine Oil Pressure Switch	12 Volts Nominal
I/O 4 J12-15 (DI)	E-19	89U3	Engine Coolant Temperature Switch	0 Volts
I/O 4 J12-16 (DI)	E-20		Spare	
I/O 4 J12-17 (DI)	E-21		Spare	
I/O 4 J12-18 (DI)	E-22		Spare	
I/O 4 J12-19 (DI)	E-23		Spare	
I/O 4 J12-20 (DI)	E-24		Spare	
I/O 4 J12-21-22 (DO)	D-36	82R	Boom Drum Pawl Enable Solenoid	12 Volts Nominal
I/O 4 J12-23-24 (DO)	D-37	82RA	Boom Drum Pawl Disable Solenoid	12 Volts Nominal
I/O 4 J12-25-26 (DO)	E-33	80G	Rotating Bed Auto-Lube Relay	12 Volts Nominal
I/O 4 J12-27-28 (DO)	E-34	85G	Swing Auto-Lube Relay	12 Volts Nominal
I/O 4 J12-29 30 (DO)	E-35	84G	Tracks Auto-Lube Relay	12 Volts Nominal
I/O 4 J12-31-32 (DO)	E-36	86A	Auxiliary Drum Pump Control Up	0 to 2.8 ± 10% (110 mA) Volts
I/O 4 J12-33-34 (DO)	E-37	86B	Auxiliary Drum Pump Control Down	0 to 2.8 ± 10% (110 mA) Volts

Master Node Pin Identification

Master Node installed on Cranestar equipped and Tier 4.

Pin #	Function Type	Description	Test Voltage (DC unless otherwise specified)
P11	Receptacle – Front Console Master Node (Unused Terminals are Omitted)		
P11-01	24 Volts	24VDC Power Bus	24 Volts Nominal
P11-03	DI-12	Load Indicator Scroll Up Switch	0 Volts Off; 24 Volts On
P11-04	DI-14	Load Indicator Scroll Down Switch	0 Volts Off; 24 Volts On
P11-05	DI-31	Load Indicator Select Switch	0 Volts Off; 24 Volts On
P11-06	DI-9	Load Indicator Confirm Switch	0 Volts Off; 24 Volts On
P11-08	DO-3	Load Indicator Warning LED	0 Volts Off; 24 Volts On
P11-09	DO-8	Beacon Alarm	0 Volts Off; 24 Volts On
P11-10	DO-6	Load Indicator Caution LED	0 Volts Off; 24 Volts On
P11-11	24 Volts	24VDC Power Bus	24 Volts Nominal
P11-18	DO-4	System Fault Beeper Alarm	0 Volts Off; 24 Volts On
P11-19	DO-7	Load Indicator Operator Cab Alarm	0 Volts Off; 24 Volts On
P11-20	DO-5	Operating Limit Buzzer	0 Volts Off; 24 Volts On
P11-27	DO-1Grd	CAN System Ground	Ground
P11-28	DO-2 Grd	CAN System Ground	Ground
P11-30	DO-4 Grd	CAN System Ground	Ground
P11-31	CANH	CAN-Hi Data Line	N/A
P11-32	CANL	CAN-Low Data Line	N/A
P11-37	DO-5 Grd	CAN System Ground	Ground
P12	Receptacle – Front Console Master Node (Unused Terminals are Omitted)		
P12-01	24 Volts	24VDC Power Bus	24 Volts Nominal
P12-02	Display	Screen Contrast Positive	N/A
P12-06	DI-2	Data Logger Enable	0 Volts Off; 24 Volts On
P12-07	DO-9	High Exhaust System Temperature Amber LED	0 Volts Off; 24 Volts On
P12-08	DO-11	Rear Drum 2 Free Fall Amber LED	0 Volts Off; 24 Volts On
P12-09	DO-16	Operating Limit Amber LED	0 Volts Off; 24 Volts On
P12-10	DO-14	Diesel Particulate Filter Amber LED	0 Volts Off; 24 Volts On
P12-11	24 Volts	24VDC Power Bus	24 Volts Nominal
P12-12	Display	Screen Contrast Wiper Adjust	N/A
P12-17	DO-10	Front Drum 1 Free Fall Amber LED	0 Volts Off; 24 Volts On
P12-19	DO-15	System Fault Red LED	0 Volts Off; 24 Volts On
P12-20	DO-13	DPF Regen Disable (Inhibit) Amber LED	0 Volts Off; 24 Volts On
P12-21	Logic Grd	CAN System Ground	Ground
P12-22	Display	Screen Contrast Negative	N/A
P12-27	DO-9 Grd	CAN System Ground	Ground
P12-28	DO-10 Grd	CAN System Ground	Ground
P12-29	DO-11 Grd	CAN System Ground	Ground
P12-31	CANH	CAN-Hi Data Line (CraneSTAR)	N/A
P12-32	CANL	CAN-Low Data Line (CraneSTAR)	N/A
P12-33	DI-19	DPF Regen Switch ON (initiate)	0 Volts Off; 24 Volts On

Pin #	Function Type	Description	Test Voltage (DC unless otherwise specified)
P12-34	DI-21	DPF Regen Switch OFF (disable)	0 Volts Off; 24 Volts On
P2	Data Download/Upload Receptacle – Front Console Master Node		
P2-1	Data TX1	RX1-35 Receive	Variable 6 to 7 Volts Nominal
P2-2	Data RX1	TX1-34 Transmit	Variable 6 to 7 Volts Nominal
P2-3	Data X	Load Indicator Data Download	N/A
P2-4	Logic Grd	Ground	Ground

DISPLAY READINGS

The display allows the operator to monitor three groups of crane information: operating conditions (normal and diagnostic), operating limits, and system faults.

Depress top or bottom of digital display selector to scroll up or down through the display readings. Release the selector when the desired information is displayed.

To access the diagnostic screens:

1. Turn limit bypass key clockwise and hold.
2. Scroll up at least one screen, release key, and scroll up or down until desired screen appears.

To turn off diagnostic screens:

1. Turn limit bypass key clockwise and hold.
2. Scroll down at least one screen and release key.

Stopping engine will also turn off diagnostic screens.

See [Table 3-5](#) for a list of abbreviations used in the tables.

See [Table 3-6](#) for drum and pump identification.

Operating Conditions

[Table 3-2](#) lists operating conditions which can be displayed and the normal operating range of each.

When an operating condition is selected (such as ENGINE SPEED), the current status of the condition displays (see [Figure 3-9](#)).

ENGINE SPEED
900 RPM

FIGURE 3-9

Operating Limits

[Table 3-3](#) lists operating limits which can be displayed.

When one or more operating limits is reached, the operating limit alert (yellow light and buzzer in cab) turns on to warn the operator. At the same time, the operating limit display immediately appears (see [Figure 3-10](#)) and automatically scrolls through the names of the limits, stopping at each for approximately three seconds.

OPERATING LIMIT
BLOCK UP

FIGURE 3-10

The operating limit alert turns off when the cause of each limit is corrected. The name of each limit reached during operation is retained in memory, however, *until two things happen*:

1. Name of limit appears on display at least once.
2. Cause of limit is corrected.

For this reason, it is normal for the names of limits to appear when you scroll to the operating limit group, even when the operating limit alert is off.

To erase the names of inactive limits, scroll to the operating limit group. Wait until the display scrolls through the name of each limit. The names of inactive limits will be erased automatically. If the alert is on, only the names of active limits will remain.

NO FAULT appears on the display (see [Figure 3-11](#)) when no limits have been reached.

OPERATING LIMIT
NO FAULT

FIGURE 3-11

System Faults

[Table 3-4](#) lists system faults which can be displayed.

When one or more system faults occur, the system fault alert (red light and beeper in cab) turns on to warn the operator. At the same time, the system fault display immediately appears (see [Figure 3-12](#)) and automatically scrolls through the names of the faults, stopping at each for approximately three seconds.

SYSTEM FAULT
ENGINE OIL PRESSURE

FIGURE 3-12

The system fault alert turns off when the cause of each fault is corrected. The name of each fault that has occurred during operation is retained in memory, however, *until two things happen*:

1. Name of fault appears on display at least once.
2. Cause of fault is corrected.

For this reason, it is normal for the names of faults to appear when you scroll to the system fault group, even when the system fault alert is off.

To erase the names of inactive faults, scroll to the system fault group. Wait until the display scrolls through the name of each fault. The names of inactive faults will be erased automatically. If the alert is on, only the names of active faults will remain.

NO FAULT appears on the display (see [Figure 3-13](#)) when there are no faults.

SYSTEM FAULT
NO FAULT

FIGURE 3-13

Selecting Display Language

Software for the Model 999 contains English and several foreign-language display readings. When a new computer chip is installed, any one of the languages could appear on the screen when the system is powered up the first time. Once the desired language is selected, it will remain in memory until another language is selected.

To select a different display language, perform both of the following steps at the same time:

1. Depress limit bypass switch.
2. Turn digital display confirm/select key switch to "confirm" position.
3. Repeat steps until the screen displays desired language.

Table 3-2 Operating Conditions

Listed below are the operating conditions that can be viewed on the display.

Display Reading	Unit of Measure	Operating Range
NORMAL OPERATING CONDITIONS		
ENGINE SPEED	RPM	1,000 rpm low idle; 1,800 rpm high idle
BOOM ANGLE	DEG	Degrees boom is positioned above horizontal. [3]
JIB ANGLE [1]	DEG	Degrees luffing jib is positioned above horizontal.
BOOM TO LUFF JIB ANG [1]	DEG	Degrees between centerline of boom and centerline of luffing jib.
BOOM ANGLE JIB ANGLE [1]	DEG	Combination screen that displays both angles at same time.
MAST ANGLE	DEG	Degrees mast is positioned above transport position [2].
CRANE MODE (name of mode)	—	See E1. Crane Mode Selector in Section 3 of the Operator Manual for procedure to select and confirm desired crane mode.
DIAGNOSTIC SCREENS		
HYD TANK FLUID TEMP	DEG F	Temperature of oil in hydraulic tank.
HYD TANK FLUID LEVEL	%	0-100% of oil remaining in tank.
A1, A2, A3	2 Rows of numbers	These numbers are used to monitor and troubleshoot controls and hydraulic systems. See Crane Diagnostics .
D1, D2, D3		
DRUM 1, 2, 4, 8		
FFALL		
SWING		
TRACKS		
ACC		
RIN	—	See RIN under Crane Diagnostics .
SWING SPEED	%	See Swing Speed/Torque Adjustment in Operator Manual.
SWING TORQUE	%	
DRUM _ SLIP	%	See Freefall Drum Slip Adjustment in Operator Manual.
HYD SYSTEM CHECK	—	See Hydraulic System Calibration in Section 2.
PROGRAM M000001.0JP CON 00000000000	—	Computer Program Version and Crane Configuration Code. The Manitowoc Crane Care Lattice Team will request these numbers when troubleshooting crane problems.

[1] Optional Item

[2] Mast angles are measured from transport position, which is 0°.

[3] Angles at which boom stops vary with attachment. See Limit Devices in this section for specifications.

Table 3-3 Operating Limits

Listed below are the limits which turn on the operating limit alert (yellow light and continuous buzzer). When the alert comes on, the OPERATING LIMIT group of the display will indicate which limit has been reached. Take corrective action.

Display Reading	Function Response	Corrective Action
BLOCK UP	Stops load drums from hoisting and boom/luffing jib from lowering.	Lower corresponding load or raise boom or jib
MAX DOWN	Stops boom from lowering (limit usually set at 0°). Stops luffing jib from lowering when boom to luffing jib angle is: <ul style="list-style-type: none"> • 60° – #135 Luffing Jib. • 55° – #149 Luffing Jib. 	Raise boom or luffing jib
MAX UP 1	Stops boom from rising when maximum up limit is reached. Stops luffing jib from rising when boom to jib angle is 168°. This angle can be bypassed to raise jib to MAXIMUM UP 2 angle of 170°.	Lower boom/luffing jib
MAX UP 2 [1]	Stops luffing jib from rising when boom to jib angle is 170°. This limit can be bypassed only when boom is below 50°.	Lower luffing jib
CONFIRM MODE	Load drums and boom hoist inoperable until an operating mode is selected and confirmed.	Select and confirm the desired operating mode (see instruction in this section)
MAX BAIL	Drum stops hoisting.	Operate drum in lowering direction
MIN BAIL	Drum stops lowering.	Operate drum in hoisting direction
GANTRY DOWN [2]	Boom hoist inoperable in both directions if gantry is down when mast angle is 120° or more.	Raise gantry with switch on remote control
JIB BELOW HORIZONTAL [1]	Luffing jib operable. See capacity chart for luffing jib minimum operating angles.	Raise luffing jib above horizontal
LOAD MOMENT [1]	Stops all load drums from hoisting and boom/luffing jib from lowering.	Land load on load drum or raise boom or jib
MAST TOO FAR FWD [2]	Boom hoist inoperable in lowering direction (occurs if mast is lowered below 175°).	Raise mast. Further lowering is not intended – mast will fall
MAST SYSTEM	Boom hoist inoperable in both directions.	Stop operating immediately. Determine cause of fault – faulty boom hoist and/or accessory system pressure sender – and correct
FUNCTION IS PARKED	Function inoperable because it is parked.	Turn corresponding park switch off and sit down in operator's seat

[1] Optional item

[2] Mast angles are measured from transport position, which is 0°.

Table 3-4 System Faults

Listed below are the faults which turn on the system fault alert (red light and beeper). When the alert comes on, the SYSTEM FAULT group of the digital display will indicate which fault has occurred. Take corrective action. The beeper sounds intermittently.

Display Reading	Function Response	Cause of Fault
BOOM ANGLE SENDER	All functions operable, but BOOM ANGLE and BOOM TO LUFF JIB ANG display will be faulty; correct cause of angle sender fault as soon as possible.	Sender output voltage 0 volts or above 9.7 volts. Fault not active when crane is in SETUP mode
ENGINE OIL PRESSURE	Does not affect operation. Correct cause of low oil pressure as soon as possible to prevent engine damage.	Oil pressure below 15 psi (1 bar)
ENGINE TEMPERATURE	Does not affect operation. Correct cause of overheating as soon as possible to prevent engine damage.	Engine coolant temperature above 205°F (96°C)
HYD TANK FLUID TEMP	Does not affect operation. Reduce loads and/or speeds to allow oil to cool.	Oil temperature in hydraulic tank above 180°F (82°C)
HYD TANK FLUID LEVEL	Does not affect operation. Fill tank as soon as possible.	Hydraulic oil at CAUTION LOW LEVEL indicated on tank gauge
MAIN CHARGE FILTER	All functions operable. Replace filters as soon as possible.	Filters are dirty.
AUX DRUM CHR G FILTER	All functions operable. Replace filter as soon as possible.	Filter is dirty.
FFALL FILTER	Replace filter(s) as soon as possible.	Filter(s) is dirty.
HYD SUCTION FILTER	Oil flow through suction screen inside hydraulic tank blocked.	Remove blockage immediately or hydraulic pumps will be damaged from cavitation
LUFF JIB ANGLE SEND [1]	All functions operable, but JIB ANGLE and BOOM TO LUFF JIB ANG display will be faulty; correct cause of angle sender fault as soon as possible.	Sender output voltage 0 volts or above 9.7 volts. Fault not active when crane is in SETUP mode.
MAST SYSTEM	Mast is disabled.	Stop operating. Find causes of fault and correct.

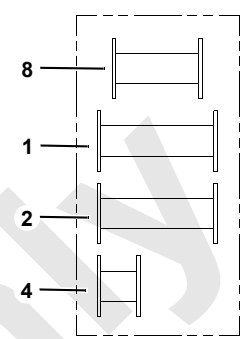
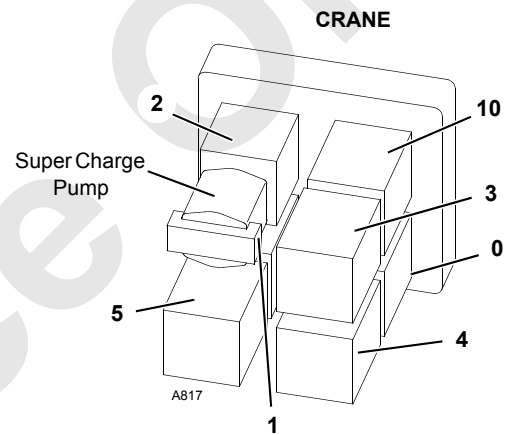
[1] Optional item

Table 3-5 Display Abbreviations

Abbreviation	Definition
+	Plus
-	Minus
%	Percent
A1	Handle Inputs
A2	Pump Control Outputs
A3	Programmer's Screen
ANG	Angle
AUX	Auxiliary
CALIB	Calibration
CHRG	Charge
CON	Configuration
D1	Digital On-Off Inputs
D2	Digital Inputs
D3	Digital Inputs or Outputs
DEG	Degrees (angle)
DEG F	Degrees Fahrenheit
FWD	Forward
FFall	Free Fall
HYD	Hydraulic
LUFF	Luffing
MIN	Minimum
MAX	Maximum
PRESS	Pressure
PSI	Pounds Per Square Inch
PSIA	Pounds Per Square Inch Absolute
RPM	Revolution Per Minute
RIN	Remote Input Node
SEND	Sender
SYS	System
TEMP	Temperature

Table 3-6 Drum and Pump Identification

Drum Number	Drum
1	Front Load Drum
2	Rear Load Drum
4	Boom Hoist
8	Auxiliary Load Drum (in boom butt)

Pump Identification

Pump Number	Crane
0	Front Load Drum
1	Rear Load Drum or Luffing Hoist
2	Boom Hoist
3	Swing
4	Right Crawler
5	Left Crawler
10	Auxiliary Load Drum (in butt)

CRANE DIAGNOSTICS

To activate the diagnostic display screens, turn the limit bypass key clockwise and scroll up at least one screen.

To deactivate the diagnostic screens, turn the limit bypass key clockwise and scroll down at least one screen. The normal operating screens will remain active.

The diagnostic display provides information about the status of all main crane components as well as the controller inputs and outputs during operation. The screen types are:

- Screens that display information about particular crane functions — DRUMS 1, 2, 4, and 8, SWING, TRACK, RIN, and ACCESSORY SYSTEM.
- Screens that display digital input and output information — A1 (analog handle inputs to crane controller), D1 (digital outputs from crane controller), and D2 (digital inputs to crane controller).
- Screens that display controller programming information — A2, A3, and D3. These screens are for factory use only, and are not shown.
- Screens that display hydraulic system calibration information — HYD SYSTEM CHECK. Check includes pressure sender, charge pressure, control calibration, and pump pressure.
- Program screens, SWING SPEED/TORQUE, and DRUM SLIP.

See [Table 3-6](#) for Drum and Pump Identification.

Drum 1 and 2 (Front and Rear Drum)

<u> 1 </u>	<u> 2 </u>	<u> 3 </u>	<u> 4 </u>	<u> 5 </u>
<u> 6 </u>	<u> 7 </u>			DRUM X

1. The handle command in percent from neutral (+ raise and - lower). For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.
2. The pump command in percent from neutral (+ raise and - lower).
3. The motor command is in percent (0% is maximum displacement, 100% is minimum displacement).
4. Parking brake command (1 release, 0 engage).
5. Clutch command (1 release, 0 engage) (applies only to drums with free fall, otherwise has no meaning).
6. Measured pump pressure (port A) in psi.
7. Measured drum speed in rpm (+ raise and - lower).

X is where the corresponding drum number appears.

Drum 4 (Boom Hoist)

<u> 1 </u>	<u> 2 </u>	<u> 3 </u>	<u> 4 </u>
<u> 5 </u>	<u> 6 </u>		DRUM 4

1. The handle command is in percent from neutral (+ raise and - lower). For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.
2. The pump command is in percent from neutral (+ raise and - lower).
3. The motor command is in percent (0% is maximum displacement, 100% is minimum displacement).
4. Park brake command (1 release, 0 engage).
5. Measured pump pressure (raise) in psi.
6. Measured drum speed in rpm (+ raise and - lower).

Drum 8 (Auxiliary)

<u> 1 </u>	<u> 2 </u>	<u> 3 </u>	<u> 4 </u>
<u> 5 </u>	<u> 6 </u>		DRUM 8

1. The handle command in percent from neutral (+ raise and - lower). For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.
2. The pump command is in percent from neutral (+ raise and - lower).
3. The motor command is in percent (0% is maximum displacement, 100% is minimum displacement).
4. Park brake command (1 release, 0 engage).
5. Measured pump pressure (raise) in psi.
6. Measured drum speed in rpm (+ raise and - lower).

FFall

<u> 1 </u>	<u> 2 </u>	<u> 3 </u>	<u> 4 </u>
<u> 5 </u>	<u> 6 </u>	<u> 7 </u>	<u> 8 </u>
			FFALL

1. The drum 1 pedal command is in percent (0% applied, 100% fully released).
2. Drum 1 PC output to proportional valve in percent of pressure (0% to 100%).
3. Drum 1 measured pressure to clutch/brake piston in psi.
4. Drum 1 clutch/brake command is (0 disengaged, 1 engaged).

5. Drum 2 pedal command is in percent (0% applied, 100% fully released).
6. Drum 2 PC output to proportional valve in percent of pressure (0% to 100%).
7. Drum 2 measured pressure to clutch/brake piston in psi.
8. Drum 2 clutch/brake command is (0 disengaged, 1 engaged).

Swing

_ 1 _	_ 2 _	SWING
_ 3 _	_ 4 _	

1. The handle command is in percent from neutral (+ right and - left). For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.
2. The pump command is in percent from neutral (+ right and - left).
3. Measured pump pressure swing right (port A) in psi.
4. Measured pump pressure swing left (port B) in psi.

Swing Speed/Torque

See Swing Speed/Torque Adjustment in Operator Manual.

Drum Slip

See Free Fall Drum Slip Adjustment in Operator Manual.

Track

_ 1 _	_ 2 _	_ 3 _	_ 4 _	TRACK
_ 5 _	_ 6 _	_ 7 _		

1. The right handle/pedal command is in percent from neutral (+ forward, - backward). For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.
2. The right pump command is in percent from neutral (+ forward, - backward).
3. The left handle/pedal command is in percent from neutral (+ forward, - backward). For certain operating conditions the handle command can be set to neutral by the controller even if the handle is not in neutral.
4. Left pump command in percent from neutral (+ forward, - backward).
5. Measured system pressure right track in psi.
6. Measured system pressure left track in psi.

7. Parking brake command (1 release, 0 engage).

RIN

Depending on the crane configuration, RIN computers are mounted in the universal boom top junction box, luffing jib top junction box, or fixed jib top junction box (Figure 3-14).

The junction boxes are interconnected in series with electrical cords that run up the boom to the last attachment component. The RIN computer in universal boom top junction box receives inputs from load sensors, limit switches, angle sensors, and other RIN computers in series.

The RIN computer in universal boom top junction box transmits output information to crane EPIC computer in operator's cab.

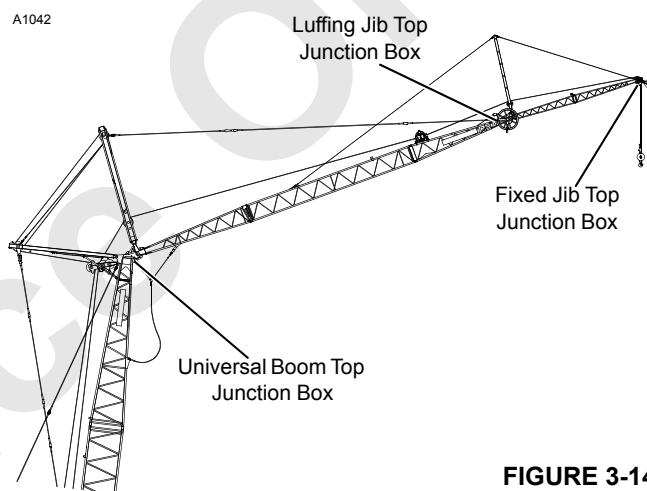


FIGURE 3-14

The RIN diagnostic screen is to assist in troubleshooting the boom top, luffing jib or fixed jib electrical system.

_ 1 _	_ 2 _	_ 3 _	_ 4 _	RIN
_ 5 _	_ 6 _	_ 7 _	_ 8 _	

The following voltages can be displayed on the first six banks of the RIN diagnostic screen. These voltage values can be compared with the voltages shown on the LMI (Rated Capacity Indicator/Limiter) diagnostic screen.

If the voltages do not match, the EPIC computer and the LMI are not communicating properly.

Bank 1	—	Boom Angle
Bank 2	—	Luffing Jib Angle
Bank 3	—	Lower Boom Point
Bank 4	—	Upper Boom Point
Bank 5	—	Lower Luffing Jib Point
Bank 6	—	Upper Luffing Jib Point or Fixed Jib Point

Bank 7 indicates the RIN digital inputs. For example, if Bank 7 displays the number 72, see [Table 3-9](#) and the shaded boxes in row 72. This indicates that Jib Maximum Up Working Limit (8) and Block-Up Limit – Luffing Jib Point (64) inputs (8 + 64 = 72) are active.

1	—	Block-Up Limit (Boom Point)
2	—	Block-Up Limit (Boom Point)
4	—	Jib Max Down Limit
8	—	Jib Max Up 1 Limit
16	—	Jib Max Up 2 Limit
32	—	Block-Up Limit (Luffing Jib/Fixed Jib Point)
64	—	Block-Up Limit (Luffing Jib Point)
128	—	Block-Up Limit (Fixed Jib on Luffing Jib Point)

To end the RIN circuit at the last used junction box, a **shorting plug** must be plugged into junction box jib cable receptacle. If shorting plug is not installed, the RIN computer sees an open circuit and assumes the electrical cable to next junction box is open. The RIN circuit turns off one or more block-up limit identifiers (switches) depending on where the open circuit exists.

With an open RIN circuit at boom top junction box jib cable receptacle, Bank 7 numbers 32, 64, and 128 are off. With an open RIN circuit at luffing jib top junction box jib cable receptacle, Bank 7 number 128 is off.

Bank 8 indicates the status of each RIN computer as shown below.

0	—	EPIC computer is communicating with boom top RIN computer.
1	—	EPIC computer is communicating with boom top RIN computer, but there is a communication fault internal to universal boom top junction box RIN computer.
2	—	EPIC computer is communicating properly with boom top RIN computer and boom top RIN computer is communicating properly with at least one other RIN computer in series.
4	—	Shorting plug is installed to cable connector end at boom limit junction box or at cable reel to bypass operating limit fault(s).
8	—	No communication, all boom top operating limits are activated when a drum control handle is moved from neutral.

Accessory System

__1__	__2__	__3__	__4__	
__5__	__6__	__7__		ACC

1. Rear drum/accessory system pump command in percent from neutral (+ retract mast cylinders; – extend mast cylinders).
2. Desired accessory system pressure in psi.
3. Actual accessory system pressure in psi.
4. Rear drum measured pump pressure (hoist) in psi.
5. The boom hoist pump command in percent from neutral (+ lower mast; – raise mast).
6. Boom hoist measured pump pressure (hoist) in psi.
7. Accessory system switches:
 - 1 - Raise Gantry Remote Switch
 - 2 - Lower Gantry Remote Switch
 - 4 - Mast Raise Switch
 - 8 - Mast Lower Switch
 - 16 - Boom Hinge Pins In Switch
 - 32 - Boom Hinge Pins Out Switch
 - 64 - Accessory System Enable Switch
 - 128 - Spare

Engine Throttle

__1__	__2__	
__3__		ENG THROTTLE

1. Throttle pedal - is expressed in *counts* 0 to 25 = low idle and up to 230 to 255 = high idle.
2. Throttle Lever - is expressed in *counts* 0 to 25 = low idle and up to 230 to 255 = high idle.
3. Throttle Command - is expressed in *Hertz* with Cummins engines — 100 Hz = low idle and 305 Hz = high idle.
 Throttle Command - is expressed in *percent* with Caterpillar engines — <20% = high idle and 70% = low idle.

A1 (Handles)

The variable control handle output voltage is represented in the controller by a number between 0 (0 Volts) and 255 (10 Volts). Diagnostic screen A1 displays this number for each of the control handles/pedals. The normal operating outputs of the handles range from:

- Approximately 38 (1.5 Volts) to 120 (4.7 Volts) for lower/reverse/right.
- Approximately 136 (5.3 Volts) to 215 (8.5 Volts) for raise/forward/left.

NOTE: Some dual-axis handles (joysticks) are internally limited and will not put out the full range stated.

A switch opens when the handle is in the neutral range of (4.7 – 5.3 volts). In the neutral range, the screen reads 0 volts.

1	_2_	_3_	_4_	_5_
6	_7_	_8_	_9_	A1

- Handle 1 – Front Drum
- Handle 2 – Rear Drum
- Handle 3 – Boom Hoist
- Handle 4 – Swing
- Handle 5 – Right Track
- Handle 6 – Left Track
- Handle 7 – Auxiliary Drum
- Pedal 1 – Right Track
- Pedal 2 – Left Track

D1, D2, and D3 (Digital Outputs and Inputs)

The status of the digital outputs from the controller and the inputs to the controller is displayed in several banks in screens D1, D2, and D3. Each bank can indicate the state of up to nine individual digital inputs or outputs.

1	_2_	_3_	_4_	_5_
6	_7_	_8_	_9_	DX

1 – 9 is the bank number.

X corresponds to digital screen number (1, 2, or 3).

Each individual input/output is assigned a number (identifier) in the binary system (powers of two). The identifiers of all inputs/outputs that are ON (active), are added to a total in each bank. Thus, the number displayed for each bank is the sum of all identifiers of the inputs/outputs that are ON (0 – 255). With this system, each possible ON/OFF combination per bank has a unique total.

For identification of the digital outputs and inputs (and the crane components connected to them) see Tables 3-7 and 3-8.

To determine the state of the individual inputs/outputs in a bank, find the number displayed for the bank in the first column in Table 3-9. In the corresponding row the identifier numbers that are ON (active) in the bank are shaded. Use Tables 3-7 and 3-8 to identify the crane components associated with the identifiers for the corresponding bank.

If number displayed for short bank is more than the total of all bank identifiers, add missing identifier numbers (64 + 128 = 192) and subtract from displayed number to obtain remaining identifier number(s).

Example 1: The number displayed in Bank 4 of screen D2 of the digital display is 41. Go to row number 41 in Table 3-9. The boxes for identifiers 1, 8 and 32 are shaded in this row, indicating that the corresponding inputs are active. Find the component description for the identifiers in Table 3-8,

Bank 4. In this example, the inputs for Front Drum Brake Switch (1), Display Scroll Up (8) and Gantry Lower Switch (32) are active.

Example 2: You want to know if the controller output for the rear drum clutch is ON. In Table 3-7 you will find Rear Drum Clutch in Bank 1 (identifier 64). Look up the current number for Bank 1 in screen D1 on the digital display (e.g. 152). Then go to the corresponding row number (152) in Table 3-9. Identifier 64 box is not shaded in this row, indicating that the controller output to the rear drum clutch is OFF.

NOTE: All numbers in screen D1 and the pump/motor command values in screens DRUM, SWING and TRACK represent controller commands to the corresponding output devices only. The state of a certain output port on the controller may not necessarily correspond to the actual state of the associated crane component (brake valve, clutch valve, etc.), since the connection between the controller and the component may be faulty due to loose connections, corroded terminals, broken wiring, or improperly operating components.

Table 3-7 D1 (Crane Digital Outputs)

Identifier*	Component
Bank 1	
1	Auxiliary Drum Pawl Enabled
2	Auxiliary Drum Pawl Disabled
4	Boom Hoist Park Brake
8	Travel Park Brake
16	Engine Clutch Cylinder Direction
32	Front Drum Proportional Valve
64	Rear Drum Proportional Valve
128	Front Drum Brake
Bank 2	
1	Rear Drum Brake
2	Engine Clutch Cylinder Speed
Bank 3	
1	Auxiliary Drum Park Brake
2	Boom Hinge Pins Retract
4	Motion Alarm
8	Front Drum Enable Valve
16	Rear Drum Enable Valve
32	Gantry Cylinders Extend
64	Gantry Cylinders Retract
128	Mast Cylinders Extend
Bank 4	
1	Mast Cylinders Retract
2	Boom Hinge Pins Extend
Bank 5	
1	Counterweight Pins Retract
2	Front Drum Rotation Indicator
4	Rear Drum Rotation Indicator
8	Boom Drum Rotation Indicator
16	Auxiliary Drum Rotation Indicator
32	High Speed Travel
64	Front Drum Pawl Enabled
128	Front Drum Pawl Disabled
Bank 6	
1	Rear Drum Pawl Enabled
2	Rear Drum Pawl Disabled
Bank 7	
1	Boom Drum Pawl Enabled
2	Boom Drum Pawl Disabled
4	Rotating Bed Auto-Lube
8	Swing Auto-Lube
16	Travel Auto-Lube
32	Auxiliary Drum Pump Control Up **
64	Auxiliary Drum Pump Control Down **
128	Not Used
Bank 8	
Not used	
* Binary	
**	These digital ports are pulsed for auxiliary pump control. For both ports a digital ON is displayed when pulsing, to prevent a flickering number for the corresponding bank.

Table 3-8 D2 (Crane Digital Inputs)

Identifier*	Component
Bank 1	
1	Travel Detent Set/Cancel
2	Front Drum Maximum Bail Limit
4	Front Drum Minimum Bail Limit
8	Engine Clutch Disconnect Switch
16	Boom/Jib Maximum Angle Bypass
32	Mast Raise Switch
64	Rear Drum Maximum Bail Limit
128	Rear Drum Minimum Bail Limit
Bank 2	
1	Crane Mode Select
2	Crane Mode Confirm
4	Mast Lower Switch
8	Boom Maximum Up Limit
16	Remote Output Node Feedback
32	Spare
Bank 3	
1	Spare
2	Hydraulic Fluid Level
4	Spare
8	Spare
16	Spare
32	Spare
64	Rear Drum Brake Switch
128	Gantry Up Limit
Bank 4	
1	Front Drum Brake Switch
2	Rated Capacity Indicator/Limiter
4	Limit Bypass
8	Display Scroll Up
16	Gantry Raise Switch
32	Gantry Lower Switch
Bank 5	
1	Counterweight Pins Extend Switch
2	Counterweight Pins Retract Switch
4	Boom Hinge Pins Extend Switch
8	Boom Hinge Pins Retract Switch
16	Display Scroll Down
32	Seat Safety Switch
64	High Speed Travel Switch
128	Accessory Pressure Switch
Bank 6	
1	Front Drum Park Switch
2	Rear Drum Park Switch
4	Boom Hoist Drum Park Switch
8	Travel Park Brake Switch
16	Auxiliary Drum Park Switch
32	Auxiliary Drum Minimum Bail Limit
Bank 7	
1	Spare
2	Swing Park Brake Switch
4	Spare
8	Main Charge Filters Switch
16	Auxiliary Drum Charge Filter Switch
32	Free-Fall Filters Switch
64	Spare
128	Engine Oil Pressure Switch
Bank 8	
1	Engine Temperature Switch
2	Not Used
4	Not Used
8	Not Used
16	Not Used
32	Not Used

Table 3-8 D2 (Crane Digital Inputs)

Identifier*	Component
Bank 9**	
1	Block Up Limit (Boom Top)
2	Block Up Limit (Boom Top)
4	Jib Minimum Down Working Limit
8	Jib Maximum Up Working Limit
16	Jib Maximum Up Stop
32	Block Up Limit (Luffing Jib/Fixed Jib Top)
64	Block Up Limit (Luffing Jib Top)
128	Block Up Limit (Fixed Jib on Luffing Jib Top)

* Binary
 ** Bank 9 inputs are from RIN computer, not system computer.

Handle/Pedal Identification

Handle Number	Crane (All Modes)
1	Front Load Drum
2	Rear Load Drum or Luffing Hoist*
3	Boom Hoist or Luffing Hoist**
4	Swing
5	Right Crawler
6	Left Crawler
7	Auxiliary Load Drum (in butt) or Luffing Hoist**
Pedal Number	
1	Right Crawler
2	Left Crawler
3	Front Drum Brake
4	Rear Drum Brake

* Activated only in luffing jib mode.
 ** Special handle arrangement activated only in luffing jib mode.

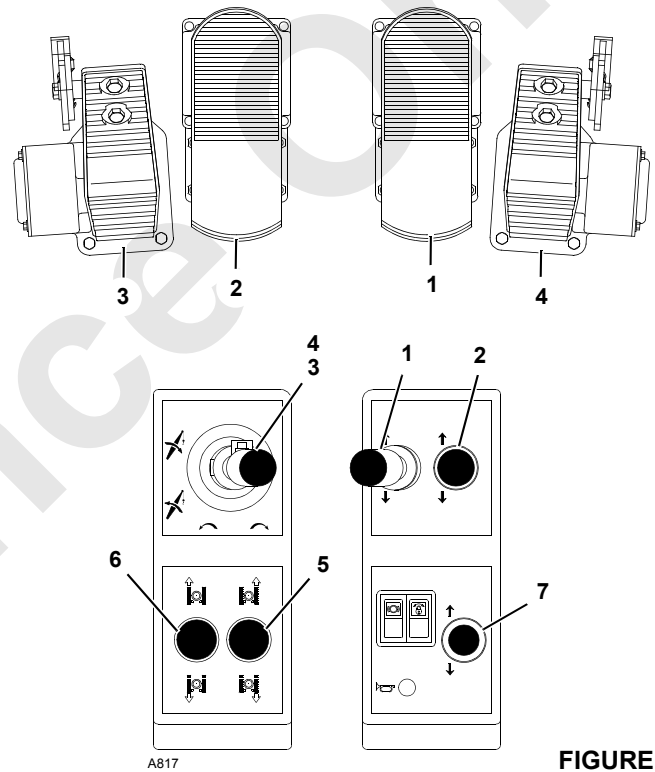


FIGURE 3-15

Table 3-9 8-Bit Binary System

	1	2	4	8	16	32	64	128
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	1	2	4	8	16	32	64	128
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128								
129								

Dark shaded boxes indicate ON; white boxes OFF.

Table 3-9 8-Bit Binary System (continued)

	1	2	4	8	16	32	64	128
130								
131								
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	1	2	4	8	16	32	64	128
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	1	2	4	8	16	32	64	128
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Dark shaded boxes indicate ON; white boxes OFF.

CPU EPROM REPLACEMENT

The central processing unit (CPU) in current production programmable controllers — to include cranes with a Tier 4 Final engine — no longer has eproms (computer chips).

For information on updating crane software, contact your Manitowoc dealer or the Manitowoc Crane Lattice Team.

DIELECTRIC GREASE

The following figures show the proper application of dielectric grease on J-tech type connectors.

Dielectric grease is need when assembling J-tech type connectors. A bead of grease needs to be applied on O-ring and face of the socket (female) connector **and only on the O-ring for a pin (male) connector**.



FIGURE 3-16

The size of the grease bead on the O-ring is as follows:

- On a 3-pin connector a 1/16 inch (1,5 mm) bead is required.
- On a 24-pin connector a 1/8 inch (3 mm) bead is required.
- On a 37-pin connector a 3/16 inch (5 mm) bead is required.

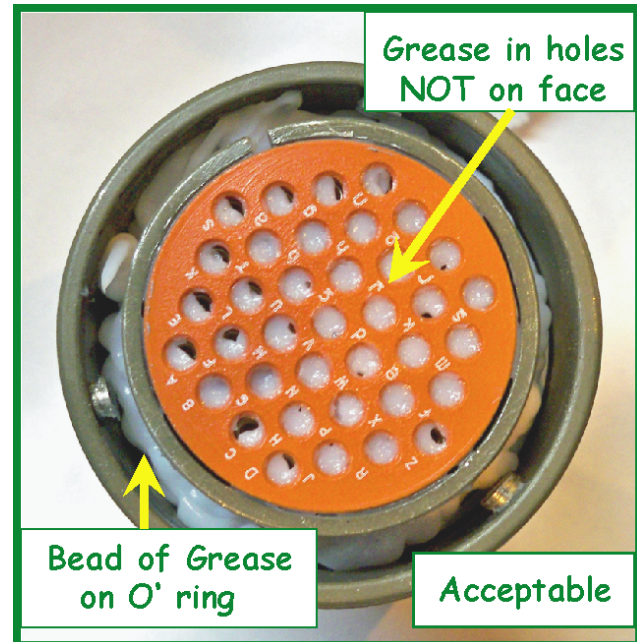


FIGURE 3-17

Place a small amount of grease on your finger for the application on the connector's face. Wipe your finger across the face leaving grease inside the socket holes and less than 0.001 inch (0,025 mm) on the connector's face. This helps assure that water will be kept out of the connectors and keep the pins from fretting.

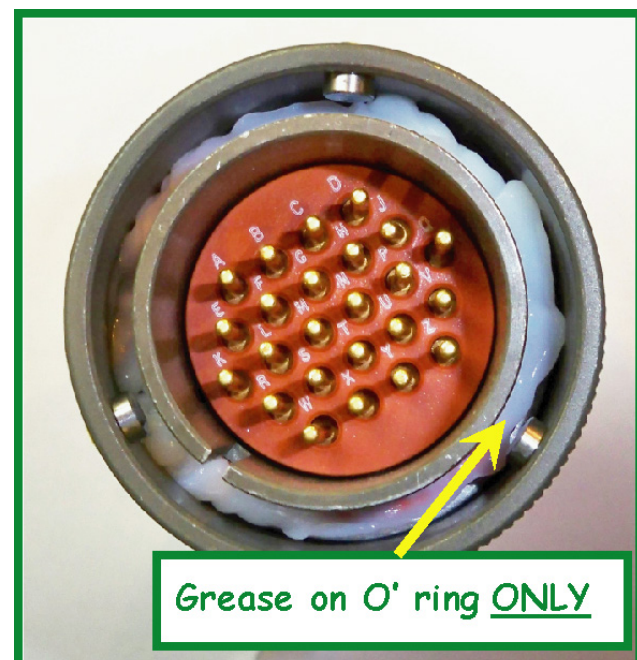


FIGURE 3-18

SECTION 4 BOOM

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SECTION 4 BOOM

AUTOMATIC BOOM STOP

Maximum Boom Angle

Boom stop limit switch assembly (5, [Figure 4-1](#)) automatically stops the boom and applies the boom hoist brake when the boom is raised to **Angle A**.

Operation

See [Figure 4-2](#) for the following description.

When the boom is below the maximum angle, limit switch (5) is closed. The boom hoist can be operated.

When the boom is raised to the maximum angle, boom butt (1) pushes adjusting rod (2a, 2b, or 2c) in and actuator rod (11, View A) opens limit switch (5). Boom hoist operation stops automatically because the open limit switch turns off power to the boom hoist electric circuit. The boom hoist pump shifts to neutral and the brake applies to stop boom movement.



WARNING

Falling Attachment Hazard!

If boom fails to stop for any reason, stop engine immediately. Troubleshoot system to determine problem.

Do not resume operation until problem has been corrected.

Maintenance

At least once weekly, check that the automatic boom stop stops the boom at the specified maximum angle. If not, replace any worn or damaged parts and/or adjust the boom stop.

Once the automatic boom stop is properly adjusted, it should not require periodic adjustment. Adjustment is required, however, when:

- The luffing jib is installed or removed.
- Parts are replaced.



WARNING

Falling Attachment Hazard!

Do not operate crane unless automatic boom stop is properly adjusted and operational. Do not adjust maximum operating angle higher than specified. Boom could be pulled over backwards or collapse, causing death or serious injury.

Table 4-1

Angle A	Adjusting Rod — Length
81° — #82 Long Reach Boom	2a — 7 in (178 mm)
82° — #22E Open-Throat Top	2a — 7 in (178 mm)
83° — #82 or 22EL Heavy Lift Boom	2a — 7 in (178 mm)
83° — #22E Open-Throat Top Offset 4-1/2°	2a — 7 in (178 mm)
88° — #82 or 22EL Heavy Lift Boom with #135 or 149 Luffing Jib when the boom up limit can be bypassed *	2b — 4-3/4 in (121 mm)
89° — #82 or 22EL Heavy Lift Boom with #135 or 149 Luffing Jib when the boom up limit cannot be bypassed *	2c — 4-3/8 in (111 mm)

* To determine if the boom up limit on your crane can be bypassed, perform Bypass Limit Test.

Bypass Limit Test

Perform the following test to determine if the boom up limit on your crane can be bypassed or not.



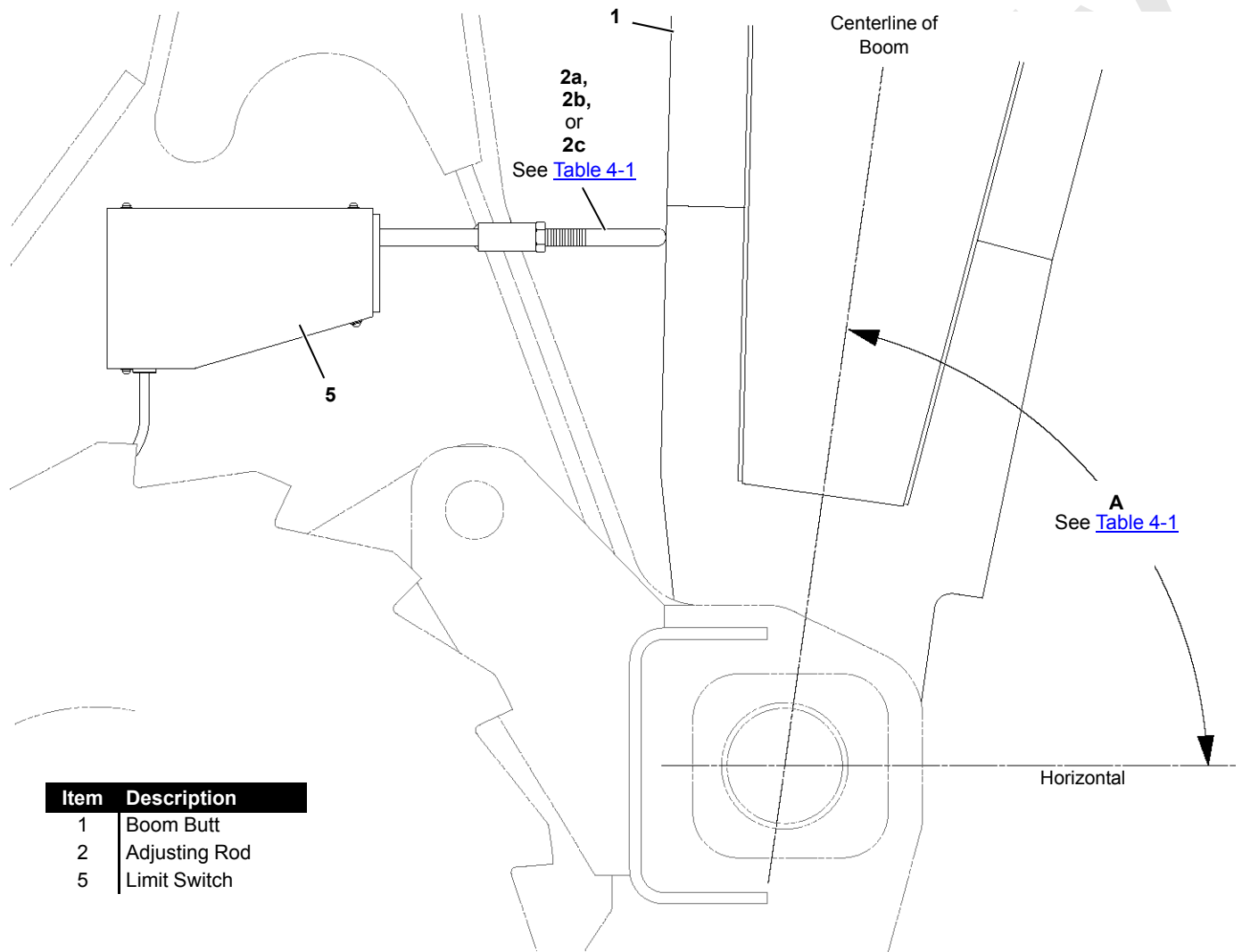
WARNING

Crush Hazard!

Maintain constant communication between operator and assistant during following steps.

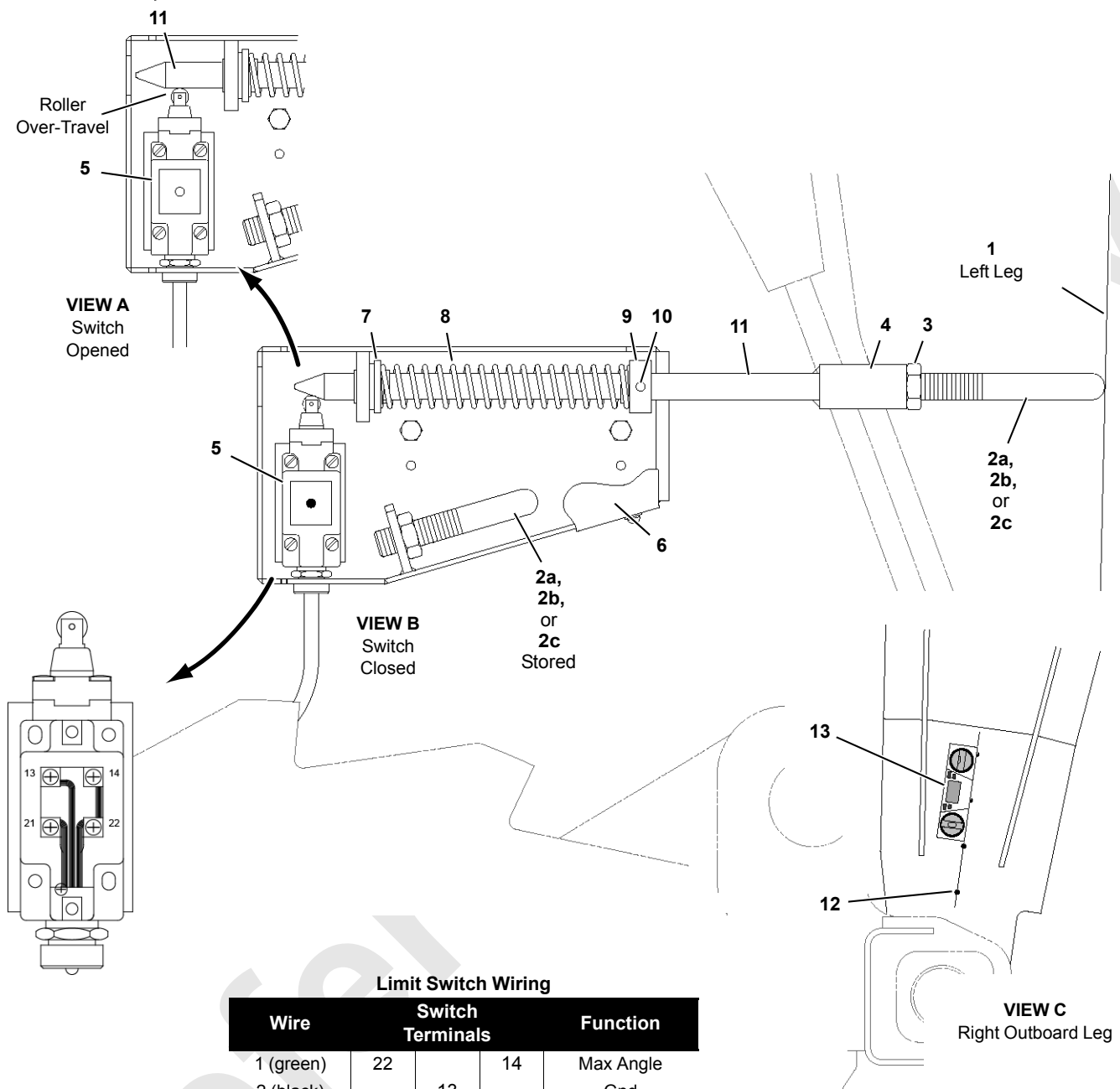
Stay clear of moving parts.

1. Lower the boom onto blocking at ground level.
2. Have an assistant push the adjusting rod ([Figure 4-2](#)) in to trip the boom stop limit switch open.
3. Rotate the limit bypass key (in crane cab) to the bypass position and hold.
4. Try to boom up — do not raise the boom any higher than necessary to perform the test:
 - a. If the boom rises, your boom up limit **can be bypassed**.
 - b. If the boom does not rise, your boom up limit **cannot be bypassed**.
5. The test is complete. Release the limit bypass key and the adjusting rod to the normal operating positions.



Item	Description
1	Boom Butt
2	Adjusting Rod
5	Limit Switch

FIGURE 4-1



Limit Switch Wiring

Wire	Switch Terminals		Function
1 (green)	22	14	Max Angle
2 (black)		13	Gnd
3 (white)	21		12 VDC Supply

Item	Description	Item	Description
1	Boom Butt	7	Spring Washer
2a	Adjusting Rod	8	Spring
2b	Adjusting Rod	9	Spring Washer
2c	Adjusting Rod	10	Dowel Pin 1/4 in (6 mm) Diameter
3	Jam Nut	11	Actuator Rod
4	Coupling	12	Punch Marks
5	Limit Switch	13	Digital Level
6	Cover		

FIGURE 4-2

Adjustment

See [Figure 4-2](#) for the following procedure.

1. Park the crane on a firm level surface or level the crane by blocking under the crawlers.
2. Make sure the proper adjusting rod is installed (see [Figure 4-1](#) and [Table 4-1](#)).
3. Raise the boom to specified **Angle A** (see [Figure 4-1](#) and [Table 4-1](#)) while monitoring the angle on the mechanical indicator or on the operating conditions screen of the front-console display.
4. Verify that the boom is at the proper Angle A:
 - a. Place an accurate digital level (13) on the centerline of the boom butt as shown in View C. **Angle A** should appear on the digital level.
 - b. Raise or lower the boom as necessary.
5. If the boom stops at the specified angle, further adjustment is not needed.
 - If the boom stops before reaching the specified angle, go to [step 6](#).
 - If the boom reaches the specified angle before it stops, go to [step 7](#).
6. If the boom stops before reaching the specified angle:
 - a. Loosen jam nut (3, View B).
 - b. Turn adjusting rod (2a, 2b, or 2c) all the way into coupling (4).
 - c. Boom up slowly until the boom reaches the specified angle.
 - d. Turn adjusting rod (2a, 2b, or 2c) out against boom butt (1) until limit switch (5) “clicks” open (View A).
 - e. Tighten jam nut (3).
7. If the boom reaches the specified angle before it stops:
 - a. Loosen jam nut (3, View B).
 - b. Turn adjusting rod (2a, 2b, or 2c) out against boom butt (1) until limit switch (5) “clicks” open (View A).
 - c. Tighten jam nut (3).
8. Check that actuator rod (11) over-travels the limit switch as shown in View A.
9. Test the adjustment as follows:
 - a. Lower the boom several degrees below specified Angle A.
 - b. Slowly raise the boom.
 - c. **Boom must stop at specified Angle A.** If the boom does not stop at the specified angle:
 - Stop raising the boom (move control handle to off)
 - Lower the boom several degrees below the specified angle
 - d. Repeat adjustment steps [3](#) through [9](#).

Actuator Rod Replacement

See [Figure 4-2](#), View B for the following procedure.

1. Remove damaged actuator rod (11).
2. Slide spring washers (7 and 9) and spring (8) over new actuator rod (12) while sliding the actuator rod into the bracket assembly.
3. Position actuator rod (11) so the tapered end just touches the roller of limit switch (5) (View B). The actuator rod must not depress limit the roller.
4. Drill a 1/4 in (6 mm) hole through spring washer (9) and actuator rod (11).
5. Install dowel pin (10).
6. Install proper adjusting rod (2a, 2b, or 2c) and adjust the boom stop.

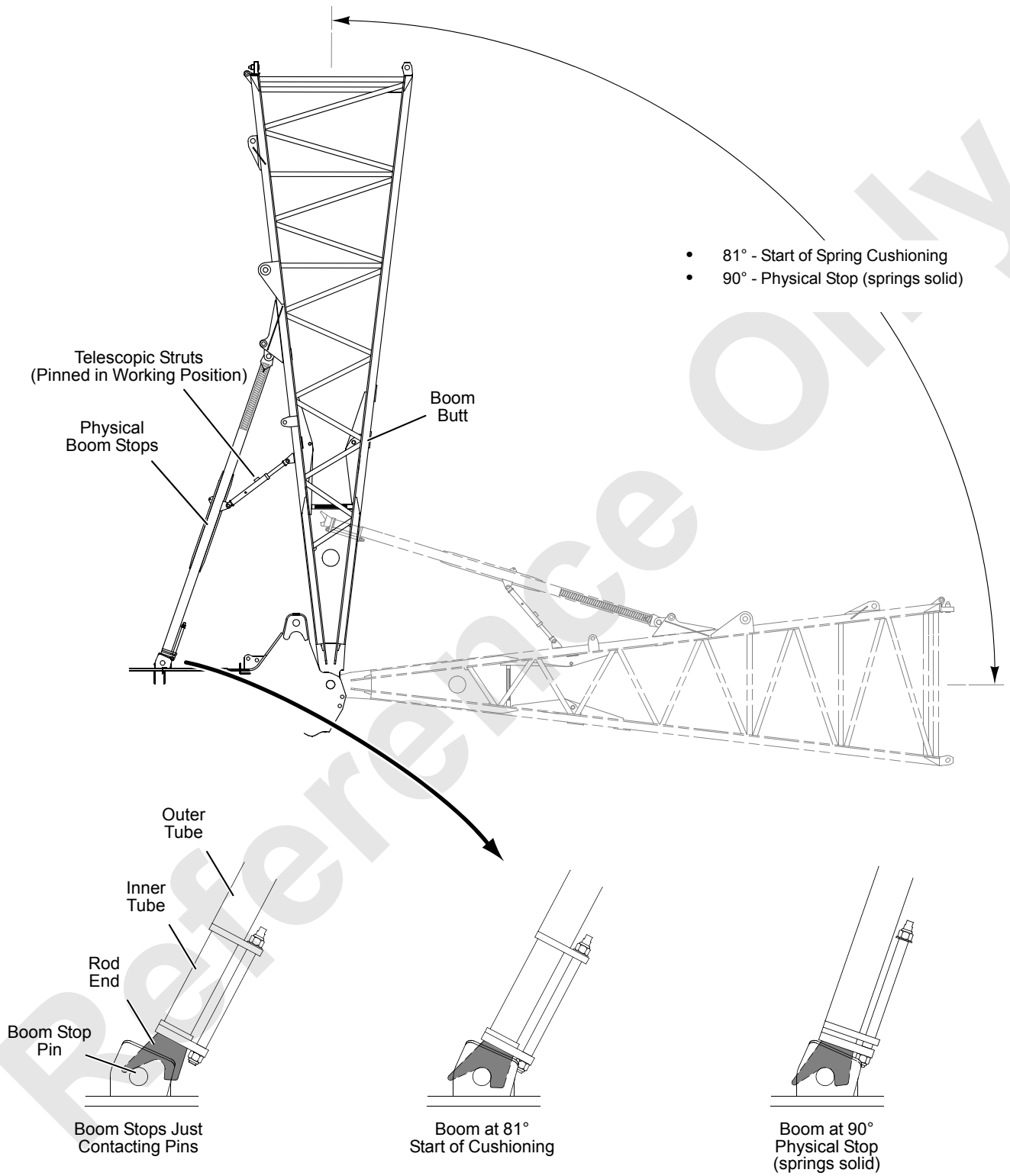


FIGURE 4-3

PHYSICAL BOOM STOP

The physical boom stops ([Figure 4-3](#)) serve the following purposes:

- Assist in stopping the boom smoothly at any angle above 81°
- Assist in preventing the boom rigging from pulling the boom back when traveling or setting loads with the boom at any angle above 8°
- Assist in moving the boom forward when lowering the boom from any angle above 81°
- Provide a physical stop at 90°

The telescopic struts between the boom stops and the boom butt have two positions:

- **WORKING POSITION** (struts extended). The physical boom stops must be in this position for all crane operations.
- **SHIPPING POSITION** (struts retracted). This position provides maximum clearance for shipping the boom butt with the physical boom stops installed.

See Crane Assembly/Disassembly in Section 4 of 999 Operator Manual for instructions on raising and lowering physical boom stops.



WARNING

Physical boom stops must be installed and pinned in working position for all crane operations.

Physical boom stops do not automatically stop boom at maximum operating angle. Automatic boom stop must be installed and properly adjusted.

Operation

See [Figure 4-3](#)

When boom is raised to 81°, springs in boom stop tubes begin to compress.

As boom is raised higher, spring compression increases to exert greater force against boom.

If for any reason boom is raised to 90°, boom stop springs fully compress to provide a physical stop.

BOOM AND LUFFING JIB ANGLE INDICATOR

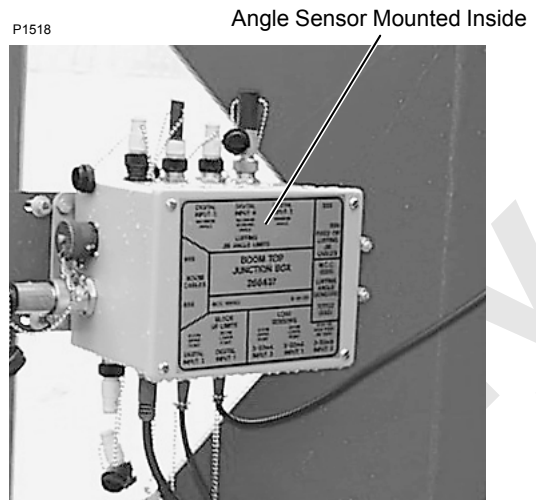
Angle indicator sensors are located inside node controllers mounted on the boom top and on the luffing jib top.

The boom and luffing jib angles are calibrated automatically by the crane's programmable controller as part of the load indicator calibration procedure (see Rated Capacity Indicator/Limiter Operation Manual for instructions).

MAST AND GANTRY SENSOR ADJUSTMENTS

Mast Angle Indicator

The mast angle sending unit (Figure 4-5) houses a sensor (Figure 4-6) which sends an electric signal to the crane's programmable controller. The programmable controller converts the electric signal into an angle which can be monitored on the digital display in the operator's cab and used to control mast operation within the limits given in Table 4-2.



Typical Node Controller Installation on Boom or Luffing Jib Top.

FIGURE 4-4

Table 4-2 Mast Operating Limits (Operating Limit Alert Comes on When any Limit is Reached)

Limit/Display Reading ¹	Function Response	Corrective Action
MAST BELOW 25°	Can't Raise Gantry or Boom Up	Raise mast with mast assist above 25°
GANTRY DOWN (occurs if mast is lowered to 135° with gantry down)	Can't Boom Down	Fully raise gantry
MAST TOO FAR FORWARD (occurs if mast is lowered to 175°)	Can't Boom Down	Raise mast. Further lowering is not intended.

¹ Mast angles are measured from transport position which is 0°.

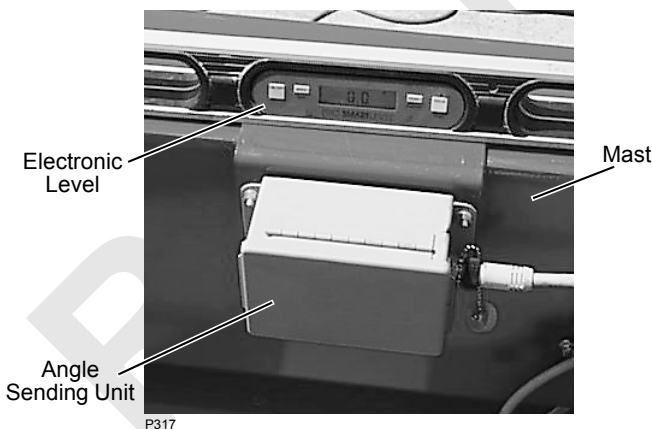


FIGURE 4-5

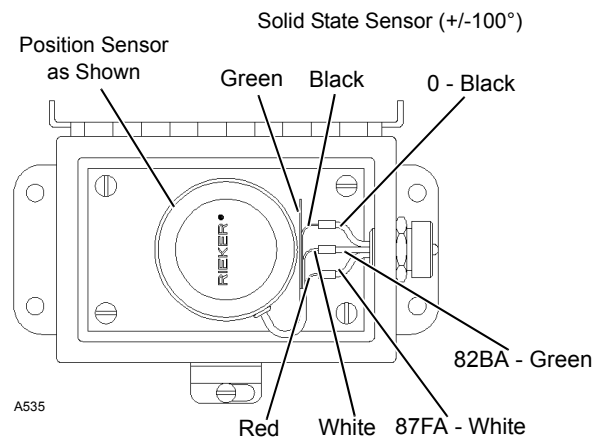


FIGURE 4-6

Adjusting Angle

Perform following adjustment steps at initial installation, after installing a new sending unit, and during assembly. Mast angle should be 0° when mast is fully lowered to the rear (transport position).

NOTE: Mast must be in transport position when checking or adjusting angle indicator.

1. Park crane on a level, solid surface.
2. Lower mast to transport position.
3. Place an electronic level on mast ([Figure 4-5](#)).
4. Record angle indicated on level.
5. Scroll to angle on digital display in operator's cab.
6. Angle shown on digital display must match angle recorded in step 4 plus or minus one degree.
7. If necessary, loosen mounting screws and rotate sending unit in mounting slots until reading on digital display matches angle on level.
8. Securely tighten mounting screws to lock adjustment.

Gantry Limit Switch

The crane has a limit switch ([Figure 4-7](#)) which alerts the operator when the gantry is raised to its maximum angle. When the gantry is less than fully raised, the limit switch is open. When the gantry is fully raised, the actuator closes the limit switch.

Check limit switch for proper operation each time crane is assembled.

Adjustment

The gantry limit switch was set at the factory and should not require periodic adjustment. However, it will need adjustment whenever parts are replaced.

1. Travel crane onto firm, level surface.
2. Make sure mast is raised.
3. Select Setup mode and confirm.
4. Using gantry switch, completely raise gantry until hydraulic cylinders are fully extended.
5. Loosen mounting bolts securing limit switch to frame.
6. Slide switch forward until actuator just “clicks” limit switch closed.

7. Hold switch in place and tighten limit switch mounting bolts.
8. Test switch for proper operation by lowering and then raising gantry.

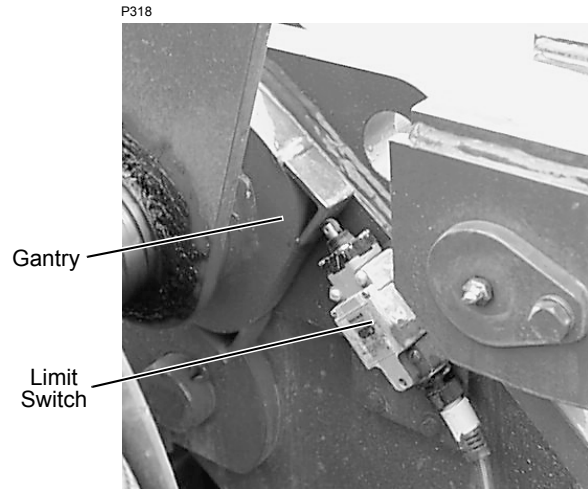


FIGURE 4-7

STRAP INSPECTION AND MAINTENANCE

This section is a guide to crane owners for properly inspecting and maintaining straps in the field. It is impossible to predict whether or when a strap may fail. Frequent and periodic inspections can help reveal potential for failure. Straps are to be inspected regularly by a **qualified person** as part of crane's preventive maintenance program. Dated records should also be kept.

Strap repairs are prohibited. Perform only the maintenance indicated in this section. For inspection procedures not covered in this manual, contact your dealer or the Manitowoc Crane Care Lattice Team.



WARNING

If strap damage was caused by overload or shock load or if there is damage to other major structural components, Manitowoc recommends that a thorough inspection be made by a qualified person. A nondestructive test of all critically stressed members must be made.

Strap connecting links are subject to same inspection procedures and replacement specifications as those for straps. In this section, **strap** means straps and connecting links.

Inspection

Regular inspection of all straps is necessary to assure that crane can lift its rated load. If a strap fails, boom or other attachment can collapse. All inspections must be performed by a qualified appointed inspector at following intervals:

- Routinely on a daily (frequent inspection) or monthly (periodic inspection)
- Before initial use
- After transport
- After an overload or shock loading has occurred
- If boom and/or jib has come into contact with another object (for example, power lines, building, another crane)
- If boom or jib has been struck by lightning

Daily Inspection

Visually inspect all straps once each work shift for obvious damage which poses an immediate hazard. Pay particular attention to areas where wear and other damage is likely to occur. Look for straps that are disconnected, loose or sagging excessively and for distortion such as kinking or

twisting. If any strap looks like it is damaged, strap must be checked to make sure it is within specifications given in this section.

Monthly Inspection

Periodic inspection must be performed at least monthly. During this inspection, entire length of strap must be inspected to assure that it is within specifications. **Strap must be within all specifications identified in this section.** Any damage found must be recorded and a determination made as to whether continued use of strap is safe.

Before beginning inspection, thoroughly clean strap of all dirt, grease, oil, etc. so a thorough inspection can be made. Closely examine those areas where paint is chipped, wrinkled, or missing and where faint rust lines or marks appear.

A qualified inspector may modify interval for periodic inspection depending on following factors:

- Severity of environment in which crane is operated
- Size, nature, and frequency of lifts
- Exposure to shock loading or other abuse

Cranes Not in Regular Use

A qualified inspector should determine type of inspection required for cranes that have been idle. A frequent inspection (visual observation) should be adequate for a crane that has been idle for less than six months. A periodic inspection is required for cranes that have been idle for more than six months.

Identifying Straps

To aid in identification, part number is stamped into both ends of each strap as shown in [Figure 4-8](#).

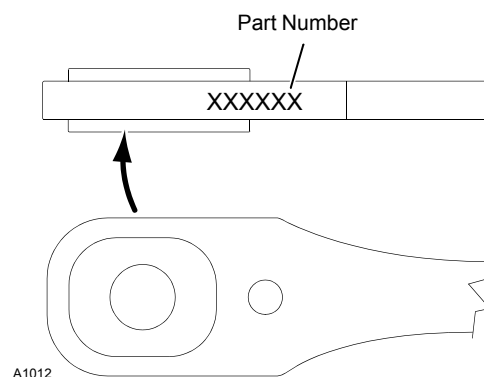


FIGURE 4-8

Replacement Specifications

Any strap not within specifications listed in [Table 4-3](#) must be replaced.

! WARNING

If damage to strap exceeds that allowed within specification, do not operate crane until strap has been replaced.

Operating crane with a damaged strap can cause structural failure or collapse of boom, jib, mast, or other crane components.

**Table 4-3
Strap Specifications**

Condition	Reference	Allowable Tolerance or Deviation	Corrective Action
Dent	Figure 4-9	< 0.12 in (3,175 mm)	Monitor condition.
		≥ 0.12 in (3,175 mm)	Remove strap from service.
Kink	Figure 4-10	None	Remove strap from service.
Crack or Break	Figure 4-11	None	Remove strap from service.
Corrosion or Abrasion	Figure 4-12	<6% of strap thickness	Sandblast and paint to maintain continuous protective coating.
		≥6% of strap thickness	Remove strap from service.
Straightness (gradual or sweeping bend)	Figure 4-13	Varies depending on strap length	Remove strap from service if deviation exceeds maximum allowed.
Flatness (includes twisted straps)	Figure 4-14	Varies depending on strap length.	Remove strap from service if deviation exceeds maximum allowed.
Elongated Holes	Figure 4-15	None	Remove strap from service.
Length	Figure 4-16	None	Remove strap from service.

< = less than
 ≥ = equal to or greater than

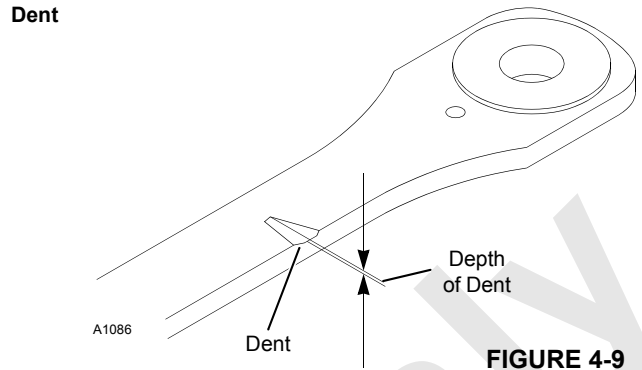


FIGURE 4-9

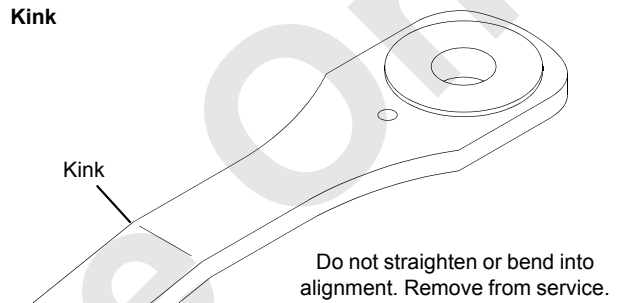


FIGURE 4-10

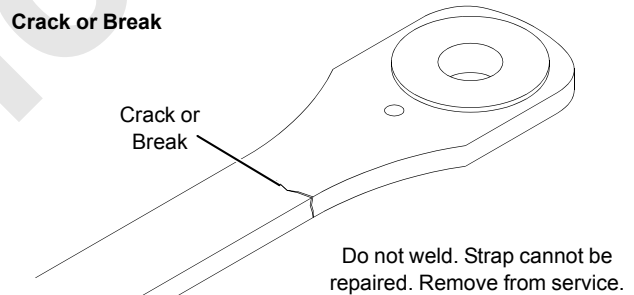


FIGURE 4-11

Corrosion or Abrasion

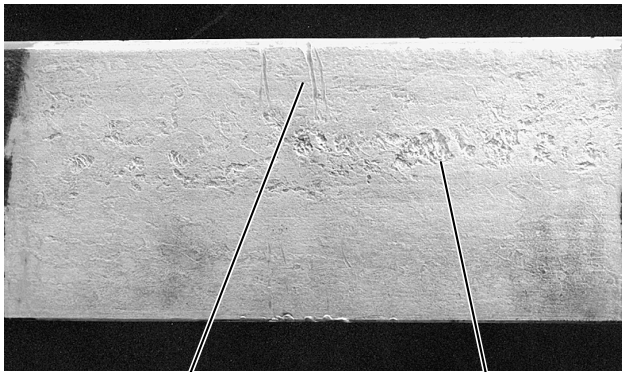
See [Figure 4-12](#) for the following procedure.

For quick identification by repair workers, clearly mark damaged areas with brightly colored tape.

1. Sandblast to remove corrosion. **Do not grind!**
2. Determine reduction in thickness.
3. If reduction is less than 6% of strap thickness, paint strap to maintain continuous protective coating.
4. If reduction is 6% or more, remove strap from service.

Corrosion or Abrasion

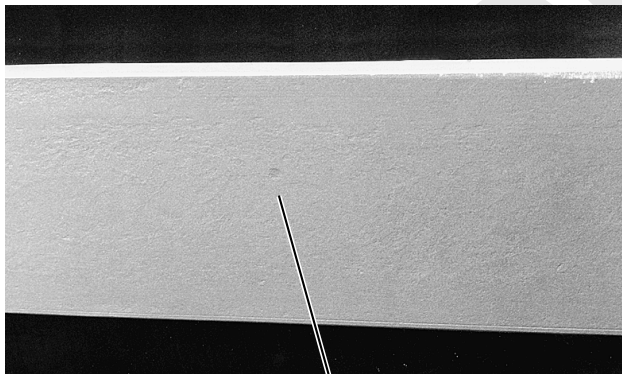
P325



Not Acceptable
Abrasion from handling with chain exceeds allowable limit.

Not Acceptable
Surface is badly pitted; exceeds allowable limit.

P326



Acceptable
Surface is relatively smooth; within allowable limit.

FIGURE 4-12

Straightness

See [Figure 4-13](#) for the following procedure.

1. Stretch a line (string or wire) from pin storage hole at one end of strap.
2. Stretch line as tight as possible and tie it off at other end.
3. Mark strap center line. **Do not use center punch!**
4. If string does not align with center line, measure distance from center line to line.

If deviation from straight is greater than maximum allowed, remove strap from service.

Strap Length (L)	Maximum Deviation Allowed
5 to <10 ft (1.5 to <3,0 m)	0.060 in (1,5 mm)
10 to <20 ft (3.0 to <6,1 m)	0.125 in (3,2 mm)
20 to <30 ft (6,1 to <9,1 m)	0.250 in (6,4 mm)
30 to <40 ft (9,1 to <12,2 m)	0.375 in (9,5 mm)
40 to <50 ft (12,2 to <15,2 m)	0.50 in (12,7 mm)
< = less than	

Straightness (gradual or sweeping bend)

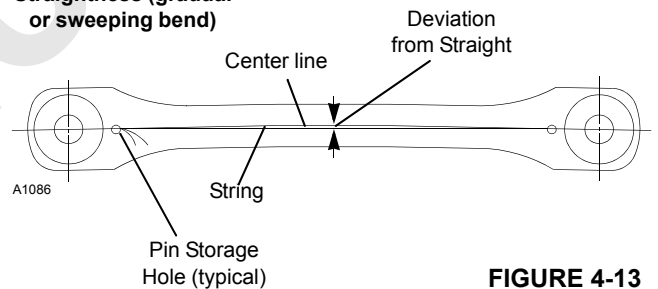


FIGURE 4-13

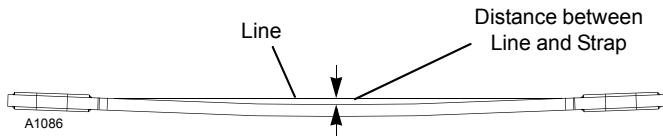
Flatness

See [Figure 4-14](#) for the following procedure.

1. Lay strap on a flat surface. **Do not block; strap may sag!**
2. Stretch a line (string or wire) across top surface of strap from pin storage hole at one end of strap.
3. Stretch line as tight as possible and tie it off at other end.
4. Check that line touches top surface of strap at all points along its length.
5. If string does not touch strap, measure distance from line to strap.

If deviation from straight is greater than maximum allowed, remove strap from service.

6. Remove line. Turn strap over.
7. Repeat steps 1-5 above.

Flatness (includes twisted straps)

Elongated Hole

See [Figure 4-15](#) for the following procedure.

1. Insert pin into hole.
2. Push pin tight against edge of hole along horizontal center line. Measure dimension between pin and hole (View A).
3. Push pin tight against edge of hole along vertical center line. Measure dimension between pin and hole (View B).

If dimensions A and B are not identical, hole is elongated. Remove strap from service.

If two dimensions are identical, but greater than 0.030 in (0,8 mm), contact factory Service Department.

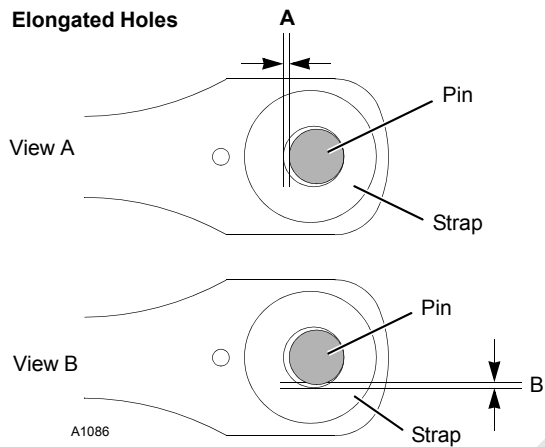


FIGURE 4-15

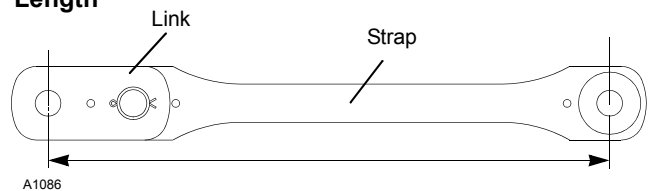
Length

Strap Length (L) ft (m)	Maximum Deviation Allowed	
	1 to <2 in (25 to <51 mm) Thick	2 to <4 in (51 to <102 mm) Thick
<3 (<0,9)	0.17 (4,3)	0.50 (12,7)
3 to <4 (0,9 to <1,2)	0.63 (15,9)	0.56 (14,3)
4 to <5 (1,2 to <1,5)	0.75 (19,1)	0.70 (17,5)
5 to <6 (1,5 to <1,8)	0.80 (20,6)	0.75 (19,1)
6 to <7 (1,8 to <2,1)	0.88 (22,2)	0.75 (19,1)
7 to <8 (2,1 to <2,4)	0.94 (23,8)	0.75 (19,1)
8 to <9 (2,4 to <2,7)	1.0 (25,4)	0.75 (19,1)
9 to <10 (2,7 to <3,0)	1.0 (25,4)	0.88 (22,2)
10 to <12 (3,0 to <3,7)	1.0 (25,4)	1.0 (25,4)
≥12 (≥3,7)	Deviation not to exceed 1 in (25,4 mm) in any 12 ft (3,7 m) length of strap	

< = less than
 ≥ = equal to or greater than

4

Length



Measure to check length. See appropriate rigging drawing in Operator Manual for original length. Strap length includes connecting link. If change in length is detected, remove strap from service.

FIGURE 4-16

Storing Straps

Straps should be stored in a protected area. If stored in open, a protective covering is recommended, especially in a corrosive environment (chemicals, salt water spray, etc.).

Inspect straps in storage for corrosion monthly. If necessary, sandblast to remove corrosion and repaint to maintain a continuous protective surface. If corrosion is not removed, strap will have to be removed from service because reduction in thickness will exceed the maximum allowed.

A full periodic inspection is required for straps returned to service from storage.

Removing Straps from Service

Straps removed from service should be clearly marked to prevent accidental future use. Rendering the strap useless in some way, such as cutting off an end, is recommended.

Inspection Checklist

A Strap Inspection Checklist is provided at the end of this section. The checklist can be reproduced as needed.

Signed and dated copies of the Strap Inspection Checklist must be kept on file at all times for each strap, as the checklists may be required to verify warranty or product liability claims.

If no damage is found or damage is within specification, check the box () next to the item to indicate that its specific condition was evaluated and found acceptable. If damage is not within specification, indicate so in the box next to the item (for example: **D** to indicate damage).

LATTICE SECTION INSPECTION AND LACING REPLACEMENT

Refer to Folio 1316 at the end of this section for lattice section inspection and lacing replacement instructions.

STRAP INSPECTION CHECKLIST

Inspector's Name _____ Signature _____ Date _____

Length _____ m Part Number _____

<input type="checkbox"/> Dents	<input type="checkbox"/> Kinks	<input type="checkbox"/> Cracks	<input type="checkbox"/> Breaks	<input type="checkbox"/> Corrosion
<input type="checkbox"/> Abrasion	<input type="checkbox"/> Bends	<input type="checkbox"/> Straightness	<input type="checkbox"/> Flatness	<input type="checkbox"/> Elongated Holes
<input type="checkbox"/> Length	<input type="checkbox"/> Other	_____		

Length _____ m Part Number _____

<input type="checkbox"/> Dents	<input type="checkbox"/> Kinks	<input type="checkbox"/> Cracks	<input type="checkbox"/> Breaks	<input type="checkbox"/> Corrosion
<input type="checkbox"/> Abrasion	<input type="checkbox"/> Bends	<input type="checkbox"/> Straightness	<input type="checkbox"/> Flatness	<input type="checkbox"/> Elongated Holes
<input type="checkbox"/> Length	<input type="checkbox"/> Other	_____		

Length _____ m Part Number _____

<input type="checkbox"/> Dents	<input type="checkbox"/> Kinks	<input type="checkbox"/> Cracks	<input type="checkbox"/> Breaks	<input type="checkbox"/> Corrosion
<input type="checkbox"/> Abrasion	<input type="checkbox"/> Bends	<input type="checkbox"/> Straightness	<input type="checkbox"/> Flatness	<input type="checkbox"/> Elongated Holes
<input type="checkbox"/> Length	<input type="checkbox"/> Other	_____		

Length _____ m Part Number _____

<input type="checkbox"/> Dents	<input type="checkbox"/> Kinks	<input type="checkbox"/> Cracks	<input type="checkbox"/> Breaks	<input type="checkbox"/> Corrosion
<input type="checkbox"/> Abrasion	<input type="checkbox"/> Bends	<input type="checkbox"/> Straightness	<input type="checkbox"/> Flatness	<input type="checkbox"/> Elongated Holes
<input type="checkbox"/> Length	<input type="checkbox"/> Other	_____		

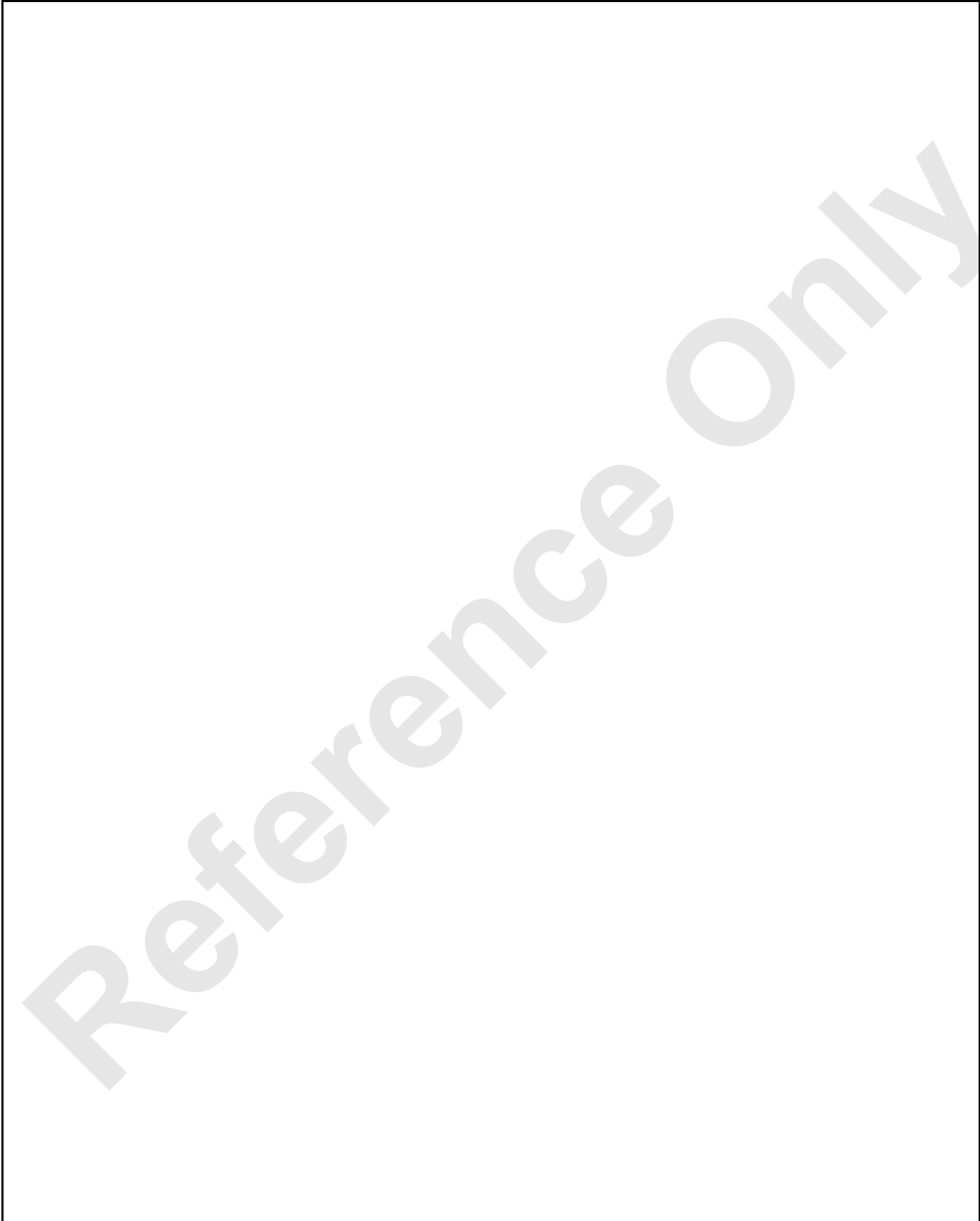
Length _____ m Part Number _____

<input type="checkbox"/> Dents	<input type="checkbox"/> Kinks	<input type="checkbox"/> Cracks	<input type="checkbox"/> Breaks	<input type="checkbox"/> Corrosion
<input type="checkbox"/> Abrasion	<input type="checkbox"/> Bends	<input type="checkbox"/> Straightness	<input type="checkbox"/> Flatness	<input type="checkbox"/> Elongated Holes
<input type="checkbox"/> Length	<input type="checkbox"/> Other	_____		

Length _____ m Part Number _____

<input type="checkbox"/> Dents	<input type="checkbox"/> Kinks	<input type="checkbox"/> Cracks	<input type="checkbox"/> Breaks	<input type="checkbox"/> Corrosion
<input type="checkbox"/> Abrasion	<input type="checkbox"/> Bends	<input type="checkbox"/> Straightness	<input type="checkbox"/> Flatness	<input type="checkbox"/> Elongated Holes
<input type="checkbox"/> Length	<input type="checkbox"/> Other	_____		





SECTION 5 HOISTS

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SECTION 5 HOISTS

HOIST DRAWINGS

Applicable hoist and load block drawings are attached at the end of this Section.

WIRE ROPE REMOVAL

To remove wire rope from any load drum, activate limit bypass switch on front console in cab. This action allows the drum to be operated in the **lower** direction when the minimum bail limit is contacted.

FREE FALL CLUTCH/BRAKE

Either or both load drums can be equipped with a free fall clutch/brake as shown in [Figure 5-1](#).

Inspection

Inspect wear indicator with **brake applied**. Note that wear indicator moves in as brake discs wear.

Replace brake discs when indicated in [Figure 5-1](#).



DANGER
Falling Load Hazard!

Free fall clutch/brake will not hold load if brake discs are worn. To prevent load from falling, inspect each wear indicator **weekly** and replace discs when indicated.

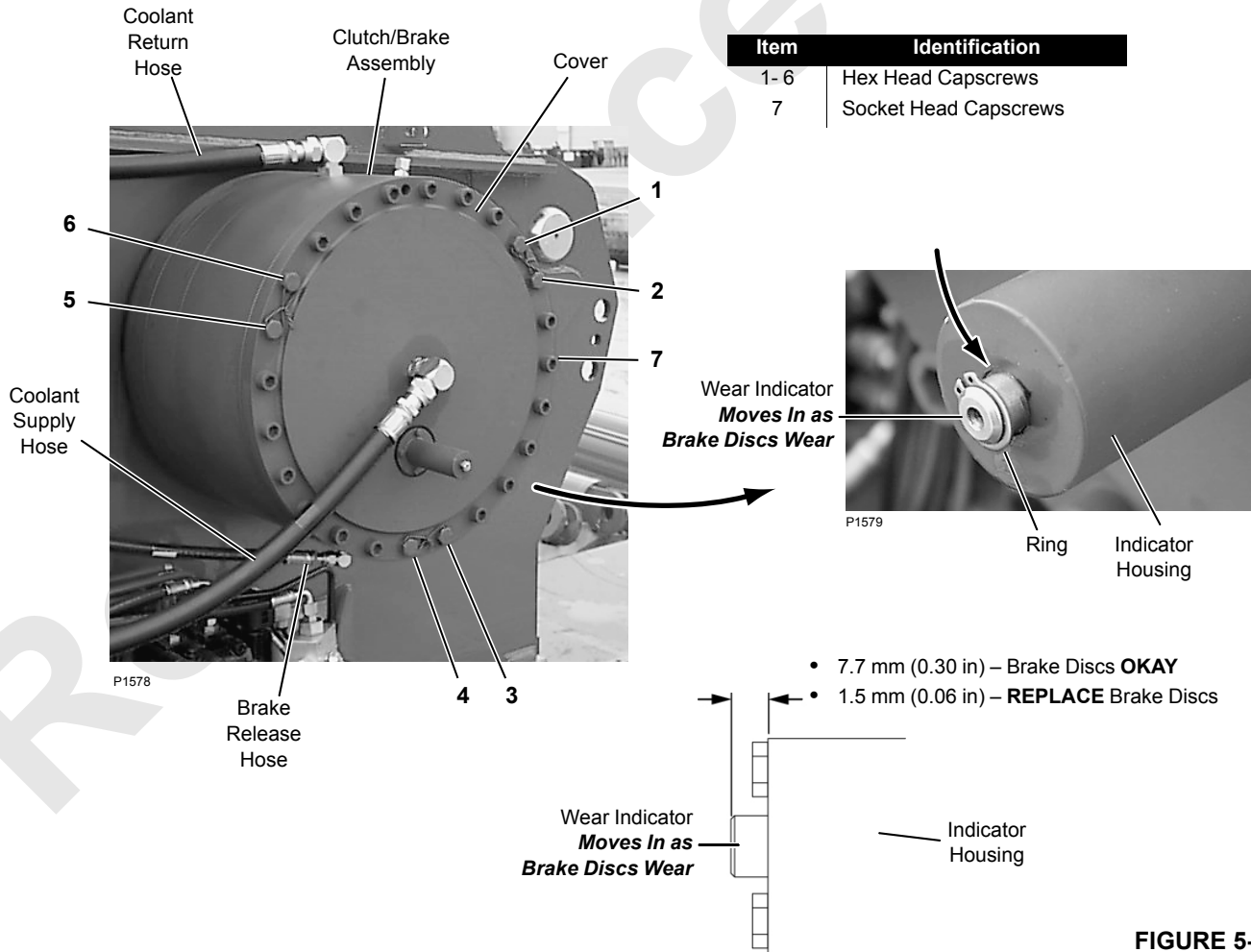


FIGURE 5-1

Overhaul

To overhaul either clutch/brake assembly, proceed as follows:



DANGER

Flying Object Hazard!

Brake springs are preloaded. Clutch/brake assembly can fly apart with dangerous force.

To prevent death or serious injury, read following instructions before disassembling clutch/brake.

See [Figure 5-1](#) for the following procedure.

1. Lower all loads to ground and stop engine.
2. Remove machinery cab door from left side of crane (retained with three pins).
3. Disconnect hydraulic lines from clutch/brake ports. *Catch oil leakage from hoses and ports in a container as hoses are disconnected.*
4. Securely attach slings from assist crane to clutch/brake assembly.

The assembly has four tapped holes — two in top of unit and two in cover — to which lifting eyes can be threaded (3/4 inch-10 UNC threads).

The assembly weighs 1,650 lb. (748 kg).



WARNING

Falling Load Hazard!

Do not perform step [5](#) until clutch/brake assembly is supported with slings from assist crane.

Clutch/brake assembly may fall off mounting adapter.

5. Remove eighteen socket head cap screws (7) and remove clutch/brake assembly from crane.

Do not loosen or remove hex head cap screws (1 – 6) until clutch/brake assembly is removed from crane.
6. Drain oil from clutch/brake assembly. A plug is provided in bottom of unit.

7. Place clutch/brake assembly on a workbench and securely block it with shaft pointing down.
8. Remove wire from hex head cap screws (1 – 6).
9. Loosen cap screws (1, 3, and 5) two full turns.
10. Loosen cap screws (2, 4, and 6) two full turns.
11. Repeat steps [9](#) and [10](#) until all spring preload is released.
12. Remove cover from clutch/brake assembly.
13. The unit can now be disassembled and repaired as required.

See Free Fall Drum Brake Assembly drawing at the end of this Section.

- Reverse the assembly steps to disassemble the clutch/brake assembly.
 - Read and perform all steps on the assembly drawing.
 - Replace all seals any time the unit is disassembled to replace brake discs.
14. Reassemble clutch/brake assembly as instructed in Free Fall Drum Brake Assembly drawing.
 15. Reinstall clutch/brake assembly on crane. Reverse steps [2](#) – [5](#) above.
 - For proper mounting orientation, see Drum Shaft Assembly drawing at the end of this Section.
 - Once the splines in the shaft are engaged with the drum planetary, it may be necessary to rotate the clutch/brake assembly to align mounting holes. Apply up to 3,000 psi (200 bar) hydraulic pressure with a portable pump to the brake release port in bottom of unit. The assembly can then be rotated by hand to align mounting holes.
 16. Test clutch/brake assembly for proper operation with free fall on and off:
 - With brake applied, check distance between ring on wear indicator and edge of indicator housing. It should be approximately 9/32 in (7 mm) as shown in [Figure 5-1](#).
 - Clutch/brake must hold rated load of 29,500 lb. (13 381 kg) single line pull, both while hoisting load and while holding load in position with brake applied.

MINIMUM BAIL LIMIT/PRESSURE ROLLER

See [Figure 5-2](#)

The minimum bail limit assembly is a protective device. It automatically stops the load drum from lowering when there are three to four wraps of wire rope remaining on the drum.

The drum can be operated in the *hoist* direction when the minimum bail limit is contacted.



WARNING

Falling Load Hazard!

Do not operate any load drum with less than three full wraps of wire rope remaining on drum. Doing so can cause wire rope to be pulled out of drum and load to drop.

Optional drum pressure roller assemblies are available for front and rear load drums.

Minimum Bail Limit

Weekly Maintenance

1. Check for proper operation of minimum bail limit assembly, as follows:
 - a. Land load.
 - b. Pay out wire rope from selected load drum.
 - c. Load drum must stop when there are three to four wraps of wire rope remaining on drum.
2. Check that cap screws (10) holding rollers (11) on bail limit lever are tight.
3. Check tension of return spring (8). If necessary, adjust eyebolt so spring holds bail limit rollers snugly against drum.

Adjustment—Front or Rear Drum

1. Land load for selected drum.
2. Loosen adjusting screws (5) and remove pins (6) from actuator (4) and lever (7). Position actuator so it does

not contact limit switch roller (3) when [step 3](#) is performed.

3. Pay out wire rope until bail limit rollers (11) are against bare or lagged drum with three full wraps of wire rope remaining on drum.
4. Position actuator out against limit switch roller only enough to open limit switch (light off).
5. Securely tighten adjusting screws, drill holes in actuator and lever, and insert pins to lock adjustment.
6. Adjust return spring eyebolt (9) to dimension shown in [Figure 5-2](#).
7. Spool six to seven wraps of wire rope onto load drum.

Pay out wire rope from load drum. Drum must stop when there are three to four wraps of wire rope remaining on drum.

If necessary, repeat adjustment.

Adjustment—Auxiliary Drum

See [Figure 5-3](#)

1. Land load for auxiliary drum.
2. Loosen jam nut on adjusting screw and turn screw fully into lever so screw does not contact switch when [step 3](#) is performed.
3. Pay out wire rope until bail limit rollers are against bare or lagged drum with three full wraps of wire rope remaining on drum.
4. Turn adjusting screw out against limit switch roller only enough to open limit switch.
5. Securely tighten jam nut on adjusting screw to lock adjustment.
6. Adjust return spring eyebolt to dimension shown in [Figure 5-3](#).
7. Spool six to seven wraps of wire rope onto load drum.

Pay out wire rope from load drum. Drum must stop when there are three to four wraps of wire rope remaining on drum.
8. If necessary, repeat adjustment.

Item	Description	Item	Description
1	Front Load Drum	8	Return Spring
2	Rear Load Drum	9	Return Spring Eyebolt
3	Limit Switch Roller	10	Cap Screw
4	Actuator	11	Bail Limit Rollers
5	Actuator Adjusting Screws	12	Bail Limit Lever
6	Pins	13	Drum Pressure Roller
7	Lever	14	Pressure Roller Spring

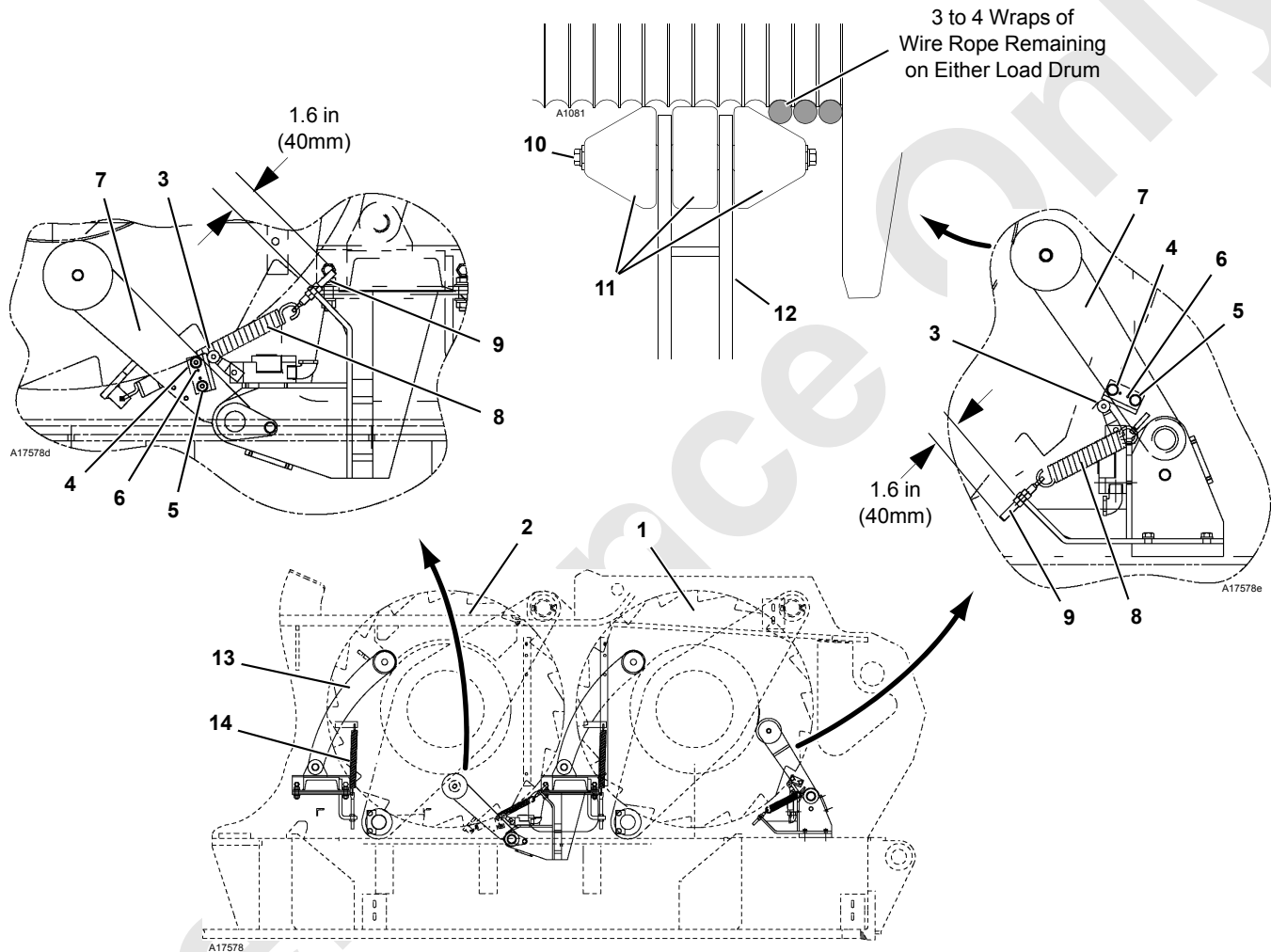


FIGURE 5-2

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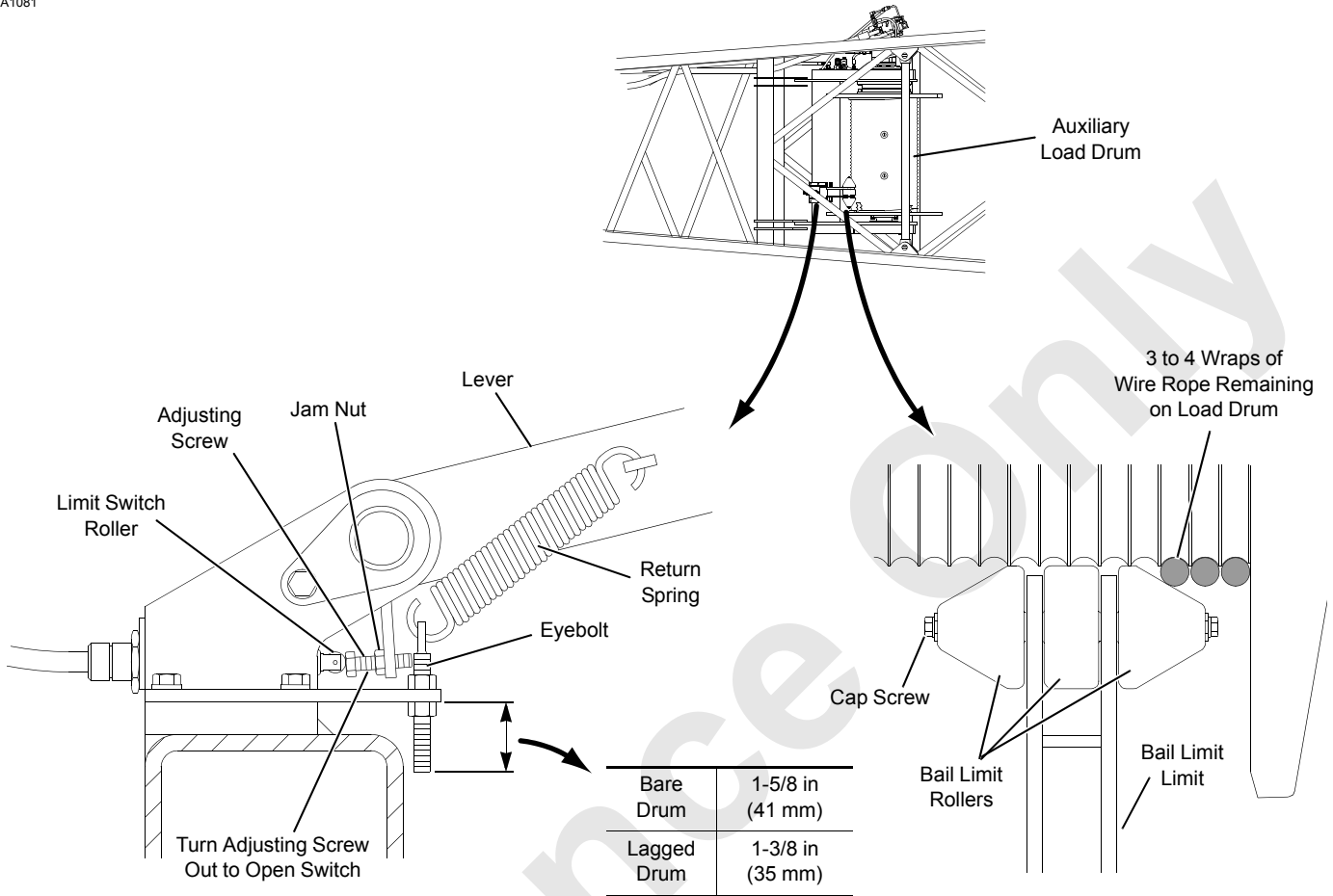


FIGURE 5-3

Drum Pressure Roller

Adjustment

See [Figure 5-2](#) for the following procedure

Optional drum pressure roller assemblies (13) are available for front and rear load drums.

The rollers are spring-loaded to assist in maintaining proper wire rope spooling by firmly holding the wire rope against the drum and subsequent layers.



WARNING

Crush Hazard!

Rollers are spring-loaded. Before adjusting, stop drums and turn off engine.

The operator must monitor drum spooling during operation. If the wire rope jumps layers or does not wind smoothly into the drum, perform following steps:

1. With either roller contacting drum barrel, adjust spring (14) to an overall length of 13 in (330 mm).

This ensures correct initial tension on drum.

NOTE: The drum pressure roller is intended to be used with one layer of rope only. It is permissible to store up to three layers of rope on drums. Spooling of more than three layers of rope on drum requires removal of roller.

BLOCK-UP LIMIT

A block-up limit control (also called anti-two-block device) is a two-blocking prevention device which automatically stops the load drum from hoisting and the boom from lowering when a load is hoisted a predetermined distance.

Two-blocking is the unsafe condition in which the load block or the weight ball contacts the sheave assembly from which either is suspended.

Two-blocking can result in failure of sheaves and wire rope, possibly causing load to fall.



WARNING

Two-Blocking Hazard!

Block-up limit control is a protective device designed only to assist operator in preventing a two-blocking condition; any other use is neither intended nor approved.

Block-up limit control may not prevent two-blocking when load is hoisted at maximum single line speed. Operator must determine fastest line speed that allows block-up limit control to function properly and thereafter not exceed that line speed.

The block-up limit controls consist of the following components (see [Figure 5-4](#)):

- Normally closed limit switch assembly fastened at any or all of the following locations:
 - Lower boom point
 - Upper boom point
 - Fixed jib point (jib on boom or on luffing jib)
 - Luffing jib point
 - Luffing jib intermediate suspension
 - Universal anchor joint
- Weight freely suspended by chain from each limit switch actuating lever (weight encircles load line as shown in [Figure 5-7](#)).
- Lift block fastened to load line or lift plates fastened to load block (see [Figure 5-7](#)).

Operation

See [Figure 5-4](#) and [Figure 5-8](#) for component identification.

NOTE: See wiring diagrams in Boom Wiring, Limits, and Load Indicator Electrical Assembly drawing in 999 Operator Manual.

Block-Up Limit Control Deactivated

During normal operation, the weight overcomes the spring force and rotates the actuating lever away from the limit switch lever. This action allows the limit switch to close the load drum **up** and boom/luffing jib **down** electric circuits. Therefore, the load can be hoisted and the boom/luffing jib can be lowered.

Block-Up Limit Control Activated

When the weight is lifted by the lift block or the lift plates, spring force rotates the actuating lever against the limit switch lever. This action causes the corresponding limit switch to open the load drum **up** and boom/luffing jib **down** electric circuits.

The load drum and boom hoist pumps stroke to off. At the same time, the load drum and boom/luffing jib parking brakes apply to stop the load drum from hoisting and the boom/luffing jib from lowering.

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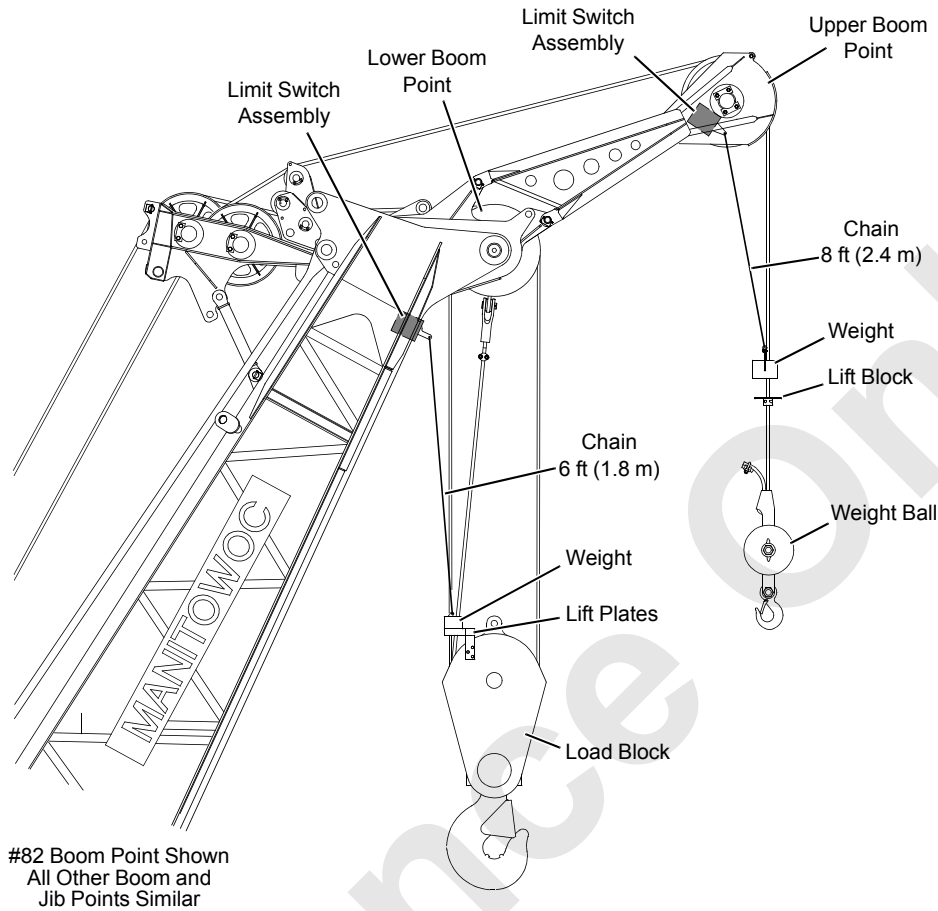


FIGURE 5-4

Installation

The block-up limit controls must be installed according to Boom Wiring, Limits and Load Indicator Electrical Assembly drawing in the 999 Operator Manual.

See [Figure 5-7](#) for installation of the weights.

Storing Electric Cable

The electric cables for the boom, fixed jib, and luffing jib are long enough to accommodate the maximum length of each attachment.

Store the excess cable for the boom and luffing jib on the reel mounted on either butt ([Figure 5-5](#)). The reel is equipped with a locking pin. Disengage the locking pin to allow the reel to be wound. Engage the locking pin to lock the reel in position. The power supply cable to the reel must be disconnected before the reel can be wound.

Store the excess electric cable for the fixed jib by winding it around the brackets on the fixed jib butt ([Figure 5-5](#)).

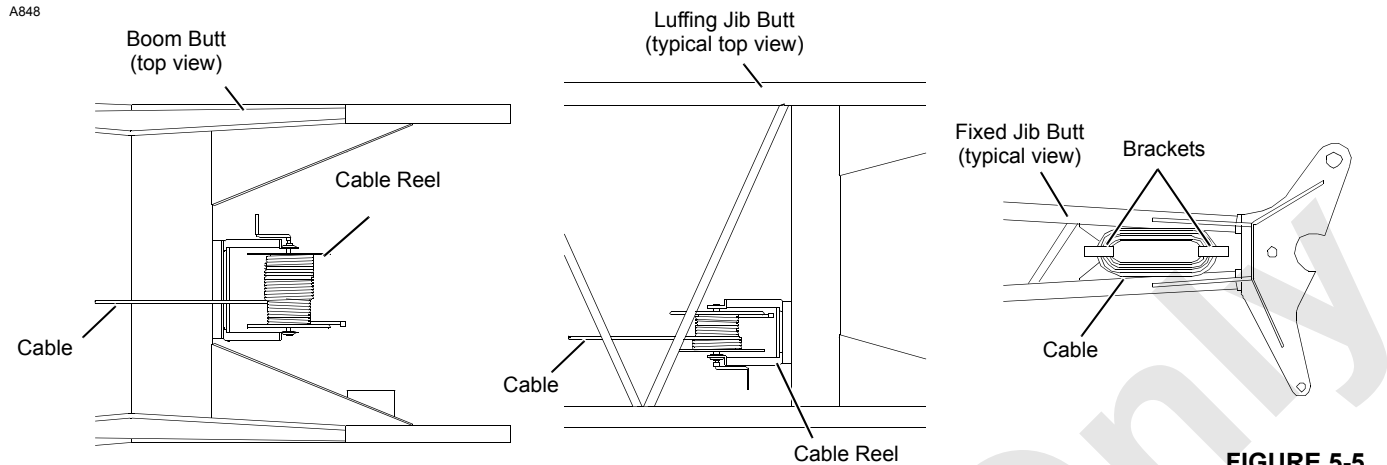


FIGURE 5-5

Disconnecting Block-Up Limit Controls

Shorting plug (SP1, View A, [Figure 5-6](#)) is provided on the left front corner of the rotating bed so the block-up limit controls can be disconnected for the following reasons:

- Crane setup and rigging
- Maintenance
- Operations not requiring use of a block-up limit control (clamshell and drag-line)

To disconnect the block-up limit controls, proceed as follows (see [Figure 5-6](#)):

1. Disconnect electric cable (C1, View B) from electric cable (C2).
2. Connect shorting plug (SP1, View A) to electric cable (C1).
3. Connect closure cap to electric cable (C2).
4. Reverse the steps to reconnect the block-up limit controls.

Removing Jib or Boom Point

The junction boxes on the boom and jib points are equipped with shorting plugs as shown in View C, [Figure 5-6](#).

When an attachment is removed, the electric cable from the corresponding limit switch must be disconnected from the junction box receptacle (View C, [Figure 5-6](#)) and the proper shorting plug connected to the receptacle.

Failing to perform this step will prevent the load drum from hoisting and the boom from lowering. Also the operating limit alert will come on.

Disconnect shorting plug and reconnect electric cable to proper receptacle on junction box when corresponding attachment is reinstalled.

Always connect closure caps to shorting plugs or ends of cables when they are not in use.

NOTE: Each junction box has a decal identifying what circuit each receptacle applies to. If in doubt, see the wiring diagrams in Boom Wiring, Limits, and Load Indicator Electrical Assembly drawing in the 999 Operator Manual.

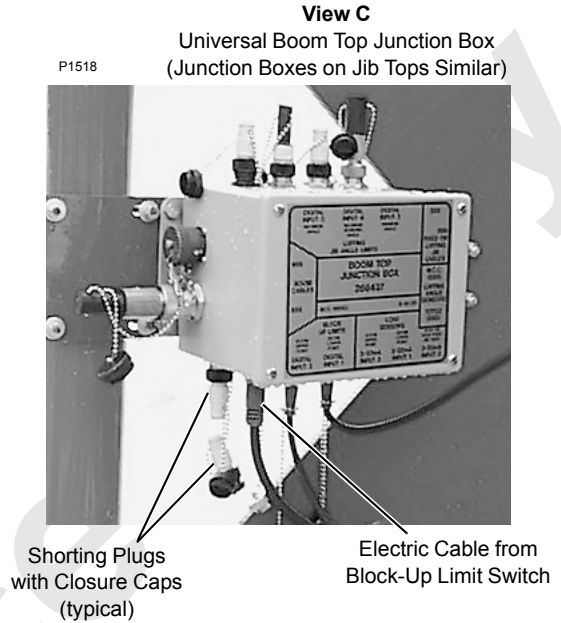
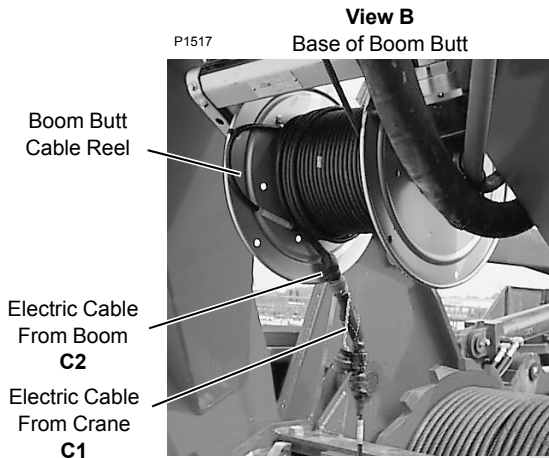
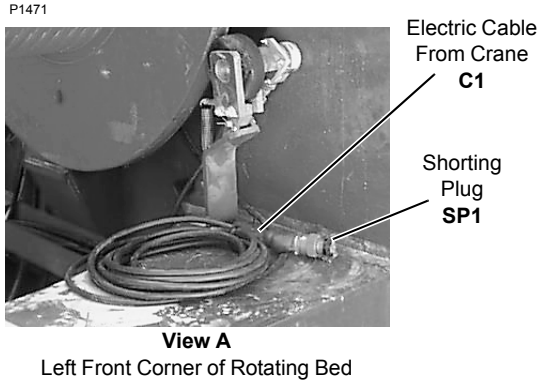


FIGURE 5-6

Maintenance

Inspect and test the block-up limit controls **weekly or every 40 hours of operation**, as follows:

Important: Do not operate crane until cause for improper operation and all hazardous conditions have been found and corrected.

1. Lower the boom onto blocking at ground level and carefully inspect the following items:
 - a. Inspect each limit switch lever and actuating lever for freedom of movement. Apply one-half shot of grease to the fitting on the actuating lever. Wipe away any excess grease.

- b. Inspect each weight for freedom of movement on the load line.
- c. Inspect each weight, each chain, each shackle and each connecting pin for excessive or abnormal wear. Make sure cotter pins for shackles are installed and spread.
- d. Inspect the entire length of electric cables for damage.
- e. Check that the electric cables are clear of all moving parts on the boom and jib and that the cables are securely fastened to the boom and jib with clips or nylon straps.
- f. Check that all plugs are securely fastened.

See Load Block Reeving drawing for Suggested Location of Weight

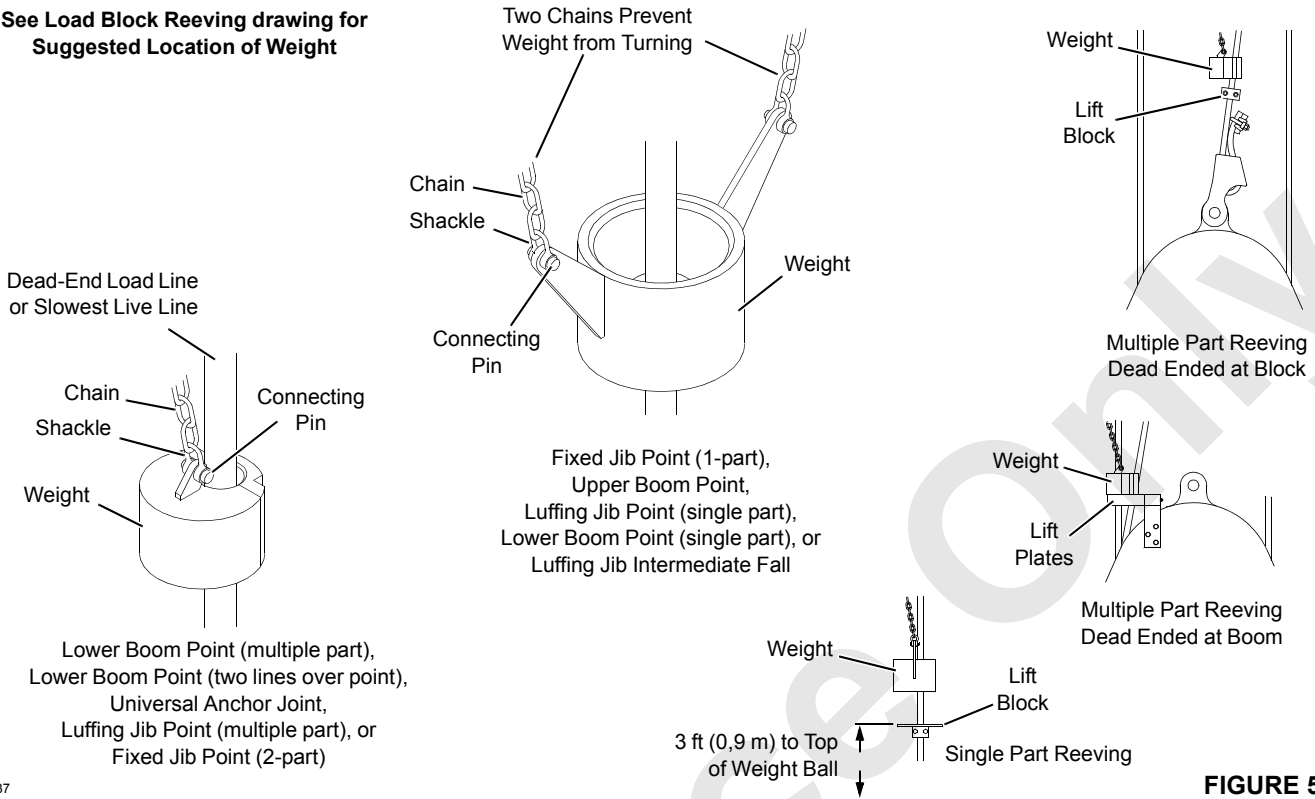


FIGURE 5-7

2. Test the block-up limit controls for proper operation using either of the following methods:
 - a. BOOM LOWERED: Manually lift each weight — **one at a time** — while the engine is running. The load drum should not operate in the **hoist** direction and the boom/luffing hoist should not operate in the **lower** direction.
 - b. BOOM RAISED: **Slowly** hoist each load block and weight ball — **one at a time** — against the weight. When the chain goes slack, the corresponding load

drum should stop hoisting and the boom/luffing hoist should not operate in the lower direction.

CAUTION

Use extreme care when testing block-up limit controls when boom is raised. If block-up limit control fails to stop load, immediately stop load by moving drum control handle to off or by applying drum working brake; otherwise, two-blocking may occur.

Adjustment

See [Figure 5-8](#) for the following procedure.

Lower the boom onto blocking at ground level and adjust each limit switch as follows:

1. Adjust spring tension so there is enough force to lift the weight of the chain and rotate the actuating lever when the weight is lifted.
2. Loosen the setscrew in the limit switch lever so the lever is free to rotate.
3. Manually lift the weight to allow the actuating lever to rotate upward.
4. Hold lever at Dimension A.
5. Hold the roller on the limit switch lever against the actuating lever while performing [step 6](#).
6. Turn the limit switch shaft **clockwise** only enough to “click” limit switch open and hold. Then securely tighten the setscrew in the limit switch lever.
7. Test the limit switch for proper operation (see [Maintenance](#)). Repeat the adjustment steps until the limit switch operates properly.

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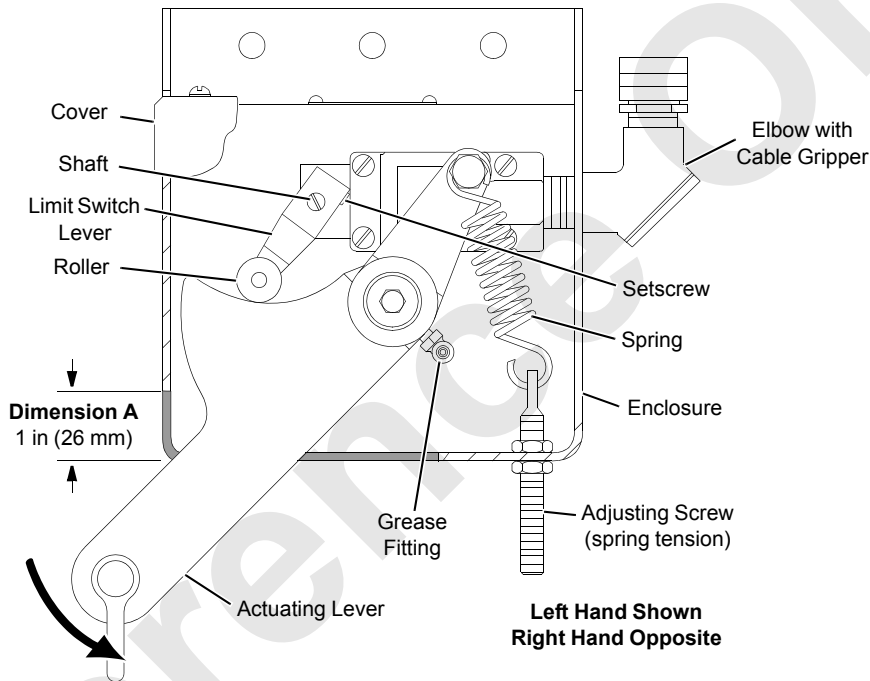


FIGURE 5-8

WIRE ROPE INSPECTION AND REPLACEMENT

The following information is from various wire rope manufacturers and includes inspection, replacement, and maintenance guidelines for wire rope as established by ASME B30.5, federal regulations, and Manitowoc Cranes.

Wire Rope Lubrication

Refer to the Lubrication Guide in section 9 for recommendations.

Maintain a Wire Rope Condition Report

Always keep on file a signed and dated periodic inspection report of the wire rope's condition. The report must cover all inspection points discussed in this section. The information in the reports can then be used to determine when a wire rope should be replaced.

After initial loading of a new rope, measure and record its diameter for comparison with future inspections. Measure the rope's diameter across the crowns of the strands so the true diameter is measured as shown in [Figure 5-10](#).

Wire rope removed from service should be examined and a corresponding report kept. This information can be used to establish a relationship between visual inspection and the rope's actual internal condition at the time of its removal from service. See [Replacement Criteria](#) on page [14](#) for inspection guidelines.

Required Inspection Intervals

The frequency of wire rope inspection shall be:

- Daily (see [Daily Inspection](#))

and, **at minimum:**

- Yearly (see [Periodic Comprehensive Inspection](#))

Wire Rope Care and Replacement Guidelines

1. When replacing fixed-length wire rope assemblies (e.g. pendants) having permanently attached end fittings, use only pre-assembled lengths of wire rope as supplied from Manitowoc. Do not build lengths from individual components.
2. Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
3. Never electroplate wire rope assemblies.
4. Do not weld any wire rope assembly or component unless welding is recommended by the wire rope manufacturer.

Welding spatter shall never be allowed to come in contact with the wire rope or wire rope ends. In addition, be sure that the wire rope is not an electrical path during other welding operations.
5. Wire ropes are manufactured from special steels. If heating a wire rope assembly is absolutely necessary for removal, the entire wire rope assembly shall be discarded.
6. On systems equipped with two or more wire rope assemblies operating as a matched set, they shall be replaced as an entire set.
7. Do not paint or coat wire ropes with any substance except approved lubricants.

Daily Inspection

Wire rope should be inspected in accordance with ANSI/ASME B30.5 and OSHA 29 CFR 1926.1413. A running record of the condition of each wire rope the wire rope should be noted in the equipment inspection log (see [Maintain a Wire Rope Condition Report](#)).

⚠ WARNING

Personal Injury Hazard

Prior to conducting an inspection of wire rope:

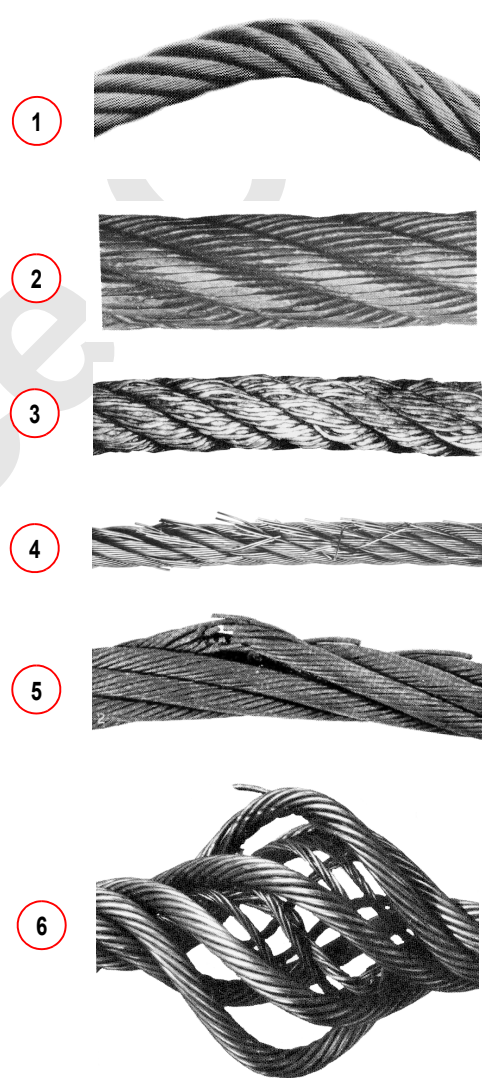
- Always lock out equipment power when removing or installing wire rope assemblies
- Always use safety glasses for eye protection
- Wear protective clothing, gloves, and safety shoes as appropriate
- Use supports and clamps to prevent uncontrolled movement of wire rope, parts, and equipment

See [Figure 5-9](#)

1. Each work day, prior to crane work, visually inspect all rope that can reasonably be expected to be used that day. Check for obvious damage, including:
 - Rope defects such as shown in [Figure 5-9](#).
 - Loss of rope diameter (see [Reduction in Rope Diameter](#)).
 - Broken wires—Record the number, distribution and type of broken wires (see [Broken Rope Wires](#)).
 - Internal wear or broken wires for ropes operating on synthetic sheaves. Common indicators of internal deterioration include localized reduction in rope diameter, corrosion between the strands, localized lengthening of lay, wire displacement, or wire distortion.
 - End fitting wear/abrasion
 - Minor or general corrosion
 - Areas that deteriorate more rapidly, such as flange points, crossover points, and repetitive pickup points on drums.
 - Take special care to observe boom hoist ropes and rotation-resistant ropes for evidence of core failure or other deterioration (remove from service). Internal deterioration of rotation-resistant ropes may not be readily observable.

2. Throughout the day, observe wire rope during operation, particularly:

- Pick-up Points—Sections of wire rope that are repeatedly stressed during each lift, such as those sections in contact with sheaves.
- End Attachments—The point where a fitting is attached to the wire rope or the point where the wire rope is attached to the drum.
- Abuse Points—The point where the wire rope is subjected to abnormal scuffing and scraping.



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Item	Description
1	Dog-Leg or Kink
2	Drum Abrasion
3	Drum Crushing
4	Sheaves Too Small
5	Corrosion
6	Bird Cage (sudden release of load)

FIGURE 5-9

Periodic Comprehensive Inspection

The comprehensive inspection must be done by a qualified person. The inspection must include pulling all the rope off the drum and carefully inspecting the entire length.

The inspection must include:

- All points listed under [Daily Inspection](#).
- Inspection of rope diameter (see [Reduction in Rope Diameter](#)).
- Comprehensive examination for broken wires (see [Broken Rope Wires](#)).
- End connections: Check for broken wires or severely corroded, cracked, bent, worn, or improperly applied end connections.
- Areas subjected to rapid deterioration such as:
 - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
 - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
- Inspection of boom sheaves, hook block sheaves, gantry/mast sheaves, boom extension/jib sheaves, jib strut sheaves, and hoist drums for wear.

NOTE: Damaged sheaves or hoist drums can accelerate wear and cause rapid deterioration of the wire rope.

Any damage of the wire rope found must be recorded and a determination made as to whether to continued use of the rope is safe. Refer to [Replacement Criteria](#).

 **DANGER**
Falling Load Hazard

- As a wire rope approaches the end of its useful life, inspections should be performed more frequently.
- All wire rope will eventually deteriorate to a point where it is no longer usable.
- A comprehensive inspection of each wire rope must be performed at least once a year.

Determining Frequency of Inspection

Intervals for comprehensive inspections may vary from machine to machine. The inspection interval must be determined by a qualified person and be based on such factors as:

- Expected rope life as determined by experience on the particular installation or similar installations.

- Size, nature, and frequency of lifts.
- Rope maintenance practices.
- Severity of environment, such as:
 - Variation in temperature
 - Continuous excessive moisture levels
 - Exposure to corrosive chemicals or vapors
 - Subjecting the wire rope to abrasive material
 - Powerline contact
- Exposure to abuse and shock loads, such as:
 - High-velocity movement, such as hoisting or swinging of a load followed by abrupt stops.
 - Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
 - Moving a load that is beyond the rated capacity of the lifting mechanism (overloading).

NOTE: Inspection intervals may also be pre-determined by state and local regulatory agencies.

Replacement Criteria

The decision as to when a wire rope should be replaced is the responsibility of the qualified person who is appointed to review rope inspection records and evaluate rope condition.

The following are indications that the rope needs to be replaced:

- Reduction in rope diameter and excessive broken wires. See [Reduction in Rope Diameter](#) and [Broken Rope Wires](#).
- Wear of one-third the original diameter of outside individual wires
- Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure
- Evidence of any heat damage from any cause
- Severe corrosion as evidenced by pitting
- Independent wire rope core (IWRC) or strand core protrusion between outer strands
- Obvious damage exists from any heat source to include—but not limited to—welding, power line strike, or lightning

Reduction in Rope Diameter

A reduction in rope diameter is often the first outward sign that the rope core is damaged. Reduction in rope diameter can be caused by loss of core support, internal or external corrosion, or wear of the outside wires.

New Wire Rope—After initial loading, measure and record the diameter of any new wire rope for comparison to future inspections. See [“Maintain a Wire Rope Condition Report.”](#)

The wire rope shall be taken out of service when the reduction from its nominal diameter is more than 5 percent.

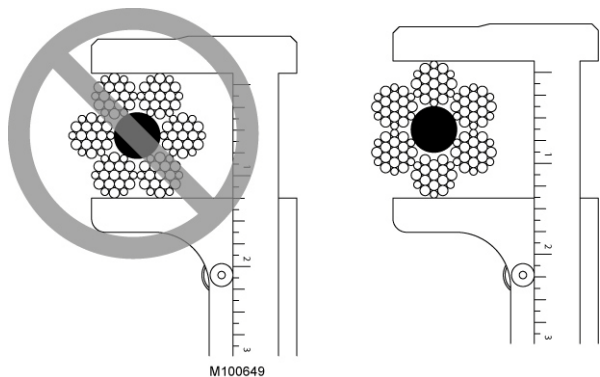


FIGURE 5-10

Broken Rope Wires

When conducting the Periodic Comprehensive Inspection, thoroughly clean the wire rope so breaks can be seen. Relax the rope, move it off “pick-up points,” and flex it as much as possible. Use a sharp awl to pick and probe between wires and strands, lifting any wire which appears loose or moves excessively. **Do not open strands of rotation-resistant rope.**

Wire breaks are typically at the crown of the strands—the area that contacts the sheave or drum when a load is picked up. Breaks at the crown will appear as small gaps in a wire. In comparison, when wires in the valley of a strand break, the broken ends will rise up and are easier to notice.

NOTE: The Daily Inspection does not require that the rope be cleaned or probed.

The wire rope shall be taken out of service when it has the following number of broken wires:

See [Figure 5-12](#) for an explanation of lay length.

- Running Ropes—six randomly broken wires in one lay length or three broken wires in one strand in one lay length.
- Standing Ropes (Pendants)—more than two broken wires in one lay length in sections beyond the end attachment, or more than one broken wire at the end attachment (see [Figure 5-11](#)).

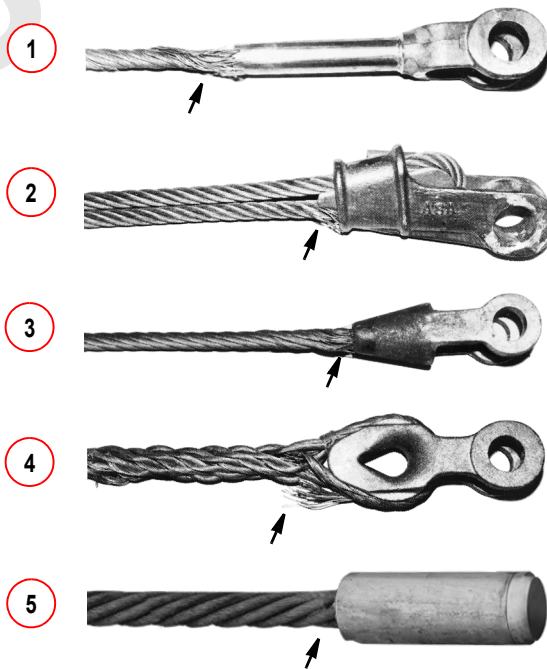
- Rotation-resistant Rope—two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- All Ropes—one outer wire broken at the point of contact with the core and protrudes or loops out of the rope structure—additional inspection is required.
- End Attachments ([Figure 5-11](#))—when more than one broken wire appears at the attachment, replace the rope or cut off the affected area and reattach the fitting.

NOTE: For galvanized bridge strand wire rope pendants—United States Steel states “Replacement criteria for galvanized strand boom suspension pendants are 25 percent of the outer wires fractured, or 10 percent of the total numbers, whichever comes first.”

WARNING
Falling Load Hazard

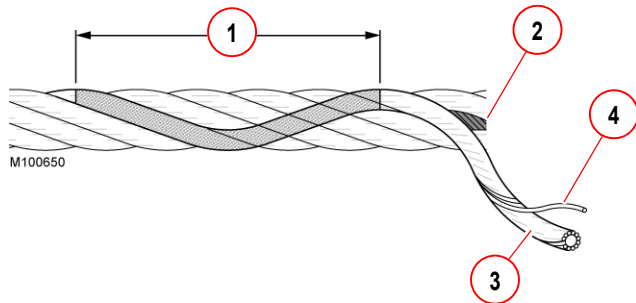
Replace wire rope when more than one broken wire appears at point marked by arrow.

Item	Description
1	Swaged Socket
2	Wedge Socket
3	Poured Zinc Socket
4	Hand-spliced Socket
5	Button Socket



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FIGURE 5-11



Item	Description
1	Lay Length: distance in which one strand makes one complete revolution around core.
2	Core
3	Strand
4	Wire

FIGURE 5-12

Rope That Has Been Idle a Month or More

Wire rope must be given a complete inspection if it has been idle for a month or more. The inspection must be performed by a qualified inspector looking for the damage identified under both Daily and Periodic Comprehensive Inspection.

NOTE: Wire rope may be purchased through the Manitowoc Crane Care Lattice Team.

! DANGER

Falling Load Hazard

Replacement wire rope can break if it does not meet Manitowoc specifications given in the following publications supplied with your crane:

- Wire Rope Specifications Chart located in Capacity Chart Manual (for load lines).
- Boom or jib assembly drawings located in crane Operator Manual (for boom or luffing hoist).
- Mast assembly drawing located in Parts Manual.

Distributing Wire Rope Wear

Wire rope wear at the "critical wear points" can be reduced and the life of the wire rope extended by moving the rope at regular intervals so different sections of rope are subjected to the wear points. This practice can also help correct spooling problems and rope vibration.

To move the wire rope, cut off a piece of wire rope at the worn end and refasten. The piece cut off should be long enough to move wire rope at least one full drum wrap.

If the wire rope is too short to allow cutting off a piece of it, reverse the rope end for end and refasten it.

SHEAVE, ROLLER, AND DRUM INSPECTION

Perform the following inspections WEEKLY.

1. Check the drum clutches and brakes for proper adjustment.
2. Check all sheaves, rollers, and drums for the following conditions:
 - Unusual noises
 - Freedom of movement—must turn freely by hand. Wire rope may have to be loosened to perform this inspection
 - Wobble—must turn true with very little side-to-side or up-and-down play
 - Signs of rust (indicating that water may have entered bearing)
 - Grease leaks (indicating a faulty seal or water in grease)

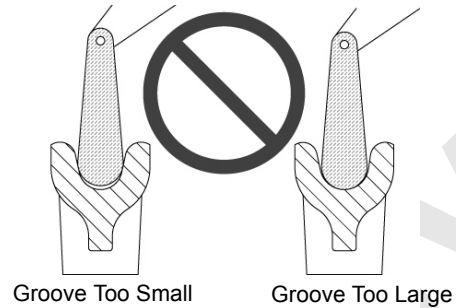
The above problems indicate bearing damage. If found, the corresponding sheave, roller, or drum should be disassembled for further inspection. New bearings should be installed.

For sheaves not equipped with grease fittings, be sure to pack new bearings with grease at assembly.

3. For steel sheaves, check depth, width, and contour of each sheave using a groove gauge as shown in [Figure 5-13](#). Replace sheaves that have over or under size grooves.
4. Replace grooved drums that allow one wrap of wire rope to contact next wrap as rope spools onto drum.
5. Inspect sheaves to verify they **do not** contact another sheave or structural plate work. There should be uniform clearance between sheaves in a cluster. Repair or replace worn or damaged sheaves.
6. Re-machine or replace steel sheaves, drums, or rollers that have been corrugated by the wire rope's print as shown in [Figure 5-14](#).
7. Inspect nylon sheaves for excessive tread diameter wear at locations **E** in [Figure 5-16](#). Measure at three places to check for uneven wear.

Wear must not exceed the limits given in the table. **Replace worn or damaged sheaves.**

Observe groove to see if contour of gauge matches contour at bottom of sheave groove.



Proper fitting sheave groove should support wire rope or 135–150° of rope circumference.

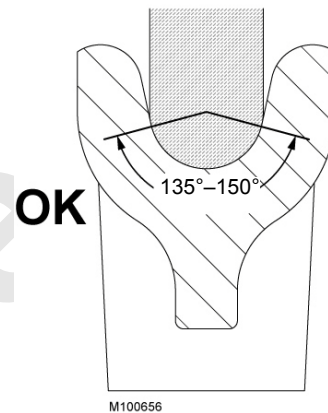
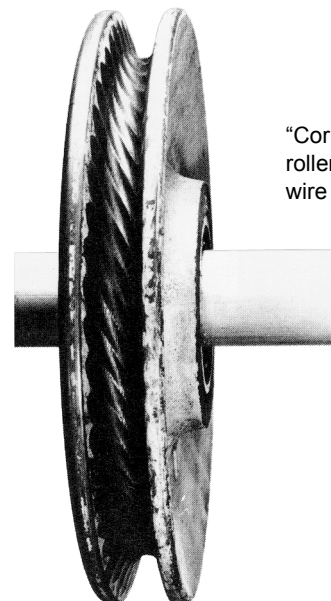


FIGURE 5-13



“Corrugated” steel sheave, roller, or drum will cause wire rope to wear rapidly.

FIGURE 5-14

8. Inspect nylon sheaves to verify they have not separated and “walked off” steel inserts or bearings as shown in [Figure 5-15](#). Maximum sideways displacement is 1/8 in (3 mm). **Replace worn or damaged sheaves.**

NOTE: Depending on the type of wire rope used, it is normal for nylon sheaves to show the wire rope print. **Do not re-machine nylon sheaves.**

NOTE: Nylon sheaves cannot be accurately inspected using conventional methods such as sheave gauges.

Due to the characteristics of nylon sheaves, the nylon material will actually move to better support the wire rope as the sheave wears normally.

Nylon sheave properties will be degraded in temperatures above 140°F (60°C).

Item	Description
1	Nylon Sheave
2	Improper Snap Ring Engagement
3	Steel Insert of Bearing
4	1/8 in (3 mm) Maximum Sideways Displacement

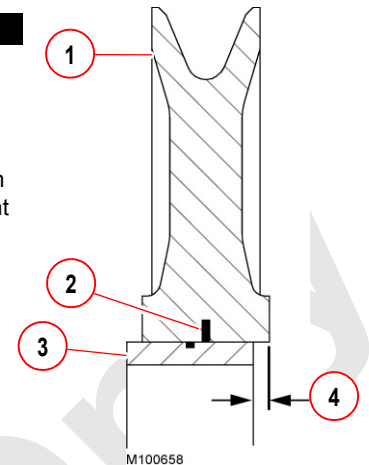


FIGURE 5-15

9. Make sure sheaves, drums, and rollers are properly lubricated according to the instructions in the lubrication guide provided with the crane (see Section 9).

NOTE: Many current production sheaves are not equipped with grease fittings, but are packed with grease at assembly. Repack the bearings of these sheaves with CraneLUBE EP #2 grease when the sheaves are overhauled.

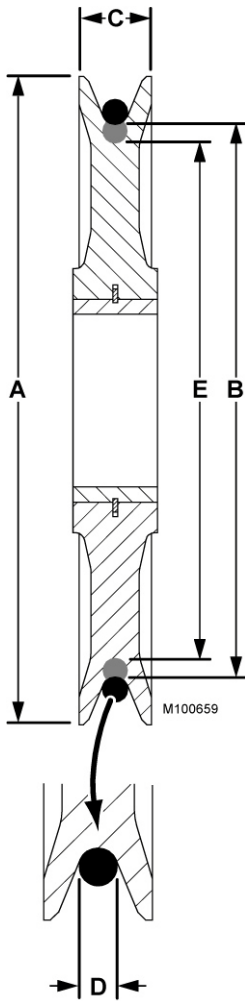
Due to application and design variations, it is not possible to give specific grease repacking intervals or the life expectancy of components.

NOTE: For some sheaves, the seals are an integral part of the bearing. Therefore, if a seal is damaged during repacking, the complete bearing may have to be replaced.

E = Replacement dimension

E = B - 3/16 in (5 mm) (maximum)

If tread print exists in root of sheave groove, measure to maximum tread diameter.



PLASTIC SHEAVE DATA								
Sheave Part No.	A Outside Diameter		B Tread Diameter		C Width		D Rope Diameter	
	inch	mm	inch	mm	inch	mm	inch	mm
912738 631056	13.19	335.0	11.42	290.1	1.77	45.0	5/8	16
631054	13.19	335.0	11.42	290.1	1.77	45.0	7/8	22
631065	16.00	406.4	13.37	339.6	2.17	55.1	9/16	14
631071	16.00	406.4	13.88	352.6	2.17	55.1	5/8	16
631526	19.25	489.0	16.63	422.4	1.94	50.8	7/8	22
631527	19.25	489.0	16.63	422.4	1.94	50.8	5/8	16
631055	19.69	500.1	17.60	447.0	1.85	47.0	7/8	22
631067	19.69	500.1	17.75	450.9	1.97	50.0	3/4	19
631529	20.00	508.0	17.00	431.8	3.00	76.2	1	25
631519 631520	23.00	584.2	20.13	511.0	2.25	57.2	7/8	22
631084 A00083	23.00	584.2	20.13	511.0	2.50	63.5	7/8	22
631102	23.00	584.2	20.13	511.0	2.50	63.5	1	25
631082 631103 A00051	27.00	685.8	23.00	584.2	3.00	76.2	1	25
631096 A00050	27.00	685.8	23.00	584.2	3.00	76.2	1.18	28
631100	30.00	762.0	27.00	685.8	3.00	76.2	1-1/8	29

FIGURE 5-16

5

LOAD BLOCK AND HOOK-AND-WEIGHT BALL INSPECTION

! WARNING Falling Load Hazard

To prevent load from dropping due to structural failure of load block or hook-and-weight ball:

- Only use a load block or a hook-and-weight ball which has a capacity equal to or greater than load to be handled.
- Do not remove or deface nameplate (Figure 5-17) attached to load blocks and hook-and-weight balls.
- See Duplex Hook topic in Section 4 of Operator Manual for recommended sling angles and capacity restrictions when load block has duplex or quadruplex hook.

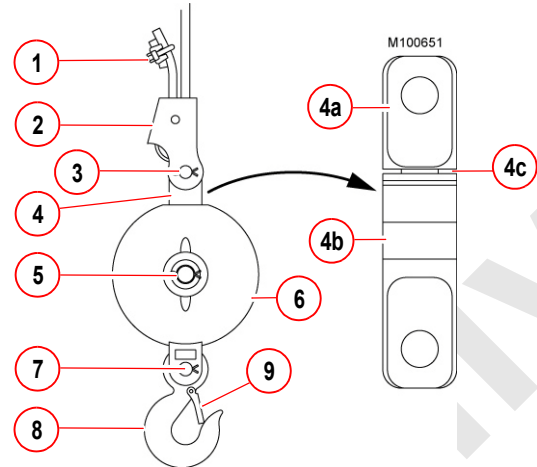


Item	Description
1	Working Load Limit (ton (US and metric)
2	Wire Rope Diameter (in and mm)
3	Block Weight (lb and kg)
4	Block Serial Number
5	Block Part Number (OEM and Manitowoc)
6	Design Factor

FIGURE 5-17

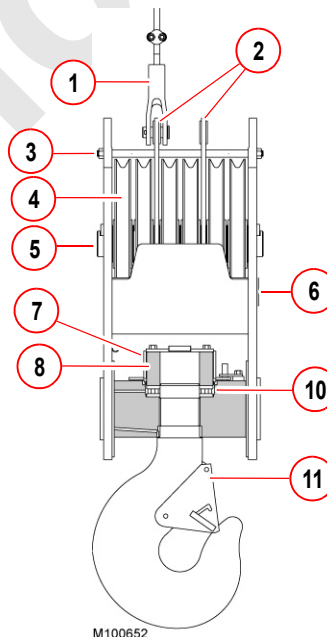
The operating condition of the load block and the hook-and-weight ball can change daily with use; therefore, they must be inspected daily (at start of each shift) and observed during operation for any defects which could affect their safe operation. Correct all defects before using the load block or the hook-and-weight ball.

Daily inspection and maintenance will include the following points (see Figures 5-18 and 5-19):



Item	Description	Item	Description
1	Dead-End Clip	4c	Check Gap Here
2	Socket and Wedge	5	Bolt or Pin
3	Bolt or Pin	6	Weight Ball
4	Swivel	7	Bolt or Pin
4a	Swivel Shank	8	Hook
4b	Swivel Barrel	9	Latch

FIGURE 5-18



Item	Description
1	Socket and Wedge
2	Center Plates
3	Tie Bolt
4	Sheaves
5	Sheave Shaft
6	Name Plate
7	Locking Cap
8	Hook Nut
9	Trunnion
10	Thrust Bearing
11	Latch
12	Hook

FIGURE 5-19

1. Clean the load block or the hook-and-weight ball.
2. Lubricate the sheaves (if fittings provided), the hook trunnion, the hook swivel, and any other part equipped with a grease fitting at the intervals specified in the "Lubrication Guide."
3. Tighten loose tie-bolts, cap screws, and set screws. Check that all cotter keys are installed and opened.

4. Check the sheaves for uneven wear in the grooves and on the flanges. Check for loose or wobbly sheaves. These conditions indicate faulty bearings or bushings.
5. Check the fit of the wire rope in the groove of each sheave. An oversize wire rope can crack the lip of the sheave flange causing rapid wear of the wire rope and sheave. The groove must be larger than the wire rope, and the groove must be free of rough edges and burrs.
6. Check that the hook, the trunnion, and the swivel rotate freely without excessive play. Faulty operation indicates faulty bushings or bearings or inadequate lubrication.
7. Check the swivel of the hook-and-weight ball for the following conditions:
 - Overloading: Spin the swivel by hand. If the motion is rough or has a ratchet-like effect, the swivel bearings are damaged.
 - Side loading: The swivel will turn freely in one spot and lock-up in another. This condition can also be checked by checking the gap (4c, [Figure 5-18](#)) between the barrel and shank (swivel must be removed from weight ball to check). If the gap is wide on one side and closed on the other side, damage is present.

NOTE: The gap between the barrel and the shank is normally 0.02 in (0.5 mm) to 0.05 in (1.3 mm). If the gap increases, swivel-bearing failure is indicated.

8. Check the load block for signs of overloading: spread side plates, elongated holes, bent or elongated tie-bolts, and cracks.
9. Check all welds for defects and cracks.
10. Check the wire rope for wear and broken wires at the point the wire rope enters the dead-end socket. Check the socket for cracks. Tighten the wire-rope clips at the dead end of the wire rope.
11. Check that each hook has a latch and that the hook latch operates properly. **The latch must not be wired open or removed.**
12. Check each hook and shackle at least yearly for cracks using a dye penetrant test, MAG particle test, ultrasonic test, or by X-ray.



WARNING
Falling Load Hazard

To prevent load from dropping due to hook or shackle failure, do not attempt to repair cracks in hooks and shackles by welding. Do not weld on any load bearing component unless proper welding methods are used (contact the Manitowoc Crane Care Lattice Team for material and welding specifications).



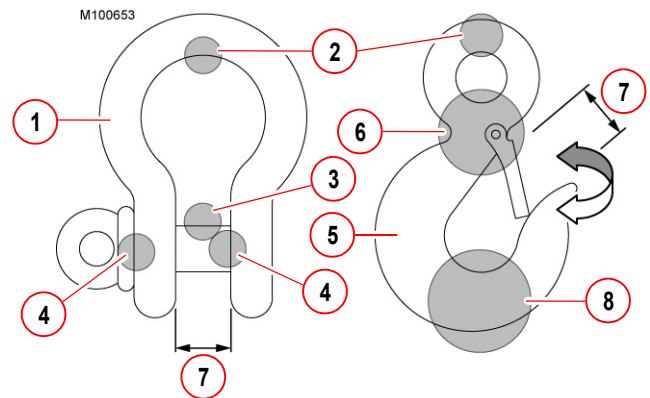
WARNING
Falling Load Hazard

To prevent load from dropping, hook latch must retain slings or other rigging in hook under slack conditions.

Hook latch is not intended as anti-fouling device, and caution must be taken to prevent hook latch from supporting any part of load.

Slings or other rigging must be seated in hook when handling load. They must never be in position to foul hook latch.

13. Inspect each hook and shackle for damage as shown in [Figure 5-20](#).
14. See the ASME B30-10 Standard for specific hook replacement guidelines. The standards are available as follows:
 - **Mail**— ASME, 22 Law Drive, Fairfield, New Jersey, 07004-2900
 - **Toll free phone**— US & Canada 800-843-2763, Mexico 95-800-843-2763, Universal 973-882-1167
 - **Fax**— 973-882-1717 or 973-882-515
 - **E-mail**— infocentral@asme.org
15. Contact the supplier of your hooks, shackles, blocks, and other rigging for repair instructions.



Item	Description
1	Shackle
2	Check for Wear and Deformation
3	Check for Wear and Straightness
4	Check that Pin is Always Seated
5	Hook
6	Check that Hook is Not Twisted
7	Check for Cracks and Twisting
8	Check for Wear and Cracks

FIGURE 5-20

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Reference Only

SECTION 6 SWING

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Manual Release Procedure	6-1

Reference Only

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Reference Only

SECTION 6

SWING

MANUAL RELEASE OF SWING BRAKE AND LOCK

The hydraulic swing brake and hydraulic swing lock must be released when the swing planetary is removed and reinstalled to allow alignment of the gear teeth in the swing shaft with the teeth in the ring gear.



WARNING

Unexpected Crane Movement!

Crane can swing suddenly when swing brake is released. Before releasing swing brake, secure crane by lower boom onto blocking at ground level to prevent sudden uncontrolled swinging.

The procedure given in this section is for servicing purposes only. Swing brake and swing lock must be fully operational when operating crane.

Manual Release Procedure

See [Figure 6-1](#) for the following procedure.

Hydraulic hand pumps with pressure gauge are needed to manually release the swing brake and swing lock.

1. Disconnect the hose from the fitting at the brake release port and at the swing lock OUT port.
2. Attach a hand pump to each port — brake release and swing lock OUT.
3. Pressurize the brake and the swing lock to 350 psi (24 bar).
4. Proceed to remove or install the swing gearbox.
5. Relieve the pressure and remove the hand pumps.

CAUTION

Avoid damage to parts!

Do not exceed 350 psi (24 bar) pressure when releasing swing brake or swing lock.



M102009

Swing Lock OUT Port
(06 ORS Fitting)

Brake Release Port
(06 ORS Fitting)

FIGURE 6-1

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SECTION 7 POWER TRAIN

BATTERIES

Safety

! WARNING
Explosion Hazard!

Batteries can explode with great violence and spraying of acid if a spark or flame is brought too near them. The room or compartment in which batteries are stored must be ventilated and away from flames or sparks.

Chemical Burn Hazard!

Battery electrolyte can cause severe burns. If electrolyte comes in contact with eyes, skin, or clothing, the area must be immediately flushed with large amounts of water.

Seek medical attention in event of an electrolyte burn.

Always wear eye protection when servicing batteries.

Battery gases are explosive. Avoid sparks while charging batteries. Do not disturb connection between batteries until charger is turned off.

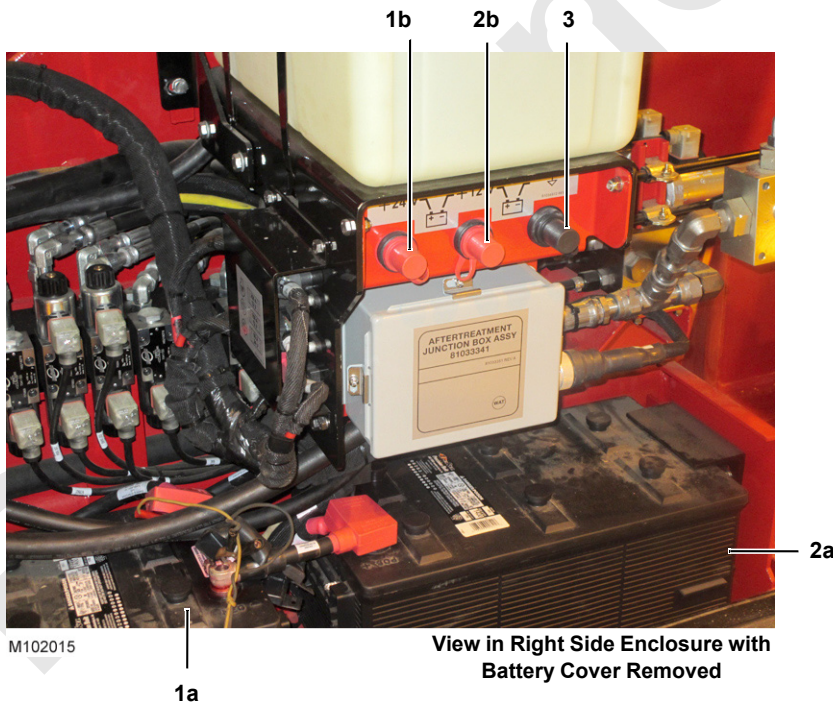
Another source of explosion lies in the reverse connection of charging equipment. This hazard is present with all types of chargers, but particularly in the case of high-rate equipment. Carefully check the connections before turning on the charger.

Jump-Starting a Battery

The 999 with Tier 4 Final Engine has remote battery terminals as shown in [Figure 7-1](#).

Improper use of a booster battery to start a crane also presents an explosion hazard. To minimize this hazard, the following procedure is suggested:

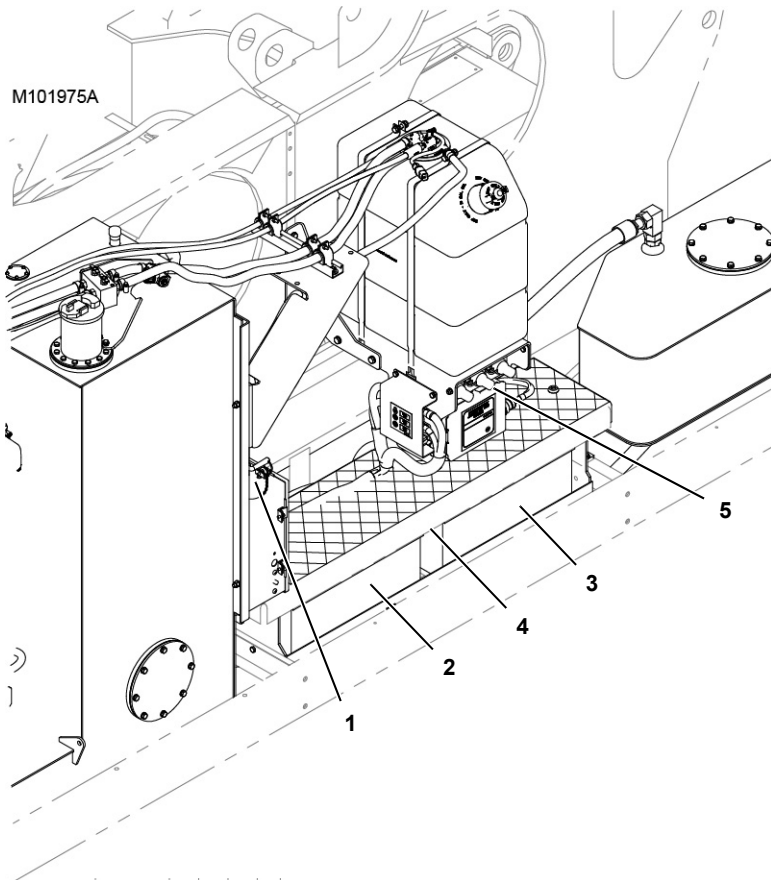
1. Connect one end of each jumper cable to the proper battery terminals on the crane to be started. Do not allow cable ends to touch.
2. Connect the positive cable to the positive terminal of the booster battery.
3. Connect the remaining cable to the frame or block of the starting vehicle. Never connect it to the grounded terminal of the starting vehicle.



Item	Description
1a	Rear Battery
1b	Rear Battery Remote Positive Terminal
2a	Front Battery
2b	Front Battery Remote Positive Terminal
3	Remote Negative Terminal

FIGURE 7-1

View in Right Side Enclosure



Item	Description
1	Battery Disconnect Switch
2	Rear Battery
3	Front Battery
4	Battery Cover with Quarter-Turn Screws
5	Remote Battery Terminal (3)
6	To Starter Motor
7	Engine Wiring Harness

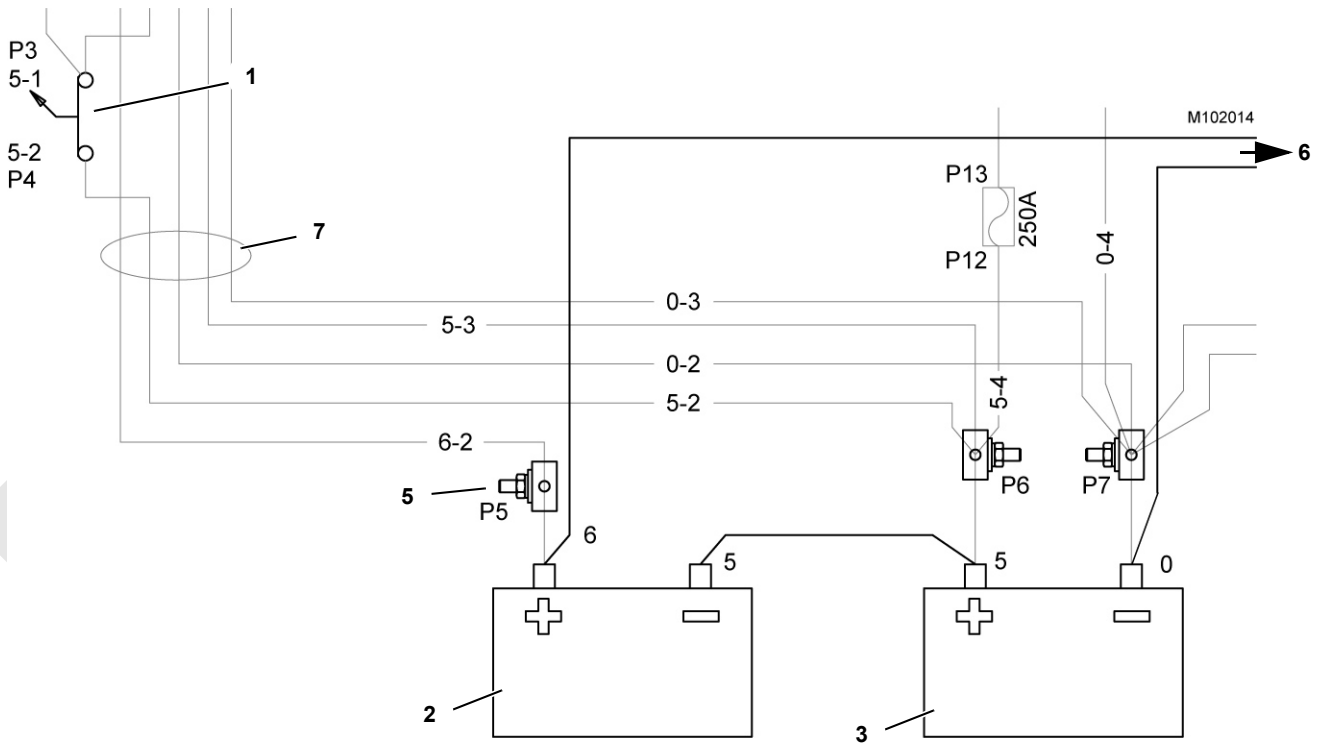


FIGURE 7-2

Causes of Battery Failure

A battery should never be left in a discharged state. When discharged, it rapidly sulfates and unless recharged within hours, will permanently lose capacity.

Overcharging

Overcharging is one cause of battery failure, and is most often caused by a malfunctioning voltage regulator.

Excessive heat is the result of overcharging. Overheating causes the plates to warp which can damage separators and cause a short circuit within a cell. This bubbling and gassing of the electrolyte can wash the active material from the plates, reducing the battery's capacity or causing an internal short.

Undercharging or Discharged

Undercharging can cause a type of sulfate to develop on the plates. The sulfate reduces battery capacity and causes strains in the positive plates which cause plate buckling. Buckled plates can pinch the separators and cause a short circuit.

Furthermore, an undercharged battery is not only unable to deliver power, but may freeze (see [Table 7-1](#)).

Table 7-1. Battery Freeze Points

State of Charge	Specific Gravity	Freeze Point °F (°C)
100%	1.26	-70 (-57)
75%	1.23	-36 (-38)
50%	1.20	-15 (-26)
25%	1.17	-2 (-19)
0%	1.11	18 (-8)

Lack of Water

The plates must be completely covered with electrolyte. If the plates are exposed, the high acid concentration will char and disintegrate the separators. The plates cannot take a full charge if not completely covered by electrolyte.

Loose Hold-Downs

Loose hold-downs will allow the battery to vibrate in the holder. This can cause cracks or wear in the container and cause acid to leak. Leaking acid corrodes terminals and cables, causing high resistance at the battery connections which weakens the battery. Hold-downs can also distort or crack the container.

Overloads

Avoid prolonged cranking or the addition of extra electric devices which will drain the battery and may cause excessive heat.

Multiple Battery System

The crane's 24V system is powered by two 12V batteries connected in series ([Figure 7-2](#)).

Always refer to wiring diagram for correct connections. **Be careful not to reverse the battery connections.** Installing batteries with reversed electrical connections will not only damage batteries but also the crane's electrical system, voltage regulator, and/or alternator.

Maintenance



WARNING

Personal Injury Hazard!

Each battery weighs 59 lb (27 kg). Use proper lifting procedures.

Checking Battery State-of-Charge

Special equipment is required to properly determine the condition of a battery that has been in service. However, a voltmeter can be used to determine a battery's state-of-charge by checking the voltage between the battery terminals (Figure 7-3) (Table 7-2).

This open-circuit test is the simplest test but not as accurate in determining a battery's condition as a hydrometer test. The advantage is that the cell covers do not need to be opened, eliminating the possibility of cell contamination and electrolyte spill.

NOTE Do not use this test method if the battery has been recently charged by a charger or alternator. Recent charging places a high surface charge voltage which is not a true indication of actual battery voltage.

Item	Description
1	Test Leads on Battery Terminals
2	Voltmeter

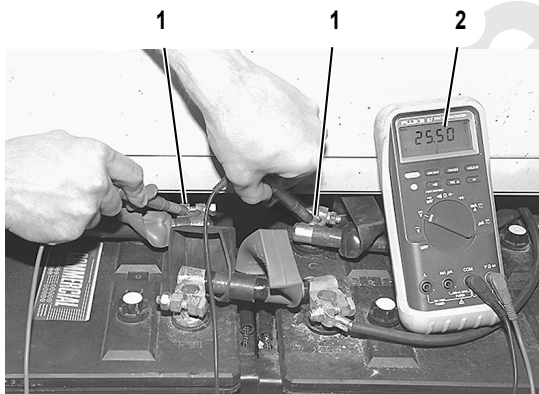


FIGURE 7-3

Table 7-2. Open Circuit Voltage

State-of-Charge	Specific Gravity	Approximate Open-Circuit Voltage (24V System)
100%	1.260	25.2
75%	1.230	24.8
50%	1.200	24.4
25%	1.170	24.0
0%	1.110	23.6

Consult the manual provided with the test meter for detailed test information.

Troubleshooting—Slow Cranking

If the starter cranks too slowly and the battery is charged and in good condition, do a voltage-drop test to make sure the starter connections are good.

When cranking, a voltage drop of more than 0.2 volts between the starting motor cable and ground can cause hard starting regardless of a battery's condition. The voltage drop can be caused by a poor contact between the cable terminal and ground or between the clamp terminal and the battery post. Poor start-switch contacts and frayed, broken, or corroded cables can also be the cause.

Quarterly Battery Maintenance

- Thoroughly clean the batteries and the holder with a baking soda/water solution.
- If provided, make sure the drain holes are open in the holder. If water collects in the holder, drill drain holes.
- Clean the posts and terminals. Lightly coat the posts with petroleum jelly to prevent corrosion.
- Replace frayed, broken, or corroded cables.
- Replace the batteries if their containers are cracked or worn to the point they leak.
- Ensure a good tight contact between the clamp terminals and battery posts.
- Make sure the hold-downs are tight enough to prevent battery movement but not so tight to cause distortion.

BATTERY DISCONNECT SWITCH

CAUTION

Engine Damage!

To avoid possible engine fault codes and undesirable operation, make sure engine ignition switch has been off five minutes before disconnecting batteries.

Do not rely on this switch to protect crane's electronic systems when welding. Disconnect battery cables at batteries before welding.

The battery disconnect switch ([Figure 7-4](#)) is located in the right side enclosure.

The switch disconnects the engine controller (Node 0) from the positive side of the battery. Since the rest of the crane's control system is powered through Node 0, opening the disconnect switch effectively removes power from the entire control system.

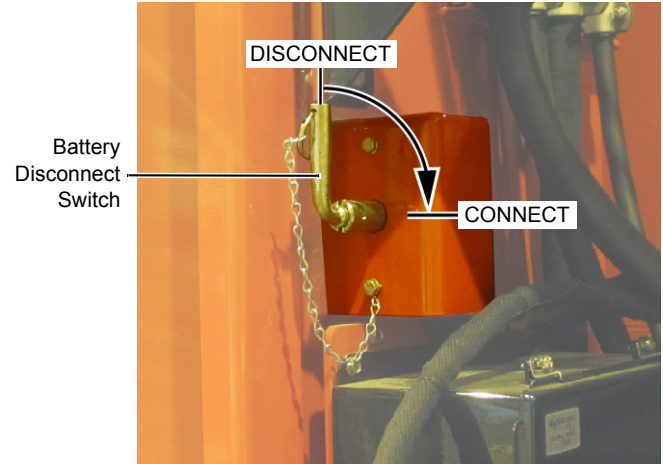
To operate the battery disconnect switch:

- Turn handle COUNTERCLOCKWISE to DISCONNECT the control system from the batteries. The handle can be removed in this position.
- Turn handle CLOCKWISE to CONNECT the control system to the batteries.

Following are reasons for using the disconnect switch:

- When servicing crane's electrical control system.
- To help prevent batteries from discharging when the crane is stored for extended periods of time.

- To prevent crane from being started by unauthorized personnel.



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FIGURE 7-4

CAUTION

Potential Control System Damage!

Before Welding:

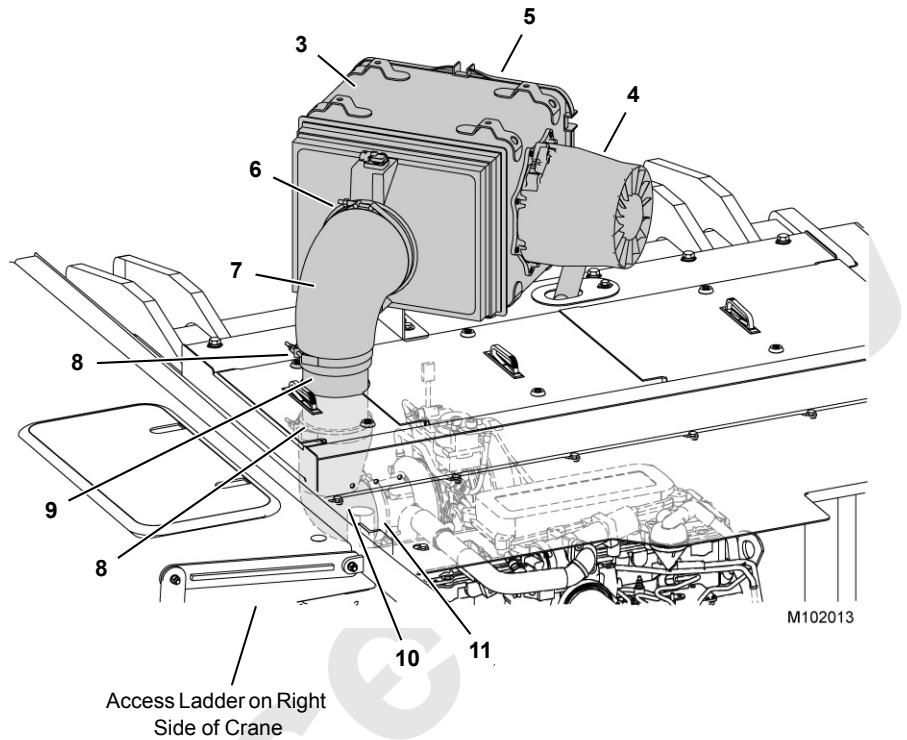
- Disconnect battery cables at batteries.
- Disconnect the cabling from any control node enclosures that are in the vicinity of the welding.

Do not rely on the disconnect switch to protect the crane's electronic systems when welding.

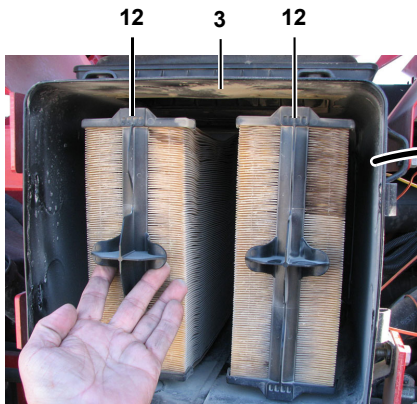


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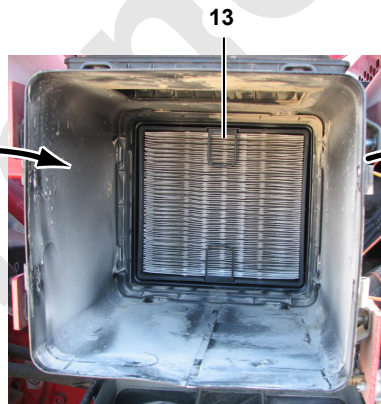
Item	Description
1	Service Indicator
2	Reset Button
3	Air Cleaner Housing
4	Pre-Cleaner
5	Service Cover
6	Clamp (7-1/4 in)
7	Rubber Elbow
8	Clamp (5-1/2 in)
9	Steel Tube
10	Rubber Reducing Elbow
11	Clamp (4-1/2 in)
12	Primary Filter (2)
13	Secondary Filter



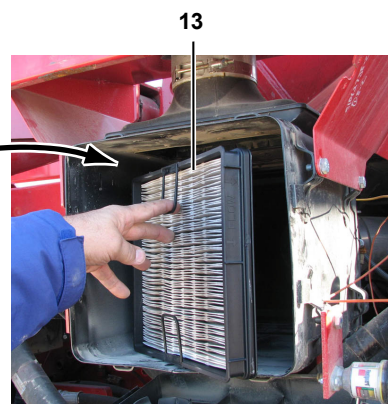
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FIGURE 7-5

AIR CLEANER

See [Figure 7-5](#) for the following procedures.

The air cleaner filters (12 and 13) require periodic maintenance.

- Clogged air cleaner filters will prevent adequate air flow to the engine, causing poor starting and increased exhaust emissions.

- An improperly installed or damaged air cleaner can allow dirty air to be drawn directly into the engine.

Either condition can cause engine damage.

Inspection

To maintain engine protection and filter service life, inspect the filters at the specified intervals:

**WARNING****Fall Hazard!**

It is necessary to climb onto the engine enclosure to inspect and service the air cleaner.

Use the access ladder on the right side of the upperworks to climb onto the engine enclosure.

Take every precaution to prevent falling off the crane.

CAUTION**Potential Engine Damage!**

- Stop engine before servicing air cleaner. Otherwise, unfiltered air will be drawn directly into engine. Never operate engine without an air cleaner.
- Before servicing, clean the fittings, mounting hardware, and the area around the component(s) to be removed.
- Replace secondary filter as quickly as possible to avoid engine ingestion of contaminants.
- Do not attempt to clean and reuse old filters. Discard old filters and install new filters. Cleaning filter elements by impact or compressed air voids the warranty and can degrade or damage the filter media, leading to engine damage.

Daily

Check the service indicator (1) with the engine running. The indicator gives a visual indication when it is time to replace the filters.

The yellow flag in the indicator window extends as the filters become plugged. Replace the filters when the yellow flag reaches the red CHANGE zone of the indicator window.

The yellow flag remains locked in place after the engine is stopped. The indicator reset button (2) on the end of the indicator can be pressed at any time. When the engine is running, the indicator will return to the proper reading.

Monthly

- Inspect the rubber elbows (7 and 10) and the tube (9) between the air cleaner and the engine for cracks or other damage which might allow unfiltered air to enter the engine. Replace worn or damaged parts.
- Check the housing (3) for dents or other damage that may allow unfiltered air to enter the engine. Replace the housing if damaged.

- Check for loose clamps (6, 8, and 11). Tighten loose parts as needed.
- Inspect the pre-cleaner (4) for obstructions. Clean as required.

Changing the Filters

The air cleaner has two primary filters (12) and one secondary filter (13).

1. Remove the service cover (5) carefully.
2. Remove the primary filters (12) gently to reduce the amount of dust that is dislodged. There will be some initial resistance, similar to breaking the seal on a jar. Using the tabs on the filters, move the ends of the filters back and forth to break the seals.

Avoid dislodging dust from filters.

NOTE The secondary (13) filter should be replaced every third time the primary filters are replaced. Inspect the secondary filter and replace as necessary.

3. Remove the secondary filter (13) by pulling on the plastic ring tabs.
4. Clean the sealing surfaces in the housing.

Use a clean cloth to wipe clean the sealing surfaces and the inside of the housing. Dust on the sealing surfaces could render the seal ineffective and cause leakage. Ensure all contamination is removed before the new filters are installed.

5. Visually inspect the old filters for leaks. A streak of dust on the clean side of filter is a telltale sign. Remove any cause of leaks before installing the new filters.
6. Inspect the new filters, especially the sealing area. Never install damaged filters.
7. Install a new secondary filter (13), if required, by gently pushing it into the back of housing. Apply pressure to all four corners and tabs to make sure the filter is completely secure in the housing.
8. Repeat this step for the primary filters (12).
9. Install the service cover (5), making sure that the O-ring is in place. Fasten the latches. The cover should go on without extra force. Push the reset button (2) on the service indicator (1).

Never use the latches on the cover to force the filters into the air cleaner housing. It is tempting to assume the cover will do the job of sealing the filter, but it will not. Using the latches to push the filters into the housing could damage the housing and will void the warranty.

ENGINE CLUTCH

A disc-type manually operated clutch (see [Figure 7-6](#)) is mounted between the engine and the pump drive. The clutch allows the pump drive to be disconnected from the engine, thereby reducing engine load and making start-up easier. The clutch can be engaged or disengaged while the engine is running or off.

The clutch can be operated either:

- Electrically with the switch on the front console in the cab
- Manually with the handle above the pumps in the left rear enclosure

CAUTION!

Parts Damage!

Do not run engine longer than 20 minutes with clutch disengaged. Clutch release bearing can be damaged.

Maintenance

1. Grease the clutch monthly. See Lubrication Guide in Section 9.
2. At least once each month:

- a. Park all crane functions (brakes applied) before disengaging the clutch.
- b. Disengage and engage the clutch several times with the engine running. This practice will clean the disc surfaces and prevent the discs from seizing.
- c. Disengaging the clutch with the handle while checking for proper free travel. Free travel should be at least 3/4 in (19 mm) as shown [Figure 7-6](#). Readjust the clutch when free travel decreases to less than 3/4 in (19 mm).

Adjustment

The clutch is adjusted internally through the hand hole on top of the clutch housing. See the manufacturer's manual for adjustment instructions.



DANGER!

Moving Machinery Hazard!

Parts inside clutch rotate when engine is running. Stop engine before adjusting clutch.

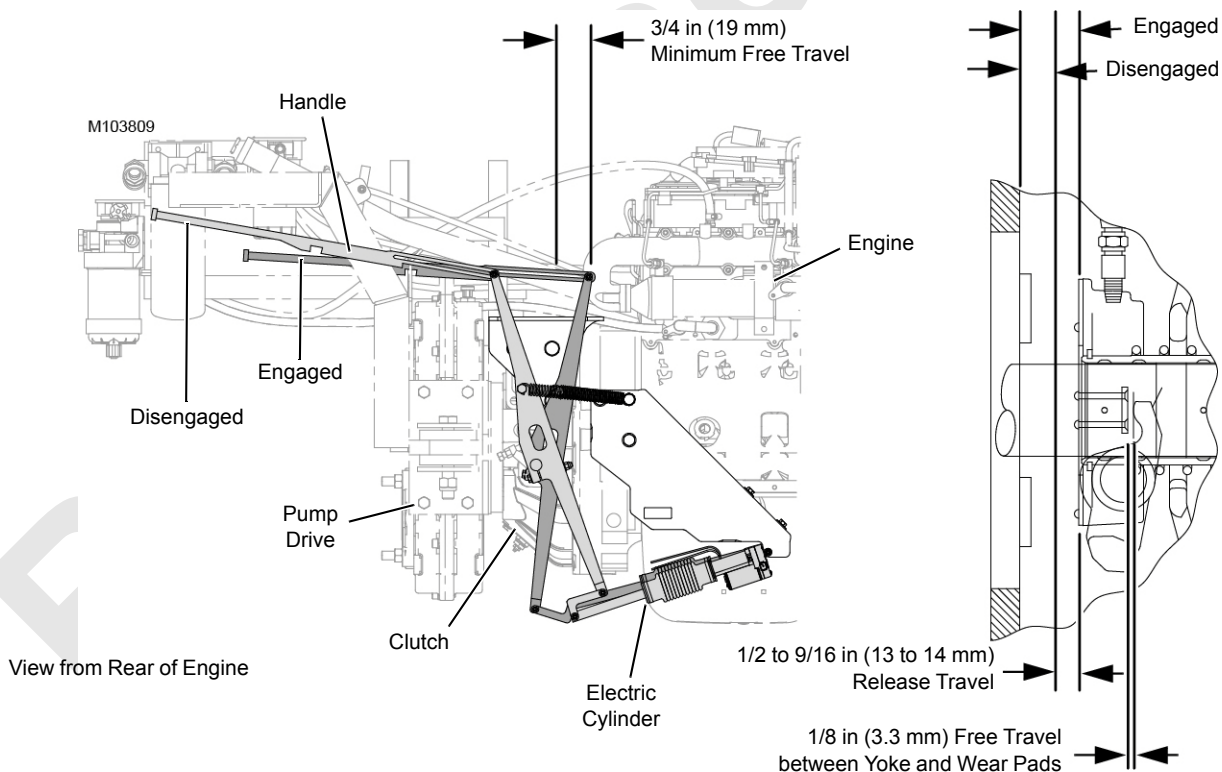


FIGURE 7-6

ENGINE THROTTLE

The throttle assembly for the Cummins engines consist of an electronic control module (ECM) on the engine, a hand throttle controller in the left console, a foot pedal on the cab floor, a foot throttle controller in the right console, associated linkage, and electrical connections.

A reach rod in the right console connects the foot pedal to the lever on the foot throttle controller. An electric cable connects the foot throttle controller in the right console to the hand throttle controller in the left console.

Foot Throttle Linkage Adjustment

See [Figure 7-7](#) for the following procedure.

1. Install spring clip (1) and rod end (2) on controller lever at dimension shown in View A and securely tighten jam nut (3).
2. Insert a 3/16 in (5 mm) thick shim or piece of floor mat between foot pedal and cab floor.
3. Press foot pedal down fully to **high idle** position against shim or floor mat.
4. Adjust reach rod (4) and rod end (5) so controller lever is rotated fully to **high idle** position. Securely tighten jam nuts (6) to lock adjustment.

NOTE: Both controllers have internal stops at high and low idle.

5. Release foot pedal to low idle position.
6. Adjust return springs so there is sufficient force to raise pedal and rotate controller lever to low idle.
7. Adjust pedal stop screw (7). Screw must be tight against cab floor and there must be 1/8 in (3,2 mm) gap between pin (9) and rear end of slot in rod end (5). Securely tighten jam nut (8).
8. With foot pedal in **low idle** position, distance from top of pedal to cab floor should be 3-15/16 in (100 mm).

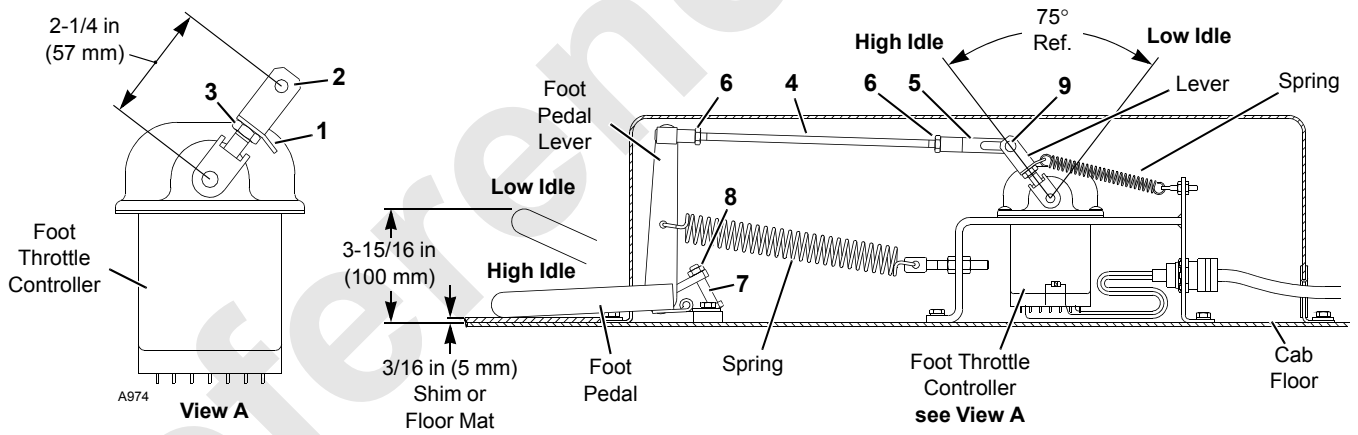
Engine Idle Speed

Engine idle speed is set by the crane's programmable controller:

- HIGH IDLE = 1,800 rpm
- LOW IDLE = 1,000 rpm

Wiring Diagram

For a wiring diagram of the system, see Electrical Operator's Cab Wiring drawing in your Parts Manual.

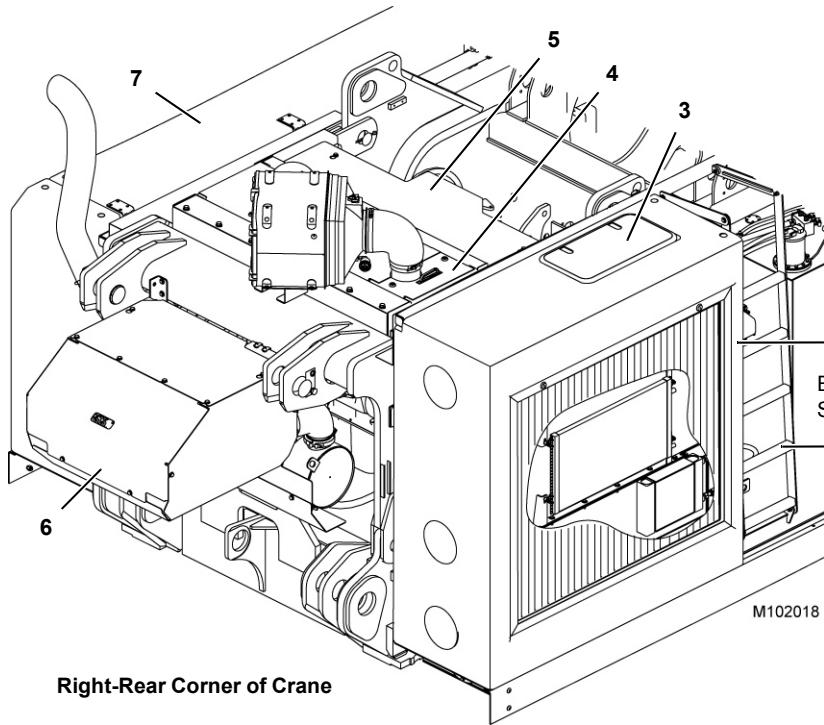


Item	Description	Item	Description
1	Spring Clip	6	Jam Nut
2	Rod End	7	Pedal Stop Screw
3	Jam Nut	8	Jam Nut
4	Reach Rod	9	Pin
5	Rod End		

FIGURE 7-7

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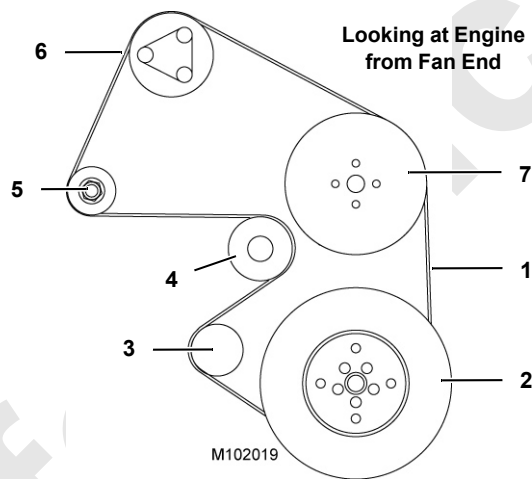
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Item	Description
1	Ladder
2	Radiator Enclosure
3	Radiator Access Door with Latches
4	Engine Covers (3) (with quarter-turn latches)
5	Engine Cover (with screws)
6	Exhaust System Enclosure
7	Left-Side Enclosure

Right-Rear Corner of Crane

FIGURE 7-8



Item	Description
1	Belt
2	Crankshaft Pulley
3	Belt Tensioner
4	Water Pump
5	Alternator
6	Air Conditioner Compressor
7	Idler Pulley

FIGURE 7-9

ENGINE ENCLOSURE



WARNING

Fall Hazard

It is necessary to climb onto the engine enclosure to inspect and service the air cleaner and engine.

Use the access ladder on the right side of the upperworks to climb onto the engine enclosure.

Take every precaution to prevent falling off the crane.

The engine enclosure ([Figure 7-8](#)) has panels that can be removed to allow access to the engine for servicing.

Do not operate the crane until all enclosures have been securely reinstalled.

ENGINE BELT ROUTING

Engine belt routing is shown in [Figure 7-9](#). Refer to the engine manufacturer's manual for maintenance instructions.

Item	Description
1	Level Sight Glass
2	Fill Cap
3	Coolant Level Sensor
4	Air Bleed Valve
5	Charge Air Cooler
6	Radiator Drain Valve with Hose
7	Hydraulic Oil Cooler
8	Radiator

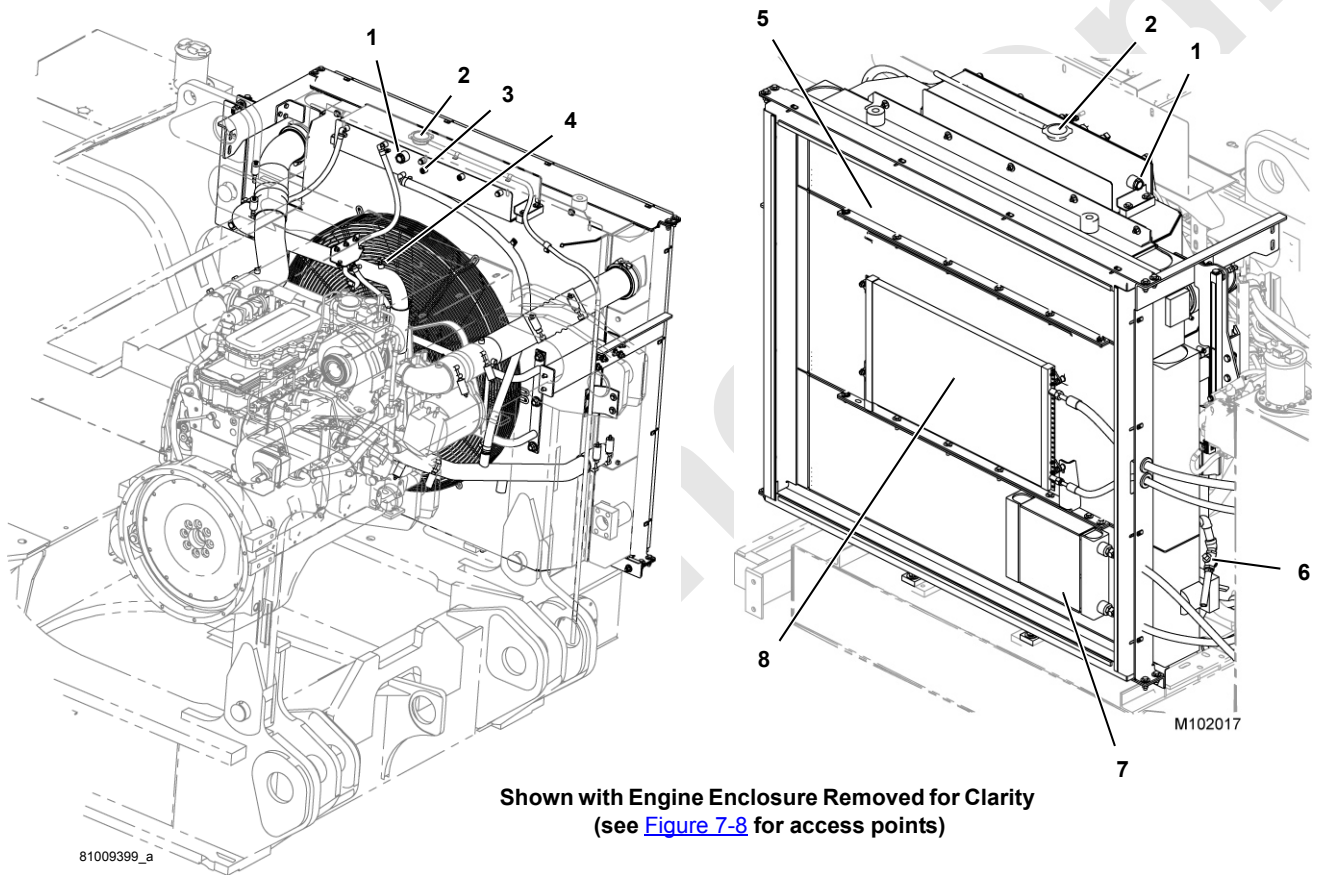


FIGURE 7-10

ENGINE COOLING SYSTEM

Refer to the engine manufacturer's manual for coolant filter replacement instructions.



WARNING

Burn Hazard!

Do not remove the radiator fill cap from a hot engine. Allow the engine to cool below 120°F (50°C) before adding coolant.

Material Hazard!

Coolant is toxic. Do not ingest. If not reused, dispose of in accordance with all local and other applicable environmental regulations.

CAUTION

Maintain Coolant Additive!

The required Supplemental Coolant Additive (SCA) concentration must be maintained to prevent engine damage.

Refer to the engine manufacturer's manual for specifications and precautions.

CAUTION

Potential Engine Damage!

The required coolant level must be maintained to prevent engine damage.

Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool below 120°F (50°C) before adding coolant.

See [Figure 7-10](#) for the following procedures.

Checking Coolant Level

Check the coolant level DAILY at the start of the shift when the coolant is cold.

The coolant should be visible in the sight glass (1). If necessary, fill the radiator as follows:

1. Open the access cover over the top of the radiator.
2. Place a heavy cloth over the fill cap (2) and turn the fill cap counterclockwise until it stops (do not depress).
3. Wait for the pressure to escape, then depress the fill cap and turn it until it can be removed.
4. Add coolant to the radiator.

Coolant added to the engine must be mixed with the correct proportions of antifreeze, water, and

supplemental coolant additive. Refer to the engine manufacturer's manual for specifications.

5. When the coolant is visible in the sight glass (1), install the fill cap (2) and securely tighten it (clockwise).

NOTE: The maximum fill rate is 3 GPM (11 liters/min).

6. Close the cover over the top of the radiator.

Draining Cooling System

Drain and refill the cooling system every 1,000 hours of operation or semiannually, whichever occurs first.

1. Wait for the cooling system to cool down.
2. Place the radiator drain hose in a container capable of holding 20 gal (76 L).
3. Place a heavy cloth over the fill cap (2) and turn it counterclockwise until it stops (do not depress).
4. Wait for the pressure to escape, then depress the fill cap and turn it until it can be removed.
5. Open drain valve (6) and completely drain the radiator.
6. When the radiator stops draining, close the drain valve and store the drain hose on the crane.
7. Fill and bleed the cooling system.
8. Refer to the Lubrication Guide supplied with your crane for cooling system capacity.

Filling and Bleeding Cooling System

Perform the following procedure to fill and bleed the cooling system.

Coolant added to the engine must be mixed with the correct proportions of antifreeze, water, and supplemental coolant additive. Refer to the engine manufacturer's manual for specifications.

1. Open the air bleed valve (4) in the upper radiator tube. This valve must be open to bleed the air from the cooling system.
2. Add coolant to the radiator while observing the bleed valve (4).
3. Securely close the bleed valve when coolant appears.
4. Continue adding coolant until the level is visible in the sight glass (1) (engine cold).

NOTE: The maximum fill rate is 3 GPM (11 liters/min).

5. Run the engine until the normal operating temperature is reached and check for coolant leaks.
6. Check the coolant level again to make sure the coolant is visible in the sight glass (1) or that the level has risen in the sight glass (engine hot).

Item	Description
Components	
1	DEF Tank
2	Coolant Flow Control Solenoid Valve
3	Coolant Manifold
4	Air Bleed Valves
5	DEF Supply Module
6	SCR Module
7	DRT Module
8	DEF Dosing Module
9	DOC Module
Coolant Hoses (BLUE)	
C1	From Coolant Manifold to DEF Tank
C2	From DEF Tank to Coolant Manifold
C3	From Engine
C4	Return to Engine
C5	From DRT Module to Coolant Manifold
C6	From Coolant Manifold to DRT Module
DEF Hoses (GRAY)	
D1	From Tank to DEF Supply Module
D2	From DEF Supply Module to DEF Tank
D3	From DEF Supply Module to DRT Module

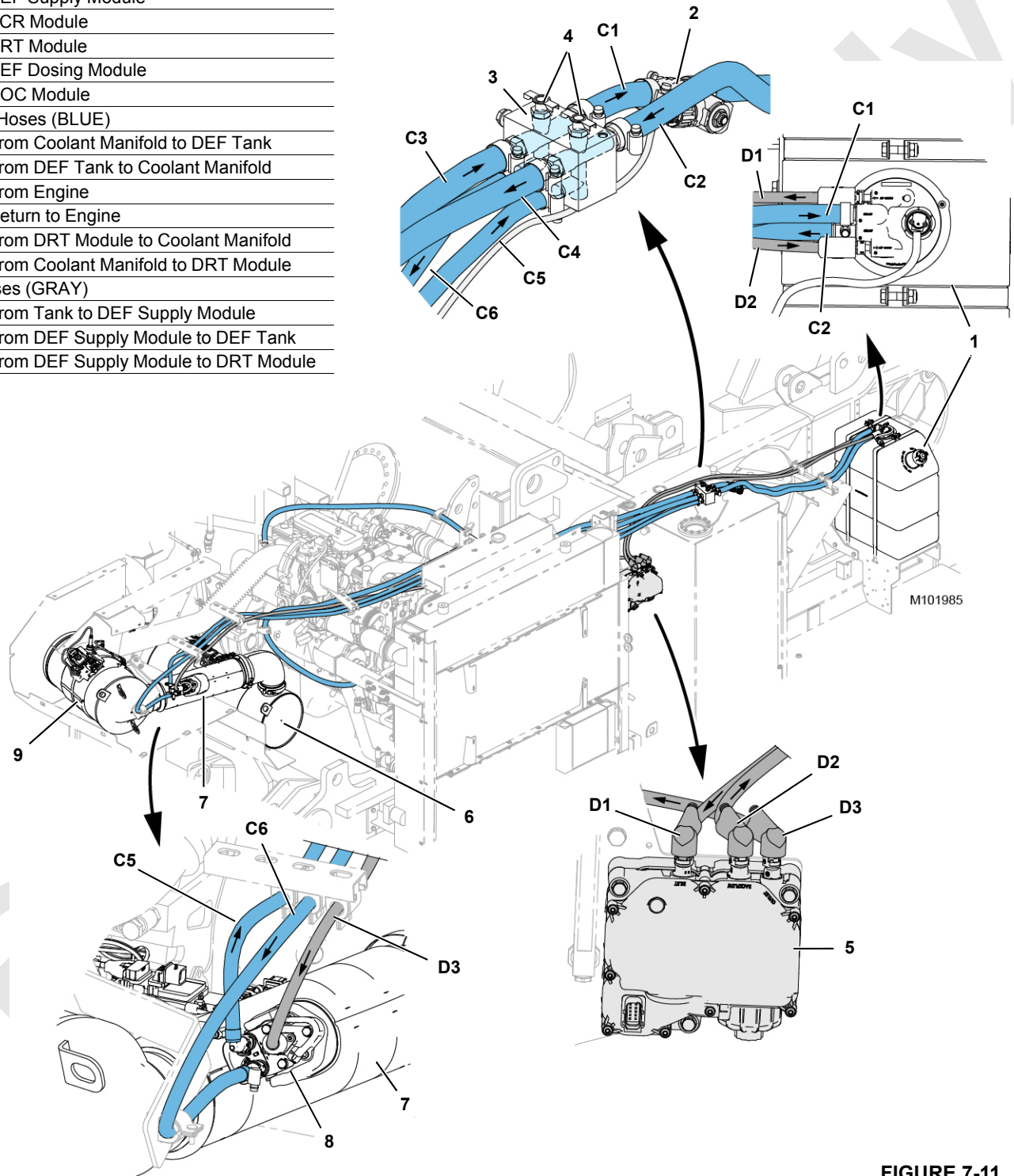


FIGURE 7-11

EXHAUST AFTERTREATMENT SYSTEM

See [Figure 7-11](#) for the following procedures.

Abbreviation	Description
APS	Aftertreatment Protection System
DEF	Diesel Exhaust Fluid
DOC	Diesel Oxidation Catalyst
dP	Dual Pressure
DRT	Decomposition Reactor Tube
ECM	Engine Control Module
HEST	Hugh Exhaust System Temperature
SCR	Selective Catalytic Reduction
NH ₃	Ammonia
NO _x	Generic term for the mono-nitrogen oxides NO and NO ₂ (nitric oxide and nitrogen dioxide). They are produced from the reaction of nitrogen and oxygen gases in the air during combustion.

WARNING

Hot Exhaust Surfaces and Inhalation Hazards

Extremely hot surfaces and exhaust gases can cause death or serious injury. Allow engine and exhaust system to cool before servicing.

The engine exhaust is treated to significantly reduce the amount of harmful by-products of combustion from contaminating breathable air.

DEF Tank

The DEF tank (1, [Figure 7-11](#)) houses 15 gallons (57 L) of DEF. DEF consists of 32% urea and 68% de-ionized water. A constant mist of DEF, equal to 2-3% of the fuel used, is injected into the DRT module (7). This is about 10 gallons (38 L) of DEF for 2 to 3 tanks of fuel.

There is a 40-micron filter in the DEF supply line. For filter maintenance intervals and procedures, refer to the engine manufacturer's manual.

A drain valve is provided in case the tank needs to be emptied of poor-quality DEF.

Item	Description
1	DEF Tank
2	Fill Cap
3	DEF Return Port
4	DEF Coolant OUT Port
5	DEF Coolant IN Port
6	DEF Suction Port
7	Electric Plug
8	Drain Valve

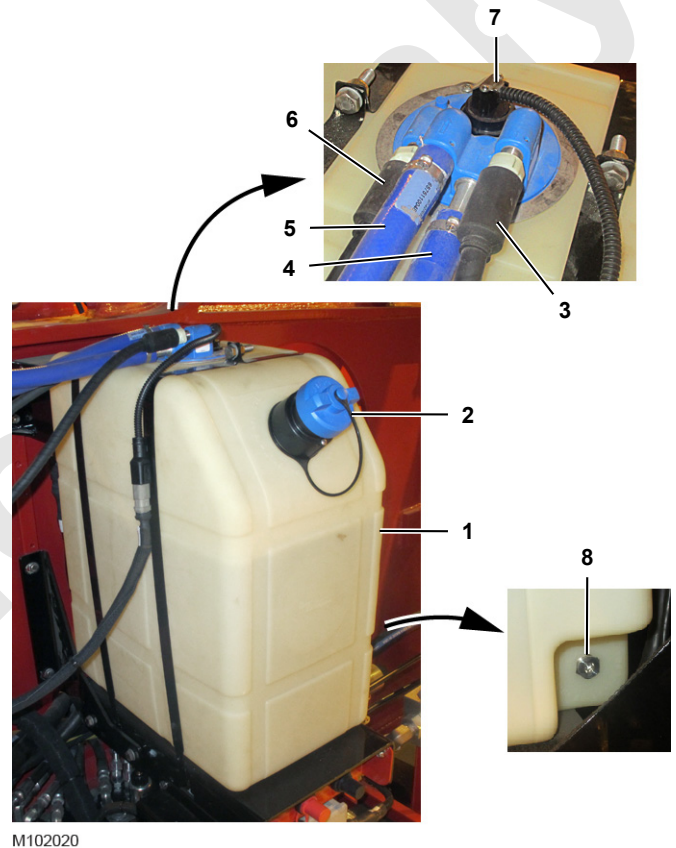


FIGURE 7-12

WARNING

Chemical Hazard!

DEF contains urea. Do not get DEF in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow. In the event the DEF is ingested, contact a physician immediately.

NOTE: Do not store DEF for long periods of time. DEF will deteriorate relative to time and temperature. Low-quality DEF may require the tank to be drained and the system purged.

CAUTION

Loss of Power or Engine Shutdown Hazard!

If poor-quality DEF or a low-level condition is sensed, an error code will be activated. These conditions can lead to engine power being reduced (de-rated) by the ECM. If the condition persists, engine shutdown may occur.

Refer to Section 3 of the 999 Operator Manual for identification and location of the engine and exhaust aftertreatment warning lights.

Coolant Solenoid Valve

When needed, the DEF is heated by engine coolant which is circulated through a heat exchanger in the tank. If the tank temperature drops below 25°F (−4°C), the ECM will open the coolant solenoid valve (2) to allow coolant to flow through the heat exchanger.

Coolant Manifold

The coolant manifold (3) routes coolant flow to the system.

Air Bleed Valves

The air bleed valves (4) are used to bleed air from the system when needed.

DEF Supply Module

The DEF supply module (5) is an electronically operated pump and metering system controlled by the ECM. The module pumps DEF to the dosing module (8) which is mounted on the DRT module (7).

At engine shutdown, the DEF supply module enters a purge cycle to prevent DEF from being left in the system, and in cold climates, from potentially freezing. When it is in the purge cycle, an audible click and pumping sound will be heard from the module, and the module will pull out all of the DEF in the system and return the DEF to the tank.

The DEF supply module is heated electrically and has a 10-micron filter that requires periodic cleaning and inspection. For filter maintenance intervals, refer to the engine manufacturer's manual.



WARNING

Personal Injury or Equipment Damage Hazard!

Do not remove hoses from or attempt to service the DEF supply module without first consulting the engine manufacturer's instructions. Personal injury and/or equipment damage may result.

CAUTION

Use Only Approved Replacement Parts!

The DEF system components are designed to withstand freezing and to be compatible with DEF fluid and the other unique characteristics of the system. Use of non-approved replacement parts may result in system damage.

SCR Module

The SCR module (6) incorporates a catalyst, two temperature sensors, an NH₃ sensor, and a NO_x sensor.

The SCR module utilizes DEF (urea and deionized water) to reduce NO_x content in the exhaust gas to nitrogen.

The SCR module does not require maintenance.

Excessive NO_x Warning System

CAUTION

Loss of Power or Engine Shutdown Hazard

If NO_x emissions exceed legislated limits, the operator will be alerted by warning lights and audible warnings. If the condition is not corrected in a set amount of time, an engine derate and shutdown sequence will begin.

Refer to Section 3 of the 999 Operator Manual for identification and location of the engine and exhaust aftertreatment warning lights.

If an excessive NO_x warning is issued, check anything that might cause an elevated NO_x level, such as:

- Disconnected DEF tank level or quality sensor
- Blocked DEF hose or dosing module
- Disconnected dosing module
- Disconnected supply module
- Disconnected SCR wiring harness
- Disconnected NO_x sensor
- EGR valve malfunction

Aftertreatment Protection System

The APS continually monitors exhaust gas temperatures. In the event of excessive exhaust temperatures, the APS will illuminate the HEST lamp in the cab.

The DRT module does not require maintenance.

DRT Module

DRT (7) is a tube mounted between the DOC module (8) and the SCR module (6).

DEF Dosing Module

The DEF dosing module (8) injects a liquid mixture of urea and deionized water (called DEF) into the exhaust stream ahead of the inlet to the SCR module (6). Coolant lines run through the dosing module to keep it cool and operable.

DOC Module

The primary function of the DOC module (9) is to oxidize the remaining hydrocarbons in the exhaust to carbon dioxide. It incorporates a NO_x sensor, a dP sensor, and two temperature sensors.

The DOC module does not require maintenance.

DEF Heating and Cooling System

See [Figure 7-11](#) for coolant hose routing and flow direction.

Warm coolant from the engine is routed to the coolant manifold (3) where it splits into two paths: one path delivers coolant to the heat exchanger in the DEF tank (1) to keep the DEF warm, and the other path delivers coolant to the DEF dosing module (8) to keep it from overheating.

The coolant solenoid valve (2) adjusts coolant flow according to the temperature of the DEF in the DEF tank. If the tank temperature drops below 25°F (–4°C), the ECM will open the solenoid valve, and engine coolant will flow through the heat exchanger in the DEF tank.

To keep the DEF flowing during cold temperatures, two heating elements are provided: one in the DEF supply module and one in DEF line. The heating elements turn on if the ambient air temperature sensor reads a temperature below 25°F (–4°C).

The DEF dosing module (8) will not prime the system until every component is completely defrosted. If ambient conditions continue to be cold after the system has primed, the ECM will command a maintenance heating cycle to prevent the DEF system from refreezing. This feature will cycle the heating on and off to the DEF lines, DEF tank, and dosing module.

NOTE: DEF will freeze at 12°F (–11°C) and when frozen will expand by 7%. There are no approved additives to improve the freezing point.

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SECTION 8

UNDER CARRIAGE

TURNTABLE BEARING

Installation

The outer ring can be installed in any position with relation to the carbody.

Two dowel pins are installed in the inner ring as shown in [Figure 8-1](#), see View Y-Y to locate the position of the inner ring on the rotating bed.

Torque Requirements



WARNING

Bolt Failure!

Loose or improperly torqued bolts can cause bolts or turntable bearing to fail, possibly allowing rotating bed to break away from carbody.

Lubrication

Before installing the turntable bearing bolts, lubricate the threads of each bolt with "Never-Seez" or an equivalent anti-seizing lubricant.

Torque Values

Torque each turntable bearing bolt to 2,100 ft-lb (2 848 Nm).

When new bolts are installed, torque the bolts in two steps: first to 600 ft-lb (814 Nm) and then to 2,100 ft-lb (2 848 Nm).

Torque Sequence

Torque two bolts at a time in the numbered sequence given in [Figure 8-1](#).

Torque Intervals

INITIAL OPERATION: torque all bolts to the specified value after the first 50 hours of operation.

YEARLY OR EVERY 2,000 HOURS OF OPERATION (whichever comes first): torque all bolts to the specified value.

Bolt Replacement

If, at the yearly inspection interval, one or more bolts are found to be torqued to less than 1,680 ft-lb (2 278 Nm), replace each loose bolt. Also replace the bolts and washers on each side of each loose bolt.

If, at the yearly inspection interval, nine or more bolts in either ring are found to be torqued to less than 1,680 ft-lb (2 278 Nm), replace all of the bolts and washers for the corresponding ring.

Replace all of the bolts and washers each time a new turntable bearing is installed.

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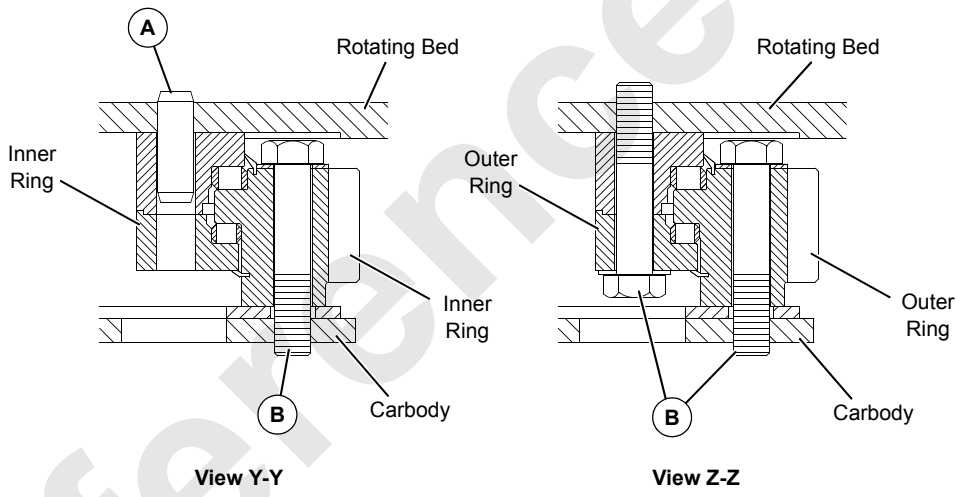
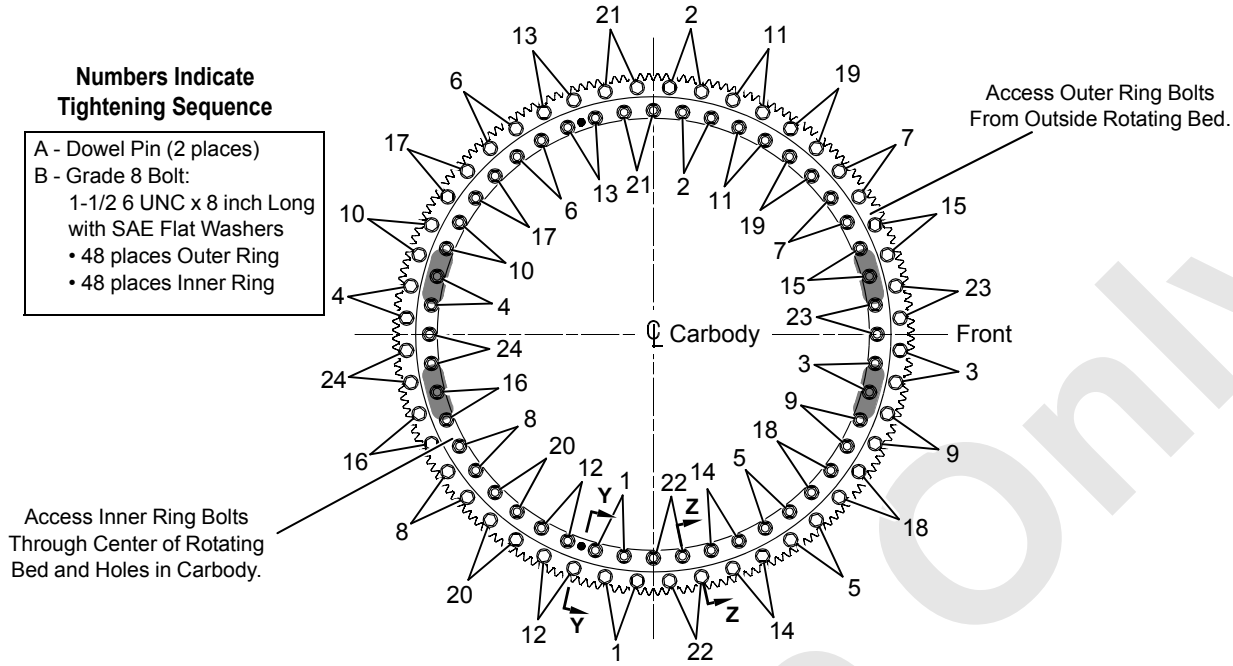


FIGURE 8-1

CRAWLER

Maintenance

Crawler wear cannot be eliminated, but the rate of wear can be reduced through regular preventive maintenance, as follows:

- Lubricate crawlers as instructed in Lubrication in Section 9.
- Keep crawlers clean and avoid dirt build-up in crawler frame.
- Keep all mounting bolts tight.
- Keep treads properly adjusted.

- Inspect crawler gear cases, crawler frames, rollers, treads, and drive shafts on a regular basis.

Look for oil leaks, excessive wear, cracks, and other damage. Broken or cracked parts can indicate that the treads are adjusted too tight.

Repair or replace damaged parts immediately to prevent further damage.

Tread Slack Adjustment

Checking Tread Adjustment

Check tread slack at the tumbler end of each crawler. Maintain equal tread slack at both crawlers.

1. Travel forward or reverse on a firm level surface so all tread slack is in top of treads at tumbler end of crawler.
2. Place straight edge on treads as shown in [Figure 8-2](#). Gap between straight edge and top of treads at lowest point should be 1 in (25 mm) (tight limit) to 2-1/2 in (64 mm) (loose limit).
3. Adjust tread slack if gap exceeds loose limit or is less than tight limit.
4. Adjust treads tighter when operating on firm ground and looser when operating on soft ground (mud or sand).

CAUTION
Pin Damage!

Do not adjust treads too tight; tread pins will wear rapidly and may break. Dirt build-up will tighten treads even more, increasing possibility of damage.

More torque is required to drive tight treads, which results in faster wear and more fuel consumption.

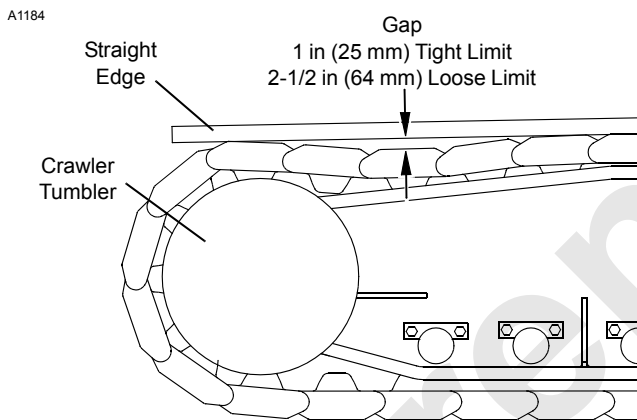


FIGURE 8-2

Adjustment Procedure

Adjust tread slack at primary roller end of each crawler ([Figure 8-3](#)):

1. Thoroughly clean crawler to be adjusted.
2. Loosen two bolts (1) at primary roller end of crawler (1 bolt, each side).
3. Remove cover (2) from both sides of crawler frame.
4. Place jack cylinder (3) on support (4).
5. Jack against rod (5) an equal amount on both sides of crawler frame.
6. Add or remove an equal thickness of shims (6) on both sides of crawler frame.

7. Remove jack cylinder (3).
8. Travel crane forward to tighten shims.
9. Check that dimension from center punch (A) in shaft to center punch line (B) in crawler frame is same on both sides of crawler to within 1/8 in (3,2 mm).

CAUTION
Part Wear!

Primary roller and tumbler must be square with crawler frame to within 1/8 in (3 mm); otherwise, parts will wear rapidly.

10. Check for proper adjustment (see [Checking Tread Adjustment](#)) and readjust as required (steps 4 through 9).
11. Tighten nuts on bolts at primary roller to 2,000 ft-lb (2 712 Nm) lubricated with Never-Seez or an equivalent oil and graphite mixture.
12. Install cover (2) on both sides of crawler frame.

NOTE: The extreme limit of tread adjustment is when the bolts are tight against the front end of the slots in the crawler frame. One crawler tread should be removed when this limit is reached.

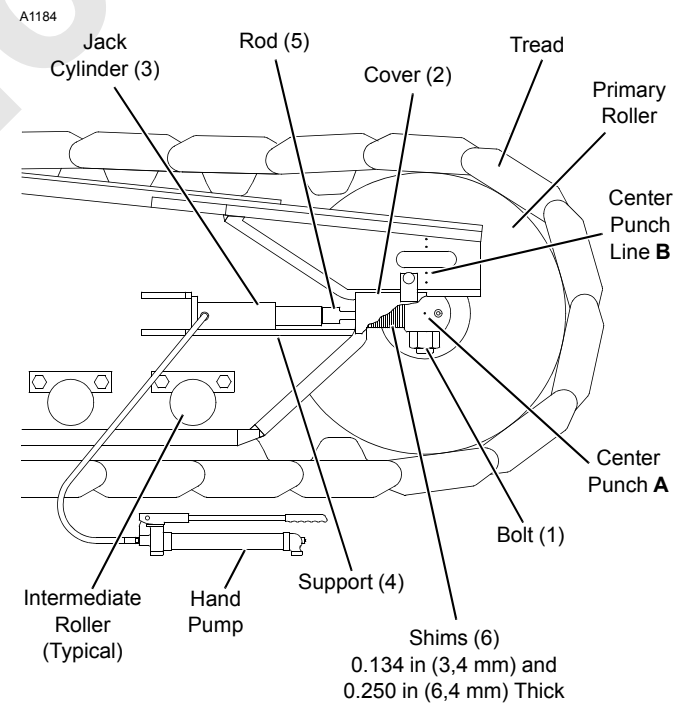


FIGURE 8-3

Hydraulic Hand Pump

See [Figure 8-4](#) for the following procedures.



WARNING

Prevent Possible Death or Serious Injury to Maintenance Personnel

Manitowoc has provided hand pump and cylinder for crawler adjustment only. Any other use is neither intended nor approved.

Wear safety glasses and other personal protective gear when operating hand pump.

Do not exceed maximum pressure rating of components (pump, cylinder, hose) – 10,000 psi (700 bar). Higher pressure can cause components to explode.

Do not set pump relief valve higher than 10,000 psi (700 bar). Higher pressure can cause components to explode.

Pump is not vented. It can explode if subjected to high pressure. Do not attempt to return more oil to pump than it is capable of holding. Do not overfill pump.

In some cases, pump handle can “kickback.” Always keep your body to side of pump, away from line of handle force.

Do not add extensions to handle. Extensions can cause unstable operation.

Assembly

1. Connect hose from pump outlet port to cylinder inlet.
2. Use 1-1/2 wraps of a high-grade thread sealant on fittings (for example, Teflon tape).

Do not apply sealant to first complete thread to ensure tape does not shed into hydraulic system and cause malfunctioning or damage.

3. Do not over-tighten connections. Connections only need to be snug and leak free. Over-tightening can cause premature thread failure and may cause fittings or castings to split at lower than their rated pressures.

Maintenance

1. Keep unit clean and stored in a safe place where it cannot be damaged.
2. Keep oil in pump at proper level. Check level as follows:
 - a. Open valve and fully retract cylinder rod to return all oil to pump. **Cylinder must be fully retracted or system will contain too much oil.**

- b. For Simplex pump:
 - Place pump in horizontal position on a flat surface
 - Using a screw driver, remove vent/fill cap
 - Add hydraulic oil until reservoir is 2/3 full. **Do not overfill.**
 - Securely reinstall vent/fill cap
- c. For Enerpac pump:
 - Place pump in vertical position with hose end down
 - Using a screw driver, remove vent/fill cap
 - Add hydraulic oil until it is at mark on dipstick. **Do not overfill.**
 - Securely reinstall vent/fill cap
- d. Test operation and remove air from system, if required. Recheck level after removing air.

Air Removal

1. Close valve finger tight only.
2. Position pump higher than cylinder and position cylinder so rod is down.
3. Operate pump to fully extend cylinder rod.
4. Open valve and retract cylinder rod to force oil and trapped air back into pump.
5. Repeat steps until cylinder operates smoothly. **Erratic operation indicates air in system.**

Operation

1. Before using pump:
 - a. Check that all fittings are tight and leak free
 - b. Check oil level
2. To pressurize cylinder and extend rod, close valve by turning clockwise until finger tight only. Then pump handle up and down.

Pressure will be maintained until valve is opened.

To reduce handle effort at high pressure, use short strokes. Maximum leverage is obtained in last five degrees of stroke.

3. To depressurize cylinder, push handle down fully and open valve by turning counterclockwise.
4. Pump can be operated in any position from horizontal to vertical as long as **hose end of pump is down.**

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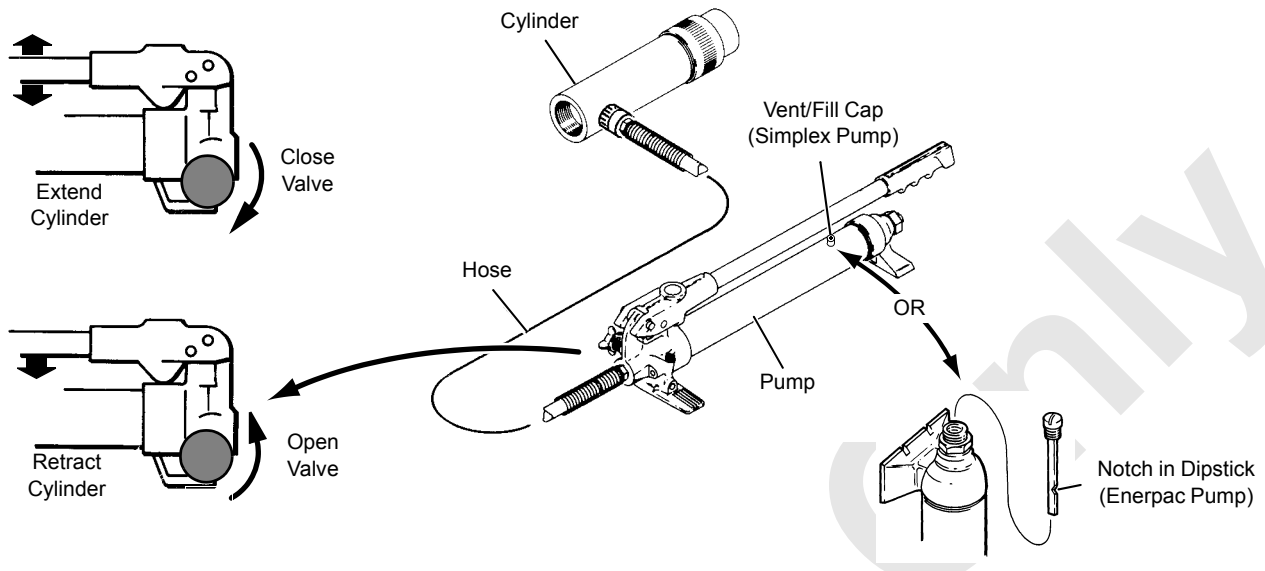


FIGURE 8-4

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SECTION 9 LUBRICATION

LUBRICATION

See F2277 in this section.

LUBE AND COOLANT PRODUCT GUIDE

See the publication in this section.

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SECTION 10

TROUBLESHOOTING

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SECTION 10

TROUBLESHOOTING

INTRODUCTION

This troubleshooting section is designed for qualified service technicians familiar with the operation and repair of electrical and hydraulic equipment. It is not possible to predict all problems that might occur or the correct procedure for troubleshooting each problem. ***If a problem is encountered that is not covered in this manual, first consult your Dealer. The Manitowoc Crane Care Lattice Team can provide assistance, if necessary.***

The first part of this section provides a series of flow charts that identify problems that could be encountered during normal operation of the Model 999. These charts contain instructions to assist in identifying and correcting problems. Follow the procedural steps in the order indicated. Some steps direct you to other charts in this manual or reference a specific test that must be performed to move through the complete troubleshooting procedure. If directed, consult the dealer or the Manitowoc Crane Care Lattice Team before proceeding.

The second part of this section contains specific instructions for testing and servicing the various systems and components described in the troubleshooting charts.

SAFETY SUMMARY

Hazards are always a possibility when performing troubleshooting operations on heavy equipment. To minimize the risk of potential hazards and to prevent serious injury or death, you must comply with the following:

- Carefully read the Model 999 Description of Operation in Section 1 before beginning troubleshooting operations.
- You must be a qualified service technician, competent in the repair and testing of electrical and hydraulic equipment. Manitowoc shall not be responsible for the training of personnel who might use this manual to perform the troubleshooting operations.
- Whenever possible, turn off the engine for your protection and keep unauthorized personnel away from the crane when troubleshooting.
- Never troubleshoot the crane alone. Always perform troubleshooting procedures with a qualified operator in the crane cab. Maintain constant communications with this operator when performing operations that require the crane to be running.

- Do not return crane to service after completion of maintenance or repair procedures until all guards and covers have been re-installed, trapped air is bled from hydraulic systems, safety devices are re-activated and maintenance equipment is removed.
- Perform a function check to ensure correct operation at the completion of maintenance or repair operations.

The following warnings apply to all troubleshooting operations. Manitowoc cannot foresee all hazards that may occur.

You must be familiar with the equipment, trained in testing methods, and use common sense while troubleshooting to avoid other hazards.



WARNING

Eye, Skin, and Respiratory Hazards!

Wear proper eye and skin protection and avoid direct contact with battery acid, oil, or ether spray when searching for leaks, opening connections, or installing pressure gauges.

Pressurized hydraulic oil can cause serious injury. Turn off engine, remove key, and relieve pressure on system before disconnecting, adjusting, or repairing any component.

Ensure that connections are made correctly, O-rings or gaskets are in place, and connectors are tight before pressurizing system.

Use necessary precautions to prevent electrical burns when checking battery charging and starter circuits.

Death or serious injury can occur if these warnings are ignored.



WARNING

Unexpected Moving Part Hazard!

Keep personnel away from crane while manually actuating a valve or pump to avoid unexpected equipment movement that can cause death or serious injury.

GUIDELINES

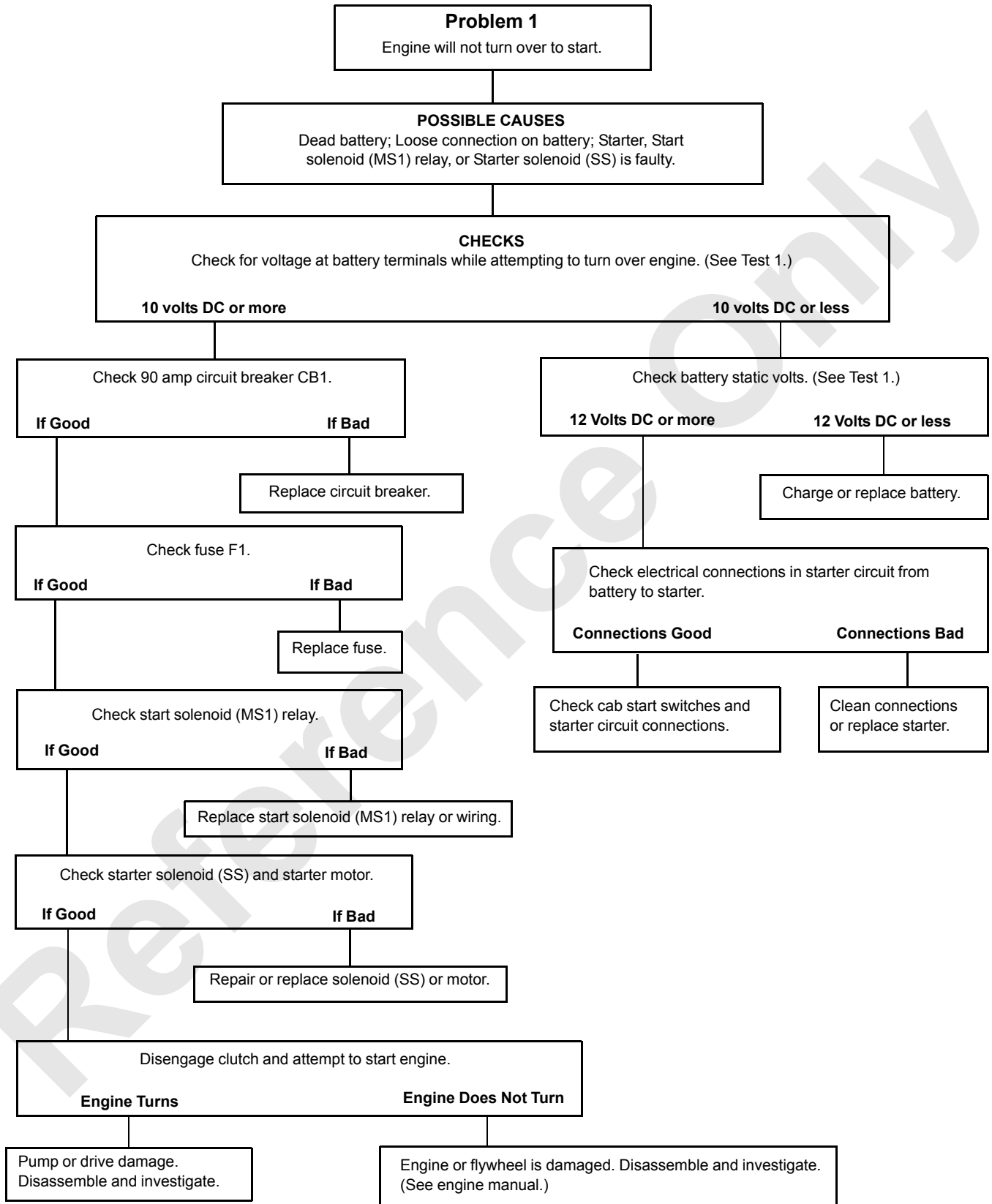
The following guidelines apply to all troubleshooting operations:

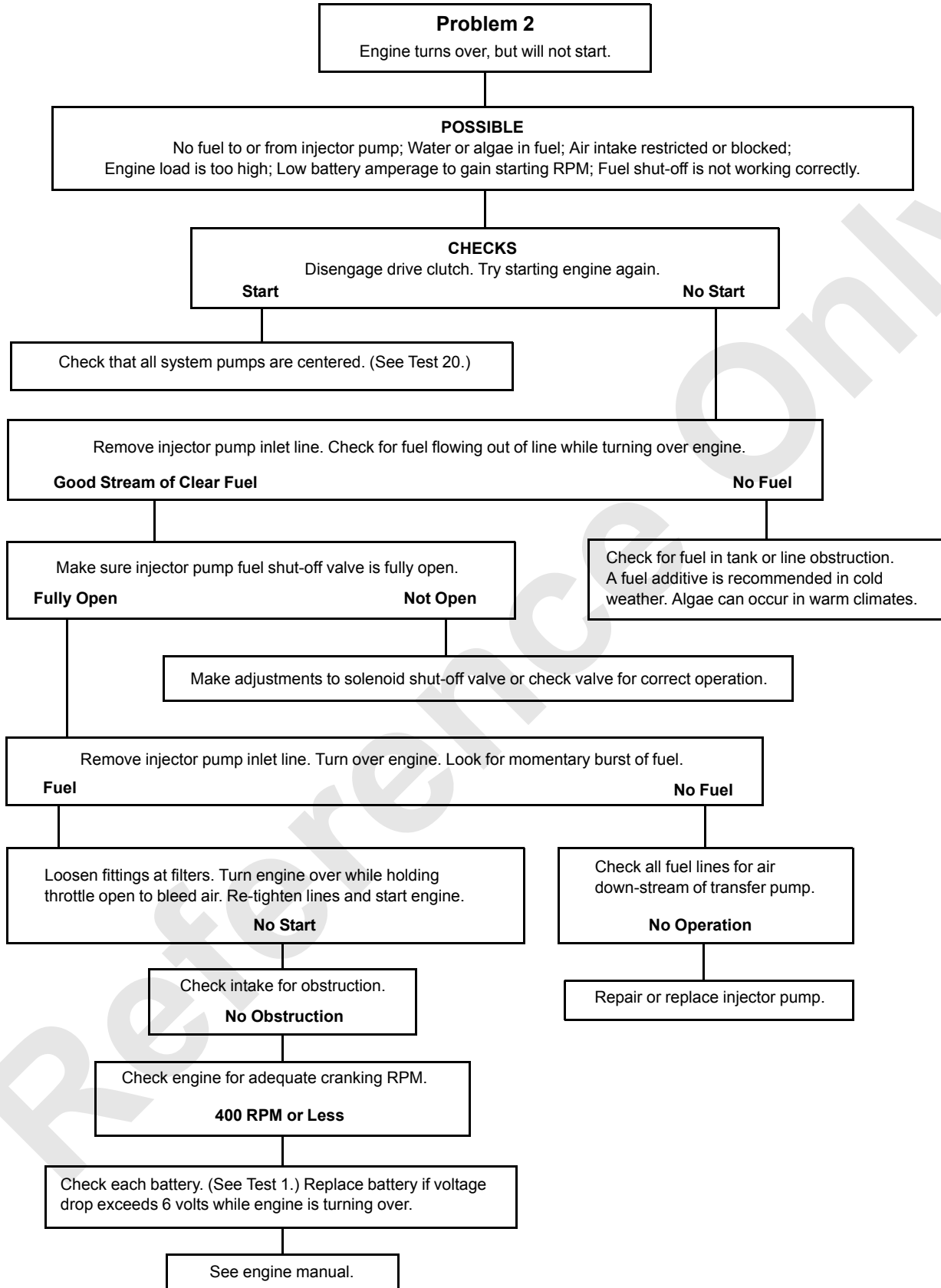
- Do not remove cylinders or counterbalance valve(s) from a cylinder until its working unit is restrained against movement.
- Do not use your hands to check for hydraulic oil leaks. Use a piece of cardboard to check for hydraulic oil leaks.
- Use a gauge of the correct pressure range when checking hydraulic circuits.
- Use the standard test plug adapters (available from the Manitowoc Crane Care Lattice Team) for electrical testing.
- Check ground potentials when testing electric circuits for continuity, voltage, or resistance. When checking voltages, use ground point for circuit being checked. If voltage does not register on multi-meter, use a known ground. If a value is read, the ground of the circuit under test is probably faulty.
- Check all terminal points for cleanliness and tighten connections.
- Check pressures at the specified hydraulic component ports.
- Check the motor pressure control pilot (PCP) valve on the motor under test. Test the pump electric displacement controls (EDC) on the pump under test.
- Check each pressure sender electric supply at the system sender.
- Check the encoder electric supply at the test plug adapter of the encoder under test.
- Check the correct operating limit electric supply by viewing the diagnostic display in the operator's cab.
- Check the control handle electrical input and output voltages at the control handle under test.
- Check the basic system electric supplies and cab power relay at the fuse box mounted above the main electrical junction box in the operator's cab.
- Check the programmable controller (PC) input and output cables at the connector pins.

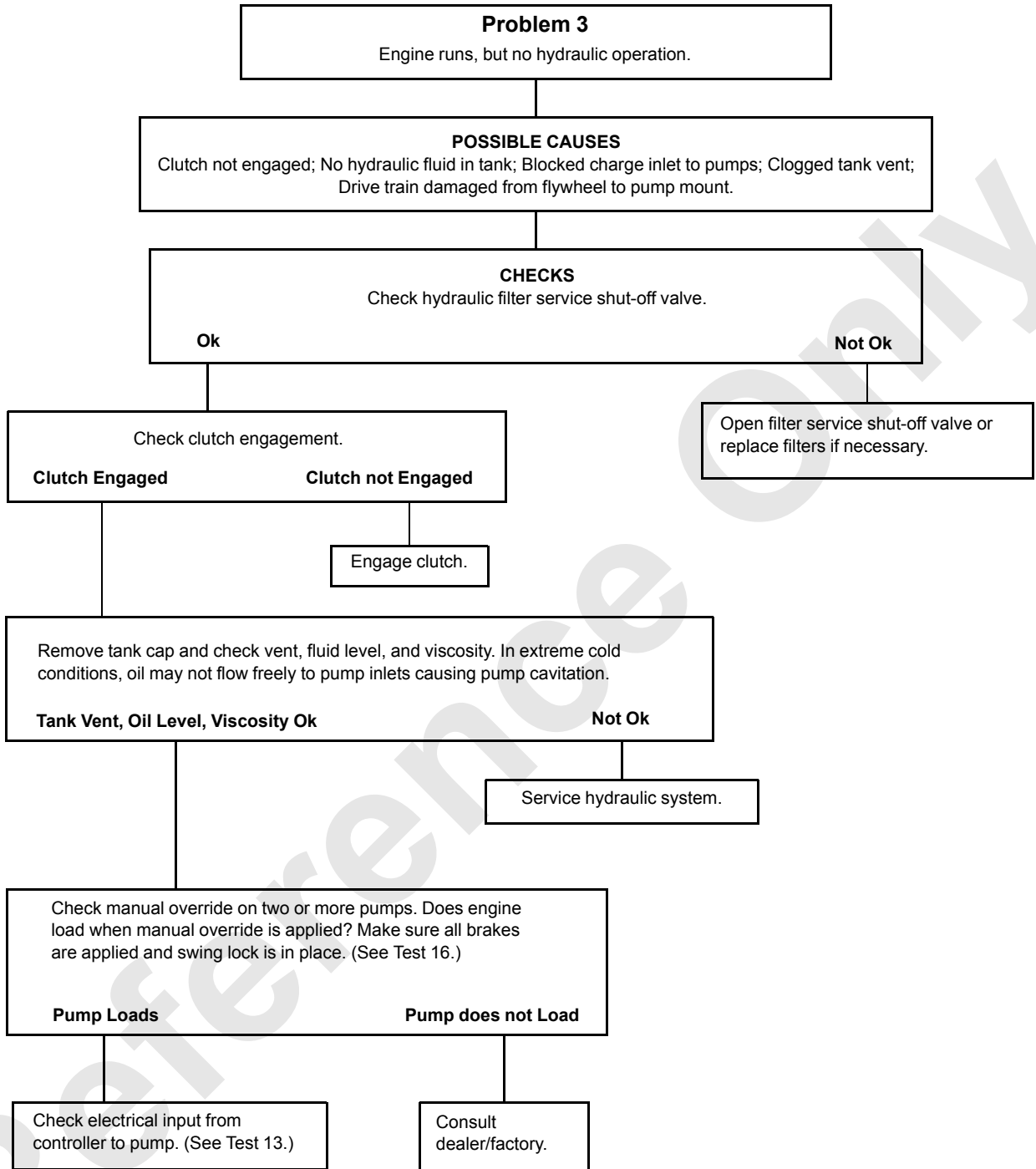
TEST EQUIPMENT

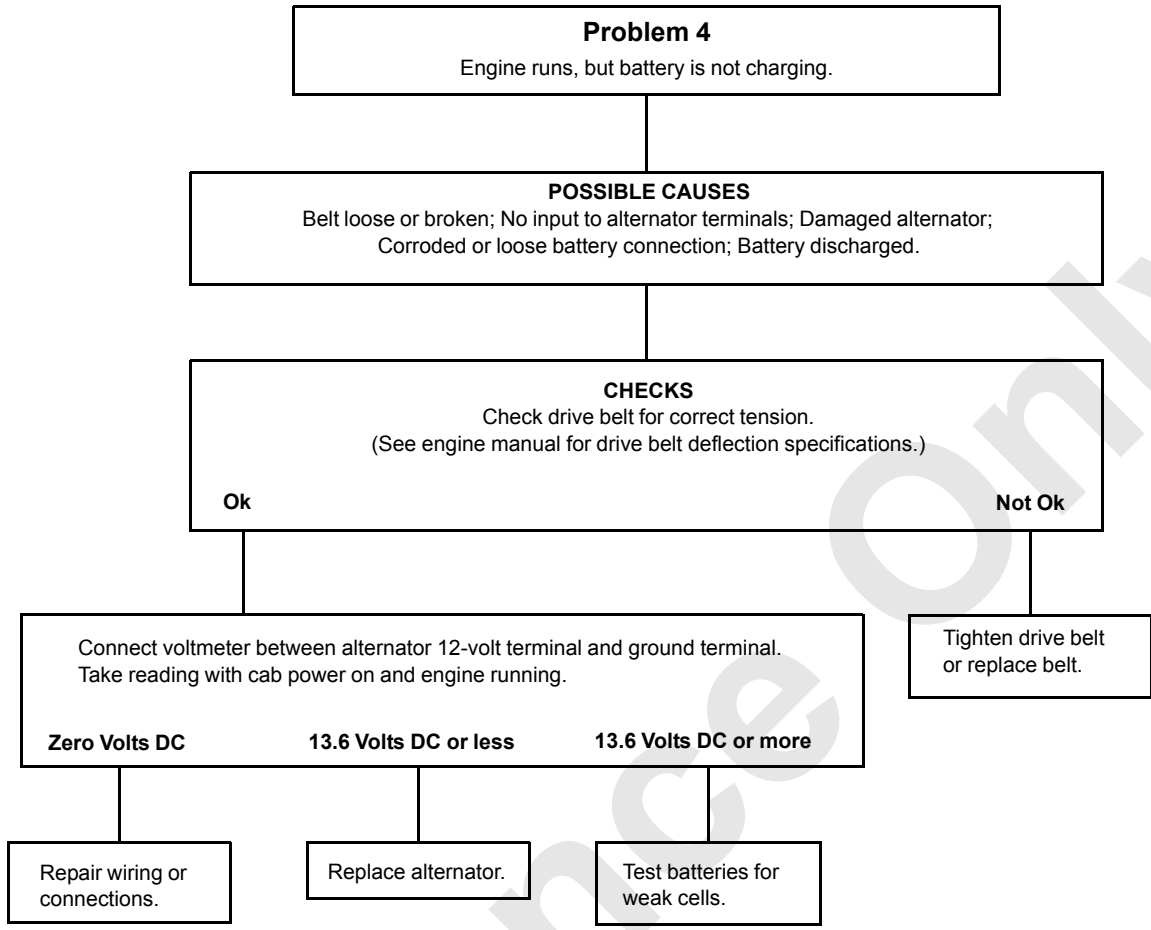
The test equipment shown or described is available for testing the Model 999 hydraulic or electrical systems. This equipment can be purchased in kit form (with or without carrying case) or separately, by contacting the Manitowoc Crane Care Lattice Team.

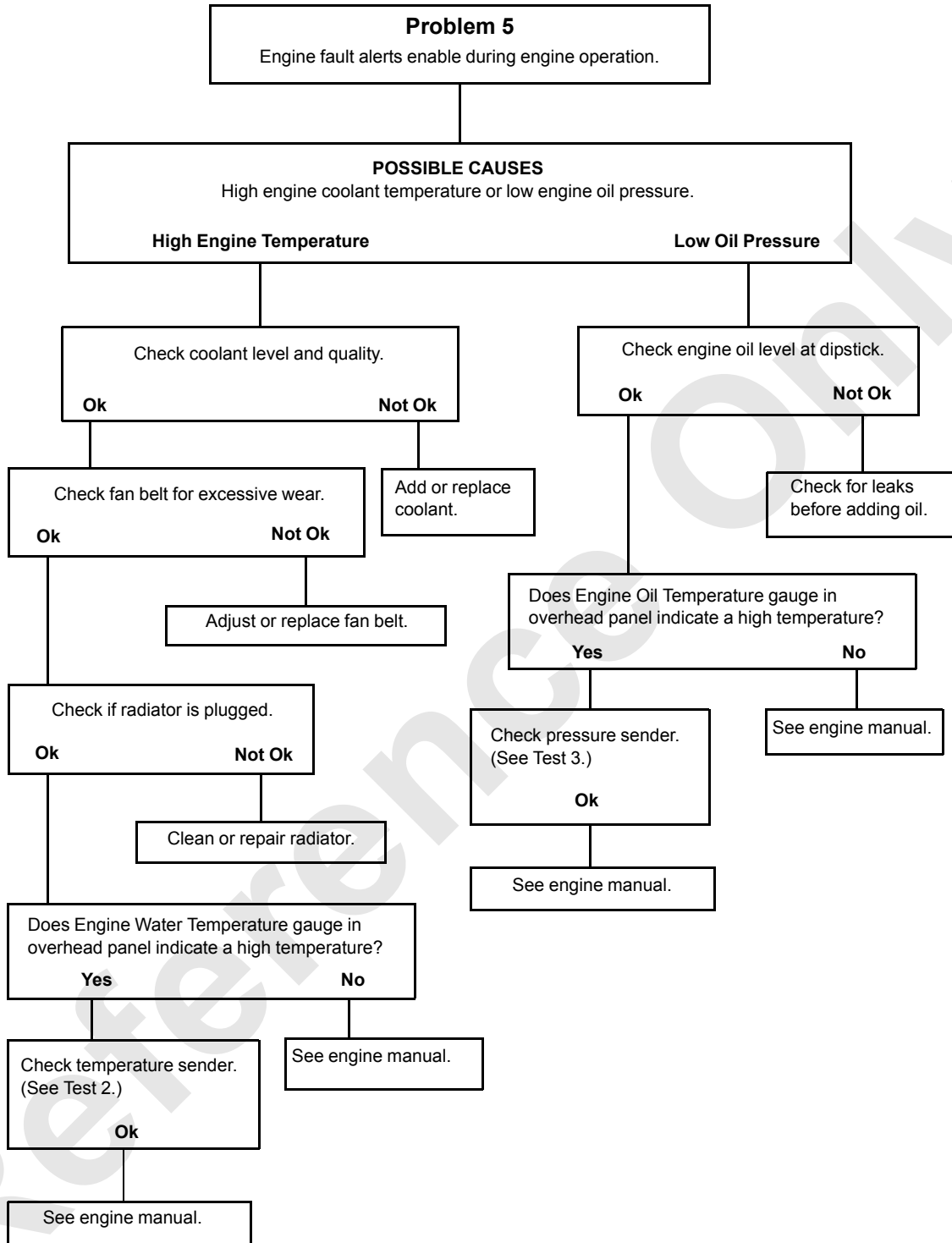
TROUBLESHOOTING CHARTS

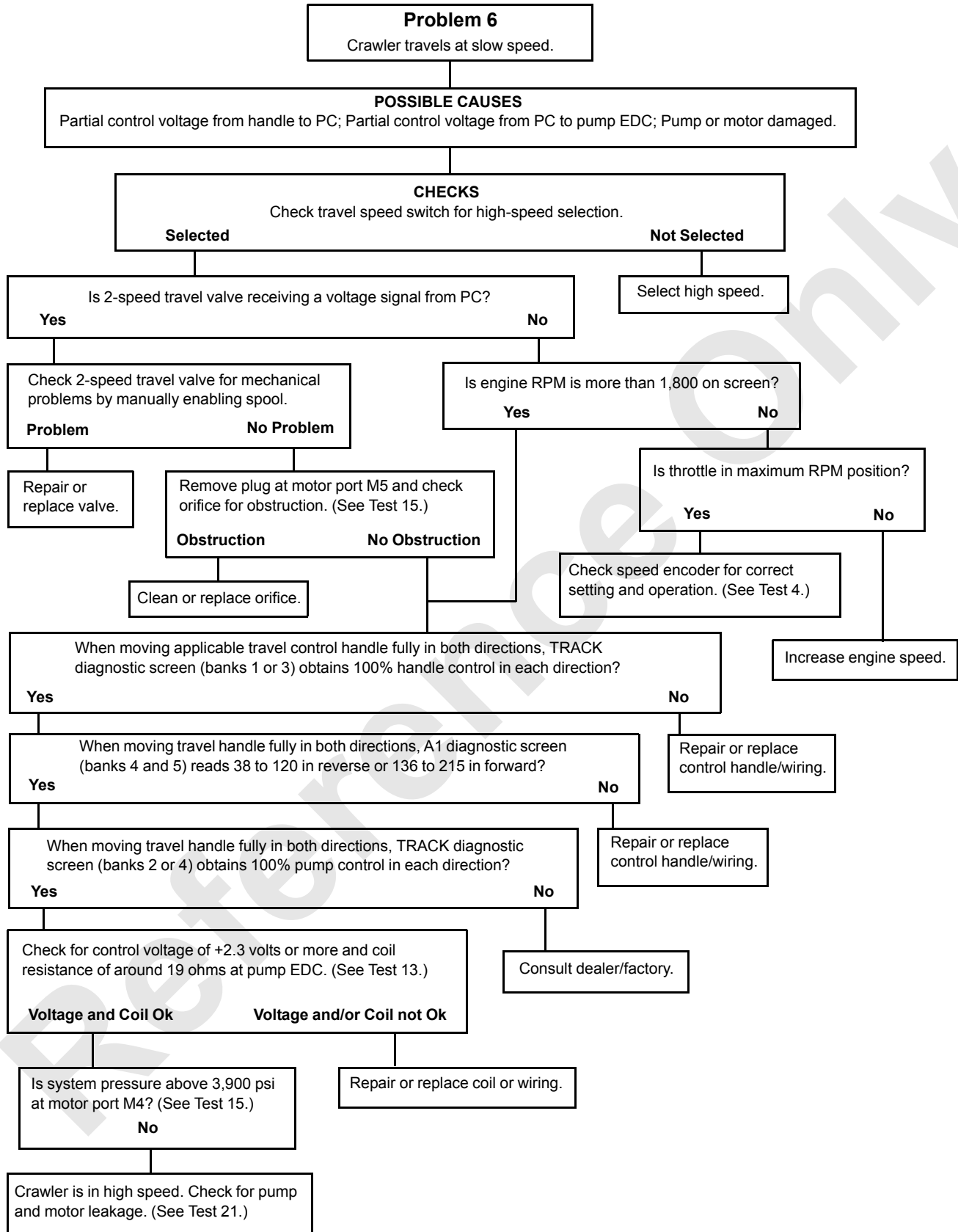


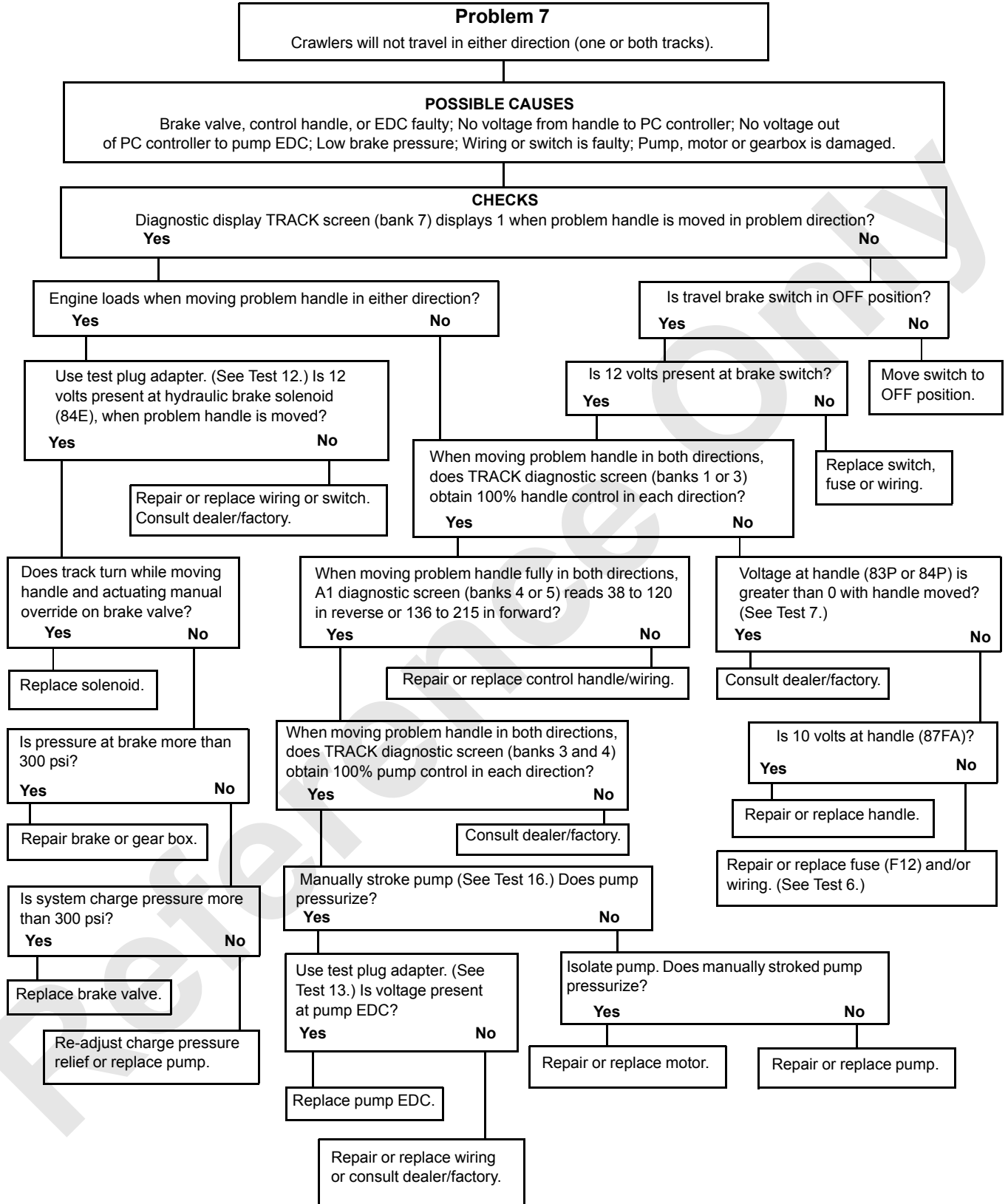


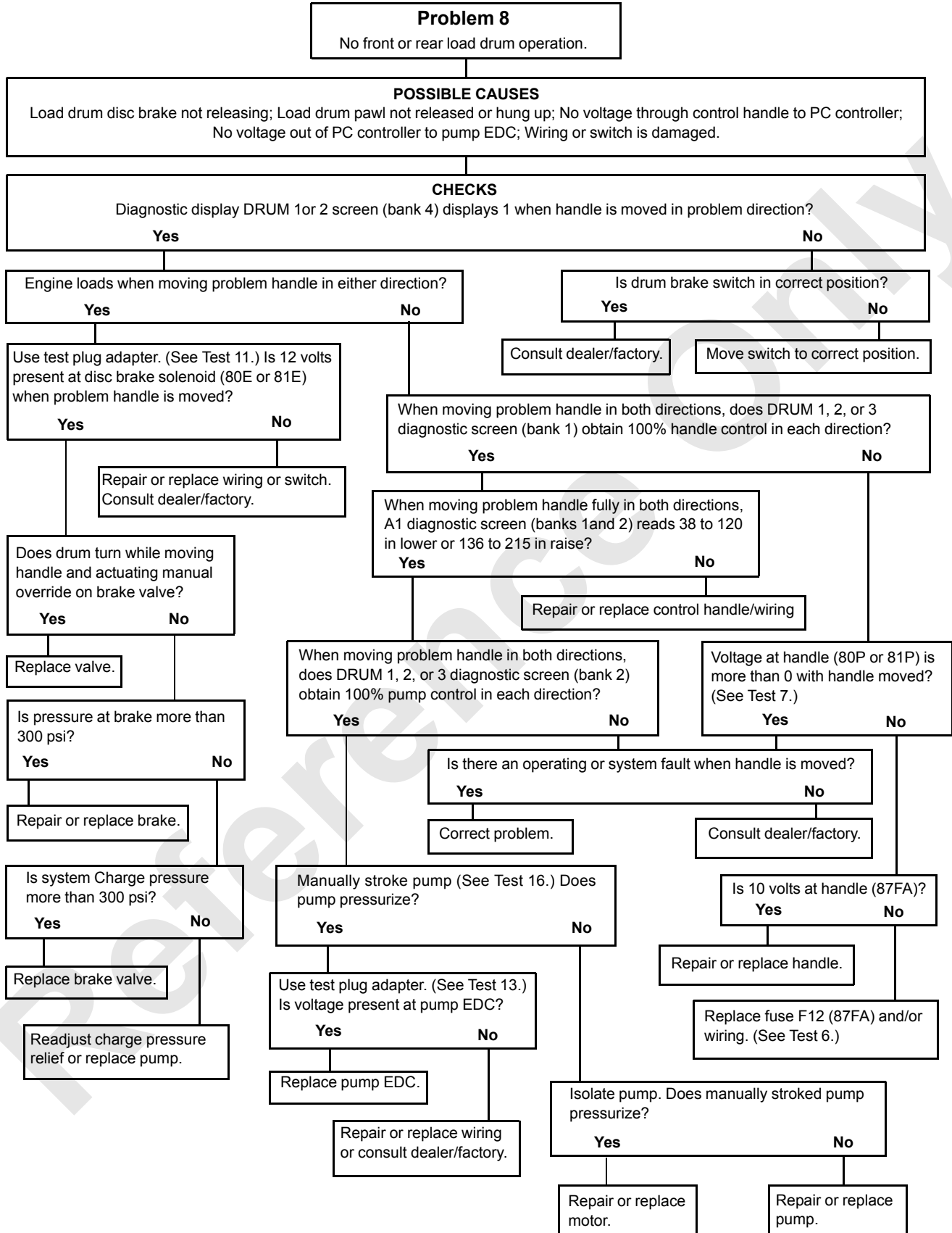


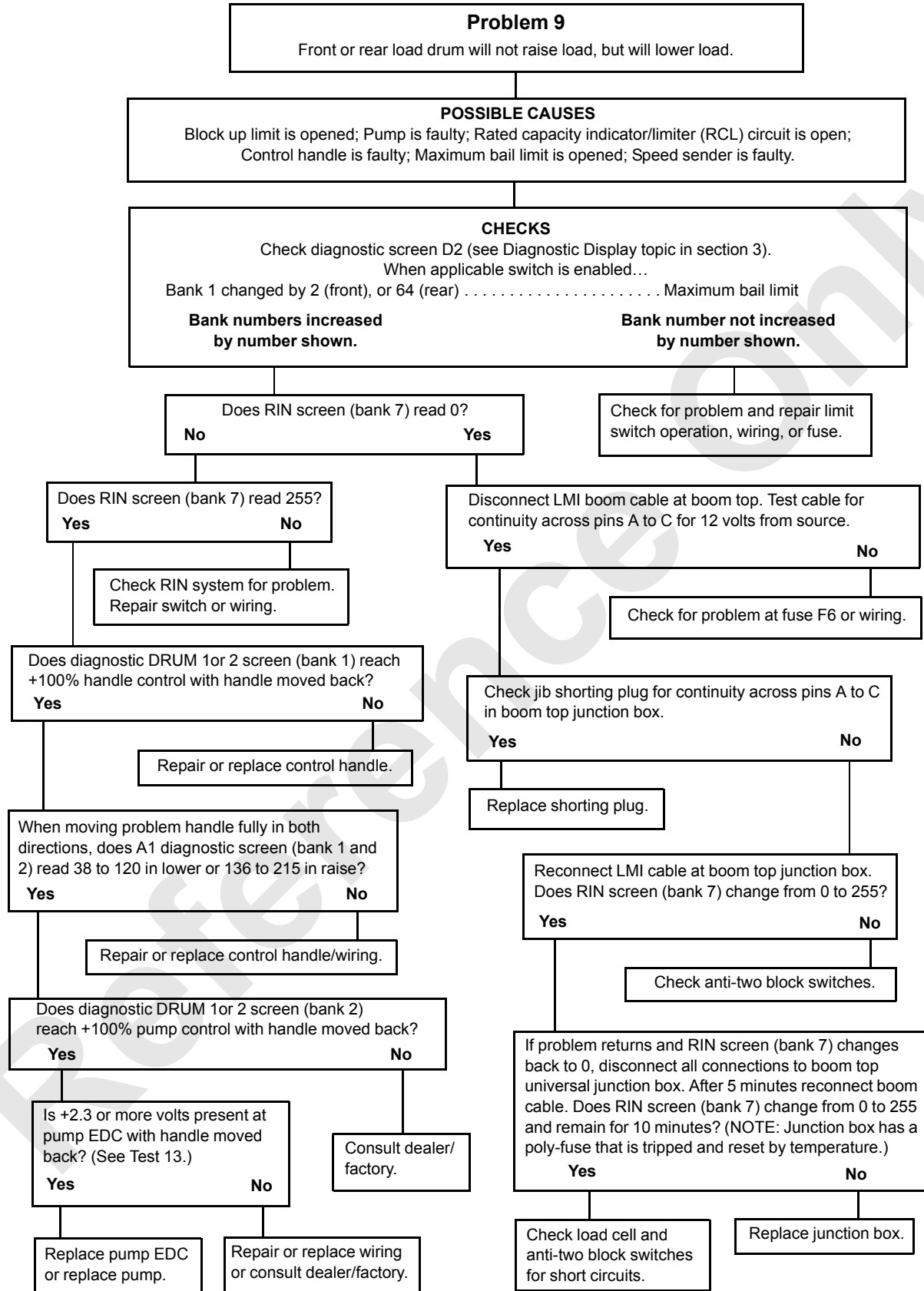


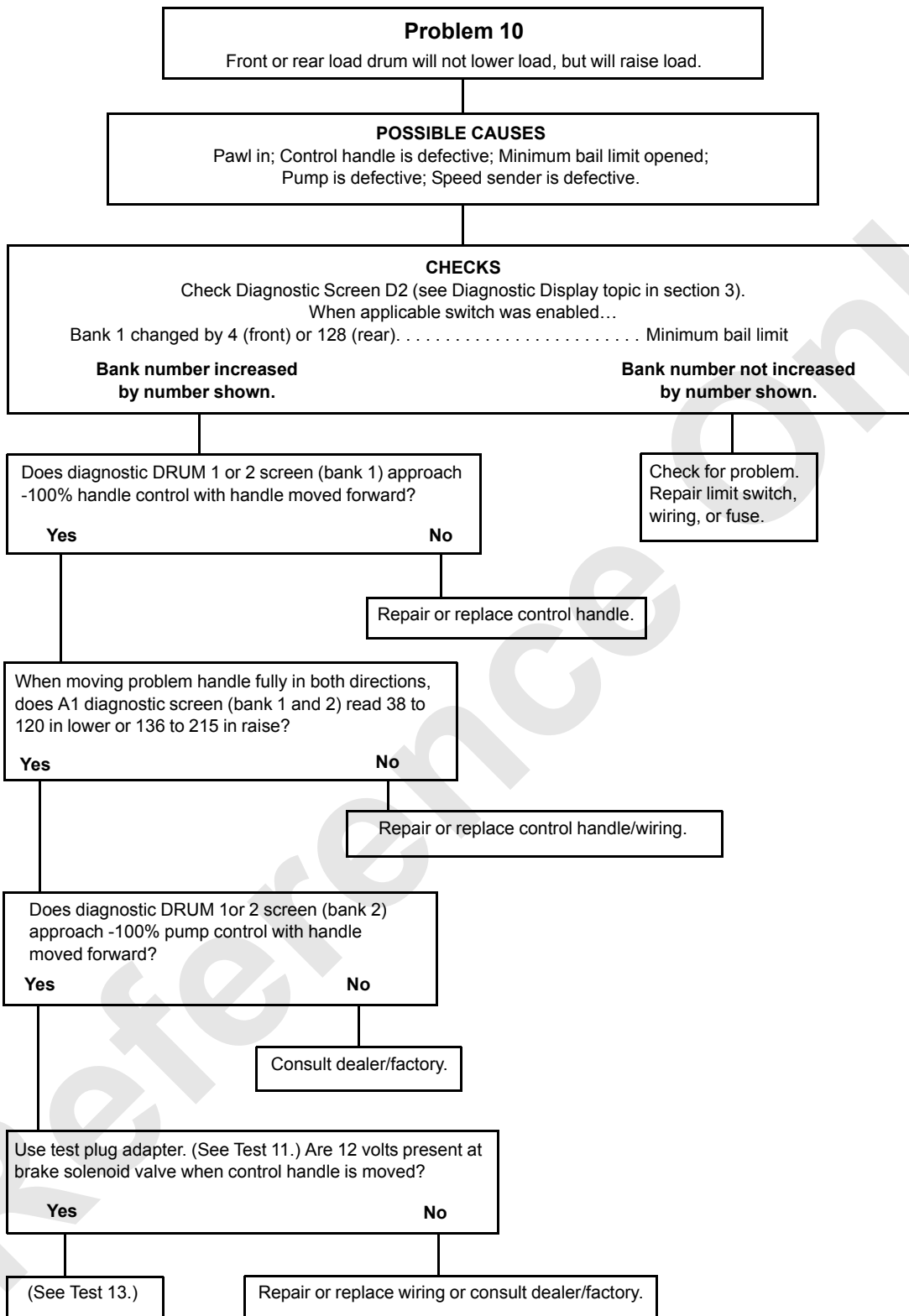


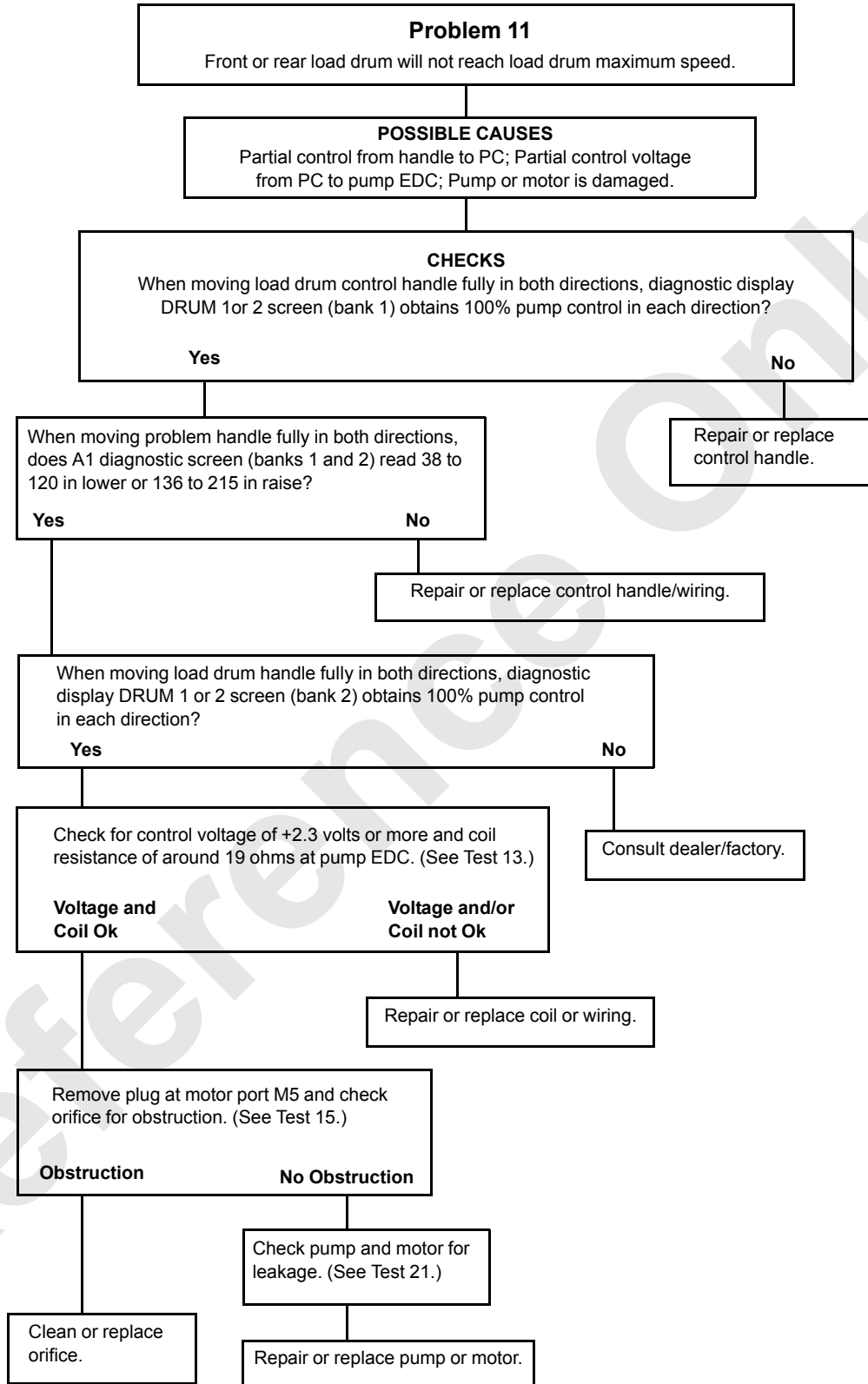


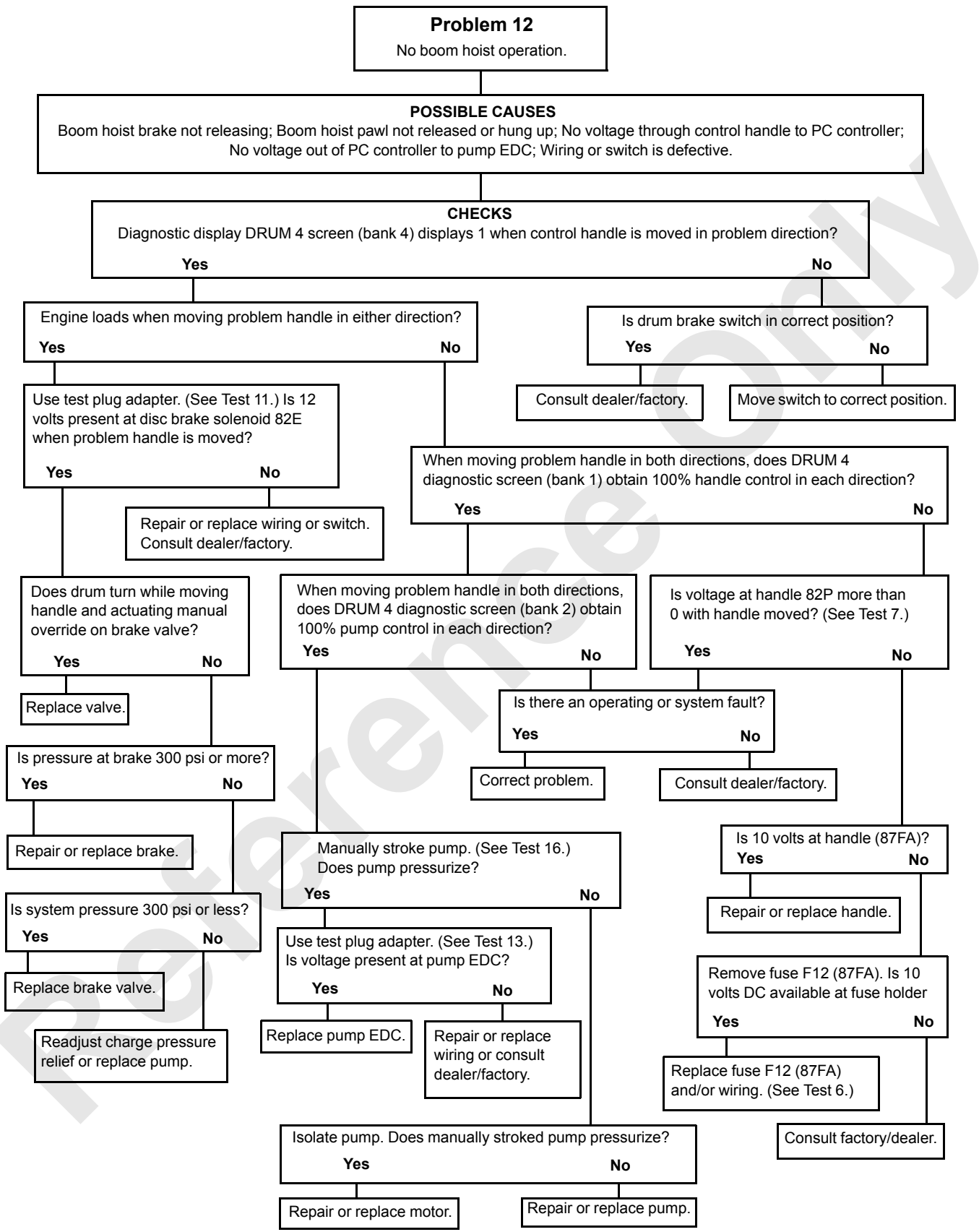


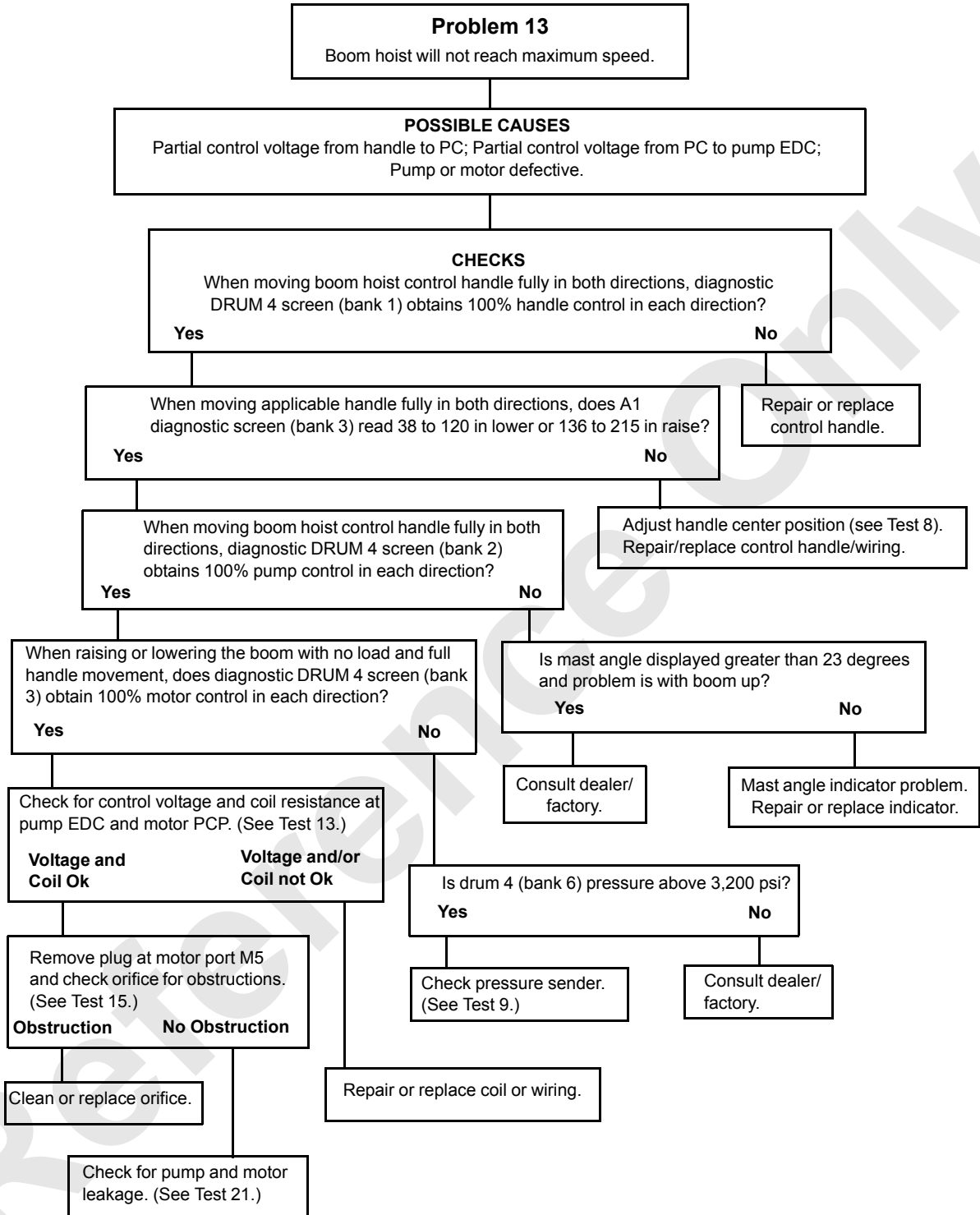


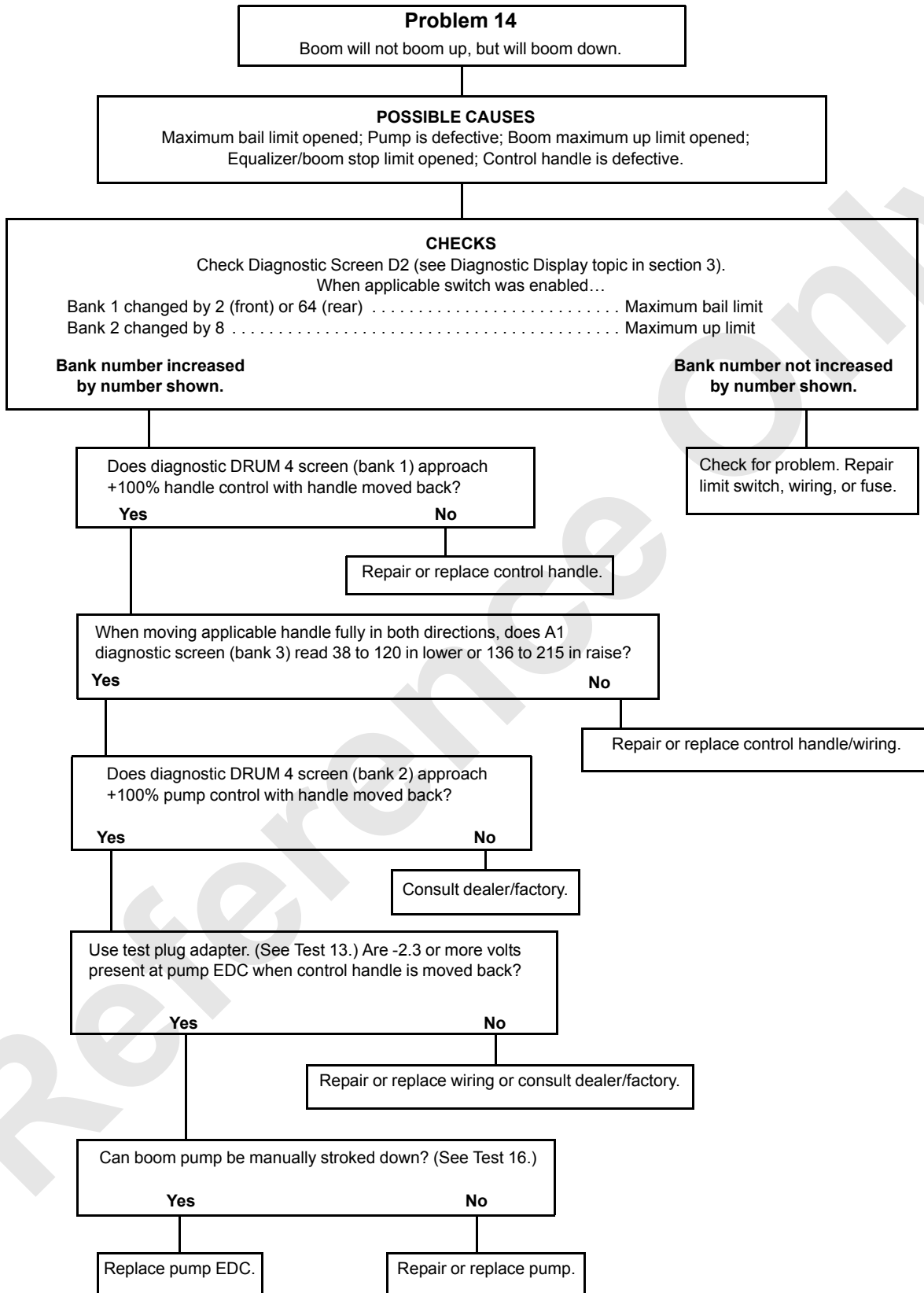


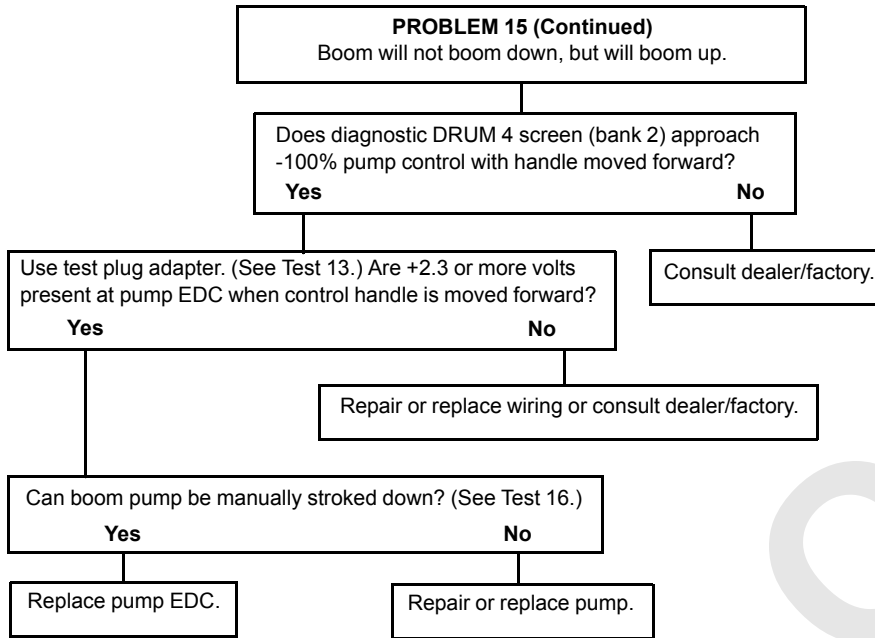


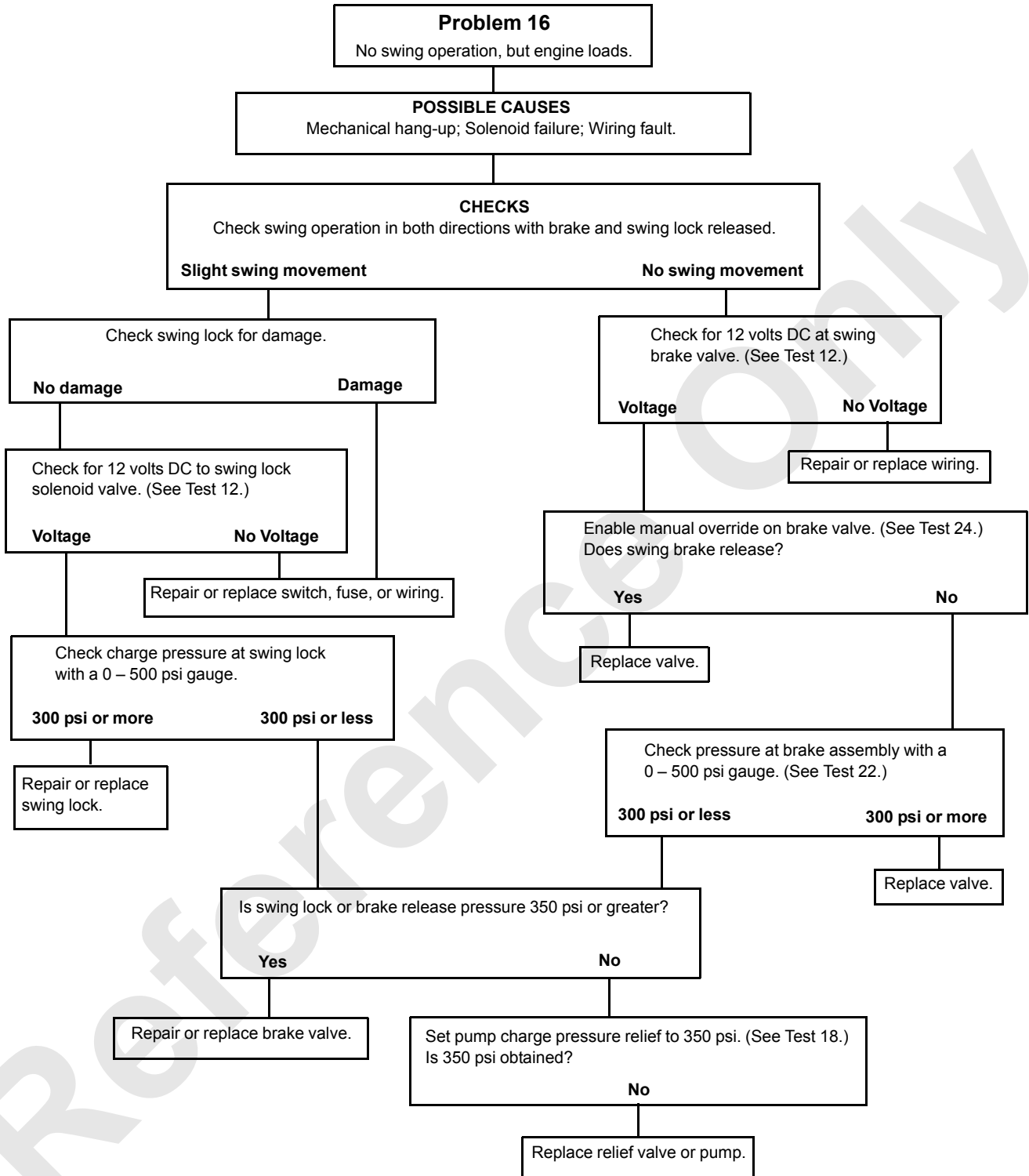


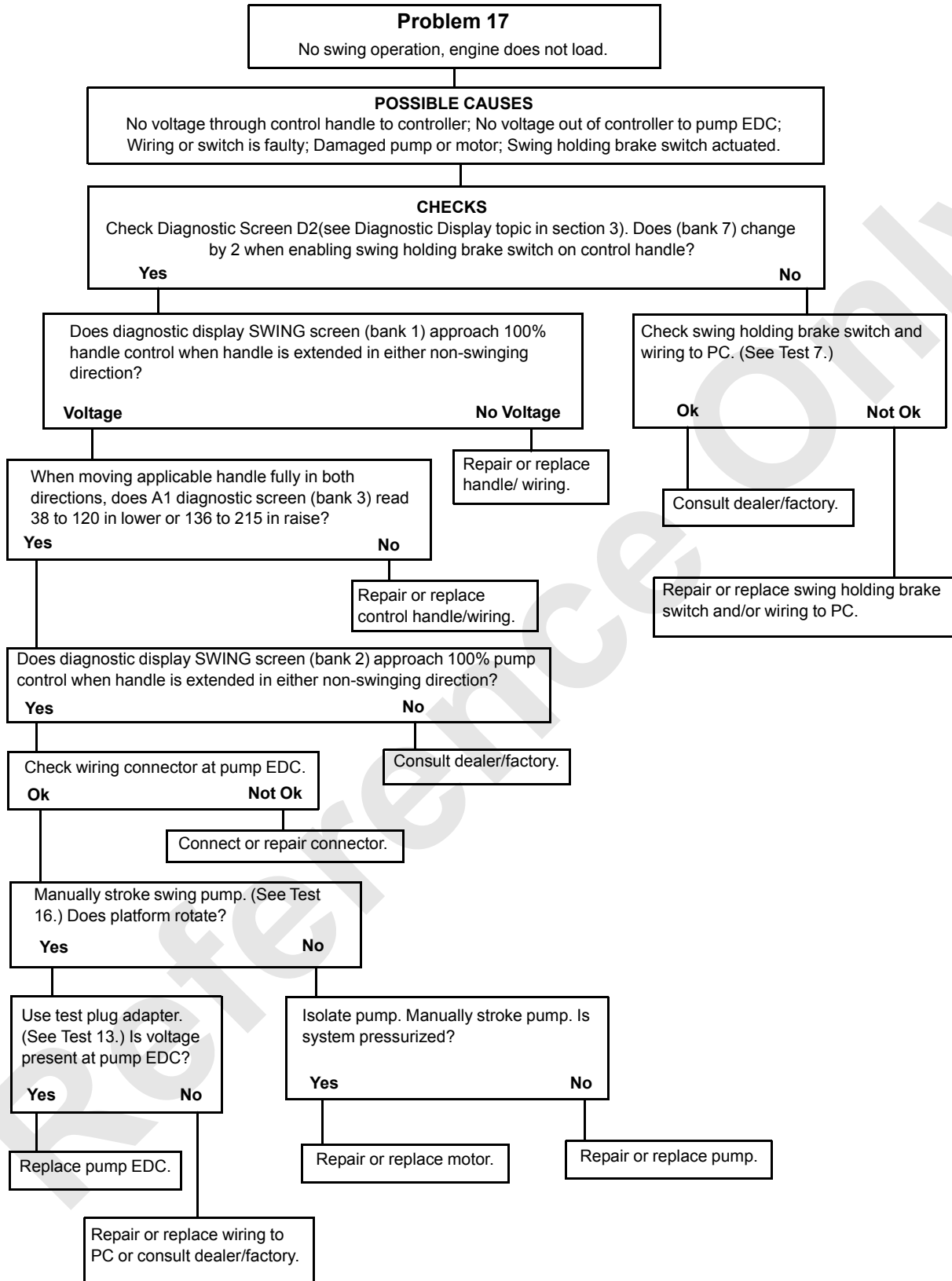


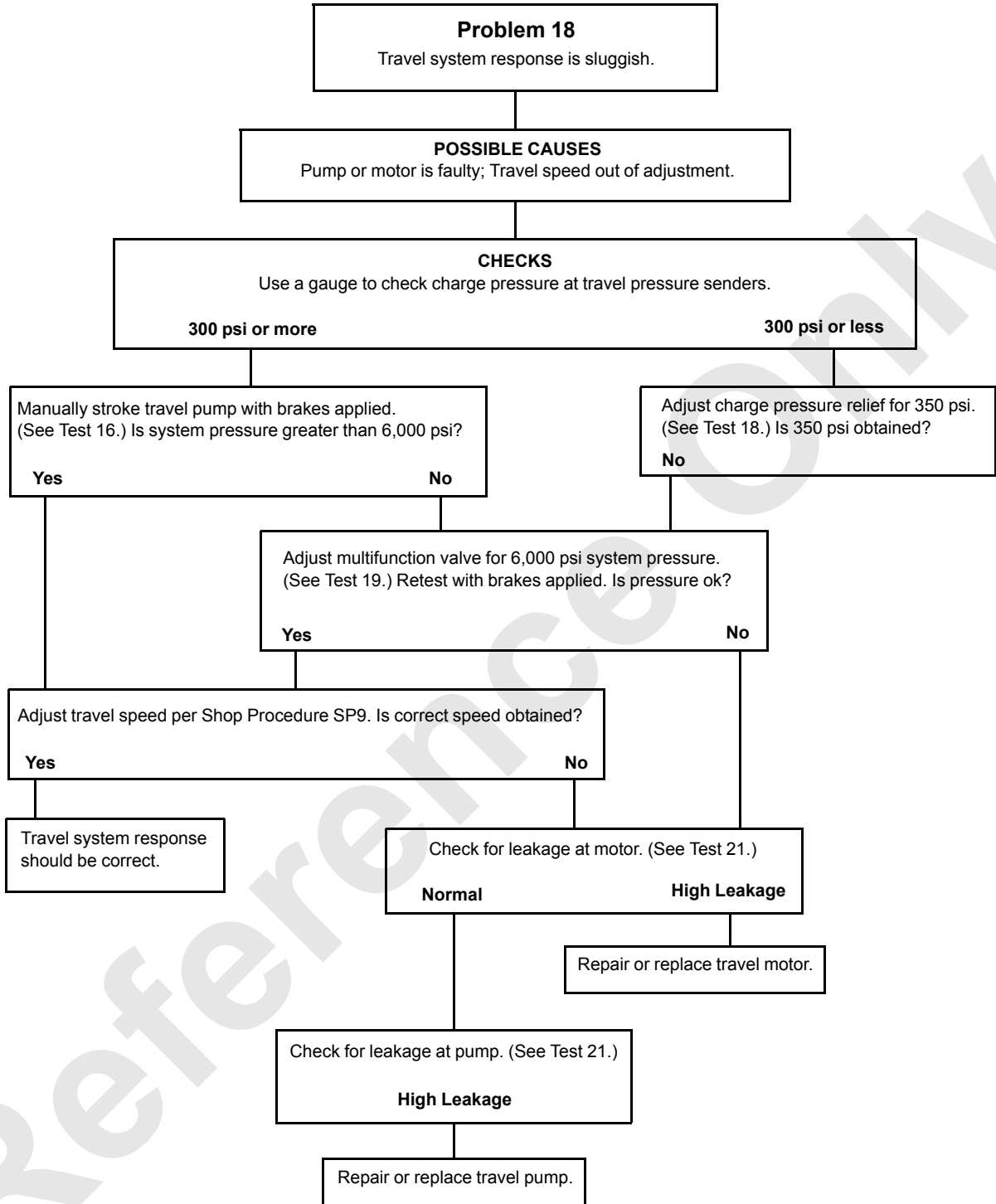


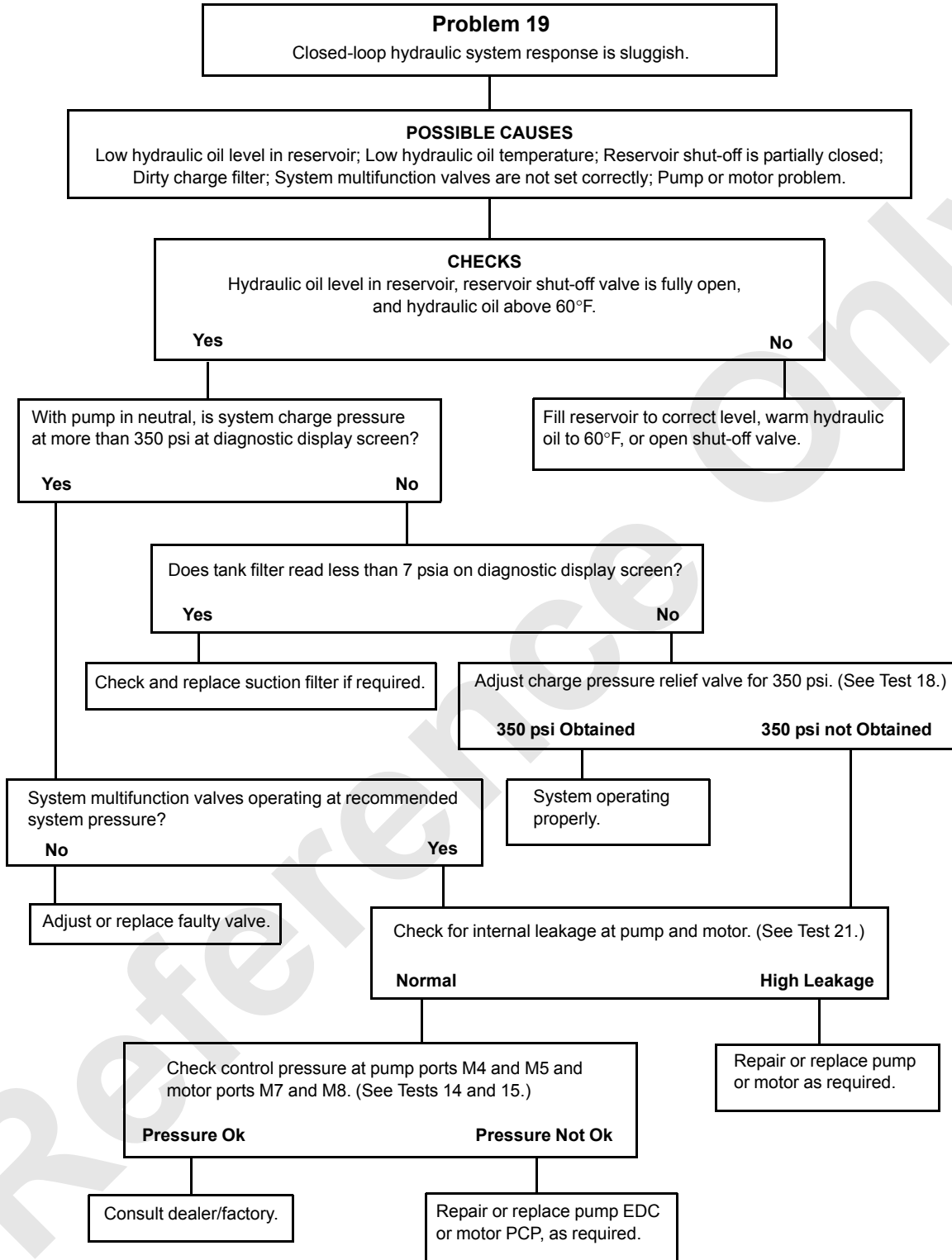


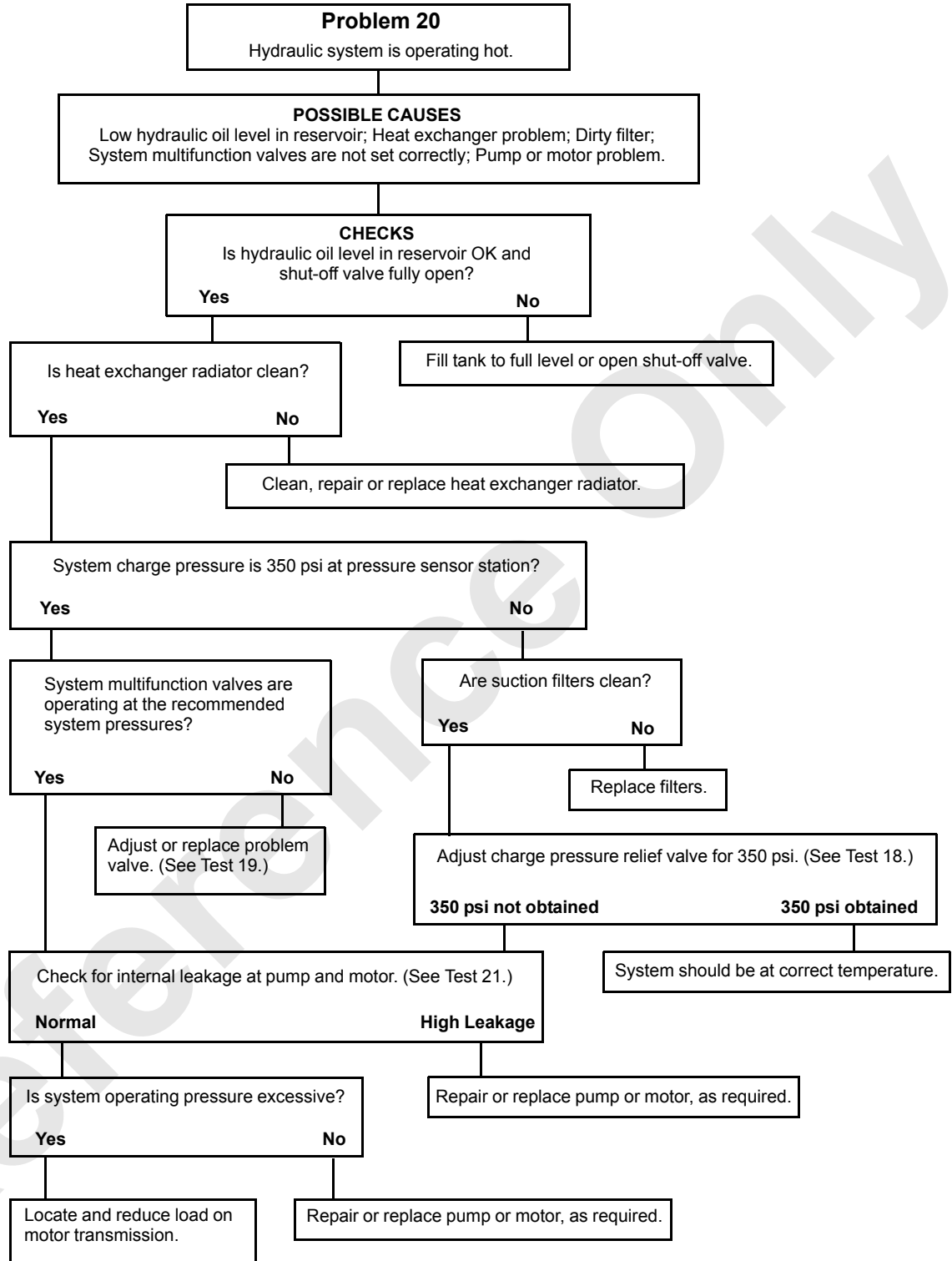


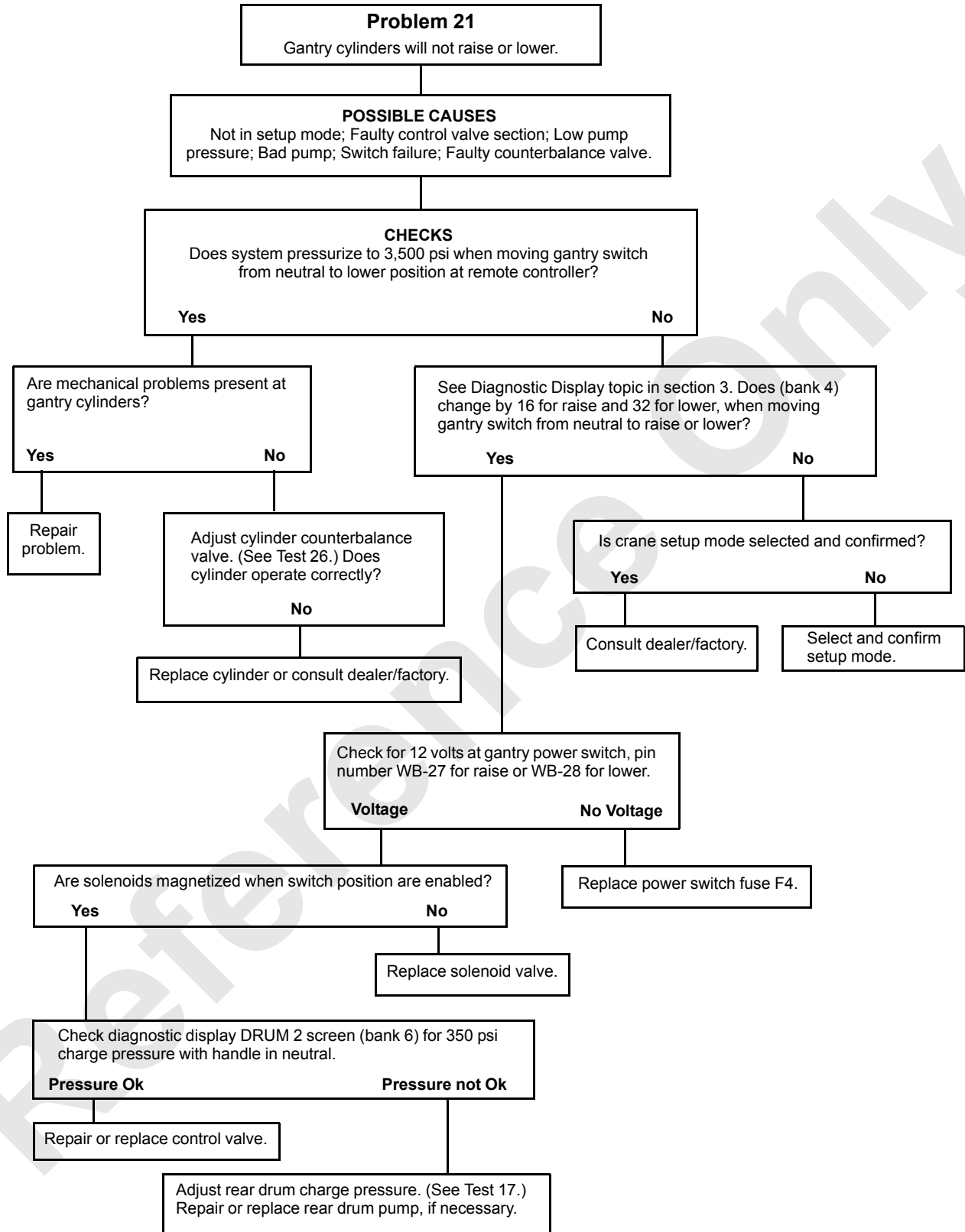


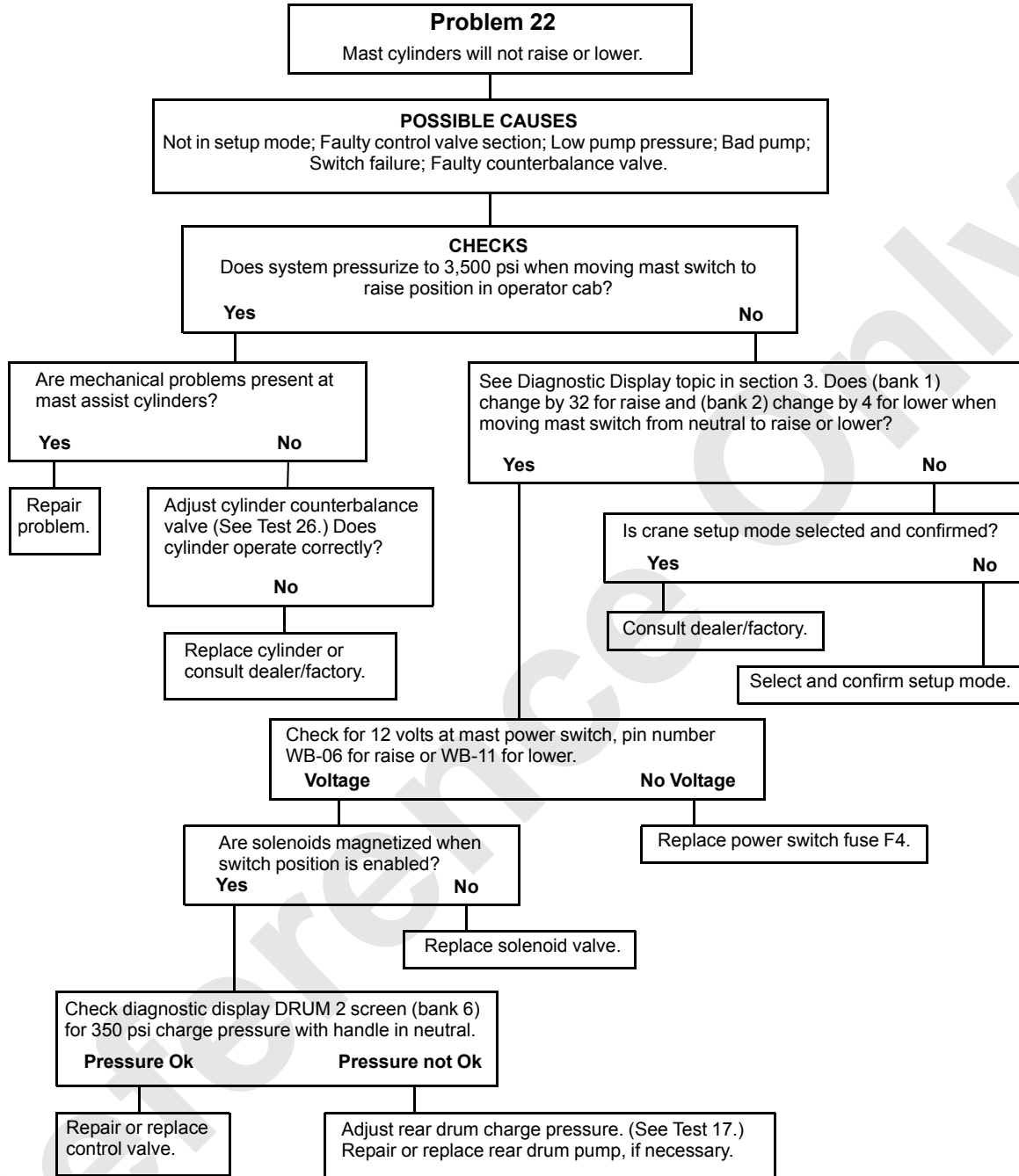




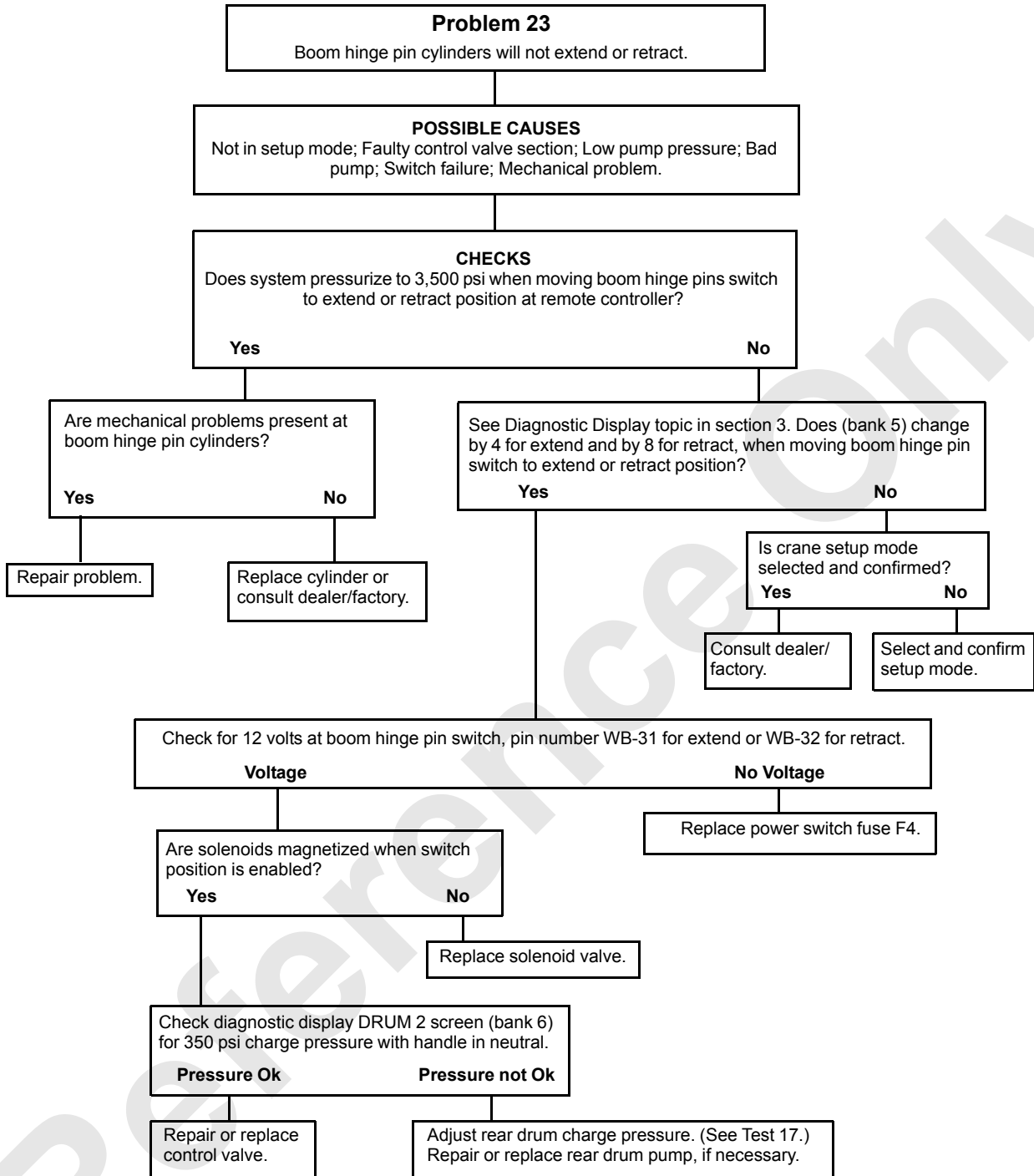


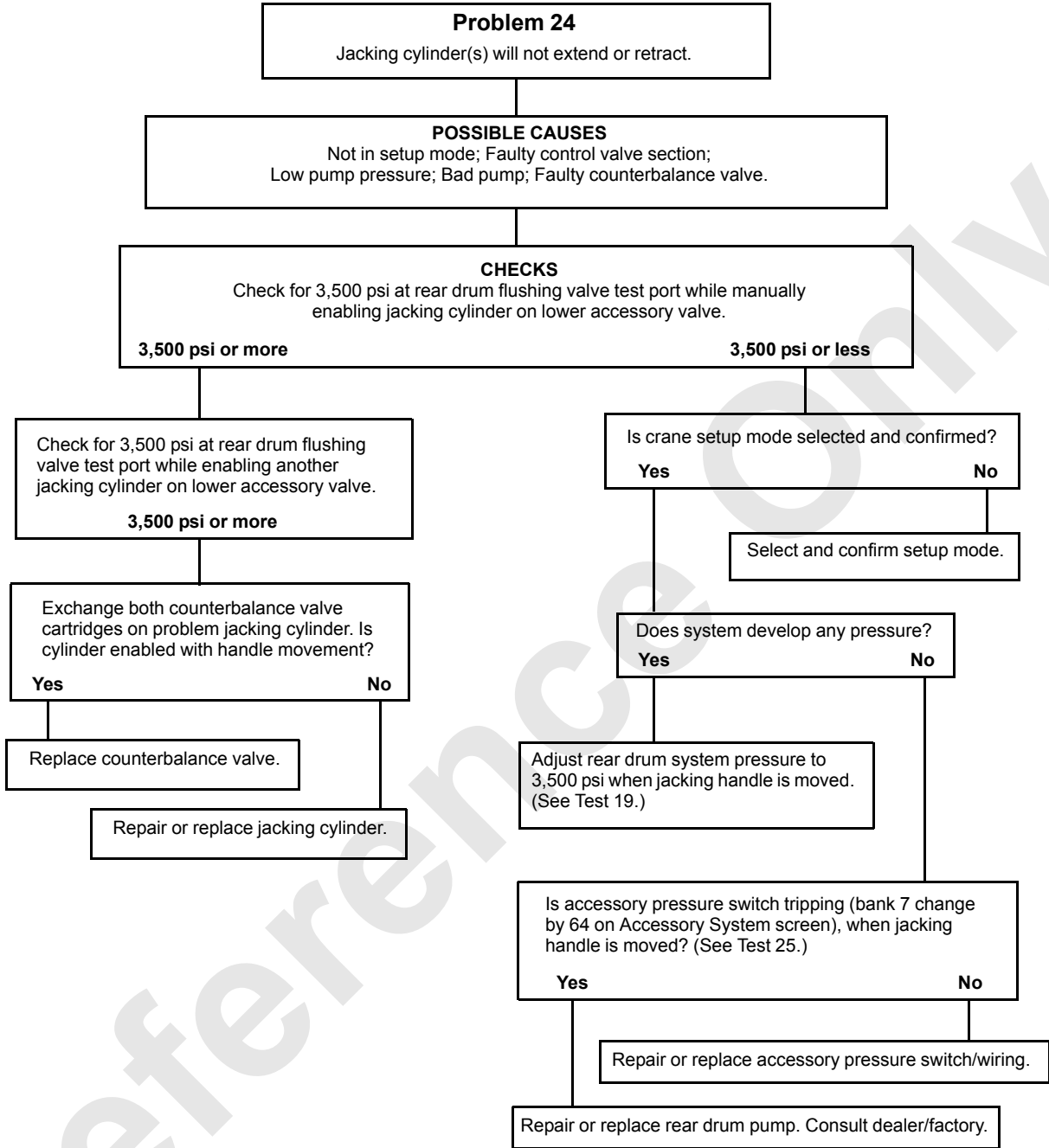


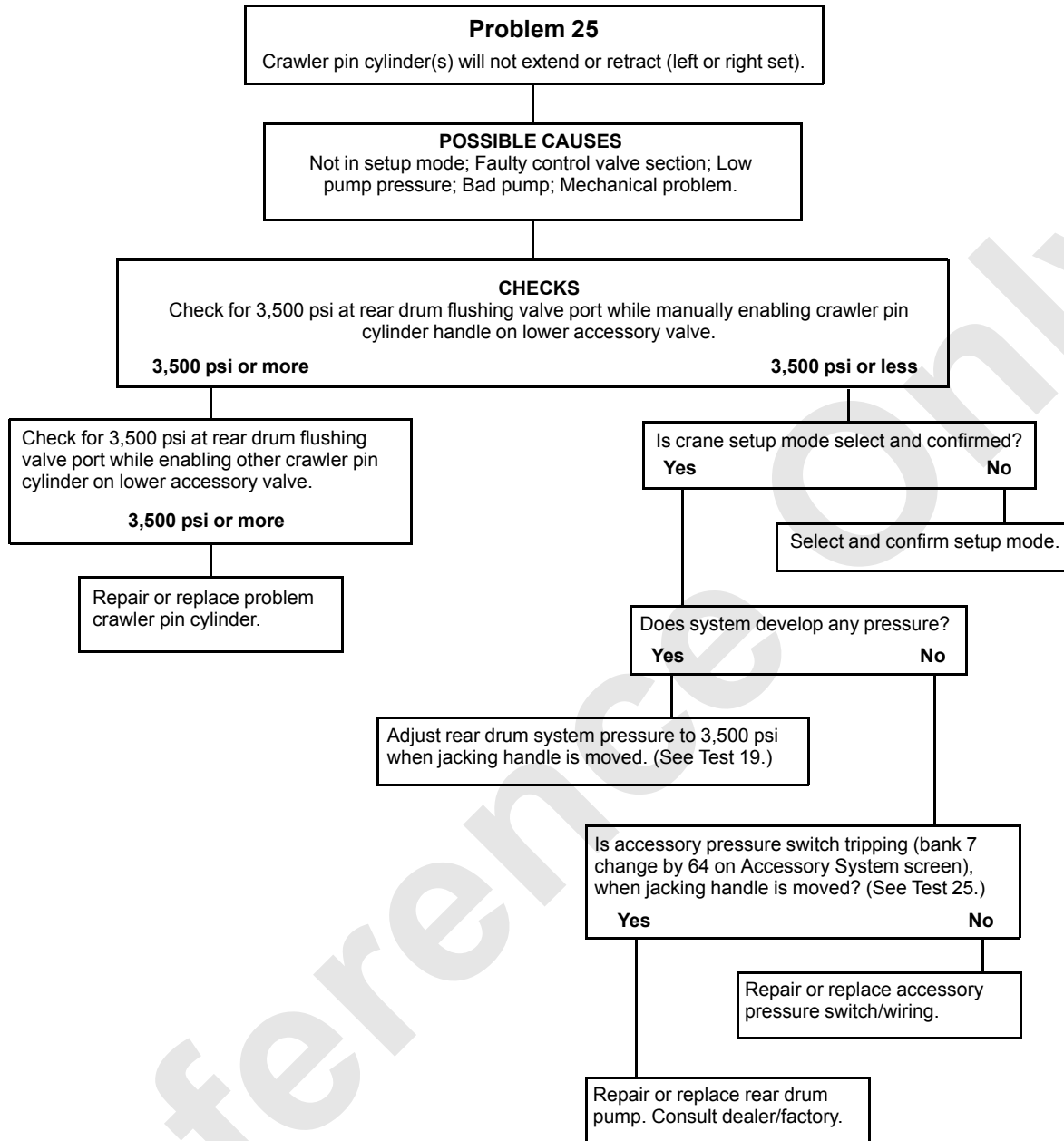


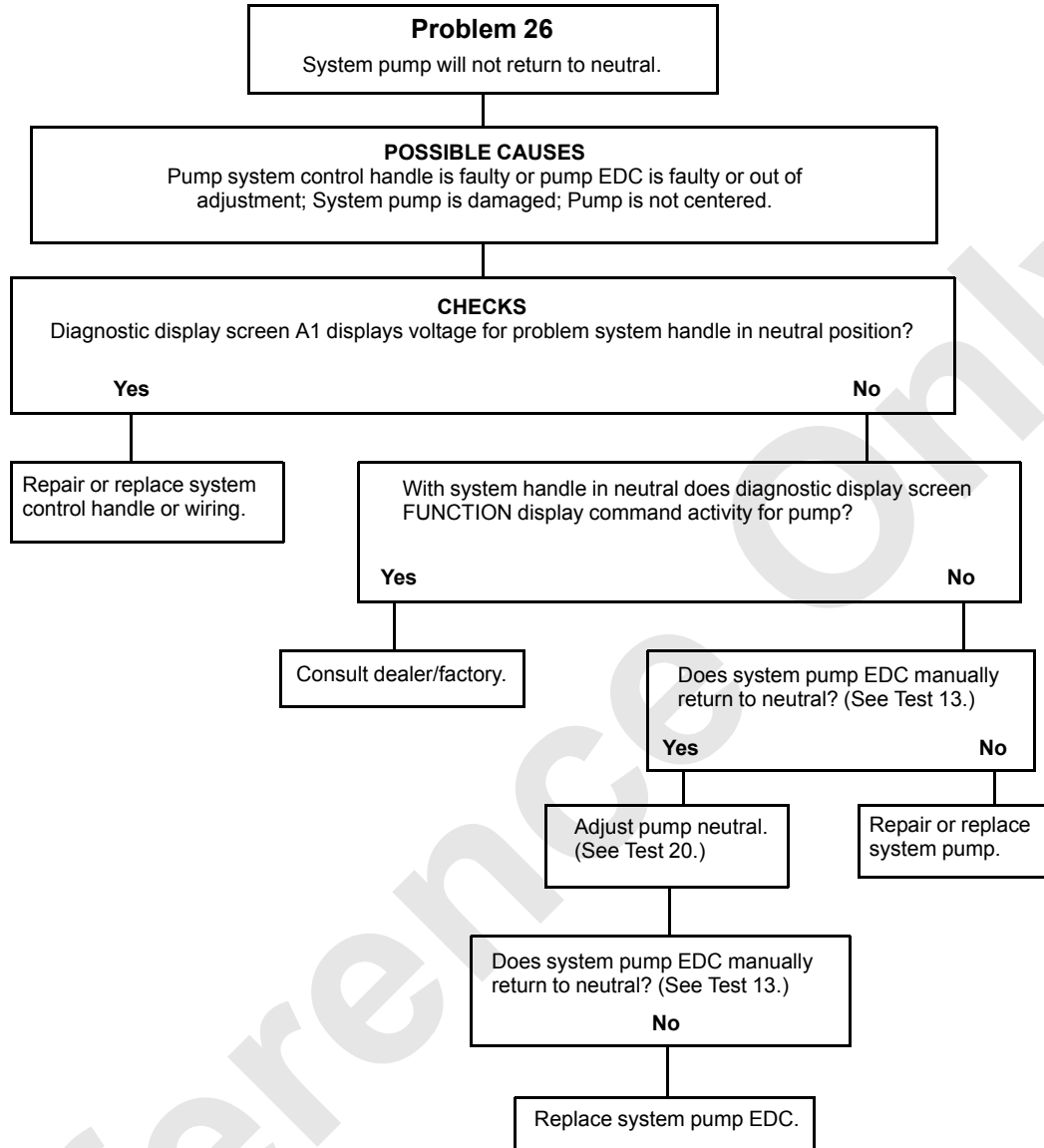


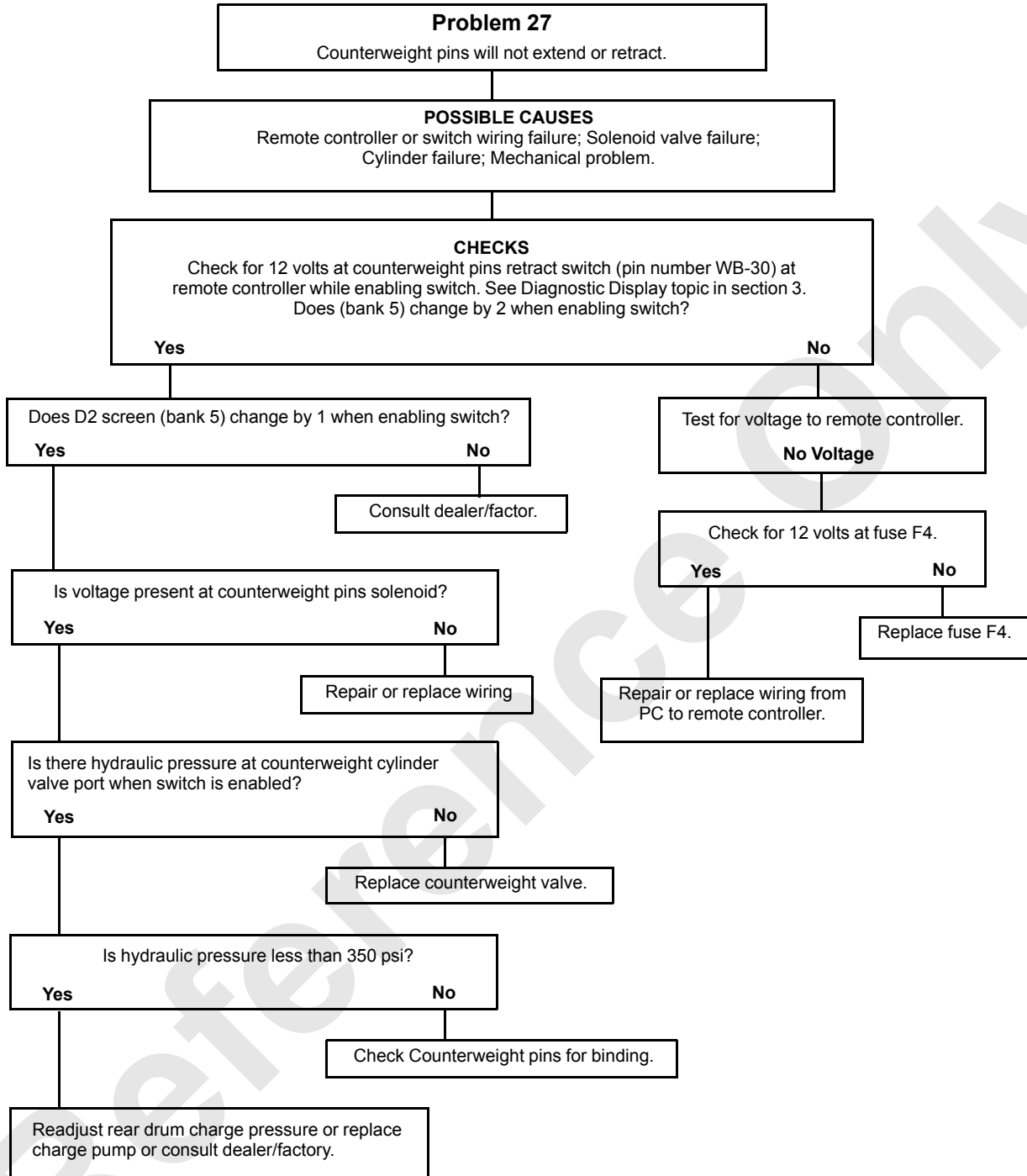
REPAIR

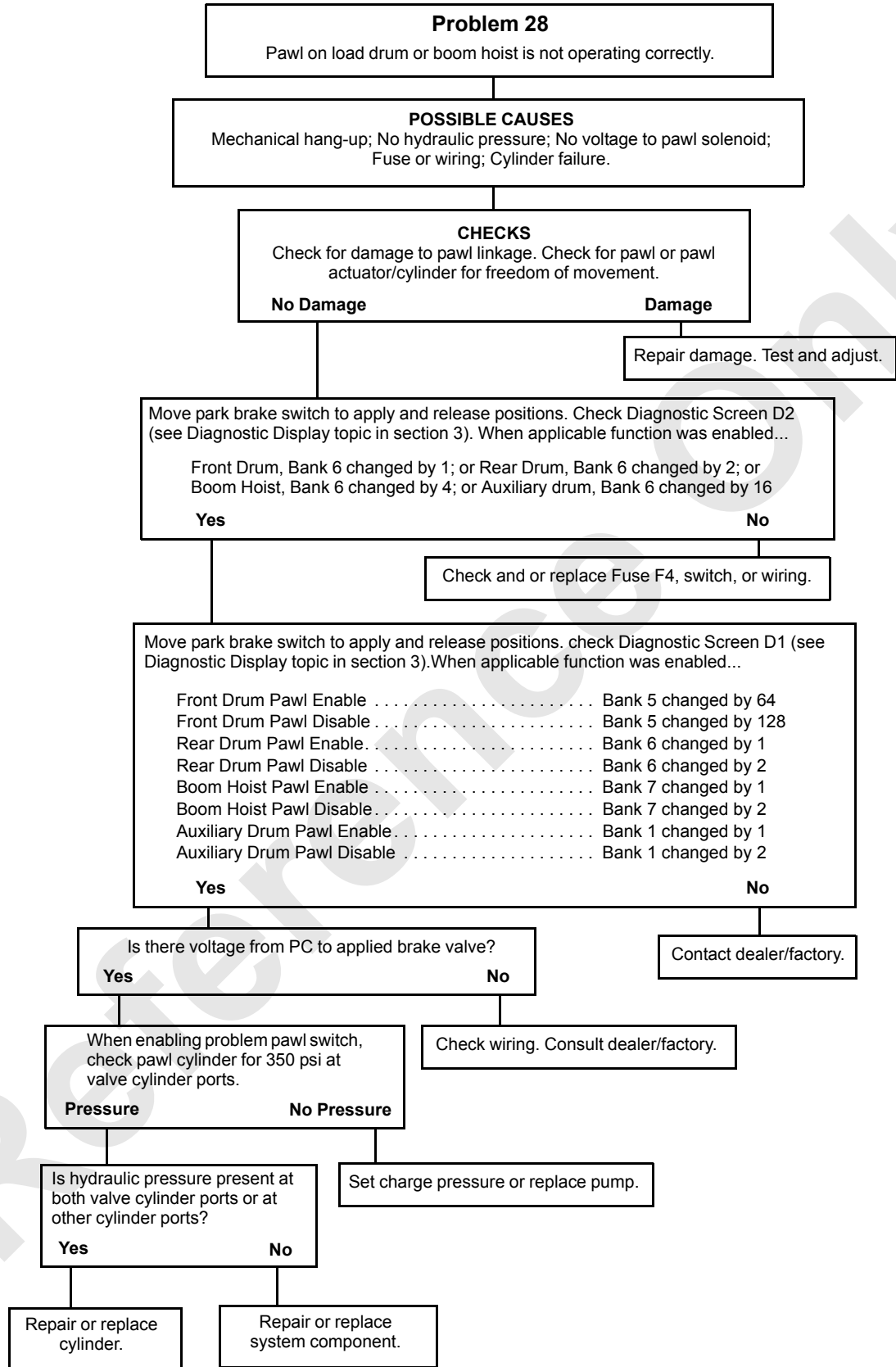












TESTING

Test 1 – Battery Test (12 and 24 volts DC)



12 VDC

AA301

1 2

Item	Description	Item	Description
1	Positive Lead	2	Negative Lead

Test the 12-volt DC accessory system voltage with a digital multi-meter. Record the voltage before and during engine cranking.

A voltage reading of 12 volts or less before cranking engine may indicate a charging system fault. A drop of 4 volts or more indicates the battery is failing.



24 VDC

P1616

Item	Description	Item	Description
1	Positive Lead	2	Negative Lead

Test the 12-volt DC starting batteries in series for 24 volts using a digital multi-meter. Record the voltage before and during engine cranking.

A voltage reading of 24 volts or less before cranking engine may indicate a charging system fault. A drop of 8 volts or more indicates the battery is failing.

Test 2– Checking Resistance at Engine Temperature Sender



P1589

Item	Description
1	Temperature Sender

Set digital multi-meter to test resistance. Make required connections to test lead adapter at the meter. Connect negative lead to a grounded component on the crane and the positive lead to engine temperature sender wire terminal. With engine cold, check for a resistance of approximately 0.70 ohms.

Refer

Test 3 – Checking Resistance at Engine Oil Pressure Sender



P1590

Item	Description
1	Oil Pressure Sender

Set digital multi-meter to test resistance. Make required connections to test lead adapter at the meter. Connect negative lead to a grounded component on the crane and the positive lead to engine pressure sender wire terminal. With engine cold, check for a resistance of approximately 240 ohms.

Test 4 – Cleaning and Adjusting the Engine RPM Transducer



P1591

Item	Description
1	Flywheel Housing
2	RPM Transducer
3	Lock Nut
4	Resistance/AC Voltage Test

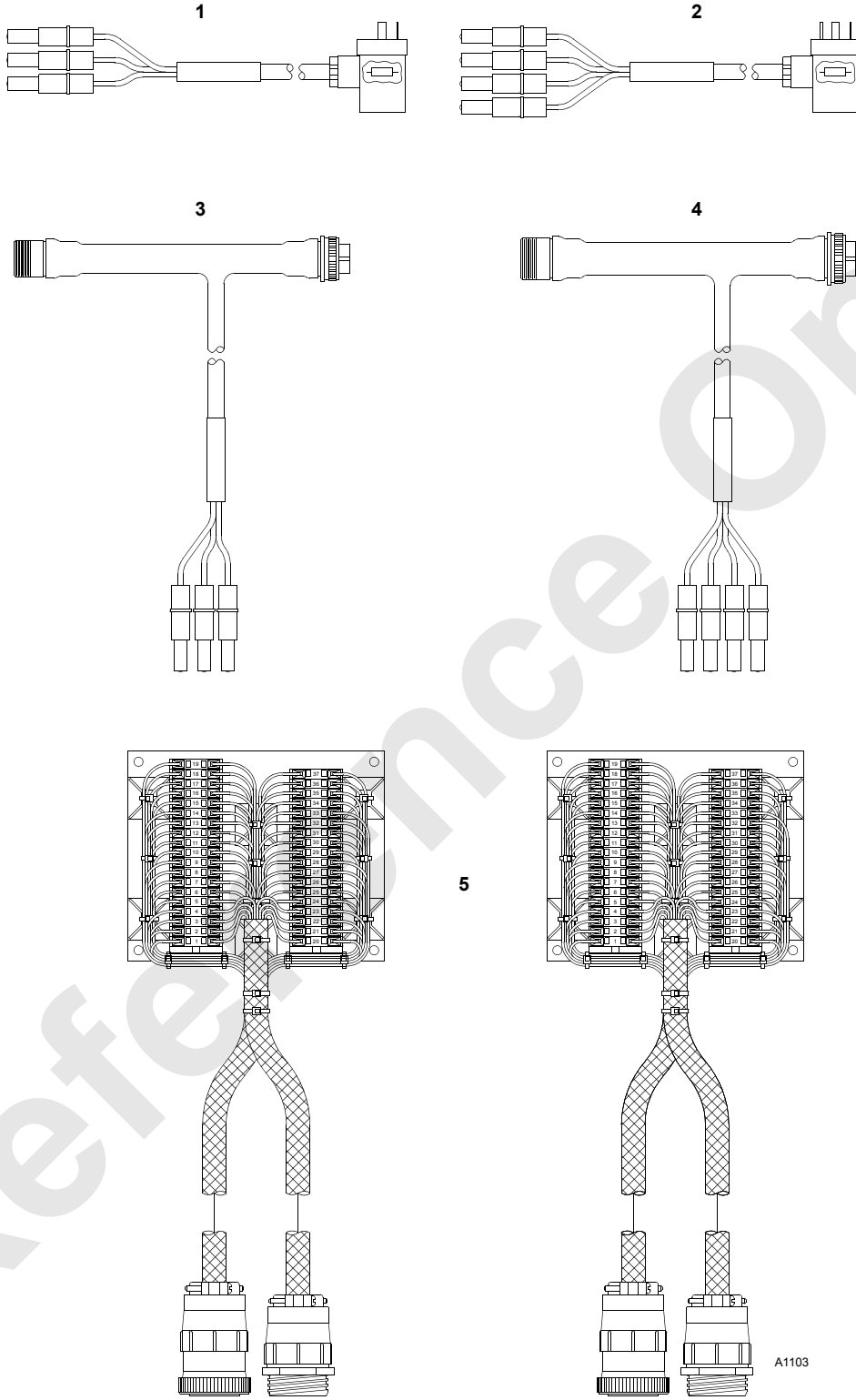
With engine cold, check for a resistance of approximately 136 ohms.

With engine running, check for AC voltage output.

To clean and adjust engine RPM transducer:

- Loosen the lock nut and remove threaded transducer from flywheel housing.
- Clean any metallic debris from the magnetic pickup on the transducer with a cleaning solvent.
- Reinstall the transducer so magnetic pickup makes contact with flywheel.
- Back off flywheel 1/2 turn and secure lock nut.

Test 5 – Test Adapters for Checking Electrical Inputs/Outputs



A1103

Test 5 – Continued

Item	Description
1	Hydraulic/Brake Valve Adapter Cable (P/N 1776422)
2	Pressure Sender Adapter Cable (P/N 1776412)
3	EDC/PCP Adapter Cable (P/N 1776442)
4	Encoder Adapter Cable (P/N 1776432)
5	In-line Testing Boards Set — Male and Female Pins (P/N 417350)
6	CPU
7	Negative Lead Ground (black)
8	Positive Lead (red)

The above test adapters can be ordered from the Manitowoc Crane Care Lattice Team. The pressure sender, encoder, EDC/PCP, and hydraulic/brake valve adapters are for testing various components as described in this manual.

To test a problem circuit, insert male or female in-line testing board (5) at CPU (6) cable connector. See [Test Voltages](#) in Section 3 of this manual for circuit wires located on each

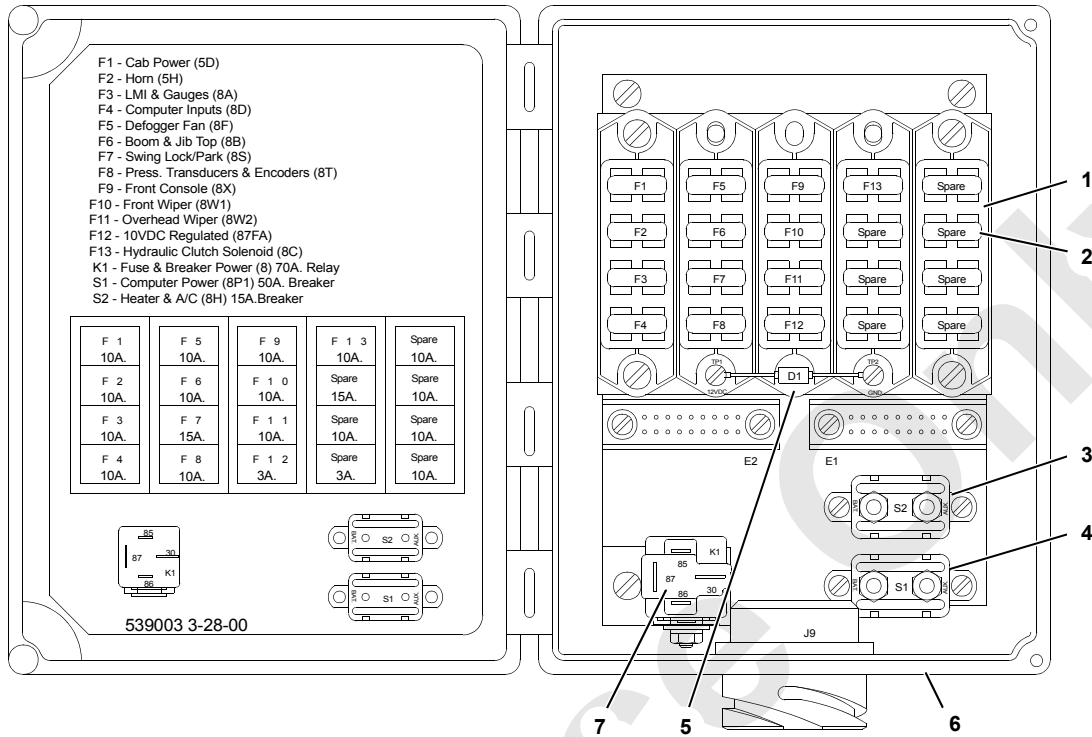
cable connector A, B, C, D and E with pins numbered 1 through 37. Connect meter negative lead (7) to ground and positive lead (8) to problem item terminal. Check for 12 volts DC (10 volts DC for regulated supply items as shown) at problem circuit wire terminal on in-line testing board.



P1592

Test 6 – Testing for Voltage at the Fuse Box

A1185



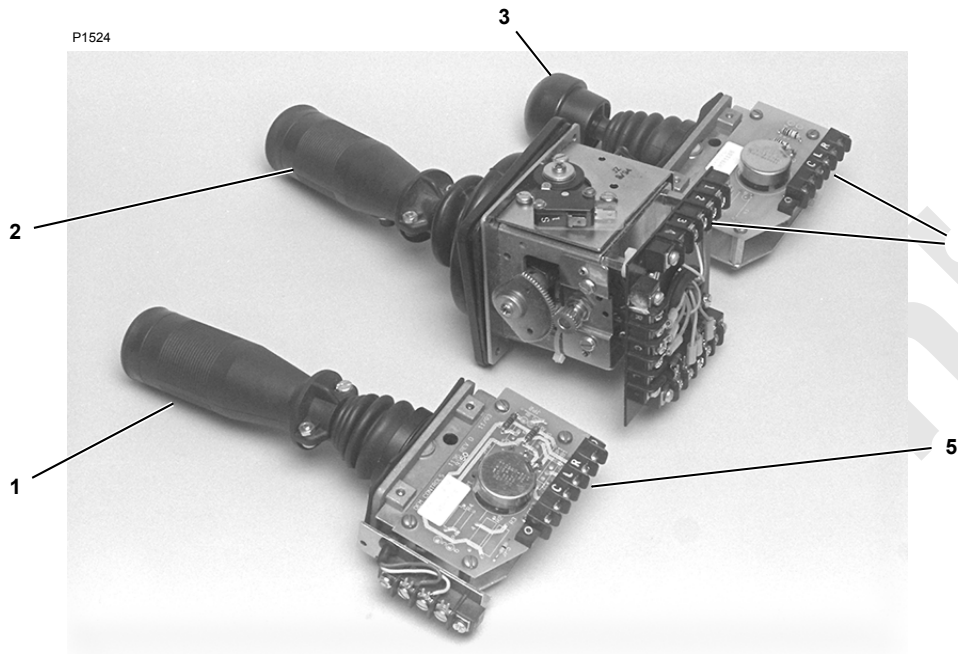
Item	Description
1	Fuse Block
2	Metal Fuse Contact
3	Air Conditioner CB (15 amp)
4	Controller CB (50 amp)
5	Transient Suppressor Diode
6	Fuse Box Chassis
7	K1 Cab Power Relay

Use a digital multi-meter for testing voltage at the fuse box.

To test for volts DC at any given fuse socket, place the positive lead on any metal fuse contact and the negative lead on the grounded fuse box chassis. Repeat this procedure using the other fuse contact as a test point. All fuse sockets except F12 (3A, 10V) should be 12 volts DC.

To determine if relay K1 is fully functional, ground the fuse box chassis and check for 12 volts DC at relay wire 8 when the relay is enabled. Also check for 12 volts constant at relay wire 5A.

Test 7 – Checking Voltage at the Control Handle



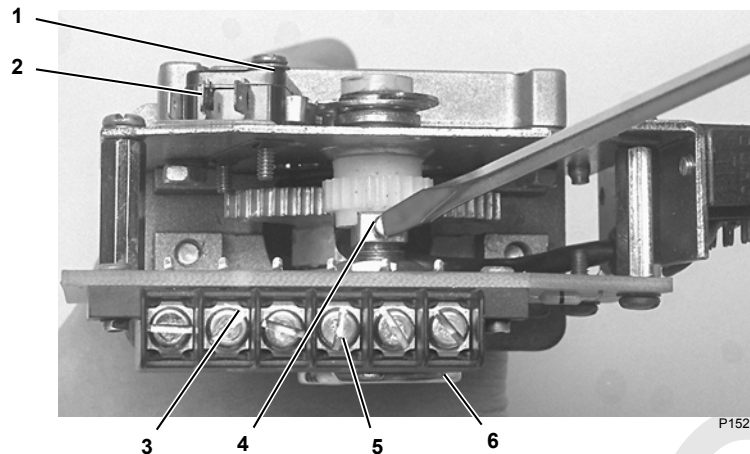
Item	Description
1	Load Drum Handle
2	Boom/Swing Handle
3	Crawler Handle
4	Test Terminal
5	Ground Terminal "R"

Use following test points to determine the correct voltages at control handle:

- Engine must be off and power on, with all brakes and locks engaged.
- Enable the test control handle and measure the voltage with a digital multi-meter.
- The positive lead must be placed on the test terminal and the negative lead on a grounded crane component or on terminal "R".
- Voltages outside the normal range may indicate a problem with the control handle, electrical circuit, or electrical components.

Hand Controller	Test Terminal	Wire No.	Acceptable Voltage (DC)	Hand Controller	Test Terminal	Wire No.	Acceptable Voltage (DC)	
Swing	Left	87FA	10	Left Travel	Left	87FA	10	
	Right	0	Ground		Right	0	Ground	1.4 to 8.6
	Center	WA-08	1.4 to 8.6		Center	WA-07	1.4 to 8.6	
	3	8S Brake	12					
Boom Hoist	4	WD-15 Brake	12	Front Load Drum	Left	87FA	10	
	Left	87FA	10		Right	0	Ground	1.4 to 8.6
	Right	0	Ground		Center	WA-03	1.4 to 8.6	
	Center	WA-05	1.4 to 8.6		1	0	Ground	12
Right Travel	1	0	Ground	Rear Load Drum	2	WD-27	12	
	2	WD-29	12		Left	87FA	10	
	Left	87FA	10		Right	0	Ground	1.4 to 8.6
	Right	0	Ground		Center	WA-04	1.4 to 8.6	
Right Travel	Center	WA-06	1.4 to 8.6	Rear Load Drum	3	0	Ground	
	3	8A	12		4	WD-28	12	
	4	WB-01	12					

Test 8 – Adjusting the Control Handle Potentiometer



Single Axis
Controller



Double Axis
Controller

Item	Description	Item	Description
1	Neutral (snap) Switch	5	Center Terminal "C"
2	Jumper Connection (N/O)	6	Potentiometer
3	Ground Terminal "R"	7	Socket Set Screw
4	Slotted Set Screw		

An unusual reaction to a control handle movement may indicate a handle misalignment to potentiometer. Adjusting a single axis or double axis control handle requires aligning the handle and potentiometer in the neutral position. Neutral is the position where 5 volts DC is present.

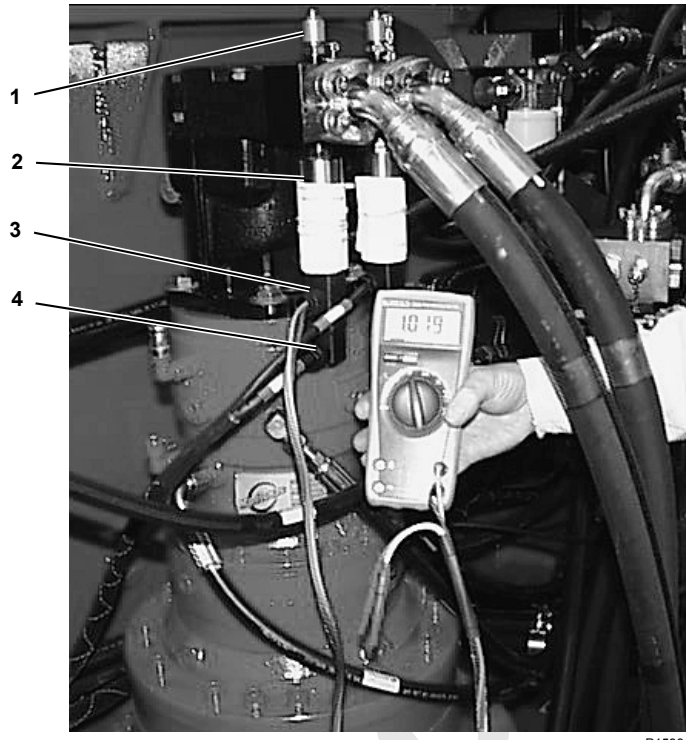
To check single axis controller:

- Engine must be off and power on, with all brakes and locks engaged.
- Connect a jumper wire between the normally open terminal on the neutral switch and terminal "C" on the handle terminal block.
- Connect the positive lead of a digital multi-meter to terminal "C".

- Connect the negative lead on a grounded crane component or on terminal "R".
- Loosen the slotted set screw (item 4) and allow handle to return to neutral position.
- Re-tighten slotted set screw and move handle until a reading of 5 volts DC is obtained.
- Holding the handle in the 5-volt position, loosen the slotted set screw (item 4).
- Allow handle to return to neutral position.
- Re-tighten slotted set screw.

The double axis control handle adjustment is the same, except the 2 socket set screws (item 7) on the gear collar are loosened.

Test 9 – Checking Voltage at the Pressure Senders



P1593

Item	Description
1	System Pressure Test Port
2	Pressure Sender
3	Pressure Sender Test Adapter
4	DIN Connector

Test voltage and resistance of a system pressure sender with a standard test adapter (can be ordered from the Manitowoc Crane Care Lattice Team) and a digital multi-meter.

To test incoming power at desired pressure sender:

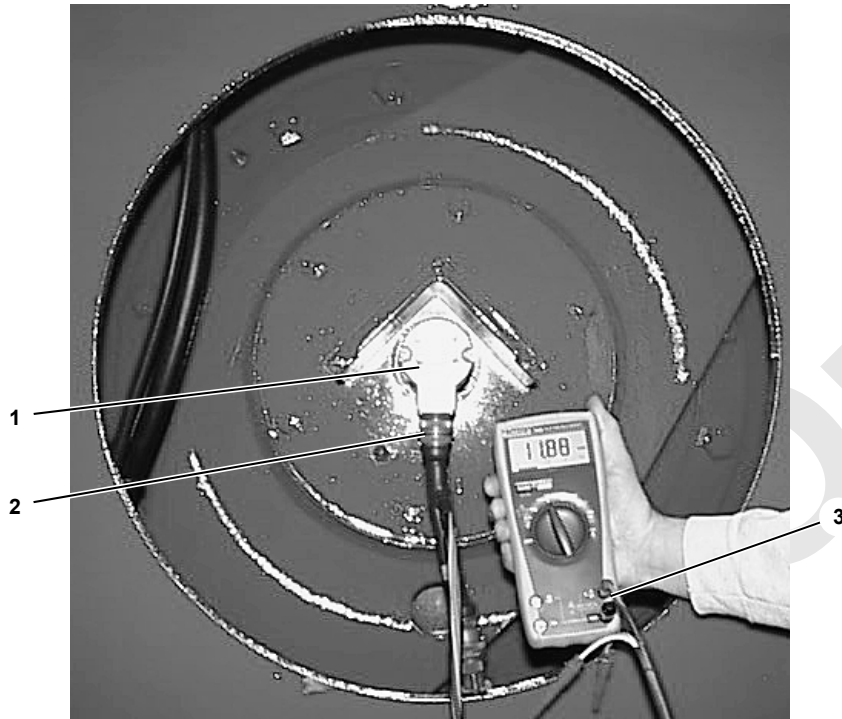
- Connect test adapter between pressure sender and DIN plug.
- Connect white (positive) and black (negative) wires from adapter cable to digital multi-meter jacks.
- Check for 12 volts DC.
- If this reading is not obtained, check for 5 amps at F8 fuse on fuse panel (see Test 6).

To test voltage output from the pressure sender to the PC:

- Engine must be off and power on, with all brakes and locks engaged.
- Connect green (positive) and black (negative) wires to digital multi-meter jacks.
- Check for 1.00 to 1.04 volts DC.

The PC null or zero routine permits the pressure sender to operate outside the above voltage range. If reading is 0.80 volts or less or 1.20 volts or more, pressure sender must be replaced.

Test 10 – Checking Voltage at the Speed Encoders



Load Drum Shown

Item	Description
1	Encoder
2	Test Adapter
3	Adapter Cable Connections

Testing the boom hoist or load drum speed encoder for correct voltages requires a standard test adapter (can be ordered from the Manitowoc Crane Care Lattice Team) and a digital multi-meter.

To test incoming power at desired speed encoder:

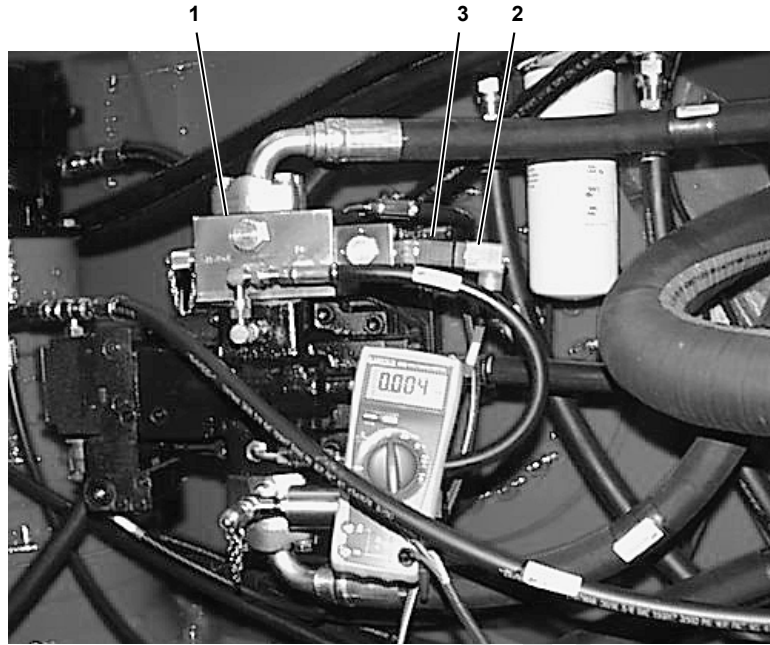
- Engine must be off and power on, with all brakes and locks engaged.
- Disconnect the output cable from the speed encoder connector.
- Install the test adapter to the encoder.
- Connect the test adapter red (positive) and black (negative) to digital multi-meter jacks.
- Start engine with all brakes and locks engaged.
- The motor or drum should remain at rest.

- Check for 12 volts DC.
- If this reading is not obtained, check the 5 amp F8 fuse at the fuse panel (see Test 6).

To test voltage output from the speed encoder to the PC:

- Engine must be off and power on, with all brakes and locks engaged.
- Connect green (positive) and black (negative) wires to digital multi-meter jacks.
- Check for 0.00 or 7.40 volts DC with motor or load drum at rest.
- With the motor or load drum enabled, check for 3.5 to 3.9 volts DC.
- If these readings are not obtained, check the encoder drive assembly and wiring.

Test 11 – Checking Voltage at the Hydraulic Brake Valve



P924

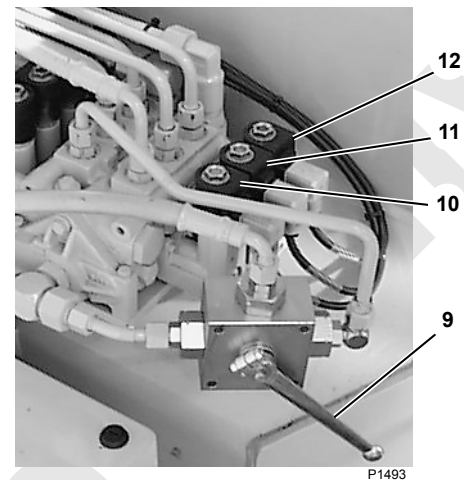
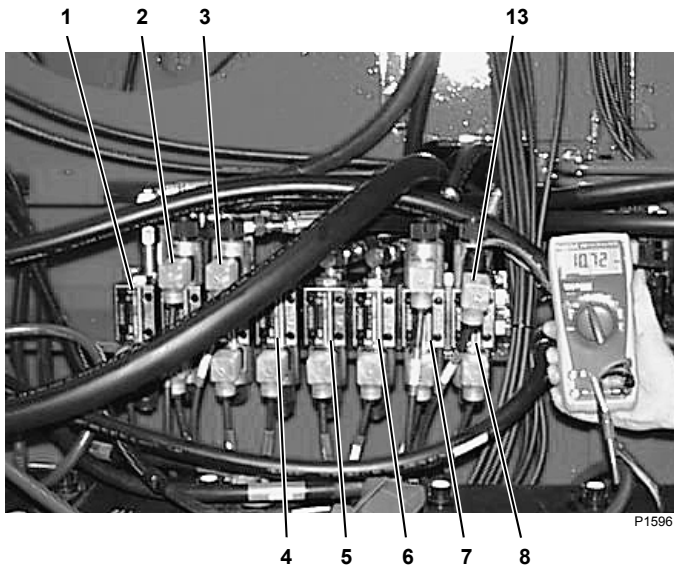
Item	Description
1	Hydraulic Brake Valve
2	DIN Plug
3	Hydraulic/Brake Valve Adaptor Cable

Testing for voltage at any hydraulic brake valve requires a standard test adapter (can be ordered from the Manitowoc Crane Care Lattice Team) and a digital multi-meter.

To test brake valve:

- Connect the test adapter between brake valve and DIN plug.
- Connect white (positive) and black (negative) wires from adapter cable to digital multi-meter jacks.
- Check for 12 volts DC while releasing the brake for the system being tested.
- Load current can be measured by connecting red and white wires from adapter cable to digital multi-meter jacks.

Test 12 – Checking Voltage at the Hydraulic Valve Assemblies



In Right Side Enclosure

Item	Description	Item	Description
1	Counterweight Pin Solenoid Valve	8	Front Drum Pawl Solenoid Valve
2	Boom Hoist Pawl Solenoid Valve	9	Mast Arms Bypass Valve
3	Swing Lock Solenoid Valve	10	Mast Assist Cylinders Solenoid Valve
4	Swing Brake Solenoid Valve	11	Gantry Cylinders Solenoid Valve
5	Two-Speed Travel Solenoid Valve	12	Boom Hinge Pins Solenoid Valve
6	Travel Brake Solenoid Valve	13	Hydraulic/Brake Valve Adapter Cable
7	Rear Drum Pawl Solenoid Valve		

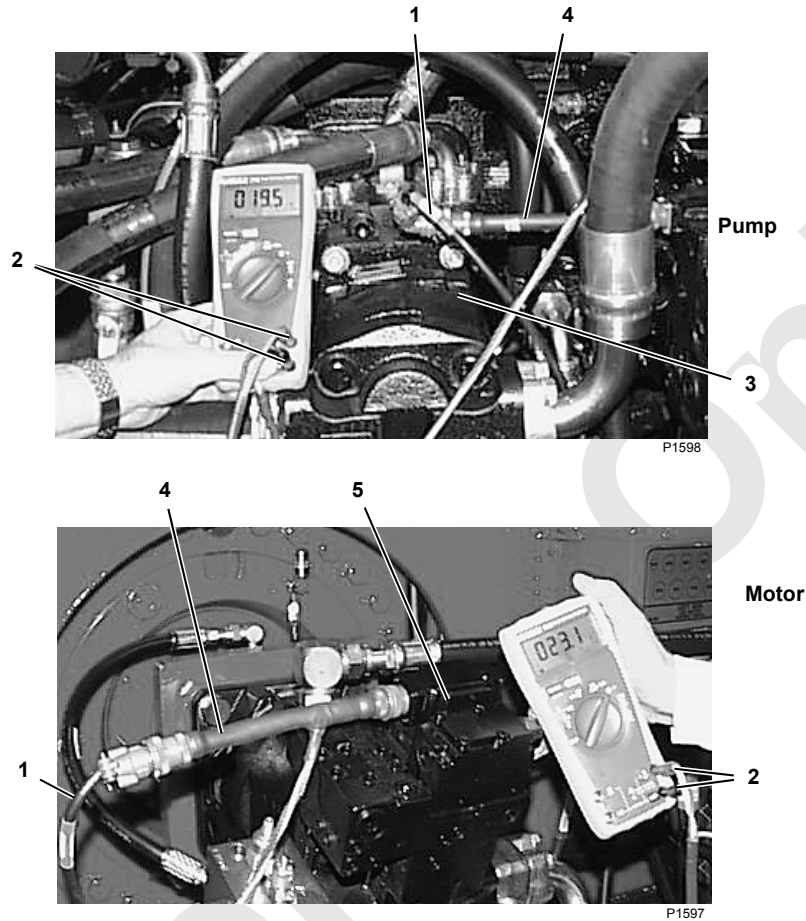
To determine if a hydraulic solenoid is enabled, place a screwdriver on the solenoid coil. The solenoid is enabled if screwdriver is magnetically pulled toward the solenoid coil.

Measure system voltage at various locations with a standard test adapter (can be ordered from the Manitowoc Crane Care Lattice Team) and a digital multi-meter.

To test a hydraulic valve:

- Set digital multi-meter for testing volts DC.
- Connect white (positive) and black (negative) wires from adapter cable to digital multi-meter jacks.
- Install test adapter between solenoid valve electrical socket and DIN plug.
- Enable valve under test.
- Check for 12 volts DC at upper valve assembly.

Test 13 – Testing the Pump EDC and Motor PCP



Item	Description	Item	Description
1	PC Input Cable	4	Test Adapter
2	Adapter Cable Connections	5	Motor PCP
3	Pump EDC		

Testing a pump EDC or motor PCP requires a standard test adapter (can be ordered from the Manitowoc Crane Care Lattice Team) and a digital multi-meter. To test a pump function:

- Disconnect the PC input cable from the pump EDC to be tested.
- Connect the double-ended test adapter EDC.
- Leave the PC end of test plug disconnected.
- Set digital multi-meter for testing resistance.
- Connect white (positive) and black (negative) wires from adapter cable to digital multi-meter jacks.
- Check that EDC resistance is between 17 and 19 ohms.

Leave test adapter installed at the pump EDC:

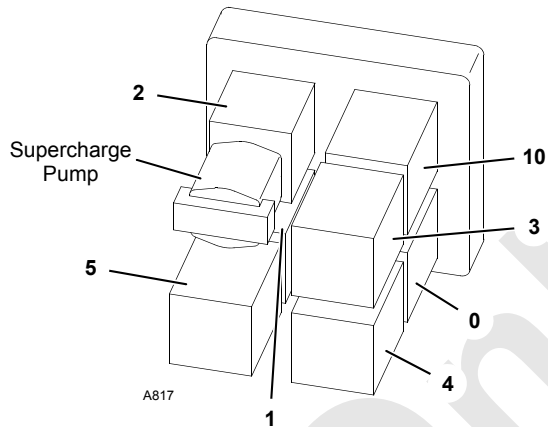
- Set the digital multi-meter for testing volts DC.
- Connect the PC input cable to PC end of test adapter.
- With engine running, slowly enable test system control handle.
- Check that the range of voltage change is between 0 and +/-2.35 volts DC.
- Load current can be measured by connecting red and white wires from adapter cable to digital multi-meter jacks.

To test motor function, remove the PC input line from the motor PCP and connect the test adapter. Perform the resistance and voltage tests as described for pump EDC. Motor PCP coil resistance should be between 23 to 26 ohms. The voltage should be between 0 and 1.96 volts DC.

Test 14 – Location of Pump Ports

Pump Identification

Pump Number	Identification
0	Front Load Drum
1	Rear Load Drum or Luffing Hoist
2	Boom Hoist
3	Swing
4	Right Crawler
5	Left Crawler
10	Auxiliary Load Drum

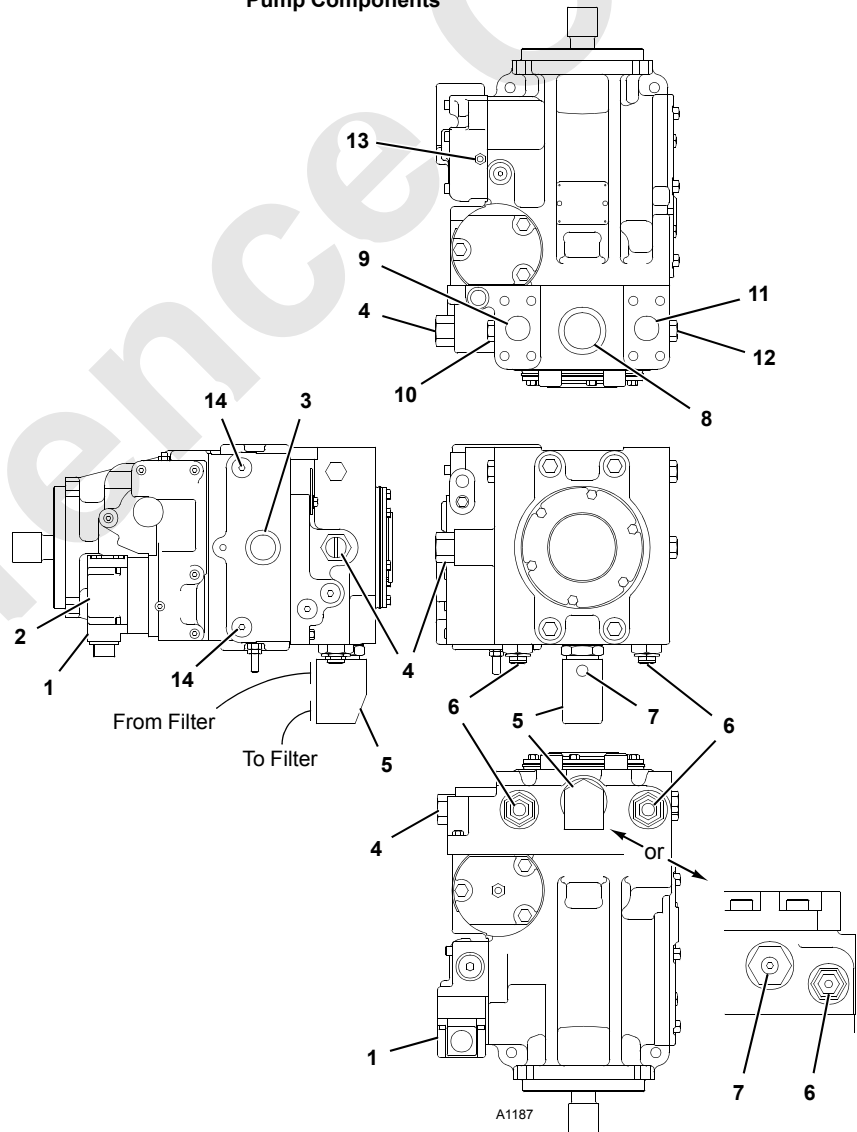


Pump Components

Item	Description
1	EDC (Electronic Displacement Control)
2	Manual Override Control
3	Case Drain Port (Note 1)
4	Charge Pressure Relief Valve
5	Filter Adapter (Note 2)
6	Multi-Function Valve (Note 3)
7	Charge Pressure Gauge Port
8	Charge Pump Inlet Port
9	Pump Port B
10	Pump Port B Gauge Port
11	Pump Port A
12	Pump Port A Gauge Port
13	Neutral Adjusting Screw
14	Servo Pressure Gauge Port

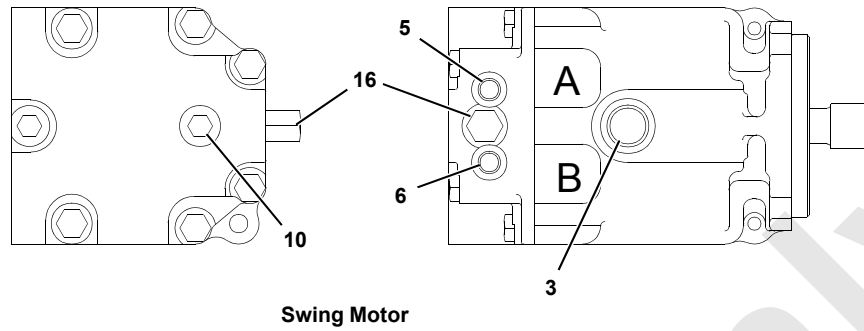
NOTE 1: Both Sides of Pump.
NOTE 2: Auxiliary Drum Pump Only.
NOTE 3: Valve is Directly Opposite Port it Protects.

Pump Components

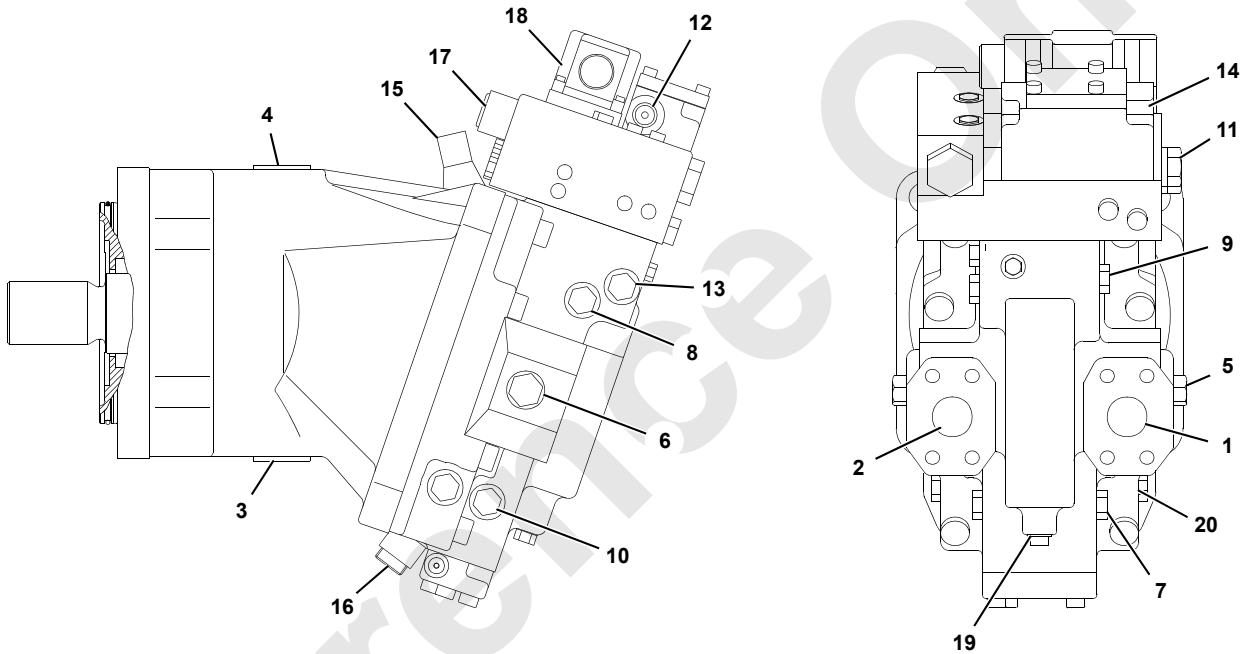


Test 15 – Location of Motor Ports

A1188



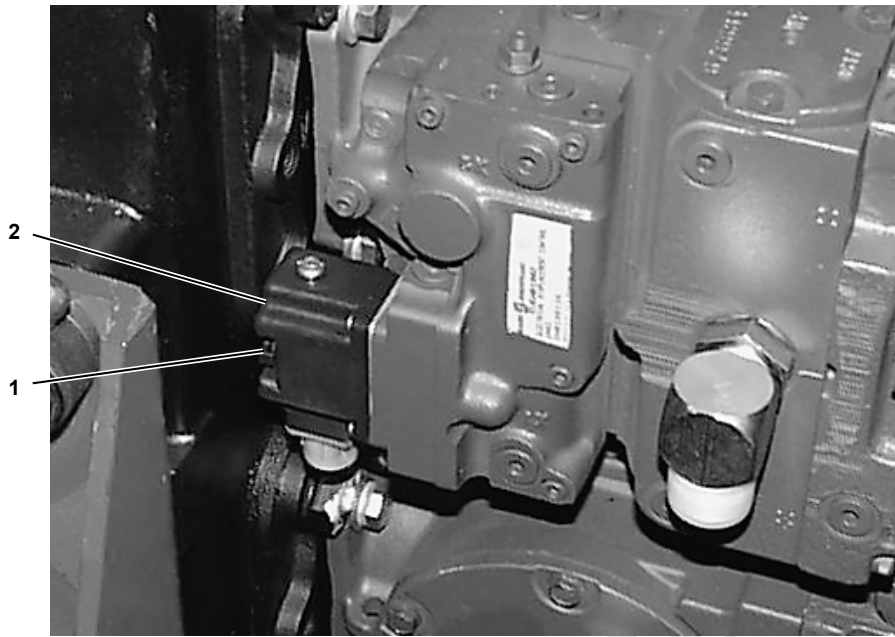
Swing Motor



Boom Hoist, Load Drums, and Travel Motor

Item	Port	Description	Item	Port	Description
1	A	Main System Pressure	11	M7	Control Pressure
2	B	Main System Pressure	12	M8	Control Pressure
3	L1	Case Pressure	13	M9	Servo Pressure Supply
4	L2	Case Pressure	14	X1	External PCP Supply Pressure
5	M1	Gauge Port A	15		Minimum Displacement Limiter
6	M2	Gauge Port B	16		Charge Pressure Relief valve
7	M3	Servo Pressure Gauge Port or Servo Pressure Supply	17		Pressure Compensator Adjuster
8	M4	Servo Pressure Gauge Port or Servo Pressure Supply	18		Manual Override
9	M5	Servo Pressure Supply	19		Control Start Setting
10	M6	Charge Pressure Gauge Port	20		Loop Flushing Shuttle Valve

Test 16 – Manually Stroking the Pump



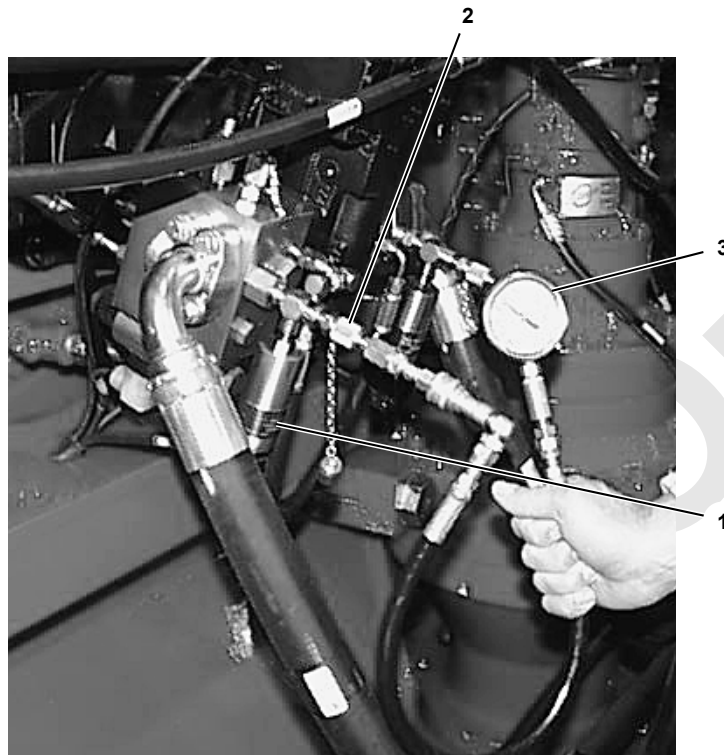
P966

Item	Description
1	Manual Stroke Override
2	Pump EDC

See Test 13 for location of pump ports. To stroke the pump:

- Start with engine running and all brakes and locks engaged.
- Rotate the pump manual override in the clockwise direction to load down and raise pressure in port "A".
- Rotate the pump manual override in the counter-clockwise direction to load down and raise pressure in port "B".

Test 17 – Checking Pump Charge Pressure



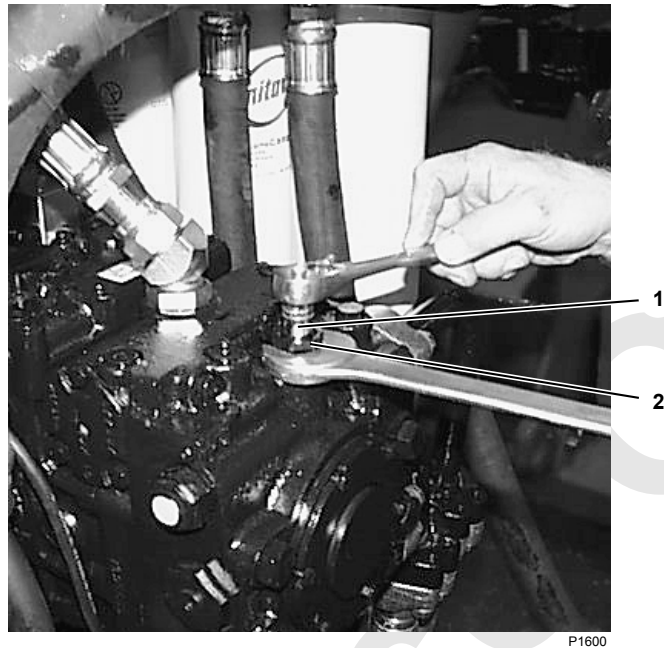
P1599

Item	Description
1	Pressure Sender
2	Charge Pressure Test Port
3	Text Gauge

Component charge systems can be checked at the desired system diagnostic gauge coupler at pressure sender. To check pump charge pressure:

- Install a 0 – 600 psi (0 – 42 bar) gauge at the desired system diagnostic gauge coupler at pressure sender.
- Start system and record charge pressure at engine idle speed.
- No hydraulic systems should be enabled.
- A reading of 350 psi (24 bar) is system charge pressure.
- A reading of less than 350 psi (24 bar) indicates a charge pressure relief adjustment is necessary. See Test 18.

Test 18 – Adjusting Pump Charge Pressure Relief

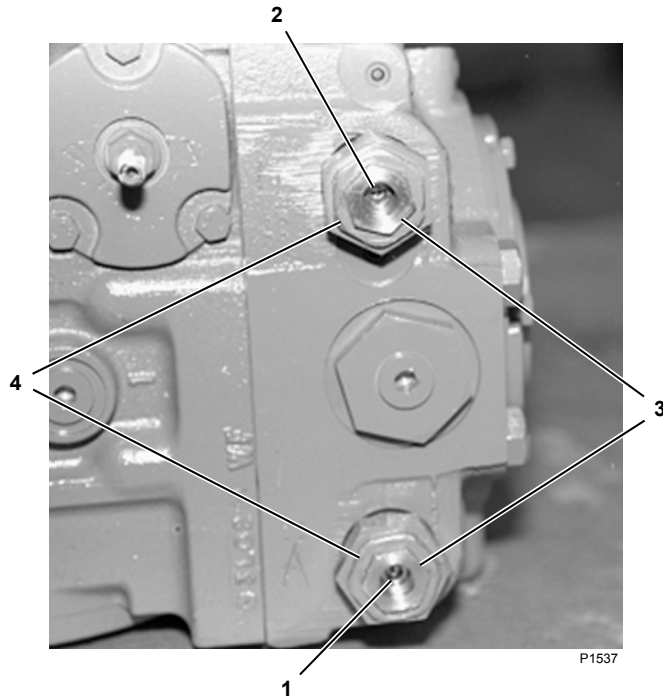


Item	Description
1	Adjusting Screw
2	Adjusting Lock Nut

The pump charge pressure must be measured to accurately adjust the charge pressure relief valve. To adjust pump charge pressure:

- Install a 0 – 600 psi (0 – 42 bar) gauge at system diagnostic gauge coupler (see Test 17).
- Start engine with all brakes and locks engaged.
- Check gauge for approximately 350 psi (24 bar).
- To adjust, loosen and hold 1-1/16 inch adjusting lock nut for series 045 – 100 units or 1-5/8 inch adjusting lock nut for series 130 units.
- Turn adjusting screw until 350 psi (24 bar) is obtained.
- Torque adjusting lock nut to 34 to 41 ft-lbs (46 to 56 Nm).
- Remove gauge and replace port plug.

Test 19 – Setting the Pump Pressure



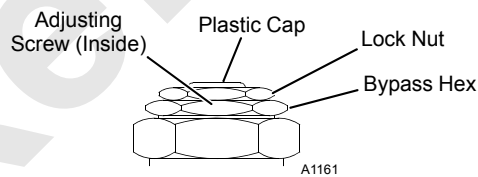
Item	Description	Item	Description
1	Multifunction Valve Adjusting Screw for Port "A"	3	Lock Nut
2	Multifunction Valve Adjusting Screw for Port "B"	4	Bypass Hex Nut

To adjust multifunction valve:

1. Remove the protective cap from the multifunction valve and loosen the lock nut.
2. Insert a hex wrench into multifunction valve adjusting screw.
 - Turning adjusting screw clockwise will increase relief pressure.

- Turning adjusting screw counter-clockwise will decrease relief pressure.

NOTE: The bypass hex nut is for special applications only and must not be rotated during setting of pump pressure without first consulting the pump manufacturer literature.



Multi-Function Valve

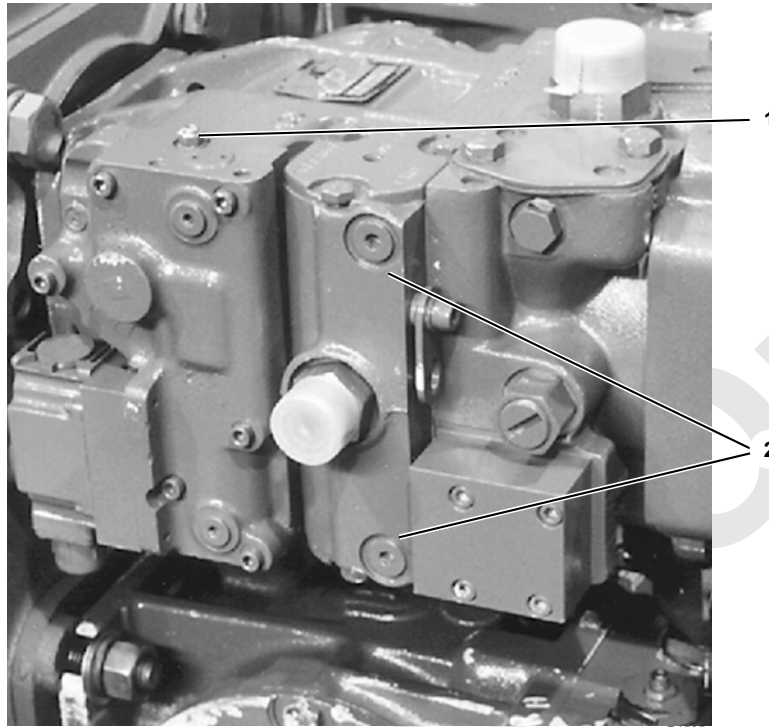
Wrench Sizes

	Locking Nut	Hex Wrench
Series 042 – 100 Units	19mm	4mm
Series 130 Units	13mm	5mm

Pump Port Control Function

Pump	Port A	Port B
Travel	Forward	Reverse
Load Drum	Hoist	Lower
Boom Hoist	Raise	Lower
Swing	Right	Left

Test 20 – Setting Pump Neutral



Item	Description
1	Neutral Adjusting Screw and Lock Nut
2	Servo Gauge Ports

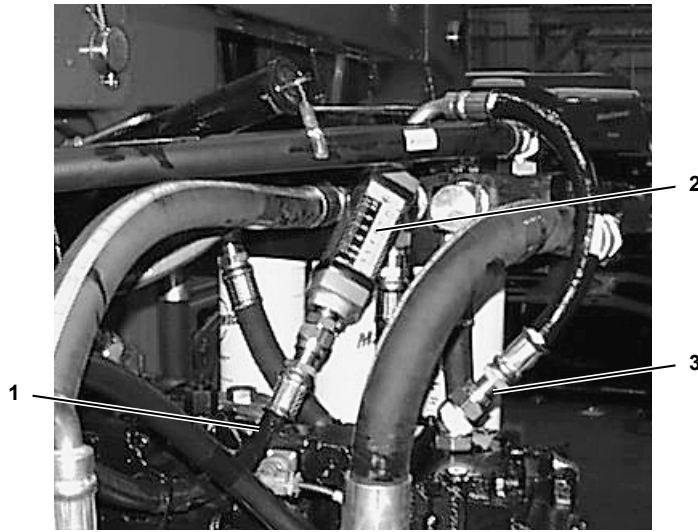
To set pump neutral:

- Engine must be off and power on, with all brakes and locks engaged.
- Disconnect the PC from the pump EDC by removing the cable at the EDC.
- Install a 0 – 600 psi (0 – 42 bar) gauge at each servo gauge port.
- Start engine with all brakes and locks engaged.
- Loosen the hex lock nut and rotate the neutral adjusting screw with hex wrench until pressure increases in one of the gauges.
- Note the handle position of the hex wrench and without moving wrench, rotate the neutral adjusting screw counter-clockwise until pressure increases in the other gauge.
- Note the handle position of the hex wrench again and without moving wrench, rotate the neutral adjusting screw clockwise halfway between the last position.
- The control should now be in neutral with both gauges reading the same case pressure.
- Hold the neutral adjusting screw with the hex wrench and tighten the lock nut.
- Remove the gauges and install the servo gauge port plugs.

Wrench Sizes

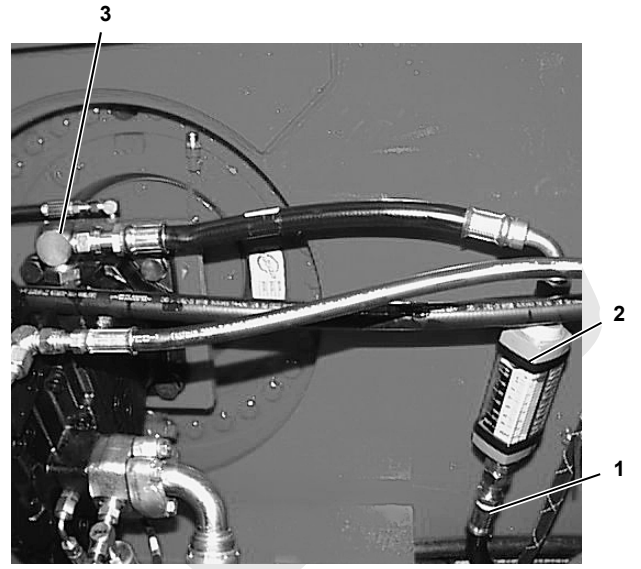
	Locking Nut	Hex Wrench
Early Series Units	17 mm	5 mm
Current Series Units	13 mm	4 mm

Test 21 – Testing for Pump and Motor Leakage



Pumps

P1601



Motors

P1602

Item	Description
1	Case Drain Hose
2	In-line Flow Meter
3	Hose to Highest Case Drain Port

Testing for pump and motor leakage requires a 0 – 3,000 psi (207 bar) in-line flow meter with a minimum flow rate capacity of 30 gpm (113 L/min). Flow meters can be ordered from the Manitowoc Crane Care Lattice Team.

Acceptable leakage is based on the combined case flow of the pump and motor. The combined case flow of the load drum pump and motor should be approximately equal to a charge pump flow or 8.9 gpm (34 L/min) per 1,000 rpm of the engine.

The combined case flow of the boom hoist, swing, travel or luffing jib hoist pump and motor should be approximately equal to a charge pump flow or 4.8 gpm (18 L/min) per 1,000 rpm of the engine. The difference between the system charge pump flow and motor case flow at neutral is the acceptable pump case flow at neutral for the system under test.

Motor Test

See Test 14 for location of motor ports. The external loop flush valve must be removed from boom hoist motor before testing (see Test 23). To test a motor:

- Connect flow meter between the motor case drain hose and the highest motor case drain port.
- With the engine running at 1,000 rpm, measure the flow rate of the motor.

- Case flow at neutral or very light loads should be approximately 5 gpm (19 L/min).
- Record all measurements at neutral.
- At heavier loads, normal case flow may go to 7 gpm (26 L/min).
- Motors that do not have loop flushing, case flow at neutral should not exceed 1.5 gpm (5.7 L/min).
- Motors that do not have loop flushing, case flow at heavier loads and higher rpm may increase to 4.5 or 5.5 gpm (17 or 21 L/min).
- Reconnect the motor case drain hose to motor drain port.

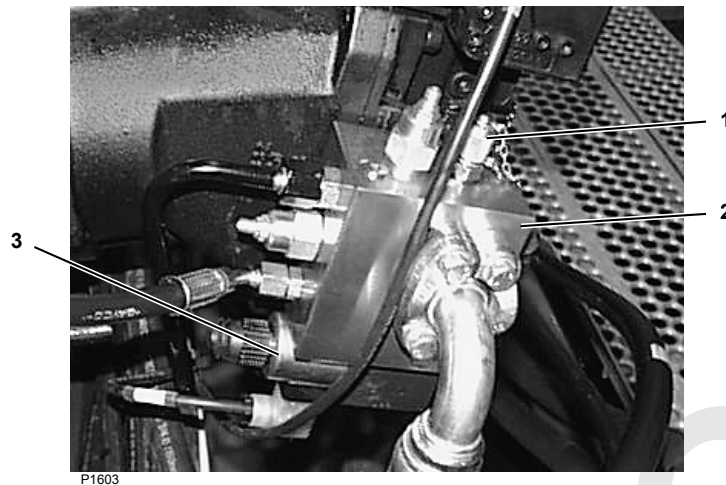
Pump Test

See Test 13 for location of pump ports. To test a pump:

- Connect the flow meter between the pump case drain hose and pump port L1 or L2.
- Use the highest port for testing.
- With the engine running at 1,000 rpm, measure the flow rate of the pump at neutral and compare to the calculated acceptable pump case flow.

Deviations from the normal or major changes with increasing system pressure more than +/- 1 gpm (3,8 L/min) are an indication of a pump or motor problem.

Test 22 – Checking Hydraulic Brake Pressure



Item	Description
1	Diagnostic Gauge Coupler
2	Loop Flushing (purge) Valve
3	Brake Solenoid Valve

The swing brake, swing lock and travel brakes operate off rear drum low-pressure charge pump pressure. The front drum brake, rear drum brake, and boom hoist brake operate off low-pressure side of each closed-loop system. The auxiliary drum brake operates off auxiliary low-pressure charge pump pressure.

To check hydraulic brake pressures for swing and travel systems:

- Engine must be off and power off, with all brakes and locks engaged.
- Disconnect a rear drum charge pressure line.
- Connect a 0 – 1,000 psi (69 bar) gauge with tee fitting in charge pressure line.
- Start engine and set throttle at high idle.
- Enable test system brake and check that brake pressure is 325 – 375 psi (22 – 26 bar). Charge pressure can also be checked at system diagnostic screen.
- If pressure is not within range, adjust rear drum charge pressure (see Test 18).
- Remove pressure gauge and replace the charge pressure line.

To check hydraulic brake pressure for front drum, rear drum, or boom hoist system:

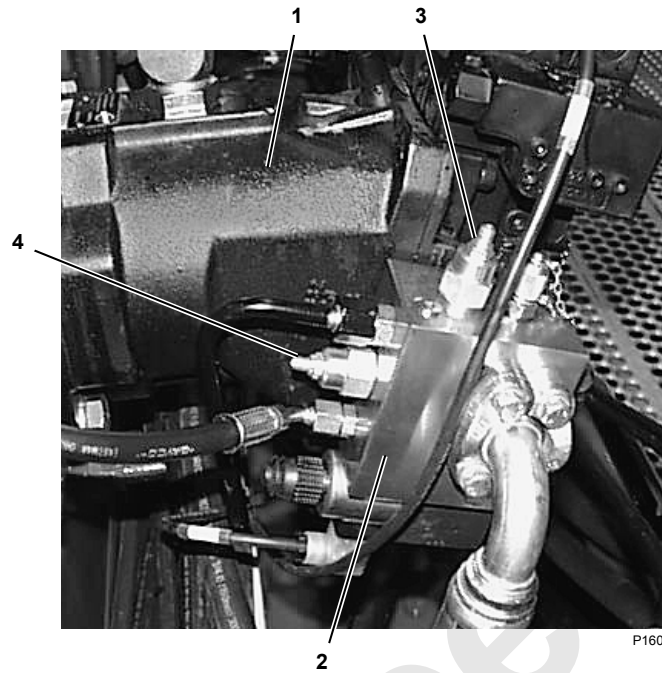
- Engine must be off and power off, with all brakes engaged.

- Connect a 0 – 1,000 psi (69 bar) gauge at diagnostic gauge coupler on loop flushing valve.
- Start engine and set throttle at high idle (2,000 rpm).
- Enable test system brake and check that brake pressure is 325 – 375 psi (22 – 26 bar). Charge pressure can also be checked at system diagnostic screen.
- If pressure is not within range, check system charge pressure (see Test 18).
- Remove pressure gauge from diagnostic gauge coupler.

To check hydraulic brake pressure for auxiliary drum system:

- Engine must be off and power off, with all brakes engaged.
- Connect a 0 – 1,000 psi (69 bar) gauge at test port on auxiliary filter manifold.
- Start engine and set throttle at high idle (2,000 rpm).
- Enable auxiliary drum brake and check that brake pressure is 325 – 375 psi (22 – 26 bar). Charge pressure can also be checked at system diagnostic screen.
- If pressure is not within range, check system charge pressure (see Test 18).
- Remove pressure gauge from test port on auxiliary filter manifold.

Test 23 – Servicing the Motor Loop Flushing (Purge) Valves

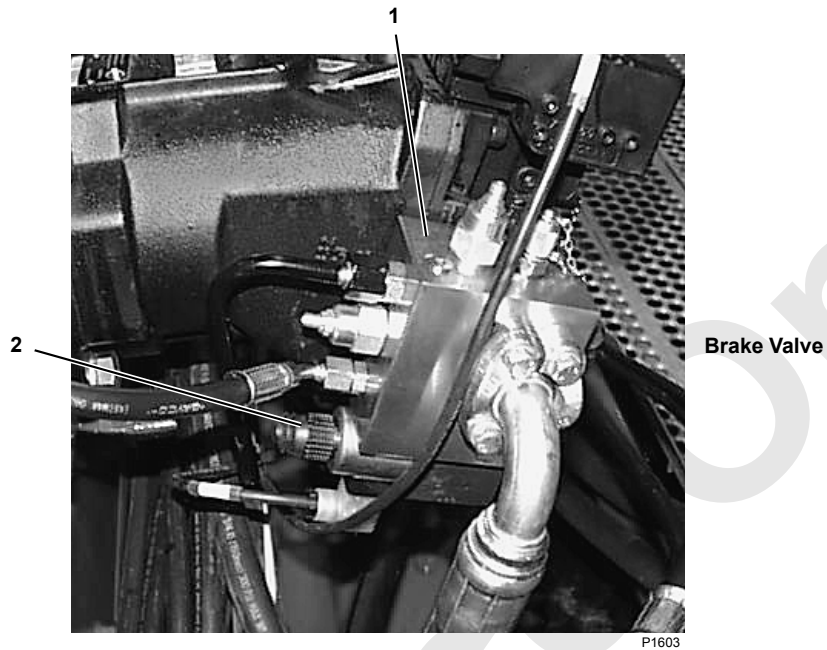


Item	Description
1	Motor
2	Loop Flushing (purge) Valve
3	Valve Flow Control
4	Sequence Valve

Problems with a faulty loop-flushing valve are best corrected by replacing the complete valve assembly. To service the loop flushing valve:

- Engine must be off and power off, with all brakes and locks engaged.
- Drain motor by removing attached hydraulic lines.
- After draining, replace hydraulic hose.
- Remove hoses from flushing valve and replace valve.
- The hydraulic fluid flow through the valve is adjusted with valve flow control on top of valve (set for 6 gpm).
- The hydraulic sequence valve is adjusted with flow control on side of valve (set for 200 psi [14 bar]).

Test 24 – Actuating the Solenoid Valve Manual Overrides



Brake Valve

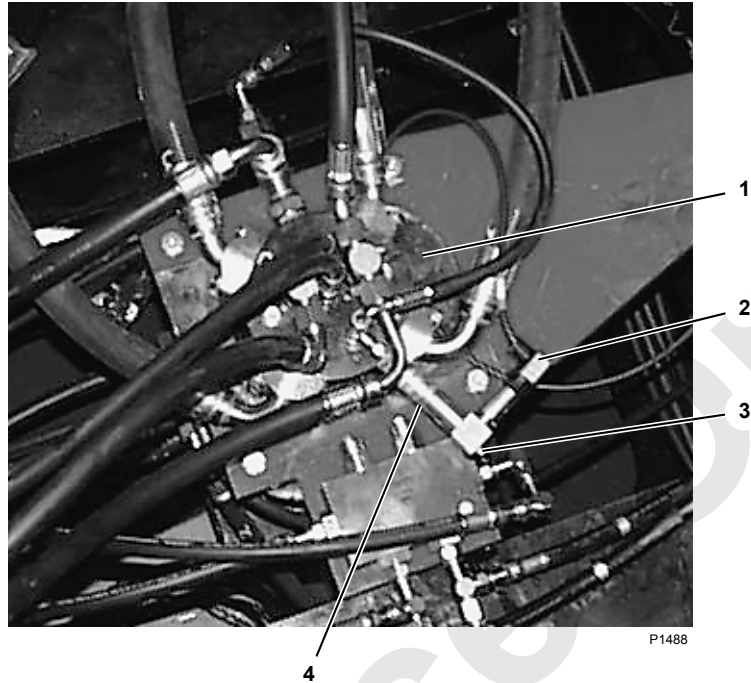
P1603

Item	Description
1	Hydraulic Brake Valve
2	Valve Override (under cap)

To check that a solenoid valve or system valve is operating correctly:

- Start the engine and actuate the manual override.
- Hydraulic brake valves have an override push button in center of black nut.
- If the valve is operating correctly, the valve shifts to perform the control function.

Test 25 – Adjusting Accessory Pressure Switch



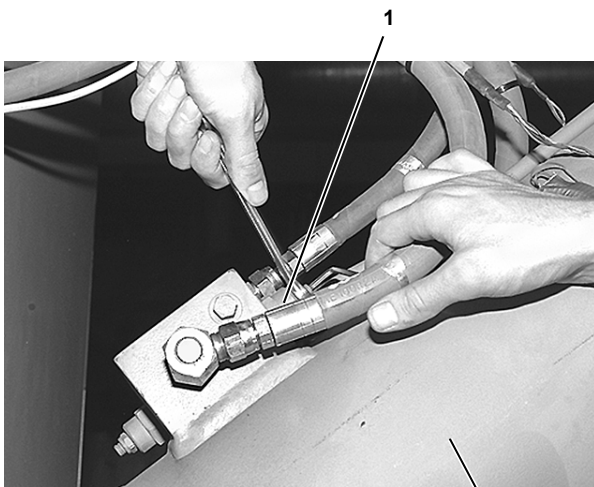
Item	Description
1	Rotating Frame Swivel
2	Electrical DIN Connector
3	Accessory Pressure Switch Adjusting Screw
4	Accessory Pressure Switch

In setup mode, when an accessory valve main spool shifts, the supply flow passages of other accessory valves are blocked, stopping fluid to accessory pressure switch. The normally closed accessory pressure switch trips at 120 psi (8.3 bar) and sends an input signal to the PC to stroke the low-pressure side of rear drum pump to enable the selected valve component.

To test the pressure switch trip pressure:

- Disconnect pressure switch (item 4) at rotating frame swivel (item 1).
- Install a manual hydraulic pump and a 0 – 600 psi (42 bar) gauge.
- Remove DIN connector and install hydraulic/brake valve adapter cable with meter.
- Switch should open at 120 psi (8.3 bar).
- If an adjustment is necessary, turn adjusting screw (item 3) at back of switch.

Test 26 – Adjusting the Counterbalance Valves



P1617



P1527

Item	Description
1	Counterbalance Valve
2	Gantry Cylinder
3	Jacking Cylinder

CAUTION

Possible Component Damage!

Special instructions and warnings apply when adjusting the gantry and boom cylinder counterbalance valves as specified in [Shop Procedures](#) in Section 2. This procedure **MUST** be followed carefully to ensure adjustments are performed safely. The gantry cylinders will not extend evenly without counterweights attached to crane. All gantry cylinder adjustments must be performed with counterweights installed.

Each jacking cylinder has a single counterbalance valve at the piston end of the cylinder. The retract adjusting screw at the valve provides adjustment for each jacking cylinder load support. The extend adjusting screw allows cylinders to be adjusted for uniform operation on level ground.

Counterbalance valves are pre-adjusted at the factory, but are not calibrated. Adjust counterbalance valves with a closed-end wrench and hex wrench.

To avoid over-adjusting the cylinders, use a hex wrench as a guide and never turn a counterbalance valve more than 1/2 turn in either direction.

To adjust a counterbalance valve:

1. Loosen the adjusting lock nut.
2. Rotate counterbalance-adjusting screw 1/2 turn clockwise (in) to lower holding pressure.
3. Rotate counterbalance adjusting screw 1/2 turn counter-clockwise (out) to raise holding pressure.
4. While holding counterbalance-adjusting screw with hex wrench, tighten lock nut.
5. Recheck cylinder(s) for correct load support and uniform operation.

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Reference Only

