GROVE

SERVICE MANUAL

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

TM500E-2

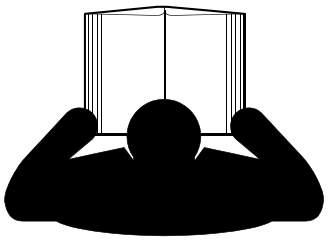
Crane Model Number

This Manual is divided into the following Sections:

NOTICE

The crane serial number is the only method your distributor or the factory has of providing you with correct parts and service information.

The crane serial number is stamped on the top of the outrigger box. ***Always furnish crane serial number*** when ordering parts or communicating service problems with your distributor or the factory.



⚠ WARNING

To prevent death or serious injury:

- Avoid unsafe operation and maintenance.
- This crane must be operated and maintained by trained and experienced personnel. Manitowoc is not responsible for qualifying these personnel.
- Do not operate or work on this crane without first reading and understanding Operator's Manual and Rating Plate supplied with crane.
- Store Operator's Manual in holder provided on crane.
- Attach laminated Capacity Charts supplied with crane to chain in operator's cab.
- If Operator's Manual or Capacity Charts are missing from cab, contact your distributor for new ones.

PRELIMINARY Published 10-19-2007, Control # 151-00

Hydraulic Systems

DANGER

Exercise extreme care around pressurized hydraulic systems. Do not work on a hydraulic system while it is in operation or until all pressure is released.

Cleanliness

Contaminants in a hydraulic system affect operation and will result in serious damage to the system components. Dirty hydraulic systems are a major cause of component failures.

Keep the System Clean

When removing components of a hydraulic system, cover all openings on both the component and the crane.

If evidence of foreign particles is found in the hydraulic system, flush the system.

Disassemble and assemble hydraulic components on a clean surface.

Clean all metal parts in a nonflammable cleaning fluid. Then lubricate all components to aid in assembly.

Sealing Elements

Inspect all sealing elements (O-ring, gaskets, etc.) when disassembling and assembling the hydraulic system components. Installation of new elements is always recommended.

Hydraulic Lines

When installing metal tubes, tighten all bolts finger-tight. Then, in order, tighten the bolts at the rigid end, the adjustable end, and the mounting brackets. After tubes are mounted, install the hoses. Connect both ends of the hose with all bolts finger-tight. Position the hose so it does not rub the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

Due to manufacturing methods there is a natural curvature to a hydraulic hose. The hose should be installed so any bend is with this curvature.

Visual Inspection of Hoses and Fittings

CAUTION

Ensure that the hydraulic hose is depressurized before loosening the connections.

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:
   - **a.** Leaks at hose fitting or in hose
   - **b.** Damaged, cut, or abraded cover
   - **c.** Exposed reinforcement
   - **d.** Kinked, crushed, flattened, or twisted hose
   - **e.** Hard, stiff, heat cracked, or charred hose
   - **f.** Blistered, soft, degraded, or loose cover
   - **g.** Cracked, damaged, or badly corroded fittings
   - **h.** Fitting slippage on hose
   - **i.** Other signs of significant deterioration

If any of the above conditions exist, evaluate hose assemblies for correction or replacement. For replacement of hose assemblies, refer to your Manitowoc CraneCARE Parts Manual.

2. At the same service interval, visually inspect all other hydraulic components and valves for the following:
   - **a.** Leaking Ports
   - **b.** Leaking valve sections or manifolds and valves installed into cylinders or onto motors.
   - **c.** Damaged or missing hose clamps, guard, or shields.
   - **d.** Excessive dirt and debris around the hose assemblies.

If any of these conditions exist, address them appropriately.

3. All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life.
4. Hydraulic hose assemblies operating in a temperature climate zone “C” (Table 1-1) are recommended to be replaced after 8000 hours of service life.
5. Hydraulic hose assemblies operating in climate zones “A” and “B” (Table 1-1) with high ambient temperatures, could see hose service life reduced by 40 to 50%, therefore, it is recommended to replace these hoses after 4000 to 5000 hours of service life.
6. Hydraulic hose assemblies operating in climate zones “D” and “E” (Table 1-1) cold climates should expect a degrade of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

Procedures for Cutting and Preparing FLEX-X 35

Flex-X 35 is a special wire rope that must be handled differently than any other rope we manufacture. One characteristic that makes this rope special is that the outer strands are not preformed. It is because of this that the following procedures for cutting and preparing Flex-X 35 must be followed:

1. The welded ends prepared by the manufacturer are not to be removed.

2. Before cutting the rope, make three separate bands with seizing strand on each side of where the cut is to be made (total of six bands for each cut). Each band is to have a minimum length of one and one half times the rope diameter. The two bands closest to the cut should be located at a distance equal to one rope diameter away from the cut. The four remaining bands should be evenly spaced at a distance equal to three rope diameters (Figure 1-10).

3.

a. If a welder is available, the cut should be made with an abrasive saw. Immediately after the cut, both ends of the rope are to be cap welded so that all inner and outer strands are welded together, preventing any movement between them.

NOTE: The outer strands must not be able to move with respect to the inner strands. The weld must not exceed the diameter of the rope.

b. If a welder is not available, the cut is to be made with an acetylene torch. The cut is to be made in such a way that both ends of the rope are completely fused so that all inner and outer strands are bonded together, preventing any movement between strands.

NOTE: The outer strands must not be allowed to move with respect to the inner strands. The fused end must not exceed the diameter of the rope.

4. Once the cuts have been completed, the seizing bands are to be left in place for shipment of the rope.

5. Attach a “Do not remove welded ends” tag on each reel flange.

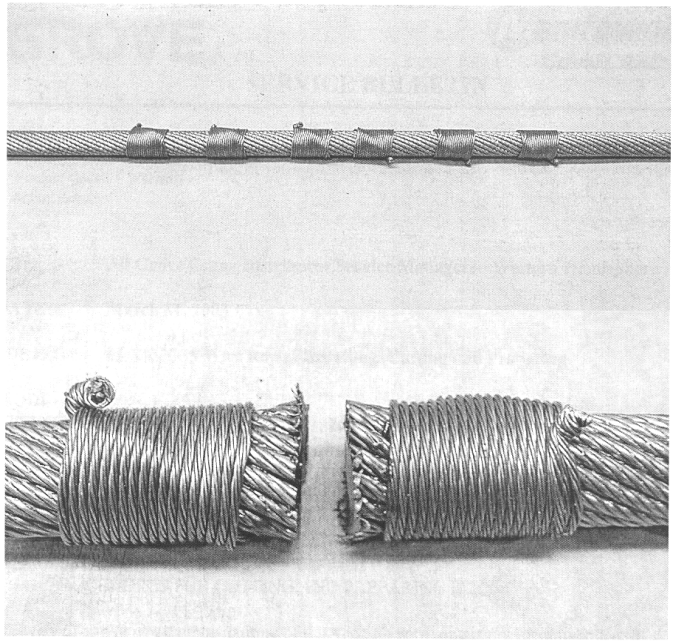


FIGURE 1-10

mechanism and hoist(s), because it can cause these units to become noisy during operation. If noisy operation occurs, first check the level of the hydraulic reservoir and replenish as necessary. Then inspect for leaks in the suction lines leading to the pumps.

Minute leaks may be hard to locate. If a leak is not readily detectable, use the following way to check for it:

Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 13.8 to 27.6 kPa (0.14 to 0.28 bar) (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.

This action should return any entrapped air to the reservoir where it can be removed from the hydraulic oil by the baffles.

DANGER

Tipping Hazard

To avoid death or serious injury, locate the machine on a firm supporting surface and position the boom over the front on outriggers when extending the boom at low angles.

To remove entrapped air from telescope cylinders, lower the boom to below horizontal and fully telescope the boom in and out several times.

If the air is not readily removed, lower the boom to below horizontal, extend the telescope cylinders as far as practicable, and allow the boom to remain in this position overnight. This should allow entrapped air to find its way to the holding valve so that telescoping the boom IN the next morning should force the air back to the reservoir. Ensure the boom is first telescoped IN (not OUT) in the morning. Telescoping OUT may cause air to be forced back into a cylinder.

DANGER

Pressurized fluid can cause serious injury or death. Extreme care must be used when removing any plugs or restrictions from a hydraulic system suspected to have entrapped air that may be pressurized.

Entrapped air may be removed from cylinders having wet rods by cycling. On certain cylinders, a plugged port is provided on the rod end to bleed off entrapped air.

DANGER

Pressurized fluid can cause serious injury or death. Do not attempt to loosen fittings in pressurized lines or while the hydraulic pumps are in operation.

In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw type fittings may become necessary.

If the above procedures fail to eliminate air entrapment, contact your authorized Grove Distributor.

Parts Replacement

Parts found damaged or out of tolerance when maintenance is being performed should be replaced. Refer to the Manitowoc CraneCARE Parts Catalog for proper replacement parts.

Directional Control Valves

The control valves that control the crane functions are installed on the right side on the outside of the superstructure side plate, and between the left and right superstructure side plates under the main hoist.

Inspection

Inspect the control valves for visible damage, binding spools, and evidence of leakage. If excessive internal leakage is suspected during operation with a spool in its center position, it is possible that the area between the spool and working section bore of the valve body is worn beyond serviceable limits. If this condition exists, the spool and body must be replaced as an assembly.

Valve Leakage

Dripping hydraulic oil indicates some type of external leakage. The machine should be removed from service for immediate repairs. External leaks sometimes develop at fittings and seals. Spool seals are susceptible since they are subject to wear. Seals may be damaged by temperatures that are too high, or by dirt or paint accumulation on the spool. Damaged or torn seals must be replaced.

A component functioning at reduced efficiency may indicate that the control valve for that component is leaking internally. If preliminary check-out reveals that adequate volume is being supplied to the affected valve bank, relief valves are properly adjusted, and the component is not at fault, check the valve for scored or worn parts. Scoring is a sign of the number one problem in hydraulics - contamination (external

d. Increase the RPM to 1500-1800 for 1 to 2 minutes with no functions actuated and make checks again as outlined in step a. Incrementally increase throttle to full RPM and then cycle the functions that the pump supples to verify proper speed. Verify pump flow.

5. Check pressure settings. Refer to PRESSURE SETTING PROCEDURES in this section.

Piston Pump Start-up Procedure

1. Ensure the reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge.

2. Ensure no air is entering the pump inlet, and that the pump suction or inlet fluid is not bleeding back to the reservoir when the engine is stopped, by making sure all suction or inlet lines are air tight.

3. Remove the case drain hose and adapter from port DR on the pump (Figure 2-7), and fill housing with the same hydraulic oil that was used to fill the hydraulic reservoir to the bottom of the O-ring case drain port. Install the case drain adapter and hose.

4. Start the engine.

a. Idle engine for two to three minutes with no functions actuated. Check for leaks and repair if required. Lay hand on pump to check for excessive heat build-up. If the pump section is too hot to keep your hand on, stop immediately. If the pump makes excessive noise, air is probably entering the pump keeping it from priming. If this occurs, stop engine, and inspect all connections of the suction hose/tube for a loose connection, or a missing or damaged O-ring. Re-start the engine and run until the pump takes prime for a maximum of 30 seconds. If the pump does not prime in 30 seconds, stop the engine and repeat until the pump primes.

b. Increase the RPM to 1500-1800 for 1 to 2 minutes with no functions actuated and make checks again as outlined in step a. Incrementally increase throttle to full RPM and then cycle the functions that the pump supples to verify proper speed. Verify pump flow.

5. Check pressure settings. Refer to PRESSURE SETTING PROCEDURES in this section.

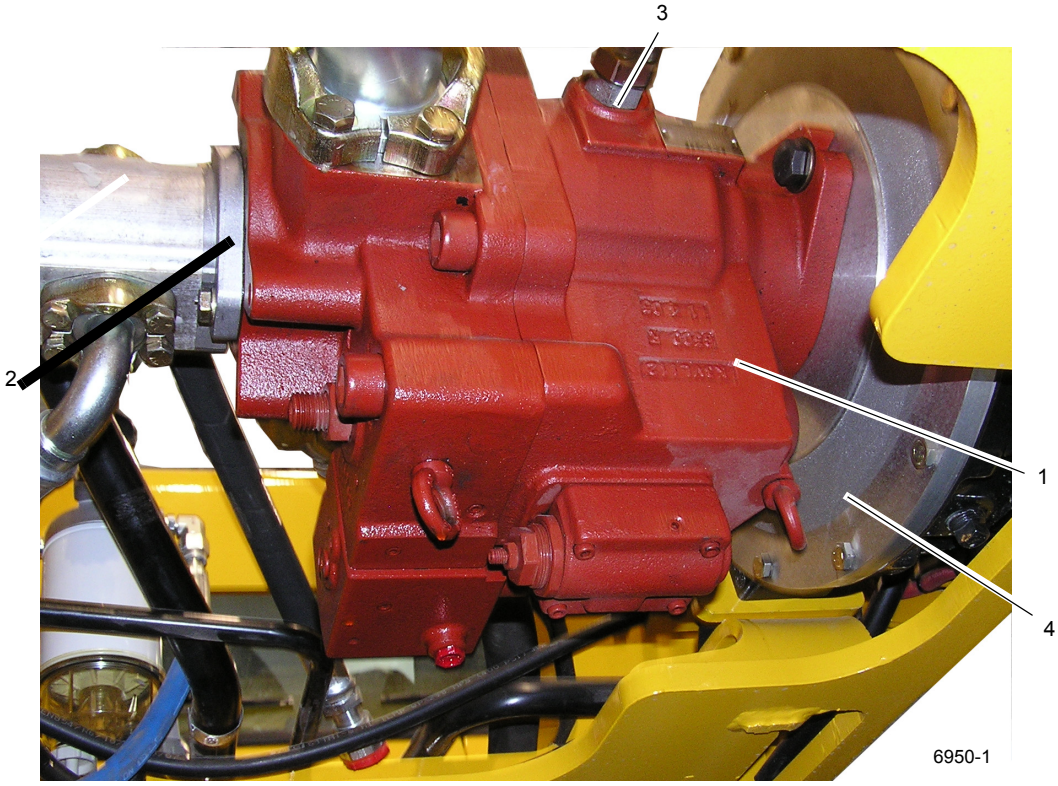


FIGURE 2-7

Item	Description
1	No. 1 - Piston Pump
2	No. 2 - Gear Pump

Item	Description
3	Case Drain To Reservoir
4	Engine

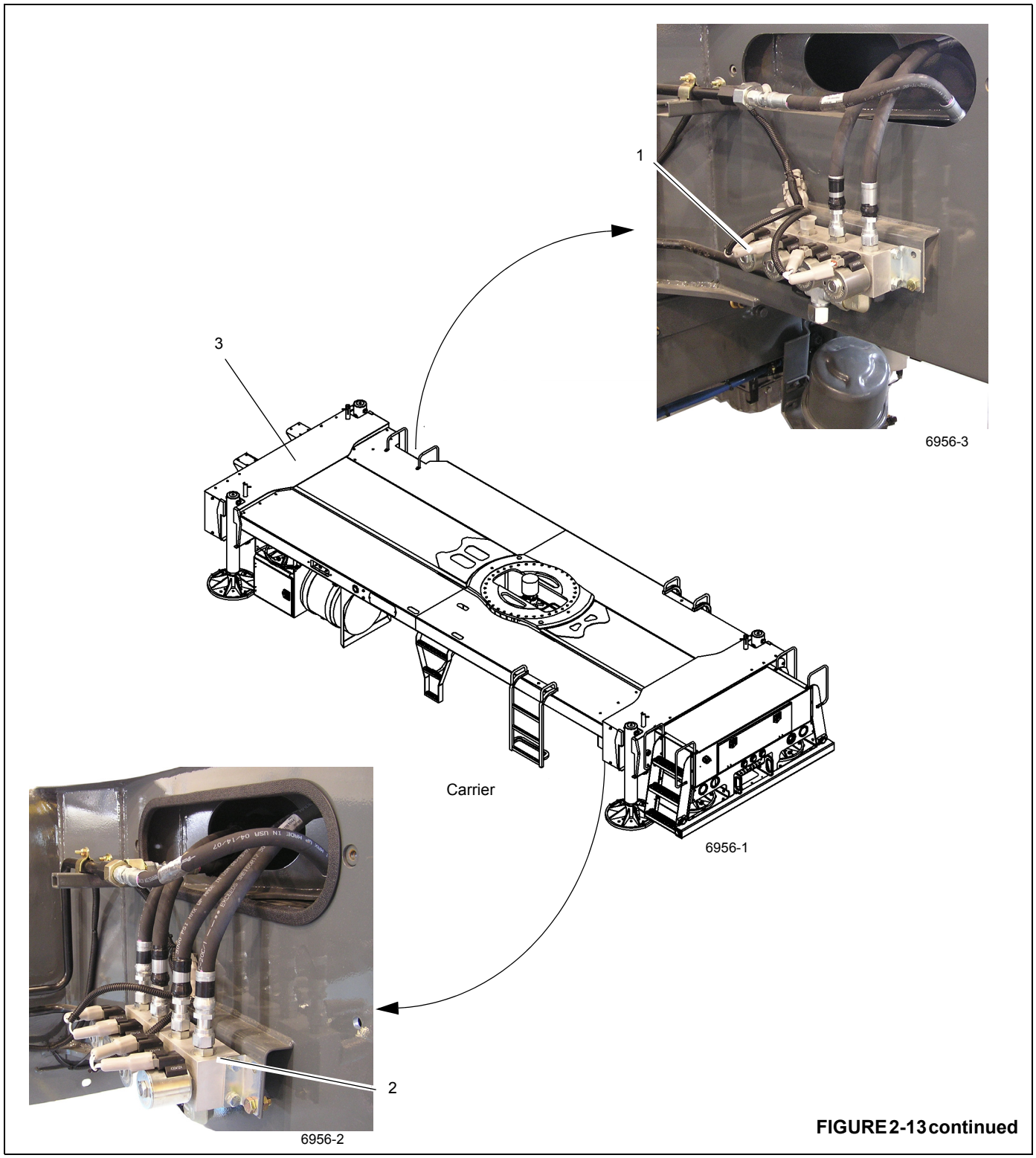


FIGURE 2-13 continued

Item	Description
1	Front Outrigger Control Manifold
2	Rear Outrigger Control Manifold

Item	Description
3	Frame

PILOT OPERATED CHECK VALVE

Description

A pilot operated (PO) check valve is located in each outrigger stabilizer cylinder port block. The check valve functions as a holding valve for the stabilizer cylinder. Oil flow is directed from the “V” port to the “C” ports, while blocking flow in the opposite direction. Flow is reversed from “C” to “V” when pressure pilot oil is applied to the opposite side “V” port (Figure 2-17)

Maintenance

Removal

1. Unscrew the check valve from the stabilizer cylinder port block.

Installation

1. Check the inside of the port block for any sharp edges or burrs and remove as necessary with emery cloth.
2. Install new O-rings onto the check valve.
3. Lubricate the check valve and O-rings with clean hydraulic oil.

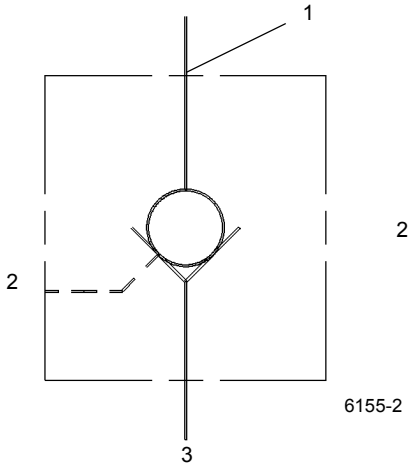
CAUTION

Do not damage the O-rings during installation of the check valve. If the check valve turns freely then gets hard to turn, then easy to turn, remove the check valve and check the O-rings. They have probably been damaged by a sharp edge of a port.

NOTE: The check valve should turn by hand until compression of the O-rings begins.

4. Carefully install the check valve into the port block until fully seated.
5. Test the check valve and port block by operating the affected outrigger’s stabilizer cylinder. Verify it extends and retracts without problems; verify there is no leaking. Make repairs as needed.

Item	Description
1	Port C - Cylinder
2	Port P - Pilot
3	Port V - Valve



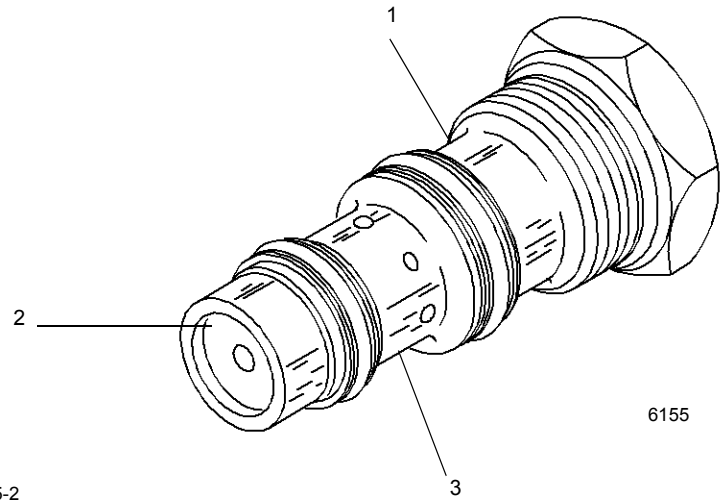


FIGURE 2-17

Item	Description
19	O-ring
20	Backup Ring
21	Buffer Seal
22	Backup Ring
23	Rod Seal
24	Backup Ring
25	Wiper Ring
26	Head
27	Wear Ring
28	O-ring
29	Backup Ring
30	Seal
31	Seal
32	Backup Ring
33	Wiper Ring
34	Holding Valve
35	Plug

16. Remove the O-ring and backup ring from the outside of the head and the wear rings, buffer seal, deep Z rod seal, backup ring and the wiper ring from the inside of the head.

17. If necessary, remove the holding valve from the inner cylinder rod and from the cylinder barrel.

Inspection

1. Clean all parts with solvent and dry with compressed air. Inspect for damaged or worn parts and replace as required.

CAUTION

Clean all surfaces and remove all burrs and nicks before installing new seals and rings. Replace all damaged or worn parts.

2. Stone out minor blemishes and polish with fine crocus cloth.

3. Clean all with solvent and dry with compressed air any parts that have been stoned and polished.

4. Inspect the barrel for scoring.

Assembly

1. If removed, install the holding valves. Refer to HOLDING VALVES in this section.

CAUTION

When installing new seals and rings, clean all surfaces and carefully remove burrs and nicks. Parts displaying excessive wear or damage should be replaced.

NOTE: Lubricate new seals and rings with clean hydraulic oil.

NOTE: Locate the gap of wear ring 180 degrees with respect to each other.

2. Install the wiper ring into the cylinder head.

3. Install the wear rings into the head (Figure 2-24).

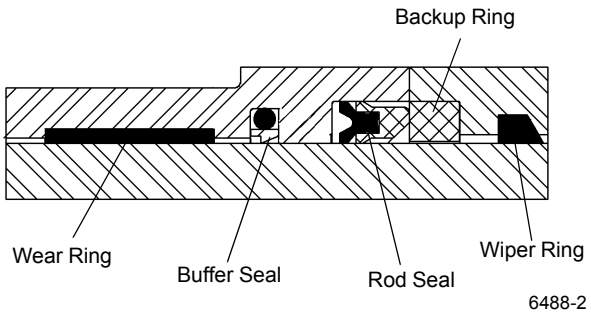


FIGURE 2-24

CAUTION

Improper seal installation can cause faulty cylinder operation.

4. Install the buffer seal, rod seal and backup ring inside the head ensuring the seals are assembled properly and installed in the correct direction (Figure 2-24).

5. Install the O-ring and backup ring onto the outside of the head.

6. Install the inner cylinder head onto the inner cylinder rod.

7. Install the wear ring onto the spacer and install the spacer onto the rod.

8. Install the O-ring and backup rings onto the rod and install the piston onto the inner cylinder rod. Secure the piston in place with the setscrew.

OUTRIGGER STABILIZER CYLINDER

Description

The four outrigger stabilizer cylinders (Figure 2-34) each have a hollow rod for internal porting. Each cylinder has a 10.1 cm (4.0 inch) diameter bore. A port block is welded to the rod of each cylinder and a pilot operated check valve is threaded into each port block.

The retracted length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 122.2 ± 30.8 cm (48.12 ±.12 inches). The extended length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 185.7 cm (73.12 inches). Its stroke is 63.5cm (25 inches). A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage

The cylinder weighs approximately 64.6 kg (142.52 pounds).

Maintenance

Disassembly

NOTE: Any maintenance requiring disassembly of the cylinder should include replacement of all cylinder seals.

1. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome. Using a spanner wrench, unscrew the head from the barrel.

DANGER

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to remove.

CAUTION

Exercise extreme care when handling or setting down the rod. Do not damage the chrome surface.

2. Open ports on the side of the cylinder barrel and drain the oil from the cylinder.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube in the vertical position with the rod assembly up.
4. Using a 5/32 inch Allen wrench, remove the setscrew on the barrel OD at the head.

NOTE: Oil or oil/air mixture may rapidly exit out of the ports during rod extension. Shield the work area from the exiting oil.

5. With the ports open, extend the rod assembly with a hoist enough to access the top of the head with spanner wrench. Do not extend completely.
6. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.
7. Extend the rod assembly slowly until the piston is free of the barrel assembly. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod.

NOTE: Cover the barrel opening to avoid contamination.

NOTE: Do not clamp on the rod working surface.

8. Secure the rod assembly using the 1 3/4 inch pinholes.
9. Remove the piston seal to gain access to the piston setscrew Using a 3/16 inch Allen wrench, remove the setscrew from the piston.
10. Remove the piston by turning counterclockwise with a fitted spanner wrench.
11. Remove the spacer and head from the rod.

CAUTION

When removing seals and rings, avoid scratching the grooved and gland surfaces.

12. Remove the seal assembly from the outside of the piston and the O-ring and backup rings from he inside of the piston.

NOTE: Arranging discarded seals and rings in the order of disassembly will aid in installation of new seals and rings. Pay attention to how each seal and ring is installed to avoid installing replacement seals and rings improperly.

13. Remove the O-ring and backup ring from the outside of the head. Remove the wear rings, buffer seal, rod seal and wiper ring from the inside of the head.

Inspection

1. Inspect the rod. There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Chrome should be present over the entire surface of the rod. If lack of chrome on rod, the rod should be replaced.
2. Inspect rod for straightness. Determine if it can be straightened or must be replaced.
3. Inspect the head. Visually inspect the inside bore for scratching or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading, and the bore should be checked for out-of-roundness.

Maintenance

General

Electrical system maintenance includes troubleshooting and replacement of damaged components. Observe standard wiring practices when replacing components.

DANGER

If it is necessary to perform electrical maintenance on live or hot circuits, remove all rings, watches, and other jewelry before performing maintenance as serious burns result from accidental grounding or shorting circuits.

DANGER

Ensure the batteries are disconnected before performing any maintenance on an electrical circuit which is not fused or when performing continuity checks.

CAUTION

Never replace original wiring with wiring of a smaller size (gauge).

General Troubleshooting

DANGER

Many steps in the troubleshooting procedures require testing live (energized) components. Perform these steps observing good safety practices to avoid electrical shock injury.

NOTE: Make voltage checks at terminations when components are installed and operating. Make continuity checks (with batteries disconnected) when components are isolated or removed. Troubleshoot per the following guidelines:

1. First, use reported symptoms to identify a problem or a suspect component.
2. Test the suspect component per instructions in this section. The instructions identify the fuses and components and guide you from the easiest and most likely problems to the hardest and least likely problems.
3. Using a multimeter, test the circuit for continuity if you suspect a broken circuit or for voltage if you suspect a power problem. Check the electrical schematic and wiring diagram for most accurate wiring information.
4. If the component proves faulty, replace it with a known working component. If wiring proves faulty, replace it with wiring of equal diameter.
5. After troubleshooting, test the repaired circuit. Verify the circuit works properly.

Troubleshooting Swivel-Caused Electrical Problems

Many crane component electrical troubles can be traced to the electrical swivel. Troubles common to the swivel are improper mounting, foreign material between the brushes and slip rings, incorrect wiring from the swivel to the components, incorrect wire size, worn brushes, improper spring tension on the brush assembly, and loose setscrews on the slip ring assembly. Refer to the electrical schematic and wiring diagram for slip ring connections and amperages.

Connector Troubleshooting

The cause of an electrical problem may be a loose or corroded connection in the pin or socket connectors. Check the connectors to ensure that the pins and sockets are properly seated and engaged. If the pins and sockets show any signs of corrosion, use a good quality electrical contact cleaner or fine sandpaper to clean them. When the pins or sockets show signs of arcing or burning, it will probably be necessary to replace them.

Refer to (Table 3-2), (Table 3-3), (Table 3-4), and (Table 3-5) listing tools necessary for connector maintenance.

Because the pins and sockets are crimped to the wires, it is not possible to remove them. Using the proper extraction tool, remove the pin(s) or socket(s) from the plug or receptacle. Cut the wire as close to the pin or socket as possible. After cutting the pin or socket off, the wire will most likely be too short. Using a wire that is too short will allow pressure to be applied to the pin or socket and wire where they are crimped when the pin or socket is inserted in the plug or receptacle. Add a short length of the same size wire to the short wire by crimp splice or solder. Use heat shrinkable tubing or other suitable material to insulate the splice.

An ABS wheel speed sensor is mounted in each monitored wheel. As the wheel spins, the sensor sends a fluctuating signal to the ABS ECU, which the ECU interprets as wheel speed.

The crane is also equipped with combination sensors that can measure both pressure and temperature of certain engine functions.

The pyrometer measures exhaust temperature and this is a direct input into the Gateway. The pyrometer is a thermocouple; the voltage potential (mV) changes with temperature.

The axle oil temperature sensor information is directly input into the Gateway. The resistance changes as the oil temperature changes.

Engine oil pressure and water temperature values are sent via the J1939 data bus to the Gateway. The Gateway sends a signal through the instrumentation bus to the speedometer. The speedometer then calculates which values the engine oil pressure and water temperature gauges should indicate.

Boost pressure, tachometer and axle oil temperature gauges use the same path to display values.

Specifications

Special Torque Chart

Item	Specification
Bulkhead Pass-Through Stud Nut	88 ± 10 in.-lb (10 ± 2 N·m)
Starter Solenoid Stud Nut	22 ± 2.6 ft-lb (31 ± 3.5 N·m)
Battery Cable Clamping Bracket	150 ± 27 in.-lb (17 ± 3 N·m)
Battery Cable Terminal Clamp	212 ± 35 in.-lb (24 ± 4 N·m)
Negative Battery Cable at the Starter Ground Stud	22 ± 2.6 ft-lb (31 ± 3.5 N·m)
Fusible Link Cable Assembly Nut-to-the-Engine Block	168 ± 35 in.-lb (19 ± 4 N·m)

Diagnostic Equipment

Example of diagnostic tools:

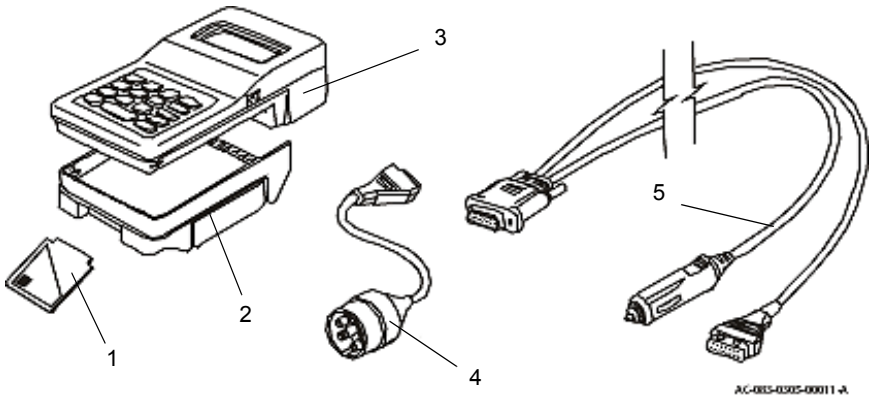
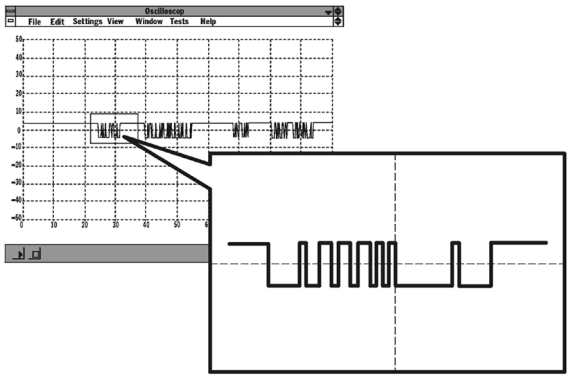


FIGURE 3-11

Item	Description
1	ABS Cartridge
2	Multi-Protocol Cartridge (MPC)
3	Digital Input/Output Data Display

Item	Description
4	9-Pin Deutsch Connector
5	Power/Data Cable



AC-365-0307-G509

FIGURE 3-29

Data links use digital communication. This means that the voltage only varies between two different values, either “high” or “low,” and that by combining these high and low signals various values can be described.

(Figure 3-29) shows an oscilloscope image where the voltage of the data link is measured. As can be seen from the diagram, a large part of the time the link is “silent,” but, at times, a number of fast pulses are sent. A group of pulses is called a message.

The enlarged portion of the diagram shows that each message consists of a combination of high and low voltage levels.

The following sections describe what type of information this message may contain.

Messages and Information Content

Different voltage levels are represented by the different numbers in the binary number system. The binary number system has only two values: one and zero (Figure 3-30).

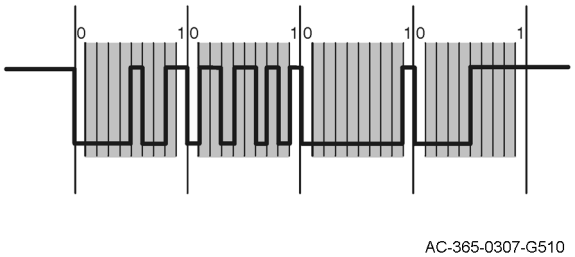


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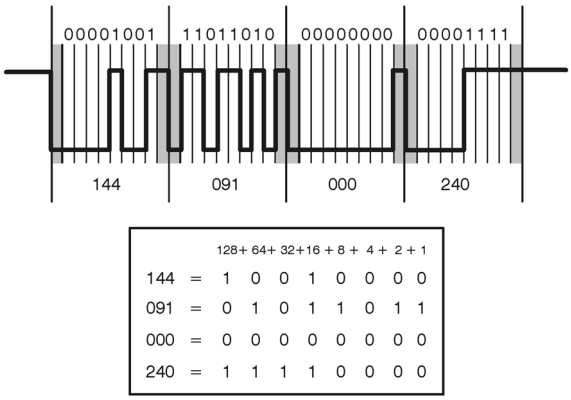
FIGURE 3-30

The value one is normally represented by a high voltage and zero by a low voltage.

Each binary number is called a “bit.” The illustrated message consists of four groups of binary numbers. Each group of eight bits makes up a “byte” (a decimal number from 0 – 255 representing information), as well as a start bit and a stop bit.

The purpose of the start and stop bits is to function as markers for where that group of data begins and ends. In the diagram above, only the start and stop bits are labeled. The other information is shaded.

Example:



		128+	64+	32+	16 +	8 +	4 +	2 +	1
144	=	1	0	0	1	0	0	0	0
091	=	0	1	0	1	1	0	1	1
000	=	0	0	0	0	0	0	0	0
240	=	1	1	1	1	0	0	0	0

AC-365-0307-G511

FIGURE 3-31

(Figure 3-31) shows the information content in the four different parts of the message. The start and stop bits are shaded since they do not contain any information.

The box in the diagram shows the different binary and decimal values which comprise the message.

NOTE: Note: The information is sent over the data link with the “least” bit first in the binary numbers. The normal way to notate binary numbers is shown in the box in the diagram.

Instrumentation Communication

Instrumentation communication takes place via the gateway module (mounted on either the right or left frame rail) which monitors the J1939 data bus and provides the necessary data via a multiplexed signal to the gauge system. The gauge system gets these and other instrumentation signals from the multiplexed data bus that joins the gateway module to the dash. The speedometer receives the initial data (signal), then forwards the data to the gauge responsible for the specific operation.

The gateway module monitors items such as the transmission sump temperature and directs the engine to turn on the radiator fan to cool the transmission oil cooler when the transmission sump temperature gets too high. Previously, this was accomplished with a temperature switch in the cooler line. The switch and its harnesses, mounting hardware, etc. have been eliminated.

The gauge tester simulates gauge parameter values to perform a range sweep by repeatedly sequencing the parameter values.

Control Data Link

See the Data Link Communications manual for troubleshooting the J1939 data bus.

Testing Using Gauge Tester

1. Locate the gateway module on the left-hand side of frame rail.
2. Remove the 10-way connector from the front of the gateway module.
3. Plug the removed connector directly into the gauge tester's 10-way connector.
4. Once connected, the gauge tester is automatically in the “on” mode. A full function gauge sweep will be initiated, confirming that the gauge tester is fully operational.
5. If any gauge shows abnormalities during the test, the gauge should be replaced.
6. Refer to Diagnostic Troubleshooting Table (Table 3-12) and the Gauge Tester Function Table (Table 3-13) To learn how each telltale and gauge should respond to the gauge tester.

Item	Description
1	Telescope Cylinder - Rod End
2	Base Section
3	Telescope Cylinder - Inner Rod
4	Inner Mid Section - Front
5	Telescope Cylinder Barrel
6	Outer Mid Section
7	Extension Cables
8	Inner Mid Section
9	Sheave Assembly
10	Telescope Cylinder
11	Fly Section Base End
12	Synchronizing Cables
13	Base Section - Rear
14	Retraction Cables
15	Sheave
16	Retraction Cable to Fly Section
17	Fly Section
18	Retraction Cables to Outside Front of Base Section
19	Sheave
20	Retract Cables to Outer Mid Section
21	Base Section Top and Bottom Wear Pads

BOOM RETRACT SEQUENCE

Refer to (Figure 4-1) 31 m (102 foot) boom or (Figure 4-91) 29 m (95 foot) for item location. As the telescope cylinder is retracted, the outer mid section (6) (attached to the cylinder barrel) and the inner mid section (4) (attached to the inner cylinder rod) are pulled in.

During retraction the two fly and four outer mid retraction cables are forced around sheaves (15, 19) at the rear of the mid section. This cable arrangement keeps the fly section, outer mid section, and the telescope cylinder in the proper sequence and timing.

TELESCOPE CIRCUIT

Description

The boom telescope circuit consists of the telescope hydraulic remote controller, telescope directional control valve, holding valve, and the telescope cylinder.

NOTE: If the crane is equipped with an auxiliary hoist, the telescope function is controlled by a foot pedal instead of a controller.

The telescope control valve is the closed spool type and is described under Valves in Section 2 - HYDRAULIC AND PRESSURE SETTINGS in this manual.

Refer to Valve in Section 2 - HYDRAULIC AND PRESSURE SETTINGS for a complete description of the hydraulic remote controller.

The boom telescope cylinder is a two stage double acting, rod ported cylinder. Foreign material is prevented from entering the cylinder by a wiper seal during rod retraction. O-ring seals prevent internal and external leakage. Refer to Cylinders in Section 2 - HYDRAULIC AND PRESSURE SETTINGS for a complete description of the telescope cylinder.

The holding valve is threaded into a port block on the inner rod end of the telescope cylinder. The holding valve functions during the retraction, extension, or holding operation. When holding the boom section at a given length, oil is trapped in the cylinder by the holding valve. Refer to Holding Valves in Section 2 - HYDRAULIC and PRESSURE SETTINGS for a complete description of the holding valve.

Theory Of Operation

Flow from the pump travels to the telescope directional control valve. Movement of the control lever for telescope functions from neutral sends a pilot pressure signal to the directional control valve to shift the spool in the directional control valve. This aligns the appropriate passages in the control valve to route oil to the telescope cylinder holding valve. The holding valve, with its' internal make-up of valves and springs, passes oil to and from the telescope cylinder. During extension, oil unseats the poppet (check) valve in the holding valve. This oil is routed to the piston sides of the cylinder which forces the rods out of the cylinder, causing the boom section to extend.

During retraction, oil enters the retract port and flows to the rod sides of the cylinder. When pilot pressure reaches a pre-determined value, the main poppet unseats, and oil flows from the piston sides of the cylinder to the reservoir causing the boom section to retract. All return flow from the directional control valve goes to the reservoir.

LIFT CIRCUIT

Description

The boom lift circuit consists of the lift hydraulic remote controller, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -3 to +76 degrees from horizontal.

The lift directional control valve is described under Valves in Section 2 - HYDRAULIC AND PRESSURE SETTINGS.

3. Place wood block (1) (Figure 4-25) under cylinder and remove the four bolts and bushings securing the cylinder barrel (2) (Figure 4-25), to the rear of the outer mid.

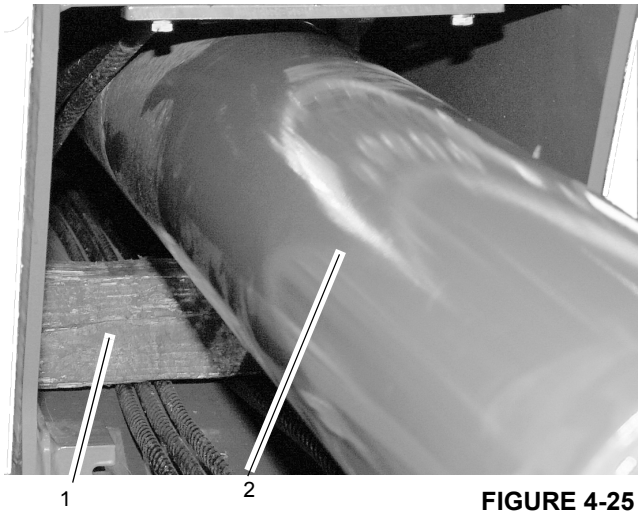


FIGURE 4-25

4. Pull the two retract cables up through the holes in the bottom of the outer mid and lay them out to the rear.

5. Turn cylinder rod inner mounting lugs (1) (Figure 4-26), so they are vertical in order to clear mounting bracket (2) (Figure 4-26), in the outer mid.

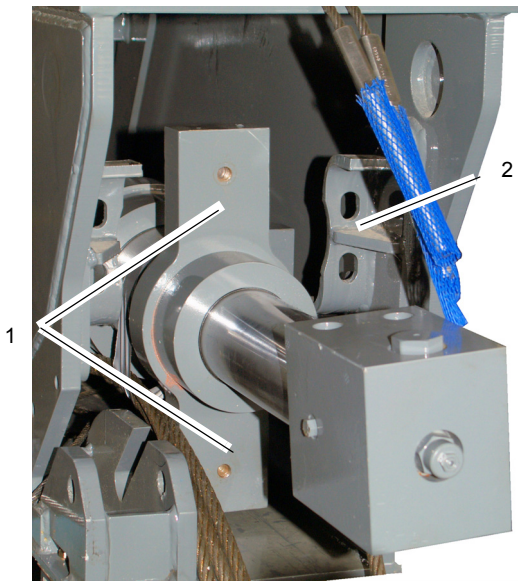


FIGURE 4-26

6. Slide the fly assembly out of the outer mid enough to gain access to the top rear adjustable wear pads on the fly through the hole in the top of the outer mid.

7. Remove the bolt, washer, and offset washer (1) (Figure 4-27) securing each top rear adjustable wear pad (2) and remove the wear pads, keeper plates (3) and bolts from the top of the fly (4).

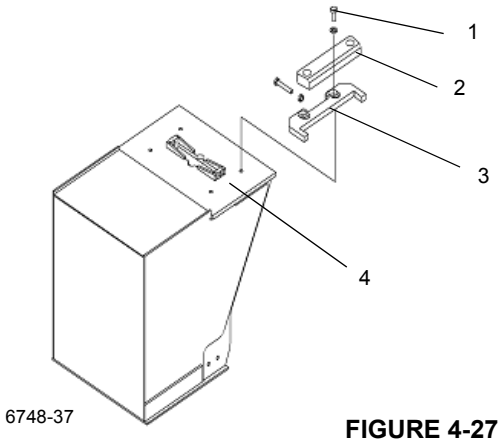


FIGURE 4-27

8. At the top front of the outer mid, remove the two capscrews (1) (Figure 4-28), securing the kickback plate. Remove the kickback plate.

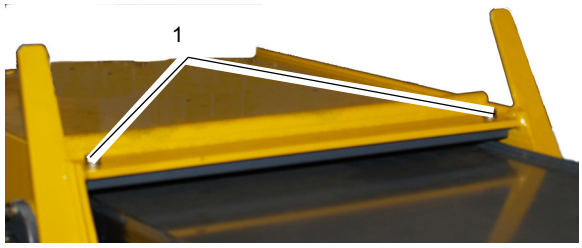


FIGURE 4-28

9. Remove the screws securing each top (1) and bottom (2) side wear pads at the front of the outer mid (Figure 4-29). Remove wear pads, shims, and mounting angle (3) (top left side only).

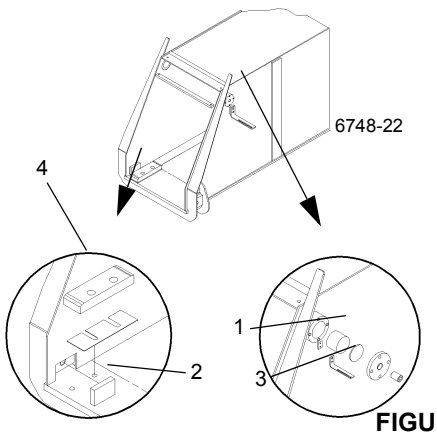


FIGURE 4-29

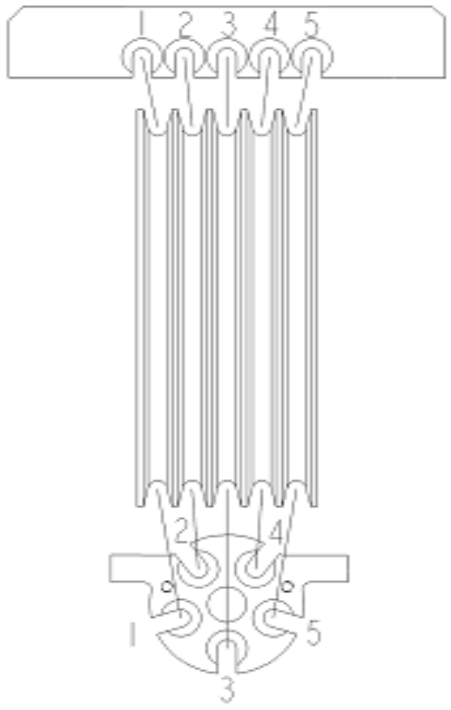


FIGURE 4-56

21. Install adjusting bolt (Figure 4-57) to the anchor assembly.

.

FIGURE 4-57

22. Temporary secure anchor assembly to the extend cylinder rod.

23. Attach the mid retract cables to the anchor point at the base end of the Outer Mid.

a. Lubricate and install pin through cable ends. Secure pin (1) (Figure 4-58) with cotter keys.

24. Lay out the threaded end of the mid retract cables through the inner mid section toward the base end.

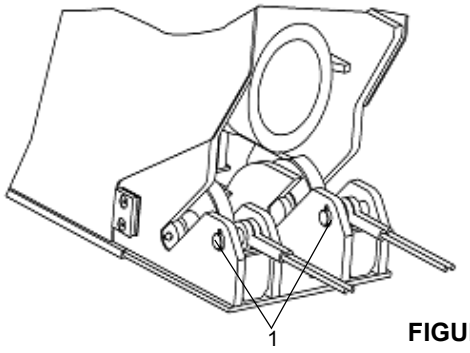


FIGURE 4-58

Install the Inner Mid Section

Do not attempt to work on the boom without experienced supervision.

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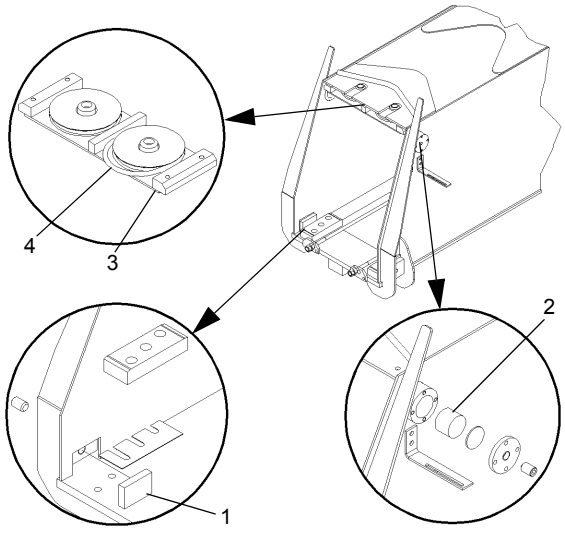
DANGER

To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

1. Install the adjustable brass wear pads (1) and the upper wear pads (2) (Figure 4-59). Do not install the bottom wear pads at this time.



6748-24

FIGURE 4-59

Item	Description
1	Telescope Cylinder - Rod End
2	Base Section
3	Telescope Cylinder - Inner Rod
4	Inner Mid Section
5	Telescope Cylinder Barrel
6	Outer Mid Section
7	Extension Cables
8	Inner Mid Section
9	Sheave Assembly
10	Telescope Cylinder
11	Fly Section Base End
12	Synchronizing Cables
13	Base Section - Rear
14	Retraction Cables
15	Sheave
16	Retraction Cable to Fly Section
17	Fly Section
18	Retraction Cables to Outside Front of Base Section
19	Sheave
20	Retract Cables to Outer Mid Section
21	Base Section Top and Bottom Wear Pads

5. Remove the capscrews and washers securing each top (1) and bottom (2) side wear pads at the front of the base section (Figure 4-92). Remove wear pads, shims, and mounting angle (top left side only).

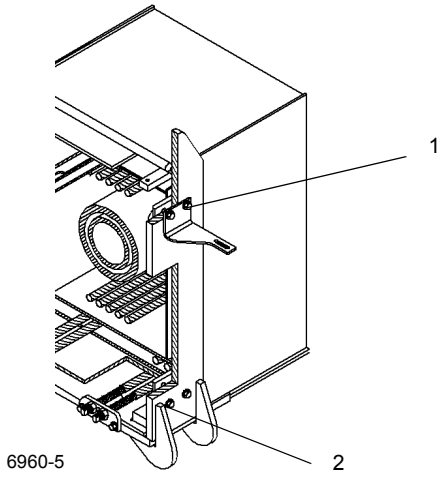


FIGURE 4-92

6. Lift up on the front of the assembly and remove the wear pads from the pockets in the bottom of the base section.

7. Continue to pull the assembly from the base section.

Disconnect Inner Mid Section

1. At the rear of the inner mid, remove the capscrew and cable retainer bushing (1) from the rear of each retract cable sheave assembly (2) (Figure 4-93).

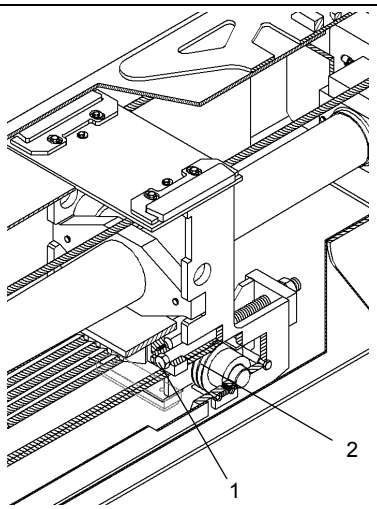


FIGURE 4-93

2. On both sides, remove the capscrews (1) securing each retract sheave assembly shaft weldment. Remove the shaft, spacer bushing, sheave assembly, and two thrust washers (3) (Figure 4-94). If necessary, remove the grease fitting from the shaft weldments.

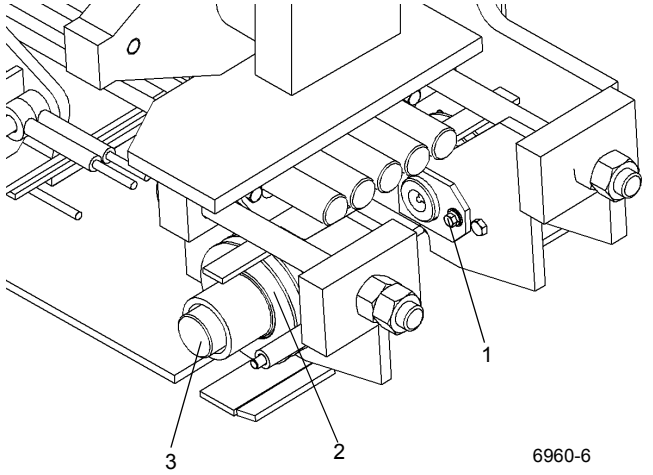


FIGURE 4-94

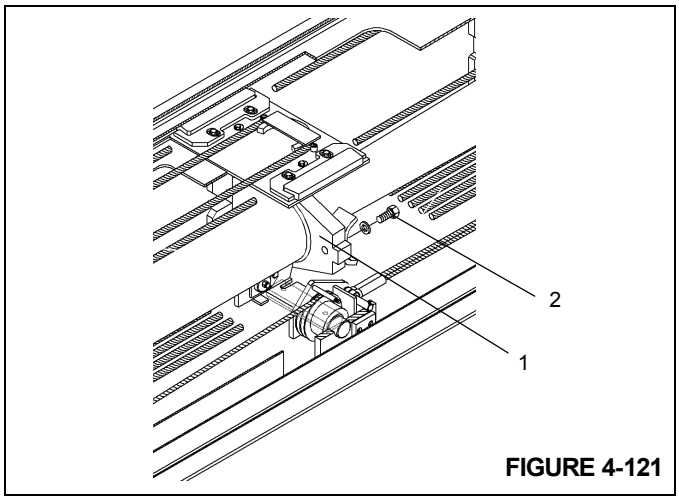


FIGURE 4-121

4. Apply grease to four thrust washers and place one on each side of the three groove retract cable sheave assemblies. Grease will keep the thrust washer in place during installation.
5. Install grease fitting in two shaft weldments. Position retract cables around sheave assemblies, install spacer bushing, and install shaft weldment through mounting lugs in inner mid and the sheave assembly and spacer bushing. Secure each shaft weldment with a capscrew. Apply grease to fittings.
6. Position cable retainer bushing to the rear of each sheave assembly and secure with a capscrew
7. Loosen plugs in cylinder port block and manually extend the outer rod approximately 15 to 20 cm (6 to 8 in). Tighten plugs.
8. Position the front of the base section at the rear of the assembly and slide together being careful not to damage any cables.

Install Base Section

1. Lift up on the front of the assembly and install the bottom front wear pads in the pockets of the base section.
2. Install base section front top (1) and bottom (2) side wear pads with two screws each (Figure 4-122). On top left side attach mounting angle (3) with both wear pad screws. Shim per note.

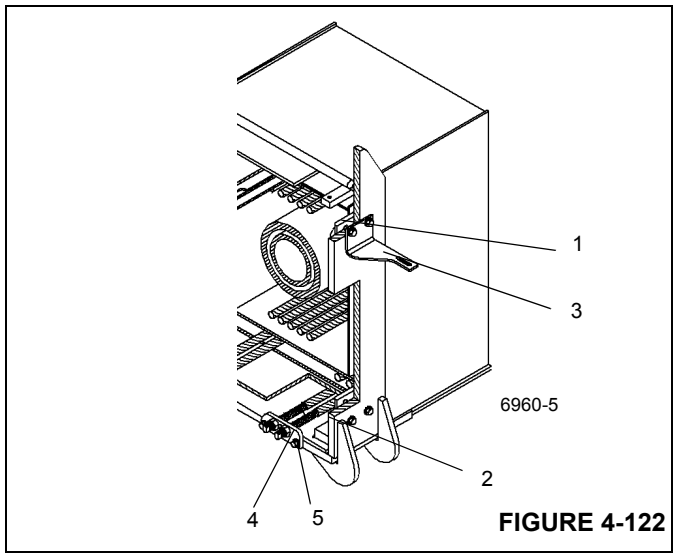


FIGURE 4-122

3. Attach outer mid retract cable anchor plates (4) to front of base section with two capscrews (5) each (Figure 4-122).
4. Install kicker plate on top of each side of base section with two capscrews each.
5. Through the top access hole in the base section, position the two adjustable wear pads on the top rear of the inner mid. Install each wear pad holder and loosely install each with two capscrews and washers. Install offset washers, capscrews, and washers. Using the offset washers, adjust the wear pads such that the wear pads are within 1mm (0.03 in) from each side plate of the next outer section. Tighten the offset washer and capscrews. Install top access hole cover.
6. Continue to slide together and route synchronizing cable threaded ends through holes in rear of base section. Install locknuts on cable ends.
7. Align cylinder outer rod mounting holes with mounting holes in rear of base section and secure with two bolts and washers.
8. Reattach the LMI, A2B/ Length cable to the boom nose. See PAT manual for proper cable reel tension.
9. Refer to Section 9 - LUBRICATION section for lubrication of wear pads and other plates on boom.
10. Install the boom in accordance with the INSTALLATION procedures outlined in this section.

SYMPTOM	PROBABLE CAUSE	SOLUTION
3. Telescope cylinder will not extend.	**a.** Low hydraulic oil level.	**a.** Replenish oil to proper level.
	b. Relief valve malfunctioning.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load.
	d. Clogged hose and fittings.	**d.** Replace hose or fittings. (Refer to Manitowoc CraneCARE Parts Manual).
	e. Broken valve spool.	**e.** Replace valve.
	f. Damaged piston seals.	**f.** Replace all cylinder seals.
	g. Damaged piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Bent boom section(s).	**h.** Replace damaged boom section(s).
	i. Broken hydraulic pump coupling.	**i.** Replace broken hydraulic pump coupling.
	j. Worn or damaged hydraulic pump section.	**j.** Repair or replace pump section.
4. Telescope cylinder will not retract.	**a.** Low hydraulic oil level.	**a.** Replenish oil to proper level.
	b. Relief valve damaged.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load. (Refer to load chart).
	d. Inoperative check valve.	**d.** Replace check valve.
	e. Clogged hose and fittings.	**e.** Replace hose or fittings. (Refer to Manitowoc CraneCARE Parts Manual).
	f. Broken valve spool.	**f.** Replace valve section.
	g. Broken piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Damaged piston seals.	**h.** Replace all cylinder seals.
	i. Bent boom section(s).	**i.** Replace damaged boom section(s).
	j. Broken hydraulic pump coupling.	**j.** Replace broken hydraulic pump coupling.
	k. Worn or damaged hydraulic pump.	**k.** Repair or replace pump.
	l. Broken hydraulic pump shaft.	**l.** Replace pump shaft.

Symptom	Probable Cause	Solution
3. The brake will not hold a load with control lever in neutral.	**a.** Excessive system back pressure acting on the brake release port	**a.** Same as 2 b
	b. Friction brake will not hold due to worn or damaged brake discs.	**b.** Same as 1c
	c. Brake clutch is slipping.	**c.** Brake clutch may be damaged or worn. Disassemble and inspect brake clutch. Refer to your Shop Reference and Maintenance Guide.
4. The hoist will not hoist the rated load	**a.** The hoist may be mounted unevenly which causes binding of the gear train.	**a.** Check the shims used to install the hoist. Refer to Hoist Installation in this section.
	b. System relief may need checked and adjusted.	**b.** Refer to Pressure Setting Procedures in Section 2 - Hydraulic and Pressure Settings.
	c. Make sure hydraulic system oil temperature does not exceed 180 degrees F. Excessive oil temperature increases motor internal leakage.	**c.** Same as 4 b
5. The hoist runs hot.	**a.** The hoist may be mounted unevenly which causes binding of the gear train.	**a.** Check the shims used to install the hoist. Refer to Hoist Installation in this section.
	b. Make sure hydraulic system oil temperature does not exceed 180 degrees F. Excessive oil temperature increases motor internal leakage.	**b.** Refer to Pressure Setting Procedures in Section 2 - Hydraulic and Pressure Settings.
	c. Too low or too high oil level in hydraulic reservoir.	**c.** Fill/drain to proper level. Refer to Section 9 - Lubrication.
	d. Excessively worn or damaged internal hoist parts	**d.** Disassembly hoist to inspect/replace worn parts. Refer to your Shop Reference and Maintenance Guide.
	e. Faulty hydraulic cylinder, motor, or valve.	**e.** Replace faulty component.
6. Hoist chatters while raising rated load.	**a.** System relief may need checked and adjusted.	**a.** Refer to Pressure Setting Procedures in Section 2 - Hydraulic and Pressure Settings.

Removal

1. If the CE option is provided, remove the hoist covers.

2. Remove all cable from the hoist drum.

3. Tag and disconnect the hydraulic lines to the hoist. Cap or plug all lines and openings.

4. Tag and disconnect the electrical wires to the hoist rotation indicator sensor box.

5. Tag and disconnect the electrical wires to the hoist hi-speed solenoid valve.

6. Remove the hoist mounting nuts, capscrews, washers, and shims (if shims are used, mark their location).

NOTE: The HP15C-17G hoist assembly, less the cable, weighs approximately 300 kg (661 pounds).

7. Using an adequate lifting device, remove the hoist from the crane.

COUNTERWEIGHT REMOVAL

Description

Description

A 1360 kg (3000 pound) or 2495 kg (5500 pound) cast counterweight (Figure 5-5) is installed at the rear of the turntable.

Removal

DANGER

Death or serious injury could result from being crushed by a falling counterweight.

NOTE: Use of a forklift to remove/install the fixed counterweight is not recommended.

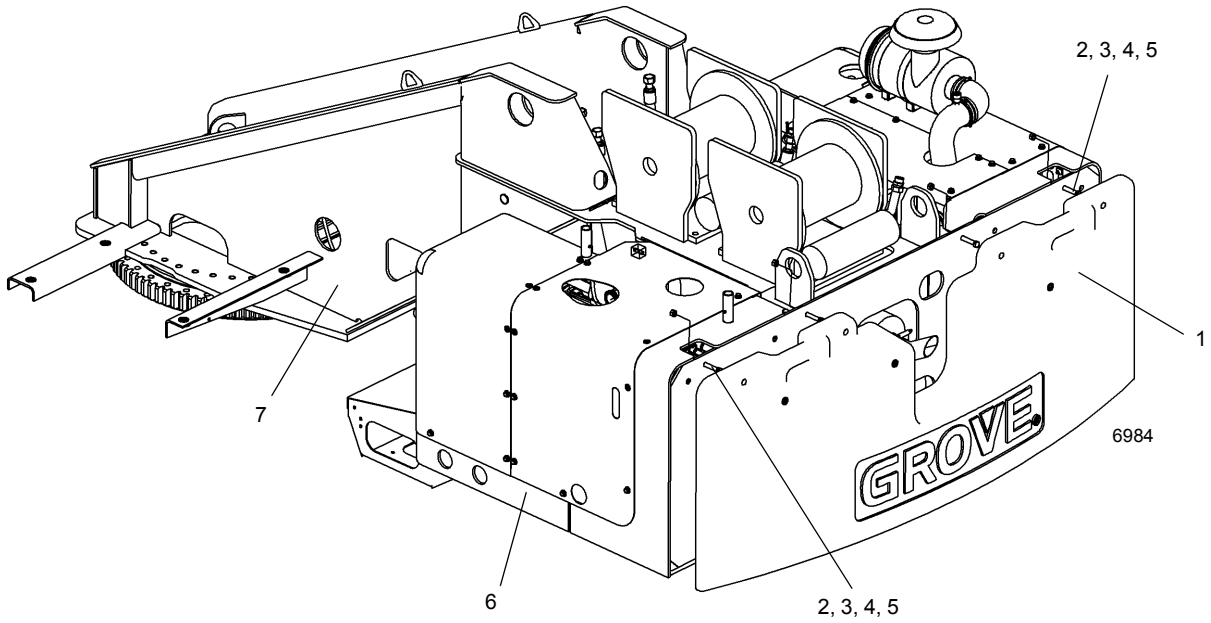


FIGURE 5-5

Item	Description
1	Cast Counterweight
2	Capscrew
3	Flatwasher
4	Lockwasher
5	Nut
6	Power Plant Tray
7	Turntable

1. Fully extend and set the outriggers.

2. Rotate the superstructure so the counterweight is over the front of the carrier to gain additional clearance. Engaging the pin type turntable lock will aid alignment.

NOTE: The counterweight weighs either 1360 kg (3000 pound) or 2495 kg (5500 pound) depending on option installed.

3. Lower and fully retract the boom

4. Shut down crane.

5. Attach an adequate lifting device to the counterweight.

6. Remove the capscrews, washers and nuts securing the counterweight.

7. Use the lifting device to remove the counterweight.

Installation

1. Fully extend and set the outriggers.

2. Shut down crane.

SWING MOTOR

Description

The swing motor is mounted on the swing brake housing and drives the swing gearbox through the brake assembly. The swing motor is a hydraulic gerotor type with low speed and high torque characteristics. It has only three moving parts, the commutator valve, the drive, and the gerotor star. The motor has two ports for connection to the hydraulic system.

Maintenance

Removal

1. Loosen the latches and remove cover on the right side of the turntable to gain access to the swing assembly.
2. Ensure the swing brake and swing lock are engaged.
3. Clean the port area around the motor. Tag and disconnect the hydraulic hoses from the motor assembly. Cap or plug all openings.

CAUTION

Oil can be hot and cause burns.

4. Unscrew the drain plug to ensure that all oil has been removed. Unscrew the filler and level plugs. After the oil has been drained, replace the drain plug and any other plugs that may have been removed.

CAUTION

Pull straight up on the motor assembly to avoid damaging the splined shaft.

5. Remove the two screws securing the motor and lift the swing motor free of the flange. Remove and discard the O-ring from the groove in the swing brake.

Installation

CAUTION

Use care when engaging the swing motor drive gear, do not force the shaft to engage.

1. Install a new O-ring in the groove of the swing brake. Position the swing motor on the swing brake, engaging the shaft with the brake input shaft.
2. Apply Loctite 243 to the screw threads. Install the screws and secure the motor to the brake housing. Torque the screws 85 to 103 Nm (44 to 72 pounds-foot).
3. Connect the hydraulic lines to the swing motor as tagged during removal.
4. Install the cover on the right side of the turntable and tighten the cover latches.

Test

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

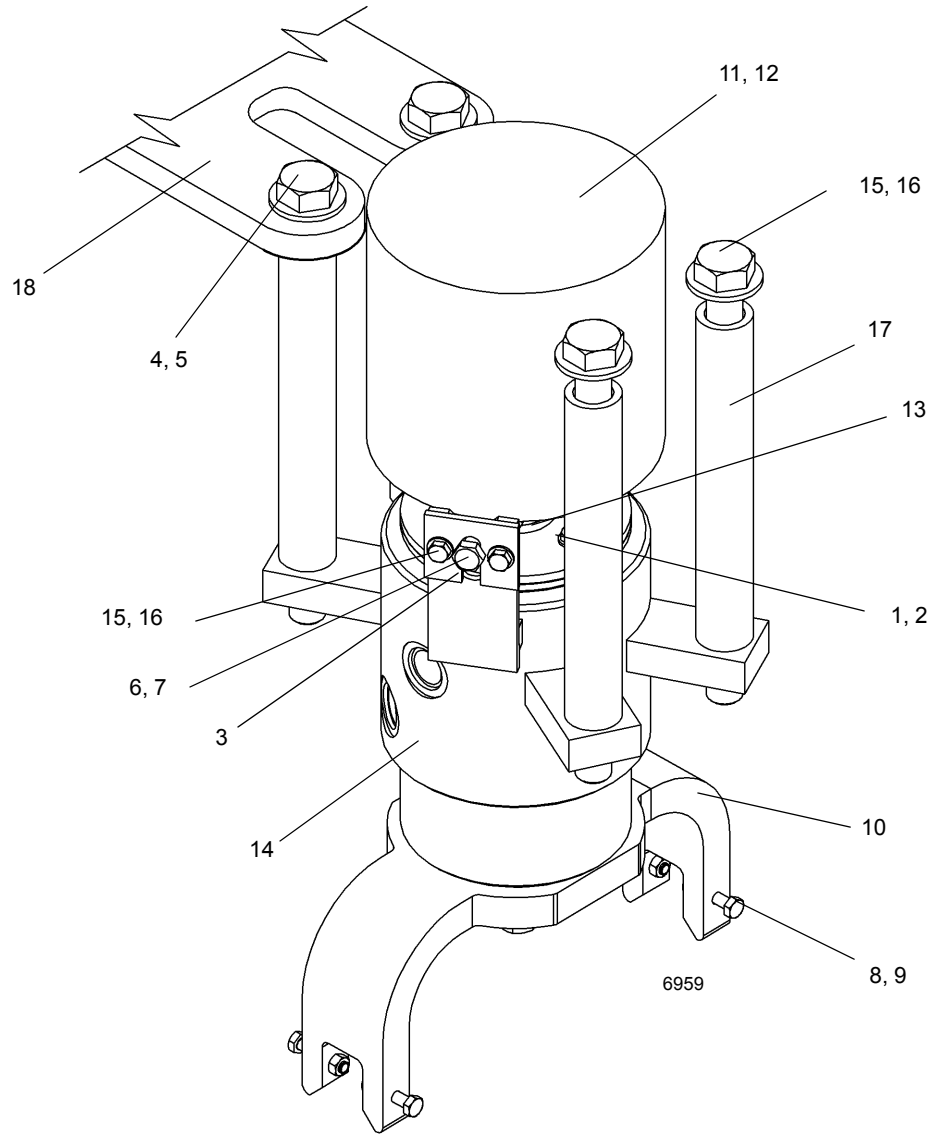


FIGURE 6-6

Item	Description
1	Capscrew
2	Washer
3	Plate
4	Capscrew
5	Washer
6	Capscrew
7	Jam Nut
8	Capscrew
9	Nut

Item	Description
10	Swivel Bracket
11	Slip Ring Assembly
12	Cover
13	Center Post
14	Hydraulic Swivel
15	Capscrew
16	Washer
17	Bushing
18	Turntable Base Plate

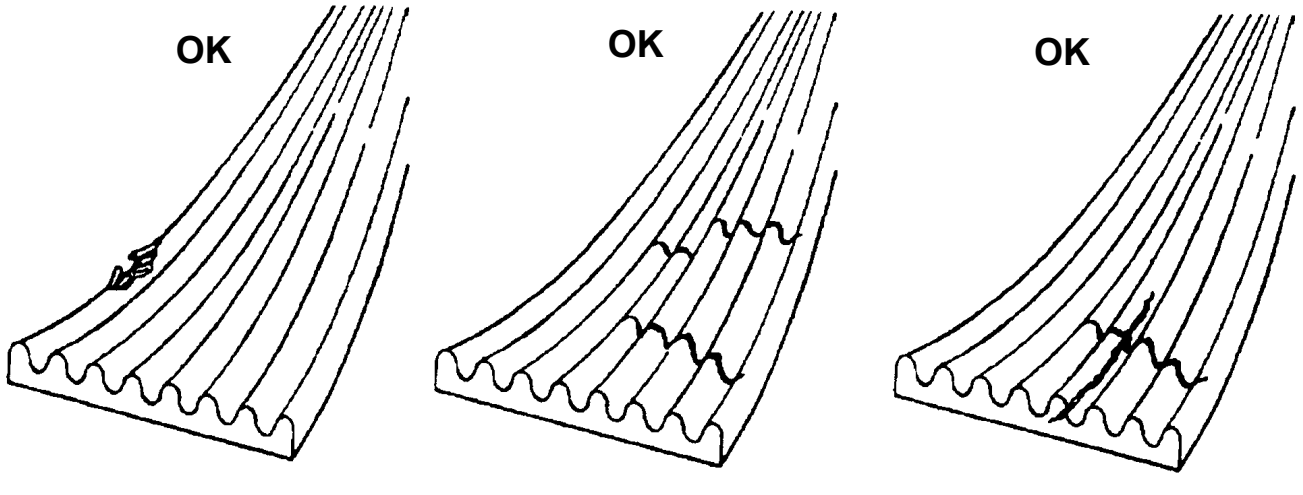


FIGURE 7-2

The engine drive belt should be inspected visually on a daily basis. The drive belt should be inspected for cracks, frayed areas, and glazed or shiny surfaces (Figure 7-2). A drive belt that is glazed or shiny indicates belt slippage.

Engine drive belt damage can be caused by various factors such as incorrect tension, incorrect belt size, misaligned engine pulleys, incorrectly installed belt, or by oil, grease, or hydraulic fluid on the belt.

Refer to the engine manufacturer's manual for any special tools or belt tension specifications.

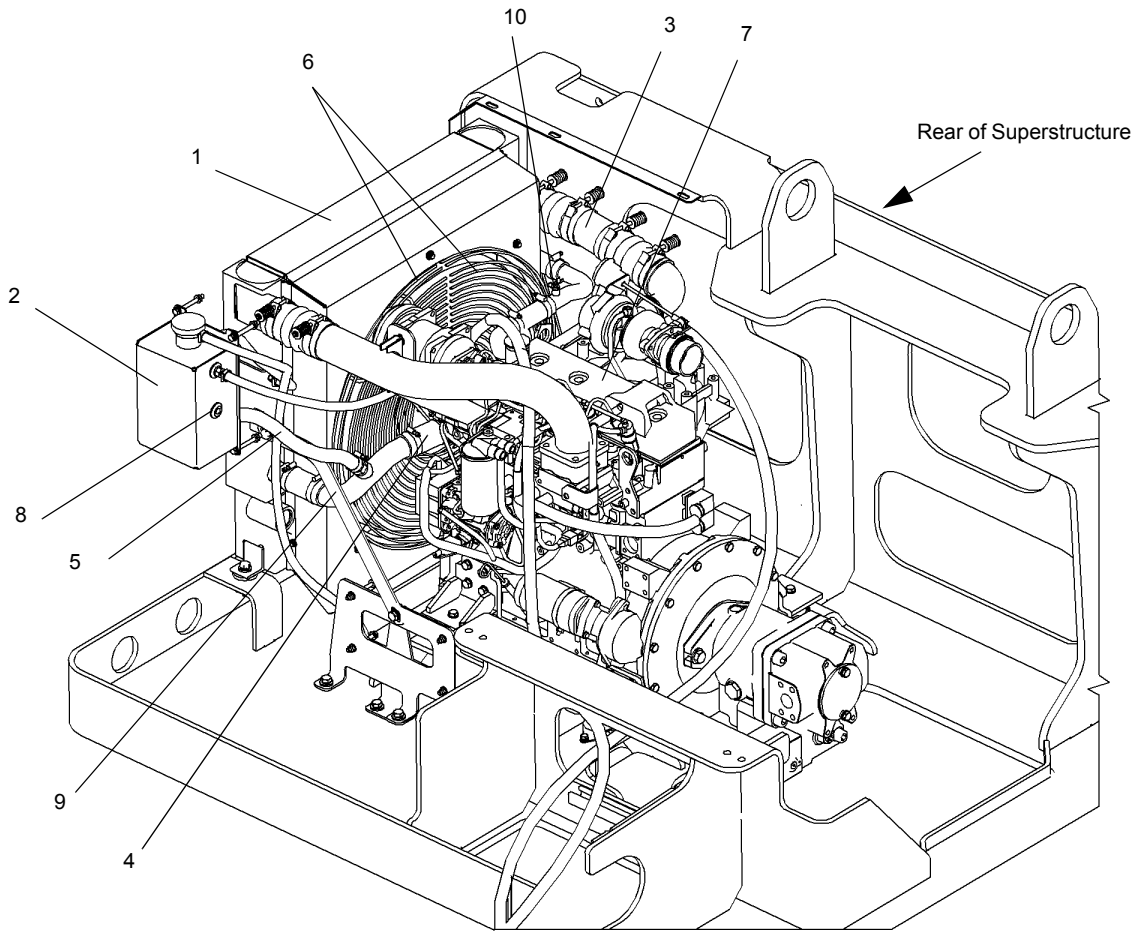


FIGURE 7-13

Item	Description
1	Charge Air Cooler/Radiator/Hydraulic Oil Cooler
2	Surge Tank
3	Charge Air Cooler Hose
4	Radiator Hose
5	Heater Hose
6	Wire Guard
7	Engine
8	Coolant Level Sensor
9	Radiator Supports
10	Pet Drain Cock Valve

Cooling/SCA Maintenance Summary

The cooling system level should be checked every 10 hours of operation or daily, whichever comes first.

6 Months or 500 Hours

- Check SCA (Supplemental Coolant Additives) Levels (use Fleetguard kit # CC2626).

If SCA levels are less than 1.2 Units/Gal, add cummins DCA-4 to maintain desired level.

1 Year or 1000 Hours

- Test coolant for contamination condemning.

  Condemning limits are:

  Sulfate level greater than or equal to 1500 ppm.

SECTION 8
UNDERCARRIAGE

DRIVESHAFT AND SHAFT PHASE ANGLES

This information covers the function, specifications, and service of driveshafts and universal joints for your crane. Information also includes recommended shaft phase angles for optimum driveline performance.

SPECIFICATIONS

Driveshaft

Universal Joint Journal Cross Dimensions

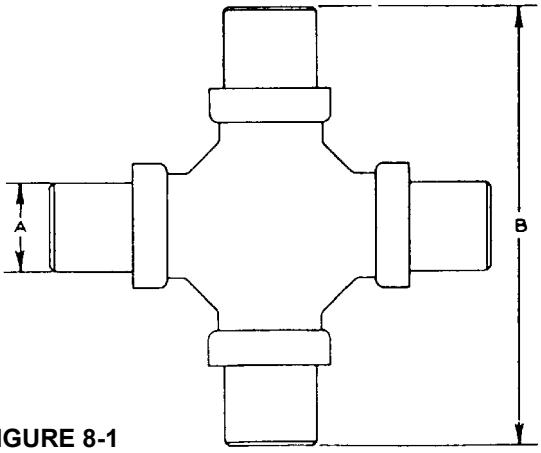


FIGURE 8-1

NOTE: Measure the diameter (A) and the span, or length (B) of the journal cross to determine universal joint size or series.

Series	A		B	
1710HD	1.30"	32.94 mm	5.78"	146.84 mm

Half-Round End Yoke 12-point Bolt Specifications

The 12-point head bolt should be alloy steel equivalent to SAE Grade 8, high strength bolt. These bolts have a nylon patch for locking. The 1/2" - 20 thread bolt should be torqued at 115 - 135 ft-lb (156 -183 N·m).

Maximum Driveshaft Operating Angle

Normal	
Angles Driveshaft RPM	**Maximum Operating Angles**
5000	3.25°
4500	3.67°
4000	4.25°
3500	5.00°
3000	5.83°
2500	7.00°
2000	3.67°
1500	1.50°

Driveshaft Phase Angles

Center Bearing Shaft Phase Angle

Crane Model	Axle	α Center Bearing Shaft Phase Angle
TM500E-2	All	0°

Main Shaft Phase Angle

Crane Model	Axle	α Main Shaft Phase Angle
TM500E-2	All	0°

Interaxle Driveshaft Phase Angle

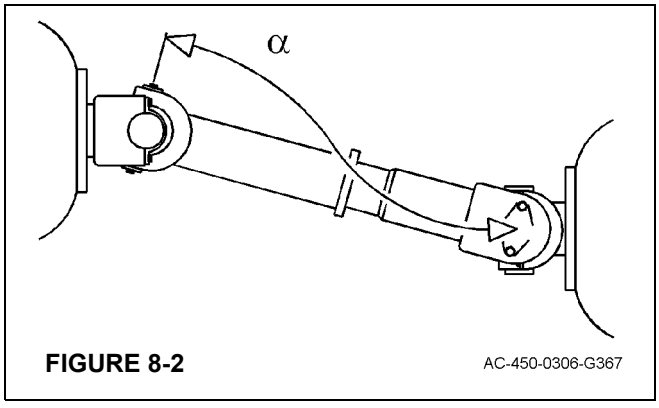


FIGURE 8-2

8

Reinstalling the Cross Into the End Yoke

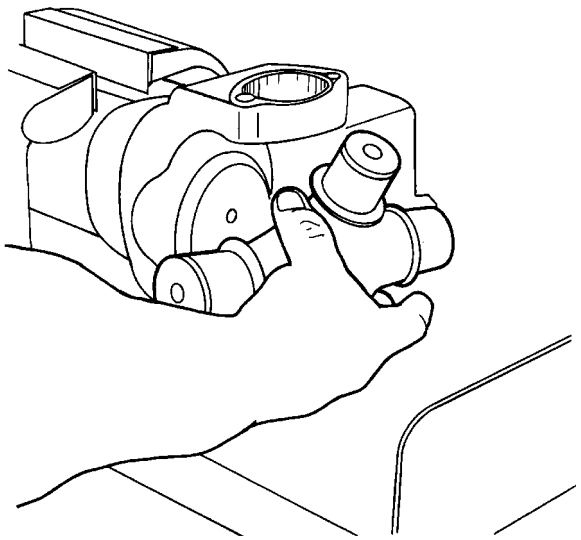


FIGURE 8-17 AC-451-0306-G401

2. Apply an anti-seize compound to the outside diameter of the four bearing assemblies. Move one end of the cross to cause a trunnion to project through the cross hole beyond the outer machined face of the yoke lug. Place a bearing assembly over the trunnion diameter and align it to the cross hole. Holding the trunnion in alignment with the cross hole, press bearing flush to face of end yoke by hand.

NOTE: Make sure to lubricate the bearing cap before installing.

Projecting the trunnion through a cross hole beyond the machined surface of the lug will provide a surface to help align the bearing assembly with the cross hole.

Reinstalling Bearing Cap on Trunnion

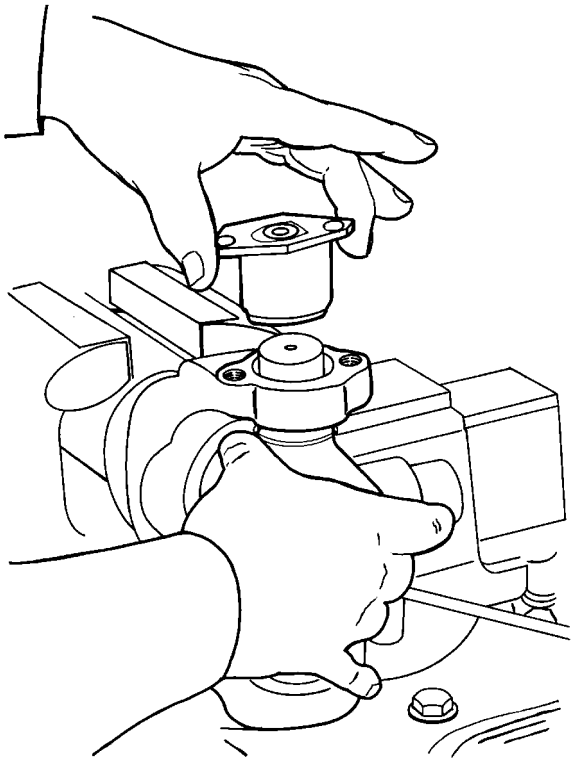


FIGURE 8-18 AC-451-0306-G404

3. When the bearing assembly is completely seated, put the lock plate tab in place. Insert the “Grade 8” cap screws that are furnished with the kit through the cap screw holes in both the lock strap and bearing assembly. Thread with hand or wrench into tapped holes in yoke. Do not torque the bolts.

4. If bearing assembly binds in cross hole, tap with ball peen hammer directly in center of bearing assembly plate. Do not tap outer edges of bearing plate.

4. Using an electronic protractor, measure the rear pinion angle with respect to the frame rail. Note that the correct angle depends on the axle model. Repeat step 3 to adjust the rear angle pinion as necessary.

WHEEL BEARING ADJUSTMENT

Introduction

This information includes component specifications and procedures for front and rear wheel bearing adjustments.

Adjusted Wheel End Systems

This system on your crane is characterized by having the bearings, seals and lubricant all pre-installed. Bearing adjustment is preset in the hub assembly. Unitized wheel end components are not serviceable and should not be disassembled.

Crane Hub Unit

The unitized hub and bearing combination for the front axle system is also referred to as the crane hub unit. The unit contains bearings which are lubricated for the life of the component. This unit has no serviceable parts and requires no adjustment.

Nut Adjustment Torque Specifications

NOTE: Never use an impact wrench when tightening or loosening lug nuts or bolts during the adjustment procedure.

Wheel Bearing Adjustment, Non-Unitized Hubs

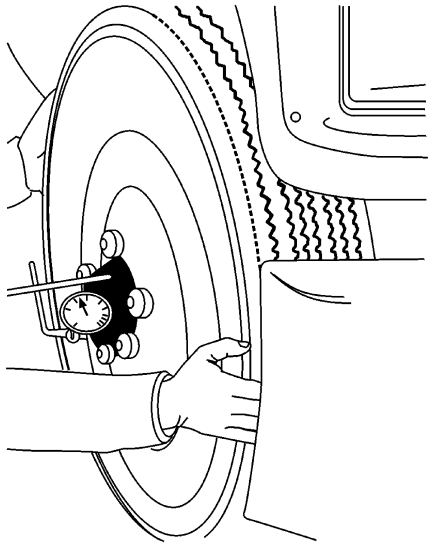


FIGURE 8-39 AC-773-0306-G425

Initial Adjusting Nut Torque	200 ft-lb (270 N·m) while rotating wheel
Initial Back Off	One full turn
Final Adjusting Nut Torque	50 ft-lb (68 N·m) while rotating wheels

BACK OFF			JAM NUT TORQUE		Acceptable End Play
Axle Type	Threads Per Inch	Final Back-off	Nut Size	Torque Specifications	
Steer (Front) Non-Drive	12	1/6 Turn*	Install Cotter Pin to Lock Axle Nut in Position		0.001 - 0.005" (0.025 - 0.127 mm) as measured per procedure with dial indicator
	18	1/4 Turn*			
	14	1/2 Turn	Less than 2-5/8" (67 mm)	200 - 300 ft-lb (270 - 405 Nm)	
	18				
Drive	12	1/4 Turn	Dowel Type Washer	300 - 400 ft-lb (405 - 540 Nm)	
Trailer	16		Tang Type Washer**	200 - 275 ft-lb (270 - 375 Nm)	
	12	1/4 Turn	2-5/8" (67 mm) and over	300 - 400 ft-lb (405 - 540 Nm)	
	16				

* If dowel pin and washer (or washer tang and nut flat) are not aligned, remove the washer, turn it over, and reinstall. If required, loosen the inner (adjusting) nut just enough for alignment.

** Bendable type washer lock only: Secure nuts by bending one wheel nut washer tang over the inner and outer nut. Bend the tangs over the closest flat perpendicular to the tang

Thrust angle is the direction that the rear wheels are pointing compared to the GC. If the thrust angle (C) is not zero, then the crane will “dog track” and the steering wheel will not be centered. If the thrust angle is positive (as in illustration), the crane tends to pull to the right and the driver has to compensate by turning the steering wheel to the right. The result is wear on the inside of one front tire and wear on the outside of the other.

If both of the tandem axles are pointing in the same direction away from the GC, it gives the same symptoms described above.

The best solution is to first center the rearmost axle to the GC, then the forward rear axle (if a tandem) and last, align the wheels on the front axle(s).

Tandem Scrub Angle

Tandem scrub angle is the angle (D) formed by the two thrust lines of a tandem axle crane if the axles are misaligned in opposite directions. This misalignment may not be noticed in the steering wheel if the axles are off by the same value. This causes wear on all the tandem tires. When the axles are off by different values (as in illustration), the driver has to compensate by turning the steering wheel, and all the tires experience wear.

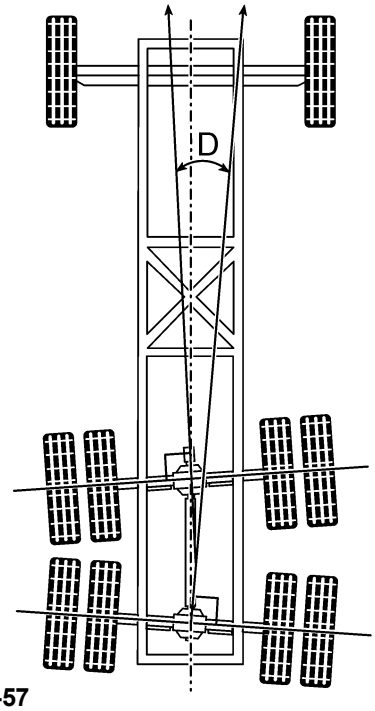


FIGURE 8-57

AC-601-0360-G365

The best solution is to first center the rearmost axle to the GC, then the forward rear axle (if a tandem) and last, align the wheels on the front axle(s).

TYPICAL WEAR PATTERNS

Incorrect Tire Pressure

Too high air pressure (A) gives rapid wear in the middle of the tire.

Too low air pressure (B) gives rapid shoulder wear.

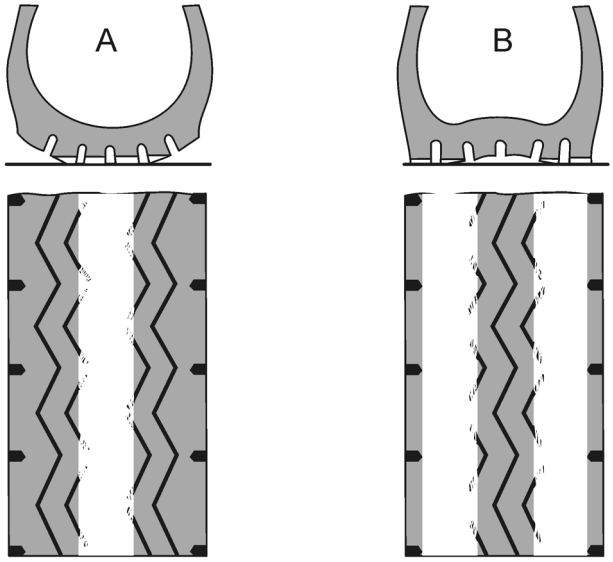
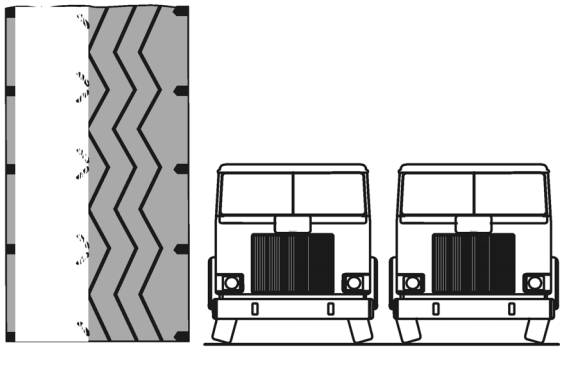


FIGURE 8-58

AC-601-0305-G201

Incorrect Camber

Incorrect camber gives abnormal wear on one-half of the tire.



AC-601-0305-G202

FIGURE 8-59

Incorrect Toe and Axle Alignment

Incorrect toe has a “scrubbing” effect on the front wheels that shows in rapid shoulder wear or across the tire.

Incorrect axle alignment has a “scrubbing” effect on all wheels.

8

shim with a thickness that is half of the difference between the two measurements.

NOTE: **EXAMPLE:** If the lateral alignment is out of specification by 6mm (1/4 inch), remove or install a 3mm (1/8 inch) shim as needed.

The mounting fasteners used with the straddle mount transverse torque rods are furnished by the vehicle manufacturer. It is important to check the locknuts for proper torque during preventive maintenance service intervals. Follow the vehicle manufacturer's specifications for tightening torque values.

All torque rods need to be inspected for looseness as follows:

With the vehicle shut down, a lever check can be made with a long pry bar placed under each rod end and pressure applied.

Visually inspect torque rod bushings for torn or shredded rubber, inspect for bent, cracked, or broken torque rods and also for end hubs that have an elongated “oval” shape. Any of these conditions require component replacement.

Rod ends can be renewed by pressing out the worn bushing, and installing a replacement bushing. In the event of structural damage the entire torque rod assembly should be replaced. The torque rods are made to a specified length or a two-piece transverse torque rod can be cut and welded to the desired length (if available).

NOTE: NOTE It is recommended that Grade 8 bolts and Grade C locknuts be used for all torque rod attachments.

Axle Pinion Angle

7019-4 **FIGURE 8-78**

Drive axle pinion angles are established by the vehicle manufacturer. If it is necessary to fine tune the pinion angle see the Alignment & Adjustments Section of this publication. To check the pinion angle, verify first that the suspension is at the proper ride height. Refer to Ride Height Adjustment in this Section. Install a digital protractor on the axle housing as shown in (Figure 8-78). Check that the pinion angle is within the range specified by the vehicle manufacturer.

Drive Axle Alignment Inspection Procedure

Proper alignment is essential for maximum ride quality, performance, and tire service life. The recommended alignment procedure is described below. This procedure should be performed if excessive or irregular tire wear is observed, or any time the QUIK-ALIGN connection is loosened or removed.

1. Use a work bay with a level surface.
2. Relax the suspension by slowly moving the vehicle back and forth several times in a straight line without using the brakes. This will slacken or loosen the suspension as the vehicle is positioned. End with all wheels positioned straight ahead.
3. **DO NOT** set the parking brake. Chock the front wheels.
4. Verify and maintain the air system at full operating pressure.
5. Verify the vehicle is at the correct ride height. Correct as necessary. Refer to Ride Height Adjustment in this section.
6. Verify all suspension components are in good condition. Repair or replace any worn or damaged suspension components before proceeding with the alignment process.
7. Ensure all drive axle tires are the same size.
8. If axle alignment equipment is not available, using C-clamps, securely clamp a six-foot piece of straight bar stock or angle iron across the lower frame flange Select a location for the angle iron as far forward of the drive axle as possible where components will not interfere.
9. Accurately square the straight edge to the frame using a carpenter’s square.
10. Using a measuring tape, measure from the straight edge to the forward face of the front drive axle arms at the centerline on both sides of the vehicle.
11. Calculate the difference between measurements.
    a. If the front drive axle is within vehicle manufacturer’s specifications, proceed to check the rear drive axle (Step 12).
    b. If alignment of the front drive axle **IS NOT** within the vehicle manufacturer’s specifications, then the alignment of this axle **MUST** be corrected **BEFORE** measuring the rear drive axle alignment (step 7). Correct the alignment of this axle by following the proper Alignment Instructions.

TESTS AND ADJUSTMENTS STEERING HYDRAULIC SYSTEM

Preparation

CAUTION

A faulty steering pump high pressure relief valve may cause excessive system pressure. Closing the high pressure shut-off valve on the tool may cause severe pump damage or high pressure hoses to rupture. Monitor the pressure closely when closing the shut-off valve. If pressure rises rapidly or exceeds the rated pump pressure, immediately open the valve. Failure to follow these precautions could result in severe equipment damage or personal injury.

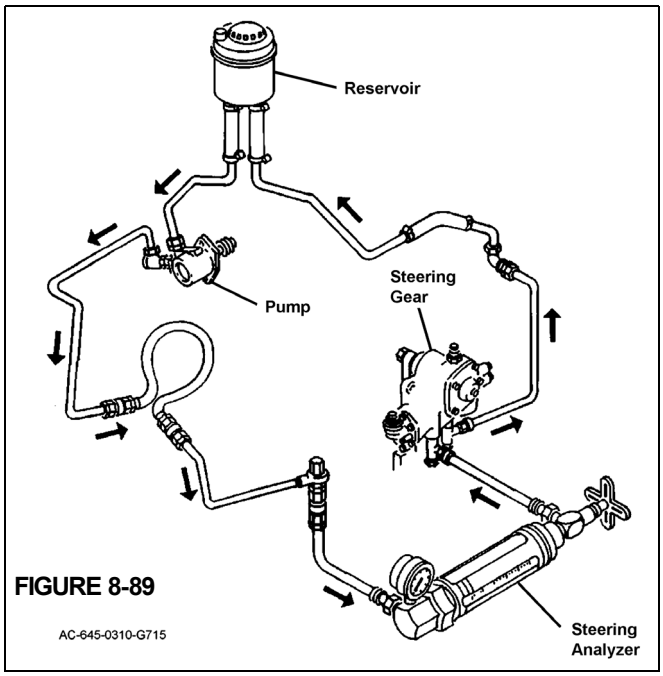


FIGURE 8-89

1. Install a steering system analyzer tool in the high pressure fluid line between the pump and the steering gear (Figure 8-89). The analyzer should include a pressure gauge, flow meter, and a shut-off valve.
2. Place a thermometer in the fluid reservoir (Figure 8-89).
3. Start the engine and warm the hydraulic system by partially closing the shut-off valve until the pressure gauge reads 1000 psi (6.9 MPa). When the fluid temperature reaches 125 - 135°F (50 - 55°C), open the shut-off valve.

Testing Pump Pressure

NOTE: Potential pump damage. Never leave the shut-off valve fully closed for more than 5 seconds. Leaving the shut-off valve fully closed too long could result in excessive fluid temperature and pump damage.

1. Close the shut-off valve and read the pressure gauge. Immediately open the shut-off valve.

NOTE: Refer to the pump manufacturer's service literature for specifications.

2. If pump pressure was below the minimum accepted pressure, repair or replace the pump.
3. Allow the fluid to cool to 125 - 135°F (50 - 55°C) before performing other tests or shutting off the engine.

Testing Pump Flow

1. Ensure the engine is idling and fluid temperature is between 125 - 135°F (50 - 55°C). Note the flow rate displayed by the tool.

NOTE: Potential equipment damage. The following steps must be performed in rapid succession. Leaving the shut-off valve closed for too long could result in excessive fluid temperatures and pump damage.

2. Fully close the shut-off valve. When the pump relief pressure is reached, verify that the flow rate is zero. Immediately open the shut-off valve. Verify that the flow rate rapidly returns to the value noted in step 1.
3. Allow the fluid temperature to return to 125 - 135°F (50 - 55°C). Set the engine to maximum governed speed and note the fluid flow rate.
4. Potential equipment damage. The following steps must be performed in rapid succession. Leaving the shut-off valve closed for too long could result in excessive fluid temperatures and pump damage.
5. Fully close the shut-off valve. When pump relief pressure is reached, verify that the flow rate is zero. Immediately open the shut-off valve. Verify that the flow rate rapidly returns to the value noted in step 3.
6. Allow the fluid to return to 125 - 135°F (50 - 55°C).
7. Repeat steps 4 and 5 two additional times.
8. If the flow rate did not immediately return to the noted flow rate, the pump is malfunctioning and should be repaired or replaced.

An LED display and a magnetically actuated reset switch are incorporated in the housing for troubleshooting and diagnostic purposes.

Two electrical connectors are used to connect the ECU to ABS components. These connectors, one 30-pin and one 18-pin Packard Electric 150 series Metri-pack, are located in the controller housing opposite the diagnostic display.

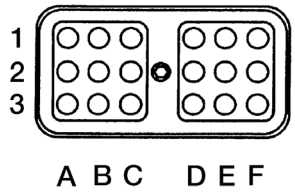


FIGURE 8-102 AC-593-0305-G81

18-pin Metri-Pack 150 Series (pull-to-seat) Connector (for detail, see the 18-pin connector table)

18-pin Connectors	
Pin	**Function**
A1	Right Rear Modulator Common
A2	Not Used
A3	Not Used
B1	Right Rear Modulator Hold
B2	Right Mid Wheel Sensor Signal
B3	Right Mid Wheel Sensor Return
C1	Right Rear Modulator Exhaust
C2	Left Mid Wheel Sensor Signal
C3	Left Mid Wheel Sensor Return
D1	Left Rear Modulator Exhaust
D2	Traction Solenoid Source
D3	Traction Solenoid Ground
E1	Left Rear Modulator Hold
E2	Right Rear Wheel Sensor Signal
E3	Right Rear Wheel Sensor Return
F1	Left Rear Wheel Modulator Common
F2	Left Rear Wheel Sensor Signal
F3	Left Rear Wheel Sensor Return

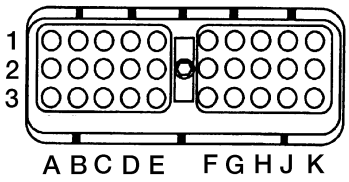


FIGURE 8-103 AC-593-0305-G82

30-pin Metri-Pack 150 Series (pull-to-seat) Connector (for detail, see the 0-pin connector table)

30-pin Connectors	
Pin	**Function**
A1	Ground
A2	Ground
A3	Ground
B1	Battery Voltage +12V
B2	Data Link + (J1922/A)
B3	Data Link - (J1922/B)
C1	Right Front Modulator Common
C2	ATC Lamp
C3	Auxiliary Output
D1	Right Front Modulator Hold
D2	Not Used
D3	Not Used
E1	Right Front Modulator Exhaust
E2	Not Used
E3	Warning Lamp
F1	Left Front Modulator Exhaust
F2	ATC Enable Switch
F3	Not Used
G1	Left Front Modulator Hold
G2	Data Link + (J1587/A)
G3	Data Link - (J1587/B)
H1	Left Front Modulator Common
H2	Right Front Wheel Sensor Signal
H3	Right Front Wheel Sensor Return
J1	Left Front Wheel Sensor Signal
J2	Left Front Wheel Sensor Return
J3	Chassis Ground
K1	Retarder Disable
K2	Battery Voltage +12V
K3	Battery Voltage -12V

7. Remove the sensor spring clip from the mounting block.
8. Disconnect any fasteners that hold the sensor cable and the hose clamp to other components.
9. Disconnect the sensor from the crane wiring at the connector closest to the sensor.

Installation

NOTE: Spring clip must be installed with the flange stops facing the inboard side of the crane.

1. Push the sensor spring clip all the way into the mounting block.
2. Insert the sensor cable through the brake spider housing, around the S-cam tube and bracket, up the brake chamber airline, and route the cable along the frame rail.
3. Connect the sensor cable connector.
4. Install the sensor into the bracket and spring clip. Install the bracket and sensor onto the spider assembly. Tighten the bracket to a torque of 130 ±10 ft-lb (175 ±15 N·m).
5. Install the P-clip on the S-cam tube and bracket. Fasten the sensor cable to the brake air line using a tie strap. Install P-clip inside the frame rail.

CAUTION

Sensor damage may result. DO NOT use a screwdriver or sharp instrument to insert or adjust the sensor. DO NOT use a hammer to drive the sensor into position. Use of a sharp instrument or hammer can permanently damage the sensor.

6. Using an ABS sensor adjustment too adjust the sensor against the tooth wheel, and install the rubber grommet.
7. Install the brake lining onto the spider housing. Install the return spring, S-cam rollers and brake drum.
8. Install the wheel and tighten wheel nuts to a torque of 475 ±25 ft-lb (645 ±35 N·m).
9. Adjust the front axle brakes.
10. Remove the jack stand(s) from under the crane.
11. Lower the crane and remove the wheel blocks.

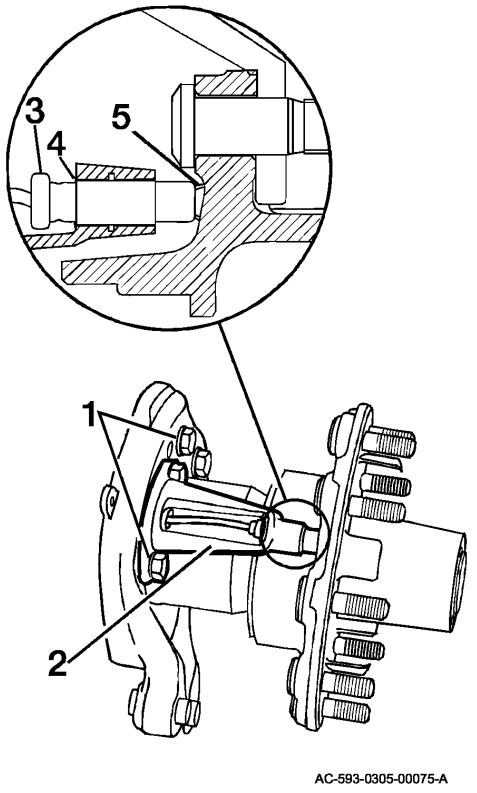


FIGURE 8-113

Item	Component
1	Spider Mounting Bolts
2	Sensor Bracket
3	Sensor
4	Spring Clip
5	Tooth Wheel

12. Readjust the brakes.
13. Verify proper sensor adjustment by driving the crane. This allows the ABS to perform an additional self-test. (ABS Self-tests on page 8-65) Once the crane reaches approximately 7 mph (11 km/h), the ABS warning lamp will go out if the sensor is properly adjusted.

8

NOTE: From this display, you can also use the up or down arrows to choose either MPC UTILITIES or LOAD ALL APPLICATIONS for the MPC UTILITIES Menu Structure. (For more information, refer to the Pro-Link/MPC operator's manual.)

7. With BENDIX ABS/ATC v1.0 on the bottom line of the display, press ENTER to continue to the "Bendix ABS/ ATC Application Menu Structure."

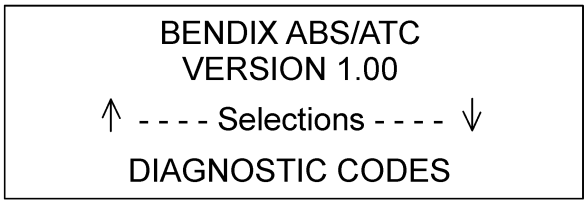
NOTE: To exit to the previous menu, press FUNC.

8. With the Bendix ABS/ATC application running, you can choose from the following main options. (For a flow chart showing application options, see MPC Application Menu Structure on page 8-83.)

- Diagnostic Codes
- Data List
- Reset ECU
- Test System
- System Configuration
- ECU Information

Use the up or down arrows to scroll to the desired option. With the DIAGNOSTIC CODES option on the bottom line of the display, press ENTER to continue.

NOTE: To exit to the main menu options, press the FUNC key.

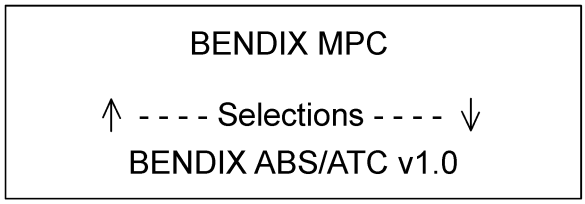


AC-083-0305-G103

9. The DIAGNOSTIC CODES menu lets you choose from the following diagnostic functions:

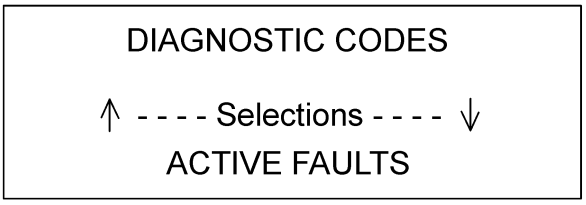
- ACTIVE FAULTS
- FAULT HISTORY
- CLEAR FAULT HISTORY
- CLEAR ACTIVE FAULTS

NOTE: As with all menu options, use the up or down arrow to scroll to the desired function, and press ENTER to begin the function. To end use of a function, press the FUNC key. This will return you to the previous screen. (Refer to the Pro-Link/MPC operator's manual for more detailed information about these functions.)



AC-083-0305-G102

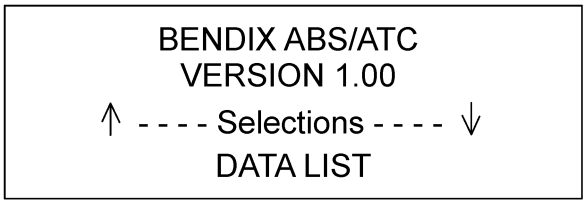
10. Return to the Bendix ABS/ATC main option menu. (You may need to press the FUNC key.) The DIAGNOSTIC CODES menu option should be on the bottom line of the display.



AC-083-0305-G104

11. Using the up or down arrow keys, scroll to the DATA LIST option.

To select the DATA LISToption, press ENTER. This lets you view data list parameters in sequence of operation. Press FUNC to exit back to the main option menu.



AC-083-0305-G105

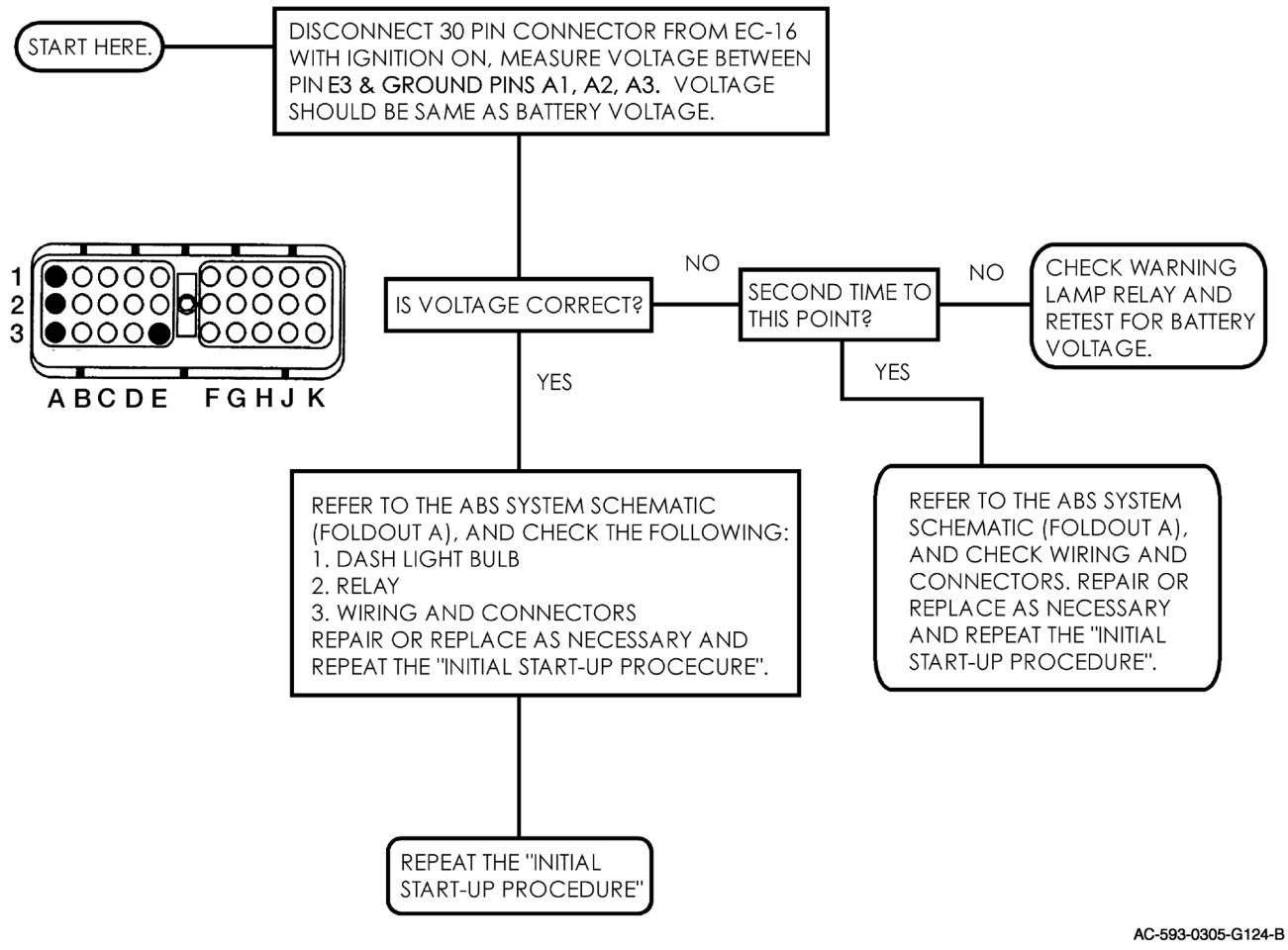
12. Using the up or down arrow keys, scroll to the RESET ECU option.

To select the RESET ECU option, press ENTER. This function lets you reset the ABS ECU. Press FUNC to exit back to the main option menu.

8

SECTION I - ABS WARNING LAMP TESTING

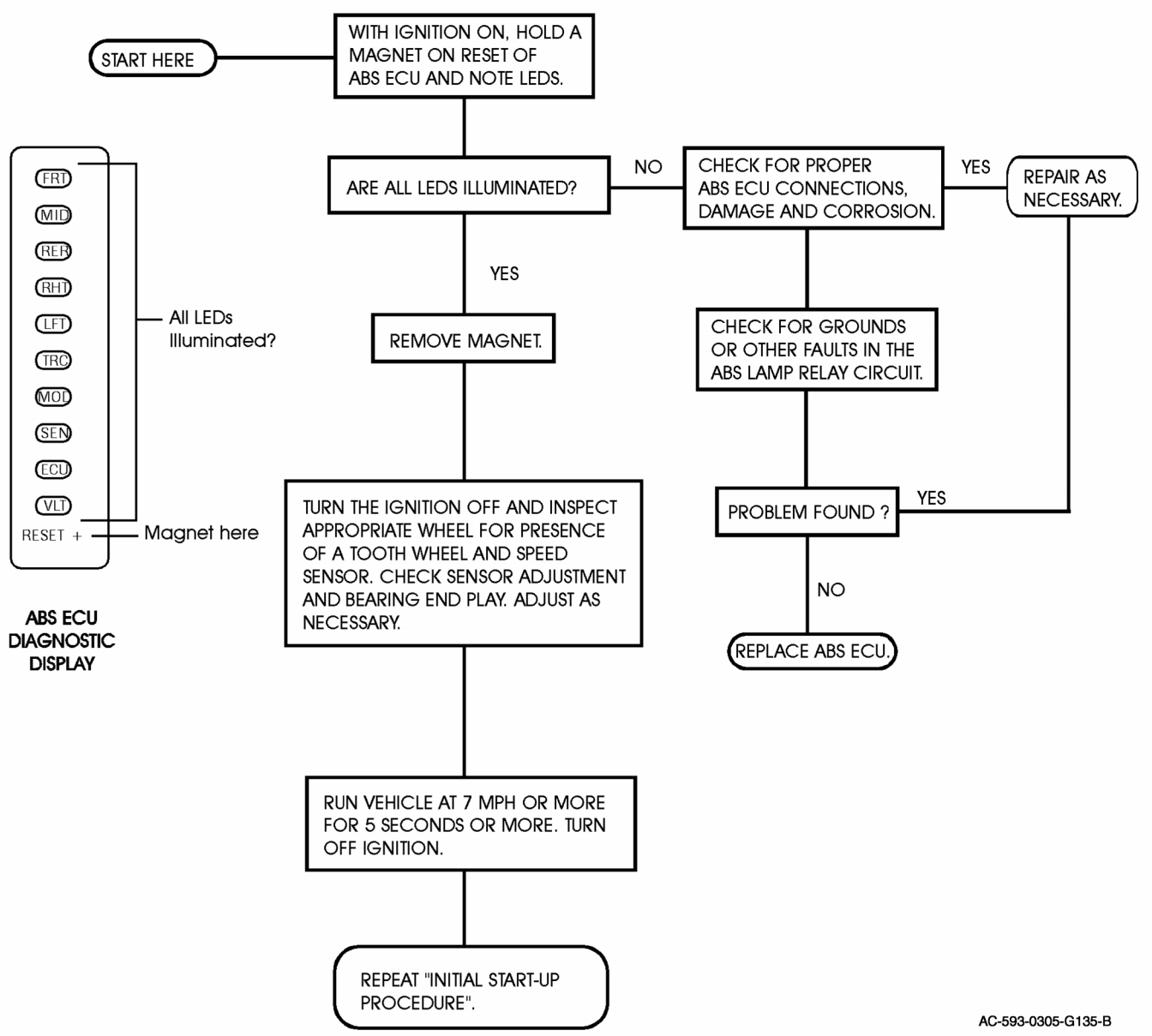
NOTE: For more detailed information, refer to Electrical Schematics, System Group 370.



AC-593-0305-G124-B

8

SECTION IX - TESTING FOR FALSE INDICATION CAUSED BY WHEEL SPEED COMPONENTS



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6. Tag and disconnect the hydraulic lines at the cylinder barrel end of the extension cylinder. Cap all lines and fittings.

NOTE: Do not allow the end of the outrigger extension cylinder to fall when the cylinder mounting shaft is removed. Use blocking to limit the drop or an adequate soft support to cushion any distance the rod will drop.

7. Remove the cotter pin and clevis pin securing the cylinder barrel end of the extension cylinder to the outrigger housing. Carefully extend the outrigger beam until the extension cylinder is free of the housing and carefully lay the end of the cylinder on the bottom of the outrigger beam or leave on blocking.

8. After attaching a suitable lifting device of straps or belts Figure 8-134 instead of chains to prevent nicking the bottom edges of the outrigger beam, pull the outrigger beam out of the outrigger box, re-adjusting the lifting attachment to prevent the extension cylinder from sliding out of the outrigger beam when the beam clears the outrigger box.

DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide. Failure to do so could result in death or injury to personnel.

NOTE: The outrigger beam assembly weighs approximately 374 kg (824 pounds).

9. Position the outrigger beam on the blocking material.

Inspection

Inspect the outrigger beams for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder, loose connection, or damaged hydraulic line.

Installation

NOTE: Apply anti-seeze compound on clevis pins and setscrews during installation.

1. Apply grease (EPMPG) to the bottom of the outrigger beam.

2. If removed, install the side adjustable wear pad in the outrigger beam.

3. Install the bottom wear pads with approximately 6 mm (0.23 in) protruding. This will prevent the beam side plates from riding on the bottom of the box Figure 8-135.

4. Attach a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam.

5. Slide the beam into the outrigger housing and align the cylinder bushing with the mounting hole.

6. Apply anti-seeze compound to the clevis pin. Secure the cylinder barrel to the housing with the clevis pin and cotter pin.

CAUTION

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

CAUTION

During initial start-up and checking of the outrigger operation, each control switch must be operated before operating the selector valve. If hydraulic lines are reversed to one or more cylinders, this will prevent damage to the cylinders.

7. Connect the hydraulic lines as tagged prior to removal.

8. Install the side adjustable wear pad in the outrigger box.

9. Adjust the wear pads, refer to WEAR PAD ADJUSTMENT in this Sub-Section.

10. Install the end cover.

NOTE: At installation, be sure that the outrigger stabilizer cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

Wear Pad Adjustment.

NOTE: When adjusting wear pads, refer to Wear Pad Adjustment Figure 8-135.

1. Adjust the bottom wear pads until a gap of 3 mm (0.11 in) is obtained between the top of the beam and the top of the outrigger box. Install and lock setscrew against wear pad.

2. Adjust outrigger box side wear pad until a gap of 2 mm (0.07 in) is obtained between beam and shims welded in top and bottom of box. Install and lock set screw against wear pad.

3. Adjust outrigger beam side wear pad until a gap of 2 mm (0.07 in) is obtained between shim welded on beam and side of box. Install and lock set screw against wear pad.