CD20

Service Manual



For Reference Only

Grove Manitowoc National Crane Potain

Manitowoc

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

Batteries, battery posts, terminals, and related accessories can expose you to chemicals, including lead and lead compounds, which are known to the State of California to cause cancer and birth defects or other reproductive harm. Wash hands after handling. For more information, go to www.P65warnings.ca.gov

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.

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The original language of this publication is English.

SERVICE MANUAL

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

CD20

Crane Model Number

This manual is divided into the following sections:

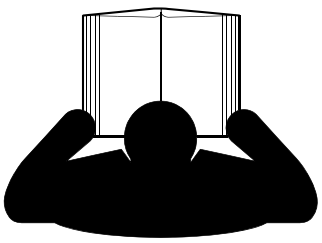
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SECTION 2	**SAFETY PRACTICES**
SECTION 3	**ELECTRIC SYSTEM**
SECTION 4	**HYDRAULIC SYSTEM**
SECTION 5	**PREVENTATIVE MAINTENANCE**
SECTION 6	**ENGINE AND ENGINE SYSTEMS**
SECTION 7	**TRANSMISSION AND TORQUE CONVERTER**
SECTION 8	**AXLES/DRIVE SHAFTS/WHEELS AND TIRES**
SECTION 9	**BRAKE SYSTEM**
SECTION 10	**STEERING SYSTEM**
SECTION 11	**STRUCTURALS**
SECTION 12	**SCHEMATICS/WIRING DIAGRAMS**

NOTICE

The crane serial number is the only method your Grove distributor or Crane Care Customer Service at Grove has of providing you with correct parts and service information.

The crane serial number is identified on the builder's decal attached to the operator's cab. ***Always furnish crane serial number*** when ordering parts or communicating service problems with your Grove distributor or Crane Care Customer Service at Grove.

Reference Only



⚠DANGER

An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:

- You are trained in the safe operation of this crane. Manitowoc is not responsible for qualifying personnel.
- You read, understand, and follow the safety and operating recommendations contained in the crane manufacturer's manuals and load charts, your employer's work rules, and applicable government regulations.
- You are sure that all safety signs, guards, and other safety features are in place and in proper condition.
- The Operator Manual and Load Chart are in the holder provided on crane.

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Item	Description
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2	Main Hoist Location
3	Engine Location
4	Outriggers (4)
5	Rear Axle
6	Operator's Cab
7	Front Axle
8	Hook Block
9	Anti-Double Blocking System
10	4th Boom Section
11	3rd Boom Section
12	2nd Boom Section
13	1st Boom Section
14	Main Control Valve Location
15	Swing Motor and Gearbox Location
16	Lift Cylinders (2)
17	Telescope Cylinder (Inside Boom)
18	Mast

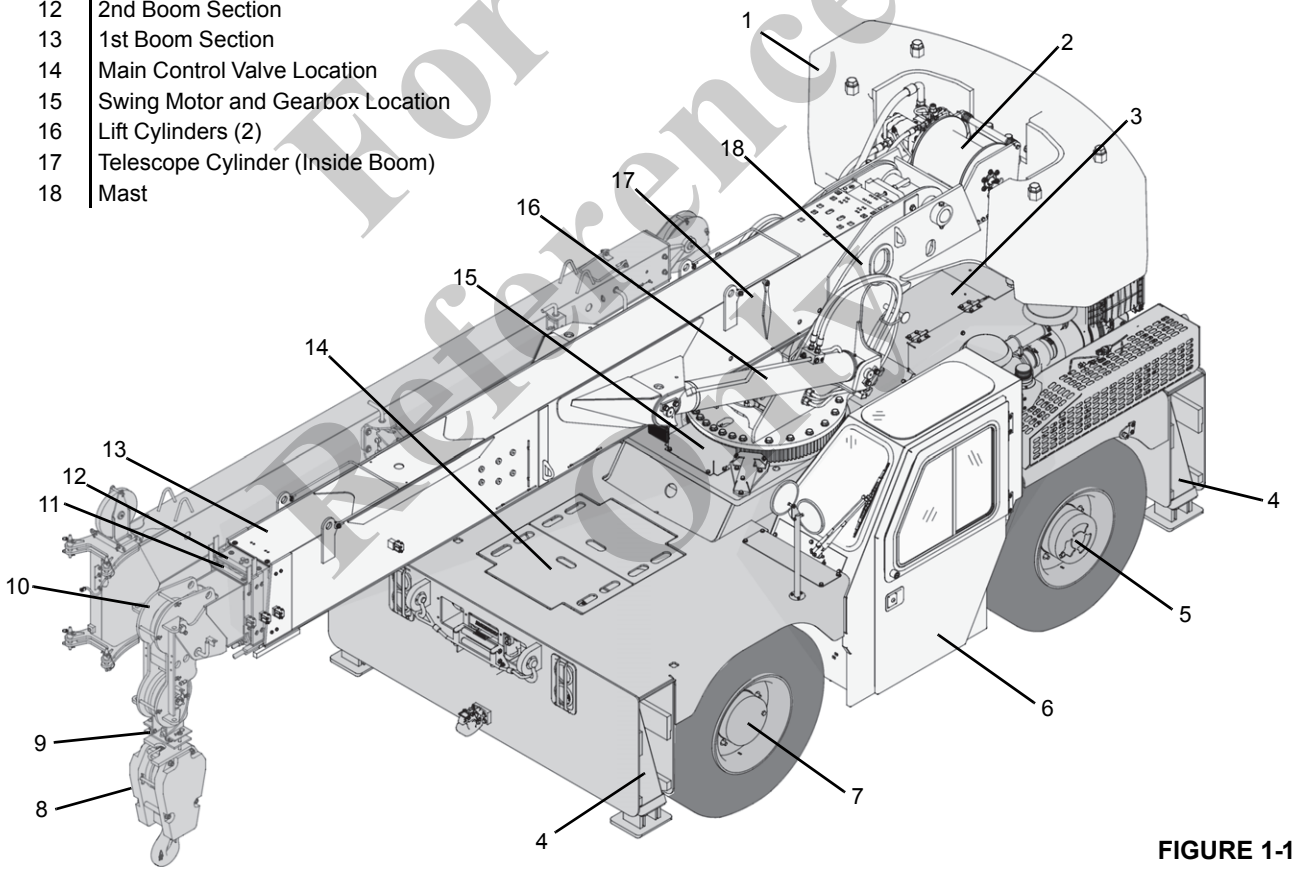


FIGURE 1-1

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SECTION CONTENTS

This manual contains information on maintenance, service and repair of the Model CD20 crane. Major components and systems are included, except service on the engine. Engine information will be found in the engine manufacturer's service manual.

CRANE NOMENCLATURE

See Figure 1-1.

DIRECTIONAL REFERENCE

All directional references in this manual, unless otherwise noted, are viewed from the normal operator's working position at the main controls. "LEFT" is the operator's left and "RIGHT" is the operator's right.

IDENTIFICATION PLATE

When assistance is required for parts and service, be sure to include the model number and serial number of the crane in the correspondence. The location of serial number plate is shown Figure 1-2.



Crane S/N Location

FIGURE 1-2

For Reference Only

GENERAL SPECIFICATIONS

ENGINE

Tier 3 Diesel Engine

Make and Model	Cummins QSF3.8L Tier 3
Type of Aspiration	Turbocharged
Horse Power	130 hp @ 2500 rpm
Low Idle Speed	900 rpm
Maximum Engine Speed (full load)	2500 rpm
Maximum Engine Speed (no load)	2750 rpm

Tier 4F Diesel Engine

Make and Model	Cummins QSF3.8 Tier 4F
Type of Aspiration	Turbocharged
Horse Power	130 hp @ 2500 rpm
Low Idle Speed	900 rpm
Maximum Engine Speed (full load)	2500 rpm
Maximum Engine Speed (no load)	2750 rpm

Dual Fuel Engine

Make and Model	GM 4.3 Liter
Type of Aspiration	Naturally Aspirated
Horse Power (gas)	95 hp @ 2600 rpm
Horse Power (LP)	108 hp @ 2600 rpm
Low Idle Speed	800 rpm
Maximum Engine Speed	2600 rpm

BOOM

Construction	Telescopic, full power
Number of Sections	Four
Length	5.64 m to 16.61 m (18.5 ft to 54.5 ft)
Elevation Angle	0° to 80°

BOOM EXTENSION (Optional)

Fixed Length	4.6 m (15 ft)
Telescopic Length	4.6 m to 7.6 m (15 ft to 25 ft)
Offsets	0°, -15°, -30°

PIVOTING BOOM NOSE

Offsets	0°, 40°and 80°

MAST ROTATION - 360°

Mast Bearing (Diameter)	860.6 mm (33.884 in)
Swing Drive Mechanism	Hydraulic motor driven gearbox
Swing Speed	2.5 rpm
Swing Lock (Optional)	360°

ELECTRICAL

Type	12 volts, direct current- negative ground
Alternator-Diesel	135 amps
Alternator-Dual Fuel	145 amps
Battery	150 amp/hr

FUEL TANK

Capacity	110 L (29 gal)

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HYDRAULIC SYSTEM

Pump	Piston, 65 cc, CCW, 155 lpm (41 gpm)
Swing Motor	Single section, gerotor-type
Hoist Motor	Gear
Hydraulic Filters	One 5-micron filter in line from valves. One 30-mesh suction filter inside hydraulic tank
Hydraulic Cylinders	Double-acting cylinders for lift, telescope, steering and outriggers
Hydraulic Tank	130.6 L (34.5 gal) capacity, steel construction with internal baffles

WIRE ROPE

Wire Rope (Main Hoist):	
Diameter	9/16 in
Type	6 x 19 EIPS-IWRC
Length	97.5 m (320 ft)
Wire Rope (Optional Below Deck Winch):	
Diameter	11.1 mm (7/16 in)
Length	35.1 m (115 ft)

TRANSMISSION

Model	International - Powershift
Type	4 speed forward and 4 speed reverse

FRONT AXLE DRIVE

Type	International Transmissions Limited
Drive Type	2wd /4wd Drive/Steer
Model	SD80 - Center Drive Head

REAR AXLE DRIVE

Type	International Transmissions Limited
Drive Type	Drive/Steer in 4wd
Model	SD80 - Offset Drive Head

REAR AXLE NON-DRIVE

Type	International Transmissions Limited
Drive Type	Non-drive with steer in 2wd
Model	SD80 - Offset with No Drive Head

OUTRIGGERS

Type	Hydraulic
Construction	Welded box

TIRES

Size	12.00R20
Type	18 ply Radial
Air pressure	9 bar (130 psi)
Wheel nut torque	680 ± 34 Nm (500 ± 25 lb-ft)

WEIGHTS

Crane	16504 kg (36,386 lb)
GVW Front Axles	5957 kg (13,132 lb)
GVW Rear Axles	10548 kg (23,254 lb)

TRAVEL SPEEDS

TWO-WHEEL STEER (approximate)

1st gear	6.4 km/hr (4 mph)
2nd gear	11.3 km/hr (7 mph)

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3rd gear ..... 21 km/hr (13 mph)
4th gear ..... 34 km/hr (21 mph)

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OPERATING DIMENSIONS

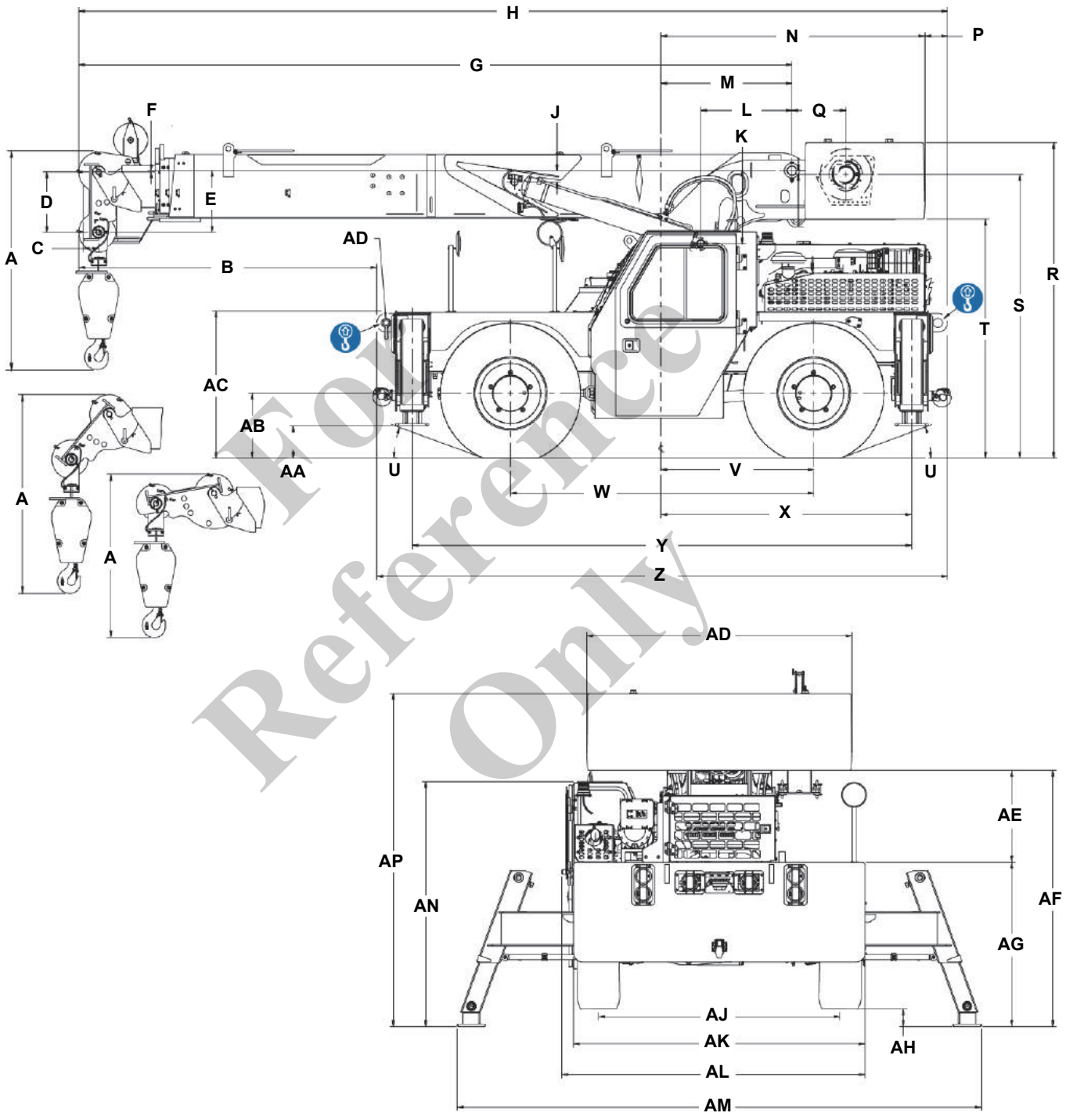


FIGURE 1-3

For Reference Only

Item	mm	ft	in	Comments
A	1362 1653 1770	4 5 5	6 5 10	80° Boom Head 40° Boom Head 0° Boom Head
B	2428	8	0	
C	125	0	5	Center of Rope to Center of Sheave
D	490	1	7	
E	502	1	8	
F	12	0	0.5	
G	5810 16774	19 55	1 0	Retracted Retracted
H	7077	23	3	
J	94	0	4	
K	598	2	0	
L	742	2	5	
M	1067	3	6	
N	2150	7	1	
P	183	0	7	
Q	440	1	5	
R	2569	8	5	
S	2310	7	7	
T	1944	6	5	
U	20°			
V	1245	4	1	
W	2470	8	1	
X	2043	6	8	
Y	4069	13	4	
Z	4649	15	3	
AA	262	0	10	
AB	529	1	9	
AC	1197	3	11	
AD	76	0	3	Diameter, 4 holes
AE	2160	7	1	
AF	748	2	5	
AG	2086	6	10	
AH	1338	4	5	
AJ	141	0	6	
AK	1965	6	5	
AL	2375	7	10	
AM	2470	8	1	
AN	4271	14	0	
AP	1993	6	6	
AQ	2711	8	11	

NOTE 1: Lifting of the crane must be accomplished utilizing the specified fittings indicated at AD.

NOTE 2: Rigging personnel shall be responsible for proper selection and placement of all slings and load handling devices.

NOTE 3: Dimensions and heights shown are for largest configuration available.

NOTE 4: Rigging personnel shall verify dimensions required for clearance.

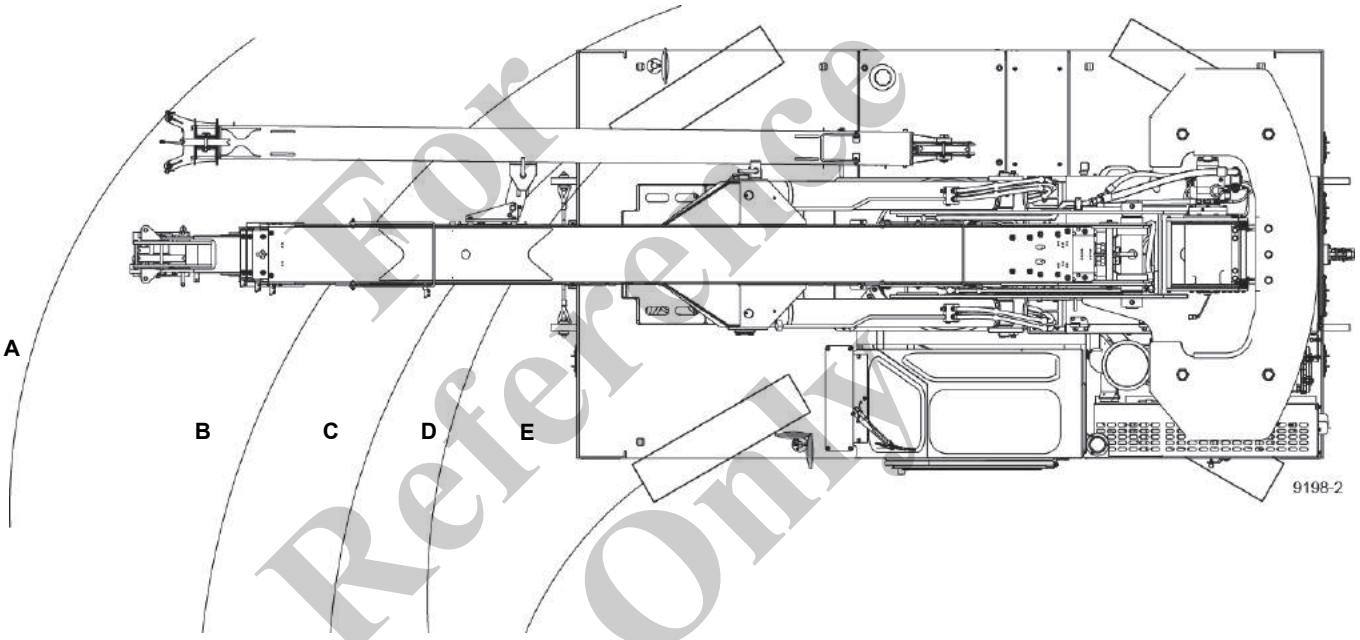
NOTE 5: Do not use pintle hooks or counterweight lugs for lifting or tie down of the crane.

Item	Qty	Lift	Tow	Tie Down	Capacity – Metric Ton (US Ton)				
					Lift	Tow	Tie Down		
							Fore Aft	Side	Down
	4	OK	OK	OK	10 (11)	30 (33)	30 (33)	1 (1.1)	30 (33)

For Reference Only

TURNING RADII

Tire Size	Radius mm (ft-in)									
	A Boom Clearance	B Carrier Clearance	C Curb Clearance	D Outside Turn	E Inside Turn	A Boom Clearance	B Carrier Clearance	C Curb Clearance	D Outside Turn	E Inside Turn
12.00R20	7407 (24-3 5/8)	6675 (21-10 7/8)	6218 (20-4 7/8)	6058 (19-10 5/8)	3375 (11-0 7/8)	5380 (17-7 7/8)	4481 (14-8 1/2)	3993 (13-1 1/4)	3841 (12-7 1/4)	1722 (5-7 7/8
	Two-Wheel Steer					Four-Wheel Steer				



For Reference Only

FIGURE 1-4

Item	Description	Item	Description
1	Counterweight	10	4th Boom Section
2	Main Hoist Location	11	3rd Boom Section
3	Engine Location	12	2nd Boom Section
4	Outriggers (4)	13	1st Boom Section
5	Rear Axle	14	Main Control Valve Location
6	Operator's Cab	15	Swing Motor and Gearbox Location
7	Front Axle	16	Lift Cylinders (2)
8	Hook Block	17	Telescope Cylinder (Inside Boom)
9	Anti-Double Blocking System	18	Mast

GENERAL SERVICE INFORMATION

Appropriate service methods and proper repair procedures are essential for safe, reliable operation of the crane and safety of the individual doing the work. This Service Manual provides general directions for accomplishing service and repair with effective techniques. Following them will assure reliability.

There are many variations in procedures, techniques, tools and parts for servicing machines as well as work skills. This manual cannot possibly anticipate all such variations and provide advice or cautions for each one. Accordingly, anyone who intends to depart from the instructions in this manual must first consider personal safety and the machine's integrity.

CLEANING INSTRUCTIONS

Complete Assemblies

Before removal or disassembly, clean the outside of the component as necessary. Steam can be used if all openings are closed to prevent water from entering the component.

Parts with Machined Surfaces

Gears, bearings, shafts, or other parts which have machined surfaces can be cleaned with a solvent that is not flammable. DO NOT clean these parts in hot solution tanks or with warm water and alkaline solutions (for example; hydroxide, othosilicates and phosphates).

WARNING

To prevent injury from burns, always use a solvent that is not flammable for cleaning component parts. DO NOT use gasoline or other flammable substances.

Rough Parts

Housings and case parts can be cleaned in hot solution tanks with a mild alkali if these parts do not have machined surfaces. Keep the parts in the solution long enough to be thoroughly cleaned and heated. Flush the parts thoroughly after cleaning to remove all residue of the alkali solution.

Rubber Parts

Use brake fluid to clean rubber parts. To inhibit damage to the part, do not use mineral base solvents (for example; acetone or paint thinner).

After Cleaning

Remove all water or solvent from the parts immediately after cleaning. Use compressed air or a clean cloth. Make sure the parts are completely dry and clean. DO NOT use compressed air on bearings. Spinning bearings without lubricant will cause damage to the bearing.

CAUTION

When using compressed air use only low air pressure and keep air stream from direction of face. Injury to eyes could occur.

To Prevent Corrosion

Apply a light weight oil to those parts which normally use lubrication and are assembled immediately. If the parts will be put into storage for any length of time, apply a rust preventative lubricant and put a protective paper on the parts.

O-RING, SEAL AND ELASTIC NUT REPLACEMENT

Replace O-rings and gaskets whenever they are disturbed. Never mix new and old seals or O-rings regardless of condition. Always lubricate new seals and O-rings (unless stated otherwise) with 10W30 oil or petroleum jelly before installation. Replace all used elastic lock nuts with new parts.

REMOVAL AND INSTALLATION

When performing maintenance, do not attempt to manually lift heavy parts when hoisting equipment should be used. Never locate or leave heavy parts in an unstable position. When raising a crane or portion thereof, ensure the crane is blocked securely and the weight is supported by blocks or jack stands rather than by lifting equipment.

When using hoisting equipment, follow the hoist manufacturers recommendations and use lifting devices that will allow you to achieve the proper balance of the assemblies being lifted and to ensure safe handling. Unless otherwise specified, all removals requiring hoisting equipment should be accomplished using an adjustable lifting attachment or straps designed for that purpose. All supporting members (straps, chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

NOTE: The capacity of an eyebolt diminishes as the angle between the supporting members and the object becomes less than 90°. Eyebolts and brackets should never be bent and should only have stress in tension

Some removals require the use of lifting fixtures to obtain proper balance. The weights of some components are given in their respective sections of the manual.

For Reference Only

If a part resists removal, check to be certain all nuts and bolts have been removed and that an adjacent part is not interfering.

DISASSEMBLY AND ASSEMBLY

When disassembling or assembling a component or system, complete each step in turn. Do not partially assemble one part and start assembling another. Make all adjustments as recommended. Always check the job after it is completed to see that nothing has been overlooked. Recheck the various adjustments by operating the crane before returning it to service.

Pressing Parts

When pressing one part into another, use an anti-seize compound or a molybdenum disulfide base compound to lubricate the mating surfaces.

Assemble tapered parts dry. Before assembling parts with tapered splines, be sure the splines are clean, dry, and free from burrs. Position the parts together by hand to mesh the splines before applying pressure.

Parts which are fitted together with tapered splines are always very tight. If they are not tight, inspect the tapered splines and discard the part if the splines are worn.

Locking Devices

Lockwashers, flat metal locks, or cotter pins are used to lock nuts and bolts.

Flat metal locks must be installed properly to be effective. Bend one end of the lock around the edge of the part. Bend the other end against one flat surface of the nut or bolt head.

Always use new locking devices on components which have moving parts.

When installing lockwashers on housings made of aluminum or thin sheet metal, use a flat washer between the lockwasher and the housing.

Wires and Cables

Batteries should always be disconnected prior to working on the electrical system.

When removing or disconnecting a group of wires or cables, tag each one to ensure proper identification during assembly.

Shims

When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are reinstalled.

HYDRAULIC SYSTEM

DANGER

High Pressure/Temperature Hazard!

Exercise extreme care around pressurized hydraulic hoses or tubes. DO NOT work on a hydraulic system while it is in operation or until all pressure is released.

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

Stay clear of all hydraulic oil leaks. Relieve system pressure and use a piece of cardboard or paper to check for leaks. Do not use your hands.

Fluid injected into skin must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene will result.

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 on the crane or another hose and has a minimum of bending and twisting. Tighten 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.

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HYDRAULIC HOSES AND TUBES

DANGER

High Pressure/Temperature Hazard!

Exercise extreme care around pressurized hydraulic hoses or tubes. DO NOT work on a hydraulic system while it is in operation or until all pressure is released.

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

Stay clear of all hydraulic oil leaks. Relieve system pressure and use a piece of cardboard or paper to check for leaks. Do not use your hands.

Fluid injected into skin must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene will result.

Inspection

Check hoses carefully. Do not use your bare hands to check for leaks.

Tighten all connections to recommended torque.

If the hose end connections are damaged, always replace the hose or tube. Damaged, dented, crushed, or leaking hose fittings restrict oil flow and the operation of the parts being served. Fittings showing signs of movement from their original position have failed and must be replaced.

Be sure hoses are in good condition. If in doubt, replace them.

Replace hoses if any of the following is evident Figure 1-5:

- Evidence of kinking or crushing (1)
- Chaffing or cuts; wire is exposed (2)
- Damaged or leaking fittings (3)
- Localized ballooning (4)

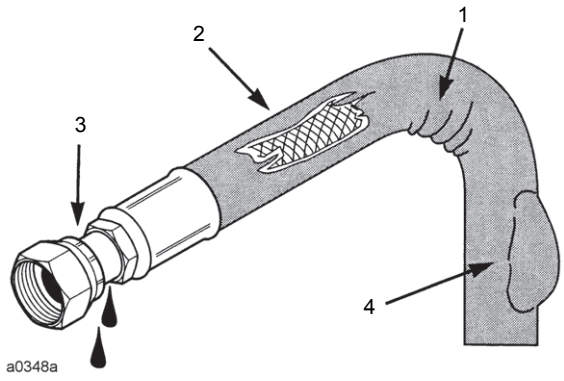


FIGURE 1-5

Installation

1. When installing a new hose, loosely connect each end and make sure the hose takes up the designed position before tightening the connection. Clamps should be tightened sufficiently to hold the hose without crushing and to prevent chafing.
2. If a hose is replaced on a part that moves during operation, be sure it moves freely by moving the part through its complete range of movement.
3. Be sure any hose which has been installed is not kinked or twisted.

Free moving, unsupported hoses must never rub on each other or related work surfaces. This causes chafing and reduces hose life.

Visual Inspection of Hoses and Fittings

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:
   - Leaks at hose fitting 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 the above conditions exist, evaluate hose assemblies for correction or replacement. For replacement of hose assemblies, refer to your Manitowoc Crane Care Parts Manual.
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 the hose assemblies.

   If any of these conditions exist, address them appropriately.

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Table 1-1 Climate Zones

Zone	Classification
A	Tropical Moist: All months average above 18°C (64°F). Latitude 15° - 25° North and South
B	Dry or Arid: Deficient precipitation most of the year. Latitude 20° - 35° North and South
C	Moist Mid-Latitude: Temperature with mild winters. Latitude 30° - 50° North & South
D	Moist Mid-latitude: Cold winters. Latitude 50° - 70° North & South
E	Polar: Extremely cold winters and summers. Latitude 60° - 75° North & South

3. All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life.
4. Hydraulic hose assemblies operating in Climate Zone “C” () are recommended to be replaced after 8000 hours of service life.
5. Hydraulic hose assemblies operating in climate zones “A” and “B” () 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” () should expect a degradation of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

HYDRAULIC PRESSURE TESTING

Prior to pressure testing, be sure all hoses are in good condition and all fittings are tight.

Use a pressure gauge with a range that is high enough to measure the specific pressure.

Comply with the correct procedure to inhibit damage to the system or the equipment and eliminate the possibility of injury.

BEARINGS

Antifriction Bearings

When an antifriction bearing is removed, cover it to keep out dirt and abrasives. Wash bearings in non-flammable cleaning solution and allow them to drain dry. The bearing may be dried with compressed air but do not spin the bearing. Discard the bearings if the races and balls or rollers are pitted, scored, or show signs of heat damage. If the bearing is serviceable, coat it with oil and wrap it in clean waxed paper. Do not unwrap new bearings until time of installation. The life of an antifriction bearing will be shortened if not properly lubricated. Dirt in an antifriction bearing can cause the bearing to lock resulting in the shaft turning in the inner race or the outer race turning within the cage.

Double Row, Tapered Roller

Double row, tapered roller bearings are precision fit during manufacture and components are not interchangeable. The cups, cones, and spacers are usually etched with the same serial number and letter designator. If no letter designators are found, wire the components together to assure correct installation. Reusable bearing components should be installed in their original positions.

Heating Bearings

Bearings which require expansion for installation should be heated in oil not to exceed 121°C (250°F). When more than one part is heated to aid in assembly, they must be allowed to cool and then pressed together again. Parts often separate as they cool and contract.

Installation

Lubricate new or used bearings before installation. Bearings that are to be preloaded must have a film of oil over the entire assembly to obtain accurate pre-loading. When installing a bearing, spacer, or washer against a shoulder on a shaft, be sure the chamfered side is toward the shoulder.

When pressing bearings into a retainer or bore, uniformly apply pressure to the outer race. If the bearing is pressed on the shaft, uniformly apply pressure on the inner race.

Preload

Preload is an initial load placed on the bearing at the time of assembly. Whether a tapered roller bearing should have preload could depend on any of several conditions: rigidity of the housings and shaft, bearing spread, speed of operation, etc.

To determine whether a bearing requires preload or end clearance, consult the disassembly and assembly instructions pertaining to that bearing.

Care should be exercised in applying preload. Misapplication while preloading bearings requiring end clearance can result in bearing failure.

Sleeve Bearings

Do not install sleeve bearings with a hammer. Use a press and be sure to apply the pressure directly in line with the

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bore. If it is necessary to drive a bearing into place, use a bearing driver or a bar with a smooth flat end. If a sleeve bearing has an oil hole, align it with the oil hole in the mating part.

GASKETS

Be sure the holes in the gaskets correspond with the passages in the mating parts. If it is necessary to make gaskets, select material of the proper type and thickness. Be sure to cut holes in the right places. Blank gaskets can cause serious damage.

When removed, always install new cylinder head and manifold gaskets using recommended gasket compound on head gaskets to allow uniform sealing.

BATTERIES

Clean batteries by scrubbing them with a solution of baking soda and water. Rinse with clear water. After cleaning, dry thoroughly and coat terminals and connections with an anti corrosion compound or grease.

If the machine is to be stored or not used for an extended period of time, the batteries should be removed. Store the batteries in a cool (not subfreezing), dry place, preferably on wooden shelves. Never store on concrete. A small charge should be introduced periodically to keep the specific gravity rating at recommended level.

ELECTRICAL SYSTEM

Visually inspect all electrical harnesses, cables, and connectors every month or 250 hours for the following:

- Damaged, cut, blistered, or cracked insulation.
- Exposed bare wires.
- Kinked or crushed wires and cables.
- Cracked or corroded connectors, battery terminals, and ground connections.

If any of the above conditions exist, evaluate, clean and replace as necessary.

The climate in which the crane operates affects the service life of the electrical components. The climate zones are defined in . Recommended replacement of harness and cables is as follows:

- Climate zone C after 10,000 hours of service.
- Climate zones A and B with high ambient temperatures and duty cycles after 8000 hours of service.
- Climate zones D and E after 5,000 hours of service.
- Salt water conditions after 8,000 hours of service.

FATIGUE OF WELDED STRUCTURES

Experience has shown that highly stressed welded structures when repeatedly subjected to varying stresses caused by twisting, shock, bending, and intentional and/or unintentional overloads, often become subject to weld cracking which may be attributed to fatigue of the welded joint. This condition is not uncommon in construction equipment.

Equipment should be periodically inspected for evidence of weld fatigue. The frequency of these inspections should increase with the age of the equipment and the severity of the application.The following are known high stress areas applicable to Grove cranes, and a visual inspection of these areas should be made part of an owner's planned preventive maintenance program:

- Telescopic Boom: wear pad retaining structures, hydraulic cylinder attaching points, boom pivot shaft retaining structures.
- Outrigger pads, beams, boxes and attachment structures.
- Main frame: generally in the area of doubler plates and crossmembers; at the junction of front and rear frame members on truck cranes.
- Turntable bearing connection—where bearing is welded to the crane superstructure or chassis.
- Counterweight support structures.
- Chassis axle and suspension mounting structures.
- Hydraulic cylinder end connections.

The above is provided only as a guide, and your inspection plan should not be limited to the areas listed. A thorough visual inspection of all weldments is good practice.

Anyone requiring more detailed inspection instructions and/or repair procedures may request same by contacting your local Manitowoc distributor.

LOCTITE®

CAUTION

Skin and/or Eye Hazard!

Loctite® type adhesives contain chemicals that may be harmful if misused. Read and follow the instructions on the container.

Always follow the directions on the Loctite® container, as not all Loctite® types are suitable for all applications.Various types of Loctite® are specified throughout the Service Manual. The following types of Loctite® brand adhesives are

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available from the Parts Department of the local Manitowoc distributor.

Application of Medium Strength Loctite®

NOTE: The fastener may be re-used; the adhesive may be re-applied over cured adhesive residue.

The following procedure covers the proper application and curing method for medium strength Loctite® adhesive/sealant (Loctite® #242) and primer (Locquic® Primer T7471). Loctite #243 can be substituted for #242; it does not require the primer.

Primer Application

NOTE: It is not necessary to bathe the threads in primer.

1. Ensure the threaded surface, both male and female, is clean and free of dirt and oil. Apply a light spray coating of primer to both male and female parts to be joined to clean and accelerate the curing process.
2. Allow the part to dry prior to adhesive/sealant application.

Adhesive/Sealant Application

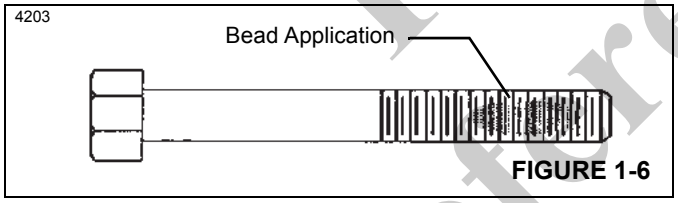


FIGURE 1-6

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-6).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.
3. After application and engagement of mated threads, fixturing will occur within five (5) minutes if primed prior to engagement. Fixturing may take up to 30 minutes on unprimed parts.
4. Time required to achieve full strength is 24 hours. Maximum ultimate strength is achieved using no primer with this specific threadlocking adhesive.

FASTENERS AND TORQUE VALUES

Use bolts of the correct length. A bolt which is too long may bottom before the head is tight against the part it is to hold. If a bolt is too short, there may not be enough threads engaged to hold the part securely. Threads can be damaged. Inspect them and replace fasteners, as necessary.

Torque values should correspond to the type bolts, studs, and nuts being used.

The torque tables are provided by Manitowoc for reference when performing maintenance.

Use of proper torque values is extremely important. Improper torquing can seriously affect performance and reliability.

Identification of fastener grade is always necessary. When marked as a high strength bolt (grade 5, 8, etc.), the mechanic must be aware that he/she is working with a highly stressed component and the fastener should be torqued accordingly.

NOTE: Some special applications require variation from standard torque values. Reference should always be made to component overhaul procedures for recommendations.

Special attention should be given to the existence of lubricant, plating, or other factors that might require variation from standard torque values.

The use of lubricants on zinc-flake coated parts shall be prohibited since this will change the required torque value.

When maximum recommended torque values have been exceeded, the fastener should be replaced.

Previously installed bolts and nuts of Grade 8 or Class 10.9 and higher may not be reused.

When referring to the applicable torque charts, use values as close as possible to the torque values shown to allow for wrench calibration tolerance.

Torque Wrenches

Flexible beam type wrenches, even though they might have a pre-set feature, must be pulled at right angle and the force must be applied at the center of the handle. Force value readings must be made while the tool is in motion. Rigid handle type, with torque limiting devices that can be pre-set to required values, eliminate dial readings and provide more reliable, less variable readings.

NOTE: If multipliers and/or special tools are used to reach hard to get at areas, ensure torque readings are accurate.

Torque wrenches are precision instruments and must be handled with care. To ensure accuracy, calibrations must be made on a scheduled basis. Whenever there is a possibility that a torque wrench may have been either overstressed or damaged, it should immediately be removed from service until recalibrated. When using a torque wrench, any erratic or jerking motion can result in the application of excessive or improper torque. ALWAYS use a slow, even movement and STOP when the predetermined value has been reached.

When using step wrenches, calculated wrench settings are valid only when the following conditions are met:

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- Torque wrenches must be those specified and forces must be applied at the handle grip. The use of handle extensions will change applied torque to the bolt.
- All handles must be parallel to the step wrench during final tightening. Multiplier reaction bars may be misaligned no more than 30 degrees without causing serious error in torque.
- Multiplier bar handles must be propped or supported within the outer 1/4 of the handle length, or serious under or over tightening will occur.

To convert pounds-foot (lb-ft) of torque to newton meters (Nm), multiply the pounds-foot quantity by 1.3558.

To convert pounds-inch (lb-in) of torque to newton meters (Nm), multiply the pounds-inch quantity by 0.11298.

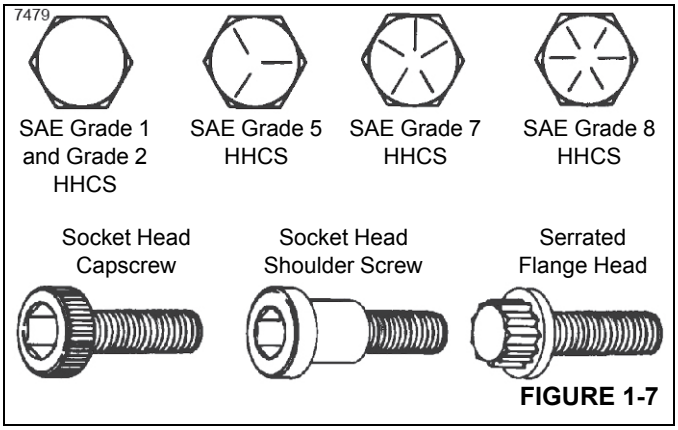


FIGURE 1-7

Torque Values

The following tables list the torque values for both ASME standard and metric fasteners. The tables list the values for grade 5 and grade 8 zinc-flake coated, untreated (black) finish and stainless steel fasteners.

For Reference Only

Table 1-2

Inch Series with Coarse Threads (UNC) – Zinc Flake Coated				
Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20 UNC	5	6.6	6.4	6.2
	8	9.3	9.0	8.8
5/16-18 UNC	5	13.5	13.2	12.8
	8	19.1	18.6	18.1
3/8-16 UNC	5	24.0	23.4	22.8
	8	33.9	33.1	32.2
7/16-14 UNC	5	38.4	37.4	36.5
	8	54.3	52.9	51.5
1/2-13 UNC	5	58.6	57.1	55.7
	8	82.8	80.7	78.6
9/16-12 UNC	5	84.5	82.4	80.3
	8	119.4	116.5	113.5
5/8-11 UNC	5	116.6	113.7	110.8
	8	164.8	160.7	156.6
3/4-10 UNC	5	206.8	201.7	196.5
	8	292.3	284.9	277.6
7/8-9 UNC	5	333.8	325.4	317.1
	8	471.6	459.8	448.0
1-8 UNC	5	500.3	487.8	475.3
	8	707.0	689.3	671.6
1 1/8-7 UNC	5	624.0	608.4	592.8
	8	1001.4	976.4	951.4
1 1/4-7 UNC	5	880.5	858.5	836.5
	8	1413.1	1377.8	1342.5
1 3/8-6 UNC	5	1154.5	1125.6	1096.7
	8	1852.8	1806.5	1760.2
1 1/2-6 UNC	5	1532.0	1493.7	1455.4
	8	2458.8	2397.3	2335.8

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Table 1-3

Inch Series with Fine Threads (UNF) – Zinc Flake Coated				
Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28 UNF	5	7.5	7.3	7.1
	8	10.6	10.4	10.1
5/16-24 UNF	5	15.0	14.6	14.2
	8	21.1	20.6	20.1
3/8-24 UNF	5	27.2	26.5	25.8
	8	38.4	37.5	36.5
7/16-20 UNF	5	42.9	41.8	40.7
	8	60.6	59.1	57.6
1/2-20 UNF	5	66.0	64.4	62.7
	8	93.3	90.9	88.6
9/16-18 UNF	5	94.3	91.9	89.6
	8	133.2	129.9	126.6
5/8-18 UNF	5	132.1	128.8	125.5
	8	186.7	182.0	177.3
3/4-16 UNF	5	231.0	225.2	219.4
	8	326.4	318.2	310.1
7/8-14 UNF	5	367.7	358.5	349.3
	8	519.6	506.6	493.6
1-12 UNF	5	547.4	533.7	520.0
	8	773.5	754.2	734.8
1 1/8-12 UNF	5	700.0	682.5	665.0
	8	1123.5	1095.4	1067.3
1 1/4-12 UNF	5	975.0	950.6	926.2
	8	1564.8	1525.7	1486.5
1 3/8-12 UNF	5	1314.4	1281.5	1248.6
	8	2109.5	2056.7	2004.0
1 1/2-12 UNF	5	1723.9	1680.8	1637.7
	8	2766.8	2697.6	2628.4

For Reference Only

Table 1-4 Metric Series with Coarse Threads – Zinc Flake Coated

Metric Series with Coarse Threads – Zinc Flake Coated				
Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	10.9	3.6	3.5	3.4
	12.9	4.2	4.1	4.0
M5x0.8	10.9	7.2	7.0	6.8
	12.9	8.4	8.2	8.0
M6x1.0	8.8	8.3	8.1	7.9
	10.9	12.2	11.9	11.6
	12.9	14.3	13.9	13.6
M8x1.25	8.8	20.2	19.7	19.2
	10.9	29.6	28.9	28.2
	12.9	34.7	33.8	33.0
M10x1.5	8.8	40.0	39.0	38.0
	10.9	58.7	57.2	55.8
	12.9	68.7	67.0	65.3
M12x1.75	8.8	69.7	68.0	66.2
	10.9	102.4	99.8	97.2
	12.9	119.8	116.8	113.8
M14x2	8.8	111.4	108.6	105.8
	10.9	163.6	159.5	155.4
	12.9	191.5	186.7	181.9
M16x2	8.8	172.8	168.5	164.1
	10.9	253.8	247.4	241.1
	12.9	296.9	289.5	282.1
M18x2.5	8.8	246.2	240.1	233.9
	10.9	350.7	341.9	333.2
	12.9	410.4	400.1	389.9
M20x2.5	8.8	348.0	339.3	330.6
	10.9	495.6	483.2	470.8
	12.9	580.0	565.5	551.0
M22x2.5	8.8	474.4	462.6	450.7
	10.9	675.7	658.8	641.9
	12.9	790.7	770.9	751.2
M24x3	8.8	601.3	586.3	571.3
	10.9	856.4	835.0	813.6
	12.9	1002.2	977.1	952.1
M27x3	8.8	881.6	859.6	837.5
	10.9	1255.7	1224.3	1192.9
	12.9	1469.4	1432.7	1395.9

For Reference Only

Metric Series with Coarse Threads – Zinc Flake Coated				
Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M30x3.5	8.8	1195.3	1165.5	1135.6
	10.9	1702.5	1659.9	1617.3
	12.9	1992.3	1942.4	1892.6
M36x4	8.8	2089.8	2037.6	1985.3
	10.9	2976.4	2902.0	2827.6
	12.9	3483.0	3395.9	3308.9

Table 1-5 Metric Series with Fine Threads – Zinc Flake Coated

Metric Series with Fine Threads – Zinc Flake Coated				
Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1.0	8.8	21.6	21.1	20.5
	10.9	31.7	30.9	30.1
	12.9	37.1	36.2	35.3
M10x.75	8.8	46.8	45.6	44.4
	10.9	68.7	67.0	65.3
	12.9	80.4	78.4	76.4
M10x1.25	8.8	42.2	41.1	40.1
	10.9	62.0	60.4	58.9
	12.9	72.5	70.7	68.9
M12x1.0	8.8	79.5	77.5	75.5
	10.9	116.7	113.8	110.9
	12.9	136.6	133.2	129.8
M12x1.25	8.8	76.2	74.2	72.3
	10.9	111.8	109.0	106.3
	12.9	130.9	127.6	124.3
M12x1.5	8.8	72.9	71.1	69.2
	10.9	107.1	104.4	101.7
	12.9	125.3	122.1	119.0
M14x1.5	8.8	120.2	117.2	114.2
	10.9	176.5	172.1	167.7
	12.9	206.6	201.4	196.2
M16x1.5	8.8	184.4	179.8	175.2
	10.9	270.9	264.1	257.3
	12.9	317.0	309.1	301.2
M18x1.5	8.8	276.6	269.7	262.8
	10.9	394.0	384.2	374.3
	12.9	461.1	449.6	438.0

For Reference Only

Metric Series with Fine Threads – Zinc Flake Coated				
Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M20x1	8.8	405.7	395.5	385.4
	10.9	577.8	563.3	548.9
	12.9	676.1	659.2	642.3
M20x1.5	8.8	386.0	376.3	366.7
	10.9	549.7	535.9	522.2
	12.9	643.3	627.2	611.1
M22x1.5	8.8	520.8	507.8	494.8
	10.9	741.7	723.2	704.7
	12.9	868.0	846.3	824.6
M24x2	8.8	655.8	639.4	623.0
	10.9	934.0	910.6	887.3
	12.9	1092.9	1065.6	1038.3
M27x2	8.8	951.4	927.6	903.8
	10.9	1355.0	1321.1	1287.2
	12.9	1585.6	1546.0	1506.3
M30x1.5	8.8	1369.2	1334.9	1300.7
	10.9	1950.0	1901.3	1852.5
	12.9	2281.9	2224.9	2167.8
M30x2	8.8	1324.6	1291.5	1258.4
	10.9	1886.6	1839.4	1792.2
	12.9	2207.7	2152.5	2097.3
M33x2	8.8	1784.5	1739.9	1695.3
	10.9	2541.6	2478.0	2414.5
	12.9	2974.2	2899.8	2825.4
M36x2	8.8	2340.1	2281.6	2223.1
	10.9	3332.8	3249.5	3166.2
	12.9	3900.2	3802.6	3705.1

For Reference Only

Table 1-6 Metric Series Screws of STAINLESS STEEL A2-70/A4-70 with Coarse Threads

Size	Torque (Nm)
M2.5x0.45	0.4
M3x0.5	0.9
M4x0.7	1.5
M5x0.8	3.1
M6x1	5.3
M8x1.25	13
M10x1.5	27

Torque Values for fasteners **with lubrication** these torque values result in an 80% utilization of the yield strength.

Stainless steel fasteners tend to gall while being tightened. To reduce this risk, lubricate the threads and torque at low speeds without interruptions. Do not use excessive pressure. Impact wrenches are not recommended.

Table 1-7 Inch Series Screws of STAINLESS STEEL 300 (18-8) with Coarse Threads

Size	Torque	
	lb-in	lb-ft
#5-40 (0.125)	6.9	-
#6-32 (0.138)	9	-
#8-32 (0.164)	18	-
#10-24 (0.190)	21	-
1/4-20	68	-
5/16-18	120	10
3/8-16	210	17.5

Torque Values for fasteners **with lubrication** these torque and preload values result in an 80% utilization of the yield strength.

Stainless steel fasteners tend to gall while being tightened. To reduce this risk, lubricate the threads and torque at low speeds without interruptions. Do not use excessive pressure. Impact wrenches are not recommended.

For Reference Only

Table 1-8

Inch Series Bearing Bolts – Untreated (black finish)				
Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
5/8-11 UNC	8	234	225	216
5/8-18 UNF	8	250	240	230
3/4-10 UNC	8	385	370	355
7/8-9 UNC	8	615	591	567
1-8 UNC	8	929	893	857
1 1/4-7 UNC	8	2043	1964	1885

Table 1-9

Metric Series Bearing Bolts– Untreated (black finish)				
Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (Nm)		
		Maximum	Nominal	Minimum
M20X2.5	12.9	756	727	698
M24X3	10.9	1089	1047	1005
M27X3	10.9	1591	1530	1469

Table 1-10

Inch Series with Coarse Threads (UNC) – Untreated (black finish)				
Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20	5	9.0	8.4	7.7
	8	12.5	12	11.5
5/16-18	5	19	18	17
	8	26	25	24
3/8-16	5	32	31	30
	8	48	46	44
7/16-14	5	52	50	48
	8	73	70	67
1/2-13	5	78	75	72
	8	120	115	110
9/16-12	5	114	110	106
	8	161	152	143
5/8-11	5	156	150	144
	8	234	225	216

For Reference Only

Inch Series with Coarse Threads (UNC) – Untreated (black finish)				
Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
3/4-10	5	270	259.5	249
	8	385	370	355
7/8-9	5	416	400	384
	8	615	591	567
1-8	5	606	583	560
	8	929	893	857
1 1/8-7	5	813	782	751
	8	1342	1288	1234
1 1/4-7	5	1141	1097	1053
	8	2043	1964	1885
1 3/8-6	5	1519	1461	1403
	8	2496	2396	2296
1 1/2-6	5	2028	1946.5	1865
	8	3276	3150	3024

For Reference Only

Table 1-11

Inch Series with Fine Threads (UNF) – Untreated (black finish)				
Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28	5	10	9.5	9
	8	14.5	14	13.5
5/16-24	5	21	20	19
	8	26	25	24
3/8-24	5	36	35	34
	8	53	51	49
7/16-20	5	57	55	53
	8	85	82	79
1/2-20	5	88	84.5	81
	8	125	120	115
9/16-18	5	126	121	116
	8	177	170	163
5/8-18	5	182	174.5	167
	8	250	240	230
3/4-16	5	312	299.5	287
	8	425	409	393
7/8-14	5	458	439.5	421
	8	672	646	620
1-12	5	658	632	606
	8	1009	970	931
1-14	5	670	644.5	619
	8	945	908.5	872
1 1/8-12	5	882	848	814
	8	1500	1440	1380
1 1/4-12	5	1251	1203	1155
	8	2092	2008.5	1925
1 3/8-12	5	1704	1638	1572
	8	2833	2719	2605
1 1/2-12	5	2288	2196.5	2105
	8	3640	3500	3360

For Reference Only

Table 1-12

Metric Series with Coarse Threads – Untreated (black finish)				
Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	8.8	3.1	2.9	2.8
	10.9	4.5	4.3	4.1
	12.9	5.4	5.2	4.9
M5x0.8	8.8	6.5	6.2	5.9
	10.9	9.2	8.9	8.5
	12.9	11	10.5	10
M6x1	8.8	11	10.5	10
	10.9	16	15	14
	12.9	19	18	17
M8x1.25	8.8	27	26	25
	10.9	38	36.5	35
	12.9	45	43.5	42
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144
M14x2	8.8	148	142	136
	10.9	212	203.5	195
	12.9	248	238	228
M16x2	8.8	230	221	212
	10.9	322	310	298
	12.9	387	372	357
M18x2.5	8.8	319	306.5	294
	10.9	455	436.5	418
	12.9	532	511	490
M20x2.5	8.8	447	430	413
	10.9	629	605	581
	12.9	756	727	698
M22x2.5	8.8	608	585	562
	10.9	856	823	790
	12.9	1029	989	949

For Reference Only

Metric Series with Coarse Threads – Untreated (black finish)				
Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M24x3	8.8	774	744	714
	10.9	1089	1047	1005
	12.9	1306	1256	1206
M27x3	8.8	1134	1090	1046
	10.9	1591	1530	1469
	12.9	1910	1836.5	1763
M30x3.5	8.8	1538	1479	1420
	10.9	2163	2080	1997
	12.9	2595	2495	2395
M36x4	8.8	2681	2578.5	2476
	10.9	3964	3812	3660
	12.9	4639	4461	4283

Table 1-13

Metric Series with Fine Threads – Untreated (black finish)				
Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1	8.8	29	28	27
	10.9	41	39.5	38
	12.9	49	47	45
M10x0.75	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M10x1.25	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M12x1	8.8	101	97.5	94
	10.9	150	144	138
	12.9	175	168	161
M12X1.25	8.8	100	96	92
	10.9	147	141.5	136
	12.9	172	165.5	159
M12x1.5*	8.8	100	96	92
	10.9	140	135	130
	12.9	168	162	156

For Reference Only

Metric Series with Fine Threads – Untreated (black finish)				
Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M14x1.5	8.8	160	153.5	147
	10.9	229	220	211
	12.9	268	257	246
M16x1.5	8.8	248	238.5	229
	10.9	348	335	322
	12.9	418	402	386
M18x1.5	8.8	345	331.5	318
	10.9	491	471	451
	12.9	575	552	529
M20X1	8.8	471	453	435
	10.9	694	667.5	641
	12.9	812	781	750
M20x1.5	8.8	483	464.5	446
	10.9	679	653	627
	12.9	816	785	754
M22x1.5	8.8	657	632	607
	10.9	924	888.5	853
	12.9	1111	1068	1025
M24x2	8.8	836	803.5	771
	10.9	1176	1130.5	1085
	12.9	1410	1356	1302
M27x2	8.8	1225	1171.5	1130
	10.9	1718	1652.5	1587
	12.9	2063	1983.5	1904
M30x1.5	8.8	1530	1471.5	1413
	10.9	2253	2166.5	2080
	12.9	2637	2536	2435
M30x2	8.8	1661	1597.5	1534
	10.9	2336	2246.5	2157
	12.9	2800	2695	2590
M33x2	8.8	2141	2059	1977
	10.9	3155	3034	2913
	12.9	3692	3550.5	3409
M36x2	8.8	2795	2688	2581
	10.9	4118	3960	3802
	12.9	4818	4634	4450

For Reference Only

WELD STUD TORQUE

Unless otherwise specified the following grade 2 torque values (+/- 10%) apply to weld studs.

Table 1-14
Weld Stud Torque Values

STUD SIZE	TORQUE
#10	20 lb in
1/4"	4 lb ft
5/16"-18	9 lb ft
5/16"-24	10 lb ft
3/8"	14 lb ft
1/2"	35 lb ft
5/8"	70 lb ft

T-2-4

HYDRAULIC FITTING TIGHTENING

F.F.F.T. METHOD (Flats from Finger Tight)

Manitowoc Cranes. recommends that the F.F.F.T. tightening method described here be used when assembling all hydraulic fittings. This method will minimize the risk of fitting damage or failure due to under or overtightening.

It will also reduce the chance of a leaky connection which is caused normally by different plating combinations of fittings. This method is particularly useful when plating type of fitting is unknown and during maintenance or repair when a joint may be oily.

Follow these steps when tightening all fitting connections:

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Align tube or hose to the mating fitting and check to see that the flare seats properly on the nose of the fitting.
3. Finger tighten the nut onto the fitting. If necessary, a wrench should be used to seat the nut snugly against the fitting. This is considered the “FINGER TIGHT” condition.
4. Using a permanent-type ink marker, make a mark on one of the flats of the nut and continue it onto the hex of the static fitting or port

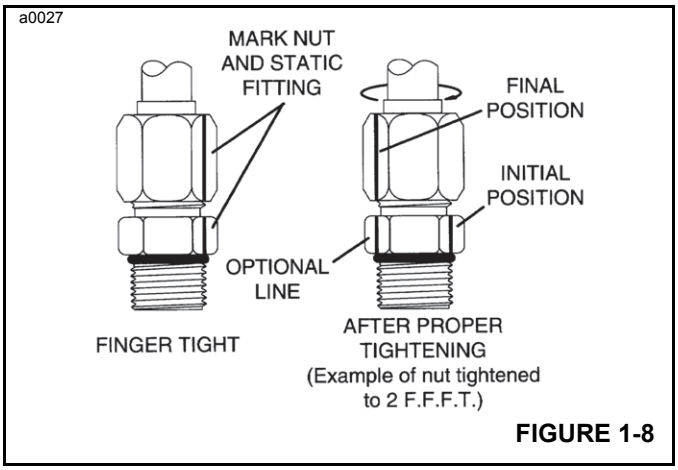


FIGURE 1-8

5. Tighten the joint by the number of flats (F.F.F.T.) as specified in Table 1-15 and 1-16 for size and type of fitting.
6. Optional for future tightening of the same connection. Extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-8).

37° Flared Steel Fitting - Tube or Hose to Fitting

7. Follow F.F.F.T. method, see F.F.F.T. METHOD (Flats from Finger Tight).

Table 1-15

SAE SIZE	TUBE CONN. (F.F.F.T.)	SWIVEL NUT/ HOSE CONN. (F.F.F.T.)
2	–	–
3	–	–
4	2	2
5	2	2
6	1.5	1.25
8	1.5	1
10	1.25	1
12	1.25	1
14	1	1
16	1	1
20	1	1
24	1	1
32	1	1

T-2-5

For Reference Only

Adjustable Straight

Table 1-16
Adjustable Straight Thread O-ring

ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS	
SAE SIZE	(F.F.F.T.)
2	1.0 ± 0.25
3	1.0 ± 0.25
4	1.5 ± 0.25
5	1.0 ± 0.25
6	1.5 ± 0.25
8	1.5 ± 0.25
10	1.5 ± 0.25
12	1.5 ± 0.25
14	1.5 ± 0.25
16	1.5 ± 0.25
20	2.0 ± 0.25
24	2.0 ± 0.25
32	2.0 ± 0.25

T-2-6

Thread O-ring Fitting–Fitting to Port

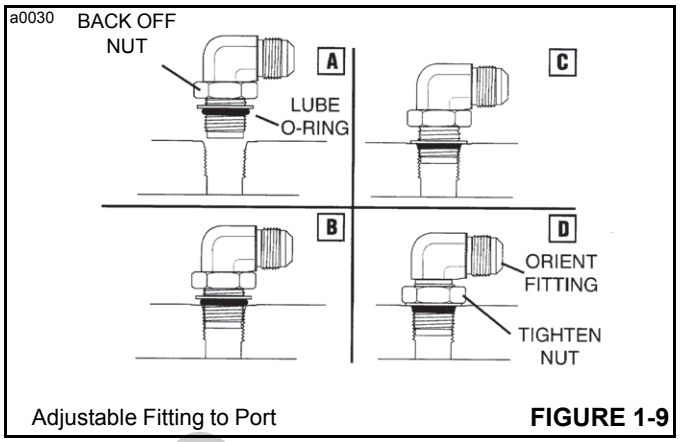
See Table 1-16

1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean oil (Figure 1-9A).
3. Back off locknut as far as possible (Figure 1-9A).
4. Screw fitting into port by hand until the backup washer contacts face of port and is pushed all the way towards the locknut (Figure 1-9B).
5. To orientate the fitting, unscrew the fitting the required amount, but not more than one full turn (Figure 1-9C).
6. Hold the fitting in the desired position and tighten the nut (Figure 1-9D) following the F.F.F.T. method, See F.F.F.T. METHOD (Flats from Finger Tight) starting with step 4.

Nonadjustable Straight Thread O-ring Fitting–Fitting to Port

See Table 1-17

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-10).
3. Turn fitting until finger tight.
4. Using the assembly torque method, tighten to given torque for size from Table 1-17.

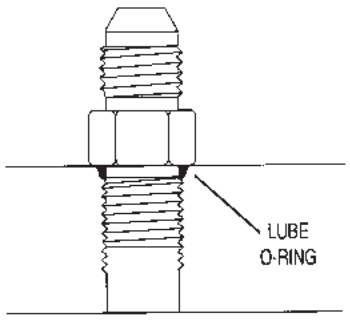


Adjustable Fitting to Port **FIGURE 1-9**

Table 1-17

T-2-7

NON--ADJUSTABLE STEEL STR. THREAD O-RING FITTINGS		
SAE SIZE	TORQUE (lb in)	(lb ft)
2	90 ± 5	7.5 ± 0.5
3	170 ± 10	14 ± 1.0
4	220 ± 15	18 ± 1.0
5	260 ± 15	22 ± 1.0
6	320 ± 20	27 ± 2.0
8	570 ± 25	48 ± 2.0
10	1060 ± 50	90 ± 5.0
12	1300 ± 50	110 ± 5.0
14	1750 ± 75	145 ± 6.0
16	1920 ± 25	160 ± 6.0
20	2700 ± 150	225 ± 12.0
24	3000 ± 150	250 ± 12.0
32	3900 ± 200	325 ± 15.0



Non-Adjustable Fitting to Port **FIGURE 1-10**

For Reference Only

SECTION 2
SAFETY INFORMATION

Introduction **2-1**
Signal Words **2-1**
Signal Word 2-1
Personal Considerations 2-2
Equipment Considerations 2-2
General Considerations 2-3
Operational Considerations 2-3
Environmental Protection **2-4**
Final Word **2-4**

INTRODUCTION

Some of the SERVICE work involves the need to drive the crane. The operator's manual supplied with each crane contains the detailed safety practices relating to driving and operating. These practices apply to the service technician and should be read, understood and practiced.

Prior to performing any service on the crane, considerations should be given to factors that may have an effect upon safety; not only for the mechanic; but also the bystanders.

SIGNAL WORDS

This safety alert symbol means **ATTENTION!** Become alert **- your safety is involved!** Obey all safety messages that follow this symbol to avoid possible death or injury.

Signal Word

It is a distinctive word on safety decals and throughout this manual that alerts the viewer to the existence and relative degree of the hazard.

DANGER

Identifies **hazards** that will result in death or serious injury if the message is ignored**.**

WARNING

Identifies **hazards** that could result in death or serious injury if the message is ignored.

CAUTION

Identifies **hazards** that could result in minor or moderate injury if the message is ignored.

CAUTION

Without the safety alert symbol, identifies **hazards** that could result in property damage if the message is ignored.

Important

The information in this manual does not replace any safety rules and laws used in your area. Before operating the crane, learn the rules and laws for your area. Make sure the machine has the correct equipment according to these rules and laws.

Your safety and the safety of others in the work area depend significantly upon your knowledge and understanding of all correct operating and service practices and procedures for this machine.

For Reference Only

Personal Considerations

	What to do	Why
Clothing	Check to see that you are suitably clothed. For certain work it may be necessary to wear flame or acid resistant clothing.	The wrong cloths or carelessness in dress can cause accidents and injury.
Eye Protection	Wear eye protection when chiseling, grinding, dazing, welding, painting, etc.	The smallest eye injury may cause loss of vision.
Breathing Protection	Wear respiratory protection.	Fume, dust and paint spray are unpleasant and harmful.
Hearing Protection	Use ear protection if noise is excessive.	A loud noise may damage your hearing. The greater the exposure, the worse the damage.
Hand Protection	Wear leather gloves, especially when handling wire rope.	Protects hands from cuts and abrasions.
	Use protective cream before work and clean hands thoroughly after.	Prevents irritation and skin contamination.
Foot Protection	Wear protective footwear with reinforced toe caps and oil-resistant soles.	Protects feet from falling objects and to avoid slipping.
Lifting	Make sure you are capable of lifting the object. If in doubt, get help.	Avoids injury through incorrect handling of components.

Equipment Considerations

	What to do	Why
Operator's Cab	Before using the crane, be sure there are no loose items in operator's cab.	Prevents operator injury from parts of operator's body or clothing being caught on objects when leaving the cab.
Lifting Equipment	Ensure that lifting equipment (chains, brackets, hooks etc.) is checked before use. If in doubt, select stronger equipment. Replace worn or damaged equipment.	Prevents serious injury or death due to falling objects.
	Never stand under a suspended load.	Prevents serious injury or death.
Compressed Air	Never use compressed air to blow dust, filings, dirt, etc., from work area unless the correct type of nozzle is used.	Prevents serious injury to operator and/or bystanders.
	Look around before using an air hose. Warn others.	Yourself and bystanders may get grit into their eyes, ears or skin.

For Reference Only

	What to do	Why
Hand Tools	Never use the wrong tool for the job.	Many cuts, abrasions and injuries are caused by defective or wrong tools.
	Always use the recommended tool.	These tools will reduce work, labor and cost.
	Always keep tools clean and in good working condition.	

General Considerations

	What to Do	Why
Solvents	Use only cleaning fluids and solvents that are known to be safe.	Certain types of fluids cause damage to components and can cause skin irritations.
Housekeeping	Clean and remove all hazards from the area.	Improves surroundings and daily environment for everybody.
First Aid	Do not overlook any cut, abrasion or burn. Have it cleaned and dressed properly.	What appears at first trivial could become painful and injurious.
	Make sure you know the location of the First Aid Box.	Results in quick application of aid procedures.
Cleanliness	Plug all hose ends and connections.	Ensures optimum performance.
	Clean exterior of all parts before repairing.	Dirt and abrasive dust can reduce the efficiency and working life of a component and lead to costly replacement.

Operational Considerations

	What to do	Why
Engine	Stop the engine and engage parking brake before performing any service.	Inhibits serious injury and/or death.
	Place a warning sign in cab to warn others that service is being performed on the crane. Disconnect the battery leads if leaving the unit unattended.	Inhibits serious injury and/or death.
	Do not attempt to start the engine while standing beside it.	Inhibits serious injury and/or death.
Hoists	Do not remove any hoist component unless the drop block or hook and ball are lowered to the ground.	Inhibits serious injury and/or death.
Radiator Cap	Always remove the radiator cap only when the engine cooling system is cool. Turn the radiator cap slowly to first stop to relieve pressure.	Escaping coolant will burn.
Supports	Make sure safe and stable supports are installed before removing any component or structural item.	Inhibits serious injury and/or death.

For Reference Only

	What to do	Why
	Be sure to remove the ignition key before working underneath the machine. Always apply the parking brake.	Inhibits accidental start and movement of the machine which could cause serious injury or death.
Oil Pressure	Before loosening hoses or tubes, make sure all hydraulic pressure is relieved.	A pressure explosion will cause serious injury.
Pressure Testing	Make sure all test equipment is in good condition. Use only specified gauges. Comply with test procedures specified.	Inhibits damage to the system or the equipment and inhibits the possibility of personal injury.
Parking	Do not park or attempt to service the crane on an incline. If unavoidable block the tires.	Inhibits serious injury and/or death.
Wheels and Tires	Do not over-inflate the tires.	Over-inflation can cause tires to burst and could result in injury.

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, observe the following:

- 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 clean up any spills.

FINAL WORD

Safety precautions are very seldom the figment of someone's imagination. They are the result of sad experiences-most likely personal injury. Heed these precautions and you will protect yourself and others accordingly. Disregard them and you may duplicate the sad experiences of others.

For Reference Only

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GENERAL

To aid in the understanding and troubleshooting of an electrical system, review the terms and information that follows.

CAUTION

Know the electrical circuit before connecting or disconnecting an electrical component. A wrong connection can cause personal injury or damage to the component and/or system.

Electrical Energy - power which comes from the movement of electrons. Electrons are particles with a negative charge. Electrons will collect around particles with a positive charge, called protons, until an electrical imbalance occurs.

Amperage - rate of flow of electrons (CURRENT), measured in amperes.

Voltage - the electromotive force (EMF) which causes electrons to move through an electrical circuit, measured in volts.

Resistance - any resistance to flow of electrons in an electrical circuit, measured in Ohms.

Ohm's Law - "Electric current increases in direct relation to the voltage and decreases in relation to the amount of resistance in any circuit."

To Find:

- **EMF (Voltage)** - Multiply CURRENT (amps) by RESISTANCE (Ohms).
- **RESISTANCE (Ohms)** - Divide EMF (voltage) by CURRENT (amps).
- **CURRENT (Amps)** - Divide EMF (voltage) by RESISTANCE (Ohms).

Consider the following when trying to find trouble in an electrical system:

1. Current always flows from (+) positive to (-) negative, or from the point of highest voltage.
2. Because the system used on this machine is a negative ground system, current that leaves the supply (battery+) returns to the supply (battery–).
3. In series circuit arrangements, the voltage is completely used in the circuit when the current is flowing. In parallel circuit arrangements, the voltage is constant.
4. When the voltage is constant, resistance controls the rate of current (amps) in the circuit. Refer to Ohm's Law.

Comparing Electrical System to a Hydraulic System

The electrical system is in many ways similar to a hydraulic system. Both systems need a “pump” to cause the flow which generates the energy. Each system needs a complete circuit so the flow can return to storage or supply. Both systems need “valves” to control the flow through the system. See Table 3-1.

Table 3-1
Comparing Electrical System and Hydraulic System

ELECTRICAL SYSTEM	HYDRAULIC SYSTEM
Alternator	Pump
Battery	Reservoir
Switches	Valves
Wires and Cables	Tubes and Hoses
Diodes	Check Valves
Volts	PSI or bar (kPa)
Amps	gpm or L/min
Ohms	Resistance

Magnetism

When electrical current passes through a conductor it creates a magnetic field around the conductor. This magnetic field can be used to induce current into a second conductor. This is the principle behind generators, coils, relays and solenoids, which are the working components of the electrical system. These components will be covered further in the discussion of the electrical system.

MAIN ELECTRICAL SYSTEM

General

The electrical system used on this machine is a 12 volt, direct current (DC) system with a (-) negative ground. The power is supplied by one 12 volt battery.

An alternator supplies the necessary current (amps) for system operation, and charging of the battery, when the engine is running. A voltage regulator on the alternator controls the voltage in the charging system. A warning light in the dash indicates when the alternator is not charging the battery.

Wire Harnesses

Five wire harnesses connect the electrical system components:

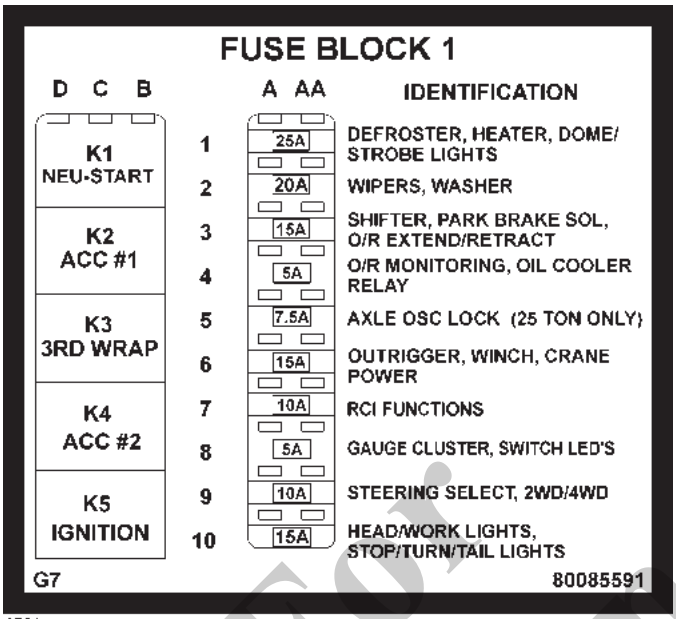
- Dash Wire Harness
- Main Frame Wire Harness
- Engine Wire Harness
- Boom Wire Harness
- Cab Wire Harness

Fuses

The fuses are located for easy access directly below the instrument panel and in the battery compartment. See Figure 3-1 through Figure 3-4.

Identification of the fuse ratings and the circuits protected is shown. Always replace the fuse with one of the same rating.

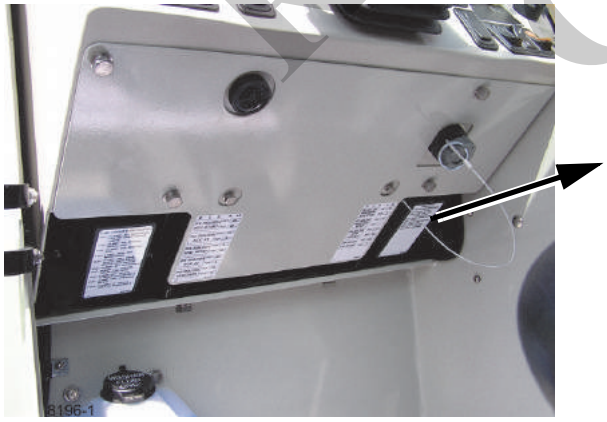
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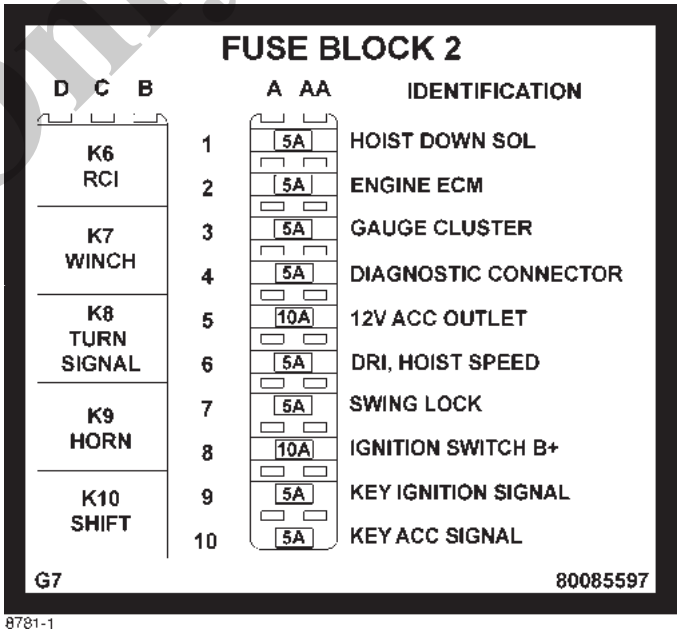




Fuse Block Location &
Relay Identification

FIGURE 3-1

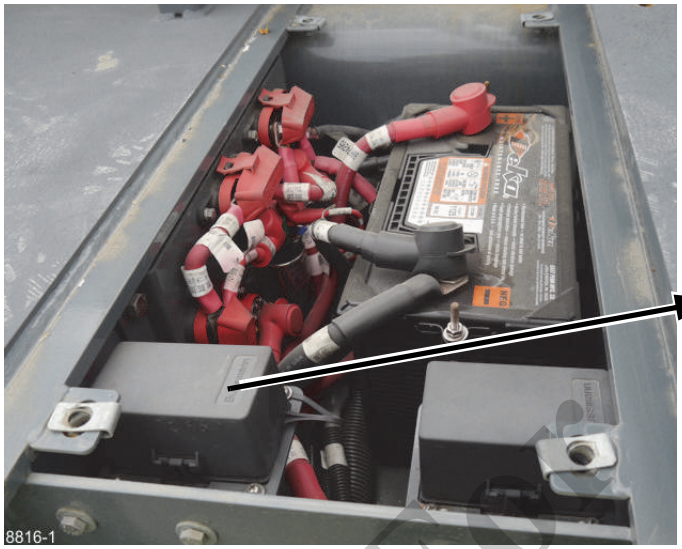


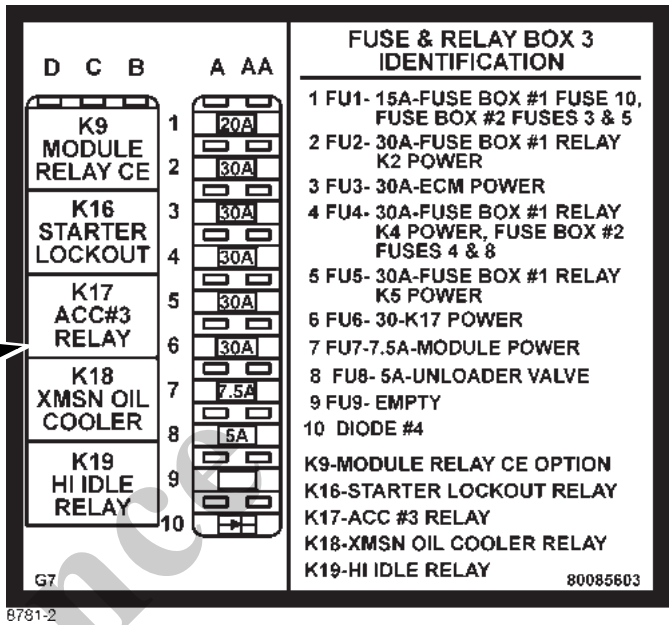


Fuse Block Location &
Relay Identification

FIGURE 3-2

For Reference Only

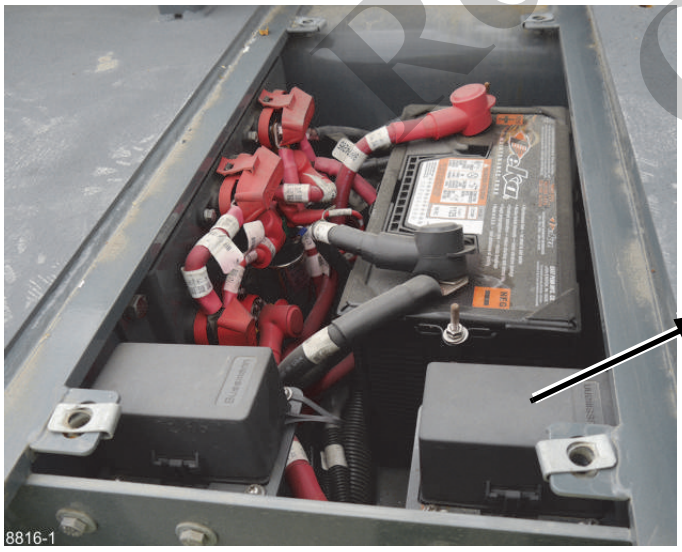


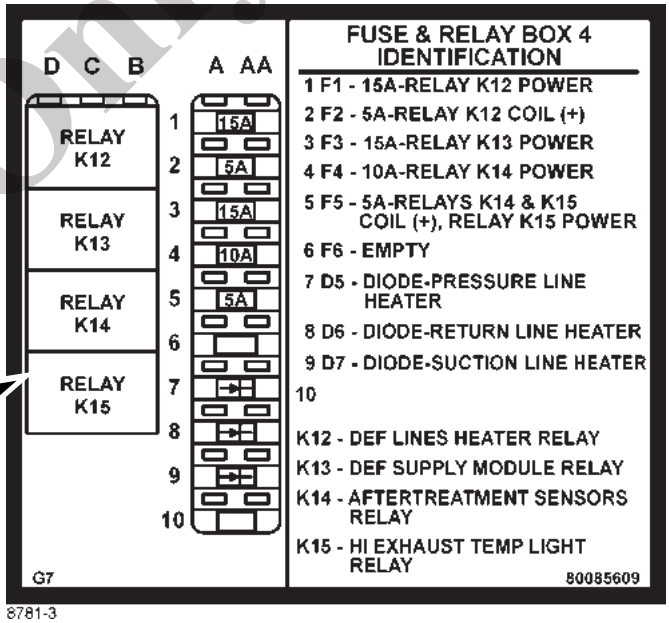


8781-2

Fuse Block Location in Battery/ Relay Compartment

FIGURE 3-3





8781-3

Fuse Block Location in Battery/Relay Compartment T4F Engine Only

FIGURE 3-4

Reference Only

CHARGING SYSTEM

The purpose of the charging system is to give power for operation of the lights, instruments, electrical accessories and controls, and to keep a full charge on the battery. The charging circuit includes the alternator, voltage regulator, warning light, battery, and wiring.

Alternator and Voltage Regulator

The alternator changes the mechanical energy from the engine into electrical energy. The alternator has a “Rotor Assembly,” which rotates inside a series of windings called the “Stator.” The field windings on the rotor receive controlled current from the voltage regulator, which causes a magnetic field around the winding. When the rotor turns, an alternating current (AC) voltage occurs in the windings of the stator. This alternating current is changed to direct current by diodes in the alternator. The alternator has an internal voltage regulator, which controls the output voltage of the alternator by controlling the amount of current through the field windings of the alternator. When the voltage on the line is 14.6 volts, current through the field winding is zero. Below 12 volts, the current is maximum. The voltage regulator keeps the voltage on the line to approximately 14 volts.

Pressure Switch

The pressure switch, when closed by engine oil pressure, energizes the hourmeter in the instrument panel display.

Resistor

The resistor is used to reduce the voltage on the field connection (D+) at the alternator. When the alternator is working, the field does not require full system voltage, therefore the resistor reduces the voltage to approximately 9 volts DC.

Special Precautions

1. Never cause a short circuit or ground in the output or field wires of the alternator. These wires are always hot (charged). A short circuit can cause damage to the alternator diodes.
2. An alternator is not the same as a generator. Never try to change the polarity of the alternator. The diodes keep the correct polarity.
3. Always connect the positive (+) cable from the starter to the positive (+) terminal of the battery. Connect the ground cable from the engine to the negative (-) terminal of the battery. Never change these connections.
4. Never operate the alternator on an open circuit or disconnect the battery when the alternator is operating. A high voltage condition will occur and cause damage to the diodes.
5. When a booster battery is used, make sure the battery is connected correctly (positive terminal to positive terminal; negative terminal to negative terminal).
6. Never use a battery charger as a booster for battery output.
7. Heat can cause damage to the diodes. Keep all sources of heat away from the alternator.

Battery Disconnect Switch

The battery disconnect switch, Figure 3-3, is located in the battery/relay compartment. Turn the switch to OFF to disconnect the battery from the electrical system.

Battery Disconnect Precautions

When disconnecting the battery use the following procedure:

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. Remove the positive battery cables.

Use the following procedure when connecting the battery:

1. Connect leads to the battery terminals starting with the positive terminals.
2. Install the ECM power fuse.
3. Turn the battery disconnect switch to ON.

BATTERY

The battery is a maintenance-free, lead-acid type battery. The battery has four functions:

1. To provide adequate power for starting the engine.
2. To be a stabilizer for voltage in the system.
3. To give power to the system when the electrical loads are greater than the output of the alternator.
4. Store power.

Battery Maintenance and Charging

Battery

A limited amount of maintenance is required on the battery. See *Batteries/Charging System on page 5-39*.

For Reference Only

Replacing Battery

WARNING

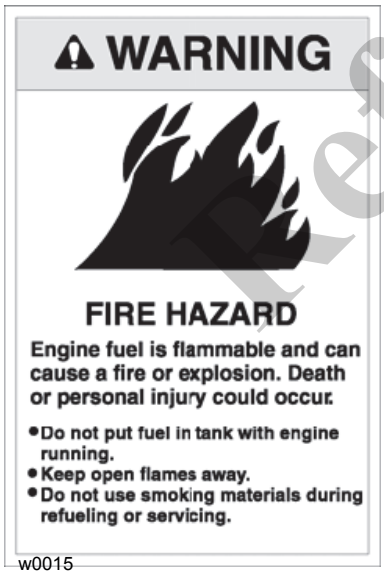
The fluid in electric storage batteries contains sulfuric acid, which is a **POISON** and can cause **SEVERE CHEMICAL BURNS**. Avoid all contact of fluid with eyes, skin or clothing. Use proper protective gear when handling batteries. **DO NOT** tip any battery beyond a 45° angle in any direction. If fluid contact does occur, perform the following First Aid suggestions.

BATTERY ELECTROLYTE FIRST AID:

- **External Contact -** Flush with water.
- **Eyes -** Flush with water for at least 15 minutes and get immediate medical attention.
- **Internal -** Drink large quantities of water. Follow with Milk of Magnesia, beaten egg or vegetable oil. Get immediate medical attention.

NOTE: In case of internal contact, DO NOT give fluids that would induce vomiting.

Remove the battery very carefully to avoid spilling battery fluid. Properly dispose of the battery.



Charging the Battery

WARNING

Batteries produce explosive gases. Keep sparks, flame and lit smoking materials away. Ventilate when charging or using batteries in an enclosed place. Always wear eye protection when working near batteries.

Charging rates between 3 to 50 amperes are satisfactory if no excessive gassing or spewing of electrolyte occurs or the battery does not feel excessively warm (over 52°C [125°F]). If spewing or gassing occurs or temperatures exceed 52°C (125°F), the charging rate must be reduced or temporarily stopped to permit cooling.

"Slow charging" is preferred to "fast charging". Fast charging saves time but risks overheating the battery(s). Slow charging at six (6) amps or less develops less heat inside the battery and breaks up the sulfate on the battery plates more efficiently to bring the battery up to full charge. The use of a "smart charger" that automatically adjusts the charging amperage rate should be used.

When charging the batteries, do not turn on the battery charger until the charging leads have been connected to the battery(s).

Also, if the battery(s) are found to be frozen, do not attempt to charge them. Remove the battery(s) from the crane, allow them to thaw, and then charge the battery(s) to full capacity.

1. Always connect the positive wire (normally red) of the battery charger to the positive (+) terminal of the battery first.
2. Connect the negative wire (normally black) of the battery charger to the engine or frame, far enough away from the battery to prevent explosion should a spark occur.

NOTE: *Sparks occur when current moves from the positive to the negative terminals of the charger. If you disconnect either of the connections, the current in both wires is stopped.*

3. When disconnecting the charger, always remove the negative (-) or ground connection first. Wait approximately one minute after the charger has stopped before disconnecting the chargers positive (+) wire. This procedure will decrease the possibility of explosion of hydrogen gas around the battery.

Jump Starting the Crane

Do not attempt to jump start the crane.

For Reference Only

CAUTION

It is strongly recommended that the batteries not be "jumped" with a different vehicle, portable power pack, etc. The surge of power from these sources can irreparably damage the various electronic controls and computer systems. Jump starting the crane batteries with a different vehicle while the engine is running can damage the donor vehicle electronics as well if done improperly.

All crane models, particularly those produced since 2000, have multiple computer systems (crane control, RCL, engine & transmission control) that are highly susceptible to voltage/amperage surges in the electrical system.

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries.

STARTING CIRCUIT

The starting circuit includes the battery, starter motor and solenoid, starter relay, neutral start relay, and the ignition switch.

General Inspections

Many starting problems can be found by making the following checks:

1. Check that the parking brake is engaged.
2. Check battery condition. Charge or replace the battery as necessary. Clean battery posts and cable connectors.
3. Inspect wiring for worn insulation or other damage. Replace bad wiring. Inspect all connections at the starter motor, starter solenoid, starter relay, neutral start relay and wire harness plugs. Clean and tighten all connections and replace any bad wiring.
4. If the starter still does not operate after correcting the circuit, See the electrical schematic at the end of this manual.

INSTRUMENT AND LIGHT CIRCUITS

General

Power is available to the light switch from a 15 amp fuse on the fuse block. The light switch has three positions. The upper position illuminates the work lights, head lights, tail lights, gauge lights and the instrument panel lights. The center position turns all lights off. The lower position illuminates the head, tail lights and instrument panel lights.

Gauges and Indicators

The gauges are 12 volt components. Power is available to the gauges through a 5 amp fuse when the ignition switch is in the ON position.

Fuel Gauge

The fuel gauge connects to a sending unit in the fuel tank. This sending unit puts a variable resistance in the circuit and causes a corresponding indication on the fuel gauge, representing fuel level.

Engine Oil Pressure Indicator

This indicator connects to the engine ECM. The ECM connects to a sending unit in the engine lubrication system. When the oil pressure is below a predetermined value the sending unit signals the ECM indicating engine oil pressure is too low.

Engine Temperature Gauge

This gauge connects to the engine ECM. The ECM connects to a sending unit in the engine cooling system. The variable resistance caused by the sending unit gives a corresponding indication of the temperature of the engine coolant.

Voltmeter Display

The voltmeter is connected in parallel with the charging circuit. The voltmeter gives an indication of electrical charging system problems that can not be seen with an ammeter.

Normally, when the engine is stopped (ignition switch in the ON position) or when the engine is running at low idle, the voltmeter will indicate 11-14 volts. When the engine is running above low idle, the voltmeter will normally indicate 14-16 volts. More than 16 volts indicates an overcharging condition Table 3-2.

Hour Meter

The hour meter is located in the gauge cluster and is triggered by the engine RPM. Power is available through the engine ECM. The hour meter operates only when the engine is running.

For Reference Only

ECM Display Toggle Switch



FIGURE 3-5

The Display Toggle Switch is used to display engine ECM error codes. With the engine running, press the button, if no engine codes are present the display cluster will read “No Errors Detected”. If a single error code is present, it will be displayed when the button is pressed. If multiple error codes are present, the display will list in the parentheses the number of error codes and will scroll through them in order of occurrence each time the button is depressed.

Table 3-2: Voltage Level Conditions

Voltage Measured	Engine Speed	Condition of Charging System
0-10 volts	Stopped or low idle.	Battery discharged. Low battery charge.
11-12 volts	Above low idle. Stopped or low idle.	Problem in charging system. See Troubleshooting - Charging System. Normal battery charge.
12-14 volts	Above low idle.	Problem in charging system. See Troubleshooting - Charging System. Battery fully charged - no load.
14-16 volts	Stopped or low idle.	If indicator is between 14 and 15 volts, the battery is newly charged. Overcharged battery.
More than 16 volts	Above idle.	Overcharge. See Troubleshooting - Charging System

For Reference Only

WIRE HARNESSES

Carrier Wire Harness

The carrier wire harness Figure 3-6 supplies electrical current to operate the electrical components attached to the main frame. It also connects to the instrument panel and engine wire harnesses.

Engine Wire Harness

The engine wire harnesses Figure 3-7 or Figure 3-8 and supply electrical current from the battery to the charging circuit, starting circuit, and senders attached to the engine. It also supplies the current to the main frame wire harness.

Transmission Wire Harness

The transmission wire harness Figure 3-9 supplies electrical current to the transmission. It connects to the main frame wire harness.

Boom Wire Harness

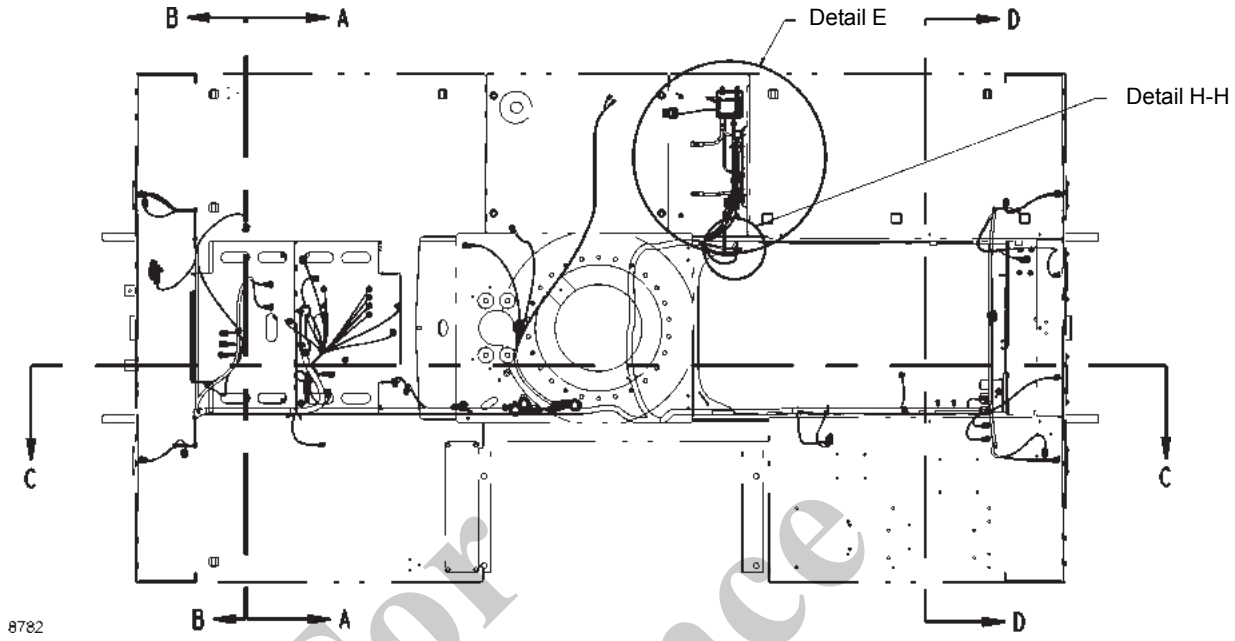
The boom wire harness Figure 3-10 supplies electrical current to the components mounted on the boom.

Cab Wire Harness

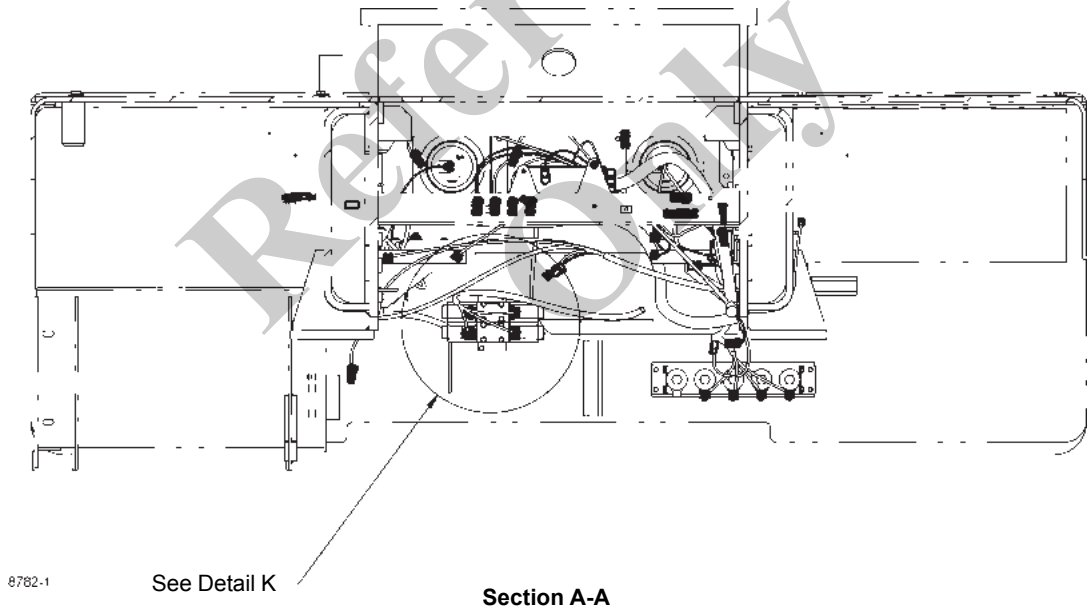
The cab wire harness Figure 3-11 supplies electrical current to the components in the cab not connected to the dash wire harness.

NOTE: *For wire harness wiring diagrams, see Schematics/ Wiring Diagrams at the end of this manual.*

For Reference Only



Top View

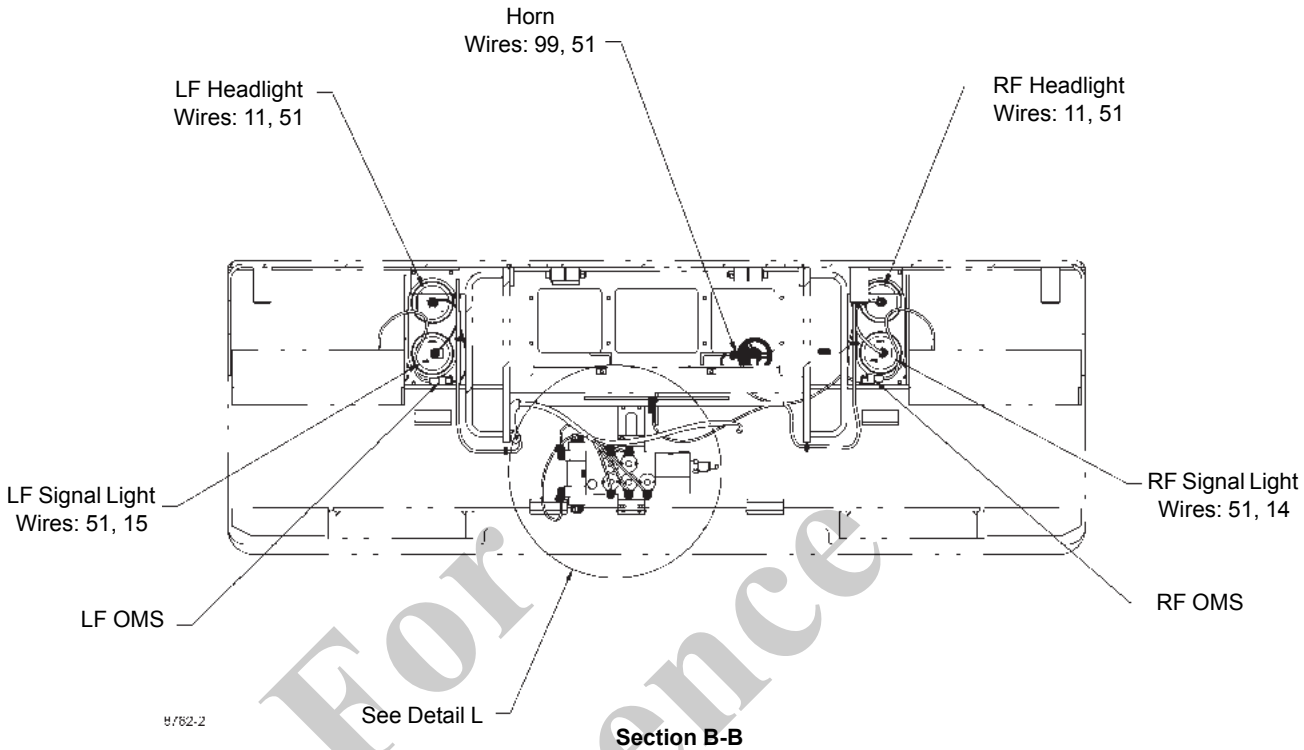


Section A-A

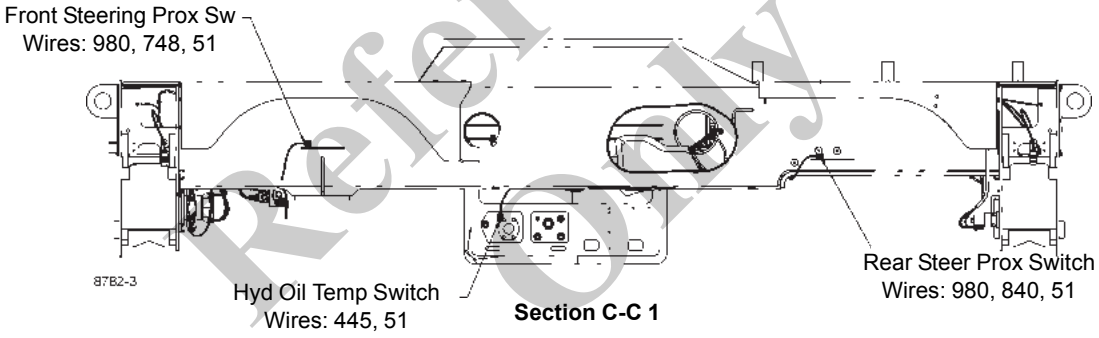
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Carrier Wire Harness

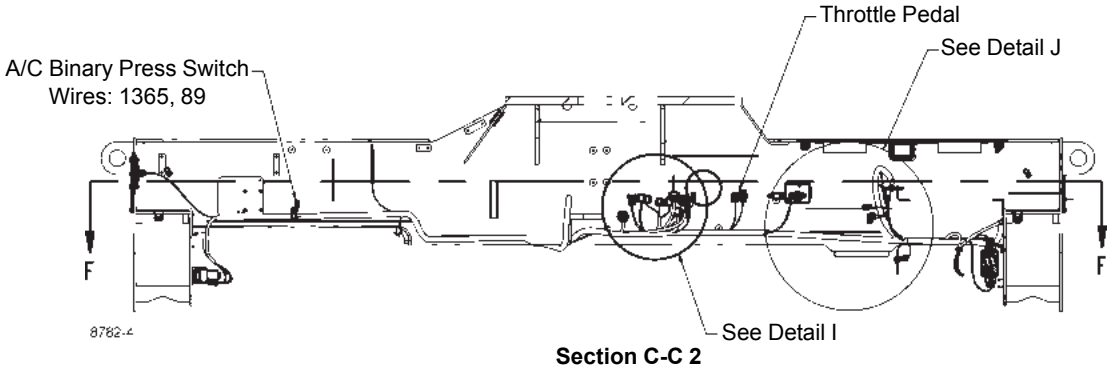
FIGURE 3-6



Section B-B



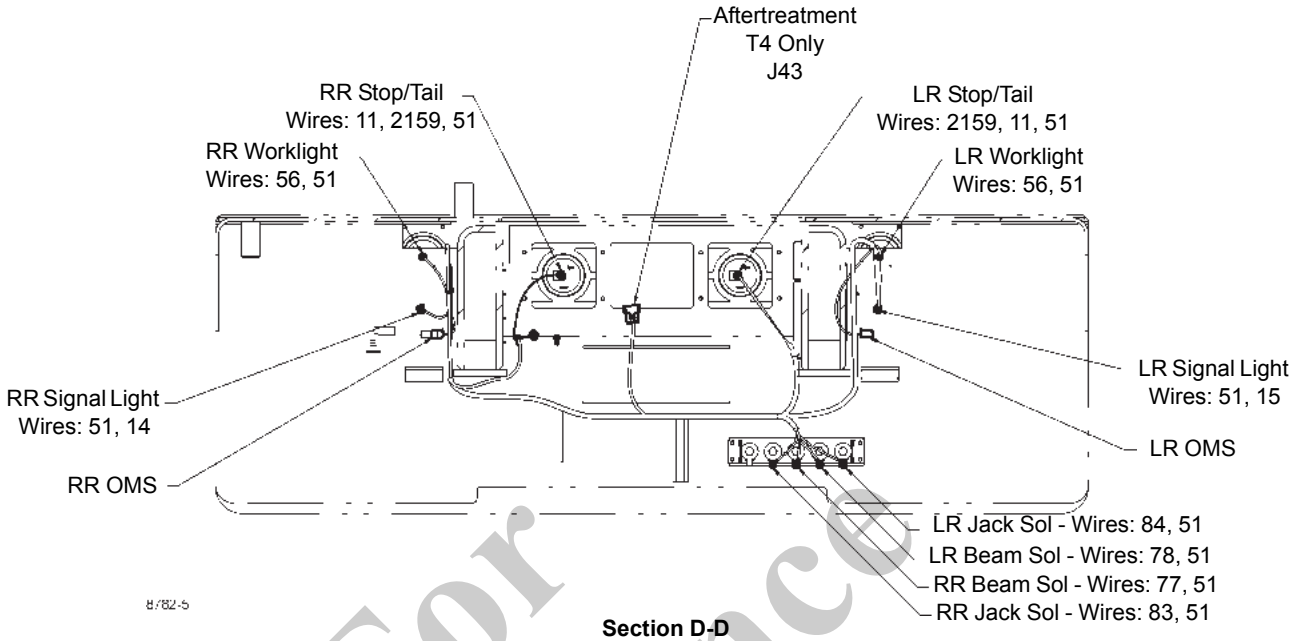
Section C-C 1



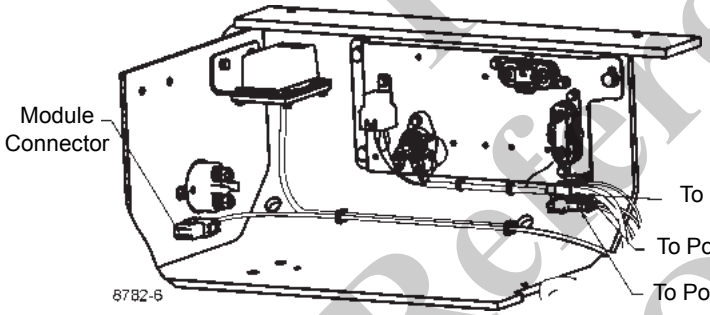
Section C-C 2

FIGURE 3-6 continued

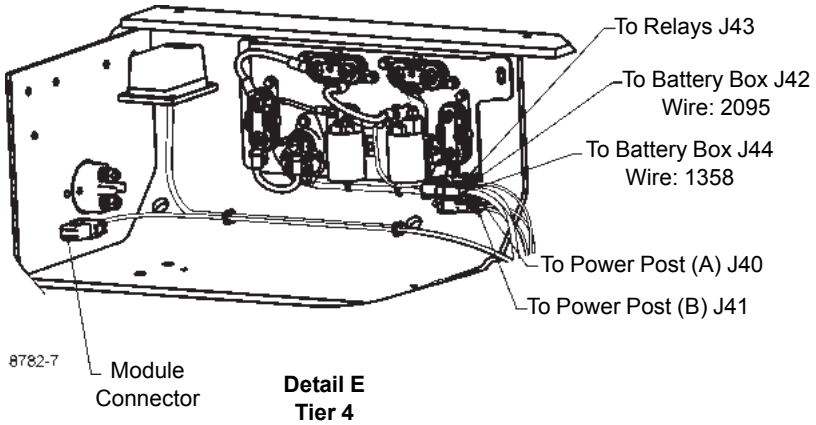
For Reference Only



Section D-D



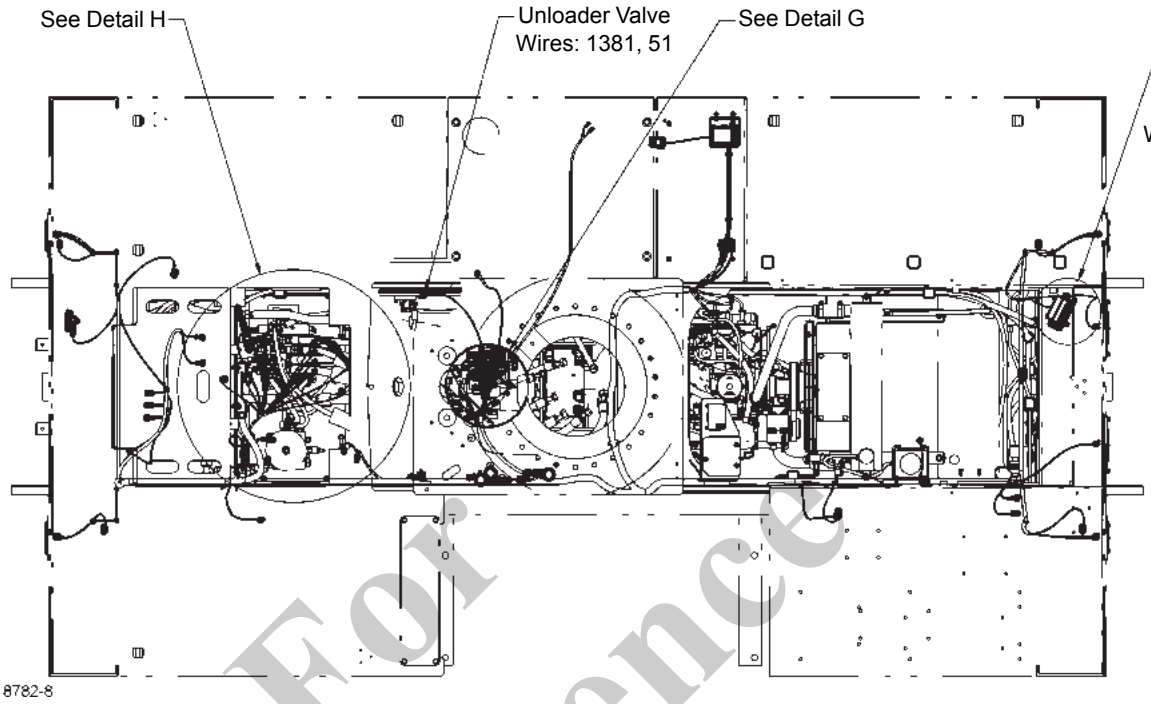
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Dual Fuel



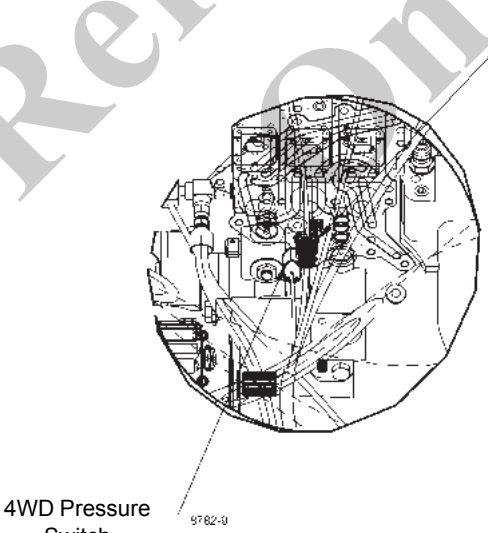
Detail E
Tier 4

FIGURE 3-6 continued

For Reference Only



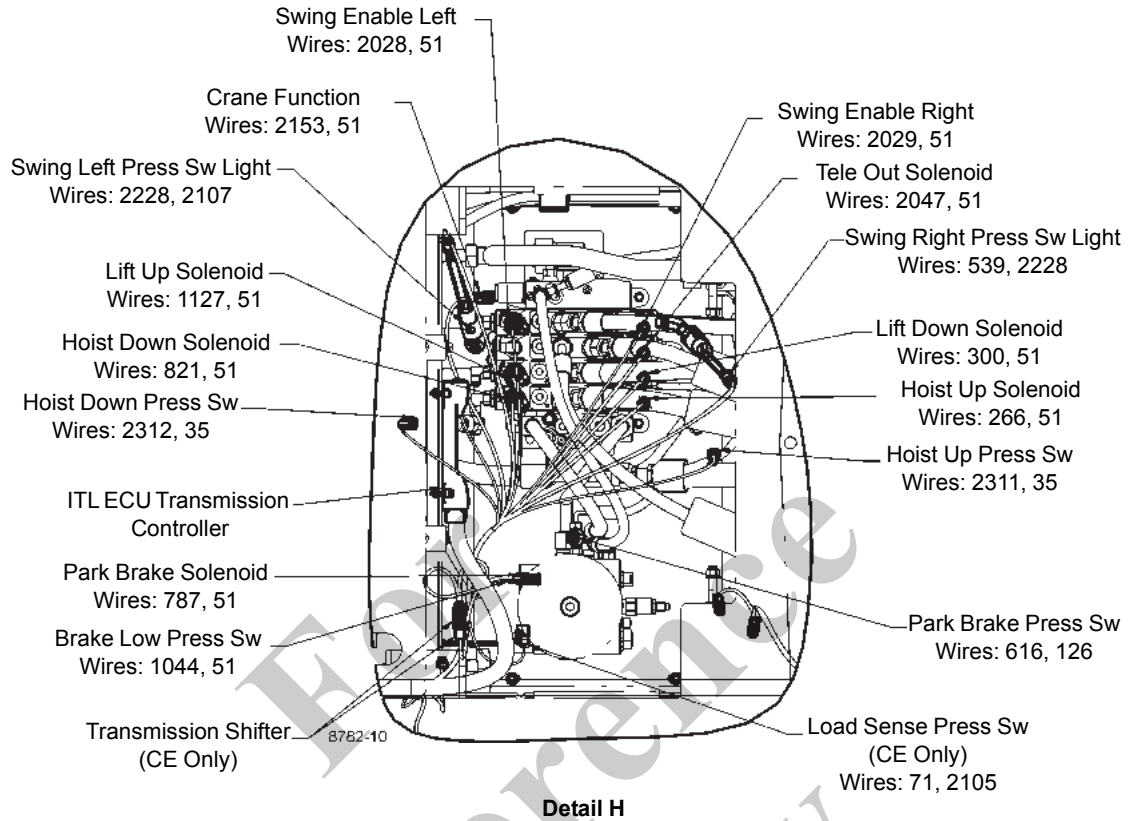
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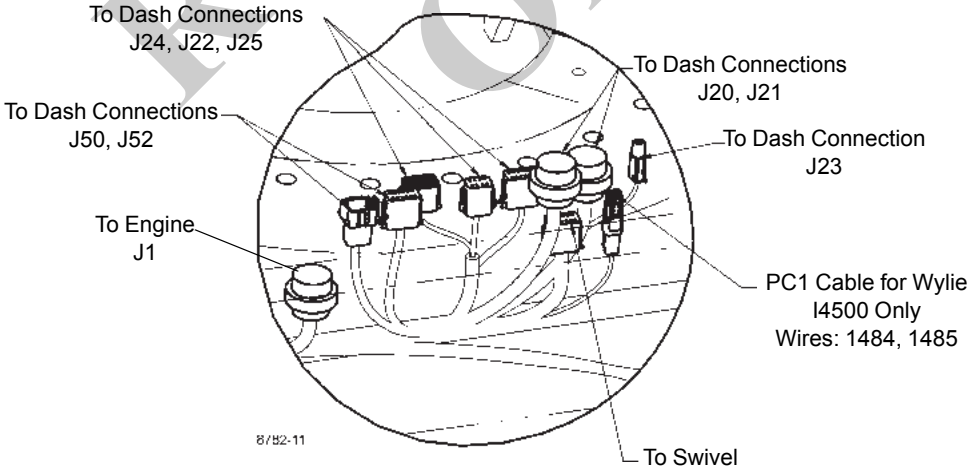
Detail G

FIGURE 3-6 continued

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Detail H



Detail I

FIGURE 3-6 continued

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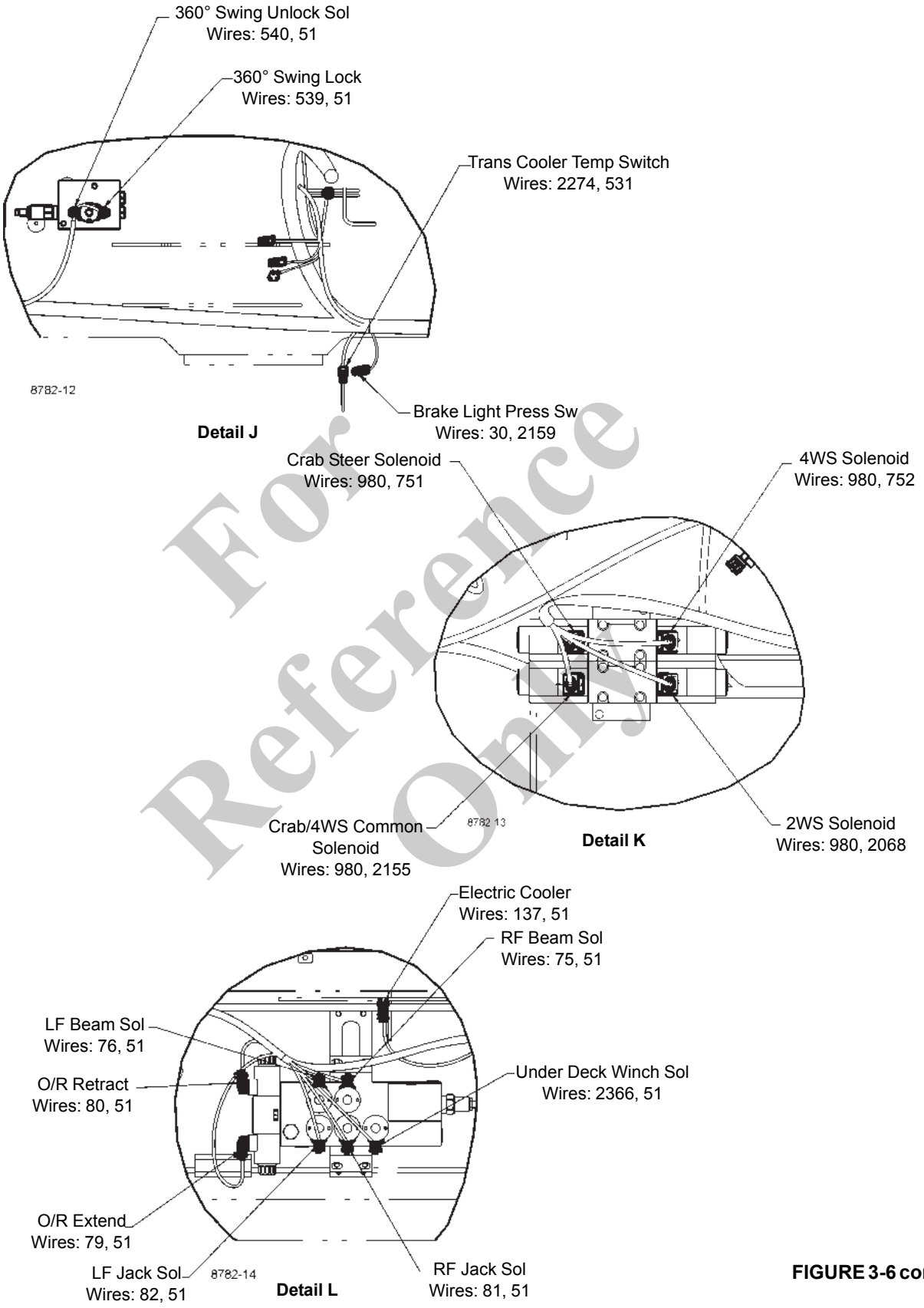
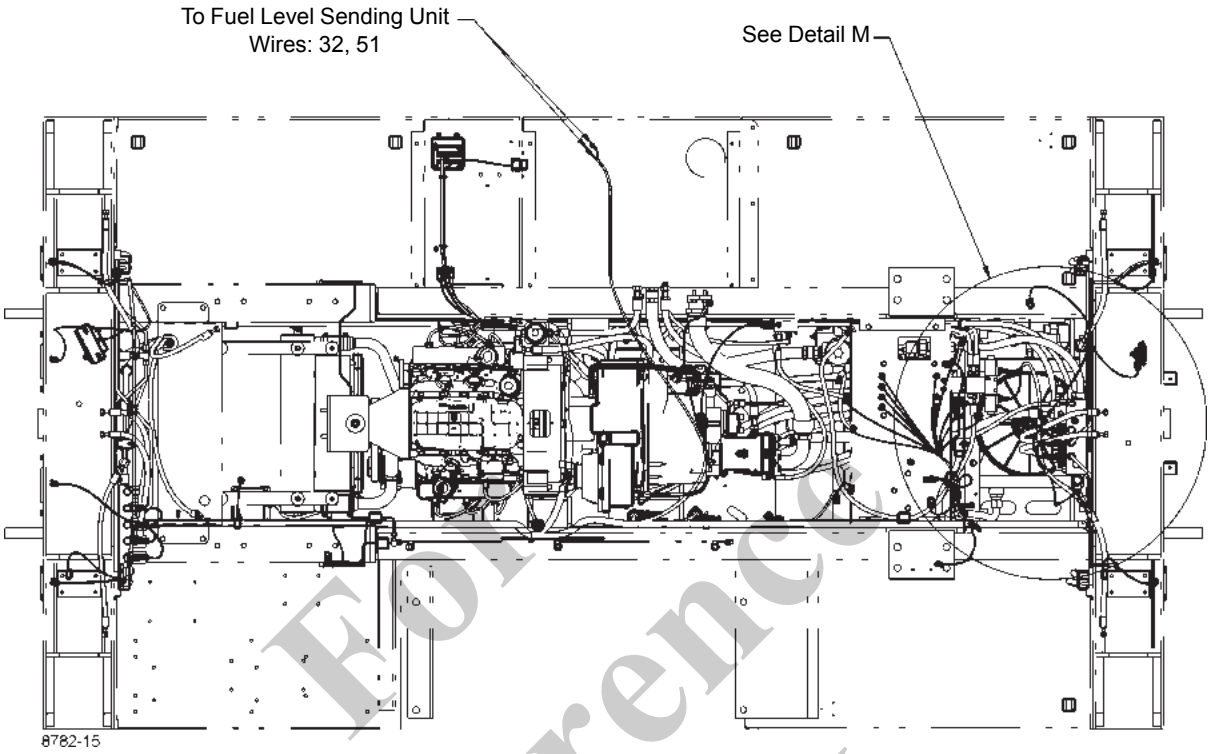
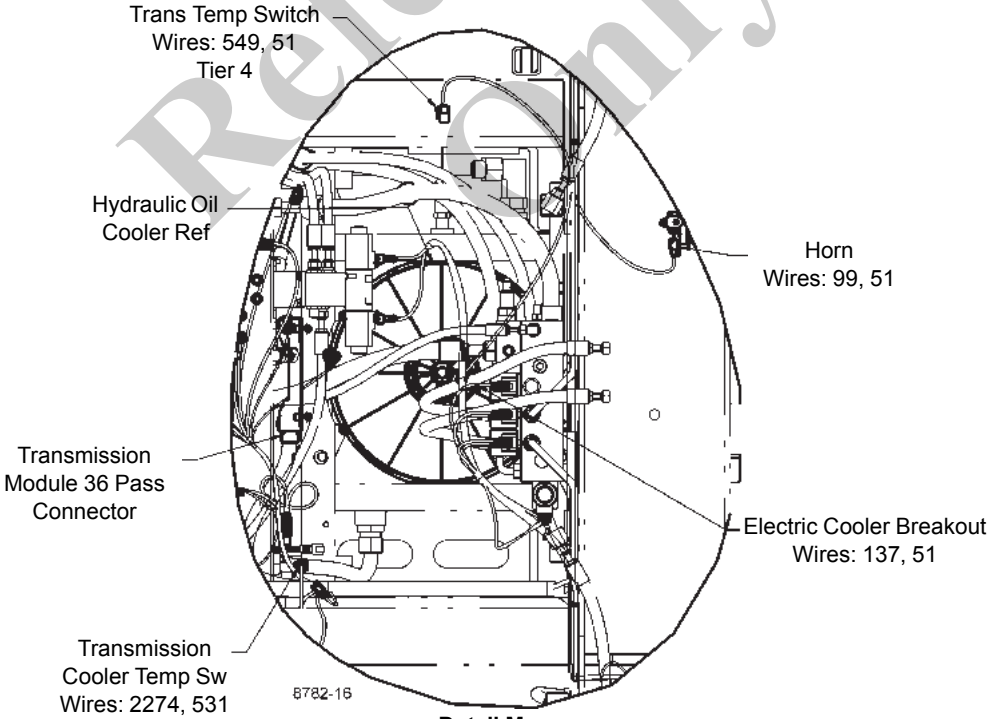


FIGURE 3-6 continued

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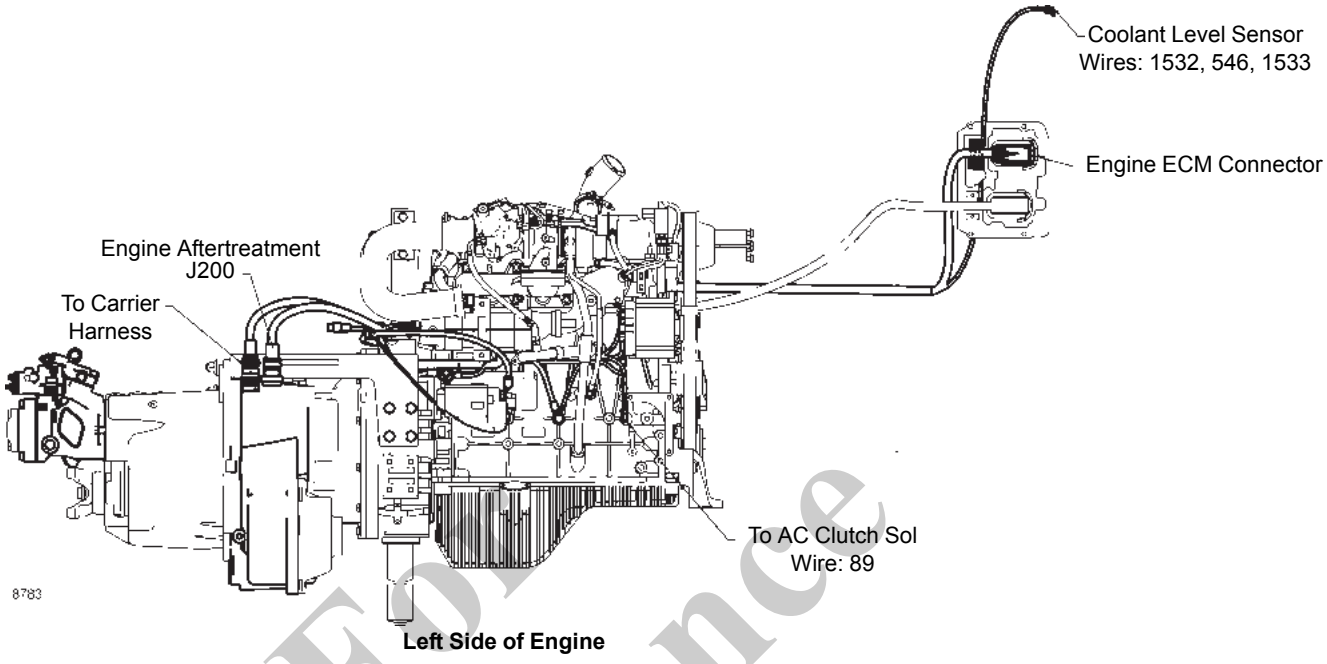
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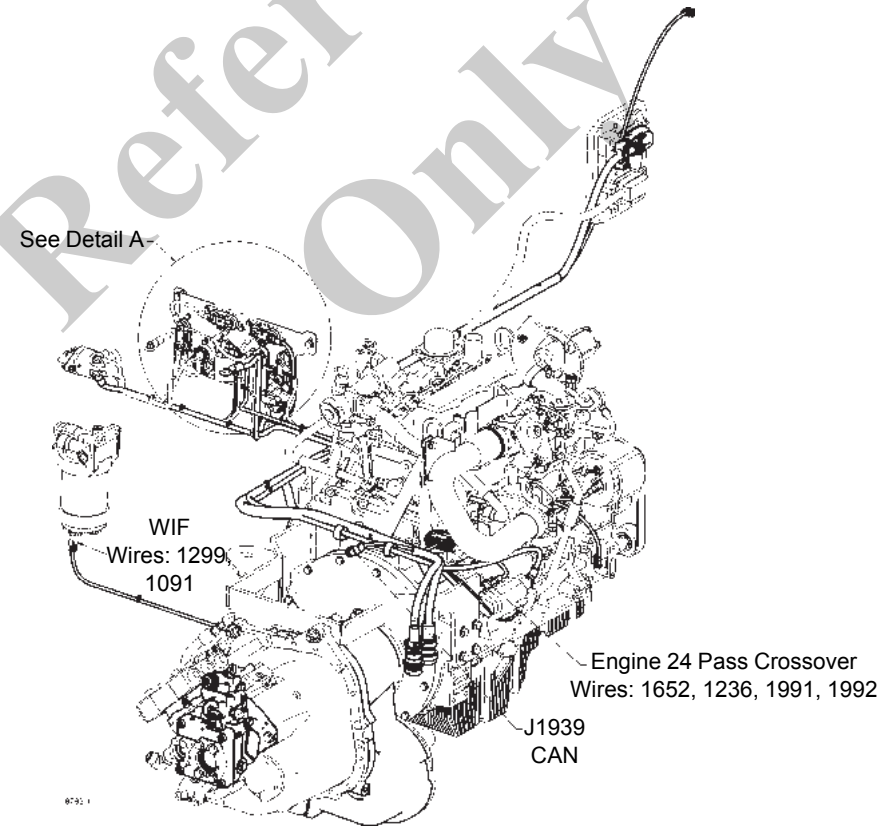
Detail M

FIGURE 3-6 continued

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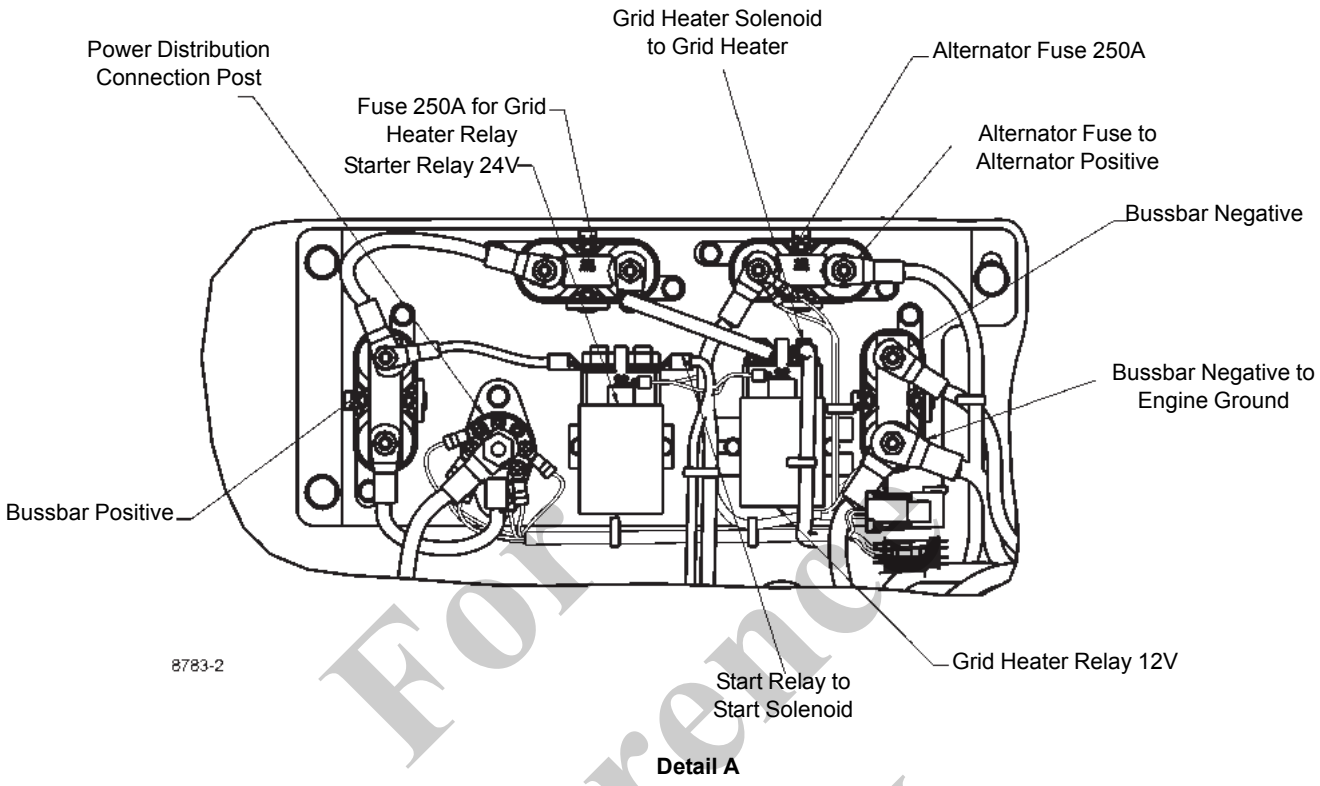
Left Side of Engine



Tier 4 Engine Wire Harness

FIGURE 3-7

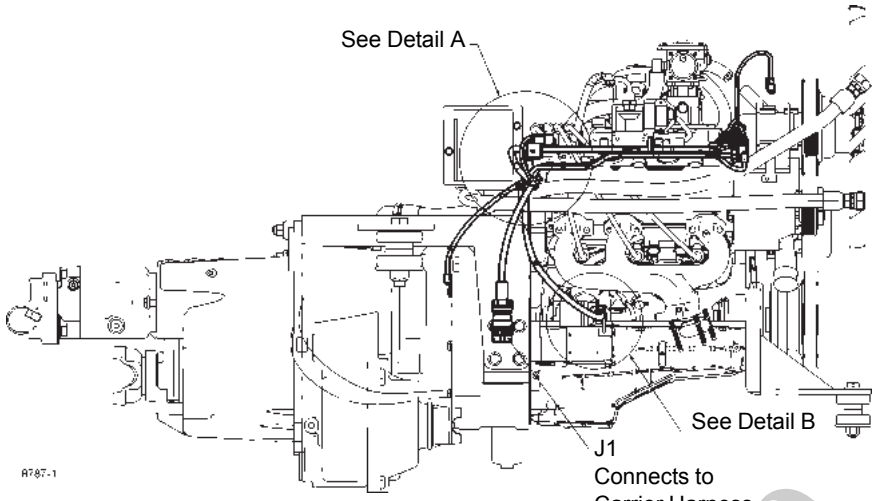
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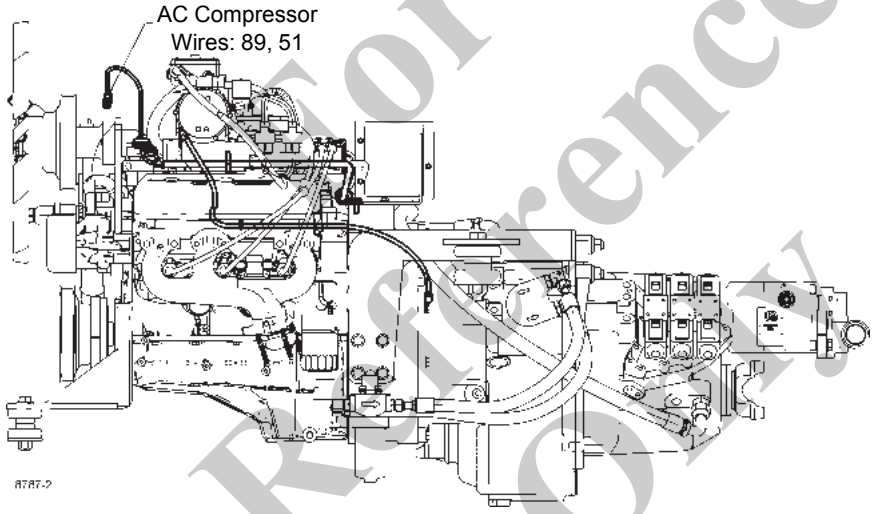
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FIGURE 3-7 continued

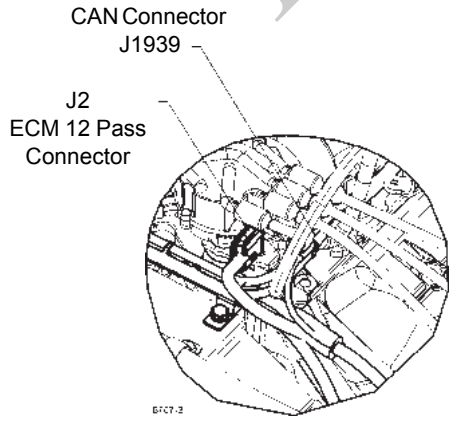
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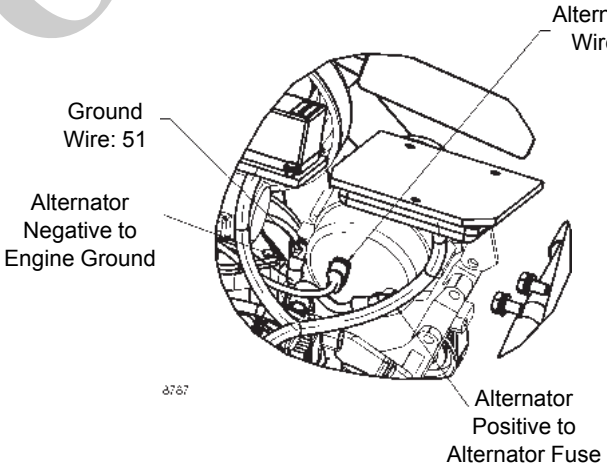
Left Side of Engine



Right Side of Engine



Detail A

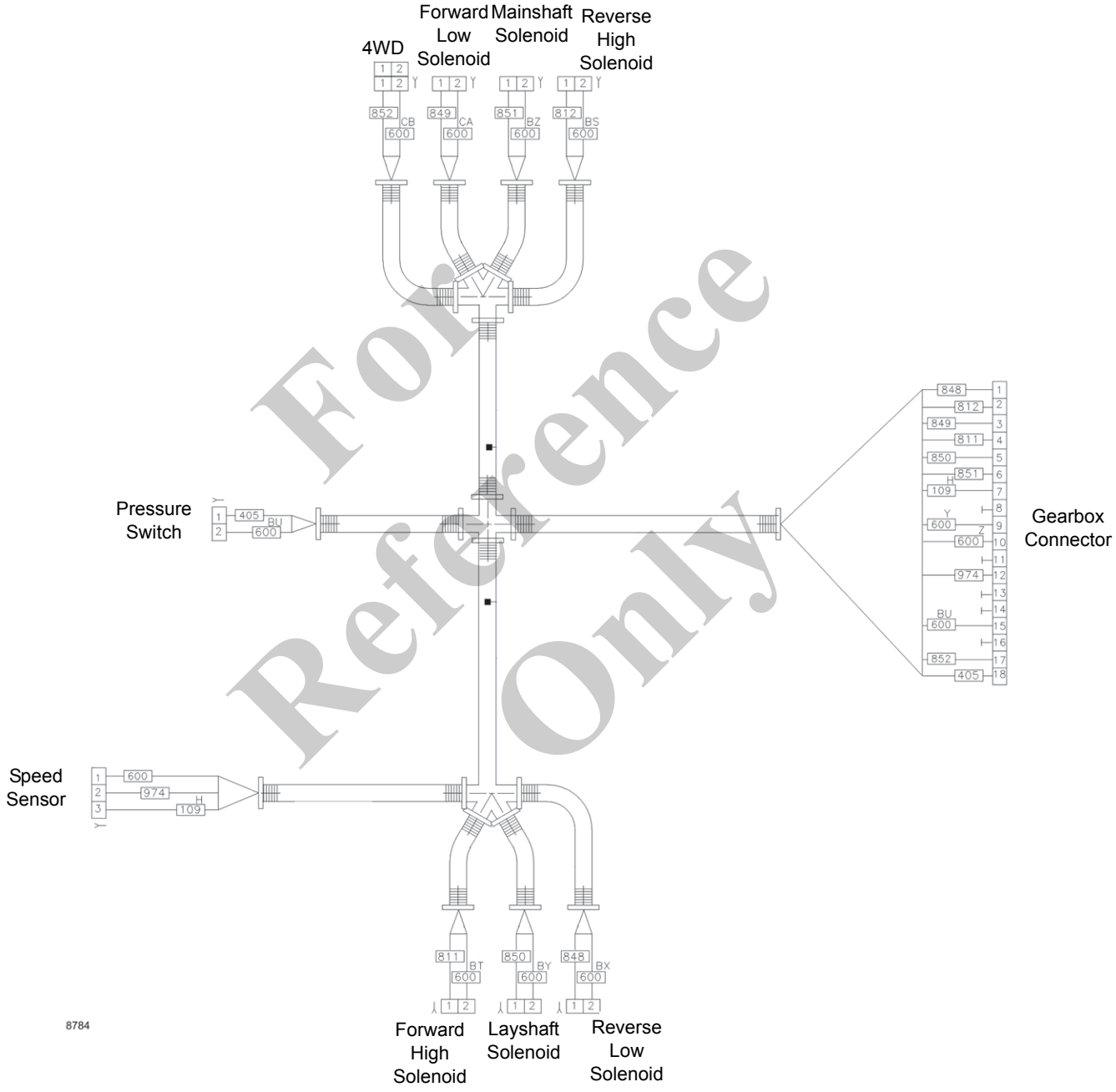


Detail B

Dual Fuel Engine Wire Harness

FIGURE 3-8

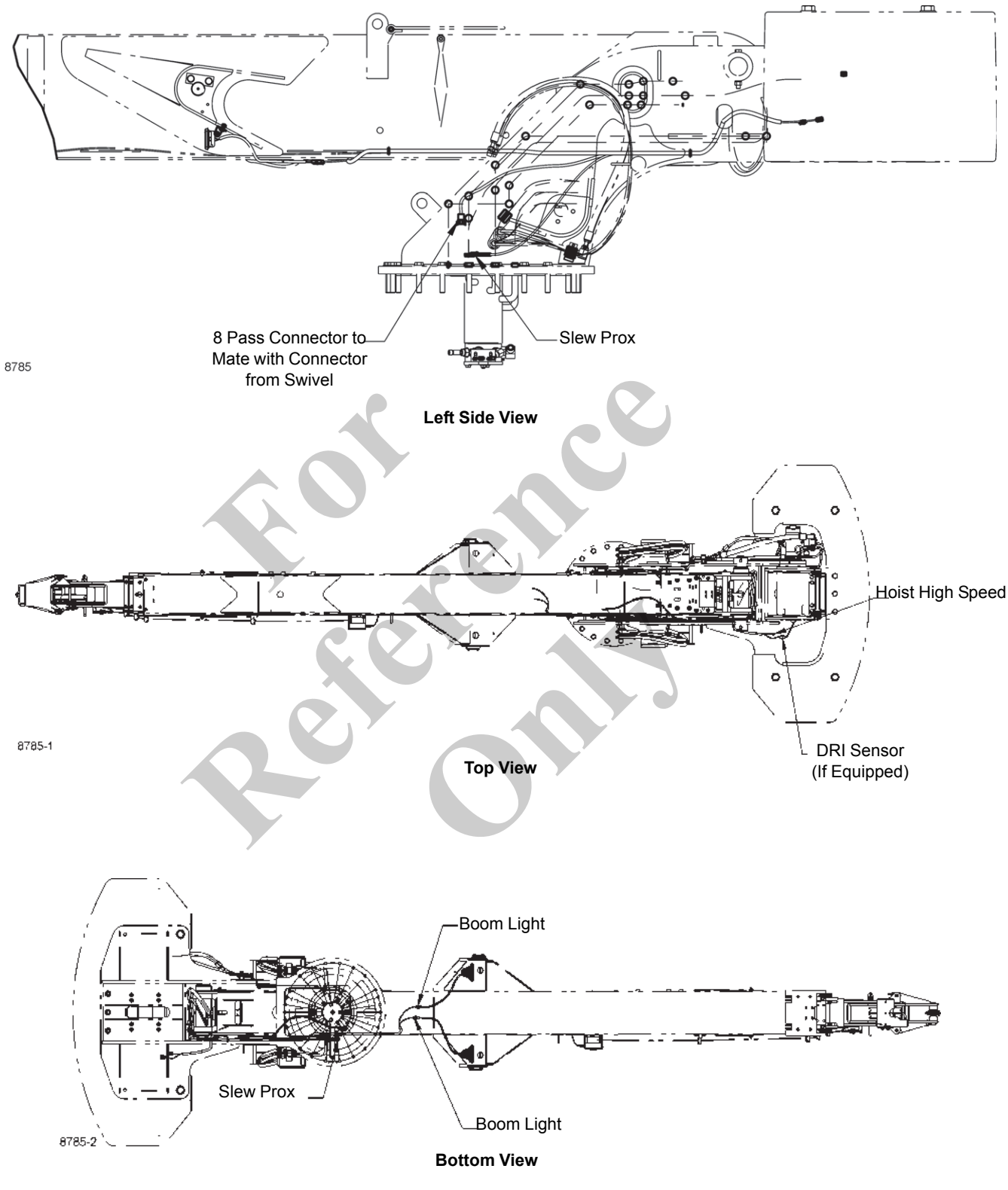
For Reference Only



Transmission Wire Harness

FIGURE 3-9

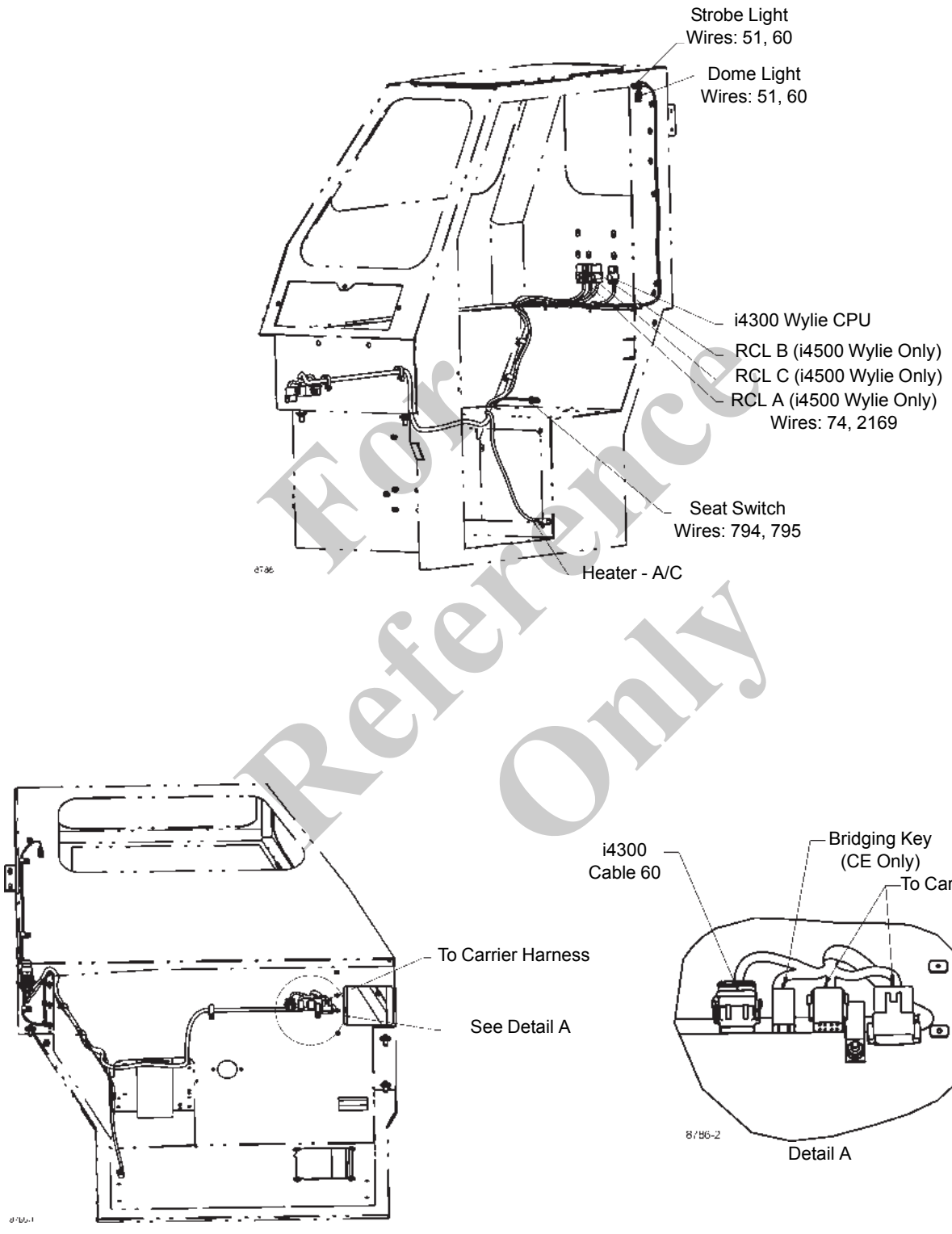
For Reference Only



For Reference Only

Boom Wire Harness

FIGURE 3-10



Cab Wire Harness

FIGURE 3-11

For Reference Only

ACCESSORY CIRCUITS

Anti-Double Blocking System

General

This mechanism (Figure 3-12) prevents the hook block from being pulled into the boom head during extension of the booms and during hoist operation. When the hook block actuates the limit switch on the boom head, oil flow to the telescope cylinder, lift cylinder and hoist motor is stopped. An alarm is activated to give a warning to the operator in all cases. To move the hook block away from the boom head, the operator must retract the boom, raise the boom or lower the hoist.

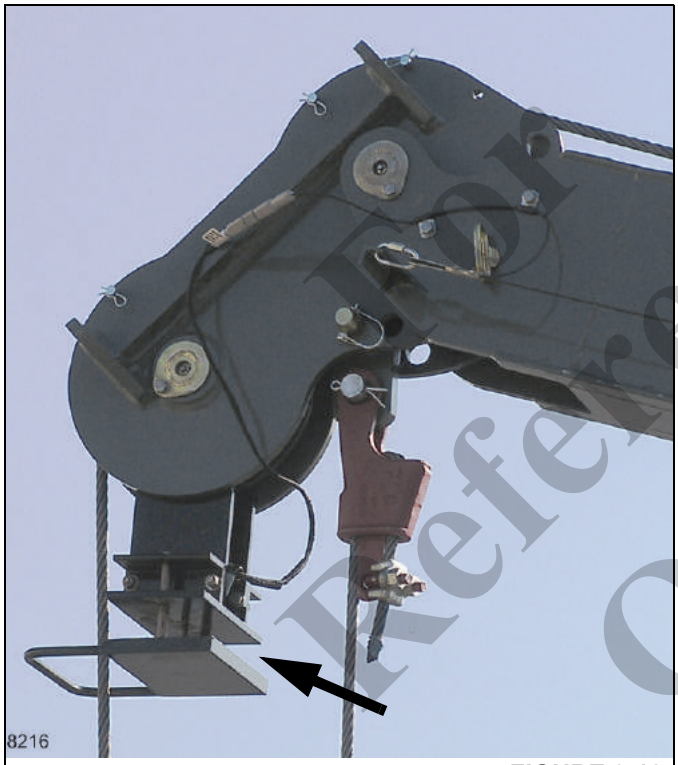


FIGURE 3-12

Circuit Description

See the wiring diagrams in *Schematics/Wiring Diagrams*. Power is made available through a 25 amp fuse to the circuit relay under the console in the cab and to the limit switch on the boom head. When the hook block reaches the upper limit, the limit switch closes, energizing the relay. The energized relay activates the three anti-double blocking solenoid valves in the lift, telescope and hoist circuits.

Electric Swivel

An electrical swivel is installed at the center of the mast rotation. The swivel gives electric current continuity through full rotation of the mast.

Rated Capacity Limiter (RCL) System

Description

The rated capacity limiter (RCL) is a length, load, angle, radius, lifting capacity and anti-double block indicator. A display in the cab provides information to assist the operator in operating the crane.

The Wylie i4500 system, available as an option, can be set with limits by the operator to warn of approach into undesired areas of angle, length or height.

For more information on the RCL system, see the Owner's Manual furnished with the crane.

See wiring diagram in *Schematics/Wiring Diagrams*.

Optional Engine Shutdown

General Description

Cranes can be furnished with an automatic engine shutdown, to protect the engine when the engine oil pressure is too low or the engine water temperature is too high. The electrical circuit includes a mag relay switch located behind the cab dash panel, two diodes in the instrument panel wire harness, the engine water temperature and oil pressure senders, and the fuel shut off valve.

Circuit Function

When the engine oil pressure drops below a safe operating pressure or the water temperature rises above a safe operating temperature, the sending unit sends a signal to the indicator light, illuminating the light. It also, sends a signal to the mag relay switch under the dash panel. Both senders are connected to the "S" terminal of the relay. To prevent current from one sender (oil pressure), illuminating the other indicator light (water temperature) the circuit has two diodes installed, which allow current to travel in one direction only. The relay is activated and cuts current from the "NC" terminal to the fuel shut off valve, closing the valve and shutting off the engine.

Heater

The heater is a hot water heater and is connected into the cooling system of the engine. An electric blower pushes air through the heater core and into the cab. A defroster fan blows air onto the windshield.

See the electrical wiring diagrams in *Schematics/Wiring Diagrams*. Power is available through a 25 amp fuse to the heater/defroster switch in the instrument panel when the ignition switch is in the ON position. The switch is a three position switch (HI, LO and OFF).

For Reference Only

TROUBLESHOOTING

Finding a problem in the electrical system is not difficult if you know basic electricity and understand the arrangement of the electrical system. Use the wiring diagrams in *Schematics/Wiring Diagrams on page 12-1* as your guide.

Accurate testing equipment is also necessary. The instruments normally used are a voltmeter, ammeter, ohmmeter and test light.

Many times the problem can be found by visual inspection of the components in the circuit. Corrosion on terminals, loose connections or bad wiring are the causes of many problems.

Each circuit in the system has a fuse for protection against overloads. Remember that a burnt fuse is an indication of an overload or **SHORT** circuit, not an **OPEN** circuit.

If you did not find the cause of the problem during the visual inspection, use a voltmeter to check the voltage at several points in the circuit, or measure voltage drop across the component. Normally, the best method is to start at the furthest component in the circuit and move backwards toward the power supply. An ohmmeter can be used to measure the resistance in any component. Remember to disconnect the component from the power supply before you connect the ohmmeter.

Table 3-3
Charging System Troubleshooting

Problem	Possible Cause	Solution
Alternator does not charge.	**1.** Alternator belt loose or broken.	**1.** Replace and/or tighten to specification.
	2. Worn brushes or open brush leads or connections.	**2.** Replace or repair alternator.
	3. Open circuit, short circuit or ground stator winding.	**3.** Replace alternator.
	4. Fault in voltage regulator.	**4.** Replace voltage regulator.
	5. Short circuit or open circuit in rectifier diodes.	**5.** Replace or repair alternator.
	6. Open circuit or short circuit in rotor (field) winding.	**6.** Replace alternator.
	7. Wires connected wrong, loose, or broken.	**7.** See wiring diagram. Repair or replace wires.
	8. Dirty slip rings or bad slip ring connections.	**8.** Inspect slip rings. Clean or repair as required.
High charging rate (battery at full charge).	**1.** Low electrolyte level in battery.	**1.** Add distilled water.
	2. Fault in wiring system.	**2.** Repair or replace faulty wiring.
	3. Loose or dirty connections.	**3.** Clean and tighten connections.
	4. Malfunction in voltage regulator.	**4.** Replace voltage regulator.
Low charging rate.	**1.** Loose or worn alternator belt.	**1.** Adjust or replace belt.
	2. Bad alternator.	**2.** Replace or repair.
	3. Bad battery.	**3.** Replace battery.
	4. Low electrolyte level.	**4.** Add distilled water.
	5. Short circuit in system.	**5.** Check and repair.
	6. Worn alternator.	**6.** Test, replace or repair alternator.
	7. Malfunctioning voltage regulator.	**7.** Replace the voltage regulator.
	8. Low engine speed.	**8.** Run engine at higher speed.

For Reference Only

Problem	Possible Cause	Solution
Alternator Noise.	**1.** Badly worn belt.	**1.** Replace belt and adjust.
	2. Pulleys out of alignment.	**2.** Align fan and alternator pulleys.
	3. Loose pulley.	**3.** Check for broken key or worn key way, if used. Tighten pulley nut.
	4. Worn bearings.	**4.** Replace or repair alternator.
	5. Short in rectifier diodes.	**5.** Replace or repair alternator.
Starter motor does not turn.	**1.** Open circuit, dirty or loose connections.	**1.** Clean and tighten connections at battery and starter. Check wiring and connections between ignition switch and starter solenoid.
	2. Bad starter relay.	**2.** Replace starter relay.
	3. Bad ignition switch.	**3.** Replace switch.
	4. Worn starter motor, bad starter solenoid, or internal problem in engine.	**4.** Repair or replace starter, replace solenoid, or see engine manual.
	5. Dead battery.	**5.** Recharge or replace battery.
	6. Parking brake not engaged.	**6.** Engage parking brake.
	7. Bad neutral start relay.	**7.** Adjust or replace relay.
	8. Bad starter lockout relay.	**8.** Replace starter lockout relay.
Starter motor runs extremely hot.	**1.** Long period of operation.	**1.** Cooling-off periods are essential to prevent overheating.
	2. Insufficient battery power.	**2.** Check battery terminal voltage under load. If 10 volts or less, replace the battery.
	3. Bad connection.	**3.** Check battery cables for corrosion, clean and grease.
Starter motor runs but with insufficient power, or with slow line speed.	**1.** Insufficient battery power.	**1.** Check battery terminal voltage under load. If 10 volts or less, replace the battery.
	2. Bad connection.	**2.** Check battery cables for corrosion, clean and grease.
Starter motor will not operate.	**1.** Defective solenoid or stuck solenoid.	**1.** Jar solenoid to free contacts Check by applying 12 volts to coil terminal (should hear an audible click when energized). Replace solenoid.
	2. Defective control switch	**2.** Check and replace if necessary.
	3. Defective motor.	**3.** If solenoids operate, check voltage at armature post. Replace motor if defective.
	4. Loose connections.	**4.** Tighten connections on bottom side of hood and on motor.

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GENERAL DESCRIPTION

General

A hydraulic system uses liquid to make a transfer of force. Any force on a confined liquid is applied to any point in the system that the liquid reaches. Oil is used as the hydraulic liquid for this system because the liquid must be a lubricant for the components of the system.

There are several main components in a hydraulic system and each component has a specific function.

The **pump** moves the oil through the system. It is important to remember that the pump causes the flow, not the pressure in the system. Pressure is caused by resistance to the flow. This resistance can be **external** (for example, a load on a cylinder or motor), or **internal** (the resistance of the components of the system). Pressure increases as the resistance to the flow increases. The pump will continue to push more oil into the system until the resistance is overcome or the relief valve opens (fixed displacement

pumps) or the pump compensator setting is reached (variable displacement pumps).

Valves are used to control the flow, pressure, direction, and volume of the oil in the system. There are many different types of valves. An explanation of the different valves used on this machine is given in the description of each circuit.

Filters remove dirt and particles of foreign materials from the oil in the system. The oil in the system must be kept clean to inhibit damage to the pumps, cylinders, valves, and other components of the system.

Motors and Cylinders are the actuators or working tools of the system. In the motors and cylinders, hydraulic energy is changed into mechanical force (rotary or straight line movement).

The **Hydraulic Oil Tank** has three important functions: storage, cooling, and supply of oil to the pumps. Because piston rods take space in the cylinders, the level of the oil in the tank will be higher when all the cylinders are retracted.

To understand how a hydraulic system works, it is important to understand the following words:

Flow - The flow through the system is caused by the pump. The amount of fluid which is sent to a circuit or actuator generally controls the speed of that function. The flow is measured in gallons per minute (gpm) or liters per minute (L/min).

Pressure - is caused by any resistance to the flow of the oil. Pressure is normally measured in pounds per square inch (psi) or bar. There are four general types of pressure.

- **High Pressure**, which is normally the result of an external load on the system.
- **Low Pressure**, normally the result of the internal resistance of the components in the system.
- **Static Pressure**, where the oil is closed in a circuit between two components. There is no movement of the oil, but there is pressure on the oil, normally because there is an external load on the circuit.
- **Series Pressure**, which is found where oil is confined between two components in a series arrangement, for example when the rod port of one cylinder is connected to the base port of another cylinder. Movement of either cylinder will cause movement in the other cylinder.

Hydraulic System

There are four hydraulic systems on this crane. Information on the hydraulic system for the transmission, brakes, and steering is found in Sections 7, 9 and 10 respectively. Only the main hydraulic system is included in this section. The main hydraulic system gives hydraulic power to:

- The swing motor
- The boom cylinders; lift and telescope
- The front and rear outrigger cylinders
- The main hoist motor

The hydraulic components on the boom and mast are connected to the hydraulic components on the lower structure through a hydraulic swivel. The hydraulic swivel is at the center of rotation of the mast. The design of the hydraulic swivel permits operation of the hydraulic functions through full rotation of the mast.

TROUBLESHOOTING

To find a problem in the hydraulic system with minimum loss of time, use the following aids and procedures.

Troubleshooting Aids

- **Hydraulic schematics** — an exact illustration of the arrangement of the system. The schematic shows all the components in relation to the system. The ability to understand the schematic is important to good troubleshooting. The schematic can be found at the end of this manual.
- **Flowmeter** — an instrument that can be connected into the system to measure the flow of the oil in the system. The flow is measured in gallons per minute (gpm) or liters per minute (Lpm). Normally, the flowmeter is used to check the output of the pump. The flowmeter can also be used to find the location of leakage or restriction in the system. Instructions for installation of the flowmeter and the use of the flowmeter are normally included with the flowmeter.
- **Pressure Gauge** — an instrument for measurement of the pressure in the system. This indication is normally given in pounds per square inch (psi) or bar. On this crane, quick couplers are installed in the pressure lines from the pumps. Pressure taken at these locations will give an indication of operating pressure or relief pressure.

Troubleshooting Procedures

For good troubleshooting, a step by step analysis of the problem and the possible cause is necessary. First, find the symptoms.

- Check with the operator. Learn if there was a loss of power (crane did not move the load) or a loss of speed (slow cycle time).
- Learn if the problem is common to all circuits or is found in one or two circuits.
- Make a visual inspection. Look for a restriction in the linkages, low level of hydraulic oil, bent tubes, collapsed or ballooned hoses, leakage around the hydraulic components, etc.

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Second, make an analysis of symptoms. The function of each component in the system must be known before a correct analysis can be made.

Remember:

- If a problem is common to all circuits, the component which is causing the problem must also be common to all circuits. Examples are: the engine, pump, hydraulic tank and filters.
- If the problem is common to only two or three circuits, the component which is causing the problem must be common to those two or three circuits. Examples are: pump section, relief valve, hydraulic swivel, etc.
- If a problem is in only one circuit, then the component which is causing the problem must be in that circuit. Examples are: valve section, cylinder, motor.

Again, use the schematic. Find which components are in the circuit or circuits. What component can cause the problem with these symptoms? Make a list of the possible causes. Start at the source of the flow in that circuit. If the problem is in all circuits, start at the pump. Know the direction of oil flow through each circuit.

Use the flowmeter and pressure gauge to check your diagnosis of the problem. Start at the source of the flow and check each component in sequence until the exact location of the problem is found.

If the problem is in two or three circuits, check each circuit separately. After a circuit is checked, use caps or plugs to remove that circuit from the system. Continue to next circuit down the line until the problem is found.

NOTE: Do not remove the main relief valve from the circuit. The relief valve must be kept in the circuit to prevent damage to the pump and other components.

TROUBLESHOOTING GUIDES

Table 4-1
General Hydraulic System Troubleshooting

Problem	Possible Cause	Remedy
Noise (above normal).	Air in system.	With engine at low rpm, operate all control functions several times to return the air to atmosphere through the tank breather.
	Low oil supply.	Add recommended oil.
	Restriction in pump inlet line.	Remove and clean inlet line to pump.
	Dirty oil.	Change oil and filters.
	Loose clamps, vibration of hydraulic lines.	Check and tighten.
	Dirt or foreign material in a relief valve.	Clean or replace the relief valve.
	Broken control valve spool.	Replace the control valve section.
	Pump bearings worn.	Replace the bearings or pump.

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Problem	Possible Cause	Remedy
Slow operating speeds (All functions).	Low engine RPM.	Increase engine RPM.
	Air leak in pump inlet line.	Tighten pump inlet line. Replace O-ring in inlet flange.
	Air in oil (foam in tank).	Check oil level, look for leaks in the system.
	Leakage in the load sense relief valve.	Remove and clean or replace the relief valve.
	Improper load sense relief valve setting.	Replace the relief valve.
	Leakage in hydraulic swivel.	Replace seals on swivel shaft.
	Control valve not fully actuated.	Check spool travel.
	Improper primary pump.	Check and adjust pump pressure settings. See *Check all pressures with:*, page 4-41.
	Faulty pump.	Overhaul or replace pump.
No movement when system is first started.	Low oil level.	Check and add oil.
	Air or restriction in inlet line to pump pressure.	Check and tighten inlet line. Clear restriction.
	Cold oil or wrong weight of oil.	Use correct oil, follow normal warming procedure.
Loss of movement during operation.	Low oil level.	Check and add oil.
	Vacuum in hydraulic tank.	Clean tank filler/breather cap.
	Restriction or leakage in the relief valve.	Clean or replace the relief valve.
	Broken hydraulic line.	Replace.
	Bad seal in hydraulic swivel.	Replace seals.
	Broken gear or shaft in pump.	Overhaul or replace.
Overheating of hydraulic oil.	Wrong operation (running over the load sense relief pressure setting for long periods).	Change procedure of operation.
	Dirty filters.	Change filter.
	Oil too light.	Use correct oil.
	Low oil level.	Check and add oil.
	Dirty oil.	Change oil and filters. See Section 5 of this manual.
Foam in hydraulic oil tank.	Leak in system.	Check O-ring on pump inlet. Check for leak in system and correct.
	Wrong type of oil.	Use correct oil.
	Low oil level.	Check and add oil.
	Bad seal in pump, motor or cylinder.	Overhaul or replace.
Short life of pump bearings, shafts, etc.	Dirt in oil.	Change oil and filter more frequently.
	Wrong type of oil.	Use correct oil.
Pump leakage (external).	Bad seal on pump shaft.	Replace shaft seal.
	Bad seals between pump sections (Swing & Steering).	Replace seals.

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Problem	Possible Cause	Remedy
Difficult to engage valve spools.	Dirt or foreign material between spool and valve bore.	Remove and clean valve spool and bore.
	Broken spring (spool return).	Replace spring.
	Distortion or damage to valve spool.	Replace valve section.

Table 4-2
Lift Circuit Troubleshooting

Problem	Possible Cause	Remedy
Lift cylinder does not extend or retract.	Control valve not actuated.	See Difficult to Engage Valve Spools.
	Not enough oil from pump to operate the cylinder.	See Loss of Movement During Operation.
	Bad leak in hydraulic swivel.	Replace seals.
	Load sense relief valve held open by dirt on valve seat.	Disassemble and clean or replace the load sense relief valve.
Cylinder extends, but does not retract.	Malfunction in holding valve.	Replace the holding valve. DO NOT ADJUST.
	Restriction in hose to control valve.	Check and correct.
Cylinder retracts but does not extend.	Malfunction in anti-double blocking electrical system.	See Electric System.
	Bad cartridge in anti-double blocking solenoid valve.	Replace cartridge.
	Restriction in pilot control line to control valve.	Locate and repair.
	Faulty controller.	Repair or replace.
Boom moves slowly downward when control valve is in NEUTRAL position.	Internal leakage in cylinder.	Replace piston seals.
	Leakage in holding valve.	Replace holding valve. DO NOT ADJUST.
	Faulty controller.	Repair or replace.
	Broken centering spring in control valve section.	Replace broken spring.

Table 4-3
Telescope Circuit Troubleshooting

Problem	Possible Cause	Remedy
Cylinder will not extend the boom under load.	Restriction in boom sections.	Clean and apply lubricant to boom slides. See Section 5 of this manual.
	Load too heavy.	Reduce load.
	Faulty pump.	Overhaul or replace.
	Leakage in hydraulic swivel.	Replace seals in the swivel.
	Load sense relief valve malfunction.	Check load sense relief pressure.
	Dirt or restriction in main relief.	Disassemble the relief valve and clean.
Boom extends, but will not retract.	Restriction in hose to the control valve.	Check and correct.
	Malfunction in the holding valve.	Replace the holding valve. DO NOT ADJUST

For Reference Only

Problem	Possible Cause	Remedy
Boom retracts but will not extend	Malfunction in anti-double blocking electrical system.	See Electric System.
	Bad cartridge in anti-double blocking solenoid valve.	Replace the cartridge
	Restriction in pilot control line to control valve.	Check and correct.
	Faulty controller.	Repair or replace control valve.
Boom slow at extending.	Restriction in boom sections.	Clean and lubricate boom slides. See Section 5 of this manual.

Table 4-4
Outrigger Circuit Troubleshooting

Problem	Possible Cause	Remedy
No movement all cylinders	Electrical problem.	See Section 3 of this manual.
	Dirt or restriction in the dump valve.	Clean or replace the dump valve.
	Dirt in relief valve keeping the valve off the valve seat.	Clean the relief valve.
	Relief valve setting too low.	Check and adjust the relief valve setting.
	Faulty pump section.	Overhaul or replace the pump.
Slow movement all outriggers.	Low engine RPM.	Increase engine speed.
	Solenoid valve on outrigger valve section not fully actuating the valve spool.	Check for restriction or binding in the solenoid valve.
	Leakage in relief valve.	Clean or replace the relief valve.
Slow movement, one cylinder.	Internal leakage in the cylinder	Replace piston seals.
Outrigger lowers but will not raise.	Problem in electrical circuit.	See Section 3 of this manual.
	Faulty lock valve in base of the cylinder.	Replace counterbalance valve.
Outrigger cylinder does not hold under load.	Leakage in counterbalance valve in base of cylinder.	Clean or replace counterbalance valve.
	Internal leakage in cylinder.	Replace piston seals.
Outriggers only on one side.	Faulty control valve section.	Repair or replace valve section.
	Faulty solenoid valve or open circuit to solenoid valve.	See Section 3 of this manual.
	Faulty selector valve.	Replace selector valve.
	Restriction or dirt between the outrigger valve spool and housing.	Remove and clean the outrigger valve spool.

For Reference Only

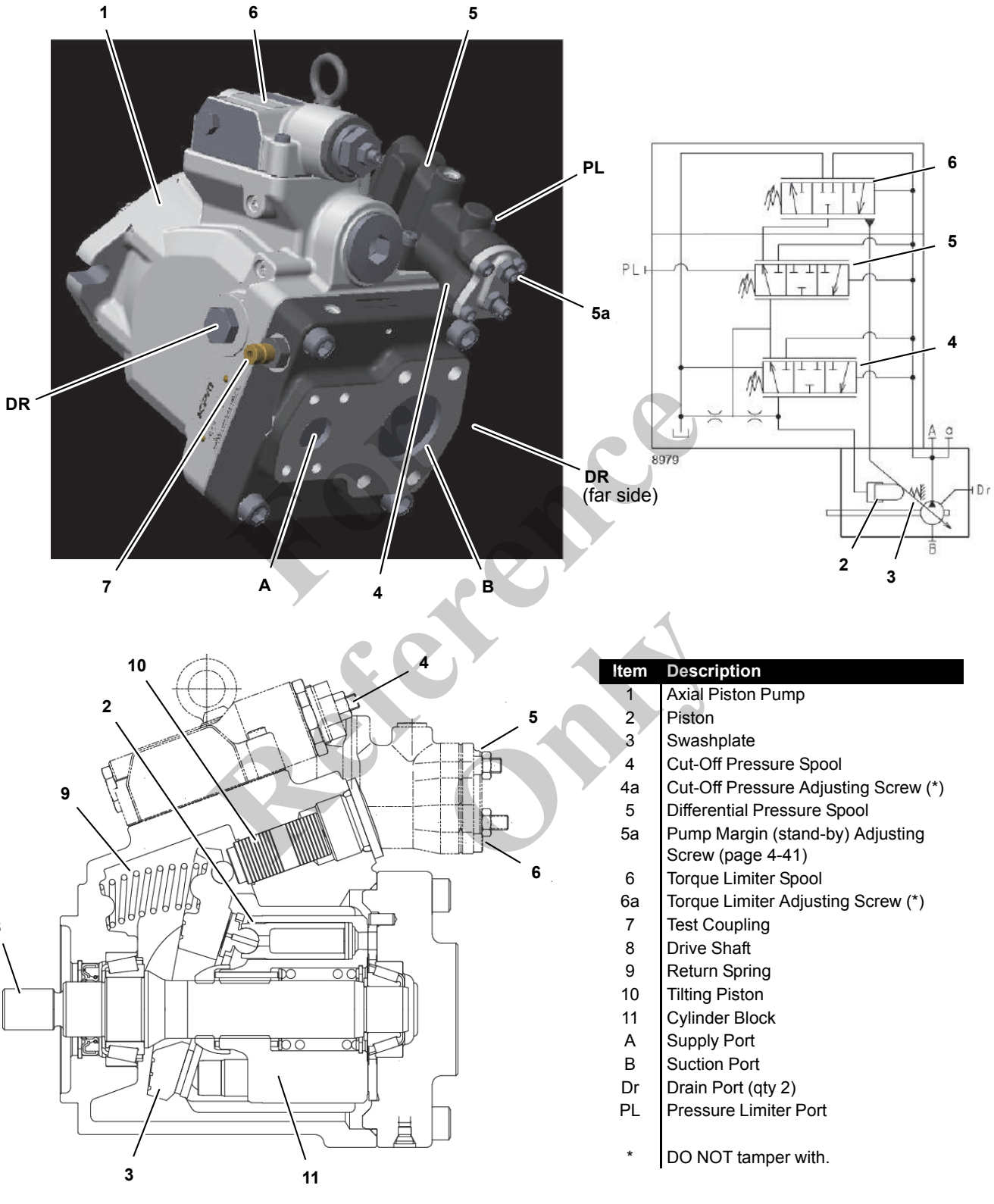
Table 4-5
Main Hoist Circuit Troubleshooting

Problem	Possible Cause	Remedy
Hoist will not lift maximum (rated) load, considerable reduction in line speed.	Faulty load sense relief valve.	Replace the relief valve.
	Dirt in load sense relief valve, keeping the valve off the valve seat.	Remove and clean the relief valve. See Main Relief and Port Relief Valves.
	Not enough oil from the pump.	Check hoses and lines for restrictions to or from pump.
	Improper primary pump pressure.	Check and adjust pressures.
	Malfunction or damage to hoist components.	Check and overhaul the hoist, if necessary. See Section 11 of this manual. Check for binding or damaged sheaves.
	Internal leakage in the hoist motor.	Replace the hoist motor.
Raise speed is slower than lowering speed.	Restriction in hose to control valve.	Check and repair.
	Faulty counterbalance valve.	Replace the counterbalance valve.
Motor will not hold the load when the control lever is in neutral — load drops rapidly.	Overload condition.	Decrease the load.
	Faulty counterbalance valve.	Replace the counterbalance valve.
Motor will not hold the load when the control lever is in neutral — load drifts down slowly.	Overload condition.	Decrease the load.
	Faulty counterbalance valve.	Replace the counterbalance valve.
Hoist does not move.	Restriction in holding valve cartridge.	Clean or replace the holding valve cartridge.
	Brake not releasing.	Check condition of the brake. Repair as necessary.
	Low pilot pressure.	Check and adjust.
Hook block lowers, but will not raise.	Malfunction in anti-double blocking electrical system.	See Section 3 of this manual.
	Bad cartridge in anti-double blocking solenoid valve.	Faulty controller.
	Faulty controller.	Repair or replace.
	Restriction in pilot control line to control valve.	Locate and correct.

Table 4-6
Swing Circuit Troubleshooting

Problem	Possible Cause	Remedy
Mast will not rotate when the swing control is actuated.	Damaged or broken motor shaft.	Repair or replace the swing motor.
	Damaged or broken gearbox shaft or gear.	Overhaul or replace the gearbox. See Section 11 of this manual.
	Faulty pump.	Overhaul or replace the pump.
	Leakage in hydraulic swivel.	Replace seals in the swivel.
	Main relief valve malfunction.	Check main relief pressure.
	Dirt or restriction in swing relief.	Clean the relief valve.
	Low pilot pressure.	Check and adjust.
	Faulty controller.	Repair or replace.
Difficult or slow swing.	Friction or restriction in mast bearing.	See Section 11 of this manual.
	Faulty swing motor or gearbox.	Repair or replace.

For Reference Only



Item	Description
1	Axial Piston Pump
2	Piston
3	Swashplate
4	Cut-Off Pressure Spool
4a	Cut-Off Pressure Adjusting Screw (*)
5	Differential Pressure Spool
5a	Pump Margin (stand-by) Adjusting Screw (page 4-41)
6	Torque Limiter Spool
6a	Torque Limiter Adjusting Screw (*)
7	Test Coupling
8	Drive Shaft
9	Return Spring
10	Tilting Piston
11	Cylinder Block
A	Supply Port
B	Suction Port
Dr	Drain Port (qty 2)
PL	Pressure Limiter Port
*	DO NOT tamper with.

FIGURE 4-1

Reference Only

HYDRAULIC PUMP

See Figure 4-1 for the following description.

Description

The hydraulic system is powered by a variable displacement, axial piston pump driven by the crane's transmission.

- Pump rotation: counterclockwise
- Displacement per revolution: 65 CC (3.97 in^3/rev)
- Max self-priming speed: 2600 rpm

The pump (1) consists of a housing, a piston (2), a drive shaft, a swash plate (3), a cut-off pressure spool (4), a differential pressure spool (5), and a torque limiter spool (6).

The load sense differential pressure spool controls pump displacement to best match the flow and pressure requirements of the load.

Pump delivery pressure is the sum of the load pressure, and the differential pressure.

When the pump discharge pressure reaches the preset value of the cut-off spool, the pump de-strokes to limit the outlet pressure to that setting. When the system requires no flow or pressure, the pump returns to an energy saving low pressure standby condition.

- The load sensing differential pressure setting is 24 bar (350 psi).
- The cut-off pressure is 283 bar (4,000 psi).

The torque limiter regulator controls pump displacement to best match the power available from the prime mover.

The torque limiter regulator monitors delivery pressure and the swashplate angle and adjusts pump displacement to limit input torque to a preset value. This prevents excessive load against the prime mover (prevents stalling).

- The torque limiter setting is 190 Nm (140 lb-ft).

Pump Output Flow

The pump output flow cannot be checked using a flowmeter. The efficiency of the pump must be checked by using function cycling speeds.

DUMP VALVE

See Figure 4-25 and the Hydraulic Schematic in Section 12 for the following description.

When the ignition key is turned to the start position, the solenoid in the load sense dump valve is energized, and the valve opens. This action dumps the load sensing pressure to tank, and the hydraulic pump de-strokes to zero flow, thereby reducing pump load on the engine during start-up.

When the ignition key is released after the engine starts, the solenoid in the load sense dump valve is de-energized, and the valve closes. This action allows load sensing pressure to shift the hydraulic pump in the normal manner.

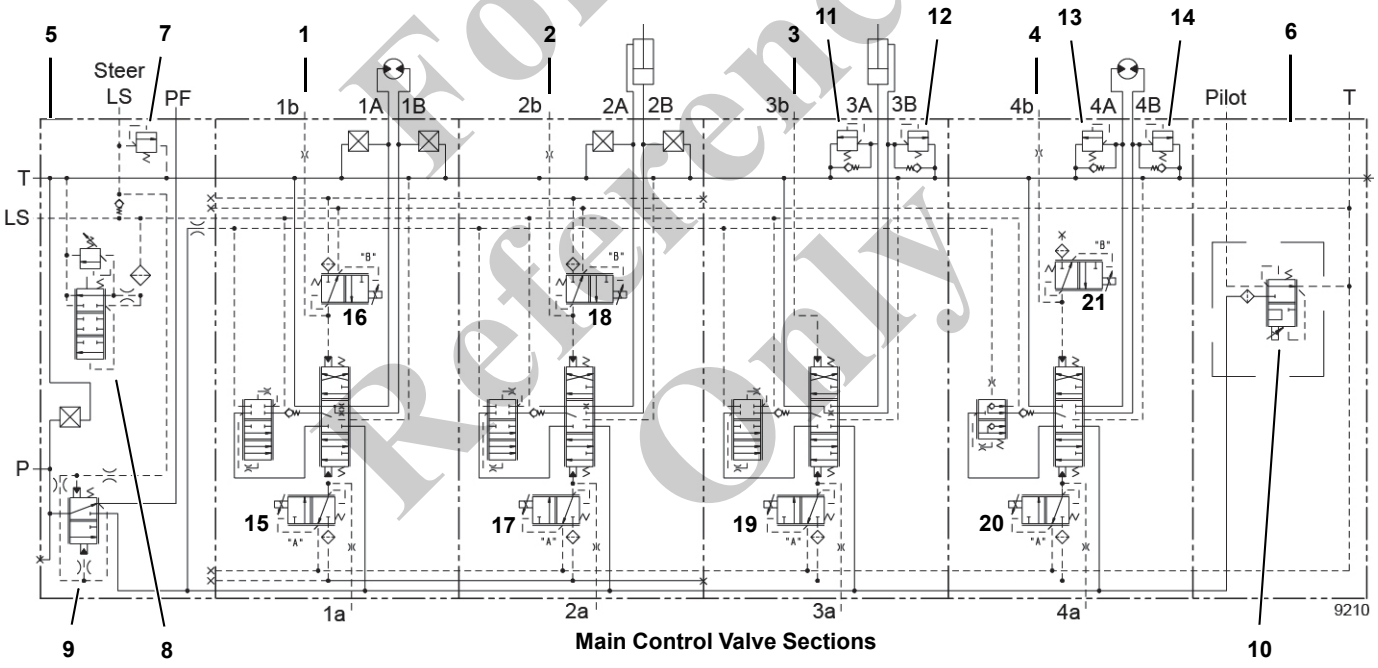
For Reference Only



Remote Control Valves
(in operator cab)

Working Port Identification	
1A	Hoist Up
1B	Hoist Down
2A	Boom Lift Down
2B	Boom Lift Up
3A	Telescope Out
3B	Telescope In
4A	Swing Right
4B	Swing Left

Pilot Port Identification	
1a	Hoist Up Pilot
1b	Hoist Down Pilot
2a	Boom Lift Down Pilot
2b	Boom Lift Up Pilot
3a	Telescope Out Pilot
3b	Telescope In Pilot
4a	Swing Right Pilot
4b	Swing Left Pilot



Main Control Valve Sections

Item	Description	Item	Description
1	Hoist Section	12	Telescope Retract Relief Valve
2	Boom Lift Section	13	Swing Right Relief Valve
3	Telescope Section	14	Swing Left Relief Valve
4	Swing Section	15	Hoist Down Valve Spool Pilot Valve (Y821)
5	Inlet Section	16	Hoist Up Valve Spool Pilot Valve (Y266)
6	Outlet Section	17	Boom Lift Down Valve Spool Pilot Valve (Y300)
7	Load Sense Relief Valve	18	Boom Lift Up Valve Spool Pilot Valve (Y1127)
8	Priority Flow Load Sense Relief Valve	19	Telescope Out Valve Spool Pilot Valve (Y2047)
9	Priority Flow Control Valve	20	Swing Right Valve Spool Pilot Valve (Y2028)
10	Crane Function Solenoid Valve	21	Swing Left Valve Spool Pilot Valve (Y2029)
11	Telescope Extend Relief Valve		

FIGURE 4-2

For Reference Only

MAIN CONTROL VALVE

See Figure 4-2 and Figure 4-3.

General

The main hydraulic system (hoist, boom lift, telescope, and swing) is a closed-center hydraulic system. Which means the hydraulic oil is blocked from returning to tank when the valve spools are in the neutral position.

The control valve sections used in the hydraulic system of the main control valve are pressure compensated valve sections incorporating a flow divider principle in their operation. This provides the ability to control multifunction operation when flow demand exceeds pump capacity though slowed down proportionally. This means that all circuits will continue to function regardless of differences in their load and regardless of the pump flow. The flow relationships specified between functions are maintained over the full range of the pump.

The control valves are shifted by metered pilot pressure from the proportional remote control valves in the cab (View A).

Inlet Section

The inlet section is connected to the pressure side of the variable displacement pump. Items 7-8, Figure 4-2 are installed in the inlet section.

- The priority flow control valve limits pump flow to the main control valve until the needs of the steering and brake circuits are met.
- The load sense relief valve limits the available pressure to the main control valve functions.
- The priority flow load sense relief valve limits the pressure to the steering and brake circuits.

Working Valve Sections

The four working sections (1-4) of the main control valve receive hydraulic oil from the variable displacement load sense pump (Figure 4-1). These sections control the hoist, telescope, lift and swing functions. They are closed-center sections, blocking any return of oil back to tank until the valve spool is actuated to operate a function.

Outlet Section

The outlet section directs return oil flow to tank.

The outlet section houses the crane function solenoid valve. The solenoid valve blocks supply oil flow to the hydraulic remote controls (prevents crane operation) until the crane function switch on the right dash in the cab is moved to the enable position.

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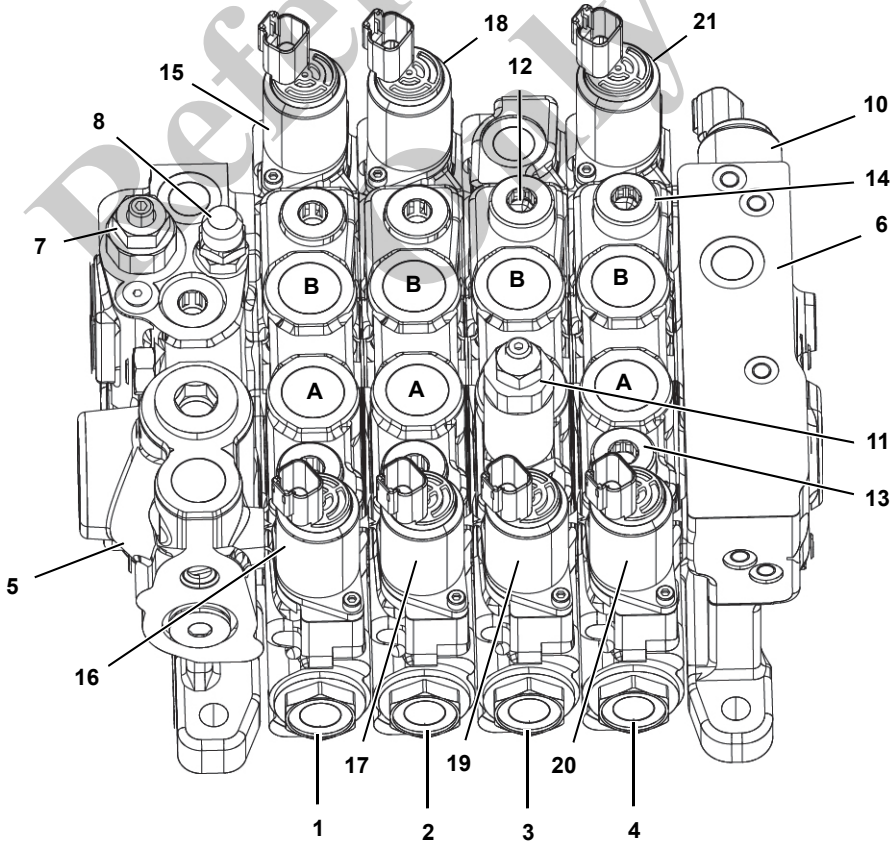
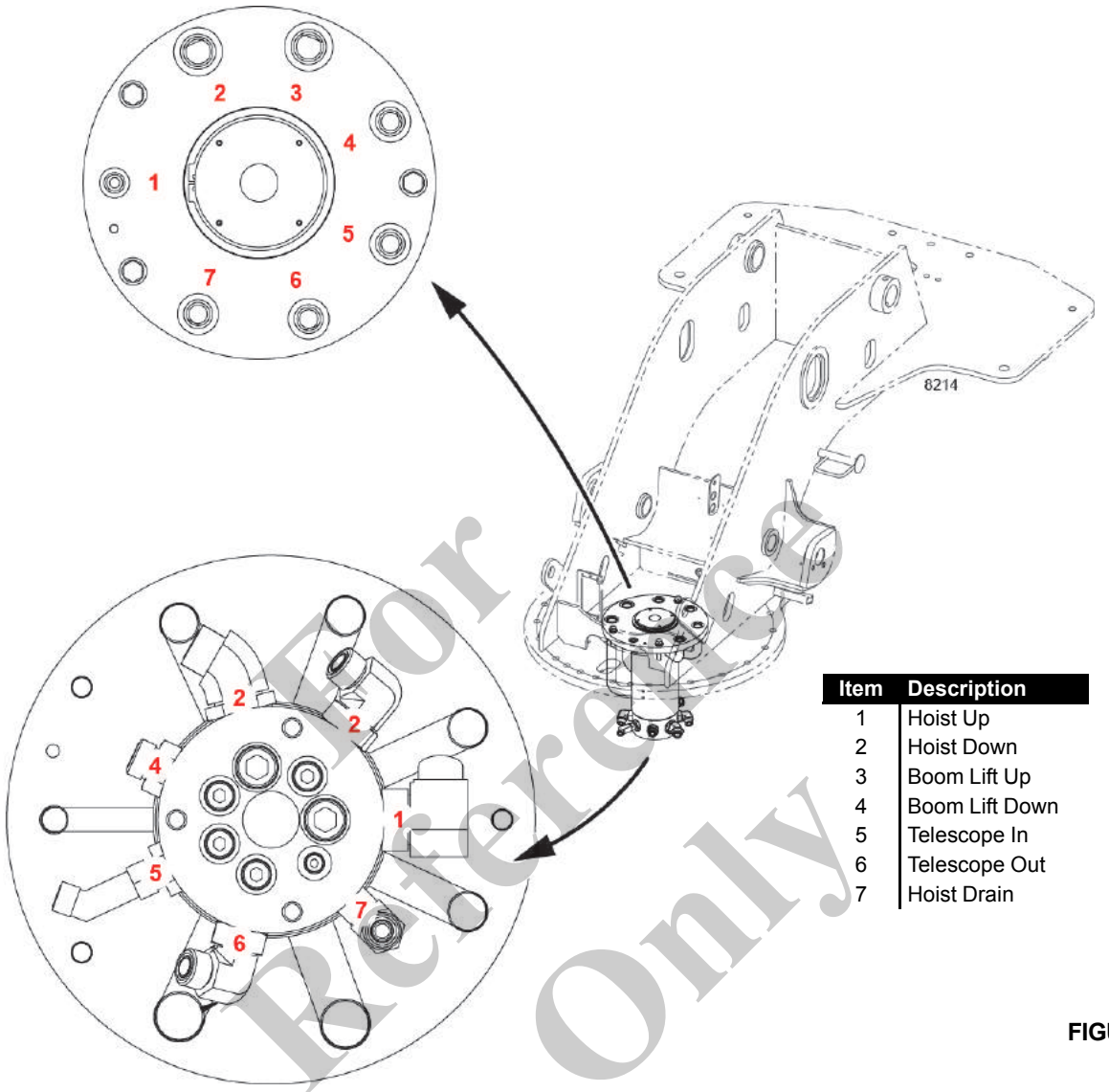


FIGURE 4-3



Item	Description
1	Hoist Up
2	Hoist Down
3	Boom Lift Up
4	Boom Lift Down
5	Telescope In
6	Telescope Out
7	Hoist Drain

FIGURE 4-4

For Reference Only

HYDRAULIC SWIVEL

See Figure 4-4.

General

The hydraulic swivel is at the center of rotation of the mast. The purpose of the hydraulic swivel is to permit the flow of oil between the hydraulic components on mast and boom and the components on the lower structure during any rotation of the mast.

The hydraulic swivel has seven passages. Grooves and ports in the shaft align with ports in the housing. Seals between the grooves of the shaft prevent leakage between the passages. The seals fit tightly against the housing. The housing rotates with the mast and the shaft is stationary.

Functions

The numbers of each port is stamped on the housing and on the lower end of the shaft.

Port No. 1

Hydraulic oil under pressure flows through this port when the hoist block is being raised. When lowering the hoist block the hydraulic oil under low pressure flows through this port.

Port No. 2

Hydraulic oil under pressure flows through this port when the hoist block is being lowered. When raising the hoist block the hydraulic oil under low pressure flows through this port.

Port No. 3

Hydraulic oil under pressure flows through this port when the boom is being raised. When lowering the boom the hydraulic oil under low pressure flows through this port.

Port No. 4

Hydraulic oil under pressure flows through this port when the boom is being lowered. When raising the boom the hydraulic oil under low pressure flows through this port.

Port No. 5

Hydraulic oil under pressure flows through this port when the boom is being retracted. When extending the boom the hydraulic oil under low pressure flows through this port.

Port No. 6

Hydraulic oil under pressure flows through this port when the boom is being extended. When retracting the boom the hydraulic oil under low pressure flows through this port.

Port No. 7

Hydraulic oil under low pressure flows through this port from the hoist motor drain.

Troubleshooting

Leakage between the passages of the hydraulic swivel will cause loss of power or possible wrong operation of one of the circuits. It is important to know the arrangement of the passages in the hydraulic swivel. Remember that the oil will always follow the path of least resistance.

BOOM LIFT CIRCUIT

See Figure 4-2, the hydraulic schematic in Section 12, and the following text to understand how the boom lift circuit functions.

General

The boom lift hydraulic circuit includes two lift cylinders, two holding valves, two RCL pressure transducers, ports 3 and 4 in the hydraulic swivel, the second section of the main control valve, two valve spool pilot valves (Y300 and Y1127), and the hydraulic lines.

Oil Flow

When the valve spool is in the neutral position, both A and B ports are closed and oil is held in the circuit to prevent movement of the lift cylinders.

Raising the Boom

Pulling the joystick toward the operator connects the pump to port B in the control valve. Oil leaves Port B of the control valve section and passes through Port 3 of the hydraulic swivel and enters the base end of the lift cylinders through the holding valves. In this direction, the oil flows freely through the holding valves and into the base end of the cylinder. The cylinder rod starts to extend, pushing oil ahead of the piston out the rod end port. The oil returns through Port 4 of the hydraulic swivel to Port A of the control valve section. From here, the oil is routed to the tank passage of the control valve assembly and returns through the return filter to the hydraulic oil tank.

For CE cranes only, the valve spool pilot valve (Y1127) will dump pilot pressure to tank, the valve spool will shift to neutral, and the boom lift cylinders will stop extending when the boom is raised to the maximum angle.

Lowering the Boom

Pushing the joystick away from the operator sends oil in the opposite direction and causes the cylinder to retract. The holding valve lets the cylinder retract only if there is oil under pressure available to the rod port of the cylinder. See Holding Valve.

The valve spool pilot valve (Y300) will dump pilot pressure to tank, the valve spool will shift to neutral, and the boom lift cylinders will stop retracting in the event the hook block comes in contact with the boom head.

Holding Valve

The holding valve has three functions:

1. Inhibit cavitation of the cylinder,
2. Give full control of the lowering of the boom,
3. Hold the load in event of a hydraulic failure.

Pilot pressure from the rod side of the piston opens the holding valve. If the cylinder starts to retract faster than the pump can fill the cylinder, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the cylinder. The holding valve will interrupt the flow as often as necessary to keep the cylinder filled. Also, if there is a failure of the pump or a hydraulic line, the holding valve will hold the boom in position.

WARNING

Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

Boom Lift Cylinder Leakage Check

If internal leakage in one or both of the cylinders is suspected, check for leakage as follows:

For Reference Only

1. Remove the suspected cylinder from the machine. See page 4-32.
2. Mount the cylinder in a suitable cylinder stand.
3. Connect a portable hydraulic system to the cylinder base end.
4. Apply pressure to extend the cylinder rod.
5. Check the amount of leakage from the rod port of the cylinder. If the cylinder leaks more than a few drops of oil per minute, replacement of the piston seals is necessary, see page 4-32.

TELESCOPE CIRCUIT

See Figure 4-2, the hydraulic schematic in Section 12, and the following text to understand how the telescope circuit functions.

General

The telescope circuit includes the telescope cylinder, a holding valve, ports 5 and 6 of the hydraulic swivel, two relief valves, the third section of the main control valve, the valve spool pilot valve (Y2047), and the hydraulic lines.

Oil Flow

Telescope Out

Pushing joystick away from operator connects the supply from the pump to port A of the control valve section. Oil leaves Port A and is routed through hydraulic swivel port 6 to the holding valve on the base end of the cylinder.

In the extending direction, oil flows freely through the holding valve and into the base end of the cylinder. The cylinder extends and pushes oil ahead of the piston through the rod end port of the cylinder. The oil returns through swivel port 5 and Port B of the control valve. From here, the oil is routed into the tank passage and returns through the return filter to the hydraulic tank.

The valve spool pilot valve (Y2047) will dump pilot pressure to tank, the valve spool will shift to neutral, and the telescope cylinder will stop extending in the event the hook block comes in contact with the boom head.

Telescope In

Pulling the joystick towards operator, routes oil out of valve port B and through the port 5 of the hydraulic swivel to the rod port of the telescope hydraulic cylinder. The cylinder starts to retract but meets resistance from the oil held in the cylinder base end by the holding valve. This restriction causes an increase in pressure as the pump continues to push more oil into the rod port of the cylinder. When the pressure is high enough to open the holding valve, the cylinder retracts. See Holding Valve.

The relief valve in the circuit protects the telescope cylinder. If the pressure should ever reach 203.40 bar (2950 psi) to the rod port or 193.05 bar (2800 psi) to the piston port the relief valve will open and return oil to tank, stopping any movement of the telescope cylinder and its cable mechanism.

Oil from the base end of the cylinder returns through port 6 of the hydraulic swivel to the control valve. From here, the oil is routed through the return filter to the hydraulic tank.

Holding Valve

The holding valve has three functions:

1. Inhibit cavitation of the cylinder.
2. Give full control of the lowering of the boom.
3. Hold the load in event of a hydraulic failure.

Pilot pressure from the rod side of the cylinder opens the holding valve. If the cylinder starts to retract faster than the pump can fill the cylinder, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the cylinder. The holding valve will interrupt the flow as often as necessary to keep the cylinder filled. Also, if there is a failure of the pump or a hydraulic line, the holding valve will hold the boom in position.

WARNING

Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

Relief Valves

Relief valves are installed Ports A and B of the telescope valve section to protect the telescope mechanism (cables, sheaves, etc.) from damage caused by high hydraulic oil pressure. See *Telescope Pressure Settings*, page 4-42.

Telescope Cylinder Leakage Test

If the cylinder does not hold the load, the problem is normally internal leakage in the cylinder. This problem can also be caused by leakage in the control valve or the holding valve. To check for leakage in the cylinder:

1. Raise the boom a little above the horizontal position.
2. Fully extend the boom.
3. Stop the engine. Move the control lever several times in each direction to release any hydraulic pressure in the circuit.
4. Disconnect the hydraulic hose from bulkhead elbow which connects to the rod port of the telescope cylinder. A little oil will drain from the elbow.

For Reference Only

5. Start the engine. Actuate the control lever in the direction to extend the boom. Check the amount of leakage from the bulkhead elbow. If the leakage is more than a few drops per minute, replacement of the piston seals is necessary.

HOIST CIRCUIT

See Figure 4-2, the hydraulic schematic in Section 12, and the following text to understand how the hoist circuit functions.

General

The hoist circuit includes the hoist motor, a brake, a brake holding valve, ports 1 and 2 of the hydraulic swivel, the first section of the main control valve, two valve spool pilot valves (Y266 and Y821), and the hydraulic lines.

Oil Flow

When the valve spool is in the neutral position, both A and B ports are bled to tank via orifices.

Hoist Up

Pulling the joystick towards the operator routes oil from the pump to port A of the control valve. The oil is routed through the swivel port 1 to the brake holding valve. In this direction, the oil flows freely through the brake holding valve to the hoist motor.

During this operation the brake is not released, since the load is driven through a one-way cam clutch in the hoist, bypassing the brake. When the hoist comes to a stop, the cam clutch locks up and the load is prevented from moving by the brake.

The oil turns the motor and returns through swivel port 2 to the control valve. From there, the oil is sent back through the filter to the hydraulic tank.

The valve spool pilot valve (Y266) will dump pilot pressure to tank, the valve spool will shift to neutral, and the hoist will stop in the event the hook block comes in contact with the boom head.

Hoist Down

Pushing the joystick away from the operator sends oil from cylinder port B of the single spool control valve though swivel port 2 to the hoist motor. The motor starts to turn, and the increase in pressure on the up stream side of the motor causes the brake holding valve to open and also the hoist brake to disengage. The oil then returns through swivel port 1 to the control valve and back to the tank.

The valve spool pilot valve (Y821) will dump pilot pressure to tank, the valve spool will shift to neutral, and the hoist will stop in the event the wire rope is spooled to the minimum wrap limit.

Drain Line

A drain line is connected to the hoist motor and returns drain oil from the motor through swivel port 7 back to the hydraulic tank.

Brake Holding Valve

The holding valve has three functions:

1. Inhibit cavitation of the motor.
2. Give full control of the lowering of the load.
3. Hold the load in event of a hydraulic failure.

Pilot pressure from the hoist down side of the motor opens the holding valve. If the motor starts to turn faster than the pump can supply oil to the motor, there will be a decrease in the pilot pressure. The holding valve will close and interrupt the flow of oil from the motor. The holding valve will interrupt the flow as often as necessary to keep the flow constant to the motor. Also, if there is a failure of the pump or a hydraulic line, the holding valve will hold the load in position.

WARNING

Do not adjust the holding valve setting. The valve is adjusted by the manufacturer.

SWING CIRCUIT

See Figure 4-2, the hydraulic schematic in Section 12, and the following text to understand how the swing circuit functions.

General

The swing circuit includes swing motor, two relief valves, the fourth section of the main control valve, two valve spool pilot valves (Y2028 and Y2029), and the hydraulic lines.

Oil Flow

Swing Right

Pushing the joystick away from the operator sends oil through motor port A of the valve section to the swing motor. The motor rotates clockwise and causes the mast to rotate to the right. Oil from downstream side of the motor returns through the B port and sent back to tank through the return filter.

The valve spool pilot valves (Y2028 and Y2029) will dump pilot pressure to tank, the valve spool will shift to neutral, and the swing function will be inoperable when the swing lock is engaged.

For Reference Only

Swing Left

Pulling the joystick towards the operator sends oil through motor port B of the valve section to the swing motor. The motor rotates counter clockwise and causes the mast to rotate to the left. Oil from downstream side of the motor returns through the A port and is sent back to the tank through the return filter.

PILOT CONTROL SYSTEM

General

The pilot control system is used to actuate the spools of the main control valve using hydraulic pressure. The system includes a relief valve, four remote control valves (View A, Figure 4-2) and the hydraulic hoses and fittings.

Oil Flow

The pilot control system receives its hydraulic oil supply from the pilot port in the outlet section of the main control valve.

The outlet section houses the crane function solenoid valve. The solenoid valve blocks supply oil flow to the hydraulic remote controls (prevents crane operation) until the crane function switch on the right dash in the cab is moved to the enable position.

Oil under pressure is routed to the four remote control valves, where it is directed by the remote control valves to actuate the spools of the main control valve.

Oil from the remote control valves is routed back to the hydraulic tank.

ANTI-TWO BLOCKING SYSTEM

See Figure 4-2 and Figure 4-5.

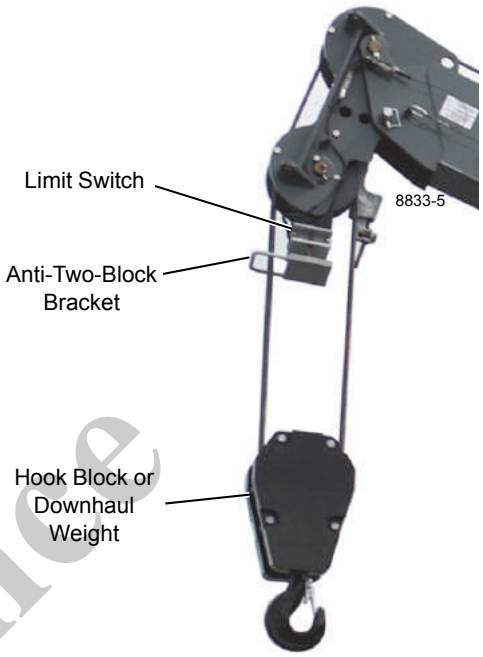
This system inhibits the hook block or the downhaul weight from being pulled into the boom (or boom extension) head during hoist up, boom lift down, and telescope out operations.

If the hook block or the downhaul weight contacts the anti-two-block bracket under the boom head or the anti-two-block lever under the boom extension head, the limit switch is actuated.

The limit switch actuates the valve spool pilot valves (Y266, Y300, and Y2047) which dumps pilot pressure to tank. This causes, the hoist, boom lift, and telescope out valve spools to shift to neutral and the hoist up, boom lift down, and telescope out functions stop.

Before operation can resume, the hook block or the downhaul weight must be lowered away from the boom or boom extension head.

NOTE: **DO NOT** disconnect the anti-two-block system. Possible damage to the boom, hoist or crane could result.



Anti-Two Blocking System — Boom

Anti-Two Blocking System — Boom Extension

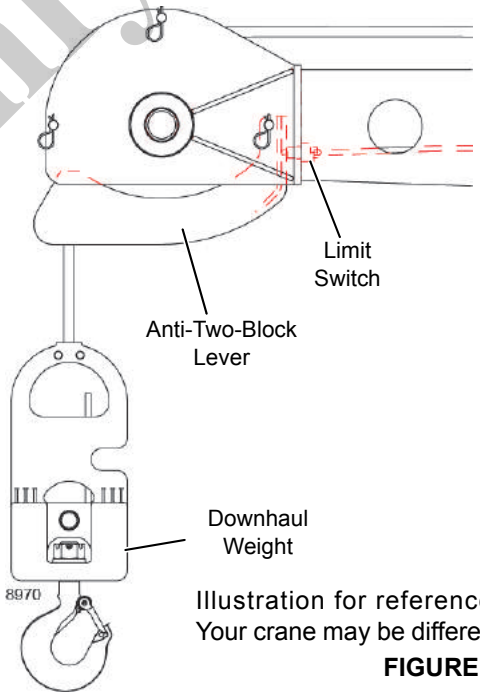


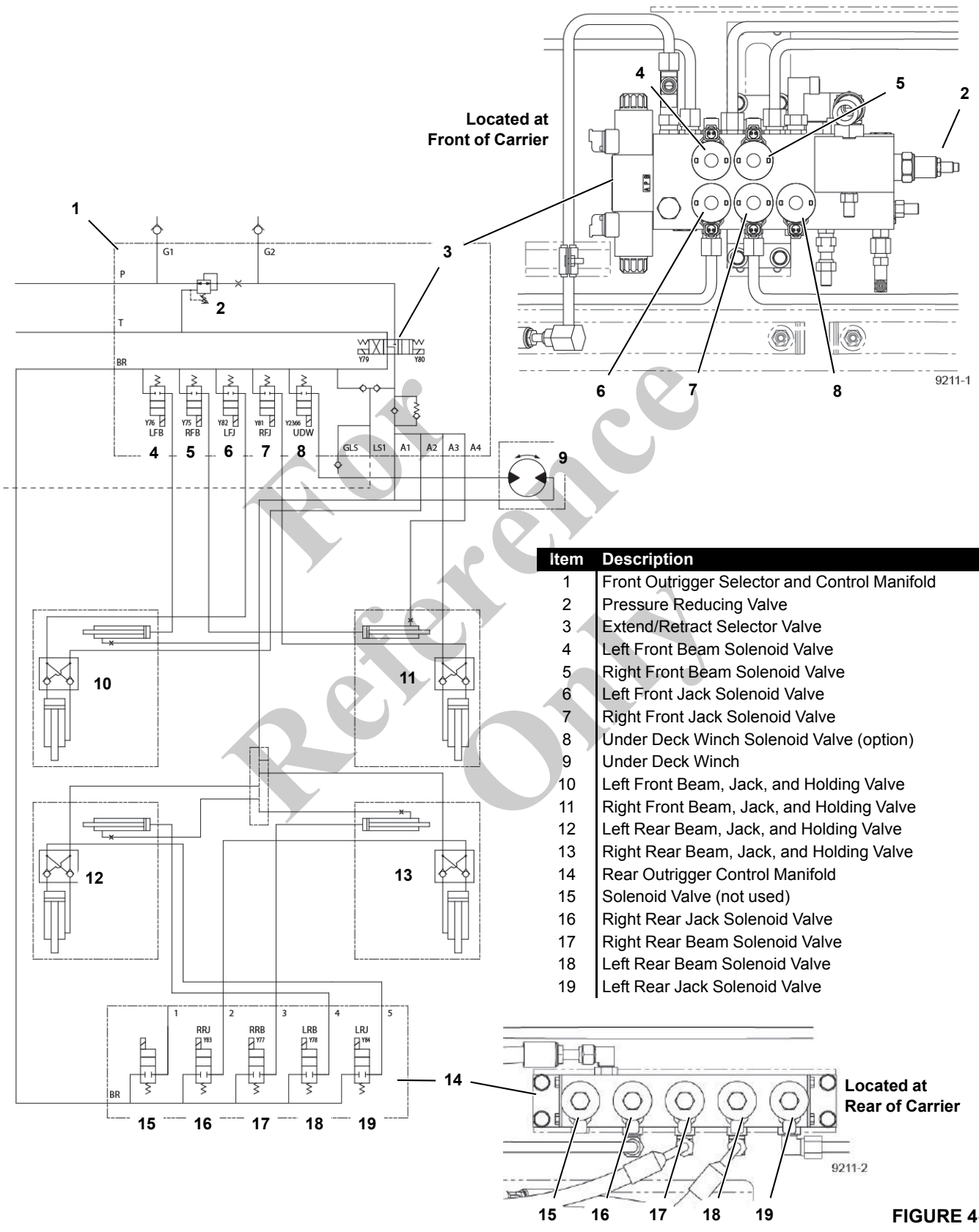
Illustration for reference only. Your crane may be different.

FIGURE 4-5

For Reference Only

For Reference Only

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Item	Description
1	Front Outrigger Selector and Control Manifold
2	Pressure Reducing Valve
3	Extend/Retract Selector Valve
4	Left Front Beam Solenoid Valve
5	Right Front Beam Solenoid Valve
6	Left Front Jack Solenoid Valve
7	Right Front Jack Solenoid Valve
8	Under Deck Winch Solenoid Valve (option)
9	Under Deck Winch
10	Left Front Beam, Jack, and Holding Valve
11	Right Front Beam, Jack, and Holding Valve
12	Left Rear Beam, Jack, and Holding Valve
13	Right Rear Beam, Jack, and Holding Valve
14	Rear Outrigger Control Manifold
15	Solenoid Valve (not used)
16	Right Rear Jack Solenoid Valve
17	Right Rear Beam Solenoid Valve
18	Left Rear Beam Solenoid Valve
19	Left Rear Jack Solenoid Valve

FIGURE 4-6

For Reference Only

OUTRIGGER CIRCUIT

The outrigger circuit includes:

- The front outrigger selector and control manifold (1) which contains the pressure reducing valve (2), the outrigger extend/retract selector valve (3), the front outrigger solenoid valves (4-7) and the optional under deck winch solenoid valve (8).

  The pressure reducing valve protects the outrigger circuit from high pressure buildup.

- Four horizontal beam cylinders and four vertical jack cylinders with holding valves (10-13).
- The rear outrigger control manifold (14) which contains the rear outrigger solenoid valves (16-19).

Supply Oil Flow

Oil from the pump enters the P port of the front outrigger selector and control manifold (1) and flows to the inlet of the of the extend/retract selector valve (3).

In the neutral position, oil flow is blocked and the beams and jacks are locked in position.

Outrigger Valves

The extend/retract selector valve (3) controls the direction of outrigger operation. The valve is controlled by the two-position, momentary, outrigger extend/retract switch on the left dash in the operator cab.

The solenoid valves (4-7) and (16-19) control the selection of which beam or jack is operated. The solenoid valves are controlled by the two-position, momentary, beam/jack selector switches on the right dash in the operator cab.

Extending an Outrigger

When the outrigger extend/retract switch in the cab is held in the extend position, oil flow from the extend/retract selector valve (3) is directed to the inlet port of each beam/jack solenoid valve (4-7 and 16-19).

When the desired beam/jack selector switch is held in the beam or jack position, the corresponding solenoid valve opens and directs oil flow to the head end of the selected beam or jack.

Oil flow extends the cylinder. Return oil flow from the rod end of the cylinder is returned to tank through the extend/retract selector valve (3).

Retracting an Outrigger

When the outrigger extend/retract switch in the cab is held in the retract position, oil flow from the extend/retract selector valve (3) is directed to the rod side of each beam and jack cylinder (10-13). Return oil flow from the cylinders is blocked by the beam/jack solenoid valves (4-7 and 16-19).

When the desired beam/jack selector switch is held in the beam or jack position, the corresponding solenoid valve opens allowing from the head end of the cylinder to return to tank through the extend/retract selector valve (3). The selected cylinder retracts.

Load Holding Valves

Each jack cylinder has a load holding valve installed in the head end of the cylinder. The purpose of the valve is to inhibit the cylinder from retracting if a hydraulic line or hose breaks. The load holding valve will hold the oil in the head end of the cylinder until there is oil from the pump available to the rod end of the cylinder.

Oil flows freely through the load holding valve and into the cylinder head when the cylinder is being extended. To retract the cylinder, oil is sent to the rod end of the cylinder. As the cylinder starts to retract, the piston meets resistance from the oil held in the cylinder head by the load holding valve. Pressure increases as the pump tries to overcome the resistance.

When the pressure of the oil is high enough to overcome the spring in the load holding valve plus the pressure of the oil in the cylinder head, the load holding valve opens and the cylinder retracts.

If the cylinder starts to retract too rapidly, for example because of a heavy load on the cylinder, pilot pressure from the rod side decreases and the load holding valve closes. The cylinder stops retracting temporarily until enough oil is again available to the rod side of the cylinder. In this way, cylinder cavitation is prevented and the load is held.

NOTE: The engine must be running to retract the outrigger cylinders. The load-holding valves inhibit retracting the outrigger jacks simply from the weight of the machine.

Outrigger Jack Leakage Check

If one of the outrigger jacks will not hold under load, the problem is either the holding valve or the cylinder piston packings. To check for internal leakage in the cylinder:

1. Start the engine and engage the parking brake.
2. Fully lower the outrigger.
3. Shut off the engine.
4. Remove the hydraulic line from the rod port of the jacking cylinder being checked.
5. Start the engine and actuate the control switch in the direction to lower the outrigger. Check the amount of leakage from the open port. If the leakage is more than a couple of drops per minute, replacement of the piston seals is recommended.

For Reference Only

UNDER DECK WINCH

The under deck winch is connected to the front outrigger control manifold. Hydraulic oil flows through an electrically activated three position directional control valve to provide directional control and a two-position control valve to supply oil flow.

COMPONENT REPAIR

Hydraulic Pump Repair

Removal

1. Drain the hydraulic tank.
2. Remove the secondary pump from the primary pump. See removal instructions.
3. Disconnect the suction line and pressure line from the primary pump. Disconnect the load sense and drain lines from the pump. Cap and plug all hoses and ports.
4. The pump is heavy. Use an overhead crane and a sling or a support to hold the pump in position.
5. Remove the pump mounting bolts and lockwashers. Remove the pump and gaskets from the transmission.

Disassembly and Repair

The hydraulic pump is not a field repairable component. The pump must be sent back to the pump manufacturer for repair. Contact your distributor for return information.

Installation

1. Attach the pump fittings to the pump before installing the pump to transmission. Check the O-rings on the inlet and outlet hose fittings. If damaged replace the O-rings.
2. Align the spline of the pump shaft with the spline of the pump coupler on the transmission. Position the pump with the three gaskets. Install the mounting hardware.
3. Install the secondary pump to the primary pump. See installation instructions.
4. Attach the suction and pressure hoses to the primary pump.
5. If a new pump is being installed, remove the two lower hex-socket capscrews from the rear of the piston pump. Discard the capscrews.
6. Connect the load sense line to the pump compensator.
7. Connect the pump drain line to the pump.
8. Fill the hydraulic tank with clean filtered hydraulic oil.

NOTE: The variable displacement pump and all other components require clean, filtered hydraulic oil for proper operation. Contaminated hydraulic oil may cause damage to the pump and other components. Before adding any oil to the hydraulic tank, be sure it is filtered through a 10 micron (absolute) or less filter.

9. The pump will fill with hydraulic oil when the tank is filled. The air in the pump will work itself back to tank.
10. Perform pump start-up. See below.

Pump Start-up

1. Start the engine and let it idle. Do not allow the engine to surge or run excessively fast during the initial start-up. **DO NOT OPERATE ANY HYDRAULIC FUNCTION AT THIS TIME**.
2. Let the pump run for about 60 seconds to release any air that might be in the hydraulic system. Check the suction hose connections for loose clamps, fittings, etc.
3. Adjust the pump to deliver system pressures. Follow the instruction under *Check all pressures with:*, page 4-41.
4. Check the level of hydraulic oil in the hydraulic oil tank. If low, add only pre-filtered hydraulic oil.

NOTE: The variable displacement pump and all other components require clean, filtered hydraulic oil for proper operation. Contaminated hydraulic oil may cause damage to the pump and other components. Before adding any oil to the hydraulic tank, be sure it is filtered through a 10 micron (absolute) or less filter.

Outrigger Control Valve

Removal

1. Stop the engine and engage the parking brake. Place chocks under the wheels.
2. Disconnect the battery using the battery disconnect switch.
3. Remove the access cover over the control valves.
4. Individual valve sections can be removed from the manifold block without removing the complete valve. Disconnect the electrical leads from the outrigger valve solenoids. Remove the four socket head capscrews securing the valve section to the manifold block. Remove the valve section.
5. If the complete valve assembly must be removed, tag all hydraulic lines for correct assembly. Clean the valve and connecting lines. Disconnect the hydraulic lines from the valve ports. Put caps on lines to keep dirt out of the hydraulic system. Remove the valve mounting screws and remove the valve.

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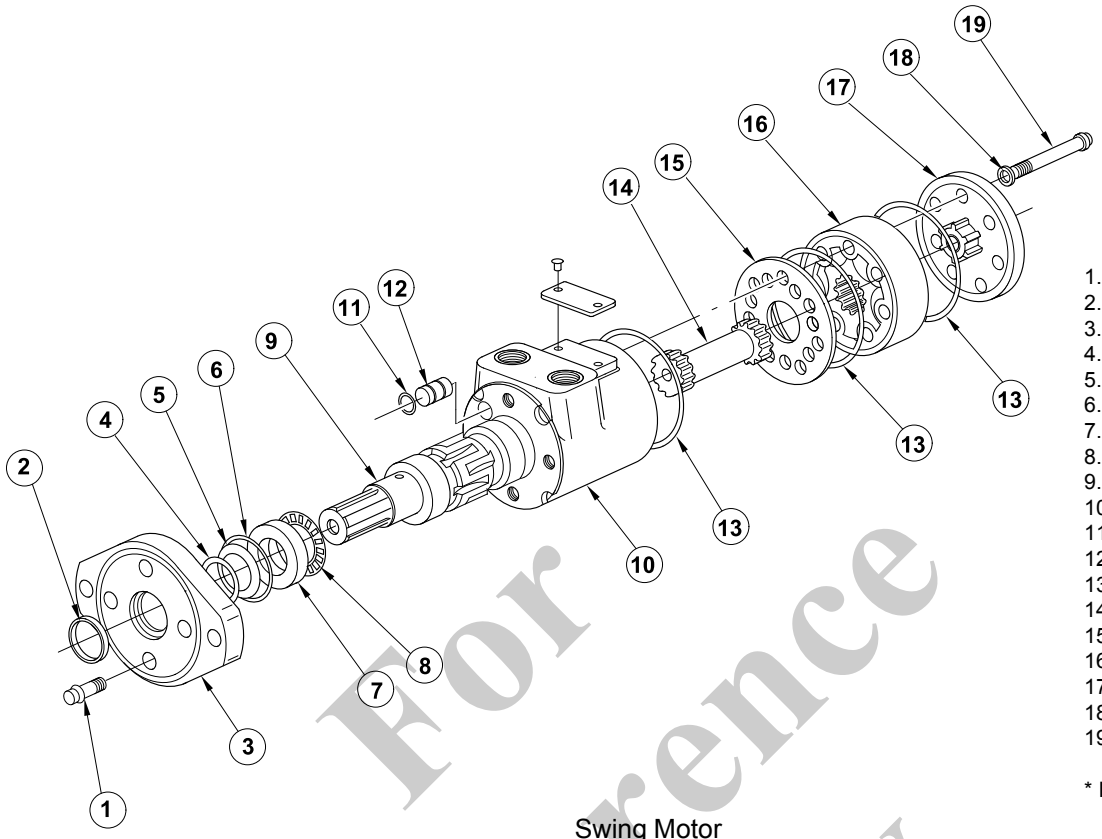
Solenoid Replacement

1. The solenoids on the valve section can be removed without removing the valve section from the manifold block.
2. Stop the engine and engage the parking brake. Place chocks under the wheels.
3. Disconnect the battery using the battery disconnect switch.
4. Open the access cover over the control valves and remove the cover plate.
5. Disconnect the wire leads from the solenoid valve.
6. Remove the plastic nut Figure 4-8 from the solenoid shaft. Slide the solenoid off of the shaft.
7. Place a new solenoid over the solenoid shaft and install the plastic nut.
8. Connect the wire leads to the solenoid valve.
9. Connect the battery using the battery disconnect switch.
10. Start the engine and test outrigger function.
11. Install the cover plate and close the access cover.

Installation

1. If the complete valve assembly is being installed, put the valve assembly in position and secure it with four mounting screws. Connect the hydraulic lines to the manifold block.
2. If only a valve section is being installed, place the valve section in position and install the socket head capscrews.
3. Connect the wire leads to the solenoid valves.
4. Connect the battery using the battery disconnect switch.
5. Start the engine and check the outriggers for correct operation. Stop the engine, check for leaks and add hydraulic fluid if necessary.

For Reference Only



1. Screw (4)
2. Exclusion Seal
3. Mounting Flange
4. Backup Ring *
5. Shaft Pressure Seal *
6. Seal *
7. Bearing Race
8. Thrust Needle Bearing
9. Output Shaft
10. Housing
11. O-Ring
12. Plug
13. Seal (3) *
14. Drive Shaft
15. Spacer Plate
16. Gerotor Set
17. End Cap
18. Seal Washer (7) *
19. Screw (7)

* Included In Seal Kit

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Swing Motor

FIGURE 4-7

For Reference Only

Swing Motor

Removal

1. Shut off the engine and release any hydraulic pressure in the swing motor circuit by moving the control lever in both directions.

CAUTION

The swing motor can only be reached from under the machine. Shut off the engine and remove the ignition key to prevent accidental starting and moving of the crane while working under it. Block all tires.

2. Before disconnecting the hydraulic lines, clean the port area of the swing motor thoroughly. Disconnect the hydraulic lines from the swing motor. Put caps and plugs on the lines and motor ports to keep dirt out.

3. Remove the two mounting bolts from the swing motor. Remove the swing motor.

Disassembly

CAUTION

Cleanliness is extremely important when repairing the swing motor. Work in a clean area. Plug the ports then use a wire brush to remove foreign material and debris from around the external joints of the motor. Check the shaft and key slot, remove all nicks, burrs or sharp edges that might damage seals during installation. Before starting the disassembly procedures, drain any remaining oil from inside the motor.

1. Place the motor in a vice and clamp across the edges of the flange Figure 4-8 with the output shaft facing down. When clamping use protective devices on the jaws, such as soft jaws, pieces of rubber or wood.

NOTE: Although not all drawings show the motor in a vice, it is recommended that you keep the motor in the vice during disassembly and assembly. Follow the clamping procedure explained in Step 1.

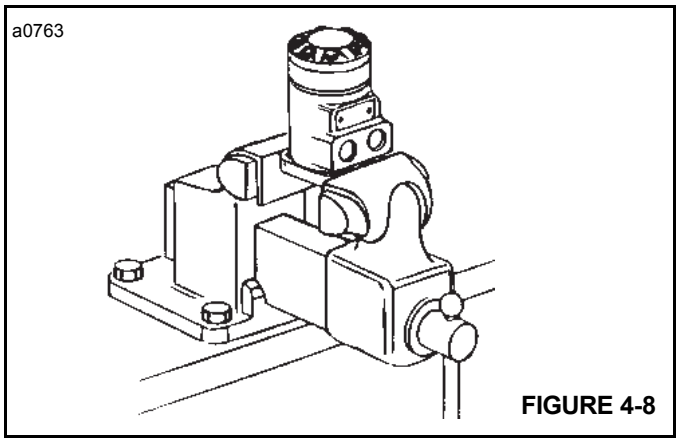


FIGURE 4-8

2. Remove seven capscrews (19) Figure 4-7 and seal washers (18).
3. Remove end cap (17). Remove and discard seal (13) from the end cap.
4. Remove gerotor (16). Remove and discard seal (13) from the gerotor.
5. Remove drive spacer, if applicable.
6. Remove drive shaft (14).
7. Remove spacer plate (15).
8. Remove seal (13) from housing (10).
9. Remove output shaft (9) from housing (10).
10. Remove needle thrust bearing (8) from shaft or housing.
11. Reposition the motor in the vice. Clamp across ports Figure 4-9. DO NOT clamp on housing. Excessive clamping pressure on side of housing causes distortion.

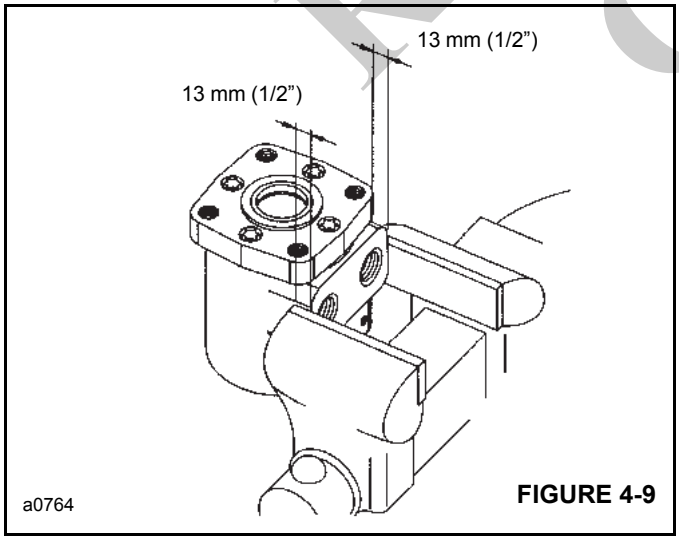


FIGURE 4-9

12. Remove four capscrews (1) from mounting flange (3). These screws were installed with Loctite® to hold them in place.

    The screws will require 35 - 45 Nm (300 - 400 lb-in) of torque to break loose and 11 Nm (100 lb-in) torque to remove. Do not use an impact wrench on the screws. This could result in rounded heads or broken sockets.

NOTE: If a torque higher than given above is required to break the capscrews loose, apply heat according to the following:

When heated, Loctite partially melts. This reduces the torque required to remove screw. Use a small flame propane torch to heat a small area of the housing where the screws enter. Figure 4-10. **Be careful not to overheat the housing** and damage the motor. Gradually apply torque to the capscrew with a socket wrench as heat is applied for 8 to 10 seconds. As soon as the screw breaks loose, remove the heat from the housing. Continue turning the screw until it is completely removed. Repeat for other capscrews.

13. Carefully remove flange (3) Figure 4-7 from housing (10).

NOTE: Some motors may have a quad seal and back-up ring in place of the pressure seal. The quad seal and back-up ring are no longer available and are replaced by the pressure seal. They are interchangeable, but some precautions must be taken to insure proper installation. Follow the reassembly instructions.

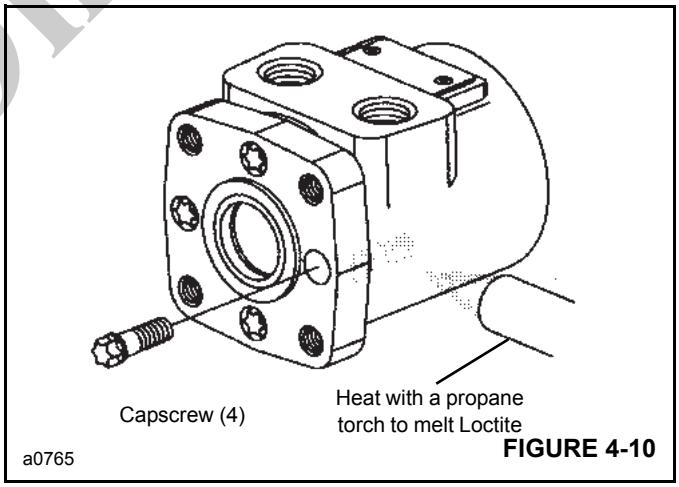


FIGURE 4-10

For Reference Only

14. Exclusion seal (2), backup ring (4), shaft pressure seal (5) and seal (6) will come off with flange (3). Use the seal removal tool to remove the exclusion and pressure seals Figure 4-11 and Figure 4-12.

NOTE: Be careful not to scratch the seal cavity outside diameter. This could create a leak path.

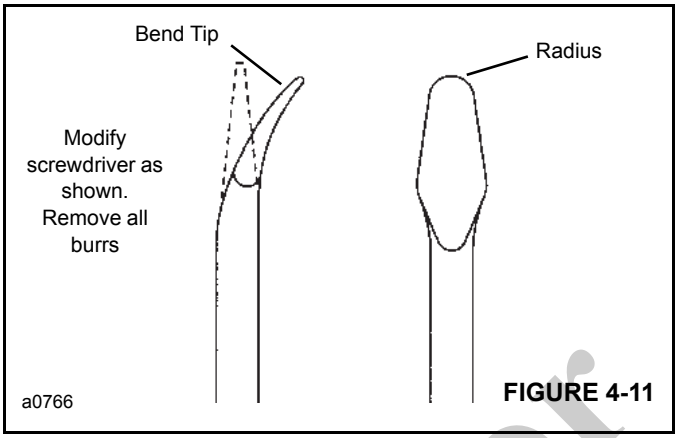


FIGURE 4-11

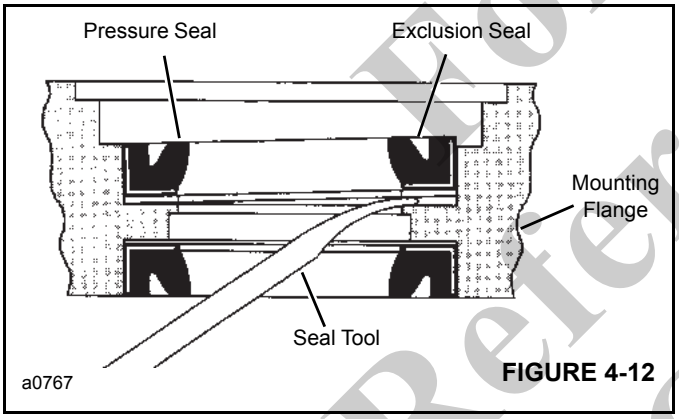


FIGURE 4-12

15. A metal plug (12) Figure 4-7, with O-ring (11), plugs a machined hole in the housing. It is not necessary to remove the plug and replace the O-ring unless leakage occurs around the plug. To remove the plug, insert a 5 mm (0.187 in) hex key through the port opening and push it out. The model 009 plug is not interchangeable with the 007 and 008 plugs.

Inspection/Cleaning

Check all mating surfaces. Replace any parts with scratches or burrs that could cause leakage or damage. Clean all metal parts in a suitable solvent. Blow dry with air. Do not wipe parts with a cloth or paper towels, because lint or other matter could get into the hydraulic system and cause damage.

Check around the key slot and chamfered area of the shaft for burrs, nicks or sharp edges that could damage seals during assembly. Remove nicks or burrs with a hard smooth stone. Do not file or grind motor parts.

NOTE: Lubricate all seals with petroleum jelly. Use new seals when assembling the motor. **DO NOT stretch the seals before installing them.**

Cleanliness is extremely important in the successful application of Loctite. Before Loctite can be applied, the parts should be cleaned as follows:

NOTE: Fully cured Loctite resists most solvents, oils, gasoline and kerosene and is not affected by cleaning operations. It is not necessary to remove cured Loctite that is securely bonded in tapped holes; however, any loose particles of cured Loctite should be removed.

1. Wash the housing with a suitable solvent to remove oil, grease and debris. Pay particular attention to the four tapped holes on the flange end.

2. Blow dry with compressed air. Clean and dry the tapped holes.

3. Wire brush the screw threads to remove cured Loctite and other debris. Discard any screws that have damaged threads or rounded heads.

4. Wash the screws with a non-petroleum base solvent. Blow dry with compressed air.

Assembly

Shaft End

1. If plug (12) Figure 4-7 was removed, lubricate the new O-ring (11) and install on the plug. The plug has two O-ring grooves, but requires only one O-ring in the groove closest to the end of the plug. Push the plug into the housing (10) until it is flush with the housing. Be careful not to damage the O-ring.

2. Lubricate output shaft (9) with hydraulic oil and install the shaft into housing (10).

CAUTION

Do not permit oil to get into the four tapped holes of housing (10).

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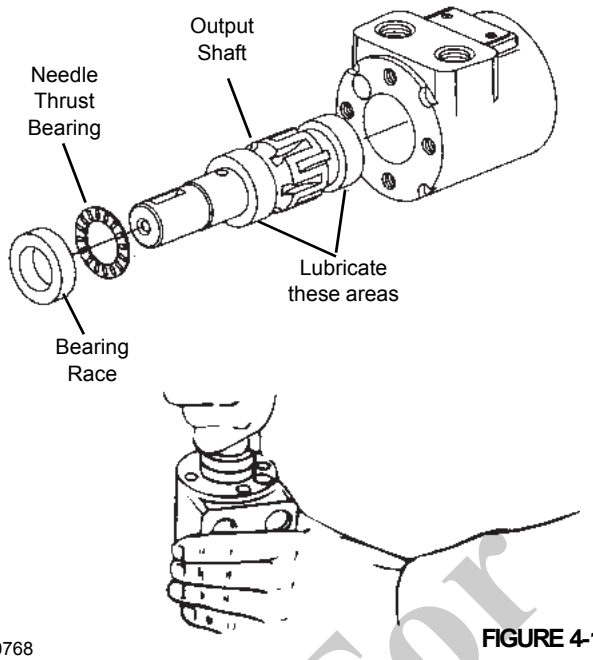


FIGURE 4-13

3. Install needle thrust bearing (8), then bearing race (7) on shaft (9). Pull shaft partially out of housing. Push all three parts in housing (10) together Figure 4-13. The bearing race must rotate freely when in position.

4. Install exclusion seal (2) Figure 4-7 in flange (3) with the lips of the seal facing out Figure 4-14. Carefully press the exclusion seal in place.

5. Visually check seal seats in the mounting flange for scratches or other marks that might damage the seals (5). Check for cracks in flange (3) that could cause leakage.

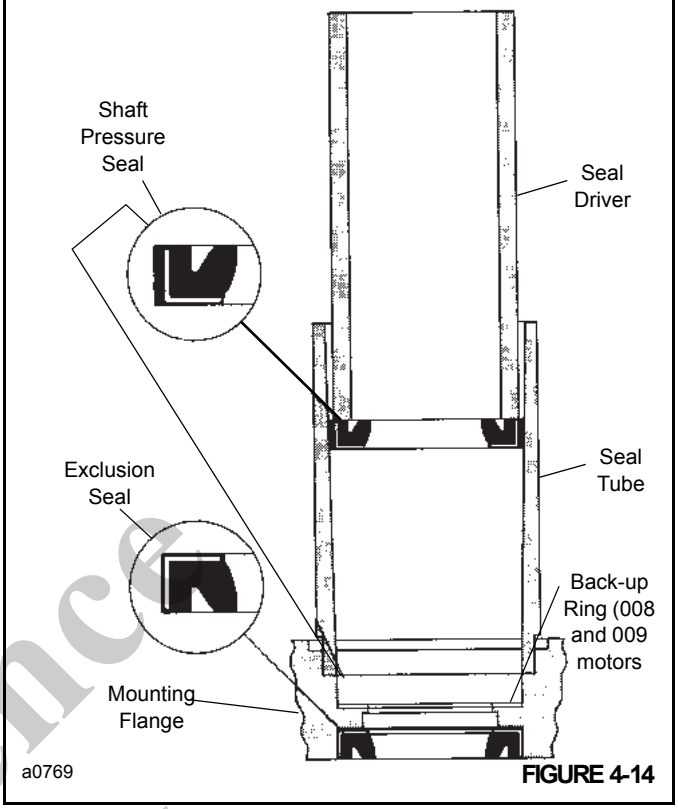


FIGURE 4-14

6. Lubricate inside diameter of seal tube and outside diameter of shaft pressure seal with light film of clean petroleum jelly. Align small inside diameter end of seal tube with seal seat in mounting flange (3). Install back-up ring (4) and pressure seal (5) in tube with lips of seal face up Figure 4-14. Insert seal driver in tube and firmly push seal seat with a rotating action.

NOTE: After installing the seal in the flange, examine the seal condition. If damaged or improperly installed, replace the seal before continuing with assembly.

7. Install O-ring (6) Figure 4-7 into groove in flange (3).

8. It is recommended to apply a light coat of Loctite® Primer NF in tapped holes of housing (10). Allow the primer to air dry for at least 1 minute. Do not force dry with air jet; the primer will blow away.

   Use of primer is optional. With primer, Loctite® curing time is approximately 15 minutes. Without the primer the curing time is approximately 6 hours.

9. Apply 3 or 4 drops of Loctite sealant at the top of the threads for each of the four holes in the housing Figure 4-15. Do not allow parts with Loctite to come in contact with any metal parts other than those for assembly. Wipe off excess Loctite from housing face, using a non-petroleum base solvent.

   Do not apply Loctite to threads more than 15 minutes before installing screws. If the housing stands for more

For Reference Only

than 15 minutes, repeat application. No additional cleaning or removal of previously applied Loctite is necessary.

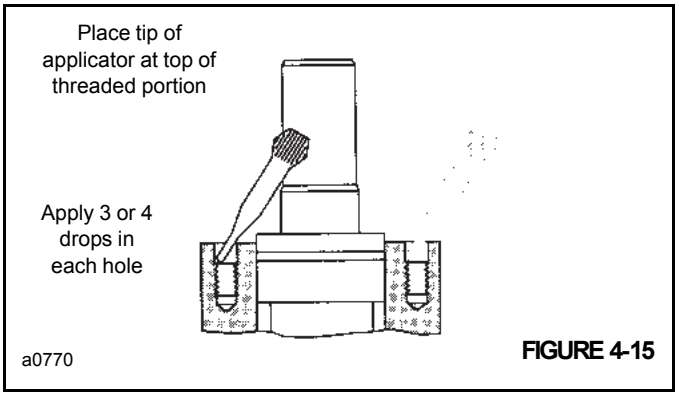


FIGURE 4-15

10. Before installing the flange and seal assembly over shaft (9) Figure 4-7, place a protective sleeve or bullet over the shaft. Then lubricate the space between exclusion seal (2) and pressure seal (5), as well as the lips of both seals Figure 4-16.

Install flange. Rotate flange slowly while pushing down over the shaft. Be careful not to invert or damage the seals.

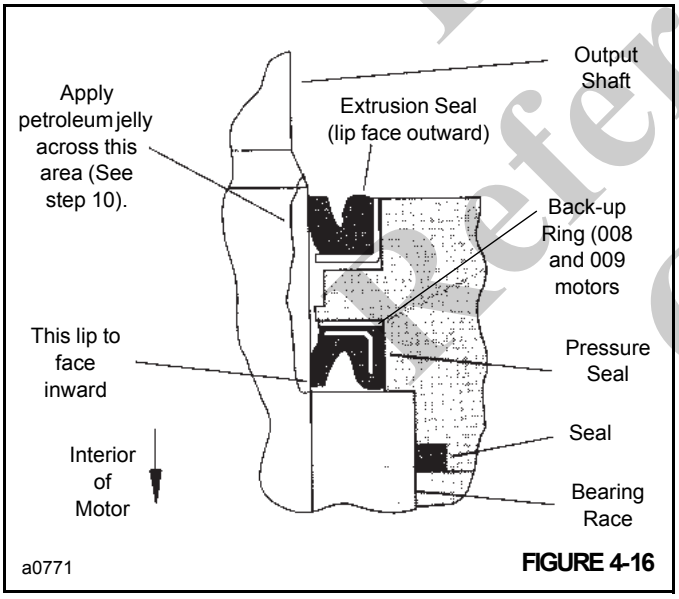


FIGURE 4-16

11. After removing the protective sleeve or bullet, clamp the motor in a vise. Make sure the shaft cannot fall out. Install dry screws and alternately torque them immediately to 28 Nm (250 lb-in). If you use primer, allow to cure for 10 to 15 minutes. Without primer, allow 6 hours curing before subjecting the motor to high torque reversals.

NOTE: If you use new screws, make sure they are the correct length: 22 mm (0.875 in) under head length.

Gerotor End

12. Reposition the motor in the vise with gerotor end up. Clamp across the ports. Do not clamp on side of housing.

NOTE: To aid installation of seals, apply a light coat of clean petroleum jelly to seals. Do not stretch the seals before installing them in a groove.

13. Pour approximately 30 cc (1 ounce) of clean hydraulic oil in the output shaft cavity.

14. Install O-ring (13) Figure 4-7 in the housing groove. Avoid twisting the seal.

Timing Procedure

15. Install drive shaft (14) Figure 4-7. Use a felt tip pen to mark one drive tooth. Align this mark with the timing dot on the output shaft Figure 4-17.

NOTE: If drive shaft (14) is not symmetrical, install larger splined end into output shaft (9).

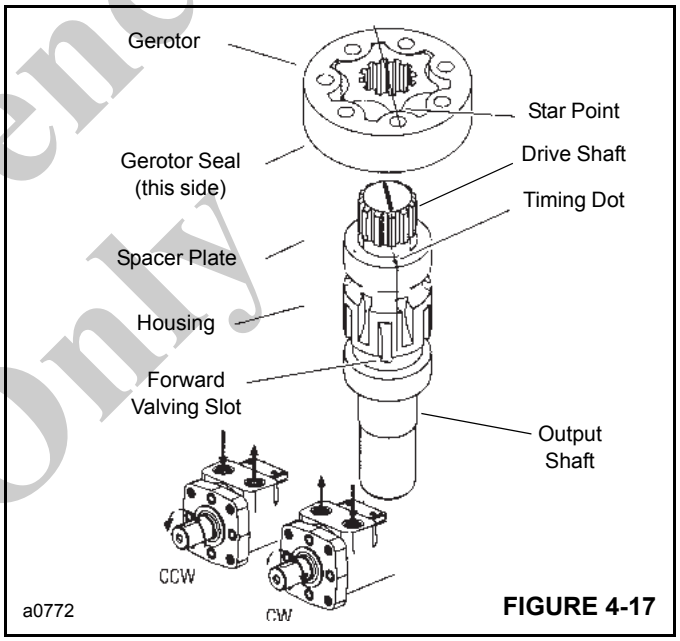


FIGURE 4-17

16. Install spacer plate (15).

17. Install seal (13) in gerotor seal groove. Carefully place gerotor on spacer plate, seal side toward the spacer plate. Align any star point with tooth marked on drive shaft Figure 4-17.

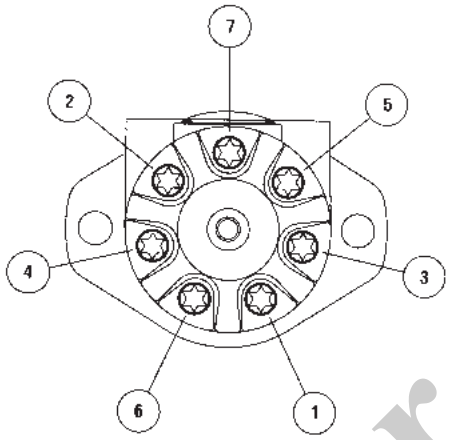
18. Rotate gerotor (16) to line up with bolt holes. Be careful not to disengage star from drive or disturb the gerotor seal.

19. Install drive spacer if applicable.

20. Install seal (13) in end cap (17). Carefully place the end cap on gerotor (16).

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21. Install capscrews (19) and seal washers (18) in end cap (17). Tighten the capscrews to 7.4 Nm (40 lb-in). Make sure the seal washers are properly seated. Then, tighten the capscrews to a torque of 27-28 Nm (235-250 lb-in) in the sequence shown Figure 4-18.



a0773 **FIGURE 4-18**

Installation

1. Place a new gasket on the face of the swing motor mounting flange.

2. Align the splines of the swing motor shaft with the splines of the worm gear shaft of the swing gear box. Install the swing motor to the gearbox with two socket head capscrews and lockwashers.

3. Connect the hydraulic lines and fittings to the swing motor.

4. Start the engine and slowly rotate the mast to remove any air in the swing hydraulic circuit. Check for leaks.

4

For Reference Only

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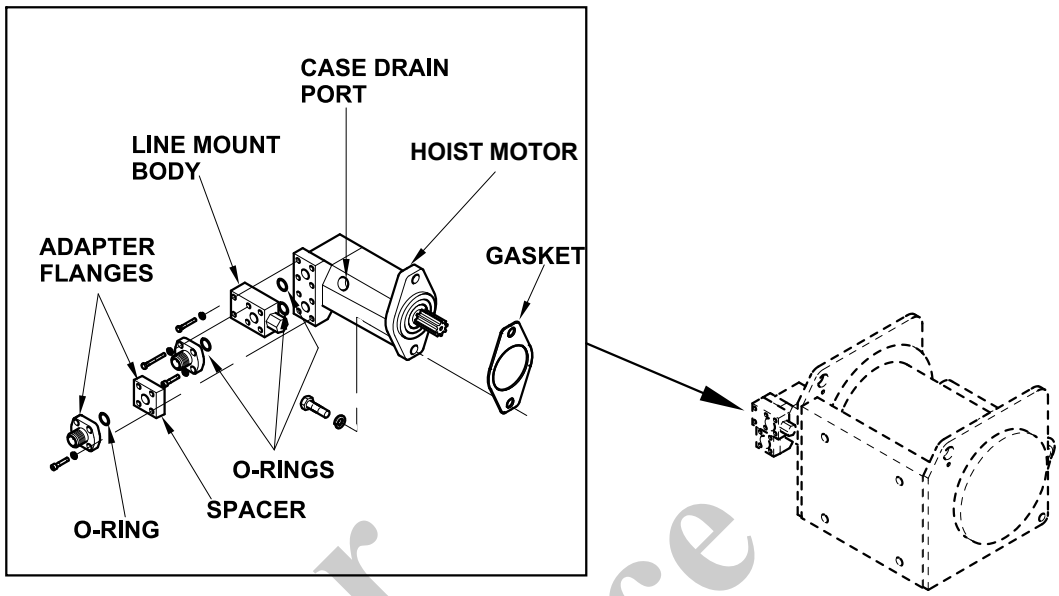


FIGURE 4-19

Hoist Motor

Removal

1. Shut off the engine, set the parking brake.
2. Before disconnecting the hydraulic lines, clean the port area of the hoist motor thoroughly. Disconnect the hydraulic lines from the hoist motor. Put caps and plugs on the hoses and ports to keep dirt out.
3. Loosen and remove the two capscrews and lockwashers securing the motor to the hoist. Remove the hoist motor and gasket. Discard the gasket.
4. Remove hoses, fittings, the adapter flanges, spacer block and line mount body Figure 4-19 from the pump. Discard all O-rings. The Tulsa model is shown, but the Braden model is similar.

Disassembly

The hoist motor is not field serviceable. It must either be replaced or returned to your distributor for repair.

Installation

1. Install the line mount body Figure 4-19, spacer and adapter flanges to the hoist motor. Be sure to use new O-ring seals.
2. Install the hoist motor and new gasket to the hoist using two capscrews and lockwashers.

CAUTION

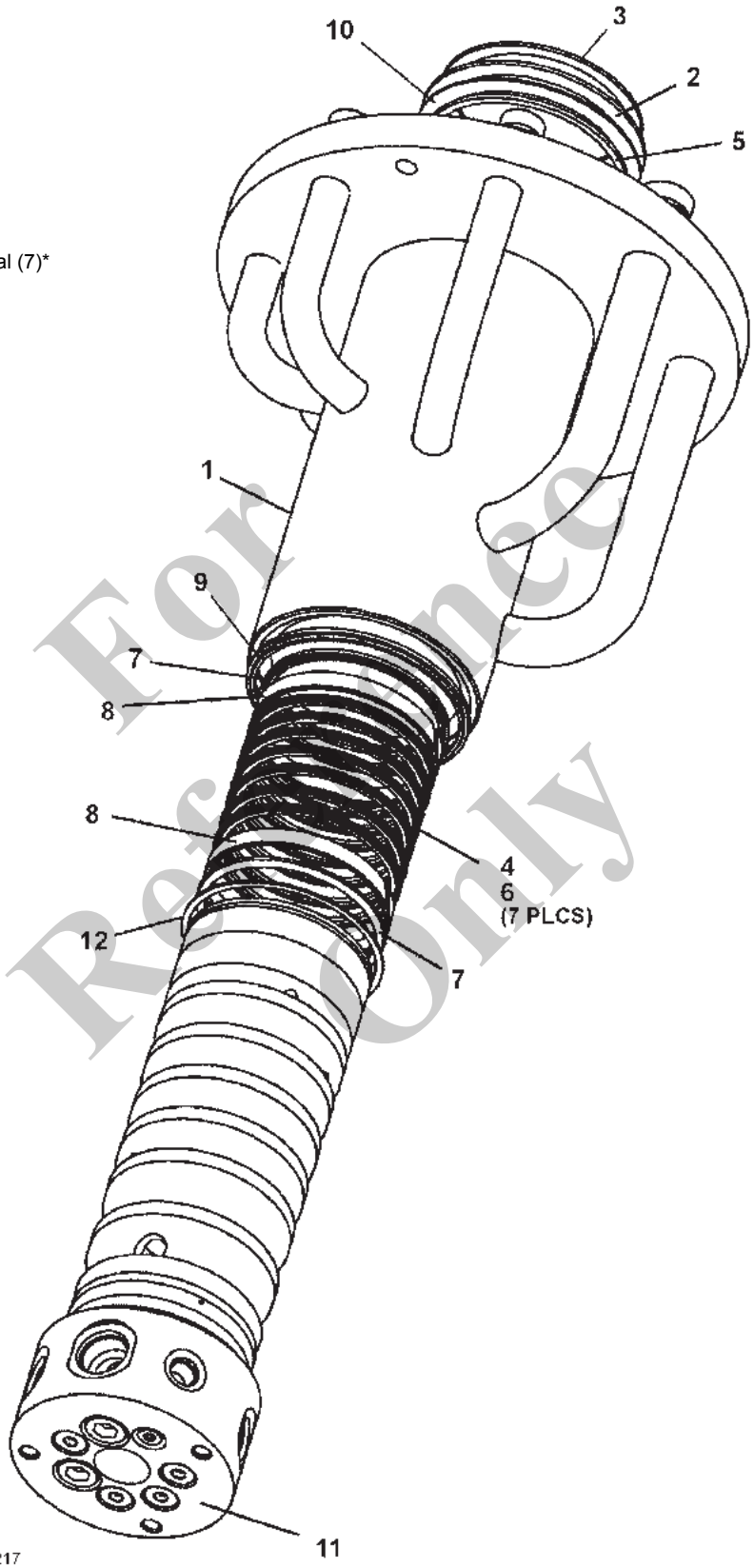
To prevent cavitation and damage to the motor due to lack of lubricating hydraulic oil, DO NOT start the motor without first filling the motor with hydraulic oil.

3. Fill the hoist motor with hydraulic fluid through the case drain port Figure 4-19 to the bottom of the fill plug with clean hydraulic oil.
4. Connect all the hydraulic hoses and fittings to the motor.
5. Start the engine and slowly run the hoist through several cycles to remove any air in the system. Check for hydraulic leaks.

For Reference Only

1. Housing Assembly
2. Washer Ring
3. Retainer Ring
4. Piston Seal (7)*
5. Wiper Ring *
6. Energizer Square Seal (7)*
7. U-cup Seal (2)*
8. Wear Ring (2)*
9. Wiper Ring *
10. Thrust Washer *
11. Spool Assembly
12. Thrust Washer *

* Included In Seal Kit



For Reference Only

FIGURE 4-20

Hydraulic Swivel

Removal

CAUTION

The area around the swivel and the swivel must be completely cleaned before removing the swivel from the machine.

1. Stop the engine and engage the parking brake. Move the controls in both directions to release any pressure in the hydraulic circuits.
2. Put tags on the hydraulic lines with the number of the hydraulic port to which the line connects.
3. Disconnect the hydraulic lines from the upper and lower swivel ports. Be prepared to collect the hydraulic oil in the lines. Put caps or plugs on the fittings and hydraulic lines.
4. Remove the stop from the bottom of the swivel.
5. Put a support under the swivel. Remove the three bolts and lockwashers securing the swivel to the mast.
6. Remove the hydraulic swivel.

Disassembly

1. Remove retaining ring 1 Figure 4-20 and retainer 2. Remove and discard thrust washer 3 and O-ring 4.
2. Carefully pull the swivel spool 10 from swivel housing 5. If the swivel spool can not be pulled from the swivel housing, hit the top of the swivel shaft with a soft hammer.
3. Remove and discard O-ring 6 and all seals and wear rings from spool 10.

Inspection

Wash the housing and spool in a suitable solvent. Check the housing for damage. If there is scoring or deep grooves, the housing must be replaced.

Use compressed air to remove foreign materials from the passages in the swivel spool. Check the spool for rough edges that could cause damage to the seals during installation.

Install new seals, wear rings and thrust washers.

Assembly

NOTE: The hard rubber piston seal 11 Figure 4-20 must be warm before installation. Heat the seal with a trouble lamp. Do not apply lubricant to the loader before installation.

1. Place the spool on the work bench in the vertical position.
2. Walk one seal 8 down each groove until it reaches the last groove. Then slide seal down the spool until it seats in groove on the spool.

CAUTION

Take care not to damage any of the seals and O-rings during installation.

3. Install an O-ring 11 into each of the eight grooves on the spool.
4. Install one heated piston seal 12 over each O-ring.
5. Install the two wear rings 9 into their appropriate grooves.
6. Install O-ring 7 into its groove.
7. Place the swivel housing 5 on the work bench with the bottom of housing facing up. Lubricate the lower 1/4 of the swivel bore with hydraulic fluid.
8. Place O-ring 6 on the end of the swivel housing 5 and then insert the assembled spool into the housing until it is seated. Be careful not to pinch or cut O-ring (6).
9. Turn the swivel over and install thrust washer 3 and O-ring 4. Install retaining ring 2 and secure with retaining ring 1.

Test

Pressure test the hydraulic swivel to 344.75 bar (5000 psi).

Test each port individually. No leakage past seals is permitted.

Installation

1. Put the hydraulic swivel in place on the machine. Fasten the hydraulic swivel to the brackets in the mast using three bolts and lockwashers.
2. Install the swivel stop to the bottom of the hydraulic swivel using three bolts and lockwashers.
3. Connect the hydraulic lines to the lower ports of the hydraulic swivel.
4. Fill the lower hydraulic system by adding recommended hydraulic oil through the upper ports of the hydraulic swivel.
5. Connect the hydraulic lines to the upper ports.
6. Start the engine and move the hydraulic oil through the swivel. Visually, check for leaks.

CAUTION

Do not rotate the mast until the oil has moved through the hydraulic swivel for several minutes.

For Reference Only

Hydraulic Cylinders

Removal

NOTE: The following removal instructions are general and should be modified to suit the cylinder being removed. Telescope cylinder removal instructions will be found in Section 11. Steering cylinder removal instructions can be found in Steering System Section 10.

1. Put a support under the component to which the cylinder is fastened. Make sure the component can not fall after the cylinder is removed.
2. Stop the engine. Release the pressure in the cylinder circuit by moving the control back and forth several times.
3. Disconnect the hydraulic lines from the cylinder. Put caps on the hydraulic lines to keep dirt out of the system.
4. Connect a hoist to lift the weight of the cylinder.
5. Remove the cylinder mounting pins. Remove the cylinder.

Disassembly

NOTE: The following procedures gives general instructions for repair of the hydraulic cylinders. Refer to illustrations for relation of the component parts.

Steering cylinder repair instructions can be found in Steering System Section 10.

1. Put the ports of the cylinder down to drain the oil from the cylinder.
2. Fasten the base of the cylinder in a vise with soft jaws. Place a support under the rod so the cylinder is level.
3. Use a spanner wrench to loosen and remove the head gland. Slide the head gland forward on the cylinder rod.
4. Pull the rod and piston straight out of the cylinder tube. If necessary, use compressed air applied to the base port of the cylinder to push the piston and rod out of the cylinder tube.
5. Fasten the eye of the rod in a vise with soft jaws. Put a support under the opposite end of the rod to hold the rod level. Use care not to cause damage to the chrome surface of the rod.
6. The piston is fastened to the rod either by internal threads or with a locking nut. To remove the piston:
   a. On pistons with internal threads, remove the set screw from the piston. Use a spanner wrench to loosen and remove the piston.
   b. On pistons which are fastened with a locking nut, use a socket wrench and extension to loosen the nut.
7. Remove and discard the seals and wear rings from the piston.
8. Remove and discard all seals, backup rings, wear rings, etc. from the head gland.

Inspection

Wash the parts in a suitable solvent. Use compressed air to remove all residue.

Check the bore of the cylinder tube for damage or distortion. Move the piston through the full length of the cylinder and check the clearance between the piston and the bore of the cylinder. If there is damage or distortion, replace the cylinder tube.

Look for damage to the chrome surface of the rod. The rod must be smooth and straight. A bent rod indicates possible loss of strength in the rod and replacement is necessary. If the chrome surface has damage, completely remove the old chrome and apply new chrome 0.03 mm (0.001 inch) thick.

Remove any rough edges on the piston to prevent damage to new rings during installation.

Assembly

1. Install new rings, rod wiper and seals on the head gland. See cylinder illustrations for location and correct installation.
2. Apply hydraulic oil to the rod and slide the assembled head gland on the rod.
3. Assemble the rings and seals on the piston.
4. Fasten the piston to the rod with locking nut and tighten specified torque. Be sure O-ring is installed between the piston and the rod. On pistons with internal threads, screw piston onto cylinder rod and install the set screw to secure the piston on the rod.
5. Apply hydraulic oil to the bore of cylinder and the rings on the piston. Carefully slide the piston and rod into the cylinder tube. Keep the rod straight during installation. Use care not to damage the piston rings when you install the piston through the threads in the bore of the cylinder tube.
6. Slide the head gland into the cylinder tube and tighten to specified torque. See illustrations. If equipped, install the set screw to secure the gland head in the cylinder.

Test

1. Fill the cylinder with clean hydraulic oil. To test the piston seal rings, continue to push oil into the rod end after the cylinder has hit bottom. Test to pressure indicated in

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Table 4-7 in both directions as directed in steps 2 through 5.

Table 4-7: Cylinder Test Pressures

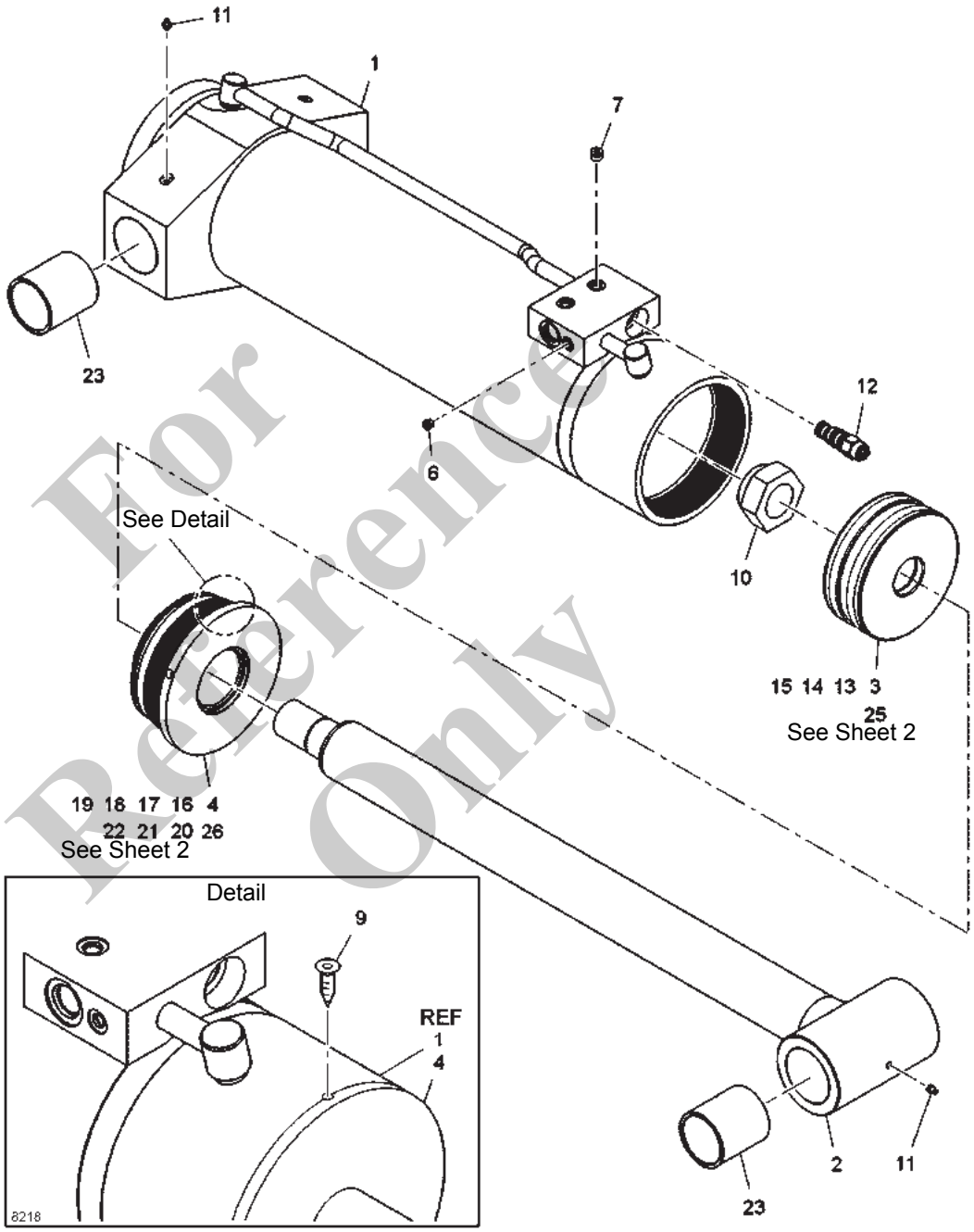
CYLINDER	TEST PRESSURE
Lift	324.05 bar (4700 psi)
Telescope	344.74 bar (5000 psi)
Horizontal Outrigger	344.74 bar (5000 psi)
Vertical Outrigger	344.74 bar (5000 psi)

2. Move the cylinder rod through two complete strokes at 55.10 bar (800 psi) to remove air from the cylinder. Look for external leaks. If the pressure difference between cylinder ports is more than 6.89 bar (100 psi) during the second stroke, the cylinder assembly is not acceptable. Disassemble and inspect for foreign materials or wrong assembly.
3. Wipe the cylinder rod clean, then move the cylinder through four complete strokes at 55.10 bar (800 psi), but do not permit the cylinder to hit bottom on each stroke. After four strokes, extend the cylinder rod just far enough to see how much oil has collected during the four strokes. Inspect the cylinder rod for indication of rod seal leakage. A thin layer of oil on the cylinder rod is normal.
4. Fully retract the cylinder rod. Keep the base port open. Apply test pressure in Table 4-7 to the rod port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.
5. Fully extend the cylinder rod. Keep the rod port open. Apply test pressure in Table 4-7 to the base port. Hold this pressure for a minimum of 10 seconds. Visually check for internal and external leakage. No internal or external leakage is permitted.
6. Put plugs in the cylinder ports to keep out dirt during installation.

Installation

1. Install the cylinder on the machine using the correct mounting hardware.
2. Connect the hydraulic lines.
3. Lubricate the cylinder grease fittings with recommended grease.
4. Check hydraulic oil level in the hydraulic oil reservoir. Add oil if necessary.
5. Start the engine and operate the cylinder(s) through several complete cycles to remove air. Check for leaks. Operate cylinders slowly and do not let the cylinders hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.
6. Check oil level in the hydraulic tank and fill if necessary.

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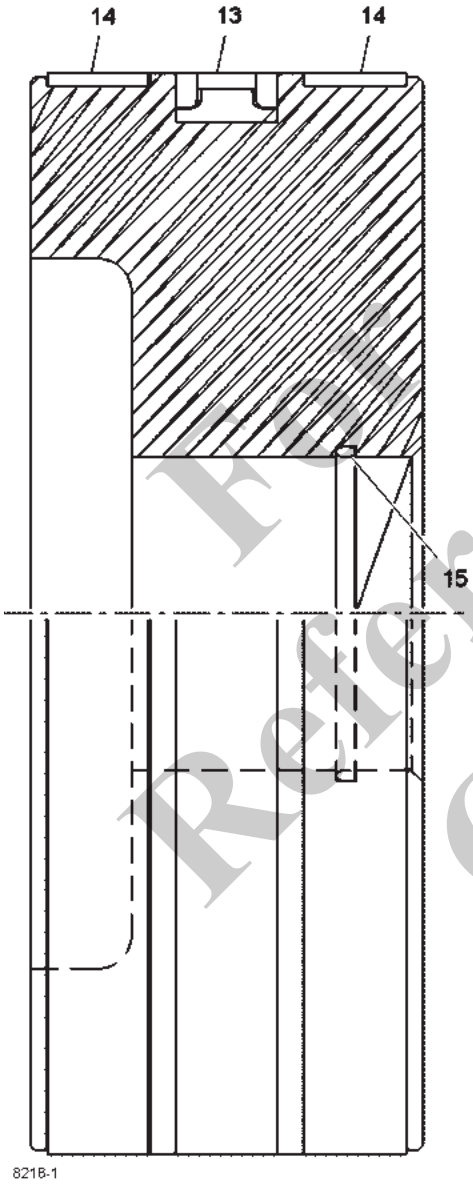
1. Barrel Assembly
2. Rod Assembly
3. Piston Assembly includes item 25
4. Head Assembly includes item 26
5. Not Used
6. O-Ring Plug
7. Metal Plug (2)
8. Not Used
9. Screw
10. Locknut
11. Grease Fitting
12. Counterbalance Valve
13. Piston Seal*
14. Wear Ring (2)*
15. O-Ring*
16. Rod Seal**
17. Buffer Seal**
18. Wear Ring (2)**
19. Wiper Ring**
20. O-Ring**
21. Backup Ring**
22. O-Ring**
23. Bushing (4)
24. Not used
25. Seal Kit, Piston
26. Seal Kit, Head

* = Repair Kit

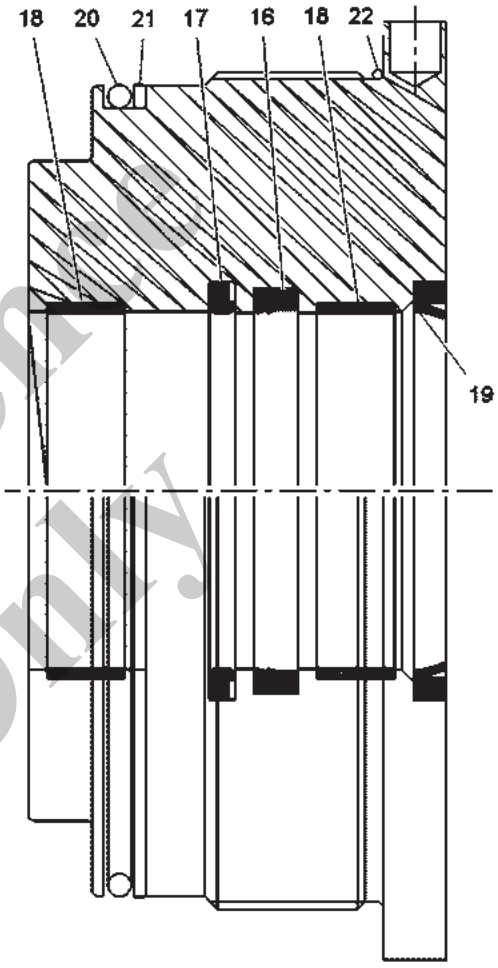
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Lift Cylinder Sheet 1

FIGURE 4-21



Detail Item 25



Detail Item 26

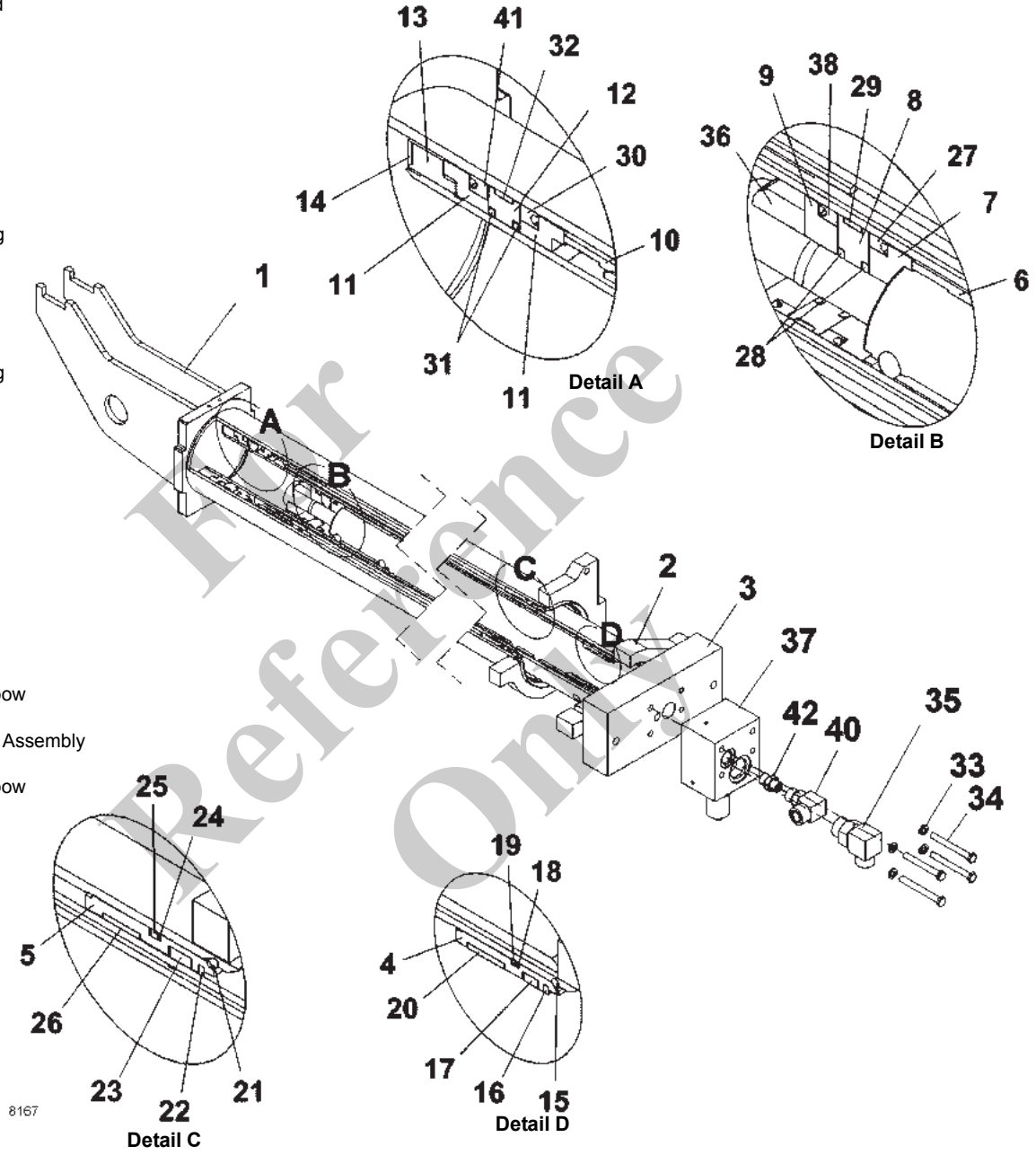
Lift Cylinder Sheet 2

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FIGURE 4-21 continued

Reference Only

1. Barrel Assembly
2. Outer Shaft Assembly
3. Inner Shaft Assembly
4. Packing Gland
5. Packing Gland
6. Stop Tube
7. Mandrel
8. Piston
9. Mandrel
10. Stop Tube
11. Mandrel
12. Piston
13. Round Nut
14. Screw
15. Retaining Ring
16. Rod Wiper
17. Rod Seal
18. Backup Ring
19. O-ring
20. Wear Ring
21. Retaining Ring
22. Rod Wiper
23. Rod Seal
24. Backup Ring
25. O-ring
26. Wear Ring
27. Piston Seal
28. O-ring
29. Wear Ring
30. Piston Seal
31. O-ring
32. Wear Ring
33. Lockwasher
34. Capscrew
35. 45 Degree Elbow
36. Locknut
37. Holding Valve Assembly
38. Piston Seal
40. 90 Degree Elbow
41. Piston Seal
42. Strait Adapter



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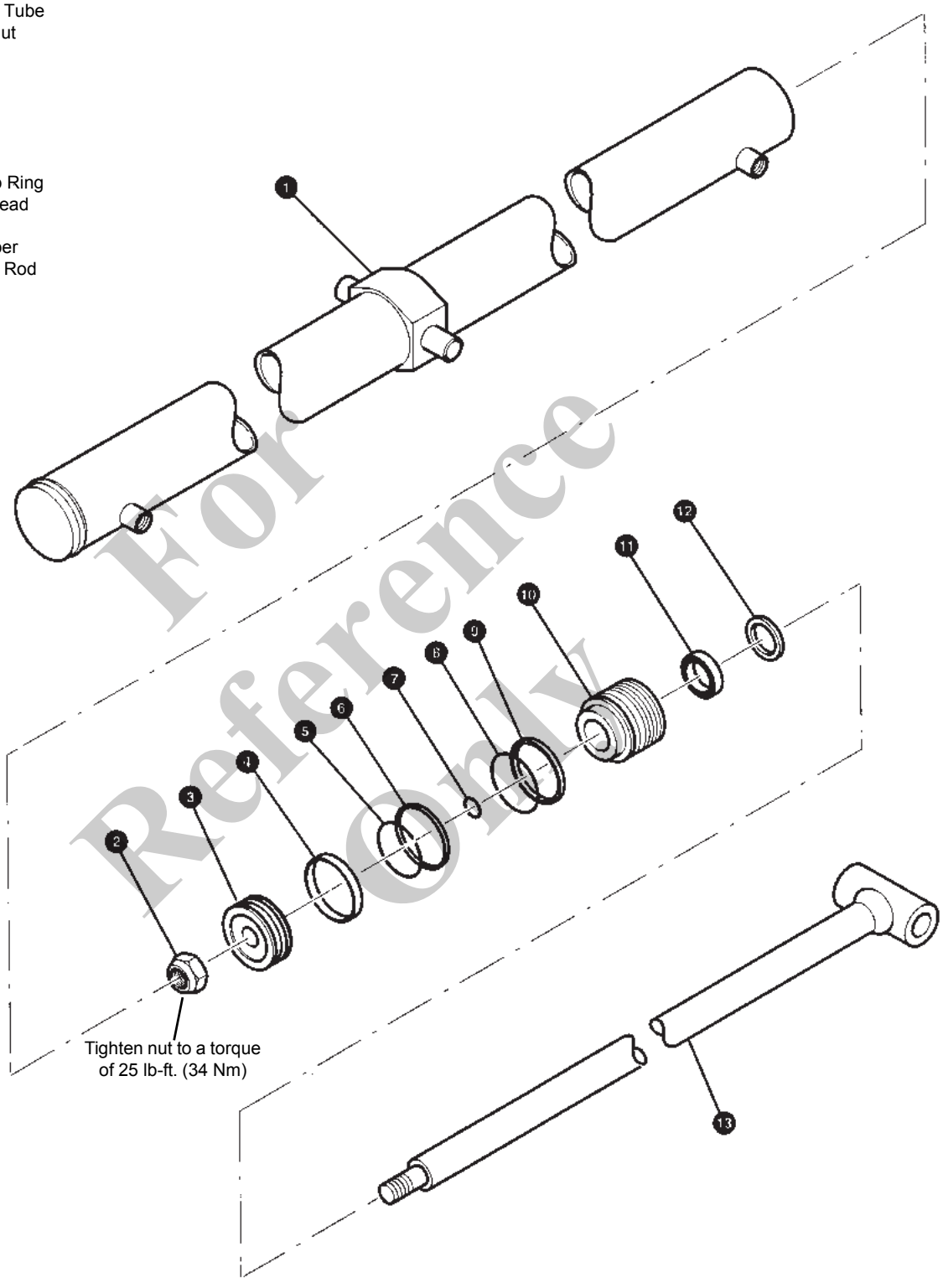
Telescope Cylinder

a0434

FIGURE 4-22

1. Cylinder Tube
2. Piston Nut
3. Piston
4. Wiper*
5. O-Ring*
6. Seal*
7. O-Ring*
8. O-Ring*
9. Back-Up Ring
10. Gland Head
11. Seal*
12. Rod Wiper
13. Cylinder Rod

*= Seal Kit



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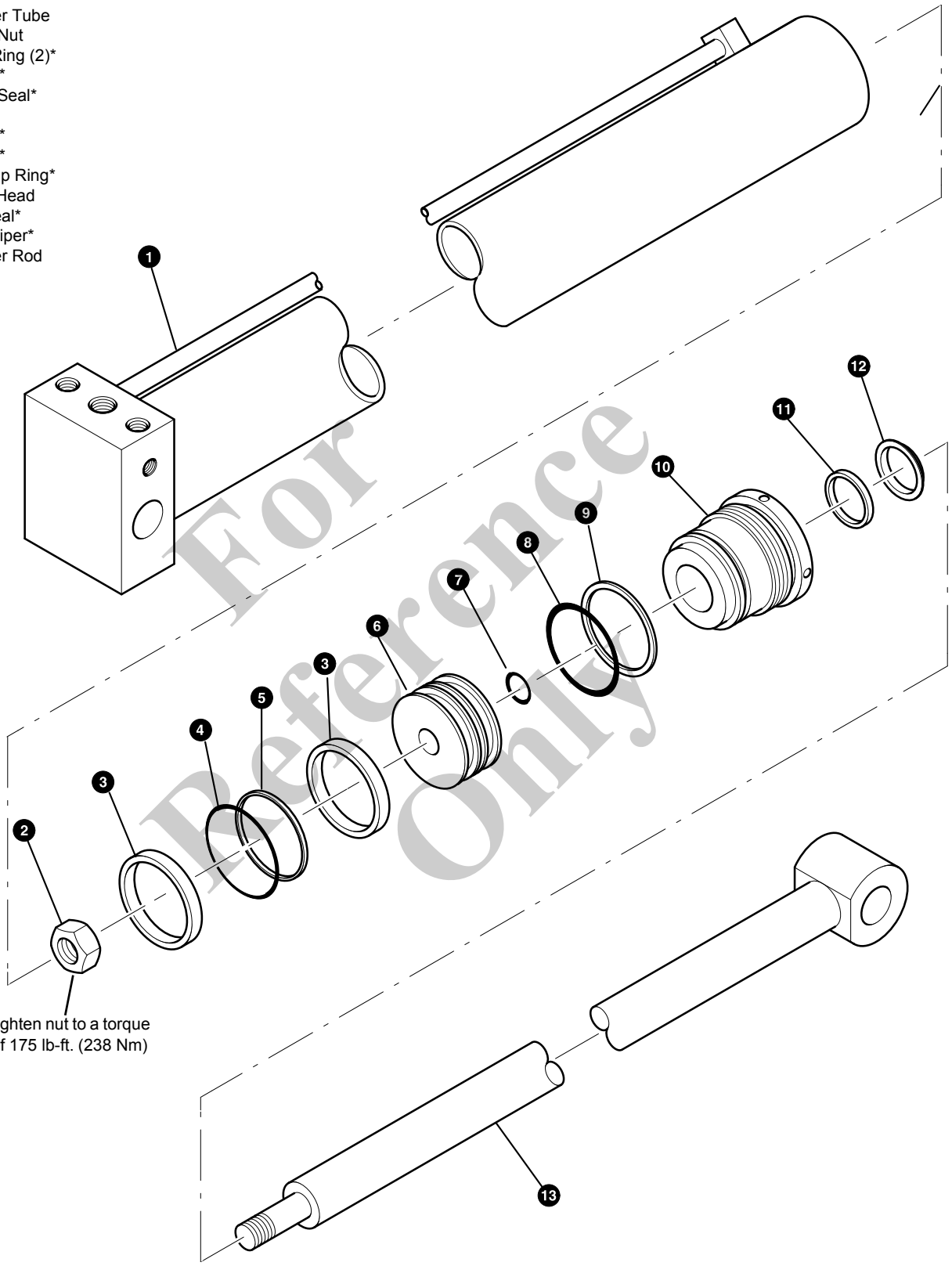
Horizontal Outrigger Cylinder

a0440

FIGURE 4-23

1. Cylinder Tube
2. Piston Nut
3. Wear Ring (2)*
4. O-Ring*
5. Piston Seal*
6. Piston
7. O-Ring*
8. O-Ring*
9. Back-Up Ring*
10. Gland Head
11. Rod Seal*
12. Seal Wiper*
13. Cylinder Rod

*= Seal Kit



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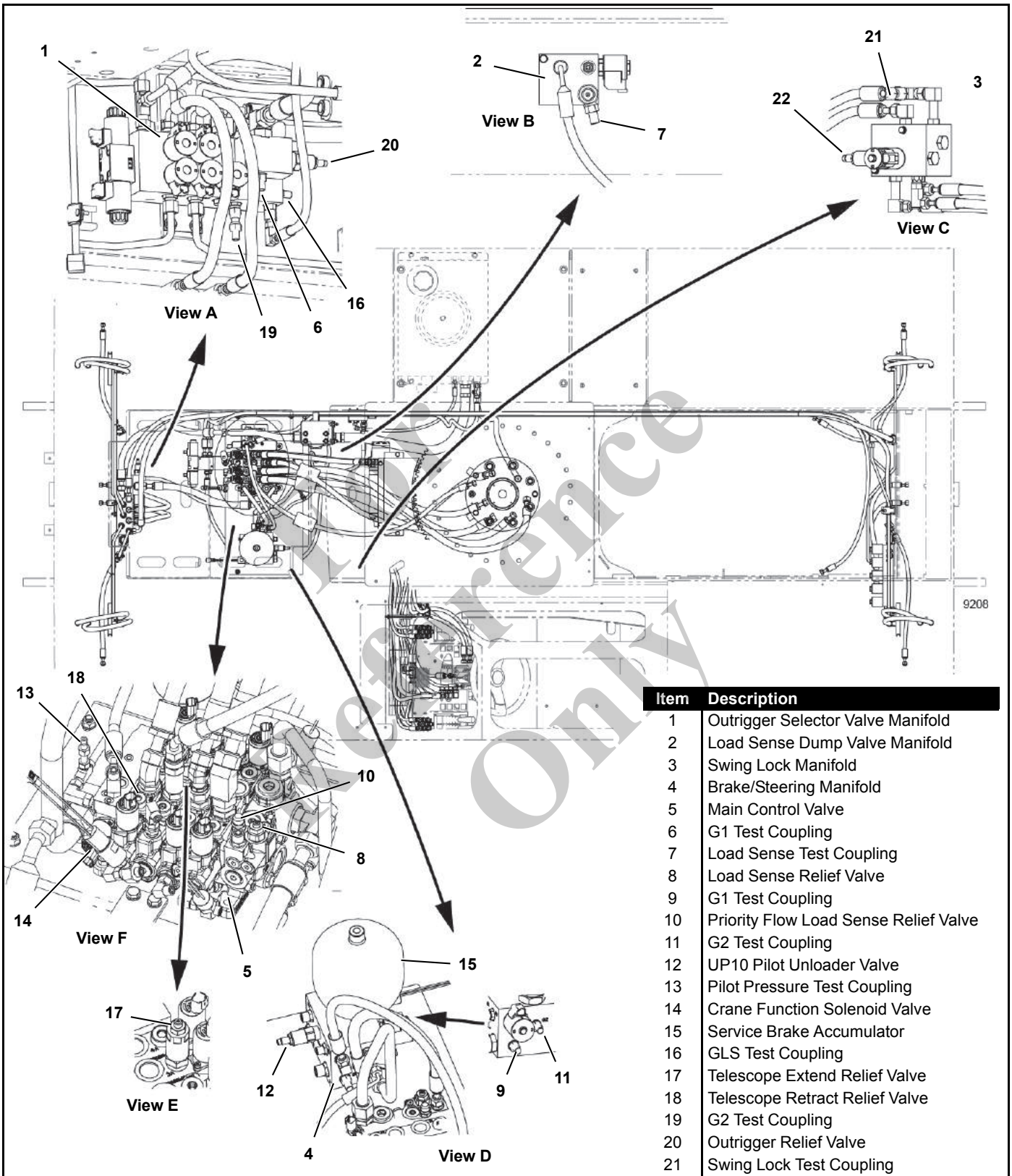
Vertical Outrigger Cylinder

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FIGURE 4-24

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Item	Description
1	Outrigger Selector Valve Manifold
2	Load Sense Dump Valve Manifold
3	Swing Lock Manifold
4	Brake/Steering Manifold
5	Main Control Valve
6	G1 Test Coupling
7	Load Sense Test Coupling
8	Load Sense Relief Valve
9	G1 Test Coupling
10	Priority Flow Load Sense Relief Valve
11	G2 Test Coupling
12	UP10 Pilot Unloader Valve
13	Pilot Pressure Test Coupling
14	Crane Function Solenoid Valve
15	Service Brake Accumulator
16	GLS Test Coupling
17	Telescope Extend Relief Valve
18	Telescope Retract Relief Valve
19	G2 Test Coupling
20	Outrigger Relief Valve
21	Swing Lock Test Coupling
22	Swing Lock Relief Valve

FIGURE 4-25

Reference Only

PRESSURE SETTING PROCEDURES

Pressure Setting Requirements

Check all pressures with:

- Hydraulic fluid at the normal operating temperature: 60°-71°C (140°-160°F). Check the hydraulic fluid temperature at the bottom of the hydraulic tank.
- Engine running at maximum RPM unless otherwise noted.
- Crane PARKED so it cannot move.

NOTE: The valves shown in Views A, D, E, and F (Figure 4-25) can be accessed by removing the cover plates from the carrier deck.

Pressure Setting Requirements

- Small adjustable wrench (for hex jam nuts)
- Small internal hex wrench set (for adjusting screws)
- Pressure diagnostic quick-disconnect (Parker PD240) with an accurate 0-345 bar (0-5000 psi) hydraulic pressure gauge.

Pump Margin Pressure Setting

1. STOP the engine.
2. Attach the pressure gauge to the G1 test coupling (6, View A, Figure 4-25).
3. Start and run the engine at idle. The pressure gauge should read 24 ± 1.7 bar (350 ± 25 psi).
4. If pressure reading is correct, stop the engine and disconnect the pressure gauge.
5. If the pressure reading is not correct:
   a. Loosen the jam nut on the pump margin adjusting screw (5a, Figure 4-1).
   b. Turn the adjusting screw until the specified pressure is obtained on the gauge. Clockwise rotation increases pressure.
   c. Hold the adjusting screw and tighten the jam nut.
   d. STOP the engine and disconnect the pressure gauge.

Load Sense Relief Valve Pressure Setting

1. STOP the engine.
2. Attach the pressure gauge to the load sense test coupling (7, View B, Figure 4-25).
3. Start and run the engine maximum rpm. Ensure the boom is all the way down and activate boom down function. The pressure gauge should read 259 ± 3.5 bar (3750 ± 50 psi).
4. If pressure reading is correct, stop the engine and disconnect the pressure gauge.
5. If the pressure reading is not correct:
   a. Loosen the jam nut on the load sense relief valve (8, View F, Figure 4-25).
   b. Turn the adjusting screw until the specified pressure is obtained on the gauge. Clockwise rotation increases pressure.
   c. Hold the adjusting screw and tighten the jam nut.
   d. STOP the engine and disconnect the pressure gauge.

IMPORTANT: The load sense relief valve must be properly adjusted before checking/adjusting all other valves

Priority Flow Load Sense Relief and Accumulator Relief Setting

1. STOP the engine.
2. Attach the pressure gauge to the G1 test coupling (9, View D, Figure 4-25).
3. With the park brake ON, start the engine. Set the crane up on a level surface with the outrigger jacks fully extended.
4. Remove the cap nut from the priority flow load sense relief valve (10, View F) Figure 4-25).
5. With engine at full rpm, turn the steering wheel all the way to one side until the steering cylinders bottom out. Adjust the priority flow load sense relief valve by turning the adjusting screw until the pressure gauge reads 172 ± 3.5 bar (2500 ± 50 psi). Clockwise rotation increases pressure.
6. Install the cap nut on the priority flow load sense relief valve.
7. STOP the engine and remove the pressure gauge.
8. Attach the pressure gauge to the G2 test port (11, View D, Figure 4-25).
9. Loosen the jam nut on the UP10 pilot unloading valve (12, View D, Figure 4-25).
10. With the engine at idle, repeatedly depress the service brake pedal on the cab floor until the pressure reading is approximately 117 bar (1700 psi).
11. Once you have found the pressure, push the brake pedal again to recharge the accumulator.

For Reference Only

- Watch the gauge and verify the low charging pressure. It should be 110 ± 7 bar (1600 ± 100 psi (when accumulator starts to recharge).
- Then watch the gauge as the valve is recharging. It should cut out at 138 + 7/-0 bar (2000 +100/-0 psi)
- If the proper pressures are not obtained, adjust the UP10 pilot unloading valve (12). Clockwise rotation increases pressure.
- If charging does not cut out, check the load sense relief valve pressure.

12. Hold the adjusting screw and tighten the jam nut.

13. STOP the engine and remove the pressure gauge.

Pilot Pressure Setting

1. STOP the engine and apply the parking brake.

2. Attach the pressure gauge to the pilot pressure test coupling (13, View F, Figure 4-25).

3. Start the engine and actuate the crane function power switch in the cab.

4. The gauge should read 15 ± 1.7 bar (362 ± 25 psi).

5. If the pressure reading is correct, stop the engine and remove pressure gauge.

6. If the pressure reading is not correct, verify the current to the crane function power solenoid valve (14, View F, Figure 4-25).

Service Brake Accumulator Charging

The service brake accumulator (15, View D, Figure 4-25) must be serviced by a qualified technician who is trained and thoroughly familiar with accumulator charging procedures.

The service brake accumulator must be charged with NITROGEN. Do not use compressed air.

If necessary, charge the accumulator to 52 ± 3.4 bar (750 ± 50 psi) using the required nitrogen charging apparatus.

Telescope Pressure Settings

IMPORTANT: The load sense relief valve must be properly adjusted before checking/adjusting all other valves

1. STOP the engine.

2. Attach the pressure gauge to the GLS test coupling (16, View A, Figure 4-25).

3. Extend pressure setting procedure:

a. Set the crane up on outriggers.

b. Operate the boom extend function to fully extend the boom and hold.

c. The pressure should be 193 +3.5/-0 bar (2800 +50/-0 psi).

d. If the pressure reading is not correct:

- Loosen the jam nut on the telescope extend relief valve (17, View E, Figure 4-25).
- Turn the adjusting screw until the specified pressure is obtained on the gauge. Clockwise rotation increases pressure.
- Hold the adjusting screw and tighten the jam nut.

4. Retract pressure checking procedure (not adjustable):

a. Leave the crane on outriggers and the pressure gauge attached to the GLS test coupling.

b. Operate the boom retract function to fully retract the boom and hold.

c. The pressure should be 203 ± 10.3 bar (2950 ± 150 psi).

d. If the pressure reading is not correct, take corrective action. the telescope retract relief valve (18, View F, Figure 4-25) is not adjustable.

5. Retract the boom and the outriggers.

6. STOP the engine and remove the pressure gauge.

Outrigger Circuit Pressure Setting

1. STOP the engine.

2. Attach the pressure gauge to the G2 test coupling (19, View A, Figure 4-25).

3. Start and run the engine at maximum RPM.

4. Move the outrigger extend/retract switch to the extend position and hold. The pressure should be 145 ± 3.5 bar (2100 psi ± 50 psi).

5. If the pressure reading is correct, stop the engine and remove the pressure gauge.

6. If the pressure reading is not correct:

a. Loosen the jam nut on the outrigger relief valve (20, View A, Figure 4-25).

b. Turn the adjusting screw until the specified pressure is obtained on the gauge. Clockwise rotation increases pressure.

c. Hold the adjusting screw and tighten the jam nut.

d. STOP the engine and remove the pressure gauge.

For Reference Only

Swing Pressure Setting

1. STOP the engine.
2. Attach the pressure gauge to the G1 test coupling (6, View A, Figure 4-25).
3. Disconnect both hydraulic hoses from the swing motor. Cap the adapters and plug the hoses.
4. Start and run the engine at maximum RPM.
5. Actuate the swing control in either direction and hold The pressure should be 150 ± 10.2 bar (2320 ± 150 psi).
6. Repeat the step in the other swing direction.
7. If the pressure reading is not correct, take corrective action. The swing pressure is not adjustable.
8. STOP the engine and remove the pressure gauge.
9. Reconnect the swing motor hoses.

Optional 360° Swing Lock Pressure Setting

1. STOP off the engine.
2. Attach the pressure gauge to the swing lock test coupling (21, View C, Figure 4-25).
3. Start and run the engine to maximum RPM.
4. Actuate the swing lock and hold. The pressure should be 172 ± 3.5 bar (2500 ± 50 psi).
5. If the pressure reading is correct, stop the engine and remove the pressure gauge.
6. If the pressure reading is not correct:
   a. Loosen the jam nut on the swing lock relief valve (22, View C, Figure 4-25).
   b. Turn the adjusting screw until the specified pressure is obtained on the gauge. Clockwise rotation increases pressure.
   c. Hold the adjusting screw and tighten the jam nut.
   d. STOP the engine and disconnect the pressure gauge.

DRAINING AND FLUSHING HYDRAULIC SYSTEM

If a component has been changed because of a failure that might allow metal or abrasive particles to enter the system, all systems must be thoroughly checked, drained, and flushed.

1. Remove the reservoir drain plug. Allow about three minutes after hydraulic oil stops flowing from the drain port for the side walls to drain.
2. Clean and install the reservoir plug and fill the reservoir with a 50/50 mixture of fuel oil and clean hydraulic oil.
3. Cycle the crane through all functions several times. Then return the crane to its stowed position and turn the front and rear wheels to the extreme left. Shut down the engine.
4. Remove the reservoir drain plug and drain the reservoir. Clean and install the drain plug and fill the reservoir with clean hydraulic oil.

NOTE: Hydraulic oil supply lines must be connected to the cylinders when flushing the system.

Draining the various components will be aided by connecting a drain line in place of the disconnected return line.

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.
6. Connect the cylinder return line and lower the boom to its stowed position. Replenish the reservoir hydraulic oil level as required.
7. Disconnect the return line from an outrigger extension cylinder and fully extend the outrigger.
8. Connect the outrigger return line and retract the outrigger. Replenish the reservoir hydraulic oil level as necessary.
9. Repeat Steps 7 and 8 for the remaining outriggers.

CAUTION

When draining the outrigger cylinders, always operate either both front or both rear cylinders together to prevent twisting the crane.

10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from both front steer cylinders and turn the front wheels to the extreme right.
16. Connect the return lines and turn the front wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Repeat Steps 15 and 16 for the rear steering cylinders.

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18. Raise the crane on outriggers.

19. Disconnect the line from port A of the axle lockout valve.

20. Using a jack under the rear wheel on one side of the crane, jack up the wheel to maximum travel.

21. Connect the line to port A of the axle lockout valve and disconnect the line from Port B.

22. Repeat step 19 using the other rear wheel.

23. Connect the line to port B of the axle lockout valve. Energize the axle lockout valve. Replenish the reservoir hydraulic oil level as necessary.

24. Disconnect the return line from the main hoist motor and fully hoist up the hoist.

25. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.

26. Repeat Steps 24 and 25 for the auxiliary hoist as necessary.

27. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.

28. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

When hydraulic oils are changed or added, ensure that hydraulic oils of different manufacturers are of the same specifications, however, discoloration (milkiness) may occur. Mixing incompatible hydraulic oils may result in improper operation or damage to the machine.

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge. After the reservoir is filled, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

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INTRODUCTION

NOTE: Do not use gasoline or other flammable fluids to clean component parts. Fire or explosion may occur causing bodily burns.

Use eye protection when performing service or maintenance tasks. Propelled and/or dropped items can cause eye injury.

If maintenance or adjustments must be performed with the engine running, have a person at the controls while another person performs the work to prevent accidental movement which could cause injury or death.

Preventive maintenance is necessary to keep the crane in good condition as long as possible. Adjust the maintenance schedule to your operation, according to the type of work, size of loads, temperature conditions and frequency of equipment use.

The intervals in the Maintenance Schedule are for average operating conditions, and must be understood as the **MINIMUM** maintenance necessary for the crane. Decrease these intervals if the crane is operated in conditions that are below average (for example, in dust, in high or low temperatures, with heavy loads or frequent starting and stopping).

Use the hourmeter and a calendar to make sure that all necessary maintenance is done according to the schedule.

NOTE: When performing service on the crane, put a tag on the key switch or remove the key to prevent operation of the crane.

Spark Arresting Mufflers

NOTE: Codes of some states or provinces may require that this crane be equipped with a **SPARK ARRESTING MUFFLER**. The State of California, as an example, is one state which has such regulations for agricultural and forestry application, plus a regulation for construction applications in forest covered, brush covered, or grass covered lands.

Safety List

Inspect the following safety equipment daily:

SAFETY BELT - Check for frayed or cut webbing, damaged buckles or loose mounting hardware.

SAFETY DECALS - Check condition of decals. Replace if worn, damaged or missing. See Section 2.

COVERS - Keep all protective covers in place.

PARKING BRAKE - Check operation. Have unit repaired if required.

ENGINE - Check operation. Remove all dirt or debris, and all flammable materials before running engine.

LUBRICANTS

Cummins Oil Registration List

Cummins has a program that lists engine oils that it has tested to meet its engineering specifications. Listing of recommended oils is on QuickServe® Online. Log on to quickserve.cummins.com and login with a current user name and password or create a new account by selecting “Create an Account” under information, choose Limited Owners Plan and register. Once logged in, click on the “Service” Tab in the top red bar, “Service Tools” mini-tab and “Oil Registration Lists” link within the Service Tools list. This will load a list of the different Cummins Engineering Specification numbers. Select the one that applies to your engine to view the registered oils.

It is not the policy of Manitowoc Cranes, Inc. to publish lists of approved lubricants or guarantee lubricant performance. The responsibility for the quality of the lubricant rests

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completely with the distributor or manufacturer of the lubricant.

In various paragraphs in this maintenance section, statements may be found, “use (lubricant brand name) or equivalent.” This statement does not constitute an unconditional guarantee of performance of the brand of lubricant mentioned. It is intended only as a guide to the type of lubricant recommended for a given application.

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, observe the following:

- 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 clean up any spills.

MAINTENANCE RECORDS

Dated records must be kept for inspection of critical components such as, brakes, crane hooks, wire ropes, hydraulic cylinders and relief valve pressure settings. These records must be kept where they can be easily obtained and reviewed.

MAINTENANCE

Preparation

Before maintenance, adjustments and repairs are started on a crane, the following precautions shall be taken as applicable:

- Place a warning tag in a conspicuous location at the controls stating that the machine requires adjustment or repair before it can be operated.
- Park the crane where it will cause the least interference with other equipment or operations in the area.
- Place all controls at the off position and set the brakes to prevent inadvertent motion.
- Disable all methods used to start the crane's engine.
- Lower the boom to the ground or otherwise secured against dropping.
- Lower the hook block to ground or otherwise secured against dropping.
- Relieve the hydraulic pressure from all hydraulic circuits before loosening or removing hydraulic components.

After maintenance, adjustments and repairs have been made, do not return the crane to service until all guards have been reinstalled, trapped air removed from the hydraulic system if required, safety devices reactivated, and maintenance equipment and all warning tags removed.

Maintenance, adjustments and repairs shall be done only by designated personnel who are properly trained. Use only Manitowoc supplied parts to repair the crane.

Hydraulic System Maintenance Precautions

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

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

Disassemble and reassemble hydraulic components on a clean surface.

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

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

When installing metal hydraulic 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.

In case of replacement hoses with angled stem reusable fittings, the hose curvature must be taken into consideration when assembling and positioning the angled stem.

Label Parts when Disassembling

When removing or disconnecting a group of wires or cables, tag each one to ensure proper identification during re-assembly.

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When shims are removed, tie them together and identify them as to location. Keep shims clean and flat until they are reinstalled.

Hydraulic Oil Recommendations

For the hydraulic oil specifications, Reference *Replace Hydraulic Oil and Filter*, page 5-37.

Draining and Flushing

If a component has been changed because of a failure that might allow metal or abrasive particles to enter the system, all systems must be thoroughly checked, drained, and flushed.

1. Remove the hydraulic tank drain plug. Allow about three minutes after hydraulic oil stops flowing from the drain port for the side walls to drain.
2. Clean and install the hydraulic tank plug and fill the hydraulic tank with a 50/50 mixture of fuel oil and clean hydraulic oil.
3. Cycle the crane through all functions several times. Then return the crane to its stowed position and turn the front and rear wheels to the extreme left. Shut down the engine.
4. Remove the hydraulic tank drain plug and drain the hydraulic tank. Clean and install the drain plug and fill the hydraulic tank with clean hydraulic oil.

NOTE: Hydraulic oil supply lines must be connected to the cylinders when flushing the system.

Draining the various components will be aided by connecting a drain line in place of the disconnected return line.

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.
6. Connect the cylinder return line and lower the boom to its stowed position. Replenish the hydraulic tank hydraulic oil level as required.
7. Disconnect the return line from an outrigger cylinder and fully extend the outrigger.
8. Connect the outrigger return line and retract the outrigger. Replenish the hydraulic tank oil level as necessary.
9. Repeat Steps 7 and 8 for the remaining outriggers.

CAUTION

When draining the outrigger cylinders, always operate either both front or both rear cylinders together to prevent twisting the crane.

10. Disconnect the return line from the telescope cylinder and fully extend the boom.
11. Connect the return line and retract the boom. Replenish the hydraulic tank oil level as necessary.
12. Disconnect the return lines from steer cylinders and turn the wheels to the extreme right.
13. Connect the return lines and turn the wheels to the extreme left and then back to center. Replenish the hydraulic tank oil level as necessary.
14. Raise the crane on outriggers.
15. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
16. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the hydraulic tank oil level as necessary.
17. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
18. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the hydraulic tank oil level as necessary.

CAUTION

When hydraulic oils are changed or added, ensure that hydraulic oils of different manufacturers are of the same specifications, however, discoloration (milkiness) may occur. Mixing incompatible hydraulic oils may result in improper operation or damage to the machine.

When hydraulic oils are changed, recheck the hydraulic tank oil level after brief system operation and add hydraulic oil as required. Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the hydraulic tank to the full mark on the sight gauge. After the hydraulic tank is filled, operate all circuits and recheck the sight gauge. Add hydraulic oil as required.

Removing Air From the Hydraulic System

Air entering the hydraulic oil will normally be removed automatically by passage of the hydraulic oil over the baffles in the hydraulic tank. If a component has been replaced, the hydraulic tank level is too low, or a leak develops in the suction lines to the pumps, air can enter the system. If air becomes entrapped in the hydraulic oil, it may be detectable in pumps and motor operated components such as the swing 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 tank and replenish as necessary. Then inspect for leaks in the suction lines leading to the pumps.

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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 hydraulic tank. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 0.138 to 0.276 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 hydraulic tank after completing any repairs or service. Operate all hydraulic circuits several times in both directions.
- This action should return any entrapped air to the hydraulic tank where it can be removed from the hydraulic oil by the baffles.

CAUTION

Always locate the machine on a firm supporting surface, extend the outriggers and level the machine and position the boom over the front to extend the boom at low angles. Injury or damage to the machine may result if this caution is not followed.

- 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 hydraulic tank. Ensure the boom is first telescoped IN (not OUT) in the morning. Telescoping OUT may cause air to be forced back into the cylinder.

CAUTION

Do not attempt to loosen fittings in pressurized lines or while the hydraulic pumps are in operation.

Extreme care must be used when removing any plugs or restrictions from a hydraulic system suspected to have entrapped air that may be pressurized. Moderate to minor injury may result from pressurized air in a hydraulic system.

- 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.
- 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 Manitowoc distributor.

Parts Replacement

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

SAFETY

Before performing any operation or maintenance procedure in the section, ***read and understand the warnings and basic safety rules found in Section 2 of this manual***.

WARNING

Falling/Moving Load Hazard!

It will be necessary to go under the carrier for many of the procedures in this section. To avoid death or serious injury from a moving crane, perform the following steps before going under the carrier:

- Move crane onto a firm level surface
- Chock wheels or level and block crane on extended outriggers
- Park crane
- Stop engine
- Remove ignition key

ENGINE MAINTENANCE

For engine maintenance guidelines, see the engine manual furnished with your crane.

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LUBRICATION

Lubrication Schematic

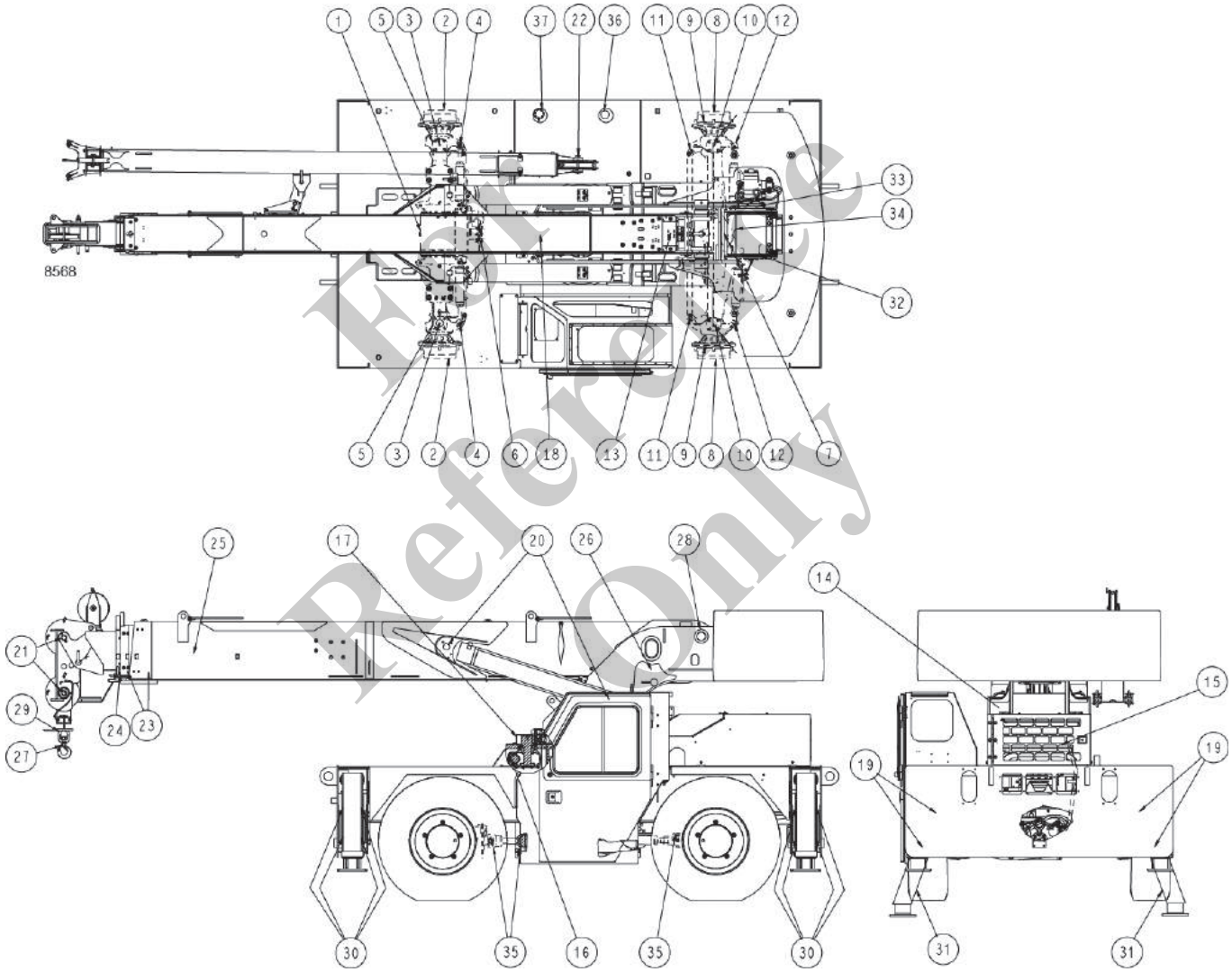


FIGURE 5-1

For Reference Only

Lubrication Symbols

Lube Symbol	Description	Grove Spec
EP-MPG	EP-MPG- Multipurpose Grease	A6-829-003477
AFC	AFC- Anti-freeze/coolant	A6-829-013562
HYDO	Hydraulic Oil	A6-829-006444
HTF	Hydraulic Transmission Fluid	80057784
EO-15W-40	Engine Oil Tier 3	A6-829-003483
EO-15W-40	Engine Oil Tier 4	A6-829-104182
EO-10W-30	Engine Oil Dual Fuel	A6-829-003480
ASC	Anti-Seize Compound	A6-829-003689
EP-OGL	Open Gear Lube (Ceplattyn 300 Spray)	A6-829-102971
EPGL-5	EPGL-5 Gear Lubricant	A6-829-003479
TransSynd	Synthetic Transmission Fluid	A6-829-101690

Lubrication Legend

Item	Location Nam	Capacity	Lube Symbol	Instruction
		Front Drive/steer Axle		
1	Differential	23 L (6.1 gal)	HYDO	
2	Planetary Hub Gears	1.5 L (1.6 qt)	EP-MPG	
3	Kingpin Bearings		EP-MPG	
4	Steer Cylinder Bearing		EP-MPG	
5	Universal Joints		EP-MPG	
6	Brake Caliper		EP-MPG	
		Rear Drive/Steer Axle		
7	Differential	18.0 L (4.8 gal)	HYDO	See Note 1
8	Planetary Hub Gears	1.7 L (1.8 qt)	EP-MPG	
9	Hub Bearings		EP-MPG	
10	Kingpin Bearings		EP-MPG	
11	Steer Linkage Bearing		EP-MPG	
12	Steering Cylinder		EP-MPG	
		Engine & Transmission		
13	Engine Crankcase Tier 3 and 4	5.5-7.0 L (5.8-7.4 qt)	EO-15W-40	See Note 2
13	Engine Crankcase KEM-4.3L Dual Fuel	4.3 L (4.5 qt)	EO-10W-30	See Note 2
14	Engine Coolant Tier 3	13.2 L (3.5 gal)	AFC	See Notes 2, 3, 4
14	Engine Coolant Tier 4	15.9 L (4.2 gal)	AFC	See Notes 2, 3, 4
14	Engine Coolant KEM-4.3L Dual Fuel	16.3 L (4.3 gal)	AFC	See Notes 2, 3, 4
15	Transmission	20.8 L (5.5 gal)	HTF/ CAT TO-4	See Note 2
		Turntable		
16	Swing Gear Box		EP-MPG	

For Reference Only

Item	Location Nam	Capacity	Lube Symbol	Instruction
17	Swing Gear & Pinion		EP-OGL	
18	Turntable Bearing		EP-MPG	
		Cylinders		
19	Outrigger Cylinder Pins		ASC	See Note 5
20	Boom Lift Cylinder Pins		EP-MPG	
		Boom		
21	Boom Nose Sheaves		EP-MPG	
22	Boom Extension Sheaves		EP-MPG	
23	Boom Sections		EP-MPG	See Note 6
24	Telescope Cylinder Wear Pads		EP-MPG	
25	Boom Extend Sheave		EP-MPG	
26	Boom Retract Sheave		EP-MPG	
27	Hook Block Swivel Bearing		EP-MPG	
28	Boom Pivot Shaft		ASC	See Note 5
29	Hook Block Sheaves		EP-MPG	
		Outriggers		
30	Outrigger Beam		EP-MPG	See Note 7
31	Outrigger Jack Tube		EP-MPG	See Note 7
		Hoist		
32	Hoist Gearbox	1 L (1 qt)	EPGL-5	
33	Hoist Brake	0.24 L (0.25 qt)	TranSynd	
34	Cable Follower		EP-MPG	
		Misc.		
35	Driveline Joints		EP-MPG	
36	Fuel Tank	104.4 L (27.6 gal)		
37	Hydraulic Tank	130.6 L (34.5 gal)	HYDO	See Notes 2 & 8

For Reference Only

Lubrication Notes

1 4 wheel drive option only.

2 Adjust final fluid levels using dipsticks, level gauges, markings, or filler plugs.

3 Use a mixture of 50% AFC and 50% water.

4 Engine coolant capacity listed is the combined capacity for coolant in the engine and radiator.

5 Apply to pins prior to assembly.

6 Lubricate all surfaces in contact with wear pads.

7 Apply to all sides.

8 Make sure hydraulic oil meets or exceeds Grove cleanliness spec 6829014631.

9 Oil or grease all points requiring periodic lubrication as required during assembly.

10 Lubricate all movable control links and clevis pins during assembly.

SPECIAL MAINTENANCE

Delivery Inspection

Fuel Tank

- Fill with correct fuel.

Engine

- Check oil in crankcase. Fill if level is low.
- Remove water from fuel filters and sediment bowl.

Cooling system

- Check coolant level. Fill if level is low.

Hydraulic Tank

- Check oil level. Fill if level is low.

Drive Axles

- Check axle housing lubricant level and wheel hub lubricant level. Fill if levels are low.

Hoist Gearbox

- Check oil level. Fill if level is low.

Tires

- Check for correct air pressure.

Wire rope cable clamps and connections

- Check for loose or missing parts.

Anti-Two-Blocking System

- Check that the system is working properly.

Controls

- Check that all controls are working properly.

After First 50 Hours of Operation (New Cranes)

Engine

- Change the engine oil and filter.

Swing Gearbox

- Check and tighten mounting bolts.

Hoist Gearbox

- Check and tighten mounting bolts.

Swing Gear Pinion and Swing Gear

- Lubricate.

Grease Fittings

- Apply grease to all grease fittings.

Boom Cables

- Inspect cables for looseness and tighten.

Boom Slides

- Lubricate.

Wheel Mounting Nuts

- Check Torque.

After First 100 Hours of Operation (New Cranes)

Transmission

- Replace oil filter.

Cranes Not in Regular Use

A crane which has been idle for a period of one month or more, but less than six months, must be given an inspection by a qualified person. This person should use the daily through monthly inspections.

A crane which has been idle for a period of over 6 months must be given a complete inspection covering all inspections through one year, by a qualified person.

Standby cranes must be inspected using the daily through monthly inspection, by a qualified person.

For Reference Only

MAINTENANCE SCHEDULE AND CHECKLIST

NOTE: Hour intervals in each maintenance chart show the correct time for service. The hourmeter located in the operator's cab indicates the total hours the crane has been running.

In addition to the following scheduled maintenance, perform the scheduled maintenance suggested in the engine manual furnished with the crane.

Maintenance should be performed using either the hourly or calendar date, whichever occurs first.

Under extremely dusty conditions items marked (*) may require replacement more frequently.

When performing maintenance, do the required current maintenance interval as well as all previous maintenance intervals. For example, when performing the 250 hour (monthly) maintenance interval, perform all the tasks required for daily, 50 hour and 100 hour maintenance.

Service Check	Daily before operation	50 Hr Weekly	100 Hr Two Weeks	175 Hr	250 Hr Monthly	500 Hr Three Months	1000 Hr Six Months	2000 Hr Yearly
Inspect wire rope	x							
Inspect reeving, clamps and connections	x							
Inspect lifting hook	x							
Inspect anti-two block system	x							
Inspect safety devices	x							
Check controls operation	x							
Check fuel level	x							
Check engine oil level	x							
Check transmission oil level and filter	x							
Check hydraulic filter indicator	x							
Check engine coolant level	x							
Check DEF level (T4F)	x							
Drain water from engine fuel filter	x							
Check hydraulic oil level	x							
Check air cleaner restriction indicator	x							
Check tire pressure	x							
Clean air cleaner dust cup		x						
Inspect wire rope and sheaves		x						
Lubricate all grease fittings		x						
Lubricate boom cable sheaves		x						
Lubricate the boom wear pads		x						
Lubricate parking brake fitting		x						
Clean heater and air conditioner filter		x						
Inspect engine fan belts			x					
Check wheel nut torque			x					
Replace transmission filter (initial only)			x					
Replace engine crane oil and filter (dual-fuel engine)				x				

For Reference Only

Service Check	Daily before operation	50 Hr Weekly	100 Hr Two Weeks	175 Hr	250 Hr Monthly	500 Hr Three Months	1000 Hr Six Months	2000 Hr Yearly
Lubricate swing gear and pinion					x			
Lubricate wire rope					x			
Inspect hydraulic hoses					x			
Clean battery and connections					x			
Clean radiator and oil cooler					x			
Replace diesel engine oil and filter *					x			
Torque critical bolts					x			
Inspect tires for damage						x		
Check axle wheel hub lubricant level (4)						x		
Check axle housing lubricant level (2)						x		
Grease drive shafts						x		
Inspect parking brake pads						x		
Add grease to swing gearbox						x		
Check hoist gearbox and brake lubricant level						x		
Add rust inhibitor to engine cooling system						x		
Replace fuel filters (diesel)						x		
Replace fuel filters (dual-fuel)						x		
Lubricate outrigger slides						x		
Replace transmission oil, strainer and filter							x	
Replace axle housing oil							x	
Replace axle wheel hub oil							x	
Replace hoist gearbox oil							x	
Replace hoist brake oil							x	
Replace hydraulic oil and filter							x	
Check swing gear to pinion backlash							x	
Replace LP gas filter							x	
Service dual-fuel engine							x	
Replace engine coolant								x
Inspect crane structure and booms for damage								x
Test Rated Capacity Limiter (RCL)-optional								x
Service dual-fuel engine								x

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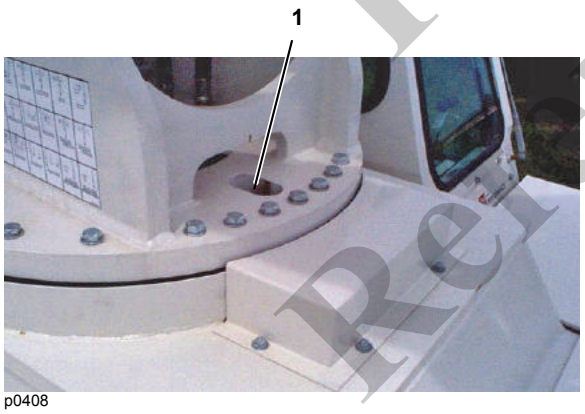
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GREASE POINTS

Apply grease to the following fittings after the first 20 hours of operation, thereafter every 50 hours of operation. Use a Lithium Base, EP 2 bearing grease or equivalent. Apply enough grease to remove the old grease.

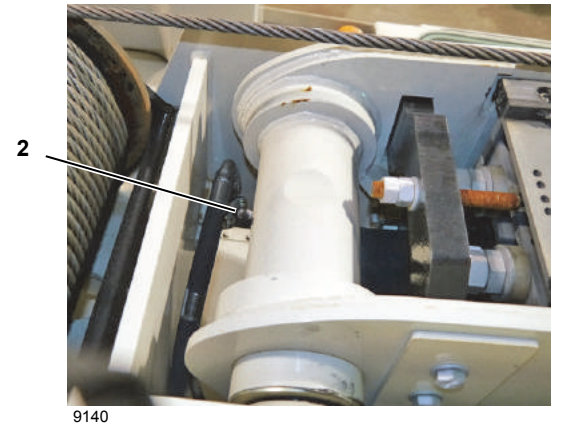
Boom and Main Frame

Item	Location	Qty	Note
1	Mast Bearing (Figure 5-2)	2	90° apart located on inside of bearing.
2	Boom Pivot (Figure 5-3)	2	
3	Lift Cylinder Pivots (Figure 5-4)	2	1 fitting each end of both lift cylinders.
4	Boom Extension Sheave (Figure 5-5)	1	Fitting in shaft.
5	Boom Extend Sheaves (Figure 5-6)	2	1 fitting each side of boom through holes in boom sections. Extend boom to access.
6	Boom Extension Deflector Sheave (Figure 5-7)	1	
7	Boom Head Sheaves and Pivot (Figure 5-7)	3	Fittings in shafts.
9	Anti-Two Block Bracket Guide Pins (Figure 5-7)	–	Coat lightly with grease.
10	Hook Block or Overhaul Weight (Figure 5-8)	–	If equipped with grease fittings, grease sheaves and swivel bearings.



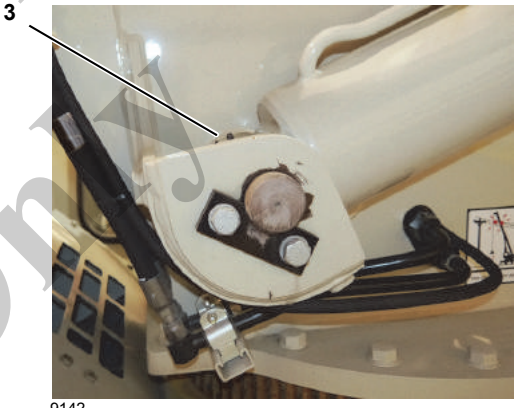
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FIGURE 5-2



9140

FIGURE 5-3



9142

FIGURE 5-4

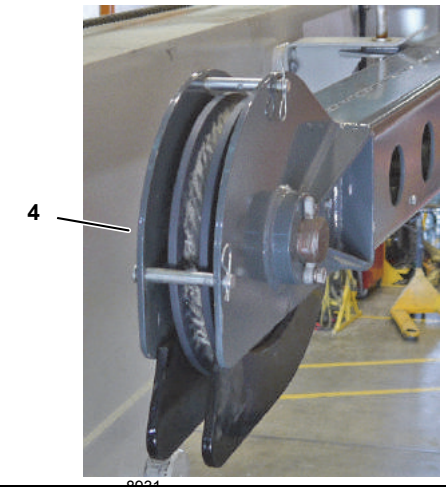


FIGURE 5-5

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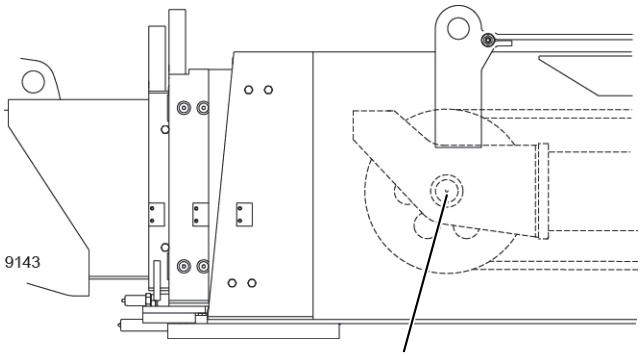


FIGURE 5-6

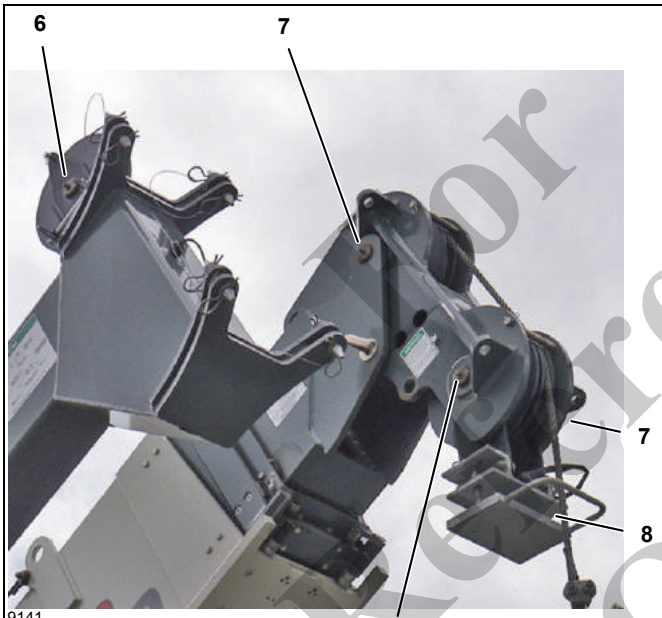


FIGURE 5-7

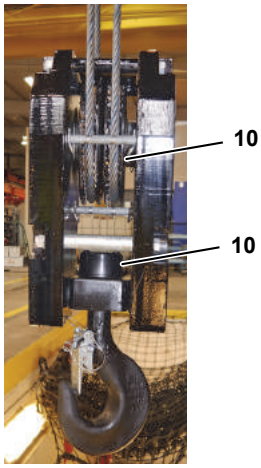


FIGURE 5-8

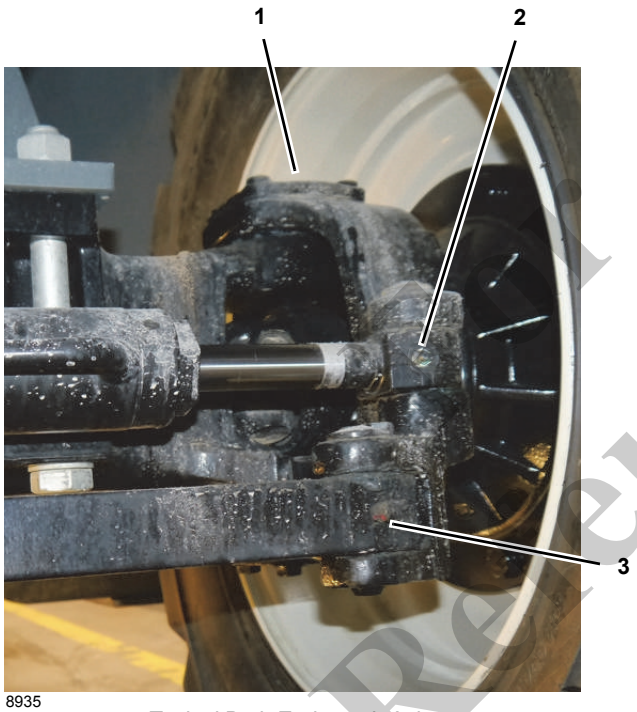
For Reference Only

5

Drive Train

Item	Location	Qty *	Note
1	Steering Knuckles (Figure 5-9)	4	2 places both ends of axle.
2	Steering Cylinder Pivot Pins (Figure 5-9)	4	1 fitting each end of each of both cylinders.
3	Steering Link (Figure 5-9)	2	1 fitting each end.
4	Rear Axle Pivot Pin (Figure 5-10)	1	

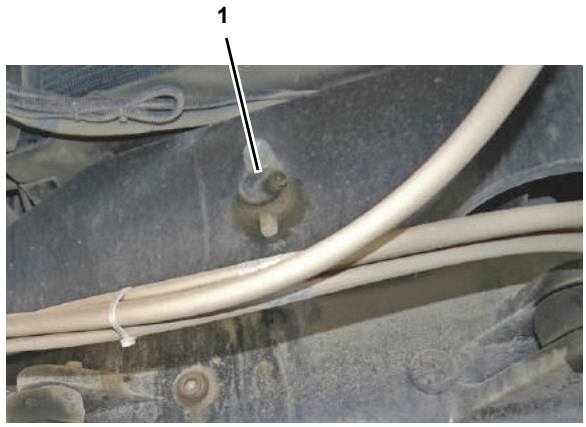
* Quantities are for each axle



8935

Typical Both Ends each Axle

FIGURE 5-9



8956

FIGURE 5-10

DAILY WALK-AROUND INSPECTION

Inspect Wire Rope

Each day before beginning operation, visually inspect the wire rope for damage. Refer to 50 Hour Maintenance for examples of damage that can be visually inspected for. If any damage is found, do not operate the crane. The wire rope must be replaced with a new rope before operation can resume.

Inspect Reeving, Clamps, and Connections

Each day before beginning operation, inspect for correct reeving of the boom and hook block.

Inspect the terminal ends of the wire rope for damaged parts, loose clamps or wrong installation.

DANGER

Loads may fall if the wedge and socket is not installed properly or has damage. A falling load can injure or kill.

Do not operate the crane if any of the above are found. Only after correcting the problem should the crane be put back in service.

Inspect the Lifting Hook

DANGER

Loads may fall if the lifting hook is damaged or loose. A falling load can injure or kill.

Daily before beginning operation, inspect the lifting hook for damage: cracks, deformation, loose retaining hardware, etc. If any damage is found, **DO NOT** operate the crane until the damage is repaired.

Reference Only

DAILY OPERATIONAL INSPECTION

Inspect the Anti-Two-Block System

Test the anti-two-block system daily before beginning operation to make sure it is functioning properly.

Raise the hook block or the downhaul weight until it hits the anti-two-blocking bracket under the boom head or the boom extension. An alarm should sound and the hoist should stop.

Lower the hook block or the overhaul weight and the alarm will stop.

If there is a malfunction in the system, **DO NOT** operate the crane. Have the malfunction corrected.

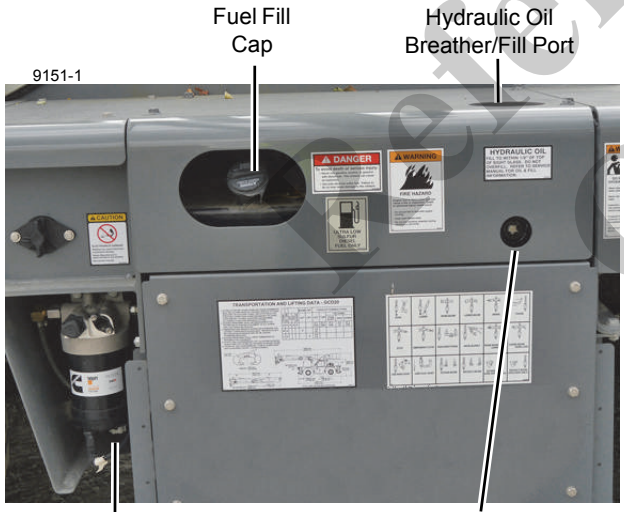
Inspect All Safety Devices

Daily before beginning operation, check all safety devices for proper operation. Examples of safety devices include, backup alarms, horn, and beacon lights.

If any is found to be malfunctioning, correct the problem before placing the crane in service.

Check Controls Operation

Check each control for proper operation after the above inspections have been completed. Do not place the crane in service if any control is not functioning properly.



Right Side of Carrier

FIGURE 5-11

DAILY COMPONENT/SYSTEM CHECKS

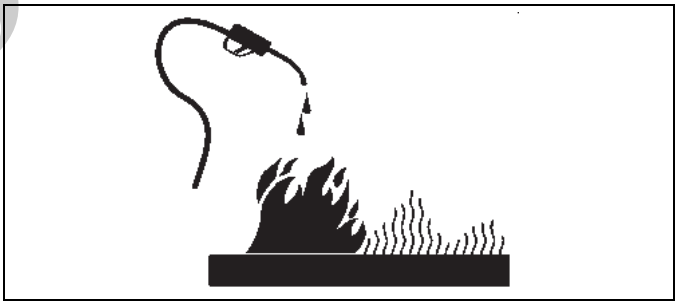
Check Diesel or Gasoline Fuel Level

Check the fuel level daily before operation. Turn the ignition key to the ON position and view the fuel gauge on the instrument panel. If necessary, fill the tank (Figure 5-11) with recommended fuel.

Engine fuel is flammable and can cause a fire and/or explosion. Avoid personal injury or death by keeping sparks, open flames, and smoking materials away from the crane and fuel during refueling or fuel system servicing. Know the location of the fire extinguishers on the job site and how to use them.



Maintain control of the hose nozzle when filling the fuel tank. Do not allow fuel to spill. Clean up spilled fuel immediately. Dispose of clean up materials properly.

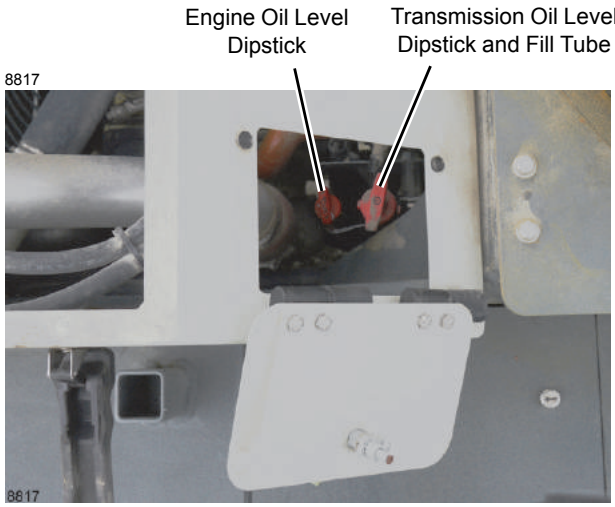


Do not fill the fuel tank to capacity. Allow room for fuel expansion.

Check LP Gas Fuel Level

The LP gas tank (Figure 5-54 on page 5-39) is owner supplied. The crane owner should purchase a tank equipped with a fuel gauge. Check the fuel level daily before operation.

For Reference Only



Right Side of Engine Compartment **FIGURE 5-12**



Typical View all Engines under Engine Hood

FIGURE 5-13

Check Engine Oil Level

1. Level the crane, engage the parking brake, and stop the engine.
2. Open the dipstick door on the engine compartment (Figure 5-12), remove the engine oil dipstick, and check the oil level. Oil should be present within the crosshatched area of the dipstick.
3. If the oil level is low, open the engine hood and support in place using the furnished prop rod.
4. Remove the engine oil fill cap and add recommended engine oil (specified in *Lubrication Legend on page 5-7*) to bring the oil level to the top of the crosshatched area of the dipstick.
5. Install the fill cap and the dipstick.
6. Close and latch the dipstick door and the engine hood.

Check Transmission Oil Level

1. Check the transmission oil level when the oil is cold.
2. Level the crane, engage the parking brake, and stop the engine.
3. Open the dipstick door on the engine compartment (Figure 5-12), remove the transmission oil dipstick, and check the oil level. Oil should be visible on the dipstick between the minimum and maximum marks.
4. If oil is low, add recommended oil (specified in Lubrication legend on page 5-7) through the fill tube to bring the oil to the proper level between the dipstick marks. **DO NOT OVERFILL**.
5. Install the dipstick. Close the dipstick cover.

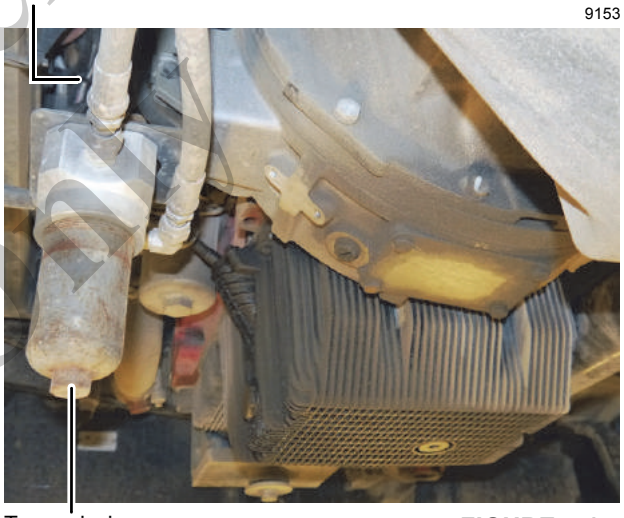


FIGURE 5-14

Check Transmission Filter Indicator

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

With the engine running, check the indicator (Figure 5-14) on the transmission filter. Replace the filter element if the indicator is in the red area.

Reference Only

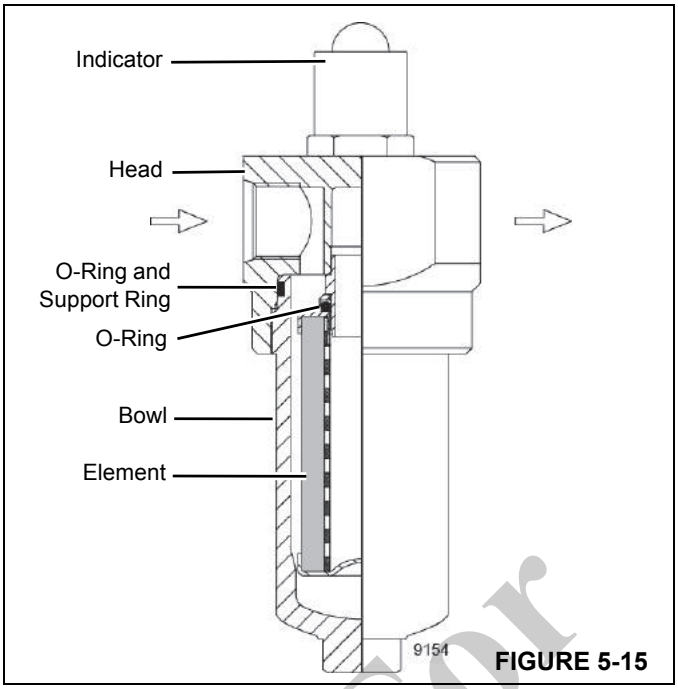


FIGURE 5-15

Replace Transmission Filter

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

If the indicator is red, replace the transmission filter as follows:

1. Engage the parking brake and stop the engine.
2. Locate the transmission filter on the right side of the engine (Figure 5-14).

See Figure 5-15 for the remaining steps.

3. Place a suitable container under the filter to catch oil.
4. Replace the filter element:
   - **a.** Using a wrench, turn the filter bowl off the head.
   - **b.** Remove and properly discard the filter element.
   - **c.** Clean the filter bowl and the mounting surface on the filter head.
   - **d.** Make sure the seals in the filter head and on the new element are not damaged.
   - **e.** Apply a small amount of clean transmission oil to the seals.
   - **f.** Install the new filter element on the filter head.
   - **g.** Install and tighten the filter bowl.
   - **h.** Start the engine and check for leaks around the filter. Correct as needed.

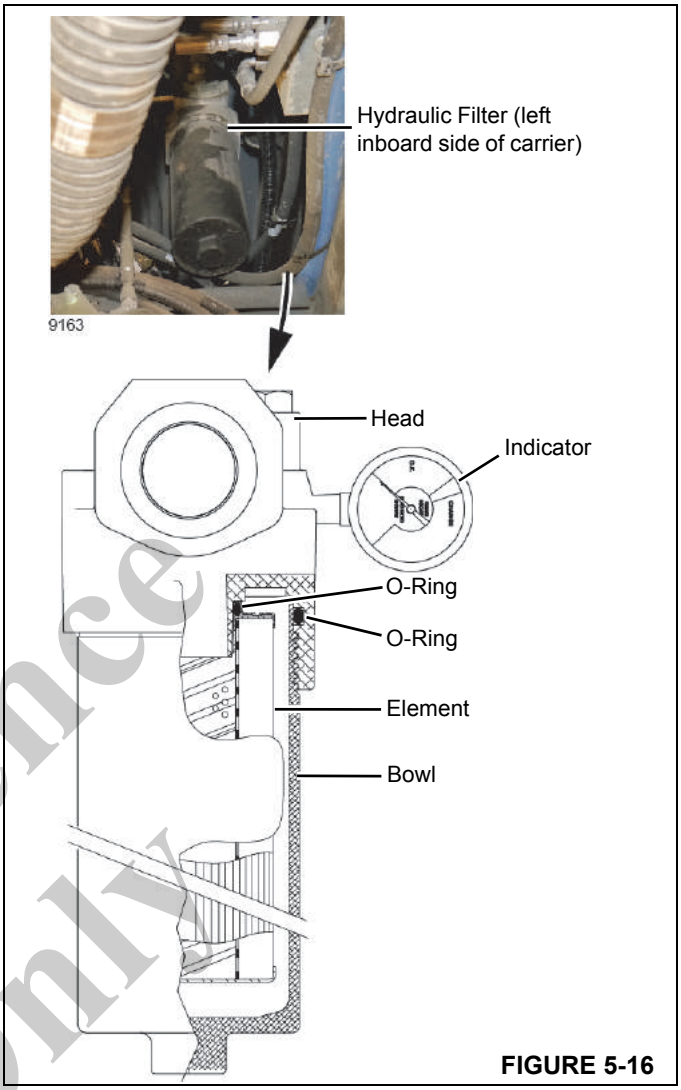


FIGURE 5-16

Check Hydraulic Filter Indicator

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

With the engine running, check the indicator (Figure 5-16) on the hydraulic filter. Replace the filter element if the indicator is in the red area.

Replace Hydraulic Filter

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

If the indicator is in the red area, replace the hydraulic filter as follows (see Figure 5-16):

1. Engage the parking brake and stop the engine.
2. Place a suitable container under the filter to catch oil.
3. Replace the filter element:
   - **a.** Using a wrench, turn the filter bowl off the head.

For Reference Only

b. Remove and properly discard the filter element.

c. Clean the filter bowl and the mounting surface on the filter head.

d. Make sure the seals in the filter head and on the new element are not damaged.

e. Apply a small amount of clean hydraulic oil to the seals.

f. Install the new filter element on the filter head.

g. Install and tighten the filter bowl.

h. Start the engine and check for leaks around the filter. Correct as needed.

Check Engine Coolant Level

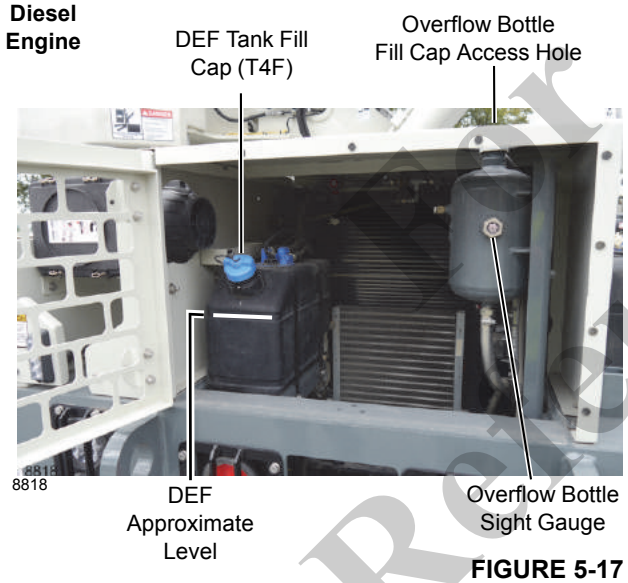


FIGURE 5-17

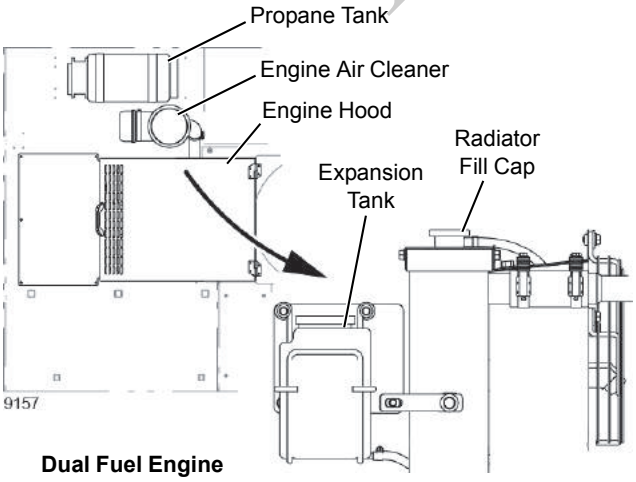
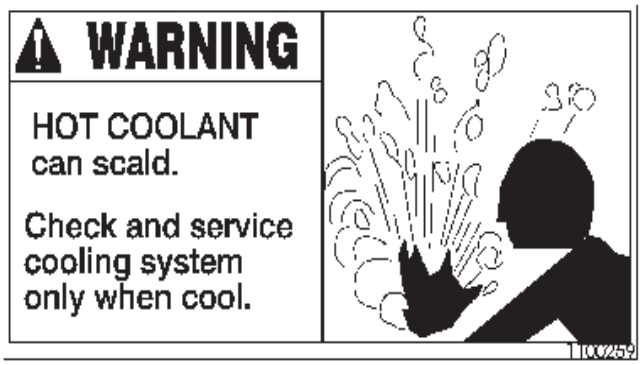


FIGURE 5-18



Never remove the fill cap while the cooling system is hot. Check the coolant level only when the coolant temperature is below 50°C (120°F). The system is under pressure and the coolant can cause severe burns or eye injury. Wear protective clothing and safety glasses. Always turn the cap slowly to the first stop and allow the pressure to escape before removing the cap completely.

1. Level the crane, engage the parking brake, and stop the engine.

2. For Diesel Engine (Figure 5-17):

a. Check the coolant level in the overflow bottle. It should be half way up the sight gauge.

b. If the level is low, **BE SURE THE ENGINE IS COOL —below 50° C (120° F)**, then slowly loosen the fill cap to the first stop. Allow all pressure to release. Completely remove the fill cap.

c. Add a 50/50 mixture of glycol antifreeze and water to the proper level. Do not add only water as this could cause rust to form in the radiator and engine.

d. Securely reinstall the fill cap.

3. For Dual-Fuel Engine (Figure 5-18):

a. **BE SURE THE ENGINE IS COOL —below 50° C (120° F)**, then slowly loosen the fill cap to the first stop. Allow all pressure to release. Completely remove the fill cap.

b. The coolant level should be up to the bottom of the fill tube in the radiator.

c. If the level is low, add a 50/50 mixture of glycol antifreeze and water to the proper level. Do not add only water as this could cause rust to form in the radiator and engine.

NOTE: For more details on proper radiator checking and maintenance procedures, refer to the engine manual that came with your crane.

Reference Only

Check DEF Level

With the T4F engine ignition switch on, the DEF (diesel exhaust fluid) level should be between the **E** and **F** marks on the gauge cluster in the operator cab. If, during operation, the amber DEF low indicator light comes on, fill the DEF tank (Figure 5-17) with DEF as specified in the engine manual.

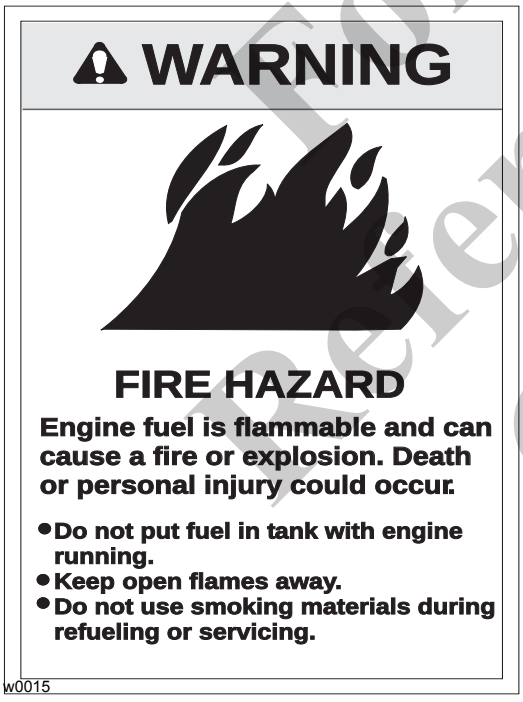
Drain Water from Engine Fuel/Water Separator

See Figure 5-11.

1. Stop the engine and engage the parking brake.
2. Refer to the engine manual furnished with the crane and follow the water draining instructions.

Check Hydraulic Oil Level

If the hydraulic oil is constantly low, check for leaks in the hydraulic system.



1. Be sure the boom is fully retracted and lowered and the outriggers are retracted and up.
2. Park the crane on a level surface, engage the parking brake, and stop the engine.
3. Check the oil level in the hydraulic oil level sight gauge (Figure 5-11).
4. The hydraulic oil should be 3 mm (1/8 in) below the top of the sight gauge.
5. If low, fill the tank with clean recommended hydraulic oil (specified in Lubrication legend on page 5-7).

Service Tier 3/Dual-Fuel Engine Air Cleaner

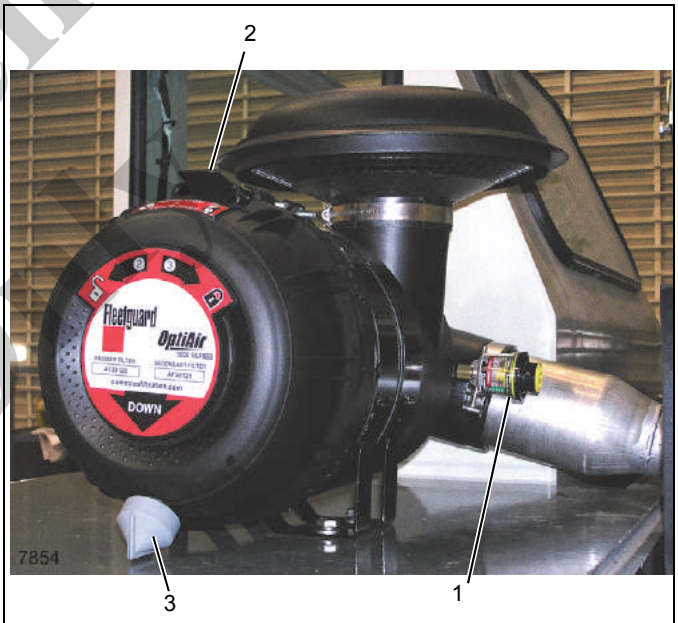
Inspecting Air Cleaner Indicator

The Tier 3 and dual-fuel air cleaner is equipped with a restriction indicator (1, Figure 5-19)that gives a visual indication when it is time to change the air cleaner elements.

Check the indicator with the engine running. The yellow stem in the indicator window extends as the air cleaner elements become plugged. Change the air cleaner elements when the yellow stem reaches the red zone of the window.

The yellow stem remains locked in place when the engine is stopped. The reset button on the top of the indicator can be pressed at any time. When the engine is started, the indicator stem returns to the proper reading.

Do not remove the elements for inspection. This will do more harm than good. Ridges of dirt on the gasket sealing surface can drop onto the clean filter side when the gasket is released.



Tier 3 Air Cleaner Shown.
Dual Fuel Air Cleaner Similar.

FIGURE 5-19

Removing Air Cleaner Elements

NOTE: Service the air cleaner only with the engine off. Dirt and debris can enter the engine and cause damage if the engine is operated with the air cleaner element removed.

1. Release the latch (2) to unlock the air cleaner cover.
2. Rotate the cover counterclockwise and remove it.

For Reference Only

3. Remove the primary element as gently as possible until you get it outside of the housing.
4. Remove the secondary element.
5. Clean the inside of the housing carefully. Any dirt left inside the housing could cause damage to the engine. Use a clean, water-dampened cloth to wipe every surface clean. Check it visually to make sure it is clean before installing new elements.
6. Always clean the gasket sealing surfaces of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure all hardened ridges are completely removed.

Installing Air Cleaner Elements

1. Install the secondary element into the housing and slide it all the way in.
2. Install the primary element and slide it all the way in.
3. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean, or if the element is the right model number. It may be too short for the housing.
4. Install the air cleaner housing cover.
5. Reset the restriction indicator (Figure 5-19) by pushing in the reset button.

Service Tier 4F Engine Air Cleaner

Air Intake Restriction Monitoring (AIRM)

The Tier 4 engine has the Cummins AIRM communications system. The AIRM calculates real-time air filter restriction at operational flow rate using the temperature and pressure input from the TBAP sensor (Figure 5-20).

Fault code (FC 5576) is initiated at the dirty filter restriction level, generating a blinking "Check Engine" light for 30 seconds at every key on until the intake air restriction drops below the dirty filter restriction threshold.

Severe warning fault code (FC 3341) is initiated if the maintenance condition degrades to a severe restriction level for a given time period, generating a solid amber "Check Engine" light and initiating a progressive engine derate to protect the engine from damage until the intake restriction drops below the dirty filter restriction threshold.

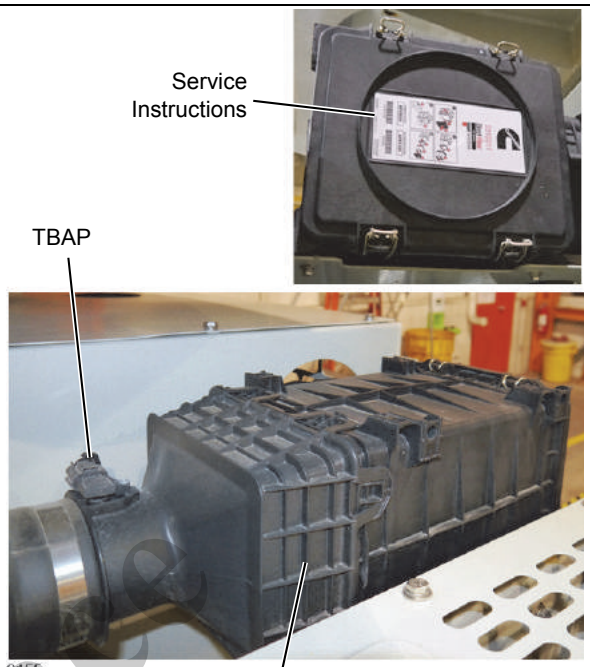


FIGURE 5-20

Removing Air Cleaner Elements

See Figure 5-20.

NOTE: Service the air cleaner only with the engine off. Dirt and debris can enter the engine and cause damage if the engine is operated with the air cleaner element removed.

1. Release the four latches to unlock the air cleaner cover.
2. Remove the primary element as gently as possible until you get it outside of the housing.
3. Remove the secondary element.
4. Clean the inside of the housing carefully. Any dirt left inside the housing could cause damage to the engine. Use a clean, water-dampened cloth to wipe every surface clean. Check it visually to make sure it is clean before installing new elements.
5. Always clean the gasket sealing surfaces of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened ridges are completely removed.

Installing Air Cleaner Elements

1. Install the secondary element in the housing and slide it all the way in.
2. Install the primary element and slide it all the way in.
3. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't

For Reference Only

have protection. Recheck to see if the sealing surface in the housing is clean.

4. Install the air cleaner housing cover.

Check Tire Pressure

Check the air pressure in the crane's four tires. The correct air pressure is 9 bar (130 psi).

Also, check for broken studs, rim damage, loose nuts, cracks and other tire damage. Take corrective action.

50 HOURS OF OPERATION

Clean Air Cleaner Dust Cup

Squeeze the dust cup (3, Figure 5-19) to remove any accumulation of dust or debris.

Inspect Wire Rope and Sheaves

All wire ropes wear out eventually and lose work capability throughout their service life. That's why periodic inspections are critical. *SAE J959, Lifting Crane, Wire-Rope Strength Factors*, requires that a thorough inspection be performed and recorded on the wire rope not less often than weekly when the crane is in continuous service.

Inspection

NOTE: Always wear gloves when working with wire rope to prevent hand injuries.

1. **Wire Rope** - Inspect for damage, rust or wear to the wire rope. Keep a record of each inspection. Replace the wire rope if any of the conditions in Figure 5-21 are present.
2. **Sheaves** - Inspect sheaves for damage and/or wear. The sheave grooves must be smooth and a little larger than the wire rope. Use a sheave gauge to check the size of the sheave groove. Rough edges, narrow or worn grooves will cause damage to the wire rope. Replace any worn or damaged sheaves.

NOTE: As a sheave wears, the groove for the wire rope becomes smaller. The tracks on the sheave are caused by the wire rope. Yet, the wire rope will continue to engage these tracks, for example like a chain engages a sprocket. As the wire rope turns and twists on the sheave, the wire rope will move out of the worn track. This will cause increased wear on the wire rope.

For Reference Only

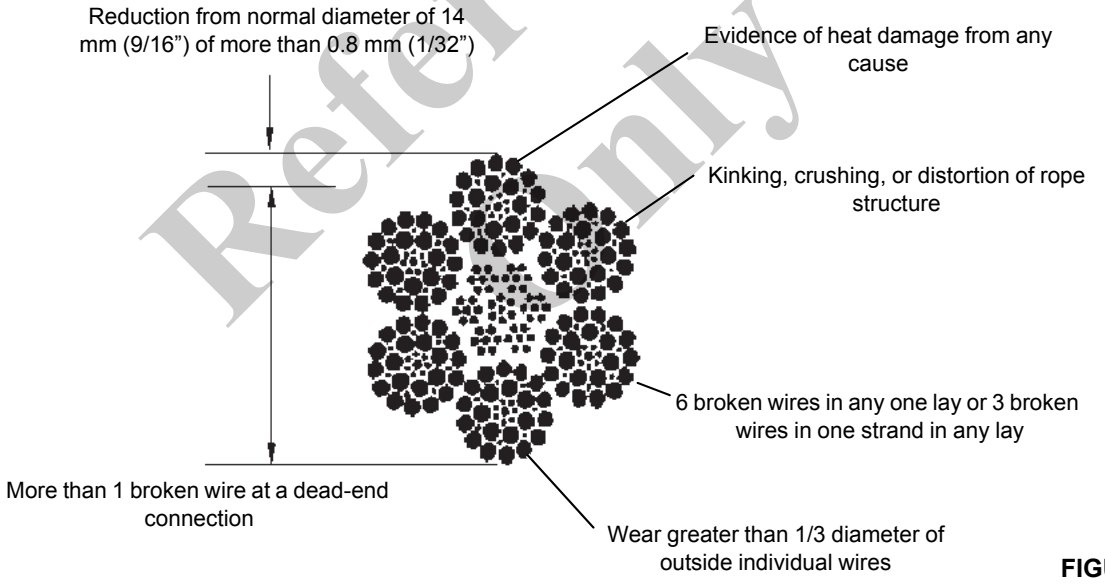


FIGURE 5-21

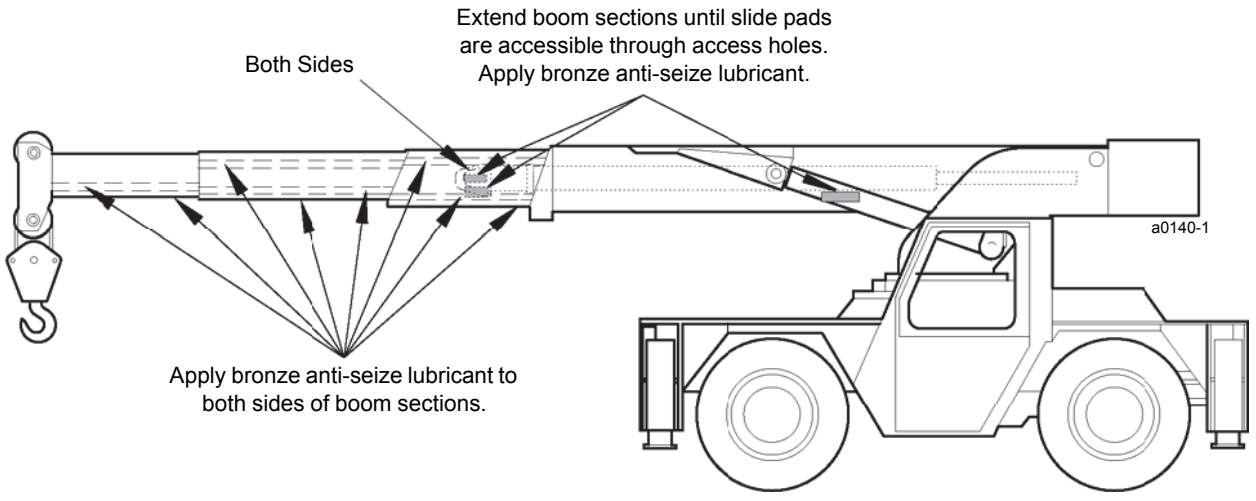


FIGURE 5-22

Lubricate Grease Fittings

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

See *Grease Points*, page 5-12.

Lubricate Boom Cable Sheaves

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations

The lubrication points on the sheaves are not equipped with grease fittings and will require a grease gun adapter to accomplish the task.

Special Tools:

Nozzle or needle grease gun fitting:

- 6.35 mm (0.25 inch) diameter nozzle grease gun tip (Grove P/N 955045). Contact Manitowoc Crane Care to obtain this tip.
- Observation through the sheave case for the extend sheaves and the hoist mount for retract sheaves.

NOTE: To determine the amount of grease required, visually inspect the sheaves. From the front of the boom, look back through the sheave case at the extend sheaves. From the back of the boom, look up through the hoist mount at the retract sheaves. A small amount of grease extrusion around the pin is adequate.

The extend sheaves are located on the boom tip end of the extend cylinder, and the retract sheaves are located on the inside rear of the 2nd section. Lubrication is as follows:

1. Extend boom until grease access hole becomes visible on side of 2nd section.
2. Check alignment between the 2nd section access hole and the 3rd section access holes. When these holes become aligned, the end of the extend cable sheave pin is visible and accessible for lubrication.
3. This boom position also aligns the access holes at the rear of the 1st section for lubrication of the retract sheaves.

Lubricate Inner Boom Wear Pads

1. With the boom fully retracted, apply grease to the wear pads on the top of second boom section with a small paint brush or a grease gun.
2. Extend boom to position the wear pad access holes directly above the wear pads on the third boom section, apply grease to the pads using the brush or gun.
3. Extend boom to position the wear pad access holes directly above the wear pads on the fourth boom section, apply grease to the pads using the brush or gun.
4. After grease is applied to all wear pads raise the boom to the maximum angle and slowly extend the boom to full extension and slowly retract completely.
5. Repeat steps 1-4 three times to ensure the boom is fully lubricated.

For Reference Only

Lubricate Side and Bottom Boom Wear Pads

1. Fully extend and set the outriggers.
2. Lower the boom to horizontal.
3. Fully extend the boom and apply grease to the side and bottom of the 2nd and 3rd sections with a brush.
4. Raise the boom to about 75° and retract the boom
5. Extend and retract the boom several times until the grease is evenly spread.
6. Repeat steps 1-3 as necessary to ensure the boom is fully lubricated.



FIGURE 5-23

Lubricate Parking Brake

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

Apply Lithium Base, EP 2 bearing grease, or equivalent, to the parking brake grease fitting (Figure 5-23).

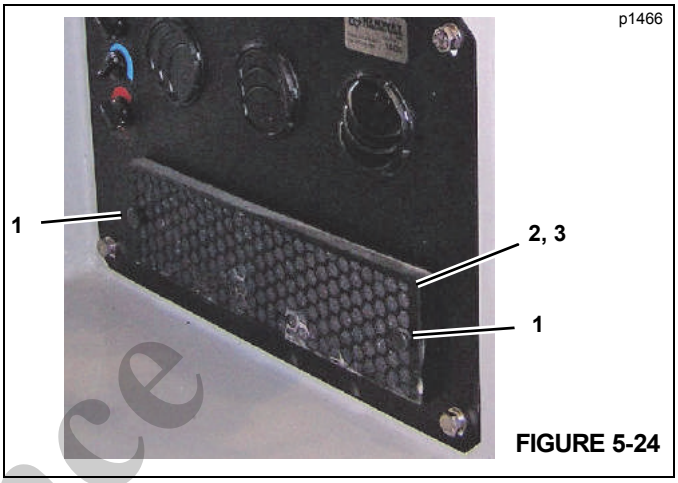


FIGURE 5-24

Clean Heater/Air Conditioner Filter

1. Remove the thumb screws (1, Figure 5-24).
2. Remove the access cover (2).
3. Remove the filter (3) and clean it with compressed air or with mild soap and water.
4. Replace a torn or damaged filter.
5. Reinstall the filter, the cover, and thumb screws.

For Reference Only

100 HOURS OF OPERATION OR TWO WEEKS

Inspect Engine Fan Belts

Keep the engine and accessory belts properly tensioned for maximum engine performance and fuel economy. Proper belt tension minimizes slippage and increases belt life.



Belts that are too loose see excessive vibration and increased wear. Belts that are too tight produce wear on the belts and the bearings of the pulleys it travels around.

Check ribbed belts for intersecting cracks. Cracks across the belt are acceptable. Cracks along the length of a ribbed belt are not acceptable. Ribbed belts with cracks along their length or intersecting cracks should be replaced. See Figure 5-25.

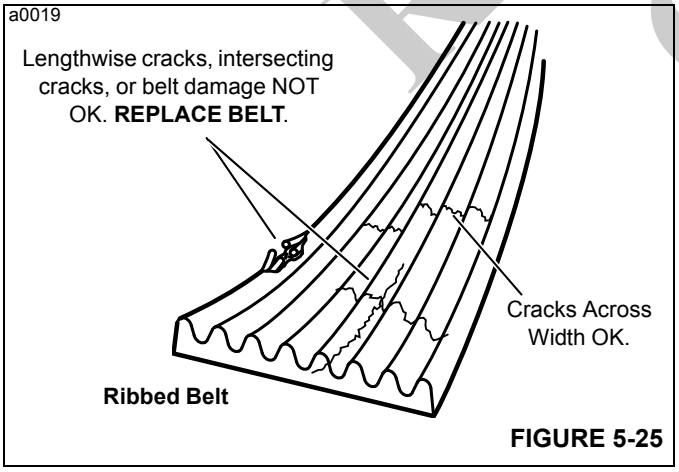


FIGURE 5-25

Any cracking on V-belts is not acceptable. Replace any V-belt that has cracking. See Figure 5-26.

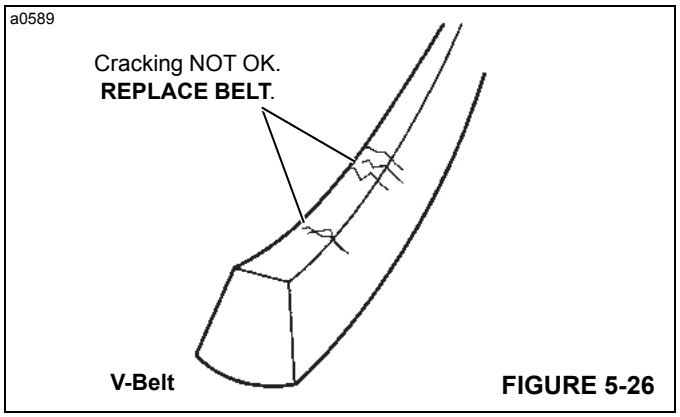


FIGURE 5-26

Any ribbed belt or V-belt showing signs of wear or that has material missing should be replaced. When a belt is replaced, check its tension again after 30 minutes of operation. New belts will stretch with use.

Check Wheel Nut Torque

Check the torque of the wheel nuts in the pattern shown in Figure 5-27. Torque the wheel nuts to 680 ± 34 Nm (500 ± 25 lb-ft).

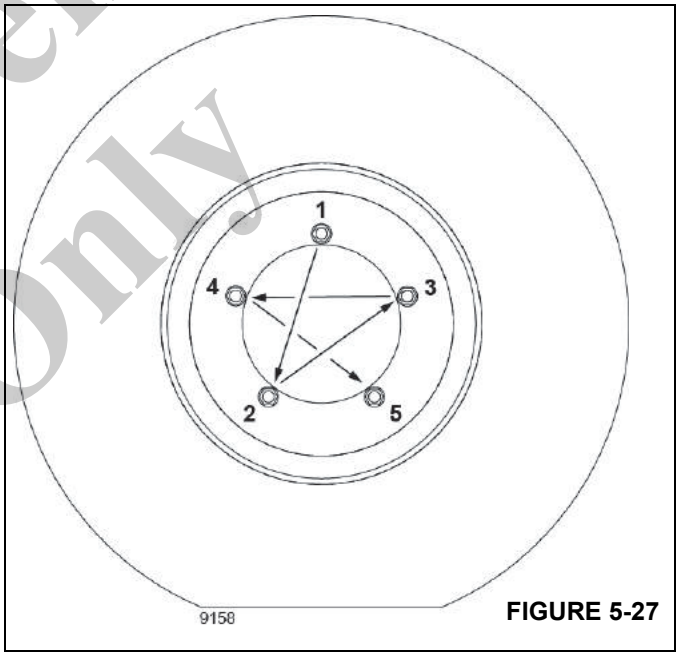


FIGURE 5-27

Replace Transmission Filter

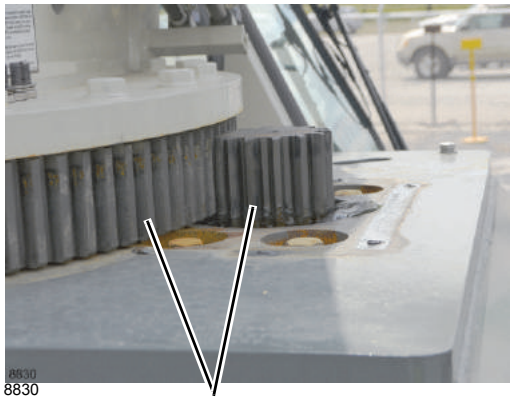
Per the transmission manufacturer, replace the transmission filter after the first 100 hours of operation. See the procedure on page 5-17.

175 HOURS OF OPERATION

If equipped with a dual-fuel engine, replace the engine oil and filter as instructed in the engine manufacturer's manual.

For Reference Only

250 HOURS OF OPERATION OR MONTHLY



Spray lubricant on gear teeth.

FIGURE 5-28

Lubricate Swing Gear and Pinion

1. Engage the parking brake and stop the engine.
2. Remove the swing pinion guard (Figure 5-28).

WARNING

Crush Hazard!

Rotating gears can crush or amputate hands and fingers. Keep hands clear of rotating pinion and gear while the mast is rotating.

3. Apply EP-OGL Ceplattyn 300 spray lube to the swing gear teeth.
4. Stand clear, start the engine and rotate the mast until any non-lubricated portion of the swing gear is exposed. Keep hands and clothing away from the rotating gear and pinion.
5. Stop the engine and apply lubricant to the swing gear and pinion.
6. Repeat steps 4 and 5 until the swing gear teeth are completely lubricated.
7. Stop the engine.
8. Install the swing pinion guard.

Lubricate Wire Rope

Apply lubricant to the hoist wire rope to prevent rust, corrosion, and wear.

1. Unwind the wire rope from the hoist drum.
2. Thoroughly clean the wire rope prior to application of any lubricant. Use a wire brush and compressed air to remove all foreign matter and old lubricant.

NOTE: To prevent personal injury from compressed air, always wear safety glasses when using compressed air for cleaning.

3. After cleaning, apply a light weight oil that will penetrate into the wire rope, or a light weight oil that has been preheated to temperature of between 18° to 36°C (60° and 100°F). Use a brush or cloth to apply the oil.

NOTE: Be sure the lubricant enters the strands of the wire rope for proper lubrication. Do not use grease to lubricate the wire rope.

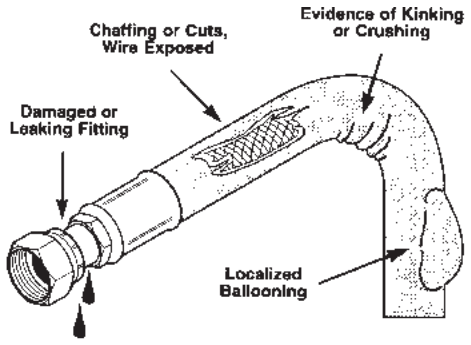
Inspect Hydraulic Hoses



Inspect hydraulic hose assemblies (Figure 5-29) for leaks, damaged fittings, and worn exterior.

Do not use your hands to check for hydraulic leaks. Hydraulic oil under pressure can cause serious injury or possible death. Use a piece of cardboard or other material as a deflector to detect leaks. Replace any problem hose before beginning work.

For Reference Only



Check hoses carefully. Do not use your bare hands to check for leaks.
Tighten all connections to recommended torque.
Replace if any of the following are found:

- *End fittings damaged or leaking.*
- *Outer covering chafed or cut and wire reinforcing exposed.*
- *Outer covering ballooning locally.*
- *Hose shows evidence of kinking or crushing.*

a0591

FIGURE 5-29

Clean Battery and Cables



1. Remove the battery cover (1, Figure 5-30).
2. Use the battery disconnect switch (2) to disconnect the battery (3).
3. Tighten the battery (3) mounting hardware (4) to keep the battery securely in place.
4. Disconnect the battery cables.
5. Inspect for any cracks, which could be a sign of acid that is leaking. In this case, the battery must be replaced.
6. If there are no cracks, continue inspecting. Look for white deposit around the battery. If there is only a little, you can continue. If there is a lot, test the battery.
7. Clean the top of the battery with a water and baking soda solution. Scrape off any deposits.
8. Use a small amount of water and a wet rag to wipe the battery clean and dry.
9. Clean the battery posts and cable ends with a battery brush.
10. Coat the battery posts with petroleum jelly and reinstall the battery cables.
11. Connect the battery with the battery disconnect switch.
12. Reinstall the battery cover.

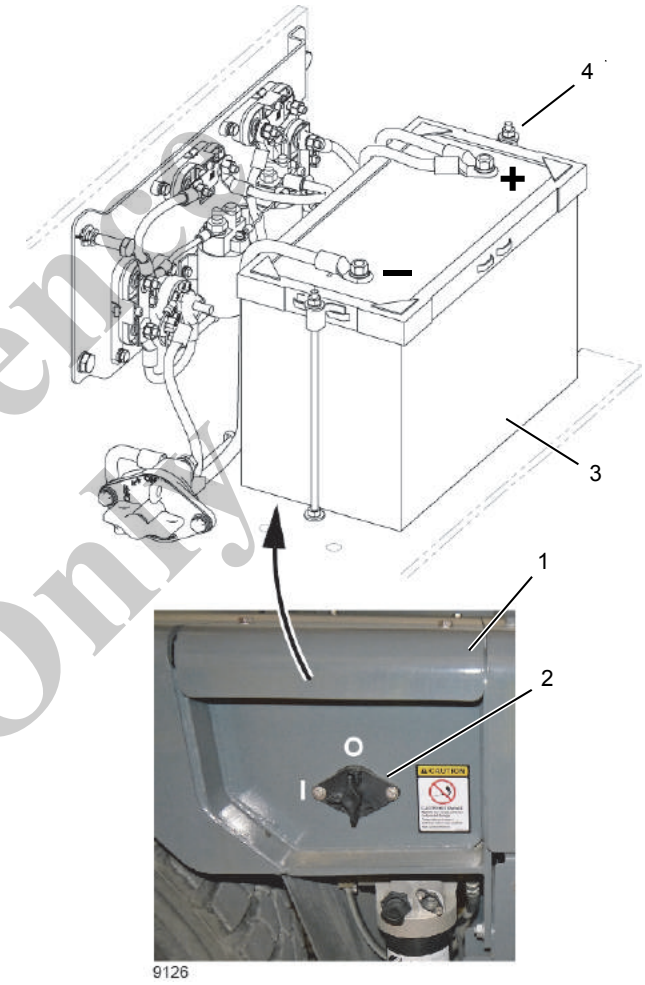


FIGURE 5-30

For Reference Only



Diesel Engine Compartment Shown
Dual Fuel Engine Compartment Similar **FIGURE 5-31**

Clean Radiator and Oil Cooler

NOTE: To prevent personal injury, always wear safety glasses when using compressed air.

See Figure 5-31.

Clean the radiator (1) and oil cooler (2) fins using compressed air or a water jet to remove all foreign material. If foreign material is not removed, the engine or hydraulic system may over heat due to blocked air through the radiator and oil cooler.

Change Diesel Engine Oil and Filter

WARNING

Avoid prolonged and repeated skin contact with used engine oils. Such prolonged and repeated contact can cause skin disorders or other bodily injury. Wash thoroughly after contact with used engine oils. Keep oil out of reach of children.

Change the engine oil more frequently if operating under difficult conditions, for example in high or low temperatures, dusty surroundings or frequent starting and stopping.

It is necessary to go under the carrier for this procedure. To avoid death or serious injury from a moving crane, perform the following steps before going under the carrier:

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

CAUTION

Hot oil can cause personal injury.

1. Operate the engine until the engine oil is hot.
2. Stop the engine.
3. Place a suitable container under the engine oil drain plug. Remove the oil drain plug and drain the engine oil into the container.
4. Clean and install the drain plug.
5. Clean the area around the engine oil filter head.
6. Remove the filter and clean the gasket surface of the filter head.

CAUTION

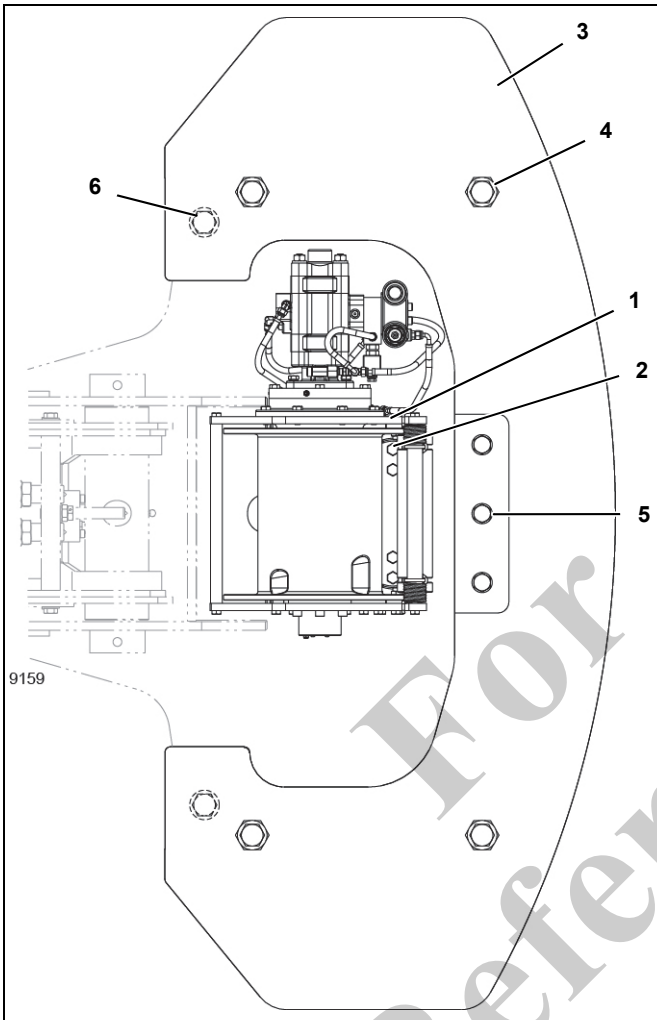
The O-ring can stick on the filter head. Make sure it is removed before installing the new filter.

7. Fill the new filter with clean recommended engine oil.
8. Apply a small amount of clean engine oil to the gasket of the new oil filter. Turn the filter clockwise to tighten it until the gasket makes contact. Then, tighten the filter 1/2 to 3/4 turn to get correct seal.
9. Fill the engine crankcase (Figure 5-13) to the proper level on the dipstick (Figure 5-12) with clean recommended engine oil.
10. Operate the engine at idle and inspect for leaks at the filter and the drain plug.

Torque Critical Bolts

NOTE: Maintain correct torque on all bolts. Failure to do so may result in severe damage to the machine and/or personal injury.

For Reference Only



1	Hoist
2	M16 Bolt, Washers and Nut (qty 8)
3	Counterweight
4	1-1/4 in Bolt and Washer (qty 4) *
5	M24 Bolt, Washer and Nut (qty 3)
6	1-1/4 in Bolt, Washer Spacer (qty 2)

* To protect 1-1/4 7UNC lifting holes.

FIGURE 5-32

Hoist Mounting Bolts

See Figure 5-32.

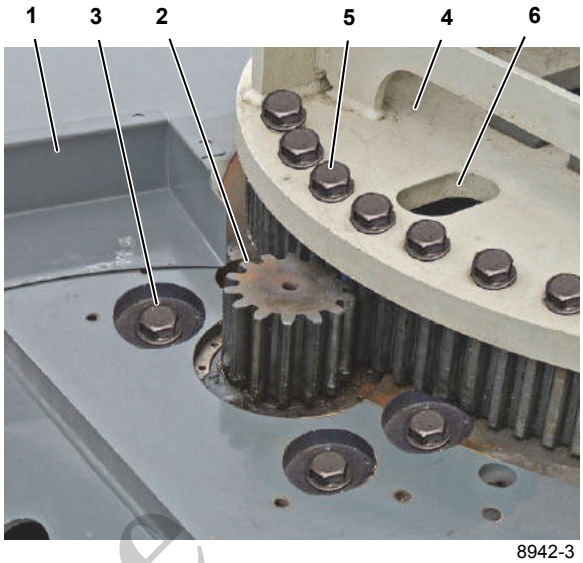
Torque the hoist mounting bolts (2) to 247±6 Nm. At installation, apply Loctite 243 to all threads.

Counterweight Mounting Bolts

See Figure 5-32.

Torque the counterweight mounting bolts (5) to 586±15 Nm. At installation, apply medium strength thread locking compound to all threads.

Torque the counterweight mounting bolts (6) to 859±22 ft/lb.



1	Cover
2	Swing Pinion
3	3/4 in Bolt, Washer and Nut (qty 4)
4	Mast
5	M20 Bolt and Washer (qty 52)
6	Access Hole

FIGURE 5-33

Swing Gearbox Mounting Bolts

See Figure 5-33.

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

Torque the swing gearbox mounting bolts (3) to 202±5 ft/lb. At installation, apply medium strength thread locking compound to all threads.

If the bolts are loose, check gear backlash as instructed in Section 11 of this manual.

Mast Mounting Bolts

The mast (4, Figure 5-33) is fastened to the carrier deck through a turntable bearing.

- The inner race of the bearing is fastened to the carrier deck with 26 bolts (5). The outer race of the bearing is fastened to the mast with 26 bolts (5).
- The outer race of the bearing has a ring gear which meshes with the swing pinion.

Because of the cyclic loading on the mast bolts, it is important that these bolts be checked at regular intervals.

Make a record of any loose bolts. If any bolt does not hold to the correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible bolt failure.

For Reference Only

Torque each mast bolt (26 inner and 26 outer) to 727 ±29 Nm.

NOTE: Use only special Class 12.9 (black finish) bolts for replacement. Order the bolts from your Grove distributor. See your parts manual.

If a broken bolt is found, replace the bolt and also replace the bolt on each side of the broken bolt.

The proper bolt torque will not be obtained without the hardened steel washers under the bolt heads.



1	Front Axle
2	1 in Grade 8 Bolt, Washers and Nut (qty 8)

FIGURE 5-34

Front Axle Mounting bolts

See Figure 5-34.

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

Torque the axle mounting bolts (2) to 689±17 ft/lb.

500 HOURS OF OPERATION OR EVERY THREE MONTHS

Inspect the Tires

Inspect each tire for any signs of damage, such as cracks, large gouges, deterioration, etc. If damage is found, it must be carefully analyzed to determine if the tire is safe to use. Replace all tires that are unsafe.

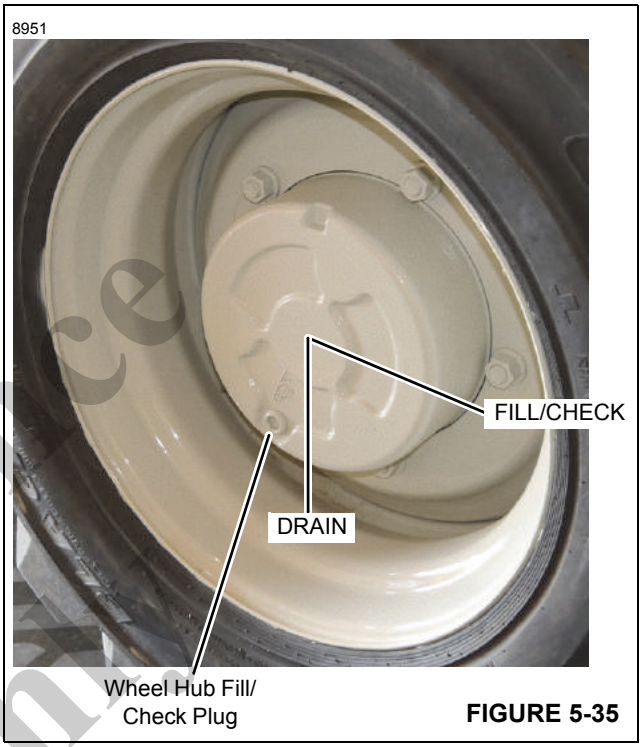


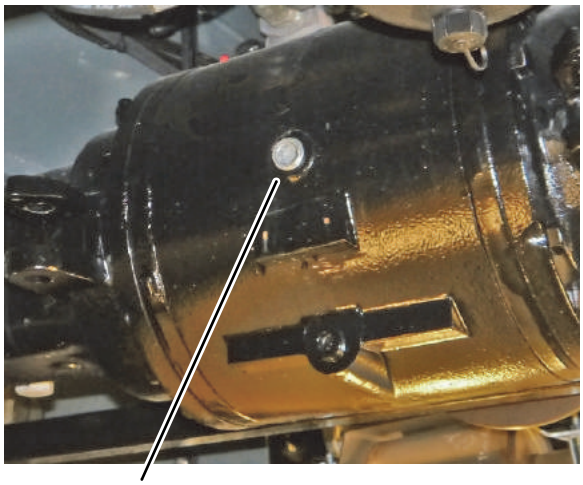
FIGURE 5-35

Check Wheel Hub Lubricant Level

1. Using the outriggers, raise the tires slightly off of the ground.
2. Place the transmission in neutral and release the parking brake.
3. Turn one of wheel hubs until the fill/check plug is horizontal with the ground (Figure 5-35).
4. Clean around the fill/check plug and remove it.
5. Check the lubricant level. It should be even with the bottom of the plug hole.
6. If necessary, add the proper type of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the plug hole.
7. Reinstall the plug.
8. Repeat the steps for the other three wheel hubs.

Reference Only

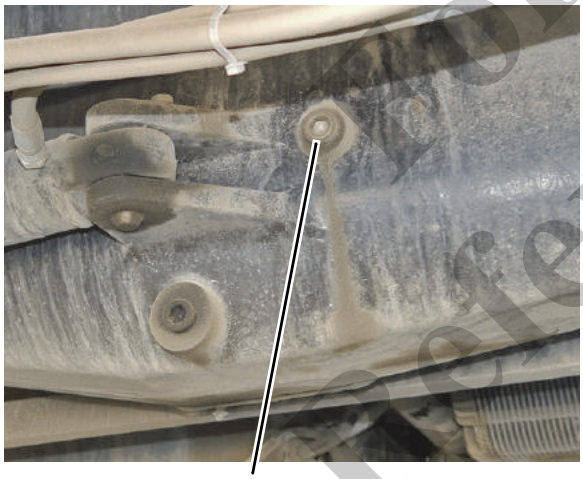
8952



Front Axle Housing Fill/Check Plug

FIGURE 5-36

8955



Rear Axle Housing Fill/Check Plug

FIGURE 5-37

Check Axle Housing Lubricant Level

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

1. At either axle, clean around the axle housing fill/check plug (Figure 5-36 or Figure 5-37) and remove it.
2. Check the lubricant level. It should be even with the bottom of the plug hole.
3. If necessary, add the proper type of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the plug hole.
4. Repeat the steps for the other axle.

Driveline Grease Fitting (2-3 each driveline)

8940

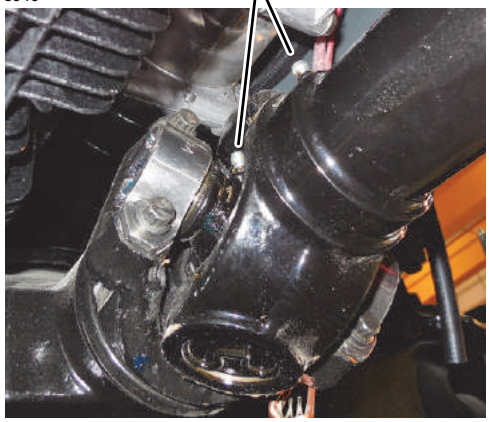


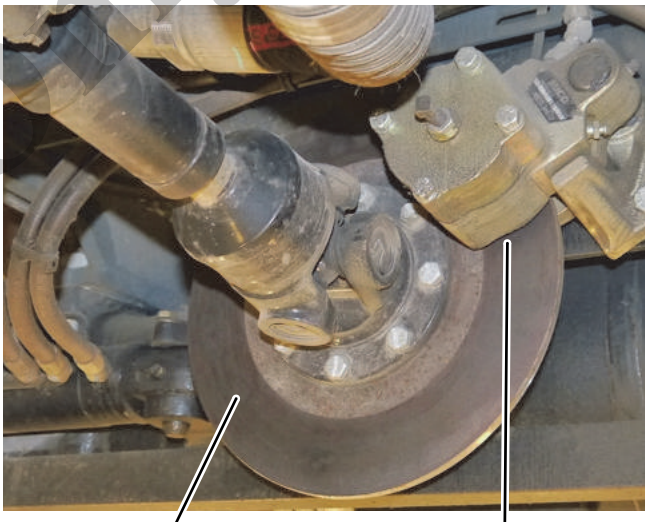
FIGURE 5-38

Lubricate Drivelines

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

1. Engage the parking brake and stop the engine. Remove the ignition key.
2. Clean the grease fittings (Figure 5-38).
3. Apply Lithium Base EP 2 grease or equivalent to the fittings.

8939



Parking Brake Disc

Parking Brake Pads

FIGURE 5-39

For Reference Only

Inspect the Parking Brake Pads

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

Inspect the thickness of the brake pads Figure 5-39. Replace the brake pads if they are 7.1 mm (0.28 in) thick or less.

Check the surface condition of the brake disc. Replace the disc if badly warped, pitted or out of tolerance.

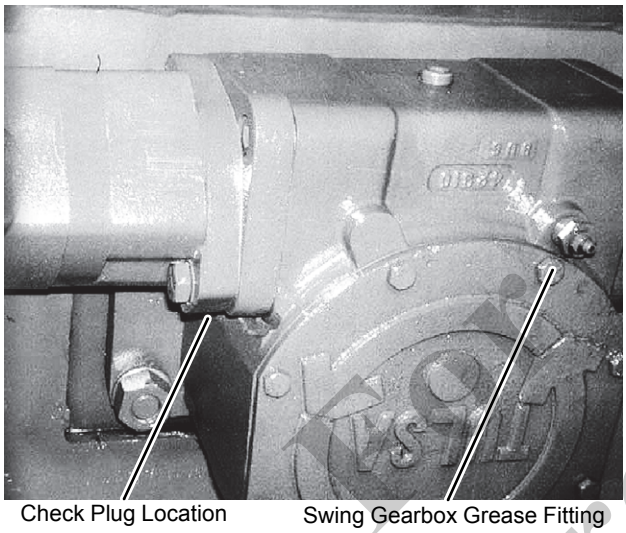


FIGURE 5-40

Add Grease to Swing Gearbox

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

1. Engage the parking brake and stop the engine. Remove the ignition key.
2. Clean the grease fitting and check plug (Figure 5-40).
3. Remove the check plug.
4. Apply Lithium Base, EP 2 grease, or equivalent, to the fitting.
5. Fill the gear box until grease exits the check plug hole.
6. Install the check plug.

Check Hoist Gearbox and Brake Lubricant Levels

1. Lower the boom to its lowest position.
2. Service the hoist gearbox as follows (see Figure 5-41):
   a. Rotate the hoist drum (1) until the plug is in the fill/check hole in the hoist frame.
   b. Engage the parking brake and stop the engine
   c. Clean the area around the plug and remove it.
   d. Check the lubricant level. It should be even with the bottom of the plug hole.
   e. If necessary, add the proper type of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the plug hole.
   f. Reinstall the plug.

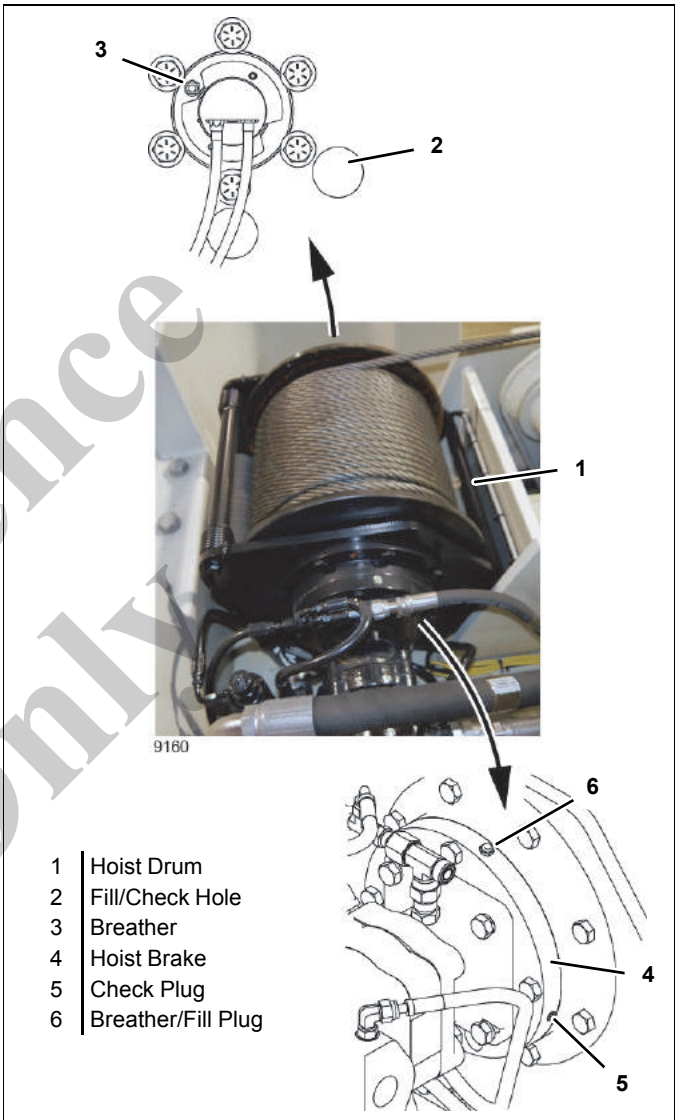


FIGURE 5-41

3. Service the hoist brake as follows:
   a. Clean the around of the check plug (5) and the breather/fill plug (6).
   b. Check the oil level. It should be even with the bottom of the check plug hole.

Reference Only

WARNING

DO NOT use EP type gear lubes in the brake section of this hoist. EP lubes may prevent the clutch from locking up, causing the load to fall and resulting in property damage, personal injury or death.

c. If necessary, add the proper type of oil (specified in Lubrication legend on page 5-7) through the breather/fill plug hole until the oil is even with the bottom of the check plug hole.

d. Install the breather/fill plug (6) and the check plug (5).



Diesel Engine FIGURE 5-42

Replace Fuel Filter

See the engine operator's manual furnished with the crane and follow the replacement procedures.

NOTE: If the filter is not filled with fuel prior to installation, the engine will not start due to air in the fuel system. The fuel system will have to be bled as instructed in the engine operator's manual furnished with the crane.

Replace Air Cleaner Element

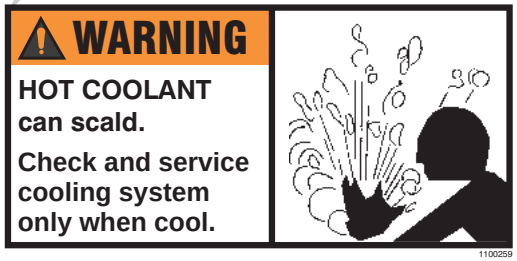
NOTE: Service the air cleaner only with the engine shut down. Dirt and debris can enter the engine and cause damage if the engine is operated with the air cleaner element removed.

1. Remove the housing cover.
2. Remove the element as gently as possible until you get it outside of housing. Accidentally bumping it while it is still inside the housing means dropped dirt and dust that may contaminate the clean side of the air cleaner housing, before the new element has a chance to do its job.
3. Remove the safety filter.
4. Clean the inside of the housing carefully. Any dirt left inside the housing could cause damage to the engine. Use a clean, water-dampened cloth to wipe every surface clean. Check the housing visually to make sure it is clean before installing a new element.
5. Always clean the gasket sealing surfaces of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened ridges are completely removed.
6. Install the safety element. Make sure it is seated all the way.

NOTE: The safety element must be replaced after two main element replacements.

7. Install the new element over the opening in the housing and slide it all the way in.
8. Make sure the gasket is seating evenly. If you don't feel the gasket is seating evenly for a perfect seal, you won't have protection. Recheck to see if the sealing surface in the housing is clean.
9. Install the air cleaner housing cover.
10. Reset the air cleaner restriction indicator by pushing in the reset button.

Add SCA to Engine



For maximum protection of the engine, add Supplemental Coolant Additive to the cooling system as instructed in the engine manufacturer's manual.

Replace Fuel Filters (Diesel Engine)

See the engine manufacturer's manual furnished with the crane and follow the replacement procedures.

NOTE: If the filter is not filled with fuel prior to installation, the engine will not start due to air in the fuel system. The fuel system will have to be bled as

For Reference Only

instructed in the engine operator's manual furnished with the crane.

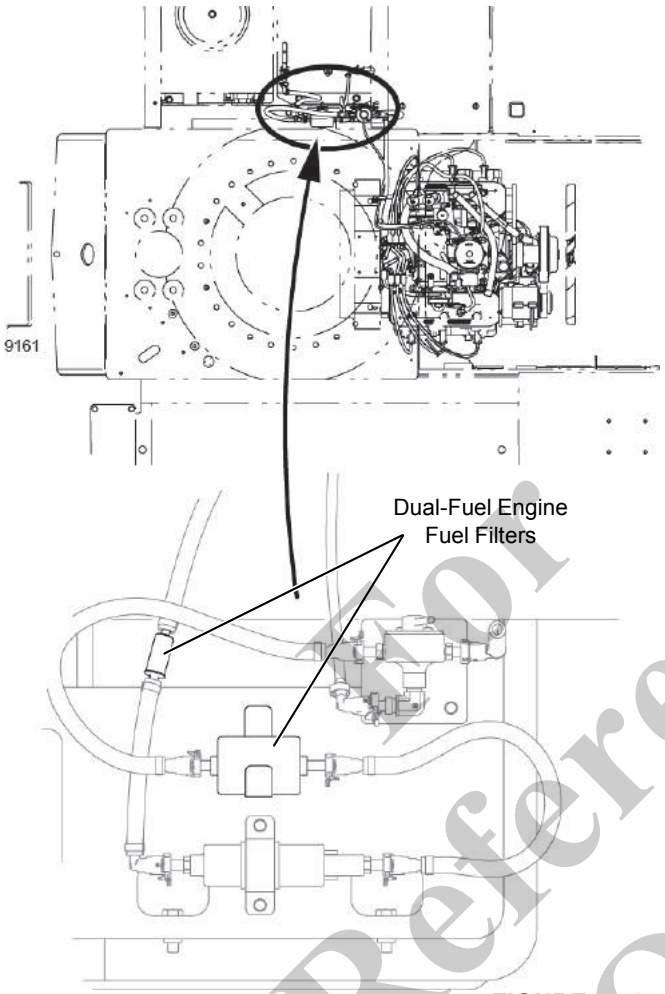
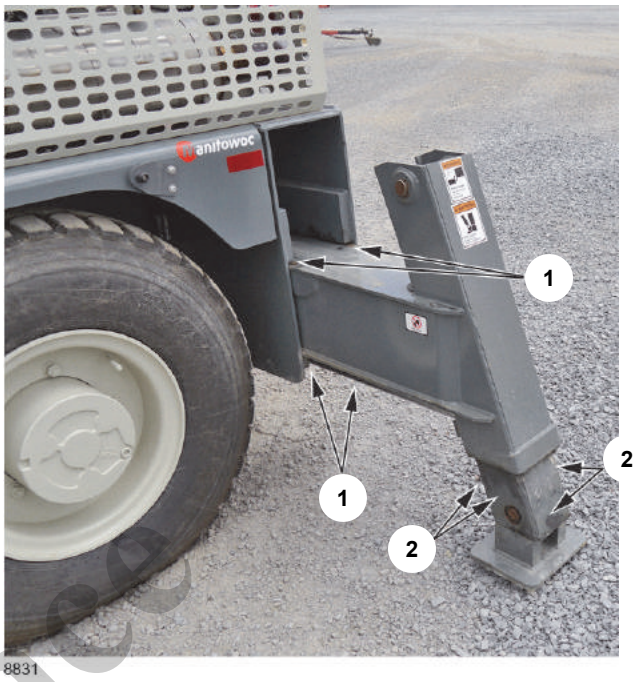


FIGURE 5-43

Replace Fuel Filters (Dual-Fuel Engine)

Replace the dual-fuel engine fuel filters shown in Figure 5-43 on page 5-33.



1	Grease sliding edges, 4 places each outrigger beam
2	Grease all 4 sides of each outrigger jack

FIGURE 5-44

Lubricate the Outrigger Slides

1. Fully extend the outrigger beams and jacks.
2. Clean the beams (top and bottom) and the jacks (all four sides) with a suitable solvent.
3. Apply a light coat of Lithium Base EP 2 grease, or equivalent, to the areas shown in Figure 5-44. Do not over lubricate.
4. Extend and retract the beams and jacks several times to spread the grease.

For Reference Only

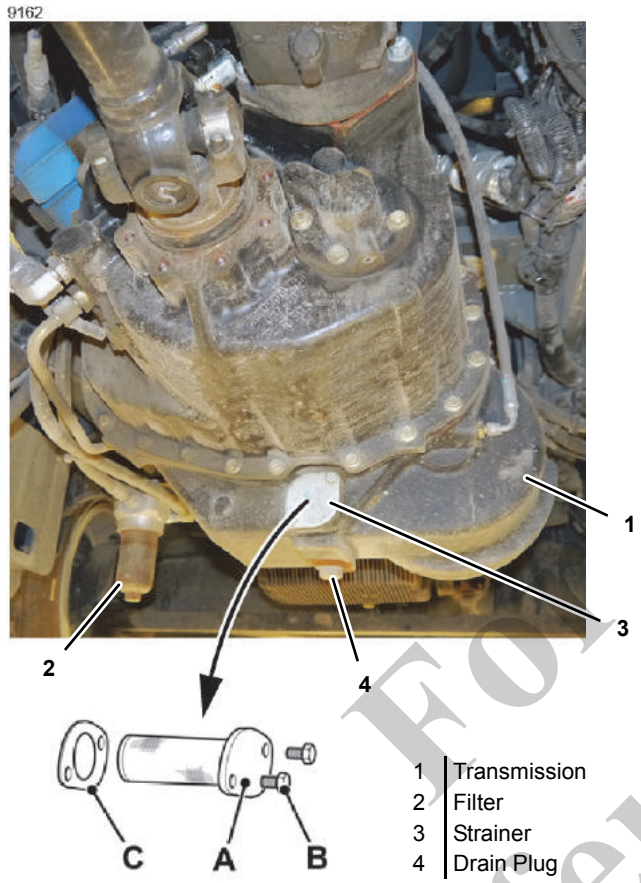


FIGURE 5-45

1000 HOURS OF OPERATION OR SIX MONTHS

Replace Transmission Oil, Strainer, and Filter

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

See Figure 5-45.

1. Engage the parking brake and stop the engine. Remove the ignition key.

NOTE: Before removing the strainer (3), be sure you have a new strainer gasket (C). The old strainer gasket will be damaged during removal of the strainer, and if it is installed with the strainer, leakage will occur. It is recommended that three gaskets be kept in supply at all times. This will cover a year of maintenance and one for emergency maintenance.

When the strainer is removed, oil will gush out. Keep to one side when you remove the strainer.

2. Place suitable container under the transmission.
3. Remove the strainer (A) and gasket (C) and drain the oil into the container. Discard the gasket.
4. Remove the drain plug (4) and drain any remaining oil from the transmission.
5. Clean and reinstall the drain plug (4).
6. Clean the strainer (A) in a suitable solvent.
7. Install the cleaned strainer (A) and a new gasket (C).
8. Install and tighten the strainer mounting bolts (B) to the torque value specified in Section 1 of this manual.
9. Service the transmission oil filter (2). See *Replace Transmission Filter on page 5-17*.
10. Fill the transmission with the proper type and amount of oil (specified in Lubrication legend on page 5-7) to the full mark on the dipstick (Figure 5-12).
11. Start the engine and let it run at idle speed for approximately five minutes. This allows the oil to fill the transmission filter, torque converter, and hoses.
12. Stop the engine, wait approximately one minute and then check the oil level. If low, add oil to the full mark on the dipstick. DO NOT OVERFILL.

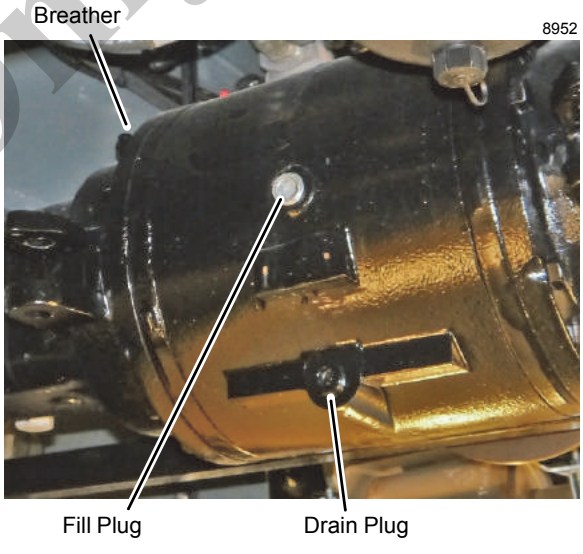


FIGURE 5-46

For Reference Only

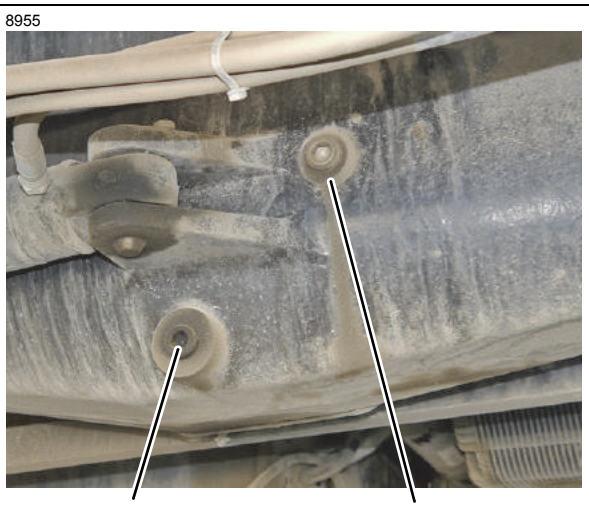


FIGURE 5-47

Replace the Axle Housing Oil

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

See Figure 5-46 and Figure 5-47.

1. Clean around the fill plug and remove it.
2. Place a suitable container under the drain plug, remove the drain plug, and drain the oil into the container.
3. Clean and reinstall the drain plug.
4. Clean the front axle breather with a suitable solvent. Be sure that the hole in the breather tube is facing toward the axle hub (toward the right).
5. Fill the axle housing with the proper type and amount of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the fill plug hole.
6. Clean and reinstall the fill plug.
7. Repeat the steps at both axles.

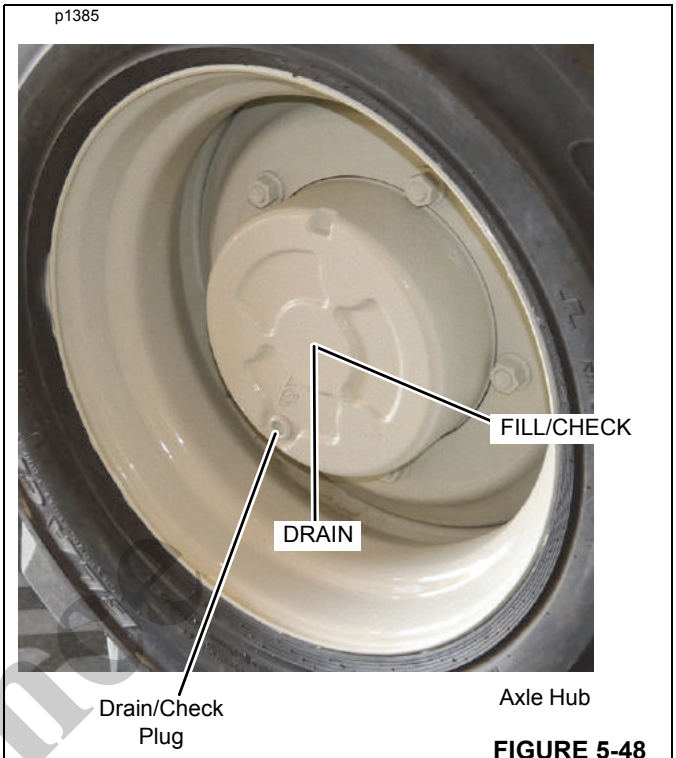


FIGURE 5-48

Replace Axle Wheel Hub Oil

See Figure 5-48.

1. Using the outriggers, raise the tires slightly off of the ground.
2. Place the transmission in neutral and release the parking brake.
3. Turn one of the axle wheel hubs (Figure 5-48) until the drain plug is located at the bottom of the wheel hub.
4. Place a suitable container under the drain plug.
5. Clean around the drain plug, remove it, and drain the wheel hub oil into the container.
6. Turn the wheel hub until the drain/check hole is horizontal (Figure 5-48).
7. Fill the wheel hub with the proper type and amount of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the plug hole.
8. Clean and reinstall the drain/check plug.
9. Repeat the above steps for the other three wheel hubs.

For Reference Only

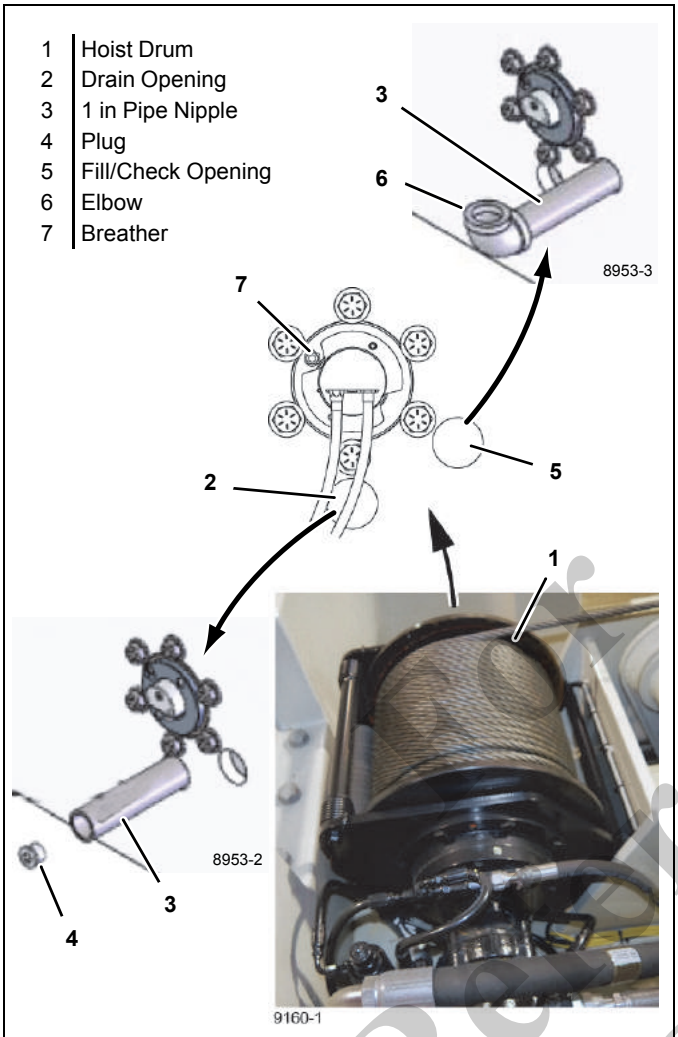


FIGURE 5-49

Replace Hoist Gearbox Oil

See Figure 5-49.

1. Lower the boom to its lowest position, engage the parking brake.
2. Rotate the hoist drum (1) so the plug in the drum is visible through the drain opening (2) in the hoist frame.
3. Screw a 1 inch pipe nipple (3) into the hole in the hoist drum.
4. Place a suitable container under the pipe nipple.
5. Using a hex wrench with an extension, remove the plug (4) through the pipe nipple.
6. Allow the oil to drain into the container. Examine the oil for signs of significant metal particles. If any particles are found, the gearbox may require disassembly and repair.
7. Remove the pipe nipple (3).
8. Rotate the drum (1) so the plug hole is visible through the fill/check opening (5) in the hoist frame.
9. Screw the pipe nipple (3) and an elbow (6) into the hole in the hoist drum.
10. Fill the hoist drum with the proper type and amount of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the plug hole.
11. Remove the elbow (6) and the pipe nipple (3).
12. Make sure the o-ring on the plug (4) is not damaged (replace if necessary) and install the plug.
13. Remove and clean the hoist gearbox breather (7) with a suitable solvent. Then reinstall it.

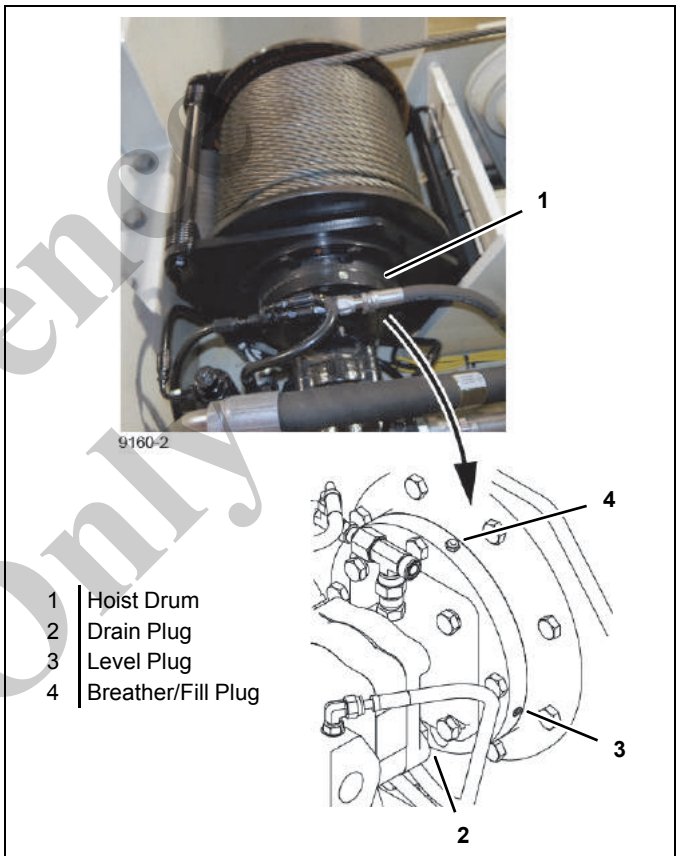


FIGURE 5-50

Replace Hoist Brake Oil

See Figure 5-50.

1. Lower the boom to its lowest position and engage the parking brake and stop the engine.
2. Place a suitable container under the hoist brake drain plug (2).
3. Clean the area around the hoist brake drain plug (2) and remove it.
4. Completely drain the oil.

Reference Only

5. Clean and reinstall the drain plug (2)
6. Clean the area around the hoist brake level plug (3) and the breather/fill plug (4) and remove both plugs.
7. Fill the hoist brake with the proper type and amount of oil (specified in Lubrication legend on page 5-7) until the oil is even with the bottom of the level plug hole.
8. Clean and reinstall the level plug (3).
9. Clean the breather with a suitable solvent.
10. Install the breather/fill plug (4).

Replace Hydraulic Oil and Filter

NOTE: ISO (International Standards Organization) #46/68 Hydraulic Oil (Mobil Fluid #424) is recommended for year-round use in the hydraulic system.

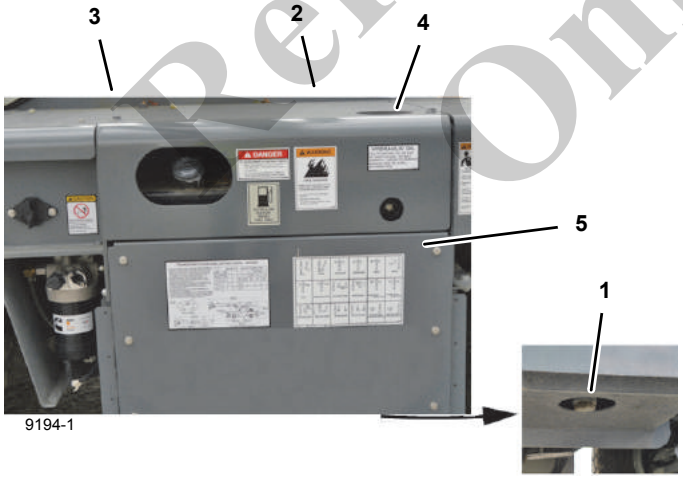
In very cold temperatures, SAE 5W or SAE 5W-20 oils can be used if the viscosity of the oil will not be less than 60 SUS (Saybolt Universal Seconds) at maximum operating temperature. It may be necessary to use a pre-heater and a longer than normal warming period at low operating speed to heat the oil to operating temperature.

You must go under the carrier for this procedure. Take necessary safety precautions. See *Safety on page 5-5*.

See Figure 5-51.

1. Fully retract and lower the boom.
2. Retract all outriggers.
3. Place a suitable container under the hydraulic tank drain plug (1).
4. Remove the drain plug and drain the hydraulic tank.
5. Clean and reinstall the drain plug.

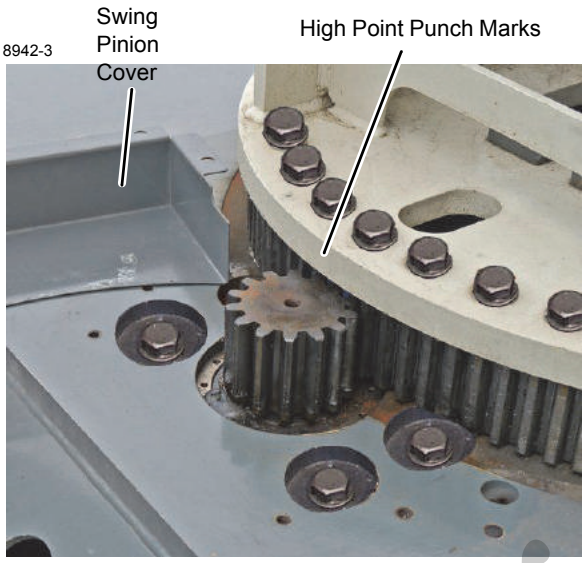
   If the oil/tank is extremely dirty, the tank can be flushed and cleaned by removing the cleanout cover (2) from the top of the tank. It will be necessary to remove the deck plate (3) to perform this step.
6. Replace the hydraulic filter. See *Replace Hydraulic Filter on page 5-17*.
7. Remove the breather (4) and discard it.
8. Fill the hydraulic tank with the proper type and amount of oil (specified in Lubrication legend on page 5-7) to 3 mm (0.125 in) from the top of the sight gauge (5).
9. Install a new breather.
10. After the tank is filled, start the engine and operate each function until all of the cylinders and lines are filled.
11. Fully retract and lower the boom and retract the outriggers. Check the hydraulic oil level. The oil must be 3 mm (0.125 in) from the top of the sight gauge. Add hydraulic oil if necessary.
12. Visually check for leaks.



1	Drain Plug (under tank)
2	Cleanout Cover (under deck plate)
3	Deck Plate
4	Breather/Fill Port
5	Sight Gauge

FIGURE 5-51

Reference Only



Swing Gear Backlash Check

FIGURE 5-52

Check Swing Gear/Pinion Backlash



Rotating gears can cause injury. Keep hands clear of rotating pinion and gear while the mast is rotating.

1. Remove the cover to expose the swing pinion and ring gear (Figure 5-52).
2. Start the engine and rotate the mast until the high point on the swing gear is in alignment with the pinion. The high point is punch-marked on the mast plate (Figure 5-52).
3. Using a feeler gauge, check the backlash between the gear and pinion. There should be no clearance between the swing gear tooth and the pinion tooth. If there is any clearance, adjust the backlash as instructed in Section 11 of this manual.

Service Dual-Fuel Engine

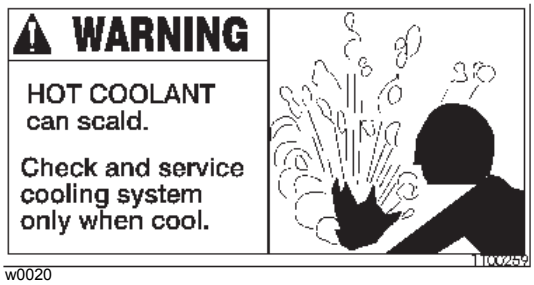
Service the dual-fuel engine per the instructions in the engine manual provided with your crane.

2000 HOURS OF OPERATION OR YEARLY



FIGURE 5-53

Replace Engine Coolant



1. Open the engine hood and support it using the furnished prop rod.
2. **BE SURE THE ENGINE IS COOL** and follow the cooling system draining, flushing, and filling procedures in the engine manual furnished with your crane.

For Reference Only

3. After the coolant is replaced, close the engine hood.

Inspect Crane Structure and Boom for Damage

Thoroughly inspect the crane structure and booms for the following:

- Inspect for loose mounting hardware. Tighten any loose hardware.
- Inspect for cracked or broken welds. Do not operate the crane if a critical weld is cracked or broken until the weld is repaired. Contact your Manitowoc Distributor.
- Inspect for missing or unreadable warning decals. Replace if necessary.
- Inspect for excessive rust or corrosion on crane structure and booms. Clean and paint any areas with excessive rust or corrosion.
- Inspect for missing items. Replace if necessary.
- Inspect the crane for any damage that might prevent safe operation of the crane. Repair any damage.

Test RCL

If equipped, see the (RCL) Rated Capacity Indicator manual furnished with this crane and test the indicator according to instructions in the manual.

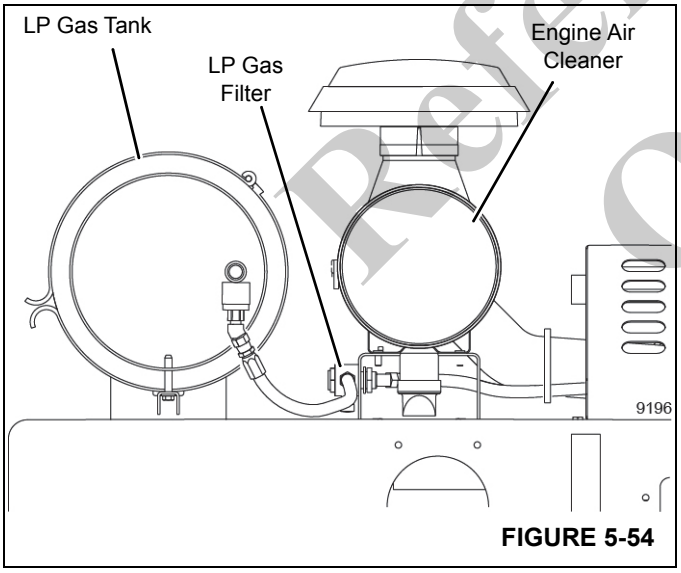


FIGURE 5-54

Replace LP Gas Filter

If equipped with the LP gas option, replace the filter (Figure 5-54).

Service Dual-Fuel Engine

Service the dual-fuel engine per the instructions in the engine manual provided with your crane.

MISCELLANEOUS MAINTENANCE

Air Conditioner

An air conditioner compressor motor is installed on the left side of the engine. When servicing the air conditioning system, observe the following specifications:

- Minimum Evacuation Time — 30 minutes
- Refrigerant Charge Levels — 3.0 pounds (± 0.5 oz)
- Additional Pag Oil Required Above the 6 ounces in Compressor — 6.0 ounces

Batteries/Charging System

NOTE: Lead-acid batteries produce flammable and explosive gases. To avoid personal injury, when checking, testing or charging batteries:

- DO NOT use smoking materials near batteries.
- Keep arcs, sparks and flames away from batteries.
- Provide ventilation and wear safety glasses.
- Never check battery charge by placing a metal object across the posts. The sparks could explode battery gases and cause injury or death. Use a voltmeter or hydrometer.



Checking Battery Charging System

If the battery warning light on the dash is illuminated, check the voltage reading using a voltmeter. Connect the voltmeter to the battery. Normal voltmeter readings are as follows:

- Engine above idle - 14 to 16 volts
- Engine stopped - 10 to 14 volts

A reading of less than 10 volts with the engine at low idle indicates a low battery charge.

A reading of less than 14 volts with the engine speed above low idle indicates a problem in the charging system. See Charging System topic in Section 3 of this manual.

When the voltmeter indicates a low battery charge, attach a battery charger and increase the battery charge.

For Reference Only

Charging Battery

Under normal conditions, the engine's alternator will have no problem keeping a charge on the battery. The only condition in which the battery may cause a problem is when it has been completely discharged for a long period of time. Under this condition the alternator may not be able to recharge the battery and a battery charger will be required for charging the battery. See *Battery on page 3-5*.

Replacing Battery

WARNING

The fluid in electric storage batteries contains sulfuric acid, which is a **POISON** and can cause **SEVERE CHEMICAL BURNS**. Avoid all contact of fluid with eyes, skin or clothing. Use proper protective gear when handling batteries. **DO NOT** tip any battery beyond a 45° angle in any direction. If fluid contact does occur, perform the following First Aid suggestions.

BATTERY ELECTROLYTE FIRST AID:

- **External Contact -** Flush with water.
- **Eyes -** Flush with water for at least 15 minutes and get immediate medical attention.
- **Internal -** Drink large quantities of water. Follow with Milk of Magnesia, beaten egg or vegetable oil. Get immediate medical attention.

NOTE: In case of internal contact, DO NOT give fluids that would induce vomiting.

Remove the battery very carefully to avoid spilling battery fluid. See *Battery on page 3-5*.Properly dispose of the battery.



Fuel Storage

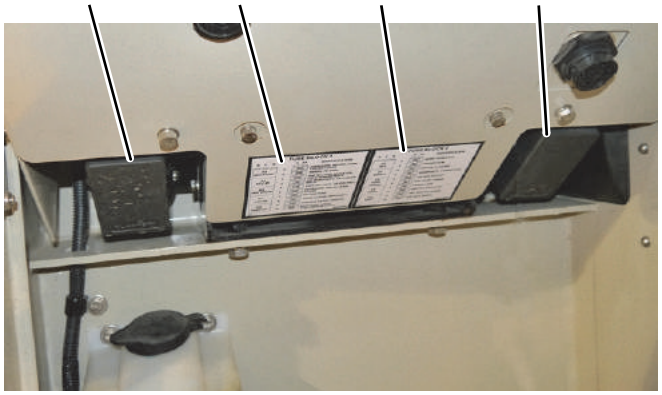
Storage of fuel for an extended period causes accumulation of sediment, dirt, water and other foreign materials in the fuel. Many engine problems are caused by dirty fuel and long storage periods.

Keep fuel in an outside location. Use a shelter to keep the fuel as cool as possible. The water from condensation must be removed at regular intervals from the storage tank.

Fuse Replacement

Refer to Figure 5-55 for the location of the fuses and replays on this crane.

For Reference Only



Left Side of Operator Cab



Right Side of Carrier

1	Fuse and Relay Box 1
2	Fuse and Relay Box 1 Identification Label
3	Fuse and Relay Box 2
4	Fuse and Relay Box 2 Identification
5	Battery Cover
6	Fuse and Relay Box 3 and Identification Label *
7	Fuse and Relay Box 4 and Identification Label *

* Located under battery cover.

FIGURE 5-55

For Reference Only

CARWELL® RUST INHIBITOR

Protecting Cranes From Rusting

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell® T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell® is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CFR-19-10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly “oily” residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleanings if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain crane parts may become corroded even though other parts remain dry; or
- in high humidity, or when temperatures are just above the freezing point.

Cleaning Procedures

To help protect against corrosion of Grove cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleanings may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

- For scratches and marks in highly visible areas:
- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

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Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell® T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell® treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 5-56.

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose ends and fittings, swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, overhaul weight pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.

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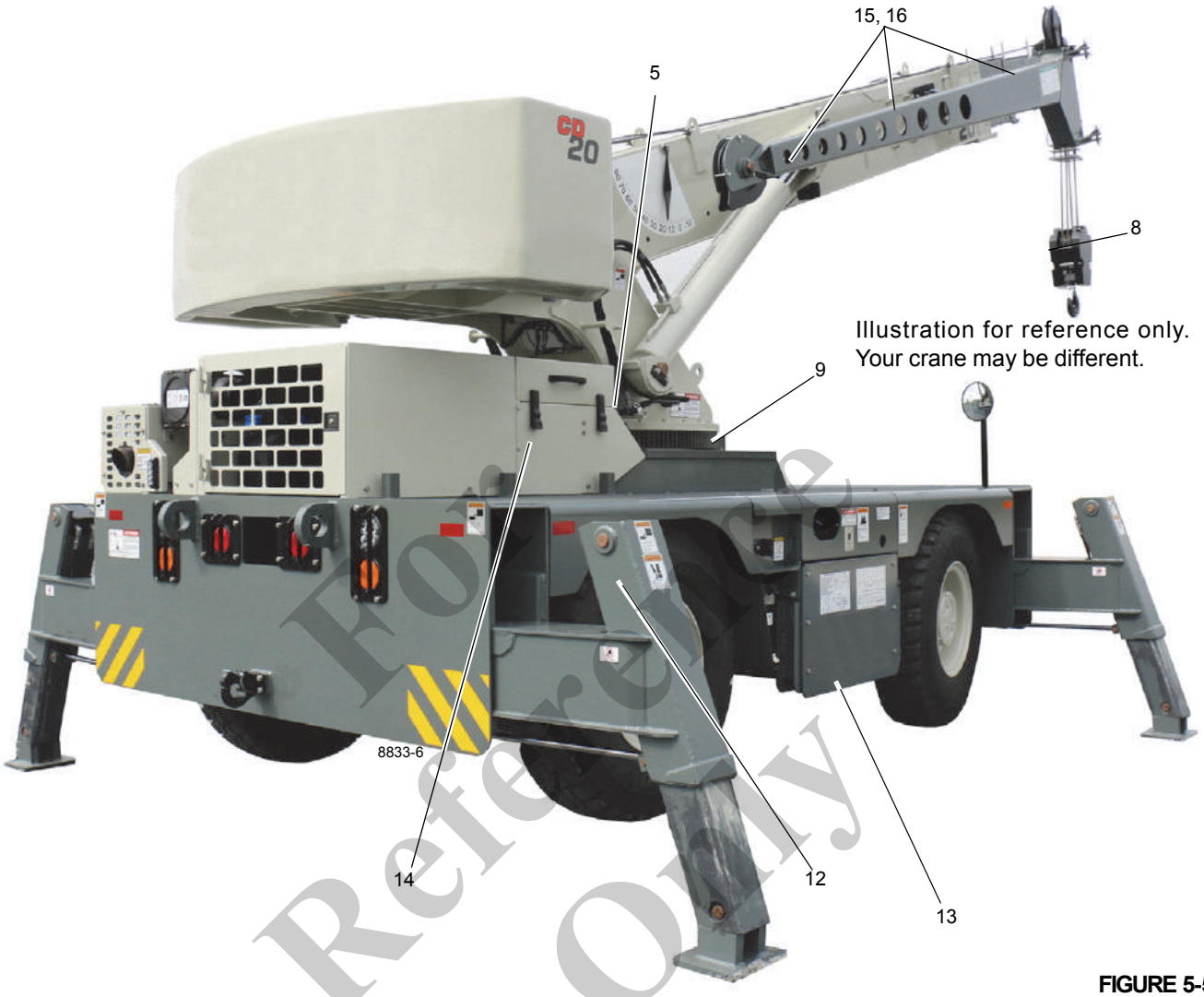


FIGURE 5-56

Item	Description
1	Hoist Tension Spring
2	Hoist Hose Connections
3	Pivot Shaft
4	Wire Rope
5	Hose Connections inside turntable
6	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
7	Boom Nose Pins, Clips

Item	Description
8	Overhaul Weight /Hook Block
9	Turntable Bearing Fasteners
10	O/R Pins, Clips
11	Hook block Tie-Down Cable
12	O/R Hose Connections
13	Entire underside of unit
14	Power Train Hardware (inside compartment)
15	Boom Extension Pins, Clips - Option
16	Boom Extension Hanger Hardware - Option

For Reference Only



FIGURE 5-56 continued

For Reference Only

5

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SECTION 6
ENGINE AND ENGINE SYSTEMS

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GENERAL

These instructions are written for worldwide use. In territories where legal requirements govern engine smoke emissions, noise, safety factors, etc., then all instructions, data and dimensions given must be applied in such a way that, after maintaining or repairing the engine, it does not contravene regulations when in use.

NOTE: These instructions cover only the routine maintenance of the engine. See the engine manual furnished with the crane for engine diagnosis, repair and component replacement.

ENGINE TYPE

Two and four wheel drive units use a Cummins QSF3.8 Tier 3 or Tier 4 Final diesel engine. Or, a GM 4.3 L dual fuel engine.

ENGINE PERFORMANCE

Engine performance is very important to the operation of the crane, the engine is the drive for the hydraulic pump, which supplies power to operate the work functions of the crane. For maximum power the engine must be kept in good working condition.

ENGINE RPM

To check the engine speed, follow the instructions in the engine operator's manual. Maximum and minimum speeds are controlled by a governor installed on the engine. The throttle gives variable control of the engine speed within the limits set by the governor.

GOVERNOR

The governor is preset at the factory and is very unlikely that it should ever have to be adjusted.

NOTE: Restrictions or wrong adjustment of the throttle linkage can be a possible cause of wrong engine RPM. Make sure the throttle linkage moves the engine throttle lever through a full stroke. If necessary, disconnect the throttle linkage and move the throttle by hand. Check the engine speed with the throttle linkage disconnected and compare results.

ENGINE CRANKCASE SYSTEM

The engine crankcase system must be well lubricated to inhibit damage to the engine. The correct type of oil must be used, as well as proper maintenance at regular intervals. For correct intervals, see *Preventative Maintenance on page 5-1*.

Crankcase Oil Data

Use oil viscosity based upon the expected air temperature range during the period between oil changes.

Oil Performance Recommendations

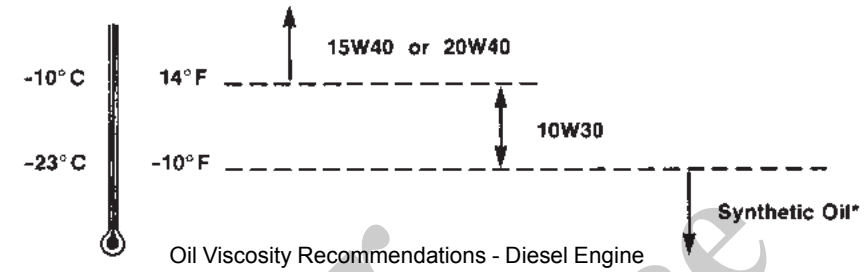
CC/SF for use in naturally aspirated engines and in engines that operate in light duty service including standby and emergency operation (equivalent to MIL-L-2104B).

Sulfated Ash Limit of 1.85% by weight is recommended. Oils with higher ash count may produce deposits on valves that can progress to guttering and valve burning.

Do not use “break-in” lubricating oils in new or rebuilt engines. Only use lubricating oils specified for normal engine operation.

Oil Viscosity Recommendations

The use of a multi-grade lubricating oil improves oil consumption control and improves engine cranking in cold temperatures while maintaining lubrication at high operating temperatures. A multi-grade oil is therefore recommended with the viscosity grades shown in the Figure 6-1. The use of single grade lubricating oils is not recommended, except for synthetic oils used in Arctic conditions.



Oil Viscosity Recommendations - Diesel Engine **FIGURE 6-1**

Arctic Operation

NOTE: *SAE 5W viscosity grade synthetic oil may be used when operating the engine in ambient temperatures below -23°C (-10°F) provided it meets the minimum viscosity at 100°C (212°F).*

When there is no provision to keep the engine warm when operating in ambient temperatures consistently below -23°C (-10°F), use a lubricating oil that meets the following requirements:

Table 6-1: Arctic Oil Recommendations

Parameter (Test Method)	Specification
Performance	API Classification CC -Naturally Aspirated API Classification CC/CD - Turbocharged
Viscosity Maximum	10,000 mPa°s at -35°C (-31°F) 3.1 mm (0.16 inch) Squared Minimum at 100°C (212°F)
Pour Point (ASTM D-97)	Maximum of 5°C (41°F) Below the Lowest Expected Ambient Temperature
Sulfated Ash Content	Maximum of 1.85% by weight (ASTM D-874)

ENGINE COOLING SYSTEM

The engine cooling system consists of the coolant passages in the engine, a thermostat, water pump, hoses and radiator.

The engine is cooled by the circulation of coolant through the passages in the engine block and head. Circulation is by a thermo-siphon action assisted by a water pump driven by a belt from the crankshaft pulley.

The water pump bearings are packed with a special grease during assembly and do not require attention during maintenance.

Coolant Requirements

The quality of coolant will determine the efficiency and life of the cooling system.

1. Check the antifreeze concentration several weeks before the beginning of the cold season or hot season. The antifreeze must have an ethylene glycol (ethanediol) base. Use a low silicone antifreeze that conforms to one of the standards below, or which contains no more than 0.1% anhydrous alkali metasilicate.

   U.S.A. - Engineering Standard GM6038-M.

   U.K. - BS3151: 1959: Ethandiol antifreeze type B with sodium nitrate inhibitors.

   Australia - AS 2108-1977: Antifreeze compounds and corrosive inhibitors for engine cooling systems.

2. There is an advantage to using antifreeze even when frost protection is not necessary. Antifreeze protects against corrosion and also raises the boiling point of the coolant. A 50% concentration of antifreeze is preferred, but if this much protection is not preferred, a 33% concentration can be used. Never use more than a 65% concentration under any conditions. Where frost protection will never be required, use a ***non-chromate corrosion inhibitor*** and clean soft water. Change the

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water/corrosion inhibitor every 12 months, or 500 hours, or to manufacturer's recommendation.

Do not use hard water in the cooling system. Hard water, or water with high levels of calcium and magnesium ions, encourages silica gel formations, especially after a number of heating and cooling cycles. These gel formations can result in loss of cooling or heating in radiators and cab heater cores by coating and plugging the tubes. The formations usually deposit in the cooler sections of the cooling system, such as the radiator bottom tank.

Use soft water, distilled water or deionized water to reduce the potential and severity of silicate dropouts.

NOTE: If you use water without a corrosion inhibitor, rust will form and plug the small holes in the head gasket. These holes are orifices and their size is critical. Do not enlarge the size of the orifices. To do so will disturb the coolant flow and will not solve any overheating problem. If you use water without a corrosion inhibitor for even a short period, the cup plugs will rust through, allowing coolant leakage. An incorrect or malfunctioning radiator cap can result in the loss of coolant and engine running hot. Any sudden loss of coolant from a heavily loaded engine can result in severe damage to the pistons and cylinder bores.

NOTE: Some corrosion inhibitor mixtures contain soluble oil which can have an adverse effect on some types of water hoses.

Antifreeze/Supplemental Coolant Additives Maintenance Summary

Cooling System Level Check Interval

Daily or 10 hours

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

SCA Level Check Interval

6 months or 500 hours

- Check SCA Levels (use only Coolant Test Kit, Grove P/N 9414101675, to check the coolant additive concentration in the cooling system).

  Only add coolant additive if levels are less than 1.2 units/gal. Refer to *Preventative Maintenance*, page 5-1.

NOTE: An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Over concentration can cause formation of a "gel" that can cause restriction or plugging of coolant passages, and overheating.

1 year or 1000 hours

- Test antifreeze/coolant for contamination.

  Condemning limits are:

  - Sulfate level greater than or equal to 1500 ppm.
  - Chloride level greater than or equal to 200 ppm.
  - The pH level is less than 6.5.
  - Oil or fuel contamination can be identified by odor or color.

  If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Preventative Maintenance*, page 5-1.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Radiator Cap and Overflow Bottle

The cooling system is designed to use a radiator cap to prevent the boiling of lubricant. The radiator cap is set to open at 0.97 bar (14 psi). When it does open it allows coolant to be expelled into the overflow bottle and as soon as the engine cools the overflow fluid is sucked back into the radiator. An incorrect radiator cap can result in a great loss of coolant and the engine running hot.

Keep the overflow bottle at least half full of coolant at all times.

Thermostat

A malfunctioning thermostat can result in the engine running hot or cold. If it becomes necessary to replace the thermostat see the engine manual furnished with the crane.

ENGINE ELECTRICAL SYSTEM

The engine electrical system, the charging and starting circuits, as well as the sending units, are described in Engine and Engine Systems.

ENGINE FUEL SYSTEM

Fuel System Description

The diesel engine fuel system is a closed-loop fuel system which includes a fuel tank, an engine fuel filter, an engine fuel pump and the fuel lines.

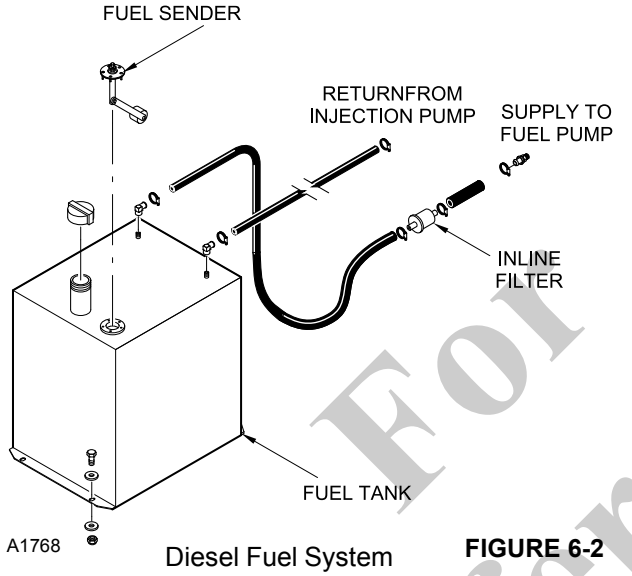
A fuel supply line carries fuel from the bottom of the fuel tank to the engine fuel pump Figure 6-2. A line carries the fuel from the engine fuel pump to the engine fuel filter. Fuel that has been filtered flows to the fuel injector pump.

Reference Only

Fuel is distributed to the fuel injectors from the fuel injector pump. Excess fuel from the fuel injector pump is returned to tank.

Fuel Tank

The fuel tank is located on the right side of the crane. It is a welded box construction with a suction tube installed in the fuel support port. The tube inhibits sediment and water from being picked up off the bottom and sent to the engine.



Diesel Fuel System **FIGURE 6-2**

Fuel Level Sender and Gauge

The fuel level sender and gauge are described in *Electric System on page 3-1*.

Fuel Pump

The fuel pump is installed internally in the engine and is used to pump fuel from the fuel tank and send it under pressure to the fuel filters and injection pump.

The fuel pump includes a priming button. This button is used to bleed the fuel system if one of the following should occur:

- The fuel filter is not filled prior to installation.
- The injection pump is replaced.
- High pressure fuel line connections are loosened or lines are replaced.
- Initial start up or start up after an extended period of time.
- The fuel tank has run empty.

Refer to the diesel operator's manual furnished with this crane for bleeding procedures.

Fuel Filter

The filter is used to collect contaminants and water that has accumulated in the fuel and is not picked up by the sediment bowl. It must be serviced at regular intervals. See *Preventative Maintenance*, page 5-1 for maintenance intervals.

Fuel Injection Pump

The fuel injection pump is a distributor-type pump with a mechanical flywheel-type governor. The pump is flange mounted and is driven from the engine timing case.

Fuel Injectors

Fuel injectors should be taken out and examined at regular intervals. Refer to the engine operator's manual.

QSF Engine Electronic Controlled Fuel System Units

Refer to the engine manual furnished with this unit for a description of the electronic controlled fuel system.

Types of Fuel to Use

Fuel represents the major portion of the crane's operating costs. Therefore, it is important to use it efficiently. Don't let cost tempt you to use an inferior diesel fuel. The savings is a false economy when you consider the damage poor fuel can do to your crane's engine.

WARNING

Do not mix gasoline or alcohol with diesel fuel. This mixture can cause an explosion.

NOTE: Use only diesel fuel designed for diesel engines. Some heating fuels contain harmful chemicals which can seriously affect engine efficiency and performance.

Due to precise tolerances of diesel fuel injection systems, it is extremely important that the fuel be kept clean and free of dirt and water. Dirt or water in the system can cause severe damage to both the injection pump and the injection nozzles.

Use either a Grade No. 1 or a Grade No. 2 low sulfur diesel fuel as defined by ASTM Designation D-975 for diesel engines. In European countries, use ISO 1585 commercial diesel fuel. Find expected air temperature at time of start up on the thermostatic scale Figure 6-3. Correct diesel fuel grade (A, B) is shown next to the scale.

For Reference Only

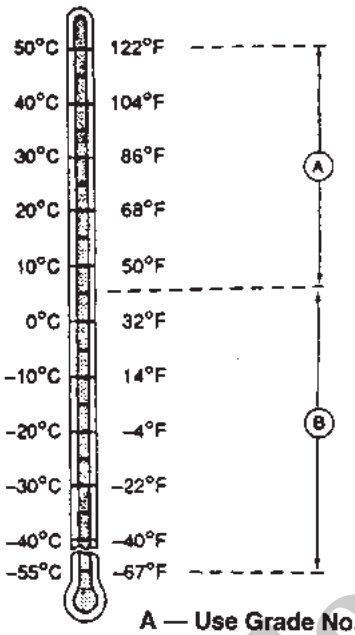


FIGURE 6-3

NOTE: If engine is operating at temperatures -40° to -57°C (-40° to -70°F), Grade DF-A arctic fuel is recommended. Also consult the engine distributor for special lubricants and starting aids.

Cetane number should be a minimum of 40 to assure satisfactory starting and overall performance. At low temperatures and/or high altitudes, minimum cetane number of 45 is recommended.

NOTE: Excessive white smoke at start up could be a result of low cetane fuel.

Use low sulfur content fuel with a cloud point of at least 6°C (10°F) below the lowest expected air temperature at time of starting. The cloud point is the temperature at which wax crystals begin to form in diesel fuel.

NOTE: When using diesel fuel with a sulfur content above 0.5%, the engine oil change interval must be reduced by 50%. DO NOT use a fuel with more than 1% sulfur.

Diesel Exhaust Fluid (DEF)

DEF is used in the after treatment exhaust system with Tier 4 final engines.The DEF tank is located in the engine compartment at the rear of the machine. DEF level must be maintained for the engine to function properly. When the level is low a light on the dash will flash and a derate of the engine will take place, if the fluid is allowed to run out the light will be on constant and a severe derate of the engine will take place.

ENGINE AIR INTAKE SYSTEM

Air for combustion is pulled through an air filter by the engine. Dust and foreign materials are removed from the air by the air filter.

Replace or clean the air filter at the intervals given in *Preventative Maintenance on page 5-1*. Make sure all clamps on the intake tube and filter are tight. If dust or foreign materials enter the engine, permanent damage can be caused to the engine.

NOTE: **NEVER** *run the engine without an air cleaner installed.*

ENGINE EXHAUST SYSTEM



FIGURE 6-4

Exhaust system components get very hot and can cause severe burns.

Annoying rattles and noise vibrations in the exhaust system are usually caused by misalignment of parts. When aligning the system, leave all bolts and nuts loose until all parts are properly aligned, then tighten working from top to bottom.

When installing exhaust parts, make sure there is sufficient clearances between the hot exhaust parts and parts that would be adversely affected by heat.

When installing an exhaust system, allow for expansion when the system is hot.

Periodic maintenance of the exhaust system is not required. However, it is advisable to check the condition of the system when performing other maintenance on the crane.

Check the complete exhaust system for broken, damaged, missing or mispositioned parts, open seams, holes, loose connections and other deterioration which could cause exhaust fumes to seep into the operator's compartment. Any damaged areas must be corrected.

For Reference Only

CHECKS AND ADJUSTMENTS

Table 6-2: Engine Troubleshooting Chart

Problem	Probable Cause	Action
Engine hard to start or will not start.	**1.** Improper starting procedure.	**1.** Review starting procedure in Engine Operator's Manual.
	2. No fuel.	**2.** Check fuel gauge.
	3. Air in fuel line.	**3.** Bleed the fuel line.
	4. Crankcase oil too heavy.	**4.** Use oil with proper viscosity.
	5. Improper type of fuel.	**5.** User proper fuel for operating conditions.
	6. Water, dirt or air in fuel system.	**6.** Drain, flush, fill and bleed system.
	7. Clogged fuel filter.	**7.** Replace the filter element.
Engine runs irregularly or stalls frequently.	**1.** Low coolant temperature.	**1.** Remove and check thermostat.
	2. Clogged fuel filter.	**2.** Replace filter element.
	3. Water, dirt or air in fuel system.	**3.** Drain, flush, fill and bleed.
	4. Dirty or faulty fuel injection nozzles.	**4.** Have authorized distributor check the nozzles.
	5. Clogged air filter.	**5.** Replace the filter elements.
Below normal engine temperature.	**1.** Defective thermostat.	**1.** Remove and check thermostat.
	2. Defective temperature gauge.	**2.** Check gauge, sender and all connections.
Lack of power.	**1.** Engine overload.	**1.** Reduce the load.
	2. Intake air restriction.	**2.** Service air cleaner.
	3. Clogged fuel filters.	**3.** Replace fuel filters.
	4. Overheated engine.	**4.** Refer to Engine Operator's Manual. Check for plugged radiator/oil cooler fins.
	5. Below normal engine temperature.	**5.** Remove and check thermostat.
	6. Faulty engine.	**6.** Refer to Engine Operator's Manual.
Low oil pressure.	**1.** Low oil level.	**1.** Add oil.
	2. Faulty gauge or sender.	**2.** Check gauge, sender and connections.
	3. Improper type of oil.	**3.** Drain and fill crankcase with proper viscosity and quality.
Engine overheats	**1.** Engine overloaded.	**1.** Reduce the load.
	2. Low coolant level.	**2.** Fill radiator to proper level, check radiator and hose for loose connections or leaks.
	3. Plugged radiator/oil cooler fins.	**3.** Clean fins.
	4. Faulty radiator cap.	**4.** Replace radiator cap.
	5. Cooling system needs flushing.	**5.** Flush cooling system.
	6. Defective thermostat.	**6.** Replace thermostat.
	7. Defective temperature gauge or sender.	**7.** Check and replace.

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REMOVAL AND INSTALLATION

Removal

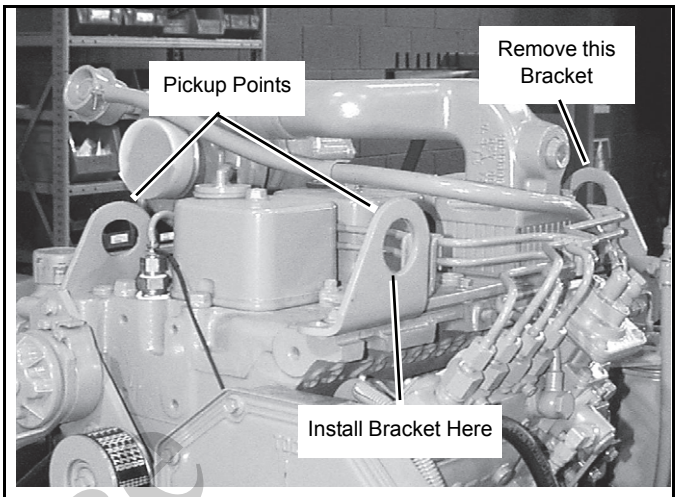
WARNING

A raised and badly supported machine can fall on you causing severe injury or death. Position the machine on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the machine hydraulics or outriggers to support the machine when working under it.

1. Raise and support the frame far enough to remove the rear axle assembly.
2. Remove the engine cover.
3. Disconnect the ground cable and battery cable from the battery.
4. Disconnect the frame electrical wire harness from the engine electrical wire harness.
5. Disconnect the transmission high temperature switch from the frame electrical wire harness.
6. Disconnect the transmission electrical wire harness from the instrument panel wire harness.
7. Drain the radiator. Disconnect the upper and lower hoses from the radiator.
8. Disconnect the transmission cooling lines from the radiator. Put plugs and caps on all lines to keep dirt out of the system.
9. Remove the radiator.
10. Remove the air cleaner and intake hose(s).

NOTE: Have a fire extinguisher handy and know how to use it before performing the next step.

11. Disconnect the fuel lines from the engine. Plug or cap the lines to prevent leakage.
12. Disconnect the drive shaft(s) from the transmission. See Section 8.
13. Disconnect the exhaust pipe from the exhaust manifold of the engine.
14. Support the hydraulic pump and then remove it from the transmission.
15. Disconnect the throttle linkage from the engine.
16. If equipped, remove the optional cold start kit from the bracket inside the chassis frame.
17. Disconnect the engine ground cable from the engine or the engine flywheel.
18. Remove the rear axle.
    a. Remove the rear engine support bracket Figure 6-5 and install it on the front of the engine.



p0105 Image for reference only **FIGURE 6-5**

Attach chains to the two front engine support brackets and to a hoist. Use the hoist to support the engine while the rear axle is being removed.

    b. Loosen and remove the wheel lug nuts and remove both rear wheels.
    c. Disconnect and plug the hydraulic hoses at the steering cylinders.
    d. Disconnect and cap and plug the brake hoses from the axle.
    e. Support the axle on a trolley jack.
    f. Remove the front engine mounting hardware.
    g. With the engine and rear axle both supported, remove the eight bolts and flat washers securing the engine/axle mounting bracket to the chassis.
    h. Lower and remove the axle clear of the chassis
19. Remove the rear engine support mounting bolts, washers, rubber mounts and nuts.
20. Using a trolly jack, raise the transmission so it can be removed out the rear of the chassis.
21. Using the hoist, slowly pull the engine and transmission forward enough to attach a sling around the torque converter housing. At the same time, check that all items are free for engine removal. Attach a pull jack to the sling and hoist.
22. Slowly raise the engine and check that all lines and components which can possibly cause interference with the engine removal have been removed. Carefully lift the engine and transmission out the rear of the frame at about a 30° angle.

For Reference Only

Installation

1. Attach a hoist to the engine the same way removal was accomplished.
2. Lift the engine into place over the chassis. Tilt the engine at about a 30° angle to insert the engine into the chassis. Lower the engine into the chassis and set the transmission on a trolley jack. Remove the sling and pull jack.
3. Move the engine and transmission into the chassis until the rear mounting bolts, washers, rubber mounts and nuts can be installed and tightened.
4. Install the rear axle.
   a. Locate the rear axle under its mounting location. Raise the axle and mounting bracket into position and install the eight mounting bolts and flat washers.
   b. Install the front engine mounting hardware.
   c. Connect the brake lines to the axle.
   d. Connect the hydraulic hoses to the steering cylinders.
5. Align the splines on the hydraulic pump shaft with the transmission splines and install the hydraulic pump to the transmission.
6. Connect the engine ground cable to the engine.
7. If equipped, install the cold start kit.
8. Connect the throttle linkage to the engine.
9. Connect the exhaust pipe to the engine manifold. If a gasket is used, install a new gasket.
10. Connect the drive shafts to the engine. See Section 8.
11. Connect the fuel lines to the engine.

NOTE: The diesel fuel supply fuel line must be bled of air before engine can be started. Refer to the engine operator's manual furnished with this crane, for bleeding procedure.

12. Install the air cleaner and intake hose.
13. Install the radiator in place on the chassis.
14. Connect the transmission cooling lines to the radiator. Connect the upper and lower radiator hoses.
15. Fill the radiator with recommended coolant.
16. Connect the transmission wire harness to the instrument panel wire harness.
17. Connect the transmission high temperature switch lead to the switch.
18. Connect the engine wire harness to the frame wire harness.
19. Install the engine cover.
20. Connect the battery cables to the battery.
21. Check complete installation to be sure all components are installed and secure.
22. Fill the engine and transmission with recommended oil.
23. Start the engine. Continue to add transmission fluid until transmission cooling lines are full. Add fluid as needed to fill the cooling system.
24. Adjust the throttle control, if necessary.
25. Steer the rear wheels in both directions several times to remove air from the steering circuit.
26. Bleed air from brake lines. Refer to *Brake System*, page 9-1.
27. Stop the engine and check for leaks. Tighten fittings if necessary.

For Reference Only

SECTION 7
TRANSMISSION AND TORQUE CONVERTER

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TECHNICAL DATA

General Technical Data

Description:

Two-Wheel Drive . . . . . Full electrohydraulic transmission unit with input, reverse, and mainshaft clutch packs. Torque converter is integral.

Four-Wheel Drive . . . . . Full electrohydraulic transmission unit with input, reverse, four wheel drive and mainshaft clutch packs. Torque converter is integral.

Designation:

- Two-Wheel Drive PS752
- Four-Wheel Drive PS754

Weight (dry):

- Two-Wheel Drive . . . . . 220 kg (484 lb)
- Four-Wheel Drive . . . . . 236 kg (520 lb)

Number of Teeth:

- Transfer Gear 46
- Layshaft 16

Gear Ratios:

- 1st 6.58:1
- 2nd 3.71.1
- 3rd 1.77:1
- 4th 1.00:1

Torque Converter Dia. . . . . 11 in. (279 mm)

Torque Converter at Stall 2.40:1

Torque Converter Color Code Identification:

- Color Coded Dots. . . . . 2 Orange
  1 Green

Minimum Engine RPM at Converter Stall:

- 2nd Gear . . . . . 2075 rpm
- 3rd Gear . . . . . 2050 rpm

For Reference Only

Converter IN pressure (neutral) at 50°C (122°F)
- 1000 rpm . . . . . 2.8 – 4.1 bar (40 – 60 psi)
- 2000 rpm . . . . . 4.8 – 6.2 bar (70 – 90 psi)

Converter OUT pressure (neutral) at 50°C (122°F)
- 1000 rpm . . . . . 1.9 – 2.3 bar (27 – 33 psi)
- 2000 rpm . . . . . 2.3 - 2.7 bar (33 – 39 psi)

Converter Inlet Relief Valve Pressure (Max.) . . . . . 6.5 bar (95 psi)

Converter Inlet Relief Valve Lubrication Pressure (in neutral) at 50°C (122°F)
- 1000 rpm . . . . . 0.14 - 0.28 bar (2.0 – 4.0 psi)
- 2000 rpm . . . . . 0.28 – 0.55 bar (4.0 – 8.0 psi)

Converter Mainline Pressure (in neutral) at 122° F (50° C)
- 1000 rpm . . . . . 9.0 - 10.0 bar (135 – 145 psi)
- 2000 rpm . . . . . 9.7 – 11.0 bar (140 – 160 psi)

Flow Rates (in neutral) at 122° F (50° C)
- Cooler (1000 rpm) . . . . . 10.4 – 13.6 bar (2.8 – 3.6 psi)
- Cooler (2000 rpm) . . . . . 14.5 – 20.0 bar (3.8 – 5.3 psi)
- Pump (1000 rpm) . . . . . 11.0 – 15.0 bar (2.9 – 4.0 psi)
- Pump (2000 rpm) . . . . . 22.5 – 29.5 bar (6.0 – 7.8 psi)

The following clutch pressures should be the same as the Mainline Pressure to within 7 bar (10 psi):
- Input Clutch Pressure (high and low ratio)
- Forward Clutch Pressure (high and low ratio)
- Layshaft Clutch Pressure
- Mainshaft Clutch Pressure

Clutch Solenoid Technical Data

Type . . . . . 4 way, 3 position, directional control

Operating Flow . . . . . 40 L/min (9.85 gpm)

Operating Pressure . . . . . 10 bar (145 psi)

Leakage (maximum . . . . . 50 cc/min @ 40° C, 10 bar (14 in./min. @ 104° F, 145 psi)

Fluid Type . . . . . CAT TO-4

Fluid Cleanliness . . . . . ISO 22/17

Waterproof Specification . . . . . IP 67

Coil Operating Voltage . . . . . +12 V DC nominal (10.8 to 13.2 V)

Pull-in Voltage . . . . . +10.5 V (max.) @ 25°C (77°F) air, after energized for 10 minutes at 16 V and off for 10 seconds

Dropout Voltage . . . . . +1.5 V (min.) at 20°C (68°F) air

Peak Voltage . . . . . +26 V DC for 5 minutes at 0°C (32°F)

Coil Resistance . . . . . 4.9 ohms ± 5% @ 20°C (68°F)

Operating Temperature Range:
- Air . . . . . -40°C to +43°C (-40°F to +109°F)
- Oil . . . . . -40°C to +100°C (-40°F to +212°F)

Diode Protection . . . . . 3 amps minimum, 50 ns maximum reverse recovery time

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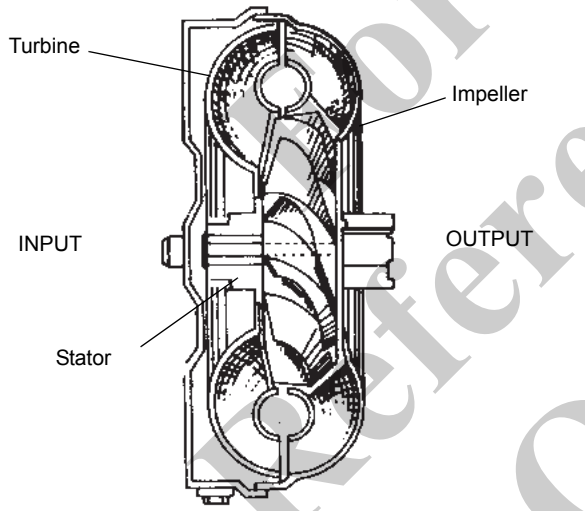
DESCRIPTION OF OPERATION

Torque Converter

The torque converter Figure 7-1 is the hydraulic link between the engine and the drive train. There are three main components in the torque converter:

- A turbine
- An impeller (pump)
- A stator and One-Way Clutch

The **impeller** is the pump for the torque converter. This component starts the movement of the oil to the other components. The impeller is connected to the engine flywheel through the torque converter and a drive plate. The impeller rotates at engine speed. Similar to a centrifugal pump, the impeller takes oil at the inner diameter and releases the oil at the outer diameter.



Torque Converter Cross-Section

a0230 **FIGURE 7-1**

The **turbine** is opposite the impeller and is connected by splines to the input shaft of the Powershift Transmission. The turbine receives oil at the outer diameter and releases the oil to the stator at the inner diameter. The movement of oil from the impeller to the turbine makes a multiplication of torque possible. The torque converter gives maximum torque when the turbine is at zero (0) rpm.

The **stator** is between and at the center of the impeller and turbine. The stator changes the direction of the oil which leaves the turbine so the oil will enter correctly again into the impeller.

The torque converter and transmission have a common hydraulic system. Figure 7-3 shows the arrangement of the system.

CAUTION

Normal operating temperature is 82° - 88°C (180° - 190°F). High temperatures will cause damage and leakage in the seals and gaskets of the torque converter. Do not continue operation if the temperature increases above 82° - 88°C (180° - 190°F). A warning light on the cab instrument panel will illuminate when the temperature rises above a safe temperature. Put the transmission in “neutral” position and let the engine run at low rpm until the temperature returns to normal and the warning light goes out. If temperature does not return to normal, check for restriction in the lubrication and cooling lines of the torque converter.

Transmission

The Powershift Transmission is an electo-hydraulic transmission unit. Gear shifting and direction selection are controlled using multi-disc clutch packs.

Electrically operated solenoid valves divert pressurized oil (provided by pump **Q** Figure 7-2) to the selected clutch packs.

A combined lever/swivel switch (travel select lever) on the steering column actuates both gear ratio and direction solenoids.

The Powershift transmission consists of a torque converter **A** Figure 7-2, input clutch assembly **B**, forward clutch **C**, layshaft assembly **E**, and a mainshaft assembly **D**.

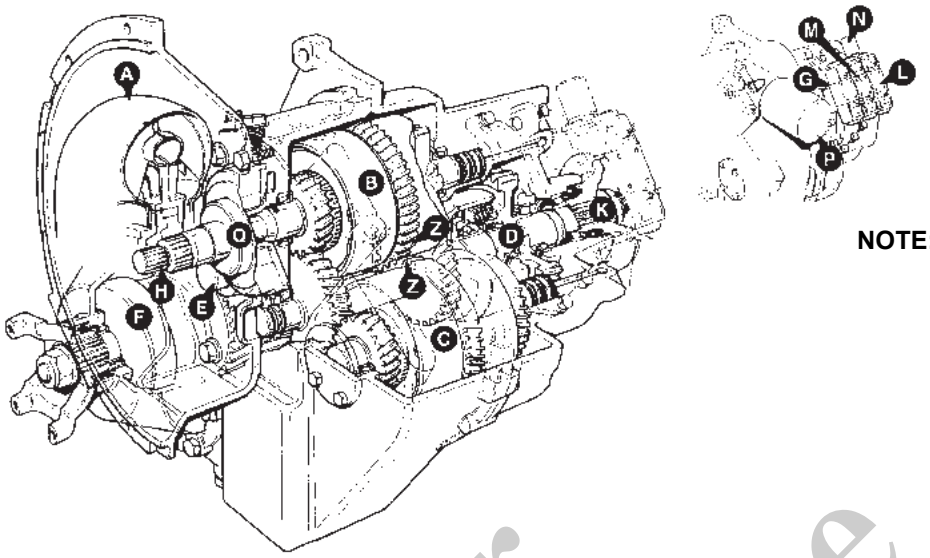
The torque converter is a fluid coupling bolted to a drive plate which is bolted to the engine flywheel. As the engine crankshaft begins to rotate, the torque converter gives a smooth power takeoff gradually increasing the torque transmitted. This torque is transferred from the torque converter assembly to the clutch/gear assemblies via the input shaft **H**.

The input clutch assembly **B** contains two hydraulically operated clutches; one clutch provides reverse low ratio drive and other a reverse high ratio drive. The three-position solenoid **G**, when energized, directs pressurized oil to either the reverse low or reverse high clutch.

The forward clutch assembly **C** is similar to the input clutch assembly. It contains two hydraulically operated clutches; one clutch provides forward low ratio drive and the other forward high ratio drive. The three-position solenoid valve **L**, when energized, directs pressurized oil either to the forward low or forward high clutch.

Forward drive is transmitted via constant meshing of spur gears **Z**.

For Reference Only



NOTE: The filter is not used on this transmission. A remote filter installation is used.

A - Torque Converter
B - Input Shaft Assembly
C - Forward Clutch Assembly
D - Main Shaft Assembly
E - Layshaft Assembly
F - 4 WD Clutch Assembly
G - 3 Position Solenoid Valve (Reverse)
H - Input Shaft
K - Spined Output Shaft
L - 3 Position Solenoid Valve (Forward)
M - 3- Position Solenoid Valve (Mainshaft/Layshaft
N - 2/4 Wheel Drive Solenoid (Not used)
P - Hydraulic Filter
Q - Pump
Z - Spur Gears

a0231

FIGURE 7-2

Both the mainshaft and the layshaft assemblies have a single clutch each. The three-position solenoid **M**, when energized, directs pressurized oil to either the mainshaft clutch or the layshaft clutch.

The 4 wheel drive unit (used on four-wheel drive cranes) has a single clutch **F**. In normal operation the clutch is spring loaded and therefore engages to give four-wheel drive. The 2/4 wheel drive solenoid **N** is not used on this crane.

Hydraulic Operation – Two-Wheel Drive

When the Powershift Transmission Figure 7-3 is operated, multi-disc clutch packs are pressurized and engaged. The engaged clutch packs then transfer drive from the engine to the road wheels (via the torque converter **A**, input shaft **H** and the drive shafts).

Different combinations of engaged clutches give four gear ratios in forward and reverse drive. There must always be two clutches engaged before the crane will drive: 1. a direction ratio clutch (i.e., forward low) and 2. a drive clutch (i.e., layshaft or mainshaft).

Figure 7-3 shows 1st gear reverse selected, therefore, the two engaged clutches will be reverse low ratio clutch **B** and layshaft drive clutch **E**.

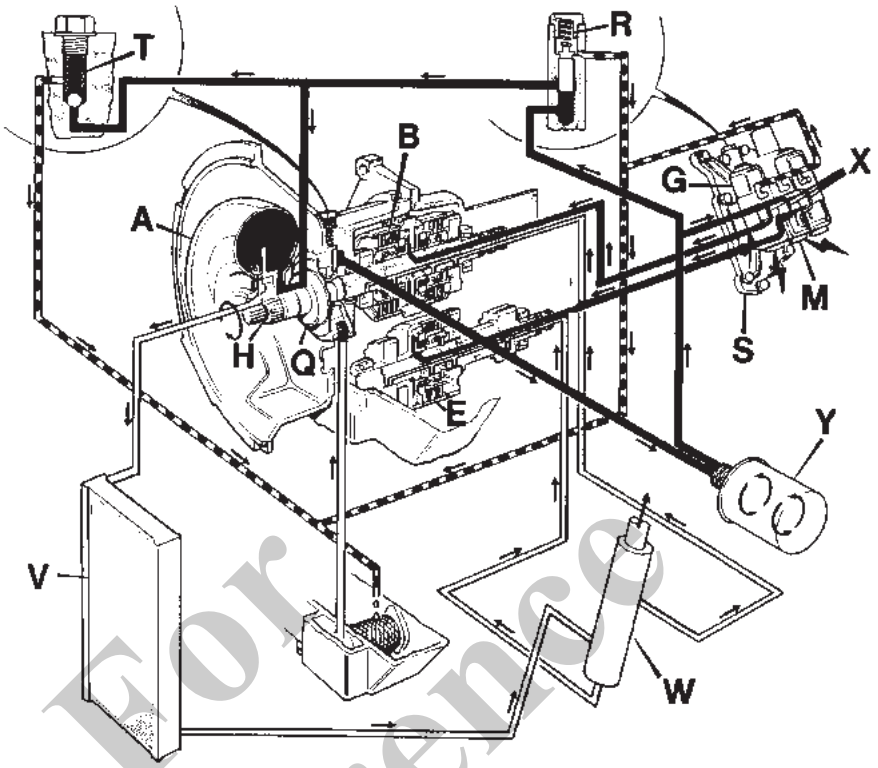
For purpose of this description, clutches not used when 1st gear reverse is selected are not shown.

Oil from the pump **Q** is fed through an internal passage by way of the filter **Y** to pressure the maintaining valve **R**, which maintains a constant pressure to the solenoid valve adapter block **S**.

The solenoid adapter block houses the solenoid valves, which are used to divert oil to the clutch packs.

Excess oil from the maintenance valve flows through the casing to the torque converter. Oil enters the converter between the converter hub and stator support, and leaves between the stator and the input shaft. Pressure in the converter is controlled by relief valve **T** which dumps oil from the converter line back to the sump.

For Reference Only



a2276

Two-Wheel Drive Transmission Hydraulic Circuits

FIGURE 7-3

Oil from the torque converter flows out of the transmission unit to the external oil cooler **V**. From the cooler, the oil flows to pipe cluster **W** (the pipe cluster is only used on earlier transmissions, on later transmissions oil flow is incorporated within the casing, which distributes the oil to pass through the center of all clutches for lubrication purposes).

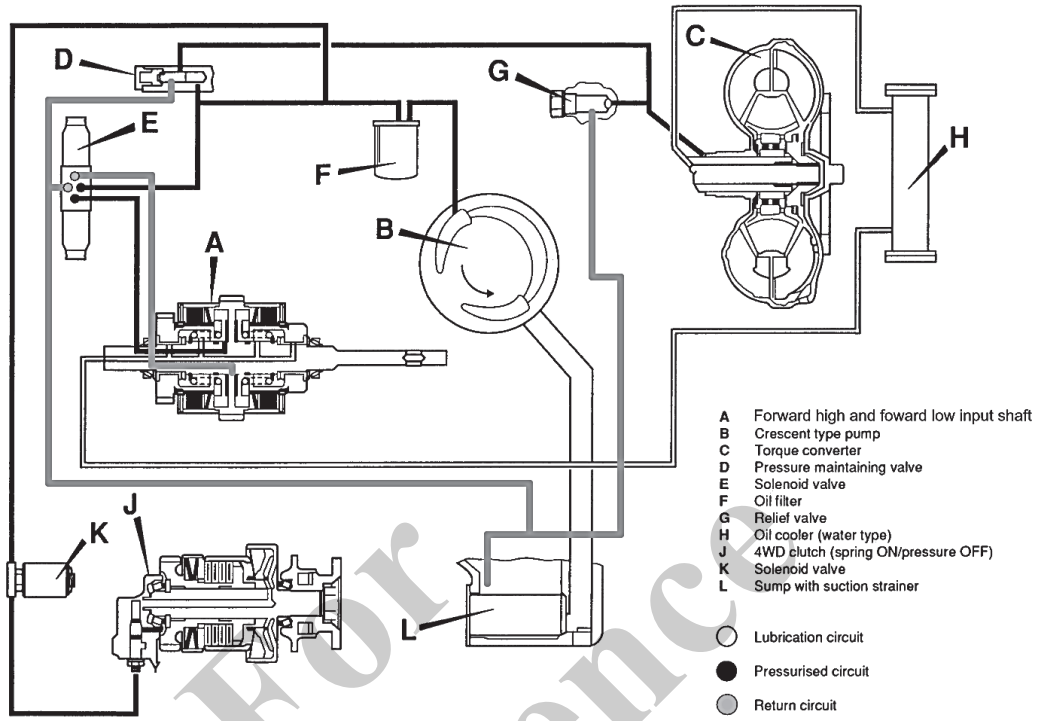
In neutral the flow of pressurized oil is blocked at the solenoid valves.

Restrictor orifice **X** in the feed lines to the solenoid valves modulates the pressure to the clutches. This ensures a smooth clutch engagement. Pressure from the clutches not engaged will vent back to the sump by way of internal passages and the solenoid spools.

When 1st gear forward is selected valves **G** and **M** are energized. The energized valves cause internal spools to move, which then divert pressurized oil to clutch packs **B** and **E** by way of internal passages.

The drive from the engine is then transferred by way of the engaged clutches and gears to the output flange and finally to the road wheels.

For Reference Only



a0233

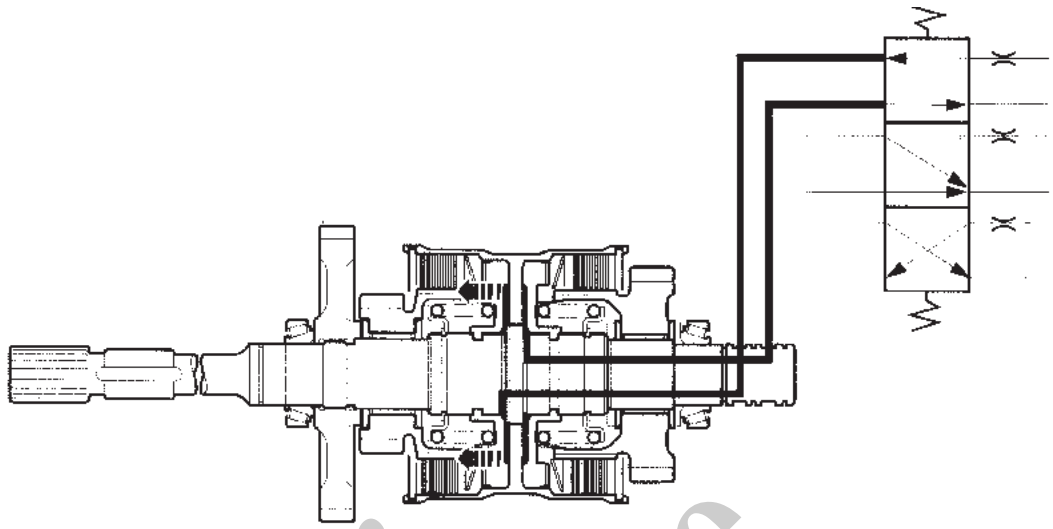
Four-Wheel Drive Transmission Hydraulic Circuits - Typical

FIGURE 7-4

For Reference Only

Hydraulic Operation - Four- Wheel Drive

The solenoid adapter block also houses a solenoid valve **K** for the four-wheel drive clutch Figure 7-5. Oil under pressure is directed to the solenoid where it stopped. The purpose of the solenoid is to change the transmission from four-wheel drive mode to two-wheel drive mode. In four-wheel drive mode the solenoid valve is not actuated and the clutch pack **J** is spring applied. In two-wheel drive mode the solenoid is actuated and hydraulic oil is directed to the clutch pack releasing the clutch. **Although the solenoid is furnished with the cranes with four-wheel drive, the two-wheel drive option is not available** and the transmission is always in four-wheel drive.



a2277

Forward High and Low Clutch Operation - Typical

FIGURE 7-5

Clutch Operation

The transmission reverse high and reverse low clutch assemblies (Figure 7-5) are operated by the double solenoid valve.

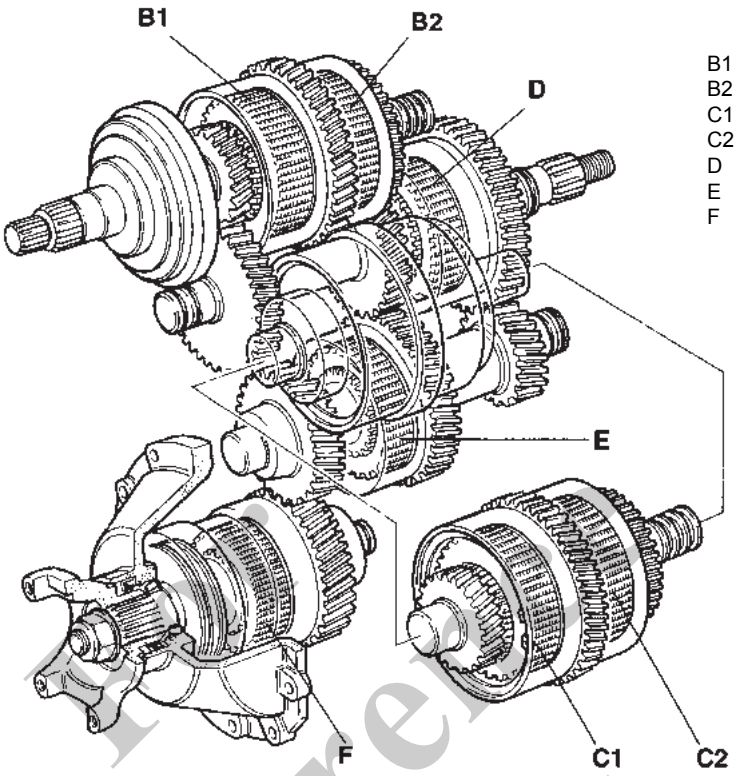
In neutral, the solenoid valve blocks the flow of pressurized oil to the clutches.

When energized, the solenoid valve, depending on which coil is energized, diverts pressurized oil by way of the shaft to the appropriate clutch in the unit. Pressure from the other clutch is vented to the sump by way of the solenoid valve spool.

NOTE: The forward high and forward low clutch unit operates in a similar manner.

The mainshaft and layshaft assemblies each have a single clutch. The principle of operation similar to the forward/reverse, high/low clutch assemblies i.e., the mainshaft/layshaft solenoid valve diverts oil to either the mainshaft clutch or the layshaft clutch.

For Reference Only

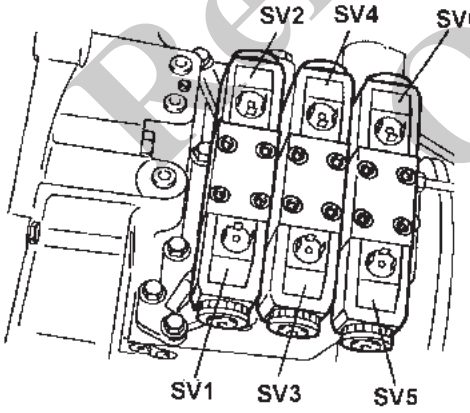


B1 Reverse Low Ration Clutch
B2 Reverse High Ratio Clutch
C1 Forward Low Ratio Clutch
C2 Forward High Ratio Clutch
D Mainshaft Clutch
E Layshaft Clutch
F 4WD Clutch

a1363

Clutch Identification

FIGURE 7-6



SV1 Reverse Low Solenoid
SV2 Reverse High Solenoid
SV6 Forward Low Solenoid
SV5 Forward High Solenoid
SV4 Mainshaft/Layshaft Solenoid
SV3 2/4WD Solenoid (Not functional)

a2278

Solenoid Identification

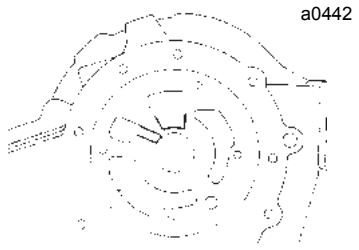
FIGURE 7-7

Reference Only

Troubleshooting

Problem	Possible Cause	Remedy
Lack of Power.	**1.** Poor engine condition.	**1.** Check and if necessary repair the engine.
	2. Low oil level.	**2.** Add oil to transmission.
	3. Worn pump.	**3.** Check, repair or replace the pump.
	4. Torque converter damaged.	**4.** Check, repair or replace the torque converter.
	5. Low mainline pressure.	**5.** See fault “Low Mainline Pressure.”
	6. Clutches slipping.	**6.** Check clutch pressures, check clutch piston rings.
	7. Internal leakage.	**7.** Check internal cored passages and the casting for porosity.
	8. High stall speeds.	**8.** See fault “High Stall Speeds” (on all clutches).
	9. Low stall speeds.	**9.** See fault “Low Stall Speeds” (on all clutches).
	10. Overheating.	**10.** See fault “Overheating.”
Low Mainline Pressure.	**1.** Worn pump.	**1.** Check, repair or replace the pump.
	2. Blocked suction strainer.	**2.** Clean suction strainer.
	3. Pressure maintaining valve sticking or leaking.	**3.** Free sticking valve or replace valve.
	4. Foaming oil.	**4.** Internal leakage (cored passages) - inspect transmission. Dirty suction strainer - clean strainer. High oil level - drain to proper level. Incorrect grade of oil - drain and refill with correct oil.
High Stall Speed (on all clutches).	**1.** Damaged torque converter blades.	**1.** Check, repair or replace the torque converter.
	2. Clutches slipping clutch friction/counter.	**2.** Remove, inspect and install new plates.
	3. Internal leakage.	**3.** Check internal passages and casing for porosity.
Low Stall Speeds (on all clutches).	**1.** Poor engine condition.	**1.** Check and repair engine.
	2. Torque converter reaction member clutch slipping.	**2.** Check and repair the torque converter.

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Problem	Possible Cause	Remedy
Low Converter Out Pressure.	**1.** Low mainline pressure.	**1.** See fault “Low Mainline Pressure.”
	2. Converter internal leakage.	**2.** Check and replace the torque converter.
	3. Converter relief valve faulty.	**3.** Check and replace the relief valve.
Low Pump Flow.	**1.** Low oil level.	**1.** Add oil to transmission.
	2. Blocked suction strainer.	**2.** Clean suction strainer.
High Converter Out Pressure.	**1.** Oil cooler/lines blockage.	**1.** Clean cooler, remove blockage.
Low Lubrication Pressure.	**1.** Low mainline pressure.	**1.** See fault “Low Mainline Pressure.”
	2. Oil cooler/lines blockage.	**2.** Clean cooler, remove blockage.
	3. Ruptured lubrication lines.	**3.** Repair line.
	4. Converter internal leakage.	**4.** Check and replace the torque converter.
	5. Converter relief valve faulty.	**5.** Check, repair or replace the relief valve.
Overheating.	**1.** Low oil level.	**1.** Add oil to transmission.
	2. High oil level.	**2.** Drain oil to correct level.
	3. Trapped or kinked hoses in cooler system.	**3.** Repair or replace hoses.
	4. Low converter out pressure relief valve.	**4.** Repair or replace the torque converter and flow rate.
	5. Oil cooler blockage.	**5.** Clean the oil cooler.
	6. Operating in wrong gear ranges.	**6.** Select correct gears to suit working conditions.
	7. Engine cooling system overheating.	**7.** Find and repair engine cooling problems.
	8. Foaming oil.	**8.** See fault “Low Mainline Pressure.”
	9. Clutch pistons sticking on return stroke.	**9.** Check and repair clutch piston(s) and seal(s).
	10. Passages on front housing pump mounting face are the wrong depth (indicated with an excessively low pressure and flow on the converter out cooling line).	**10.** Replace front housing (or repair existing housing).  **FIGURE 7-8**
	11. Leakage across pump mounting face and front case.	**11.** Check for damaged surface on both components and loose pump mounting bolts.

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Electrical Troubleshooting

System Operation

Each powershift transmission is provided with electrical safety locks which inhibit inadvertent operation of the crane while in an unsafe condition.

When the parking brake is ENGAGED the crane is prevented from moving by “dumping” oil in the transmission’s oil system to the internal oil reservoir. No oil is directed to any of the drive mechanisms, thereby inhibiting crane movement. When DISENGAGED the crane will only start when the shift control lever is in the NEUTRAL position.

Change of crane travel direction is accomplished by moving the shift control lever, located on the steering column, from Neutral (center) position up to the FORWARD position or down to the REVERSE position. Change of speed range is accomplished by rotating the shift control handle COUNTERCLOCKWISE to increase the travel speed range or CLOCKWISE to decrease the travel speed range.

Movement of the shift control lever and rotation of the shift control handle energizes combinations of solenoid valves through the ECU, which are connected to two shafts located in the transmission (See Table 7-1).

Transmissions are furnished with six solenoid valves (SV1, SV2, SV3, SV4, SV5 and SV6) See arrangement in Figure 7-9. Two of the solenoid valves control speed ranges while the remaining four control speed and the direction of travel.

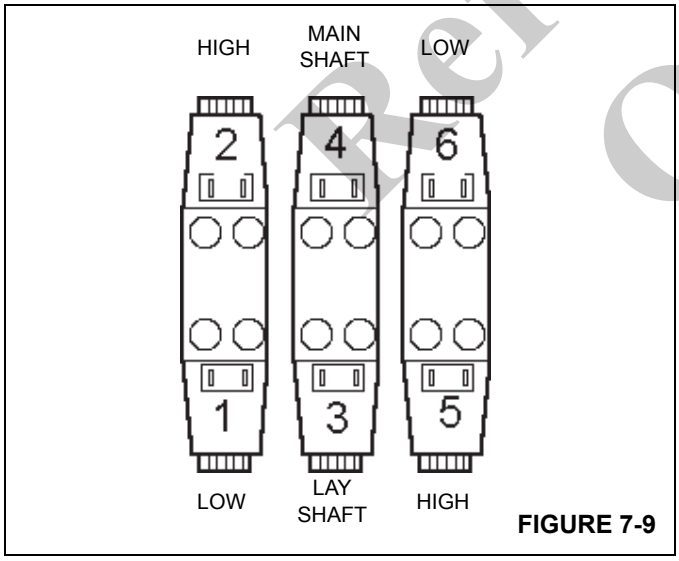


FIGURE 7-9

The solenoids are controlled by the transmission Electronic Control Unit (ECU) and are connected through the wire harness.

Table 7-1 shows which solenoid valves are energized for the four speeds and two directions of travel.

Table 7-1: Solenoid Valve Energizing Sequence

GEAR	DIRECTION	VALVES
First	Forward	SV6 and SV3
Second	Forward	SV5 and SV3
Third	Forward	SV6 and SV4
Fourth	Forward	SV5 and SV4
First	Reverse	SV1 and SV3
Second	Reverse	SV2 and SV3
Third	Reverse	SV1 and SV4
Fourth	Reverse	SV2 and SV4

Electronic Control Unit (ECU)

The Electronic Control Unit (ECU) is designed to do two things Figure 7-10:

- To control the selection of gears and direction of travel.
- To protect the gearbox from damage due to incorrect use of the controls.

It is a microprocessor controlled unit which is mounted in the battery compartment. A wire harness connects the ECU to the transmission harness, which connects to the solenoids, the oil pressure switch and a speed sensor, on the transmission. A second harness connects the unit to various switches and selectors in the cab.

The unit receives signals from the gear/direction and other switches in the cab and operates the appropriate transmission solenoids accordingly. Built-in software prevents potentially damaging (and dangerous) selections from being made. The control features provided by the ECU software are listed below:

1. **Downshift Inhibit -** prevents too low of a gear being selected for a given speed.
2. **Kickdown -** operated by a button on the shift lever in the cab - changes down a gear (from 2nd, 3rd or 4th) for a period of 6 seconds before reverting to the selected gear.
3. **Reverse Inhibit -** prevents directional changes if the speed is too high.
4. **Neutral Start -** the machine will only start with the shift control handle in neutral, irrespective of gear selection (speed) position.

For Reference Only



FIGURE 7-10

Electrical Troubleshooting Chart

Problem	Possible Cause	Remedy
No drive at engine start up	**1.** Blown ECU fuse.	**1.** Check ECU fuse (also check fuse to shift lever).
	2. ECU connector loose.	**2.** Check that connector is mating correctly with ECU.
No drive and continuous warning buzzer.	**1.** Attempting to select drive with parking brake engaged.	**1.** Release parking brake.
No drive.	**1.** Faulty shift control.	**1.** Check control and wiring.
	2. Parking brake sticking.	**2.** Check parking brake assembly.
	3. Faulty transmission harness.	**3.** Check harness continuity and connector.
Missing gears.	**1.** Faulty solenoid(s).	**1.** Check solenoid(s) and wiring.
	2. Faulty shift control.	**2.** Check control and wiring.
	3. Low oil pressures.	**3.** Check clutch pack and mainline pressures.
No 4th gear.	**1.** Faulty speed signal.	**1.** Check speed sensor and wiring.
		2. Check speed sensor installation (i.e., distance from transfer case).
Down speed protection does not seem to be working.	**1.** Faulty speed signal.	**1.** Check speed sensor and wiring.
Will not downshift and repeating double beep sounded.	**1.** Speed too high for selected downshift.	**1.** Slow crane with brakes. Deselect downshift.
Lower gear than lever selected.	**1.** Kickdown engaged.	**1.** Check kickdown switch and wiring.
Kickdown will not engage and double beep sounded.	**1.** Speed too high to engage lower gear.	**1.** Slow crane and try kickdown again.
Kickdown not operating.	**1.** Faulty kickdown input.	**1.** Check kickdown switch and wiring.

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Problem	Possible Cause	Remedy
Machine will not perform a reversal of direction and repeating double beep sounded.	1. Speed too high for reversal of direction.	1. Slow crane with brakes. Deselect reversal.
Sporadic gear changes.	1. Moisture in ECU connectors.	1. Check that connector seals are installed and are in good condition.

Finding Electrical Problems

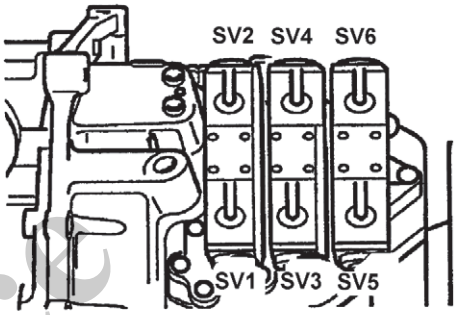
It is possible to carry out a large portion of the ECU diagnostics with basic workshop tools, such as a test lamp and/or voltmeter.

CAUTION

Never check for voltage directly across any pins on the ECU. Internal damage can result from shorting pins.

Checking Solenoid Operation

Gear Selection	Solenoids
Forward 1st	Forward Low (SV6) and Layshaft (SV3)
Forward 2nd	Forward High (SV5) and Layshaft (SV3)
Forward 3rd	Forward Low (SV6) and Mainshaft (SV4)
Forward 4th	Forward High (SV5) and Mainshaft (SV4)
Reverse 1st	Reverse Low (SV1) and Layshaft (SV3)
Reverse 2nd	Reverse High (SV2) and Layshaft (SV3)
Reverse 3rd	Reverse Low (SV1) and Mainshaft (SV4)
Reverse 4th	Reverse High (SV2) and Mainshaft (SV4)

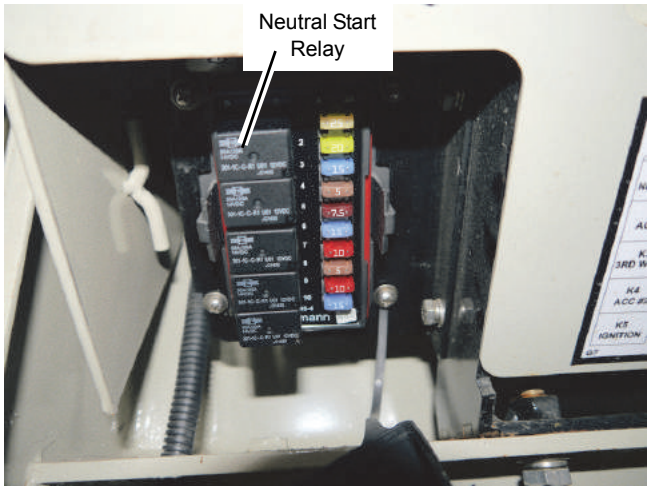


SV1Reverse Low
SV2Reverse High
SV3Layshaft
SV4Main Shaft
SV5Forward High
SV6Forward Low

a0797 **FIGURE 7-11**

The correct operation can be confirmed as follows:

1. Chock the wheels.
2. Disable the crane neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash Figure 7-12.



9548 **FIGURE 7-12**

For Reference Only

3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shifter control lever.
5. Identify the two solenoids which give the required gear Figure 7-11.
6. Check the magnetic attraction on the ends of the solenoid using a feeler gauge or small screwdriver.
7. If solenoid(s) are not being energized, check that they are receiving power.
8. If the wrong solenoids are being energized for the gear selection check the wire harness for proper connections.
9. If the solenoids are being energized correctly and the problem persists, the problem may be in the transmission itself or a stuck spool in the solenoid.

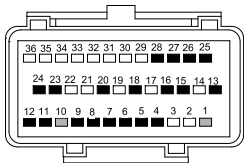
If the problem seems to be intermittent (e.g. transmission dropping to neutral), select a gear and place a small washer on the ends of the energized solenoids. The washers will be held in place by the magnetic attraction. Drive the crane around without changing gear or direction. If the problem reappears examine the washers. If one or both of the washers have dropped off, it is a good indication that there is an electrical problem. In this case, examine the wire harness and ECU further. If both washers are still in place the problem lies elsewhere (possibly in the transmission itself).

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Table 7-2: Instrument Panel Wire Harness Check

Key

✔	Full Battery Charge
–	No voltage measured with key ON
NC	Pin not connected



Pin No.	Function	Forward Gears F1	F2	F3	F4	Reverse Gears R1	R2	R3	R4
1	Jumps To 1	–	–	–	–	–	–	–	–
2	NC								
3	NC								
4	Reverse	–	–	–	–	✔	✔	✔	✔
5	4th Gear	–	–	–	✔	–	–	–	✔
6	Kickdown	–	–	–	–	–	–	–	–
7	2nd Gear	–	✔	–	–	–	✔	–	–
8	Parking Brake	–	–	–	–	–	–	–	–
9	Alarm Buzzer	–	–	–	–	–	–	–	–
10	Jumps to 1	–	–	–	–	–	–	–	–
11	GND	–	–	–	–	–	–	–	–
12	GND	–	–	–	–	–	–	–	–
13	Low Oil Pressure Switch	✔	✔	✔	✔	✔	✔	✔	✔
14	NC								
15	3rd Gear	–	–	✔	✔	–	–	✔	✔
16	Forward	✔	✔	✔	✔	–	–	–	–
17	NC								
18	1st Gear	✔	–	–	–	✔	–	–	–
19	NC								
20	Neutral	–	–	–	–	–	–	–	–
21	NC								
22	NC								
23	+12V	✔	✔	✔	✔	✔	✔	✔	✔
24	+12V	✔	✔	✔	✔	✔	✔	✔	✔
25	GRN Pison	Factory Use Only							
26	RX Pison	Factory Use Only							
27	TX Pison	Factory Use Only							
28	CTS Pison	Factory Use Only							
29	NC								
30	NC								
31	NC								
32	NC								
33	NC								
34	NC								
35	NC								
36	NC								

1. ECU operation - The application of the parking brake de-energizes all solenoids except when in 4th gear (to enable stall testing.

2. ECU Operation - Pressing the kickdown button places the transmission in the next lowest gear, i.e., 4th gear goes to 3rd, 3rd goes to 2nd, 2nd goes to 1st. This lasts until the timer runs out or another gear or direction is selected.

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Checking for (+ V) Supply to Solenoids

1. Chock all four tires, or lower all outriggers.
2. Disable the machine neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash Figure 7-12.
3. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
4. Select the desired gear on the shift control lever.
5. Identify the two solenoids which give the required gear Figure 7-11.
6. Remove the electrical connector on the solenoids relating to gear selection.
7. Test across the connector terminals with a test lamp or voltmeter.

   When using a voltmeter for the above check, the following results can be seen.

   - Energized solenoid (ON) = full battery charge.
   - De-energized solenoid (OFF) = reduced voltage (Typically 5 - 9 V).

This reduced voltage should not be interpreted as a problem. When an electrical load is placed across the terminals this voltage drops to zero.

Checking the Main Frame Harness

NOTE: The following checks should be carried out with the parking brake DISENGAGED.

1. Chock the four tires, or lower all outriggers.
2. Disable the crane neutral start protection to prevent the engine from starting. This can be accomplished by removing the neutral start relay located beneath the dash Figure 7-12.
3. Disconnect the main frame wire harness from the ECU. The main frame wire harness connector is the larger of the two ECU connectors.
4. Check the condition of the connector and socket for signs of water entry. Check the condition of the rubber seal in the instrument panel wire harness connector.
5. Turn the ignition switch to the ON position. Do not set the parking brake as this dumps the transmission to a neutral state.
6. Test the voltages on the pins in the harness connector **(DO NOT check the ECU pins)** using a test lamp or voltmeter. Refer to Table 7-2 for pin identification.
7. If the lamp illuminates, or the voltmeter shows full battery charge, where indicated in the table, then the integrity of the harness and power supply to the ECU is verified.

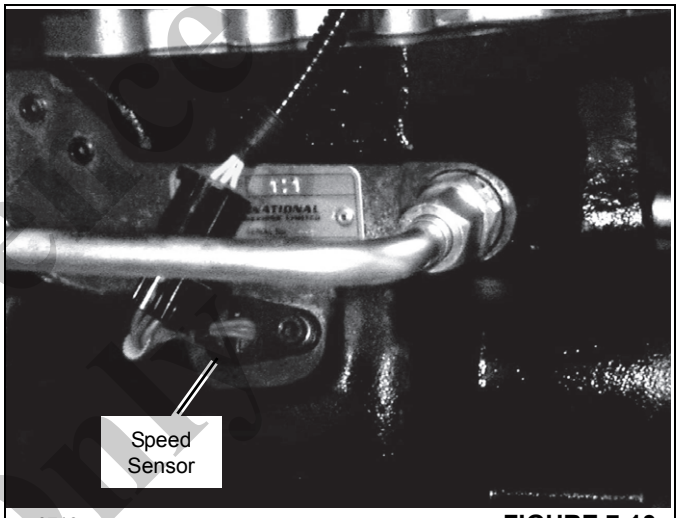
Checking Parking Brake Switch

The correct operation of the parking brake can be checked using either of the following tests:

1. Check continuity between **pin 8** and ground (**pin 11** or **12**) when parking brake is applied.
2. Connect a test lamp between **pin 23** or **24** and **pin 8**. The lamp will illuminate when the parking brake is applied.

Checking Sensor Operation

The speed sensor Figure 7-13 detects the speed of rotation of the output shaft for the transfer gear and sends this information to the ECU.



p0716 **FIGURE 7-13**

The ECU requires a speed signal to determine the operating speed of the crane. Some gear selections will not be permitted if the speed signal is too high (i.e. downshifts).

NOTE: The ECU is designed to inhibit 4th gear selection if the speed sensor fails to send a signal.

A test lamp should be used to check operation of the speed sensor, as follows:

1. Park the crane on a firm, level ground. Engage the parking brake and set the forward/reverse lever to the neutral position.
2. Turn off the engine and remove the ignition key.
3. Disconnect the speed sensor from the wire harness.
4. Remove the speed sensor from the transmission. Place a suitable container underneath to catch the oil.
5. Check that the sensor is working by connecting a volt/ohm meter to the pins in the speed sensor connector and checking the voltage reading. Connect

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the positive (+) meter lead to the pin for the RED wire and the negative (-) meter lead to the pin for the BLUE wire. Move a piece of metal in front of the sensor. When the metal passes the front of the sensor, the meter should be registering 12 VDC. If it does not register 12 VDC, replace the speed sensor.

6. While the sensor is removed, check the sensor for damage.
7. If the sensor is working properly, the problem is most likely in the harness itself. Repair or replace the harness.

Speed Sensor Depth

The speed sensor depth is not adjustable and is set at time of manufacturing during case machining.

Tips On Common Problems

ECU Mounting

If the ECU mounting capscrews are overtightened the ECU and internal components can be damaged. Hand tighten the capscrews only.

Speed Sensors

Generally speed sensors do not fail. Most problems seen are caused by physical damage due to transit, installation or faulty wiring.

Occasionally sensors are out of tolerance or installed incorrectly.

Harnesses

By far the most troublesome cause of ECU inoperability are the wire harnesses. The integrity of the electrical connectors and components is paramount to problem free operation.

It has been noticed that water entry into the shift control assembly can occur if the control is damaged (replace the control). This is particularly important on open cab cranes. It is possible that the water can short internal switches providing false signals to the ECU. If water is trapped in the control it can corrode internal switch contacts making them stick on or off.

Moisture or contamination trapped in connectors is a probable cause of many faults.

However effective an electrical connector, it can not be expected to sustain direct steam cleaning using high pressure hoses. It is recommended that operators should make themselves aware of connectors which are vulnerable to a direct jet from a steam cleaner and avoid continued contact.

Poor ground of electrical components can cause problems. Check that the grounding to the ECU, shift control and other switches is sound.

No 4th Gear

There are two main causes for this problem:

- The speed sensor is inoperable (Check speed sensor and installation).
- Shift control switch contact or wiring problems.

Erratic/Sticking Gears

It is possible that a mechanical issue is the cause of this problem. A known problem is if the transmission has at some point suffered coolant failure and water has entered the transmission. If the original plastic clutch pistons are still being used then there is a risk that they will stick.

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TESTING

Solenoid Identification

When testing individual clutch pressures page 7-19, it is necessary to isolate the clutch being tested. For instance, to check the layshaft clutch, you could select 1st gear forward. This would energize the layshaft and forward low clutches. Because we only want to check the layshaft clutch pressure and not the forward low clutch pressure, remove the electrical connector to the forward low clutch BEFORE selecting 1st gear.

Use the tables below to determine which solenoid electrical connectors should be removed when pressure-testing individual clutches. Table 7-3 identifies the solenoid connectors and Table 7-4 and Figure 7-14 identifies which clutches are engaged when the various gears are selected.

NOTE: Travel directions as described are the actual travel directions of the crane.

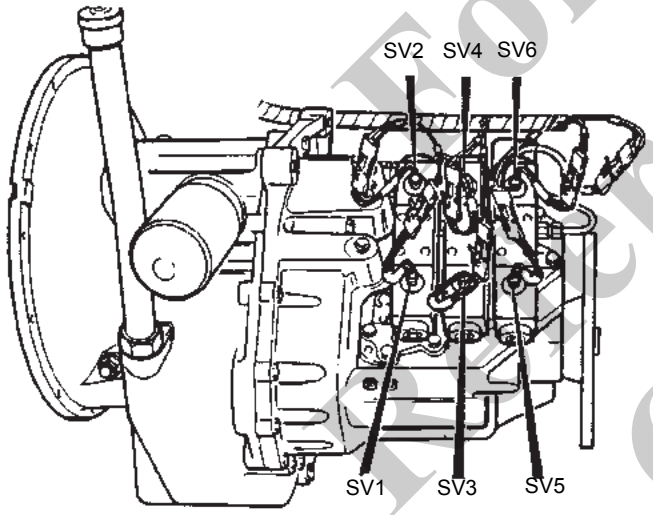


FIGURE 7-14

Table 7-3: Solenoid Descriptions

Item	Solenoid Description
SV1	Reverse Low
SV2	Reverse High
SV3	Layshaft
SV4	Mainshaft
SV5	Forward High
SV6	Forward Low

Table 7-4: Solenoid Valve Energizing Sequence

Gear	Direction	Clutches Engaged Solenoids
First	Forward	Forward Low & Layshaft SV6 and SV3
Second	Forward	Forward High & Layshaft SV5 and SV3
Third	Forward	Forward Low & Mainshaft SV6 and SV4 (SV4 only used on six solenoid transmissions)
Fourth	Forward	Forward High & Mainshaft SV5 and SV4 (SV4 only used on six solenoid transmissions)
First	Reverse	Reverse Low & Layshaft SV3 and SV1
Second	Reverse	Reverse High & Layshaft SV3 and SV2
Third	Reverse	Reverse Low & Mainshaft SV4 and SV1
Fourth	Reverse	Reverse High & Mainshaft SV4 and SV2

Test for Clutch Leakage

WARNING

DO NOT go under the crane with the engine running. Turn off the engine, apply the parking brake, chock the wheels and remove the ignition key before going underneath the crane.

Isolating A Suspect Clutch

Stop the engine, connect a 0-20 bar (0-300 psi) pressure gauge to the test connector A Figure 7-15 (mainline pressure test point).

Make sure that both sides of all four wheels are chocked. Apply the foot brake and the parking brake.

Start the engine and run at 1000 rpm. Engage 1st gear forward. Record the pressure reading. Repeat the test for all rear ratios in forward drive and record the pressure readings as shown below.

For Reference Only

Example Only:

Gear Selected	Ratio Clutch	Mainshaft or Layshaft Clutch	PSI	Bar
First	Forward Low	Layshaft	140	9.62
Second	Forward High	Layshaft	125	8.62
Third	Forward Low	Mainshaft	140	9.65
Fourth	Forward High	Mainshaft	125	8.62

Readings should not vary between clutches by more than 0.7 bar (10 psi). In the example shown, we can see that pressure is low when 2nd and 4th gear forward is selected, indicating clutch leakage.

From the example you can see that the forward clutch high is used for selection of both 2nd and 4th gear forward. We know from the table that the mainshaft and layshaft clutches are working normally (1st and 3rd gear selection shown normal operating pressures). So it can be assumed that the forward high clutch is leaking.

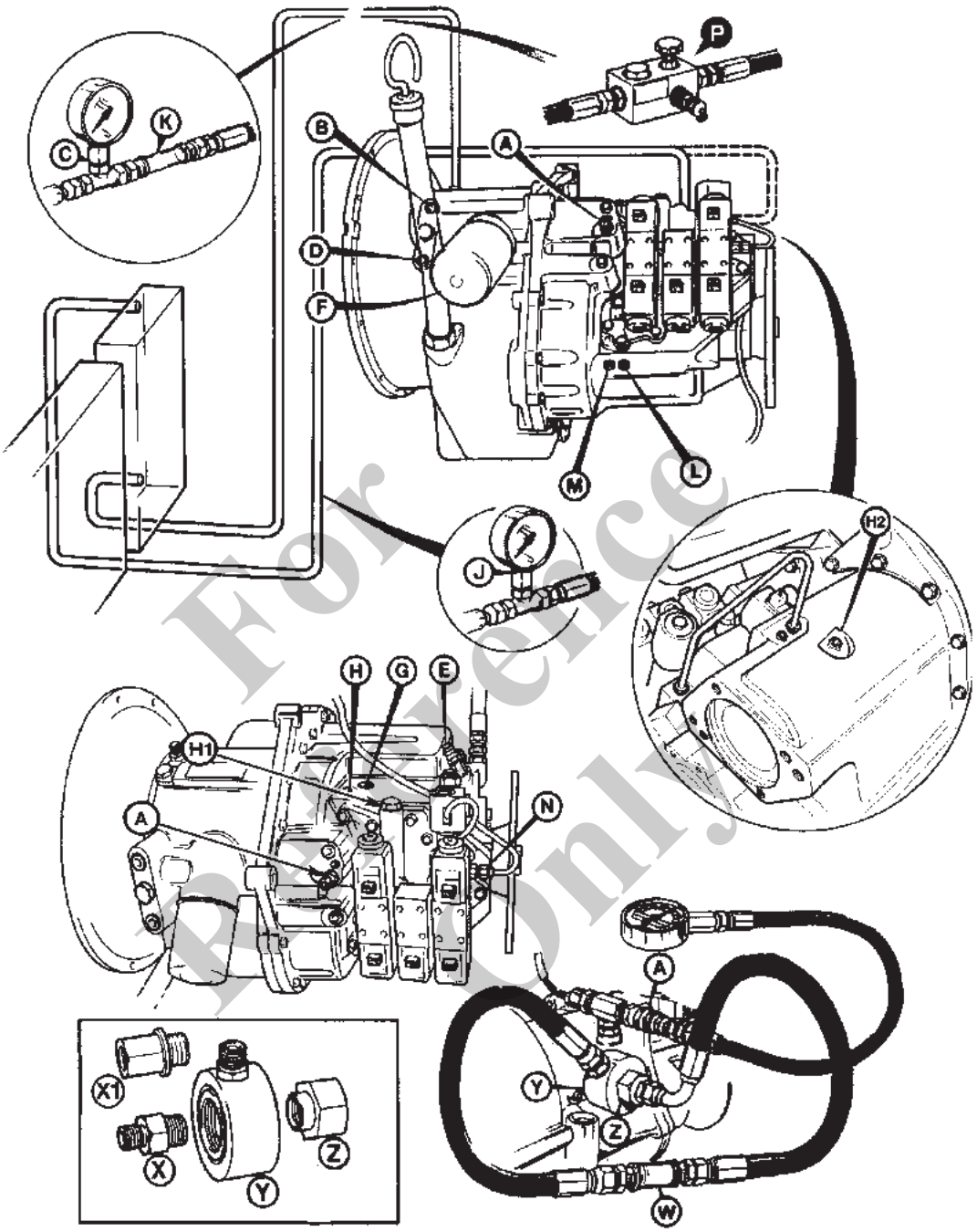
We can now confirm the forward reverse clutch is leaking by completing an “Individual Clutch Leakage Test.”

NOTE: Repeat the above procedure using reverse ratios if necessary.

Individual Clutch Leakage Test

In the following procedures the forward high clutch is tested, therefore, in Step 2 a pressure gauge is connected to the forward high clutch test point.

For Reference Only



TEST POINTS

A - Mainline Pressure
B - Converter inlet/converter relief valve pressure
C - Converter outlet pressure
D - Mainshaft clutch pressure
E - Layshaft clutch pressure
F - Pump flow (remove filter and fit adapters)
G - Reverse high ratio clutch pressure
H - Reverse low ratio clutch pressure
J - Lubrication Pressure
K - Cooler flow (flowmeter in line from cooler to transmission)
L - Forward high ratio clutch pressure
M - Forward low ratio clutch pressure
N - 5- wheel drive clutch pressure
P - Load valve

a2279

FIGURE 7-15

For Reference Only

When testing other suspect clutches, connect a gauge to the relevant suspect clutch pressure test point. See Figure 7-15 for position of individual clutch pressure test points. Because the forward high clutch is suspect, a gear must be selected that will use the forward high clutch, in this instance 2nd gear forward.

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to test connector **A**, Figure 7-15 (mainline pressure test point).
2. Connect a 0-20 bar (0-300 psi) pressure gauge to test connector **L** (forward high ratio clutch test point).

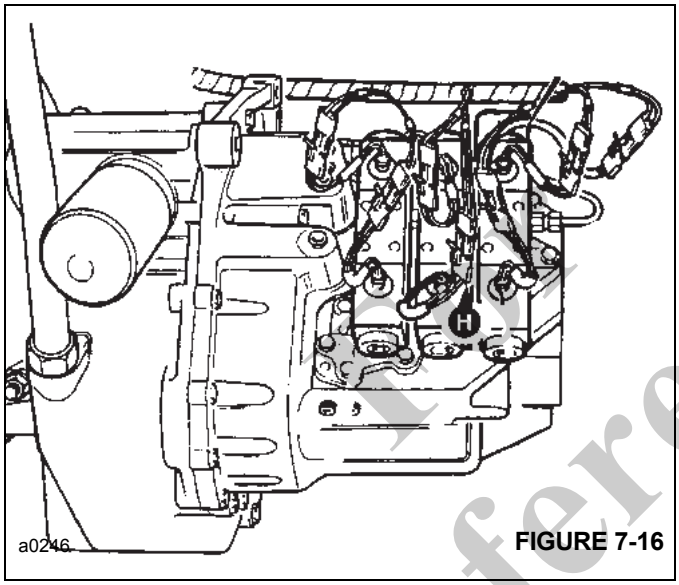


FIGURE 7-16

3. Remove the layshaft clutch solenoid feed connector **H**, Figure 7-16. This ensures only the forward high clutch is energized when 2nd gear forward is selected.

NOTE: See Figure 7-15 for identification and position of solenoid feed connectors when testing other suspect clutches.

4. Make sure that both sides of all four wheels are chocked. Apply foot brake and parking brake.
5. Start the engine and run at 1000 rpm, select 2nd gear forward. Note the pressure readings on both gauges, which should not vary more than 0.7 bar (10 psi). If the difference on the gauges is greater than 0.7 bar (10 psi) do the following:
   - **a.** Stop the engine and interchange the gauges.
   - **b.** Start the engine and run at 1000 rpm. Select 2nd gear forward. If the difference on the gauges is still greater than 0.7 bar (10 psi), service the forward high clutch.
   - **c.** If after interchanging the gauges, the readings are different than in step 4, have the gauges calibrated and repeat the test procedure.

Converter Stall Test

NOTE: Engine speed must be recorded during this test. This machine is not equipped with a tachometer. One must be installed to perform this test.

CAUTION

DO NOT stall the converter longer than 10 seconds or the transmission fluid will overheat. Make sure that the oil level is correct and at normal operating temperature.

Before completing the following test, remove the transmission dipstick. If there is any sign of smoke emitting from the dipstick tube, **STOP THE TEST IMMEDIATELY** and service the transmission.

1. Ensure that the engine and transmission are at normal working temperatures. Run the engine at maximum speed and check the **No Load Speed (High Idle Specs)**. See Engine Technical Data in the engine operator's manual.
2. Apply the parking brake and the foot brake firmly. If necessary, set the machine against a fixed obstruction.
3. Select 2nd gear forward and run engine at maximum RPM. Record the engine speed from the tachometer. Repeat the test for 3rd gear forward and record the speed reading.
4. Repeat step 3, except this time select 2nd gear reverse and 3rd gear reverse respectively. Record the speed readings.

NOTE: Using 2nd and 3rd gears in forward and reverse will ensure that all clutches are energized during the test.

5. All recorded readings should be as specified in Torque Converter Stall in technical data.

If the engine speed is below the stated figures, either the engine is loosing power and should be serviced/overhauled or the torque converter reaction member clutch is slipping.

To check the engine, select Neutral, open the throttle fully, and raise the booms fully to bring the main relief over relief. The engine speed should fall slightly above the Maximum Governed Speed. If engine speed is correct, the torque converter reaction member is slipping.

If engine speed is higher than the Maximum Governed Speed, check the transmission for clutch slippage or internal leakage. To isolate a suspected clutch, tabulate the recorded readings as shown in the example below.

Reference Only

Gear Selected	Direction Clutch	Mainshaft or Layshaft Clutch	RPM
Second	Forward High	Layshaft	2060
Third	Forward Low	Mainshaft	1990
Second	Reverse High	Layshaft	1985
Third	Reverse Low	Mainshaft	1980

In the example shown, the engine speed is abnormally high when 2nd gear forward is selected, indicating a slipping clutch.

From the example, it is evident that the layshaft clutch is working normally (2nd gear reverse indicates 1985 rpm). Therefore, it follows that the suspect clutch is the forward high. Assuming all other possible faults have been eliminated (see Troubleshooting), this clutch should be serviced.

Pressure and Flow Tests

WARNING

Fine jets of hydraulic oil at high pressure can penetrate the skin. Do not use your hand to check for hydraulic leaks. Do not put your face close to suspected leaks. Hold a piece of cardboard close to suspected leaks and inspect the cardboard for signs of hydraulic oil. If hydraulic oil penetrates your skin, get medical help immediately.

If the machine to be raised has a 4WD transmission installed, make sure all four wheels are off the ground. If only the front or rear tires are raised, the crane could still drive through the wheels on the ground.

Take care when disconnecting hydraulic hoses and fittings. The oil will be hot and could cause burns.

DO NOT go under the crane with the engine running. Turn the engine off, apply the parking brake and remove the ignition key before going underneath the crane.

Before completing any transmission pressure/flow tests, make sure that the oil level is correct and is at normal operating temperature.

Pump Flow

NOTE: Special adapters are required to perform the following test. Contact Manitowoc Crane Care.

Stop the engine. Remove the filter adapter from the transmission. Install a special test adapter **X** or **X1** (depending on the filter head adapter) onto the threaded spigot Figure 7-15. Install special test adapter **Y** and secure with adapter **Z**. Connect flowmeter **W**.

Start the engine and run at 1000 rpm. With the transmission in neutral, the flowmeter will show the pump flow. Compare this reading with the pump flow specification on page 7-2. A low reading indicates a worn pump or blocked suction strainer.

Repeat the test and note the gauge reading with the engine running at 2000 rpm.

Stop the engine and remove all test adapters. Install the filter or the adapter.

Mainline Pressure

Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to the test connector **A** Figure 7-15.

Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show the mainline pressure. Compare this pressure reading with the one listed on page 7-2. Either a faulty pressure maintenance valve or a worn pump can cause a low reading. A high reading may indicate a faulty pressure maintenance valve.

Repeat the test and note gauge reading with engine running at 2000 rpm.

Stop the engine and remove the test gauge.

Converter Out Pressure/Oil Cooler Flow Rate

Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge and flowmeter into the converter out line as shown at **C** and **K** respectively Figure 7-15.

Run the engine at 1000 rpm with the transmission in neutral. The pressure gauge indicates the converter out pressure and the flowmeter indicates the oil cooler flow rate. Compare both readings with the specifications on page 7-2. A blocked oil cooler could cause a high pressure together with a low flow.

Repeat step 2 and note the gauge reading with engine running at 2000 rpm.

Stop the engine, remove the test gauge and flowmeter and install hoses to original position.

Converter In Pressure

1. Stop the engine and connect a 0-20 bar (0-300 psi) pressure gauge to test point **B** Figure 7-15.
2. Start the engine and run at 1000 rpm. With the transmission in neutral the pressure gauge will show “Converter In Pressure”. Compare the gauge reading with the figures listed in the General Technical Data on

For Reference Only

page 7-1. A high or low reading could indicate a faulty converter relief valve.

3. Remove the pressure test gauge.

Converter Relief (Safety) Valve Pressure

1. Connect a 0-20 bar (0-300 psi) pressure gauge to test point **B** Figure 7-15.
2. Install a load valve **P** into the converter out line.

NOTE: Make sure the load valve is in the OPEN position (the adjusting knob screwed fully out) before starting the following pressure test. If the load valve is not fully open, damage to the converter seals will occur.

CAUTION

DO NOT allow the pressure to exceed 10.34 bar (150 psi) or damage to the converter seals will occur.

3. Start the engine and run at 1000 rpm. With the transmission in neutral, slowly screw down the load valve **P** while observing the gauge reading which should rise to the converter relief valve setting specified on page 7-1.
4. If the reading is higher than specified the converter relief valve is faulty. A low reading indicates a leaking pump seal or faulty converter relief valve.
5. Stop the engine and remove the test gauges and install hoses to original position.

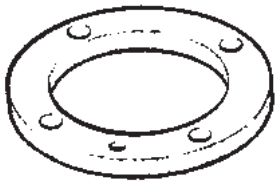
Lubricating Pressure

1. Stop the engine and connect a suitable pressure gauge into the return line from the oil cooler to the transmission as shown in **J** Figure 7-15.
2. Start the engine and run at 1000 rpm. With the transmission in neutral, the pressure gauge will indicate the lubricating pressure. Compare the pressure reading with the specification on page 7-1.
3. Repeat step 2 and note the pressure with the engine running at 2000 rpm.
4. Stop the engine and remove the pressure gauge.

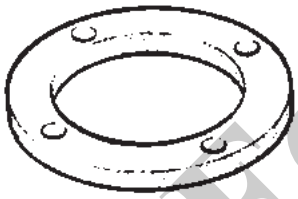
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TRANSMISSION REPAIR

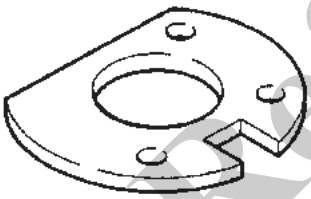
Special Service Tools



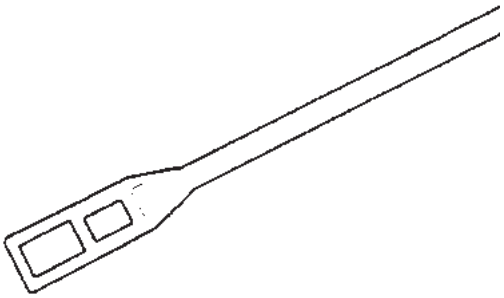
a0254 End Float Setting Tool **FIGURE 7-17**



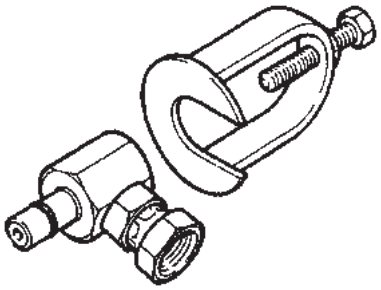
a0249 Reverse Clutch End Float Setting Tool **FIGURE 7-18**



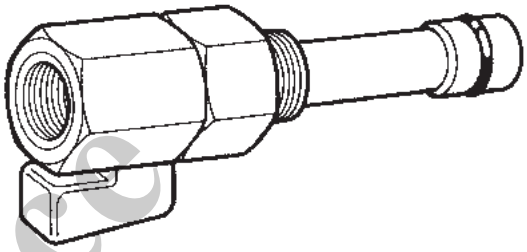
a1397 End Float Setting Tool **FIGURE 7-19**



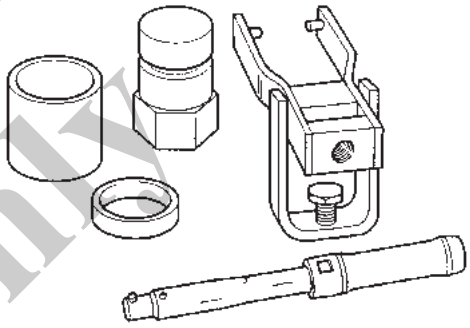
a0180 Drive Coupling Spanner for Yoke Couplings **FIGURE 7-20**



a1518 4WD Pressure Test Kit **FIGURE 7-21**



a1411 Mainshaft Air Line Adapter **FIGURE 7-22**



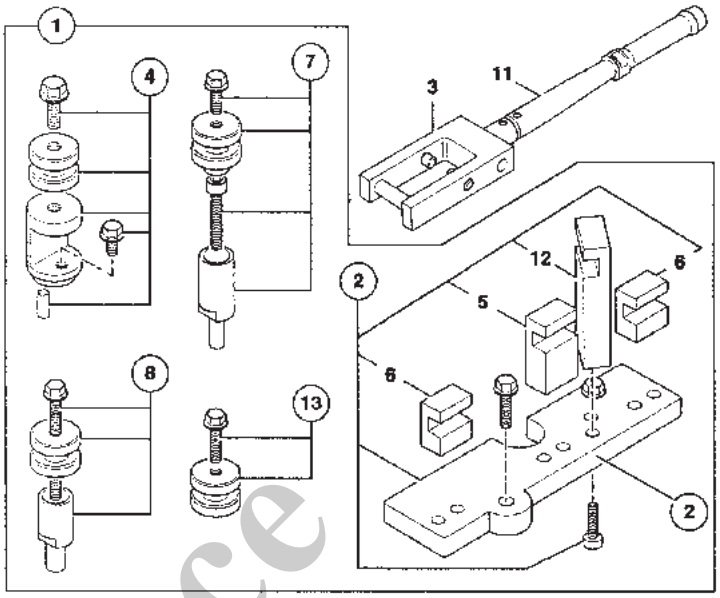
Seal
Stake Nut
Setting Tool Kit
Torque Wrench
Spacer Kit (Includes spacers listed below:

Spacer - 12,75 mm	Spacer - 13,40 mm
Spacer - 13,80mm	Spacer - 13,45 mm
Spacer - 13,85 mm	Spacer - 13,50 mm
Spacer - 13,90 mm	Spacer - 13,55 mm
Spacer - 13,95 mm	Spacer - 13,60 mm
Spacer - 13,00 mm	Spacer - 13,65 mm
Spacer - 13,05 mm	Spacer - 13,70 mm
Spacer - 13,10 mm	Spacer - 13,75 mm
Spacer - 13,15 mm	Spacer - 13,80 mm
Spacer - 13,20 mm	Spacer - 13,85 mm
Spacer - 13,25 mm	Spacer - 13,90 mm
Spacer - 13,30 mm	Spacer - 13,95 mm
Spacer - 13,35 mm	Spacer - 14,00 mm

a1386 Setting Tool Kit **FIGURE 7-23**

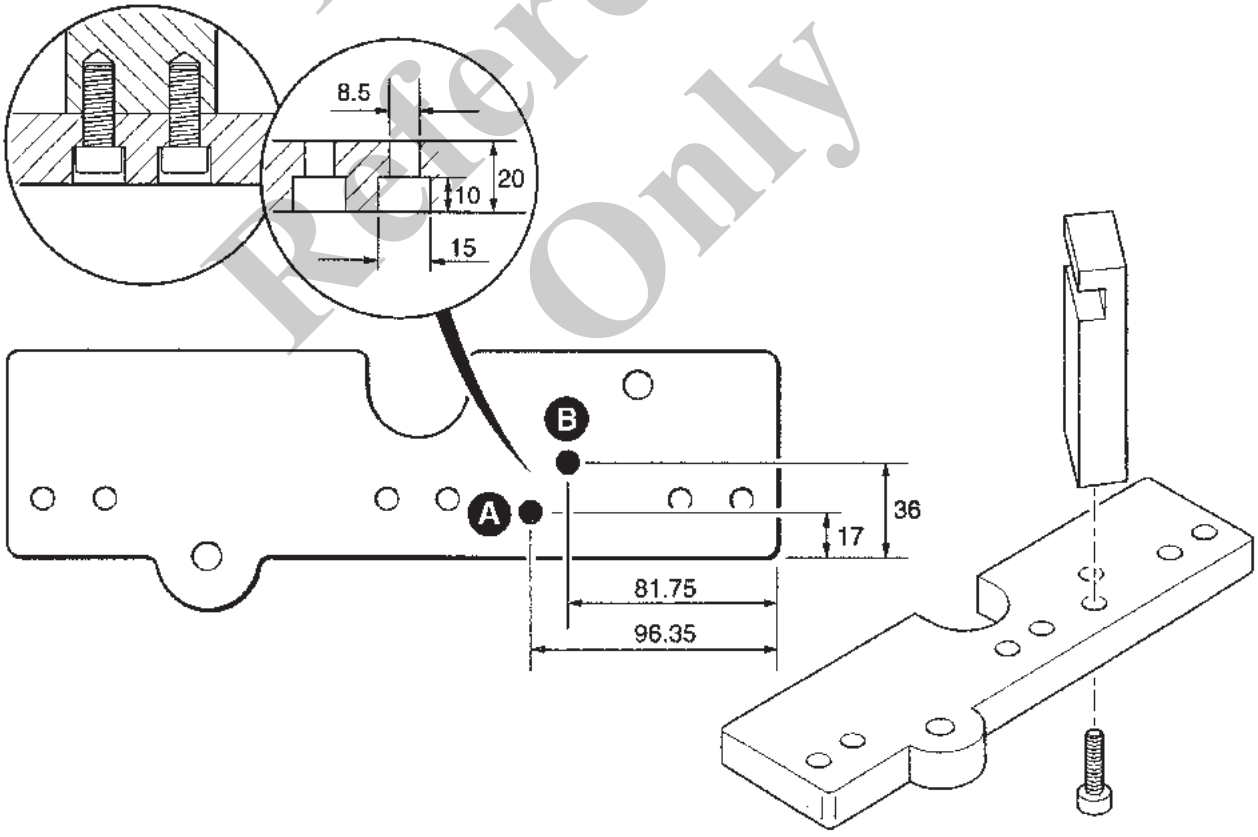
For Reference Only

1. End Play Checking Kit (Includes Items 2 - 13)
2. Base Plate and Bolts
3. Yoke
4. Mainshaft Adapter
5. Pillar (20,75 mm)
6. Pillar (45,75 mm)
7. Setting Body (54 mm)
8. Setting Body (64 mm)
9. Setting Tool (12 mm)
10. Setting Tool (10 mm)
11. Setting Wrench - 0 - 74 lb-ft. (0-100 Nm)
12* Pillar, Input Shaft
13* Setting Body



Torque Converter Removal/Installation a1398

* If these items are not in your kit, they may be ordered separately, but base plate **2** will have to be drilled to secure item **12**, see **A** and **B**. Dimensions in mm.

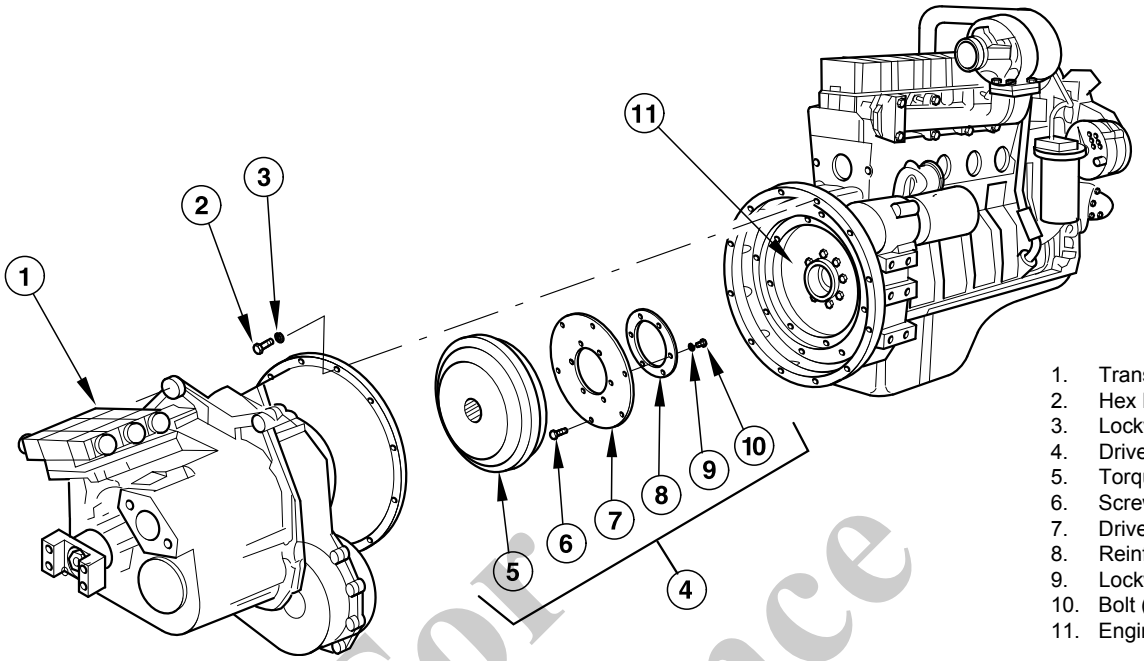


End Play Checking Kit a1399

FIGURE 7-24

For Reference Only

7



1. Transmission
2. Hex Bolt (12)
3. Lockwasher (12)
4. Drive Plate Kit
5. Torque Converter
6. Screw (6)
7. Drive Plate
8. Reinforcement
9. Lockwasher
10. Bolt (6)
11. Engine

a0257

FIGURE 7-25

Servicing the Torque Converter

Removal

1. Remove complete power unit. See Section 6.

2. Fasten engine to an engine stand.

3. Use a hoist and chains to support the weight of the transmission, which must be removed to gain access to the torque converter.

CAUTION

The transmission is very heavy and could cause personal injury if not supported properly when it is removed.

4. Remove the 12 bolts **2** Figure 7-25 and lockwashers **3** that fasten the transmission/torque converter housing **1** to the engine flywheel housing **11**. Remove the transmission and torque converter assembly **4** and place in a clean, work area where the torque converter can be removed. It is recommended that the transmission be mounted in the service fixture.

5. The torque converter assembly **4** is fastened to the engine flywheel **11** through a drive plate **7**. Remove the six drive plate mounting screws **6** to remove the torque converter and drive plate.

6. Remove the six bolts **10** and lockwashers **9** securing torque converter **5** to drive plate **7** and remove the drive plate and its reinforcement **8**.

7. Replace the complete torque converter. The parts are not serviced separately. Replace drive plate if there is distortion or damage.

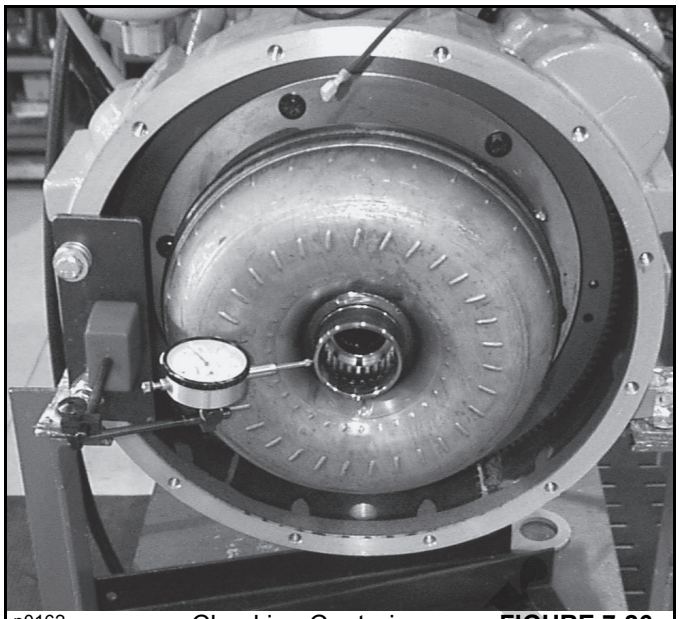
NOTE: It is recommended that the torque converter be replaced any time system contamination occurs. It is not possible to completely clean the torque converter by flushing to remove the contamination. Replacement of the complete assembly is necessary to prevent early failure of other components in the system.

Installation

1. Assemble the drive plate **7** Figure 7-25 and reinforcing plate **8** to the torque converter **5** using bolts **10** and lockwashers **9**. Apply Loctite® 243 to threads of bolts **10** and tighten to a torque of 40 Nm (30 lb-ft).

2. Clean the pilot bore of the engine flywheel.

For Reference Only



p0162 Checking Centering **FIGURE 7-26**

3. Install the torque converter and drive plate assembly **4** to the engine flywheel using six bolts **6**. Check the alignment of the torque converter to the flywheel using a dial indicator held in position against the converter hub Figure 7-26. The torque converter must be centered on the flywheel within 0.15 mm (0.006 in).

NOTE: If the alignment should exceed 0.15 mm (0.006 in), remove the torque converter and check the spline shaft for burrs, remove the drive shaft and rotate it 180° on the torque converter and repeat step 3.

4. Apply Loctite® 243 to drive plate mounting bolts **6** and tighten to a torque of 19 Nm (14 lb-ft).

5. Clean and lubricate the splines of the transmission input shaft.

6. Align the transmission input shaft splines with the splines of the torque converter impeller and assemble the transmission/torque converter housing to engine flywheel housing. Install the 12 bolts and lockwashers and tighten to proper torque of 39 Nm (28 lb-ft).

7. Install the power unit into the crane.

8. Connect all removed hydraulic lines, electrical harnesses, cables, etc. Fill the transmission with recommended transmission fluid. Refer to Section 5, Preventive Maintenance.

For Reference Only

For Reference Only

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SECTION 8
AXLES/DRIVE SHAFTS/WHEELS AND TIRES

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Rear Axle 8-1
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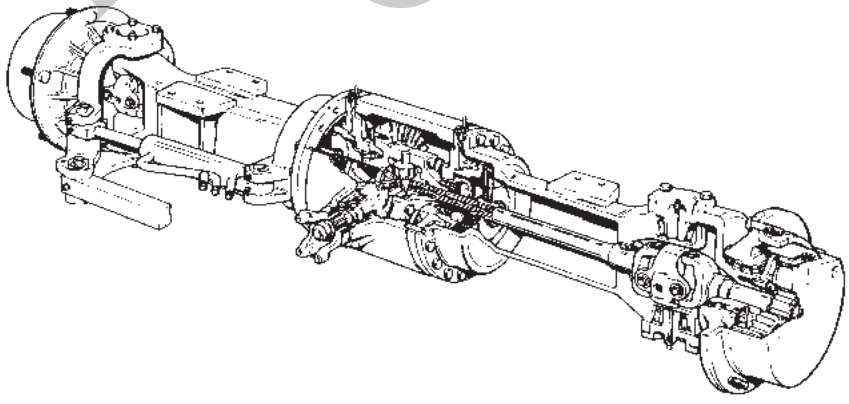
DESCRIPTION

Front Axle

The front axle Figure 8-1 is a rigid-mounted drive axle, attached to the frame of the crane by eight bolts, washers and nuts. The axle includes a 3 piece spiral bevel input, two reduction drive hubs and inboard brakes.

Rear Axle

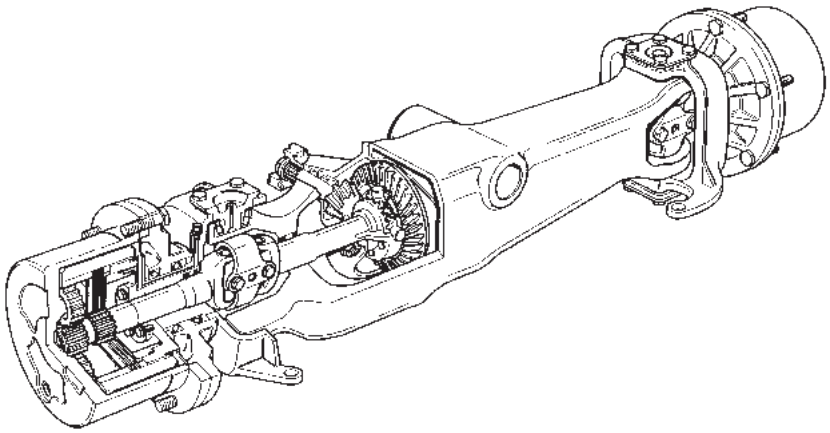
The crane may be equipped with either a rear drive axle or rear non-drive axle. Figure 8-2 shows only the drive axle. The axle is pin mounted to the frame of the crane, allowing it to pivot in both directions. The axle will pivot 1-1/2° in both directions. The drive axle includes spiral bevel input, two reduction drive hubs and brakes in the drive hubs. The non-drive axle does not have a 3 piece spiral input.



a0165

Front Drive Axle

FIGURE 8-1



a0166 Rear Drive Axle **FIGURE 8-2**

TECHNICAL DATA

Front Drive Axle

Type	3 piece spiral bevel input with epicyclic hub reduction and inboard braking
Installation	Rigid pad mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	420 kg (926 lb) approximate
Half (Axle) shaft braking/type	5 plate (each half shaft). Standard retraction type.
Input type	1480 half yoke
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1
Overall ratio	15.78:1
Crownwheel and pinion ratio	2.538:1
Number of teeth:	
Crownwheel	33
Pinion	13

Rear Drive Axle

Type	Spiral bevel input with epicyclic hub reduction
Installation	Pin mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	450 kg (992 lb) approximate
Hub brakes	3 plate (each hub) standard retraction type.

For Reference Only

Input type	1480 half yoke
Oscillation (Both Directions)	1-1/2°
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1
Overall ratio	24.975:1
Crownwheel and pinion ratio	4.625:1
Number of teeth:	
Crownwheel	37
Pinion	8

Rear Non-Drive Axle

Type	Spiral bevel input with epicyclic hub reduction
Installation	Pin mount
Number of steering cylinders	2
Weight (dry, with no steering cylinders and without wheels)	424 kg (931 lb) approximate
Hub brakes	3 plate (each hub) standard retraction type.
Input type	1480 half yoke
Oscillation (Both Directions)	1-1/2°
Toe-in	0°
Caster angle	0°
Camber angle	1°
King pin inclination	0°
Hub reduction	5.4:1

For Reference Only

FRONT DRIVE AXLE REPAIR

Removal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Loosen the wheel lug nuts then raise and support the crane on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing the eight bolts, lockwashers and nuts securing the drive shaft to the parking brake disc plate.
3. Disconnect parking brake hydraulic line from the parking brake. Plug and cap hose and fitting.
4. Disconnect and plug the hydraulic hoses to the steering cylinders.
5. Disconnect the brake lines from the front axle.
6. Support the axle on a trolley jack.
7. Loosen and remove the eight mounting bolts and nuts.
8. Remove the axle from the machine.

Installation

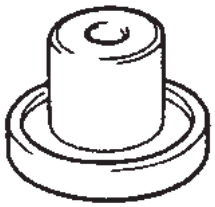
1. Place the axle on a trolley jack.
2. Position the axle and trolley jack under the crane frame.
3. Install the eight bolts and nuts with the nuts on top of the axle. Tighten the bolts to the proper torque, see *Fasteners and Torque Values on page 1-15*.
4. Connect the brake line or hose to the axle.
5. Connect the hydraulic hoses to the steering cylinder.
6. Connect the hydraulic line to the parking brake.
7. Connect the front drive shaft to the parking brake disc plate using eight bolts, lockwashers and nuts.
8. Bleed the air from both service and parking brake system. See Section 9.
9. Bleed the air from the steering circuit. See Section 10.
10. Install the wheels to the axle. Lower the crane. Torque the lug nuts to 680 Nm (500 lb-ft).

Special Tools

To completely disassemble and assemble the front drive axle, special service tools are required. Unless you have these or similar tools DO NOT service the axle.

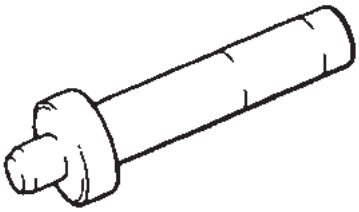
The tools illustrated on the next page are available from your Grove distributor.

For Reference Only



a0167

Driver - Crownwheel Bearing and Differential Bearing Cones



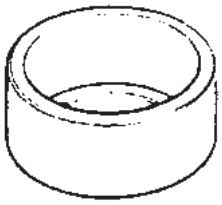
a0174

Bearing Pad Driver



a0168

Adapter - Steer/Drive Axle Pinion Bearing Cone



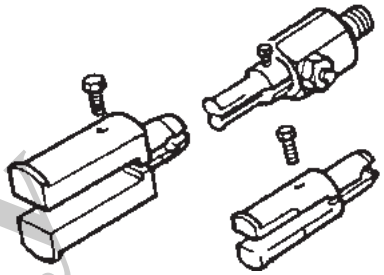
a0171

Measuring Cup - Pinion Head Bearing



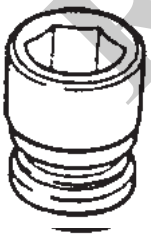
a0169

Spacer - Pinion Bearing Pre-load



a0172

Adapter - Impulse Extractor
Small - 17 to 25 mm
Medium - 25 to 45 mm
Large 45 to 80 mm



0173

17 mm A/F x 3/4 in. square drive



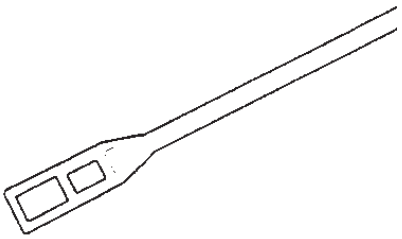
a0175

Driver - Pinion Head Bearing Cup



a0179

Impulse Extractor Set for Hub Bearing Seals



a0180

Drive Coupling Spanner for Axle York Couplings

FIGURE 8-3

For Reference Only

8

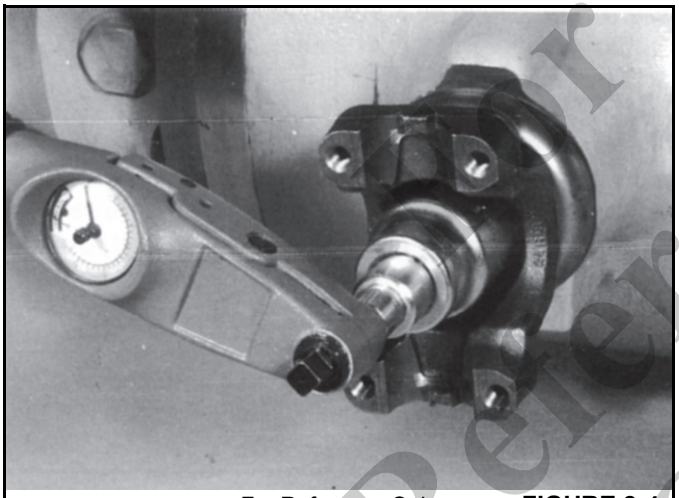
Replacing the Pinion Oil Seal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

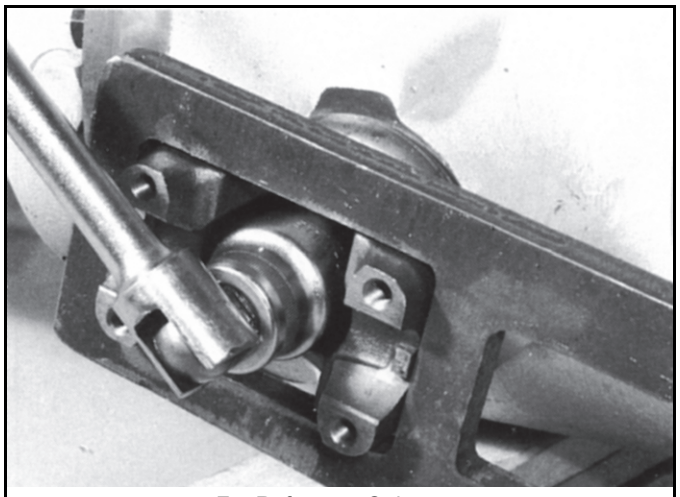
1. Remove the wheel and tires and disconnect the axle drive shaft. Measure the axle rolling torque and record the reading Figure 8-4.



p0078 For Reference Only **FIGURE 8-4**

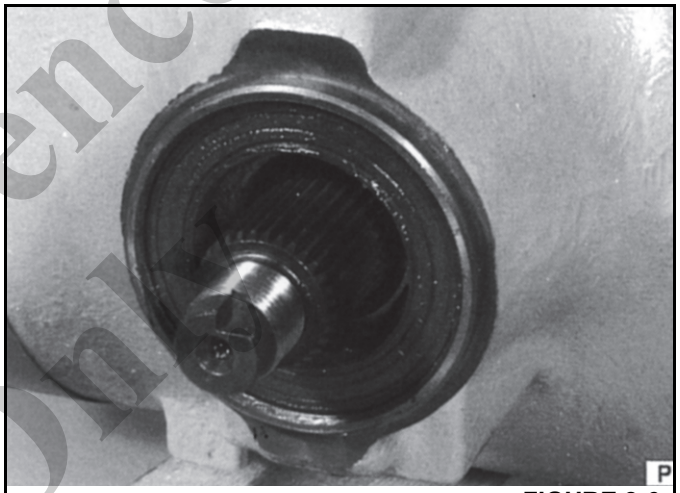
2. Mark the position of the coupling yoke on the splined shaft. Using the drive coupling spanner, remove the coupling yoke Figure 8-5 together with its stake nut and washer.

NOTE: On later axles, the stake nut and washer are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.



p0079 For Reference Only **FIGURE 8-5**

3. Remove the seal Figure 8-6 and install a new one. Pack the lips of the new seal with grease before installing.



p0080 **FIGURE 8-6**

NOTE: Take care not to damage the housing when removing the old oil seal.

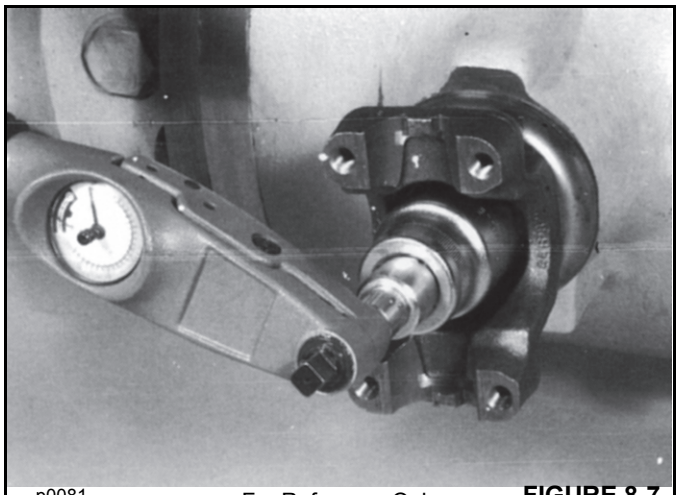
4. Align the locating marks on the yoke and the splined shaft. Install the coupling yoke and a new combined stake nut and washer.

5. Using the drive coupling spanner Figure 8-10, tighten the nut to a torque of 250 Nm (184 lb-ft).

6. Measure the rolling axle torque Figure 8-9. The reading should be the 0.5 to 1 Nm (0.37 to 0.74 lb-ft) more than that recorded in Step 1.

   If necessary, progressively tighten the nut to achieve the correct rolling torque.

For Reference Only



p0081 For Reference Only **FIGURE 8-7**

CAUTION

If the rolling torque value (new pinion seal installed) exceeded the reading in Step 1 by 1 Nm (0.74 lb-ft) or more, then the collapsible spacer mounted on the axle pinion MUST be replaced.

7. Stake the nut using a square ended staking tool.

Axle Hub Repair

Disassembly

NOTE: The axle does not have to be removed to disassemble the axle hub.

1. Drain the oil from the axle hub.

2. Remove screws **24** Figure 8-8.

3. Using a soft-faced mallet, tap the planet gear carrier **18** to “crack” the joint between the carrier and the bearing carrier **8**. Then pry the planet gear carrier from the bearing carrier. Remove and discard O-ring **23**.

4. Remove a planet gear **19** only if it is defective. A planet gear can only be replaced as an assembly, which consists of the pinion, a bearing and two “L” shaped retaining rings. To remove a planet gear, first remove the retaining ring **4**, then pull off the planet gear.

5. The drive shaft thrust pad **17** is drilled and tapped M6 for removal purposes. Remove the drive shaft thrust pad from planet gear carrier.

6. Remove the external retaining ring **22** and sun gear **20**.

7. Remove the Verbus Ripp bolts **16**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of an extension as possible. Discard the Verbus Ripp bolts.

8. Using two metric bolts jack the annulus assembly **12, 13 & 14** off bearing carrier **8**.

NOTE: Be sure annulus ring position is marked for reassembly.

Fretting between the hub swivel and annulus carrier mating surfaces might be evident. This condition is normal, do not attempt to repair.

If the hub swivel and annulus carrier are to be replaced, they must be replaced as a pair not individually.

9. Remove internal retaining ring **14** to separate the annulus ring **12** from the annulus carrier **13**.

10. Pull off bearing carrier **8** together with the outer wheel bearing cone **10** and cup **11**. Remove combination seal **9**. Remove the inner bearing cup **7** from the inboard side of the carrier.

11. Pull off inner wheel bearing **6**.

NOTE: Earlier type axles may have an O-ring and wear ring installed in place of combination seal **9**. These parts should be discarded.

12. On later units, remove and discard combination seal **9**.

13. Disconnect the track rod and steering cylinder from the axle steering knuckles.

NOTE: If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

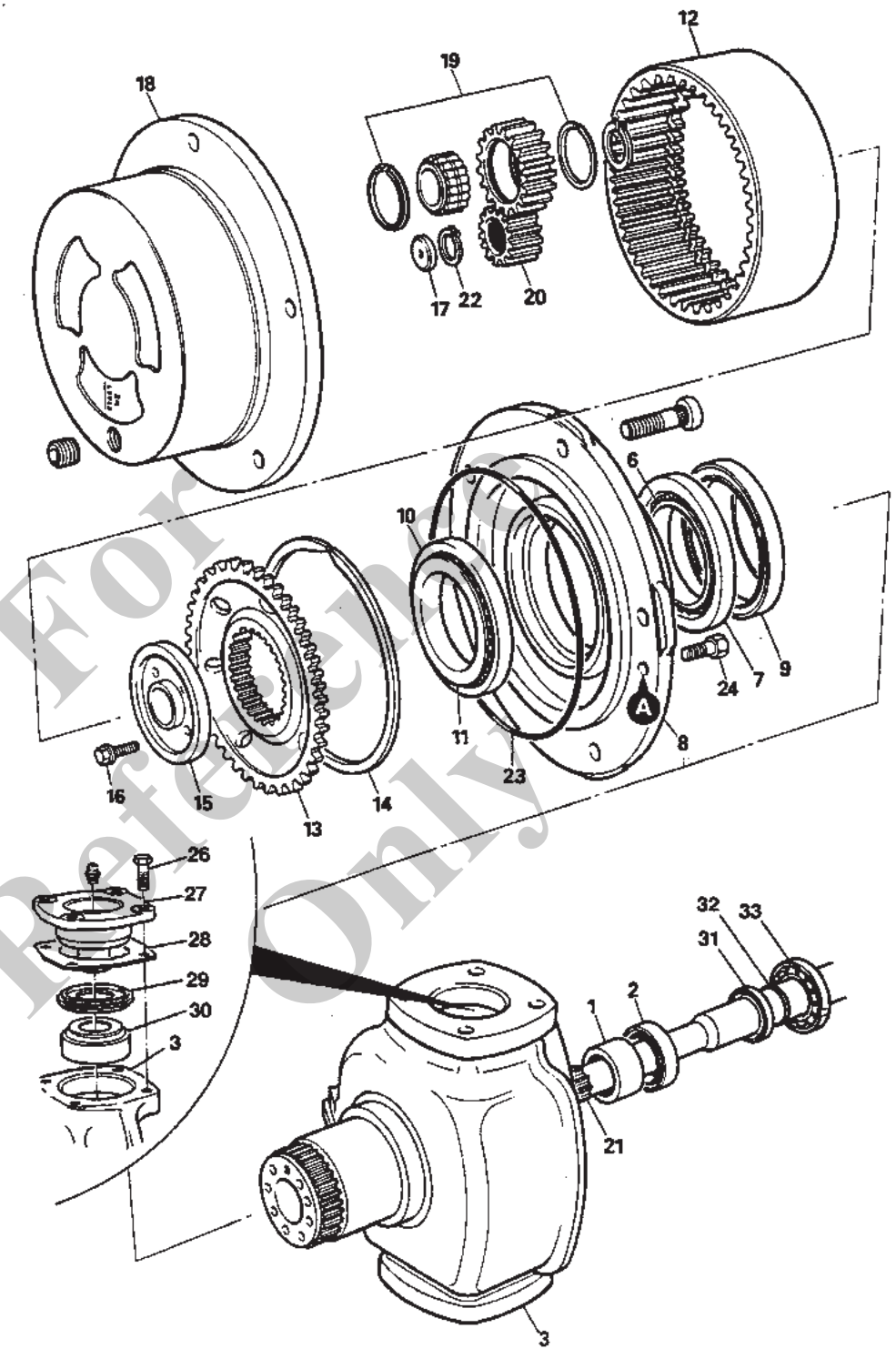
14. Mark the position of the top and bottom trunnions **27**, remove bolts **26** and remove the trunnions. Retain shims **28** with top trunnion. Remove hub swivel **3**.

NOTE: Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

15. Remove top and bottom trunnion seals **29** and bearings **30**.

For Reference Only

1. Bearing
2. Oil Seal
3. Hub Swivel
4. Snap Ring
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Annulus Ring
13. Brake Carrier
14. Retaining Ring
15. Retainer Plate
16. Verbus Ripp Bolts (4)
17. Thrust Pad
18. Planetary Gear Carrier
19. Planet Gear Assembly (3)
20. Sun Gear
21. Drive Shaft
22. Snap Ring (3)
23. O-Ring
24. Capscrew (2)
26. Trunnion Bolts (8)
27. Trunnion (2)
28. Shim
29. Seal (2)
30. Bearing (2)
31. Oil Seal
32. Retaining Ring
33. Bearing



For Reference Only

a0181

FIGURE 8-8

16. Remove drive shaft **21** from the axle casing.

17. Pry out drive shaft inner oil seal **2**.

18. Using a bearing puller, remove bearing **1**.

19. Pry out drive shaft inner seal **31B.**

20. Remove retaining ring **32**.

21. Using a bearing puller, remove bearing **33**.

22. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion not shown), the only difference being that shims **28** are installed to the top trunnion only.

1. Tap the drive shaft inner bearing **33** Figure 8-8 into position in the hub swivel drive shaft bore. Secure with retaining ring **32**.

2. Install a new oil seal **31.** Pack grease between lips of the seal.

3. Install drive shaft **21**, taking care to locate inner end into the splines of the differential gears.

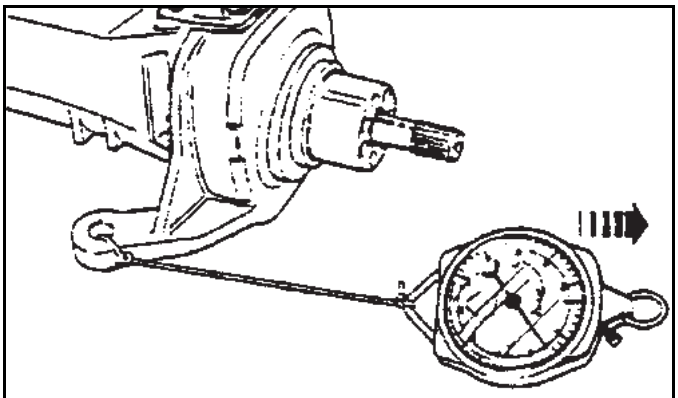
4. Tap drive shaft outer bearing **1** into position in the hub swivel.

5. Install new oil seal **2**. Pack grease between the lips of the seal.

6. Press new top and bottom oil seals **29** into position followed by bearings **30**. Grease bearings and oil seal before installing in axle.

7. Locate hub swivel **3** and install bottom trunnion **27**. Apply Loctite® 243 to the threads of the bottom trunnion bolts **26** and then tighten to a torque of 56 Nm (42 lb-ft). Install top trunnion **27** with normal 0.25 mm (0.10 in) shim **28** and leave top trunnion bolts **26** finger tight).

8. Attach a spring balance Figure 8-9 to track rod swivel and turn the swivel. Tighten the top trunnion bolts **26** to eliminate end float but without bearing pre-load, i.e. no increase in spring balance reading.



a0182 **FIGURE 8-9**

9. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

Gap = 1.55 mm (0.061 inches)

less = 1.00 mm (0.040 inches)

Shim = 0.55 mm (0.021 inches)

NOTE: If the gap measures 1 mm (0.040 inches), then no shim is required.

If after installing the shims, the bearing pre-load is not attainable, install new bearings.

10. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 56 Nm (42 lb-ft).

Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 8.

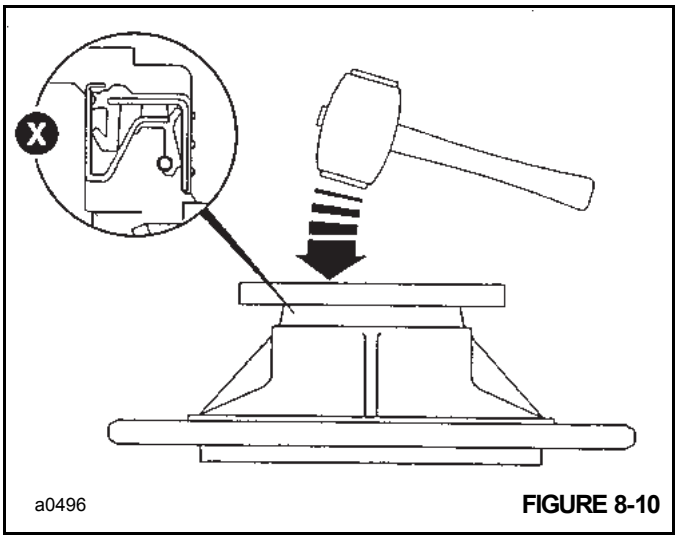
11. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 135 Nm (100 lb-ft), then continue to tighten to next castellation and insert the pin.

12. Lightly oil the inner wheel bearing **6** and its cup **17**. Then install them into bearing carrier **8**.

13. Install a new combination seal **9** into the bearing carrier **8**.

Do not lubricate before installing. Drive the seal squarely into the bearing carrier **8** until the locating lip is flush, as shown in **X** Figure 8-10.

For Reference Only



a0496 **FIGURE 8-10**

NOTE: After assembling the bearing carrier to the swivel hub, make sure that there is sufficient clearance between the hub and seal.

14. Install the cup of outer wheel bearing **10** Figure 8-8 into the bearing carrier **8**. Grease the bore of the combination seal **9** and the surface of the hub.

15. Install the bearing carrier **8** onto hub swivel **3**.

16. Lightly oil the bearing race of outer wheel bearing **11**. Install the bearing onto the axle arm. Rotate the carrier **8** (and therefore the bearing) during installation.

17. Assemble annulus ring **12** to annulus carrier **13**. Secure with retaining ring **14**.

18. Install the annulus assembly in the same angular position as removal (see Note after step 9 on page 8-7) using new Verbus Ripp bolts **16**. Do not fully tighten the bolts but allow the bearing carrier to rock slightly.

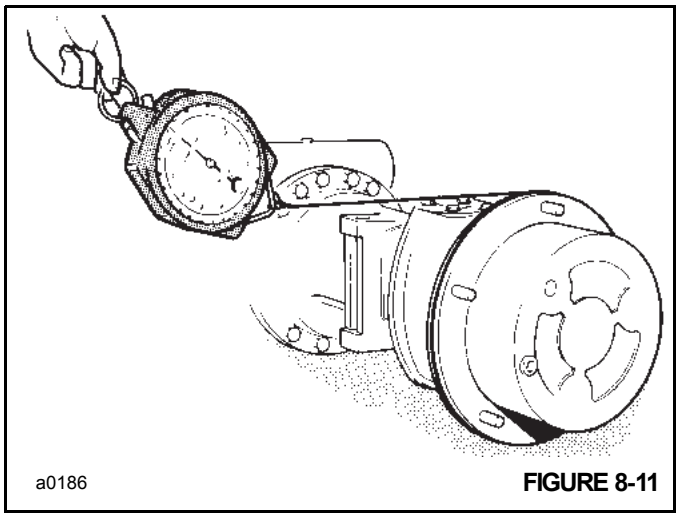
CAUTION

Verbus Ripp bolts must **NOT** be reused.

19. Check the bearing carrier rolling force:

a. Use a spring balance and cord wrapped around the planet carrier bolts Figure 8-8. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.

b. Remove the planet gear carrier **18** Figure 8-8 and tighten the new Verbus Ripp bolts **16** to 166 Nm (122 lb-ft).



a0186 **FIGURE 8-11**

c. Repeat steps 19 and 19A and record the reading.

d. To get the rolling force, subtract the seal drag rolling force (Step 19 A) from reading obtained at step 19C. The result should be 1.4 to 15.3 kg (3 to 34 lb).

If the resulting force is outside these limits check that seal **19** is installed correctly and/or replace bearings (**6** and **11**).

NOTE: A high rolling force reading may indicate that the oil seal was damaged during installation.

20. Press the drive shaft thrust pad **17** (chamfered side down) into the recess in planet gear carrier **18**.

21. Install new planet gears **19** in place of any that were removed (see Step 4 in Disassembly). Secure with retaining ring **4**.

NOTE: Large radius end of the bearing core installs onto the pin first.

22. Slide sun gear **20** onto the drive shaft and secure with retaining ring **22**.

23. Install a new O-ring **23**.

24. Install planet gear carrier **18** onto bearing carrier **8** turning it slightly to engage the gear teeth and aligning the two tapped holes **A** Figure 8-8 in the planet gear carrier. (The tapped holes are diametrically opposite one another). Ensure that the gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the center of planet gear carrier **18** when installed, as this may dislodge drive shaft thrust pad **17**.

25. Install screws **24** and tighten to a torque of 56 Nm (41.3 lb-ft).

26. Fill the axle hub with oil. See *Preventative Maintenance on page 5-1*.

For Reference Only

Drive Head Repair

The following procedures can only be carried out with the axle removed from the crane. See “Removal”, on page 8-4.

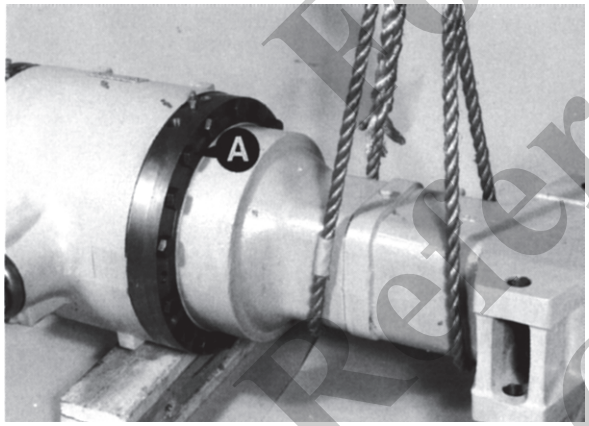
It will be necessary to provide a suitable stand to support the axle after removal.

The crownwheel and pinion are a matched set and should be replaced together if either is damaged or excessively worn.

The differential case halves are also a matched set as are the differential side gears and planet gears. Do not use unmatched case halves and gears.

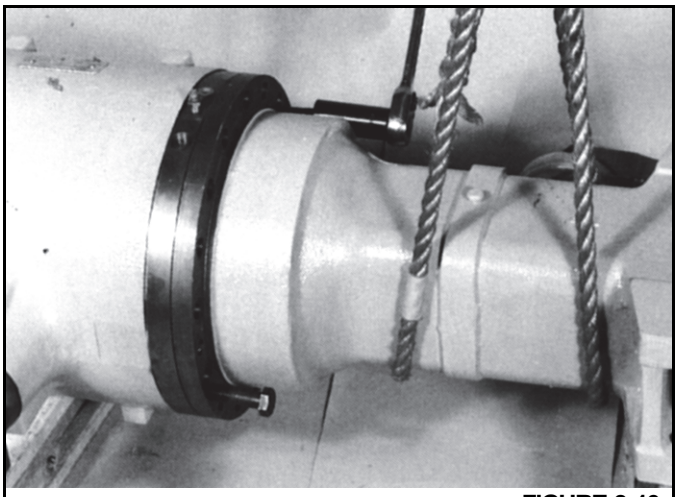
Disassembly

1. Before disassembling the axle, drain the oil from the axle into a suitable container.
2. Remove the steering cylinders and track rod.
3. Remove both axle arms.
   a. Support the axle arm and remove bolts **A** Figure 8-12.



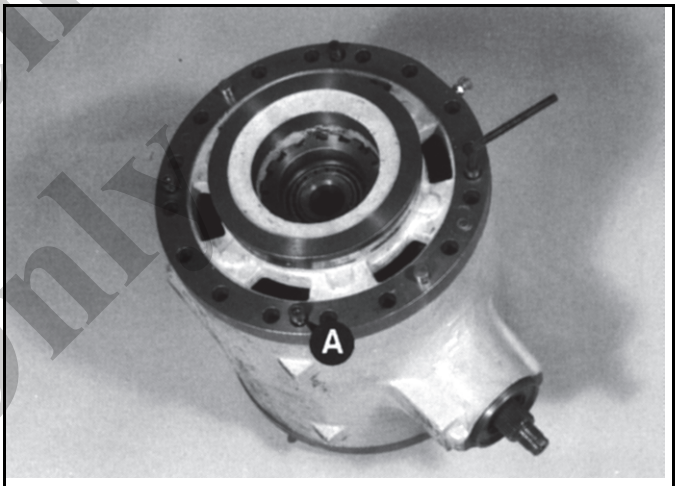
a0187 **FIGURE 8-12**

   b. Jack the axle arm off of the drive head, using the drive head securing bolts Figure 8-13. Remove all traces of gasket material from the mating surfaces.



a0188 **FIGURE 8-13**

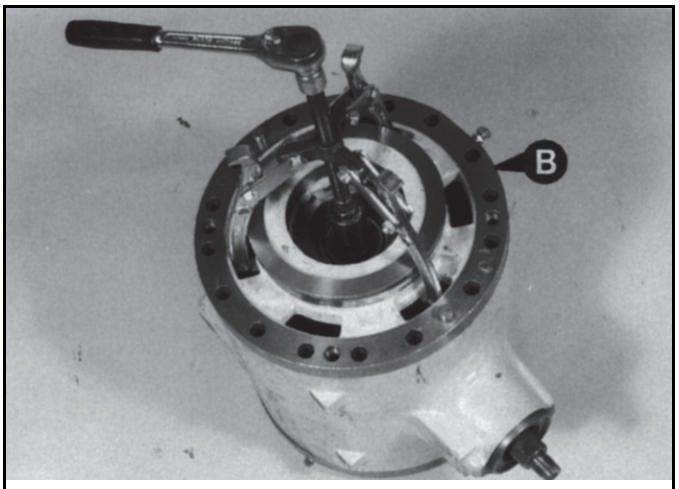
4. Remove the drive shaft coupling. See Replacing the Pinion Oil Seal on page 8-6.
5. Position the drive head as shown in Figure 8-14, with the crownwheel at the top. Remove capscrews **A**.



a0189 **FIGURE 8-14**

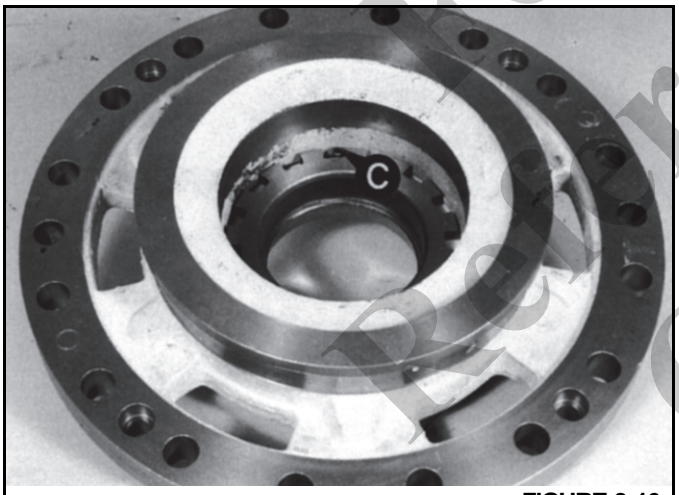
6. Match - mark the brake piston housing **B** Figure 8-15 and the drive head. Pull off the brake piston housing.

For Reference Only



a0190 **FIGURE 8-15**

7. Drive out the differential side nut locking pin **C** Figure 8-16, to allow readjustment upon assembly. Remove the other brake piston housing only if damaged, but remove its locking pin **C** regardless (to allow side load adjustment upon assembly).



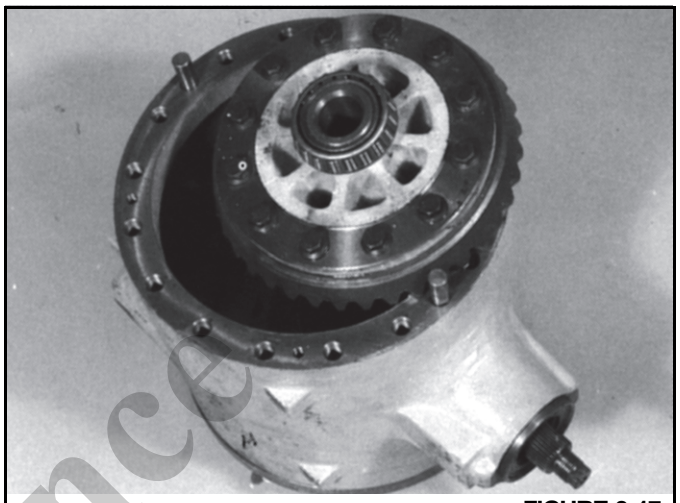
a0191 **FIGURE 8-16**

CAUTION

METAL SPLINTERS. You can be injured by flying metal splinters when driving metal pins in and out. Use a soft faced hammer or drift to remove and install metal pins. Always wear safety glasses.

8. Lift out the crownwheel/differential assembly Figure 8-17.

NOTE: If both brake piston housings are removed, put a mark on the crownwheel end of the drive head casing to ensure that the assembly is returned to its original position.



a0192 **FIGURE 8-17**

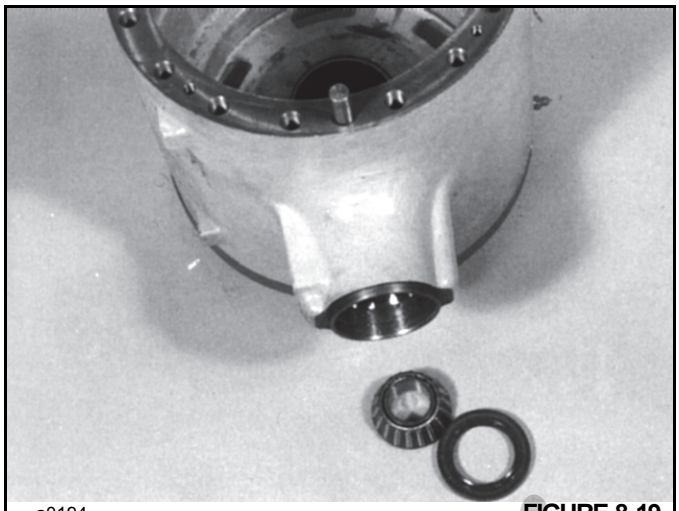
9. Using a soft hammer, hit the pinion end shaft until the pinion is free from its front bearing. Remove the pinion Figure 8-18.



a0193 **FIGURE 8-18**

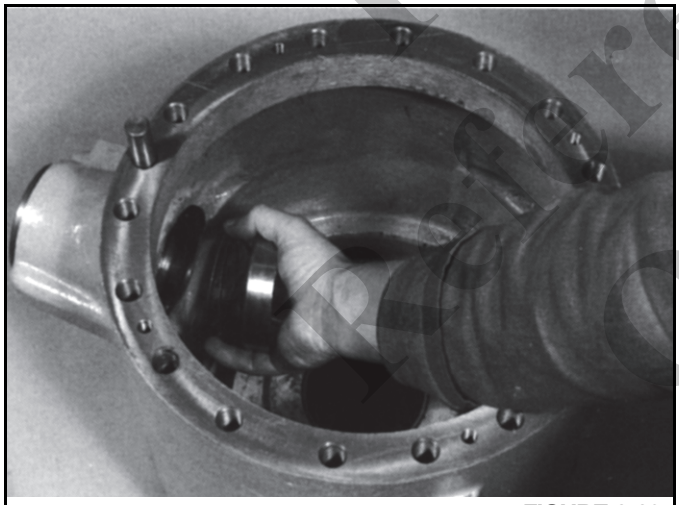
For Reference Only

10. Remove the pinion seal and outer bearing cone Figure 8-19.



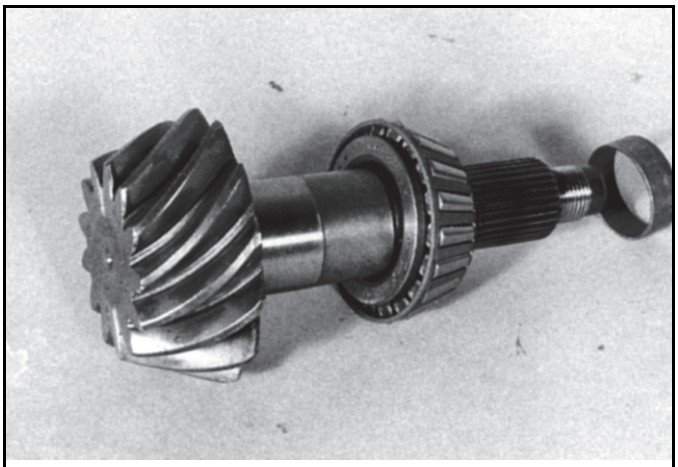
a0194 **FIGURE 8-19**

11. If necessary, drive out the pinion inner bearing cup and shims Figure 8-20. Discard the shims. Repeat for the outer bearing cup, if required. There are no shims for the outer bearing cup.



a0195 **FIGURE 8-20**

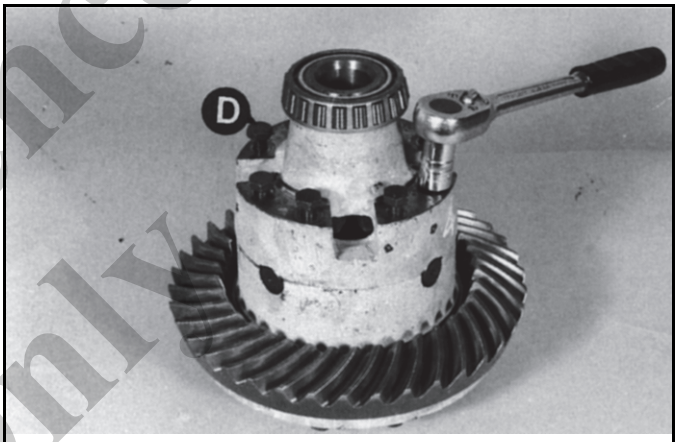
12. Remove and discard the pinion collapsible spacer Figure 8-21. Pull off the bearing cone.



a0196 **FIGURE 8-21**

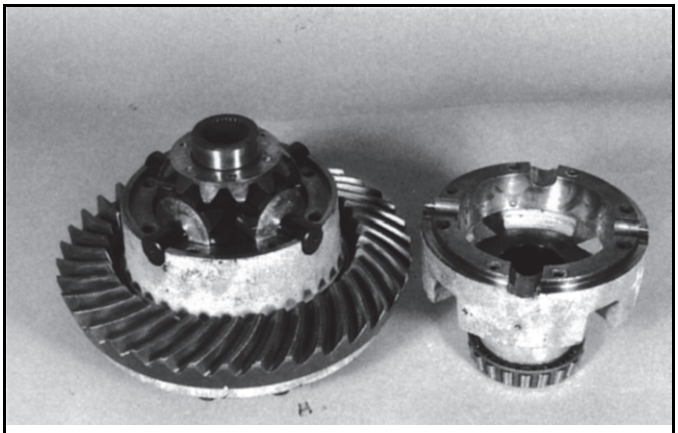
13. To dismantle the differential assembly:

a. Remove bolts **D** Figure 8-22.



a0197 **FIGURE 8-22**

b. Lift off the top half housing Figure 8-23.



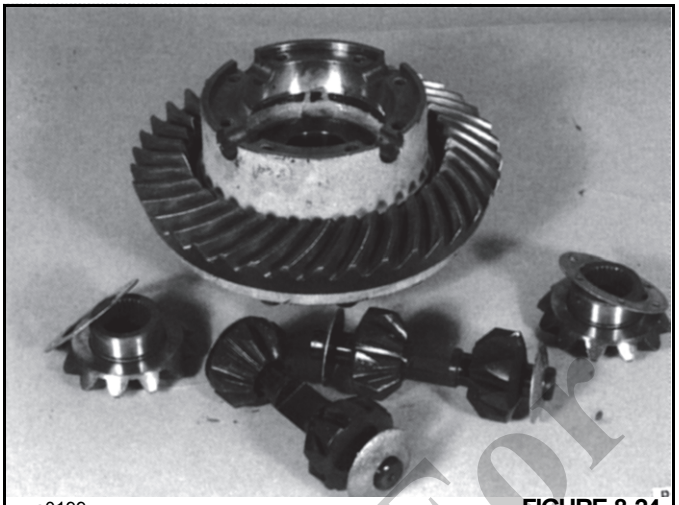
a0198 **FIGURE 8-23**

For Reference Only

8

c. Remove the differential gears and spherical washers Figure 8-24. Pull off both differential bearing cones.

If required, remove the crownwheel to differential case half retaining bolts and remove the crownwheel.



a0199 **FIGURE 8-24**

Assembly

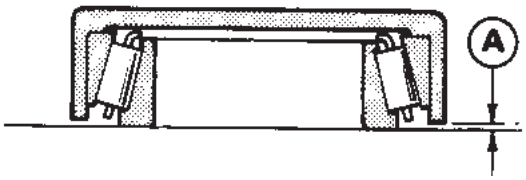
Pinion Depth Setting Procedure

Determine the pinion depth setting as follows:

NOTE: See page 8-15 for general guidance on crownwheel and pinion adjustment.

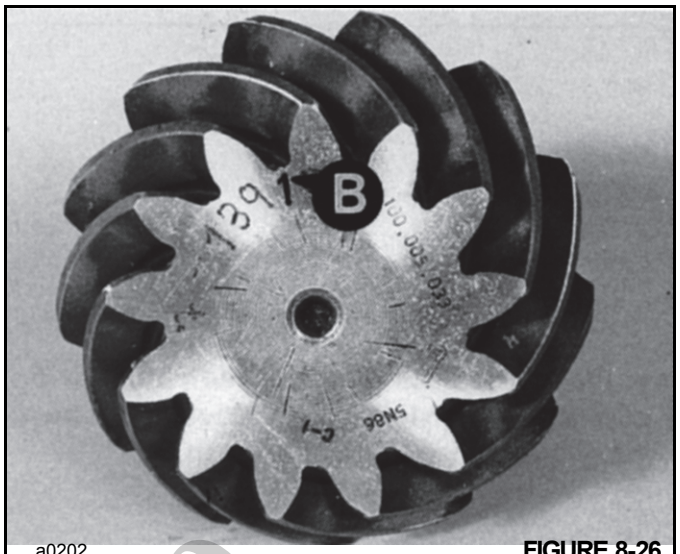
1. Assemble the pinion inner bearing and its cup on a flat surface.

2. Place the pinion bearing measuring cup over the bearing assembly Figure 8-25. Measure gap A. Add tool depth of 30.1 mm. (1.18 in) to gap A to give bearing depth.

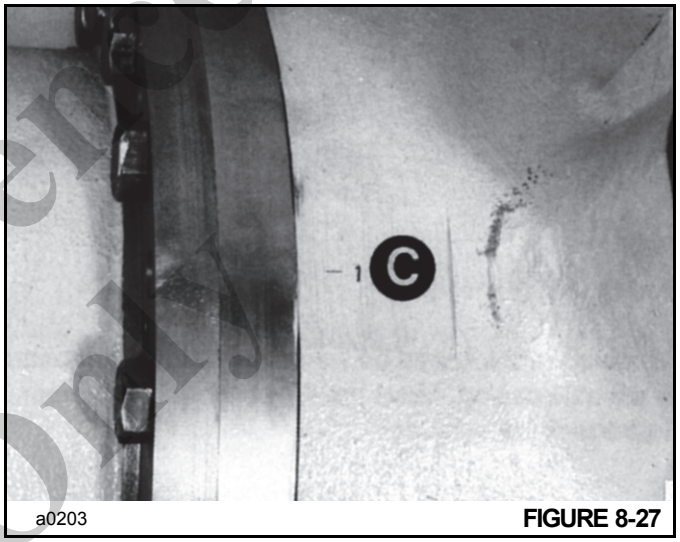


a0201 **FIGURE 8-25**

3. Find the mounting distance value **B** Figure 8-26 on the pinion and deviation **C** Figure 8-27 on the drive head housing. Both units are in millimeters. To convert millimeters to inches, multiply millimeters by 0.03937.



a0202 **FIGURE 8-26**



a0203 **FIGURE 8-27**

4. If dimension **B** is positive, add it to the bearing depth. If dimension **B** is negative, subtract it from the bearing depth. See example Crownwheel and Pinion Adjustment on page 8-15.

5. If dimension **C** is positive, subtract it from the total. If dimension **C** is negative, add it to the total. See example Crownwheel and Pinion Adjustment on page 8-15.

6. Subtract the result from the standard value of 31.19 mm (1.23 inches) to give the required shim thickness. See example Crownwheel and Pinion Adjustment on page 8-15.

For Reference Only

Example:

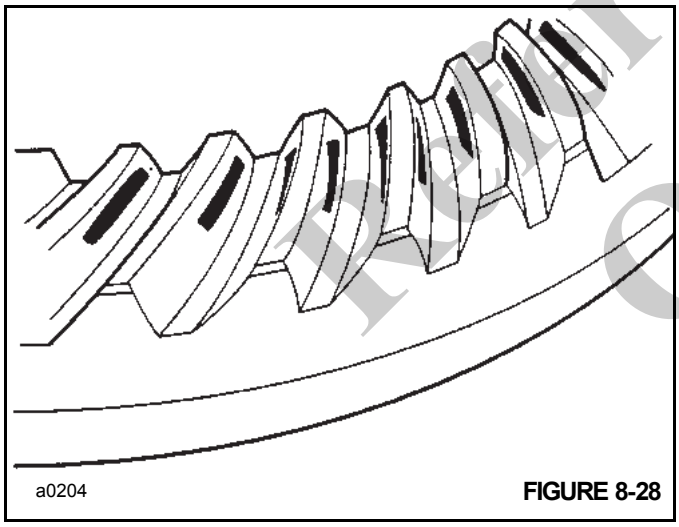
Dimensions in Millimeters	
Dimension A	0.25
Add to depth	+30.01
Total	**30.26**
Add dimension B, if positive. (Subtract if negative)	+0.01
Total	**30.27**
Add dimension C if negative. Subtract if positive	(+) -0.01
Total	**30.28**
Standard Value	31.19
Less Calculated total from above	-30.28
Shim Thickness	**0.91**

Crownwheel and Pinion Adjustment

Meshing of the gears should be checked by marking three of the pinion teeth with engineers marking compound and rotating the pinion.

The marking will then be transferred to the crown wheel teeth.

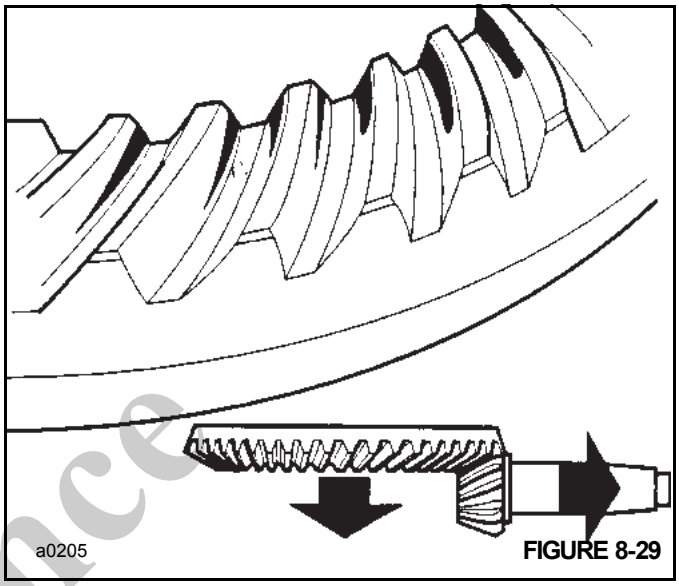
Correct teeth marking Figure 8-28



a0204 **FIGURE 8-28**

Pinion too deeply in mesh Figure 8-29

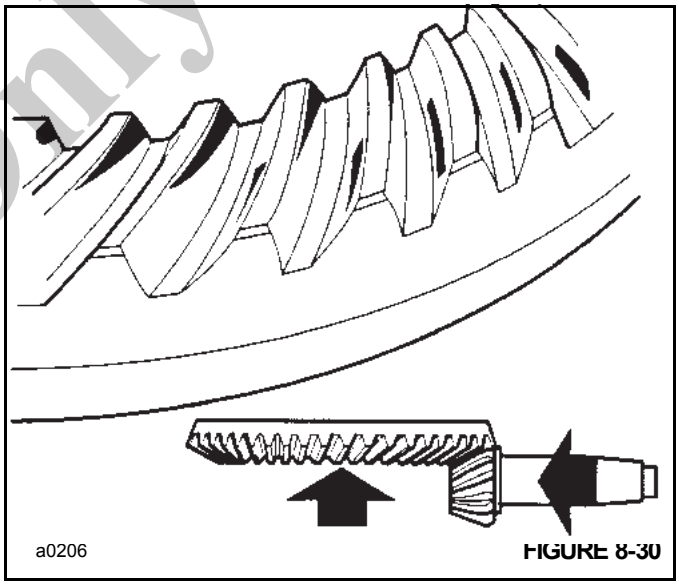
Decrease the shim thickness between the pinion inner bearing cup and the axle casing. Move the crown wheel towards the pinion to correct the backlash.



a0205 **FIGURE 8-29**

Pinion too far out of mesh Figure 8-30.

Increase the shim thickness between the pinion inner bearing and the axle casing. Move the crownwheel away from the pinion to correct the backlash.



a0206 **FIGURE 8-30**

For Reference Only

8

Assembly Procedures

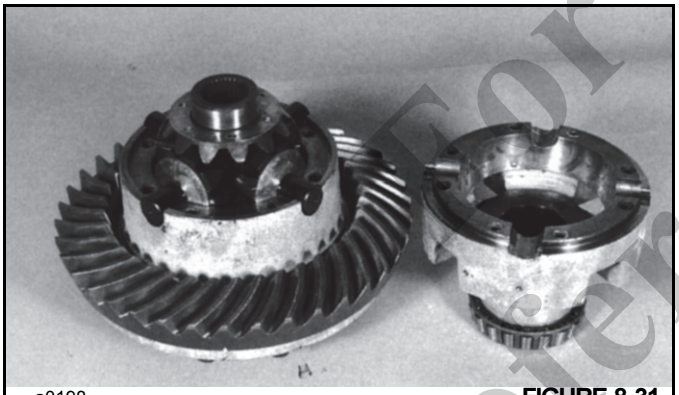
NOTE: The crownwheel and pinion are matched and should be replaced as a set, if either one is damaged or excessively worn.

The two differential case halves are also matched, as are the differential side gears and planet gears. Do not use unmatched case halves or gears.

NOTE: Make sure all bearings are lightly oiled before installing and setting. Make sure to rotate bearings while setting.

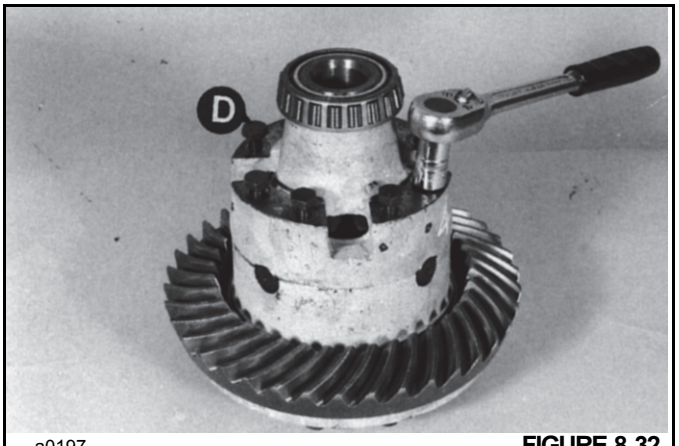
1. If required, install the crownwheel to the differential case half. Tighten the crownwheel retaining bolts to a torque of 166 Nm (122 lb-ft).

Assemble the differential gears and their spherical washers into the bottom half housing Figure 8-31. Install the differential bearing cones.



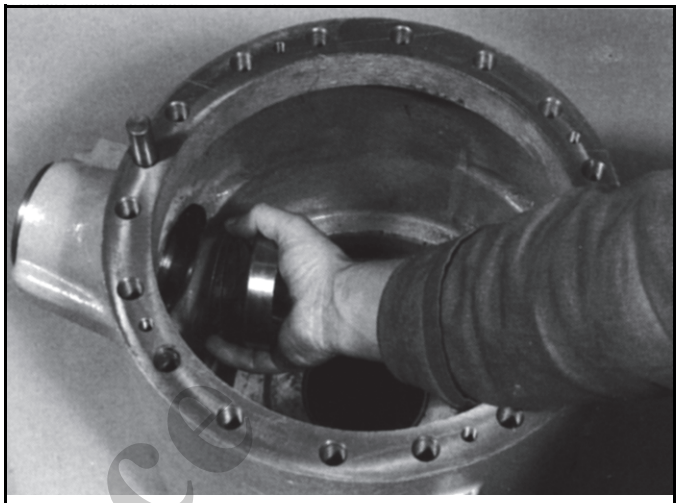
a0198 **FIGURE 8-31**

2. Position the top half housing onto the differential, aligning the match mark letters. Apply Loctite® 243 to the threads of bolts **D** Figure 8-32. Install the bolts and tighten to a torque of 56 Nm (42 lb-ft). Check the gears for free rotation.



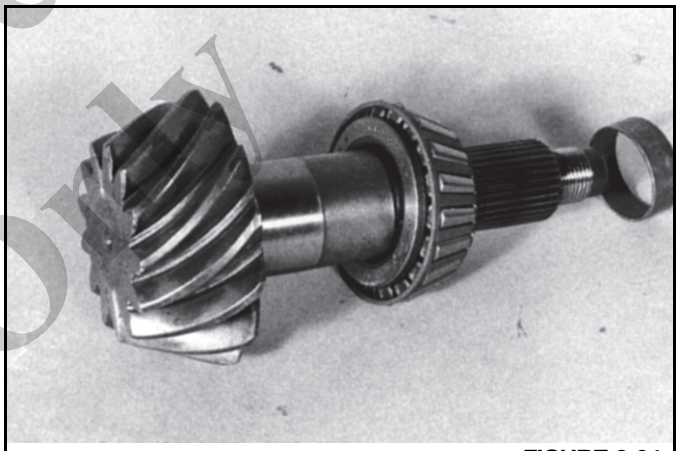
a0197 **FIGURE 8-32**

3. Install the pinion bearing cup Figure 8-33, together with the required thickness of shims to give correct pinion depth (see Pinion Depth on page 8-14). To ensure that cup is installed square, use a suitable puller assembly. Do not use a hammer. Install the outer bearing cup.



a0195 **FIGURE 8-33**

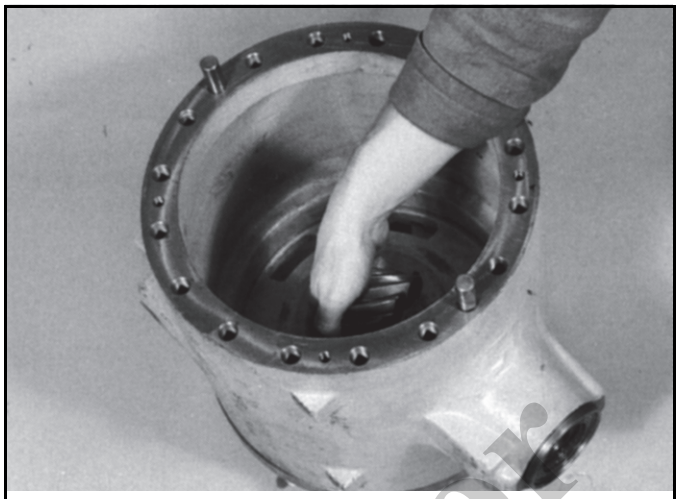
4. Install the pinion inner bearing cone Figure 8-34 and a new collapsible spacer.



a0196 **FIGURE 8-34**

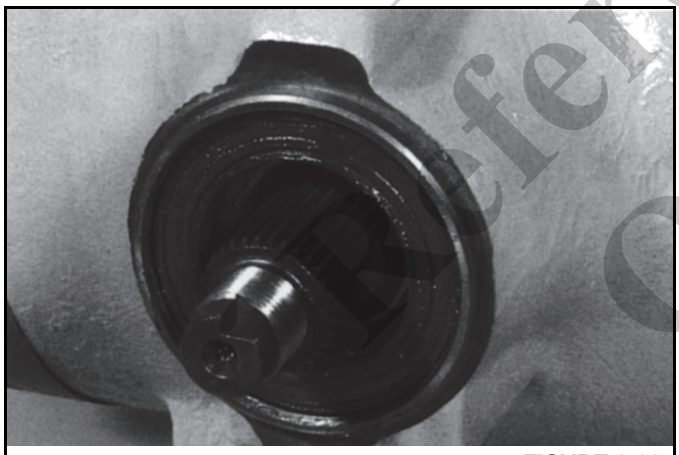
For Reference Only

5. Insert the pinion into its bore Figure 8-35. Before inserting, ensure that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter should be the same.



a0193 **FIGURE 8-35**

6. Install the outer bearing cone Figure 8-36 and the seal. Pack grease between the lips of the seal before installing.

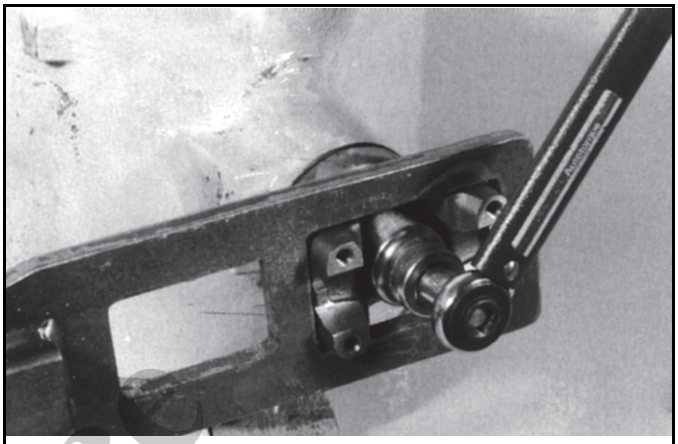


a0207 **FIGURE 8-36**

7. Install the drive coupling yoke and secure it with a new stake nut and washer.

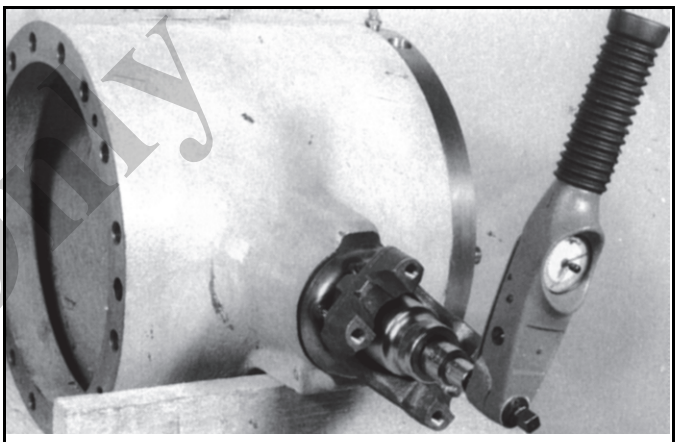
Hold the yoke Figure 8-37 with the drive coupling spanner. Tighten the stake nut until end float is almost zero, then check the seal drag torque. It should be between 0.40 to 1.0 Nm (3.5 to 8.9 lb-in).

Continue to tighten the stake nut to achieve the correct rolling torque as described in Step 8. If the nut is overtightened, the collapsible spacer must be replaced.



a0208 **FIGURE 8-37**

8. Measure the rolling torque Figure 8-38, which should be 1.7 to 2.8 Nm (1.3 to 2.1 lb-ft) excluding seal drag. When the torque is correct, stake the nut to the pinion shaft using a square-ended staking tool.

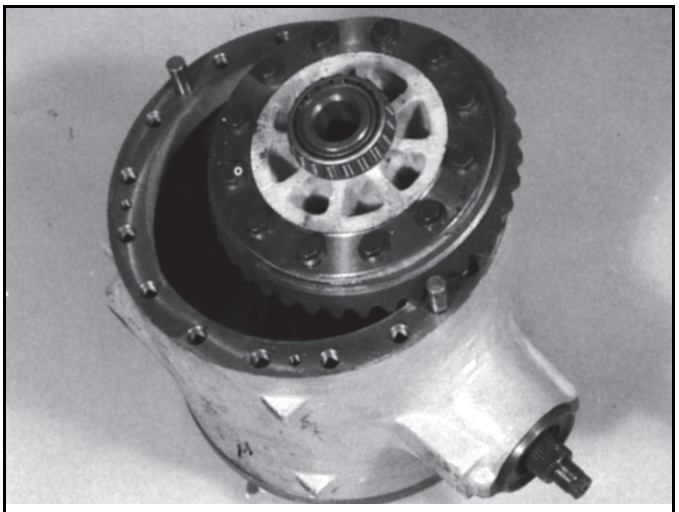


a0210 **FIGURE 8-38**

9. If both brake piston housings were removed, install one at the opposite end of the crownwheel Figure 8-39, using the procedure in Step 10. Then install the crownwheel/ differential assembly into the drive head.

For Reference Only

8

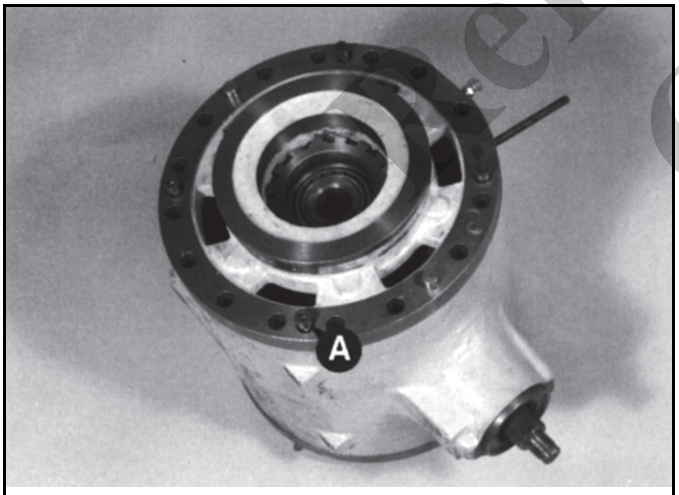


a0192 **FIGURE 8-39**

10. Apply Loctite® 275 to the drive head mating face. Install the brake piston housing. Ensure that the match marks made during disassembly are aligned. Install capscrews **A** Figure 8-40 (see Note) and tighten to a torque of 56 Nm (42 lb-ft). Torque applies to both piston housings.

NOTE: If the old capscrews are to be used, clean the threads with a wire brush and then coat the threads with Loctite® 243. Install and tighten to a torque of 56 Nm (42 lb-ft).

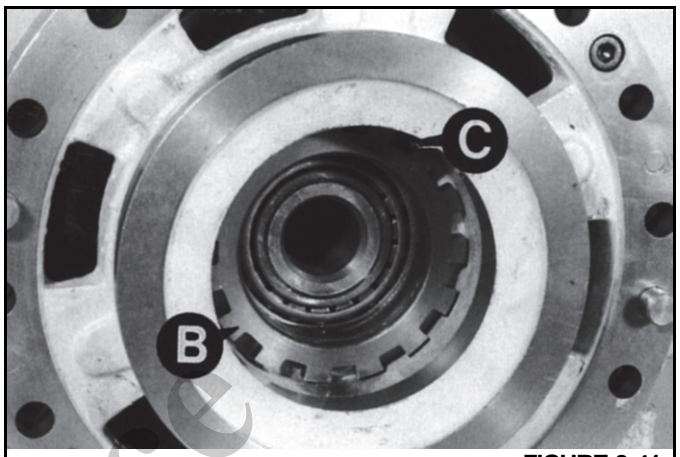
New capscrews are encapsulated and do not require cleaning or manually coating with sealant.



a0189 **FIGURE 8-40**

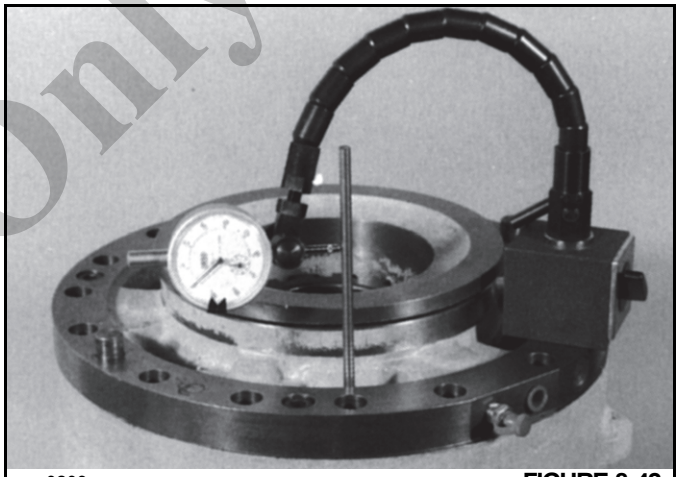
11. Adjust differential side nuts **B** Figure 8-41 to give a bearing pre-load of 1,36 to 2,5 Nm (1.0 to 1.84 lb-ft).

Measure the pre-load by taking another rolling torque reading and subtracting the torque value measured at Step 8. The difference is the bearing pre-load.



a0211 **FIGURE 8-41**

12. Measure the crownwheel backlash, which should be 0.13 to 0.2 mm (0.005 to 0.008 in) Figure 8-42. Adjust the differential side nuts by equal amounts when altering backlash. When backlash and pre-load are both correct, install the side nut locking pins **C** Figure 8-41. Verify crownwheel, pinion and pre-load are set properly. See Crownwheel and Pinion Adjustment on page 8-15.



a0209 **FIGURE 8-42**

For Reference Only

REAR AXLES REPAIR

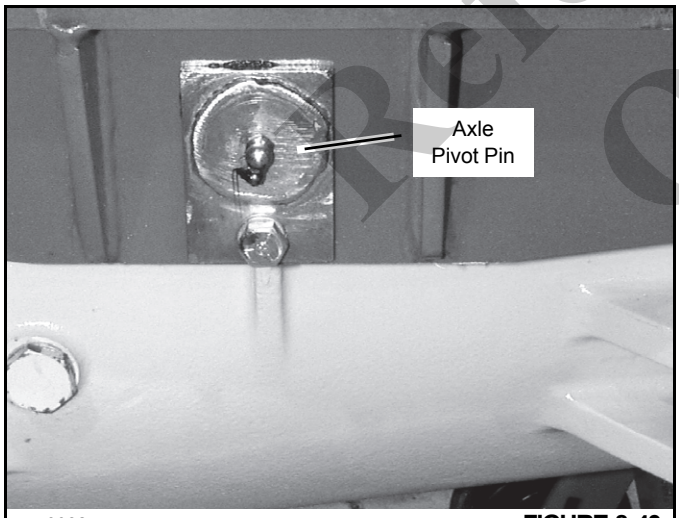
Removal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Loosen the wheel lug nuts and raise and support the crane on axle stands or blocks positioned under the chassis frame. Remove the wheels.
2. Disconnect the drive shaft from the axle by removing four bolts and lockwashers.
3. Disconnect and plug the hydraulic hoses to the steering cylinder.
4. Disconnect, cap and plug the brake hoses from the axle.
5. Support the axle on a trolley jack.
6. Remove the bolt and lockwasher Figure 8-43 securing the axle pivot pin. Remove the axle pivot pin.



p0082 **FIGURE 8-43**

7. Lower the axle clear of the mounting bracket and remove it from the crane.

Installation

1. Place the axle on a trolley jack and position it under the crane frame.
2. Raise axle and position it in the mounting frame.
3. Install the axle pivot pin.
4. Coat the threads of the pin retaining bolt with Loctite® 243 and then secure the axle pivot pin with the bolt and lockwasher.
5. Grease the axle pivot pin through two grease fittings.
6. Connect the brake lines and the steering lines to the axle.
7. Bleed the air from the brake system. See Section 9.
8. Bleed the air from the steering circuit. See Section 10.

Service Tools

To completely disassemble and assemble the rear axle, special tools are required. Unless you have the tools illustrated in Figure 8-3, DO NOT service the axle.

Replacing the Pinion Oil Seal

The procedure for replacing the pinion oil seal on the rear drive axle is the same as the front drive axle. Refer to page 8-6 for replacement procedures.

Axle Hub Repair

Disassembly Figure 8-45

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Disconnect the track rod and steering cylinders.

NOTE: If the track rod is removed completely, identify R.H. and L.H. ends to ensure correct assembly.

2. Drain all oil from the hub.
3. Remove screws **33** Figure 8-45.
4. Pry off planet gear carrier **27** at the pry points. Remove and discard O-ring **32**.

For Reference Only

5. Remove planet gears **28** only if defective. Note that gears can only be removed as assemblies, which consist of the gear, the bearing and two “L” shaped retaining rings. To remove the planet gear, remove the external retaining ring **29**.

6. Pull off the planet gear **28**.

7. The drive shaft thrust pad **26** is drilled and tapped M6 for removal purpose. Remove the thrust pad from gear carrier **27**.

8. Remove retaining ring **31** to allow sun gear assembly **30** to be slid off the drive shaft **42**.

9. Remove retaining ring **25** to allow the brake pack assembly to be slid off the drive shaft **42**.

10. Remove brake pressure plate **24**, counter plates **23** and friction plates **22**.

NOTE: If the brake pack is to be reused, note the position of the plates before removing.

11. Examine the friction plates. Wear limit of the friction plates is to the depth of the crosshatching Figure 8-44. Check all plates for flatness and damage. (Some scoring of the counter plates is normal.) Completely replace the brake pack if it is worn or damaged. Do not replace individual plates.

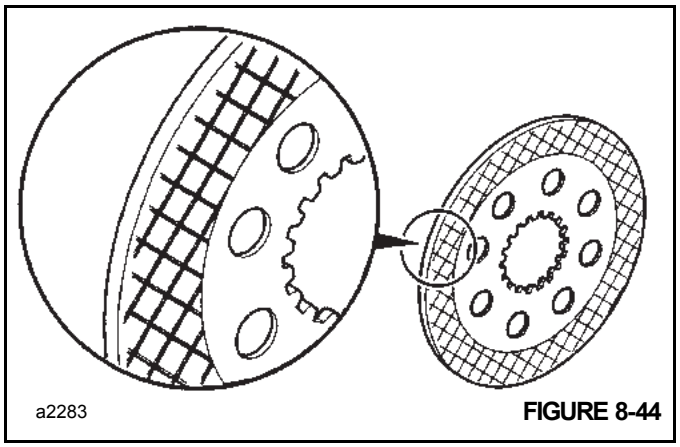


FIGURE 8-44

NOTE: Excessive wear of the brake and counterplates can indicate sticking brakes or possible residual pressure in the braking system. See *Brake System on page 9-1*.

12. Remove Verbus Ripp bolts **21** Figure 8-45 and retaining plate **20**. These bolts are very tight and care must be taken not to distort the bolt heads. Use as short of extension as possible with a six sided socket. Discard the Verbus Rip bolts after removal.

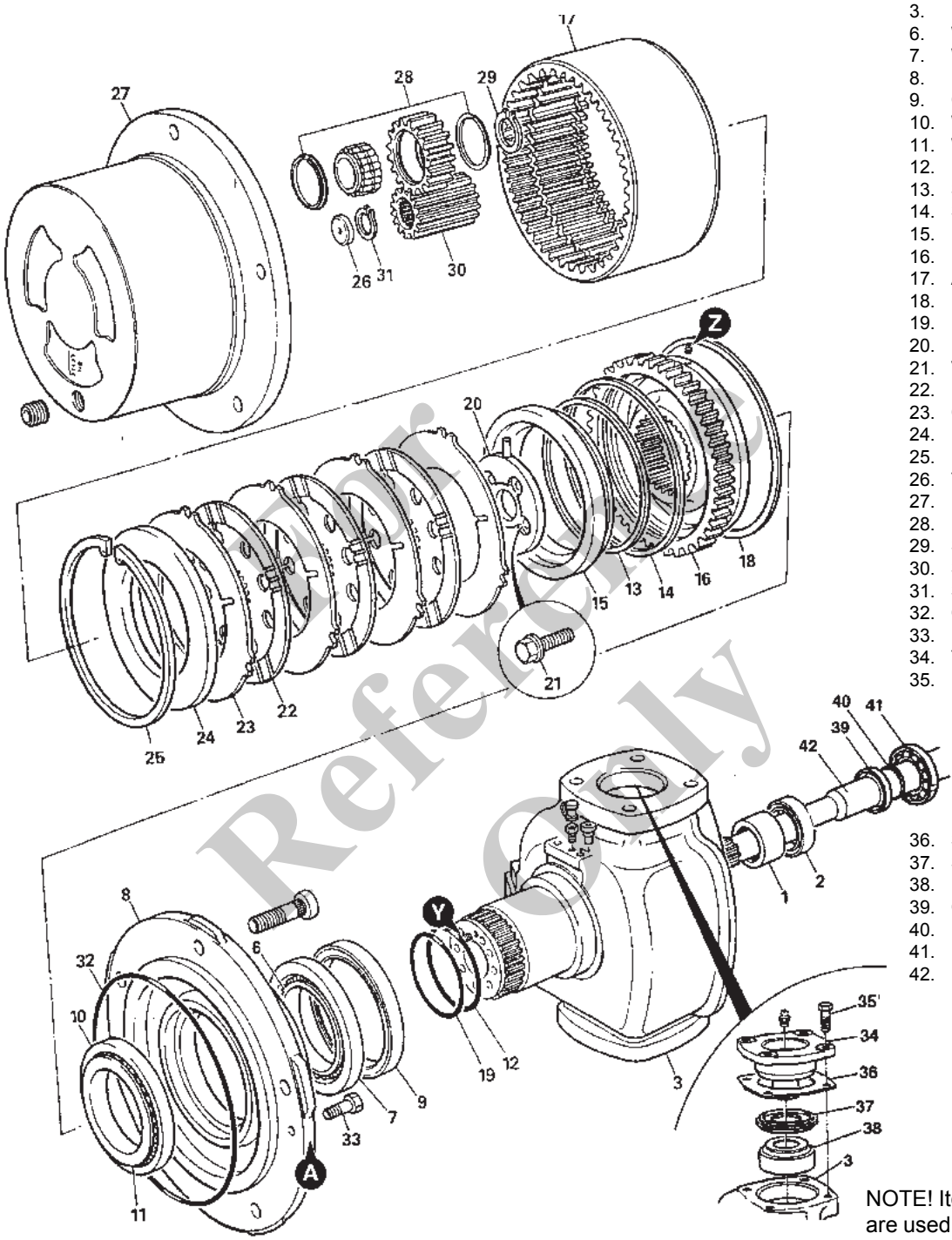
CAUTION

Do **NOT** reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

13. Remove brake seal **19**, then mark the relationship between the annulus carrier **16**, annulus ring **17** and the hub swivel. Remove the annulus carrier with the annulus ring from the hub swivel.

14. Remove retaining ring **18** to separate the annulus ring from the annulus carrier. Remove brake seal **12** from the hub swivel.

For Reference Only



1. Bearing
2. Oil Seal
3. Hub Swivel
6. Wheel Bearing Cone
7. Wheel Bearing Cup
8. Bearing Carrier
9. Combination Seal
10. Wheel Bearing Cone
11. Wheel Bearing Cup
12. Brake Seal
13. Seal
14. Seal
15. Brake Piston
16. Brake Carrier
17. Annulus Ring
18. Retaining Ring
19. Brake Seal
20. Retainer Plate
21. Verbus Ripp Bolts (4)
22. Friction Plate (3)
23. Counter Plate (4)
24. Pressure Plate
25. Retaining Ring
26. Thrust Pad
27. Planet Gear Carrier
28. Planet Gear Assembly (3)
29. Snap Ring (3)
30. Sun Gear
31. Snap Ring
32. O-ring
33. Bolt (2)
34. Trunnion (2)
35. Bolt (8)
36. Shim
37. Seal (2)
38. Bearing (2)
39. Oil Seal
40. Retaining Ring
41. Bearing
42. Drive Shaft

NOTE! Items 39, 40 and 41 are used on drive axles only.

Reference Only

a2284

FIGURE 8-45

15. If removal is necessary, carefully remove the brake piston **15** from its housing. A hydraulic hand pump can be used to force the piston out of the housing.

16. Remove and discard seals **13** and **14**. Inspect the housing bore for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.

17. Pull off bearing carrier **8** together with outer bearing **11**.

18. Pull off inner bearing **6**.

19. Remove and discard combination seal **9**.

NOTE: Earlier axles may have an O-ring and wear ring installed. These parts should be discarded.

NOTE: The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-45) the only difference being that shims **36** are installed to the top trunnion.

20. Mark the position of the top and bottom trunnions **34**, remove bolts **35** and remove the trunnions. Keep shims **36** with the top trunnion. Remove hub swivel **3**.

NOTE: Trunnions may be removed easily and without damage to the shims by pumping grease through the grease fitting.

On non-drive axles the short drive shaft will be removed with the hub swivel.

21. Remove top and bottom trunnion seals **37** and bearings **38**.

22. Remove drive shaft **42** from the hub swivel on non-drive axles and from the axle casing on drive axles.

23. Pry out the drive shaft outer oil seal **2**.

24. Remove bearing **1** using an impulse extractor adapter.

NOTE: Steps 25 through 27 are for drive axles only.

25. Pry out drive shaft inner seal **39**.

26. Remove retaining ring **40**.

27. Using an impulse extractor remove bearing **41**.

28. If there has been a component failure, remove all traces of debris and clean the magnetic drain plug.

Assembly

NOTE: The top and bottom trunnions are very similar (bottom trunnion is not illustrated in Figure 8-45, the only difference being that shims **36** are installed to the top trunnion.

NOTE: Steps 1 through 3 are for drive axles only.

1. Tap the drive shaft inner bearing **41** into position in the axle casing.

2. Install retaining ring **40**.

3. Install new oil seal **39**. Pack grease between the lips of the seal.

4. Tap drive shaft inner bearing **1** into position in hub swivel **3** drive shaft bore.

5. Install new oil seal **2**. Pack grease between the lips of the seal.

6. Install drive shaft **42**. Take care to locate inner end into splines of differential gears on the drive axle.

7. Press new top and bottom trunnion seals **37** into position, followed by bearings **38**.

8. Locate hub swivel **3** and install the bottom trunnion **34**. Apply Loctite® 243 to threads of bottom trunnion bolts **35** and then tighten to a torque 56 Nm (42 lb-ft). Install top trunnion **34** with normal 0.25 mm (0.010 inch) shim **36** and leave top trunnion bolts **35** finger tight.

9. Attach a spring balance Figure 8-46 to track rod swivel and turn the swivel. Tighten the top trunnion bolts **35** to eliminate end play, but without bearing pre-load, i.e. no increase in spring balance reading.

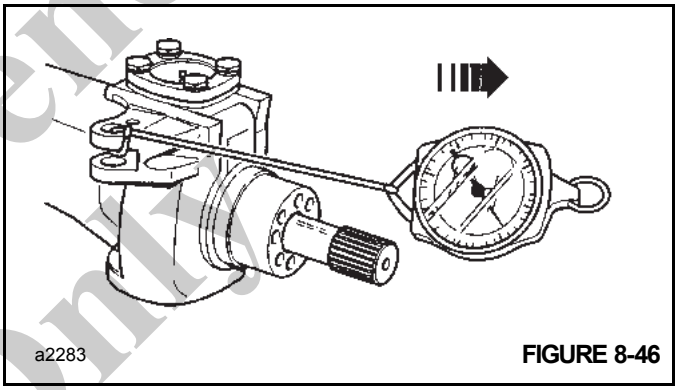


FIGURE 8-46

10. Measure the gap at the top trunnion and subtract 1 mm (0.040 inches) to give shim thickness (bearing pre-load). For example:

Gap = 1.55 mm (0.061 inches)

less = 1.00 mm (0.040 inches

Shim = 0.55 mm (0.021 inches)

NOTE: If the gap measures 1.00 mm (0.040 inches), then no shim is required.

If, after installing the shims, the bearing pre-load is not attainable, install new bearings.

11. Reinstall the top trunnion. Apply Loctite® 243 to the top trunnion bolt threads, install and tighten to a torque of 56 Nm (42 lb-ft).

12. Check the spring balance reading which should be 4.5 kg (10 lb) more than the reading recorded in step 9.

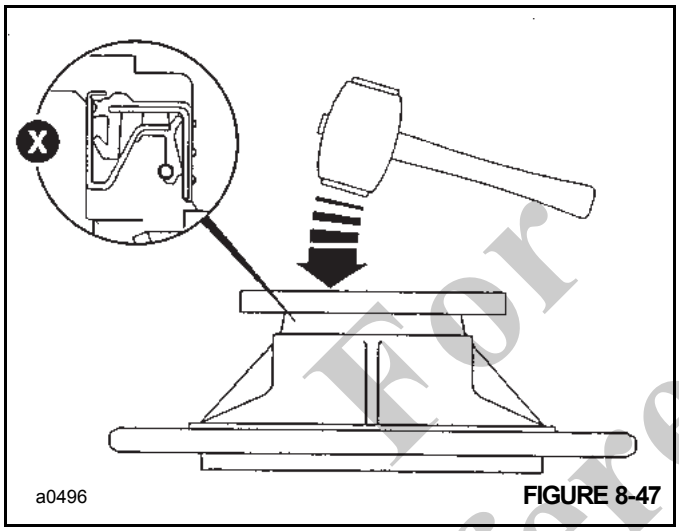
For Reference Only

13. Connect the track rod and steering cylinder to the axle steering knuckle. Tighten the track rod nut to a torque of 135 Nm (100 lb-ft), then continue to tighten to next castellation and insert the pin.

14. Lightly oil the inner wheel bearing **6** and its cup **7**. Then install them into bearing carrier **8**.

15. Install a new combination seal **9** into the bearing carrier. Figure 8-47.

Do not lubricate before installing. Drive the seal squarely into carrier until locating lip is flush as shown at **X**.



a0496 **FIGURE 8-47**

NOTE: After assembling the bearing carrier to the swivel hub, make sure that there is sufficient clearance between the hub and seal.

16. Install the cup **10** of outer wheel bearing **11** into the bearing carrier **8**. Grease the bore of the seal and the surface of the hub.

17. Install the bearing carrier **8** onto hub swivel **3**.

18. Install new brake seal **12** to the hub swivel.

19. Install new seals **13** and **14** into the grooves in the brake piston **15** and annulus carrier **16**.

20. Carefully press piston **15** all the way into the annulus carrier housing.

21. Align relationship marks made on disassembly. Assemble annulus ring **17** to annulus carrier **16** and secure with retaining ring **18**. Make sure the two blanking plugs **Z** Figure 8-45 are installed to the annulus carrier. Apply Loctite® 243 to threads.

NOTE: Inspect the inside of the annulus carrier and piston for marks. Any sign of scoring on a seal contact surface can cause leaks.

Make sure blanking screw **Y** are installed. Apply Loctite 243 to threads.

22. Install the annulus assembly onto the splined hub. Check that the relationship marks align. Push the annulus assembly into the splined hub until the splines of the annulus assembly are flush with the end of the splined hub. Fit brake seal **19** onto the hub swivel.

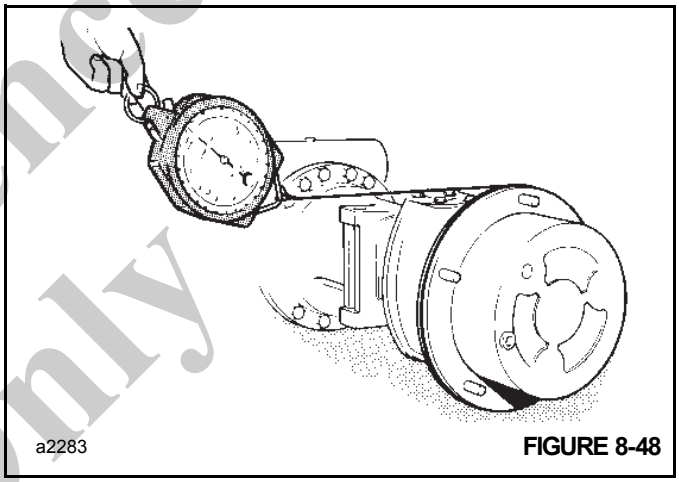
23. Install retainer plate **20**, making sure the breather hole and brake galleries align. Secure using Verbus Ripp bolts **21** and tighten until the annulus assembly just locks.

24. Check the seal drag rolling force:

a. Use a spring balance and cord wrapped around the planet carrier flange Figure 8-48. Pull the spring balance so that the hub rotates. Do this several times to set the seal and then record the reading.

b. Remove the planet gear carrier and tighten the new Verbus Ripp bolts **21** to 166 Nm (122 lb-ft).

c. Repeat steps 24 and 24A and record the reading.



a2283 **FIGURE 8-48**

d. To get the rolling force, subtract the seal drag rolling force (Step 24 A) from reading obtained at step 24C. The result should be 1.4 to 15.3 kg (3 to 34 lb).

If the resulting force is outside these limits check that seal **9** is installed correctly and or replace bearings **6** and **11**.

NOTE: A high rolling force reading may indicate the oil seal was damaged during installation.

25. Assemble friction plates **22** and counter plates **23** onto the carrier **16**. If the original brake pack is being used, return the plates to their original positions (see Disassembly, step 10). Soak new friction plates in gear oil before assembly.

26. Assemble the brake friction plate **24**. Install retaining ring **25**.

27. If axle is attached to the machine, bleed the brake system. With the engine running, gently apply the brakes and then release them. Check that the piston

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activates and retracts correctly and does not stick in the applied position before installing planet gear carrier **27**.

If the brake piston has not retracted, the brake seal or piston assembly may have been assembled incorrectly. Alternatively, there may be residual pressure holding the piston. Unscrew the brake bleed nipple with the engine running and check that the piston retracts when the pressure is released. Investigate the cause if the piston remains in the applied position. See Residual Brake System Pressure in Section 9.

28. Press drive shaft thrust pad **26** (chamfered side down) into the recess in planet carrier **27**.

29. Install new planet gears **28** in place of any that were removed. Secure with retaining ring **29**.

NOTE: The large radius at the end of the bearing bore installs on the pin first.

30. Install sun gear **30** onto the drive shaft and secure with external retaining ring **31**. Install new O-ring **32**.

31. Install planet gear carrier **27** onto bearing carrier **8**, turning it slightly to engage the gear teeth and align the two tapped holes **A** Figure 8-45 in the bearing carrier. (The tapped holes are diametrically opposite each other.) Ensure that the planet gear carrier butts fully against the bearing carrier.

NOTE: Do not strike the center of the planet gear carrier **27** when installed, as this may dislodge drive shaft thrust pad **26**.

32. Install screws **33** and tighten to a torque of 56 Nm (41.3 lb-ft).

33. Fill the axle hub with oil.Drive Head Repair (Drive Axles Only)

Disassembly Figure 8-49

NOTE: The axle need not be removed to disassemble the drive head.

1. Drain the oil from the axle center casing. Remove the rear drive shaft from the axle.

2. Remove both hub assemblies with drive shafts (see page 8-7).

3. Mark the installation position of the drive head carrier **2** Figure 8-49.

4. Remove bolts **1** and remove drive head carrier **2** from the axle casing.

5. Clean the drive head carrier and axle casing mating surfaces.

6. Pull out tension pins **3** and **4** and remove castellated nuts **5** and **6**.

7. Remove bearing outer races **7** and **8**.

8. Drive off the taper roller bearing cone **9** from the crownwheel differential case half.

9. Remove differential assembly **10** from the carrier.

10. Remove retaining bolts **11** and separate case halves **12** and **13**.

11. Remove the two differential side gears **14** and thrust washers **15**.

12. Remove the four planet gears **16** and thrust washers **17** from trunnion pins (**B**).

13. Pull off taper roller bearing cone **18** from differential case halve **12**.

14. Remove Verbus Ripp bolts **19** and separate the crownwheel **20** from differential case halve **13**.

CAUTION

Do NOT reuse Verbus Ripp bolts. They must be replaced throughout the assembly.

15. Use a drive coupling spanner to prevent drive yoke **23** from rotating. Remove pinion nut **21** and washer **22**. Remove the drive yoke.

NOTE: On later axles, pinion nut **21** and washer **22** are combined. The separate nut and washer should be discarded and replaced with the new combined nut and washer.

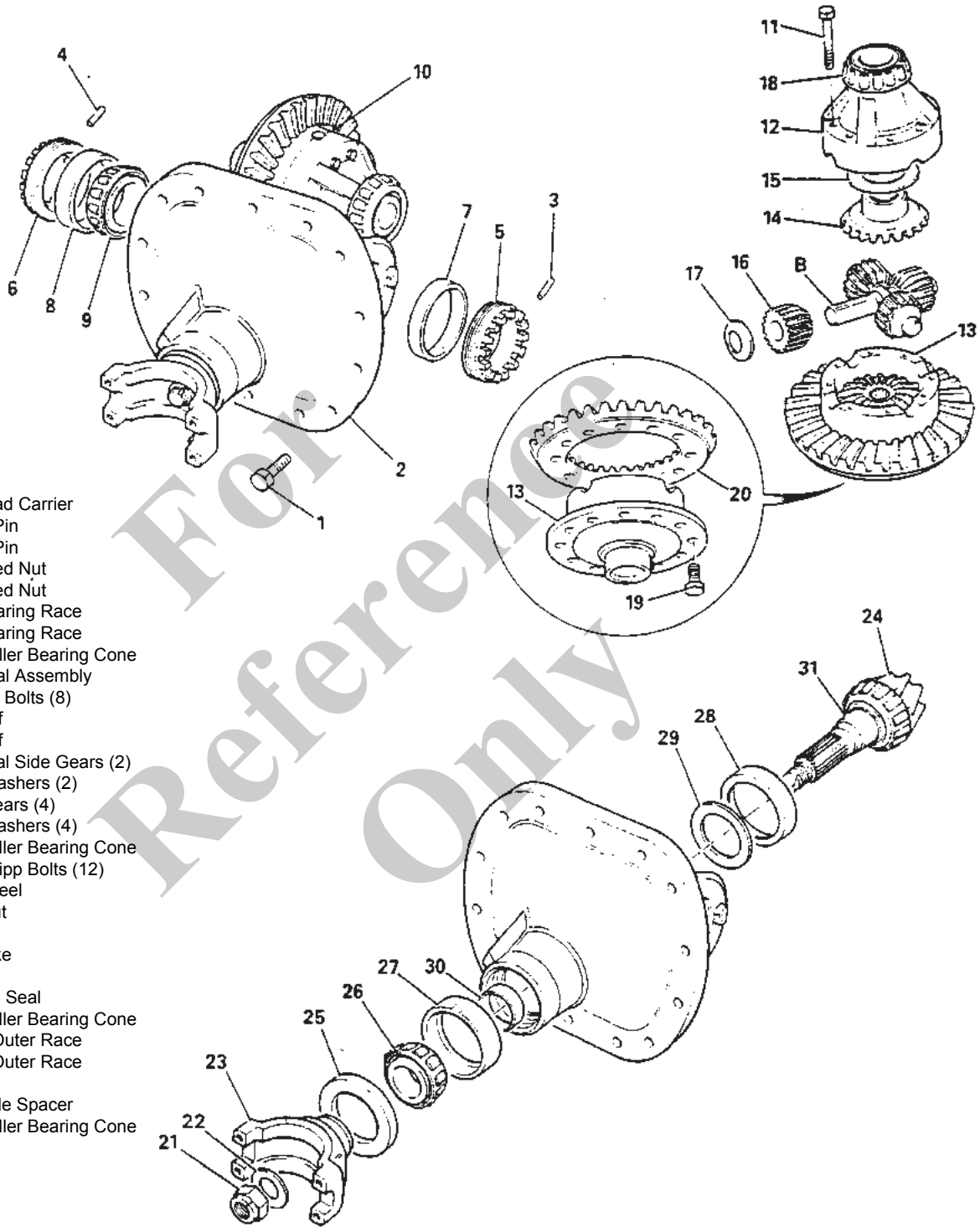
16. Press pinion **24** from drive head carrier **2**.

17. Pull out pinion oil seal **25** and taper roller bearing cone **26**. If necessary remove bearing outer race **27**.

18. If necessary, drive out pinion bearing outer race **28** and shim(s) **29** from inner side of the drive head carrier.

19. Remove the collapsible spacer **30** and taper roller bearing cone **31** from pinion **24**.

For Reference Only



1. Bolts (16)
2. Drive Head Carrier
3. Tension Pin
4. Tension Pin
5. Castellated Nut
6. Castellated Nut
7. Outer Bearing Race
8. Outer Bearing Race
9. Taper Roller Bearing Cone
10. Differential Assembly
11. Retaining Bolts (8)
12. Case Half
13. Case Half
14. Differential Side Gears (2)
15. Thrust Washers (2)
16. Planet Gears (4)
17. Thrust Washers (4)
18. Taper Roller Bearing Cone
19. Verbus Ripp Bolts (12)
20 Crownwheel
21. Pinion Nut
22. Washer
23. Drive Yoke
24. Pinion
25. Pinion Oil Seal
26. Taper Roller Bearing Cone
27. Bearing Outer Race
28. Bearing Outer Race
29. Shims
30. Collapsible Spacer
31. Taper Roller Bearing Cone

For Reference Only

Drive Head

a0213

FIGURE 8-49

8

Assembly

NOTE: The crownwheel **20** Figure 8-49 and pinion **24** are matched and should be replaced as a pair if either one is damaged or excessively worn. The differential case halves **12** and **13** are also matched as are gears **14** and **16**. Do not use unmatched halves or gears.

Make sure all bearings are lightly oiled before installing and setting. Make sure bearings are rotated while being set.

1. Install pinion bearing outer race **28** Figure 8-49 to drive head carrier **2** together with required thickness of shims **29** to give correct pinion depth. (See Pinion Depth Setting Procedure on page 8-14). Install the shims behind the outer race Figure 8-49.
2. Install new taper roller bearing cone **31** and a new collapsible spacer **30** onto pinion **24**.
3. Install outer race **27** to drive head carrier **2**.
4. Insert pinion **24** into its bore. (Before inserting verify that the pinion matches the crownwheel. The code numbers etched on the pinion end face and the crownwheel perimeter must be the same).
5. Install new taper roller bearing cone **26**. Pack the cavity between the lips of new oil seal **25** with grease and install the seal to the drive head carrier **2**.
6. Install the drive coupling yoke **23** and secure it with a new combined stake nut **21** and washer **22**.
   a. Hold the yoke with a drive coupling spanner.
   b. Tighten the stake nut until end float is almost zero then check the seal drag torque which should be between 0.40 to 0.75 Nm (3.5 to 6.6 lb-ft).
   c. Continue to tighten the stake nut to collapsible spacer **30** and give a rolling torque of 1.7 to 2.8 Nm (1.3 to 2.1 lb-ft) excluding seal drag, crownwheel not installed.

      IF THE STAKE NUT IS OVERTIGHTENED, THE COLLAPSIBLE SPACER MUST BE REPLACED.

      Make sure that yoke **23** is rotated in both directions to fully seat the bearings before measuring rolling torque.
   d. When the torque is correct, stake the nut to the pinion shaft, using a square ended staking tool.
7. Install crownwheel **20** to case halve **13**, tighten the Verbus Ripp bolts **19** to a torque of 166 Nm (122 lb-ft).
8. Assemble the four planet gears **16** and thrust washers **17** onto the trunnion pins. Install the planet gear assembly and two differential side gears **14** and thrust washers **15** into case half **13**.
9. Position top case half **12** onto bottom half assembly **13** aligning the match mark letters (see Note on page 8-7). Apply Loctite® 243 to the threads of bolts **11**, then install them and tighten to a torque of 56 Nm (32 lb-ft). Check the gears for free rotation.
10. Press taper roller bearing cone **18** onto the spigot of case half **12**.
11. Install the differential assembly **10** into the drive head carrier **2**.
12. Press taper roller bearing cone **9** onto the spigot of case half **13**.
13. Install bearing outer races **7** and **8**, castellated nuts **5** and **6** to drive head carrier **2**.
14. Adjust castellated nuts **5** and **6** to give bearing pre-load (see Note) of 1.36 to 2.5 Nm (1.0 to 1.84 lb-ft).

NOTE: Measure the pre-load by taking another rolling torque reading and subtract the torque figure measured at step 6C. The difference is the bearing pre-load.

15. Measure the crown wheel backlash, which should be 0.13 to 0.20 mm (0.005 to 0.008 in). Adjust castellated nuts **5** and **6** by equal amounts when altering backlash. When backlash and pre-load are both correct, install tension pins **3** and **4**.
16. Verify that the crownwheel and pinion are set correctly: use an engineers marker on three of the pinion teeth and check markings on the crownwheel are as indicated on page 8-15. Adjust if necessary.
17. Apply Loctite® 275 to the drive head carrier mating face and then install the axle casing (the carrier assembly locates on two dowels). Make sure the assembly is installed in the same match-mark position (see step 3, Disassembly of page 8-11.
18. Apply Loctite® 243 to bolts **1** and install. Tighten the bolts to a torque indicated in *Fasteners and Torque Values on page 1-15*.
19. Assemble both hubs and drive shafts and install the rear drive shaft.
20. Fill the axle with recommended oil. See *Preventative Maintenance on page 5-1*.

NOTE: Tightening torque depends on bolt type. The grade is stamped on the bolt head. If standard grade 8 bolt, tighten to a torque of 98 Nm (72 lb-ft).

If Verbus Ripp 12.9 grade bolt is used, tighten to a torque of 166 Nm (122 lb-ft).

Use heavy duty socket.

For Reference Only

CAUTION

Verbus Ripp bolts must **NOT** be reused.

DRIVE SHAFTS

Removal

NOTE: Before removing drive shafts always mark both companion flanges and also mark the sliding joints prior to removal.

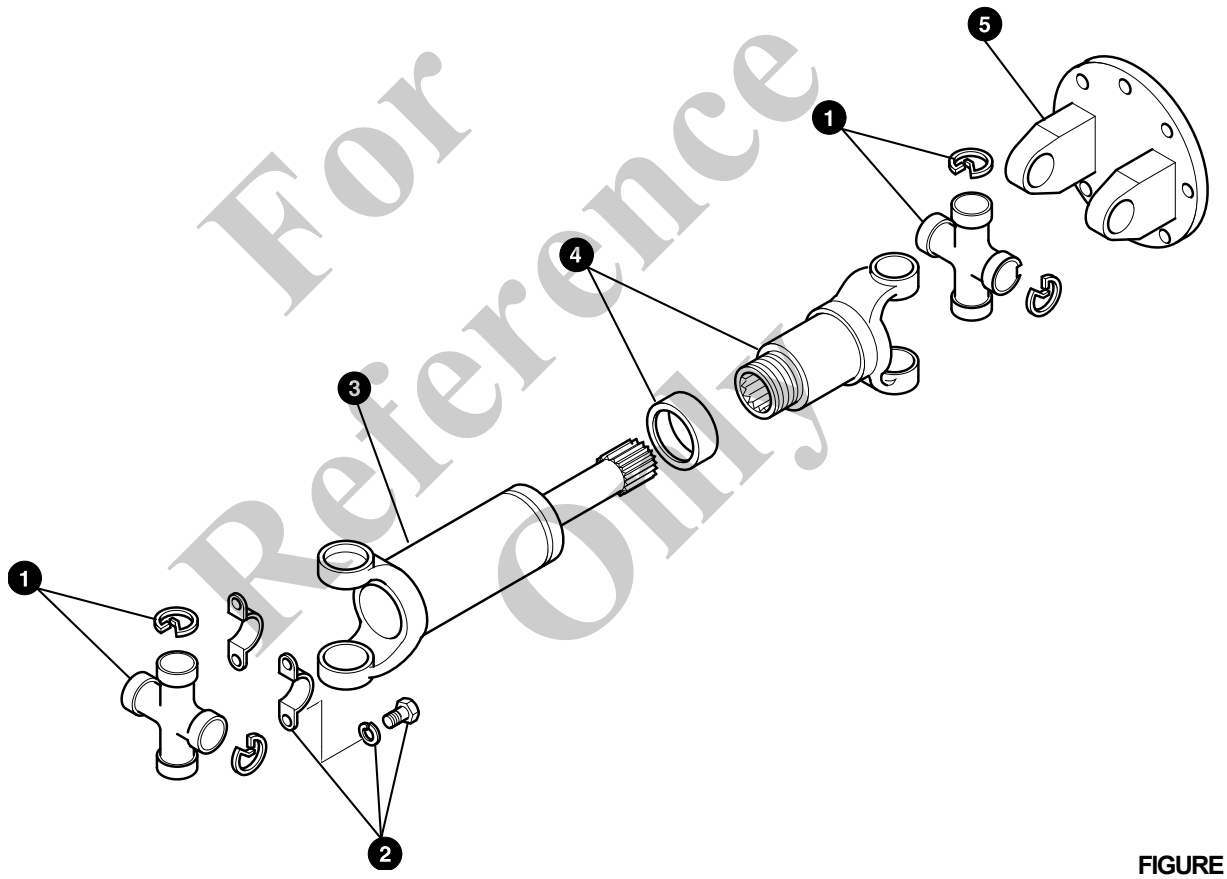
The retaining straps **2** Figure 8-50 and Figure 8-51 stretch with use, therefore these straps must always be replaced with new ones.

Front Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **2** Figure 8-50 from transmission.
2. Remove flange **5** from the parking brake disc.

Rear Axle Drive Shaft

1. Remove bolts, lockwashers and mounting straps **2**, Figure 8-50 from transmission.
2. Remove bolts, lockwashers and mounting straps **2** from rear axle.



a0315

FIGURE 8-50

For Reference Only

Disassembly

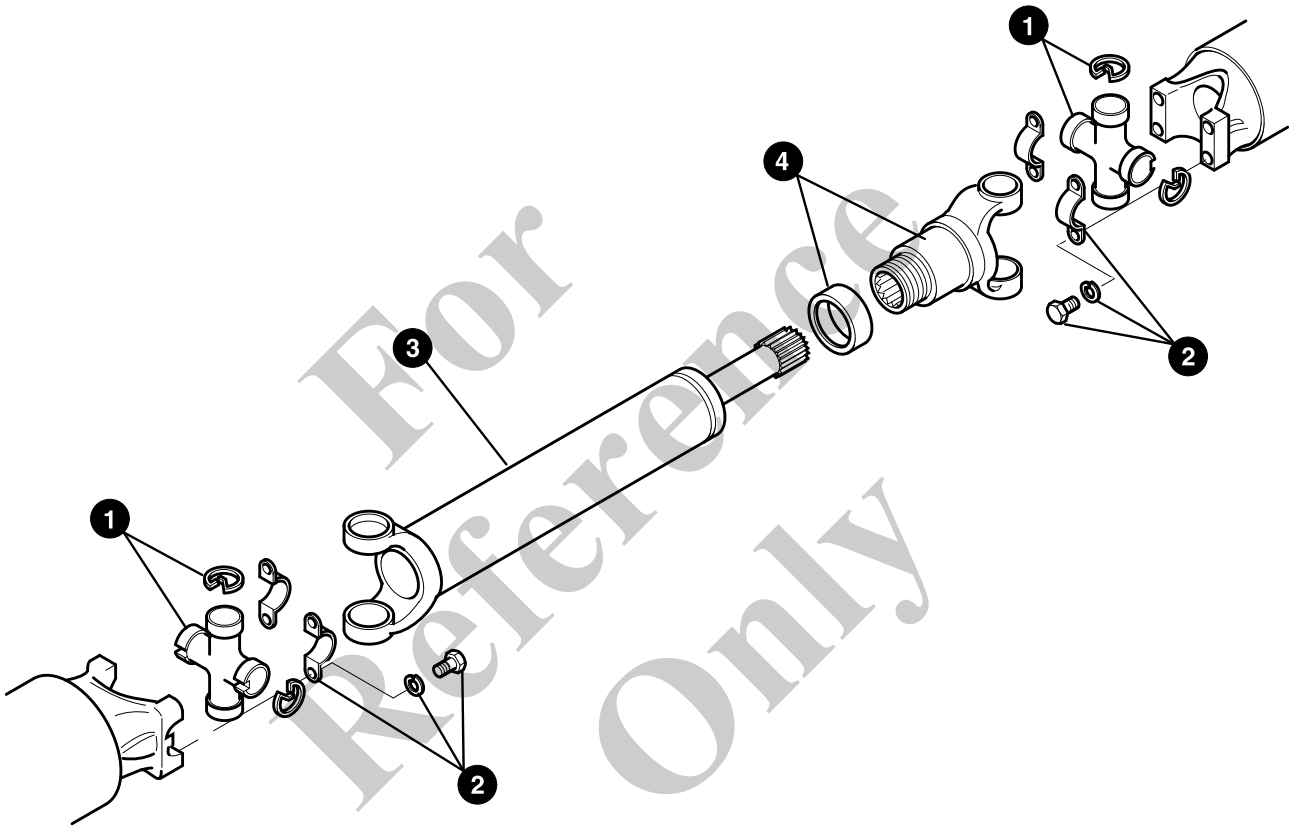
Front Axle Drive Shaft

1. Put the flange yoke **5** Figure 8-50 in a vice. Using pliers, remove two snap rings from the bearing caps in the flange yoke.
2. Apply force on the drive shaft in the direction of the bearings to push the bearings out of the flange yoke. When the bearings are removed, tilt the journal cross to permit removal of the universal joint.
3. Disassemble the journal crosses **1** from the drive shaft using the procedure in step 2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
4. To disassemble the sleeve yoke (3) from the slip yoke (4), turn the dust cap counterclockwise. When the dust

cap is free, pull the sleeve yoke and dust cap free of the slip yoke.

Rear Drive Shaft

1. Remove two snap rings from the bearing caps in the slip yoke **4** Figure 8-51.
2. After the snap rings are removed, use a soft drift with a flat face slightly smaller than the diameter of the bearing to remove the bearings.
3. Repeat steps 1 and 2 to the sleeve yoke end.
4. To disassemble the sleeve yoke **3** from the slip yoke **4**, turn the dust cap assembly counterclockwise. When the dust cap assembly is free, pull the sleeve yoke and dust cap free of the slip yoke.



a0447

FIGURE 8-51

For Reference Only

Inspection

Clean all parts with a suitable solvent. Remove all rough areas from any finished surfaces. Make sure the bearing surfaces on the journal crosses are smooth. Do not disassemble the needle bearings. Clean with a brush and compressed air. Apply a small amount of SAE 140 oil into each bearing cap and rotate the bearing on the trunnion to check for wear. If there is any indication of wear or damage to the needle bearings, bearing cap or journal crosses, replace the journal and bearings as an assembly.

Check for damage to the splines of the sleeve yoke. Make sure the splines are clean and smooth. Look for damage or distortion of the drive shaft tube. Damage can cause failure of the drive shaft under high torque loads. The drive shaft must be straight to inhibit vibration during operation. Replace the drive shaft if there is damage.

Assembly

Front Axle Drive Shaft

1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap

assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.

4. Repeat steps 1 through 3 on opposite end of drive shaft.
5. Repeat steps 1 through 3 to install the flange yoke to the drive shaft.
6. Apply SAE 140 oil to splines on the sleeve yoke **3** Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke (4). Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

Rear Axle Drive Shaft

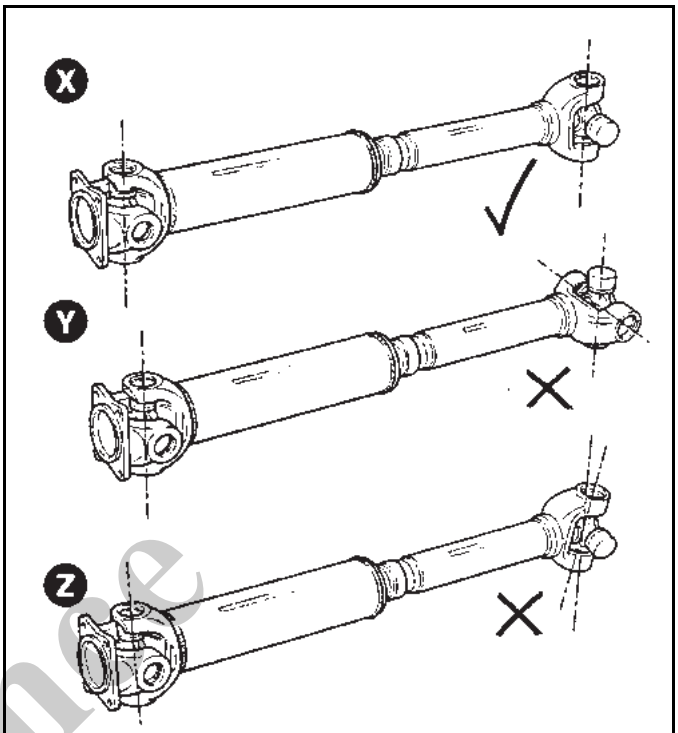
1. If new journal and bearings are not being installed, inspect the seals in the bearing retainers. If they are damaged in any way, replace the complete journal and bearing assembly.
2. Install the journal cross into the yoke of the sleeve yoke. The relief must be towards the sleeve yoke.
3. Apply a small amount of SAE 140 oil to the trunnions on the journal cross. Press the bearings and cap assemblies into place. Use care not to cause damage to the bearings or caps. Install the snap rings. Make sure the snap rings are engaged fully in the groove.
4. Repeat steps 1 through 3 on opposite end of drive shaft.
5. Apply SAE 140 oil to splines on the sleeve yoke **3** Figure 8-50 and Figure 8-51. Assemble the dust cap assembly to the sleeve yoke. Slide the sleeve yoke into the slip yoke **4**. Make sure both ends of the drive shaft are in the same plane. Tighten the dust cap assembly.

Installation

Front Axle Drive Shaft

1. Fasten the flange yoke **5** Figure 8-50 to the parking brake disc on the front axle with eight bolts, lockwashers and nuts.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** Figure 8-52. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.



a0316 **FIGURE 8-52**

2. Fasten the other end to the transmission using a new strap kit.

NOTE: The retaining straps (2) stretch with use, therefore these straps must always be replaced with new ones.

3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See *Lubrication Procedure on page 8-30*.
4. Check the drive shaft for correct balance before the crane is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the engine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

Rear Axle Drive Shaft

1. Fasten cross **1** Figure 8-51 to the front axle yoke using a new strap kit **2**.

NOTE: The retaining straps **2** stretch with use, therefore these straps must always be replaced with new ones.

2. Fasten the other end cross **1** to the transmission yoke with a new strap kit **2**.

NOTE: The drive shaft must have both ends exactly on the same plane as shown in **X** Figure 8-52. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.

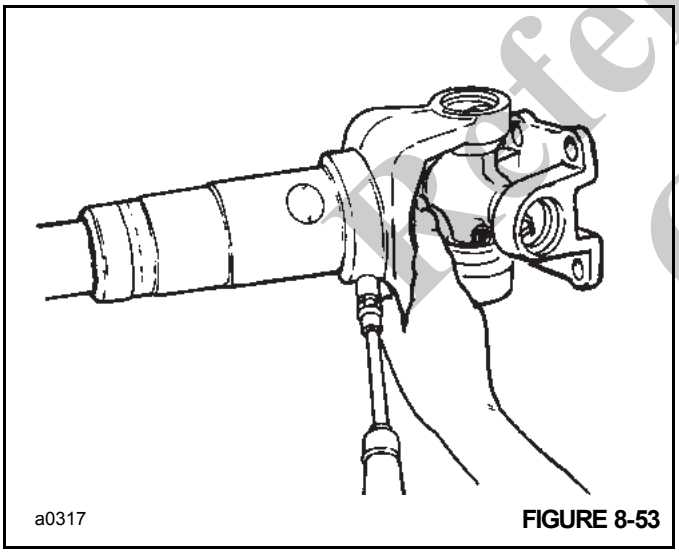
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3. Apply grease with a grease gun to the fittings on the journal crosses and on the slip joint. Apply grease until it exists through the seals. See Lubrication Procedure on this page.
4. Check the drive shaft for correct balance before the machine is put into operation. Lower the outriggers to lift the wheels off the ground. Operate the drive train and check for vibration. If vibration is found, stop the machine and check the drive shaft. Make sure the drive shaft yokes are in the same plane.

Lubrication Procedure

The drive shaft is an important part of the drive train and needs regular maintenance. There is a grease fitting on the slip joint and on each journal cross. Apply grease to these fittings every week or 50 hours of operation, whichever occurs first. Use Lithium based, E.P. No. 2 bearing grease. Always apply enough grease to the fitting to remove old grease. On the slip joint, apply grease to the fitting until the grease comes through the hole in the end off the shaft. Put your finger over the hole Figure 8-53 and continue to apply grease until the grease shows at the seal on slip joint.

At each lubrication, check the drive shaft for side movement. As wear in the bearings increases, the side movement will increase. Movement must be to minimum to prevent vibration during operation.



a0317 **FIGURE 8-53**

WHEELS & TIRES

WARNING

Never try to disassemble the wheel until all air is released from the tire. The retaining ring and rim of the wheel and tire can come off with explosive force and can cause serious injury or death. Be extremely careful when working with them. Always use a tire and rim cage guard when inflating tires.

Tire Inflation

Check the tire pressure daily before operation. Also look for cuts and damage.

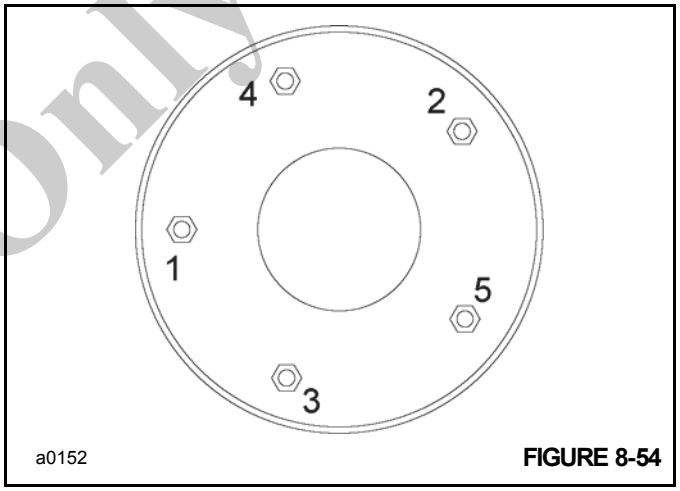
Tire Pressures

Tire Size	Pressure
12:R20 Radial	9.31 bar (135 psi)

Wheel Stud Nuts

The tightening order of the stud nuts is shown in Figure 8-54. Check the tightness of the lug nuts weekly or after every 50 hours of operation, whichever occurs first.

Wheel stud torque is 680 Nm (500 lb-ft).



a0152 **FIGURE 8-54**

For Reference Only

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BRAKE SYSTEM

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TECHNICAL DATA

Front Axle Brakes

Type	Oil-immersed multi-plate disc
Actuation	Hydraulic
Location	Inboard - Axle center casing (2 brake sets)
Friction Plates	5 per set
Outside Diameter	220 mm (8.66 in)
Inside Diameter	180 mm (7.09 in)
Nominal facing area/plate	12,616 mm² (19.5 in²)
Hydraulic Piston Diameter	216 mm (8.5 in)
Piston Operation	Standard retraction

Rear Axle Brakes

Type	Oil-immersed multi-plate disc
Actuation	Hydraulic
Location	Outboard - Axle hubs
Friction Plates	3 per set
Outside Diameter	220 mm (8.66 in)
Inside Diameter	180 mm (7.09 in)
Nominal facing area/plate	12,616 mm² (19.5 in²)
Hydraulic Piston Diameter	216 mm (8.5 in)
Piston Operation	Standard retraction

Accumulator

Type	Piston, Hydro-pneumatic
Volume	2632 cu. cm (120.63 cu. in)
Nitrogen Recharge Pressure	51.71 ± 2.75 bar (750 ± 40 psi)

Accumulator Charging Valve

Nominal Accumulator Charge Rate	10.2 ± 1.9 L/min (2.7 ± 0.5 gpm)
Nominal High Limit	137.90 ± 3.45 bar (2000 ± 50 psi)
Nominal Low Limit	113.76 ± 3.45 bar (1650 ± 50 psi)

Priority Flow Control Valve

Priority Flow Set At	12.3 L/min (3.25 gpm)
Control Pressure	7.58 bar (110 psi)
Relief Valve Setting	172.37 bar (2500 psi)

For Reference Only

DESCRIPTION

There are two brake systems used on the crane; the service brake system and the parking brake system.

Service Brake System

The service brake system Figure 9-1 consists of the second section of the secondary hydraulic pump, a relief valve included in the priority flow control valve, an accumulator charging valve, a low pressure warning switch, an accumulator, a needle valve, a brake modulating valve, a brake light switch and the front and rear axle service brakes.

Description of Operation

Hydraulic Pump

The pump supplies hydraulic oil flow to the priority flow control valve Figure 9-1.

Priority Flow Control Valve

The priority flow control valve in normal operation supplies oil to the accumulator charging valve. If oil is required for the steering operation the priority flow control valve shifts to furnish flow to the steering system. (See *Steering System on page 10-1*) The priority flow control valve also includes the relief valve used to protect the steering and brake systems.

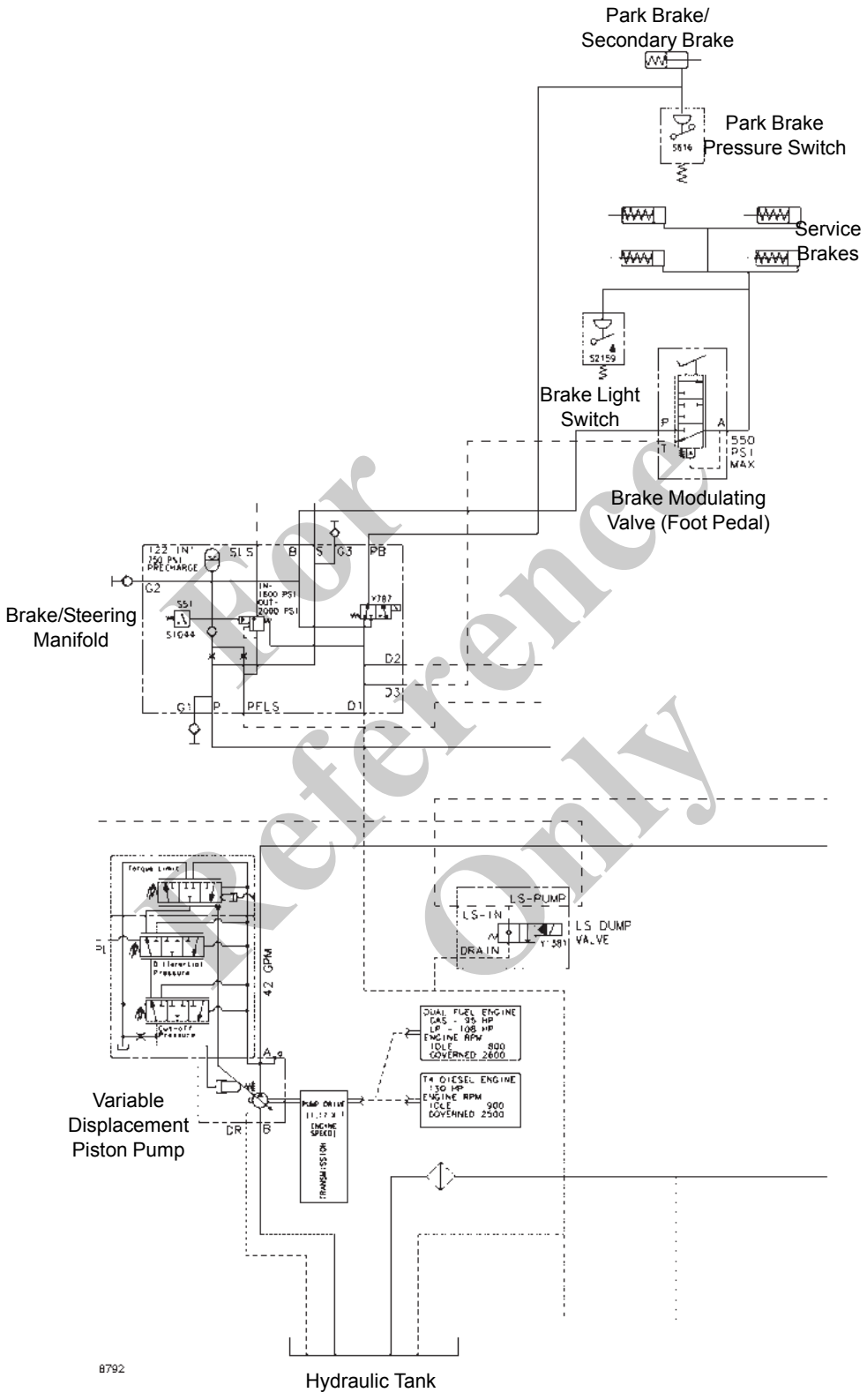
Accumulator Charging Valve

The accumulator charging valve supplies oil to the accumulator on demand. This is accomplished at a preset rate at a selected pressure; neither of which is adjustable.

The flow to the downstream brake modulating valve will be reduced fractionally for a short time when the accumulator is charging. This does not noticeably affect the operation of these components. Full system pressure is available to the downstream components at all times, providing oil delivery and pressure from the pump and relief valve are not impeded.

The accumulator charging flow rates and upper and lower pressure limits are set at the time of manufacture and are not adjustable.

For Reference Only



For Reference Only

FIGURE 9-1

Low Pressure Warning Switch

The low pressure warning switch illuminates a red light on the dash when the brake pressure goes below 58.61 bar (850 psi). When the red light illuminates, there still is enough pressure for brake application to stop the crane. After which, the brake system must be checked and repaired.

Accumulator

The accumulator is a hydro-pneumatic, bladder-type accumulator. This means that the accumulator is charged with nitrogen and stores hydraulic fluid to a pressure of 137.90 bar (2000 psi) for brake system usage.

Brake Modulating Valve

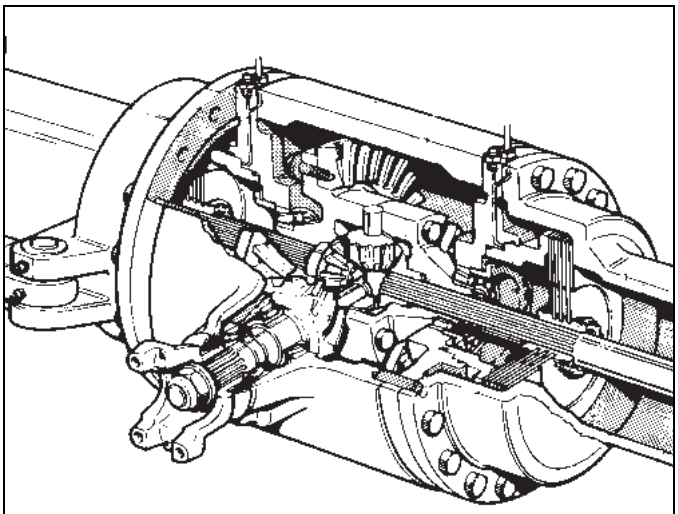
The brake modulating valve is a closed-center spool design. When the valve is in no-applied position, brake port, **A** Figure 9-1 is open to tank port **T**. As the valve is initially actuated, tank port **T** is closed off from brake port **A**. Additional actuation opens pressure port **P** to brake port **A**. More input force will increase the pressure to brake port **A** until actuation effort and hydraulic reaction forces are balanced. When actuation is released, the valve returns to its non-applied position.

Brake Light Switch

The brake light switch illuminates the brake lights when the brake modulating valve builds system pressure to 4.14 bar (60 psi).

Front Axle Brakes

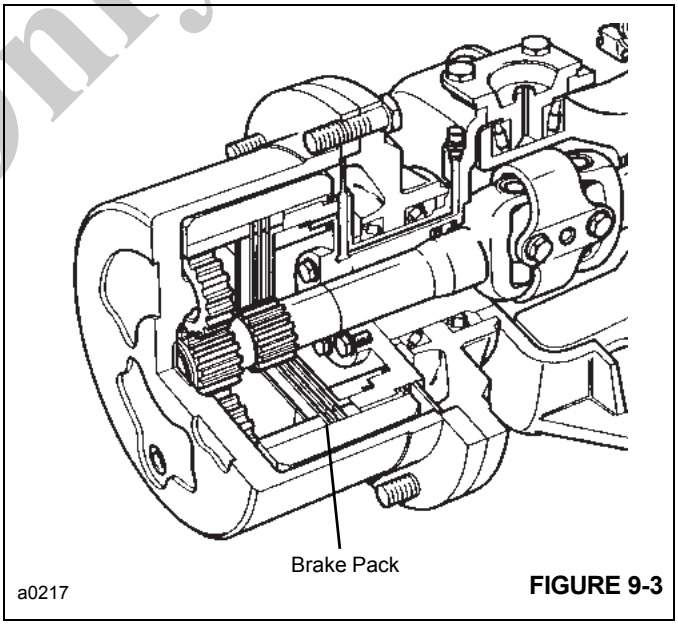
The front brakes are self-adjusting oil immersed and are located on both sides of the axle center housing Figure 9-2. Each brake assembly consists of five friction plates and six counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of the axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.



a0216 **FIGURE 9-2**

Rear Axle Brakes

The rear brakes are self-adjusting, oil immersed and are located in each axle hub Figure 9-3. Each brake assembly consists of three friction plates and four counter plates. The brakes are applied when the brake pedal in the operator's compartment is actuated. Brake fluid is forced from the master cylinder through the brake lines to both of the axle brakes. The brake fluid under pressure reacts against the brake pistons, forcing the friction plates against the counter plates, slowing and/or stopping the crane.



a0217 **FIGURE 9-3**

For Reference Only

9

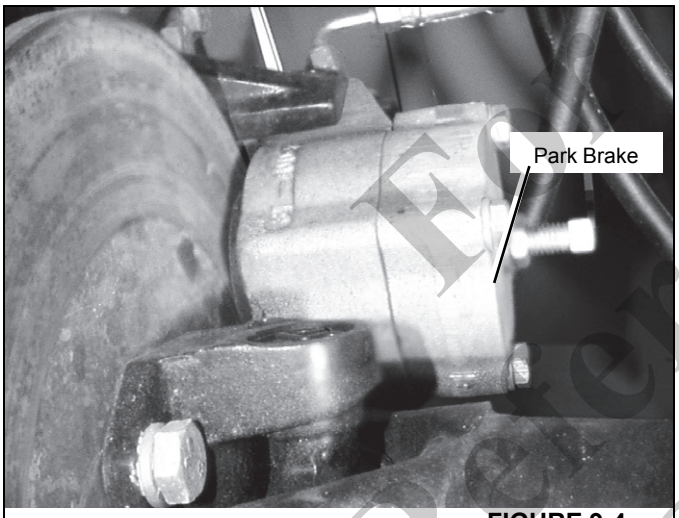
Parking Brake System

Description of Operation

The parking brake system consists of a two-way switch in the instrument panel, a solenoid valve and a parking brake. The system connects into the service brake system and uses the accumulator for system pressure.

Parking Brake

The parking brake is a disc-type brake Figure 9-4. The brake disc is attached to the input shaft of the front axle. The brake is attached to the frame behind the front axle. When the parking brake switch is placed in the engage position, hydraulic supply is shut off to the parking brake and the springs in the parking brake apply the brake pads against the brake disc, holding the crane from moving.

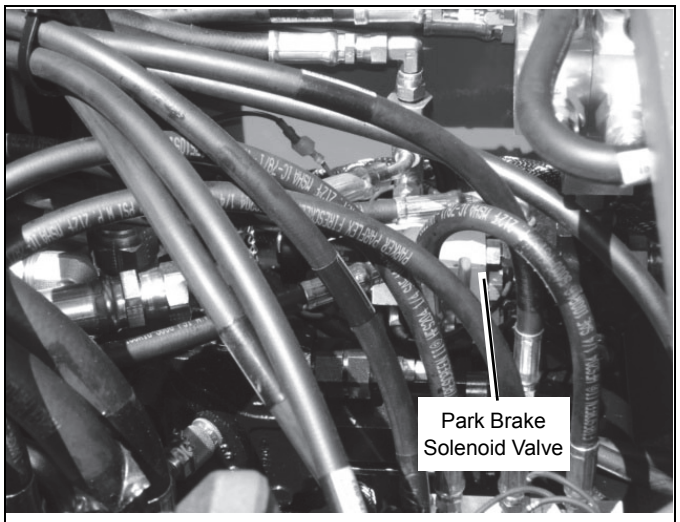


p0329 **FIGURE 9-4**

Parking Brake Solenoid Valve

The parking brake solenoid valve Figure 9-5 is activated by the parking brake switch in the operator's instrument panel. It is a normally-closed solenoid valve. When the switch is placed in the ENGAGE position, no current is sent to the solenoid valve, thus the solenoid valve remains closed and the parking brake is engaged.

When the parking brake switch is placed in the DISENGAGE position, electrical current is sent to the solenoid valve. The solenoid shifts the spool in the valve to open the circuit to the parking brake. The hydraulic fluid, under pressure, disengages the brake pads from the brake disc. Even though the parking brake switch may be in the DISENGAGE position, in the event of a loss of pressure in the accumulator below what it takes to apply the service brakes, the parking brake will engage.



p1870 **FIGURE 9-5**

MAINTENANCE AND ADJUSTMENTS

Service Brake Bleeding

When ever a brake line is disconnected, the brake system must be bled to remove any trapped air. Air in the brake lines will cause the brakes to be spongy.

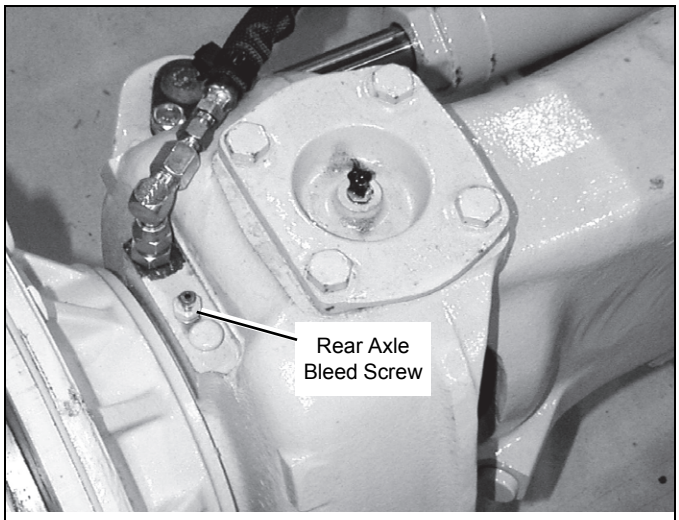
NOTE: Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

The accumulator must be drained of pressure before working on the brake system. This can be done by pumping the brake pedal with the engine off until the pressure is relieved completely.

Rear Axle

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to the right hand bleed screw **A** Figure 9-6 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply full pedal strokes of the brake pedal until all air is expelled.
4. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 using the left hand bleed screw.

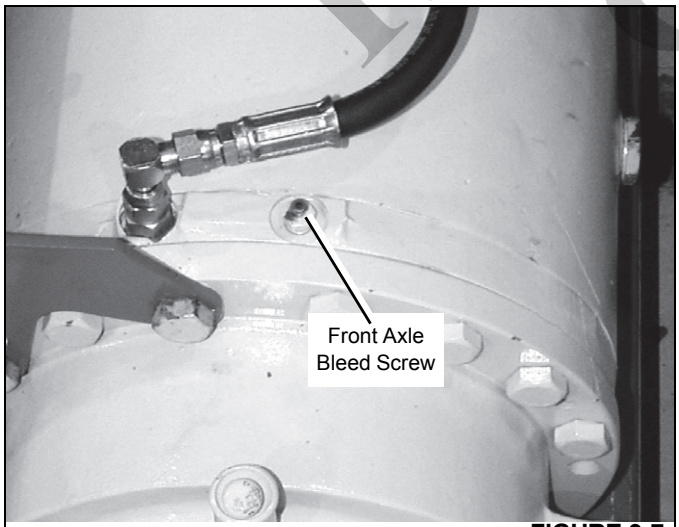
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p0085 **FIGURE 9-6**

Front Axle

1. Engage the parking brake and shut off the engine. Block the rear wheels on both sides.
2. Attach a tube to one of the wheel bleed screws Figure 9-7 ensuring that the free end of the tube is immersed in fluid contained in a suitable container.
3. Open the brake bleeder screw and apply one rapid stroke of the pedal followed by three rapid short strokes from the pedal half way down. After the third short stroke allow the pedal to return quickly to its stop.
4. Continue bleeding normally until all air is expelled. Close the brake bleed screw with the pedal fully depressed.
5. Repeat steps 2 through 4 for the other side.



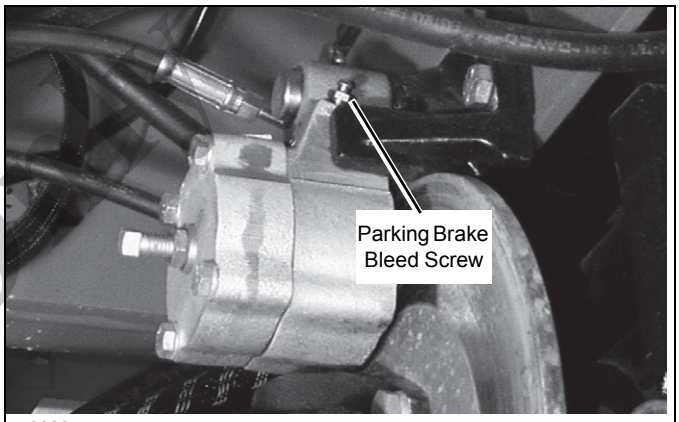
p0086 **FIGURE 9-7**

Parking Brake Bleeding

NOTE: Before working on the brake system, make sure the crane is on level ground and that all four wheels are chocked.

The accumulator must be drained of pressure before working on the brake system. This can be done by pumping the brake pedal with the engine off until the pressure is relieved completely.

1. Engage the parking brake and shut off the engine. Block all wheels on both sides.
2. Attach a tube to the bleed screw on the parking brake Figure 9-8 and place the other end in a suitable container.
3. Open the bleed screw, then disengage the parking brake.
4. Observe the fluid exiting the hose. When there is no air or fluid being released, close the bleed screw with the parking brake still disengaged.
5. Engage the parking brake.
6. Repeat steps 3-5 as needed until no air is release from the fluid.



p0828 **FIGURE 9-8**

Parking Brake Adjustment

WARNING

Before adjusting the parking brake, make sure that the machine is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the adjustment.

For Reference Only

When the parking brake is engaged and it will not hold the crane in position it may be necessary to adjust the parking brake disc pads.

1. Shut off the engine and place chock blocks in front and behind all four wheels. Release the parking brake. Check that the brake moves freely on the guide/slide pin.
2. Loosen the lock nut and adjusting screw Figure 9-9.
3. Place a 0.030 mm (0.012 in) feeler gauge between the disc and one of the linings.
4. Tighten the adjusting screw until it is just possible to remove the feeler gauge.
5. Tighten the jam nut while holding the adjusting screw with a wrench. Remove the feeler gauge.
6. Engage the parking brake. Then, release the parking brake and recheck that the brake moves freely on the guide/slide pin.

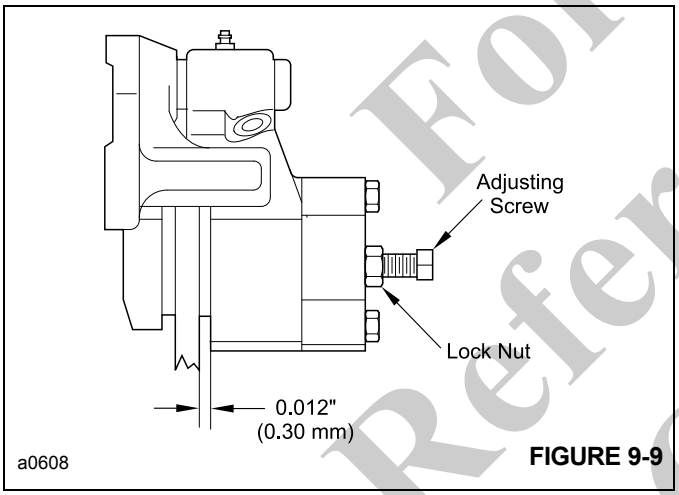


FIGURE 9-9

Accumulator Charging

The accumulator must be charged with NITROGEN. Do not use compressed air. Remove the rubber cap over the charging valve on top of the accumulator and install nitrogen charging apparatus. Charge the accumulator to 51.71 ± 2.75 bar (750 ± 40 psi).

Residual Brake System Pressure

If residual pressure is greater than the pressure required to overcome the brake retraction springs in the axle, brake piston retraction will not occur resulting in excessive heat and wear on the brake components,

If the residual pressure in the braking system is above 0.35 bar (5 psi) in the hot condition, the system should be checked to identify the cause of the problem.

NOTE: Pressure cannot build up in the hydraulic tank until the oil is hot, or if the pressure is vented by removing the tank cap/breather.

Checking For Residual Pressure

The following should be done with the engine running and the hydraulic oil at working temperature.

1. Apply and release the brakes. Check that the brakes release immediately.
2. If the brakes do not release immediately, place a container under the axle hub to collect any spilled oil. Unscrew the bleed nipple on the axle to release any residual pressure.

NOTE: The same effort should be needed to rotate the hub with bleed nipple either open or closed. If the problem affects only one hub, disassemble and inspect the affected hub.

3. If the brakes release immediately, residual pressure should be suspected.
4. If the brakes do not release immediately, tighten the bleed nipple and check the following:
   a. Operation of the hydraulic tank breather.
   b. Foot brake valve operation.
   c. Hydraulic tank is overfilled.

TESTS

Brake Piston Seal Leakage Test (Front Axle Only)

The following test procedure explains how to check if a brake piston is severely damaged/destroyed or if the seals have a small cut or nick. The test procedure must only be done when the axle is COLD.

NOTE: Before working on the brake system make sure the crane is on level ground and chock all four wheels.

Do not drive the crane with any part of the brake system disconnected. When the test has been completed, reconnect all brake lines and bleed the brake system using recommended procedures, page 9-6.

1. With the engine shut off and the parking brake engaged, actuate the brake foot pedal until no resistance is felt and the system pressure has been released.

NOTE: Do not disconnect any lines until the brake circuit pressure has been released.

2. Remove and cap the brake piston feed line **A** Figure 9-10.

For Reference Only

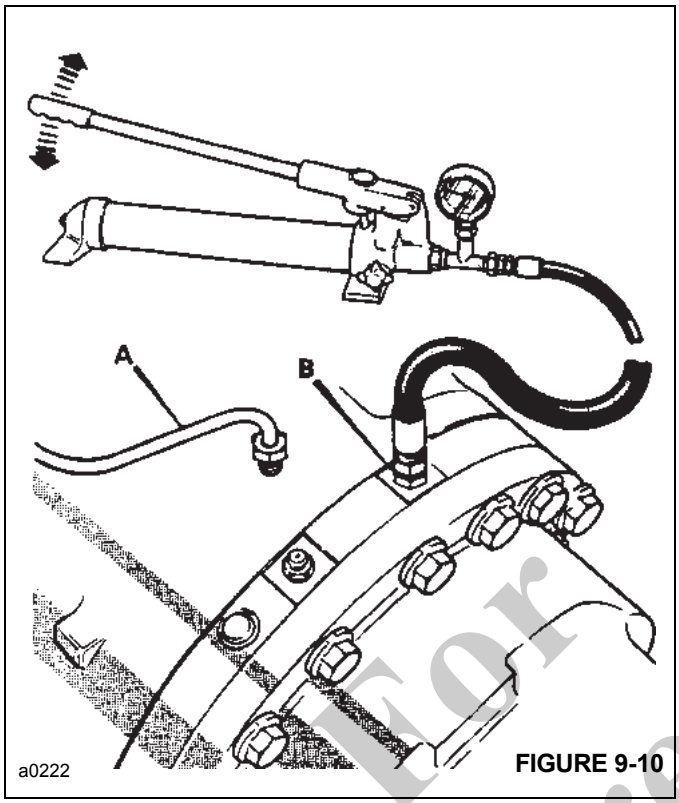


FIGURE 9-10

3. To check for severe piston seal damage:
   a. Fill the housing of hand pump with Mobil fluid 424, or equivalent hydraulic oil.
   b. Install the hand pump fitted with a 0 to 68.90 bar (0 to 1000 psi) pressure gauge to port **B** Figure 9-10.

NOTE: The hand pump MUST be filled with Mobil fluid 424 or equivalent hydraulic oil. System pressure is 37.90 bar (550 psi) DO NOT exceed 41.34 bar (600 psi).

   c. Use the hand pump to generate a pressure in the brake piston housing.
   d. If the pressure falls off rapidly, or if no pressure reading can be obtained, the seals are severely damaged and must be replaced.

4. If pressure falls off slowly, the piston seals may have small cuts or nicks. To verify for small cuts or nicks in the piston seals perform the following test:
   a. Install an adapter fitted with a piece of clear tube (approximately 120 mm (4.75 in) long to the brake piston port **B** Figure 9-11.

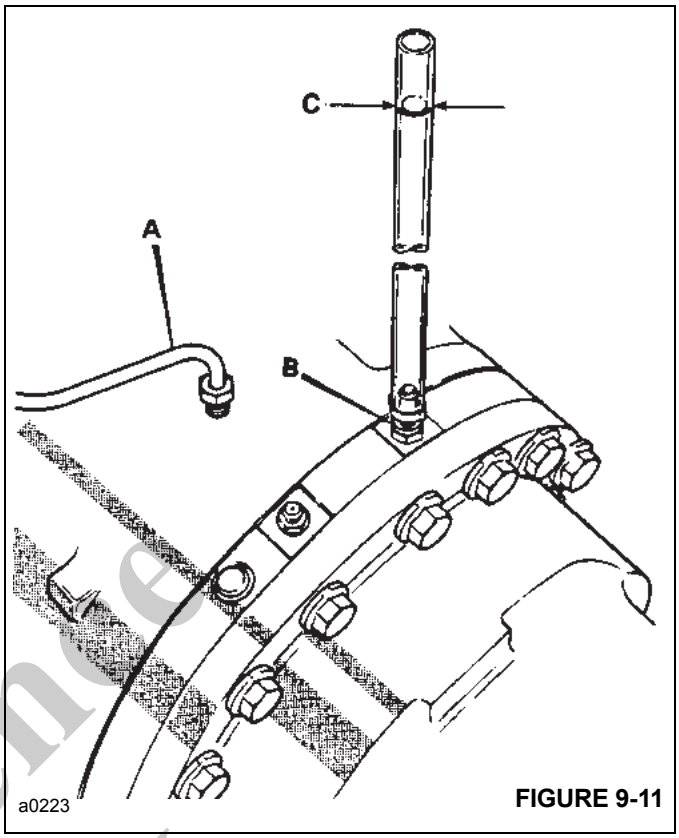


FIGURE 9-11

NOTE: The tube must be kept vertical during the test. Use tape to attach the tube to the side of machine.

   b. Fill the tube until is approximately three quarters full with Mobil fluid 424 or equivalent hydraulic oil.
   c. Using a suitable pen, mark the level line (**C**) of the fluid in the tube.
   d. After approximately 1/2 hour, check if the level has dropped below the original marked line. If it has then check the brake piston seals for slight nicks, cuts or general wear.

5. Repeat steps 3 through 5 for the opposite brake piston seals.
6. Reconnect all brake lines and bleed the brake system as recommended on page 9-6.

SERVICE BRAKE REPAIR

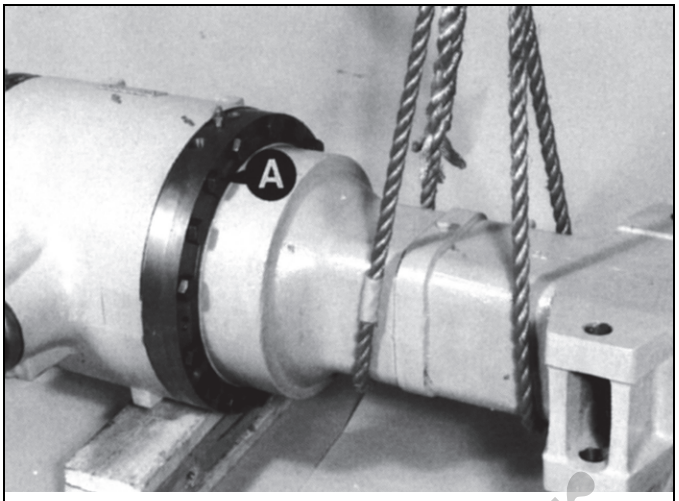
Front Axle Brakes

NOTE: It is recommended that the axle be removed from the machine when disassembling the front axle brakes. See Servicing the Front Axle in Section 8.

For Reference Only

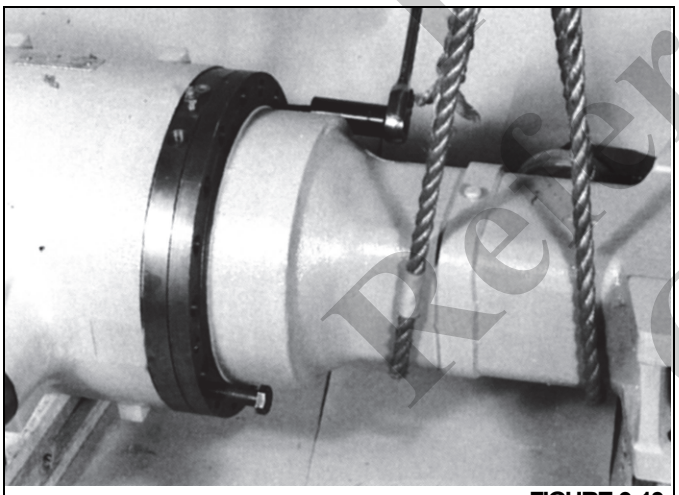
Disassembly

1. Support the axle arm Figure 9-12 and remove bolts **A**.



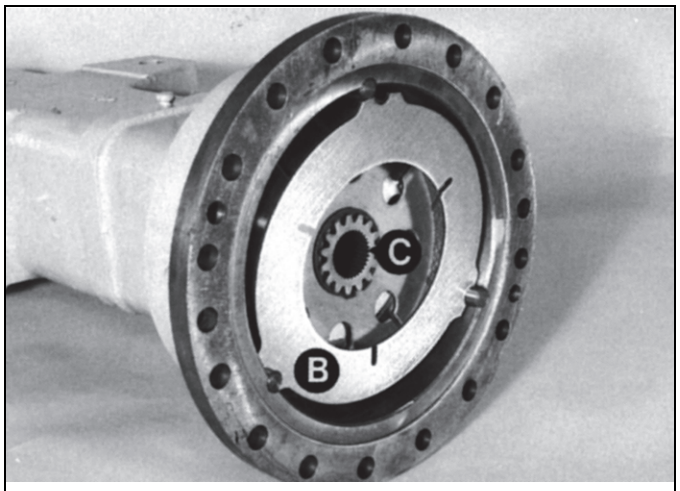
p0088 **FIGURE 9-12**

2. Jack the axle arm off the drive head, using drive head securing bolts Figure 9-13. Remove all traces of gasket from the mating surfaces.



p0089 **FIGURE 9-13**

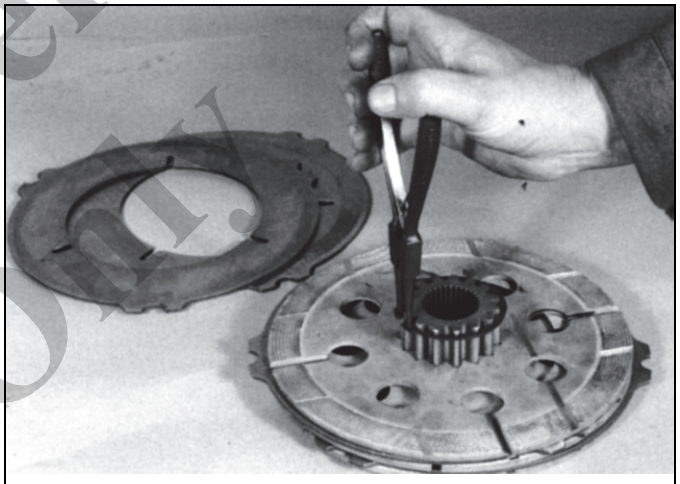
3. There are two counterplates **B** Figure 9-14 one at each end of the brake pack, which are secured to the plate carrier **C**. If the plates are to be reused, note their position and which way round they are then remove the brake pack.



p0090 **FIGURE 9-14**

4. Remove the retaining ring Figure 9-15. If the brake pack is to be reused, note the position of the plates before removing them.

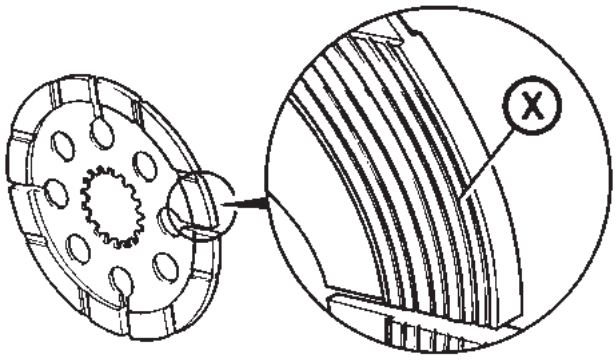
NOTE: The planet carrier has an internal chamber at the end which faces away from the drive head.



p0091 **FIGURE 9-15**

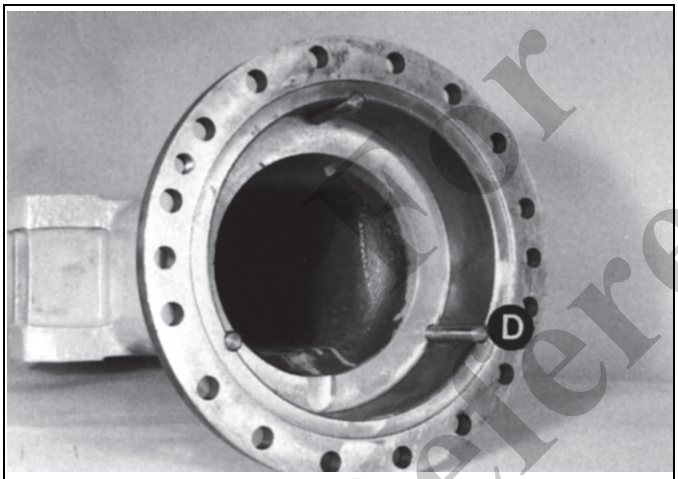
5. Wear limit of friction plates is to the depth of the circumferential grooves **X** Figure 9-16. Check all plates for flatness and damage. (Some scoring of the counterplates is normal.) Completely replace the brake pack if worn or damaged. Do not replace individual plates.

For Reference Only



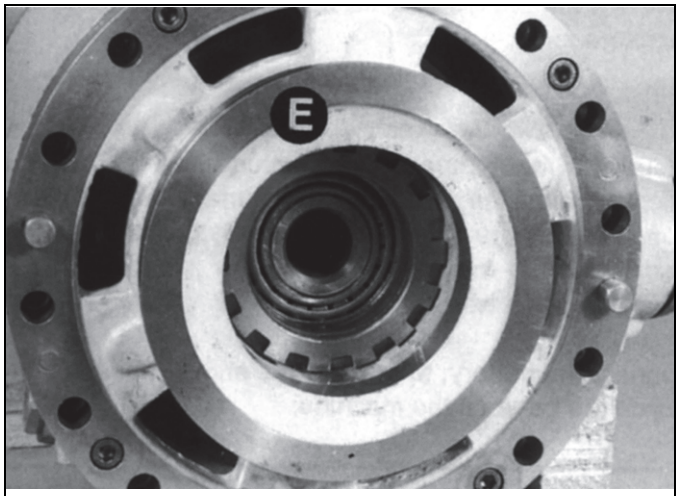
a0228 **FIGURE 9-16**

6. Remove the three reaction pins **D** Figure 9-17. Inspect for damage.



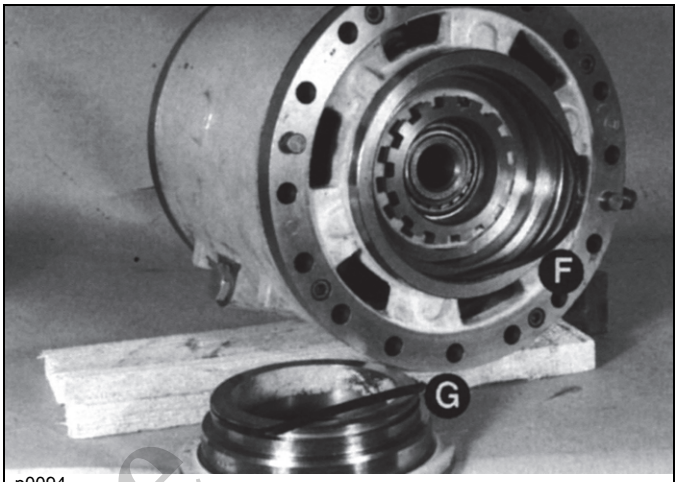
p0092 **FIGURE 9-17**

7. Carefully remove brake piston **E** Figure 9-18 from its housing, if removal is necessary. A hydraulic hand pump can be used to force the piston out of the housing.



p0093 **FIGURE 9-18**

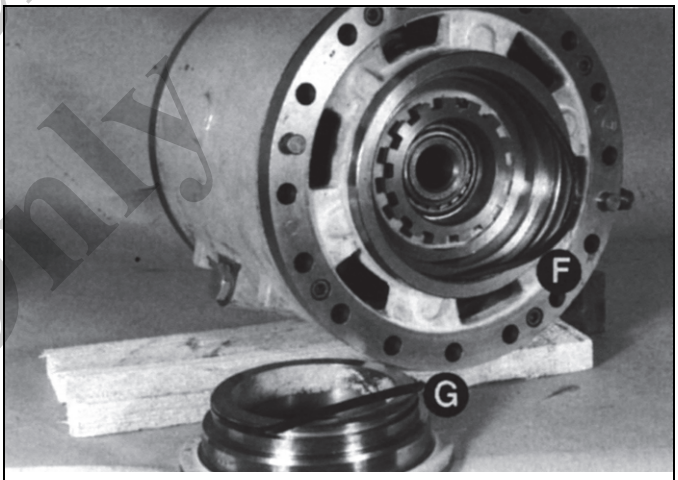
8. Remove and discard seals **F** and **G** Figure 9-19. Inspect the housing for damage and scoring. Nicks or cuts in the seals may be responsible for loss of brake fluid.



p0094 **FIGURE 9-19**

Assembly

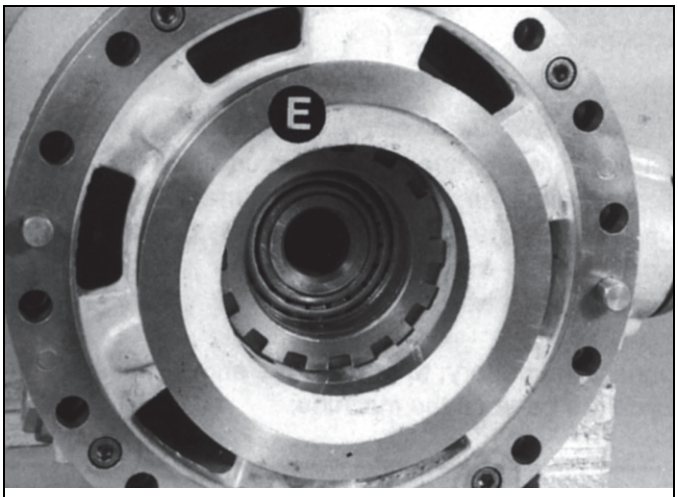
1. Install new seals **F** and **G** Figure 9-20. Make sure they seat squarely in their grooves.



p0094 **FIGURE 9-20**

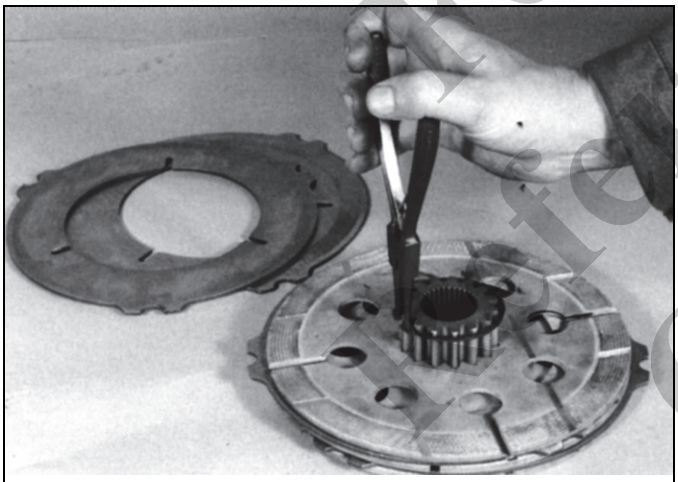
2. Carefully press piston **E** Figure 9-21 all the way into its housing.

For Reference Only



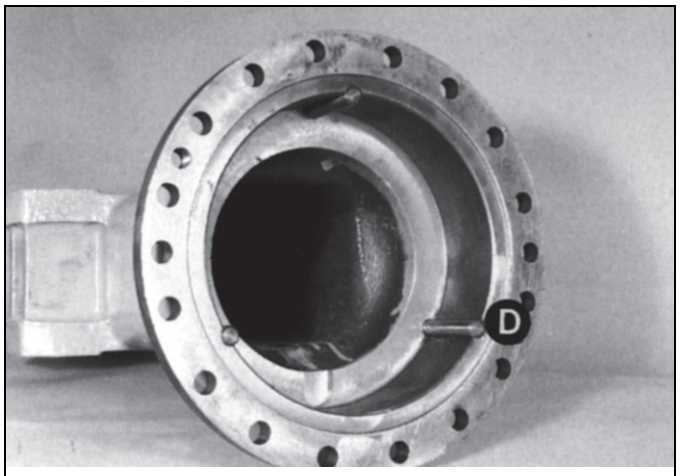
p0093 **FIGURE 9-21**

3. Assemble the friction plates and counterplates onto the carrier. If the original brake pack is being reused, return the plates to their original positions (see Disassembly step 3). Soak new friction plates in gear oil before assembly. Install retaining ring Figure 9-22.



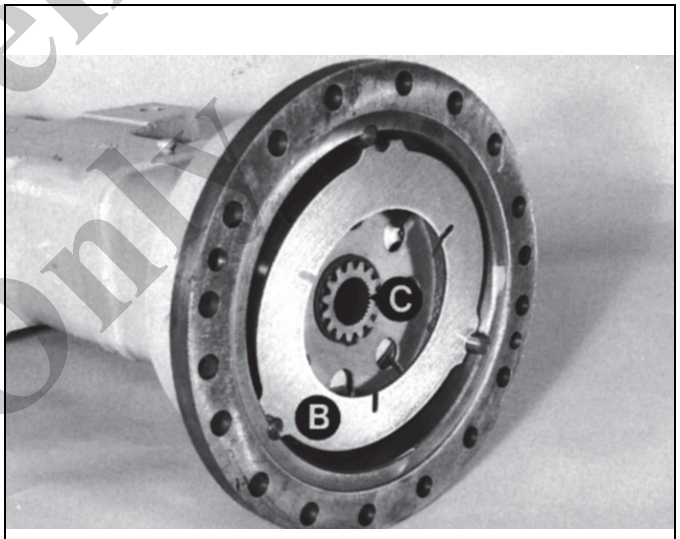
p0091 **FIGURE 9-22**

4. Locate the three reaction pins **D** Figure 9-23 into their grooves, securing them with grease. Push the pins fully into their location holes in the housing.



p0092 **FIGURE 9-23**

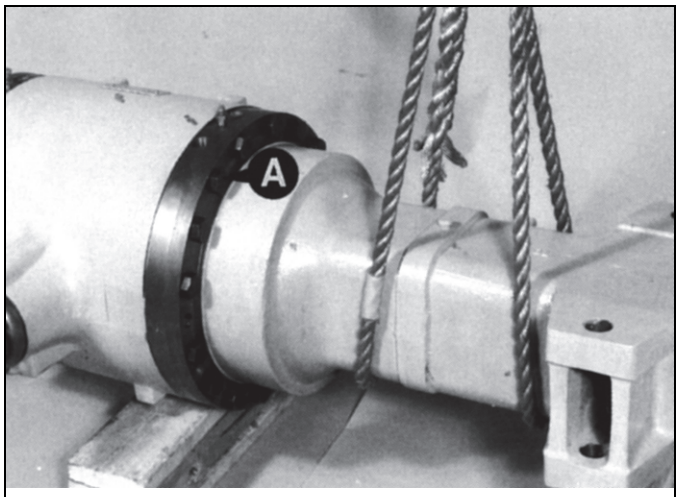
5. Install one counterplate **B** Figure 9-24 into the housing, then the brake pack, then the other counterplate. Ensure that the chamfered end of the brake carrier **C** faces away from the drive head. Return reused counterplates to their original positions. Push the brake pack fully home.



p0090 **FIGURE 9-24**

6. Apply Loctite® 275 to the mating face of the drive head. Locate the axle arm onto the drivehead, with the embossed word “TOP” on the axle arm up most.

Reference Only



p0088 **FIGURE 9-25**

7. Install bolts **A** Figure 9-25 and tighten to a torque of 244 Nm (178 lb-ft).

NOTE: Check the grade of bolts installed. Grade 8.8 should be tightened to a torque of 244 Nm (178 lb-ft). Grade 12.9 bolts should be tightened to a torque of 400 Nm (295 lb-ft).

8. Fill the axle with recommended lubricant. See *Preventative Maintenance on page 5-1*.

9. Install the axle to the crane's frame. Refer to *Axles/Drive Shafts/Wheels and Tires on page 8-1*.

Rear Axle Brakes

Refer to *Axles/Drive Shafts/Wheels and Tires on page 8-1* for Axle Hub Assembly Service. The service instructions include disassembly, replacement and assembly of the rear axle brakes.

For Reference Only

PARKING BRAKE REPAIR

Lining Kit Replacement

WARNING

Before replacing the parking brake linings, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

NOTE: The new linings must be kept free of grease, oil, etc.

The lining kit is indicated in Figure 9-26 with a ■ symbol.

1. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.
5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake.
6. Separate the mounting bracket assembly **31** from the brake assembly.
7. Clamp the brake in a vice with soft jaws with the clearance slot facing straight up.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

8. Remove two screws **27** through access holes in housing **26**. Using a thin blade tool, pry lining **25** from housing **26** and remove the lining and two bushings **24** through the disc clearance slot.
9. Rotate lining assembly **22** until screws **21** are aligned with the access holes in housing **26**. Remove the two flat head screws **21**. Pry lining **20** from piston **19** and remove the lining through the disc clearance slot.
10. Install new lining **20** into piston **19** through the disc clearance slot. Install new flat head screws **21** and tighten to a torque of 3.4 - 4.5 Nm (30-40 lb-in).
11. Insert new bushings **24** into new lining **25**. Install the new lining into housing **26** through the disc clearance slot. Line up the holes with the housing and fasten with two new screws **27**. Tighten to a torque of 2.5 - 3.2 Nm (22-28 lb-in).
12. Assemble the brake assembly onto mounting bracket **31**. Install the parking brake assembly onto the frame of the crane. Attach the hydraulic hose.
13. Adjust the lining clearance as described on page 9-7.
14. Open the accumulator needle valve and then bleed air from the system as described on page 9-6.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

For Reference Only

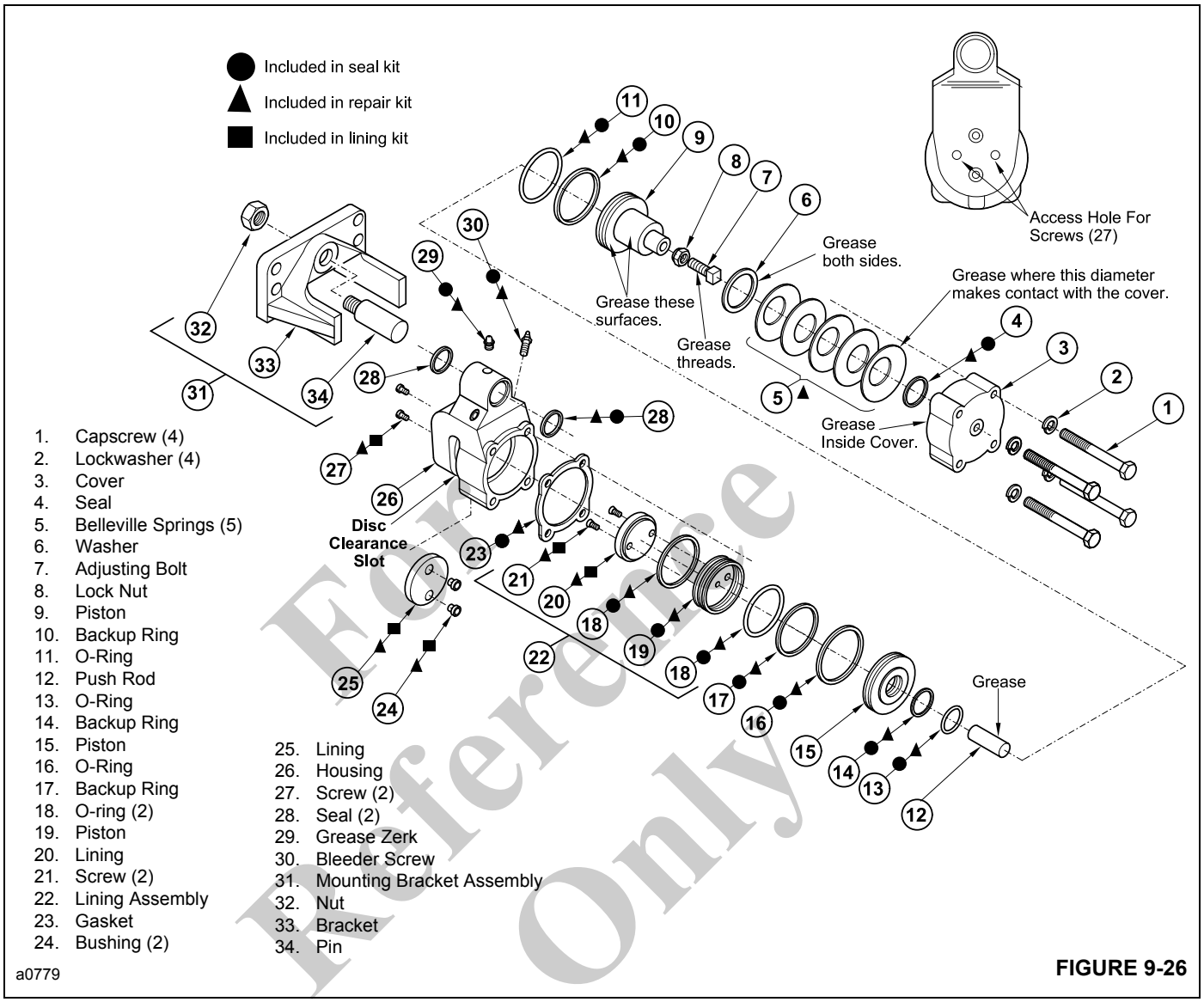


FIGURE 9-26

For Reference Only

Repair Kit Installation

The parking brake has a repair kit available. It includes all the parts necessary to rebuild the brake. These parts are indicated in Figure 9-26 with a ▲ symbol.

WARNING

Before repairing the parking brake, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

NOTE: When removing seals and backup rings be careful not to scratch or mar the pistons.

The new linings must be kept free of grease, oil, etc.

1. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.
2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.
3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.
4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.

5. Remove the bolts and nuts used to fasten the brake mounting bracket assembly to the crane. Remove the parking brake assembly.

6. Separate the mounting bracket assembly **31** from the brake assembly.

7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

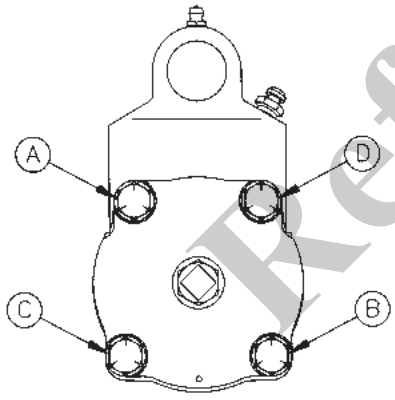
8. Remove bleeder screw **30**.

9. Using a sharp bladed tool, carefully remove two seals **28** from housing **26**. Note the direction the seals were installed.

WARNING

Cap (3) is under spring pressure. Use care when removing the cap to prevent personal injury.

10. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27 until spring pre-load is released.



a0783 **FIGURE 9-27**

11. Remove capscrews **1** Figure 9-26, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade screw driver, remove seal **4** from cover **3**.

12. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.

13. Remove piston **9** from housing **26** bore. Remove O-ring **11** and backup ring **10** from the piston. Push rod **12** should also come out with piston **9**.

14. Remove piston **15** from housing **26** bore. Remove O-rings **13** and **16** and backup rings **14** and **17** from piston **15**.

15. Remove lining and piston assembly **22** from housing **26** bore. Holding assembly on a flat surface, separate lining **20** and piston **19** by removing two flat head screws **21**. Remove O-rings **18** from piston **19**.

16. Loosen vice jaws and rotate the brake so that the disc clearance slot is facing upward. Remove pan head screws **27**, lining **25** and bushings **24** from housing **26**.

17. Lubricate all rubber components (NOT THE BRAKE LININGS) in clean hydraulic oil. Use the same type as used in the hydraulic system.

18. Clean all parts (EXCEPT LININGS) and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces indicated in Figure 9-26 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

19. Install new lining **25** Figure 9-26 in housing **26** using new bushings **24** and pan head screws **27**. Tighten the screws to 2.5 - 3.3 Nm (22-28 lb-in).

20. Install new lining **20** on piston **19** using new flat head screws **21**. Tighten screws to a torque of 3.4 - 4.5 Nm (30-40 lb-in). Install new O-rings **18** on piston **19** and insert lining and piston assembly **22** into housing **26** bore.

21. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.

22. Install bleed screw **30**. Tighten to a torque of 12.2 - 20.3 Nm (9-15 lb-ft).

23. Install new O-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.

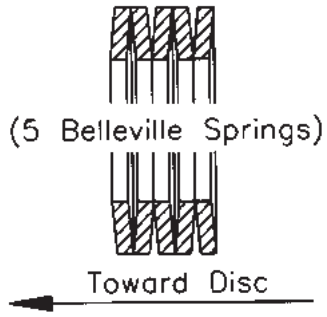
24. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-rings on the inlet ports.

25. Install new backup ring **10** and new O-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.

26. Fully lubricate the threads of adjusting screw **7** and lock nut **9** and install into cover **3**.

27. Install washer **6**, if used, and new belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-28.

For Reference Only



a0782 **FIGURE 9-28**

28. Install new seal **4** in cover **3**. Be sure inside of cover is coated with grease.

29. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27. When installed, tighten each screw to a torque of 29.8 - 36.6 Nm (22-27 lb-ft).

30. Assemble the brake assembly onto the mounting bracket **31**.

31. Install the parking brake assembly onto the frame of the crane.

32. Attach the hydraulic hose.

33. Adjust the lining clearance as described on page 9-7.

34. Open the accumulator needle valve and then bleed air from the system as described on page 9-6.

Seal Kit Installation

The parking brake has a seal kit available. It includes all the parts necessary to replace all the seals in the brake. These parts are indicated in Figure 9-26 with a ● symbol.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

WARNING

Before replacing the parking brake seals, make sure that the crane is on level ground. Place chocks on both sides of the four tires. Remove the ignition key. If these precautions are not adhered to, the crane could run you over while performing the repair.

NOTE: When removing seals and backup rings be careful not to scratch or mar the pistons.

The linings must be kept free of grease, oil, etc.

1. This will shut off hydraulic pressure to the parking brake. Release system pressure by actuating the service brake pedal until no resistance is felt. Then, engage and disengage the parking brake to release its pressure.

2. Slowly, loosen the hydraulic hose from the parking brake. Some pressure may still be present in the hydraulic hose. Let the pressure escape and then remove the hydraulic hose.

3. Cap the hydraulic hose to prevent contamination from entering the hydraulic system.

4. Loosen lock nut **8** Figure 9-26 and back off adjusting bolt **7**.

5. Remove the bolts and nuts used to fasten the brake mounting bracket to the crane. Remove the parking brake assembly.

6. Separate the mounting bracket **31** from the brake assembly.

7. Clamp the brake in a vice with soft jaws with the cover **3** in a vertical position.

NOTE: Clamping should be done on sides of the brake, not on machined surfaces.

8. Using a sharp bladed tool, carefully remove two seals **28** from housing **26**. Note the direction the seals were installed.

WARNING

Cover **3** is under spring pressure. Use care when removing the cap to prevent personal injury.

9. Loosen but do not remove four capscrews **1**. Loosen screws evenly in the order of **A**, **B, C** and **D** Figure 9-27 until spring pre-load is released.

10. Remove capscrews **1** Figure 9-26, lockwashers **2**, cover **3** and gasket **23**. Using a thin blade, remove seal **4** from cover **3**.

11. Remove belleville springs **5** and if present, washer **6**. When removing the belleville springs take note of the stacking sequence.

12. Remove piston **9** from housing **26** bore. Remove O-ring **11** and backup ring **10** from piston. Push rod **12** should also come out with piston **9**.

13. Remove piston **15** from housing **26** bore. Remove O-rings **13** and **16** and backup rings **14** and **17** from piston **15**.

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14. Remove lining and piston assembly **22** from housing **26** bore. Remove O-rings **18** from the lining and piston assembly.

15. Lubricate all rubber components in clean hydraulic oil. Use the same type as used in the hydraulic system. Keep the linings free of oil, grease and solvents.

16. Clean all parts and housing bore thoroughly with a suitable solvent and then coat them with clean hydraulic oil of the same type used in the hydraulic system. Keep all parts free of contaminants, dirt and debris.

NOTE: Coat the surfaces noted in Figure 9-26 with a Lithium Base, E.P. No. 2 bearing grease or equivalent.

17. Install new O-rings **18** on lining and piston assembly **22** and insert the assembly into housing **26** bore.

18. Carefully install two new seals **28** in housing **26**. Be sure to install the seals the same direction as they were removed.

19. Install new O-rings **13** and **16** and new backup rings **14** and **17** on piston **15**. Be sure they are installed in the correct order.

20. Install piston **15** into housing **26** bore. Be sure piston is installed in the correct direction. Be careful not to pinch the O-ring on the inlet ports.

21. Install new backup ring **10** and new O-ring **11** on piston **9**. Be sure they are installed in the proper order. Install push rod **12** in bore of piston **9**. Install piston into housing **26** bore.

22. Fully lubricate the threads of adjusting screw **7** and lock nut **8** and install into cover **3**.

NOTE: Completely lubricate belleville springs with a light coat of Lithium Base, E.P. No. 2 bearing grease.

23. Install washer **6**, if used, and belleville springs **5** over end of piston **9**. Follow the stacking sequence Figure 9-28.

24. Install new seal **4** in cover **3**. Be sure inside of cover is coated with grease.

25. Install new gasket **23**, cover **3**, lockwashers **2** and capscrews **1**. Tighten the screws evenly in the order of **A**, **B**, **C** and **D** Figure 9-27. When installed, tighten each screw to a torque of 29.8 - 36.6 Nm (22-27 lb-ft).

26. Assemble the brake assembly onto the mounting bracket **31**.

27. Install the parking brake assembly onto the frame of the crane.

28. Attach the hydraulic hose.

29. Adjust the lining clearance as described on page 9-7.

30. Open the accumulator needle valve and then bleed air from the system as described on page 9-6.

NOTE: The needle valve must be in the open position for the brake system to operate properly. If it is not open, the charging pump will cycle every time the brake pedal is depressed and if the crane's engine stops there may not be enough pressure to stop the crane.

BRAKE MODULATING VALVE REPAIR

Removal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane's hydraulics or jacks to support the crane when working under it.

Disconnect the battery cables while you're under the crane to prevent the engine from being started.

1. Raise the crane by lowering the outriggers.

2. Install jack stands under the frame of the crane.

3. Shut off the engine and set the parking brake.

4. Press the foot brake pedal (brake modulating valve) as many times as it takes to release any pressure remaining in the brake system.

5. From underneath the operator's cab, disconnect the hydraulic hoses from the fittings. Plug the hoses to prevent contaminating the hydraulic system.

6. Remove the three capscrews and self-locking nuts securing pedal mounting plate to the cab floor. Remove the brake modulating valve and pedal assembly.

Disassembly

1. Remove the brake modulating valve from the pedal assembly, by removing two capscrews **13** Figure 9-29.

2. Remove boot **1** from piston **2** and housing **12**.

3. Remove piston **2**, springs **3**, **4** and **5**, shims **6** and retainer assembly **7** from housing **12**.

NOTE: Observe and take note of the number of shims **6** being removed from the housing.

4. Carefully remove cup **14** and seal **15** from housing **12** bore. Be careful not to scratch or mar the bore.

For Reference Only

5. Remove end plug **8** and spring **10** from housing **12**. Remove O-ring **9** from plug **8**.
6. Carefully remove spool **11** from end plug **8** end of housing **12**.

NOTE: Be careful not to damage the spool or housing bore as they are a matched set and not sold separately.

Assembly

A seal kit is available for repair of the valve. It consists of the items indicated with a ● in Figure 9-29.

NOTE: Lubricate all rubber components in repair kit with clean hydraulic oil of the same type used in the hydraulic system.

1. Clean all parts before assembling. Use a suitable solvent.
2. Lubricate spool **11** Figure 9-29 with clean hydraulic oil and carefully slide into plug end of housing **12**.

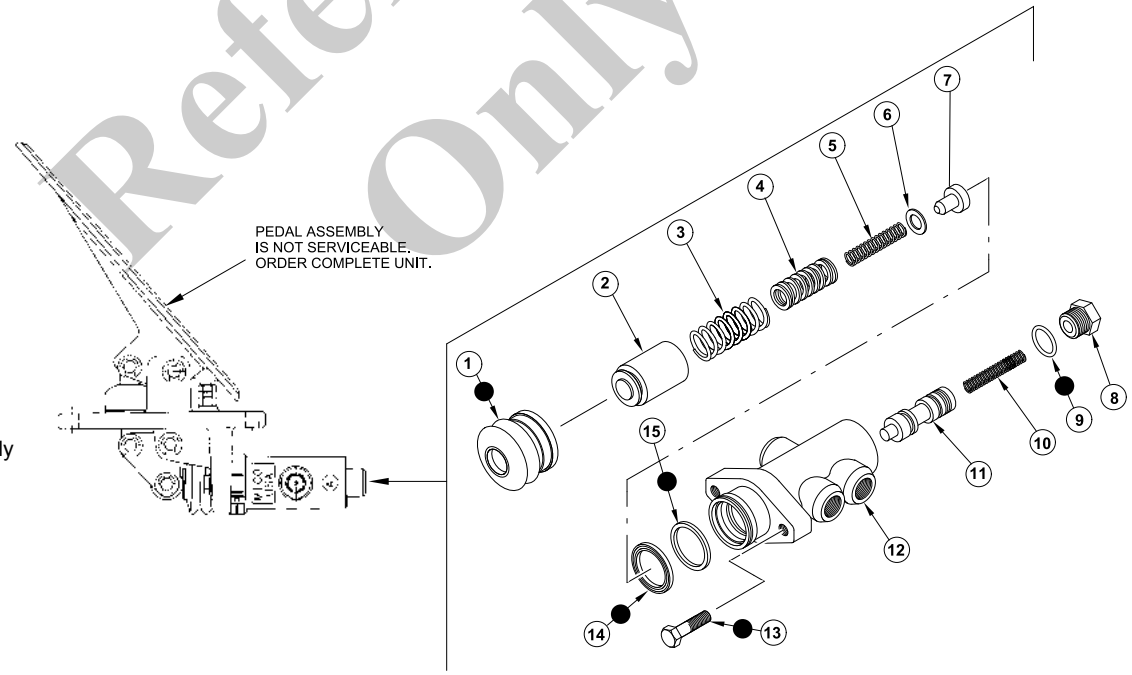
NOTE: The spool must slide freely into the bore. If either part is damaged, a new valve assembly may be required.

3. Install new O-ring **9** on end plug **8**.
4. Install spring **10** and end plug **8** into housing **12**. Tighten to a torque of 54.2 - 67.8 Nm (40 - 50 lb-ft).
5. Carefully install new cup **14** and new seal **15** into bore of housing **12**. Make sure they are installed in the proper order and direction. Take care when installing not to scratch or mar the housing bore.
6. Assemble springs **3**, **4** and **5**, shims **6** and retainer assembly **7** into piston **2**.
7. Carefully install piston **2** assembly into bore of housing **12**.
8. Install new boot **1** on housing **12** and piston **2**.
9. Install the valve assembly onto the pedal assembly with new capscrews (13). Tighten to a torque of 24.4 - 29.8 Nm (18 - 22 lb-ft).
10. After final assembly, the valve must develop a pressure of 37.92 ± 3.45 bar (550 ± 50 psi).

Installation

1. Place the brake modulating valve and pedal assembly in location in the operator's cab. Secure to the cab floor with three capscrews and self-locking nuts.
2. Connect the three hydraulic hoses to the valve.
3. Open the accumulator needle valve and then start the engine. Allow pressure to build in the brake system.
4. Bleed air from the brake system. See page 9-6.

For Reference Only



Brake Modulating Valve

FIGURE 9-29

TROUBLESHOOTING

Service Brakes

PROBLEM	POSSIBLE CAUSE	REMEDY
Warning light on instrument panel illuminates.	**1.** Loss of brake pressure.	**1.** Any cause under NO BRAKES.
No brakes.	**1.** Faulty brake modulating valve.	**1.** Repair or replace.
	2. Faulty priority flow control valve.	**2.** Replace.
	3. Loss of fluid from broken line, loose fitting or hose.	**3.** Check all circuit lines, hoses and fittings. Tighten or replace.
	4. Leakage past both brake pistons.	**4.** Perform leakage test.
	5. Faulty pump section.	**5.** Replace pump.
	6. Faulty accumulator charging valve.	**6.** Replace valve.
Bad brakes (pedal fully applied, crane gradually stops).	**1.** Severe wear in service brake discs.	**1.** Replace brake discs. See Section 8.
	2. Leakage past one brake piston.	**2.** Perform leakage test. Repair or replace. See Section 7.
Soft brake pedal.	**1.** Air in system.	**1.** Bleed brake system.
	2. High pressure leaks - external.	**2.** Apply full brake pressure, inspect for leakage in lines, hoses and fittings.
Charging valve actuates every time foot pedal is pressed.	**1.** Accumulator needle valve closed.	**1.** Open needle valve.
	2. Loss of nitrogen in accumulator.	**2.** Charge accumulator.
	3. Insufficient hydraulic pressure in accumulator.	**3.** Faulty accumulator charging valve. Replace.
Parking brake will not release.	**1.** Faulty solenoid valve.	**1.** Replace solenoid valve.
	2. Loss of fluid from broken line, loose fitting or hose.	**2.** Check all circuit lines, hoses and fittings. Tighten or replace.
	3. Faulty priority flow control valve.	**3.** Replace.
	4. Faulty parking brake switch.	**4.** Replace switch.
	5. Loose electrical connections.	**5.** Check and tighten.
	6. Faulty pump section.	**6.** Replace pump.
Parking brake will not hold.	**1.** Improperly adjusted parking brake.	**1.** Adjust brake lining clearance.
	2. Severely worn brake linings.	**2.** Replace brake linings.
	3. Faulty parking brake assembly.	**3.** Repair or replace.

For Reference Only

SECTION 10
STEERING SYSTEM

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DESCRIPTION

General

The main components of the steering system are the hydraulic pump (Figure 10-1), the priority flow control valve, the load sensing steering orbital, hydraulic tank, two front steering cylinders, two rear steering cylinders and the steering select valve.

When the steering wheel is turned, a pressure demand is sensed by the priority flow control valve through load sensing line between the priority flow control valve and the flow sensing steering orbital.

Oil from the hydraulic pump is then distributed through the priority flow control valve and a check valve to the steering orbital.

When a turn is made, oil is distributed from the steering orbital directly through the steering select valve and/or to the steering cylinders.

When the steering orbital is neutral, the load sense signal is discontinued,

Maximum steering system pressure is controlled by a relief valve in the priority flow control valve.

Steering Modes

The crane can be operated in three steering modes. These modes are selected using the Steering Selector Switch located to the left of the operator on the side instrument panel. The three modes are:

- Two-wheel steering
- Four-wheel steering
- Crab steering

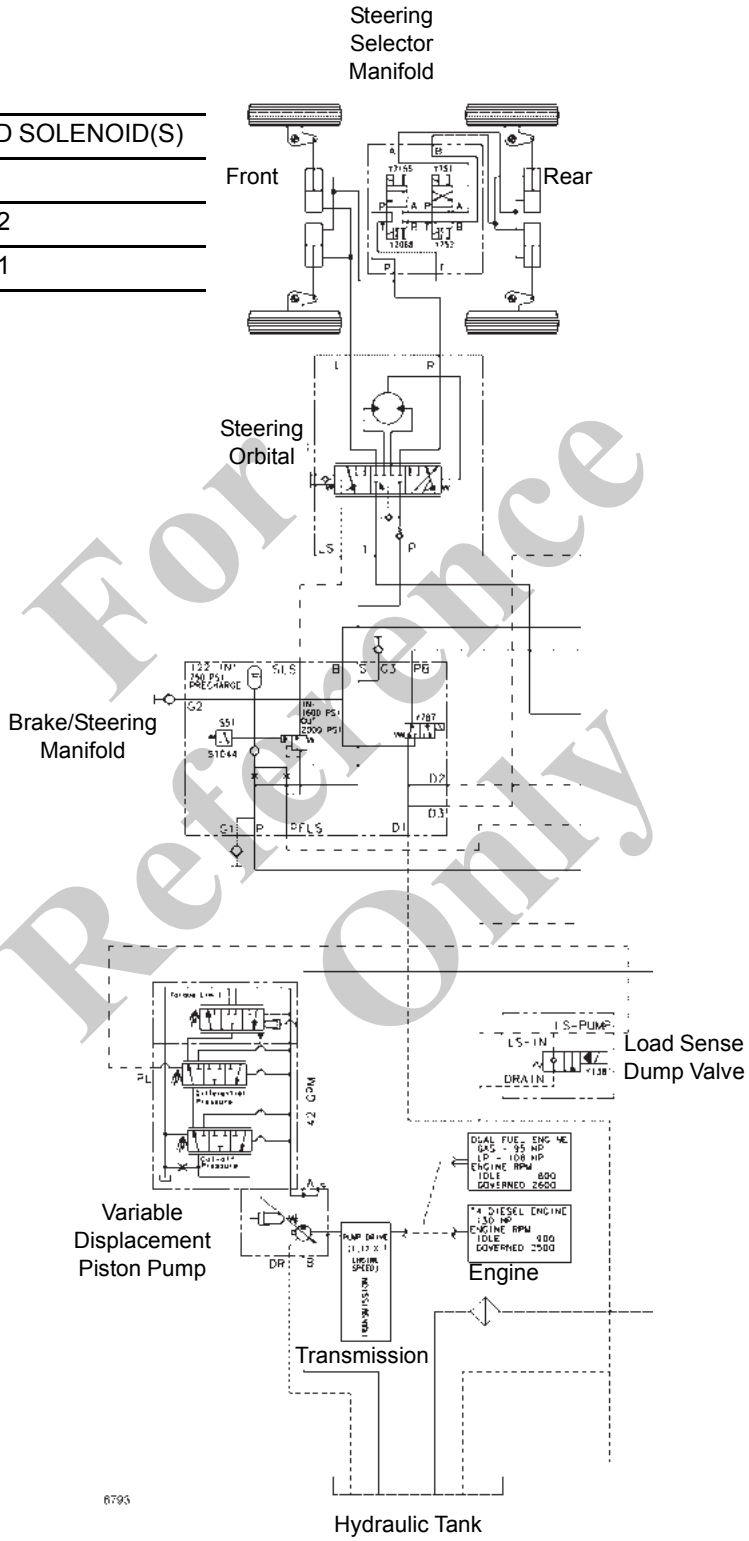
Two-Wheel Steering

During two-wheel steering, the front wheels steer in the same direction that the steering wheel turns. The rear wheels remain in a fixed forward position.

When turning to the right, hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the P port of the steering orbital in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbital to port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operators compartment. When the steering select switch is placed in the two-wheel steering mode solenoid A is actuated. Oil passes through the porting of the valve block to the base end of the front axle steering cylinder. The piston moves to the left, extending the left cylinder rod and retracting the right cylinder rod, creating a right turn. Return oil from the steering cylinder flows into port L, out of port T of the steering orbital and back to tank.

Notes:
1.Y numbers are solenoid wire reference numbers
2.S number are switch wire reference numbers

	ENERGIZED SOLENOID(S)
2WS	Y2068
4WS	Y2155, Y752
CRAB	Y2155, Y751



Steering System

8793-1

FIGURE 10-1

For Reference Only

Four-Wheel Steering

During four-wheel steering, the front wheels steer in the direction that the steering wheel is turned, while the rear wheels turn in the opposite direction. This mode provides an extremely short turning radius. It allows the rear wheels to follow the track of the front wheels, which is an advantage in muddy or sandy conditions.

When turning to the right, hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the P port of the steering orbital in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbital to port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the four-wheel steering mode solenoids C and D are actuated. Oil passes through the porting of the valve block and out port A to the rear axle steering cylinder. Oil is directed to the rod end of the left steering cylinder and base end of the right cylinder, causing the rear wheels to turn to the left. Return oil under pressure from the rear steering cylinders flows into Port B of the steering select valve block and out Port T to the front steering cylinder. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder flows into port L and out of port T of the steering orbital and back to tank.

Crab Steering

During crab steering all the wheels steer in the same direction. This mode allows the operator to move the crane sideways for short distances. This is especially helpful in tight areas on the job.

When turning sideways to the right, hydraulic oil under pressure from the steering pump flows through the priority flow control valve to the P port of the steering orbital in the operator's compartment. When the steering wheel is turned to the right, hydraulic fluid is directed through port R of the steering orbital into port P of the steering select valve. The steering select valve has four solenoid valves. These valves are activated by the steering select switch in the operator's compartment. When the steering select switch is placed in the crab-steering mode solenoids B and C are actuated. Oil passes through the porting of the valve block and out port B to the rear axle steering cylinders. Oil is directed to the base end of the left steering cylinder and rod end of the right cylinder, causing the rear wheels to turn to the right. Return oil under pressure from the rear steering cylinders flows to Port A of the steering select valve block and out port T to the front steering cylinder. The left rod of the steering cylinder extends and the right rod retracts, turning the front wheels to the right. Return oil from the front steering cylinder into port L and out of port T of the steering orbital and back to tank.

STEERING PROXIMITY SWITCHES

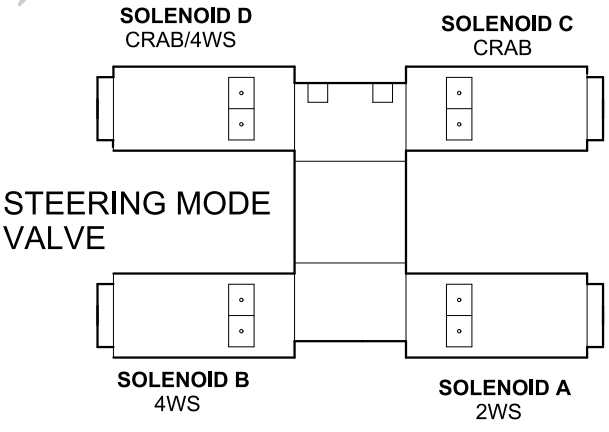
General

The purpose of the steering proximity switches in the steering system is to prevent the changing of steering modes until all wheels are aligned forward. The sensors are positioned on the front and rear axles and are activated when a bracket attached to the steering yoke of the axle, is aligned with the sensor.

Principle Of Operation

The steering system electrical circuit includes two sensors one selector switch, one relay box and two solenoid valves. The selector switch is controlled by the operator in the cab to select the steering modes. The relay box, located under the instrument panel, contains relays that control the steering mode solenoid valves.

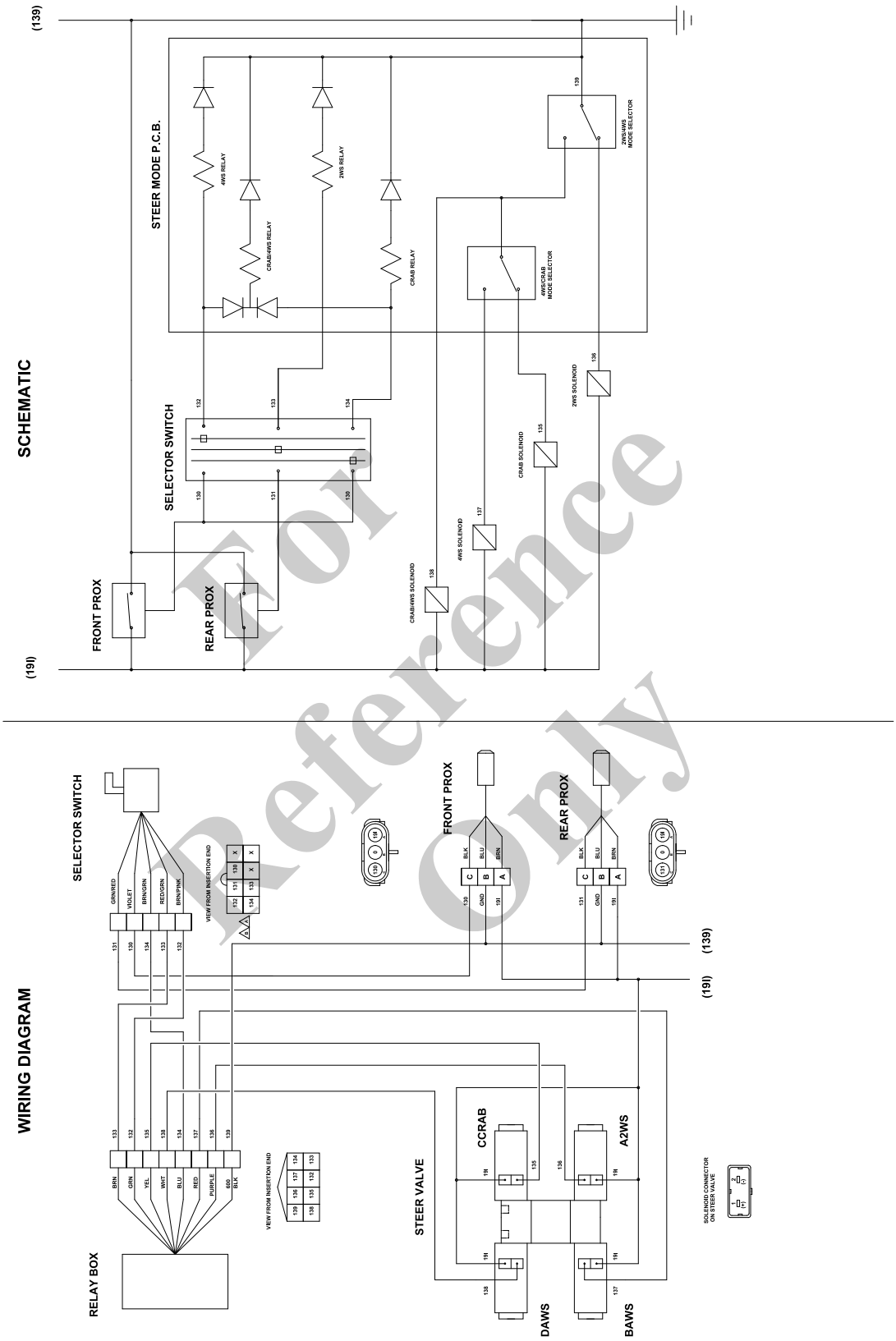
The system is used to select one of the three steering modes. When the selector switch in the cab is placed in either two-wheel steer, four-wheel steer or crab steer, that particular mode of steering is used to steer the crane. The system, however, will not activate unless the front and rear wheels are in or pass over the forward position. For example, when the front wheels are not aligned forward in two wheel steer mode and the crane must be placed in four wheel steer, placing the steering selector switch, located in the cab, to four wheel steer will not place the steering system in four wheel steer mode. Turning the front wheels to forward position or past, activates the proximity switches and energizes the relays in the relay box, which in turn energize the correct solenoid arrangement to put the steering system in four wheel steer.



a0761 **FIGURE 10-2**

Print Reference Only

10



For Reference Only

a2096

Steering Electrical Wiring Diagram

FIGURE 10-3

Sensor Operation and Spacing Checks

Checking Alignment and Operation

Both sensors must be working and spaced properly for the steering mode selection to function properly.

Proper Operation Check

1. Using the outriggers, raise the crane. Shut off the engine but leave the ignition key switch in the ON position to energize the steering sensor circuit.
2. Remove the two tires (front and rear) on left side (cab side) of the crane to obtain access to the steering sensors.
3. Using a piece of metal, pass it within 3.2 mm (1/8 inch) to 5.2 mm (7/32 inch) in front of the sensor. A yellow light will illuminate, indicating that the sensor is functioning.
4. If the sensor is working properly, check the spacing between the sensor and sensor bracket. Adjust if necessary.
5. If the sensor is malfunctioning, replace it and adjust the sensor spacing.

Sensor Spacing Check

1. Align the sensor bracket on the axle steering knuckle with the sensor on the axle Figure 10-4.

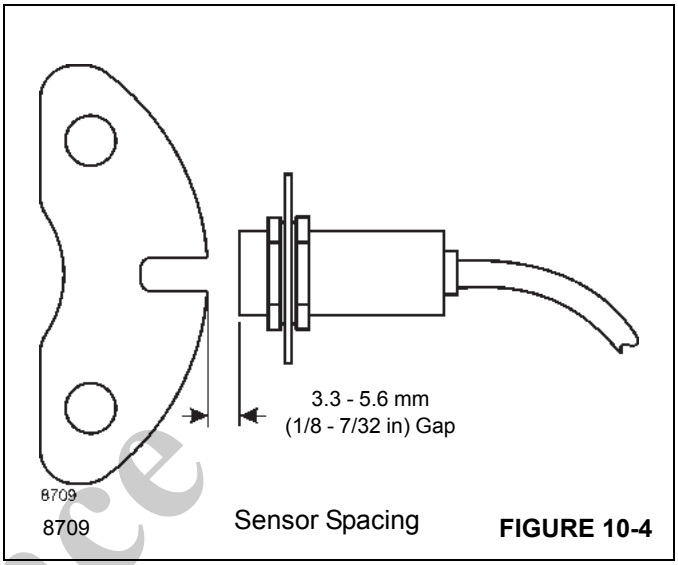


FIGURE 10-4

2. Measure the distance between the end of the sensor and edge of the sensor bracket. The sensor spacing must be between 3.3 mm (1/8 inch) to 5.6 mm (7/32 inch). If the spacing is incorrect, adjust the spacing with the jam nuts on the sensor. Be sure they are tightened after proper gap is obtained.

For Reference Only

Symptom	Probable Cause	Action
Slow steering, hard steering, or loss of power assist.	**1.** Worn or malfunctioning pump.	**1.** Repair or replace the pump.
	2. Priority valve not operating correctly.	**2.** Check for stuck spool. Repair or replace. Check load sense line for leaks or poor connection.
	3. Malfunctioning relief valve.	**3.** Replace the priority valve.
	4. Overloaded steering axle.	**4.** Reduce the load.
	5. Air in hydraulic system.	**5.** Bleed system - bleed the load sense line.
	6. Malfunctioning steering orbital.	**6.** Remove and inspect.
	7. Malfunctioning steering mode valve.	**7.** Check if spools are sticking. Repair or replace. Check if solenoids are operating. Replace if needed.
	8. Mechanical failure.	**8.** Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
Steering wheel turns on its own.	**1.** Dirt in steering orbital (causing sleeves to stick open).	**1.** Clean and inspect unit.
	2. Steering actuator centering springs damaged or broken.	**2.** Check orbital. Repair or replace.
	3. Steering actuator - position of rotor to shaft slot incorrect.	**3.** See page 10-8. Correct if required.
Crane will not turn when the steering wheel is turned.	**1.** Insufficient oil level.	**1.** Check for leaks and fill tank.
	2. Leaks in relevant hoses or component connections.	**2.** Check hoses and connections for leaks.
	3. Air in the hydraulic system.	**3.** Bleed system -bleed the load sense line.
	4. Low pump flow.	**4.** Check pump flow. If required, repair or replace the pump.
	5. Malfunctioning relief valve.	**5.** Replace priority valve.
	6. Worn or damaged parts in the steering orbital.	**6.** Remove, inspect and repair.
	7. Priority valve not operating correctly.	**7.** Check if the priority valve is sticking and repair if necessary. Check the load sense line for leaks or loose connections.
	8. Steering mode valve not operating correctly.	**8.** Check for sticking spools. Clean or replace. Check for faulty solenoids. Replace if necessary.
	9. Mechanical failure.	**9.** Check for damaged axle components, such as cylinders, tie rods, linkages, etc.
	10. Steering column splined shaft not fully engaged in orbital.	**10.** Check shaft engagement.

For Reference Only

Symptom	Probable Cause	Action
Steering fails to respond to selected mode. IMPORTANT: The wheels must pass the proximity sensor to actuate relays to change steering mode.	**1.** Selector switch faulty.	**1.** Replace switch.
	2. Proximity switches not operating correctly.	**2.** Check setting of proximity switch. Reset or replace switches.
	3. Steering mode valve not operating.	**3.** Check if spools are sticking. Repair or replace.
	4. Leaks in relevant hoses or component connections.	**4.** Check hoses and connections for leaks. Tighten or replace.
	5. Electrical failure.	**5.** Check relevant electrical connectors if problem still persists, do a wiring continuity check of relevant circuits.
Wander - Tendency of vehicle to deviate from course.	**1.** Air in system.	**1.** Correct condition and add fluid. Bleed system and load sense line.
	2. Worn steering linkage.	**2.** Repair or replace linkage.
	3. Loose steering cylinder piston.	**3.** Repair or replace cylinder.
	4. Severe wear in steering orbital.	**4.** Repair or replace the orbital.
Slip - A slow movement of steering wheel fails to cause any movement in steering wheels.	**1.** Leakage of cylinder piston seals.	**1.** Repair or replace cylinder.
	2. Worn steering orbital.	**2.** Repair or replace orbital.
Erratic steering.	**1.** Air in system due to low level of hydraulic oil, cavitating pump, leaky fitting, pinched hose, etc.	**1.** Correct condition and add fluid. Bleed system and load sense line.
	2. Loose steering cylinder piston.	**2.** Repair or replace cylinder.
	3. Sticking check valve.	**3.** Clean or replace.
	4. Turning steering wheel too rapidly.	**4.** Slow movement.
Spongy or soft steering.	**1.** Air in hydraulic system. Most likely air trapped in cylinders or lines.	**1.** Correct conditions. Bleed air out of system and load sense line.
	2. Low fluid level.	**2.** Add fluid and check for leaks.
Free wheeling - Steering. Wheel turns freely with no feel of pressure and no action on steering wheels.	**1.** Steering column shaft is loose or damaged.	**1.** Tighten the steering wheel nut.
	2. Lower splines of column may be disengaged or broken.	**2.** Repair or replace the column.
	3. Steering orbital meter has a lack of oil. This can happen on start up, after repair, or long down time intervals.	**3.** Usually starting engine will cure the problem. Bleed system if necessary.
	4. Steering cylinder piston seal blown out.	**4.** Determine cause. Correct and replace the seal.
Excessive free play at steering wheel.	**1.** Loose steering wheel nut.	**1.** Tighten the nut.
	2. Steering column shaft worn or damaged.	**2.** Repair or replace the steering wheel connection or column.
Excessive free play at steered wheels.	**1.** Leaky steering cylinder seals.	**1.** Replace cylinder seals.

For Reference Only

Symptom	Probable Cause	Action
Binding or poor centering of steering wheel.	**1.** Large dirt particles can cause binding between orbital spool and sleeve.	**1.** Clean the orbital. Repair or replace if necessary. If another component has failed, generating contaminants, flush the hydraulic system while bypassing the orbital.
Steering orbital locks up.	**1.** Large particles of contamination in metering section. **2.** Severe wear and/or broken pin.	**1.** Clean the orbital. Repair or replace if necessary. **2.** Repair or replace the orbital.

STEERING ORBITAL

Description

General

The steering orbital Figure 10-5 provides directional control and metering of oil for precise steering control. In the neutral or balance position, when the steering wheel is not turned, the IN port (P) is connected to the OUT port (T) and oil from the pump returns to tank Figure 10-5. Oil is locked in the lines by the interacting spool and sleeve. Centering springs keep the spool and sleeve in relative position. The spool is coupled to the steering wheel and rotates inside the sleeve when the steering wheel is turned. Corresponding ports in the spool and sleeve align to meter oil from the pump into the steering circuit and also allow return to tank. When the sleeve catches up with the spool, oil flow is blocked to the steering cylinder lines, and the available supply from the pump is returned to tank.

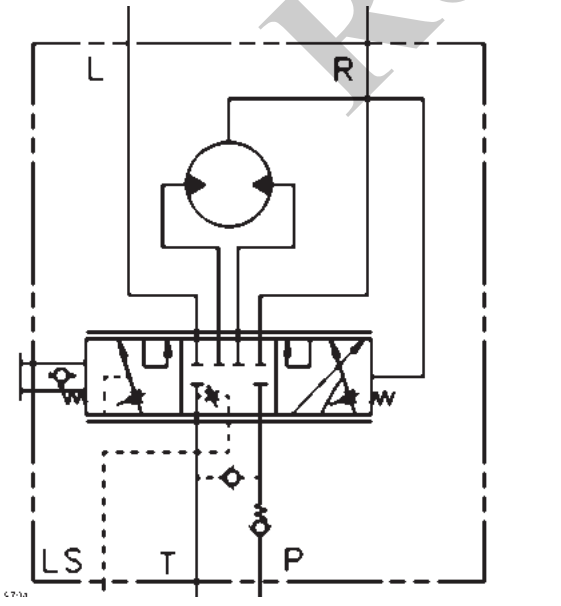


FIGURE 10-5

Steering Left

When making a left turn, flow from the pump enters port P Figure 10-5. The gerotor takes this flow and meters it to port L (left turn). Return flow from the steering cylinders, enters port R and is returned to tank through port T.

Steering Right

When making a right turn, flow from the pump enters port P Figure 10-5. The gerotor takes this flow and meters to port R (right turn). Return flow from the steering cylinders, enters port L and is returned to tank through port T.

Emergency Manual Steering

The gerotor Figure 10-5 in the orbital permits steering, with difficulty, when power is lost. A check valve between the IN and OUT ports allows for recirculation of the oil to prevent cavitation when steering without power.

Orbital Repair

The steering orbital is not serviceable in the field.

Reference Only

STEERING CYLINDER

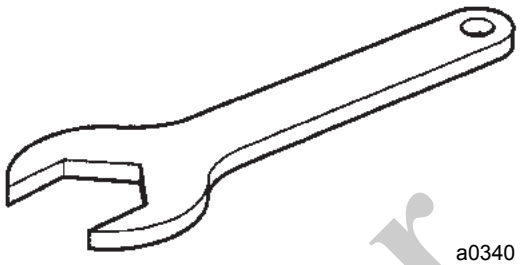
Technical Data

Cylinder Bore . . . . . 60 mm (2.36 inches)

Stroke . . . . . .211 mm (8.30 inches)

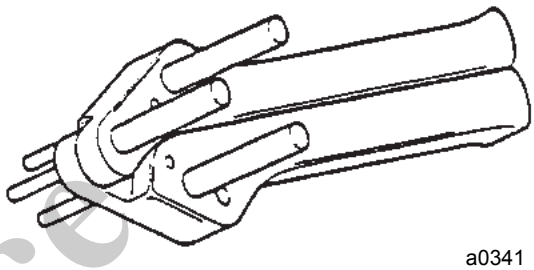
Rod Diameter . . . . . 30 mm (1.18 inches)

Special Tools



a0340

Hexagon Spanners for Cylinder Pistons and End Caps



a0341

Gland Seal Fitting Tool

FIGURE 10-6

Cylinder Repair

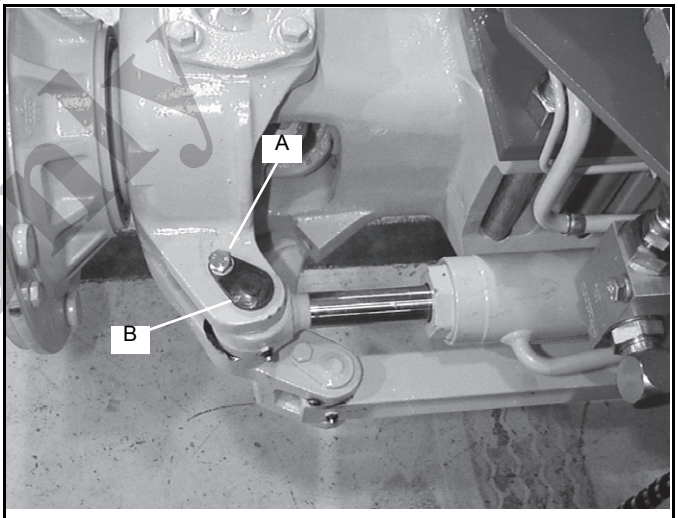
Removal

WARNING

A raised and badly supported crane can fall on you causing severe injury or death. Position the crane on a firm, level surface before raising one end. Ensure that the other end is securely chocked. Do not rely solely on the crane hydraulics or outriggers to support the crane when working under it.

Disconnect the battery cables while you are under the crane, to prevent the engine from being started.

1. Raise and support the crane to gain access to the steering cylinder.
2. With the engine not running, turn the steering wheel in both directions to release any pressure in the hydraulic lines to the steering cylinder.
3. Be prepared to collect the oil as you remove the steering lines. Slowly loosen the hydraulic hoses to release any remaining pressure. Install a plug in the hose end and a cap on the cylinder port. Place a tag on the hoses for identification and correct assembly.
4. Remove locking bolts (A) Figure 10-7 and pivot pins (B) from both ends of the steering cylinder.
5. Remove the steering cylinder from the axle.



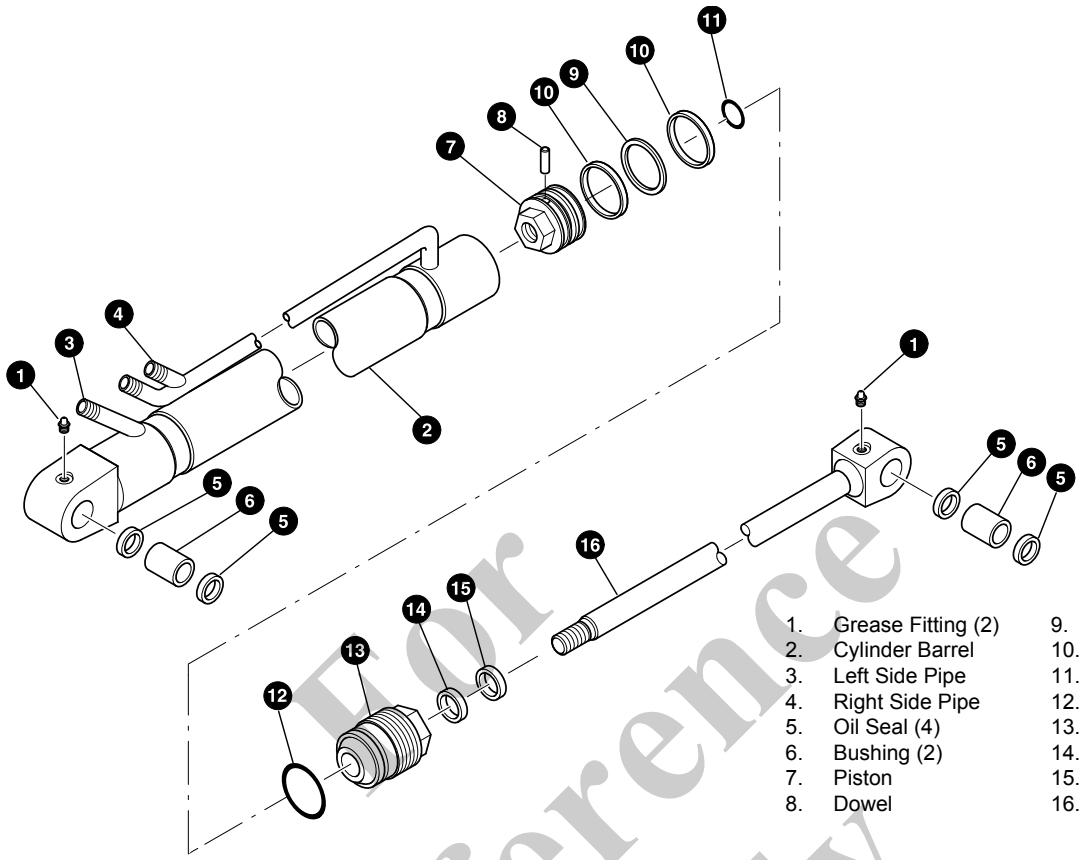
p0102

FIGURE 10-7

Disassembly

1. Remove the caps from the cylinder ports and drain remaining oil from the cylinder.
2. Secure the cylinder. If a vice is used, clamp only on the base end of the cylinder, DO NOT clamp across the cylinder tube.
3. Loosen end cap **13** Figure 10-8 using a special spanner wrench (See Special Tools, above) and remove the piston rod assembly **16** from the cylinder barrel.

For Reference Only



1. Grease Fitting (2)
2. Cylinder Barrel
3. Left Side Pipe
4. Right Side Pipe
5. Oil Seal (4)
6. Bushing (2)
7. Piston
8. Dowel
9. Piston Seal
10. Wear Ring
11. O-Ring
12. O-Ring
13. End Cap
14. Gland Seal
15. Wiper Seal
16. Cylinder Rod

FIGURE 10-8

CAUTION

If air or hydraulic pressure is used to force out the piston assembly, ensure that the end cap is securely installed. Severe injury can be caused by a sudden release of the piston rod.

4. Fasten the bushing end of the cylinder rod in a vice. Do not clamp a vise on the cylinder rod.
5. Remove and discard piston seal **9** and wear rings **10** from piston **7**.
6. Remove dowel **8** from piston head **7** using a metric screw threaded into the extraction hole in the dowel.
7. Using a special spanner wrench (See *Special Tools on page 10-9*) remove the piston **7** from rod **16**.
8. Remove and discard O-ring **11**.
9. Remove cap end **13** from cylinder rod **16**.
10. Remove and discard O-ring **12**, seal gland **14** and wiper seal **15** from end cap **13**.
11. Remove and discard the oil seals **5** from both the rod end and base ends of the cylinder.

Inspection

1. Clean all parts in a suitable solvent. Dry with compressed air. Make sure threads of piston rod, piston, end cap and cylinder are thoroughly cleaned using a wire brush to remove grease, hydraulic oil and Loctite.
2. Inspect cylinder rod for rust, distortion, pitting or damage to the chrome. If there is damage to the cylinder rod, replace it. Do not try to straighten a bent cylinder rod.
3. Inspect inside of the cylinder barrel for grooves, distortion or other damage. Use a light to illuminate the cylinder bore for careful inspection. Replace any cylinder barrel if there is distortion or damage.
4. Inspect the piston for damage to the lands.
5. Inspect rod and barrel bushings for wear or damage.
6. Replace all seals and rings.

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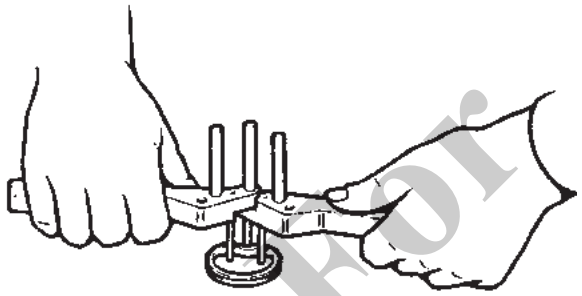
Assembly

1. Install new gland seal **14** Figure 10-8 using the special installation tool as follows:

NOTE: The size (diameter) and position of pins is determined by the diameter and radial width of the gland seal being installed.

The pins are screwed into threaded holes in the tool body, the spacing of the holes is designed to fit small and large diameter gland seals.

a. Open the tool Figure 10-9 and insert the new gland seal. The seal must be installed behind the two front pins but in front of the rear pin as shown.



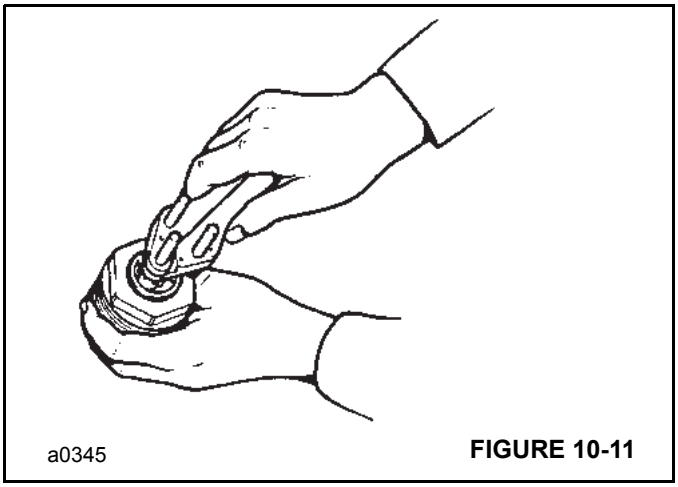
a0343 **FIGURE 10-9**

b. Close the tool Figure 10-10. The seal must form a kidney shape.



a0344 **FIGURE 10-10**

c. Locate the seal in the end cap groove Figure 10-11. When the seal is in position, open the tool to release the seal. Make sure the seal is correctly installed in its groove then remove the tool.



a0345 **FIGURE 10-11**

2. Install a new wiper seal **15** Figure 10-8 and new O-ring **12** to end cap **13**. The lip of the wiper seal must be facing out.

3. Apply Loctite Activator T to threads of the end cap and cylinder barrel. Allow the activator to dry for 15 minutes before bringing in contact with Loctite.

NOTE: Be sure that lubricants used during assembly do not come in contact with Loctite.

4. Cover the threads on the cylinder rod to prevent lubricant from contacting the Loctite.

5. Apply petroleum jelly to the inside bore of the end cap. Carefully slide the end cap assembly over the end of the piston rod.

6. Install O-ring **11** into piston **7**.

7. Install piston **7** onto cylinder rod **16**. Tighten to a torque of 405 Nm (300 lb-ft).

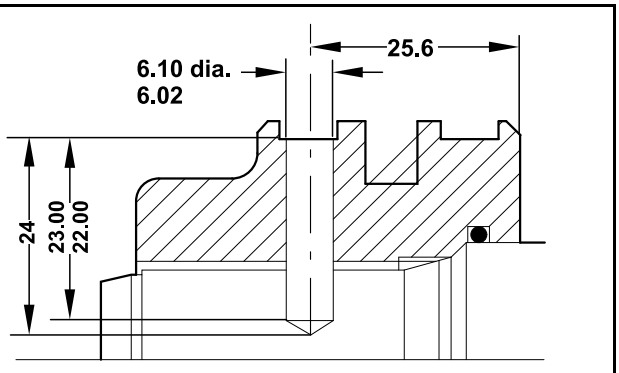
8. New cylinder rod and piston installed.

If both are required, the following procedure should be followed:

a. Drill through the piston into the cylinder rod at the dimension Figure 10-12. Use an undersize drill first as a guide, drill to a depth of 24 mm (0.94 in). Then using a 6 mm drill bit, drill the hole for the dowel.

b. Remove all debris and contamination. Insert dowel **8** Figure 10-8 into drilled hole. Make sure threaded extractor hole is to the outside.

For Reference Only



DIMENSIONS IN MILLIMETERS

a0346 **FIGURE 10-12**

9. New piston on a predrill cylinder rod.

- **a.** Re-drill and dowel BOTH the piston and cylinder rod at 90° from the existing drilled dowel hole in the cylinder rod. Follow procedures in step 8.

10. New cylinder rod installed to a predrilled piston.

Use the predrilled hole in the piston. Care must be taken not to elongate the existing hole in the piston.

- **a.** Using a 6 mm drill make a center mark in the cylinder rod. DO NOT drill the cylinder rod at this time.
- **b.** Use an undersized diameter drill bit to drill a guide hole to the depth of 24 mm (0.94 in) Figure 10-12. Make sure the drill bit is centered correctly on the center mark made in Step a.
- **c.** Use a 6 mm drill bit and drill a hole to the depth of the guide hole.
- **d.** Remove all debris and contamination. Install dowel **8** Figure 10-8.

11. Install wear ring **10** and piston seal **9** onto piston **7**.

12. Carefully insert the assembled cylinder rod into the cylinder barrel. Use care to prevent damage to the piston seal and wear ring during installation. Work the piston rod straight into the cylinder barrel.

13. Apply Loctite 932 to the first three threads of the end cap. Slide the end cap into the cylinder barrel and engage the threads. Tighten the end cap with the spanner wrench to a torque of 678 Nm (500 lb-ft).

NOTE: If hydraulic oil contacts uncured Loctite a weakening of the bond will result. Cure times vary according to the ambient temperature and the type of activator used. The curing time for Loctite 932 and Activator T at an ambient temperature of 20°C (68°F) is two hours. Do not apply oil to the cylinder before this time.

14. Fill and test the cylinder.

Installation

1. Locate the steering cylinder on the axle.

2. Apply anti-seize compound to pivot pins and install in both the rod end and base end of the cylinder.

3. Install locking bolts to hold pins in place.

4. Connect the hydraulic hoses to the cylinder.

5. Lubricate the grease fitting with Lithium based, E.P. No. 2 bearing grease.

6. Check the hydraulic oil level and add oil if necessary.

7. Start the engine and operate the cylinder(s) through several complete cycles to remove air from the system. Operate the cylinders slowly and do not let them hit bottom until movement is positive in both directions. After the circuit is filled with oil, the cylinders can be operated normally.

8. Check for leaks and repair if necessary.

9. Check the hydraulic oil level and fill if necessary.

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SECTION 11
STRUCTURALS

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BOOM OPERATION

A rod-fed, two-stage double-acting cylinder, attached to the 1st, 2nd, and 3rd boom sections, supports and propels the 2nd and 3rd boom sections. The extend cables attach to the base end of the 2nd boom section, are reeved around sheaves attached to the cylinder, and attach to the base end of the 4th boom section, therefore providing support and extension of the 4th boom section. The 3rd section retract cables attach to the tip end of the 1st boom section, are reeved around sheaves attached to the 2nd boom section, and attach to the base end of the 3rd boom section, therefore providing retraction of the 3rd boom section. The 4th section retract cables attach to the tip end of the 2nd boom section, are reeved around sheaves attached to the 3rd boom section, and attach to the base end of the 4th boom section, therefore providing retraction of the 4th boom section. A proportioning cable attached to the rear of the 1st section, reeved around a sheave at the tip of the 2nd section, and anchored to the rear of the 3rd section maintain proper cylinder extension proportion, therefore maintaining equal boom section proportion. Detailed service and maintenance is required to insure smooth and proper operation.

BOOM MAINTENANCE

Refer to Figure 11-4.

WARNING

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

Internal Cable Sheave Lubrication

Special Tools: Nozzle or needle grease gun fitting.

The lubrication points on the sheaves are not equipped with grease fittings (zerks), therefore a 6.35 mm (0.25 inch) diameter nozzle grease gun tip will be required. Contact Manitowoc Crane Care to obtain this nozzle tip (NCC Part No. 955047), or numerous variations of the nozzle tip can be purchased at local hardware or auto parts retail outlets.

NOTE: Observation through the sheave case for the extend sheaves and the hoist mount for retract sheaves will visually determine the amount of grease necessary for proper lubrication. A slight amount of grease extrusion around the pin joint is adequate for proper lubrication.

Lubrication of the extend cable sheaves located on the boom tip end of the extend cylinder, and the retract cable sheaves located on the inside rear of the 2nd and 3rd section and the extend cable sheave attached to the bottom of the top plate of the second section at the sheave case end of the boom, are accomplished as follows:

1. Extend boom until grease access hole becomes visible in side plate of 2nd section as it extends out of 1st section.
2. Visually check alignment between the 2nd section access hole and the access holes in 3rd and 4th section. When these holes become aligned, the end of the extend cable sheave pin will be visible and accessible for lubrication.
3. This boom extended position will coincide with proper alignment of the access holes in the rear of the 1st section for lubrication of the retract sheaves attached to the rear of the 2nd and 3rd section.
4. The extend cable sheave located on the bottom of the top plate of the 2nd section at the sheave case end of the boom can be accessed at any boom length for lubrication.

Cable Tensioning

After boom reassembly or from time to time if interior proportioning cables appear loose, cable tensioning may be required. Tensioning must be done with the boom horizontal

1. Slightly tighten all cables. Then cycle the boom approximately 120 cm (4 feet) out and in a few times to equalize the extend and retract cable boom section sequence positioning.
2. Fully retract boom. Do not induce and hold hydraulic pressure. At full retraction, observing through the hoist mount end of the boom, the second section should be bottomed on the extend cylinder butt plate, the third section should be bottomed on the thick vertical side plates welded to the inside of the second section, the fourth section should be bottomed on the thick vertical side plates welded to the inside of the third section.
3. It is important to achieve these boom section positions before torquing. If the boom sections do not bottom out as specified (boom is out of sequence), adjust cables to achieve proper section positioning. After proper section position has been established, a scribe mark on all the sections at the boom tip end to identify proper section position relative to each other may be helpful during the tensioning process.
4. Torque 2-3-4 retract cables to 8 Nm (6 ft-lb). Cable adjustment point is located at the sheave case end of the boom, on the bottom of the 2nd section. Use the flats at the front of the cable ends to keep the cables from turning while torquing retainer nuts.
5. Torque large extend cables to 27 Nm (20 ft-lb). Cable adjustment point is located at the rear of the boom on the cable anchor located in the rear of the 2nd section
6. Torque 1-2-3 retract cables to 8 Nm (6 ft-lb). Cable adjustment point is located at the sheave case end of the boom, on the bottom of the 1st section. Use the flats at the front of the cable ends to keep the cables from turning while torquing retainer nuts.
7. Torque 1-2-3 extend cable to 8 Nm (6 ft-lb). Cable adjustment point is located at rear of boom, on the hoist crossbar spanning the 1st section.
8. Repeat steps 4, 5, 6, and 7, torquing the 2-3-4 retract cables to 16 Nm (12 ft-lb). Torque the large extend cables to 41 Nm (30 ft-lb). The 1-2-3 retract cables to 20 Nm (14 ft-lb) and the 1-2-3 extend cable to 20 Nm (14 ft-lb).
9. Cycle the boom fully, check that all cables are torqued properly and that all sections are retracted completely, utilizing scribe marks or bottoming position of boom sections then add jam nuts to all cables. All threaded cable ends must be equipped with retainer nuts and jam nuts.

Boom Service

Boom Length (Retracted)	Boom Weight	CG from pivot point
5.64 m (18.5 ft)	2209 kg (4869 lb)	2.67 m (105 in)

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1. Extend and set crane outriggers. Boom must be completely retracted.
2. If equipped, remove swing around jib according to procedures outlined in the *Operator's Manual*.
3. Remove hook block or downhaul weight, wind up rope on hoist drum and stow wedge socket on pegs provided on 1st section. Shutdown engine.
4. Attach a lifting device to provide even weight distribution and raise the boom until weight is removed from the boom pivot pin.
5. Attach a lifting device to rod end of lift cylinder, remove boom lift cylinder pin keeper and pin from bottom of the 1st section boom. Lower lift cylinder to a suitable support.
6. Tag and disconnect extend cylinder lines and hoist hydraulic lines. Cap all open lines and ports.
7. Remove boom pivot pin keeper and boom pivot pin. Lift boom free of turret.

BOOM DISASSEMBLY

The boom can be disassembled by using two different methods. Alternative #1 disassembles the boom in the conventional manner. Alternative #2 removes the extend cylinder from the rear of the boom, after removal of the hoist. This feature facilitates cylinder service with out complete boom tear down.

For reference, the front of the boom refers to the sheave case end, the rear of the boom is the hoist mount end. Left and right are viewed from front to rear.

If the boom is to be unpinned from the turret of the crane structure, please refer to the Boom Removal Procedure section in this book. If the required service procedure is to be performed on the boom while still pinned to the turret, please follow these directions.

.

WARNING

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

1. Extend and set the outriggers.
2. Fully retract the boom and place in a horizontal position.

Boom Disassembly Alternative #1

1. Gaining access through rear of boom, loosen capscrews retaining the keeper plates holding the extend cable anchor and retract cables in the rear of the 3rd section, remove keeper plates. Loosen capscrew on the anti-two block wire clamp on the anchor assembly.
2. Extend boom 60 cm (24 inches). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Remove nut from anti-two block spade bolt. Tag and disconnect hydraulic lines to the extend cylinder.
3. Drape extend cables and anti-two block cable inside boom, and slide cable anchor plate out of the side of the hoist mount if hoist has been removed from boom.
4. Loosen and remove two capscrews, lock washers and spacers which anchor the extend cylinder rod butt plate to the rear of the 1st section.
5. Loosen and remove two capscrews and lock washers securing spacer bar to the inside top of the front of the 1st section. Remove spacer bar.
6. Loosen and remove four capscrews securing wear pads to the bottom of the 1st section. Removal of side wear pads is optional. Adequate clearance exists between adjoining section side pads for boom disassembly. If side pad removal is required, tag all pads, shims, and corresponding locations for proper reassembly.
7. Support 2nd-3rd-4th assembly at the front with an appropriate lifting method. Raise the 2nd-3rd-4th assembly inside the 1st section to allow for front bottom pad removal. Remove bottom wear pads.
8. With the 2nd-3rd-4th assembly supported, slide assembly out of the 1st. Relocation of the sling point on the 2nd-3rd-4th assembly will be necessary for proper balancing of the assembly as it slides out of the 1st section. Keep tension on retract cables as the assembly is pulled out of the 1st to minimize the chance of retract cable damage.
9. Place 2nd-3rd-4th assembly on a suitable horizontal surface. Take care not to pinch or crush retract cables while lifting or supporting assembly.
10. Remove top rear wear pads on the 2nd section. They will lift off the cam plates easily. Do not remove or loosen the capscrews holding the cam plates to the section. This will affect side clearance during re-assembly.
11. Loosen and remove four capscrews securing the rear bottom wear pads on the 2nd section. This pad serves as a bottom and side pad as well as the retract cable keeper under the retract sheaves. Removal of this pad will allow the retract cables to uncoil off the retract sheaves. Place retract cable ends in a location to minimize the possibility of damage.
12. Loosen and remove six capscrews securing retract sheave pin and retract sheaves to 2nd section. Remove sheaves and pins.

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13. Loosen and remove two capscrews functioning as upper retract cable keepers. Remove retract cables.
14. Loosen and remove two capscrews securing lock bar to the extend cylinder collar. This bar constrains the vertical movement of the extend cylinder. Remove bar.
15. Loosen capscrews retaining extend cable anchor to back of the 4th section. Total removal of the capscrews will allow the cable anchor to be completely disassembled, backing capscrews out approximately 12 mm (0.5 in) will allow the anchor assembly to slide rearward out of the section as the extend cylinder is removed.
16. Support extend cylinder with an appropriate lifting device and pull the extend cylinder out of the boom while keeping the extend cables and anti-two block wire tensioned slightly by hand to minimize the possibility of damage to the cables. Pull cylinder to within 91 cm (3 ft) of complete removal from the boom sections.
17. Reach into the rear of the 4th section and loosen and remove the anti-two block cable clamp on the extend cable anchor. Pull the extend cable anchor out from its retaining pocket on the bottom of the 4th section. A slight angle applied to the anchor as it's being pulled to the rear will permit easier removal through the 2nd and 3rd sections.
18. Remove the extend cylinder from the boom. Do not allow the sheaves to fall off the pin on the end of the extend cylinder. Remove extend cables. Place cylinder and cables in suitable area to prevent possible damage.
19. Anti-two block wire can be removed, if necessary, by disassembly of the clamp arrangement at the sheave case and pulling wire through boom.
20. Loosen and remove two capscrews, cable guide, wear pad and spacer bar from the front top of the second section.
21. Loosen and remove four capscrews attaching the bottom pad plate to the second section. Slightly lift third section, and remove pad plate.
22. Slide 3rd section out of 2nd section. Removal of side pads is optional, as the side pads have adequate clearance for boom disassembly. If removal of side pads is required, tag all shims, pads and corresponding locations for proper re-assembly.
23. Loosen and remove all remaining capscrews and wear pads from boom sections.

Boom Disassembly Alternative #2

The boom design allows for removal of the extend cylinder from the rear of the boom without complete disassembly of the boom sections. This procedure allows quick access to the cylinder, retract cables, and various internal boom components for service or replacement. If this procedure is used for disassembly, reverse procedure for reassembly, or locate the appropriate step in the assembly procedure in this manual to start reassembly from.

.

WARNING

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

1. Remove hoist.
2. Gaining access through rear of boom, loosen and remove capscrews retaining the extend cable anchor in the rear of the 4th section as well as the anti-two block wire clamp on the anchor assembly. Loosen and remove two capscrews retaining lock bar to extend cylinder. Remove lock bar.
3. Loosen and remove the nuts which secure the extend cables to the extend cable anchor in the back of the second section, remove capscrews from keeper plates holding extend anchor in place, remove keepers. Remove anchor. Remove nut from anti-two block spade bolt.
4. Drape extend cables and anti-two block wire inside boom, and slide cable anchor plate out of the side of the hoist mount.
5. Loosen and remove two capscrews, lock washers and spacers which anchor the extend cylinder rod butt plate to the rear of the 1st section.
6. Using appropriate lifting device, lift extend cylinder up and out of retaining slots on rear of 2nd and 3rd sections. Retracting cylinder with an external hydraulic power source during this step may be necessary.
7. Pull cylinder out through rear of boom assembly approximately one-half the length of the cylinder. Turning of the butt plate and rod 90 degrees may aid in sliding cylinder through hoist mount area. Keep extend cables tight to minimize the possibility of damage.

BOOM ASSEMBLY

NOTE: Do not use Loctite on any cable threaded ends. Always use the locknut and nut provided.

When initially assembling threaded ends of cables, thread the first on past the flat in the cables so adjustment can be made later.

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1. Assemble sheaves into 4th section sheave case. Top sheave is to be installed to the left hand side of the boom with the spacer to the right hand side.
2. Attach rear wear pads on bottom of 4th section. Using Loctite 243 blue, Loctite all wear pad mounting capscrews.
3. Install 4th section boom into 3rd section. Slide together approximately 150 cm (5 feet).
4. Assemble bottom front wear pads with Teflon plugs for 3rd section. Attach pads to pad plate.
5. Using appropriate lifting device, lift 4th section to allow for wear pad/pad plate installation in front of 3rd. Install wear pad/pad plate assembly. Slide sections together within 30 cm (12 inches) of full retraction.
6. Install cable guide and upper spacer to front of 3rd section
7. Install front side wear pads with appropriate shims, between 4th and 3rd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book. Slide boom sections completely together.
8. Assemble top rear wear pads to the top of the 4th boom section. Wear pads can be inserted from the hoist mount end of the boom, and the cam plates dropped through the holes in the aligned boom top plates.

   The wear pad on each side at the top/rear of the boom can be adjusted over a range of 4.8 mm (3/16 in) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 1.5 mm (0.06 in) off center in the plate and 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.

   a. Adjust pads until they are within 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allows the adjustment.

   b. Torque retainer capscrews to 149 Nm (110 ft-lb). Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.
9. Uncoil 4/3/2 retract cable assemblies, and insert button end into anchors in back of the 4th section. Place uncoiled cable in area that will minimize the potential for damage.
10. Uncoil 1/2/3 retract cable assemblies, and insert button end into cable anchor pockets in back of the 3rd section. Place uncoiled cable in area that will minimize the potential for damage. Assemble retract sheaves and retract sheave pins in rear of 3rd section. Coat surfaces of bearings and keeper plates with grease before assembly.
11. Place retract cables anchored to 4th over the top of the retract sheaves on the 3rd. Install keeper capscrew above sheave to hold retract cables in place.
12. Reeve cables over retract sheave and install keeper/ wear pad to bottom rear of 3rd section. This pad acts as a side pad, bottom pad, and a cable retainer. Loctite rear wear pad hardware on bottom of 3rd section with Loctite 243 blue. Loctite all wear pad mounting capscrews.
13. Loop the 1/2/3 extend cable in half and place it on the top of the 3rd section, with the loop end towards the sheave case end and the threaded and button end towards the rear of the section.
14. Install clamp plate and capscrews with the button end of the cable installed in the anchor slot on the rear top of the 3rd section.
15. Place sheave pin and sheave for the 1/2/3 extend cable in position on the sheave case end of the boom, inside the loop of cable
16. Install 3rd and 4th section boom assembly into 2nd section. Slide together approximately 150 cm (5 ft). Use caution as retract cables and upper extend cable attached to the 4th-3rd section assembly slide into the 2nd section to prevent damage or crossing of cables.
17. Assemble bottom front wear pads for 2nd section and Teflon plugs. Attach pads to pad plate.
18. Using appropriate lifting device, lift 3rd and 4th section assembly to allow for wear pad/pad plate installation in front of 2nd. Install wear pad/pad plate assembly. Slide sections together within 30 cm (12 in) of full retraction.
19. Install cable guide and spacer to top of 2nd section
20. Install front side wear pads with appropriate shims between 3rd and 2nd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used. If locations are in question, refer to shim calibration section in this book. Slide sections fully together
21. Assemble top rear wear pads to the top of the 3rd boom section. Wear pads can be inserted from the hoist mount end of the boom, and the cam plates dropped through the holes in the aligned boom top plates.

    The wear pad on each side at the top/rear of the boom can be adjusted over a range of 4.8 mm (3/16 in) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The

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holes are 1.5 mm (0.06 in) off center in the plate and 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.

a. Adjust pads until they are within 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allows the adjustment.

b. Torque retainer capscrews to 149 Nm (110 ft-lb). Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.

22. Position sheave and sheave pin located in cable loop on top of 3rd to allow capscrew installation, through top plate of 2nd. Install capscrews and torque to specification, clamping sheave pin and sheave to the bottom of the 2nd section top plate.

23. Assemble retract sheaves, retract sheave pins and cable keeper plates in rear of 2nd section. Coat surfaces of bearings with grease before assembly.

24. Place retract cables anchored to 3rd over top of retract sheaves attached to rear of 2nd. Install keeper capscrew above sheave to hold retract cables in place.

25. Reeve cables over retract sheave and install keeper/wear pad to bottom rear of 2nd section. This pad acts as a side pad, bottom pad, and a cable retainer.

26. Assemble exterior extend cylinder components. Install and center sheave pin and anti-two block sheave into sheave case end of extend cylinder. Install bearings into extend cable sheaves. Coat surface of bearings with grease and assemble extend sheaves on sheave pin.

27. Wrap approximately 300 cm (10 ft) of each 15.88 mm (5/8 inch) diameter 2/3/4 extend cable around extend sheaves and install 4th section extend cable anchor around cables at button end. Do not tighten capscrews clamping anchor together completely. These capscrews if tightened completely will not allow cable anchor to install into 4th section.

28. Install wear pad over extend cylinder sheave side plates. This serves as a wear pad to keep the end of the extend cylinder centered in the boom, as well as an extend cable retainer.

29. Slide extend cylinder/extend cables into 2nd/3rd/4th boom assembly enough to assemble extend cable anchor into bottom rear of 4th section. Be aware of extend cable location when inserting cylinder into boom sections, inadvertent crushing or other damage to cables will warrant replacement.

30. Tighten capscrews clamping extend cable anchor together. This will also lock anchor in place in the anchor cutouts in the 4th section.

31. Visually verify that the extend cables are properly routed on their sheaves and continue to slide with the extend cylinder and cables into the boom sections. Keep extend cables supported and slightly tensioned during insertion of cylinder to maintain proper cable placement.

32. As the extend cylinder nears complete insertion into the 2nd/3rd/4th section assembly, adjust the height of the cylinder to allow the cylinder anchor collars to access the cylinder keeper cut outs in the doubler plates on the sides of the 2nd and 3rd sections.

33. Drop the cylinder down into the vertical cutouts in the doubler plates on the sides of the 2nd and 3rd sections. Cylinder length or boom section placement may have to be adjusted to allow cylinder collars to drop into their proper position.

34. Install lock bar and capscrews to the extend cylinder collar in the 3rd section.

35. Route 2/3/4 anti-two block cable segment through boom sections (see Anti-Two-Block Installation section) and attach accordingly.

36. Install large extend cable anchor into anchor cut outs in the doubler plates in the rear of the 2nd by routing the 15.88 mm (5/8 inch) extend cables through the anchor and the small 9.53 mm (3/8 inch) cable over the anchor. Slide anchor fully into cutout.

37. Install keeper plates and hardware. This keeper plate retains both the horizontal movement of the extend anchor and the vertical movement of the extend cylinder.

38. Anchor 2/3/4 anti-two-block cord in the extend anchor (see anti-two-block Installation section) using appropriate hardware.

39. Route 1/2 anti-two-block segment on the bottom of the 1st section boom (see anti-two-block Internal Wire System section).

40. Install 2/3/4 section boom assembly into lst section boom, use caution when sliding sections together, 3rd retract cables must maintain their position to prevent damage, do not let boom rest on cables. Damage will result.

41. Assemble bottom front wear pads for 1st section and Teflon plugs.

42. Using appropriate lifting device, lift 2/3/4 section assembly to allow for wear pad installation in front of 1st. Install wear pads. Slide sections together within 30 cm (12 in) of full retraction.

43. Install upper spacer to front of 1st section.

44. Install front side wear pads with appropriate shims between 2nd and 1st sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously

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used. If locations are in question, refer to shim calibration section in this book.

45. Push boom together until extend cylinder butt plate makes contact with the rear cylinder anchor plates in the rear of the 1st section. Install spacers, washers and capscrews, attaching cylinder to 1st section boom. If cylinder is misaligned with anchor points, cylinder butt plate can be rotated to achieve proper alignment (holding valve up, parallel with boom top plate).

46. Assemble top rear wear pads to the top of the 2nd boom section. Wear pads can be inserted from the hoist mount end of the boom, and the cam plates dropped through the holes in the aligned boom top plates.

The wear pad on each side at the top/rear of the boom can be adjusted over a range of 4.8 mm (3/16 in) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 1.5 mm (0.06 in) off center in the plate and 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.

a. Adjust pads until they are within 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allows the adjustment.

b. Refer to *Fasteners and Torque Values on page 1-15* for torque of retainer capscrews. Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.

47. Install thick hoist attachment bar through hoist mount. This bar anchors the 9.53 mm (3/8 in) extend cable and serves as the upper hoist attachment point. Hold this bar up in its slot with a spacer on each side. This will facilitate easier assembly.

48. Install the threaded end of the 9.53 mm (3/8 in) extend cable through hole in center of the hoist attachment bar.

49. Slightly tighten all cables. Cycle boom slowly to assure proper operation before torquing cables. Refer to the Cable Tensioning section to properly torque the cables in the extend system. Cables must be torqued to proper specifications for proper boom operation.

50. Install hoist.

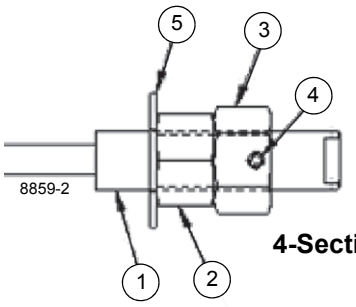


8860-5


8860-6

FIGURE 11-1

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4-Section Boom

Item	Description
1	Threaded Cable End
2	Nut (Adjustment)
3	Nut (Torqued and Positive Lock)
4	Set Screw
5	Washer
6	Nut (Torqued)

FIGURE 11-2

For Reference Only

Table 11-1 Cable Hardware Torque Values

Cable end Thread Size	Minimum Nut Strength GRADE	Nut Type	Torque ft lbf
5/8-11	SAE 2	Hex Jam (half)	31
3/4-10	SAE 2	Hex Jam (half)	47
1 1/4-7	SAE 2	Hex Jam (half)	203
Cable end Thread Size	**Minimum Nut Property Class**	**Nut Type**	**Torque Nm**
M16x2	5	Hex Jam (thin)	26

BOOM CABLE TENSIONING

A boom assembly is considered properly timed when the telescoping sections extend equally relative to each other and bottom out simultaneously at full retraction and do not spring back out after retract pressure is returned to neutral.

Extend cylinder construction dictates which extendable section will be the driver that the other extend sections will need to be adjusted to, utilizing the cable adjustment.

- A single stage cylinder will control the first extendable section.
- A dual stage cylinder will control the second extendable section.

The timing sequence of the cables depends on the number of sections and the extend cylinder construction.

The design intent of the cable tensioning is to balance the preload of the extend and retract cables for each extendable section. In addition, sequencing of the sections during retraction requires the retract cables of every section to be indexed relative to each other.

Tensioning Procedure for all Booms

1. Tensioning must be done with the boom in the horizontal position.
2. Refer to Figure 11-2 for cable hardware arrangements.
3. When tightening/loosening the first (adjustment) nuts on the cables, secure the cables using the wrench flats at the front of the cable ends to prevent cable twist.
4. CAUTION: Do not use an impact wrench to tighten the cables. Excess cable twisting can cause premature failure.
5. Once the boom is completely assembled and fully retracted, mark the front of each section with a chalk line as indicated in Figure 11-1.
6. After the cable adjustment procedure is completed for the entire boom assembly. The second (torqued) nut must be installed on all retract and extend cables.
7. The second nut should be hand tightened until it comes in contact with the back of the first nut.
8. Use a standard combination wrench to hold the first (adjustment) nut stationary and a crow foot wrench adapter attached to a calibrated torque wrench to tighten the second (torqued) nut against the first (adjustment) nut to the values indicated in Table 11-1.

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4-Section Boom w/ 2 Stage Cylinder

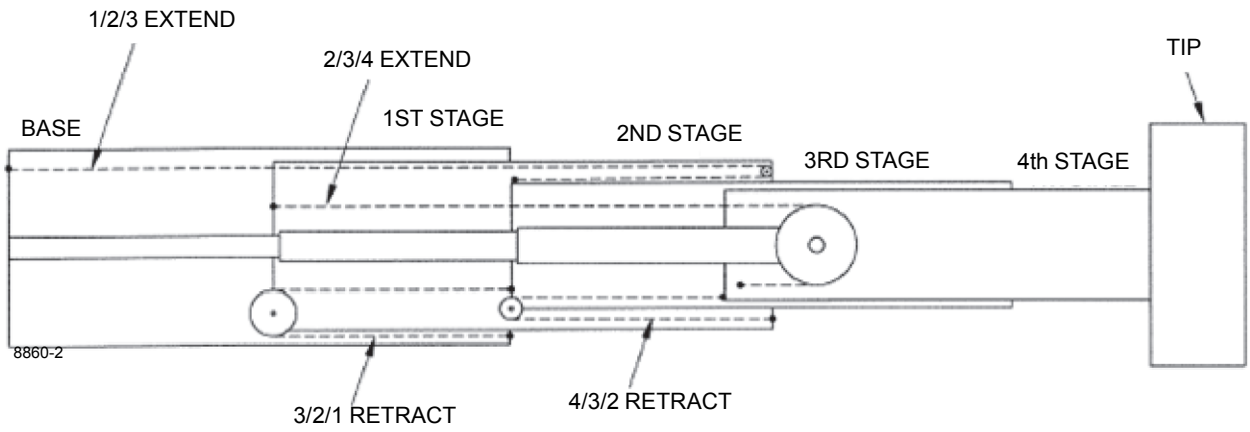


FIGURE 11-3

Tensioning Procedure for 4 Section Boom

See Figure 11-3 for this procedure.

1. Retract the boom fully so that all sections are bottomed out on the stops at the back end of each section. Ensure all sections are fully bottomed out and do not spring back.
2. Mark white lines on the side plate of each section (Figure 11-1).
3. Extend and retract the boom several times to establish the working state of the cables.
4. Extend the boom so the scribed lines are exposed by approximately 305 mm (12 in).
5. Measure the extension gaps between each boom section and the scribed line and note the values.
6. Retract the boom so the scribed lines are exposed by approximately 152 mm (6 in).
7. Measure the retraction gaps between each boom section and the scribed line and note the values.
8. Balance the control cables.

321 and 123 cable balancing

Extension

1. Measure the extension gaps between the first and second section and the second and third section.
2. If the extension gap between the first and second section is less than the extension gap between the second and third section, proceed as follows:
   - Tighten the **321** retract cable (located at the front bottom of the base section) the difference in the extension gap measurements.
   - Extend and retract the boom a few times and then repeat measuring the extension gaps.
   - The second section should have moved out.
   - Keep tightening until the extension gap between the first and second section and the extension gap between the second and the third section is equal.
   - If, when tightening the **321** retract cable, the third section starts to go out with the second section the **123** synchronizing cable (located at the top back of the base section) may need to be loosened.

Retraction

1. Measure the retraction gaps between the first and second section and the second and third section.
2. If the retraction gap is greater between the first and second section than the retraction gap between the second and third section, proceed as follows:
   - Tighten the **123** synchronizing cable (located at the back of the base section) the difference in the retraction gap measurements.
   - Extend and retract the boom a few times and then repeat measuring the retraction gaps.
   - The third section should have moved out.
   - Keep tightening until the retraction gap between the first and second section and the retraction gap between the second and the third is equal.
   - At this time, the second and first extendable sections should extend and retract equally and bottom out against the stops simultaneously.

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234 and 432 cable balancing

Extension

1. Measure the extension gaps between the third and fourth section and the second and third section.
2. If the extension gap between the third and fourth section is less than the extension gap between the second and third section, proceed as follows:
   - Tighten the **234** extend cable (located at the back top of the second section) the difference in the extension gap measurement.
   - Extend and retract the boom a few times and then repeat measuring the extension gaps.
   - The fourth section should have moved out.
   - Keep tightening until the extension gap between the third and fourth section is equal to the extension gap between the second and third section.

Retraction

1. Measure the retraction gaps between the second and third section and the third and fourth section.
2. If the retraction gap is greater between the third and fourth section than the retraction gap between the second and third section, proceed as follows:
   - Tighten the **432** retract cable (located at the front bottom of the second section) the difference in the retraction gap measurement.
   - Extend and retract the boom a few times and then repeat measuring the retraction gaps.
   - The fourth section should have moved in.
   - Keep tightening until the retraction gap between the third and fourth section is equal to the retraction gap between the second and third section.
   - At this time, all extendable sections should extend and retract equally and bottom out against the stops simultaneously.

TOP/BOTTOM PAD REPLACEMENT ASSEMBLED BOOM

Inspect top and bottom wear pads periodically for signs of abrasion or excessive wear. Excessive is defined as 4.76 mm (3/16 inch) from the original pad thickness, top rear pad thickness 19 mm (0.75 in), bottom front 1st section 25 mm (1 in), bottom front 2nd and 3rd section 13 mm (0.44 in). Uneven pad wear of 2 mm (3/32 in) from side to side on the wear pad would be considered excessive as well. If any of these conditions exist, the top and bottom pads can be replaced without complete disassembly of the boom.

Top Rear Pad Replacement

Pad maintenance can be made easier by removal of the hoist and or removal of the hoist mounting bar spanning the end of the 1st section. Additional clearance can be achieved by loosening the large extend cables and removing the extend cable anchor located in the 2nd section.

1. Retract boom completely.
2. Remove capscrews through access holes on top rear of sections.
3. Remove wear pads, shims, and cam plates from the rear of the boom through open hoist mount end.
4. Note all pad locations and tag accordingly.
5. Inspect pads for wear using previously mentioned inspection criteria.
6. Assemble new wear pads with the cam plates and install through the hoist mount end of the boom. Install capscrews through holes in outer boom sections. The wear pad on each side at the top/rear of the boom can be adjusted over a range of 4.8 mm (3/16 in) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 1.5 mm (0.06 in) off center in the plate and 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.
   a. Adjust pads until they are within 0.8 mm (0.03 in) off center in the wear pad. Various combinations of rotation of these parts allows the adjustment.
   b. Torque retainer capscrews to 149 Nm (110 ft-lb). Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.

Front Bottom Pad Replacement

1. Extend boom approximately 120 cm (4 ft) out.
2. Remove cable guides and upper spacer bars from front of boom sections
3. Loosen and remove hex nuts on retract cables on the front of the 1st and 2nd sections
4. Using an appropriate lifting device, sling around the 4th section boom and lift it up until weight is removed from the bottom pads in the front of the 3rd, 2nd, and 1st boom sections.
5. Loosen and remove the four capscrews holding the pad doubler plate in between the 4th and 3rd sections. Remove plate. Remove pads from this plate. Note all pad locations and tag accordingly.

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6. Loosen and remove the four capscrews holding the pad doubler plate in between the 3rd and 2nd sections. Remove plate. Remove pads from this plate. Note all pad locations and tag accordingly.
7. Loosen and remove the four capscrews holding the pads in between the 2nd and 1st sections. Remove pads. Note all pad locations and tag accordingly.
8. Inspect pads for wear using previously mentioned inspection criteria.
9. Install new pads with Teflon inserts on plates or boom sections. Reassemble plates in boom in proper locations.

WIRE ROPE, SHEAVE AND HOIST BLOCKS

Wire Rope Description

A wire rope is a machine, by definition: “As an assemblage of parts, that transmit forces, motion and energy one to another in some predetermined manner and to some desired end.”

A typical wire rope may contain dozens--even hundreds-- of individual wires which are formed and fabricated to operate at close bearing tolerances one to another. When a wire rope bends, each of its many wires slide and adjusting the bend to accommodate the differences in length between the inside and the outside of the bend. The sharper the bend, the greater the movement.

Every wire rope has three basic components (Figure 11-4): (1) The wires which form the strands and collectively provide rope strength; (2) the strands, which are laid helical around the core, and (3) the core, which forms a foundation for the strands. The core used in the gantry wire rope is an Independent Wire Rope Core (IWRC), which is actually a smaller rope, or a strand similar to the outer strands of the rope. The IWRC core adds about 7.5% to the nominal strength of the wire rope.

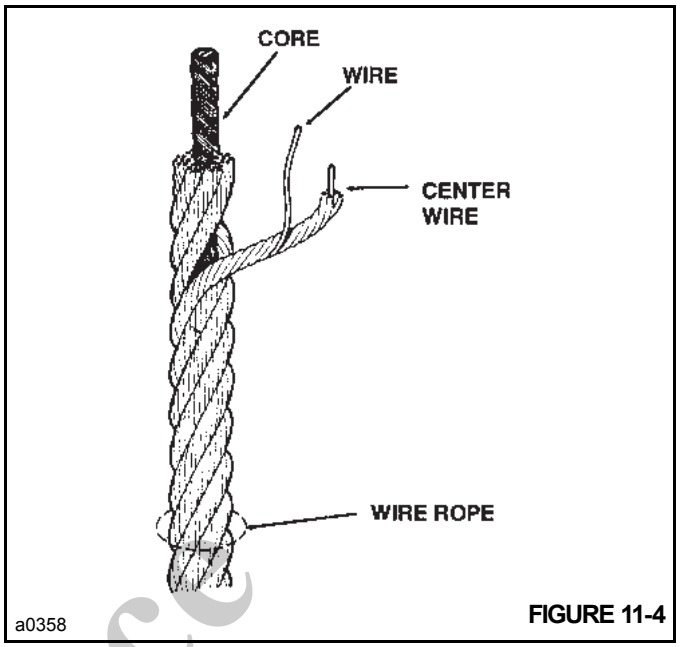


FIGURE 11-4

The greatest differences in wire ropes are found in the strands, which may vary widely in the pattern and number of wires which are laid together. The wires of the rope may be made of various metals, including steel, iron, stainless steel, monel, and bronze. The materials of which wires are made is the primary determination of rope strength. High-carbon steel is used in the gantry wire ropes.

Carbon steel wire ropes come in various grades.The term “Grade” is used to designate the nominal strength of the wire rope. The most common grades are Traction Steel (TS), Plow Steel (PS), Improved Plow Steel (IPS), Extra Improved Plow Steel (EIPS) and Extra Extra Improved Plow Steel (EEIPS). The wire rope used on the gantry is an EIPS Grade.

One cannot determine the grade of wire rope by its feel or appearance. To be sure you are using the proper rope, always obtain the wire rope from your Grove distributor.

Wire Rope Safety

The following information is not a complete discussion of wire rope. What follows is a brief outline of the basic information required to safely use wire rope.

1. Wire rope WILL FAIL IF WORN-OUT, OVERLOADED, MISUSED, DAMAGED or IMPROPERLY MAINTAINED.
2. In service, wire rope loses strength and work capability. Abuse and misuse increases the rate of loss.
3. The NOMINAL STRENGTH, sometimes called CATALOG strength, of a wire rope applies ONLY to a NEW, UNUSED rope.
4. The Nominal Strength of a wire rope SHOULD BE CONSIDERED the straight line pull which will ACTUALLY BREAK a NEW UNUSED rope. The

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Nominal Strength of a wire rope SHOULD NEVER BE USED AS ITS WORKING LOAD.

5. WIRE ROPES WEAR OUT. The strength of a wire rope begins to decrease when the rope is put to use and continues to decrease with each use.
6. NEVER OVERLOAD A WIRE ROPE. This means NEVER USE the wire rope where the load applied to it is greater than the working load determined by Grove.
7. NEVER “SHOCK LOAD” a wire rope. A sudden application of force or load can cause both visible external and internal damage. There is no practical way to estimate the force applied by shock loading a rope. The sudden release of a load can also damage a wire rope.
8. Lubricant is applied to the wires and strands of a wire rope when it is manufactured. The lubricant is depleted when the rope is in service and should be replaced periodically. Refer to *Preventative Maintenance on page 5-1*, for lubrication intervals.
9. In the U.S.A., regular INSPECTIONS of the wire rope and keeping of PERMANENT RECORDS SIGNED BY A QUALIFIED PERSON ARE REQUIRED BY OSHA FOR ALMOST EVERY WIRE ROPE APPLICATION. The purpose of the inspection is to determine whether or not a wire rope may continue to be safely used on the application. Inspection criteria, including number and location of broken wires, wear and elongation, have been established by OSHA, ANSI, ASME and similar organizations.

   IF IN DOUBT, REPLACE THE ROPE. An inspection should include verification that none of the specified removal criteria for this usage are met by checking for such things as:

- Surface wear; nominal and unusual.
- Broken wires; number and location.
- Reduction in diameter.
- Rope stretch (elongation).
- Integrity of end attachments.
- Evidence of abuse or contact with another object.
- Heat damage.
- Corrosion.

  In addition, an inspection should include condition of sheaves, drums and other apparatus with which the wire rope makes contact.

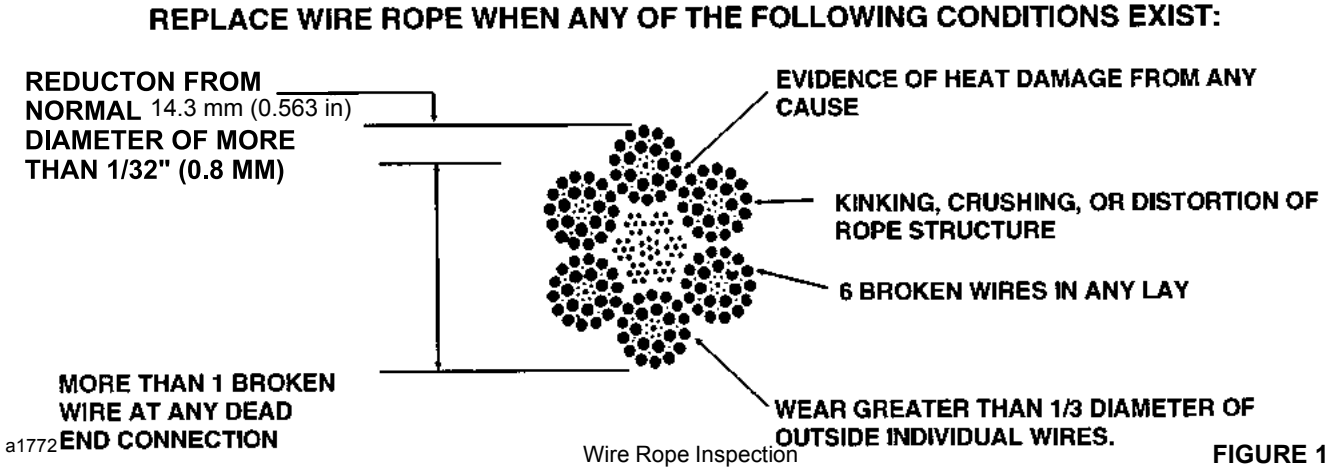
10. When a wire rope has been removed from service because it is no longer suitable for use, it must not be reused on another application.
11. Every wire rope user should be aware of the fact that each type of fitting attached to a wire rope has a specific efficiency rating which can reduce the working load of the wire rope assembly or rope system, and this must be given due consideration.
12. Some conditions that lead to problems in wire rope systems include:
    a. Sheaves that are too small, worn or corrugated causes damage to a wire rope. Broken wires mean a loss in strength.
    b. Kinks permanently damage a wire rope and must be avoided.
    c. Wire ropes are damaged by knots. Wire rope with knots must never be used.
    d. Environmental factors such as corrosive conditions and heat can damage a wire rope.
    e. Lack of lubrication can significantly shorten the useful life of a wire rope.
    f. Contact with electrical wires and resulting arcing will damage a wire rope.

Inspecting Wire Rope

Inspect entire length of wire rope for any conditions listed in Figure 11-5. If any of the conditions exist, replace the wire rope.

If the wire rope shows severe wear, make a full inspection of sheaves and drums for grooves, correct alignment, etc.

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Wire Rope Inspection **FIGURE 11-5**

Inspection of Sheaves

Inspect all sheaves for wear and proper alignment.

For maximum life of the wire rope, the sheave grooves must be smooth and must be a little larger than the diameter of the wire rope.

As wear in the sheaves increases, the groove for the wire rope gets smaller, NOT larger. Tracks in the sheaves are caused by the wire rope, yet the wire rope will continue to engage the tracks (example; a chain engaging a sprocket). A twist in the wire rope or a small change of lay will prevent the wire rope from engaging the track in the sheave. The result will be a rapid wear on the wire rope.

Wire Rope Lubrication

Lubricate the wire rope See Chapter 5, Preventative Maintenance with a light weight oil. A more frequent time frame (more than monthly) may be required due to operating conditions and usage. Proper lubrication of the wire rope is just as important as lubrication of other components. The wire rope has many moving parts. Initial lubrication will not last throughout the life of the wire rope. Lubrication is essential to reduce wear and prevent corrosion of the wires.

Wire Rope Installation

Anchoring Wire Rope

Take the free end of the wire rope and insert it through the small opening on the anchor pocket. Loop the wire rope and push the free end about 3/4 of the way through the pocket. Install the wedge, then pull the slack out of the wire rope. The wedge will slip into the pocket and secure the wire rope into the drum. The anchor is designed to fit several different sizes of wire rope. Make sure the anchor is installed large end first. See Figure 11-6.

Refer to Figure 11-7 and verify that the wedge is installed correctly.

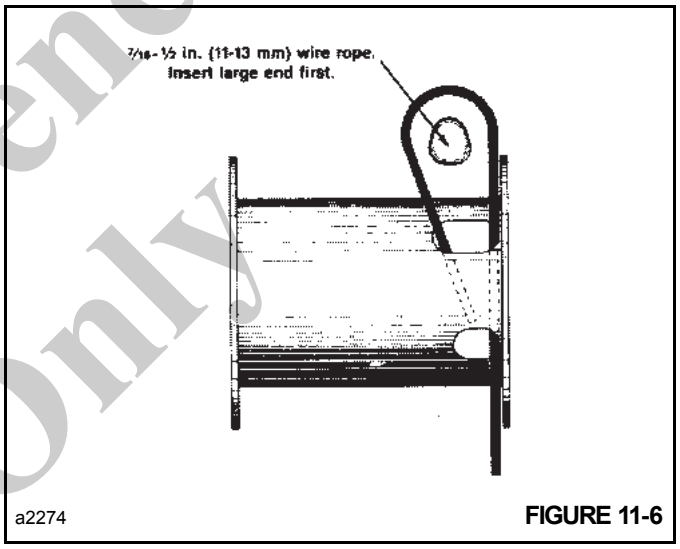
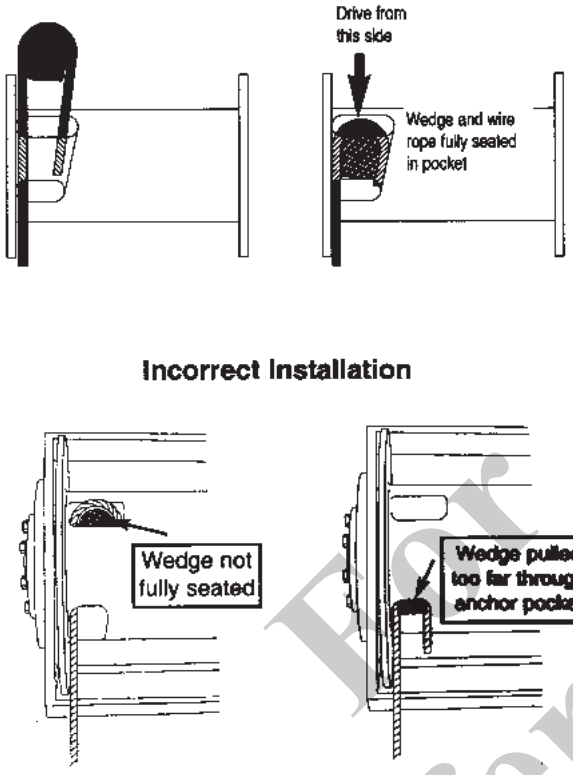


FIGURE 11-6

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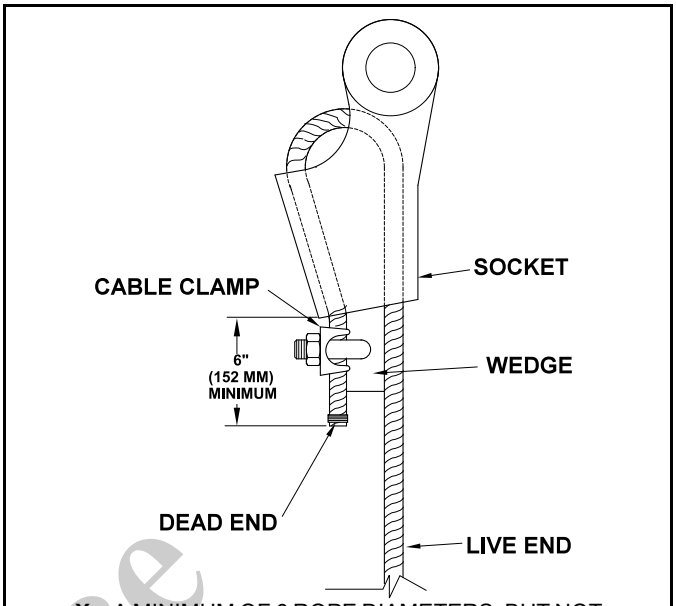
a2275 FIGURE 11-7

Installation of Socket and Wedge

Always connect the socket so that the load is pulled on the same line as the socket (See Figure 11-8).

When installing the wedge, hit the wedge several times with a SOFT hammer to make sure the wedge is fully engaged with the socket. Be sure not to damage the wire rope. Install cable clamp on the loose end of the wire rope as shown in Figure 11-8.

To properly seat the wedge, lift a load equal to the rated capacity of the crane.

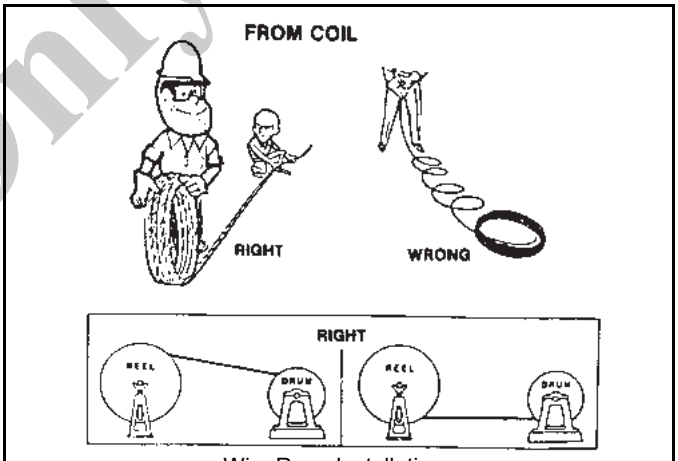


X = A MINIMUM OF 6 ROPE DIAMETERS, BUT NOT LESS THAN 6 INCHES (152 MM).

a0069 FIGURE 11-8

Installation of A New Wire Rope

The wire rope is given a natural bend or winding from coil. If the wire rope is on a reel, unwind the wire rope from the reel as shown in Figure 11-9. Use care to prevent reverse bend in the wire rope.

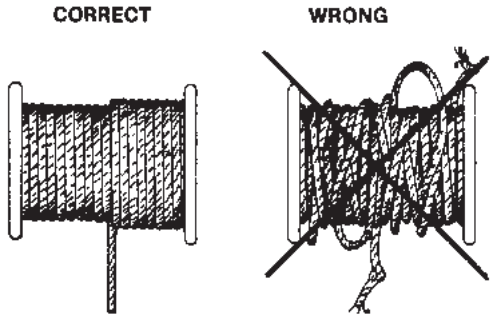


a0473 Wire Rope Installation FIGURE 11-9

1. Make sure that the equipment (Hoists, sheaves, etc.) are in good condition.
2. Unwind enough rope from the reel to connect the wire rope to the hoist drum. Use care to prevent twists or sharp bends.
3. Operate the hoist slowly to move the wire rope directly from the reel to the hoist. Make sure the wire rope winds

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correctly on the drum. Loose windings will increase wear on the wire rope and cause bad performance.

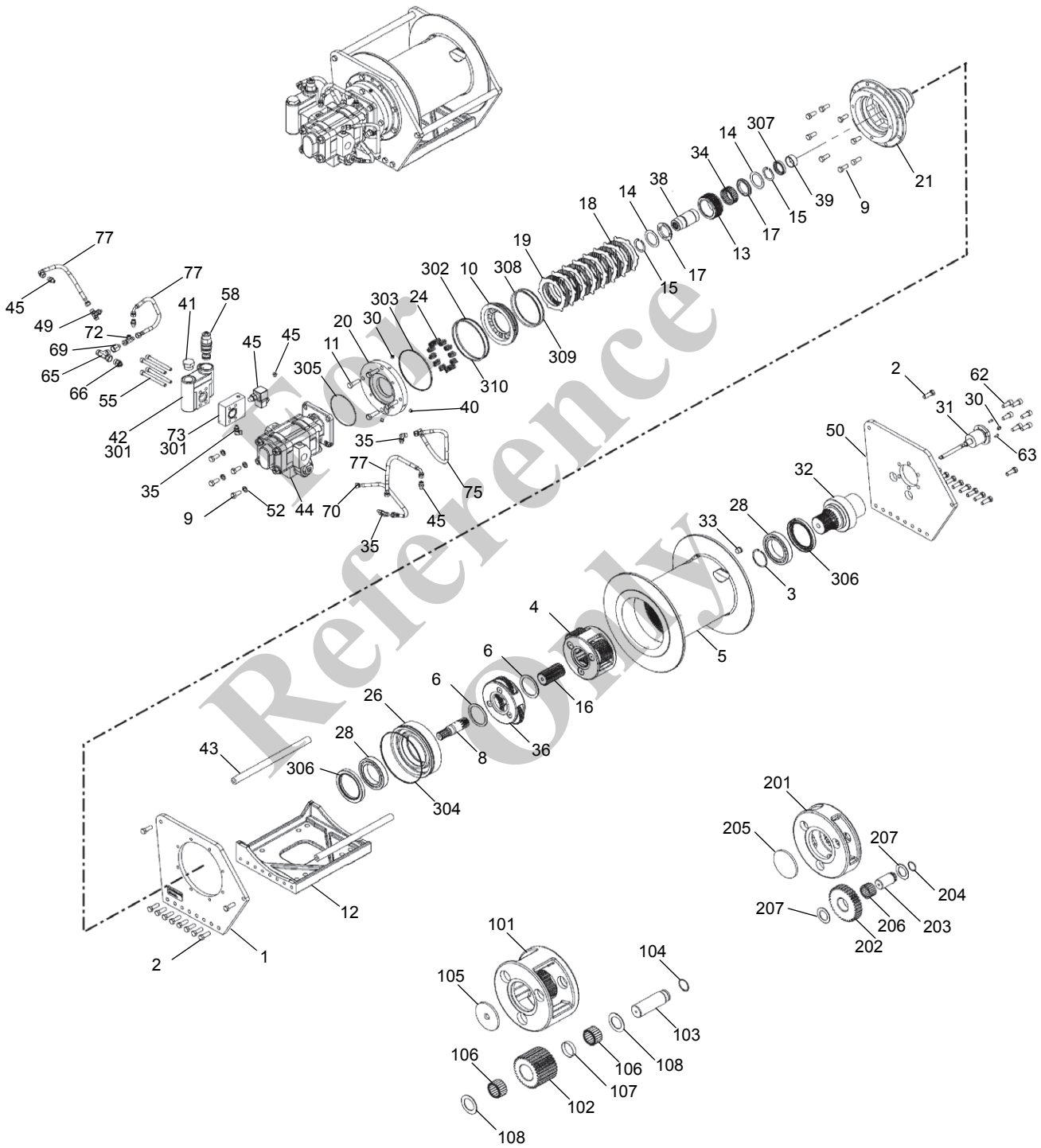


a0474 Correct Winding of Wire Rope **FIGURE 11-10**

4. After installation, operate the hoist with a minimum load until you see the wire rope is moving easily over the sheaves and winding correctly on the hoist drum.
5. Gradually increase the speed and load until the wire rope is moving at normal load and speed. This run-in period adjusts the moving parts to each other.

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HOIST EXPLODED VIEW



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FIGURE 11-11

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11

Legend for Figure 11-11

Item	Quantity	Description
1	1	Plate, Side
2	20	Capscrew
3	1	Snap Ring
4	1	Gear Set
5	1	Drum Housing
6	2	Race, Bearing
8	1	Gear, Input Sun
9	12	Capscrew
10	1	Brake Piston
11	4	Screw
12	1	Base Plate
13	1	Brake Driver
14	2	Race
15	2	Snap Ring
16	1	Gear, Sun Output
17	2	Bushing
18	7	Friction Disc
19	8	Plate, Stator
20	1	Cover, Brake
21	1	Brake Housing
24	12	Brake Spring
26	1	Carrier, Bearing
28	2	Bearing
30	2	Breather
31	1	Sender, DRI/MWI
32	1	Shaft, Output
33	1	Plug, O-ring
34	1	Clutch
35	3	Fitting, 90 deg
36	1	Input Gear Set - 201 thru 207
38	1	Driver, Input
39	1	Bushing
40	2	Plug
41	1	Plug, Flush
42	1	Counterbalance Block
43	2	Support Rod
44	1	Motor Assy
45	4	Fitting, Adapter
49	1	Fitting, Tee
50	1	Plate, Side
52	4	Lockwasher, 1/2 ID
55	4	Capscrew
58	4	Counterbalance Valve
61	4	NCC Label
62	6	Capscrew
63	2	Screw, Buttonhead
64	1	Cord Set
65	1	Fitting, Tee
66	1	Fitting, Straight Adapter
69	1	Fitting, Reducer
70	1	Hose Assy
72	1	Fitting, Tee Adapter
73	1	Manifold Block
74	1	Valve, Cart. Solenoid
75	1	Hose Assy
77	3	Hose Assy
80	1	O-ring
81	1	Cord Set Rotation
82	1	Shaft DRI
101	1	Housing, Carrier
102	3	Gear, Planet
103	3	Pin
104	3	Retainer
105	1	Plate
106	6	Bearing
107	3	Spacer
108	6	Race, Bearing
201	1	Housing, Carrier
202	3	Gear, Planet
203	3	Pin
204	3	Retainer
205	1	Plate
206	3	Bearing
207	6	Race, Bearing
301	2	O-ring
302	1	O-ring
303	1	O-ring
304	1	O-ring
305	1	O-ring
306	2	Seal, Oil
307	1	Seal, Oil
308	1	O-ring
309	1	Ring, Back-up
310	1	Ring, Back-up
315	1	Kit, Seal

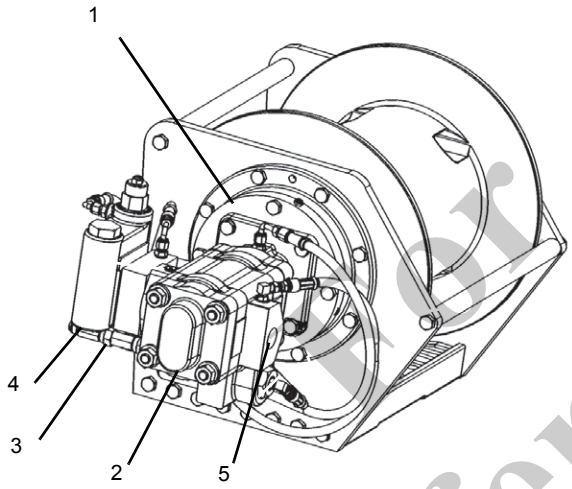
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HOIST

Hoist Description

The hoist is composed of motor control valve, a fixed displacement hydraulic motor, a multiple disc brake, and a pair of planetary gear sets.

The multiple disc brake is spring applied and hydraulically released through a port in the brake housing. An overrunning clutch allows the hoist to raise the load without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down.



Item	Component
1	Brake
2	Motor
3	Case Drain
4	Pressure Port to Raise
5	Pressure Port to Lower

FIGURE 11-12

Hoist Maintenance

Inspect the hoist daily for oil leaks, loose bolts, and worn hoist cable. Check the gearbox and brake oil every 500 hours. Do an oil change every 1000 hours. Refer to *Preventative Maintenance*, page 5-1. Inspect the hoist from the deck of the crane. Do not stand on the turret.

WARNING

Fall Hazard!

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state, or federal regulations. Death or serious injury may result.

Inspect the hydraulic hoses and replace as required.

Hoist Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential if ambient temperature is below 4°C (+40°F). Run the crane at idle with the hoist control lever in neutral and allow sufficient time for the hydraulic system to warm up. Operate the hoist at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil and circulate lubricant through the planetary gear sets.

Hoist Removal

WARNING

Crushing Hazard!

The combined weight of the hoist and 119 m (390 ft) of wire rope is 331 kg (730 lbs). Death or serious injury may result.

NOTE: See Figure 11-12 for item identification.

1. Remove the cable from the hoist drum.
2. Tag and disconnect the hoist hydraulic lines. Cap and plug all hydraulic openings.
3. Attach a lifting device to the hoist and take up the slack.
4. Remove the mounting bolts from the hoist.
5. Remove the hoist from the crane with the lifting device.

Hoist Installation

1. Attach a lifting device to the hoist.
2. Lift the hoist with a lifting device onto the turret.
3. Install mounting bolts and washers.
4. Remove the lifting device.
5. Reinstall the hydraulic hoses as per removal tags.

Hoist Repair

Disassembly

The following steps describe how to disassemble the hoist. Inspect and replace all worn parts.

1. Stand the hoist on its end with the motor pointing up. Place blocking under the side plate so the hoist is not sitting on the shaft (Figure 11-13).

NOTE: See Figure 11-11 for item number identification.

2. Remove the brake hose (46) from the straight adapter (45).
3. Remove the motor and counterbalance assembly from the hoist by removing two capscrews (47) and two

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lockwashers holding the motor (44) to the brake cover (20). See *Motor*, page 11-22 for motor and counterbalance valve disassembly.

4. Remove the brake sub-assembly from the hoist by removing the eight capscrews (9) holding the brake housing to the side plate (41). Re-install two of these capscrews into the two extra tapped holes and tighten them evenly until the brake housing is loose from the side plate. Take note of the vent (30) location for reassembly. See *Brake*, page 11-21 for brake repair.

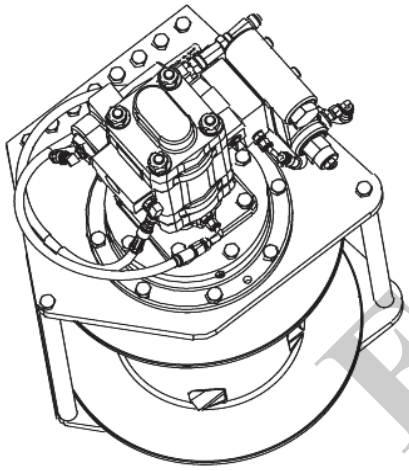


FIGURE 11-13

5. Remove the side plate (41) by removing the three capscrews (1).
6. Lift the bearing carrier (26) from the drum. If necessary remove and replace the bearing (28) and seal (306).
7. Remove the input sun gear (8) and thrust washer (6) from the input planet assembly (36).
8. Remove the input planet set (36) from the drum. Inspect the planet set for wear. See *Planetary Set*, page 11-22 for disassembly and repair.
9. Remove the output sun gear (16) and thrust washer (6) from the output planet assembly (4).
10. Remove the output planet set (4) from the cable drum. Inspect the planet set for wear. See *Planetary Set*, page 11-22 for disassembly and repair.
11. Remove the cable drum (5) and inspect the gear teeth for excessive wear. Remove and replace the bearing (28) and seal (306) located in the drum.
12. Inspect retaining ring (48) to insure it is still in groove and is not bent over.
13. If necessary remove output shaft (32) from side plate (29) by removing six capscrews (3) holding side plate (29) to shaft (32). Take note of vent (30) location for reassembly.

Reassembly

NOTE: See Figure 11-11 for item number identification.

1. Thoroughly clean all parts. Replace those that show wear or damage.
2. Inspect the cable drum (5) for structural integrity and replace if necessary.
3. Attach the shaft (32) to the side plate (29) using the six capscrews (3). Make sure the vent (30) is oriented properly. Torque the capscrews to recommended values, refer to *Fasteners and Torque Values on page 1-15*.
4. Install retaining ring (48) onto the shaft (32)
5. Lay the unit down with the rods (2) pointing up. Support the side plate (29) with blocking (Figure 11-13) so that the hoist is not setting on shaft (32).
6. Set cable drum (5) onto shaft (32) and seat drum on bearing (28). Be careful not to damage seal (306).
7. Install the output planet set (4).
8. Install the output sun gear (16) into the output planet set.
9. Install the thrust washer (6) into the output planet set.
10. Install the input planet set (36) into the drum. Make sure that it fits over the output sun gear (16).
11. Install the input sun gear (8) and thrust washer (6) into the input planet set.
12. Install the thrust washer (6) into the input planet set.
13. Install a new O-ring (304) and if necessary bearing (28) & seal (306) into the bearing carrier (26). Grease the O-ring and seal then install the bearing carrier into the drum.
14. Position the side plate (1) over cable drum on rods (43). Secure the side plate with the three capscrews (2). Tighten capscrews to 109 to 122 Nm (80 to 90 lb-ft).
15. Install the brake sub-assembly into the side plate (1). Make sure that the pilot of the brake housing aligns with the bore in the bearing and that the bolt holes for the motor and vent are oriented properly. Install the eight capscrews (2). Tighten the capscrews evenly to 109 to 122 Nm (80 to 90 lb-ft).
16. Install a new O-ring (305) onto the face of the motor and reinstall the motor/counterbalance valve assembly. Reconnect the hose (70).
17. Fill both the gearbox and the brake section with the proper amount and type of lubricants. See *Preventative Maintenance*, page 5-1.

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Hoist Service

Brake

NOTE: See Figure 11-11 for item number identification.

1. Evenly remove the four capscrews (11) holding the brake cover (20) in place. Spring pressure will raise the cover up as the capscrews are loosened. Remove the cover from the brake housing.
2. Remove the springs (24) from the piston and check the springs for free height. Each spring should measure at least 30.5 mm (1.20 in) with no force.
3. To remove the brake piston (10), install two pieces of all-thread (3/8-16NC) in the bottom of two spring pockets.
4. Using jam nuts, screw the all-thread pieces in evenly until the piston is clear of the housing. An alternate way of removing the piston is to use shop air to slowly pressurize the brake cavity until the piston is out of the bore.
5. Grasp the brake driver/clutch assembly (Items 38, 13, 23, 14, 15 & 17) and remove it from the brake housing.
6. Remove the stator plates (19) and friction discs (18) from the brake housing and check for excessive wear. Be sure to check the top stator plate for scoring caused by the removal tools and polish if necessary. Friction discs should measure no less than 1.397 mm (0.055 in) thickness and stator plates should measure no less than 1.727 mm (0.068 in) thickness.
7. With a hook wire or pry bar, remove the seal.
8. Examine the bushing (39) in the brake housing for wear and replace if necessary.
9. If brake housing (21) is removed from the hoist, examine the journal on the brake housing, where the seal (304) fits, for wear. If severely worn, replace the brake housing.
10. Carefully disassemble the brake driver/clutch assembly noting the direction of lockup for the clutch (34). The clutch assembly must be re-assembled with the arrow pointing in the proper direction for the hoist to function properly. Inspect the outside diameter on the input driver (38) and inside diameter of the brake driver (13) where the clutch (34) runs. If there is any pitting or spalling (flakes of a material that are broken off) on the driver then it and the clutch must be replaced.
11. Re-assemble the driver/clutch assembly, making sure that the clutch is installed properly.
12. Install a new seal into the brake housing. If the brake housing is removed from the hoist temporarily install the input sun gear into the brake housing, and slide the driver/clutch assembly onto the sun gear spline.
13. Install the stator plates (19) and friction discs (18) into the brake housing starting with a stator and alternating friction discs and stator plates. There is one more stator plate than friction disc so the last item installed is a stator plate.
14. After installation, check the brake stack up to make sure that the dimensions are within the tolerance shown in Figure 11-14. If your measurement is greater than shown, either some friction discs and stator plates have been left out, or the friction discs are worn beyond acceptable tolerances. If your measurement is less than shown, too many plates or discs have been inserted or they are not seated properly.
15. Coat the new backup rings and O-rings with light oil and install onto the piston (10) with the backup rings toward the outside of the piston. See Figure 11-14 for proper O-ring and backup ring installation.

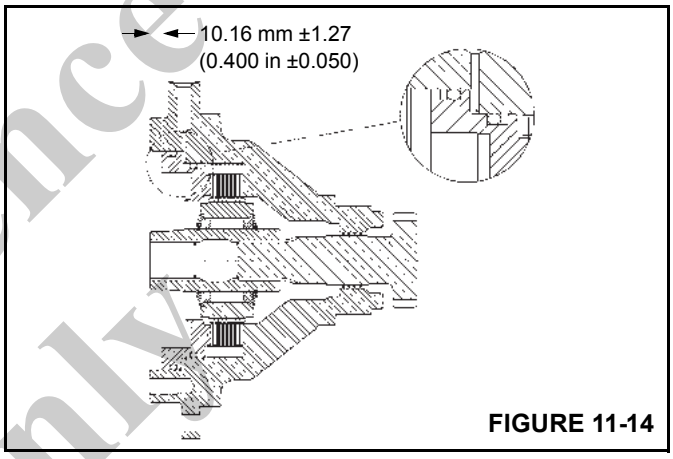


FIGURE 11-14

16. Carefully install the piston into the brake housing and gently tap it down until it is seated.
17. Install the springs (24) into the spring pockets of the piston. If working in a horizontal position, coat the bottom of each spring with chassis lube to keep it in position.
18. Coat the new O-ring with light oil and install into the groove on the brake cover (20).
19. Install the cover (20) onto the brake housing (21) and tighten it evenly, alternating between opposite capscrews. Make sure that the cover is aligned properly with the brake housing to orient the motor and vent as they should be.
20. Check the brake release with a portable hydraulic pump. Full release should be obtained at 17.24 bar ± 1.38 bar (250 psi ± 20 psi). Also, check the brake for proper operation by applying 10.69 bar (155 psi) to the brake port and adapting a torque wrench to the input shaft. The torque in the hoist-down, or payout, direction should be 120 to 156 Nm (95 to 115 lb-ft).

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Planetary Set

NOTE: See Figure 11-11 for item number identification.

1. Remove the spiral retaining rings from the planet pins.
2. Remove the pins from the carrier by carefully tapping them out.
3. Remove the planet gears, thrust washers and bearings from the carriers.
4. Inspect the pins, bearings, and gear bores for evidence of wear and replace if necessary.
5. On output planet sets, note that two bearings with a spacer between them are used.
6. Before reassembly, be sure to insert the round plates into the carriers.
7. To re-assemble, be careful to line up the planet pins with the thrust washers and bearings and then press the knurled part of the pin into the carrier.

CAUTION

Possible Equipment Damage!

If the pins are not lined up properly, the thrust washers can be shattered during the pressing operation.

Motor

1. Remove the hose and the counterbalance block (42) from the motor assembly.
2. To remove the counterbalance block (42), loosen and remove the 4 capscrews (55).
3. Remove the counterbalance valve (58) from the counterbalance block and inspect the small metering hole located on the side of the cartridge valve to make sure it is not obstructed (Figure 11-15). Also inspect the O-rings to insure that they are not cut or flattened.
4. Motors and cartridge valves are not serviceable in the field. Return them to an authorized distributor for service.

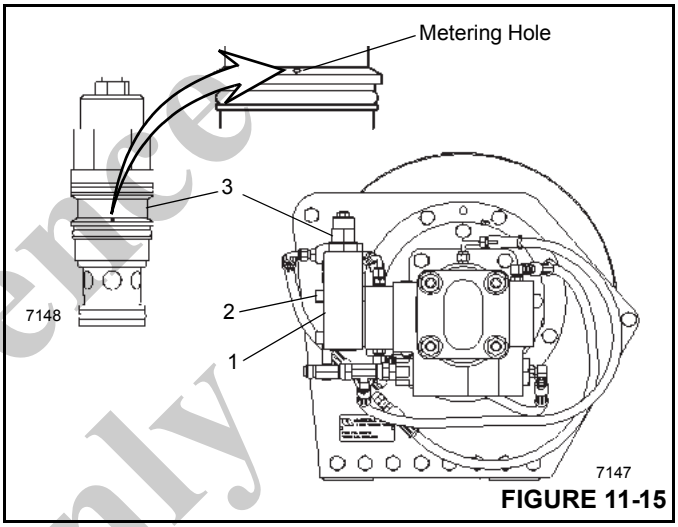
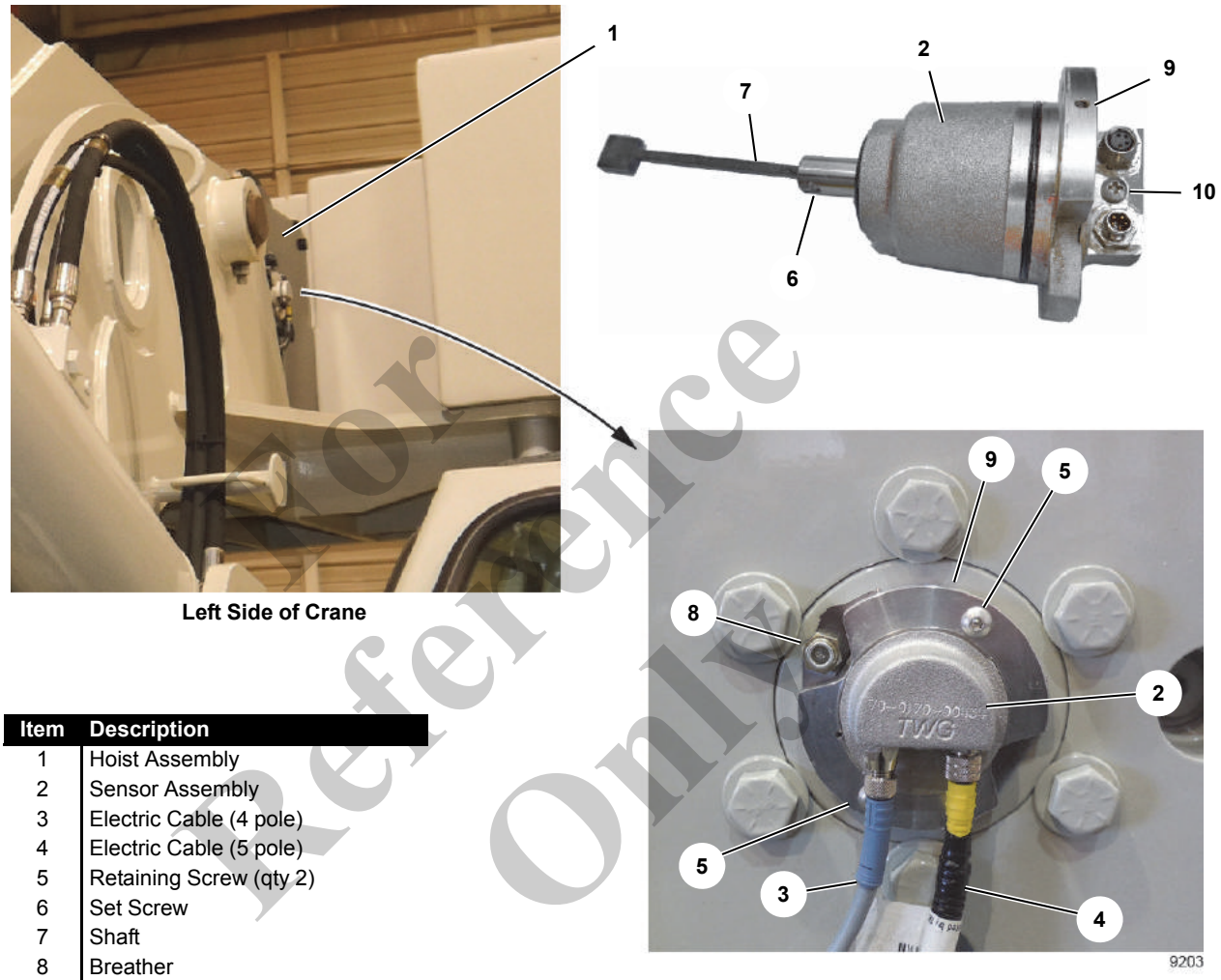


FIGURE 11-15

HOIST TROUBLESHOOTING

Problem	Cause	Solution
Hoist does not hold load	Excessive back pressure in the system.	Check the system for restrictions and reduce the back pressure.
	Brake discs are worn out.	Replace brake discs.
	Hoist clutch is slipping.	Inspect the clutch and driver for wear and replace worn parts.
The hoist does not raise the load it should.	Relief valve setting may be too low to allow proper lifting.	Increase relief valve pressure setting.
	Load being lifted may be more than the hoist's rating.	Reduce the load or re-rig to increase mechanical advantage.
The hoist does not lower the load.	The brake valve was connected improperly after being disconnected.	Check plumbing and connect lines properly.
	The cartridge in the brake valve may have a plugged metering hole.	Remove the cartridge and clean it if necessary.
Oil leaks from the vent on the motor side of the hoist.	The motor shaft seal may have failed.	Replace this seal and reduce back pressure if high pressure caused the shaft seal to fail.
	Brake piston seals may have failed.	Service the brake section and replace worn parts.

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Left Side of Crane

Item	Description
1	Hoist Assembly
2	Sensor Assembly
3	Electric Cable (4 pole)
4	Electric Cable (5 pole)
5	Retaining Screw (qty 2)
6	Set Screw
7	Shaft
8	Breather
9	Set Screw (qty 2)
10	Access Screw

FIGURE 11-16

For Reference Only

DRUM ROTATION/MINIMUM WRAP INDICATOR

The drum rotation (DRI)/Minimum Wrap (MWI) indicator (Figure 11-16) is located on the left side of the hoist. It serves the following purposes:

- The sensor transmits a rotation signal (DRI) to a solenoid (thumb thumper) located in the end of the hoist control lever in the cab.
- The sensor also turns on the MWI alarm (warning buzzer and minimum wrap red warning light) on the instrument panel when there are three wraps of cable left on the drum.

Replacing the DRI/MWI Sensor

See Figure 11-16 for this procedure.

Tools Required

- 3/16 in Allen wrench
- 1/16 in Allen wrench
- Phillips screw driver

Sensor Removal

1. Disconnect the electric cables (3 and 4).
2. Remove the two retaining screws (5).
3. Remove the sensor assembly (2) from the hoist.
4. Loosen the set screw (6) and remove the shaft (7) from the sensor assembly (2).

Sensor Installation

1. Install the shaft (7) into the sensor assembly (2) and tighten the set screw (6) to 7 in-lb.
2. Liberally apply silicone sealant on the set screw to prevent oil from getting into the electronics.
3. Carefully insert the sensor assembly (2) into the drum so the shaft (7) engages the drive inside the drum.
4. Align the notch in the sensor assembly (2) with the breather (8).
5. Secure the sensor assembly (2) with two retaining screws (5).Tighten to 16 in-lb.
6. Loosen two set screws (9) in the sensor flange.
7. Rotate the sensor center section so the electrical connectors point down.
8. Tighten the set screws (9) to 2 in-lb.
9. Securely attach the electric cables to the connectors.

WARNING

Moving Machinery Hazard!

It is necessary to operate the hoist while programming the minimum wrap indicator.

Stay clear of the drum and the wire rope while it is being operated. Death or serious injury may result.

Programming the Minimum Wrap Indicator

See Figure 11-16 for this procedure.

1. Start the engine.
2. Operate the hoist until there are three wraps of rope on the first layer of the drum. This is the first set point to deactivate the alarm.
3. Disconnect the electric cable (4) to turn off power to the sensor assembly.
4. Remove the access screw (10) to the programming button.

NOTE: During the programming steps, use an Allen wrench or other small tool with a flat, blunt end approximately 1.5 mm (1/16 in) in diameter and at least 76 mm (3 in) long.

DO NOT use a pointed or sharp tool. A faulty setting or damage can occur. Also, excess force can cause damage.

5. Insert the programming tool into the access hole.
6. Gently press and hold the programming button and reconnect the electric cable (4) to turn on power to the sensor assembly.

   Hold the programming button for at least 2 seconds, but less than 15 seconds, after power is on. Then release the button.
7. Operate the hoist until there are THREE wraps of wire rope on the first layer of the drum. This is the second set point to activate the MWI alarm.
8. Gently press and hold the programming button for 1-2 seconds. Then release the button.
9. The MWI alarm should come on.
10. Install the access screw and tighten to 7 in-lbs.

NOTE: Failing to install the access screw could effect operation of the MWI.

11. The MWI setup routine is complete.

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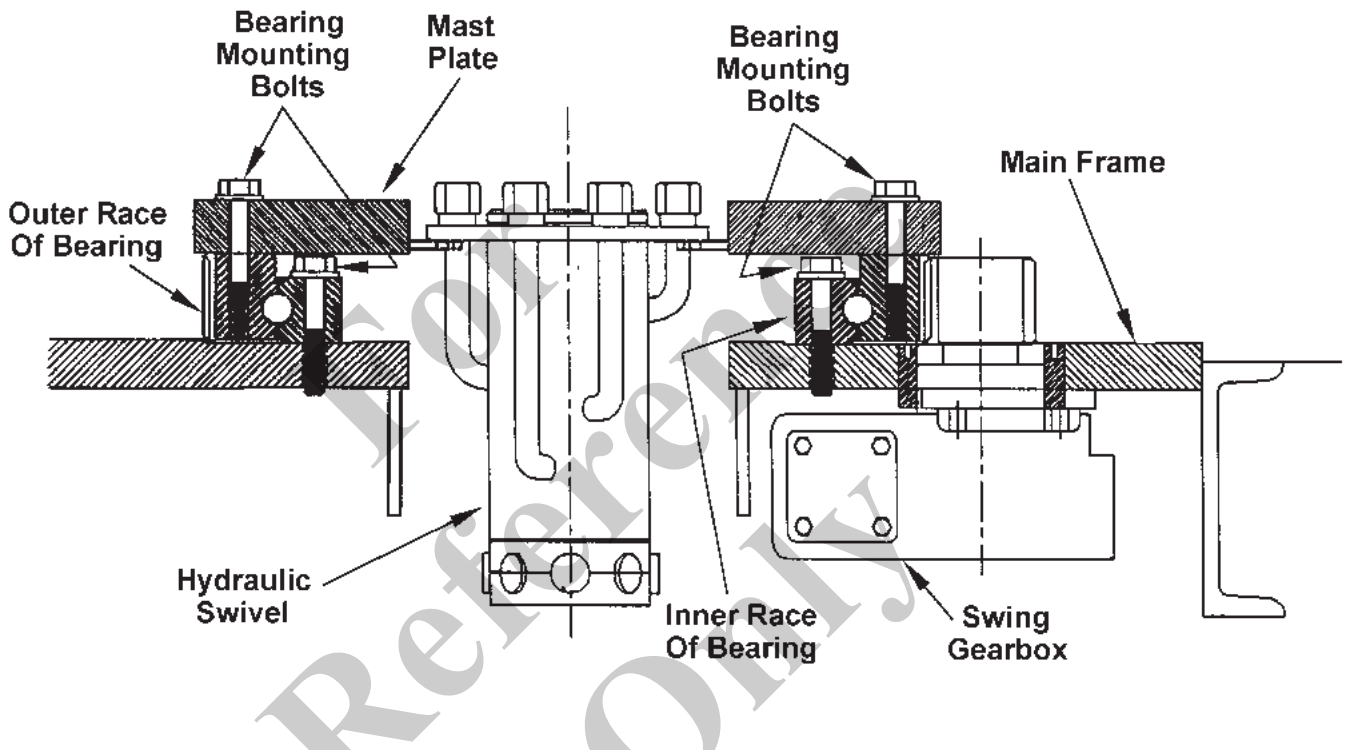
BEARING, MAST AND RELATED PARTS

General

The mast is fastened to the main frame of the crane through a bearing. The inner race of the bearing is fastened to the frame and the outer race of the bearing is fastened to the mast. See Figure 11-17 and 11-18.

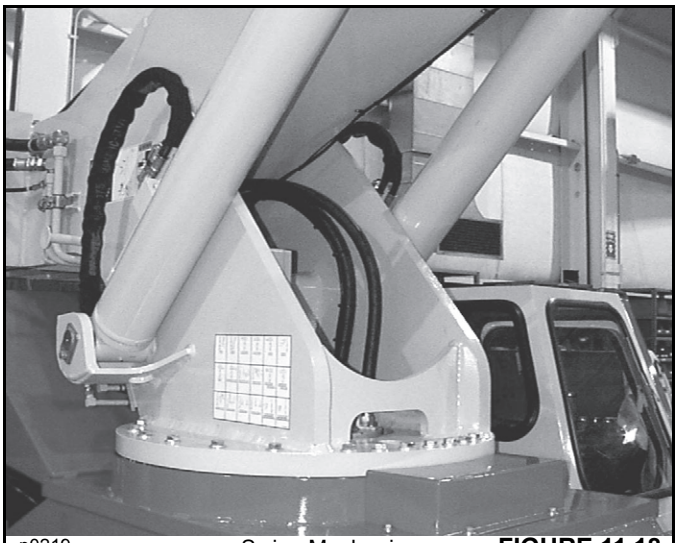
The rotation of the mast is done by a gearbox which is mounted below the frame deck. A hydraulic motor connected to the gearbox provides power for rotation of the mast.

The bearing is filled with grease through two grease fittings on the inner race of the bearing. A slotted hole in the mast plate allows access to the inner race and the grease fittings.



a0490 Cross Section of Mast Bearing **FIGURE 11-17**

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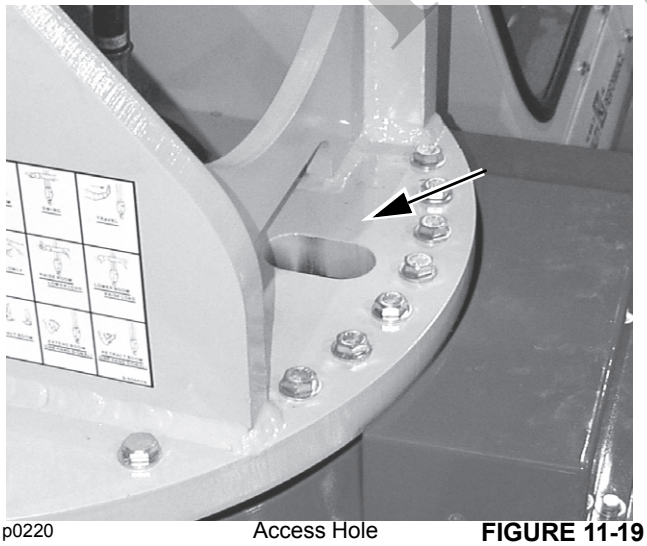
p0219 Swing Mechanism **FIGURE 11-18**

Mast Bearing

The bearing is a ball thrust bearing. The inner race rotates inside the outer race on a row of steel balls.

Apply grease weekly or every 50 hours of operation, whichever occurs first. Use a Lithium based, E.P. No. 2 bearing grease, or equivalent.

There are two grease fittings to grease the bearing and they are directly across from each other. Rotate the mast until the access hole (Figure 11-19) aligns with the grease fitting. Apply grease to the bearing. Rotate the mast through several rotations and then repeat the procedure with the other grease fitting. The old grease will be removed at the bottom of the bearing.



p0220 Access Hole **FIGURE 11-19**

Mast Bearing Bolts

Very high stress is put on the mast bolts during crane operation. It is important that these bolts be checked at regular intervals.

Check the torque on the bolts after the first week or 50 hours of operation, whichever occurs first, and then every month or 250 hours of operation, whichever occurs first. Make a record of any loose bolt. If any bolt does not hold to correct torque after the second check, remove and replace the bolt. A loose bolt indicates possible failure of the bolt.

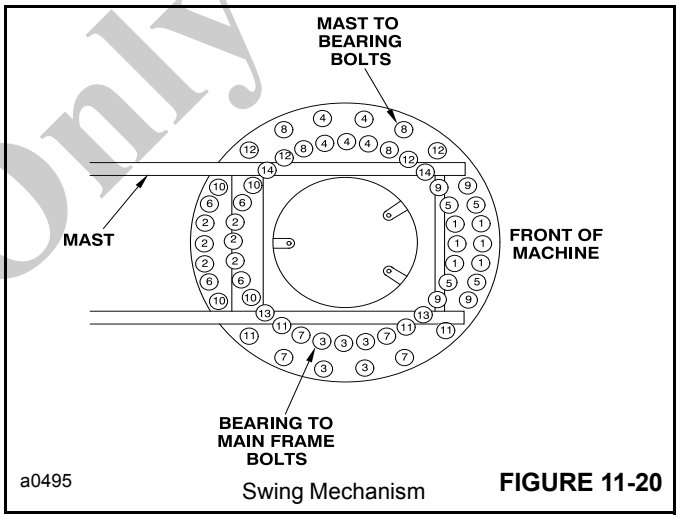
Tighten each outside bolt (mast to swing bearing) and each inside bolt (swing bearing to frame) to torque referred to in sub-section titled *Fasteners and Torque Values on page 1-15*.

Use the torque sequence shown in Figure 11-20 when checking the torque on the bolts.

NOTE: Use only special Class 12.9 bolts for replacement of the mast bolts. Order the bolts from your Grove distributor, see your parts manual.

If a broken bolt is found, replace the bolt and also replace the bolt on each side of the broken bolt.

The proper torque will not be obtained without the hardened steel washers under the bolt heads on the outer (mast) bolt circle.



a0495 Swing Mechanism **FIGURE 11-20**

Inspection for Bearing Wear

Because of conservative design parameters, static loading and slow intermittent rotation, there are very few mast bearings that ever see their full design use.

However, the mast bearing does have moving internal parts that are prone to wear if not maintained properly. As the bearing wears, there will be free-play or movement in the bearing. Some of the symptoms of mast bearing wear are:

a. Metal particles in the grease around the seal.

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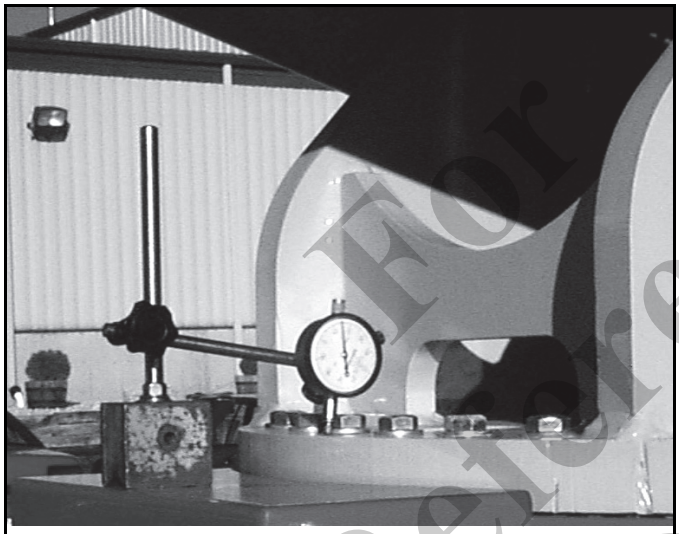
b. Increased drive power required.

c. Noisy rotation.

d. Rough rotation.

If one or more of the above symptoms are present, the following procedure should be used to test the bearing for excessive wear.

1. On a level, hard packed surface, set the crane up on its outriggers.
2. With the boom forward, fully extended and in a horizontal position, place a dial indicator on the swing gearbox cover and mast as shown in Figure 11-21.
3. Set the dial indicator to zero.



p0222 **FIGURE 11-21**

4. Raise the boom to its full raised position and record the amount of movement on the dial indicator.
5. Lower the boom and then rotate it 180°. Repeat steps 2 though 4.
6. Average the two readings. The maximum allowable movement is 1.52 mm (0.060 in). The mast bearing must be replaced if the movement is greater than the stated measurement.

Replacing the Mast Bearing

Removal

1. Refer to boom removal in this section and remove the boom from the mast.
2. Remove swivel stop (36, Figure 11-23) from the bottom of the hydraulic swivel (15).
3. Attach tags to the hydraulic hoses and lines with the swivel port number to which they connect.
4. Disconnect the hydraulic lines from the lower swivel ports. Put caps or plugs on the fittings and hydraulic lines.
5. Using an overhead crane, remove the counterweight from the mast.
6. Refer to hoist removal in this section and remove the hoist assembly.
7. Connect a hoist to the mast capable of handling the weight of the mast. Remove the 26 bolts (16) and flat washers (17), which fasten the mast to the mast bearing.
8. Remove the mast and place it on blocks.
9. Remove the 26 bolts (18) and flat washers (17) and remove the mast bearing (19) from the frame.

Installation

1. Using a suitable solvent, clean the holes in the bearing plate on the main frame. Remove the residue with compressed air. Clean all dirt from the bearing plate.
2. Locate the mast bearing (19, Figure 11-23) in place on the bearing plate.
3. Install the bolts (18) and flat washers (17) to fasten the mast bearing to the bearing plate.
4. Figure 11-20 shows order of tightening the bolts. Each bolt must first be tightened to a torque of 698-756 Nm (515-558 lb-ft) and then loosened slightly. After which, each bolt must again be torqued to 698-756 Nm (515-558 lb-ft).
5. Make sure the top surface of the mast bearing and the bottom surface of the mast base are clean.
6. With a hoist, raise and then lower the mast into position over the mast bearing. Install bolts (16, Figure 11-23) and washers (17).
7. Figure 11-20 shows the order for tightening the bolts. Each bolt must first be tightened to a torque of 698-756 Nm (515-558 lb-ft), and then loosened slightly. After which, each bolt must again be tightened to a torque of 698-756 Nm (515-558 lb-ft).
8. Install swivel stop (36, Figure 11-23) to hydraulic swivel (15).
9. Connect the hydraulic lines to the hydraulic swivel.
10. Install counterweight (2) onto the mast.
11. Install the hoist assembly to the mast.
12. Install the boom assembly.

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Swing Gearbox and Pinion

Maintenance

Gearbox

The swing gearbox has a worm gear set which rotates on taper roller bearings. The gears and bearings are given lubrication by the grease in the gearbox. Gaskets inhibit external leakage from the gearbox. Keep the gear case filled with grease.

Swing Gear/Pinion

The swing pinion and gear must be lubricated at regular intervals.

Adjustment

Checking Backlash

Check the backlash between the swing gear and the swing gearbox pinion every six months or after 1500 hours of operation, whichever occurs first.

1. Remove the swing gear pinion cover.
2. Start the engine and rotate the mast until the high point on the swing gear is engaged with the pinion (Figure 11-22). The high point is punch-marked on the edge of the gear or is a painted mark on the gear.
3. Using a 0.013 mm (0.005 in) feeler gauge, check the backlash between the gear and pinion. There should be 0.013 mm (0.005 in) clearance between the swing gear tooth and the pinion tooth. If there is any other clearance, adjust the backlash.

Backlash Adjustment

NOTE: Be sure the swing gear and pinion are aligned at the high spot of the swing gear.

1. Slightly loosen the four bolts securing the gearbox (Figure 11-22).
2. Use a 0.013 mm (0.005 in) feeler gauge between the pinion and swing gear.
3. With a spanner wrench, turn the eccentric ring to move the pinion until it contacts the feeler gauge (0.013 mm (0.005 in) backlash).
4. Tighten the four bolts to appropriate torque.
5. Install the swing pinion cover.

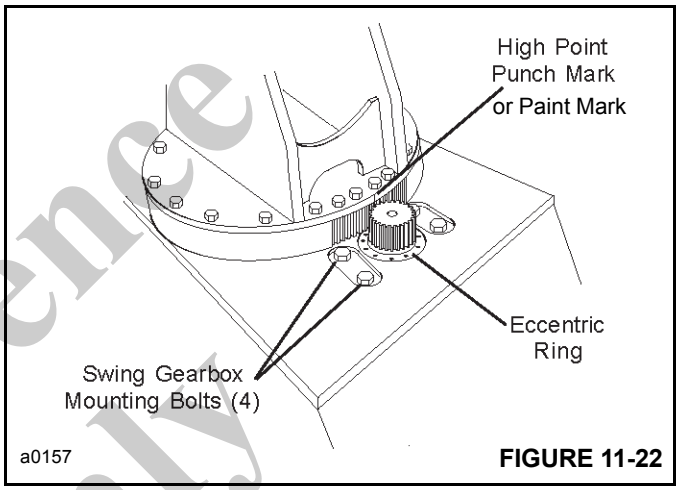


FIGURE 11-22

For Reference Only

Item	Description
1	Mast
2	Counterweight
3	Hoist
4	Bolt
5	Washer
6	Washer
7	Nut
8	Washer
9	Nut
10	Bolt
11	Washer
12	Bolt
13	Lock Washer
14	Washer
15	Hydraulic Swivel
16	Bolt
17	Washer
18	Bolt
19	Swing Bearing
20	Bolt
21	Washer
22	Bolt
23	Lock Washer
24	Washer
25	Pinion Gear Cover
26	Bolt
27	Washer
28	Swing Motor
29	Gasket
30	Swing Gear Box
31	Nut
32	Washer
33	Bolt
34	Lock Washer
35	Bracket
36	Stop Assembly
37	Bar
38	Eccentric Ring

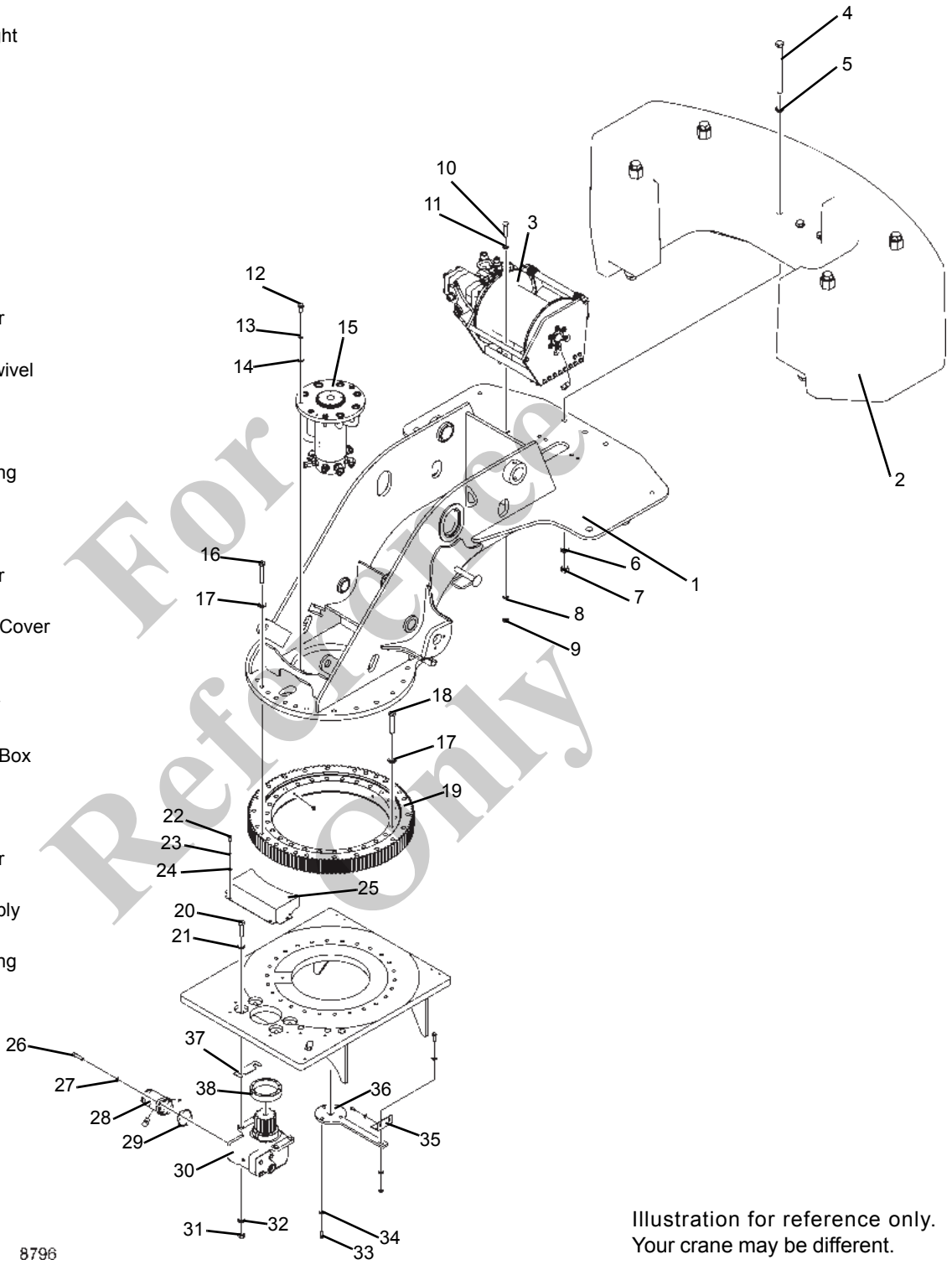


Illustration for reference only.
Your crane may be different.

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Mast Assembly

FIGURE 11-23

11

Swing Gearbox Repair

Removal

1. Use a hoist and blocks to hold the boom in position and prevent the mast from rotating.
2. Remove the swing motor from the gearbox.

NOTE: Do not rotate the mast after the hydraulic motor has been removed from the gearbox. Internal bearings will become dislodged. Make note of the position of the swing motor for installation.

3. Provide support for the gearbox and remove the four bolts which fasten the gearbox to the frame. Remove the gear box and eccentric ring from beneath the crane.

Disassembly

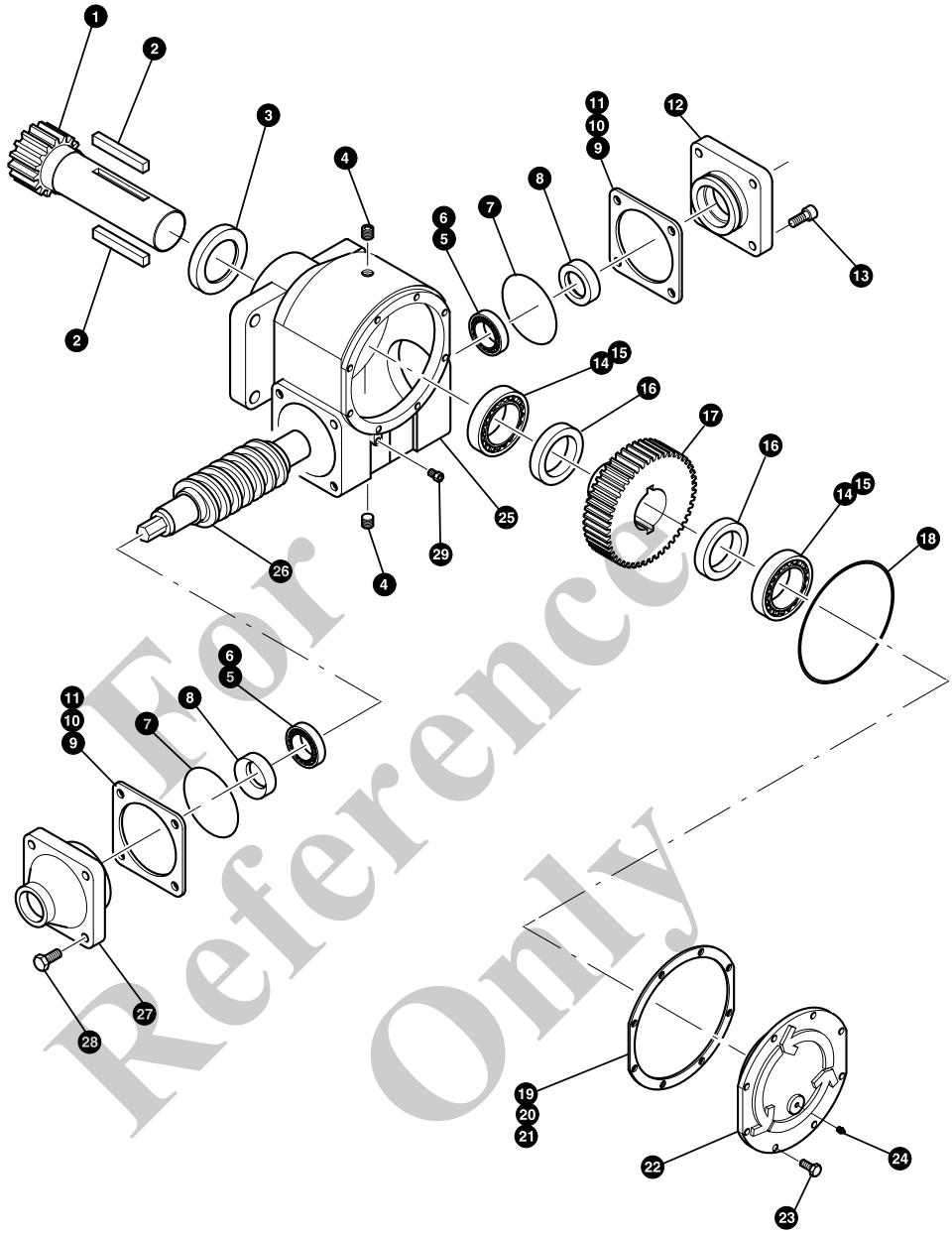
1. Clean the outside of the gearbox before disassembly.
2. Loosen bolts (23, Figure 11-24) from cover (22). Remove the cover from the gear housing (25).
3. Clean as much grease out of the housing as possible. Properly dispose of the grease.

NOTE: Tie the shim sets together to prevent any shim from being lost.

4. Remove shims (19) through (21) from the gear case. Be careful not to damage or lose any of the shims.
5. Remove O-ring (18) and cover (22).
6. Remove socket head capscrews (13). Remove end motor cap (12).
7. If shims (9) through (11) are located between cover (12) and housing (25) remove the shims. Be sure not to damage or lose any of the shims.
8. Remove and discard O-ring (7) and seal (8).
9. Remove capscrews (28) and remove end cap (27).
10. If shims (9) through (11) are located between cover (27) and housing (25) remove the shims. Be sure not to damage or lose any of the shims.
11. Remove and discard O-ring (7) from end cap (27).
12. Using a suitable puller, remove bearing cup (5) from end cap (27). Remove and discard seal (8).
13. Using a suitable puller, remove bearing cone (15) from pinion shaft (1). Remove spacer (16).
14. Using a suitable puller, remove worm gear (17) from pinion shaft (1). Remove spacer (16).
15. Using a suitable puller, remove bearing cone (15) from pinion shaft (1).
16. Remove pinion shaft (1) and worm (26) from housing (25).
17. Remove wiper seal (3) from housing (25).

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For Reference Only



Item	Description
1	Pinion Shaft
2	Key (2)
3	Oil Seal
4	Pipe Plug (2)
5	Bearing Cup (2)
6	Bearing Cone (2)
7	O-Ring (2)
8	Seal (2)
9	Shim (2)
10	Shim (2)

Item	Description
11	Shim (2)
12	End Motor Cap
13	Socket Head Capscrew
14	Bearing Cup (2)
15	Bearing Cone (2)
16	Spacer (2)
17	Worm Gear
18	O-Ring
19	Shim
20	Shim

Item	Description
21	Shim
22	Cover
23	Capscrew (8)
24	Grease Fitting
25	Housing
26	Worm
27	End Cap
28	Capscrew (4)
29	Breather

Illustration for reference only.
Your crane may be different.

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Tulsa Swing Gearbox Exploded View

FIGURE 11-24

For Reference Only

18. Using a suitable puller, remove bearing cup (14) from housing (25).
19. Using a suitable puller, remove bearing cup (14) from cover (22).

Inspection

Clean all parts. Make sure the breather (29, Figure 11-24) is clean. Make a careful inspection of all parts, including gears, shafts and bearings.

Replace all seals and gaskets.

Assembly

1. If removed, install a new bearing cup (14) into housing (25).
2. Install new wiper (3) into housing (25).
3. Install pinion shaft (1) into housing (25) through seal (3) Be careful not to damage the seal.

NOTE: Before installing any bearing cone, pack the bearing with a Lithium base, E.P. No. 2 bearing grease.

4. Pack both bearing cones (6) with grease and install onto worm (26).
5. Insert worm (26) into housing (25).
6. Pack first bearing cone (15) with grease and install onto pinion shaft (1). Install first spacer (16).
7. Using two keys (2), install worm gear (17) onto pinion shaft (1).
8. Install second spacer (16) and second bearing cone (15) onto pinion shaft (1). Be sure bearing cones are packed with grease before assembly.
9. Install seal (8) into end cap (12). Install bearing cup (5). Install O-ring (7). Lubricate the seal and O-ring with grease before assembly.
10. Install seal (8) into motor cap (27). Install O-ring (7). Lubricate seal and O-ring with grease before assembly.
11. Insert the end of worm (25) into end motor cap (12). Fasten end motor cap (12) to housing (25) with socket head capscrews (13).
12. Align the gear teeth of worm (25) with the teeth of worm gear (17).
13. If the original bearing cups and cones were installed in the end caps and onto the worm, the existing shims (9) through (11) may be installed between housing (25) and end cap (27). Install the shims and end cap. Attach end cap (27) with capscrews (28).

    If new bearings were installed, proper bearing pre-load must be determined before final installation of the end cap (27).

    a. Install end cap without shims installed.
    b. Using a dial indicator, measure the amount of axial movement of the worm. Proper axial movement must be between -0.025 to +0.05 mm (-0.001 to + 0.002 in).Determine the amount of shims required to attain the proper axial movement. Then, install the shims between housing (25) and end cap (27). Fasten with capscrews (28).

14. If the original bearings were installed on pinion shaft (1), then the existing shims (19) through (21) may be installed between cover (22) and housing (25). Install shims and fasten cover (22) with capscrews (23).

    If new bearings were installed, proper bearing pre-load must be determined before final installation of the cover.

    a. Install the cover without shims.
    b. Using a dial indicator, measure the amount of axial movement of the pinion shaft.Proper axial movement must be between -0.076 to -0.127 mm (-0.003 to -0.005 in). Determine the amount of shims required to acquire the proper axial movement. Then, install the shims between housing (25) and cover (22). Fasten with capscrews (23).

15. Fill the housing with a Lithium base E.P. No. 2 bearing grease through the grease fitting on the cover.

Installation

1. Install the gearbox in reverse order of removal.
2. When installing the swing motor, use a new gasket.
3. Align the pinion gear with the swing gear following instructions.

OUTRIGGERS

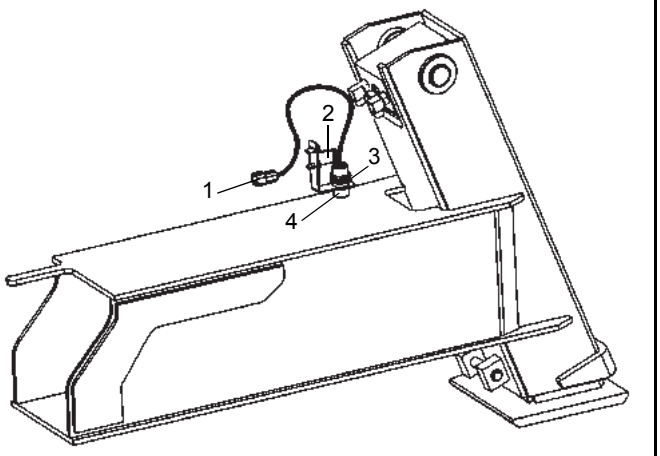
Outrigger Monitoring System (OMS) (Optional—Standard in North America)

The Outrigger Monitoring System (OMS) proximity switches (if equipped) are mounted inside the outrigger housing tubes. The proximity switches identify whether an outrigger beam is at the fully extended position or at any position less than fully extended.

Removal

1. Disconnect switch cable (1) from harness.
2. Remove switch mounting bracket (2).
3. Remove jam nuts (3) and thread switch (4) out of the mounting bracket.

For Reference Only



7955 **FIGURE 11-25**

Installation

1. Feed cable through the mounting bracket and jam nuts.
2. Thread switch through mounting bracket.
3. Thread nuts on switch.
4. Thread switch up until it touches tab of mounting bracket and LED is pointed away from the bracket.
5. Tighten jam nuts against mounting bracket.
6. Adjust bracket and/or switch to have 3 to 10 mm (0.12 to 0.38 in) gap between end of switch and outrigger beam.
7. Connect switch cable to wire harness.

Removal

1. Engage the parking brake and put blocks under the wheels to prevent crane movement.

NOTE: If outrigger proximity switches are installed, disconnect them before removing the outriggers.

2. Extend the outrigger. Disconnect rod of the horizontal outrigger cylinder (3, Figure 11-26) from the outrigger beam (1). Retract the horizontal cylinder.
3. Lower the jack outrigger (2) just far enough to remove the load on the outrigger beam (1).
4. Stop the engine. With the ignition switch in the ON position, actuate the outrigger switches in both directions to release pressure in the hydraulic circuits. Turn the ignition switch to the OFF position.
5. Disconnect the two hydraulic lines for the vertical cylinder (19) from the bulkhead elbow attached to the frame.
6. Use a hoist to remove the outrigger assembly from the frame.

Disassembly

1. Remove retaining ring (7, Figure 11-26) from either side of mounting pin (5). Drive the pin out.
2. Pull outrigger jack (2) from outrigger beam (1).
3. Disconnect the hydraulic hoses from the vertical cylinder (11). Remove the hoses.
4. Remove retaining ring (7) from either side of mounting pin (6). Hold the cylinder in position and drive out the mounting pin.

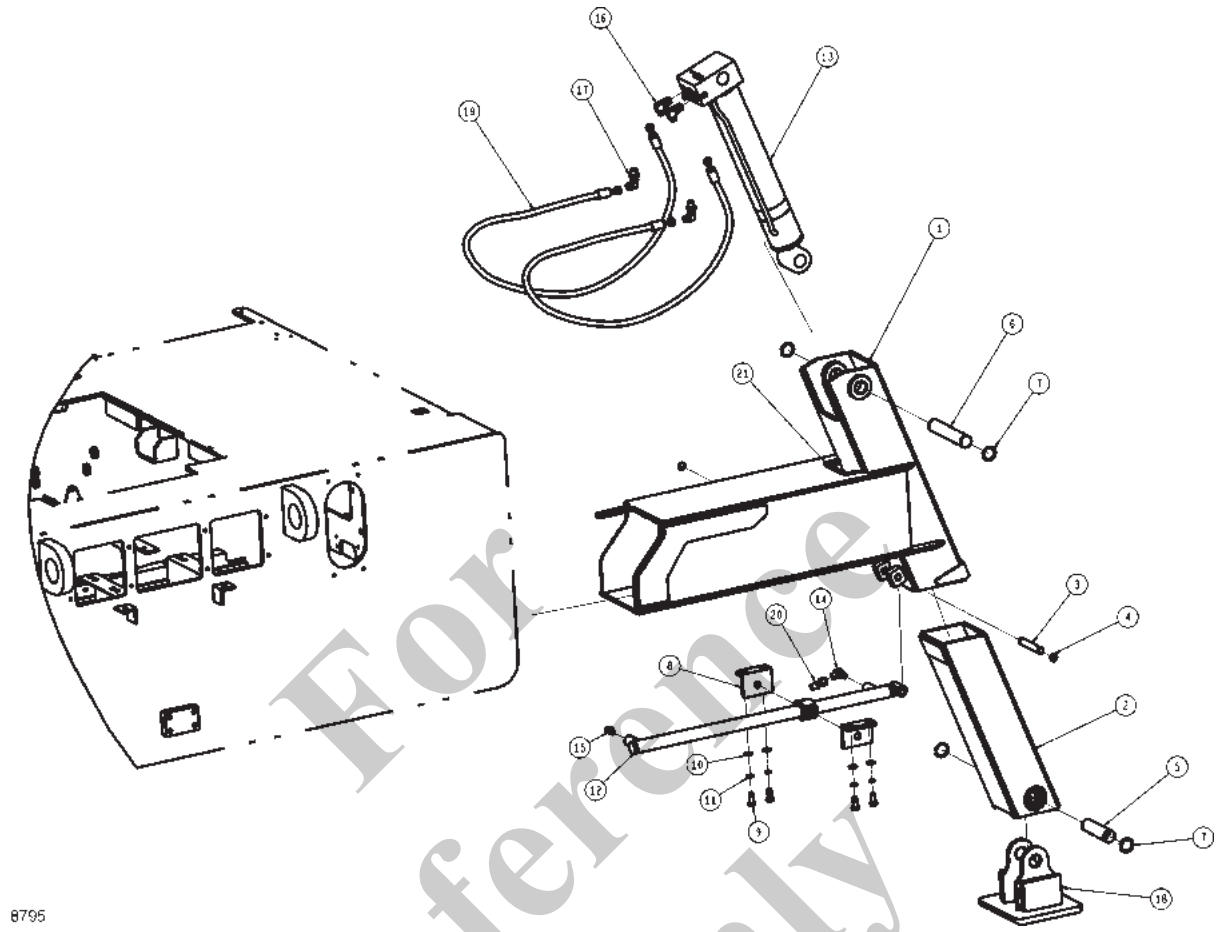
Assembly

1. Completely clean the outrigger beam and outrigger jack. Use steam or a suitable solvent. Also, clean the slide contact surfaces of the main frame.
2. Install outrigger jack (2, Figure 11-26) over the vertical cylinder (13). Align the cylinder rod with the mounting holes in the jack outrigger. Install pin (5) and retaining ring(s) (7).
3. Lubricate the inside of outrigger beam box and the outside of the jack outrigger with STP Oil Treatment, “LUBAID NF”, or bronze anti-seize compound.
4. Align and install the jack outrigger and cylinder into the outrigger beam. Install pin (6) and retaining ring(s) (7).
5. Install the hydraulic hoses to the vertical cylinder ports.
6. Connect the outrigger proximity switches, if equipped.

Installation

1. Lubricate the slide blocks inside the mainframe with STP Oil Treatment, “LUBAID NF” or bronze anti-seize compound. Use a hoist and install the outrigger assembly into the main frame.
2. Connect the hoses to the bulkhead elbows on the main frame. Make sure the hoses routed in the top center of the outrigger beam and will not be damaged when the outriggers are retracted.
3. Connect the horizontal outrigger cylinder (12, Figure 11-26) to the outrigger beam (1). Install pin (3) and retaining ring(s) (4).
4. Apply a thin layer of STP Oil Treatment, “LUBAID NF”, or bronze anti-seize compound to the slide block contact surfaces on the outrigger beam.
5. Operate outrigger and check for correct installation. Stop the engine. Check for leakage at the hose connections.

For Reference Only



Item	Description
1	Outrigger Beam
2	Outrigger Vertical Tube
3	Pin
4	Snap Ring
5	Jack Pin
6	Outrigger Upper Pin
7	Retaining Ring

Item	Description
8	Cylinder Mount
9	Hex Bolt
10	Flat Washer
11	Lock Washer
12	Hydraulic Cylinder
13	Jack Cylinder
14	90 Degree Elbow

Item	Description
15	Straight Adapter
16	90 Degree Elbow
17	Bulkhead 90 Degree Elbow
18	Outrigger Pad
19	Hose Assembly
20	Orifice Adapter
21	Plastic Channel

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Outrigger Assembly

FIGURE 11-26

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SECTION 12
SCHEMATICS/WIRING DIAGRAMS

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