

# Grove RT9130E-2

## Service/Maintenance Manual





## **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](http://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](http://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 -

## RT9130E-2

Crane Model Number

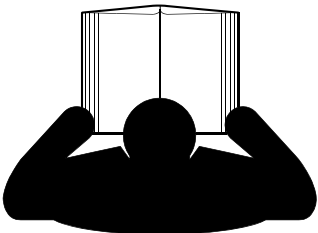
This Manual is Divided into the following Sections:

SECTION 1	INTRODUCTION
SECTION 2	HYDRAULIC SYSTEM
SECTION 3	ELECTRICAL SYSTEM
SECTION 4	BOOM
SECTION 5	HOIST AND COUNTERWEIGHT
SECTION 6	SWING SYSTEM
SECTION 7	POWER TRAIN
SECTION 8	UNDERCARRIAGE
SECTION 9	LUBRICATION

### NOTICE

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

The crane serial number is 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 distributor or the factory.



## ⚠ 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.

*For  
Reference  
Only*

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## SECTION 1 INTRODUCTION

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### DESCRIPTION

This Manual provides information for the maintenance of the Model RT9130E Series Grove Crane.

The lift capacities are listed on the Load Chart stored in the cab.

The crane incorporates an all welded parallel box construction steel frame, using planetary drive axles to provide four-wheel drive. Axle steering is accomplished utilizing hydraulic steer cylinders. The engine is mounted at the rear of the crane carrier and provides motive power through a six speed forward and a three speed reverse transmission. Hydraulic, double box, sliding beam outriggers are removable.

The carrier frame incorporates an integral fifth wheel, to which the rear axle is mounted, to provide axle oscillation. Axle oscillation lockout is automatic when the superstructure rotates from the travel position.

The superstructure is capable of 360 degree rotation in either direction. All crane functions are controlled from the fully-enclosed cab mounted on the superstructure. The crane is equipped with a five-section, full power, sequenced and synchronized boom. Additional reach is obtained by utilizing an optional swingaway boom extension. Lifting is provided by a main hoist and an optional auxiliary hoist.

**NOTE:** Throughout this manual, reference is made to left, right, front, and rear when describing locations.

When operating the crane, these reference locations are to be considered as those viewed from the operator's seat with the superstructure facing forward over the front of the carrier frame.

**NOTE:** The Transportation and Lifting Data Decal is shown in (Figure 1-1). Basic nomenclature is shown in (Figure 1-2).

**LIST OF SPECIFICATIONS**

**General**

Model .....	RT9000E Series
Rated Capacity .....	See Load Chart in cab
Drive .....	4 x 4 x 4
Gross Weight .....	See Axle Weight Distribution Table

**Dimensions**

**NOTE:** Dimensions listed are for a crane with all components fully retracted in the travel mode with 33.25 x 29 tires.

Wheelbase .....	194.5 in (4940 mm)
Overall Crane Length .....	54 ft 1 in (16.48 m)
Overall Crane Width .....	12 ft 5 in (3.80 m)
Overall Crane Height .....	13 ft 8.25 in (4.172 m) (Std)
.....	13 ft 5 in (4089 mm) (Opt)
Tail-Swing .....	14 ft 2.5 in (4.331 m)
Outrigger Spread	
Retracted .....	11 ft 8 in (3.56 m)
Mid Extend .....	19 ft 9 in (6.02 m)
Fully Extended .....	27 ft 10 in (8.49 m)

**Capacities**

Fuel Tank .....	100 gal (378 l)
Coolant System .....	See Engine Manual
Engine Lubrication System .....	See Engine Manual
Hydraulic Tank (Reservoir Capacity)	
Total .....	360 gal (1363 l)
at Full Level .....	324.1 gal (1226 l)

at Low Level .....	310.6 gal (1176 l)
Expansion Space .....	13.5 gal (51 l)
Hoists .....	22 qt (21 l)
Swing Gearbox .....	5-1/4 qt (5 l)
Axle Planetary Hubs .....	12 qt (11 l)
Axle Differentials .....	29 qt (27-1/2 l)
Transmission (Includes Torque Converter)	
.....	34 qt (32 l)

**Torque Converter**

Stall Ratio .....	2.29:1
Charge Pump Capacity .....	31 gpm (117.3 l/min)
	@ 2000 rpm

**Transmission**

Gear Ratios:	
Forward	
1st .....	7.87
2nd .....	5.94
3rd .....	2.98
4th .....	2.25
5th .....	0.95
6th .....	0.73
Reverse	
1st .....	7.87
2nd .....	2.98
3rd .....	0.95

**Engine**

**Cummins QSL or (QSC)**

HP Rating .....	320 (300) hp @ 2200 rpm
Peak Torque .....	1020 (1000) lb-ft @ 1500 rpm
Lube Amount .....	24 (20)qt [22.7 l(18.9 l)]
Coolant System .....	36 qt (34.1 l)

**Axles**

Total Ratio (w/differential lock) .....	33.43:1
Total Ration (standard) .....	31.94:1
Carrier Ratio (w/differential lock) .....	6.429:1
Carrier Ratio (standard) .....	6.143:1
Planetary Ratio .....	5.20:1



**Brakes**

Type . Hydraulic/Split system acting on all four wheels  
Size . . . . . 18.5 x 1.575 in (470 x 40 mm)

**Wheels And Tires**

Lugs . . . . . 24  
Torque . . . . . 340 - 360 lb-ft (461 to 488 Nm)  
Tire Size  
Standard . . . . . 33.25 x 29-38 ply rating  
Optional . . . . . 29.5R29

**NOTE:** For roading and lifting pressures, refer to the Load Chart Book in the cab.

**Swing Gearbox**

Reduction Ratio . . . . . 36:2  
Output Torque . . . . . 4152 lb-ft (5629 Nm)

**Boom**

Length  
Retracted . . . . . 42 ft (12.8 m)  
Extended . . . . . 159 ft 3.6 in (48.5 m)  
Power . . . . . 5 Section, Full Power  
Elevation . . . . . -3 to +78 degrees  
Extensions  
Fixed\* . . . . . 36 ft 1.2 in (11 m)  
Folding\* . . . . . 36 ft 1.2 in or 59 ft 1.2 in  
(11 m or 18 m)  
\*Extensions are offsettable at 0, 20, or 40 degrees.  
Extension Insert . . . . . 26 ft 2.4 in (8 m)

**Swivel Assembly**

Electrical . . . . . 20 Slip Rings  
Hydraulic . . . . . 11 ports  
Water . . . . . 2 ports

**Hydraulic Pumps**

**NOTE:** Pump output figures are theoretical.

**Pump #1**

Type . . . . . Gear  
Sections . . . . . 2  
Output @ 2710 rpm w/no load  
Section 1 . . . . . 58.1 gpm (209 l/min)  
Section 2 . . . . . 34.7 gpm (125 l/min)

**Pump #2**

Type . . . . . Gear  
Sections . . . . . 1  
Output @ 2710 rpm w/no load  
Section 1 . . . . . 26.3 gpm (94.6 l/min)

**Pump #3**

Type . . . . . Gear  
Sections . . . . . 2  
Output @ 2710 rpm w/no load  
Section 1 . . . . . 58.1 gpm (209 l/min)  
Section 2 . . . . . 17.4 gpm (62.5 l/min)

**Pump #4**

Type . . . . . Gear  
Section . . . . . 1  
Output @2400 rpm w/no load  
Section 1 . . . . . 10.3 gpm (39.0 l/min)

**Hoists**

Model . . . . . HP35-26G  
Drum Dimensions  
Length . . . . . 26.65 in (626 mm)  
Diameter . . . . . 15 in (381 mm)  
Length (Standard) . . . . . 26.63 in (676 mm)  
Cable  
Diameter . . . . . 0.75 in (19 mm)  
Length-Main . . . . . 290 m (951 ft)  
Length-Aux . . . . . 214 m (702 ft)  
Max. Permissible Line Pull (6x36)  
. . . . . 17,070 lb (7760 kg)  
Max. Single Line Speed . . . . . 562 fpm (171.3 m/min)  
Hoist Motor Displacement  
Low . . . . . 4.9 in<sup>3</sup> (80.3 cm<sup>3</sup>) per revolution  
High . . . . . 2.8 in<sup>3</sup> (46 cm<sup>3</sup>) per revolution  
Oil Capacity . . . . . 22 qt (21 l)

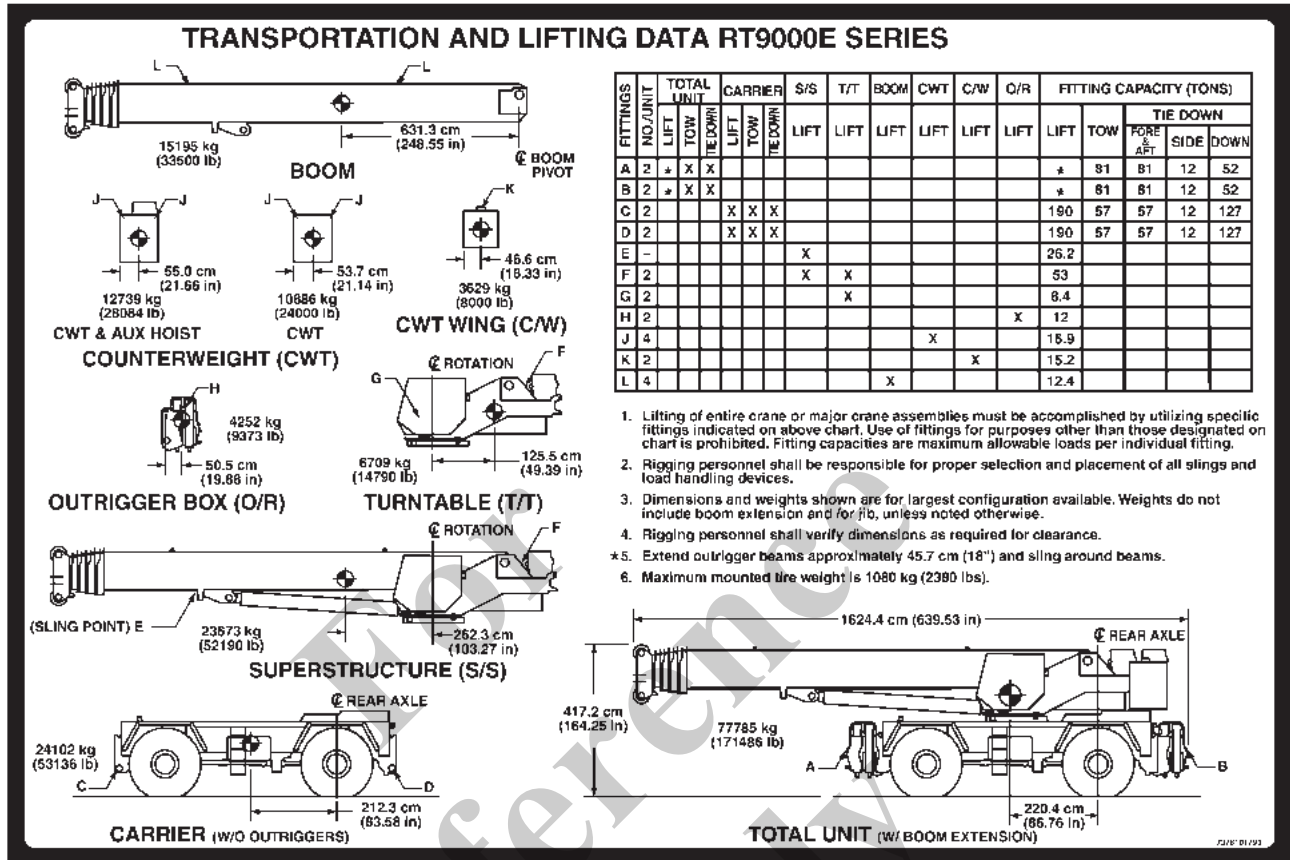


FIGURE 1-1

**Table 1-1**  
**Axle Weight Distribution Table**

Description	CG to CL Bogie in (cm)	Weight lb (kg)	Front Axle lb (kg)	Rear Axle lb (kg)
<b>Basic Unit</b>				
Maximum Axle Loads Allowed			90000 (40824)	90000 (40824)
Maximum Tire Loads Allowed			90000 (40824)	90000 (40824)
Carrier 4 x 4; All Fluids	83.50 (212.1)	53202 (24132)	22840 (10360)	30362 (13772)
Front Outrigger Box and Beam Assembly	266.00 (675.6)	9427 (4276)	12892 (5848)	-3465 (-1572)
Rear Outrigger Box and Beam Assembly	-82.00 (-208.3)	9427 (4276)	-3974 (-1803)	13401 (6079)
Superstructure w/cab plus w/main hoist plus 950 ft cable; less counterweight plus lower lift pin	42.69 (108.4)	14786 (6707)	3245 (1472)	11541 (5235)
Removable Counterweight (includes cylinders, aux hoist and cables)	-56.47 (-143.4)	28084 (12739)	-8154 (-3698)	-36238 (-16437)
Boom Assembly; w/RCL, 2/7 Nose Sheaves, Pivot Pins	260.55 (661.8)	33482 (15187)	44852 (20345)	-11370 (-5158)
Lift Cylinder	213.50 (542.3)	3900 (1769)	4281 (1942)	-381 (-173)
Complete Basic Machine 4 x 4 chassis; Cummins QSC8.3 300 Tier 3 engine w/ transmission; front and rear axles; 33.25 x 29 tires; main hoist w/289 m (950 ft) of 3/4 in. cable; full fuel and hydraulic oil; RCL; plus all the above.	97.03 (246.5)	152308 (69086)	75983 (34466)	76325 (34620)
<b>Add To Basic Unit Weight</b>				
10.97 to 17.98 m (36 to 59 ft) Bi-Fold Boom Extension	295.25 (749.9)	3110 (1411)	4721 (2141)	-1611 (-730)
10.97 meter (36 ft) Fixed Boom Extension	329.56 (837.1)	2300 (1043)	3897 (1768)	-1597 (-725)
10.97 to 17.98 m (36 to 59 ft) Bi-Fold Hydraulic Boom Extension	317.00 (805.2)	3516 (1595)	5730 (2599)	-2214 (-1004)
10.97m (36 ft) Fixed Hydraulic Boom Extension	351.83 (893.6)	2722 (1235)	4924 (2234)	-2202 (-999)
Components for Hydraulic Boom Extension	368.65 (936.4)	202 (92)	383 (174)	-181 (-82)
Boom Ext. Carrier Brackets (Bolt On)	238.62 (606.1)	220 (100)	270 (122)	-50 (-22)
Auxiliary Boom Nose - Installed	530.00 (1346.2)	125 (57)	341 (155)	-216 (-98)
72 mt (80 Ton), 7 Sheave Hookblock - Stowed in trough	185.00 (469.9)	1600 (726)	1522 (690)	78 (36)
118 mt (130 Ton), 8 Sheave Hookblock - Stowed in trough	185.00 (469.9)	2530 (1147)	2406 (1091)	124 (56)
9.0 mt (10 Ton), Headache Ball (Swivel)- Attached to O/R Box	310.00 (787.4)	680 (308)	1084 (491)	-404 (-183)
Driver	92.00 (233.7)	250 (113)	118 (53)	132 (60)
Rear Mounted Pintle Hook	-83.50 (-212)	30 (14)	-13 (-6)	43 (20)
Boom Removal Kit	236.66 (601.0)	85 (39)	103 (47)	-18 (-8)

Description	CG to CL Bogie in (cm)	Weight lb (kg)	Front Axle lb (kg)	Rear Axle lb (kg)
Delete: Counterweight (24,000 pounds)	-56.10 (-142.5)	-24000 (-10886)	6922 (3140)	-30922 (-14026)
Delete: Auxiliary Hoist Cable (700 ft)	-62.76 (-159.4)	-875 (-397)	282 (128)	-1157 (-525)
Delete: Air Conditioning	-21.37 (-54.3)	-205 (-93)	23 (10)	-228 (-103)
Delete: General 33.25 X 29 (38) Tires (for travel)	97.25 (247.0)	-9520 (-4318)	-4760 (-2159)	-4760 (-2159)
Heavy Counterweight Package (16000 lb)	-54.03 (-137.2)	16000 (7258)	-4445 (-2016)	20445 (9274)
Lift Cylinder Travel Support	224.75 (570.9)	125 (57)	144 (65)	-19 (-8)
Counterweight Stand (pinned to carrier)	242.74 (616.6)	172 (78)	214 (97)	-43 (-19)
26 ft Boom Extension Insert w/RCL		1437 (652)		
Tire Removal Tool		545 (247)		

For  
Reference  
Only

### Component Location

(Figure 1-2) shows the location of some of the main components of the RT9130 Crane.

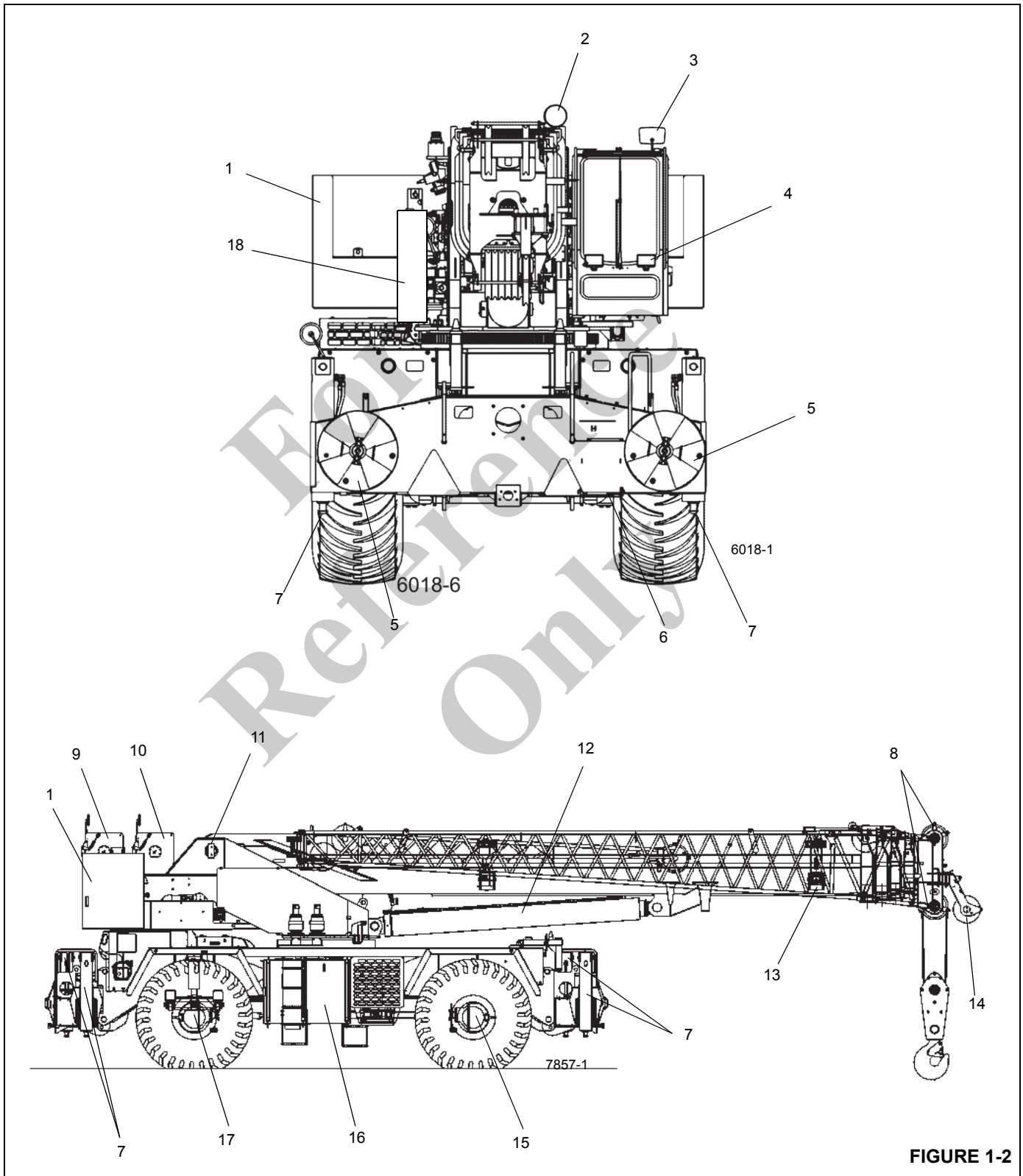


FIGURE 1-2

Item	Description
1	Counterweight
2	Spotlight
3	Cab
4	Work Light
5	Outrigger Float
6	Steps
7	Outrigger Jack Cylinder
8	Boom Nose Sheaves
9	Auxiliary Hoist
10	Main Hoist
11	Boom Pivot
12	Lift Cylinder
13	Swingaway

Item	Description
14	Auxiliary Boom Nose
15	Front Axle
16	Hydraulic Tank
17	Rear Axle
18	Boom
19	Swingaway Extension
20	Air Conditioning Components
21	Windshield Washer Fluid Container
22	Fuel Water Separator
23	Muffler
24	Battery
25	Fuel Tank

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Reference  
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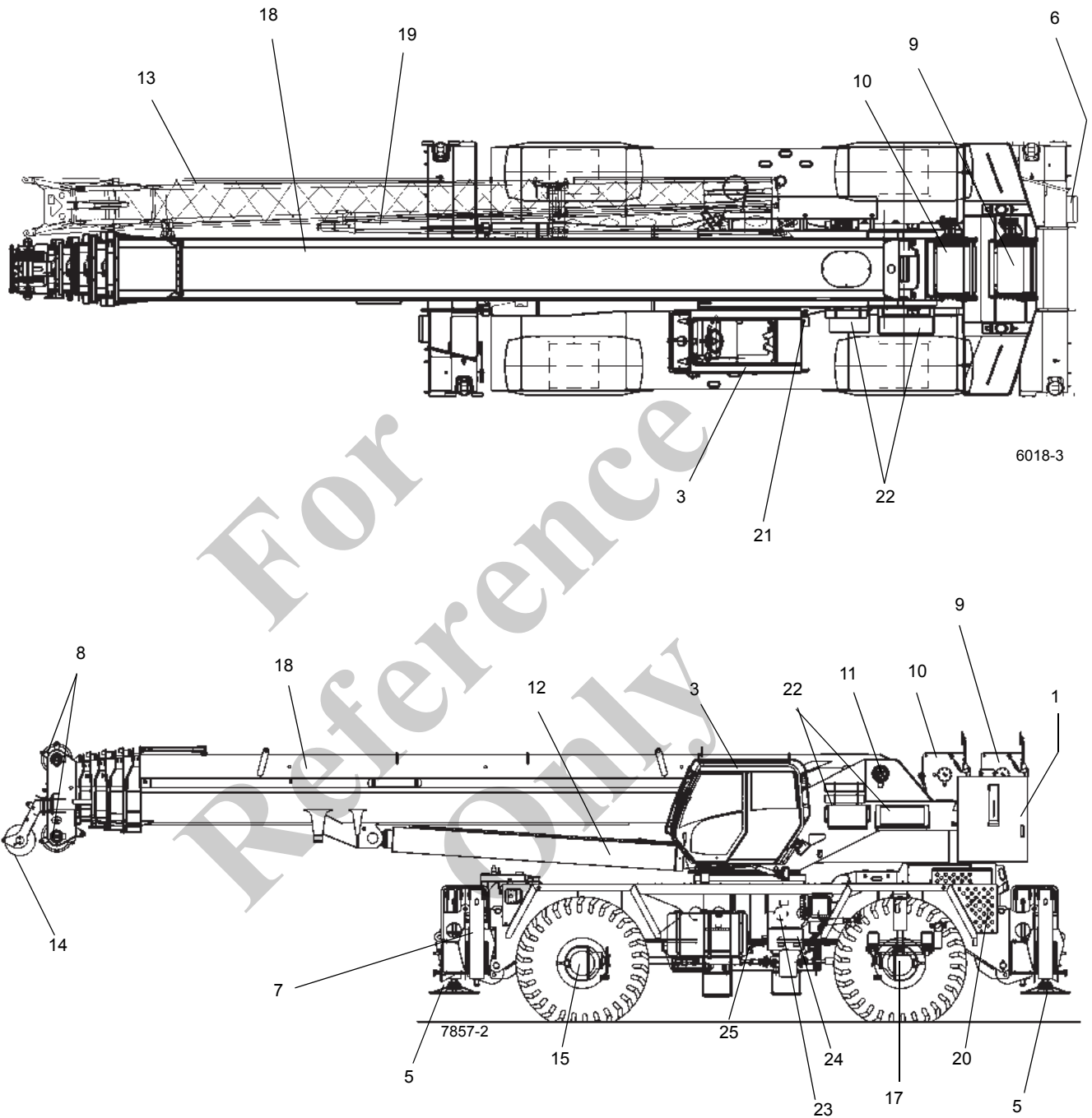


FIGURE 1-2 continued

## GENERAL MAINTENANCE

These general suggestions should be helpful in following the instructions in this manual. In analyzing a system malfunction, use a systematic approach to locate and correct the problem.

**NOTE:** Your safety and that of others is always the number one consideration when working around machines. Safety is a matter of thoroughly understanding the job to be done and the application of good common sense. It is not just a matter of do's and don'ts. Stay clear of all moving parts.

1. Determine the problem.
2. List possible causes.
3. Devise checks.
4. Conduct checks in a logical order to determine the cause.
5. Consider the remaining service life of components against the cost of parts and labor necessary to replace them.
6. Make the necessary repair.
7. Recheck to ensure that nothing has been overlooked.
8. Functionally test the replacement part in its system.

## Cleanliness

An important item in preserving the long life of the machine is keeping dirt out of working parts. Enclosed compartments, seals, and filters have been provided to keep the supply of air, fuel, and lubricants clean. It is important that these enclosures be maintained.

Whenever hydraulic, fuel, lubricating oil lines, or air lines are disconnected, clean the adjacent area, as well as, the point of connection. As soon as the disconnection is made, cap, plug, or tape each line or opening to prevent entry of foreign material. The same recommendations for cleaning and covering apply when access covers or inspection plates are removed.

Clean and inspect all parts. Be sure all passages and holes are open. Cover all parts to keep them clean. Be sure parts are clean when they are installed. Leave new parts in their containers until ready for assembly.

Clean the rust preventive compound from all machined surfaces of new parts before installing them.

## 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, and could cause the bearing to fly apart.



### CAUTION Eye Injury Hazard!

When using compressed air use only low air pressure and keep air stream from direction of face.

Always wear eye and face protection when using compressed air. Injury to eyes could occur.

## 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.

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 machine 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.

## 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.

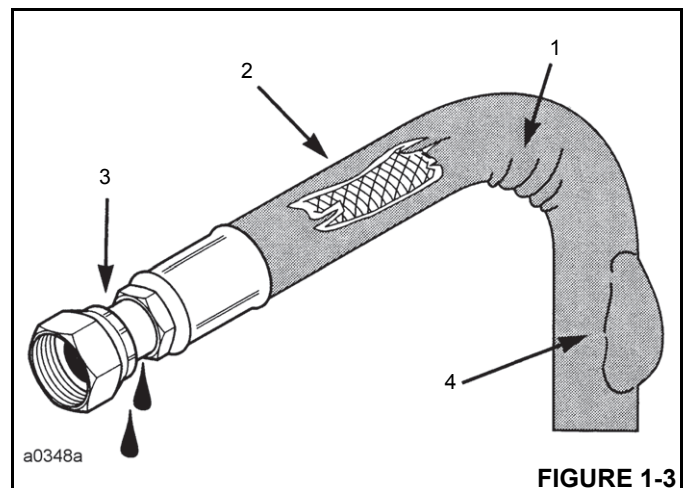
Tighten all connections to recommended torque.

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 1-3):

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



### **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.

## **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 250°F (121°C). 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 onto a 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 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.

## Hydraulic Systems

### DANGER

#### High Pressure/Temperature Hazard!

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

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-rings, 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 machine 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.

### 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.
3. All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life.
4. Hydraulic hose assemblies operating in a temperature climate zone “C” (Table 1-2) 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.

If any of these conditions exist, address them appropriately.

**Table 1-2: Climate Zones**

Zone	Classification
A	Tropical Moist: All months average above 18° C. 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

Reference Only

## Hydraulic Fittings

### Flats from Finger Tight (F.F.F.T.) Method

Manitowoc 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.

This method will also reduce the chance of a leaky connection which is normally caused by combinations of fittings with different types of plating. This method is particularly useful when the type of plating on the 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

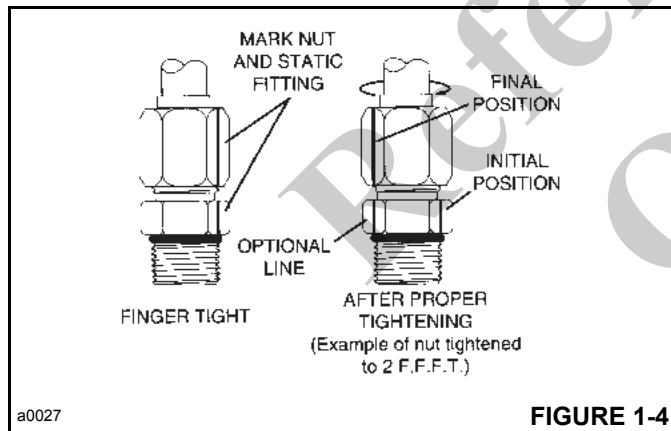


FIGURE 1-4

5. Tighten the joint by the number of flats as specified in Table 1-3 and 1-4 for size and type of fitting.
6. Optionally 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 1-4)).

### 37° Flared Steel Fitting: Tube or Hose to Fitting

Follow the F.F.F.T. method, described above.

Table 1-3: Tube and Swivel Nut/Hose Fittings

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

1-2-5

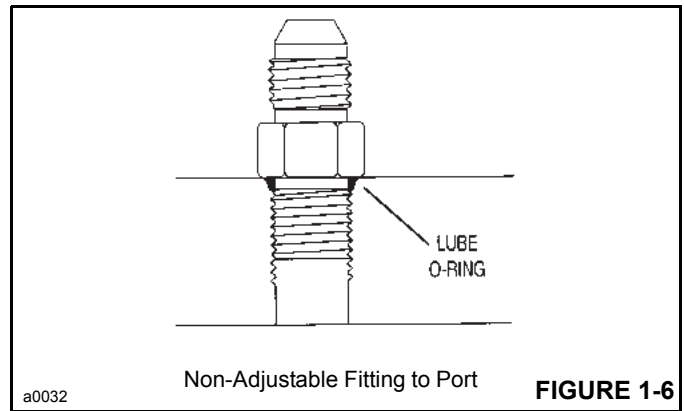
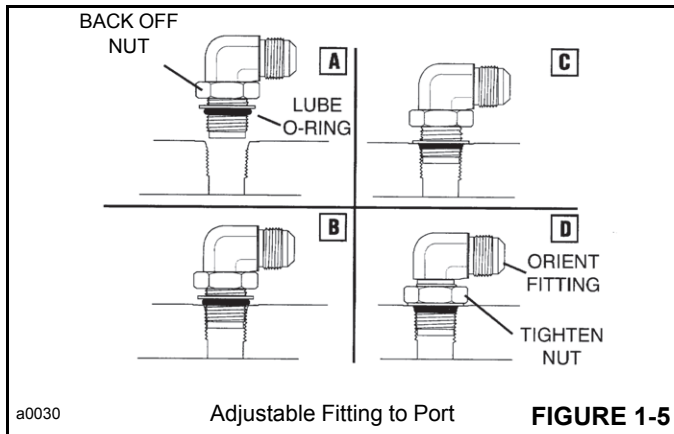
### Adjustable Straight Thread O-Ring Fittings

Refer to (Figure 1-5) and (Table 1-4) for the following procedure.

Table 1-4: Adjustable Straight Thread O-Ring Fittings

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

1-2-6



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

3. Turn fitting until finger tight.
4. Using the assembly torque method, tighten to given torque for size from Table 1-5.

Table 1-5: Straight Thread Fittings

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

**Nonadjustable Straight Thread O-Ring Fitting: Fitting to Port**

Refer to (Table 1-5) for the following procedure.

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 1-6)).

## Electrical System

### Harnesses, Wires, and Connectors

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 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 Table 1-2. Recommended replacement of harness and cables is as follows:

- Climate zone C after 10,000 hours of service.
- Climate zones A and C, 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 machines, 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 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.

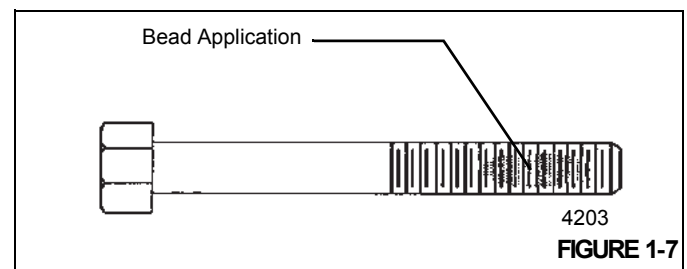
The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant (Loctite #243) and primer (Locquic Primer T7471).

#### **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**



1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-1).
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:

- 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.

## 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.



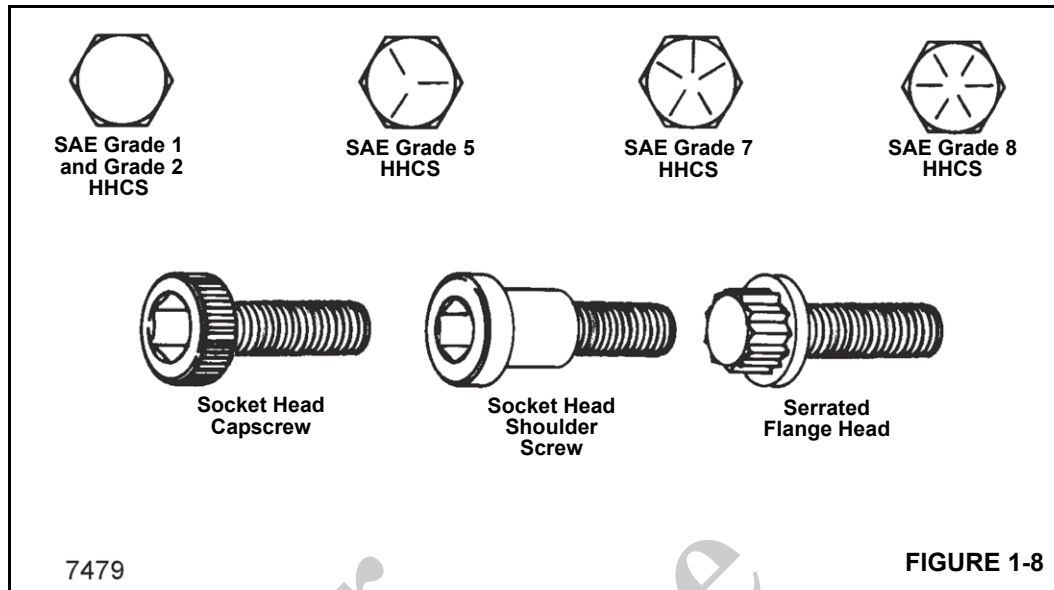


Table 1-6: UNC (Coarse) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners

		Bolt Diameter - Inches													
		Torque Values (Pounds-Foot, Maximum/Minimum)													
	SAE Grade	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2	
Zinc-Flake	5	7	14	25	40	61	88	121	213	342	512	636	884	1532	
	8	10	20	36	57	86	124	171	301	483	723	1032	1433	2488	
Untreated	5	9.0	19	32	52	78	114	156	270	416	606	813	1141	2028	
		7.7	17	30	48	72	106	144	249	384	560	751	1053	1865	
	8	12.5	26	48	73	120	161	234	385	615	929	1342	2043	3276	
		11.5	24	44	67	110	143	216	355	567	857	1234	1885	3024	

NOTE: Studs shall be torqued using capscrew values when grade is known.

Table 1-7: UNF (Fine) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners

		Bolt Diameter - Inches													
		Torque Values (Pounds-Foot, Maximum/Minimum)													
	SAE Grade	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4	1-1/2	
Zinc-Flake	5	8	15	28	44	66	95	132	229	364	543	785	944	1654	
	8	11	22	39	61	94	134	186	323	514	766	1109	1530	2682	
Untreated	5	10	21	36	57	88	126	182	312	458	658	882	1251	2288	
		9	19	34	53	81	116	167	287	421	606	814	1155	2105	
	8	14.5	26	53	85	125	177	250	425	672	1009	1500	2092	3640	
		13.5	24	49	79	115	163	230	393	620	931	1380	1925	3360	

NOTE: Studs shall be torqued using capscrew values when grade is known.

Table 1-8: Metric Fasteners, Coarse Thread, Zinc-Flake Coating

Bolt Diameter - Metric																
Torque Values (Nm)																
Class	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30	M33	M36
8.8	2.6	5.2	9.0	21.6	42.4	73.1	116	178	250	349	467	600	877	1195	1608	2072
10.9	3.7	7.5	12.5	31.5	62.0	110	170	265	365	520	700	900	1325	1800	2450	3150
12.9	4.3	9.0	15.0	36.0	75.0	128	205	315	435	615	830	1060	1550	2125	2850	3700

Table 1-9: Metric Fasteners, Coarse Thread, Untreated

Bolt Diameter - Metric																
Torque Values (Nm, Maximum/Minimum)																
Class	M4	M5	M6	M7	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30	
8.8	3.1	6.5	11	19	27	53	93	148	230	319	447	608	774	1134	1538	
	2.8	5.9	10	17	25	49	85	136	212	294	413	562	714	1046	1420	
10.9	4.5	9.2	16	26	38	75	130	212	322	455	629	856	1089	1591	2163	
	4.1	8.5	14	24	35	69	120	195	298	418	581	790	1005	1469	1997	
12.9	5.4	11	19	31	45	89	156	248	387	532	756	1029	1306	1910	2595	
	4.9	10	17	28	42	83	144	228	357	490	698	949	1206	1763	2395	

Table 1-10: Metric Fasteners, Fine Thread, Zinc-Flake Coating

Bolt Diameter - Metric															
Torque Values (Nm)															
Class	M8x1	M10x1	M10x1.25	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M20x1.5	M22x1.5	M24x2	M27x2	M30x2	M33x2	M36x3	
8.8	23	46	44	75	123	185	270	374	496	635	922	1279	1707	2299	
10.9	34	71	66	113	188	285	415	575	770	980	1425	2025	2500	3590	
12.9	41	84	79	135	220	335	485	675	900	1145	1675	2375	2900	4200	

Table 1-11: Metric Fasteners, Fine Thread, Untreated

Bolt Diameter - Metric															
Torque Values (Nm, Maximum/Minimum)															
Class	M8x1	M10x1	M10x1.25	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M20x1.5	M22x1.5	M24x2	M27x2	M30x2	M33x2	M36x3	
8.8	29	57	57	100	160	248	345	483	657	836	1225	1661	—	—	
	27	53	53	92	147	229	318	446	607	771	1130	1534	—	—	
10.9	41	81	81	1140	229	348	491	679	924	1176	1718	2336	—	—	
	38	75	75	130	211	322	451	627	853	1085	1587	2157	—	—	
12.9	49	96	96	168	268	418	575	816	1111	1410	2063	2800	—	—	
	45	90	90	156	246	386	529	754	1025	1302	1904	2590	—	—	

**Table 1-12: UNC (Coarse) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication**

Size	Torque Value	
	lb-in	lb-ft
#5 (0.125)	6.9	—
#8 (0.164)	18	—
#10 (0.190)	21	—
1/4	68	—
5/16	120	10
3/8	210	17.5
7/16	340	28
1/2	—	39
5/8	—	74
3/4	—	114

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

**Table 1-13: Metric Coarse Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication**

Size	Torque Value Nm
M2.5	0.4
M3	0.9
M4	1.5
M5	3.1
M6	5.3
M8	13.0
M10	27.0
M12	45.0
M14	71.1
M16	109
M18	157
M20	220

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

**Weld Studs**

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

**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

## WIRE ROPE

### General

The following compendium of information is from various wire rope manufacturers and includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and Manitowoc. The inspection interval shall be determined by a qualified person and shall be based on such factors as expected rope life as determined by experience on the particular installation or similar installations, severity of environment, percentage of capacity lifts, frequency rates of operation, and exposure to shock loads. Periodic inspections need not be at equal calendar intervals and should be performed at shorter time intervals as the wire rope approaches the end of its useful life. A periodic inspection shall be performed at least once a year. The following provides inspection and maintenance procedures for wire ropes used on Grove products (e.g. wire rope used as load lines [hoisting cables], boom extension and retraction cables, pendant cables, tow winch cables, and hookblock tie down cables).

### Environmental Conditions

The life expectancy of wire rope may vary due to the degree of environmental hostility and other conditions to which these mechanical devices are subjected. Variation in temperature, continuous excessive moisture levels, exposure to corrosive chemicals or vapors or subjecting the wire rope to abrasive material may shorten normal wire rope life. Frequent/periodic inspections and maintenance of your wire rope is recommended for preventing premature wear and to insure long-term satisfactory performance.

### Dynamic Shock Loads

Subjecting wire rope to abnormal loads beyond the endurance limit will shorten the wire rope's life expectancy. Examples of this type of loading are listed below:

- High velocity movement e.g.; hoisting or swinging of a load followed by abrupt stops.
- Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
- Moving a load that is beyond the rated capacity of the lifting mechanism, i.e.; overloading.

### Lubrication

A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added throughout the life of a rope to replace factory lubricant which is used or lost. It is important that lubricant applied as part of a maintenance program shall be compatible with the original lubricant, and to this end, the rope manufacturer should be consulted. Lubricant applied

shall be of the type which does not hinder visual inspection. Those sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention when lubricating rope. The object of rope lubrication is to reduce internal friction and to prevent corrosion.

During fabrication, ropes receive lubrication; the kind and amount depends on the rope's size, type, and anticipated use. This in-process treatment will provide the finished rope with ample protection for a reasonable time if it is stored under proper conditions. But, when the rope is put into service, the initial lubrication may be less than needed for the full useful life of the rope. Because of this possibility, periodic applications of a suitable rope lubricant are necessary.

The following are important characteristics of a good wire rope lubricant:

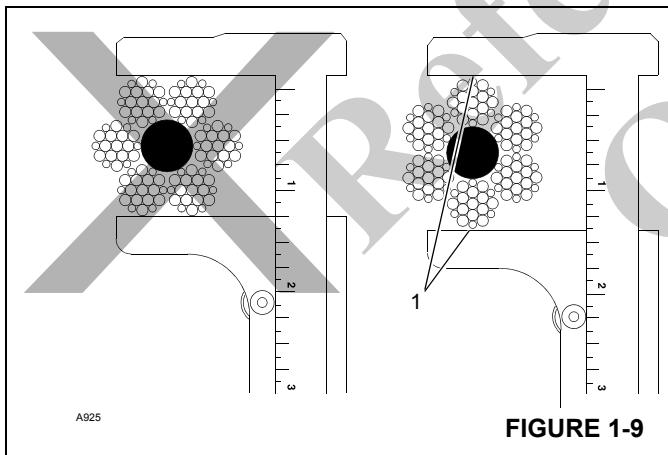
- It should be free from acids and alkalis.
- It should have sufficient adhesive strength to remain on the rope.
- It should be of a viscosity capable of penetrating the interstices between wires and strands.
- It should not be soluble in the medium surrounding it under the actual operating conditions (i.e. water).
- It should have a high film strength.
- It should resist oxidation.

Before applying lubrication, accumulations of dirt or other abrasive material should be removed from the rope. Cleaning can be accomplished by using a stiff wire brush and solvent, compressed air, or live steam. Immediately after the wire rope is cleaned, it should be lubricated. Many techniques may be used; these include bath, dripping, pouring, swabbing, painting or pressure spray methods. Whenever possible, the lubricant should be applied at the top of a bend in the rope, because at that point the strands are spread by bending and are more easily penetrated. There should be no load on the rope while it is being lubricated. It should be noted, the service life of wire rope will be directly proportional to the effectiveness of the method used and amount of lubricant reaching the working parts of the rope.

### Precautions and Recommendations During Inspection or Replacement

1. Always lock out equipment power when removing or installing wire rope assemblies.
2. Always use safety glasses for eye protection.
3. Wear protective clothing, gloves, and safety shoes as appropriate.
4. Use supports and clamps to prevent uncontrolled movement of wire rope, parts, and equipment.

5. When replacing fixed length cable assemblies (e.g. pendants) having permanently attached end fittings use only pre-assembled lengths of wire rope as supplied from Manitowoc. Do not build lengths from individual components.
6. Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
7. Never electroplate wire rope assemblies.
8. Do not weld any wire rope assembly or component unless welding is recommended by the wire rope manufacturer. Welding spatter shall never be allowed to come in contact with the wire rope or wire rope ends. In addition, be sure that the wire rope is not an electrical path during other welding operations.
9. Wire ropes are manufactured from special steels. If heating a wire rope assembly is absolutely necessary for removal, the entire wire rope assembly shall be discarded.
10. On systems equipped with two or more wire rope assemblies operating as a matched set, they shall be replaced as an entire set.
11. Do not paint or coat wire ropes with any substance except approved lubricants.
12. Measure the rope's diameter across crowns (1) of the strands when determining if rope has become damaged (Figure 1-9).



### Wire Rope Inspection—Running Ropes and Pendant Cables

Wire rope should be inspected frequently/daily and periodically/yearly in accordance with the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies. Recommended inspection intervals may vary from machine to machine and may vary based on environmental

conditions, frequency of lifts, and exposure to shock loads. The inspection time intervals may also be predetermined by state and local regulatory agencies.

**NOTE:** Wire rope may be purchased through Manitowoc Crane Care.

Any deterioration observed in the wire rope should be noted in the equipment inspection log and an assessment concerning wire rope replacement should be made by a qualified person.

### Keeping Records

A signed and dated report of the wire rope's condition at each periodic inspection must be kept on file at all times. The report must cover all inspection points listed in this section. The information in the records can then be used to establish data which can be used to determine when a wire rope should be replaced.

It is recommended that the wire rope inspection program include reports on the examination of wire rope removed from service. This information can be used to establish a relationship between visual inspection and the rope's actual internal condition at the time of removal from service.

### Frequent Inspection

A frequent daily visual inspection is recommended for all running ropes in service. This inspection should be made on all wire rope which can be expected to be in use during the day's operation. This inspection should be used to monitor progressive degradation and to discover severe damages necessitating wire rope replacement such as:

- Distortion, kinking, crushing, un-stranding, birdcaging, reduction of diameter, etc.
- General corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- End fitting wear/abrasion.

Pay particular attention to areas of the rope where wear and other damage is likely to occur:

- Pick-up Points: Sections of wire rope that are repeatedly stressed during each lift, such as those sections in contact with sheaves.
- End Attachments: The point where a fitting is attached to the wire rope or the point where the wire rope is attached to the drum.
- Abuse Points: The point where the wire rope is subjected to abnormal scuffing and scraping.

**Periodic Inspection**

Wire rope should be inspected periodically/annually or at a shorter time interval if necessitated by environmental or other adverse conditions, and shall cover the entire length of the wire rope. Only the outer surface of the wire rope need be inspected, and no attempt should be made to open the rope. Periodic inspection should include all items listed under frequent inspection plus the following:

- Inspect for reduction of rope diameter below nominal diameter.
- Inspect for severely corroded or broken wires at end connections.
- Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
  - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
- Inspect boom nose sheaves, hookblock sheaves, boom extension/jib sheaves, auxiliary boom nose sheaves, and hoist drums for wear. Damaged sheaves or hoist drums can accelerate wear and cause rapid deterioration of the wire rope.

**Wire Rope Inspection—Boom Extension and Retraction Cables****Periodic Inspection**

It is recommended that a weekly inspection of all boom extension and retraction cables be performed using the following guidelines. This inspection shall cover the entire length of the extension and retraction cables. This inspection should be used to monitor progressive degradation and to discover severe damages necessitating wire rope replacement or equipment repair. Inspection criteria are as follows:

- Inspect for reduction of rope diameter below nominal diameter.
- Inspect for severely corroded or broken wires at end connections.
- Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.

- Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
- Sections of wire rope in contact with stationary surfaces where abrasion or chafing may take place as a result of equipment vibration.
- Inspect for damaged or wobbly boom extension and retraction sheaves that may cause rapid deterioration of the wire rope.
- Inspect for unusual cable sag/stretch and be sure cables used in sets all have an equal tension applied. Repeated need for adjustment of an individual cable is evidence of cable stretch and indicates the need for additional and more thorough inspection in order to determine and correct the cause.
- The inspection shall cover all visible areas of the extension and retraction cables of an assembled boom. Note that extending and/or retracting the boom may be required to access visual inspection holes. The inspection shall cover the entire length of the extension and retraction cables of a disassembled boom prior to reassembly.

**Wire Rope Inspection/Replacement (All Wire Rope)**

No precise rules can be given for determination of the exact time for replacement of wire rope since many variable factors are involved. Determination regarding continued use or replacement of wire rope depends largely upon the good judgement of an appointed and qualified person who evaluates the remaining strength in a used rope after allowance for any deterioration disclosed by inspection.

Wire rope replacement should be determined by the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies and as recommended by Manitowoc. All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall be taken out of service when any of the following conditions exist:

- Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than 5%.
- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.

- Severe corrosion as evidenced by pitting.
- Manitowoc recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Manitowoc recommends for cable extended booms, that boom extension cables be replaced every seven (7) years.

**Seizing Wire Rope**

It is important to seize the ends of rotation resistant wire ropes to prevent the displacement and unraveling of the individual wires and strands at the ends. All preformed and non-preformed styles of wire rope should be seized prior to cutting. Seizings must be placed on both sides of the point where the wire rope is to be cut.

The two preferred methods for seizing wire ropes are:

**Method 1**

Using a length of soft annealed wire (Figure 1-10), place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

The two ends of the annealed wire should be twisted together tightly. Cut off the excess wire and pound the twist flat against the wire rope.

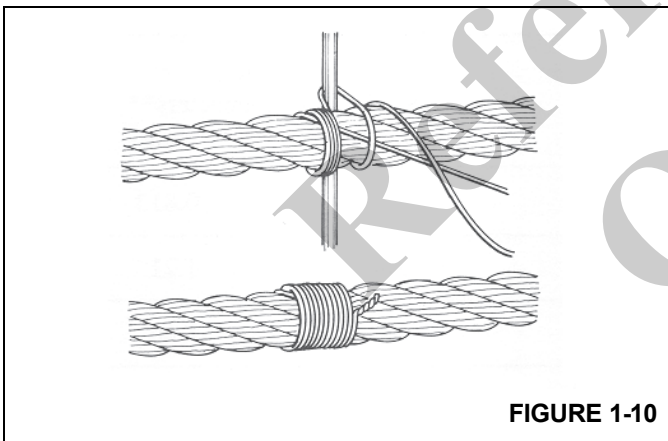


FIGURE 1-10

**Method 2**

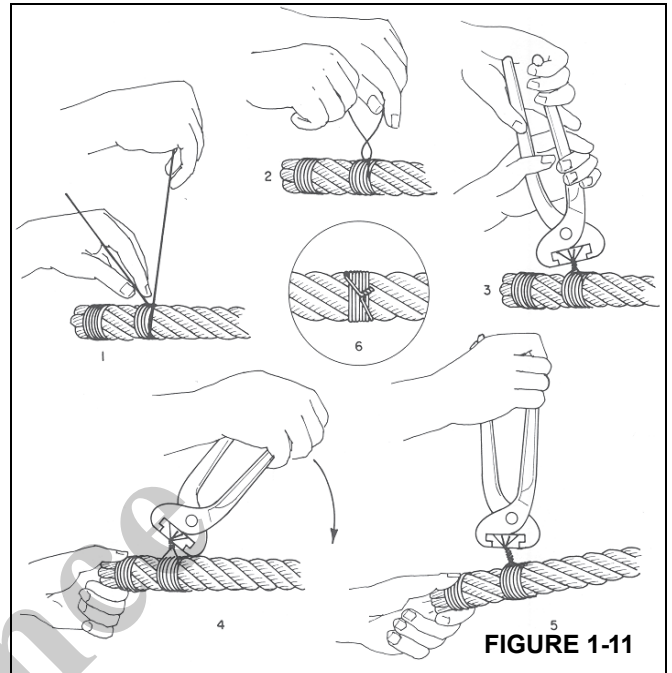
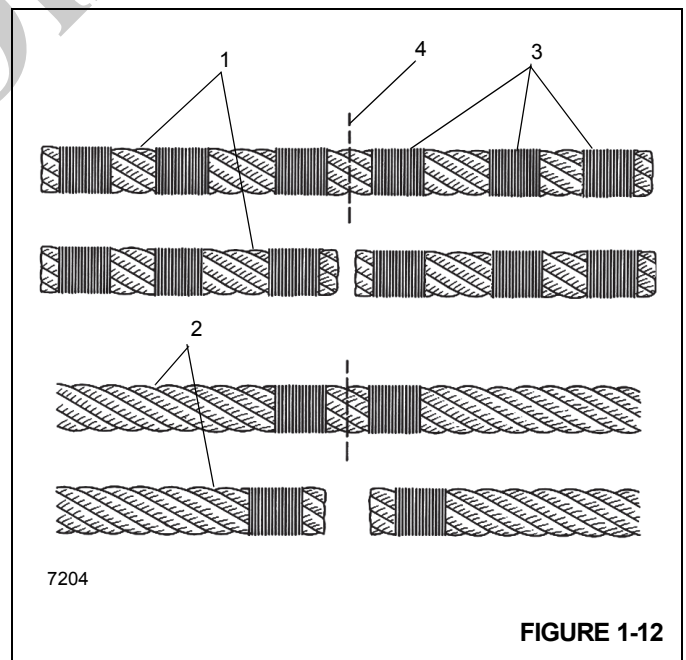


FIGURE 1-11

Wind a length of soft annealed wire (Figure 1-11) around the wire rope at least seven times. The two ends should be twisted together in the center of the seizing. Tighten the seizing by alternately prying and twisting. Cut off both ends of the wire and pound the twist flat against the rope.

**NOTE:** Non-preformed wire rope (1) (Figure 1-12) should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).



7204

FIGURE 1-12

## Installing 35x7 Class Wire Rope

### CAUTION

Any cutting of this specific wire rope is not recommended. If 35x7 Class Wire Rope must be cut for any reason, it is necessary to follow the following instructions. Also, unlike other types of wire rope, the ends on this wire rope must be welded to retain the rotation resistant characteristics.

1. Unload properly and relieve any twists. Pull the rope off the shipping reel or unroll it from a shipping coil. (If done improperly, you may kink the rope, which will result in permanent damage to the rope.) Then, lay the rope on the ground in direct line with the boom. This helps release any twist in the rope.
2. Pull the rope over the point sheave and attach the end to the hoist drum. Be sure not to remove the welded end.
3. Wind rope onto drum slowly and carefully. At this point, it isn't necessary to provide additional load other than the weight of the rope being pulled across the ground.
4. Spool first layer tightly. It is essential on smooth-faced drums that the first layer is spooled with wraps tight and close together since the first layer forms the foundation for succeeding layers. If need be, use a rubber, lead or brass mallet (but never a steel hammer) to tap the rope into place.
5. Spool multiple layers with sufficient tension. It's very important to apply a tensioning load to the ropes during the rope breaking-in process. (If not, the lower layers may be loose enough that the upper layers become wedged into the lower layers under load, which can seriously damage the rope.) The tensioning load should range from 1 to 2% of the rope's minimum breaking force.
6. For ropes in multi-part systems: Reeve the traveling block and boom tip sheaves so the rope spacing is maximized and the traveling (hook) block hangs straight and level to help assure block stability.
7. Breaking in new 35x7 Class Wire Rope—After installation, properly break in the rope, which allows the rope's component parts to adjust themselves to the operating conditions:

With the boom fully raised and fully extended, attach a light load at the hook and raise it a few inches off the ground. Allow to stand for several minutes. Then cycle the load between the full "up" and "down" positions

several times. Observe the drum winding and rope travel for any potential problems.

After making the lifts with a light load, increase the load and cycle it up and down a few times. This procedure will train the rope and help assure smooth operation during its useful life.

Ideally, you should run these loads with reeving that lets you place the loads on the block with all rope off the drum except the last three wraps. If this is not possible, alternate methods must be used to assure proper tensioning of the rope on the drum.

## Procedures for Cutting and Preparing 35x7 Class Wire Rope

35x7 Class Wire Rope is a special wire rope that must be handled differently than any other rope manufactured. One characteristic that makes this rope special is that the outer strands are not preformed. It is because of this that the following procedures for cutting and preparing 35x7 Class Wire Rope must be followed:

1. The welded ends prepared by the manufacturer are not to be removed.
2. Before cutting the rope, make three separate bands with seizing strand on each side of where the cut is to be made (total of six bands for each cut). Each band is to have a minimum length of one and one half times the rope diameter. The two bands closest to the cut should be located at a distance equal to one rope diameter away from the cut. The four remaining bands should be evenly spaced at a distance equal to three rope diameters.
  - a. If a welder is available, the cut should be made with an abrasive saw. Immediately after the cut, both ends of the rope are to be cap welded so that all inner and outer strands are welded together, preventing any movement between them.
  - b. If a welder is not available, the cut is to be made with an acetylene torch. The cut is to be made in such a way that both ends of the rope are completely fused so that all inner and outer strands are bonded together, preventing any movement between strands.

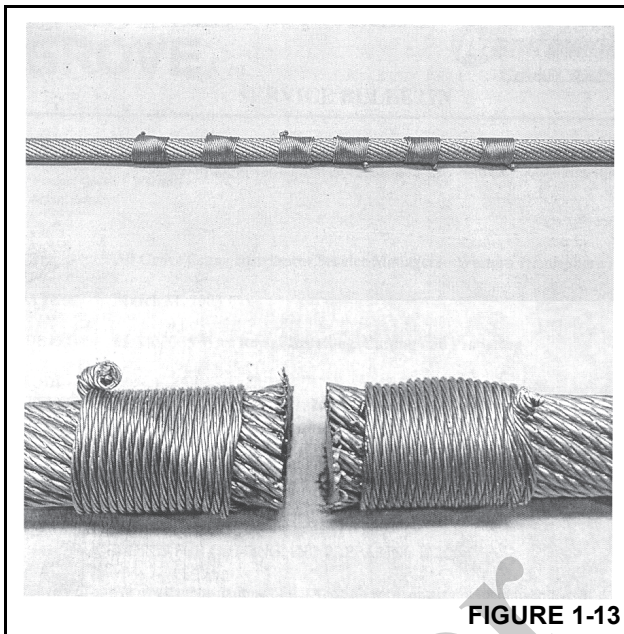
**NOTE:** The outer strands must not be able to move with respect to the inner strands. The weld must not exceed the diameter of the rope.

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

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

3. Once the cuts have been completed, the seizing bands are to be left in place.





For Reference Only

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Reference  
Only

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## SECTION 2 HYDRAULIC SYSTEM

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**DESCRIPTION**

This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return hydraulic circuit, hydraulic pumps, all hydraulic valves, and all hydraulic cylinders. Detailed descriptions and operation of individual hydraulic circuits are discussed within

their individual sections as applicable. A complete hydraulic system schematic showing all options is at the back of this manual and Figure 2-1 and Figure 2-2 provides A.N.S.I. Graphical Symbols information for this section. Maintenance

**Hydraulic Oil Recommendations**

For the hydraulic oil specifications, refer to *Section 9 Lubrication*, page 9-1.

LINES AND LINE FUNCTIONS			
LINE, WORKING		CYLINDER-SINGLE ACTING	
LINE, PILOT		CYLINDER-DOUBLE ACTING DIFFERENTIAL	
LINE, DRAIN		NON-DIFFERENTIAL	
CONNECTOR		<b>VALVES</b>	
LINE, FLEXIBLE			
LINE, JOINING		CHECK	
LINES, PASSING		ON-OFF (MANUAL SHUT-OFF)	
DIRECTION OF FLOW		PRESSURE RELIEF	
LINE TO RESERVOIR ABOVE FLUID LEVEL		PRESSURE REDUCING	
BELOW FLUID LEVEL		FLOW CONTROL ADJUSTABLE NON-COMPENSATED	
LINE TO VENTED MANIFOLD		FLOW CONTROL ADJUSTABLE (TEMPERATURE AND PRESSURE COMPENSATED)	
PLUG OR PLUGGED CONNECTION		TWO POSITION TWO CONNECTION	
RESTRICTION, FIXED		TWO POSITION THREE CONNECTION	
RESTRICTION, VARIABLE		TWO POSITION FOUR CONNECTION	
<b>PUMPS</b>		THREE POSITION FOUR CONNECTION	
SINGLE, FIXED DISPLACEMENT		TWO POSITION IN TRANSITION	
SINGLE, VARIABLE DISPLACEMENT		VALVES CAPABLE OF INFINITE POSITIONING (HORIZONTAL BARS INDICATE INFINITE POSITIONING ABILITY)	
<b>ACTUATORS</b>			
MOTOR, FIXED DISPLACEMENT REVERSIBLE			
MOTOR, FIXED DISPLACEMENT NON-REVERSIBLE			
MOTOR, VARIABLE DISPLACEMENT, REVERSIBLE			

1951-1

FIGURE 2-1

METHOD OF OPERATION		MISCELLANEOUS	
SPRING		ROTATING SHAFT	
MANUAL		ENCLOSURE	
PUSH BUTTON		RESERVOIR VENTED	
PUSH - PULL LEVER		PRESSURIZED	
PEDAL OR TREADLE		PRESSURE GAUGE	
MECHANICAL		ELECTRIC MOTOR	
DETENT		ACCUMULATOR, SPRING LOADED	
PRESSURE COMPENSATED		ACCUMULATOR, GAS CHARGED	
SOLENOID, SINGLE WINDING		HEATER	
REVERSING MOTOR		COOLER	
PILOT PRESSURE REMOTE SUPPLY		TEMPERATURE CONTROLLER	
INTERNAL SUPPLY		FILTER, STRAINER	

FIGURE 2-2

## 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 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.

---

### CAUTION

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

When flushing and draining fluids, always provide an adequate container to prevent fluids from polluting the environment.

**NOTE:** 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 jack 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.
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 hookblock.
25. Connect the return line to the main hoist motor and fully lower the hookblock, then hoist the hookblock 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 each of the swing motors and drive the motors in the direction they will go.
28. Connect the lines to the swing motors, then drive the swing motors 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 may occur.

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Working reservoir capacity

(capacity to full mark) is 324 gal (1226 l). 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.

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

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

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

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



#### **DANGER**

Locate the machine on a firm supporting surface and position the boom over the front on outriggers when extending the boom at low angles.

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

If the air is not readily removed, lower the boom to below horizontal, extend the telescope cylinders as far as practicable, and allow the boom to remain in this position overnight. This should allow entrapped air to find its way to the holding valve so that telescoping the boom IN the

next morning should force the air back to the reservoir. Ensure the boom is first telescoped IN (not OUT) in the morning. Telescoping OUT may cause air to be forced back into a cylinder.



#### **DANGER**

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

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



#### **DANGER**

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

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

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

### Parts Replacement

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

### Directional Control Valves

The control valves that control the crane functions are installed on the right side of the turntable.

#### **Inspection**

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

#### **Valve Leakage**

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



A component functioning at reduced efficiency may indicate that the control valve for that component is leaking internally. If preliminary checks reveal that adequate volume is being supplied to the affected valve bank, relief valves are properly adjusted, and the component is not at fault, check the valve for scored or worn parts. Scoring is a sign of the number one problem in hydraulics - contamination (external contamination by dust or internal contamination by debris from deteriorating components or oxidized hydraulic oil). Scored or severely worn valve components must be replaced.

Check valves in the control valves are designed to permit a flow of hydraulic oil in one direction only. If a piece of dirt or rust has worked its way into the check valve and lodges between the poppet and seat, it will keep the valve open and allow a return flow of hydraulic oil. The remedy is to clean the valve, but it is also a good idea to follow through and ensure the hydraulic system filter is still serviceable.

**Binding Spools**

Some of the most common causes for stiff spool movement or jammed spool action are system overheating, excessive pressure, contaminated or deteriorated hydraulic oil, or warped mountings. When scorched, deteriorated hydraulic oil or contamination is the cause, flushing the system and replenishing with clean hydraulic oil may solve the problem. If the spool bores are badly scored or galled, the valve must be removed for servicing.

Warping occurs when mounting plates are not level or they become distorted from machine damage. As mentioned previously, the valve can be shimmed level.

Also, check the valve for rust. Rust or dirt collecting on the valves can prevent free movement of the spool, and keep it from the true center position. Excessive system pressure can create both internal and external leaks in valves that are otherwise sound. Only qualified technicians using the correct equipment should make pressure adjustments when pressure adjustments are needed.

**Visual Inspection of Hoses and Fittings**

**CAUTION**

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

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:
  - 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, guard, or shields.
  - Excessive dirt and debris around the hose assemblies.

If any of these conditions exist, address them appropriately.

3. Hydraulic hose assemblies operating in a temperature climate zone "C" (Table 2-1) are recommended to be replaced after 8000 hours of service life.
4. Hydraulic hose assemblies operating in climate zones "A" and "B" (Table 2-1) with high ambient temperatures, could see hose service life reduced by 40 to 50%, therefore, it is recommended to replace these hoses after 4000 to 5000 hours of service life.
5. Hydraulic hose assemblies operating in climate zones "D" and "E" (Table 2-1) cold climates should expect a degradation of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

**Table 2-1**

Zone	Classification
A	Tropical Moist: All months average above 64° F (18° C). 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

## SUPPLY PRESSURE AND RETURN CIRCUIT

### Description

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, four hydraulic pumps, a hydraulic oil cooler, and a 11-port hydraulic swivel. Refer to *Hydraulic Pumps*, page 2-16 in this section for descriptions and maintenance instructions for each hydraulic pump.

Refer to *Swivels*, page 6-16 for description and maintenance instructions for the 11-port hydraulic swivel. The supply pressure and return circuit uses Ports 2 and 3 for pump supply and the dual Port 1 for return.

Each operating circuit's description and components begin with the circuit's directional control valve.

### Hydraulic Reservoir and Filter

The reservoir Figure 2-3, attached to the right side of the carrier frame, has a total capacity of 360 gal (1363 liters) total, or 324 gal (1226 liters) to the full mark. The all-steel reservoir has an internally mounted full-flow filter and integral baffles that help cool the hydraulic oil and prevent hydraulic oil foaming.

Hydraulic oil flows through four tubes at the lower rear of the reservoir to the four hydraulic pumps. Almost all of the return

flow goes through the filter at the top of the reservoir. The return line that goes directly into the reservoir (instead of through the filter) is from the No. 4 port (drain) of the 11-port swivel.

A magnetized drain plug in the bottom of the reservoir collects metal particles from the hydraulic oil if it becomes contaminated.

A sight gauge is located on the right side of the reservoir to indicate hydraulic oil level.

A filler neck and breather on the top of the reservoir are for filling the reservoir and for venting it. The filler neck includes a strainer for catching contaminants and gaskets to prevent leaking. The breather, which screws onto the filler neck, allows air to enter or exhaust from the reservoir. It is most important that the breather be kept clean to prevent damage to the reservoir.

Two large round access covers on the top of the reservoir provide access for cleaning. The covers are bolted to the top of the reservoir and have a gasket to prevent leaking. The access holes can also be used to fill the reservoir after it has been completely drained.

The hydraulic oil filter is located in the reservoir. It bolts to the top of the reservoir. The filter contains a replaceable filter element. Returning hydraulic oil flows through the filter's filter element into the reservoir. Bypass fluid internal to the filter flows to the reservoir also.

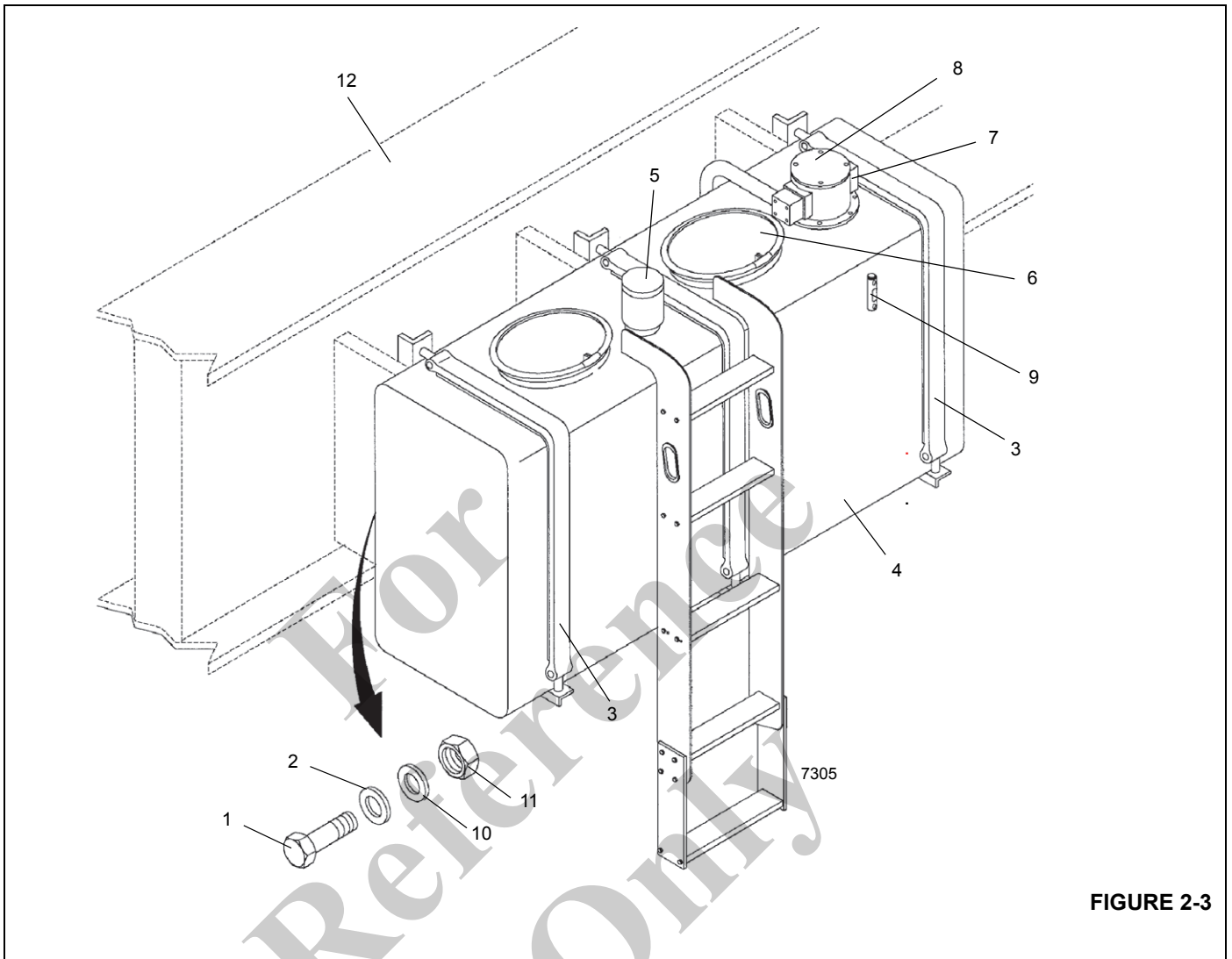


FIGURE 2-3

Item	Description
1	Capscrew
2	Flatwasher
3	Mounting Strap
4	Magnetized Drain Plug (Not shown on bottom of tank)
5	Fill Cap and Breather
6	Access Cover
7	Filter Indicator
8	Hydraulic Filter
9	Sight Gauge
10	Lockwasher
11	Hex Nut
12	Frame

A gauge on the filter head indicates how restricted (clogged) the filter element is. When back pressure caused by a dirty filter element exceeds 40 psi (275 kPa), the filter assembly's bypass feature functions to allow hydraulic oil to bypass the filter element and flow into the reservoir through the bypass valve instead. For filter replacement instructions, refer to *Filter Maintenance*, page 2-12.

### Pump Distribution

#### Pump No. 1

The torque converter drives Pump No. 1.

Section one of pump No. 1 supplies the hoist, lift, and telescope directional control valve. The valve sections control the main hoist, boom lift, boom telescope, and, when equipped, auxiliary hoist functions. Hydraulic oil flowing from this valve bank returns to the reservoir filter.

Section one also supplies the counterweight removal, counterweight removal pin, boom removal pin, and cab tilt functions, and when installed, the luffing jib function.

Section Two of Pump No. 1 supplies the front steer valve, the swing/steer directional control valve, and if installed, the CE option load sense steering valve. A load sense flow divider located in the swing directional control valve ensures the front steer valve gets priority flow upon demand and the swing directional control valve gets any excess flow.

**Pump No. 2**

The torque converter drives Pump No. 2.

The hydraulic pump No. 2 priority port supplies the dual accumulator charge valve and the hydraulic air conditioner. The dual accumulator charge valve in the supply line ensures the brake circuit gets priority flow and the hydraulic air conditioner gets the excess flow.

The hydraulic pump No. 2 secondary port supplies the charge air cooler fan.

**Pump No. 3**

The torque converter drives Pump No. 3.

Section one of pump No. 3 supplies the hoist, lift, and telescope functions. It also supplies the rear axle oscillation lockout valve.

Section two of pump No. 3 supplies the integrated outrigger/rear steer valve and the pressure reducing sequence valve. When the enabled solenoid is de-energized, the flow is supplied to the “power beyond” port of the integrated outrigger/rear steer valve which then is directed to the pressure reducing sequence valve. When the enabled solenoid is energized, the “power beyond” port is blocked and the flow is only available to the integrated outrigger/rear steer valve.

**Pump No. 4**

The engine drives Pump No. 4.

Pump No. 4 priority port supplies flow to the oil cooler motor to drive it. Pump No. 4 secondary port returns oil to the reservoir when the outrigger boost solenoid is de-energized. When the outrigger boost solenoid is energized, the pump supplies oil flow to the integrated outrigger/rear steer valve’s outrigger valve.

**MAINTENANCE**

**Troubleshooting**

Table 2-2

Symptom	Probable Cause	Solution
1. No hydraulic oil flows in systems.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Reservoir-to-pump suction lines broken or restricted. Air entering at suction lines. Pump not priming.	b. Clean, repair, or replace lines as necessary. Check lines for security, absence of cracks, and proper attachment. Tighten, repair, or replace parts as necessary.
	c. Pump shaft sheared or disengaged.	c. If drive shaft is damaged or sheared, remove and repair or replace as necessary
	d. Internal contamination.	d. Drain, flush with recommended oil mixture, then drain and refill system with recommended hydraulic oil.

Symptom	Probable Cause	Solution
2. Slow response.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Hydraulic oil temperature too high (watery thin oil) or too low (thick sluggish oil).	b. If too low, warm up system. As needed, troubleshoot cooler circuit. If too high, troubleshoot cooler circuit. Likely suspects are in-line check valve and related hydraulic circuits.
	c. Faulty pump section(s).	c. Repair or replace pump section(s) or entire pump.
3. Pump noise accompanied by hydraulic oil foaming in reservoir.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Excessive engine speed.	b. Regulate engine speed.
	c. Air entering at suction lines.	c. Check all lines for security and proper repair. Tighten, repair, or replace as needed.
4. Excessive pressure buildup.	a. System relief valve set too high.	a. Using adequate pressure gauge, adjust system relief valve as necessary.
	b. Restricted pump-to-control valve supply line.	b. Clean, repair, or replace line as necessary.
5. Specific hydraulic system (lift, hoist, telescope, swing) not working.	a. Leak in system.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Faulty hydraulic remote control valve.	b. Adjust or replace valve.
	c. Faulty directional control valve.	c. Replace valve.
	d. Poorly adjusted control in circuit.	d. Troubleshoot circuit with schematic. Adjust hydraulic component per schematic.
	e. Faulty hydraulic cylinder, motor, or valve.	e. Replace faulty component.

## Filter Maintenance

### Filter Element Removal



#### WARNING

Ensure that all hydraulic systems are shut down and the pressure is relieved.

1. Shut down all hydraulic systems.
2. Wipe any dirt from the filter head and cap Figure 2-4.
3. Remove the capscrews and lockwashers and disconnect the return manifold tube from the filter. Discard O-ring.
4. Unbolt and remove the filter assembly from the reservoir. Discard the gasket. If necessary, the filter can be disassembled without removing the entire filter from the reservoir.
5. Remove the four bolts securing the cap to the filter head. Remove the cap and spring. Take care when removing the spring as it may be under pressure. Discard O-ring.
6. Unscrew the filter gauge from the filter head.
7. Remove the filter head and discard the O-ring.
8. Remove the bypass valve from the filter tube on the filter bowl.
9. Remove the filter element.
10. Ensure the new filter element is correct by comparing their part numbers with the part numbers of the used filter element.

11. Discard the used filter element.
12. If not done earlier, unbolt the filter bowl from the reservoir. Remove the filter bowl. Discard gasket.

### Filter Element Installation

1. Inspect all parts; replace any defective part.
2. As required, install a new gasket around the filter bowl, then secure the filter bowl to the hydraulic reservoir with four capscrews and lockwashers. Assemble the filter and install it in the reservoir later.
3. Install the new element around the filter tube inside the filter bowl.
4. Install the bypass valve in the filter tube of the filter bowl.
5. Install a new O-ring in the groove of the head. Install the head on the filter bowl.
6. Install a new O-ring in its groove on the cap.
7. Place the spring inside the circular spring guide on the top of the bypass valve.
8. Secure the cap to the filter head with four capscrews and washers.
9. Screw the gauge into the filter head.
10. If not done earlier, install a new gasket around the filter bowl. Secure the filter to the hydraulic reservoir with four capscrews and lockwashers.
11. Install a new O-ring in its groove on the return manifold tube. Secure the return manifold tube to the filter head with four capscrews and lockwashers.
12. Activate the hydraulic system and check for leaks. Make repairs as needed.

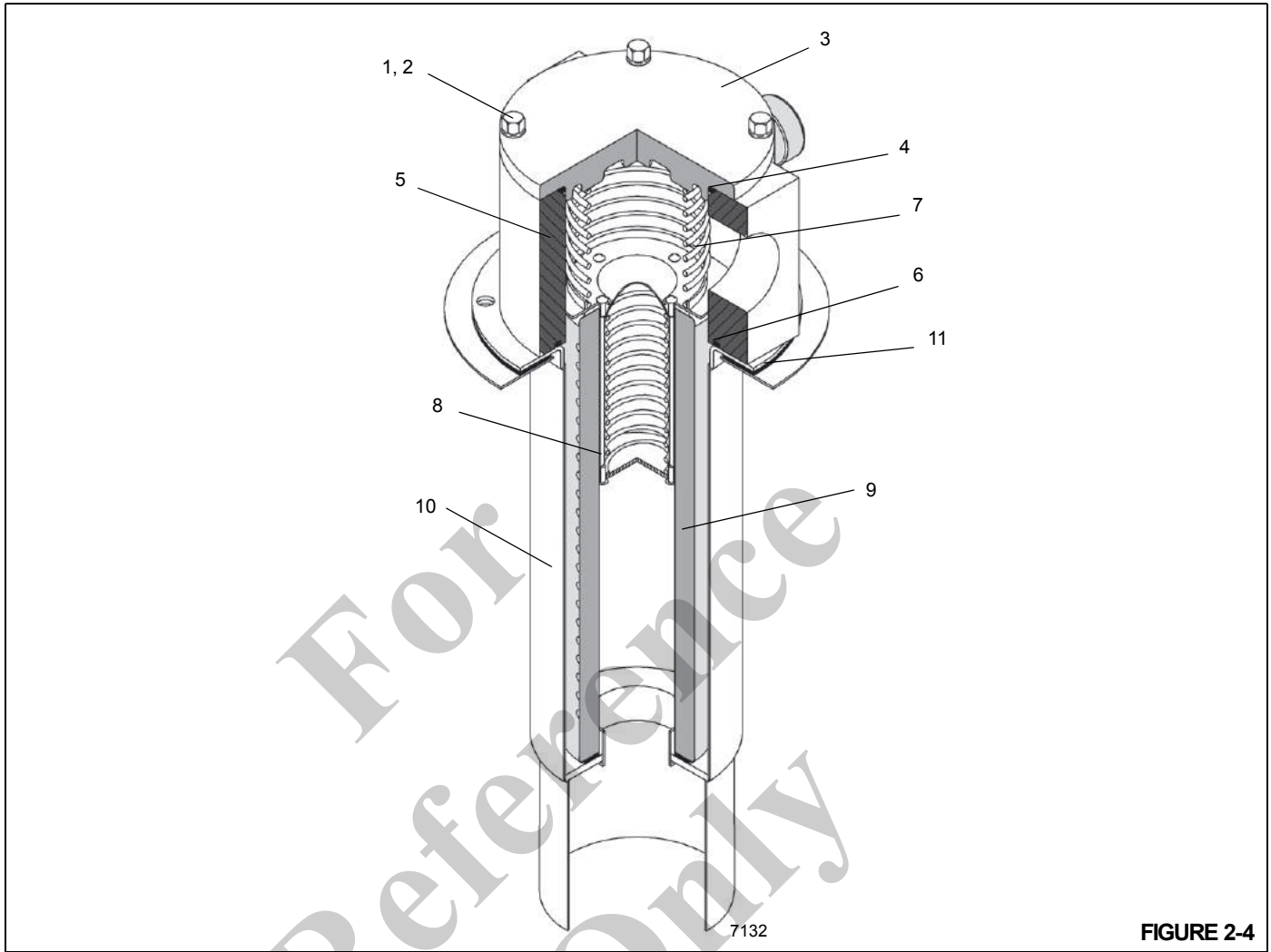


FIGURE 2-4

Item	Description
1	Capscrew
2	Washer
3	Cap
4	O-ring
5	Head
6	O-ring

Item	Description
7	Spring
8	Bypass Spring
9	Filter Element
10	Bowl
11	Gasket

**DANGER**

Ensure that all hydraulic systems are shut down and the pressure is relieved. Wear eye protection. Hydraulic fluid can blind or severely damage eyes.

---

**Hydraulic Reservoir Removal**

1. Drain reservoir. Tag and disconnect lines from the reservoir. Cover lines and reservoir fittings to prevent contamination.
2. Secure reservoir with proper lifting device.
3. Remove the capscrews, flatwashers, lockwashers and nuts securing the reservoir to the frame. Using a suitable lifting device, remove the reservoir.
4. Clean reservoir and magnetic plug. Service filter assembly. Then reinstall plug and filter assembly.

**Hydraulic Reservoir Installation**

1. Using a suitable lifting device, place the reservoir on the frame. Secure reservoir with the capscrews, flatwashers, lockwashers and nuts.
  2. Attach lines to reservoir.
  3. Fill reservoir; verify there is no leakage.
- 

**DANGER**

Ensure that all hydraulic systems are shut down and the pressure is relieved. Wear eye protection. Hydraulic fluid can blind or severely damage eyes.

---

**Breather Removal and Replacement**

1. Wipe any dirt from the breather.
2. Unscrew the breather from the fill neck.
3. Screw the replacement breather into the fill neck.

For Reference Only



### OIL COOLER

#### Description

An air cooled hydraulic oil cooler is the right rear portion of the hydraulic/transmission oil cooler Figure 2-5. When the oil temperature reaches 120°F, the oil cooler solenoid valve is de-energized, via a normally closed pressure switch, to allow pressurized oil from pump No. 4 to the oil cooler motor which drives the oil cooler fan.

The oil cooler fan pulls cool air through the cooling fins on the cooler. Normally, most hydraulic oil from components is routed through the oil cooler by way of a return line and on to

the filter in the reservoir. When several hydraulic functions are being used at one time (i.e., hoisting, lifting, and telescoping), more oil has to flow through this return line, causing a pressure buildup. When this pressure reaches 15 psi (100 kPa), the normally closed check valve in the return line (in parallel with the return line through the hydraulic oil cooler) will open, letting some hydraulic oil bypass the hydraulic oil cooler and flow directly into the reservoir filter.

When fewer functions are being used, the pressure in the system will decrease below 15 psi (100 kPa) and the check valve will close again.

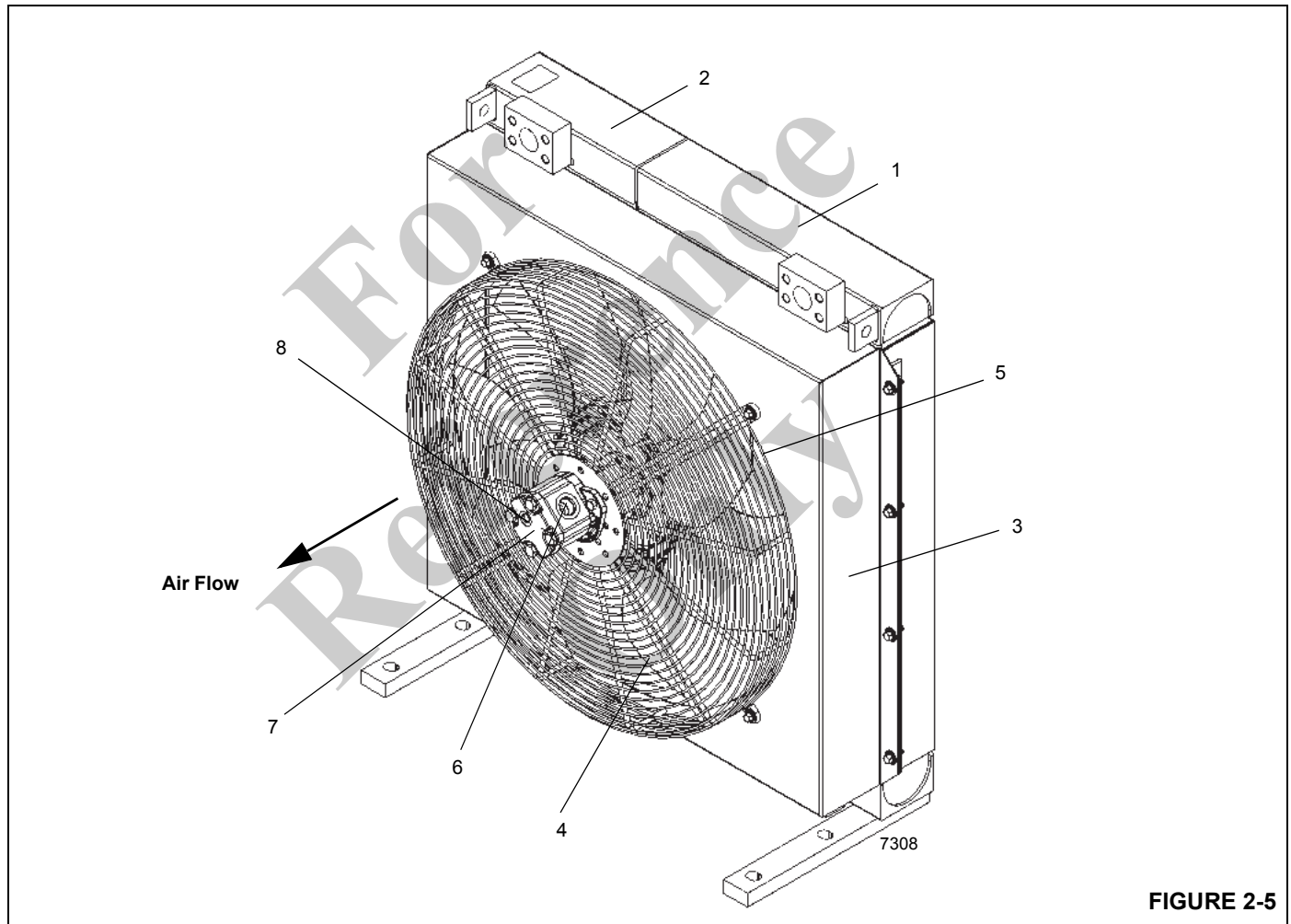


FIGURE 2-5

Item	Description
1	Hydraulic Oil Cooler
2	Transmission Oil Cooler
3	Fan Shroud
4	Fan

Item	Description
5	Finger Guard
6	Outlet Port
7	Motor
8	External Drain

## HYDRAULIC PUMPS

### Description

**NOTE:** Refer to Figure 2-6 for pump locations.

Pumps No. 1 and No. 2 are mounted on drive pads of the torque converter. Pump No. 3 is mounted off of the torque converter via pump disconnect. Pump No. 4 is mounted on a drive pad of the engine.

The purpose of these pumps is to convert mechanical energy into fluid energy for the operation of the crane's hydraulic components.

All four pumps are positive displacement gear-type pumps. Pumps No. 1 and No. 3 have two sections and pumps No. 2 and No. 4 have only one section.

#### Pump No. 1

The first section of pump no. 1, the closest to the mounting face, is a 4.95 in<sup>3</sup>/rev (81.1 cm<sup>3</sup>/rev) section with an output of 55.2 gpm (209 l/min) at 2710 rpm. The second section is a 2.96 in<sup>3</sup>/rev (48.5 cm<sup>3</sup>/rev) section with an output of 33.0 gpm (125 l/min) at 2710 rpm.

#### Pump No. 2

Pump No. 2 is a 2.241 in<sup>3</sup>/rev (36.7 cm<sup>3</sup>/rev) pump with an output of 25 gpm (95 l/min) at 2710 rpm. An integral flow divider/relief valve ensures a constant 10 gpm (38 l/min) at 3000 psi (20,670 kPa) at the primary port.

#### Pump No. 3

The first section of pump No. 3, the closest to the mounting face, is a 4.95 in<sup>3</sup>/rev (81.1 cm<sup>3</sup>/rev) section with an output of 55.2 gpm (209 l/min) at 2710 rpm. The second section is a 1.48 in<sup>3</sup>/rev (24.3 cm<sup>3</sup>/rev) section with an output of 16.5 gpm (62 l/min) at 2710 rpm.

#### Pump No. 4

Pump No. 4 is a 0.878 in<sup>3</sup>/rev (14.4 cm<sup>3</sup>/rev) pump with an output of 9.8 gpm (37 l/min) at 2712 rpm. An integral flow divider/relief valve ensured a constant 6 gpm (23l/min) at 2700 psi (18,600 kPa) at the primary port.

## Maintenance

### Pump No. 1 Removal

#### CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

1. Remove hardware as needed to gain access to the pump. The pump is bolted to the engine's torque converter.
2. Tag and disconnect the supply line from the pump. Cap or plug the line and port.
3. Tag and disconnect the pump distribution lines from the pump. Cap or plug the lines and ports.

#### CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

4. Remove the four bolts and washers attaching the pump to the drive pad on the torque converter. Remove the pump.
5. Clean the gasket material from the drive pad of the torque converter and from the pump.
6. Cover the drive pad's opening to prevent dirt from entering.

### Pump No. 1 Installation

1. Clean the pump and the torque converter drive pad with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. Apply a light coating of Loctite primer N7649 to pump and drive pad. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
3. Apply gasket material Loctite Master Gasket 518 to pump and drive pad mounting surfaces. (This material partially cures in 4 hours and fully cures in 48 hours.)
4. Install pump and gasket on drive pad with bolts and washers. Make sure the splines mesh properly. Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the pump mounting bolts.
5. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old o-ring and install a new o-ring in its place.

### Pump No. 2 Removal

#### CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

1. Remove hardware as needed to gain access to the pump. The pump is bolted to the drive-through charge pump on the engine's torque converter.
2. Tag and disconnect the supply line from the pump. Cap or plug the line and port.
3. Tag and disconnect the pump distribution lines from the pump. Cap or plug the lines and ports.

---

### CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

---

4. Remove the two bolts and washers attaching the pump to the drive-through charge pump on the torque converter. Remove Pump No. 2.
5. Clean the gasket material from the drive pad of the drive-through charge pump and from the pump.
6. Cover the drive pad's opening to prevent dirt from entering.

### Pump No. 2 Installation

1. Clean the pump and the drive pad of the drive-through charge pump with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. Apply a light coating of Loctite primer N7649 to pump and drive-through charge pump drive pad. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
3. Apply gasket material Loctite Master Gasket 518 to pump and drive pad mounting surfaces. (This material partially cures in 4 hours and fully cures in 48 hours.)
4. Apply antiseize compound to the splined shaft of Pump No. 2 and to the splined socket of the coupler on the shaft inside the drive-through charge pump.
5. Install Pump No. 2 and gasket on drive-through charge pump drive pad with bolts and washers. Make sure the splined shaft of Pump No. 2 meshes properly with the splined socket of the coupler on the shaft inside the drive-through charge pump. Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the pump mounting bolts.
6. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.

### No. 3 Pump Removal

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### CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

---

1. Remove hardware as needed to gain access to the pump. The pump is bolted to the engine's torque converter.
2. Tag and disconnect the supply line from the pump. Cap or plug the line and port.
3. Tag and disconnect the pump distribution lines from the pump. Cap or plug the lines and ports.
4. Remove attaching hardware to free pump disconnect linkage from torque converter pump disconnect shaft.

---

### CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

---

5. Remove the four bolts and washers attaching the pump to the drive pad on the torque converter. Remove the pump and the attached cable mounting weldment and push-pull cable. Remove cable mounting weldment and push-pull cable from the pump.
6. Clean the gasket material from the drive pad of the torque converter and from the pump.
7. Cover the drive pad's opening to prevent dirt from entering.

### No. 3 Pump Installation

1. Clean the pump and the torque converter drive pad with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. Apply a light coating of Loctite primer N7649 to pump and drive pad. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
3. Apply gasket material Loctite Master Gasket 518 to pump and drive pad mounting surfaces. (This material partially cures in 4 hours and fully cures in 48 hours.)
4. Install pump and gasket on drive pad with bolts and washers. Make sure the splines mesh properly. Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the pump mounting bolts.
5. Install cable mounting weldment and push-pull cable on the pump. Secure pump disconnect linkage to torque

converter pump disconnect shaft with attaching hardware.

6. Adjust the push-pull cable as needed so the torque converter pump disconnect shaft sticks 1.50 in (38.1 mm) farther out of the torque converter in the disengaged position than it does in the engaged position.
7. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.

#### No. 4 Pump Removal

##### CAUTION

Absolute cleanliness is essential when working on the hydraulic pumps. Always work in a clean area. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

1. Remove hardware as needed to gain access to the pump. The pump is bolted to the engine.
2. Tag and disconnect the supply line from the pump. Cap or plug the line and port.
3. Tag and disconnect the pump distribution lines from the pump. Cap or plug the lines and ports.

##### CAUTION

When removing the pump, keep the pump as level as possible to avoid damaging the input spline.

4. Remove the two bolts and washers attaching the pump to the drive pad of the engine. Remove the pump.
5. Remove the two gaskets and spacer from the pump (or the engine drive pad). Discard them.
6. Cover the drive pad's opening to prevent dirt from entering.
7. Remove the nut, key, and gear from the pump.

#### No. 4 Pump Installation

1. Ensure the mating surfaces of the pump shaft and gear are clean and dry. Install gear on pump's tapered shaft. Secure gear with key and nut. Torque nut to 120 ft-lb (163 Nm). Remove the nut and apply Loctite 243 to the threads. Install the nut and retorque to 120 ft-lb (163 Nm).
2. Clean the pump and the engine drive pad with Loctite cleaning solvent 7070 or similar non chlorinated solvent. Likewise clean both surfaces of the new rubber/steel gasket, the spacer, and the new vellomoid gasket.
3. Apply a light coating of Loctite primer N7649 to Pump No. 4's mounting surface, but do not apply any to the

engine's drive pad. Also apply a light coating of Loctite primer N7649 to both surfaces of the vellomoid gasket, and apply a light coating of Loctite primer N7649 to the surface of the spacer that will be next to the vellomoid gasket, but not to the surface of the spacer that will be next to the rubber/steel gasket. Do not coat either side of the rubber/steel gasket or the facing sides of the parts that will touch it. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.

4. Apply gasket material Loctite Master Gasket 518 to Pump No. 4's mounting surface, but do not apply any to the engine's drive pad. Also apply a light coating of Loctite Master Gasket 518 to both surfaces of the vellomoid gasket, and apply a light coating of Loctite Master Gasket 518 to the surface of the spacer that will be next to the vellomoid gasket, but not to the surface of the spacer that will be next to the rubber/steel gasket. Do not coat either side of the rubber/steel gasket or the facing sides of the parts that will touch it. (This material partially cures in 4 hours and fully cures in 48 hours.)
5. Around the pilot of the pump, install the vellomoid gasket, then install the spacer (coated surface away from rubber/steel gasket), then install the rubber/steel gasket. Then secure the pump and gaskets and spacer on the drive pad with bolts and washers. Make sure the teeth of the gear on the pump mesh properly with the mating gear inside the engine. Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the pump mounting bolts.
6. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.

#### Testing After Repair or Replacement

##### CAUTION

Do not feed hot hydraulic oil into a cold pump. This may cause the pump to seize.

1. Ensure the reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge.
2. Ensure no air is entering the pump inlet, and that the pump suction or inlet fluid is not bleeding back to the reservoir when the engine is stopped, by making sure all suction or inlet lines are air tight.
3. Remove all pump outlet hoses. Fill pump outlet port of each pump section with as much hydraulic oil as it can take. Connect all pump outlet hoses again.
4. Start the engine and idle it for two or three minutes without running any hydraulic functions. Check for leaks; as needed, stop the engine and make repairs.

---

**CAUTION**

If the pump becomes hot to the touch, it is binding and may seize. Stop the engine, disassemble the pump, and repair it so it will not bind.

---

**CAUTION**

For Pump No. 2, pay special attention to the service brake charge pump if your crane has the dual accumulator charging valve for hydraulic service brakes.

If the dual accumulator charge is set too high, the pump will continually push all its flow through an integral relief valve that dumps the heated fluid back into the pump's inlet. This causes a "hot loop" problem that will very quickly heat the pump section above hydraulic reservoir temperature. If this happens, stop the engine immediately. Adjust the dual accumulator charging valve socket head screw in the valve's tank port, out (CCW) to lower the pressure. (See Procedure E of the Pressure Setting Procedure portion of this section.)

Restart the engine; listen for the dual accumulator charge valve to cycle on and off (cycle changes one to two seconds.) Perform Step 5 again.

---

5. Place your hand on the pump to check for excessive heat buildup caused by binding or other problems. If the pump is too hot to keep a hand on, stop the engine. Each section should feel about the same warmth, but pressure drops in each pump section's circuit would explain some difference between sections.
6. Listen for abnormal noises indicating low hydraulic oil level or internal pump problems. If the pump is making excessive noise, it is probably sucking air into its inlet, keeping it from priming. In case of abnormal noise, stop engine, and inspect the pump and the suction line for a loose connection, a leak, or a damaged or missing O-ring.
7. If the pump seems to be running properly, increase the rpm to 1500 to 1800 rpm for one to two minutes while operating no hydraulic functions. Repeat checks in steps 4, 5, and 6.
8. Increase engine speed in steps to full RPM. Repeat checks in steps 4, 5, and 6.
9. Cycle the components the pump sections power to verify the pump sections drive them properly. Verify there is no leaking.
10. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-21.

Reference Only

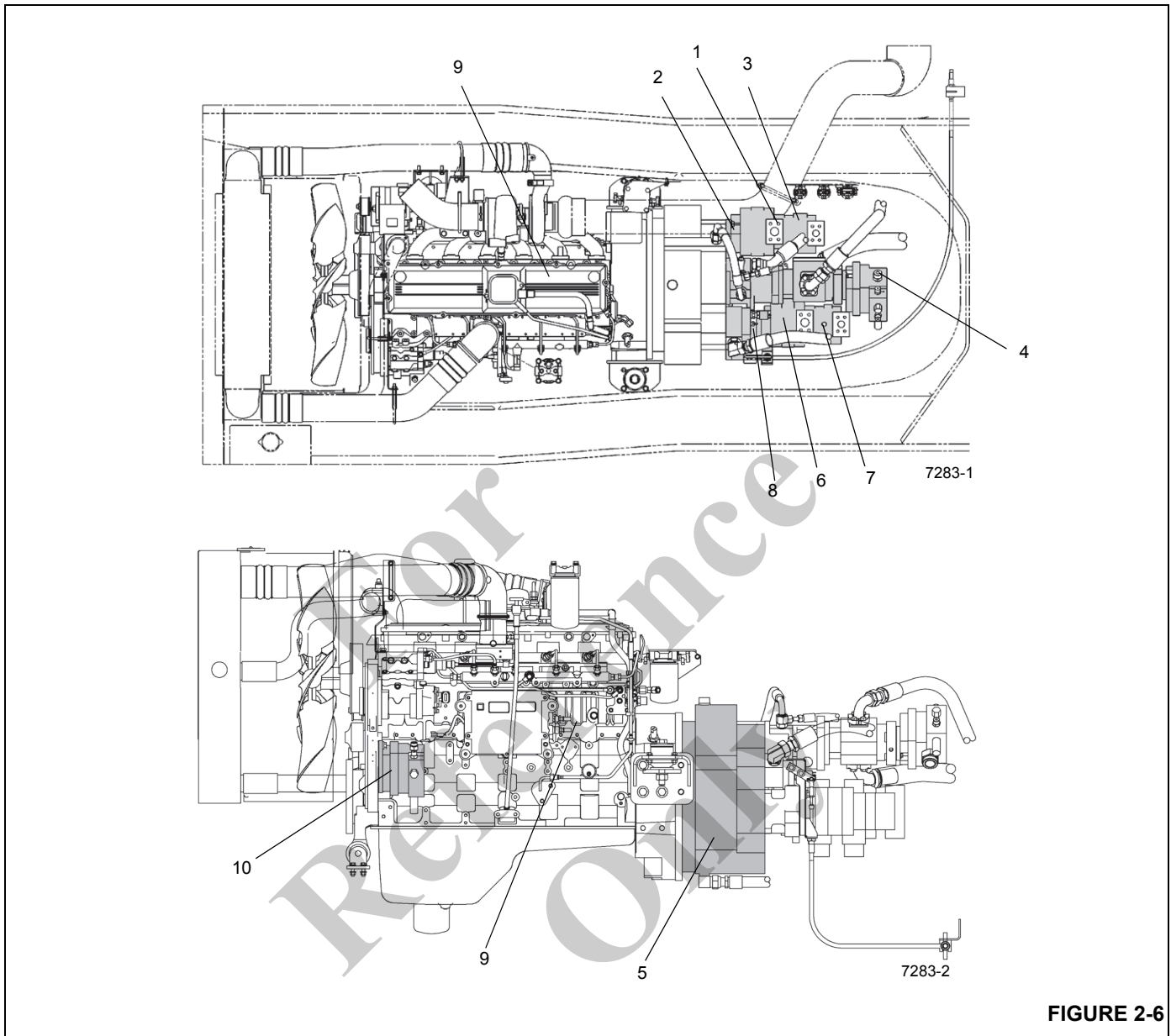


FIGURE 2-6

Item	Description
1	Hydraulic Pump No. 1
2	Section No. 1 (Pump No. 1)
3	Section No. 2 (Pump No. 1)
4	Hydraulic Pump No. 2
5	Torque Converter

Item	Description
6	Hydraulic Pump No. 3
7	Section No. 2 (Pump No. 3)
8	Section No. 1 (Pump No. 3)
9	Engine
10	Pump No. 4

## PRESSURE SETTING PROCEDURES

The following procedures should be used to properly check, adjust and set the hydraulic system pressures.

The following equipment is required for checking the hydraulic pressure settings.

- Three dial pressure gauge, 0-5000 psi
- Pressure check diagnostic quick disconnect - Grove P/N 9999101806 and straight adapter fitting 7447040401
- ORFS reducers as required to attach work port hoses to the gauge.

**NOTE:** When checking directional control valve relief settings, unless otherwise specified, start with the engine at idle RPM and move the controller to its fully stroked position. Then slowly accelerate the engine to the specified RPM. Read gauge and make adjustments to the specified setting.

When checking the outrigger relief valve setting, start with the engine at idle RPM and activate and hold the extend switch. Then slowly accelerate the engine to the specified RPM. Read gauge and make adjustment as required.

**Table 2-3**  
**Valve Pressure Setting Table**

Valve To Be Set	Pressure Setting PSI (MPa)	Tolerance PSI (MPa)	Adjustment Location
Max System Pressure	4000 (27.6)	± 50 (0.4)	Main Valve Inlet Section
Telescope Inner Mid Retract	3500 (24.1)	± 50 (0.4)	Main Valve Tele Inner Mid Retract Port
Tele Inner Mid Extend	3000 (20.7)	± 50 (0.4)	Main Valve Tele Inner Mid Extend Port
Telescope Center/Outer Mid Retract	3500 (24.1)	± 50 (0.4)	Main Valve Tele Center/Outer Mid Retract Port
Tele Center Mid Extend	2500 (17.2)	± 50 (0.4)	Main Valve Tele Center Mid Extend Port
Tele Outer Mid Extend	3000 (20.7)	± 50 (0.4)	Main Valve Tele Center/Outer Mid Extend Port
Pressure Reducing Sequence	1200 (8.3)	+50/-0 (+0.4/-0)	Pressure Reducing Sequence Valve
Swing Brake Supply Pressure Reducing	250 (1.7)	+50/-0 (+0.4/-0)	Pressure Reducing Sequence Valve
Controller Supply Pressure Reducing	400 (2.7)	± 50 (0.4)	Pressure Reducing Sequence Valve
Front Steer Relief Valve	2500 (17.2)	± 50 (0.4)	Swing/Steer Control Valve
Swing "Left" Relief	2500 (17.2)	± 50 (0.4)	Swing/Steer Control Valve
Swing "Right" Relief	2500 (17.2)	± 50 (0.4)	Swing/Steer Control Valve
Outrigger Beam Extend	2000 (13.8)	± 50 (0.4)	Outrigger/Rear Steer Valve Inlet
Outrigger Jack/Rear Steer/Pin Removal	3500 (24.2)	± 50 (0.4)	Outrigger/Rear Steer Valve Inlet
Service Brake & A/C Relief	3000 (20.7)	± 50 (0.4)	Service Brake & A/C Pump
Service Brake High Charge Limit	2490 (17.2)	+72/-145 (+0.5/-1.0)	Dual Accumulator Charge Valve
Service Brake Low Charge Limit	2100 (14.5)	±145 (1.0)	Dual Accumulator Charge Valve
Accumulator Pre-charge	1400 (9.7)	+50/-0 (+0.4/-0)	Accumulator
Make-up Oil Manifold	200 (2.8)	+0,-25 (0.2)	Make-up Manifold, Pressure Reducing Valve
Charge Air Cooler Relief Valve	1700 (11.7)	± 50 (0.4)	Charge Air Cooler Control Valve
Counterweight Removal Relief	3800 (26.2)	± 50 (0.4)	Counterweight Removal Valve
Luffing Extension Lower Relief	1450 (10.0)	± 50 (0.4)	Counterweight Removal Valve

Valve To Be Set	Pressure Setting PSI (MPa)	Tolerance PSI (MPa)	Adjustment Location
Cab Tilt Relief	2500 (17.2)	± 50 (0.4)	Counterweight Removal Valve
Counterweight Removal Pin Relief-Extend	2500 (17.2)	± 50 (0.4)	Counterweight Removal Valve-Port A
Counterweight Removal Pin Relief-Retract	1600 (11.0)	± 50 (0.4)	Counterweight Removal Valve-Port B

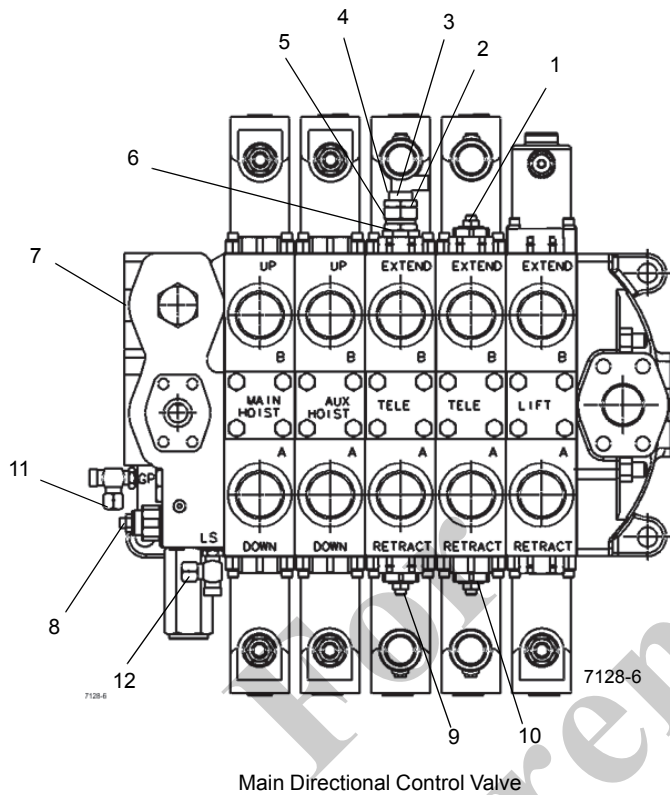
\*This setting is for Hoist "UP" and "DOWN" circuits.

**NOTE:** Procedures A through M in the following text correlate with Figure 2-7 through Figure 2-16.

### Procedure A - For Setting Main Directional Control Valve Relief Pressures

1. Remove cap and install pressure gauge on the main directional control valve system pressure port (Figure 2-7).
2. Completely retract the Lift Cylinder or disconnect and cap the hose from the Main Directional Control Valve Retract port "A" to the lift cylinder. With the engine running @ FULL RPM, attempt to operate Lift DOWN, adjust the Load Sense relief in the Main Directional Control Valve to 4000 ±50 PSI (27.6 ± 0.4 MPa). Remove cap and re-connect plumbing. Remove pressure gauge.
3. With boom installed, completely RETRACT the boom or with out boom installed, disconnect and cap hoses from the Main Directional Control Valve Retract ports "A" to each Telescope cylinder. In the Cab, on the over head console, set the Boom Mode switches to "Manual" and "IM". With the engine running @ FULL RPM, attempt to Telescope IN, adjust the Telescope Inner Mid port "A" relief in the Main Directional Control Valve to 3500 ± 50 PSI (24.1 ± 0.4 MPa). Set the Boom Mode switches to "Manual" and "CM", then adjust the Telescope Center/Outer Mid port "A" relief in the Main Directional Control Valve to 3500 ± 50 PSI (24.1 ± 0.4 MPa). Remove caps and re-connect plumbing.
4. With Boom installed, telescope mid section full out or with out boom installed, disconnect and cap the hoses from the Main Directional Control Valve Inner Mid Extend port "B" to each Telescope cylinder. In the Cab, on the over head console, set the Boom Mode switches to "Manual" and "IM". With the engine running @ FULL RPM, attempt to Telescope OUT, adjust the Telescope Inner Mid port "B" relief in the Main Directional Control Valve to 3000 ± 50 PSI (20.7 ± 0.4 MPa). With the hoses still capped, continue on to step 5.
5. In the Cab, on the over head console, set the Boom Mode switches to "Manual" and "CM". With the engine running @ FULL RPM, Telescope full OUT, or disconnect and cap hoses and adjust the Telescope Center/Outer Mid two stage port "B" relief (see Figure 2-7) in the Main Directional Control Valve to 2500 ± 50 PSI (17.2 ± 0.4 MPa). If adjustment is required, loosen the Low Pressure Jam Nut, and then turn the Low Pressure Adjustment Nut until the relief setting is reached and tighten the jam nut. With the hoses still capped, and the Boom Mode switches set to "Manual" and "CM", continue on to step 6.
6. With Boom installed, telescope outer mid fully out or with out boom installed, disconnect the Deutsch connectors for the Telescope Center/Outer Mid 2-way solenoid and the Swing Brake Pressure switch. Actuate the Telescope Center/Outer Mid 2-way solenoid by connecting it to the "Battery Hot" wire harness for the Swing Brake solenoid. With the engine running @ FULL RPM, attempt to Telescope OUT, adjust the Telescope Center/Outer Mid two stage port "B" relief in the Main Directional Control Valve to 3000 ± 50 PSI (20.7 ± 0.4 MPa). If adjustment is required, loosen the High Pressure Jam Nut, and then turn the High Pressure Adjustment Nut until the relief setting is reached and tighten the jam nut. Re-connect the Deutsch connectors on both solenoids to their correct wire harness. Remove caps and re-connect telescope plumbing.
7. Remove pressure gauge from the System pressure Test Port & re-install cap.





Item	Description
1	Telescope Inner Mid Extend Port Relief
2	High Pressure Jam Nut
3	High Pressure Adjustment Nut
4	Telescope Center Outer Mid Extend 2 Stage Port Relief
5	Low Pressure Adjustment Nut
6	Low Pressure Jam Nut
7	Valve Inlet Section
8	Load Sense Relief
9	Telescope Center/Outer Mid Retract Port Relief
10	Telescope Inner Mid Retract Port Relief
11	System Pressure Test Port
12	Load Sense Test Port

FIGURE 2-7

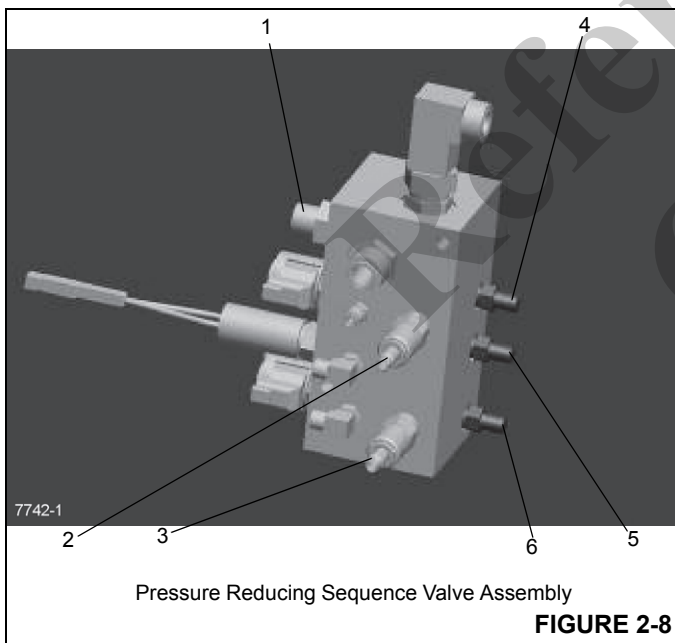
**Procedure B - For Checking Pressure Reducing/Sequence Valve Setting**

*Procedure for Checking Sequence Valve Setting (see Figure 2-8).*

1. Remove cap and install pressure gauge on the G2 test port (5).
2. With the engine running at idle, adjust the sequence valve cartridge to 1200 psi +50/-0 (8.3 MPa +0.4/-0). If adjustment is required, use a shim with an outside diameter of 0.56 in, an inside diameter of 0.375 in, and a thickness of 0.06 in to increase pressure about 50 PSI.
3. Remove pressure gauge from the G2 port and reinstall cap.

**Procedure for Checking Controller Supply Pressure Reducing Valve Setting**

1. Remove cap and install pressure gauge on the controller supply G1 test port (Figure 2-8).
2. With the engine running at full RPM, adjust the controller supply pressure reducing valve cartridge (3) to 400 psi ±50 (2.8 MPa ±0.4).
3. Remove pressure gauge from the test port and reinstall cap.



Item	Description
1	Sequence Valve Cartridge
2	Swing Brake Supply Pressure Adjustment
3	Control Supply Adjustment

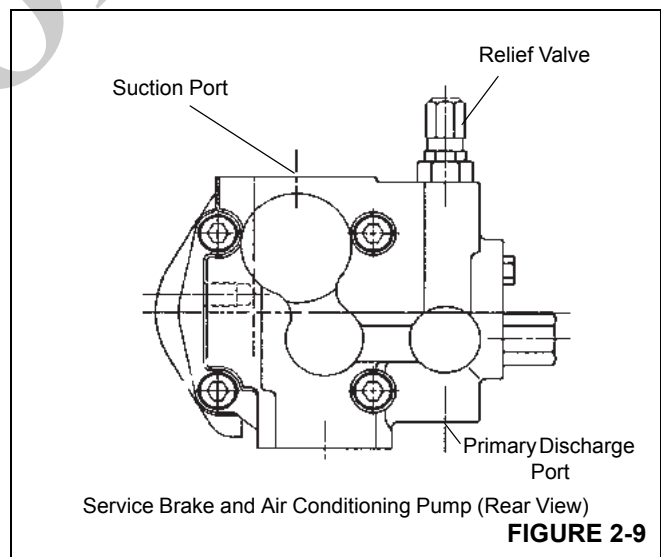
Item	Description
4	Swing Brake Supply Test Port, G3
5	Hose Reel Brake and Motor Test Port, G2
6	Controller Supply Test Port, G1

**Procedure C - For Checking Swing Brake Supply Pressure**

1. Remove cap and install pressure gauge on swing brake supply valve test port, G3 (Figure 2-8).
2. With the engine running at idle, adjust the swing brake pressure reducing valve cartridge to 250 psi +50/-0 (1.7 MPa +0.4/-0).
3. Remove pressure gauge from the test port and reinstall cap.

**Procedure D - For Checking Service Brake and Air Conditioning Circuit Relief Valve Pressure**

1. Disconnect pressure hose at the Primary Discharge port (Figure 2-9) and attach a pressure gauge.
2. Run the engine at idle (900 rpm), for only 5-10 seconds since the flow will be "Hot Looped". Check the pressure. Adjust the service brake and air conditioning relief valve in the pump mounted on the back side of the charge pump (Figure 2-9) to 3000 psi ±50 (20.7 MPa ±0.4). If this step needs to be repeated, make sure the pump is not hot to the touch. If it is, let it cool before proceeding.
3. Remove pressure gauge and reconnect the pressure line.



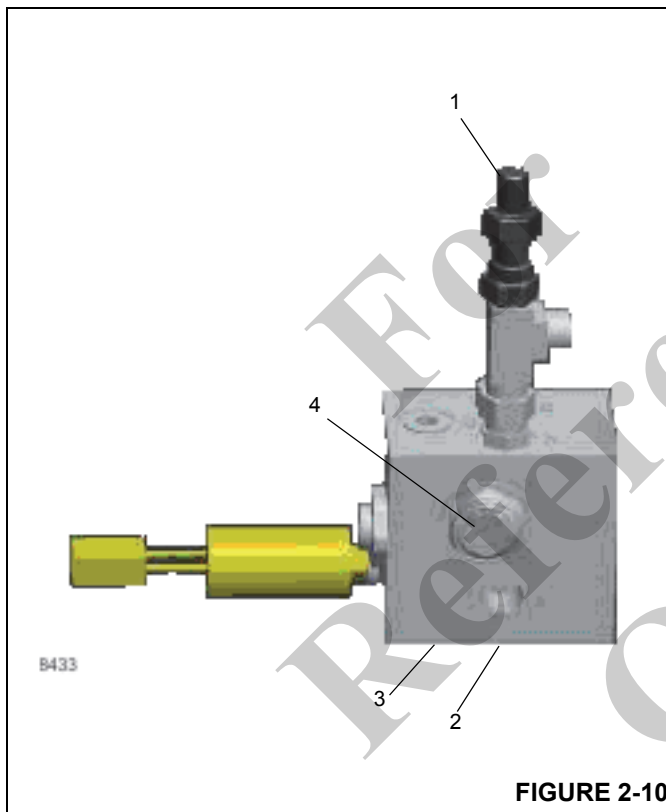
**Procedure E - For Checking Service Brake Dual Accumulator Charge Valve Pressure Limits**

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4-6 times.
2. Install a pressure gauge at the service brake dual accumulator charge valve "A1" pressure test port (Figure 2-10).
3. Start the engine. The charging valve will immediately start to charge the accumulators. Watch the pressure

gauge. The high charge limit pressure should read 2490 +72/-145 psi (17 +.5/-1 MPa) when the pressure gauge stops rising.

4. With the engine still running at idle, repeatedly depress the service brake pedal. As the pressure approaches 2250 psi (15.5 MPa). Pay close attention as the next application should make the valve start recharging. Watch the pressure gauge, the pressure should be 2100 +145/-145 psi (14.5 ± 1.0 MPa) when it starts to recharge.
5. Turn the engine off, remove diagnostic connector with gauge from test nipple.

2

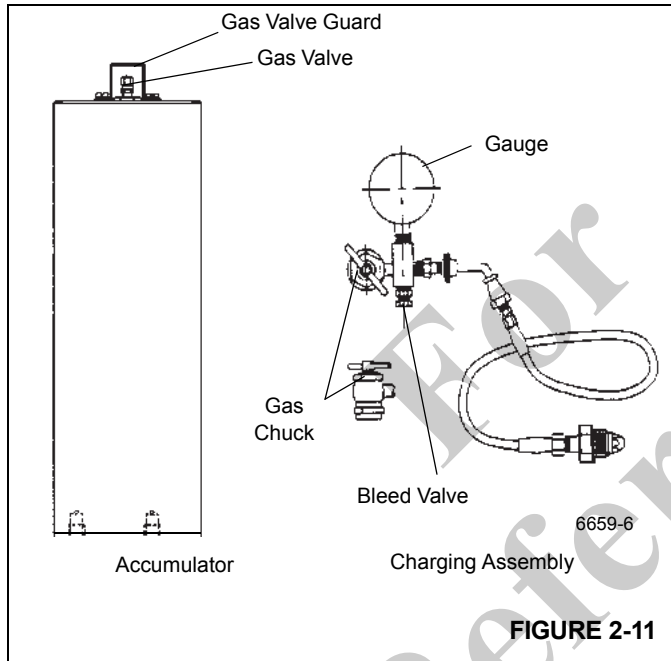


**FIGURE 2-10**

Item	Description
1	Accumulator A1 Pressure Test Port
2	Pressure "P" Port
3	Tank Port
4	Socket Head Screw Adjustment

### Procedure F - For Checking Accumulator Pre-Charge Pressure

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor several times. Remove the gas valve guard and cap on the accumulator (Figure 2-11).
2. Before attaching the gas charging assembly (Figure 2-11) onto the accumulator gas valve, back the gas chuck "T" handle all the way out (counterclockwise).



**FIGURE 2-11**

3. Close the charging assembly bleed valve. Without twisting hose, attach the swivel nut onto the gas valve and tighten (10-15 lb-in).
4. Turn the gas chuck T-handle all the way down (clockwise) to depress the core in the gas valve.
5. Check the pre-charge pressure. It should be 1400 psi +50/-0 (9.7 MPa +0.4/-0).
6. If the pressure is 1400 psi +50/-0 (9.7 MPa +0.4/-0), remove the charging valve assembly by turning the T-handle all the way out on the gas chuck and then opening the bleed valve (Figure 2-11).
7. Hold gas valve to keep it from turning. Loosen swivel nut and remove charging assembly. Reinstall gas valve cap and guard.

### Procedure G - For Pre-Charging Accumulator

1. With the engine off, discharge all oil stored in the accumulators by pushing the service brake pedal several times. Remove the gas valve guard and gas valve cap on the accumulator (Figure 2-11).
2. Check that the nitrogen supply bottle valve is shut off, then attach charging assembly hose to nitrogen bottle.
3. Before attaching charging assembly (Figure 2-11) to the accumulator gas valve, back the gas chuck T-handle all the way out (counterclockwise).
4. Close the charging assembly bleed valve. Without looping or twisting hose, attach the swivel nut onto the gas valve and tighten.
5. Turn the gas chuck T-handle all the way down (clockwise) to depress the core in the gas valve.
6. Crack open the nitrogen bottle valve and slowly fill the accumulator. Shut off the valve when the pre-charge pressure is 1400 psi +50/-0 (9.7 MPa +0.4/-0).
7. If the pre-charge pressure is higher than 1400 psi +50/-0 (9.7 MPa +0.4/-0), then close the nitrogen bottle valve and slowly open the bleed valve on the charging assembly (Figure 2-11) until the pre-charge pressure is correct.
8. Remove charging assembly by turning T-handle all the way out (counterclockwise) on gas chuck and then open bleed valve.
9. Hold gas valve to keep it from turning, loosen swivel nut, and remove charging assembly. Replace gas valve cap and guard.

### Procedure H - For Checking Front Steer Relief Valve Pressure

1. Remove cap and install pressure gauge on steer valve load sense test port (Figure 2-12).
2. With the engine running at 1000 RPM, turn the steering wheel to LOCK position and adjust pressure at the steer priority flow divider section relief to 2500 psi ±50 (17.2 MPa ±0.4).
3. Remove pressure gauge from the Load Sense Test Port and reinstall cap.

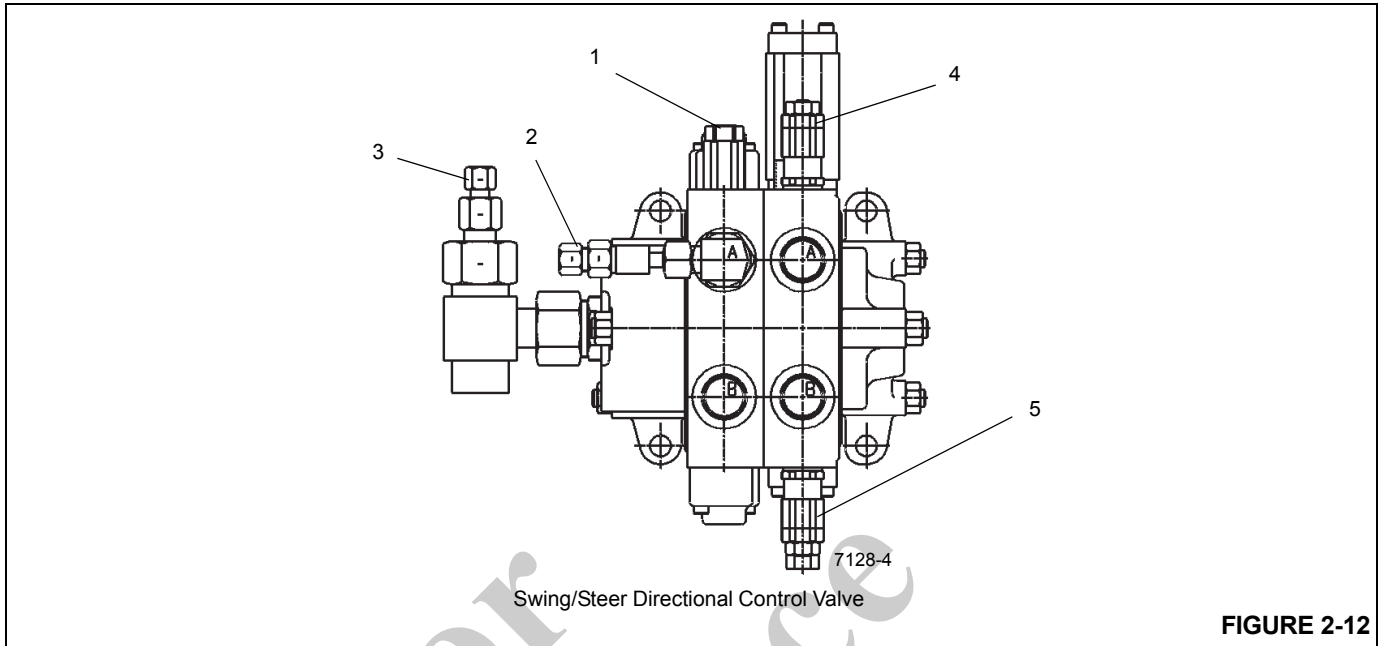


FIGURE 2-12

Item	Description
1	Steer Priority Flow Divider Section Relief
2	Steering Load Sense Test Port
3	Swing Inlet Test Port
4	Swing Relief "A" Port
5	Swing Relief "B" Port

**Procedure I - For Checking Swing Valve Work Port Relief Pressure**

1. Remove cap and install pressure gauge on swing valve inlet test port (Figure 2-12).
2. With the swing house lock **Engaged** and the engine running at FULL RPM, swing LEFT and adjust "A" port swing relief to 2500 psi ±50 (17.2 MPa ±0.4).
3. With the swing house lock **Engaged** and the engine running @ FULL RPM, swing RIGHT and adjust "B" port swing relief to 2500 psi ±50 (17.2 MPa ±0.4).
4. Remove pressure gauge from the swing inlet test port and reinstall cap.

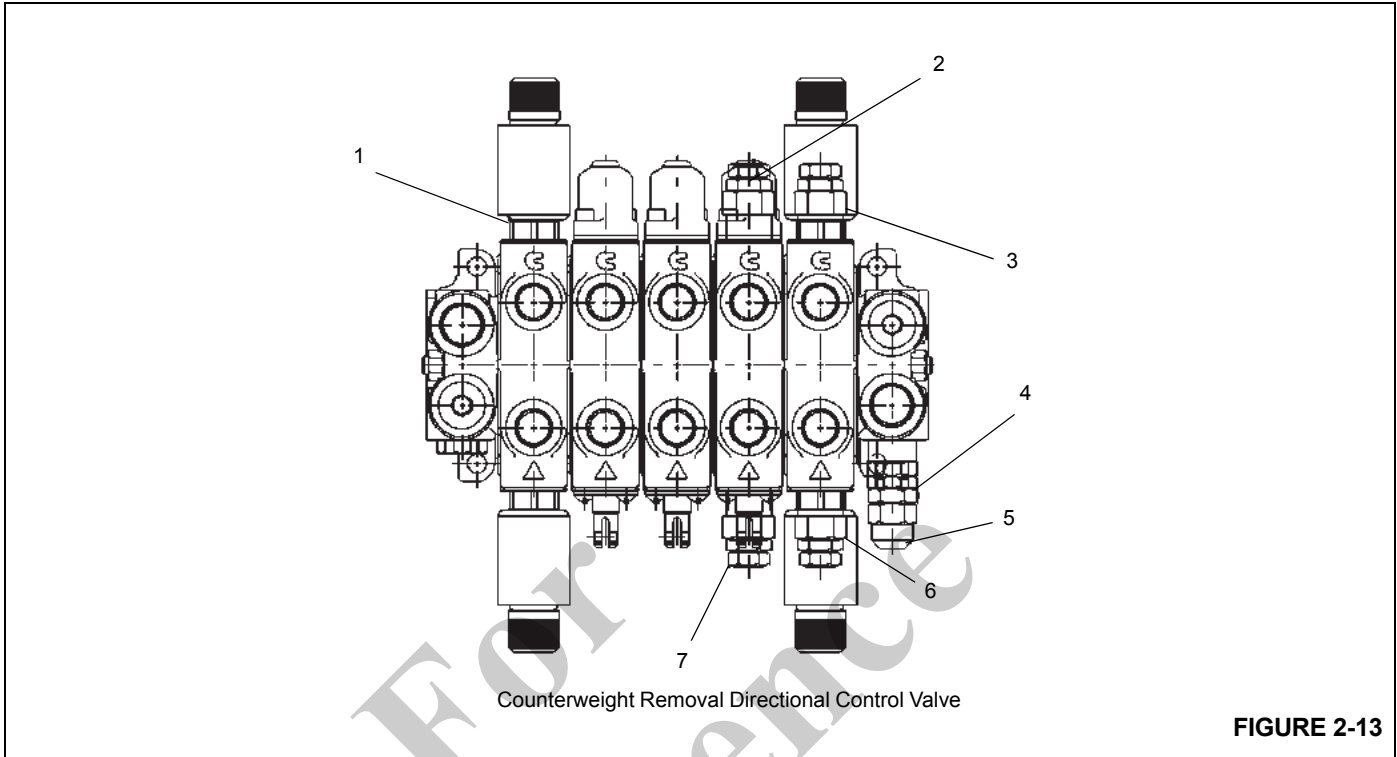
**Procedure J - For Checking Relief Setting for Counterweight Supply Control Valve**

1. Remove cap and install gauge on load sense relief test port on main directional control valve (Figure 2-7).
2. Operate the counterweight directional control valve by fully raising or lowering the counterweight cylinders.

Adjust the counterweight removal directional control valve load sense relief valve to 3800 psi ±50 (26.2 MPa ±0.4).

3. In the cab, press the Luffing Extension Switch to ON and the Luffing Raise/Lower Switch to LOWER in the LH armrest. Adjust the luffing extension "B" port relief valve to 1450 psi ±50 (10.0 MPa ±0.4) (Figure 2-13).
4. In the cab, press the cab Tilt Switch to the RAISE position and adjust the cab tilt "A" port relief valve to 2500 psi ±50 (17.2 MPa ±0.4).
5. In the cab, press the cab Tilt Switch to the LOWER position and adjust the cab tilt "B" port relief valve to 2500 psi ±50 (17.2 MPa ±0.4).
6. Disconnect the couplers for the counterweight pin from the cylinder located at the rear of the turntable. DO NOT PERFORM THIS TEST IF THE COUPLERS ARE CONNECTED TO EITHER THE COUNTERWEIGHT PIN CYLINDER OR THE BOOM PIVOT CYLINDER! Operate the counterweight pin lever to retract. Adjust the counterweight pin "B" port relief to 1600 ± 50 psi (11.0 ± 0.4 MPa).
7. Operate the counterweight pin lever to extend. Adjust the counterweight pin "A" port relief to 2500 psi ±50 (17.2 MPa ±0.4). Connect the couplers to the counterweight pin cylinder.

8. Remove gauge and reconnect plumbing.



Item	Description
1	Luffing Extension Relief "B" Port
2	Counterweight Pin Relief "B" Port
3	Cab Tilt Relief "B" Port

Item	Description
4	LS Relief Valve Adjustment: Turn Screw Clockwise to Increase Pressure
5	Remove Cap
6	Cab Tilt Relief "A" Port
7	Counterweight Pin Relief "A" Port

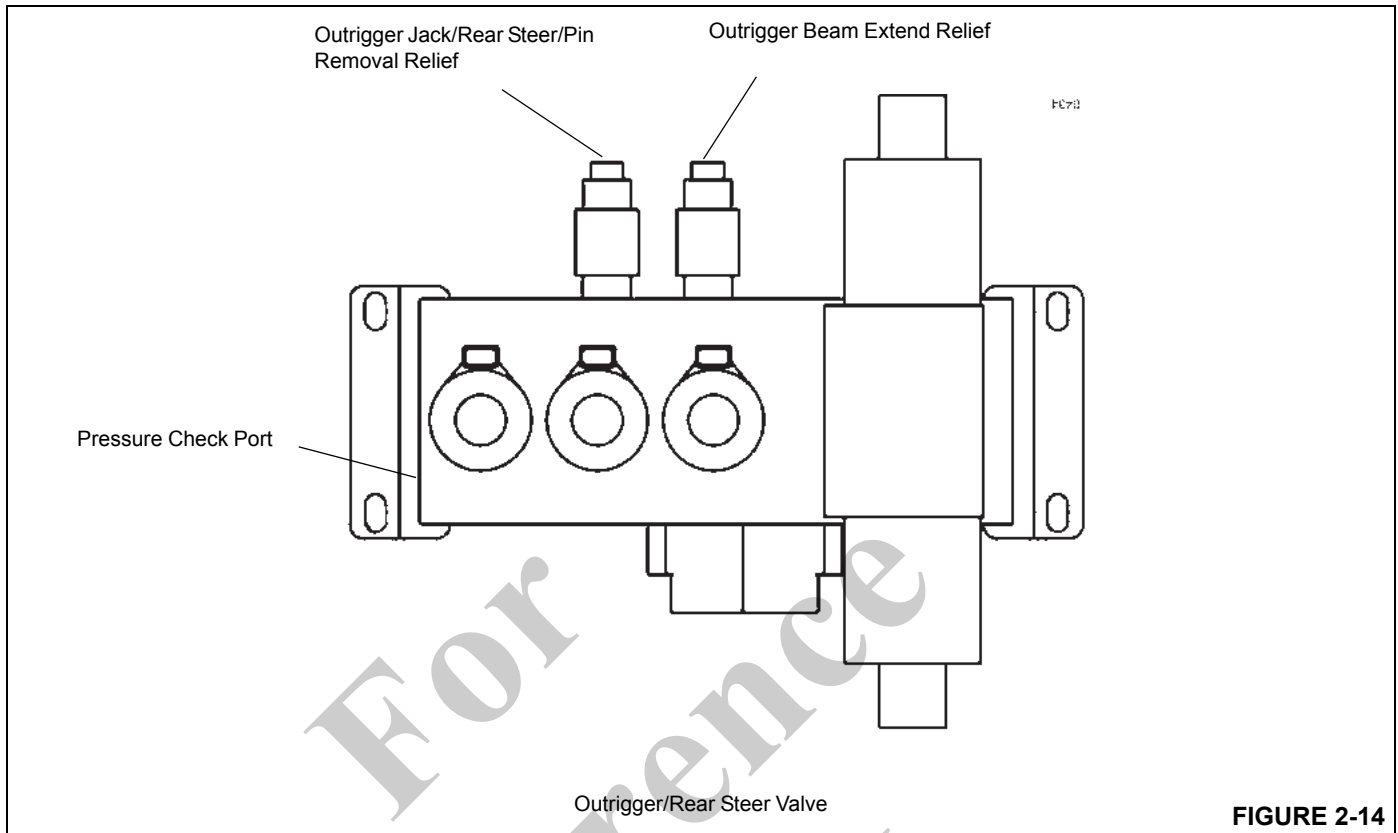


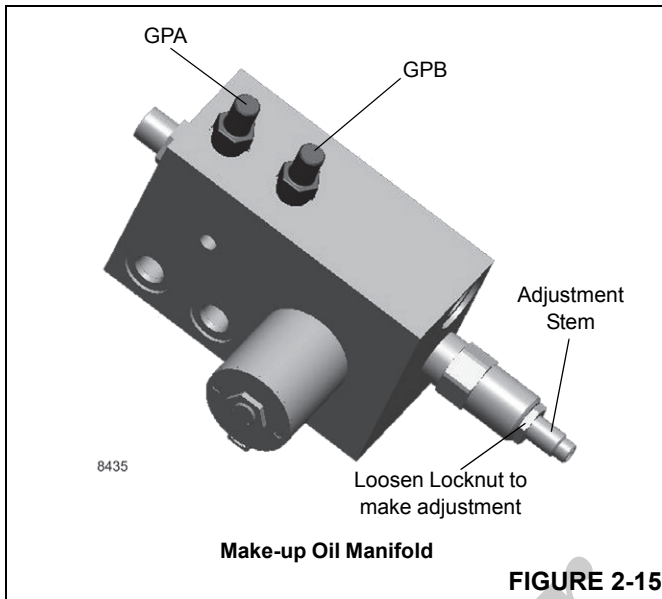
FIGURE 2-14

### Procedure K - For Checking Outrigger/Rear Steer Relief Valve Pressure

1. Remove cap and install pressure gauge (Figure 2-14) on outrigger/rear steer valve pressure check port.
2. With engine running at full RPM, fully extend one outrigger beam. Adjust the sequence relief valve to 2000 psi  $\pm$ 50 (13.8 MPa  $\pm$ 0.4). If adjustment is required, remove socket head plug from end of cartridge. Adjust internal socket head plug in (CW) to increase pressure or out (CCW) to decrease pressure. When complete, reinstall socket head plug into end of cartridge.
3. With the engine running at full RPM, fully extend one outrigger jack cylinder. Adjust the outrigger jack/ rear steer/ pin removal relief valve to 3500 psi  $\pm$ 50 (24.2 MPa  $\pm$ 0.4). If adjustment is required, loosen locknut and use 1/4 inch Allen wrench to turn adjustment screw in (CW) to increase pressure or out (CCW) to decrease pressure. When complete, tighten locknut.
4. Remove pressure gauge from outrigger/rear steer valve and reinstall cap.

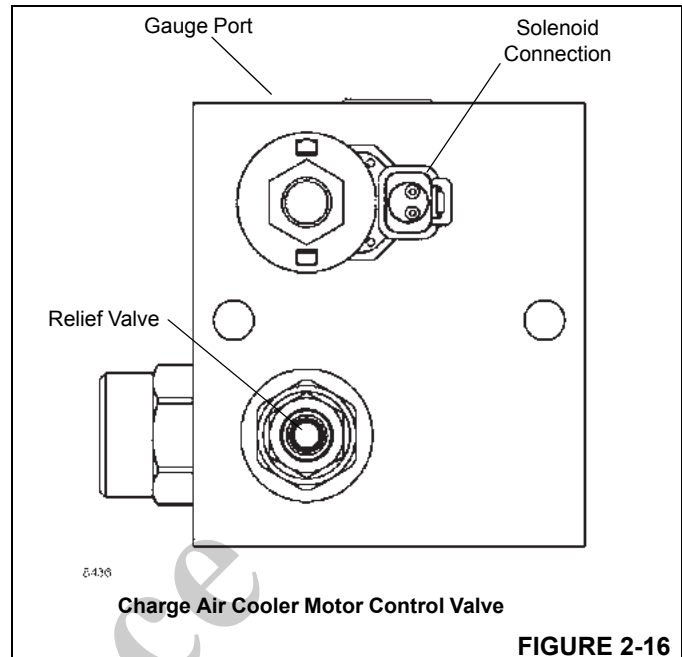
### Procedure L - For Checking/Setting the Make-up Oil Manifold (Thermal Contraction)

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ GPA or GPB on the make-up oil manifold (Figure 2-15).
2. Boom lift up to achieve a boom angle greater than 35° (Boom Telescope cylinder must be fully retracted).
3. With the engine at idle RPM, check to ensure pressure is 200 psi. If the pressure is low, adjust the pressure reducing valve adjusting stem clockwise (in). If pressure is higher than specification, adjust the adjustment stem counterclockwise (out).
4. Once pressure is set move pressure gauge to the other (GPA or GPB) diagnostic coupler on the make-up oil manifold check to ensure the pressure reads the same as set in step #3.
5. Stop engine and remove quick disconnect.



### Procedure M - For Checking Charge Air Cooler Circuit Relief Valve Pressure (Tier 3 Only)

1. Install a pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ the Charge Air Cooler Motor Control Valve (Figure 2-16).
2. With engine at full RPM, unplug harness connection on control solenoid to turn cooler on. Adjust relief valve to obtain a reading of  $1700 \pm 50$  PSI ( $11.7 \pm 0.4$  MPa). Turn in to raise, out to lower.
3. Stop engine. Remove the diagnostic coupler. Re-connect wires to solenoid.



### Checking Charge Air Cooler (CAC) Motor Control Valve – Tier 3 Only

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at Charge Air Cooler Motor Control Valve.
2. With engine at full RPM, unplug harness connection on control solenoid to turn cooler on. Adjust relief valve to obtain a reading of  $1700 \pm 50$  psi ( $11.7 \pm 0.4$  MPa). Turn in to raise, out to lower.
3. Remove pressure gauge and plug harness connection back into control solenoid.



**VALVES**

**General**

This subsection provides descriptive information for hydraulic valves used on this crane. For a listing of valves, the circuit they are used in, and their physical location, refer

to Table 2-4. Refer to Figure 2-17 for location of valves installed on the superstructure and carrier frame.

The description of each valve given here is for the valve itself. For information on how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

**Table 2-4  
Valve Usage Table**

Valve Name	Circuit Used In	Physical Location
Directional Control Valves	Boom Lift/Telescope(s)/Hoist(s) Front Steer Pressure/Swing Counterweight Removal/Cab Tilt	Superstructure (Right Side) Superstructure (Right Side) Between Superstructure Side Plates
Swing Series Parallel Selector Valve	Swing	Superstructure Right Side
Pressure Reducing Sequence Valve with Solenoid Controls Manifold	HRC Pilot Pressure Swing Brake Release Hose Reel Motor Hose Reel Brake	Superstructure Right Side
Steering Control Unit	Front Axle Steer	Cab Steering Column
Hydraulic Remote Controllers (HRC)	Boom Lift Telescope (Floor) Main Hoist Auxiliary Hoist Swing	Cab Seat Arm Rests (2)
Swing Power Brake Valve	Swing	Cab Floor
Double PO Check Valve	Cab Tilt	Superstructure Left Side
Tandem Brake Valve with Treadle	Service Brakes	Cab Floor
Dual Accumulator Charging Valve	Service Brakes	Superstructure inside Left Side Plate
Accumulator(s)	Service Brake	Superstructure Left Side
Accumulator	Main Crane Function Load Sense	Superstructure Right Side
Holding Valves	Boom Lift Telescope (3) Counterweight Removal (4)	Lift Cylinder (Bolt on Manifold) Cylinder Port Blocks (Cartridge style) Cylinder Port Blocks (Cartridge style)
Shuttle Valve	Telescope	Superstructure Right Side

Valve Name	Circuit Used In	Physical Location
Solenoid Valves: Oil Cooler Motor	Oil Cooler	In-line on the Hydraulic Return Manifold
Telescope Rod Drain	Telescope	Superstructure Right Side
Outrigger Boost	Outrigger	In-line on the Hydraulic Reservoir
Parking Brake	Parking Brake	Carrier Inside Right Side Rail
Axle Disconnect	Two/Four Wheel Drive	Carrier Inside Right Side Rail
Telescope Two Stage Relief	Telescope	Superstructure Right Side
Cross Axle Differential Lock	Differential Lock (Optional)	Carrier Inside Right Side Rail
Hoist Motor Control Valve	Hoist(s)	Both Hoists (see Hoist section)
	Return Circuit	One on Swing Outlet
Check Valves	Return Circuit	One in Parallel with Oil Cooler
	Outrigger Boost	One between Pump Two and Pump Three (Outrigger Boost)
	Counterweight Removal/Cab Tile	In-line in Load Sense Line
Outrigger/Rear Steer/Outrigger Box Pin Removal Valve	Outrigger/Rear Steer	On Rear Face of Carrier Frame Front Cross Member
Outrigger Control Manifold	Outrigger	Inside of Front & Rear Outrigger Box
Pilot Operated Check Valve	Outrigger	Port Block of each Stabilizer Cylinder (4)
Pressure Bleed-Off Valve	Telescope	Superstructure Right Side
	Outrigger	Right Rear Carrier Fender
Axle Lockout Valve	Rear Axle Lockout	Carrier Left Side Rail
Hose Reel Motor Relief Valve	Telescope Hose Reel	In-Line at the Hose Reel

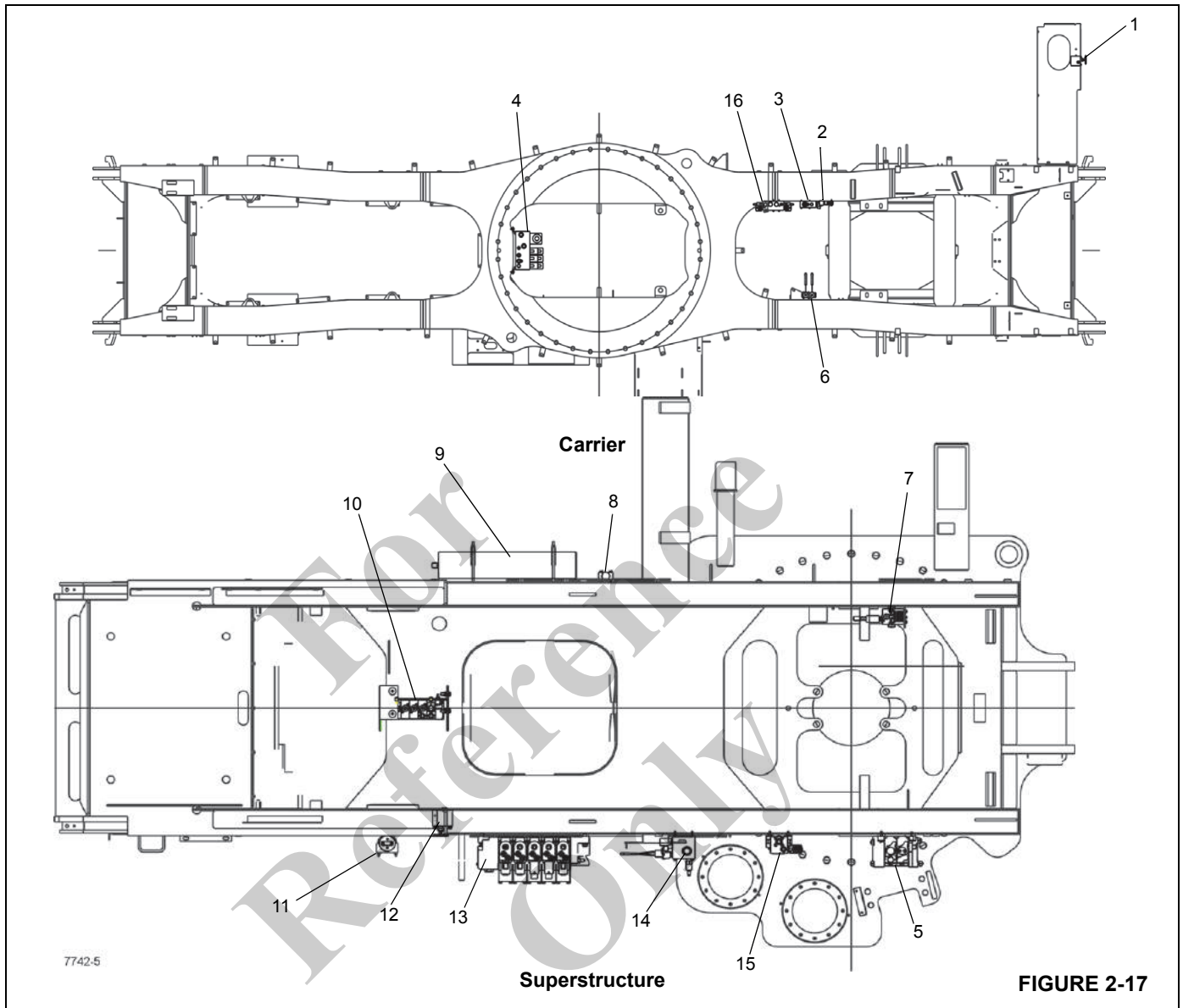


FIGURE 2-17

Item	Description
1	Manual Bleed Off Pressure Valve
2	Park Brake Valve
3	Axle Disconnect Valve
4	Integrated Outrigger/Rear Steer Valve
5	Swing/Steer Directional Control Valve
6	Axle Lockout Valve
7	Dual Accumulator Charge Valve
8	Pilot Operated Check Valve
9	Accumulators

Item	Description
9	Accumulators
10	Directional Control Valve (Counterweight Removal/Cab Tilt)
11	Accumulator
12	Manual Bleed Off Valve
13	Main Directional Control Valve (Telescope/Lift/Hoist)
14	Pressure Reducing/Sequence Valve
15	Series/Parallel Selector Valve
16	Dual Fan Valve

## DIRECTIONAL CONTROL VALVES

### Description

#### General

The directional control valves direct and control hydraulic oil flow from the pumps to the boom lift and telescope cylinders, each hoist motor, each swing motor, the counterweight removal/cab tilt cylinders, and the front steer cylinders via the steer control valve. The swing and front steer directional control valve and the boom lift/telescope hoist directional control valve are located on the outside of the right superstructure side plate. The counterweight removal/cab tilt directional control valve is located between the left and right superstructure side plates forward of the hose reel. Each valve bank is removed and installed as an assembly.

#### Main Directional Valve (Hoist/Telescope/Lift)

The boom lift/telescope/hoist directional control valves Figure 2-19 are sectional, hydraulic remote pilot actuated three position four way, pressure compensated, closed center directional valves. The inlet section contains a pump unloading valve and load sense relief valve set at 4800 psi (3310 kPa) protecting the main and auxiliary hoist sections. The unloading valve has a 200 psi (1379 kPa) standby or pump margin pressure setting. The telescope inner mid section has port relief's set a 3000 psi (2068 kPa) for extend and 3500 psi (2413 kPa) for retract. The center mid/outer mid telescope section has a two-stage port relief. When unpressurized it is set for center mid cylinder extend at 2500 psi (1724 kPa). When pressurized it is set for the outer mid cylinder at 3000 psi (2068 kPa). The retract port relief for both the center and outer mid sections is set at 3500 psi (2413 kPa). All working sections have a two position three way solenoid LMI lockout valve in each pilot end cap. Both telescope cylinder's solenoid valves are proportionally controlled by the LMI system.

#### Swing and Front Steer Directional Valve

The swing section of the swing and front steer valve Figure 2-18 is a sectional, hydraulic remote pilot actuated three position four way open center directional control valve. Both working ports have 2500 psi (1724 kPa) port relief valves and anti void check valves to provide make-up oil to the swing motors when the valve is centered. The steer section is a load sense priority type flow control valve. On a load sense signal from the cab steering control valve the spool shifts directing 18.5 gpm (4.9 lpm) to the cab steering control unit. The load sense port maintains a constant 125 psi (862 kPa) standby pressure. Any excess flow is directed

upstream to the swing section. The circuit is protected by a 2500 psi (1724 kPa) load sense relief valve.

#### Counterweight Removal/Cab Tilt Directional Control Valve

The counterweight removal/cab tilt directional control valve is a sectional, hydraulic remote pilot actuated three position four way, pressure compensated, closed center directional valve. It is plumbed in parallel with the boom lift/telescope/hoist directional control valve. The inlet section contains a load sense relief valve set at 2500 psi (1724 kPa) protecting all four working sections.

### Maintenance

#### Hoist/Lift/Telescope Directional Valve Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Remove the capscrews, flatwashers, and lockwashers securing the valve. Remove the valve.

#### Hoist/Lift/Telescope Directional Valve Installation

1. Place the valve on the turntable upright and fasten it with the capscrews, flatwashers and lockwashers.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valve as tagged during removal.

#### Swing/Steer Directional Valve Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Remove the capscrews, flatwashers and lockwashers securing the valve. Remove the valve bank.

#### Swing/Steer Directional Valve Installation

1. Place the valve on the turntable upright and secure it with the capscrews, flatwashers and lockwashers.
2. Connect the hydraulic lines to the valves as tagged during removal.

#### Counterweight Removal/Cab Tilt Directional Valve Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Remove the capscrews, flatwashers, nuts and lockwashers securing the valve. Remove the valve bank.

**Counterweight Removal/Cab Tilt Directional Valve Installation**

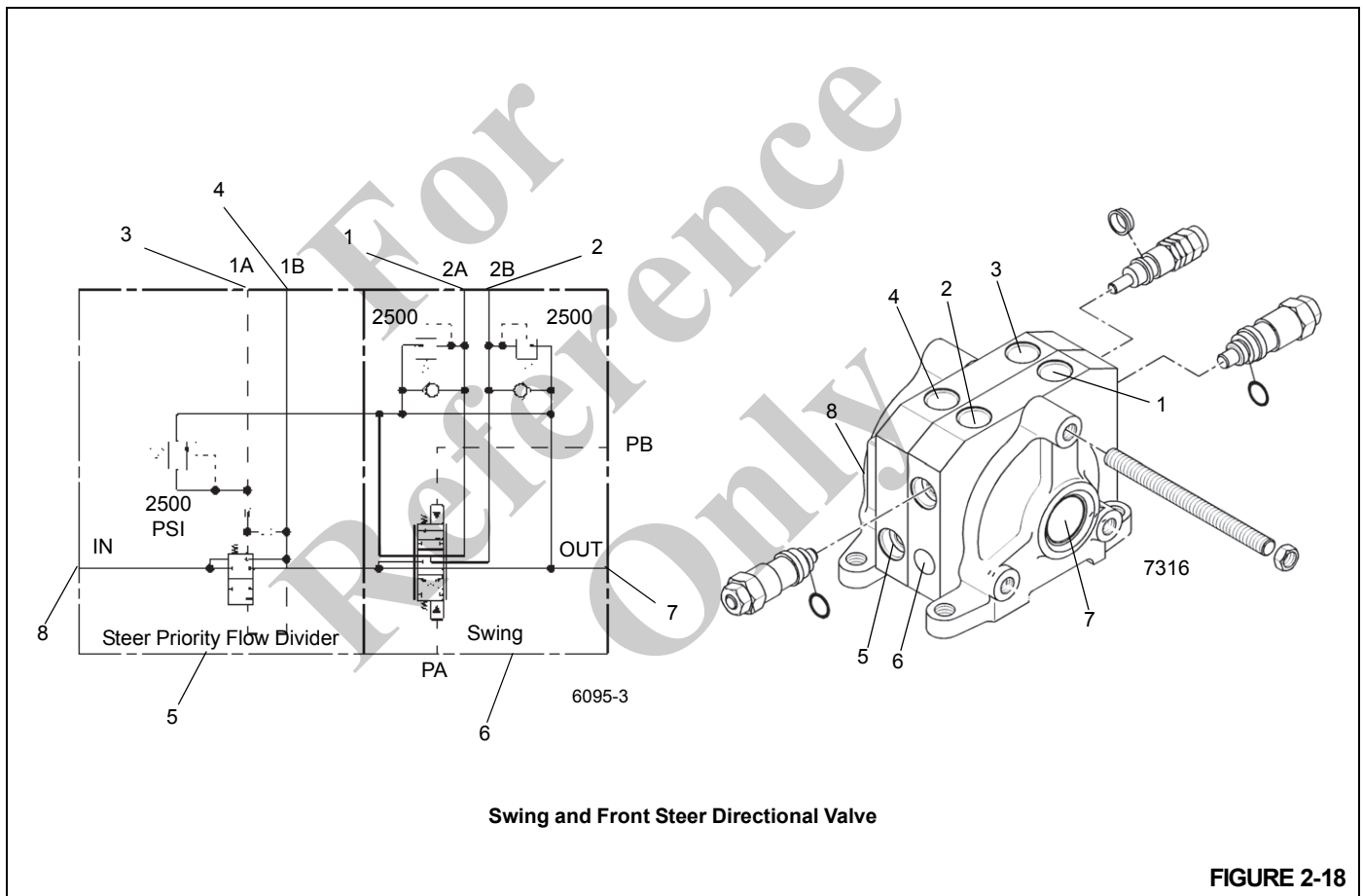
1. Place the valve on the turntable and secure it with the capscrews, flatwashers, nuts and lockwashers.
2. Connect the hydraulic lines to the valves as tagged during removal.

**Functional Check (Both Valve Banks)**

1. Start the engine and run it at normal speed.
2. Operate the control levers of the valve bank(s). Check for smooth operation of cylinders and motors.
3. Check the valve bank(s) and lines for leakage. Make repairs as needed.

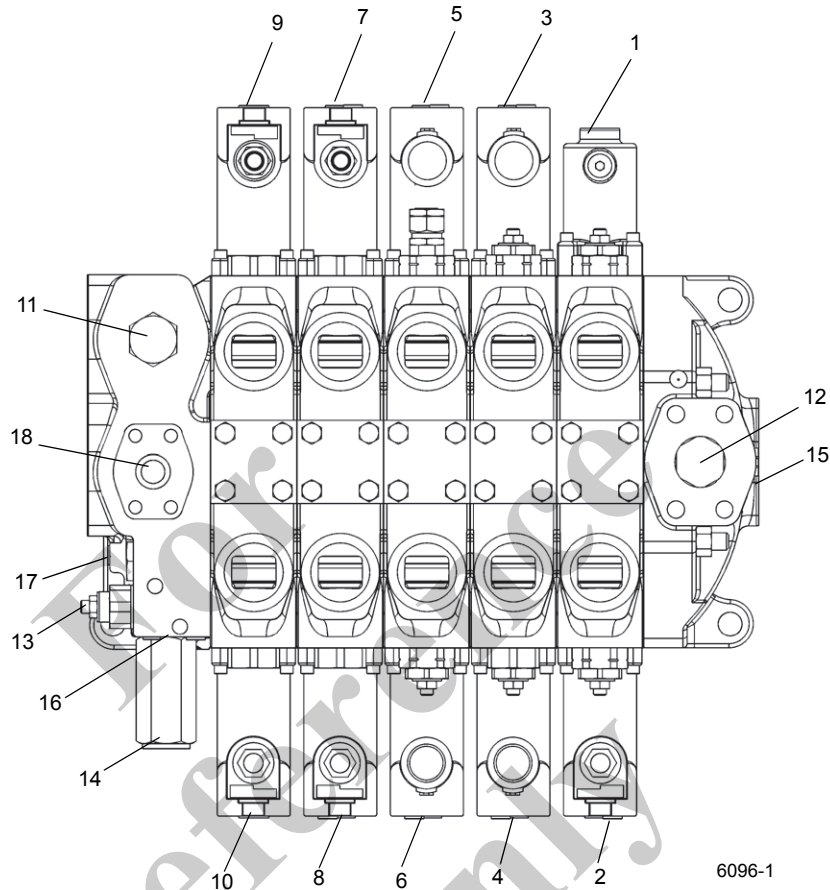
**Function Check - LMI Lockout Valves**

1. Remove circuit breaker F16 from the power panel in the cab. This cuts off power to the LMI.
2. Start the engine.
3. Try to telescope the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify none of these functions work.
4. Shut down the engine. Reinstall F16.
5. Telescope the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify all of these functions work.
6. Check for leaks. Make repairs as needed.



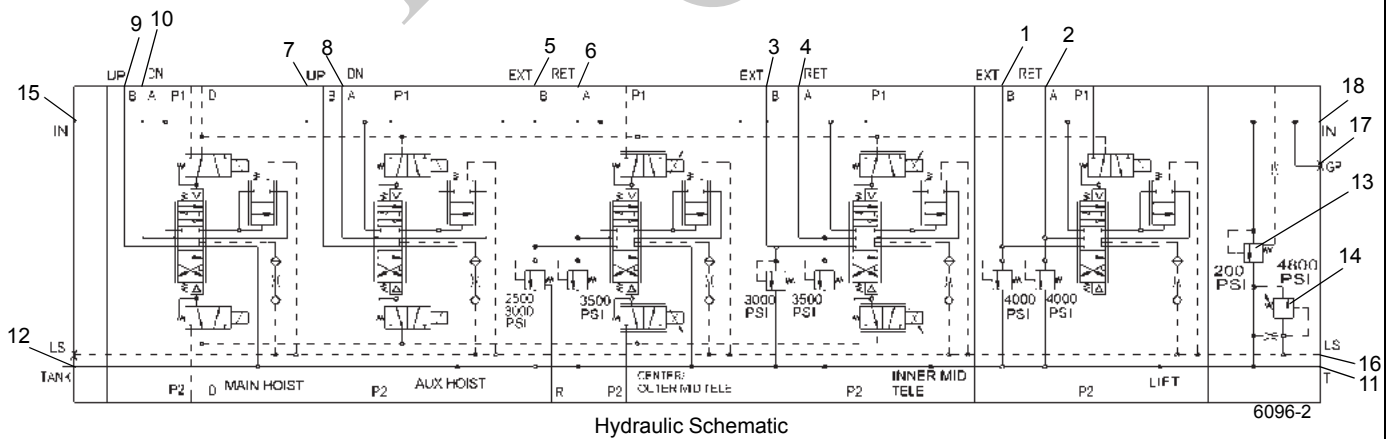
Item	Description
1	Port 2A - Swing Right
2	Port 2B - Swing Left
3	Port 1A Load Sense Flow Control (Standby Pressure)
4	Port 1B - Priority Flow

Item	Description
5	Steer Priority Flow Divider Section
6	Swing Section
7	Outlet Port
8	In Port



6096-1

Hoist/Telescope/Lift Directional Valve



6096-2

Hydraulic Schematic

FIGURE 2-19

Item	Description
1	Port B - Lift Extend Relief
2	Port A - Lift Retract Relief
3	Port B - Inner Mid Telescope Extend
4	Port A - Inner Mid Telescope Retract
5	Port B - Center/Outer Mid Telescope Extend
6	Port B - Center/Outer Mid Telescope Retract
7	Port B - Auxiliary Hoist Up
8	Port A - Auxiliary Hoist Down
9	Port B - Main Hoist Up

Item	Description
10	Port A - Main Hoist Down
11	Outlet Port - Tank
12	Outlet Port - Tank
13	Adjustable Relief Valve
14	Unloading Valve
15	Inlet
16	Load Sense Port
17	Gauge Port
18	Inlet

For  
Reference  
Only

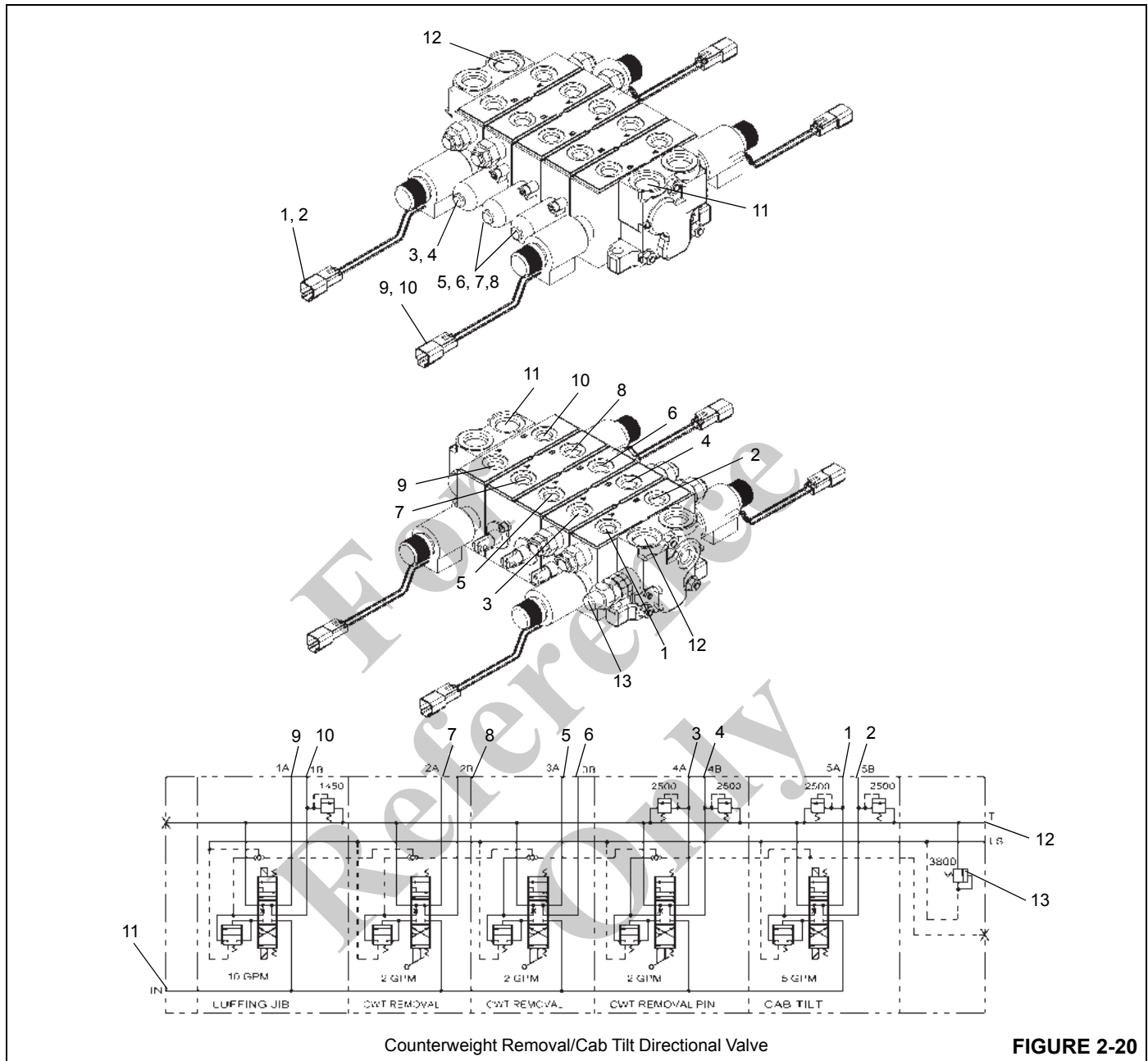


FIGURE 2-20

Item	Description
1	Port 5A - Cab Tilt
2	Port 5B - Cab Tilt
3	Port 4A - Counterweight Removal Pin
4	Port 4B - Counterweight Removal Pin
5	Port 3A - Counterweight Removal Right Cyl.
6	Port 3B - Counterweight Removal Right Cyl.
7	Port 2A - Counterweight Removal Left Cyl.

Item	Description
8	Port 2B - Counterweight Removal Left Cyl.
9	Port 1A - Luffing Jib
10	Port 1B - Luffing Jib
11	Inlet
12	Outlet
13	Load Sense Relief



## SWING SERIES PARALLEL SELECTOR VALVE

### Description

The series parallel selector valve Figure 2-21 is used to select the swing motor speed. It is located on the outside of the turntable right hand side plate. It consists of a pilot operated two-position four-way valve (1) and a solenoid actuated two position three-way valve (2) Figure 2-21 that is the pilot valve. It is plumbed between the swing directional control valve and the swing motors.

Swing speed is selected by the swing speed control switch on the left-side of the console. In the de-energized position or LOW SPEED switch position, the pilot operated two-position three way solenoid vents the pilot operated four-way valve to the tank leaving its spring return spool position connecting the swing motors in parallel or low speed mode. In the HIGH SPEED position, the pilot operated two-position three-way solenoid valve is actuated and shifts the spool of the operated two-position four-way valve which connects the swing motors in series or high speed mode. The port reliefs of the swing directional control valve are set to allow a full load swing in both modes.

The 250 psi (1724 kPa) pilot pressure source is supplied via the pressure reducing sequence with solenoid controls manifold valve.

### Maintenance

#### Removal

1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the two retaining screws securing the valve to the turntable side plate.
4. Remove valve.

#### Installation

1. Secure the valve to the crane using the two retaining screws.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Verify proper operation of the valve. Refer to the Operator's Manual
5. Check valve and hydraulic connections for leaks. Make repairs as needed.

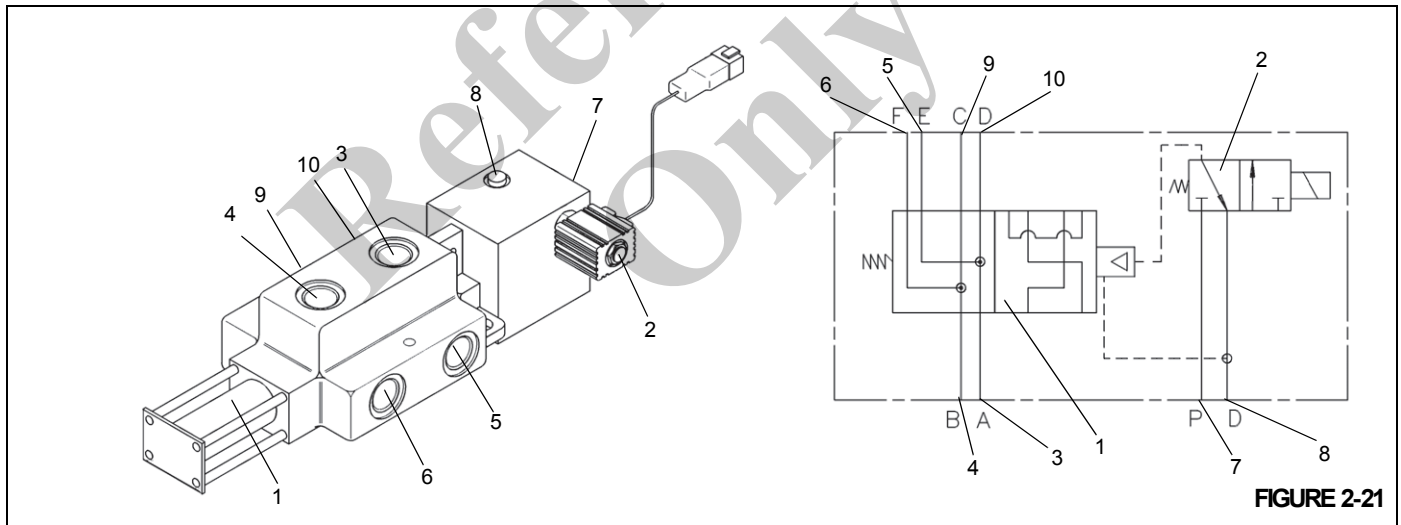


FIGURE 2-21

Item	Description
1	Pilot Operated Two-Position Four-Way Valve
2	Solenoid Actuated Two-Position Three-Way Valve
3	Port "A" From Swing/Steer Directional Valve
4	Port "B" From Swing/Steer Directional Valve
5	Port "E" To Swing Motor

Item	Description
6	Port "F" To Swing Motor
7	Pilot Port
8	Drain Port
9	Port "C" To Swing Motor
10	Port "D" To Swing Motor

## PRESSURE REDUCING SEQUENCE VALVE WITH SOLENOID CONTROLS MANIFOLD

### Description

The pressure reducing sequence with solenoid controls manifold Figure 2-22 is located on the outside of the superstructure right hand side plate. It is used to control a regulated pressure and flow of hydraulic oil to the swing brake 250 psi (1723.6 kPa), cab hydraulic remote controllers (HRCs), telescope two stage relief 400 psi (2757.9 kPa), telescope hose reel motor 1200 psi (8273.7 kPa) and hose reel brake 1200 psi (8273.7 kPa). An inlet port contains a 100 mesh screen to prevent large contaminants from damaging the cab hydraulic remote controllers (HRCs).

The swing brake, HRCs, and hose reel motor are controlled by a two position three way normally open to tank solenoid valve. When energized, pressurized oil is allowed to flow to the respective functions.

The two position three way swing brake release solenoid valve serves as the swing brake release. When de-energized and the Swing Brake switch is ON, the springs in the swing brake push oil to the tank allowing each brake to engage. When the Swing Brake switch is OFF, pressurized oil is directed to the swing brakes, releasing them.

The HRC two position three way solenoid valve serves as the controller armrest lockout valve. When the Crane Function switch is OFF, or the armrest is raised, the valve is de-energized which prevents pressurized oil from reaching the HRC's. When the Crane Function switch is ON, pressurized oil is directed to the HRC's allowing crane operation. This valve, when de-energized, prevents accidental turntable, hoist, or boom movement.

### Maintenance

#### Removal

1. Tag and disconnect the electrical connectors to the swing brake and armrest lockout valve.
2. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, lockwashers and flatwashers securing the valve. Remove the valve and two spacer bushings.

#### Installation

1. Position the valve and spacer bushings on the turntable and secure it with the capscrews, flatwashers and lockwashers.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.

### Swing Brake Release Valve-Function Check

1. Position the Swing Brake switch to OFF. Verify the LED in the switch goes out.
2. Swing the turntable to verify the swing brake has released. Step on the swing brake pedal to stop the turntable.
3. Position the Swing Brake switch to ON. Verify the LED in the switch comes on.
4. Activate swing and ensure the turntable will not rotate, indicating the swing brake is on.
5. Check for leaks. Make repairs as needed.

### Crane Function Valve-Function Check

1. Position the Crane Function switch to OFF.
2. Start the engine.
3. Try to telescope the boom in and out, lower and raise the boom, hoist each hoist up and down, and swing the turntable left and right. Verify none of these functions work.
4. Position the Crane Function switch to ON, put the armrest down, and sit in the seat.
5. Telescope the boom in and out, lower and raise the boom, operate each hoist up and down, and swing the turntable left and right. Verify all of these functions work.
6. Check for leaks. Make repairs as needed.

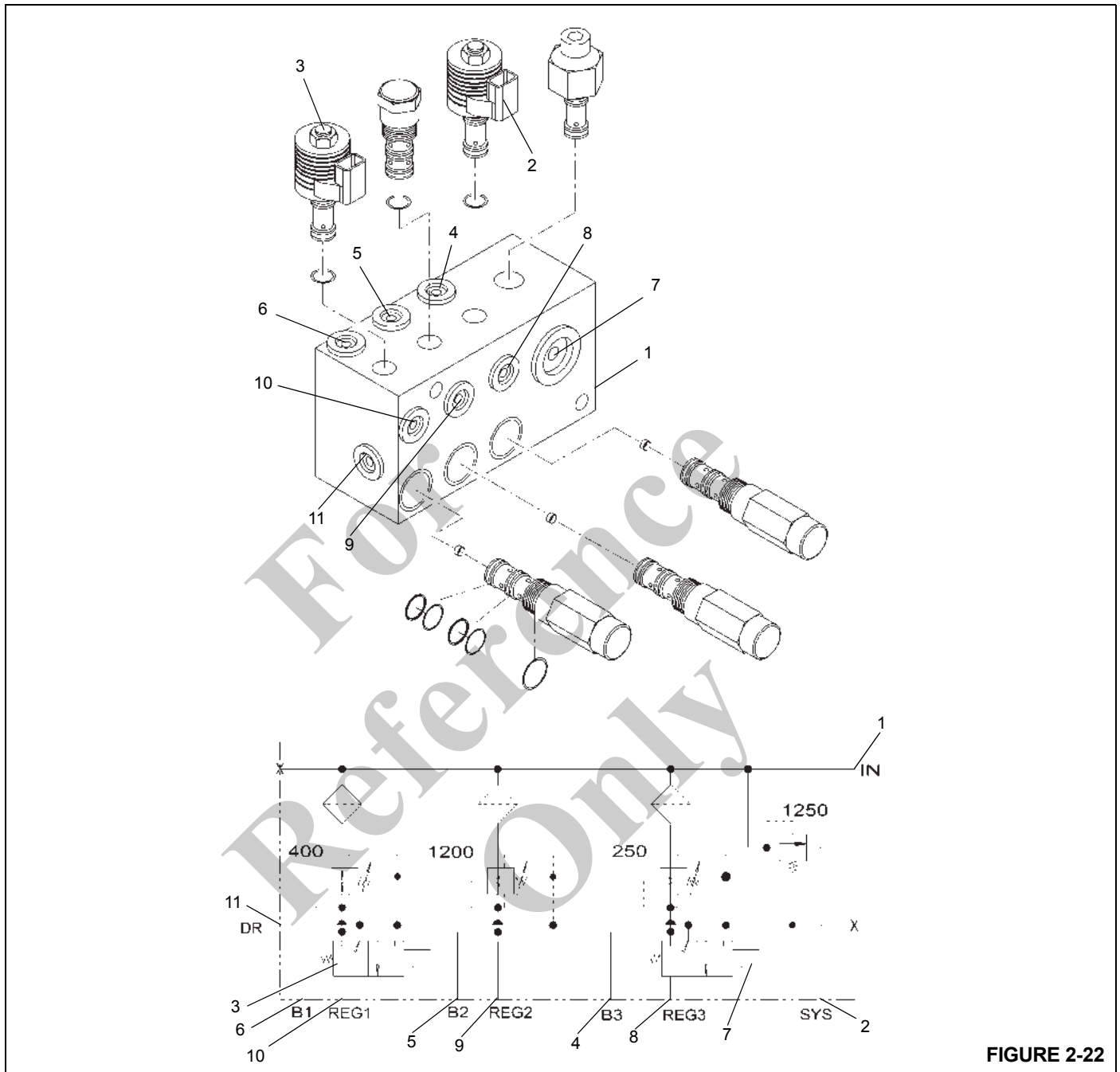


FIGURE 2-22

Item	Description
1	IN Port (Not Shown) From Swivel Port 6
2	Two-Position Three-Way Solenoid Valve - Swing Brake Release
3	Two-Position Three-Way Solenoid - Armrest Lockout Valve
4	Port B3 - Power Brake Valve
5	Port B2 - Hose Reel Motor

Item	Description
6	Port B1 - Telescope Solenoid - Outer Mid
7	System Port
8	Port REG 3 - Swing Brake Release
9	Port REG 2 - Hose Reel Brake
10	Port REG 1 - Telescope Foot Pedal
11	Drain Port

**STEERING CONTROL VALVE-DUAL DISPLACEMENT**

**Description**

The dual displacement load sense steering control unit Figure 2-24 controls hydraulic flow to the front steering circuit. It is located in the steering column of the cab. Both work ports are connected to the rod side of one steer cylinder and to the piston side of the other. The dual displacement control unit; one at 35.9 in<sup>3</sup>/rev and the other at 57.5 in<sup>3</sup>/rev. allows flow amplification (larger displacement) to the steer cylinders when turning the steering wheel at medium to fast speeds.

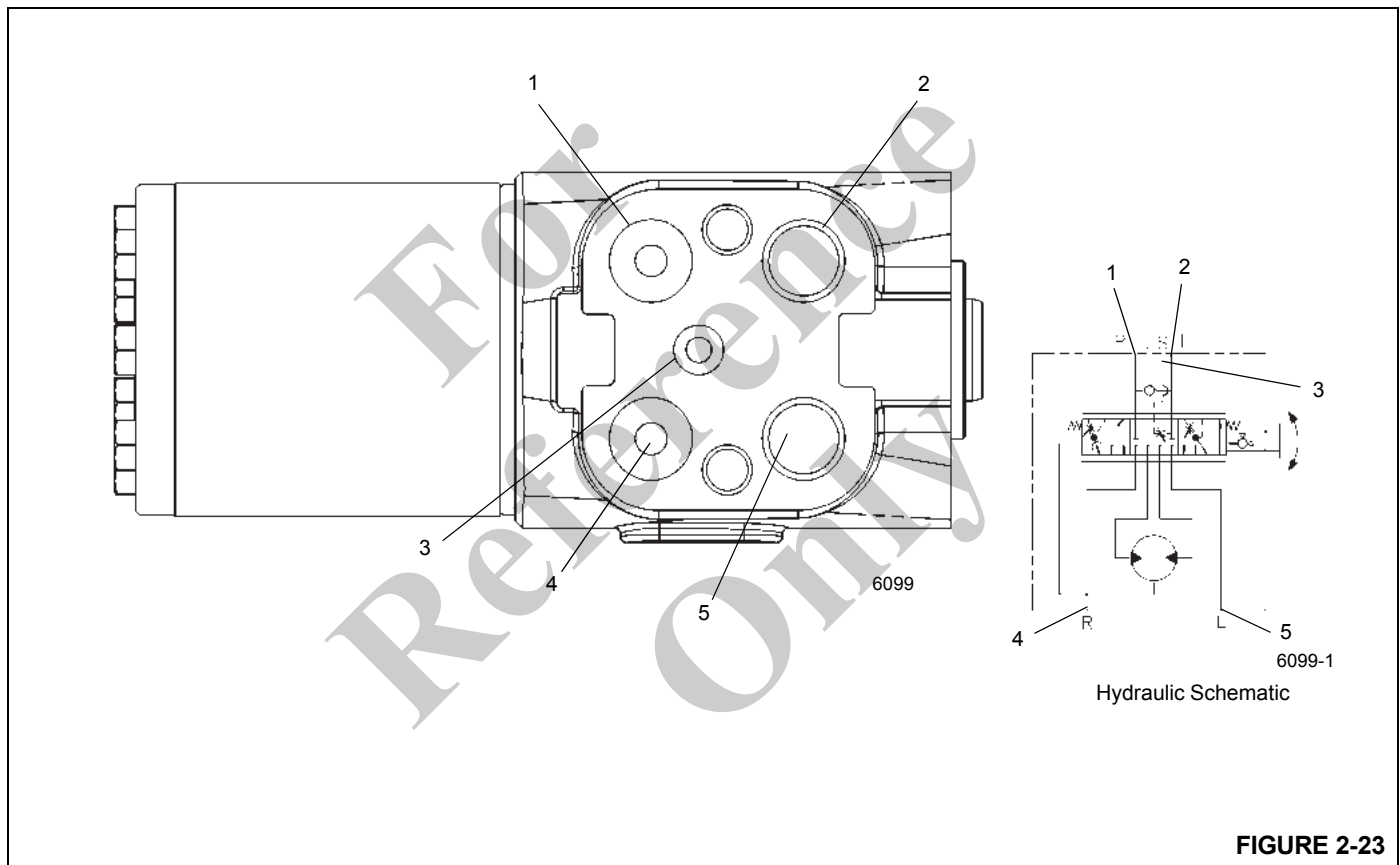
**Maintenance**

**Removal**

1. Tag and disconnect the hydraulic lines to the valve.
2. Remove the bolts and washers securing the valve and remove the valve.

**Installation**

1. Install the valve and secure in place with the bolts and washers.
2. Connect the hydraulic lines to the valve.



Item	Description
1	Pressure Port
2	Tank Port
3	Load Sense Port

Item	Description
4	Steer Right port
5	Steer Left Port

## DUAL MOTOR CONTROL VALVE

### Description

The dual motor control valve Figure 2-24 controls hydraulic flow to the hydraulic oil cooler fan and the cold air charge (CAC) fan. It is located inside the frame behind the right side of the turntable in front of the axle disconnect and park valve. One work port is connected to the hydraulically operated oil cooler fan motor. The other work port is connected to the hydraulically operated CAC fan motor. The solenoid valves open to allow oil flow to each circuit when the engine is running. Each circuit has a relief valve to limit pressure and an orifice to limit oil flow. The valve also has two test fittings to aid in setting the pressure of the relief valves.

### Maintenance

#### Removal

1. Tag and disconnect the hydraulic lines to the valve.
2. Tag and disconnect the electrical connectors to the valve.
3. Remove the bolts and washers securing the valve and remove the valve.

#### Installation

1. Install the valve and secure in place with the bolts and washers.
2. Connect the electrical connectors to the valve.
3. Connect the hydraulic lines to the valve.

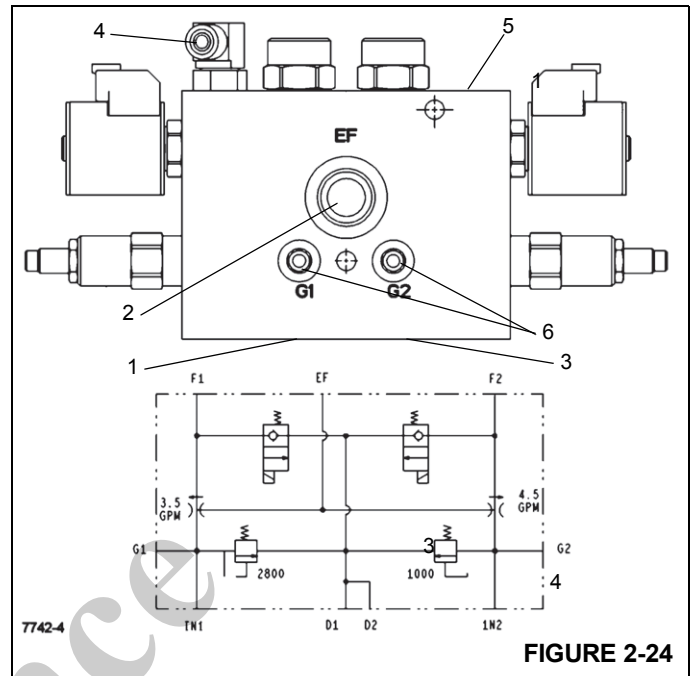


FIGURE 2-24

Item	Description
1	Pressure Port from Pump 4
2	Tank Port
3	Pressure Port from Pump 2
4	Oil Cooler Fan Port
5	CAC Fan Port
6	Test Fittings

## HYDRAULIC REMOTE CONTROL VALVE

### Single Axis Control Valves

The crane has four single axis hydraulic remote control valves Figure 2-25. Each crane function has a control lever for the operator's use.

The four hydraulic remote control valves are single function type valves. Moving the control lever forward or back operates the selected function. Two valves are located in each armrest. The valves in the right armrest control the main hoist and boom lift. The valves in the left armrest control swing and telescope or optional auxiliary hoist.

If equipped with optional auxiliary hoist, the telescope function is controlled by a pedal operated single function control valve. The pedal is on the cab floor. The control valve is mounted on the left rear underside of the cab and is connected to the pedal by linkage.

When the armrests are up, the crane function switch is off, if the operator leaves the seat, the controller lockout valve is de-energized and the functions are disabled.

### Dual Axis Control Valves (Optional)

The two hydraulic remote control valves are dual function type valves. Moving the control lever forward or back operates the selected function, moving the lever side to side operates another function. One valve is located in each armrest. The valve in the right armrest controls the main hoist and boom lift.

If the crane doesn't have an auxiliary hoist, the valve in the left armrest controls swing and boom telescope.

If the crane has an auxiliary hoist, the valve in the left armrest controls swing and auxiliary hoist. The telescope function is controlled by a pedal operated single function control valve. The pedal is on the cab floor. The control valve is mounted on the left rear underside of the cab and is connected to the pedal by linkage.

When the armrests are up, the crane function switch is off, if the operator leaves the seat, the controller lockout valve is de-energized and the functions are disabled.

## Maintenance

### Armrest Control Valve Removal

1. Gain access to the base of the control valve by raising the armrest and removing the plastic cover screwed onto the bottom of the armrest.
2. Tag and disconnect the hydraulic lines to the control valve. Cap or plug the lines and ports.

3. Remove the bolts securing the control valve to the armrest. Remove the control valve.

### Armrest Control Valve Installation

1. Place the valve on the armrest. Secure the valve to the armrest with the attaching bolts.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Install the plastic cover on the bottom of the armrest. Secure it with screws, washers and nuts.

### Armrest Control Valve Functional Check

1. Start the engine and run it at normal speed.
2. Move each control lever to operate the function controlled by the corresponding control valve. Verify proper operation of the hoist motor, swing motors, lift cylinder, and telescope cylinder.
3. Check valve and lines for leakage. Make repairs as needed.

### Telescope Pedal Control Valve Removal

1. Disconnect the pedal linkage from the control valve by removing the pin and cotter pin.
2. Tag and disconnect the hydraulic lines from the control valve. Cap or plug the lines and ports.
3. Remove the four bolts and washers securing the control valve to the mounting bracket. Remove the valve.

### Telescope Pedal Control Valve Installation

1. Place the valve on the mounting bracket and secure in place with the bolts and washers.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the pedal linkage to the control valve with the pin and cotter pin.

### Telescope Pedal Control Valve Functional Check

1. Start the engine and run it at normal speed.
2. Telescope the boom the fully out and then the fully back in. Verify proper telescoping.
3. Check valve and lines for leakage. Make repairs as needed.

**NOTE:** R.H. and L.H. controllers oriented from seated operator.  
Ports of control lever seen facing aft looking at seat with armrest in up position.

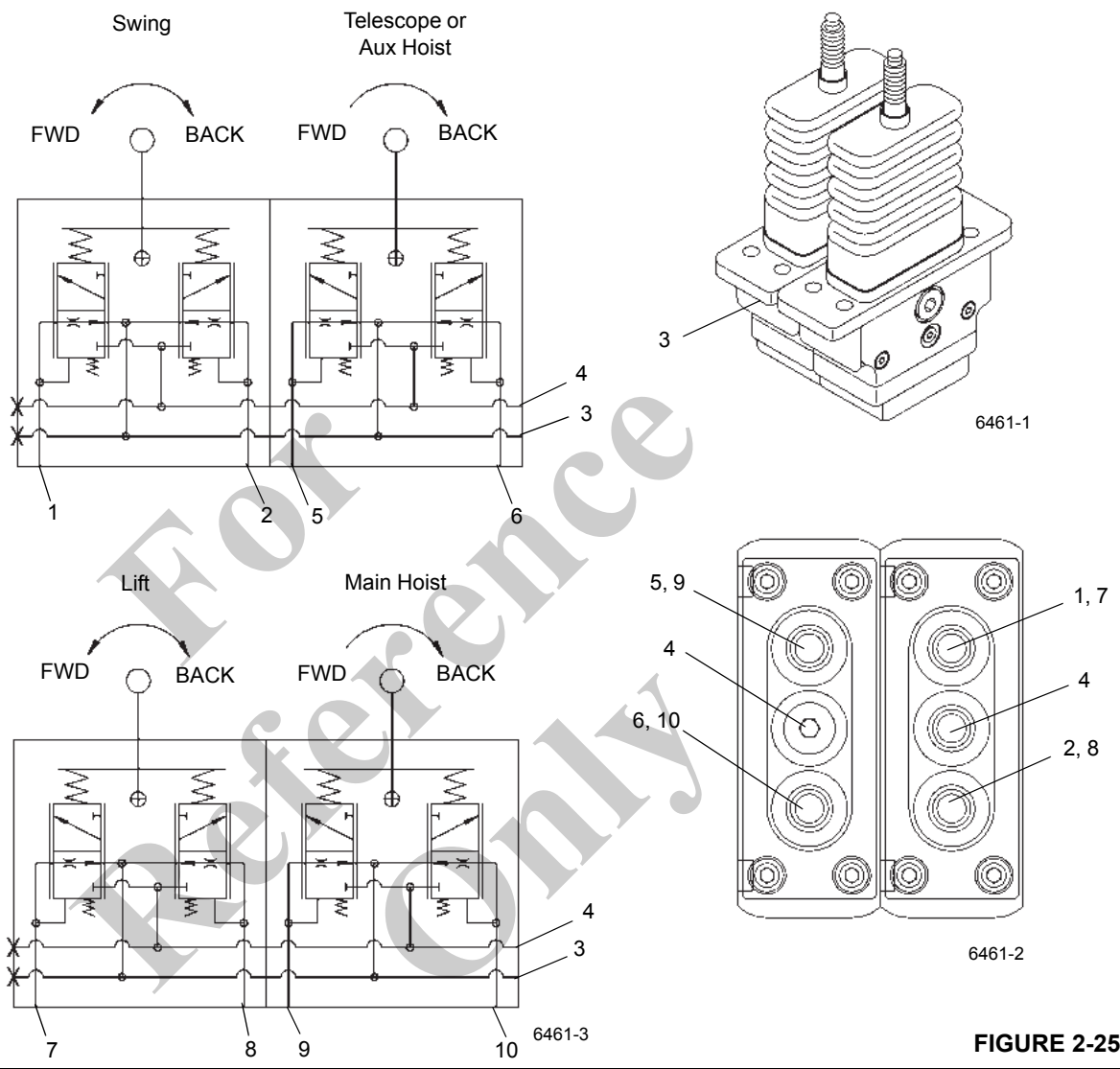


FIGURE 2-25

Item	Description
1	A Port - Swing Right
2	B Port - Swing Left
3	T Port - Tank Port
4	P Port - Pressure Port
5	A Port - Telescope Out or Auxiliary Hoist Down

Item	Description
6	Telescope In or Auxiliary Hoist Up
7	A Port - Lift Down
8	B Port - Lift Up
9	A Port - Main Hoist Down
10	B Port - Main Hoist Up

## SWING POWER BRAKE VALVE

### Description

The swing power brake valve Figure 2-26 is used to provide hydraulic pressure to the piston of the swing brakes to apply the brakes. The valve receives its supply of oil through the swing brake and armrest lockout valve manifold.

Depressing the brake pedal causes hydraulic oil to flow to the top of each brake piston where, combined with spring tension, the total force overcomes each brake's release pressure and applies the brakes. When the valve is released, excess hydraulic oil flows from the valve to the case drain manifold and back to the reservoir.

### Maintenance

#### Removal

1. Tag and disconnect hydraulic lines attached to the brake valve. Cap or plug the lines and ports.
2. Remove the four bolts, lockwashers, flat washers, and nuts which secure the brake valve to the cab floor. Remove the brake valve.

#### Installation

**!** **DANGER**  
**Crushing Hazard!**

Engage the swing lock before installing the swing brake valve.

1. Engage the swing lock.
2. Install the brake valve and secure in place with the four bolts, flat washers, lockwashers, and nuts.
3. Attach the hydraulic lines to the brake valve as tagged during removal.

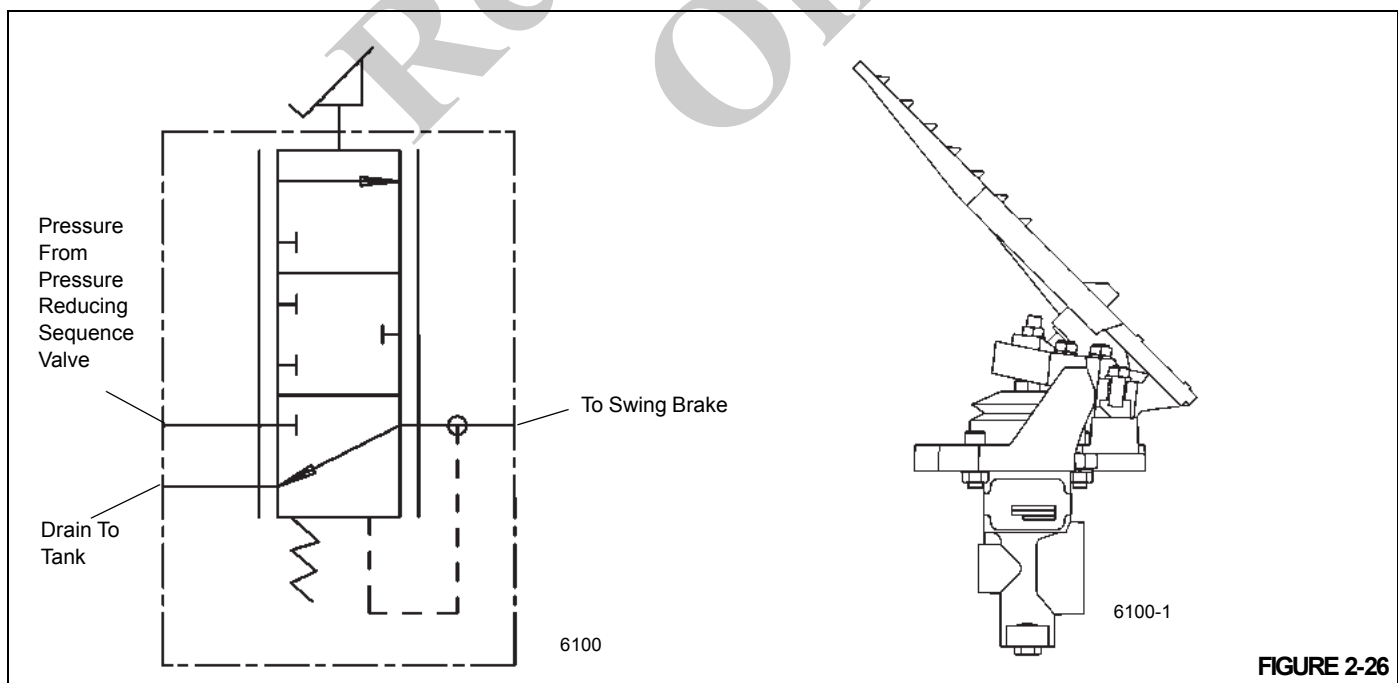
#### Function Check

1. Start the engine and let it idle.
2. Disengage the swing lock.
3. Slowly swing the turntable.

**!** **DANGER**  
**Crushing Hazard!**

Engage the swing lock before adjusting the swing brake valve.

4. Test the valve by engaging the swing brake control valve and operating the swing brake. Verify the swing brake works when the pedal is pressed. Verify the brake is off when the pedal is not pressed. Engage the swing lock and make adjustments to the pedal as needed.
5. Check for leaks. Make repairs as needed.





**DOUBLE PILOT OPERATED CHECK VALVE**

**Description**

The double pilot operated (PO) check valve Figure 2-27 is located on the outside of the left superstructure side plate behind the cab. It is used to hold or lock the cab tilt cylinder in place. Oil flow is directed from the “V” ports to the “C” ports, while blocking flow in the opposite direction. Flow is reversed from “C” to “V” when pressure pilot oil is applied to the opposite side “V” port.

**Maintenance**

**Removal**

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug all openings.
2. Remove the capscrews, flatwashers and lockwashers securing the valve to the turntable and remove the valve.

**Repair**

1. Install new O-rings onto the check valve.
2. Lubricate the check valve and O-rings with clean hydraulic oil.

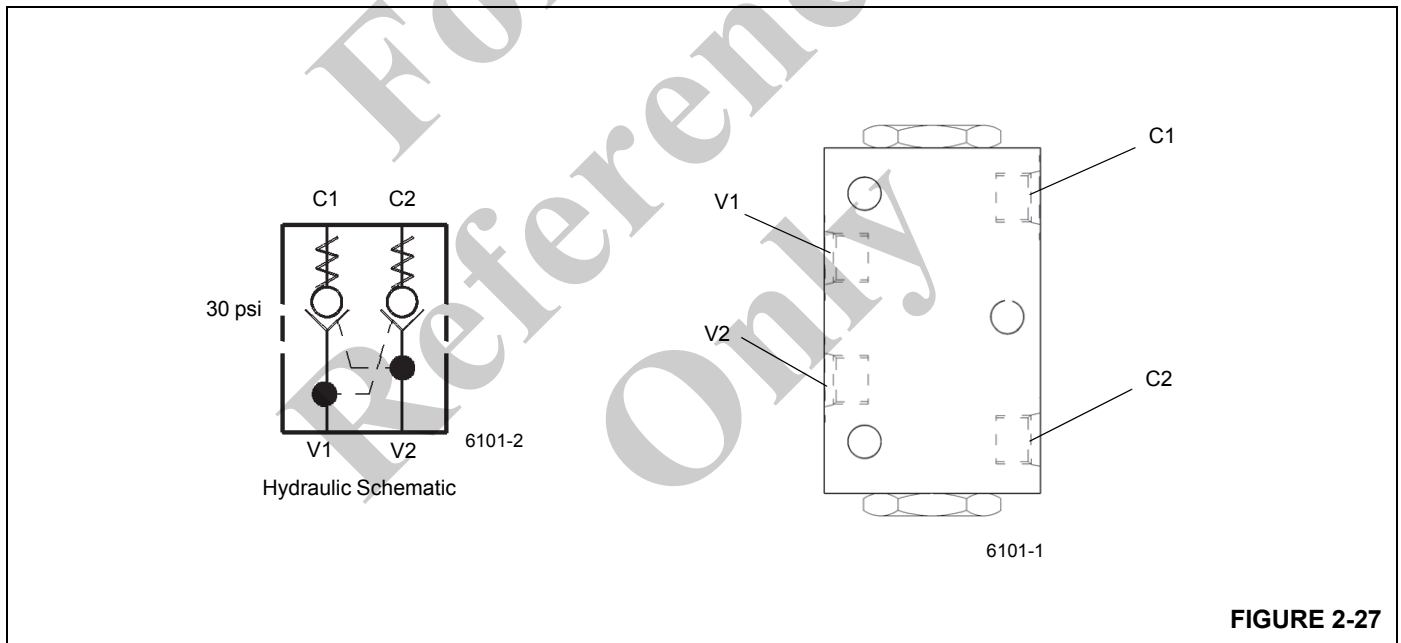
**CAUTION**

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

3. Carefully install the check valve into the port block until fully seated.

**Installation**

1. Install the valve to the turntable and secure with the capscrews, flatwashers and lockwashers.
2. Test the check valve by operating the cab tilt cylinder. Verify it extends and retracts without problems; verify there is no leaking. Make repairs as needed.



**FIGURE 2-27**

## TANDEM BRAKE VALVE W/ TREADLE PEDAL

### Description

The tandem brake valve with treadle pedal Figure 2-28 is located on the floor of the cab. The tandem brake valve provides split system braking for the primary (front) brakes and the secondary (rear) brakes. The valve is a closed center spool design which modulates the output pressure 2100 psi  $\pm$ 75 (14,483 kPa  $\pm$ 517) to the brake actuators.

The valve is mechanically actuated by a treadle pedal. The direct acting spool provides a pedal feel which accurately represents the brake pressure, similar to automotive style pedal feedback as the brake pedal pressure increases, the pedal effort increases proportionally.

As the pedal is initially actuated, the tank ports are closed off from the brake ports. With further application of the pedal, the pressure ports are opened to the brake ports until the pedal actuation force and the hydraulic pressure force are balanced. Also when the pedal is actuated, the integral proximity switch is engaged to provide an electrical signal for brake lights. When the pedal is released, the valve and the pedal return to the non-applied position. In normal operation, the secondary system is piloted from the primary section providing pressure to both systems.

The tandem brake valve consists of a tandem valve body, a closed center spool, a treadle pedal, an integral proximity switch and a mechanical spring assembly to limit the output pressure to the brake actuators to 2100 psi  $\pm$ 75 (14,483 kPa  $\pm$ 517).

### Maintenance

#### Removal

1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the nuts and bolts securing the valve to the cab floor. Remove the valve.

#### Installation

1. Secure the valve to the cab floor with the nuts and bolts.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Start the engine and check valve and hoses for leaks. Make repairs as needed.

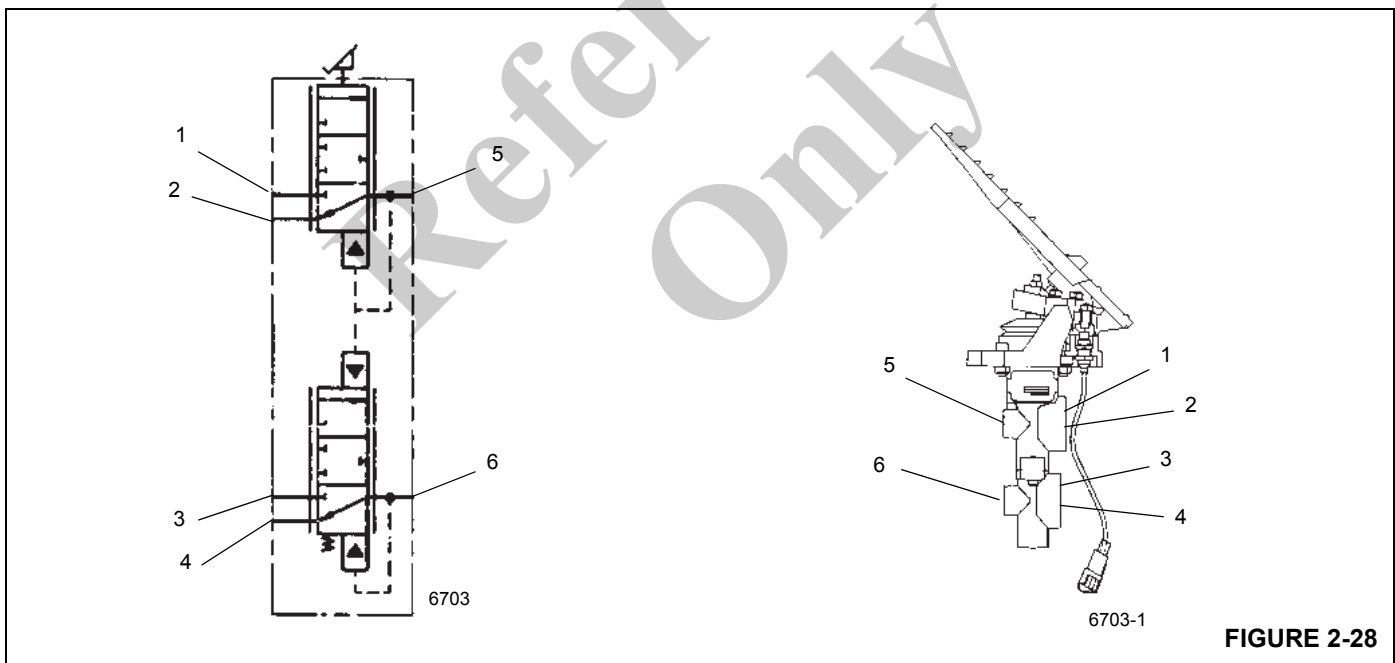


FIGURE 2-28

Item	Description
1	P1 - Pressure port
2	Tank Port
3	P2 - Pressure Port

Item	Description
4	Tank Port
5	Port B1 - Front Disc Brakes
6	Port B2 - Rear Disc Brakes

## DUAL ACCUMULATOR CHARGE VALVE

### Description

The dual accumulator charge valve Figure 2-29 is located on the turntable left side, inside the superstructure. The purpose of the valve is to provide a priority regulated flow dependent on the maximum pressure required to the service brake circuit and a secondary source of flow for the front steer and swing circuits. The dual accumulator charge valve regulates flow to the hydraulic accumulators at a rate of 2.2 to 3.2 gpm (8.3 to 12.1 l/min) to provide stored energy for the primary (front) and the secondary (rear) service brake circuits.

The dual accumulator charge valve consists of a charging section with a proportional flow divided spool and a main check valve, a control section with a pilot spool with a low limit check ball and a high limit check ball, and an inverted shuttle cartridge.

When the valve is charging the accumulators, the proportional flow divider spool, in the charging section, is in neutral to allow the charging flow to pass through the main check valve and on to the pilot control section and the inverted shuttle cartridge. The pilot control section controls the opening and closing of the low and high limit check balls. The pilot spool permits only one of these balls to be open at any one time. When the low limit check ball is open, the pressure from the accumulators is applied to shift the charging section flow divider spool and allow pump flow to the inverted shuttle cartridge which is normally open to charge the accumulators.

When the accumulators are charged to the high limit pressure of 2750 psi (19,000 kPa), pilot pressure will open the high limit check ball and close the low limit check ball. The inverted shuttle senses the pressure in the accumulators and the brake circuits to pilot close the cartridge when the maximum pressure is reached. After the accumulators are fully charged, the high limit check ball opens and the proportional flow divider spool is fully opened to direct all of the pump flow to the excess flow port and on to the air conditioning circuits.

### Maintenance

#### Removal

1. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
2. Remove the capscrews, flatwashers and lockwashers securing the valve to the turntable. Remove the valve.

#### Installation

1. Position the valve on the turntable and secure with the capscrews, washers and lockwashers.
2. Connect the hydraulic hoses to the valve ports as tagged during removal.
3. Start the engine and check for leaks. Make repairs as needed.
4. Depress the brake pedal several times, make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing, and front steering work properly.

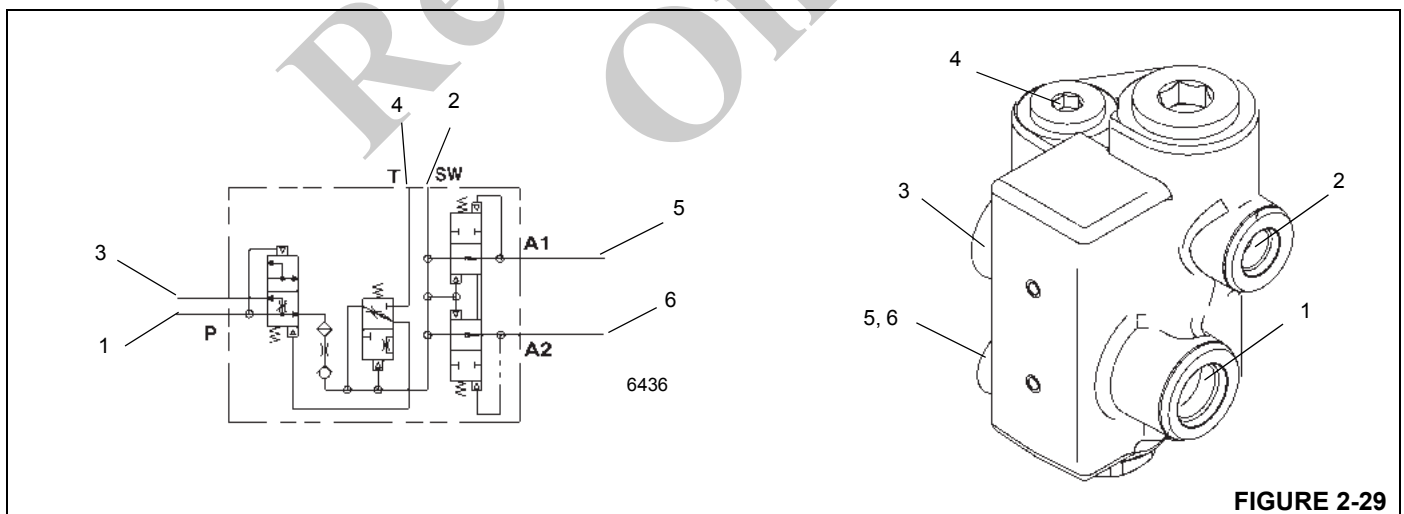


FIGURE 2-29

Item	Description
1	Pressure port
2	Switch Port
3	Flow Thru Port

Item	Description
4	Tank Port
5	Port A1 - To Accumulator
6	Port A2 - To Accumulator

## SERVICE BRAKE HYDRAULIC ACCUMULATOR

### Description

The service brake hydraulic accumulators are located on the outside of the left superstructure side plate behind the cab. The purpose of each accumulator is to provide stored energy, an oil volume of 231 cu in (3.8 liters) at a maximum pressure of 2750 psi (18,966 kPa), to actuate the service brake circuits. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits.

Each accumulator has two chambers divided by a piston. One side is pre-charged to 1400 psi (9655 kPa) with high purity nitrogen. This maintains a constant pressure in the other chamber which is connected to the modulating brake valve. After the accumulators are fully charged, they will provide the necessary brake system flow and pressure to actuate the brakes.

The accumulator consists of a tube, piston, seals, gas charging valve, and a gas valve guard.

### Maintenance

#### Removal

1. With the engine shutdown, deplete the hydraulic pressure in the accumulators by depressing the service brake pedal several times.
2. Tag and disconnect the hydraulic hose from the accumulator. Cap or plug the line and port.
3. Remove the two nuts securing each clamp half. Remove the each clamp half and accumulator from the turntable.

#### Installation

1. Position the accumulator in the clamps and secure with the removable clamp halves and nuts.
2. Connect the hydraulic hose to the port on the accumulator as tagged during removal.
3. Pre-charge the accumulator. Refer to paragraph titled Pre-Charging Accumulator in Sub-Section titled Hydraulic Pressure Adjustment.
4. Start the engine and check accumulator and hoses for leaks. Make repairs as needed.
5. Depress the brake pedal several times, make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing, and front steering work properly.

### Servicing

The pre-charge nitrogen pressure should be checked every 200 hours or once a month, whichever comes first. Refer to the Sub-Section titled *Pressure Setting Procedures*, page 2-21.

## LOAD SENSE HYDRAULIC ACCUMULATOR

### Description

The main directional control valve load sense accumulator is located on the right hand superstructure side plate beside the main directional control valve. The purpose of the accumulator is to dampen the load sense signals from the cylinders and motors to the inlet unloader. The accumulator has two chambers divided by a piston. One side is precharged to 600 psi (4,138 kPa) with high purity nitrogen while the other chamber is connected to the load sense port of the directional valve.

The accumulator consists of a tube, piston, seals, gas charging valve, and charging valve guard.

### Maintenance

#### Removal

1. With the engine shutdown, deplete the hydraulic pressure in the accumulators by depressing the service brake pedal several times.
2. Tag and disconnect the hydraulic hose from the accumulator. Cap or plug the line and port.
3. Remove the two nuts securing each clamp half. Remove the each clamp half and accumulator from the turntable.

#### Installation

1. Position the accumulator in the clamps and secure with the removable clamp halves and nuts.
2. Connect the hydraulic hose to the port on the accumulator as tagged during removal.
3. Pre-charge the accumulator. Refer to paragraph titled *Procedure G - For Pre-Charging Accumulator*, page 2-26.
4. Start the engine and check accumulator and hoses for leaks. Make repairs as needed.
5. Depress the brake pedal several times, make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing, and front steering work properly.

### Servicing

The pre-charge nitrogen pressure should be checked every 200 hours or once a month, whichever comes first. Refer to the Sub-Section titled *Pressure Setting Procedures*, page 2-21.

## HOLDING VALVES

### Description

A bolt-on manifold style holding valve is installed on the boom lift cylinder and a cartridge style holding valve is used on each telescope cylinder installed in the piston side of the cylinder. The counterweight removal cylinders have two cartridge style holding valves installed in both the piston and rod.

The holding valve installed on the outlet of the cylinder provides meter out control, will lock the cylinder in place, prevents a load from running ahead of the oil supply, and relieves excess pressure caused by thermal expansion.

### Maintenance

**!** **DANGER**  
**Crushing Hazard!**

Boom must be fully lowered and fully retracted before removing lift cylinder and telescope cylinder holding valves. The counterweight must be removed or pinned before removing counterweight removal cylinder holding valves.

#### Removal

1. Unscrew holding valve from its port block or manifold.

#### Repair

1. Check the inside of the port block or manifold for any sharp edges or burrs and remove as necessary with emery cloth.
2. Install new O-rings onto the holding valve.

#### Installation

1. Lubricate the holding valve and O-rings with clean hydraulic oil.

**CAUTION**  
**Equipment Damage!**

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

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

2. Carefully install the holding valve into the port block or manifold until fully seated.

3. Test the holding valve and port block or manifold by operating the lift cylinder and/or the telescope cylinder, as applicable. Verify lift cylinder and/or telescope cylinder works without problems; verify there is no leaking. Make repairs as needed.

### Lower Lift Cylinder Holding Valve

#### Removal

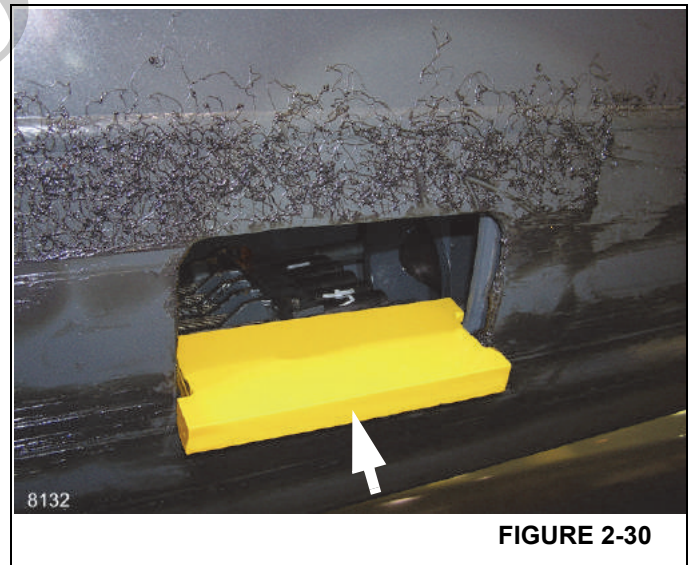
**!** **WARNING**  
**Pinch Point Hazard!**

Before accessing the holding valve install the telescope hold valve tool to prevent section 3 from retracting into section 2 when the holding valve is removed. Serious injury may result.

1. Lower the boom to below horizontal.
2. Extend the boom to align the access holes in second and third boom sections.
3. Install the telescope hold valve tool, P/N 80041761, see Figure 2-30. While holding the tool in position have a helper retract section 3 to lock the tool into place.

**!** **WARNING**  
**Flying Object Hazard!**

The holding valve can fly with explosive force if the hydraulic pressure is not relieved. Serious injury may result.



**FIGURE 2-30**

4. From the access holes in the opposite side of the boom, relieve the pressure in the lower telescope cylinder by loosening the bleed plug.



**FIGURE 2-31**

5. Unscrew holding valve from its port block. (See Figure 2-31.)

#### Installation

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

#### CAUTION

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

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

4. Carefully install the holding valve into the port block until fully seated.
5. Remove the telescope hold valve tool.
6. Test the check valve and port block by operating the telescope cylinder. Verify telescope cylinder works without problems; verify there is no leaking. Make repairs as needed.

## SHUTTLE VALVE

### Description

The in-lined plumbed shuttle valve is used as a directional selector valve. It is located at the inlet of the telescope rod drain solenoid valve. It is used to direct the higher trapped pressure of the rod side telescope cylinders to the telescope rod drain solenoid valve inlet.

It consists of a ball that moves between two opposing check seats. When one port is pressurized, the ball is forced against the opposite seat, blocking that inlet and providing a flow path to the outlet port.

### Maintenance

#### Removal

1. Tag and disconnect hydraulic lines from valve and cap or plug all openings, and remove valve.

#### Installation

1. Connect the hydraulic lines as tagged during removal.
2. Check valve and hydraulic connections for leaks. Make repairs as needed.

## SOLENOID VALVES

### Description

There are seven solenoid valves utilized in the crane hydraulic system. When the solenoid is energized, the plunger assembly forces the spool or poppet to shift, causing the valve to open, close, or change its port flow paths. De-energizing the solenoid allows spring force to shift spool or poppet to its normal position. The oil cooler motor control and the telescope rod drain solenoid valves are normally closed two position two way solenoid valves. The outrigger boost solenoid is a normally open two position two way solenoid valve. The park brake, axle disconnect, and the telescope two stage relief solenoid valves are two position three way.

#### **Oil Cooler Motor Control Solenoid Valve**

The oil cooler motor control solenoid valve mounted on the outside of the left superstructure side plate, is a normally closed two position two way. When the solenoid is energized, the valve opens to direct oil flow to the reservoir. When the return manifold temperature reaches 120° F (49° C) power is removed from the solenoid and the valve spring returns, blocking the tank port and directing pressurized oil to the cooler motor.

#### **Cold Air Charge Fan Control Solenoid Valve**

The oil cooler motor control solenoid valve mounted on the outside of the left superstructure side plate, is a normally closed two position two way. When the solenoid is energized, the valve opens to direct oil flow to the reservoir. When the return manifold temperature reaches 120° F (49° C) power is removed from the solenoid and the valve spring returns, blocking the tank port and directing pressurized oil to the cooler motor.

#### **Telescope Rod Drain Solenoid Valve**

The telescope rod drain solenoid valve, mounted in-line off of the telescope work port hydraulic tubing, is a normally closed two position two way. When the solenoid is energized, the valve opens to drain trapped pressure from the rod side of the telescope cylinders to the reservoir. Trapped pressure is directed from the rod sides of the cylinder via shuttle valve.

#### **Outrigger Boost Solenoid Valve**

The outrigger boost solenoid valve, mounted in-line off the outrigger/rear steer valve is a normally open two position two way. Excess flow from pump No. 2 and No. 3 is directed through the valve to the reservoir in its de-energized position. When the solenoid is energized, the valve closes and directs pressurized oil to the inlet of the outrigger/rear steer/box pin removal valve to boost the outrigger circuit speed.

#### **Parking Brake Solenoid Valve**

The parking brake solenoid valve, mounted off of the carrier right hand side rail, is a two position three way. In its de-energized position, the inlet port is blocked and the parking brake actuators are drained to the reservoir. When the solenoid is energized, the reservoir port is blocked and pressurized oil is directed to the actuators engaging the parking brake.

#### **Axle Disconnect Solenoid Valve**

The axle disconnect solenoid, mounted off of the carrier right hand side rail, is a two position three way. In its de-energized position, the inlet port is blocked and the disconnect actuator is drained to the tank. When the solenoid is energized, the reservoir port is blocked and pressurized oil is directed to the actuator.

#### **Telescope Two-Stage Relief Solenoid Valve**

The telescope two stage relief solenoid valve, mounted in-line off of the pressure reducing sequence valve, is a two position three way. In its de-energized position, the two stage port relief in the center/outer mid section of the main directional control valve is drained to the reservoir limiting the center mid telescope cylinder to 2500 psi (1724 kPa). When the solenoid is energized, pressurized oil is directed to the relief valve to shift it to limit the outer mid telescope cylinder to 3000 psi (2069 kPa).

#### **Cross-Axle Differential Lock Solenoid Valve**

The optional cross-axle differential lock solenoid valve mounted off of the carrier right hand side rail, is a two position four way. In its de-energized position, pressurized oil is directed to disengage the actuator port and the engaged actuator port is drained to the tank on both axle differentials. When energized, the valve ports reverse, directing pressurized oil to the engaged actuator port and drain the disengage actuator port on both axle differentials.

## Maintenance

**NOTE:** Valve Maintenance is limited to the removal of the cartridges and replacing the solenoid coils and/or seals.

### Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug all openings.
2. Tag and disconnect the electrical lines from the valve.
3. Remove the nuts and washers securing the valve to the frame or sub plate and remove the valve.

**Installation**

1. Position the valve to the frame and secure with the nuts and washers.
2. Connect the electrical lines to the valve as tagged during removal.
3. Connect the hydraulic lines to the valve as tagged during removal.
4. Operate the applicable system and check the valve for proper operation and any leaks.

**CROSS AXLE DIFFERENTIAL LOCK VALVE****Description**

The cross axle differential lock valve is located on the right side of the rear frame. The valve is a three-way, two position solenoid valve. The valve is used to control the application of the crane's hydraulically applied and released cross axle differential lock actuators.

Positioning the Axle Diff switch to LOCK shifts the three-way, two-position solenoid valve so hydraulic oil can flow to the engage port of the cross axle differential lock actuators, extending them. When the actuators extend, they engage the splines on the differential case and the axle shafts to lock the differential assemblies together.

Positioning the Axle Diff switch to UNLOCK shifts the three-way, two-position solenoid valve so hydraulic oil can flow to the disengage port of the actuators, retracting them. As the actuators retract, they unlock the axles.

**Maintenance****Removal**

1. Tag and disconnect the electrical connector from the valve.
2. Tag and disconnect the hydraulic lines attached to the valve. Cap or plug lines and ports.
3. Remove the capscrews, flatwashers and nuts securing the valve to the frame. Remove the valve.

**Installation**

1. Secure the valve to the frame with the capscrews, flatwashers and nuts.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.

4. Apply and release the cross axle differential lock several times. Verify the cross axle differential lock holds the axle from moving when applied so there is no differential action between the wheels.
5. Check for leaks. Make repairs as needed.

**CHECK VALVES****Description**

There are five check valves utilized in the crane hydraulic system. The check valves are used to block flow in one direction and allow free flow in the opposite direction.

The crane's hydraulic dual return circuit has an in-line plumbed check valve in one of the two return lines. It is used to force hot return oil in the other return line to the hydraulic oil cooler.

The swing/steer directional control valve has a check valve installed in its outlet port to ensure there will be enough pressure to force oil through the port anti-void check valves for motor over run when the directional control valve is centered.

There is an in-line mounted check valve between the secondary ports of pump No. 1 and No. 3. It is used to boost flow to the outrigger circuit.

The counterweight removal/cab tilt directional control valve utilizes a check valve in its load sense line from the hoist/telescope/boom lift directional control valve. It blocks the load sense signal from the hoist/telescope/boom lift directional control valve from bleeding through the counterweight removal/cab tilt directional control valve's load sense bleed.

There is an inlet plumbed checked valve on the front steer control valve. It prevents steering wheel kick-back if the steer cylinder pressure rises above the inlet port pressure.

**Maintenance****Removal**

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.

**Installation**

1. Connect the hydraulic lines to the ports on the valve as tagged during removal.
2. Verify proper operation of the valve. Check hydraulic connections for leaks.



## OUTRIGGER/REAR STEER/OUTRIGGER BOX PIN REMOVAL VALVE

### Description

The outrigger/rear steer/outrigger removal valve Figure 2-32 directionally controls the outrigger circuit, rear steer circuit, and the pin cylinders that remove the front and rear outrigger boxes. The valve is mounted on the front face of the carrier frame member forward of the swivel. The manifold valve has five stations, an inlet, and four working stations.

The inlet station contains a 2000 psi (13789.5 kPa) relief valve and a two position two way solenoid valve that is normally open bypassing oil from the inlet port to the pressure beyond port. Activation of either outriggers, rear steer, or removal pin stations will energize the solenoid valve to close, pressurizing the working sections. The next two sections control the outrigger box pin removal cylinders. Each station contains a three position four way solenoid controlled directional control valve cartridge. The forth station controls the rear steer. It contains a three position four way solenoid controlled directional control valve cartridge and two pilot operated check valve cartridges. The fifth station controls the outrigger extend and retract. It contains two bolt-on three position four way solenoid directional control valves, internally connected in parallel, two pilot operated check valves with integral 4000 psi (2759 kPa) thermal relief valve.

Item	Description
1	Outrigger Solenoid - Retract
2	Outrigger Solenoid - Extend
3	Sequence Relief - Screw Adjustable
4	Two Stage Relief - Screw Adjustable
5	Solenoid for Outrigger Two Stage Relief
6	Solenoid for Port PB
7	Solenoid for Port B2 - Rear Removal Pin Extend
8	Solenoid for Port A2 - Rear Removal Pin Retract
9	Solenoid for Port B1 - Front Removal Pin Extend
10	Solenoid for Port A1 - Front Removal Pin Retract

## Maintenance

### Removal

1. Tag and disconnect the electrical connectors to the integrated outrigger/rear steer valve. Tape the lead ends.
2. Tag and disconnect the hydraulic lines to the integrated outrigger/rear steer valve. Cap or plug the lines and ports.
3. Remove the capscrews, nuts and flatwashers securing the integrated outrigger/rear steer valve to the frame. Remove the valve as a complete assembly.

### Installation

1. Install the integrated outrigger/rear steer valve to the frame. Secure the valve with the nuts, flatwashers and capscrews.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.

### Functional Check

1. Cycle an outrigger cylinder several times. Verify the cylinder extends and retracts properly.
2. Rear steer the crane to the left and to the right several times. Verify the crane steers properly in both directions.

Item	Description
11	Solenoid for Port BST - Steer Left
12	Solenoid for Port AST Steer Right
13	Pressure Port
14	Tank Port
15	Rear Steer BST Port
16	Rear Steer AST Port
17	Gauge G Port
18	Outrigger B Port - Extend
19	Front Removal Pin A & B Ports
20	Rear Removal Pin A2 & B2 Ports
21	Power Beyond Port
22	Outrigger A Port - Retract

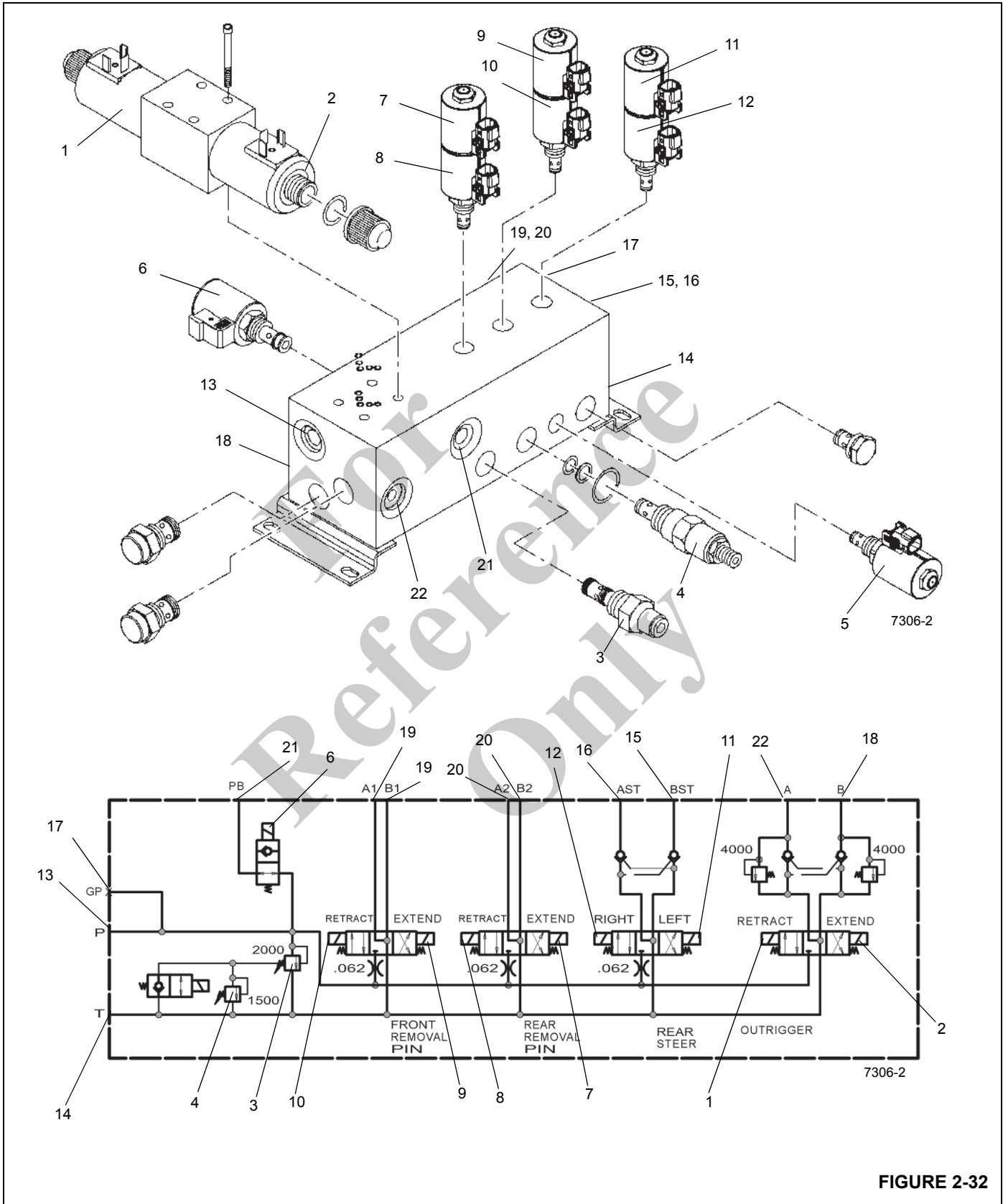


FIGURE 2-32

## OUTRIGGER CONTROL MANIFOLD

### Description

There are two outrigger control manifolds utilized on the crane, one for the front outriggers and one for the rear outriggers Figure 2-33. Each manifold consists of four normally closed two position two way solenoid valves. They are mounted inside the frame on their respective outrigger box.

When energized, the solenoid shifts the spool to open allowing extension or retraction of the outrigger cylinders.

### Maintenance

#### Removal

1. Tag and disconnect the hydraulic lines to the solenoid valves; cap all lines and openings.
2. Tag and disconnect the electrical connectors.
3. Remove the bolts and nuts securing the manifold to the outrigger box; remove the manifold.

### Inspection

Visually inspect the valves and hydraulic connections for any evidence of leaks or other damage. Check security of the electrical connections. Inspect the wiring for any evidence of cracks or breaks.

### Installation

1. Position the manifold on the mounting; secure with the nuts and bolts.
2. Connect the electrical connectors to the solenoids as marked during removal.
3. Connect the hydraulic lines to the valves as marked during removal.

### Functional Check

Activate the hydraulic system and cycle the affected cylinder(s) several times. Observe for proper functioning of the affected cylinder(s). Ensure the solenoid valve hydraulic connections are secure.

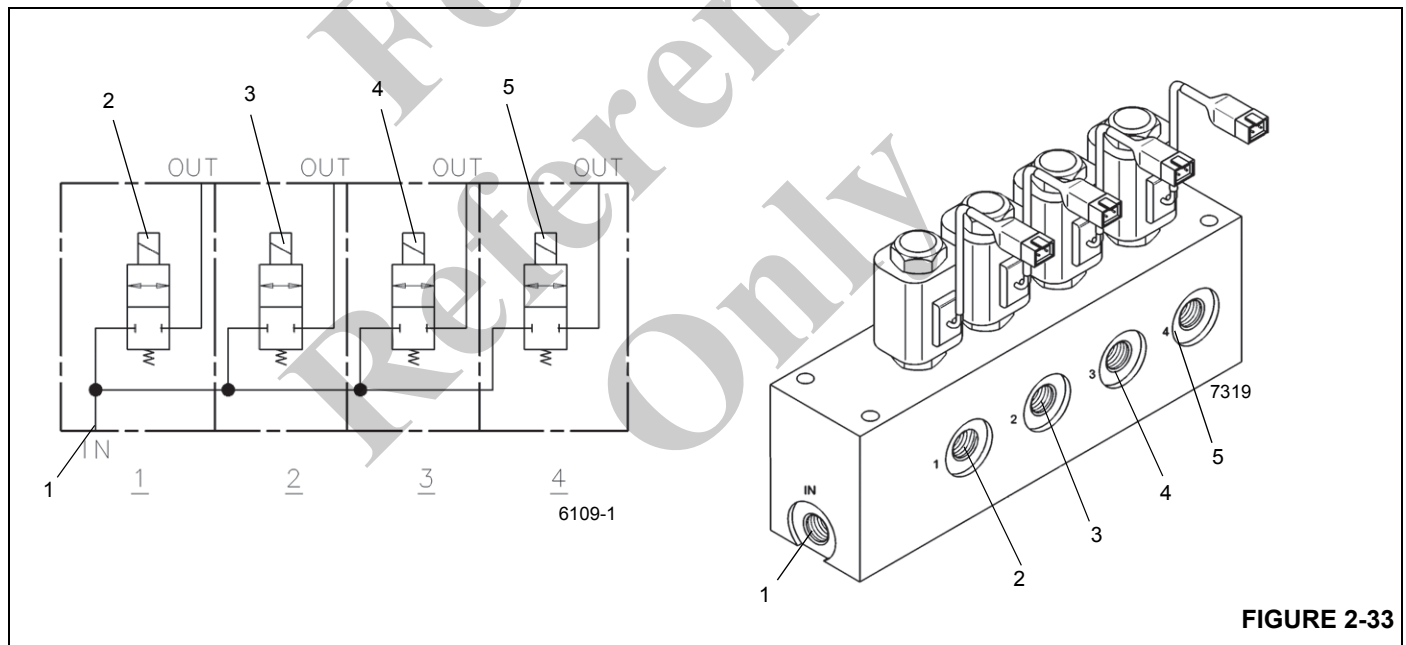


FIGURE 2-33

Item	Description
1	In Port
2	Left Front Extension Cylinder
3	Left Front Stabilizer Cylinder

Item	Description
4	Right Front Stabilizer Cylinder
5	Right Front Extension Cylinder

## PILOT OPERATED CHECK VALVE

### Description

A pilot operated (PO) check valve is located in each outrigger stabilizer cylinder port block Figure 2-34. The check valve functions as a holding valve for the stabilizer cylinder. Oil flow is directed from the "V" port to the "C" ports, while blocking flow in the opposite direction. Flow is reversed from "C" to "V" when pressure pilot oil is applied to the opposite side "V" port.

### Maintenance

#### Removal

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

#### Installation

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

3. Lubricate the check valve and O-rings with clean hydraulic oil.

### CAUTION

#### Possible Equipment Damage!

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

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

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

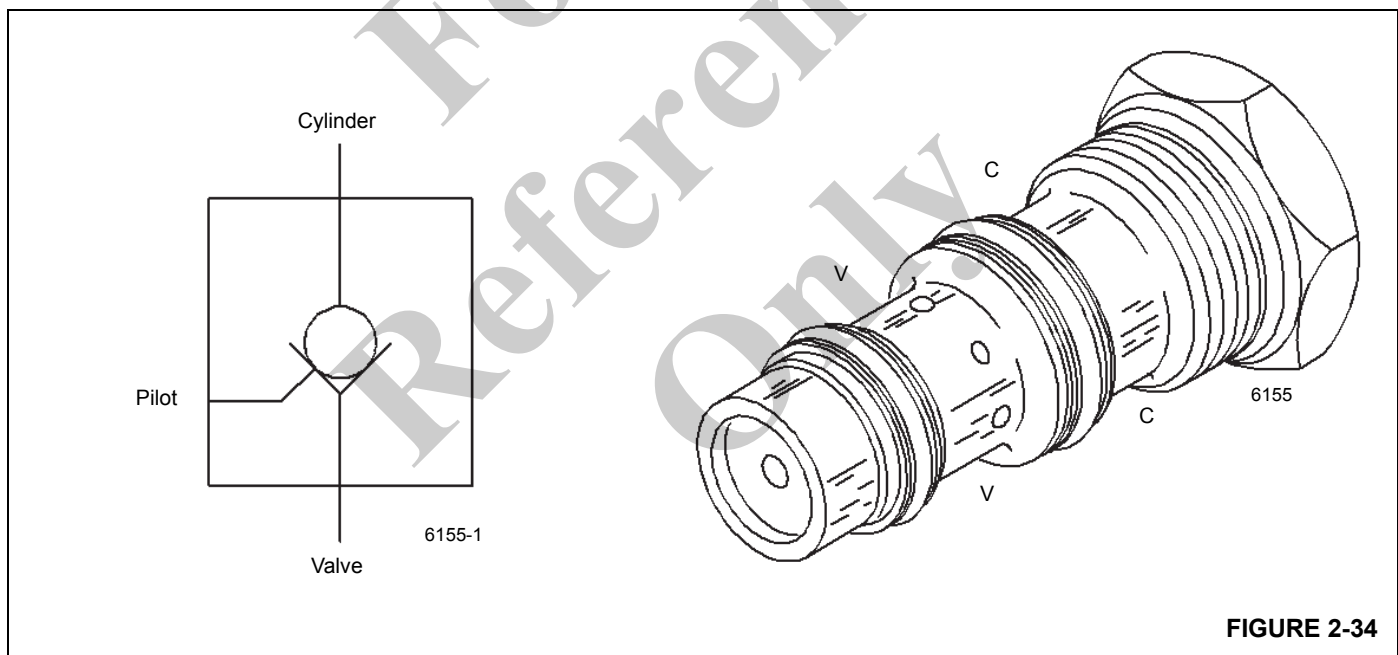


FIGURE 2-34

## PRESSURE BLEED-OFF VALVE

### Description

The pressure bleed-off valve (Figure 2-35) is used to manually drain to reservoir any trapped pressure from behind the outrigger box removal quick disconnects or the telescope boom removal quick disconnects.

The in-line plumbed pressure bleed-off valve consists of a knob adjustable flow control valve and a shuttle valve. The adjustable flow control valve knob can be turned counterclockwise to open or clockwise to close. Full adjustment is five turns of the knob. The shuttle valve acts as a directional selector, allowing only the pressurized circuit to open to the flow control drain valve.



### WARNING

When bleeding hydraulic fluid, operate the system below 500 psi. To avoid injury, ensure that all persons are clear of the path of discharge. Another recommended practice is to attach a section of hose over the bleed screw/adapter to direct oil away from the area and to reduce oil spillage.

Whenever possible, the bleed adapter should be mounted at the highest point within the hydraulic system. The trapped air can be relieved while the system is running at low pressure. To bleed, loosen the bleed screw 1/2 turn counterclockwise. After the hydraulic fluid begins to run freely from the bleed screw, the bleed screw should be re-tightened.

**NOTE:** Pressure bleed-off valve must be opened to bleed off pressure before quick couplers are disconnected.

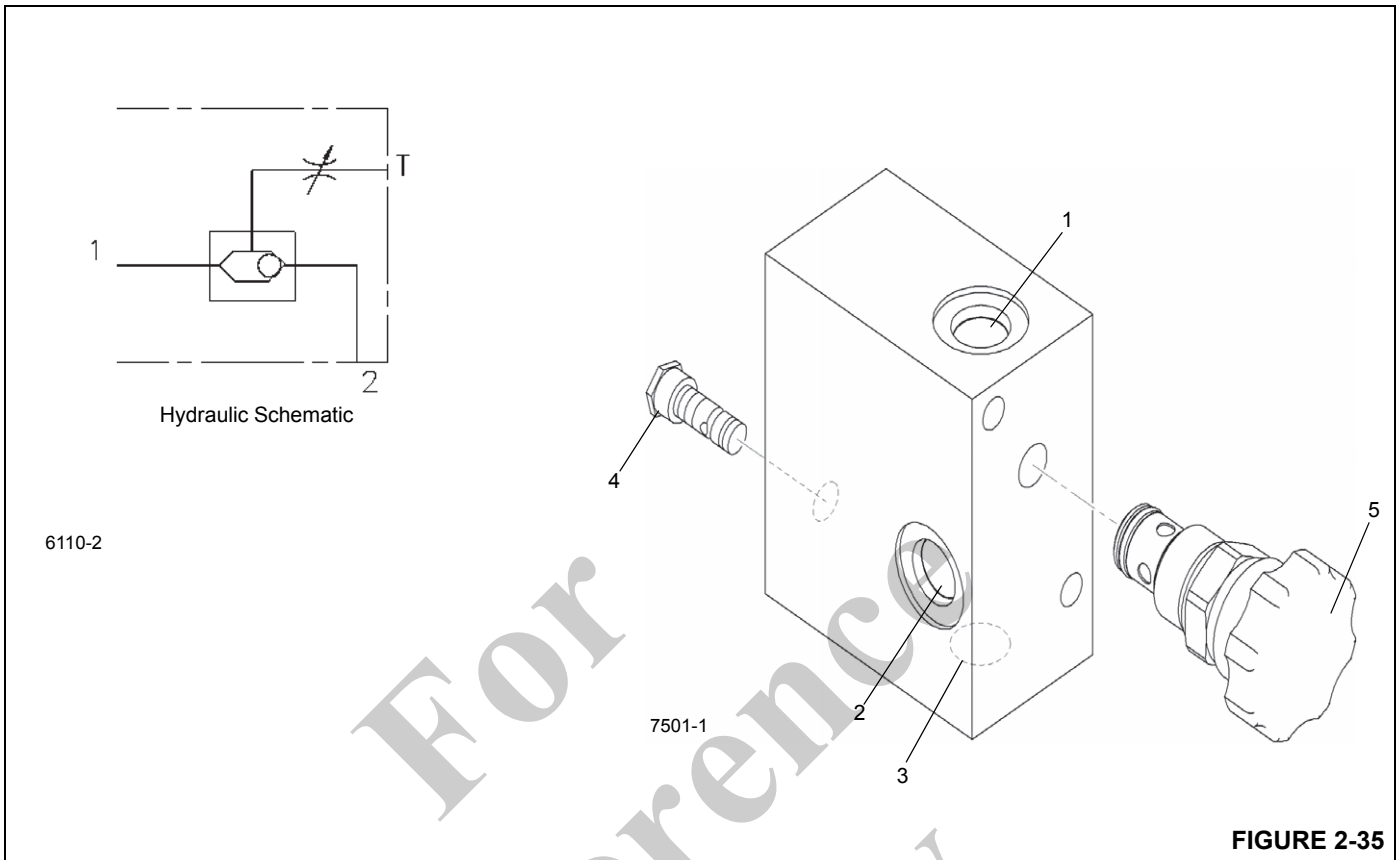
### Maintenance

#### Removal

1. Tag and disconnect hydraulic lines from valve. Cap or plug all openings and remove valve.
2. Remove the capscrews and washers securing the valve. Remove the valve.

#### Installation

1. Connect the hydraulic lines as tagged during removal.
2. Connect the hydraulic lines to the valve as tagged during removal.



Item	Description
1	Tank Port
2	To Outrigger Extend Port "B"
3	To Outrigger Retract Port "A"

Item	Description
4	Shuttle Valve
5	Manual Bleed-Off Pressure Valve

## AXLE OSCILLATION LOCKOUT VALVE

### Description

The axle oscillation lockout valve (also called the double solenoid valve) is used in the rear axle oscillation lockout circuit. The valve is mounted on the right rear face of the carrier frame forward of the rear axle. It consists of a valve body and two normally-closed, two-way, two-position solenoid valves. It keeps the lockout cylinders from oscillating unless the turntable is centered forward.

The area definition potentiometer in the electrical swivel energizes and de-energizes the axle oscillation relay. When the superstructure is more than 6 degrees left or right of directly over the front, the axle oscillation relay is de-energized.

When the axle oscillation relay's contacts are open, the normally closed solenoid valves are de-energized and isolate the lockout cylinders from hydraulic oil supply. This keeps the cylinders from oscillating (moving up and down to damp axle movement) because hydraulic oil cannot leave the cylinders. Instead, the cylinders remain full of hydraulic oil and more rigid.

When the axle oscillation relay's contacts are closed, the solenoid valves are energized and open. This allows hydraulic oil in and out of the cylinders, allowing them to oscillate.

### Maintenance

#### Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, nuts and washers securing the valve to the frame bracket. Remove the valve.

#### Installation

1. Secure the valve to the crane with the capscrews, nuts and washers.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.
4. Verify proper operation. Refer to Section 3 in the *Operator's Manual*.
5. Check valve and hoses for leaks. Make repairs as needed.

## RELIEF VALVE

### Description

The in-line plumbed direct acting relief valve is installed at the hydraulic hose reel motor. It is used to protect the motor in case of a pressure surge.

The valve consists of a manifold and cartridge. When pressure at the inlet port exceeds the bias spring force or setting holding the valve closed, the valve will open, directing pressurized oil to the reservoir.

### Maintenance

#### Removal

1. Tag and disconnect hydraulic lines from the valve. Cap or plug all openings and remove valve.

#### Installation

1. Connect the hydraulic lines as tagged during removal.
2. Check valve and hydraulic connections for leaks. Make repairs as needed.

## TELESCOPE CYLINDER CHARGE VALVE MANIFOLD (IF EQUIPPED)

### Description

The telescope cylinder charge valve manifold is used in the telescope cylinder charge system. The charge valve manifold is mounted to the stiffener bracket, which is located behind the swivel, that connects the two vertical sections of the turret together (1, Figure 2-36).

The charge valve manifold (Figure 2-37) consists of a manifold (1); a spring offset, solenoid controlled, two-way control valve with integral check valve (2); a pressure reducing valve (3) set to 13.8 bar (200 psi); two check valves (4); and a normally-closed pressure switch (5).

The telescope cylinder charge valve manifold prevents the boom from retracting due to thermal contraction of the oil in the telescope cylinders under certain circumstances (refer to *Telescope Circuit*, page 4-24 for more detailed information). The charge valve manifold does this by supplying oil to the telescope cylinder extend circuits when the boom is elevated above 35 degrees. The solenoid valve (2) is energized by the LMI when the boom angle is greater than 35 degrees, allowing oil to flow through the pressure reducing valve (3) and on to the telescope extend circuits. Pressure in the telescope extend circuits is maintained by the two check valves (4). The normally-closed pressure switch (5) is plumbed into the charge valve manifold and is used to alert the operator by way of a buzzer and warning indicator if the pressure in the telescope cylinder charge system is less than approximately 6.9 bar (100 psi). For a schematic of the telescope cylinder charge system, refer to Figure 2-38.

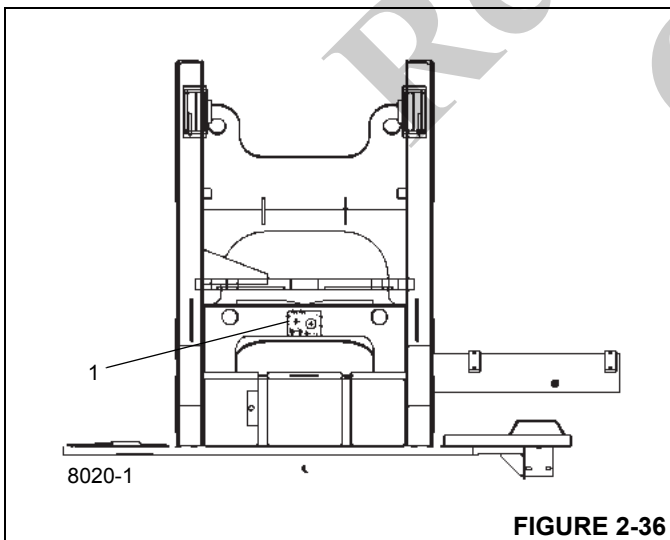


FIGURE 2-36

### Checking/Setting the Charge Valve Manifold

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ GPA or GPB on the charge valve manifold.
2. Boom lift up to achieve a boom angle greater than 35° (Boom Telescope cylinder must be fully retracted).
3. With the engine at idle rpm, check to ensure pressure is 200 psi. If the pressure is low, adjust the pressure reducing valve (3, Figure 2-37) adjusting stem clockwise (in). If pressure is higher than specification, adjust the adjustment stem Counter Clockwise (out).
4. Once pressure is set move pressure transducer to the other (GPA or GPB) diagnostic coupler on the make-up oil manifold check to ensure the pressure reads the same as set in step #3.
5. Stop engine and remove transducer

### Maintenance

#### Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, nuts and washers securing the valve to the turret bracket. Remove the valve.

#### Installation

1. Secure the valve to the crane with the capscrews, nuts and washers.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.
4. Elevate boom above 35 degrees and ensure buzzer does not sound and telescope cylinder charge indicator does not illuminate.
5. Check valve and hoses for leaks. Make repairs as needed.



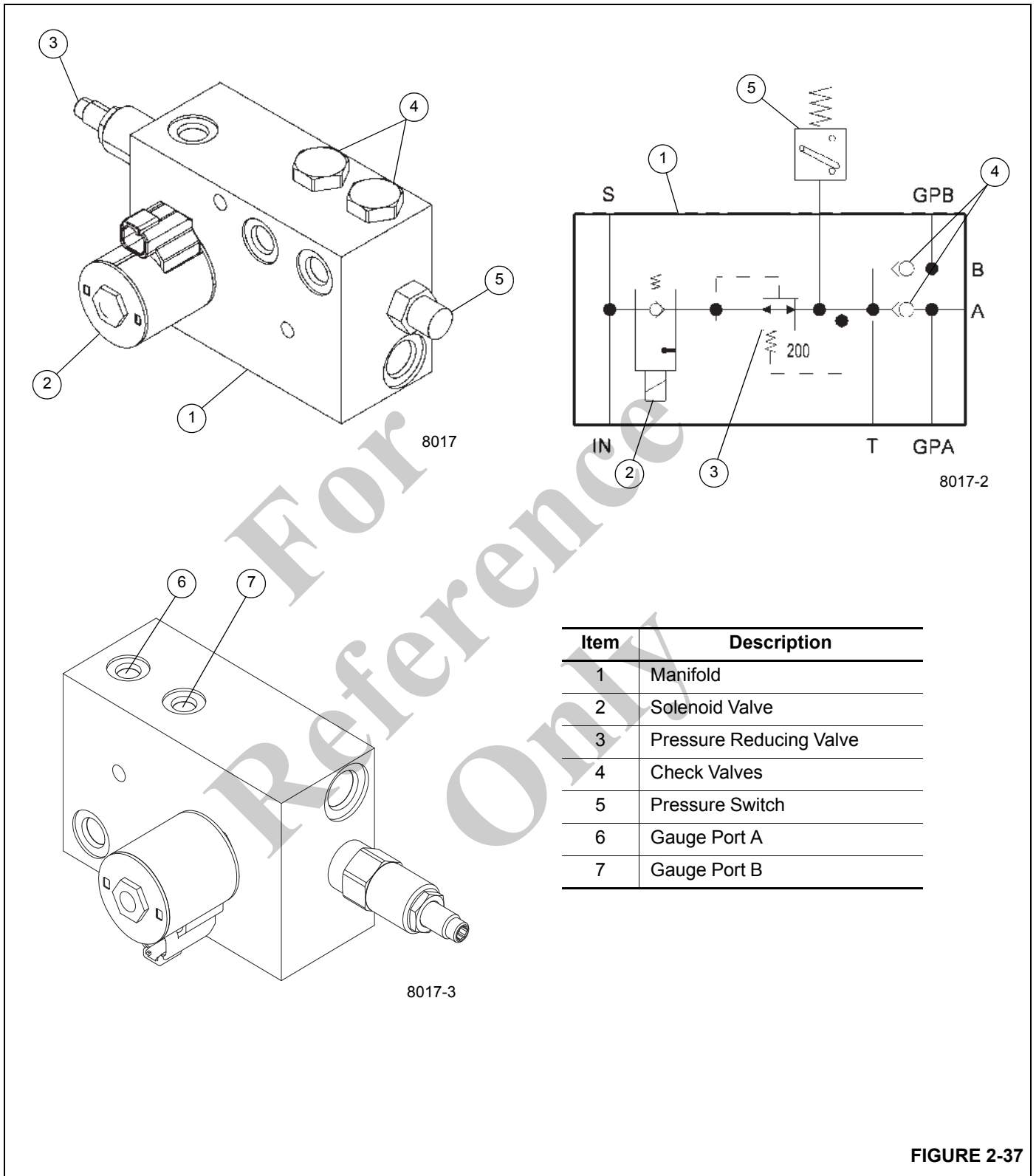
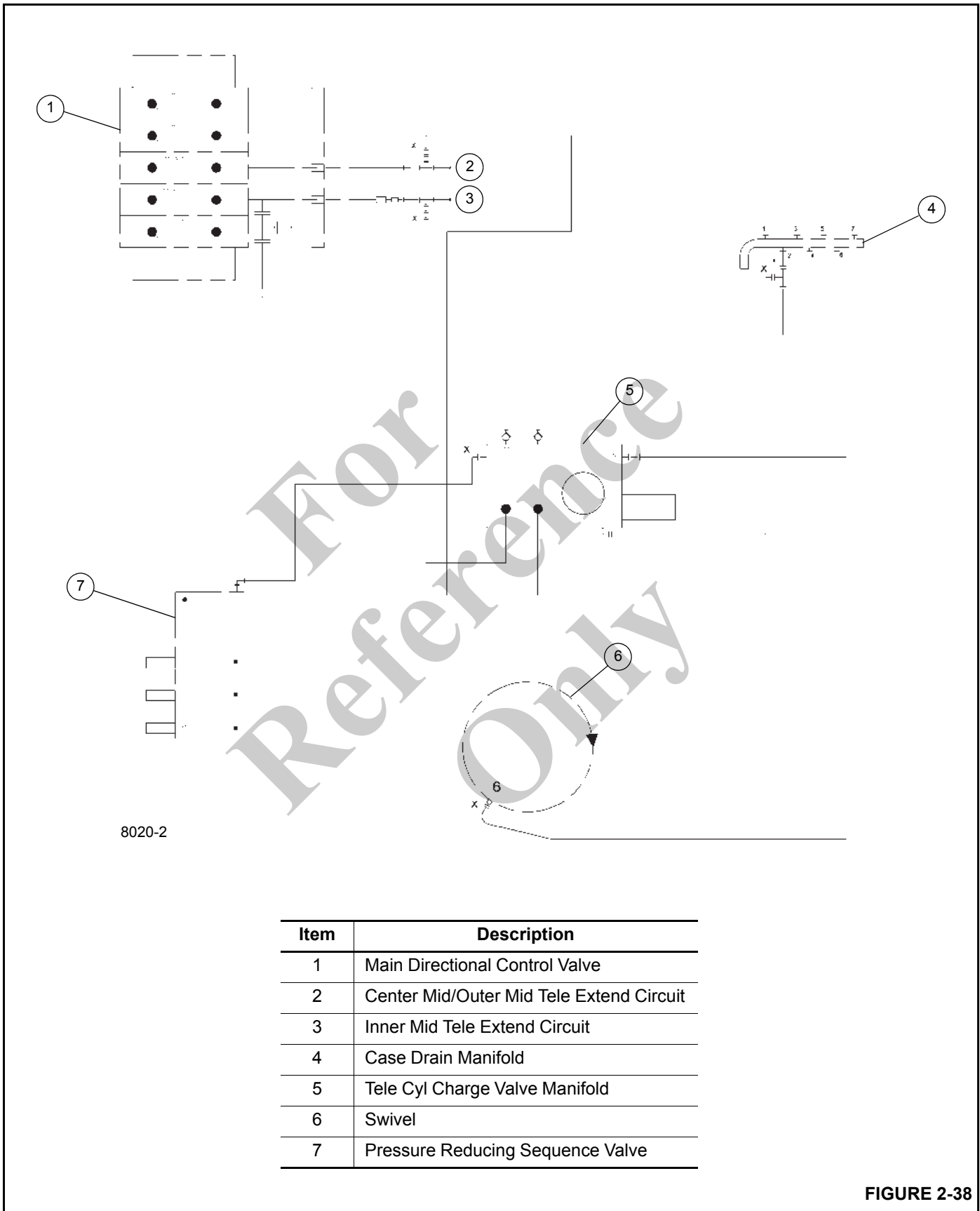


FIGURE 2-37



8020-2

Item	Description
1	Main Directional Control Valve
2	Center Mid/Outer Mid Tele Extend Circuit
3	Inner Mid Tele Extend Circuit
4	Case Drain Manifold
5	Tele Cyl Charge Valve Manifold
6	Swivel
7	Pressure Reducing Sequence Valve

FIGURE 2-38

**Checking Charge Air Cooler Motor Control Valve – For Tier 3 ONLY**

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at Charge Air Cooler Motor Control Valve
2. With engine at full RPM, unplug harness connection on control solenoid to turn cooler on. Adjust relief valve to obtain a reading of  $1000 \pm 50$  PSI ( $6.9 \pm 0.4$  MPa). Turn in to raise, out to lower.
3. Remove pressure gauge and plug harness connection back into control solenoid. Cylinders

For  
Reference  
Only

**CYLINDERS**

**General**

This subsection provides descriptive information for all the hydraulic cylinders used on this crane. The description of the cylinder given here is for the cylinder itself. For information on how the cylinder functions in the individual circuits, refer to the Description and Operation of that circuit.

**Table 2-5 Wear Ring Gap**

Head (or Piston) Size		Wear Ring Gap	
Inch	mm	Inch	mm
1 to 4.75	25.4 to 120.7	0.125	3.18
5 to 10.0	127.0 to 254.0	0.187	4.75
greater than 10.0	greater than 254.0	0.250	6.35

**Surface Protection For Cylinder Rods**

Steel cylinder rods include a thin layer of chrome plating on their surfaces to protect them from corroding. However, chrome plating inherently has cracks in its structure which can allow moisture to corrode the underlying steel. At typical ambient temperatures, hydraulic oil is too thick to penetrate these cracks. Normal hydraulic operating temperatures will allow hydraulic oil to warm sufficiently to penetrate these cracks and if machines are operated daily, protect the rods. Machines that are stored, transported, or used in a corrosive environment (high moisture, rain, snow, or coastline conditions) need to have the exposed rods protected more frequently by applying a protectant. Unless the machine is operated daily, exposed rod surfaces will corrode. Some cylinders will have rods exposed even when completely retracted. Assume all cylinders have exposed rods, as corrosion on the end of the rod can ruin the cylinder.

It is recommended that all exposed cylinder rods be protected using Boeshield® T-9 Premium Metal Protectant. Manitowoc Crare Care has Boeshield® T-9 Premium Metal Protectant available in 12 oz. aerosol cans by ordering part number 9999101803.

**NOTE:** Cylinder operation and inclement weather will remove the Boeshield® protectant; therefore, inspect machines once a week and reapply Boeshield® to unprotected rods.

**Maintenance**

There must be a gap between the ends of each wear ring when it is installed onto the piston (as applicable) or head Table 2-5. In addition, each wear ring gap is to be located as follows: Divide 360 degrees by the number of wear rings on the component. The resulting value is the number of degrees each wear ring gap is to be located with respect to each other.

The approximate wear ring gaps are as follows:

**Leakage Check**

A hydraulic cylinder should not be disassembled unless it is essential. The following checks will provide a means of determining if a cylinder has a faulty or leaking piston seal.

1. Extend the rod to its maximum stroke. Remove the retract hose from the cylinder. Cap the retract hose.



**CAUTION**

Ensure pressure is applied to the piston side of the cylinder only and the retract hose is capped.

2. Apply hydraulic pressure to the piston side of the cylinder and observe the open cylinder port for leakage. If leakage is observed, the seals in the cylinder must be replaced.

3. Fully retract the cylinder rod (except the telescope cylinder). Remove the extend hose from the cylinder. Cap the extend hose.



**CAUTION**

Ensure pressure is applied to the retract (rod) side of the cylinder only and the extend hose is capped.

4. Apply hydraulic pressure to the retract (rod) side of the cylinder and observe the open cylinder port for leakage. If leakage is observed, the seals in the cylinder must be replaced.
5. Reconnect all cylinder ports.

### **Temperature Effects on Hydraulic Cylinders**

Hydraulic oil expands when heated and contracts when cooled. This is a natural phenomena that happens to all liquids. The coefficient of expansion for API Group 1 hydraulic oil is approximately 0.00043 cubic inches per cubic inch of volume for 1° F of temperature change. **Thermal contraction will allow a cylinder to retract as the hydraulic fluid which is trapped in the cylinder cools.** The change in the length of a cylinder is proportional to the extended length of the cylinder and to the change in temperature of the oil in the cylinder. For example, a cylinder extended 25 feet in which the oil cools 60° F would retract approximately 7.75 inches (see Table 2-6). A cylinder extended 5 feet in which the oil cools 60° F would only retract approximately 1.5 inches. The rate at which the oil cools depends on many factors and will be more noticeable with a larger difference in oil temperature verses the ambient temperature.

Thermal contraction coupled with improper or inadequate lubrication or improper wear pad adjustments and operation at low boom angles may, under certain conditions, cause a "stick-slip" condition in the boom. This "stick-slip" condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement, of the

boom may be undetected by the operator unless a load is suspended for a long period of time. To minimize the effects of thermal contraction of "slip stick" it is recommended that the telescope control lever is activated periodically in the extend position to mitigate the effects of the cooling oil.

If a load and the boom is allowed to remain stationary for a period of time and the ambient temperature is cooler than the trapped oil temperature, the trapped oil in the cylinders will cool. The load will lower as the telescope cylinder(s) retracts allowing the boom to come in. Also, the boom angle will decrease as the lift cylinder(s) retracts causing an increase in radius and a decrease in load height.

This situation will also occur in reverse. If a crane is set up in the morning with cool oil and the daytime ambient temperature heats the oil, the cylinders will extend in similar proportions.

Table 2-6 has been prepared to assist you in determining the approximate amount of retraction/extension that may be expected from a hydraulic cylinder as a result of change in the temperature of the hydraulic oil inside the cylinder. The chart is for dry rod cylinders. If the cylinder rod is filled with hydraulic oil, the contraction rate is somewhat greater.

**NOTE:** Operators and service personnel must be aware that load movement, as a result of this phenomena, can be easily mistaken as leaking cylinder seals or faulty holding valves. If leaking seals or faulty holding valves are suspected to be the problem, refer to Service Bulletin 98-036 dealing with testing telescope cylinders.

Table 2-6 Boom Drift Chart (Cylinder length change in inches)

BOOM DRIFT CHART (Cylinder length change in inches)

Coeff. = 0.00043 (in<sup>3</sup>/in<sup>3</sup>/ °F)

STROKE (FT.)	Temperature Change (°F)									
	10	20	30	40	50	60	70	80	90	100
5	0.26	0.52	0.77	1.03	1.29	1.55	1.81	2.06	2.32	2.58
10	0.52	1.03	1.55	2.06	2.58	3.10	3.61	4.13	4.64	5.16
15	0.77	1.55	2.32	3.10	3.87	4.64	5.42	6.19	6.97	7.74
20	1.03	2.06	3.10	4.13	5.16	6.19	7.22	8.26	9.29	10.32
25	1.29	2.58	3.87	5.16	6.45	7.74	9.03	10.32	11.61	12.90
30	1.55	3.10	4.64	6.19	7.74	9.29	10.84	12.38	13.93	15.48
35	1.81	3.61	5.42	7.22	9.03	10.84	12.64	14.45	16.25	18.06
40	2.06	4.13	6.19	8.26	10.32	12.38	14.45	16.51	18.58	20.64
45	2.32	4.64	6.97	9.29	11.61	13.93	16.25	18.58	20.90	23.22
50	2.58	5.16	7.74	10.32	12.90	15.48	18.06	20.64	23.22	25.80
55	2.84	5.68	8.51	11.35	14.19	17.03	19.87	22.70	25.54	28.38
60	3.10	6.19	9.29	12.38	15.48	18.58	21.67	24.77	27.86	30.96

Length change in inches = Stroke (Ft.) X Temperature Change ( °F) X Coeff. (in<sup>3</sup>/in<sup>3</sup>/ °F) X 12 in/ft

Temperature Effects on Hydraulic Cylinders

**FIGURE 2-39**

Table 2-7 Boom Drift Chart (Cylinder length change in millimeters)

Coeff. = 0.000774 (1/ °C)

STROKE (m)	Temperature Change (°C)										
	5	10	15	20	25	30	35	40	45	50	55
1.5	5.81	11.61	17.42	23.22	29.03	34.83	40.64	46.44	52.25	58.05	63.86
3	11.61	23.22	34.83	46.44	58.05	69.66	81.27	92.88	104.49	116.10	127.71
4.5	17.42	34.83	52.25	69.66	87.08	104.49	121.91	139.32	156.74	174.15	191.57
6	23.22	46.44	69.66	92.88	116.10	139.32	162.54	185.76	208.98	232.20	255.42
7.5	29.03	58.05	87.08	116.10	145.13	174.15	203.18	232.20	261.23	290.25	319.28
9	34.83	69.66	104.49	139.32	174.15	208.98	243.81	278.64	313.47	348.30	383.13
10.5	40.64	81.27	121.91	162.54	203.18	243.81	284.45	325.08	365.72	406.35	446.99
12	46.44	92.88	139.32	185.76	232.20	278.64	325.08	371.52	417.96	464.40	510.84
13.5	52.25	104.49	156.74	208.98	261.23	313.47	365.72	417.96	470.21	522.45	574.70
15	58.05	116.10	174.15	232.20	290.25	348.30	406.35	464.40	522.45	580.50	638.55
16.5	63.86	127.71	191.57	255.42	319.28	383.13	446.99	510.84	574.70	638.55	702.41
18	69.66	139.32	208.98	278.64	348.30	417.96	487.62	557.28	626.94	696.60	766.26

Length change in mm = Stroke (m) X Temperature Change ( °C) X Coeff. (1/ °C) X 1000 mm/m

## LIFT CYLINDER

### Description

The lift cylinder has a bore of 14.0 in (35.56 cm) Figure 2-40. The retracted length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 194.6 in (494.2 cm). Its stroke is 153.8 in (390.6 cm). A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 3893 lb (1766 kg).

### Maintenance

#### Disassembly

**NOTE:** Any maintenance requiring disassembly of the cylinders should include replacement of all seals and rings. A seal kit will supply the required items.

1. Disconnect the tube assembly from the holding valve.
2. Remove the capscrews and flatwashers securing the holding valve. Remove the holding valve from the cylinder barrel.
3. Remove the two socket head capscrews securing the head retainer ring to the head.
4. Using a spanner wrench or chain wrench, unscrew the head retainer ring from the barrel.



#### **CAUTION** Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

#### **CAUTION**

##### Possible Equipment Damage!

Exercise extreme care when handling or setting down the rod. Damage to the rod surface may cause unnecessary maintenance and expense.

5. Remove the rod and attached parts from the barrel.

**NOTE:** Cover the barrel opening to avoid contamination.

#### **CAUTION**

##### Possible Equipment Damage!

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

6. Remove the two hydrolock seals from the outside of the piston.

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

7. Remove the setscrew securing the piston to the rod.
8. Unscrew the piston from the rod.
9. Remove the T-seal from the inside of the piston.
10. Remove the head from the rod. Remove the O-ring and the backup ring from the outside of the head. Remove the wear rings, the buffer seal, the deep Z rod seal, backup ring, and the wiper ring from the inside of the head.
11. Remove and discard the two threaded inserts from the head.
12. Remove the head retainer ring from the rod.

#### Inspection

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.
2. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
3. Check piston for damage. If piston is damaged, determine if it can be repaired or must be replaced.
4. Inspect rod for straightness. Determine if it can be straightened or must be replaced.

#### **CAUTION**

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

5. Stone out minor blemishes and polish with a fine crocus cloth.
6. Clean with solvent and dry with compressed air any parts that have been stoned and polished.

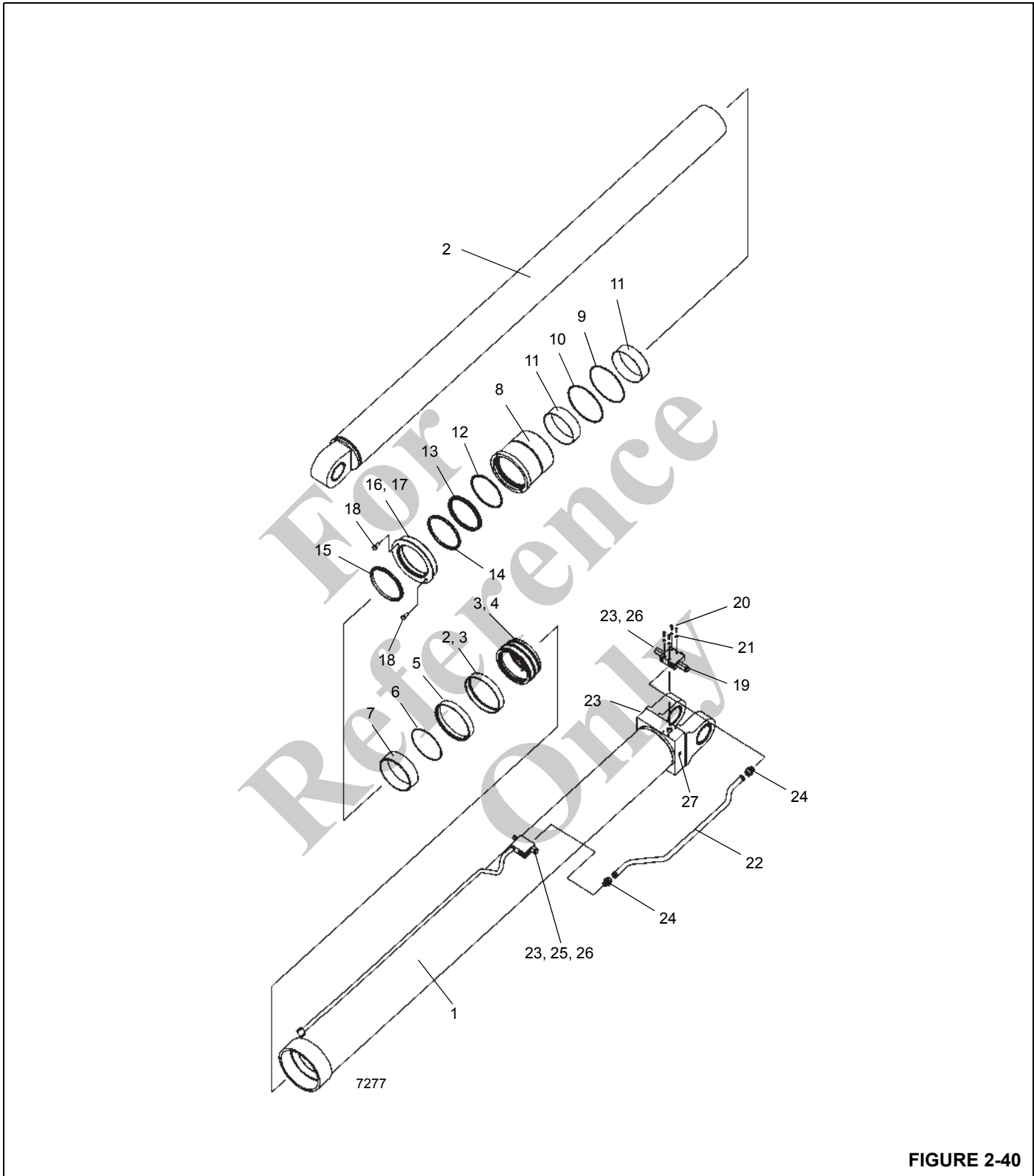


FIGURE 2-40



Item	Description
1	Barrel
2	Rod
3	Piston
4	Setscrew
5	Piston Seal
6	T-Seal
7	Spacer
8	Cylinder Head
9	O-ring
10	Backup Ring
11	Wear Ring
12	Buffer Seal Assembly
13	Rod Seal
14	Backup Ring
15	Wiper Ring
16	Retainer Ring
17	Insert
18	Socket Head Capscrew
19	Holding Valve
20	Capscrew
21	Flatwasher
22	Tube Assembly
23	Plug
24	Adapter
25	Plug
26	Plug
27	Grease Fitting

**Assembly**

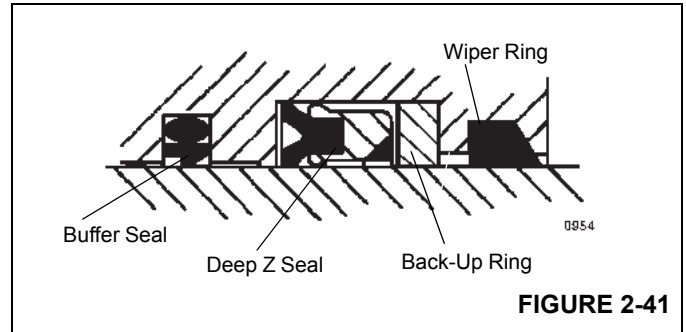
**CAUTION**

**Possible Equipment Damage!**

When installing new seals and rings, avoid stretching seals or scratching the grooved or gland surfaces. Make sure parts are clean before and during assembly. Make sure seals and rings are installed in the proper order.

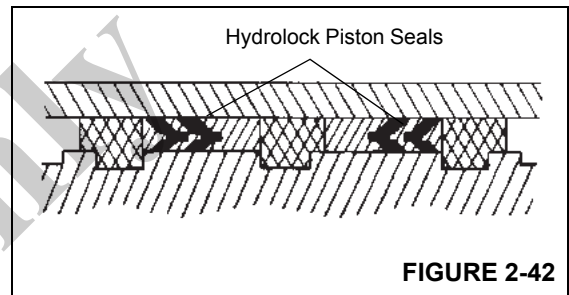
**NOTE:** Lubricate seals and rings with clean hydraulic oil.

1. Install head retainer ring on rod.
2. Install two new threaded inserts into head.



**FIGURE 2-41**

3. Install the replacement wear rings, buffer seal, deep Z rod seal, backup ring, and wiper ring Figure 2-41 in the inside of the head. Make sure the buffer seal's step is closer to the deep Z rod seal. Make sure the deep Z rod seal's rim groove is closer to the buffer seal.
4. Install the replacement o-ring and the backup ring on the outside of the head.
5. Install the replacement T-seal in the inside of the piston.
6. Lubricate the rod with clean hydraulic oil.
7. Slide the head, wiper ring end first, onto the rod.
8. Screw the piston onto the rod tightly. Secure the piston with the set screw.



**FIGURE 2-42**

9. Install the replacement hydrolock seals Figure 2-42 on the outside of the piston. Make sure the "vees" on the two hydrolock seals point at each other.
10. Lubricate all parts freely with clean hydraulic oil.

**CAUTION**

**Possible Equipment Damage!**

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

11. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
12. Install new gasket material to the cylinder head retainer ring flange as follows.

- a. Clean the barrel and retainer ring with Loctite cleaning solvent 7070 or similar non-chlorinated solvent.
  - b. Apply a light coating of Loctite primer N7649 to both surfaces. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
  - c. Apply gasket material Loctite Master Gasket 518 to one surface. Partial cure is obtained in four hours, with full cure in 48 hours.
13. Screw the head retainer ring into the barrel and align holes in retainer ring with holes in head. Install and tighten two socket head capscrews. Re-torque after completion of cylinder hydraulic test procedure.
  14. Using a spanner wrench or chain wrench, continue to screw the retainer ring/head into place in the barrel.
  15. Position the holding valve on the cylinder barrel and secure with the capscrews and flatwashers. Connect tubing to holding valve.

**CAUTION****Flying Parts Hazard!**

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

- 
16. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 4500 psi (31026 kPa). Check for proper operation and any leakage. Make repairs as needed.

For  
Reference  
Only

## DUAL ROD TELESCOPE CYLINDER

### Description

The boom dual rod telescope cylinder (upper telescope cylinder) Figure 2-45 has a 9.25 in (235 mm) bore. The cylinder is internally ported (rod ported). Oil from the telescope control valve is routed to the cylinder by external lines. Foreign material is prevented from entering the cylinder rod during retraction by a wiper seal in the head. O-ring seals prevent internal and external leakage.

The retracted length of the telescope cylinder is 36 ft 1.24 in (11.005 m). The cylinder incorporates two cylinder rods; each rod has a stroke of 29 ft 5 in (8.966 m) which provides a combined overall stroke of 58 ft 10 in (17.932 m). This gives the cylinder an overall extended length of 94 ft 11 in (28.931 m) from the end of the cylinder barrel to the center of the attachment fittings on the cylinder rod.

### CAUTION

Do not retract the cylinder completely if it is not attached to the boom. Install a spacer, that is split or hinged, 6.88 in long to prevent the cylinder from retracting completely.

The cylinder weighs approximately 4345 lb (1971 kg) wet.

### Maintenance

#### Disassembly

**NOTE:** Any maintenance requiring disassembly of the cylinder should include replacement of all cylinder seals and O-rings.

- Using a spanner wrench, unscrew the outer cylinder head from the cylinder barrel.



### CAUTION Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

### CAUTION

#### Possible Equipment Damage!

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

- Remove the cylinder rod assembly from the cylinder barrel and cover the barrel to avoid contamination.

### CAUTION

#### Possible Equipment Damage!

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

**NOTE:** Aligning discarded seals and rings in the order of disassembly will facilitate installation of new seals and rings.

- Remove the hydrolock piston seal to gain access to the setscrew securing the piston to the outer cylinder rod.
- Remove the setscrew and unscrew the piston from the cylinder rod.
- Remove the remaining hydrolock seal from the outside of the piston and the O-ring and two backup rings from the inside of the piston.
- Remove the spacer from the rod and remove the wear ring from the spacer.
- Remove the cylinder head from the outer rod.
- Remove the O-ring and backup ring from the outside of the head and the wear rings, buffer seal, deep Z rod seal, and the wiper ring from the inside of the head.
- Using a spanner wrench, unscrew the inner cylinder head from the outer cylinder rod.

### CAUTION

#### Possible Equipment Damage!

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

- Remove the inner cylinder rod assembly from the outer cylinder rod and cover the opening to avoid contamination.
- Remove the hydrolock piston seal to gain access to the setscrew securing the piston to the inner cylinder rod.
- Remove the setscrew and unscrew the piston from the cylinder rod.
- Remove the remaining hydrolock seal from the outside of the piston and the O-ring and two backup rings from the cylinder rod.
- Remove the spacer from the rod and remove the wear ring from the spacer.
- Remove the cylinder head from the inner rod.
- Remove the O-ring and backup ring from the outside of the head and the wear rings, buffer seal, deep Z rod seal, and the wiper ring from the inside of the head.

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

**Inspection**

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

**CAUTION**

**Possible Equipment Damage!**

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

2. Stone out minor blemishes and polish with fine crocus cloth.
3. Clean all parts with solvent and dry with compressed air any parts that have been stoned and polished.
4. Inspect the barrel for scoring.

**Assembly**

1. If removed, install the holding valves. Refer to *Holding Valves*, page 2-51.

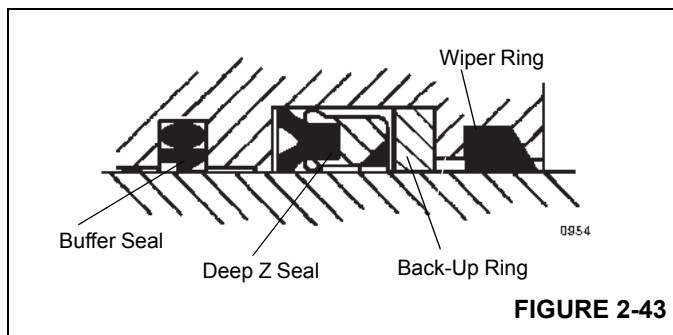
**CAUTION**

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

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

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

2. Install the wiper ring into the cylinder head.
3. Install the wear rings into the head.

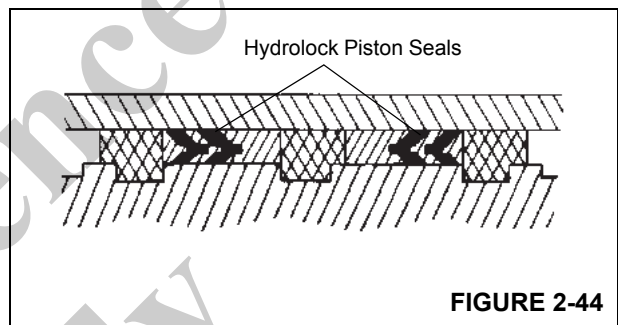


**FIGURE 2-43**

**CAUTION**

Improper seal installation can cause faulty cylinder operation.

4. Install the buffer seal and deep Z rod seal inside the head ensuring the seals are assembled properly and installed in the correct direction.
5. Install the O-ring and backup ring onto the outside of the head.
6. Install the inner cylinder head onto the inner cylinder rod.
7. Install the wear ring onto the spacer and install the spacer onto the rod.
8. Install the O-ring and backup rings onto the rod and install the piston onto the inner cylinder rod. Secure the piston in place with the setscrew.



**FIGURE 2-44**

9. Install the hydrolock seals onto the piston. Refer to Figure 2-44 for proper seal orientation.

**CAUTION**

**Possible Equipment Damage!**

Avoid scratching or damaging the grooved and gland surfaces or the seals and rings.

10. Lubricate the inner cylinder rod assembly with clean hydraulic oil and install the rod assembly into the outer cylinder rod with a slight twisting motion.
11. Using a spanner wrench, secure the inner cylinder head to the outer cylinder rod.
12. Install the wiper ring into the outer cylinder head.
13. Install the wear rings into the head.

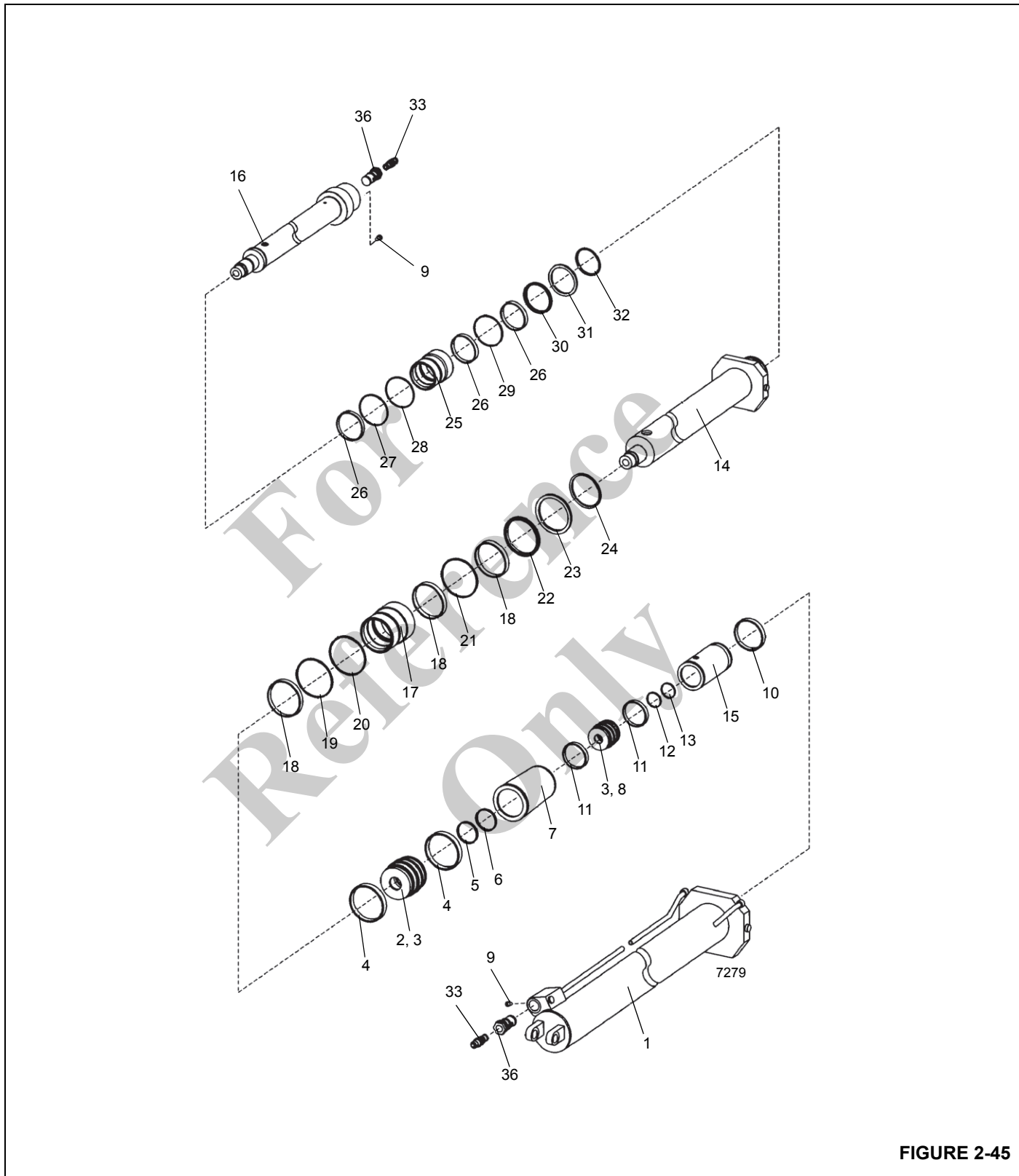


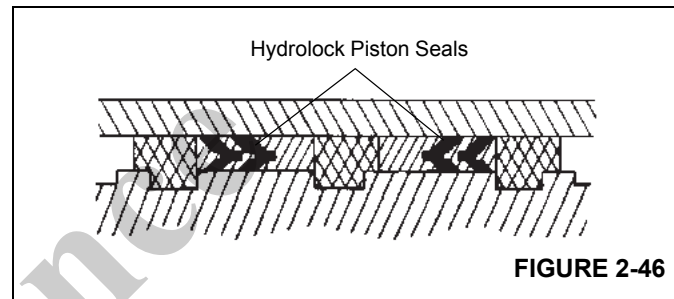
FIGURE 2-45

Item	Description
1	Barrel
2	Piston
3	Setscrew
4	Seal
5	Backup Ring
6	O-ring
7	Spacer
8	Piston
9	Plug
10	Wear Ring
11	Seal
12	O-ring
13	Backup Ring
14	Outer Rod
15	Spacer
16	Inner Rod
17	Outer Cylinder head
18	Wear Ring
19	O-ring
20	Backup Ring
21	Buffer Seal
22	Rod Seal
23	Backup Ring
24	Wiper Ring
25	Inner Cylinder Head
26	Wear Ring
27	O-ring
28	Backup Ring
29	Buffer Seal
30	Rod Seal
31	Backup Ring
32	Wiper Ring
33	Counterbalance Valve
34	Adapter

**CAUTION**

Improper installation of seals could cause faulty cylinder operation.

14. Install the buffer seal and deep Z rod seal inside the head ensuring the seals are assembled properly and installed in the correct direction.
15. Install the O-ring and backup ring onto the outside of the outer cylinder head.
16. Install the outer cylinder head onto the outer cylinder rod.
17. Install the wear ring onto the spacer and install the spacer onto the rod.
18. Install the O-ring and backup rings into the piston and install the piston onto the outer cylinder rod. Secure the piston in place with the setscrew.



19. Install the hydrolock seals onto the piston. Refer to Figure 2-46 for proper seal orientation.

**CAUTION**

**Possible Equipment Damage!**

Avoid scratching or damaging the grooved or gland surfaces or the ring and seals.

20. Lubricate the outer cylinder rod assembly with clean hydraulic oil and install the rod assembly into the cylinder barrel with a slight twisting motion.
21. Using a spanner wrench, secure the outer cylinder head to the cylinder barrel.



**CAUTION**

**Flying Parts Hazard!**

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

22. Pressurize and cycle the cylinder with hydraulic oil pressure. Test pressure should be 5250 psi (36197.4 kPa) (rod side pressure) and 3500 psi (24131.6 kPa) extended (piston side pressure). Check for proper operation and any leakage.

## UPPER TELESCOPE CYLINDER

### Description

The upper boom telescope cylinder Figure 2-47 has a 7.5 in (190.5 mm) bore and is internally ported (rod ported). Oil from the telescope control valve is routed to the cylinder by external lines. Foreign material is prevented from entering the cylinder during rod retraction by a wiper ring in the head and O-ring seals prevent internal and external leakage. The retracted length of the upper telescope cylinder is 34 ft 9.5 in (10.6045 m) and an extended length of 64 ft 5.25 in (19.64055 m) from the end of the barrel to the end of the port block on the rod.

The cylinder weighs 2022 lb (921.4 kg).

### Maintenance

#### Disassembly

**NOTE:** Replace all cylinder seals and O-rings with new ones anytime the cylinder is disassembled.

1. Using a chain wrench, unscrew the cylinder head from the cylinder barrel.



#### **CAUTION** Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

#### **CAUTION**

##### **Possible Equipment Damage!**

Do not damage the cylinder rod chrome surface.

2. Remove the cylinder rod assembly from the cylinder barrel and cover the barrel to avoid contamination.

#### **CAUTION**

##### **Possible Equipment Damage!**

Do not scratch the grooved and gland surfaces.

**NOTE:** Align old seals in order of removal to facilitate installation of new seals.

3. Remove the guide lock ring at the top of the piston to gain access to the setscrew securing the piston to the cylinder rod.
4. Remove the set screw and discard.
5. Unscrew the piston from the rod.
6. Remove the remaining guide lock ring and hydrolock seal assembly from the outside of the piston.
7. Remove the O-ring and backup rings from the inside of the piston.
8. Remove the spacer from the rod.
9. Remove the cylinder head from the rod.
10. Remove the O-ring and backup ring from the outside of the cylinder head.
11. Remove the wear ring, buffer seal, deep Z rod seal and wiper ring from the inside of the head.

#### Inspection

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.
2. Stone out minor blemishes and polish with fine crocus cloth.
3. Clean with solvent and dry with compressed air parts that have been stoned and polished.
4. Inspect the barrel for scoring.

#### Assembly

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

#### **CAUTION**

##### **Possible Equipment Damage!**

Do not scratch the grooved and gland surfaces or damage the seals and O-rings.

**NOTE:** Lubricate new seals and rings with clean hydraulic oil. Orient wear ring gaps 180° apart.

2. Install the wiper ring and wear ring on the inside of the cylinder head.
3. Install the buffer seal assembly and deep Z rod seal inside the head. Make sure the seals are properly assembled and installed in the correct direction.

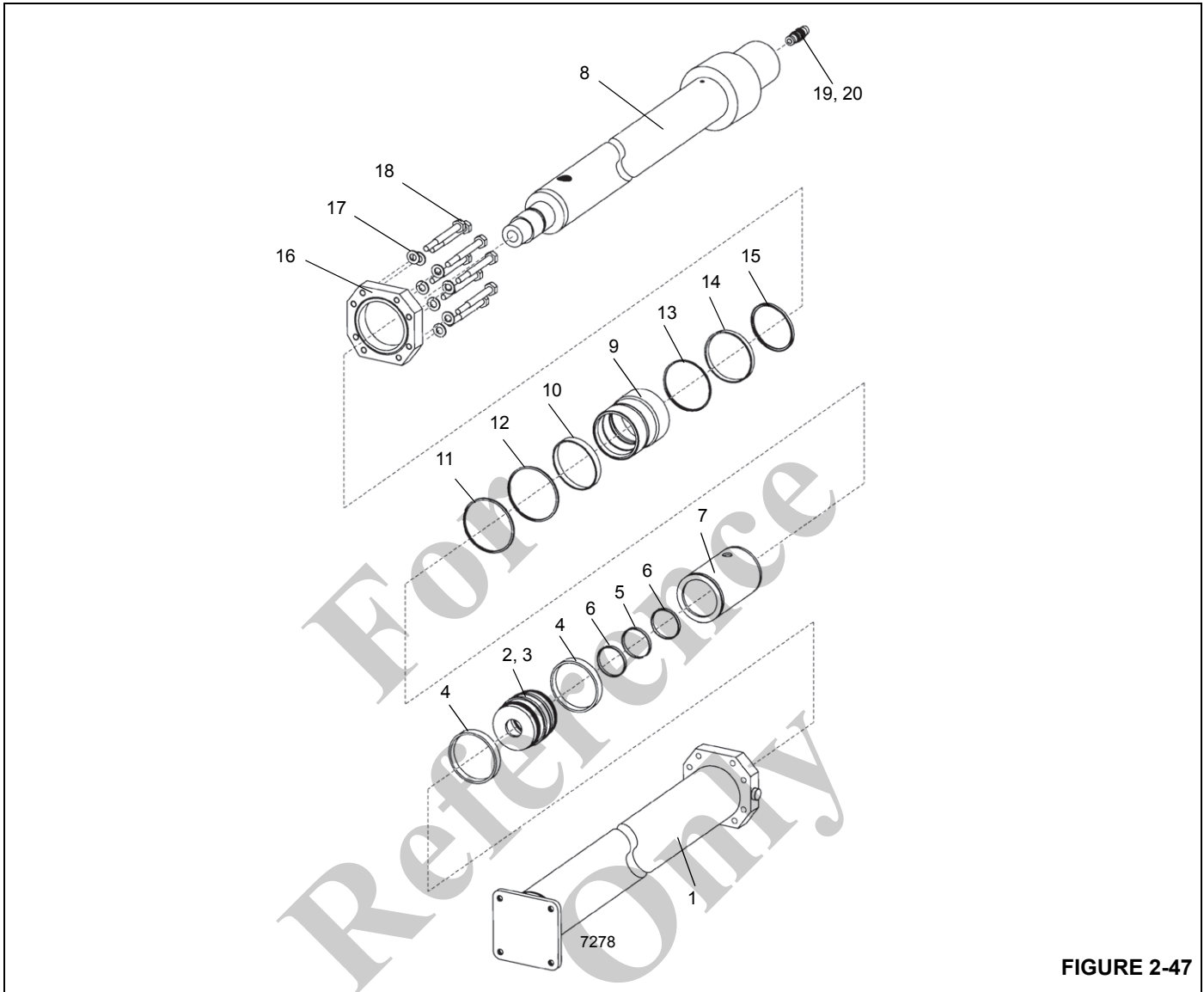
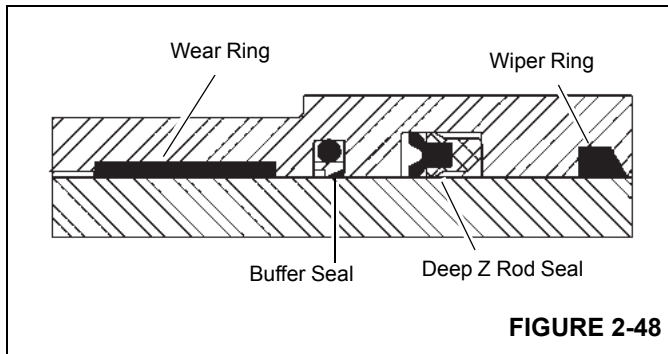


FIGURE 2-47

Item	Description
1	Barrel
2	Piston
3	Setscrew
4	Seal
5	O-ring
6	Backup Ring
7	Spacer
8	Rod
9	Head
10	Wear Ring

Item	Description
11	O-ring
12	Backup Ring
13	Buffer Seal
14	Rod Seal
15	Wiper Ring
16	Head Plate
17	Washer
18	Capscrew
19	Counterweight Valve
20	Adapter





4. Install the low temperature O-ring and backup rings onto the outside of the head.
5. Install the cylinder head onto the cylinder rod.
6. Install the spacer onto the cylinder rod.

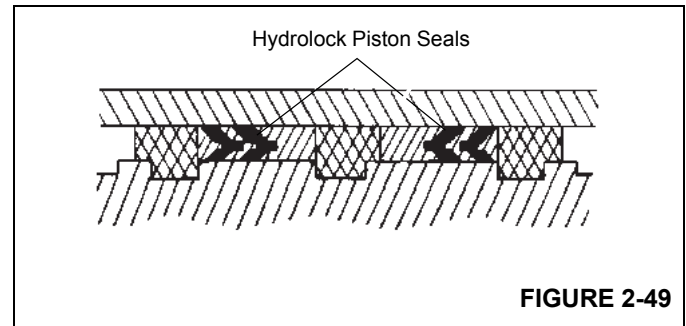
### CAUTION

Improper seal installation could cause faulty cylinder operation.

7. Install the O-ring and backup rings into the inside of the piston.

**NOTE:** Use a new self-locking soft-tip setscrew.

8. Screw the piston onto cylinder rod and secure with a new setscrew.
9. Install the guide lock rings and hydrolock seals onto the outside of the piston. Refer to Figure 2-49.



### CAUTION

#### Possible Equipment Damage!

Do not scratch the grooved and gland surfaces or damage the seals and O-rings.

10. Clean all oil from the threads of the cylinder head and apply Loctite #290 to the threads.
11. Lubricate the piston seals and cylinder head O-ring with clean hydraulic oil and install the rod assembly into the cylinder barrel with a slight twisting motion.
12. Using a chain wrench, secure the cylinder head to the cylinder barrel.



### CAUTION

#### Flying Parts Hazard!

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

13. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 5250 psi (36197.4 kPa) retracted (rod side pressure) or 3750 psi (25855.3 kPa) extended (piston side pressure). Check for proper operation and any leakage. Make repairs as needed.

## AXLE OSCILLATION LOCKOUT CYLINDER

### Description

The two oscillation lockout cylinders Figure 2-50 each have 7 in (177.8 mm) diameter bores. The retracted length of each cylinder is 26.31 in (671.6 mm) from the center of the lug holes to the center of the barrel bushing. The extended length of each cylinder from the center of the lug holes to the center of the barrel bushing is 34 in (866.1 mm). Its stroke is 7.62 in (193.5 mm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 192.0 lb (87.1 kg).

### Maintenance

#### Disassembly

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

1. Using a chain wrench, unscrew the head from the barrel.



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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

### CAUTION

#### Possible Equipment Damage!

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

2. Remove the rod and attached parts from the barrel.

**NOTE:** Cover the barrel opening to avoid contamination.

### CAUTION

#### Possible Equipment Damage!

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

3. Remove the seal and wear rings from the outside of the piston.

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

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

#### Inspection

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.
2. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
3. Check rod's piston area for damage. If it is damaged, determine if it can be repaired or must be replaced.
4. Inspect rod for straightness. Determine if it can be straightened or must be replaced.

### CAUTION

#### Possible Equipment Damage!

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

5. Stone out minor blemishes and polish with a fine crocus cloth.
6. Clean with solvent and dry with compressed air any parts that have been stoned and polished.

#### Assembly

### CAUTION

When installing new seals and rings, avoid stretching seals or scratching the grooved or gland surfaces. Make sure parts are clean before and during assembly. Make sure seals and rings are installed in the proper order.

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

1. Install the replacement wiper ring, wear rings, and seal, in the inside of the head.
2. Install the replacement O-ring and the backup ring on the outside of the head.
3. Lubricate the rod with clean hydraulic oil.

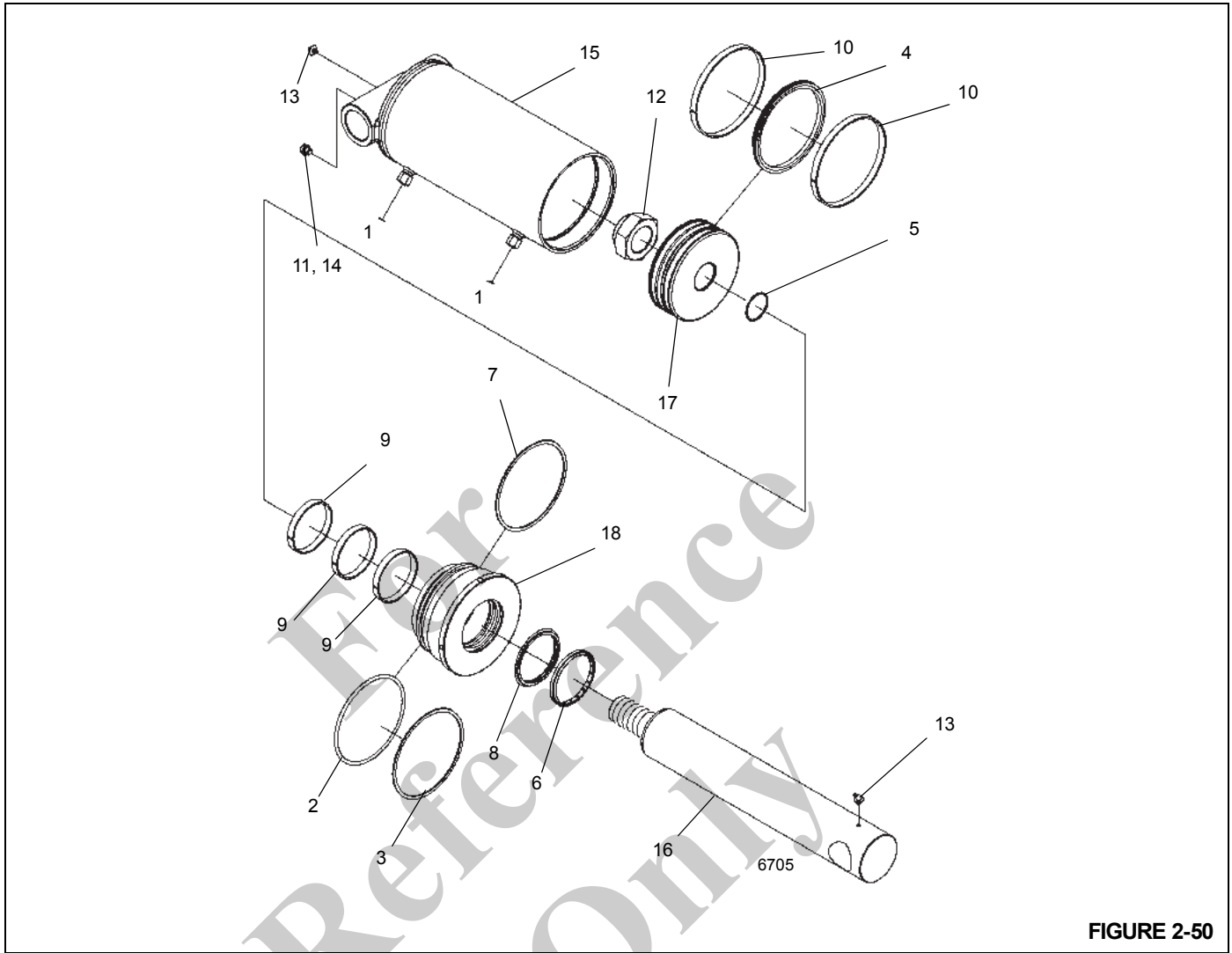


FIGURE 2-50

Item	Description
1	O-ring
2	O-ring
3	Backup Ring
4	Seal
5	O-ring
6	Wiper Ring
7	O-ring
8	Seal
9	Wear Ring

Item	Description
10	Wear Ring
11	Washer
12	Locknut
13	Grease Fitting
14	Plug
15	Barrel
16	Rod
17	Piston
18	Head

4. Install the replacement seal and wear ring on the outside of the piston.
5. Slide the head onto the rod.
6. Lubricate freely all parts with clean hydraulic oil.

---

### CAUTION

#### Possible Equipment Damage!

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

7. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
8. Clean all oil from the threads of the head. Coat the threads with an anti-seize compound (ex: Never-Seez paste lubricant or similar lubricant). Screw the head into place on the barrel tightly so it holds the head's larger OD end flush with the end of the barrel.



### CAUTION

#### Flying Parts Hazard!

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

9. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 3750 psi (25855.3 kPa). Check for proper operation and any leakage. Make repairs as needed.

## STEER CYLINDER

### Description

The steer cylinders Figure 2-51 are mounted on the axles, two cylinders on each axle.

The front and rear steer cylinders each have 3.5 in (8.89 cm) diameter bores. The front and rear steer cylinders each have a retracted length of 28 in (711.2 mm) from bushing center to bushing center. The front and rear steer cylinders each have an extended length of 42.25 in (1073.2 mm) from bushing center to bushing center. Each cylinder has a stroke of 14.25 in (362 mm).

A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 40 lb (20 kg).

### Maintenance

#### Disassembly

**NOTE:** Any maintenance requiring disassembly of the cylinders should include replacement of all seals and rings. A seal kit will supply the required items.

1. Extend the rod until the piston is approximately 4 in (10.2 cm) from fully extended.
2. Using a spanner wrench or chain wrench, unscrew the head from the cylinder barrel.



### CAUTION

#### Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

---

### CAUTION

#### Possible Equipment Damage!

Exercise extreme care when handling or setting down the rod. Damage to the rod surface may cause unnecessary maintenance and expense.

3. Remove rod and attached parts from the barrel.

**NOTE:** Cover the barrel opening to avoid contamination.

**CAUTION****Possible Equipment Damage!**

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

4. Remove the seal and two wear rings from the outside of the piston.

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

5. Loosen and remove the nut securing the piston. Remove the piston from the rod.
6. Remove the O-ring from the inside of the piston.
7. Remove the head from the rod.
8. Remove the O-ring and backup ring from the outside of the head and the wiper ring and rod seal from the inside of the head.

**Inspection**

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.
2. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
3. Check piston for damage. If piston is damaged, determine if it can be repaired or must be replaced.

4. Inspect rod for straightness. Determine if it can be straightened or must be replaced.

**CAUTION****Possible Equipment Damage!**

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

5. Stone out minor blemishes and polish with a fine crocus cloth.
6. Clean with solvent and dry with compressed air any parts that have been stoned and polished.

**Assembly****CAUTION**

When installing new seals and rings, avoid stretching seals or scratching the grooved or gland surfaces. Make sure parts are clean before and during assembly. Make sure seals and rings are installed in the proper order.

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

1. Install the replacement wiper ring and rod seal in the inside of the head. Make sure the lips of the seal face the piston.
2. Install the replacement o-ring and the backup ring on the outside of the head.

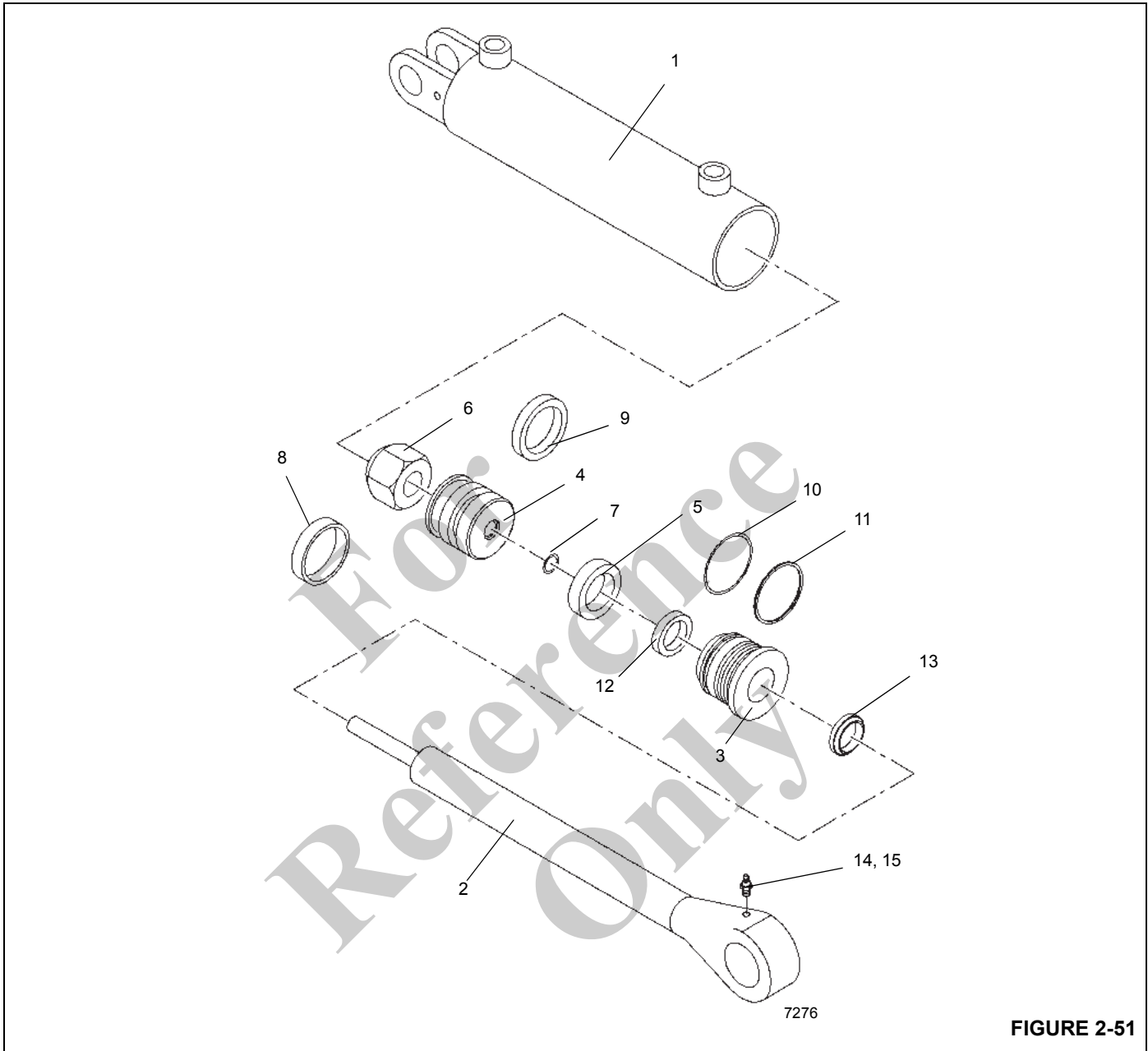


FIGURE 2-51

Item	Description
1	Barrel
2	Rod
3	Head
4	Piston
5	Spacer
6	Nut
7	O-ring
8	Wear Ring

Item	Description
9	Piston Seal
10	O-ring
11	Backup Ring
12	Rod Seal
13	Wiper Ring
14	Grease Fitting
15	Grease Cap

3. Install the replacement o-ring in the inside of the piston.
4. Lubricate the rod with clean hydraulic oil.
5. Slide the head, larger OD end first, onto the rod.
6. Install the piston onto the rod. Secure the piston with the nut.
7. Install the replacement piston seal and wear ring on the outside of the piston.
8. Lubricate all parts freely with clean hydraulic oil.
9. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
10. Thread the head into the barrel and using a spanner wrench or chain wrench, tighten the head.

---

**CAUTION****Possible Equipment Damage!**

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

---

**CAUTION****Flying Parts Hazard!**

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

---

11. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 3500 psi (24131.6 kPa). Check for proper operation and any leakage. Make repairs as needed.

For Reference Only

## OUTRIGGER EXTENSION CYLINDER

### Description

The four extension cylinders have 2.5 in (63.5 mm) diameter bores.

Each cylinder Figure 2-52 has a retracted length of 9 ft 0.88 in (2.7655 m) from the center of the rod bushing to the center of the barrel bushing. Each cylinder's extended length is 17 ft 1.9 in (5.2293 m). The stroke of each cylinder is 8 ft 1 in (2.44 m).

A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 104.9 lb (47.6 kg).

### Maintenance

#### Disassembly

**NOTE:** Any maintenance requiring disassembly of the cylinders should include replacement of all seals and rings. A seal kit will supply the required items.



#### **CAUTION** Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

#### **CAUTION**

##### Possible Equipment Damage!

Exercise extreme care when handling or setting down the rod. Damage to the rod surface may cause unnecessary maintenance and expense.

1. Loosen the head's setscrew. Using a chain wrench, unscrew the head from the barrel.
2. Rapidly pull the rod against the head to free it. Remove rod and attached parts from the barrel.

**NOTE:** Cover the barrel opening to avoid contamination.

#### **CAUTION**

##### Possible Equipment Damage!

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

3. Remove the wear rings and piston seal from the outside of the piston.

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

4. Remove the head from the rod.
5. Remove the O-ring and backup ring from the outside of the head and the wear ring, rod seal and wiper ring from the inside of the head.

#### Inspection

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.
2. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
3. Check rod's piston area for damage. If it is damaged, determine if it can be repaired or must be replaced.
4. Inspect rod for straightness. Determine if it can be straightened or must be replaced.

#### **CAUTION**

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

5. Stone out minor blemishes and polish with a fine crocus cloth.
6. Clean with solvent and dry with compressed air any parts that have been stoned and polished.

#### Assembly

#### **CAUTION**

When installing new seals and rings, avoid stretching seals or scratching the grooved or gland surfaces. Make sure parts are clean before and during assembly. Make sure seals and rings are installed in the proper order.

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

1. Install the replacement wear ring, rod seal and wiper ring in the inside of the head. Make sure the rod seal's rim groove is closer to the wear ring.
2. Install the replacement O-ring and the backup ring on the outside of the head.
3. Lubricate the rod with clean hydraulic oil.
4. Slide the head, wear ring end first, onto the rod.



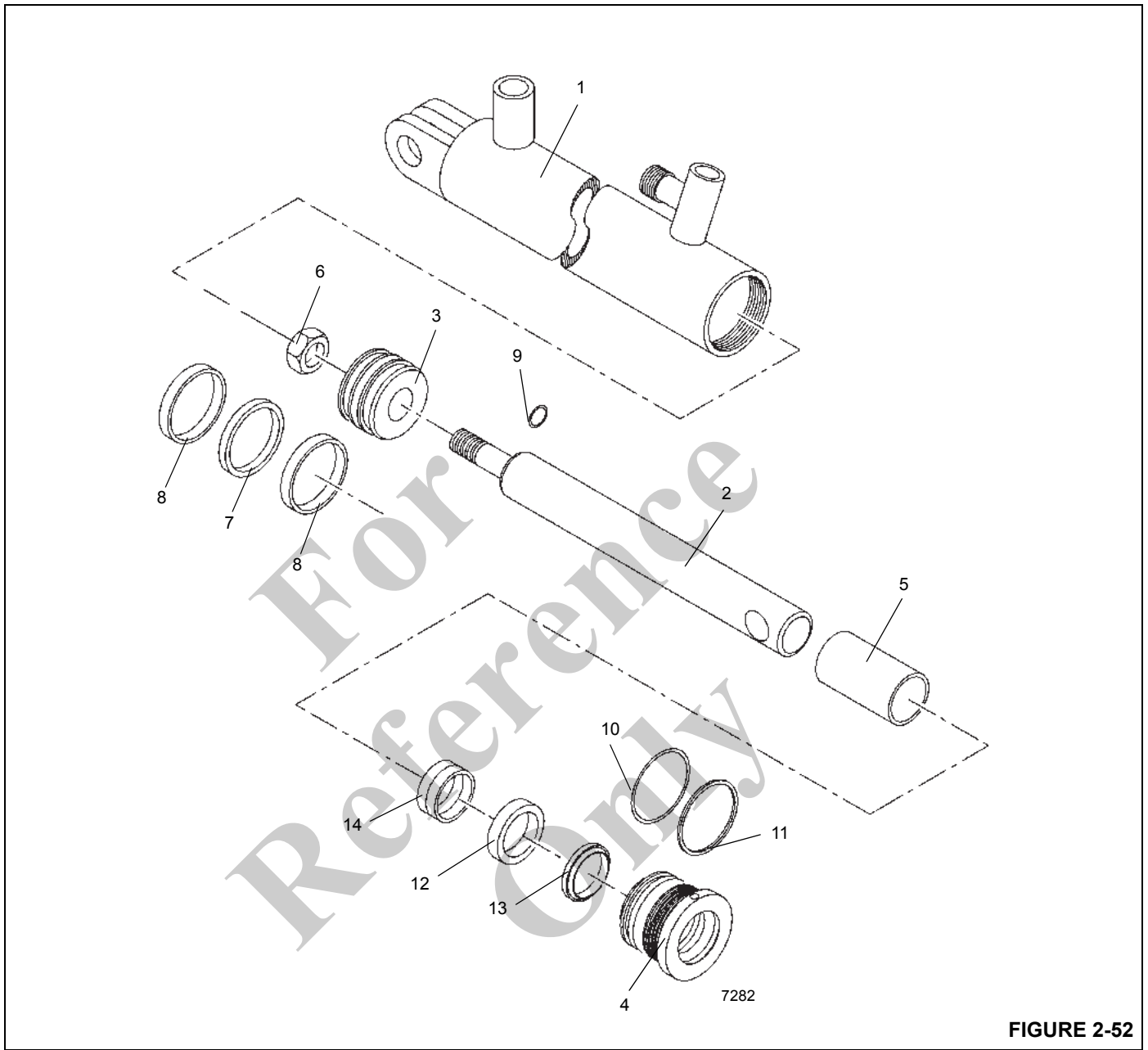


FIGURE 2-52

Item	Description
1	Barrel
2	Rod
3	Piston
4	Head
5	Spacer
6	Nut
7	Piston Seal
8	Wear Ring

Item	Description
9	O-ring
10	O-ring
11	Backup Ring
12	Rod Seal
13	Wiper Ring
14	Wear Ring
15	Grease Cap

5. Install the replacement wear rings and seal on the outside of the piston.
6. Lubricate all parts freely with clean hydraulic oil.

---

### CAUTION

#### Possible Equipment Damage!

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

7. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
8. Push the head into the barrel.
9. Using a chain wrench, screw the head into the barrel. Tighten the head's setscrew.



### CAUTION

#### Flying Parts Hazard!

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 3000 psi (20684 kPa). Check for proper operation and any leakage. Make repairs as needed.

## OUTRIGGER STABILIZER CYLINDER

### Description

The four outrigger stabilizer cylinders each have a hollow rod for internal porting Figure 2-53. Each cylinder has a 6.5 in (165.1 mm) diameter bore. A port block is welded to the rod of each cylinder and a pilot operated check valve is threaded into each port block.

The retracted length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 55.75 in (1416 mm). The extended length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 88 in (2235.2 mm). Its stroke is 32.25 in (819.2 mm).

A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 220.4 lb (100 kg).

## Maintenance

### Disassembly

**NOTE:** Any maintenance requiring disassembly of the cylinders should include replacement of all seals and rings. A seal kit will supply the required items.

1. Remove the check valve from the port block.
2. Loosen the head's setscrew. Using a chain wrench, unscrew the head from the barrel.



### CAUTION

#### Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

---

### CAUTION

#### Possible Equipment Damage!

Exercise extreme care when handling or setting down the rod. Damage to the rod surface may cause unnecessary maintenance and expense.

3. Remove the rod and attached parts from the barrel.

**NOTE:** Cover the barrel opening to avoid contamination.

---

### CAUTION

#### Possible Equipment Damage!

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

4. Remove a hydrolock seal from the outside of the piston to gain access to the set screw.

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

5. Remove the piston's set screw. Unscrew the piston from the rod.
6. Remove the other hydrolock seal from the outside of the piston.
7. Remove the O-ring and the two backup rings from the inside of the piston.
8. Remove the spacer from the rod.

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

**Inspection**

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.
2. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
3. Check piston for damage. If piston is damaged, determine if it can be repaired or must be replaced.

4. Inspect rod for straightness. Determine if it can be straightened or must be replaced. Verify internal passages and ports are clean and undamaged.

**CAUTION**

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

5. Stone out minor blemishes and polish with a fine crocus cloth.
6. Clean with solvent and dry with compressed air any parts that have been stoned and polished.

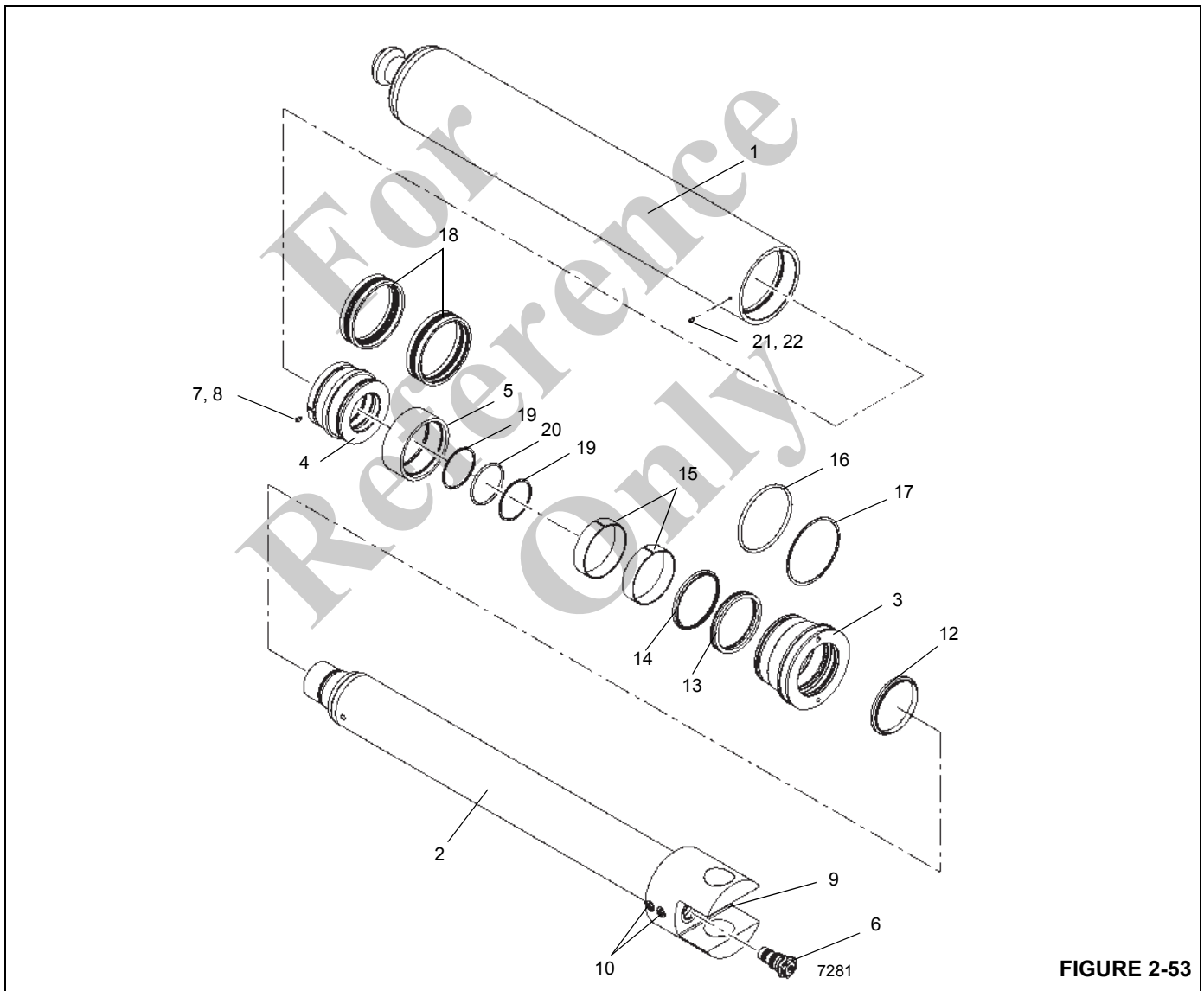


FIGURE 2-53

Item	Description
1	Barrel
2	Rod
3	Head
4	Piston
5	Spacer
6	Check Valve
7	Setscrew
8	Insert
9	Plug
10	Plug
11	Wiper Ring

Item	Description
12	Rod Seal
13	Buffer Seal
14	Wear Ring
15	O-ring
16	Backup Ring
17	Seal
18	O-ring
19	Backup Ring
20	Setscrew
21	Insert

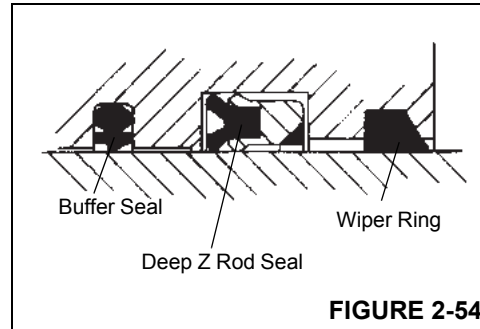
**Assembly**

**CAUTION**

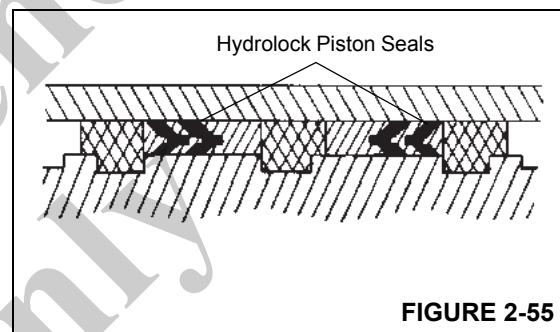
When installing new seals and rings, avoid stretching seals or scratching the grooved or gland surfaces. Make sure parts are clean before and during assembly. Make sure seals and rings are installed in the proper order.

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

Make sure the gaps of the two wear rings are 180 degrees apart.



1. Install the replacement wear rings, buffer seal, rod seal and wiper ring in the inside of the head Figure 2-54. Make sure the buffer seal's step is away from the wear rings. Make sure the deep Z rod seal rim groove is closer to the wear rings.
2. Install the replacement O-ring and the backup ring on the outside of the head.
3. Install the replacement O-ring and backup rings in the inside of the piston.



4. Install one replacement hydrolock seal on the outside of the piston Figure 2-55. Leave the other hydrolock seal off for now so there is still access to the piston's set screw hole.
5. Lubricate the rod with clean hydraulic oil.
6. Slide the head, larger OD end first, onto the rod.
7. Slide the spacer onto the rod.
8. Screw the piston onto the rod until it can go no farther. Hold the piston in place with the set screw.
9. Install the other replacement hydrolock seal on the outside of the piston over the set screw. Make sure the "vees" on the two hydrolock seals point at each other.
10. Lubricate all parts freely with clean hydraulic oil.

**CAUTION****Possible Equipment Damage!**

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

11. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
12. Clean all oil from the threads of the head. Coat the threads with an anti-seize compound (Never-Seez paste lubricant or similar lubricant). Using a chain wrench, screw the head into place on the barrel so its larger OD end is flush with the end of the barrel.
13. Check the inside of the port block for any sharp edges or burrs and remove as necessary with emery cloth.
14. Install new O-rings onto the check valve.
15. Lubricate the check valve and O-rings with clean hydraulic oil.

**CAUTION****Possible Equipment Damage!**

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

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

16. Carefully install the check valve into the port block until fully seated.

**CAUTION****Flying Parts Hazard!**

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

17. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 5250 psi (3620 kPa). Check for proper operation and any leakage. Make repairs as needed.

**TILT CYLINDER****Description**

The tilt cylinder Figure 2-56 installed beneath the cab has a 2.5 in (6.3 cm) diameter bores.

The cylinder has a retracted length of 20.94 in (53.1 cm) and an extended length of 29.19 in (74.1 cm) from bushing center to bushing center. Each cylinder has a stroke of 8.25 in (20.9 cm).

A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 19.9 lb (9.07 kg).

**Maintenance****Disassembly**

**NOTE:** Any maintenance requiring disassembly of the cylinders should include replacement of all seals and rings. A seal kit will supply the required items.

1. Secure the cylinder in a clean work area by use of clamps or a chain vise to prevent rolling.
2. Retract the cylinder fully to avoid damaging the rod during removal.

**NOTE:** Mark or note the piston and head relationship to the rod and barrel.

3. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.

**CAUTION****Flying Parts Hazard!**

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

**CAUTION****Possible Equipment Damage!**

Exercise extreme care when handling or setting down the rod. Damage to the rod surface may cause unnecessary maintenance and expense.

4. Position the rod mount with the ports facing down.

5. Using a means of collecting the oil, remove the port plugs and allow cylinder to drain.
6. Rapidly pull the rod against the head to free it. Remove rod and attached parts from the barrel. Place the rod on a surface that will not damage the chrome or allow the rod assembly to drop.

**NOTE:** Cover the barrel opening to avoid contamination.

---

### CAUTION

#### Possible Equipment Damage!

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

7. Remove the seal from the outside of the piston.

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

8. Loosen and remove the nut securing the piston. Remove the piston from the rod.
9. Remove the O-ring from the inside of the piston.
10. Remove the head from the rod.
11. Remove the O-ring and backup ring from the outside of the head. Remove the wiper ring and the rod seal from the inside of the head.

### Inspection

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

---

### CAUTION

#### Possible Equipment Damage!

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

2. Stone out minor blemishes and polish with fine crocus cloth.
3. Clean with solvent and dry with compressed air any parts that have been stoned and polished.
4. Inspect the barrel for scoring.

### Assembly

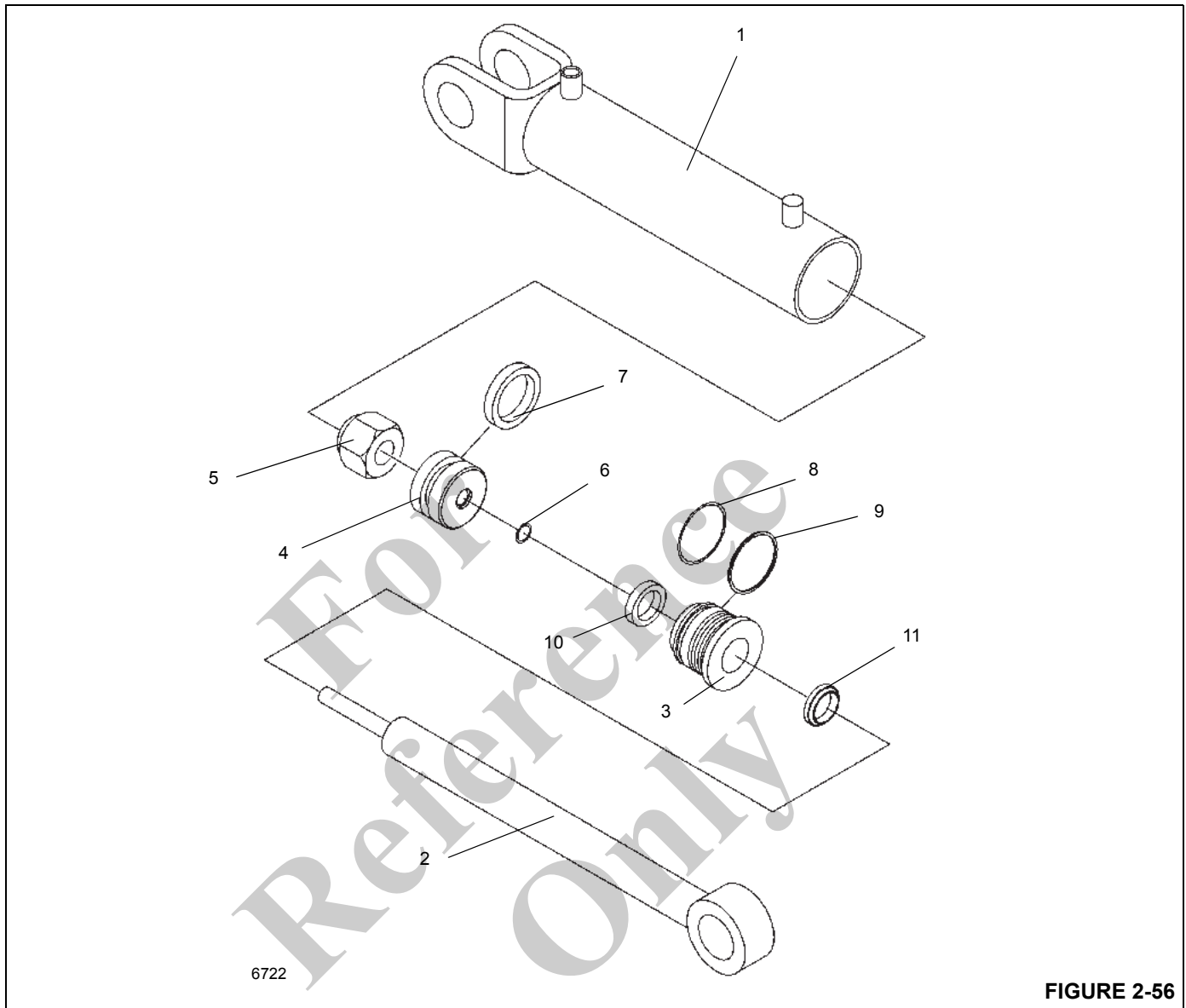
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### CAUTION

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

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

1. Install the replacement wiper ring into the head.
2. Install the rod seal in the inside of the head. Make sure the lips of the seal face the piston.



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FIGURE 2-56

Item	Description
1	Barrel
2	Rod
3	Head
4	Piston
5	Nut
6	O-ring

Item	Description
7	Piston Seal
8	O-ring
9	Backup Ring
10	Rod Seal
11	Wiper Ring

3. Install the O-ring and backup ring onto the outside of the head.
4. Install the O-ring in the inside of the piston.
5. Lubricate the rod with clean hydraulic oil.
6. Slide the head, larger OD end first, onto the rod.
7. Install the piston onto the rod. Secure the piston with the nut. Lubricate the threads and torque the nut  $130 \pm 5$  lb-ft ( $176.2 \pm 6.7$  Nm).
8. Install the seal on the outside of the piston.
9. Lubricate all parts freely with clean hydraulic oil.
10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
11. Push the head into the barrel. Torque the head.

**CAUTION****Flying Parts Hazard!**

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

---

**CAUTION****Possible Equipment Damage!**

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

---

12. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 3000 psi (20,684 kPa). Check for proper operation and any leakage. Make repairs as needed.

For Reference Only



## POWER PIN CYLINDER

### Description

The power pin cylinders Figure 2-56 are installed in the outrigger box assemblies have a 4.0 in (10.1 cm) diameter bores.

The cylinder has a retracted length of 20.31 in (51.5 cm) and an extended length of 26.43 in (67.1cm). Each cylinder has a stroke of 6.12 in (15.5 cm).

A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 60.1 lb (27.3 kg).

### Maintenance

#### Disassembly

**NOTE:** Any maintenance requiring disassembly of the cylinders should include replacement of all seals and rings. A seal kit will supply the required items.

1. Secure the cylinder in a clean work area by use of clamps or a chain vise to prevent rolling.
2. Retract the cylinder fully to avoid damaging the rod during removal.

**NOTE:** Mark or note the piston and head relationship to the rod and barrel.

3. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.



#### **CAUTION** Flying Parts Hazard!

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

Parts can fly from the cylinder at dangerous speeds when using air pressure.

#### **CAUTION**

##### **Possible Equipment Damage!**

Exercise extreme care when handling or setting down the rod. Damage to the rod surface may cause unnecessary maintenance and expense.

4. Position the rod mount with the ports facing down.

5. Using a means of collecting the oil, remove the port plugs and allow cylinder to drain.
6. Remove the setscrew from the flange.
7. Remove rod assembly and attached parts from the barrel. Place the rod on a surface that will not damage the chrome or allow the rod assembly to drop.

**NOTE:** Cover the barrel opening to avoid contamination.

#### **CAUTION**

##### **Possible Equipment Damage!**

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

8. Unscrew the rod end from the rod.
9. Remove the seal and wear rings from the outside of the piston.

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

10. Loosen and remove the nut securing the piston. Remove the piston from the rod.
11. Remove the O-ring from the inside of the piston.
12. Remove the head from the rod.
13. Remove the O-ring, backup ring and wire wrap from the outside of the head.
14. Remove the wiper ring and rod seal from the inside of the head.

#### **Inspection**

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

#### **CAUTION**

##### **Possible Equipment Damage!**

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

2. Stone out minor blemishes and polish with fine crocus cloth.
3. Clean with solvent and dry with compressed air, any parts that have been stoned and polished.
4. Inspect the barrel for scoring.

**Assembly**

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

**CAUTION**

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

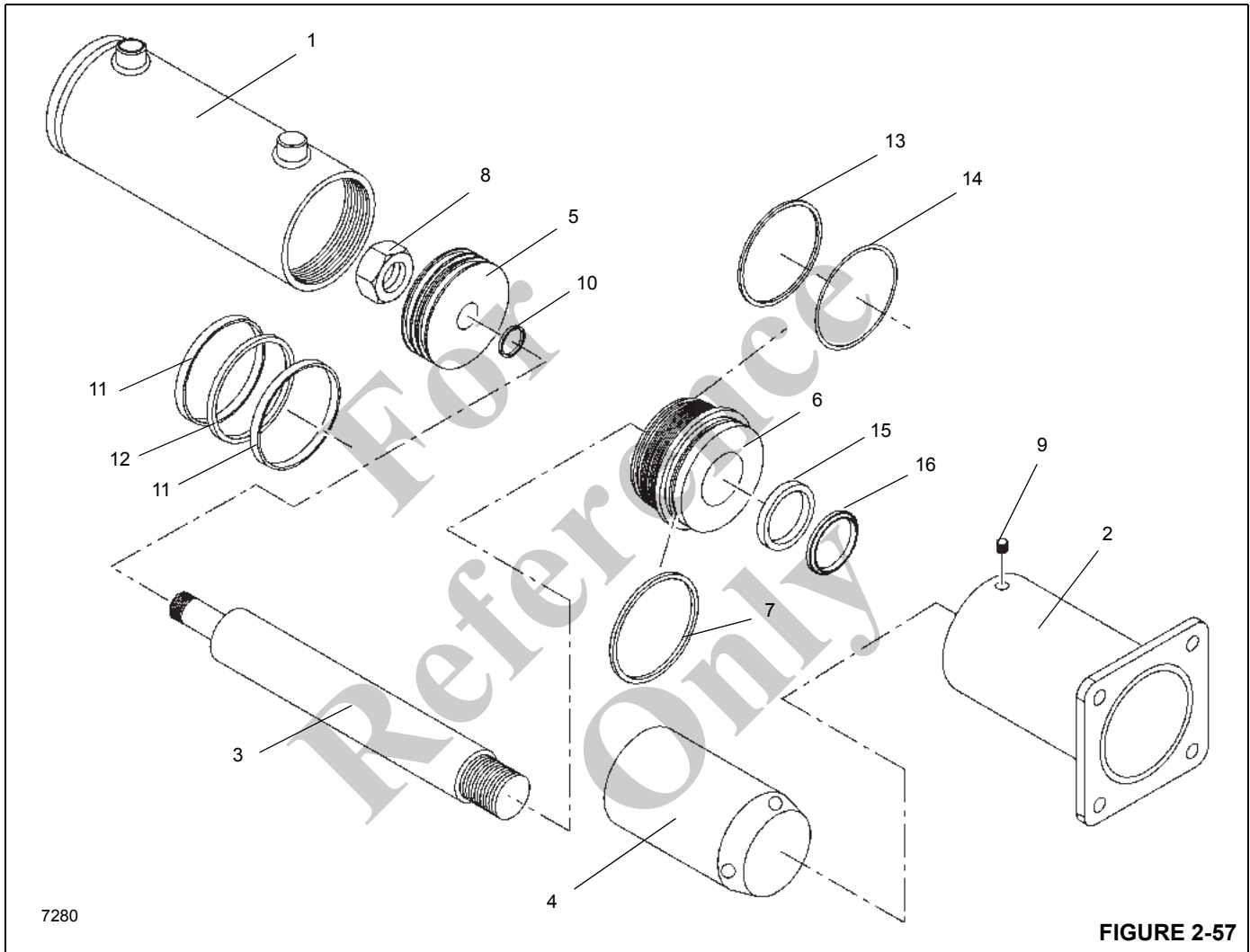


FIGURE 2-57

Item	Description
1	Barrel
2	Flange
3	Rod
4	Rod End
5	Piston
6	Head
7	Wire Wrap
8	Nut

Item	Description
9	Setscrew
10	O-ring
11	Wear Ring
12	Piston Seal
13	O-ring
14	Backup Ring
15	Rod Seal
16	Wiper Ring

1. Install the replacement wiper ring and rod seal into the inside of the head.
2. Install the O-ring, backup ring and wire wrap on the outside of the head.
3. Install the O-ring in the inside of the piston.
4. Lubricate the rod with clean hydraulic oil.
5. Install the head onto the rod. Torque to  $200 \pm 20$  lb-ft ( $271.1 \pm 27.1$  Nm).
6. Install the piston onto the rod. Secure the piston with the nut. Lubricate the threads and torque the nut to  $245 \pm 15$  lb-ft ( $332.1 \pm 20.3$  Nm).
7. Install the seal and wear rings on the outside of the piston.
8. Lubricate all parts freely with clean hydraulic oil.
9. Apply 1/8 bead of Loctite thread adhesive #277 or equivalent across the length of the threads on the rod end side of the rod. Install the rod end on the rod and torque 375 to 450 lb-ft (508.4 to 610.1 Nm).

---

### CAUTION

#### Possible Equipment Damage!

Exercise extreme care when handling the rod. Damage to the rod surface may cause unnecessary maintenance and expense. Also, take care to avoid damaging grooved or gland surfaces or rings or seals during rod insertion.

10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.



### CAUTION

#### Flying Parts Hazard!

Use only a source of controlled hydraulic oil pressure to cycle or pressurize the cylinder.

Parts can fly from the cylinder at dangerous speeds when using air pressure.

11. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 2250 psi (15,513 kPa/15.5 bar). Check for proper operation and any leakage. Make repairs as needed.

## PARK BRAKE CYLINDER

### Description

The park brake cylinder, mounted on the front axle, releases and applies the park brake. The park brake cylinder consists of a hydraulic cylinder and a lever. When the operator positions the Park Brake switch to ON, the park brake solenoid valve de-energizes and closes the valve, removing hydraulic force from the cylinder's piston. This allows the cylinder's spring to extend, retracting the cylinder lever, and applying the park brake to hold the crane in place. When the operator positions the Park Brake switch to OFF, the park brake solenoid valve energizes and opens the valve to apply hydraulic force to the cylinder's piston. This allows the piston to compress the spring, extend the cylinder lever, and release the park brake.

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Reference  
Only*

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## SECTION 3 ELECTRICAL SYSTEM

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### DESCRIPTION

#### General

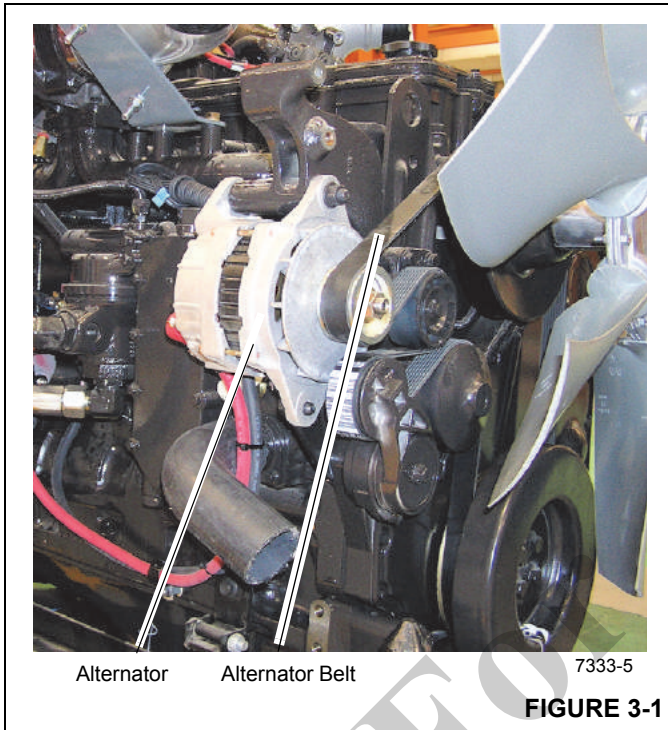
The electrical system is 12-volt negative ground with 12-volt starting, consisting of an alternator and three 12-volt lead-acid batteries. The system is the single wire ground return type, using the machine's structure as ground.

Electrical power is transferred to and from the carrier and superstructure through the electrical swivel. For more detailed information on the electrical swivel, refer to *Section 6 Swivels*, page 6-16.

Refer to the electrical schematic in the back of this manual to aid in troubleshooting an electrical problem.

#### Alternator

The alternator (Figure 3-1) is mounted on the engine and is belt driven. It is a 145 ampere alternator with an integral transformer - rectifier unit. When the engine is running, and the alternator is turning, the alternator's 12-volt output terminal supplies the crane's electrical circuits. The output terminal also supplies the voltage to recharge the batteries and maintains them at a full state of charge.

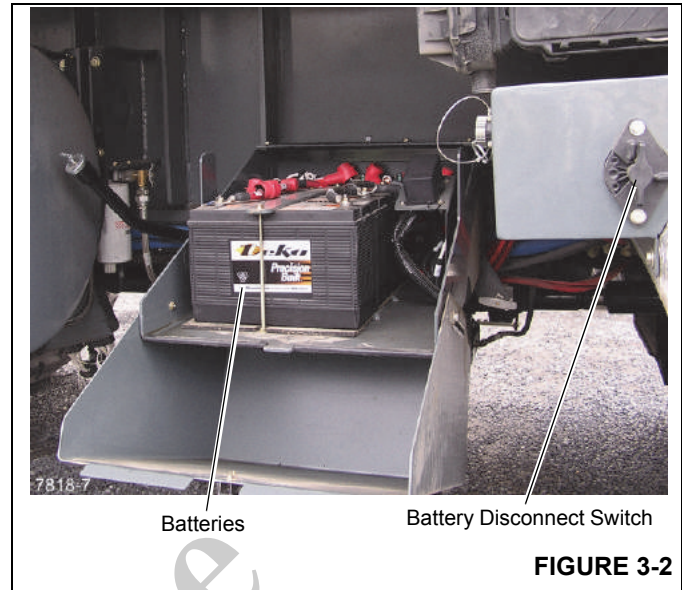


Alternator      Alternator Belt

7333-5  
**FIGURE 3-1**

## Batteries

The batteries (Figure 3-2) are located in the battery box on the left side of the crane behind the fuel tank. Each battery is the maintenance free type and is completely sealed except for a small vent hole in the side. The vent hole allows what small amount of gases that are produced in the battery to escape. On some batteries, a test indicator located on the top of the battery is used to determine if the battery can be tested in case of a starting problem.



Batteries

Battery Disconnect Switch

**FIGURE 3-2**

A battery disconnect switch is located on the right side of the battery box (Figure 3-2). To disconnect the batteries, turn the battery disconnect switch to OFF. Turn the switch to ON to connect the batteries.

## CAUTION

### Possible Equipment Damage!

To avoid possible engine fault codes and undesirable operation, ensure the keyswitch has been off two minutes before disconnecting batteries.

Disconnect batteries, if machine will be inactive for over 24 hours.

## Fuse Panel

**NOTE:** Refer to the electrical schematic in the back of this manual for a diagram of the electrical system.

Most electrical circuits are protected by the components of the relay panel assembly and the fuse panel.

The fuse panel (Figure 3-3 and Figure 3-4) is located behind the seat and contains up to 20 fuses. To gain access to the fuses, remove the snap-on cover. A decal in the cover identifies each fuse and its function.

Fuses 1, 2, 3, 4, 5, 6, 7 and 8 are energized when the battery is connected. When the battery is connected and the ignition switch is in the ignition (run) or accessory power position, fuses 9 to 12 are energized through ACC relay #1 (K1) and 13 to 20 are energized through ACC relay #2 (K2).



S/S CAB FUSES				
F1 5A	F5 7.5A	F9 10A	F13 15A	F17 7.5A
F2 5A	F6 5A	F10 25A	F14 5A	F18 10A
F3 15A	F7 5A	F11 25A	F15 20A	F19 10A
F4 7.5A	F8 5A	F12 25A	F16 7.5A	F20 5A

F1	Ignition, Start
F2	Steering Column Power
F3	Dome Light, Work Lights
F4	Spare (5A Max)
F5	ACC Power Outlet
F6	Ignition Power Out
F7	Engine ECM Ignition Signal
F8	Key Switch Accessory Power
F9	Cab Control Modules
F10	T/T I/O Module
F11	T/T Power Module (Horn, Fan Motor)
F12	T/TPower Module (AC Condenser Motor, Boom Lights, Cwt Removal-Opt)
F13	LMI CPU
F14	Luffing Jib (Option)
F15	Jib Stowage Power (Option)
F16	Spare (5A Max)
F17	Spare (5A Max)
F18	Windshield Wiper
F19	Skylight Wiper
F20	Circulating Fan

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80025951

**FIGURE 3-4**

The following fuse assignments apply:

Fuse 51 (Figure 3-5) protects the charging circuit, fuse 52 protects the power relay in the battery box and line 5 to the swivel.

Fuses 53, 54 and 55 are inside the battery box compartment located behind the fuel tank on the left side of the crane. These fuses protect the superstructure electrical power system (Figure 3-5).

Fuse 56 is located inside the battery box compartment behind the batteries on the left side of crane. This fuse protects the Cummins engine electronic control module (ECM) and carrier control module (CCM).

For machines with the retarder option, a 10A fuse in line 180 protects the retarder circuit parts.

**Relays**

**NOTE:** Refer to the electrical schematic in the back of this manual for a diagram of the electrical system.

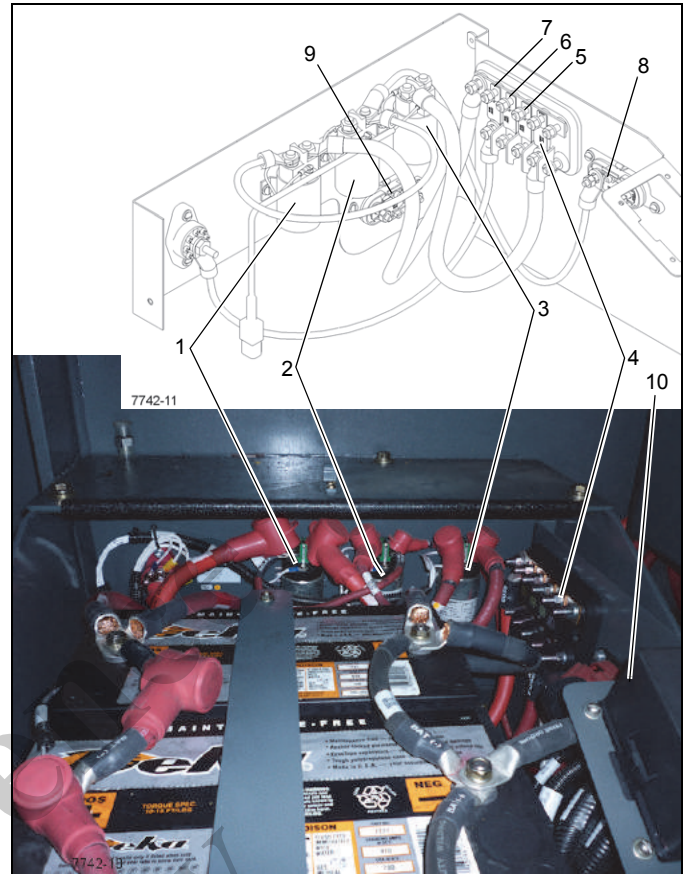
The fuse and relay panel (Figure 3-3) contains 2 relays ACC #1 and ACC #2 (K1 and K2), the cab fuse panel, and a buzzer. It is located behind the driver's seat in the cab. Access is gained by removing the cover thumb screws.

The crane has 5 or 6 relays which control many of its functions. In addition to relays K1 and K2 in the cab, relays K301, K302, and K303 are located in the battery box (Figure 3-5).

The coil of the start relay (K303) is energized when the transmission is in neutral and the ignition switch is at the START (2) position.

The coil of the accessory relays (K1 and K2) are energized when the ignition switch is at the RUN (1) or ACC (3) position.

For cranes with air conditioning, there is an optional AC Fans relay (A/C).



Item	Description
1	Power Relay (K301)
2	Start Relay (K303)
3	Grid Heater Relay (K302)
4	250 Amp Fuse (F53)
5	100 Amp Fuse (F54)
6	100 Amp Fuse (F55)
7	100 Amp Fuse (F56)
8	100 Amp Fuse (F52)
9	250 Amp Fuse (F51)
10	Fuse and Relay Panel (see Figure 3-6)

FIGURE 3-5



For the grid heater relay coils to energize, the battery must be connected and signals from the engine ECM must be sent.

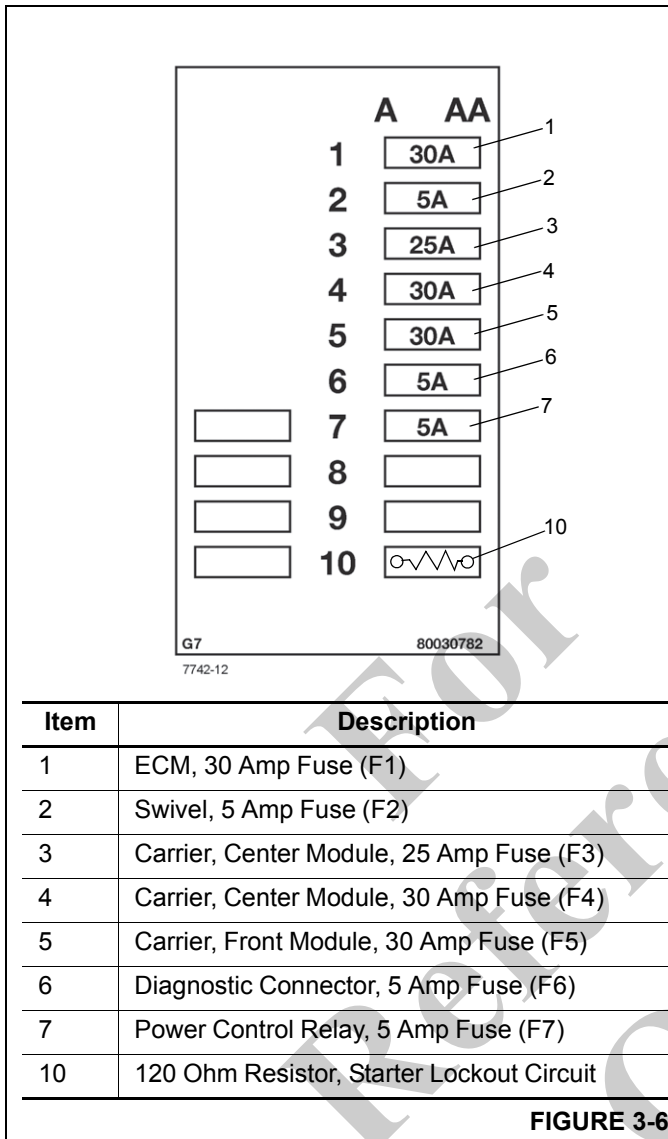


FIGURE 3-6

## MAINTENANCE

### General

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



#### CAUTION

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

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

#### CAUTION

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

### General Troubleshooting



#### CAUTION

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

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

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

5. After troubleshooting, test the repaired circuit. Verify the circuit works properly.

### Troubleshooting Engine Starting Problems

1. Verify the battery terminals are connected and clean, the transmission is in neutral, and the machine is fueled.
2. Try to turn on the headlights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights to verify the batteries have at least some charge. If none of these lights come on, suspect the batteries. Charge batteries as needed, or replace the batteries if they fail to hold a charge.
3. If you hear the starter relay clicking repeatedly, power is reaching the starter, but not enough. Suspect the batteries. Charge, or replace, the batteries as needed if you can jump-start the crane from another vehicle.
4. Check Fuse 52 (100 amp) inside battery box. If fuse is blown, replace it.
5. Turn the ignition switch to RUN (1). Check the voltmeter. If it doesn't move (but the headlights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights will come on), suspect the ignition switch and the power circuit to it starting at the ignition switch fuse. Repair or replace circuit, switch, or fuse as needed.
6. If the battery, fuses, ignition switch, and power circuit to the ignition switch check out, do one of the following:
  - a. If you hear no noise when you try to turn the starter, troubleshoot the start circuit (ignition switch, electric shifter, and wiring from ignition switch to the module located in the steering column, on the carrier, troubleshoot the resistor located in the fuse box in fuse #10 location, see Figure 3-6. Also troubleshoot carrier center module located above the battery box for starter lockout signal, pin B16 must have 12v to allow starter to engage and pin B13 must have 12v when key is in start position to send a signal to start relay (K303). Make repairs as needed.
  - b. If the engine still won't start, and you hear no noise or just a single click, suspect the starter. Troubleshoot the start circuit from the starter relay through the starter solenoid to the starter motor and ground. Make repairs as needed. If the starter solenoid or the starter motor is faulty, replace the starter.
  - c. If the starter engages but can't turn the engine (and the lights dim, signaling power drain during start attempt), check the starter's feed circuit from the batteries for resistance. If the resistance is high, make repairs. If the circuit checks out, replace the starter. If the engine still won't start, suspect a seized engine.

- d. If the starter turns the engine, but it still won't start, check fuses F1, 54, 55, 56, and 57 in the battery box. Replace if required. Ensure fuel system can draw fuel from the tank and pump it to the engine; make repairs as needed. Also check engine ECM connector pin 3 to insure it has 12v with ignition switch in the ON position and START position.
7. Refer to the engine manual for further instructions.

**NOTE:** If the starter won't disengage during running, verify the starter is mounted properly so its gear won't mesh with the engine's flywheel when not trying to start engine. Troubleshoot the starter relay and ignition switch for closed contacts. If these components check out, replace the starter.

### Troubleshooting Engine Charging Problems

1. Verify battery terminals are connected and clean and all wires in the charging system are in good repair and are connected properly.
2. Verify the alternator belt is properly installed and is properly tensioned.
3. Verify each battery puts out 12 volts minimum. Charge batteries as needed so they can supply a minimum excitation voltage to the engine's charging system.
4. Verify there is a minimum of 12 volts at the alternator from the batteries, and that the alternator is properly grounded.
5. Replace the alternator if the other conditions check out.
6. Refer to the engine manual for further instructions.

**NOTE:** If the alternator runs noisily, check belt tension. If problem persists, replace alternator.

If the alternator overcharges (voltmeter reads high, light bulbs burn out quickly), look for a ground where one shouldn't exist. If external wiring checks out, replace alternator. (The alternator probably has an internal ground or a faulty internal voltage regulator.)

### Troubleshooting Accessories

If the crane's engine starts and charges properly, but none of its components except the horn or lights work, the accessory circuitry may be faulty. Check as follows:

1. Turn the ignition switch to the ACC (3) position. Try to turn on the cab circulating fan, the windshield wipers or skylight wiper. If none of these come on (but the head lights, tail lights, marker lights, dome light, work light, or

gauge lights and panel lights will come on), there is an accessory circuitry problem.

2. Check the primary power circuit to the accessory relays KS1 and KS2. Make circuit repairs as needed.
3. If the problem remains, check the ignition switch and the accessory control circuit from the ignition switch through the coil of the accessory relays KS1 and KS2 to ground. Turn the ignition switch to the ACC (3) position and listen for audible click of relays KS1 and KS2. If neither relay clicks, then there is no power through the switch when it is in the ACC (3) position. Replace ignition switch if there is no power through it when in the ACC (3) position. If one relay clicks and the other does not, check continuity of the coil of the relay that does not click. If there is no continuity through its coil, replace the relay. Make circuit repairs to accessory control circuit as needed.
4. If the problem remains, check the accessory relay KS1 or KS2 contacts and the accessory power circuit. Replace relay if its contacts stay open when the coil is energized. Make circuit repairs as needed.

### Troubleshooting Swivel-Caused Electrical Problems

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

### Connector Troubleshooting

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

After cutting the pin or socket off, the wire will most likely be too short. Using a wire that is too short will allow pressure to be applied to the pin or socket and wire where they are crimped when the pin or socket is inserted in the plug or receptacle. Add a short length of the same size wire to the short wire by crimp splice or solder. Use heat shrinkable tubing or other suitable material to insulate the splice.

**Table 3-1**  
**Deutsch Extraction Tool Table**

Description	Deutsch Part Number	Grove Part Number
12 gauge wire	114010	9-999-100194
16 gauge wire	0411-204-1605	9-999-100195
8-10 gauge wire	114008	7-902-000012
4-6 gauge wire	114009	7-902-000009

**Table 3-2**  
**Deutsch Crimping Tool Table**

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT48-00	9-999-100808
4, 6, 8, 10 gauge wire	HDT 04-08	9-999-100842

For  
Reference  
Only

**Indicator Lights**

The dash indicator lights (Figure 3-7) are located in the cab on the front console. The lights are linked to various parts of the crane by the control module and notify the operator when a certain condition occurs during the operation of the crane. When the ignition key is turned to the ACC or RUN position

the indicator lights go through all operations check to see if the lights are working. This operation check takes about two seconds in which all of the lights turn on and off allowing the operator to know that the lights are working. For more description on the front console indicator lights, refer to Section 3 in the Operator's Manual

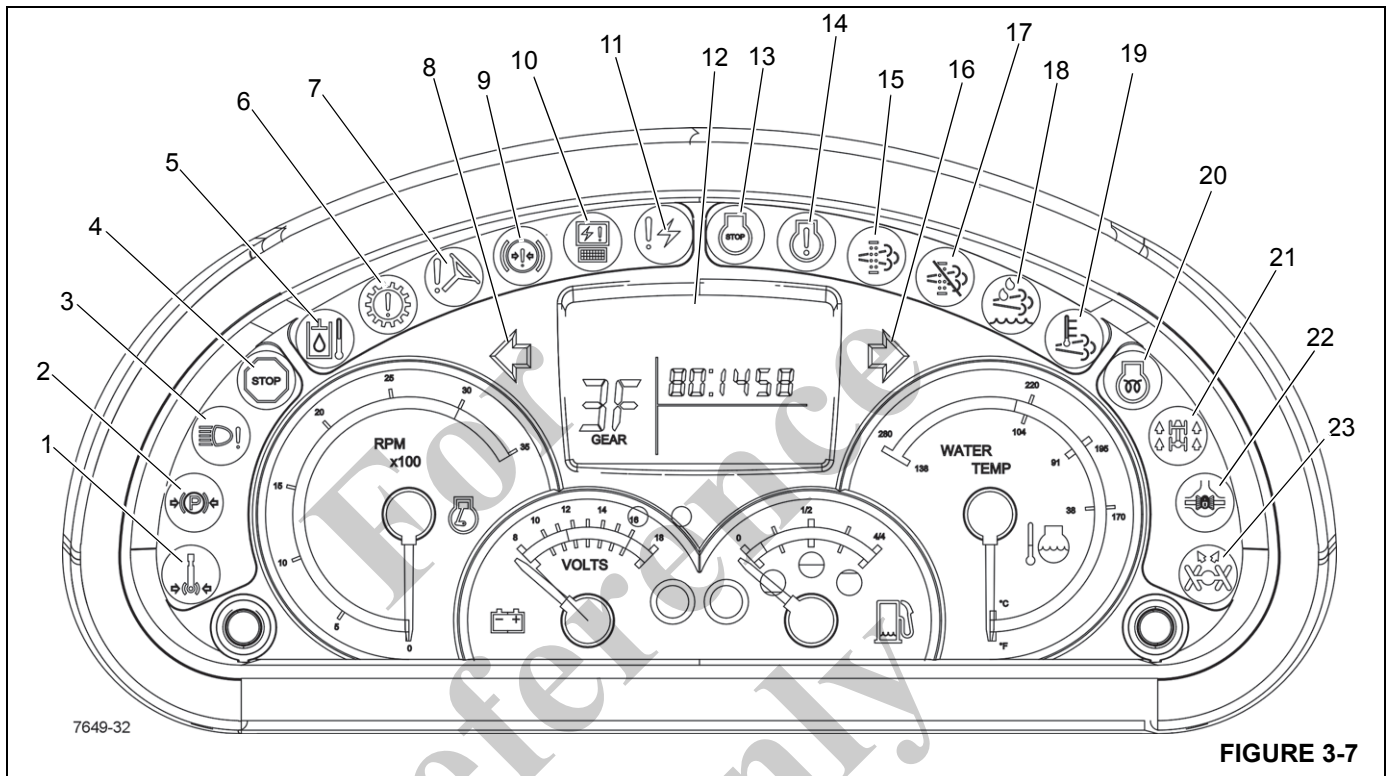


FIGURE 3-7

Figure 3-7 Item Numbers

Item	Description
1	Swing Brake Engaged
2	Parking Brake Engaged
3	Light Malfunction
4	Emergency Stop
5	Hydraulic Oil High Temperature
6	Transmission Warning
7	Low Steer Pressure
8	Left Turn Signal
9	Low Brake Pressure
10	Electronic Module Control
11	Electrical System Diagnostics

Item	Description
12	LCD Display
13	Engine Stop
14	Engine Warning
15	Diesel Particulate Filter, Regeneration Required
16	Right Turn Signal
17	Disable Regeneration
18	Not used
19	High Exhaust System Temperature
20	Engine Wait to Start
21	4 Wheel Drive Engaged
22	Interaxle Locked
23	Rear Wheels Not Centered

## Troubleshooting Crane Components and Accessories

1. If a crane component or accessory won't work when it is supposed to, check and replace fuse. Also check and replace its relay as needed.
2. Check the component or accessory, its control or triggering component, and its circuit for continuity problems and other problems. Repair any faulty component or accessory or trigger. Repair wiring if faulty.
3. Repair:
  - a. MOTOR: Remove faulty motor or faulty trigger (switch or relay), install new motor or trigger, install new fuse, test motor. For further information, see the applicable section in this manual.
  - b. SOLENOID VALVE: Remove faulty valve or solenoid, install new valve or solenoid, install new fuse, fill fluid system, test valve.
  - c. RCL: Repair per RCL manual, install new fuse, test per RCL manual.
  - d. ROTATION INDICATOR: Remove thumper solenoid or sensor, install sensor, install new thumper, test thumper. For further information on rotation indicator, refer to *Section 5 Hoist Drum Rotation Indicator System*, page 5-18.

## Alternator Replacement

### Removal

1. Ensure that the key switch has been off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. Turn the tensioner clockwise to remove tension from the belt. Slip the belt off of the alternator pulley, then let the tensioner return to its normal position.
8. Remove and tag all wires. Remove the alternator link capscrew and the mounting capscrew. Remove the alternator.

### Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. To assemble the alternator, the mounting components must be tightened in the following sequence.
  - a. Alternator-to-alternator bracket capscrew.
  - b. Lower brace-to-alternator capscrew.
  - c. Lower alternator brace-to-water pump capscrew.
3. Install the belt on all engine pulleys except the alternator pulley for now.
4. Turn the tensioner clockwise. Slip the belt onto the alternator pulley, then carefully return the tensioner to its normal position so it puts tension on the belt. Make sure the belt is centered on the tensioner.
5. Check belt tension at the belt's longest span (longest distance between pulleys). At the center point of the longest span, push in on the belt with your thumb. Verify you can deflect the belt no more than 3/8 to 1/2 in (10 to 13 mm) with your thumb. (Or, using a belt tension gauge, verify there is 60 to 130 lb (267 to 578 N) of tension on the belt in the middle of its longest span.) Replace belt if it is too loose (overstretched).
6. Ensure tensioner bolt is tight.
7. Connect the electrical leads to the terminals as tagged during removal.
8. Connect the batteries. Close the engine compartment.
9. Install the ECM power fuse.
10. Turn the battery disconnect switch to the ON position.

### Check

1. Run engine. Verify reading of voltmeter on front console is 12 volts or greater. Make repairs as needed.
2. Continue troubleshooting charging system, as needed, if replacement of alternator did not correct problem in charging system.

## Starter Replacement

### Removal

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

6. Tag and disconnect the electrical leads from the terminals on the starter.
7. Remove the bolts holding the starter to the mounting pad. Remove the starter.

### Installation

1. Place the starter on its mounting pad. Secure the starter with the bolts.
2. Connect the electrical leads to the terminals as tagged during removal.
3. Connect the batteries.
4. Install the ECM power fuse.
5. Turn the battery disconnect switch to the ON position.
6. Close the engine compartment.

### Check

1. Try to start the engine. Verify the starter starts the engine.
2. Start engine again, and listen for starter noises. Verify there is no abnormal noise indicating the starter's gear is meshing improperly with the flywheel, that the starter's gear hasn't disengaged from the flywheel after the ignition switch is in the ignition (run) position, or some other problem. Install starter properly as needed.

## Battery Replacement

### Removal

#### CAUTION

#### Possible Equipment Damage!

To avoid possible engine fault codes and undesirable operation, ensure the keyswitch has been off two minutes before disconnecting batteries.

Disconnect batteries if machine will be inactive for over 24 hours.

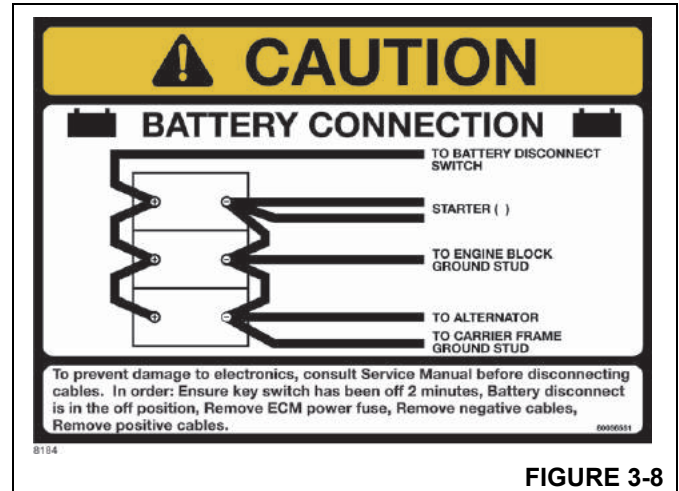


FIGURE 3-8

1. Ensure that the key switch has been off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove negative battery cables.
5. Remove positive battery cables.
6. Tag and disconnect leads from the battery terminals starting with the positive terminals.
7. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
8. Remove the batteries.

### Installation

1. Place the batteries in the battery box.
2. Install the hold down bracket so it can hold down the batteries. Secure the bracket to the bracket hold down rods with nuts and washers.
3. Connect leads to the battery terminals starting with the positive terminals.
4. Close the battery box cover.
5. Install the ECM power fuse.
6. Turn the battery disconnect switch to ON.
7. Verify replacement batteries work by starting crane's engine and operating various crane components.

## Relay Panel Component Replacement

### Accessory Relay

1. Turn the ignition switch to the OFF position.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.

4. Working behind the operator's seat, remove the hardware securing the panel cover and open the cover.
5. Tag and disconnect the electrical leads from the suspect relay.
6. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
7. Install replacement relay on relay panel and secure it with attaching hardware.
8. Connect the electrical leads to the relay as tagged during removal.
9. Position the cover on the panel and secure with the attaching hardware.
10. Turn the battery disconnect switch to the ON position.
11. Verify proper installation by operating all components involved with the replacement relay verifying they all work.

### **Buzzer Replacement**

1. Working behind the operator's seat, remove the hardware securing the panel cover and open the cover.
2. Tag and disconnect the electrical leads from the buzzer.
3. Unscrew the plastic collar ring from under the panel and remove the buzzer from the hole in the panel.
4. Install replacement buzzer through the hole in panel and secure with the plastic collar ring.
5. Connect the electrical leads to the buzzer as tagged during removal.
6. Position the console front cover on the console and secure with the attaching hardware.
7. Verify proper operation by positioning the ignition switch to RUN (1). Buzzer should sound when engine is not running.

### **Gauge Cluster Replacement**

Use the following procedures and refer to Figure 3-9 when removing/installing the gauge cluster.

#### **Removal**

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.

6. Remove the steering wheel by doing the following:
  - a. Remove the steering wheel cap (1) using a twisting motion by pushing on the side of the cap closest to you with your thumbs while simultaneously pulling on the side of the cap farthest from you with your fingers.
  - b. Remove the securing nut from the steering column shaft and remove the steering wheel (2).
7. Remove the four screws (13) securing the left and right side covers (8, 9) together.
8. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
9. Remove the left side cover (8) from the steering column.
10. Disconnect the wire harness from the back of the ignition switch (10).
11. Remove the right side cover (9) from the steering column.
12. Disconnect the wire harness from the bottom of the gauge cluster (5).
13. Remove the gauge cluster (5) from the gauge/switch cover (6) by pushing in on the left and right sides of the gauge cluster (5), then pushing the gauge cluster (5) up through the gauge/switch cover (6).

#### **Installation**

1. Install the gauge cluster (5) in the top of the gauge/switch cover (6) by pushing the gauge cluster (5) down through the top of the gauge/switch cover (6) until the gauge cluster's retaining clips click in place.
2. Connect the wire harness to the bottom of the gauge cluster (5).
3. Install the right side cover (9) on the steering column.
4. Connect the wire harness to the ignition switch (10).
5. Install the left side cover (8) on the steering column.
6. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
7. Secure the left and right side covers (8, 9) together using four screws (13).
8. Install the steering wheel (2); torque the securing nut to 30 lb-ft  $\pm$ 4 (40 Nm  $\pm$ 5).
9. Install the steering wheel cap (1).
10. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
11. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
12. Turn the battery disconnect switch to the ON position.



**Check**

1. Start the engine and verify that the instruments work.
2. As needed, troubleshoot further any system malfunction not corrected by repair or replacement of the gauge cluster or associated wiring.

**Rocker Switch Replacement**

Use the following procedures and refer to Figure 3-9 when removing/installing a switch.

**Removal**

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the four screws (13) securing the left and right side covers (8, 9) together.
7. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
8. Remove the left side cover (8) from the steering column.
9. Disconnect the wire harness from the back of the ignition switch (10).
10. Remove the right side cover (9) from the steering column.
11. Disconnect the wire harness from the bottom of the switch (4) that must be replaced. Remove the switch by squeezing the retaining clips on each side of switch and pushing upwards until switch is free of cover.

**Inspection**

1. Visually check the switch for evidence of cracks, damaged connections, or other damage. Replace damaged switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Check all connectors for corrosion. Replace corroded components as needed.
4. Perform the following check to determine switch serviceability.
  - a. Using an ohmmeter, check for continuity between the switch terminals with switch at ON or activated position(s). Ohmmeter should register zero ohms (continuity).

- b. Place switch at OFF or deactivated position. Ohmmeter should register infinity (no continuity).
- c. Replace switch if it fails either part of the check.

**Installation**

1. Remove the rocker (3) from the old switch by holding the switch by its sides in one hand and then squeezing the left and right sides of the rocker with the other hand and pulling up.
2. Orient the rocker (3) correctly relative to the new switch (4), then install rocker in switch.
3. Install the switch (4) in the gauge/switch cover (6) by pushing the switch (4) down through the top of the gauge/switch cover (6) until the switch's retaining clips click in place.
4. Connect the wire harness to the bottom of the switch (4).
5. Install the right side cover (9) on the steering column.
6. Connect the wire harness to the ignition switch (10).
7. Install the left side cover (8) on the steering column.
8. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
9. Secure the left and right side covers (8, 9) together using four screws (13).
10. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
11. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
12. Turn the battery disconnect switch to the ON position.

**Check**

1. Operate the switch per the Operator's Manual. Verify each of its functions works.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

**Ignition Switch Replacement**

Use the following procedures and refer to Figure 3-9 when removing/installing the ignition switch.

**Removal**

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).

5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the four screws (13) securing the left and right side covers (8, 9) together.
7. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
8. Remove the left side cover (8) from the steering column.
9. Disconnect the wire harness from the back of the ignition switch (10).
10. Remove the right side cover (9) from the steering column.
11. Remove the locking nut that secures the ignition switch (10) to the right cover (9) and remove the ignition switch.

### Inspection

1. Visually check the ignition switch for evidence of cracks, damaged connections, or other damage. Replace damaged ignition switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Check all connectors for corrosion. Replace corroded components as needed.
4. Perform the following check to determine ignition switch serviceability.
  - a. Using an ohmmeter, check for continuity between the switch terminals with switch at ON or activated position(s). Ohmmeter should register zero ohms (continuity).
  - b. Place switch at OFF or deactivated position. Ohmmeter should register infinity (no continuity).
  - c. Replace switch if it fails either part of the check.

### Installation

1. Install the ignition switch (10) in the right side cover (9) and secure with the locking nut.
2. Install the right side cover (9) on the steering column.
3. Connect the wire harness to the ignition switch (10).
4. Install the left side cover (8) on the steering column.
5. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
6. Secure the left and right side covers (8, 9) together using four screws (13).
7. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
8. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).

9. Turn the battery disconnect switch to the ON position.

### Check

1. Operate the ignition switch per the Operator's Manual. Verify each of its functions works.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

## Turn Signal Lever and Transmission Shift Lever Replacement

Use the following procedures and refer to Figure 3-9 when removing/installing the turn signal lever or transmission shift lever.

### Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the steering wheel by doing the following:
  - a. Remove the steering wheel cap (1) using a twisting motion by pushing on the side of the cap closest to you with your thumbs while simultaneously pulling on the side of the cap farthest from you with your fingers.
  - b. Remove the securing nut from the steering column shaft and remove the steering wheel (2).
7. Remove the four screws (13) securing the left and right side covers (8, 9) together.
8. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
9. Remove the left side cover (8) from the steering column.
10. Disconnect the wire harness from the back of the ignition switch (10).
11. Remove the right side cover (9) from the steering column.
12. Disconnect the wire harness from the bottom of the gauge cluster (5).
13. Tag and disconnect the wire harness from the bottom of each switch (4).
14. Remove the gauge/switch cover (6) from the steering column.

15. Disconnect the wire harnesses from the bottom of the turn signal and transmission shift levers (7).
16. Remove the two bolts and nuts securing the two levers (7) together.

### **Installation**

1. Align the location pins of the turn signal and transmission shift levers (7) with the holes in the steering column.
2. Secure the two levers (7) together using the two bolts and nuts.
3. Connect the wire harnesses to the levers (7).
4. Install the gauge/switch cover (6) on the steering column.
5. Connect the wire harness to the bottom of the gauge cluster (5).
6. Install the wire harnesses on the switches (4) as tagged during removal.
7. Install the right side cover (9) on the steering column.
8. Connect the wire harness to the ignition switch (10).
9. Install the left side cover (8) on the steering column.
10. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
11. Secure the left and right side covers (8, 9) together using four screws (13).
12. Install the steering wheel (2); torque the securing nut to 30 lb-ft  $\pm$ 4 (40 Nm  $\pm$ 5).
13. Install the steering wheel cap (1).
14. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
15. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
16. Turn the battery disconnect switch to the ON position.

### **Check**

1. Operate the turn signal lever or transmission shift lever per the Operator's Manual. Verify each of its functions work.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the signal lever or transmission shift lever or associated wiring.

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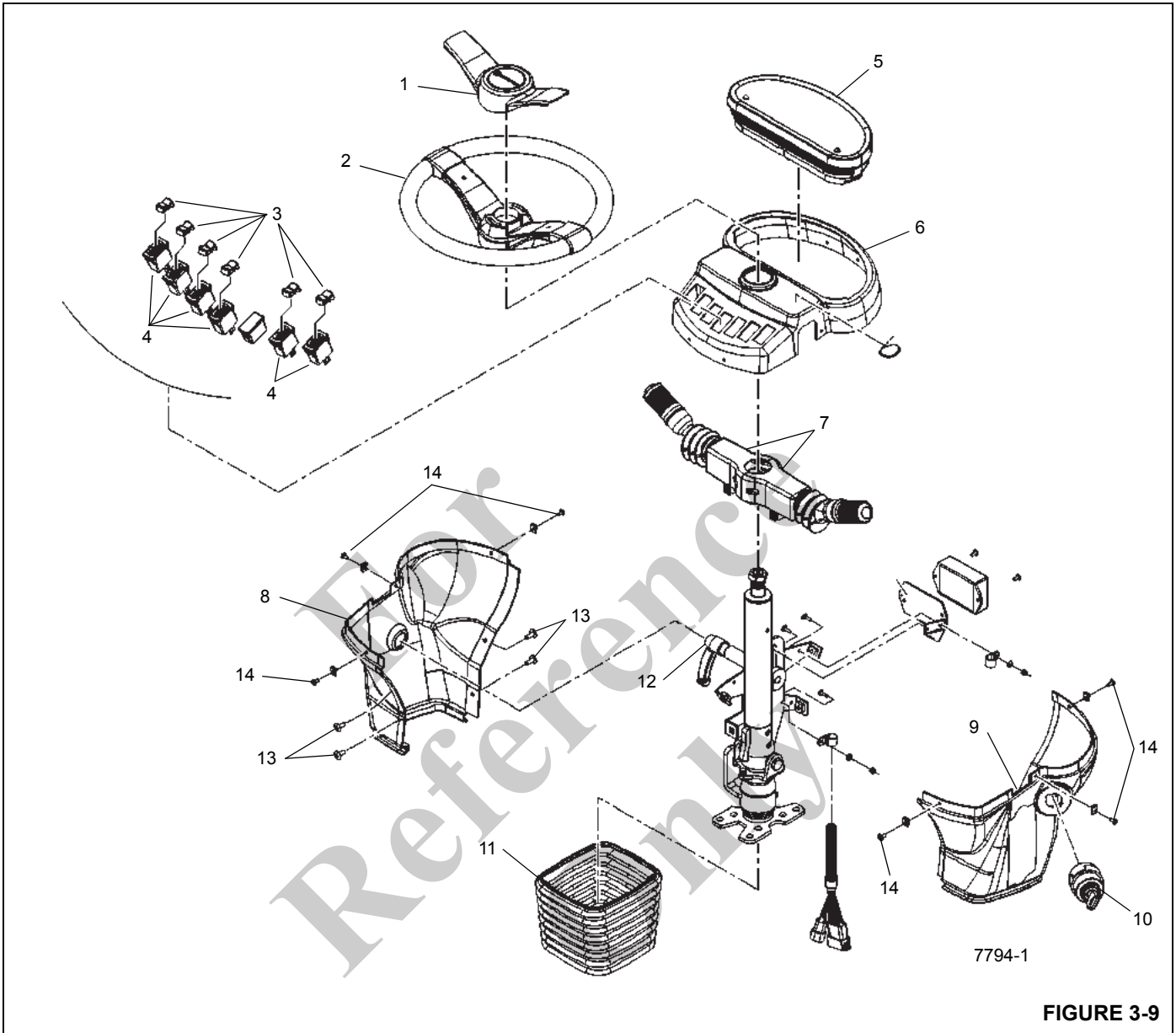


FIGURE 3-9

## Windshield Wiper Assembly Replacement

### Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Tag and disconnect the electrical leads from the motor.
5. Disconnect the washer hose on the wiper arm (also called the pantograph arm assembly) from the washer nozzle fitting assembly (Figure 3-10).

**NOTE:** The nut and washer are part of the pantograph adapter kit. The nut, washer and sleeve are part of the pivot shaft kit.

6. Remove the cap nut and washer securing the wiper arm to the pantograph adapter kit. Remove the cap nut, washer, and tapered sleeve securing the wiper arm to the pivot shaft.
7. Remove the wiper arm from the pantograph adapter and the pivot shaft.
8. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft.
9. Remove the two capscrews and lockwashers securing the pantograph adapter to the cab exterior. Remove the pantograph adapter and gasket.
10. Remove attaching hardware to free the windshield wiper motor bracket from the cab interior. Remove the bracket, with motor and pivot shaft connected, from the cab.

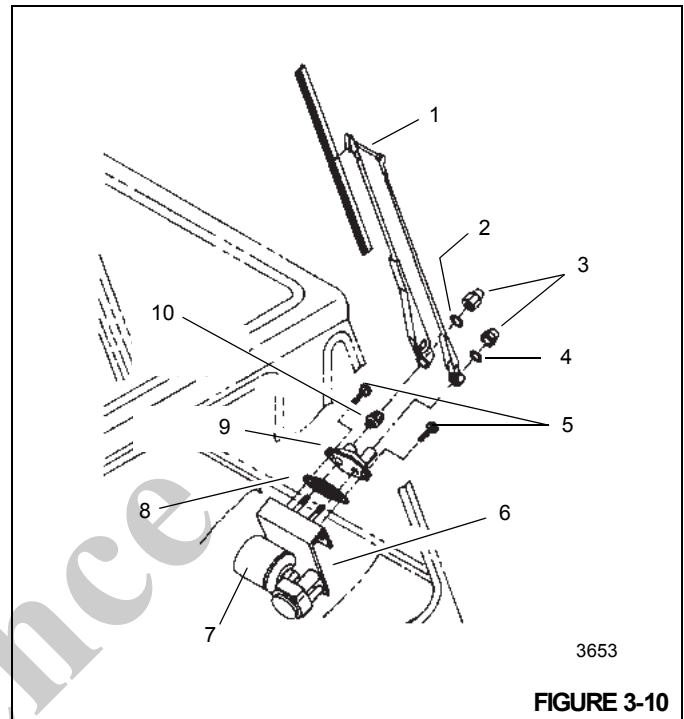
**NOTE:** You may have to remove or move other parts to get the bracket and attached parts around the steering column. Take care not to damage any parts.

11. Remove the nut to free the wiper motor's shaft from the wiper motor crank. Remove the three screws and washers to free the wiper motor from its bracket. Remove the wiper motor from its bracket. Leave the other parts attached to the bracket for now.

### Inspection

1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if worn or damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts of the linking component kits (pantograph adapter, pivot shaft, wiper motor link

and crank, wiper motor bracket) for damage. Replace as needed.



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**FIGURE 3-10**

Item	Description
1	Windshield Wiper Arm
2	Washer
3	Nut
4	Washer
5	Screw
6	Mounting Bracket
7	Motor
8	Gasket
9	Mounting Plate
10	Serrated Collar

### Installation

1. Verify the pivot shaft and the wiper motor link and crank are in place on the motor bracket. (Washers and clip springs fasten the link to the pivot pins on the crank and the pivot shaft. The pivot shaft's pivot pin mounts in the hole nearest the end of the pivot shaft's lever.)
2. Connect the wiper motor to the motor bracket with screws and washers. Connect the wiper motor's shaft to the wiper motor crank with the nut and washer. Secure the adapter and the gasket of the pantograph adapter to the cab exterior with capscrews and lockwashers.

3. Install the motor bracket and attached parts in the cab interior with attaching hardware. Ensure the pivot shaft sticks through the hole in the pantograph adapter.

**NOTE:** Take care not to damage any parts while moving the bracket and attached parts around the steering column.

4. Secure the pivot shaft to the pantograph adapter with the pivot shaft's nut and washers. Install the flanged sleeve on the pivot shaft.
5. Install the wiper arm on the shafts of the pantograph adapter and the pivot shaft. Secure the wiper arm to the pantograph adapter shaft with the washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft's own tapered sleeve, washer, and cap nut.
6. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
7. Connect the electrical leads to the wiper motor as marked before removal.
8. Turn the battery disconnect switch to the ON position.

### Check

1. Squirt some cleaning fluid onto the windshield with the windshield washer.
2. Operate the windshield wiper and verify it works. Replace wiper blade as needed if it streaks or otherwise wipes poorly.

## Windshield Washer Assembly Replacement

### Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Locate the windshield washer container and pump on the left rear side of the cab.
5. Tag and disconnect the pump's electrical lead and ground wire.
6. Disconnect the hose from the windshield washer pump. Point it so it won't spill cleaning fluid. Catch cleaning fluid from the windshield washer container with a suitable container.
7. Remove four self tapping screws securing the windshield washer container to the cab. Remove the windshield washer container and pump.
8. Remove pump and pump seal from container.

### Inspection

1. Visually check the pump for evidence of cracks, leaks, or other damage. Replace pump if damaged.
2. Inspect the container for leaking. Replace pump seal if it is leaking. Replace container if it is damaged and/or leaking.
3. Inspect spray nozzle on the wiper arm. As needed, clean the nozzle with a fine piece of wire and compressed air.

### Installation

1. Install pump and pump seal on container.
2. Install windshield washer container on the cab. Secure the container with four self tapping screws.
3. Attach the hose to the windshield washer pump.
4. Connect the pump's electrical lead and ground wire as tagged during removal.
5. Turn the battery disconnect switch to the ON position.
6. Fill the container with cleaning fluid.

### Check

1. Squirt some cleaning fluid onto the windshield with the windshield washer.
2. Make repairs if windshield washer doesn't work.

## Skylight Wiper Assembly Replacement

### Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Tag and disconnect the electrical leads from the motor.
5. Remove the wiper arm from the motor shaft.
6. Remove the nut, spacer, leather washer, and nylon flat washer from the motor shaft outside the cab roof.
7. Remove the nut and lockwasher securing the motor bracket to the cab roof and remove the motor from the cab roof. Remove large nylon flat washer from motor shaft and flat washer and smaller nylon flat washer from mounting screw.
8. Remove mounting screw and nylon flat washer from outside cab roof.
9. Clean any sealing material from around holes in cab roof.

**Inspection**

1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts for damage. Replace as needed.

**Installation**

1. Install sealant material around both holes in cab roof, both inside and outside.
2. Install screw with nylon flat washer (from outside) through mounting hole in cab roof.
3. Install flat nylon washer on motor shaft and insert motor shaft through hole in cab roof. Position small nylon washer and flat washer on screw between mounting bracket and cab roof. Secure with lockwasher and nut.

4. Install nylon flat washer, leather washer, spacer, and nut on motor shaft. Tighten nut.
5. Install wiper arm and blade on motor shaft.
6. Connect the electrical leads to the wiper motor as marked before removal.
7. Turn the battery disconnect switch to the ON position.

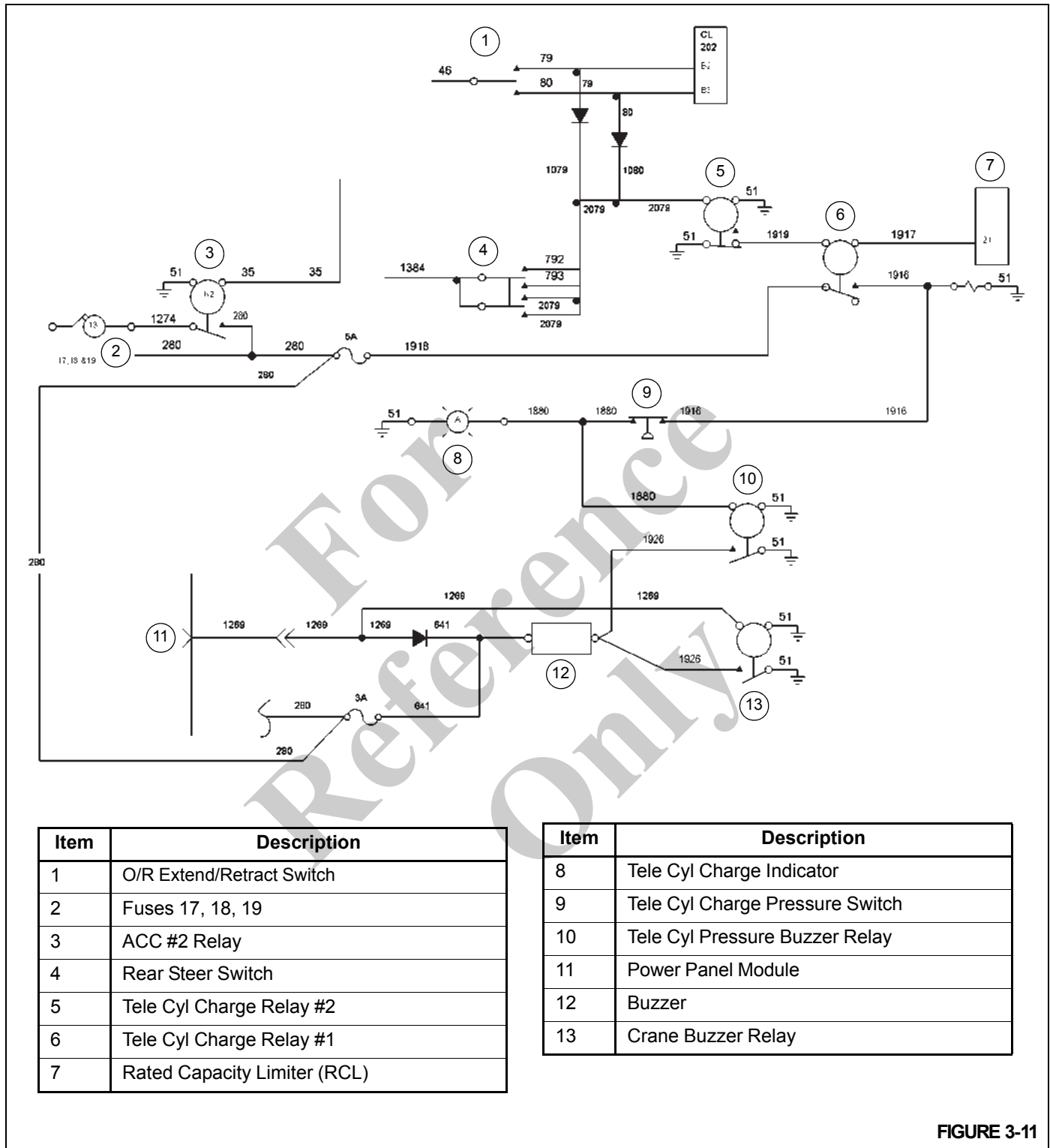
**Check**

1. Operate the skylight wiper and verify it works. Replace wiper blade as needed if it streaks or otherwise wipes poorly.

**Telescope Cylinder Charge System - Electrical Schematic (If Equipped)**

The telescope cylinder charge system prevents boom retraction due to thermal contraction under certain operating conditions. Refer to the sub-section titled *Telescope Circuit*, page 4-24 for detailed information of this system's operation. Refer to Figure 3-11 for an electrical schematic of the telescope cylinder charge system.

For Reference Only



Item	Description
1	O/R Extend/Retract Switch
2	Fuses 17, 18, 19
3	ACC #2 Relay
4	Rear Steer Switch
5	Tele Cyl Charge Relay #2
6	Tele Cyl Charge Relay #1
7	Rated Capacity Limiter (RCL)

Item	Description
8	Tele Cyl Charge Indicator
9	Tele Cyl Charge Pressure Switch
10	Tele Cyl Pressure Buzzer Relay
11	Power Panel Module
12	Buzzer
13	Crane Buzzer Relay

FIGURE 3-11



## TOOLS FOR TROUBLESHOOTING

This machine incorporates a CAN bus Multiplex system.

To effectively troubleshoot the electrical system, you need a Windows-based personal computer, CAN-Link service software (Part No. 9999102587), and a connection cable (Part No. 80026376).

Manitowoc Crane Care requests you have, as part of your service tool kit inventory, the CAN-Link service tool kit for the RT9000. The software will allow you to see in real time the status of all inputs and outputs on the system, and it will allow you to detect any errors on input or output. The CAN-Link service software and connection cable are available through Crane Care to those service technicians who have attended the Grove New Technology training course.

## OPTIONAL EQUIPMENT

This section is provided to give a brief description of the optional equipment available for the crane which is not discussed elsewhere within this service manual.

### Beacon Light

The beacon light is installed on the right side of the turntable in front of the main hoist.

### Boom Mounted Floodlights

The boom light switch is located in the cab overhead panel. The switch is an On/Off rocker switch that will turn the lamps located on the underside of the boom On and Off.

### Rear View Mirror

The rear view mirror installation consists of a rear view mirror mounted on the top left corner of the cab. The mirror can be adjusted as required for optimum view from the cab while the boom is over the front of the crane.

### Air Conditioner

A hydraulic driven air conditioner is installed on the left side of the turntable. It consists of a compressor motor, a condenser unit, and a cab unit mounted under the operators seat. It is turned on and off by a rotary switch mounted on the overhead console, refer to Air Conditioner Control Switch (Optional) in the Operator's Handbook in Section 3 - Operating Controls and Procedures. The air conditioning compressor motor is driven by the No. 2 hydraulic pump. The dual accumulator charge valve ensures the brake circuit gets the priority flow and the air conditioner circuit receives the excess flow.

### Cold Weather Operation

The following recommendations are for operating Grove cranes in regions with ambient temperatures below -9°C (15°F) which are considered arctic.

Use particular care to ensure that cranes being operated in very cold temperatures are operated and maintained in accordance with the procedures as provided by Manitowoc. Therefore, always ensure adequate lubrication during system warm-up and proper operation of all crane functions when operating in cold weather and regardless of the oil viscosity of the crane's lubricants, always follow the cold weather start-up and operating procedures described in the *Operator Manual*. To ensure adequate lubrication during system warm-up and proper operation of all crane functions, (Refer to *Arctic Lubricants and Conditions*, page 9-3.)

Individual crane functions should be operated to ensure they are sufficiently warmed prior to performing a lift.

Operation of cranes at full rated capacities in ambient temperatures between -9°C and -40°C (15°F and -40°F) or lower should be accomplished only by competent operators who possess the skill, experience, and dexterity to ensure smooth operation.

### Component Coolant Heater

A diesel fueled coolant heater circulates warm coolant through engine and crane components when operating during arctic temperatures. The coolant heater should be activated 2 hours before starting the crane to allow sufficient time to preheat fluids and assist with easy start-up conditions.



### WARNING Explosion Hazard!

Before switching on, check if the heater can be operated at the current site of the crane. There is a danger of explosion when using the heater around combustible objects! Do not park the vehicle near objects that are flammable.

Use caution near the exhaust tailpipe as it will also become very hot.

To activate the heater, ensure the fuel supply valve from the heater fuel reservoir is turned to the ON position. Ensure the battery disconnect switch is turned to the ON position and push the activation button at the heater control panel. A green light will illuminate indicating the system is activated. The start-up and shutdown cycles may take approximately 2 minutes for initialization. Ensure the coolant, transmission heater, swivel, battery heater, in-line fuel pump, in-line fuel heater, and hydraulic reservoir heater are heating properly.

To de-activate the heater, push the button at the heater control panel. The green light will turn off indicating the system is de-activated. The shutdown cycle may take approximately 2 minutes.

**NOTE:** Accelerated discharging of battery will occur when the crane engine is switched off. If you run the

heater while the crane engine is stopped, the batteries voltage will need to be recharged after short periods of time.

### **Troubleshooting**

In case of faults, please check the following points:

- If the heater does not start after being switched on:
  - switch the heater off and on again.
- If the heater still does not start, check whether:
  - There is fuel in the tank?
  - The fuses are OK?
  - The electrical cables, connections etc. are OK?
  - Anything is clogging the combustion air supply or exhaust system?
- Check the openings of the combustion air supply and exhaust system after longer standstill periods, clean if necessary!

- If the heater remains faulty even after these points have been checked, or another malfunction occurs in your heater, contact an authorized Manitowoc distributor or Manitowoc Crane Care.

### **Maintenance Instructions**

- Switch the heater on once a month for about 10 minutes, even outside the heating period.
- Before the heating period starts, the heater should undergo a trial run. If persistent extreme smoke develops, unusual burning noise or a clear fuel smell can be perceived or if electric / electronic parts heat up, the heater must be switched off and put out of service by removing the fuse. In this case, the heater should not be started up again until it has been checked by qualified staff who have been properly trained.

For Reference Only

## SECTION 4 BOOM

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### DESCRIPTION

One boom is available on the crane; a five section, full power, sequenced and synchronized, 42 to 159.3 ft (12.8 to 48.5 m) boom. The boom assembly utilizes a mega form design. The five section boom utilizes two sequenced telescope cylinders for telescoping and retracting of the boom plus cable synchronization for the extension and retraction of the fly section. Boom lift is provided by a single lift cylinder and boom elevation is from -3 degrees to +78 degrees.

#### Lattice Extension

The 11 to 18 m (36 to 59 ft) offsettable bifold lattice swingaway extension stows alongside the base boom section. Offsets are 0°, 20°, and 40°.

#### Optional Lattice Extension

36 to 59 ft (11 to 18 m) hydraulically offsettable bifold lattice swingaway extension stows alongside the base boom section. Offsets are from 0° to 40°.

#### Optional Lattice Extension Inserts

The 26 ft (8 m) non-stowable lattice extension inserts install between the boom nose and bifold extension. A standard auxiliary boom nose (rooster sheave) is available for the boom to simplify single part cable usage. The rooster sheave is installed on the main boom nose and is secured by pins that pass through the rooster sheave and main boom nose.

## Boom Control Switches

The following switches and indicators are located in the crane's superstructure cab and are used together to control the boom telescope function.

### Boom Auto/Manual Telescope Mode Switches

The boom auto/manual telescope mode switch and indicator are located on the overhead control panel. The switch is a two-position rocker switch.

When the switch is in the Auto mode, the boom sections extend in a predetermined sequence when telescoping the boom; the inner mid extends 75% and stops, then the center mid extends to 75% and stops, then the inner mid extends to 100%, the center mid extends to 100%, and then the outer mid and fly section extend in a synchronized fashion. The sections retract in the same manner in reverse order.

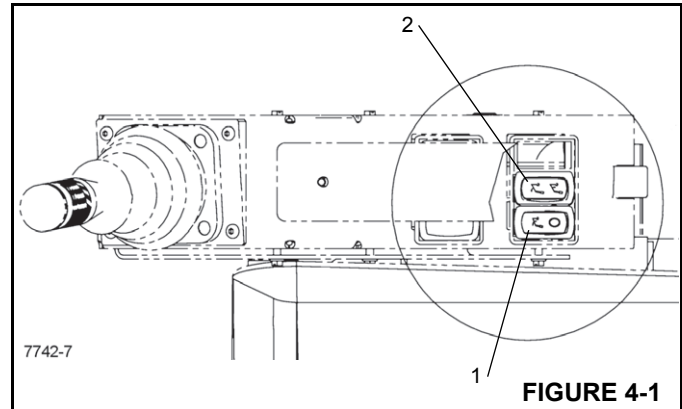
When in the manual mode, the switch will illuminate. The boom telescope section select switch is positioned to either the center mid or inner mid position in order to extend or retract the selected section until it is returned to the proper position for normal boom synchronization to occur.

### Center Mid/Inner Mid Boom Telescope Sections Select Switch

The center mid/inner mid boom telescope section select switch is located on the overhead control panel. This switch is a three position rocker switch that is used in conjunction with the boom auto/manual telescope mode switch. When the boom mode switch is positioned to manual, the boom telescope section select switch is positioned to either of the two positions. When placed in the upper position, the center mid can be extended. When the center mid is fully extended, the outer mid and fly can be controlled. The switch will illuminate when the it is positioned in either the inner mid or center mid position.

### Luffing Jib Switches

The luffing jib switches are located on the right armrest. Each switch is two position. The power switch (1) (Figure 4-1) enables the RAISE/LOWER momentary switch (2) that energizes a solenoid to raise or lower the jib, when in the ON position.



## THEORY OF OPERATION

### Boom Extension

Boom extension and retraction is accomplished with two telescope cylinders, five extension cables, and two retraction cables. The lower telescope cylinder is a two stage cylinder. The rod for the first stage is secured to the rear of the boom base section and the barrel of the first stage is secured to the inner mid boom section by a trunnion. The second stage of the first telescope cylinder barrel is secured to the rear of the center mid boom section by a trunnion. The rod end of the upper telescope cylinder is attached to the rear of the center mid and the barrel is secured to the outer mid boom section by a trunnion. The extension cables are secured to the back of the fly section and run around extension sheaves on the front of the upper telescope cylinder to the front of the second stage barrel of the lower telescope cylinder.

The hydraulic fluid for the first stage of the lower cylinder is supplied by hoses from the turntable. The hydraulic fluid for the second stage of the lower cylinder and the upper cylinder is routed through the hose reel that is mounted in the turntable into a manifold that is attached at the rear of the center mid section. There are two cam operated check valves mounted at the rear of the center mid which control flow to the second stage of the lower cylinder and the upper telescope cylinder. With both cylinders retracted, the check valve for the second stage of the lower telescope cylinder is open and the check valve for the upper cylinder is closed allowing the second stage of the lower cylinder to extend. When the lower cylinder is fully extended, the check valve for the upper cylinder opens allowing the upper cylinder to extend. The check valve for the lower cylinder closes after the upper cylinder starts to extend and shuts off the flow to the lower cylinder. As the upper telescope cylinder barrel extends, the extend cables around the extend sheaves on the end of the cylinder barrel push on the extend cables to pull the fly section out at the same time the outer mid is extending.

## Boom Retraction

The upper telescope cylinder retracts the outer-mid and two retract cables pull the fly section in at the same time. When the upper cylinder is fully retracted, the check valve for the lower telescope cylinder is opened and the lower cylinder starts to retract. The check valve for the upper cylinder is closed as the lower cylinder starts to retract. The outer mid and fly retract first and then the center mid and lastly the inner mid.

## RATED CAPACITY LIMITER (RCL) SYSTEM (WITH BOOM CONTROL SYSTEM)

### General

The crane has a 5-section sequence synchronized boom assembly. The electronic control system interfaces with the actuating systems, and provides the necessary controls, according to the following system standards.

### Telescoping Control System Description

#### Boom Configuration

The boom is a five section configuration (i.e. one fixed section and four telescoping sections). The fully retracted length of the boom is 42 ft (12.8 m) and the fully extended length is 159.33 ft (48.5 m). The full extension value of all four telescoping sections is the same (i.e.,  $159.33 \text{ ft} - 42 \text{ ft}/4 = 29.33 \text{ ft}$  [ $48.564 \text{ m} - 12,805 \text{ m}/4 = 8.940 \text{ m}$ ]).

#### Extension/Retraction Modes

The boom telescoping system operates in either of two modes selected by the operator, Automatic or Manual.

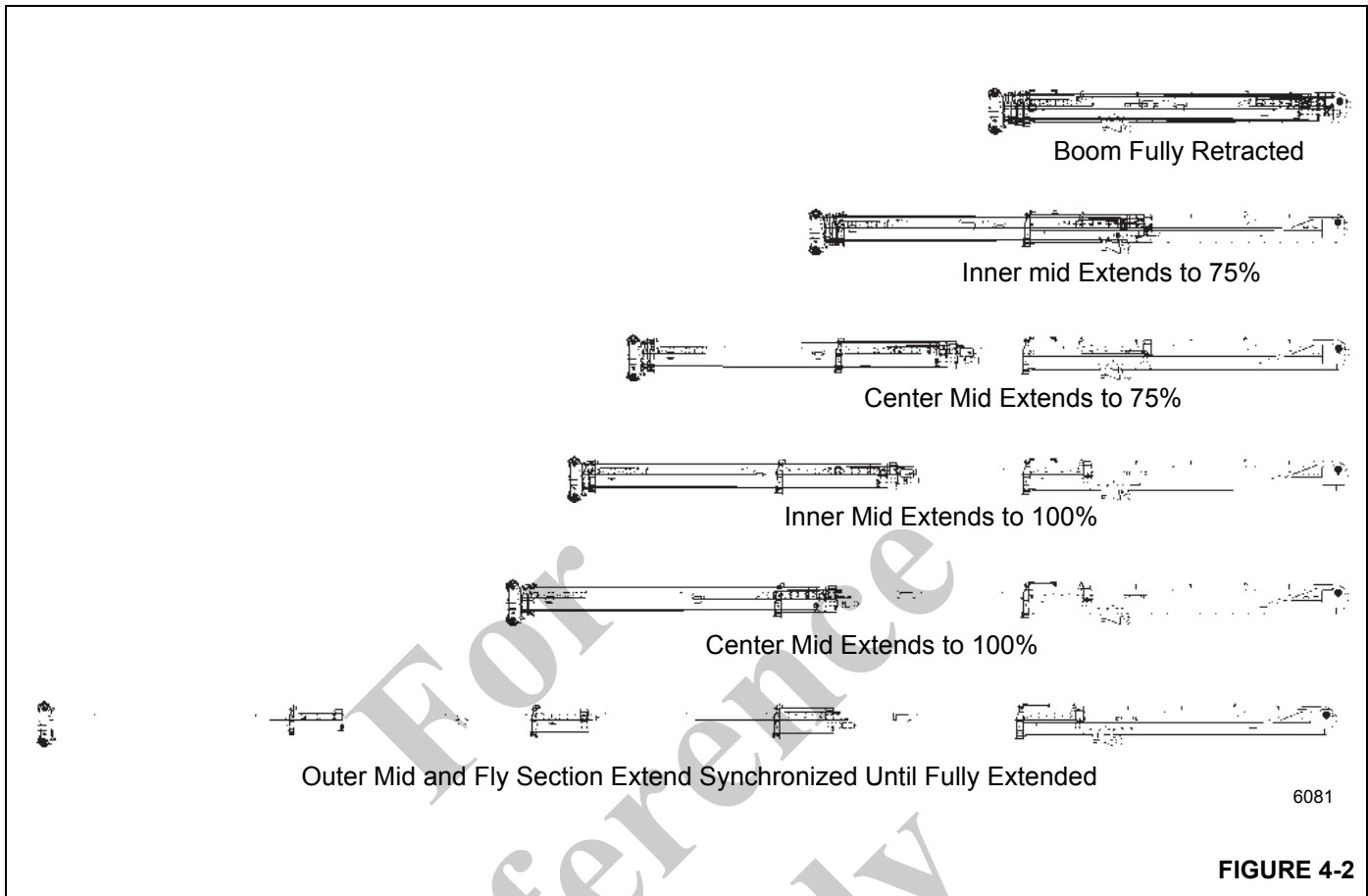
- a. In Automatic mode, a single telescope controller extends or retracts the boom at the correct speeds, in the correct sequence of section movements, with no action by the operator other than to actuate the controller and to cease actuating it when the desired boom length is achieved. The system also

automatically enforces a “soft” transition at each section changeover point in the sequence, resulting in smooth changes from section to section without the need for the operator to “feather” the telescope control.

- b. In Manual mode, the operator has the selective capability to adjust the extension of the inner mid and center mid sections independently. Manual mode adjustment is utilized only to reconfigure the boom sections into a synchronized relationship according to the programmed criteria for automatic mode operation (if the boom has for any reason become unsynchronized during operation in the Automatic mode), or to extend the boom intentionally in non-synchronized mode, so that access holes in the boom sections align, and serviceable internal components of the boom are made accessible for maintenance. To prevent overloading of the boom while the sections are unsynchronized, when the Manual mode has been selected, the RCL electronic controller limits the allowable gross load to 22,046 lb (10,000kg) or 50% of the load chart allowable capacity at the applicable measured boom length, whichever figure is less. In the Manual mode, the smoothness of the changeover from section to section is entirely under the control of the operator.

#### Extension/Retraction Sequence (Automatic Mode)

Boom extension in the Automatic mode does not follow the customary sequence whereby all the boom sections are extended by the same proportion for any given boom length. Instead, in order to optimize the crane structural and/or stability limitations, the sections extend in particular proportions according to the following sequences (as directed by the particular load chart/crane configuration selected by the operator; i.e. these sequences reside in the system data software, not in the control software):



### Extension Sequence For the Main Boom

- The inner mid section alone extends to 75% of its maximum, all other sections remain retracted.
- The center mid section alone extends to 75% of its maximum, the inner mid section remaining at 75% of its maximum, the outer mid and fly sections remain retracted.
- The inner mid section alone extends to its full extension, the center mid section remaining at 75% of its maximum, and the outer mid and fly sections remain retracted.
- The center mid section alone extends to its full extension, the outer mid and fly sections remain retracted.
- The outer mid and fly sections extends simultaneously, synchronized, to their full extension.

### Extension Sequence for the Main Boom with Boom Extensions or Offset Jibs

There are no discrete boom extension or jib capacity charts for boom lengths less than 100% extension of the center mid section. Therefore, to reduce telescoping time, the following

Automatic mode extension sequence is activated whenever an offset jib load chart is selected by the operator:

- The inner mid section alone extends to its full extension, all other sections remaining retracted.
- The center mid section alone extends to its full extension, the outer mid and fly sections remaining retracted.
- The outer mid and fly sections extends simultaneously, synchronized, to their full extension.

The boom retraction sequences are the reverse of the above extension sequences.

### Rated Boom Lengths

The boom carries capacity ratings according to the boom section extension proportions shown in the table titled Boom Section Extension Proportions (again shown as a percentage of extension of each section).

### Capacities at Intermediate Boom Lengths

It is not mandatory that only the specified discrete boom lengths are utilized for lifting, and intermediate boom lengths will be usable. The allowable capacities at intermediate

lengths behave in accordance with customary practice, in that they reduce to the figure applicable to that adjacent boom length having lower capacities (either the next longer or shorter rated boom length, according to the particular load chart in use), whenever the actual boom length differs from the rated length by more than 500 mm. (For any given boom length, the capacities vary steplessly with load radius according to the particular calibration curves).

**Hydraulic Actuation and Control System**

Extension of the inner mid, center mid, and outer mid sections occurs by way of three hydraulic cylinders (one 2-stage cylinder moving the inner mid and center mid sections, and one single-stage cylinder, moving the outer mid section). The fly section is cable extended and retracted by the movement of the outer mid section and center mid sections, and thus is mechanically synchronized with the outer mid section, but the other sections are electro-hydraulically sequenced/synchronized by the boom telescoping control system.

Controlling the telescope cylinders, the boom telescoping hydraulic actuating system consists of the following elements:

- a. A single pilot pressure joystick or foot pedal controller, which actuates two pilot operated 4-way, 3-position, pressure compensated proportional control valves controlling the flow and pressure of hydraulic oil respectively to the inner mid and center mid/outer mid section telescope circuits.
- b. The propositional control valve(s) noted in a. above, in which are incorporated solenoid operated proportional pressure reducing valves in both of the valves' pilot pressure spool actuator sections (i.e. both "extend" and "retract" directions), acting to vary the pilot pressure being applied to shift the valve spool, and thereby controlling the flow of oil to the inner mid center mid, outer mid section telescope cylinders. Thus, when so directed by electrical

signal, the pressure reducing valves effectively override the pilot pressure signal being transmitted from the operator's pilot controller to the telescope control valves, automatically opening, feathering and closing so as to initiate, control and halt motion of the respective sections according to the predetermined sequence.

- c. Mechanically actuated valves sensing the status of the center mid and outer mid sections (i.e. outer mid section fully retracted, and center mid section fully extended) and diverting the flow of oil, when extending, from the center mid section cylinder to the outer mid cylinder when the center mid section (and therefore also the inner mid section) is fully extended, and vice versa during boom retraction. Thus the outer mid section is not able to receive any oil to extend until the center mid section is already fully extended; and similarly, no "retract" oil will flow to the center mid section until the outer mid section is fully retracted.
- d. A normally closed, solenoid operated 2-way, 2-position control valve, which bleeds off residual rod side pressure from the telescope cylinders (as selected by a double check valve, according to the cylinder being telescoped, and an orifice to prevent significant loss of oil to tank that would compromise cylinder retraction speed). The purpose of this valve is to allow residual pressure trapped in the rod side of the cylinders to escape, preventing subsequent unseating of the holding valve and transfer of the trapped oil to the piston side, which can cause a slight spontaneous and unwanted extension of the boom sections
- e. Unless overridden by the pilot signal pressure reducing valves in paragraph b. (above), the oil flow and pressure applied to the telescoping cylinders is under the direct control of the joystick pilot controller.



**Table 4-1: Boom Section Extension Proportions**

Boom Length (ft)	42	56.68	71.34	86	100.67	115.34	130	144.67	159.33
Inner-Mid	0	50	75	75	100	100	100	100	100
Center-Mid	0	0	25	75	100	100	100	100	100
Outer-Mid	0	0	0	0	0	25	50	75	100
Fly	0	0	0	0	0	25	50	75	100

## Electronic Control System

As mentioned previously, the electro-hydraulic sequencing and synchronization of the inner mid and center mid section telescope cylinders are controlled through a combination RCL/boom control system electronic processor/controller, since both systems need to sense the various section extensions (i.e. to determine the boom length and its configuration [sectional extension relationships] in order to compute allowable load moment and the corresponding allowable hook load for RCL purposes, and to close the telescope sequencing/synchronization system feedback control loop).

### System Interfaces and Logic

The electronic system is supplied with electrical power of 12 VDC.

The electronic system collects electrical inputs from boom length sensors that separately measure overall boom length, and extension of the inner mid section. Since the outer mid and fly sections are mechanically [cable-] synchronized, and change over of hydraulic oil supply to or from the outer mid/fly section telescope cylinder is mechanically effected by trip valves upon full extension of the center mid section, or full retraction of the outer mid section, it is assumed that these sections cannot become unsynchronized. Therefore, on this basis the computed difference between the measured boom extension value and the measured inner mid section extension value allows the system to infer the extension of the center mid section.

The system also collects electrical inputs of boundary conditions (operator selection, by switch, of "Automatic" or Manual mode, electrical sensing, by proximity switches, of retracted condition of the inner mid section relative to the base section, and of the center mid section relative to the inner mid section, and of telescope extend or retract pilot pressure being applied). The system then produces current controlled electrical outputs to the appropriate pilot system proportional pressure reducing valves, allowing the pilot pressure to shift the telescoping control valve spools appropriately to direct oil to the inner mid or to the center mid section telescope cylinder, according to prevailing boom length and to the direction of motion selected.

In Automatic mode, the control system output current being applied to the applicable valve is automatically reduced as each section approaches a position at which the selected telescope sequence would require it to stop and the next section to begin to move. This causes the pilot oil pressure being applied to the control valve spool to be proportionately reduced according to the current, (overriding the operator's pilot control valve), so that the section telescoping speed reduces smoothly before the section finally comes to rest. In the same way the current supply to the valve controlling the following section is initiated just before the previous section finally comes to a halt, and rises smoothly to its regulated

value, giving a smooth acceleration of that section. This system prevents out of sequence conditions occurring as a result of overshoot of the section that is coming to a halt, and also enforces a smooth transition from section to section.

An additional benefit occurs in situations in which the operator is simultaneously operating the hoist, in order to keep the load at a constant height while telescoping the boom. Since telescoping speed inevitably varies from section to section according to the bore of the cylinder, and also whether a section is indirectly moved by a cable extension system, the compensating speed of the hoist has to be varied by the operator as each successive section change occurs, so that the load does not immediately rise or fall. The smooth changeover effect enforced by the telescope control system allows the operator a wider band in which to adjust compensatory speed of the hoist so that the load can be more easily kept at a constant height.

The inner mid and center mid sections are extended by a 2-stage cylinder, the larger diameter cylinder being the center mid section stage. Therefore this stage has the capability to exert higher load than the inner mid section stage, for a given hydraulic pressure. Such loads would exceed the buckling resistance of the smaller inner mid section stage, which in Automatic mode is already at 75% extension before the center mid section cylinder is actuated. For this reason, the system provides an additional electrical output to a dual pressure relief valve integrated in the telescope control valve block, causing it to reduce the maximum pressure that can be applied to the center mid section telescope cylinder, so that the cylinder is protected from such excessive buckling loads. The system programming always ensures that the lower pressure is selected before the center mid section cylinder is pressurized, and that the center mid section cylinder is isolated or fully extended, before the higher pressure is selected and applied to the other cylinders.

The system also provides a control signal to the solenoid operated telescope cylinder rod drain valve, opening the valve whenever either the inner mid or center mid section is not fully retracted (i.e. either of the section "retracted" switches is open), and closing the valve whenever both the switches are closed, indicating complete boom retraction condition.

If for any reason loss of synchronization of the inner mid/center mid section telescoping system is detected by the boom length sensing and computing system, the system inhibits all telescoping control signals to all four of the pilot system proportional control valves, preventing any further telescoping motion. To correct the condition, manual switches are incorporated, which, when actuated, change the system from Automatic to Manual mode, and select either the inner mid or center mid section for correction in Manual mode. The selected section can then be telescoped individually, bypassing the automatic synchronization system, until it is brought into correct synchronization (the system constantly displays the prevailing percentage of



extension of the sections, an indicator light on the console remains illuminated as long as the unsynchronized condition persists, and the inner mid or center mid section telescope cylinder selection is indicated by respective lights on the control panel, thereby allowing the operator to telescope the section[s] appropriately). As long as the system continues to detect the unsynchronized condition, and/or the manual mode is selected, the rated capacity limiter/lockout system also limits the allowable load moment to 22,046 lb (10,000 kg) or 50% of the rated capacity at the particular prevailing boom length, the intent being that, while the sections are unsynchronized, any hook load will be deposited, only the hookblock remaining suspended while the necessary adjustment of the boom sections occurs: only when synchronization has been achieved will the system reset and normalize the load monitoring system when switched back to Automatic mode.

The standard used by the system to define an unsynchronized condition is an error or  $\pm 3\%$  of the full extension value of one section. Since the inner mid, center mid, and the outer mid/fly combination all extend individually, compliance with the criterion can only be assessed at section extensions corresponding to the points of changeover of movement from section to section. Therefore, the system reviews the extension of each section prior to permitting the changeover, and unless all section extension values are within 3% of their programmed changeover length, the system defaults to the out-of-synchronization condition described above. The same default occurs if, in the course of operation, any boom section moves out of synchronization to a length corresponding to one of its own changeover lengths (since it then invokes the  $\pm 3\%$  criterion against the other sections), or moves away from such a changeover length by more than the 3% margin.

## BOOM MAINTENANCE

### Removal

**NOTE:** The boom weighs approximately 36,610 lb (16,606 kg). Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached.

1. Extend and set the outriggers to level the crane and ensure the boom is fully retracted and in a horizontal position over the front of the crane.
2. If equipped, remove the swingaway boom extension and aux nose according to the removal procedures in this section.



### CAUTION

Wear gloves when handling wire rope.

3. Remove the hookblock or headache ball and wind all the wire rope onto the hoist drum.
4. Position the boom to make sure that the lift cylinder is resting securely in the lift cylinder support.



### DANGER

#### Crushing Hazard!

Ensure blocking and lifting devices are capable of supporting the boom assembly.

5. Attach a lifting device to the boom to provide for equal weight distribution.
6. Tag and disconnect any electrical wiring from the boom.
7. Tag and disconnect the hydraulic lines to the lower telescope cylinder and plug.
8. Remove the capscrews, washers and nut fasteners securing the base cover to the top of the boom base section near the pivot shaft. Remove the cover.
9. With the engine off, disconnect the hose reel supply line from the side of the valve bank (Figure 4-3). Plug or cap all openings.

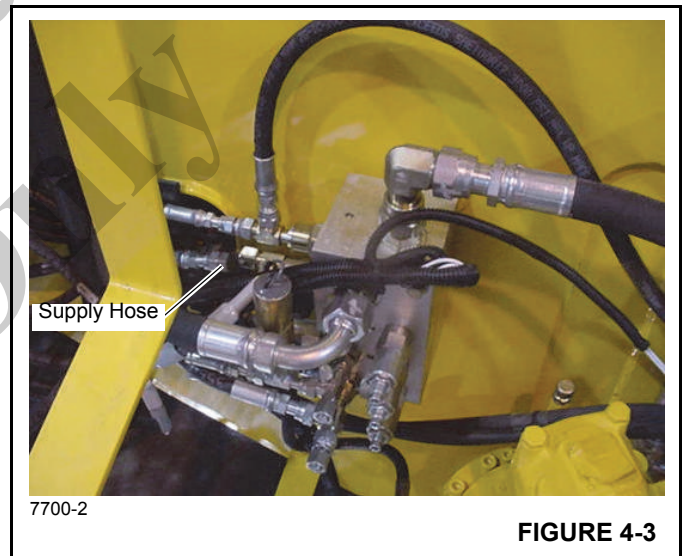


FIGURE 4-3

10. Using the S-hook, secure the spring loaded side of the hose reel in the turntable to prevent the reel from rotating before proceeding to the next step (Figure 4-4). Reach through the hole in the top of the base section and tag and disconnect the hose reel lines from the hydraulic manifold that is mounted on the rear of the center mid. Cap all lines and openings. Feed the hoses through the rollers at the rear of the base. If crane is being readied for transport, secure the hoses to the hoist.

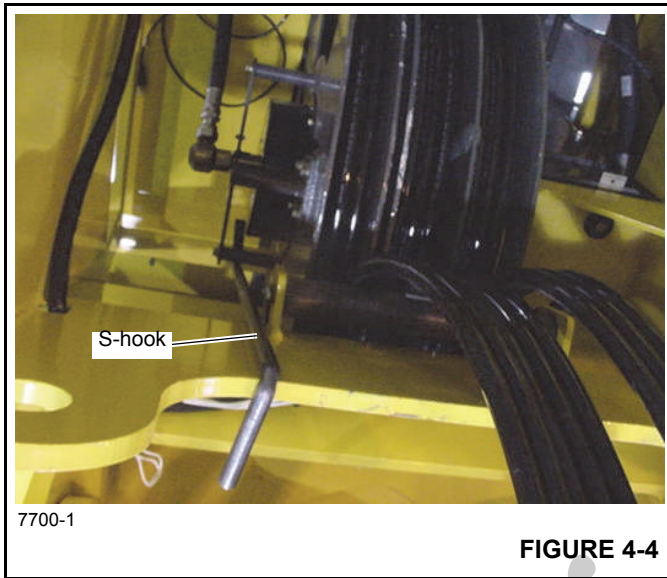


FIGURE 4-4

**! DANGER**  
**Crushing Hazard!**

Ensure the boom lift cylinder is properly supported before disconnecting it from the boom.

11. Block the lift cylinder.
12. Remove the capscrew and washer securing the upper lift cylinder shaft to the side of the attach fitting on the boom.
13. Insert the pump lever (found in cab) into the hand pump located on the left side of the boom. Turn the pump flow control lever clockwise and pump the lever until the upper lift cylinder pin is clear of the boom's left side lift cylinder attachment lug. The lift cylinder may need to be raised or lowered to aid in the release of the lift cylinder pivot shaft from the attachment lug. This can be done by using the jack on the lift cylinder support.
14. Once the shaft is clear of the attachment lug, activate the hydraulic system and retract the lift cylinder enough to clear the attachment lugs. For removal of the lift cylinder from the crane refer to the removal procedures outlined in *Lift Circuit*, page 4-32 in this section.
15. Take up the slack on the boom lifting device.

16. Remove the capscrews and lockwashers from the two pivot lock weldments that retain the pivot shafts to the boom and the turntable weldment. Remove the hoses from the counterweight removal cylinder, and match up the quick disconnects of the hoses to the disconnects on the pivot shaft removal cylinder. Activate the cylinder to pull the pivot shafts inward, to clear the bushings in the turntable weldment and in the boom.
17. Raise the boom clear of the crane and lower to ground and set cribbing to support the boom and prevent tipping.

### Boom Disassembly

**NOTE:** Boom assembly illustration shown in (Figure 4-5)

1. Remove the boom in accordance with the *Removal* procedures outlined in this section.
2. If necessary, on the left side of the boom remove the two bolts and washers securing the RCL cable angle brackets to the base, inner mid, center mid, and outer mid.

**NOTE:** The boom weighs approximately 34,000 lb (15420 kg). The above weight is for the boom without the swingaway boom extension attached.

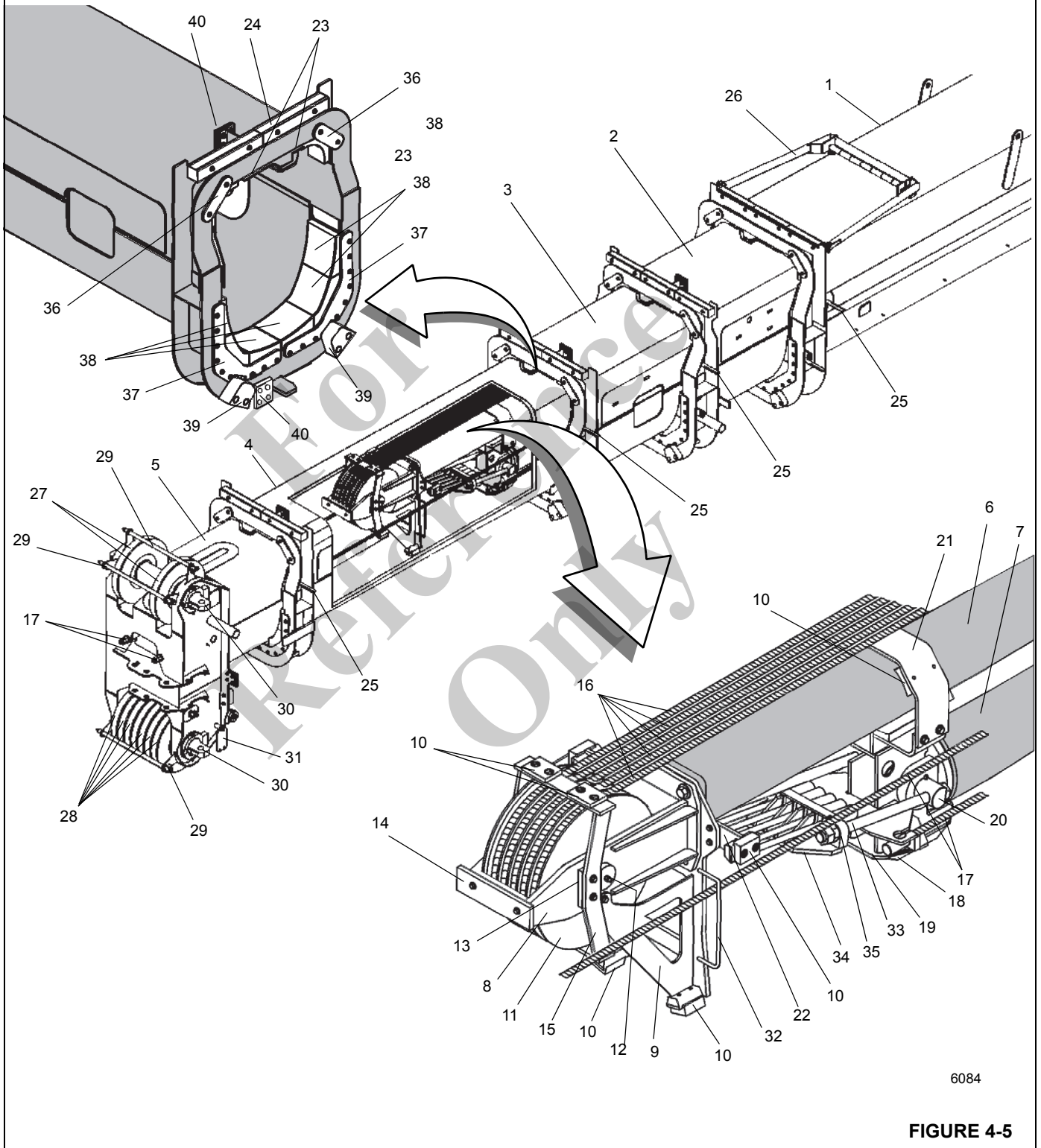
The boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

A rollover fixture with webbing is recommended to rotate boom and sections. Chains are not recommended. If a rollover fixture is not available, rotate sections using adequate support with webbing.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of section or sections.

3. On the top front of the base section, remove the capscrews, washers, nuts and three cable pads.
4. Repeat step 3 on the inner mid, removing three cable pads.
5. Repeat step 3 on the center mid, removing two cable pads.
6. Repeat step 3 on outer mid, removing two cable pads.

**NOTE:** Boom assembly must be rotated 180° before performing assembly or disassembly procedures.



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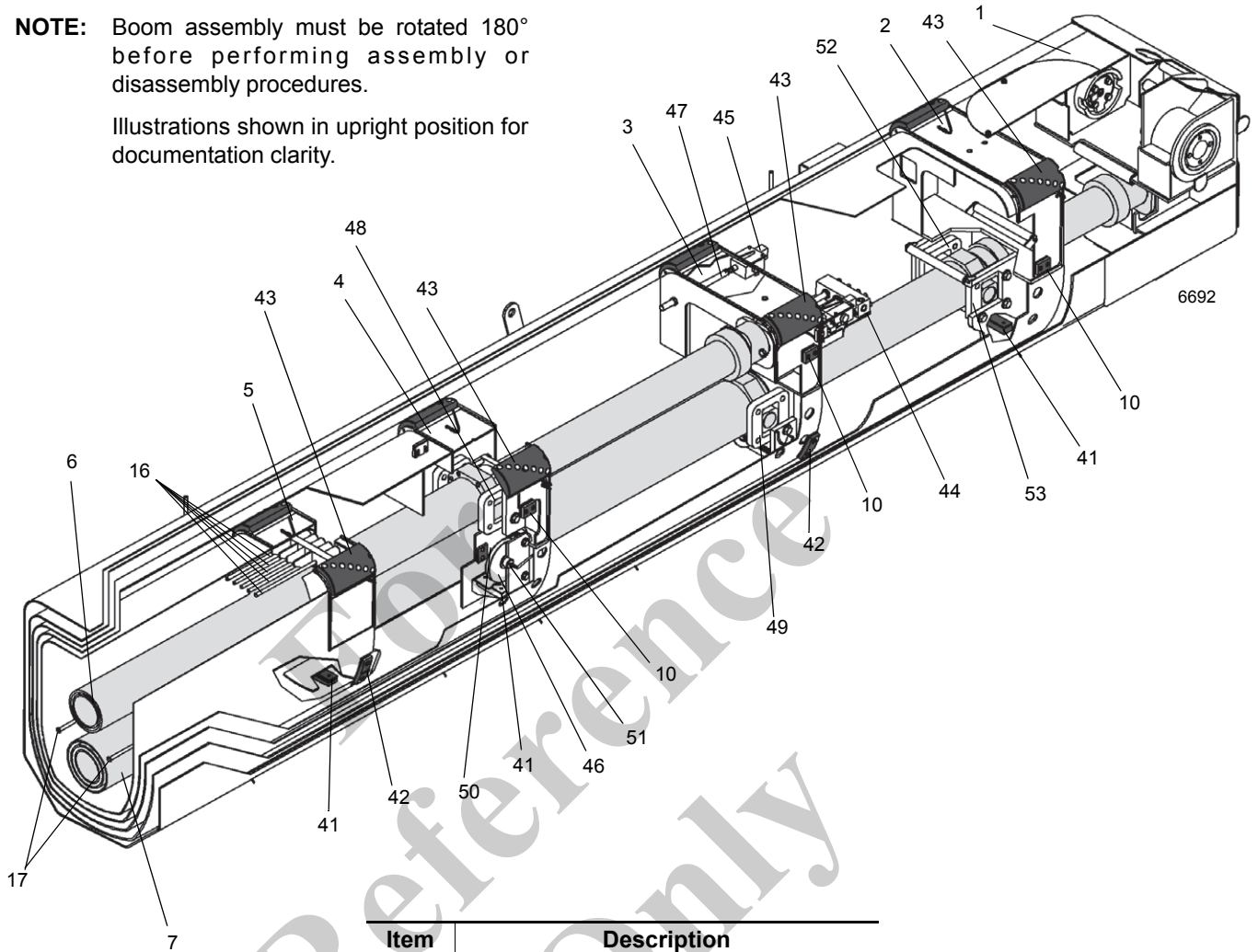
**FIGURE 4-5**

Item	Description
1	Base Section
2	Inner Mid Section
3	Center Mid Section
4	Outer Mid Section
5	Fly Section
6	Upper Telescope Cylinder
7	Lower Telescope Cylinder
8	Extend Sheave Mounting Assembly
9	Upper Cylinder Support Foot
10	Wear Pads
11	Extend Sheave Assembly
12	Extend Sheave Shaft With Grease Fitting
13	Extend Sheave Shaft Plate
14	Cable Retainer
15	Cable Guide
16	Extend Cables
17	Retract Cables
18	Skid Pad
19	Lower Cylinder Mount
20	Lower Cylinder Mount Shaft

Item	Description
21	Upper Cylinder Support
22	Wear pad Support
23	Shims
24	Cable Pads
25	RCL Cable Mounting Angles
26	Cable Guide Assembly
27	Upper Boom Nose Sheaves
28	Lower Boom Nose Sheaves
29	Cable Retainer Pins
30	Sheave Shaft/Boom Extension Anchor Lugs
31	A2B Plate
32	Cable Retainer Bar
33	Bolt
34	Sled Weld
35	Plate Cover
36	Upper Keeper Plates
37	Lower/Side Keeper Plates
38	Wear Pad Assembly
39	Stop block
40	Guide Block

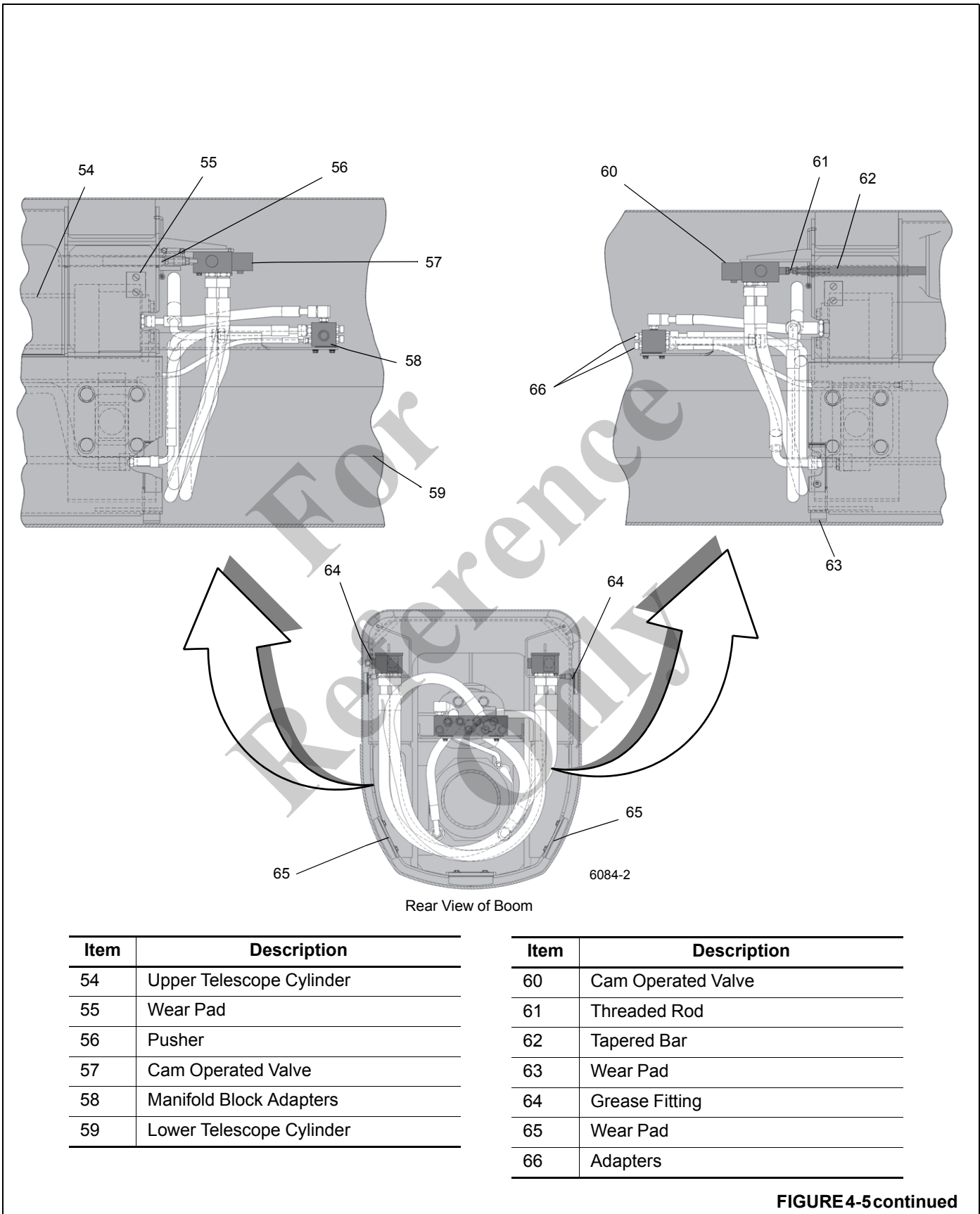
**NOTE:** Boom assembly must be rotated 180° before performing assembly or disassembly procedures.

Illustrations shown in upright position for documentation clarity.



Item	Description
41	Bottom Wear Pads
42	Rear Side Wear Pads
43	Top Rear Wear Pads
44	Manifold Block
45	Cam Operated Check Valve
46	Retract Cable Sheave
47	Pusher Rod
48	Upper Cylinder Mounting Plate
49	Lower Cylinder Mounting Plate
50	Retract Cable Sheave Mounting Plate
51	Retract Cable Sheave Shaft
52	Upper Cylinder Rod Mounting Plate
53	Lower Cylinder Rod Mounting Plate

FIGURE 4-5continued



Item	Description
54	Upper Telescope Cylinder
55	Wear Pad
56	Pusher
57	Cam Operated Valve
58	Manifold Block Adapters
59	Lower Telescope Cylinder

Item	Description
60	Cam Operated Valve
61	Threaded Rod
62	Tapered Bar
63	Wear Pad
64	Grease Fitting
65	Wear Pad
66	Adapters

FIGURE 4-5 continued

7. On the top front of the base section, remove clip pins washers and the cable guide assembly.
  8. Remove the capscrews, washers and the tele lock plate from the lower telescope cylinder.
- NOTE:** The combined weight of the boom inner mid, center mid, outer mid, and fly sections, including the telescope cylinders, is approximately 11,882 kg (26,200 pounds).
9. Slide the assembly out of the base part way.
  10. Remove the two capscrews and washers securing each top wear pad keeper plate to the base section. Remove the keeper plates.
  11. Remove the ten capscrews and washers securing the bottom and side wear pad keeper plates to the base section. Remove the keeper plates.
  12. Remove the two capscrews and washers securing each front top wear pad to the base section. Remove the wear pads and shims, noting quantity, size, and location of shims.
  13. Lift up on the front of the base and remove the bottom and side wear pads and shims from the base section, noting quantity, size, and location of shims.
  14. Continue to pull the assembly from the base section removing the top rear wear pads from the inner mid section as they clear the base section.
  15. Remove the two flat headed screws securing the rear side wear pads to the inner mid section. Remove the wear pads and shims, noting quantity and size of shims.
  16. Remove the two capscrews, washers, spacer, and lower wear pad from the inner mid, noting the quantity and size of shims.
  17. Remove the cotter pins, shaft, and roller from the rear of the inner mid.
  18. Remove the four capscrews and hardened washers securing each trunnion mounting plate and block from the lower cylinder barrel.
  19. Reach in through the rear of the inner mid to the bottom rear pad mounted on the center mid section. Remove the two capscrews and washers for that pad. Remove pad and shims, noting the number of shims.
  20. Remove the bolts, washers, pusher block, and shims from the front left side grease access hole, noting the quantity of the shims.
- NOTE:** Together the boom center mid, outer mid and fly sections, and telescope cylinders weigh approximately 20,700 lb (9388 kg).
21. Slide the assembly out of the inner mid part way.
  22. If necessary, remove the four capscrews, washers and hex nuts securing the stop block to the lower front of the inner mid. Remove the guide block and note the position it was in.
  23. Remove the two capscrews and washers securing each top wear pad keeper plate to the inner mid. Remove the keeper plates.
  24. Remove the nine capscrews and washers securing the bottom and side wear pad keeper plates to the inner mid. Remove the keeper plates.
  25. Remove the four capscrews and washers securing each front top wear pad to the inner mid. Remove the wear pads and shims, noting quantity, size, and location of shims.
  26. Lift up on the front of the inner mid and remove the bottom and side wear pads and shims from the inner mid, noting quantity, size, and location of shims.
  27. Continue to pull the assembly from the inner mid, removing the top rear wear pads from the center mid as they clear the inner mid.
  28. Remove the two flat head screws securing the rear side wear pads to the center mid section. Remove the wear pads and shims, noting quantity and size of shims.
  29. Remove the two capscrews and washers securing each of the bottom wear pads to the center mid and remove the wear pads noting quantity and size of shims.
  30. If necessary, remove both grease fittings, connectors, and grease lines from the rear of the inner mid.
  31. Remove the mounting plates from the lugs on the lower cylinder barrel.
  32. Tag and disconnect the hydraulic hoses and tubes from the telescope cylinders, the two cam valves and the hydraulic manifold. Cap and plug all openings.
  33. Remove the bolts and nuts securing each cam valve to its mounting plate and remove the valves.
  34. Remove the four capscrews and washers securing the hydraulic manifold to the mounting plate and remove the hydraulic manifold and the shims, noting the quantity of the shims.
  35. On the right side of the center mid, remove the valve pusher rod from the tube.
  36. On the left side of the center mid, remove spring and the valve pusher weld from the tube. Disassemble as necessary.
  37. Place blocking under the lower second stage cylinder barrel.

38. Remove the four capscrews and washers securing each lower cylinder barrel mounting plate and block to the center mid.
39. Remove four capscrews, washers, and the tele lock plate from the upper telescope cylinder.
- NOTE:** Together the boom, outer mid, fly section, and telescope cylinders weigh approximately 15,415 lb (6991 kg).
40. Slide the assembly out of the center mid part way.
41. If necessary, remove the four capscrews, washers and nuts securing the guide block to the lower front of the center mid. Remove the guide block and note the position it was in.
42. Remove the two capscrews and washers securing each top wear pad keeper plate to the center mid. Remove the keeper plates.
43. Remove the nine capscrews and washers securing the bottom and side wear pad keeper plates to the center mid. Remove the keeper plates.
44. Remove the four capscrews and washers securing each front top wear pad to the center mid. Remove the wear pads and shims, noting quantity, size, and location of shims.
45. Lift up on the front of the center mid section and remove the bottom and side wear pads and shims from the center mid, noting quantity, size, and location of shims.
46. Continue to pull the assembly from the center mid, removing the top rear wear pads from the outer mid section as they clear the center mid.
47. Remove the two flat head screws securing the rear side wear pads to the outer section. Remove the wear pads and shims, noting quantity and size of shims.
48. Remove the two capscrews and hardened washers securing the bottom wear pad to the outer mid and remove the wear pad.
49. If necessary, remove both grease fittings, connectors, and grease lines from the rear of the outer mid.
50. Remove the retract cable sheave mounts from the rear of the outer mid section, remove retract sheaves.
51. Remove the mounting plates from the second stage of the lower cylinder barrel mounting lugs.
52. Place blocking under the upper telescope cylinder barrel.
53. Remove the four capscrews and hardened washers securing each trunnion mounting plate from the upper cylinder barrel mounting plate to the outer mid.
- NOTE:** Together the boom, fly section, and telescope cylinders weigh approximately 11,217 lb (5087 kg).
54. Slide the assembly out of the outer mid part way.
55. Remove the two capscrews and washers securing each top wear pad keeper plate to the outer mid. Remove the keeper plates.
56. Remove the eight capscrews and washers securing the bottom and side wear pad keeper plates to the outer mid. Remove the keeper plates.
57. Remove the four capscrews and washers securing each front top wear pad to the outer mid. Remove the wear pads and shims, noting quantity, size, and location of shims.
58. Remove the four capscrews and hardened washers securing the stop block to the bracket on the bottom front of the outer mid section.
59. Lift up on the front of the outer mid section and remove the bottom and side wear pads and shims from the outer mid, noting quantity, size, and location of shims.
60. Continue to pull the assembly from the outer mid, removing the top rear wear pads from the fly section as they clear the outer mid.
61. Remove the two flat head screws securing the three rear wear pads to the fly section. Remove the wear pads and shims, noting quantity and size of shims.
62. If necessary, remove both grease fittings connectors, and grease lines from the rear of the fly section.

**DANGER****Crushing Hazard!**

Ensure the telescope cylinders are securely blocked and some means used to hold them together to prevent any accidental movement. Severe injury can occur if the cylinders drop.

**NOTE:** The telescope cylinder assembly weighs approximately 4500 lb (2041 kg).

63. Slide the telescope cylinder assembly part way out (approximately ten feet) of the rear of the fly. Support the end of the telescope cylinders with adequate blocking.

**NOTE:** The telescope cylinder assembly weighs approximately 2300 lb (1043 kg).

64. Slide the lower two stage cylinder farther out of the fly until the end of the cylinder is out of the fly.

65. Remove the four capscrews and washers holding the top plate cover to the cylinder mount. Remove the two flat head screws securing each wear pad if necessary.

66. Remove the two nuts and swivel nuts that attach the sled weldment to the two adjusting bolts at the end of the lower cylinder.



67. Slide the sled weldment off the two adjusting bolts and remove the adjusting bolts from the shaft on the lower cylinder.
68. Rotate the dead ends of the two retract cables so the ends can clear the cylinder mount, remove the retract cables from the cylinder mount.
69. Remove the lower cylinder assembly and place on adequate support.
70. If necessary, remove one cotter pin from the shaft that holds the cylinder mount to the lower cylinder.

**NOTE:** The telescope cylinder assembly weighs approximately 2200 lb (998 kg).

71. Remove the shaft and cylinder mount from the lower cylinder. If necessary, remove the flat head screws securing each pad to the cylinder mount.
72. Remove the two capscrews and hardened washers securing the extend cable keeper plate to the rear of the fly. Remove the keeper plate and remove the extend cable ends from the slots in the fly.
73. Continue to slide the upper cylinder out of the fly making sure that the cables are moving with the cylinder. Slide the telescope cylinder outward until the foot weldment at the end of the upper telescope cylinder is approximately two feet from the rear of the fly.
74. Remove the two capscrews and washers from each side of the foot weldment and remove both wear pad supports. If necessary, remove two flat head screws and pad from each support.
75. Continue to slide the telescope cylinder assembly out of the fly section. Raising the rear of the fly section and lowering the rod end of the cylinder will aid in removal.
76. On the front of the fly section, remove the two nuts and hardened washers from the end of each retract cable and remove the retract cables from the fly section.
77. Remove the four capscrews and hardened washers securing the guide block to the bracket on the rear of the boom nose.
78. Remove the two capscrews and washers on both sides of the sheave mount on the end of the upper cylinder that holds the cable guide and shaft plates. Remove the cable guide and shaft plates.
79. Remove the two capscrews and washers securing the extend cable retainer plate to the front of the sheave mount. Remove the retainer plate.
80. Remove the five extend cables from the sheave assembly.

81. Remove the grease fitting from the shaft. Remove the sheave shaft and the sheave assembly from the mounting assembly.

82. Remove the four capscrews and hardened washers securing the sheave mounting assembly and the support foot to the front of the telescope cylinder. Remove the two capscrews and washers holding the cylinder support foot to the sheave mount. Remove the sheave mounting assembly and the support foot.
83. If necessary, remove the two screws securing each wear pad to the support foot and remove the wear pads.
84. Remove the two capscrews and washers that retain the plate cover to the sled weldment. Remove the plate cover and remove the five extension cables.
85. If removal of the boom nose sheaves are required, refer to *Boom Nose Sheaves*, page 4-15.
86. Refer to *Boom Extension and Retraction Cables*, page 4-22 for cable inspection.

## Boom Nose Sheaves

### Removal

1. Remove the clip pins from the cable retainer pins and remove the cable retainer pins from the upper and lower part of the boom nose.
  2. Flatten out the tab on the lockwasher.
  3. Backoff locknut until there is no pressure on the lockwasher.
  4. Remove the bolt, washer, and nut securing the upper boom nose sheave shaft. Remove the collar.
- NOTE:** The boom nose sheave shafts weigh approximately 161 lb (73 kg) each. The boom nose sheaves weigh approximately 28 lb (13 kg) each.
5. Carefully pull the upper boom nose sheave shaft from the boom nose, removing the spacers, shims, and boom nose sheaves.
  6. Repeat steps 2 and 3 and remove the lower boom nose sheave shaft.
  7. Remove the shim, keyed washer and locknut from both sheave shafts.

### Installation



#### CAUTION

Do not install the boom nose sheaves over the threaded end of the boom nose sheave shaft.

**NOTE:** The boom nose sheave shafts weigh approximately 161 lb (73 kg) each. The boom nose sheaves weigh approximately 28 lb (13 kg) each.

1. Install the spacers and sheaves onto the sheave shaft while installing the sheave shafts into the boom nose.

**NOTE:** The lockwasher can be used more than once but must be replaced if not in good condition.

**NOTE:** Install the lockwasher onto the sheave shaft with the tabs facing out.

2. Install the locknut, washer, keyed washer, and shims (if necessary) onto the boom nose sheave shaft with the chamfer side out. Install the collar onto the opposite end of the sheave shafts and secure in place with the bolt, washer, and nut.

**NOTE:** If more than one shim is required, install an equal amount on each side of the boom nose.

3. Tighten the locknut until the play in the entire assembly is within 0.03 to 0.06 in (1 to 2 mm) total. Install shims as necessary to achieve the correct dimension. Bend the lockwasher tabs to secure the locknut in place.
4. Install the cable retainer pins into the upper and lower part of the boom nose and secure in place with the hitch pins.

### Additional Maintenance, Disassembled Boom

1. Clean all boom sections and inspect for wear, dents, bent or crooked boom sections, gouged metal, broken welds or any abnormal conditions. Repair or replace as required.
2. Inspect all sheaves for excessive groove wear or abnormal rim wear. Replace as required.
3. Inspect all sheave bearings for excessive wear or cut inner liner material. If installed bearing diameter is 0.015 in larger than pin diameter, bearing must be replaced. Any cut or gouge which causes the bearing liner to lose strands is cause for bearing replacement.
4. Clean and inspect all extend and retract cable assemblies according to wire rope inspection procedures in this section. Pay particular attention to any wire breakage at the end connections. Replace cable assemblies as required. Lubricate all cable assemblies as required. Lubricate all cable assemblies before reinstalling them in boom.
5. Inspect all sheave pins for nicks, gouges or pitting due to rust in the bearing surface area. Replace if any damage is evident.
6. Inspect all grease fittings and grease paths in pins to ensure proper grease flow. Clean and replace as required.
7. Inspect all wear pads for excessive wear, gouges, or abnormal conditions. Clean and replace as required.

## Boom Assembly

### CAUTION

#### Possible Equipment Damage!

When adjusting cables, hold the cable end and turn the nut. Do not allow the cable to turn. Turning of the cable while adjusting will result in damage or failure of cable.

Install cables in their natural untwisted condition. Do not twist cable. Twisting of cable will result in damage or failure of cable.

**NOTE:** Apply Loctite 243 to the threads of all attaching hardware except cable ends and cable lock nuts.

Apply multipurpose grease (MPG) to all wear surfaces.

Use standard Grade 5 and/or 8 torque values specified in *Fasteners and Torque Values*, page 1-18 in this manual, unless otherwise specified.

The boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during insertion of section or sections.

1. Install wear pads on the bottom of the upper telescope cylinder support foot using two screws each.
2. Install the support foot and the sheave mounting assembly on the front of the upper telescope cylinder assembly, with four capscrews and washers. Attach the support foot and the sheave mounting assembly together using two capscrews and washers.

**NOTE:** The sheave shaft should be installed with grease fitting hole to the left side.

3. Using the sheave shaft, install the sheave assembly in the sheave mounting assembly, making sure the grease fitting hole is toward the left of the assembly.

Secure the shaft and the cable guide with a plate and two capscrews and washers on each side of the sheave mounting assembly. Install grease fitting in the shaft and apply grease.

4. Route the end of the five extension cables up and around the upper telescope cylinder sheaves about one foot on to cylinder. To aid in assembly, secure the cables to the end of the cylinder by wrapping tape around the cylinder.
5. Position the cable retainer plate on the front of the sheave mounting assembly and secure with two capscrews and washers.

6. If removed, install the two wear pads on the top of the cable guide by using two flathead screws.
7. Install the other ends of the extension cables into the sled weldment, making sure the extension cables are not crossed and twisted.
8. Install the plate cover on the sled weldment and secure with two capscrews and washers.
9. At the rear of the fly section, install the upper wear pad grease line, connector and grease fitting on each side.

**NOTE:** The grease lines are designed to be used only on one side or the other (i.e. RH or LH).

10. Install the three lower rear wear pads and shims on the fly section with two flat head screws.
11. Route the two retract cables (threaded ends) through the fly section to the front. Insert the threaded ends through the holes on the front of the fly section and install a hardened washer and two nuts on each cable end.
12. Using an adequate lifting device, position the upper telescope cylinder into the rear of the fly section.
13. Slide telescope cylinder assembly into the rear of the fly section until foot support clears the gussets at the rear of the fly section. Raising the rear of the fly and lowering the rod end of the cylinders will aid in sliding these together.
14. Place the extend cable lug ends in the slots at the top of the fly section and secure them with the keeper plate and two capscrews and hardened washers.
15. Install a wear pad on the two upper telescope cylinder wear pad holders using two flat head screws.
16. Position the wear pad holders on each side of the upper telescope cylinder support foot and secure each with two capscrews and washers.
17. Slide the upper telescope cylinder assembly part way in (approximately ten feet). Place blocking under the rear of the telescope cylinder to aid in assembly.
18. Using the cylinder mount shaft attach the lower cylinder mount to the end of the lower cylinder. Attach cotter pins to secure shaft.
19. Install the wear pad and skid pad with flathead screws to the lower cylinder mount.
20. Lift lower telescope cylinder assembly and place on upper telescope cylinder.
21. Install the wear pads with flathead screws to the top plate cover.
22. Install the top plate cover assembly with four capscrews and washers to the lower cylinder mount, to attach the upper and lower cylinders together.

23. Install both ends of the retract cables to the appropriate holes in the lower cylinder mount, making sure that the cables are not crossed or twisted.
24. Install the adjusting bolts through the holes in the lower mount shaft.
25. Install the sled assembly onto the adjusting bolts and install both swivel nuts, making sure that the extension cables are not crossed and twisted.



### **WARNING** **Crushing Hazard!**

Ensure the telescope cylinders are securely blocked and some means used to hold them together to prevent any accidental movement. Severe injury can occur if the cylinders drop.

26. Secure each retract cable to the side of the upper cylinder assembly near the trunnion with tape or ty-wraps.
  27. Slide the telescope cylinders into the fly section until the trunnion on the upper cylinder is three feet from the back of the fly.
  28. Block up the telescope cylinders at the rear of the fly section to aid in installing the fly section assembly into the outer mid.
  29. At the rear of the outer mid section, install the upper wear pad grease line, connector and grease fitting on each side.
- NOTE:** The grease lines are designed to be used only on one side or the other (i.e. RH or LH).
30. Install the bottom rear wear pad on the outer mid section with two capscrews and hardened washers.
  31. Position the front end of the outer mid at the rear of the fly/telescope cylinder assembly.
  32. Place the mounting plates on the upper telescope cylinder barrel mounting lugs.
  33. Slide the fly/telescope cylinder assembly into the outer mid section installing top rear wear pads in pockets of fly section (cutout should align with grease line). Stop and check rear wear pad clearance and shim if needed.
- NOTE:** Use shims as they are necessary to adjust wear pads within 0.078 in (2 mm) of the outer mid section side plate. Use equal number of shims on side pads.
34. Continue to slide together being careful not to damage cables.
  35. Install bottom and side front wear pads in outer mid. Lift up on the front of the fly section assembly and check

clearance between the pads and the pad box weldment on the outer mid section. Install shims as necessary so there is no more than 0.03 in (1 mm) clearance between the wear pads and the fly section.

- 36.** Install outer mid front top wear pads and shims as noted during disassembly. Secure with four capscrews and hardened washers each.

**NOTE:** Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 0.078 in (2 mm) of the fly section side plate at both the top and side surfaces of the top radius.

- 37.** Install bottom and side wear pad keeper plate on each side of the outer mid and secure with eight capscrews and washers each.

- 38.** Install top wear pad keeper plate on each side of the outer mid and secure with two capscrews and washers each.

- 39.** Continue to completely slide together.

- 40.** Lift up on end of the upper cylinder to align barrel mounting plate holes with holes in outer mid. Secure each with four capscrews and hardened washers.

- 41.** Remove any blocking under the upper cylinder.

- 42.** Detach the retract cables from the upper telescope cylinder, place the cables around each retract sheave, place the sheave onto the shaft weld and use four bolts and washers to secure each shaft weld assembly into the rear of the outer mid, making sure that the retract cables are not crossed and twisted.

- 43.** Position the guide blocks on the boom nose to the correct clearance of 0.00 in to 0.06 in (0 mm to 2 mm) with respect to the guide bars on the outer mid. Secure with four capscrews and washers for each.

- 44.** Place the mounting plates and blocks on the second stage lower cylinder barrel mounting lugs.

- 45.** At the rear of the outer mid install the fittings and hoses to both retract sheaves, grease sheaves.

- 46.** At the rear of the center mid section, install the upper wear pad grease line, connector and grease fitting on each side.

**NOTE:** The grease lines are designed to be used only on one side or the other (i.e. RH or LH).

- 47.** Install the two side lower side wear pads and shims on the rear of the center mid with two capscrews and washers. The bottom rear pad and shims will be installed after the center mid assembly is inserted into the inner mid.

- 48.** Position the front end of the center mid at the rear of the outer mid/fly/telescope cylinder assembly.

- 49.** Slide the outer mid/fly/telescope cylinder assembly into the center mid section installing top rear wear pads in pockets of outer mid section (cutout should align with grease line). Stop and install rear side wear pads and shims on outer mid section with two flat head screws each.

**NOTE:** Use shims as they are necessary to adjust wear pads within 0.078 in (2 mm) of the center mid section side plate. Use equal number of shims on each side.

- 50.** Install bottom and side front wear pads in center mid. Lift up in the front of the outer mid section assembly, check clearance between the pads and the pad box weldment on the center mid section. Install shims as necessary so there is no more than 0.03 in (1 mm) clearance between the wear pads and the outer mid section.

- 51.** Install center mid front top wear pads and shims as noted during disassembly. Secure with four capscrews and washers each.

**NOTE:** Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 0.078 in (2 mm) of the outer mid section side plate at both the top and side surfaces of the top radius.

- 52.** Install bottom and side wear pad keeper plate on each side of the inner mid and secure with nine capscrews and washers each.

- 53.** Install top wear pad keeper plate on each side of the center mid and secure with two capscrews and washers each.

- 54.** Continue to slide together aligning the upper cylinder rod end with bushing in center mid trunnion. Slide completely together.

**NOTE:** Use shims as necessary to adjust guide block so that the guide block is within 0.118 to 0.197 in (3 to 5 mm) of the top of the outer mid section.

- 55.** Secure the telescope lock plate to the upper cylinder rod end with four capscrews and hardened washers.

- 56.** Install bolt, nut, and hardened washer in right side valve tapped pusher rod. Install the rod assembly through hole on right side of center mid.

- 57.** Install left side valve pusher weld assembly in tube on left side of center mid, attach return spring.

- 58.** Lift up on end of the lower cylinder to align barrel mounting plate holes with holes in inner mid. Secure each with four capscrews and hardened washers.

- 59.** Remove any blocking under cylinder.

- 60.** Access through the rear of the inner mid to install the bottom wear pad and shims onto the rear of the center mid with two capscrews.

**NOTE:** Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 0.078 in (2 mm) of the outer mid section side plate at both the top and side surfaces of the top radius.

61. Install the cam valves on the mounting plates on each side of the inner mid using three bolts, hardened washers, and nuts (early models only) each.
62. Install hydraulic manifold and shims on the mount plate at the rear of the center mid with four capscrews and washers.
63. If removed, install hydraulic fittings in the ports of the valves, hydraulic manifold, and the cylinders as tagged during disassembly.
64. Connect the hydraulic hoses and tubing to the valves, hydraulic manifold, and cylinders as tagged during disassembly.
65. Place the mounting plates and blocks on the lower cylinder barrel mounting lugs.
66. Position the guide blocks on the front of the outer mid to the correct clearance, 0.00 in to 0.06 in (0 mm to 2 mm), with respect to the guide bars on the center mid. Secure with four capscrews, washers and nuts for each.
67. At the rear of the inner mid section, install the upper wear pad grease line, connector, and fitting on each side.

**NOTE:** The grease lines are designed to be used only on one side or the other (i.e. RH or LH).

68. Install the bottom rear wear pad on the inner mid section with two capscrews and hardened washers.
69. Position the front end of the inner mid at the rear of the center mid/outer mid/fly/telescope cylinder assembly.
70. Slide the center mid/outer mid/fly/telescope cylinder assembly into the inner mid section installing top rear wear pads in pockets of the center mid section (cutout should align with grease line). Stop and install rear side wear pads and shims on center mid section with two flat head screws each.

**NOTE:** Use shims as necessary to adjust wear pad so it is within 0.078 in (2 mm) of the inner mid section side plate. Use equal number of shims on each side.

71. Continue to slide together.
72. Install bottom and side front wear pads in the inner mid. Lift up in the front of the center mid section assembly, check clearance between the pads and the pad box weldment on the inner mid section. Install shims as necessary so there is no more than 0.03 in (1 mm) clearance between the wear pads and the center mid section.

73. Install inner mid front top wear pads and shims as noted during disassembly. Secure with four capscrews and washers each.

**NOTE:** Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 0.078 in (2mm) of the outer mid section side plate at both the top and side surfaces of the top radius.

74. Install bottom and side wear pad keeper plate on each side of the inner mid and secure with nine capscrews and washers each.
75. Install top wear pad keeper plate on each side of the inner mid and secure with two capscrews and washers each.
76. Continue to completely slide together.
77. Lift up on end of the lower cylinder to align barrel mounting plate holes with holes in inner mid. Secure each with four capscrews and hardened washers.
78. Remove any blocking under cylinder.
79. Install the pusher block at the front left grease access hole on the inner mid. Replace the shims and secure with two bolts and washers.

80. Position the guide blocks on the front of the center mid to the correct clearance of 0.00 in. to 0.06 in (0 mm to 2 mm) with respect to the guide bars on the inner mid. Secure with four capscrews and washers for each.

81. Position the front end of the base at the rear of the inner mid/center mid/outer mid/fly/telescope cylinder assembly.

82. Slide the inner mid/center mid/outer mid/fly/telescope cylinder assembly into the base section installing top rear wear pads in pockets of inner mid section (cutout should align with grease line). Stop and install rear side wear pads and shims on inner mid section with two flat head screws each.

**NOTE:** Use shims as necessary to adjust wear pad so it is within 0.078 in (2 mm) of the base section side plate. Use equal number of shims on each side.

83. If removed, install the roller shaft and cotter pins at the rear of the inner mid.

84. Continue to slide together.

85. Install bottom and side front wear pads in base. Lift up in the front of the inner mid section assembly, check clearance between the pads and the pad box weldment on the base section. Install shims as necessary so there is no more than 0.03 in (1 mm) clearance between the wear pads and the inner mid section.

86. Install base section front top wear pads and shims as noted during disassembly. Secure with four capscrews and washers each.

**NOTE:** Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 0.078 in (2mm) of the inner mid section side plate at both the top and side surfaces of the top radius.

87. Install bottom and side wear pad keeper plate on each side of the base section and secure with ten capscrews and washers each.
88. Install top wear pad keeper plate on each side of the base section and secure with two capscrews and washers each.
89. Continue to completely slide together.
90. Continue to slide together aligning the lower cylinder rod end with bushing in base trunnion block. Slide completely together.
91. Install hydraulic fittings if removed from lower telescope cylinder rod.
92. Secure the telescope lock plate to the lower cylinder rod end with four capscrews and hardened washers.
93. If removed, install the five rollers, spindle roller, and cotter pins to the rear of the base section.
94. Position the guide blocks on the front of the inner mid to the correct clearance of 0.00 in. to 0.06 in (0 mm to 2 mm) with respect to the guide bars on the base. Secure with four capscrews and washers for each.
95. On the top front of the base section, install bolts, washers, and three cable pads.
96. Repeat step 95 on the inner mid, installing three cable pads.
97. Repeat step 95 on the center mid, installing two cable pads.
98. Repeat step 95 on outer mid, installing two cable pads.

**NOTE:** The boom assembly must be rotated 180° right side up to install on crane.

A rollover fixture with webbing is recommended to rotate boom and sections. Chains are not recommended. If a rollover fixture is not available, rotate sections using adequate support with webbing.

The boom weighs approximately 34,000 lb (15420 kg). The above weight is for the boom without the swingaway boom extension attached.

99. Lower the boom to ground level and secure with cribbing to prevent tipping.
100. On the top front of the base section, install clip pins, washers, and the cable guide assembly.

101. On the left side only, install a RCL cable angle bracket on the base, inner mid, and outer mid using two capscrews and washers each.

102. Install the boom in accordance with the INSTALLATION procedures outlined in the following section.

## Installation

**NOTE:** The following procedure applies to a boom totally removed from the crane.



### DANGER

#### Crushing Hazard!

Ensure blocking and lifting devices are capable of supporting the boom assembly.

1. Attach an adequate lifting device to the boom and suspend the boom over the machine.
2. Lower the boom into position and align the boom pivot shaft mounting holes for installation of the pivot shaft to the superstructure assembly.
3. Lubricate the pivot shafts and related pivot bushings in the boom assembly and the turntable weldment.



### DANGER

#### Crushing Hazard!

Block the boom before doing any work under the boom.

4. Block the boom in place.
5. The boom may need to be raised or lowered to aid in the installation of the pivot shafts. Remove the hoses from the counterweight removal cylinder, match up the quick disconnects of the hoses to the disconnects on the pivot shaft removal cylinder.
6. Activate the cylinder to install the pivot shafts. Ensure the pivot shafts seat fully in the pivot bushings in the boom assembly and the turntable weldment; the pivot shafts are stepped because the bushings are of different diameters.
7. Remove the hoses from the pivot shaft cylinder. Match up the quick disconnects of the hoses to the disconnects on the counterweight removal cylinder.
8. Install the two pivot lock weldments to secure the pivot shafts to the turntable weldment. Fasten them to the pivot shafts with capscrews and washers.

**DANGER****Crushing Hazard!**

Failure to properly support the boom lift cylinder may result in death or serious injury.

**CAUTION**

If the hydraulic system must be activated to extend or retract the lift cylinder, ensure the rod end is properly aligned with the lift cylinder attach fitting.

9. Lubricate the upper lift cylinder pin and related bushings in the lift cylinder rod end and the boom's lift cylinder attach lugs.
10. Using the lifting device attached to the boom, lower the boom onto the lift cylinder rod end. Activate the crane's hydraulic system and align the lift cylinder rod end with the boom's lift cylinder attachment lug holes as needed.
11. Using the hand pump located on the left side of the boom, insert the pump lever (found in cab) into the hand pump. Turn the pump flow control lever counterclockwise and pump the pump lever until the upper lift cylinder pin pins the rod end of the lift cylinder to the boom's lift cylinder attachment lugs, and the upper lift cylinder pin's flange portion fits completely against the left side of the boom's left lift cylinder attachment lug. The lift cylinder may need to be raised or lowered to aid in the installation of the upper lift cylinder pin. This can be done by using the jack on the lift cylinder support. Shut down the engine.
12. Apply Grove-approved threadlocking compound to the upper lift cylinder pin's related capscrew. Secure the upper pivot shaft to the boom with the capscrew and washer.
13. Lower the jack on the lift cylinder support.
14. Remove the boom lifting device.
15. Activate the hydraulic system and remove the boom and lift cylinder blocking devices. Lower the boom to horizontal. Shut down the crane.
16. Connect the hydraulic lines to the lower telescope cylinder as tagged prior to removal.
17. Feed the hose reel lines through the rollers at the rear of the base. Reach through the hole in the top of the base section and attach the hose reel lines to the hydraulic manifold as tagged prior to removal.
18. Using your hand, pull on the hose reel lines, then remove the S-hook from the hose reel (Figure 4-4).

Continue to hold tension on the hoses as you allow them to wrap up on the reel.

19. Being careful not to pinch or damage the hoses, extend the boom to take up the majority of the slack in the hoses; be sure to leave some slack in the lines.
20. With the engine off, connect the hose reel supply line to the valve bank (Figure 4-3).
21. While watching to ensure the hoses on the hose reel wrap up correctly, have an assistant start the engine, but do not actuate the telescope control; the hydraulic system will automatically finish wrapping the hoses on the hose reel.
22. Install the base cover on top of the boom base section, secure with four bolts and washers.
23. Connect any electrical wires as tagged prior to removal.

**CAUTION**

If removed, ensure the large access covers on each side of the boom base section are installed before extending the boom.

24. Refer to *Boom Extension and Retraction Cables*, page 4-22 for cable adjustments.
25. Refer to *Cam Operated Check Valve Adjustment*, page 4-22 for valve adjustment.

**Functional Check**

1. Activate the hydraulic system and check for proper operation and any leaks.
2. Ensure the boom will extend and retract properly.
3. Ensure the lift cylinder will not allow the boom to drift down until the operator lowers it.
4. Ensure all electrical components disconnected during removal are operating properly.

**Inspection**

Visually inspect telescoping sections for adequate lubrication of all wear surfaces. Observe extended sections for evidence of cracks, warping, or other damage. Periodically check security of boom wear pads. Check boom nose sheaves for security and freedom of movement.

Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. Refer to *Lubrication*, page 9-1.

**Boom Alignment and Servicing**

Refer to *Arctic Lubricants and Conditions*, page 9-3 for the proper lubricant.

Boom alignment is done as the boom sections are being assembled into one another. A check and fine adjustment is as follows.

1. Fully extend the boom horizontally.
2. Lubricate the boom bottom channels and top corners.
3. Shim the front top wear pads such that wear pad is just touching or is no more than 0.078 in (2 mm) from contacting the next section both at the top and side surfaces of the top radius.

### CAUTION

#### Equipment Damage Hazard!

When extending and retracting the boom during alignment, movement should be stopped if a restriction is encountered, and wear pads adjusted as necessary to provide free travel of the affected boom section(s).

4. Retract and extend the boom; check for the high point where the boom has brushed the wear pads at the widest point.
5. Retract the boom sections to align the high point on the boom section with the adjacent wear pads.
6. Add or subtract shims as necessary.
7. Attach a weight and extend the boom full length. Check for side deflection.

Example: If the boom deflects to the left, the top left wear pad would have shims added and the top right wear pad would have shims removed.

### Cam Operated Check Valve Adjustment

There are two cam operated valves mounted on the back of the center mid section. When the boom is fully retracted or the center mid is fully extended and the outer mid is fully retracted, the valve on the right side of the boom is held open to supply flow to the second stage of the lower cylinder. When the center mid is fully extended, the valve on the left side of the boom opens to supply flow to the upper telescope cylinder. For a short period of time, both valves are open because the booms second stage lower cylinder is fully extended before the upper cylinder starts to extend. As the outer mid starts to extend, the valve on the right side closes to shut off the flow to the second stage of the lower cylinder.

1. Ensure the extend and retract cables are adjusted.
2. Extend the inner mid section out of the base section until the front grease access holes on the inner mid section are accessible. The inner mid section can be extended completely if needed. Extend the center mid section completely making sure that the outer mid section is against the stop blocks on the center mid section.

3. Access the check valves through the front grease access holes on each side of the inner mid section.
4. Left side valve: on the left side of the inner mid section, adjust the bolt to move the pusher weldment causing the pusher to just contact the valve stem. Continue to adjust the bolt until the pusher depresses the valve stem approximately 0.39 in (10 mm). Tighten the nut.
5. Right side valve: through the access hole in the inner mid section on the right rear of the center mid, loosen the lock nut and adjust the bolt until it just contacts the valve stem. Continue to adjust the bolt until it depresses the valve stem approximately 0.39 in (10 mm). Tighten the lock nut.

### Guide Block Adjustment

1. Align and service the boom. Refer to BOOM ALIGNMENT AND SERVICING in this section.
2. Rotate the guide block at the top and bottom of the inner mid/center mid section, and outer mid section so that the guide block is within 0 to 0.078 in (0 to 2 mm) of the welded block on the top of the next section.
3. Repeat the same for the fly section guide blocks at the top and left side of the back of the boom nose.

**NOTE:** The guide block hole pattern is so designed that the guide block has four mounting positions which provide 0.125 in (3 mm) incremental settings.

4. After obtaining proper clearance, tighten the four bolts.

### BOOM EXTENSION AND RETRACTION CABLES

#### Maintenance

**NOTE:** For more detailed information concerning maintenance of the extension and retraction cables, refer to *Wire Rope*, page 1-22.

#### Inspection



#### CAUTION

Never handle wire rope with bare hands. Always wear gloves to prevent cuts or abrasions.

The following information is taken from a National Consensus standard as referenced by Federal Government Agencies.

All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall be taken out of service when any of the following conditions exist.



1. In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
2. Wear of one-third the original diameter of outside individual wires. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
3. Evidence of any heat damage from any cause.
4. Reductions from nominal diameter of more than:
  - 0.016 in (0.4 mm) for diameters up to and including 0.3125 in (8 mm).
  - 0.031 in (0.79 mm) for diameters 0.375 and 0.5 in (10 and 13 mm) inclusive.
  - 0.047 in (1.19 mm) for diameters 0.5625 to 0.75 in (14 to 19 mm) inclusive.
  - 0.063 in (1.59 mm) for diameters 0.875 to 1.125 in (22 to 29 mm) inclusive.
  - 0.094 in (2.38 mm) for diameters 1.25 to 1.5 in (32 to 38 mm) inclusive.
5. In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
3. With the inner mid section completely retracted extend the center mid section until the large access hole at the front of the center mid is lined up with the large access hole in the outer mid section.
4. With the front of the boom in the above position extend the boom approximately 1 in (25 mm) to relieve the tension in the retract cables. Access the retract cables from the front of the boom nose and view the slack of the retract cables through the hole in the back of the boom nose. Using the nuts on the retract cables, remove slack evenly, until both retract cables are at least 25 mm (1 in) above the lower leg of the cable retainer bars on the cylinder foot support on the upper telescope cylinder.
5. Retract the boom approximately 1 in (25 mm) to relieve tension on the extension cables. Shut down the crane. Access the extension cable adjusting bolts through the access hole in front of the center mid section. Evenly tighten the swivel nuts on the adjusting bolts, until the extension cables are up to 6 in (150 mm) off the top of the bottom pad plate at the back of the fly section. Look through the access hole on the center mid section.
6. Lock the adjustments with the jam nuts.
7. Extend the boom until the outer mid/fly extends several inches (cm).
8. Retract the boom until either the fly section just contacts the outer mid stop block or the outer mid section just contacts the inner mid stop block.
9. Check the gap between the stop blocks and the boom sections. If there is a gap between the center mid section's stop block and the outer mid of more than 0.125 in (3 mm), loosen the retract cable. If there is a gap between the outer mid section's stop block and the fly section, tighten the retract cable slightly.

### Adjustment

At near fully extended boom length, during sudden extension after retracting the boom some distance, and with high telescoping speeds, the extension cables may slap the inside of the boom section. This will make a somewhat audible noise, however this will not cause any damage and is acceptable. If the cables do not make a slapping noise under these conditions, it is an indication that the extension cables may be too tight and should be readjusted. Be aware that there may also be a similar noise made by the telescope cylinder rod mount at the rear of the base section and center mid section and confusion between the two could be experienced.

#### CAUTION

When adjusting cables, hold the cable end and turn the nut. Do not turn cable. Turning cable while adjusting will result in damage or failure of cable.

**NOTE:** The extension cables must be adjusted properly before the retract cables can be adjusted.

1. Extend and set the outriggers, ensuring the crane is level.
2. Ensure the boom is over the front and at a horizontal position (boom angle elevation 0 degrees or lower).
10. Extend the boom approximately 6 in (150 mm). Retract the boom again until one of the stop blocks just contacts its boom section.
11. Again check the gap as in step 10 and if necessary, make further adjustments.
12. Repeat steps 11 and 12 until there is a 0.125 in (3 mm) gap at the outer mid section's stop block when the fly section's stop block has just made contact.
13. Lock the retract cable adjustments with the jam nuts.

#### CAUTION

Over tightening of the retract cable will damage the cable. Take care when retracting the boom fully, while adjusting the cable, to avoid full boom retraction if the fly section contacts its stop block more than 0.125 in (3 mm) before the outer mid section contacts its stop block on the inner mid.

## TELESCOPE CIRCUIT

### Description

The boom telescope circuit consists of the telescope hydraulic remote controller, telescope directional control valve, holding valve, hose reel, and the upper and lower telescope cylinders.

The telescope control valve is the closed spool type and is described under *Valves*, page 2-31.

Refer to *Valves*, page 2-31 for a complete description of the hydraulic remote controller.

The boom telescope system has a lower and an upper telescope cylinder. The lower telescope cylinder is a two stage cylinder. The first stage has a 7.50 in (190.5 mm) bore and the second stage is a 9.25 in (235 mm) bore. The upper telescope cylinder has a 7.50 in (190.5 mm) bore. Foreign material is prevented from entering the cylinder by a wiper seal during rod retraction. O-ring seals prevent internal and external leakage. Refer to *Temperature Effects on Hydraulic Cylinders*, page 2-67 for a complete description of the telescope cylinder.

A holding valve is threaded into a port block on the rod end of the upper telescope cylinder and the first stage rod end on the lower telescope cylinder. The holding valve for the second stage of the lower telescope cylinder is mounted into the port block on the barrel end of the second stage barrel. The holding valves function during the retraction, extension, or holding operation. When holding the boom section at a given length, oil is trapped in the cylinder by the holding valve. Refer to *Valves*, page 2-31 for a complete description of the holding valve.

Cranes equipped with a telescope cylinder charge system will have an additional valve manifold in the telescope circuit to prevent boom retraction due to thermal contraction under the following operating conditions: If the crane is operated

with a long boom length and low boom angle, and the hydraulic oil in the telescope cylinders cools and contracts, the friction forces in the extended boom will prevent the boom from retracting. Then, if the operator begins to elevate the boom without telescoping out slightly, the crane may reach a boom elevation angle where the weight of the boom sections and load overcomes the friction forces in the boom sections, causing the boom to retract until the column of oil inside the cylinders once again supports the boom sections. The telescope cylinder charge system will prevent the boom from retracting under these conditions by automatically replenishing the volume of hydraulic oil lost in the telescope cylinders due to thermal contraction.

Additionally, the system utilizes a pressure switch plumbed into the telescope extend circuit, which will turn on the telescope cylinder charge indicator and sound the warning buzzer in the operator's cab if the charge system is not functioning properly (see *Telescope Cylinder Charge Indicator* in *Section 3* of the applicable *Operator's Manual*). Refer to *Valves*, page 2-31 for a complete description of the telescope cylinder charge valve manifold. Refer to the subsection titled *Boom Drift Chart (Cylinder length change in millimeters)*, page 2-68 for an electrical schematic of this system.

### Theory Of Operation

Flow from the pump travels to the telescope directional control valve. Movement of the telescope hydraulic remote controller (foot pedal, when equipped with optional auxiliary hoist) for telescope functions from neutral sends a pilot pressure signal to the directional control valve to shift the spool in the directional control valve. This aligns the appropriate passages in the control valve to route oil to the telescope cylinders.

For more information, refer to *Theory Of Operation*, page 4-2.

## Maintenance

Table 4-2: Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Erratic operation of extending telescoping cylinder.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Damaged relief valves.	b. Repair or replace relief valves.
	c. Air in telescope cylinder.	c. Bleed by lowering telescope cylinder below horizontal.
	d. Low engine rpm.	d. Increase engine rpm to recommended setting.
	e. Lack of lubrication on boom sections.	e. Properly lubricate all boom sections.
	f. Extremely tight boom extension sheaves.	f. Inspect and properly lubricate boom extension sheaves.
	g. Improper boom alignment caused from side loading.	g. Reduce and properly hoist load.
	h. Worn boom wear pads.	h. Replace wear pads and properly lubricate.
	i. Distorted boom section.	i. Replace distorted section.
	j. Damaged telescope cylinder.	j. Repair or replace cylinder.
	k. Clogged, broken, or loose hydraulic lines or fittings.	k. Clean, tighten, or replace lines or fittings.
l. Damaged control valve.	l. Repair or replace control valve.	

Reference Only

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Erratic operation of retracting telescoping cylinder.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Damaged relief valve.	b. Repair or replace relief valve. Refer to your Manitowoc Crane Care Parts Manual.
	c. Air in cylinder.	c. Bleed by lowering telescoping cylinder below horizontal and cycle telescope cylinder.
	d. Low engine rpm.	d. Increase engine rpm to recommended setting.
	e. Lack of lubrication.	e. Properly lubricate all boom sections.
	f. Check valve malfunctioning.	f. Repair or replace check valve.
	g. Improper boom alignment caused from side loading.	g. Reduce and properly hoist load.
	h. Extremely tight boom retraction sheave.	h. Inspect and properly lubricate.
	i. Distorted boom section.	i. Replace distorted section.
	j. Worn boom wear pads.	j. Replace wear pads and properly lubricate.
	k. Bent cylinder rod(s).	k. Replace cylinder rod(s) and all cylinder seals.
	l. Scored cylinder barrel.	l. Repair or replace cylinder barrel.
	m. Damaged piston seals.	m. Replace all cylinder seals.
	n. Loose or damaged piston(s).	n. Replace all seals and re-torque or replace piston(s).
3. Telescope cylinder will not extend.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Relief valve malfunctioning.	b. Repair or replace relief valve.
	c. Excessive load.	c. Reduce load.
	d. Clogged hose and fittings.	d. Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	e. Broken valve spool.	e. Replace valve.
	f. Damaged piston seals.	f. Replace all cylinder seals.
	g. Damaged piston(s).	g. Replace piston(s) and all cylinder seals.
	h. Bent boom section(s).	h. Replace damaged boom section(s).
	i. Broken hydraulic pump coupling.	i. Replace broken hydraulic pump coupling.
	j. Worn or damaged hydraulic pump section.	j. Repair or replace pump section.

SYMPTOM	PROBABLE CAUSE	SOLUTION
4. Telescope cylinder will not retract.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Relief valve damaged.	b. Repair or replace relief valve.
	c. Excessive load.	c. Reduce load. (Refer to load chart).
	d. Inoperative check valve.	d. Replace check valve.
	e. Clogged hose and fittings.	e. Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	f. Broken valve spool.	f. Replace valve section.
	g. Broken piston(s).	g. Replace piston(s) and all cylinder seals.
	h. Damaged piston seals.	h. Replace all cylinder seals.
	i. Bent boom section(s).	i. Replace damaged boom section(s).
	j. Broken hydraulic pump coupling.	j. Replace broken hydraulic pump coupling.
	k. Worn or damaged hydraulic pump.	k. Repair or replace pump.
l. Broken hydraulic pump shaft.	l. Replace pump shaft.	
5. Center mid will not extend.	a. Right side check valve blocked.	a. Readjust, repair, or replace valve.
6. Center mid will not retract.	a. Right side check valve closed.	a. Readjust valve.
7. Outer mid will not extend.	a. Left side check valve is closed.	a. Readjust valve.
8. Center mid retracts before outer mid.	a. Right side check valve is open or hosed backwards.	a. Install hoses properly.
9. Outer mid extends only a short distance then stops.	a. Left check valve is open or hosed backwards.	a. Install hoses properly.

### Removal and Installation

Removal and installation of the telescope cylinder from the boom is described under disassembly and assembly of the boom. Refer to *Boom Maintenance*, page 4-7.

### Disassembly and Assembly

Disassembly and assembly procedures of the telescope cylinder and control valve are provided in *Hydraulic System*, page 2-1 under *Cylinders* and *Valves* respectively.

## HOSE REEL

### Description

The hydraulic hose reel (Figure 4-6) supplies the boom manifold for the upper telescope cylinder. The hose reel is mounted in the turntable center section, under the boom.

The hose reel is spring return. The spring return provides drag on the hoses so that no slack develops when the telescope cylinders are being extended or the boom is being lowered, and retrieves the hoses as the telescope cylinders are being retracted or when the boom is raised.

### Maintenance

#### Service

Lubricate the hose reel spring with engine oil through the drain access holes located around the circumference of the spring cover. Lubricate every 50 operating hours.

With the boom fully retracted, spray motor oil, under pressure, into the hose reel spring housing. The spring should be saturated with oil. If air pressure lubricating equipment is not available, use a pump oil can, but ensure the spring is completely saturated with oil.

#### Removal



### DANGER

Before disconnecting the hoses from the outer mid telescoping cylinders, secure the hoses from rotating by using the hose reel retaining bolt and drum locking brackets.

1. Secure the rotation of the hose reel by using the retaining bolt and drum locking bracket.
2. Tag and disconnect the hydraulic supply hoses for the hose reel assembly; cap hoses and openings.
3. Tag and disconnect the hose reel hydraulic hoses from the manifold block assembly; cap hoses and openings.
4. Remove the capscrews and washers securing the hose reel to the turntable, remove the hose reel.

#### Installation

1. Position the hose reel assembly on the turntable and secure with the washer and capscrews.
2. Pre-tension twin-line hose by rotating the twin line section of hose reel only two complete revolutions counterclockwise (as seen from left side of crane looking

in). There must be two complete revolutions of the reel spring maintained when the boom is level and fully retracted.

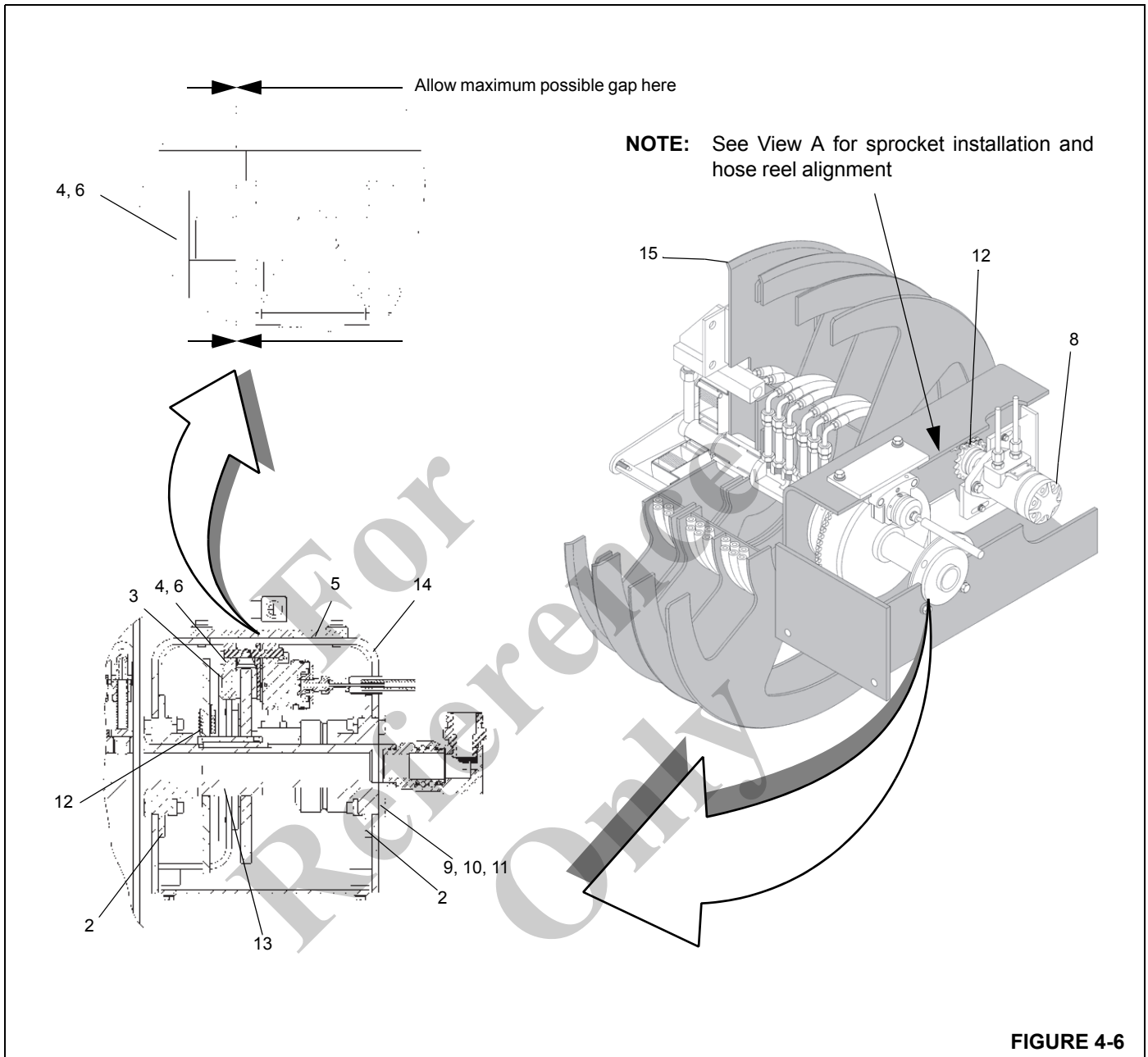
3. Assemble brake (Figure 4-7) onto brake disc and adjust as follows:
  - a. Ensure the brake pads and disc are free of grease and oil.
  - b. Loosen setscrew and unscrew spring brake housing enough to slide brake over brake disc.
  - c. Pressurize brake housing to 1200 psi (8274 kPa).
  - d. Screw in spring brake housing until a total gap of 0.012 in (.304 mm) exists between disc and pads.
  - e. Retighten spring brake housing setscrew using access hole provided in brake mount.
  - f. Secure brake mount to hose reel housing using the capscrew. Make sure to maintain the 0.012 in (.304 mm) gap as noted in step d.
  - g. Release the 1200 psi (8274 kPa) hydraulic pressure.
4. Install sprocket (Figure 4-7) as follows:
  - a. Do not use lubricants during installation. Remove all oil and grease from tapered surface of bushing and sprocket.
  - b. Slide the loosely assembled unit on shaft.
  - c. Carefully tighten capscrews alternately and progressively until the tapers are seated (approximately half of recommended torque).
  - d. Continue careful alternate and progressive tightening of the capscrews. Do not over-torque.
  - e. When properly mounted, there will be a gap between the bushing flange and the sprocket.
5. Install chain. Use the lockwasher, flatwasher and hex nut to apply tension. Measure chain slack near the center of chain span. Chain slack should be 0.25 in  $\pm$  0.12 (0.6 cm  $\pm$  0.3)(Figure 4-7).
6. Connect the hydraulic supply hoses to the hose reel assembly.

**NOTE:** Ensure there is enough hose unwound from the hose reel to attach the hoses to the telescope cylinders.



### DANGER

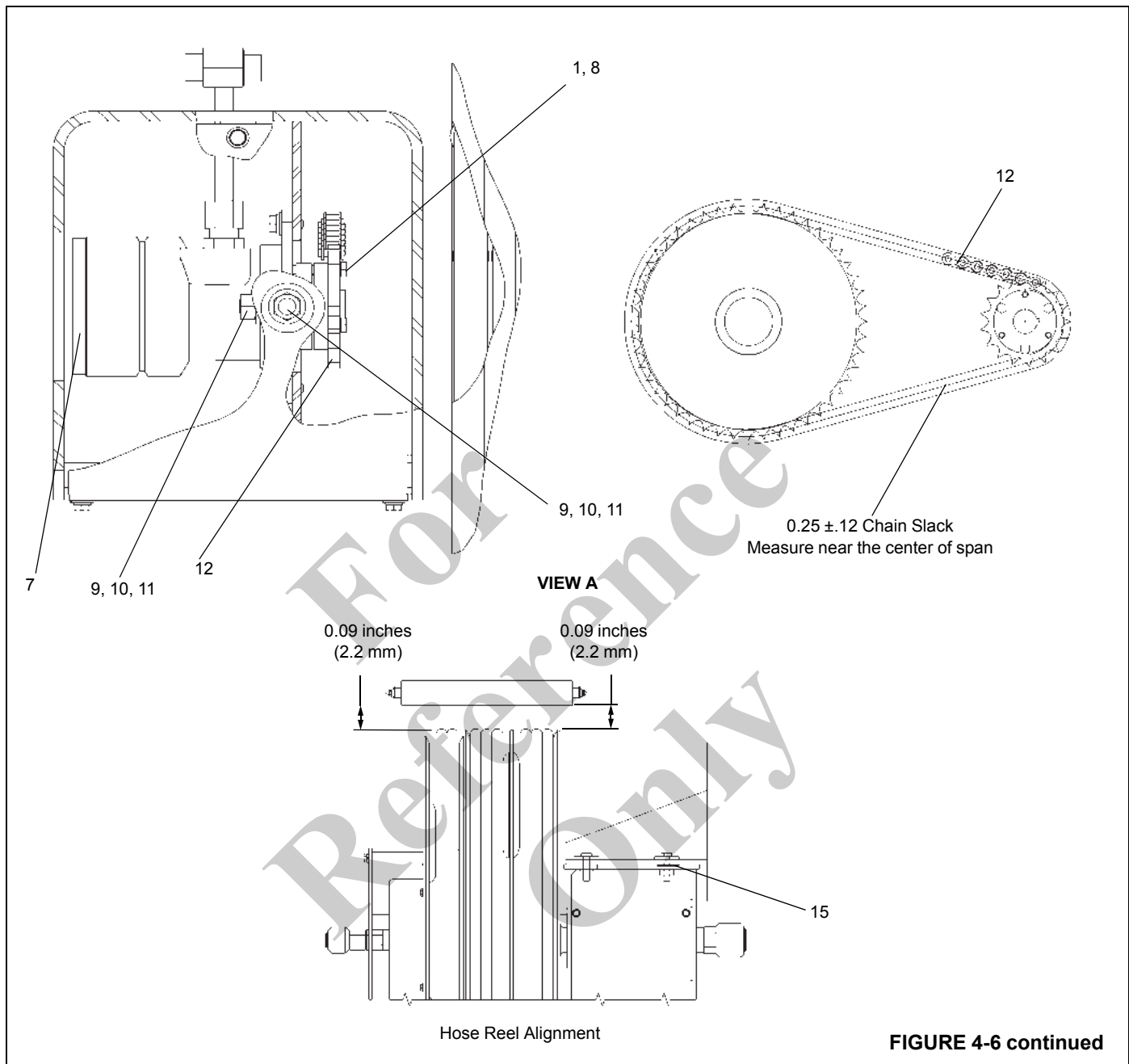
Ensure the retaining bolt remains installed until the hoses are attached to the telescope cylinders.



4

Item	Description
1	Sprocket
2	Bearing
3	Brake
4	Clevis Pin
5	Brake Mount
6	Cotter Pin
7	Motor
8	Capscrew

Item	Description
9	Lockwasher
10	Flatwasher
11	Hex Nut
12	Chain
13	Disc Weld
14	Housing
15	Hose Reel



7. Connect the hydraulic hoses to the manifold block assembly located at the rear of the boom inner mid section.
8. Remove the retaining bolt from the hose reel to allow tension to be applied to the hoses.
9. Secure the retaining bolt to the hose reel so the hose reel is allowed to rotate.
10. Adjust and secure the hose retainer.

### **Hose Reel Alignment**

After hose reel is installed and the attaching bolts properly torqued, check hose reel to hose guide roller alignment (Figure 4-6).

1. Check measurements between the hose reel's hose flanges and its guide roller (Figure 4-6).
2. Add shims as required to align the hose reel assembly to the roller within 0.09 in (2.2 mm).



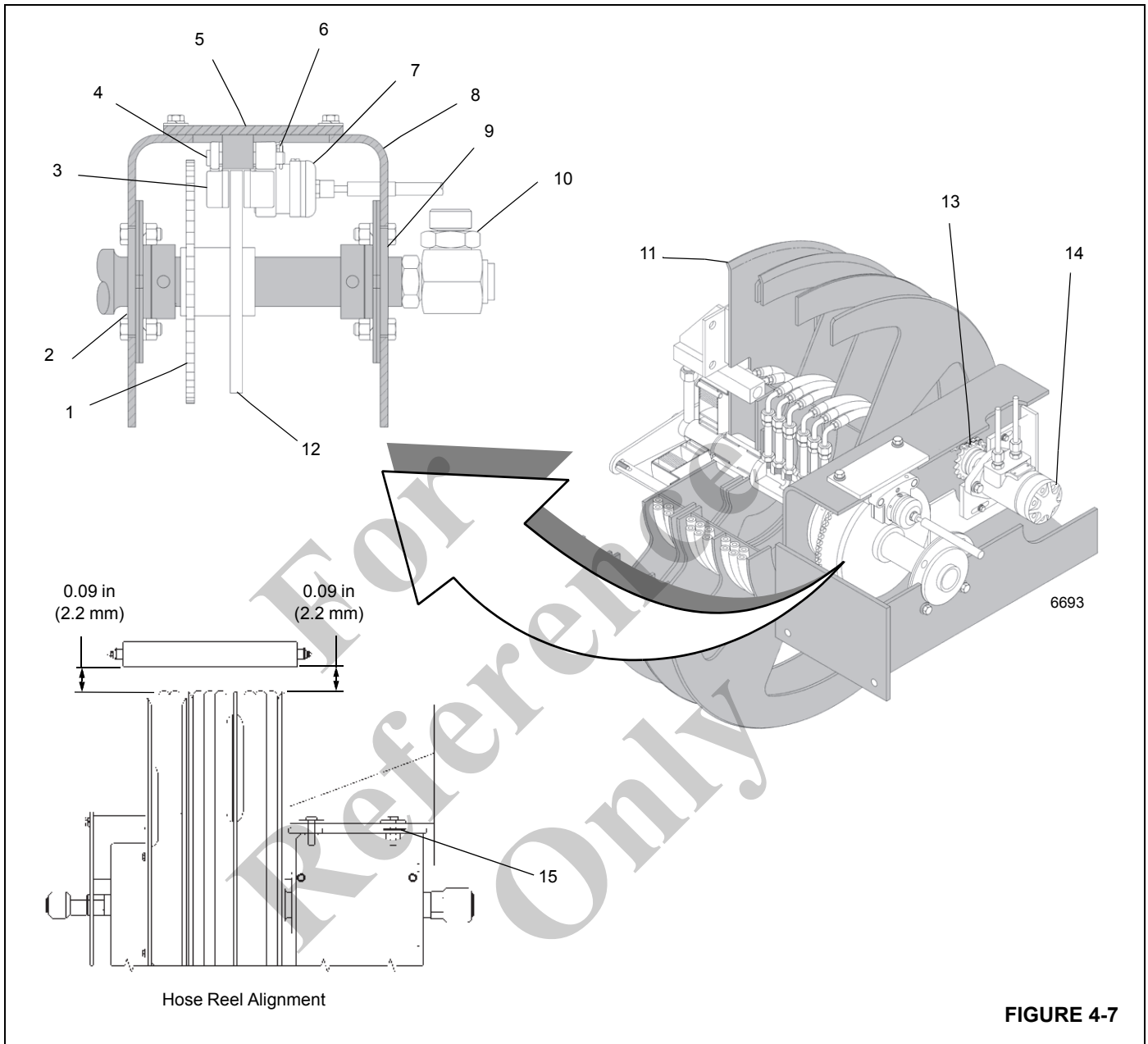


FIGURE 4-7

Item	Description
1	Sprocket
2	Bearing
3	Brake
4	Clevis Pin
5	Brake mount
6	Cotter Pin
7	Boot
8	Housing

Item	Description
9	Bearing
10	Swivel Joint
11	Hose Reel
12	Disk
13	Chain
14	Orbit Motor
15	Shims

## LIFT CIRCUIT

### Description

The boom lift circuit consists of the lift hydraulic remote controller, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -3 to +78 degrees from horizontal.

The lift directional control valve is the closed spool type and is described under *Valves*, page 2-31 along with the hydraulic remote controller.

The lift cylinder has a 14.0 in (35.56 cm) bore. The cylinder is a double acting type. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage by a wiper seal during rod retraction. Oil Seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage. Refer to *Temperature Effects on Hydraulic Cylinders*, page 2-67 for a complete description of the lift cylinder.

### Maintenance

Table 4-3

### Troubleshooting

Symptom	Probable Cause	Solution
1. Boom raises erratically.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine rpm.	b. Increase engine rpm to recommended setting.
	c. Main relief valve damaged.	c. Replace relief valve.
	d. Air in cylinder rod.	d. Bleed cylinder rod.
	e. Bent boom pivot shaft.	e. Replace pivot shaft.
2. Boom lowers erratically.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine rpm.	b. Increase engine rpm to recommended level.
	c. Circuit and/or relief valve inoperative.	c. Repair or replace relief valve.
	d. Air in hydraulic cylinder.	d. Bleed air from cylinder.
	e. Damaged hydraulic pump section.	e. Repair or replace pump section.

The holding valve is a balanced poppet type hydraulic valve. It is threaded into the port block which is an integral portion of the lift cylinder barrel. The holding valve functions when booming up (cylinder rod extended), booming down (cylinder rod retracted), or holding (cylinder rod stationary).

### Theory Of Operation

The directional control valve bank housing the lift control valve is supplied by flow from the hydraulic pump.

When booming up, oil unseats the poppet (check) valve in the holding valve, letting oil flow to the piston side of the cylinder. Pressure is applied to the piston, forcing the rod to extend, raising the boom.

When booming down, oil enters the retract port of the port block and flows to the cylinder rod side. When pilot pressure reaches a pre-determined value, the main poppet unseats and oil flows from the piston side of the cylinder to the reservoir.

All return flow from the control valve goes to the reservoir.

Symptom	Probable Cause	Solution
3. Boom raises slowly.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine rpm.	b. Increase and maintain engine rpm.
	c. Damaged relief valve.	c. Repair or replace relief valve.
	d. Extremely cold hydraulic oil.	d. Operate unit to bring oil to operating temperature.
	e. Improper hose or fittings, installed.	e. Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	f. Operating two functions in the same control valve bank assembly.	f. Feather controls to obtain desired speed of both functions.
	g. Restriction in return hose.	g. Replace return hose.
	h. Cylinder piston seals leaking.	h. Replace all cylinder seals.
	i. Scored cylinder barrel.	i. Hone or replace barrel.
	j. Worn hydraulic pump section.	j. Repair or replace pump section.
4. Boom lowers slowly.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine rpm.	b. Increase rpm to recommended level.
	c. Damaged relief valve.	c. Repair or replace relief valve.
	d. Operating two functions within the same control valve bank assembly.	d. Feather controls to obtain desired speed of both functions.
	e. Extremely cold hydraulic oil.	e. Operate unit to bring oil to operating temperature.
	f. Improper hose or fittings installed.	f. Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	g. Restriction in return hose.	g. Replace return hose.
	h. Cylinder piston seals worn.	h. Replace all cylinder seals.
	i. Scored cylinder barrel.	i. Hone or replace barrel.
	j. Worn hydraulic pump section.	j. Repair or replace pump section.
	k. Piston rod broken (loose from piston).	k. Replace piston rod and all cylinder seals.
5. Boom will not raise.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Main relief valve or circuit relief valve damaged.	b. Repair or replace relief valve.
	c. Excessive load.	c. Reduce load as required.
	d. Worn or damaged hydraulic pump section.	d. Repair or replace pump section.
	e. Broken pump shaft.	e. Replace pump shaft and seals.
	f. Broken pump drive coupling.	f. Replace drive coupling.
	g. Broken control valve spool.	g. Replace control valve.

Symptom	Probable Cause	Solution
6. Boom will not lower.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Main relief valve or circuit relief valve damaged.	b. Repair or replace relief valve.
	c. Worn or damaged hydraulic pump section.	c. Repair or replace pump section.
	d. Broken pump shaft.	d. Replace pump shaft and seals.
	e. Broken pump drive coupling.	e. Replace drive coupling.
	f. Broken control valve spool.	f. Replace control valve.

**NOTE:** Refer to *Disassembly*, page 2-69 for lift cylinder disassembly and assembly procedures. Maintenance not requiring removal of the cylinder barrels, such as packing, may be performed without removing the cylinders from the turntable. However, all disassembly and assembly should be conducted in a clean dust-free area.

### Removal

1. Extend and set the outriggers and level the crane.
2. Elevate the boom slightly so that the lift cylinder is extended approximately 1 ft (0.3 m).



### **DANGER** Crushing Hazard!

Ensure any blocking or cribbing used is capable of supporting the boom.

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.
4. Remove the capscrew and washer securing the lift cylinder upper pivot shaft to the boom.
5. Remove the capscrew and locknut securing the lift cylinder lower pivot shaft to the turntable.



### **DANGER** Crushing Hazard!

Ensure the lifting/supporting device is capable of supporting the lift cylinder.

6. Attach an adequate lifting/supporting device to the lift cylinder.
7. Insert the pump lever (found in cab) into the hand pump located on the left side of the boom. Turn the pump flow control lever clockwise and pump the lever until the

upper lift cylinder pin is clear of the boom's left side lift cylinder attachment lug. The lift cylinder may need to be raised or lowered to aid in the release of the lift cylinder pivot shaft from the attachment lug. This can be done by using the jack on the lift cylinder support.

8. Once the shaft is clear of the attachment lug, activate the hydraulic system and retract the lift cylinder enough to clear the attachment lugs.
9. Tag and disconnect all the hydraulic lines to the lift cylinder. Cap or plug all openings with high pressure fittings.
10. Pull the lower lift cylinder pivot shaft out far enough to remove the lift cylinder.
11. Move the lift cylinder to a clean work area.

### **Disassembly and Assembly**

Disassembly and assembly procedures of the lift cylinder holding valve, and control valve are provided in *Hydraulic System*, page 2-1.

### **Installation**

**NOTE:** Refer to Figure 4-8 for lift cylinder and boom pivot shaft installation.

1. Lubricate the lower lift cylinder pivot shaft and related bushings in the lift cylinder barrel end and the turntable weldment.
2. Attach an adequate lifting device to the lift cylinder and position the cylinder over the attach fittings on the turntable.
3. Lower the lift cylinder into the attach fittings on the turntable and align the lift cylinder bushing with the boom's lift cylinder attachment lug holes.

**NOTE:** Install pivot shaft with tapped hole on the right side, the side opposite the cab.

4. Pin the lift cylinder to the turntable attach fittings with the lower lift cylinder pivot shaft. Secure shaft with the capscrew and locknut. Torque the capscrew; refer to

*Fasteners and Torque Values*, page 1-18 for the torque value for the capscrew.

5. Connect the extend and retract hoses to the lift cylinder.
6. Lubricate the upper lift cylinder pin and related bushings in the boom's lift cylinder attachment lugs and in the lift cylinder rod end.
7. Activate the crane's hydraulic system and align the lift cylinder rod end with the boom's lift cylinder attachment lug holes as needed.
8. Using the hand pump located on the left side of the boom, insert the pump lever (found in cab) into the hand pump. Turn the pump flow control lever counterclockwise and pump the pump lever until the upper lift cylinder pin pins the rod end of the lift cylinder to the boom's lift cylinder attachment lugs, and the upper lift cylinder pin's flange portion fits completely against the left side of the boom's left lift cylinder attachment lug. The lift cylinder may need to be raised or lowered to aid in the installation of the upper lift cylinder pin. This can be done by using the jack on the lift cylinder support. Shut down the engine.
9. Apply medium strength adhesive/sealant to the upper lift cylinder pin's related capscrew. Secure the upper lift cylinder pin to the boom with the capscrews and washers. Torque the capscrews; refer to *Fasteners and Torque Values*, page 1-18 for the torque values for the capscrews.
10. Remove the lifting and supporting devices from the boom and lift cylinder. Activate the hydraulic system and check the lift cylinder for proper operation and any leaks.
11. Lubricate the pivot shafts at their grease fittings.

For  
Reference  
Only

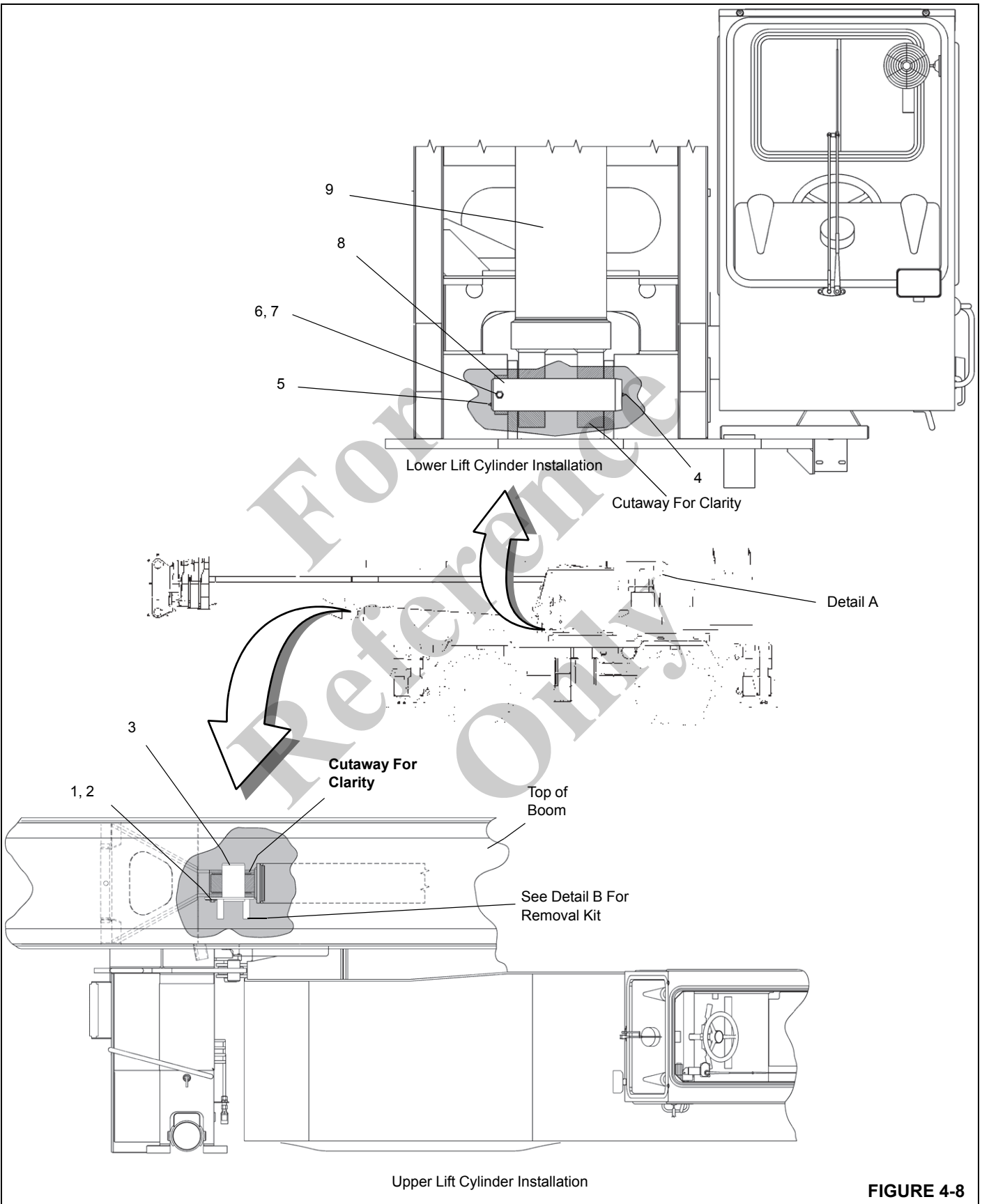


FIGURE 4-8

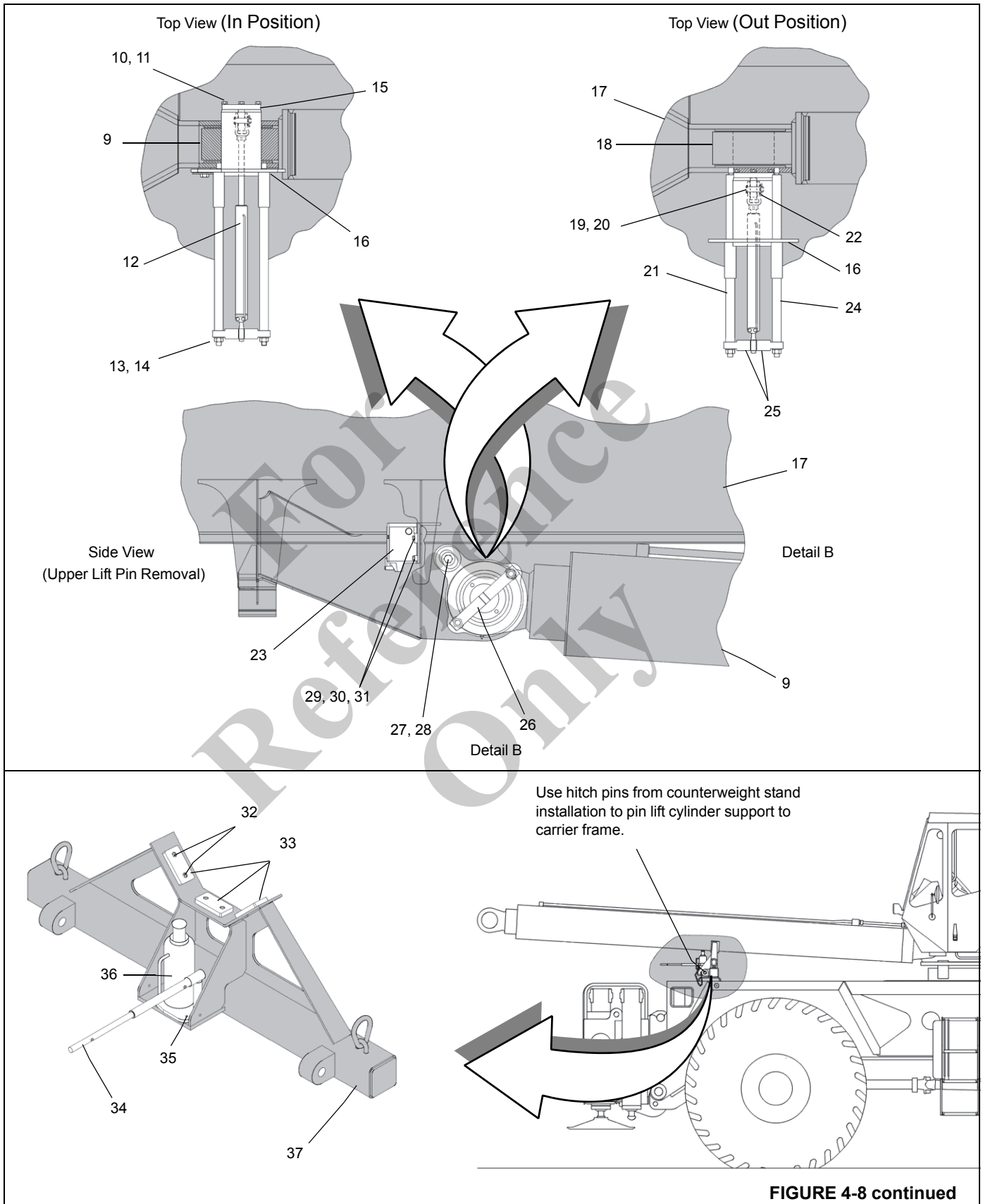


FIGURE 4-8 continued

Item	Description
1	Bolt
2	Washer
3	Lift Pin
4	Grease Fitting
5	Grease Fitting
6	Capscrew
7	Nut
8	Lower Lift Cylinder Pivot Shaft
9	Lift Cylinder
10	Capscrew
11	Lockwasher
12	Jack Cylinder aka Pin Removal Cylinder
13	Nut
14	Lockwasher
15	Lid Weldment
16	Upper Lift Cylinder Pin
17	Boom Base Section
18	Lift Cylinder
19	Clevis Pin

Item	Description
20	Washer
21	Support Rod
22	Hitch Pin Clip
23	Jack
24	Support Rod
25	Snap Rings
26	Latch Plate
27	Washer
28	Capscrew
29	Capscrew
30	Nut
31	Washer
32	Screws
33	Wear Pads
34	Jack Handle
35	Capscrew
36	Bottle Jack
37	Cylinder Support

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## BOOM REMOVAL SYSTEM

### Description

The boom removal system (Figure 4-9) uses hydraulic cylinders to extend and retract the upper lift cylinder pin and the pivot shafts. The upper lift cylinder pin uses a hand activated pump. The pivot shaft cylinder uses the hydraulic lines from the counterweight removal system.

### Maintenance

**NOTE:** The upper lift cylinder pin and the boom pivot shafts should only be serviced when the boom is off of the crane. These procedures assume the lift cylinder has been removed from the boom.

#### Upper Lift Cylinder Pin and Cylinder Disassembly

1. Tag and disconnect the hydraulic lines from the hand pump to the cylinder used to remove the upper lift cylinder pin at this cylinder. Plug these lines.
2. Remove capscrew and washer from upper lift cylinder pin as needed.
3. Remove the two nuts and lockwashers from the two support rods.
4. Pull the upper lift cylinder pin and its pin removal cylinder (jack cylinder) away from the boom until the latch plate clears the threads on the support rods.
5. Remove the snap rings from the latch plate. Remove the latch plate from the pin removal cylinder.
6. Remove the capscrews and lockwashers from the lid weldment. Remove the lid weldment and pin removal cylinder from the upper lift cylinder pin.
7. Remove hitch pin clip, washer, and clevis pin from the lid weldment. Remove pin removal cylinder from lid weldment.
8. Remove upper lift cylinder pin from boom's lift cylinder attachment lugs as needed.
9. Remove support rods from the boom's left lift cylinder attachment lug as needed.

#### Upper Lift Cylinder Pin and Cylinder Assembly

1. If removed, secure support rods to the boom's left lift cylinder attachment lug.
2. If upper lift cylinder pin was removed, coat upper lift cylinder pin and surfaces of bushings in boom's lift cylinder attachment lugs with grease. Install this pin onto support rods.
3. Install pin removal cylinder (jack cylinder) on lid weldment. Secure cylinder to lid weldment with hitch pin clip, washer, and clevis pin.

4. Install the lid weldment and cylinder onto the upper lift cylinder pin. Secure lid weldment with capscrews and lock washers.
5. Secure the pin removal cylinder to the latch plate with two snap rings.
6. Secure the latch plate to the two support rods with two nuts and lock washers.
7. Connect the hydraulic lines from the hand pump to the cylinder as tagged before removal.
8. Install upper lift cylinder pin into lift cylinder attach lugs of boom and secure with the capscrews and washers. Torque the capscrews; refer to *Fasteners and Torque Values*, page 1-18 for the torque values for the capscrews.

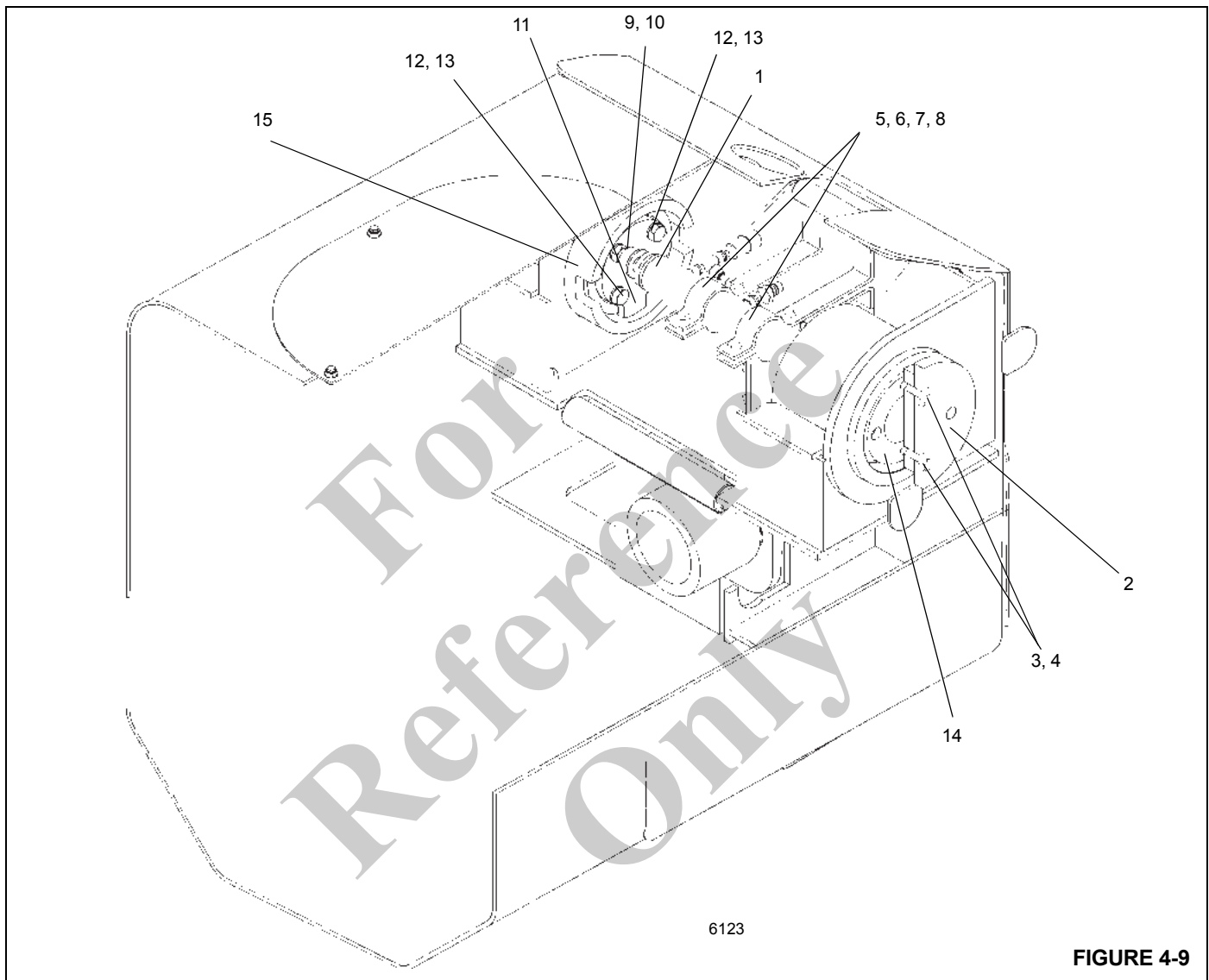
#### Boom Pivot Shafts and Cylinder Disassembly

1. If attached, remove capscrews, washers and nut fasteners from the base cover. Remove base cover.
2. If installed, remove capscrews and washers from each pivot lock weldment. Remove pivot lock weldments from pivot shafts.
3. Working through the pivot pins, remove nuts and washers from both of the cylinder's rod ends. Pull both pivot shafts outward to free cylinder. Remove cylinder through the base access hole.
4. Remove capscrews, washers, and nuts from each set of brackets. Remove brackets from cylinder, noting position of brackets.
5. If needed, tag and disconnect hydraulic line and fittings from cylinder.
6. Remove capscrews and washers from each lock plate weldment. Remove lock plate weldments from the pivot shafts.
7. Remove pivot shafts if needed. Remove grease fittings from the pivot shafts if needed.

#### Boom Pivot Shafts and Cylinder Assembly

1. Install grease fittings in the pivot shafts.
2. Coat the pivot shafts and the boom pivot bushings with grease. Install the pivot shafts into the boom's pivot bushings.
3. Install each lock plate weldment onto the pivot shafts. Secure lock plate weldments to pivot shafts with capscrews and washers.
4. Install pivot shaft cylinder through base access hole and position the rod end flats to match with the tabs on each lock plate weldment. Slide pivot shafts onto the rod ends. Secure both cylinder rod ends to the pivot pins with nuts and washers.

5. Install brackets as positioned before removal. Secure both sets of brackets with capscrews and washers.
6. Connect hydraulic line and fittings to cylinder as tagged prior to removal.
7. Install each pivot lock weldment and secure with capscrews and washers.
8. Install base cover and secure with capscrews, washers and nut fasteners.



**FIGURE 4-9**

Item	Description
1	Removal Cylinder
2	Pivot Lock Weldment (typical of 2)
3	Capscrews
4	Lockwashers
5	Brackets
6	Capscrews
7	Lockwashers
8	Nuts

Item	Description
9	Nut (typical of 2)
10	Washer (typical of 2)
11	Lock Plate Weldment (typical of 2)
12	Capscrews
13	Lockwashers
14	Pivot Pin (typical of 2)
15	Boom Pivot Bushing (typical of 2)

## BI-FOLD SWINGAWAY BOOM EXTENSION

### Description

A 59 ft (18m) two stage, offsetable swingaway boom extension is provided to obtain additional boom reach. The fly swingaway section is a 23 ft (7m) section. The base section is a 36 ft (11m) section.

The boom extension mounts directly to the boom nose utilizing a four point attachment. In addition, the swingaway can be stowed on the right side of the boom base section.

Refer to the Operator's Manual to install, deploy or remove the extensions.

### Identification

The maximum boom extension consists of the 59 ft two-stage swingaway lattice extension and two boom extension inserts. The boom extension is designed for the crane it was delivered with. The parts belonging to the crane have the same serial number as the crane.

The following parts are labelled with the serial number:

- all parts of the 59 ft (18m) two-stage swingaway lattice extension
- both 26 ft (8 m) boom extension inserts.

---

### CAUTION

Operate the crane only with those sections of the boom extension which have the same serial number as the crane. This prevents malfunctions and damage.

---

If you wish to use the boom extension on several Grove cranes, the parts of the boom extension must be adjusted for

these cranes and labelled with all of the respective serial numbers.

---

### CAUTION

Have the adjustment of the boom extension carried out only by your local Grove distributor or Manitowoc Crane Care.

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## HOOKBLOCK

### Description

A 130 ton (118 metric ton) hookblock, a 80 ton (72 metric ton) hookblock, and a 10 ton (9 metric ton) top swivel overhaul ball are available for the crane. The hookblocks utilize a one-piece pivot block and the hook is equipped with a safety latch. Both hookblocks are the quick reeve design.

### Maintenance

#### *Periodic Maintenance*

It is recommended that the hookblock and/or headache ball be inspected every 50 hours. A complete disassembly inspection should be conducted every quarter or 500 hours in the area of the hook, hex nut, and threaded areas for corrosion and proper fit. After assembly of the hook, a liberal coating of multipurpose grease should be applied to the nut and threaded areas by brush or hand to prevent corrosion.

For hookblocks and other load handling devices not manufactured by Grove; follow the manufacturer's inspection and testing recommendations to assure an adequate preventative maintenance program is established.

*For  
Reference  
Only*

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## SECTION 5 HOIST AND COUNTERWEIGHT

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### DESCRIPTION

The hoist incorporates one dual displacement piston motor which drives a reduction unit within the hoist. The hoist utilizes planetary reduction with a multi-disc automatic brake that is spring applied and hydraulically released. An overrunning clutch allows the hoist to be raised without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down. The hoist motor controls both speed and torque of the hoist.

There are two modes in which the hoist operates. One mode is high speed. The pilot solenoid valve shifts the selector spool on the motor to provide minimum motor displacement. This gives high line speed and low torque.

The second mode is low speed. The pilot solenoid valve shifts the selector spool on the motor to provide maximum motor displacement. This gives low line speeds and high torque.

### THEORY OF OPERATION

Each hoist is controlled by controls in the cab.

When the main hoist control lever in the cab is moved from neutral, it causes the main hoist section of the directional control valve to shift the valve spool to route hydraulic flow to

the main hoist motor control valve. The hoist motor control valve routes the hydraulic flow to the hoist motor. The motor turns one direction to hoist up, and turns the other direction to hoist down, depending on whether the hoist controls route fluid to the hoist up or hoist down port of the hoist motor control valve.

When the auxiliary hoist control lever in the cab is moved from neutral, it causes the auxiliary hoist section of the directional control valve to shift the valve spool to route hydraulic flow to the auxiliary hoist motor control valve. The hoist motor control valve routes the hydraulic flow to the hoist motor. The motor turns one direction to hoist up, and turns the other direction to hoist down, depending on whether the hoist controls route fluid to the hoist up or hoist down port of the hoist motor control valve.

Each hoist motor control valve is used to stop or slow its hoist when the load is trying to drive the hoist down too quickly. The motor control valve is piloted open by the hoist down pressure. If the load lowers faster than the flow of oil in the hoist down line, the pilot pressure decreases and the motor control valve partially closes to restrict the oil leaving the motor until a balance occurs. This results in the load lowering at a uniform speed based on the position of the hoist control lever.

During stopping, when the hoist down flow ceases, the pilot pressure holding the motor control valve open decays to

zero and the motor control valve spool closes, thus blocking all flow of oil out of the hoist motor. This same pressure decay allows the spring applied pressure released hoist brake to apply when the load is fully stopped. This brake acts as a “parking brake” and holds the load in the stopped position.

## MAINTENANCE

### Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below +40° F (4° C).

The engine should be run at its lowest recommended rpm with the hydraulic hoist control valve in neutral allowing

sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.



### WARNING

#### Crushing Hazard!

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

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Troubleshooting

Table 5-1

Symptom	Probable Cause	Solution
1. The hoist will not lower the load or not lower the load smoothly	<p>a. The problem could be a plugged or loose pilot orifice. The pilot orifice is a small pipe plug with a hole drilled through it located behind the pilot port fitting on the brake valve. If it becomes plugged, it will prevent the pilot pressure, from the manifold, from opening the brake valve. If it becomes loose, it will allow an unregulated amount of oil in to operate the brake valve which causes erratic brake valve operation.</p>	<p>a. Remove the pilot hose and fitting from the brake valve, then use a 5/32 inch Allen wrench to remove the pilot orifice. The diameter of the orifice is approximately 0.020 in (0.5 mm). Clean and install the pilot orifice tightly in the brake valve.</p>
	<p>b. The friction brake may not be releasing as a result of a defective brake cylinder seal.</p> <p><b>NOTE:</b> If the brake cylinder seal is defective, oil could be leaking from the hoist vent plug.</p>	<p>b. Check the brake cylinder seal as follows:</p> <ul style="list-style-type: none"> <li>• Disconnect the swivel tee from the brake release. Connect a hand pump with accurate 0 - 2000 psi gauge and shut-off valve to the -4 J.I.C. fitting in the brake release port.</li> <li>• Apply 1000 psi to the brake. Close shut-off valve and let stand for five (5) minutes.</li> <li>• If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and replacement of the seals.</li> </ul>
	<p>c. Friction brake will not release as a result of damaged brake discs.</p>	<p>c. Disassemble brake to inspect brake discs. Check stack height by placing the pressure plate on top of brake spacer. Press pressure plate down firmly by hand and measure gap between motor adapter and pressure plate. Average gap must measure between 0.160 in (4 mm) maximum and 0.080 in (2.0 mm) minimum. Adjust with discs as required.</p>

Symptom	Probable Cause	Solution
2. Oil leaks from vent plug	a. Same as 1b	a. Same as 1b
	b. Motor seal may be defective as a result of high system back pressure or contaminated oil.	b. System back pressure must not exceed 150 psi. Inspect hydraulic system for a restriction in the return line from the control valve to the reservoir. Make sure control valve and plumbing is properly sized to hoist motor.  Oil analysis may indicate contamination has worn motor shaft and seal. Thoroughly flush entire hydraulic system and install new filters and oil. Install new motor seal.
3. The brake will not hold a load with the control lever in neutral.	a. Excessive system back pressure acting on the brake release port.	a. Same as 2b
	b. Friction brake will not hold due to worn or damaged brake discs.	b. Same as 1c
	c. Brake clutch is slipping.	Improper planetary gear oil may cause the brake clutch to slip. Drain old gear oil and flush hoist with solvent. Thoroughly drain solvent and refill hoist with recommended planetary gear oil. Refer to <i>Lubrication</i> , page 9-1.  Brake clutch may be damaged or worn. Disassemble and inspect brake clutch assembly. If any parts require replacement, the entire clutch assembly must be replaced.
4. The hoist will not raise the rated load.	a. The hoist may be mounted unevenly which causes distortion of the hoist base and binding of the gear train. Binding in the gear train will absorb horsepower needed to raise the rated load and cause heat.	a. Use shim to level the hoist. Refer to Hoist Installation in this section.
	b. System relief valve may be set too low.	b. Check relief pressure. Refer to <i>Pressure Setting Procedures</i> , page 2-21.

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Symptom	Probable Cause	Solution
The hoist will not raise the rated load (continued)	<p>c. Make sure hydraulic system temperature is not more than 180°F (82°C). Excessive hydraulic oil temperature increases motor internal leakage and reduces motor performance.</p>	<p>a. Same as 4a and 4b</p>
5. The hoist runs hot	<p>a. Same as 4a</p>	<p>a. Same as 4a</p>
	<p>b. Make sure the hydraulic system temperature is not more than 180° F (82° C). Excessive hydraulic oil temperatures may be caused by:</p> <ul style="list-style-type: none"> <li>• Plugged heat exchanger.</li> <li>• Hydraulic oil level in reservoir too low or too high.</li> <li>• System relief valve may be set too low.</li> <li>• Hydraulic pump not operating efficiently.</li> <li>• Excessively worn or damaged internal hoist parts.</li> </ul>	<ul style="list-style-type: none"> <li>• Thoroughly clean exterior and flush interior.</li> <li>• Drain/fill to proper level.</li> <li>• Check relief pressure. Refer to <i>Pressure Setting Procedures</i>, page 2-21.</li> <li>• Pump worn. Replace pump.</li> <li>• Disassemble hoist. Inspect/replace worn parts.</li> </ul>
6. Hoist chatters while raising rated load.	<p>a. Same as 4b</p>	<p>a. Same as 4b</p>
	<p>b. Hydraulic oil flow to motor may be too low.</p>	<p>b. Same as 5b</p>

**Removal**

1. Remove all cable from the hoist drum.
2. Tag and disconnect the hydraulic lines to the hoist. Cap or plug all lines and openings.
3. Tag and disconnect the electrical wires to the hoist rotation indicator sensor.
4. Tag and disconnect the electrical wires to the hoist motor high speed solenoid valve.

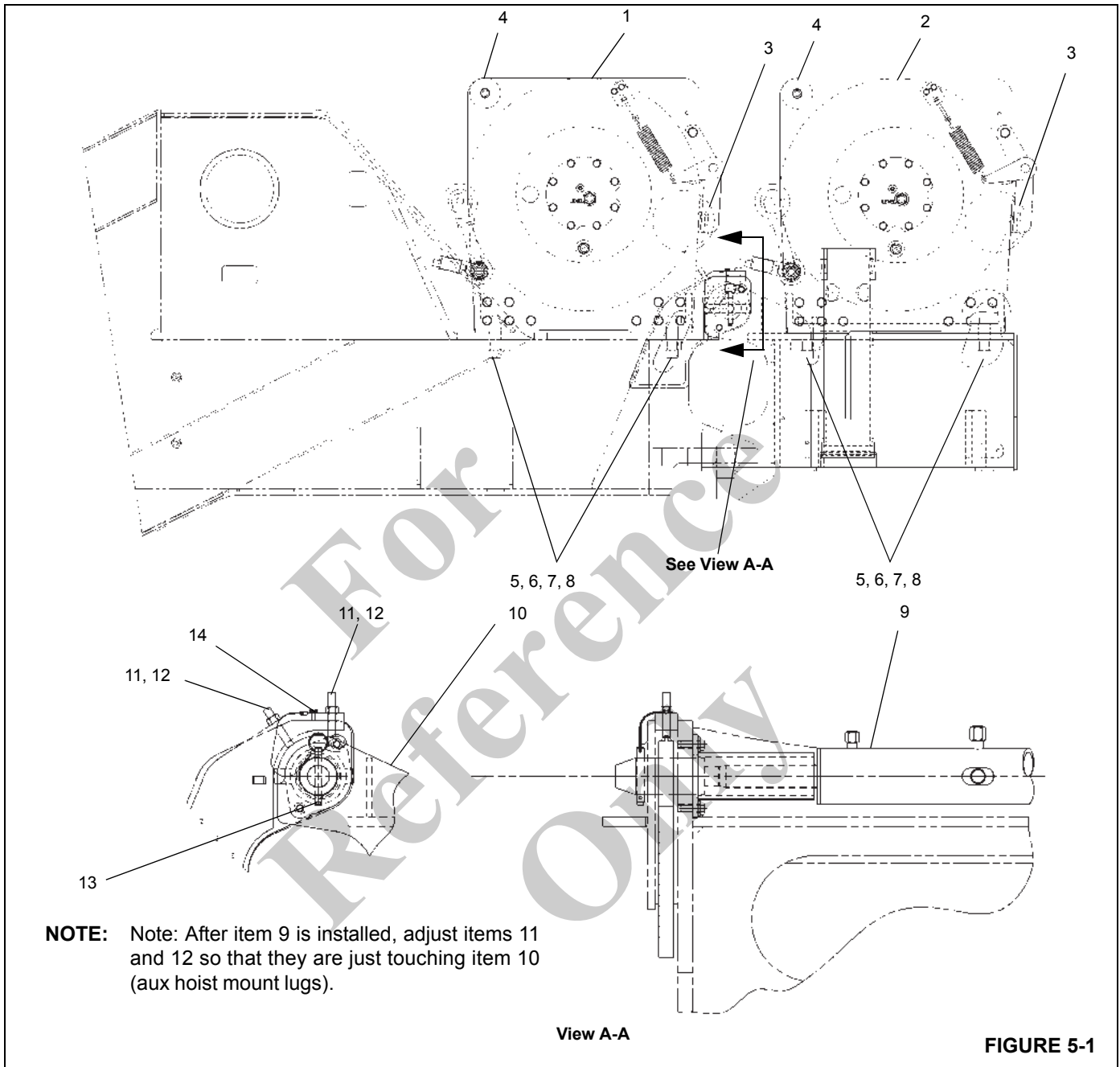
**NOTE:** To remove the right front capscrew, the hose reel rear cover must first be removed.

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

**NOTE:** The hoist assembly, less the cable, weighs approximately 1841 lb (835 kg).

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





Item	Description
1	Main Hoist
2	Auxiliary Hoist
3	Cable Follower
4	Idler Drum
5	Shims
6	Capscrew
7	Nut

Item	Description
8	Washer
9	Pin Removal Cylinder
10	Aux Hoist Weldment
11	Setscrew
12	Locknut
13	Ball Detent Pin
14	Flange Screw

**Installation**

1. Ensure the mounting plate and hoist pads are clean and free from debris and the hoist has not been damaged during handling.
2. With the hoist supported by a suitable lifting device, position the hoist on the mount.
3. Check the hoist to boom alignment according to the *Hoist to Boom Alignment*, page 5-10 procedure.
4. Place a level between the boom pivot shaft bushings.
5. Place a level across the top of the hoist drum and determine if the hoist is sitting in the same plane in relation to the level positioned between the boom pivot shaft bushings.
6. With the hoist level, check to determine if all the hoist mounting pads are in contact with the mounting plate by rocking the hoist.
7. Keeping the hoist level, use a feeler gauge to determine the amount of gap existing between the pads and the mounting plate.
8. Add shims to satisfy any existing gaps. Altering the shim thickness to fit a tapering gap is acceptable. Install the capscrews, washers, and nuts. Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the hoist mounting bolts.
9. Remove the lifting device from the hoist.
10. Connect the hydraulic lines to the hoist ensuring the proper lines are connected to the correct ports as marked during removal.
11. Connect the electrical wires to the hoist hi speed solenoid valve as marked during removal.
12. Connect the electrical wires to the hoist rotation indicator sensor as tagged during removal.
13. If equipped, connect the wires for the third wrap indicator switch.
14. Install the cable, following the procedures outlined under *Installing Cable on the Hoist*, in the Operator's Manual.

**Functional Check**

1. Attach a test weight to the hook and raise and lower the load several times.
2. Check the hoist for smooth operation of the hoist motor and brake system.
3. Ensure the hydraulic connections are secure and free from leaks.

**Usage and Inspection**

Inspection procedures for hoists are divided into five general categories based upon their usage or duty cycle, which in turn determines appropriate intervals for inspections. The usage categories must be assigned by the crane user on a consistent crane-by-crane basis. The five crane/hoist usage categories are as follows:

- Idled - The crane/hoist has not been used for three months.
- Infrequent Usage - The crane/hoist is used less than ten hours per month based on a three month average
- Moderate Usage - Crane/hoist used 10 - 50 hours per month based on a three month average.
- Heavy Usage - Crane/hoist used 50 - 200 hours per month.
- Severe Usage - Crane/hoist is operated more than 200 hours per month OR where 50% of the lifts exceed 75% of the rated capacity for the hoist.

The following chart lists the inspections that are required for each type of usage category.

INSPECTION USAGE CATEGORY	PRE-USE DAILY INSPECTION	QUARTERLY INSPECTION	SEMI-ANNUAL INSPECTION	ANNUAL INSPECTION
<b>IDLED</b> Not used for 3 months or longer	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	---
<b>INFREQUENT USAGE</b> less than ten hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
<b>MODERATE USAGE</b> 10-50 hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
<b>HEAVY USAGE</b> 50-200 hours per month	REQUIRED	REQUIRED MONTHLY	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)
<b>SEVERE USAGE</b> 200+ hours per month or 50% of lifts exceed 75% rated capacity	REQUIRED	REQUIRED	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)

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**Preventative Maintenance**

It is extremely important to be aware of the possibility that deterioration of internal critical components within the hoist reduction unit can occur. Hoist reduction units incorporate planetary gears, multi-disc brake assemblies, and sprag clutches which do not have an infinite life span. Although these components have been designed to achieve long service life, reliability can be substantially reduced by a variety of influencing factors such as:

- High cycle operation.
- Operating in high ambient temperatures.

- High external contaminations, such as dusty or sandy conditions.
- Level of maintenance.

The following should be carried out following instructions in *Lubrication*, page 9-1 and/or manufacturers instructions.

#### 1. Pre-Use or Daily Inspection.

Must include but is not limited to the following inspections that will be performed prior to placing the crane into service and then as necessary during extended operation. This inspection must be performed by a qualified crane operator or qualified crane technician.

- Check for external oil leaks and repair as necessary. This is extremely important due to the accelerated wear that will result from insufficient lubricating oil in the hoist. Hoists with a sight glass; check oil level daily. Hoists without a sight glass; check oil level monthly if no external oil leaks are detected. Lubricant level must be maintained between the minimum and maximum levels; midway up sight glass or at bottom of level plug port as equipped. Use ONLY the recommended type of lubricant. Refer to *Lubrication*, page 9-1.
- Check hydraulic fittings and hoses for chaffing, deterioration or corrosion and repair as necessary.
- Visually inspect for corroded, loose or missing bolts, pins or other fasteners and replace or tighten as necessary.
- Visually inspect rotation indicator transmitters, anti-two-blocking switches and other safety equipment and repair as necessary.

#### 2. Quarterly Inspection (every three months).

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

- Perform the pre-use inspection.
- Inspect for corrosion of fasteners, hoist base, drum, etc. and repair/replace as required to maintain the structural integrity of the hoist.
- Check the hoist oil level. Inspect for any oil leaks from the hoist gearbox.

#### 3. Every 250 hours or 3 months.

- If applicable, lubricate the cable guide roller and cable guard roller bearings.

#### 4. Semi-Annual Inspections (every six months).

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

- Perform the Pre-Use and Quarterly inspections.

- Take a sample of the lubricant from the hoist gear cavity as described in *Gear Oil Sampling and Analysis*, page 5-9 and analyze it for wear metals content, correct viscosity, lubricant deterioration, moisture and other contaminants. If the oil sample contains a high amount of metallic particles, the hoist must be taken out of service to undergo a tear down inspection.

**NOTE:** Oil analysis alone cannot detect nor warn against a fatigue failure.

#### 5. Annual Inspection.

This inspection must be carried out by a qualified crane technician. The annual inspection MUST include, but not be limited, to the following:

- Perform the Pre-Use/Daily Inspection, Quarterly inspection and Semi-Annual Inspection.
- Change the lubricating oil in the hoist gear cavity after an oil sample has been taken as described in *Gear Oil Sampling and Analysis*, page 5-9. Refill the hoist to the proper level with recommended lubricant. Refer to *Lubrication*, page 9-1.



#### WARNING

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury or death. Some gear lubricants contain large amounts of EP (extreme pressure) and anti-friction additives which may contribute to brake clutch slippage or damage to brake friction discs or seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Our tests indicate that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

- Check for correct function of the hoist brake by conducting a high line pull load test, ensuring the brake holds without creeping and that the hoist control is correct. The function of the hoist brake should be checked more often if abnormal operating conditions or characteristics exist.
- #### 6. Every 10,000 hours or every ten years, it is recommended that the hoist assembly be disassembled and that all major components be examined for damage and/or wear, i.e. gears, spline couplings, shafts, etc. New components must be installed if any are found to be worn or if there is evidence of heat or other damage. The hoist should be reassembled using all new seals, bearings, fasteners, washers, brake discs, brake stators, sprag clutch, and springs. A comprehensive

hoist line pull and load holding test must be conducted following the repair work.

## Oil Sampling

### Oil Change

The hoist gear oil must be changed after the first 100 operating hours then on an annual basis, at a minimum thereafter. In severe duty applications, the gear oil should be changed every six months. Use the recommended lubricants. Refer to *Lubrication*, page 9-1.

### Gear Oil Sampling and Analysis

Proper gear oil sampling and analysis is a vital part of a comprehensive preventive maintenance program. Information obtained from the oil analysis allows the maintenance technician to substitute preventive maintenance for more costly unscheduled down time or a far more dangerous failure. Early detection of accelerated component wear allows the scheduling of corrective maintenance.



### CAUTION

Hot oil may cause personal injury and/or burns to unprotected skin. Make certain the oil has cooled to a safe temperature (typically less than 110°F or 43°C) before taking an oil sample, changing oil or servicing the hoist.

Prepare the hoist by cleaning the drain plug area and drain extension tube in order to obtain an uncontaminated sample. Operate the hoist in both directions for one or two minutes to thoroughly mix the gear oil then take the sample from the midstream flow of the oil to obtain an accurate representation of the oil condition. After taking the oil sample continue with the oil change or refill the hoist gear cavity to the proper level with recommended lubricant. General Guidelines for Iron Contaminant Level

#### 100-500 ppm

Normal

#### 500-800 ppm

Caution - Abnormal Sample. Change oil and retake sample after 50 hours of operation. If second sample is above 500 ppm, remove hoist from service and perform tear-down inspection to determine source of contamination.

#### 800+ ppm

Unacceptable. Remove hoist from service and perform tear-down inspection to determine source of contamination.

Iron contaminant levels will be on the high side of "Normal" during initial break-in.

Equally important as the level of contamination is the change in level of contamination. An effective oil analysis program should provide the technician with a view of the progression of wear or a trend. If a sample shows a sudden rise in contaminant level action should be taken to determine what has changed.

**NOTE:** Oil analysis alone cannot detect nor warn against a fatigue failure.

### Brake Test Procedure

These planetary hoists have a spring applied, hydraulically released, multiple disc brake inside the hoist housing. This brake holds a suspended load when the directional control valve is in neutral, or when hydraulic power is lost. An over-running brake clutch assembly permits the power train and drum to rotate in the direction to lift a load, while the brake remains fully applied. A load cannot be lowered, however, without applying hydraulic pressure to the release port and releasing the brake.

(Test to be performed with no load on the hoist)

Remove and cap or plug the brake release line from fitting in the hoist brake release port.

With the hydraulic power unit running, move the directional control valve handle slowly to the full open, lowering position.

Increase the engine speed, if necessary, to bring system pressure up to the relief valve setting. The hoist drum should remain stationary.

If the hoist drum rotates, the hoist should be disassembled and the brake components should be examined for wear. In addition, the brake springs should be measured for the correct free length in those hoist using helical compression springs.

Replace any parts showing excessive wear and any spring whose length is shorter than the minimum shown in the applicable hoist Service Manual.

Reassemble the brake and hoist and repeat the above steps.

When testing is complete, reattach the brake release line to the brake release port.

## HOIST TO BOOM ALIGNMENT

### Preparation

Boom alignment (Figure 5-3) must be completed before attempting hoist alignment. If the hoist is not properly aligned, the cable can be damaged or fine control could be affected.

The crane must be set on outriggers fully extended and the crane must be leveled. The boom must be over the front.

### Tools Required

- Two foot square
- Mason cord
- Chalk
- Protractor

### Procedure

The hoist mounting location will determine the alignment procedure used. Shift one side of the hoist back or forward to align the hoist with the boom sheave. It may be necessary to shim under one side of the hoist to make it level.

The hoist must be checked in two directions, one at 0 degree and the other is above 45 degrees boom angle on any crane that the hoist is not mounted directly to the boom, stationary mounted.

Check the hoist at 0 degrees to see if the hoist is aligned to the boom nose sheave. The main hoist is aligned to the right hand sheave and the auxiliary hoist is aligned to the center sheave.

**NOTE:** The hoist cable will have gaps on the drum during spooling if the alignment is not correct.

The hoist is not level if the cable is piling up on one side of the drum.

1. The boom must be extended one half of full extension on all hoist alignments. This length is used because when the main hoist cable is positioned on the top right hand boom nose sheave, the cable must leave the center of the drum at a 90 degree angle. The boom has the ability to extend, retract, and change the angle of departure from the drum. Extend the boom half way to provide a

center point of adjustment to check the fleet angle of the cable.

2. All the cable must be removed from the hoist drum to check the fleet angle. Using mason cord or fishing line you will be able to pull the line tight to make an accurate measurement of the fleet angle. Find the centerline of the hoist drum by using a square and drawing a line horizontal on the drum. Put a line vertical to the horizontal line in the absolute center of the drum by using a tape measure. With the boom at 0 degree, tie the line tight to the boom nose and have it in the center of the right hand boom nose sheave.

**NOTE:** If this special equipment is not available, sufficient accuracy in locating a centerline may be obtained by using a steel square against the machine's inner surfaces of both flanges. It is advisable to avoid using any cast surfaces in this procedure unless a check from both flanges indicates that the resultant line is straight.

3. Tie the line around the hoist drum so that the line is very tight and the line is crossing the absolute center of the drum at the centerline mark you put on the drum.
4. Using a protractor, lay it on the vertical line on the hoist drum so the string line is in the center of the protractor. The string line will be at the 90 degree mark on the protractor if the hoist is straight with the boom nose sheave. If it is not at the 90 degree mark, the hoist mounting bolts will have to be loosened and the hoist moved so it is.

**NOTE:** This test is for cable leaving gaps while spooling.

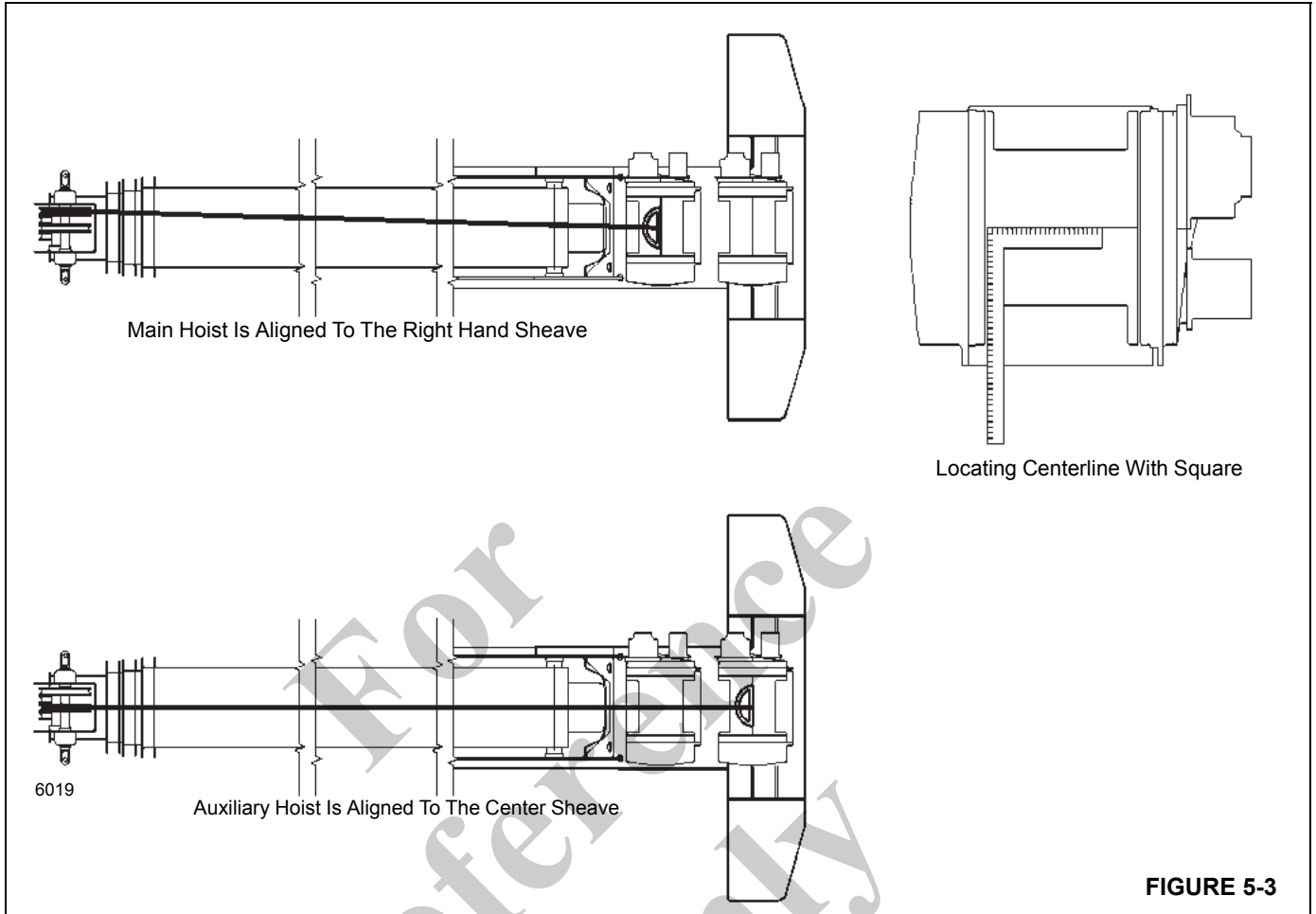
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### CAUTION

Do not alter holes or stop blocks on the crane mounting plate, as very small adjustments result in large angular changes. Extreme care should be taken to avoid over-correction.

5. Elevate the boom above 45 degrees boom angle to check if the hoist is level. Reposition the hoist drum and tighten the cord so you can have the cord in the center of the protractor at the 90 degree mark. If the cord is not at the 90 degree mark, the hoist will have to be shimmed until the cord is at the 90 degree mark.

**NOTE:** This test is for cable piling up on one side of the hoist drum.



5

## MOTOR AND BRAKE

### Description

Each hoist has a hydraulic motor, a brake valve, a brake cylinder, and a brake clutch which control motion of the hoist's drum. These parts mount on one of the support end brackets of the hoist. The hydraulic motor connects to the hoist's brake clutch, which in turn connects to the gear train of the hoist.

### Maintenance

#### Removal

1. Drain the oil from the hoist drum by removing the plugs. Reinstall the plugs when the drum is finished draining.
2. Power-wash the hoist on the motor side to wash away potential contaminants from the drive components of the hoist. Dry the area with compressed or forced air.
3. If needed, tag and disconnect wires from the hoist drum indicator parts. Then remove these parts from the hoist.
4. Tag and disconnect wiring from the hoist motor's high speed solenoid valve.
5. Tag and disconnect the hydraulic lines from the motor and the brake valve. Cap or plug all lines and openings.
6. Remove the four capscrews and lockwashers to free the motor and brake valve from the brake cylinder and brake clutch on the support end bracket. Remove the motor and brake valve as a unit. Discard the O-ring.
7. Cover the motor opening in the brake cylinder to protect drive components inside the hoist drum. As needed,

secure the brake clutch located inside the brake cylinder.

#### Installation

**NOTE:** Assure the primary thrust plate remains properly located in its counterbore when installing the motor. If operating the hoist with the primary thrust plate wedged between the primary gears and the planet carrier, or with a thrust washer out of position, severe damage to internal hoist parts could result.

1. Uncover the motor opening in the brake cylinder. Verify the brake clutch is secure in the brake cylinder. Verify these parts are clean.
2. Install a replacement O-ring on the motor's pilot after lubricating it with gear oil or petroleum jelly.
3. Engage the motor shaft with the inner race of the over-running clutch and lower the motor into place. Apply Loctite No. 243 to the capscrews for the motor. Secure the motor and brake valve to the brake cylinder with capscrews and washers.
4. Connect the hydraulic lines to the motor and brake valve as tagged during removal.
5. Reinstall any hoist drum rotation indicator parts removed during removal. Connect electrical wires as tagged during removal. Tighten CPU bolt. Adjust sensor per instructions in *Hoist Drum Rotation Indicator System*, page 5-18.
6. Reinstall electrical wiring to hoist motor's high speed solenoid valve as tagged during removal.
7. Fill the drum with oil. Refer to *Lubrication*, page 9-1.



## IDLER DRUM AND CABLE FOLLOWER

### Description

The main and auxiliary hoists are equipped with an idler drum (Figure 5-4) on the forward side of the hoist. The main hoist idler drum is used to keep the hoist cable from coming in contact with the boom.

When the crane is also equipped with an auxiliary hoist, the idler drum on the auxiliary hoist is used to keep the hoist cable from coming in contact with the main hoist. The cable follower (Figure 5-4) is mounted on the rear side of its respective hoist. The cable follower applies a downward spring pressure against the cable onto the hoist drum, to ensure that the cable will be uniformly wound onto the hoist drum, and also prevent cable from jumping under abnormal line conditions.

### Maintenance

#### Idler Drum

##### Removal and Disassembly

1. Remove the bolt, washer, and lockwasher from the right side of the idler roller.
2. Support the idler roller and withdraw the shaft from the left side. Take care not to lose the dowel pin on the end.
3. Remove the roller from between the side plates.

##### Cleaning and Inspection

1. Clean all rust and dirt from the shaft.
2. Inspect the shaft and roller for cracks, scoring, or grooving. Replace if necessary.

##### Assembly and Installation

1. Position the roller between the side plates
2. Install the shaft through the left side plate and the roller. Ensure the flat on the shaft end aligns with the stop welded on the side plate, align the dowel pin.
3. Secure the shaft to the right side plate with a bolt, washer and lockwasher. Apply Loctite 243 to the bolt threads.

#### Cable Follower

##### Removal And Disassembly

1. Loosen the adjusting nuts and remove the tension spring and adjusting rod from both sides of the hoist.
2. Remove the tack welds from the bolt heads securing the arm to the cable follower roller.
3. Remove and disassemble the cable follower roller as follows:

- a. For a cable follower roller that has bearings, support the cable follower roller and remove the bolts and washers securing the arms to the angles on each end of the roller. Remove the cable follower roller. Remove the two bolts and washers securing the angle to the right side of the shaft. Remove the shims and roller from the shaft. If necessary, remove the bearing and bearing housing from both ends of the roller.

- b. For a cable follower roller that has bushings instead of bearings, support the cable follower roller and remove the bolts and washers securing the pivot arms to the mounting brackets on each end of the roller. Remove the cable follower roller. Remove cotter pins and washers from roller shaft, then remove mounting brackets from roller shaft.

4. Remove the bolt and locknut securing the arm to the spring attaching lever on each side of the hoist. Remove arms and levers from the side plates.

**NOTE:** Be sure to mark each arm and lever as to what side (left or right) they were removed from. This will be helpful during installation.

5. Remove grease fittings if present.

##### Cleaning and Inspection

1. Clean all grease from the shaft, bearings or bushings, and roller.
2. Check the shaft, roller, and bearings or bushings for cracks, scoring, or grooving. Replace if necessary.
3. Check the spring tension. If the springs will not provide sufficient tension when adjusted, replace them.

##### Assembly and Installation

1. Install grease fittings if needed.
2. Install the left arm through the bushing on the left side plate. Install left spring attaching lever on the arm and secure with a bolt and locknut. Apply Loctite 243 to the bolt threads.
3. Repeat step 2 on the right side.
4. For a cable follower roller that has bearings, assemble the cable follower roller as follows:
  - a. Apply high strength retaining compound Loctite 680 to the bearing housings and the bearings. Install them in both ends of the roller.
  - b. Install the shaft into the roller with a least one shim on each end.
  - c. Apply Loctite 243 to the bolt threads. Position the angle on the right side of the shaft and secure with two bolts and washers.

5. Position the cable follower roller on the arms. Secure the cable follower roller shaft to its mounting angles or mounting brackets with fasteners removed earlier. (For a roller with bushings instead of bearings, there are two washers and two cotter pins.)
6. Secure the mounting angles or mounting brackets to the pivot arms with four bolts and washers. Center the roller between the hoist drum flanges and tighten the bolts.
7. Tack weld the bolt heads.
8. Attach one end of each tension springs to the lever on each side. Install each adjusting rod through the lug on each side plate and connect to the other end of the spring. Install the adjusting nuts on each rod and tighten enough to take the slack out of the spring.
9. Using a grease gun, apply grease to any fittings.
10. Adjust the roller as follows:
  - a. With one layer of cable on the hoist drum, adjust the bolts on the front of each side plate (that push against each arm) so the roller applies pressure on the layer of cable, and does not interfere with filler/riser protrusions on the hoist drum flanges. Tighten jam nuts to secure setting.
  - b. Adjust each rod and nut and spring so the end of the rod is 1.30 in (33 mm) from the near surface of the nut.

### **Complete Assembly**

#### **Removal**

1. Remove all tension from the springs on each side by loosening the nuts and jam nuts.
2. Support the weight of the cable follower assembly and remove the two bolts and washers securing each side plate to the hoist. Remove cable follower assembly from the hoist.
3. If necessary to completely disassemble or remove any part of the assembly, refer to the applicable paragraphs in this Sub-section.

#### **Installation**

1. Position cable follower assembly on the hoist and secure each side plate to the hoist with two bolts and washers.
2. Adjust the tension on the cable follower. Refer to instructions in *Cable Follower*, page 5-13.

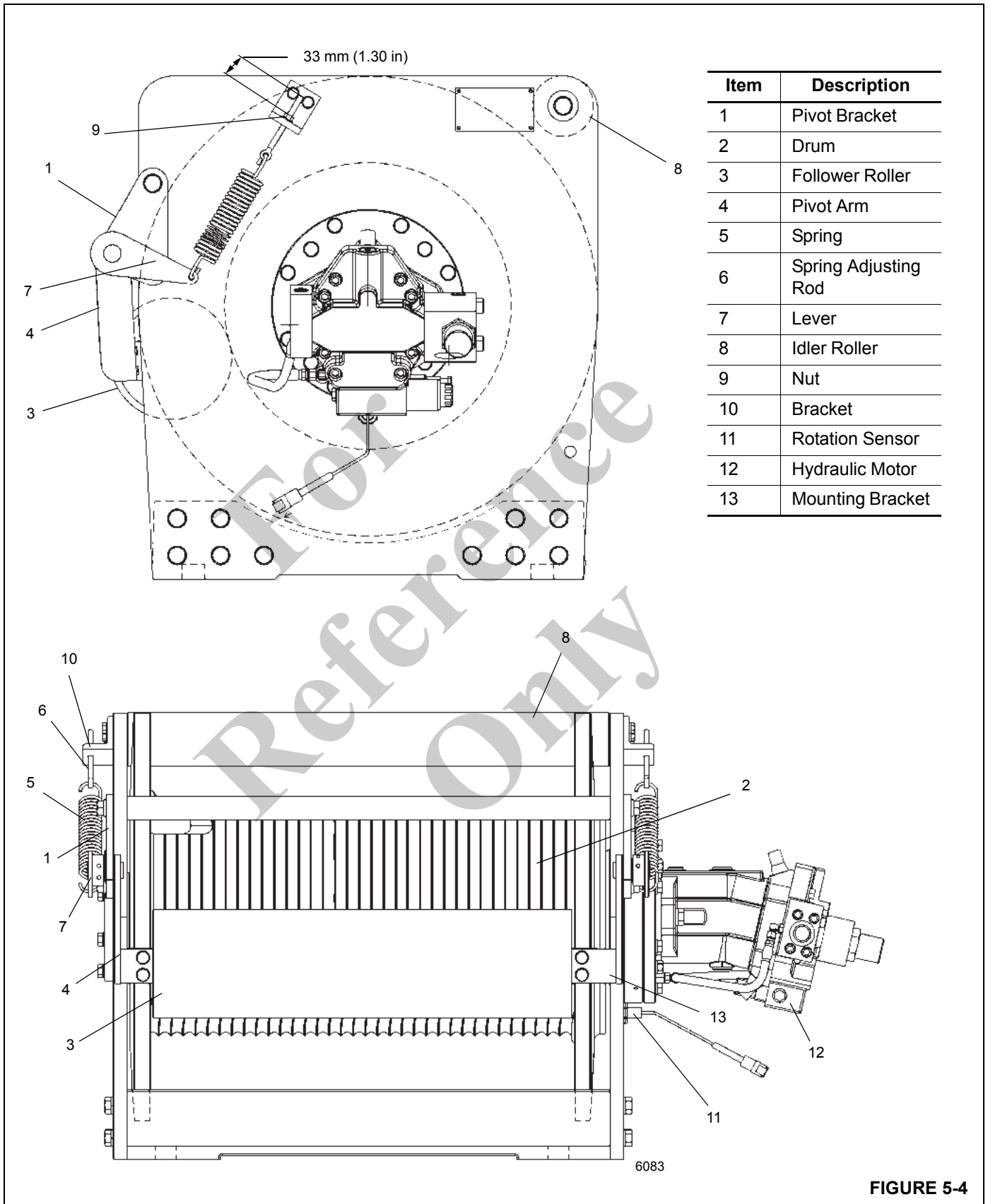


FIGURE 5-4

## THIRD WRAP INDICATOR

### Description

The third wrap indicator (Figure 5-4) is installed to give the operator an indication that the wire rope is down to the last three wraps on the hoist drum and no more rope should be reeled out. In addition to the warning light in the cab, a lockout valve is actuated to stop hoist down operation.

### Maintenance

#### Removal

1. Disconnect third wrap indicator from power by removing fuses F17 and F16. Tape over the sockets of the removed fuses.
2. Remove the control unit cover. Tag and disconnect the wiring to the limit switch.
3. Loosen and remove the outside nut and washer securing the threaded rod to the hoist mounting.
4. Loosen and back off the inside nut on the threaded rod.
5. Loosen and back off the nut holding the sensor shaft in place against the side plate.
6. Unscrew the threaded rod from the sensor shaft.
7. While removing the nuts and remaining washer from the inside end of the threaded rod, pull the threaded rod out through the hoist housing.
8. Remove the setscrews and slide the limit switch bracket and limit switch, actuating cam, arm (with roller), spring, and spring holder collar from the sensor shaft.
9. Loosen and remove the capscrew and washer securing the sensor shaft to the hoist housing.

#### Installation

**NOTE:** All fasteners must be treated with medium strength threadlocking adhesive sealant and primer.

1. Install the capscrew and washer to secure the sensor shaft to the hoist housing.

**NOTE:** Apply antiseize grease to inside of indicator arm before installing onto sensor shaft.

2. Position center of roller approximately 3 in (7.6 cm) from the inside flange of the hoist drum such that the roller drops to the drum after the fourth wrap is unwound from the drum.
3. Adjust actuating cam and/or limit switch collar such that switch plunger drops into notch when roller drops to bare hoist drum.
4. Adjust spring holder collar such that spring applies ample pressure to arm.
5. Slide spring holder collar, spring, arm (with roller), actuating cam, limit switch bracket and limit switch onto the sensor shaft. Secure with the related setscrews.
6. Install the threaded rod through the opening in the hoist housing and thread the washer and two nuts onto the rod.
7. Screw the threaded rod into the sensor shaft.
8. Tighten the nut to hold the sensor shaft to the side plate.
9. Tighten the nut securing the threaded rod to the hoist housing.
10. Install the remaining washer and nut onto the outside end of the threaded rod. Adjust so the centerline of the roller is 3.0 in (7.6 cm) from the inside face of the nearby side plate. Tighten the set screws in the limit switch bracket, actuating cam, arm (with roller), and spring holder after final adjustment.
11. Tighten the three nuts. Ensure the centerline of the roller is still 3.0 in (7.6 cm) from the inside face of the nearby side plate.
12. Reconnect the wires to the third wrap indicator limit switch and reinstall the control unit cover.
13. Restore power to third wrap indicator by installing fuses F17 and F16.

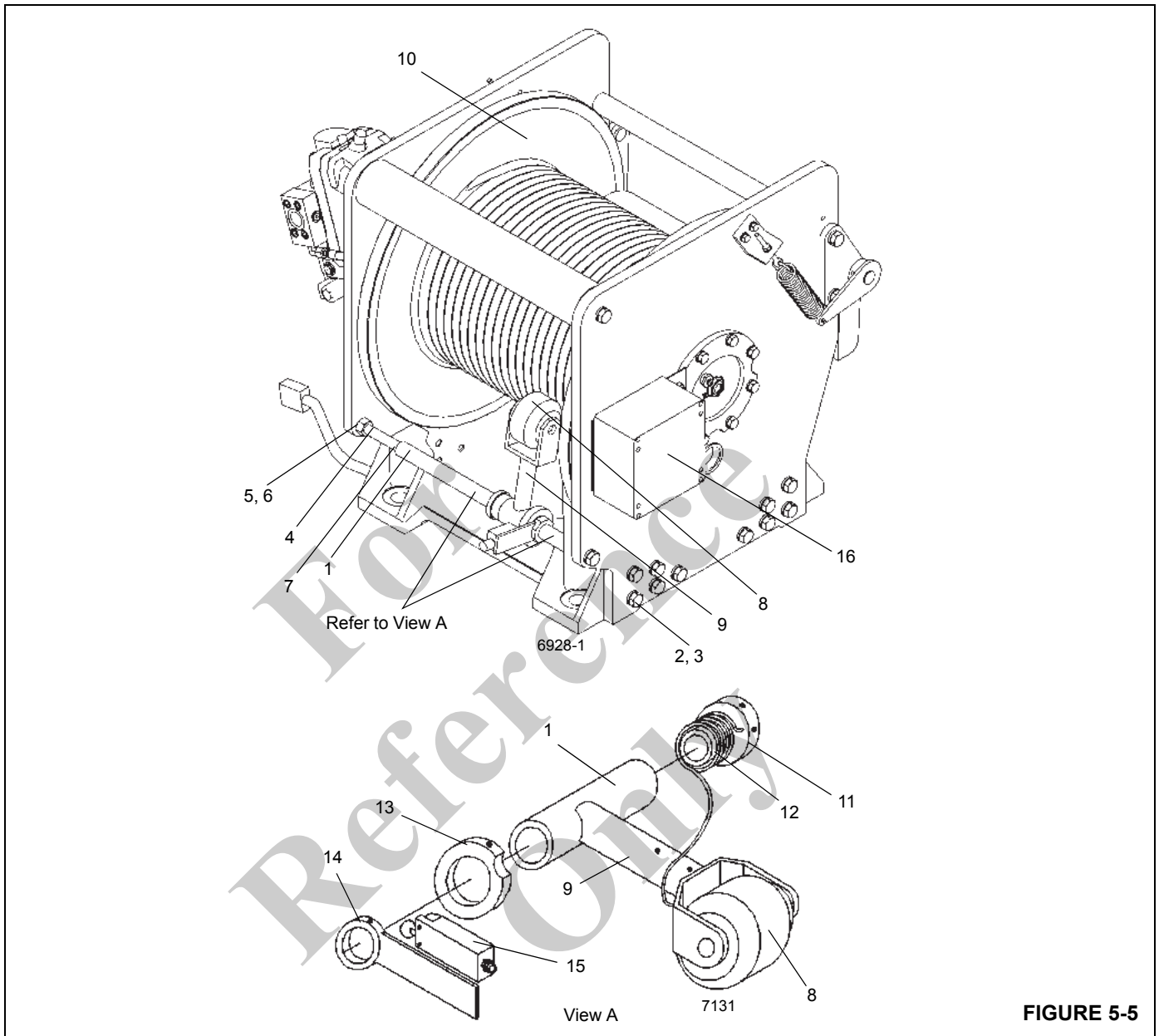


FIGURE 5-5

Item	Description
1	Sensor Shaft
2	Nut
3	Washer
4	Threaded Rod
5	Washer
6	Nut
7	Nut
8	Roller

Item	Description
9	Arm
10	Hoist
11	Spring Holder Collar
12	Spring
13	Actuating Cam
14	Limit Switch Bracket
15	Limit Switch
16	Control Unit

## HOIST DRUM ROTATION INDICATOR SYSTEM

### Description

The hoist drum rotation indicator system is an electrically operated system that provides the operator with a touch indication of drum rotation so he will know if and at what speed the hoist drum is rotating, even under the most distracting conditions.

The rotation indicator system consists of two separate electrical components; the rotation indicator sensor and thumb thumper solenoid. The rotation sensor is located on the hoist. The pulsing thumb thumper solenoid is located in the applicable hoist control lever handle.

### Maintenance

#### General



#### CAUTION

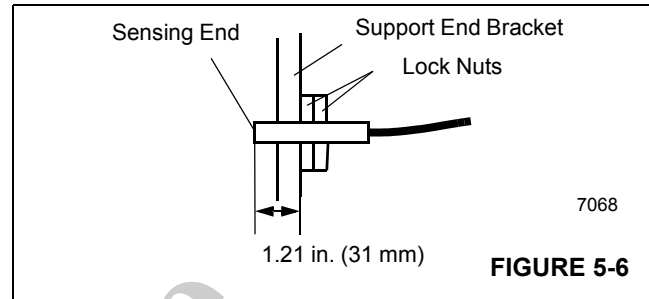
Disconnect the batteries before performing any maintenance on this system. Serious burns may result from accidental shorting or grounding of live circuits.

Proper circuit operation can be checked for each individual electrical component. If a malfunction occurs within the system, repairs should be limited to finding and replacing the faulty component(s). If difficulty persists, contact your local distributor for additional troubleshooting aid.

#### Rotation Sensor

The rotation sensor is screwed into the hoist support end bracket that holds the hydraulic motor (Figure 5-6). It senses the rotation of the drum. When installing the sensor, ensure its sensing end is 1.21 in (31 mm) from the first lock nut. (This

is the length of the sensor from its sensing end through to the outside surface of the hoist support end bracket.) If sensor will not work properly, loosen both lock nuts and turn the sensor counterclockwise up to one turn, then re-tighten lock nuts to hold sensor position. If sensor will still not work properly, ensure its sensing end is 1.21 in (31 mm) from the first lock nut, then turn the sensor clockwise up to one turn, then re-tighten lock nuts to hold sensor position.



#### Thumb Thumper Solenoid

The thumb thumper solenoid provides feedback proportional to the hoist line speed by pulsing the rubber button on top of the hoist control lever.

#### Troubleshooting

Using a digital VOM check if the thumper solenoid resistance is 6-10 ohms. If it doesn't measure correctly the solenoid is worn or damaged and should be replaced.

Using a digital VOM, measure the voltage in the thumper solenoid between wires 508 and 51, for the main hoist, or 509 and 51, for the auxiliary hoist. The voltage should measure 12v  $\pm$  10 percent, if it doesn't, check the voltage on the superstructure module pin A01, for the main hoist, and pin A02, for the auxiliary hoist. If voltage is within range but not present at the solenoids, the power or ground wires are defective, replace wires as necessary.

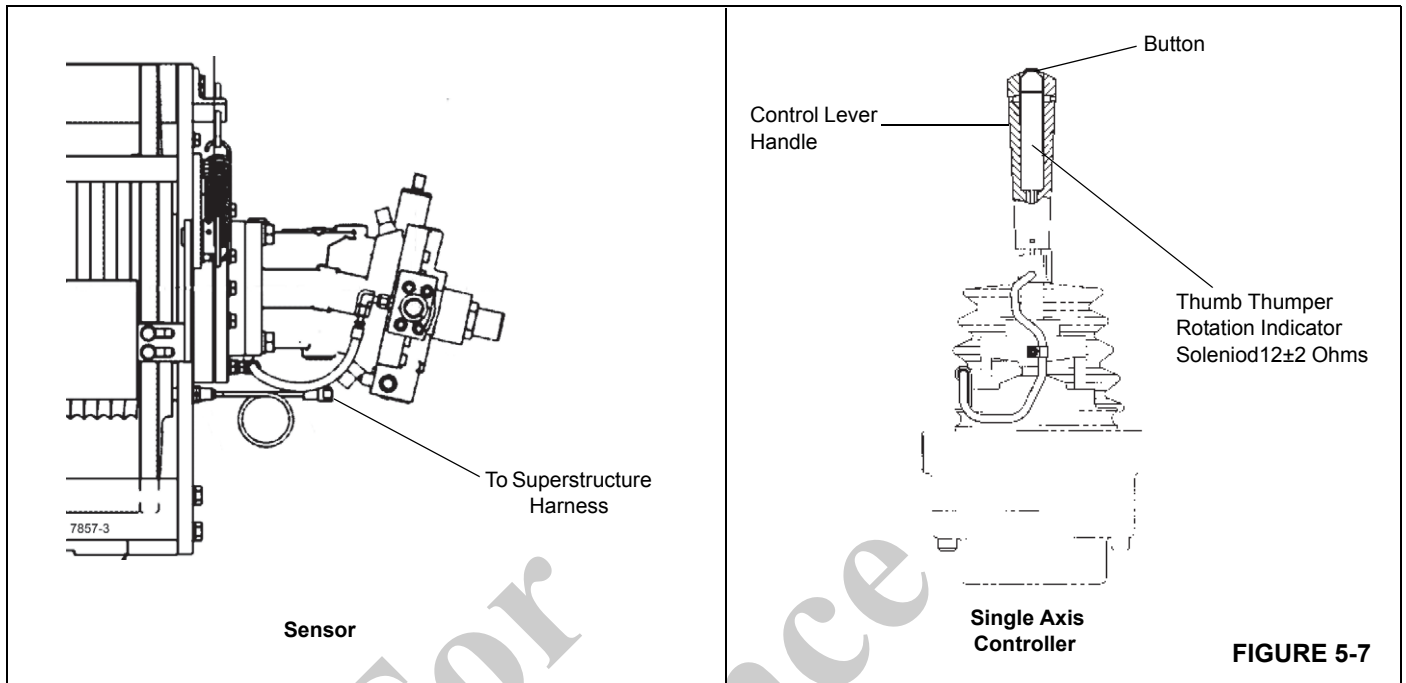


FIGURE 5-7

**Hoist Rotation Indicator (HRI) Display System**

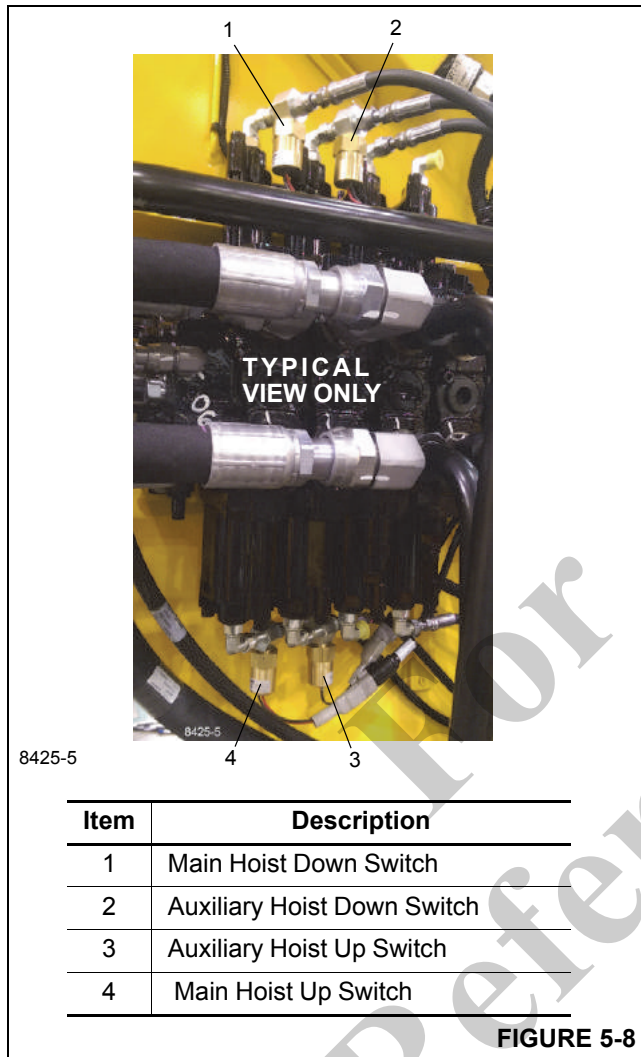
The HRI Display consists of an LED display that indicates the direction the hoist(s) are rotating, pressure switches that

monitor hydraulic pilot pressure, and a control module mounted in the cab.

**Pressure Switches**

The pressure switches are located on the main control valve (Figure 5-8). The switch contacts close at 75 psi (5.17 bar).

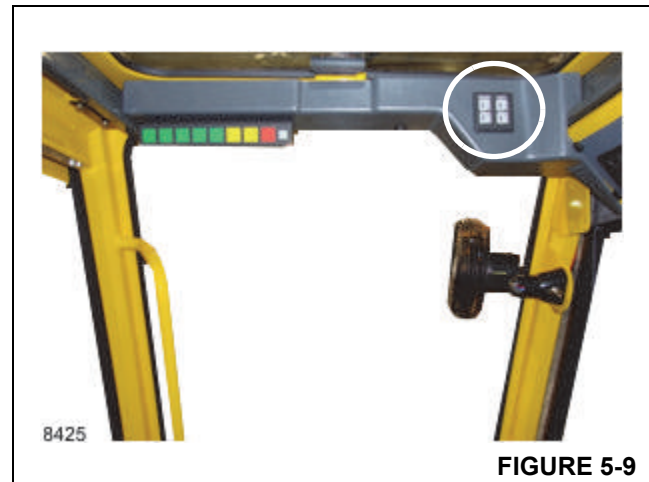
Reference Only



**HRI Display**

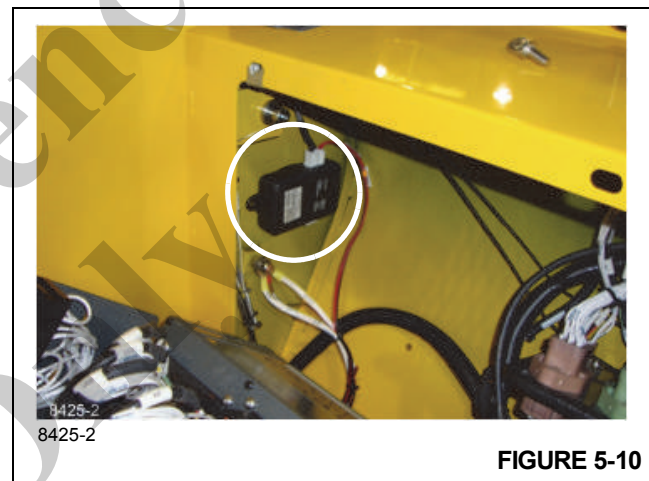
The display is located in the front overhead panel (Figure 5-9).

To replace the display, remove the overhead panel. Disconnect the electrical connector and pry the display off of the panel. Clean the panel where the display was affixed with isopropyl alcohol, remove the paper from the adhesive back of the new display and stick it into the panel. Connect the wires to the display. Replace the panel and secure with the hardware.



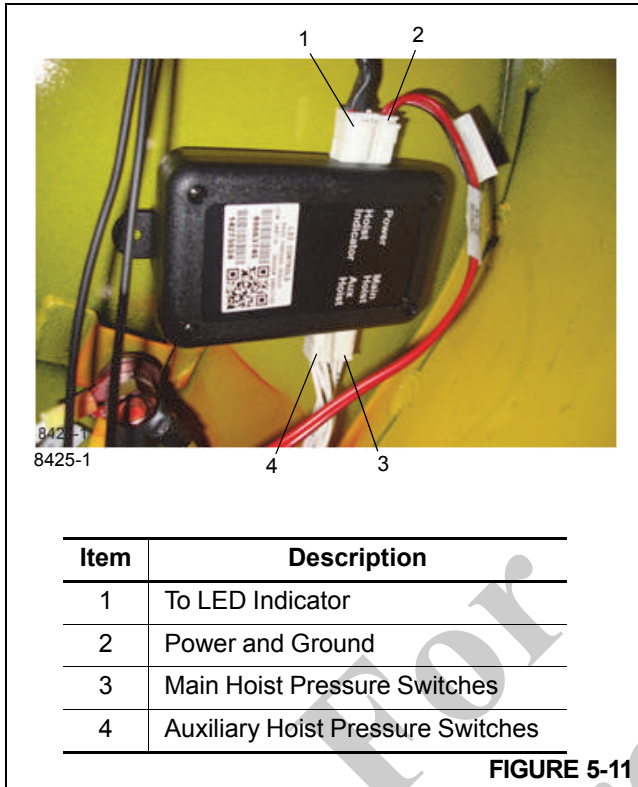
**HRI Control Module**

The control module is located in the fuse and relay panel behind the driver's seat in the cab (Figure 5-10).



To replace the control module, tag and disconnect the wires from the module (Figure 5-11). The module is mounted to the bulkhead using double-sided adhesive tape. To remove the module, pry it off the bulkhead. Remove any residual tape from the bulkhead. Secure the replacement module to the bulkhead with the foam tape. Connect the wires as tagged during removal.





carrier frame (3) (Figure 5-12) and secure with the hitch pins (4) (Figure 5-12).



2. Rotate foot plates (5) (Figure 5-12) on the counterweight stands (1) (Figure 5-12) until they come to rest on top of the front outrigger box (2) (Figure 5-12).

## COUNTERWEIGHT REMOVAL AND INSTALLATION

### Counterweight Stand Installation

**NOTE:** The counterweight stands must be installed on the front of the carrier before removing either the standard or heavy counterweight assembly.

1. Using an adequate lifting device, install the counterweight stands (1) (Figure 5-12) to the front of the

**! DANGER**

Adjustment of the counterweight stand (1) (Figure 5-12) supports is prohibited when the counterweight (1) (Figure 5-13) is resting on them.

3. Adjust the foot plate (5) (Figure 5-12) and adjusting screw (6) (Figure 5-12) into or out of the counterweight support until the counterweight pads on top of the counterweight support are level. Do not exceed 2.25 in (5.72 cm).
4. Tighten jam nut (7) (Figure 5-12) against counterweight support.

## Standard and Heavy Counterweight and Auxiliary Hoist Structure

### Removal



#### DANGER

Read and understand the following when removing and installing the counterweight, auxiliary hoist structure or counterweight stand, to avoid serious injury or death.

- Outriggers must be properly extended and set and crane level before installation or removal of counterweight or auxiliary hoist structure.
  - Lifting operations are not permitted with any counterweight on the carrier deck except for the removal or installation of the counterweight and/or auxiliary hoist structure.
  - Boom is not permitted over carrier deck when the boom angle is less than 30° and any counterweight is positioned on deck.
  - Hookblock is not permitted to come in contact with counterweight, auxiliary hoist or auxiliary hoist structure during removal or installation.
  - When installing counterweight (1) (Figure 5-13), make sure that both auxiliary hoist structure (7) (Figure 5-14) hydraulic mounting pins are fully extended and retainer pins are in place before counterweight is lifted.
  - Before unpinning auxiliary hoist structure (7) (Figure 5-14), all counterweights must be fully lowered and firmly supported. Before lowering, make sure the auxiliary hoist structure (7) (Figure 5-14) is properly supported by counterweight removal cylinders (5) (Figure 5-13) and both hydraulic mounting pins are completely retracted.
  - Travel is not permitted with any counterweight on the carrier deck.
-

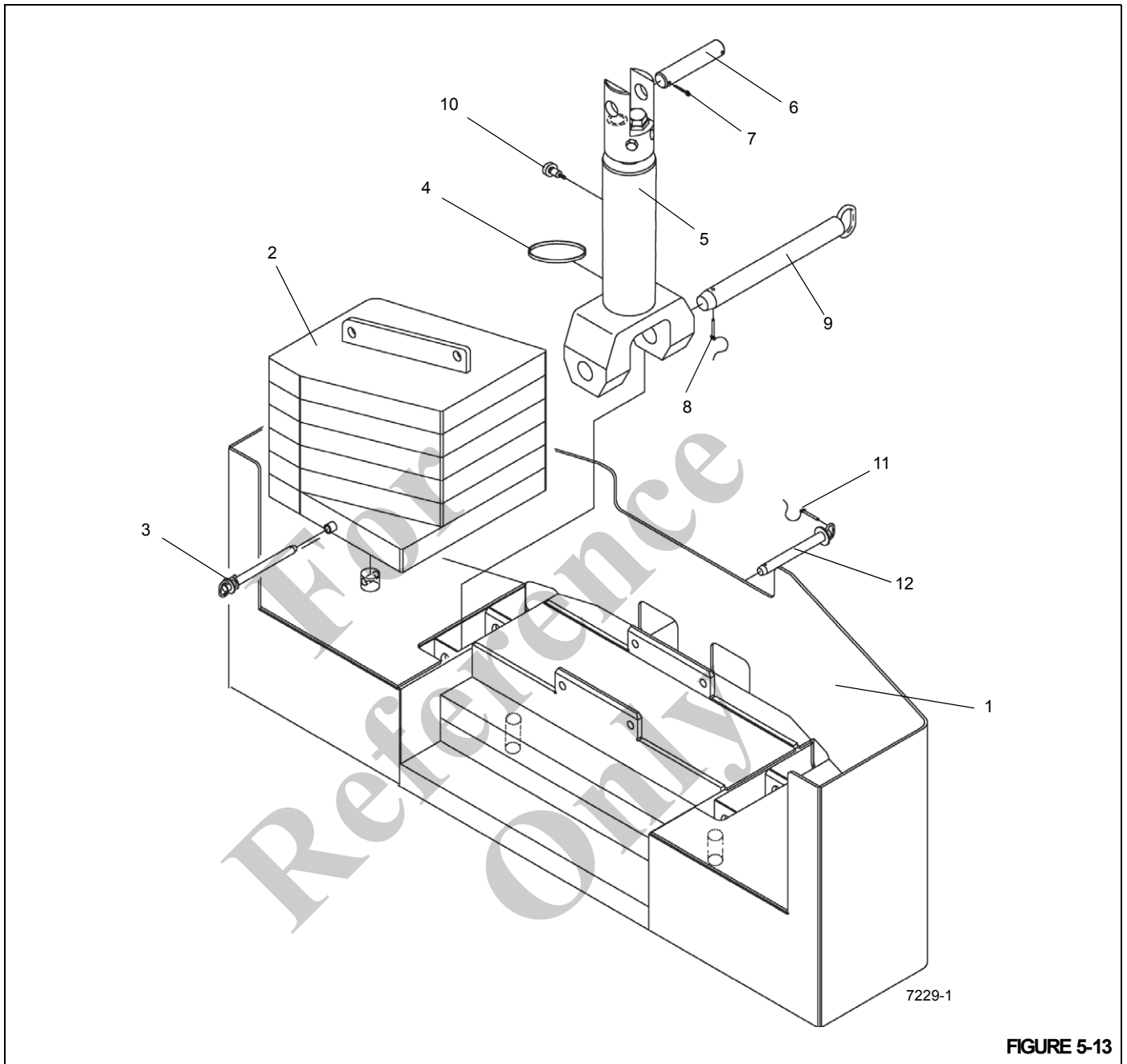


FIGURE 5-13

Item	Description
1	Counterweight Weldment
2	Heavy Counterweight Weldment
3	Heavy Counterweight Weldment Pin
4	Wear Ring
5	Counterweight Removal Cylinder
6	Pin

Item	Description
7	Cotter Pin
8	Cotter Pin
9	Cylinder to Counterweight Pin
10	Shoulder Bolt
11	Hitch Pin
12	Counterweight to Hoist Structure Pin

1. Position the crane on a firm level surface.
2. Fully extend and set the outriggers. Level the crane.
3. Position the superstructure over the rear with the counterweight positioned over the counterweight support on the front of the carrier frame.
4. Remove any load handling device from the auxiliary hoist cable and retract all cable onto the hoist drum. Secure the cable.
5. Tag and disconnect the auxiliary hoist hydraulic lines and electrical harnesses. Cap or plug all line openings. Secure lines so they will not be damaged during auxiliary hoist structure removal.
6. Do not disconnect the lines to the counterweight removal cylinders (5) (Figure 5-13) at this time.

**NOTE:** It may be necessary to retract the counterweight removal cylinders (5) (Figure 5-13) to relieve weight from the counterweight to auxiliary hoist structure pins (12) (Figure 5-13).

7. Remove the hitch pins (11) (Figure 5-13) and the counterweight to hoist structure pins (12) (Figure 5-13). These are accessible through the holes in the back of the counterweight (1) (Figure 5-13).

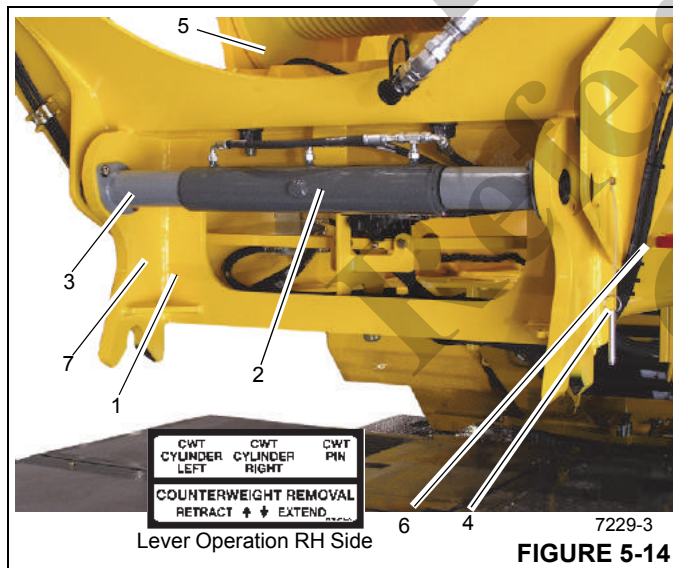


FIGURE 5-14

8. Using the counterweight removal levers (6) (Figure 5-14), extend the counterweight removal cylinders (5) (Figure 5-13) and carefully lower the counterweight (1) (Figure 5-13) onto the counterweight supports.
9. Remove the detent pins (4) (Figure 5-14) to allow the pin removal cylinder (2) (Figure 5-14) to retract the pins on its rod ends.

10. Use the counterweight removal levers (6) (Figure 5-14) to retract the pins on the rod ends of the pin removal cylinder (2) (Figure 5-14) and unpin the auxiliary hoist structure (7) (Figure 5-14) from the turntable.
11. Retract the counterweight removal cylinders (5) (Figure 5-13) and carefully lower the auxiliary hoist structure (7) (Figure 5-14) onto the counterweight.
12. Tag, disconnect and secure the counterweight removal cylinder hydraulic lines. Cap or plug all line openings.



**WARNING**

Travel is not permitted with any counterweight on the carrier.

13. Secure the counterweight (1) (Figure 5-13) to the auxiliary hoist structure (7) (Figure 5-14) with the counterweight to hoist structure pins (12) (Figure 5-13) and hitch pins (11) (Figure 5-13).



**WARNING**

Do not attempt to separate the auxiliary hoist structure (7) (Figure 5-14) from the counterweight (1) (Figure 5-13) while on the counterweight stand (1) (Figure 5-12). The auxiliary hoist structure (7) (Figure 5-14) may hit the counterweight (1) (Figure 5-13) and knock it off the stand.

14. Disengage the swing lock pin and swing the superstructure over the front.



**WARNING**

**Death or serious injury may result with improper use!**

On the heavy removable counterweight option (2) (Figure 5-13), do not use the lifting lugs on the heavy counterweights to lift the entire heavy counterweight and auxiliary hoist structure. The heavy counterweight lifting lugs are designed to lift the heavy removable counterweight only.

15. Attach an adequate lifting device with slings to the auxiliary hoist structure (7) (Figure 5-14). Use the crane to carefully transfer the auxiliary hoist structure (7) (Figure 5-14) and counterweight (1) (Figure 5-13) to the ground or suitable transport vehicle.

**NOTE:** Step 16 applies to the heavy removable counterweight (2) (Figure 5-13).

16. If desired, lessen the weight on the counterweight by removing the two heavy counterweight weldments (2) (Figure 5-13). To remove the weldments, attach an adequate lifting device with slings attached to the lifting lugs. Free the weldments from the counterweight by removing the pins. Using the lifting device, remove the weldments.

### Installation

1. Position the crane on a firm level surface.
2. Fully extend and set the outriggers. Level the crane.



### WARNING

Assemble the standard removable counterweight (1) (Figure 5-13) and auxiliary hoist structure (7) (Figure 5-14) on the ground or on a suitable transport vehicle. Do not attempt to assemble on the counterweight stand. The auxiliary hoist structure may hit the counterweight and knock it off the stand.

Assemble the heavy removable counterweight (2) (Figure 5-13) and auxiliary hoist structure (7) (Figure 5-14) on the ground or on a suitable transport vehicle. Do not attempt to assemble on the counterweight stand (1) (Figure 5-12). The auxiliary hoist structure (7) (Figure 5-14) may hit the counterweight and knock it off the stand.

The heavy removable counterweight assembly (2) (Figure 5-13) must be installed with both heavy counterweights. Using only one heavy counterweight may cause the crane to become unstable.

**NOTE:** Step number 3 applies to the heavy removable counterweight (2) (Figure 5-13).

3. Attach an adequate lifting device with slings to each heavy counterweight weldment's lifting lugs. Using the lifting device, carefully install the two heavy counterweight weldments (2) (Figure 5-13) in place on the counterweight auxiliary hoist structure (7) (Figure 5-14). Pin the counterweight weldments in place with the pins.
4. Using an adequate lifting device with slings attached to the auxiliary hoist structure (7) (Figure 5-14), carefully place the auxiliary hoist structure (7) (Figure 5-14) onto the counterweight (1) (Figure 5-13).
5. Secure the counterweight (1) (Figure 5-13) to the counterweight removal cylinders (5) (Figure 5-13) with the cylinder to counterweight pins (9) (Figure 5-13) and hitch pins (8) (Figure 5-13). Secure the counterweight (1) (Figure 5-13) to the auxiliary hoist structure (7)

(Figure 5-14) with the counterweight to hoist structure pins (12) (Figure 5-13) and hitch pins (11) (Figure 5-13).



### WARNING

The main boom must not be lowered below horizontal while swinging over the front while the counterweight supports are installed.

6. Install the counterweight stands (1) (Figure 5-12) on the front of the carrier.
7. Using an adequate lifting device with slings, carefully transfer the auxiliary hoist and counterweight to the counterweight stands.



### WARNING

The main boom must not be elevated above horizontal while swinging into the auxiliary hoist mounting structure.

8. Swing the superstructure over the rear and engage the swing lock pin.
9. Connect the counterweight removal cylinder hydraulic lines disconnected and tagged earlier.
10. Remove the hitch pins (8) (Figure 5-13) and the counterweight to hoist structure pins (9) (Figure 5-13) to free the auxiliary hoist structure (7) (Figure 5-13) from the counterweight (1) (Figure 5-13).
11. Using the counterweight levers (6) (Figure 5-14), fully extend the counterweight removal cylinders (5) (Figure 5-13) and carefully raise the auxiliary hoist structure (7) (Figure 5-14) to meet the mating plates on the turntable.
12. Use the pin control lever (6) (Figure 5-14) to extend the pins on the rod ends of the pin removal cylinder (5) (Figure 5-14) and pin the auxiliary hoist structure (7) (Figure 5-14) to the turntable.
13. Install the detent pins (4) (Figure 5-14) to secure the pins on the rod ends of the pin removal cylinder (2) (Figure 5-14) to keep the auxiliary hoist structure (7) (Figure 5-14) secured.
14. Retract the counterweight removal cylinders (5) (Figure 5-13) and carefully raise the counterweight (1) (Figure 5-13) to its installed (working) position.
15. Secure the counterweight (1) (Figure 5-13) to the auxiliary hoist structure (7) (Figure 5-14) with the counterweight-to-hoist structure pins (12) (Figure 5-13).

---

**CAUTION**

Do not power the counterweight into the counterweight-to-hoist mounting pins.

---

16. Slowly extend the counterweight removal cylinders (5) (Figure 5-13) so the counterweight-to-hoist mounting pins (12) (Figure 5-13) take the weight of the counterweight (1) (Figure 5-13).
17. Connect the auxiliary hoist hydraulic lines and electrical wires as tagged and disconnected earlier.
18. Remove the counterweight supports from the front of the carrier.

**Counterweight Stand Removal**

1. Attach an adequate lifting device with slings to a counterweight stand (1) (Figure 5-12).
2. Loosen jam nut (7) (Figure 5-12).
3. Rotate foot plates (5) (Figure 5-12) on the counterweight stand (1) (Figure 5-12) away from the outrigger box (2) (Figure 5-12).
4. Remove the counterweight stand (1) (Figure 5-12) to carrier frame hitch pins (4) (Figure 5-12).
5. Using the lifting device with slings, remove the counterweight stand (1) (Figure 5-12).

For  
Reference  
Only

## SECTION 6 SWING SYSTEM

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### DESCRIPTION

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term free swing means that, with the Swing Brake switch in the OFF position, the superstructure will swing freely after the Swing control lever is released until it coasts to a stop or the glide swing brake pedal is depressed.

Swing is activated using the control lever in the cab. When the swing lever is actuated, hydraulic pressure is routed to the swing motors to drive the swing gearboxes in the appropriate direction. As the gearboxes rotate, their pinion gears mesh with the teeth on the swing bearing and rotate the superstructure. Swing speed can be controlled by the control lever and a High/Low Swing Speed switch on the

front console. The maximum rotation speed is 2.5 rpm in HIGH speed and 1.25 rpm in LOW speed. Braking is accomplished by depressing a glide swing brake pedal which is a proportionate control valve that provides a controlled braking of the swing motion.

The swing system consists of a hydraulic remote controller, swing speed switch, series/parallel selector valve, a directional control valve, the swing drives, the swing brake assemblies, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The crane is equipped with a pin type swing lock as standard and a standard 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type swing lock will only lock the turntable in a straight ahead position over the front or rear of machine. Both swing locks are operated from the cab.



## THEORY OF OPERATION

### Swing Drive

The hydraulic power for the swing drive is supplied by the engine driven hydraulic Pump No. 1. Oil flows from the pump to the hydraulic Port 5 swivel. Flow from the swivel is routed to the front steering flow divider valve in the swing directional control valve. Bypass flow from the flow divider valve is used to supply the swing directional control valve.

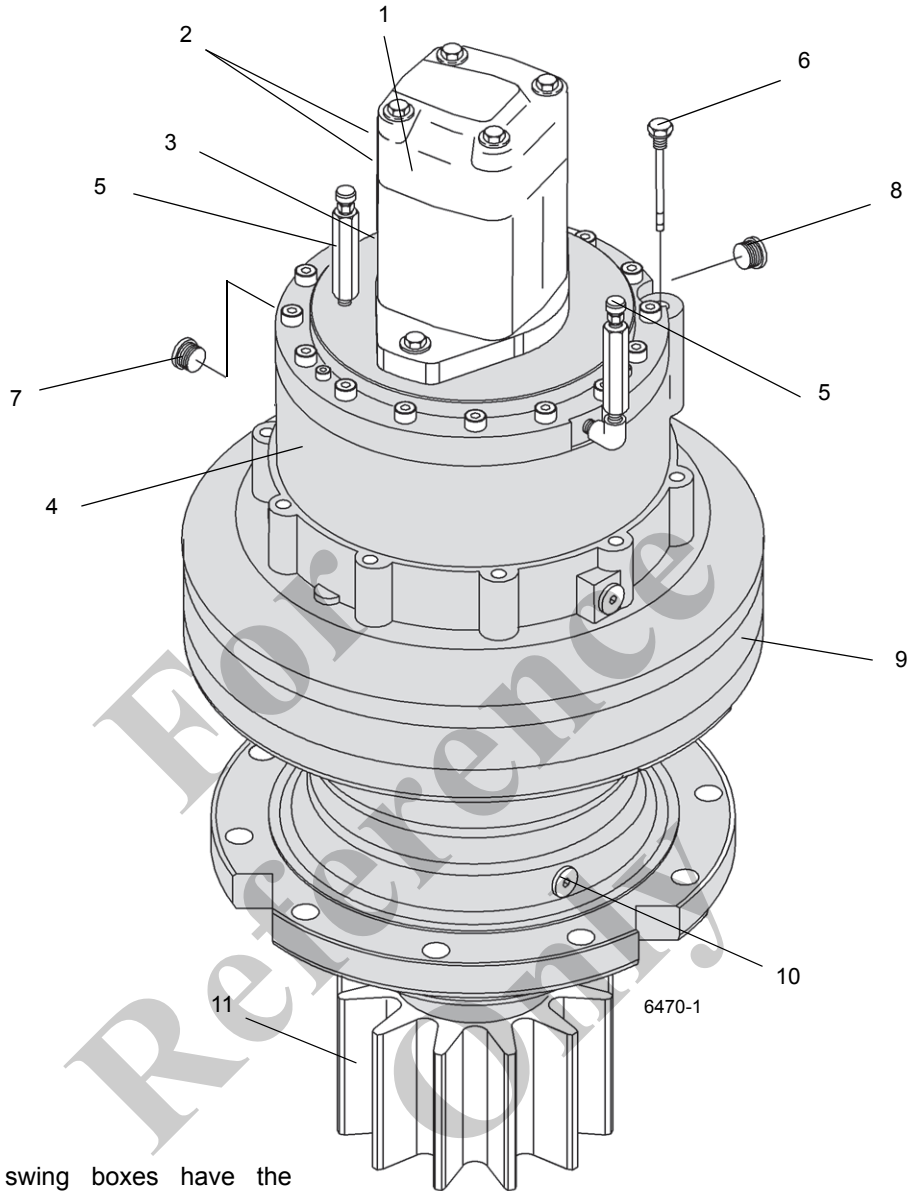
When the hydraulic remote control is positioned to select right or left swing, the flow through the control valve is directed to the series/parallel valve, and then routed to the swing motors. If the Swing Brake selector switch is in the OFF position, the superstructure will rotate in the desired direction. Shifting the control to neutral and depressing the brake pedal will stop the swing.

### Swing Brake

The hydraulic power for the swing brake is supplied by the pressure reducing/sequence valve in the swing brake and armrest lockout manifold. With the Swing Brake selector switch positioned to ON, the swing brake release valve blocks the regulated flow to the brake release ports and spring pressure in the swing brakes applies the brakes. When the Swing Brake selector switch is positioned to OFF, the regulated flow is directed from the pressure reducing/sequence valve to the brake release ports, overcoming the brake spring pressures and releasing the swing brakes. Regulated flow from the pressure reducing/sequence valve is also provided to the power brake valve where it is available for the activation of the swing brake when the pedal is depressed.

For  
Reference  
Only





**NOTE:** Some swing boxes have the notches in the mounting flange. Other swing boxes do not.

**FIGURE 6-1**

Item	Description
1	Swing Motor
2	Swing Motor Ports
3	Swing Motor Drain Plug
4	Swing Brake Assembly
5	Breather Plugs
6	Filling Plug/Level Indicator

Item	Description
7	Hydraulic Apply Brake Port
8	Hydraulic Release Brake Port
9	Swing Gearbox
10	Drain Plug
11	Pinion Gear

MAINTENANCE

Troubleshooting

Table 6-1

Symptom	Probable Cause	Solution
1. Boom swing operation erratic in either direction.	a. Damaged relief valve.	a. Replace relief valve.
	b. Swing brake dragging (not releasing properly).	b. Readjust and/or replace necessary parts.
	c. Low engine rpm.	c. Increase engine rpm to obtain smooth swing operation.
	d. Low hydraulic oil.	d. Check system for leaks. Make repairs as needed. Fill reservoir. Refer to <i>Lubrication</i> , page 9-1.
	e. Improper movement of control to neutral.	e. Feather controls to neutral to maintain smooth stopping action.
	f. Insufficient lubricant on swing bearing.	f. Lubricate bearing properly. Refer to <i>Lubrication</i> , page 9-1.
	g. Crane not level.	g. Level crane using outriggers.
	h. Damaged swing motor.	h. Repair or replace swing motor.
	i. Excessive overload.	i. Reduce load. Refer to load capacity chart.
	j. Restricted or partly clogged hydraulic hose or fittings.	j. Replace hose or fittings. Refer to the Manitowoc Crane Care Parts Manual.
	k. Pump cavitation in swing section.	k. Tighten suction hose or replace any damaged fitting. Check hydraulic tank level.
	l. Improperly torqued turntable bolts.	l. Torque turntable bolts evenly.
	m. Excessive preload on upper and lower pinion shaft bearing.	m. Adjust as necessary.
	n. Improperly torqued swing motor attachment bolts.	n. Torque swing motor attachment bolts.
	o. Malfunction of the swing box.	o. Remove swing box and make necessary repairs.
	p. Worn or damaged pump.	p. Repair or replace damaged pump.
	q. Damaged swing directional control valve.	q. Repair or replace swing directional control valve.
	r. Damaged swing pinion.	r. Replace pinion.
	s. Damaged turntable bearing.	s. Replace turntable bearing.
t. Controller settings.	t. Check settings.	
u. Electrical connection.	u. Inspect wiring and connections.	

Symptom	Probable Cause	Solution
2. Boom swing operation erratic in one direction only.	a. Crane not level.	a. Level crane using outriggers.
	b. Turntable bearing binding due to continuous limited swing. (Example: concrete pourer.)	b. Rotate machine 360 degrees in both directions several times and lubricate bearing.
	c. Restricted hose or fitting.	c. Replace hose or fitting.
	d. Damaged swing directional control valve.	d. Replace swing directional control valve.
	e. Damaged swing pinion.	e. Replace pinion.
	f. Damaged turntable bearing.	f. Replace turntable bearing.
3. Boom will not swing in either direction.	a. Damaged relief valve.	a. Remove, clean, and repair or replace relief valve.
	b. Damaged swing motor.	b. Repair or replace swing motor.
	c. Swing brake not releasing properly.	c. Repair as necessary.
	d. Damaged hydraulic remote control valve.	d. Replace hydraulic remote control valve.
	e. Internal damage to swing box.	e. Remove swing box and repair.
	f. Worn or damaged hydraulic pump.	f. Replace pump section.
	g. Damaged swing directional control valve.	g. Replace swing directional control valve.
	h. Damaged swing pinion.	h. Replace pinion.
	i. Damaged turntable bearing.	i. Replace turntable bearing.
	j. Excessive overload.	j. Reduce load. Refer to load capacity chart.
4. Swing operation slow in either direction.	a. Damaged relief valve.	a. Adjust, repair or replace valve.
	b. Improperly adjusted swing brake.	b. Readjust.
	c. Damaged hydraulic remote control valve.	c. Replace hydraulic remote control valve.
	d. Improperly lubricated swing bearing.	d. Lubricate bearing per <i>Lubrication</i> , page 9-1.
	e. Improper size hose and/or fittings installed.	e. Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	f. Clogged or restricted hydraulic hoses or fittings.	f. Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	g. Replace bearings.
	h. Worn or damaged swing motor.	h. Repair or replace motor.
	i. Worn or damaged hydraulic pump.	i. Repair or replace pump.
	j. Crane not level.	j. Level crane.
k. Damaged swing directional control valve.	k. Replace swing directional control valve.	

Symptom	Probable Cause	Solution
<b>5.</b> Swing operation slow in one direction only.	<b>a.</b> Crane not level.	<b>a.</b> Level crane.
	<b>b.</b> Damaged hydraulic remote control valve.	<b>b.</b> Replace hydraulic remote control valve.
	<b>c.</b> Damaged swing directional control valve.	<b>c.</b> Replace the swing directional control valve.
	<b>d.</b> Clogged or restricted hose.	<b>d.</b> Replace hose or fitting.
	<b>e.</b> Improperly torqued turntable bearing.	<b>e.</b> Torque turntable bearing.
<b>6.</b> Swing brake operation erratic.	<b>a.</b> Improper brake adjustment.	<b>a.</b> Adjust brake.
	<b>b.</b> Air in swing brake system.	<b>b.</b> Bleed brake system.
	<b>c.</b> Brake pedal not fully retracted.	<b>c.</b> Check brake pedal return spring; repair or replace spring.
	<b>d.</b> Dirty or glazed brake disc.	<b>d.</b> Clean or replace disc.
	<b>e.</b> Malfunction of the glide swing power brake valve.	<b>e.</b> Repair or replace glide swing power brake valve.
	<b>f.</b> Kinked or bent lines and/or hoses and fittings.	<b>f.</b> Straighten or replace as required.
<b>7.</b> Swing brake system will not operate.	<b>a.</b> Damaged swing brake release valve.	<b>a.</b> Replace release valve.
	<b>b.</b> Damaged glide swing power brake valve.	<b>b.</b> Repair or replace glide swing power brake valve.
	<b>c.</b> Internal damage to the swing brake assembly.	<b>c.</b> Repair or replace affected parts.
	<b>d.</b> Loose or restricted brake lines or fittings.	<b>d.</b> Tighten or replace lines and fittings.
<b>8.</b> Swing brake pedal is spongy.	<b>a.</b> Damaged glide swing power brake valve.	<b>a.</b> Repair or replace the glide swing power brake valve.
	<b>b.</b> Loose or restricted brake lines or fittings.	<b>b.</b> Tighten or replace brake lines and fittings.
<b>9.</b> Swing brake drags.	<b>a.</b> Damaged glide swing power brake valve.	<b>a.</b> Repair or replace the glide swing power brake valve.
	<b>b.</b> Damaged swing brake release valve.	<b>b.</b> Replace release valve.
	<b>c.</b> Internal damage to the swing brake assembly.	<b>c.</b> Repair or replace affected parts.
	<b>d.</b> Loose or restricted brake lines or fittings.	<b>d.</b> Tighten or replace brake lines and fittings.
<b>10.</b> Boom swings slowly.	<b>a.</b> Insufficient hydraulic volume.	<b>a.</b> Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	<b>b.</b> Damaged relief valve.	<b>b.</b> Adjust, repair, or replace valve.
	<b>c.</b> Damaged swing motor.	<b>c.</b> Repair or replace motor.
<b>11.</b> Swing motor continues to operate when swing control is in neutral.	<b>a.</b> Hydraulic remote control valve sticking or valve otherwise damaged.	<b>a.</b> Repair or replace valve.
	<b>b.</b> Control valve sticking or valve otherwise damaged.	<b>b.</b> Repair or replace valve.

Symptom	Probable Cause	Solution
12. Swing motor turning in wrong direction.	a. Improper port connections.	a. Reverse port connection.
	b. Improper wiring connection	b. Inspect wiring and connections. Make repairs as needed.
13. Swing motor noisy.	a. Air in system.	a. Refer to <i>Removing Air from the Hydraulic System</i> , page 2-6, for removal of air from the system.
	b. Motor binding.	b. Repair or replace motor.

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## SWING BOX ASSEMBLIES

### Description

There are two swing box assemblies (Figure 6-1) for turning and stopping the turntable and superstructure. Each swing box assembly consists of a hydraulic motor on top, a brake assembly, and a swing gearbox on the bottom. Each swing motor rotates the swing gearbox gear pinion output shaft applying turning force to the turntable bearing's gear teeth to turn the turntable. Operator-controlled hydraulic power applied to the brake assemblies stops the gearbox from rotating.

Each swing motor runs on hydraulic power to drive its gearbox. Each swing motor has two ports for connection to the hydraulic system.

Each swing brake assembly is between the swing motor and its gearbox. The brake assembly's mechanism is a disc pack that is hydraulically released and spring applied. The operator steps on a pedal on the cab floor to trigger the swing brake assemblies to stop the swing boxes from turning. When the Swing Brake switch is ON it prevents the swing brake assemblies from releasing; this prevents inadvertent swing during travel or other situations when the superstructure should not turn.

Each gearbox bolts to the superstructure base plate. Each gearbox uses double reduction planetary gearing. The gearbox's pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

A filing plug in the top of the swing brake system assembly housing allows the operator to add gear oil to the swing gearbox and swing brake assembly. There is one drain plug for draining gear oil from the gearbox housing.

There are hydraulic lines to each swing brake assembly; these lines are in a system sealed from gear oil. The hydraulic lines are only for applying or releasing the brake, not providing brake or gearbox lubrication.

There are hydraulic lines to the swing motor; these lines are also in a system sealed from gear oil. The hydraulic lines are for driving the motor in the chosen rotation. There is one drain plug for draining hydraulic oil from the swing motor.

### Swing Motor Maintenance

**NOTE:** Each swing motor can be removed and disassembled independently of the swing brake assembly.

### Removal

1. Engage the swing brake and the swing lock pin.

---

### CAUTION

Oil can be hot and cause burns.

2. Clean the port area around the swing motor. Tag and disconnect the hydraulic hoses from the swing motor. Cap or plug all openings.
3. Unscrew the drain plug, and drain the oil. After oil is drained, reinstall the drain plug.

---

### CAUTION

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

4. Remove the capscrews securing the swing motor to the swing brake assembly housing flange. Remove and discard the O-ring from the groove in the swing brake assembly housing.

### Installation

---

### CAUTION

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

1. Install a new O-ring in the groove of the swing brake assembly's housing. Position the swing motor on the swing brake.
2. Apply Loctite 243 on the capscrews. Secure the swing motor to the swing brake assembly housing with the capscrews.
3. If needed, fill the swing gear box with gear oil. Refer to *Lubrication*, page 9-1.
4. Connect the hydraulic lines to the swing motor as tagged during removal.

### Testing

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

## Swing Brake Assembly Maintenance

**NOTE:** Each swing brake assembly can be removed and disassembled independently of the swing gearbox.

### Removal

1. Engage the swing lock pin.



### CAUTION

Oil can be hot and cause burns.

2. Tag and disconnect the hydraulic lines connected to the swing motor and the swing brake assembly. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake assembly per the procedure in this section.
4. While observing tension on the bolts due to internal brake springs, unscrew socket head capscrews securing the swing brake assembly to the gearbox. Remove the brake assembly.
5. Remove and discard the O-ring from the swing brake assembly housing.
6. Cover the opening of the swing gearbox to ensure no dirt, dust or other foreign material get into the gearbox.

### Installation

1. Install a new O-ring onto the brake assembly's housing and insert the brake assembly into the gearbox.
2. Secure the brake assembly with the socket head capscrews.
3. Install the swing motor on the swing brake assembly per the procedure in this section.
4. Connect the hydraulic lines to the swing motor and swing brake assembly.
5. Bleed all air from the swing brake assembly.

### Testing

1. With the Swing Brake Switch in the ON position, move the swing control lever in both directions. Superstructure rotation should not occur.
2. Put the Swing Brake Switch to OFF and swing the superstructure in both directions. Use the swing brake pedal to stop rotation.
3. Check for hydraulic leaks and repair as necessary.

## Swing Gearbox Maintenance

### Removal

1. Engage the swing lock pin.



### CAUTION

Oil can be hot and cause burns.

2. Tag and disconnect the hydraulic lines from the swing motor and the swing brake assembly. Cap and/or plug all openings.
3. If necessary, remove the swing motor per instructions in this section. Or, do so after removing entire swing box assembly from superstructure.
4. If necessary, remove the swing brake assembly per instructions in this section. Or, do so after removing entire swing box assembly from superstructure.

**NOTE:** The swing gearbox with swing brake assembly and swing motor attached weighs about 335 lb (about 150 kg).

5. Attach a suitable lifting device to the swing gearbox.
6. Remove the capscrews, flatwashers and bushings securing the swing gearbox to the superstructure base plate. Remove the swing gearbox.
7. Remove the counter-sunk allen bolts and bottom plate attaching the pinion gear to the swing gearbox shaft. Remove the pinion gear.
8. Cover the opening of the swing gearbox to ensure no dirt, dust, or foreign material gets into the gearbox.

### Installation

1. Install the pinion gear and bottom plate on the swing gearbox splined shaft. Secure pinion gear with the counter-sunk allen bolts.
2. Install the swing brake assembly on the swing gearbox per instructions in this section.
3. Install the swing motor on the swing brake assembly per instructions in this section.
4. Attach a suitable lifting device to the swing gearbox and position the swing gearbox on the superstructure base plate.
5. Install the capscrews, washers and bushings removed earlier to secure the swing gearbox to the superstructure base plate.
6. Connect the hydraulic lines to the swing brake.
7. Connect the hydraulic lines to the swing motor.

8. Service the gearbox per the following instructions.

### **Servicing**

Normal maintenance should only consist of proper lubrication and a periodic check of mounting bolt torque values. Lubrication consists of maintaining the gearbox oil level. Oil in a new gearbox should be drained and flushed after approximately 250 hours of operation, and replaced with premium quality SSGL-5 after about 500 hours of operation or each year, whichever occurs first. Operation in high humidity or polluted air areas will require more frequent changes to minimize moisture or contaminate accumulation.

### **Oil Changing**

Change the oil as follows.

1. Unscrew drain plug; remove breather and dipstick. Ensure all oil has been removed.
2. Flush the case with a light flushing oil. Flushing of the gearbox with a solvent helps prevent an accumulation of contaminants. Avoid steam cleaning where moisture

and dirt might be driven into the vent of the swing bearing.

3. After oil is drained, reinstall the drain plug and any other plugs that were removed to drain the oil.
4. To refill with oil, make sure the breather is open. Fill until proper location on dipstick.
5. Tighten breather and dipstick.

### **Checking Oil Level**

1. Check level on dipstick
2. If no lubricant is visible on dipstick, add SSGL-5 until between minimum and maximum on dipstick. Refer to *Lubrication*, page 9-1.
3. Reinstall the dipstick in the brake housing.

### **Testing**

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

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## SWING BEARING

### Description

The swing bearing is an anti-friction roller bearing that mates the superstructure to the carrier. The bearing inner race is bolted to the superstructure and the outer race is bolted to the carrier. The inner race contains grease fittings for lubrication of the bearing which are hoses to two fittings at the front of the turntable center section. The outer race has gear teeth that mesh with the pinion gear of the swing gearbox to provide rotation.

### Maintenance

#### General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the superstructure and carrier. Therefore, proper care of the bearing and periodic maintenance of the turntable-to-bearing attach bolts IS A MUST to ensure safe and efficient operation.

#### Torquing Turntable Bolts

##### General



### WARNING

Failure to maintain proper torque of the turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the superstructure from the carrier.

### CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt

must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.



### WARNING

It is mandatory that bearing attaching bolts be inspected for lack of torque and retorqued, as required, after the first 300 hours of crane operation. The bolts may loosen in service due to vibration, shock-loads, and temperature changes, therefore, periodic inspection should be accomplished every 500 hours thereafter, ensuring the bolts are properly torqued.

Refer to *Fasteners and Torque Values*, page 1-18 for information on torque wrenches and torque multipliers.

#### Torque Values

Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the turntable bolts.

#### Tools Required

Special Turntable Bolt Torquing Tools (Figure 6-3) illustrates and lists the complete set of special tools required to torque the turntable bolts.

#### Inner Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts to 80% of their specified torque value using the following sequence pattern: 11, 31, 21, 1, 16, 36, 26, and 6 (Figure 6-2). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and torque all 40 bolts sequentially in a clockwise direction to their final torque value specified.

#### Outer Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts to 80% of their specified torque value using the following sequence pattern: 10, 28, 19, 1, 15, 33, 24 and 6 (Figure 6-2). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and torque all 36 bolts sequentially in a clockwise direction to their final torque value specified.

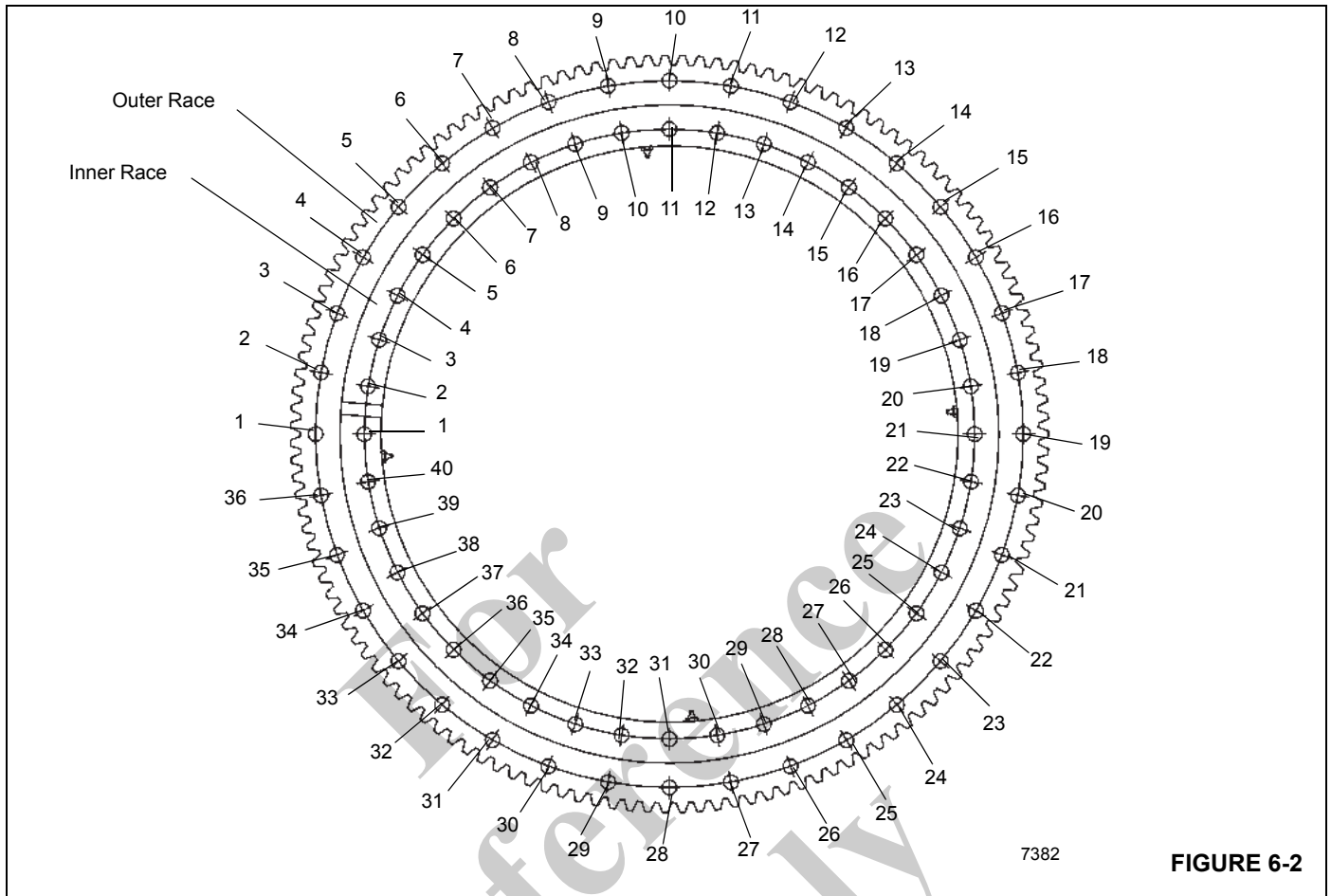


FIGURE 6-2

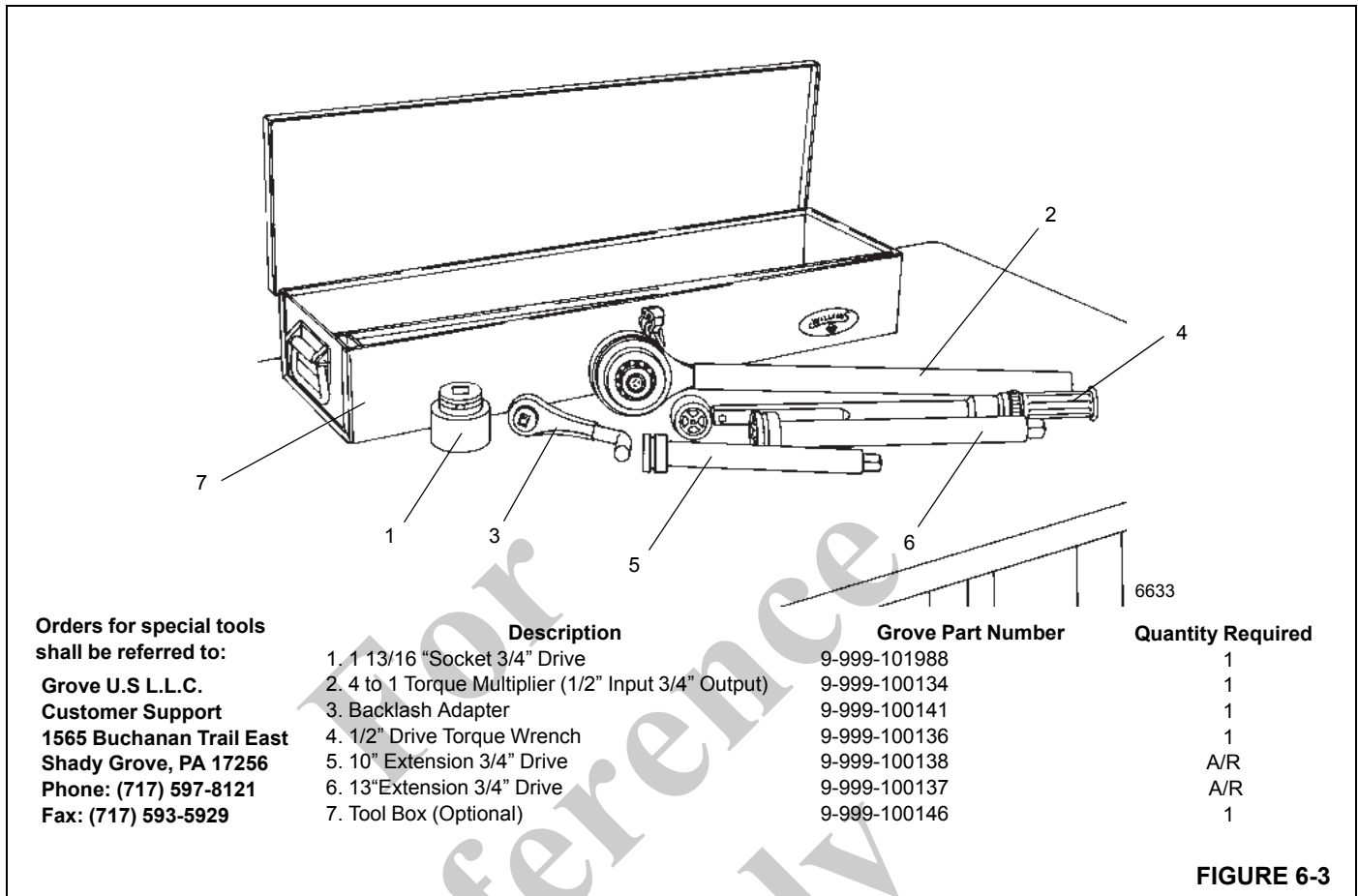


FIGURE 6-3

**Removal**

1. Fully extend and set the outriggers enough to take up the slack in the pads.

**NOTE:** Do not raise the machine on the outriggers.

2. Ensure the boom is in the travel position and the turntable lock pin is engaged.

3. Elevate the boom slightly and shut down the engine.

4. Tag and disconnect the battery cables from the batteries.

**NOTE:** The boom assembly weighs approximately 36,610 lb (16,600 kg) without stowed boom extension. Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached. The lift cylinder weighs approximately 3893 lb (1770 kg).

5. Remove the boom and lift cylinder following the procedures outlined in *Boom*, page 4-1.

**NOTE:** The counterweight/auxiliary hoist and structure weighs approximately 45,000 lb (20,400 kg).

6. Remove the counterweight and auxiliary hoist following procedures outlined in *Counterweight Removal and Installation*, page 5-21.

7. Tag and disconnect all water and oil lines from the bottom of the swivel. Cap or plug all lines and openings.

8. Locate the connectors and ground wire that joins the swivel wiring harness to the receptacles and ground stud on the carrier.

9. Disconnect the swivel wiring harness connectors from the carrier wiring receptacles. Remove the ground wire from the ground stud.

10. Remove the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.

11. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turntable removal.

12. On the bottom of the hydraulic swivel, bend the retainer tabs away from the bolt heads. Remove the eight bolts and four bolt retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

**NOTE:** The swivel assembly will be removed with the turntable.



**DANGER**  
**Crushing Hazard!**

Ensure the lifting device is capable of fully supporting the weight of the superstructure. Ensure the superstructure will not tilt or slide during lifting and moving. Failure to do so may result in death or injury to personnel and damage to equipment.

**NOTE:** If a lifting device capable of lifting the entire superstructure is not available, superstructure weight may be reduced by removing various components such as the hoist(s).

13. Attach a suitable lifting device to the four superstructure lifting lugs (two near the boom pivot shaft bushings and two near the lower lift cylinder pivot shaft bushings). Take in cable or chain to remove slack. Do not pull up on the superstructure.



**WARNING**  
**Crushing Hazard!**

Ensure the superstructure is fully supported before proceeding.

**NOTE:** It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be removed from the swing drive side of the turntable.

14. Remove the 36 bolts and washers securing the turntable bearing outer race to the carrier.



**WARNING**  
**Crushing Hazard!**

Ensure that any blocking material used is capable of fully supporting the weight of the superstructure and will not allow it to tilt or shift. Failure to do so may result in death or injury to personnel.

15. Carefully lift the superstructure, using care not to damage the swivel assembly, and set it on blocking that will not allow the superstructure to tilt or shift, or rest on the swivel. Leave the lifting device attached.

**NOTE:** If the same bearing is to be used again, mark the position of the bearing on the superstructure so it

can be installed in the exact position it was before removal.

**NOTE:** The bearing weighs approximately 2030 lb (921 kg). Ensure the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 40 bolts and washers securing the turntable bearing to the superstructure.
17. Using the lifting device, remove the turntable bearing from under the superstructure.

**Inspection**

Check the bearing teeth for chipping or cracking. If any evidence of these are found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

**Installation**



**WARNING**

Anytime a grade 8 turntable bolt has been removed, it must be replaced with a new grade 8 bolt.

**NOTE:** If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

1. Using an appropriate lifting device, position the turntable bearing under the superstructure. If the same bearing is being used, position it as marked prior to removal.
2. Install 40 new bolts and washers to secure the bearing to the superstructure. Refer to *Inner Race Torquing*, page 6-11.
3. Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

**NOTE:** It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the swing drive side of the turntable.

4. Install 36 new bolts and washers to secure the bearing to the carrier. Refer to *Outer Race Torquing*, page 6-11.

**NOTE:** If a new bearing is being installed, a new pinion gear must also be used. Align the high point (maximum eccentricity) on the bearing with the new pinion gear high point.

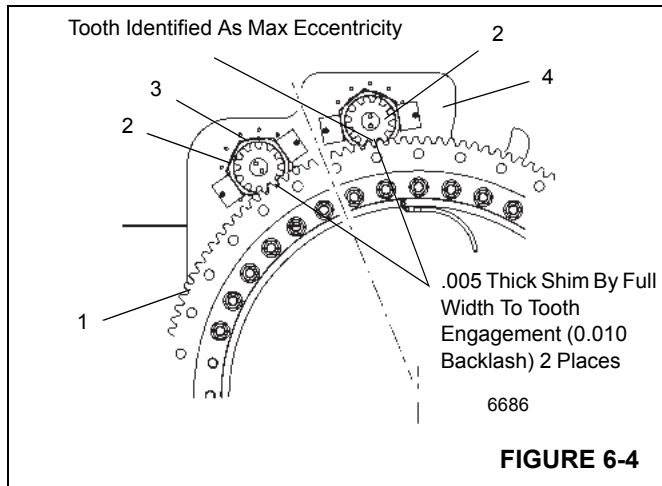


FIGURE 6-4

Item	Description
1	Bearing
2	Swing Gearbox
3	Pinion Guard
4	Turntable

5. Orient ring gear such that its point of max eccentricity ("high point") is located between the swing drives. Position swing drives so that pinion is centered within cutout in base plate and motor ports face towards the outboard side (Figure 6-4).

**CAUTION**

Do not clamp over pinion.

- a. Using shims, set backlash by moving the swing drive assemblies toward the bearing in order to mesh the pinion with the ring gear teeth.
  - b. Check tooth engagement squareness and vertical tooth engagement.
  - c. Remove backlash shims and recheck backlash.
6. Position the two retainer plates on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure them to the spool with four bolt retainers and eight bolts. Bend all the retainer tabs to make contact with the bolt heads.
  7. Plug the swivel wiring harness connectors into the carrier receptacles. Secure the ground wire to the ground stud using a washer, lockwasher, and nut.
  8. Install the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel.
  9. Connect all water and hydraulic lines to the ports on the bottom of the swivel as tagged during removal.
  10. Install the boom and lift cylinder following the procedures outlined in *Boom*, page 4-1.
  11. Install the counterweight and auxiliary hoist following procedures outlined in *Hoist and Counterweight*, page 5-1.
  12. Reconnect the batteries.
  13. Check the slew potentiometer in the electrical swivel for proper orientation. Refer to *Swivels*, page 6-16.

**Testing**

Activate the crane and check for proper function.

**NOTE:** If the superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

**SWIVELS**

**Description**

The swivel assembly consists of a 11 port hydraulic swivel, a 2 port water swivel, and a 20 conductor slip ring electrical swivel (Figure 6-5). Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts, washers and bushings, which connect to mounting lugs on the case. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier by bolts, and bolt retainer plates attached to the swivel retainer plate which engages the carrier frame lugs with bolts and jam nuts. This allows the spool to remain stationary with the carrier as the case rotates with the superstructure.

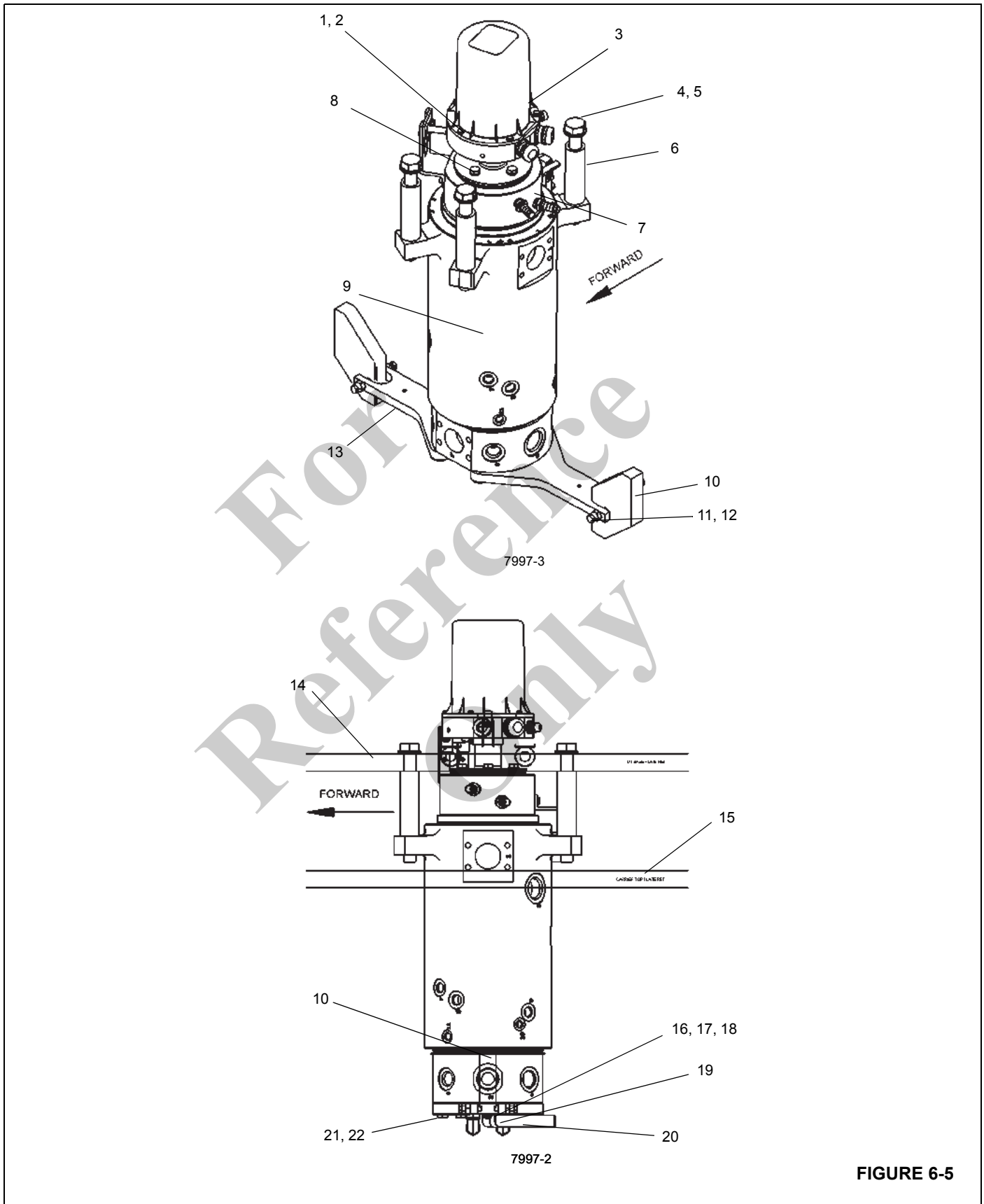
The spool portion of the water swivel is attached to the spool of the hydraulic swivel by four bolts. The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case contains a lug which is keyed to a corresponding lug on the hydraulic swivel case, causing the water swivel to rotate with the superstructure.

The electrical swivel center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the

brush assembly to rotate with the superstructure around the stationary collector core.

Item list for the swivel assembly (Figure 6-5).

Item	Description
1	Nut
2	Washer
3	Electric Swivel
4	Capscrew
5	Washer
6	Spacer Bushing
7	Water Swivel
8	Mounting Bolts
9	Hydraulic Swivel
10	Frame Mounting Lugs
11	Screw
12	Jam Nut
13	Retainer Plate
14	Turntable Base plate
15	Carrier Top Plate
16	Lockwasher
17	Flatwasher
18	Bolt
19	Tubing Clamp
20	Electric Swivel Harness
21	Bolt
22	Bolt Retainer Plate



6

## Hydraulic Swivel

### Description

Each of the ports on the spool and case of the swivel is stamped with the port number. The function of each port is described below.

Table 6-2

Port #	Test Pressure psi (kPa) (bar)	Function
1	500 (3400) (34)	Dual Return
2	4000 (27500) (275)	Hoist/Lift/Tele
3	4000 (27500) (275)	Hoist/Lift/Tele
4	500 (3400) (34)	Case Drain
5	4000 (27500) (275)	Steer/Swing
6	2500 (17000) (170)	Pilot, Swing Brake, Hose Reel
7	4000 (27500) (275)	Front- Steer Left
8	4000 (27500) (275)	Front- Steer Right
9	2500 (17000) (170)	Brakes/Air Conditioning
10	2500 (17000) (170)	Brakes, Front
11	2500 (17000) (170)	Brakes, Rear
A	----	Heater Supply (Coolant)
B	----	Heater Return (Coolant)

### Theory Of Operation

The hydraulic swivel allows oil to flow from the pumps to various crane functions on the superstructure. All oil is routed into the spool portion of the swivel where, through a series of internally drilled passages, oil is transferred to circumferential channels on the spool exterior. These channels correspond with a mating port on the outer case of the swivel. Each channel is separated by a series of nylon and O-ring seals that prevent transfer of oil and pressure. Return flow from the crane superstructure is accomplished in the same manner through another set of ports.

### Maintenance

#### Removal

1. Extend and set the outriggers. Ensure the crane is level and the boom is over the front.
2. Elevate the boom and note at what boom angle, you have the most clearance between the lift cylinder and the turntable side plate. Shut down the engine.
3. Measure the distance from the top of the lift cylinder to the base of the boom section where the lift cylinder attaches. Cut two pieces of 4 x 4 in (10 x 10 cm) oak to fit.

**NOTE:** It might be necessary to raise the boom slightly to allow installation of the blocking.

**NOTE:** This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or

internally in the cylinders will allow the boom to settle over a period of time.

4. Use the oak blocking to block between the barrel of the lift cylinder and the boom base section.
5. Tag and disconnect the hydraulic lines from the case of the hydraulic swivel. Cap or plug all lines and openings.
6. Tag and disconnect the hydraulic lines and water lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
7. Tag and disconnect the water lines from the case of the water swivel. Cap or plug all lines and openings.
8. Disconnect the swivel wiring harness connectors from the carrier receptacles and the yellow ground wire from the connector mounting bracket on the carrier frame. If necessary, remove the electrical swivel. Refer to *Electrical Swivel*, page 6-20.

**NOTE:** The hydraulic swivel weighs approximately 430 lb (195 kg). The hydraulic, water, and electrical swivel combined weigh approximately 520 lb (236 kg).

9. On the bottom of the swivel, bend the retainer tabs away from the capscrew heads. Remove the eight capscrews and four capscrew retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

**NOTE:** It may be necessary to remove some drive line components to remove the swivel.



10. Position an adequate supporting device beneath the swivel.
11. Remove the four capscrews, washers, and bushings securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

### Installation

**NOTE:** The hydraulic swivel weighs approximately 430 lb (195 kg). The hydraulic, water, and electrical swivel combined weigh approximately 520 lb (236 kg).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews, and washers. Torque the bolts, refer to *Fasteners and Torque Values*, page 1-18 for the torque value.
3. Position the two retainer plates on the hydraulic swivel spool ensuring they engage the lugs on the carrier frame. Secure the retainer plates with eight capscrews and four capscrew retainers. Apply Loctite 271 to the capscrew threads. Refer to *Fasteners and Torque Values*, page 1-18 for the torque value for the eight retainer plate bolts. Bend all the retainer tabs to make contact with the capscrew heads. Tighten the four retainer plate capscrews, leaving a maximum 0.0313 in (0.8 mm) gap between each bolt and lug on carrier frame, then tighten the locking nuts.

**NOTE:** Allow a 1/32" max gap between bolt and the retaining lug on the frame. Do not tighten bolt against lug.

4. If removed, install the electrical swivel. Refer to *Electrical Swivel*, page 6-20. Connect the swivel wiring harness connectors to the carrier receptacles and the ground wire to the mounting bracket on the carrier frame. Use the bolt and star washers taken off at removal and refer to Grove Engineering Specification A-829-100386 for proper electrical termination of grounds.
5. Install the clamp, lockwasher, flat washer and capscrew to the bottom of the swivel retainer plate securing the wiring harness.
6. Connect the hydraulic lines and water lines to the spool of the hydraulic swivel as tagged during removal.
7. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.
8. Connect the water lines to the water swivel case as tagged during removal.
9. Remove the blocking material from the lift cylinder.

10. Activate all systems; cycle all functions and observe for proper operation and any leakage.

### Two-Port Water Swivel

#### Description

The two-port water swivel allows engine coolant to flow from the carrier-mounted engine to the hot water heater in the operator's cab. Through an internally drilled passage in the 11 port hydraulic swivel spool, coolant is transferred to a circumferential groove on the water spool exterior. This groove corresponds with a mating port on the outer case of the water swivel. The spool grooves are separated by a quad ring/teflon bronze ring seal. The lip seal prevents coolant from leaking externally. Return engine coolant flow from the hot water heater is accomplished in the same manner through the opposite port of the water swivel.

#### Maintenance

##### Removal

1. Perform steps 1 thru 4 of *Hydraulic Swivel*, page 6-18.
2. Remove the electrical swivel. Refer to *Electrical Swivel*, page 6-20.
3. Tag and disconnect the lines from the case of the water swivel. Cap or plug all lines and openings.
4. Remove the bolt and shim(s) from the water/hydraulic swivel keying lugs.
5. Remove the four capscrews and washers securing the water swivel and electrical swivel center post to the hydraulic swivel. Remove the water swivel and center post.

##### Disassembly

**NOTE:** Any maintenance requiring disassembly of the water swivel should include replacement of all seals and rings.

1. Withdraw the spool from the case.
2. Place the spool on a clean work surface in a dust-free area and block the spool to prevent movement during disassembly.

---

### CAUTION

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

---

**NOTE:** Placing removed seals and rings in the order of disassembly will assist with installation of new seals and rings.

## Cleaning and Inspection



### WARNING

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid prolonged skin contact, inhalation of vapors, or smoking. Failure to comply can result in injury or death to personnel.

1. Clean the spool and case with a suitable solution and dry with compressed air. Plug all ports with plastic caps.
2. Check the spool and inside of the case for scratches, grooves, scoring, etc. If any grooves have developed with a depth of 0.005 in (0.127 mm) the unit should be replaced.

## Assembly

**NOTE:** Lubricate the interior of the swivel to prevent rusting from condensation.

1. Lubricate the spool, seals, and rings.

### CAUTION

When installing seals and rings, avoid stretching seals or scratching grooved or gland surfaces.

2. Install new seals and rings on the spool.

### CAUTION

Proper alignment when inserting the spool is required. Do not force the spool into the case.

3. Insert the spool into the barrel.

## Installation

1. Install the water swivel on top of the hydraulic swivel aligning the keyed lug on the water swivel with the lug on the hydraulic swivel. Secure the water swivel and the electrical swivel center post with the four bolts and washers.
2. Install the shim(s) on the keying lug to provide a snug fit and secure with a bolt.
3. Connect the lines to the swivel case as tagged during removal.
4. Install the electrical swivel. Refer to *Electrical Swivel*, page 6-20.
5. Perform steps 8 and 9 of *Hydraulic Swivel*, page 6-18.
6. Activate all systems, cycle all functions, and observe for proper operation and any leakage.

## Electrical Swivel

### Description

The swivel assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes, leads, and clips which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the swivel. The collector ring leads are formed into one harness which is routed downward through the center of the hydraulic swivel. Extending from the base of the hydraulic swivel, the collector ring leads are also formed into connectors which plug into receptacles from the chassis power supply.

The swivel cover is secured with a seal and bolts.

The electrical swivel also incorporates a slew potentiometer. The potentiometer controls functions in the rated capacity limiter, working area definition, and rear axle oscillation lockout systems.

### Theory Of Operation

The electrical swivel is located on top of the water swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity between the swivel and carrier, and superstructure.

### Maintenance

#### Removal

1. Perform steps 1 through 4 of *Hydraulic Swivel - Removal* in this section.



### CAUTION

Disconnect the batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

2. Disconnect the batteries. Refer to *Batteries*, page 3-2.
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.

**NOTE:** If the connectors are too large to go through the center of the hydraulic swivel, they must be removed, see instructions below.

5. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.

**NOTE:** If connectors are too large to go through the center of the hydraulic swivel, tag each wire on each of the connectors. Using the appropriate pin removal tools, remove the pins, with wires still attached, and mark each wire with the pin socket number in the connector. Collect the wires and secure into one bundle. Mark the bundle with the connector number. For a list of the appropriate pin removal tools, refer to *Connector Troubleshooting*, page 3-7.

6. Secure the connectors and wires from each of the numbered connectors so the harness can be withdrawn through the center of the hydraulic swivel.
7. Tag and disconnect the connectors from the receptacles on the cab bulkhead mounting plate.
8. Remove the nuts and washers, and remove the cover from the electrical swivel.
9. Loosen the setscrews securing the electrical swivel mounting tube to the center post on the water swivel.
10. Remove the bolt and nut securing the electrical swivel case to the bracket on the case of the water swivel.

### CAUTION

When withdrawing the wiring harness through the center of the hydraulic and water swivels, ensure the wires do not get caught and damaged.

11. Remove the swivel and wiring harness from the crane. If necessary, remove the spacer bushing from the center post.

### Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic and water swivels.

**NOTE:** The boom should be centered directly over the front of the crane before adjustment is made to the slew potentiometer.

2. Slide the electrical swivel mounting shaft onto the center post.
3. Ensure the threaded hole on the bottom of the electrical swivel base is aligned with the mounting hole in the bracket on the water swivel case. Install the bolt through the hole in the bracket and install the nut. Screw the bolt into the hole in the electrical swivel base until the bolt head is approximately 0.25 in (6.4 mm) from the bracket. Tighten the nut against the electrical swivel (Figure 6-6).

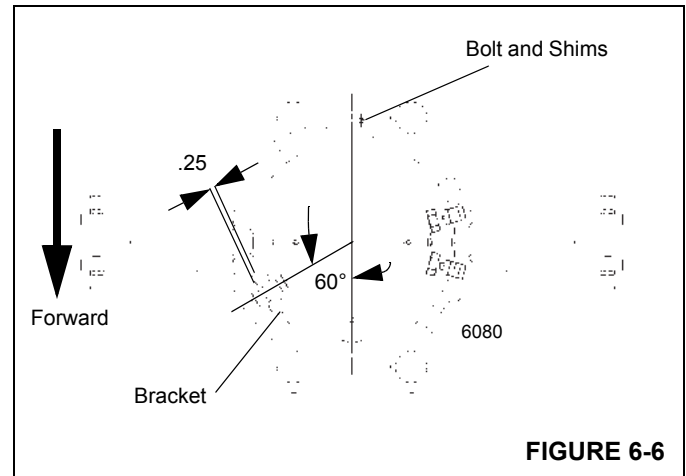


FIGURE 6-6

4. Apply Loctite to the set screws securing the electrical swivel to the center post and tighten.
5. Install the swivel cover and secure with two nuts and washers.
6. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal.
7. Plug the connector into the carrier wiring receptacle, connect the wires as tagged during removal. Install the ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken off at removal and refer to Grove Engineering Specification A-829-100386 for proper electrical termination of grounds.
8. Install the clamp securing the harness to the retainer plate on the bottom of the hydraulic swivel assembly.
9. Connect the batteries.

### CAUTION

It is imperative that the slew potentiometer be adjusted anytime work is done to the electrical swivel.

10. Activate all systems, cycle all functions, and observe for proper operation. Adjust the slew potentiometer in accordance with *Slew Potentiometer Adjustment*, page 6-22 procedures.

### Preventive Maintenance

It is recommended that a normal inspection of the electrical swivel collector ring and brush assembly be established. An example of this could be at approximately 100 to 150 engine operating hours. When this time limit is reached, perform the following:

1. Check the collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check the collector ring setscrews and ensure they are tight.
3. Check the brush and arm assembly springs. Ensure they are holding the brushes firmly against the collector rings.

### Slew Potentiometer Preliminary Zero Adjustment Procedure

1. Rotate the superstructure over the front and engage the swing lock pin.

**NOTE:** Refer to the PAT rated capacity limiter operator's manual for detailed instructions. Complete the RCL console setup according to the crane's current operating configuration.

2. Press the 1 keypad button on the RCL console.
3. Press the CTRL keypad button on the RCL console.
4. Enter authorization code 64356, then press the return keypad button on the RCL console.
5. Press the return keypad button two more times to display the slew adjustment screen.
6. Press the + and the - keypad buttons on the RCL console simultaneously. Note the indicator line moves to zero on the bar graph on the slew adjustment screen.
7. Press the ESC keypad button on the RCL console.

### Slew Potentiometer Adjustment

1. Rotate the superstructure over the front and engage the swing lock pin.
2. Set the RCL console to read slewing angle as follows:

**NOTE:** Refer to the PAT rated capacity limiter DS350/1319 operator's manual for detailed instructions.

- a. Complete the RCL console setup according to the crane's current operating configuration.
  - b. Press limits LIM.
  - c. Press 4 for slew angle/work area definition limits.
  - d. Press 1 for slew angle.
  - e. Press 2 or 3 to display slewing angle.
3. Remove the electrical swivel cover.

4. Disengage the swing lock pin and swing the superstructure approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the swing lock pin.

**NOTE:** If the superstructure swings past the swing lock pin engaged position, step 4 must be repeated.

5. Loosen the three screws that secure the slew potentiometer to the mounting plate.
6. Rotate the body of the slew potentiometer until the slew angle indicates  $0.6 \pm 0.1$  degree.

**NOTE:** The slew angle indication in step 6 may not be obtainable due to limited wire length on the potentiometer, or the electrical terminals interference with one of the three mounting screws. If this occurs, reposition the collar on the potentiometer shaft and repeat steps 4 thru 6.

7. Tighten the three screws that secure the slew potentiometer to the mounting plate. Install the electrical swivel cover.
8. Disengage the swing lock pin and swing approximately 10 degrees to the left (counterclockwise). Slowly swing back to the right and engage the swing lock pin.

**NOTE:** If the superstructure swings past the swing lock pin engaged position, step 8 must be repeated.

9. If the angle indicated on the console does not exceed  $\pm 1.0$  degree, proceed to step 10. If the indicated angle exceeds  $\pm 1.0$  degree, return to step 4.
10. Disengage the swing lock pin and swing approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the swing lock pin.

**NOTE:** If the superstructure swings past the swing lock pin engaged position, step 10 must be repeated.

11. If the angle indicated on the console does not exceed  $\pm 1.0$  degree, proceed to step 12. If the indicated angle exceeds  $\pm 1.0$  degree, return to step 3.
12. Disengage the swing lock pin and swing approximately 10 degrees to the left (counterclockwise). Slowly swing back to the right and engage the swing lock pin.

**NOTE:** If the superstructure swings past the swing lock pin engaged position, step 12 must be repeated.

13. Verify the angle indicated on the console does not exceed  $\pm 1.0$  degree. If the indicated angle exceeds  $\pm 1.0$  degree, return to step 3.

---

## CAUTION

Do not attempt to rotate the slotted shaft in the center of the slew potentiometer.

---

## SWING LOCK PIN

### Description

The purpose of the swing lock pin is to lock the superstructure in position directly over the front or the rear of the carrier. The swing lock pin installation consists of a large pin, a control handle in the right side of the cab, and a control cable and linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front, pushing the control handle in drops the swing lock pin into a socket on the carrier frame, locking the superstructure in place. Pulling the control handle out pulls the pin out of the socket, unlocking the superstructure.

### Maintenance

Verify linkage and cable are undamaged and installed to avoid damage from superstructure rotation. Verify pin, the turntable bushing the pin passes through, and the sockets on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage and cable are adjusted properly. If they are, the pin bottom will stick out about 4.0 inches (10.16 cm) from the bottom of its bushing in the turntable. (If it is too far in, it might not lock properly. If it is too far out, it might hang up). Using the jam nuts on the linkage parts and cable, adjust the linkage and cable so the pin bottom will be flush with the bottom of its bushing in the turntable when not applied, and the pin will stick out about 4.0 inches (10.16 cm) from the bottom of its bushing in the turntable when applied. Verify the superstructure can lock properly when the pin is applied and the superstructure can rotate without pin hangup when the pin is not applied.

## 360° SWING LOCK CONTROL—POSITIVE LOCK TYPE (OPTIONAL)

### Description

The purpose of the swing lock is to secure the superstructure in position at one of the positions in its rotation. There are roughly 135 spots about 2.7 degrees apart for the superstructure to lock to in its 360 degree of rotation. The 360 degree swing lock control lever is on the right side of cab. Pushing the swing lock control lever down engages the lock between the teeth of the swing gear. Pulling the swing lock control lever up disengages the lock.

### Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify swing lock assembly is undamaged and working properly. Verify springs are undamaged and have enough strength to pull blade of swing lock assembly completely out of the gear teeth when the control lever is up. Verify the linkage can put the blade of the swing lock assembly as far as possible between the gear teeth when the control lever is down.

Verify all attaching hardware is secure and undamaged. Make adjustments as needed.

If the swing lock assembly is damaged, install a replacement. Align the blade of the swing lock assembly so it will fall between gear teeth. Use the shim and the related attaching hardware (two 5/16-18 screws and 5/16 ID lockwashers) to ensure the swing lock assembly cannot move side to side, and can lock the superstructure. Torque the four 1-8 mounting bolts.

As needed, adjust the swing lock control and cable per above instructions. Then operate the control lever several times to verify the swing lock blade assembly engages and disengages properly. Adjust cable as required.

*For  
Reference  
Only*

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## SECTION 7 POWER TRAIN

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### DESCRIPTION

The engine is a Cummins QSL or QSC diesel engine (Figure 7-1). This Service Manual does not include detailed information on the engine itself. A separate manual as prepared in detail by the engine manufacturer, is supplied with this Service Manual. However, a short description and maintenance of certain components of the fuel system, air intake system, and water cooling system is provided in this section.

The engine is electronically controlled by the Electronic Control Module (ECM), it is the control center of the system. It processes all of the inputs and sends commands to the fuel systems as well as vehicle and engine control devices.

Engine speed is controlled by the foot throttle pedal in the cab. It controls engine RPM which increases or decreases proportionately with the amount of foot pressure applied to the pedal. Engine speed is also controlled by an engine idle momentary rocker switch located on the steering column. The foot throttle pedal and engine idle switch are electrically connected to the superstructure control module which sends the signal to the engine ECM via the J1939 data link.

The engine and its components are enclosed in a hood assembly with a grill in the rear of the hood for adequate air circulation. Access to the engine is gained through a door assembly in the top of the hood that opens from both sides.

The air intake filter is mounted on the front of the left rear fender. The muffler is mounted on the left side of the frame behind the left rear fender.



### DANGER

#### Risk of Explosion!

Do not spray starting fluid into the air inlet. The spray will contact the heater elements and could explode causing personal injury.

The engine is equipped with electric air heating elements that are located in the engine's intake air stream to aid in cold starting and reduce white smoke at start-up. In the preheat mode, the engine should not be cranked until the Wait-to-Start Lamp turns off. The Wait-to-Start Lamp is illuminated during the preheat time that takes place when the ignition switch is in the ON position during cold weather starting. The ECM checks intake manifold temperature to determine how long to energize the air heater before extinguishing the Wait-to-Start Lamp. Once the engine is started, the electric air heating element will be energized again for a time period determined by intake air temperature.

## MAINTENANCE

### Engine Removal

1. Set the outriggers and position the boom to over the side.
2. Open the hood top door assembly.
3. Disconnect the air filter tubing at the engine and air cleaner (Figure 7-3). Remove and lay aside. Cap all tube and hose ends to prevent dirt and other foreign matter from entering.
4. Disconnect the exhaust tubing at the engine and muffler. Remove and lay aside.
5. Tag and disconnect the hourmeter wiring, the engine electrical harness connector from the carrier harness connector, the starter and grid heater relay harness from the carrier harness and the battery cables from the batteries and the engine.
6. Tag and disconnect the left and right rear backup lights, stop lights and the backup alarm from the carrier harness. Take off the clamps holding the harness to the engine hood.
7. Remove the capscrews and washers securing the remote secondary fuel filter and mounting bracket to the engine hood. Tie strap the filter and bracket to the engine so it is out of the way for removal of the engine.
8. Remove the engine hood assembly and pump cover from the machine.
9. Drain the engine coolant system into a suitable container.
10. Drain the engine lubrication system into a suitable container.
11. Drain the transmission/torque converter oil system into a suitable container.
12. Tag and disconnect the oil lines from the torque converter. Cap or plug all openings.
13. Remove the driveline between the torque converter and the transmission. Refer to *Drive Lines*, page 7-25 in this section.
14. Tag and disconnect all lines from hydraulic pump No. 4 on the right side of the engine. Place a suitable container under the hydraulic pumps to catch any oil that is spilled. Cap or plug all openings. Position the hydraulic lines so the disconnected end is higher than the hydraulic tank. Refer to *Hydraulic Pumps*, page 2-16.
15. Remove the capscrews and flatwashers securing the three hydraulic pumps to the torque converter. Remove the pumps from the torque converter and position them so they do not interfere with removing the engine.
16. Unhook the hydraulic pump disconnect. Remove the pin and clip and lever securing the disconnect cable to the torque converter. Next remove the capscrew and flatwasher securing the pump disconnect mounting bracket to the torque converter and lay aside.
17. Tag and disconnect all lines from the radiator. Cap or plug all openings. Disconnect the coolant level sensor harness from the engine harness and tie up excess harness so it is out of the way.
18. Remove the fan guard and fan ring. Refer to *Radiator Removal and Installation*, page 7-22.
19. Tag and disconnect all fuel lines at the engine. Place a suitable container under the fuel line connection to catch any spills. Cap or plug all openings. Position the fuel lines so the disconnected end is higher than the fuel tank.
20. Tag and disconnect all lines and tubing from the engine. Cap or plug all openings.
21. If equipped with optional engine block heater, tape and stow the electrical plug to the engine so it is out of the way for engine removal.
22. Remove the capscrews, flatwashers and lockwashers securing the remote engine oil filter bracket to the side of the frame. Tie strap the oil filter and mounting bracket to the side of the engine so it is out of the way for removal of the engine.
23. Remove the capscrews attaching the remote water conditioner to the left side frame rail. Tie strap the filter and mounting bracket to the engine so it is out of the way for removal of the engine.



### WARNING

#### Crushing Hazard!

The lifting device must be able to support the combined weight of the engine and torque converter. Serious injury or death may occur.

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**NOTE:** The engine and torque converter assembly weighs approximately 2579 lb (1170 kg).



24. Attach a lifting device to the engine and torque converter, capable of supporting the combined weight of the engine and torque converter,.
25. With the lifting device supporting the weight of the engine, remove the capscrews, nuts and washers securing the front of the engine to the frame. Remove the capscrews, nuts, washers, shock mounts, and dockwashers (one set on each side) securing the rear of the engine to the frame.
26. Using the lifting device, lift the engine and torque converter as an assembly from the crane.
27. Remove the torque converter from the engine. Refer to *Torque Converter*, page 7-26.
28. If a new engine is to be installed, remove all components, fittings, etc., from the old engine and install them on the new engine in the same location.
8. Connect the hydraulic lines to hydraulic pump No.4 as marked at removal. Remove all caps or plugs placed on openings during removal so no blockage can occur in the hydraulic system. Refer to *Hydraulic Pumps*, page 2-16.
9. Rehook the hydraulic pump disconnect. Install the lever and clip and secure the disconnect cable to the torque converter. Install the capscrew and flatwasher securing the pump disconnect mounting bracket to the torque converter. Adjust the pump disconnect cable as needed for proper operation.
10. Connect the fuel lines to the engine as tagged during removal. Remove all caps or plugs placed on openings during removal so no blockage can occur in the fuel system.
11. Connect all lines and tubing to the engine, torque converter, and all other components in accordance with the identification marks made during removal. Remove all caps or plugs placed on openings during removal so no blockage can occur.

## Engine Installation

**NOTE:** Use the same grade hardware, torque values, and Loctite used by the factory.



### WARNING

#### Crushing Hazard!

The lifting device must be able to support the combined weight of the engine and torque converter. Serious injury or death may occur.

**NOTE:** The engine and torque converter assembly weighs approximately 2579 lb (1170 kg).

1. Install the torque converter on the engine. Refer to *Torque Converter*, page 7-26.
2. With all components and fittings installed on the engine, lift the engine and torque converter into the crane.
3. With the engine in position, secure the rear of the engine with the capscrews, nuts, washers, shock mounts, and dockwashers (one set on each side).  
At the front of the engine secure the engine mount to the frame with the capscrews, nuts and washers.
4. Remove the lifting device.
5. Secure the remote engine oil filter and mounting bracket to the side of the engine frame with the capscrews, flatwashers and lockwashers.
6. Secure the remote water conditioner filter and mounting bracket to the side of the frame with the capscrews.
7. Install the three hydraulic pumps on the torque converter. Refer to *Hydraulic Pumps*, page 2-16.
12. Install the hydraulic hoses as tagged on removal.
13. Install the radiator. Refer to *Radiator Removal and Installation*, page 7-22. Connect all hoses and electrical harnesses to the radiator as tagged during removal. Remove all caps or plugs placed on openings during removal so no blockage can occur in the radiator system.
14. Connect the drive shaft between the torque converter and the transmission. Refer to *Drive Lines*, page 7-25.
15. Install the hood assembly. Install the pump cover.
16. Secure the remote secondary fuel filter to the engine hood with capscrews, washers, and lockwashers.
17. Connect the left and right rear backup lights, stop lights and left side backup alarm at the rear of the engine hood. Use clamps removed during disassembly to route harness along engine hood.
18. Connect the start and grid heater relay panel to the carrier harness.
19. Connect all electrical connections as tagged during removal.
20. Reconnect battery cables as tagged during removal.
21. If equipped with engine block heater, reroute the cord for the heater.
22. Connect the muffler exhaust piping to the engine.

### CAUTION

Do not apply sealant to hydraulic hoses.

23. Connect the air filter tubing at the engine and the air filter. Insure the inside of all tubing and connectors is clean.

### CAUTION

#### Equipment Damage Hazard!

The cleanliness of the Air Intake and Charge-Air-Cooling system is critical to engine durability since any contamination will be ingested directly into the engine cylinders and passed through the turbocharger machinery and may result in serious engine damage.

24. Service the transmission, engine lubrication system, and engine cooling system.
25. Start the engine. Check all hoses and fittings for leaks. Recheck all fluid levels. Refer to *Lubrication*, page 9-1.

### Engine Drive Belts

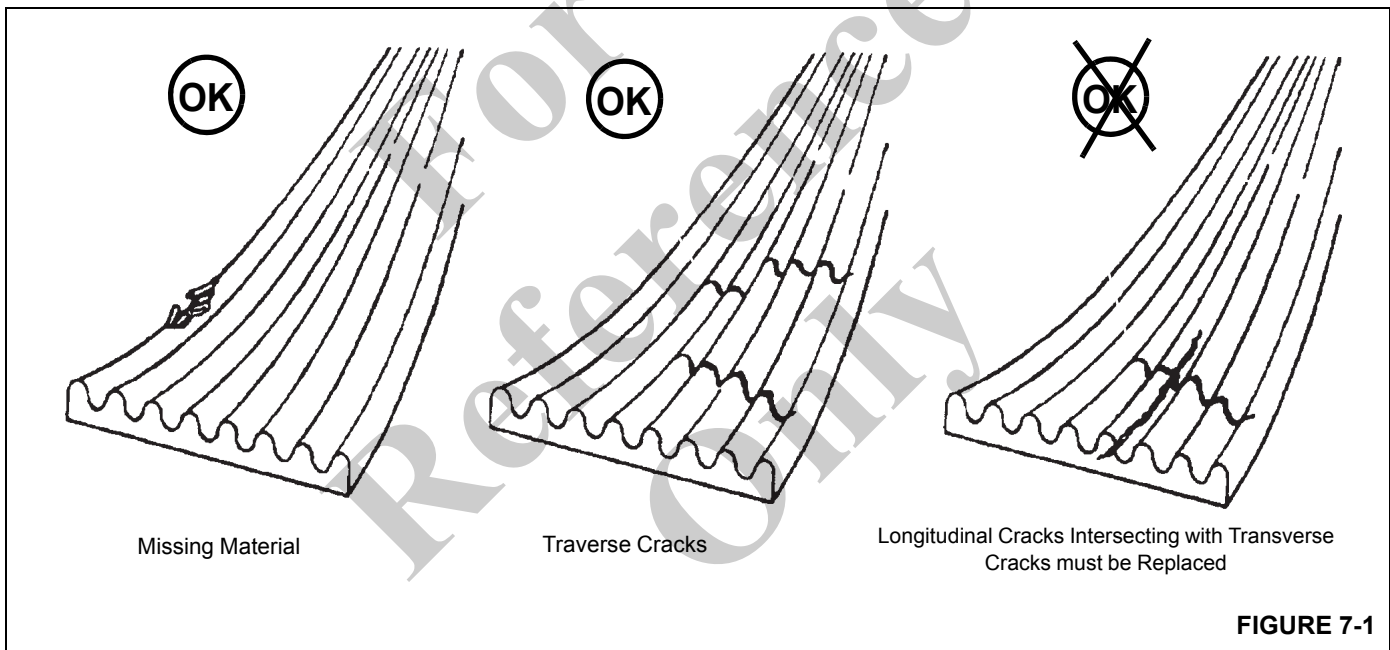
The proper operation of engine belt-driven components such as the alternator, fan, and water pump depend on the proper condition and tension of the engine drive belt.

**NOTE:** Belt tension is maintained with an automatic belt tension device.

The engine drive belt (Figure 7-1) should be inspected visually on a daily basis. The drive belt should be inspected for cracks, frayed areas, and glazed or shiny surfaces. A drive belt that is glazed or shiny indicates belt slippage.

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

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



## ELECTRONIC CONTROL SYSTEM

The engine control system is an electronically operated fuel control system that also provides many operator and vehicle features as well as reducing exhaust emissions while optimizing engine performance.

The ECM performs diagnostic tests on most of its circuits and will activate a fault code if a problem is detected in one of these circuits. Along with the fault code identifying the problem, a snapshot of engine operating parameters at the time of fault activation is also stored in memory. Some fault codes will cause a diagnostic lamp to activate to signal the driver. The fault codes can be read using the LCD display in the steering column or with the correct service tools. The ECM communicates with service tools through a SAE J1939 datalink.

### Engine Control System Switches and Indicator Lamps

Refer to the Operator's Manual for complete information on the following switches and indicator lamps.

#### *Engine Diagnostic Test Mode Switch*

The Diagnostic Test Mode Switch is used when servicing the engine's electronic control system. It is a two position on/off rocker switch used to activate the testing mode (fault codes). When the test mode switch is on, and used in conjunction with the Diagnostic/Idle Switch, access will be gained to toggle up and down through the fault codes displayed on the steering column LCD display.

#### *Diagnostic/Idle Switch*

The Diagnostic/Idle Switch is a two position (+/-) momentary rocker switch that provides idle-control inputs that increases the engine idle (when the test mode switch is in the OFF position) or diagnostic mode fault codes—when the test mode switch is in the ON position.

#### *Manual DPF Regen Switch*

The Engine DPF (Diesel Particulate Filter) Switch is located on the right side of the overhead control panel. This switch is a three position switch; Disable Regen/Off/Start Regen. Press this switch to Start Manual Engine Regeneration or to Disable Regeneration.

#### *Emergency Stop Switch*

The crane Emergency Stop Switch is located on the right hand console and is used to shut down the engine. Push the red button in to shut down the engine, rotate the knob and pull out to resume normally operation.

#### *Engine Warning Indicator*

The Engine Warning indicator is located in the steering column gauge display. It illuminates amber when energized by a signal from the engine ECM.

If this indicator light illuminates, see Engine Operator's Manual.

#### *Disable Regeneration Indicator*

The Disable Regeneration indicator is located in the steering column gauge display. When the manual regen switch is in the regeneration disabled position this indicator is illuminated.

#### *High Exhaust System Temperature Indicator*

The High Exhaust System Temperature indicator is located in the steering column gauge display.

During regeneration it is possible for the engine exhaust to reach temperatures exceeding 1200° F (649° C). The DPF indicator will illuminate to warn the operator of these high temperatures.

#### *Engine Wait To Start Indicator*

The Engine Wait To Start indicator is located in the steering column gauge display. It illuminates amber for a period of time when the ignition switch is in the ON position. The engine should not be cranked until the Wait-To-Start light turns off. This light is controlled by the engine ECM.

#### *Emergency Engine Stop Indicator*

The Emergency Engine Stop indicator is located in the steering column gauge display. It illuminates red when energized by a signal from the Emergency Stop Switch. In addition, a warning buzzer will also sound.

The engine will not start when this indicator is illuminated.

## FUEL SYSTEM

### Description

The fuel system consists of the Fuel Tank, Primary Fuel Filter with Water Separator and Water in Fuel Sensor, Secondary Fuel Filter, Lift Pump, Injection Fuel Pump, Fuel Injectors, and Return Fuel Cooler. All components except the Fuel Tank and are installed on the engine or supplied with the engine for remote mounting.

#### *Fuel Tank*

The Fuel Tank (Figure 7-2) is a steel cylinder-type tank located on the left side of the machine. The Fuel Tank has a draw capacity of 100 gal (379 l). A connection on the bottom of the tank provides for fuel supply to the engine. Surplus fuel from the engine is provided to the bottom of the Fuel Tank below the fuel level. The tank is equipped with a non-vented

filler cap, chain-attached to the tank, and a fuel quantity sender unit which provides a signal to a fuel level gauge on the instrument panel in the Cab.

### **Injection Fuel Pump**

The fuel oil is finely atomized as it is injected into the cylinder and ignited by the heat of the compression. It is also metered before injection, to meet the load requirements imposed upon the engine. Surplus fuel, returning from the injectors, is bypassed back to the fuel tank or to the inlet side of the pump. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

### **Fuel Filter-Water Separator**

The primary fuel filter/water separator removes impurities from the fuel and also removes water from the fuel before it reaches the engine. The Primary Fuel Filter is located on the frame beside the Fuel Tank. The Secondary Fuel Filter is mounted on the right side of the engine hood.

The fuel mixture passes through the outer wrap of the first stage of the filter paper, where large droplets of water are formed as it is stripped from the fuel. The water falls out into the void between the two paper elements and goes to a reservoir in the bottom of the housing, where it can be drained through a drain plug at the bottom of the housing.

The Water-in-Fuel Sensor is located in the Primary Fuel Filter. Once the storage space in the bottom of the filter housing fills with a certain amount of water, the sensor will signal the ECM. The Water-in-Fuel Lamp will illuminate at the operator controls, indicating that the water should be drained from the fuel filter assembly.

### **Electric Lift Pump**

The ECM controls the Electric Lift Pump located between the Fuel Tank and the Injection Pump. Whenever the Keyswitch is turned to the ON position, the lift pump will be energized for a few seconds to make sure the low pressure fuel lines are fully primed. The Electric Lift Pump shuts off after the engine is started.

## **Maintenance**

**NOTE:** The entire fuel system must be maintained air tight to prevent loss of prime.

### **Fuel Tank**

The Fuel Tank should be kept filled, especially overnight, to reduce condensation to a minimum. Refer to the applicable engine manual for the recommended schedule for draining any water or sediment from the tank.

### **Removal**

1. Position a suitable container under the Fuel Tank and drain all fuel from the tank.
2. Tag and disconnect the two lines from the bottom of the tank.
3. Disconnect the electrical lead from the Fuel Level Sender unit.
4. Support the weight of the tank, loosen and remove the nuts, washers and capscrews securing the straps to the mounting brackets. Remove the tank and steps.
5. If a new tank is to be installed, remove the two fittings, the fuel quantity sender, and steps from the tank and install them on the new tank.

### **Installation**

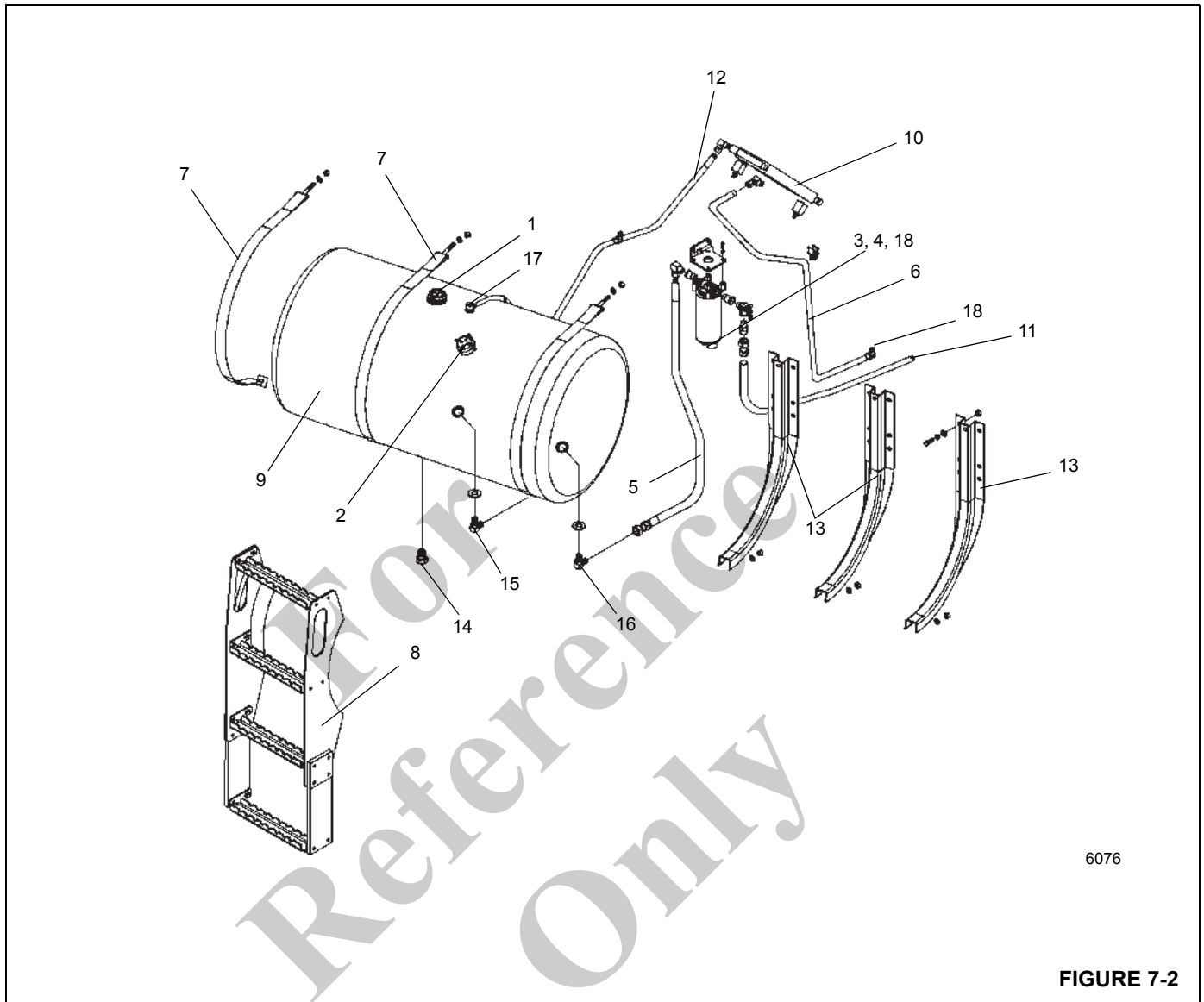
1. Position the tank on the mounting brackets and install the nuts, washers and capscrews on the three straps. Tighten the capscrews.
2. Connect the electrical lead to the Fuel Level Sender unit.
3. Connect the two lines to the fittings on the bottom of the tank in accordance with the identification marks made during removal.
4. Service the tank.

### **Fuel Filter-Water Separator**

#### **Draining**

The sump of the Fuel Filter-Water Separators should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure.

1. Open the drain plug.
2. Drain into suitable container until fuel appears.
3. Close the drain plug.

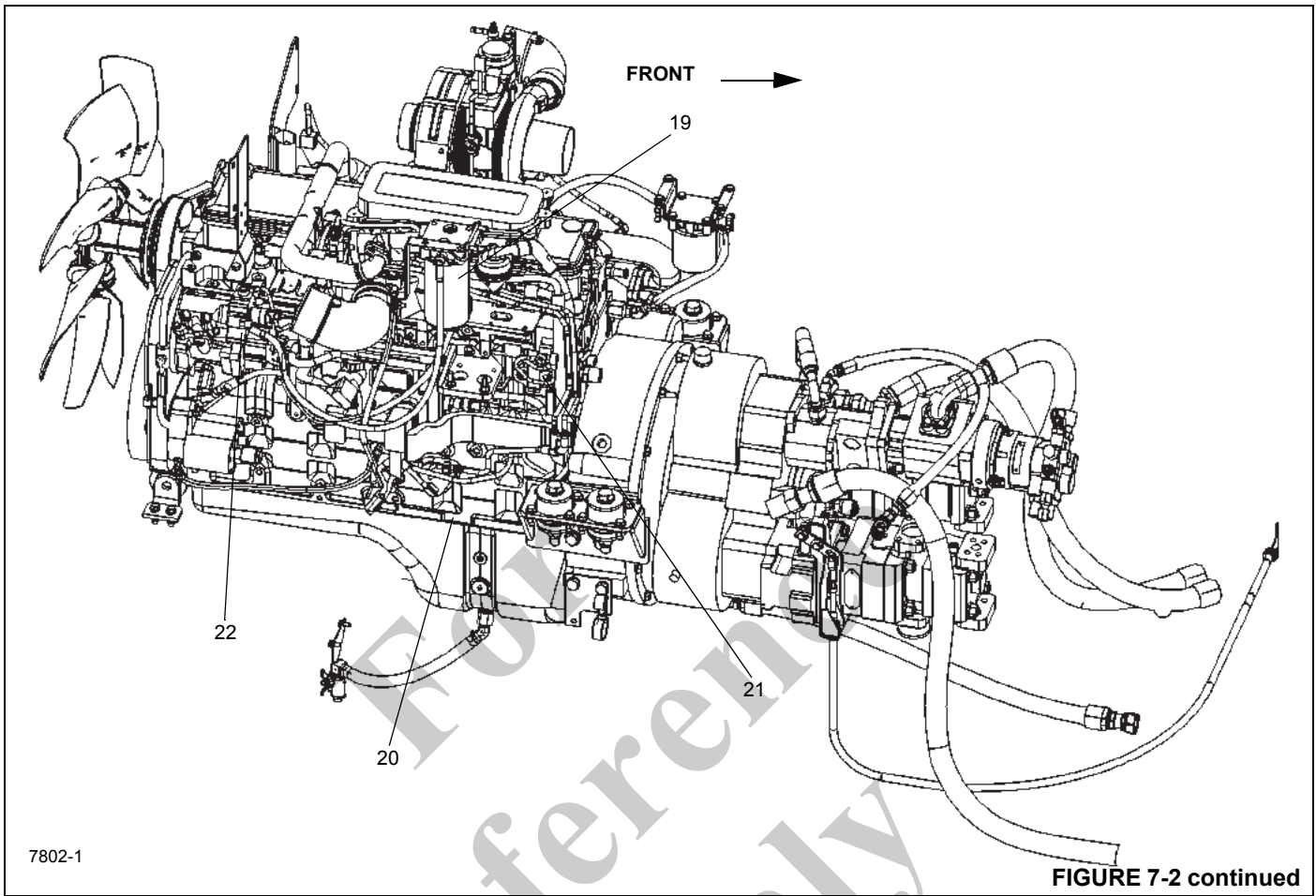


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FIGURE 7-2

Item	Description
1	Fuel Quantity Sending Unit
2	Filler Cap
3	Fuel Filter
4	Fuel-Water Separator
5	Fuel Supply
6	Fuel Return
7	Strap Assembly
8	Steps
9	Fuel Tank

Item	Description
10	Oil Cooler
11	Line To Engine
12	Line To Return Port On Tank
13	Bracket
14	Drain Port
15	Return
16	Supply
17	Vent
18	Water-in-Fuel Sensor



Item	Description
19	Fuel Filter
20	Engine

Item	Description
21	Fuel Injector Pump
22	Electric Lift Pump

## AIR INTAKE AND EXHAUST SYSTEM

### Description

There are two air filters available for this machine, depending on which engine is installed, the tier 3 (Figure 7-3) for export cranes and the tier 4 (Figure 7-4) for cranes in North America and some European countries. The air intake system controls the quality and amount of air available for combustion. System components are the Air Cleaner, Turbocharger, Charge Air Cooler, Cylinder Head, and Exhaust Manifold. Inlet air is pulled through the Air Cleaner, compressed and heated in the compressor side of the Turbocharger. The air is pushed through the Charge Air Cooler to the Air Inlet Manifold. Cooling the inlet air increases combustion efficiency, lowers fuel consumption, and increases the horsepower. The air is forced into the cylinder head to fill the inlet ports. Air flow from the inlet port into the cylinder is controlled by the intake valves.

Each cylinder has two intake valves and two exhaust valves. When the intake valves open, cooled compressed air from the inlet port is pulled into the cylinder. The intake valves close and the piston begins to move up on the compression stroke. Fuel is injected into the cylinder and combustion starts. The piston is forced down and is on the exhaust stroke when it moves up again. The exhaust valves open and exhaust is expelled through the exhaust port into the exhaust manifold.

The exhaust gas from the exhaust manifold enters the turbine side of the turbocharger and causes the turbine to turn driving the compressor. Exhaust from the turbocharger passes through the exhaust pipe and muffler/diesel particulate filter into the atmosphere.

The Air Cleaner is the dry-type with a replaceable element and is located on the left rear fender. A service indicator, designed to indicate red when servicing is required, is installed in the left center deck and is connected to the Air Cleaner by plastic air line.

On the Cummins QSC and QSL Engines there are electric air heating elements that are located in the engine's intake air stream. These elements heat the intake air when starting the engine in cold ambient conditions. Startability and white smoke control are enhanced by the use of the intake air heater. A Wait-to-Start Lamp is located on the center front console to indicate when to crank the engine.

### Maintenance

#### Air Cleaner Checks

Dust passing the Air Cleaner can cause rapid engine wear. All connections between the Air Cleaner and the engine must be tight and sealed. If these connections are well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

**NOTE:** Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Ensure the element gasket washer is not damaged and the washer's rubber face seals against the element.
3. Inspect the element gasket for damage.
4. Check for structural failures and replace damaged parts.
5. Inspect the restriction indicator tap for leaks.

#### Check for Filter Restriction

As a dry cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (at the air cleaner outlet) increases.

The vacuum is generally measured as restriction in inches of water or kilopascals. The engine manufacturer places a recommended limit on the amount of restriction the engine will stand without loss in performance before the element must be cleaned or replaced. Cummins allows a vacuum of 25 inches of water (6.2 kPa) maximum with a dirty air cleaner at maximum governed RPM.

A service indicator on the air cleaner housing will indicate when the filter needs to be replaced. Reset the indicator each time the air cleaner is serviced. If the indicator's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring vacuum.

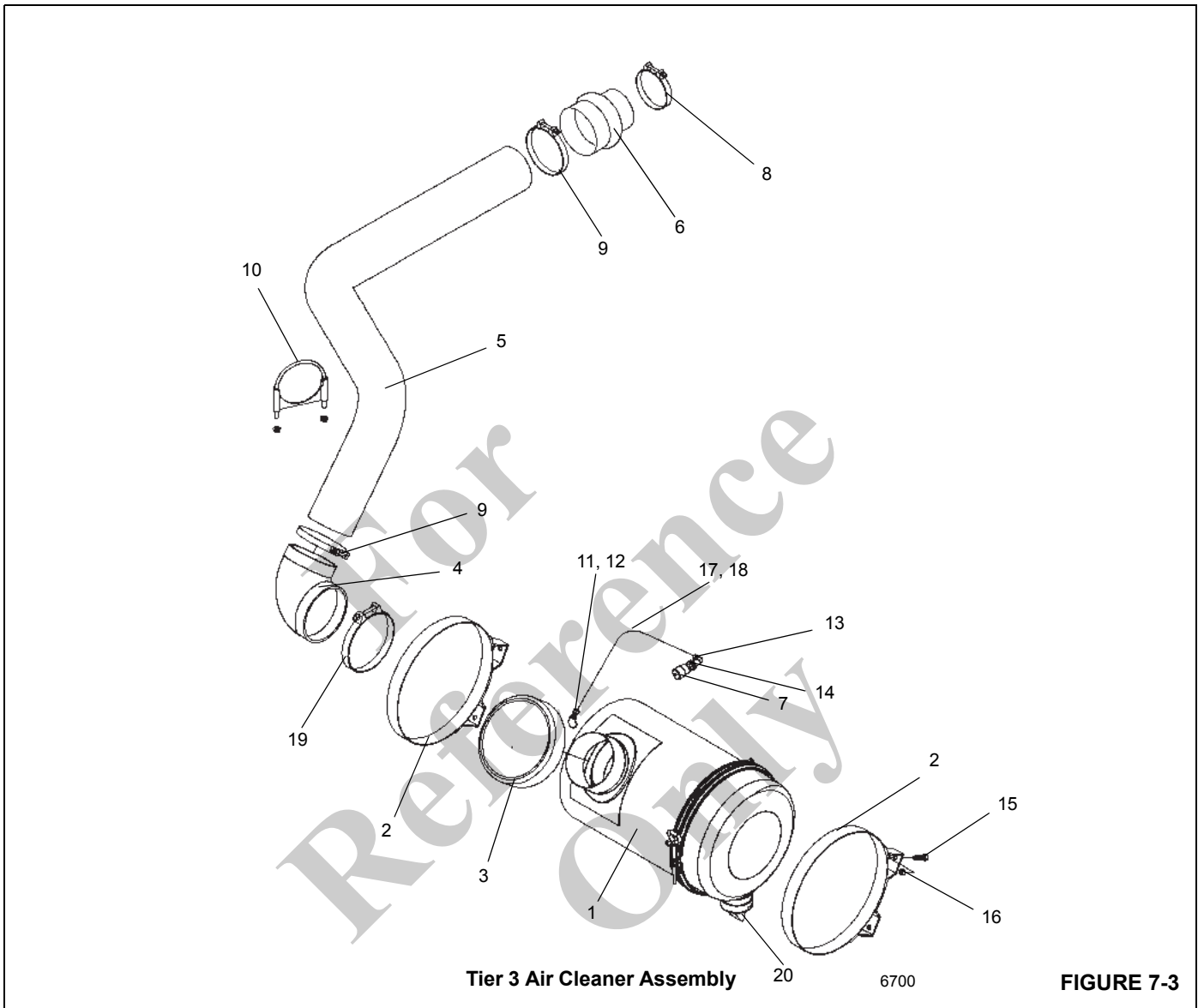
To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters, is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up. If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Ensure the air cleaner inlet is not plugged.
2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.
3. Ensure the correct size connections are used between the air cleaner and the engine.

4. Ensure all inlet accessories are the correct size and are not plugged by any foreign object.



**FIGURE 7-3**

Item	Description
1	Air Cleaner
2	Mounting Bands
3	Air Inlet Hood
4	Elbow
5	Intake Tube
6	Reducer
7	Restriction Indicator
8	T-Bolt Clamp

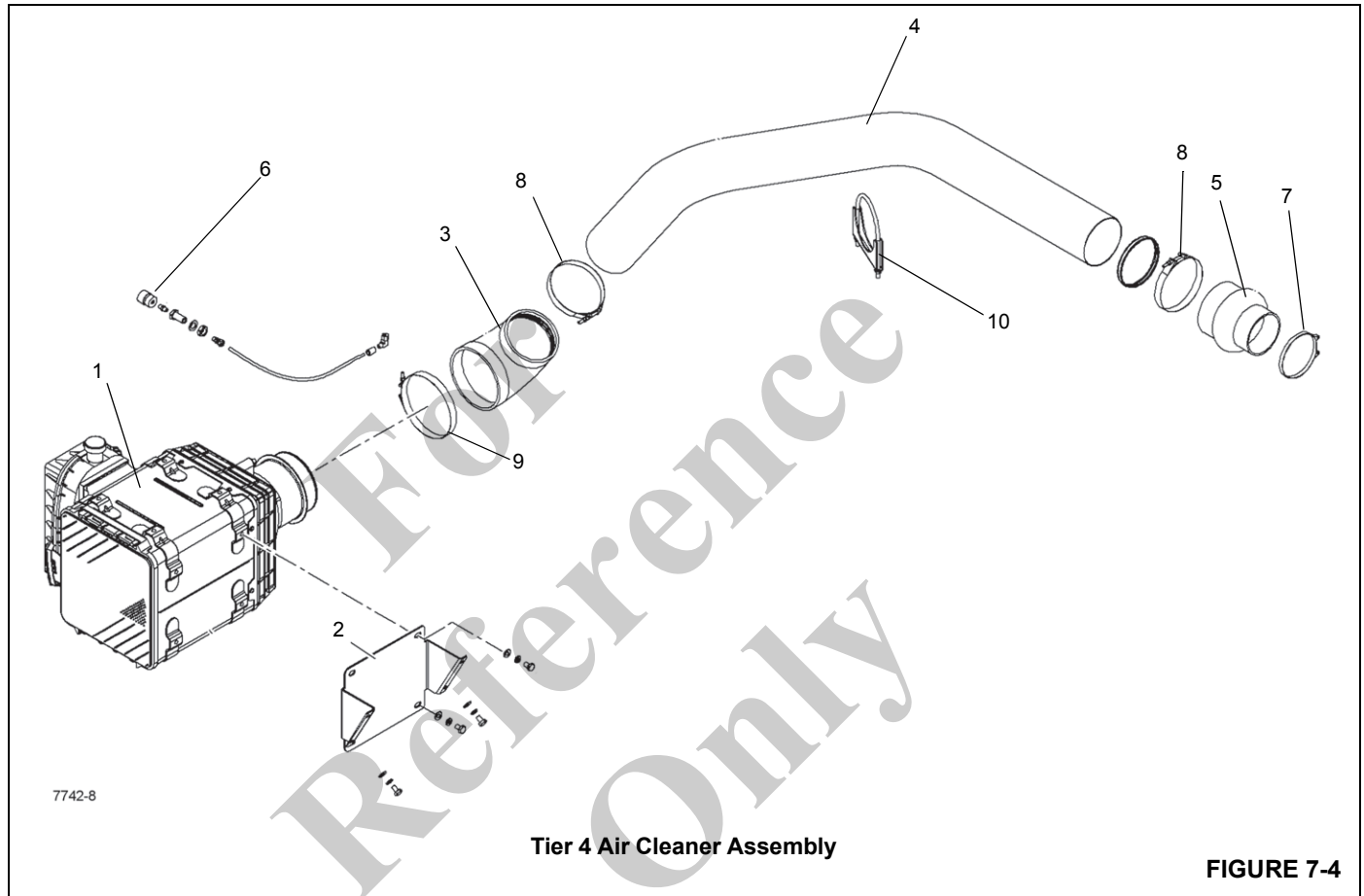
Item	Description
9	T-Bolt Clamp
10	Muffler Clamp

Item	Description
11	Elbow
12	Connector
13	Elbow
14	Bulkhead Coupling
15	Flange Screw
16	Locknut



Item	Description
17	Tubing
18	Flex Guard
19	Clamp
20	Vacuator Valve



Item	Description
1	Air Cleaner
2	Mounting Bracket
3	Elbow
4	Intake Tube
5	Reducer

Item	Description
6	Restriction Indicator
7	T-Bolt Clamp
8	T-Bolt Clamp
9	T-Bolt Clamp
10	Muffler Clamp

**Tier 3 Filter Element Replacement****CAUTION**

Never service the air cleaner while the engine is running.

1. Unlatch the latches, open the air cleaner body and withdraw the element as follows (Figure 7-5):
  - a. **RELEASE THE SEAL GENTLY.** The filter element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the filter endcap. The filter should be removed gently to reduce the amount of dust dislodged. There will be some initial resistance, similar to breaking the seal on a jar.

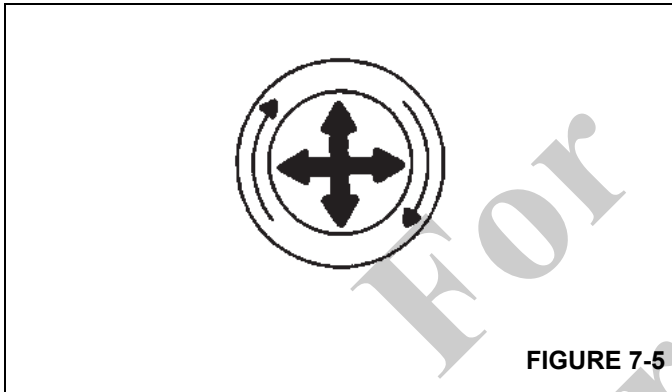


FIGURE 7-5

- b. **AVOID DISLODGING DUST FROM THE FILTER.** Gently pull the filter off the outlet tube and out of the housing. Avoid knocking the filter against the housing (Figure 7-6).

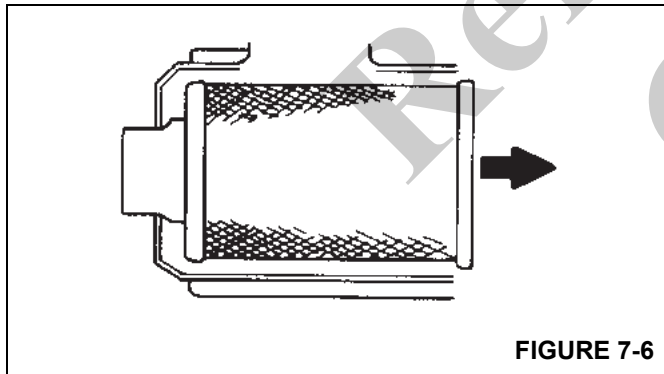


FIGURE 7-6

2. Clean the element as outlined in ELEMENT CLEANING. Replace the element after six cleanings or annually, whichever comes first.

3. Inspect all parts of the intake system and air cleaner. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube.
4. Install the cleaned or new element into the air cleaner body as follows:
  - a. **INSPECT THE FILTER FOR DAMAGE.** Always look for filter damage, even if a new filter element is being installed. Pay special attention to the inside of the open end (sealing area). Do not install a damaged filter.
  - b. **INSERT THE FILTER PROPERLY.** The seal area is on the inside of the open end of the primary filter. A new filter has a dry lubricant to aid installation. The critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly. To complete a tight seal, apply pressure at the outer rim of the filter, not the flexible center. No cover pressure is required to hold the seal (Figure 7-7).

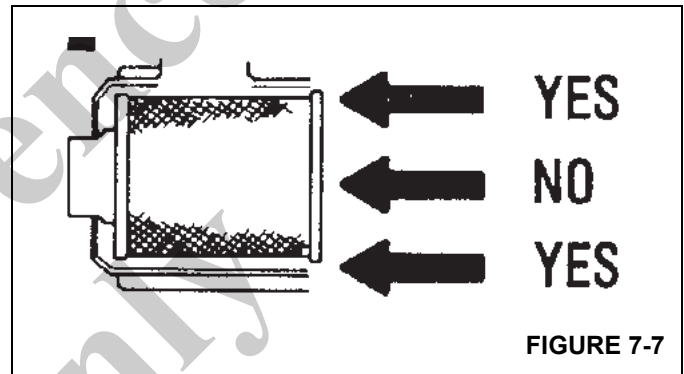


FIGURE 7-7

5. Install the cover on the air cleaner body with the two arrows pointing up. Secure the cover with the latches.
6. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.

**Air Cleaner Body**

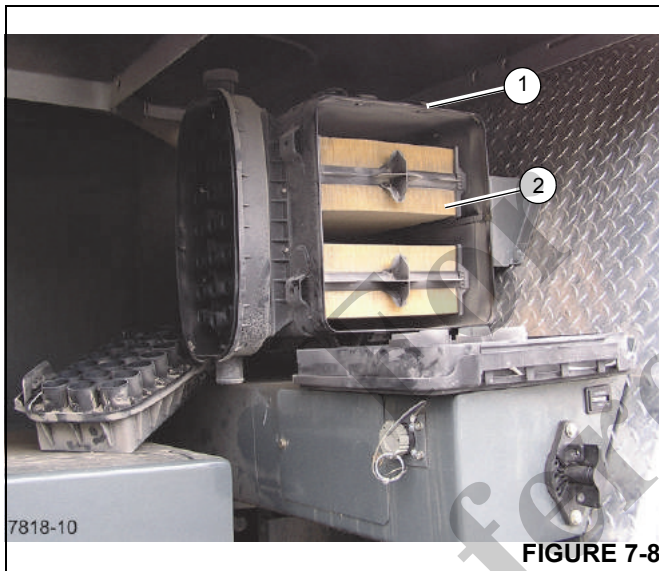
Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for dents or other damage that would interfere with air flow or with the fins on the element or inside the body. Repair any body dents, being careful not to damage the sealing surfaces. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

**Tier 4 Filter Element Replacement****CAUTION**

Never service the air cleaner while the engine is running.

Remove decking access plate behind steps. Unlatch the latches, open the air cleaner body and withdraw the element as follows:

1. Lift the clips (1) (Figure 7-8) securing the cover to the air cleaner body and remove the cover.

**FIGURE 7-8**

2. Remove Primary Filter (2) from the Air Cleaner and inspect for foreign material and marks of dust. Replace as necessary.
3. Remove Secondary Filter from behind the Primary Filter (not shown) from the Air Cleaner. Replace the Secondary Filter every third time the primary filter is change.
4. Thoroughly clean the sealing surface and inside of the air filter housing. Inspect all parts of the intake system and air cleaner.
5. Place the cover back on the air cleaner housing and secure with clips (1).
6. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.
7. Replace decking access plate.

**Element Cleaning**

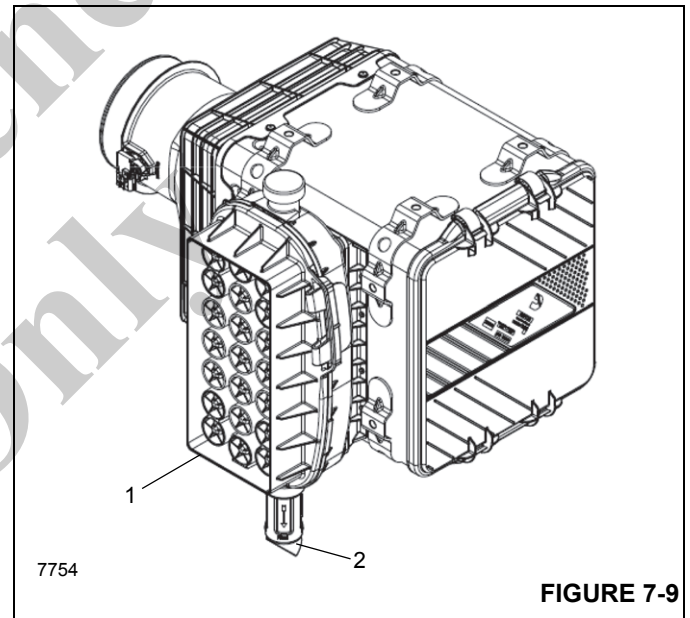
It is not recommended that filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.

**Air Cleaner Body**

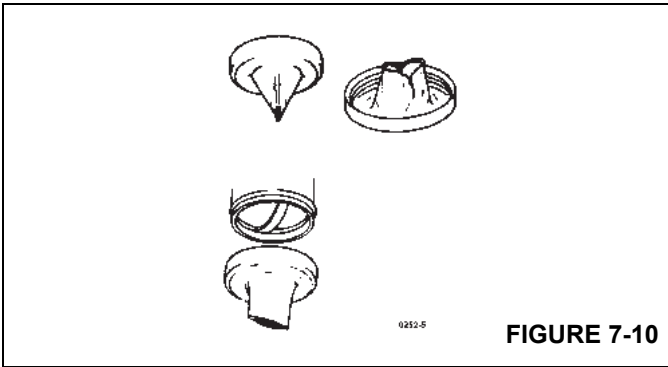
Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for damage that would interfere with air flow or with the fins on the element or inside the body. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

**Precleaner**

The Precleaner (1) (Figure 7-9) prevents large debris from entering the Air Cleaner and should be cleaned periodically, especially when working in severe dust conditions. Remove the top half of the precleaner by releasing the two latches on the sides of the precleaner. Remove all debris from inside precleaner and reassemble.

**FIGURE 7-9****Vacuator Valve**

Vacuator valves (20, Figure 7-3, 2, Figure 7-9 and Figure 7-10) are designed to expel loose dust and dirt from the air cleaner body automatically, thus lengthening the element service life. The valve lips must point straight down and be kept free from debris to operate effectively. Mud and chaff can lodge in these lips periodically and hold them open during engine operation.



Check the condition of the valve and lips frequently and keep them clean. The valve lips should be open only when the engine is shut down, or running at low idle speed. If the valve is turned outside in, check for a clogged air cleaner inlet.

Malfunction of this valve does not reduce the air cleaner effectiveness, but does allow the element to get dirty faster and reduces serviceable life. If a valve is lost or damaged, replace it with a new valve of the same part number.

#### **Duct Work**

1. Check the intake pipe for accumulation of leaves, trash, and other debris that could restrict air flow.
2. Check all mounting hardware for security to eliminate possible vibration of intake piping. Such vibration leads to early failure of hoses, clamps, and mounting parts, and can cause hoses to slip off the connecting pipes, allowing un-filtered air into the engine air intake.
3. Check hoses for cracks, chafing, or deterioration, and replace at the first sign of probable failure.

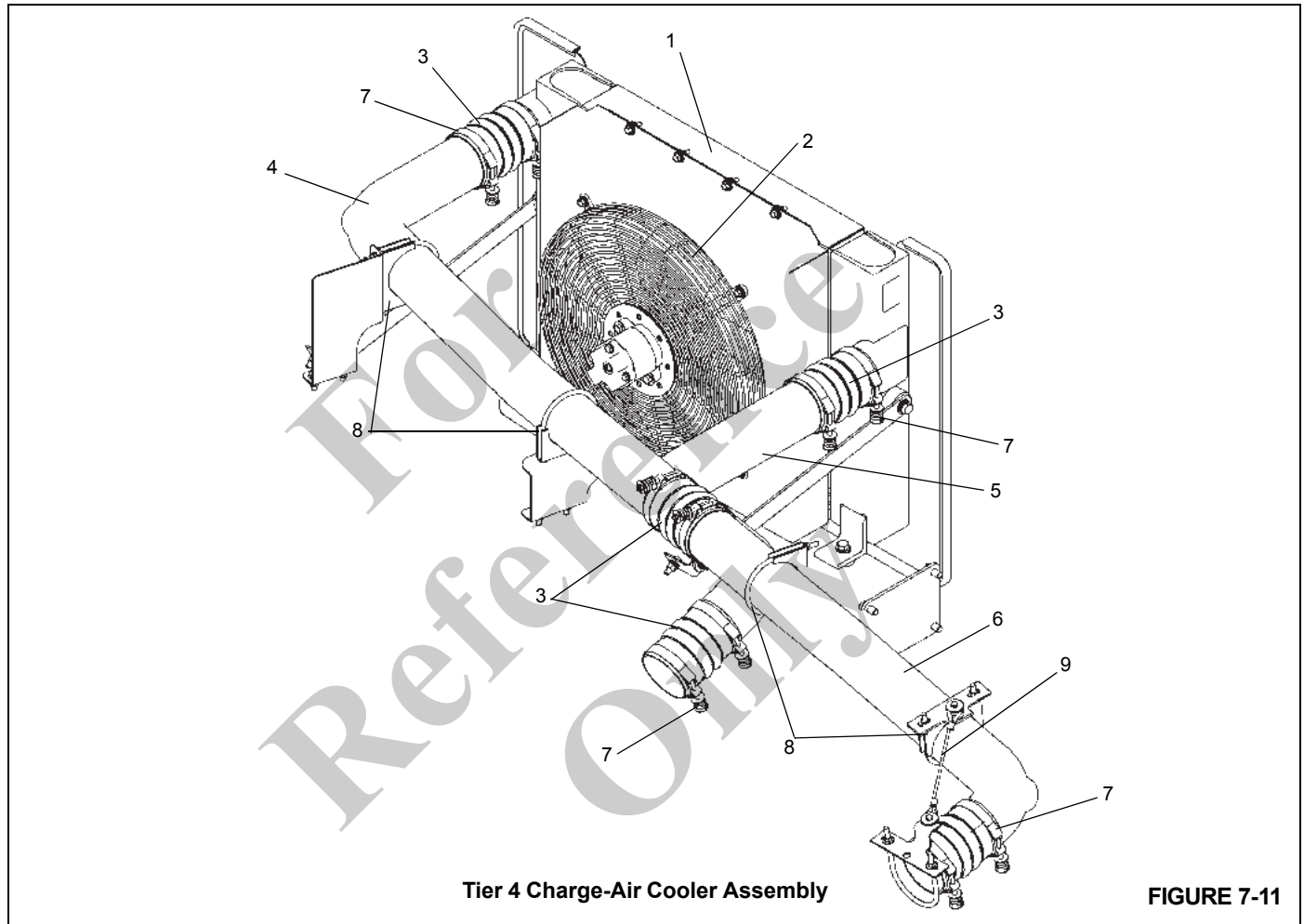
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### Charge-Air Cooler System

The charge-air cooler (CAC) (Figure 7-11) is used to cool engine air after it has passed through a turbocharger, but before it enters the engine. The charge-air cooler provides better horsepower, increased fuel efficiency, and reduces engine emissions.

The CAC system consists of the ducting to and from the charge-air cooler and a hydraulically driven fan. The charge-air cooler system must be air-tight in order to work efficiently.

The ducting consists of metal tubing, hose clamps and bellows. The recommended installation torque of the spring loaded T-bolt clamps is 100 lb-in (11.3 Nm). Do not compress the spring completely, the bellows and/or clamp may be damaged from thermal expansion of the CAC tube.



Tier 4 Charge-Air Cooler Assembly

FIGURE 7-11

Item	Description
1	Charge-air Cooler Assembly
2	Fan Assembly
3	Bellows
4	Tube
5	Tube
6	Tube
7	T-Bolt Clamp
8	Muffer Clamp
9	Strain Relief Cable

#### Maintenance

Check the hose clamps for proper torque.

Inspect the bellows for cracks or holes.

Clean the charge-air cooler, removing any dirt or debris.

Verify the fan is operating correctly and there are no hydraulic leaks.

## MUFFLER

**NOTE:** Tier 3 muffler and Tier 4 muffler are similar in removal and installation (Figure 7-13) despite the differences in the two mufflers, the exhaust tailpipes, and the mounting bracket weldments.

The Tier 4 muffler (diesel particulate filter) is different in that it has sensors and electrical connections.

### Removal



#### CAUTION

##### Burn Hazard!

Do not touch muffler or exhaust parts until they are at ambient temperature. Severe burning may result.

- 
1. Remove the sheet metal guard to gain access to the muffler.
  2. Remove clamp to free exhaust tailpipe from muffler.

3. Remove clamp to free muffler from exhaust tube.
4. Disconnect and tag electrical connections.
5. Remove mounting bands to free muffler from muffler mounting bracket.
6. Inspect muffler, exhaust tailpipe, exhaust tubes, bracket, and attaching hardware. Repair or replace any of these parts if damaged or missing.

### Installation

1. Secure the muffler to the exhaust tube with a clamp.
2. Install the exhaust tailpipe on the muffler. Secure the exhaust tailpipe to the muffler with clamp. Adjust the clamp as needed.
3. If removed, secure the muffler mounting brackets to the mountings with capscrews and nuts as needed. Secure the muffler to the muffler mounting bracket with mounting bands.

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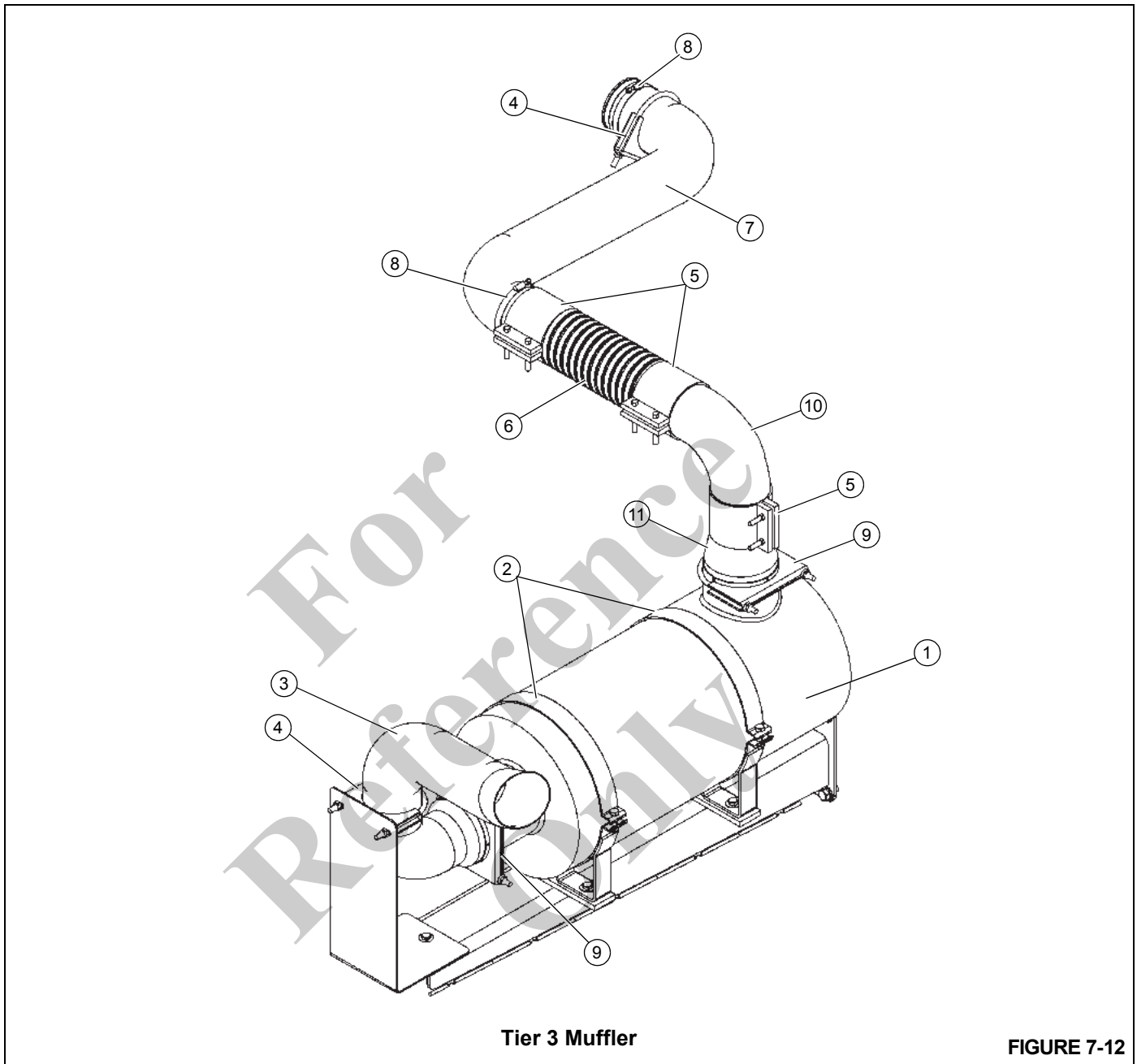
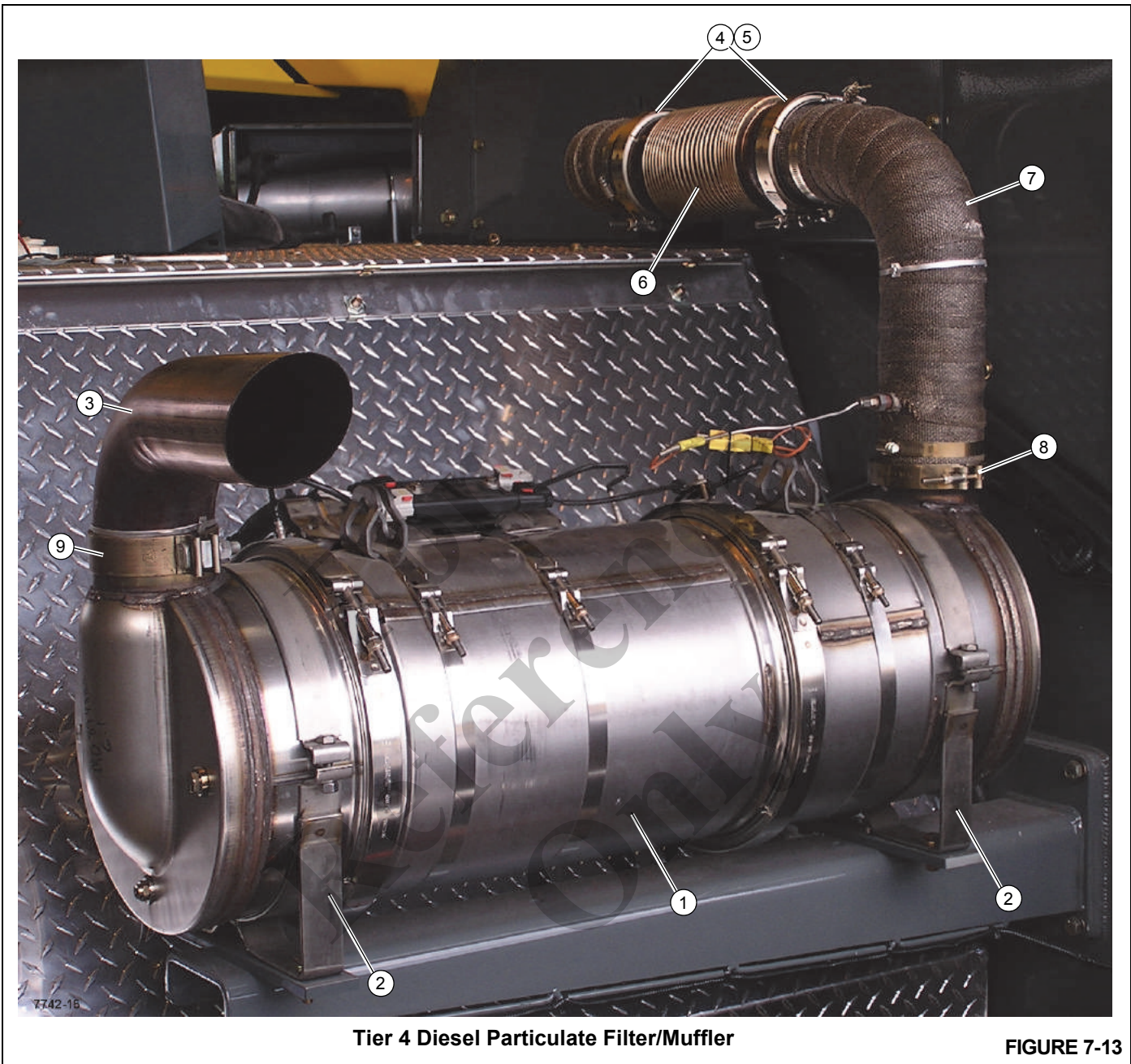


FIGURE 7-12

Item	Description
1	Muffler
2	Bracket w/mounting bands
3	Tail Pipe
4	Clamp
5	Seal Clamp
6	Bellows

Item	Description
7	Tube w/Exhaust Wrap
8	Clamp
9	Clamp
10	Tube
11	Adapter



Tier 4 Diesel Particulate Filter/Muffler

FIGURE 7-13

Item	Description
1	Muffler—Diesel Particulate Filter
2	Bracket w/mounting bands
3	Tail Pipe
4	Clamp

Item	Description
5	Gasket
6	Bellows

Item	Description
7	Tube w/Exhaust Wrap
8	Clamp
9	Clamp

### WATER COOLING SYSTEM

#### Description

The cooling system consists of a Radiator, Surge Tank, engine cooling circuit, the connecting hoses and connecting tubes. At all times, the antifreeze/coolant should properly



inhibit corrosion. It is recommended that a mixture of 50/50 blended ethylene-glycol, low silicate, fully formulated, extended life engine antifreeze/coolant mixture which does not require a pre-charge of supplemental coolant additives (SCA) be used for fill of heavy duty liquid cooled internal combustion engines.

## Maintenance

### General

The cooling system includes the Radiator, Surge Tank, Thermostat, the Fan, and Water Pump. Radiator hoses are also included in this group.

The cooling system is often neglected because the effects or damage that result from an improperly maintained system usually occur gradually. The cooling system needs to be maintained with the same attention as other systems.

The circulation of water through the cooling system relies entirely upon the water pump. The water pump draws water from the radiator and forces it through the water jacket and cylinder head. There it accumulates heat and flows to the radiator tank. Then the water flows across through the radiator core and is cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

### Effects of Cooling System Neglect

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the part directly responsible is not a part of the cooling system. Most of these problems can be traced to overheating; however, an engine that is running too cold can be just as troublesome.

### Overheating

An engine that is overheating may lead to troubles such as the following:

1. Burned valves.
2. Pinging or knocking.
3. Excessive fuel consumption.
4. Poor lubrication - increased engine wear.
5. Sticking valves.
6. Short injector life.
7. Engine hot spots.
8. Need for higher grade fuel.

### Overcooling

The following engine troubles result when an engine is overcooled:

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids formed in crankcase.
4. Excessive fuel deposits in the exhaust system.

### Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times. Refer to *Lubrication*, page 9-1. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

### Rust Prevention

To keep engines operating at like new efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times. Supplemental coolant additives (SCA) are recommended for this cooling system. Antifreeze/coolant alone does not provide sufficient protection for heavy-duty diesel engines. Refer to *Section 9* for SCA specification and compatible brands.

### Engine Antifreeze/Coolant Fill Procedure (when level is low)

1. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant. Open bleed valve located at upper radiator tube, coolant manifold (top and bottom, and coolant heater (if equipped) prior to filling. Fill to the bottom of the surge tank filler neck. Fill slowly. Flow exceeding 3 gpm (11.2 l/min) can give a false reading.

**NOTE:** If the engine coolant is changed, the coolant filter must also be changed.

2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 1. Ensure petcock bleed valves are closed after fluid starts flowing out and before running engine.
3. Run the engine for 5 minutes and recheck the antifreeze/coolant level. Refill as necessary repeating step 1. Refer to *Lubrication*, page 9-1.

### 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. Refer to *Lubrication*, page 9-1.

#### SCA Level Check/Coolant Filter Change 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).

The Coolant Filter contains molybdate. Therefore, it is important to use the Grove Coolant Test Kit, which checks the molybdate level, regardless of whether the SCA used to replenish the coolant system contains molybdate or not.

Only add coolant additive if levels are less than 1.2 units/gal (see *Lubricants and Lubrication Intervals*, page 9-1 for specification and recommended additives).

**NOTE:** An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Overconcentration can cause formation of a “gel” that can cause restriction or plugging of coolant passages, and overheating.

- Change coolant filter.

Install charged filter if SCA levels are normal or below normal; install non-charged filter if SCA levels are above normal (contact Manitowoc Crane Care for filter part number).

##### 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 *Lubrication*, page 9-1.

**NOTE:** Remove the radiator cap when draining the system to ensure proper draining.

### Cleaning



#### CAUTION

##### Burn Hazard!

The cooling system contains very hot pressurized liquid and injury can result when removing the radiator cap at operating temperature. Use proper protection to remove the radiator cap.

1. Coolant shut-off valves to heaters and other accessories should be open to allow complete circulation during cleaning, flushing, and draining. Run the engine with radiator covered if necessary until temperature is up to operating range 160 to 180° F (71 to 82° C). Stop the engine, remove the radiator cap, and drain the system by opening the drain cocks on the radiator and engine block.

**NOTE:** Use a cleaning compound that is not corrosive to aluminum to prevent damage to the radiator.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 180° F (82° C) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 180° F (82° C) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*) and repeat the cleaning operation.
8. If problem persists, replace radiator.

#### Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of

hose to the radiator inlet opening to carry away the flushing stream.

3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill the core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
9. After completing the flushing operation, clean out the surge tank overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
10. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

### Component Inspection

#### Radiator/Surge Tank

1. Side Tanks - Look for leaks, particularly where the tank is attached to the core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler Neck - The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Ensure the overflow tube is not plugged.
3. Radiator Cap - This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

When removing the pressure type cap, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 0.13 in (3 mm). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.



### CAUTION

#### Burn Hazard!

Loosen cap slowly and pause a moment to avoid possible burning by hot water or steam. Continue to turn the cap to the left until it can be removed.

4. Tubes are very small and can easily become clogged by rust and scale. The general condition of the cooling system and operating temperature are indications as to whether or not tubes are clean. Another good test is to feel the core for cold spots.
5. Fins are thin metal sheets that dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw etc., so as to allow the free passage of air. Bent fins should be straightened.

#### Engine Water Jacket

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged, if the cooling system does not receive the proper maintenance.

1. Core Plugs - These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.
2. Drain Plugs - The water jacket of each engine could have one or more drain plugs (see (Figure 7-1)). These should receive seasonal care and be kept free of rust and scale.
3. Gaskets - All gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

#### Water Pump

The pump should be checked carefully for leaks and proper lubrication. Replace or rebuild if leaking, cracked, or worn.

### Fans and Belts

The fan should be checked for cracked or broken blades.

Refer to *Engine Drive Belts*, page 7-4.

### Thermostat

The thermostat is of the nonadjustable type and is incorporated in the cooling system for the purpose of retarding or restricting the circulation of coolant during engine warm up. Engine overheating and loss of coolant is sometimes due to an inoperative thermostat. To check for this condition, remove the thermostat and test by submerging it in hot water and noting the temperature at which the thermostat opens and closes. Use an accurate high temperature thermometer for making this test.

### Hoses and Clamps

Hoses and their connections must be checked regularly because they are often the source of hidden trouble. Hoses may often times appear in good condition on the outside while the inside will be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. The clamps should be inspected to make sure they are strong enough to hold a tight connection.

### Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. "Floating ball" type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

### Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant at all times. Refer to *Lubrication*, page 9-1. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

### Radiator Removal and Installation

#### Removal

1. Set the outriggers and position the boom to over the side.
2. Open the drain cock at the end of drain hose and drain the coolant into a suitable container. If necessary, dispose of the coolant in accordance with local and EPA regulations.
3. Open the air bleed pet cock to ensure proper draining.

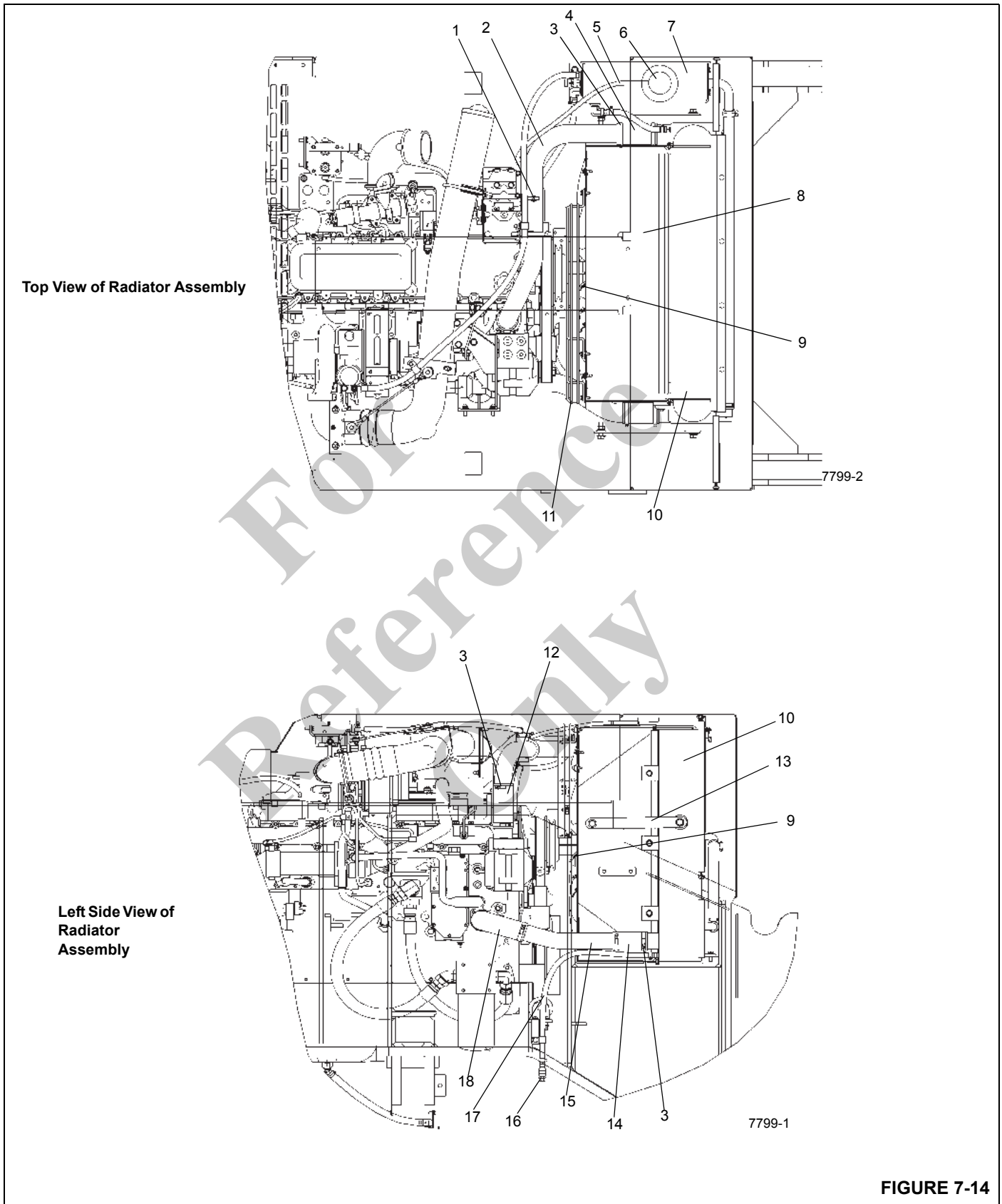
4. Open and remove the hood top door assembly.
5. Remove the hardware securing the rear engine hood panel to the engine hood. This will gain access to the rear of the radiator.
6. Remove the engine hood assembly.
7. Tag and disconnect the hoses from the surge tank to the engine and from the surge tank to the radiator. Remove surge tank assembly.
8. Remove the hose clamps and radiator hose connecting the radiator to the radiator tubes.
9. Disconnect the coolant level harness from the engine harness.
10. Remove the capscrews and flatwashers attaching the fan guard to the shroud ring. Remove the fan guard.
11. Remove the hardware securing the shroud ring to the shroud box and slide the shroud ring back onto the engine fan.
12. Remove the capscrews, flatwashers and lockwashers that connect the plates to the middle of the radiator and the frame rail.

**NOTE:** The radiator assembly weighs approximately 240 lb (109 kg).

13. Attach an adequate lifting device to the radiator assembly.
14. Remove the capscrews and washers securing the radiator flange to the frame mounting brackets. Remove the radiator assembly from the carrier.
15. If a new radiator is to be installed, remove all fittings and hoses from the old one and install them in the same locations on the new one.

#### Installation

1. Ensure all fittings and hoses are installed on the radiator.
2. Position the radiator assembly in the carrier using a lifting device. Take caution not to tear or misplace the rubber molding around the radiator assembly. Secure the radiator flange to the frame mounting brackets using capscrews and washers.
3. Reconnect the two plates between the middle of the radiator and the of the frame rail using capscrews, flatwashers, lockwashers and nuts.
4. Connect the shroud ring to the shroud box using the hardware taken off during removal.
5. Position the fan guard on the shroud ring and secure with bolts and washers.
6. Reconnect the coolant level harness to the engine harness.



7

FIGURE 7-14

Item	Description
1	Air Bleed Pet Cock
2	Upper Radiator Tube
3	Hose Clamp
4	Radiator Hose
5	Overflow Hose
6	Surge Tank Cap
7	Surge Tank
8	Fan Shroud
9	Fan
10	Radiator
11	Fan Guard
12	Radiator Hose
13	Radiator Stabilizer
14	Radiator Hose
15	Lower Radiator Tube
16	Drain Cock

Item	Description
17	Drain Hose
18	Radiator Hose, Elbow

7. Connect the two radiator tubes to the radiator with hose clamps and the radiator hose.
8. Secure the radiator tube to the top of the engine using nuts, washers and a muffler clamp.
9. Reinstall surge tank and connect the hoses between the surge tank and engine and the surge tank and the radiator.
10. Tighten the drain cock at the bottom of the radiator drain hose.
11. Install the hood assembly.
12. Install the hardware holding the rear engine hood panel to the engine hood.
13. Install the hood top door assembly.
14. Service the engine coolant system as necessary, See *Engine Antifreeze/Coolant Fill Procedure (when level is low)*, page 7-19. Refer to *Lubrication*, page 9-1. Start the engine, operate all systems and check for leaks.

For Reference Only

## DRIVE TRAIN

### Description

The drive train consists of the Torque Converter, Transmission, and four Drive Shafts.

The torque converter is mounted on and driven by the engine. The torque converter provides for mounting and driving hydraulic pumps No. 1, No. 2, and No. 3.

The transmission is a Spicer R36000 Series (R36626) powershift with six forward speeds and three reverse speeds. The transmission is controlled electrically by a shift lever/knob located on the right side of the steering column and an axle drive mode selector rocker switch located on the left side of the front console.

The torque converter and transmission oil is cooled by passing the oil through an externally mounted transmission cooler. The cooler is mounted on the right side of the machine in front of the hydraulic reservoir. An oil filter is located on the left side of the frame behind the fuel tank.

Four drive shafts are used. One drive shaft is connected between the torque converter and the transmission. The other three drive shafts are connected between the transmission and the front and rear axles.

### Maintenance

#### Drive Lines

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#### CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

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### Removal

1. Support the drive shaft being removed so it does not fall when disconnected. If removing the coupling shaft or the front slip shaft, support the other shaft also.
2. If removing the coupling shaft, free its bearing from its bracket by removing two bolts, two nuts, and four washers.
3. Remove the bolts from the bearing cap on each end of the drive shaft. Note the lengths of the bolts and if they have lockwashers. Remove the drive shaft.

### Installation

1. For any drive shaft which has mating marks (arrows), align these mating marks to ensure proper phasing of coupler yokes.
2. Position the drive shaft between the couplers on the two components it is joining.
3. For the coupling shaft, secure its bearing to its bracket with two bolts, two nuts, and four washers.
4. Secure the drive shaft to the coupler with bolts. Torque all bolts according to *Fasteners and Torque Values*, page 1-18.

### Lubrication

The drive line slip joints require lubrication. Refer to *Lubrication*, page 9-1.

## TORQUE CONVERTER

### Description

The torque converter assembly is mounted on and driven by the engine. The torque converter provides for mounting and driving hydraulic pumps No. 1, No. 2, and No. 3.

### Theory of Operation

The transmission and torque converter function together and operate through a common hydraulic system. Therefore, it is necessary to consider both units in discussing operation.

With the engine running, the converter charging pump draws oil from the transmission pump through the removable oil suction screen and directs it through the pressure regulating valve and oil filter.

The pressure regulating valve maintains pressure to the transmission control for actuating the direction and speed clutches. This requires a small portion of the total volume of oil used in this system. The remaining volume of oil is directed through the torque converter circuit to the oil cooler and returns to the transmission for positive lubrication. This regulator valve consists of a hardened valve spool operating in a closely fitted bore. The valve spool is spring loaded to hold the valve in a closed position. When a specific pressure is achieved, the valve spool works against the spring until a port is exposed along the side of the bore. This sequence of events provides the proper system pressure.

After entering the converter housing, the oil is directed through the reaction member support to the converter blade cavity and exits in the passage between the turbine shaft and reaction member support. The oil then flows out of the converter to the oil cooler. After leaving the cooler, the oil is directed to a fitting on the transmission. Through a series of tubes and passages, the transmission bearings and clutches are lubricated. The oil then drains to the transmission sump by gravity.

The torque converter consists basically of three elements and their related parts to multiply engine torque. The engine power is transmitted from the engine flywheel to the impeller element through the impeller cover. This element is the pump portion of the hydraulic torque converter and is the primary component which starts the oil flowing to the other components which results in torque multiplication. This element can be compared to a centrifugal pump, in that it picks up fluid at its center and discharges at its outer diameter.

The torque converter turbine is mounted opposite the impeller and is connected to the output shaft of the torque converter. This element receives fluid at its outer diameter and discharges at its center. Fluid directed by the impeller out into the particular design of blading in the turbine and

reaction member is the means by which the hydraulic torque converter multiplies torque.

The reaction member of the torque converter is located between and at the center of the inner diameters of the impeller and turbine elements. Its function is to take the fluid which is exhausting from the inner portion of the turbine and change its direction to allow correct entry for recirculation into the impeller element.

The torque converter will multiply engine torque to its designed maximum multiplication ratio when the output shaft is at zero rpm. Therefore, as the output shaft is decreasing in speed, the torque multiplication is increasing.

The shift control valve assembly consists of a valve body with selector valve spools. A detent ball and spring in the selector spool provides one position for each speed range. A detent ball and spring in the direction spool provides three positions, one each for forward, neutral, and reverse.

With the engine running and the directional control lever in the neutral position, oil pressure from the regulating valve is blocked at the control valve, and the transmission is in neutral. Movement of the forward and reverse spool will direct oil, under pressure, to either the forward or reverse direction clutch, as desired. When either directional clutch is selected, the opposite clutch is relieved of pressure and vents back through the direction selector spool. The same procedure is used in the speed selector.

The direction or speed clutch assembly consists of a drum with internal splines and a bore to receive a hydraulically actuated piston. The piston is oil tight by the use of sealing rings. A steel disc with external splines is inserted into the drum and rests against the piston. Next, a friction disc with splines at the inner diameter is inserted. Discs are alternated until the required total is achieved. A heavy back-up plate is then inserted and secured with a snap ring. A hub with OD splines is inserted into the splines of discs with teeth on the inner diameter. The discs and hub are free to increase in speed or rotate in the opposite direction as long as no pressure is present in that specific clutch.

To engage the clutch, the control valve is placed in the desired position. This allows oil under pressure to flow from the control valve, through a tube, to a chosen clutch shaft. This shaft has a drilled passageway for oil under pressure to enter the shaft. Oil pressure sealing rings are located on the clutch shaft. These rings direct oil under pressure to the desired clutch. Pressure of the oil forces the piston and discs against the heavy back-up plate. The discs, with teeth on the outer diameter, clamping against discs with teeth on the inner diameter, enables the hub and clutch shaft to be locked together and allows them to drive as a unit.

There are bleed balls in the clutch piston which allow quick escape for oil when the pressure to the piston is released.



**Maintenance**

**General Information**

1. Always check the oil level with the engine idling, and the transmission in neutral and at normal operating temperature—180 to 200 °F (82 to 93 °C).
2. Change the oil filter element every 500 hours. Drain and refill the system every 1000 hours or 6 months. Refer to *Lubrication*, page 9-1.

**Troubleshooting**

The following data is presented as an aid to locating the source of difficulty in a malfunctioning unit. It is necessary to consider the torque converter charging pump, transmission, oil cooler, and connecting lines as a complete system when checking for the source of trouble, since the proper operation of any unit therein depends greatly on the condition and operation of the others. By studying the principles of operation together with the data in this section, it may be possible to correct any malfunction which may occur in the system. Troubleshooting procedures basically consist of hydraulic checks.

**Hydraulic Checks**

Before checking the transmission/torque converter and associated hydraulic system for pressures and rate of oil flow, it is essential that the following preliminary checks be made.

1. Check oil level in transmission. This should be done with oil temperature at 180 to 200° F (82 to 93° C). Do not attempt these checks with cold oil.
2. To bring the oil temperature to this level, it is necessary to either work the machine or stall out the converter. When it is impractical to work the machine, stall out the converter as follows.
  - a. Apply the parking brake and service brakes.
  - b. Position the shift lever to forward and high speed.
  - c. Accelerate the engine to between half and three-quarter throttle.

**CAUTION**

**Possible Equipment Damage!**

Full throttle stall speeds for an excessive length of time will overheat the torque converter.

- d. Hold converter stalled until desired temperature is reached.

**NOTE:** Always make all troubleshooting checks with the converter outlet temperature at least 180 to 200 °F (82 to 93 °C).

**Troubleshooting Procedures**

**Table 7-1**

SYMPTOM	PROBABLE CAUSE	REMEDY
1. Low clutch pressure.	a. Low oil level.	a. Fill to proper level. Refer to <i>Lubrication</i> , page 9-1
	b. Clutch pressure regulating valve spool stuck open.	b. Clean valve spool and housing.
	c. Faulty charging pump.	c. Replace pump. Refer to your Manitowoc Crane Care Parts Manual.
	d. Broken or worn clutch shaft or piston sealing rings.	d. Replace clutch shaft or sealing rings, as applicable.
	e. Clutch piston bleed valve stuck open.	e. Clean bleed valves thoroughly.
2. Low converter charging pump pressure.	a. Low oil level.	a. Fill to proper level. Refer to <i>Lubrication</i> , page 9-1
	b. Suction screen plugged.	b. Clean suction screen.
	c. Defective oil pump.	c. Replace pump. Refer to your Manitowoc Crane Care Parts Manual.

SYMPTOM	PROBABLE CAUSE	REMEDY
3. Overheating.	a. Worn oil sealing rings.	a. Remove, disassemble, and rebuild converter assembly.
	b. Worn oil pump.	b. Replace pump. Refer to your Manitowoc Crane Care Parts Manual.
	c. Low oil level.	c. Fill to proper level. Refer to <i>Lubrication</i> , page 9-1
4. Noisy converter.	a. Worn oil pump.	a. Replace pump.
	b. Worn or damaged bearings.	b. A complete disassembly will be necessary to determine what bearing is faulty.
5. Lack of power.	a. Low engine RPM at converter stall.	a. Tune engine and check governor.
	b. See "Overheating" and make same checks.	b. Make corrections as explained in "Overheating."

### Removal

1. Extend and set the outriggers just enough to take up the slack in the outrigger pads. Chock the wheels.
2. Position the boom over the side and stop the engine.
3. Remove the front section of the engine hood.
4. Refer to *Drive Lines*, page 7-25 in this section and disconnect the drive line from the torque converter.
5. Tag and disconnect all hydraulic lines from the torque converter to the transmission and the transmission oil cooler. Cap all lines and openings.
6. Remove the two-section and single section hydraulic pumps from the transmission/torque converter. Cover all openings. Refer to *Hydraulic Pumps*, page 2-16 for removal of the pump.

**NOTE:** The torque converter weighs approximately 500 lb (225 kg) dry.

7. Attach an adequate lifting device to the torque converter and take up any slack.
8. Remove the screws and lockwashers securing the drive plate assembly to the flywheel.
9. Remove the bolts and washers securing the torque converter housing to the engine flywheel housing.

### Installation

**NOTE:** The torque converter assembly weighs approximately 500 lb (225 kg) dry.

1. If a new torque converter is to be installed, remove all fittings and brackets from the converter one and install them in the same locations on the new torque converter.
2. Position the torque converter to the engine with the lifting device.
3. Remove all burrs from the flywheel mounting face and nose pilot bore. Clean the drive plate surface with solvent.

**NOTE:** Refer to (Figure 7-15) for a typical transmission/torque converter installation.

4. Check the engine flywheel and housing for conformance to standard SAE No. 1-SAE J-927 tolerance specifications for bore size, pilot bore runout and mounting face flatness. Measure and record engine crankshaft end play.
5. Rotate the engine flywheel to align a drive plate mounting screw hole with the flywheel housing front access hole.
6. Install a 4.00 in (101.6 mm) long drive plate locating stud 7/16-20 UNF thread in a drive plate nut.
7. Rotate the torque converter to align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step 5. Locate the torque converter on the flywheel housing. Install the torque converter to the flywheel housing nuts and washers. Tighten the bolts.

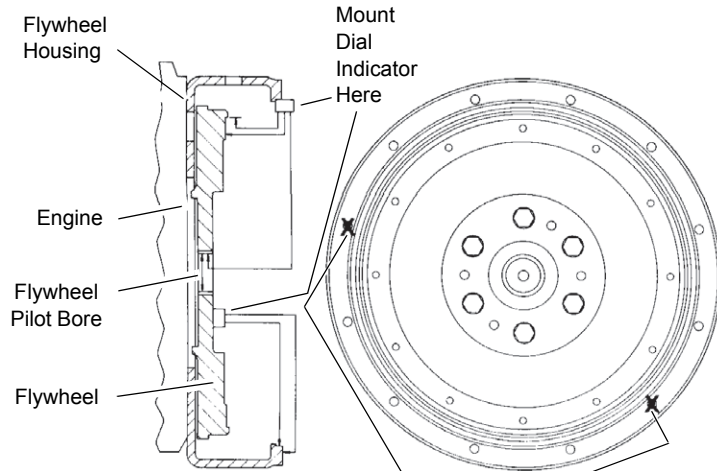


Figure 1

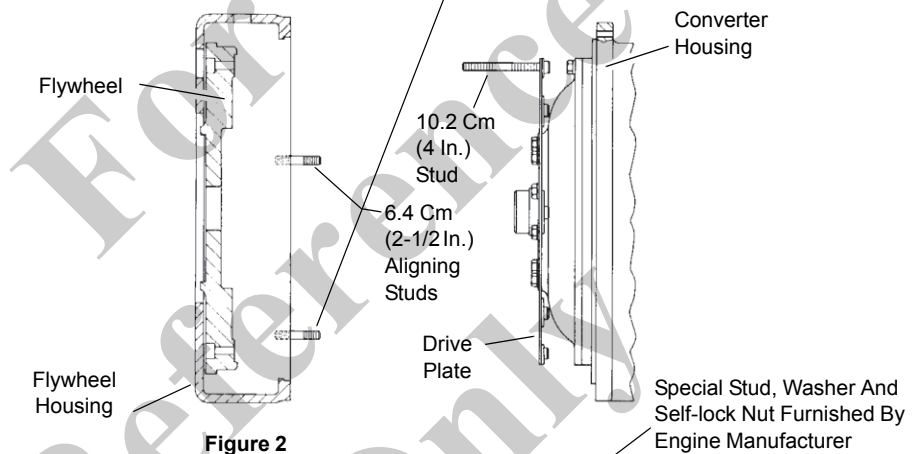


Figure 2

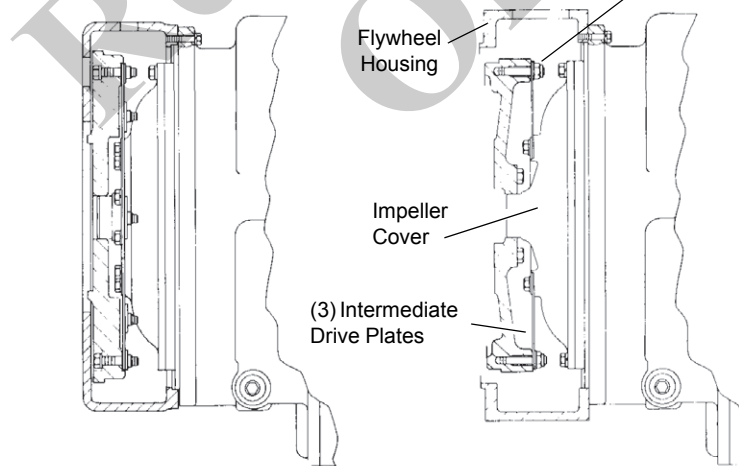


Figure 3

Figure 4

FIGURE 7-15

8. Remove the drive plate locating stud. Install one drive plate attaching bolt. Snug the bolt but **do not tighten**.

**NOTE:** Some engine flywheel housings have a hole located on the flywheel housing circumference in-line with the drive plate bolt access hole. A screwdriver or pry bar used to hold the drive plate against the flywheel will facilitate installation of the drive plate bolts. Rotate the engine flywheel and install the remaining seven flywheel to drive plate attaching bolts and washers. Snug the bolts but **do not tighten**. After all eight bolts and washers have been installed, tighten the bolts. This will require torquing each bolt, then rotating the engine flywheel until all eight bolts have been torqued.

9. Measure the engine crankshaft end play after the torque converter has been completely installed on the engine flywheel. This value must be within 0.001 in (0.025 mm) of the end play recorded in step 4.
10. Install the two section hydraulic pumps and the single section hydraulic pump on the torque converter. Refer to *Hydraulic Pumps*, page 2-16 for installation of the hydraulic pumps.
11. Install the hydraulic lines to the torque converter.
12. Connect the drive line to the torque converter. Refer to *Drive Lines*, page 7-25 in this section for installation of the drive line.
13. Install the front section of the engine hood.
14. Service the crane. Refer to *Servicing the Crane After Transmission/Torque Converter Overhaul* in this section.
15. Cycle all functions and observe for proper operation.

### **Servicing the Crane After Transmission/Torque Converter Overhaul**

The transmission/torque converter and its allied hydraulic system are important links in the drive line between the engine and the wheels. The proper operation of either the unit or the system depends greatly on the condition and operation of the other; therefore, whenever repair or overhaul of the transmission/torque converter is performed, the balance of the system must be considered before the job can be considered completed.

After the overhauled or repaired transmission/torque converter has been installed in the crane, the oil cooler and connecting hydraulic system must be thoroughly cleaned. This can be accomplished in several ways, and a degree of good judgement must be exercised as to the method employed.

The following are considered the minimum steps to be taken:

1. Drain the entire system thoroughly.
2. Disconnect and clean all hydraulic lines. Where feasible, hydraulic lines should be removed from the machine for cleaning.
3. Replace oil filter elements, cleaning out the filter cases thoroughly.
4. The oil cooler must be thoroughly cleaned. The cooler should be back flushed with oil and compressed air until all foreign material has been removed. Flushing in the direction of normal oil flow will not adequately clean the cooler. If necessary, the cooler assembly should be removed for cleaning, using oil, compressed air and a steam cleaner for that purpose.

---

### **CAUTION**

Do not use flushing compounds for cleaning purposes.

---

5. Remove the drain plug from the transmission/torque converter and inspect the interior of the unit housing, gears, etc. If the presence of considerable foreign material is noted, it will be necessary for the unit to be removed, disassembled, and cleaned thoroughly. It is realized this entails extra labor, however, such labor is a minor cost compared to the cost of difficulties which can result from the presence of such foreign material in the system.
6. Assemble all components and use only the type oil recommended. Fill the transmission through the fill pipe until fluid is at the top of the fill range on the dipstick. Run the engine for two minutes at idle (900 rpm) to prime the torque converter and hydraulic lines. Recheck the level of oil in the transmission with the engine running at idle (900 rpm). Add oil as necessary to bring the level to the LOW mark on the dipstick. After the oil temperature reaches 180 to 200° F (82 to 93° C), add oil to bring the level to the FULL mark on the dipstick.
7. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

### **Lubrication**

#### **Type Of Oil**

Hydraulic Oil (HYDO) or equivalent. Refer to *Lubrication*, page 9-1.

#### **Capacity**

System Capacity (includes torque converter, lines, and transmission), approximately 34 qt (32 l).

#### **Check Period**

Check oil level every 10 hours or daily with engine running at 900 RPM and oil at 150 to 200° F (82 to 93° C). Maintain oil level to FULL mark. Refer to *Lubrication*, page 9-1.

### Normal Drain Period

**NOTE:** Normal drain periods and filter change intervals are for average environmental and duty-cycle conditions. Severe or sustained high operating temperatures or very dusty atmospheric conditions will cause accelerated deterioration and contamination. For extreme conditions, judgment must be used to determine the required change intervals.

8. Change oil filter element. Refer to *Lubrication*, page 9-1.

**NOTE:** It is recommended that filter elements be changed after 50 and 100 hours of operation on new and rebuilt or repaired units, then at normal intervals thereafter.

- a. Drain transmission and remove pump screen. Clean screen thoroughly and reinstall it, using a new gasket.
- b. Remove and discard both filter elements. Clean filter housing and install new filter elements.
- c. Refill transmission to LOW mark.
- d. Run engine at 800 RPM to prime converter and lines.
- e. Recheck level with engine running at 800 RPM and add oil to bring level to LOW mark. When oil temperature is hot, 180 to 200 °F (82 to 93 °C), make final oil level check. Bring oil level to FULL mark.

## TRANSMISSION

### Description

The transmission is a powershift with six forward and three reverse speeds.

The transmission is controlled electrically by a shift lever/knob located on the right side of the steering column and an axle drive mode selector rocker switch located on the left side of the front console.

### Maintenance

#### Removal

1. Extend and set the outriggers just enough to take up the slack in the outrigger pads. Chock the wheels.
2. Refer to *Drive Lines*, page 7-25 and disconnect the three drive lines from the torque converter and axles.
3. Tag and disconnect the electrical leads and connectors from the valve body.

4. Tag and disconnect all hydraulic lines to the transmission. Cap all lines and openings.
5. Remove the bolt attaching the oil fill tube to the frame mount.

**NOTE:** The transmission weighs approximately 1,303 lb (591 kg) dry.

6. Position a transmission jack or some other means of support that is capable of supporting the weight of the transmission, under the transmission.
7. With the weight of the transmission on the supporting device, remove the capscrews, washers and nuts securing the transmission mounts to the frame mounts.
8. Using the support device, lower and remove the transmission.

#### Installation

**NOTE:** The transmission weighs approximately 1,303 lb (591 kg) dry.

1. If a new transmission is to be installed, remove all fittings and brackets from the old transmission and install them in the same locations on the new transmission.
2. Using a transmission jack or suitable device capable of supporting the transmission weight, position the transmission under the frame and raise it into position.
3. Install the capscrews, washers and nuts and secure the transmission mount to the frame mount.
4. Remove the supporting device from under the transmission.
5. Connect all the transmission oil lines to appropriate fittings.
6. Connect all electrical leads and connectors to the valve body.
7. Connect the oil fill tube to the frame mount.
8. Connect the three drive lines to the transmission. Refer to *Drive Lines*, page 7-25 for installation of the drive lines.
9. Service the crane. Refer to *Servicing the Crane After Transmission/Torque Converter Overhaul*, page 7-30 in this section.
10. Cycle all functions and observe for proper operation.

#### Towing or Pushing

Before towing the crane, disconnect both front and rear drive lines. The engine cannot be started by pushing or towing because of the design of the hydraulic system.

*For  
Reference  
Only*

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## SECTION 8 UNDERCARRIAGE

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### AXLES

#### Description

To provide maximum maneuverability, both the front and rear axles are steerable. The rear axle is mounted on a pivoting cradle (fifth wheel) which allows the axle to oscillate while traversing uneven terrain. The front axle is bolted directly to the frame. All four wheels utilize a hydraulic braking system. Cranes are equipped with disc type brakes. A disc-type parking brake is mounted on the front axle input shaft.

Each axle incorporates a single reduction carrier with hypoid gearing mounted in the axle center. The final reduction is of planetary design spur gearing built into the wheel hubs.

The design of these axles permits the hypoid gearing of the differential carrier and the axle shafts to carry only a nominal torsional load while at the same time providing the highest practical numerical gear reduction at the wheels.

The hypoid pinion and differential assembly of the first reduction are supported by tapered roller bearings. The pinion bearing preload is adjusted and maintained by a hardened precision spacer between the inner and outer bearing. The differential tapered bearing preload is adjusted

and maintained by the positioning of the threaded adjusting rings in the carrier leg and cap bores.

In the planetary wheel ends, the spur teeth of the sun gear mesh with teeth of the planet spur gears. The planet spur gears rotate on planet pins which are mounted in a spider. The planet spur gear teeth in turn mesh with teeth of the floating ring gear.

Power is transmitted by the hypoid gear set in the differential carrier to the axle shafts and the sun gear of the final reduction, through the revolving planet gears, and into the planetary spider which drives the wheel hub.

As an option, the front axle and rear axle may be provided with a differential lock. When in the locked mode, the axle shafts and the differential are locked together and there is no differential action between the wheels.

#### CAUTION

##### Axle Damage!

Operating the machine with the differentials in the locked position while maneuvering on improved surfaces may result in damage to the axles.

## MAINTENANCE

**NOTE:** The axles do not have to be removed from the crane to remove the planetary wheel ends or the drive units.

### Removal

1. Using the outriggers, raise the wheels off the ground.
2. Install blocking under the frame at the outboard ends of the four outrigger boxes.

---

### CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

3. Disconnect and remove the drive line from the applicable axle. Do not disassemble the drive lines. Refer to *Drive Lines*, page 7-25.
4. Tag, disconnect, and cap the hydraulic brake line at each wheel.
5. Tag, disconnect, and cap the hydraulic lines to the steer cylinders.
6. On the front axle only, tag and disconnect the hydraulic line from the park brake actuator.
7. On the right side of the rear axle only, tag and disconnect the electrical wires from the rear wheels not centered switch.
8. On machines equipped with cross-axle differential locks remove hoses and wires from the differentials.

**NOTE:** Each tire and wheel assembly weighs approximately 2400 lb (1089 kg).

9. Remove the wheels from the axle.

**NOTE:** Each axle weighs approximately 6050 lb (2750 kg) with oil. Refer to in this section.

10. Position jacks, which are capable of handling the weight of the axle, under the axle for support.
11. Remove the eight nuts, washers, and bolts securing the axle to the frame/cradle.
12. Lower the axle to the ground and remove it to a clean working area.

### Cleaning

Completely assembled axles may be steam cleaned on the outside only, to facilitate initial removal and disassembly, providing all openings are closed. Breathers, vented shift

units, and all other openings should be tightly covered or closed to prevent the possibility of water entering the assembly.

### Installation

1. If a new axle is to be installed, remove the following from the old axle and install them on the new one.
  - a. The steer cylinders.
  - b. The rear wheels not centered switch actuator bracket (rear axle only).
  - c. The parking brake actuator (front axle only). Refer to *Brake System*, page 8-12 in this section.
2. Position the axle under the crane on jacks which are capable of handling the weight of the axle.
3. Raise the axle into place and secure with the eight attaching bolts, washers, and nuts. Torque the bolts to 1885 to 2043 lb-ft (2556 to 2770 Nm).
4. Install the wheels onto the axle. Refer to *Wheels and Tires*, page 8-4 in this section.
5. Connect the hydraulic lines to the steer cylinder as tagged during removal.
6. Connect the hydraulic brake line to each wheel as marked during removal.
7. On the front axle only, connect the hydraulic line to the parking brake actuator.
8. On the right side of the rear axle only, connect the electrical wires to the rear wheels not centered switch. Refer to *Rear Wheels Not Centered Switch Adjustment Procedure*, page 8-3 and adjust the switch.
9. Connect the drive line to the applicable axle. Refer to *Drive Lines*, page 7-25.
10. Reconnect differential lock hoses and wires if applicable.
11. Refer to *Brake System*, page 8-12 in this section and bleed the hydraulic brake system.
12. Remove the blocking under the outrigger beams and retract the outriggers to lower the wheels to the ground.

### Wheel Alignment Check Procedure

1. Check the axle for wheel alignment. The wheels are to be straight ahead with no toe-in or toe-out. Adjust if necessary by turning the tie rod ends in the direction necessary.
2. Check pre-set axle stop by turning the wheels to the extreme left. Check the clearance between the inside of the tire and the nearest object. If the clearance is less than 1.0 in (25.4 mm), adjust the axle stop to provide clearance.



3. Turn the wheels to the extreme right and repeat step 2 for the right side.

**Rear Wheels Not Centered Switch Adjustment Procedure**

1. Ensure the wheels are straight ahead.

**NOTE:** Refer to (Figure 8-1) for rear wheels not centered switch adjustment.

2. Ensure proximity sensor switch is centered in the slot of the sensor plate bolted to the axle oscillation lockout cylinder. Adjust by moving the sensor mounting bracket.

3. Ensure a maximum gap of 0.19 in (4.8 mm) exists between the sensor switch and the sensor plate. Adjust by loosening switch mounting bolts and moving switch up or down on the mounting bracket. Tighten the mounting bolts.

4. Turn the rear wheels to verify proper operation. Rear Wheels Not Centered Lamp in cab should be out when rear wheels are centered and the sensor switch is centered in the slot of the sensor plate.

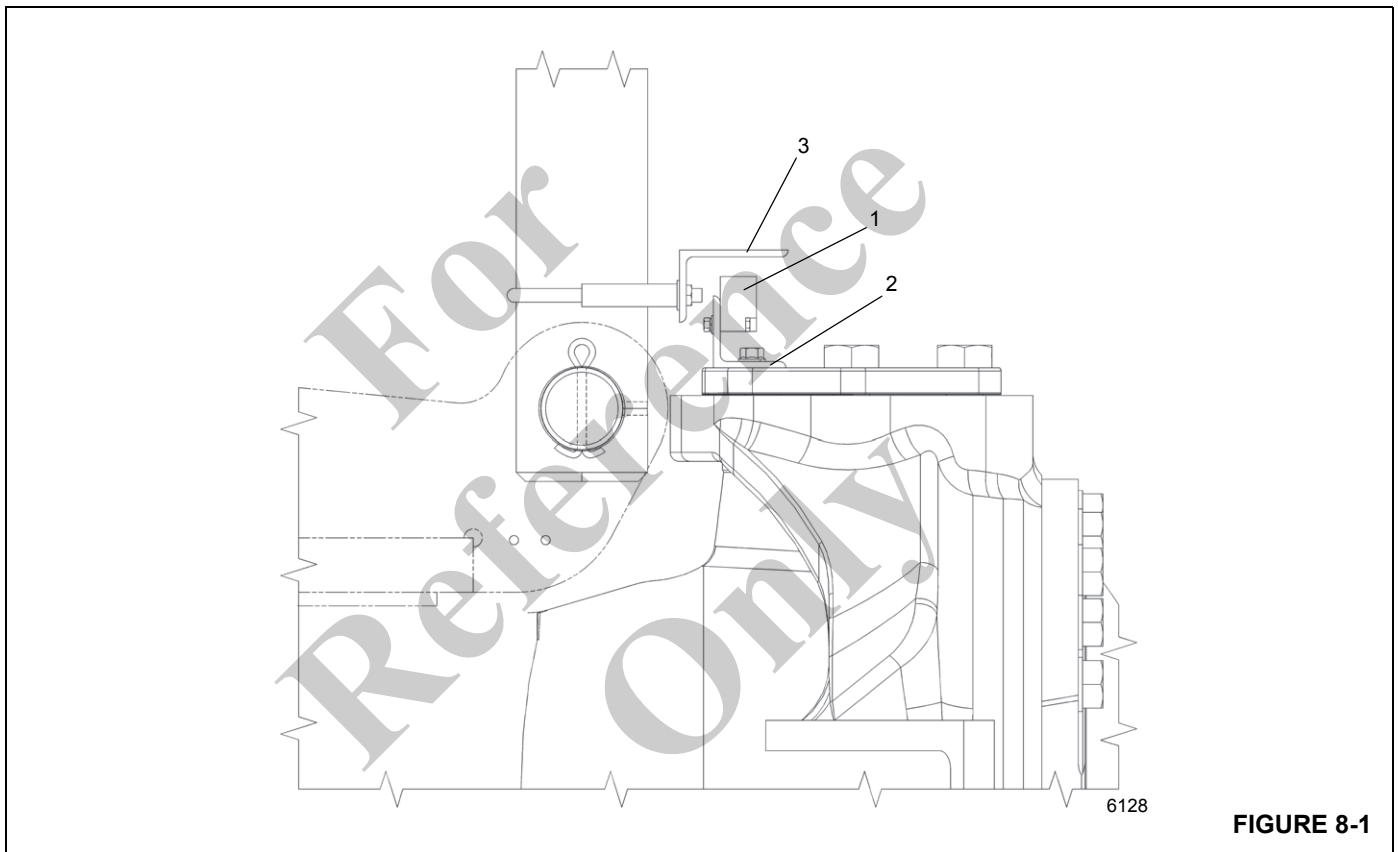


FIGURE 8-1

Item	Description
1	Proximity Switch

Item	Description
2	Angle Bracket
3	Sensor Plate

**WHEELS AND TIRES**

**Description**

The standard tire size for this unit is 33.25 x 29-38 ply; also available as an option, is a 29.5R29 tire.

**CAUTION**

Do not mix tires and rims of different manufacturers.

Each wheel assembly (tire and rim) is mounted on the planetary hub with 24 grade 8 lug nuts.

**NOTE:** The tire diameters, widths, and weights may vary slightly depending on the tire manufacturer.

Off-highway tires are designed to operate with a certain sidewall deflection or bulge. Correct air pressure ensures proper deflection which, in turn, ensures proper traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lowered rim life.



**WARNING**

**Possible equipment damage and/or personal injury!**

Driving the crane with a tire under inflated at 80% or less of its recommended pressure can cause the wheel and/or tire to fail. Per OSHA Standard 1910.177(f)(2), when a tire has been driven under inflated at 80% or less of its recommended pressure, it must first be completely deflated, removed from the axle, disassembled, and inspected before re-inflation.

Refer to and adhere to the inflation pressures in the *Load Chart Book* in the crane cab.

**Maintenance**



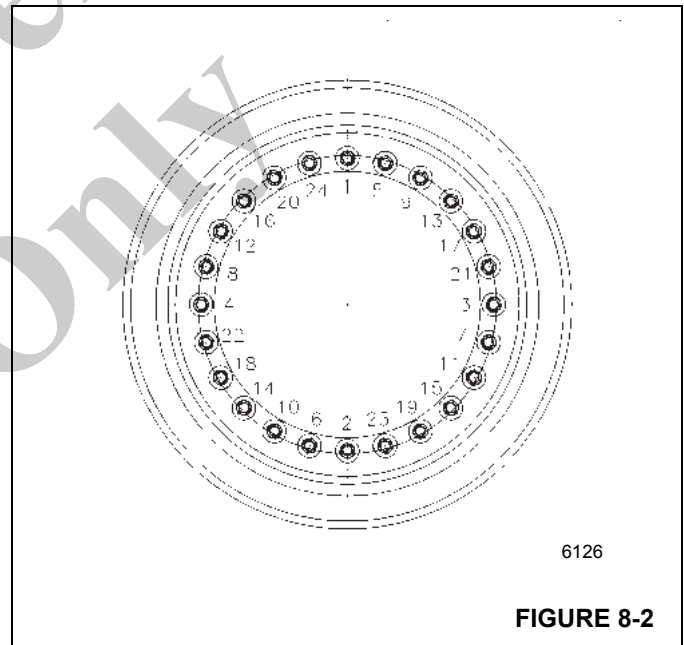
**WARNING**

Do not attempt to demount or mount tires without proper training. The high pressures involved can cause tire and rim parts and tools to fly with explosive force, if proper procedures are not used, causing severe injury or death to personnel and damage to the crane and surrounding area.

**Mounting Wheel Assemblies**

**NOTE:** Do not lubricate the wheel studs or lug nuts.

1. Raise the crane on outriggers so the wheels are off the ground.
2. The 29.5R29 tire and wheel is a directional assembly. These tires must be properly oriented on the left hand or right hand side of the crane.
3. Install the wheel assembly on the mounting studs. Install the lug nuts and tighten them to 50 lb-ft (68 Nm) in the sequence shown in (Figure 8-2).
4. Ensure the wheel assembly is properly on the hub.
5. Torque the lug nuts to 340 to 360 lb-ft (461 to 488 Nm) in the sequence shown in (Figure 8-2).
6. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.
7. Road-test the tire, then retorquing to 340 to 360 lb-ft (461 to 488 Nm). Maintain proper torque on wheel lugs and check for proper wheel mounting. Retorque the lug nuts after about an hour of travel after the wheels are removed and reinstalled. This will reseal the lug nuts. Check the torque every 500 miles (800 km) thereafter.



**FIGURE 8-2**

## STEERING SYSTEMS

### Description

To maximize maneuverability, the crane can be steered by the front axle, the rear axle, or by the front and rear axles simultaneously. The crane utilizes two separate steering systems, one to control front axle steering and one for rear axle steering.

#### Front Steering System

The front steering system consists of a hydraulic pump, load sense steer priority flow divider valve (part of the swing directional control valve), load sense steering control valve, and two steer cylinders. The hydraulic pump is driven by the engine and supplies a hydraulic flow of 33.0 gpm (125 l/min) to the load sense steering priority flow divider. The load sense steer priority flow divider valve provides 0 to 18.5 gpm (0 to 70 l/min) to the front steering control valve and 14.5 to 33.0 gpm (55 to 125 l/min) to the swing system. When the steering wheel is turned, the load sense steering control valve sends a load sense signal to the load sense steer priority flow divider. As the load sense pressure increases, the priority flow divider spool shifts to direct oil from the hydraulic pump to the steering control valve, and to direct oil from the L port and R port of the steering control valve to the steer cylinders.

### Maintenance

#### Front Steering System

Table 8-1  
Troubleshooting

Symptom	Probable Cause	Solution
1. Hard to steer left and right.	a. Hydraulic oil low.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	b. Clean or tighten lines or fittings.
	c. Defective flow divider valve(s).	c. Repair or replace valve(s).
	d. Defective steering control valve.	d. Repair or replace valve. Refer to your Manitowoc Crane Care Parts Manual.
	e. Defective hydraulic pump.	e. Repair or replace pump.
2. Hard to steer either left or right.	a. Clogged or loose hydraulic lines or fittings.	a. Clean or tighten lines or fittings.
	b. Defective steer cylinder.	b. Repair or replace cylinder.

#### Rear Steering System

The rear steering system is controlled through a section of the integrated outrigger/rear steer valve and consists of the control valve and two steer cylinders. A rear steer indicator system is provided to indicate when the rear wheels are not centered. This system consists of an indicator light located on the front console in the cab and a switch located on the right side of the rear axle. When the rear wheels are turned to the left or right, the amber indicator light will illuminate.

### Theory of Operation

#### Front Steering System

Hydraulic oil flow from Pump No. 1 flows through port 5 of the hydraulic swivel to the steer/swing directional control valve. Regulated flow from the steer priority flow divider valve is routed to the front steering control valve upon turning of the steering wheel and pressurizing of the load sense line. The front steering control valve routes the oil to the appropriate ends of the front steer cylinders to turn the wheels in the desired direction.

#### Rear Steering System

Hydraulic flow from the second section of pump number 3 is directed to the integrated outrigger/rear steer valve. When the Rear Steer Control Switch in the cab is positioned to left (L) or right (R), a signal is sent to the rear steer solenoid, shifting the control valve spool, routing the supply pressure to the appropriate ends of the rear steer cylinders to turn the wheels in the desired direction.

Symptom	Probable Cause	Solution
3. Steering is erratic left and right.	a. Hydraulic oil low.	a. Refill hydraulic reservoir. Refer to <i>Lubrication</i> , page 9-1.
	b. Clogged or loose hydraulic lines or fittings.	b. Clean or tighten lines or fittings.
	c. Defective steering control valve.	c. Repair or replace valve.
	d. Defective hydraulic pump.	d. Repair or replace pump.
4. Noisy hydraulic pump caused by cavitation.	a. Hydraulic oil low.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Suction line plugged or too small.	b. Clean line and check for size.
5. Hydraulic pump shaft seal leakage.	a. Worn shaft seal. <b>NOTE:</b> If replacing the shaft seal does not stop leakage, the pump should be disassembled and checked for the following:	a. Replace shaft seal. Refer to your Manitowoc Crane Care Parts Manual.
	b. Broken diaphragm seal or backup gasket.	b. Replace seal or gasket.
	c. Bearing out of position.	c. Replace bearing.
	d. Excessive internal wear.	d. Replace pump.

**Functional Check**

A normal periodic functional check of the entire steering system will generally be adequate to ensure satisfactory service.

1. Check all fittings for leakage. An accumulation of moist, black dirt is a good indication of leakage.
2. With the engine running at idle and at full throttle, and with the machine standing still and moving, turn the steering wheel through the full range of travel. Note any speed irregularities and sticky sensation. This may indicate dirt in the fluid. If the steering wheel continues to rotate when started and released, a condition known as motoring exists. This may also indicate dirty fluid in the system.
3. Ensure the system has adequate power. If there is an indication of hard steering, this can be caused by either

a reduced oil flow to the control valve or a reduced system relief pressure. Adequate oil flow under all conditions can best be checked by timing the full travel of the cylinder with the steered axle unloaded and loaded. If there is a great difference at low engine speed and slight difference at high engine speeds this may indicate a defective pump. Adequate oil pressure can only be determined by connecting a pressure gauge (3500 psi (24 MPa/240 bar) full scale recommended) at the swing control valve bank pressure gauge test port. With the engine running at a medium speed, turn the steering wheel to one end of the travel and hold the cylinders at the travel limit briefly, just long enough to read the pressure gauge. Never hold the system at relief pressure for more than a few seconds at a time. The pressure gauge should indicate 2500 psi (17.2 MPa/172 bar).

Rear Steering System

Table 8-2  
Troubleshooting

Symptom	Probable Cause	Solution
1. Rear steering inoperative.	a. Hydraulic oil low.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged, broken, or loose hydraulic lines or fittings.	b. Clean, tighten, or replace lines or fittings.
	c. Steer cylinder locked.	c. Repair or replace cylinders. Refer to your Manitowoc Crane Care Parts Manual.
	d. Defective control valve.	d. Repair or replace valve.
	e. Defective steer cylinder(s).	e. Repair or replace cylinder(s).
	f. Lack of electrical signal	f. Check electrical connections/wiring
2. Hard to steer left and right.	a. Hydraulic oil low.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	b. Clean or tighten lines or fittings.
	c. Defective steering control valve.	c. Repair or replace valve.
	d. Defective hydraulic pump.	d. Repair or replace pump.
	e. Clogged or loose hydraulic lines or fittings.	e. Clean or tighten lines or fittings.
	f. Defective steer cylinder.	f. Repair or replace cylinder.
	g. Damaged relief.	g. Replace relief valve.
3. Steering is erratic left and right.	a. Hydraulic oil low.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	b. Clean or tighten lines or fittings.
	c. Defective steering control valve.	c. Repair or replace valve.
	d. Defective hydraulic pump.	d. Repair or replace pump.

## Hydraulic Pumps

### Description

#### Front Steer

Section 2 of pump #1 provides the hydraulic flow necessary to power the front steer cylinders and the swing drive system. The pump is a gear type pump; the section provides a flow of approximately 33.0 gpm (125 l/min).

#### Rear Steer

Section 2 of pump # 3 provides the hydraulic flow necessary to power the rear steer cylinders, the outrigger circuit, the front and rear pairs of outrigger box pin cylinders, and the rear axle oscillation lockout system. The pump is a gear type pump; the section provides a flow of approximately 16.5 gpm (62.5 l/min).

## Front Steering Control Valve

### Description

The steering control valve is located under the dash and is actuated by a conventional steering wheel and steering column, providing precise, full hydraulic steering. Precise steering is accomplished by a metering system within the valve that is directly connected to the steering column and wheel.

### Maintenance

#### Removal

1. Thoroughly clean the steering control valve and the surrounding area before removing the hydraulic hoses from the valve.
2. Tag and disconnect the five hydraulic hoses from the steering control valve. Cap or plug each hose and the five ports of the valve.
3. Remove the capscrews, lockwashers, and flat washers securing the valve to the bracket and the steering column. Remove the control valve, leaving the steering column in the cab.

#### Installation

1. Position the control valve to the bracket and steering column and install the flat washers, lockwashers, and capscrews. Tighten the capscrews.
2. Connect the five hydraulic hoses to the control valve as tagged during removal.
3. Start the engine and check for proper operation and any leakage.

## Integrated Outrigger/Rear Steer Control Valve

### Description

The integrated outrigger/rear steer valve directionally controls the outrigger circuit, outrigger pin circuit, and the rear steer circuit. The valve is mounted on the rear of the carrier frame front cross member.

The inlet section of the valve contains two solenoid valves and two relief valves. The solenoid valve is normally open, bypassing oil to the reservoir. Operation of either system energizes the solenoid valve to close it and route oil to the applicable circuit.

The valve also contains four three position four-way solenoid valves that control the following:

- The rear steer solenoid valve is controlled by the Rear Steer switch in the operator's cab through port AST and BST of the valve.
- The removal pin solenoid valve for the front outrigger box is controlled by the Pin Unlock switch in the outrigger control box in front of the left front fender through ports A1 and B1 of the valve.
- The removal pin solenoid for the rear outrigger box is controlled by the Pin Unlock switch in the outrigger control box behind the right rear fender through ports A2 and B2 of the valve.
- The outrigger section solenoid valve is controlled by the Extend/Retract switch in the operator's cab through ports A and B of the valve.

The valve also contains double pilot operated check valves in the rear steer and outrigger lines.

### Maintenance

#### Removal

1. Tag and disconnect the electrical connectors to the integral outrigger/rear steer valve.
2. Tag and disconnect the hydraulic lines to the integrated outrigger/rear steer valve. Cap or plug the lines and ports.
3. Remove the capscrews, nuts and washers securing the integrated outrigger/rear steer valve to the carrier frame. Remove the valve as a complete assembly.

#### Installation

1. Position the integrated outrigger/rear steer valve on the frame. Secure the valve with the capscrews, nuts and washers. Tighten the capscrews.
2. Connect the hydraulic lines to the integrated outrigger/rear steer valve as tagged during removal.

3. Connect the electrical connectors to the integrated outrigger/rear steer valve as tagged during removal.

### Functional Check

1. Cycle each outrigger cylinder several times. Verify each cylinder extends and retracts properly.
2. Activate the rear steer function and steer to the left and right several times. Verify the crane steers properly in both directions.
3. Check the valve and lines for leakage. Make repairs as needed.

**NOTE:** For further information on the integrated outrigger/rear steer valve, refer to *Valves*, page 2-31.

## Steer Cylinders

### Description

The steer cylinders are mounted on the axles, two cylinders on each axle. The barrel end of each cylinder is attached to the axle housing and the rod end is attached to the steering lug on the axle end. The front steer cylinders are controlled hydraulically by the front steer control valve through the swing/steer directional valve. The rear steer cylinders are controlled by a solenoid valve located in the integrated outrigger/rear steer valve.

### Maintenance

**NOTE:** For Disassembly and Assembly procedures, refer to *Temperature Effects on Hydraulic Cylinders*, page 2-67.

### Removal

1. Tag and disconnect the hydraulic lines going into the steer cylinder. Cap or plug all openings.
2. Remove the capscrew, flatwasher, and lockwashers securing each pin weldment in the rod end and barrel end of the cylinder.

**NOTE:** Steer cylinder weighs approximately 44 lb (20 kg).

3. Remove both pin weldments and two thrust washers (rod end only), and remove the cylinder from the axle.

### Installation

1. Position the cylinder onto the attachment fittings on the axle and install both pin weldments. On the rod end, install a thrust washer on the top and bottom of lug.
2. Secure each pin weldment with the capscrew, flatwasher and lockwasher. Tighten the capscrews.

3. Connect the hydraulic lines to the cylinder as tagged during removal.

4. Operate the steering system and check the cylinder for proper operation and any leakage.

## Rear Axle Oscillation Lockout System

### Description

The rear axle oscillation system (Figure 8-3) consists of two lockout cylinders, a lockout valve, an axle oscillation relay, and an area definition potentiometer. The lockout cylinders are mounted between a cradle (fifth wheel) and the carrier frame. The lockout valve is mounted on the left inner center frame rail and hydraulically controls the oscillating abilities of the lockout cylinders. The axle oscillation relay is located on the relay panel in the cab and the area definition potentiometer is located in the electrical swivel assembly.

### Theory of Operation

The rear axle is mounted on a cradle (fifth wheel) allowing maximum oscillation of 10 in (25 cm) total while traveling over uneven terrain. Oscillation is provided only when the superstructure is within 6 degrees left or right of directly over the front. When the superstructure is within 6 degrees left or right of directly over the front, the area definition potentiometer energizes the axle oscillation relay which in turn energizes the solenoids on the lockout valve. When the solenoids are energized, the valve spools are shifted to allow hydraulic transfer between the two lockout cylinders.

As one side of the axle is forced up by traveling over uneven terrain, the hydraulic oil flows from the rod end of cylinder A to the barrel end of cylinder B and from the rod end of cylinder B to the barrel end of cylinder A (Figure 8-4). The system is not pressurized and oil is moved from one cylinder to the other by the action of the axle moving the cylinder.

When the superstructure is more than 6 degrees left or right of directly over the front, the area definition potentiometer deenergizes the axle oscillation relay. This deenergizes the solenoids on the lockout valve and allows the springs in the valve to shift the valve spools to the closed position to prevent hydraulic oil flow between the cylinders. By stopping the flow of oil, a hydraulic lock is created and the axle is held rigid in that position.

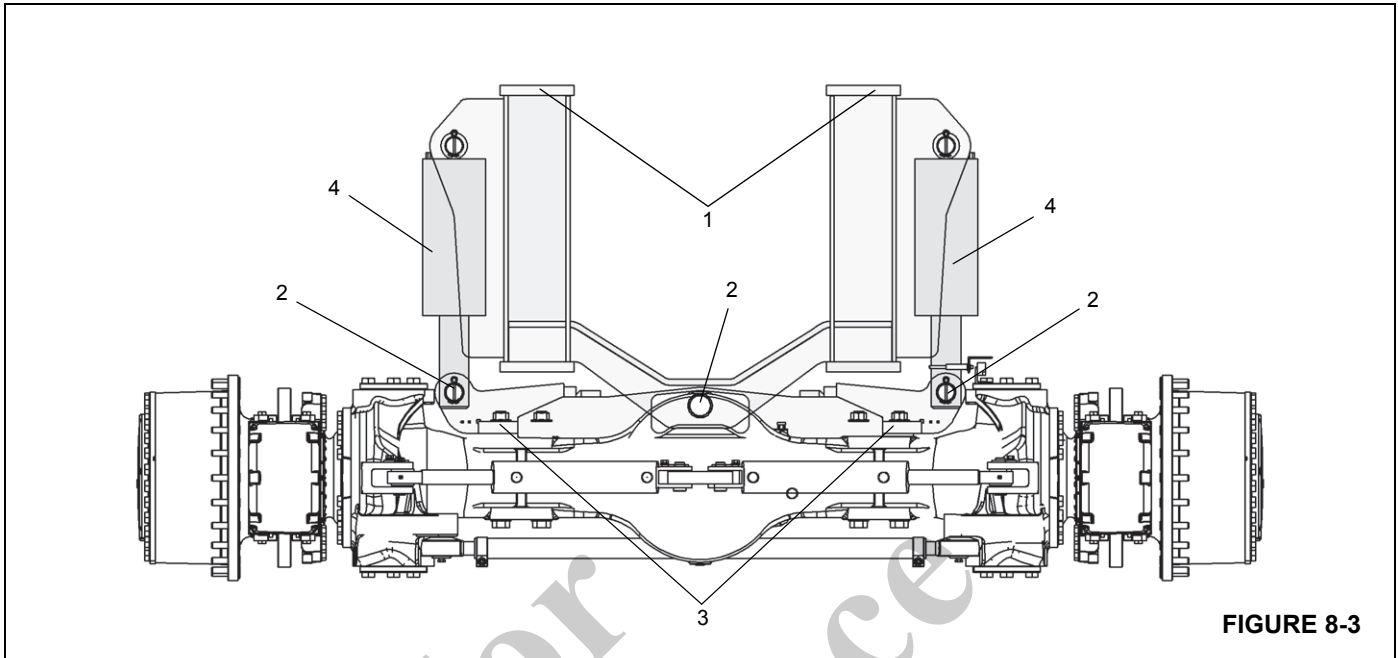


FIGURE 8-3

Item	Description
1	Carrier Frame
2	Pivot Point

Item	Description
3	Fifth Wheel
4	Oscillation Lockout Cylinder

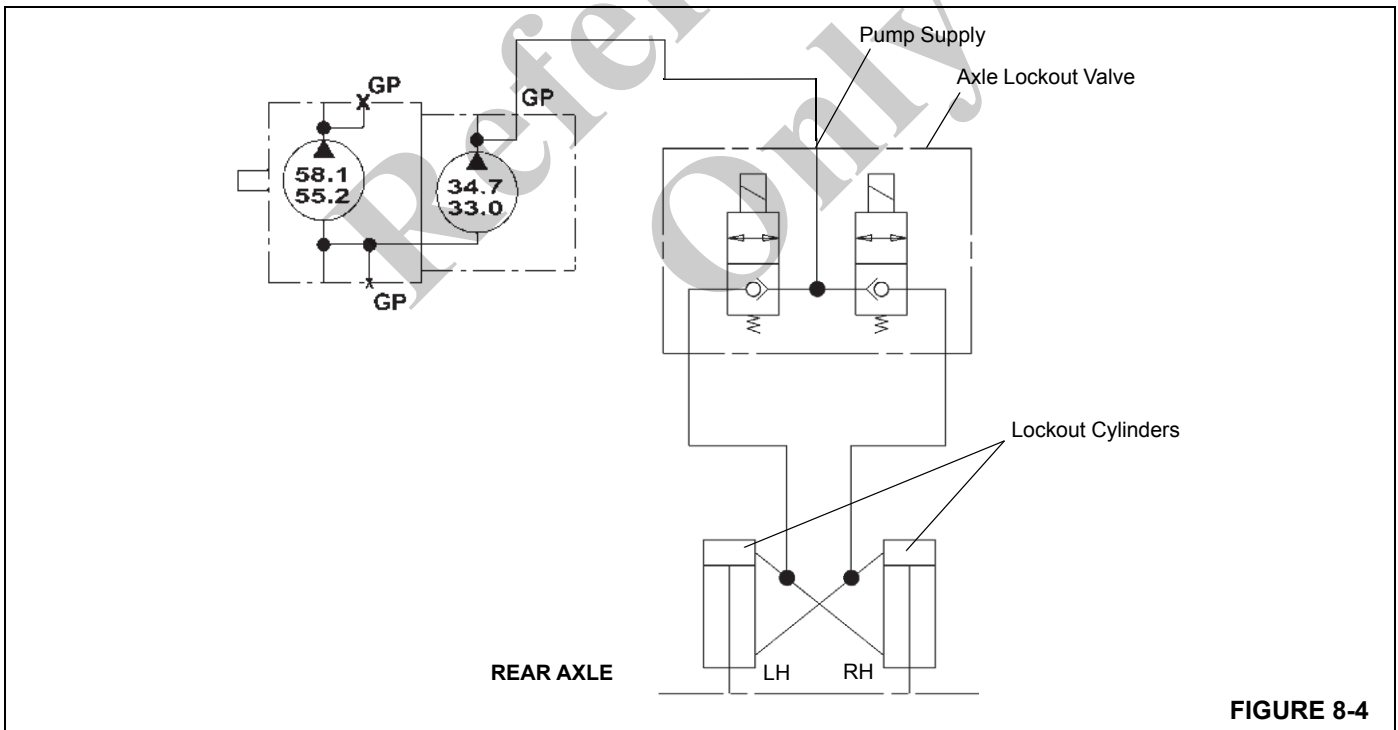


FIGURE 8-4



## Axle Oscillation Lockout Cylinders

### Description

Two 7.0 in (17.8 cm) hydraulic lockout cylinders are installed on the rear axle, one left side and one right side. The barrel end of each cylinder is attached to each side of the carrier frame and the rod ends are attached to each side of the cradle (fifth wheel).

The lockout cylinders are connected hydraulically so that hydraulic oil flows from the rod side of the left cylinder to the barrel side of the right cylinder and from the rod side of the right cylinder to the barrel side of the left cylinder.

Each cylinder weighs approximately 192 lb (87 kg).

### Maintenance

**NOTE:** For disassembly and assembly procedures, refer to *Axle Oscillation Lockout Cylinder*, page 2-80.

### Removal

1. Raise the crane up on outriggers.
2. Rotate the turntable more than 6 degrees in either direction from directly over the front to lock out the oscillation cylinders.
3. Remove the wheel and tire assembly from the axle. Refer to *Wheels and Tires*, page 8-4 in this section.
4. Tag and disconnect both hydraulic hoses from the ports on the cylinder. Cap or plug both hoses and the ports on the cylinder.
5. At the rod end of the cylinder, remove one of the cotter pins securing the retaining pin to the cradle attach fitting.
6. Remove out the retaining pin, freeing the rod end from the cradle.
7. At the barrel end of the cylinder, remove one of the cotter pins securing the retaining pin to the frame attach fitting.
8. Remove out the retaining pin and remove the cylinder.

### Installation

1. Position the barrel end of the cylinder in the frame attach fitting and install in the retaining pin.
2. Secure the retaining pin with the cotter pin.
3. Align the rod end of the cylinder in the cradle attach fitting and install the retaining pin.
4. Secure the retaining pin with the cotter pin.
5. Remove the caps or plugs from the two hydraulic hoses and the cylinder ports and connect the hoses to the appropriate cylinder ports as tagged during removal.
6. Install the wheel and tire assembly on the axle. Tighten the lug nuts using the procedure under *Wheels and Tires*, page 8-4.

7. Lubricate both ends of the cylinder using the fittings provided.
8. Function test the axle oscillation system. Refer to *Section 3 - Operating Controls and Procedures* in the *Operator's Manual*.

## Axle Oscillation Lockout Valve

### Description

The axle oscillation lockout valve, also called the double solenoid valve, is used in the rear axle oscillation lockout circuit. The valve consists of a valve body and two solenoid valves, which keep the lockout cylinders from oscillating unless the superstructure is within 6 degrees left or right of directly over the front. The lockout valve is located on the left side of the frame in front of the front rear axle cross member.

When the superstructure is within 6 degrees left or right of directly over the front, the area definition potentiometer energizes the axle oscillation relay which energizes the solenoids on the axle oscillation lockout valve. This allows hydraulic oil to flow in and out of the lockout cylinders, allowing the axle to oscillate.

When the superstructure is more than 6 degrees left or right of directly over the front, the area definition potentiometer deenergizes the axle oscillation relay which deenergizes the solenoids on the axle oscillation lockout valve. This keeps the axle from oscillating because hydraulic oil cannot leave the cylinders.

### Maintenance

#### Removal

1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the two capscrews, nuts and washers securing the valve to the carrier frame.

#### Installation

1. Secure the valve to the carrier frame using two capscrews, washers and nuts. Tighten the capscrews.
2. Connect the hydraulic hoses to the applicable valve ports as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Function test the axle oscillation system. Refer to *Section 3 - Operating Controls And Procedures* in the *Operator's Manual*.
5. Check the valve and hoses for signs of leakage. Tighten fittings as required.

## BRAKE SYSTEM

### Description

The brake system includes all the components necessary for the application of the service brakes and the parking brake.

#### *Service Brakes*

The service brakes are full power hydraulic disc brakes which are hydraulically controlled and are used to apply the brake assemblies on all four wheels. The system consists of the tandem brake valve with treadle pedal, the dual accumulator charge valve, two hydraulic accumulators, the brake assemblies, and all the associated hoses and tubing.

The operator depresses the pedal on the tandem brake valve, located on the cab floor, and the valve modulates the brake line pressure to the brake assemblies at each wheel. The full powered brake system supplies a high brake system pressure with relatively low reactive pedal forces, while controlling the maximum brake line pressure. The service brake dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve.

#### *Parking Brake*

The parking brake is a hydraulic release, spring apply, disc-type brake, located on the front axle. It is spring applied and hydraulically released. The system consists of a two-position switch, a three-way solenoid valve, actuator, two brake assemblies, and all the associated hardware and tubing. The selector switch, located on the front console in the cab, is used to activate the solenoid valve which controls the park brake actuator, which applies and releases the park brake. There are two brake actuators on the front axle.

**NOTE:** For Description and Maintenance of the tandem brake valve with treadle pedal, the accumulators, and the dual accumulator charge valve, refer to *Valves*, page 2-31.

### Theory of Operation

#### *Service Brakes*

Braking begins when the operator depresses the brake pedal in the cab. Mechanical linkage transfers the force created by the lever action of the brake pedal to the hydraulic brake valve which modulates the brake line pressure to the brake assemblies at each wheel.

Hydraulic oil from hydraulic pump number 2 flows to swivel port 9 to the dual accumulator charge valve. The dual accumulator charge valve charges the accumulators from the open center circuit upon demand and within its present operating charge rate and the high limit pressure setting. When the open center circuit pressure reaches the brake relief setting, which is higher than the high accumulator charge limit, the accumulators will be charged to the regulated maximum pressure setting. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve. The charged accumulators supply pressurized fluid to the closed tandem brake valve.

After the accumulators are fully charged, the high limit check opens and all of the pump flow is directed to the excess flow port and on to the front steer and swing circuits. When pressure to the steering or swing circuit becomes greater than accumulator pressure, the main check valve opens and charges the accumulator without the aid of the charging valve. In this condition, the maximum accumulator pressure is the brake circuit relief valve setting of 3000 psi (20,700 kPa/207 bar).

Once the operator depresses the brake pedal, the tandem brake valve modulates fluid out to the brakes to provide the means of braking. The tandem brake valve will modulate the pressure in the brake system by increasing or decreasing pressure as required in proportion to the input force from the operator via the brake pedal. The hydraulic force acts within the brake assemblies to force the brake pads against the brake discs, acting to slow wheel rotation. Fully powered separate primary (front) and secondary (rear) braking circuits are provided with independent accumulators. A low pressure warning switch is used to sense the accumulator pressures and warn the operator through visual brake warning indicator light on the cab console in the event the pressure in the accumulators drops to an unsafe operating level. In the event of engine failure, the accumulators are pre-charged with dry nitrogen gas and properly sized to provide power-off stopping capacity for secondary braking.

#### *Parking Brake*

Hydraulic flow from the transmission charge pump is routed to the parking brake control valve. When the Park Brake Switch is in the ON position, the parking brake solenoid valve shifts to route flow from the hydraulic parking brake actuator back to the transmission sump. The actuator spring pulls on the lever on the brake assembly, applying the parking brake.

**Maintenance**

**Troubleshooting**

**Table 8-3**

Symptom	Probable Cause	Solution
1. Brakes are poor.	a. Lining thickness less than 0.125 in (3mm).	a. Replace lining.
	b. Brake pedal operation.	b. Free mechanical linkage.
	c. Restriction or leaks in lines.	c. Check all lines for leaks and restrictions.
	d. Low hydraulic oil flow.	d. Check the hydraulic oil level in reservoir and check flow from the tandem brake valve.
	e. Air in brake lines.	e. Bleed the brakes.
	f. Brake pads/linings are grease-soaked.	f. Replace pads/linings.
	g. Engine not running.	g. Start engine. Due to the operation, the engine must be running to provide full brake power.
	h. Brake relief valve stuck open.	h. Replace the relief valve. Refer to your Manitowoc Crane Care Parts Manual.
	i. Dual accumulator charge valve not charging	i. Check valve operation and repair or replace valve.
	j. Accumulators not pre-charged.	j. Check accumulator pre-charge.
2. Hard brake pedal with engine running.	a. Pedal travel being interfered with.	a. Check all pedal linkage and ensure it is free and adjusted properly.
3. Brakes lock up.	a. Too much hydraulic flow.	a. Check the flow from the flow divider. Too much flow will cause the brakes to be applied by the oil trapped in the power boost chamber.
	b. Brake pedal push rod improperly adjusted, causing brakes to be always applied.	b. Adjust the push rod linkage so the brake pedal and push rod fully return.
4. Uneven braking or pad wear.	a. Lining thickness less than 0.125 in (3 mm).	a. Replace the lining.
	b. Grease on the pads/linings.	b. Replace the pads/linings.

**General**

A schedule for the periodic adjustment, cleaning, inspection, and lubrication of brake equipment should be established by the operator on the basis of past experience and severity of operation.

The disc brakes are not adjustable. Brakes should be cleaned, inspected, and linkage lubricated periodically to assure maximum performance.

**Bleeding the Brake System**

The brake system should be bled whenever air becomes entrapped within the brake system (usually characterized by a spongy feeling during brake pedal application), whenever any brake system line has been opened, or whenever any brake component has been replaced.

Always start at the point in the system that is furthest from the tandem brake valve and work back toward the tandem brake valve. Bleed every bleeder screw on every caliper/actuator on every wheel. When you complete a bleeder screw, go to the next closest bleeder screw on the same caliper/actuator. When you complete a wheel, go to the furthest bleeder screw on the next closest wheel.

**Service Brakes**

**Description**

The brakes utilized are hydraulic disc-type brakes. Two brake assemblies are used at the end of each axle. The action of the brake pads riding against the brake discs acts to slow the rotation of the wheels.

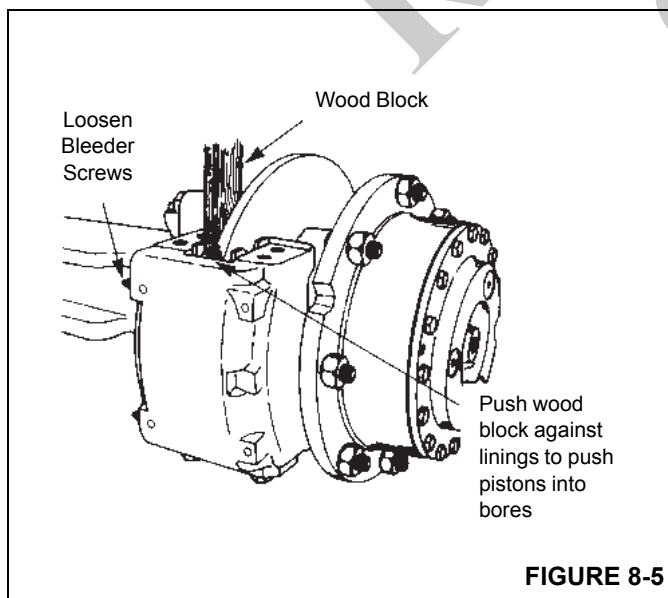
**Maintenance**

**NOTE:** To perform maintenance on the brake caliper, remove the tire and wheel assembly. Refer to *Axles*, page 8-1.

**Removal**

**Linings**

1. Remove the bolts securing the end plates to one side of the caliper housing. Remove the end plates.
2. Loosen the bleeder screws to release hydraulic pressure in the caliper (Figure 8-5).



3. Use a piece of wood against the linings as a pry bar to push the pistons completely into the housing. Tighten the bleeder screws.
4. Remove the linings from the caliper housing. If necessary, discard the linings.

**Caliper**

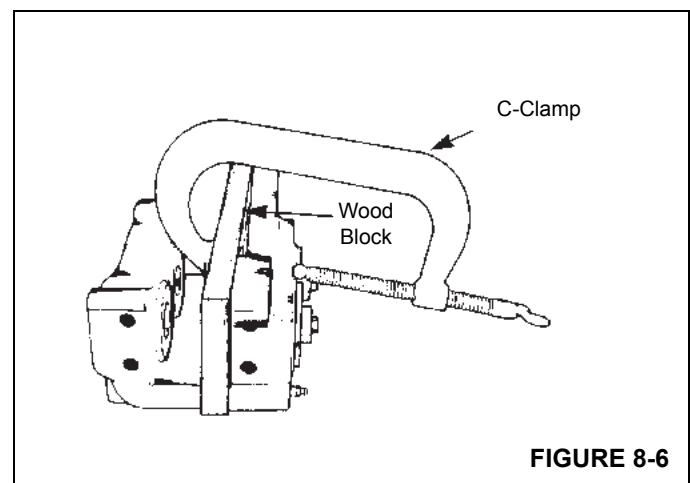
**NOTE:** To lighten caliper weight, remove the brake linings from the caliper before removing the caliper from the vehicle.

1. Disconnect the hydraulic brake line from the inlet fitting on the caliper. Cap or plug all openings.
2. Remove the linings as described previously.
3. Remove the bolts securing the caliper housing to the mounting bracket. Remove the caliper housing from the mounting bracket. If shims are used mark the position of the shims.

**Disassembly**

**Caliper**

1. Remove the inlet fitting and o-ring from the cylinder cap.
2. Drain and discard the hydraulic fluid.
3. Clean the outside of the housing with isopropyl alcohol. Dry the housing with a clean cloth.
4. If installed, remove the bolts that secure the end plates to the housing. Remove the end plates and linings.
5. Remove the pistons from the side of the housing opposite the mounting plate according to the following procedure.
  - a. Use a C-clamp to hold a 0.5 in (12.7 mm) block of wood against three pistons on the mounting side of the housing. Ensure the C-clamp is not in the area in front of the piston bore (Figure 8-6).



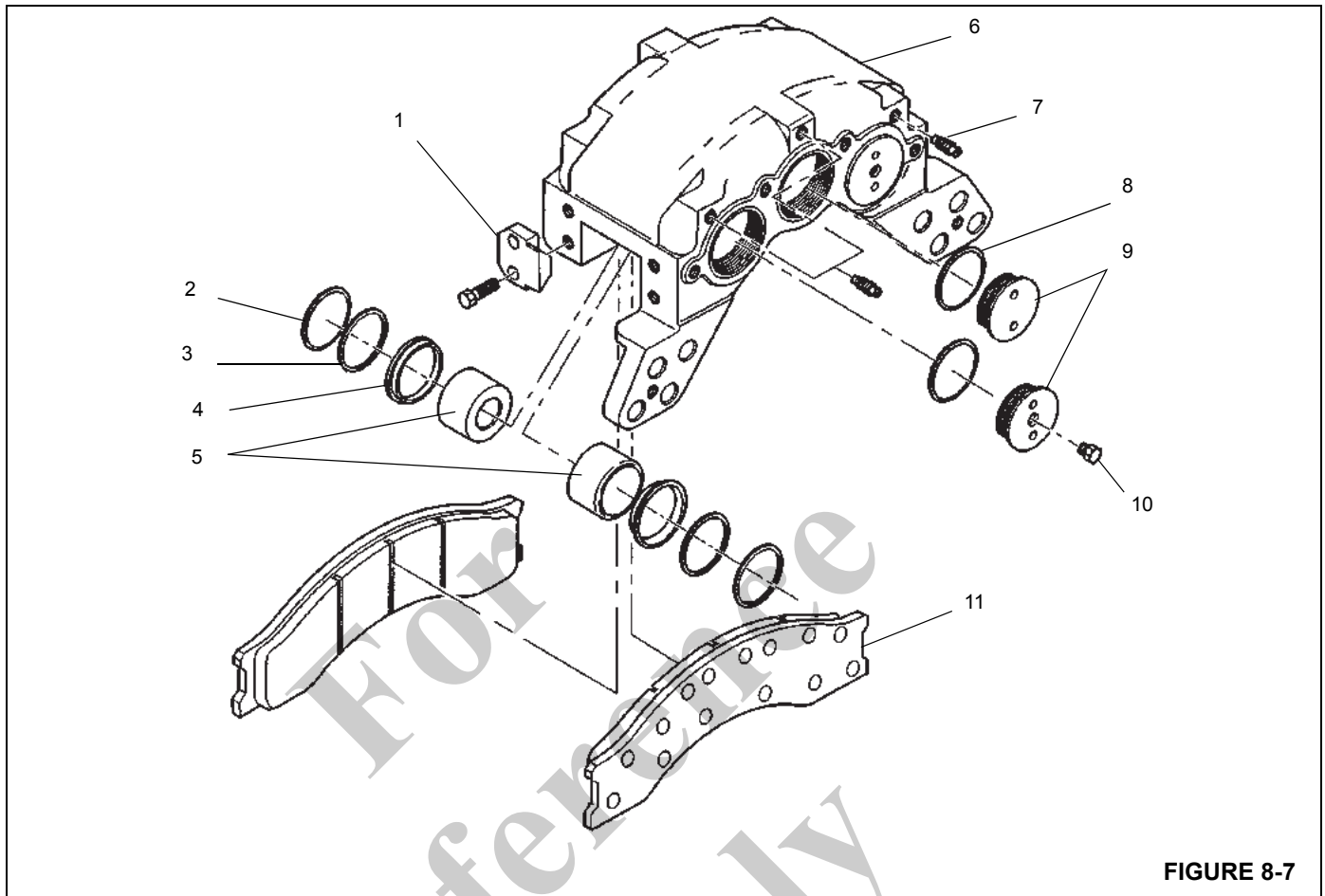


FIGURE 8-7

Item	Description
1	End Plate
2	O-ring
3	Backup Ring
4	Dust Seal
5	Pistons
6	Housing
7	Bleeder Screw
8	O-ring
9	Cylinder Caps
10	Cap
11	Lining Assembly

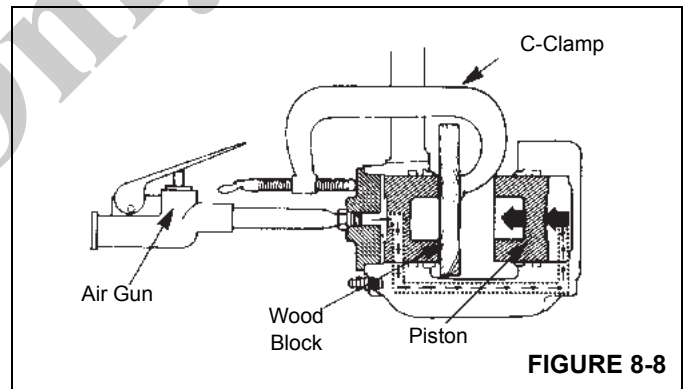


FIGURE 8-8

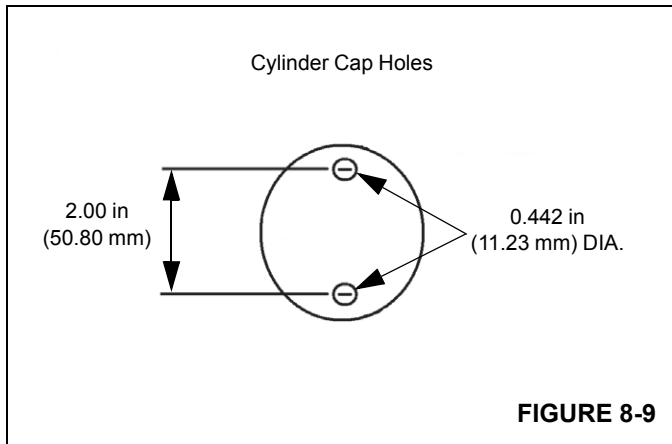
- b. Apply compressed air to the inlet fitting to force the pistons out of the other housing. If one piston comes out before the other piston, put a piece of wood in front of the piston that comes out first. Apply compressed air to force the other piston out of the housing (Figure 8-8).
- c. Remove the wood block and the C-clamp from the housing.
- d. Remove the pistons (Figure 8-7) from the bores that are opposite from the mounting plate.



**CAUTION**

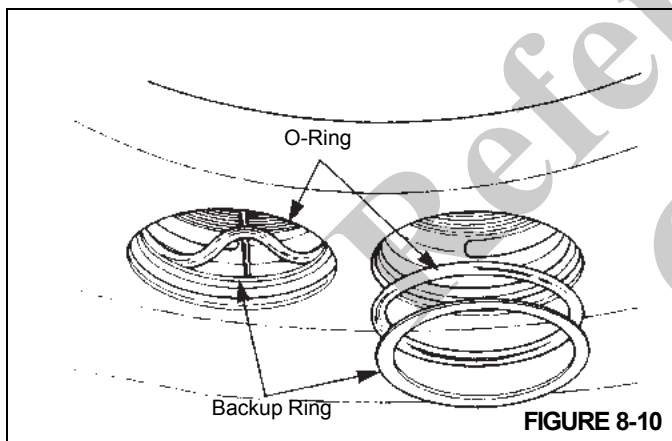
Do not place hand in front of pistons when forcing them out. Serious personal injury may occur.

- Remove the cylinder caps from the housing. Remove and discard the o-rings (Figure 8-9).



- Remove the pistons from the mounting plate side of the housing. Push on the cap ends of the pistons to force them out of the disc side of the housing.
- Remove the dust seals from the housing.
- Remove and discard the o-ring and the backup rings (Figure 8-10).

**NOTE:** Use a soft tool to prevent scratching the housing and grooves.



- Inspect the ring grooves in the housing for scratches and rust. Remove small scratches and rust with emery cloth. Replace the housing if there are large scratches or large amounts of rust. Refer to *Caliper Parts*, page 8-17.
- Inspect the pistons and the bores for scratches and rust. Remove small scratches and rust with emery cloth. Replace the components if they are worn or if there are

large scratches or large amounts of rust. Refer to *Caliper Parts*, page 8-17.

**Inspection**

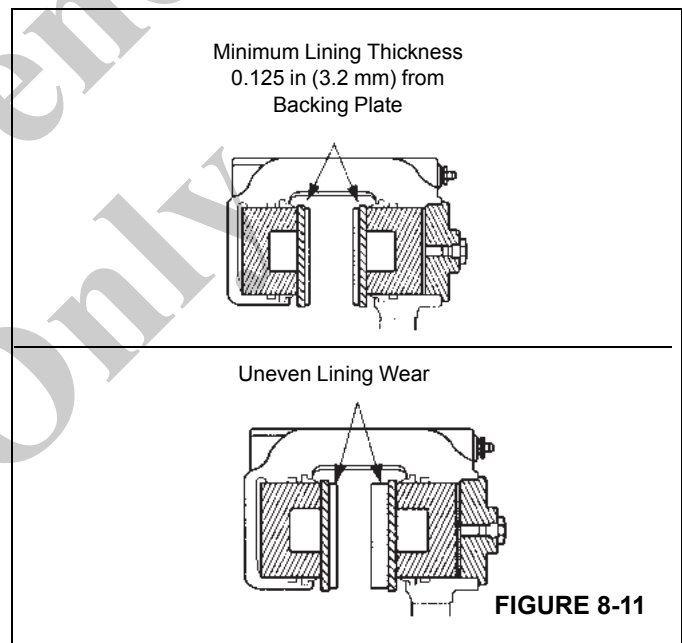
**Periodic On-vehicle**

Inspect the caliper, linings, and disc for any damage.

**Shoes, Linings, and End Plates**

Remove the shoes and linings. To help prevent abnormal lining wear, replace worn, bent, or cracked end plates and distorted backing plates. Inspect end plate bolts for wear. Replace the bolts if worn. Inspect the linings for:

- Lining Wear—Replace the linings when the thickness of the lining is less than 0.125 in (3.2 mm) from the back plate (Figure 8-11).
- Lining wear not even—Replace the linings if the thickness of the two linings is significantly different. Check the pistons for correct operation. Replace the piston and/or housing if a piston is cocked in the bore. Check that the disc surface is flat and parallel to the linings (Figure 8-11).

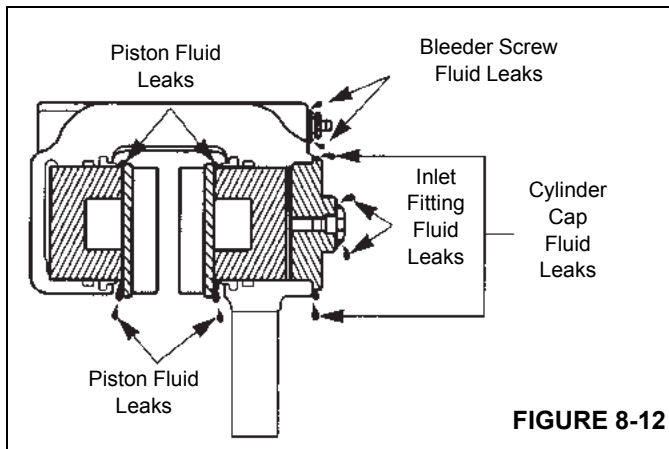


- Oil or Grease on Linings—Replace the linings.
- Cracks on Linings—Replace linings that have large or deep cracks.

**NOTE:** Small, tight cracks on the surface of the lining are normal when the caliper is used under high temperature conditions.

**Caliper For Leaks**

Inspect the following areas for fluid leaks (Figure 8-12).



**FIGURE 8-12**

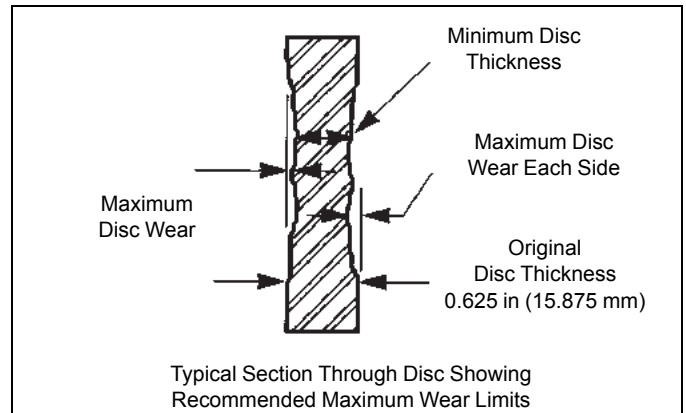
- **Pistons.** If fluid leaks at a piston, disassemble the caliper. Inspect the piston, the bore, the o-rings, and back-up rings. Service as necessary.
- **Cylinder Cap.** If fluid leaks at a cylinder cap, tighten the cylinder cap, the inlet fitting, and the plug. If the leak continues, disassemble the caliper. Inspect the cylinder cap threads, the housing threads, and the O-ring. Service as necessary.
- **Bleeder Screw.** If fluid leaks at the bleeder screw, tighten the bleeder screw. If the leak continues, replace the bleeder screw.
- **Inlet Fitting.** If fluid leaks at the inlet fitting, tighten the fitting. If the leak continues, replace the O-ring.

**Dust Seals**

Ensure the dust seals are soft and flexible. Disassemble the caliper and replace dust seals that are hard or damaged.

**Disc**

If the disc is worn beyond the wear limits, replace the disc (Figure 8-13).

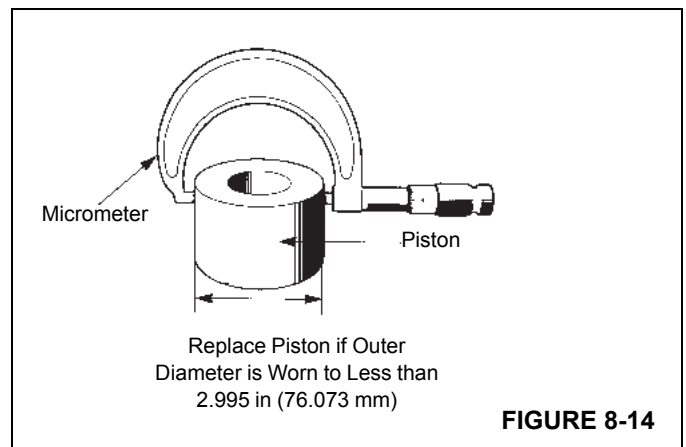


**FIGURE 8-13**

Lining Backing Plate Thickness	Maximum Disc Wear Each Side	Minimum Disc Thickness
0.28 in (7.1 mm)	0.06 in (1.5 mm)	0.50 in (12.7 mm)
0.34 in (8.6 mm)	0.09 in (2.3 mm)	0.44 in (11.2 mm)

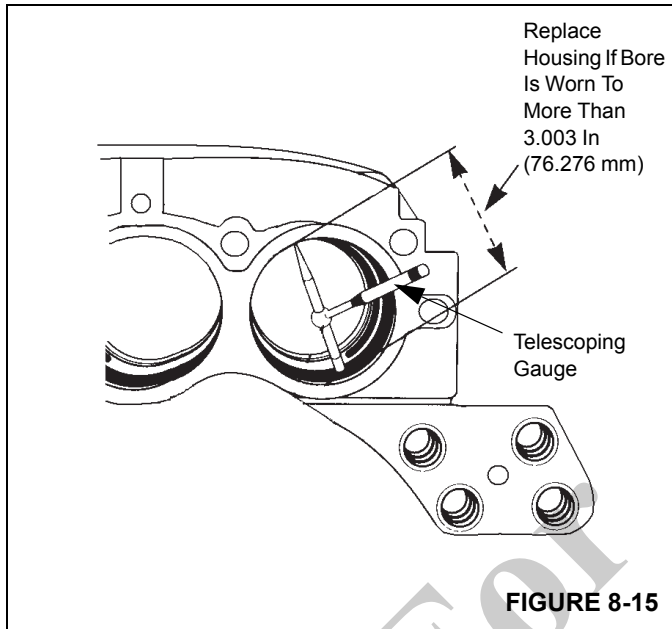
**Caliper Parts**

1. Inspect the pistons, housing bores, and O-ring grooves for scratches or corrosion. Remove small scratches or corrosion with fine emery cloth. Replace the components if they are worn beyond wear limits or if there are large scratches or large amount of corrosion.
2. Measure the diameter of the piston. Replace the piston if the outer diameter is worn to less than 2.995 in (76.073 mm) (Figure 8-14).



**FIGURE 8-14**

3. Measure the diameter of the housing bore. Replace the housing if the diameter is worn to more than 3.003 in (76.276 mm) (Figure 8-15).



4. Inspect the linings as described previously.
5. Inspect the threads of the caliper, cylinder caps, and all fittings. Replace any component that has thread damage that cannot be repaired.
6. Discard all back-up rings, O-rings, and dust seals. Use new ones when assembling the caliper.

**Cleaning**



**WARNING**

Use of cleaning solvents, hot solution tanks, or alkaline solutions incorrectly, can cause serious personal injury. To prevent serious personal injury, follow the instructions supplied by the manufacturer of these products. Do not use gasoline to clean parts. Gasoline can explode and cause serious personal injury.

**CAUTION**

Use only solvent cleaners to clean ground or polished metal parts. Hot solution tanks or water and alkaline solutions will damage these parts. Isopropyl alcohol, kerosene, or diesel fuel can be used for this purpose.

- Use solvent cleaners to clean all metal parts that have ground or polished surfaces. Examples of ground or polished parts are the piston and the piston bore in the caliper.

- Metal parts with rough surfaces can be cleaned with solvent cleaners or with weak alkaline solutions.
- Use a wire brush to clean the threads of fasteners and fittings.
- Use soap and water to clean parts that are not made of metal.
- Scrape away build-ups of mud and dirt on the linings. Replace all linings contaminated with oil or grease.
- Immediately after cleaning, dry all parts with clean paper towels or rags.

**Corrosion Protection**

Apply brake system fluid to the cleaned and dried parts that are not damaged and are to be immediately assembled. **Do Not** apply fluid to the brake linings or the disc.

If parts are to be stored, apply a special material that prevents corrosion to all surfaces. **Do Not** apply the material to the brake linings or the disc. Store the parts inside special paper or other material that prevents corrosion.

**Assembly**

*Caliper*



**CAUTION**

Use only specified components when assembling the calipers. Do not mix components from other calipers. Installing the wrong components may cause the caliper not to operate correctly and may cause damage to equipment. Use of non manufacturer's parts can cause damage, loss of braking, and serious personal injury.

**NOTE:** The O-rings, back-up rings, pistons, and bores must be lubricated before installing the pistons.

1. Lubricate all pistons, bores, O-rings, and back-up rings with silicone grease. If silicone grease is not available, use the same type of fluid that is used in the brake system.
2. Install new O-ring and a new back-up ring in the groove in the middle of the bore. The O-ring is installed toward the outboard end of the bore. The back-up ring is installed toward the lining side of the bore. Refer to the following figure.

**CAUTION**

Do not use silicone grease on the dust seal.



3. Install a new dust seal in the top groove of the bore (Figure 8-16).

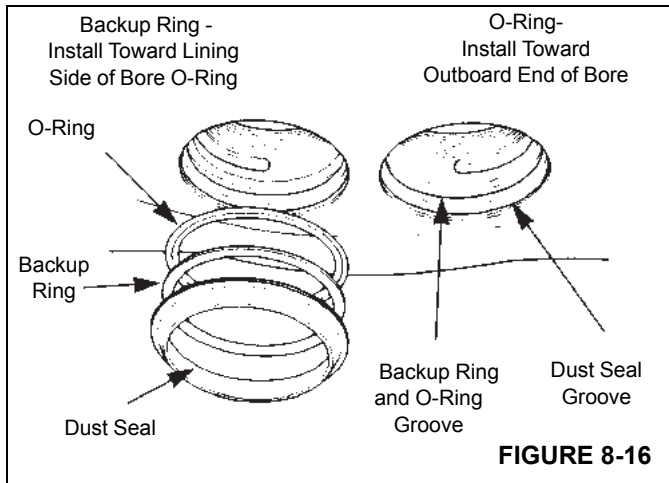


FIGURE 8-16

**NOTE:** Take care when you install the O-ring, so that the cylinder cap threads do not cut the O-ring.

4. Install the pistons in the housing. Push the pistons in from the lining side of the housing. Ensure the pistons are straight in the bores. Push each piston into the bore until the top of the piston is even with the top of the dust seal (Figure 8-17).

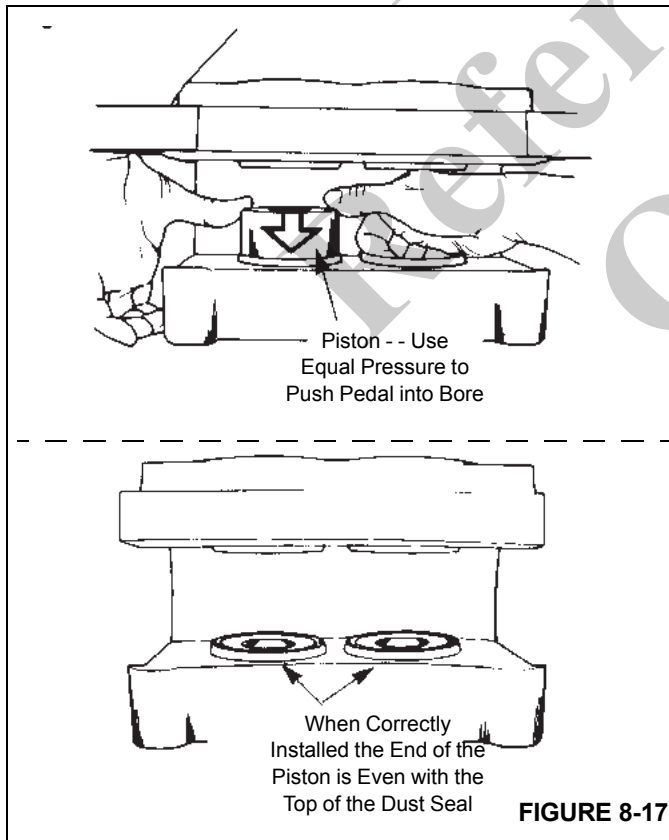


FIGURE 8-17

5. Install a new O-ring in the groove of the cylinder cap. Ensure the O-ring is not cut by the threads on the cylinder cap.

**NOTE:** Apply extra grease on O-ring before installing cylinder caps. This will keep O-ring from catching on threads as cylinder cap is threaded into housing.

6. Install the cylinder caps in the caliper housing. Tighten the cylinder caps to 500 lb-ft (680 Nm) minimum as shown in the following figure.
7. Install the bleeder screws in the housing. Tighten to 100 to 180 lb-in (11.3 to 20.3 Nm).
8. Install the O-ring and the inlet fitting in the cylinder cap.

**Installation**

**Caliper**

1. Position the caliper housing on the mounting bracket. If shims were used, place them as marker during removal.
2. Secure the caliper housing with the bolts and tighten them to 500 to 600 lb-ft (678 to 813 Nm).
3. Install the linings. Refer to Linings - Installation in this section.
4. Ensure the housing is installed correctly on the mounting bracket. The disc must be within  $\pm 0.06$  in ( $\pm 1.5$  mm) of being centered between the lining end plates.
  - a. To increase outboard clearance and decrease inboard clearance, install a shim either between the housing and mounting bracket or between the hub and disc.
  - b. The shims must be steel, ground flat, and parallel and must cover the entire mounting surface of the hub or housing. The linings must move freely in the housing and between the end plates (Figure 8-18).

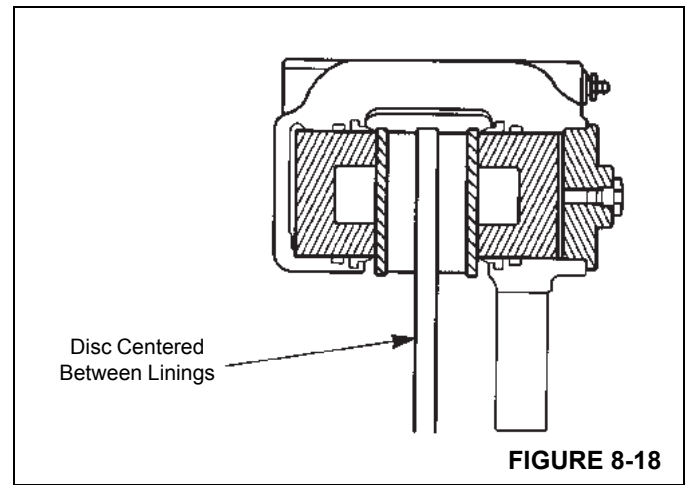


FIGURE 8-18

5. Connect the hydraulic brake line to the inlet fitting.
6. Bleed the brake system.
7. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

### Linings

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#### CAUTION

Always replace both linings. If only one lining is replaced, possible disc damage can occur.

---

1. Install the linings in the caliper housing with the metal backing against the piston and not toward the disc.
2. Position the end plates on the housing and secure with bolts. Apply Loctite 271 or equivalent to the bolt threads.
3. Ensure the linings move freely in the housing.
4. Bleed the brake system.
5. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

### Parking Brake Actuator

#### Description

The spring-applied, hydraulically-released parking brake actuators are located on the front axle and are used to apply and release the parking brake.

#### Maintenance

##### Removal

1. Chock the wheels to prevent crane movement.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the brake. Engine must remain running. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator.
3. Remove the washer and nut securing the brake actuator rod ball joint to the brake linkage lever.
4. Remove the nuts, washers, and lockwashers securing the brake actuator to the mounting bracket and tilt the actuator so the ball joint will clear the linkage lever bolt.

5. Position the Park Brake Switch to ON and shut down the engine.
6. Disconnect the hydraulic line from the brake actuator, then cap or plug all openings.

##### Installation

1. Connect the hydraulic line to the brake actuator.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the brake. Engine must remain running. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator.
3. It will be necessary to tilt the actuator so the ball joint will clear the linkage lever bolt. Position the brake actuator on the mounting bracket and secure in place with the attaching nuts, washers, and lockwashers.
4. Secure the brake actuator rod ball joint to the brake linkage lever with the washer and nut.
5. Position the Park Brake Switch to ON and shut down the engine.

##### Adjustment

1. Chock the wheels to prevent crane movement.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the tension on the brake linkage. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator. Screw the caging nut up under the actuator chamber.
3. Install the rod ball joint until the ball joint will just connect to the brake linkage with the brake lever in a horizontal position.
4. Lock the rod ball joint with the jam nut and back off the caging nut.
5. Position the Park Brake Switch to ON and shut down the engine.

### Parking Brake

#### Description

The parking brake is mounted on the front axle. The brake is a disc-type brake that is controlled by a switch on the front console in the cab and is spring-applied and hydraulically released by an actuator.

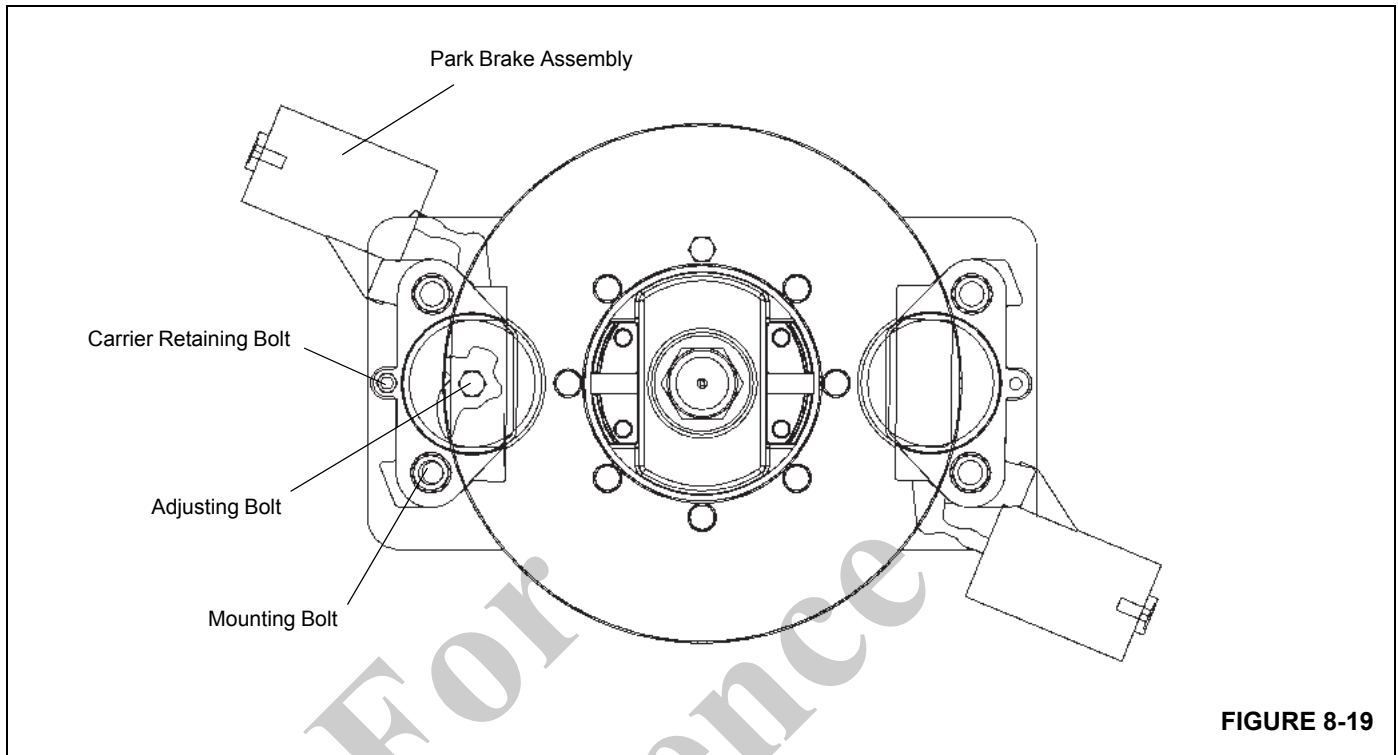


FIGURE 8-19

### Maintenance

#### Removal

1. Chock the wheels to prevent crane movement.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the tension on the brake linkage. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator. Screw the caging nut up under the actuator chamber.
3. Position the Park Brake Switch to ON and shut down the engine.
4. Tag and disconnect the hydraulic hose from the actuator. Cap or plug all openings.
5. Unthread the two mounting bolts securing the brake assembly to the mounting bracket, then carefully remove the brake assembly from the mounting bracket and the brake disc.
6. Repeat steps 4 and 5 for the second caliper.

#### Installation

1. Slide the brake over the disc and align with mounting bracket holes.

**NOTE:** Mount the brake so that the linings are parallel with the disc within 0.015 in.

2. Start the hex mounting bolts into the mounting bracket far enough to just support the brake.
3. Remove plug, loosen the coupling nut and tighten socket setscrew until linings are clamped to the disc. This locates and holds the brake in the proper position to set the hex mounting bolts and hex nuts.
4. Tighten hex mounting bolts until they make contact with the urethane springs, then tighten 4 flats (approximately 0.07 in) more. This puts the proper amount of pre-load on the urethane springs.
5. Tighten jam nut/sleeves against mounting surface.

### CAUTION

Brake linings are susceptible to contamination. When installing or servicing brakes, keep all oil and fluids away from the linings. Poor brake performance may result if linings are contaminated.

6. Attach brake line to inlet port located on the top of the hydraulic cylinder.

### CAUTION

To avoid damage to the brake, do not exceed 270 psi (1861kPa) hydraulic pressure.

7. Apply hydraulic pressure to the brake.
8. With plug removed, loosen coupling nut and set running clearance 0.020 - 0.030 in total by adjusting the socket setscrew. Tighten the coupling nut while holding the socket setscrew in position.
9. Replace plug.
10. Even up the running clearance of the pads 0.010 to 0.015 in (0.254 to 0.381 mm) each side by adjusting the socket head capscrew.
11. Readjust the brake when running clearance reaches a total of 0.100 in (2.54 mm).

## Park Brake Solenoid Valve

### Description

The park brake solenoid valve is located on the right side frame rail in front of the rear axle. The valve is a three-way, two position solenoid valve. The park brake valve is used to control the application of the crane's spring-applied, hydraulically-released parking brake.

Positioning the Park Brake Switch to OFF shifts the three-way, two-position solenoid valve so hydraulic oil can flow to the parking brake actuator, extending it. When the actuator extends, it releases the park brake.

Positioning the Park Brake Switch to ON shifts the three-way, two-position solenoid valve so hydraulic oil can drain from the actuator. The parking brake actuator's rod retracts, forcing hydraulic oil through the valve and the case drain manifold back to the transmission reservoir. As the actuator retracts, it applies the parking brake.

A pressure switch is installed in the line to the actuator. When the park brake is applied, a lack of hydraulic oil pressure keeps the pressure switch closed, which turns on the red LED indicator on the switch. When the park brake is released, pressure buildup opens the switch, which turns off the indicator.

### Maintenance

#### Removal

1. Tag and disconnect the electrical connector from the valve.
2. Tag and disconnect the hydraulic lines attached to the valve. Cap or plug lines and ports.
3. Remove the capscrews, nuts and washers securing the valve to the frame. Remove the valve.

#### Installation

1. Secure the valve to the frame and secure with the washers, nuts and capscrews.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Apply and release the park brake several times. Verify the park brake holds the crane when applied. Verify the park brake doesn't drag when released.
5. Check for leaks. Make repairs as needed.

## OUTRIGGER CIRCUIT

### Description

The outrigger circuit consists of four extension cylinders, four jack cylinders, an integrated outrigger/rear steer valve, front and rear outrigger control manifolds, pilot operated check valves and four Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometers. The front two extension cylinders are mounted in the front outrigger beams and the rear two extension cylinders are mounted in the rear outrigger beams. The front and rear outrigger beams are mounted in their respective outrigger boxes; in turn a jack cylinder is mounted on the end of each outrigger beam. The integrated outrigger/rear steer valve is mounted on the front face of the carrier frame front cross member. The front and rear outrigger control manifolds are mounted on the inside center of their respective outrigger box. An OMS string potentiometer (if equipped) is mounted inside each outrigger box. The potentiometer is connected by a cable to the outrigger beam to monitor the beam's position—fully retracted, mid-extend, or full extended.

The outrigger selector controls are located in the cab on the front console. Both the integrated outrigger valve and the manifold solenoid valves are electrically actuated from these controls. The solenoid switches must be held depressed to actuate the solenoid valve. The integrated outrigger valve switch is spring loaded to the off position. The console is labeled with switch positions.

A sight bubble level is mounted on the right side of the cab by the right side controls. The sight bubble level provides the operator with a visual indication of crane level attitude.

### Theory Of Operation

The appropriate Extension/Jack Switch must be depressed before the Outrigger Extend/Retract Switch is depressed. Depressing one of the outrigger selector switches causes that solenoid valve to open. As the Outrigger Switch is moved, the integrated outrigger valve spool shifts allowing flow to either the extend or retract line as applicable. If the Outrigger Switch is in the EXTEND position, the flow continues through the open solenoid valve to the piston side of the cylinder. If the jack is to be extended, the flow first unseats the cylinder check valve then extends the cylinder. The oil from the rod end flows through the integrated outrigger valve, and then to the reservoir.

When the Outrigger Switch is in the RETRACT position, the flow through the selector valve is directed to the rod side of the cylinder. The oil in the piston side flows through the open solenoid back to the integrated outrigger valve. If a jack cylinder is to be retracted, pilot pressure from the pressurized retract line unseats the cylinder check valve allowing oil to flow from the piston side through the open solenoid valve to the integrated outrigger valve. The integrated outrigger valve directs the flow to the reservoir.

The integrated outrigger/rear steer valve contains three relief valves. The main relief is set at 3500 psi (24,133 kPa). Thermal relief protection is provided on the extend side by a 4000 psi (27,580 kPa) relief valve. Thermal relief protection is provided on the retract side by a 4000 psi (27,580 kPa) relief valve.

Maintenance

Table 8-4  
Troubleshooting

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	a. Damaged relief valve.	a. Remove relief valve; clean or replace.
	b. Low hydraulic oil.	b. Check system for leaks. Make repairs as needed. Fill reservoir. Refer to <i>Lubrication</i> , page 9-1.
	c. Sticking solenoid valve spool.	c. Repair or replace valve spool.
	d. Improper ground to base of solenoid.	d. Ground properly.
	e. Directional selector switch sticking.	e. Clean or replace switch.
	f. Collector ring dirty or glazed.	f. Clean and deglaze collector ring.
	g. Damaged wiring to solenoid.	g. Replace wiring.
	h. Weak brush springs on collector ring.	h. Replace brush springs. Refer to your Manitowoc Crane Care Parts Manual.

For Reference Only

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders. (continued)	i. Damaged extension cylinder (internal parts).	i. Remove extension cylinder and repair as necessary.
	j. Bent cylinder rods.	j. Replace piston rods and seals.
	k. Excessive material on outrigger beams.	k. Clean outrigger beams.
	l. Binding outrigger beam.	l. Repair or replace outrigger beam.
	m. Damaged outrigger valve.	m. Repair or replace valve.
	n. Damaged valve coil.	n. Replace coil.
	o. Main hydraulic pump cavitation.	o. Replace or tighten hose or fitting. Refer to your Manitowoc Crane Care Parts Manual.
	p. Partially shifted hydraulic spool in selector valve or manifolds.	p. Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	q. Insufficient voltage for operation of solenoid valve.	q. Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical coupling collector rings.
	r. Damaged piston seals.	r. Replace all cylinder seals.
	s. Worn or damaged hydraulic pump section.	s. Repair or replace pump section.
2. Sticking spool.	t. Scored cylinder barrel.	t. Repair or replace extension cylinder.
	u. Cracked or damaged piston.	u. Replace rod weldment and all cylinder seals.
	a. Dirt in the system.	a. Change oil and flush system.
	b. Distortion caused by tie bolts being overtorqued.	b. Retorque tie bolts.
	c. Flow in excess of valve rating.	c. Limit flow through valve to that recommended. Check pump output and cylinder ratio.
3. External leakage.	d. Pressure in excess of valve rating.	d. Check relief valve setting or pump compensation with that recommended.
	e. Electrical failure.	e. Check wiring and solenoids.
	a. Damaged O-ring or quad rings.	a. Check for chipped packings and replace.
	b. Loose tie bolts.	b. Retorque tie bolts.
	c. Damaged solenoid.	c. Replace damaged parts.

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Symptom	Probable Cause	Solution
4. Solenoid failure.	a. No current.	a. Check power source of at least 85% of coil rating.
	b. Damaged solenoid assembly.	b. Replace solenoid.
	c. Short in solenoid.	c. Replace coil.
	d. Loss of solenoid force.	d. Decrease time of solenoid energization, decrease cycle rate.
5. Outrigger jack cylinder slow or erratic.	a. Low in hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Damaged main relief valve.	b. Repair or replace valve.
	c. Damaged holding valve seals.	c. Replace holding valve seals.
	d. Bent cylinder rod.	d. Replace cylinder rod and seals.
	e. Bent outrigger housing.	e. Repair or replace outrigger housing.
	f. Excessive material on beams.	f. Clean outrigger beams.
	g. Sticking solenoid valve spool.	g. Repair or replace valve spool.
	h. Damaged wiring to solenoid.	h. Repair or replace wiring.
	i. Weak brush springs on collector rings.	i. Replace brush springs.
	j. Collector ring dirty or glazed.	j. Clean or deglaze collector ring.
	k. Directional selector switch sticking.	k. Clean or replace switch.
	a. Main hydraulic pump cavitation.	l. Replace or tighten hose and fittings.
	b. Worn or damaged hydraulic pump section.	m. Repair or replace pump section.
6. Outrigger jack cylinder retracts under load.	a. Damaged piston seals.	a. Replace all cylinder seals.
	b. Damaged holding valve seals.	b. Replace seals.
	c. Damaged holding valve.	c. Replace valve assembly.
	d. Scored cylinder barrel.	d. Repair or replace cylinder.
	e. Cracked or damaged piston.	e. Replace piston and all cylinder seals.
7. Outrigger jack cylinder extends while machine is traveling.	a. Damaged piston seals.	a. Replace all cylinder seals.
	b. Scored cylinder barrel.	b. Replace jack cylinder.
	c. Cracked or damaged piston.	c. Replace piston and seals.
	d. Piston loose on cylinder rod.	d. Replace seal and retorque.



Symptom	Probable Cause	Solution
8. Outrigger system will not activate (from stowed or extended and down position).	a. Hydraulic oil low.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Loose or broken wire on switch.	b. Repair or replace wiring.
	c. Clogged, broken, or loose lines or fittings.	c. Clean, tighten, or replace lines or fittings.
	d. Damaged relief valve or damaged control valve.	d. Repair or replace valve.
9. Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	a. Clogged, broken, or loose hydraulic lines or fittings.	a. Clean, tighten, or replace lines or fittings.
	b. Loose or broken wire on control switch or solenoid valve.	b. Repair or replace wiring.
	c. Damaged solenoid valve.	c. Repair or replace valve.
	d. Damaged control switch.	d. Replace switch.
	e. Damaged hydraulic cylinder.	e. Repair or replace cylinder.
10. Outriggers will not set.	a. Improper sequence of activation.	a. Activate individual control switch; then activate system control switch.
11. Two outriggers activate from single control switch	a. Damaged solenoid valves.	a. Repair or replace.
12. The two outriggers will not stow.	a. Hydraulic lock.	a. Recycle individual outrigger(s).
13. Individual outrigger will not set or stow.	a. Damaged piston seals.	a. Replace seals.
	b. Damaged check valve.	b. Repair or replace valve.
	c. Loosen or broken wire on control switch or solenoid valve.	c. Repair or replace wiring.
	d. Damaged solenoid valve.	d. Repair or replace valve.

**Outrigger Beam**

**Description**

The outrigger beam assembly consists of an outrigger beam, a jack cylinder, a extension cylinder, an Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometer, and the required hoses and mounting hardware.

**Theory Of Operation**

When the outrigger extension is activated, it extends or retracts the outrigger beam within the outrigger box. The outrigger beam can be extended to the mid-extend position by allowing the lock pin to ride on the top of the beam while it's extending. The lock pin will automatically drop into the hole when the beam reaches the mid-extend position.

The jack cylinder is mounted to the end of the beam and applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

The Outrigger Monitoring System (OMS) string potentiometer (if equipped) is mounted inside the outrigger box and is connected to the outrigger beam by a cable. The string potentiometer identifies whether an extension beam is at the fully retracted, mid-extend, or fully extended position. The OMS communicates the position of each outrigger beam to the rated capacity limiter (RCL), aiding the operator in accurately programming the crane's configuration.

**Maintenance****Removal**

1. On the jack cylinder end of the beam, remove the set screw from the side adjustable wear pad and back off the wear pad from the outrigger box.
2. Remove the cover from the opposite end of the outrigger box. Remove the setscrew from the side adjustable wear pad and back off the wear pad from the beam.
3. Remove the setscrews from the bottom adjustable wear pads and back off the wear pads leaving approximately 0.125 in (3.2 mm) protruding.

For  
Reference  
Only

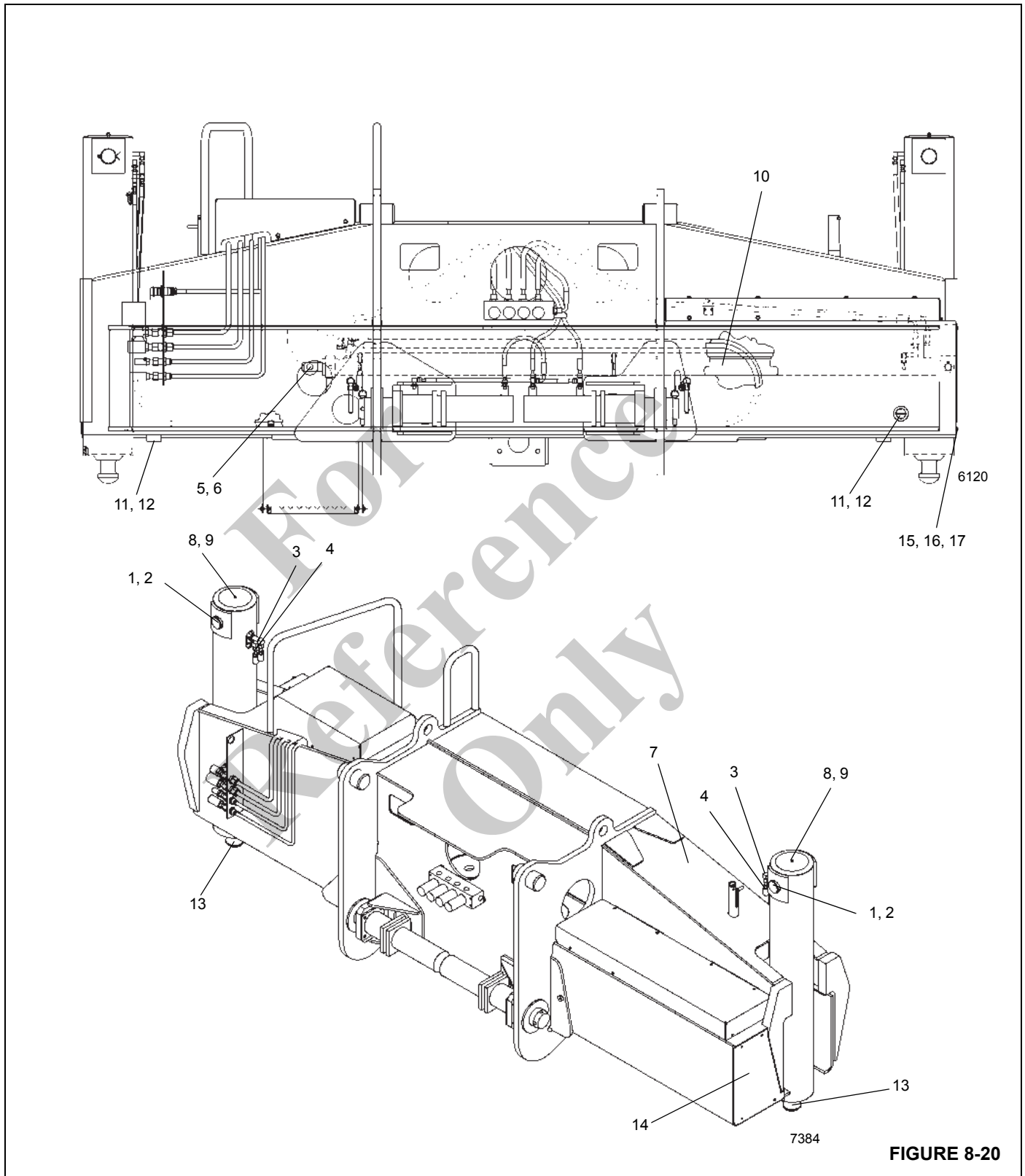
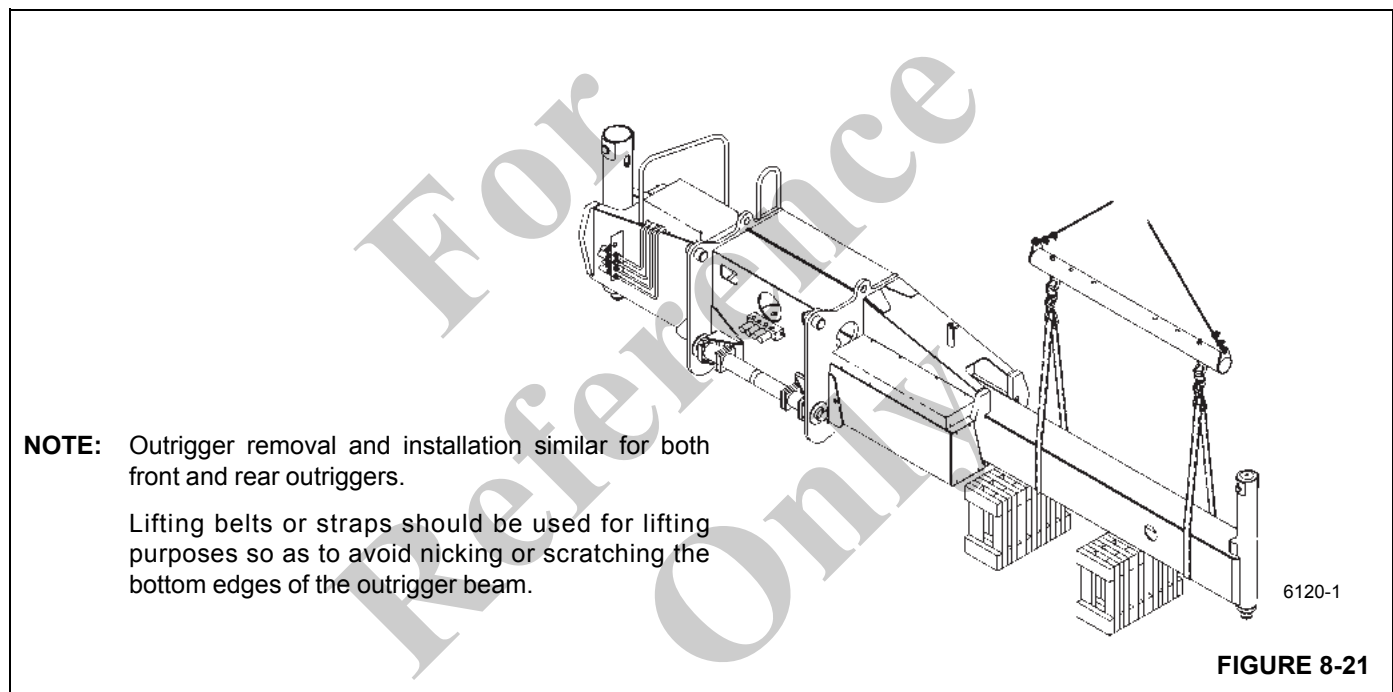


FIGURE 8-20

Item	Description
1	Retainer Pin
2	Cotter Pin
3	Extend Port
4	Retract Port
5	Clevis Pin
6	Cotter Pin
7	Outrigger Box
8	Locknut
9	Lockwasher

Item	Description
10	Extension Cylinder
11	Wear Pad
12	Setscrew
13	Jack Cylinder
14	Cover Plate
15	Nut
16	Cotter Pin
17	Capscrew



**NOTE:** Outrigger removal and installation similar for both front and rear outriggers.

Lifting belts or straps should be used for lifting purposes so as to avoid nicking or scratching the bottom edges of the outrigger beam.

**! WARNING**

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

4. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
5. Place blocking material under the outrigger beam (Figure 8-21).
6. Tag and disconnect the hydraulic lines at the cylinder barrel end of the extension cylinder. Cap all lines and fittings.

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

7. Remove the OMS string potentiometer cable (if equipped) from the attaching point on the outrigger beam.

**NOTE:** Avoid free-release of cable to prevent damage to OMS string potentiometer caused by over-range of cable.

8. Remove the cotter pin and clevis pin securing the cylinder barrel end of the extension cylinder to the outrigger housing. Carefully extend the outrigger beam until the extension cylinder is free of the housing and

carefully lay the end of the cylinder on the bottom of the outrigger beam or leave on blocking.

**NOTE:** Do not allow the end of the outrigger extension cylinder to fall when the cylinder mounting shaft is removed. Use blocking to limit the drop to prevent damage to the OMS string potentiometer (if equipped).

OMS string potentiometer may be easily removed to avoid damage during extension cylinder pin removal. Refer to *Outrigger Monitoring System (Optional—Standard in North America)*, page 8-33.

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



### **WARNING** **Crushing Hazard!**

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

**NOTE:** The outrigger beam assembly weighs approximately 2132 lb (967 kg).

- Position the outrigger beam on the blocking material.

#### **Inspection**

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

#### **Installation**

- Apply grease (EP-MPG) to the bottom of the outrigger beam.
- If removed, install the side adjustable wear pad in the outrigger beam.
- Install the bottom wear pads with approximately 0.125 in (3.2 mm) protruding. This will prevent the beam side plates from riding on the bottom of the box.
- Attach a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam.
- Slide the beam into the outrigger housing and align the cylinder bushing with the mounting hole.

- Apply anti-seize compound to the clevis pin. Secure the cylinder barrel to the housing with the clevis pin and cotter pin.
- Attach the OMS string potentiometer cable (if equipped) to the attaching point on the outrigger beam.

If the OMS string potentiometer was removed, install the potentiometer at this time. Refer to *Outrigger Monitoring System (Optional—Standard in North America)*, page 8-33.

**NOTE:** Avoid free-release of cable to prevent damage to OMS string potentiometer caused by over-range of cable.

### **CAUTION**

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

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

- Connect the hydraulic lines as tagged prior to removal.
- Install the side adjustable wear pad in the outrigger box.
- Adjust the wear pads, refer to *Wear Pad Adjustment* in the following section.
- Install the end cover.

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

#### **Wear Pad Adjustment**

**NOTE:** When adjusting wear pads, refer to (Figure 8-22).

- Adjust each of the bottom wear pads (about 1/2 turn) until there is a gap of 0.12 to 0.18 in (3.0 to 4.5 mm) between the top of the beam and the top of the outrigger box. Install and lock set screws against wear pads.
- Adjust outrigger box side wear pad until there is a gap of 0.12 to 0.18 in (3.0 to 4.5 mm) between beam and shims welded in top and bottom of box. Install and lock set screw against wear pad.
- Adjust outrigger beam side wear pad until there is a gap of 0.12 to 0.18 in (3.0 to 4.5 mm) between shim welded on beam and side of box. Install and lock set screw against wear pad.

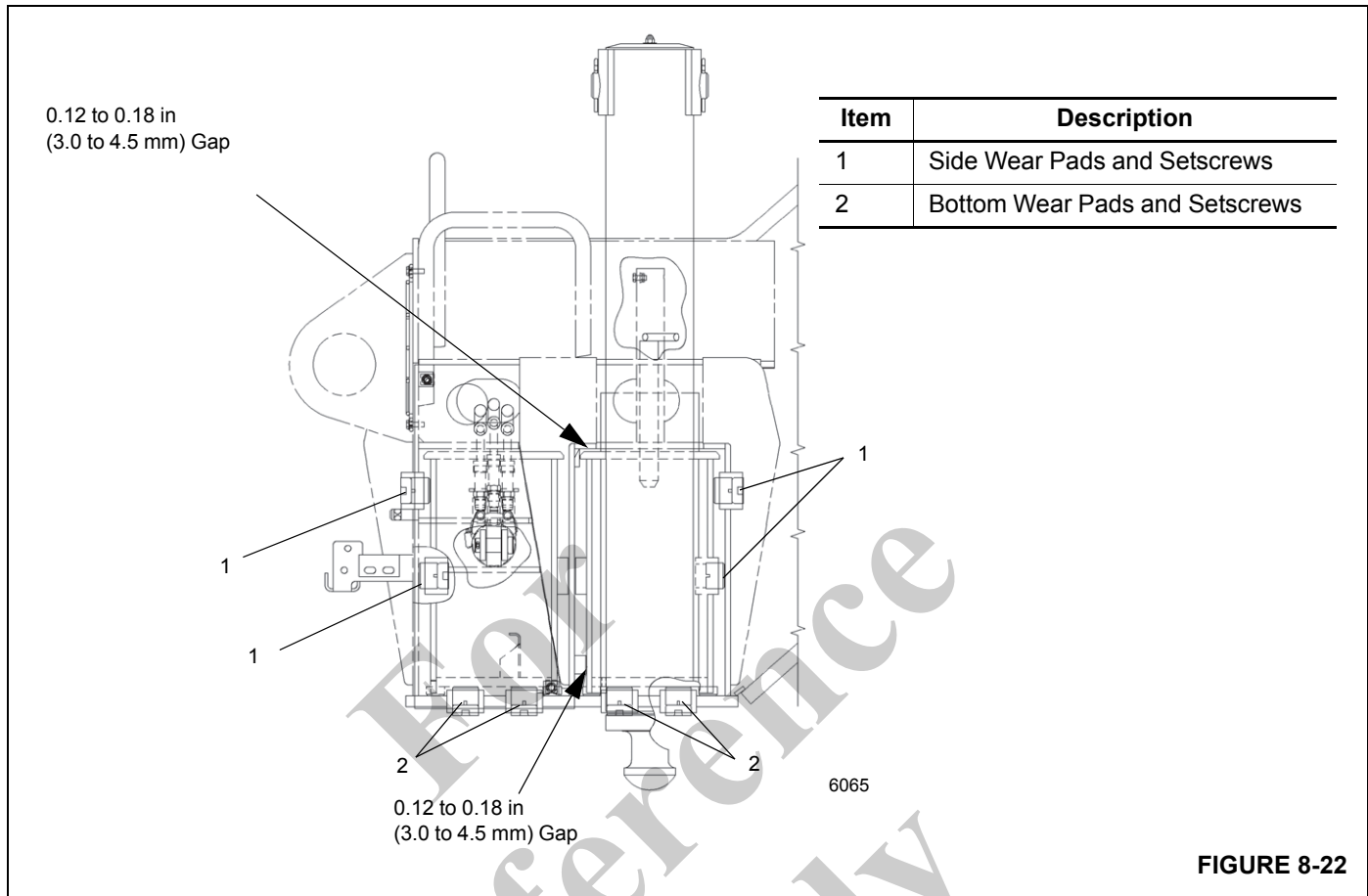


FIGURE 8-22

**Extension Cylinder**

**Description**

Two outrigger extension cylinders are utilized within each outrigger box assembly. The extension cylinders provide the force for the outrigger beam's horizontal movement. The cylinder weighs approximately 104.9 lb (47.6 kg).

**Maintenance**

**NOTE:** Refer to *Outrigger Extension Cylinder*, page 2-86 for disassembly and assembly of the cylinder.

**Removal**

1. Remove the outrigger beam. Refer to *Outrigger Beam*, page 8-27 in this section.
2. Remove the cotter pin and clevis pin securing the rod end of the extension cylinder to the outrigger beam.
3. Pull the extension cylinder from the outrigger beam until the hydraulic hoses on the rod end of the cylinder can be accessed. Tag and disconnect the hoses from the rod end of the cylinder. Cap or plug all openings.
4. Remove the cylinder.

**Installation**

1. Place the cylinder in the beam.

**NOTE:** Keep hydraulic fittings and hoses close to angles shown and as low as possible to prevent rubbing with the beam top plate and side plate, and for proper tracking during beam extension and retraction (Figure 8-23).

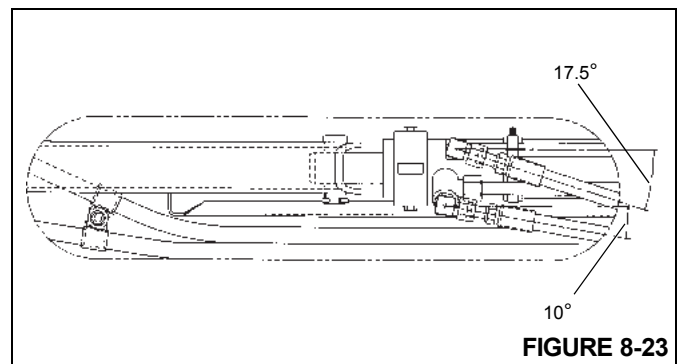


FIGURE 8-23

2. Position the extension cylinder so the hydraulic ports on the rod end of the cylinder can be accessed. Connect the hydraulic hoses to the ports as tagged during removal. Verify the piston side of the extension cylinder

is connected to the solenoid valve bank to prevent damage.

3. Push the cylinder into the outrigger beam. Align the cylinder rod with the clevis in the beam. Apply anti-seize compound to the clevis pin and secure in place with the clevis pin and cotter pin.
4. Install the outrigger beam. Refer to *Outrigger Beam*, page 8-27 in this section. Verify no jack cylinder hose will be trapped by full outrigger beam retraction.

#### Functional Check

1. Activate the hydraulic system; extend and retract the outrigger.
2. Observe the operation of the outrigger beam.
3. Check the hydraulic connections for any evidence of leakage.

#### Outrigger Monitoring System (Optional—Standard in North America)

##### Description

The Outrigger Monitoring System (OMS) aids the operator in accurately programming the rated capacity limiter (RCL) by automatically identifying the position of each outrigger beam. The OMS uses four sensors, one per outrigger beam, to identify when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

##### Removal

1. Remove the outer access cover plate from outrigger box.
2. Remove the OMS string potentiometer connector (1, (Figure 8-24)) from the attaching point on the outrigger beam.

**NOTE:** Avoid free-release of cable to prevent damage to OMS string potentiometer.

3. Disconnect electrical harness connector (2) and secure to avoid damage.
4. Loosen top mounting hardware enough to disengage OMS string potentiometer from the slotted top mounting hole.
5. Completely remove the lower mounting hardware.
6. Remove OMS string potentiometer from inside outrigger beam.

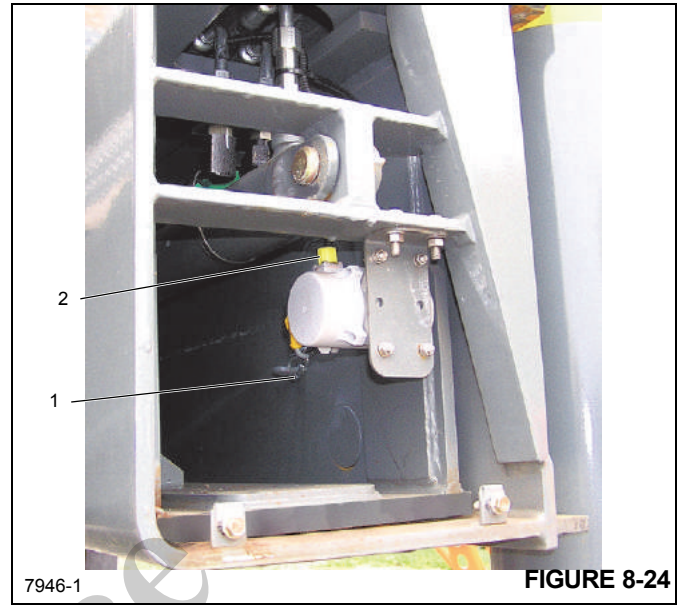


FIGURE 8-24

##### Installation

1. Install string potentiometer inside outrigger beam.
2. Install the OMS string potentiometer enough to engage slotted hole with top mounting hardware ((Figure 8-24)).
3. Install the lower mounting hardware.
4. Attach the OMS string potentiometer connector to the attaching point on the outrigger beam.

**NOTE:** Avoid free-release of cable to prevent damage to the OMS string potentiometer.

5. Connect electrical harness connector to string potentiometer.
6. Install access cover plate to outrigger box.

#### Jack Cylinder

##### Description

Four jack cylinders are used on the crane, one at the end of each outrigger beam. The jack cylinders provide the force for the outrigger beam's vertical movement. The cylinder weighs approximately 220.4 lb (100 kg).

##### Maintenance

**NOTE:** Refer to *Outrigger Extension Cylinder*, page 2-86 for disassembly and assembly of the cylinders.

**Removal**

1. Extend the outrigger beam slightly for improved access to the jack cylinder; shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder. Remove the fittings from the ports. Cap or plug all openings.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
6. Jack the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure the pin in place with the cotter pins.

**CAUTION**

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

**Installation**

1. Apply grease (EP-MPG) to the inside diameter of the jack cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under *Removal*, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.
5. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam.

6. Apply anti-seize compound to the retaining pin. Secure the cylinder and cylinder cap retaining bracket to the support tube with the retaining pin and cotter pins.
7. Install the cylinder cap.
8. Install the fittings in the cylinder ports and connect the hoses as tagged during removal. Verify the piston side of the jack cylinder is connected to the solenoid valve bank to prevent damage. Verify no jack cylinder hose will be trapped by full outrigger beam retraction.

**Functional Check**

1. Activate the hydraulic system.
2. Observe the operation of the jack cylinder. If hydraulic lines are reversed, stop immediately and connect lines properly per instructions. Verify no jack cylinder hose is trapped by full outrigger beam retraction; if any is, stop immediately and install lines properly to avoid trapping.
3. Check the hydraulic connections and hoses for evidence of leakage. Make repairs as needed.

**Outrigger Control Valves****Description**

There are four valve assemblies responsible for controlling the outrigger system, the integrated outrigger/rear steer valve, the front and rear outrigger control manifolds, and the pilot operated check valves.

**NOTE:** For a more detailed description and maintenance of the valves, refer to *Outrigger Control Manifold*, page 2-57.

**Pilot Operated Check Valve**

The pilot operated check valves are located in the outrigger jack port blocks. The check valve provides two functions; the first function is a holding valve, the second function provides a thermal relief of the jack.

**Integrated Outrigger/Rear Steer Valve**

The integrated outrigger/rear steer valve is mounted on the rear face of the carrier frame front cross member. The outrigger portion of the valve consists of a 4-way two position solenoid valve. The inlet section contains the main relief valve.

**Outrigger Control Manifold**

The front and rear outrigger control manifolds are located on the respective outrigger boxes. Each manifold consists of four 12 volt solenoid valves and an assembly mounting kit.



## SECTION 9 LUBRICATION

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### GENERAL

Following the designated lubrication procedures is important in ensuring maximum crane lifetime and utilization. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information.

### 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.

### LUBRICANTS AND LUBRICATION INTERVALS

The service intervals specified are for normal operation where moderate temperature, humidity, and atmospheric conditions prevail. In areas of extreme conditions, the service periods and lubrication specifications should be altered to meet existing conditions.

For information on extreme condition lubrication, contact your local Manitowoc Cranes distributor or Manitowoc Crane Care.

**NOTE:** All fluids and lubricants may be purchased by contacting an authorized Manitowoc distributor or Manitowoc Crane Care Parts Department.

**CAUTION****Possible Equipment Damage!**

Chassis grease lubricants must not be applied with air pressure devices as this lubricant is used on sealed fittings.

The multipurpose grease applied during manufacturing is of a lithium base. Use of a noncompatible grease could result in damage to equipment.

**Standard Lubricants**

Standard lubricants are used on all Manitowoc cranes unless the crane is ordered with a cold weather package. These standard lubricants are effective in temperatures down to -9°C (15°F). Refer to (Table 9-1) for a list of the recommended standard lubricants.

**Table 9-1: Standard Lubricants [Down to -9°C (15°F)]**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
<b>Axle Gear Oil</b>	6829012964	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO	80W-90	
<b>Tier 3 Engine Oil</b>	6829003483	Exxon XD-3 Conoco Fleet Supreme	15W-40	CI-4
<b>Tier 4 Engine Oil</b>	6829104182	Conoco Fleet Supreme EC Mobil Delvac 1300 Super	15W-40	CJ-4
<b>Hydraulic/Transmission Oil</b>	6829006444	Kendall Hyken 052 Exxon Torque Fluid 56 Esso Torque Fluid 56 BP-Eldoran UTH & Trak-Tran 9 BP- Blend- 7367	10W-20	Must Meet John Deere Std. JDM J20c
		Exxon Mobil 424	10W-30	
<b>Hoist Gear/Swing Drive Oil</b>	6829100213	Mobil: Mobilfluid 629 Texaco: Meropa 150		AGMA No. 4 EP
<b>Grease, Multipurpose</b>	6829003477	Citgo Lithoplex MP# 2 Texaco Starplex Moly # 2 Phillips 66 Philube M Mobil Mobilgrese XHP 222 Special Chemtool Inc, Lube-A-Boom	NLGI 2	
<b>Open Gear Lube</b>	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
<b>Antifreeze Coolant</b>	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
<b>Supplemental Coolant Additive (SCA)</b>	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		

**Arctic Lubricants and Conditions**

**Temperatures Below -9°C (15°F)**

Regions with ambient temperatures below -9°C (15°F) are considered arctic. In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results in these temperatures. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, may not be compatible with hydraulic system seals and wear bands. Therefore, always check with an authorized Manitowoc distributor or Manitowoc Crane Care if in doubt of the suitability of a specific fluid or lubricant.

When operating in cold weather and regardless of the oil viscosity of the crane’s lubricants, always follow the cold weather start-up and operating procedures described in the *Operator Manual* to ensure adequate lubrication during system warm-up and proper operation of all crane functions.

**Cold Weather Package and Lubricants**

Manitowoc recommends the following cold weather lubricants for use with ambient temperatures down to -29°C (-20°F) ((Table 9-2)) and -40°C (-40°F) (Table 9-3). But, these cold weather lubricants alone are not sufficient to operate the crane in extreme low temperatures. Therefore, it is also recommended that the crane be equipped with the following accessories:

**Down to -29°C (-20°F) Package**

- Battery heater
- Fuel line heater
- Engine hood insulation
- Fan clutch

- Radiator air shutters
- Air diverter
- Diesel fired cab heater
- Cold weather alternator
- Fluids suitable to -29°C (-20°F)
  - Arctic windshield washer fluid
  - Arctic fuel

**Down to -40°C (-40°F) Package**

- Coolant heater (to circulate warm coolant through heaters and engine)
- Transmission heater
- Swivel heater
- Battery heater
- Fuel line heater
- Hydraulic reservoir heater
- Engine hood insulation
- Fan clutch
- Radiator shutters
- Air diverter
- Diesel fired cab heater
- Cold weather alternator
- Super-capacitor starting system
- Fluids suitable to -40°C (-40°F):
  - Arctic windshield washer fluid
  - Arctic fuel

**Table 9-2: Cold Weather Lubricants [Down to -29°C (-20°F)]**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
<b>Axle Gear Oil</b>	6829014058	Petro-Canada Traxon E Synthetic CITGO, Syntetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	
<b>Tier 3/Tier 4 Engine Oil</b>	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4

Table 9-2: Cold Weather Lubricants [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
Hoist Gear/Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencoool 3000		
Hydraulic Oil	6829006993	Exxon Mobil Univis HVI	26	
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III Product #1	#1	NLOCK08

Table 9-3: Cold Weather Lubricants [Down to -40°C (-40°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Axle Gear Oil	6829014058	Petro-Canada Traxon E Synthetic CITGO, Syntetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	
Tier 3/Tier 4 Engine Oil	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d

Table 9-3: Cold Weather Lubricants [Down to -40°C (-40°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Hoist Gear/Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829104212	Old World Industries, Inc. Fleet Charge SCA Pre-charged Fleetguard Compleat EG Petro-Canada	Mix 60/40	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Hydraulic Oil	6829006993	Exxon Mobil Univis HVI	26	
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III	#1	NLOCK08

**SURFACE PROTECTION FOR CYLINDER RODS**

Steel cylinder rods include a thin layer of chrome plating on their surfaces to protect them from corroding. However, chrome plating inherently has cracks in its structure which can allow moisture to corrode the underlying steel. At typical ambient temperatures, hydraulic oil is too thick to penetrate these cracks. Normal machine operating temperatures will allow hydraulic oil to warm sufficiently to penetrate these cracks and if machines are operated daily, protect the rods. Machines that are stored, transported, or used in a corrosive environment (high moisture, rain, snow, or coastline conditions) need to have the exposed rods protected more frequently by applying a protectant. Unless the machine is operated daily, exposed rod surfaces will corrode. Some cylinders will have rods exposed even when completely retracted. Assume all cylinders have exposed rods, as corrosion on the end of the rod can ruin the cylinder.

It is recommended that all exposed cylinder rods be protected using Boeshield® T-9 Premium Metal Protectant. Manitowoc Crane Care has Boeshield® T-9 Premium Metal Protectant available in 12 oz. aerosol cans by ordering part number 9999101803 through the Parts Department.

Cylinder operation and inclement weather will remove the Boeshield® protectant; therefore, inspect machines once a week and reapply Boeshield® to unprotected rod

**WIRE ROPE LUBRICATION**

Wire rope is lubricated during manufacturing so that the strands, and individual wires in strands, may move as the rope moves and bends. A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added periodically throughout the life of a rope to replace factory lubricant which is used or lost. For more detailed information concerning the lubrication and inspection of wire rope, refer to Wire Rope in Section 1- Introduction in the Service Manual.

**LUBRICATION POINTS**

A regular frequency of lubrication must be established for all lubrication points. Normally, this is based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log indicating crane usage. The log must use the engine hourmeter to ensure coverage of lube points that will receive attention based on their readings. Other lubrication requirements must be made on a time basis, i.e. weekly, monthly, etc.

All oil levels are to be checked with the crane parked on a level surface in transport position, and while the oil is cold, unless otherwise specified.

On plug type check points, the oil levels are to be at the bottom edge of the check port.

On all hoists with a check plug in the drum, the fill plug shall be directly on top of the hoist, and the check plug level.

All grease fittings are SAE Standard unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. One ounce (28 grams) of EP-MPG equals one pump on a standard one pound (0.45 kg) grease gun.

Over lubrication on non-sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.

On sealed U-joints, care must be exercised to prevent rupturing seals. Fill only until expansion of the seals first becomes visible.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, levers, etc., should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to ensure complete lubrication of the entire wear area.

### CraneLUBE

Manitowoc highly recommends the use of CraneLUBE lubricants to increase your crane's reliability and performance. Contact your Manitowoc Distributor for

information about the Manitowoc's CraneLUBE lubrication program.

### 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 username 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.

### Safety

To lubricate many of the locations the engine will need to be started. After positioning areas of the unit for lubrication the engine must be turned off and the moved areas stable before approaching.



### WARNING

#### Crushing Hazard!

Movement of the superstructure and the boom may create a crushing and/or pinching hazard. Failure to observe this warning could result in death or serious injury if the message is ignored.

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Steering and Suspension						
Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
1	Steer Cylinder Pivot Pins	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	8 grease fittings
2	Upper and Lower King Pins	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	8 grease fittings
<p><b>NOTE:</b></p> <ul style="list-style-type: none"> <li>Grease the top side bearing of the king pin with the crane on rubber until the grease is observed oozing from the bearing.</li> <li>Grease the bottom side bearing of the king pin with the crane on outriggers (wheels have no contact with ground) until the grease is observed oozing from the bearing.</li> <li>After greasing the bushings, turn/steer the hub ends a few times without load (crane on out riggers).</li> </ul>						
3	Fifth Wheel Pivots	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings
4	Lockout Cylinder Pivot Pins	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	4 grease fittings
5	Tie Rod Pivot Pins	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	4 grease fittings

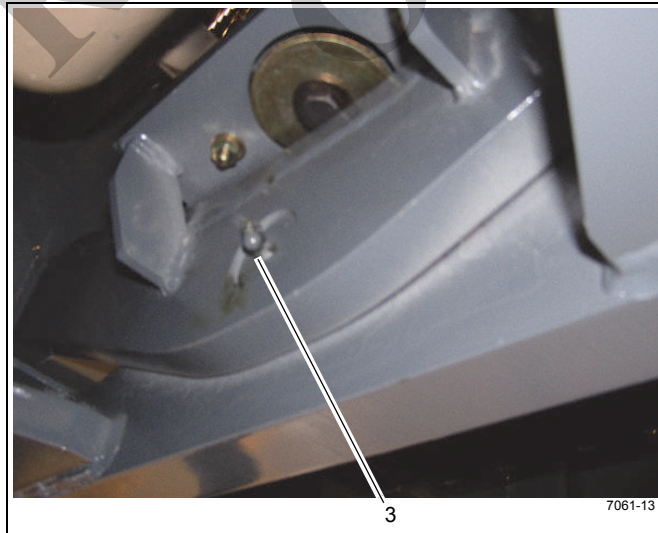
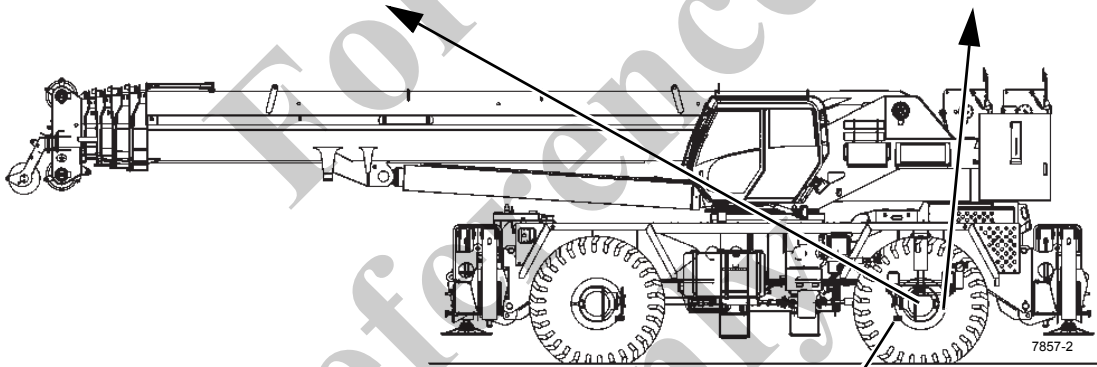
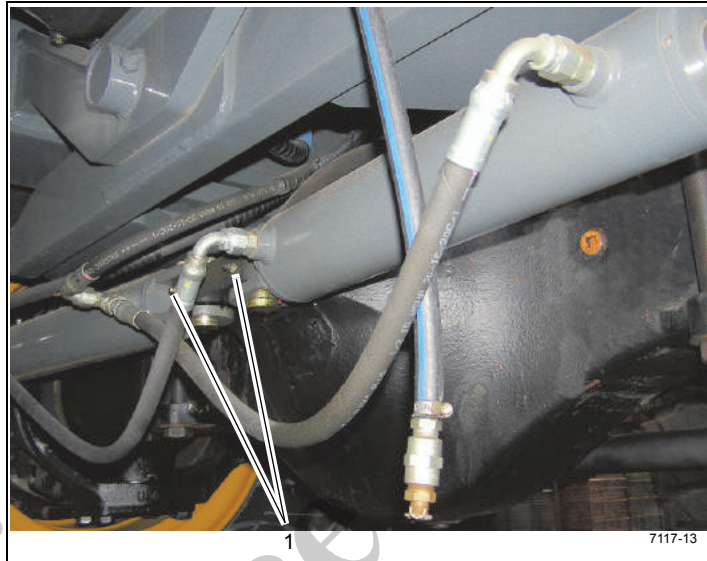
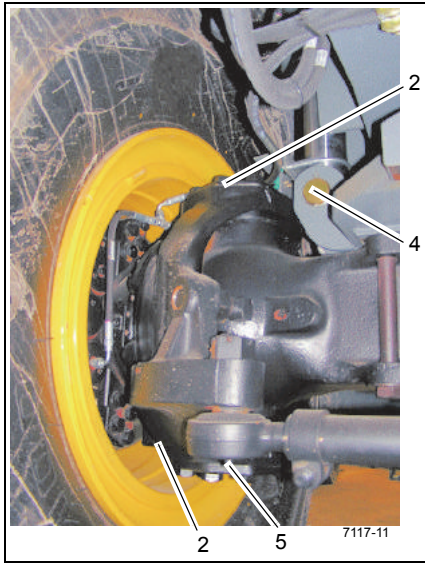


FIGURE 9-1



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Axles</b>						
11	Differentials	Figure 9-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	72 pints (34 l)	<ul style="list-style-type: none"> <li>• Check level every 500 hours or 3 months</li> <li>• Drain and fill every 4000 hours or 2 years</li> </ul>	Fill to bottom of hole in housing on the steer cylinder side
<p><b>NOTE:</b> Lube level close enough to the hole to be seen or touched is not sufficient. It must be level with the hole. When checking lube level, also check and clean housing breathers.</p> <p><b>CAUTION:</b> Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.</p> <p><b>CAUTION:</b> If the makeup amount is substantially more than 0.23 liter (0.5 pint), check for leaks.</p>						
12	Planetary Hubs and Wheel Bearings	Figure 9-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	30 pints (14 l)	<ul style="list-style-type: none"> <li>• Check level every 500 hours or 3 months</li> <li>• Drain and fill every 4000 hours or 2 years</li> </ul>	Fill to the bottom of the level hole in the housing with the fill plug and the oil level mark horizontal.
<p><b>CAUTION:</b> Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.</p>						

For Reference Only

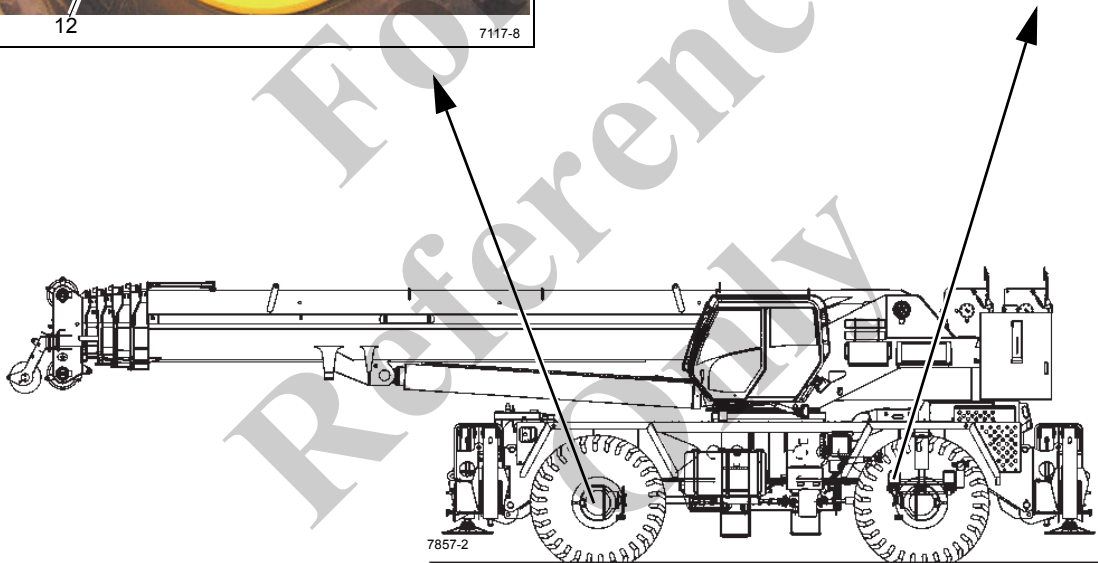
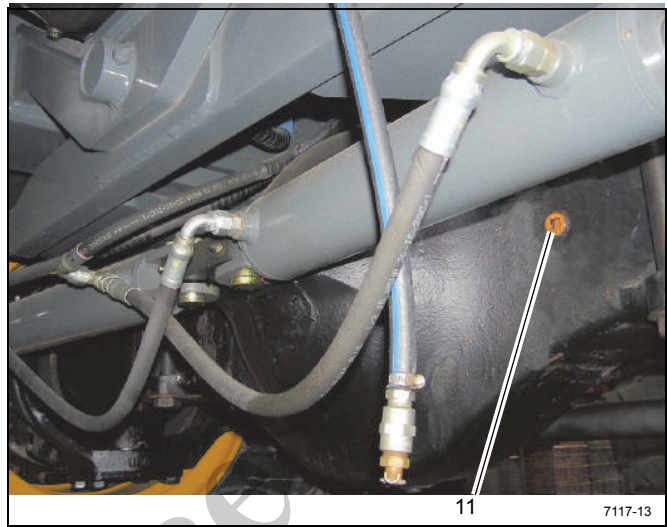


FIGURE 9-2

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Drive Train</b>						
20a 20b	a. Engine Crankcase b. Filter	Figure 9-3	EO-15W/40 Engine Oil SAE 15W-40 T3 Engine: 6829003483 T4 Engine: 6829104182	21 qt (20 l)	<ul style="list-style-type: none"> <li>Check level every 10 hours or daily</li> <li>Drain, fill and replace filter every 500 hours</li> </ul>	<ul style="list-style-type: none"> <li>Through fill pipe to FULL mark on dipstick</li> <li>Filter located under radiator</li> </ul>
21a 21b	a. Transmission, Torque Converter b. Filter	Figure 9-3	HYDO Hydraulic Oil 6829006444	34 qt (32.1 l)	<ul style="list-style-type: none"> <li>Check level every 10 hours or daily</li> <li>Drain and refill every 1000 hours or 6 months</li> <li>Change transmission filter after first 50 and 100 hours of service, then every 500 hours thereafter</li> </ul>	Through fill pipe to FULL mark on dipstick
<p><b>NOTE:</b></p> <ul style="list-style-type: none"> <li>Check fluid level with engine running at low idle and the oil at 180 to 200 ° F (82 to 93° C). Do not attempt an oil level check with cold oil. To bring the oil temperature to this range, it is necessary to either work the crane or stall the converter. Converter stall should be accomplished by engaging shift lever in forward high range with the brakes applied and then accelerating the engine to half or three-quarter throttle. Hold the stall until the required converter temperature is reached and stabilized.</li> </ul> <p>Do not operate the converter at stall condition for longer than 30 seconds at one time. Shift to neutral for 15 seconds and repeat the procedure until the desired temperature is reached. Excessive temperature, i.e, 250° F (120° C) maximum will cause damage to transmission clutches, fluid, converter and seals.</p> <ul style="list-style-type: none"> <li>Drain and fill with the oil at 150 to 200° F (65 to 93° C).</li> <li>Transmission filters are located on the outside left hand frame in the area of the hydraulic oil cooler.</li> <li>Do not operate the machine in two wheel drive while the machine is up on outriggers. Serious transmission damage could result.</li> <li>To add fluid:             <ol style="list-style-type: none"> <li>Fill to FULL mark on dipstick</li> <li>Run engine at low idle to prime torque converter and lines</li> <li>Check oil level with engine running at low idle and oil at 180 to 200 ° F (82 to 93° C). Add oil to bring oil level to FULL mark on dipstick.</li> </ol> </li> </ul>						
22a 22b	a. Engine Cooling System and SCA Levels b. Coolant Filter	Figure 9-3	AFC 50/50 50/50 Blended Fully Formulated Antifreeze Coolant 6829101130 SCA 6829012858	36 qt (34 l)	<ul style="list-style-type: none"> <li>Check coolant level every 10 hours or daily</li> <li>Change filter and check SCA levels every 500 hours</li> <li>Check coolant for contamination every 1000 hours</li> </ul>	See <i>Water Cooling System</i> , page 7-18.

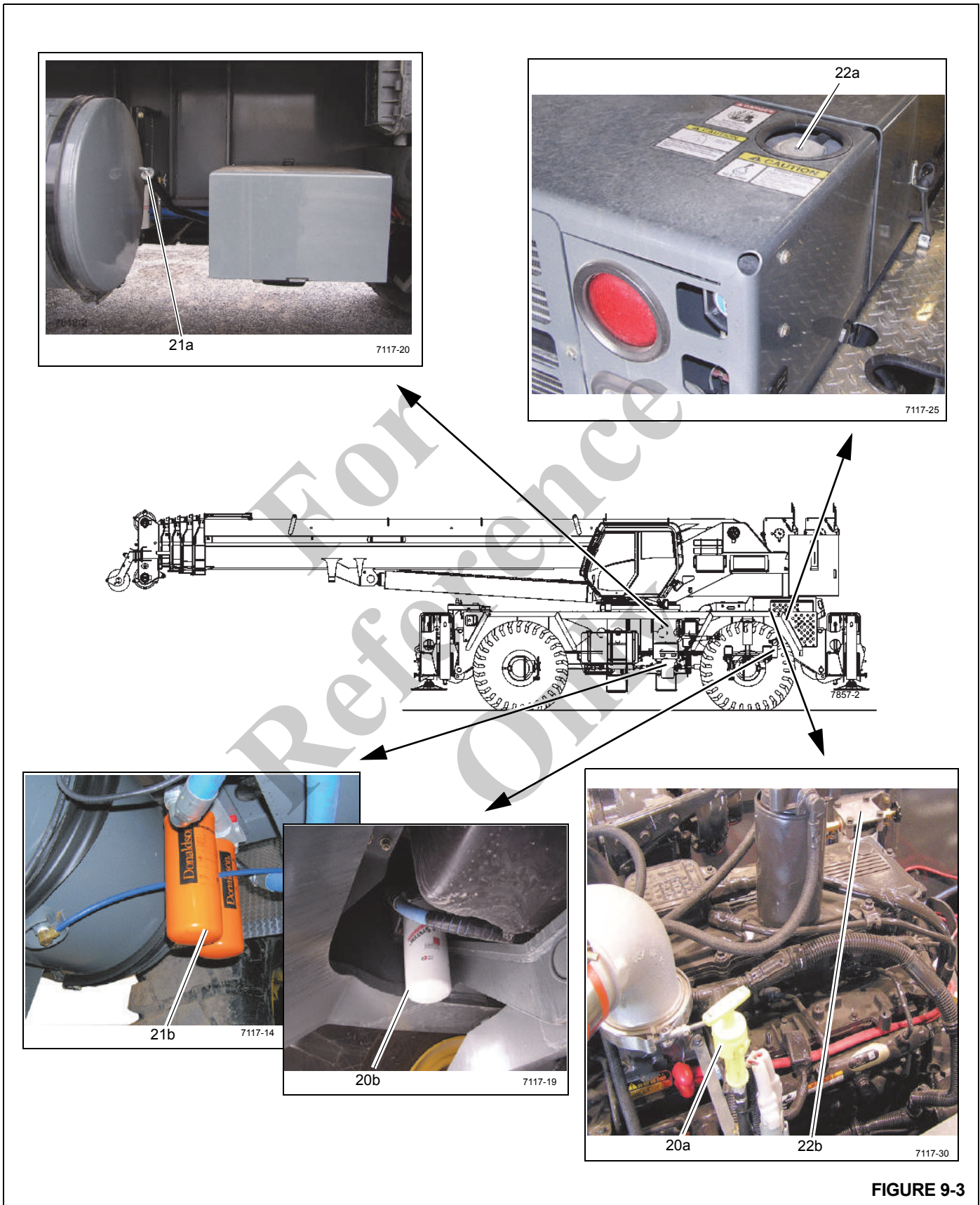


FIGURE 9-3

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Drive Train (continued)</b>						
23	Coolant Strainer (Cab Heater)	Figure 9-4	---	---	Clean strainer screen after first 100 hours and every 2000 hours or 12 months thereafter.	Close shutoff valves. Unscrew hex plug to clean filter.
24a	Air Cleaner Filters	(Figure 9-4)	---	---	<ul style="list-style-type: none"> <li>Replace primary filter element when indicator shows red (25 in of H<sub>2</sub>O). Replace secondary filter every third time primary filter is replaced.</li> <li>In severe dust conditions the pre-cleaner may need to be serviced.</li> </ul>	Right hand side of engine hood.
24b	Pre-cleaner					
25a 25b	Water Separator Fuel Filter	Figure 9-4	---	---	<ul style="list-style-type: none"> <li>Drain water trap every 10 hours or daily.</li> <li>Change filter every 500 hours or 6 months.</li> </ul>	Primary fuel/water separator is located beside the fuel tank
26a 26b	Driveline - Slip Joints	Figure 9-4	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	3 grease fittings
27	Retarder (Optional)	Figure 9-4	---	---	After 2000 hours	Grease using hand grease gun
<p><b>NOTE:</b> Grease using hand grease gun until grease comes out of vent tube outlet located near grease nipple.  <b>CAUTION: DO NOT OVER GREASE.</b></p>						



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Turntable</b>						
30	Turntable Gear Box	Figure 9-5	GL-5 Extended Service Interval Gear Lubricant 6829012964	5.28 qt (4.9 l)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours</li> <li>• Drain and fill after first 250 hours and every 500 hours or 12 months thereafter.</li> </ul>	Fill until oil is at dipstick markings
31	Turntable Gear and Drive Pinion	Figure 9-5	EP-OGL Open Gear Lubricant 6829102971	Coat all teeth	500 hours or 6 months	Spray on
32	Turntable Bearing	Figure 9-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes the whole circumference of the bearing	500 hours or 6 months	2 grease fittings at the front of the turntable.
32a	Swivel Lock Pin		EP-OGL Open Gear Lubricant 6829102971	Coat pin	500 hours or 6 months, whichever interval occurs first	Spray on
<b>NOTE:</b> Rotate the turntable 90° and apply grease to fittings. Continue rotating 90° and grease the fittings until the whole bearing is greased.						
34	Hose Rollers	Figure 9-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3months	2 grease fittings

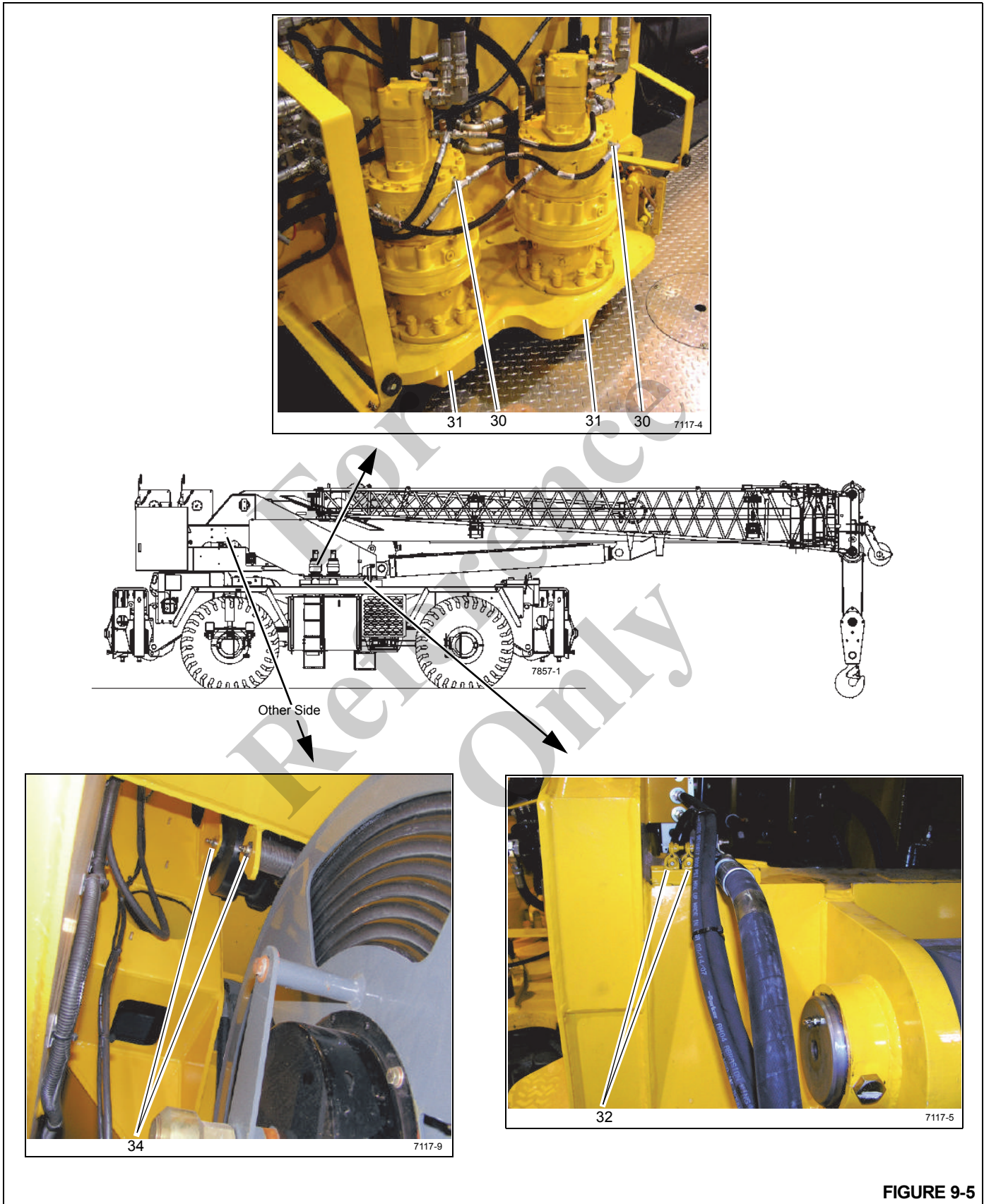


FIGURE 9-5



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Cab Tilt</b>						
40	Cab Tilt Cylinder Pivot Pins	Figure 9-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings
41	Pillow Block	Figure 9-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings

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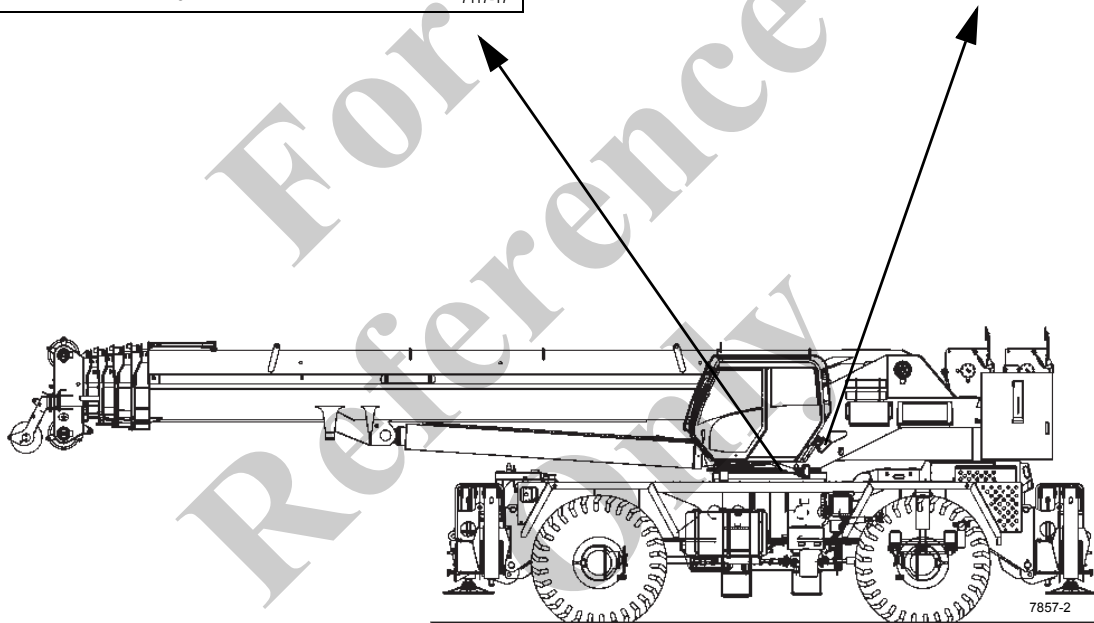
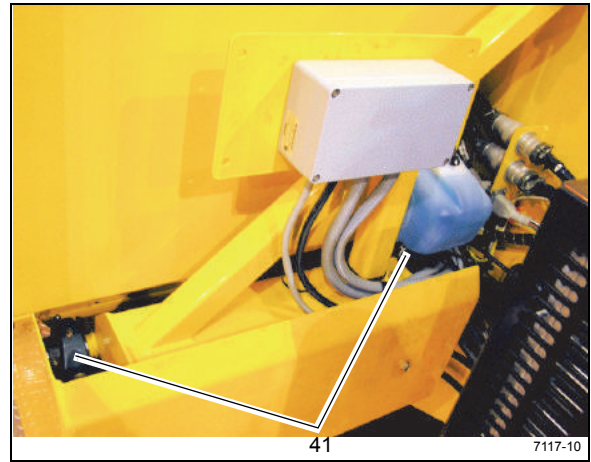
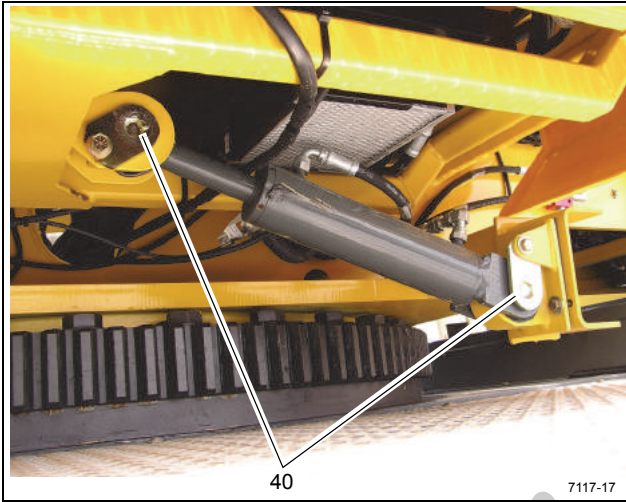


FIGURE 9-6

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Outriggers</b>						
50	Outrigger Beams	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on bottom of outrigger beams
51	Jack Cylinder Support Tubes	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on inside diameter of jack cylinder support tubes, four places, before installing jack cylinders
52	Jack Cylinder Barrels	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on outside diameter of jack cylinder barrels at four places before installing jack cylinders

For Reference Only

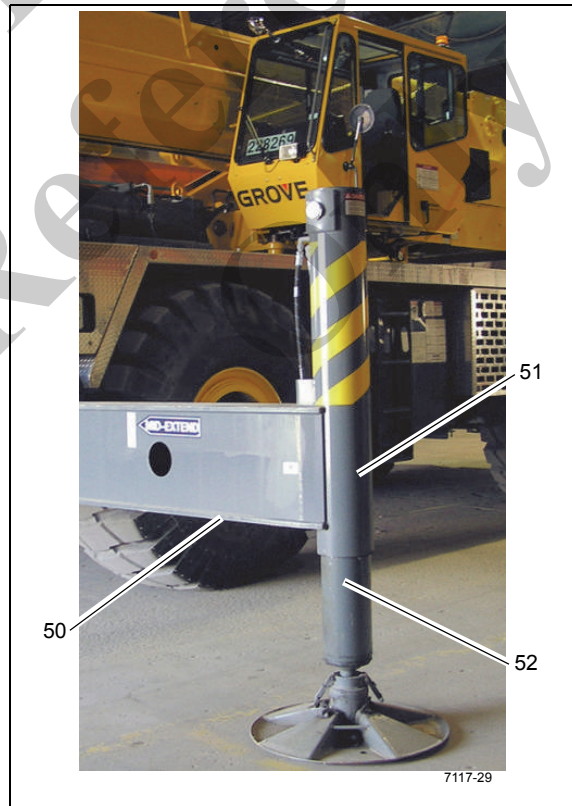
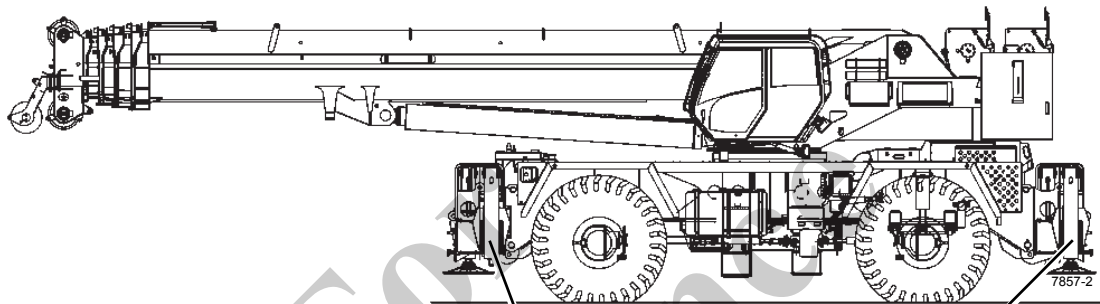


FIGURE 9-7

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom</b>						
60	Upper Lift Cylinder Pin	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until greases extrudes	500 hours or 3 months	1 grease fittings
61	Lower Lift Cylinder Pin	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until greases extrudes	500 hours or 3 months	2 grease fittings
70	hookblock Swivel Bearing	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
71	hookblock Sheaves	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting per sheave (80 Ton - 5 fittings total) (130 Ton - 8 fittings total)
72	Headache Ball	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
73	Telescope Cylinder Wear Pads	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat	Every boom teardown	5 places by brush
<b>⚠ WARNING</b>						
<p><b>Crane Setup for Items 74 &amp; 75:</b> Crane to be set up on firm level surface with fully extended outriggers and 40,000 lb counterweight installed. Ensure crane is level. Boom must be directly over the front and the house lock engaged. Set boom angle at zero degrees. No load is permitted on the boom. The weight of the hookblock, overhaul ball and rigging must not be supported by the boom. Do not extend the boom until the weight of these components is totally removed from the boom.</p>						
74	Internal Side and Bottom Wear Pads (Inner Sections)	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	250 hours or 3 months	14 places by brush; through access holes with boom in extended position
<p><b>See Table 9-4, page 9-31</b> at the end of this sections for how to access lubrication points 74 &amp; 75</p>						
75	Boom Section Upper Wear Pads	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	50 hours or 1 week	8 grease fittings; through access holes with boom in extended position

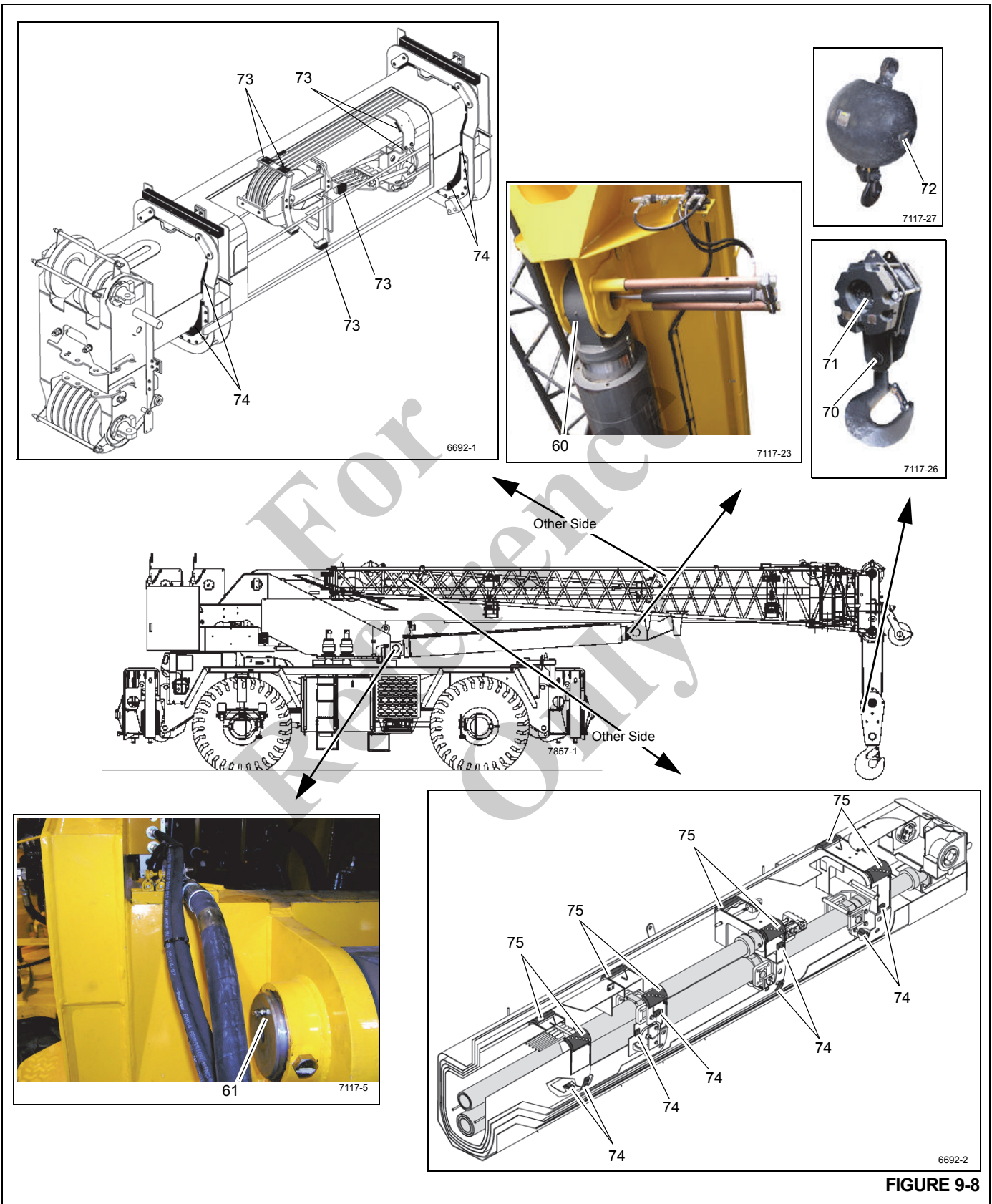


FIGURE 9-8

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom (continued)</b>						
<b>▲ WARNING</b>						
<p><b>Crane Setup for Items 76, 77, 78:</b> Crane to be set up on firm level surface with fully extended outriggers and 40,000 lb counterweight installed. Ensure the crane is level. Boom must be directly over the front and the house lock engaged. Set boom angle at zero degrees. No load is permitted on the boom. The weight of the hookblock, overhaul ball and rigging must not be supported by the boom. Do not extend the boom until the weight of these components is totally removed from the boom.</p>						
76	Boom Section Upper and Lower Wear Pads	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	50 hours or 1 week	12 places by brush
<b>See Table 9-4, page 9-31</b> at the end of this sections for how to access lubrication points 76, 77, 78						
77	Extend Cable Sheaves	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
78	Retract Cable Sheaves	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings one on each side

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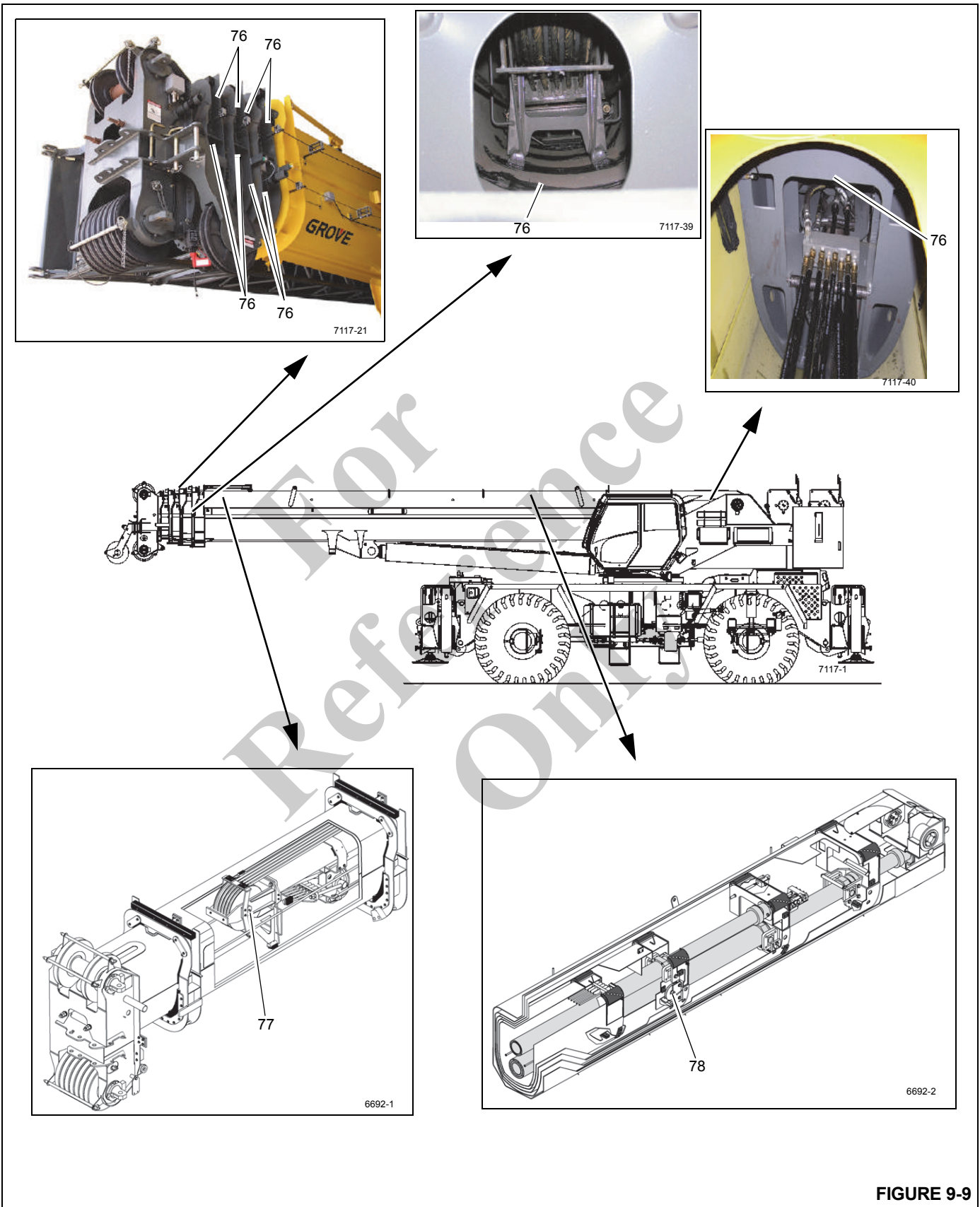


FIGURE 9-9



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom (continued)</b>						
79	Boom Pivot Shaft	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	4 grease fittings
80	Upper Boom Nose Sheave	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings one per sheave
81	Lower Boom Nose Sheave	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting per sheave, 7 sheaves total
82	Hose Rollers	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	4 grease fittings
83	Auxiliary Boom Nose Sheave	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting

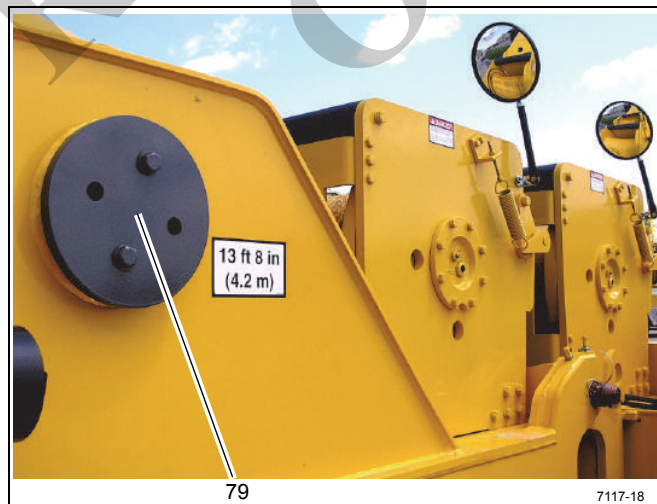
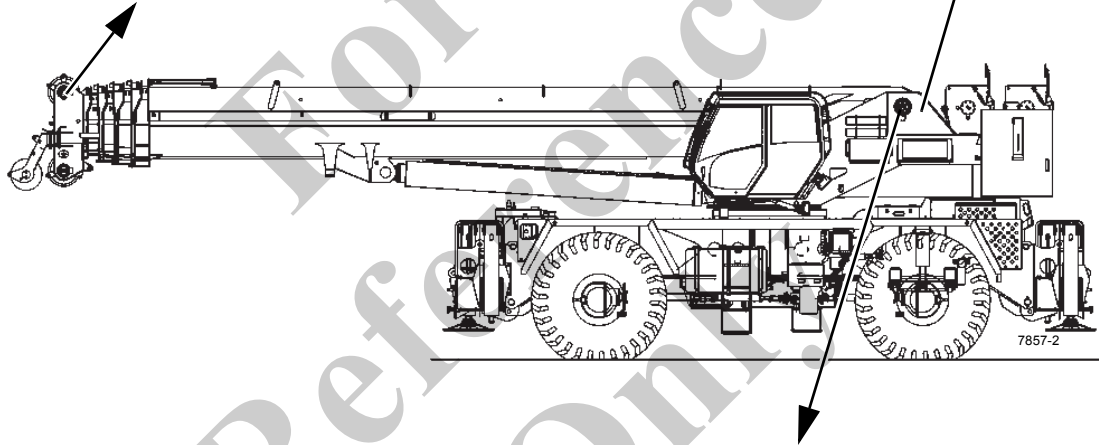
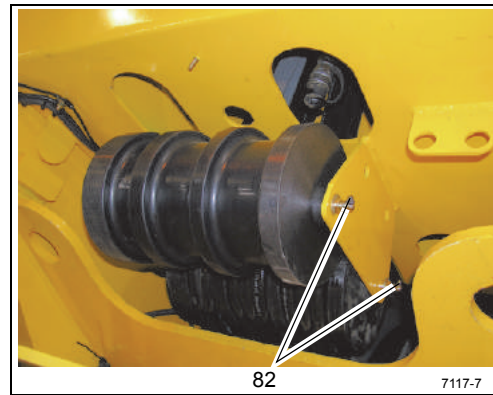
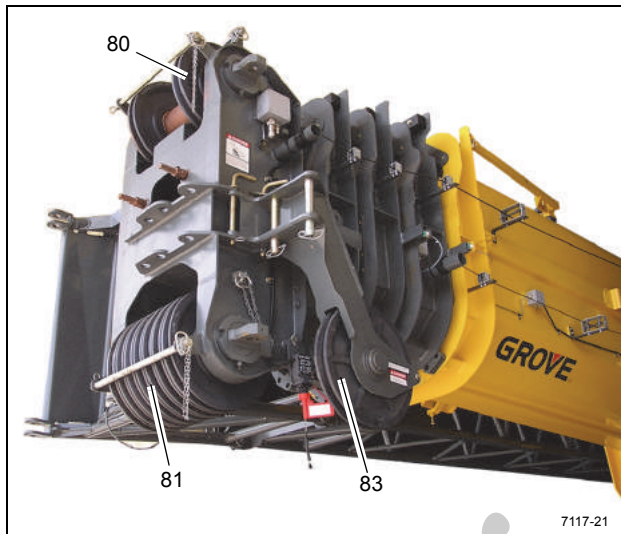


FIGURE 9-10

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Hoist</b>						
90	Main Hoist	Figure 9-11	AGMA Extreme Pressure Gear Lubricant 6829100213	22 qt (20.8 l)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours or weekly</li> <li>• Drain and fill every 1000 hours or 12 months</li> </ul>	Oil level must be visible in the sight glass. (See note) Remove hose at top of sight gauge. Fill hoist through hose until fluid is at full mark on sight gauge. Variations in oil temperature will cause oil level to fluctuate.
91	Auxiliary Hoist	Figure 9-11	AGMA Extreme Pressure Gear Lubricant 6829100213	22 qt (20.8 l)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours or weekly</li> <li>• Drain and fill every 1000 hours or 12 months</li> </ul>	
<p><b>NOTE:</b> To check hoist oil, ensure hoist is level and the fill plug is horizontal and centered in access hole at the 9:00 position. The oil must have settled for 20 minutes with the temperature in 70°F +/- 20°F range.</p> <p>If oil level is not visible in sight glass, the hoist may be underfilled. Oil escaping from vent plug is an indication the hoist may be overfilled.</p>						
92	Cable Follower (Arms)	(Figure 9-11)	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat	250 hours or 3 months	Spray on
<p><b>NOTE:</b> Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.</p>						

Reference Only!

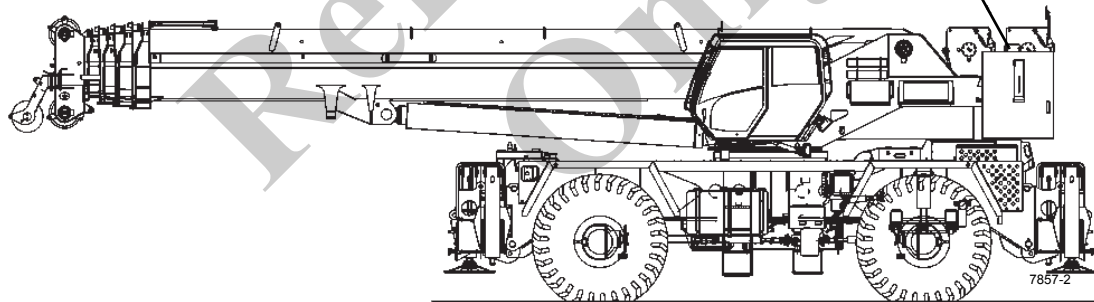
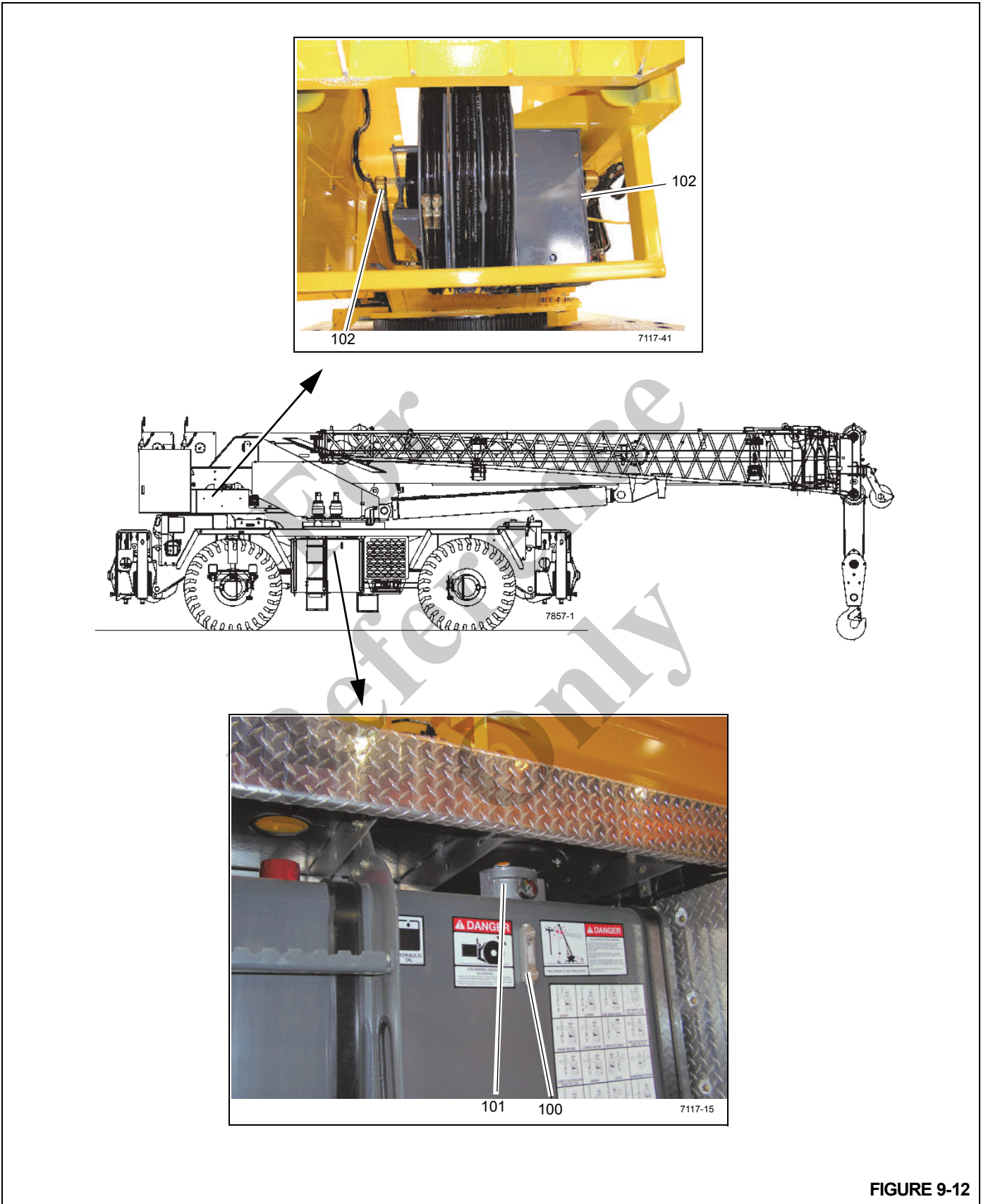


FIGURE 9-11

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Hydraulic</b>						
100	Hydraulic Tank	Figure 9-12	HYDO Hydraulic Oil 6829006444	324 gal (1473 l)	Check fluid level every 10 hours or daily.	<ul style="list-style-type: none"> <li>Use sight gauge on side of tank, with boom down and all outrigger cylinders retracted.</li> <li>Drain and refill as necessary</li> </ul>
<p><b>NOTE:</b></p> <ul style="list-style-type: none"> <li>Environmental and other conditions can dramatically affect the condition of hydraulic oil and filters. Therefore, specific intervals for servicing/changing hydraulic oil, filters and hydraulic tank breathers cannot be set. However, it is imperative for the continued satisfactory performance of Grove cranes that inspections be performed on the basis of how and where each crane is used. Air borne and ingested contaminants can significantly reduce the life of oil and the condition of hydraulic oil filters and tank breathers.</li> <li>Under normal operating conditions, it is recommended that hydraulic oil, filters and breathers be inspected and oils sampled at least every 3 to 6 months and more frequently for severe operating conditions. The inspections should be for air borne and/or ingested particles and water that deteriorate and contaminate the oil (e.g., oil appears "milky" or no longer has a transparent clear to amber color). The return filter by-pass indicator should be observed daily to determine if the contaminants content may be high. If the indicator reaches the red zone or indicates a by-pass condition, the hydraulic oil must be sampled. The hydraulic tank breather should also be inspected to assure that it is not restricting air flow into and out of the reservoir.</li> <li>To inspect hydraulic oil, fill a small glass container with a sample of reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one to two hours and then compare the samples. If the reservoir oil is heavily contaminated with water the sample will appear "milky" with only a small layer of transparent oil on top. If the "milky" appearance was due to air foaming, it will dissipate and the oil should closely match the fresh oil. Should you have any questions, please contact your local authorized Manitowoc distributor.</li> <li>The hydraulic oil shall meet or exceed ISO #4406 class 17/14 cleanliness level.</li> </ul>						
101	Hydraulic Filter	Figure 9-12	HYDO Hydraulic Oil 6829006444	---	Change filter when the indicator is red	---
102	Hose Reel Swivel Joint	Figure 9-12	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 6 months	3 Grease fittings



**Instructions for Accessing Lubrication Points on Boom**

**Table 9-4 Accessing Lubrication Points on Boom**

Item	Boom Section	Access Location	Auto Mode	Manual Mode	Inner Mid %	Center Mid %	Outer Mid %
74	Inner	Large hole in center & outer mid	N/A	Yes	0	100	60
74	Inner	Large hole in inner mid	Yes	N/A	100	75	0
75	Outer mid & fly	Small holes on the sides	N/A	Yes	0	100	100
75	Inner mid	Small holes on the sides	Yes	N/A	100	75	0
75	Center mid	Small holes on the sides	Yes	N/A	100	100	0
76	Center, outer mid & fly	External on the boom	N/A	Yes	0	100	100
76	Inner mid	External on the boom	Yes	N/A	100	75	0
77	Extend cable sheaves	Small hole left side on the front of the outer mid	N/A	Yes	0	100	100
78	Retract cable sheaves	Oblong holes at the end of the center mid	N/A	Yes	0	100	100

1. Set RCL operating code to 0001.
  2. Set auto boom mode. Extend the boom sections to gain access to the Lubrication points as indicated in the table above for "Auto Mode". The RCL system will lockout at approximately 145 ft boom extension.
  3. After performing the lubrication requirements accessible in one of the above, fully retract all boom sections.
  4. Set boom configuration to manual boom mode and select the center mid switch to fully extend the center mid section.
  5. Fully extend the center mid section.
  6. Once the center mid is fully extended, continue extending the outer mid and fly section to reach the points indicated in the table above. The center, outer, and fly section lube points may be fully extended during this step.
  7. Once lubrication is complete, fully retract all boom sections and return boom to auto boom mode.
- NOTE:** During this extension you must override the RCL system.



**WARNING**

Do **NOT** extend the inner mid. The inner mid must remain fully retracted.

## 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 can 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 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.

### 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 primed 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 onto 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.

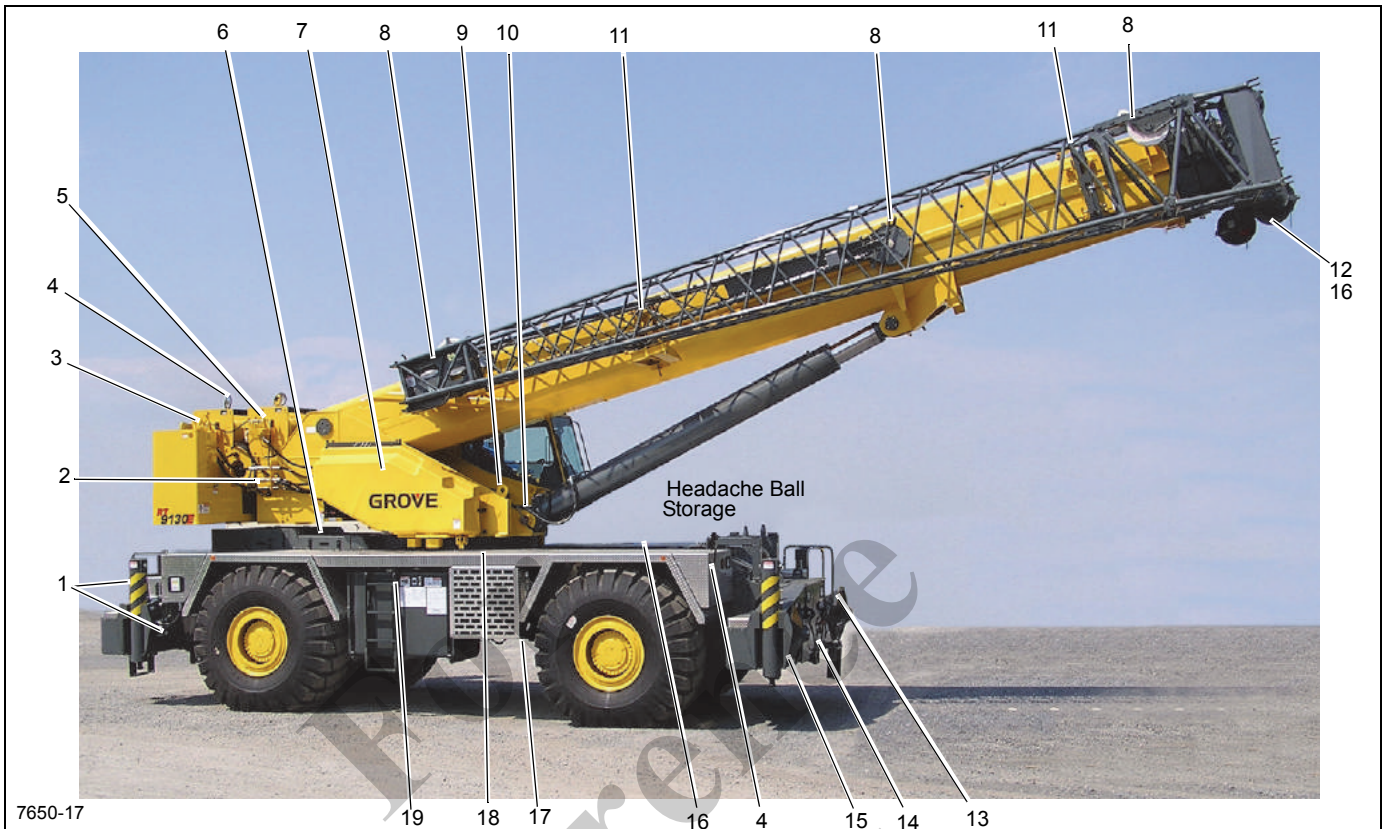
### Areas of Application

Refer to Figure 9-13

- 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 end 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.
- All hardware, clips, pins, hose connections not painted will have treatment applied.
- Boom applications areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hookblock pins and fasteners.

For  
Reference  
Only



7650-17



7650-18

FIGURE 9-13

Item	Description
1	O/R Hose Connections
2	Counterweight Removal Hoses
3	Hoist Tension Springs
4	Mirror Mounting Hardware
5	Hoist Hose Connections
6	Powertrain Hardware inside compartment
7	Valve Bank
8	Boom Extension Pins,Clips
9	Hose Connections inside turntable
10	Pivot Shaft
11	Boom Extension Hanger Hardware

Item	Description
12	Boom Nose Pins, Clips
13	O/R Pins, Clips
14	Hookblock Tiedown Cable
15	O/R Beam Wear Pad Adjustment Hardware
16	Hookblock\Headache Ball
17	Entire underside of unit
18	Turntable Bearing Fasteners
19	All Hardware, Clips, Pins, Hose Connections not painted, O/R Pins,Clips
20	Wire Rope
21	Counterweight Mounting Hardware
22	Hose Connections

For  
Reference  
Only

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