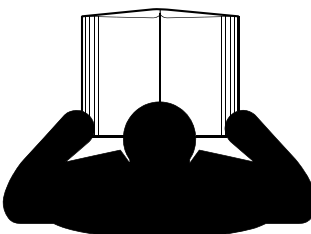


# SERVICE MANUAL

## Supplement

### Leak Path Test-Montan Telescope Cylinder

For Reference Only

	<p style="text-align: center;"><b>⚠ DANGER</b></p> <p><b>An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:</b></p> <ul style="list-style-type: none"><li>• You are trained in the safe operation of this crane. Manitowoc is not responsible for qualifying personnel.</li><li>• 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.</li><li>• You are sure that all safety signs, guards, and other safety features are in place and in proper condition.</li><li>• The Operator Manual and Load Chart are in the holder provided on crane.</li></ul>
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This Supplement provides information on performing a Leak Path Test for A/B Mode, Discreet Stage Control Telescope Cylinder (RT770 Montan Cylinder - p/n 80035407)

## LEAK PATH TEST PROCEDURE

1. Raise and extend boom to appropriate position, 60 degree or higher angle with moderate hook load and at least 50% T1 and 50% T2 preferred.
2. Allow crane to normalize to ambient conditions; minimizing thermal drift as a factor.
3. Record ambient temp and perform drift test measurement for at least 1hr.
4. Record change in lengths of T1 & T2. Record ambient temp.
5. If start/stop ambient temps are different, factor out thermal drift; refer to document 6829002741.
6. If leakage drift exists, install valve in each of the following lines if present:
  - Extend (between main directional valve and stage select valve)
  - Retract (between main directional valve and cylinder retract port)
  - Fill Tube (between fill valve and cylinder port)
  - Drain (between case drain and tank port on cylinder)
7. Close all valves.
8. Repeat steps 1 thru 5. Verify zero drift.
9. Open Drain (Tank) valve.
10. Repeat steps 1 thru 5. Drift on T2 only = leaking pressure relief valve; test concluded. No drift = close drain valve and proceed to step 11.
11. Open Fill Tube valve.
12. Repeat steps 1 thru 5. Drift = leaking telescope fill valve; test concluded. No drift = close fill tube valve and proceed to step 13.
13. Open the Retract valve.
14. Repeat steps 1 thru 5. Drift = Internal seal bypass; test concluded. No drift = close retract valve proceed to step 15.
15. Open the Extend valve.
16. Repeat steps 1 thru 5. Drift = leaking hold valve(s) seat(s); test concluded.

Reference Only

# Grove RT770E

## 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 -

## RT770E

Crane Model Number

Crane Serial Number

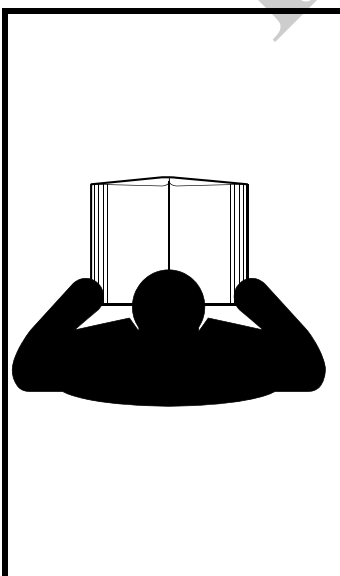
This Manual is Divided into the following Sections:

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's 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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### GENERAL

This Manual provides important information concerning your Grove Crane.

#### Overview of Manuals

Before placing the crane in service, take time to thoroughly familiarize yourself with the contents of this manual. After all sections have been read and understood, retain the manual for future reference in a readily accessible location.

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

Engine & RCL operating procedures and routine maintenance procedures are supplied in separate manuals with each crane, and should be referred to for detailed

information. A separate safety manual is also provided with each crane. See the Operating Manual Section #2 for other Safety related issues.

## Customer Support

Manitowoc and our Dealer Network want to ensure your satisfaction with our products and customer support. Your local distributor is the best equipped and most knowledgeable to assist you for parts, service and warranty issues. They have the facilities, parts, factory trained personnel, and the information to assist you in a timely manner. We request that you first contact them for assistance. If you feel you need factory assistance, please ask the distributor's service management to coordinate the contact on your behalf.

## General Crane Design

The Grove crane has been designed for maximum performance with minimum maintenance. With proper care, years of trouble-free service can be expected.

Constant improvement and engineering progress makes it necessary that we reserve the right to make specification and equipment changes without notice.

## Specific Crane Description

The crane incorporates an all welded parallel box construction steel frame, utilizing two drive steer axles. 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

reverse transmission. The outriggers are single stage, double box, telescopic beam type outriggers.

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. One boom is available on the crane; a five section, full power, synchronized, 36 to 138 ft (10.97 to 42.06 m) boom. Additional reach is obtained by utilizing one of two optional boom extensions; a 32 ft (9.75 m) fixed length offsettable swingaway and a 32 to 56 ft (9.75 to 17.07 m) folding offsettable swingaway.

## Lifting Capacities (Load Chart)

Lift Capacities are listed on the Load Chart in the cab.

## Basic Components

For basic Crane Component locations see Figure 1-2.

## Axle Weight Distribution

For Axle Weight Distribution see Table 1-2.

## Serial Number Location

Crane Serial Numbers are stamped on the left side of front frame and on manual holder in cab.

## Transportation and Lifting Data

Transportation and Lifting data Figure 1-1 are located on the hydraulic tank on the right side of the crane.

## LIST OF SPECIFICATIONS

### General

Model	RT770E
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 29.5 x 25 tires.

Wheelbase	4.06 m (160 in)
Overall Crane Length	13.6 m (44.6 ft)
Overall Crane Width	3.33 m (11.0 ft)
Overall Crane Height	3.60 m (10.9 ft)
Outside Turning Radius	
2 Wheel Steer	11.342 m (37 ft 2.55 in)
4 Wheel Steer	6.744 m (22 ft 1.5 in)
Outside Curb Clearance	
2 Wheel Steer	11.7 m (38 ft 5.88 in)
4 Wheel Steer	7.1 m (23 ft 3.5 in)
Outrigger Spread	
Retracted	3.18 m (10 ft 5 in)
Mid Extend	5.28 m (17 ft 4 in)
Fully Extended	7.11 m (23 ft 4 in)

### Capacities

Fuel Tank	280 liters (74 gal)
Coolant System	See Engine Specifications
Engine Lubrication System	See Engine Specifications
Hydraulic Tank (Reservoir Capacity)	
Total	717 L (189.5 gal)
Hoists	
Model GHP-30A	14.7 L (15.5 qt)
Swing Gearbox	4.9 L (5.25 qt)
Axle Planetary Ends	4 L (8 pt)
Axle Differentials	23 L (48 pt)
Transmission (includes Torque Converter)	38 L (40 qt)

### Torque Converter

Stall Ratio	1.82:1
Charge Pump Capacity	76 L/min (20 gpm)
	@ 2000 rpm

### Transmission

Gear Ratios	
Forward and Reverse	
Low Range	
1st	12.59
2nd	6.06
3rd	2.22
High Range	
4th	4.33
5th	2.08
6th	0.76

### Engine

#### Cummins QSB 6.7

Type	4 cycle, Diesel, Turbocharged
Number of Cylinders	6

Horse Power Rating	179 kW (240 hp) @ 2500 rpm
Oil Pan Capacity	15.6 L (18.5 qt)
Coolant System	38 L (40 qt)

### Axles

Total Ratio	24.817:1
Carrier Ratio	5.86:1
Planetary Ratio	4.235:1

### Brakes

Type	Hydraulic Disc
Size	470 x 16 mm (18.5 x 0.63 in)

### Wheels and Tires

Lugs	24
Torque	461 to 488 Nm (340 to 360 lb-ft)
Tire Size	
Standard	29.5 x 25, 28 ply rating
Optional	29.5R25, 34 ply rating

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

### Swing Gearbox

Reduction Ratio	36:1
Output Torque	45,000 in-lb

### Boom

Length	11 to 42 m (35.9 to 137.9 ft)
Power	5 Tele Section, Full Power
Elevation	-3 to +78 degrees
Extensions	
Fixed*	10 m (32.6 ft)
Folding*	10 or 17 m (32.6 or 56 ft)
*Extensions are offsettable at 0, 25, or 45 degrees.	

### Swivel Assembly

Electrical	20 Slip Rings
Hydraulic	12 ports
Water	2 ports

### Hydraulic Pumps

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

#### Pump #1

Type	Gear
Sections	2
Output - @ loaded engine speed	
Section 1	191 L/min (50.4 gpm)
Section 2	95 L/min (25.1 gpm)

#### Pump #2

Type	Gear
Sections	1
Output - @ loaded engine speed	
Section 1	105 L/min (27.8 gpm)

#### Pump #3

Type	Gear
Sections	1
Output - @ loaded engine speed	
Section 1	77.6 L/min (20.5 gpm)

Hoists

- Drum Dimensions
  - Diameter . . . . . 381 mm (15 in)
  - Length (Standard) . . . . . 467 mm (18.38 in)
- Cable
  - Diameter . . . . . 19 mm (0.75 in)
  - Length-Main . . . . . 198 m (650 ft)
  - Length-Aux. . . . . 199 m (653 ft)
- Max. Permissible Line Pull (6x36)
  - . . . . . 74.7 kN (16,800 lb)
- Max. Single Line Speed . . . . . 153 m/min (500 fpm)

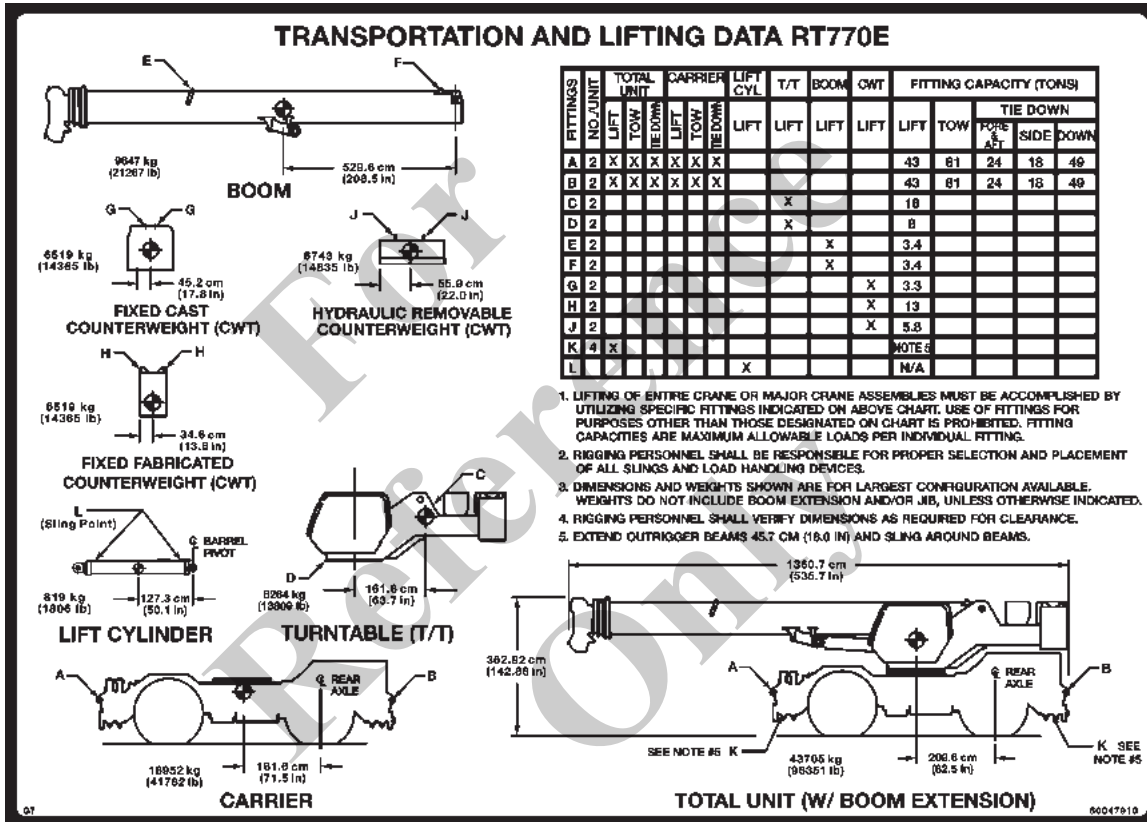


FIGURE 1-1

Table 1-1Axle Weight Distribution Table

Description	CG From Rear Axle cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
<b>Basic Unit</b>				
Maximum Axle Loads Allowed			23360 (51500)	23360 (51500)
Maximum Tire Loads Allowed			53600 (24312)	53600 (24312)
Standard Carrier 4 x 4, w/O/R Beams, plus all Fluids	180.90 (71.22)	18986 (41856)	8451 (18631)	10535 (23225)
Superstructure w/Cab, Main Hoist w/Cable, & IPOCwt	54.25 (21.36)	5813 (12816)	776 (1711)	5037 (11105)
Pinned on Counterweight	-160.02 (-63.00)	6515 (14365)	-2566 (-5656)	9081 (20021)
Boom Assembly @0° w/RCL, 2/4 Nose Sheaves, Lift Cyl, Pivot Pins, over front	566.42 (223.00)	9330 (20569)	13004 (28668)	-3674 (-8099)
Lift Cylinder & Lower Shaft	299.44 (117.89)	821 (1811)	605 (1334)	216 (477)
Basic Machine: 4-Sect Boom, Tier 4 Engine, Tires, Main Hoist w/500 ft of 3/4 in 6x37 Cable, all Fluids	198.65 (78.21)	41466 (91417)	20270 (44688)	21196 (46729)
<b>Add To Basic Unit Weight</b>				
10.0 to 17.0 m (33 to 56 ft) Bi-Fold Boom Extension	665.73 (262.10)	1132 (2495)	1854 (4087)	-722 (-1592)
10.0 m (33 ft) Fixed Boom Extension	739.42 (291.11)	782 (1723)	1422 (3135)	-640 (-1412)
Boom Extension Carrier Brackets (Bolt On) - Bi-fold Ext	561.34 (221.00)	133 (293)	184 (405)	-51 (-112)
Boom Extension Carrier Brackets (Bolt On) - Fixed Ext	581.66 (229.00)	104 (229)	149 (328)	-45 (-99)
Auxiliary Boom Nose - Installed	1191.26 (469.00)	59 (130)	173 (381)	-101 (-223)
6.1 m (20 ft) Boom Ext. Insert w/RCL (not included in unit weight)		407 (898)		
60 t (65 US ton) Hookblock (5 Sheave), Stowed in Tray	406.40 (160.00)	581 (1280)	581 (1280)	0
7.5 t (8.3 US ton), Headache Ball (Swivel) - Attached to O/R Box	661.67 (260.50)	161 (355)	262 (578)	-101 (-223)
Air Conditioning	93.12 (36.66)	40 (89)	9 (20)	31 (69)
Driver	208.28 (82.00)	113 (250)	58 (128)	55 (122)
Rear Mounted Pintle Hook	-194.31 (-76.50)	5 (11)	-2 (-5)	7 (16)
Driver Controlled Differential Locks	205.74 (81.00)	16 (35)	8 (18)	8 (17)
Rubber mat in front Stowage Tray	406.40 (160.00)	20 (44)	20 (44)	0 (0)
Russian Certification Package	172.19 (67.79)	17 (38)	7 (16)	10 (22)
360 Degree Swing Lock	259.08 (102.00)	20 (45)	13 (29)	7 (16)
Sound Package for CE - Carrier & S/S - Main Hoist	49.40 (19.45)	311 (686)	38 (83)	274 (603)
Sound Package for CE - Carrier & S/S - Main and Aux Hoist	29.97 (11.80)	332 (732)	24 (54)	308 (678)

Description	CG From Rear Axle cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
<b>Substitutions, Deletions, and Removals from Basic Unit Weight</b>				
Sub: Removable Cwt System	229.13 (90.21)	375 (827)	211 (466)	164 (361)
Sub: Add'l Hoist Access Platform Weight w/ Removable Counterweight	-213.82 (-84.18)	20 (44)	-10(-23)	30 (67)
Sub: Cwt Stand on Front O/R Box w/ Removable Counterweight	553.72 (218.00)	53 (117)	72 (159)	-19 (-42)
Sub: Aux Hoist (replace IPO Cwt with Aux Hoist and Cable)	-143.00 (-56.30)	258 (568)	-91 (-200)	348 (768)
Rem: Removable Counterweight System - Cwt only	-138.84 (-54.66)	-6729 (-14835)	2299 (5068)	-9028 (-19903)
Rem: Main Hoist Cable (198 m (650 ft) of 3/4 in 6x37)	-66.04(-26.00)	-307(-676)	50(110)	-357(-786)
Rem: Aux Hoist Cable (153 m (502 ft) of 3/4 in 35x7)	-149.86 (-59.00)	-278 (-612)	103 (226)	-380 (-838)
Sub: Optional Cable on Main Hoist (199 m (653 ft) of 3/4 in 35x7)	-66.04 (-26.00)	55 (121)	-9 (-20)	64 (141)
Sub: Tier 3 Engine	-35.56 (-14.00)	-124 (-274)	11 (24)	-135 (-298)
Sub: Kaydon Bearing	208.28 (82.00)	57(126)	29 (65)	28 (61)

For Reference Only



Crane Nomenclature

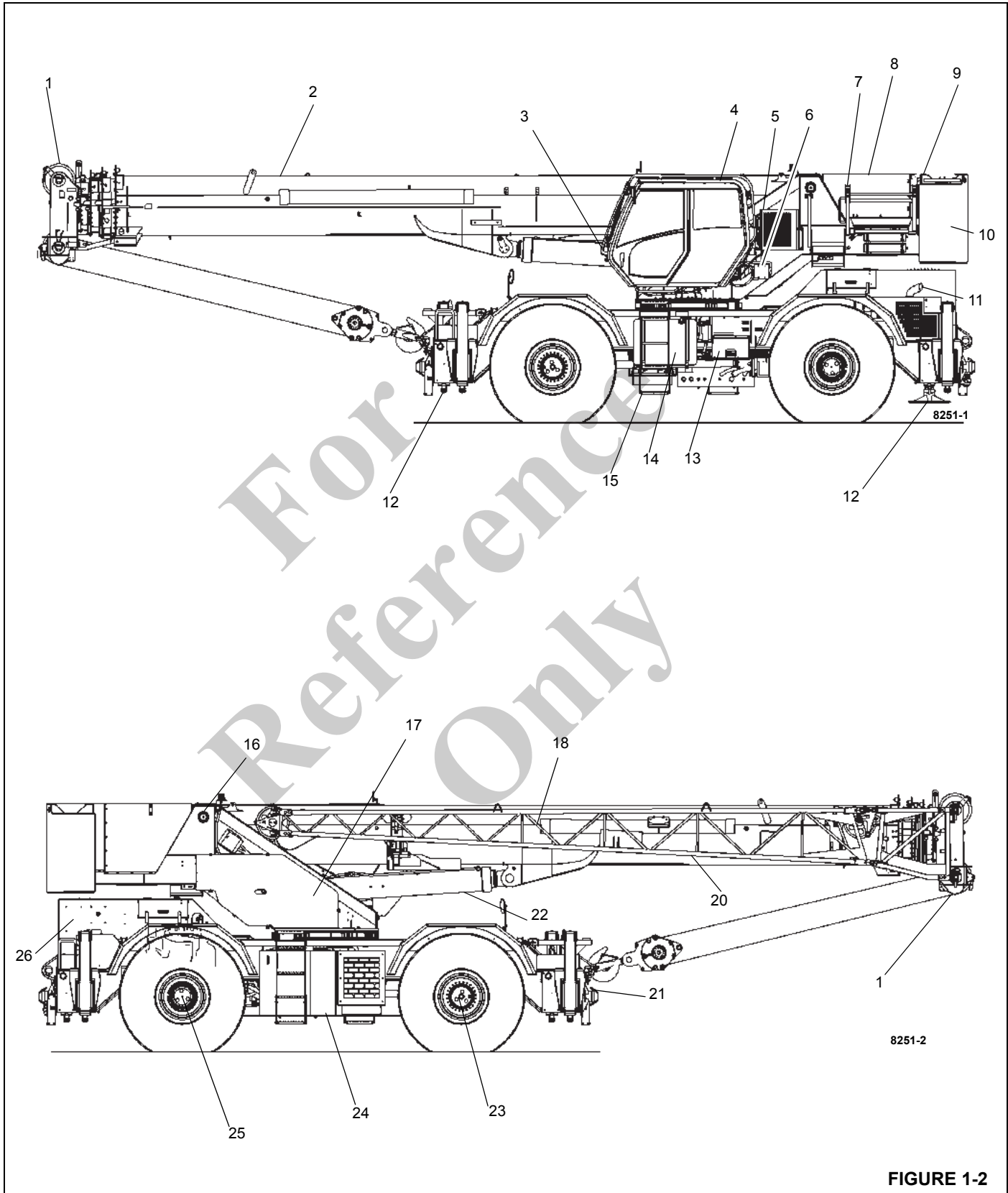


FIGURE 1-2

Item	Description
1	Boom Nose Sheaves
2	Boom
3	Work Lights
4	Cab
5	Air Conditioning Components
6	Windshield Washer Fluid Container
7	Hoist Access Platform (Fixed Counterweight Units Only)
8	Main Hoist
9	Auxiliary Hoist
10	Counterweight
11	Muffler
12	Outrigger Jack Cylinder
13	Battery

Item	Description
14	Fuel Tank
15	Crane Steps
16	Boom Pivot Pin
17	Hydraulic Valves and Swing Motor Cover
18	Swingaway Extension
19	Auxiliary Boom Nose
20	Job Extension
21	Outrigger Pads
22	Lift Cylinder
23	Front Axle
24	Hydraulic Fuel Tank
25	Rear Axle
26	Air Intake Cleaner

For Reference Only

## 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 failed 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 sheetmetal, 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.

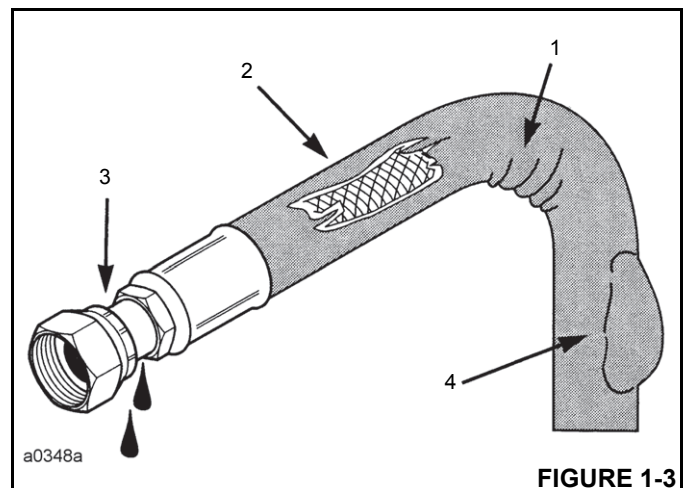
Tighten all connections to recommended torque.

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 anti friction 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 anti friction bearing will be shortened if not properly lubricated. Dirt in an anti friction 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 on the shaft, uniformly apply pressure on the inner race.

### **Preload**

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

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

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

### **Sleeve Bearings**

Do not install sleeve bearings with a hammer. Use a press and be sure to apply the pressure directly in line with the 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-ring, gaskets, etc.) when disassembling and assembling the hydraulic system components. Installation of new elements is always recommended.

#### Hydraulic Lines

When installing metal tubes, tighten all bolts finger-tight. Then, in order, tighten the bolts at the rigid end, the adjustable end, and the mounting brackets. After tubes are mounted, install the hoses. Connect both ends of the hose with all bolts finger-tight. Position the hose so it does not rub on the 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.

If any of these conditions exist, address them appropriately.

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

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

### 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

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

T-2-5

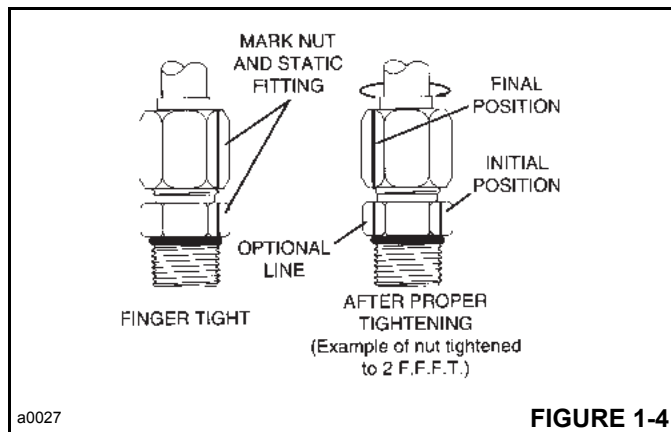


FIGURE 1-4

a0027

#### Adjustable Straight Thread O-ring Fittings

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

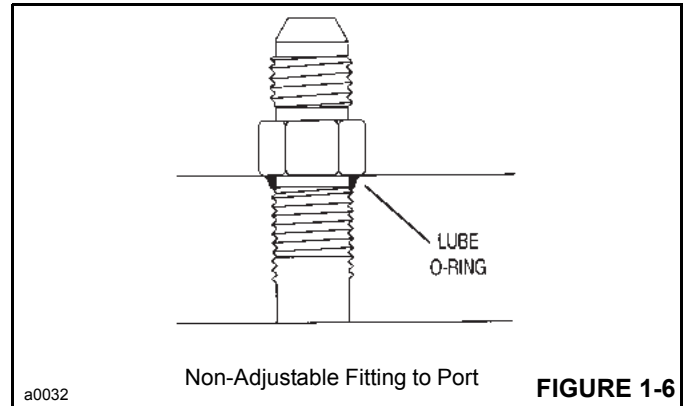


**Table 1-4: Adjustable Straight Thread O-ring Fittings**

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. 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).



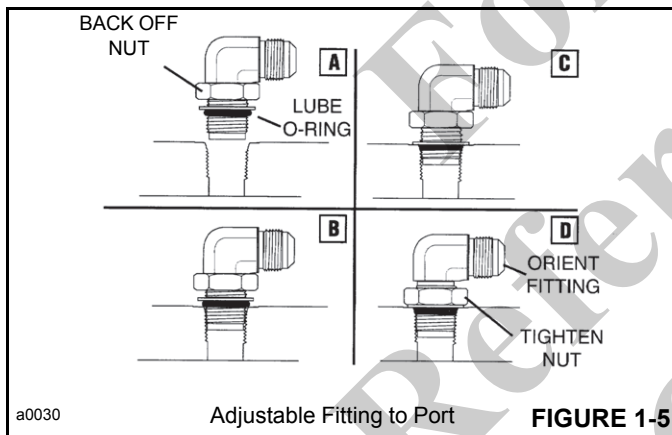
**FIGURE 1-6**

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

1-2-7



**FIGURE 1-5**

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.

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

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

**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 bolted 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 (Loctite® 7649 Primer N).

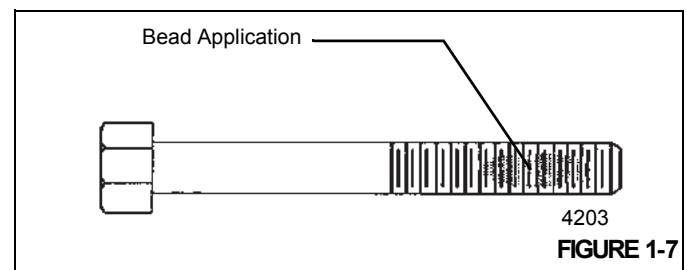
#### Primer Application

**NOTE:** Primer is not required for Loctite #243, it is required for #242.

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.

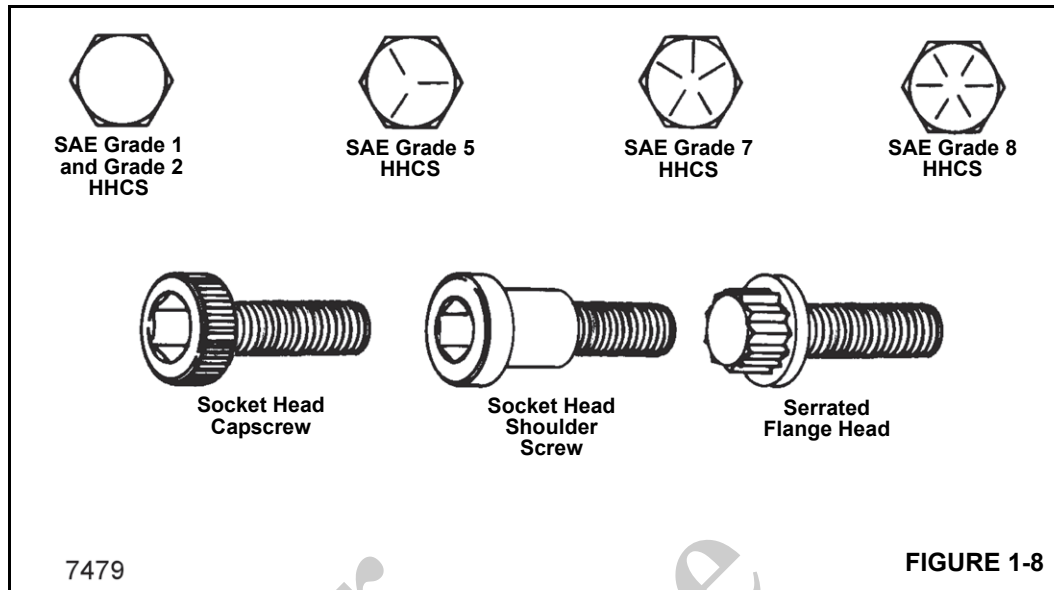


Table 1-6: UNC (Coarse) Thread: Torque Values for Zinc-Flake Coated and Untreated Fasteners

		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 hook block 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 ropes life expectancy. Examples of this type of loading are listed below.

1. High velocity movement e.g.; hoisting or swinging of a load followed by abrupt stops.
2. Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
3. 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)).

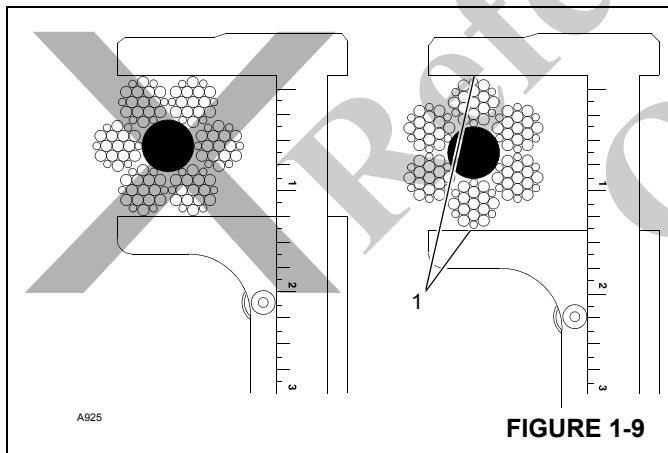


FIGURE 1-9

13. When checking for broken wires (5) (Figure 1-10) relax the rope, move it off "pick-up points", and flex it as much as possible. Defect in the rope is in relation to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around the core (4).

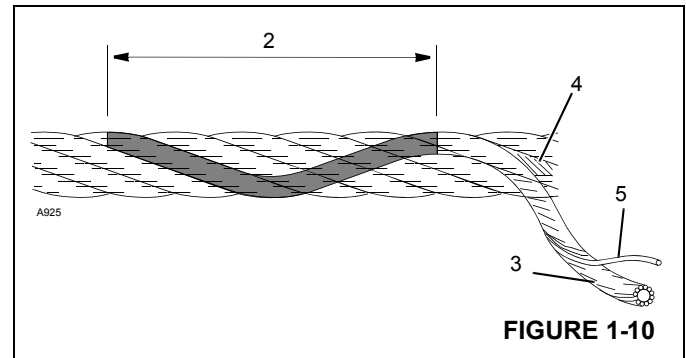


FIGURE 1-10

### 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, hook block 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 periodic 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.
- Manitowoc recommends that boom extension cables be replaced every seven (7) years.

## **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 1-11), 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.

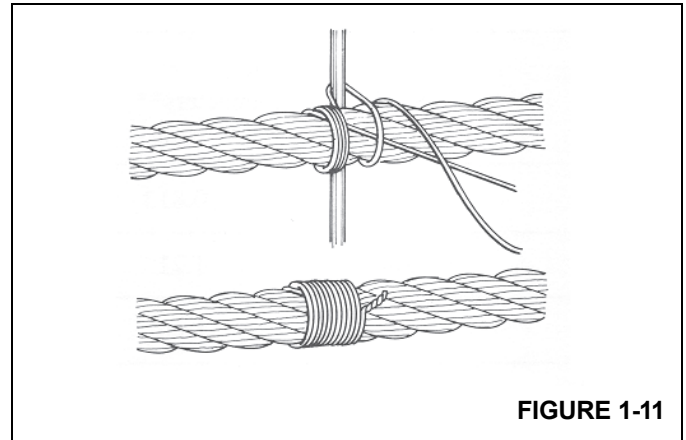


FIGURE 1-11

#### Method 2

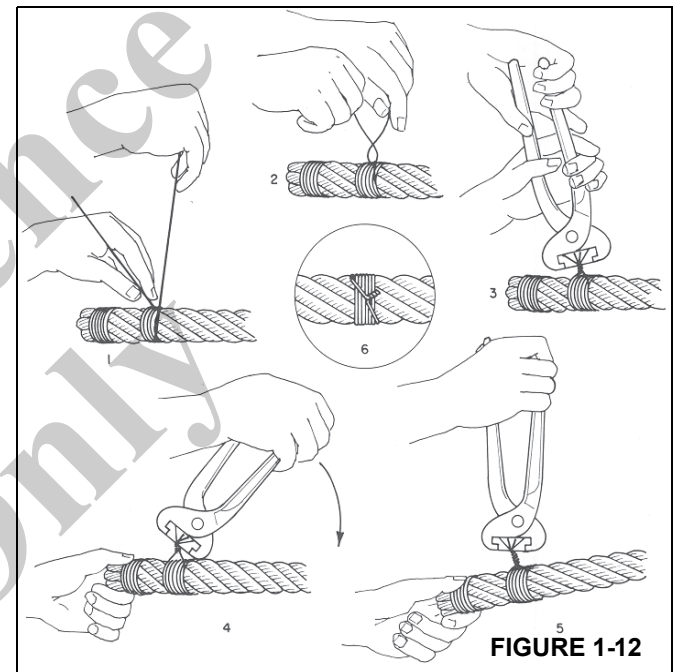


FIGURE 1-12

Wind a length of soft annealed wire (Figure 1-12) 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 1-13) should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

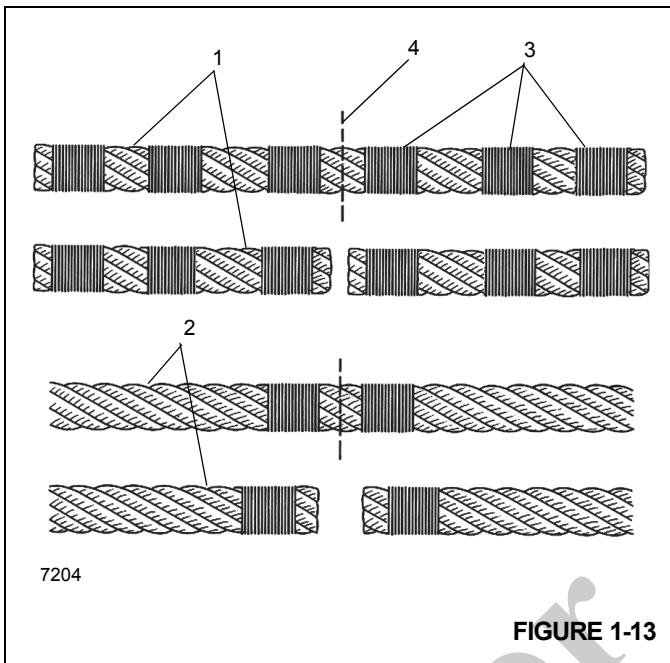


FIGURE 1-13

## 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 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 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 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.

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

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

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

3. Once the cuts have been completed, the seizing bands are to be left in place.
4. Attach a "Do not remove welded ends" tag on each reel flange.

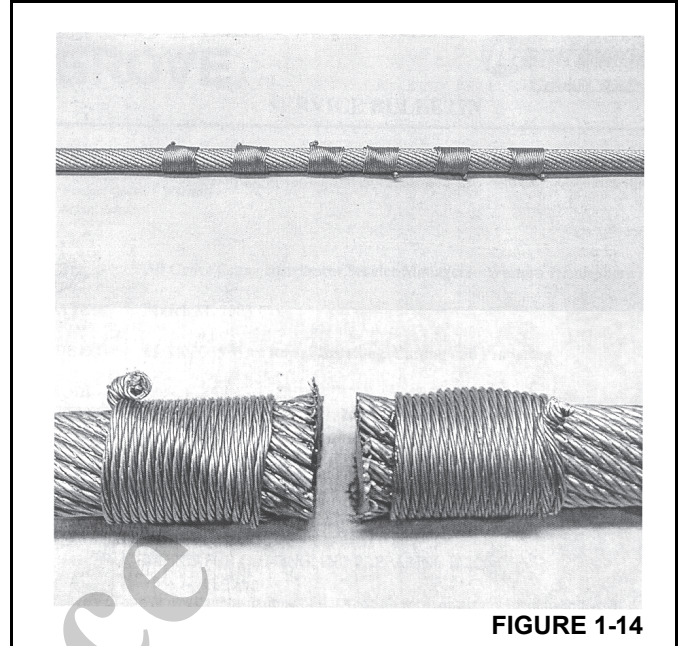


FIGURE 1-14

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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.

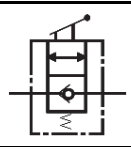
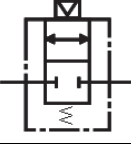
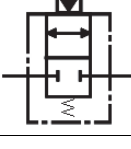
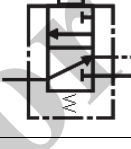
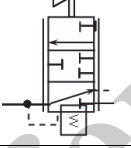
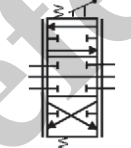
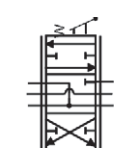
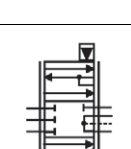
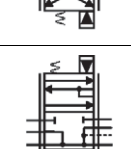



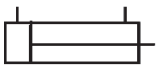
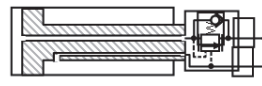
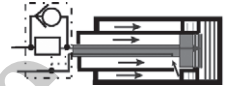

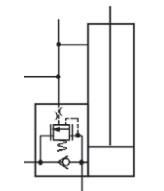
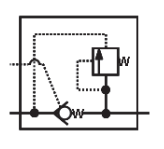
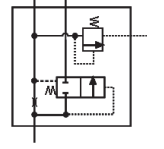
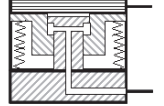
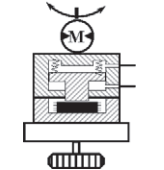
**HYDRAULIC SYMBOLS**

The following pages show basic hydraulic symbols as use on the schematics.

Description	Symbol
Hydraulic Reservoir - Stores, cools, and cleans machines hydraulic fluid supply.	
Hydraulic Return Lines - Terminated at (1) below fluid level (2) above fluid level.	
Hydraulic Pump - (1) fixed displacement (2) variable displacement.	
Power Source - Powers hydraulic pump (1) combustion engine, (2) electric motor.	
Hydraulic Motors - (1) unidirectional, (2) bidirectional.	
Pump Disconnect - Disconnects pump from power source.	
Continuous Line - Supply or return lines.	
Connecting Lines - Branch lines connected to main line.	
Dashed Line - Pilot pressure.	
Dotted Line - Case drain or load sense.	
Chain Line - Enclosure of two or more functions contained in one unit.	
Pressure Transducer - Hydraulic/ electrical located in lift cylinder circuit for cranes RCL circuit.	

Description	Symbol
Filter - Removes contamination from hydraulic fluid.	
Filter with Bypass Valve - Bypass valve allows hydraulic fluid to bypass the filter if the filter becomes clogged.	
Accumulator - Used to either develop flow or absorb shock.	
Check Valve - Creates back pressure.	
Orifice - In-line fixed restriction.	
Adjustable Orifice - In-line restriction used for control device.	
Hydraulic Oil Cooler - Cools hydraulic fluid.	
Temperature Switch - Regulates the hydraulic fluid temperature.	
Hydraulic Pressure Switch - Senses hydraulic pressure to energize electrical components.	
Flow Switch - Illuminates indicator light to indicate a fault.	
Relief Valve - Protects system from being over pressurized.	
Pressure Reducing Valve - Regulates maximum pressure.	
Shuttle Valve - Used to direct maximum pressure to components.	

Description	Symbol
Manually Operated - Valve shifted manually with check to allow flow back to tank.	
Pneumatic Operated - Valve shifted by pneumatic device.	
Pilot Operated - Valve shifted by pilot pressure.	
Electric Operated - Valve shifted by electrical energy.	
Brake Valve - Activates swing brake.	
Open Center Cylinder Spool - Directional control valve for hydraulic cylinder function that directs flow back to tank through the open center when in the neutral position	
Open Center Motor Spool - Directional control valve for hydraulic motor function that directs flow back to tank through the open center when in the neutral position. Allows flow back to tank when the crane is shut down.	
Closed Center Cylinder Spool - Pressure compensated directional control valve for hydraulic cylinder which directs flow back to tank with an unloader valve cartridge.	
Closed Center Motor Spool - Pressure compensated directional control valve for motor with open port for flow back to tank. Allows flow back to tank when the crane is shut down.	

Description	Symbol
Single Acting Cylinder - Extended hydraulically and retracted with a spring.	
Double Acting Cylinder - Extended and retracted hydraulically.	
Double Acting Telescope Cylinder - Anchored rod pushes barrel out when check valve is unseated.	
MultiStage Telescope Cylinder - Used in multi/section synchronized operations.	
Inverted Outrigger Jack Cylinder - Extends the barrel down to raise the crane off the ground.	
Holding Valve - Keeps boom lift cylinder from collapse if hydraulic pressure failure occurs (i.e. hose rupture).	
Pilot Operated Check Valve (with thermal relief) - Requires pilot pressure to unseat the one way check (nonadjustable).	
Flow Divider Valve - Regulates flow to a selected circuit.	
Hoist Brake - Holds load after control is returned to neutral (spring applied and hydraulically released).	
Swing Brake - Spring applied hydraulically brake holds superstructure in place.	



## MAINTENANCE

### Preparation

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

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

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

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

### Hydraulic System Maintenance Precautions

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

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

Disassemble and reassemble hydraulic components on a clean surface.

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

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

When installing metal hydraulic tubes, tighten all bolts finger tight. Then, in order, tighten the bolts at the rigid end, the adjustable end, and the mounting brackets. After tubes are mounted, install the hoses. Connect both ends of the hose with all bolts finger tight. Position the hose so it does not rub

the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

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

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

### Label Parts When Disassembling

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

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

### Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to *Hydraulic*, page 9-32.

### 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.

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

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

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.
6. Connect the cylinder return line and lower the boom to its stowed position. Replenish the reservoir hydraulic oil level as required.

7. Disconnect the return line from an outrigger extension cylinder and fully extend the outrigger.
8. Connect the outrigger return line and retract the outrigger. Replenish the reservoir hydraulic oil level as necessary.
9. Repeat Steps 7 and 8 for the remaining outriggers.

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### CAUTION

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

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

26. Repeat Steps 24 and 25 for the auxiliary hoist as necessary.
27. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
28. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

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### CAUTION

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

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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 770 L (190 gal). 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 mechanism and hoist(s), because it can cause these units to become noisy during operation. If noisy operation occurs, first check the level of the hydraulic reservoir and replenish as necessary. Then inspect for leaks in the suction lines leading to the pumps.

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

- Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 0.138 to 0.276 bar (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the 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.



### CAUTION

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

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



### CAUTION

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

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

- Entrapped air may be removed from cylinders having wet rods by cycling. On certain cylinders, a plugged port is provided on the rod end to bleed off entrapped air.
- In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw type fittings may become necessary.
- If the above procedures fail to eliminate air entrapment, contact your authorized Grove distributor.

## Parts Replacement

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

## 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 check-out reveals that adequate volume is being supplied to the affected valve bank, relief valves are properly adjusted, and the component is not at fault, check the valve for scored or worn parts. Scoring is a sign of the number one problem in hydraulics - contamination (external 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.

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.

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.

All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life. Working conditions, ambient temperatures and high duty circuits can affect service life of hose assemblies and must be taken into account when inspecting and replacing hoses. High duty circuits can include, but are not limited to, outriggers, hoist(s), boom lift, swing, pump suction and discharge to directional valves and directional valve return to the reservoir.

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

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.

Hydraulic hose assemblies operating in climate zones “D” and “E” (Table 2-1), cold climates, should expect a degrade of mechanical properties, long term exposure to these cold temperatures will negatively impact service life. Therefore it is recommended for these hoses to be inspected thoroughly as service life may be less than 8000 hours.

**Table 2-1**

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

**SUPPLY PRESSURE AND RETURN CIRCUIT**

**Description**

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the three 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, three hydraulic pumps, a hydraulic oil cooler and a 10-port hydraulic swivel. Refer to Hydraulic Pumps in this section for descriptions and maintenance instructions for each hydraulic pump. Refer to *Swing System*, page 6-1 for description and maintenance instructions for the hydraulic swivel.

The supply pressure and return circuit uses Ports 5, 6 and 8 for pump supply and the dual Port 4 for return. Each operating circuit's description and components begin with the circuit's directional control valve.

**Hydraulic Reservoir and Filter**

The reservoir (Figure 2-1), attached to the right side of the carrier frame has a total capacity of 717 L (189.5 gal), with a full level of 641 L (169 gal) and a low level of 602 L (159 gal).

The all-steel reservoir has an internally mounted full-flow filter (Figure 2-2) and integral baffles that help cool the hydraulic oil and prevent hydraulic oil foaming.

Hydraulic oil flows through two tubes at the lower rear of the reservoir to the three 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. 10 port (drain) of the 10-port swivel.

There are three temperature switches (4,6 and 7, Figure 2-3), located in the tube that routes return oil to the hydraulic oil return filter in the reservoir. Switches 6 and 7 are part of a circuit that controls the oil cooler fan speed; refer to *Oil Cooler*, page 2-15 for more detailed information on the operation of these switches.

The third temperature switch (4) is part of a circuit that will alert the operator to a high hydraulic oil temperature condition. The switch is normally closed and will open and cause the circuit to lose ground when the hydraulic oil temperature exceeds 93°C (200°F). When the circuit loses ground, the CAN bus system will turn on power to illuminate the Hydraulic Oil High Temperature Indicator in the gauge display in the operator's cab. See *Section 3 - Operating Controls and Procedures*, in the *Operator's Manual* for details of the Hydraulic Oil High Temperature Indicator.

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

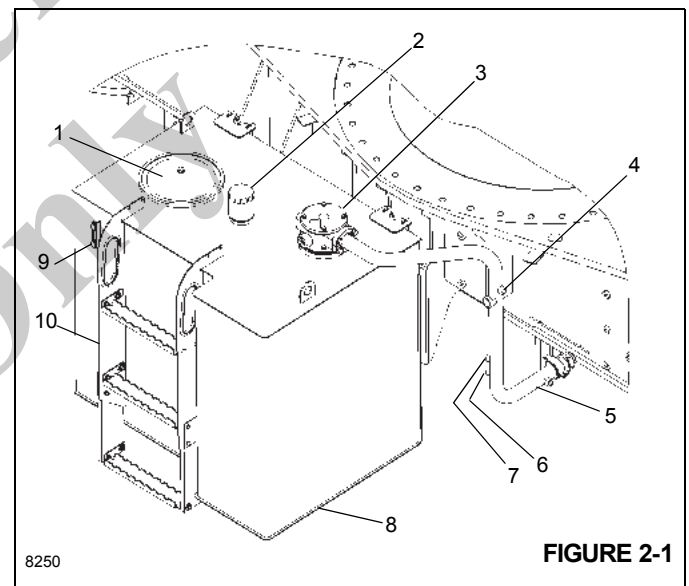
A sight gauge is located on the front end of the reservoir to indicate hydraulic oil level.

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. A breather guard protects the breather and filler neck.

A large round access cover on the top of the reservoir provides access for cleaning. The cover is bolted to the top of the reservoir and has a gasket to prevent leaking. The access hole 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 housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element, and into the reservoir.

A gauge on the filter head indicates how restricted (clogged) the filter element is. When back pressure caused by a dirty filter element exceeds 1.7 bar (25 psi), the filter head's bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead.



**FIGURE 2-1**

Figure 2-1 Table

Item	Description
1	Cover
2	Fill Cap/Breather
3	Return Filter
4	Temperature Switch- High Oil Temp. Indicator Light
5	Return Hose

Item	Description
6	Temperature Switch- Low Fan Speed
7	Temperature Switch-High Fan Speed
8	Hydraulic Tank
9	Oil Level Gauge
10	Step

**Pump Distribution**

**No. 1 Pump**

The torque converter drives the No. 1 pump.

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

Section one also supplies the swing brake and armrest lockout manifold. The manifold contains the swing brake release valve and the controller armrest lockout valve. Hydraulic oil flowing through the manifold supplies the swing power brake valve, and the hoist, swing, telescope, and lift hydraulic remote control valves.

Section two of the No. 1 hydraulic pump supplies the rear axle oscillation lockout valve and the integrated outrigger/rear steer valve.

Output from pump number 1, section 2 passes through a priority flow control valve for the hydraulic oil cooler motor and the high speed boost selector valve. When the boost valve is de-energized, the oil flows to the normal delivery. When the valve is energized, the oil is combined with the output of pump number 1, section 1 to provide additional oil capacity to the section 1 functions.

**No. 2 Pump**

The engine drives the No. 2 pump.

The No. 2 hydraulic pump supplies the front steer/swing directional control 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.

**No. 3 Pump**

The torque converter drives the No. 3 pump.

The No. 3 hydraulic pump supplies the service brake dual accumulator charge valve and the charge air cooler fan motor. The pump delivers its flow via a 15.1 L/min (4.0 gpm) priority flow divider to the dual accumulator charge valve; excess flow passes through a 17.0 L/min (4.5 gpm) priority flow divider and on to the charge air cooler fan motor.

**Troubleshooting**

**Symptoms and Solutions**

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.



## Troubleshooting Aids

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

## Troubleshooting Procedures

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

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

or ballooned hoses, leakage around the hydraulic components, etc.

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

Remember:

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

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

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

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

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



## Hydraulic Oil Return Filter Assembly

The hydraulic oil return filter assembly (see Figure 2-1 and Figure 2-2) is located in the reservoir. It bolts to the top of the reservoir, and its bypass outlet fits into a tube welded in the reservoir. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element, and into the reservoir.

An element condition indicator on the filter head indicates when to change the filter element. When back pressure caused by a dirty filter element exceeds 1.72 bar (25 psi), the filter head's bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead. A bypass filter screen prevents gross contamination from passing through the filter even during bypass.

Refer to the following procedures and Figure 2-2 when removing or installing the hydraulic oil return filter element.



### CAUTION

Ensure that all hydraulic systems are shut down and the pressure is relieved. Moderate to minor injury may result when working on a pressurized system.

Wear eye protection. Hydraulic fluid can blind or severely damage eyes.

### Element Removal

1. Shut down all hydraulic systems.
2. Wipe any dirt from the cap on top of the return filter head.
3. Remove the four bolts securing the cap to the return filter head; remove cap.
4. Inspect the bypass valve (attached to the cap) for any damage; replace if necessary.

5. Remove and discard the O-ring between the cap and the return filter head.
6. Remove the element from the return filter head.

### Element Installation

1. Replace the filter with one having the same part number as the one removed. Lube the O-rings on both ends of the element and insert the element into the return filter head.
2. Install the cap on top of the return filter head making sure that the bypass valve is inserted into the element and that the new O-ring between the cap and filter head is installed correctly.
3. Secure the cap to the filter head using the bolts and lock washers; torque bolts to their specified value.
4. Activate the hydraulic system and check for leaks. Make repairs as needed.

## Fill Cap/Breather

### Removal and Replacement



### CAUTION

Ensure that all hydraulic systems are shut down and the pressure is relieved. Moderate to minor injury may result when working on a pressurized system.

Wear eye protection. Hydraulic fluid can blind or severely damage eyes.

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

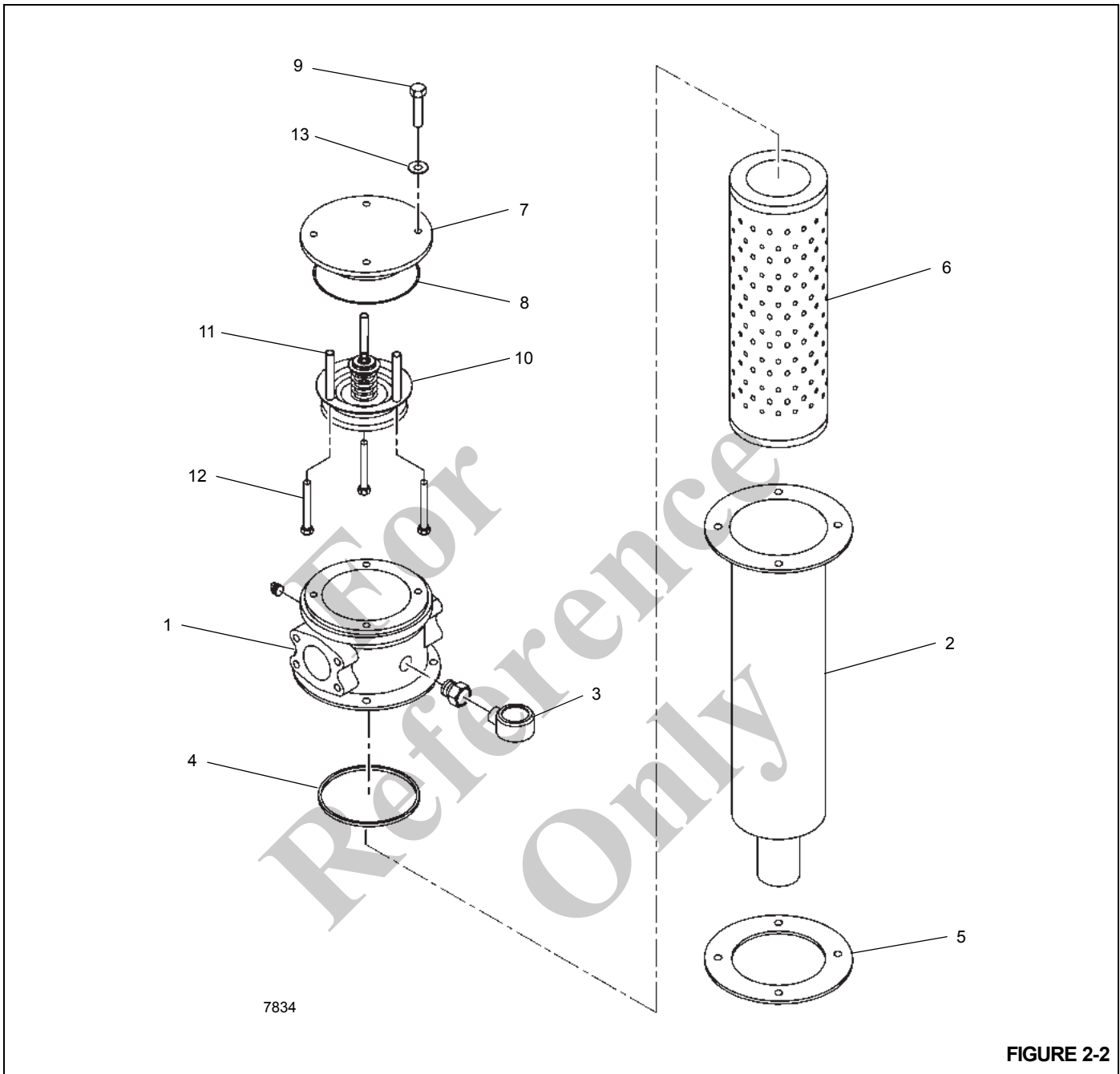


FIGURE 2-2

Item	Description
1	Filter Head
2	Bowl, w/Extension
3	Gauge Assembly
4	Square O-ring
5	Gasket
6	Element
7	Cap

Item	Description
8	O-ring
9	Capscrew
10	Bypass Valve Assembly
11	Spacer
12	Capscrew
13	Washer

## OIL COOLER

### Description

An air cooled hydraulic/transmission oil cooler (Figure 2-3) is located next to the hydraulic tank. The front section is the transmission oil cooler and the rear section is the hydraulic oil cooler.

The hydraulic driven fan pulls cool air through the cooling fins on the cooler. Normally, the hydraulic oil coming from the different 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 1.0 bar (15 psi), 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 1.0 bar (15 psi) and the check valve will close again.

### Oil Temperature Switches

A hydraulic oil high temperature indicator switch (4), Figure 2-1 and two oil cooler fan motor temperature switches (6 and 7) are installed in the return tube. The two oil cooler fan motor temperature switches are normally closed at low oil temperatures. When the hydraulic oil temperature reaches 48.9°C (120°F), one of the oil cooler fan motor temperature switches will open, causing the CAN bus system to turn on the oil cooler fan motor to its low RPM setting. When the hydraulic oil temperature reaches 71°C (160°F), the other oil cooler fan motor temperature switch will open, causing the CAN bus system to increase the RPM of

the oil cooler fan motor to high. The hydraulic oil high temperature indicator switch is normally closed and will open when the hydraulic oil temperature reaches 87.8°C (190°F), causing the CAN bus system to turn on the hydraulic oil high temperature indicator in the gauge cluster to alert the operator to the condition.

The temperature switch (5, Figure 2-3), located in the inlet tube of the transmission oil cooler, is part of a circuit that will alert the operator to a high transmission oil temperature condition. The switch is normally closed and will open and cause the circuit to lose ground when the transmission oil temperature exceeds 93°C (200°F). When the circuit loses ground, the CAN bus system will turn on power to illuminate the Transmission Warning Indicator in the operator's cab. See *Section 3 - Operating Controls and Procedures*, in the *Operator's Manual* for details of the Transmission Warning Indicator.

### Maintenance

The oil cooler should be checked daily for dirt buildup, as a dirty cooler will result in high oil temperatures. High oil temperatures will reduce the performance and useful life of the oil, which can ultimately result in component failure.

If the cooler is contaminated with dust, it can be cleaned using compressed air. If the cooler is contaminated with a mixture of oil and dust, it should be disassembled and treated with a liquid cleaner, then cleaned of debris using compressed air. Take care when using compressed air, a high pressure washer, or a steam cleaner, as the fins of the cooler may be damaged. To ensure effective cleaning, the direction of air, water, or steam must be opposite to the direction of normal airflow through the cooler. On cranes that operate in corrosive environments (salt), frequently clean the cooler with water to help prevent corrosion.

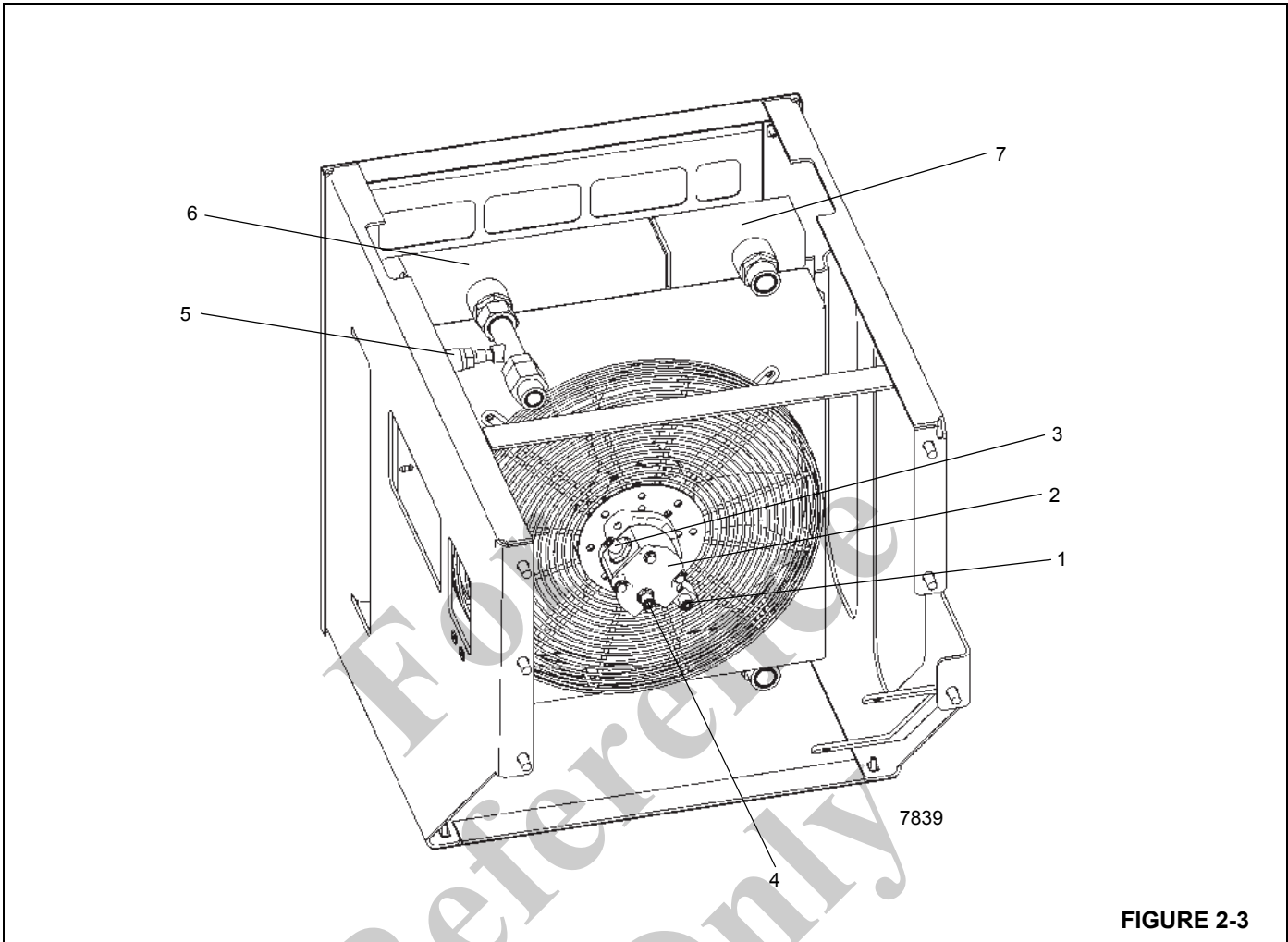


FIGURE 2-3

Item	Description
1	Outlet Port
2	Fan Motor
3	Inlet Port
4	Drain Port

Item	Description
5	Temperature Switch
6	Transmission Oil Cooler
7	Hydraulic Oil Cooler

## HYDRAULIC PUMPS

### Description

The No. 1 and No. 3 hydraulic pumps Figure 2-4 are mounted on a drive pad of the torque converter. The No. 2 hydraulic pump Figure 2-4 is mounted on a drive pad of the engine. The torque converter drives the No. 1 and No. 3 pumps. The engine directly drives the No. 2 pump.

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

#### Pump No. 1

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

The No. 1 hydraulic pump is a positive displacement, gear-type pump that has two separate sections.

The first section of the pump, the one closest to the mounting face, is a 81.1 cm<sup>3</sup> (4.95 in<sup>3</sup>) section with an output of 190.8 L/min (50.4 gpm) at 2451 rpm (loaded). The second section is a 40.3 cm<sup>3</sup> (2.46 in<sup>3</sup>) section with an output of 95.0 L/min (25.1 gpm) at 2451 rpm (loaded).

#### Pump No. 2

The No. 2 hydraulic pump is a positive displacement, gear-type pump with a 43.9 cm<sup>3</sup> (2.68 in<sup>3</sup>) section, and an output of 105.2 L/min (27.8 gpm) at 2500 rpm (loaded).

#### Pump No. 3

The No. 3 hydraulic pump is a positive displacement, gear-type pump with a 38.0 cm<sup>3</sup> (2.32 in<sup>3</sup>) section with an output of 74.9 L/min (19.8 gpm) at 2451 rpm (loaded).

### Maintenance

#### No. 1 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. Gain access to the pump. It is bolted to the right side of 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

Keep the pump as level as possible to avoid damaging the input spline.

4. Remove the capscrews and washers attaching the No. 1 pump to the drive pad on the torque converter. Remove the pump.
5. Clean the gasket material from the drive pad on the torque converter and the pump.
6. Cover the drive pad's opening to prevent dirt from entering.

#### No. 1 Pump Installation

1. Clean the drive pad and the pump with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. Apply a light coating of Loctite primer N7649 to drive pad and pump mounting surface. 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 drive pad and pump mounting surface.
4. Install pump and gasket on torque converter drive pad with capscrews and washers. Make sure the splines mesh properly. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
5. Connect the distribution and supply lines to the pump as tagged during removal. For the two distribution lines, install new O-rings with the flange halves and capscrews.

#### No. 1 Pump and Pump Disconnect Assembly Removal (Optional)

#### 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. Gain access to the pump. It is bolted to the right side of 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. Pull handle to disengage the splined coupler from the drive pad.

---

**CAUTION**

Keep the pump as level as possible to avoid damaging the input spline.

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5. Remove the four nuts and washers attaching the pump and pump disconnect assembly to the drive pad on the torque converter. Remove the pump and pump disconnect assembly from the studs.
6. Separate the pump and the pump disconnect assembly. Clean the gasket material from the drive pad on the torque converter and the pump and the pump disconnect assembly.
7. Examine the four studs that the pump and pump disconnect assembly mount on. Remove any damaged stud.
8. Cover the drive pad's opening to prevent dirt from entering.

**No. 1 Pump and Pump Disconnect Assembly Installation (Optional)**

1. Clean the drive pad and the pump disconnect assembly with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. As needed, prepare to install stud(s) to replace any removed previously. Apply Loctite 271 or equivalent per Grove specification to the threads of each stud that screw into the drive pad. Install stud(s).
3. Apply anti-seize compound to the internal and external splines of the splined coupler.
4. Apply a light coating of Loctite primer N7649 to drive pad mounting surface, to both pump disconnect assembly mounting surfaces, and pump mounting surface. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
5. Apply gasket material Loctite Master Gasket 518 to drive pad mounting surface, to both pump disconnect assembly mounting surfaces, and pump mounting surface.
6. Route pump disconnect assembly and its gasket on the studs. Make sure the splined coupler's splines mesh properly with the splined shaft in the drive pad. Press the pump disconnect assembly and its gasket into place so they seat properly on the drive pad.
7. Route pump and its gasket on the studs. Make sure the pump's splined drive shaft meshes with the pump disconnect assembly's splined coupler. Press the pump

and its gasket into place so they seat properly on the pump disconnect assembly.

8. Secure pump drive assembly and pump to torque converter drive pad with nuts and washers. Torque nuts; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
9. Connect the distribution and supply lines to the pump as tagged during removal. For the two distribution lines, install new O-rings with the flange halves and capscrews.

**No. 2 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. Gain access to the pump. It is bolted to the right side of 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 line from the pump. Cap or plug the line and port.
- 

**CAUTION**

Keep the pump as level as possible to avoid damaging the input spline.

---

4. Remove the capscrews, nuts and washers attaching the No. 2 pump to the drive pad on the engine. Remove the pump.
5. Clean the gasket material from the engine drive pad and the pump.
6. Cover the drive pad's opening to prevent dirt from entering.

**No. 2 Pump Installation**

1. Clean the drive pad and the pump with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. Apply a light coating of Loctite primer N7649 to drive pad and pump mounting surface. 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 drive pad and pump mounting surface.

4. Install pump and gasket on engine drive pad with capscrews and washers. Make sure the splines mesh properly. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
5. Connect the distribution and supply lines as tagged during removal. Use new O-rings on the connections to the pump.
6. Refer to *Testing After Repair or Replacement* for pump start up procedure.

### No. 3 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. Gain access to the pump. It is bolted to the left side of 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 line from the pump. Cap or plug the line and port.

#### CAUTION

Keep the pump as level as possible to avoid damaging the input spline.

4. Remove the capscrews and washers attaching the No. 3 pump to the drive pad on the torque converter. Remove the pump.
5. Clean the gasket material from the drive pad on the torque converter and the pump.
6. Cover the drive pad's opening to prevent dirt from entering.

### No. 3 Pump Installation

1. Clean the drive pad and the pump with Loctite cleaning solvent 7070 or similar non chlorinated solvent.
2. Apply a light coating of Loctite primer N7649 to drive pad and pump mounting surfaces. 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 drive pad and pump mounting surface.

4. Install pump and gasket on torque converter drive pad with capscrews and washers. Make sure the splines mesh properly. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
5. Connect the distribution and supply lines as tagged during removal. Use new O-rings on the connections to the pump.
6. Refer to *Testing After Repair or Replacement* for pump start up procedure.

### 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 engine, disassemble pump, and repair it so it will not bind.

For Pump No. 3, 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.

If it is suspected that the dual accumulator is set too high, perform steps under *Procedure F - Brake Dual Accumulator Charge Valve Pressure Limits*, page 2-26 to verify proper cut-in and cut-out pressures. Replace valve if pressures are not correct. Then 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 2-23.

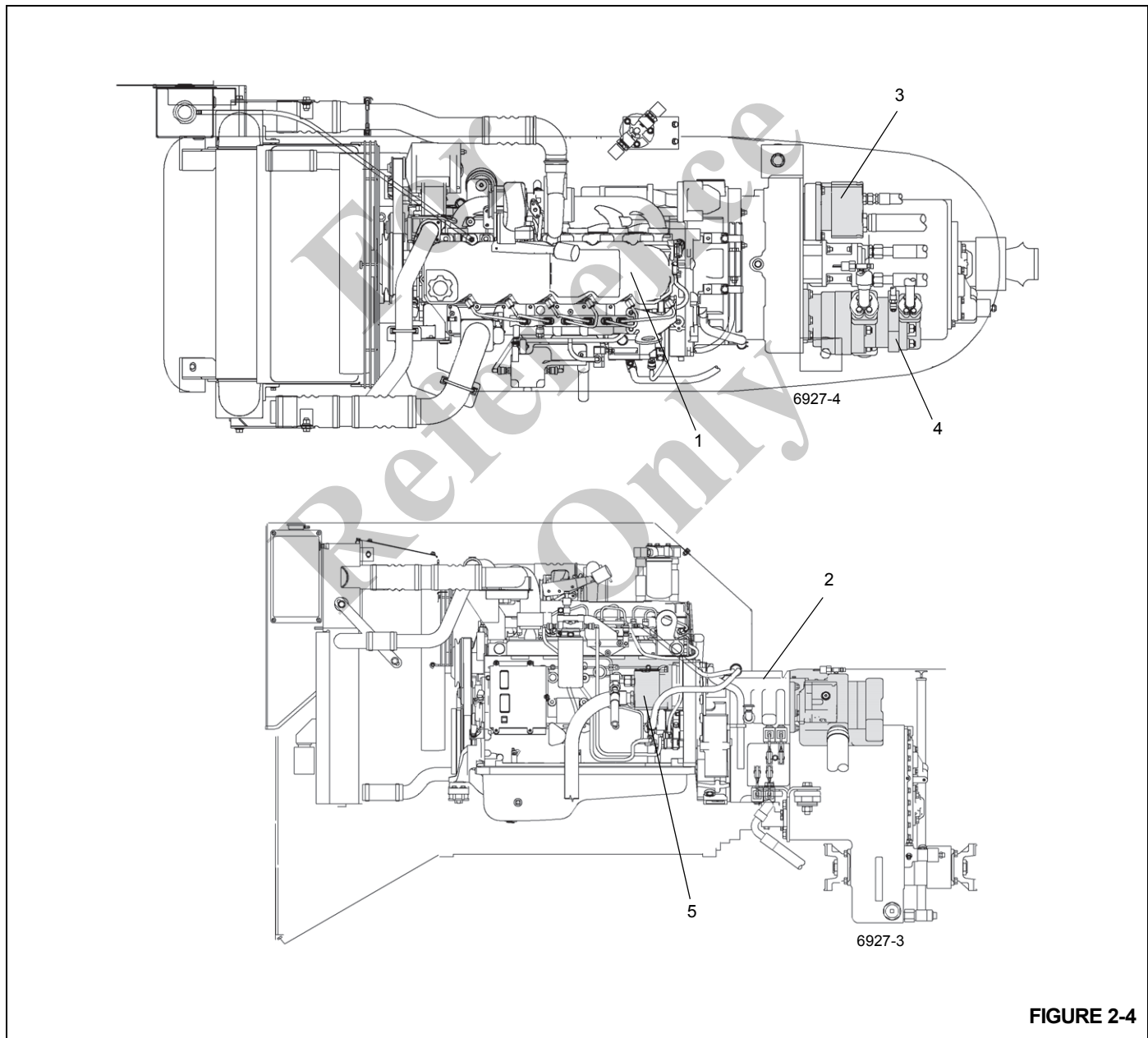


FIGURE 2-4



Item	Description
1	Engine
2	Transmission
3	Hydraulic Pump No. 3
4	Hydraulic Pump No. 1
5	Hydraulic Pump No. 2

### Pump Disconnect Assembly

#### Disassembly

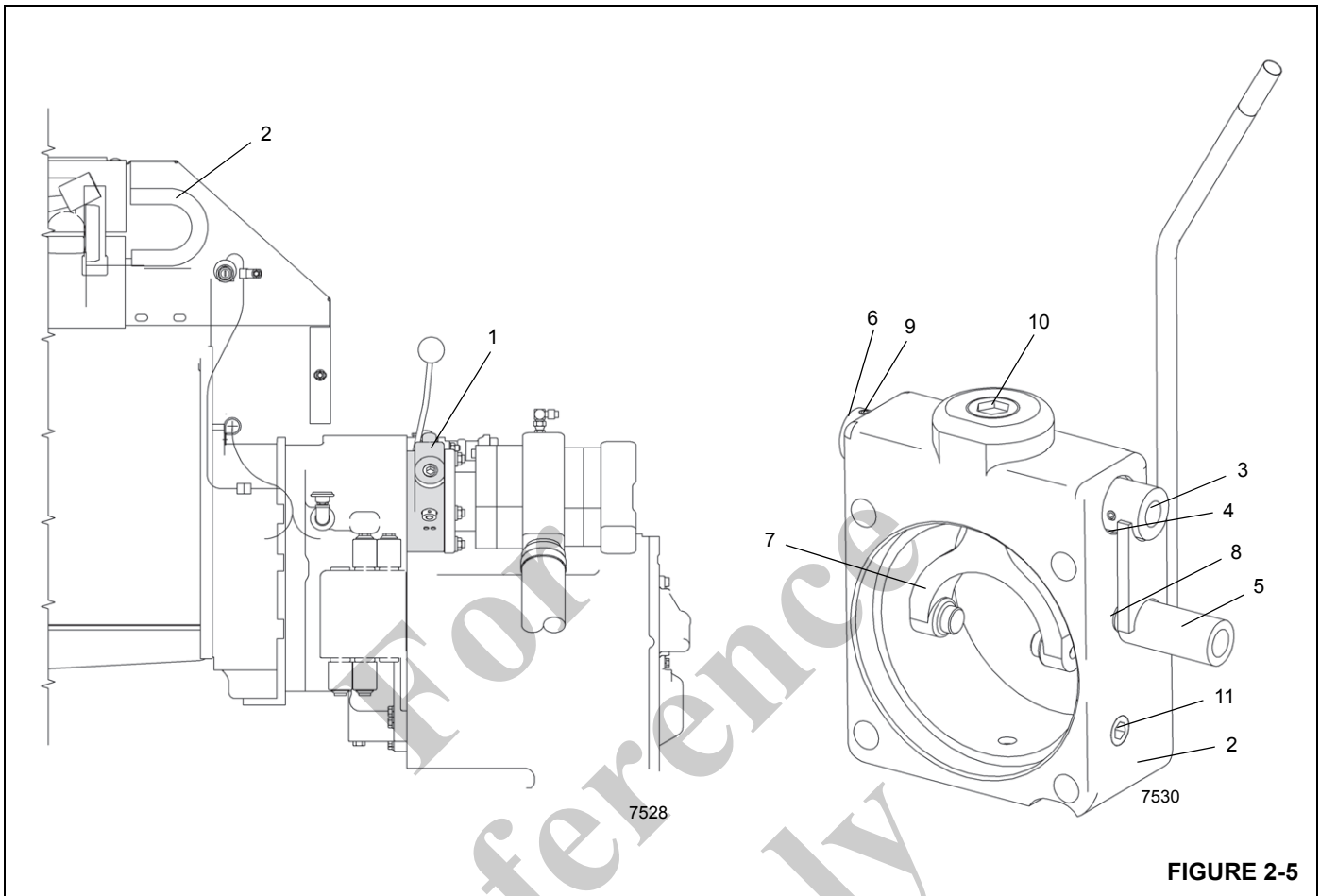
1. Remove pipe plug and plugs from their holes in the housing.
2. Remove roll pin to free shifter assembly from shaft. Remove shifter assembly.
3. Remove roll pin to free collar from shaft. Remove collar and shaft and attached parts from housing.
4. Remove roll pin to free handle from shaft. Remove handle. Remove shifter lock from handle.

5. Remove oil seals from housing.

#### Assembly

1. Install two oil seals into holes in housing.
2. Pin shifter assembly in housing with shaft.
3. Pin collar to shaft with roll pin.
4. Install shifter lock on handle.
5. Install handle on free end of shaft. Pin handle to shaft with roll pin.
6. Adjust shifter lock so handle can lock it into the IN detent position and into the OUT detent position. Then place handle at the OUT position.
7. Pin shifter assembly to shaft with roll pin.
8. Verify shifting parts shift properly. In other words, verify the handle moves the shifter assembly in and out, the shifter lock locks properly at each position, and the shaft and attached parts pivot without binding.
9. Repeat above step with splined coupler in place.
10. Install pipe plug and plugs in their holes in the housing.

For Reference Only



Item	Description
1	Pump Disconnect Assembly
2	Housing
3	Shaft
4	Oil Seal
5	Handle
6	Collar

Item	Description
7	Shifter Assembly
8	Shifter Lock
9	Roll Pin
10	Plug
11	Pipe Plug
12	Engine

## 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.

- Pressure Gauge (1) three dial gauge 0 to 34.5 MPa (0 to 5000 psi)
- Accumulator charging and gauging assembly for 20.7 MPa (3000 psi)
- ORFS reducers as required to attach work port hoses to the gauge.

**NOTE:** When checking the 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 specified setting.

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

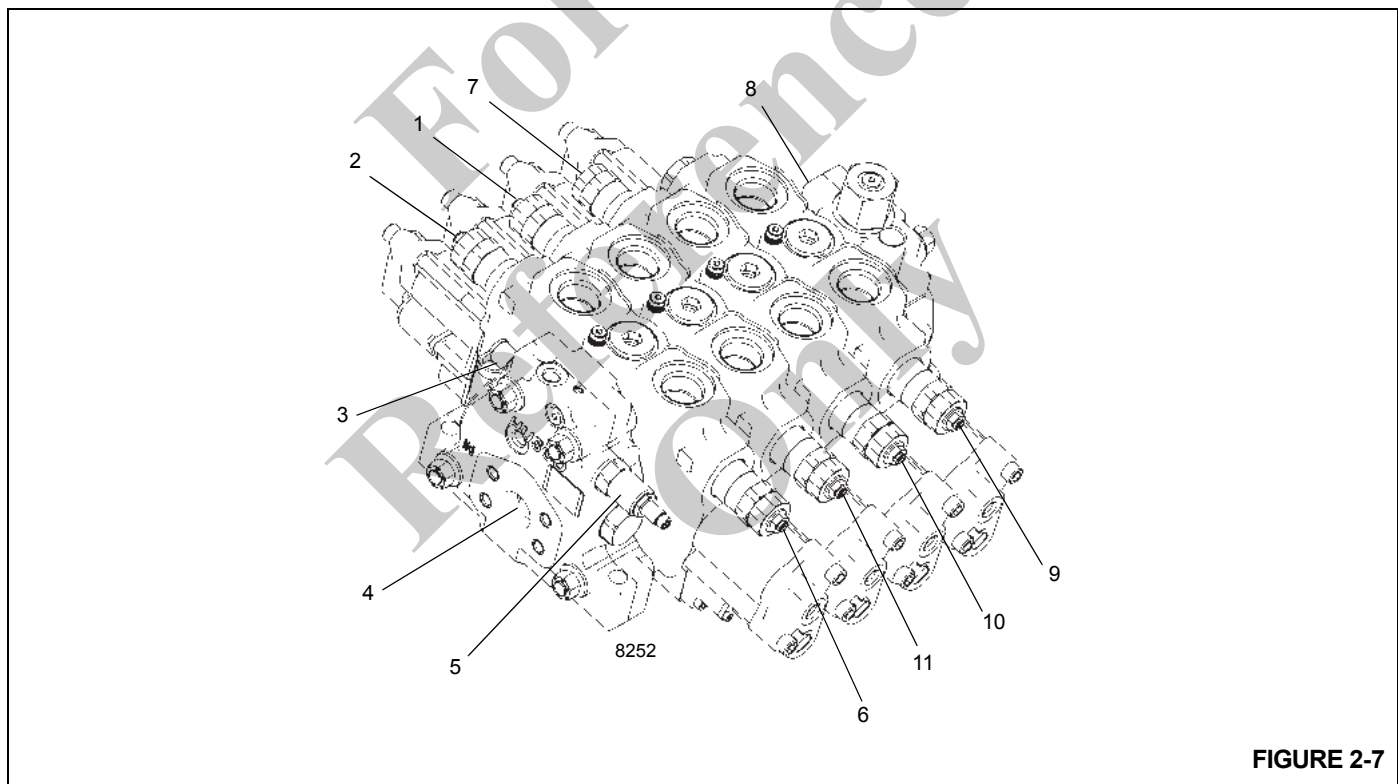
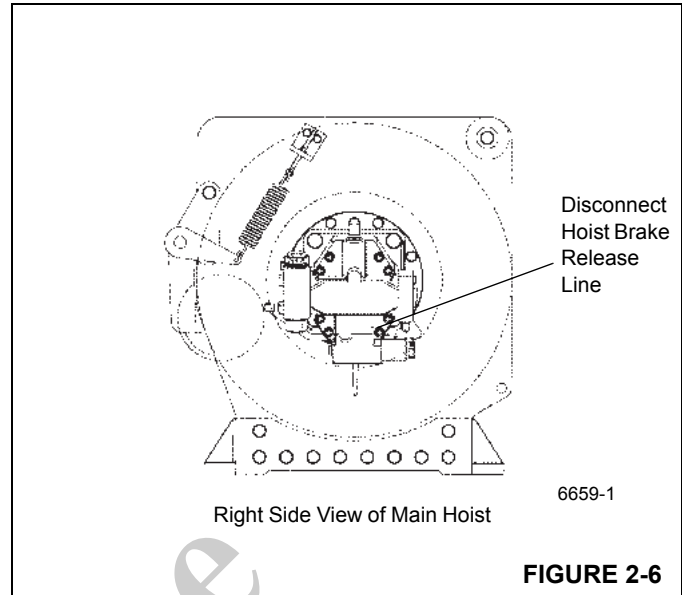
**Table 2-2**  
**Valve Pressure Setting Table**

Valve To Be Set	Pressure Setting MPa (PSI)	Tolerance MPa (PSI)	Adjustment Location
Load Sense Relief*	27.6 (4000)	±0.4 (±50)	Main Control Valve Inlet Gauge Port
Lift Down Relief	13.8 (2000)	+4.8/-0 (+700/-0)	
Telescope Retract Relief	24.1 (3500)	±0.4 (±50)	Main Control Valve Telescope Retract Port
Telescope Extend Relief	18.6 (2700)	±0.4 (±50)	Main Control Valve Telescope Extend Port
Hoist Raise	24.1 (3500)	±0.4 (±50)	Main Control Valve Hoist Raise Port
Hoist Lower	24.1 (3500)	±0.4 (±50)	Main Control Valve Hoist Lower Port
Pilot Pressure Supply	2.2 to 3.1 (325 to 450)	within listed range only	Main Control Valve Inlet
Swing Brake Pilot Supply	1.7 (250)	+0.4/-0 (+50/-0)	Pressure Reducing Valve
Front Steer Relief Valve	17.2 (2500)	±0.4 (±50)	Swing/Steer Control Valve
Swing "Left" Relief	15.2 (2200)	±0.4 (±50)	Swing/Steer Control Valve
Swing "Right" Relief	15.2 (2200)	±0.4 (±50)	Swing/Steer Control Valve
Outrigger/Rear Steer Relief	17.2 (2500)	±0.4 (±50)	Outrigger/Rear Steer Valve Inlet
Service Brake	20.7 (3000)	±0.4 (±50)	Service Brake/CAC Fan Valve
Service Brake High Charge Limit	17.4 (2320)	+0.5/-1.0 (+72/-145)	Dual Accumulator Charge Valve
Service Brake Low Charge Limit	13.5 (1950)	±1.0 (±145)	Dual Accumulator Charge Valve
Accumulator Pre-Charge	6.2 to 6.6 (900 to 950)	+0.4/-0 (+50/-0)	Accumulator
Charge Air Cooler Fan Motor Relief	6.9 (1000)	+ .4/-0 (+50/-0)	Service Brake/CAC Fan Valve
Counterweight Valve	12.07 (1750)	±0.4 (±50)	Counterweight Valve

\*This setting is for Boom Lift "UP" Circuit

**Procedure A - Main Control Valve Reliefs**

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at main directional control valve inlet gauge port Figure 2-7.
2. Completely extend lift cylinder (or cap hose from "A" port to the lift cylinder), attempt to lift up with engine running at full RPM. Adjust the load sense relief to 4000 psi  $\pm$ 50 (276 bar  $\pm$ 4).
3. Remove pressure gauge.
4. Install pressure check diagnostic quick disconnect with gauge onto test nipple at main directional control valve load sense relief test port Figure 2-7.



Item	Description
1	Auxiliary Hoist Down Port Relief
2	Main Hoist Down Port Relief
3	Load Sense Relief Test Port
4	Inlet Gauge Port
5	Pilot Supply Pressure Reducing Cartridge
6	Main Hoist Up Port Relief

Item	Description
7	Telescope Extend Port Relief
8	Load Sense Relief
9	Lift Down Port Relief
10	Telescope Retract Port Relief
11	Auxiliary Hoist Up Port Relief

5. Disconnect and cap the hose running from the main directional control valve to the hoist(s) port "A" on the hoist motor control valve. Disconnect the hoist brake release line at the hoist Figure 2-6. Cap fitting and plug hose.
6. With the boost switch on, attempt to hoist up with the engine running at full RPM. Adjust the main directional control valve hoist "B" port relief to 241 bar  $\pm 4$  (3500 psi  $\pm 50$ ).
7. With the boost switch on, attempt to hoist down with the engine running at full RPM. Adjust the main directional control valve hoist "A" port relief to 241 bar  $\pm 4$  (3500 psi  $\pm 50$ ).
8. If auxiliary hoist is installed, repeat 5, 6 and 7 for the auxiliary hoist.
9. Reconnect hose to port "A" of the hoist motor control valve and reconnect hoist brake release line on the hoist.
10. Completely retract lift cylinder. Attempt to lift down with the engine running at full RPM. Gauge should read 2000 psi +700/-0 (138 bar +48/-0). This relief valve is non-adjustable.
11. Completely retract the boom; attempt to telescope in with engine running at full RPM. Adjust the main directional control valve to telescope "B" port relief to 241 bar  $\pm 4$  (3500 psi  $\pm 50$ ).
12. Completely extend boom; attempt to telescope out with engine running at full RPM. Adjust the main directional control valve telescope "A" port relief to 186 bar  $\pm 4$  (2700 psi  $\pm 50$ ).
13. Remove pressure gauge from the load sense test port.

### Procedure B - Main Directional Control Valve Pilot Supply Pressure

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at pilot supply test port Figure 2-7.
2. Disconnect the hoist brake release line at the main hoist Figure 2-6. Cap fitting and plug hose.
3. While attempting to hoist down with the engine running at full RPM, check the pilot supply pressure.
4. Adjust the pressure reducing cartridge located in the inlet of the hoist/lift/telescope directional control valve to 22 to 31 bar (325 to 450 psi). Turn adjustment clockwise

to increase or counterclockwise to decrease the pressure setting.

5. Remove pressure gauge from the pilot supply test port.
6. Reconnect the hoist brake release line on the hoist.

### Procedure C - Swing Brake Pilot Supply Pressure

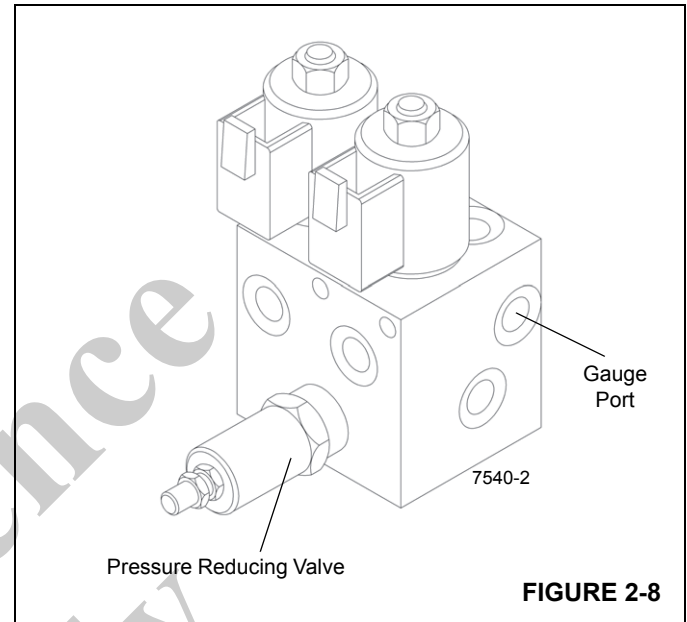


FIGURE 2-8

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at swing brake pilot supply valve test port Figure 2-8.
2. Adjust pressure reducing valve cartridge to 17 bar +4/-0 (250 psi +50/-0 psi).
3. Remove pressure gauge from the test port.

### Procedure D - Brake Charge Supply Valve Relief Pressure

1. With engine off, disconnect hose at port "CF1" at the brake charge/CAC fan motor supply valve Figure 2-9; cap and plug all openings.
2. Install pressure check diagnostic quick disconnect with gauge onto test nipple at brake charge/CAC fan motor supply valve test port.
3. Start engine and operate at full RPM. Adjust "Inlet Relief Valve" to 204 bar +4/-0 (3000 psi +50/-0).
4. Remove pressure gauge from test port, and reconnect hose to port "CF1".

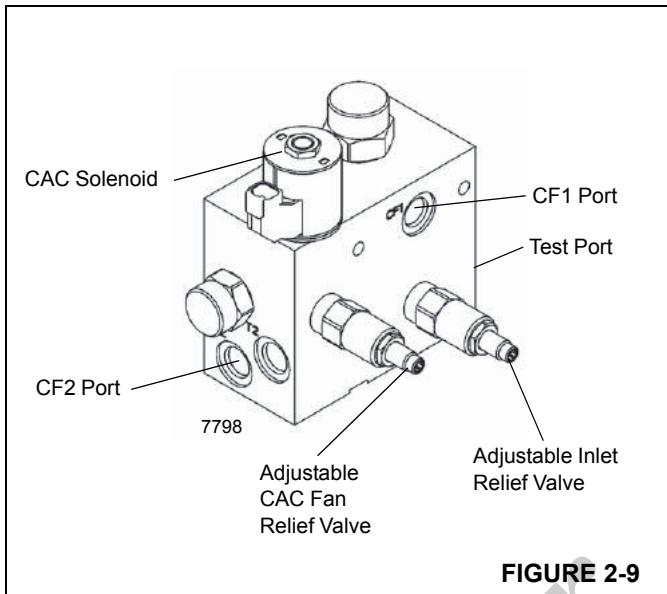


FIGURE 2-9

### Procedure E - Charge Air Cooler Valve Relief Pressure

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto Test Port, Figure 2-9.
2. Unplug CAC Solenoid.
3. Start engine and operate at Full RPM. Adjust "CAC Fan Relief Valve" to 69 bar  $\pm 4/-0$  (1000 psi  $\pm 50/-0$ ).

**NOTE:** Note: If brake valve begins charging accumulators, test port pressures above 124.1 bar (1800 psi) may be observed. Wait until charge is complete and then adjust CAC Relief to 69 bar  $\pm 4/-0$  (1000 psi  $\pm 50/-0$ ).

4. Remove pressure gauge from the Test Port, and reconnect CAC Solenoid.

### Procedure F - 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 8-10 times.
2. Install a pressure gauge at the service brake dual accumulator charge valve "A1" pressure test port (1, Figure 2-10).
3. Start and idle the engine. The charging valve will immediately start to charge the accumulators. Watch the pressure gauge. The high charge limit pressure should read 174 bar  $\pm 5/-10$  (2320 psi  $\pm 72/-145$ ) when the valve stops charging. The accumulator charge valve is non-adjustable.

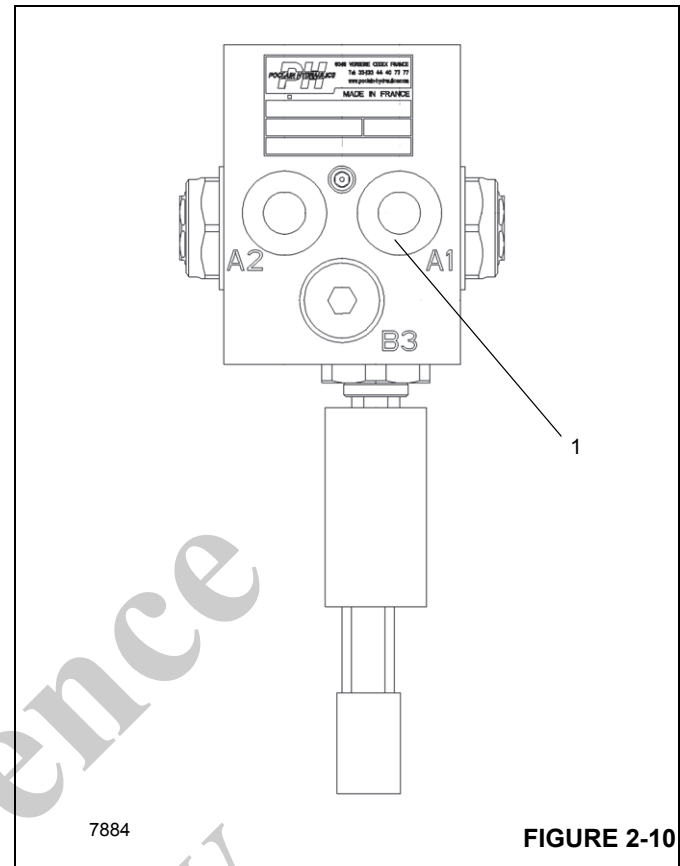


FIGURE 2-10

4. With the engine running, bleed off the hydraulic pressure stored in the accumulators by pushing the service brake pedal on the cab floor until the gauge reads about 134 bar (1950 psi). Listen to hear when the service brake dual accumulator charge valve starts to recharge. Push the service brake pedal once more; the valve should start to recharge. Watch the pressure gauge. The low charge limit should be 134 bar  $\pm 10$  (1950 psi  $\pm 145$ ) when the valve starts to recharge. The accumulator charge valve is non-adjustable.
5. Turn engine off. Remove the pressure gauge.

### Procedure G - 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).
3. Close the charging assembly bleed valve. Attach the swivel nut onto the gas valve and tighten to 1.1 to 1.7 Nm (10 to 15 lb-in).

4. Turn the gas chuck "T" handle all the way down (clockwise) which will depress the core in the gas valve.
5. Check the pre-charge pressure. It should be 62 bar +4/-0 (900 psi +50/-0).
6. If the pressure is 62 bar +4/-0 (900 psi +50/-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 from turning. Loosen swivel nut and remove charging assembly. Reinstall gas valve cap and guard.
8. Repeat for other accumulator.

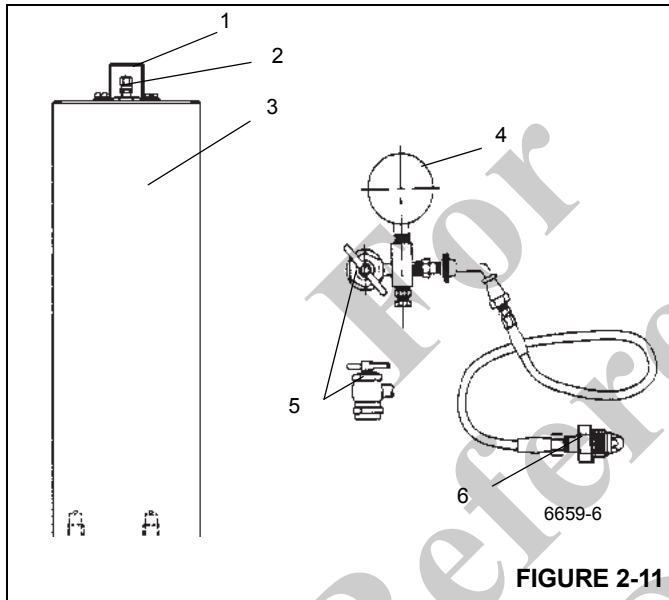


FIGURE 2-11

Item	Description
1	Gas Valve Guard
2	Gas Valve
3	Accumulator
4	Gauge
5	Gas Chuck
6	Bleed Valve

**Procedure H - PreCharging The Accumulator**

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 gas valve cap on the accumulator Figure 2-11.
2. Ensure that the nitrogen supply bottle is shut off, then attach the charging valve assembly to it.
3. Before attaching the 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 the hose, attach the swivel nut to the accumulator gas valve and tighten to 1.1 to 1.7 Nm (10 to 15 lb-in).
5. Turn the gas chuck "T" handle all the way in (clockwise), which will 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 62 bar +4/-0 (900 psi +50/-0).
7. If the pre-charge pressure is higher than 62 bar +4/-0 (900 psi +50/-0), 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 the charging assembly by turning the "T" handle all the way out (counterclockwise) on the gas chuck and then open the bleed valve.
9. Hold gas valve from turning. Loosen the swivel nut and remove the charging assembly. Reinstall the gas valve cap and guard.
10. Repeat for the other accumulator, as required.

**Procedure I - Swing Valve Work Port Reliefs Pressure**

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at swing valve inlet test port (5, Figure 2-12).
2. With the swing brake ON and the engine running at full RPM, swing left and adjust "A" port swing relief to 152 bar ±4 (2200 psi ±50).
3. With the swing brake ON and the engine running at full RPM, swing right and adjust "B" port swing relief to 152 bar ±4 (2200 psi ±50).

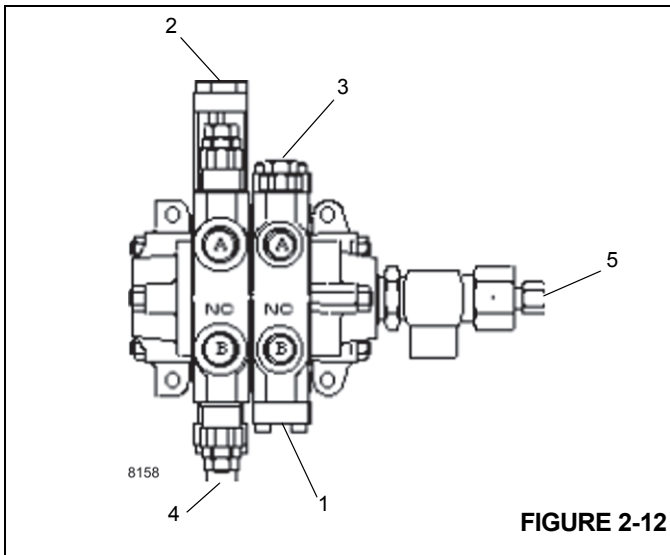


FIGURE 2-12

Item	Description
1	Steer Priority
2	Swing "A" Port Relief
3	Adjustable Relief Valve
4	Swing "B" Relief
5	Swing Inlet Test Port

**Procedure J - Front Steer Relief Valve Pressure**

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at swing valve test port per Procedure I.
2. Run the engine at full RPM and steer full right or full left and hold. Check the pressure and adjust the relief valve (3, Figure 2-12) to 172 bar  $\pm$ 4 (2500 psi  $\pm$ 50).
3. Remove the pressure gauge from the swing inlet test port.

**Procedure K - Outrigger/Rear Steer Valve Relief**

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at outrigger/rear steer valve pressure check port Figure 2-13.
2. With the boost switch OFF and the engine running at full RPM, press the extend switch and adjust the outrigger/rear steer relief valve to 172 bar  $\pm$ 4 (2500 psi  $\pm$ 50).

3. Remove pressure gauge from the pressure check port.

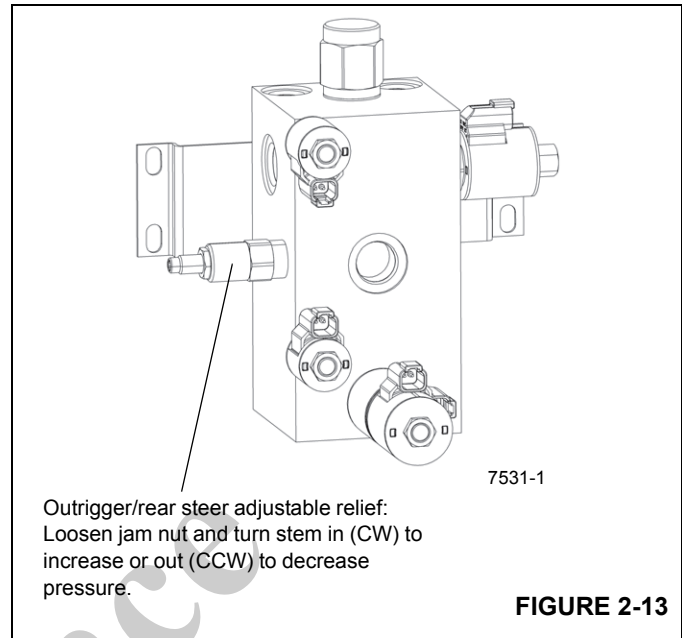


FIGURE 2-13

**Procedure L - Hydraulic Oil Cooler Fan Motor Control Valve**

1. Make sure that machine is up to operating temperature then unplug oil cooler valve solenoid (located near oil cooler fan motor) to assure fan is running at full speed.
2. Run the engine at idle and using a photo tachometer adjust flow control valve until a fan speed of 2400 to 2500 rpm is achieved.
3. Run the engine at full RPM and adjust the relief valve until a fan speed of 2400 to 2500 rpm is achieved.
4. Shut off engine and plug in the oil cooler valve solenoid.

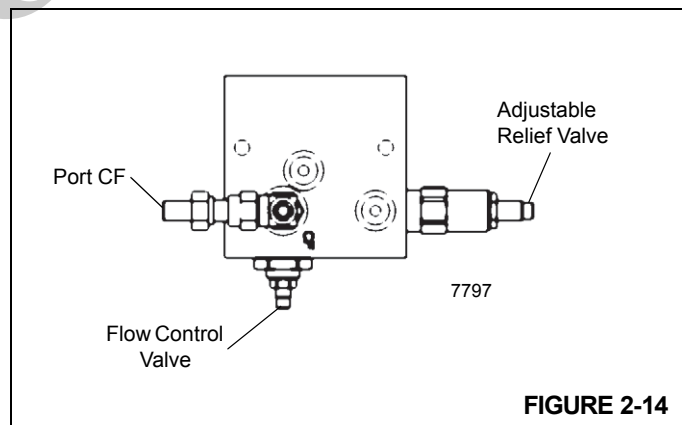
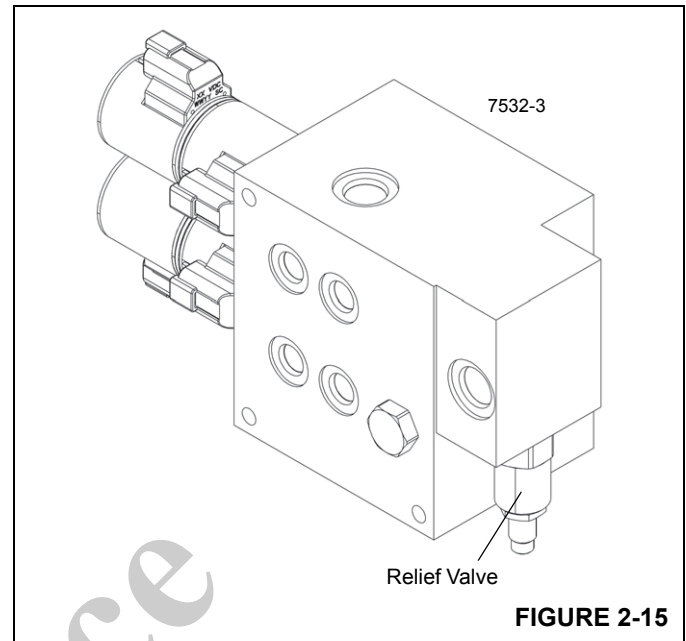


FIGURE 2-14



**Procedure M - Counterweight Removal Valve**

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at main directional control valve load sense relief test port Figure 2-7.
2. With engine at full RPM, retract counterweight cylinder and set relief valve on counterweight valve Figure 2-15 to 121 bar  $\pm$ 4 (1750 psi  $\pm$ 50); turn in to raise or out to lower pressure.
3. Remove pressure gauge from main directional valve.

**FIGURE 2-15**

**VALVES**

location, refer to Table 2-3. Refer to Figure 2-16 and Figure 2-17 for valve locations.

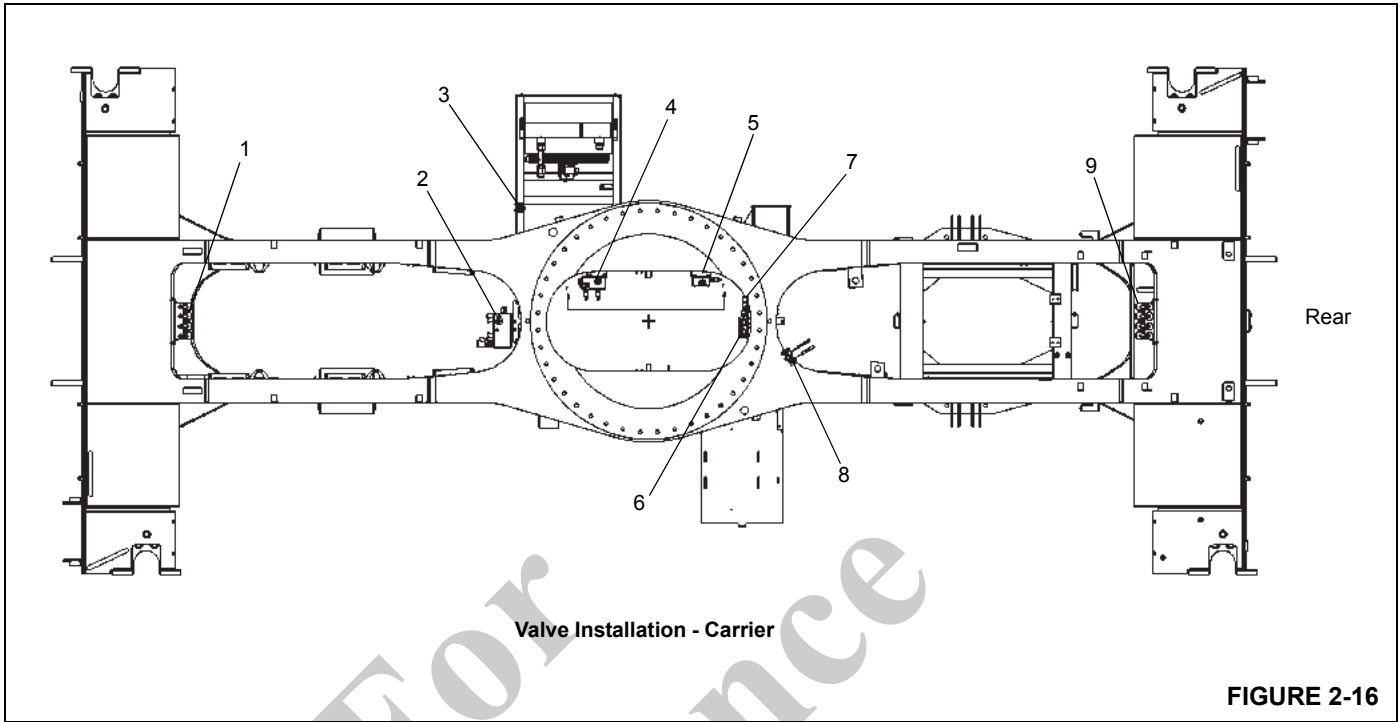
**General**

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

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 2-3  
Valve Usage Table**

Valve Name	Circuit Used In	Physical Location
<b>Superstructure</b>		
Directional Control Valves	Hoist/Lift /Telescope Swing/Steer Counterweight Removal (Optional)	Superstructure (Right Side) Superstructure (Right Side) Rear Turntable
Hydraulic Remote Controllers (Joysticks)	Hoist/Lift Swing/Telescope	Right Armrest Left Armrest
Dual Accumulator Charge Valve	Service Brakes	Superstructure (inside left side)
Swing Brake/Armrest Lockout Manifold • Swing Brake Release • Crane Function	Swing Each hoist, swing, lift and telescope controller circuit	Superstructure (right side) Superstructure (right side)
Holding Valves	Lift Telescope	Lift cylinder (bolt on) Telescope cylinder port blocks
<b>Carrier</b>		
Integrated Outrigger/Rear Steer Valve	Outrigger and Rear Steer	On front face of carrier frame front cross member
Outrigger Control Manifold	Outrigger	Front and Rear Outrigger Boxes
Axle Lockout Valve (Double Solenoid Valve)	Rear Axle Lockout	On carrier left side rear center frame cross member
High Speed Boost Selector Valve	Hoist and Telescope	On swivel port #6
Priority Flow Control Valves	Fan Motor	On carrier, RH fan structure
Cross Axle Differential Lock Solenoid Valve	Optional axle differential lock	On carrier front side rear center frame cross member
Axle Disconnect Solenoid Valve	Two/Four Wheel Drive	On carrier left side rear center frame cross member



Item	Description
1	Front Outrigger Control Valve
2	Integrated Outrigger/Rear Steer Valve
3	Fan Bypass Valve
4	Priority Flow Divider Valve
5	Adjustable Flow Valve

Item	Description
6	Park Brake Range Shift Valve
7	Differential Lock Valve (Optional)
8	Axle Lockout Valve
9	Rear Outrigger Control Valve

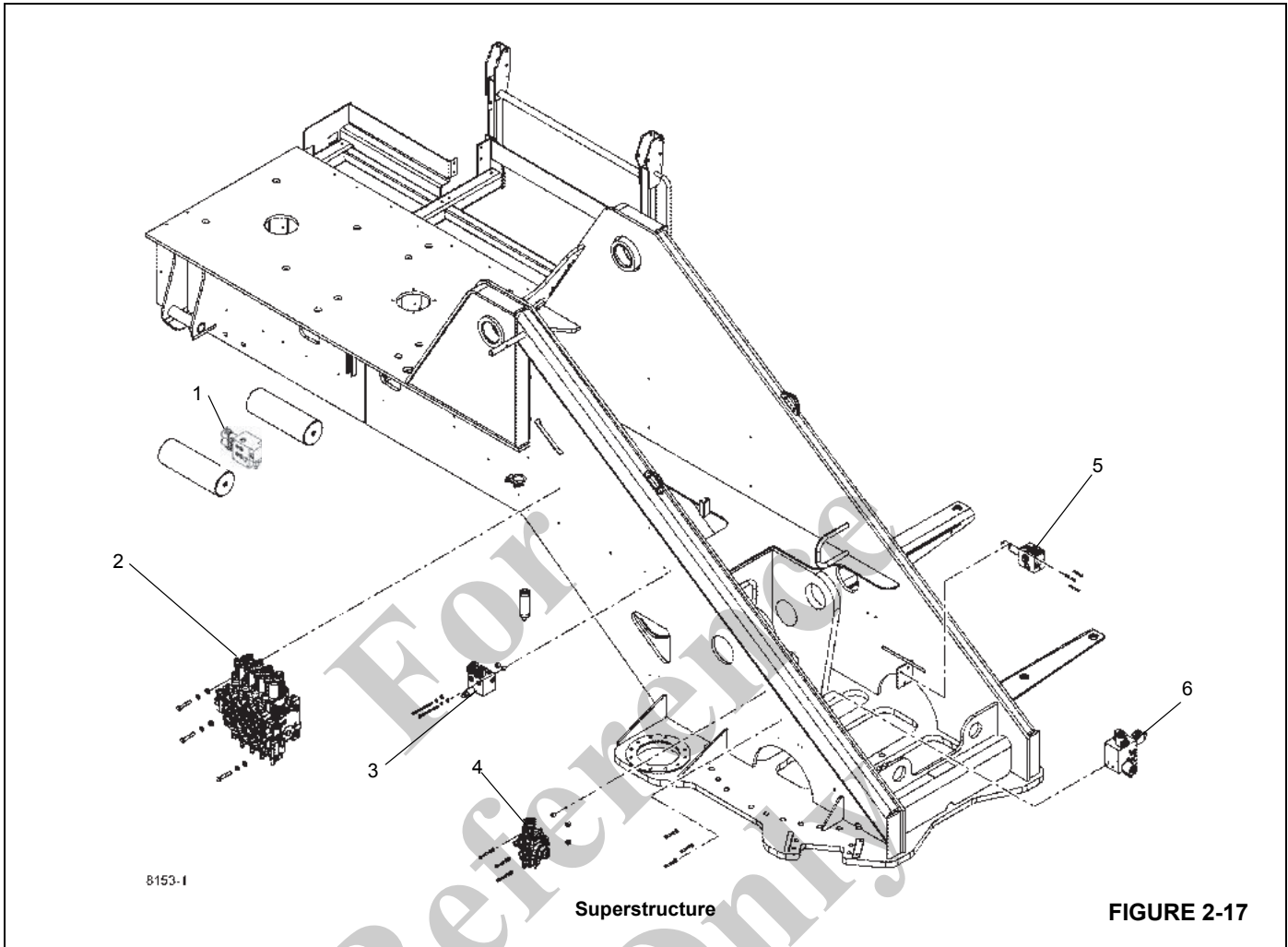


FIGURE 2-17

Item	Description
1	Counterweight Removal Manifold
2	Directional Control Valve (Hoist/Lift/Tele)
3	Swing Brake and Armrest Lockout Manifold

Item	Description
4	Steering Priority/Swing Control Valve
5	Dual Accumulator Control Valve
6	Telescope Fill Control Manifold

## DIRECTIONAL CONTROL VALVES

### Description

The directional control valves direct and control hydraulic oil flow from the pumps to function to be operated; lift and telescope cylinder, each hoist, the swing motor, and the front steering orbital motor.

#### *Lift/Telescope/Hoist Directional Valve*

The lift, telescope, and hoist(s) directional valves Figure 2-18 located on the superstructure side plate are three position normally closed valves. Hydraulic oil pressure applied by the remote control valves through the pilot circuits shift the directional control valves so they can drive their respective cylinders and motors. RCL lockout valve(s) for hoist up, lift down, and telescope out functions are located in each directional control valve. These valves are in series in the pilot lines between the remote control valve and the directional control valve. When energized, they allow operation of that function.

A load sense relief valve in the hoist/lift/telescope directional control valve controls the main system pressure at 276 bar (4000 psi). The unloading valve maintains a 20.7 bar (300 psi) standby pressure and a constant 20.7 bar (300 psi) pressure differential between the inlet and work port.

#### *Swing/Steer Directional Valve*

The swing/steer directional valve Figure 2-19 located on the superstructure side plate is a three position normally open valve. Hydraulic oil pressure applied by the remote control valves through the pilot circuits shift the directional control valves so they can drive their respective cylinders and motors.

#### *Counterweight Removal Directional Valve (Optional)*

The counterweight removal directional valve Figure 2-20 is installed on the rear of the turntable between the accumulators.

The valve contains two five-way, three position closed center directional valves. The inlet contains a load sense relief valve set at 120.66 bar (1750 psi) which protects all four working sections.

### Maintenance

#### *Swing/Steer Directional Valve Removal*

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

#### *Swing/Steer Directional Valve Installation*

1. Install the valve on the turntable upright and secure with the capscrews, flatwashers, lockwashers and bushings. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the hydraulic lines to the valves as tagged during removal.

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

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

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

1. Install the valve on the turntable upright and secure with the capscrews, flatwashers, and lockwashers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valves as tagged during removal.

#### *Counterweight Removal Directional Valve Removal*

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Tag and disconnect electrical connectors from the valve.
3. Remove the capscrews and nuts securing the valve. Remove the valve.

#### *Counterweight Removal Directional Valve Installation*

1. Install the valve to the turntable and secure with the capscrews and nuts. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valves as tagged during removal.

#### *Functional Check (All Directional Valves)*

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.



Item	Description
1	Load Sense Gauge Port
2	From Pump
3	Gauge Port
4	Main Hoist Directional Valve
5	Auxiliary Hoist Directional Valve
6	Telescope Directional Valve
7	Lift Directional Valve
8	Unloader
9	To Tank
10	Load Sense Relief
11	Pilot Generator
12	Auxiliary Pilot Port
13	Pilot Drain
14	Port 1A - Hoist Down
15	Port 1B - Hoist Up
16	Port 3A - Telescope Extend
17	Port 3B - Telescope Retract

Item	Description
18	Port 4A - Lift Extend
19	Port 4B - Lift Retract
20	Relief Valve - Auxiliary Hoist Up
21	Relief Valve - Telescope Extend
22	Relief Valve - Telescope Retract
23	Boom Lift Thermal Relief
24	Pilot to B Ports On Controller
25	Pilot to A Ports On Controller
26	Port 2A - Auxiliary Hoist Down
27	Port 2B - Auxiliary Hoist Up
28	Load Sense
29	Relief Valve - Hoist Down
30	Relief Valve - Auxiliary Hoist Down
31	Relief Valve - Hoist Up

For Reference Only

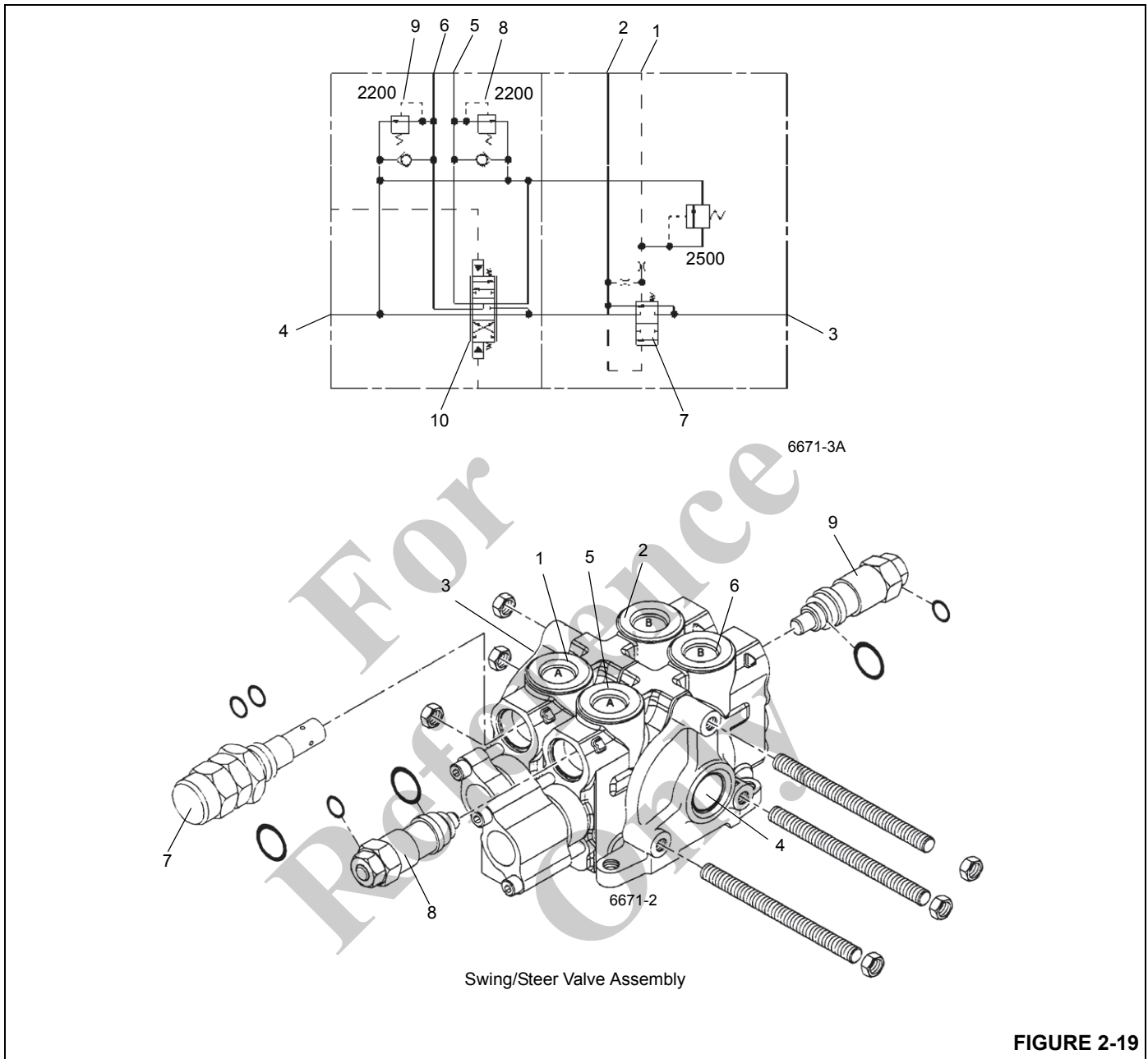


FIGURE 2-19

Item	Description
1	Port 1A - Load Sense
2	Port 1B - Priority Flow
3	Inlet Port
4	Outlet Port
5	Port 2A - Work Port

Item	Description
6	Port 2B - Work Port
7	Steer Priority Flow Divider
8	Swing WP Relief Valve
9	Swing WP Relief Valve
10	Swing Directional Valve



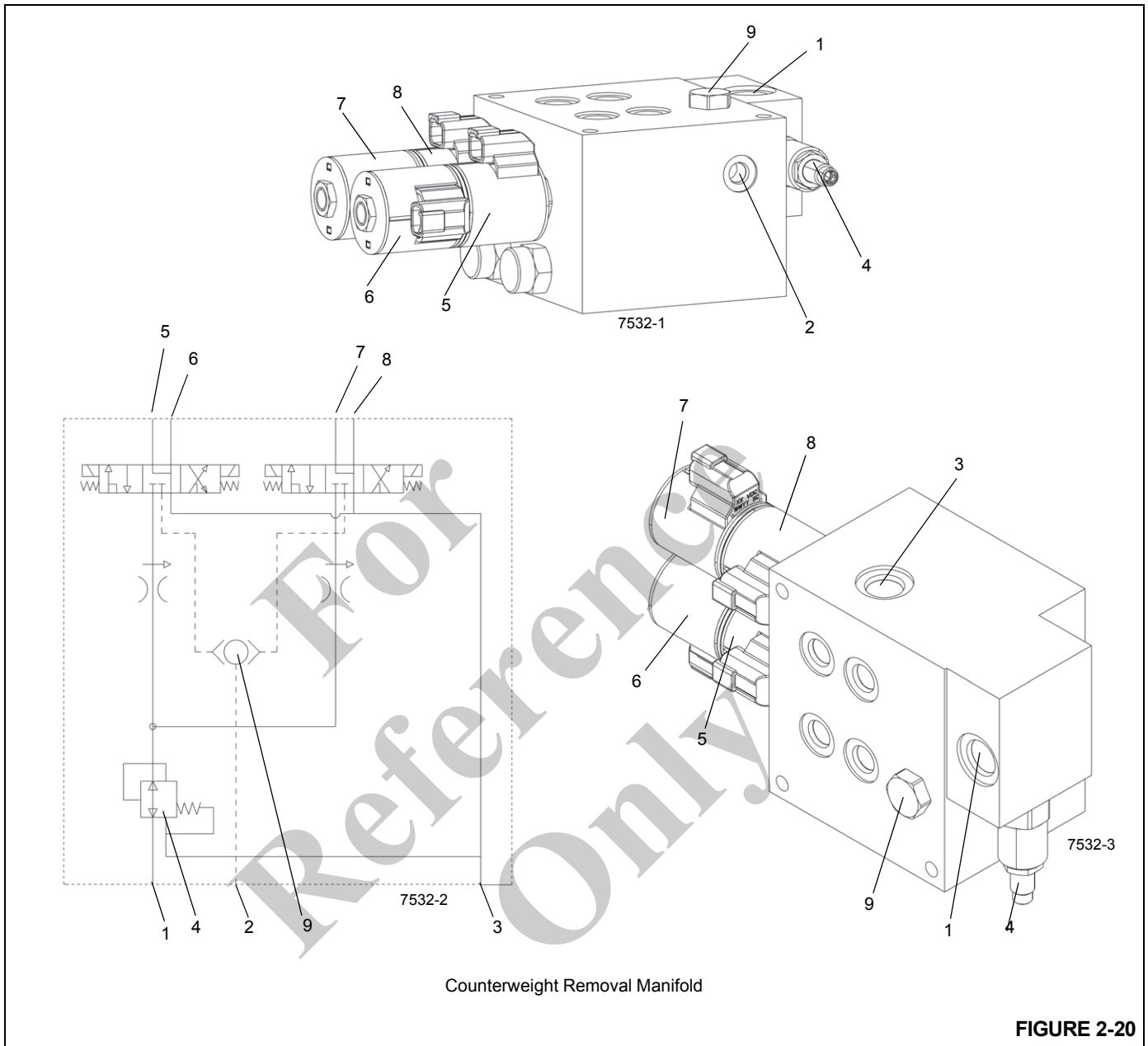


FIGURE 2-20

Item	Description
1	Port P - Pressure to Directional Valve
2	Port LS - Load Sense
3	Port T - Tank to Swivel Port #4
4	Pressure Compensated Regulator
5	Port 1A - Solenoid Valve SV2

Item	Description
6	Port 1B - Solenoid Valve SV1
7	Port 2B - Solenoid Valve SV3
8	Port 2A - Solenoid Valve SV4
9	Load Shuttle

## HYDRAULIC REMOTE CONTROL VALVE

### Description

The crane has four single axis hydraulic remote control valves (Figure 2-21). Each valve 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.

**NOTE:** If the crane has an optional auxiliary hoist, the auxiliary hoist function replaces the telescope function on the control lever on the left armrest. 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, or the operator leaves his seat, the controller lockout valve is de-energized and the functions are disabled.

### Dual Axis Controllers (CE Units)

The two hydraulic remote control valves Figure 2-22 are dual function joystick type valves. One valve is located in each armrest. The valve in the right armrest controls the main hoist and boom lift. Moving the control lever straight forward or back operates the main hoist function. Pushing the control lever to either side operates boom lift. Positioning the lever in a diagonal direction operates both functions simultaneously. The valve in the left armrest controls swing and telescope. Pushing the control lever straight forward or back controls the telescope function. Pushing the control lever to either side operates swing. Positioning the lever diagonally operates both functions simultaneously.

**NOTE:** If the crane is equipped with an optional auxiliary hoist, the auxiliary hoist function replaces the telescope function on the control lever of the left armrest and the telescope function is controlled by a pedal operated single function control valve Figure 2-23. The pedal is located on the left side of the cab floor. The control valve is mounted beneath the cab and is connected to the pedal by linkage.

## 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 motor, lift cylinder, and telescope cylinder (or auxiliary hoist).
3. Check valve and lines for leakage. Make repairs as needed.

**Telescope Pedal Control Valve Removal (With Auxiliary Hoist Option)**

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 (With Auxiliary Hoist Option)**

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 (With Auxiliary Hoist Option)**

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

For  
Reference  
Only

**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.

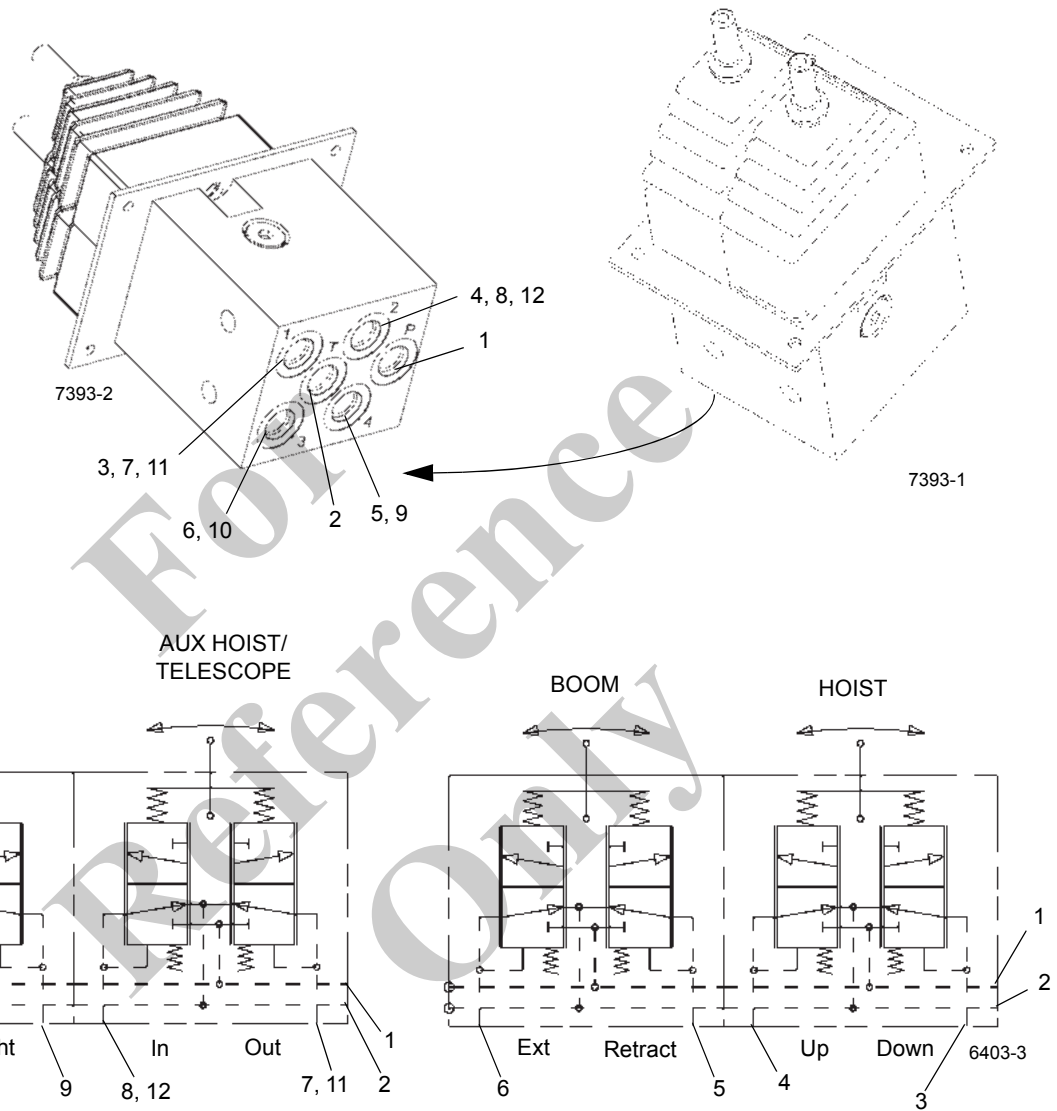


FIGURE 2-21

Item	Description
1	P Port - Pressure
2	T Port - Tank
3	A Port - Hoist Down
4	B Port - Hoist Up
5	A Port - Boom Retract
6	B Port - Boom Extend

Item	Description
7	B Port - Telescope Out
8	A Port - Telescope In
9	A Port - Swing Right
10	B Port - Swing Left
11	A Port - Aux Hoist Up
12	B Port - Aux Hoist Down

Item	Description
1	Tank Port
2	Pump Port
3	Port B2 - Swing Left
4	Port B1 - Swing Right
5	Port A1 - Auxiliary Hoist Cable In
6	Port A2 - Auxiliary Hoist Cable Out
7	Port B2 - Boom Lift Up
8	Port B1 - Boom Lift Down
9	Port A1 - Main Hoist - Cable In
10	Port A2 - Main Hoist - Cable Out

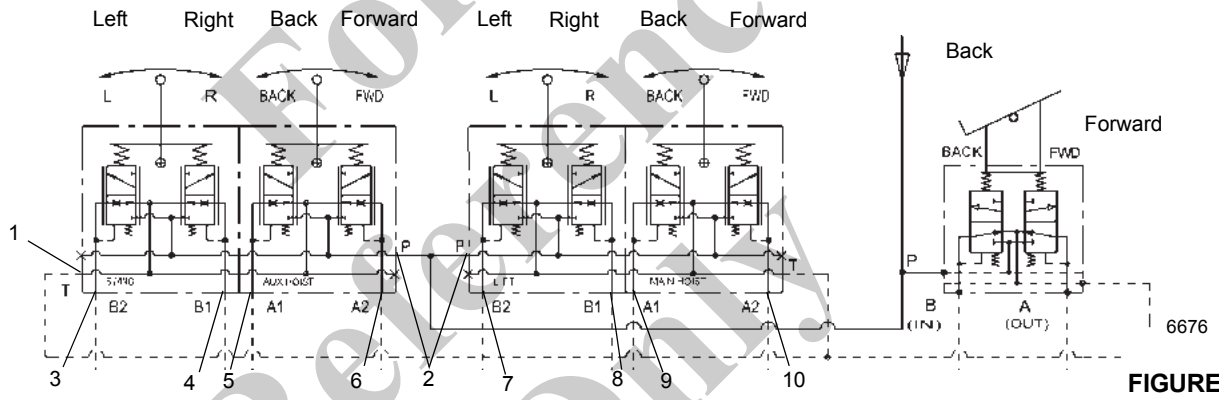
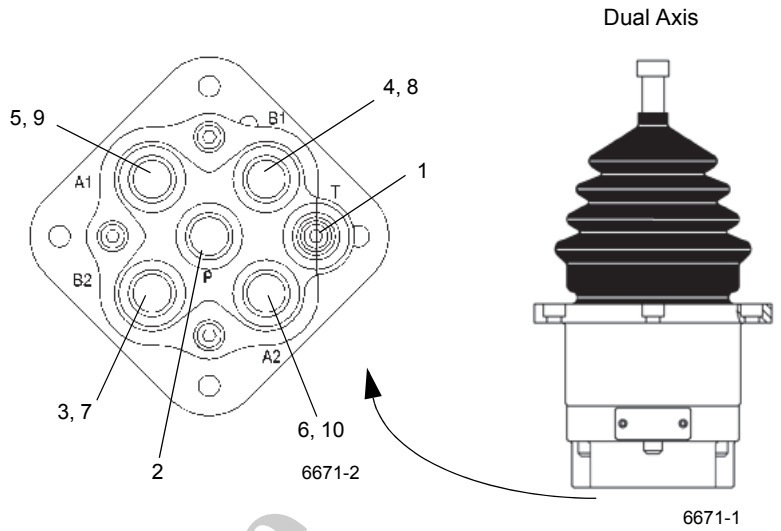
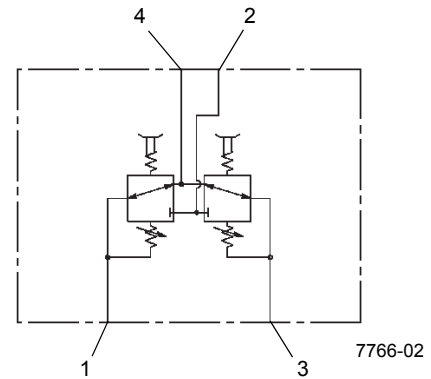
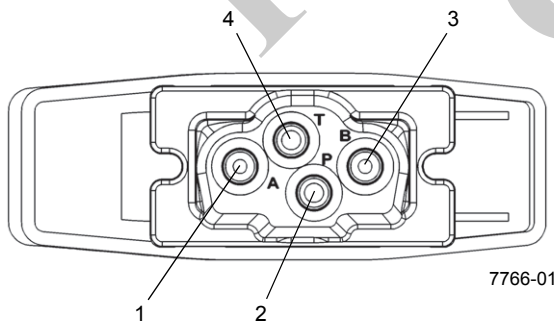


FIGURE 2-22



Item	Description
1	Telescope In
2	Pressure Port
3	Telescope Out
4	Port To Tank

Telescope Foot Controller

FIGURE 2-23

## DUAL ACCUMULATOR CHARGE VALVE

### Description

The load sensing dual accumulator charging valve is located on the inside of the left superstructure side plate. The purpose of the valve is to provide pressure regulation to the service brake circuit.

The dual accumulator charge valve consists of a flow divider spool, cut-in/cut-out spool, check valve and two sequence valves (see Figure 2-24).

When used with a fixed displacement pump, the flow divider spool shifts to ensure priority flow to the accumulators until the cut-out pressure is obtained. The balance of the flow exits the valve through the auxiliary port (A) to tank. When used with a LS piston pump, the LS port is connected to the pump when the accumulator pressure reaches the cut-in setting [134 bar (1950 psi)]. The pump will deliver the required charge flow to charge the accumulators. When the cut-out setting of 160 bar (2320 psi) is reached, the cut-in/cut-out spool shifts to vent the LS line to tank. The sequence valves isolate the two accumulators. If one of the accumulator loses pressure, the other accumulator will continue to charge and provide flow to the brake circuit when required.

### Maintenance

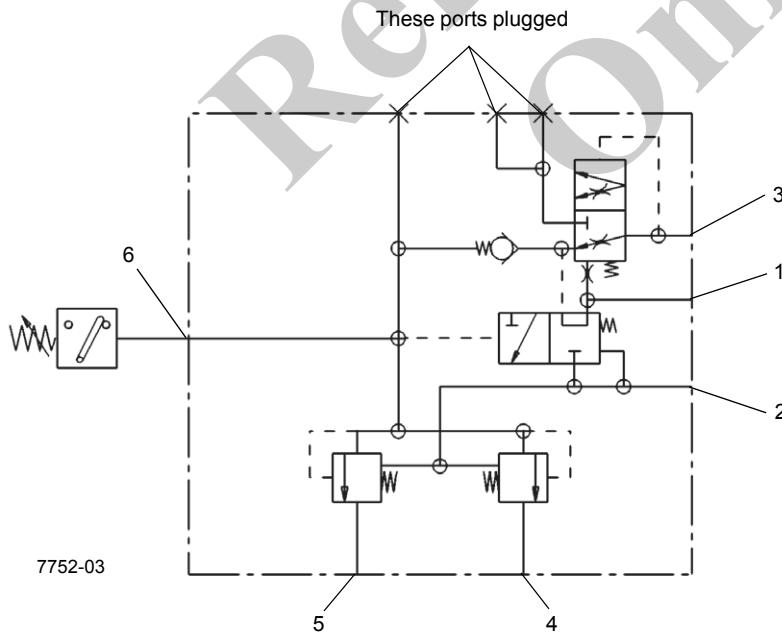
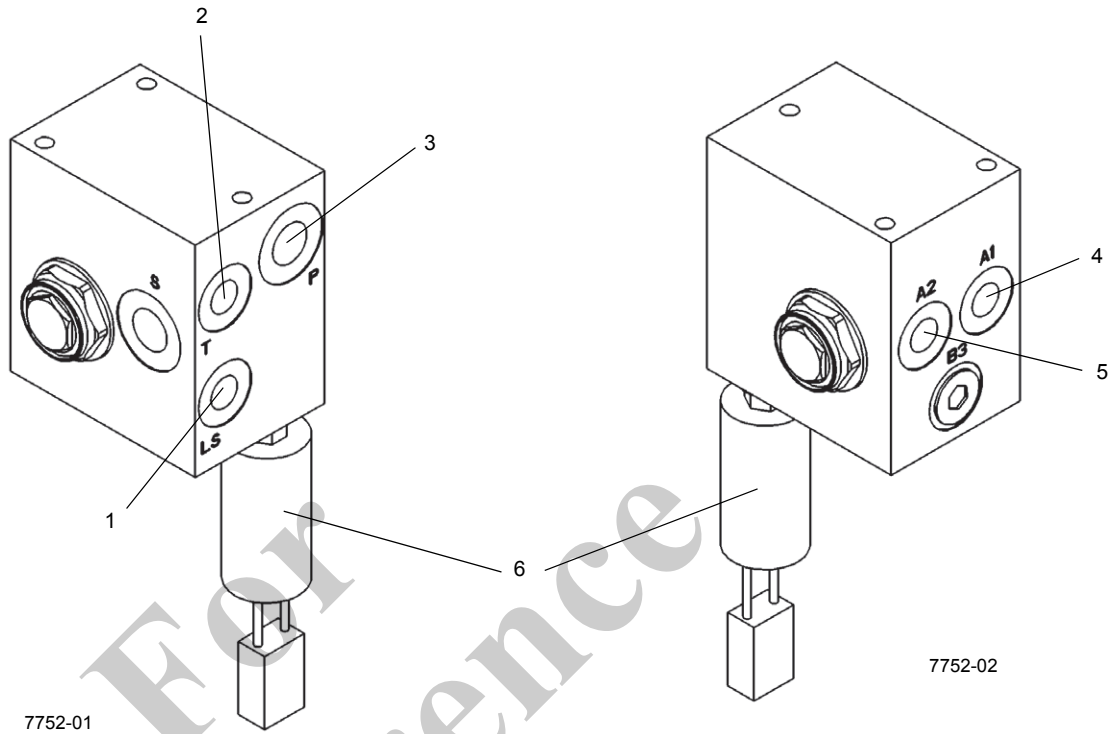
#### Removal

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

#### Installation

1. Position the valve on the superstructure with ports A1, A2, and B3 facing up and secure with three bolts, washers, and lockwashers. Torque bolts.
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 to cause the brake valve to charge. Make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing, and front steering work properly.

For Reference Only



Item	Description
1	Load Sense Port
2	Tank Port
3	Pressure Port
4	Accumulator Port 1A
5	Accumulator Port 2A
6	Pressure Switch

Valve Hydraulic Schematic

FIGURE 2-24

## SWING BRAKE AND ARMREST LOCKOUT VALVE MANIFOLD

### Description

The swing brake and armrest lockout valve manifold Figure 2-25 is located on the right side of the turntable. The manifold contains a pressure reducing valve, a 100 mesh filter screen in the inlet port, and two three-way, two position solenoid valves.

The pressure reducing valve provides 17.2 bar (250 psi) for operation of the swing brake and the foot throttle.

Each solenoid valve is held in its normally open to tank position by a spring. When the solenoid is energized, the plunger assembly forces the spool to shift, causing the valve to shift. Deenergizing the solenoid causes spring pressure to shift the spool to its normally closed position.

One solenoid valve serves as the swing brake release valve. This normally open to tank valve, when de-energized, prevents hydraulic oil pressure from releasing the swing brake. When the Swing Brake Switch is in OFF, this valve opens to allow hydraulic oil pressure to release the swing brake.

The other three-way, two-position solenoid valve serves as the controller armrest lockout valve. This normally open to tank valve is de-energized when the Crane Function Switch is in OFF, the armrest is raised, or the operator is not in the seat. When de-energized, the valve prevents hydraulic oil pressure from reaching the pilot circuits (the circuits the swing, lift, telescope, and each hoist remote control valve use to control the directional control valves). When the Crane Function Switch is ON, this valve opens to allow hydraulic oil pressure to all of the pilot circuits, remote control valves, and directional control valves. This valve, when closed, prevents accidental turntable, hoist, or boom movement.

### Maintenance

#### Removal

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

#### Installation

1. Position the manifold and spacer bushings on turntable and secure with the capscrews, flatwashers and

lockwashers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.

2. Connect the hydraulic lines to the manifold as tagged during removal.
3. Connect the electrical connectors to the manifold as tagged during removal.

#### Function Check - Swing Brake Release Valve.

1. Position the Swing Brake Switch to OFF. Verify the Swing Brake Engaged LED in the steering column display goes out.
2. Swing the turntable to verify the swing brake has released. Step on the power brake valve to stop the turntable.
3. Position the Swing Brake Switch to ON. Verify the Swing Brake Engaged LED in the steering column display 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.

#### Function Check - Crane Function Valve

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. Verify the following functions:
  - a. Telescope the boom in and out
  - b. Lower and raise the boom
  - c. Hoist each hoist up and down,
  - d. Swing the turntable left and right.
6. Check for leaks. Make repairs as needed.

#### Inlet Filter Screen Replacement

**NOTE:** The filter screen should be replaced every 2000 hours or if crane functions slow down.

1. Disconnect the inlet line from the "P" port on the valve and remove the fitting from the port.
2. Remove hollow lock screw, spacer, and filter screen.
3. Install new filter screen, spacer, and hollow lock screw.
4. Install fitting in the "P" port and connect the inlet line.



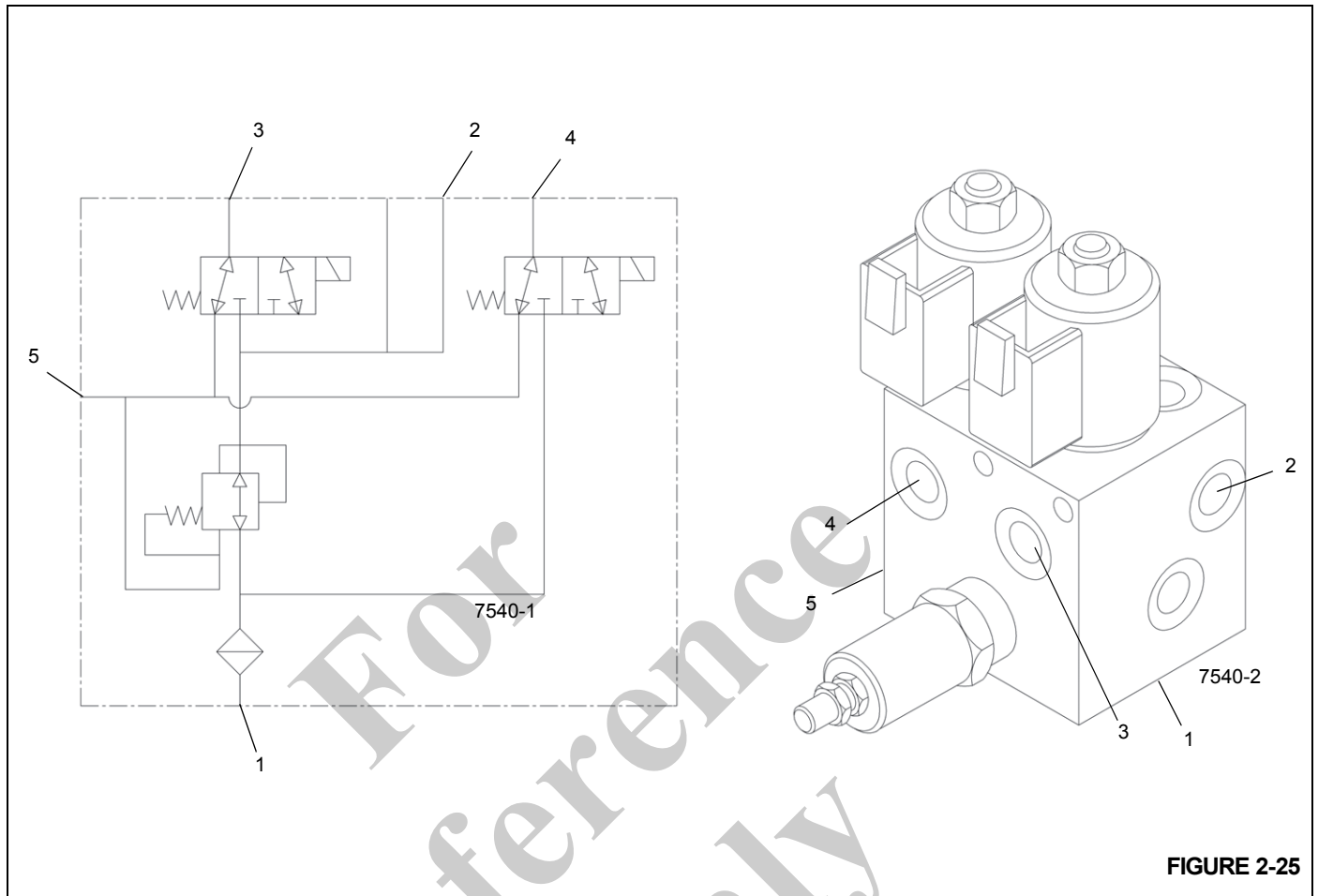


FIGURE 2-25

Item	Description
1	Port P - Inlet Port
2	Port G - Gauge Port
3	Port REG 1 - Swing Brake Release

Item	Description
4	Port REG 2 - Controller Armrest Lockout Valve
5	Drain

## HOLDING VALVE

### Description

A bolt-on externally piloted manifold style holding valve is installed on the lift cylinder and a cartridge style holding valve is installed into each telescope cylinder port block.

### Maintenance

#### Removal

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

#### Installation

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.
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 or manifold until fully seated.
5. 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.

For Reference Only

**OUTRIGGER/REAR STEER VALVE**

**Description**

The outrigger/rear steer valve Figure 2-26 controls the outrigger circuit and the rear steer circuit. The valve is mounted on the front face of the carrier frame front cross member forward of the swivel.

The inlet section contains a 172 bar (2500 psi) relief valve and a solenoid valve. The solenoid valve is normally open bypassing oil from the inlet port to the tank port. Activation of

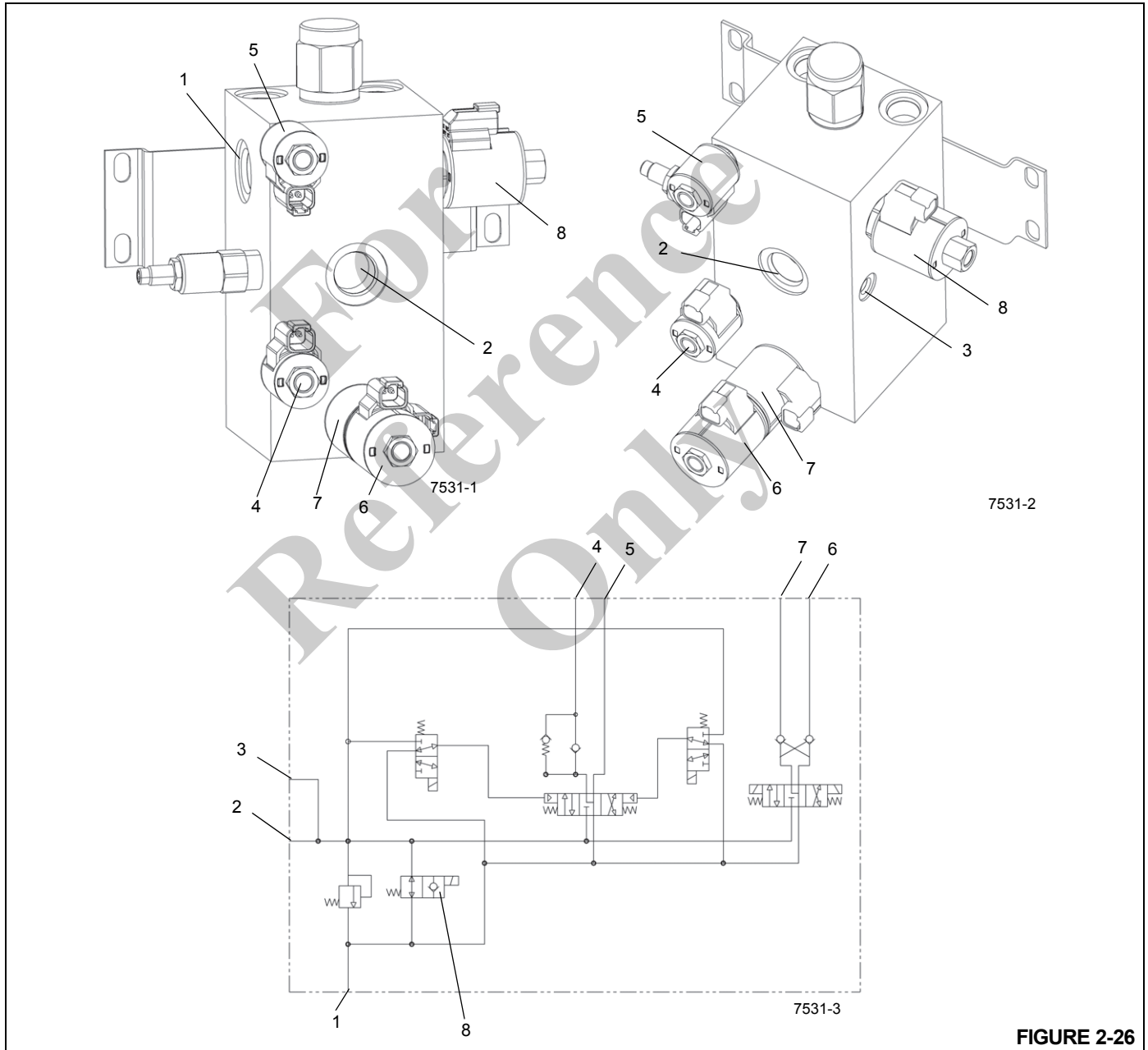
either the outriggers or the rear steer energizes the solenoid valve to close and allow oil to flow to the selected circuit.

The rear steer section contains a three position four-way solenoid controlled directional valve.

The outrigger section contains a three position four-way solenoid controlled directional valve.

Both four-way solenoid valves contain manual override actuators which allow the valves to be shifted if electrical power is lost.

2



**FIGURE 2-26**

Item	Description
1	Port T - Tank
2	Port P - Pressure from High Speed Boost Selector Valve
3	Port GP - Gauge Port
4	Port OA - Solenoid Valve SV2 - Jack Cylinders
5	Port OB - Solenoid Valve SV1 - Extension Cylinders
6	Port SA - Solenoid Valve SV5 - Rear Steer Cylinders
7	Port SB - Solenoid Valve SV4 - Rear Steer Cylinders
8	Solenoid Valve SV3 from High Speed Boost Selector Valve

## Maintenance

### Removal

1. Tag and disconnect the electrical connectors to the valve. Tape the lead ends.
2. Tag and disconnect the hydraulic lines to the valve. Cap or plug the lines and ports.

3. Remove the capscrews, nuts, and washers securing the 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 flatwashers, lockwashers, hex nuts and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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 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.

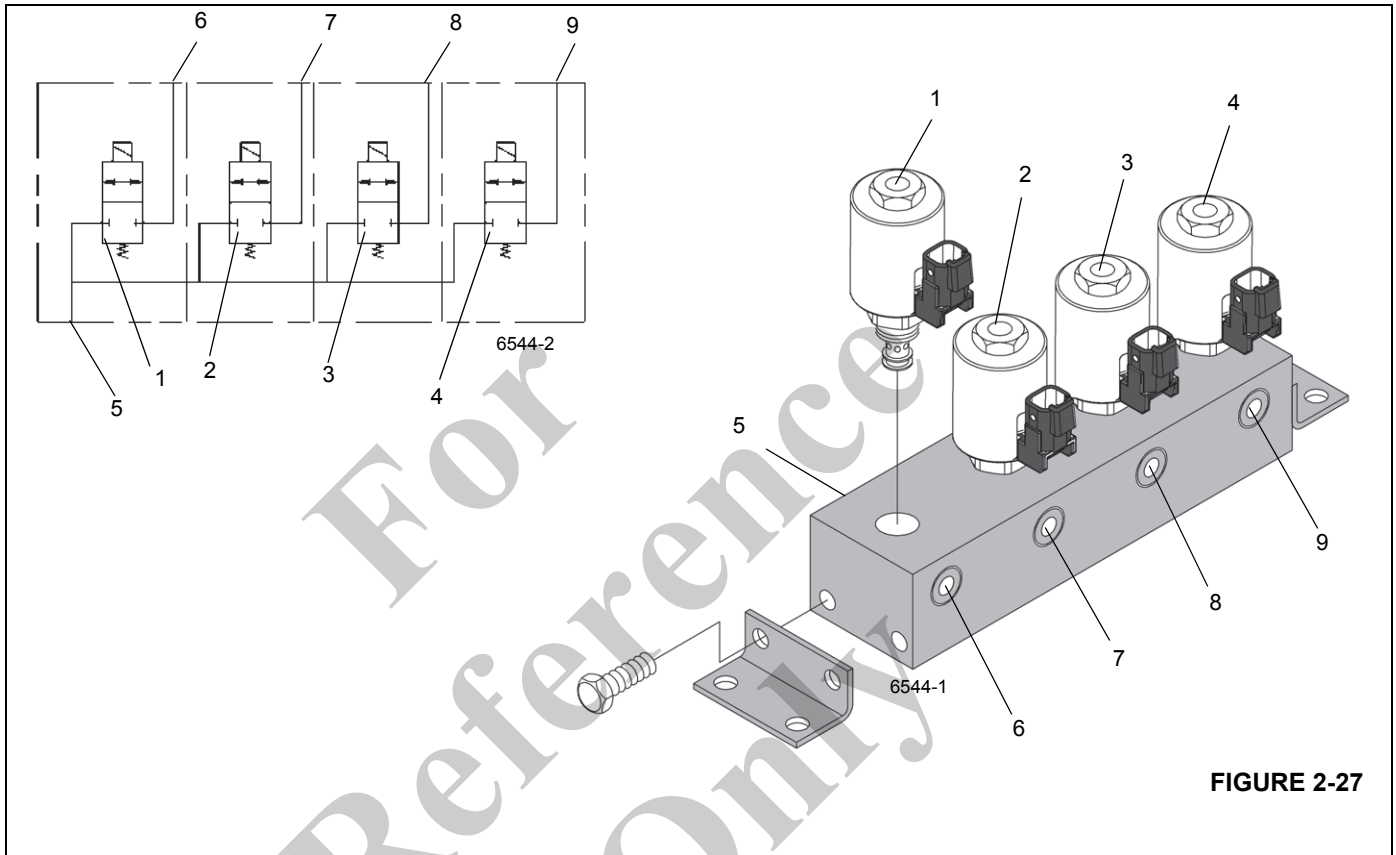
**OUTRIGGER CONTROL MANIFOLD**

**Description**

There are two outrigger control manifolds Figure 2-27 utilized on the crane, one for the front outriggers and one for the rear outriggers. Each manifold consists of four normally

closed two position two way solenoid valve assemblies, one for each cylinder. They are mounted inside the frame on their respective outrigger box. Each solenoid valve contains a manual override actuator which allows the valve to be opened if there is a loss of electrical power.

2



**FIGURE 2-27**

Item	Description
1	Solenoid Valve (Left Front or Left Rear Extension Cylinder)
2	Solenoid Valve (Left Front or Left Rear Jack Cylinder)
3	Solenoid Valve (Right Front or Right Rear Jack Cylinder)
4	Solenoid Valve (Right Front or Right Rear Extension Cylinder)
5	Inlet Port (From Port B of Outrigger Selector Valve)

Item	Description
6	Outlet Port (Left Front or Left Rear Extension Cylinder)
7	Outlet Port (Left Front or Left Rear Jack Cylinder)
8	Outlet Port (Right Front or Right Rear Jack Cylinder)
9	Outlet Port (Right Front or Right Rear Extension Cylinder)

## 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 capscrews, hex nuts and washers 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 outrigger box and secure with the washers, hex nuts, and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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.

For  
Reference  
Only

## PARKING BRAKE/RANGE SHIFT VALVE

### Description

The parking brake/range shift valve controls the flow of oil to the parking brake, hi-low range and axle disconnect actuators by the use of two solenoid valves Figure 2-28. The valve is located on the center of the frame. Pressure is supplied to the valve from the transmission charge pump.

The parking brake solenoid valve is a two position three-way valve. In its de-energized position, the inlet port is blocked and the parking brake actuator is drained to the reservoir. When the solenoid is energized, the reservoir port is blocked and pressurized oil is directed to the actuator, engaging the parking brake.

The range shift solenoid valve is a two position four-way valve. In its de-energized position, pressurized oil flows to the "A" port of the range shift actuator, while the "B" port is drained to the reservoir along with the axle disconnect actuator for two wheel drive/high range. When the solenoid is energized, pressurized oil is directed to the "B" port of the range shift actuator and the axle disconnect actuator while port "A" of the range shift actuator is drained to the reservoir for four wheel drive/low range.

### 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, lockwashers, flatwashers and nuts securing the valve to the frame. Remove the valve.

#### Installation

1. Secure the valve to the frame with the nuts, flatwashers, lockwashers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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.

#### Functional Tests

1. Start and idle engine.
2. With units on outriggers, check for proper two/four wheel operation.

Reference Only

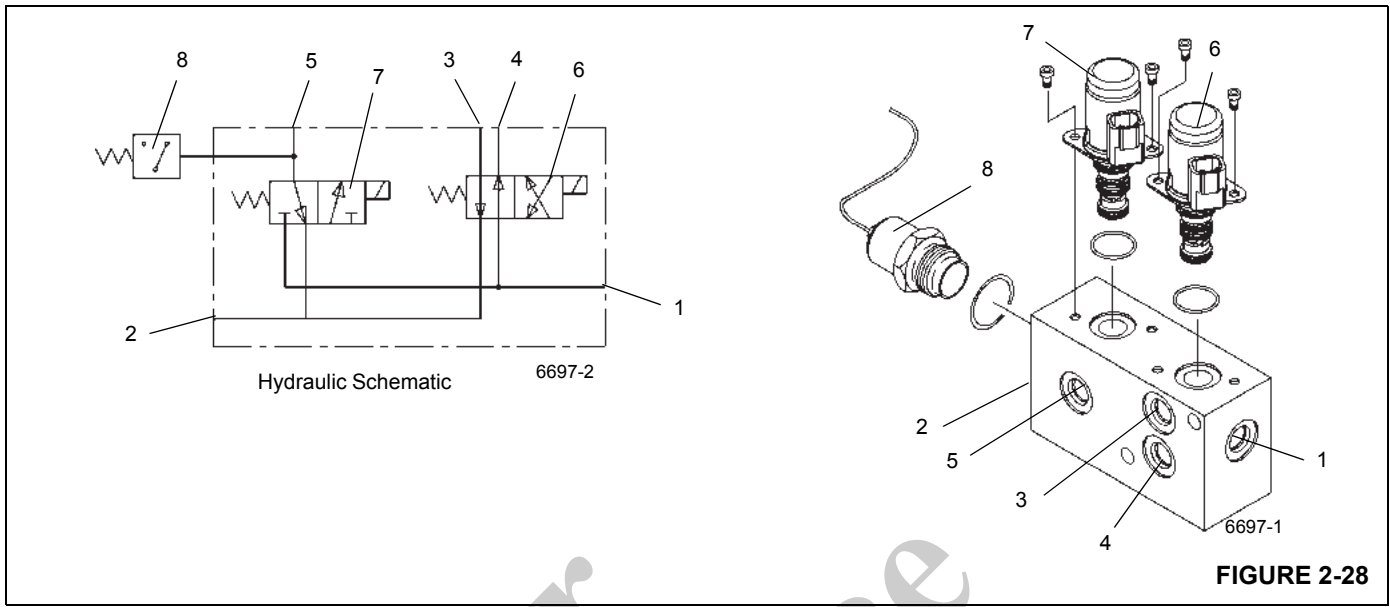


FIGURE 2-28

Item	Description
1	Port P - Pressure
2	Port T - Tank
3	Port A - Range Shift Actuator
4	Port B - Range Shift Actuator

Item	Description
5	Port PB - To Park Brake
6	Solenoid Valve - Range Shift
7	Solenoid Valve -Park Brake
8	Pressure Switch

Reference Only



## AXLE OSCILLATION LOCKOUT VALVE

### Description

The axle oscillation lockout valve Figure 2-29 (also called the double solenoid valve) is used in the rear axle oscillation lockout circuit. The valve is mounted on the left rear face of the carrier frame rear cross member 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.

For the CE units with dual axis controllers, the axle oscillating lockout valve is replaced with four two-way solenoid operated poppet cartridge valves installed in the ports of the lockout cylinders.

An angle encoder located in the top of the electrical slip ring assembly sends a CAN bus message to the RCL. The RCL converts the data in the message to a position angle of the superstructure relative to the carrier (slew angle). If the slew angle is  $\pm 2^\circ$  of directly over the front, the RCL sends a CAN bus message to the Crane Control System to allow axle oscillation. When the Crane Control System receives this message it switches ON a digital output thus energizing the axle oscillation solenoids. If the angle is more than  $2^\circ$  left or  $2^\circ$  right of directly over the front, the Crane Control System switches OFF the digital output thus de-energizing the axle oscillation solenoids.

When the axle oscillation normally closed solenoid valves are de-energized the lockout cylinders are isolated 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 solenoid valves are energized and open, hydraulic oil is allowed 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 hex nuts, capscrews and washers securing the valve to the frame bracket. Remove the valve.

#### Installation

1. Secure the valve to the crane with the washers, capscrews and hex nuts. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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 *Proper Operation Of Axle Oscillation Lockouts* in Section 3 of the *Operator's Manual*.
5. Check valve and hoses for leaks. Make repairs as needed.

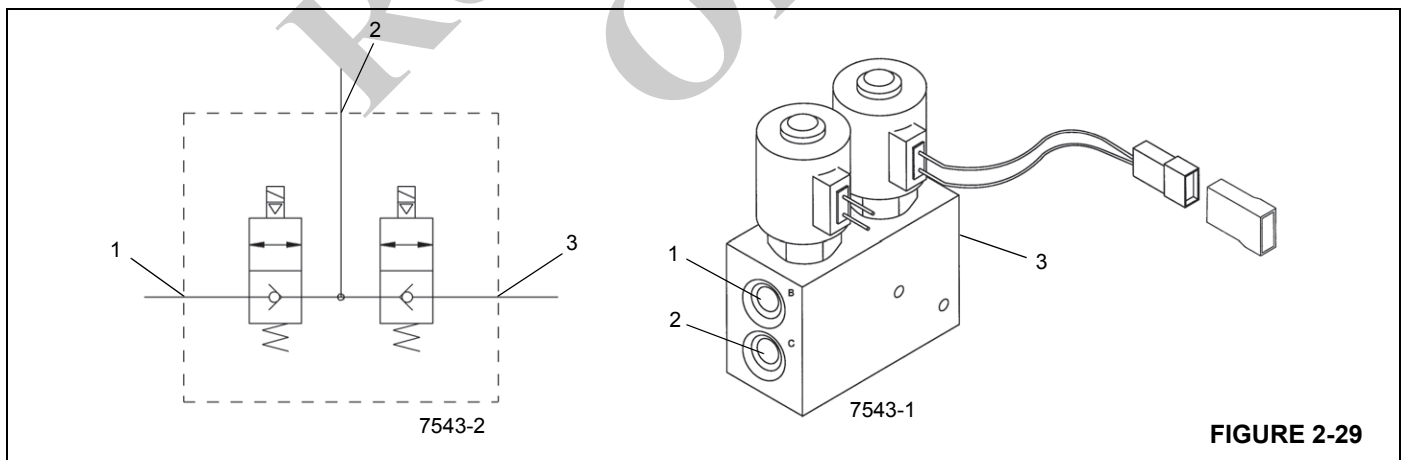


FIGURE 2-29

Item	Description
1	Port B - To Right Hand Rear Axle Lockout Cylinder
2	Port C - From Pump # 1, Section 2

Item	Description
3	Port A - To Left Hand Rear Axle Lockout Cylinder

**HIGH SPEED BOOST SELECTOR VALVE**

**Description**

The high speed boost selector valve Figure 2-30 is located on port #6 of the hydraulic swivel spool. Output from pump number 1, section 2 passes through the high speed boost selector valve. When the valve is de-energized, the oil flows to the outrigger/rear steer valve. When the valve is energized, the oil is combined with the output of pump number 1, section 1 to provide additional oil capacity to the main crane functions. With the valve in the energized position, the rear steer and outriggers are inoperative.

The high speed boost selector valve consists of a valve body, one normally open two-way, two position solenoid valve, and a pilot to close poppet check valve.

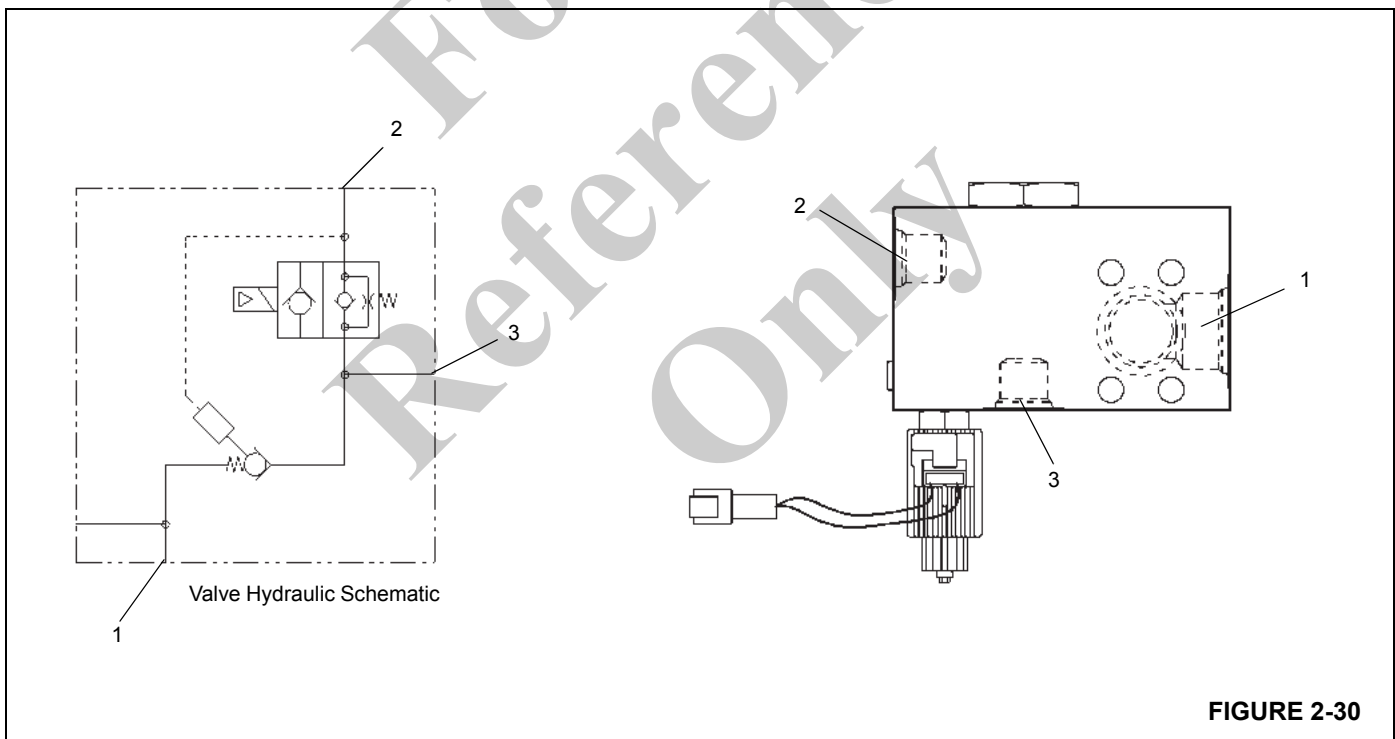
**Maintenance**

**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 hydraulic fitting securing the valve to the #6 port of the hydraulic swivel spool. Remove the valve.

**Installation**

1. Install the valve to the #6 port of the hydraulic swivel spool and tighten the fitting.
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. Start the engine and check valve and hoses for leaks. Make repairs as needed.



**FIGURE 2-30**

Item	Description
1	Port P1 - From Pump #1 Section 1
2	Port B - To Integrated Outrigger/Rear Steer Valve

Item	Description
3	Port P2 - To Priority Flow Control Valve

## TELESCOPE STAGE SELECTOR VALVE MANIFOLD

### Description

The software sends output signals to the Telescope Stage Selector Valve Manifold, based on inputs from the operator controlled Mode Selector Switches in the cab and the cylinder length sensing components, to control whether the first or second stage of the telescope cylinder extends and retracts first or second. The manifold consists of two pilot-operated poppet valves(1); one spring offset, solenoid

controlled, four-way directional control valve (2); and two shuttle valves (3). The oil flow from the Telescope Directional Control Valve is split after entering the Telescope Stage Selector Valve Manifold and goes to the two poppet valves. One poppet valve controls oil flow to the first stage and the other poppet valve controls oil to the second stage. Whether extending or retracting, pilot oil from one of the working lines passes through the shuttle valve(s) to the solenoid controlled directional control valve, which diverts the pilot oil to close the appropriate poppet valve, which then allows oil to flow to or from the selected cylinder stage through the other poppet valve.

2

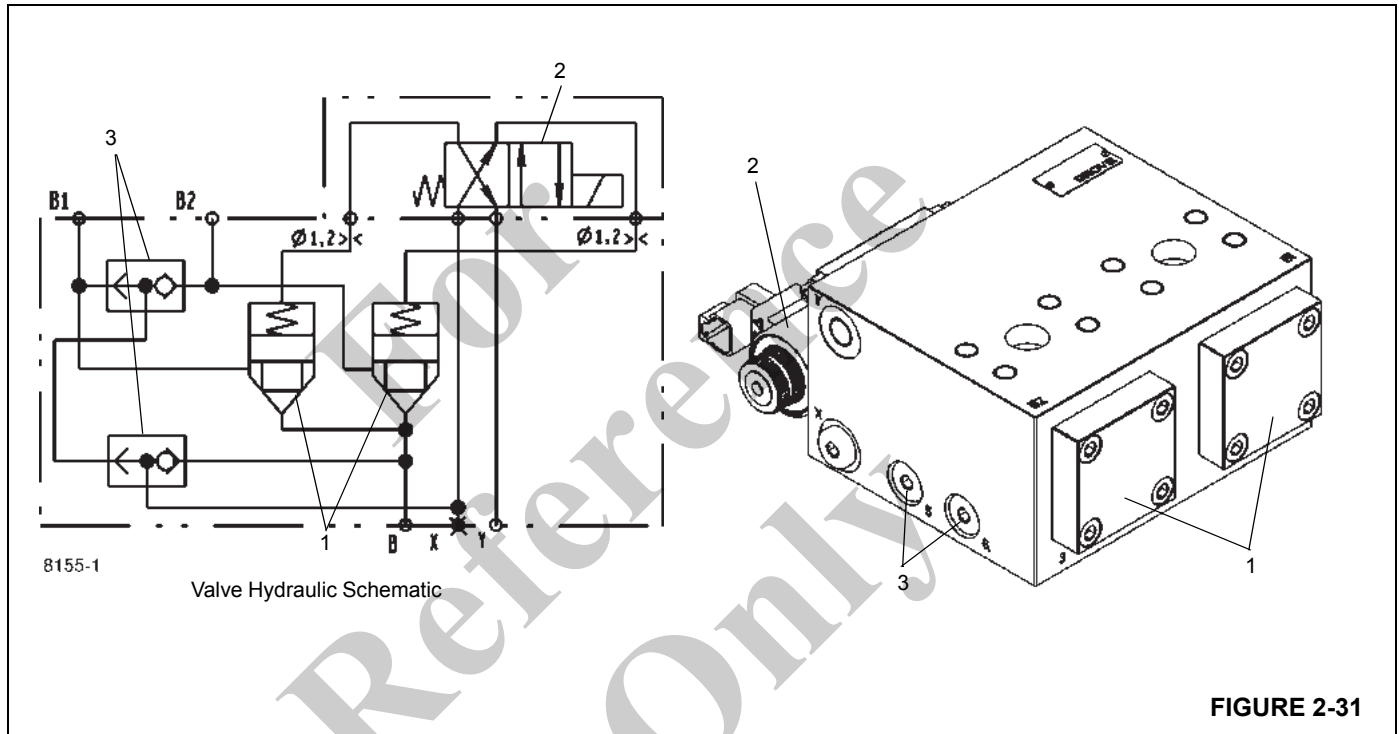


FIGURE 2-31

Item	Description
1	Pilot Operated Poppet Valves
2	Four-way Directional Control Valve
3	Shuttle Valves

3. Remove the capscrews, lockwashers, flatwashers securing the valve. Remove the valve.

### 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.

#### Installation

1. Secure the valve with the nuts, flatwashers, lockwashers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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.

## TELESCOPE FILL TUBE CONTROL VALVE MANIFOLD

### Description

The Telescope Fill Tube Control Valve Manifold, located on the turntable, is controlled by the RCL. The Telescope Fill Tube Control Valve Manifold prevents the first stage (boom tele sections 2, 3, and 4) from moving when the second stage (tele section 1) is extending or retracting by maintaining oil pressure in the fill tube of the first stage. The Telescope Fill Tube Control Valve Manifold prevents the first stage from retracting as the second stage extends by first diverting oil flow it receives from the Brake Charge and CAC Fan Priority Flow Control Valve to the pressure port of the Dual Accumulator Charge Valve Manifold by way of a 4.0 gpm priority flow valve (1, Figure 2-32). Excess oil flow from the flow valve goes to a spring offset, solenoid controlled, three-way directional control valve (2) that diverts oil to tank when de-energized. Only when the second stage is extending will the RCL energize the directional control valve, which diverts oil to the first stage. This flow of oil to the

first stage is maintained at two pressure settings by a solenoid controlled relief valve (3). As the second stage extends, the RCL, based on inputs from the cylinder length sensing components, will cause the relief valve to maintain a low pressure ( $\leq 100$  psi) if the first stage is fully retracted or a high pressure (2200 psi) if the first stage is fully extended. Conversely, the Telescope Fill Tube Control Valve Manifold also prevents the first stage from extending as the second stage retracts by varying the excess flow it receives from the first stage at two pressure settings. Oil coming from the first stage enters the Telescope Fill Tube Control Valve Manifold and is diverted by way of a check valve (4) to a pilot-operated, spring returned, two-position, proportional flow control valve (5) and a solenoid controlled, spring returned, two-position, proportional flow control valve with manual override (6). Only when the second stage is retracting will the RCL energize the flow control valve (7). As the second stage retracts, the RCL, based on inputs from the cylinder length sensing components, will cause the solenoid controlled flow valve to maintain a low pressure ( $\leq 100$  psi) if the first stage is fully retracted or a high pressure (2200 psi) if the first stage is fully extended.

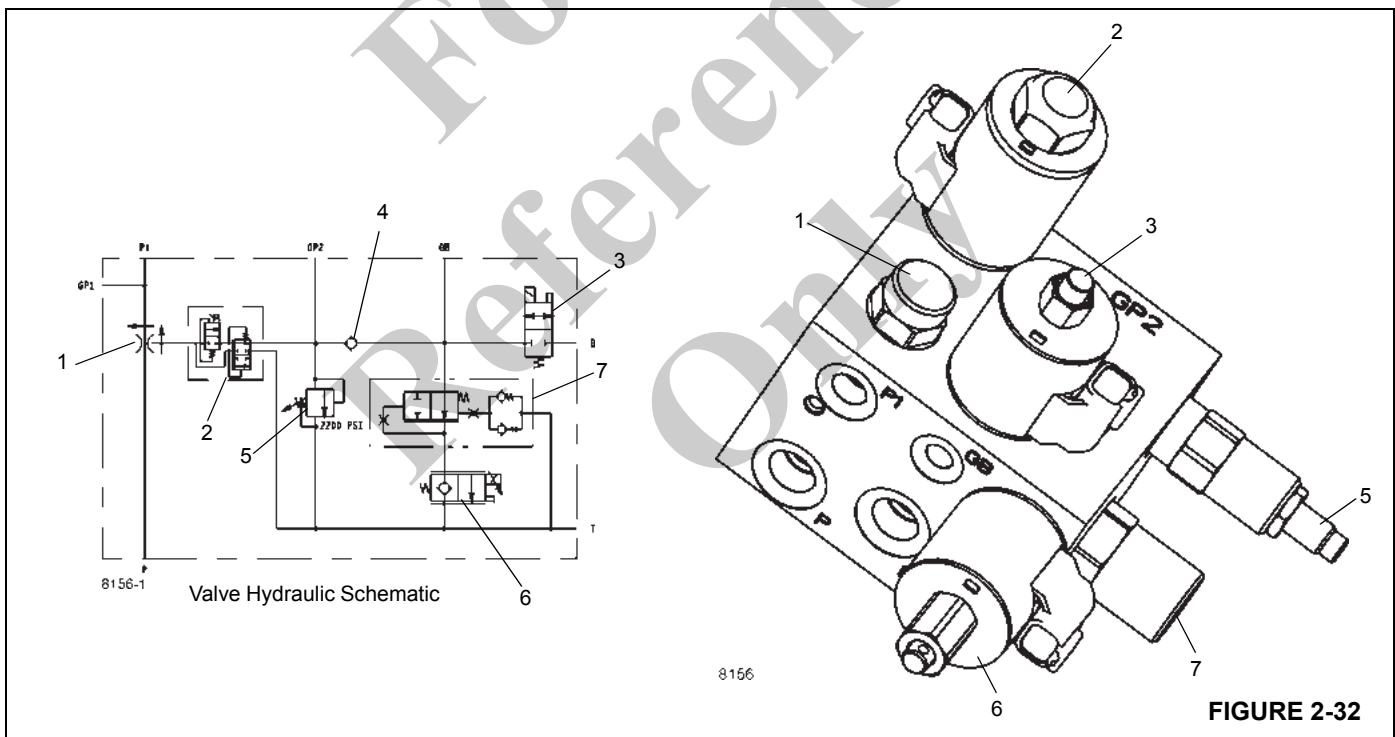


FIGURE 2-32

Item	Description
1	4.0 gpm Priority Flow Valve
2	Three-way Directional Control Valve
3	Check Valve
4	Relief Valve

Item	Description
5	Two-Position Proportional Flow Control Valve
6	Two-Position, Proportional Flow Control Valve
7	Flow Control Valve

**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, lockwashers, flatwashers and nuts securing the valve to the frame. Remove the valve.

**Installation**

1. Secure the valve to the frame with the nuts, flatwashers, lockwashers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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.

For  
Reference  
Only

## HYDRAULIC ACCUMULATOR

### Description

The hydraulic accumulators are located inside the superstructure on the left side under the main hoist. The purpose of each accumulator is to provide stored energy, an oil volume of 1.99 L (122 in<sup>3</sup>) at a maximum pressure of 138 bar (2000 psi), 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 62 bar (900 psi) 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 piston, seals, gas 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 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 *Procedure H - PreCharging The Accumulator*, page 2-27.
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 *Procedure G - Accumulator Pre-Charge Pressure*, page 2-26.

## SERVICE BRAKE AND CAC FAN MOTOR PRIORITY FLOW CONTROL VALVE

### Description

The priority flow control valve is located inside the left frame rail at the center of the frame. The purpose of the valve is to ensure the brake circuit gets the priority flow and the charge air cooler fan motor circuit receives the excess flow. Hydraulic pump number 3 supplies the priority flow control valve which provides 15.1 L/min (4.0 gpm) to port 8 on the swivel for the dual accumulator charge valve, then the charge air cooler fan motor.

### Maintenance

**NOTE:** Maintenance procedures are limited to the removal and replacement of the valve.

### Removal

1. Tag and disconnect the hydraulic lines attached to the valve. Cap or plug the lines and ports.
2. Remove the capscrews, washers, flatwashers and nuts securing the valve to the valve mounting plate and remove the valve.

### Installation

1. Place the priority flow control valve on the mounting plate and secure it with the capscrews, washers, flatwashers and nuts. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Start the crane and apply the service brake several times. Verify the service brake works properly.
4. Check for leaks. Make repairs as needed.

For  
Reference  
Only

## OIL COOLER FAN MOTOR PRIORITY FLOW CONTROL VALVE

### Description

The priority flow control valve is located inside the right frame rail at the center of the frame. The purpose of the valve is to insure the oil cooler fan motor gets the priority flow and the integrated outrigger/rear steer valve circuit receives the excess flow. Hydraulic pump number 1, section 2 supplies the priority flow control valve which provides 18.9 L/min (5.0 gpm) to the hydraulic oil cooler fan motor and the excess flow to the integrated outrigger/rear steer valve unless the high speed boost selector valve is energized and then the oil is combined with the output of pump 1, section 1 to provide additional oil capacity to the section 1 functions.

### Maintenance

**NOTE:** Maintenance procedures are limited to the removal and replacement of the valve.

#### Removal

1. Tag and disconnect the hydraulic lines attached to the valve. Cap or plug the lines and ports.
2. Remove the capscrews, washers, flatwashers and nuts securing the valve to the valve mounting plate and remove the valve.

#### Installation

1. Place the priority flow control valve on the mounting plate and secure it with the capscrews, washers, flatwashers and nuts. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the hydraulic lines to the valve as tagged during removal.

3. Start the crane and energize the high speed boost and operate the crane several times. Verify the hydraulic oil cooler fan motor works properly.
4. Check for leaks. Make repairs as needed.

### Procedure for checking Hydraulic Oil Cooler Fan Control Valve

1. Attach pressure gauge at quick disconnect in CF port Figure 2-33. Make sure that machine is up to operating temperature then unplug oil cooler valve solenoid (located near oil cooler fan motor) to assure fan is running at full speed.
2. While using photo tachometer to check the fan speed, adjust the flow control to achieve a fan speed of 2400-2500 rpm with the engine running at idle.
3. Run the engine at full rpm and adjust the relief valve until a fan speed of 2400-2500 rpm is achieved.
4. Shut off engine, remove pressure gauge and plug oil cooler valve solenoid back in.

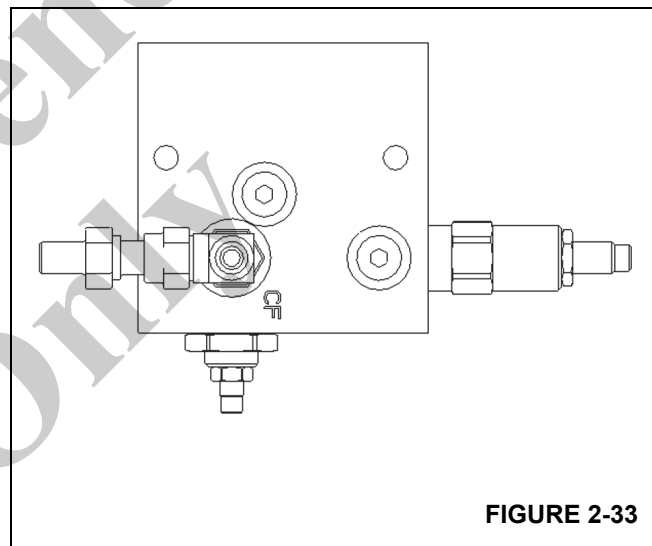


FIGURE 2-33



**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 2-4  
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 Crane Care has Boeshield® T-9 Premium Metal Protectant available in 12 oz. aerosol cans by ordering part number 9999101803.

**CAUTION**

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

**Maintenance**

**General**

There must be a gap between the ends of each wear ring when it is installed onto the piston (as applicable) or head. 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.



**DANGER**

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.



**DANGER**

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 3/4 inches (see chart below). A cylinder extended 5 feet in which the oil cools 60°F would only retract approximately 1 1/2 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 or “Stick-slip” it is recommended that the telescope control lever is activated periodically in the extend position to mitigate the effects of 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.

The chart below 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 2-5 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



Table 2-6 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 Figure 2-34 has a bore of 12.0 in (30.5 cm). The retracted length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 118.75 in (301.6 cm). The extended length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 207.8 in (527.8 cm). Its stroke is 89.06 in (226.2 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 770 kg (1700 lb).

### 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 washers securing the holding valve. Remove the holding valve from the cylinder barrel.
3. Remove the socket head cap screws securing the head retainer ring to the head.
4. Using a spanner wrench or chain wrench, unscrew the head retainer ring from the barrel.



### DANGER

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to move. Injury may result from the cylinder rod unexpectedly exiting the cylinder barrel.

### CAUTION

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

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 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.
7. Remove the setscrew securing the piston to the rod.
  8. Unscrew the piston from the rod.
  9. Remove the piston seal 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 and the wear rings, buffer seal and deep Z rod seal from the inside of the head.
  12. Remove and discard the two threaded inserts from the head.
  13. Remove the head retainer ring from the rod.
  14. Remove the wiper ring and backup ring from the inside of the retaining ring.

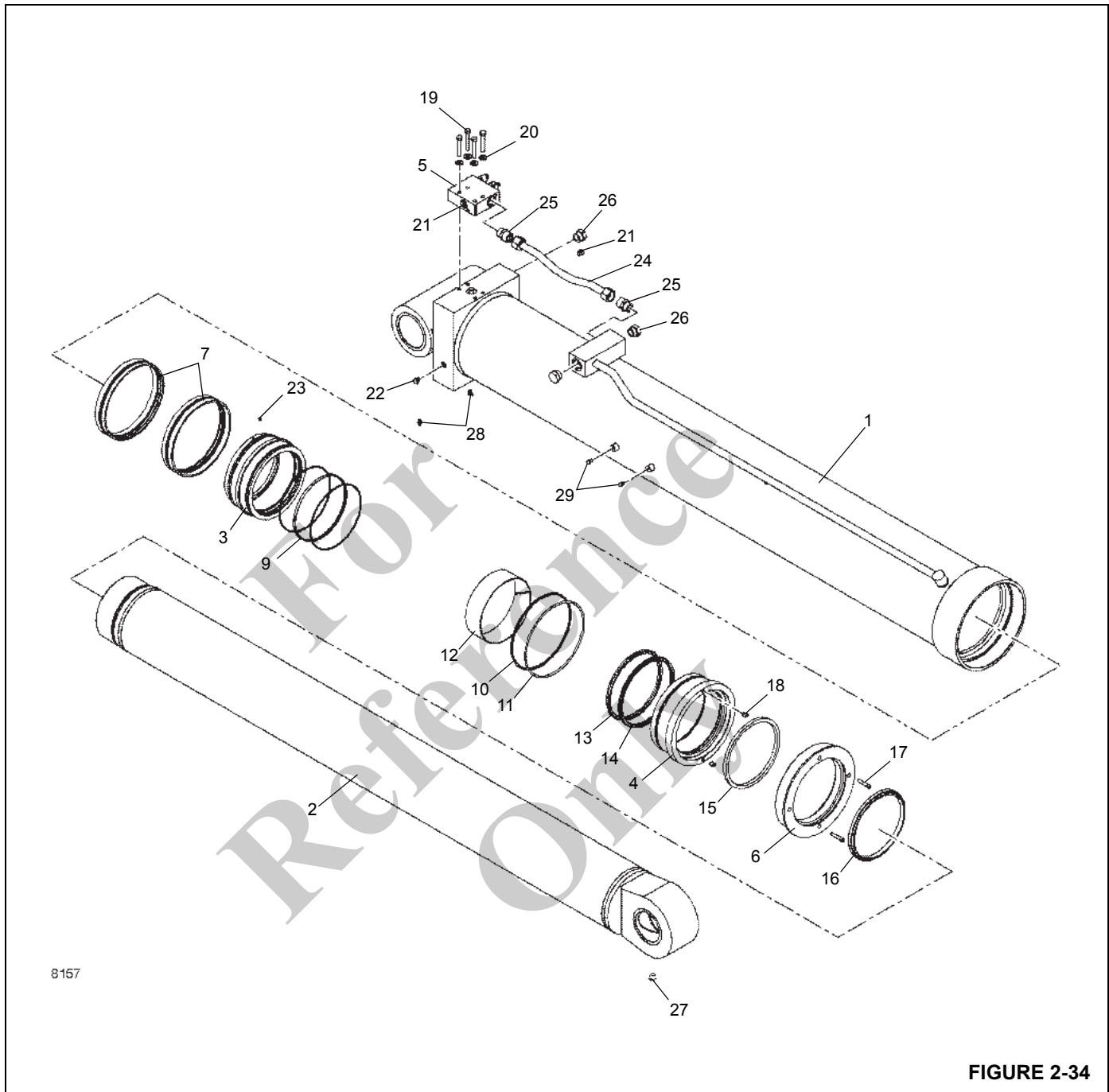
### Inspection

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.



8157

FIGURE 2-34

Item	Description
1	Barrel
2	Rod
3	Piston
4	Head

Item	Description
5	Holding Valve
6	Retaining Ring
7	Seal Assembly
8	Not Used

Item	Description
9	T-Seal
10	O-ring, Low Temperature
11	Back-up Ring
12	Wear Ring
13	Seal
14	Rod Seal
15	Back-up Ring
16	Wiper Ring
17	Capscrew
18	Insert
19	Capscrew
20	Flatwasher
21	O-ring Plug
22	Plug
23	Set Screw
24	Tube
25	Straight Adapter
26	Pipe Plug
27	Grease Fitting
28	Grease Fitting
29	Capscrew

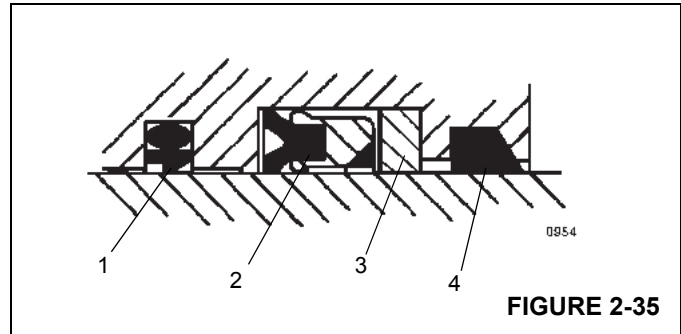
**Assembly**

**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. Damage to the cylinder or unexpected operation may result.

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

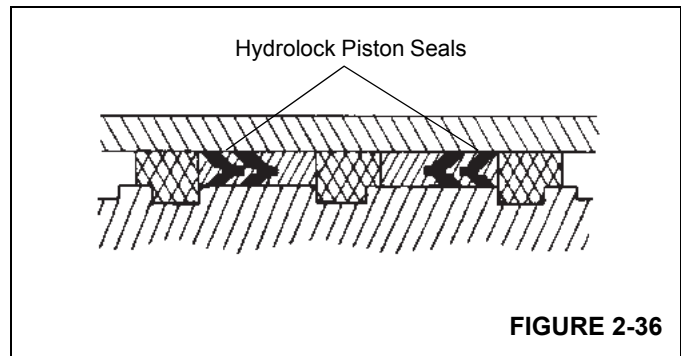
1. Install head retainer ring on rod.
2. Install two new threaded inserts into head.
3. Install the wiper ring and backup ring in the inside of the retaining ring.



**FIGURE 2-35**

Item	Description
1	Buffer Seal
2	Deep Z Rod Seal
3	Backup Ring
4	Wiper Ring

4. Install the replacement wear rings, buffer seal and deep Z rod seal in the inside of the head. Make sure the buffer seal's step is closer to the deep Z rod seal Figure 2-35. Make sure the deep Z rod seal's rim groove is closer to the buffer seal.
5. Install the replacement O-ring and backup ring on the outside of the head.
6. Install the replacement piston seal in the inside of the piston.
7. Lubricate the rod with clean hydraulic oil.
8. Install the retaining ring onto the rod.
9. Slide the head onto the rod.
10. Screw the piston onto the rod tightly. Secure the piston with the setscrew.
11. Install the replacement hydrolock seals on the outside of the piston, Figure 2-36. Make sure the "vees" on the two hydrolock seals point at each other.



**FIGURE 2-36**

12. Lubricate all parts freely with clean hydraulic oil.

---

**CAUTION**

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

---

13. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
14. 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.

15. Screw the head retainer ring into the barrel and align holes in retainer ring with holes in head. Secure the head retainer ring to the head with two socket head capscrews. Torque screws to 60 to 65 Nm (44 to 48 lb-ft).
16. Using a spanner wrench or chain wrench, continue to screw the retainer ring/head into place in the barrel.

---

**CAUTION**

Do not use air pressure to cycle or pressurize the cylinder. Damage to the seals may result.

---

17. Position the holding valve on the cylinder barrel and secure with screws and washers.
18. Connect the tubing to the holding valve.
19. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder rod side at 241 bar (3500 psi). Test the cylinder piston side at 413 bar (6000 psi). Check for proper operation and any leakage. Make repairs as needed.
20. After successful pressure testing, retorque screws holding retainer ring to head to 60 to 65 Nm (44 to 48 lb-ft).

For Reference Only

## TELESCOPE CYLINDER

### Description

The boom telescope cylinder is not field serviceable and must be returned to the manufacturer for repair.

The cylinder, with oil, weighs approximately 1745 kg (3847 lb), retracted.

### Maintenance

For removal and installation instructions refer to *Boom*, page 4-1.

For  
Reference  
Only



## AXLE OSCILLATION LOCKOUT CYLINDER

### Description

The oscillation lockout cylinder Figure 2-37 has a 12.7 cm (5 in) diameter bore.

The retracted length of each cylinder is 48.8 cm (19.25 in) from the center of the lug holes to the center of the barrel bushing. The cylinder has a stroke of 16.8 cm (6.62 in) which gives an extended length of 65.7 cm (25.88 in) from the end of the barrel to the center of the cylinder block.

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

The cylinder weighs approximately 38.8 kg (85.5 lb).

### Maintenance

#### Disassembly

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

1. Drain the oil from the cylinder.
2. Open both ports on the side of the barrel.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube preferably in the vertical position with the rod assembly up.



#### CAUTION

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. Injury may result from the cylinder rod unexpectedly exiting the cylinder barrel.

#### CAUTION

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

4. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome. Using a spanner wrench, unscrew the head from the barrel.
5. Using a screwdriver or 1/4 inch wrench, remove the screw from the head.
6. Remove the grease fitting from the rod.

7. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.

**NOTE:** Residual oil will spill over the end of the barrel. Make Provisions to contain the oil.

8. Using a hoist, extend the rod assembly slowly until the piston is free of the barrel.
9. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod. Cover the open end of the barrel to avoid contamination.
10. Remove the retaining ring from the rod.
11. The head can be pulled off the rod assembly by hand.

#### CAUTION

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

**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.

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

#### Inspection

1. Inspect the rod. There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Chrome should be present over the entire surface of the rod. If lack of chrome on rod, the rod should be replaced.
2. Inspect rod for straightness. Determine if it can be straightened or must be replaced.
3. Inspect the head. Visually inspect the inside bore for scratching or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading, and the bore should be checked for out-of-roundness.
4. Inspect the piston. Visually inspect the outside surface for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading, and the diameter should be checked for out-of-roundness.
5. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
6. Thoroughly rinse parts, allow to drain, and wipe with a lint-free rag. Inspect all parts for serviceability.

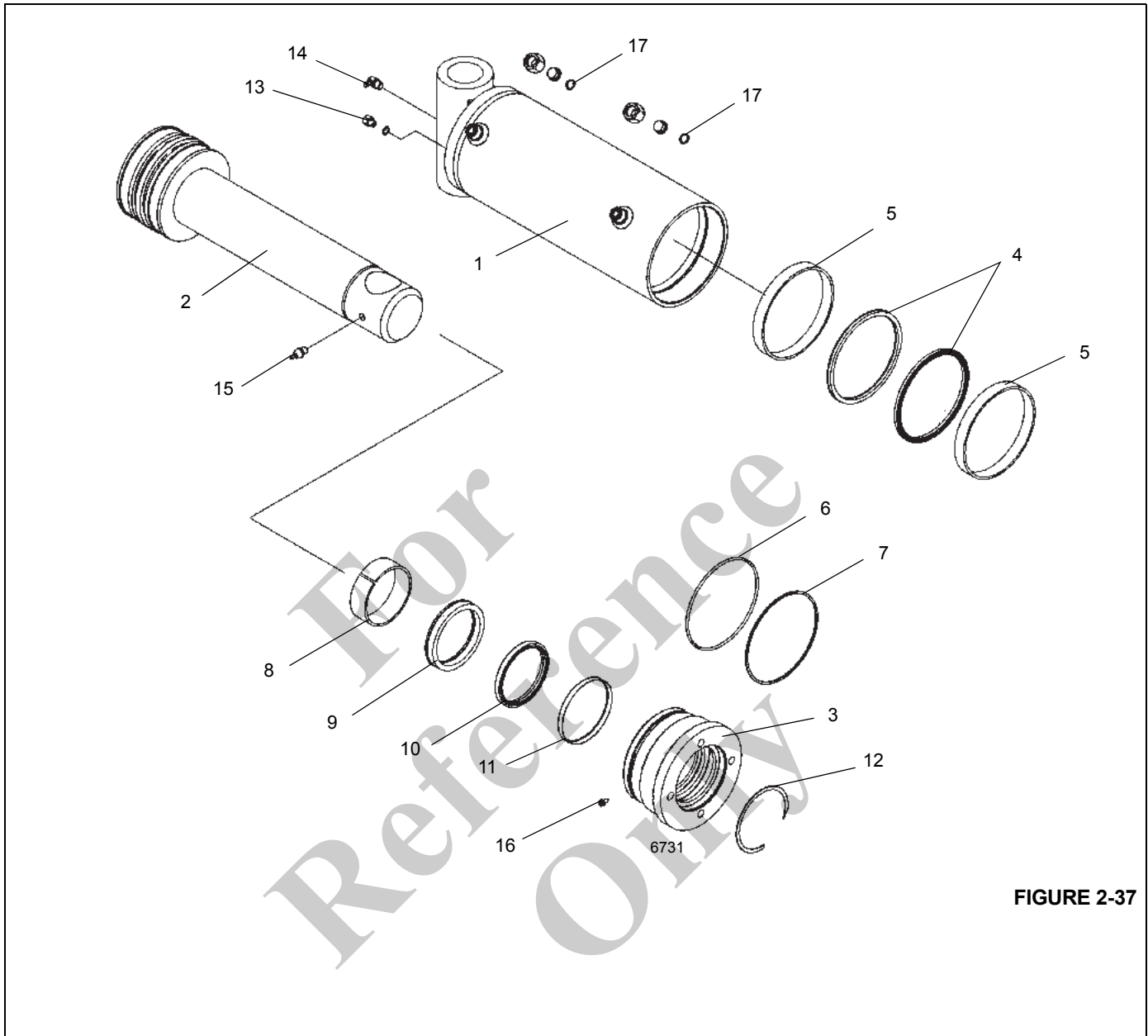


FIGURE 2-37

Item	Description
1	Barrel
2	Rod
3	Head
4	Lip Seal
5	Wear Ring
6	O-ring
7	Backup Ring
8	Wear Ring
9	Buffer Seal
10	Lip Seal
11	Wiper Ring
12	Retainer Ring
13	Bleeder Plug
14	Grease Fitting
15	Grease Fitting
16	Setscrew
17	O-ring

**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.

7. Stone out minor blemishes and polish with a fine crocus cloth.
8. 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 light hydraulic oil.

1. Install the wear ring, buffer seal and wiper ring in the inside of the head and the O-ring and backup ring on the outside of the head.
2. Install the wear rings and lip seals on the outside of the piston.

**CAUTION**

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.

3. 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).
4. Slide the head onto the rod. The head will have to be tapped on with a rubber mallet to engage the seals. Push the head about half way down the length of the rod assembly.
5. With the hoist, raise the rod assembly back into a vertical position taking care not to damage the OD of the seals on the head and piston.
6. Remove the cover from the barrel.
7. Lubricate the OD of the seals on the piston and head with clean light hydraulic oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
8. Place the spanner wrench on the head and turn counterclockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the shoulder of the head and the top of the barrel.
9. Install the retaining ring.
10. Make sure the setscrew hole is clean of all debris. Using a screwdriver or 1/4 inch wrench, install the setscrew in the head.

**CAUTION**

Do not use air pressure to cycle or pressurize the cylinder. Damage to the seals may result.

11. Pressurize and cycle the cylinder with hydraulic oil pressure. Static test the cylinder at 258.4 bar (3750 psi). Check for proper operation and any leakage. Make repairs as needed.

**NOTE:** After cycle test is complete, check that the setscrews are properly torqued to prevent cylinder leakage.

## STEER CYLINDER

### Description

The steer cylinders Figure 2-38 are mounted on the axles, two cylinders on each axle. The front steer cylinders have a 10.16 cm (4 in) diameter bore and the rear steer cylinders have a 8.89 cm (3.5 in) diameter bore.

The steer cylinder has a retracted length of 72.1 cm (28.38 in) from bushing center to bushing center. The steer cylinder has a stroke of 21.3 cm (8.38 in) which gives an extended length of 93.4 cm (36.8 in) from bushing center to bushing center.

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

The front cylinder weighs approximately 20 kg (44 lb) and the rear cylinder weighs approximately 18 kg (40 lb).

### 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. Drain the oil from the cylinder.
2. Open both ports on the side of the barrel.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube preferably in the vertical position with the rod assembly up.



### DANGER

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to move. Injury may result from the cylinder rod unexpectedly exiting the cylinder barrel.

### CAUTION

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

4. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome. Using a spanner wrench, unscrew the head from the barrel.
5. Remove the grease fitting from the rod.
6. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.

**NOTE:** Residual oil will spill over the end of the barrel. Make provisions to contain the oil.

7. Using a hoist, extend the rod assembly slowly until the piston is free of the barrel.
8. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod. Cover the open end of the barrel to avoid contamination.
9. Remove the locknut from the rod.
10. Remove the O-ring from the rod.
11. The head, piston and spacer can be pulled off the rod assembly by hand.

### CAUTION

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

**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.

12. Remove the wear ring and piston seal from the outside of the piston.
13. Remove the O-ring and backup ring from the outside of the head. Remove the rod seal and wiper ring from the inside of the head.

### Inspection

1. Inspect the rod. There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Chrome should be present over the entire surface of the rod. If lack of chrome on rod, the rod should be replaced.
2. Inspect rod for straightness. Determine if it can be straightened or must be replaced.
3. Inspect the head. Visually inspect the inside bore for scratching or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading, and the bore should be checked for out-of-roundness.
4. Inspect the piston. Visually inspect the outside surface for scratches or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading, and the diameter should be checked for out-of-roundness.
5. Inspect the barrel carefully for scoring, scratches and pits. There should be no scratches or pits deep enough to catch the fingernail. If barrel is scored, it must be repaired or replaced.
6. Thoroughly rinse parts, allow to drain, and wipe with a lint-free rag. Inspect all parts for serviceability.

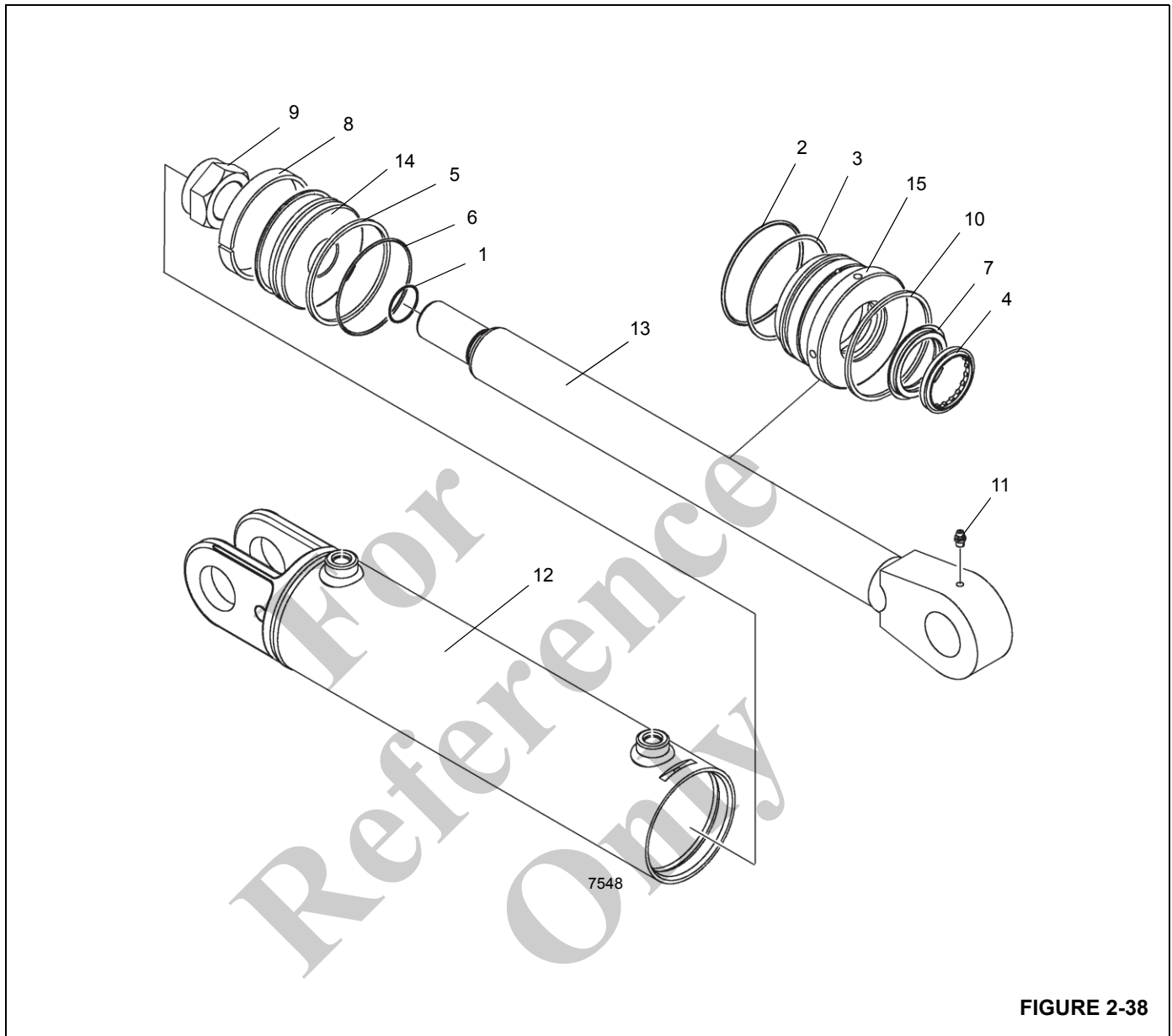


FIGURE 2-38

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

Item	Description
9	Locknut
10	Retainer Ring
11	Grease Fitting
12	Barrel
13	Rod
14	Piston
15	Head

**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 light hydraulic oil.

1. Install the rod seal and wiper ring in the inside of the head and the O-ring and backup ring on the outside of the head.
2. Install the wear ring and piston seal on the outside of the piston.

---

**CAUTION**

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.

3. 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).
4. Slide the head onto the rod. The head will have to be tapped on with a rubber mallet to engage the seals.

Push the head about half way down the length of the rod assembly. Install the spacer and piston onto the rod.

5. Install the locknut on the rod.
6. With the hoist, raise the rod assembly back into a vertical position taking care not to damage the OD of the seals on the head and piston.
7. Remove the cover from the barrel.
8. Lubricate the OD of the seals on the piston and head with clean light hydraulic oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
9. Place the spanner wrench on the head and turn counterclockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the shoulder of the head and the top of the barrel.

---

**CAUTION**

Do not use air pressure to cycle or pressurize the cylinder. Damage to the seals may result.

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 241.2 bar (3500 psi) in both directions. Check for proper operation and any leakage. Make repairs as needed.
11. Install the port plugs.

## OUTRIGGER EXTENSION CYLINDER

### Description

The extension cylinder Figure 2-39 has a 63.5 mm (2.5 in) diameter bore.

Each cylinder has a retracted length of 231.4 cm  $\pm$ 30.4 (91.12 in  $\pm$ 12) from the center of the rod bushing to the center of the barrel bushing. The stroke of each cylinder is 196.9 cm (77.50 in) which gives an extended length of 428.2 cm (168.6 in).

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

The cylinder weighs approximately 42.0 kg (92.5 lb).

### 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. Drain the oil from the cylinder.
2. Open both ports on the side of the barrel.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube preferably in the vertical position with the rod assembly up.



#### DANGER

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to move. Injury may result from the cylinder rod unexpectedly exiting the cylinder barrel.

#### CAUTION

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

4. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome. Using a spanner wrench, unscrew the head from the barrel.
5. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.

**NOTE:** Residual oil will spill over the end of the barrel. Make Provisions to contain the oil.

6. Using a hoist, extend the rod assembly slowly until the piston is free of the barrel.

7. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod. Cover the open end of the barrel to avoid contamination.
8. Remove the locknut from the rod.
9. Remove the O-ring from the rod.
10. The head, piston and spacer can be pulled off the rod assembly by hand.

#### CAUTION

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

**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.

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

#### Inspection

1. Inspect the rod. There should be no scratches or pits deep enough to catch the fingernail. Pits that go to the base metal are unacceptable. Chrome should be present over the entire surface of the rod. If lack of chrome on rod, the rod should be replaced.
2. Inspect rod for straightness. Determine if it can be straightened or must be replaced.
3. Inspect the head. Visually inspect the inside bore for scratching or polishing. Deep scratches are unacceptable. Polishing indicates uneven loading, and the bore should be checked for out-of-roundness.
4. Inspect the piston. Visually inspect the outside surface for scratches or polishing, Deep scratches are unacceptable. Polishing indicates uneven loading, and the diameter should be checked for out-of roundness.
5. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
6. Thoroughly rinse parts, allow to drain, and wipe with a lint-free rag. Inspect all parts for serviceability.

#### 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.

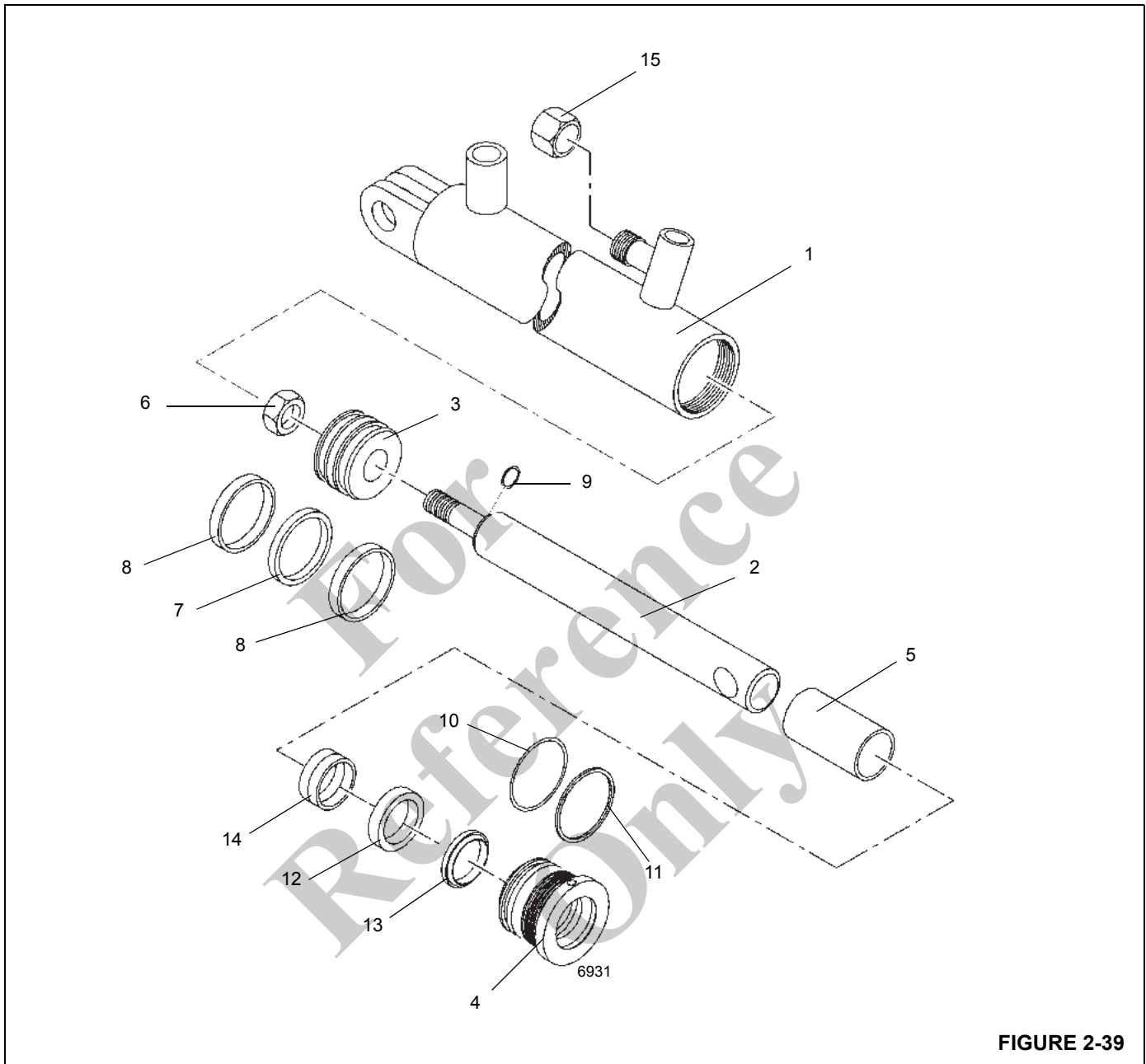


FIGURE 2-39

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	Cap



7. Stone out minor blemishes and polish with a fine crocus cloth.
8. 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.

1. Install the rod seal, wear ring and wiper ring in the inside of the head and the O-ring and backup ring on the outside of the head.
2. Install the wear rings and piston seal on the outside of the piston.

---

#### CAUTION

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.

3. 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).

4. Slide the head onto the rod. The head will have to be tapped on with a rubber mallet to engage the seals. Push the head about half way down the length of the rod assembly. Install the spacer and piston onto the rod.
5. Install the locknut on the rod.
6. With the hoist, raise the rod assembly back into a vertical position taking care not to damage the OD of the seals on the head and piston.
7. Remove the cover from the barrel.
8. Lubricate the OD of the seals on the piston and head with clean light hydraulic oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
9. Place the spanner wrench on the head and turn counterclockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the shoulder of the head and the top of the barrel.

---

#### CAUTION

Do not use air pressure to cycle or pressurize the cylinder. Damage to the seals may result.

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Static test the cylinder at 206.7 bar (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

## OUTRIGGER JACK CYLINDER

### Description

The outrigger jack cylinder Figure 2-40 has a 11.4 cm (4.5 in) diameter bore. A port block is welded to the rod of each cylinder and a pilot operated check valve is threaded into each port block.

The retracted length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 122.0 cm  $\pm 0.30$  (48.12 in  $\pm 0.12$ ). The stroke of the cylinder is 63.5 cm (25.0 in) which gives an extended length of 185.8 cm (73.12 in).

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

The cylinder weighs approximately 63.30 kg (139.5 lb).

### 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. Open ports and drain the oil from the cylinder.
2. Secure cylinder barrel in a chain vise preferably in the vertical position with the rod assembly up at about chest level.



### DANGER

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to move. Injury may result from the cylinder rod unexpectedly exiting the cylinder barrel.

### CAUTION

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

3. With the ports open, extend rod assembly with a hoist enough to access the top of the head with a spanner wrench.

**NOTE:** Do not extend the rod completely. Oil or oil/air mixture may rapidly exit out of the ports during extension. Shield the work area from the exiting oil.

4. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.
5. Extend the rod assembly slowly until the piston is free of the barrel.
6. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod. Cover the barrel opening to avoid contamination.
7. Remove the piston seal to gain access to the setscrew. Using a 3/16 inch allen wrench, remove the setscrew from the piston.
8. Turn the piston counterclockwise and remove with a fitted spanner wrench.
9. Remove the spacer and head from the rod.

### CAUTION

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

10. Remove the seals from the outside of the piston and the back up rings and O-ring from the inside of the piston.
11. Remove the O-ring and backup ring from the outside of the head and the wear rings, buffer seal, rod seal and wiper ring from the inside of the head.

### Inspection

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

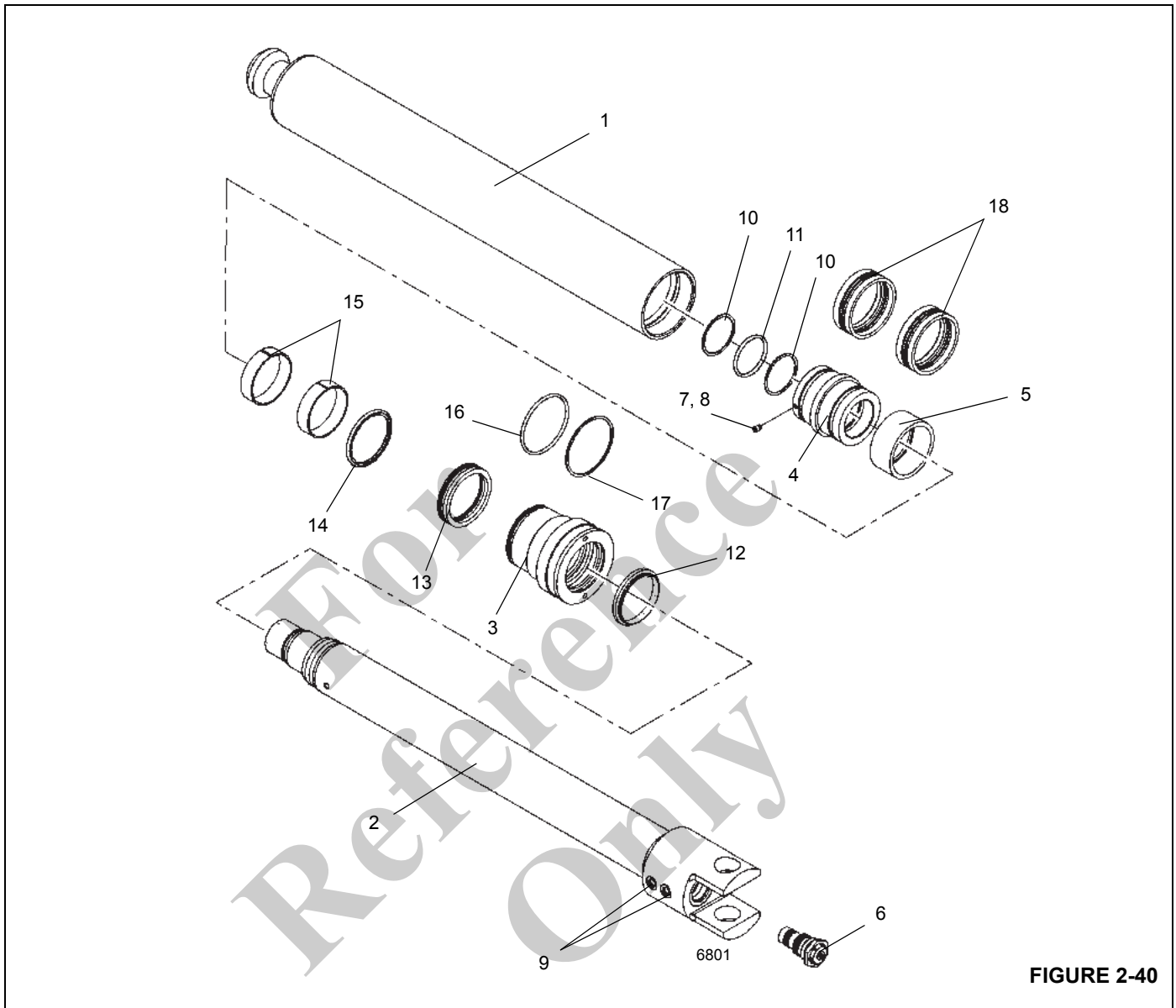


FIGURE 2-40

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

Item	Description
10	Backup Ring
11	O-ring
12	Wiper Ring
13	Rod Seal
14	Buffer Seal
15	Wear Ring
16	O-ring
17	Backup Ring
18	Seal

**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:** Do not use any sharp objects to install seals. Make sure to install all seals with sealing lips facing the correct direction.

1. Install the seals on the outside of the piston and the back up rings and O-ring in the inside of the piston.
2. install the O-ring and backup ring on the outside of the head and the wear rings, buffer seal, rod seal and wiper ring in the inside of the head.
3. Lubricate the head seals with clean light oil and slide the head onto the rod. Tap on with a rubber mallet to engage the seals.
4. Push the head half way down the length of the rod.
5. Install the spacer on the rod.
6. Lubricate the piston seals with a clean light oil and thread the piston clockwise onto the rod with the spanner wrench until it bottoms out.
7. Install the setscrew with a 3/16 inch allen wrench until hand tight. Seat the piston seal bottom ring into the groove.
8. Using the hoist, raise the rod assembly back into a vertical position taking care not to damage the OD seals on the head and piston.
9. Apply anti-seize lubricant to the head outer threads.
10. Lubricate the OD seals on the piston and head with clean light oil and lower the assembly into the barrel. Stop just before the gland enters the barrel. Using the spanner wrench turn the head counterclockwise while applying light downward force until the threads engage.

11. Continue turning the head counterclockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the head shoulder and the top of the barrel.
12. Install the setscrew with a 5/32 inch allen wrench until hand tight.
13. Slowly lower the rod to the fully retracted position.

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

14. Install the plugs.

**Test**

1. Set test stand pressure to 310.1 bar (4500 psi).
2. Attach hose fittings to cylinder.
3. Connect a ball valve to the "test extend" port (marked "PC" on rod mount) so that the pressure can be released after testing and is not trapped in the valve. Test cylinder through working ports with ball valve closed.
4. The cylinder shall be stroked its full length in both directions to fill it with oil and remove trapped oil.
5. Pressurize to recommended test pressure at each end, beginning with the rod end for a minimum of 10 seconds per end. While under pressure, cylinder shall be checked for leaks at welds, SAE fittings, valve, and all external static and dynamic seals. Refer to *Outrigger Circuit*, page 8-26 for outrigger jack cylinder Internal Leak Testing. Cycle cylinder completely (retract and extend) three times under pressure.
6. When testing is complete, relieve pressure on working ports. Slowly open ball valve on PC port to relieve trapped oil pressure. Plug the extend port (marked "EXT") and retract the cylinder with air using a regulator at the RET port and a return line connected to the PC port. Reclaim all oil. Carefully bleed off air pressure once cylinder is fully retracted.
7. Seal ports with port plugs to prevent contamination from entering cylinder.

## COUNTERWEIGHT REMOVAL CYLINDER

### Description

The counterweight cylinder Figure 2-41 has a 8.9 cm (3.5 in) diameter bore.

The retracted length of the cylinder from the end of the barrel to the center of the rod lug is 99.5 cm  $\pm 0.22$  (39.19 in  $\pm 0.09$ ). The stroke of the cylinder is 71.12 cm (28.0 in) which gives an extended length of 170.66 cm  $\pm 0.22$  (67.19 in  $\pm 0.09$ ).

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

The cylinder weighs approximately 41.7 kg (92 lb).

### 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 holding valve from the port block.
2. Remove the bolts, washers, and nuts securing the rod end lug to the cylinder rod and remove the lug.
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. Using a spanner wrench, unscrew the head from the barrel.



#### DANGER

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to move. Injury may result from the cylinder rod unexpectedly exiting the cylinder barrel.

#### CAUTION

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

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

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

#### CAUTION

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

**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 locknut securing the piston. Remove the piston from the rod.
6. Remove the wear ring and piston seal from the outside of the piston.
7. Remove the spacer from the rod.
8. Remove the head from the rod.
9. Remove the O-rings and the backup ring from the outside of the head. Remove the rod seal, wiper ring and O-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.

#### 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.

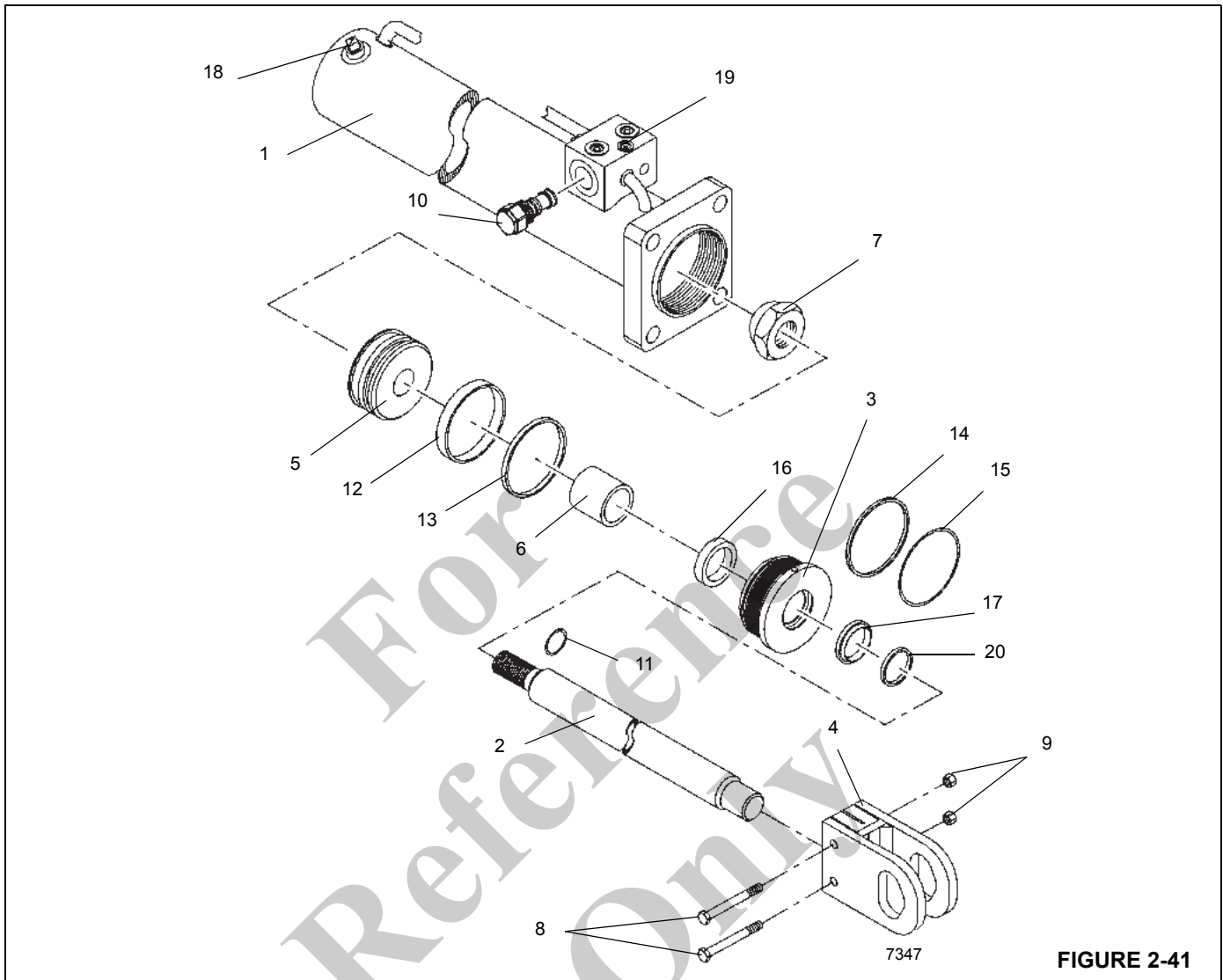


FIGURE 2-41

Item	Description
1	Barrel
2	Rod
3	Head
4	Lug
5	Piston
6	Spacer
7	Nut
8	Bolt
9	Locknut
10	Holding Valve

Item	Description
11	O-ring
12	Wear Ring
13	Piston Seal
14	O-ring
15	Backup Ring
16	Rod Seal
17	Wiper Ring
18	Bleeder Plug
19	Plug
20	O-ring

1. Install the rod seal, wiper ring and O-ring in the inside of the head.
2. Install the O-ring and backup ring on the outside of the head.
3. Lubricate the rod with clean hydraulic oil.
4. Install the cylinder head on the rod.
5. Install the spacer on the rod.
6. Install the seal and wear ring on the outside of the piston, and the O-ring on the inside of the piston.
7. Lubricate all parts freely with clean hydraulic oil.

---

### CAUTION

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.

8. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
9. Clean all oil from the threads of the head. Coat the threads with Loctite 271. Using a spanner wrench, screw the head into place in the barrel.
10. Check the inside of the port block for any sharp edges or burrs and remove as necessary with emery cloth.

11. Install new O-rings onto the holding valve.
12. 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.

13. Carefully install the holding valve into the port block until fully seated.
14. Install the rod end lug on the cylinder rod and secure with the bolts, washers, and nuts.

---

### CAUTION

Do not use air pressure to cycle or pressurize the cylinder. Damage to the seals may result.

15. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 206.7 bar (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

*For  
Reference  
Only*

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## SECTION 3 ELECTRICAL SYSTEM

### SECTION CONTENTS

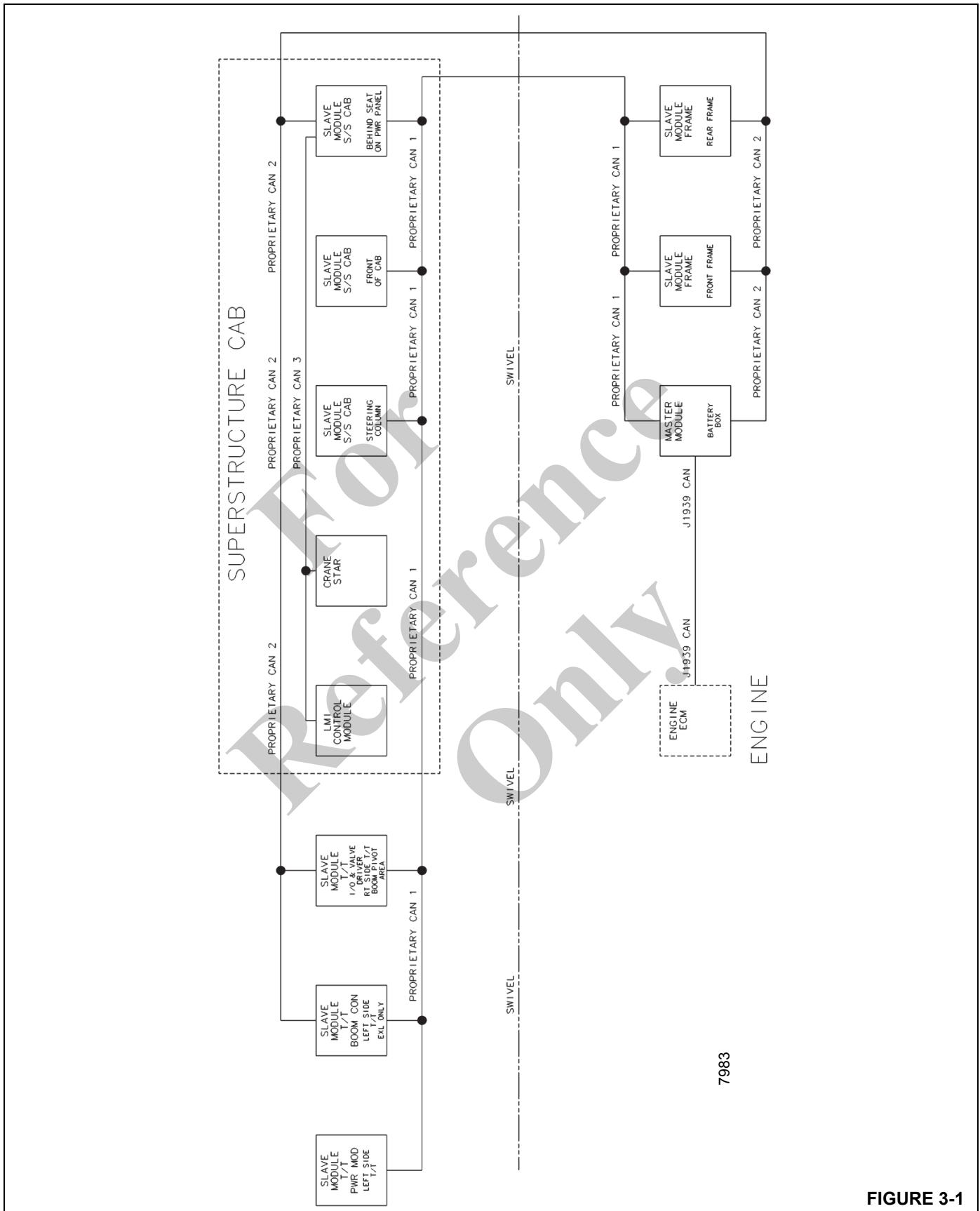
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### DESCRIPTION

#### General

The electrical system is 12-volt operation with 12-volt starting, consisting of an alternator and three lead-acid batteries. Electrical power is transferred to and from the

carrier and superstructure through the electrical swivel. The CAN bus system consists of many control modules which are located on the carrier, superstructure, and operator's cab. Refer to Figure 3-1 for a list of the different control modules and their locations. For more detailed information on the electrical swivel, refer to *Swing System*, page 6-1.



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FIGURE 3-1

## Alternator

The alternator (Figure 3-2) 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 maintain them at a full state of charge.



FIGURE 3-2

## Batteries

The batteries (Figure 3-3) are located in a box on the left side of the crane. The batteries are the maintenance free type and 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.

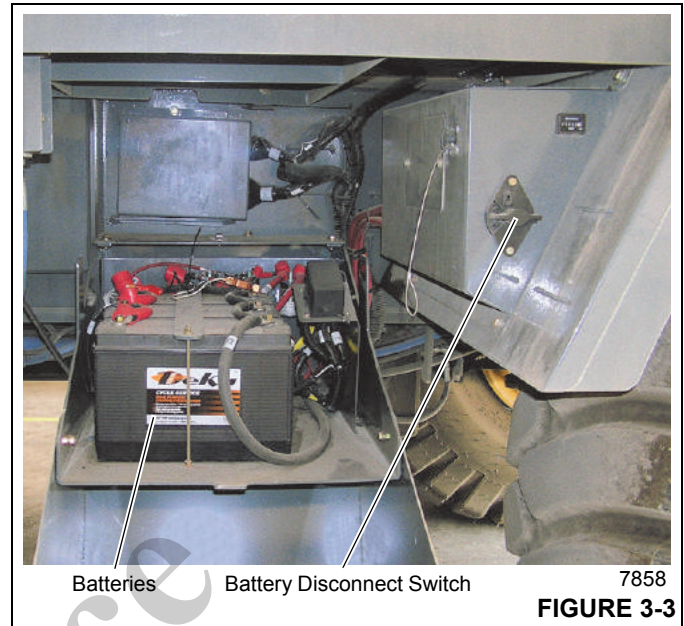


FIGURE 3-3

A Battery Disconnect Switch is located to the right of the battery box (Figure 3-3). To disconnect the batteries, turn the Battery Disconnect Switch to OFF. Turn the switch to ON to connect the batteries.

## Cab Electrical Panel

**NOTE:** Refer to the electrical schematic in the back of this manual for a diagram of the electrical system.

The cab electrical panel (6) (Figure 3-4) contains the cab and superstructure relays, fuse box, wiring harness connector bulkhead, RCL module, RCL Override switch, and the fast pulse buzzer alarm. It is located inside the crane cab, behind the operator's seat. Access is gained to the back of the panel by removing the two screws (3) (Figure 3-4) securing the panel cover.

The two accessory relays (9, 10) (Figure 3-4) behind the cab electrical panel control power to fuses 9 - 20 in the fuse box. The coils of the accessory relays are energized when the ignition switch is at the RUN or ACC position.

The fuse box (2) (Figure 3-4) in the cab electrical panel contains twenty fuses. Fuses 1 through 5 are energized when the battery is connected. When the battery is connected and the Ignition Switch is at the RUN position, fuses 6 through 8 are energized. If the Ignition Switch is at the ACC position, fuse 8 will be energized while fuses 6 and 7 remain de-energized. Fuses 9 through 12 are energized through ACC relay # 1 and 13 through 20 are energized through ACC Relay#2.

**NOTE:** The cab control modules and RCL module are not serviceable; contact Crane Care Customer Service with any service or repair questions about the modules.

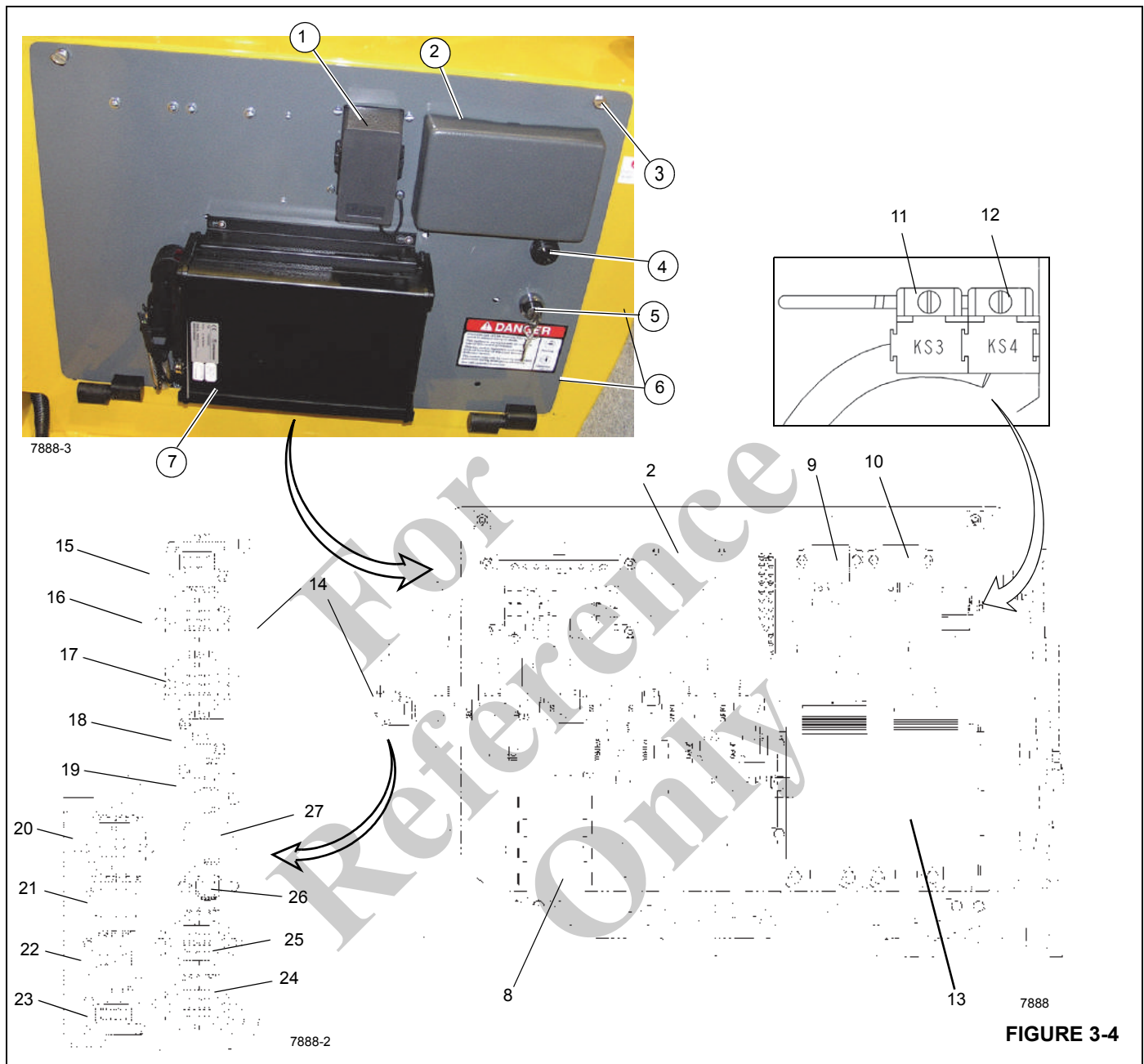


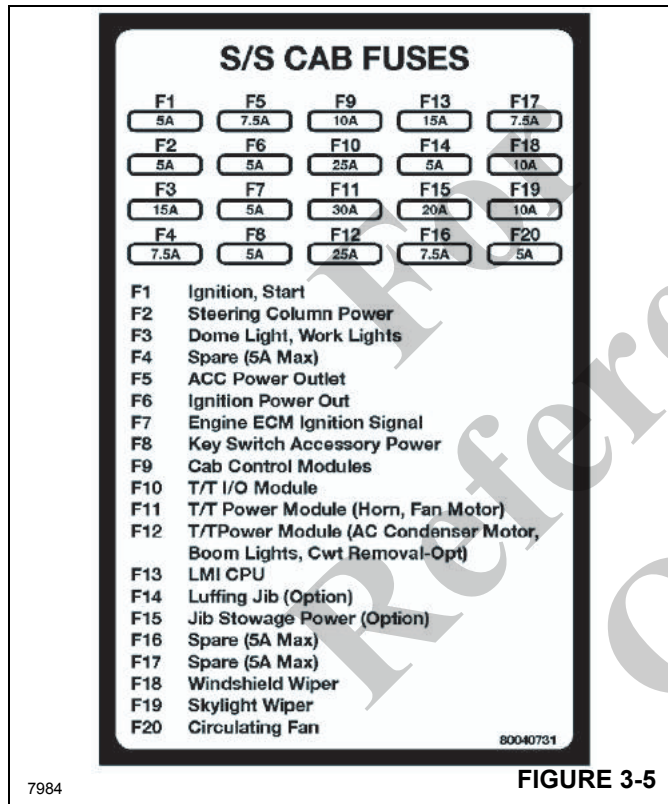
Figure 3-4 Item Numbers

Item	Component
1	Diode Box
2	Fuse Box
3	Panel Screw
4	Fast Pulse Buzzer Alarm
5	RCL Override Switch
6	Electrical Panel
7	RCL Controller
8	CAN Junction Box

Item	Component
9	ACC Relay, CAB and T/T Modules Power(KS1)
10	ACC Relay, Jib Stow, RCL Override, Jib Option
11	Relay, Windshield Wiper Low Speed
12	Relay, Windshield Wiper High Speed
13	CAB Module
14	Connector Bulkhead
15	Cab Interior Harness
16	Swivel Harness
17	Seat Harness

Item	Component
18	Seat Harness
19	Superstructure Harness
20	Overhead Harness
21	Empty
22	Cab Interior Harness
23	Cab Interior Harness
24	Cab Interior Harness
25	Cab Interior Harness
26	Superstructure Harness
27	Empty

- Fuse 9 - Cab Control Modules Power
- Fuse 10 - Turntable I/O Module
- Fuse 11 - Turntable Power Module (Horn, Fan Motor)
- Fuse 12 - Turntable Power Module (AC Condenser Motor, Boom Lights, Counterweight Removal - Option)
- Fuse 13 - RCL CPU
- Fuse 14 - Luffing Jib Option
- Fuse 15 - Jib Stowage Power Option
- Fuse 16 - Spare - 5A Max
- Fuse 17 - Spare - 5A Max
- Fuse 18 - Windshield Wiper
- Fuse 19 - Skylight Wiper
- Fuse 20 - Circulating Fan



**Carrier Electrical Panel**

The carrier electrical panel contains the battery disconnect switch, main power relay, and fuses that control power to the crane's entire electrical system. The panel (Figure 3-6) is located on the fuel tank side of the crane, inside the battery box assembly.

The coil of the main power relay (1) (Figure 3-6) is energized when the ignition switch is at the RUN or ACC position, or while the crane's control system Master Module commands it to be on, or when the head lights, tail lights or brake lights are activated.

The fuse panel consists of:

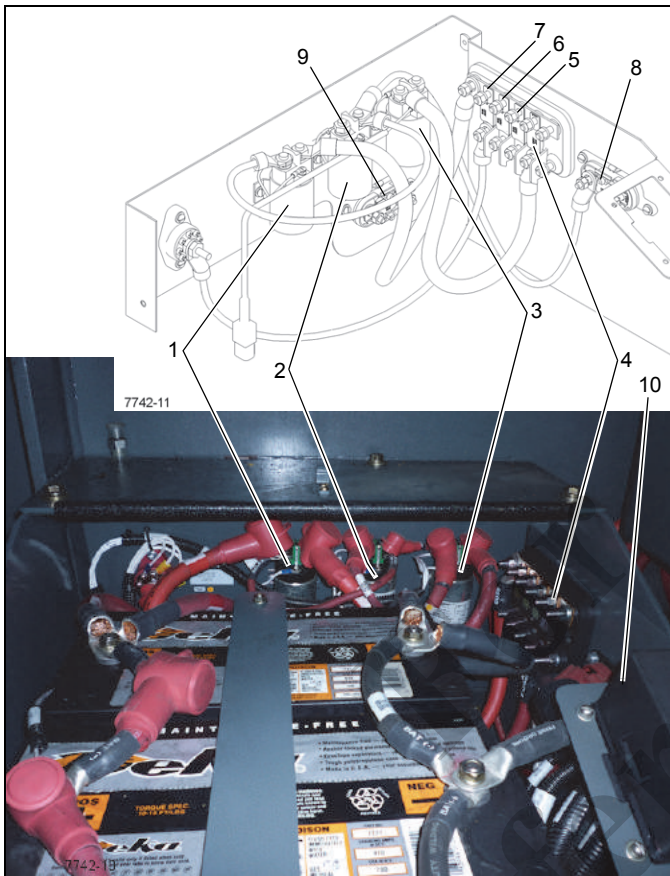
- Fuses 1 through 5 are energized anytime the battery disconnect switch is closed and the batteries are connected.
- Fuses 6 and 7 are only energized when the Ignition keyswitch is in the RUN and START positions.
- Fuse 8 is energized when the Ignition keyswitch is in the ACC and RUN positions. It is not energized while in START position.
- Fuses 9 through 12 are energized when ACC Relay #1 is energized. ACC Relay # 1 is energized during the following:
  - Anytime the Ignition keyswitch is in the ACC and RUN positions.
  - Brake pedal is depressed.
  - Headlight switch is turned on.
  - Hazard switch is turned on.
- Fuses 13 thru 20 are energized when ACC Relay #2 is energized. ACC Relay #2 is energized anytime the

The following fuse assignments apply:

- Fuse 1 - Ignition Power in circuit
- Fuse 2 - Steering Column Power circuit
- Fuse 3 - Dome Light and Working Lights
- Fuse 4 - Spare - 5A Max
- Fuse 5 - ACC power and Diagnostic Connector circuit
- Fuse 6 - Ignition Power out
- Fuse 7 - Engine ECM Ignition Signal and Emergency Stop
- Fuse 8 - Key Switch Accessory Power

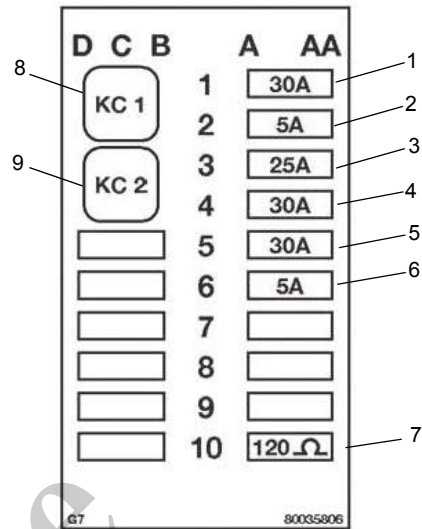


Ignition key switch is in the ACC and RUN positions.  
ACC Relay #2 is not energized while in START position.



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 3-7)

FIGURE 3-6



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Item	Description
1	ECM, 30 Amp Fuse (F1)
2	Cranestar, 5 Amp Fuse (F2)
3	Carrier, Rear Module, 25 Amp Fuse (F3)
4	Carrier, Rear Module, 30 Amp Fuse (F4)
5	Carrier, Front Module, 30 Amp Fuse (F5)
6	Power Control Relay, 5 Amp Fuse (F6)
7	120 Ohm Resistor, Starter Lockout Circuit
8	Relay KC1, Power Control Relay
9	Relay KC2, Remote Crank Relay

FIGURE 3-7

## MAINTENANCE

### General

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

### DANGER

When possible, ensure the battery is disconnected before performing any maintenance on an electrical circuit.

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 may result from accidental grounding or shorting circuits.

### CAUTION

Never replace original wiring with wiring of a smaller size (gauge). Fire or other damage to the machine may result.

### *Visual Inspection and Replacement of Electrical Harnesses and Cables*

### CAUTION

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

Visually inspect all electrical harness and cable assemblies every month or at 250 hours of service life for the following:

- Damaged, cut or deteriorated harness loom covering.
- Damaged, cut or abraded individual wires or cable insulation.
- Exposed bare copper conductors.
- Kinked, crushed, flattened harnesses or cables.
- Blistered, soft, degraded wires and cables.

- Cracked, damaged, or badly corroded battery terminal connections.
- Inspect all machine ground connections for damaged terminals or excessive corrosion.
- Other signs of significant deterioration.

If any of these conditions exist, evaluate the harness assemblies for repair or replacement. For replacement of harness assemblies, refer to your Manitowoc Crane Care Parts Manual.

At the same service interval, visually inspect all Controller Area Network (CAN) nodes and electrical junction boxes for the following:

- Damaged or loose connectors.
- Damaged or missing electrical clamps or tie straps.
- Excessive corrosion or dirt on the junction box assemblies.
- Loose junction box mounting hardware.

If any of these conditions exist, address them appropriately.

Ambient temperature, humidity and other factors affect the life of electrical harness and cable assemblies. Use the following information for the inspection and replacement of these assemblies:

- Cranes operating in climate zone "C" should have the harness and cable assemblies replaced after 10,000 hours of service life.
- Cranes operating in climate zones "A" or "B" with high ambient temperatures could see electrical service life reduced by 25% to 40%. It is recommended to replace these assemblies after 8000 hours of service life.
- Cranes operating in climate zones "D" and "E", cold climates, should expect a degradation of mechanical properties, long term exposure to these cold temperatures will negatively impact service life. Therefore, it is recommended these electrical harnesses and cable assemblies be inspected regularly as service life may be less than 10,000 hours.
- Cranes operating in salt water climates could see a significant reduction in service life. Therefore it is recommended for these electrical harnesses and cable assemblies to be inspected regularly as service life may be less than 8,000 hours.

Table 3-1

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

## General Troubleshooting

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

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

## Tools for Troubleshooting

This machine Incorporates a CAN bus Multiplex system. In order to effectively troubleshoot the electrical system, you need a Windows-based PC, CAN-link service software and a connection cable. 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.

Table 3-2  
AMP Extraction Tool Table

Description	AMP Part Number	Manitowoc Part Number
14 gauge wire (connectors)	305183	9999100176
12 to 8 gauge wire (connectors)	91019-3	9999100175

## 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, worn brushes, improper spring tension on the brush assembly, and loose setscrews on the slip ring assembly. Refer to the electrical schematic and wiring diagram for slip ring connections and amperages.

## Connector Troubleshooting

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

Refer to the following tables listing tools necessary for connector maintenance.

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



Description	AMP Part Number	Manitowoc Part Number
4 to 9 circuit (in-line connectors)	453300-1	N/A
15 circuit (in-line connectors)	458944-1	N/A

**Table 3-3**  
**AMP Crimping Tool Table**

Description	AMP Part Number		Manitowoc Part Number	
	Tool	Die	Tool	Die
14 to 12 gauge wire	69710-1	90145-1	9999100177	N/A
10 to 8 gauge wire	69710-1	90140-1	9999100177	9999100178
4 to 9 circuit (in-line connectors)	69710-1	90306-1	9999100177	N/A
15 circuit (in-line connectors)	90299-1	--	N/A	--

**Table 3-4**  
**Deutsch Extraction Tool Table**

Description	Deutsch Part Number	Manitowoc Part Number
12 gauge wire	114010	9999100194
16 gauge wire	0411-204-1605	9999100195
8-10 gauge wire	114008	7902000012
4-6 gauge wire	114009	7902000009

**Table 3-5**  
**Deutsch Crimping Tool Table**

Description	Deutsch Part Number	Manitowoc Part Number
12, 14, 16, 18, 20 gauge wire	HDT-48-00	9999100808
4, 6, 8, 10 gauge wire	HDT04-08	9999100842

## Alternator/Charging System Troubleshooting

Anytime there is a problem with the charging system the batteries, alternator and cables should be tested.

### Required Tools

The following is a list of tools needed to diagnose the charging system:

Equipment	Example	Manitowoc Part No.
Digital Multimeter	Fluke® 177	9999101763
Carbon Pile Load Tester	Autometer® SB5	9999101765
Current Clamp Meter	Fluke® 336	9999101764

### Visual Check

- Belts: tight, in good condition, not frayed, cracked or glazed
- Pulley: tight, aligned with other pulleys, not glazed
- Alternator mounting bolts and wiring connections: clean and tight, no signs of heat damage
- Batteries: terminals and cables, clean and tight, no corrosion or signs of heat damage
- Check alternator fuse, if the Alternator Charge Lamp is illuminated on the steering column display while the engine is running.

**Engine Off Tests****Batteries****DANGER**

Do not smoke or allow sparks or open flame near batteries, they can explode.

When working with batteries always wear protective clothing, gloves and eye protection. Batteries contain corrosive liquids that can burn skin and eyes and destroy clothing.

Remove rings, watches or other jewelry before working with batteries. A battery can produce a short-circuit current high enough to weld a ring, or the like, to metal causing severe burns

Disconnect the batteries and test each battery individually.

Check the electrolyte level, if possible

Using the multimeter, measure the voltage across the terminals. If the voltage is 12.4 V or above, perform the following load test. If the voltage is lower than 12.4 V, recharge the battery(s) before performing the load test.

**Load Test**

1. Refer to the load tester manual for instructions on performing the load test.
2. Connect the load tester to one battery and test.
3. Connect the tester to the second battery and test.
4. Connect the tester to the third battery and test.

Proceed to the next test if the batteries passed the load test. Replace a battery if it failed the load test.

**Voltage at Alternator**

Measure voltage from alternator case to output terminal. The meter should read 12.6V or above.

**Battery Drain**

With a DC ammeter capable of measuring milliamps, and a 10 amp capability, perform the following test:

1. Make sure the ignition key is off.
2. Set the meter to the 10 amp position.
3. Check for a drain by disconnecting the negative battery terminals and measuring between the battery post and the cable with the ammeter.

This reading should not be more than 80 milliamps (.08 A) with all accessories OFF. A higher reading indicates something is draining the batteries and the system must be troubleshot and repaired.

**Engine On Tests****Output Voltage Test**

1. Connect multimeter to negative and positive battery terminals.
2. Connect ammeter clamp around output wire of alternator to the batteries.
3. Start engine and increase speed to 2000 rpm.

With fully charged batteries and no loads on the system, the multimeter should read 14 V.

**Maximum Amperage Test**

1. Connect an adjustable carbon pile load tester to the batteries' positive and negative cables.
2. Run engine at 2000 rpm.
3. Adjust carbon pile to obtain maximum amperage while not letting voltage fall below 13 volts.
4. Amperage should be within 10 to 15 amps of alternator rating; this alternator is rated at 145 A, so the meter should read 130 A to 135 A.

**NOTE:** If the correct readings were not obtained in the Engine On Tests, perform the following two tests.

**Voltage Drop Test****Positive Side**

1. Set the multimeter to the 2 volt range.
2. Connect the positive (+) lead to the alternator output terminal and the negative (-) lead to the battery positive terminal or post. Do not connect the meter to the battery cable.
3. Run the engine at 2000 rpm.
4. Load system with carbon pile load or lights and heater blower.

Allowable drop is 0.2 to 0.5 volts. Higher voltage drop indicates loose, corroded, or broken connections.

**Negative Side**

1. Set the multimeter to the 2 volt range.
2. Connect the negative (-) lead to alternator case and the positive (+) lead to the battery negative terminal or post. Do not connect the meter to the battery cable.
3. Run the engine at 2000 RPM.
4. Load system with carbon pile load or lights and heater blower.

Allowable drop is 0.1 to 0.3 volts. Higher voltage drop indicates loose, corroded, or broken connections.

If any voltage drop is greater than the normal range, troubleshoot the system and repair any problems.

After correcting any problems, perform the Engine On Tests again. If satisfactory results are not obtained, remove the alternator and bench test.

## Alternator Replacement

### Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. Using a 1/2 in drive bar/ratchet, turn the tensioner, below the alternator, 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 the alternator mounting capscrews. Remove the alternator.

### Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. Install the alternator using the mounting bolts and washers. Torque bolts; refer to *Fasteners and Torque Values*, page 1-16 for the proper torque value.
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. Verify tensioner bolt is torqued to 32 lb-ft (43 Nm).
7. Connect the electrical leads to the terminals as tagged during removal.

8. Close the engine compartment.
9. Reconnect the ground cables to the battery.
10. Install the ECM power fuse.
11. 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 in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. 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. Torque the bolts to 32 lb-ft (43 Nm).
2. Connect the electrical leads to the terminals as tagged during removal.
3. Reconnect the ground cables to the battery.
4. Install the ECM power fuse.
5. Turn the battery disconnect switch to the ON position.

### 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 properly with the flywheel, that the starter's gear hasn't remained engaged to the flywheel after the ignition switch is in the ignition (run) position, or some other problem. Install starter properly as needed.

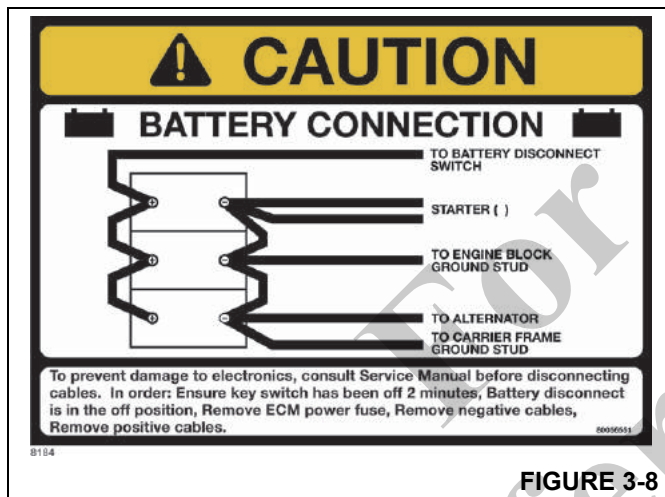
## Battery Replacement

### Removal

### CAUTION

To avoid possible engine fault codes and undesirable operation, ensure the keyswitch has been off 2 minutes before disconnecting batteries.

Disconnect batteries if machine will be inactive for over 24 hours.



1. Open the battery box cover.
1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. Remove the positive battery cables.
6. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
7. 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 (and batteries) 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. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Working behind the operator's seat, remove the hardware securing the panel cover and remove the cover.
4. Tag and disconnect the electrical leads from the suspect relay.
5. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
6. Install replacement relay on relay panel and secure it with attaching hardware.
7. Connect the electrical leads to the relay as tagged during removal.
8. Position the cover on the panel and secure with the attaching hardware.
9. Connect the batteries.
10. 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 remove 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. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. 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).
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 gauge cluster (5).
12. 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. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. Remove the four screws (13) securing the left and right side covers (8, 9) together.
6. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
7. Remove the left side cover (8) from the steering column.
8. Disconnect the wire harness from the back of the ignition switch (10).
9. Remove the right side cover (9) from the steering column.
10. 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. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. Remove the four screws (13) securing the left and right side covers (8, 9) together.
6. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
7. Remove the left side cover (8) from the steering column.
8. Disconnect the wire harness from the back of the ignition switch (10).
9. Remove the right side cover (9) from the steering column.
10. Remove the locking nut that secures the ignition switch (10) to the right cover (9) and remove the ignition switch (10).

**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. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
4. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
5. 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).
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 gauge cluster (5).
12. Tag and disconnect the wire harness from the bottom of each switch (4).
13. Remove the gauge/switch cover (6) from the steering column.
14. Disconnect the wire harnesses from the bottom of the turn signal and transmission shift levers (7).
15. 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).



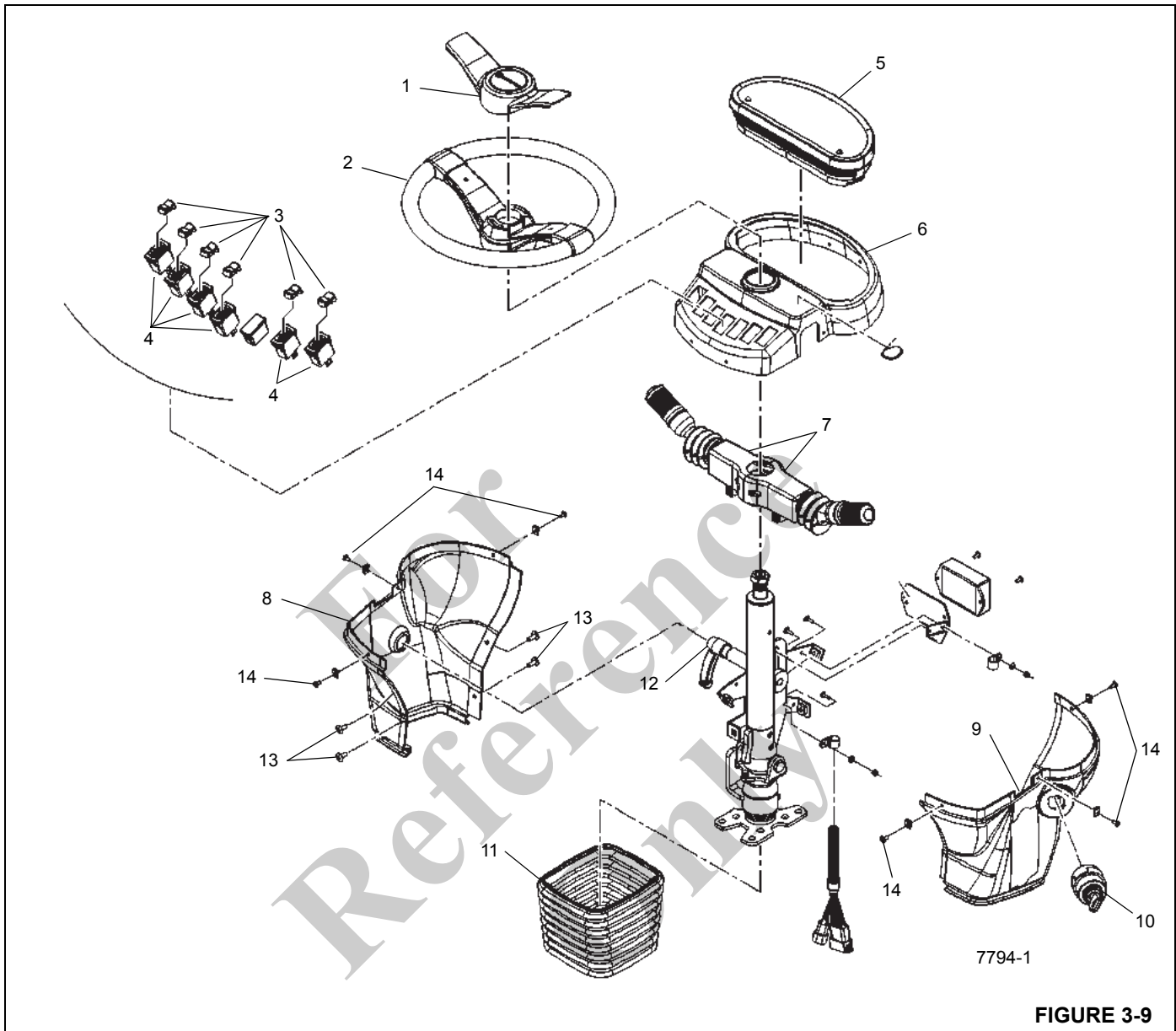


FIGURE 3-9

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 switch or associated wiring.

## Windshield Wiper Assembly Replacement

### Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the motor.
4. Disconnect the washer hose on the wiper arm (also called the pantograph arm assembly) from the washer nozzle fitting assembly.
5. Remove the cap nut and washer securing the wiper arm to the pantograph adapter kit. (The nut and washer are part of the pantograph adapter kit.) Remove the cap nut,



washer, and tapered sleeve securing the wiper arm to the pivot shaft kit. (The nut, washer, and sleeve are part of the pivot shaft kit.)

6. Remove the wiper arm from the pantograph adapter kit and the pivot shaft kit.
  7. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft kit. (The sleeve, nut, and washers are part of the pivot shaft kit.)
  8. Remove the two capscrews and lockwashers securing the pantograph adapter kit's adapter to the cab exterior. Remove the pantograph adapter kit's adapter and gasket.
  9. 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.
10. Remove the nut to free the wiper motor's shaft from the wiper motor kit 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

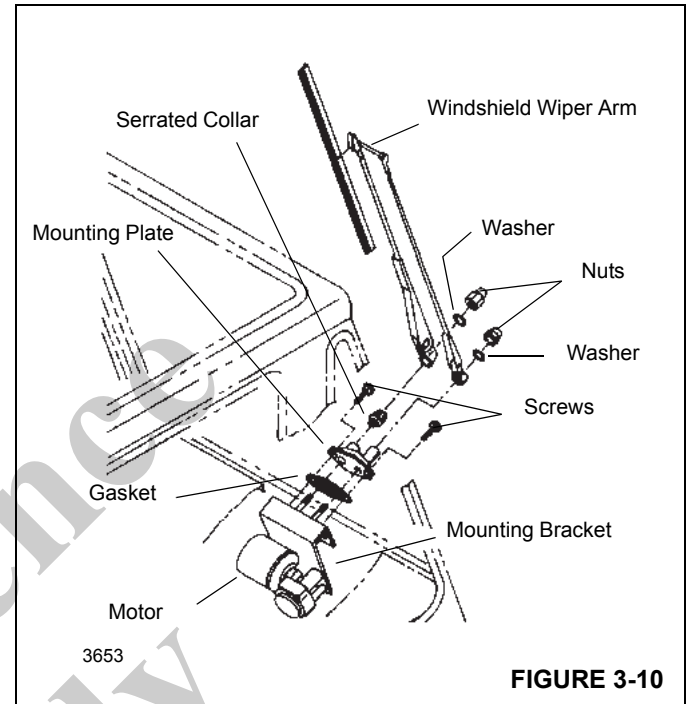
1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts of the linking component kits (pantograph adapter kit, pivot shaft kit, wiper motor kit link and crank, wiper motor bracket) for damage. Replace as needed.

### Installation

1. Verify the pivot shaft and the wiper motor kit 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 (see Figure 3-10). Connect the wiper motor's shaft to the wiper motor kit crank with the nut and washer.
3. Secure the adapter and the gasket of the pantograph adapter kit to the cab exterior with capscrews and lockwashers.

4. 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 kit.

**NOTE:** Take care not to damage any parts while moving the bracket and attached parts around the steering column.



**FIGURE 3-10**

5. Secure the pivot shaft to the pantograph adapter with the pivot shaft kit's nut and washers. Install the flanged sleeve on the pivot shaft.
6. Install the wiper arm on the shafts of the pantograph adapter kit and the pivot shaft kit. Secure the wiper arm to the pantograph adapter kit shaft with the kit's own washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft kit's own tapered sleeve, washer, and cap nut.
7. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
8. Connect the electrical leads to the wiper motor as marked before removal.
9. 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. Verify it works. (Replace wiper blade as needed if it streaks or otherwise wipes poorly.)

## Windshield Washer Assembly Replacement

### Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Locate the windshield washer container and pump on the left rear side of the cab.
4. Tag and disconnect the pump's electrical lead and ground wire.
5. 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.
6. Remove four self tapping screws securing the windshield washer container to the cab. Remove the windshield washer container and pump.
7. 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 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. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the motor.
4. Remove the wiper arm from the motor shaft.
5. Remove the nut, spacer, leather washer, and nylon flat washer from the motor shaft outside the cab roof.
6. 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.
7. Remove mounting screw and nylon flat washer from outside cab roof.
8. 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. Verify it works. (Replace wiper blade as needed if it streaks or otherwise wipes poorly.)

**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 RT770E. 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**

Regions with ambient temperatures below -9°C (15°F) are considered arctic. The following recommendations are for operating Grove cranes in very low (i.e., sub-zero) temperatures.

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 *Warm-up Procedure*, page 5-2.)

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

#### SECTION CONTENTS

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#### DESCRIPTION

A five section 11 m to 42 m (35.9 ft to 138 ft), full power, sequenced, and synchronized boom (Figure 4-1) is installed on this crane.

The boom utilizes one telescope cylinder to extend and retract Tele 1 and Tele 2, and a synchronized cable system to extend and retract Tele 3 and 4. The telescoping boom sections are supported on graphite impregnated nylatron wear pads. Side wear pads prevent metal to metal contact between the tele sections.

Boom assembly lift is provided by one lift cylinder. Boom elevation is from  $-3^{\circ}$  to  $78^{\circ}$ .

An optional 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.

A 10.1 m (33 ft) fixed offsetable or a 10.1 m to 17.07 m (33 ft to 56 ft) folding offsetable swingaway boom extension is provided to obtain additional boom reach. Optional inserts are available for additional reach.

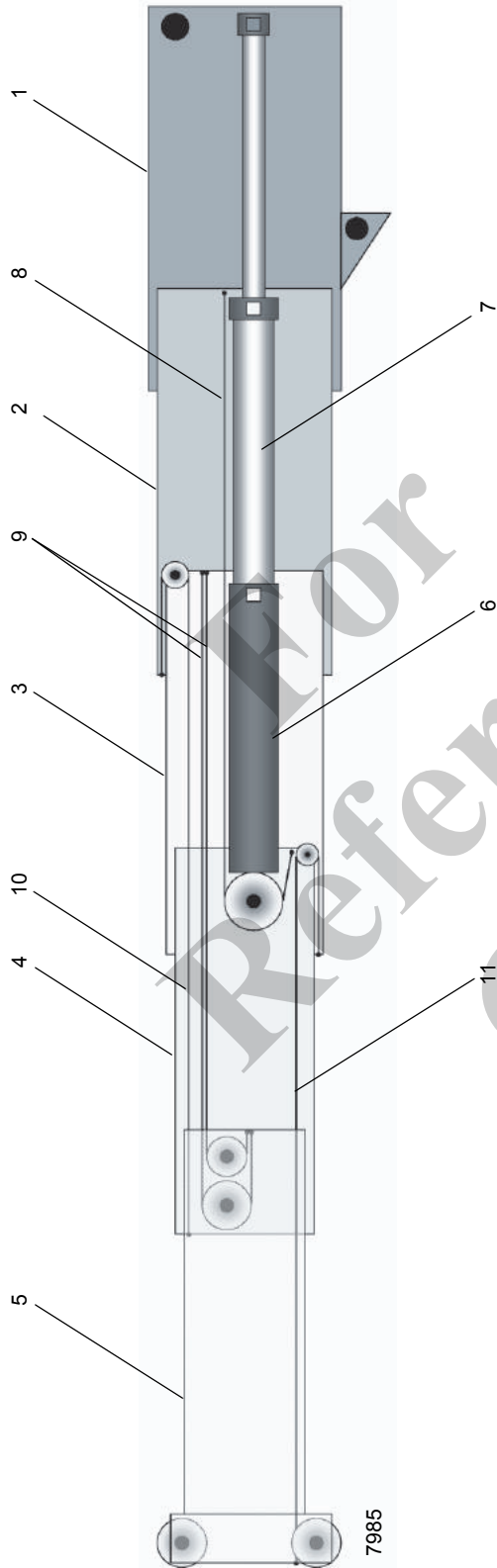
The bi-fold boom extension mounts directly to the boom nose utilizing a four point attachment. In addition, the bi-fold extension base section and/or fly section can be stowed on the right side of the boom base section.

## THEORY OF OPERATION

Boom extension and retraction is accomplished with one two-stage telescope cylinder, 10 extension cables, and 6 retraction cables. The cylinder rod of the second stage (7, Figure 4-1) is secured to the rear of the boom base section and the barrel is secured to the rear of tele 1 by a trunnion; therefore, extending and retracting the second stage of the cylinder causes tele 1 to extend and retract, respectively. The cylinder rod of the first stage (6, Figure 4-1) is secured to the rear of tele 2 by a trunnion; therefore, extending and retracting the first stage of the cylinder causes tele 2 to extend and retract, respectively. The tele 3 extension cables (qty 6) (8, Figure 4-1) are secured to the rear of tele 2 on one end, run around the extension sheaves on the front of the

telescope cylinder, and are secured to the rear of tele 3 on the other end; the tele 4 extension cables (qty 4) (9, Figure 4-1) are secured to the rear of tele 2 on one end, run around the extension sheaves on the front of tele 3, and are secured to the rear of tele 4 on the other end. Tele 3 retraction cables (qty 4) (10, Figure 4-1) are secured to the front of tele 1, run around the retraction sheaves on the rear of tele 2, and are secured to the front of tele 3; the tele 4 retraction cables (qty 2) (11, Figure 4-1) are secured to the front of tele 2, run around the retraction sheaves on the rear of tele 3, and are secured to the front of tele 4. Therefore, when the first stage of the telescope cylinder extends and retracts, tele sections 2, 3, and 4 will extend and retract, respectively, in a synchronized manner.

For  
Reference  
Only



7985

Item	Description
1	Base Section
2	Section 1
3	Section 2
4	Section 3
5	Section 4
6	Telescope Cylinder - 1st Stage
7	Telescope Cylinder - 2nd Stage
8	Section 3 Extend Cables
9	Section 4 Extend Cables
10	Section 3 Retract Cables
11	Section 4 Retract Cables

FIGURE 4-1

## MAINTENANCE

### Removal

**NOTE:** The boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

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#### CAUTION

A rollover fixture with webbing is recommended to rotate boom and tele sections. Chains are not recommended. If a rollover fixture is not available, rotate tele 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 any section or sections.

**NOTE:** The boom may be disassembled with the base section left on the crane if repair of the base section is not necessary.

**NOTE:** The boom weighs approximately 9125 kg (20,150 lb). 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 according to the removal procedures in this section; refer to *Bi-Fold Boom Extension*, page 4-45.

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#### CAUTION

Wear gloves when handling wire rope. Moderate to minor injury may result if using bare hands.

3. Remove the hook block or headache ball and wind all wire rope onto the hoist drum.
4. Elevate the boom slightly to allow for the withdrawal of the lift cylinder rod end from the lift cylinder attach fitting on the bottom of the boom.

---

#### WARNING

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

5. Attach a lifting device to the boom that provides for equal weight distribution.
6. Disconnect any electrical wiring from the boom.
7. Tag and disconnect the hydraulic lines to the telescope cylinder. Cap/plug all openings.

---

#### WARNING

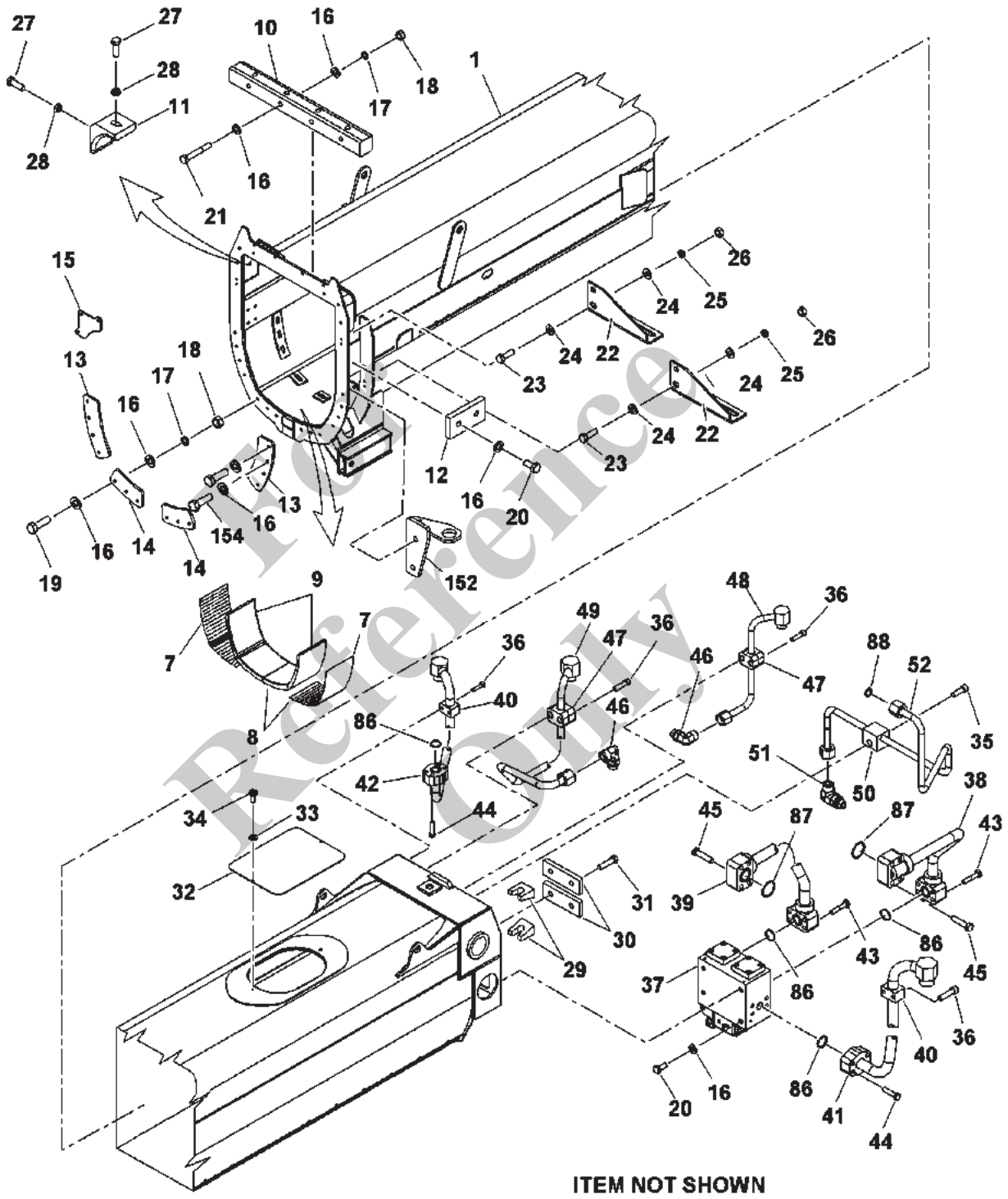
Ensure the boom lift cylinder is properly supported before disconnecting it from the boom. Death or serious injury may result if the lift cylinder is not supported.

8. Block the lift cylinder.
9. Remove the capscrews, washers, and end plate securing the upper lift cylinder shaft to the side of the attachment fitting on the boom.
10. Remove the upper lift cylinder shaft.
11. Activate the hydraulic system and retract the lift cylinder rod enough to clear the attachment fitting. For removal of the lift cylinder from the crane, refer *Lift Cylinder Removal*, page 4-43.

**NOTE:** Shut down the crane before proceeding.

12. Take up the slack on the boom lifting device.
13. Remove the capscrew, washer and nut that passes through the end of the weld pin that secures the boom pivot pin in place, then remove the weld pin. Remove the grease fitting from each end of the boom pivot shaft, then remove the boom pivot shaft.
14. Raise the boom clear of the crane and lower to ground level. Set cribbing under base section to level boom for service.

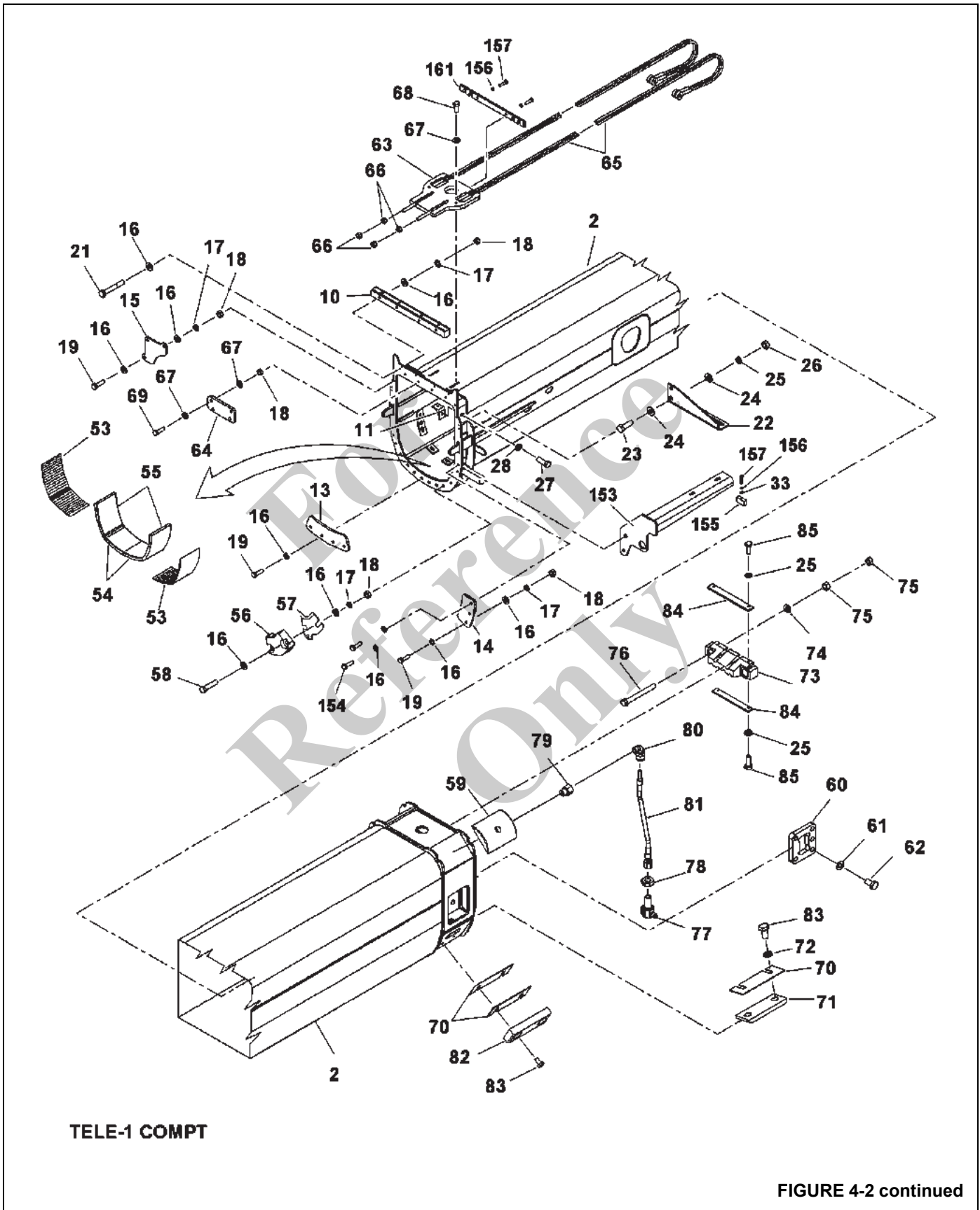


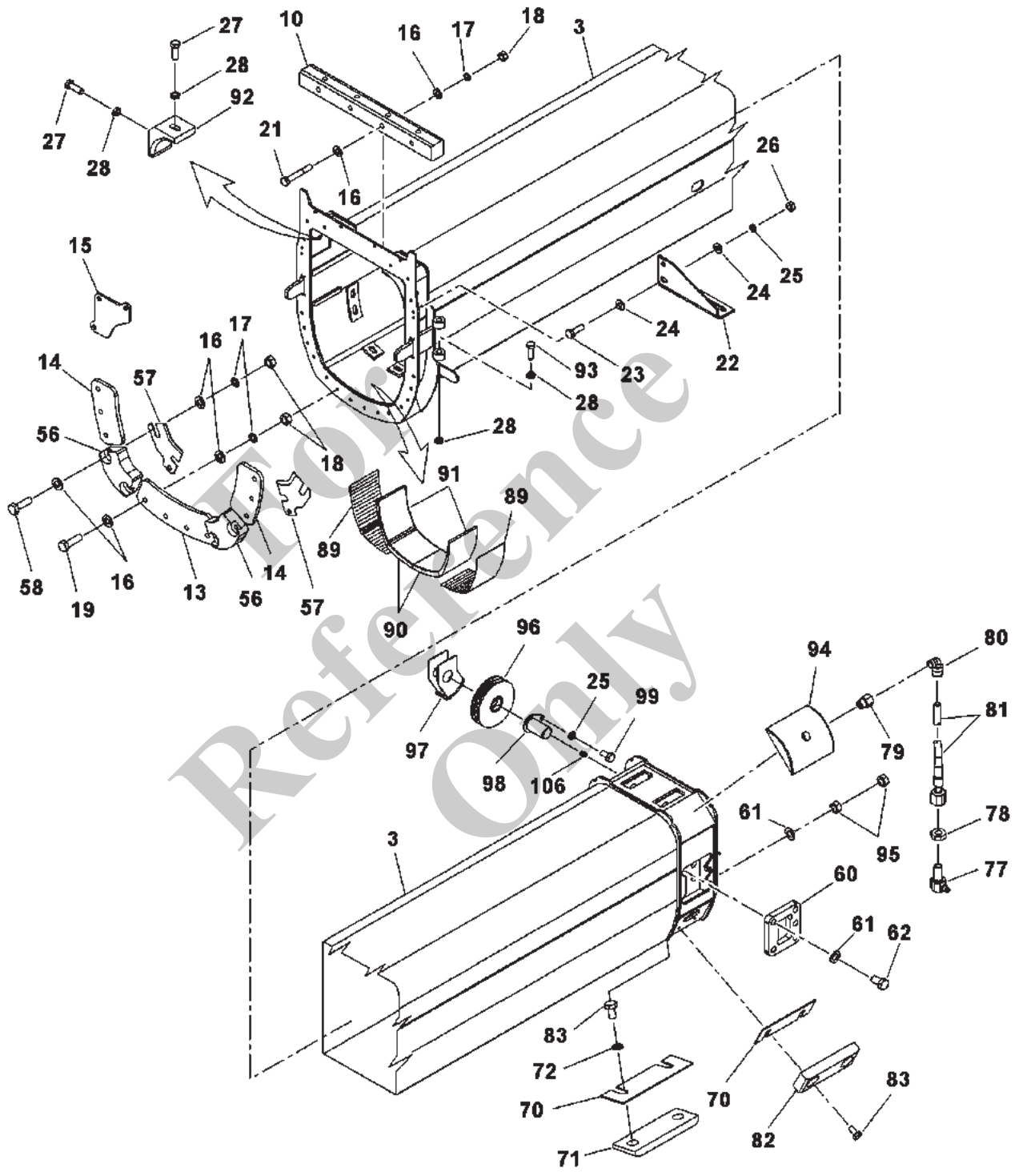


BASE SECTION

ITEM NOT SHOWN  
NBR 159  
NBR 160  
NBR 162  
NBR 300

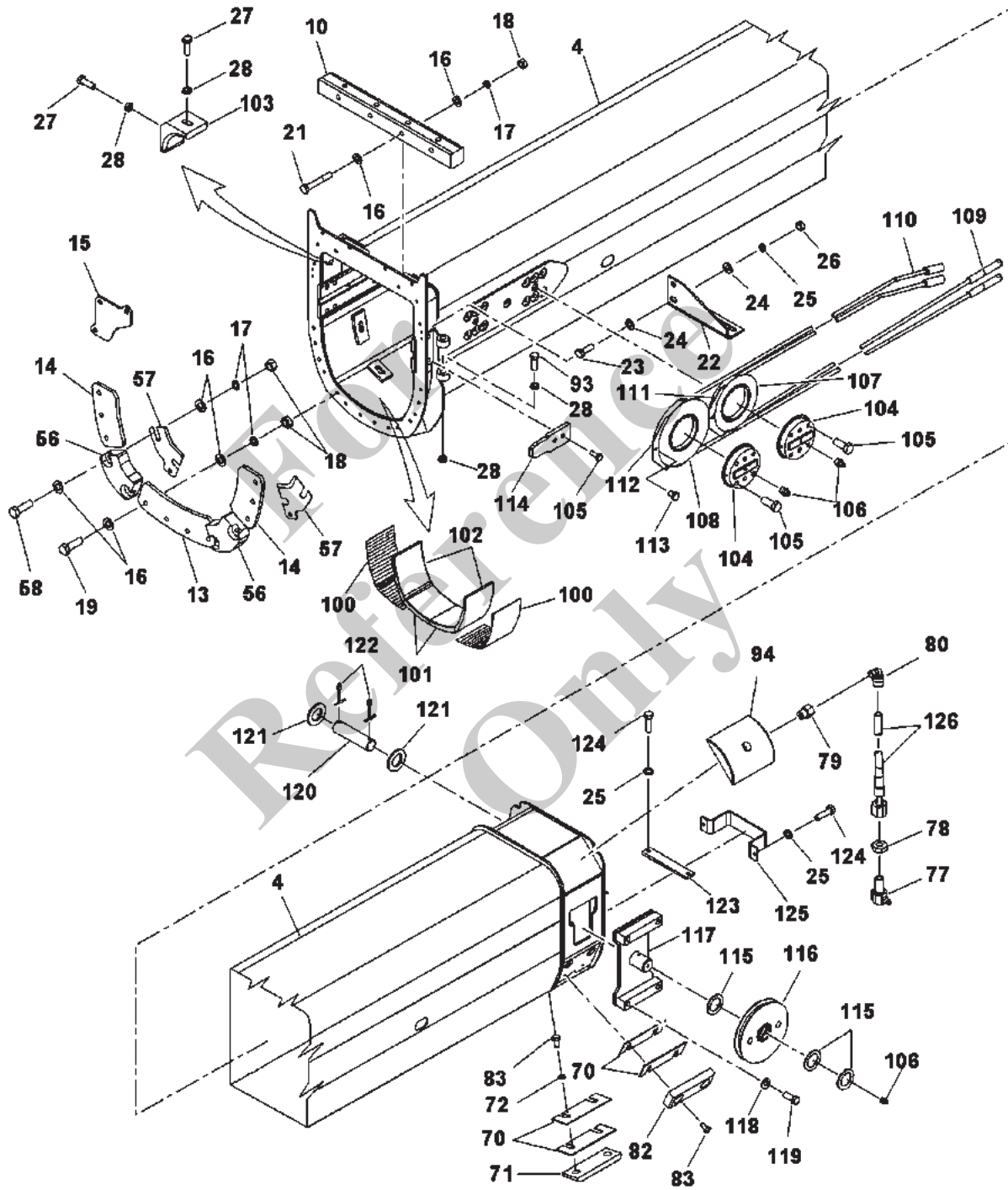
FIGURE 4-2





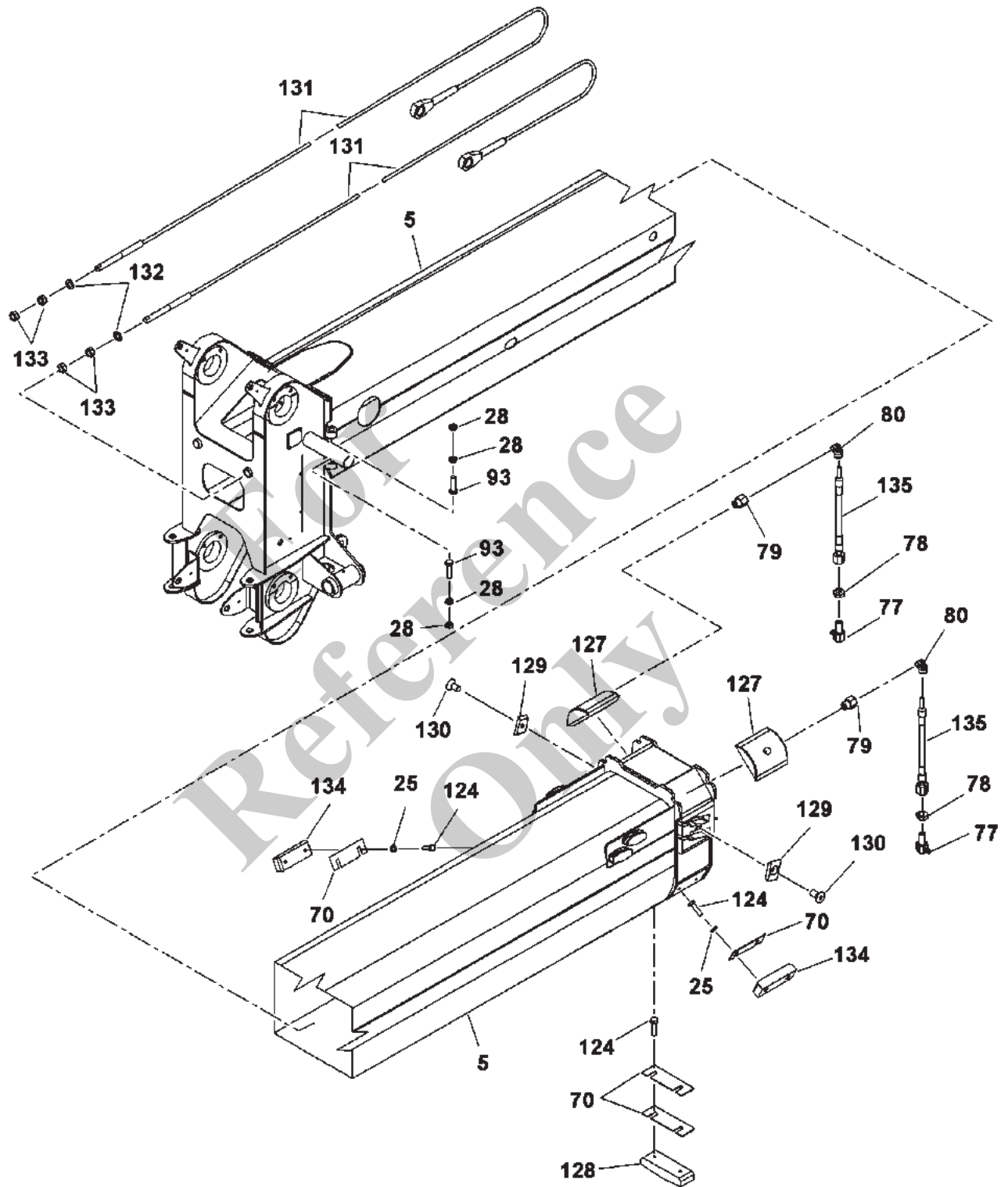
TELE 2

FIGURE 4-2 continued



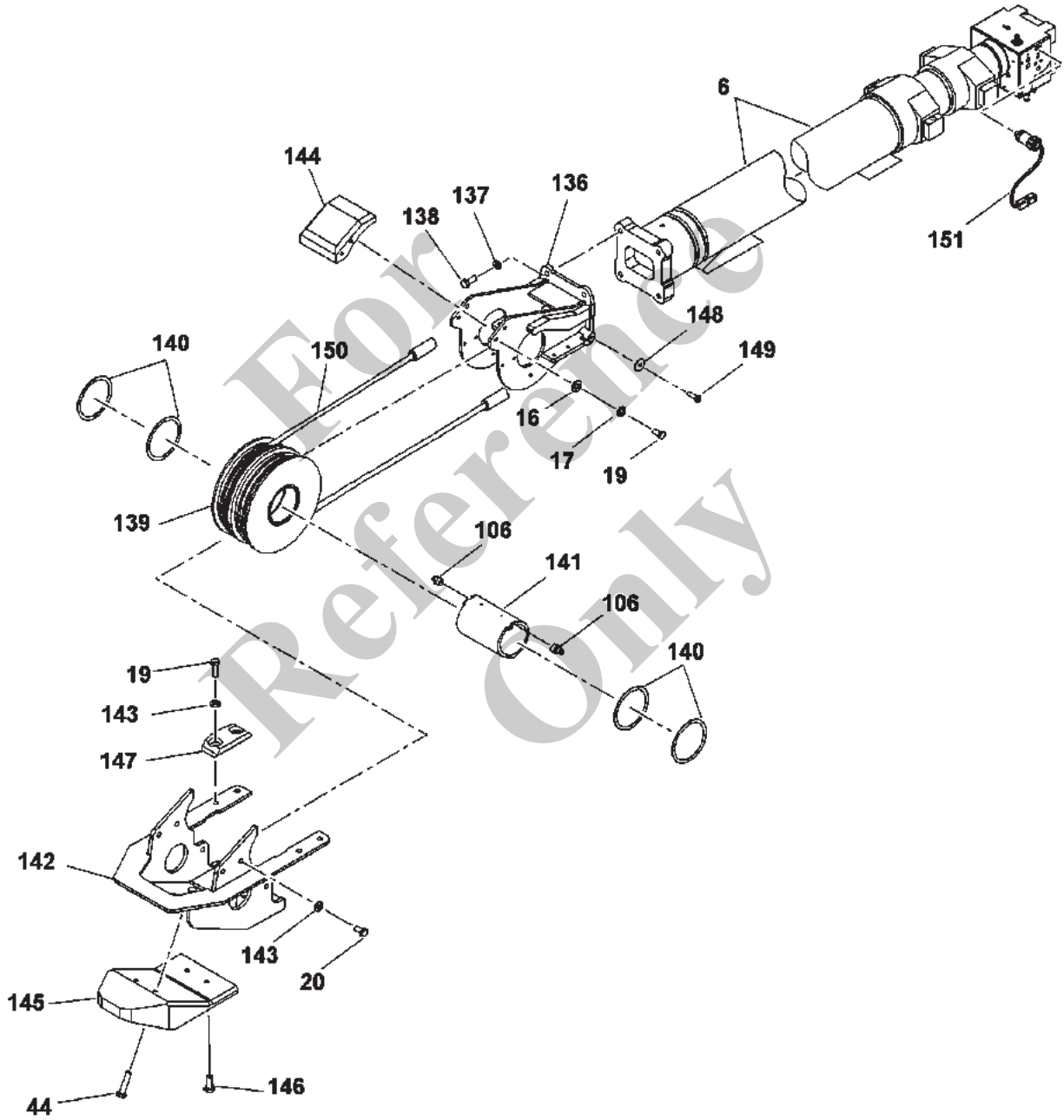
TELE 3

FIGURE 4-2 continued



TELE 4

FIGURE 4-2 continued



TELESCOPE CYLINDER

FIGURE 4-2 continued

Item	Description
1	Base Section Weld
2	Tele-1 Weld
3	Tele 2 Weld
4	Tele 3 Weldment
5	Tele 4 Weld
6	Cylinder, Telescope
7	Shim-Base
8	Front Lower Wear Pad Base
9	Front Lower Wear Pad Base
10	Protection Strip G-Nr.3006000-
11	Upper Wear Pad Assy
12	Plate
13	Keeper Plate
14	Keeper Plate
15	Keeper Plate
16	F Washer 12 -St ISO 7089
17	L Washer 12 -Hrc44-51 Din 7980
18	Hex Nut M12 8 ISO 4032
19	HHCS M12x40 8.8 ISO 4017
20	HHCS M12x25 8.8 ISO 4017
21	HHCS M12x80 8.8 ISO 4014
22	Pat Bracket
23	HHCS M8x25 8.8 ISO 4017
24	F Washer 8 -St ISO 7089
25	L Washer 8 -Hrhc44-51 Din 798
26	Hex Nut M8 8 ISO 4032
27	HHCS M20x60 8.8 ISO 4017
28	Hex Jam Nut M20 04 ISO 4035
29	Wedge S890 QI
30	Bar S890 QI
31	HHCS M24x115 10.9-Flz ISO 4014
32	Plate
33	F Washer 6 -St ISO 7089
34	Slot Pms M6x16 4.8 ISO 1580
35	SHCS 1/4-20uncx0.75 A574
36	SHCS 1/4-20uncx1 A574
37	Manifold, Tele Stage Selection
38	Tube Assy
39	Tube Assy
40	Pipe Clamp
41	Tube Assy
42	Tube Assy
43	SHCS M10x50 -10.9 ISO 10642
44	SHCS M10x35 8.8-A3c ISO 4762
45	SHCS M12x55 8.8-A3c ISO 4762

Item	Description
46	Male 90 Deg Elbow ORFS/BSPP
47	Pipe Clamp - 1/2" I.D.
48	Tube Assy
49	Tube Assy
50	Pipe Clamp
51	Male 90 Deg Elbow ORFS/BSPP
52	Tube Assy
53	Shim-Tele 1
54	Front Lower Wear Pad Tele 1
55	Front Lower Wear Pad Tele 1
56	Stop Block
57	Plate Dc03-A-M
58	HHCS M12x55 8.8 ISO 4017
59	Rear Upper Wear Pad
60	Trunnion Plate
61	F Washer 1-1/8" Hard ASTM F-43
62	HHCS M30x55 10.9 ISO 4017
63	Retract Anchor Weld
64	Anchor Plate
65	Retract Cable Tele 3
66	Hex Nut M16 8 ISO 4032
67	F Washer 1/2" Hard ASTM F-436
68	HHCS M12x30 10.9 ISO 4017
69	HHCS M12x40 10.9 ISO 4017
70	Spacer
71	Wear Pad Assy
72	L Washer 10 -Hrc44-51 Din 7980
73	Anchor Plate
74	F Washer 1-1/2" Nar Ms
75	Hex Nut 1-1/2-6unc Sae-8
76	HHCS 1-1/2-6uncx14 G8
77	Pipe Union Sv-06l/Sw17 M12x1,
78	Thin Nut M12x1.5 5 Din 80705
79	Adapter 304-19509-1 M10x1/M10x
80	Elbow, Push-In 226-14123-3 Wek
81	Lubricant Hose L=280
82	Wear Pad
83	HHCS M10x20 SS ISO 4017
84	Plate Cover
85	HHCS M8x20 8.8 ISO 4017
86	O-Ring 0.75" S.F.
87	O Ring 1"
88	O-Ring
89	Shim-Tele 2
90	Front Lower Wear Pad Tele 2

Item	Description
91	Front Lower Wear Pad Tele 2
92	Upper Wear Pad Assy Tele 2
93	HHCS M20x100 8.8 ISO 4017
94	Rear Upper Wear Pad
95	Hex Nut M30 8 ISO 4032
96	Sheave Assembly
97	Sheave Guard Weld
98	Shaft Weld
99	HHCS M8x16 SS ISO 4017
100	Shim Tele 3
101	Front Lower Wear Pad Tele 3
102	Front Lower Wear Pad Tele 3
103	Upper Wear Pad Assy Tele 3
104	Shaft
105	HHCS M16x40 10.9 ISO 4014
106	Lube Nipple A M10x1 5.8-A3c
107	Sheave Assembly
108	Sheave Assembly
109	Extend Cable Tele 4
110	Extend Cable Tele 4
111	Guard Weld
112	Guard Weld
113	HHCS M12x16 8.8-A3c ISO 4017
114	Anti Roll Plate
115	Thrust Washer 1.75x2.6x0.13" B
116	Sheave Assembly
117	Sheave Mount Weld
118	F Washer 5/8" Hard ASTM F-436
119	HHCS M16x40 8.8 ISO 4017
120	Pin
121	F Washer 20 -St ISO 7089
122	Cotter Pin 0.13x1.5" St
123	Cyl Wear Pad
124	HHCS M8x30 8.8 ISO 4017
125	Cable Keeper
126	Lubricant Hose L=230
127	Rear Upper Wear Pad
128	Wear Pad Assy
129	Plate S690 QI
130	SFHCS M10x30 10.9 ISO 10642
131	Retract Cable Tele 4
132	F Washer 1" Hard
133	Hex Nut M24 8 ISO 4032
134	Wear Pad Assy
135	Lubricant Hose L=195

Item	Description
136	Tele Sheave Mgt Weld
137	F Washer 3/4" Hard ASTM F-436-
138	HHCS M20x50 10.9 ISO 4014
139	Sheave Assy
140	Spacer-154mm I.D.
141	Hollow Tele Shaft
142	Sled Weld
143	F Washer 1/2" Hard ASTM F-436
144	Upper Sled Pad
145	Lower Sled Pad
146	HHCS M10x35 SS ISO 4017
147	Bumper Pad
148	F Washer 0.41x1.75x0.13"
149	SBCS 3/8-16uncx1.25 F835
150	Extend Cable Tele 3
151	Esi - Boom
152	Prox Switch Mount
153	Target Weld
154	HHCS M12x45 8.8 ISO 4014
155	Target Plate
156	L Washer 6 -Hrc44-51 Din 7980
157	HHCS M6x25 8.8 ISO 4017
158	HHCS M10x45 8.8 ISO 4017
159	Keeper Plate
160	SHCS M8x25 12.9 ISO 4762
161	Keeper Plate
162	Shim
163	Tubing Clamp 1" I.D.
164	Tubing Clamp 1/2" I.D.
165	Run Tee ORFS/BSPP/ORFS
166	Elbow-Male ORFS To Male BSPP
167	Tube Assy Tele Drain
168	Spacer-154mm I.D.
169	HHCS M20x25 10.9 ISO 4017
170	Roller Assy
171	Shaft
172	F Washer 5/16" Wide Ms
173	SBCS M8x10 10.9 Flznnc ISO7380
174	Bent Plate
175	HHCS M12x240 -8.8 ISO 4014
300	Wear Pad Kit



## Disassembly

**NOTE:** The boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

### CAUTION

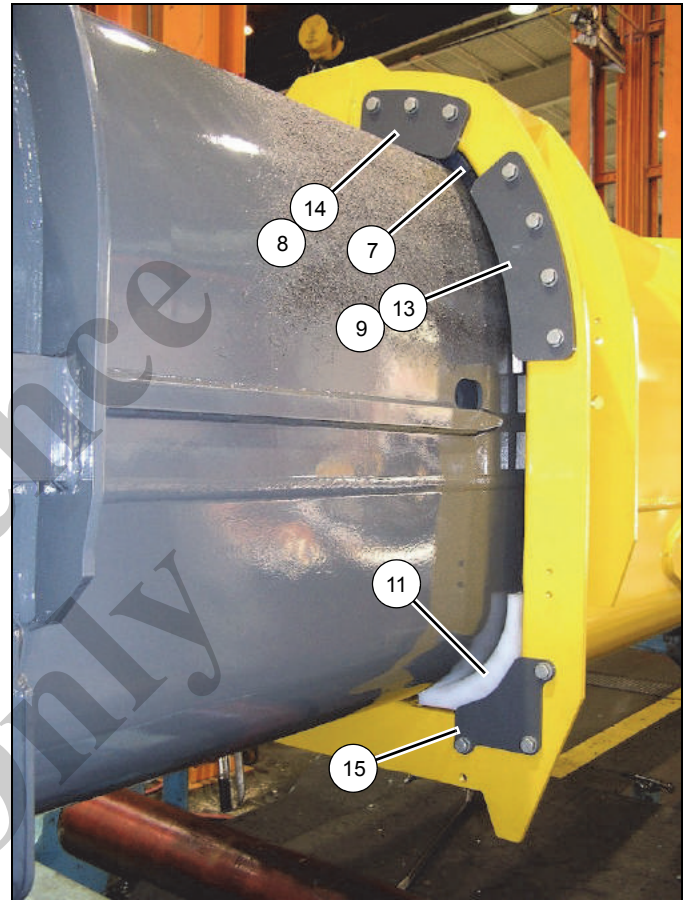
A rollover fixture with webbing is recommended to rotate the boom sections. Chains are not recommended. If a rollover fixture is not available, rotate the sections using adequate support with webbing.

A secure fixture that will prevent damage to the boom is recommended to stabilize and hold the boom from moving during removal of any section or sections.

When removing the extend and retract cables, hold the cable end and turn the nut. Do not turn the cable. Turning the cable will result in damage or failure of the cable.

Use the following procedures and refer to Figure 4-2 when disassembling the boom.

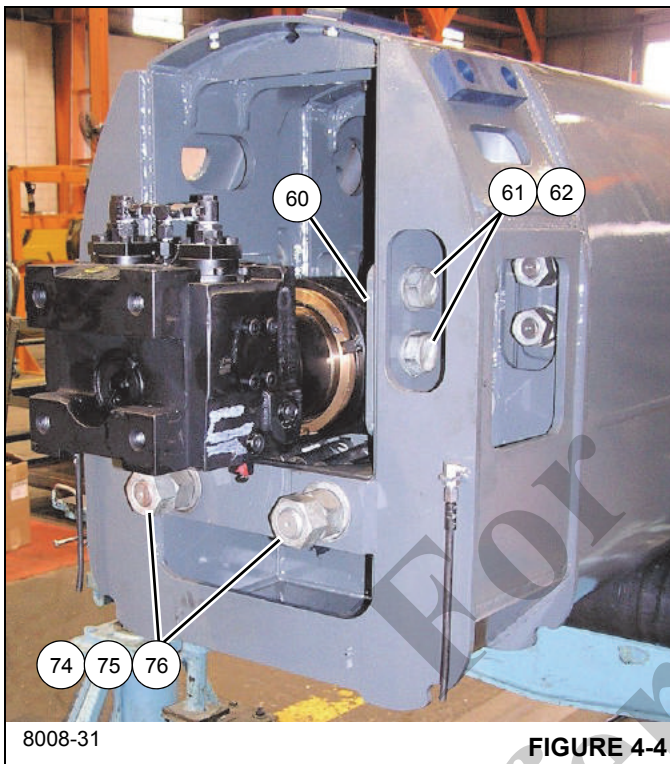
1. Remove the boom in accordance with the REMOVAL procedures outlined in this section.
2. Position the boom assembly upside down on adequate supports.
3. Tag and remove all hydraulic tube assemblies from the tele stage selection manifold (37) and telescope cylinder (6); cap and plug all openings.
4. Remove the four bolts (20) and flat washers (16) securing the tele stage selection manifold (37) to the bottom rear of the base section (1).
5. Remove the transducer (151) from the end of the telescope cylinder (6).
6. Remove the two plates (30) and four bolts (31) securing the telescope cylinder (6) to the base section (1).
7. Working at the front of the base and tele sections 1, 2, 3, 4, loosen the two jam nuts (28) and bolts (27) on all upper wear pads (11, 92, 103) (left and right sides).
8. Extend tele 1 (2) one-quarter of the ways out of the base section (1).
9. Using an adequate lift and sling, slightly raise the front of tele 1 (2) for the purpose of removing the wear pads from the front of the base section (1).
10. Remove the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) securing the keeper plate (15) to the front of the base section (1) (left and right sides) (see Figure 4-3).
11. Remove the two bolts (27) and nuts (28) securing the upper wear pad (11) to the front of the base section (1) (left and right sides) (see Figure 4-3).
12. Remove the two bolts (20) and flat washers (16) securing the plate (12) to the inside of the base section (1) (left and right sides).
13. Slightly lower tele 1 (2).
14. Remove the bolts (19), flat washers (16), lock washers (17), and nuts (18) securing the bottom keeper plates (2x-14, 2x-13) to the front of the base section (1) (see Figure 4-3).
15. Remove the shims (2x-7) and the front lower wear pads (8, 9) from the bottom of the base section (1) (see Figure 4-3).
16. Remove tele 1 (2) from the base section (1); set tele 1 (2) on adequate supports.
17. Remove the wear pad (59)/grease hose assembly (81, 79, 80, 77, 78) from the attaching bracket on each side of the rear of tele 1 (2).
18. Remove the two capscrews (83) securing the wear pad assembly (82) to each side of the bottom rear of tele 1 (2).
19. Remove the two capscrews (83) and lock washers (72) securing the wear pad assembly (71) to each side of the bottom rear of tele 1 (2).



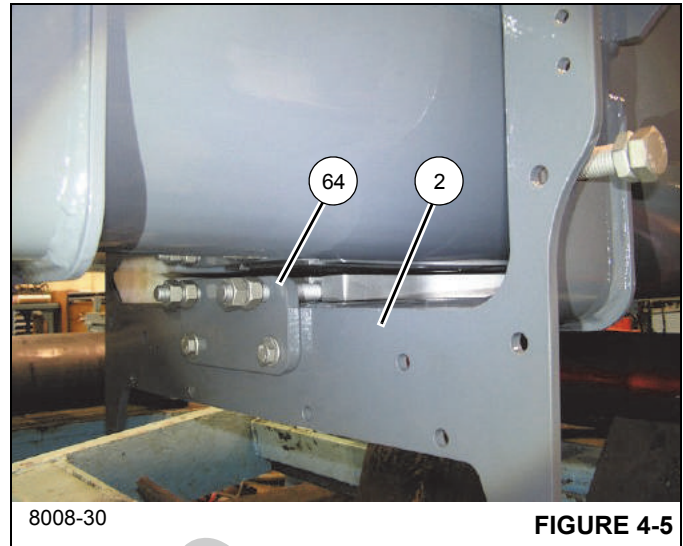
8008-32

FIGURE 4-3

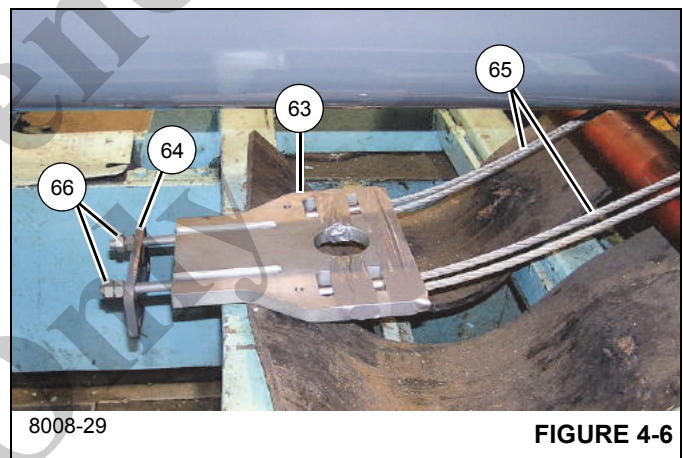
20. Remove the four nuts (75) and two flat washers (74) securing the two bolts (76), which pass through the anchor plate (73), to the rear of tele 1 (2) (see Figure 4-4).



21. Remove the five bolts (62) and flat washers (61) securing the trunnion plate (60) to the inside of tele 1 (2) (left and right sides) (see Figure 4-4).
22. Slightly extend tele 2 (3).
23. Using an adequate lift and sling, slightly raise the front of tele 2 (3) for the purpose of removing the wear pads from the front of tele 1 (2).
24. Remove the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) securing the keeper plate (15) to the front of tele 1 (2) (left and right sides).
25. Remove the two bolts (27) and nuts (28) securing the upper wear pad (11) to the front of tele 1 (2) (left and right sides).
26. Remove the two bolts (69), four flat washers (67), and two nuts (18) securing the anchor plate (64) to the top of tele 1 (2) (see Figure 4-5).



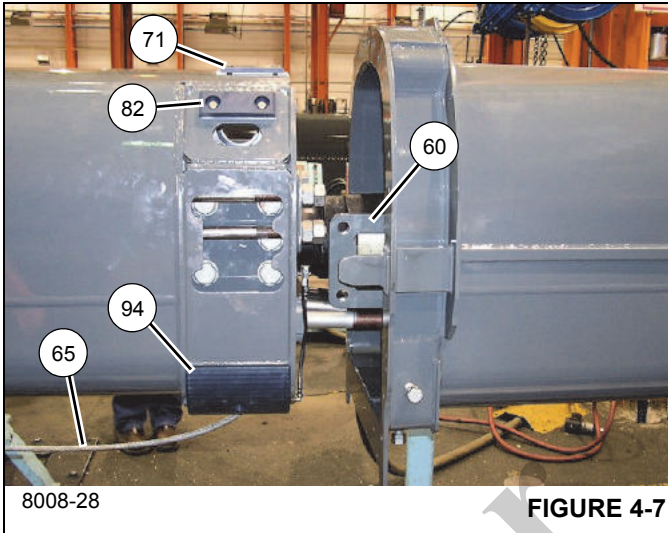
27. Remove the nuts (66) securing the anchor plate (64) to the studs of the retract anchor weldment (63) (see Figure 4-6).



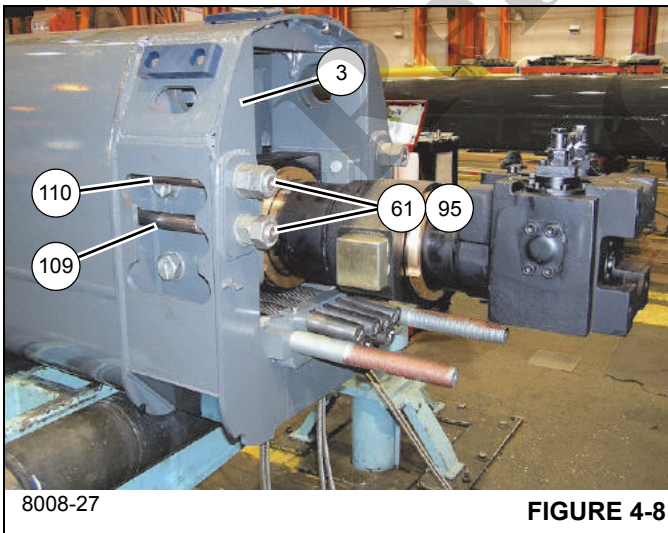
28. Remove the four tele 3 retract cables (65) from the slots of the retract anchor weldment (63) (see Figure 4-54).
29. Slightly lower the front of tele 2 (3).
30. Remove the two bolts (58), four washers (16), two lock washers (17), and two nuts (18) securing the stop block (56) and shim (57) to the front of tele 1 (2) (left and right sides).
31. Remove the bolts (19), flat washers (16), lock washers (17), and nuts (18) securing the left, right, and bottom keeper plates (2x-14, 13) to the front of tele 1 (2).
32. Remove the front lower wear pads (54, 55) and shims (53) from the bottom of tele 1 (2).
33. Remove tele 2 (3) from tele 1 (2); set tele 2 (3) on adequate supports.



- 34. Remove the wear pad (94)/grease hose assembly (81, 79, 80, 77, 78) from the attaching bracket on each side of the rear of tele 2 (3) (see Figure 4-7).

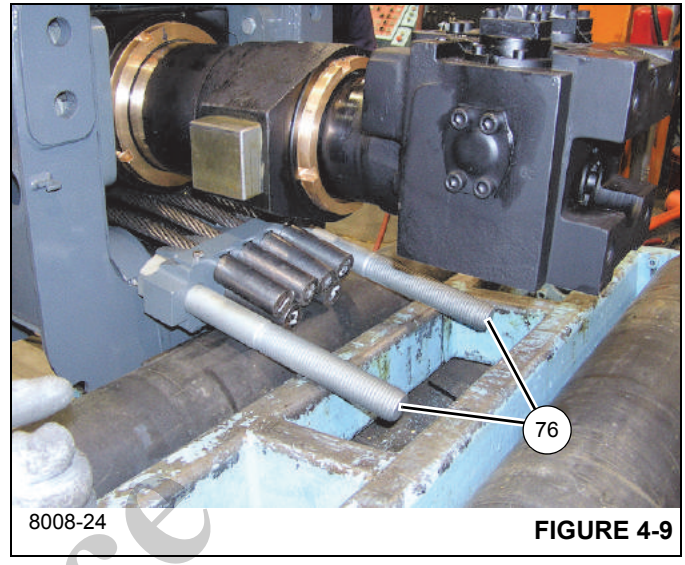


- 35. Remove the two capscrews (83) and lock washers (72) securing the wear pad assembly (71) to each side of the bottom rear of tele 2 (3) (see Figure 4-7).
- 36. Remove the two capscrews (83) securing the wear pad assembly (82) to each side of the bottom rear of tele 2 (3) (see Figure 4-7).
- 37. Remove the two nuts (95) and one flat washer (61) securing each of the four tele 4 extends cables (109, 110) to the top rear of tele 2 (3) (see Figure 4-8).

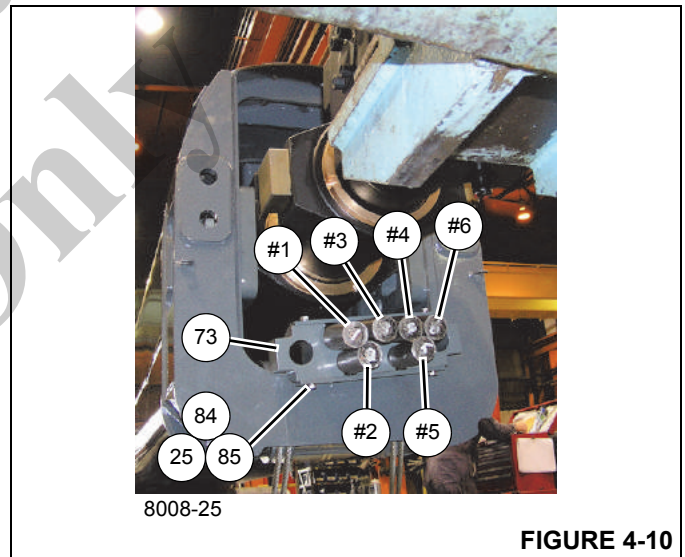


- 38. Remove the two tele 4 extend cables (109, 110) from the holes in the rear of tele 2 (3) (left and right sides) (see Figure 4-8).

- 39. Remove the two bolts (76) from the anchor plate (73) (see Figure 4-9).

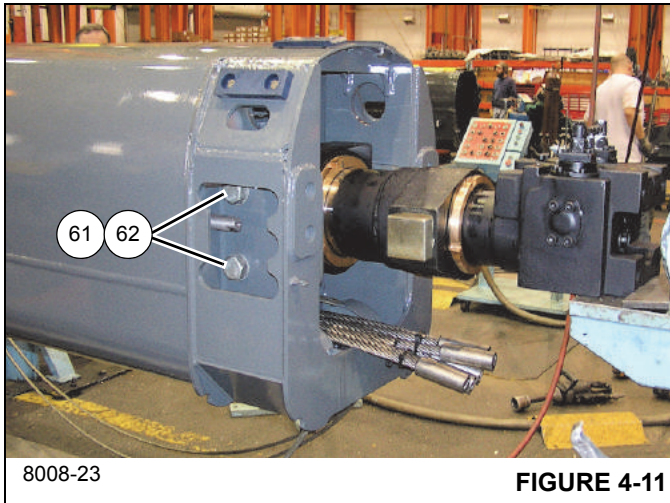


- 40. Remove the two bolts (85) and lock washers (25) securing the plate cover (84) to the anchor plate (73), then remove the four tele 3 extend cables (150), labeled 1, 3, 4, and 6, from the anchor plate (73) (see Figure 4-10).



- 41. Remove the two bolts (85) and lock washers (25) securing the plate cover (84) to the anchor plate (73), then remove the two tele 3 extend cables (150), labeled 2 and 5, from the anchor plate (73) (see Figure 4-10).
- 42. Remove the five bolts (62) and flat washers (61) securing the trunnion plate (60) to the inside of tele 2 (3) (left and right sides) (see Figure 4-11).

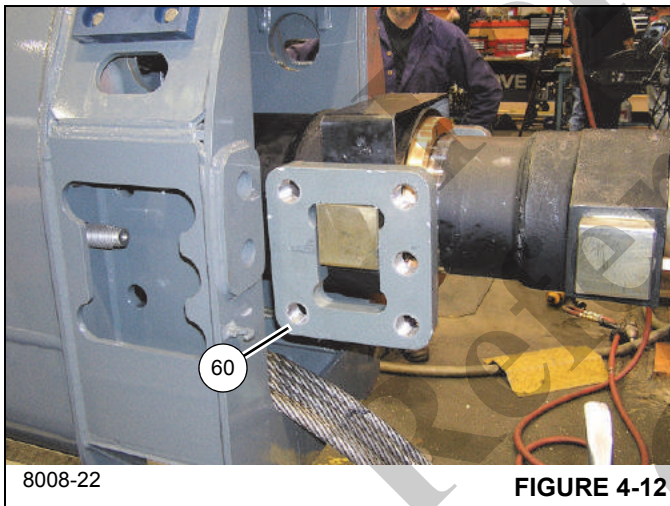




8008-23

FIGURE 4-11

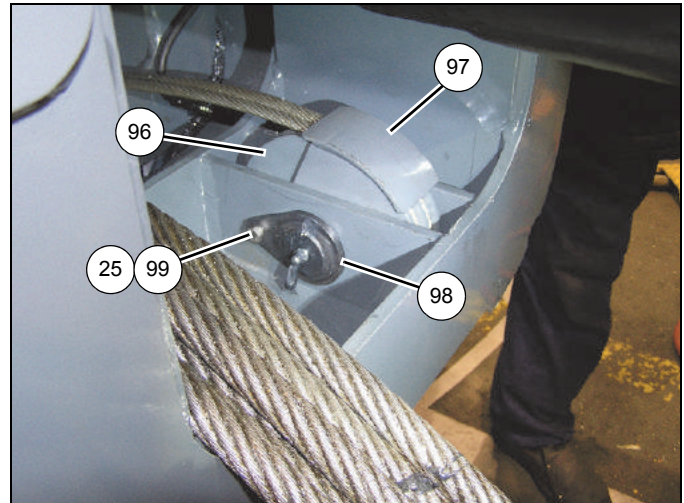
43. Remove the trunnion plate (60) from the front square lug of the telescope cylinder (6) (left and right sides) (see Figure 4-12).



8008-22

FIGURE 4-12

44. Remove the bolt (99), lock washer (25), and shaft weldment (98) securing the sheave guard weldment (97) and sheave assembly (96) to the rear of tele 2 (3) (left and right sides) (see Figure 4-13).

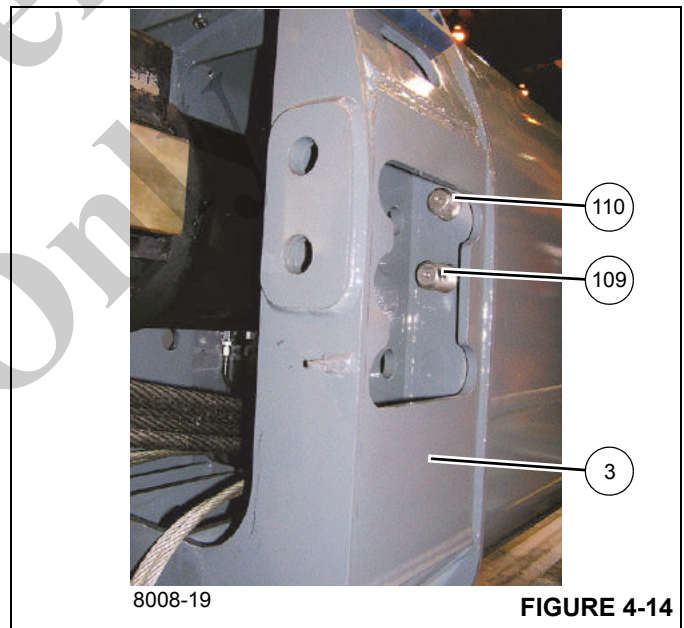


8008-21

FIGURE 4-13

45. Coil the four tele 3 retract cables (65) and set them on top of the telescope cylinder (6).

46. Remove the two tele 4 extend cables (109, 110) from the holes in the rear of tele 2 (3) (left and right sides) (see Figure 4-14).

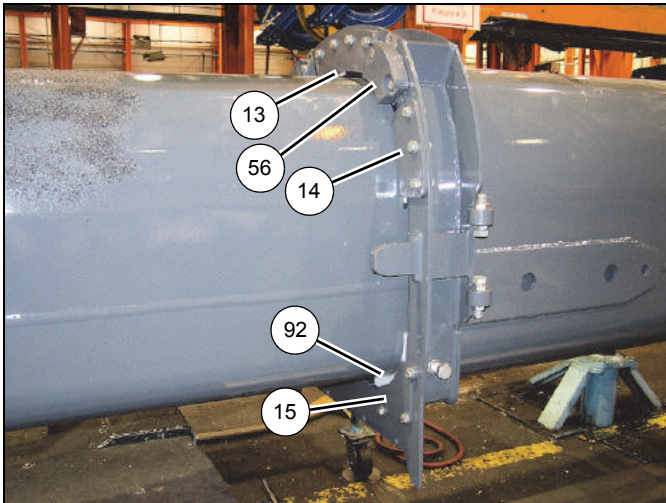


8008-19

FIGURE 4-14

47. Extend tele 3 (4) one-quarter of the way out of tele 2 (3).

48. Remove the two bolts (58), four washers (16), two lock washers (17), and two nuts (18) securing the stop block (56) to the front of tele 2 (3) (left and right sides) (see Figure 4-15).

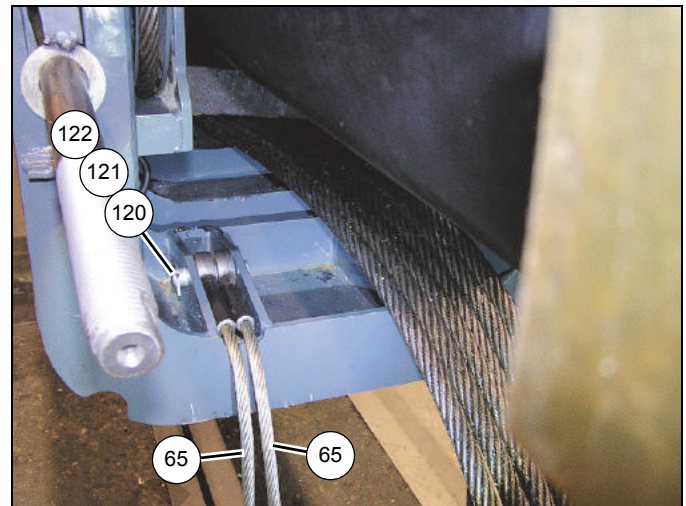


8008-18

FIGURE 4-15

49. Remove the bolts (19), flat washers (16), lock washers (17), and nuts (18) securing the left, right, and bottom keeper plates (2x-14, 13) to the front of tele 2 (3) (see Figure 4-15).
50. Remove front lower wear pads (90, 91) and shims (89) from the bottom of tele 2 (3).
51. Using an adequate lift and sling, slightly raise the front of tele 3 (4) for the purpose of removing wear pads from the front of tele 2 (3).
52. Remove the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) securing the keeper plate (15) to the front of tele 2 (3) (left and right sides) (see Figure 4-15).
53. Remove the two bolts (27) and nuts (28) securing the upper wear pad (92) to the front of tele 2 (3) (left and right sides) (see Figure 4-15).
54. Remove tele 3 (4) from tele 2 (3); set tele 3 (4) on adequate supports.
55. Remove the wear pad (94)/grease hose assembly (126, 79, 80, 77, 78) from the attaching bracket on each side of the rear of tele 3 (4).
56. Remove the two capscrews (83) and lock washers (72) securing the wear pad assembly (71) to each side of the bottom rear of tele 3 (4).
57. Remove the two capscrews (83) securing the wear pad assembly (82) to each side of the bottom rear of tele 3 (4).
58. Remove the two cotter pins (122), two flat washers (121), and pin (120) securing the two tele 3 retract

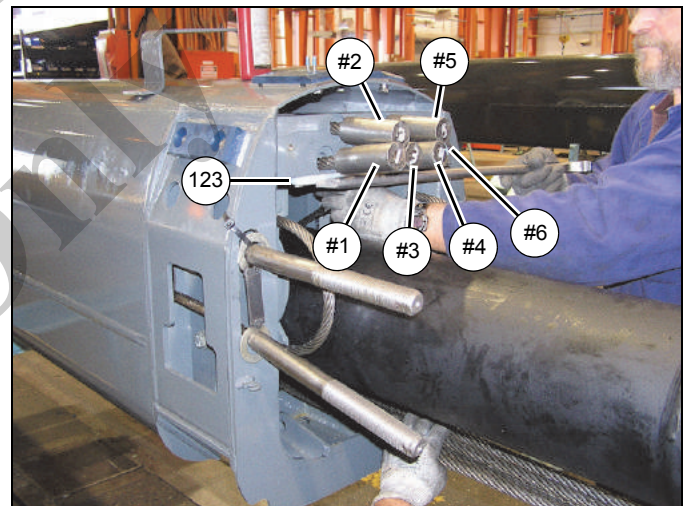
cables (65) to the rear of tele 3 (4) (left and right sides) (see Figure 4-16).



8008-15

FIGURE 4-16

59. Remove the two bolts (124) and lock washers (25) securing the cable keeper (125) to the rear of tele 3 (4).
60. Remove the two bolts (124) and lock washers (25) securing the cylinder wear pad (123) to the top of the anchor point at the rear of tele 3 (4) (see Figure 4-17).

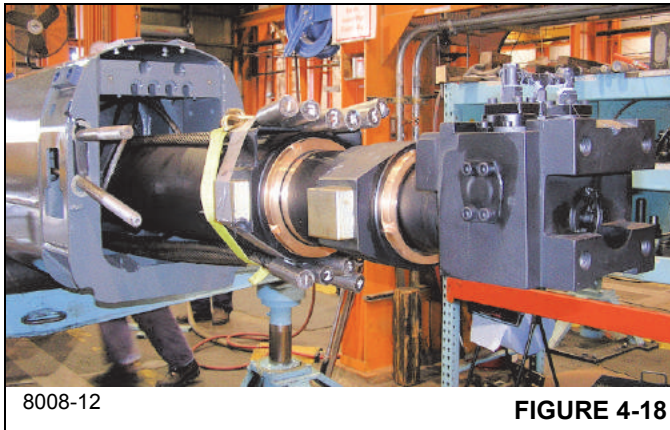


8008-14

FIGURE 4-17

61. Remove the six tele 3 extend cables (150), labeled 1 through 6, from the anchor points at the rear of tele 3 (4) (see Figure 4-17).
62. Duct tape the six tele 3 extend cables (150) to the top of the cylinder (see Figure 4-18).

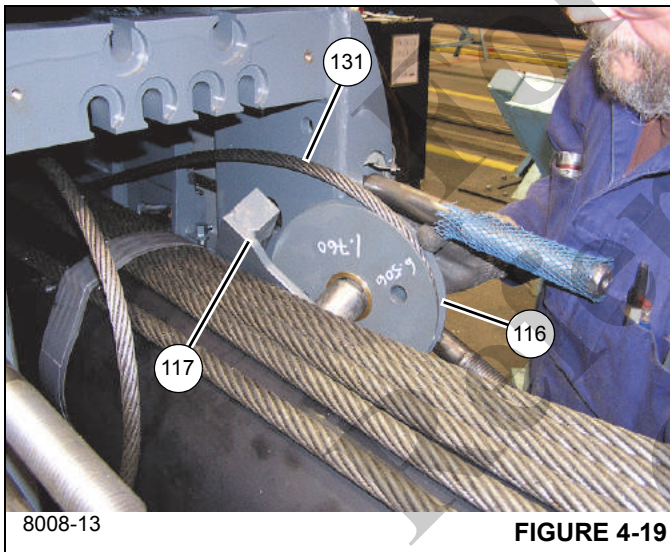




8008-12

FIGURE 4-18

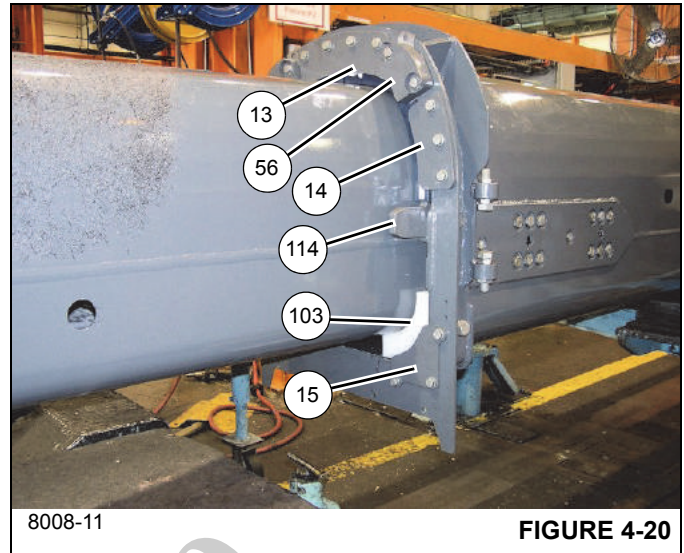
63. Remove the four bolts (119) and flat washers (118) securing the sheave mount weldment (117) to the inside of tele 3 (4), then remove the sheave mount weldment/sheave assembly (116/117) along with the three thrust washers (115) (left and right sides) (see Figure 4-19).



8008-13

FIGURE 4-19

64. Extend tele 4 (5) one-quarter of the way out of tele 3 (4).
65. Remove the two bolts (58), four washers (16), two lock washers (17), and two nuts (18) securing the stop block (56) to the front of tele 3 (4) (left and right sides) (see Figure 4-20).



8008-11

FIGURE 4-20

66. Remove the bolts (19), flat washers (16), lock washers (17), and nuts (18) securing the left, right, and bottom keeper plates (2x-14, 13) to the front of tele 3 (4) (see Figure 4-20).
67. Remove the front lower wear pads (101, 102) and shims (100) from the bottom of tele 3 (4).
68. Using an adequate lift and sling, slightly raise the front of tele 4 (5) for the purpose of removing the wear pads from the front of tele 3 (4).
69. Remove the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) securing the keeper plate (15) to the front of tele 3 (4) (left and right sides) (see Figure 4-20).
70. Remove the two bolts (27) and nuts (28) securing the upper wear pad (103) to the front of tele 3 (4) (left and right sides) (see Figure 4-20).
71. Remove the two bolts (105) securing the anti-roll plate (114) to the inside of tele 3 (4) (left and right sides) (see Figure 4-20).
72. Remove the tele 4 extend cables (109, 110) from the slotted holes in the rear of tele 3 (4) (see Figure 4-21).



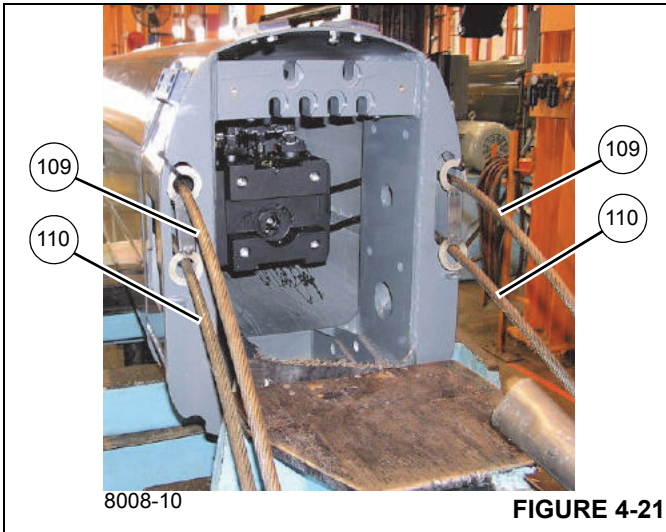


FIGURE 4-21

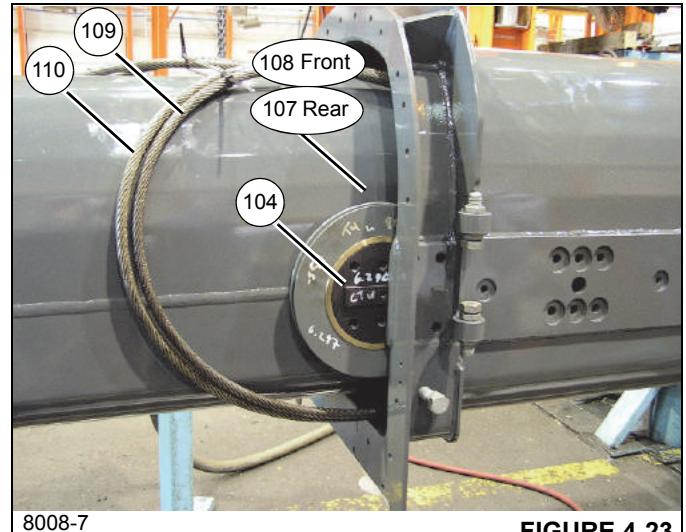


FIGURE 4-23

- 73. Extend tele 4 (5) one-quarter of the way out of tele 3 (4).
- 74. Remove the grease fitting (106) from each of the four shafts (104).
- 75. Remove the capscrew (113) securing the front guard weldment (112) over the tele 4 extend cable (110) (left and right sides) (see Figure 4-22).

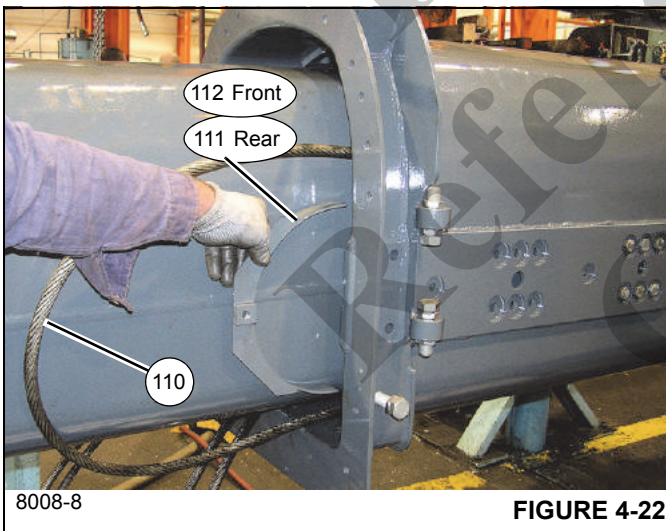


FIGURE 4-22

- 78. Remove capscrew (113) securing the rear guard weldment (111) over the tele 4 extend cable (109) (left and right sides) (see Figure 4-22).
- 79. Pull the tele 4 forward extend cables (109) away from the rear sheaves (107) (see Figure 4-23).
- 80. Remove the six capscrews (105) and shaft (104) securing the rear sheave (107) to the inside of tele 3 (4) (left and right sides) (see Figure 4-23).
- 81. Remove tele 4 (5) from tele 3 (4); set tele 4 (5) on adequate supports.
- 82. Remove the capscrew (130) and cable anchor (129) securing the tele 4 extend cables (109, 110) to the side of the rear of tele 4 (5) (left and right sides) (see Figure 4-24).

- 76. Pull the tele 4 forward extend cables (110) away from the front sheaves (108).
- 77. Remove the six capscrews (105) and shaft (104) securing the front sheave (108) to the inside of tele 3 (4) (left and right sides) (see Figure 4-23).

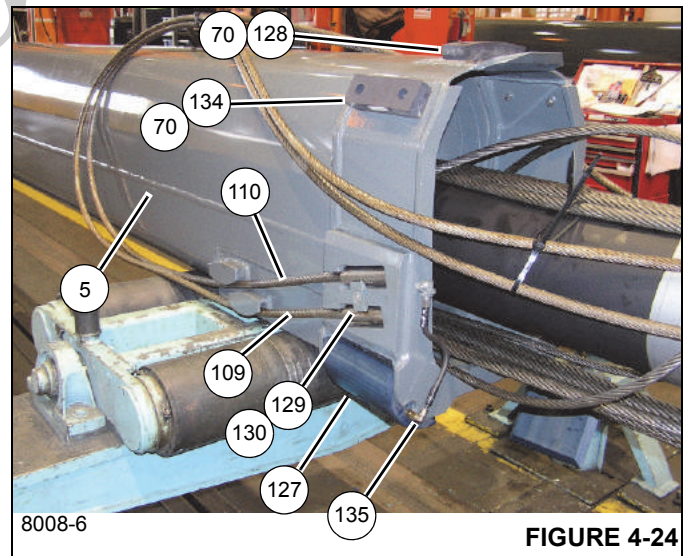
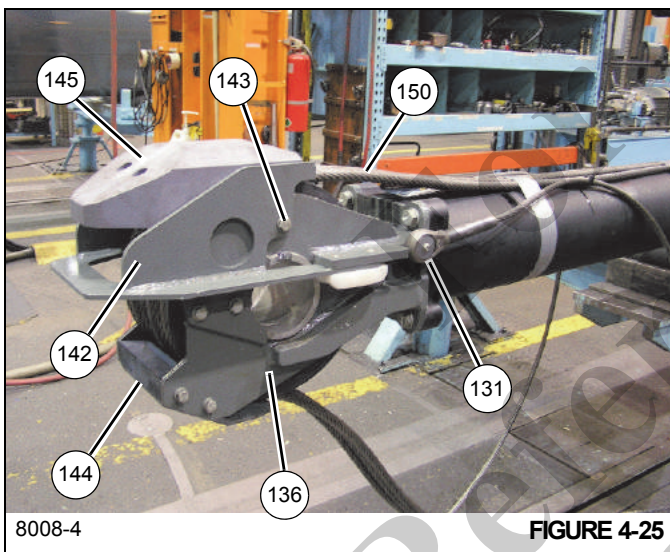
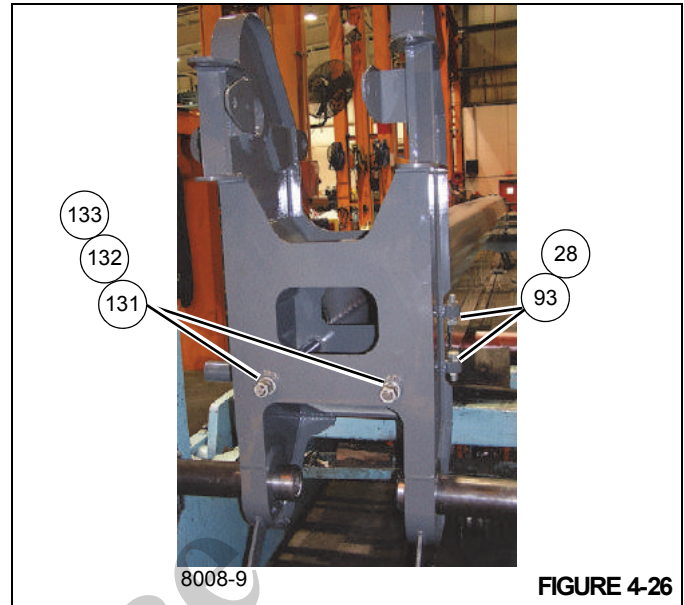


FIGURE 4-24

83. Remove the wear pad (127)/grease hose assembly (135, 79, 80, 77, 78) from the attaching bracket on each side of the rear of tele 4 (5) (see Figure 4-24).
84. Remove the two capscrews (124) and lock washers (25) securing the wear pad assembly (134) to each side of the bottom rear of tele 4 (5) (see Figure 4-24).
85. Remove the two capscrews (124) securing the wear pad assembly (128) to the bottom rear of tele 4 (5) (see Figure 4-24).
86. Slide the telescope cylinder (6) out of tele 4 (5).
87. Remove the capscrews (149) and flat washers (148) securing the ends of the two tele 4 retract cables (131) to the telescope cylinder sheave mounting weldment (136) (see Figure 4-25).



88. Remove the four nuts (133) and two washers (132) securing the two tele 4 retract cables (131) to the boom nose; remove the cables from tele 4 (5) (see Figure 4-26).



89. Remove the two grease fittings (106) from each end of the hollow shaft (141).
90. Remove the four capscrews (19), lock washers (17), and flat washers (16) securing the upper sled pad (144) to the telescope cylinder sheave mounting weldment (136) (see Figure 4-25).
91. Remove the capscrews (44, 146) securing the lower sled pad (145) to the sled weldment (142) (see Figure 4-25).
92. Remove the four capscrews (19) and flat washers (143) securing the bumper pads (147) to the sides of the sled weldment (142) (see Figure 4-25).
93. Remove the six capscrews (20) and flat washers (143) securing the sled weldment (142) to the telescope cylinder sheave mounting weldment (136) (see Figure 4-25).
94. Remove the six tele 3 extend cables (150) from around the sheave assembly (139).
95. Remove the four spacers (140) and the hollow shaft (141) securing the sheave assembly (139) to the telescope cylinder sheave mounting weldment (136).
96. Remove the four capscrews (138) and hardened flat washers (137) securing the telescope cylinder sheave mounting weldment (136) to the end of the telescope cylinder (6).



## 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. Remove the capscrew, washer, and nut securing the upper boom nose sheave shaft. Remove the collar.

**NOTE:** The boom nose sheave shafts weigh approximately 42.9 kg (95 lb) each. The boom nose sheaves weigh approximately 5.5 kg (12.5 lb) apiece.

3. Carefully pull the upper boom nose sheave shaft from the boom nose, removing the spacers, shims, and boom nose sheaves. Note location of each.
4. Repeat steps 2 and 3 and remove the lower boom nose sheave shaft.
5. Remove the shim, keyed washer, 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. Component damage could occur.

**NOTE:** The boom nose sheave shafts weigh approximately 42.9 kg (95 lb) each. The boom nose sheaves weigh approximately 5.5 kg (12.5 lb) apiece.

1. Install the spacers and sheaves onto the sheave shaft while installing the sheave shafts into the boom nose. Ensure that top spacer and sheaves are in proper orientation to lower sheaves and grease fittings point outward.

**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 end play in the entire assembly is within 1 mm to 2 mm (0.04 in to 0.08 in) 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 clip pins.

### Assembly

**NOTE:** The boom assembly must be rotated 180° (upside down) before performing any assembly or disassembly procedures.

#### CAUTION

A rollover fixture with webbing is recommended to rotate the boom sections. Chains are not recommended. If a rollover fixture is not available, rotate the 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 any section or sections.

When adjusting the extend and retract cables, hold the cable end and turn the nut. Do not turn the cable. Turning the cable while adjusting will result in damage or failure of the cable.

Install the cables in their natural untwisted condition. Do not twist the cable. Twisting the cable will result in damage or failure of the cable.

**NOTE:** Apply Loctite 243 to the threads of all attaching hardware except cable ends and cable lock nuts.

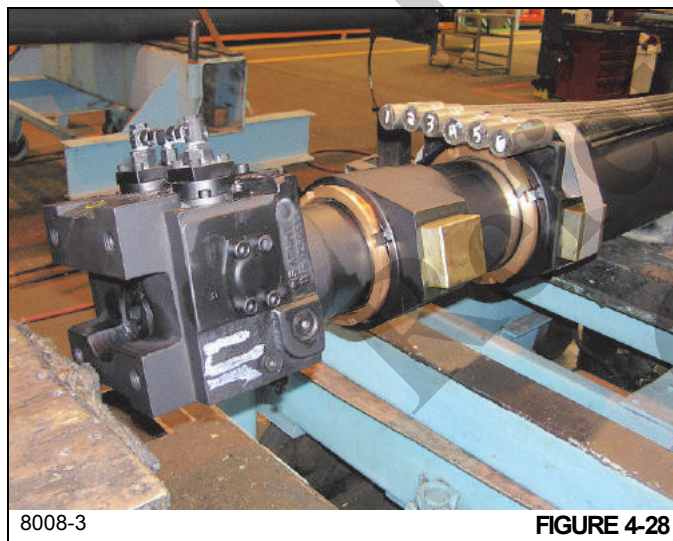
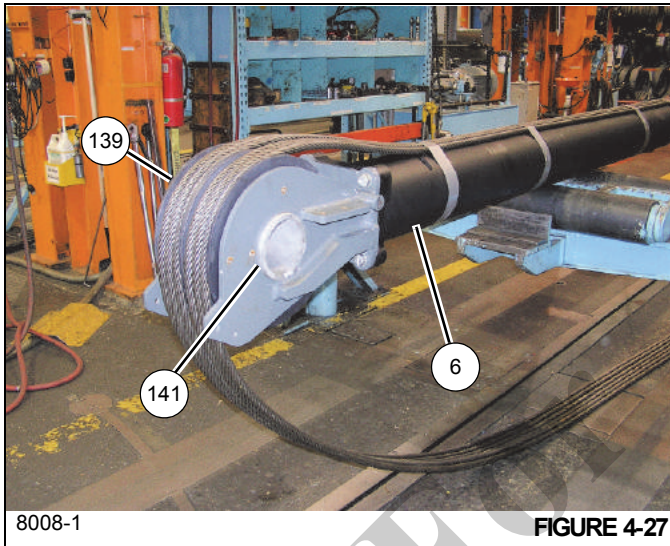
**NOTE:** Apply multipurpose grease (MPG) to all wear surfaces.

**NOTE:** Use standard Grade 5 and/or 8 torque values specified in Section 1 of this manual unless otherwise specified.

Use the following procedures and refer to Figure 4-2 when assembling the boom.

1. Position the telescope cylinder (6) up side down on adequate supports.
2. Attach the telescope cylinder sheave mounting weldment (136) to the end of the telescope cylinder (6) using four capscrews (138) and hardened flat washers (137).
3. Attach the sheave assembly (139) to the telescope cylinder sheave mounting weldment (136) using the hollow shaft (141) and four spacers (140); ensure the machined notches on the ends of the hollow shaft face towards the boom tip (see Figure 4-27).
4. Evenly lay out the six tele 3 extend cables (150) beneath the cylinder; label the cables on both ends with sequence numbers (1-2-3-4-5-6) to prevent them from being crossed during future installation.

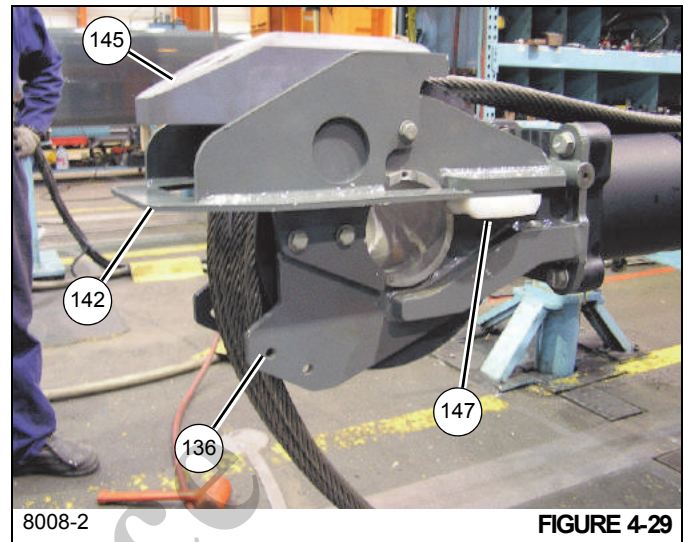
- Wrap the six tele 3 extend cables (150) around the sheave assembly (139) and bring all cable ends back to the base of the cylinder; ensure the cable ends with threads are hanging underneath the telescope cylinder. Duct tape the tele 3 extend cables to the top of the cylinder (see Figure 4-27 and Figure 4-28).



- Install the sled weldment (142) (see Figure 4-29) onto the telescope cylinder sheave mounting weldment (136) using the six capscrews (20) and flat washers (143).

**NOTE:** For ease of assembly, mount the sled (142) to the telescope cylinder sheave mounting weldment

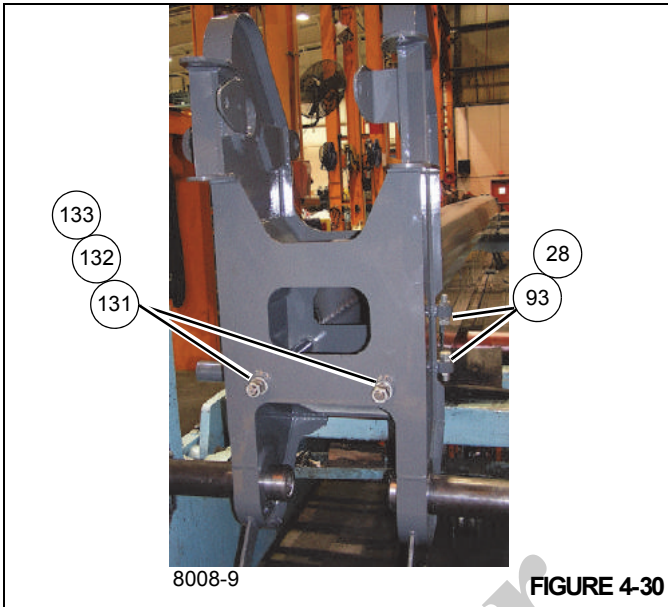
(136) by first installing only the two upper capscrew (20). Rotate the notched shaft (141) aligning it with the sled while installing the remaining capscrews.



- Mount the bumper pads (147) to the sides of the sled weldment (142) with the four capscrews (19) and flat washers (143); ensure the taper side of each pad faces outward (see Figure 4-29).
- Mount the lower sled pad (145) to the sled weldment (142) using the capscrews (44, 146) (see Figure 4-29).
- Mount the upper sled pad (144) to the telescope cylinder sheave mounting weldment (136) using the four capscrews (19), lock washers (17), and flat washers (16).
- Install the two grease fittings (106) into each end of the hollow shaft (141); add grease until the grease extrudes through the sheaves.
- Position tele 4 (5) up side down and in front of the telescope cylinder (6); set tele 4 (5) on adequate supports.
- Install the two tele 4 retract cables (131) through the inside of tele 4 (5) and attach to the boom nose with the four nuts (133) and two washers (132) (see Figure 4-30).

Using tie wraps or belt straps, temporarily secure the cables (131) to the cylinder.

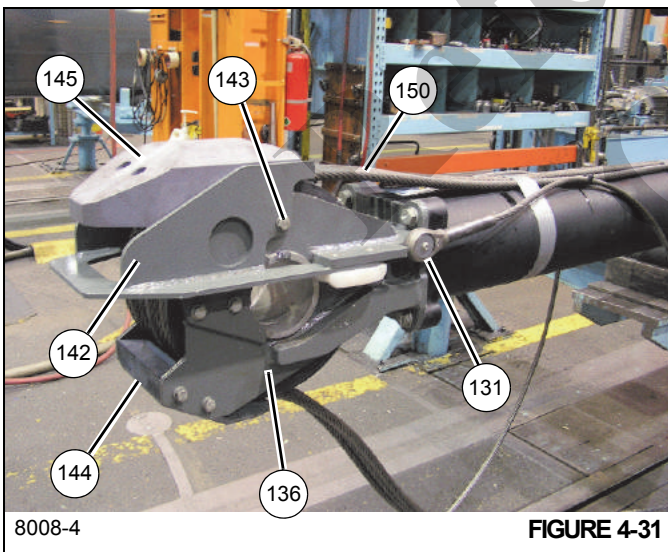




13. Install the four leveling bolts (93) and eight nuts (28) to the boom nose.

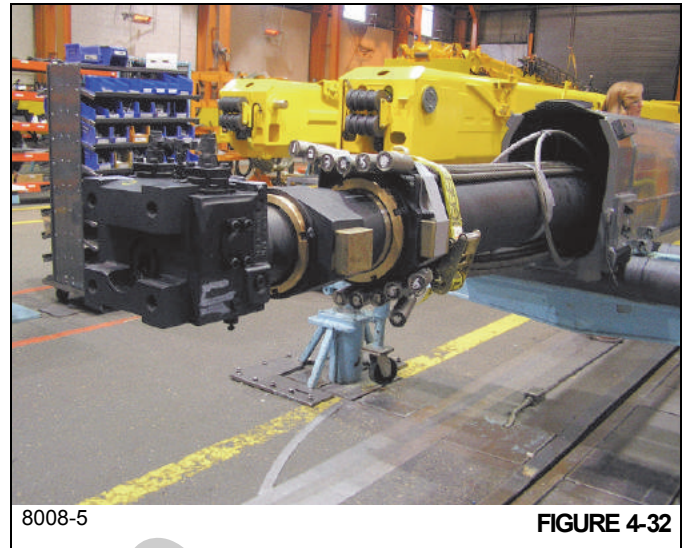
14. Attach the opposite end of the two tele 4 retract cables (131) to the telescope cylinder sheave mounting weldment (136) using the capscrews (149) and flat washers (148) (see Figure 4-31).

Using tie wraps or suitable straps, temporarily secure the cables (131) to the cylinder.

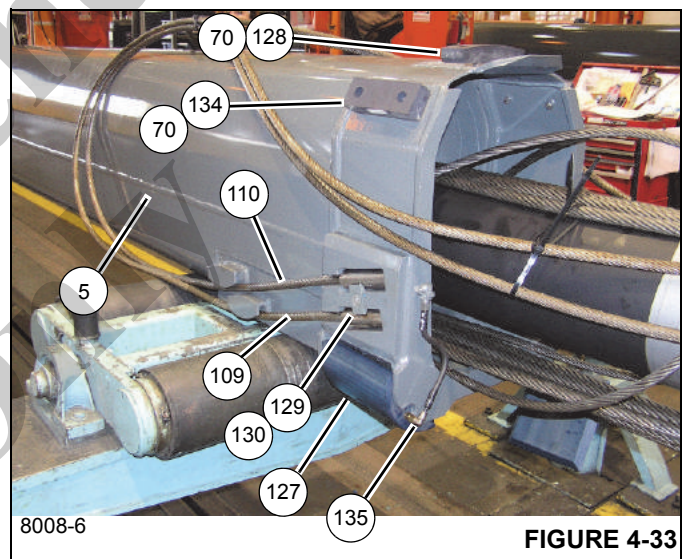


15. Slide the telescope cylinder (6) into tele 4 (5) being careful not to pinch or cross any cables.

**NOTE:** Temporarily insert a block of wood to support the cylinder so that the cables do not get damaged.



16. Mount the wear pad assembly (134) to each side of the bottom rear of tele 4 (5) using the two capscrews (124) and lock washers (25) (see Figure 4-33).



17. Mount the wear pad assembly (128) to the bottom rear of tele 4 (5) using the two capscrews (124).

18. Install the two sets of tele 4 extend cables (109, 110) to each side of the rear of tele 4 (5); secure each set of cables to tele 4 (5) using the cable anchor (129) and capscrew (130) (see Figure 4-33).

19. Using tie wraps or belt straps, temporarily secure the cables (109, 110) together, then secure the set of cables to the side of the telescope cylinder (6) (left and right sides).

20. Position tele 3 (4) up side down and behind tele 4 (5); set tele 3 (4) on adequate supports.

21. Using a grease gun or brush, apply grease to the inside of tele 3 (4) in the areas where the tele 4 rear wear pads will touch upon assembly.
22. Align tele 3 (4) and tele 4 (5) with each other.
23. Attach the grease hose (135) and related parts (79, 80, 77, 78) to each rear top wear pad (127), then install the wear pad/grease hose assembly into the attaching bracket on each side of tele 4 (5) (see Figure 4-33).

**NOTE:** Do not allow the wear pad (127) to hang from the grease hose, as the threads of the wear pad can be damaged. If wear pad threads are damaged, replace the wear pad; do not try to repair with thread tape.

24. Apply multipurpose grease to all wear pads and contact surfaces.
25. Partially insert tele 4 (5) into tele 3 (4).
26. Use the shims (70) to adjust the tele 4 rear wear pad assemblies (128, 134) such that the wear pads are within 2 mm (0.08 in) of the sides and the bottom of tele 3. An equal number of shims should be used on each side.
27. Insert tele 4 (5) into tele 3 (4) until the loops in the tele 4 extend cables (109, 110) are close to the tip of tele 3 (4) (see Figure 4-34).

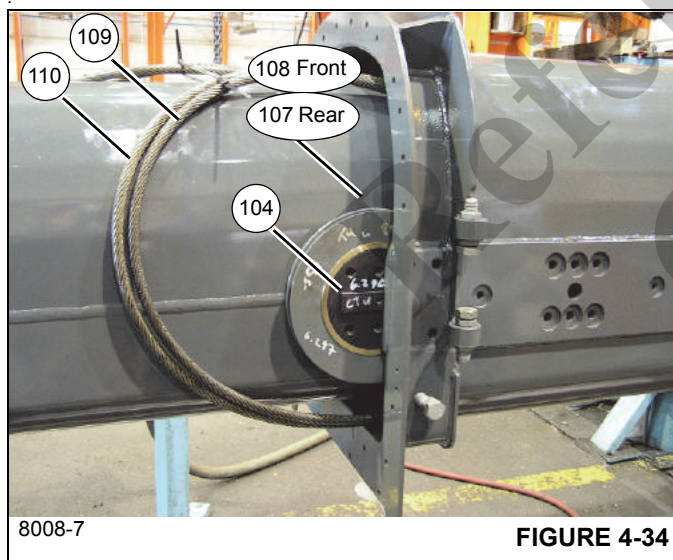


FIGURE 4-34

28. Using the shaft (104) and six capscrews (105), mount the rear sheave (107) to the inside of tele 3 (4) (left and

right sides) using the rear set of mounting holes (see Figure 4-34); ensure the rectangular tab on the shaft (104) slides into the groove in tele 3 (4).

29. Working at the rear of tele 3 (4), pull the tele 4 extend cables (109) until they seat into the sheaves (107).
30. Install the rear guard weldment (111) (left and right sides) over the tele 4 extend cable (109), where the cable wraps around the sheave (107), and secure with the capscrew (113) (see Figure 4-35).

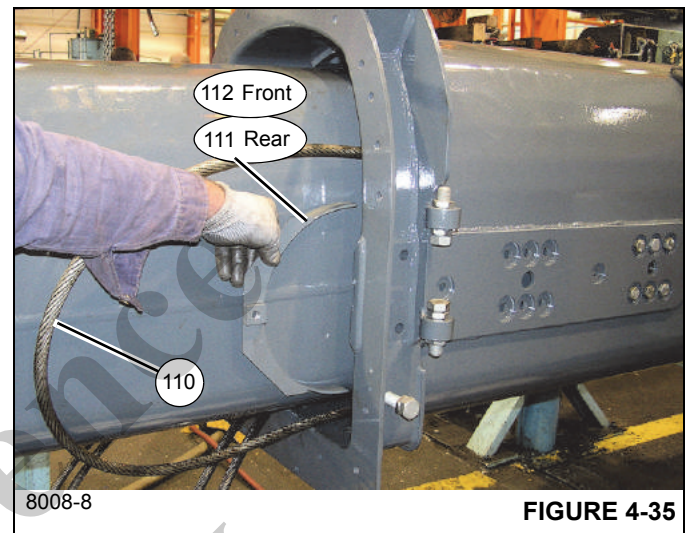


FIGURE 4-35

31. Using the shaft (104) and six capscrews (105), mount the front sheave (108) to the inside of tele 3 (4) (left and right sides) (see Figure 4-34); ensure the rectangular tab on the shaft (104) slides into the groove in tele 3 (4).
32. Working at the rear of tele 3 (4), pull the tele 4 forward extend cables (110) until they seat into the front sheaves (108).
33. Install the front guard weldment (112) (left and right sides) over the tele 4 extend cable (110), where the cable wraps around the sheave (108), and secure with the capscrew (113).
34. Install the grease fitting (106) into each of the four shafts (104). Add grease until the grease extrudes through the sheaves.
35. Route the tele 4 extend cables (109, 110) through the slotted holes in the rear of tele 3 (4), ensuring the 109 cables and 110 cables are oriented as shown in Figure 4-36.



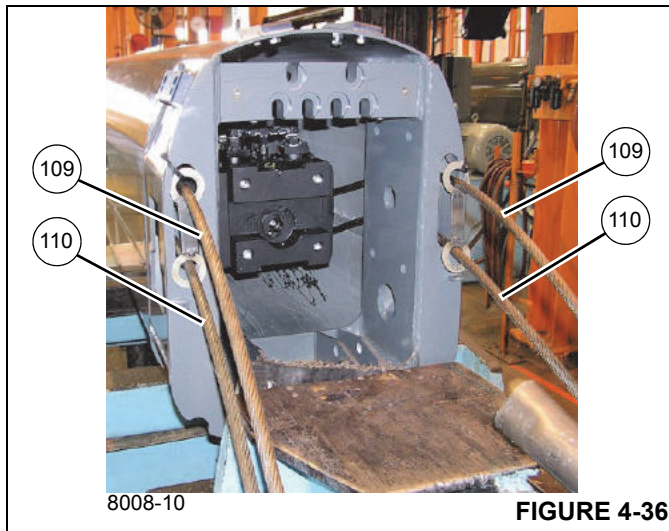


FIGURE 4-36

36. Insert tele 4 (5) three-quarters of the way into tele 3 (4).
37. Install the anti-roll plate (114) to the inside of tele 3 (4) using the two bolts (105) (left and right sides) (see Figure 4-37).

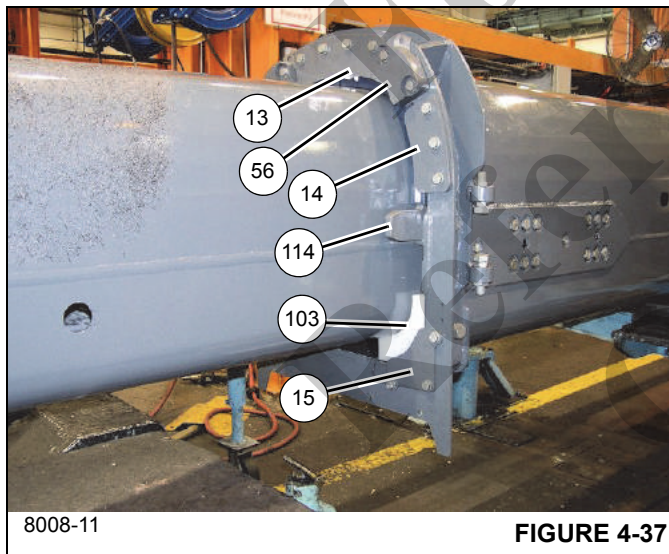


FIGURE 4-37

38. Using an adequate lift and sling, slightly raise the front of tele 4 (5) for the purpose of installing wear pads into the front of tele 3 (4).
39. Install the upper wear pad (103) into the front of tele 3 (4) using the two bolts (27) and nuts (28) (left and right sides); ensure the thin portion of the upper wear pad (103) is oriented to the side of tele 3 (4) (see Figure 4-37).

40. Install the keeper plate (15) to the front of tele 3 (4) using the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) (left and right sides) (see Figure 4-37).
41. Lower tele 4 (5) down onto the newly installed wear pads (103).
42. Install the shims (100) and the front lower wear pads (101, 102) into the bottom of tele 3 (4).
43. Install the left, right, and bottom keeper plates (2x-14, 13) to the front of tele 3 (4) using the bolts (19), flat washers (16), lock washers (17), and nuts (18) (see Figure 4-37).
44. Install the stop block (56) to the front of tele 3 (4) using the two bolts (58), four washers (16), two lock washers (17), and two nuts (18) (left and right sides) (see Figure 4-37).
45. Fully insert tele 4 (5) into tele 3 (4), ensuring the telescope cylinder (6) passes through the rear of tele 3 without damaging tele 3 and telescope cylinder (see Figure 4-38).

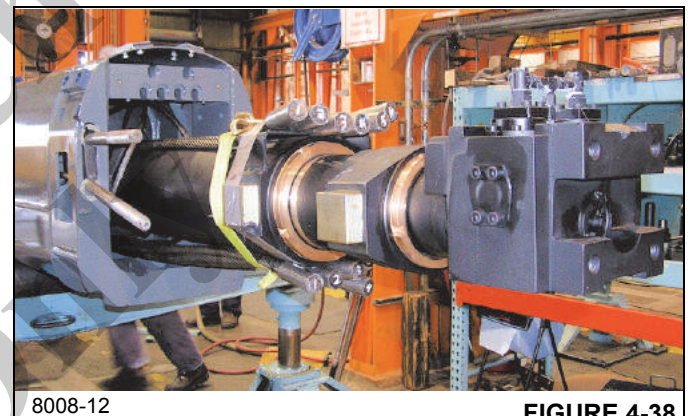
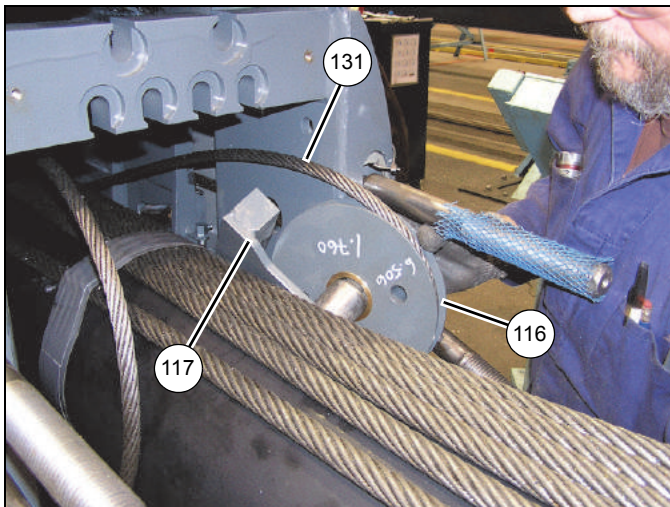


FIGURE 4-38

46. Install the sheave assembly (116) and three thrust washers (115) onto the shaft of the sheave mount weldment (117), ensuring one thrust washer is installed between the sheave mount weldment and the sheave assembly (perform this step two times).
47. Install the sheave mount weldment/sheave assembly (116/117) into the rear of tele 3 (4), ensuring the tele 4 retract cable (131) wraps around the sheave assembly (116); mount the sheave mount weldment (117) to the inside of tele 3 (4) using the four bolts (119) and flat washers (118) (left and right sides) (see Figure 4-39).

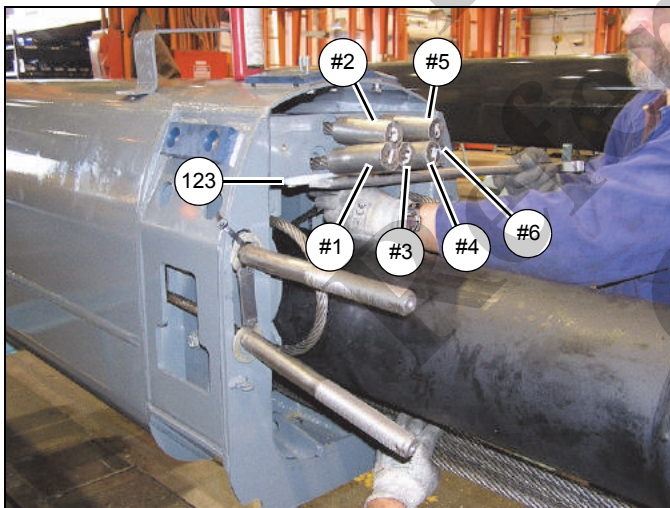




8008-13

FIGURE 4-39

48. Install the grease fitting (106) into the shaft of the sheave mount weldment (117) (left and right sides). Add grease until the grease extrudes through the sheaves.
49. Install the two tele 3 extend cables (150), labeled 2 and 5, into the anchor points at the rear of tele 3 (4) (see Figure 4-40).

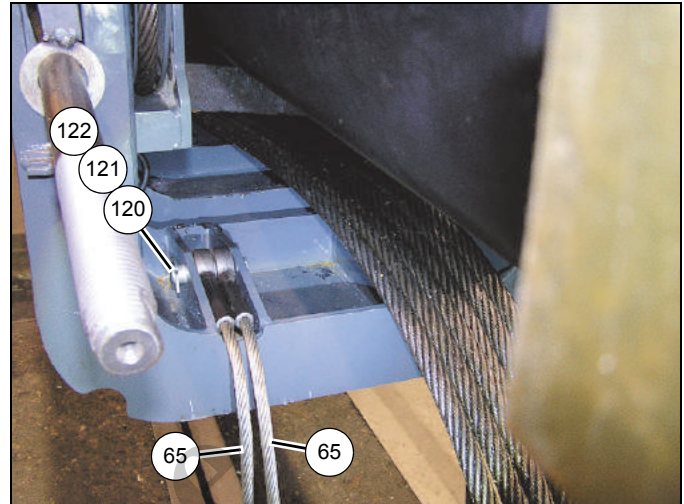


8008-14

FIGURE 4-40

50. Install the four tele 3 extend cables (150), labeled 1, 3, 4, and 6, into the anchor points at the rear of tele 3 (4) (see Figure 4-40).
51. Mount the cylinder wear pad (123) to the top of the anchor point at the rear of tele 3 (4) using the two bolts (124) and lock washers (25) (see Figure 4-40).
52. Pull the six tele 3 extend cables (150) until they seat into the anchor points at the rear of tele 3 (4).
53. Attach the cable keeper (125) to the rear of tele 3 (4) using the two bolts (124) and lock washers (25).

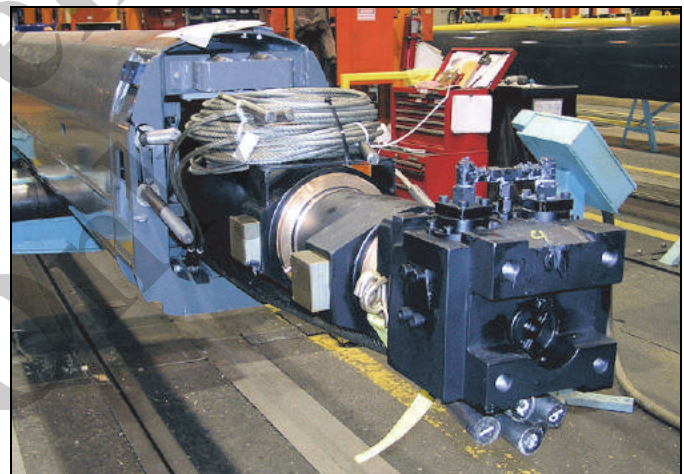
54. Attach the two tele 3 retract cables (65) to the rear of tele 3 (4) using the pin (120), two flat washers (121), and two cotter pins (122) (left and right sides) (see Figure 4-41).



8008-15

FIGURE 4-41

55. Coil the four tele 3 retract cables (65) and set them on top of the telescope cylinder (6) (see Figure 4-42).



8008-16

FIGURE 4-42

56. Mount the wear pad assembly (82) to each side of the bottom rear of tele 3 (4) using the two capscrews (83).
57. Mount the wear pad assembly (71) to each side of the bottom rear of tele 3 (4) using the two capscrews (83) and lock washers (72).
58. Position tele 2 (3) up side down and behind tele 3 (4); set tele 2 (3) on adequate supports.
59. Using a grease gun or brush, apply grease to the inside of tele 2 (3) in the areas where the tele 3 rear wear pads will touch upon assembly.
60. Attach the grease hose (126) and related parts (79, 80, 77, 78) to each rear top wear pad (94), then install the



wear pad/grease hose assembly into the attaching bracket on each side of tele 3 (4).

**NOTE:** Do not allow the wear pad (94) to hang from the grease hose, as the threads of the wear pad can be damaged. If wear pad threads are damaged, replace the wear pad; do not try to repair with thread tape.

61. Align tele 2 and 3 with each other, then partially insert tele 3 (4) into tele 2 (3).
62. Use the shims (70) to adjust the tele 3 rear wear pad assemblies (71, 82) such that the wear pads are within 2 mm (0.08 in) of the sides and the bottom of tele 2. An equal number of shims should be used on each side.
63. Insert tele 3 (4) three-quarters of the way into tele 2 (3).
64. Using an adequate lift and sling, slightly raise the front of tele 3 (4) for the purpose of installing wear pads into the front of tele 2 (3).
65. Install the upper wear pad (92) into the front of tele 2 (3) using the two bolts (27) and nuts (28) (left and right sides); ensure the thin portion of the upper wear pad (92) is oriented to the side of tele 2 (3) (see Figure 4-43).

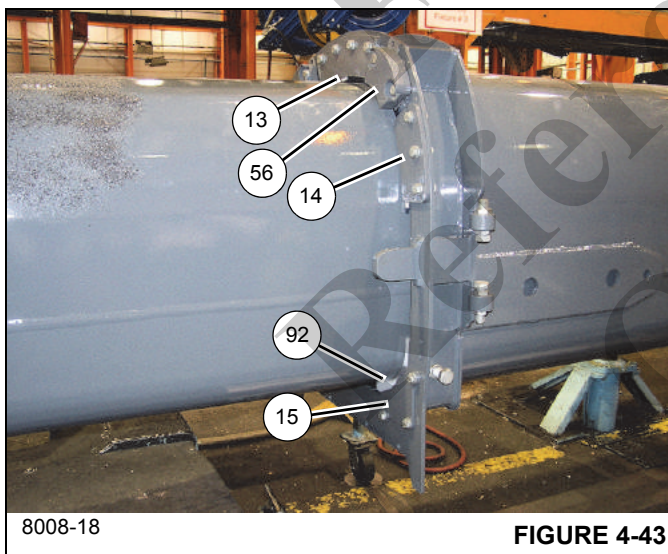


FIGURE 4-43

66. Install the keeper plate (15) to the front of tele 2 (3) using the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) (left and right sides) (see Figure 4-43).
67. Lower tele 3 (4) down onto the newly installed wear pads (92).
68. Install the shims (89) and the front lower wear pads (90, 91) into the bottom of tele 2 (3).
69. Install the left, right, and bottom keeper plates (2x-14, 13) to the front of tele 2 (3) using the bolts (19), flat washers (16), lock washers (17), and nuts (18) (see Figure 4-43).

70. Install the stop block (56) to the front of tele 2 (3) using the two bolts (58), four washers (16), two lock washers (17), and two nuts (18) (left and right sides) (see Figure 4-43).
71. Fully insert tele 3 (4) into tele 2 (3), ensuring the telescope cylinder (6) passes through the rear of tele 2 without damaging tele 2 and telescope cylinder.
72. Install the two tele 4 extend cables (109, 110) into the holes in the rear of tele 2 (3) (left and right sides) (see Figure 4-44).

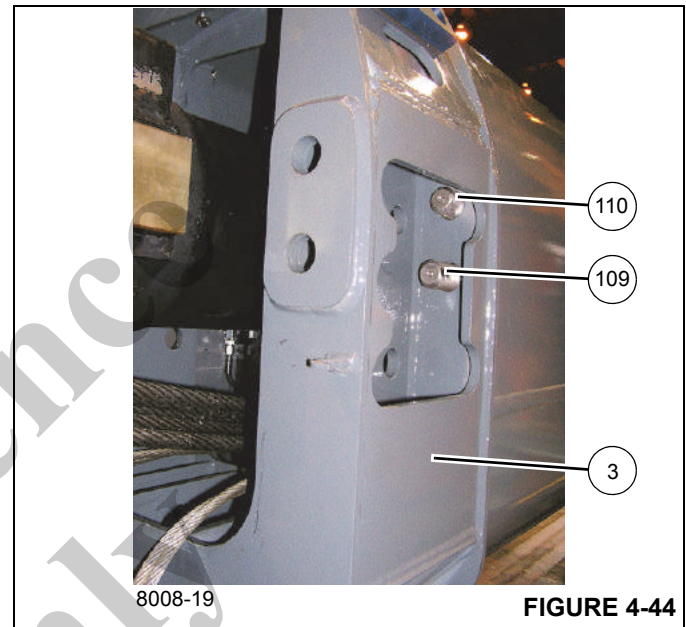


FIGURE 4-44

73. Route the two tele 3 retract cables (65) through the holes in tele 2 (3) and around the sheave assembly (96) (left and right sides); ensure cables do not cross one another (see Figure 4-45).

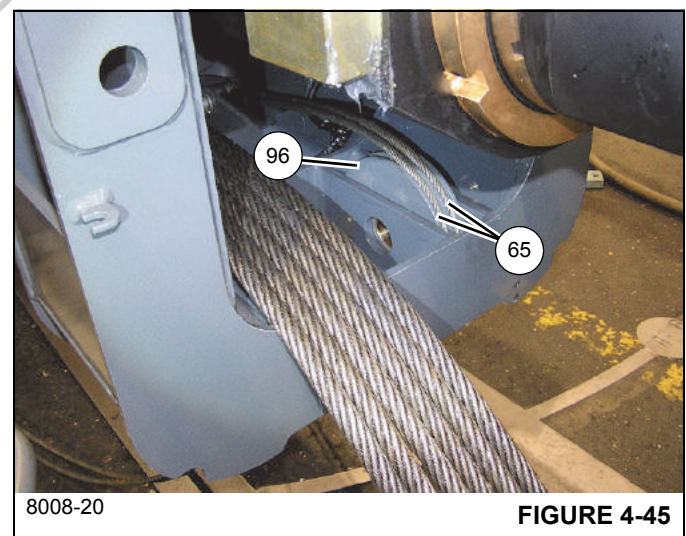
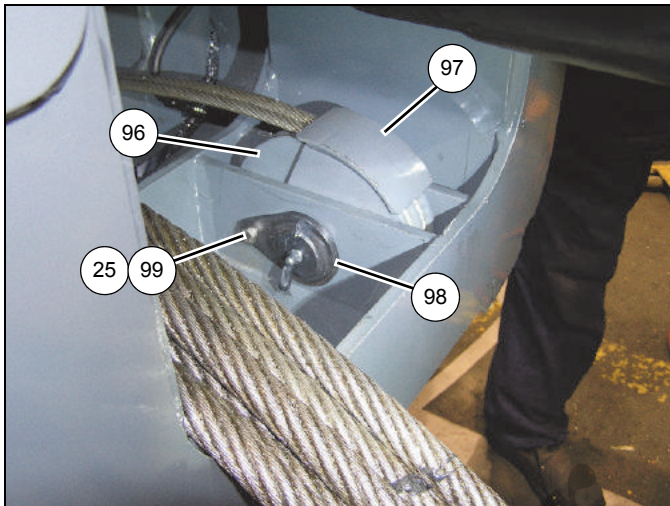


FIGURE 4-45

74. Install the sheave guard weldment (97) over the top of the two tele 3 retract cables (65), then secure the



sheave guard weldment (97) and sheave assembly (96) in place using the shaft weldment (98), bolt (99), and lock washer (25) (left and right sides) (see Figure 4-46).

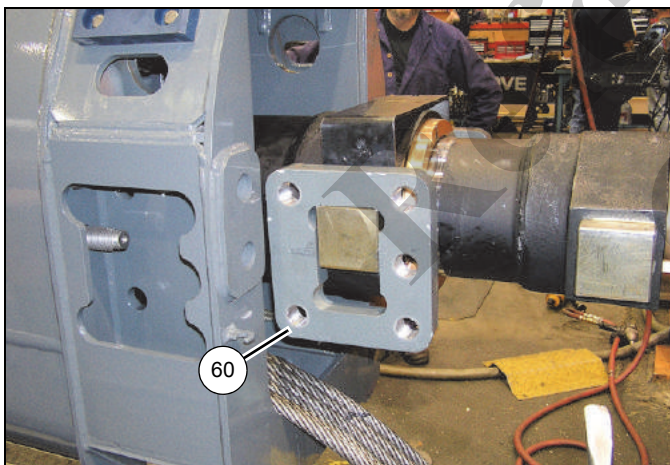


8008-21

FIGURE 4-46

75. Install the grease fitting (106) into the shaft weldment (98) (left and right sides). Add grease until the grease extrudes through the sheaves.

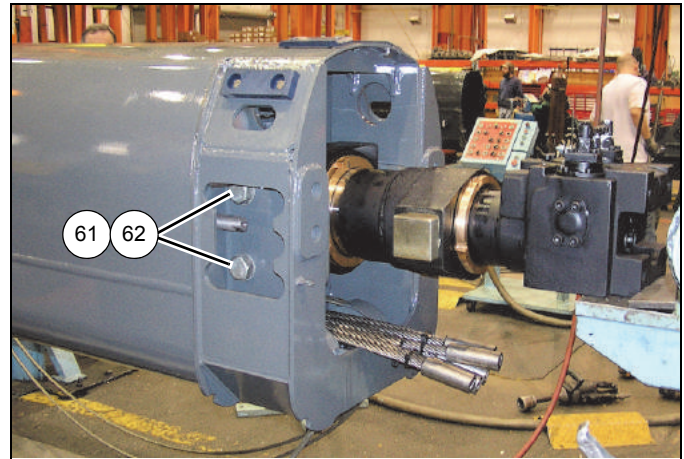
76. Install the trunnion plate (60) onto the front square lug of the telescope cylinder (6) (left and right sides) (see Figure 4-47).



8008-22

FIGURE 4-47

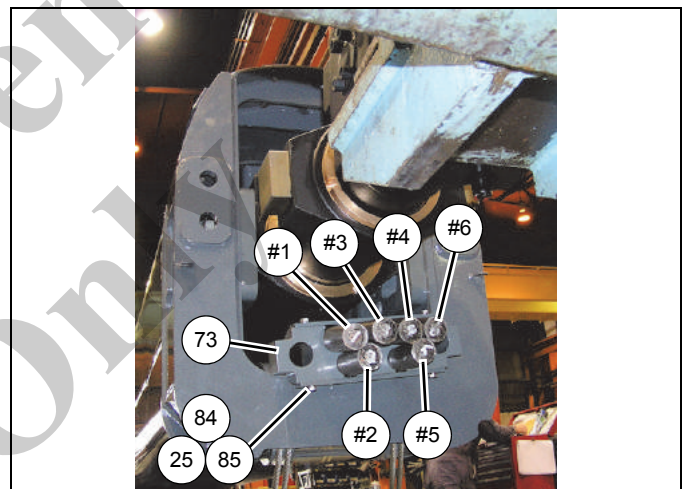
77. Attach the trunnion plate (60) to the inside of tele 2 (3) using the five bolts (62) and flat washers (61) (left and right sides) (see Figure 4-48).



8008-23

FIGURE 4-48

78. Being careful not to cross the cables, install the two tele 3 extend cables (150), labeled 2 and 5, into the anchor plate (73) and secure in place using the plate cover (84), two bolts (85), and two lock washers (25) (see Figure 4-49).



8008-25

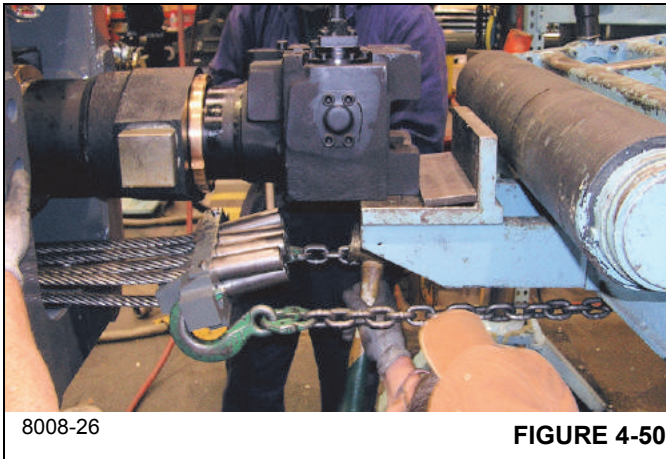
FIGURE 4-49

79. Being careful not to cross the cables, install the four tele 3 extend cables (150), labeled 1, 3, 4, and 6, into the anchor plate (73) and secure in place using the plate cover (84), two bolts (85), and two lock washers (25) (see Figure 4-49).

80. Attach hooks and chains to the holes in the anchor plate (73) and pull on the anchor plate until all six tele 3 extend cables (150) seat themselves into the anchor plate (see Figure 4-50).

**NOTE:** All boom sections may extend slightly when pulling on the tele 3 extend cables (150).

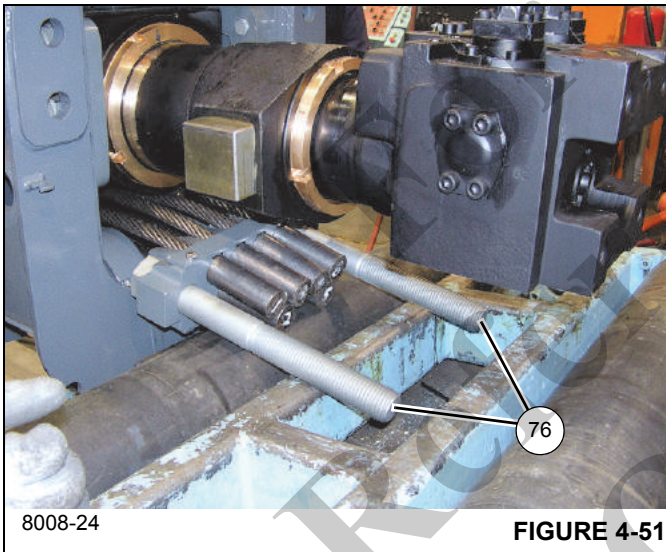




8008-26

FIGURE 4-50

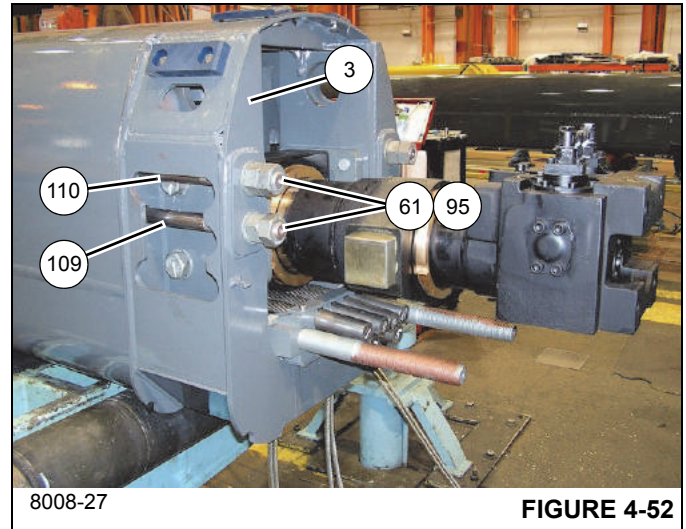
81. Install the two bolts (76) into the anchor plate (73) (see Figure 4-51).



8008-24

FIGURE 4-51

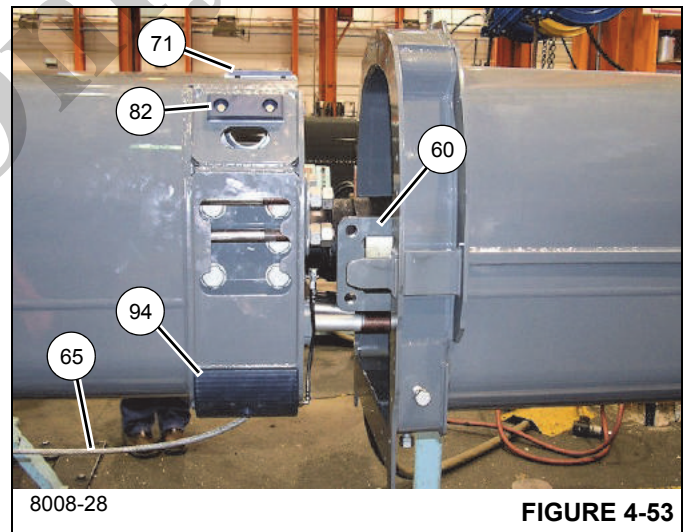
82. Apply never-seize to the threads of the two bolts (76).
83. Install the two tele 4 extend cables (109, 110) into the holes in the rear of tele 2 (3) (left and right sides) (see Figure 4-52).



8008-27

FIGURE 4-52

84. Apply never-seize to the threads of the four tele 4 extend cable ends (109, 110).
85. Install one flat washer (61) and two nuts (95) to each of the four tele 4 extends cables (109, 110) (see Figure 4-52).
86. Mount the wear pad assembly (82) to each side of the bottom rear of tele 2 (3) using the two capscrews (83) (see Figure 4-53).
87. Mount the wear pad assembly (71) to each side of the bottom rear of tele 2 (3) using the two capscrews (83) and lock washers (72) (see Figure 4-53).



8008-28

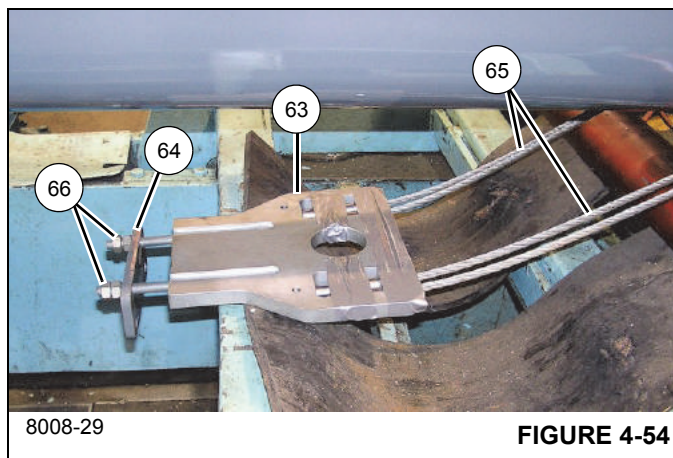
FIGURE 4-53

88. Pull the four tele 3 retract cables (65) toward the front of the boom sections in preparation for future steps; ensure cables are not crossed (see Figure 4-53).
89. Install the trunnion plate (60) onto the rear square lug of the telescope cylinder (6) (left and right sides) (see Figure 4-53).

90. Position tele 1 (2) up side down and behind tele 2 (3); set tele 1 (2) on adequate supports.
91. Using a grease gun or brush, apply grease to the inside of tele 1 (2) in the areas where the tele 2 rear wear pads will touch upon assembly.
92. Attach the grease hose (81) and related parts (79, 80, 77, 78) to each rear top wear pad (94), then install the wear pad/grease hose assembly into the attaching bracket on each side of tele 2 (3) (see Figure 4-53).

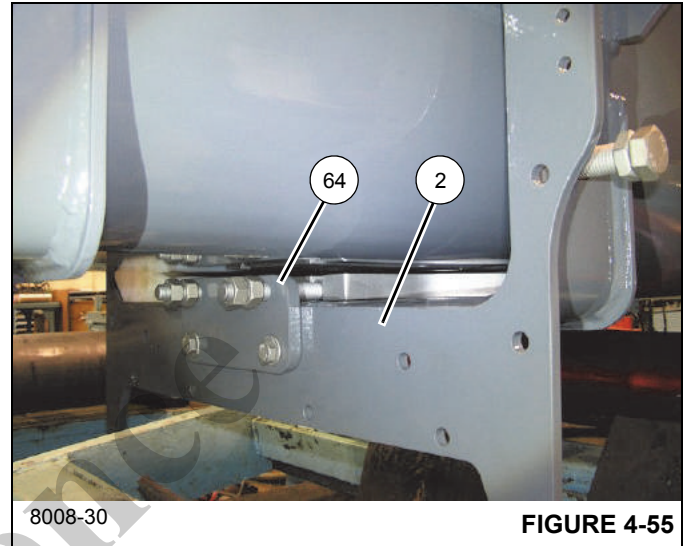
**NOTE:** Do not allow the wear pad (94) to hang from the grease hose, as the threads of the wear pad can be damaged. If wear pad threads are damaged, replace the wear pad; do not try to repair with thread tape.

93. Align tele 1 and 2 with each other, then partially insert tele 2 (3) into tele 1 (2).
94. Use the shims (70) to adjust the tele 2 rear wear pad assemblies (71, 82) such that the wear pads are within 2 mm (0.08 in) of the sides and the bottom of tele 1. An equal number of shims should be used on each side.
95. Insert tele 2 (3) three-quarters of the way into tele 1 (2).
96. Install the shims (53) and the front lower wear pads (54, 55) into the bottom of tele 1 (2).
97. Install the left, right, and bottom keeper plates (2x-14, 13) to the front of tele 1 (2) using the bolts (19), flat washers (16), lock washers (17), and nuts (18).
98. Install the stop block (56) and shim (57) to the front of tele 1 (2) using the two bolts (58), four washers (16), two lock washers (17), and two nuts (18) (left and right sides).
99. After ensuring that the tele 3 retract cables (65) are not crossed, install the four cable ends into the slots of the retract anchor weldment (63); wrap duct tape around the anchor weldment to secure the cables in place (see Figure 4-54).



100. Install the anchor plate (64) onto the studs of the retract anchor weldment (63) and secure with the nuts (66) (see Figure 4-54).

101. Attach the anchor plate (64) to the top of tele 1 (2) using the two bolts (69), four flat washers (67), and two nuts (18) (see Figure 4-55).



102. Using an adequate lift and sling, slightly raise the front of tele 2 (3) for the purpose of installing wear pads into the front of tele 1 (2).

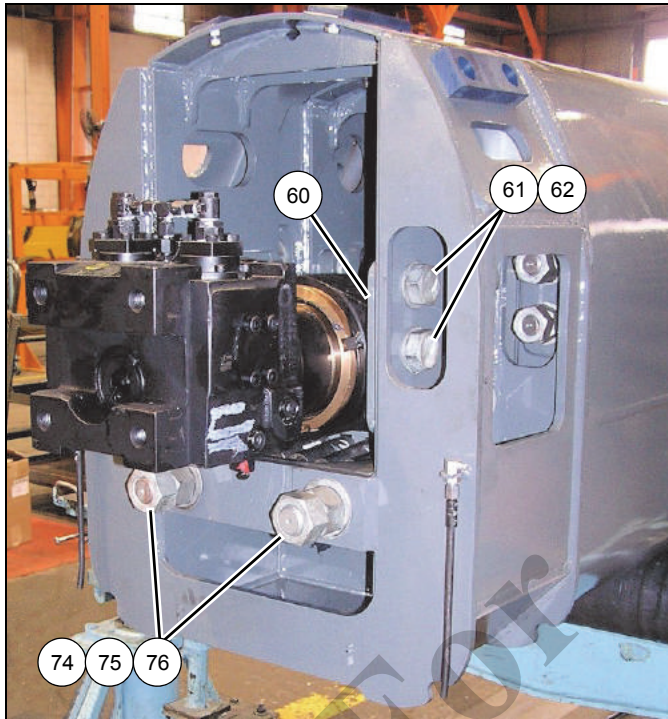
103. Install the upper wear pad (11) into the front of tele 1 (2) using the two bolts (27) and nuts (28) (left and right sides); ensure the thin portion of the upper wear pad (11) is oriented to the side of tele 1 (2).

104. Install the keeper plate (15) to the front of tele 1 (2) using the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) (left and right sides).

105. Lower tele 2 (3) down onto the newly installed wear pads (11).

106. Attach the trunnion plate (60) to the inside of tele 1 (2) using the five bolts (62) and flat washers (61) (left and right sides) (see Figure 4-56).





8008-31

FIGURE 4-56

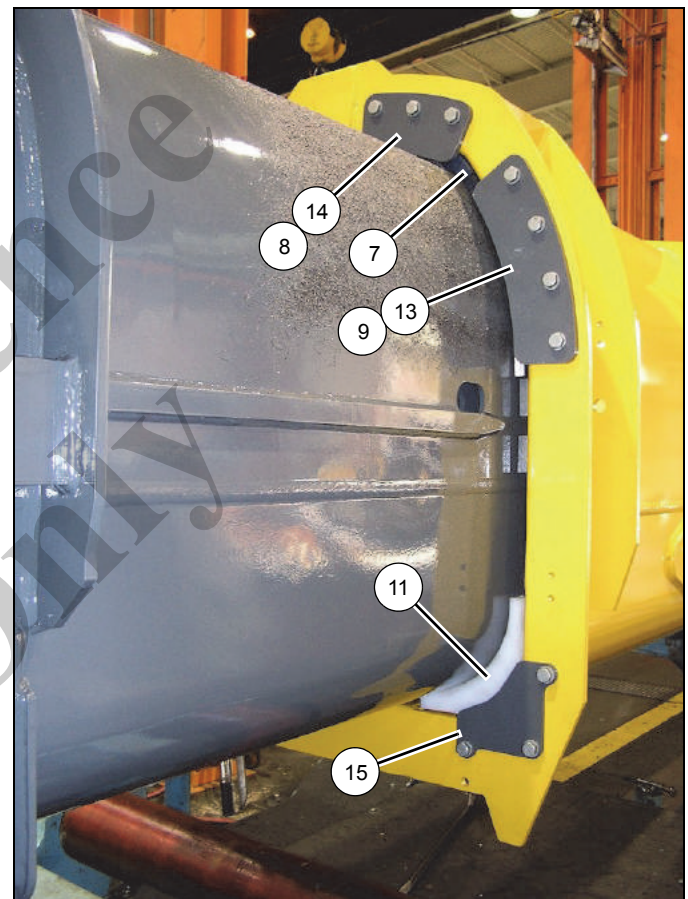
- 107.** Install the two bolts (76) that pass through the anchor plate (73) into the holes in the rear of tele 1 (2), then secure in place with the four nuts (75) and two (flat washers (74) (see Figure 4-56).
- 108.** Mount the wear pad assembly (82) to each side of the bottom rear of tele 1 (2) using the two capscrews (83).
- 109.** Mount the wear pad assembly (71) to each side of the bottom rear of tele 1 (2) using the two capscrews (83) and lock washers (72).
- 110.** Attach the grease hose (81) and related parts (79, 80, 77, 78) to each rear top wear pad (59), then install the wear pad/grease hose assembly into the attaching bracket on each side of tele 1 (2).

**NOTE:** Do not allow the wear pad (59) to hang from the grease hose, as the threads of the wear pad can be damaged. If wear pad threads are damaged, replace the wear pad; do not try to repair with thread tape.

- 111.** Position the base section (1) up side down and behind tele 1 (2); set the base section (1) on adequate supports.
- 112.** Using a grease gun or brush, apply grease to the inside of the base section (1) in the areas where the tele 1 rear wear pads will touch upon assembly.
- 113.** Align the base section and tele 1 with each other, then partially insert the tele 1 (2) into the base section (1).
- 114.** Use the shims (70) to adjust the tele 1 rear wear pad assemblies (71, 82) such that the wear pads are within

2 mm (0.08 in) of the sides and the bottom of the base section. An equal number of shims should be used on each side.

- 115.** Insert tele 1 (2) three-quarters of the way into the base section (1).
- 116.** Using an adequate lift and sling, slightly raise the front of tele 1 (2) for the purpose of installing wear pads into the front of the base section (1).
- 117.** Install the upper wear pad (11) into the front of the base section (1) using the two bolts (27) and nuts (28) (left and right sides); ensure the thin portion of the upper wear pad (11) is oriented to the side of the base section (1) (see Figure 4-57).



8008-32

FIGURE 4-57

- 118.** Install the keeper plate (15) to the front of the base section (1) using the three bolts (19), six flat washers (16), three lock washers (17), and three nuts (18) (left and right sides) (see Figure 4-57).
- 119.** Lower tele 1 (2) down onto the newly installed wear pads (11).
- 120.** Install the shims (2x-7) and the front lower wear pads (8, 9) into the bottom of the base section (1) (see Figure 4-57).

- 121.** Install the left, right, and bottom keeper plates (2x-14, 13) to the front of the base section (1) using the bolts (19), flat washers (16), lock washers (17), and nuts (18) (see Figure 4-57).
- 122.** Install the plate (12) to the inside of the base section (1) using the two bolts (20) and flat washers (16) (left and right sides).
- 123.** Fully insert tele 1 (2) into the base section (1).
- 124.** Locate and weld the two wedges (29) to the base section (1) by doing the following (see Figure 4-58):
- Position the wedges (29) between the telescope cylinder (6) and the plates on the trunnion.
  - Center the telescope cylinder (6) between the top and bottom plates.
  - Bolt the telescope cylinder in place using the two plates (30) and four bolts (31).
  - Tack weld the two wedges (29) to the plates of the trunnion.
  - Remove the four bolts (31) and two plates (30).
  - Remove the telescope cylinder (6) from the trunnion area, then weld the two wedges (29) in place.
  - Reattach the telescope cylinder (6) to the base section (1) using the two plates (30) and four bolts (31).



FIGURE 4-58

- 125.** Install the transducer (151) into the end of the telescope cylinder (6).

- 126.** Mount the tele stage selection manifold (37) to the bottom rear of the base section (1) using the four bolts (20) and flat washers (16).
- 127.** Install all hydraulic tube assemblies to the tele stage selection manifold (37) and telescope cylinder (6) as tag during disassembly; replace all O-rings.
- 128.** Once the boom assembly is positioned right-side up, adjust the top front wear pads (11, 92, 103) of each boom tele section using the upper and side adjustment bolts (27). Adjust the wear so that they are just touching or are no more than 2 mm (0.08 in) away from contacting the next inner tele section. Tighten the jam nuts.

## Installation

**NOTE:** The following procedure applies to a boom totally removed from the crane.

### WARNING

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

- Attach an adequate lifting device to the boom and suspend the boom over the machine.
- Lower the boom into position and align the boom pivot shaft mounting holes for installation of the pivot shaft to the superstructure assembly.
- Lubricate and install the boom pivot shaft. Secure in place with the locknut and capscrew. Install the grease fitting in each end of the shaft.

### DANGER

Block the boom before doing any work under the boom. Failure to properly support the boom may result in death or serious injury.

- Block the boom in place.
- Attach a suitable lifting device to the lift cylinder.

### DANGER

Failure to properly support the boom lift cylinder may result in death or serious injury.

- Using the lifting device attached to the boom, lower the boom onto the lift cylinder rod end and extend the lift cylinder as necessary to align rod with attach fitting on boom.

**WARNING**

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.

7. Lubricate and install the upper lift cylinder shaft. Install a thrust washer on each side of the lift cylinder rod end. Secure in place with the stop plate, two bolts, and two washers.
8. Remove the boom lifting device.
9. Activate the hydraulic system and remove the boom and lift cylinder blocking devices. Lower the boom to horizontal. Shut down the crane.
10. Connect the hydraulic lines to the telescope cylinder as tagged prior to removal.
11. 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. Boom damage could occur.

12. Refer to *Boom Extension and Retraction Cables*, page 4-33 for cable adjustments.

**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 *Lubrication*, page 9-1 for the proper lubricant.

Boom alignment is achieved as the boom sections are being assembled into one another. A check of 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 2 mm (0.078 in) from contacting the next tele section both at the top and side surfaces of the top radius.

**CAUTION**

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 tele 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 tele sections to align the high point on the boom tele 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.

**BOOM EXTENSION AND RETRACTION CABLES****Maintenance**

**NOTE:** For more detailed information concerning maintenance of the extension and retraction cables, refer to WIRE ROPE in Section 1-INTRODUCTION.

**Inspection****CAUTION**

Wear gloves when handling wire rope. Moderate to minor injury may result if using bare hands.

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. 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 5%.
  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.
8. Ensure Tele 3 and 4 bottom out on their respective stop blocks 3mm to 4mm prior to Tele 2 bottoming out on Tele 1.

Tighten the extend and retract cables as necessary to insure that all sections bottom out properly and that they do not drift out when the hydraulic valve is in neutral.

To attain these conditions, perform the following procedures.

- a. If Tele 3 bottoms out prior to Tele 4, loosen Tele 3 extend and retract cables. Extend and retract the boom a few feet. Tighten Tele 3 extend cables. Extend the boom a few feet and tighten Tele 3 retract cables. Retract the boom fully. Repeat until the section bottoms out properly. Re-torque the Tele 3 retract cables and the Tele 3 extend cables to verify that the minimum torque value is achieved as specified in Table 4-1.
- b. If Tele 3 does not bottom out completely, loosen Tele 3 extend and retract cables. Extend the boom a few feet. Tighten Tele 3 retract cables. Retract the boom a few feet and tighten Tele 3 extend cables. Extend and retract the boom a few times. Repeat until the section bottoms out properly. Re-torque the Tele 3 retract cables and the Tele 3 extend cables to verify that the minimum torque value is achieved as specified in Table 4-1.
- c. If Tele 4 is fully retracting early, loosen the Tele 4 extend and retract cables. Extend and retract the boom a few feet. Tighten the Tele 4 extend cables. Extend the boom a few feet and tighten Tele 4 retract cables. Retract the boom fully. Repeat until the section bottoms out properly. Re-torque the Tele 4 retract cables and the Tele 4 extend cables to verify that the minimum torque value is achieved as specified in Table 4-1.
- d. If Tele 4 does not bottom out completely, loosen Tele 4 extend and retract cables. Extend the boom a few feet. Tighten Tele 4 retract cables. Retract the boom a few feet and tighten Tele 4 extend cables. Extend and retract the boom a few times. Repeat until the section bottoms out properly. Re-torque the Tele 4 retract cables and the Tele 4 extend cables to verify that the minimum torque value is achieved as specified in Table 4-1.
- e. If Tele 2 extends (drifts) back out after the hydraulic valve is in neutral, extend the boom a few feet. Loosen Tele 3 retract cables slightly. Extend and retract the boom a few times. If Tele 2 continues to drift out, extend and then retract the boom. Tighten Tele 3 extend cables slightly. Extend and retract the boom fully. Repeat until Tele 2 does not drift back out.

## Adjustment

Adjustment of the interior proportioning cables (extend and retract cables) is necessary after assembly of the boom or when interior proportioning cables appear loose.

Refer to the following procedures and Figure 4-59 when adjusting the extend and retract cables.

### CAUTION

When tightening/loosening the cables, secure cable using the flats at the front of the cable ends to prevent cable twist. Do not use an impact wrench. Do not turn cable. Turning the cable while adjusting will result in damage or failure of the cable.

**NOTE:** Ensure the boom is in the horizontal position when tensioning the cables.

**NOTE:** Ensure all cables are torqued to the minimum torque values specified in Table 4-1 to ensure adequate cable tensions.

**NOTE:** Assure that all threaded studs allow the nut to thread on and off by hand.

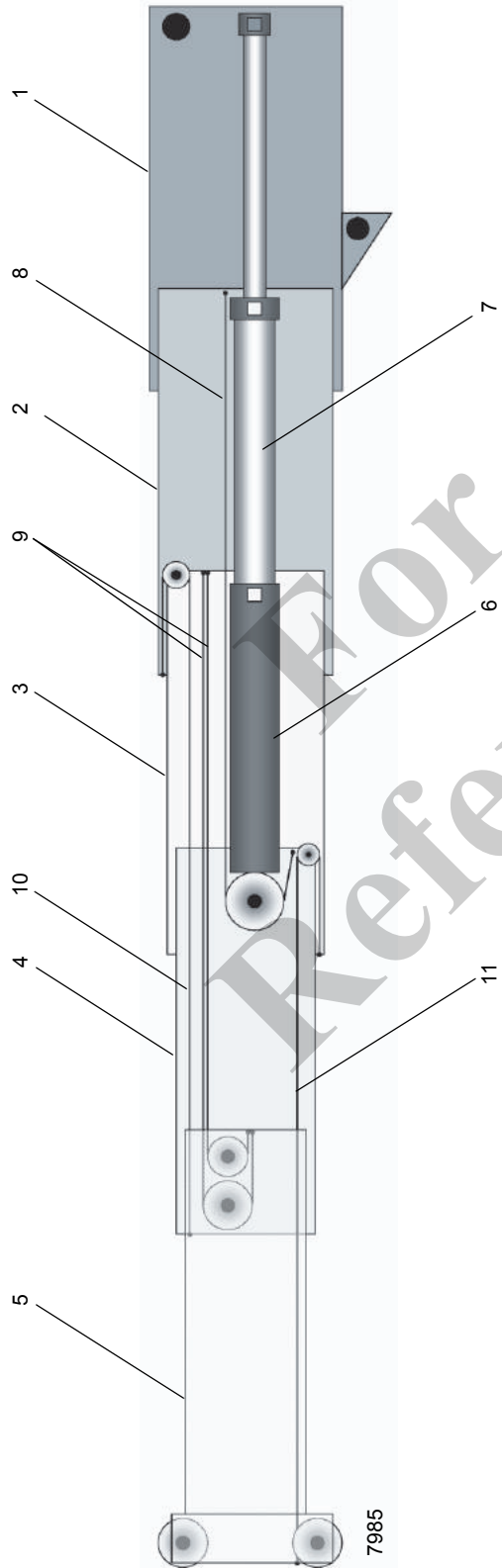
1. Extend and set the outriggers, ensuring the crane is level.
2. Ensure the boom is over the front and at a horizontal position (boom angle elevation 0°).
3. Slightly tighten all cables.
4. Fully retract the boom.
5. Tighten the Tele 4 retract, Tele 4 extend, Tele 3 retract, and Tele 3 extend cables (in order listed) to remove excess slack from the cables.
6. Torque the Tele 4 retract, Tele 4 extend, Tele 3 retract, and Tele 3 extend cables (in order listed) to the minimum torque values as specified in Table 4-1.
7. Fully extend and retract the boom.

9. Ensure all extend and retract cables achieve the **minimum torque value** as specified in **Table 4-1**.
10. Add jam nuts and tighten. Coat threads with Never Seize. All threaded cable ends must be equipped with retainer nuts and jam nuts.

**Table 4-1 Cable Tensioning Minimum Torque Values**

Cables (Extend/Retract)	Minimum Torque Values
Tele 4 Retract Cables	34 Nm (25 lb-ft)
Tele 4 Extend Cables	13.5 Nm (10 lb-ft)
Tele 3 Retract Cables	13.5 Nm (10 lb-ft)
Tele 3 Extend Cables	40.5 Nm (30 lb-ft)

For  
Reference  
Only



Item	Description
1	Base Section
2	Tele 1
3	Tele 2
4	Tele 3
5	Tele 4
6	Telescope Cylinder - 1st Stage
7	Telescope Cylinder - 2nd Stage
8	Tele 3 Extend Cables
9	Tele 4 Extend Cables
10	Tele 3 Retract Cables
11	Tele 4 Retract Cables

FIGURE 4-59

## TELESCOPE CIRCUIT

### Description

The boom telescope circuit consists of the telescope hydraulic remote controller, telescope directional control valve, Telescope Stage Selector Valve, Telescope Fill Tube Control Valve, holding valve, and the 2-stage telescope cylinder.

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

Refer to *Valves*, page 2-30 for a complete description of the hydraulic remote controller, the Telescope Stage Selector Valve Manifold, and the Telescope Fill Tube Control Valve Manifold.

### Theory of Operation

The boom can be operated using several different modes. The boom is operated in a synchronized sequence using a two-stage telescope cylinder. Tele 1 is controlled by the cylinder's smaller piston and Tele 2 is controlled by the larger piston. Tele 3 and 4 are controlled by cables fixed to Tele 2.

The cylinder is controlled using several proportionally control solenoid operated valves.

Pressure in the telescope cylinder is monitored by two pressure transducers, TR1 and TR2. TR1, also called the Fill Tube Pressure Transducer, monitors the pressure in the telescope cylinder fill tube. TR2, called the Small Piston Pressure Transducer, monitors the pressure on the telescope extend circuit. When Tele 2 is extended, TR1 and TR2 monitor the same pressure. Both pressure transducers communicate via CAN messages to the boom control system. Pressure readings are monitored by the boom control system and are controlled to maintain synchronization of the boom in Auto and Manual Modes.

### Boom Control Modes

The boom control offers four methods of telescoping the boom: Auto Mode A, Auto Mode B, Manual Mode, and Recovery Mode.

### Auto A Mode

In the auto A mode, the boom extends to full length by extending Tele 2 first then Tele 1. The crane decides how and when to stop extending Tele 2 and start extending Tele 1. This mode is an option for normal crane work. The boom control system uses length feedback to ramp the telescoping speed of the boom sections when approaching the fully retracted or fully extended positions, and near the transition point. This mode has the best stability performance.

### Auto B Mode

In the auto B mode, the boom extends to full length by extending Tele 1 first then Tele 2. The crane decides how and when to stop extending Tele 1 and start extending Tele 2. This mode is a second option for normal crane work. The boom control system uses length feedback to ramp the telescoping speed of the boom sections when approaching the fully retracted or fully extended positions, and near the transition point. This mode has the best structural performance.

### Manual Mode

In the manual mode, either Tele 1 or Tele 2 extends based on the cab switch position. Once the selected section is extended the operator must change the T1/T2 switch position to extend the other section of the boom. This mode may be used for lifting, but the load charts are substantially reduce as compared to the Auto modes. Manual mode has been designed for use in bringing the boom back into the sequence of Auto Mode A or Auto Mode B. It is also useful for lubrication or maintenance of the boom.

When the operator telescopes Tele 1, the boom control system will maintain the relative position (percent extended) of Tele 2, 3, and 4. When the operator telescopes Tele 2, 3, and 4, the relative position of Tele 1 is maintained.

Manual mode does not ramp the speed of the boom near transition points. The boom speed is controlled by the operator.

**Recovery Mode**

The recovery mode operates similar to the manual mode, but requires no sensors, only inputs from the cab switches. The operator can extend and retract, but this mode should only be used if Auto and Manual modes are not functional. When operating in recovery mode, the control system does not maintain the position of the section that is not being moved (example: when Tele 1 is extended, Tele 2 will retract slightly; and when Tele 1 is retracted, Tele 2 will extend slightly).

**Boom Control System Features****Jib Rigging**

This jib rigging feature prevents the extension of Tele 2 when erecting the jib, and limits the Tele 1 from extending past the anti-rotation features on the base section. The jib rigging state is entered when the stop block is disengaged (pulled

down from the base section), and Tele 1 is retracted to align the boom extension mounting holes. When the control system detects a length less than the fully retracted length with the stop block engaged, the jib rigging state is activated. When jib rigging is active, Tele 2 is prevented from extending (retract is allowed). Tele 1 can extend enough to pull the jib from the hangers on the base. Once the jib is fully pinned, the operator must fully retract against the engaged stop block to exit the jib rigging mode and resume normal operation.

**Anti-Thermal Contraction**

With this feature, the control system maintains a positive pressure in the big piston of the telescope cylinder while booming up. This prevents Tele 2 from drifting back after the hydraulic fluid has cooled with the Tele 2 extended at a low angle.

For  
Reference  
Only

## Maintenance

### 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.
2. Erratic operation of retracting telescoping cylinder.	l. Damaged control valve.	l. Repair or replace control valve.
	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.
	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).	



SYMPTOM	PROBABLE CAUSE	SOLUTION
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 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.
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 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.	

### Removal And Installation

Removal and installation of the telescope cylinder from the boom is described under disassembly and assembly of the boom. Refer to *Maintenance*, page 4-4.

### Disassembly And Assembly

Disassembly and assembly procedures of the telescope control valve and cylinder are provided in *Valves*, page 2-30 and *Cylinders*, page 2-61 respectively.

## 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 in *Valves*, page 2-30.

Refer to *Valves*, page 2-30 for a complete description of the hydraulic remote controller.

The lift cylinder has a 30.48 cm (12.0 in) bore. Both are the 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 *Cylinders*, page 2-61 for a complete description of the lift cylinder.

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.

### Maintenance

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.

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 Manitowoc Crane Care Parts Manual).
	f. Operating two functions with 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 Manitowoc Crane Care 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 *Lift Cylinder*, page 2-64 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.

### Lift Cylinder 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).



### WARNING

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.

**NOTE:** Refer to Figure 4-60 for removal and installation of lift cylinder.

4. Attach an adequate lifting/supporting device to the lift cylinder.
5. Remove the two capscrews and washers, and the stop plate securing the lift cylinder upper pivot shaft to the boom.
6. Remove the capscrew and locknut securing the lift cylinder lower pivot shaft to the turntable.
7. Remove the upper pivot shaft and any attached shims. Activate the hydraulic system and retract the lift cylinder enough to clear the upper attach point.
8. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.

9. Pull the lower lift cylinder pivot shaft out far enough to remove the cylinder.

10. 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 *Cylinders*, page 2-61 and *Valves*, page 2-30 respectively.

### Lift Cylinder Installation

1. Attach an adequate lifting device to the lift cylinder and position the cylinder over the attach fitting on the turntable.
2. Lower the lift cylinder into the attach fittings on the turntable and align the lift cylinder bushing with the attach fitting holes.

**NOTE:** Install pivot shaft with tapped hole on the right side of the crane, side opposite the cab.

3. Install the lift cylinder lower pivot shaft and secure with the capscrew and locknut.
4. Connect the extend and retract hoses to the lift cylinder.
5. Activate the crane's hydraulic system and align the lift cylinder rod end with the attach point on the boom. Install the upper pivot shaft through the cylinder and boom attach points. Shut down the engine.
6. Shim lift cylinder, as needed, using thrust washer(s) on each side.
7. Secure the upper pivot shaft with the stop plate, capscrews and washers.
8. Remove the lifting and supporting devices from the boom and lift cylinders. Activate the hydraulic system and check the lift cylinders for proper operation and any leaks.
9. Lubricate the pivot shafts using grease fittings.

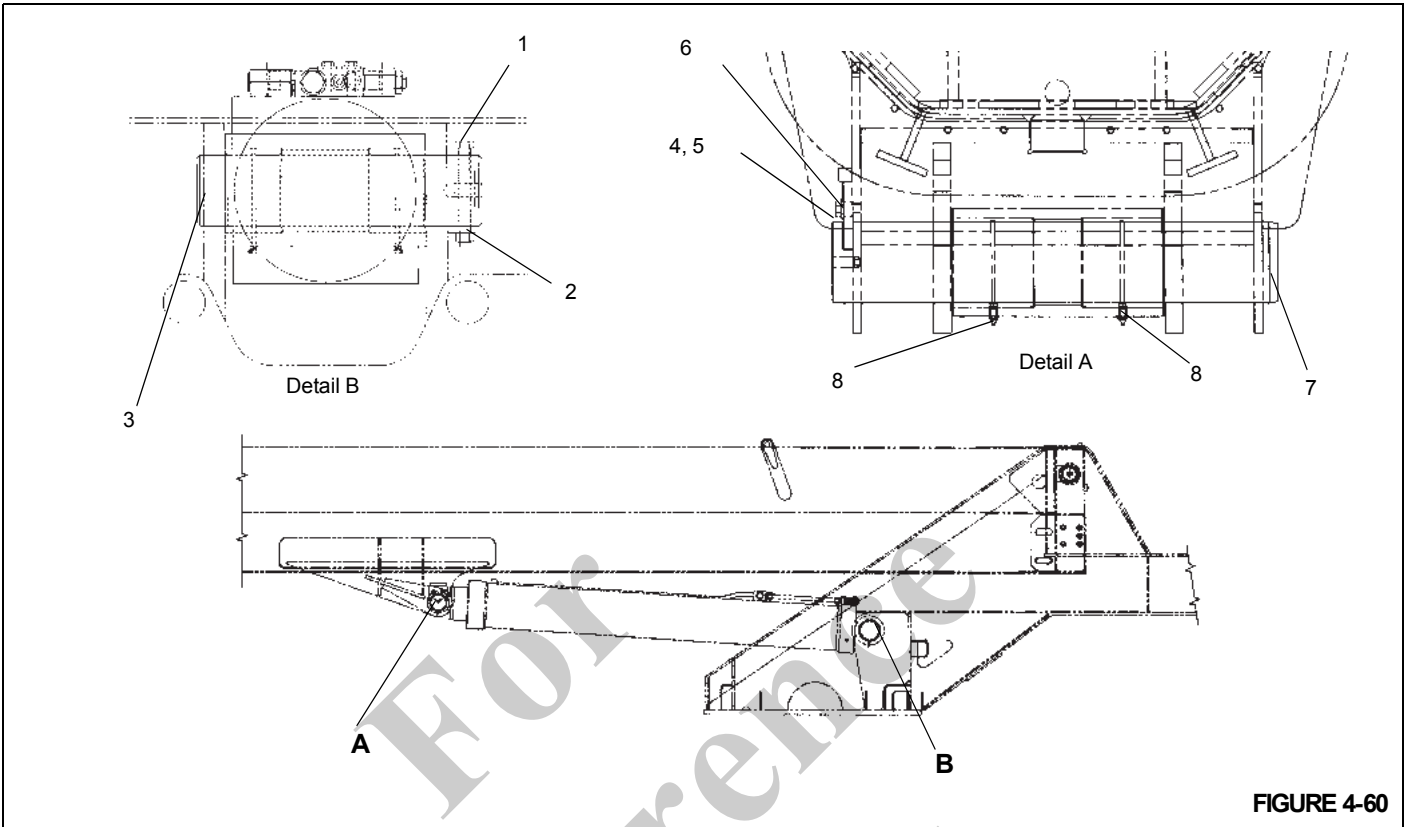


FIGURE 4-60

Item	Description
1	Capscrew
2	Locknut
3	Shaft
4	Capscrew (2)

Item	Description
5	Washer (2)
6	Stop Plate
7	Shaft
8	Grease Fitting (2)

## BI-FOLD BOOM EXTENSION

### Description

A 33 ft (10.1 m) fixed offsetable or a 10.1 to 17.1 m (33 to 56 ft) folding offsetable swingaway boom extension is provided to obtain additional boom reach.

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.

Removing the attach pins from the attach points on the left side of the boom nose allows the swingaway to be rotated and stowed on the right side of the boom base section.

The fixed swingaway weighs approximately 1706 lb (774 kg) and the folding swingaway weighs approximately 2430 lb (1102 kg).



### DANGER

Before attempting to erect or stow the boom extension; read and strictly adhere to all danger decals installed on the boom/boom nose, boom extension, and stowage brackets.

Lifting over the bi-fold extension base section is strictly prohibited, when the fly extension is either erected or folded along side of extension base section.



### DANGER

Extending boom sections 2 through 4 during the erection or stowage of the boom extension could permit disengagement of the anti-roll guides, allowing an uncontrolled movement of the extension, resulting in death, personal injury, or property damage.

Always ensure the crane is in the B mode during erection or stowage of the boom extension. Never erect or stow the boom extension in the recovery mode.

### Boom Extension Rigging Mode

This crane is equipped with a boom control system that enters a Boom Extension Rigging Mode when the boom stop block is disengaged and a minimum boom length is detected. While in the Boom Extension Rigging Mode the crane will not allow the following movements:

- Extension of the boom in Auto Mode, with A Mode selected

- Extension of the boom in Manual Mode, with Boom Section 2-4 selected

The Boom Extension Rigging Mode requires that the boom be extended in Auto Mode with B Mode selected, or Manual Mode with Section 1 selected until the boom automatically stops and is clear of the guide ramps and stowage pins on the front and rear stowage brackets.

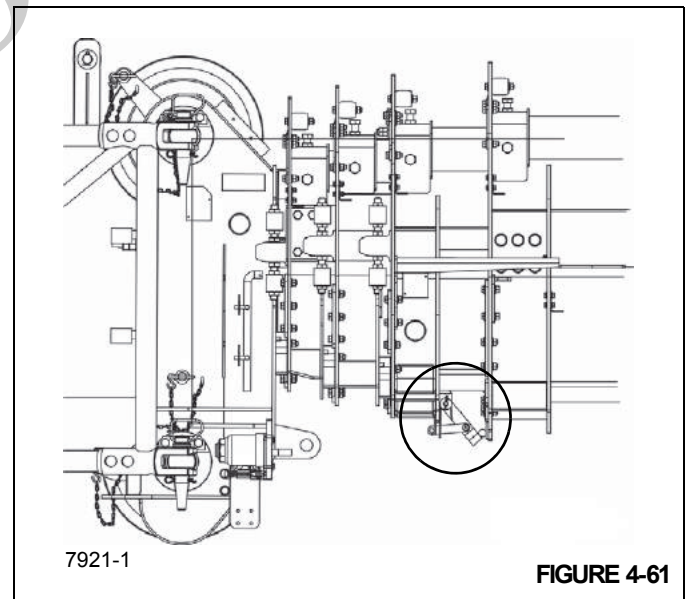
To exit the Boom Extension Rigging Mode the boom must be fully retracted causing the section 1 and section 2 proximity switches to be activated. Upon exiting the Boom Extension Rigging Mode, restrictions of boom operating modes are removed.

### Erecting the Boom Extension

1. Fully extend and set the outriggers.
2. Position the boom over the front.
3. Set the boom manual/automatic mode selector switch to the AUTO position.
4. Set the boom A/B mode selector switch to the B mode.
5. If extended, fully retract all the boom sections and lower the boom to minimum elevation to permit ease of installation of pins and access to the boom nose.

**NOTE:** The auxiliary boom nose (rooster sheave) does not have to be removed. However, if reeved, the hoist cable must be removed from the sheave.

6. Rig either the main hoist or optional auxiliary hoist cable for single part line with nothing but the wedge socket on the end of the cable.
7. Extend the boom enough to disengage the spring loaded boom stop block (Figure 4-61).





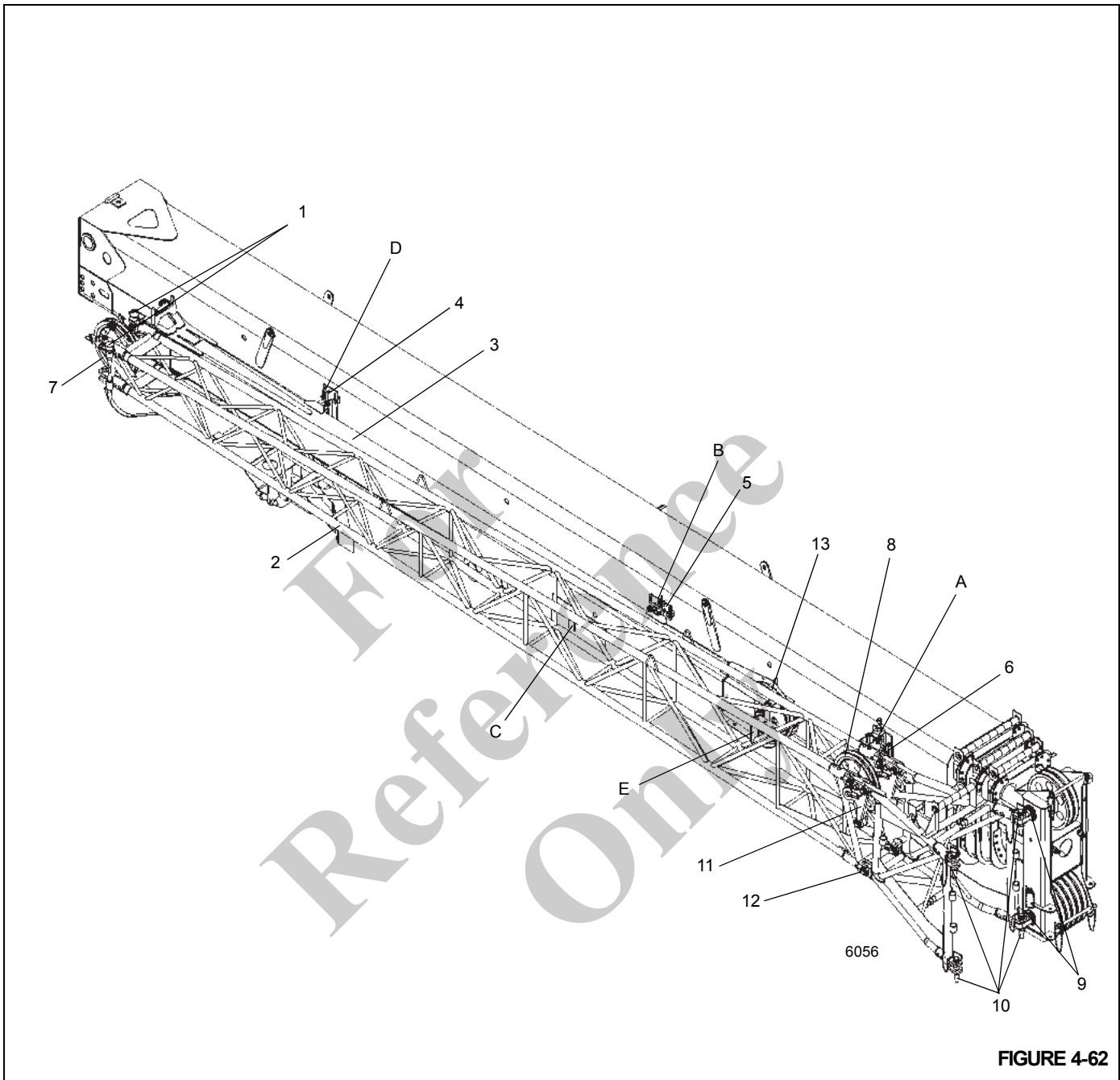
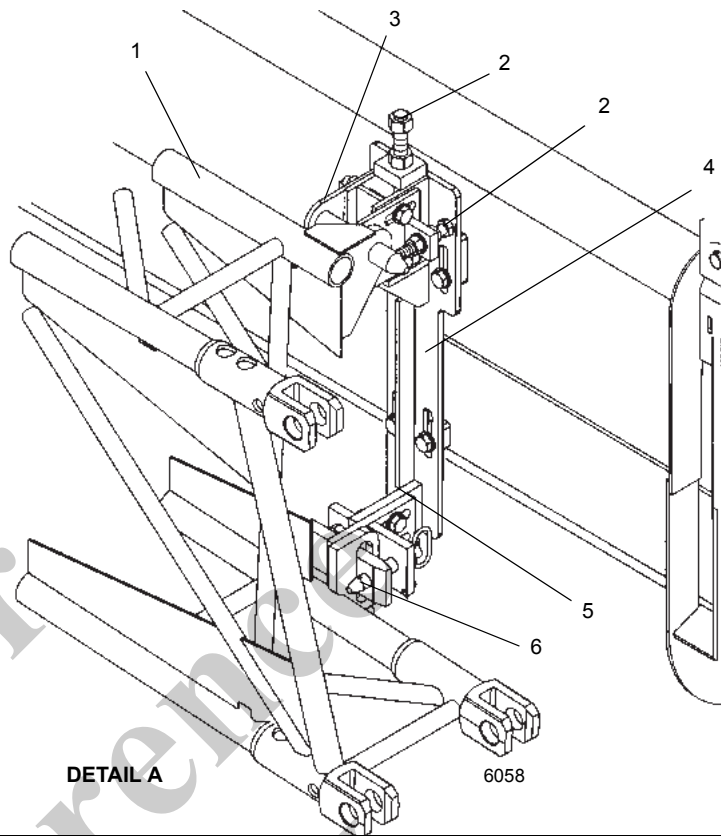
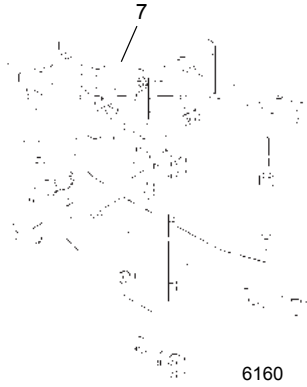


FIGURE 4-62

Item	Description
1	Base To Fly Attachment Pins
2	Boom Extension Base Section
3	Boom Extension Fly Section
4	Fly Rear Stowage Bracket
5	Stinger Section Front Stowage Bracket
6	Front Stowage Bracket
7	Swingaway Base Sheave

Item	Description
8	Mast Assembly
9	Boom Nose To Boom Extension Attachment Anchor Fittings
10	Boom Nose To Boom Extension Attachment Pins
11	Offset Links
12	Offset Pivot Point
13	Stinger Sheave

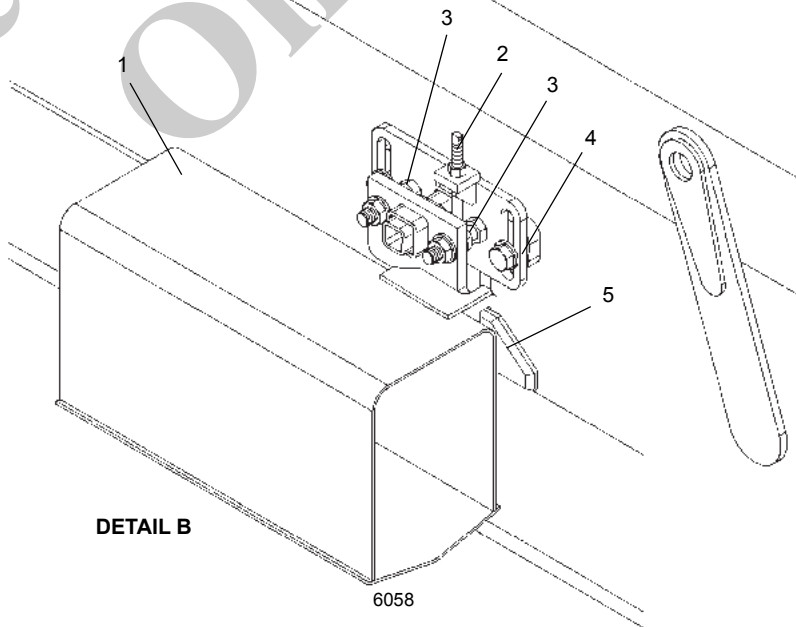


Item	Description
1	Boom Extension Base Section
2	Adjusting Bolt
3	Upper Hanger
4	Main Hanger
5	Lower Support
6	Lock Hitch Pin
7	Adapter

DETAIL A

Reference Only

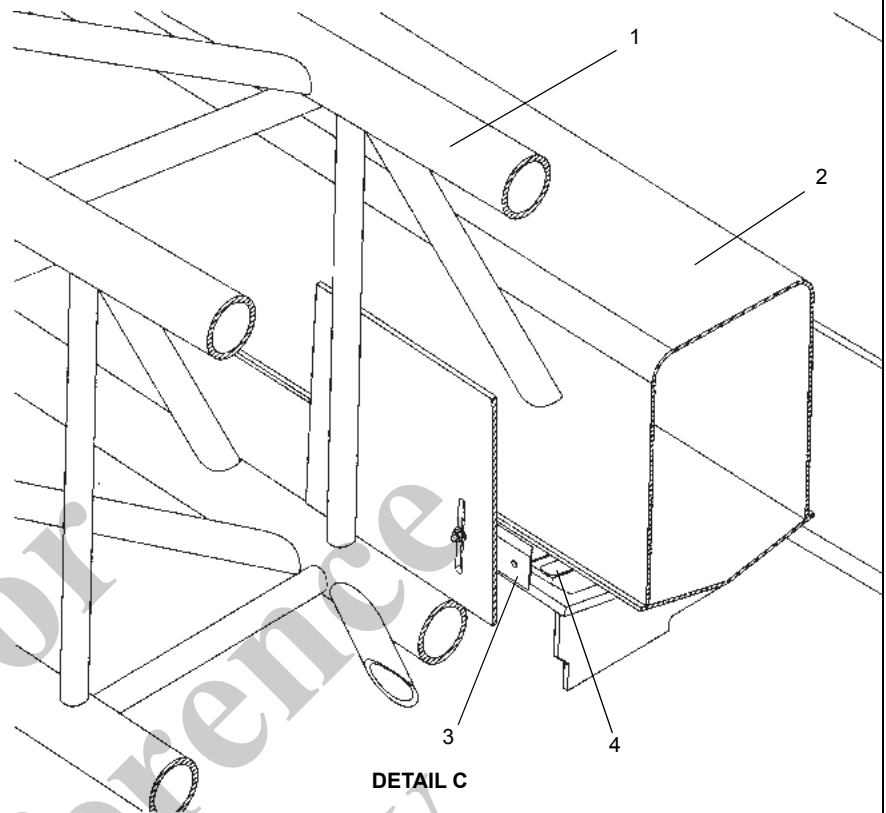
Item	Description
1	Boom Extension Fly Section
2	Adjusting Bolt
3	Adjusting Bolts
4	Front Mount
5	Hanger



DETAIL B

FIGURE 4-62 continued

Item	Description
1	Boom Extension Base Section
2	Boom Extension Fly Section
3	Shock Wear Pad and Shim
4	Ramp Wear Pad and Shim



Item	Description
1	Boom Extension Base Section
2	Boom Extension Fly Section
3	Fly Attachment Pin and Hitch Pin
4	Adjusting Bolts
5	Pin Stowage Lug
6	Upper Support
7	Lower Mount Ramp
8	Wear Pad

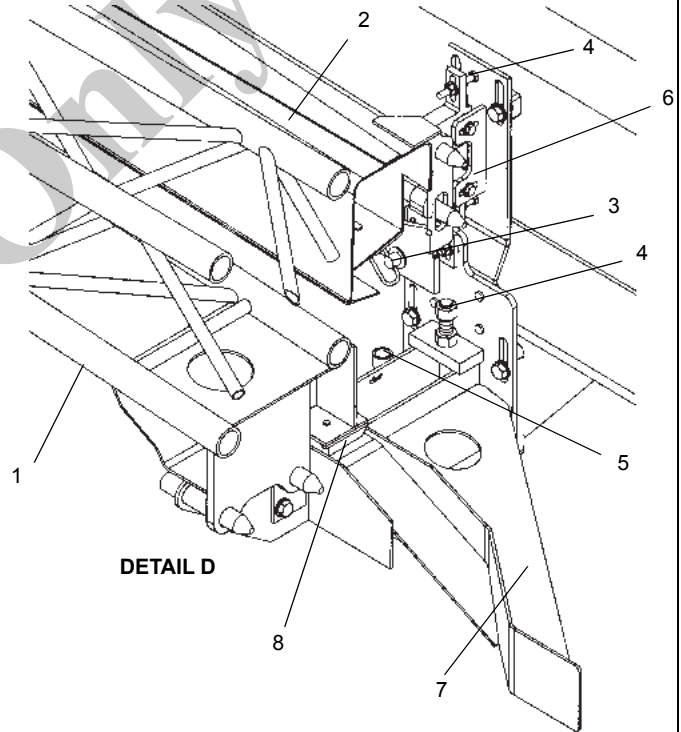
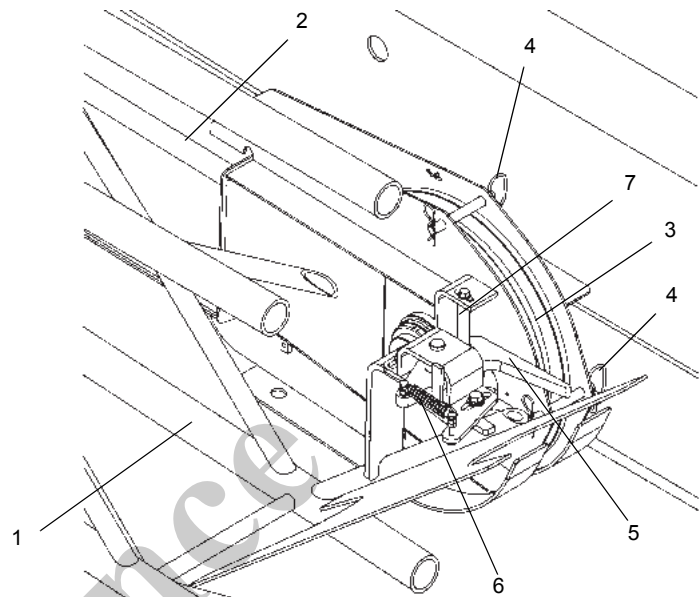


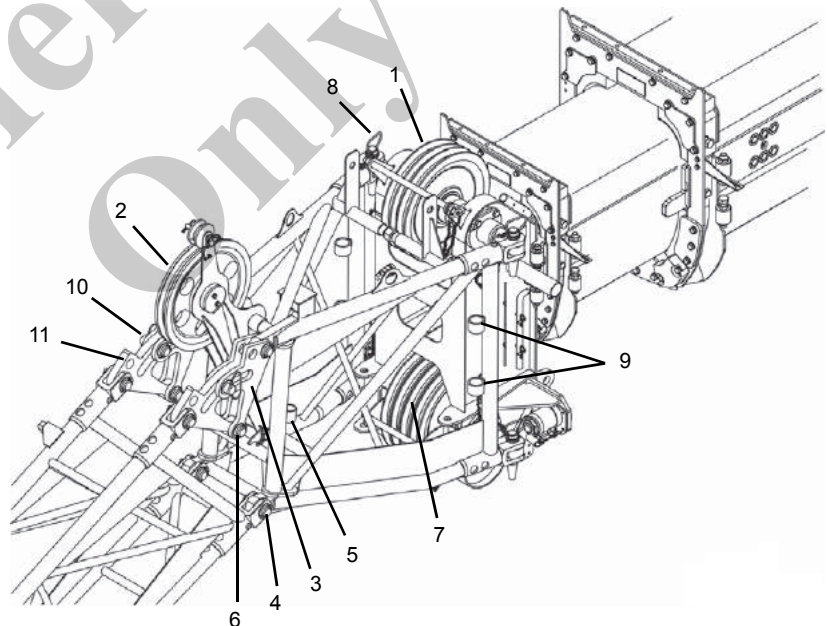
FIGURE 4-62 continued

Item	Description
1	Boom Extension Base Section
2	Boom Extension Fly Section
3	Fly Sheave
4	Cable Retainer Pins
5	Latch Hook
6	Spring
7	Latch Bar



DETAIL E

Item	Description
1	Boom Nose Upper Sheaves
2	Mast Assembly
3	Offset Links
4	Offset Pivot Points
5	Offset Link Pins Stowage Lugs
6	Mast Assembly Pin
7	Boom Nose Lower Sheaves
8	Boom Extension Attachment Pins
9	Boom Extension Attachment Pins Stowage Lugs
10	Offset Link Pins
11	Zero Degree Offset Holes



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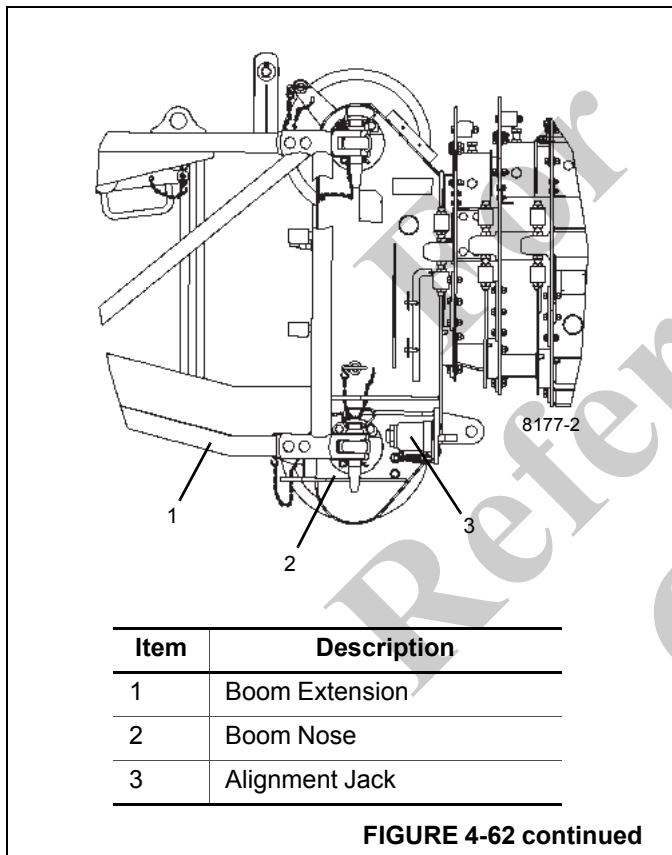
**NOTE:** Offset Shown At 25 Degrees. To Obtain 45 Degree Offset, Remove Pins (Item 10) and Stow in Lug.

**FIGURE 4-62 continued**

- 8. Pull down on the handle to disengage the spring loaded boom stop block. Place the end of the handle in the retainer plate. Fully retract the boom.

**NOTE:** When the boom retracts, the handle will be released allowing the stop block to engage when the boom is extended.

**NOTE:** The length indication on the rated capacity limiter (RCL) will display 0 (zero) when the spring-loaded stop block is in the working position (engaged) and the boom is fully retracted. During the process of stowing and erecting the boom extension, the RCL may display a negative dimension when the stop block is retracted (disengaged) and the boom is fully retracted.



- 9. Remove the retainer clips from the attachment pins stowed in the base of the boom extension and insert the attachment pins through the attachment and anchor fittings on the right side of the boom nose. Install the retainer clips in the attachment pins.

**CAUTION**

If the boom extension fly section (stinger) is not to be erected, it should remain on the stowage brackets on the side of the boom.

- 10. Attach a length of rope to the extension base section tip to aid in the extension of the swingaway into place ahead of the boom nose.

**NOTE:** If erecting the boom extension fly section with the boom extension base section, skip to step 15. If not erecting the boom extension fly section, perform steps 11 to 14.

- 11. Remove retainer clip from base to fly attachment pin and remove attachment pin from base section to fly section attachment fittings.
- 12. Stow the pin in the opposite attach fitting or the stowage lug.
- 13. Ensure the pin attaching the fly section to the boom base section rear stowage bracket (Figure 4-62), (Detail D) is in place.
- 14. At fly section sheave end Figure 4-62, (Detail E) push in on the spring loaded latch hook to release latch, allowing the base to separate from the fly. Skip to step 16.
- 15. Remove the pin attaching the fly extension section to the boom base section rear storage bracket ((Figure 4-62), (Detail D)). Ensure that the latch hook at the fly section sheave end ((Figure 4-62), (Detail E)) is latched.
- 16. Remove the lock hitch pin securing the extension base to the front stowage bracket ((Figure 4-62), (Detail A)). Stow lock hitch pin in lug provided.
- 17. Raise the boom to slightly above horizontal, then extend the boom until the extension is clear of the guide ramps and stowage pins on the front and rear stowage brackets.



**DANGER**

When erecting the boom extension, ensure that all personnel and equipment are kept clear of the swing path.

- 18. Slightly raise and/or lower the boom to help control the extension. Using the rope attached to the tip of the extension, swing the extension into place ahead of the boom nose, engaging the anchor fittings with the attachment fittings on the left side of the boom nose.



**DANGER**

Do not modify the attach points to permit the installation of the attach pins.

- 19. Install the attachment pin into the upper left anchor and attachment fitting of the boom nose. Install retainer clip in attachment pin.



20. Extend the boom extension alignment jack until the lower left side boom nose and boom extension adapter lugs are aligned; install the attachment pin into the lower left anchor and attachment fitting of the boom nose. Install retainer clip in attachment pin.
21. Retract the alignment jack to its original position, then return the jack handle to its stowed position.
22. Extend the boom until it automatically stops.
- NOTE:** Reaching this stopping point is required for the Boom Extension Rigging Mode process.
23. Lower the boom and remove the rope from the tip of the extension base section.

**DANGER**

Do not attempt to erect the fly section unless it was attached to the boom extension base section during the initial erection procedure.

24. Retract the boom until it stops on the stop block.
- NOTE:** When the boom reaches this stopping point and the section 1 and section 2 proximity switches are activated, the Boom Extension Rigging Mode is complete and the restrictions on the boom operating modes are removed.
25. Connect RCL cables:
- Remove RCL cable end connector (1) Figure 4-63 from extension and route through boom extension.

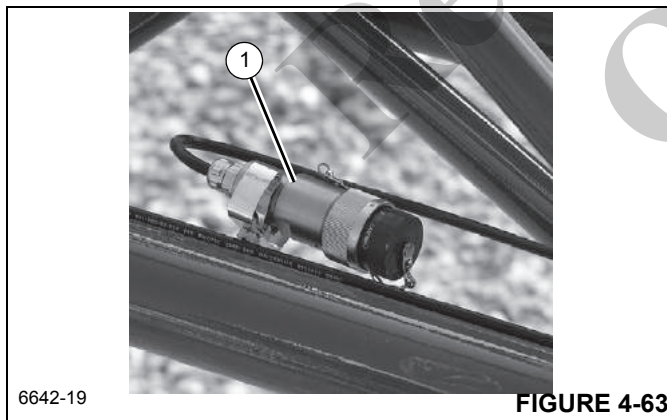


FIGURE 4-63

- Remove dummy plug (1) Figure 4-64 from junction box on boom nose.

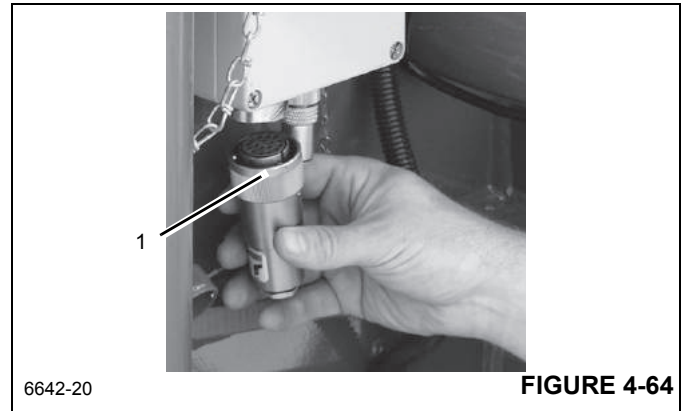


FIGURE 4-64

- Install cable end connector (1) Figure 4-65 from boom extension where dummy plug was removed.

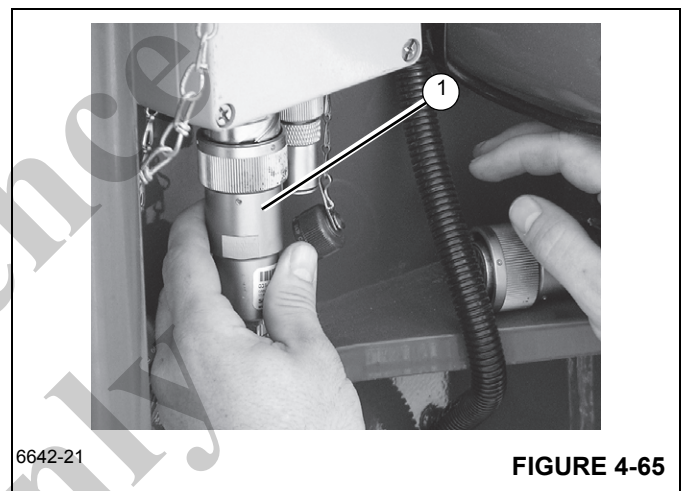


FIGURE 4-65

26. Erect the boom extension fly section as follows:
- Attach a length of rope to the tip of the extension fly section to aid in swinging the fly into place ahead of the base section. Ensure that the right base to fly extension attachment pin is in place.
  - Position the boom to horizontal.
  - At the fly section sheave end (see detail E), push in on the spring loaded latch hook to release the latch allowing fly to separate from the base.

**DANGER**

When erecting the extension fly section, ensure that all personnel and equipment are kept clear of the swing path.

- Slightly raise and/or lower the boom to help control the extension fly. Using the rope attached to the tip of the fly section, swing the fly into place ahead of the extension base, engaging the anchor fittings with the attachment fittings on the left side of the base section.



- e. Install the attachment pin into the anchor and attachment fittings on the left side of the base section.
- f. Lower the boom and remove the rope from the tip of the extension.

**NOTE:** Refer to *Setting the Folding Swingaway Offset*, page 4-54 to obtain a 25 or 45 degree offset with the swingaway.

- 27. Remove the cable retainer pins and clip pins from the tip of the extension base section or extension fly section.

**NOTE:** For zero (0) degree offset, leave the mast assembly in the stowed position.

- 28. Remove the mast assembly clip pin and pin from the stowed position on the extension and raise the mast assembly to an upright position. Install the pin and clip pin. Remove the cable retainer pin and clip pin from the mast.

**NOTE:** The hoist cable is not routed over the base extension sheave when using the fly extension.

- 29. Route the hoist cable over the mast sheave, the rollers on the adapter, the roller on the fly extension, and the sheave on the extension tip. Install the cable retainer pins and clip pins.

**NOTE:** Do not reeve hoist cable through sheaves on the main boom nose.

- 30. Rig the hoist cable.

### Stowing the Boom Extension

**NOTE:** The boom extension must be set at the zero (0) degree offset. Refer to *Setting the Folding Swingaway Offset*, page 4-54.

**NOTE:** If so equipped, the folding fly section must be stowed on the side of the base section.

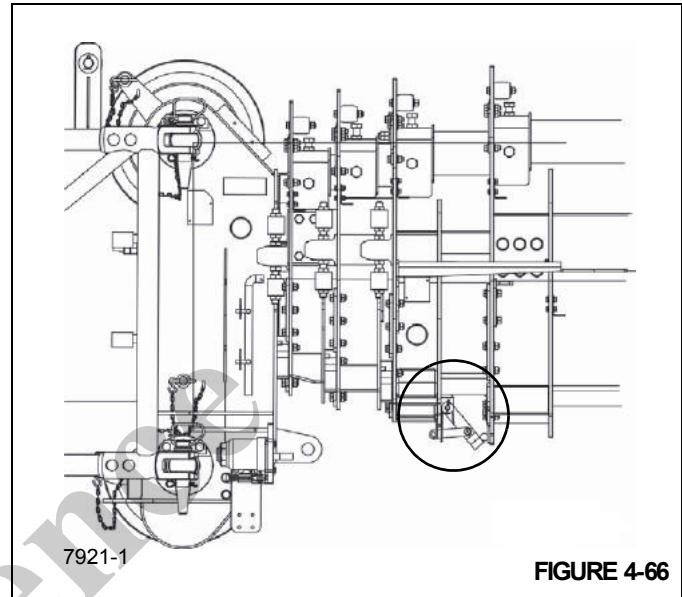


### DANGER

During disengagement of the stop block, extend the boom only enough to free the block. Extending the boom too far will cause the base extension to slide off the guide ramps and allow the extension to swing.

1. Fully retract the boom and swing it over the front.
2. Set the boom manual/automatic mode selector switch to the AUTO position.
3. Set the boom A/B mode selector switch to the B mode.

4. Lower the boom, then extend the boom only enough to disengage the spring loaded boom stop block.
5. Pull down on the handle to disengage the spring loaded boom extension stop block (Figure 4-66). Place the end of the handle in the retainer plate.

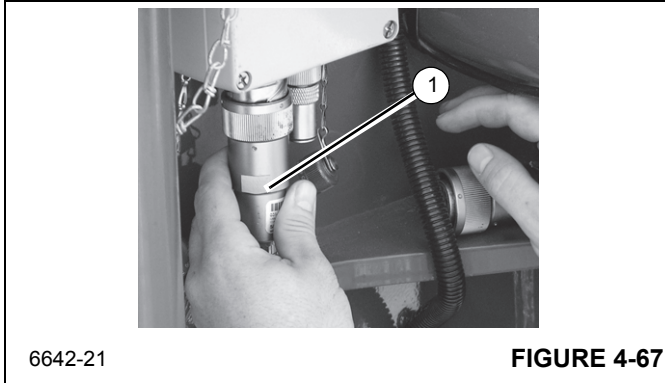


6. Fully retract the boom.

**NOTE:** When the boom retracts, the handle will be released allowing the stop block to engage when the boom is extended.

**NOTE:** The length indication on the rated capacity limiter (RCL) will display 0 (zero) when the spring-loaded stop block is in the working position (engaged) and the boom is fully retracted. The RCL may display a negative dimension when the stop block is retracted (disengaged) and the boom is fully retracted during the process of stowing and erecting the boom extension.

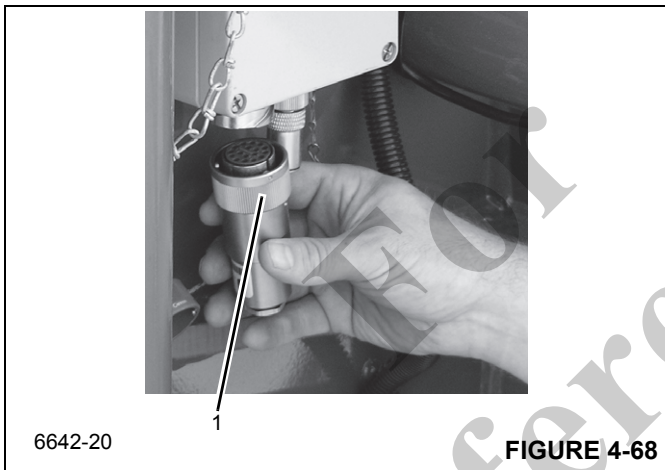
7. Lower the boom to minimum elevation.
8. Remove the cable retainer pins and clip pins from the swingaway tip and mast assembly. Remove the hoist cable from the extension sheave and or mast. Install the cable retainer pins and clip pins.
9. Remove the mast assembly pin and clip pin securing the mast in the upright position. Lay the mast over to the stowed position and install the mast assembly pin and clip pin.
10. Disconnect RCL cable.
  - a. Remove connector (1, Figure 4-67) from junction box on boom nose.



6642-21

FIGURE 4-67

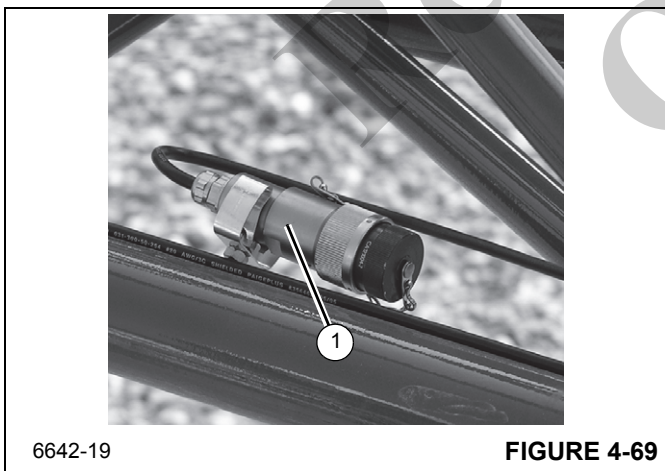
- b. Install dummy plug (1, Figure 4-68) on junction box.



6642-20

FIGURE 4-68

- c. Route cable through boom extension and stow connector (1, Figure 4-69).



6642-19

FIGURE 4-69

11. If erected, stow the extension fly section as follows:
- Attach a length of rope to the fly extension tip.
  - Raise the boom to horizontal.
  - Remove the retainer clip and attachment pin from the anchor and attach fittings on the left side of the base section and stow in the base section.

### DANGER

When stowing the extension fly, ensure that all personnel and equipment are kept clear of the swing path.

- Slightly raise and/or lower the boom to help control the extension fly. Using the rope attached to the tip of the fly section, swing the fly to the side of the base section.
  - Elevate the boom and push in on the fly section to engage the spring loaded latch hook (Detail E) on the base section. Ensure the latch hook is properly engaged.
  - Lower the boom and remove the rope from the fly section.
- Lower the boom to minimum elevation.
  - Attach a length of rope to the base extension tip.
  - Raise the boom to horizontal.
  - Extend the boom approximately 12 in so that the extension base and fly stowage lugs will line up in front of the guide ramps and pins on the stowage brackets when the swingaway is positioned to the side of the boom.
  - Extend the boom extension alignment jack until the bottom left side attachment pin is free. Remove the bottom left side boom retainer clip pin and attach pin.
  - Retract the alignment jack to its original position, then return the jack handle to its stowed position.
  - Pull down on the handle to disengage the spring loaded boom stop block. Place the end of the handle in the retainer plate.
  - Remove the retainer clip and attach pin from the anchor and attachment fitting on the top left side of the boom nose; stow all pins in the base of the base extension.

### DANGER

When stowing the extension, ensure that all personnel and equipment are kept clear of the swing path.

- Raise and/or lower the boom to help control the swingaway and using the rope attached to the tip of the base extension, swing the base extension to the side of the boom.
- Elevate the boom and push in on the extension to align the stowage lugs on the extension with the guide ramps and pins on the stowage brackets and fully retract the boom.

22. Ensure that all of the stowage lugs on the base and fly are fully engaged with the pins on the stowage brackets.
  23. Fully lower the boom.
  24. Install the pin securing the extension base to the front stowage bracket Figure 4-8, (Detail A). Ensure the lock hitch pin is pushed all the way in.
  25. Install the pin attaching the fly section to the boom base section stowage bracket (Figure 4-62), (Detail D).
- NOTE:** If the extension fly section remained on the boom stowage brackets, perform steps 26 through 29.
26. Remove retainer clip and attachment pin from the bushing on base section.
  27. Insert the attachment pin into the base section to fly section attachment fittings and install the retainer pin.
  28. Ensure the spring loaded latch hook is engaged on fly section sheave end (Figure 4-62), (Detail E).
  29. Ensure the pin attaching the fly section to the boom base section stowage bracket (Figure 4-62), (Detail D) is in place.
  30. Remove the retainer clips and attachment pins from the anchor and attach fittings on the right side of the boom nose and stow them in the base of the swingaway.

**DANGER**

Failure to maintain the proper clearance between the base extension anchor fittings and the boom nose attach fittings could cause these fittings to contact each other during operation of the boom.

31. Extend the boom in AUTO mode with B mode selected, or Manual Mode with Section 1 selected, until the boom stops.

**NOTE:** Reaching this stopping point is required for the Boom Extension Rigging Mode process.

32. Retract the boom until it stops on the stop block.

**NOTE:** When the boom reaches this stopping point and the section 1 and section 2 proximity switches are activated, the Boom Extension Rigging Mode is complete and the restrictions on the boom operating modes are removed.

33. Rig the boom nose and hoist cable as desired and operate the crane using normal operating procedures.

**Setting the Folding Swingaway Offset****DANGER****Crushing Hazard!**

Ensure any blocking material used is adequate to support the weight of the extension assembly without tipping or falling.

1. Extend and set the outriggers and swing the boom to over the front. Position the boom to above horizontal.
2. Block under the tip of the extension assembly section.
3. To set the offset from a lesser degree to higher degree perform the following procedures:

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

Do not overload the extension anchor fittings or the extension base section when lowering the boom.

- a. Slowly lower the boom until the pressure is relieved on the offset link pins.
- NOTE:** For 25 or 45 degree offset, make sure the mast is in the raised position.
- b. Remove the offset link clip pins and attach pins securing the offset links in the lesser degree offset position. If going to maximum offset stow them in the stowage lugs. If going to the intermediate (25 degree) offset install them in the offset links for that degree of offset.
  - c. Slowly elevate and telescope the boom at the same time so that the extension does not move off of the blocking until the offset links take the full weight of the extension.
  - d. Reeve the hoist cable as described under normal erecting procedures.
4. To set the offset from higher degree to lesser degree, perform the following procedures:

**CAUTION**

Do not overload the extension anchor fittings or the extension base section when lowering the boom.

- a. Slowly lower the boom until the pressure is relieved from the offset links.
- b. Remove the offset link clip pins and attachment pins and lower the boom until the holes for the lesser

degree offset position align in the offset links. Install the offset pins and clip pins.

- c. Slowly elevate and telescope the boom at the same time so that the extension does not move off of the blocking until the offset links take the full weight of the extension.
- d. Reeve the hoist cable as described under normal erecting procedures.

### Boom Extension Alignment Device Adjustment

1. Ensure the boom extension and retraction cables are properly adjusted. If necessary, adjust the cables.
2. Fully retract the boom.
3. Following the boom installation procedures, install the pins into the boom attachment lugs on the right side of the boom nose and secure in place with the retainer clips.
4. Following the boom installation procedures, swing the boom extension around and install the pin in the upper left boom extension lug and secure in place with the clip pin.

If the pin cannot be installed because of lateral misalignment, adjust the upper cross strut adjustment screw on the swingaway adapter to align the holes.

5. Extend the boom extension alignment jack until the lower left side boom nose and boom extension adapter lugs are aligned; install the attachment pin into the lower left lug and attachment fitting of the boom nose. Install retainer clip in attachment pin.

If the attachment pin cannot be installed because of lateral misalignment, adjust the lower cross strut adjustment screw on the extension adapter to align the holes.

6. Secure the adjustment bolt in place by tightening the collar clamp.

### Swingaway Mounting Adjustment

The following procedures may be used to adjust the existing installation or for installing a new swingaway and/or stinger. For the referenced details in text, refer to Figure 4-62.

1. With the swingaway base laying on the ground or cribbing, use an adequate lifting device to place the stinger on the side of the base and install the one attach pin.
2. Raise the sheave end of the stinger until the attach pin installed in step 1 is loose. Install the ramp wear pad Figure 4-62 (Detail C) on the bottom of the stinger and

shim to provide a clearance of 12 mm (0.5 in) between wear pad and ramp on swingaway base.

3. Install the shock wear pad Figure 4-62 (Detail C) on the extension base bracket. Shim the wear pad to provide a clearance of 3 mm (1/8 in) between shock wear pad and ramp wear pad installed in step 2.
4. With the stinger supported on the base ramp wear pad and held tight against the shock wear pad, adjust the stinger latch hook Figure 4-62 (Detail E) so that a 4 mm (5/32 in) clearance is maintained between the hook and the latch bar.
5. Remove the stinger from the side of the extension base.
6. Disengage the boom stop and fully retract the boom.
7. Mount the extension base of the right side on the boom base and install the pins attaching the extension base to the boom nose.
8. Loosen the front and rear stowage bracket attaching hardware.
9. Lift the sheave end of the extension base until the attachment pins installed in step 7 are loose. Refer to Figure 4-62 (Detail D) (rear stowage bracket) and adjust the lower mount and the pin mount to maintain a loose condition of the attachment pins. Tighten all rear stowage bracket attaching hardware.
10. Refer to Figure 4-62 (Detail A) (front stowage bracket) and adjust the main hanger, upper hanger, and lower support to maintain a loose condition of the attachment pins.
11. Move the extension base away from the boom base and mount the stinger on the extension base using one attach pin. Position extension base on stowage brackets on side of boom.
12. Lift up on sheave end of stinger until attachment pin is loose and stinger is 3 mm (1/8 in) from shock wear pad at the ramp Figure 4-62 (Detail C).
13. Refer to detail B (stinger front stowage bracket) and adjust the front mount and hanger to maintain the attachment pin in a loose condition.
14. Refer to Figure 4-62 (Detail D) (rear stowage bracket) and adjust the stinger upper hanger and lower hanger to maintain the attachment pin in a loose condition.
15. Some final adjustment of the stinger latch may be required. With the extension base and stinger in the final stowed position on the stowage brackets, ensure there is approximately a 3 mm (1/8 in) clearance between the shock wear pad and the ramp wear pad on the stinger Figure 4-62 (Detail C). In addition, the stinger latch must be free (approximately a 1.5 mm (0.06 in) clearance between the surfaces of the latch hook and the latch bar.

## HOOK BLOCK

### Description

A 60 t (65 US ton) hook block and a 7.5 t (8.3 US ton) overhaul top swivel ball are available for the crane. The hook block utilizes a one-piece pivot block and the hook is equipped with a safety latch. The hook block is of quick-reeve design and meets ANSI B30.5 and CE standards. The hook block weighs 850 kg (1275 lb). Grease fittings are provided to ensure lubrication of all moving parts.

### Maintenance

#### *Periodic Maintenance*

It is recommended that the hook block 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 hook blocks 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

## SECTION 5 HOIST AND COUNTERWEIGHT

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### DESCRIPTION

One standard hoist is available for both the main and auxiliary, the GHP30A Figure 5-2. 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

Flow from section one of pump number one is routed through the swivel to the directional control valve bank.

When the main hoist control lever in the cab is moved from neutral, it sends a pilot pressure signal to the main hoist directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve internally routes the hydraulic flow to the hoist motors in a series or parallel hydraulic circuit as selected by the operator.

When the auxiliary hoist control lever in the cab is moved from neutral, it sends a pilot pressure signal to the auxiliary hoist directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve internally routes the hydraulic flow to the hoist motors in a series or parallel hydraulic circuit as selected by the operator.

Additional flow (high speed boost) is obtained by using the Hydraulic Boost Switch. Positioning the switch to HI allows



the flow from section two of pump number one to combine with flow from section one.

## MAINTENANCE

### Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below 4°C (40°F).

The prime mover 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

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.

## Hoist Area Access

### WARNING

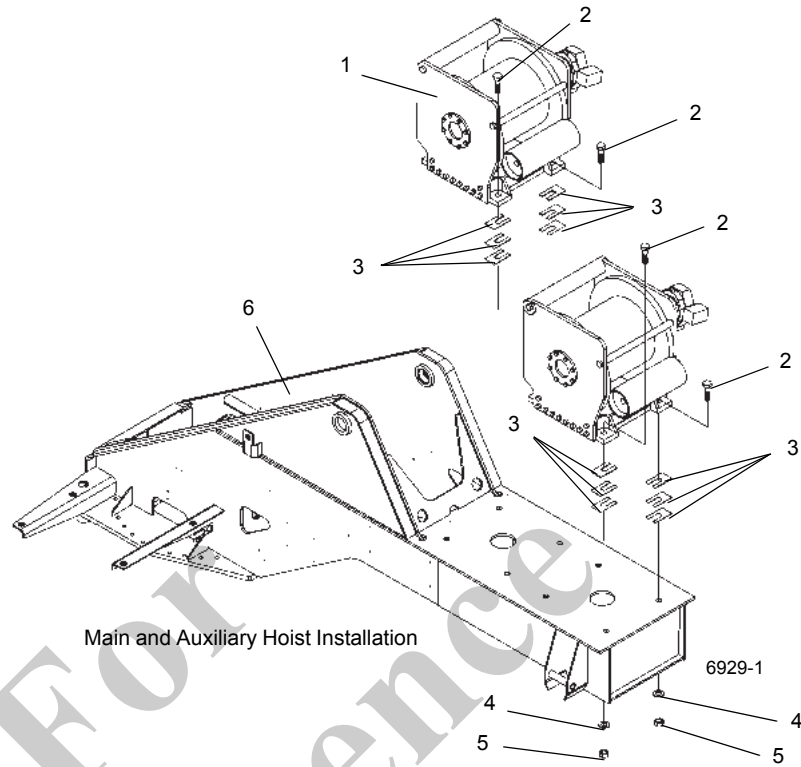
Platform must not be used for hauling passengers as death or serious injury could occur.

No storage of components are allowed on the platform.

Only one person at a time is allowed on the platform.

Use the hoist access platform (1) (Figure 5-1) when working in the hoist area.

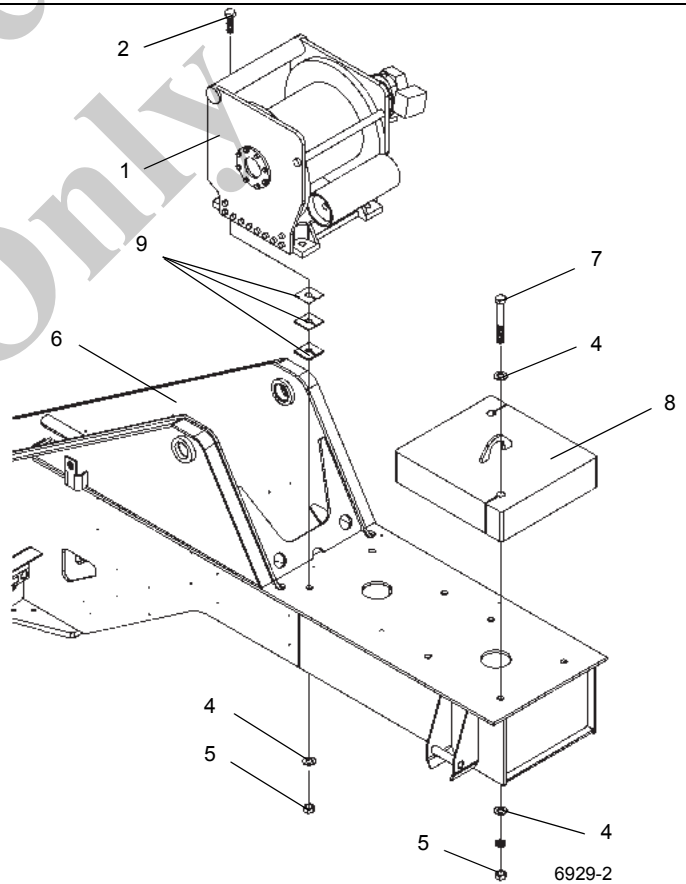




Main and Auxiliary Hoist Installation

6929-1

Item	Description
1	Hoist
2	Capscrew
3	Shim
4	Washer
5	Nut
6	Turntable
7	Capscrew
8	Counterweight Plate
9	Shim



Main Hoist Only Installation

6929-2

FIGURE 5-2

Item	Description
1	Hoist
2	Capscrew
3	Shim
4	Washer
5	Nut
6	Turntable
7	Capscrew
8	Counterweight Plate
9	Shim

## 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 control valve.
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 1400 lb (635 kg).

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

## 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 5-9 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 1-16 for proper torque value.
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 control valve as marked during removal.
12. Connect the electrical wires to the hoist rotation indicator sensor as tagged during removal.
13. 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.

## Fluid Level

**NOTE:** Failure to align the fill/drain plug (1) with the upper access hole (2) as shown in Figure 5-3 prior to checking the oil level will result in an inaccurate reading.

1. Rotate the hoist drum until the fill/drain plug (1) appears in the upper access hole (2) shown in Figure 5-3.

This will ensure that the planetary gears are in proper alignment and will permit an accurate reading of the oil level in the hoist.

2. Allow the hoist to stand idle for 20 minutes before checking the oil.
3. The oil level should be visible in the sight glass (3).

Table 5-1

Reading	Diagnosis	Action Required
Oil is not visible in the sight glass.	The hoist is under filled.	Fill the hoist with oil from the upper access hole until the oil level rises within the sight glass. Do not fill above 3 mm (1/8 in) from the top of the site glass. Refer to <i>Hoist</i> , page 9-30 for the correct type of oil.
Oil is visible in the sight glass and the level is no more than 3 mm (1/8 in) from the top of the sight glass.	The oil level is correct.	No action is required.
Oil level is more than 3 mm (1/8 in) from the top of the sight glass or the oil is escaping from the vent plug (4).	The hoist is overfilled.	Drain the hoist drum from the upper access hole until the oil level falls to within 3 mm (1/8 in) from the top of the sight glass.

Compare your reading with (Table 5-1) and take the required action.

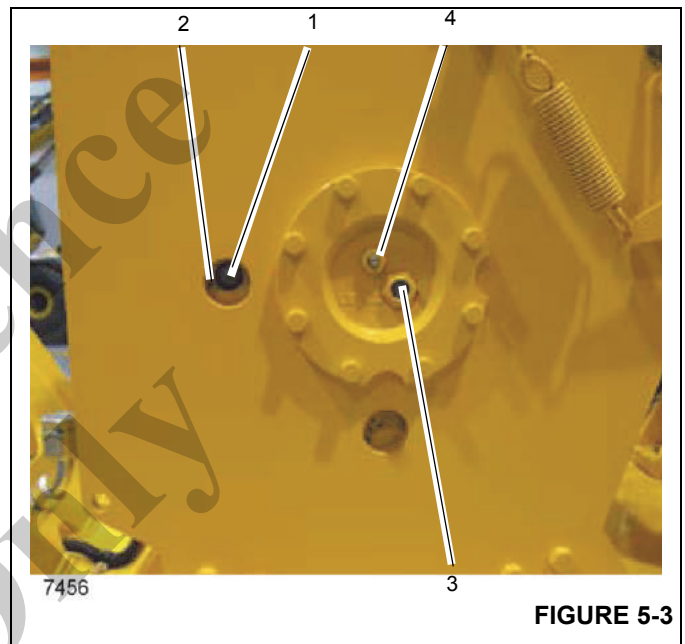


FIGURE 5-3

A comprehensive hoist line pull and load holding test must be carried out following any such repair work.

Manitowoc Crane Care offers prepackaged kits that include all the seals, bearings, fasteners, washers, brake disks, brake stators, sprag clutch, and springs that are required for reassembling the hoist after inspection. During the inspection, if components not included in the kit are found to be worn or damaged, contact your Manitowoc Cranes distributor or Manitowoc Crane Care to order replacement.

**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.



**WARNING**

Failure to implement and adhere to a hoist inspection and maintenance program may result in damage to the crane, other property damage, and/or serious injury or death to persons working on or near the crane.

The following should be carried out following instructions in *Lubricants and Lubrication Intervals*, 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 *Lubricants and Lubrication Intervals*, 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 5-7 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 5-7. Refill the hoist to the proper level with recommended lubricant. Refer to *Lubricants and Lubrication Intervals*, 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 *Lubricants and Lubrication Intervals*, 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 must be completed before attempting hoist alignment Figure 5-5. 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 for cranes that have the hoist mounted either directly to the boom or on a mount attached to the boom. 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 degree 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 in it during spooling if the alignment is not correct.

**NOTE:** 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 cat gut 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.

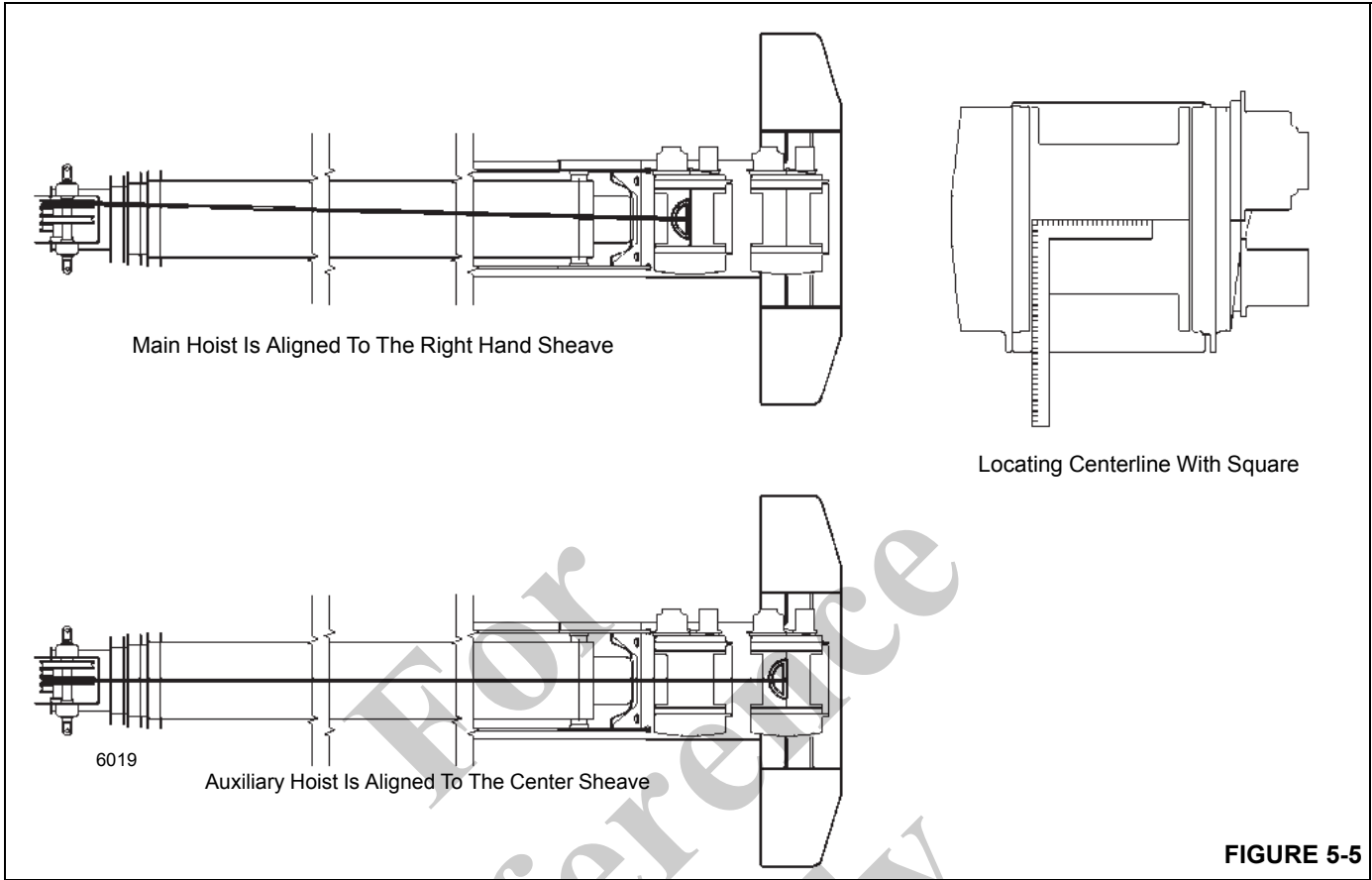
**NOTE:** This test is for cable leaving gaps while spooling.

### 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. Damage to the hoist or wire rope may result.

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.



Reference Only

## 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.
3. Tag and disconnect the hydraulic lines from the motor and the brake valve. Cap or plug all lines and openings.
4. Remove the two bolts and washers 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.

5. Cover the motor opening in the brake cylinder to protect drive components inside the hoist drum. As needed, secure the brake clutch from 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 to the inner race of the brake clutch when installing the motor and attached brake valve. Apply Loctite No. 243 to the bolts for the motor. Secure the motor and brake valve to the brake cylinder with bolts and washers. Torque bolts to 382 Nm (282 lb-ft).
4. Connect the hydraulic lines to the motor and brake valve as tagged during removal.
5. Fill the drum with oil. Refer to *Lubrication*, page 9-1 in this manual.

Reference Only

## IDLER DRUM AND CABLE FOLLOWER

### Description

The main and auxiliary hoists (Figure 5-6) are each equipped with an idler drum 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 is mounted on the forward 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 and end cap from the right side of the idler roller Figure 5-6.
2. Support the idler roller and withdraw the shaft from the left side. Take care not to lose the shim(s) on each 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 with at least one shim on each end.
2. Install the shaft through the left side plate and the roller and shims. Ensure the flat on the shaft end aligns with the stop welded on the side plate.
3. Apply Loctite 243 to the bolt threads. Secure the shaft to the right side plate with a bolt and end cap.

#### Cable Follower

#### Removal and Disassembly

1. Loosen the adjusting nuts and remove the tension spring and adjusting rod from both sides of the hoist Figure 5-6.
2. Remove the tack welds from the bolt heads securing the arm to the cable follower roller.
3. 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.

4. Disassemble the cable follower roller as follows.
  - a. Remove the two bolts and washers securing the angle to the right side of the shaft.
  - b. Remove the shims and roller from the shaft.
  - c. If necessary, remove the bearing and bearing housing from both ends of the roller.
5. 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.

6. Remove the grease fittings from the bushing on each side plate.

#### Cleaning and Inspection

1. Clean all grease from the shaft, bearing, and roller.
2. Check the shaft, roller, and bearings 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 a grease fitting in the bushing on each side plate.
2. Install the left arm through the bushing on the left side plate. Apply Loctite 243 to the bolt threads. Install left spring attaching lever on the arm and secure with a bolt and locknut.
3. Repeat step 2 on the right side.
4. 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 and secure with four bolts and washers. Center the roller between the hoist drum flanges and tighten the bolts. Tack weld the bolt heads.
6. Attach one end of the tension springs to the levers on each side. Install the 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 springs.

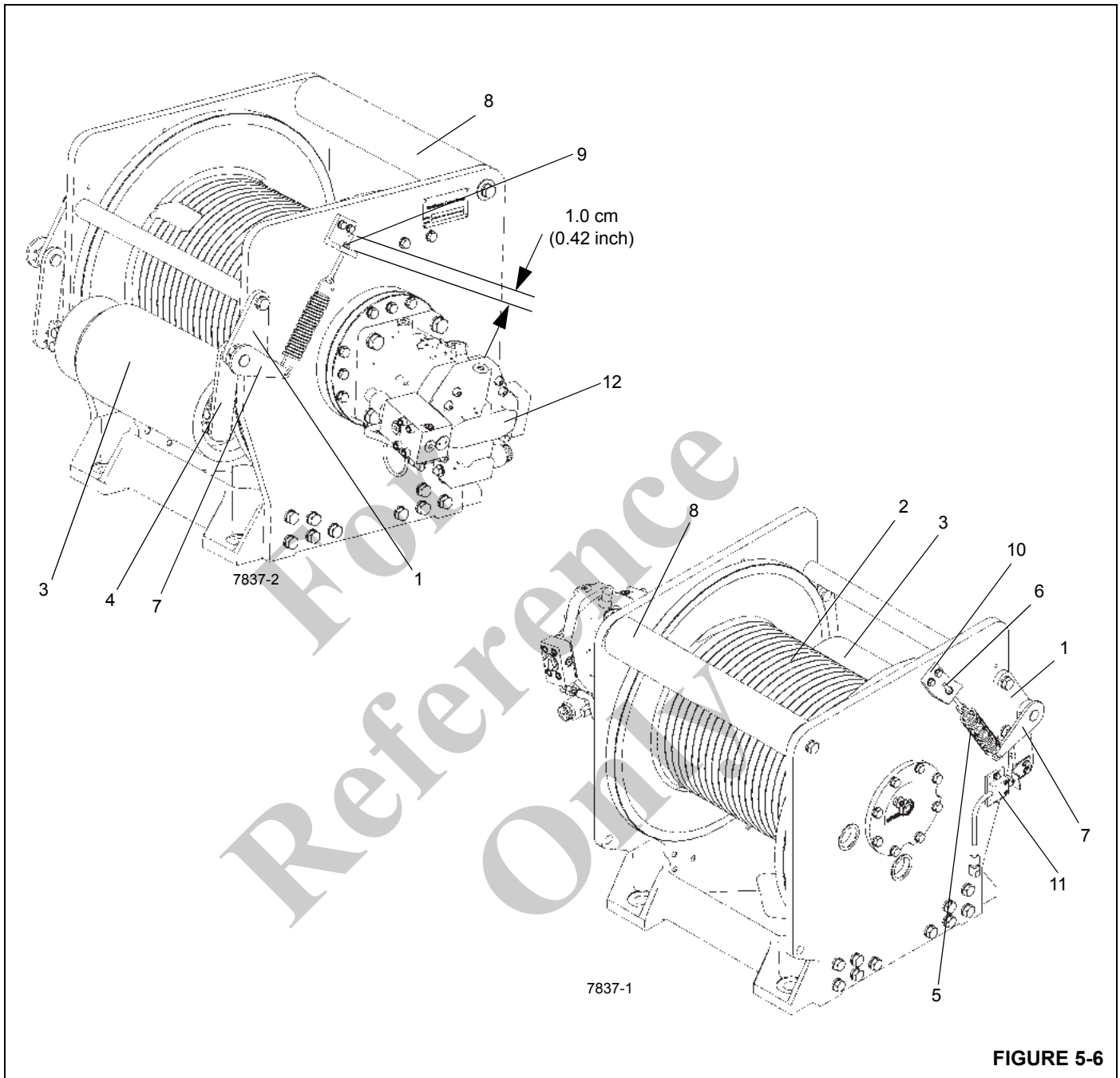


FIGURE 5-6

Item	Description
1	Pivot Bracket
2	Drum
3	Follower Roller
4	Arm
5	Spring
6	Spring Adjusting Rod

Item	Description
7	Lever
8	Idler Roller
9	Nut
10	Bracket
11	3rd Wrap Limit Switch (Optional)



7. Using a grease gun, apply grease to the fittings on each side plate bushing.
8. Adjust the roller as outlined in steps 9 and 10.
9. 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.
10. With a full drum of cable, the adjusting spring length from eye to eye should not exceed 10.12 in (25.7 cm). Adjust rods as necessary and tighten jam nuts to secure this setting.

### **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 assembly and remove the two bolts and washers securing each side plate to the hoist. Remove the idler drum and 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 the idler drum and cable roller 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 5-12.

For  
Reference  
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### THIRD WRAP INDICATOR (OPTIONAL— STANDARD ON CE)

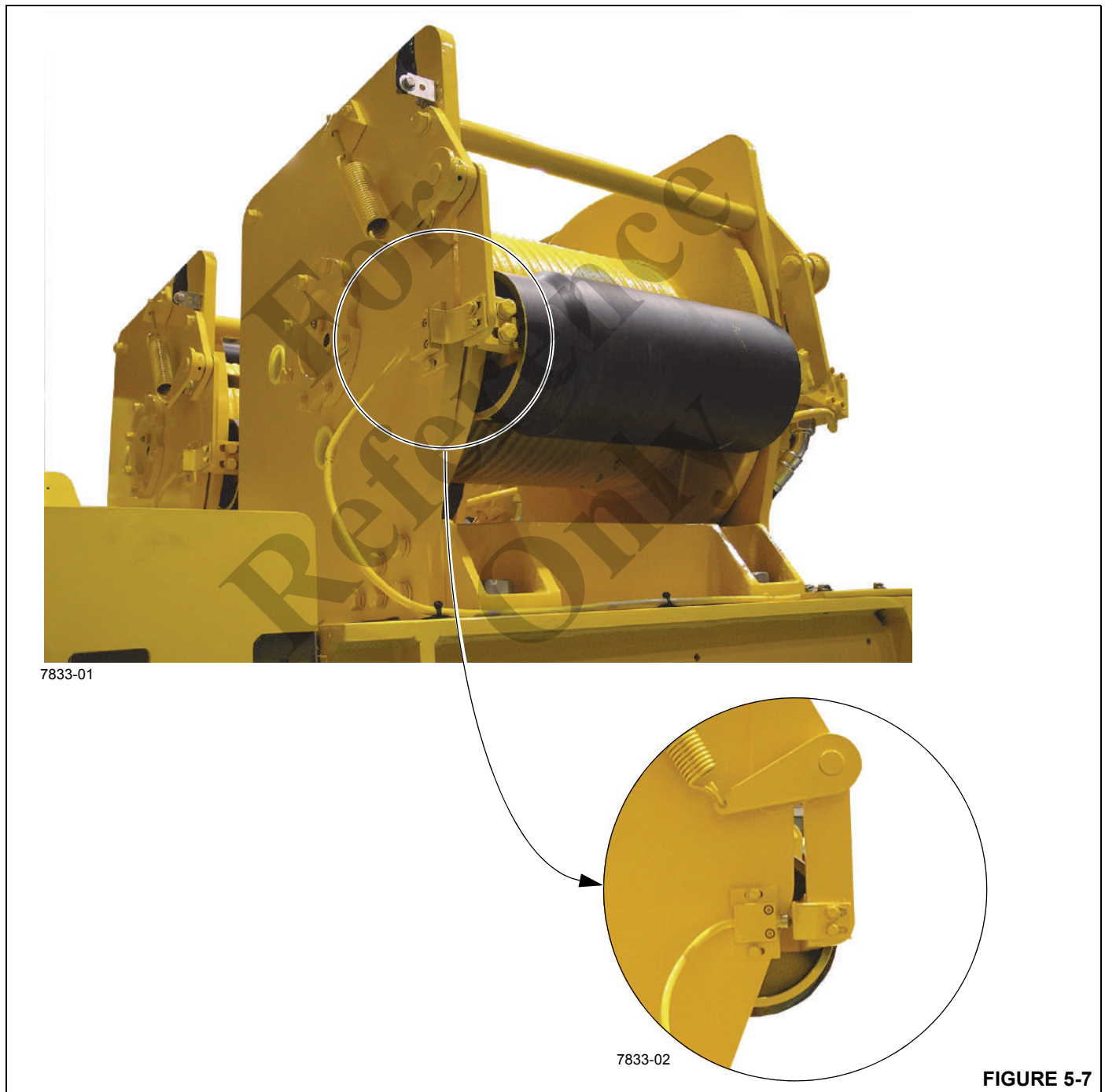
#### Description

The third wrap indicator (Figure 5-7) 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

illuminating when down to the third wrap, hoist down operation will be locked out.

#### Maintenance

The third wrap indicator switch mechanism must be adjusted such that only when the hoist has three wraps of cable remaining on the drum, the switch is actuated. Once adjusted properly, ensure there is no continuity through the switch when actuated and continuity through the switch when not actuated.



## HOIST ROTATION INDICATOR (HRI) AND DISPLAY SYSTEM

The HRI 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 system also includes a visual display located in the front overhead panel that indicates hoist rotation direction.

## HOIST DRUM ROTATION INDICATOR SYSTEM

### Description

The hoist drum rotation indicator system Figure 5-9 is an electrically operated system that provides the operator with a touch indication of drum rotation so the operator will know if and at what speed the hoist drum is rotating, even under the most distracting conditions.

The drum rotation indicator system consists of the drum rotation sensor and thumb thumper solenoid. The drum rotation sensor is located on the hoist Figure 5-9 and senses the rotation of the primary drive end driven gear. The pulsing thumb thumper solenoid is located in the applicable hoist control lever handle Figure 5-9. Actuation of the thumb thumper is controlled by the CAN bus system from input supplied by the drum rotation sensor. The thumb thumper solenoid provides feedback proportional to the hoist line speed by pulsing the rubber button on top of the hoist controller. The thumb thumper will cease operation at high line speeds to prevent damage to the solenoid.

### Maintenance

#### General



### DANGER

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). To determine which component is at fault, refer to the troubleshooting section of your CAN bus CD.

### Troubleshooting

**NOTE:** This machine incorporates a CAN bus Multiplex system. In order to effectively troubleshoot the electrical system, you will need a Windows-based PC, CAN-link service software (9999102409), and a connection cable (9999102296). The CAN-Link service software and connection cable are available through Manitowoc Crane Care to those service technicians who have attended the Grove New Technology training course.

### Removal

1. Disconnect the wire at the drum rotation sensor.
2. Loosen the jam nut securing the drum rotation sensor and then remove the sensor.

### Installation

1. Turn the two jam nuts on the drum rotation sensor to produce 1.25 in. (31 mm) installed length of threads measured from the bottom of the sensor to the bottom jam nut Figure 5-8.

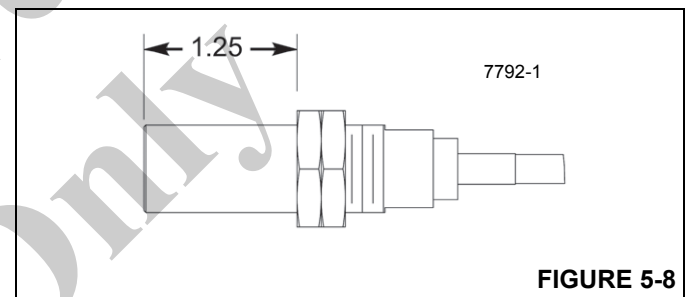
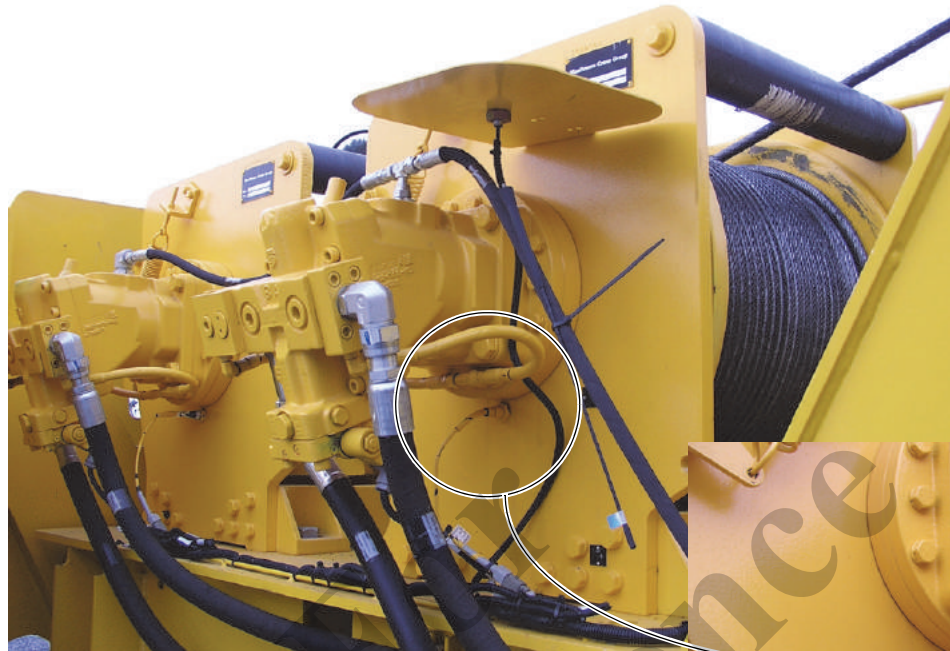
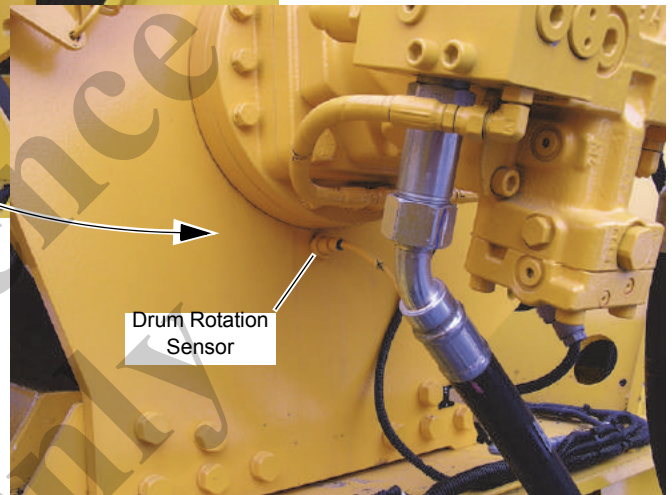


FIGURE 5-8

2. Hold the bottom jam nut with a wrench and tighten the top jam nut against it. Check the length of threads to be sure the installed length did not change.
3. Apply a small amount of general purpose grease to the threads and install the drum rotation sensor into the motor end-plate.
4. Using the outer jam nut, tighten the sensor until just snug to avoid damage to the sensor.
5. Connect the wire to the drum rotation sensor.



7792-2



7792-3

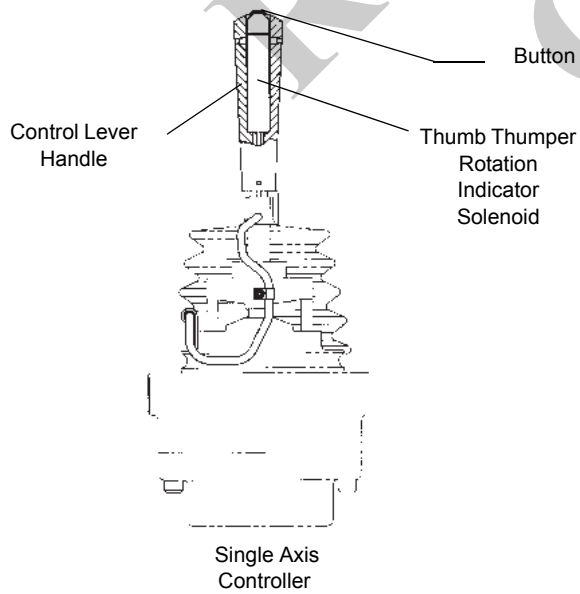


FIGURE 5-9

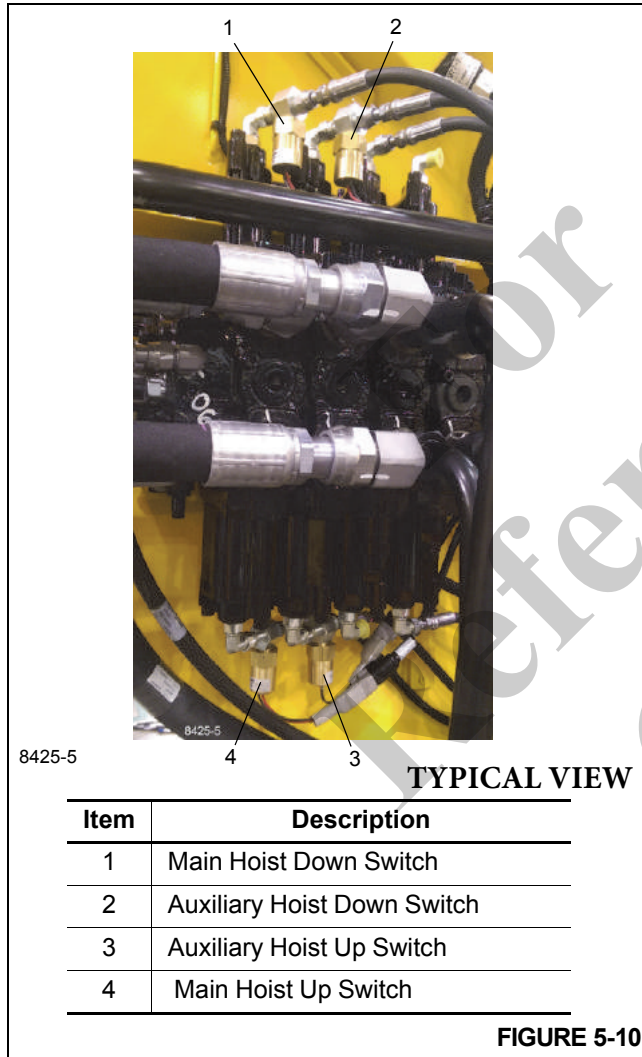


### Hoist Rotation Indicator (HRI) Display System

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 5-10. The switch contacts close at 75 psi (5.17 bar).



#### HRI Display

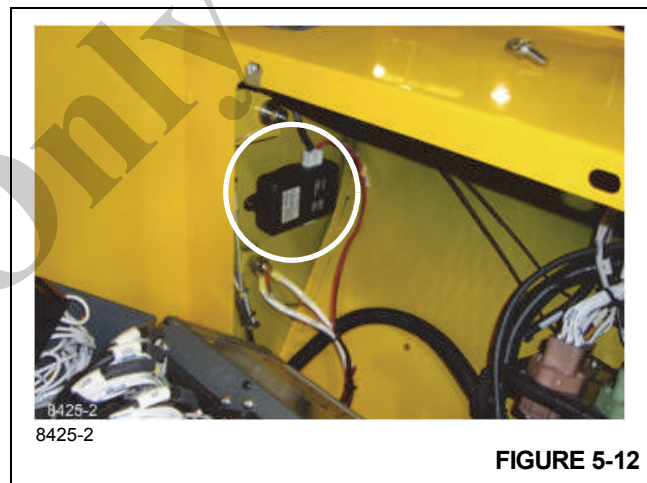
The display is located in the front overhead panel Figure 5-11.

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.

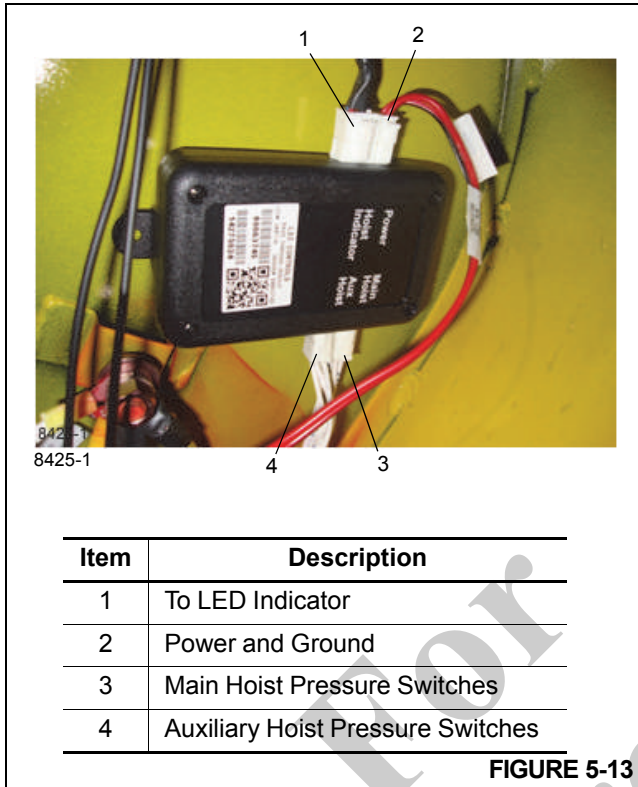


#### HRI Control Module

The control module is located in the fuse and relay panel behind the driver's seat in the cab Figure 5-12.



To replace the control module, tag and disconnect the wires from the module Figure 5-13. 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.



**Hydraulic Hoist Motor Control Valve**

The hydraulic hoist motor control valve is mounted on the hoist and is designed to provide an even flow of oil to the hoist motor in both directions. This is a different valve than the hoist motor control valve that applies and releases the hydraulic piston and hydraulic cylinder.

**Hoist Directional Control Valve**

The hoist directional control valve is used to control the operation of the hoist. It is a four-way, pilot operated valve and is mounted on the right side of the turntable.

**HOIST CONTROL VALVES**

**Description**

**NOTE:** For more detailed information, refer to *Valves*, page 2-30 in Section 2 - Hydraulic System.



## FIXED COUNTERWEIGHT

### Description

The counterweight Figure 5-14 is pinned to the rear of the superstructure and weighs about 6540 kg (14,400 lb). For cranes without an auxiliary hoist, an additional 672 kg (1478 lb) counterweight is bolted to the hoist mounting area instead of the auxiliary hoist.

### Maintenance



### **DANGER** Crushing Hazard!

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

Ensure the counterweight pin assemblies are installed properly and are secure in their catches.

When lifting/handling the counterweight, keep the chains/straps vertical to minimize side pull on the lifting lugs.

### Removal

1. Fully extend and set the outriggers.
2. Rotate the superstructure so the counterweight is over the front of the carrier to gain additional clearance.

**NOTE:** The counterweight weighs approximately 6540 kg (14,400 lb).

3. Lower and fully retract the boom.

**NOTE:** Use of a forklift to install or remove the counterweight is not recommended. Damage or misalignment of the counterweight can result if a forklift is used for installation or removal.

4. Attach an adequate lifting device to the counterweight.
5. Adjust the four counterweight leveling bolts to provide maximum clearance of the counterweight from the superstructure.
6. Take up any slack on the lifting device and raise the counterweight just enough to remove any pressure on the left and right counterweight pin assemblies.
7. Remove the pins from the superstructure frame lugs and the counterweight. To remove each pin, push pin in and

turn it so its roll pin disengages from the related catch on the counterweight.

8. Lower the counterweight enough to clear the superstructure. Remove the counterweight from the crane and replace the retainer pins in mounting lugs.
9. Rotate the superstructure to the normal travel position.

### Installation

1. Fully extend and set the outriggers.
2. Rotate the superstructure so the counterweight will be over the front of the carrier to gain additional clearance.

### CAUTION

When lifting/handling the counterweight, keep the chains/straps vertical to minimize side pull on the lifting lugs

**NOTE:** The counterweight weighs approximately 6540 kg (14,400 lb).

Use of a forklift to install or remove the counterweight is not recommended; damage or misalignment of the counterweight can result.

3. Attach an adequate lifting device to the counterweight and lift the counterweight into place on the superstructure, aligning the mounting holes on the counterweight to the holes in the superstructure.
4. Secure the counterweight to the superstructure with the two pins. Secure the pin by pushing it in and turning it so the roll pin engages the related catch on the counterweight. Release the pin so its spring can hold the pin in place.
5. Remove the lifting device from the counterweight.
6. Using the four counterweight leveling bolts, level the counterweight and eliminate any relative movement between the counterweight and turntable. Maximum height of counterweight shall not exceed 6 mm (0.24 in) out of level with the turntable bearing when measured from either counterweight outer edge.

### Counterweight Plate

The counterweight has a removable counterweight plate attached to its rear wall with capscrews, flat washers and nuts. This plate weighs 395 kg (870 lb). Use appropriate caution and safety equipment in removing and installing this plate.

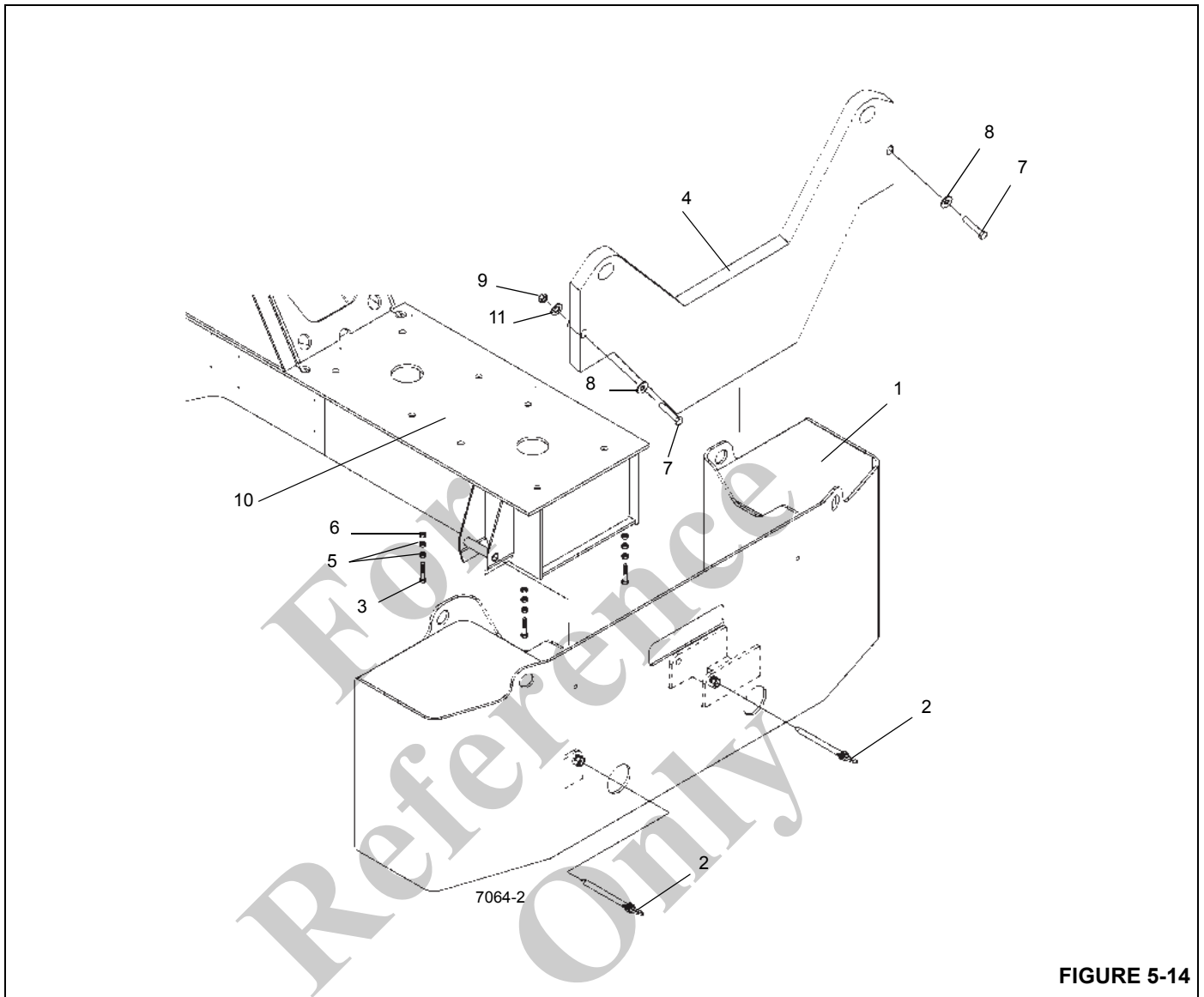


FIGURE 5-14

Item	Description
1	Fixed Counterweight
2	Pin Assembly
3	Capscrew
4	Counterweight Plate
5	Flatwasher

Item	Description
6	Locknut
7	Capscrew
8	Flatwasher
9	Locknut
10	Turntable

5

## REMOVABLE COUNTERWEIGHT (OPTIONAL)

### DANGER

Ensure that all mounting pins are properly installed and locked, during, and after operating the counterweight removal system. Failure to follow this warning could result in death or serious injury.

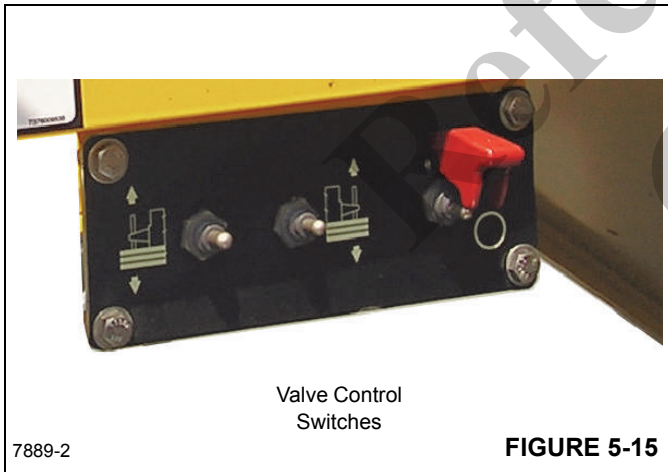
Death or serious injury could result from being crushed by a falling counterweight.

### Removal

1. Position the crane on a firm level surface. Fully extend and set the outriggers.
2. Rotate the superstructure to align the counterweight with the support weld on the front outrigger box. Engaging the pin type turntable lock will aid alignment.

**NOTE:** It may be necessary to jog the counterweight removal control valve switches to remove the weight of the counterweight from the upper attach pins.

3. Using the counterweight removal control valve switches (Figure 5-15), raise the counterweight cylinders to relieve weight on the upper attach pins.



4. Push in, turn, and remove the upper attach pins from the superstructure frame lugs and the counterweight.
5. Stow the upper attach pins in the bushings on the side of the superstructure.
6. Using the counterweight removal control valve switches, slowly lower the counterweight onto the carrier stowage area.

7. Remove the attach pins from the counterweight lugs and cylinder ends. Raise the cylinders and stow the attach pins in cylinder and insert retainer clip pins.

### DANGER

Travel is not permitted with the removable counterweight on the carrier deck.

**NOTE:** The counterweight weighs approximately 6895 kg (15,200 lb).

8. Remove counterweight from the support weld on the front outrigger box before moving crane.
9. Using the crane's boom and hoist or other crane, lift the counterweight from the carrier deck to the auxiliary transport vehicle.

### Installation

1. Position the crane on a firm level surface. Fully extend and set the outriggers.
2. Select the proper "Without Counterweight" operating code on the RCL.

**NOTE:** The counterweight weighs approximately 6895 kg (15,200 lb).

3. Using the crane's boom and hoist or other crane, lift the counterweight from the auxiliary transport vehicle and position the counterweight.
4. Rotate and align the rear of the superstructure above the removable counterweight setting on the support weld on the front outrigger box. Engaging the pin type turntable lock will aid alignment.
5. Using the counterweight removal control valve switches (Figure 5-15) located on either side of the turntable, lower the counterweight cylinders. Pin the cylinders to the counterweight using the attach pins in the cylinders. Insert the retaining pins in the attach pins.

6. Using the control switches, raise the counterweight up under the superstructure frame.

**NOTE:** It may be necessary to jog the counterweight removal control valve switches to install the upper attach pins.

7. Remove the upper attach pins from the stowage bushings and install them into the upper counterweight and superstructure frame lugs.
8. Push in on the pins and turn to lock pin in the notch.

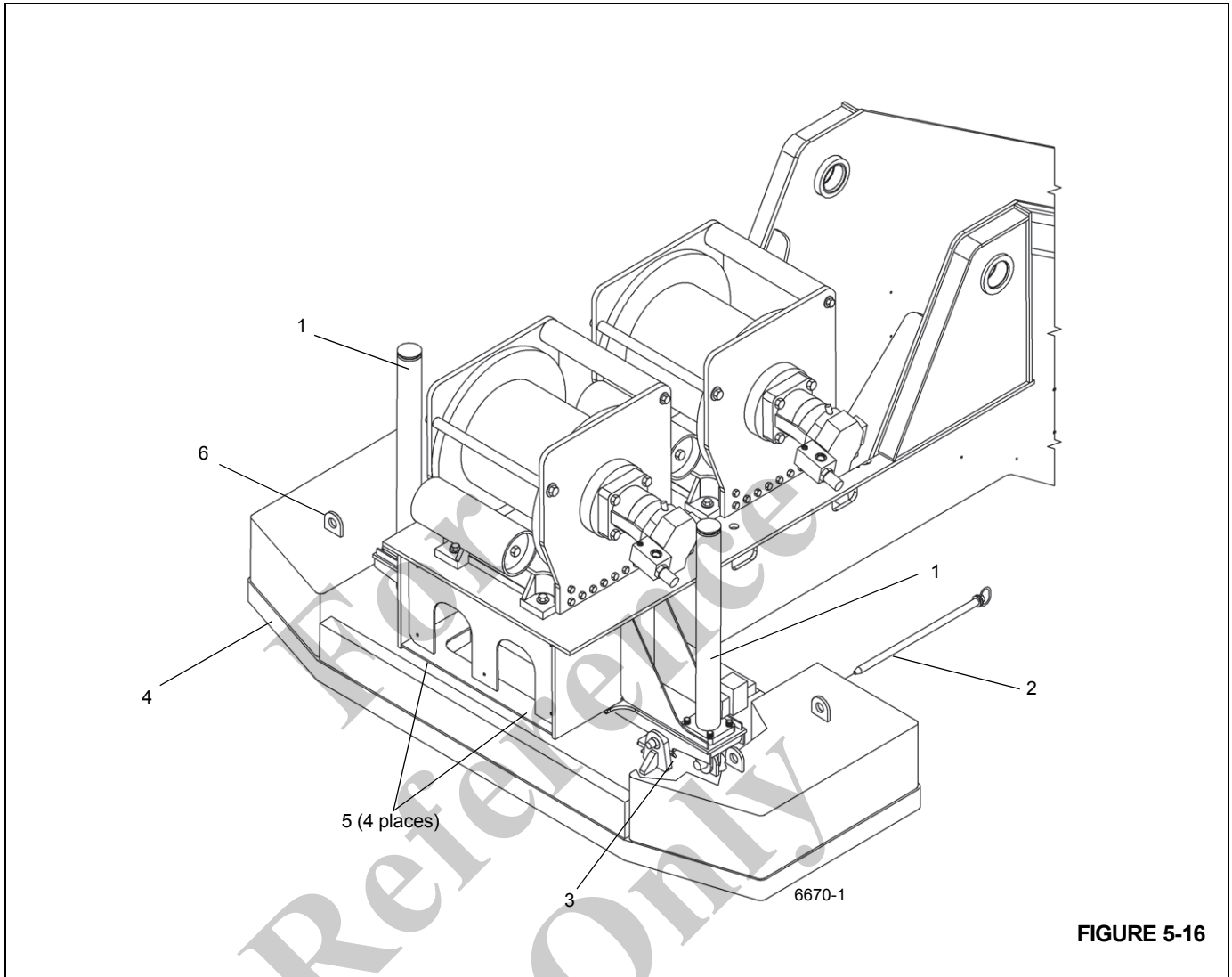


FIGURE 5-16

Item	Description
1	Removal Cylinders
2	Cylinder Attach Pins
3	Counterweight Attach Pins
4	6042 kg (13,300 lb) Counterweight
5	Leveling Bolts (4 places)
6	Counterweight Lifting Lugs (4 places)

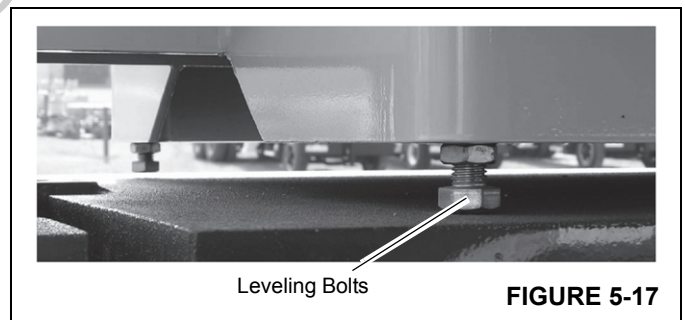


FIGURE 5-17

9. Adjust the four counterweight leveling bolts (Figure 5-17) to eliminate any relative movement between the counterweight and the turntable.

The crane is now ready for operation with the counterweight installed.

For  
Reference  
Only

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## SECTION 6

## SWING SYSTEM

## SECTION CONTENTS

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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 Swing Brake Pedal is depressed.

Swing is activated using a control lever in the cab. When the Swing Control Lever is actuated, hydraulic pressure is routed to the Swing Motor to drive the gearbox in the appropriate direction. As the gearbox rotates, the pinion gear meshes with the teeth on the swing bearing and rotates the superstructure. The maximum rotation is 2.5 rpm. Braking is accomplished by depressing a 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, a directional control valve, the swing drive, the swing brake assembly, 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 an optional 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 can only be engaged when the boom is centered over the front or rear of the carrier. Both swing locks are operated from the cab.

## THEORY OF OPERATION

## Swing Drive

The hydraulic power for the swing drive (Figure 6-1) is supplied by the engine driven hydraulic pump. Oil flows from the pump to the hydraulic swivel. Flow from the swivel is routed to the service brake dual accumulator charge valve. Bypass flow from the Dual Accumulator Charge Valve 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 Swing Motor. 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 port and spring pressure in the swing brake applies the brake. 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 port, overcoming the brake spring pressure and releasing the swing brake. 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.

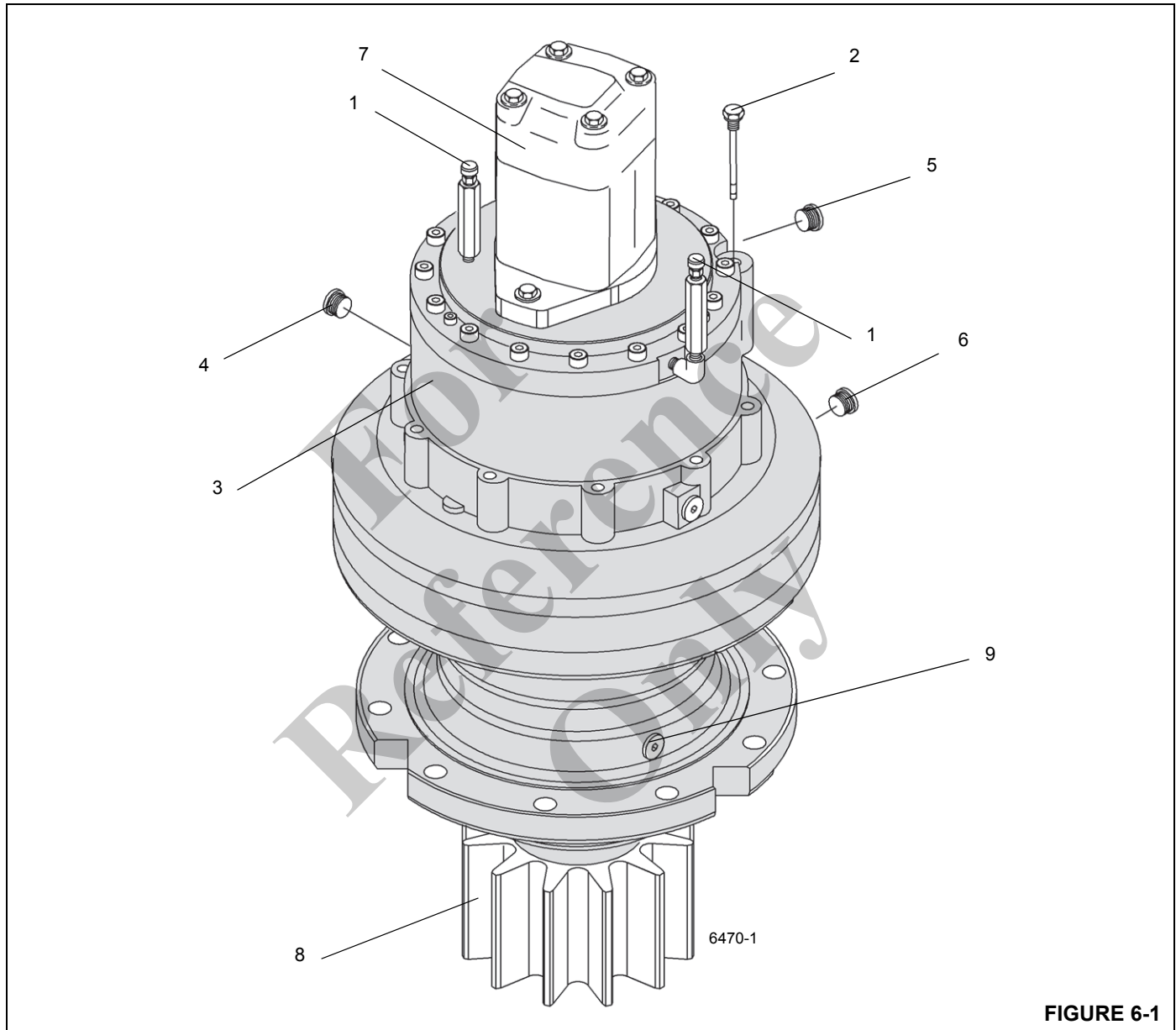


FIGURE 6-1

Item	Description
1	Breather Plug
2	Filler Plug
3	Swing Drive and Brake
4	Hydraulic Apply Brake Port
5	Hydraulic Release Brake Port

Item	Description
6	Level Plug
7	Motor
8	Pinion
9	Drain Plug

## MAINTENANCE

Table 6-1: Troubleshooting

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.
	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 recommendations. Refer to <i>Lubrication</i> , page 9-1.
	e. Improper size hose and/or fittings installed.	e. Replace hose or fittings. Refer to the 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
5. Swing operation slow in one direction only.	a. Crane not level.	a. Level crane.
	b. Damaged hydraulic remote control valve.	b. Replace hydraulic remote control valve.
	c. Damaged swing directional control valve.	c. Replace the swing directional control valve.
	d. Clogged or restricted hose.	d. Replace hose or fitting.
	e. Improperly torqued turntable bearing.	e. Torque turntable bearing.
6. Swing brake operation erratic.	a. Improper brake adjustment.	a. Adjust brake.
	b. Air in swing brake system.	b. Bleed brake system.
	c. Brake pedal not fully retracted.	c. Check brake pedal return spring; repair or replace spring.
	d. Dirty or glazed brake disc.	d. Clean or replace disc.
	e. Malfunction of the glide swing power brake valve.	e. Repair or replace glide swing power brake valve.
	f. Kinked or bent lines and/or hoses and fittings.	f. Straighten or replace as required.
7. Swing brake system will not operate.	a. Damaged swing brake release valve.	a. Replace release valve.
	b. Damaged glide swing power brake valve.	b. Repair or replace glide swing power brake valve.
	c. Internal damage to the swing brake assembly.	c. Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	d. Tighten or replace lines and fittings.
8. Swing brake pedal is spongy.	a. Damaged glide swing power brake valve.	a. Repair or replace the glide swing power brake valve.
	b. Loose or restricted brake lines or fittings.	b. Tighten or replace brake lines and fittings.
9. Swing brake drags.	a. Damaged glide swing power brake valve.	a. Repair or replace the glide swing power brake valve.
	b. Damaged swing brake release valve.	b. Replace release valve.
	c. Internal damage to the swing brake assembly.	c. Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	d. Tighten or replace brake lines and fittings.
10. Boom swings slowly.	a. Insufficient hydraulic volume.	a. Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	b. Damaged relief valve.	b. Adjust, repair, or replace valve.
	c. Damaged swing motor.	c. Repair or replace motor.
11. Swing motor continues to operate when swing control is in neutral.	a. Hydraulic remote control valve sticking or valve otherwise damaged.	a. Repair or replace valve.
	b. Control valve sticking or valve otherwise damaged.	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
13. Swing motor noisy.	a. Air in system.	a. Refer to <i>Hydraulic System</i> , page 2-1, for removal of air from the system.
	b. Motor binding.	b. Repair or replace motor.

For  
Reference  
Only

## SWING MOTOR

### Description

The Swing Motor is mounted on the swing brake housing and drives the swing gearbox through the brake assembly (Figure 6-1). The motor has two ports for connection to the hydraulic system.

### Maintenance

#### Removal

1. Ensure the swing brake and swing lock are engaged.
2. Clean the port area around the motor. Tag and disconnect the hydraulic hoses from the motor assembly. Cap or plug all openings.



#### WARNING

Hydraulic oil can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

3. Unscrew the drain plug, filler and level plugs, and drain the oil. After oil is drained, replace the drain plug.

#### CAUTION

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

4. Remove the two screws and separate the motor from the brake flange. Remove and discard the O-ring from the groove in the swing brake.

#### Installation

#### CAUTION

Use care when engaging the swing motor drive gear; do not force the shaft to engage. Damage to the gears may result

1. Install a new O-ring in the groove of the swing brake. Position the swing motor on the swing brake.
2. Apply Loctite 243 on the two screws. Install the screws and secure the motor to the brake housing. Torque the screws to 88 Nm to 107 Nm (65 lb-ft to 79 lb-ft).
3. Replace plugs, extensions, and fill the assembly with oil. Refer to *Lubrication*, page 9-1.
4. Connect the hydraulic lines to the swing motor as tagged during removal.

#### Test

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

Reference Only



## SWING GEARBOX AND BRAKE

### Description

The Swing Gearbox and Brake (Figure 6-1), used in conjunction with the Swing Motor, rotates and stops the superstructure. A pedal on the cab floor is used to activate the Swing Brake. The Swing Gearbox is bolted to the superstructure base plate, and its pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

The Swing Gearbox utilizes double reduction planetary gearing. The multi-disc swing brake assembly is an integral part of the Swing Gearbox and is located between the swing Motor and the swing Gearbox. The brake mechanism is a disc pack that is hydraulically released and spring applied.

### Maintenance

**NOTE:** The Swing Brake can be removed and disassembled independently of the Swing Gearbox.

#### Swing Brake

##### Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines connected to the swing motor and the brake. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake according to the procedures found in this Section under Swing Motor - Removal.
4. Remove the bolts and washers securing the brake to the gearbox. Remove the brake assembly.
5. Remove and discard the O-ring from the brake housing.
6. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

##### Installation

1. Install a new O-ring onto the brake housing and insert the brake assembly into the gearbox. Secure with the eight socket head capscrews.
2. Install the swing motor into the swing brake according to the procedures found in this Section under Swing Motor - Installation.
3. Connect the hydraulic lines to the motor and brake.
4. Bleed all air from the brake assembly.

### Testing

1. With the Swing Brake switch in the ON position, position the swing control lever in both directions. Superstructure rotation should not occur.
2. Position 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.

### Gearbox

##### Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines from the swing motor and swing brake. Cap and/or plug all openings.
3. Remove the three bolts attaching the pinion gear to the output shaft and remove the pinion gear.

**NOTE:** The complete gearbox assembly with motor weighs approximately 150 kg (333 lb).

4. Attach a suitable lifting device to the swing gearbox. Remove the capscrews, washers and bushings securing the gearbox to the mounting plate.
5. Remove the swing gearbox.
6. If necessary, remove the swing motor according to the procedures found in this Section under Swing Motor - Removal.
7. If necessary, remove the swing brake according to the procedures found in this Section under Swing Brake Removal.
8. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

##### Installation

1. If removed, install the swing brake according to the procedures found in this Section under Swing Brake - Installation.
2. If removed, install the swing motor according to the procedures found in this Section under Swing Motor - Installation.
3. Attach a suitable lifting device to the swing gearbox and lift and position the swing gearbox in place on the mounting plate.
4. Install the capscrews, washers and bushings. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
5. Install the pinion gear on the output shaft and secure with three bolts. Torque to 70.2 Nm to 85.2 Nm (52 lb-ft to 63 lb-ft).

6. Connect the hydraulic lines to the swing brake.
7. Connect the hydraulic lines to the swing motor.
8. Service the gearbox as indicated under Servicing.

### Servicing

As with all highly stressed mechanisms, reasonable operating procedures are always required. 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 out after approximately 250 hours of operation, and replaced with premium quality AGMA No. 4 EP gear lube after approximately 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. Change the oil as follows.

- a. Unscrew drain plug; remove breather and dipstick to ensure all oil has been removed.
- b. Flush the case with a light flushing oil.

**NOTE:** Cleaning of the gearbox with a solvent is recommended to prevent an accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the vent of the swing bearing.

- c. After oil is drained, replace the drain plug and any other plugs that were removed to drain the oil.
- d. To refill with oil, make sure the breather is open. Fill until proper location on dipstick.
- e. Tighten breather and dipstick.

### Checking The Oil Level

- a. Check level on dipstick
- b. If no lubricant is visible on dipstick, add GL-5 until between minimum and maximum on dipstick
- c. Replace the dipstick in the brake housing.

### Testing

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

For Reference Only

## 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 two grease fittings for lubrication of the bearing which are hoses to two fittings at the front of the turntable center section. The outer race also contains two grease fittings and incorporates 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



### CAUTION

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.

**KNOW YOUR TORQUE WRENCH!** 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.

If it is reported by the crane operator or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the crane's capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

Turntable bolts should be torqued according to the procedures outlined in this section.

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

1. 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.
2. 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.

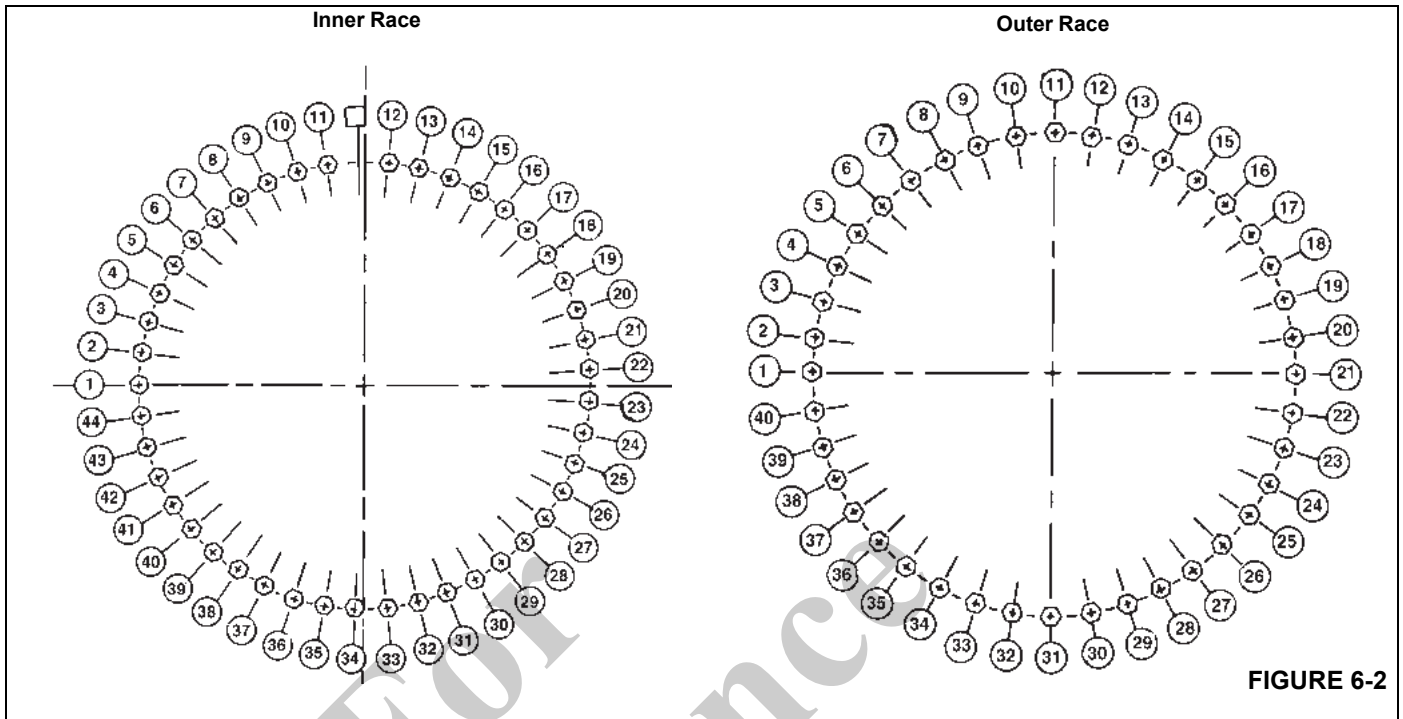


FIGURE 6-2

3. 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.
4. The inner race of the bearing is secured to the turntable by 44, one-inch Grade 8 bolts. The outer race of the bearing is secured to the carrier frame by 40, one-inch, Grade 8 bolts.

### Tools Required

The figure (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; 12, 34, 23, 2, 17, 39, 28 and 7; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value. Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to their final torque value specified. The same tools are used as in step 1.

### 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; 11, 31, 11, 21, 1, 16, 36, 26 and 6; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value. Tools used are the

socket, multiplier, backlash adapter, necessary extensions, and torque wrench.

3. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to their final torque value specified. The same tools are used as in step 1.

### Removal

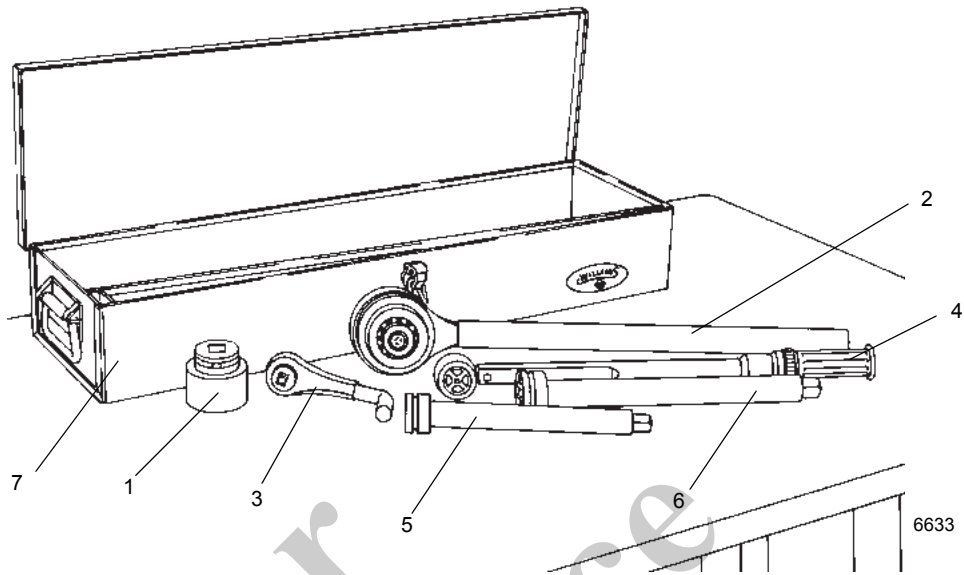
1. Fully extend and set the outriggers enough to take up the slack in the pads.

**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.
5. Remove the boom and lift cylinder following the procedures outlined in Section 4 - Boom.

**NOTE:** The fixed counterweight weighs approximately 6540 kg (14,400 lb). The removable counterweight weighs approximately 6740 kg (14,860 lb).

6. Remove the counterweight. Refer to *Hoist and Counterweight*, page 5-1.
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.



**Orders for special tools shall be referred to:**

The Manitowoc Company, Inc  
 1565 Buchanan Trail East  
 Shady Grove, PA 17256  
 Phone: (717) 597-8121  
 Fax: (717) 593-5929

Description	Grove Part Number	Quantity Required
1. 1½" Socket 3/4" Drive	9999100143	1
2. 4 to 1 Torque Multiplier (1/2" Input 3/4" Output)	9999100134	1
3. Backlash Adapter	9999100141	1
4. 1/2" Drive Torque Wrench	9999100136	1
5. 10" Extension 3/4" Drive	9999100138	A/R
6. 13" Extension 3/4" Drive	9999100137	A/R
7. Tool Box (Optional)	9999100146	1

**FIGURE 6-3**

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 four bolts and two bolt retainers securing the retainer plate to the spool. Remove the retainer plate from the spool and the lugs on the carrier frame.

**NOTE:** The swivel assembly will be removed with the turntable.

**! WARNING**

Ensure the lifting device is capable of fully supporting the weight of the superstructure and the superstructure will not tilt or slide during lifting and moving. Failure to do so may result in death or serious injury 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 at the boom pivot shaft bushings and two at the lower lift cylinder pivot shaft bushings). Take in cable or chain to remove slack. Do not pull up on the superstructure.

### WARNING

Ensure the superstructure is fully supported before proceeding. Death or serious injury may result.

**NOTE:** It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be removed from the front or from under the cab.

14. Remove the 40 bolts and washers securing the turntable bearing outer race to the carrier.

### WARNING

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 serious injury.

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 before removal.

**NOTE:** The bearing weighs between 585 kg (1290 lb) and 642 kg (1415 lb) depending on the bearing used. Ensure the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 44 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 is found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

### Installation

### WARNING

Anytime a turntable bolt has been removed, it must be replaced with a new grade 8 bolt. Death or serious injury may result.

**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 44 new bolts and washers securing the bearing to the superstructure. Refer to Inner Race Torquing in this Sub-Section.
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 front or from under the cab.

4. Install 40 new bolts and washers. 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.

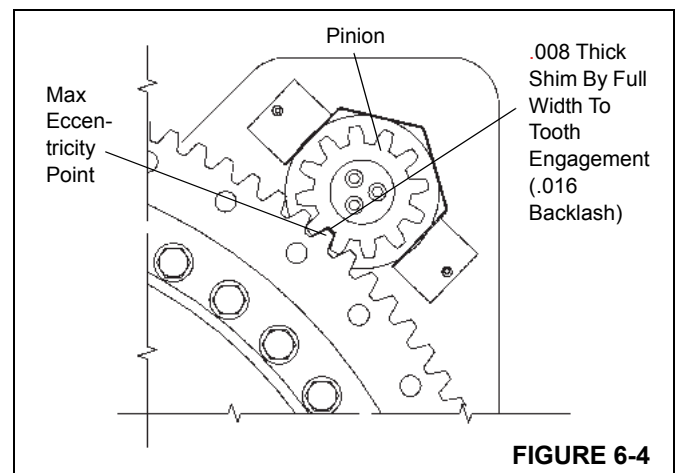


FIGURE 6-4



5. Install the gearbox pinion aligning the high point (maximum eccentricity) on the turntable bearing. Using a 0.203 mm (0.008 in) thick shim, check the backlash (Figure 6-4). If the pinion must be moved to achieve proper backlash, contact your local distributor.
  6. Position the retainer plate on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure it to the spool with two bolt retainers and four bolts after applying Loc-tite #271 to bolt threads. Torque the bolts to 270 Nm (199 lb-ft). 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 Section 4 - Boom.
- NOTE:** The fixed counterweight weighs approximately 6540 kg (14,400 lb). The removable counterweight weighs approximately 6740 kg (14,860 lb).
11. Attach an adequate lifting device to the counterweight. Position the counterweight under the turntable aligning the pin holes. Install the pins and clip pins securing the counterweight to the turntable.
  12. Reconnect the batteries.
  13. Check the slew potentiometer in the electrical swivel for proper orientation. Refer to *Swivels*, page 6-15.

### 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.

For Reference Only

## SWIVELS

### Description

The swivel assembly consists of a 12 port hydraulic swivel (Figure 6-5), a 2 port water swivel, and a 20 conductor slip ring electrical swivel. 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.

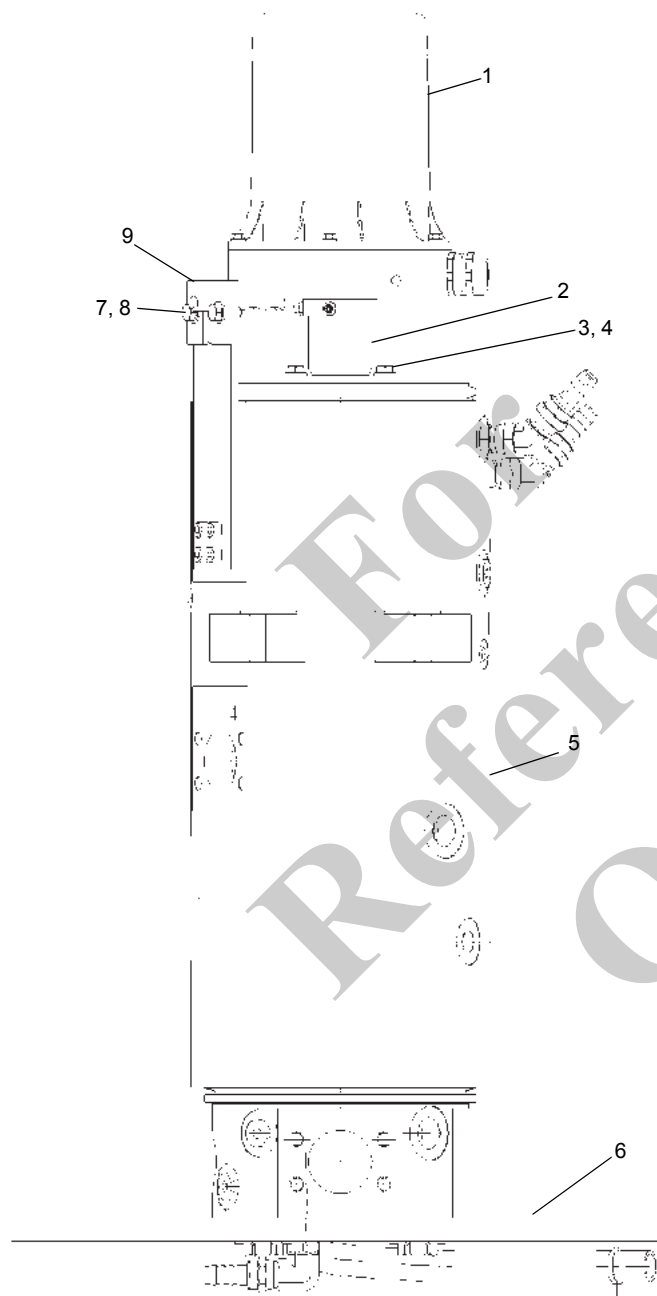
The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts, washers and bushings, which connect to mounting lugs on the case. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier 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.

For Reference Only



Item	Description
1	20 Conductor Slip Ring Assembly
2	Center Post
3	Capscrew
4	Flatwasher
5	Swivel Assembly
6	Retainer Plate
7	Capscrew
8	Flat Washer
9	Plate

7897-3

FIGURE 6-5

## 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.

Port #	Test Pressure kPa (psi)	Function
1	25,000 (3625)	Brake-Front (Primary)
2	25,000 (3625)	Brake-Rear (Secondary)
3	25,000 (3625)	
4	5000 (725)	Dual Return
5	25,000 (3625)	Swing/Steer
6	30,000 (4350)	Hoist/Lift/Tele
7	25,000 (3625)	Steer, Front-Left
8	25,000 (3625)	Accum Charge Valve
9	25,000 (3625)	Steer, Front-Right
10	5000 (725)	Drain
11		A/C
12		A/C
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 10 x 10 cm (4 x 4 in) 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 in this Section.

**NOTE:** The hydraulic swivel weighs approximately 175 kg (386 lb). The hydraulic, water, and electrical swivel combined weigh approximately 206 kg (454 lb).

9. On the bottom of the 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:** 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 bolts, 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 175 kg (386 lb). The hydraulic, water, and electrical swivel combined weigh approximately 206 kg (454 lb).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the bushings, bolts, and washers. Torque bolts' refer to *Fasteners and Torque Values*, page 1-16 for proper torque.
3. Position the retainer plate on the hydraulic swivel spool ensuring they engage the lugs on the carrier frame.

**NOTE:** Allow a 1/32" max gap between bolt and the retaining lug on the frame. Do not tighten bolt against lug.

4. Secure the retainer plate with four bolts two bolt retainers. Apply Loctite 271 to the bolt threads. Torque the bolts to 270 Nm (199 lb-ft). Bend all the retainer tabs to make contact with the bolt heads. Snug the four retainer plate bolts against the lugs on the carrier frame and tighten the locking nuts.
5. If removed, install the electrical swivel. Refer to Electrical Swivel in this Section. Connect the swivel wiring harness connectors to the carrier receptacles and the yellow ground wire to the mounting bracket on the carrier frame. Use the bolt and star washers taken of at removal and refer to Grove Engineering Specification 6829100386 for proper electrical termination of grounds.
6. Install the clamp, washer, flatwasher and capscrew to the bottom of the swivel retainer plate securing the wiring harness.
7. Connect the hydraulic lines to the spool of the hydraulic swivel as tagged during removal.
8. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.
9. Connect the water lines to the water swivel case as tagged during removal.
10. Remove the blocking material from the lift cylinder.
11. Activate all systems; cycle all functions and observe for proper operation and any leakage.

## TWO PORT WATER SWIVEL

### Description

The 2 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 12 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 - Removal in this section.
2. Remove the electrical swivel. Refer to Electrical Swivel - Removal in this section.
3. Tag and disconnect the lines from the case of the water swivel. Cap or plug all lines and openings.
4. Remove the screw 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. Damage to the spool may result in unexpected operation.

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

3. Remove the seals and rings from the spool.

### 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. Always use approved safety equipment; gloves, face masks, and eye wear. 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 0.127 mm (0.005 in) 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 and gland surfaces. Damage to the spool assembly may result in unexpected operation.

Proper alignment when installing the case is required. Do not force the spool into the case. Damage to the seals may result.

2. Install new seals and rings on the spool.
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 capscrews and washers.
2. Install the shim(s) on the keying lug to provide a snug fit and secure with a screw.
3. Connect the lines to the swivel case as tagged during removal.
4. Install the electrical swivel. Refer to Electrical Swivel - Installation in this Section.
5. Perform steps 8 and 9 of Hydraulic Swivel - Installation in this Section.



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 and leads 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 slip ring assembly contains an angle encoder. The encoder sends data via CAN bus to the RCL. The RCL converts this data into a slew angle which is used to determine the working area definition and also for controlling the rear axle oscillation.

### 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 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 *Electrical System*, page 3-1.
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:** The connectors are too large to go through the center of the hydraulic swivel. They must be removed.

5. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.
6. 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 3-8.
7. Secure the connectors and wires from each of the numbered connectors so the harness can be withdrawn through the center of the hydraulic swivel.
8. Tag and disconnect the connectors from the receptacles on the cab bulkhead mounting plate.
9. Loosen the jam nuts and 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 anti-rotation pin 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.

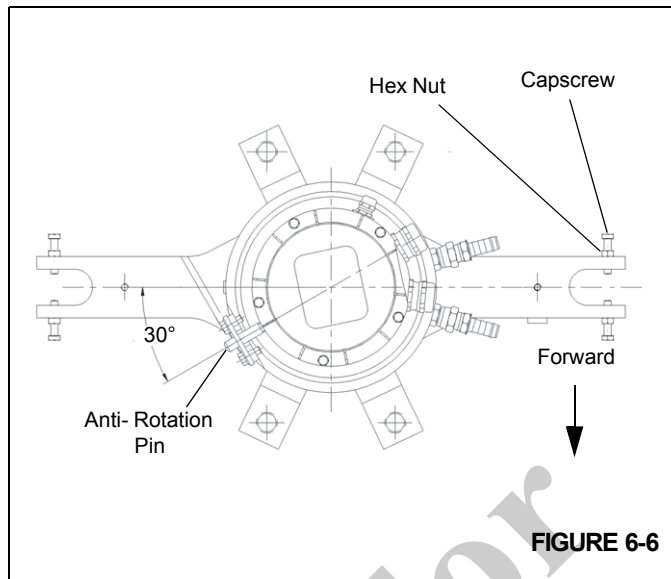
#### Installation

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 encoder.

2. Slide the electrical swivel mounting shaft onto the center post.

3. Ensure the anti-rotation pin in the bottom of the electrical swivel base is aligned with the mounting hole in the bracket on the water swivel case (Figure 6-6).



4. Apply medium strength Loc-tite to the set screws securing the electrical swivel to the center post and tighten them 45 to 55 lb-in (5 to 6 Nm). Tighten the jam nuts.
5. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal.
6. Unbundle the wires of the collector core wiring harness. Install the pins, with wire attached, to the connector as tagged during removal.
7. Plug the connector into the carrier wiring receptacle, connect the wires as tag during removal. Install the yellow ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken of at removal and refer to Grove Engineering Specification 6829100386 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 most important that the slew potentiometer be adjusted anytime work is done to the electrical swivel. Personnel injury or damage to the machine may result.

10. Activate all systems, cycle all functions, and observe for proper operation. Adjust the slew angle in accordance with *Slew Angle Verification*, page 6-21.

### 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 Angle Zero Adjustment Procedure

1. Rotate the superstructure over the front and engage the lock pin.

**NOTE:** Refer to the Hirschmann Rated Capacity Limiter Operator's Handbook for detailed instructions. Complete the RCL console setup according to the crane's current operating configuration.

2. Select the Info icon.
3. Select the Info icon.
4. Enter authorization code 64356, then select return.
5. Select return until the slew adjustment screen is displayed.
6. Select the Auto 0 (zero) icon. 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 Angle Verification

1. Rotate the superstructure over the front and engage the house lock pin.
2. Set the RCL console to read slewing angle as follows:

**NOTE:** Refer to the Hirschmann Rated Capacity Limiter Operator's Handbook for detailed instructions.

- Complete the RCL console setup according to the crane's current operating configuration.
  - Select the Info icon.
  - Select the Info icon.
3. Verify the angle indicated on the console does not exceed  $\pm 1.0$  degree.

**SWING LOCK PIN**

**Description**

The purpose of the swing lock pin is to lock the superstructure in position directly over the front for pick and carry loads. The pin swing lock installation consists of a large pin, a control handle in the right side of the cab, and control linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front, pushing the control handle down drops the swing lock pin into a socket on the carrier frame, locking the superstructure in place. Pulling the control handle up pulls the pin out of the socket, unlocking the superstructure.

**Maintenance**

Verify linkage is installed to avoid damage from superstructure rotation and is undamaged. Verify pin, turntable bushing pin passes through, and socket on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage is adjusted properly. If it is, the pin bottom will stick out about 5.89 cm (2.32 in) 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, adjust the linkage so the pin bottom will stick out about 5.89 cm (2.32 in) from the bottom of its bushing in the turntable; verify the superstructure can lock properly and the superstructure can rotate without lock pin hangup.

**360° SWING LOCK CONTROL (POSITIVE LOCK TYPE) (OPTIONAL)**

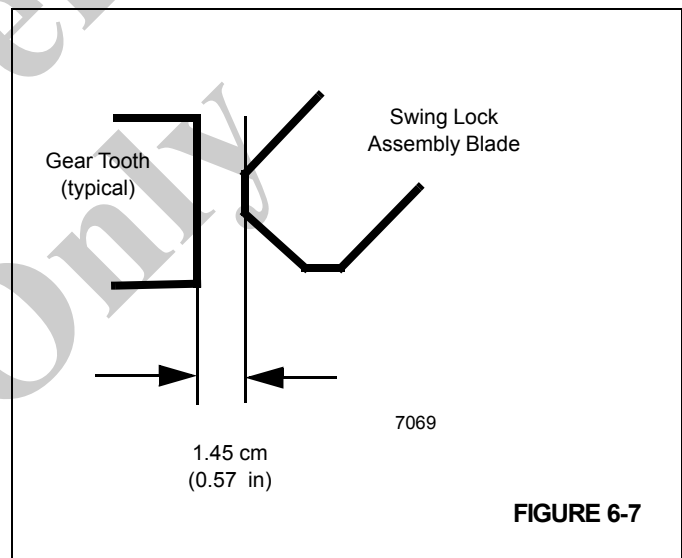
**Description**

The purpose of the swing lock is to secure the superstructure in position at one of the positions in its rotation. There are roughly 120 spots about 3.0 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 spring is undamaged and has 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. When the lever is fully up, the top diagonal surface of the blade of the swing lock assembly (the beveled surface from the blade's top horizontal surface to its "ax blade" vertical surface should be 1.45 cm (0.57 in) from the tips of the gear teeth.

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 up the superstructure. Torque the four 3/4-10 mounting bolts to their specified torque found in *Fasteners and Torque Values*, page 1-16.



## SECTION 7 POWER TRAIN

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### ENGINE

#### Description

The engine is a Cummins QSB 6.7 diesel engine. 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 the idle switch, which is a three position rocker switch located on the front of the steering column. The idle switch allows the operator to infinitely vary and hold the engine speed between the engine's minimum and maximum idle settings (refer to Section 3, Operating Controls and Procedures in the applicable Operation Manual for details on the operation of the idle switch). The foot throttle pedal is 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 right rear hood assembly. The muffler is mounted on the left side on the rear outrigger box.



#### CAUTION

Do not spray starting fluid into the air inlet. The spray will contact the heater elements and could explode causing personal injury.

To aid in starting the engine in cold weather, 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 information it receives from various sensors on the engine 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 and remove the hood top door assembly.
3. Disconnect the air filter tubing at the engine and air cleaner. Remove and lay aside.
4. Disconnect the exhaust tubing at the engine and muffler. Lay to the side.
5. Tag and disconnect the engine electrical harness connector from the carrier harness connector and battery cables.
6. Unbolt the fuel filter and engine lubrication filter from the frame and lay on the engine.
7. Drain the engine coolant system.
8. Drain the engine lubrication system.
9. Drain the transmission/torque converter oil system.
10. Remove the engine hood assembly and pump cover from the machine.
11. Disconnect and remove the drive shaft(s) between the transmission/torque converter and the axle(s). Refer to DRIVE LINES in this Section.
12. Tag and disconnect all lines from the radiator. Disconnect the coolant level sensor harness from the engine harness and tie up excess harness so it is out of the way. Remove the radiator. Refer to RADIATOR - Removal in this Section.
13. Tag and disconnect all lines and tubing from the engine, transmission/torque converter, and all other components.



### DANGER

The lifting device must be able to support the combined weight of the engine and transmission.

**NOTE:** The engine and transmission/torque converter assembly weighs approximately 1100 kg (2400 lb).

14. Attach to the engine a lifting device capable of supporting the weight of the engine and transmission/torque converter.
15. With the lifting device supporting the weight of the engine, remove the four sets of bolts, washers, and nuts securing the front of the engine to the frame. Remove

the four sets of capscrews, locknuts, and washers (two sets on each side) securing the transmission/torque converter to the frame.

16. Using the lifting device, lift the engine and transmission/torque converter as an assembly from the crane.
17. 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 locations.

Ensure that the same grade hardware, torque values, and Loctite as were installed by the factory are used.

### Engine Installation

**NOTE:** Use the same grade Hardware, torque values, and Loctite that were used by the factory.



### DANGER

The lifting device must be able to support the combined weight of the engine and transmission.

1. With all components and fittings installed on the new engine, lift the engine into the crane.
2. With the engine in position, secure each side of the transmission/torque converter with four sets of capscrews, nuts and washers (two sets on each side). At the front of the engine secure the engine mount to the frame with the four sets of bolts, washers, and nuts.
3. Remove the lifting device.
4. Connect all lines and tubing to the engine, torque converter, and all other components in accordance with the identification marks made during removal.

### CAUTION

Do not apply sealant to the inside of the hydraulic suction hoses.

5. Apply a moderate coat of Permatex® Type No. 2 to the male hose adapter and install the hydraulic hoses. Do not apply sealant to the inside of the hydraulic hose, and push it onto the male adapter. This can result in excess sealant being pushed ahead of the male adapter and being exposed to the hydraulic oil.
6. Install the radiator. Refer to *Radiator Removal and Installation*, page 7-20. Connect all hoses and electrical harnesses to the radiator as tagged during removal.
7. Connect the drive shafts between the transmission/torque converter and the axles. Refer to *Drive Shafts*, page 7-24.
8. Install the hood assembly. Install the pump cover.

9. Attach the fuel filter and engine lubrication filter to the frame. Connect the battery cables and engine electrical harness connector in accordance with the identification marks made during removal.
10. Connect the electrical wiring to the hourmeter as tagged during removal.
11. Connect the air filter tubing at the engine and the air filter. Connect the exhaust tubing to the engine and muffler. On Tier IV engines, replace the exhaust tube gaskets with new
12. Install the hood top door assembly.
13. Service the transmission, engine lubrication system, and engine cooling system.
14. Start the engine. Check all hoses and fittings for leaks. Recheck all fluid levels.

### 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 should be inspected visually on a daily basis. The drive belt should be inspected for cracks, frayed areas, and glazed or shiny surfaces (see Figure 7-1). A drive belt that is glazed or shiny indicates belt slippage.

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

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

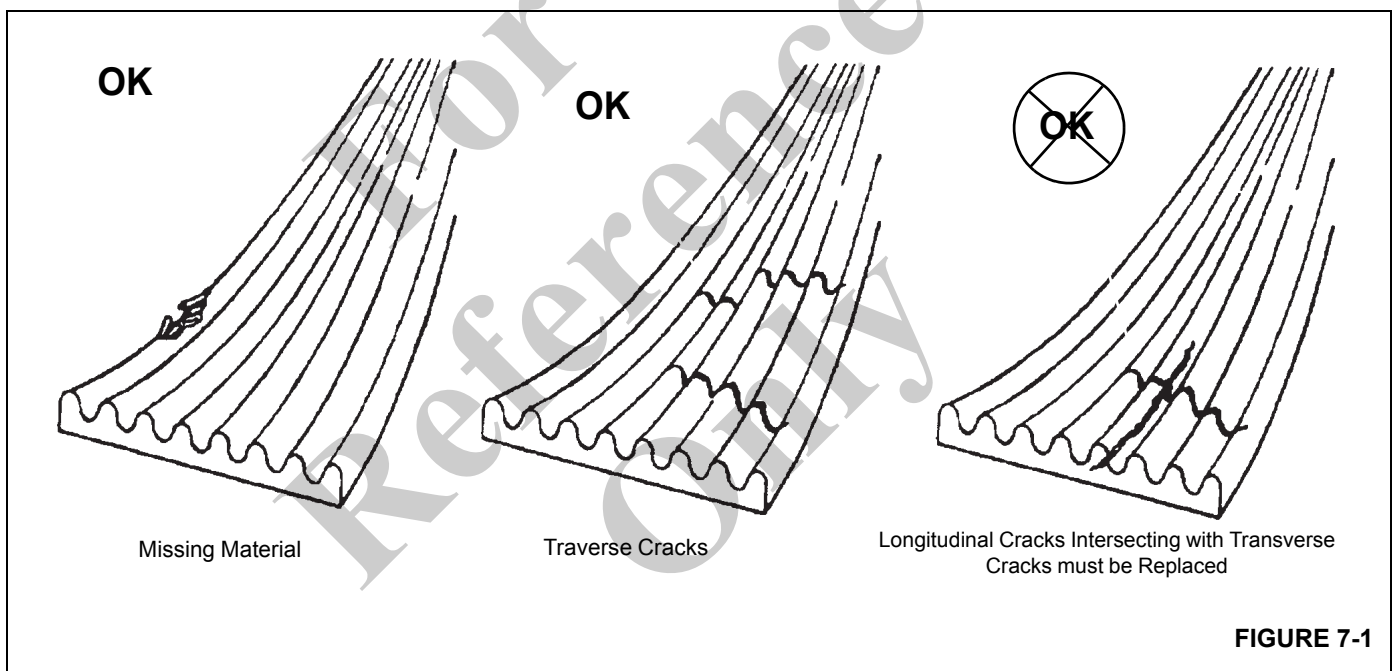


FIGURE 7-1



## ELECTRONIC CONTROL SYSTEM

### Description

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 on the steering column display while the ignition switch is in the RUN position and the engine is Off. The ECM communicates with service tools supplied by Cummins through a SAE J1939 datalink.

The ECM also monitors the condition of the diesel particulate filter and will alert the operator by way of an indicator in the cab if the filter becomes clogged with carbon. When the filter becomes clogged, the ECM will control the regeneration process to clean the filter of particulate matter.

### Engine Control System Switches And Indicator Lights

#### *Engine Diagnostic/Speed Control Switch*

The Engine Diagnostic/Speed Control Switch is a two position maintained on/off rocker switch used to access the engine fault codes or enable the control of the low engine idle and engine rpm functions.

Diagnostic function — With the Ignition Switch in the RUN position and the engine off, press the top of the Engine Diagnostic/Speed Control Switch to view the engine fault codes on the steering column display. If there is more than one active engine fault code, use the Increment/Decrement Switch to toggle forward and backward through the fault codes. If there are no engine fault codes, zeroes will be shown in the steering column display.

Engine low idle function — With the engine running and the top of the Engine Diagnostic/Speed Control Switch pressed, the engine low idle is adjusted using the Increment/Decrement Switch.

Engine rpm function — With the engine running and the bottom of the Engine Diagnostic/Speed Control Switch pressed, the engine rpm is adjusted using the Increment/Decrement Switch.

#### *Increment/Decrement Switch*

The Increment/Decrement Switch is a three position momentary rocker switch with center maintained position being off. Use this switch to toggle backward and forward through active engine fault codes or adjust engine speed.

Diagnostic function — With the Ignition Switch in the RUN position, the engine off, and the top of the Engine Diagnostic/Speed Control Switch pressed, press the top or bottom of the Increment/Decrement Switch to toggle forward and backward through the engine fault codes shown on the steering column display. If there are no engine fault codes, zeroes will be shown in the steering column display.

Engine low idle function — With the engine running and the top of the Engine Diagnostic/Speed Control Switch pressed, press the top or bottom of the Increment/Decrement Switch to increase or decrease the low engine idle.

Engine rpm function — With the engine running and the bottom of the Engine Diagnostic/Speed Control Switch pressed, the Increment/Decrement Switch is used to adjust engine rpm. Quickly press the top of the switch once to go to full engine rpm; quickly press the bottom of the switch once to return to low engine idle. If the engine speed is below the maximum rpm setting, pressing and holding the top of the switch will cause the engine rpm to slowly increase; release the switch when the desired rpm is attained. If the engine speed is above the minimum rpm setting, pressing and holding the bottom of the switch will cause the engine rpm to slowly decrease; release the switch when the desired rpm is attained.

**Engine Stop Light**

The Engine Stop Light is located in the steering column gauge display. It is a red indicator light that illuminates to signify a serious engine problem that requires the vehicle and the engine to be stopped as soon as safely possible. The engine should remain shut down until the fault can be repaired.

**Engine Warning Light**

The Engine Warning Light is located in the steering column gauge display. It is an amber indicator light that is a part of the engine's electronic control system and when illuminated, gives the operator a signal that there is a engine problem which must be corrected.

**Diesel Particulate Filter Indicator (Tier 4 Engines Only)**

The Diesel Particulate Filter (DPF) indicator is located in the steering column gauge display. This indicator illuminates amber when the diesel particulate filter is getting filled with soot and needs to be cleaned out.

**CAUTION****Engine Shut-down Condition!**

When the DPF indicator illuminates or flashes start regeneration process.

Should the engine light come on with the DPF indicator, the engine will shut down and an authorized engine manufacturer service person must be contacted to re-start the engine.

The indicator will be lit continuously during the early stages of clogging. If the system continues to clog, the lamp will begin to flash.

If even more clogging occurs, the engine warning light will illuminate in addition to the DPF indicator and the engine will shut down.

**WARNING****Fire or Burn Hazard!**

During the regeneration process the exhaust becomes very hot. Do not park the vehicle near flammable objects.

Use caution near the exhaust tailpipe during regeneration as it will become very hot.

The regeneration process can take place in three different modes:

**Passive:** The exhaust is hot enough during normal working operation to burn off any hydrocarbon (soot) accumulation.

**Active:** Active self-regeneration occurs when there is not sufficient heat in the exhaust to convert all the hydrocarbon being collected in the DPF. Exhaust temperatures are raised by injecting a small amount of fuel. The resulting chemical reaction raises exhaust gas temperatures high enough to oxidize the hydrocarbon from the filter. This is all done without any operator intervention.

**Manual:** Manual or stationary, regeneration is the same as active regeneration but takes place while the equipment is not being operated. It offers the equipment operator the option, if needed, of performing regeneration outside the normal duty cycle.

### ***Diesel Particulate Filter Regeneration Switch (Tier 4 Engines Only)***




#### **WARNING**

#### **Fire or Burn Hazard!**

During the regeneration process the exhaust becomes very hot. Do not park the vehicle near flammable objects.

Use caution near the exhaust tailpipe during regeneration as it will become very hot.

The Engine Diesel Particulate Filter (DPF) switch is located on the right side of the overhead control panel. This switch is a three position switch, Inhibit Regen/Permit Regen/Start Regen. Press this switch to start engine regeneration or to disable regeneration:

- Start Regeneration  (7649-10)

- Inhibit Regeneration  (7649-11)

To regenerate, set the crane parking brake, the crane transmission must be in neutral and have all pedals released.

Set up a safe exhaust area around the crane; remove tools, rags, grease or any debris from the engine exhaust area.

With the engine idling push the DPF Regen Switch to initiate regeneration.

Within 5 seconds the engine should rev up to 1000 to 1400 rpm. The engine will continue to run at this speed for up to 45 minutes.

Pressing the brake or throttle pedal during regeneration or activating the Inhibit Regen switch will interrupt the regeneration process.

Make sure the crane and surrounding area are monitored during manual regeneration. If any unsafe condition occurs, shut off the engine immediately.

During this period the sound of the engine may change. When regeneration is complete the engine will return to its idle speed.

#### ***Inhibit Regeneration Indicator***

The Inhibit Regeneration indicator is located in the steering column gauge display. When the Diesel Particulate Filter Regeneration switch is in the inhibit regeneration position, this amber indicator is illuminated.

#### ***High Exhaust System Temperature***

The High Exhaust System Temperature (HEST) indicator is located in the steering column gauge display.

During regeneration it is possible for the engine exhaust to reach temperatures exceeding 648°C (1200°F). The HEST indicator will illuminate red to warn the operator of when temperatures reach 675°C (1247°F) and will stay on until the temperatures fall below 625°C (1157°F).

Warning lights near the tailpipe will flash during regeneration when high exhaust temperatures exist.

## FUEL SYSTEM

### Description

The fuel system consists of the fuel tank, fuel-water separator, secondary filter, lift pump, high-pressure pump, high-pressure common fuel rail (Tier 4 only) and the fuel injectors. All components except the fuel tank 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 280 L (74 gal). 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 quantity gauge on the instrument panel in the cab. The fuel tank for the CE units has a lockable vented filler cap.

#### **Injection Fuel Pump**

The fuel oil is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is metered also, 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 fuel filter-water separator removes impurities from the fuel and also removes water from the fuel before it reaches the engine. The filter is mounted near the fuel tank on the left side of the crane.

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 fuel filter housing. 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.

### 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 quantity sender unit.
4. Support the weight of the tank, loosen and remove the two nuts and washers 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 in the new tank.

#### **Installation**

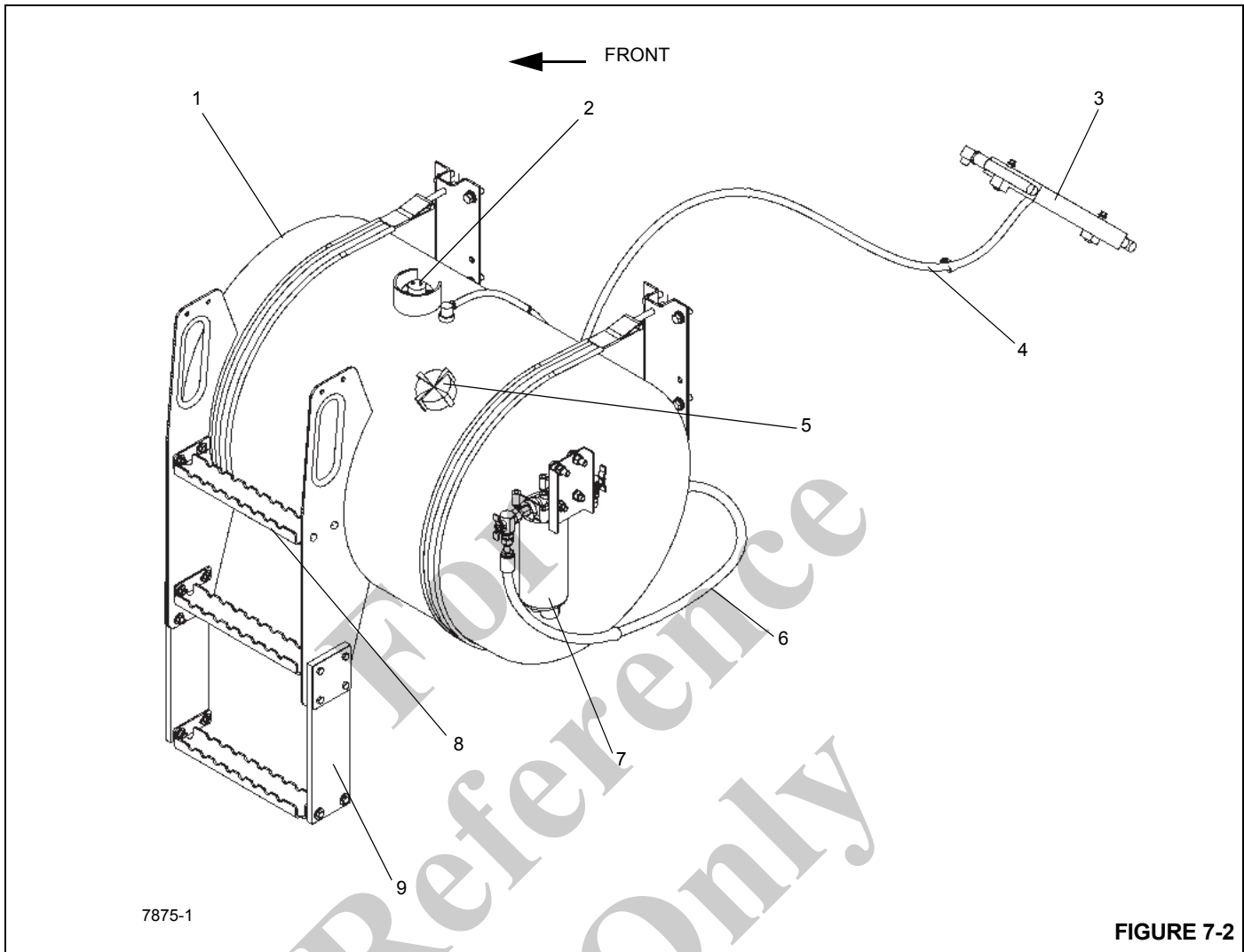
1. Position the new tank on the mounting brackets and install the nuts and washers on the two straps.
2. Connect the electrical lead to the fuel quantity sender unit.
3. Connect the two lines to the fittings on the bottom of the tank in accordance with the identification marks made during removal.
4. Service the tank.

#### **Fuel Filter-Water Separator**

##### **Draining**

The sump of the fuel filter-water separator 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 until fuel appears.
3. Close the drain plug.



Item	Description
1	Fuel Tank
2	Fuel Quantity Sender
3	Cooler
4	Fuel Return
5	Filler Cap

Item	Description
6	Fuel Supply
7	Fuel Water Separator
8	Step
9	Step Extension To Engine

## AIR INTAKE AND EXHAUST SYSTEM

### Description

The air intake system (Figure 7-3) 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 (4)(Figure 7-3), designed to indicate red when servicing is required, is installed in the air cleaner body.

On the Cummins QSB Engine 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.

### Air Intake

#### Air Cleaner Checks

Dust passing the air cleaner, even through small holes, can cause rapid engine wear. Ensure all connections between the air cleaner and the engine are tight and sealed. If these connections are all 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 sealing surface is not damaged and seals well against the element.
3. Inspect the element sealing surface for damage.
4. Check for structural failures. Any damaged parts must be replaced.
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. 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.

A service indicator (Figure 7-3) attached to the air cleaner housing will indicate when the filter needs to be cleaned. Reset the gauge each time the air cleaner is serviced. If the gauge's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring.

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.

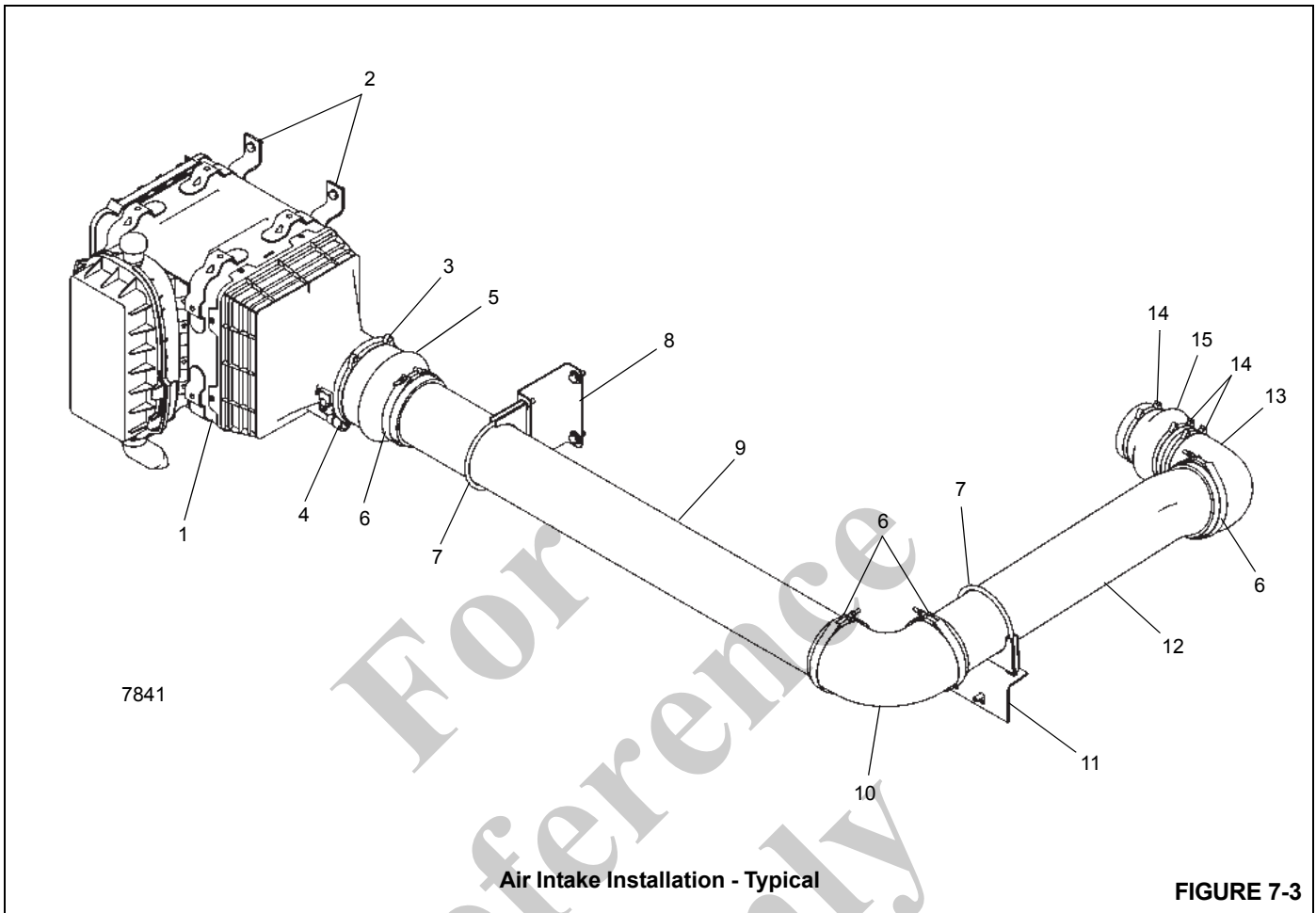
Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

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.





Item	Description
1	Air Cleaner Assembly
2	Mounting Bracket
3	Clamp
4	Service (Restriction) Indicator
5	Reducer
6	Clamp
7	Muffler Clamp
8	Mounting Bracket

Item	Description
9	Air intake Tube
10	Adapter
11	Bracket
12	Air Intake Tube
13	Elbow
14	T-bolt clamp
15	Adapter

### Filter Element Replacement

#### CAUTION

Never service the air cleaner while the engine is running.

1. Lift the clips (1) (Figure 7-4) securing the cover to the air cleaner body and remove the cover.

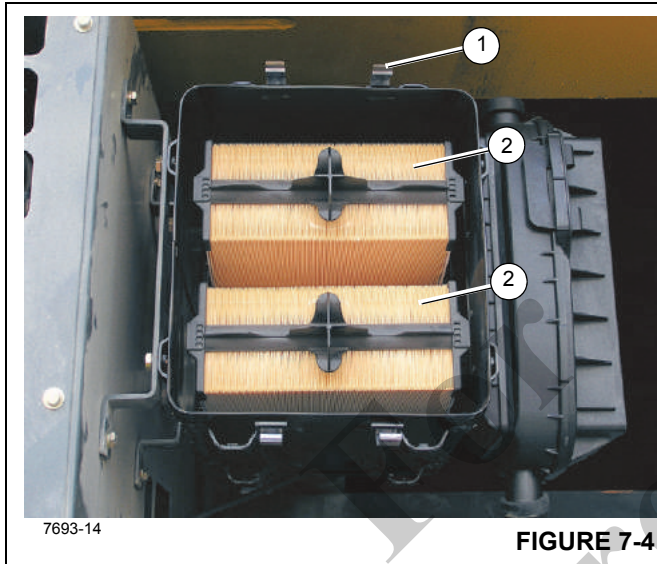


FIGURE 7-4

2. Remove Primary Filter from the Air Cleaner and inspect for foreign material and marks of dust. Replace as necessary
3. Remove Secondary Filter (not shown) from behind the Primary Filter. Replace 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.

#### 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 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.

#### Precleaner

The precleaner (1, Figure 7-5) 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.

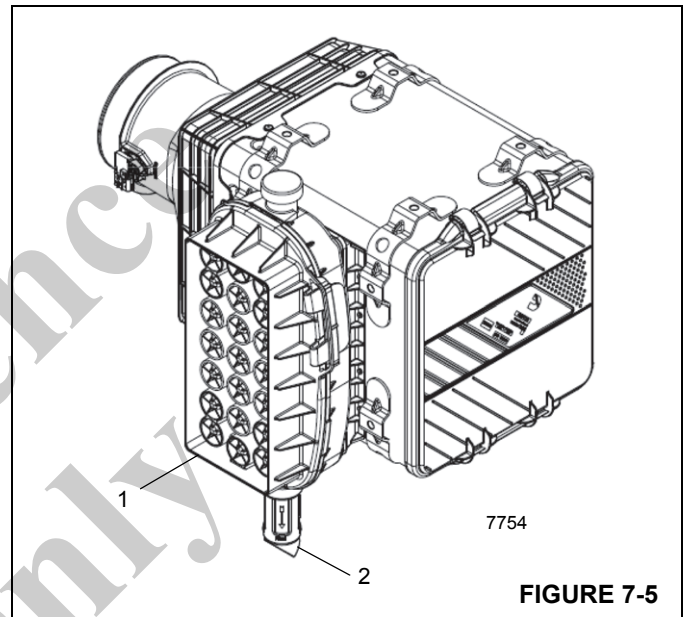


FIGURE 7-5

#### Vacuator Valve

Vacuator valves (2, Figure 7-5) (Figure 7-6) 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.

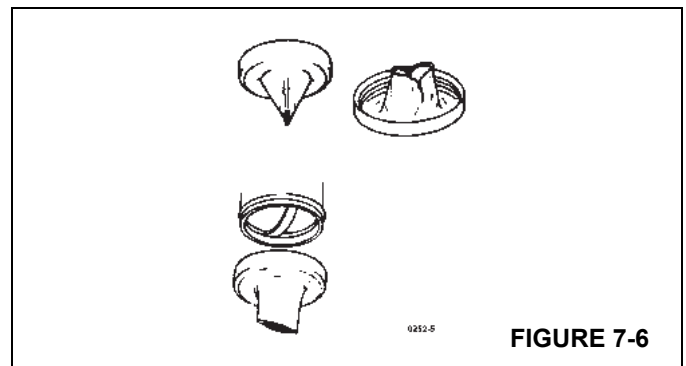


FIGURE 7-6

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 cap and screen for accumulation of leaves, trash, and other debris that could restrict air

flow. Repair the screen or replace the cap if any large holes are found in the screen.

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.

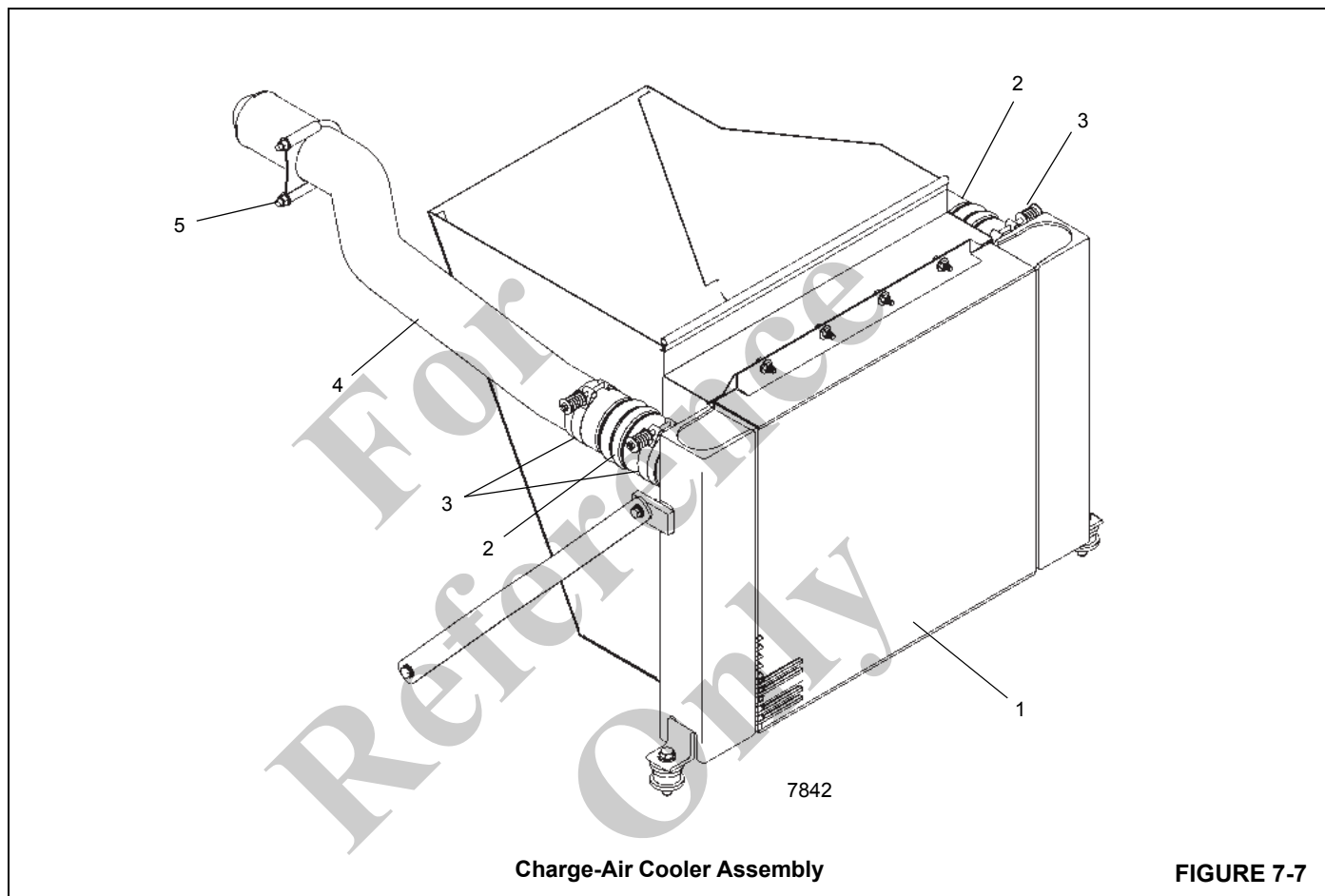
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### Charge-Air Cooler System

The charge-air cooler (CAC) (Figure 7-7) 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.



Item	Description
1	CAC Assembly
2	Bellows
3	Clamp
4	CAC Hot Tube
5	Muffer Clamp

#### 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 (Figure 7-8) and Tier 4 muffler (Figure 7-9) are similar in removal and installation 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!

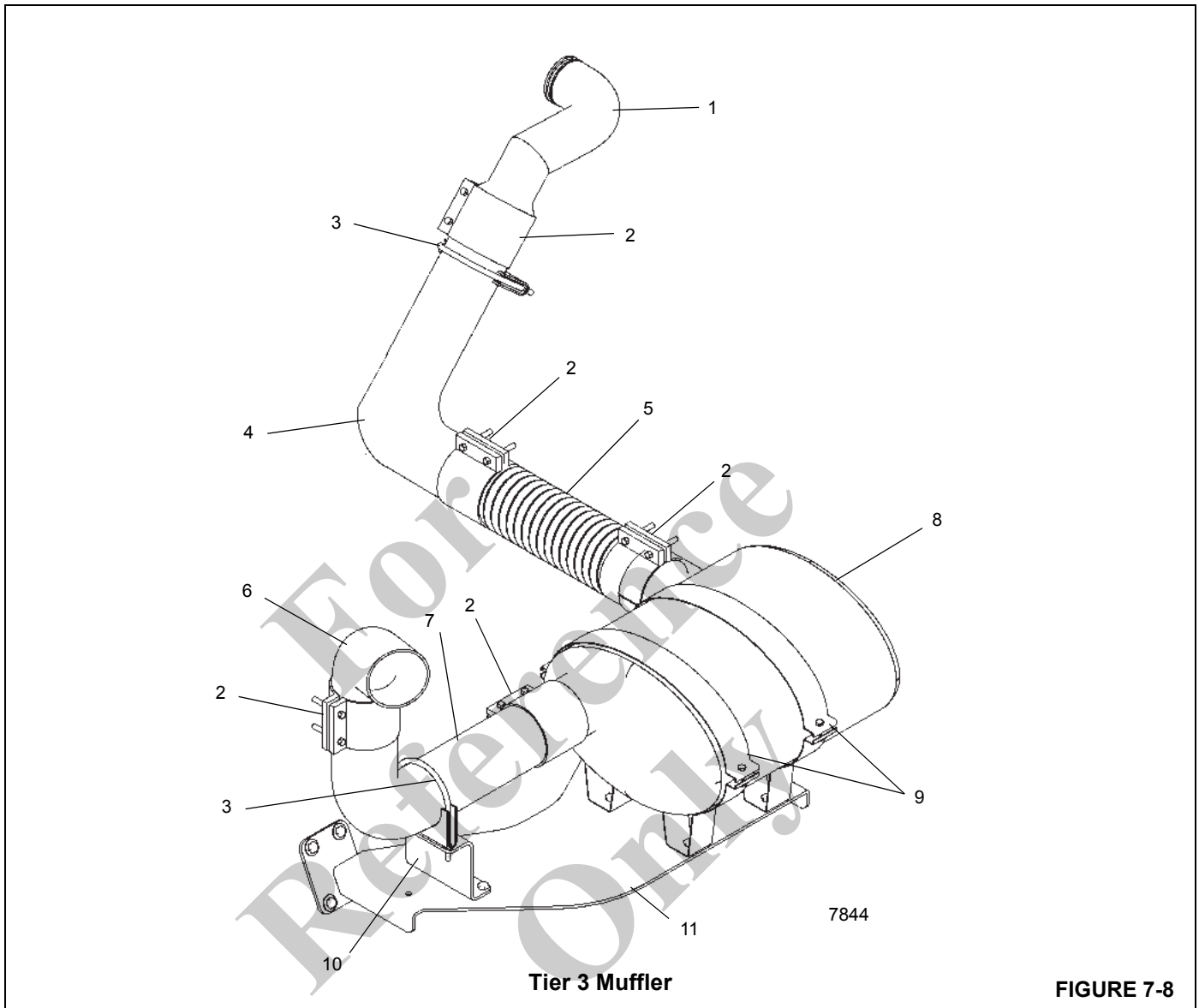
Do not touch muffler or exhaust parts until they are at ambient temperature. Severe burning may result.

- 
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. Tier 4 only—tag and disconnect 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

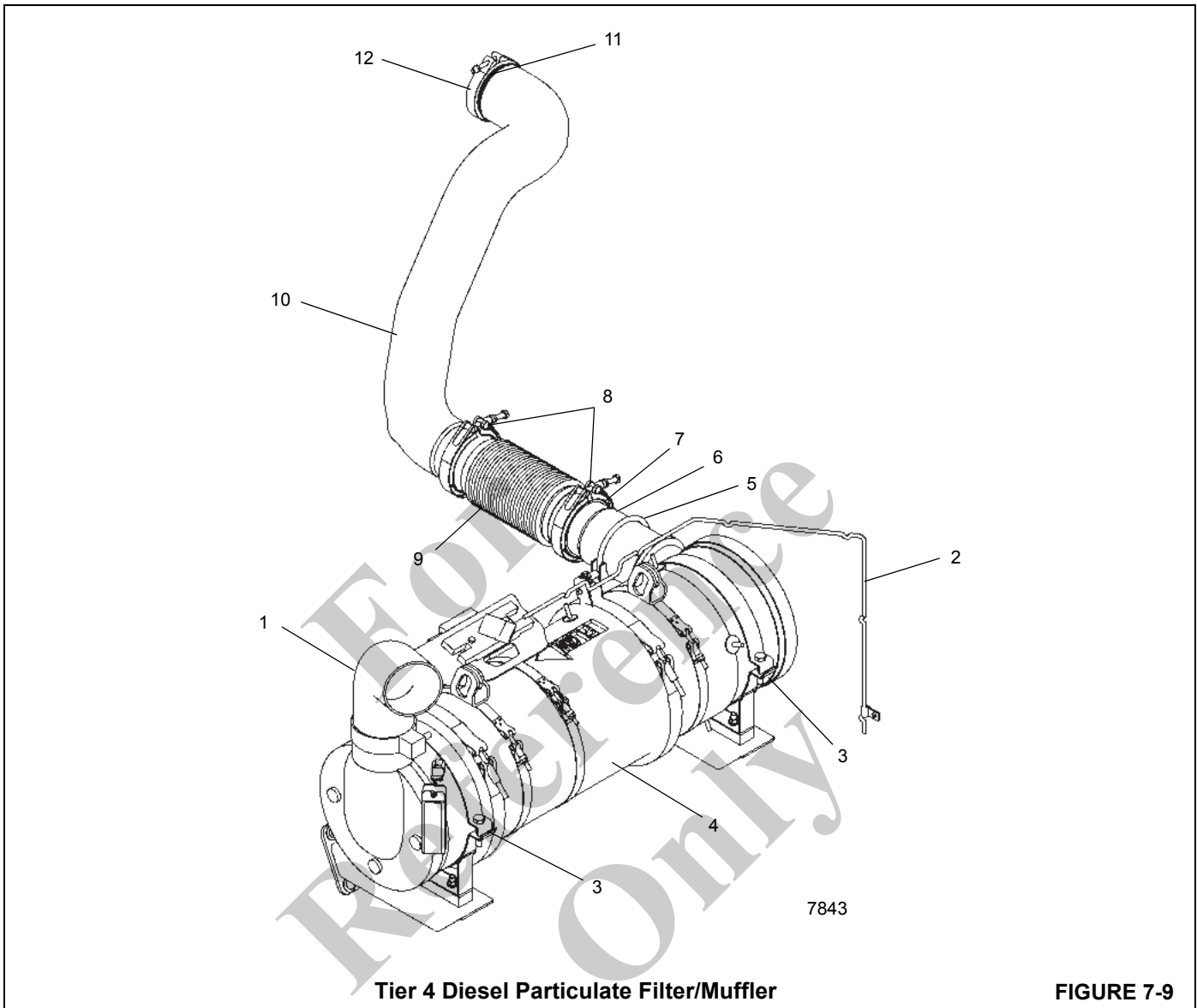
1. Secure the muffler to the exhaust tube with a clamp.
2. Install the exhaust tailpipe on the muffler. Secure the exhaust tailpipe to the muffler with clamp. Adjust the clamp as needed.
3. If removed, secure the muffler mounting brackets to the mountings with capscrews and nuts as needed. Secure the muffler to the muffler mounting bracket with mounting bands.
4. Tier 4 only—connect electrical connections as tag during disassembly.
5. Install sheet metal guard.



Item	Description
1	Exhaust Tube
2	Clamp
3	Muffler Clamp
4	Elbow
5	Flex Tube
6	Elbow

Item	Description
7	Exhaust Elbow
8	Muffler
9	Mounting Band
10	Exhaust Bracket
11	Bracket





Tier 4 Diesel Particulate Filter/Muffler

FIGURE 7-9

Item	Description
1	Elbow
2	Wire Tie Bar
3	Mounting Band Clamp
4	Diesel Particulate Filter
5	Muffler Clamp
6	Exhaust Tube

Item	Description
7	Gasket
8	V-Band Clamp
9	Bellows
10	Exhaust Tube
11	Gasket
12	V-Band Clamp

## WATER COOLING SYSTEM

### Description

The cooling system Figure 7-10 consists of a radiator, surge tank, engine cooling circuit, and the connecting hoses and connecting tubes. Cooling system capacity is approximately 40 qt (37.9 L). The temperature is controlled by a 181°F (83°C) thermostat located between the top of the engine and the top of the radiator. At all times, the antifreeze/coolant should be properly inhibited against corrosion. It is recommended that a mixture of AFC-50/50 blended ethylene-glycol, low silicate, fully formulated, engine antifreeze/coolant concentrate and water which does not require a pre-charge of supplemental coolant additives (SCA) for use in initial fill of heavy duty liquid cooled internal combustion engines be used at all times.

The crane is equipped with a cab hot water heater. Hot water is supplied by the engine coolant system through a strainer and two port water swivel to the cab heater. The strainer is a cleanable type and is located on the left side of the transmission by the rear engine/transmission mount. Refer to *Lubrication*, page 9-1 for service of the strainer.

### 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. 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.

2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.
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 Interval**

##### **6 months or 500 hours**

- Check SCA Levels (use only Coolant Test Kit, Grove part number 9414101675, to check the coolant additive concentration in the cooling system).

Only add coolant additive if levels are less than 1.2 units/gal (see : *Standard Lubricants [Down to -9°C (15°F)]*, page 9-2 for specification and recommended additives).

**NOTE:** An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Over concentration can cause formation of a "gel" that can cause restriction or plugging of coolant passages, and overheating.

##### **1 year or 1000 hours**

- Test antifreeze/coolant for contamination.  
Condemning limits are:
  - Sulfate level greater than or equal to 1500 ppm.
  - Chloride level greater than or equal to 200 ppm.
  - The ph level is less than 6.5
  - Oil or fuel contamination can be identified by odor or color.

If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *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 71 to 82°C (160 to 180°F). 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 82°C (180°F) 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 82°C (180°F) 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 3 mm (0.13 in). 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. 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 7-3.

### 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.

### Radiator Removal and Installation

#### Removal

1. Set the outriggers and position the boom to over the side.
2. Open the drain cock at the bottom of the radiator and drain the coolant into a suitable container. Dispose of the coolant in accordance with local and EPA regulations.

**NOTE:** Remove the radiator cap when draining the system to ensure proper draining.

3. Open and remove the hood top door assembly.
4. Disconnect the air filter tubing at the engine and air cleaner. Remove and lay aside.
5. Tag and disconnect the hourmeter wiring.
6. Remove the capscrews, nuts and washers holding the rear engine hood panel to the engine hood. This will gain access to the rear of the radiator and the surge tank mounting hardware.
7. Tag and disconnect the hoses from the surge tank to the engine and from the surge tank to the radiator.
8. Remove the capscrews, washers, flatwashers and nuts holding the surge tank to the side of the engine hood.
9. Remove the bolts and washers holding the transmission filter to the mounting bracket on the left side of the engine hood.
10. Remove the engine hood assembly.
11. Remove the nuts, washers and muffler clamps securing the two charge air cooler tubes to the left and right sides of the fan shroud.

12. Remove the hose clamps and bellows connecting the radiator to the charge air cooler tubes.
13. Remove the nuts, washers and muffler clamp securing the radiator return tube.
14. Remove the hose clamps and radiator hose connecting the radiator to the radiator tubes.
15. Disconnect the coolant level harness from the engine harness.
16. Remove the bolts and washers attaching the fan guard to the shroud ring. Remove the fan guard.
17. Remove the capscrews, washers and four spacer plates securing the shroud ring to the radiator and slide the shroud ring back onto the engine fan.
18. Remove the capscrews, washers and lockwashers that connect the plates to the top of the radiator and the top of the frame rail.

**NOTE:** The radiator weighs approximately 34 kg (75 lb).

19. Attach an adequate lifting device to the radiator assembly.
20. Remove the capscrews, washers, lockwashers, nuts and mounting angles securing the radiator flange to the frame mounting capscrews. Remove the radiator assembly from the carrier.
21. 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, washers, lockwashers, nuts and mounting angles.
3. Reconnect the two plates between the top of the radiator and the top of the frame rail using the capscrews, washers, lockwashers and nuts.
4. Connect the shroud ring to the radiator using the capscrews, washers, lockwashers and four spacers 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. Connect the two radiator tubes to the radiator with hose clamps and the radiator hose.

8. Secure the radiator return tube to the top of the engine using nuts, washers and a muffler clamp.
9. Reconnect the charge air cooler (CAC) tubes to the radiator using hose clamps and bellows. The recommended installation torque of the spring loaded hose clamp is 11.3 Nm (100 lb-in). Do not compress spring completely, clamp may be damaged from thermal expansion of CAC tube.
10. Secure the charge air cooler tubes with nuts, washers and muffler clamps to the left and right side of the fan shroud.
11. Tighten the drain cock at the bottom of the radiator.
12. Install the hood assembly.
13. Mount the surge tank to the side of the engine hood using the capscrews, washers, flatwashers and nuts.
14. Connect the hoses between the surge tank and engine and the surge tank and the radiator.
15. Install the capscrews, nuts and washers holding the rear engine hood panel to the engine hood.
16. Install the transmission filter to the mounting bracket on the left side of the engine hood.
17. Connect the air filter tubing at the engine and air cleaner.
18. Connect the hourmeter wiring.
19. Install the hood top door assembly.
20. Fill the radiator per the following instructions.
21. Start the engine, operate all systems and check for leaks. Make any repairs needed.

### Radiator Fill and Servicing

Refer to *Lubrication*, page 9-1 for complete fill and service procedures.

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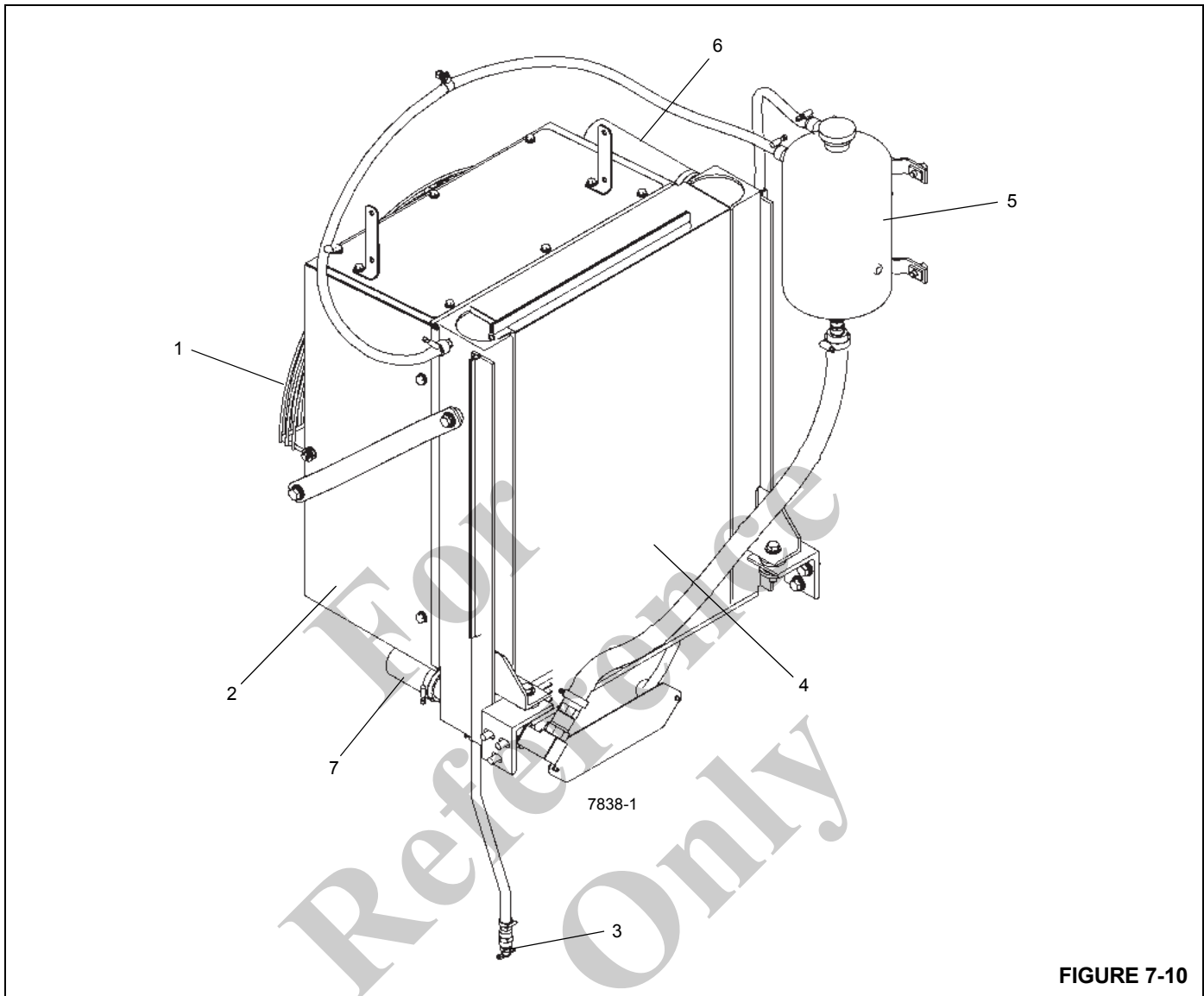


FIGURE 7-10

Item	Description
1	Fan & Fan Guard
2	Shroud
3	Drain Valve
4	Radiator

Item	Description
5	Surge Tank
6	Upper radiator Hose
7	Lower Radiator Hose

## DRIVE TRAIN

### Description

The drive train consists of the transmission/torque converter assembly and two drive lines.

The transmission/torque converter is mounted on and driven by the engine. The torque converter assembly provides for mounting and driving the two section main and single section hydraulic pumps. The transmission is a Range Shift with six forward speeds and six 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 transmission/torque converter oil is cooled by passing the oil through an externally mounted transmission cooler.

The cooler is located beside the hydraulic oil tank. An oil filter is located on the left side of the engine hood. Access to the filter is gained by opening the top left side hood door.

Three drive lines are used. Two drive lines are connected between the transmission/torque converter and the front axle and the other drive line is connected between the transmission/torque converter and the rear axle.

### Maintenance

#### Transmission

Refer to the Cummins engine and Spicer transmission manual and other portions of this section for removal, scheduled maintenance and corrective maintenance, and installation.

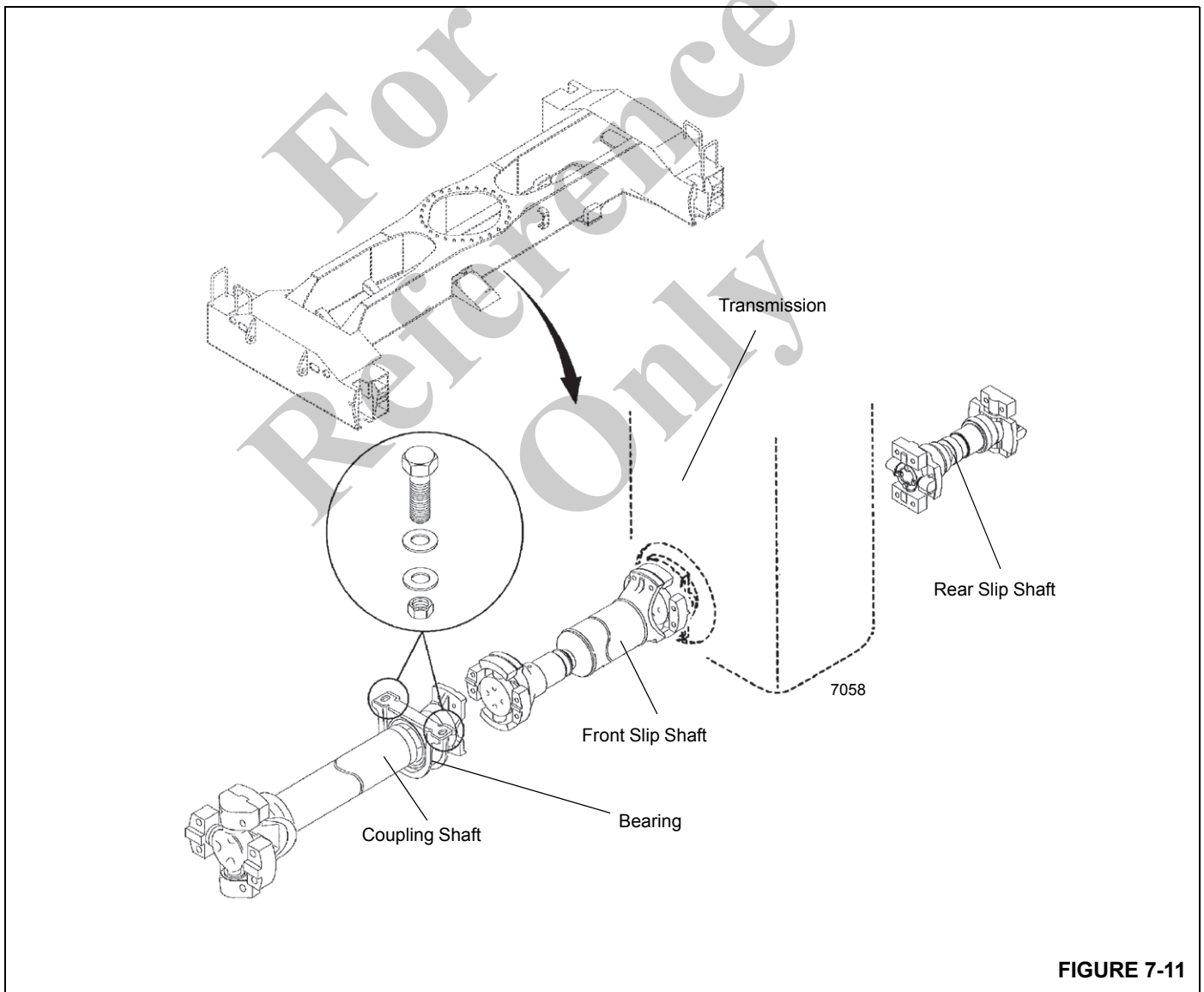


FIGURE 7-11

**Drive Shafts**

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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.

---

**Removal**

1. Support the drive shaft being removed so it does not fall when disconnected. If removing the coupling shaft or the forward slip shaft, support the other shaft also.
2. If removing the coupling shaft, free its bearing from the frame by removing two bolts, two locknuts, and four washers.

3. Remove the bolts from the bearing cap on each end of the drive line. Note the lengths of the bolts and if they have lockwashers. Remove the drive line.

**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 the frame with bolts, locknuts, and washers.
4. Secure the drive shaft to the coupler with bolts. Torque the bolts to 149 Nm to 163 Nm (110 lb-ft to 120 lb-ft).

**Lubrication**

The drive line slip joints require lubrication. Refer to *Lubrication*, page 9-1.

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## TRANSMISSION/TORQUE CONVERTER

### Description

The transmission/torque converter assembly is mounted to the engine and is connected to the front and rear axles by three drive shafts. The main hydraulic pump and hydraulic pump number three are mounted on the torque converter.

### 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. Then, through a series of tubes and passages, lubricates the transmission bearings and clutches. The oil then gravity drains to the transmission sump.

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.

### 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 82°C to 93°C (180°F to 200°F). 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

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 82°C to 93°C (180°F to 200°F).

## Troubleshooting Procedures

Table 7-1

SYMPTOM	PROBABLE CAUSE	REMEDY
1. Low clutch pressure.	a. Low oil level.	a. Fill to proper level.
	b. Clutch pressure regulating valve spool stuck open.	b. Clean valve spool and housing.
	c. Faulty charging pump.	c. Replace pump.
	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.
3. Overheating.	a. Worn oil sealing rings.	a. Remove, disassemble, and rebuild converter assembly.
	b. Worn oil pump.	b. Replace pump.
	c. Low oil level.	c. Fill to proper level.

SYMPTOM	PROBABLE CAUSE	REMEDY
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 engine and transmission/torque converter from the crane as an assembly. Refer to *Engine Removal*, page 7-2.
4. Remove the two-section and single section hydraulic pumps from the transmission/torque converter. Cover all openings. Refer to in *Hydraulic Pumps*, page 2-17 for removal of the pump.

**NOTE:** The transmission/torque converter weighs approximately 438 kg (966 lb) dry.

5. Attach an adequate lifting device to the transmission/torque converter and take up any slack.
6. Remove the capscrews and hardened flat washers securing the drive plate assembly to the flywheel.
7. Remove the nuts and washers securing the transmission/torque converter housing to the engine flywheel housing.

### Installation

**NOTE:** The transmission/torque converter assembly weighs approximately 438 kg (966 lb) dry.

1. If a new transmission/torque converter is to be installed, remove all fittings and brackets from the old one and install them in the same locations on the new transmission/torque converter.
2. Install the two-section and single section hydraulic pumps on the transmission/torque converter. Refer to *Hydraulic Pumps*, page 2-17 for installation of the hydraulic pump.
3. Position the transmission/torque converter to the engine with the lifting device.
4. Remove all burrs from the flywheel mounting face and nose pilot bore. Clean the drive plate surface with solvent.

**NOTE:** Refer to Figure 7-12.

5. Check the engine flywheel and housing for conformance to standard S.A.E. No. 3/S.A.E. J-927 tolerance specifications for bore size, pilot bore runout and mounting face flatness. Measure and record engine crankshaft end play.
6. Install the 12 studs in the engine flywheel housing. Rotate the engine flywheel to align a drive plate mounting screw hole with the flywheel housing front access hole.
7. Install a 101.6 mm (4.00 in) long drive plate locating stud 3/8-24 UNF in a drive plate nut.
8. Rotate the transmission/torque converter to align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step 6. Locate the transmission on the flywheel housing, aligning the drive plate to the flywheel and the transmission on the flywheel housing mounting studs. Install the transmission to flywheel housing nuts and washers. Tighten the nuts to 41 Nm (30 lb-ft).
9. Remove the drive plate locating stud. Install one drive plate attaching capscrew and lockwasher. Snug the capscrew but **do not tighten**.

**NOTE:** Some engine flywheel housings have a hole located on the flywheel housing circumference in line with the drive plate screw access hole. A screwdriver or pry bar used to hold the drive plate against the flywheel will facilitate installation of the drive plate capscrews.

10. Rotate the engine flywheel and install the remaining seven flywheel to drive plate attaching capscrews and hardened flat washers. Snug the capscrews but **do not tighten**. After all eight capscrews and hardened flat washers have been installed, torque the capscrews to 38 Nm (28 lb-ft). This will require torquing each capscrew, then rotating the engine flywheel until all capscrews have been torqued.
11. Measure the engine crankshaft end play after the transmission/torque converter has been completely installed on the engine flywheel. This value must be within 0.025 mm (0.001 in) of the end play recorded in step 5.



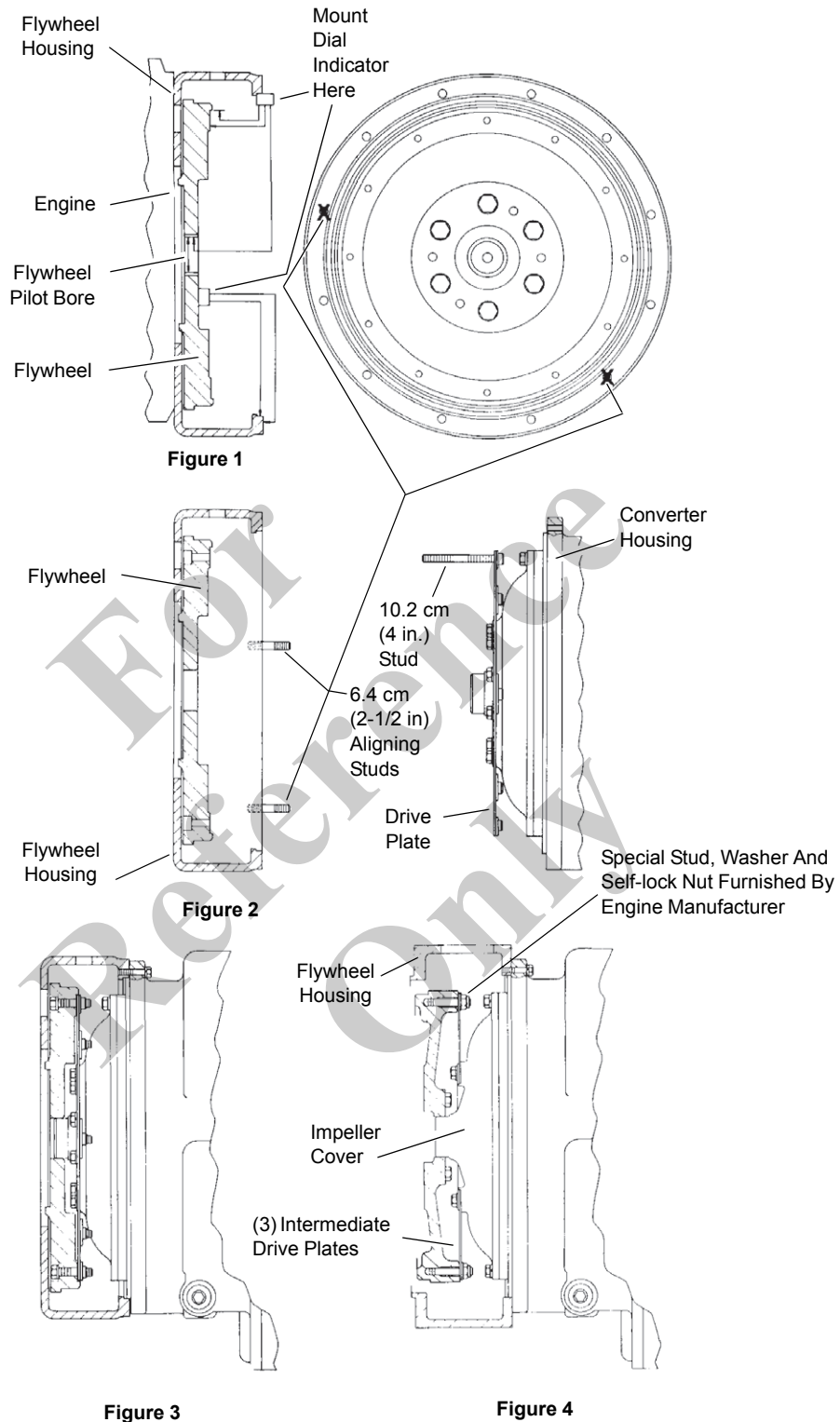


FIGURE 7-12

12. Install the engine and transmission/torque converter in the crane as an assembly. Refer to *Power Train*, page 7-1.
13. Service the crane as outlined under *Servicing The Crane After Transmission/torque Converter Overhaul*, page 7-29.
14. 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 (950 rpm) to prime the torque converter and hydraulic lines. Recheck the level of oil in the transmission with the engine running at idle (950 rpm). Add oil as necessary to bring the level to the LOW mark on the dipstick. After the oil temperature reaches 82°C to 93°C (180°F to 200°F), 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 and Capacities**

Refer to *Lubrication*, page 9-1 for types of oil and capacities.

#### **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.

**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. Refer to *Lubrication*, page 9-1.

- a. Drain transmission and remove pump screen. Clean screen thoroughly and replace, using a new gasket.
- b. Remove and discard oil filter. Clean filter housing and install new filter.
- c. Refill transmission to LOW mark.
- d. Run engine at 950 RPM to prime converter and lines.
- e. Recheck level with engine running at 950 RPM and add oil to bring level to LOW mark. When oil temperature is hot [82°C to 93°C (180°F to 200°F)], make final oil level check. Bring oil level to full mark.

### **Towing or Pushing**

Before towing the crane, disconnect both front and rear drive lines. The engine can not be started by pushing or towing because of the design of the hydraulic system.

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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 disc type hydraulic braking system. A disc-type parking brake is mounted of 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.

## 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.

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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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3. Disconnect and remove the drive line from the applicable axle. Do not disassemble the drive lines. Refer to *Drive Shafts*, page 7-24.
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 left side of the rear axle only, tag and disconnect the electrical wires from the rear wheels not centered switch.

**NOTE:** Each tire and wheel installation weighs approximately 1360.7 kg (3000 lb).

8. Remove the wheels from the axle.

**NOTE:** Each axle weighs approximately 1400 kg (3086 lb).

9. Position jacks, which are capable of handling the weight of the axle, under the axle for support.
10. Remove the eight nuts, washers, bushings and bolts securing the axle to the frame/cradle.
11. Lower the axle to the ground and move it to a clean working area.

12. 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 8-13 in this section.

### 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 8-13 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, bushings and nuts. Torque the bolts to 759 Nm to 822 Nm (560 lb-ft to 606 lb-ft).
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 left side of the rear axle only, connect the electrical wires to the rear wheels not centered switch. Adjust the switch as outlined under, *Rear Steer Indicator Adjustment Procedure*, page 8-3.
9. Connect the drive line to the applicable axle. Refer to *Drive Shafts*, page 7-24.
10. Refer to *Brake System*, page 8-13 and bleed the hydraulic brake system.
11. Remove the blocking under the frame 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 as follows:
  - a. Turn the wheels to the extreme left.
  - b. Check the clearance between the inside of the tire and the nearest object.
  - c. Clearance should be 25.4 mm (1.00 in) minimum, if necessary, adjust the axle stop to provide clearance.
3. Turn axle to extreme right and repeat step 2.
4. With the axles set at a 25.4 mm (1.00 in) clearance, check the steer cylinders to see that they are not bottomed out. To check the steer cylinders, remove the

pin at the rod end and apply pressure to move the cylinder rod. The cylinder rod should travel a minimum of 3.0 mm (0.12 in).

**Rear Steer Indicator Adjustment Procedure**

1. Ensure the wheels are straight ahead.

**NOTE:** When performing rear steer indicator adjustment using the following steps, refer to Figure 8-1.

2. Slide the proximity switch through hole in rear steer sensor bracket and secure with nuts and washers.
3. Set face of proximity switch 6 mm (0.24 in) from opening in rear steer sensor plate. Tighten the fasteners.
4. Turn the rear wheels to verify proper operation. Rear Wheels Not Centered Light in cab should be out when rear wheels are centered and the sensor switch is centered in the slot of the sensor plate.

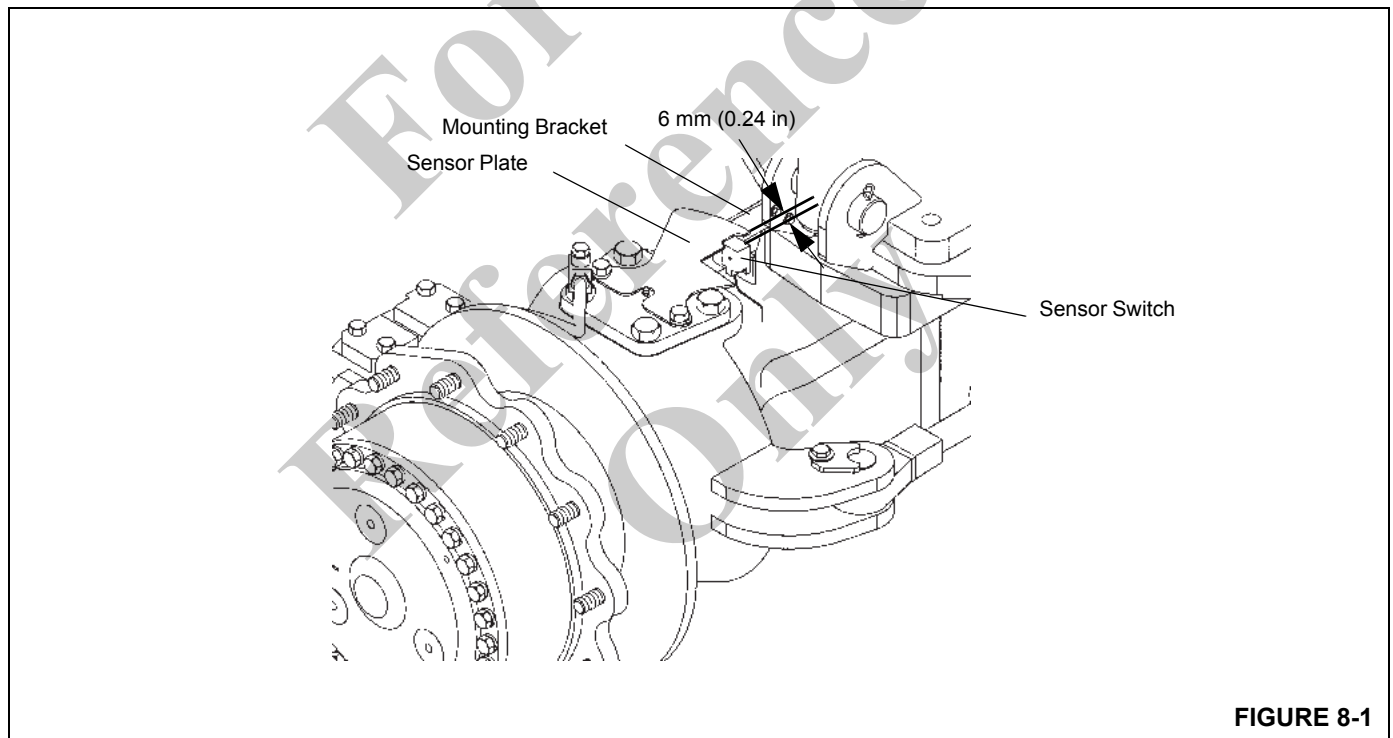


FIGURE 8-1

**Wheels And Tires**

**Description**

The standard tire size for this unit is 29.5 x 25; also available as an option, is a 29.5R25 tire.



**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.

**CAUTION**

Do not mix tires or rims from different manufacturers. Vehicle stability can be affected.

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 traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lowered rim life.

Refer to and adhere to the inflation pressures in the Load Chart Book in the crane cab.

**Maintenance**



**DANGER**

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**

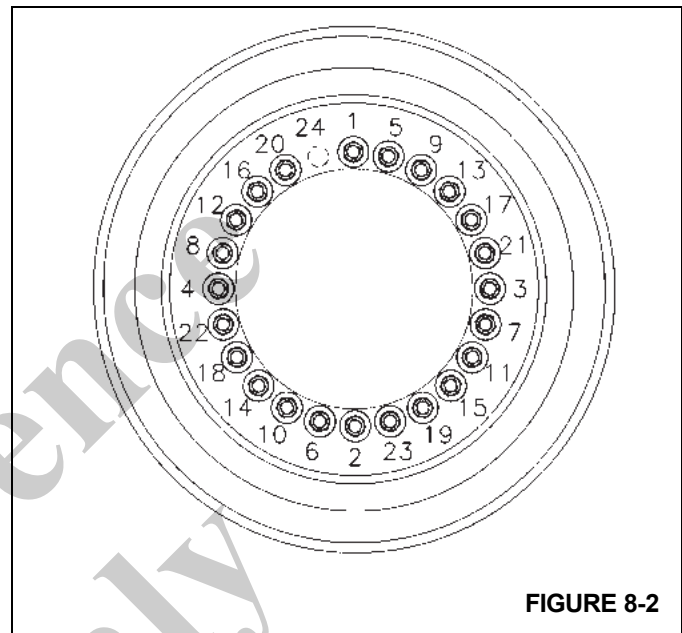
**NOTE:** Do not lubricate the wheel studs or lug nuts.

1. Raise the crane on outriggers so the wheels are off the ground.

**NOTE:** Prior to wheel installation remove any dirt or grease from wheel mounting surfaces.

2. Position the wheel assembly on the mounting studs. Install the lug nuts and tighten them to 68 Nm (50 lb-ft) in the sequence shown in Figure 8-2.

3. Ensure the wheel assembly is positioned properly on the hub.



**FIGURE 8-2**

4. Continue to torque the lug nuts 461 Nm to 488 Nm (340 lb-ft to 360 lb-ft) in the sequence shown in Figure 8-2.

5. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.

6. Road-test the tire, then retorque to 461 Nm to 488 Nm (340 lb-ft to 360 lb-ft).

7. Maintain proper torque on wheel lugs and check for proper wheel mounting. Retorque the lug nuts 80 km to 160 km (50 miles to 100 miles) after the wheels are removed and reinstalled. This will reseal the lug nuts. Check the torque every 800 km (500 miles) thereafter.

**Typical Wear Patterns**

**Incorrect Tire Pressure**

Too high air pressure Figure 8-3, View 1) gives rapid wear in the middle of the tire. Too low air pressure (Figure 8-3, View 2) gives rapid shoulder wear.



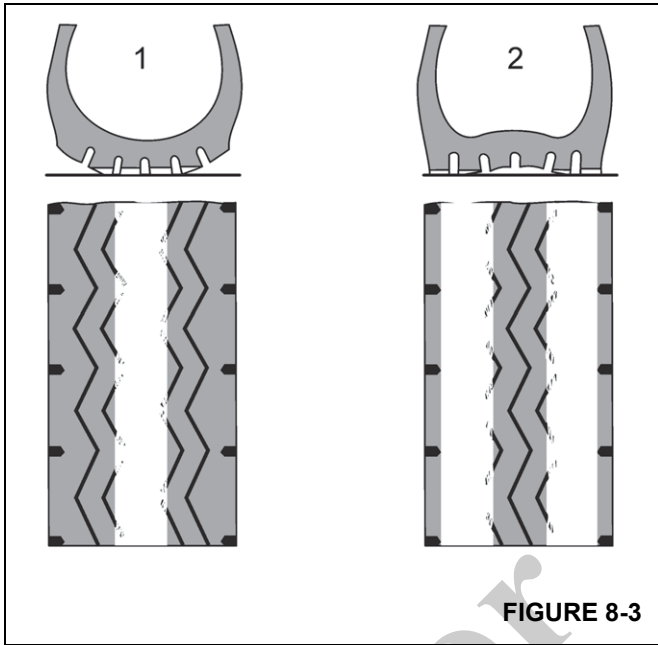


FIGURE 8-3

**Incorrect Camber**

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

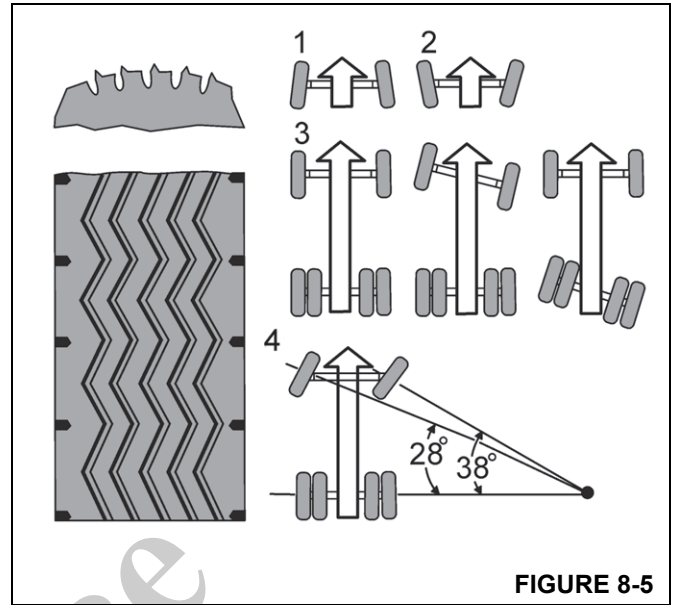


FIGURE 8-5

Item	Description
1	Incorrect Toe-In
2	Incorrect Toe-Out
3	Out-of-line Axles
4	Steering Arm Defect

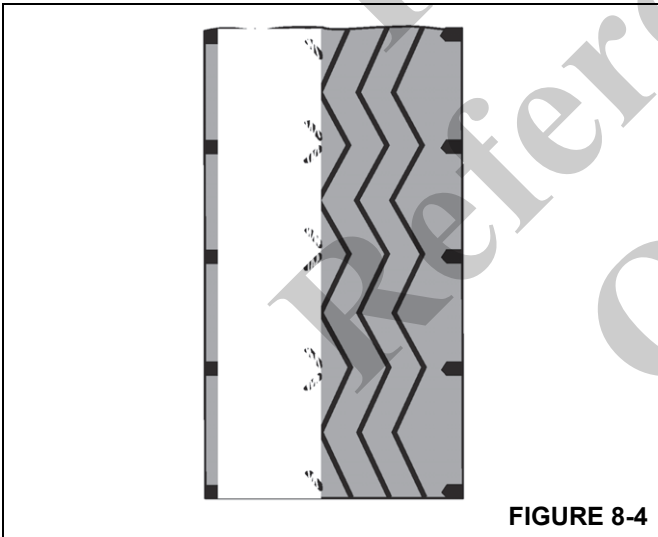


FIGURE 8-4

**Incorrect Toe and Axle Alignment**

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

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

**Incorrect Caster and Wheel Imbalance**

Incorrect caster or wheel imbalance shows as spot wear that is either in the middle of the tire or extends to the shoulder.

This rapidly wears the mechanical parts of steering linkage, kingpin and wheel bearing.

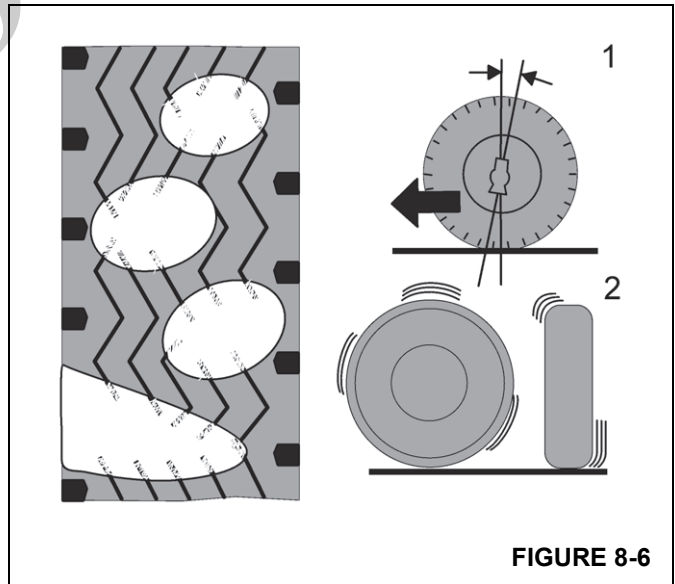
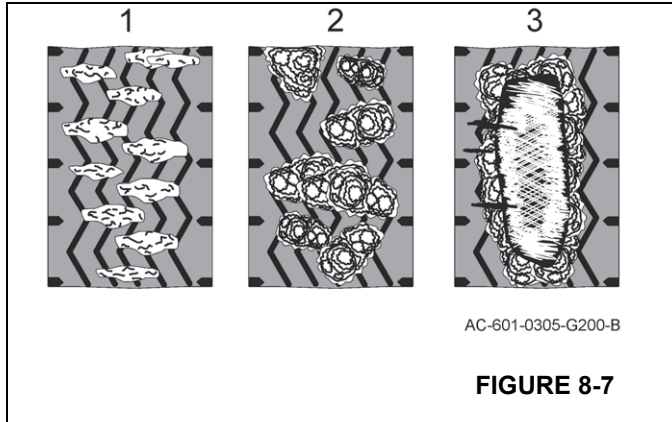


FIGURE 8-6

**Cuts in the Tire Tread**

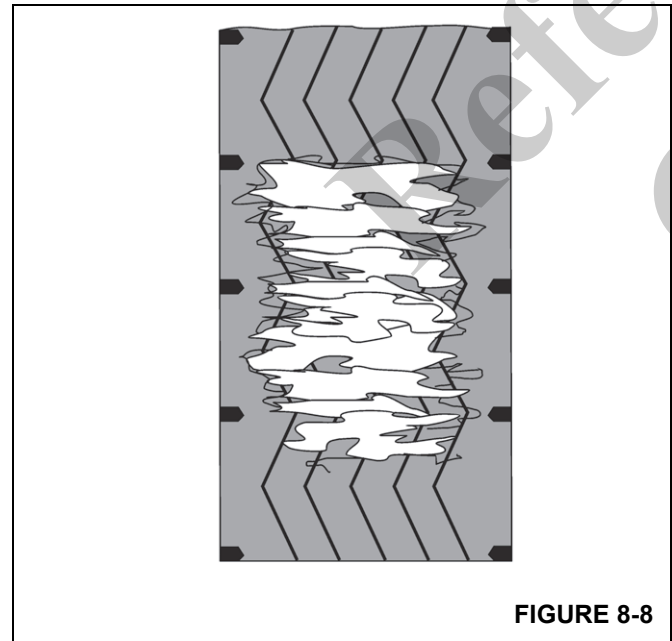
Cuts are due to poor roads, air pressure too high or incorrect tire type for the application.



Item	Description
1	Cuts
2	Flaking Cuts
3	Rubber Flaking

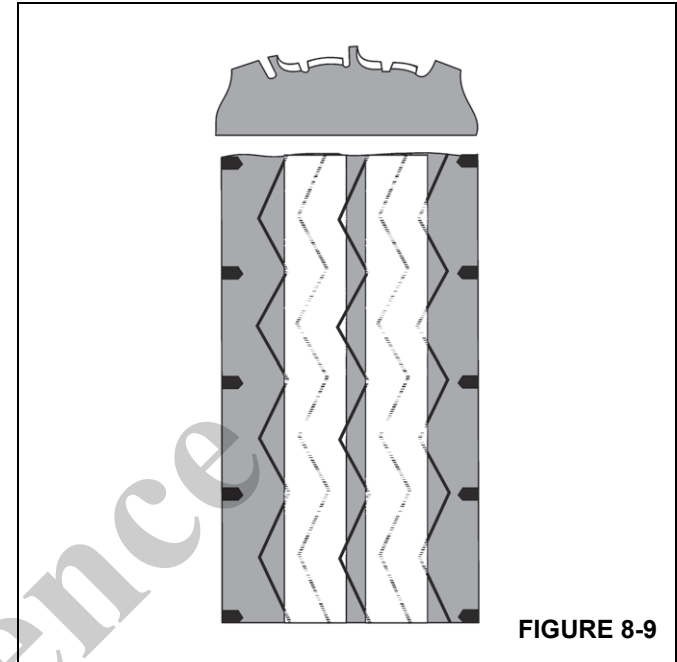
**Spot Wear**

Sudden braking, locking brakes or out-of-round brake drums give spot wear.



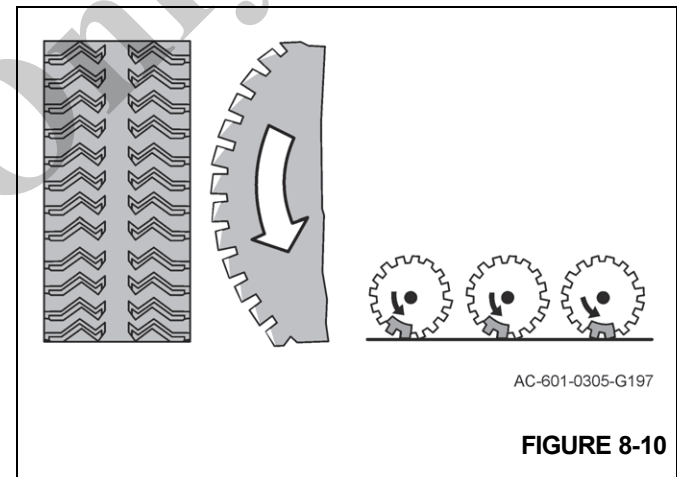
**Feathered Edges**

Normal occurrence on non-driving wheels on good roads and high mileage.



**Cupping**

Cupping is a normal occurrence that depends on the tread pattern - the higher the load, the greater the wear.



## 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 122.6 L/min (32.4 gpm) to the load sense steering priority flow divider valve. The load sense steer priority flow divider valve provides 34.1 L/min (9 gpm) to the load sense steering control valve and 80.2 L/min to 114.3 L/min (21.2 gpm to 30.2 gpm) 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.

#### **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 left side of the rear axle. When the rear wheels are turned to the left or right, the amber indicator light will illuminate.

#### **Secondary Steering System (CE Units)**

The secondary steering system is provided to back up the normal front steering system if loss of hydraulic flow occurs. The system consists of an hydraulic accumulator, two check valves, a pressure switch, and a pilot operated, 2 position 3-way valve used in conjunction with the service brake dual accumulator charge valve and the load sense steering control valve.

## Theory Of Operation

### **Front Steering System**

A hydraulic oil flow from pump number 2 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 steering control valve upon turning of the steering wheel and pressurizing of the load sense line. The 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 1 is directed through the boost selector valve 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.

### **Secondary Steering System (CE Units)**

When the engine is running, the load sense steering priority flow divider valve maintains a constant 862 kPa (125 psi) standby pressure in the steering load sense line. When a minimum 862 kPa (125 psi) load sense pressure is maintained in the pilot circuit, the pilot operated, 2 position, 3-way valve ports are aligned to charge the secondary steering hydraulic accumulator. The hydraulic accumulator is charged from the switch (SW) port on the service brake dual accumulator charge valve when the engine is running. A check valve is installed in the pressure line to prevent back flow from the secondary steering hydraulic accumulator to the service brake dual accumulator charge valve and the service brake pressure switch.

When flow from the steer pump stops for any reason, the load sense pressure will drop to zero. When the load sense pressure drops below 862 kPa (125 psi), the pilot ports so hydraulic fluid stored in the secondary steering hydraulic accumulator will flow to the load sense steering control valve. The secondary steering hydraulic accumulator charge will allow the operator to safely steer the crane to a safe stop. When the load sense pressure drops below 689 kPa (100 psi), the secondary steer pressure switch will close its contacts and energize the red Engine Distress Indicator and sound the warning buzzer.

**Maintenance**

**Front Steering System**

**Troubleshooting**

Table 8-1

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.
	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.
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.
4. Noisy hydraulic pump caused by cavitation.	a. Hydraulic oil low.	a. Refill hydraulic reservoir. Refer to <i>Lubrication</i> , page 9-1.
	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.
	b. Broken diaphragm seal or backup gasket.	b. Replace seal or gasket. Refer to your Maniowoc Crane Care Parts Manual.
	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 drive. Adequate oil pressure can only be determined by connecting a pressure gauge (3500 psi (24 MPa) 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 3000 psi (20 MPa).

### Secondary Steering System

Refer to *Hydraulic System*, page 2-1 for checking accumulator pre-charge pressure and for pre-charging accumulator using the steering control valve to discharge the accumulator pressure.

## REAR STEERING SYSTEM

### Troubleshooting

Table 8-2

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.
	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

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

#### Front Steer

The hydraulic pump is mounted on and driven by the engine. Pump number 2 provides the hydraulic flow necessary to power the front steer cylinders and the swing drive system. The pump is a gear type pump that provides an output of approximately 122.6 L/min (32.4 gpm).

#### Rear Steer

The hydraulic pump is mounted on and driven by the torque converter. Section 2 of pump number 1 provides the hydraulic flow necessary to power the rear steer cylinders, the outrigger circuit, and the rear axle oscillation lockout system. The pump is a gear type pump that provides a flow of approximately 86.6 L/min (22.9 gpm).

**NOTE:** For more detailed information, refer to *Hydraulic Pumps*, page 2-17.

## 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 flatwashers 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 flatwashers, lockwashers, and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque.
2. Connect the 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 outrigger/rear steer valve controls the outrigger circuit and the rear steer circuit. The valve is mounted on the front face of the carrier frame front cross member forward of the swivel.

The inlet section contains a 17,200 kPa (2500 psi) relief valve and a solenoid valve. The solenoid valve is normally open bypassing oil from the inlet port to the tank port. Activation of either the outriggers or the rear steer energizes the solenoid valve to close and allow oil to flow to the selected circuit.

The rear steer section contains a three position four-way solenoid controlled directional valve.

The outrigger section contains a three position four-way solenoid controlled directional valve.

Both four-way solenoid valves contain manual override actuators which allow the valves to be shifted if electrical power is lost.

### Maintenance

**NOTE:** Refer to *Hydraulic System*, page 2-1 for removal and installation of the valve.

### Functional Check

1. Cycle each outrigger cylinder several times. Verify each 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.
3. Check the valve and lines for leakage. Make repairs as needed.

## 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 a bracket on the axle housing and the rod end is attached to the steering lug on the axle end. The cylinders are controlled hydraulically by the steering control valve.

### Maintenance

**NOTE:** For Disassembly and Assembly procedures, refer to *Steer Cylinder*, page 2-72.

## Removal

1. Tag and disconnect the hydraulic lines from the steer cylinder. Cap or plug all openings.
2. Remove the capscrew, flatwasher, and lockwasher securing each pin weld in the rod end and barrel end of the cylinder.
3. Remove both pin welds 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 welds. On the rod end, install a thrust washer top and bottom of lug.
2. Secure each pin weld with the capscrew, flatwasher, and lockwasher. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
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 8-11 and Figure 8-12 consists of two lockout cylinders, a lockout valve, and an angle encoder. 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 angle encoder is located in the electrical swivel assembly.

### Theory Of Operation

The rear axle is mounted on a cradle (fifth wheel) allowing maximum oscillation of 5.9 in (15 cm) total while traveling over uneven terrain. Oscillation is provided only when the superstructure is within  $\pm 2$  degrees left or right of directly over the front. When the superstructure is within  $\pm 2$  degrees left or right of directly over the front, the RCL sends a CAN bus message to the Crane Control System to allow axle oscillation. When the Crane Control System receives this message it switches ON a digital output thus energizing the axle oscillation solenoids. 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. 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  $\pm 2$  degrees left or right of directly over the front, the Crane Control System switches OFF the digital output thus de-energizing the axle oscillation solenoids. This de-energizes 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.

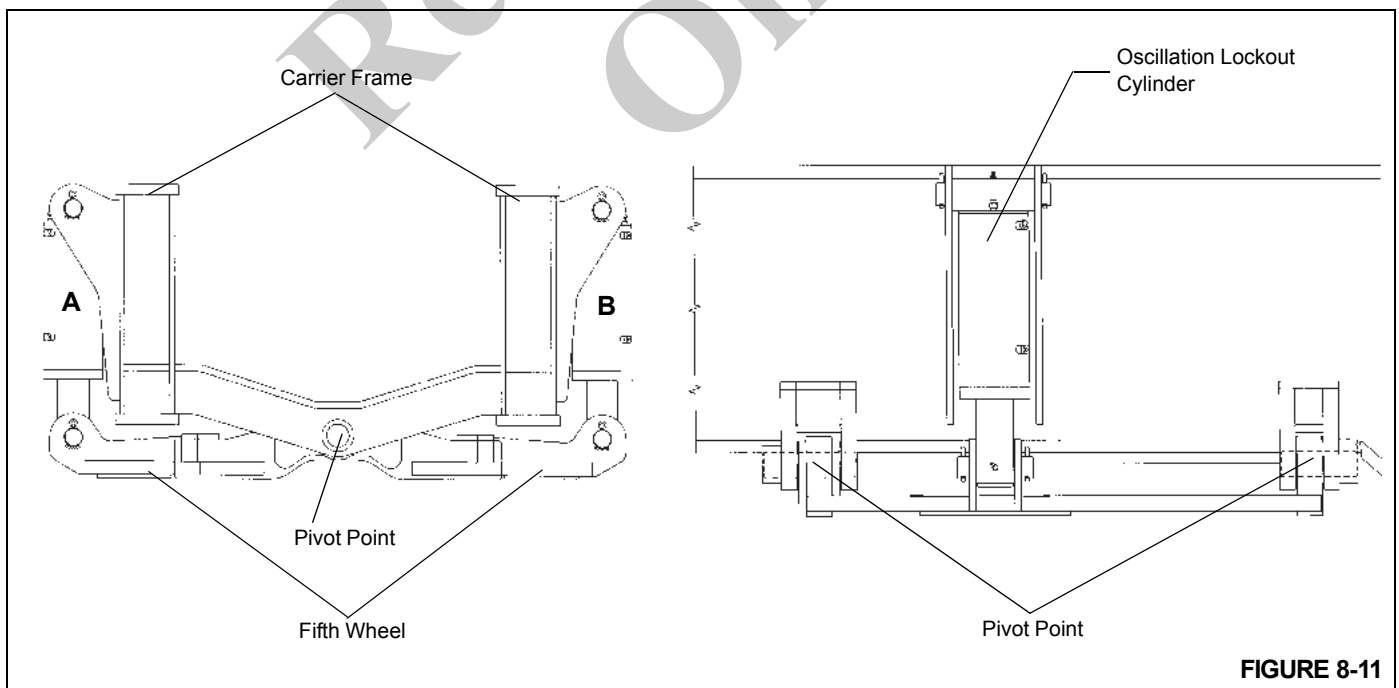
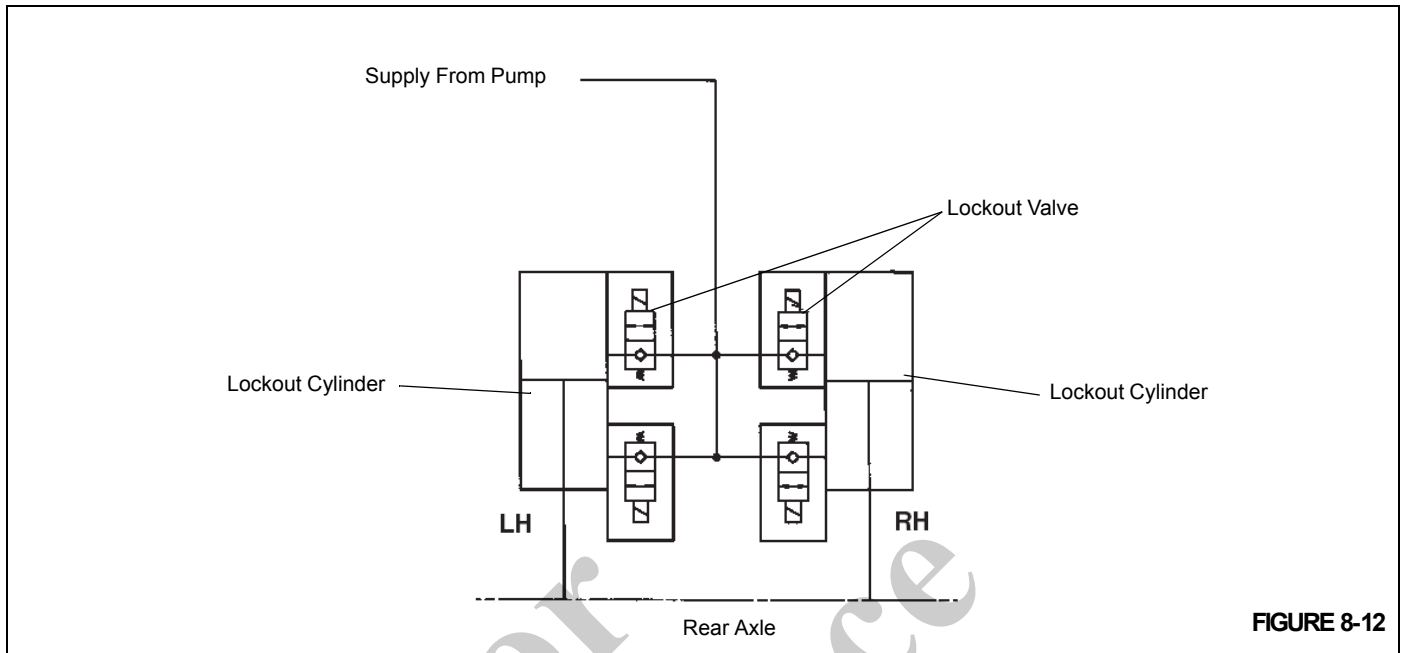


FIGURE 8-11





For Reference Only

## Axle Oscillation Lockout Cylinders

### Description

Two 12.7 cm (5.0 in) hydraulic lockout cylinders are installed on the rear axle, one left side and one right side. The base 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 38.8 kg (85.5 lb).

### Maintenance

**NOTE:** For disassembly and assembly procedures, refer to *Hydraulic System*, page 2-1.

### Removal

1. Raise the crane up on outriggers.
2. Rotate the turntable more than  $\pm 2$  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.
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. Tap 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. Tap out the retaining pin and remove the cylinder.

### Installation

1. Position the barrel end of the cylinder in the frame attach fitting and tap 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 tap in 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. Refer to *Wheels And Tires* in this section.
7. Lubricate both ends of the cylinder using the fittings provided.

8. Function test the axle oscillation system in accordance with the Operator's Manual to ensure proper operation.

## 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 left rear face of the carrier frame rear cross member 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.

For the CE Units with Dual Axis Controllers, the axle oscillating lockout valve is replaced with four two way solenoid operated poppet cartridge valves installed in the ports of the lockout cylinders.

The angle encoder located in the top of the electrical slip ring assembly sends a CAN bus message to the RCL. The RCL converts the data in the message to a position angle of the superstructure relative to the carrier (slew angle). If the slew angle is  $\pm 2^\circ$  of directly over the front, the RCL sends a CAN bus message to the Crane Control System to allow axle oscillation. When the Crane Control System receives this message it switches ON a digital output thus energizing the axle oscillation solenoids. If the angle is more than  $2^\circ$  left or  $2^\circ$  right of directly over the front, the Crane Control System switches OFF the digital output thus de-energizing the axle oscillation solenoids.

When the axle oscillation normally closed solenoid valves are de-energized the lockout cylinders are isolated 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 solenoid valves are energized and open, hydraulic oil is allowed in and out of the cylinders, allowing them to oscillate.

### Maintenance

**NOTE:** Refer to *Hydraulic System*, page 2-1 for removal and installation of the valve.

## 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 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. The brake assemblies are disc type brakes.

### **Parking Brake**

The parking brake is a hydraulically-controlled, 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, brake assembly, and all the associated hardware and tubing. The selector switch, located on the steering column in the cab, is used to activate the solenoid valve which controls the park brake actuator, which applies and releases the park brake.

**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 2-30.

## **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 3 flows to a 37.9 L/min (10 gpm) priority flow control valve then through swivel port 8 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. However, when the open center circuit pressure reaches the brake relief setting, which is higher than the high accumulator charge limit, then the accumulators will be charged to the relief valve 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 cab air conditioning circuit.

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 (3 mm).	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.
	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.

**Pressure Bleeding The Brake System**

**NOTE:** Before bleeding the brake system, ensure the hydraulic accumulators are fully charged.

1. Install the bleeding adapter.
2. Using a clean bleeding tank, fill the tank at least half full with hydraulic oil. Position the tank so it will not have to be moved again until all bleeding is finished.
3. Connect a 240 kPa (35 psi) air source to the bleeder tank.
4. Open the bleeder tank valve and bleed all air out of the hose to be connected to the adapter. Connect the bleeder hose to the adapter and open the bleeder valve.
5. Connect the end of the bleeder hose to the bleeder screw on the caliper/actuator. Submerge the other end in a glass jar partially filled with the proper type of clean hydraulic oil.
6. Open the bleeder screw and allow fluid to flow into the jar until it is a solid stream free of air bubbles. Close the bleeder screw and torque 11.3 Nm to 13.6 Nm (100 lb-ft to 120 lb-in).
7. Repeat steps 5 and 6 for the remaining wheel calipers/actuators.
8. Remove the air supply from the bleeder tank.
9. Close the bleeder tank valve and disconnect the hose and the bleeder adapter.
10. Remove the bleeder tank and hose.
11. Remove the bleeder adapter.

**Manually Bleeding the Brake System**

**NOTE:** Before bleeding the brake system, ensure the hydraulic accumulators are fully charged.

1. Connect the end of the bleeder hose to the bleed screw on the caliper. Submerge the other end in a jar partially filled with clean hydraulic oil.
2. Open the bleed screw on the caliper/actuator and allow fluid to flow into the jar, while depressing the brake pedal. Depress the brake pedal and close the bleeder screw, then release the brake pedal. Torque the bleeder screw (11.3 Nm to 13.6 Nm (100 lb-ft to 120 lb-in).
3. Repeat step 2 until a solid stream free of air bubbles is obtained.
4. Repeat steps 1 thru 3 for the remaining wheel calipers/actuators.

**SERVICE BRAKES**

**Description**

The brakes utilized on the later model axles are hydraulic disc-type brakes. One brake assembly is 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 in this section.



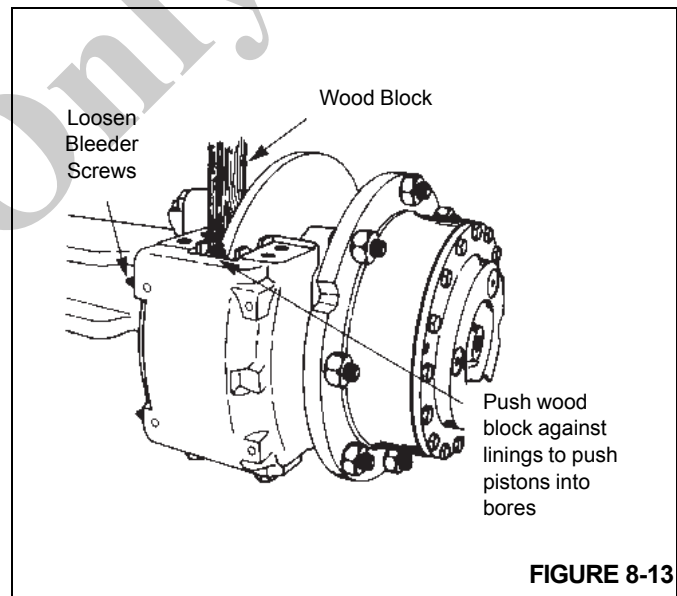
**CAUTION**

To prevent serious eye injury, always wear eye protection when doing maintenance or service.

**Removal**

**Linings**

1. Block the wheels.
2. Remove the bolts securing the end plates to one side of the caliper housing. Remove the end plates.
3. Loosen the bleeder screws to release hydraulic pressure in the caliper.



**FIGURE 8-13**

4. Use a piece of wood against the linings as a pry bar to push the pistons completely into the housing. Tighten the bleeder screws Figure 8-13.
5. Remove the linings from the caliper housing. If necessary, discard the linings.

### Caliper

1. Block the wheels
2. Disconnect the hydraulic brake line from the inlet fitting on the caliper. Cap or plug all openings.
3. Remove the linings as described under linings.
4. 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 brake 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 12.7 mm (0.5 in) block of wood against two pistons on the mounting side of the housing. Ensure the C-clamp is not in the area in front of the piston bore. Refer to Figure 8-14.

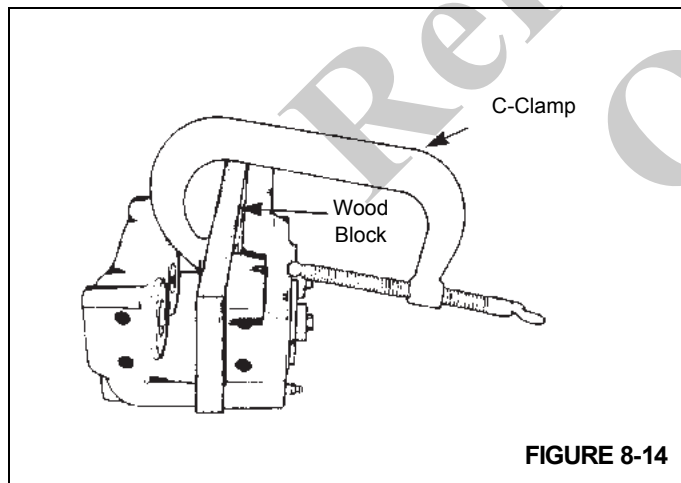


FIGURE 8-14



Do not place hand in front of pistons when forcing them out. Serious personal injury may occur.

- 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. Refer to Figure 8-15.

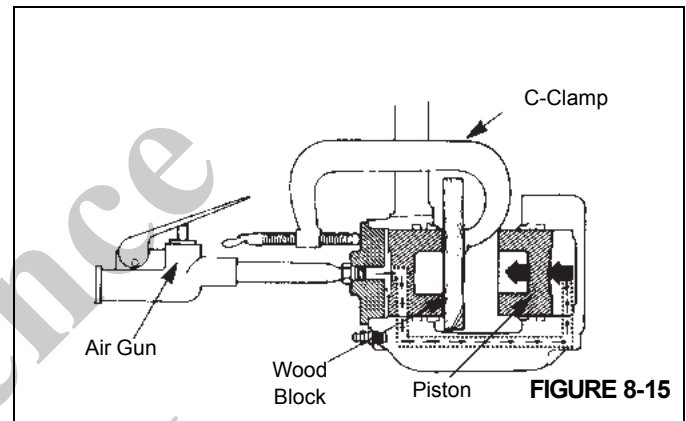


FIGURE 8-15

- c. Remove the wood block and the C-clamp from the housing.
    - d. Remove the pistons from the bores that are opposite from the mounting plate.
6. Remove the two bleeder screws from the housing.
7. Remove the cylinder caps from the housing using an open end wrench. Remove and discard the O-rings (Figure 8-16).

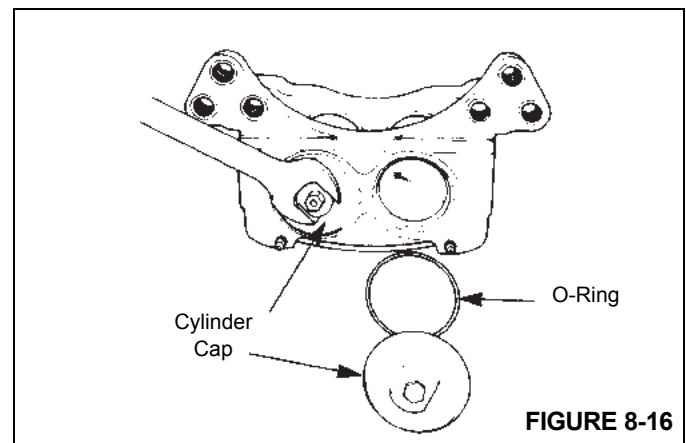
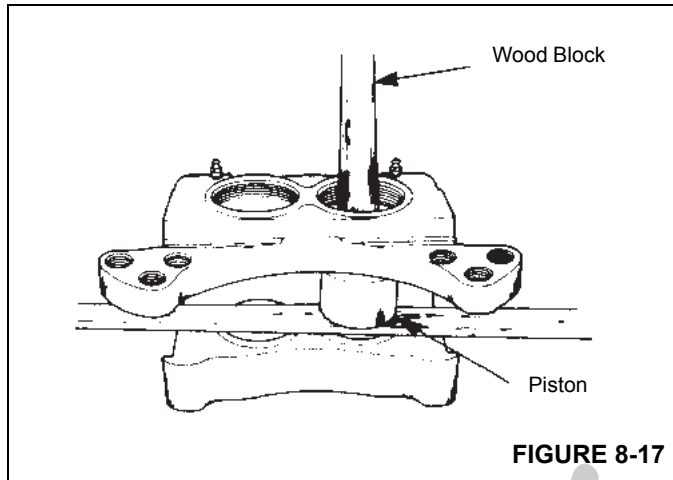
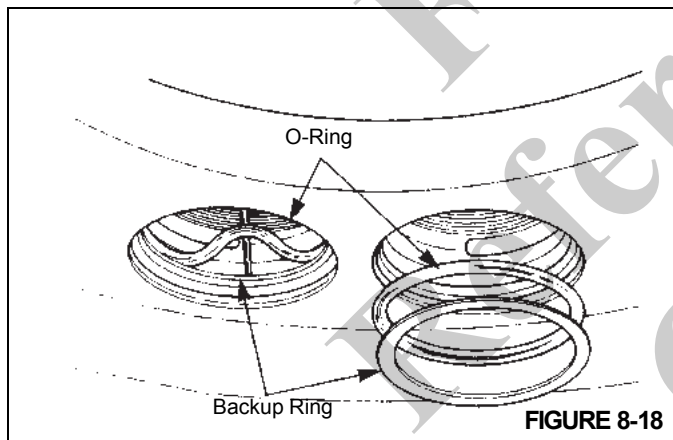


FIGURE 8-16

8. Remove the pistons from the mounting plate side of the housing. Push on the ends of the pistons to force them out of the disc side of the housing. Refer to Figure 8-17.



9. Remove the dust seals from the housing.
10. Remove and discard the O-ring and the backup rings. Refer to Figure 8-18.



11. 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 8-19 in this section.
12. 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 8-19 in this section.

**Inspection**

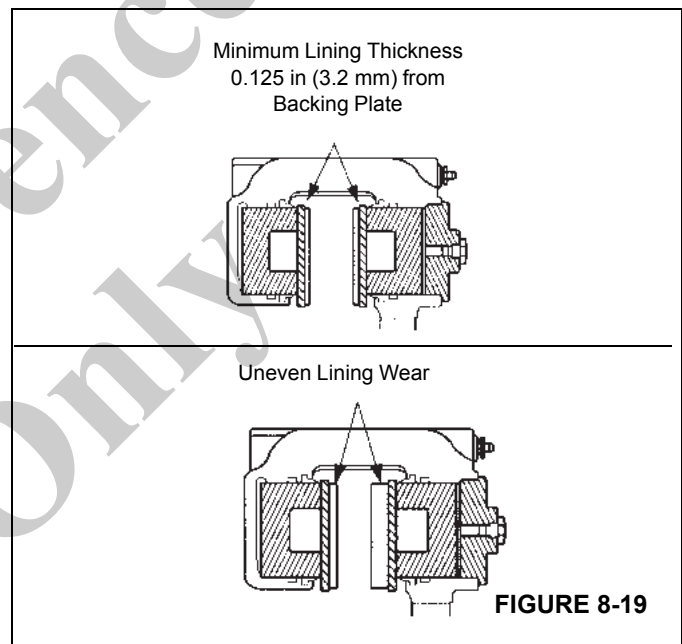
**Periodic On-Vehicle**

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. Refer to Figure 8-19.
- 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. Refer to Figure 8-19.



- 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. Refer to Figure 8-20.



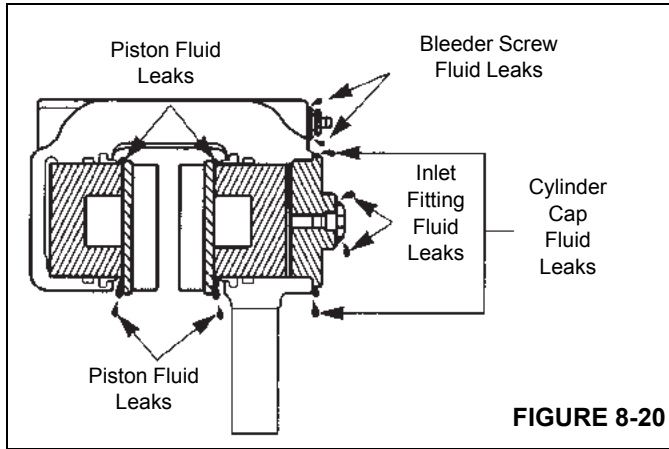


FIGURE 8-20

- **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 continued, 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. Refer to Figure 8-21.

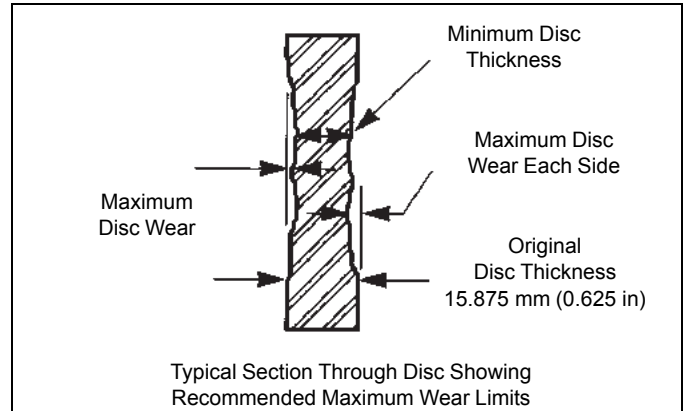


FIGURE 8-21

Lining Backing Plate Thickness	Maximum Disc Wear Each Side	Minimum Disc Thickness
7.1 mm (0.28 in)	1.5 mm (0.06 in)	12.7 mm (0.50 in)
8.6 mm (0.34 in)	2.3 mm (0.09 in)	11.2 mm (0.44 in)

**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 less than 76.073 mm (2.995 in). Refer to Figure 8-22.

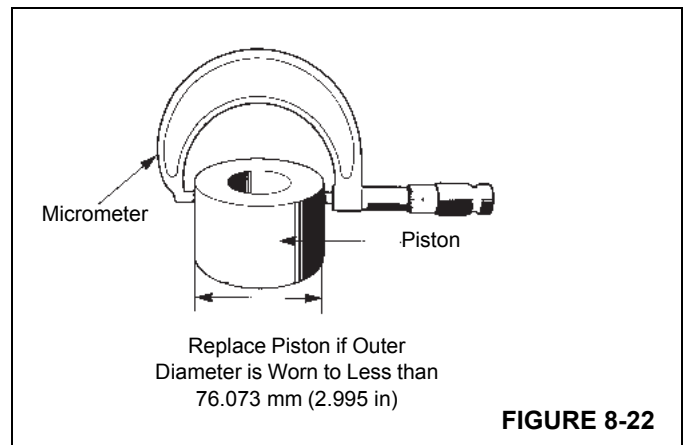
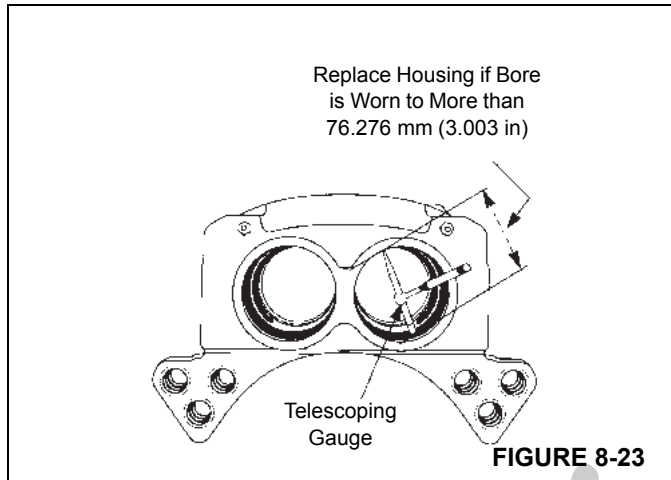


FIGURE 8-22

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). Refer to Figure 8-23.



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**

**! DANGER**

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.

- 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 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 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 Figure 8-24.

**CAUTION**

Do not use silicone grease on the dust seal. Damage to the seal could occur

3. Install a new dust seal in the top groove of the bore. Refer to Figure 8-24.

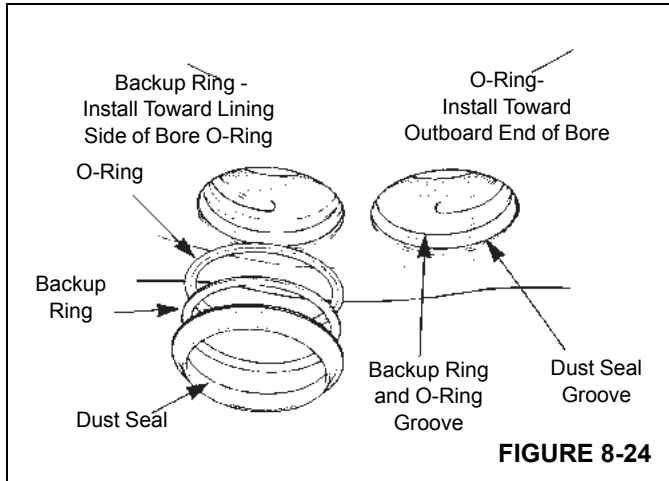


FIGURE 8-24

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. Refer to Figure 8-25.

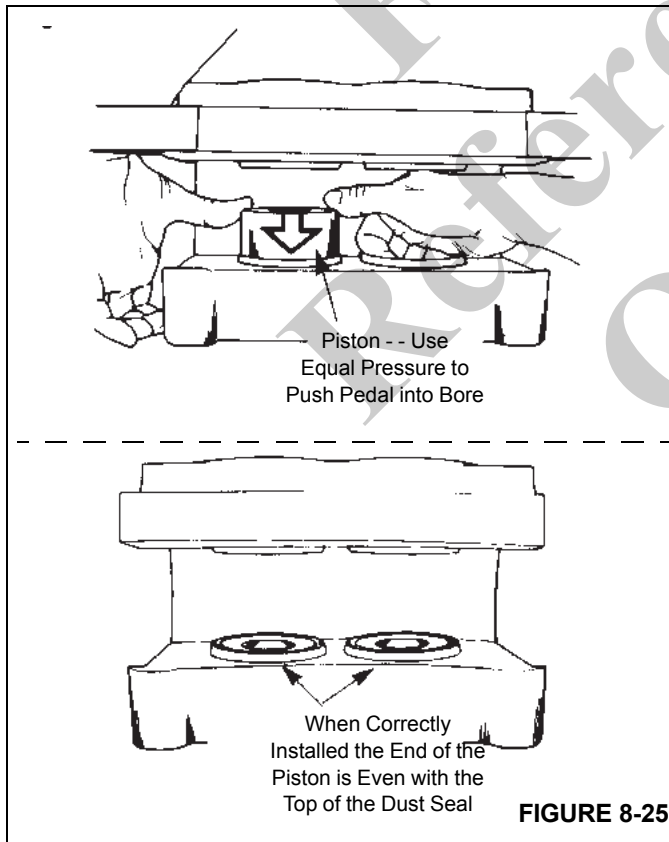


FIGURE 8-25

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 102 Nm (75 lb-ft) minimum as shown in Figure 8-26.

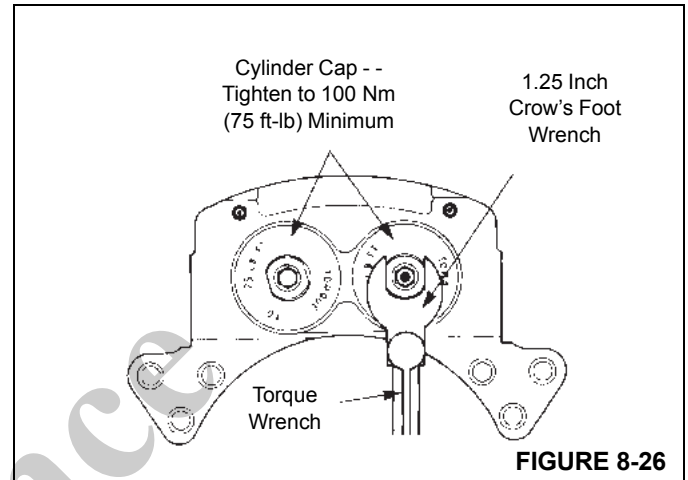


FIGURE 8-26

7. Install the bleeder screws in the housing. Tighten to 11.3 Nm to 13.6 Nm (100 lb-ft to 120 lb-in).

8. Install the O-ring and the inlet fitting in the cylinder cap.

**Installation**

**Linings**

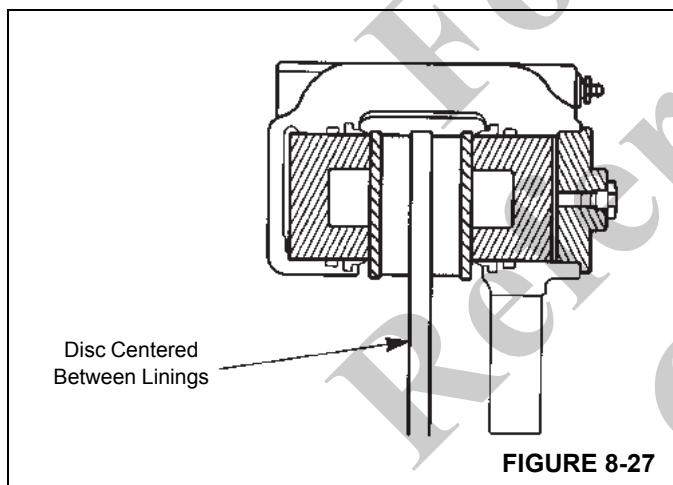
**CAUTION**

Always replace both linings. If only one lining is replaced, possible disc damage can occur.

1. Block the wheels.
2. Install the linings in the caliper housing.
3. Apply Loctite 271 or equivalent to the bolt threads. Position the end plates on the housing and secure with bolts. Tighten the bolts to 224 Nm to 285 Nm (165 lb-ft to 210 lb-ft).
4. Ensure the linings move freely in the housing.
5. Bleed the brake system.
6. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

**Caliper**

1. Position the caliper housing on the mounting bracket. If shims where used, place them as marker during removal.
2. Secure the caliper housing with the bolts and tighten them to 678 Nm to 813 Nm (500 lb-ft to 600 lb-ft).
3. Install the linings. Refer to *Linings*, page 8-16.
4. Ensure the housing is installed correctly on the mounting bracket. The disc must be within  $\pm 1.5$  mm ( $\pm 0.06$  in) 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. Refer to Figure 8-27.



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.

**PARKING BRAKE ACTUATOR**

**Description**

The spring-applied, hydraulically-released parking brake actuator is located on the front axle and is 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 tension on the brake linkage. Engine must remain running. Air pressure of 1862 kPa (270 psi) may be used to pressurize the actuator.
3. Remove the capscrews holding actuator to the brake caliper, and slide the actuator off the actuator rod.
4. Position the Park Brake Switch to ON and shut down the engine.
5. 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 tension on the brake linkage. Engine must remain running. Air pressure of 1862 kPa (270 psi) may be used to pressurize the actuator.
3. Slide the actuator over the actuator rod and install the capscrews to attach the actuator to the caliper.
4. 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 1862 kPa (270 psi) 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 input shaft in line between the front axle and the driveline from the transmission. 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.

### Maintenance

#### Removal

Use the following procedure and refer to Figure 8-28 when removing the brake.

1. Chock the wheels to prevent crane movement.

#### CAUTION

Do not exceed 1861.5 kPa (270 psi) hydraulic pressure to avoid damage to the brake; 1170 kPa (170 psi) is required to fully release the brake.

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.
3. Remove plug (16), back off both jam nuts (39), loosen socket head cap screw (38) and socket set screw (12).
4. Position the Park Brake Switch to ON and turn off engine.
5. Loosen the brake line and cap inlet port.
6. Loosen jam nut/sleeves (35), remove hex mounting bolts from the bracket and remove brake.

#### Installation

Use the following procedure and refer to Figure 8-28 when installing the brake.

**NOTE:** Mount brake so that the linings are parallel with the disc within 0.381 mm (0.015 in).

1. Slide brake over disc and into the mounting position.
2. Start hex mounting bolts (36) into mounting surface far enough to just support the brake.
3. Remove plug (16), loosen the coupling nut (13) and then tighten socket setscrew (12) until linings (37) are clamped to the disc. This locates and holds the brake in the proper position to set the hex mounting bolts.
4. Tighten hex mounting bolts (36) until they make contact with the urethane springs (33), then tighten 4 flats

approximately 1.778 mm (0.07 in) more. This puts the proper amount of pre-load on the urethane springs.

5. Tighten jam nut/sleeves (35) against mounting surface and torque 271.1 Nm (200 lb-ft).

#### 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 the linings are contaminated.

6. Attach brake line to inlet port located on the top of the hydraulic cylinder (26).

#### CAUTION

Do not exceed 1860 kPa (270 psi) hydraulic pressure to avoid damage to the brake; 1172.1 kPa (170 psi) is required to fully release the brake.

7. Apply hydraulic pressure to the brake.
8. Set the running clearance by doing the following:
  - a. Remove the plug(16).
  - b. Loosen coupling nut (13).
  - c. Rotate the socket set screw (12) until the brake is clamped onto the disc.
  - d. Loosen the outer hex nut (39) and rotate socket head cap screw (38) until it makes contact with the bump stop on the mounting bracket, then back it off 1/4 turn (0.406 mm/0.016 in).
  - e. Hold the socket head cap screw (38) in place while tightening the outer hex nut (39) against the inner hex nut (39) to 40.7 Nm to 47.5 Nm (30 lb-ft to 35 lb-ft).
  - f. Back off the socket set screw (12) 1/2 turn (0.711 mm/0.028 in).
  - g. Hold the socket set screw (12) in place and torque coupling nut (13) to 67.8 Nm to 74.6 Nm (50 lb-ft to 55 lb-ft).
  - h. Replace plug. Torque plug 61.0 Nm to 67.7 Nm (45 lb-ft to 50 lb-ft).

**NOTE:** Re-adjust the brake when running clearance reaches a total of 2.50 mm (0.10 in).

9. Position the Park Brake Switch to ON and shut down the engine.

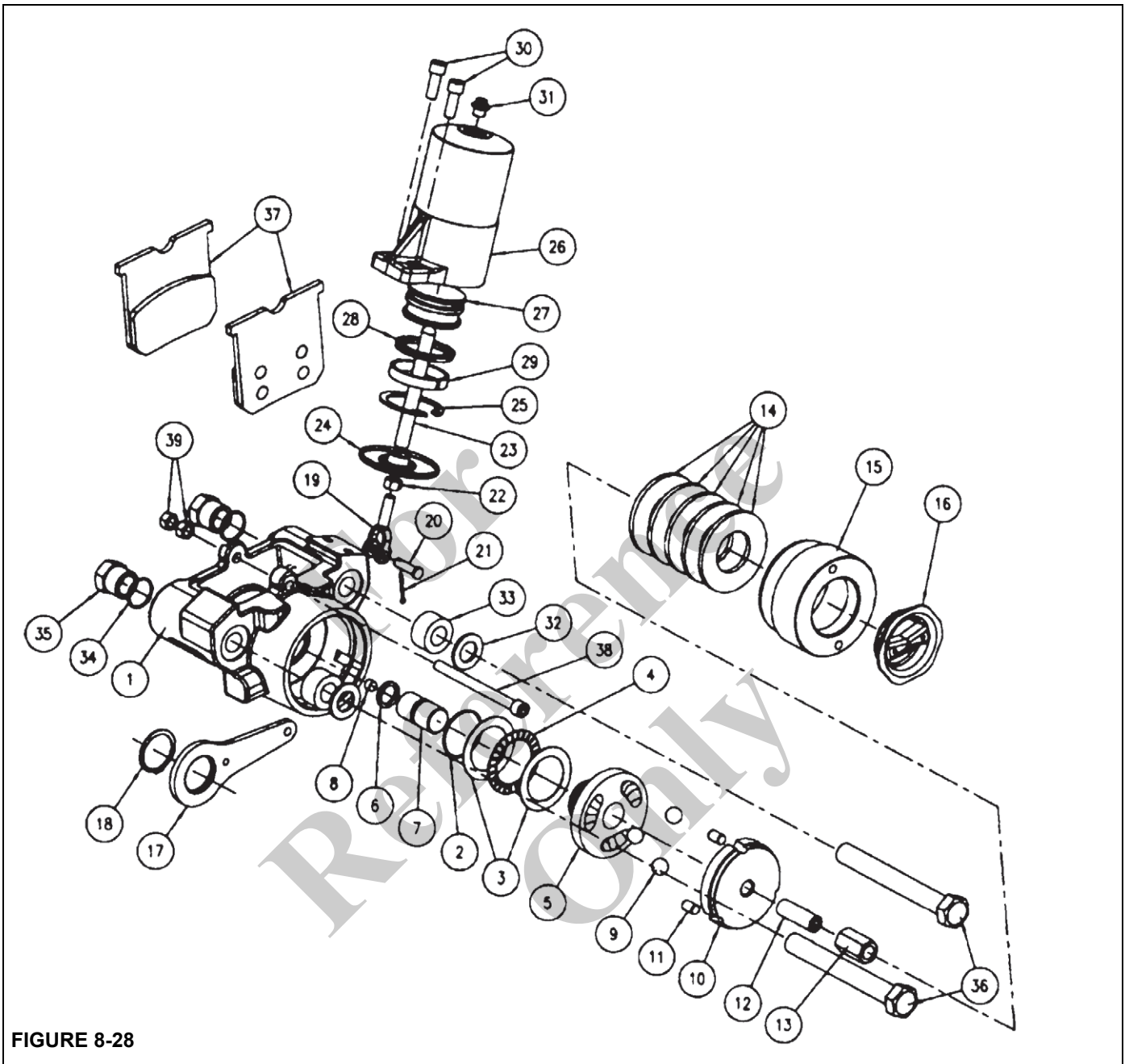


FIGURE 8-28

Item	Description
1	Torque Plate
2	O-ring Seal
3	Washer
4	Bearing
5	Thrust Cam
6	O-ring Seal
7	Piston Assembly
8	Magnet
9	Ball Bearing
10	Cam
11	Dowel Pin
12	Setscrew
13	Nut
14	Disc Spring
15	Housing
16	Plug
17	Lever
18	Retainer Ring
19	Clevis

Item	Description
20	Clevis Pin
21	Cotter Pin
22	Jam nut
23	Rod
24	Excluder Rod
25	Retainer Ring
26	Cylinder Housing
27	Piston
28	Seal
29	Ring
30	Capscrew
31	Flatwasher
32	Spring
33	O-ring Seal
34	Jam Nut
35	Capscrew
36	Lining and Carrier Assembly
37	Capscrew
38	Nut

For Reference Only



## PARK BRAKE SOLENOID VALVE

### Description

The park brake solenoid valve is located on the front side of the carrier aft center frame cross member. 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 located in the steering column display. 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. Remove the valve.

#### Installation

1. Position the valve and connect the hydraulic lines to the valve as tagged during removal.
2. Connect the electrical connector to the valve as tagged during removal.
3. 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.
4. Check for leaks. Make repairs as needed.

## OUTRIGGER

### 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 an Outrigger Monitoring System (OMS) (Optional—Standard in North America). 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 on their respective outrigger boxes; in turn the jack cylinders are 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. The OMS (if equipped) consists of a string potentiometer sensor mounted inside each outrigger box. The sensor is connected by a cable to the outrigger beam to monitor its position—full, half or retracted.

The outrigger control station is located in the left front of the cab. 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 placarded with switch positions.

A sight bubble level is mounted on the left side of the cab by the door latch plate. The sight bubble level provides the operator with a visual indication of crane level attitude.

#### Theory Of Operation

The appropriate Extension/Stabilizer 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 cylinder 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, then 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 one relief valve that is set at 2500 psi (17,200 kPa).

## Maintenance

## Troubleshooting

Table 8-4

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.
	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.
	1. Slow or erratic operation of outrigger extension cylinders. (continued)	i. Damaged extension cylinder (internal parts).
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.
t. Scored cylinder barrel.		t. Repair or replace extension cylinder.
u. Cracked or damaged piston.		u. Replace rod weld and all cylinder seals.

Symptom	Probable Cause	Solution
2. Sticking spool.	a. Dirt in the system.	a. Change oil and flush system.
	b. Distortion caused by tie bolts being <del>overtorqued</del> over torqued.	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.
	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.
3. External leakage.	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.
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.
	l. Main hydraulic pump cavitation.	l. Replace or tighten hose and fittings.
	m. Worn or damaged hydraulic pump section.	m. Repair or replace pump section.

Symptom	Probable Cause	Solution
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.
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, an 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 Outrigger Monitoring System (OMS) (if equipped) has a string potentiometer sensor mounted inside each outrigger box near the fixed end of the extension cylinder. The sensor is connected to the outrigger beam by a cable to monitor position of the extension beam—full, half or retracted.

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.

### Maintenance

#### Removal

**NOTE:** Outrigger removal and installation is similar for both the front and rear outriggers (Figure 8-29).

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 3.2 mm (0.125 in) protruding.
4. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.



### DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

5. Place blocking material under the outrigger beam.

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 the 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 prevent damage to the OMS (if equipped) string potentiometer.

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 8-34.

**NOTE:** Lifting belts or straps should be used for lifting purposes so as to avoid nicking or scratching the bottom edges of the outrigger beam (Figure 8-30).

9. 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.



### DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

**NOTE:** The outrigger beam assembly weighs approximately 525 kg (1157 lb).

10. 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

1. Apply grease (EP-MPG) to the bottom of the outrigger beam.
2. If removed, install the side adjustable wear pad in the outrigger beam.
3. Install the bottom wear pads with approximately 3.2 mm (0.125 in) protruding. This will prevent the beam side plates from riding on the bottom of the box.
4. Attach a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam.
5. Slide the beam into the outrigger housing and align the cylinder bushing with the mounting hole.
6. Apply anti-seeze compound to the clevis pin. Secure the cylinder barrel to the housing with the clevis pin and cotter pin.
7. 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 8-34.

**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.

8. Connect the hydraulic lines as tagged prior to removal.
9. Install the side adjustable wear pad in the outrigger box.
10. Adjust the wear pads, refer to Wear Pad Adjustment in this Section.
11. 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 8-31.

1. Adjust the bottom wear pads (approximately 1/4 turn) until a gap of 1.5 mm (0.06 in) is obtained between the top of the beam and the top of the outrigger box. Install and lock set screw against wear pad.
2. Adjust outrigger box side wear pad until a gap of 1.5 mm (0.06 in) is obtained between beam and shims welded in top and bottom of box. Install and lock set screw against wear pad.
3. Adjust outrigger beam side wear pad until a gap of 1.5 mm (0.06 in) is obtained between shim welded on beam and side of box. install and lock set screw against wear pad.

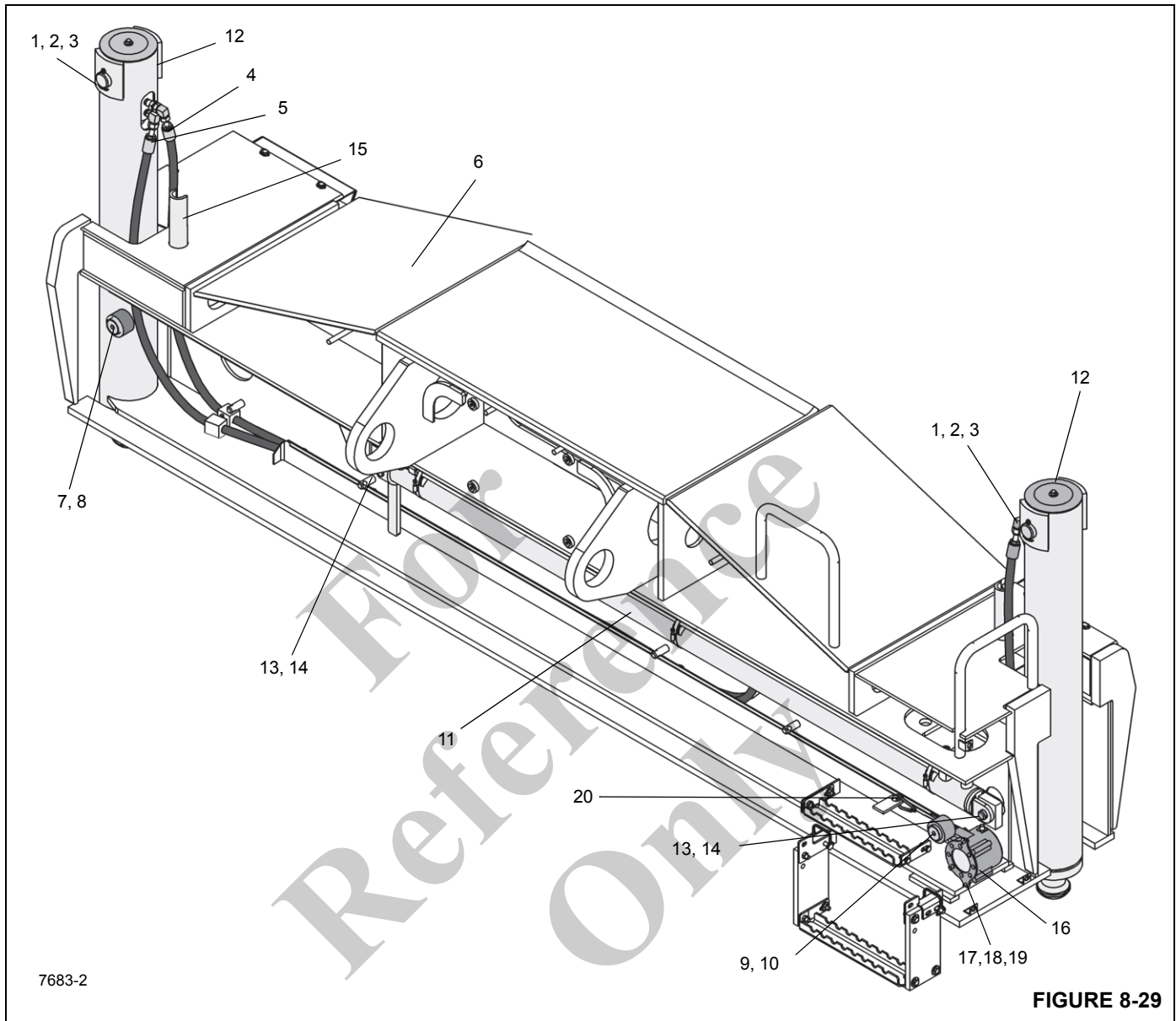
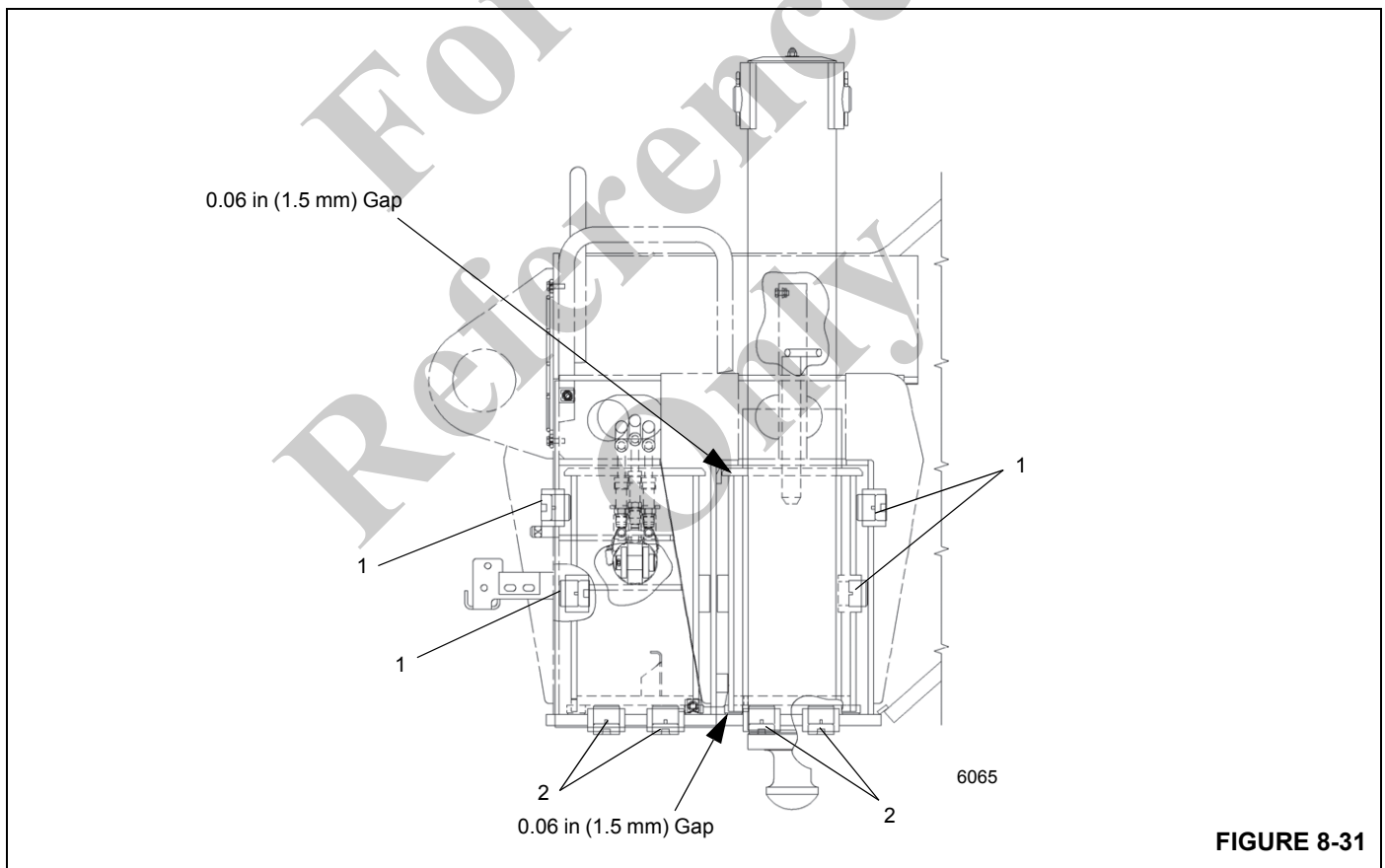
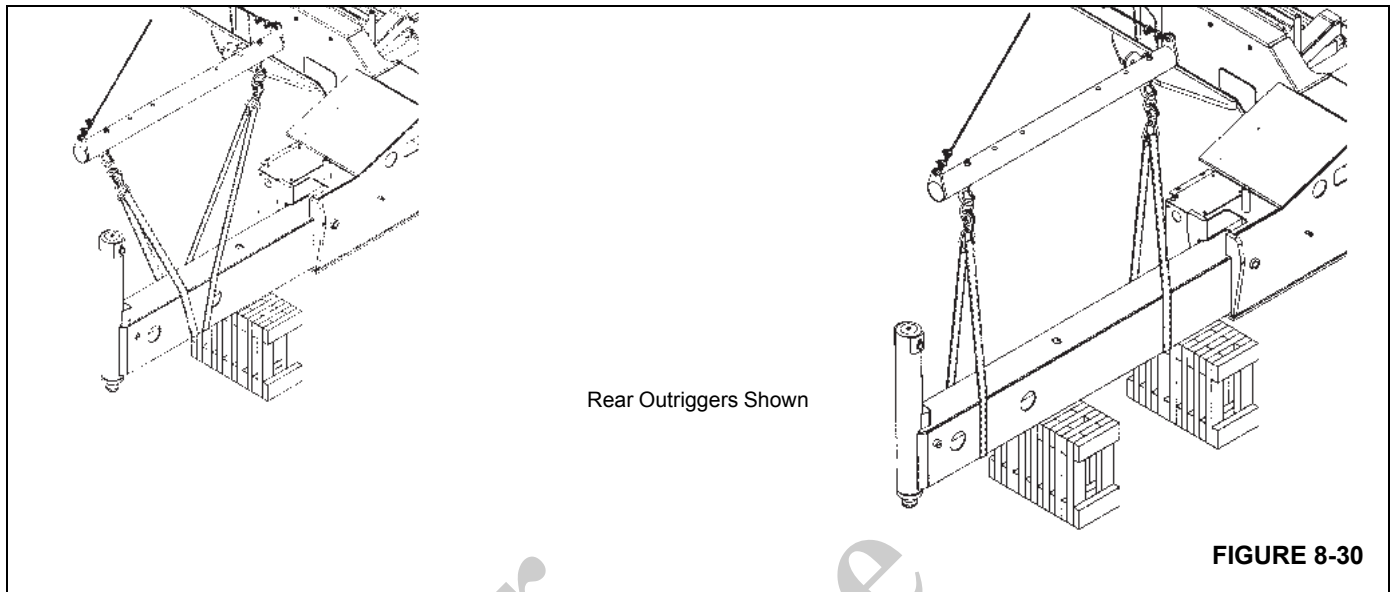


FIGURE 8-29

Item	Description
1	Retainer Pin
2	Cotter Pin
3	Pin
4	Extend Port
5	Retract Port
6	Outrigger Box
7	Side Wear Pad
8	Setscrew
9	Wear Pad
10	Setscrew

Item	Description
11	Extension Cylinder
12	Jack Cylinder
13	Cotter Pin
14	Clevis Pin
15	Pin
16	OMS Potentiometer
17	Capscrew
18	Lockwasher
19	Flatwasher
20	Spring Snap





Item	Description
1	Side Wear Pads and Setscrews

Item	Description
2	Bottom Wear Pads and Setscrews

## 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 51 kg (112 lb).

### Maintenance

**NOTE:** Refer to Cylinders in *Hydraulic System*, page 2-1 for Disassembly and Assembly of the cylinder.

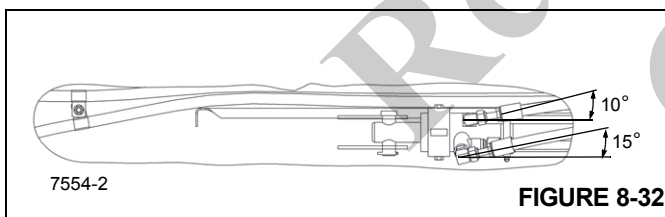
### Removal

1. Remove the outrigger beam. Refer to *Outrigger Beam*, page 8-30 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 8-32.



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-seeze 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 8-30. 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. 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 any evidence of leakage. Make repairs as needed.

## 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 horizontal position of each outrigger beam. The OMS uses four sensors, one per outrigger beam, to indicate when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

If the crane is setup on outriggers and “On Outriggers” is chosen when programming the RCL, then the OMS indicates to the RCL the horizontal position of each of the four outrigger beams. Based on this information, the RCL will default to the most conservative outrigger beam configuration; that is, if three outriggers are fully extended and one is retracted, the RCL will select retracted as the outrigger configuration. A confirmation of this outrigger configuration is all that is needed. Refer to the *Rated Capacity Limiter Operator's Handbook* for detailed instructions.

### Removal

1. Extend the outrigger beam slightly for improved access and shut down the engine.
2. Remove the outer access cover plate from the outrigger box.
3. Remove the OMS string potentiometer connector Figure 8-33 from the attaching point on the outrigger beam.

**NOTE:** Avoid free-release of cable to prevent damage to the OMS string potentiometer.

4. Disconnect electrical harness connector and secure to avoid damage.
5. Loosen top mounting hardware enough to disengage OMS string potentiometer from the slotted top mounting hole.
6. Completely remove the lower mounting hardware.

- Remove OMS string potentiometer from inside outrigger beam.

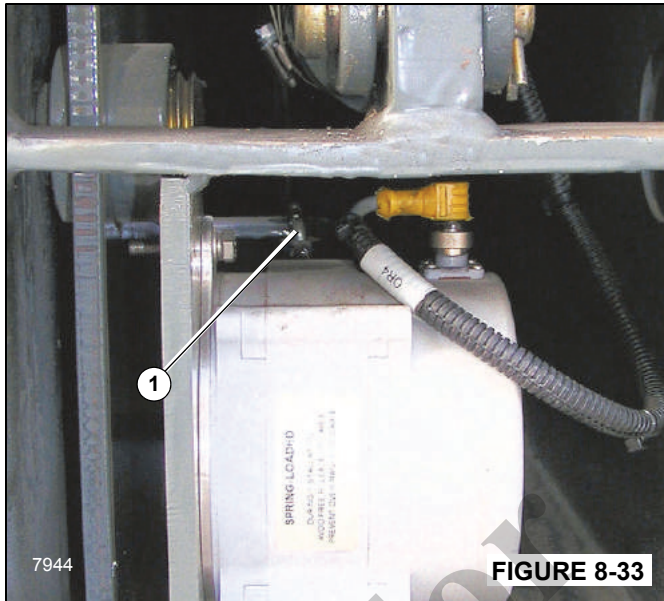


FIGURE 8-33

### Installation

- Install string potentiometer inside outrigger beam.
- Install the OMS string potentiometer enough to engage slotted hole with top mounting hardware.
- Install the lower mounting hardware.
- 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.

- Connect electrical harness connector to string potentiometer.
- 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 63.30 kg (139.5 lb).

### Maintenance

**NOTE:** Refer to *Cylinders*, page 2-61 for Disassembly and Assembly of the cylinders.

### Removal

- Extend the outrigger beam slightly for improved access to the jack cylinder; shut down the engine.
- Tag and disconnect the hydraulic hoses from the jack cylinder. Remove the fittings from the ports. Cap or plug all openings.
- Remove the cylinder cap.
- 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.
- Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
- 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.

- 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

- Apply grease (EP-MPG) to the ID of the jack cylinder support tube.
- If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
- 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.
- Remove the retaining pin and cotter pins from the cylinder.
- Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam.
- 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.
- 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; extend and retract the jack cylinder.
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 *Hydraulic System*, page 2-1.

#### Pilot Operated Check Valve

The pilot operated check valves are located in the outrigger jack cylinder port blocks. The check valve provides two functions; the first function is a holding valve, the second function provides a thermal relief of the outrigger.

#### Integrated Outrigger/Rear Steer Valve.

The integrated outrigger/rear steer valve is mounted on the front 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 inside the frame on the respective outrigger box. 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.

**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:

#### --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

#### -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
<b>Transmission Oil</b>	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
<b>Hoist Gear/Swing Drive Oil</b>	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
<b>Grease, Multipurpose</b>	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	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		
<b>Hydraulic Oil</b>	6829006993	Exxon Mobil Unavis HVI	26	
<b>Windshield Washer fluid</b>	90037773	Splash De-icer		
<b>Diesel Fuel</b>	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
<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
<b>Transmission Oil</b>	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
<b>Hoist Gear/Swing Drive Oil</b>	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
<b>Grease, Multipurpose</b>	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
<b>Open Gear Lube</b>	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
<b>Antifreeze Coolant</b>	6829104212	Old World Industries, Inc. Fleet Charge SCA Pre-charged Fleetguard Compleat EG Petro-Canada	Mix 60/40	
<b>Supplemental Coolant Additive (SCA)</b>	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
<b>Hydraulic Oil</b>	6829006993	Exxon Mobil Univis HVI	26	
<b>Windshield Washer fluid</b>	90037773	Splash De-icer		
<b>Diesel Fuel</b>	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 rods.

## 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*, page 1-20.

For  
Reference  
Only

## 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.

Overlubrication on non-sealed fittings will not harm the fittings or components, but underlubrication will definitely lead to a shorter lifetime.

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 Maniowoc distributor for information about the Maniowoc's CraneLUBE lubrication program.

## 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.

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 **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
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

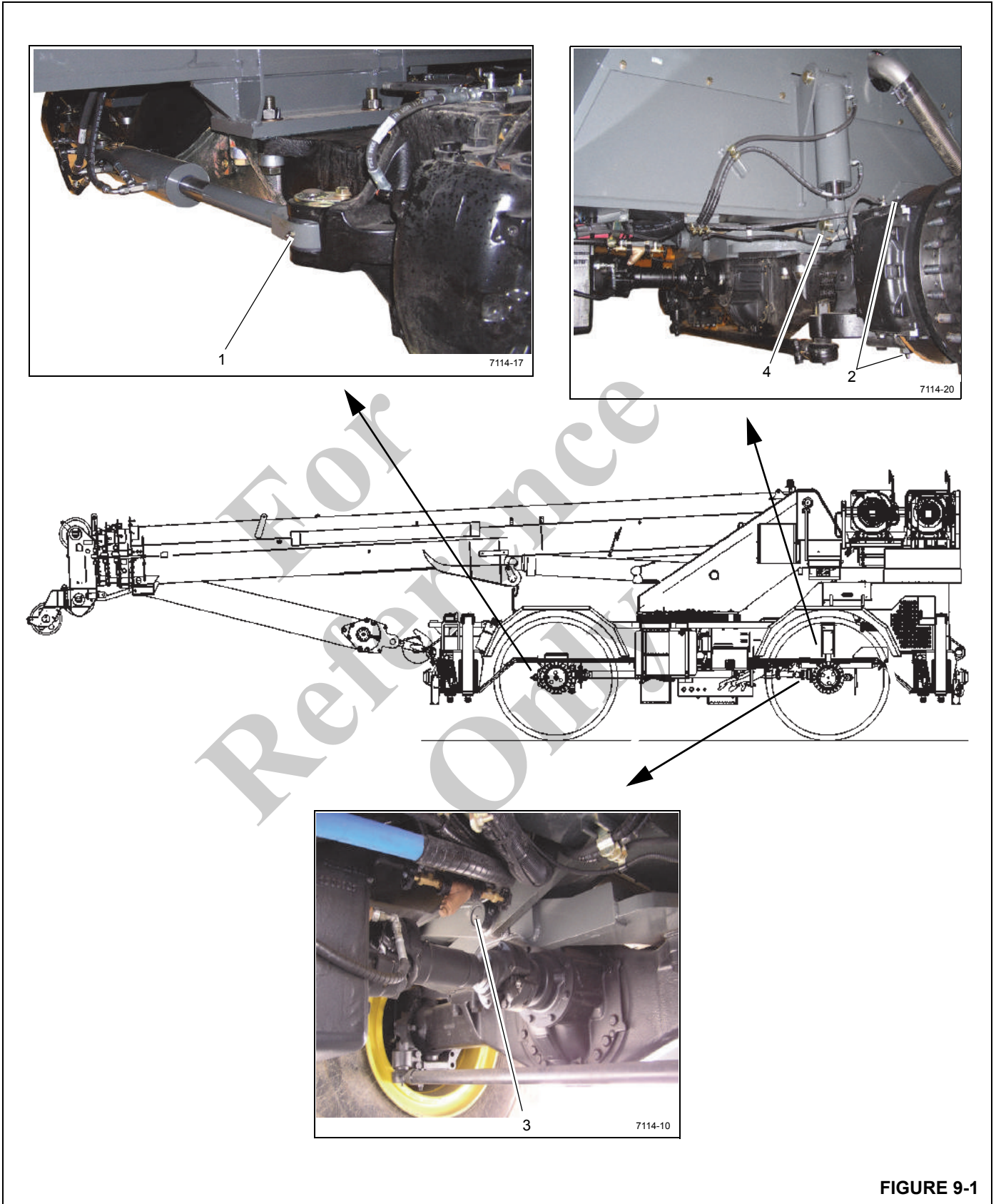
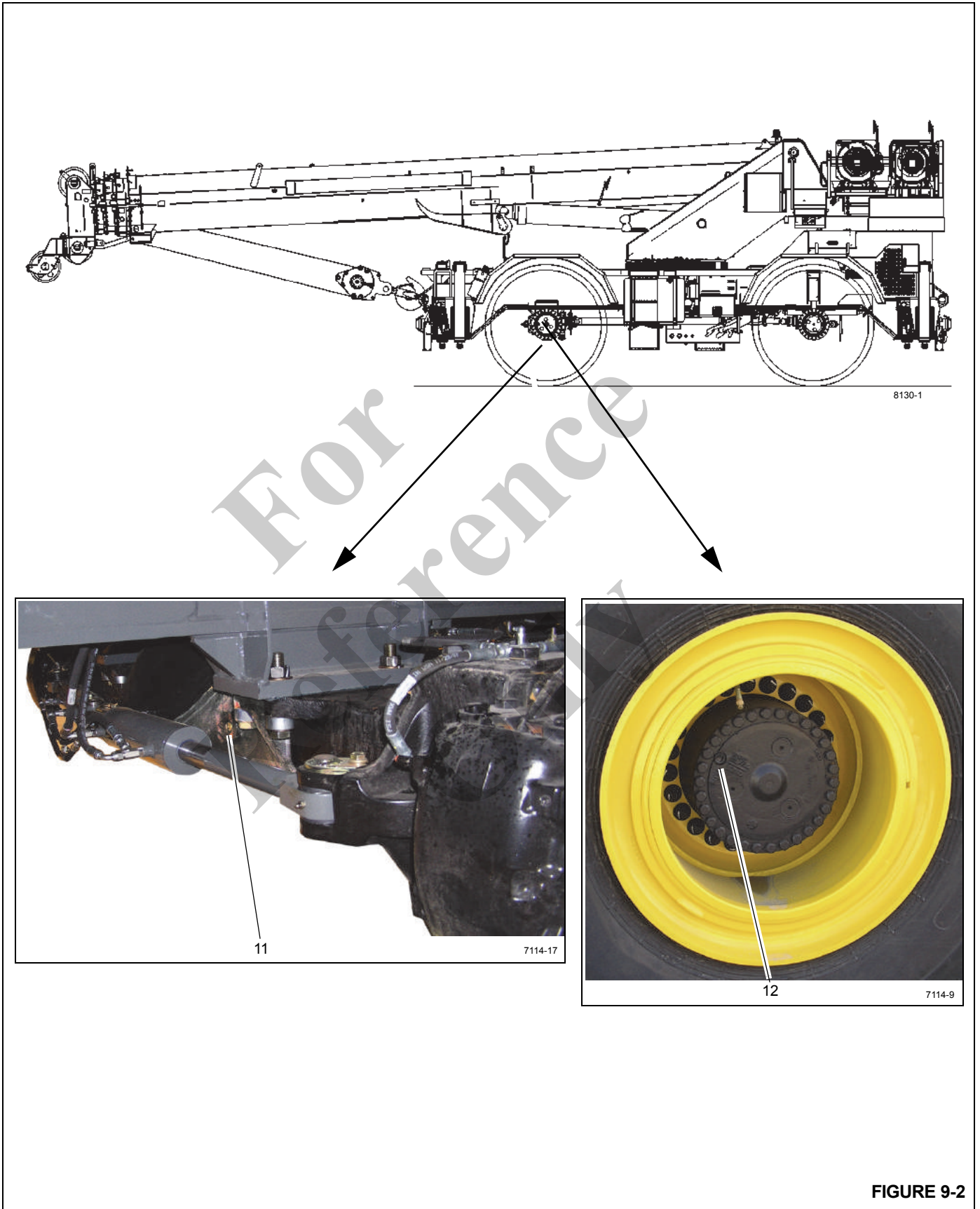


FIGURE 9-1

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	22.7 L (48 pt)	<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 L (0.5 pt), check for leaks.</p>						
12	Planetary Hubs and Wheel Bearings	Figure 9-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	3.8 L (8 pt)	<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>						





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	18.9 L (20 qt)	<ul style="list-style-type: none"> <li>Check level every 10 hours or daily</li> <li>Drain, fill and replace filter every: 500 hours (0-500 ppm sulfur fuel); 400 hours (500-5000 ppm sulfur fuel); 250 hours (&gt;5000 ppm sulfur fuel)</li> </ul>	<ul style="list-style-type: none"> <li>Through fill cap to FULL mark on dipstick</li> <li>Filter located on left side of frame beneath radiator</li> </ul>
21a 21b	a. Transmission, Torque Converter, Dipstick b. Filter	Figure 9-3	HYDO Hydraulic Oil 6829006444	37.9 L (40 qt)	<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
<b>NOTE:</b>						
<ul style="list-style-type: none"> <li>Check the transmission fluid level with engine running at 850 rpm idle and the converter oil at 83°C to 93°C (180°F to 200°F). 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. (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, 120°C (250°F) maximum will cause damage to transmission clutches, fluid, converter and seals.)</li> <li>Drain the oil at 65°C to 93°C (150°F to 200°F).</li> <li>Transmission filters are located on the outside left hand frame in the area of the hydraulic oil cooler inside left hand engine cover.</li> <li>To add fluid: <ul style="list-style-type: none"> <li>a. Fill to FULL mark on dipstick</li> <li>b. Run engine at 850 rpm to prime torque converter and lines</li> <li>c. Check oil level with engine running at 850 rpm and converter oil at 82°C to 93°C (180°F to 200°F). Add oil to bring oil level to FULL mark on dipstick.1</li> </ul> </li> </ul>						
22	Engine Cooling System and SCA Levels	Figure 9-3	AFC 50/50 50/50 Blended Fully Formulated Antifreeze Coolant 6829101130 SCA 6829012858	37.9 L 40 qt	<ul style="list-style-type: none"> <li>Check coolant level every 10 hours or daily</li> <li>Check SCA levels every 500 hours or 3 months</li> <li>Check coolant for contamination every 1000 hours or 6 months</li> </ul>	See <i>Service Manual</i>
23	Coolant Strainer (Cab Heater)	Figure 9-3	---	---	Clean strainer screen after first 100 hours and every 2000 hours or 12 months intervals thereafter.	Close shutoff valves. Unscrew hex plug to clean filter.

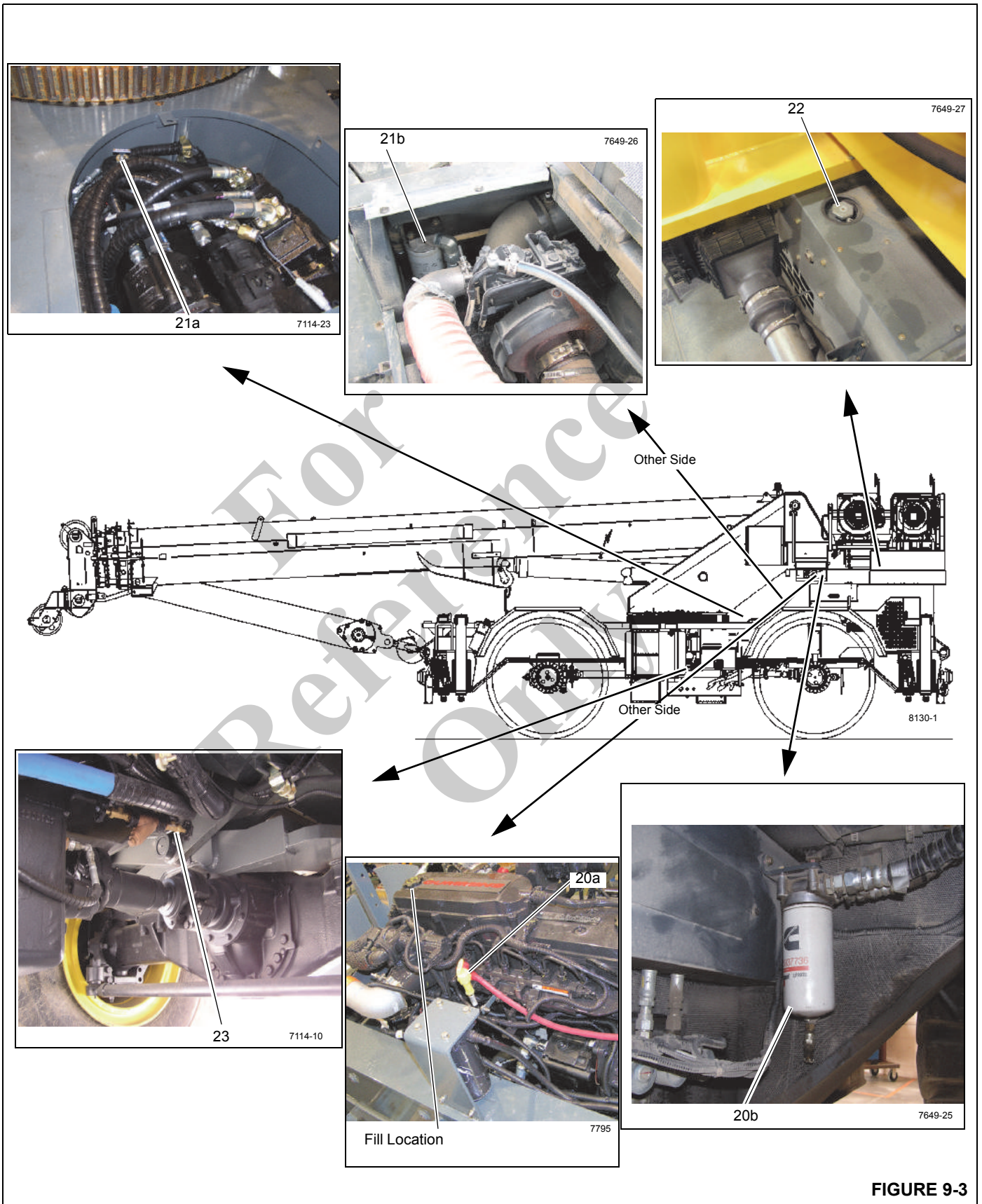


FIGURE 9-3

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Drive Train (continued)</b>						
<b>24a</b>	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.
<b>24b</b>	Pre-cleaner					
<b>25a</b>	a. Fuel Filter	Figure 9-4	---	---	<ul style="list-style-type: none"> <li>Change filter every 500 hours or 6 months.</li> <li>Drain water trap every 10 hours or daily.</li> </ul>	<ul style="list-style-type: none"> <li>Fuel filter is located on the intake manifold of engine.</li> <li>Water Separator is located near oil cooler.</li> </ul>
<b>25b</b>	b. Water Separator					
<b>NOTE:</b> During replacement of the water separator, take note of the direction of the arrow. The arrow must point towards the fuel filter						
<b>26a</b> <b>26b</b>	Driveline - Slip Joints	Figure 9-4	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings



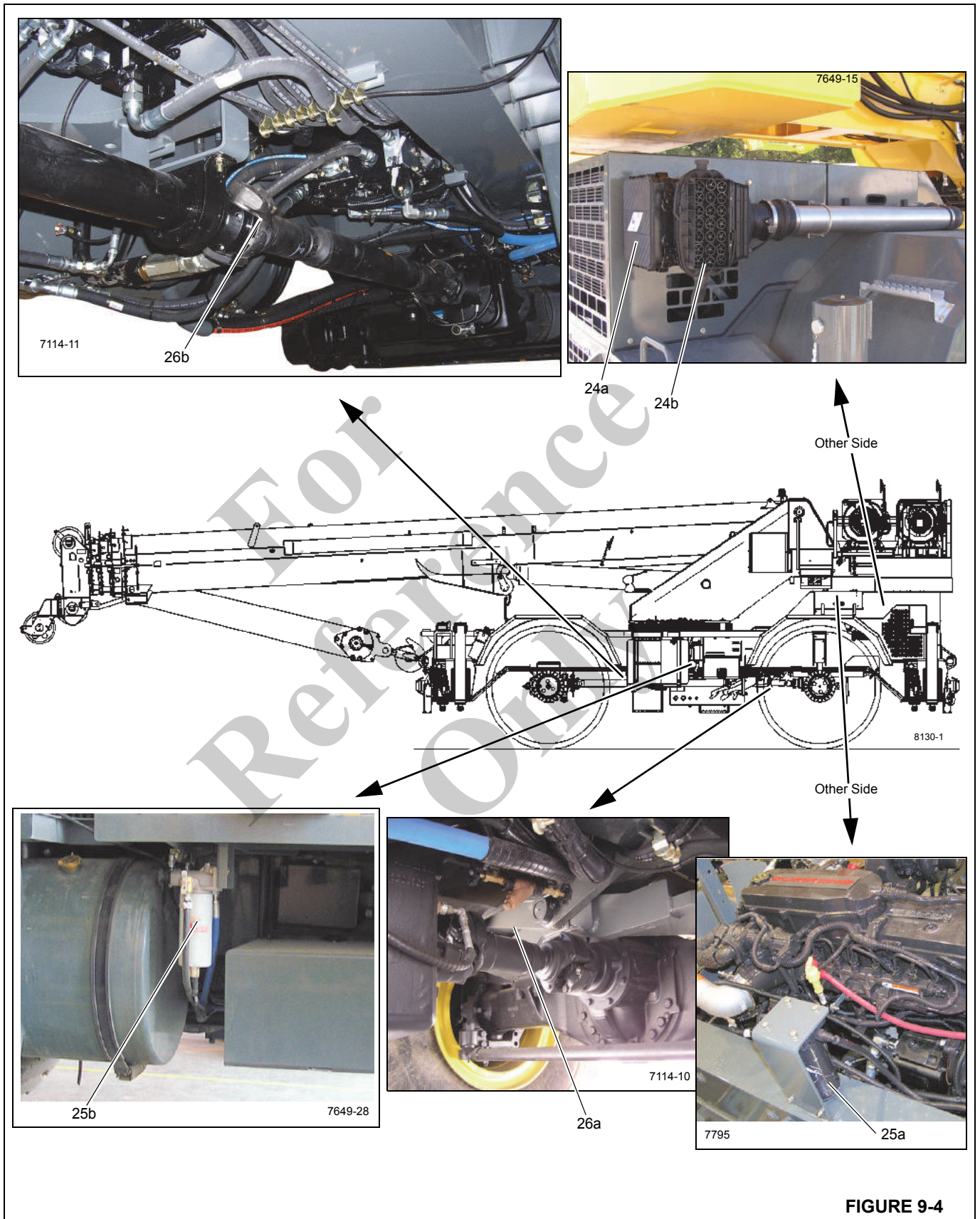


FIGURE 9-4

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Turntable</b>						
40	Turntable Gear Box	Figure 9-5	AGMA No. 4 Extreme Pressure Gear Lubricant 6829100213	5 L (5.25 qt)	<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 to max level on level plug.
41a	Turntable Gear and Drive Pinion	Figure 9-5	EP-OGL Open Gear Lubricant 6829102971	Coat all teeth	500 hours or 6 months	Spray on
41b	Turntable Swivel Lock Pin	Not shown	EP-OGL Open Gear Lubricant 6829102971	Coat pin	500 hours or 6 months	Spray on
42	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.
<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.						

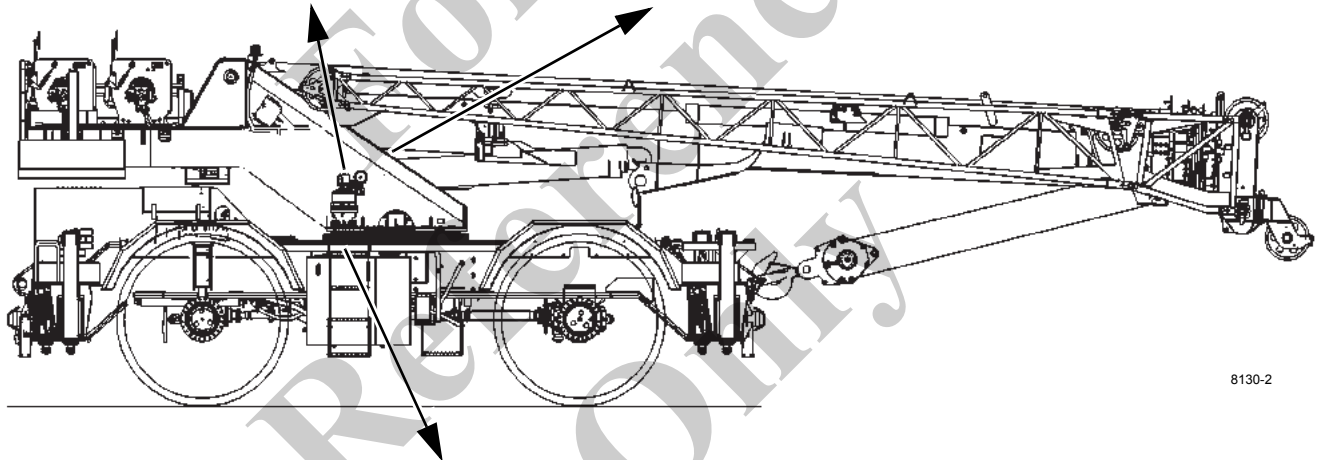
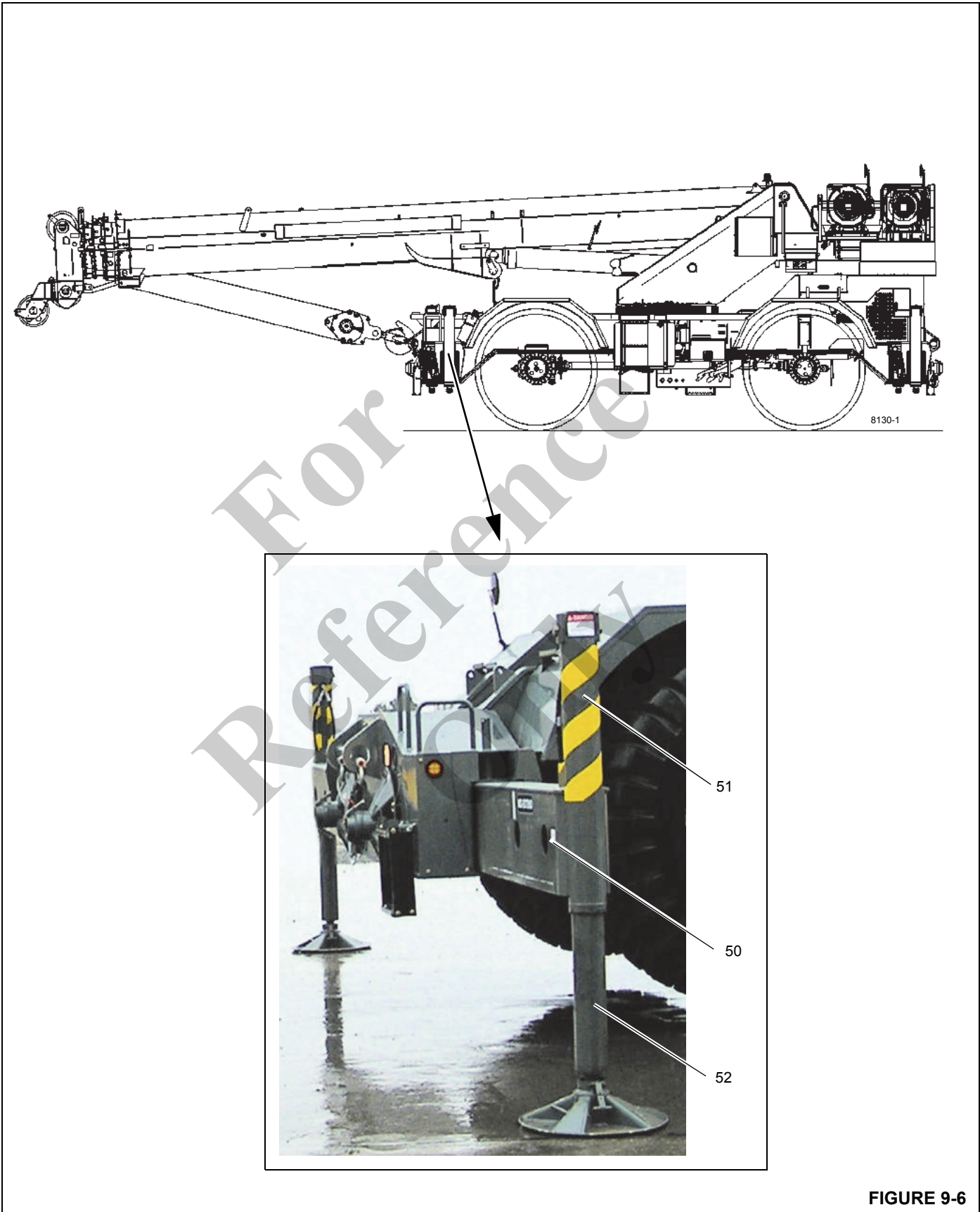


FIGURE 9-5



Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Outriggers</b>						
50	Outrigger Beams	Figure 9-6	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 9-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on ID of jack cylinder support tubes (4) places and wear bands before installing jack cylinders
52	Jack Cylinder Barrels	Figure 9-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush on

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8130-1

FIGURE 9-6

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom</b>						
60	Upper Lift Cylinder Pin	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until greases extrudes	500 hours or 3 months	2 grease fittings
61	Lower Lift Cylinder Pin	Figure 9-7		Until greases extrudes	500 hours or 3 months	2 grease fittings
70	Hook Block Swivel Bearing	Figure 9-7		Until grease extrudes	250 hours or 3 months	1 grease fitting
71	Hook Block Sheaves	Figure 9-7		Until grease extrudes	250 hours or 3 months	5 grease fittings - 65 Ton

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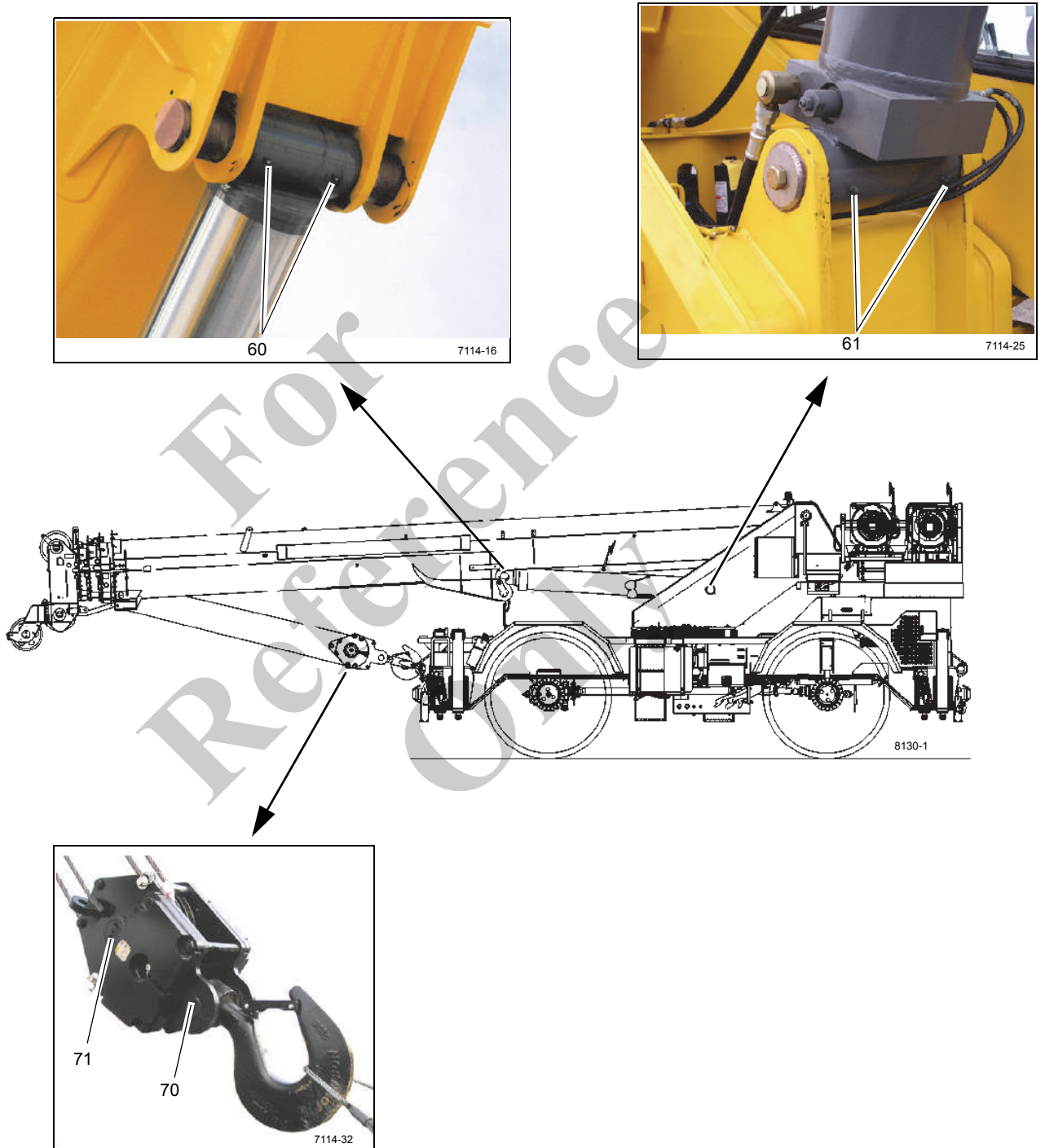


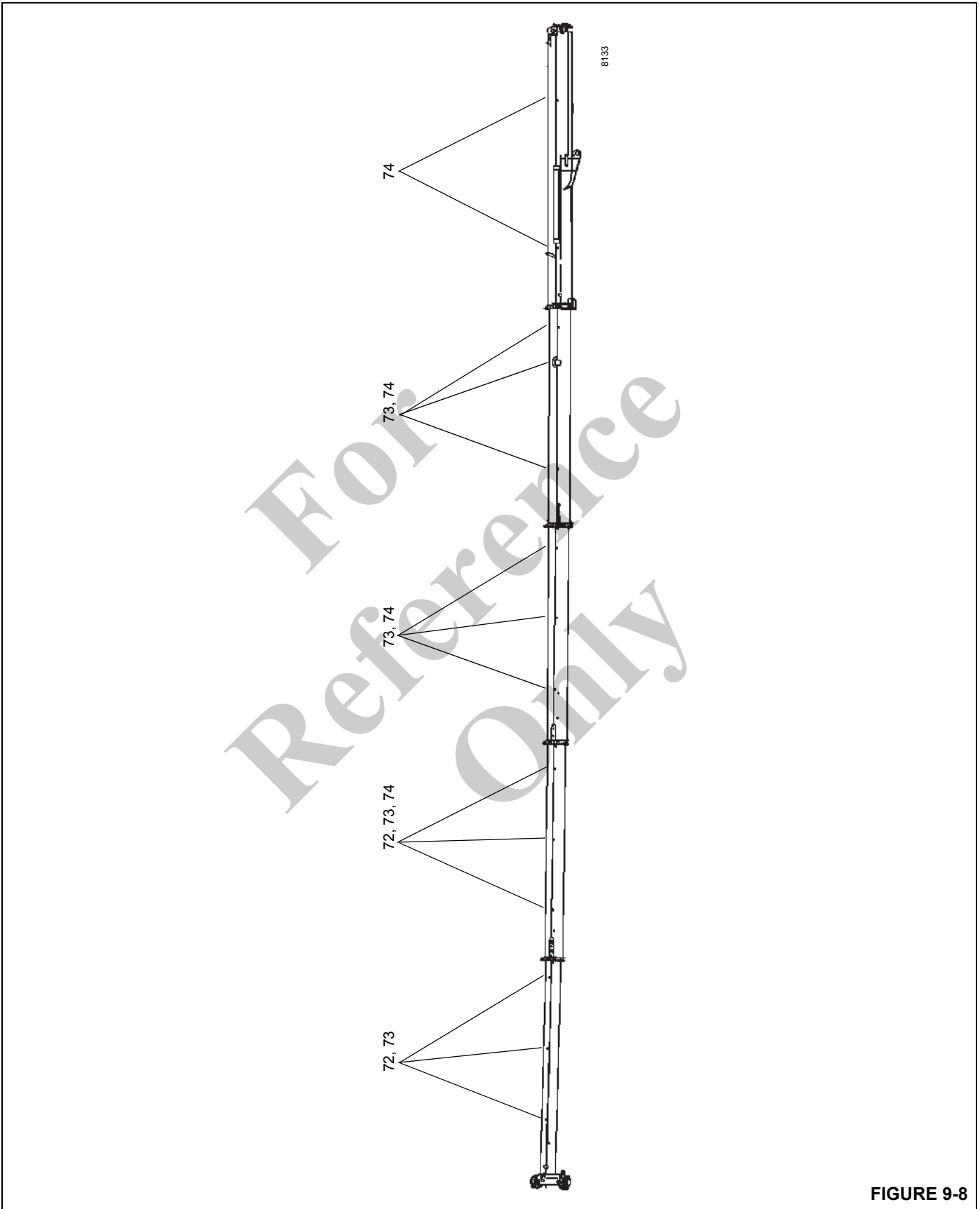
FIGURE 9-7

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application	Boom Operation Mode and Length
<p><b>Boom (continued)</b></p> <p><b>NOTE:</b> Crane Setup: Machine Shall be set up on firm level surface with fully extended outriggers and counterweight installed. Ensure the crane is level.</p> <p>Boom must be directly over the front and the swing lock engaged.</p> <p>Set boom angle at zero degrees.</p> <p>Do not exceed 38.1 m (125.3 ft) boom length in Auto Mode A.</p> <p>Do not exceed 34.2 m (112.3 ft) boom length in Auto Mode B.</p> <p>All lubrication points can be accessed by operating the crane in the 0001 RCL operating mode by using both A and B boom configurations.</p> <p><b>CAUTION:</b> Do not operate the crane in RCL bypass to lubricate the boom.</p>							
72	Telescope Cylinder Wear Pads	Figure 9-8		Thoroughly coat	125 hours/ 3 months	<ul style="list-style-type: none"> <li>• 12 places</li> <li>• Extend boom for access through holes in side of sections 3 &amp; 4</li> </ul>	<ul style="list-style-type: none"> <li>• N/A</li> </ul>
73A	Tel 1 - Rear internal Side and Bottom Wear Pads	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	250 hours or 3 months	<ul style="list-style-type: none"> <li>• 2 points</li> <li>• 15 places</li> <li>• Extend boom for access through holes in side of boom sections</li> </ul>	<ul style="list-style-type: none"> <li>• [B] 18.7 m (61.4 ft)</li> </ul>
73B	Boom Tele 2, 3, & 4 Rear internal Side and Bottom Wear Pads	Figure 9-8		Thoroughly coat all areas the wear pad moves on	250 hours or 3 months	<ul style="list-style-type: none"> <li>• Spread grease on bottom plates, top plates, and side plates of boom in area that wear pads move on</li> </ul>	<ul style="list-style-type: none"> <li>• [A] 34.2 m (112.5 ft)</li> </ul>
<p><b>NOTE:</b> Lubricate items more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.</p>							

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application	Boom Operation Mode and Length
74A	Boom Tele 1 - Rear Upper Wear Pads -	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	50 hours or 1 week	<ul style="list-style-type: none"> <li>• 4points</li> <li>• 16 places</li> <li>• Extend boom, aligning grease fittings with holes in side of each boom section</li> </ul>	<ul style="list-style-type: none"> <li>• [B] 18.7 m (61.4 ft)</li> </ul>
74 B	Boom Tele 2, 3, & 4 Rear Upper Wear Pads	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	50 hours or 1 week	<ul style="list-style-type: none"> <li>• 4 Points</li> <li>• 16 places</li> <li>• Extend boom, aligning grease fittings with holes in side of each boom section</li> </ul>	<ul style="list-style-type: none"> <li>• [A] 34.2 m (112.5 ft)</li> </ul>

**NOTE:** Lubricate items more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.

**CAUTION:** Do not apply excessive pressure or force when greasing the wear pad, as this can cause the grease fitting to separate from the wear pad. Only apply grease until resistance is felt.





Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application	Boom Operation Mode and Length
<b>Boom (continued)</b>							
75A	Boom Tele 1 Section Lower Front 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	<ul style="list-style-type: none"> <li>• 8 Points</li> <li>• 24 places by brush</li> <li>• Spread grease on the outside of Tele 1, 2, 3, &amp; 4 in the area that the wear pads move on</li> </ul>	• [B] 18.7 m (61.4 ft)
75B	Boom Section Lower Front and Upper Front Wear Pads			Thoroughly coat all areas the wear pad moves on	50 hours or 1 week		• [A] 34.2 m (112.5 ft)
<b>NOTE:</b> Lubricate items more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.							
76a	Extend Cable Sheaves	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	<ul style="list-style-type: none"> <li>• 2 grease fittings</li> <li>• Extend Tele 1 approx. 3 ft for access through Tele 3 and Tele 4 holes</li> </ul>	• [B] 12 m (39.4 ft)
76b	Extend Cable Sheaves	Figure 9-9		Until grease extrudes	250 hours or 3 months		<ul style="list-style-type: none"> <li>• 4 grease fittings</li> <li>• Extend Tele 2 approx. 3 ft for access through holes</li> </ul>

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application	Boom Operation Mode and Length
77a	Retract Cable Sheaves	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	<ul style="list-style-type: none"> <li>• 2 Points</li> <li>• 2 grease fittings</li> <li>• Fully extend Tele 1, then extend Tele 2 until grease fittings are accessible through large access hole in side of Tele 1</li> </ul>	<ul style="list-style-type: none"> <li>• [B] 26.2 m (86 ft)</li> </ul>
77b	Retract Cable Sheaves	Figure 9-9			Until grease extrudes	250 hours or 3 months	<ul style="list-style-type: none"> <li>• 2 Points</li> <li>• 2 grease fittings</li> <li>• Fully extend Tele 2 and Tele 4, then access grease fittings at back of Tele 3 through access holes toward the front of Tele 2</li> </ul>

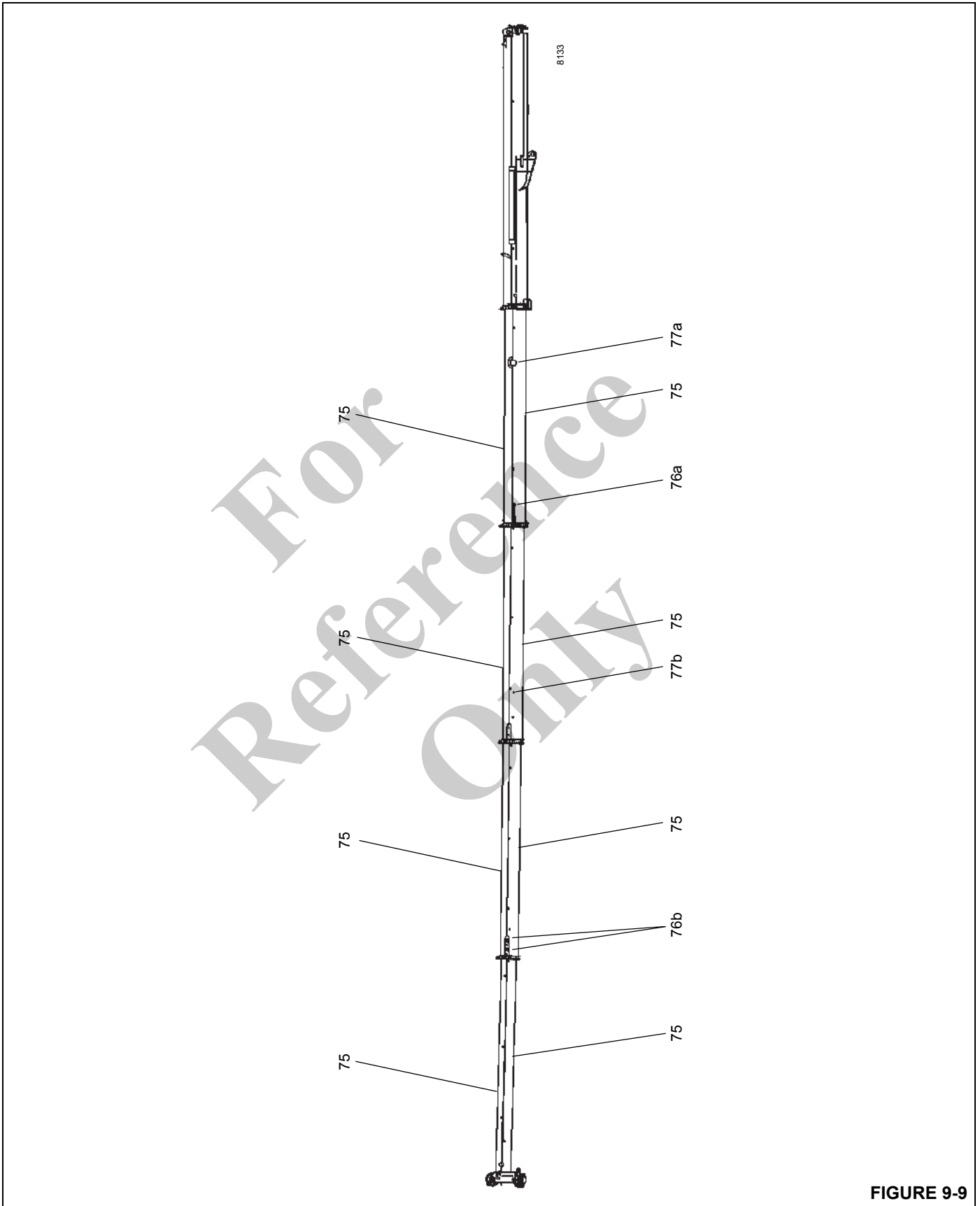


FIGURE 9-9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom (continued)</b>						
78	Boom Pivot Shaft	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings
79	Boom Extension Sheave	Figure 9-10		Until grease extrudes	250 hours or 3 months	1 grease fitting
81	Upper Boom Nose Sheave	Figure 9-10		Until grease extrudes	250 hours or 3 months	2 grease fittings (1) per sheave
82	Lower Boom Nose Sheave	Figure 9-10		Until grease extrudes	250 hours or 3 months	5 grease fittings
83	Auxiliary Boom Nose Sheave	Figure 9-10		Until grease extrudes	250 hours or 3 months	1 grease fitting

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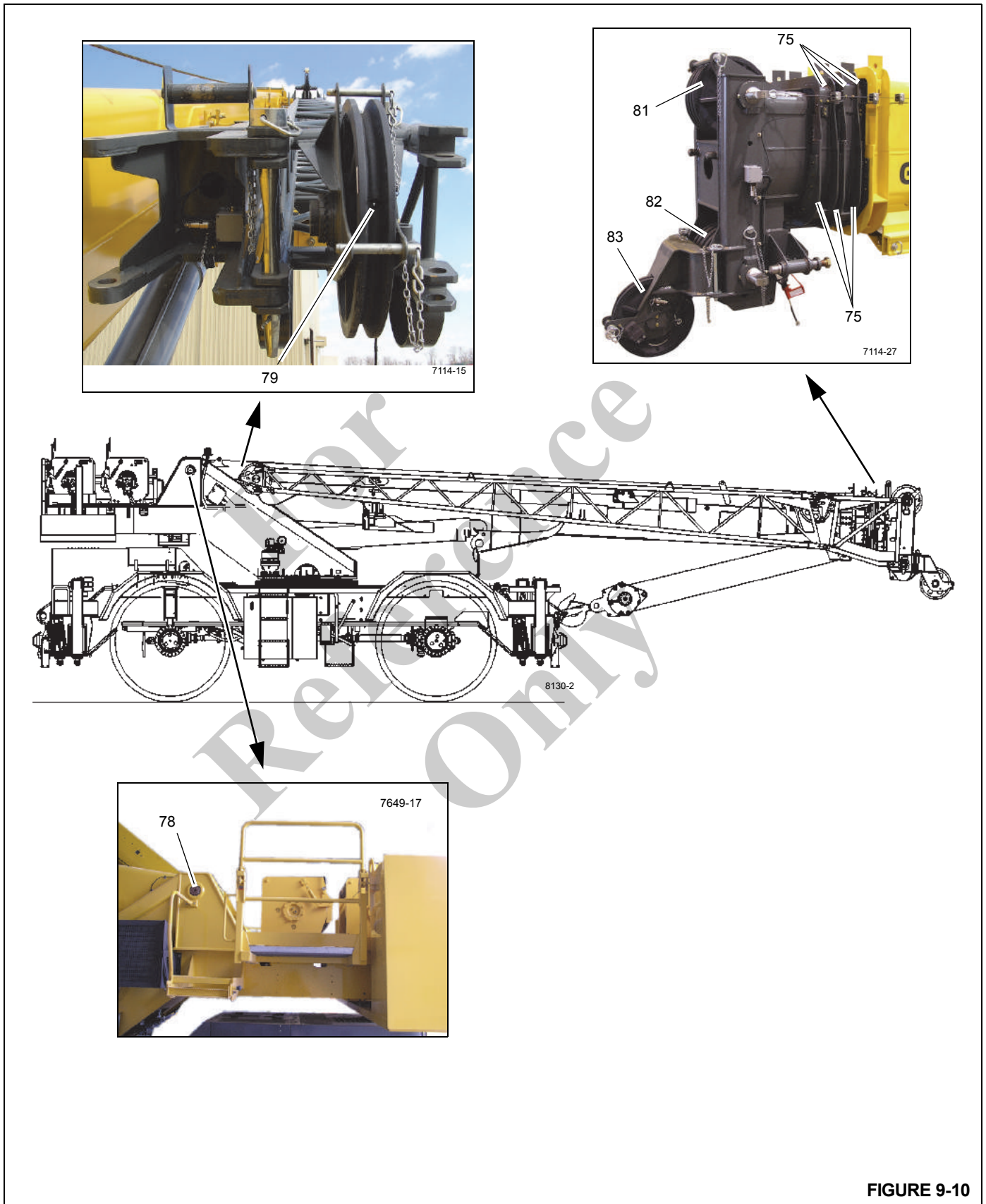


FIGURE 9-10

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Boom (continued)</b>						
84	Mast Sheave	Figure 9-11	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 12 months	1 grease fitting
85	Headache Ball	Figure 9-11		Until grease extrudes	250 hours or 3 months	1 grease fitting

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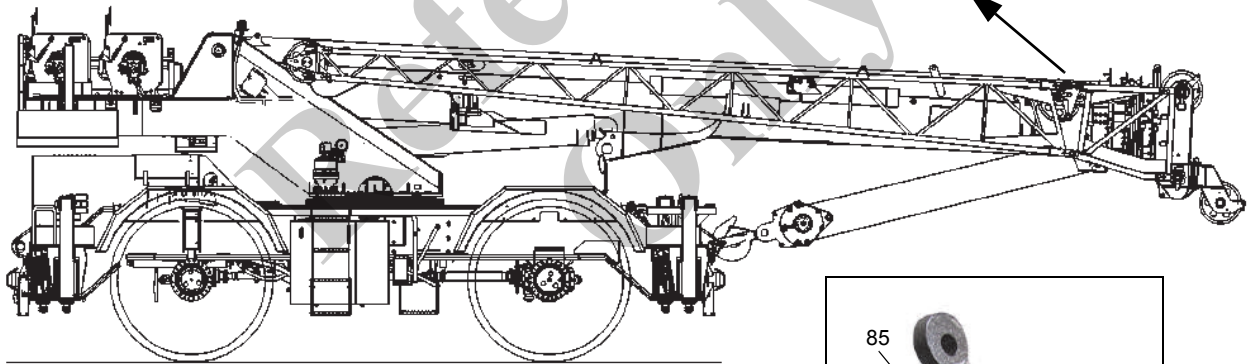
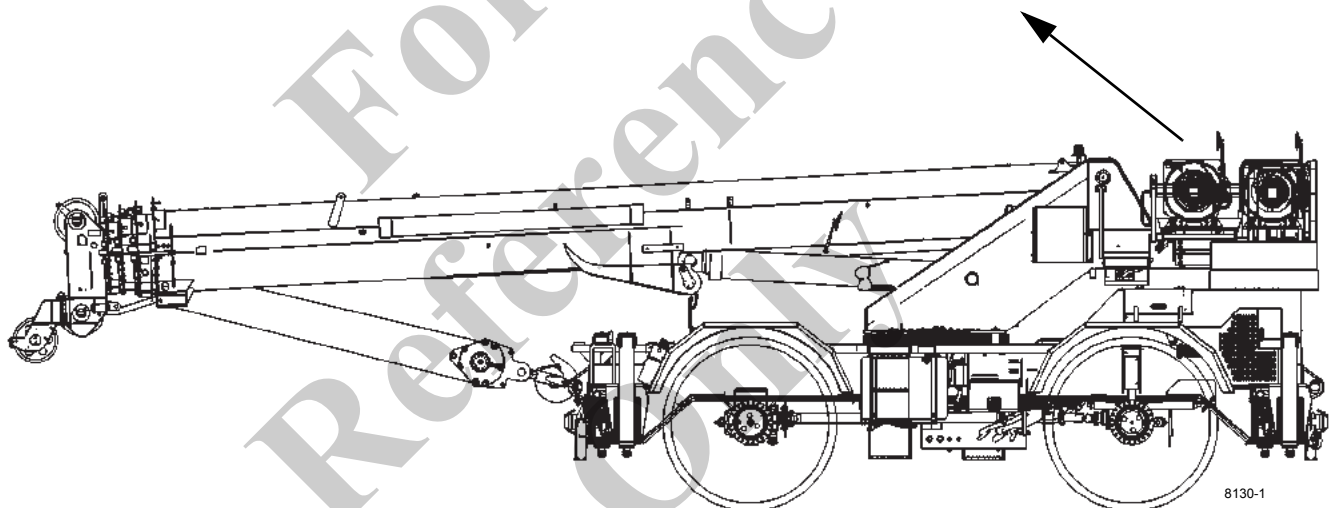
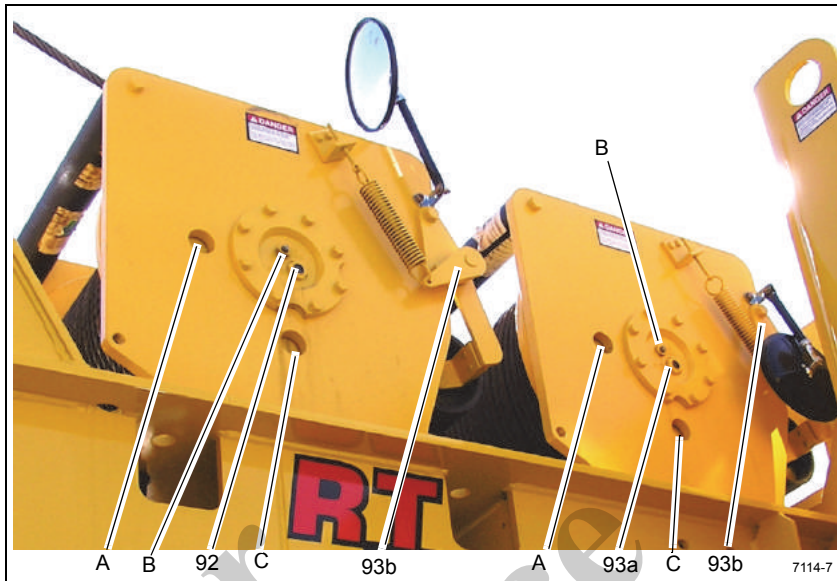


FIGURE 9-11



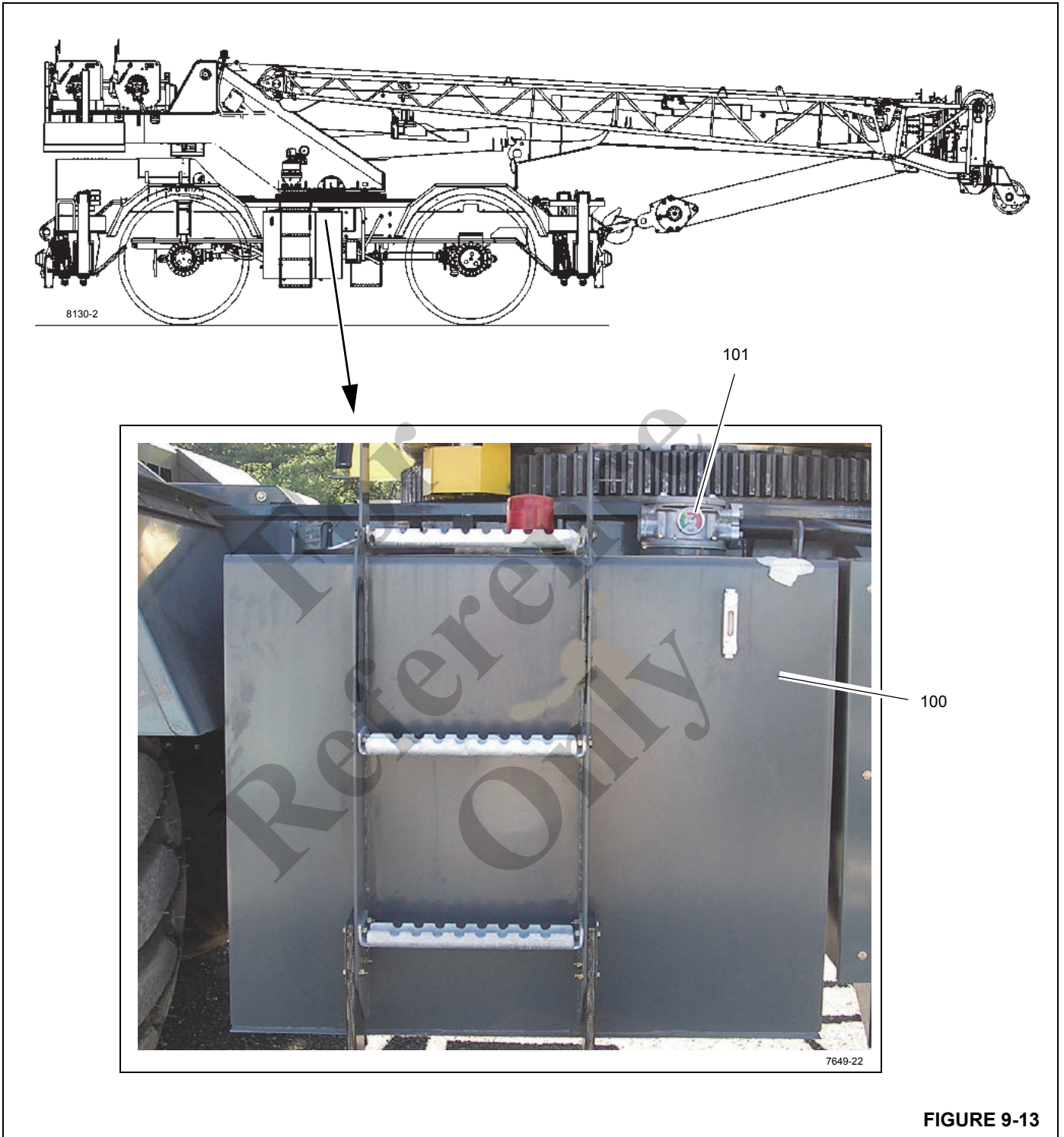
Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Hoist</b>						
92	Main Hoist	Figure 9-12	AGMA Extreme Pressure Gear Lubricant 6829100213	14.7 L (15.5 qt)	<ul style="list-style-type: none"> <li>• Check and fill every 50 hours or weekly</li> <li>• Drain and fill every 1000 hours or 12 months</li> </ul>	Oil must be visible in the sight glass and the level no more than 3 mm (0.13 in) from the top of the sight glass
93a	Auxiliary Hoist	Figure 9-12	AGMA Extreme Pressure Gear Lubricant 6829100213	14.7 L (15.5 qt)	<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 must be visible in the sight glass and the level no more than 3 mm (0.13 in) from the top of the sight glass
<p><b>NOTE:</b> Line up the Fill/Drain Plug with the upper access hole (A). Let hoist sit idle for 20 minutes for an accurate reading. If oil level is not visible in sight glass, the hoist is underfilled. Oil escaping from vent plug (B) or is more than 3 mm (0.13 in) from the top of the sight glass is an indication the hoist is overfilled. If hoist is over filled drain the oil from the Fill/Drain Plug at the upper access hole. When replacing the oil, align the Fill/Drain Plug with the lower access hole (C) and drain the oil.</p> <p>Failure to align the Fill/Drain Plug with the upper access hole prior to checking the oil level will result in an inaccurate reading.</p>						
93b	Cable Follower (Arms)	Figure 9-12	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 if environmental and/or operating conditions necessitate.</p>						



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FIGURE 9-12

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
<b>Hydraulic</b>						
100	Hydraulic Tank	Figure 9-13	HYDO Hydraulic Oil 6829006444	644 L (170 gal)	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>
<b>NOTE:</b>						
<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 9-13	HYDO Hydraulic Oil 6829006444	---	Change filter when the indicator is red	---
102	Diesel Particulate Filter	Figure 9-14	---	---	See Engine Owner's Manual	---



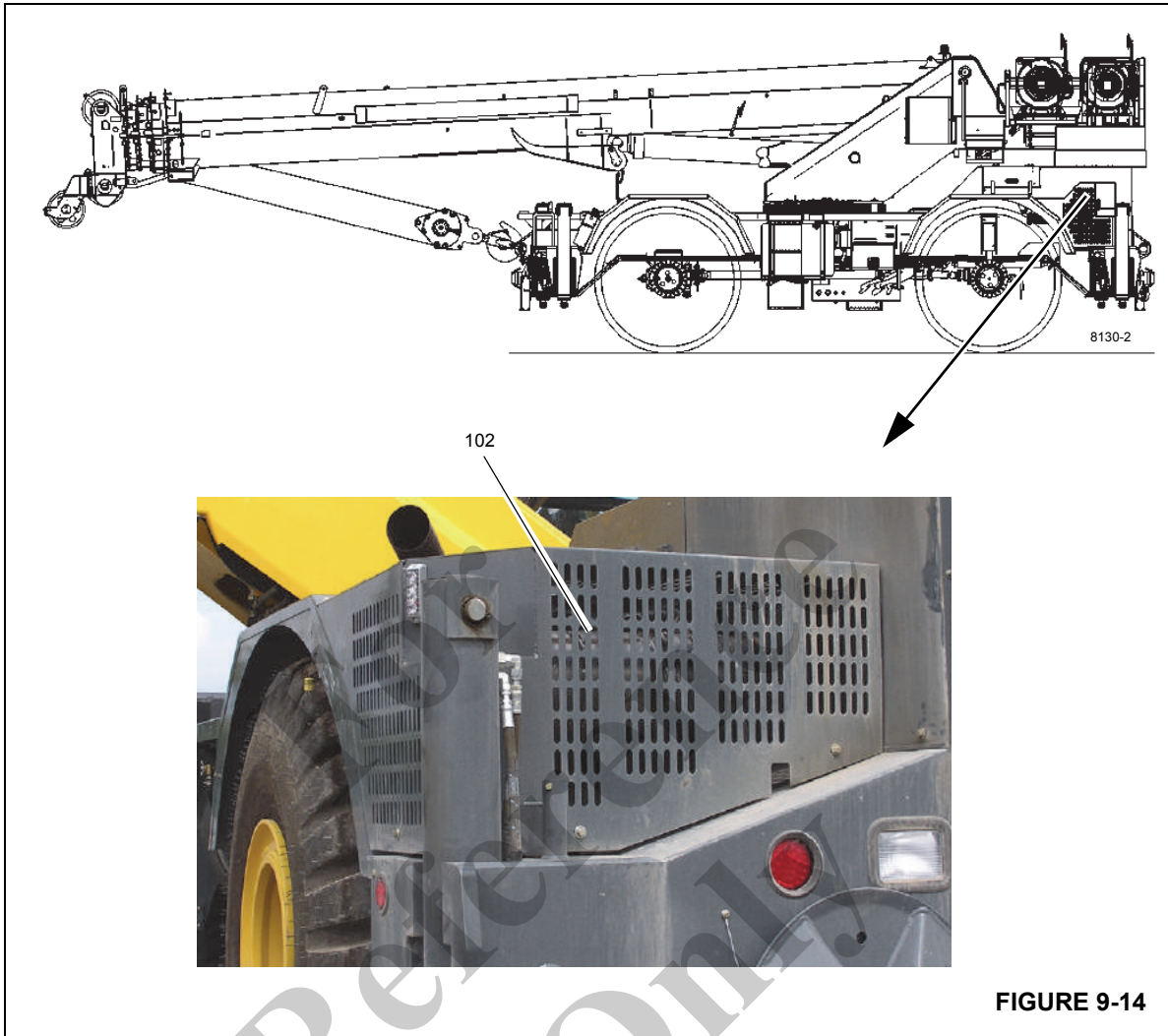


FIGURE 9-14

## 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 are treated with a rust inhibitor called Carwell® T32 (CP-90). While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CFR-19-10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly "oily" residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleaning 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 changeling 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 on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

## Areas of Application

Refer to Figure 9-15 and Figure 9-16.

- 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, drive lines, 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 end and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.



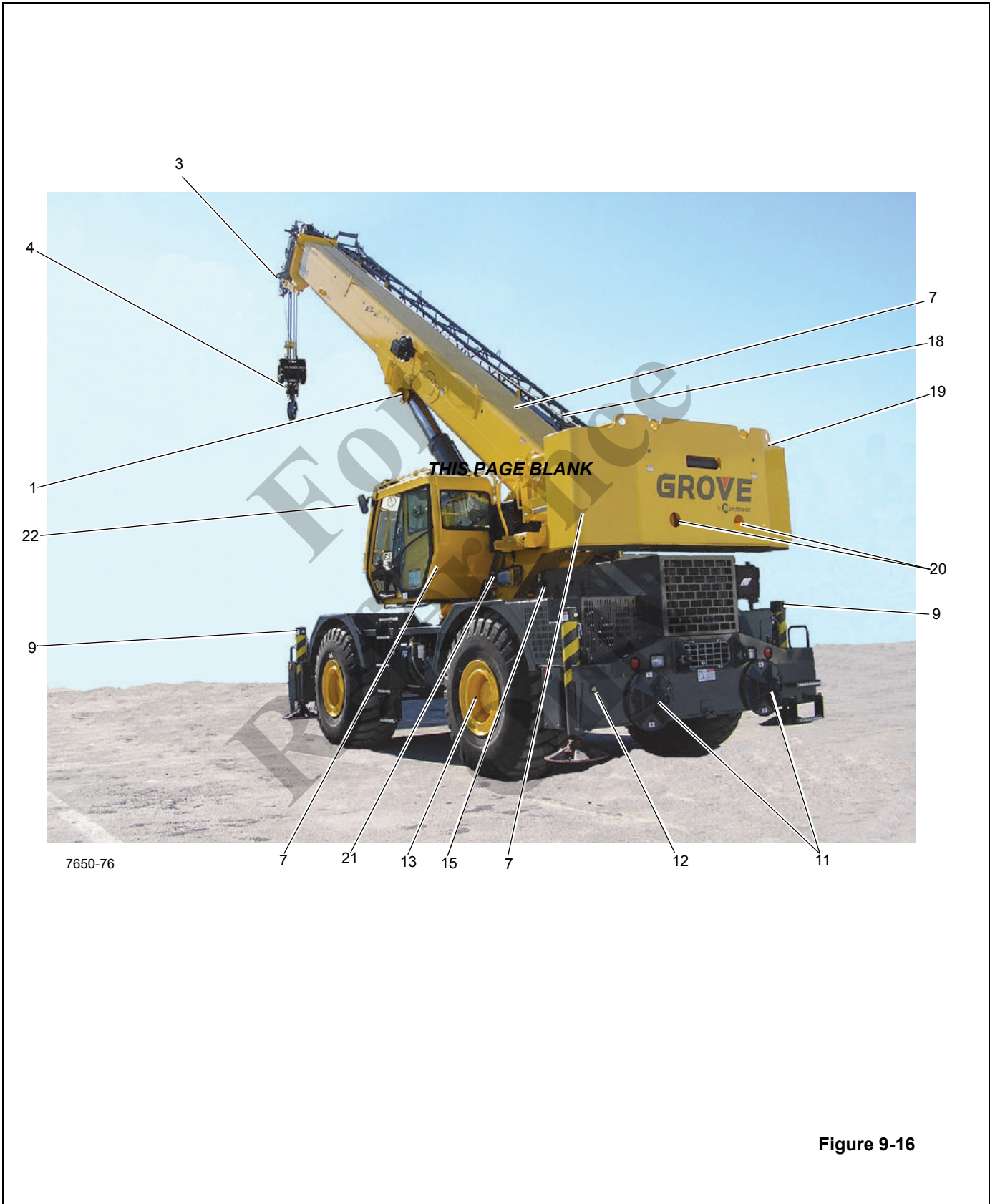


Figure 9-16

Item	Description
1	Pivot Shaft
2	Boom Extension Pins, Clips
3	Boom Nose Pins, Clips
4	Hook Block/Headache Ball
5	Boom Extension Hanger Hardware
6	Hose Connections inside turntable
7	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
8	Turntable Bearing Fasteners
9	O/R Hose Connections
10	Hookblock Tiedown Cable

Item	Description
11	O/R Pins, Clips
12	O/R Beam Wear Pad Adjustment Hardware
13	Entire underside of unit
14	Powertrain Hardware Inside Compartment
15	Valve Bank
16	Hoist Hose Connections
17	Tension Spring
18	Wire Rope
19	Counterweight Mounting Hardware
20	Counterweight Pins
21	Hose Connections
22	Mirror Mounting Hardware

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