Grove RT880E

Service/Maintenance Manual

SERVICE MANUAL

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

RT880E

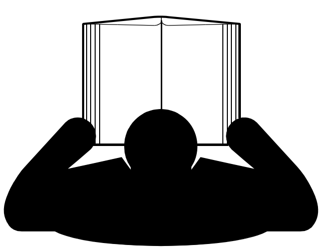
Crane Model Number

This Manual is divided into the following Sections:

NOTICE

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

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



DANGER

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

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

Published 11-10-14 Control# 524-00

CALIFORNIA PROPOSITION 65 WARNING

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

CALIFORNIA PROPOSITION 65 WARNING

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

The original language of this publication is English.

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RT880E SERVICE MANUAL

SECTION 1
INTRODUCTION

SECTION CONTENTS

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 *Operator Manual* Section #2 for other Safety related issues.

Customer Support

Manitowoc and our Distributor 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. The crane is equipped with a four-section, full power, sequenced and synchronized boom. Additional reach is obtained by utilizing an optional swingaway boom extension. Lifting is provided by a main hoist and an optional auxiliary hoist.

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 1-1.

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 RT880E4
Rated Capacity. . . . . .See Load Chart in cab
Drive. . . . . .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 25-34 bias ply tires.

Wheelbase . . . . 166 in (4216 mm)
Overall Crane Length. . . . . 598 in (15,189 mm)
Overall Crane Width. . . . . 131 in (3340 mm)
Overall Crane Height . . . . 148 in (3759 mm)
Tail-Swing. . . . . 174 in (4420 mm)
Outrigger Spread
- Retracted. . . . . .10 ft 4 in (3150 mm)
- Mid Extend . . . . .17 ft 4 in (5283 mm)
- Fully Extended . . . . 24 ft (7315 mm)

Capacities

Fuel Tank . . . . .74 gal (280 liters)
Coolant System . . . . See Engine Specifications
Engine Lubrication System . . . . See Engine Specifications
Hydraulic Tank (Reservoir Capacity)
- Total. . . . . 253 gal (959 l)
- at Full Level. . . . . 228 gal (864 l)
- at Low Level . . . . 213 gal (808 l)
- Expansion Space . . . . 25 gal (95 l)

Hoists . . . . 15.5 qt (14.7 l)
Swing Gearbox. . . . . 5.7 qt (5.4 l)
Axle Planetary Hubs. . . . . 11.0 pt (5.2 l)
Axle Differentials . . . . 51.9 pt (24.6 l)
Transmission (includes Torque Converter) . . . . 40 qt (37.9 l)
DEF Tank . . . . .5 gal (18.9 l)

Torque Converter/Transmission

Stall Ratio 1.82:1
Charge Pump Capacity . . . . . . .28 gpm (106 l/min) @ 2000 rpm
Gear Ratios
Forward/Reverse
- Lo 1st 12.59
- Lo 2nd 6.06
- Lo 3rd 2.22
- Hi 1st. 4.33
- Hi 2nd 2.08
- Hi 3rd 0.76

Engine

Cummins QSB6.7

Displacement. . . . . 409 cu in (6.7 l)
Firing Order 1-5-3-6-2-4
Lube Amount . . . . 18.5 qt (17.5 l)
Coolant System . . . . .50 qt (47.3 l)
Radiator . . . . 5.25 gal (19.9 l)
CAC . . . . 3.3 gal (12.5 l)

Axles

Total Ratio 25.35:1
Carrier Ratio 4.87:1
Wheel End Ratio 5.20:1

Brakes

Type . . . . Hydraulic/Split system acting on all four wheels

Wheels and Tires

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

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

Swing Gearbox

Reduction Ratio 33.6:1
Output Torque . . . . 72,222 lb-in

Boom

Length . . . .
- Retracted . . . . .41.3 ft (12.6 m)
- Extended. . . . . 128 ft (39.0 m)

Power. . . . . .4 Section, Full Power
Elevation . . . .-3 to +78 degrees
Extensions
- Fixed* . . . . 33 ft (10.1 m)
- Folding*. . . . . .33 or 56 ft (10.1 or 17 m)
- *Extensions are offsettable at 0, 20, or 40 degrees.

Extension Insert . . . . 20 ft (6.1 m)

Swivel Assembly

Electrical . . . . 20 Slip Rings
Hydraulic . . . . 12 Ports
Water . . . . 2 Ports

Hydraulic Pumps

Pump #1

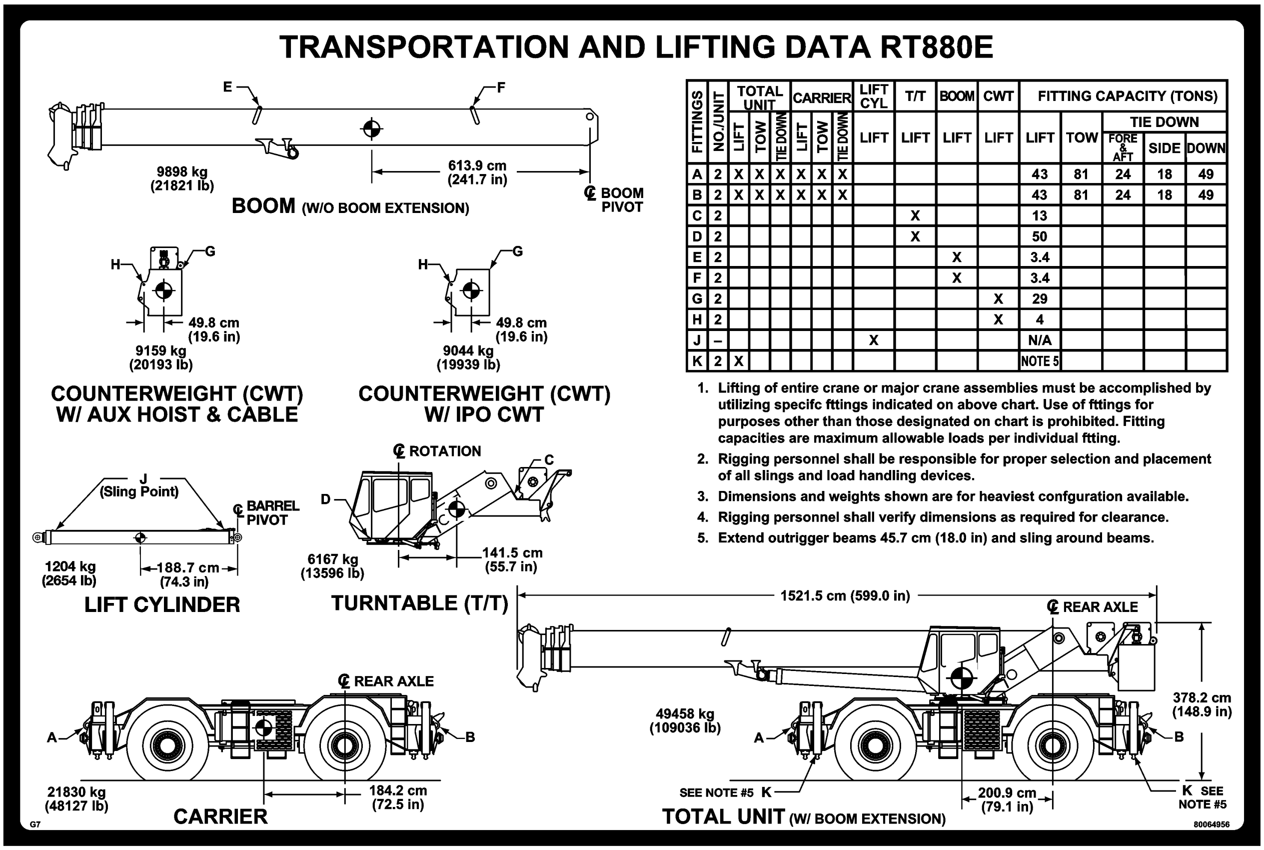
Type . . . . Piston
Sections 1
Output - @ 2700 rpm w/no load
Section 1 . . . . .98.7 gpm (373 l/min)

Pump #2

Type . . . . Gear
Sections 1
Output - @ 2700 rpm w/no load
Section 1 . . . . .38.9 gpm (147 l/min)

Hoists

Drum Dimensions
Diameter . . . . 15 in (381 mm)
Length (Standard) . . . . .18.38 in (467 mm)
Cable
Diameter . . . . .3/4 in (19 mm)
Length-Main. . . . . .600 ft (182.8 m)
Length-Aux. . . . . .600 ft (182.8 m)
Max. Permissible Line Pull
(6x36) EIPS IWRC . . . . 16,800 lb (7,620 kg)
(35x7) Flex-X . . . . 16,800 lb (7,620 kg)
Max. Single Line Speed . . . 514 fpm (156.7 m/min)
Hoist Motor Displacement
Low . . . . .6.53 in^3 ($107\ cm^3$) per revolution
High . . . . .3.72 in^3 ($61\ cm^3$) per revolution



FITTINGS	NO./UNIT	TOTAL UNIT			CARRIER			LIFT CYL	T/T	BOOM	CWT	FITTING CAPACITY (TONS)				
		LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN	LIFT	LIFT	LIFT	LIFT	LIFT	TOW	TIE DOWN FORE & AFT	TIE DOWN SIDE	TIE DOWN DOWN
A	2	X	X	X	X	X	X					43	81	24	18	49
B	2	X	X	X	X	X	X					43	81	24	18	49
C	2								X			13				
D	2								X			50				
E	2									X		3.4				
F	2									X		3.4				
G	2										X	29				
H	2										X	4				
J	–							X				N/A				
K	2	X										NOTE 5				

1. Lifting of entire crane or major crane assemblies must be accomplished by utilizing specifc fttings indicated on above chart. Use of fttings for purposes other than those designated on chart is prohibited. Fitting capacities are maximum allowable loads per individual ftting.
2. Rigging personnel shall be responsible for proper selection and placement of all slings and load handling devices.
3. Dimensions and weights shown are for heaviest confguration available.
4. Rigging personnel shall verify dimensions as required for clearance.
5. Extend outrigger beams 45.7 cm (18.0 in) and sling around beams.

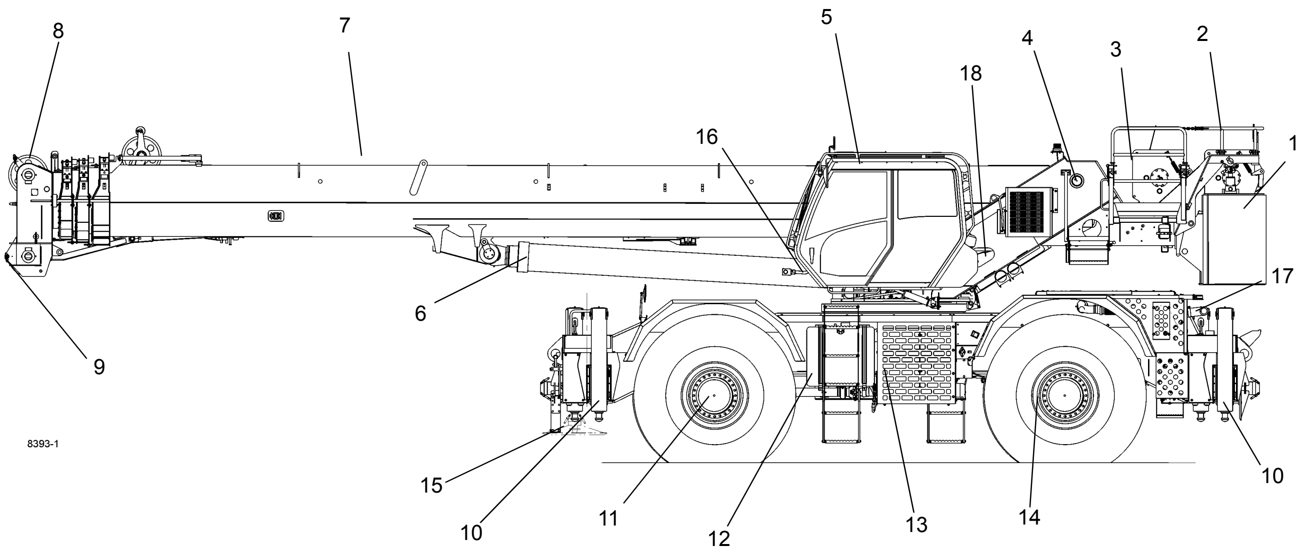
8405

FIGURE 1-1

Table 1-1: AXLE WEIGHT DISTRIBUTION TABLE

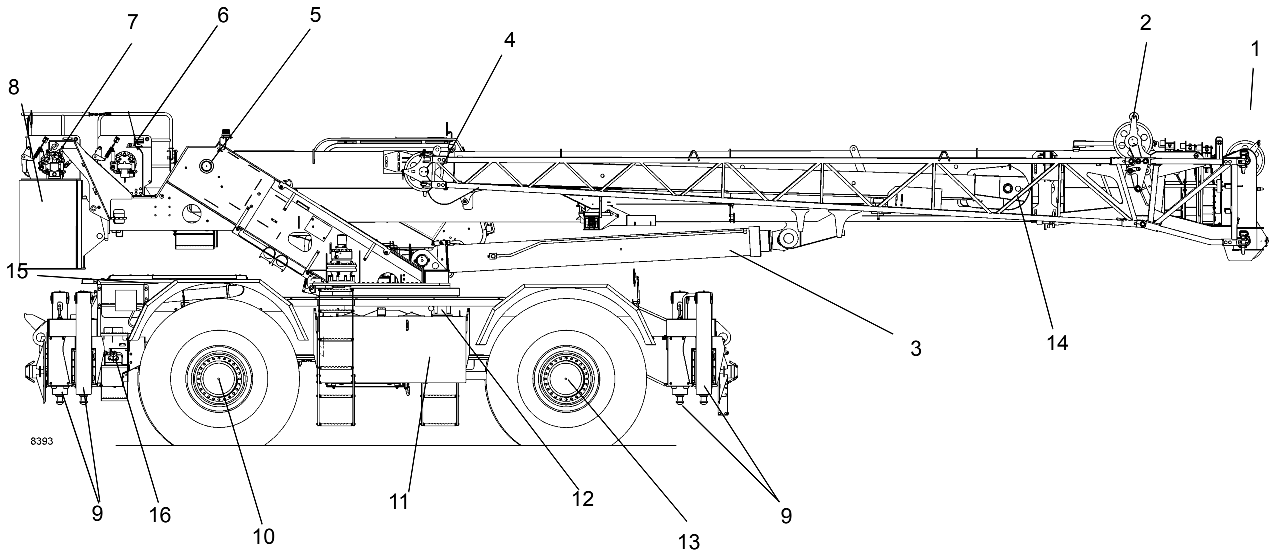
Description	CG From Rear Axle cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Basic Unit				
Maximum Axle Loads Allowed			29484 (65000)	29484 (65000)
Maximum Axle Loads while Towing			27216 (60000)	27216 (60000)
Maximum Tire Loads Allowed			28885 (63680)	28885 (63680)
Standard Carrier 4 x 4, plus all Fluids	184.35 (72.58)	21683 (47803)	9481 (20902)	12202 (26901)
Superstructure w/Cab; w/Main Hoist, plus 600 ft Cable	68.55 (26.99)	5872 (12945)	955 (2105)	4917 (10840)
Removable Counterweight (Includes Cylinders, Aux. Hoist and Cable)	-201.42 (-79.30)	9159 (20193)	-4375 (-9646)	13535 (29839)
Boom Assy, 2/4 Sheaves, Lift Cyl Upr Pin & Pivot Pin	595.35 (234.39)	9672 (21323)	13657 (30108)	-3985 (-8785)
Lift Cylinder & Lower Shaft	435.64 (171.51)	1204 (2654)	1244 (2742)	-40 (-88)
Complete Basic Machine: 12.6 - 39.0 m (41 - 128 ft) 4-Section Boom, Cummins QSB6.7 Tier 4 Final Engine, 29.5x25 (34 ply) Tires, Main Hoist w/185 m (607 ft) of 19 mm (3/4 in) 35x7 cable, Full Fuel and Hydraulic Oil	185.70 (73.11)	47590 (104918)	20961 (46210)	26630 (58708)
Add To Basic Unit Weight				
33 to 56 ft (10.0 to 17.0 m) Bi-Fold Boom Extension w/RCL	758.39 (298.58)	1200 (2645)	2158 (4757)	-958 (-2112)
33 ft (10.0 m) Fixed Boom Extension w/RCL	838.15 (329.98)	829 (1827)	1647 (3632)	-819 (-1805)
Boom Extension Carrier Brackets (Bolt On)	608.05 (239.39)	167 (368)	241 (531)	-74 (-163)
Auxiliary Boom Nose - Installed	1288.92 (507.45)	59 (130)	180 (397)	-121 (-267)
20 ft (6.1 m) Boom Ext. Insert w/RCL (Pinned at Boom Nose) (Not included in weight)	1532.76 (603.45)	397 (875)	1443 (3181)	-1046 (-2306)
12 Ton (10.9 mt), Headache Ball (Swivel) - Attached to O/R Box	688.49 (271.06)	258 (568)	420 (927)	-163 (-359)
80 Ton (75 mt) Hookblock (5 Sheave), Stowed in Trough	422.00 (166.14)	598 (1319)	599 (1320)	0 (-1)
Rubber mat in front Stowage Tray	421.64 (166.00)	27 (60)	27 (60)	0 (0)
Air Conditioning - Carrier	17.78 (7.00)	12 (26)	0 (1)	11 (25)
Air Conditioning - Superstructure	43.18 (17)	32 (71)	3 (7)	29 (64)
360 Degree Swing Lock	152.40 (60.00)	29 (64)	10 (23)	19 (41)
Driver	189.76 (74.71)	113 (250)	51 (113)	62 (137)
Sound Package for CE - Carrier	91.44 (36)	108 (238)	24 (52)	84 (186)
Sound Package for CE - S/S - Main Hoist	22.86 (9.00)	156 (344)	9 (19)	147 (325)
Sound Package for CE - S/S - Main and aux Hoist	-23.00 (-58.42)	503 (228)	-70 (-32)	573 (260)

Description	CG From Rear Axle cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Substitutions, Deletions, and Removals from Basic Unit Weight				
Sub: Removable Ctwt (includes Cylinders & IPO Ctwt)	-201.42 (-79.30)	-115 (-254)	55 (121)	-170 (-375)
Sub: Aux Hoist additional weight (not part of Ctwt)	312.42 (123.00)	6 (13)	5 (10)	1 (3)
Sub: Tier 3 Engine	-104.14 (-41.00)	-107 (-235)	26 (58)	-133 (-293)
Rem: Main Hoist Cable (607 ft (185 m) of 19mm (3/4 in) 35x7)	-113.79 (-44.80)	-336 (-741)	91 (200)	-427 (-941)
Rem: Aux Hoist Cable (607 ft (185 m) of 19mm (3/4 in) 35x7)	-200.66 (-79.00)	-336 (-741)	160 (353)	-496 (-1094)



Item	Description
1	Counterweight
2	Auxiliary Hoist
3	Main Hoist
4	Boom Pivot
5	Cab
6	Lift Cylinder
7	Boom
8	Boom Nose Sheaves
9	Aux. Boom Nose (Not Shown)
10	Outrigger Jack Cylinder
11	Front Axle
12	Fuel Tank
13	Oil Cooler
14	Rear Axle
15	Outrigger Float
16	Work Lights
17	Tailpipe
18	Windshield Washer Fluid

FIGURE 1-2



Item	Description
1	Boom Nose Sheaves
2	Boom Extension Mast Sheave
3	Lift Cylinder
4	Swingaway Nose
5	Boom Pivot
6	Main Hoist
7	Auxiliary Hoist
8	Counterweight
9	Outrigger Jack Cylinder
10	Rear Axle
11	Hydraulic Tank
12	Hydraulic Filter
13	Front Axle
14	Swingaway Extension
15	Air Cleaner
16	Diesel Exhaust Fluid Tank

FIGURE 1-3

GENERAL MAINTENANCE

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

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.

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.

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 disconnect. 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.

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 portion of a crane or a complete crane, ensure the crane is blocked securely and the weight is supported by blocks 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. All supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

CAUTION

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 assembling or disassembling a component or system, complete each step in turn. Do not partially assemble one part and start assembling some other part. 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 the job.

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.

Locks

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 lock washers on housings made of aluminum or thin sheet metal, use a flat washer between the lock washer 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 1-4:

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

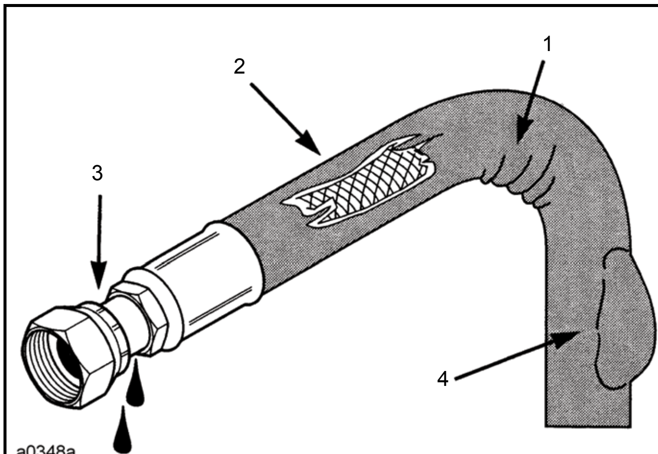


FIGURE 1-4

Installation

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

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

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

When pressing bearings into a retainer or bore, uniformly apply pressure to the outer race. If the bearing is pressed 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 of preload to 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 on a bearing, 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 lubricant passages in the mating parts. If it is necessary to make gaskets, select material of the proper type and thickness. Be sure to cut holes in the right places. Blank gaskets can cause serious damage.

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

Batteries

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

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

Hydraulic Systems

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

When installing metal tubes, tighten all fittings finger-tight. Then, in order, tighten the fittings 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 fittings finger-tight. Position the hose so it does not rub the machine or another hose and has a minimum of bending and twisting. Tighten fittings in both couplings.

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

Visual Inspection of Hoses and Fittings

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: Temperate 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

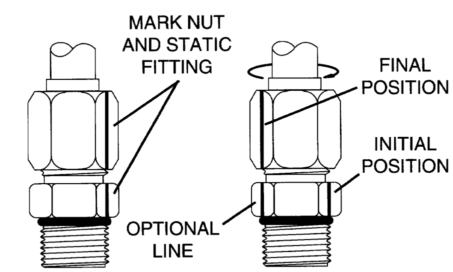


FIGURE 1-5

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 1-5).

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

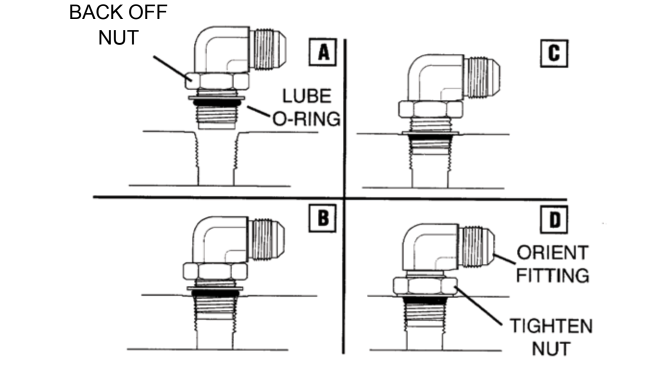
Adjustable Straight Thread O-ring Fittings

Refer to Figure 1-6 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

T-2-6



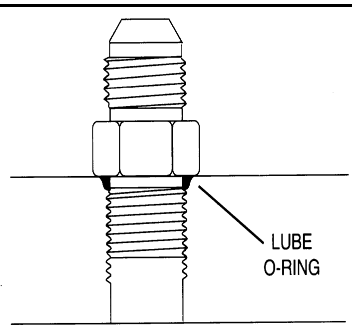
a0030 Adjustable Fitting to Port **FIGURE 1-6**

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

Nonadjustable Straight Thread O-ring Fitting: Fitting to Port

Refer to Table 1-5 for the following procedure.

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-7).



a0032 Non-Adjustable Fitting to Port **FIGURE 1-7**

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

T-2-7

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 be commensurate with the age of the equipment, the severity of the application, and the experience of the operators and maintenance personnel.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:

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

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

Anyone requiring more detailed inspection instructions and/ or repair procedures may request them by contacting the local Manitowoc Cranes distributor.

Loctite®

CAUTION

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 Cranes distributor.

Application of Medium Strength Loctite

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

The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant (Loctite #243) and primer (Locquic Primer T 7471). (Primer is not required with Loctite #243, but is with Loctite #242.)

Primer Application

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

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

Adhesive/Sealant Application

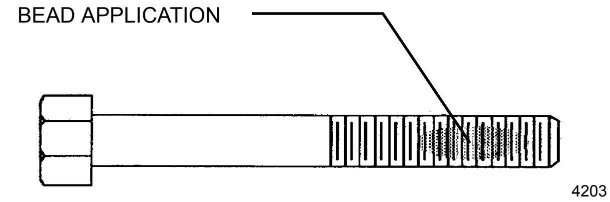


FIGURE 1-8

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (Figure 1-3).
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, bonding will occur within five (5) minutes if primed prior to engagement. Fixture 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.

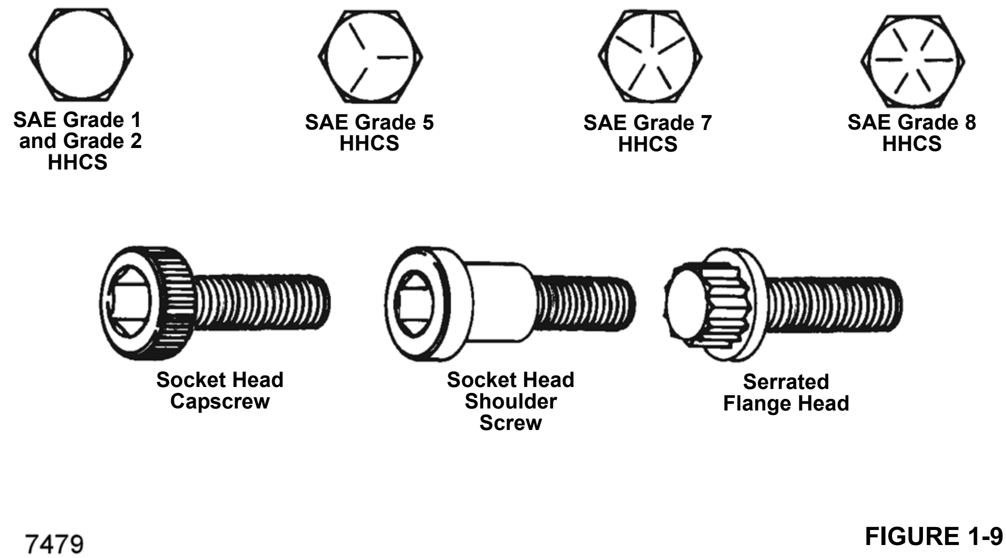


FIGURE 1-9

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 information is a compendium of information 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 rope's 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 it's 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 ropes.
- 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

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

- 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.
- Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
- Never electroplate wire rope assemblies.
- 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.
- 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.
- On systems equipped with two or more wire rope assemblies operating as a matched set, they shall be replaced as an entire set.
- Do not paint or coat wire ropes with any substance except approved lubricants.
- Measure the rope's diameter across crowns (1) of the strands when determining if rope has become damaged Figure 1-10.

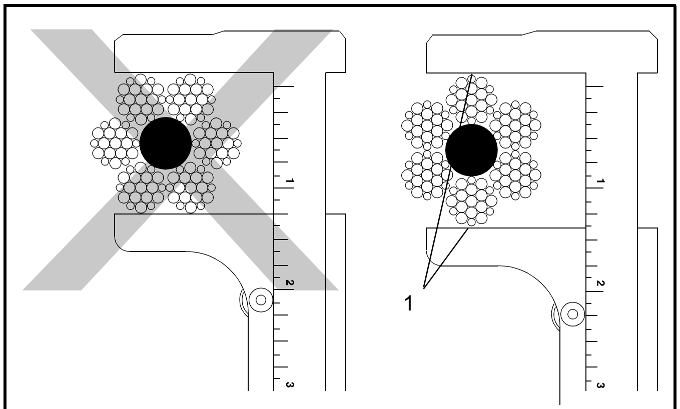


FIGURE 1-10

- When checking for broken wires (5) Figure 1-11 relax the rope, move it off "pick-up points", and flex it as much as possible. Defect in the rope is spoke of in relations to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around core (4).

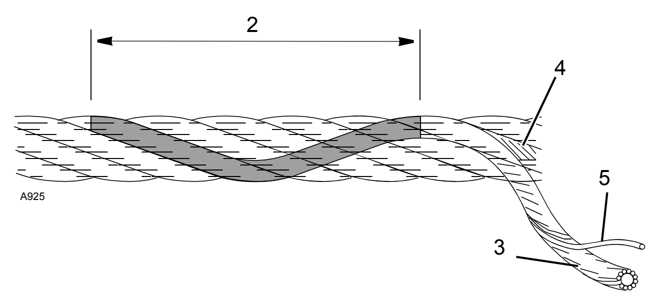


FIGURE 1-11

Wire Rope Inspection (Running Ropes and Pendant Cables)

Wire rope should be inspected frequently/dally 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, Bird caging, 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.

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, bird caging, 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 rope, 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 1-12, 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.

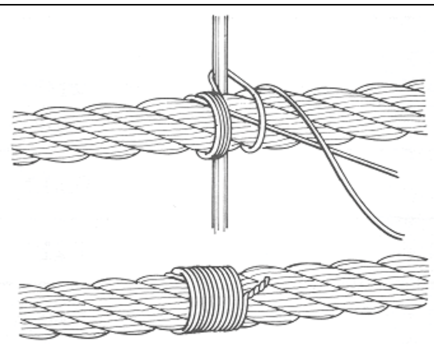


FIGURE 1-12

Method 2

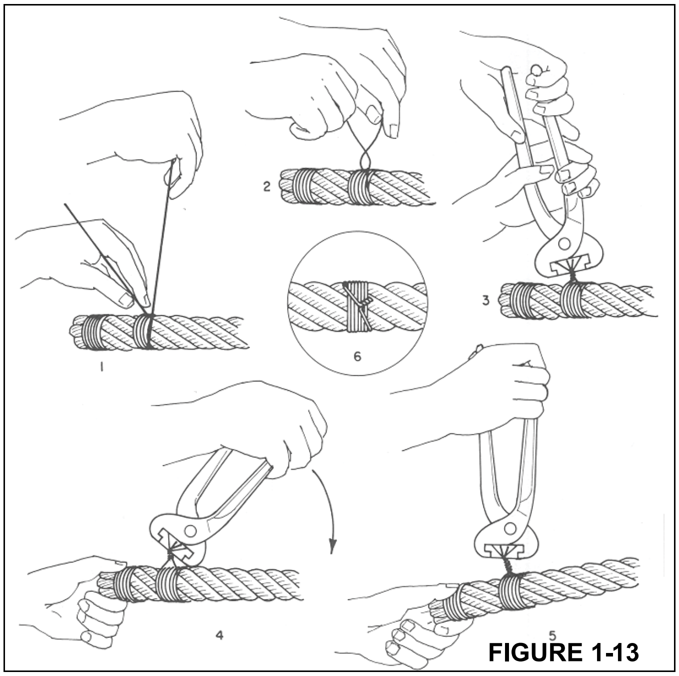


FIGURE 1-13

Wind a length of soft annealed wire Figure 1-13 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 1-14 should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

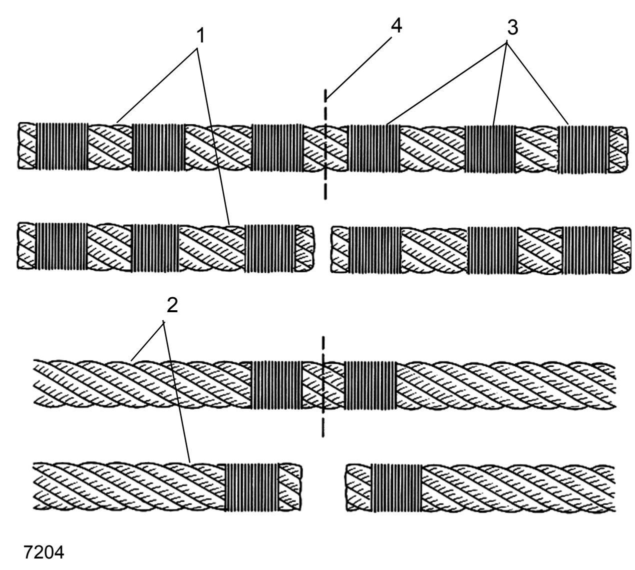


FIGURE 1-14

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 attached 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. Attach rope's end to drum. Pull the rope over the point sheave and attach the end to the 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 in 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, you should properly break in your rope, which allows the rope's component parts to adjust themselves to your 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. Stand back and watch 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 we manufacture. One characteristic that makes this rope special is that the outer strands are not preformed. It is because of this that the following procedures for cutting and preparing 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 for shipment of the rope.
4. Attach a "Do not remove welded ends" tag on each reel flange.

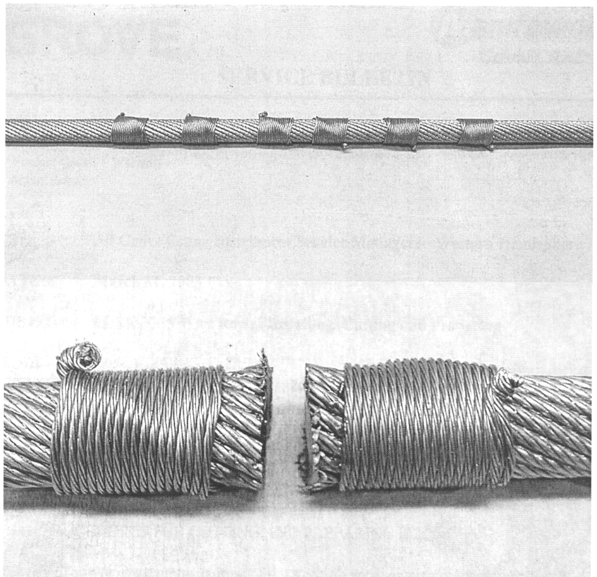


FIGURE 1-15

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SECTION 2
HYDRAULIC SYSTEM

SECTION CONTENTS

DESCRIPTION

This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return hydraulic circuit, hydraulic pumps, all hydraulic valves, and all hydraulic cylinders. Detailed descriptions and operation of individual hydraulic circuits are discussed within their individual sections as applicable. A complete hydraulic system schematic showing all options is at the back of this manual and A.N.S.I. Graphical Symbols charts Figure 2-1 and Figure 2-2 provides hydraulic symbol information for this section.

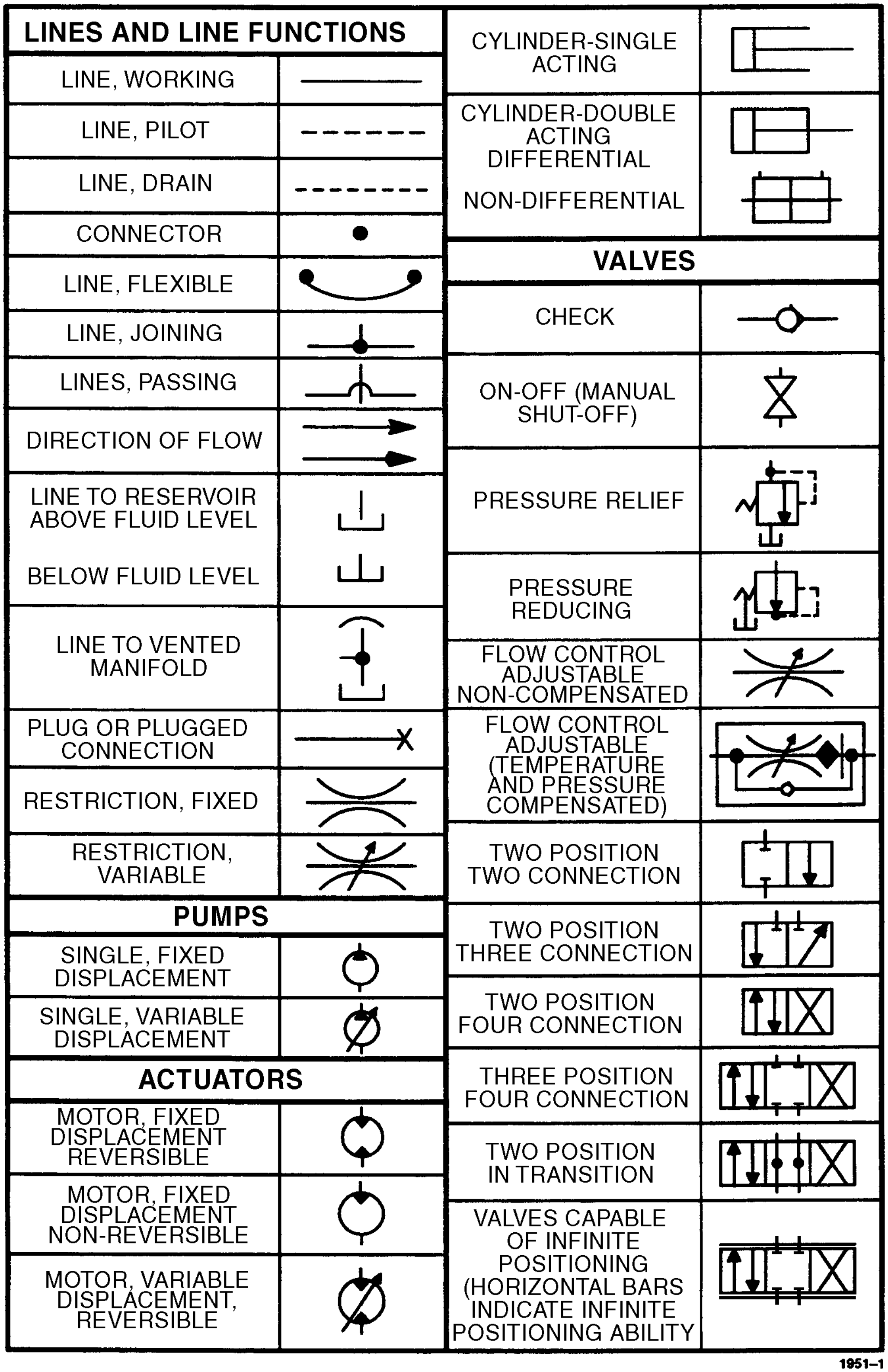

LINES AND LINE FUNCTIONS
LINE, WORKING
LINE, PILOT
LINE, DRAIN
CONNECTOR
LINE, FLEXIBLE
LINE, JOINING
LINES, PASSING
DIRECTION OF FLOW
LINE TO RESERVOIR ABOVE FLUID LEVEL
BELOW FLUID LEVEL
LINE TO VENTED MANIFOLD
PLUG OR PLUGGED CONNECTION
RESTRICTION, FIXED
RESTRICTION, VARIABLE
PUMPS
SINGLE, FIXED DISPLACEMENT
SINGLE, VARIABLE DISPLACEMENT
ACTUATORS
MOTOR, FIXED DISPLACEMENT REVERSIBLE
MOTOR, FIXED DISPLACEMENT NON-REVERSIBLE
MOTOR, VARIABLE DISPLACEMENT, REVERSIBLE
CYLINDER-SINGLE ACTING
CYLINDER-DOUBLE ACTING DIFFERENTIAL
NON-DIFFERENTIAL
VALVES
CHECK
ON-OFF (MANUAL SHUT-OFF)
PRESSURE RELIEF
PRESSURE REDUCING
FLOW CONTROL ADJUSTABLE NON-COMPENSATED
FLOW CONTROL ADJUSTABLE (TEMPERATURE AND PRESSURE COMPENSATED)
TWO POSITION TWO CONNECTION
TWO POSITION THREE CONNECTION
TWO POSITION FOUR CONNECTION
THREE POSITION FOUR CONNECTION
TWO POSITION IN TRANSITION
VALVES CAPABLE OF INFINITE POSITIONING (HORIZONTAL BARS INDICATE INFINITE POSITIONING ABILITY
1951–1

FIGURE 2-1

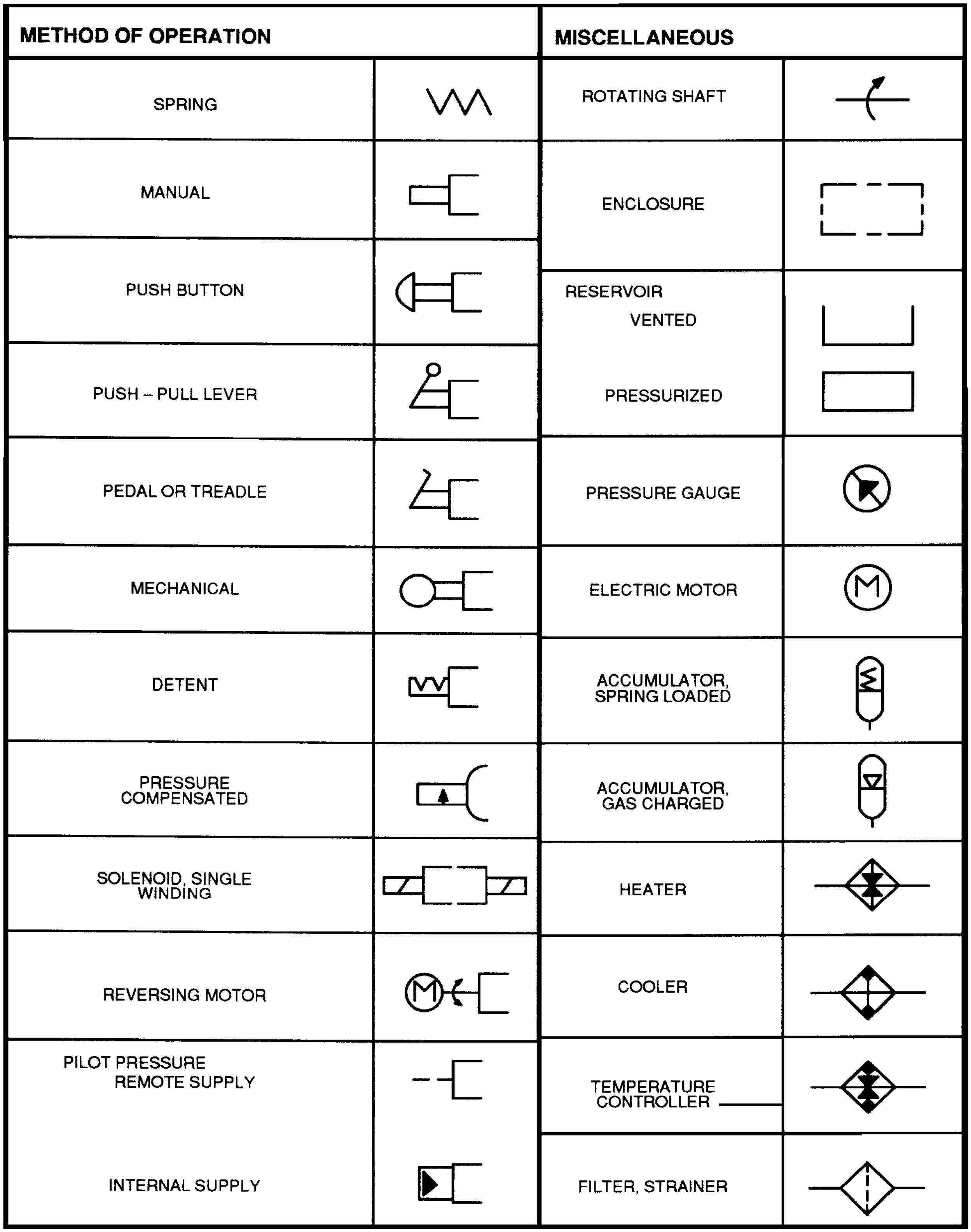

METHOD OF OPERATION
SPRING
MANUAL
PUSH BUTTON
PUSH – PULL LEVER
PEDAL OR TREADLE
MECHANICAL
DETENT
PRESSURE COMPENSATED
SOLENOID, SINGLE WINDING
REVERSING MOTOR
PILOT PRESSURE
REMOTE SUPPLY
INTERNAL SUPPLY
MISCELLANEOUS
ROTATING SHAFT
ENCLOSURE
RESERVOIR
VENTED
PRESSURIZED
PRESSURE GAUGE
ELECTRIC MOTOR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

FIGURE 2-2

THEORY OF OPERATION

Three different control systems are used in the hydraulic system; load sense (LS), constant pressure unloaded (CPU), and open center (OC).

Hoist, lift, telescope, cab tilt, and counterweight removal are constant pressure unloaded (CPU) functions. They are supplied oil flow via a variable displacement supercharged piston pump. CPU functions have directional spools that meter the required flow and pressure to the function. The pump delivers only the required flow at the pumps compensator setting.

Outriggers, rear steer, service brakes, oil cooler motor, telescope hose reel motor/brake controller supply and swing brake release are load sense (LS) functions.They are supplied oil flow by the same pump as the CPU functions. The LS functions are in parallel with the CPU valves. LS signal shuttle valves send the highest load signal of all the functions that are activated. The function's spools or orifices meter the required flow to the function. The pump will deliver only the required flow up to the compensator setting. When a load sense function is operated at the same time as a constant pressure unloaded function, the pump stays at it's compensated setting.

The swing function is the only open center (OC) function. Swing is supplied with oil from a single section gear pump. Front steer is also supplied with oil from this gear pump and is prioritized to take any required flow before swing. Front steer acts like a load sense function because of the priority valve.

Both load sense and constant pressure unloaded functions utilize a signal control line that loops through all valves common to the pump by the shuttle valves. When using a LS function, the highest signal PSI up to the pumps compensator setting is sent to the variable displacement piston pump. When a CPU function is activated, the signal line being drained across the directional control valve spool is blocked, causing the pump to rise in pressure to its compensated pressure setting.

A load signal dump valve prevents the pump from coming on stroke during engine start. It is activated by the ignition key switch during the starting mode. This ensures the engine does not start against a load in the event the accumulators are charging or the fan motor is activated.

MAINTENANCE

Hydraulic Oil Recommendations.

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

Draining and Flushing

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

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

CAUTION

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

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

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

CAUTION

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

10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.

12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from both front steer cylinders and turn the front wheels to the extreme right.
16. Connect the return lines and turn the front wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Repeat Steps 15 and 16 for the rear steering cylinders.
18. Raise the crane on outriggers.
19. Disconnect the line from port A of the axle lockout valve.
20. Using a jack under the rear wheel on one side of the crane, jack up the wheel to maximum travel.
21. Connect the line to port A of the axle lockout valve and disconnect the line from Port B.
22. Repeat Step 19 using the other rear wheel.
23. Connect the line to port B of the axle lockout valve. Energize the axle lockout valve. Replenish the reservoir hydraulic oil level as necessary.
24. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
25. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
26. Repeat Steps 24 and 25 for the auxiliary hoist as necessary.
27. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
28. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

When hydraulic oils are changed or added, ensure that hydraulic oils of different manufacturers are of the same specifications. However, discoloration may occur.

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Working reservoir capacity (capacity to full mark) is 236 U.S. gal (894 l). Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge. After the reservoir is filled, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

Removing Air from the Hydraulic System

Air entering the hydraulic oil will normally be removed automatically by passage of the hydraulic oil over the baffles in the hydraulic reservoir. If a component has been replaced, the reservoir level is too low, or a leak develops in the suction lines to the pumps, air can enter the system. If air becomes entrapped in the hydraulic oil, it may be detectable in pumps and motor operated components such as the swing 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 2 to 4 psi (13.8 to 27.6 kPa/0.14 to 0.28 bar) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.

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

DANGER

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

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

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

WARNING

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

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

WARNING

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

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

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

Parts Replacement

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

Directional Control Valves

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

Inspection

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

Valve Leakage

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

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

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, two hydraulic pumps, a hydraulic oil cooler, and a 14-port hydraulic swivel. Refer to *Hydraulic Pumps*, page 2-13 for descriptions and maintenance instructions for each hydraulic pump. Refer to *Swing System*, page 6-1 for description and maintenance instructions for the 14-port hydraulic swivel.

The supply pressure and return circuit uses Ports 6 and 7 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

The reservoir (see Figure 2-3), attached to the right side of the carrier frame, has a capacity of 253.3 gallons (958.7 l) total, 228 gal (863.8 l) to the full mark. The all-steel reservoir has an internally mounted full-flow filter and integral baffles that help cool the hydraulic oil and prevent hydraulic oil foaming.

Hydraulic oil flows through two tubes at the lower rear of the reservoir to the two 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 14-port swivel.

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

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

Item	Description
1	Return Filter
2	Filter Indicator
3	Sight Gauge
4	Return Line
5	Suction Line
6	Access Cover
7	Filler Neck and Breather
8	Step Assembly
9	Magnetic Plug
10	Capscrew
11	Flatwasher
12	Spring Lockwasher
13	Hex Nut
14	Temperature Switch (High Hydraulic Oil Temperature)
15	Temperature Switch (Oil Cooler Fan Motor Speed)

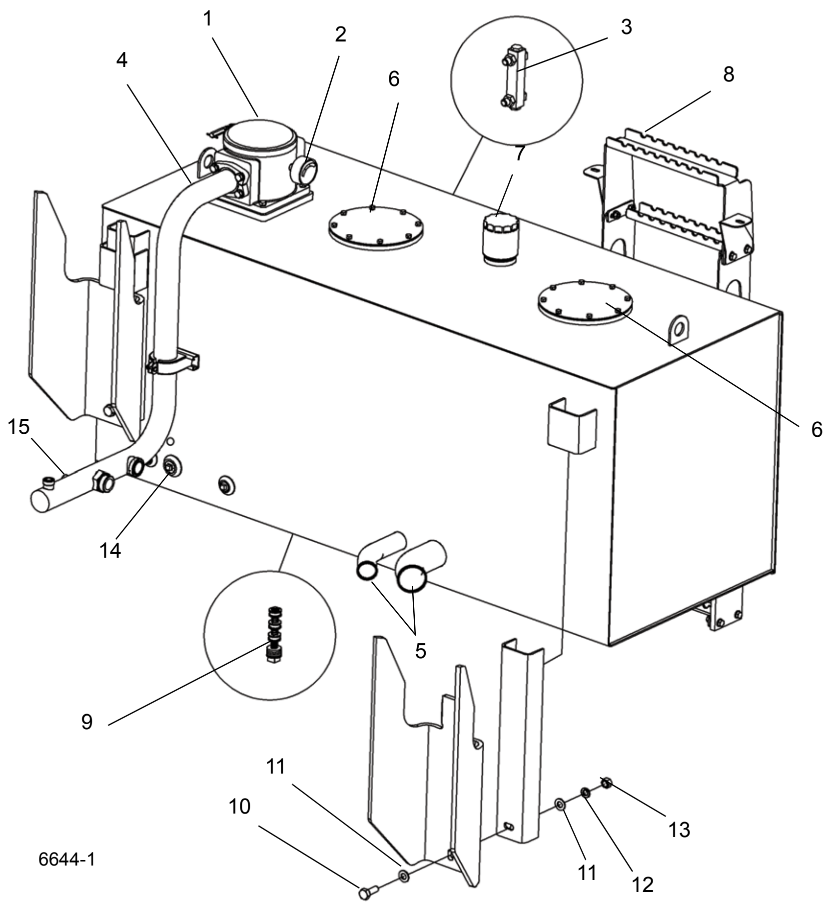


FIGURE 2-3

A temperature switch (15), located in the tube that routes return oil to the hydraulic oil return filter in the reservoir, is part of a circuit that controls the oil cooler fan speed; refer to *Oil Cooler*, page 2-12 for more detailed information on its operation.

A second temperature switch (14) in the hydraulic reservoir 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 190°F (88°C). 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 Manual* for details of the Hydraulic Oil High Temperature Indicator.

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.

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

Hydraulic Oil Return Filter Assembly

The hydraulic oil return filter assembly (see Figure 2-3 and Figure 2-4) 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 25 psi (172.3 kPa/ 1.72 bar), 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 2-4 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. Remove the spring and bypass valve and inspect 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.
2. Install the bypass valve and spring.
3. Install the cap on top of the return filter head making sure that the new O-ring between the cap and filter head is installed correctly.
4. Secure the cap to the filter head using the bolts and lock washers; torque bolts to their specified value.
5. Activate the hydraulic system and check for leaks. Make repairs as needed.

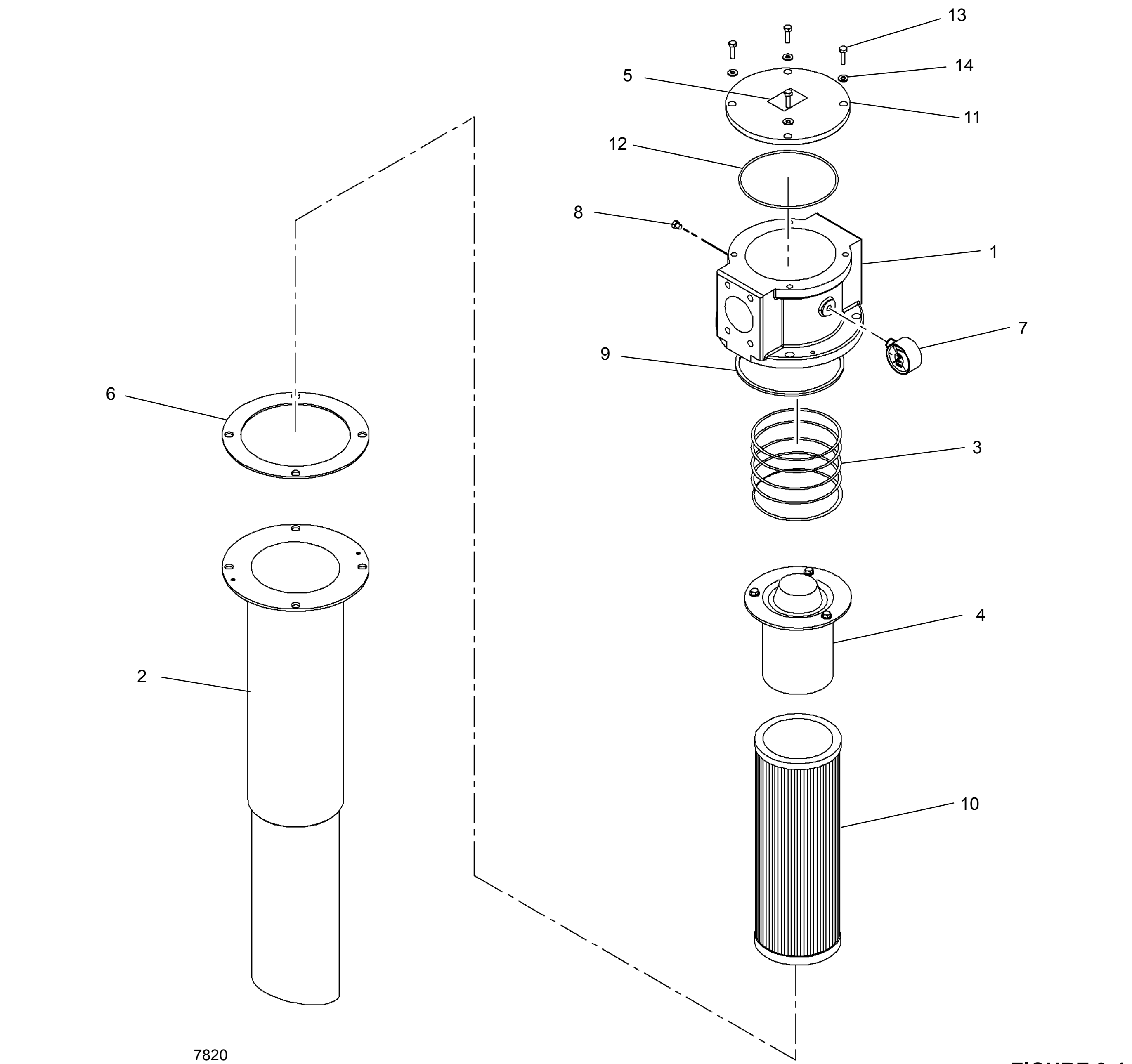


FIGURE 2-4

Item	Description
1	Filter Head
2	Bowl Assembly
3	Compression Spring
4	Bypass Valve Assembly
5	I.D. Plate
6	Gasket
7	Gauge Assembly

Item	Description
8	Plug
9	O-ring
10	Element
11	Cap
12	O-ring
13	Screw
14	Washer

Oil Cooler

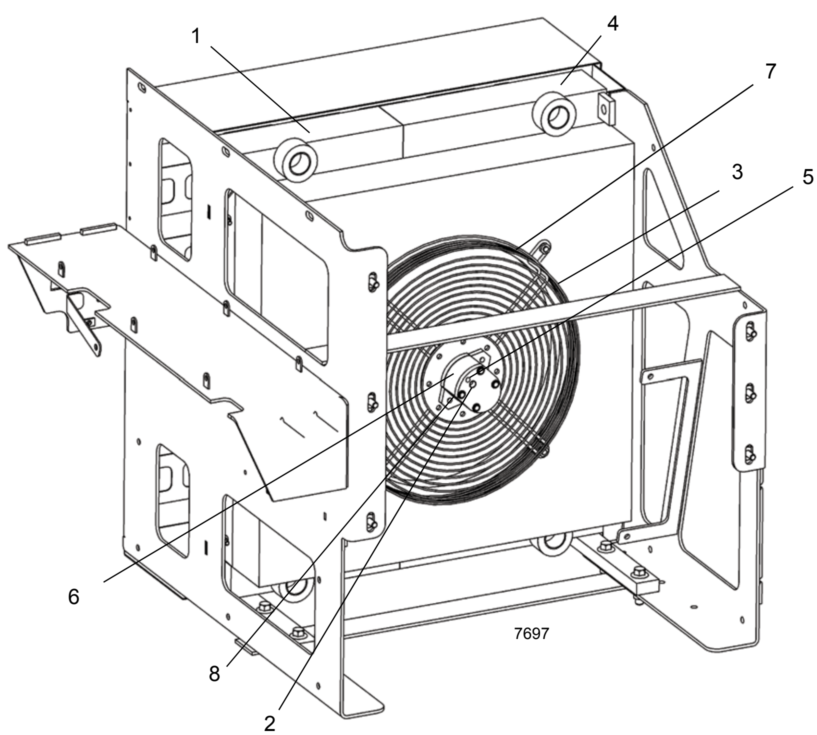
An air cooled oil cooler (see Figure 2-5) is located on the left side of the crane and consists of a transmission oil cooler and a hydraulic oil cooler.

The fan pulls cool air through the cooling fins on the coolers. Normally, most hydraulic oil from components is routed through the oil cooler by way of a return line and on to the filter in the reservoir. When several hydraulic functions are being used at one time (i.e., hoisting, lifting, and telescoping), more oil has to flow through this return line, causing a pressure buildup. When this pressure reaches 15 psi (103.4 kPa), the normally closed check valve in the return line (in parallel with the return line through the hydraulic oil cooler) will open, letting some hydraulic oil bypass the hydraulic oil cooler and flow directly into the reservoir filter.

When fewer functions are being used, the pressure in the system will decrease below 15 psi (103.4 kPa) and the check valve will close again.

A temperature switch (15, Figure 2-3), located in the tube that routes return oil to the hydraulic oil return filter in the reservoir, is part of a circuit that controls the oil cooler fan motor. The switch is normally closed and will open and cause the circuit to lose ground when the hydraulic oil temperature exceeds 120°F (48.8°C). When the circuit loses ground, the CAN bus system will de-energize the oil cooler solenoid valve, allowing pressurized oil from Pump No. 1 to flow to the oil cooler fan motor.

A second temperature switch 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 200°F (93°C). When the circuit loses ground, the CAN bus system will turn on power to illuminate the Transmission Warning Indicator in the gauge display in the operator's cab. See *Section 3 - Operating Controls and Procedures*, in the *Operator Manual* for details of the Transmission Warning Indicator.



Item	Description
1	Transmission Oil Cooler
2	External Drain Port
3	Fan
4	Hydraulic Oil Cooler
5	Inlet Port
6	Motor
7	Shroud
8	Outlet Port

FIGURE 2-5

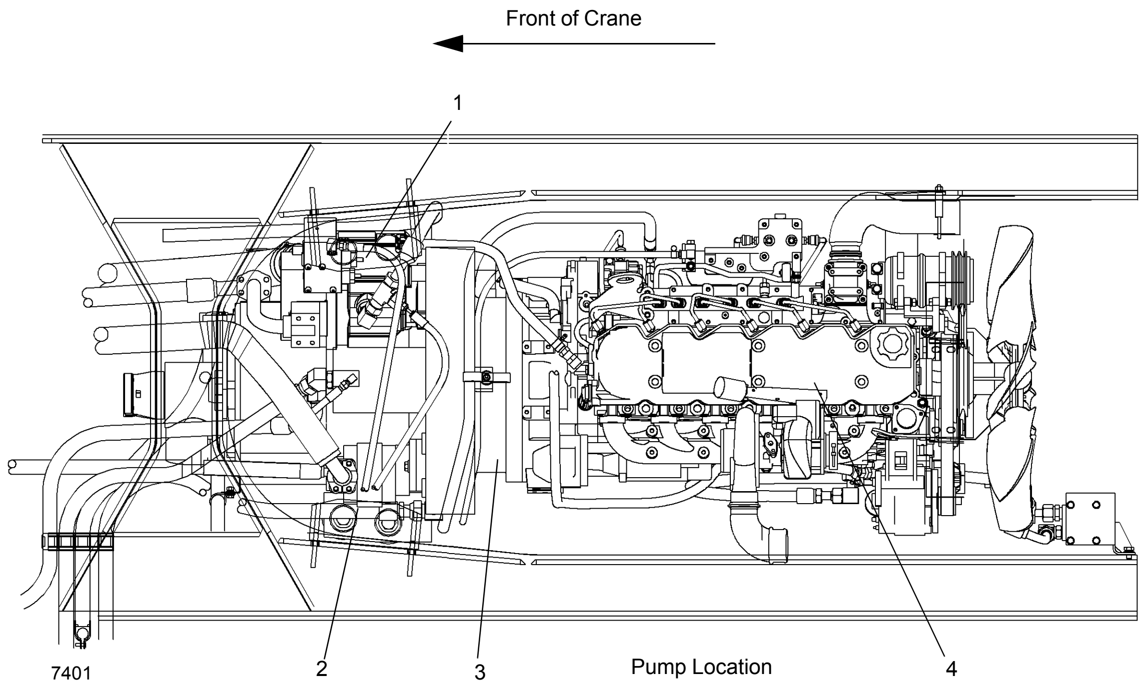
Hydraulic Pumps

Pump No. 1 and 2 are mounted off drive pads of the torque converter (Figure 2-6).

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

Pump No. 1 is a variable displacement, pressure compensated load sense piston pump @ 8.85 in^3/rev (145 cm^3/rev) delivering a theoretic flow of 96 gpm (363 lpm) @ 2500 engine RPM. It has an integral inlet impeller to insure proper self-priming. The pump differential or standby pressure is 275 psi (1896 kPa/19 bar). Pump No. 1 supplies oil to the outrigger, rear steer, axle lockout, boom lift, telescope, hoist, and pilot functions.

Pump No. 2 is a single positive displacement gear pump @ 3.48 in^3/rev (57 cm^3/rev) delivering a theoretic flow of 38 gpm (144 lpm). Pump No. 2 supplies oil to the front steer and swing circuits.



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

FIGURE 2-6

Pump No. 1 Troubleshooting

Symptom	Probable Cause	Solution
1. Oil Leakage	**a.** Hose fittings loose, worn or damaged	**a.** Check and replace damaged fittings or O-rings.
	b. Oil seal rings deteriorated by excess heat.	**b.** Replace oil seals by disassembling pump. Contact Manitowoc Crane Care for instructions, or refer to Volume 2 of the Service Maintenance Manual
	c. Bolt loose or its sealing area deteriorated by excess heat.	**c.** Loosen bolt, then torque, or replace bolt.
	d. Shaft seal worn or damaged.	**d.** **NOTE:** Check fluid leaking from housing weep hole to better determine which seal has failed. If pump is leaking hydraulic fluid, the inboard seal has failed. If the pump is leaking transmission fluid, the outboard seal has failed. - Remove seal carrier from pump - Remove damaged seal - If shaft is worn, install new seal - Reinstall seal carrier
2. No flow from pump (if pump does not prime in 30 seconds, STOP)	**a.** Pump not installed correctly.	**a.** Check proper drive rotation. Make sure pump shaft is turning (i.e. drive coupling is engaged). Check for sources of suction leaks. Check that inlet flange is tight. Check for pinched O-rings.
	b. Pump not getting oil.	**b.** Make sure reservoir is at proper level.
3. Pump does not build pressure.	**a.** Flow has an unrestricted path	**a.** Check for open circuit to reservoir.
4. Pump only builds a few hundred PSI 290 to 435 psi (20 to 30 bar)	**a.** Pump control settings too low	**a.** - Check if compensator is backed out - Check for load sense pressure signal - Check that system relief valve is vented
	b. Control is malfunctioning	**b.** Make sure orifices are not plugged and that control spools/springs are assembled correctly.
	c. Internal leakage in cylinders, valves, motors, or pumps.	**c.** Repair component
5. Pump won't compensate	**a.** Control is malfunctioning.	**a.** Clean orifices in control of contamination. Confirm orifice and plugs are properly assembled.

Pump No. 1 Removal

CAUTION

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

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

CAUTION

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

NOTE: On some models the charge pump and two studs must be removed for wrench access to piston pump mounting bolts.

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

Pump No. 1 Installation

1. Install new gasket material to the pump mounting flange as follows.
   a. Clean the drive pad and the pump 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.
2. Install pump on torque converter drive pad with bolts and washers. Make sure the splines mesh properly. Torque bolts to 150 lb-ft (203 Nm).
3. Replace the charge pump and studs.
4. Connect the distribution and supply lines as tagged during removal.

Pump No. 2 Removal

CAUTION

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

1. Tag and disconnect the supply line from the pump. Cap or plug the line and port.
2. Tag and disconnect the pump distribution line(s) from the pump. Cap or plug the line(s) and port.

CAUTION

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

3. Remove the bolts and washers attaching the No. 2 pump to the drive pad on the torque converter. Remove the pump.
4. Remove the gasket material from the drive pad on the torque converter.
5. Cover the drive pad's opening to prevent dirt from entering.

Pump No. 2 Installation

1. Install new gasket material to the pump mounting flange as follows.
   a. Clean the drive pad and the pump 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.
2. Install pump on torque converter drive pad with bolts and washers. Make sure gear teeth mesh properly. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
3. Connect the distribution and supply lines as tagged during removal.

CAUTION

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

Pump No. 1 Bleeding and Start-up

CAUTION

Failure to follow this procedure can cause the pump to fail

CAUTION

The Pump Priming Tool is set to 1-2 psi to prevent the reservoir from being over-pressurized and damaged. Do not adjust the Pump Priming Tool. Always monitor the pressure gauge of the Pump Priming Tool to ensure that 2 psi is not exceeded during the air bleeding process.

1. Ensure reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge. If hydraulic oil is aerated (oil has a foamy white tint with bubbles), allow crane to sit until the air has escaped and the fluid is a dark solid color.
2. Remove the plug from the Dr port of the pump (Figure 2-7). Fill the pump casing with hydraulic oil, then re-install plug; torque plug to 123 lb-ft (166.8 Nm).
3. Place an adequate container under Pump No. 1 to catch the hydraulic oil. Remove the plug from the pump's Tair port (Figure 2-7).
4. Remove the breather from the Hydraulic Oil Reservoir, then install the Pump Priming Tool (Figure 2-8) (Grove P/N 80030367) onto the reservoir in place of the breather. Connect a compressed air supply (nominal 100 psi (6.9 bar), maximum 300 psi (20.7 bar)) to the Pump Priming Tool.
5. Wait for a solid stream of fluid, free of air bubbles, to exit the Tair port, then re-install the plug in the Tair port while oil is still coming out; torque plug to 9 lb-ft (12.2 Nm).
6. Remove the air supply from the Pump Priming Tool.
7. Start the engine and do the following:
    - **a.** Idle engine for two to three minutes with no functions actuated. Check for leaks and repair if required. Lay hand on pump to check for excessive heat build-up. If the pump section is too hot to keep your hand on, stop immediately. If the pump makes excessive noise it is probably sucking air, which prevents the pump from priming. If this occurs, stop engine, and inspect all connections of the suction hose/tube for a loose connection, or a missing or damaged O-ring. Re-start the engine and run until the pump takes prime for a maximum of 30 seconds. If the pump does not prime in 30 seconds, stop the engine and repeat procedure until the pump primes.
    - **b.** Increase the RPM to 1500-1800 for 1 to 2 minutes with no functions actuated and make checks again as outlined in step a. Incrementally increase throttle to full RPM and then cycle the functions that the pump supplies to verify proper speed. Verify pump flow.
8. Check pressure settings; refer to *Pressure Setting Procedures*, page 2-21.

Pump No. 2 Bleeding and Start-up

CAUTION

Failure to follow this procedure can cause the pump to fail

CAUTION

Do not retract hydraulic cylinders with the pump priming tool connected to the reservoir. Damage to the reservoir may occur due to the priming tool's inability to properly vent the reservoir of air.

CAUTION

The pump priming tool is set to 1-2 psi to prevent the reservoir from being over-pressurized and damaged. Do not adjust the pump priming tool. Always monitor the pressure gauge of the pump priming tool to ensure that 2 psi is not exceeded during air bleeding.

1. Ensure reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge. If hydraulic oil is aerated (oil has a foamy white tint with bubbles), allow crane to sit until the air has escaped and the fluid is a dark solid color.
2. If gear pump is equipped with 7/16-20 UN-2B port(s) in the inlet side of the pump housing, place an adequate container under Pump No. 2 to catch the hydraulic oil and then remove the plug from this port (if the pump has more than one gear section, remove the plug that is most convenient as they are common to the inlet).

   If gear pump is not equipped with 7/16-20 UN-2B ports in the inlet side of the pump housing, place an adequate container under Pump No. 2 to catch the hydraulic oil and then slightly loosen the inlet port hose.
3. Remove the breather from the Hydraulic Oil Reservoir, then install the Pump Priming Tool (Figure 2-8) (Grove P/N 80030367) onto the reservoir in place of the breather. Connect a compressed air supply (nominal 100 psi (6.9 bar), maximum 300 psi (20.7 bar)) to the Pump Priming Tool.

4. If gear pump is equipped with 7/16-20 UN-2B port(s), wait for a solid stream of fluid, free of air bubbles, to exit the port, then re-install the plug while oil is still coming out; torque plug to 10 lb-ft (13.6 Nm).

If gear pump is not equipped with 7/16-20 UN-2B port(s), wait for a solid stream of fluid, free of air bubbles, to exit the loose hose connection, then re-tighten the hose fitting while oil is still coming out; refer to *Hydraulic Fittings*, page 1-13 for proper tightening procedure.

5. Perform this step on gear pumps that start up against high pressure, such as service brake charging or sequence valve circuits.

With the compressed air supply (nominal 100 psi (6.9 bar), maximum 300 psi (20.7 bar)) still attached to the Pump Priming Tool, slightly loosen the outlet port hose of the pump. Jog the engine starter until a solid stream of fluid, free of air bubbles, exits the loose hose connection, then re-tighten the hose fitting while oil is still coming out; refer to *Hydraulic Fittings*, page 1-13 for proper tightening procedure.

6. If the pump's hydraulic circuit includes an air conditioning compressor motor, ensure this function is turned off.

7. With the compressed air supply (nominal 100 psi (6.9 bar), maximum 300 psi (20.7 bar)) still attached to the Pump Priming Tool, start the engine and let it idle for two to three minutes with NO crane functions actuated. Check for leaks and repair if required.

If the pump outlet becomes too hot to keep your hand on it comfortably, stop the engine immediately.

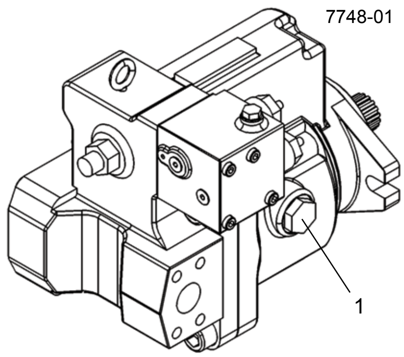
8. Stop the engine and remove the Pump Priming Tool and re-install the breather.

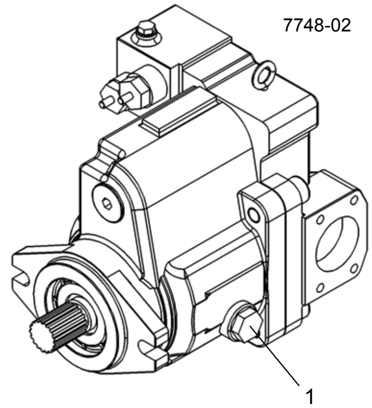
9. Start the engine. Slowly increase the engine speed to approximately 1500 rpm and hold for approximately 1 minute while making sure the hydraulic reservoir is filled to the proper level and the fluid is not aerated.

10. Slowly increase the engine speed to full RPM and hold for 1 minute while making sure the hydraulic reservoir is filled to the proper level and the fluid is not aerated.

11. At full engine RPM, cycle all functions without fully extending or retracting the cylinders to their stops to verify operation and that the pump(s) stay quiet and do not become excessively hot.

12. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-21.





Item	Description
1	Dr Port
2	Tair Port

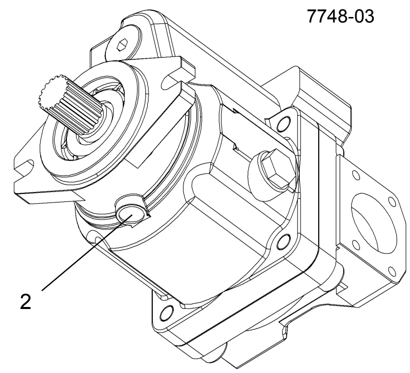
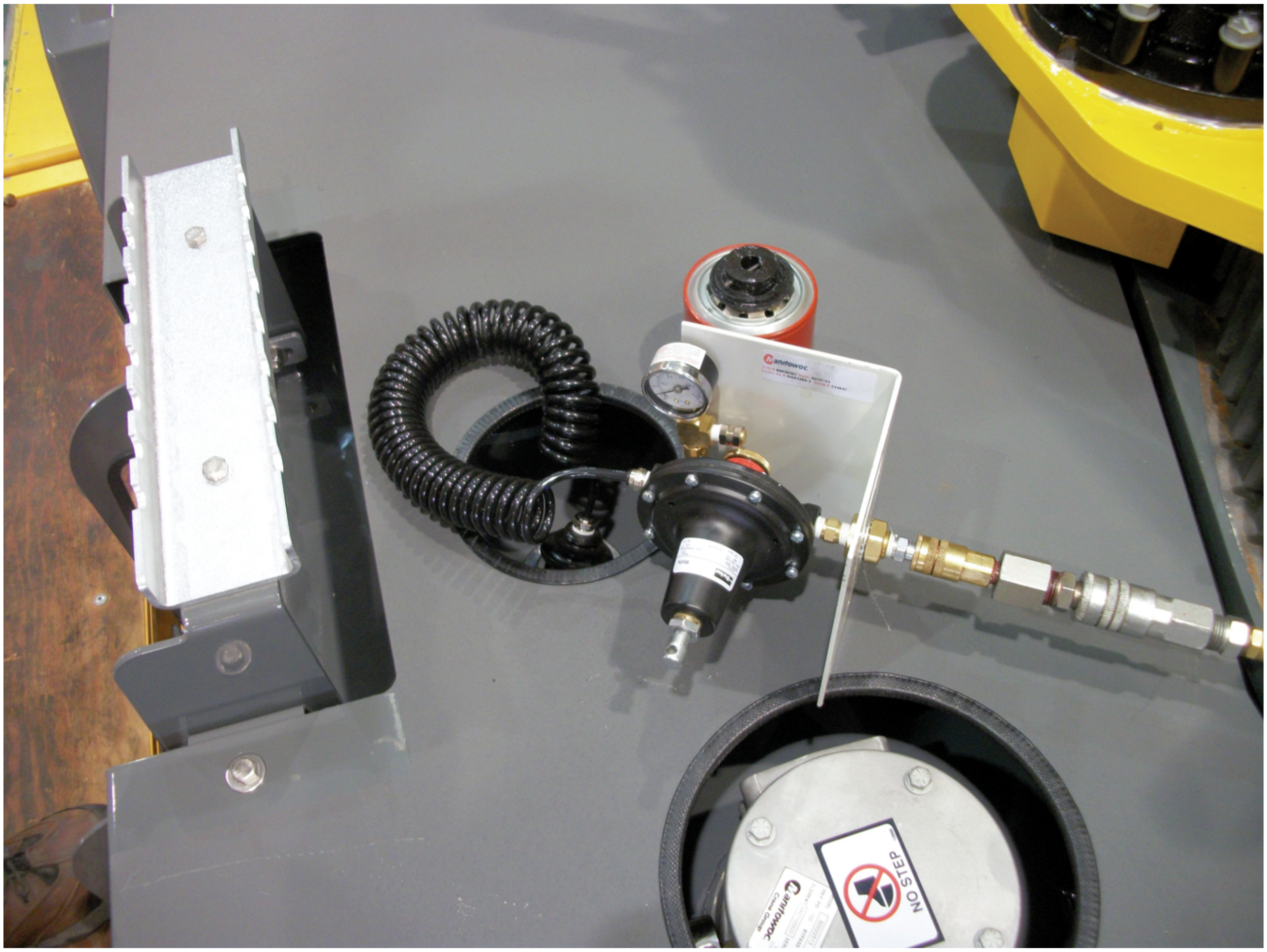


FIGURE 2-7



Pump Priming Tool (Grove P/N 80030367)

FIGURE 2-8

Troubleshooting

Symptom	Probable Cause	Solution
1. No hydraulic oil flows in systems.	**a.** Low hydraulic oil level.	**a.** 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.
2. Slow response.	**a.** Low hydraulic oil level.	**a.** 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.** 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.

PRESSURE SETTING PROCEDURES

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

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

- Three dial gauge 0-5000 psi (0-34.5 MPa)
- Pressure check diagnostic quick disconnect—Grove P/N 9999101806 and straight adapter fitting P/N 7447040401
- 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 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 PSI (MPa)	Tolerance PSI (MPa)	Adjustment Location
Hoist(s) & Lift	4000 (27.6)	± 50 (0.4)	Pump 3 Piston Pump (see Figure 2-10)
Telescope Extend	2800 (19.4)	± 50 (0.4)	Main Directional Control Valve Port Relief (see Figure 2-11)
Telescope Retract	3200 (22.1)	± 50 (0.4)	Main Directional Control Valve Port Relief (see Figure 2-11)
Outrigger Extend & Retract	2000 (13.8)	± 50 (0.4)	Outrigger Control Manifold (see Figure 2-12)
Hyd/Trans. Oil Cooler Motor	3000 (20.7)	+0/-100 (+0/-0.8)	Outrigger Control Manifold (see Figure 2-12)
Service Brake High Charge Limit	2320 (17.4)	+72/-145 (+0.5/-1.00)	Dual Accumulator Charge Valve (see Figure 2-13)
Service Brake Low Charge Limit	1950 (13.5)	±145 (±1.00)	Dual Accumulator Charge Valve (see Figure 2-13)
Accumulator Pre-charge	1500 to 1550 (10.3 to 10.7)	See Range	Accumulator (see Figure 2-14)
Front Steer	2600 (18.0)	± 50 (0.4)	Front Steer, Swing & Accessory Manifold (see Figure 2-9)
Swing "Left" Relief	2400 to 2550 (16.6 to 17.6)	See Range	Front Steer, Swing & Accessory Manifold (see Figure 2-9)
Swing "Right" Relief	2400 to 2550 (16.6 to 17.6)	See Range	Front Steer, Swing & Accessory Manifold (see Figure 2-9)
Swing Brake Release Pressure	250 to 300 (1.7 to 2.1)	See Range	Front Steer, Swing & Accessory Manifold (see Figure 2-9)
Controller Supply	350 to 400 (2.4 to 2.8)	See Range	Front Steer, Swing & Accessory Manifold (see Figure 2-9)
*Counterweight Removal Extend	1000 (6.91)	± 100 (0.8)	Counterweight Removal Valve (see Figure 2-15)
*Counterweight Removal Retract	1800 912.5)	± 100 (0.8)	Counterweight Removal Valve (see Figure 2-15)

Valve To Be Set	Pressure Setting PSI (MPa)	Tolerance PSI (MPa)	Adjustment Location
Cab Tilt & Counterweight Removal Pin	2500 (17.2)	+0, -25 (0.2)	Cab Tilt Valve (see Figure 2-16)
Make-up Oil Manifold	200 (2.8)	± 100 (0.8)	Make-up Oil Manifold, Pressure Reducing Valve (see Figure 2-17)
* Non-Adjustable			

Procedure A - Main Control Valve Pressure for Hoists, Boom Lift, Telescope - Check/ Adjust

Set hoist(s) boom lift and telescope inner mid retract as follows:

1. Install pressure check diagnostic quick disconnect with gauge onto test port at the inlet tube of the Boom Lift/ Telescope/Hoist Valve Bank (see Figure 2-11).
2. If the lift cylinder is not installed, plug the extend hose (the larger of the two). If lift cylinder is installed, omit this step.
3. Start engine and throttle up to full RPM. Feather into the boom lift controller to full controller stroke (up or down) and hold. Adjust the maximum pressure adjusting screw on the main piston pump "in" to increase or "out" to decrease so that a gauge pressure reading of 4000 psi ±50 (see Figure 2-10).
4. Stop engine and remove the diagnostic couplers from the test port.

Set the telescope extend and retract as follows:

Extend

5. If the boom is installed, completely retract all sections and boom lift down to below a horizontal boom angle and disconnect the extend hose (the larger of the two) running from port B, inner mid telescope section of the VG35 directional control valve to the cylinder port block at the back of the base section and cap adapter.
6. Install a pressure gauge into the disconnected hose running to the directional control valve.
7. Start engine and throttle up to full RPM. Attempt to telescope OUT by feathering into the controller to full controller stroke. Adjust the work port relief valve "in" to increase or "out" to decrease so that a gauge pressure reading of 2800 psi ±50 is achieved (see Figure 2-11).
8. Stop engine and remove pressure gauge and re-connect plumbing.

Retract

9. If the boom is installed, completely retract all sections and boom lift down to below a horizontal boom angle and disconnect the retract hose (the smaller of the two) running from port A, telescope section of the VG35 directional control valve to the cylinder port block at the back of the base section and cap adapter.
10. Install a pressure gauge into the disconnected hose running to the directional control valve.
11. Start engine and throttle up to full RPM. Attempt to telescope IN by feathering into the controller to full controller stroke. Adjust the work port relief valve "in" to increase or "out" to decrease so that a gauge pressure reading of 3200 psi ±50 is achieved (see Figure 2-11).
12. Stop engine. Remove the pressure gauge and re-connect plumbing.

Procedure B - Outrigger Pressures - Adjust

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at GP1 port of the Outrigger Control Manifold (see Figure 2-12).
2. Start engine and throttle up to full RPM. Select and hold the outrigger "extend or retract" switch on the cab dash. Adjust the pressure reducing valve integrated in the Outrigger Control Manifold "in" to increase or "out" to decrease so that a gauge pressure of 2000 psi ±50 is achieved (see Figure 2-12).
3. Stop engine. Remove the diagnostic coupler.

Procedure C - Oil Cooler Motor Pressure - Adjust

1. With engine off, install a pressure check diagnostic coupler with gauge onto the diagnostic nipple at G8 port of the Front Steer, Swing and Accessory Manifold (see Figure 2-9).
2. Start engine, throttle up to full RPM. Stroke lift, hoist or telescope controller by feathering into the controller to full stroke. Adjust the pressure reducing valve integrated in the Outrigger Control Manifold "in" to increase or "out" to decrease so that a gauge pressure of 3000 psi ±50 is achieved (see Figure 2-12).
3. Stop engine. Remove diagnostic couplers and re-connect plumbing.

Procedure D - Set Service Brake Accumulator Charge Valve Limits - Check/ Adjust

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4 to 6 times or until the pedal has no back pressure.
2. Install a pressure check diagnostic coupler with gauge onto the diagnostic nipple at “A1” port of the Dual Accumulator Charging Valve (see Figure 2-13).
3. Start engine and idle. The charging valve will immediately start to charge the accumulators. Watch the pressure gauge. The high charge limit pressure should read 2320 psi +72/-145 when the pressure gauge stops rising.
4. With the engine still running at idle, repeatedly depress service brake pedal on the cab floor until the gauge pressure approaches 2100 psi. Watch the gauge closely and push the brake pedal again to recharge. The low charging limit should be 1950 psi ±145 when it starts to recharge. Replace the valve if the pressures are not within the specified range.
5. Stop engine. Remove diagnostic couplers and reconnect plumbing.

Procedure E - Accumulator Pre-Charge Pressure - Check

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4 to 6 times or until the pedal has no back pressure. Remove the gas valve guard and cap on the accumulator (see Figure 2-14).
2. Before attaching the gas charging assembly onto the 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 (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 1500 to 1550 psi.
6. If the pressure is 1500 to 1550 psi, remove the charging valve assembly by turning the “T” handle all the way out on the gas chuck and then opening the bleed valve (see Figure 2-14).
7. Secure the gas valve, loosen the swivel nut and remove the charging assembly. Replace the gas valve cap and guard.

Procedure F - Pre-Charging 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 4 to 6 times or until the pedal has no back pressure. Remove the gas valve guard and cap on the accumulator (see Figure 2-14).
2. Ensure that the nitrogen supply bottle is shut off, then attach the charging valve assembly to it.
3. Before attaching the charging assembly 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 (10 to 15 lb-in).
5. Turn the gas chuck “T” handle all the way down (clockwise) which will depress the core in the gas valve.
6. Crack the nitrogen bottle valve and slowly fill the accumulator. Shut off the valve when the pre-charge is 1500 to 1550 psi.
7. If the pre-charge pressure is higher than specified in step #6, close the nitrogen bottle valve and slowly open the bleed valve on the charging assembly (see Figure 2-14) until the pressure is to specification.
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. Secure the gas valve, loosen the swivel nut and remove the charging assembly. Replace the gas valve cap and guard.

Procedure G - Front Steer Pressure - Check/ Adjust

1. Install pressure check diagnostic quick disconnect with gauge onto test port at GP7 port of the Front Steer, Swing and Accessory Manifold (see Figure 2-9).
2. Start engine and throttle up to full RPM. Fully turn the steering wheel to left or right against the axle stop. Adjust the priority flow control relief valve in the Front Steer, swing and Accessory Manifold (see Figure 2-9) by removing the adapter and hose in the end of the cartridge to access the hex adjustment screw and adjust “in” to increase or “out” to decrease so that a gauge pressure of 2600 psi ±50 is achieved.
3. Stop engine. Remove diagnostic couplers.

Procedure H - Swing Work Port Pressure - Check/Adjust

1. Install pressure check diagnostic quick disconnect with gauge onto test port at GP5 port of the Front Steer, Swing and Accessory Manifold (see Figure 2-9).
2. Start engine and throttle up to full RPM. With the swing house lock engaged, swing right and hold. Adjust the work port relief “in” to increase or “out” to decrease so that a gauge pressure reading of 2400 to 2550 psi is achieved (see Figure 2-9).
3. With house lock still engaged, swing left and hold. Adjust the work port relief “in” to increase or “out” to decrease so that a gauge pressure reading of 2400 to 2550 psi is achieved (see Figure 2-9).
4. Stop engine. Remove diagnostic couplers.

Procedure I - Swing Brake Release Pressure - Check/Adjust

1. Install pressure check diagnostic quick disconnect with gauge onto test port at GP3 port of the Front Steer, Swing and Accessory Manifold (see Figure 2-9).
2. Start engine and idle, adjust the swing brake release pressure reducing valve “in” to increase or “out” to decrease so that a gauge pressure reading of 250 to 300 psi is achieved (see Figure 2-9).
3. If a gauge reading of 250 to 400 psi cannot be attained, stop the engine and install a pressure check diagnostic quick disconnect with gauge onto the inlet gauge port of the Main Directional Control Valve (see Figure 2-11). Start engine and idle. Adjust the piston pump differential pressure adjusting screw “in” to increase or “out” to decrease so that a gauge reading of 350 psi is achieved (see Figure 2-10). Repeat Steps 1 and 2.
4. Stop engine. Remove diagnostic couplers.

Procedure J - Controller Supply Pressure - Check/Adjust

1. Install pressure check diagnostic quick disconnect with gauge onto test port at GP4 port of the Front Steer, Swing and Accessory Manifold (see Figure 2-9).
2. Start engine and idle, lower left armrest, stroke the joystick of any crane function enough to start movement of that function and adjust the controller pressure reducing valve of the Front Steer, Swing and Accessory Manifold “in” to increase or “out” to decrease so that a gauge pressure reading of 350 to 400 psi is achieved (see Figure 2-9).
3. Stop engine. Remove diagnostic couplers.

Procedure K - Counterweight Removal Cylinder Extend/Retract Pressure - Check

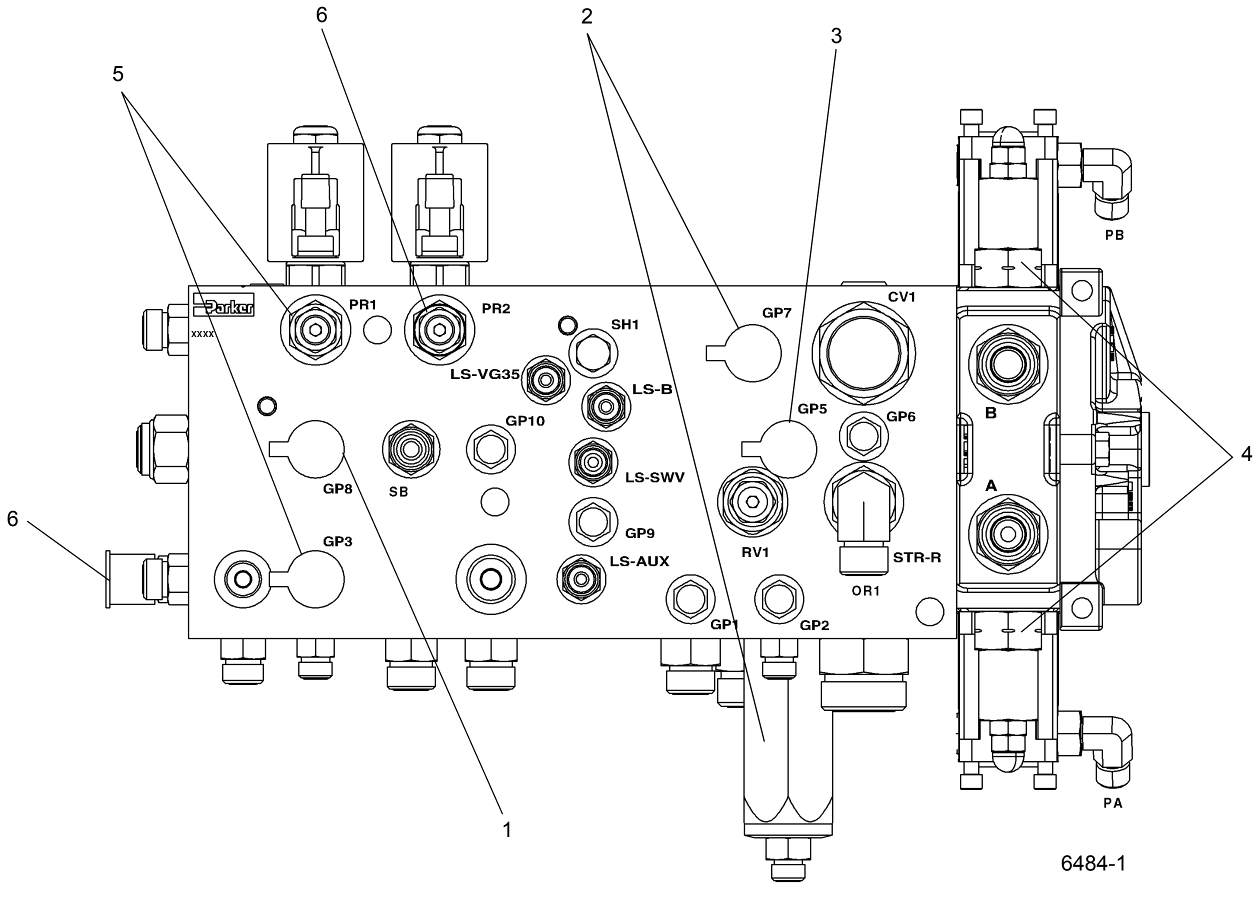
1. With the engine off, and the counterweight pinned, disconnect the extend hose from port “A” of the Counterweight Removal Directional Control Valve for both left and right removal cylinders and cap and plug the adapter in the cylinder port (see Figure 2-15).
2. Install a pressure gauge onto the disconnected hose.
3. Start engine and idle. Attempt to lower left counterweight cylinder. Gauge should read 1000 psi ±100. If not, replace the relief valve as it is non-adjustable (see Figure 2-15).
4. Stop engine. Remove the pressure gauge and reconnect the plumbing.
5. With the engine off, and the counterweight pinned, disconnect the extend hose from port “B” of the Counterweight Removal Directional Control Valve for both the left and right removal cylinders and cap and plug the adapter in the cylinder port.
6. Install a pressure gauge onto the disconnected hose.
7. Start engine and idle. Attempt to raise the left counterweight cylinder. Gauge should read 1800 psi ±100. If not, replace the relief valve as they are non-adjustable (see Figure 2-15).
8. Stop engine. Remove the pressure gauge and reconnect the plumbing.

Procedure L - Cab Tilt Cylinder Extend/ Retract and Counterweight Pin Removal Pressure - Check/Adjust

1. With the engine off, remove the hose running from the Cab Tilt Manifold “A” port to the cylinder rod port at the cylinder and cap or plug the adapter in the cylinder (see Figure 2-16).
2. Install a pressure gauge onto the disconnected hose.
3. Start engine and idle. Attempt to lower the cab. Gauge should read 2500 psi ±100. If not, adjust the relief valve “in” to increase or “out” to decrease pressure (see Figure 2-16).
4. Stop engine. Remove the pressure gauge and reconnect the plumbing.

Front Steer, Swing and Accessory Manifold

Item	Description
1	Procedure C - Oil Cooler Motor Pressure - Adjust - Step No. 1
2	Procedure G - Front Steer Pressure - Check/Adjust - Step No. 1 & No. 2
3	Procedure H - Swing Work Port Pressure - Check/Adjust - Step No. 1
4	Procedure H - Swing Work Port Pressure - Check/Adjust - Swing WP Relief Valve - Step No. 2 & No. 3
5	Procedure I - Swing Brake Release Pressure - Check/Adjust - Step No. 1 & No. 2
6	Procedure J - Controller Supply Pressure - Check/Adjust - Steps No. 1 & No. 2



Front View As Facing T/T Side Plate

FIGURE 2-9

P1 Piston Pump

Item	Description
1	Procedure A - Main Control Valve Pressure for Hoists, Boom Lift, Telescope - Check/Adjust - Step No. 3 (Maximum Pressure)
2	Procedure I - Swing Brake Release Pressure - Check/Adjust - Step No. 3

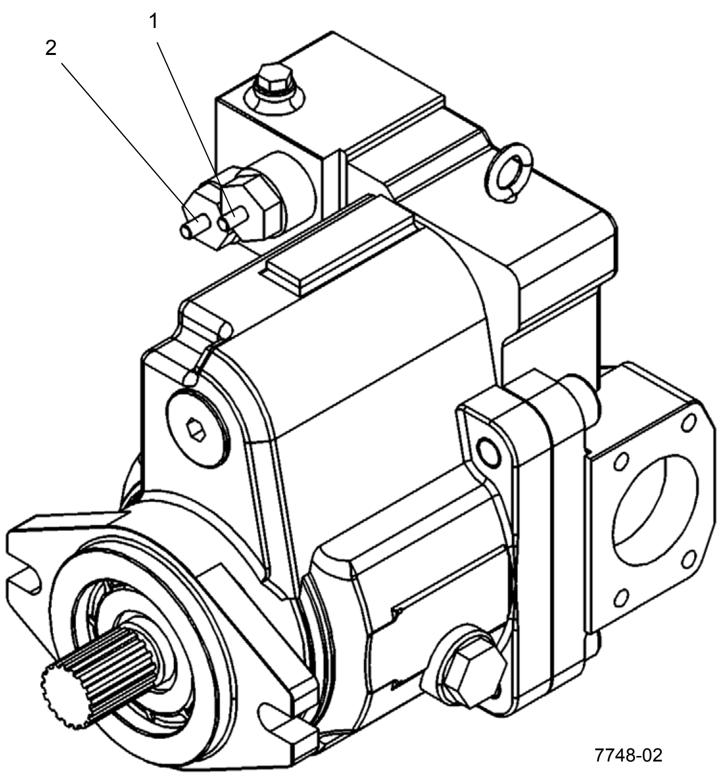


FIGURE 2-10

Boom lift/Telescope/Hoist Valve Bank

Item	Description
1	Procedure A - Main Control Valve Pressure for Hoists, Boom Lift, Telescope - Check/Adjust - Step No. 1 Procedure I - Swing Brake Release Pressure - Check/Adjust - Step No. 3
2	Procedure A - Main Control Valve Pressure for Hoists, Boom Lift, Telescope - Check/Adjust - Step No. 7
3	Procedure A - Main Control Valve Pressure for Hoists, Boom Lift, Telescope - Check/Adjust - Step No. 11

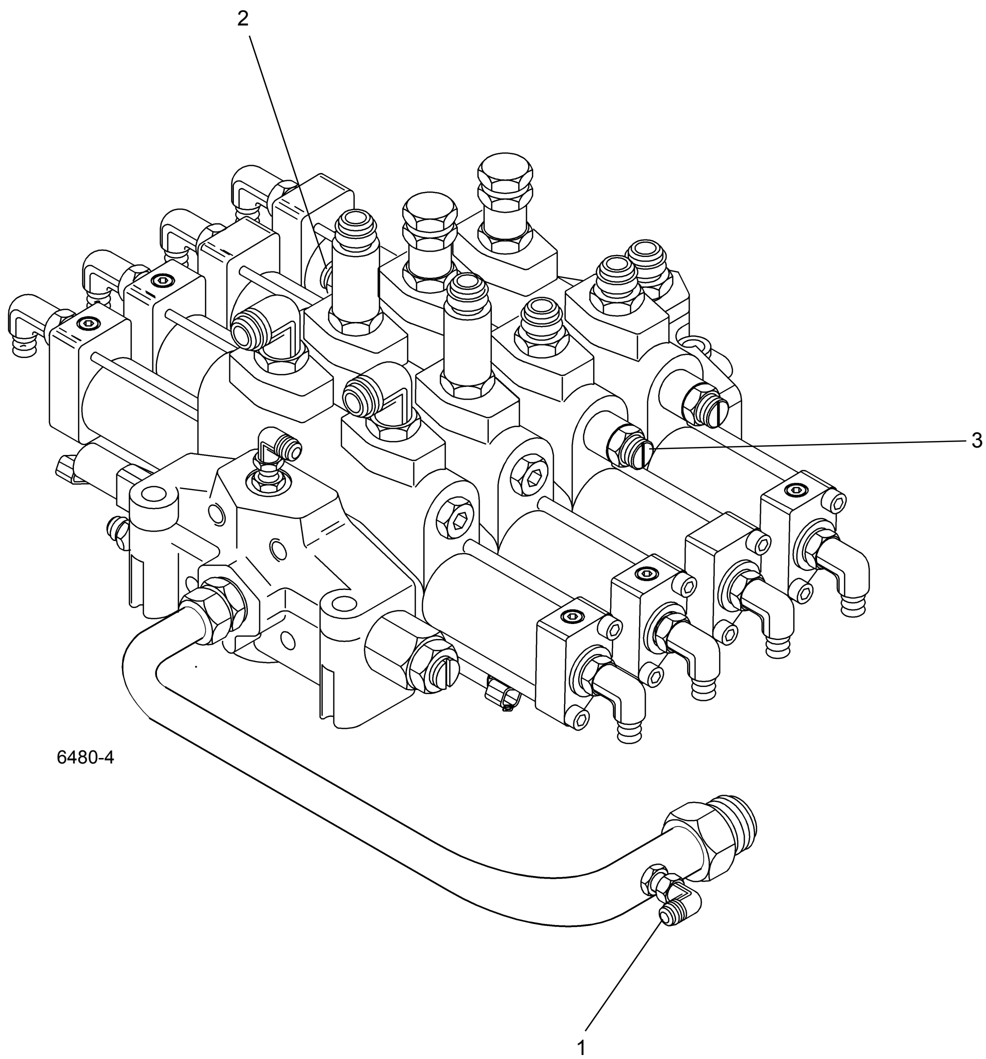


FIGURE 2-11

Outrigger Control Manifold Valve

Item	Description
3	Procedure B - Outrigger Pressures - Adjust - Step No. 1 & No. 3
4	Procedure B - Outrigger Pressures - Adjust - Step No. 2
5	Procedure C - Oil Cooler Motor Pressure - Adjust - Step No. 2

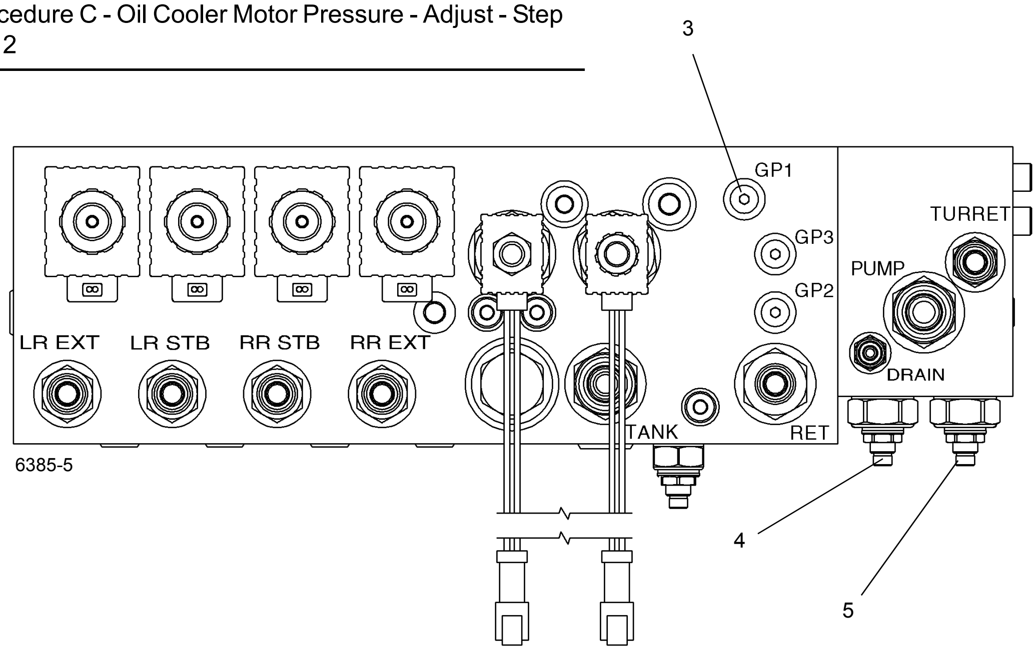


FIGURE 2-12

Service Brake Dual Accumulator Charge Valve

Item	Description
1	Procedure D - Set Service Brake Accumulator Charge Valve Limits - Check/ Adjust - Step No. 2

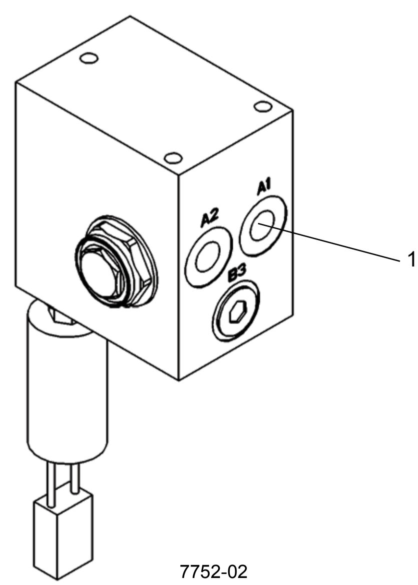


FIGURE 2-13

Checking and Pre-Charging the Accumulator

Item	Description
1	Gas Valve Guard
2	Gas Valve

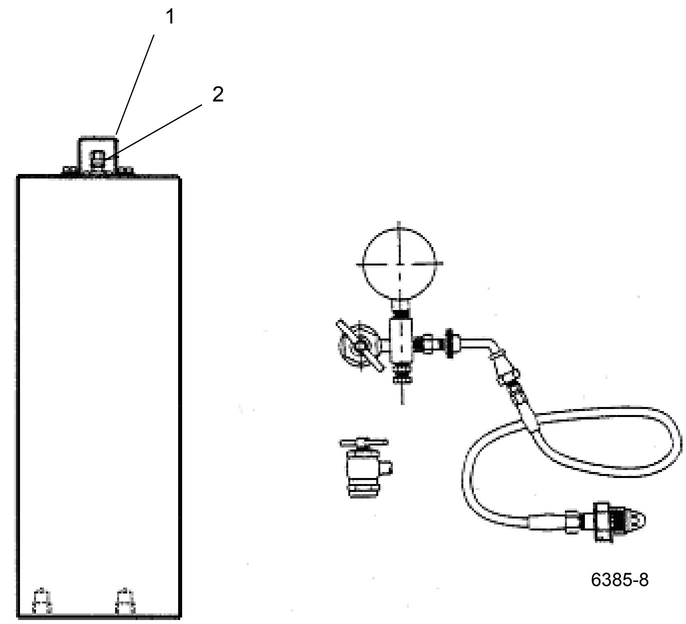


FIGURE 2-14

Counterweight Removal Valve Bank

Item	Description
1	Non-Adjustable Port Relief Location

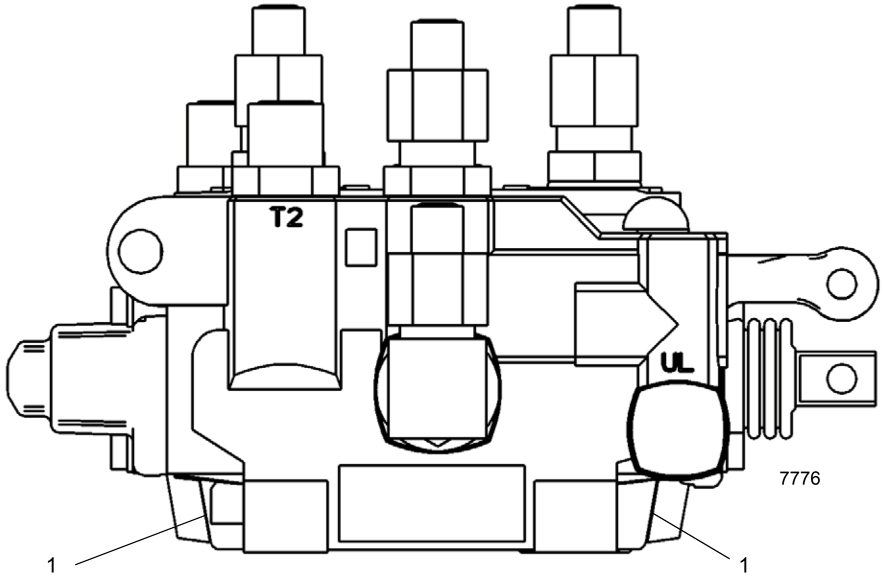


FIGURE 2-15

Cab Tilt Manifold

Item	Description
1	Procedure L - Cab Tilt Cylinder Extend/ Retract and Counterweight Pin Removal Pressure - Check/Adjust - Step No. 1 & No. 3

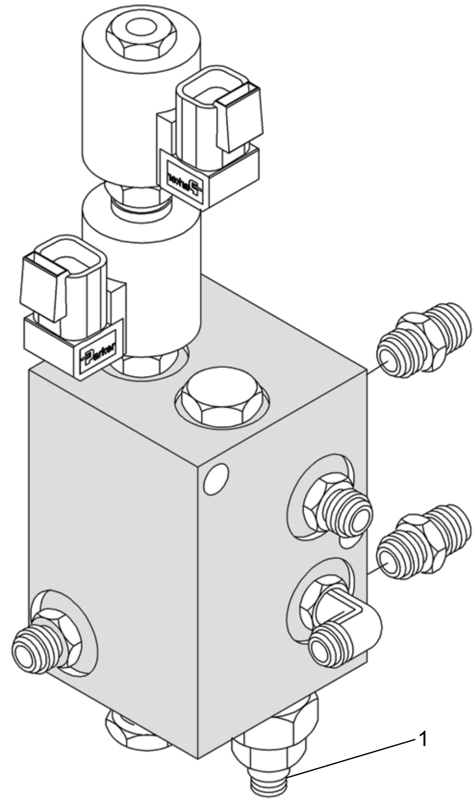


FIGURE 2-16

VALVES

General

This subsection provides descriptive information for all the hydraulic valves used on this crane. For a listing of all valves, the circuit they are used in, and their physical location, refer to the Valve Usage Table. Refer to Figure 2-17 for a valve locations pictorial. 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.

NOTE: On each valve illustration in this section, each item number in table correlates to location on the valve, and to the valve hydraulic schematic.

Table 2-3
Valve Usage Table

Valve Name	Circuit Used In	Physical Location
Directional Control Valves	Boom Lift/Telescope(s)/Hoist(s) Counterweight Removal Cab Tilt /Luffing Jib	Superstructure (Right Side Plate) Between Superstructure Side Plates Between Superstructure Side Plates
Steering Control Valve	Front Axle Steer Control	Cab Steering Column
Front Steer/Swing/Accessory Manifold	Front Axle Steer Supply Swing Directional Control Telescope Relief Control Swing Brake Pressure Controller Supply Hose Reel Brake Control Hose Reel Motor Supply	Superstructure Right Side Plate
Steering Control Unit	Front Axle Steer	Cab Steering Column
Hydraulic Remote Controllers (HRC)	Boom Lift Telescope (Floor) Main Hoist Auxiliary Hoist Swing	Cab Seat Arm Rests (2) Cab Floor for Telescope with Optional Aux Hoist
Swing Power Brake Valve w/Treadle Pedal	Swing	Cab Floor
Double PO Check Valve	Cab Tilt	Between Superstructure Side Plates
Tandem Brake Valve with Treadle	Service Brakes	Cab Floor
Dual Accumulator Charging Valve	Service Brakes	Superstructure inside Left Side Plate
Accumulator(s)	Service Brake	Superstructure Left Side
Holding Valves	Boom Lift Telescope (3) Counterweight Removal (2)	Lift Cylinder (Bolt on Manifold) Cylinder Port Blocks (Cartridge style) Cylinder Port Blocks (Cartridge style)
Axle Lockout, Rear Steer and Oil Cooler Fan Motor Control Manifold	Axle Lockout Control Rear Steer Control Oil Cooler Motor Control	Left Hand Carrier Frame Rail
Solenoid Valves: Cross Axle Differential Lock	 Differential Lock (Optional)	 Carrier Inside Right Side Rail

Valve Name	Circuit Used In	Physical Location
Hoist Motor Control Valve	Hoist(s)	Both Hoists (see Hoist section)
Check Valves	Return Circuit	One in Parallel With Oil Cooler
Outrigger Control Manifold	Outrigger	On Rear Face of Carrier Frame Front Cross Member
Load Sense Dump Manifold	Load Sense line to Pump No. 1	Left Hand Carrier Frame Rail Fwd of Engine
Pilot Operated Check Valve	Outrigger	Port Block of each jack Cylinder (4)
Telescope Rod Drain Solenoid Manifold	Telescope	Horizontal Plate Between the Superstructure Side Plates
Cross Axle Differential Lock Valve	Differential Lock (Optional)	Carrier Bulkhead Plate Forward of the Engine
Hi-Low Range Shift, Axle Disconnect And Parking Brake Valve	Parking Brake Axle Disconnect	Front Side of the Rear Frame Bulkhead in the Swivel Area.

Valve Installation

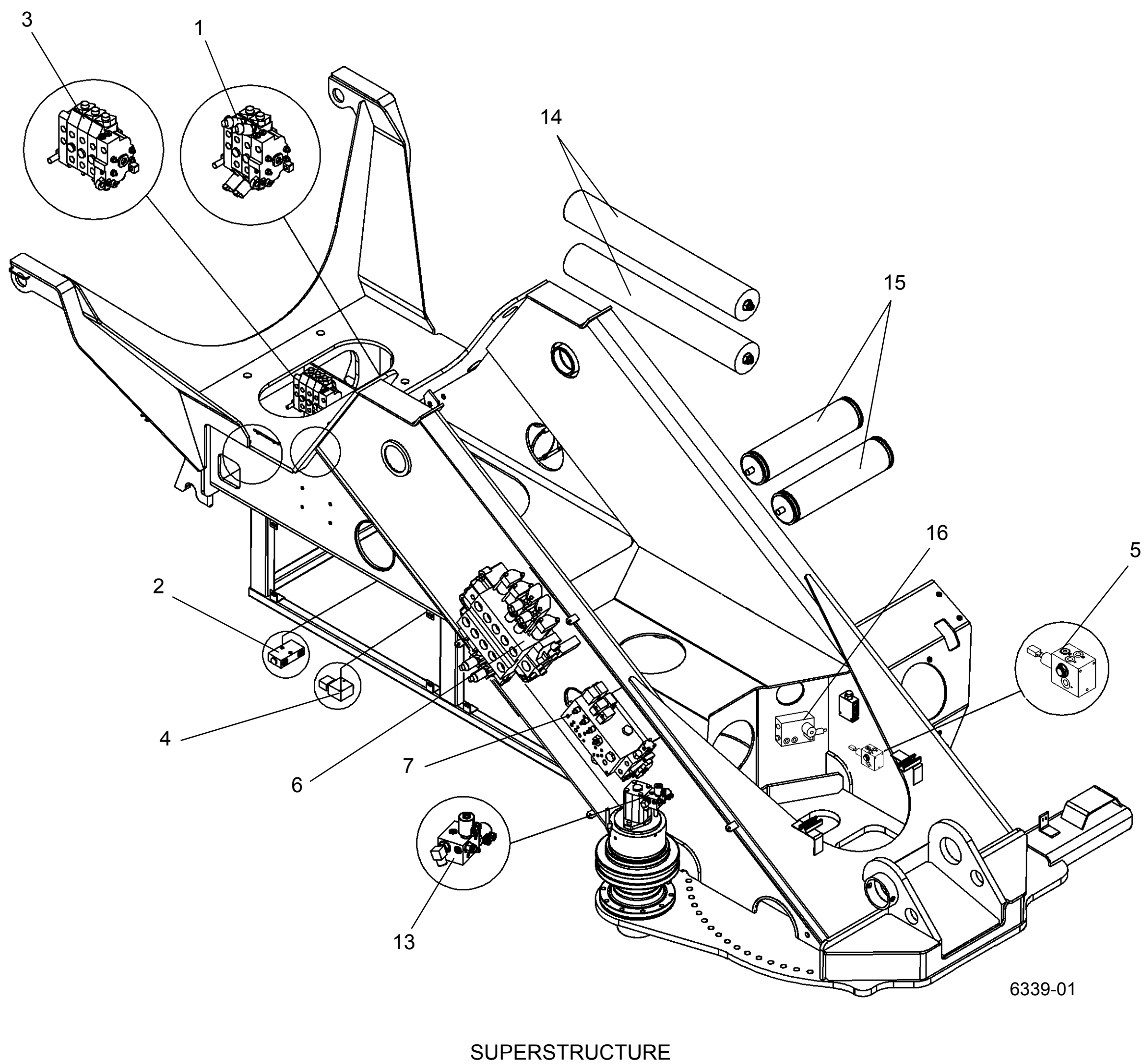


FIGURE 2-17

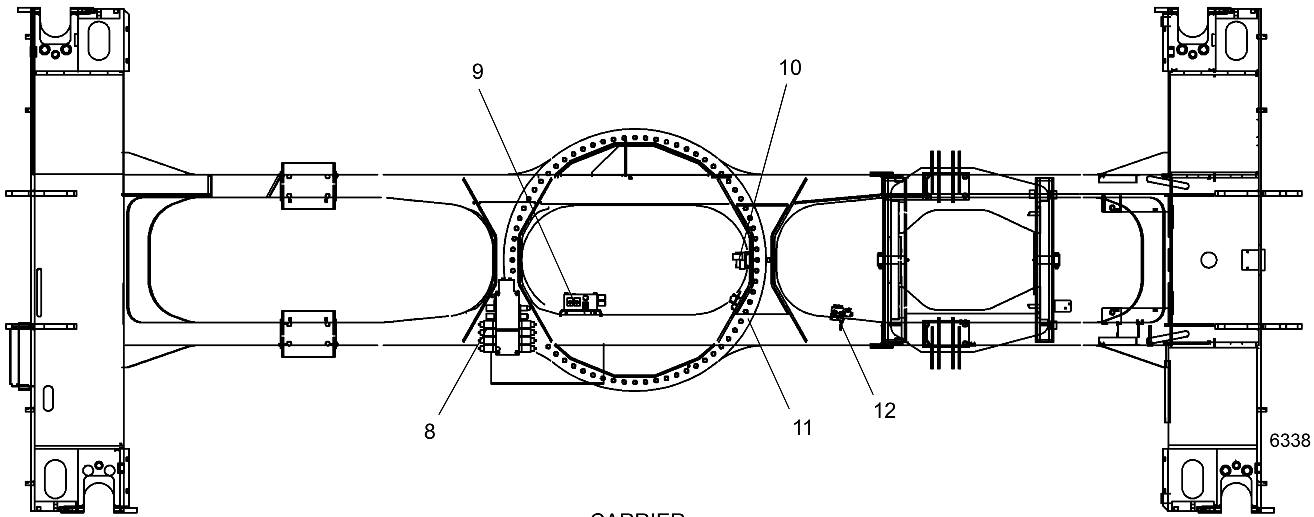


FIGURE 2-17 continued

Item	Description
1	Cab Tilt Directional Valve
2	Cab Tilt Check Valve
3	Counterweight Removal Directional Valve
4	Telescope Rod Manifold Drain
5	Accumulator Brake Charge Valve
6	Directional Valve (Boom/Lift/Telescope(s)/ Hoist(s)/Counterweight Removal/Cab Tilt/ Luffing Jib)
7	Swing/Steer/Brake Valve
8	Outrigger Manifold

Item	Description
9	Rear Steer/Axle Lockout/Fan Drive Valve
10	Range Shift/Park Brake Manifold
11	Differential Lock Valve
12	Load Sense Dump Valve
13	Two Speed Swing Valve
14	Emergency Steer Accumulators (CE Machines)
15	Brake Accumulator
16	Make-up Oil Manifold

DIRECTIONAL CONTROL VALVES

Description

The directional control valves direct and control hydraulic oil flow from the pumps to the boom lift and telescope cylinders, each hoist motor, the swing motor, the counterweight removal/cab tilt cylinders, and the front steer cylinders from the steer control valve. The swing, front steer and accessory directional control valve/manifold (see Figure 2-21) and the boom lift/telescope/hoist directional control valve (see Figure 2-19) are located on the outside of the right superstructure side plate. The counterweight removal (see Figure 2-18) and the cab tilt directional control valve (see Figure 2-20) are located between the left and right superstructure side plates under the main hoist. Each valve bank is removed and installed as an assembly.

The boom lift/telescope/hoist is a four section, hydraulic remote pilot actuated with three position four way spools that are pressure and flow compensated. It receives pump flow from hydraulic swivel port 6 and Pump No. 1. The inlet section of the boom lift/telescope/hoist directional control valve contains a 0.052 Ø orifice controlling the piston pump No. 1 differential or standby pressure at 350 psi (2413 kPa) and a 4350 psi (29992 kPa) clipper relief valve that protects the piston pump (No. 1 pump) from transient pressure spikes. The control valve has integral port reliefs that thermally protect the extend and retract sides of the telescope cylinders. The boom lift section has an integral port relief that thermally protects the retract side of the cylinder. All working sections have a two position three-way solenoid RCL lockout valve in their pilot end cap except the boom lift up and telescope in. When the hoist(s), boom lift or telescope spool is actuated, the signal line (load sense) connecting the load to the pump is blocked by the shifting spool causing the pump to go to its full compensating setting. The individual working sections meter only the required flow of oil to the function at full pump compensator setting.

The swing directional control valve is a single cast iron section bolted onto the front steer and accessory manifold. Refer to Front Steer, Swing and Accessory Manifold. It is located on the outside of the right turntable side plate. The valve contains a three position four way open center design that is remote pilot operated. Both working ports have port relief valves and anti-void check valves that are flooded by a 150 psi (1034.2 kPa/10.3 bar) resistance check valve located in the front steer and accessory manifold providing make-up oil to the swing motor for motor over-run when the valve is centered. It receives oil from the fixed displacement gear pump No. 2 internally through the front steer and accessory manifold and also returns oil internally through the front steer and accessory manifold.

The counterweight removal directional control valve is a three section, manually actuated three position four way, pressure compensated, closed center directional valve. It is plumbed in parallel with the boom lift/telescope/hoist directional control valve and the cab tilt directional control valve. The first and second sections control the left and right removal cylinders, while the third section controls the counterweight pin cylinder. The removal cylinder sections have an integral port relief for both raise and lower functions.

The cab tilt directional control valve is a solenoid controlled three position four way, pressure compensated, closed center directional valve. It is plumbed in parallel with the boom lift/telescope/hoist directional control valve and the counterweight removal directional control valve.

Maintenance

Boom Lift/Telescope/Hoist Valve Bank Removal

1. Tag and disconnect all of the electrical connectors or manual control levers.
2. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.

NOTE: The lift/telescope/hoist valve bank weighs approximately 181.6 lb (82.41 kg).

3. Remove the capscrews and washers securing the valve bank and remove the valve bank.

Boom Lift/Telescope/Hoist Valve Bank Installation

1. Place the valve bank on the superstructure side plate and secure it with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for the proper torque value.
2. Connect the hydraulic lines to the valves as tagged during removal.
3. Connect the electrical connectors and manual control levers as tagged during removal.

Counterweight Removal Valve Bank Removal

1. Tag and disconnect all of the electrical connectors or manual control levers.
2. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.

NOTE: The counterweight removal valve bank weighs approximately 43.9 lb (16.4 kg).

3. Remove the capscrews, lockwashers, flatwashers, and hex nuts securing the valve bank and remove the valve bank.

Counterweight Removal Valve Bank Installation

1. Place the valve bank on the superstructure side plate and secure it with the capscrews, lockwashers, flatwashers, and nuts. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper

2

torque value.

2. Connect the hydraulic lines to the valves as tagged during removal.
3. Connect the electrical connectors and manual control levers as tagged during removal.

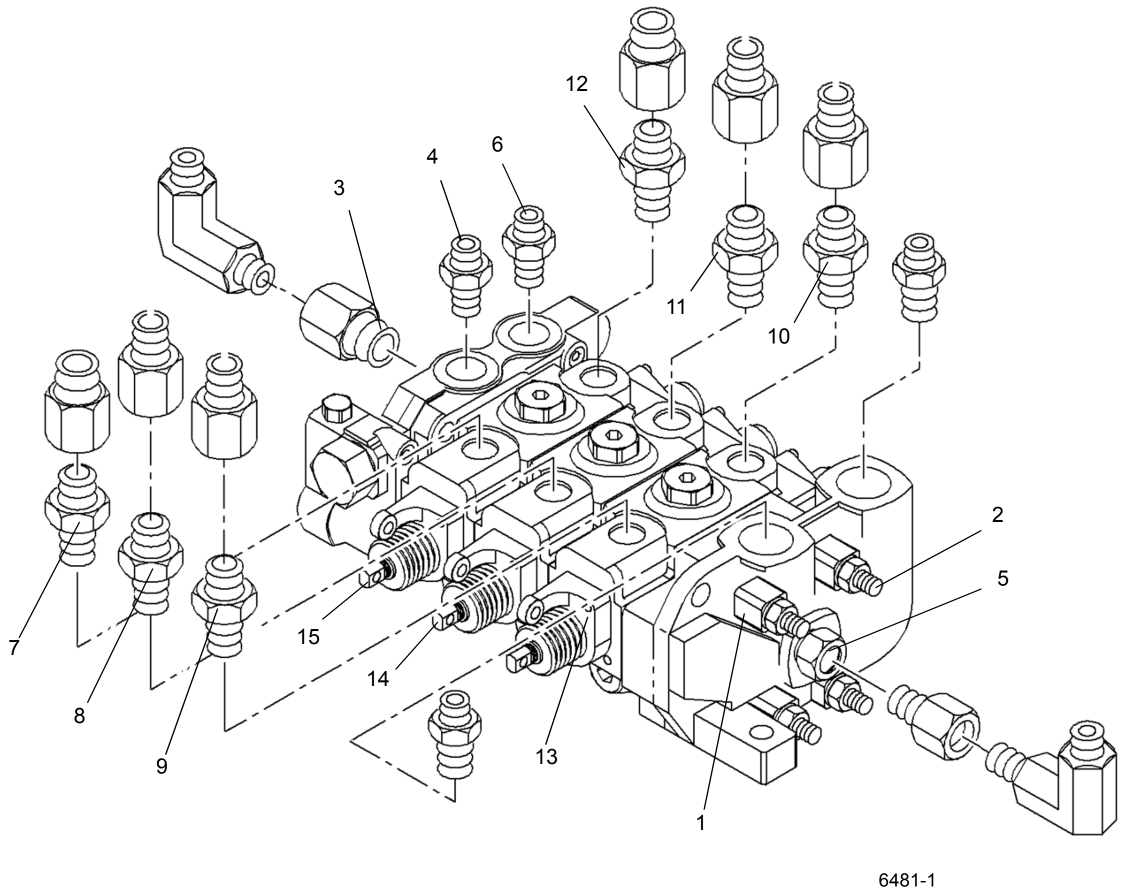
Functional Check (All Valve Banks)

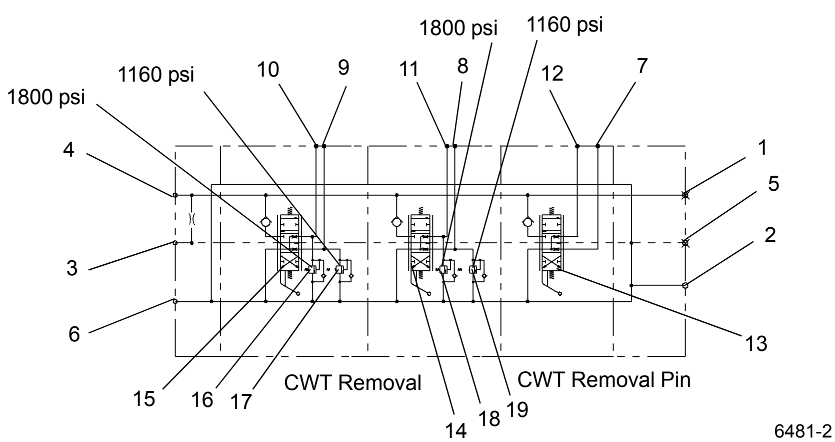
1. Start the engine and run it at normal speed.
2. Operate the control levers of the valve bank(s). Check for smooth operation of cylinders and motors.
3. Check the valve bank(s) and lines for leakage. Make repairs as needed.

Function Check - RCL Lockout Valves

1. Remove fuse F13 from the power panel in the cab. This cuts off power to the RCL.
2. Start the engine.
3. Try to telescope the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify none of these functions work.
4. Shut down the engine. Reinstall fuse F13.
5. Telescope the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify all of these functions work.
6. Check for leaks. Make repairs as needed.

Counterweight Removal Valve Bank





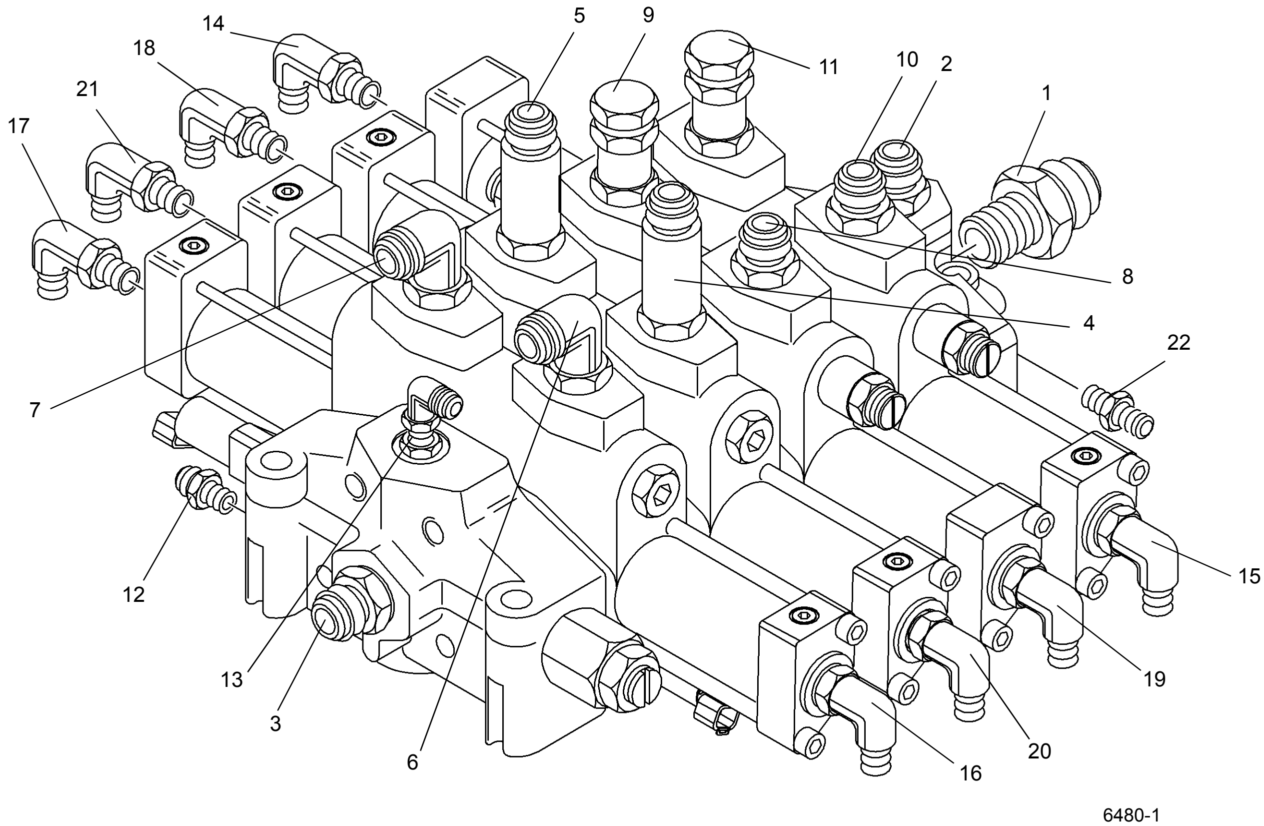
Valve Hydraulic Schematic

FIGURE 2-18

Item	Description
1	Port P3
2	Port T2
3	Port P1
4	Port P2
5	Port T1
6	Port T2
7	Pin Cylinder - A Port - Extend
8	Right Hand Counterweight Cylinder - A Port - Extend
9	Left Hand Counterweight Cylinder - A Port - Extend
10	Left Hand Counterweight Cylinder - B Port - Retract
11	Right Hand Counterweight Cylinder - B Port - Retract

Item	Description
12	Pin Counterweight Cylinder - B Port - Retract
13	Counterweight Pin Removal Solenoid
14	Counterweight Removal Right Cylinder Solenoid
15	Counterweight Removal Left Cylinder Solenoid
16	Pressure Relief Valve - Counterweight Removal Left Hand Cylinder - Retract
17	Pressure Relief Valve - Counterweight Removal Left Hand Cylinder - Extend
18	Pressure Relief Valve - Counterweight Removal Right Hand Cylinder - Retract
19	Pressure Relief Valve - Counterweight Removal Right Hand Cylinder - Extend

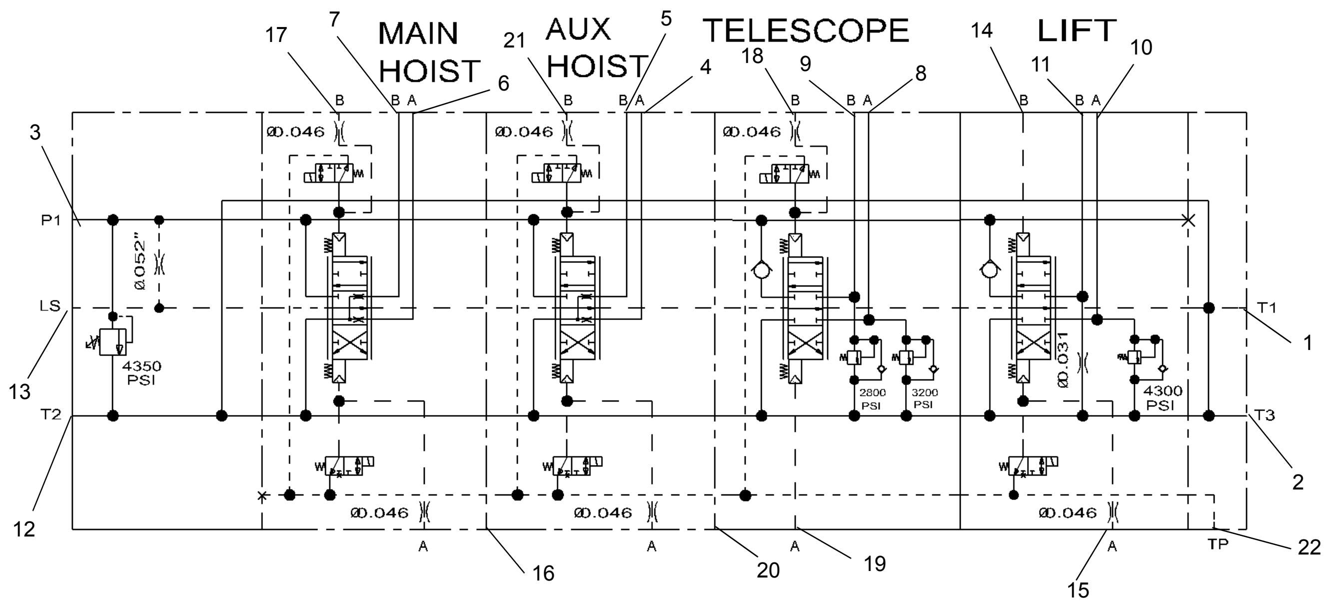
Boom Lift/Telescope/Hoist Valve Bank



Item	Description
1	Port T1
2	Port T3
3	Port P1
4	Aux Hoist - Down - Port A
5	Aux Hoist - Up - Port B
6	Main Hoist - Down - Port A
7	Main Hoist - Up - Port B
8	Telescope Retract - Port A
9	Telescope Extend - Port B
10	Lift Retract - Port A
11	Lift Extend - Port B
12	Port T2

Item	Description
13	Port LS
14	Lift Port PB - Boom Extend
15	Lift Port PA - Boom Retract
16	Main Hoist Port PA - Hoist Down
17	Main Hoist Port PB - Hoist Up
18	Telescope Port PB - Extend
19	Telescope Port PA - Retract
20	Aux Hoist Port PA - Down
21	Aux Hoist Port PB - Up
22	Port TP

FIGURE 2-19



Boom Lift/Telescope/Hoist Main Valve Hydraulic Schematic

FIGURE 2-19 continued

Cab Tilt Valve Bank

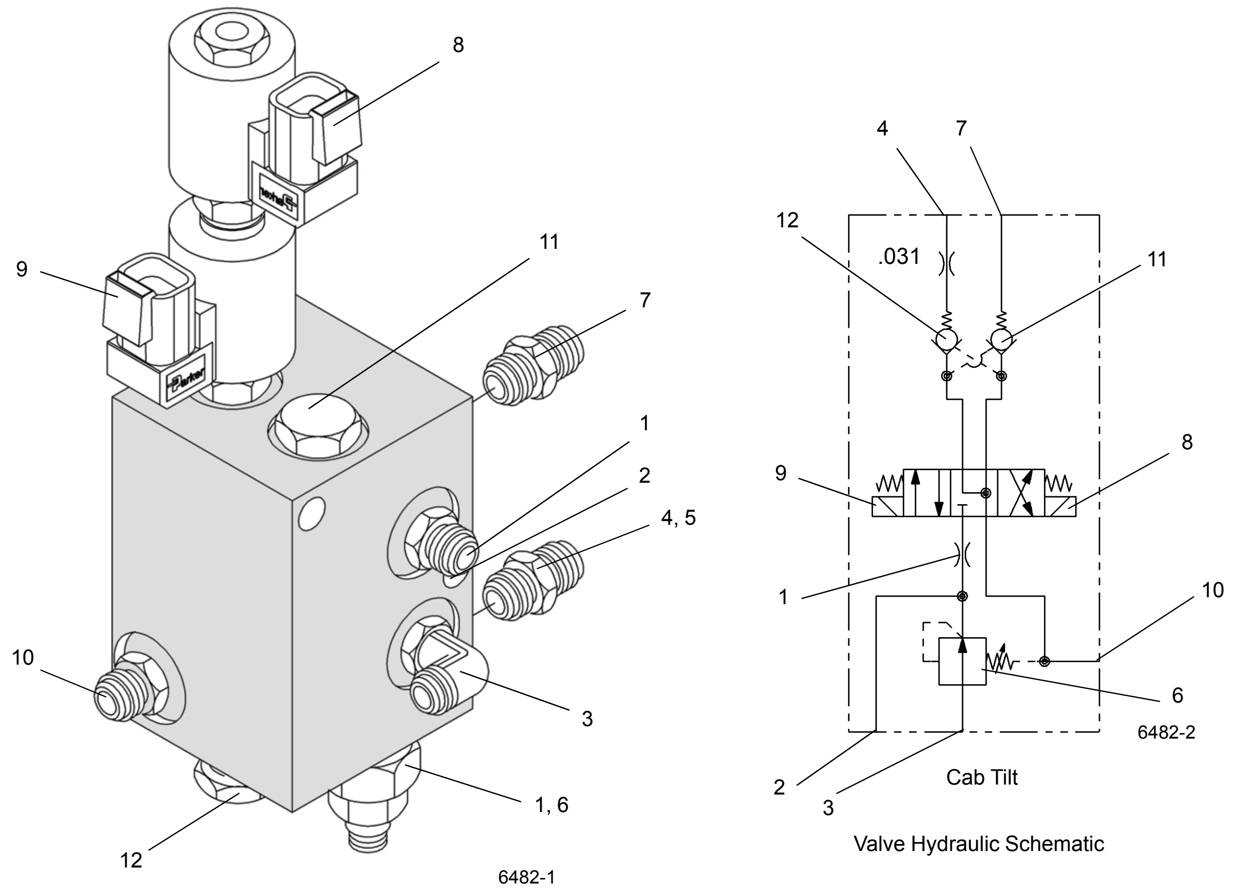


FIGURE 2-20

Item	Description
1	Orifice OR2 - Tilt Cylinder Retract Line
2	Port P2 - From Counterweight Removal Valve
3	Port P1 - From Main Valve
4	Port B - Cab Tilt Cylinder Extend
5	Orifice OR1 - Tilt Cylinder Extend Line (.031)
6	Pressure Relief PR1 (2500 psi)

Item	Description
7	Port A - Cab Tilt Cylinder Retract
8	Solenoid Valve SV1
9	Solenoid Valve SV2
10	Tank Port T
11	Check Valve CV2 - Tilt Cylinder Extend Line
12	Check Valve CV1 - Tilt Cylinder Retract Line

FRONT STEER/SWING/BRAKE MANIFOLD

Description

The front steer, swing and brake manifold (Figure 2-21) houses cartridge components that control the front steer, pilot functions, swing brake release and the telescope hose reel. It is located on the outside of the right hand superstructure side plate under the removable valve cover. The manifold has two inlets, one for the piston pump No. 1 and one for the gear pump No. 2. The end opposite the bolt on swing directional valve houses the low pressure case drain that manifolds low pressure oil from swivel port 10, and returns it to the tank. It is located on the outside of the right hand superstructure side plate under the removable valve cover.

Oil from pump No. 2 enters the P2 inlet port from port 5 of the hydraulic swivel. The oil flows to the front steer flow control valve to a second flow control valve for the swing directional valve which is bolted onto the front steer, swing and accessory manifold. A main inlet relief protects pump No. 2. The front steer flow control valve is a load sense priority type flow control valve. On a load sense signal from the cab steering control valve, the spool shifts, directing controlled flow to the cab steering control unit. The load sense port maintains a constant 861.8 kPa/8.6 bar (125 psi) standby pressure. Any excess flow is directed to the swing section. The circuit is protected by a load sense relief valve incorporated in this section. The second flow control valve is unloaded when the swing directional valve is in neutral. When the swing is actuated, the valve delivers a maximum of 95 lpm (25 gpm).

Pump No. 1 enters the P1 inlet through swivel port 7. The oil flows first through a 100 mesh screen then supplies three pressure reducing valves and five two position three way solenoid valves in parallel for the pilot and hose reel functions. It has a separate connection, before the 100 mesh screen that supplies the service brake charge valve.

One pressure reducing valve and solenoid are used for the swing brake and brake release, one pressure reducing valve feeds solenoids for the controllers and telescope two stage relief, and one pressure reducing valve is used for the hose reel motor and hose reel brake. The pump load sense and (4) load sense shuttle checks are required to bring the pump on and off stroke when the hose reel or telescope two stage relief valve is selected and located in this manifold. All other pilot functions use the pump standby pressure to fully operate at engine idle.

Maintenance

Removal

1. Tag and disconnect all of the electrical connectors or manual control levers.
2. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.

NOTE: The swing/steer/brake valve bank weighs approximately 69.6 lb (31.6 kg).

3. Remove the bolts and lockwashers securing the valve bank and remove the valve bank.

Installation

1. Place the valve bank on the superstructure side plate and fasten it with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
2. Connect the hydraulic lines to the valves as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.

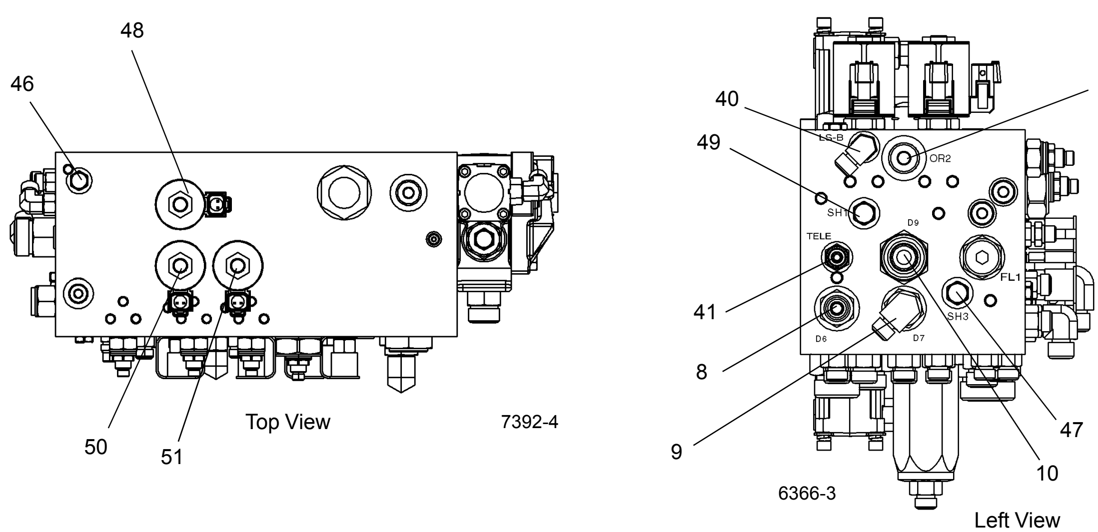
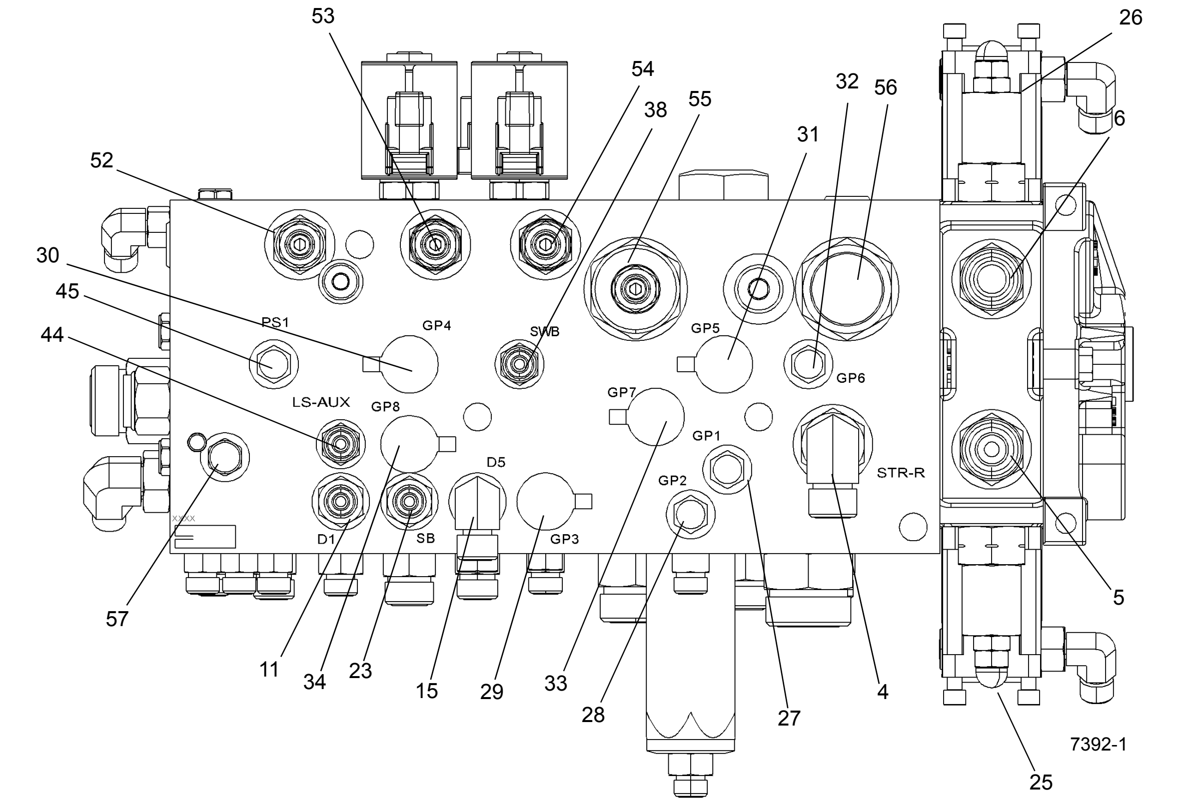


FIGURE 2-21



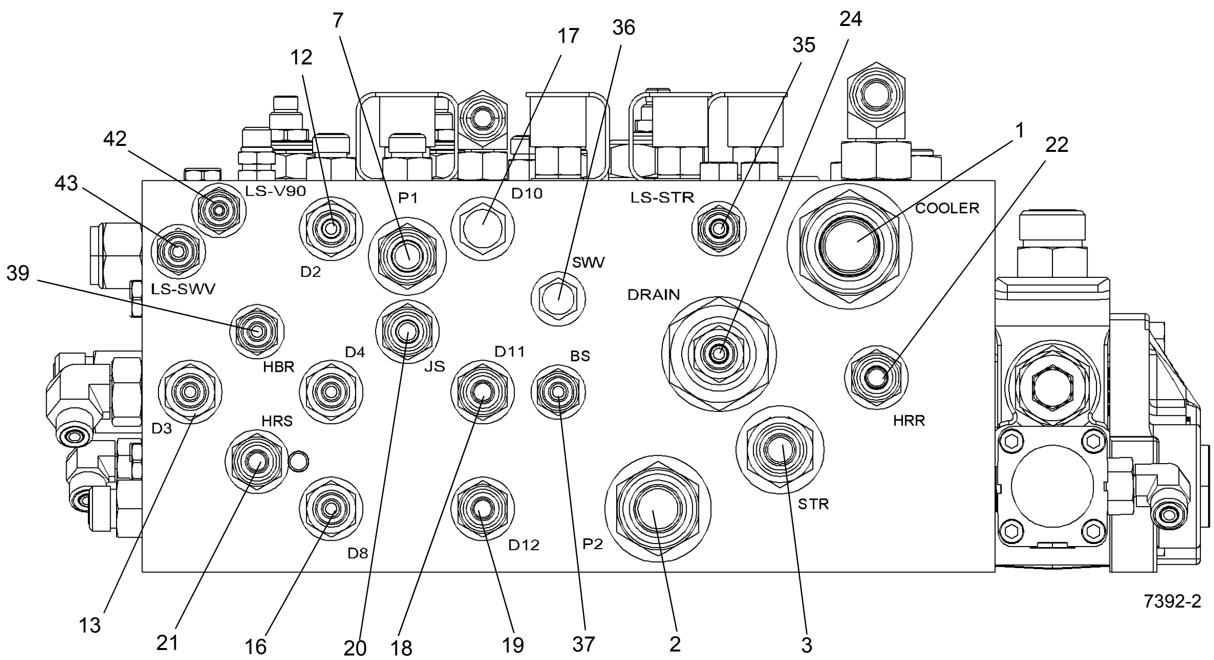
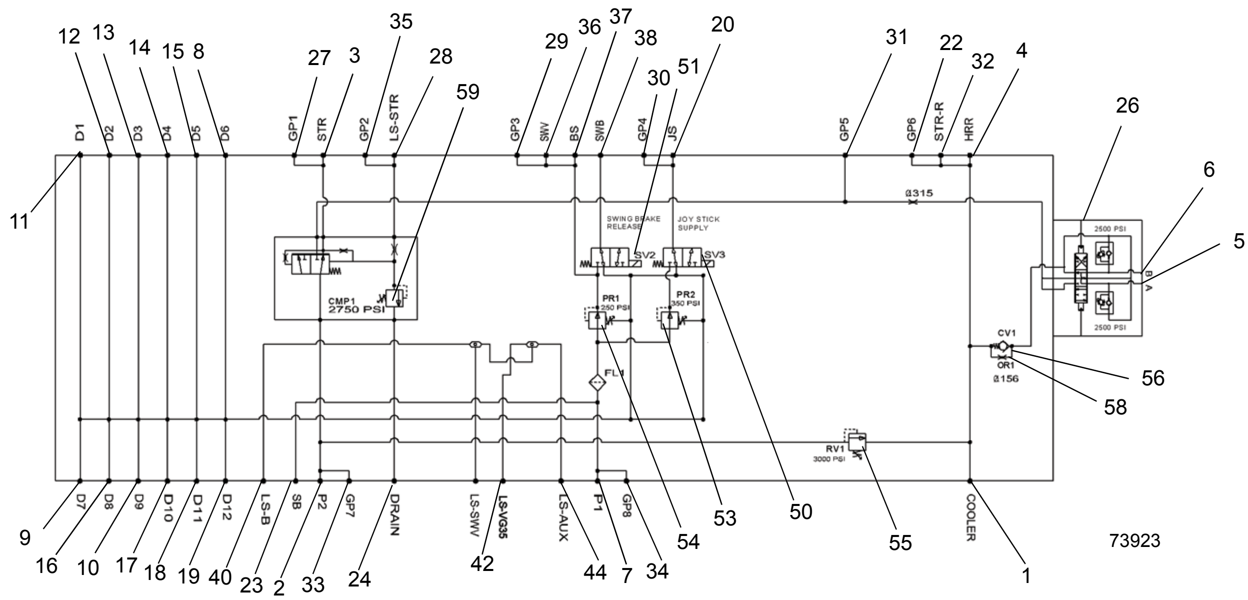


FIGURE 2-21 continued



Valve Hydraulic Schematic

FIGURE 2-21 continued

Item	Description
1	Cooler Port - Return Swivel Port #4
2	Pump P2 Inlet
3	STR - Front Steer Control valve
4	STR-R - Steer Relief
5	A Port - Swing Right
6	B Port - Swing Left
7	P1 - Pump P1 Inlet
8	D6 - Drain
9	D7 - Drain
10	D9 - Drain
11	D1 - Drain

Item	Description
12	D2 - Drain
13	D3 - Drain
14	D4 - Drain
15	D5 - Drain
16	D8 - Drain
17	D10 - Drain
18	D11 - Drain
19	D12 - Drain
20	JS - Joystick Supply
22	HRR - Hose Reel Relief

Item	Description
23	SB - Swing Brake
24	Drain - Front Steer Control Valve
25	PA - Swing Pilot
26	PB - Swing Pilot
27	GP1 - Gauge Port 1 - Steer Inlet Pressure
28	GP2 - Gauge Port 2 - Steer Load Sense Pressure
29	GP3- Gauge Port 3 - Swing Brake Foot Pedal Inlet Pressure
30	GP4 - Gauge Port 4 - Joystick Supply
31	GP5 - Swing Valve Inlet Pressure
32	GP6 - Gauge Port 6 - Return Pressure from Gear Pump to cooler
33	GP7 - Gauge Port 7 - Gear Pump Outlet to Steer/ Swing Valve
34	GP8 - Gauge Port 8 - Pressure From jack cylinder Manifold
35	LS-STR - Front Steer Control Load Sense
36	SWV - Swing Valve
37	BS - Brake Supply
38	SWB - Swing Brake Release

Item	Description
40	LS-B - Hose Reel Brake Load Sense
42	LS - Load Sense Hoist/Telescope Lift Direction Valve
44	LS-Aux - Auxiliary Load Sense
47	SH3 - Shuttle Valve - Hose Reel/Telescope Relief Circuit
49	SH1 - Shuttle Valve - Hose Reel/Telescope Relief Circuit
50	SV3 - Solenoid Valve - Joystick Supply
51	SV2 - Solenoid Valve - Swing Brake Release
53	PR2 - Pressure Reducing Valve (350 psi) - Joystick Supply
54	PR1 - Pressure Reducing Valve (250 psi) - Swing Brake Release
55	RV1 - Relief Valve (3000 psi) - Pump #2 - Inlet Relief
56	CV1 - Check Valve - Swing
57	SH4 - Shuttle Valve - Hose Reel/Telescope Relief
58	OR1 - Orifice (ø.156)- Swing
59	CMP1 (2750 psi) - Front Steer Control Valve

2

STEERING CONTROL VALVE

Description

The load sense steering control unit (see Figure 2-22) controls hydraulic flow to the front steering cylinders. It is located in the steering column of the cab.

Both work ports are connected to the rod side of one steer cylinder and to the piston side of the other steer cylinder.

Displacement of the valve is 35.9 in³ (588.2 cm³).

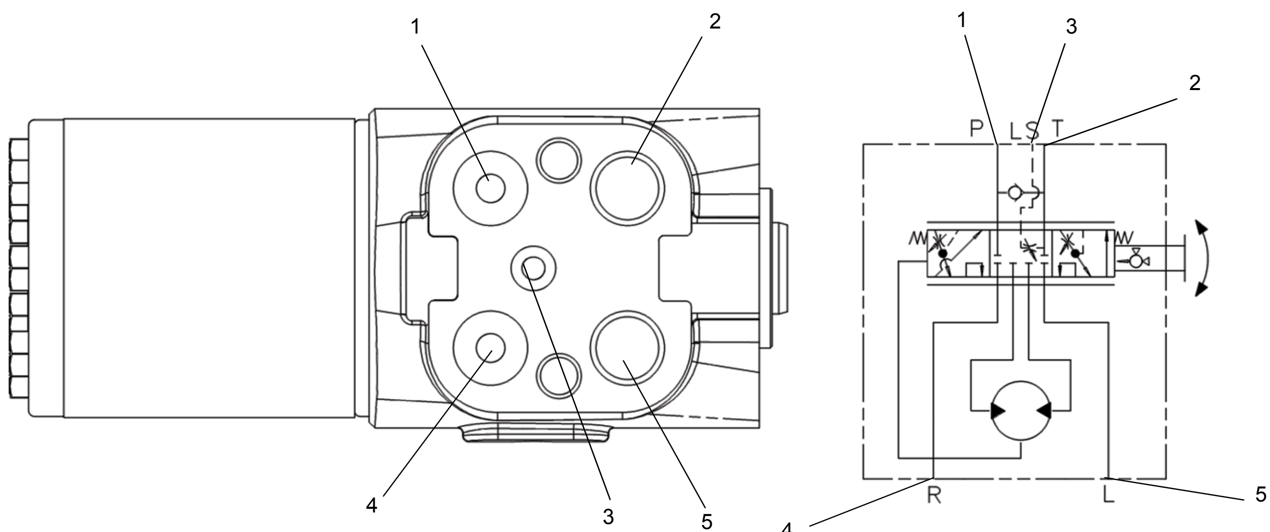
Maintenance

Removal

1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the four mounting bolts and remove the valve from the steering column.

Installation

1. Secure the valve to the steering column and secure with the four mounting bolts. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Verify proper operation of the valve.
5. Check valve and hydraulic connections for leaks. Make repairs as needed.



Valve Hydraulic Schematic

Item	Description
1	Pressure Port
2	Tank Port
3	Load Sense Port
4	Steer Right Port
5	Steer Left Port

FIGURE 2-22

HYDRAULIC REMOTE CONTROL VALVE

Description

Single Axis Controller

The crane has four single axis hydraulic remote control valves Figure 2-23. Each crane function has a control lever for the operator's use.

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

If the crane has an optional auxiliary hoist, the auxiliary hoist function replaces the telescope function on the control lever on the left armrest. Instead, the telescope function is controlled by a pedal operated single function control valve. The pedal is on the cab floor (Figure 2-25). 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 Controller

The two hydraulic remote control valves (Figure 2-24) 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. The valve in the left armrest controls swing and telescope.

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. 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.
3. Check valve and lines for leakage. Make repairs as needed.

Telescope Pedal Control Valve Removal

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

Telescope Pedal Control Valve Installation

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

Telescope Pedal Control Valve Functional Check

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

Single Axis Controller

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.

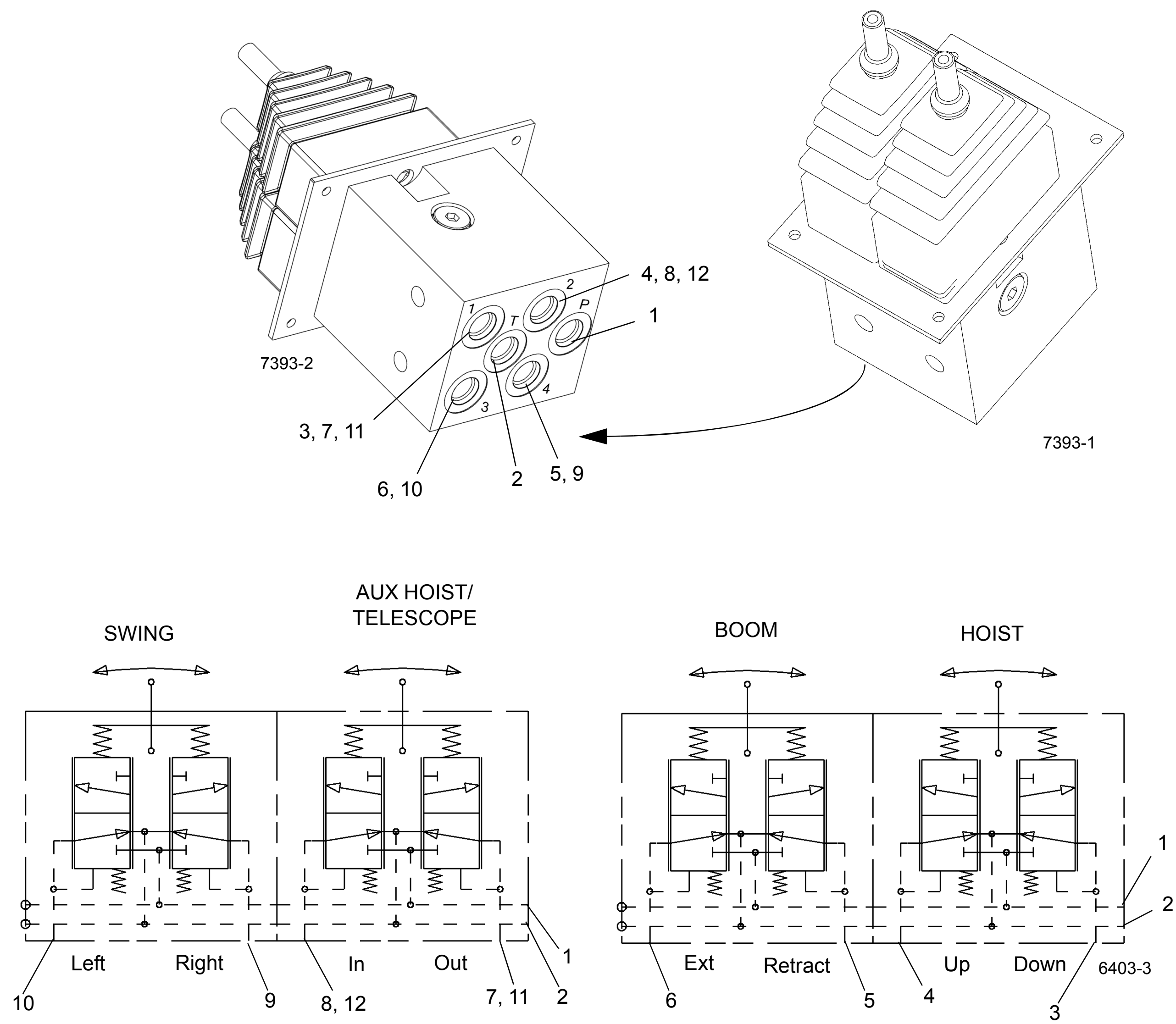


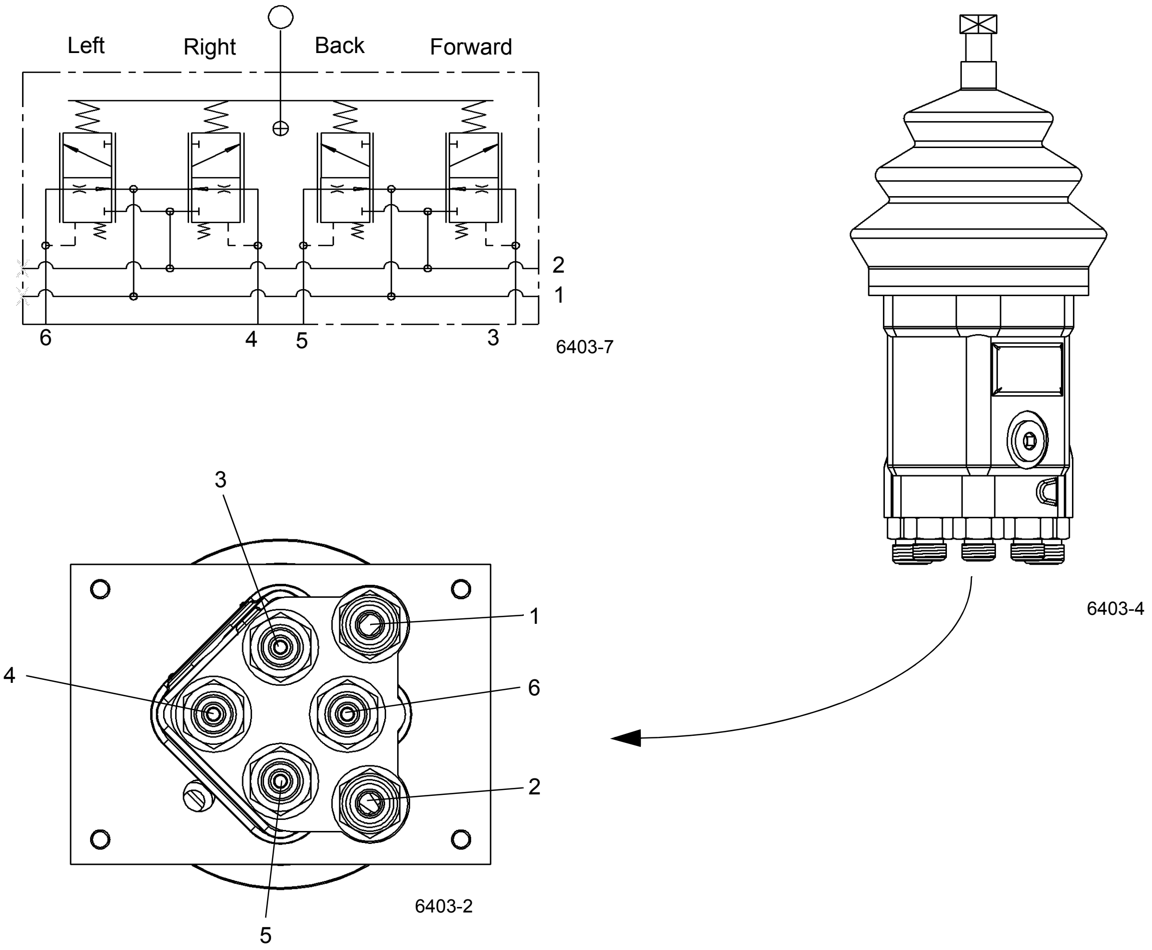
FIGURE 2-23

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

Manitowoc Crane Care

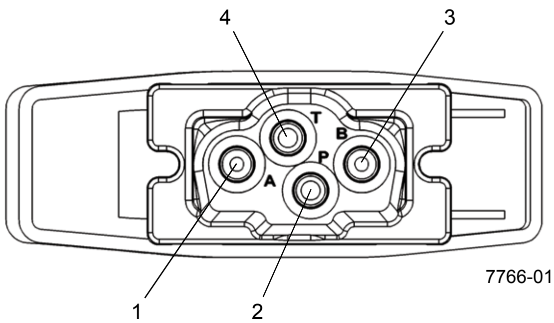
Dual Axis Controller



Item	Description
1	Tank Port
2	Pump Port
3	Tele Out, Hoist Down, Aux Hoist Down
4	Swing Right, Boom Down
5	Tele In, Hoist Up, Aux Hoist Up
6	Swing Left, Boom Up

FIGURE 2-24

Telescope Foot Controller



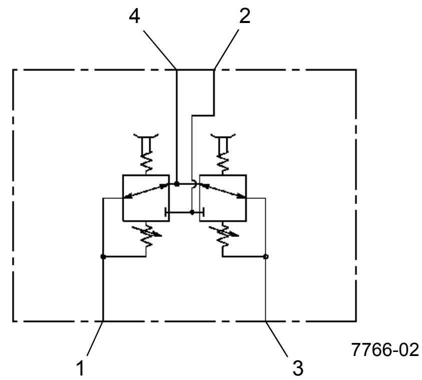


FIGURE 2-25

Item	Description
1	Telescope In
2	Pressure Port

Item	Description
3	Telescope Out
4	Port To Tank

SWING POWER BRAKE VALVE WITH TREADLE PEDAL

Description

The swing power brake valve is used to provide hydraulic pressure to the piston of the swing brake to apply the brake. The valve receives its supply of oil from the front steer and accessory manifold. Depressing the brake pedal causes hydraulic oil to flow to the top of the brake piston where, combined with spring tension, the total force overcomes the brake release pressure and applies the brake. When the valve is released, excess hydraulic oil flows from the valve to the case drain manifold and back to the reservoir (see Figure 2-26).

Maintenance

Removal

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

Installation

DANGER

Engage the swing lock before installing the swing brake valve.

1. Engage the swing lock.
2. Install the brake valve and secure in place with the three bolts, flat washers, spring lockwashers, and nuts. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
3. Attach the hydraulic lines to the brake valve as tagged during removal.

Function Check

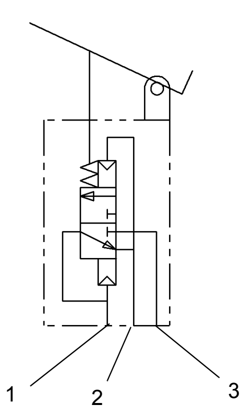
1. Start the engine and let it idle.
2. Disengage the swing lock.
3. Slowly swing the turntable.

DANGER

Engage the swing lock before adjusting the swing brake valve.

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

Item	Description
1	A Port - To Swing Drive
2	T Port - To Reservoir
3	P Port - Pressure From Swing, Steer and Accessory Manifold



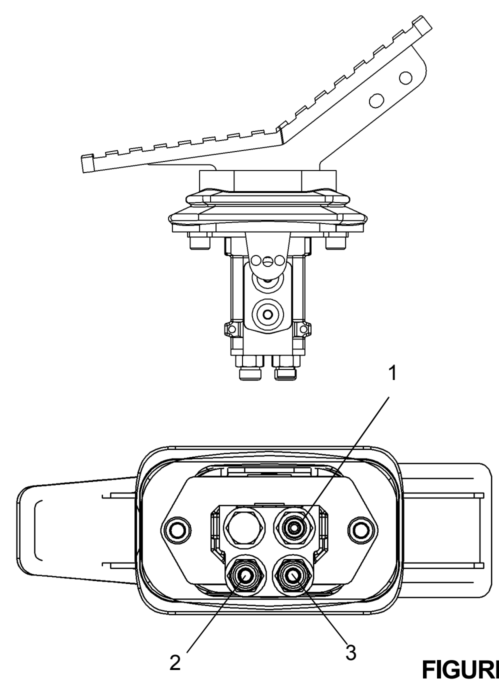


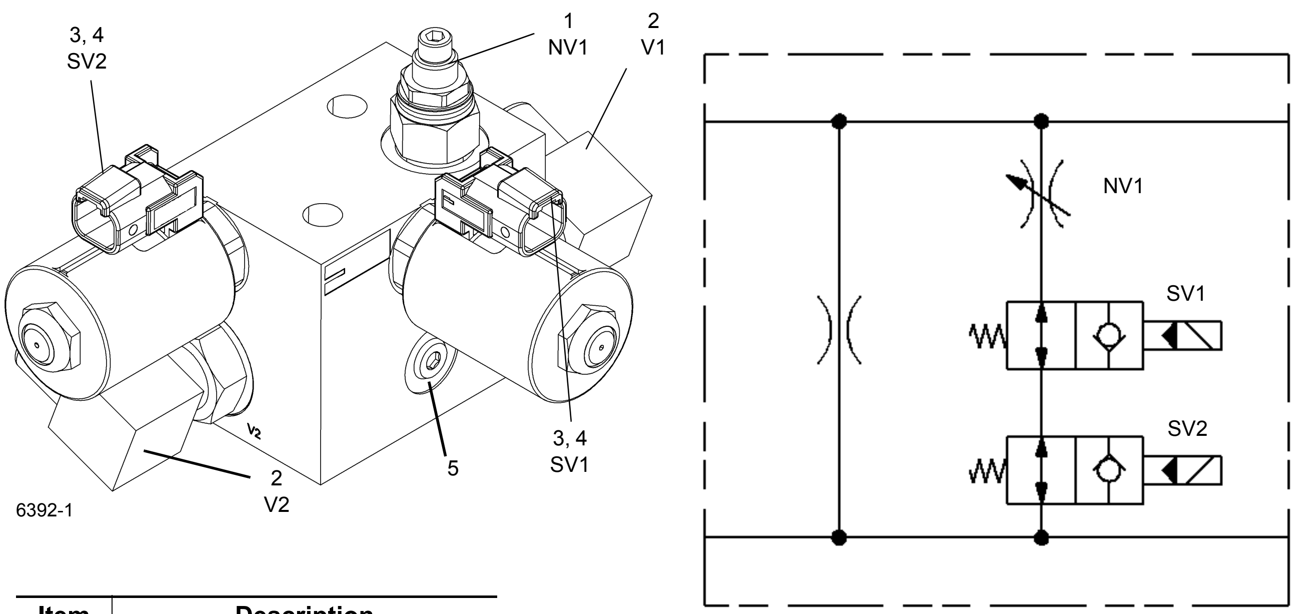
FIGURE 2-26

2 SPEED SWING VALVE

Description

The 2-speed swing valve (see Figure 2-27) is used to select the swing motor speed. The valve is bolted directly to the swing motor. It consists of two solenoid actuated two position two-way valves and an adjustable flow control.

Swing speed is selected in the cab via the dashboard Swing High/Low Speed Switch. In the deenergized position or LOW SPEED switch position, the two solenoid actuated two position two-way valves allow oil to pass across the adjustable flow control to the opposite side of the motor thus reducing the flow available to the motor. When selecting the HIGH SPEED switch position, the two solenoid actuated two position two-way valves are energized thus not allowing oil to pass across the adjustable flow control and forcing all available flow to the motor.



Item	Description
1	Needle Valve
2	Adapter
3	2-Way Valve
4	Coil
5	Plug

FIGURE 2-27

Maintenance

Removal

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

Installation

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

TANDEM BRAKE VALVE WITH TREADLE PEDAL

Description

The tandem brake valve with treadle pedal is located on the floor of the cab. The tandem brake valve provides split system braking for the primary (front) brakes and the secondary (rear) brakes.

The valve is a closed center spool design which modulates the output pressure [1500 psi ±75 (10,342 kPa ±517)] to the brake actuators. The valve is mechanically actuated by a treadle pedal (see Figure 2-28). The direct acting spool provides a pedal feel which accurately represents the brake pressure, similar to automotive style pedal feedback as the brake pedal pressure increases, the pedal effort increases proportionally. As the pedal is initially actuated, the tank ports are closed off from the brake ports. With further application of the pedal, the pressure ports are opened to the brake ports until the pedal actuation force and the hydraulic pressure force are balanced.

Also when the pedal is actuated, the integral proximity switch is engaged to provide an electrical signal for brake lights. When the pedal is released, the valve and the pedal return to the non-applied position.

The tandem brake valve consists of a tandem valve body, a closed center spool, a treadle pedal, an integral proximity switch and a mechanical spring assembly to limit the output pressure to the brake actuators to 1500 psi ±75 (10,342 kPa ±517).

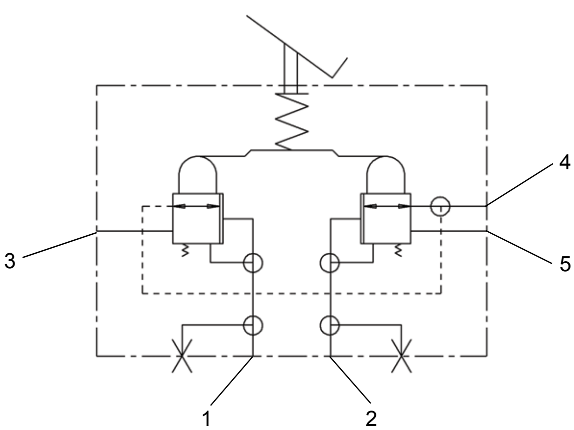
Maintenance

Removal

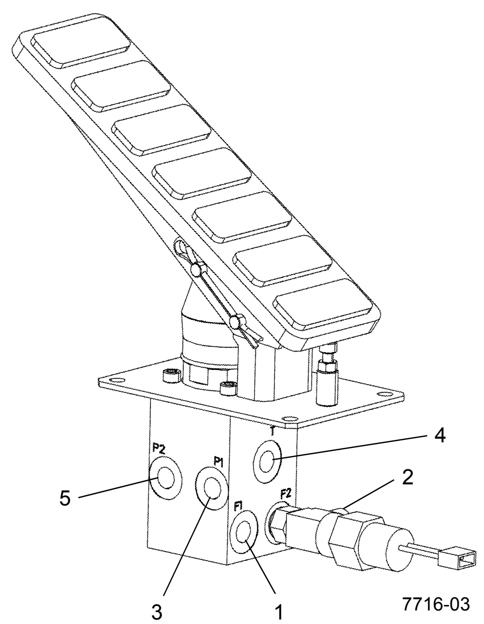
1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the nuts and bolts securing the valve to the cab Floor. Remove the valve.

Installation

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



Valve Hydraulic Schematic



Item	Description
1	Port B1
2	Port B2
3	Pressure Port P1
4	Tank
5	Pressure Port P2

FIGURE 2-28

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 2-29).

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 [1950 psi (13,445 kPa)]. The pump will deliver the required charge flow to charge the accumulators. When the cut-out setting [2320 psi (15,996 kPa)] 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.

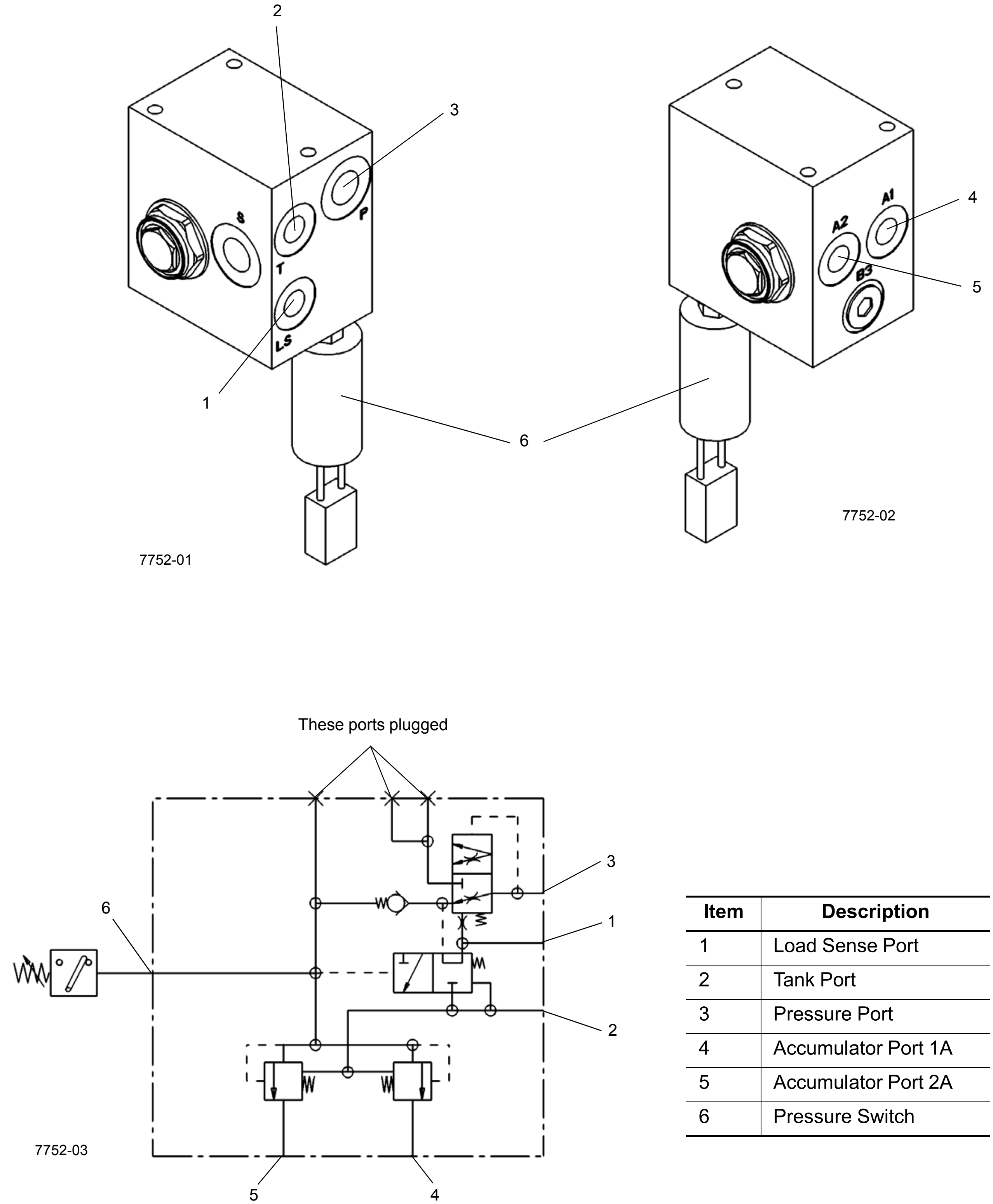
Maintenance

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.



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 2-29

HYDRAULIC ACCUMULATOR SERVICE BRAKE

Description

The service brake hydraulic accumulators are located on the outside of the left superstructure side plate behind the cab. The purpose of each accumulator is to provide stored energy, an oil volume of 173 cu in (3.0 l) at a maximum pressure of 2320 psi (15,996 kPa/159.9 bar), 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 1500 psi (10,342 kPa) with high purity nitrogen. This maintains a constant pressure in the other chamber which is connected to the modulating brake valve. After the accumulators are fully charged, they will provide the necessary brake system flow and pressure to actuate the brakes.

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

Maintenance

Removal

1. With the engine shutdown, deplete the hydraulic pressure in the accumulators by depressing the service brake pedal several times.
2. Tag and disconnect the hydraulic hose from the accumulator. Cap or plug the line and port.
3. Remove the two nuts securing each clamp half. Remove 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 F - Pre-Charging the Accumulator*, page 2-23.
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 Pressure Setting Procedures in this section.

HOLDING VALVES

Description

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

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

Lower Lift Cylinder Holding Valve

Removal

DANGER

Pinch Point Hazard!

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

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

WARNING

Flying Object Hazard!

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

FIGURE 2-30

4. From the access holes in the opposite side of the boom, relieve the pressure in the lower telescope cylinder by loosening the bleed plug, (35, Figure 2-43).

FIGURE 2-31

5. Unscrew holding valve from its port block. (See Figure 2-31 and Figure 2-43.)

Installation

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

CAUTION

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

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

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

Maintenance

DANGER

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

Removal

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

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.

CROSS AXLE DIFFERENTIAL LOCK VALVE

Description

The cross axle differential lock valve Figure 2-32 is mounted off the carrier bulkhead plate forward of the engine. The valve is a four-way, two position solenoid valve. The valve is used to control the application of the crane's hydraulically applied and released cross axle differential lock actuators.

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

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

CAUTION

Axle Damage!

Operating the machine with the differentials in the locked position while maneuvering on improved surfaces may result and damage to the axles.

Maintenance

Removal

1. Tag and disconnect the electrical connector from the valve.
2. Tag and disconnect the hydraulic lines attached to the valve. Cap or plug lines and ports.
3. Remove the two bolts and washers securing the valve to the frame. Remove the valve.

Installation

1. Secure the valve to the frame with the two bolts and washers. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Apply and release the cross axle differential lock several times. Verify the cross axle differential lock holds the axle from moving when applied so there is no differential action between the wheels.
5. Check for leaks. Make repairs as needed.

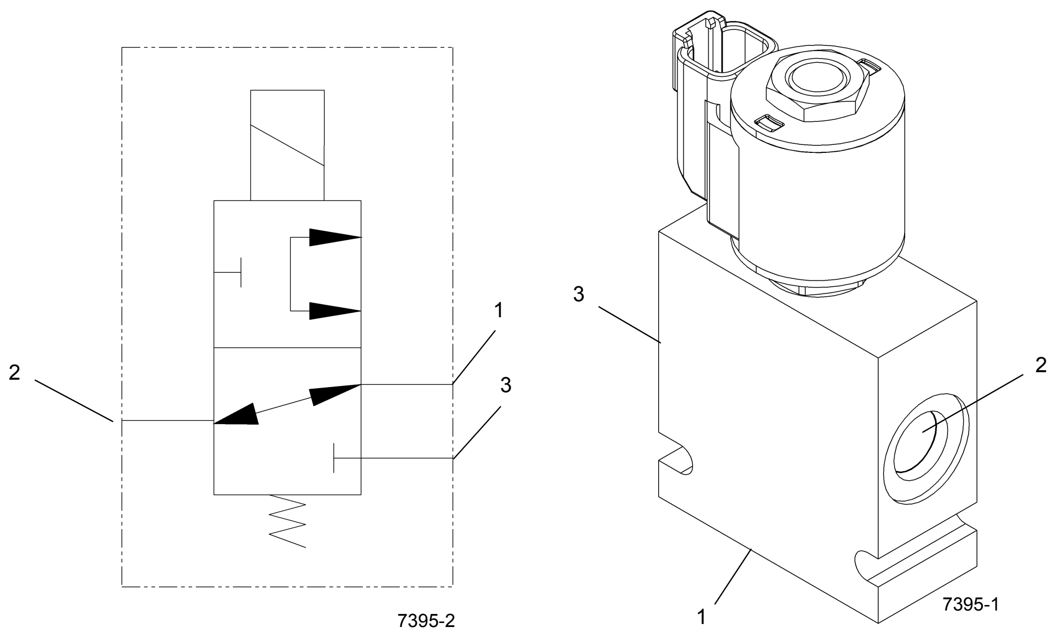


FIGURE 2-32

Item	Description
1	To Front and Rear Axle
2	Port T - To Port T Of Park Brake Range Shift Valve
3	Port P - To Port P Of Park Brake Range Shift Valve

OUTRIGGER CONTROL MANIFOLD

Description

The outrigger control manifold reduces the pressure supplied to the front steer accessories manifold and directionally controls the outrigger circuit. The valve is mounted from the bottom of the frame rail in front of the oil cooler.

The inlet of the manifold has a bolt on block that houses two pressure reducing valves. One reduces the internal outrigger pressure to 2000 psi (13,789 kPa) and the other reduces the system pressure to 3000 psi (20,684 kPa) for an external port feeding the front steer accessories manifold and the rear steer/fan drive axle lockout manifold.

The outrigger control consists of four (two for extend and two for retract), two position two-way solenoid control valves, internally connected in parallel and two pilot operated check valves with integral thermal relief valves set at 300 psi (2068 kPa) for the retract circuit and 3000 psi (20,684 kPa) for the extend circuit (see Figure 2-33). The manifold also includes eight (four front and four rear) normally closed two position two-way solenoid valves. When energized, the solenoid shifts the spool to open allowing extension or retraction of the outrigger cylinders.

Maintenance

Removal

1. Tag and disconnect the electrical connectors or manual control levers.
2. Tag and disconnect the hydraulic lines to the solenoid valves; cap all lines and openings.
3. Remove the bolts, flatwashers and spring lockwashers securing the manifold to the bracket and remove the manifold.

Inspection

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

Installation

1. Position the manifold on the mounting bracket and secure with the bolts, flatwashers and spring lockwashers. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 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

1. Start engine and run at medium speed.
2. Operate the outriggers and check for smooth operation of the cylinder(s).

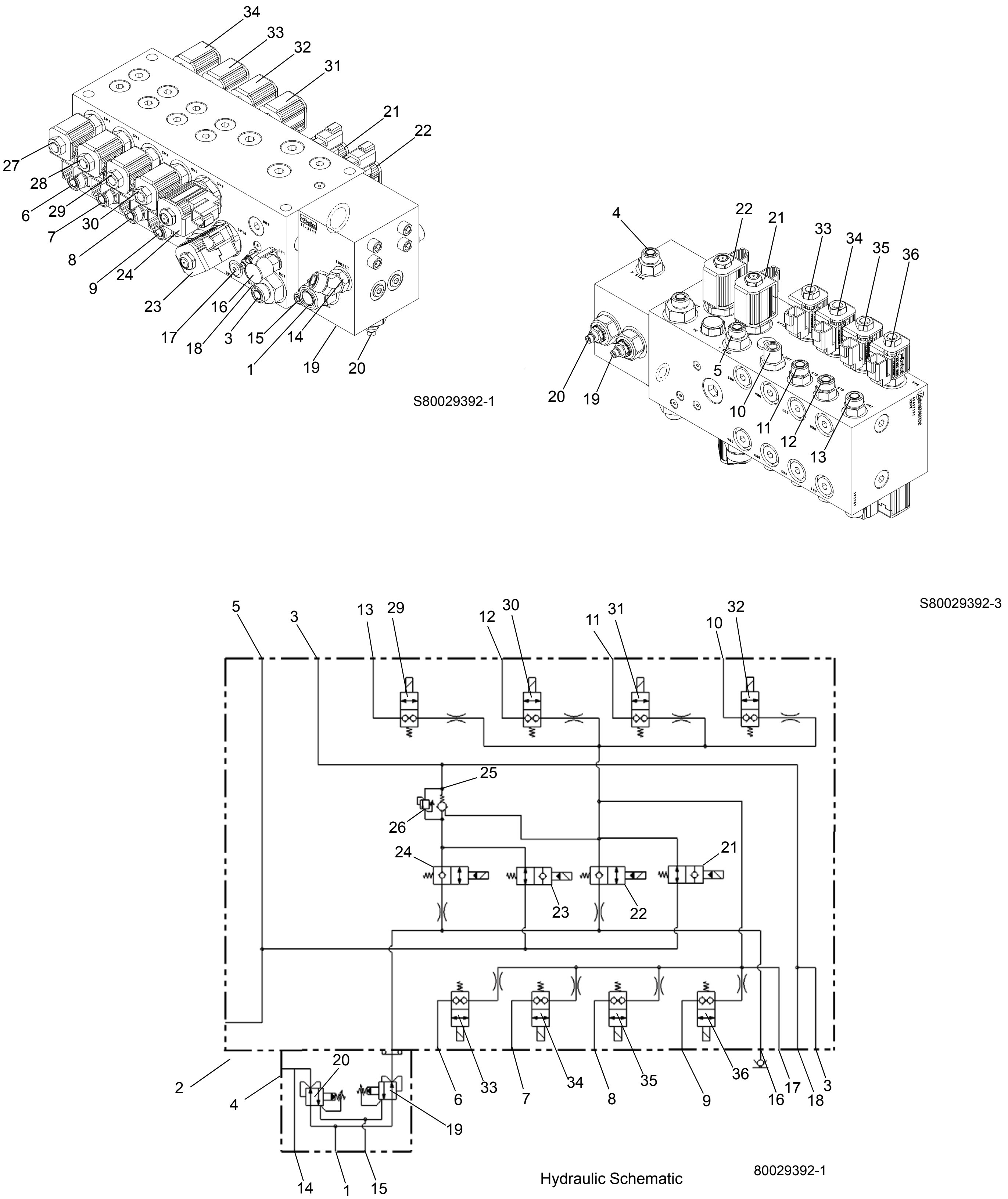


FIGURE 2-33

Item	Description
1	Pump Port
2	Tank Port
3	RET Port
4	P STAB Port
5	T STAB Port
6	Left Rear Extension Cylinder Port
7	Left Rear jack Cylinder Port
8	Right Rear jack Cylinder Port
9	Right Rear Extension Cylinder Port
10	Right Front Extension Cylinder Port
11	Right Front jack Cylinder Port
12	Left Front jack Cylinder Port
13	Left Front Extension Cylinder Port
14	Turret Port
15	Drain Port
16	Gauge Port 1
17	Gauge Port 2
18	Gauge Port 3

Item	Description
19	Pressure Reducing Valve PR2
20	Pressure Reducing Valve PR1
21	Solenoid Valve SV12
22	Solenoid Valve SV11
23	Solenoid Valve SV10
24	Solenoid Valve SV9
25	Pilot Operated Check Valve POCV
26	Thermal Relief Valve RV
27	Solenoid Valve SV1 - Left Front Extension
28	Solenoid Valve SV2 - Left Front jack cylinder
29	Solenoid Valve SV3 - Right Front jack cylinder
30	Solenoid Valve SV4 - Right Front Extension
31	Solenoid Valve SV5 - Left Rear Extension
32	Solenoid Valve SV6 - Left Rear jack cylinder
33	Solenoid Valve SV7 - Right Rear jack cylinder
34	Solenoid Valve SV8 - Right Rear Extension

PILOT OPERATED CHECK VALVE

Description

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

Maintenance

Removal

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

Installation

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

CAUTION

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

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

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

2

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

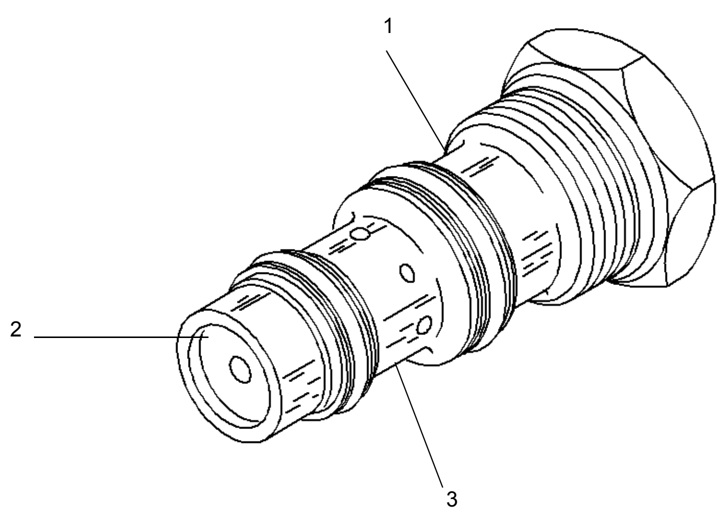


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FIGURE 2-34

AXLE LOCKOUT, REAR STEER AND OIL COOLER FAN MOTOR CONTROL MANIFOLD

Description

The manifold cartridge components controls the axle lockout and supplies flow for the oil cooler fan motor. It is located on the inside of the left hand carrier frame rail, forward of the hydraulic swivel.

The pump “P” and tank “T” ports are connected by hoses in parallel to the outrigger control manifold. The load sense/ CPU control line from the superstructure passes through the manifold and is connected onward to the pump by two load sense shuttle valves. One shuttle valve senses oil cooler pressure and the other senses rear steer and outrigger pressure. A two position three-way solenoid valve connects the fan drive to the pump load sense.

The oil cooler motor is controlled by two position three-way solenoid cartridge valves and is limited to 3.5 gpm (13.3 lpm) by a pressure compensated flow control valve located between the two position three-way solenoid and the port to the cooler motor (see Figure 2-35).

The rear axle lockout hydraulic circuit consists of a pressure reducing valve, set to 500 psi (3447 kPa), that supplies oil to two normally closed, two position, two-way cartridge solenoid valves. The two solenoid valves keep the lockout cylinders from oscillating unless the turntable is centered forward. Included in the rear axle lockout system is an angle encoder located in the top of the electrical slip ring assembly. The encoder sends a message to the RCL, which converts the message to a positional angle of the superstructure relative to the carrier (slew angle). If the slew angle is within ±2° of directly over the front, the RCL sends a CAN bus message to the Crane Control System to allow axle oscillation. Upon receiving this message, the Crane Control System will switch on a digital output, thus energizing and opening the rear axle lockout solenoids. This allows hydraulic oil in and out of the cylinders allowing them to oscillate. If the slew angle is greater that 2° left or right of directly over front, the Crane Control system switches off the digital output, thus de-energizing and closing the rear axle lockout solenoids. This isolates the lockout cylinders from oil supply and prevents the lockout cylinders from oscillating because oil is trapped in the cylinders.

The rear steer is controlled by a three position four-way solenoid actuated directional control valve. The valve shifts in one direction for right turn and the other direction for left turn. To ensure the steering cylinders do not drift out of a locked position, a double pilot operated check valve is installed between the directional valve and the cylinder work ports.

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 and washers securing the valve to the frame bracket. Remove the valve.

Installation

1. Secure the valve to the frame bracket with the washers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 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 operation as follows:

- Operate the rear steer left and right to verify smooth operation.
- On outriggers, swing over the front outriggers to ensure the oscillation cylinders lockout.
- Remove the electrical connection from the oil cooler motor two position three-way solenoid valve to verify that it operation.

5. Check valve and hoses for leaks. Make repairs as needed.

NOTE: Models without axle lockout do not have solenoid SV1 and SV2 installed on the manifold

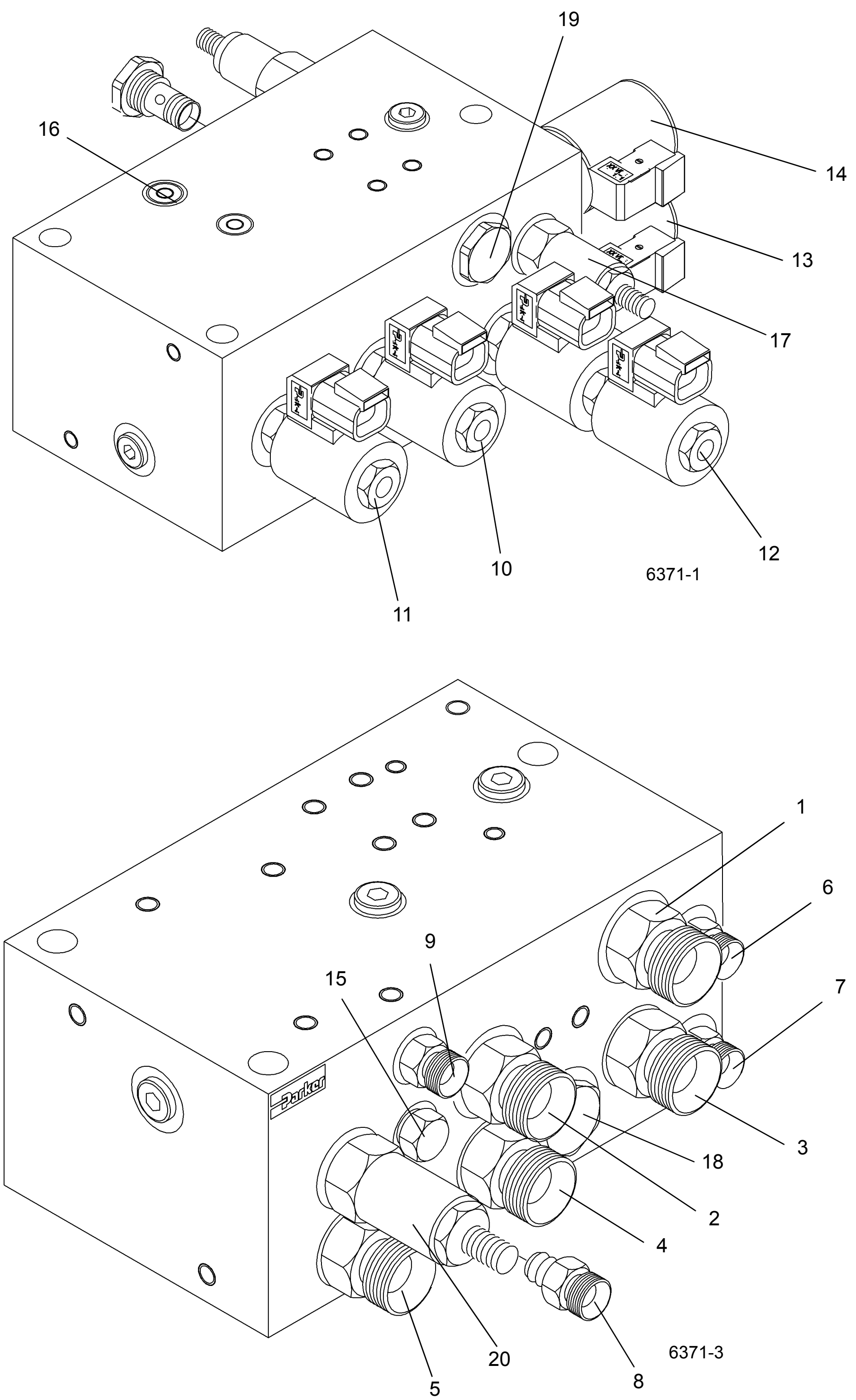


FIGURE 2-35

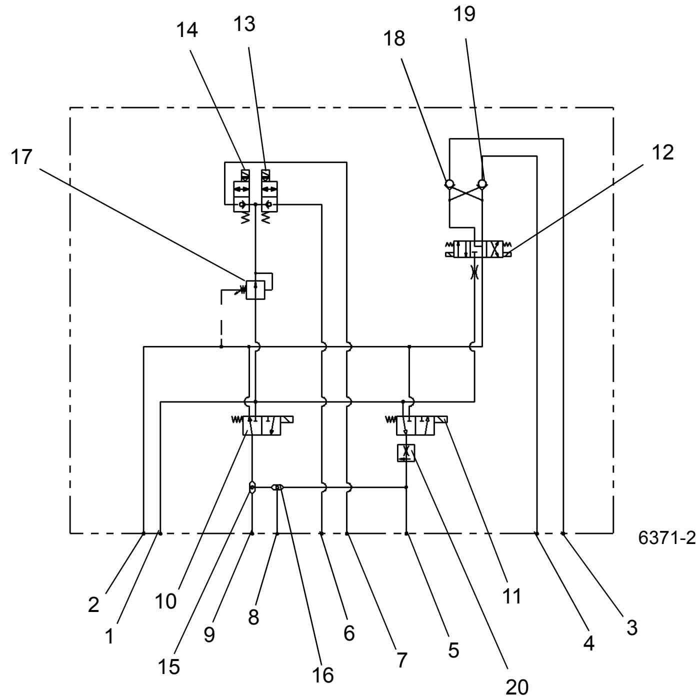


FIGURE 2-35 continued

Item	Description
1	P STAB Port - Pressure to jack cylinders
2	T STAB Port - To Tank
3	STEER A Port - Rear Steer Cylinder
4	STEER B Port - Rear Steer Cylinder
5	FAN DRIVE Port - Hydraulic Oil Cooler
6	ALO A Port - Right Axle Lockout Cylinder
7	ALO B Port - Left Axle Lockout Cylinder
8	LS PUMP Port - Load Sense
9	LS TURRET Port - Load Sense
10	Solenoid Valve SV4 - Pump On Stroke Valve
11	Solenoid Valve SV5 - Fan Drive

Item	Description
12	Solenoid Valve SV3 - Rear Steer
13	Solenoid Valve SV1 - Axle Lockout - Right
14	Solenoid Valve SV2 - Axle Lockout - Left
15	SH1 Shuttle Valve - Load Sense/CPU To Pump
16	SH2 Shuttle Valve - Load Sense/CPU To Pump
17	Pressure Reducing Valve - Axle Lockout
18	Check Valve CV1 - Rear Steer
19	Check Valve CV2 - Rear Steer
20	FR1 - Flow Restrictor - Oil Cooler/Fan Drive

CHECK VALVES

Description

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

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

The second check valve is plumbed in-line at the inlet of the front steer control valve. It prevents steering wheel kick-back if the steer cylinder pressure rises above the inlet port pressure.

Maintenance

Removal

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

Installation

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

RANGE SHIFT/PARKING BRAKE VALVE

Description

The range shift/parking brake valve Figure 2-36 controls the flow of oil to the parking brake, hi-low range and axle disconnect actuators by the use of two solenoid valves. 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

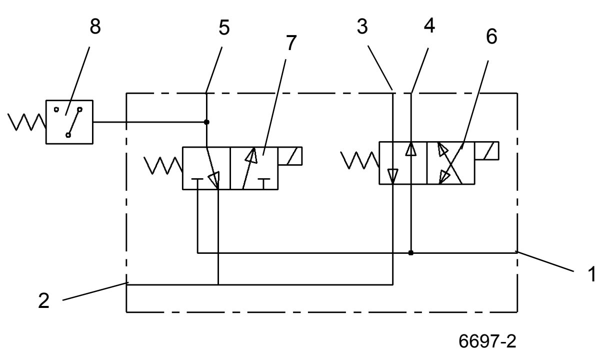
1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the capscrews, lockwashers and nuts securing the valve to the frame. Remove the valve.

Installation

1. Secure the valve to the frame with the nuts, flatwashers, lockwashers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for the 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.



Item	Description
1	Port P - Pressure
2	Port T - Tank
3	Port A - Range Shift Actuator
4	Port B - Range Shift Actuator
5	Port PB - To Park Brake
6	Solenoid Valve - Range Shift
7	Solenoid Valve - Park Brake
8	Pressure Switch

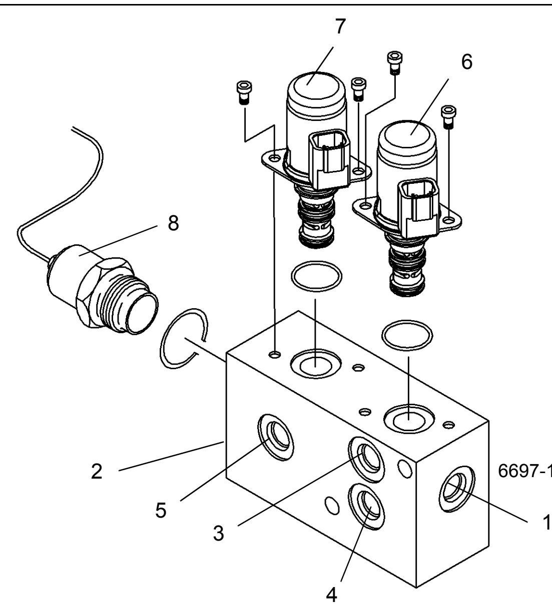


FIGURE 2-36

LOAD SENSE DUMP VALVE

Description

The Load Sense Dump Valve prevents Pump No. 1 from coming on stroke during engine start. It is activated by the Ignition Key Switch during the starting mode. This ensures the engine does not attempt to start against a load in the event the accumulators are charging or the fan motor is activated.

The Load Sense Dump Valve consists of a solenoid actuated two position two-way valve that is normally open and deenergized during normal crane operation (Figure 2-37). In this valve position the load sense circuit to the pump is complete, allowing any load sense signal (pressure) from an actuated function to stroke the pump to its full compensating pressure of 4000 psi (27.6 MPa). Only during engine cranking (ignition switch in the START position) does the solenoid become energized, shifting the valve to a closed position and directing any load sense signal (pressure) to the reservoir, thereby preventing the pump from stroking and building pressure over its standby pressure of 350 psi (2.41 MPa).

Maintenance

Removal

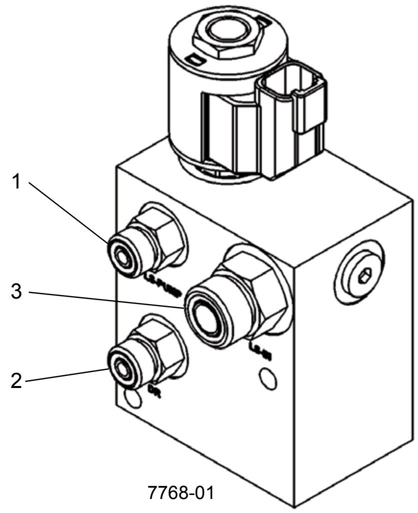
1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug all openings.
3. Remove the capscrews, spring washers, and washers securing the valve to the frame rail. Remove the valve.

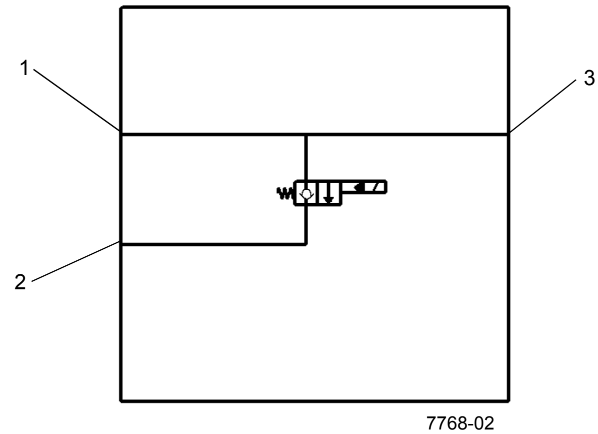
Installation

1. Secure the valve to the frame rail with the washers, spring washers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 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. Remove the electrical connector from the solenoid on the Load Sense Dump Valve. Using a multimeter set to measure voltage, probe the connector.
2. Turn the Ignition Switch to START and crank the engine; verify 12 V is measured only when engine is cranking (Ignition Switch in the START position).
3. Turn off engine.
4. Install the electrical connector onto the solenoid.
5. Install a pressure check diagnostic quick disconnect with gauge onto the test port at the inlet tube of the Boom Lift/ Telescope/Hoist Valve Bank (see Figure 2-11).
6. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the Service Brake Pedal on the cab floor 4-6 times or until the pedal has no back pressure.
7. Turn the Ignition Switch to START and crank the engine while observing the pressure gauge; during engine cranking (ignition switch in the START position), a pressure reading of 350 psi (2.41 MPa) should be observed.
8. Turn off engine. Remove the diagnostic coupler.





Hydraulic Schematic

Item	Description
1	LS-PUMP Port - To Pump No. 1
2	DRAIN Port - To Reservoir
3	LS-IN Port - Load Sense In To Manifold

FIGURE 2-37

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.

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:

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 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. cans by ordering part number 9999101803 through the Parts Department.

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

Leakage Check

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

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

CAUTION

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

2. Apply hydraulic pressure to the piston side of the cylinder and observe the open cylinder port for leakage. If leakage is observed, the seals in the cylinder must be replaced.
3. Fully retract the cylinder rod. Remove the extend hose from the cylinder. Cap the extend hose.

CAUTION

Ensure pressure is applied to the retract (rod) side of the cylinder only and that 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 table 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 versus the ambient temperature.

Thermal contraction coupled with improper lubrication or improper wear pad adjustments 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 tables (see Table 2-5 and Table 2-6) have 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 tables are 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^3/in^3/ °F)							
STROKE	Temperature Change (°F)								
(FT.)	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^3/in^3/ °F) X 12 in/ft

Table 2-6Boom 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

2

LIFT CYLINDER

Description

The lift cylinder Figure 2-38 has a bore of 12.0 in (30.48 cm). The retracted length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 172.75 in (438.7 cm). The extended length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 309.75 in (786.7 cm). Its stroke is 137 in (347.9 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 2809 lb (1274 kg).

Maintenance

Disassembly

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

1. Disconnect the tube assembly from the holding valve.
2. Remove the capscrews and washers securing the holding valve and remove the holding valve from the cylinder barrel.
3. Remove the two 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.

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 T-seal from the inside of the piston.
10. Remove the head from the rod. Remove the O-ring and the backup ring from the outside of the head.
11. Remove the wear ring, buffer seal, deep Z rod seal, backup ring, and wiper ring 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.

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.

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.

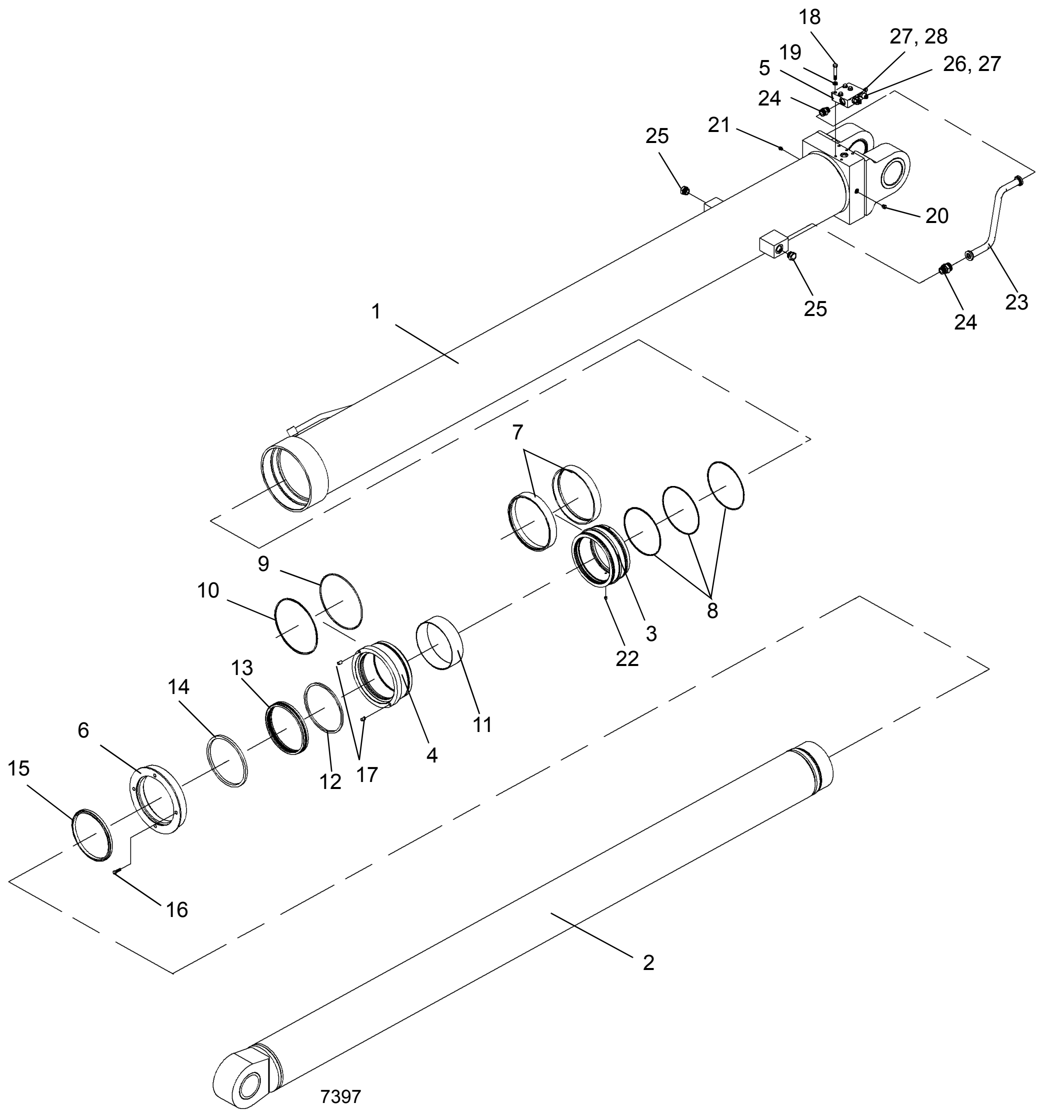


FIGURE 2-38

Item	Description
1	Barrel
2	Rod
3	Piston
4	Head
5	Holding Valve
6	Retaining Ring
7	Seal Assembly
8	T-Seal
9	O-ring
10	Backup Ring
11	Wear Ring

Item	Description
12	Buffer Seal
13	Rod Seal
14	Backup Ring
15	Wiper Ring
16	Socket Head Capscrew
17	Insert
18	Capscrew
19	Flatwasher
20	Plug
21	Plug
22	Socket Setscrew

Item	Description
23	Tube Assembly
24	Adapter
25	Plug
26	Elbow
27	Cap Assembly
28	Adapter

1. Install head retainer ring on rod.
2. Install two new threaded inserts into head.
3. Install the replacement wear ring, buffer seal, deep Z rod seal, backup ring, and wiper ring in the inside of the head. Make sure the buffer seal's step is closer to the deep Z rod seal. Make sure the deep Z rod seal's rim groove is closer to the buffer seal.
4. Install the replacement O-ring and the backup ring on the outside of the head.
5. Install the replacement T-Seal in the inside of the piston.
6. Lubricate the rod with clean hydraulic oil.
7. Slide the head, wiper ring end first, onto the rod.
8. Screw the piston onto the rod tightly. Secure the piston with the setscrew.

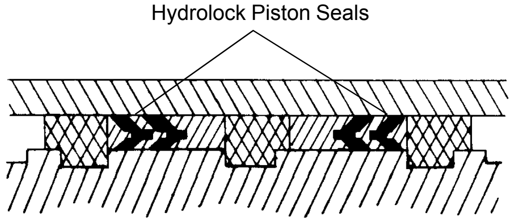


FIGURE 2-39

9. Install the replacement hydrolock seals on the outside of the piston. Make sure the "vees" on the two hydrolock seals point at each other Figure 2-39.
10. 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.

11. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
12. Install new gasket material to the cylinder head retainer ring flange as follows.
    a. Clean the barrel and retainer ring with Loctite cleaning solvent 7070 or similar non-chlorinated solvent.
    b. Apply a light coating of Loctite primer N7649 to both surfaces. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
    c. Apply gasket material Loctite Master Gasket 518 to one surface. Partial cure is obtained in four hours, with full cure in 48 hours.
13. Screw the head retainer ring into the barrel and align holes in retainer ring with holes in head. Install two socket head capscrews. Torque the capscrews 44 to 48 lb-ft (59.6 to 65.0 Nm).
14. 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.

15. Position the holding valve on the cylinder barrel and secure with four capscrews and washers. Connect tubing to holding valve.
16. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 41,368.5 kPa/413.6 bar (6000 psi). Check for proper operation and any leakage. Make repairs as needed.

TROMBONE TELESCOPE CYLINDER

Description

The boom trombone telescope cylinder (lower telescope cylinder) has a 7.0 in (17.7 cm) bore, a 6 in (15.2 cm) hollow rod and is internally ported. Oil from the telescope control valve is routed to the cylinder by external lines. Foreign material is prevented from entering the cylinder rod during retraction by a wiper seal in the head. O-ring seals prevent internal and external leakage (Figure 2-43).

The retracted length of the telescope cylinder is 389.5 in (1014.8 cm). The cylinder has a stroke of 347.0 in (8815 cm) which gives an extended length of 746.5 in (1896 cm).

The cylinder weighs approximately 2908 lb (1319 kg) wet.

Maintenance

Disassembly

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

1. Remove the bolts and washers securing the rod retaining plate to the barrel.
2. Remove the bolts and washers that secures the rod retaining plate to the inner rod end.

WARNING

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

CAUTION

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

3. Using a chain wrench, unscrew the cylinder head from the barrel.
4. Remove the cylinder rod assembly from the cylinder barrel and cover the barrel to avoid contamination.

CAUTION

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

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

5. Remove the guide lock ring to gain access to the setscrew securing the piston to the outer cylinder rod.
6. Remove the setscrew and unscrew the piston from the cylinder rod.
7. Remove the hydrolock seals and wear rings from the outside of the piston and the O-ring and backup ring from the inside of the piston.
8. Remove the spacer from the rod and remove the wear ring from the spacer.
9. Remove the cylinder head from the outer rod.
10. Remove the O-ring and backup rings from the outside of the head and the wear rings, buffer seal, deep Z rod seal, backup ring and the wiper ring from the inside of the head.

CAUTION

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

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

11. Using a spanner wrench, unscrew the inner rod from the outer cylinder rod and cover the opening to avoid contamination. The seal retainer will slide out from the inner rod.
12. Remove the polyseal ring from the inner rod end.
13. Remove the O-ring and backup rings from the outside of the inner rod.
14. Remove the wear rings and rod seals from the inside of the seal retainer.
15. Remove the O-ring and backup rings from the outside of the seal retainer.
16. If necessary, remove the holding valve from the inner cylinder rod and from the cylinder barrel.

Inspection

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

CAUTION

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

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

4. Inspect the barrel for scoring.

Assembly

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

CAUTION

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

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

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

2. Install the O-ring and backup rings on the outside of the seal retainer and the rod seals and wear rings in the inside of the seal retainer Figure 2-40.

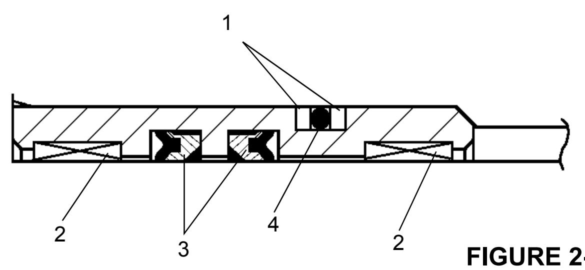


FIGURE 2-40

Item	Description
1	Backup Ring
2	Wear Ring
3	Deep Z Rod Seal
4	O-ring

3. Slide the seal retainer onto the inner rod.
4. Slide the inner rod and seal retainer into the outer rod.
5. Install the wiper ring, backup rings, deep Z rod seal, buffer seal assembly and wear rings into the inside of the cylinder head Figure 2-41.

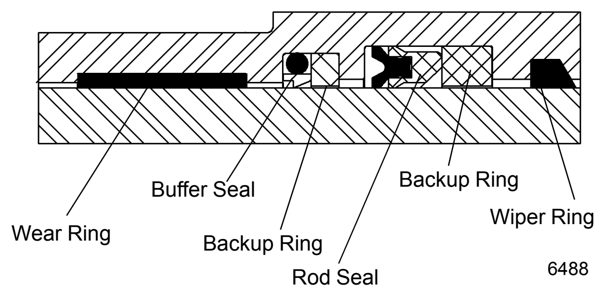


FIGURE 2-41

CAUTION

Improper seal installation can cause faulty cylinder operation.

6. Slide the spacer and head onto the outer rod.
7. Install the O-rings and backup rings into the inside of the piston.
8. Screw the piston onto the outer rod and secure with a new setscrew.
9. Install the guide lock rings, piston hydrolock seal assemblies and wear rings on the outside of the piston Figure 2-42

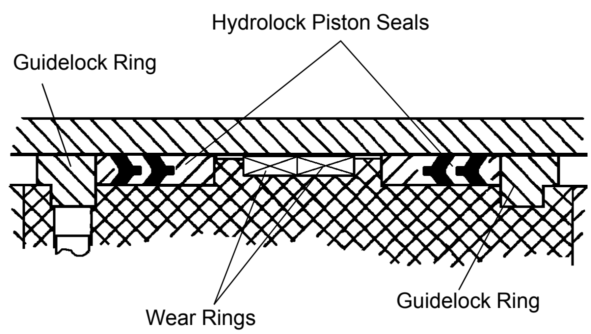


FIGURE 2-42

10. Install the wear ring onto the outside of the spacer.
11. Install the O-ring and backup ring onto the outside of the head.
12. Install the backup ring and O-ring onto the outside of the inner rod end.
13. Clean all oil from the threads of the cylinder head and apply Loctite #290 to the threads.
14. Slide the rod assembly into the cylinder barrel and screw the cylinder head into the barrel.

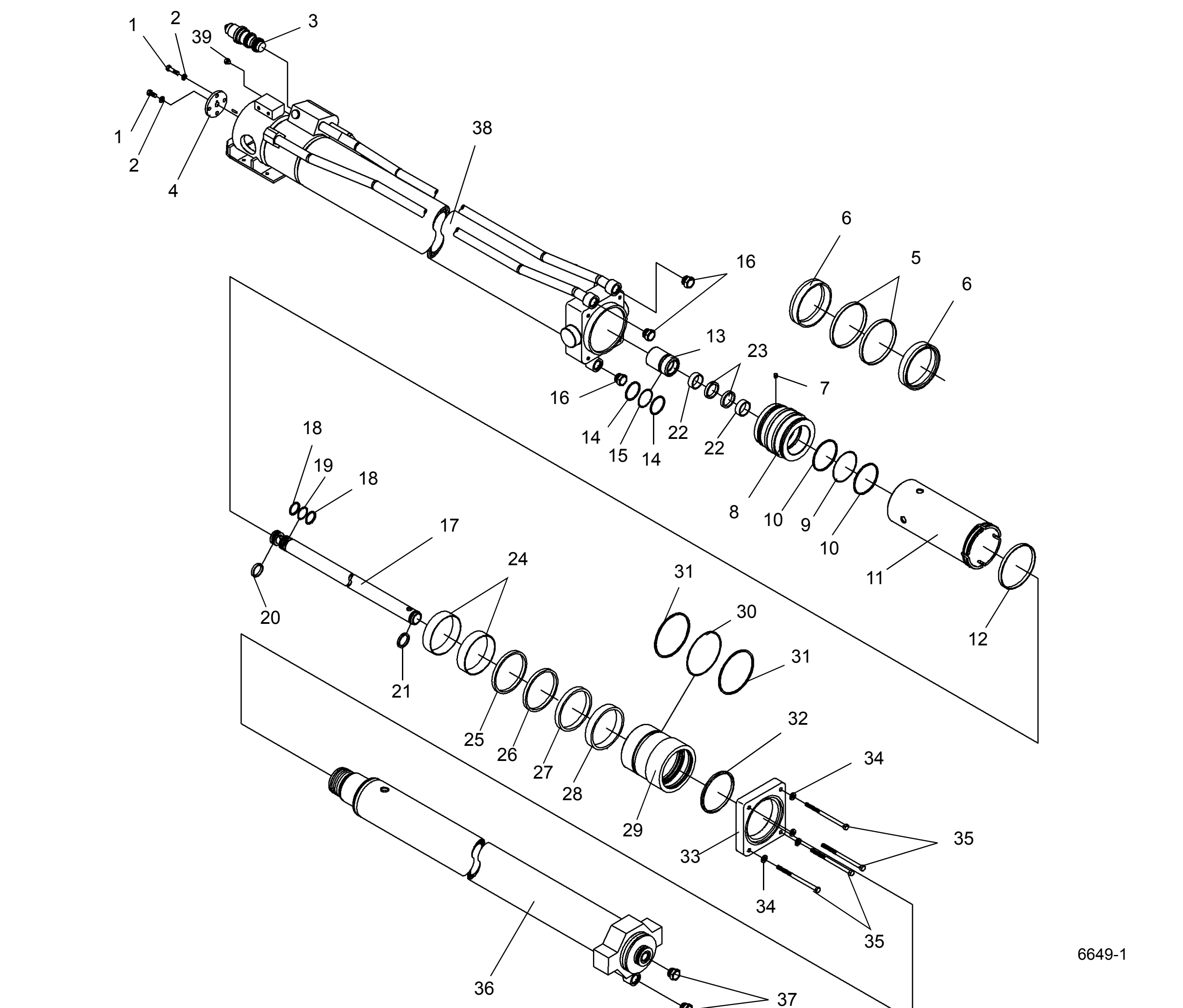


FIGURE 2-43

Item	Description
1	Capscrew
2	Flatwasher
3	Holding valve
4	Plate
5	Wear Ring
6	Hydrolock Seal
7	Setscrew
8	Piston
9	O-ring

Item	Description
10	Backup Ring
11	Spacer
12	Wear Ring
13	Seal Retainer
14	Backup Ring
15	O-ring
16	Plug
17	Inner Rod
18	Backup Ring

Item	Description
19	O-ring
20	Polyseal Ring
21	Guidelock Ring
22	Wear Ring
23	Rod Seal
24	Wear Ring
25	Buffer Seal
26	Backup Ring
27	Rod Seal
28	Backup Ring
29	Head
30	O-ring
31	Backup Ring
32	Wiper Ring
33	Retaining Plate
34	Washer
35	Capscrew
36	Outer Rod
37	Plug
38	Barrel
39	Bleed Plug

15. Coat the threads of the 5/8 inch capscrew with Loctite #290. Install the rod end plate and bolt the plate to the inner rod end with the 5/8 inch capscrew and washer. Torque the bolt 144 to 156 lb-ft (195 to 211 Nm) Figure 2-44.

16. Install the 7/16 inch capscrews and washers into the inner rod retaining plate. Torque the capscrews 48 to 52 lb-ft (65 to 70 Nm) Figure 2-44.

17. Bolt the rod retaining plate to the cylinder barrel with the capscrews and washers. Torque the capscrews 106 to 115 lb-ft (144 to 156 Nm) in the sequence shown (see Figure 2-45).

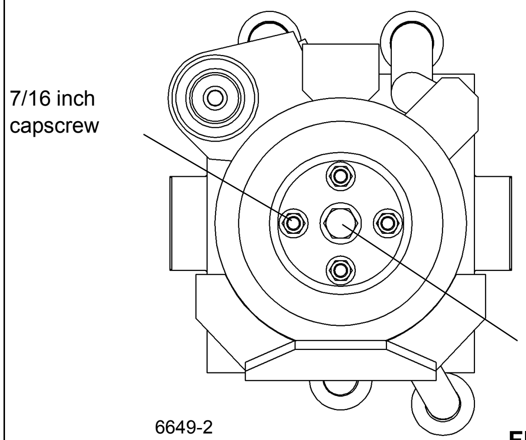


FIGURE 2-44

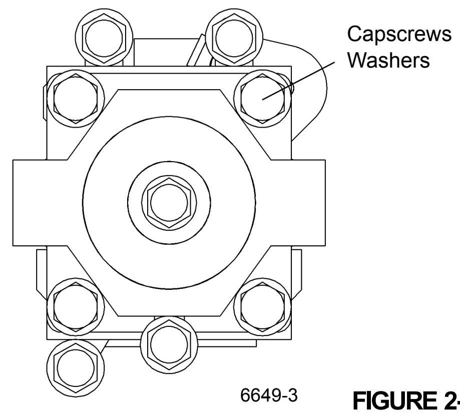


FIGURE 2-45

WARNING

Do not use air pressure to cycle or pressurize the cylinder.

18. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 4500 psi (31,026.4kPa). Check for proper operation and any leakage.

UPPER TELESCOPE CYLINDER

Description

The upper boom telescope cylinder Figure 2-46 has a 17.7 cm (7.0 inch) bore and is internally ported (rod ported). Oil from the telescope control valve is routed to the cylinder by external lines. Foreign material is prevented from entering the cylinder during rod retraction by a wiper ring in the head and O-ring seals prevent internal and external leakage. The retracted length of the telescope cylinder is 399 in (1013.5 cm) and the extended length is 746.5 in (1896.1 cm) from the end of the barrel to the end of the port block on the rod.

The cylinder weighs 2181.9 lb (989.7 kg).

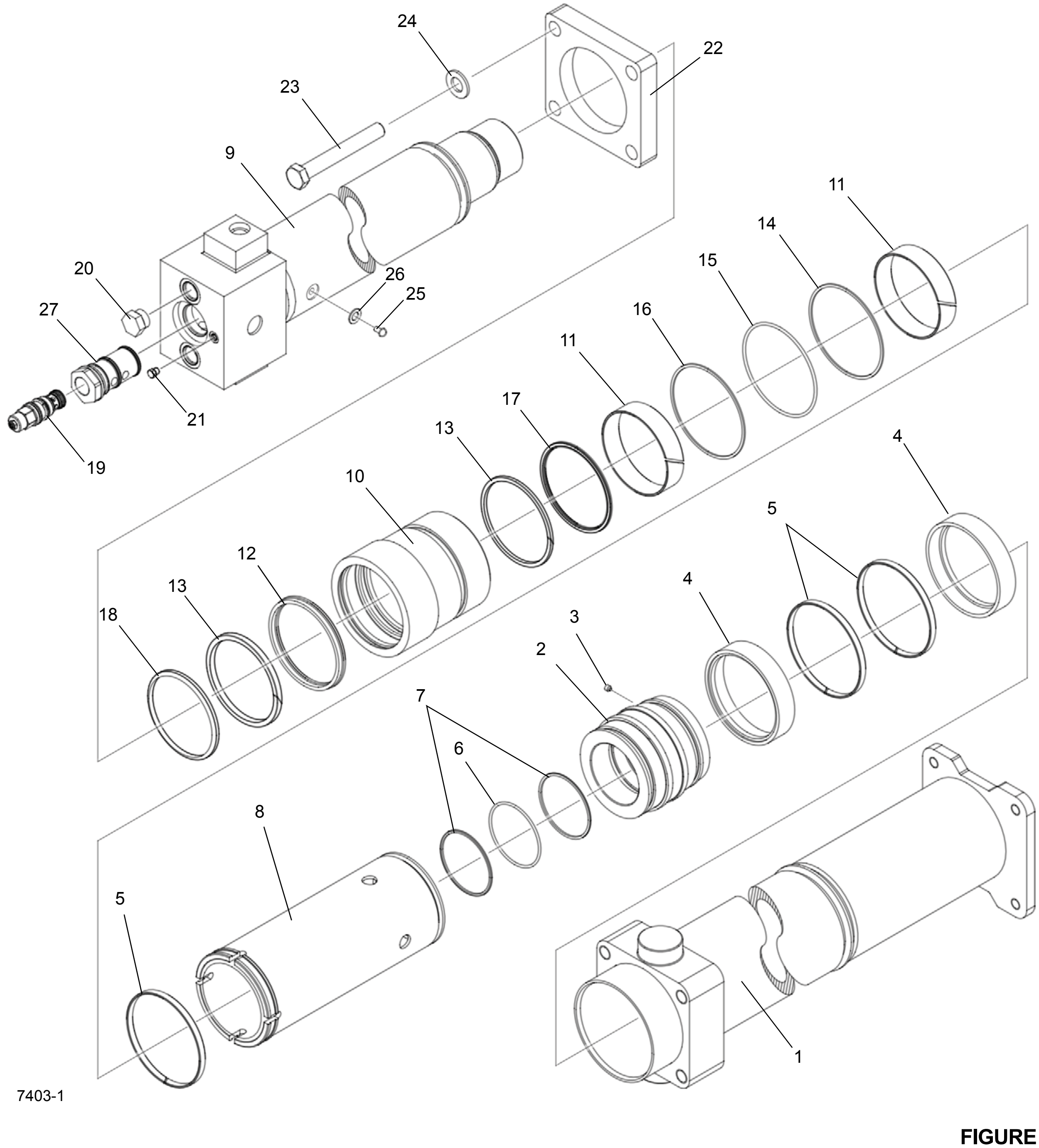


FIGURE 2-46

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

Maintenance

Disassembly

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

1. Remove the capscrews and washers securing the retaining ring to the barrel.

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

CAUTION

Do not use air pressure to remove the cylinder rod. Use only controlled hydraulic pressure.

Do not damage the cylinder rod chrome surface.

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

CAUTION

Do not scratch the grooved and gland surfaces.

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

4. Remove the guide lock ring at the top of the piston to gain access to the setscrew securing the piston to the cylinder rod.

5. Remove the setscrew and discard.

6. Unscrew the piston from the rod.

7. Remove the hydrolock seal assemblies and wear rings from the outside of the piston.

8. Remove the O-ring and backup rings from the inside of the piston.

9. Remove the spacer from the rod and the wear ring from the spacer.

10. Remove the cylinder head from the rod.

11. Remove the O-ring and backup ring from the outside of the cylinder head.

12. Remove the wear rings, buffer seal, backup rings, rod seal, and the wiper ring from the inside of the head.

13. If necessary, remove the holding valve from the rod.

Inspection

1. Clean all parts with solvent and dry with compressed air. Inspect all parts for serviceability.

CAUTION

Clean all surfaces and remove all burrs and nicks. Replace all damaged or worn parts.

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

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

4. Inspect the barrel for scoring.

Assembly

1. If removed, install the holding valve. Refer to *Valves*, page 2-31.

CAUTION

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

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

2. Install the wiper rings and wear ring on the inside of the cylinder head.
3. Install the buffer seal assembly and nylatron backup rings on the inside of the cylinder head.
4. Install the rod seal inside the head. Make sure the seals are properly assembled and installed in the correct direction Figure 2-47.

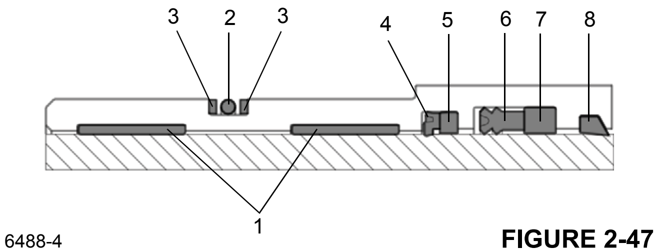


FIGURE 2-47

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

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

CAUTION

Improper seal installation could cause faulty cylinder operation.

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

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

9. Screw the piston onto cylinder rod and secure with a new setscrew.
10. Install the guide lock rings and hydrolock seals onto the outside of the piston Figure 2-48.

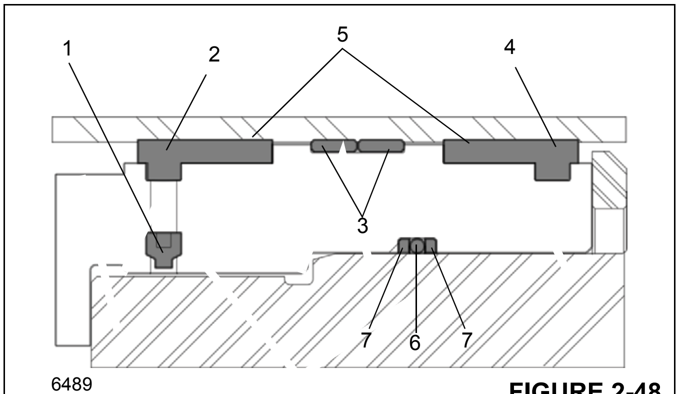


FIGURE 2-48

Item	Description
1	Setscrew
2	Guide Lock Ring
3	Wear Rings
4	Guide Lock Ring
5	Hydrolock Seals
6	O-ring
7	Backup Ring

11. Install the wear ring on the outside of the spacer.

CAUTION

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

12. Clean all oil from the threads of the cylinder head and apply Loctite #290 to the threads.
13. Lubricate the piston seals and cylinder head O-ring with clean hydraulic oil and install the rod assembly into the cylinder barrel with a slight twisting motion.
14. Using a chain wrench, secure the cylinder head to the cylinder barrel.
15. Install the retaining plate to the cylinder barrel and secure with the capscrews and washers. Torque the capscrews 88 to 96 lb-ft (120 to 130 Nm).

WARNING

Do not use air pressure to cycle the cylinder. Use only controlled hydraulic pressure.

16. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 4500 psi (31026.4 kPa). Check for proper operation and any leakage. Make repairs as needed.

AXLE OSCILLATION LOCKOUT CYLINDER

Description

The two oscillation lockout cylinders Figure 2-49 each have 5 in (12.7 cm) diameter bores. The retracted length of each cylinder is 19.21 in (48.7 cm) from the center of the lug holes to the center of the barrel bushing. The extended length of each cylinder from the center of the lug holes to the center of the barrel bushing is 25.8 in (65.5 cm). Its stroke is 6.62 in (16.8 cm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 86 lb (39 kg).

Maintenance

Disassembly

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

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

WARNING

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

CAUTION

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

2. Open both ports on the side of the cylinder barrel and drain the oil from the cylinder.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube preferably in the vertical position with the rod assembly up.
4. Using a screwdriver, or 1/4 inch wrench, remove the screw from the head.
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 when the rod assembly is extended. Make provisions to contain the oil.

7. Using a hoist, extend the rod assembly slowly until the piston is free of the barrel.
8. 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.

9. Remove the lip seals and wear rings from the outside of the rod piston.

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

10. Remove the retaining ring from the rod.
11. Remove the head from the rod. Remove the O-ring and backup ring from the outside of the head. Remove the wear ring, buffer seal, lip 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.

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.

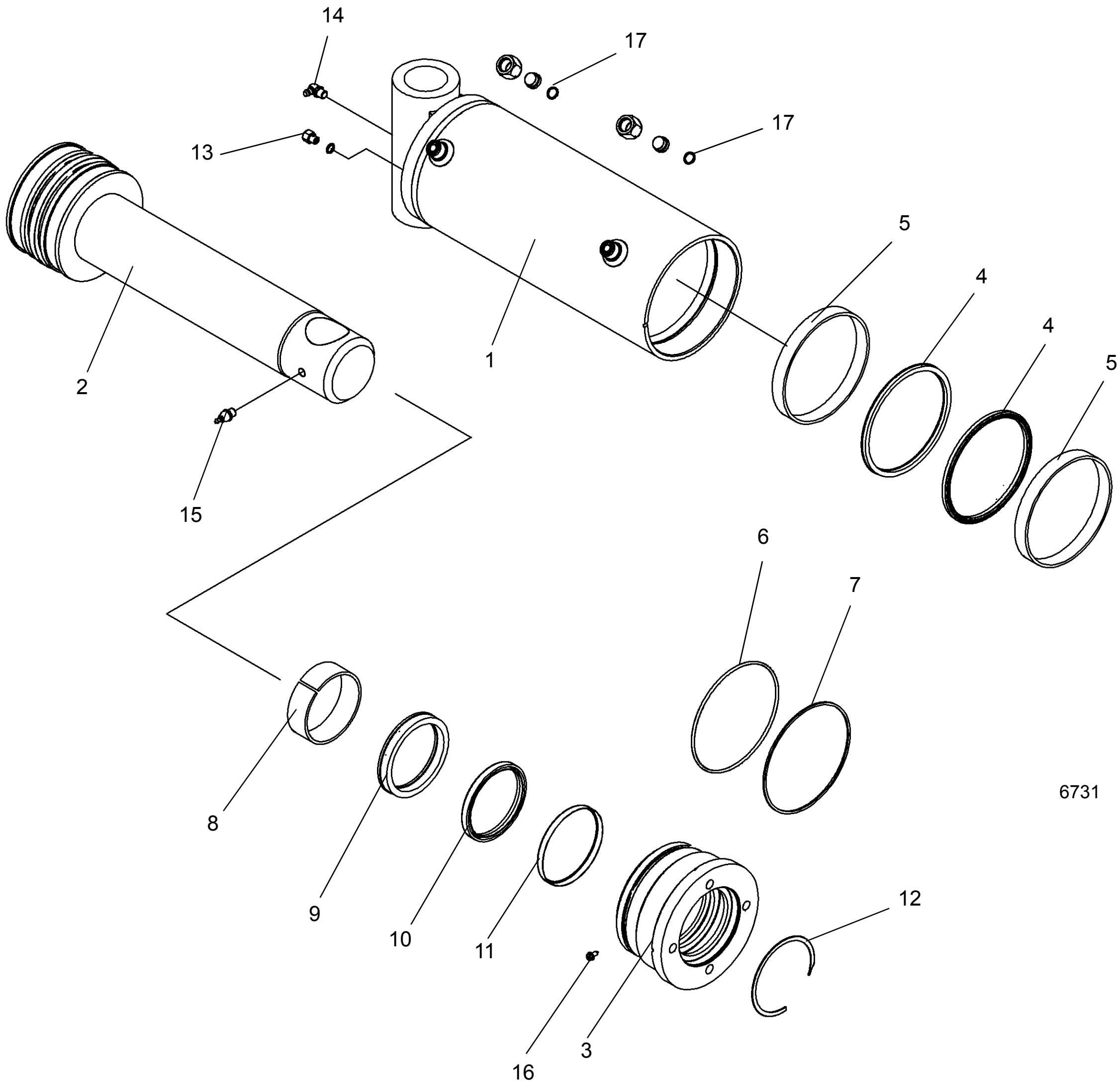


FIGURE 2-49

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

Item	Description
10	Lip Seal
11	Wiper Ring
12	Retainer Ring
13	Bleeder Plug
14	Grease Fitting
15	Grease Fitting
16	Screw
17	O-ring

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 hydraulic oil.

1. Install the replacement wiper ring, lip seal, buffer seal and wear ring in the inside of the head.
2. Install the replacement O-rings and backup ring on the outside of the head.
3. Install the lip seals and wear rings onto the outside of the piston.
4. Lubricate the rod with clean hydraulic oil.
5. Slide the head, onto the rod. Tap the head with a rubber mallet to engage the seals. Push the head about half way down the length of the rod assembly.
6. Remove the cover from the barrel.

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.

7. With a hoist, raise the rod assembly back into a vertical position taking care not to damage the OD seals on the head and piston.
8. Lubricate the OD seals on the piston and head with clean light oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
9. Place a spanner wrench on the head and turn counter-clockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the head shoulder and top of barrel.
10. Install the retaining ring onto the rod.
11. Install the setscrew into the head.

CAUTION

Do not use air pressure to cycle or pressurize the cylinder.

12. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 3750 psi (25,856 kPa). Check for proper operation and any leakage. Make repairs as needed.

STEER CYLINDER

Description

The steer cylinders Figure 2-50 are mounted on the axles, two cylinders on each axle. The front and rear steer cylinders each have 3.5 in (8.89 cm) diameter bores. The front and rear steer cylinders each have a retracted length of 26 in (66.0 cm) from bushing center to bushing center. The front and rear steer cylinders each have an extended length of 37.5 in (95.25 cm) from bushing center to bushing center. Each cylinder has a stroke of 11.50 in (29.21 cm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 44 lb (20 kg).

Maintenance

Disassembly

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

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

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

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

WARNING

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.

CAUTION

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

4. Position the rod mount with the ports facing down.
5. Using a means of collecting the oil, remove the port plugs and allow cylinder to drain.
6. Turn the head counterclockwise with a spanner wrench until the threads disengage.
7. With a hoist, extend rod slowly until the piston is free of the barrel.
8. Place the rod assembly on a surface that will not damage the chrome or allow the rod assembly to drop.
9. Cover the open end of barrel to avoid contamination.
10. Secure the rod assembly by clamping on the rod mount. Do not clamp on the chrome surface.
11. Remove the locknut and slide the piston off over the threads. Use a rubber mallet only if the piston will not pull or turn off.
12. Remove the head from the rod by hand.
13. Remove the seal and wear ring 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.

14. Remove the O-ring from the inside of the piston.
15. Remove the O-ring and backup ring from the outside of the head.
16. Remove the wiper ring and rod seal 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.

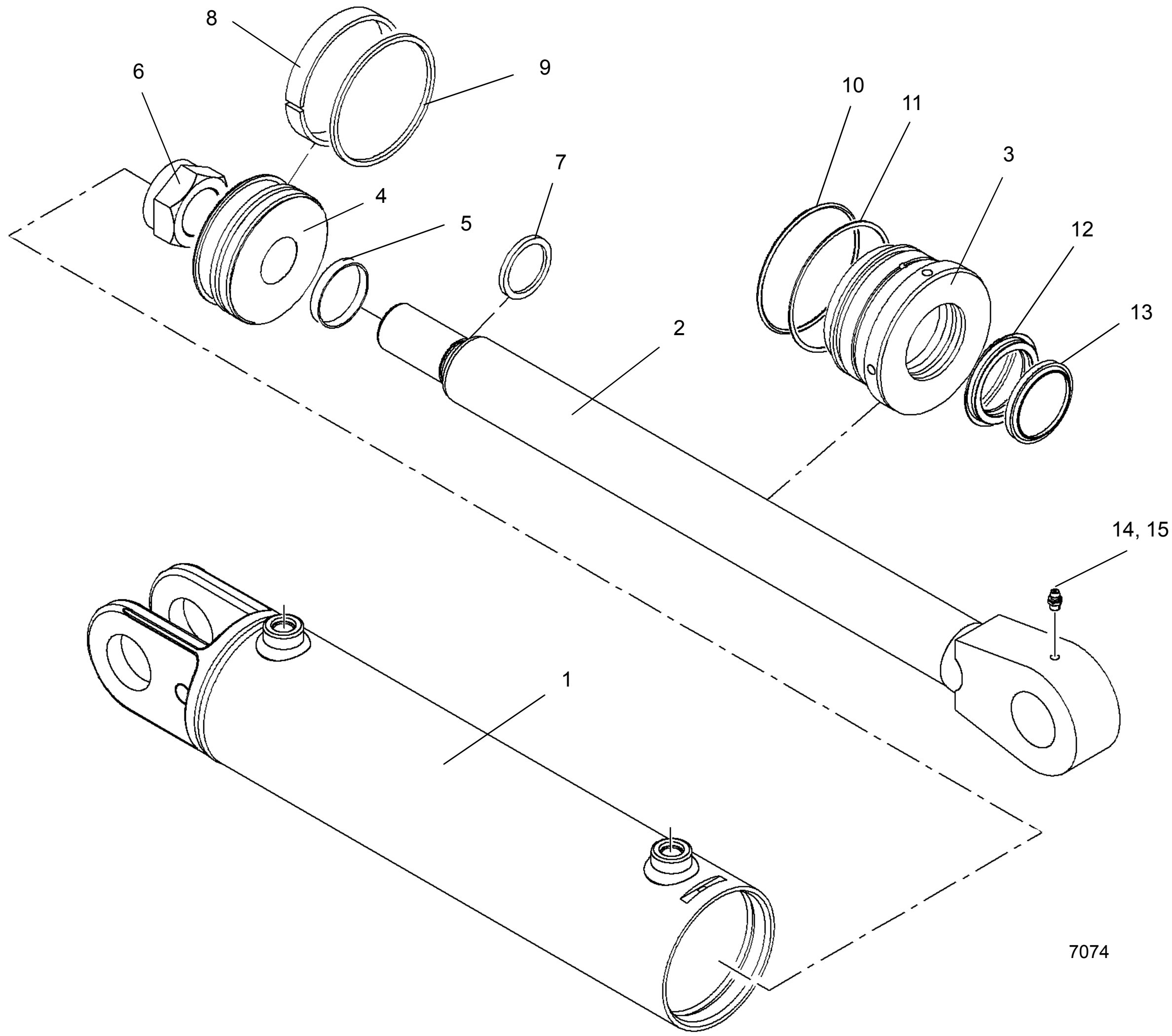


FIGURE 2-50

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

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

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 head and all seals and rings with clean hydraulic oil.

1. Install wiper ring and rod seal in the inside of head and the O-ring and backup ring on the outside of the head.
2. Install the O-ring on inside of piston and the seal and wear ring on the outside of the piston.
3. Place the rod on a clean table
4. Install the head using a rubber mallet to ensure the seals are engaged. Push the head about half way down the length of the rod assembly.
5. With a hoist, raise the rod assembly back into a vertical position taking care not to damage seals.
6. Brush piston seals and head seals with hydraulic oil.

CAUTION

Ensure there are no rags or other contaminants left in the cylinder barrel before installing rod assembly. Lubricate the barrel ID with hydraulic oil to ease the rod assembly installation.

7. Lower the rod into barrel. Stop just before the head enters the barrel.
8. Place a spanner wrench on the head and turn counter-clockwise until the threads click, then reverse direction to clockwise and thread on until there is no gap between the head shoulder and top of barrel.
9. Install piston onto rod.
10. Install the locknut onto rod.
11. Install the port plugs.

WARNING

Before testing, ensure all fittings, hoses, ball valves, and pump components are rated higher than test pressures. Do not use air pressure to cycle or pressurize the cylinder. Failure to do so could result in personal injury or death.

12. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 4000 psi (27,579 kPa) in both directions. Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER EXTENSION CYLINDER

Description

The four extension cylinders Figure 2-51 have 2.5 in (63.5 mm) diameter bores. Each cylinder has a retracted length of 93.88±12 in (238.4 cm ± 30.4) from the center of the rod bushing to the center of the barrel bushing. Each cylinder's extended length is 175.88 in (446.7 cm). The stroke of each cylinder is 82 in (208.2 cm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 100.3 lb (45.5 kg).

Maintenance

Disassembly

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

1. Remove all dirt, grease and other contaminants from around the ports and the head

WARNING

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.

CAUTION

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

2. Using a spanner wrench, unscrew the cylinder head.
3. Remove rod and attached parts from the barrel.

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

5. Remove the nut from the rod.
6. Remove the piston, spacer and head from the rod.
7. Remove the O-ring and the backup ring from the outside of the head.
8. Remove the rod seal, wear ring and wiper ring from the inside of the head.
9. Remove the O-ring from the rod.

Inspection

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

CAUTION

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

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

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

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

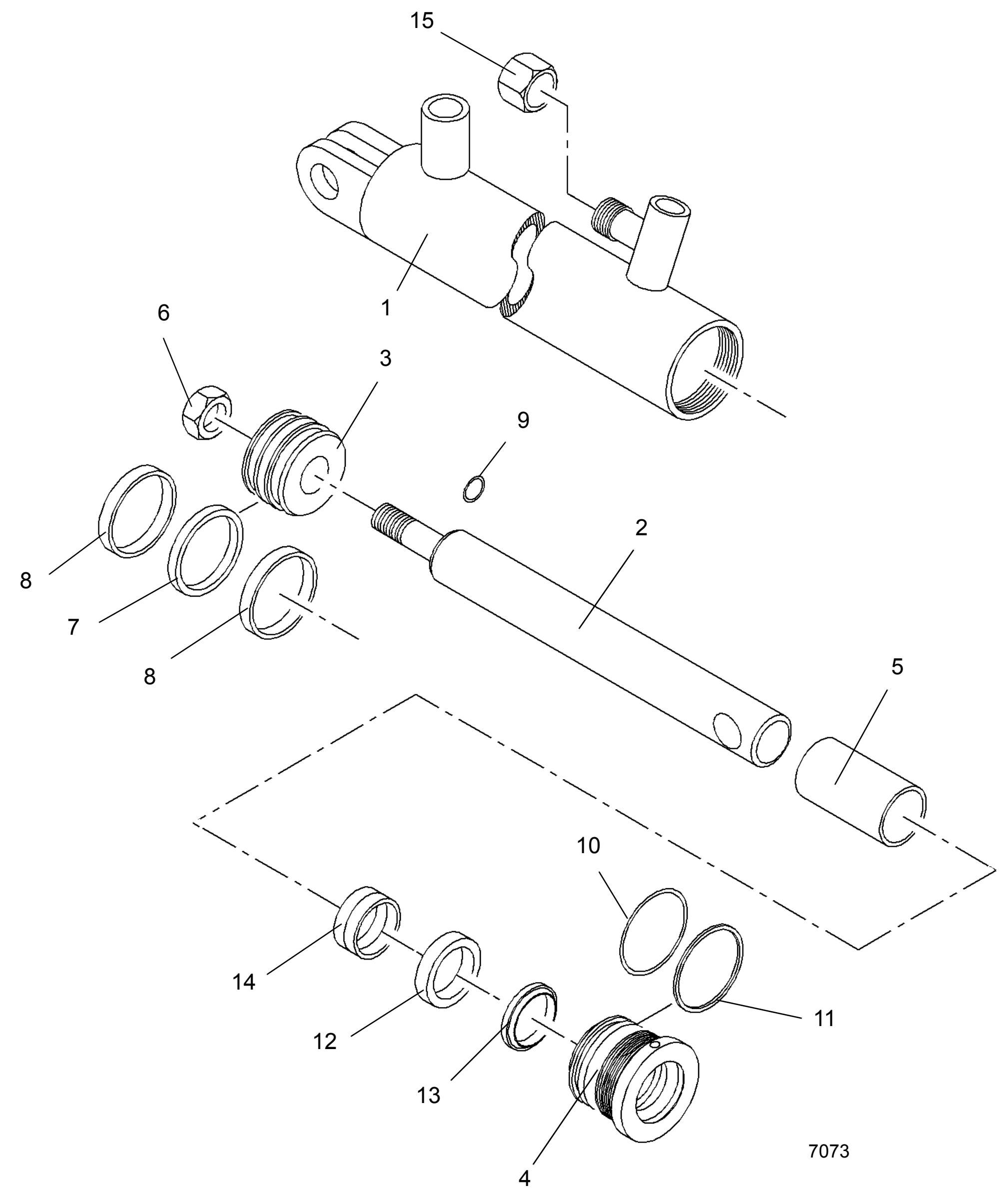


FIGURE 2-51

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

8. Install the replacement piston seal and wear rings on the outside of the piston.
9. 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, rings or seals during rod insertion.

10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
11. Push the head into the barrel.

WARNING

Do not use air pressure to cycle or pressurize the cylinder.

12. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 3500 psi (24,131.6 kPa). Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER JACK CYLINDER

Description

The four outrigger jack cylinders Figure 2-52 each have a hollow rod for internal porting. Each cylinder has a 5.5 in (13.9 cm) 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 50.62 in ±0.12 (128.5 cm ±30.8). The extended length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 78.62 in (199.6 cm). Its stroke is 28 in (71.1 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 228.8 lb (103.8 kg).

Maintenance

Disassembly

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

1. Open ports and drain the oil from the cylinder.

WARNING

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.

CAUTION

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

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2. Secure cylinder barrel in a chain vise preferably in the vertical position with the rod assembly at chest level.

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

3. With the ports open, extend the rod assembly with a hoist enough to access the top of the head with a spanner wrench. Do not extend completely.
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 assembly. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod.
6. Cover the open end of the barrel.
7. Secure the rod assembly using the pinholes. Do not use a clamp on the rod working surface.
8. Using an Allen wrench, remove the setscrew from the piston. The piston seal must be removed to access the setscrew.
9. Turn the piston counterclockwise with a fitted spanner wrench to remove.
10. Remove the spacer and head from the rod 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 O-ring and backup rings from the inside of the piston and the seals from the outside of the piston.
12. Remove the O-ring and backup ring from the outside of the head and the wear rings, 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. If barrel is scored, it must be repaired or replaced.

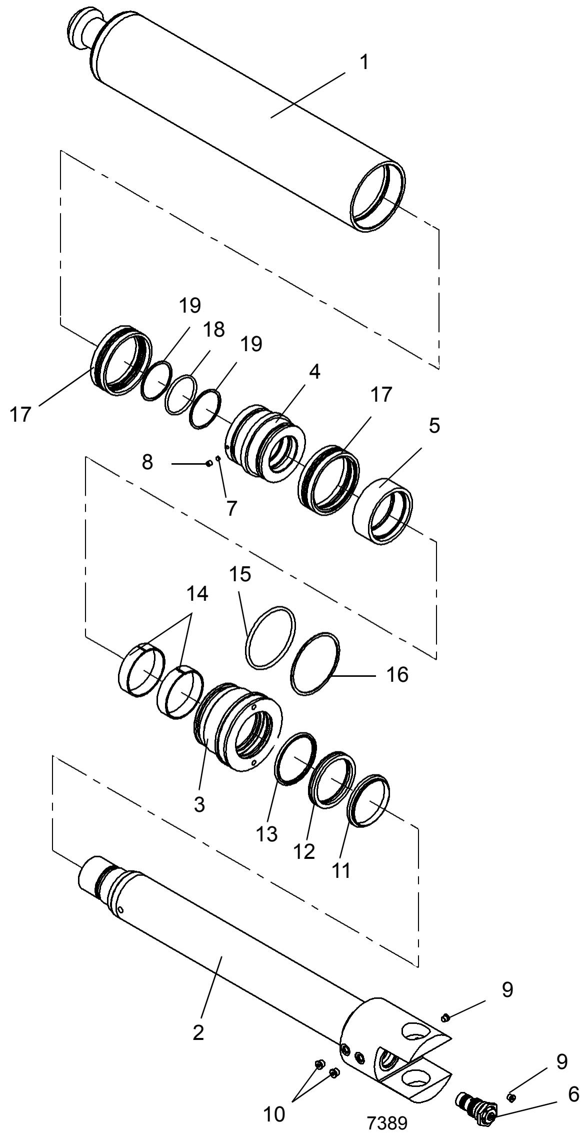

FIGURE 2-52

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

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

6. Thoroughly rinse parts, allow to drain, and wipe with a lint-free rag. Inspect all parts for serviceability.
7. Flush the barrel and fluid tube. Drain and wipe dry with a lint-free cloth. Compressed air may be used to blow out barrel port.
8. Inspect the bore of barrel for nicks, gouges or scratches. Replace barrel assembly if any of these conditions exist.

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.

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.

NOTE: Leave access to the setscrew hole on the piston by only partially installing the bottom ring of the piston seal into the groove leaving the gap in the ring at the hole location.

9. Install the wear rings, rod seal and wiper ring in the inside of the head and the O-ring and backup ring on the outside of the head.
10. Install the O-ring and backup rings in the inside of the piston and the seals on the outside of the piston.
11. Lubricate the ID of the head seals with clean light oil and slide the head onto the rod. The head will need to be tapped on with a rubber mallet to engage the seals. Push the head about half way down the length of the rod.
12. Install the spacer onto the rod with the ID lip at the piston end.
13. Lubricate the ID piston seals with clean light oil and thread the piston clockwise onto the rod assembly with the spanner wrench until it bottoms out.
14. Install the setscrew with an allen wrench until hand tight. Seat the piston seal bottom ring into the groove.
15. With the hoist, raise the rod assembly into a vertical position taking care not to damage the OD seals on the head and piston.
16. Lubricate the OD seals on the piston and head with clean light oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
17. Place the spanner wrench on the head and turn counter-clockwise while applying light downward force until threads engage. Continue turning 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.
18. Instal the setscrew with an Allen wrench until hand tight.
19. Slowly lower the rod down to the fully retracted position.

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

20. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 4500 psi (31,026.4 kPa) in both directions. Check for proper operation and any leakage. Make repairs as needed.

CAB TILT CYLINDER

Description

The cab tilt cylinder Figure 2-53 has a 2.50 in (6.35 cm) diameter bore. The retracted length of each cylinder is 20.94 in (53.1 cm) from the center of the rod bushing to the center of the barrel bushing. The extended length of each cylinder from the center of the rod bushing to the center of the barrel bushing is 29.1 in (73.9 cm). Its stroke is 8.25 in (20.9 cm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 19.9 lb (9.07 kg).

Maintenance

Disassembly

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

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

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

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

WARNING

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.

CAUTION

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

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

Inspection

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

CAUTION

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

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

Assembly

CAUTION

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

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

1. Install the replacement wiper ring into the head.
2. Install the rod seal in the inside of the head. Make sure the lips of the seal face the piston.

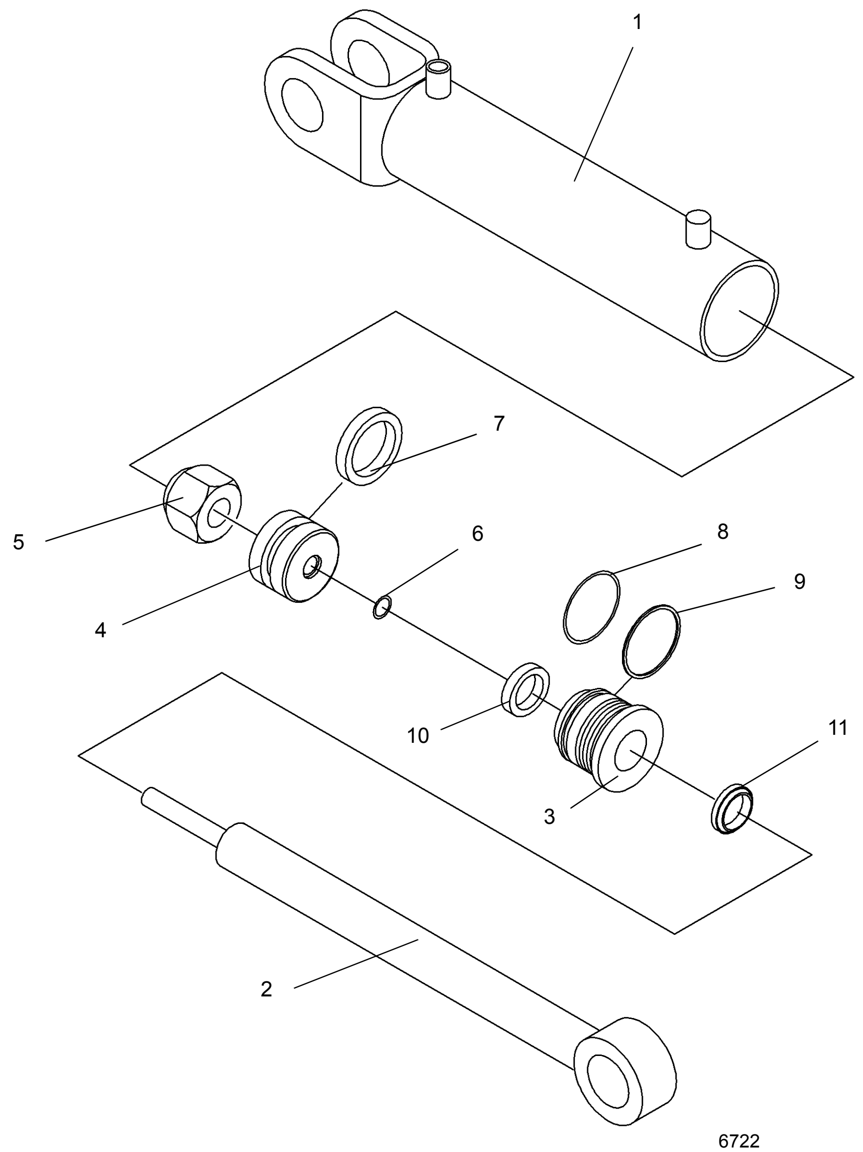

FIGURE 2-53

Item	Description
1	Barrel
2	Rod
3	Head
4	Piston
5	Locknut
6	O-ring

Item	Description
7	Piston Seal
8	O-ring
9	Backup Ring
10	Rod Seal
11	Wiper

3. Install the O-ring and backup ring onto the outside of the head.
4. Install the O-ring in the inside of the piston.
5. Lubricate the rod with clean hydraulic oil.
6. Slide the head, larger OD end first, onto the rod.
7. Install the piston onto the rod. Secure the piston with the nut. Lubricate the threads and torque the nut to 130 ± 5 lb-ft (176.2 ± 6.7 Nm).
8. Install the seal on the outside of the piston.
9. 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.

10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
11. Push the head into the barrel. Torque the head 20 lb-ft (27.1 Nm).

CAUTION

Do not use air pressure to cycle or pressurize the cylinder.

12. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 3000 psi (20,684 kPa). Check for proper operation and any leakage. Make repairs as needed.

COUNTERWEIGHT REMOVAL CYLINDER

Description

The counterweight removal cylinder, Figure 2-54, has a 3.50 in (8.89 cm) diameter bore. The retracted length of the cylinder is 9.25 in (23.4 cm) from the center of the rod bushing to the center of the barrel bushing. The extended length of the cylinder is 34.25 in (86.9 cm). The stroke of the cylinder is 25 in (63.5 cm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 93.9 lb (42.63 kg).

Maintenance

Disassembly

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

1. Remove the counterbalance valves from the port block.
2. Clean away all dirt from the head and ports. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.
3. Secure the cylinder with ports facing down using clamps or a vise to prevent rolling.
4. Using a means of collecting the oil, carefully remove the plugs. Since high pressure may be trapped in the cylinder, remove the port plugs and counterbalance valves and allow cylinder to drain
5. With the cylinder secured, pull the rod to full extension to remove additional oil. Keeping the rod supported, tap the rod back in 1 in (2.54 cm) after all oil has drained.
6. Using a spanner wrench, unscrew the head from the barrel. After unthreading, tap the head out with a rubber mallet and allow any excess fluid to drain into catch pan.

WARNING

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.

CAUTION

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

7. With the rod still supported, gently pull the piston from the tube assembly being careful not to cock the piston in the tube. Place the rod assembly on a surface that will not damage the chrome or allow the rod assembly to drop.

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

8. Remove the wear ring from the outside of the piston to gain access to the setscrew.

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.

9. Loosen the piston's setscrew. Remove the piston from the rod.
10. Remove the spacer from the rod.
11. Remove the other wear ring and seal from the outside of the piston.
12. Remove the head from the rod.
13. Remove the O-ring and backup ring from the outside of the head. Remove the rod seal, wiper and O-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.

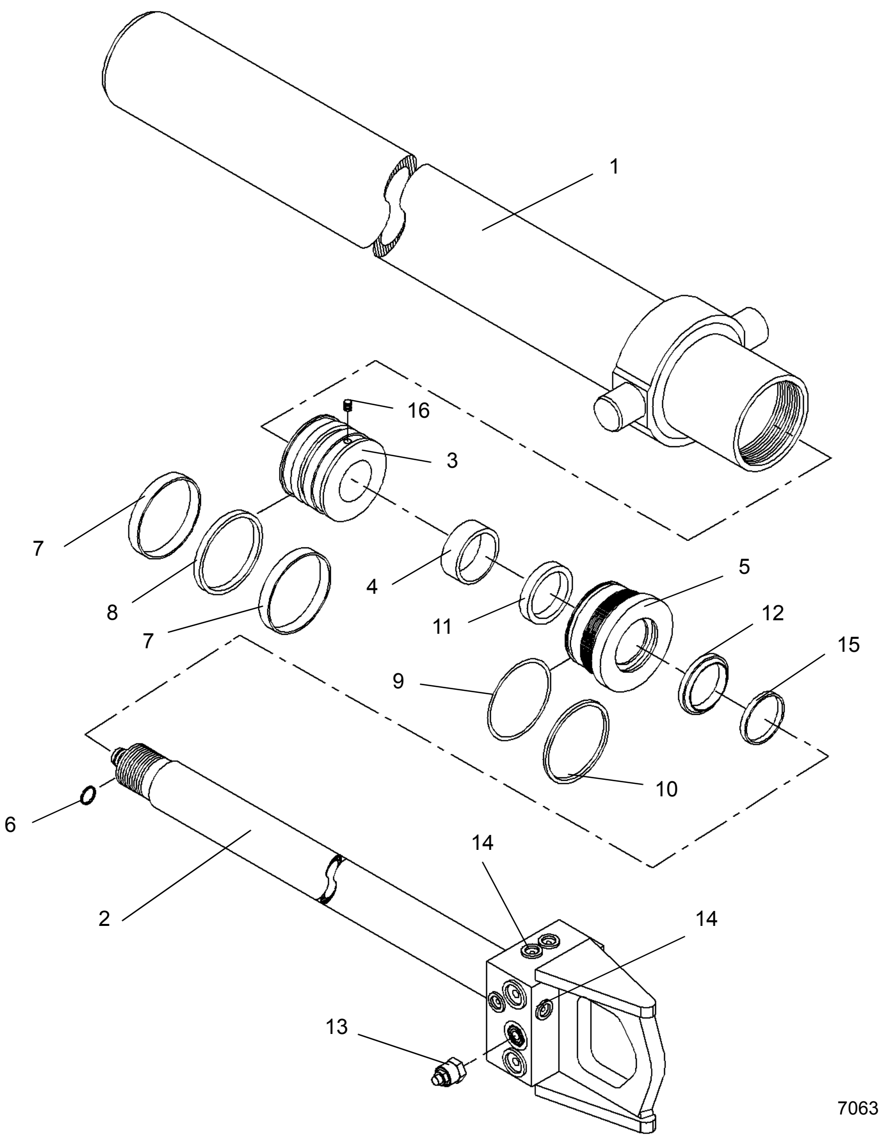

FIGURE 2-54

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

9	O-ring
10	Backup Ring
11	Rod Seal
12	Wiper Ring
13	Counterbalance Valve
14	Plug
15	O-ring
16	Setscrew

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 hydraulic oil.

1. Install the replacement O-ring, wiper, and rod seal in the inside of the head.
2. Install the replacement O-ring and backup ring on the outside of the head.
3. Install one replacement wear ring on the outside of the piston. Leave the other wear ring off for now so there is still access to the piston's setscrew hole.
4. Lubricate the rod with clean hydraulic oil.
5. Slide the head, larger outside diameter end first, onto the rod.
6. Slide the spacer onto the rod.
7. Screw the piston onto the rod until it can go no further. Hold the piston in place with the setscrew.
8. Install the other replacement wear ring on the outside of the piston over the setscrew.
9. 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.

10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
11. Clean all oil from the threads of the head. Coat the threads with an anti-seize compound (Never-Seez paste lubricant or similar). Using a chain wrench, screw the head into place on the barrel so its larger outside diameter end is flush with the end of the barrel.
12. Check the inside of the port block for any sharp edges or burrs and remove as necessary with emery cloth.
13. Lubricate the counterbalance valves with clean hydraulic oil.
14. Carefully install the counterbalance valves into the cylinder port block until fully seated.

CAUTION

Do not use air pressure to cycle or pressurize the cylinder.

15. Pressurize and cycle the cylinder with hydraulic oil pressure. Static test the cylinder at 3,000 psi (20,684 kPa). Check for proper operation and any leakage. Make repairs as needed.

COUNTERWEIGHT PIN CYLINDER

Description

The counterweight pin removal cylinder Figure 2-55 has a bore of 3.0 in (7.62 cm). The retracted length of the cylinder is 38 in (96.5 cm). The extended length of the cylinder is 50 in (127 cm). Its stroke is 12 in (30.4 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 69.9 lb (31.75 kg).

Maintenance

Disassembly

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

1. Using a spanner wrench, unscrew the rod end from the rod.

WARNING

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.

CAUTION

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

2. Using a spanner wrench, unscrew the head from the barrel.
3. 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.

4. Remove the locknut and unscrew the piston from the rod.
5. Remove the wear ring and seal from the outside of the piston and O-ring from the inside of the piston.
6. Remove the head and spacer from the rod.
7. Remove the O-ring and the backup ring from the outside of the head. Remove the seal and wiper ring from the inside of the head.
8. Repeat steps 1 through 7 for the remaining rod assembly.

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.

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 hydraulic oil.

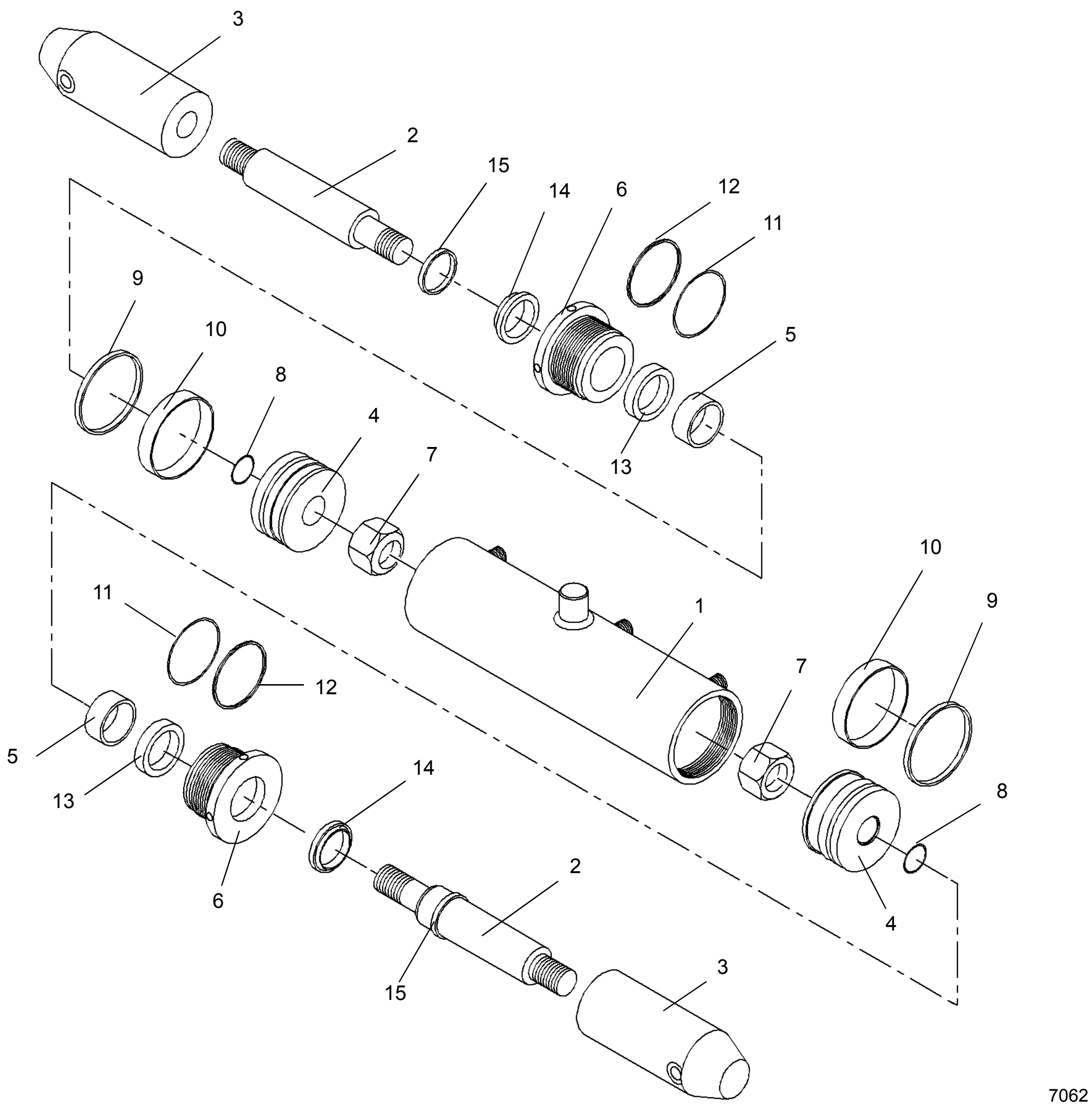

FIGURE 2-55

1	Barrel
2	Rod
3	Rod End
4	Piston
5	Spacer
6	Head
7	Nut
8	O-ring

9	Piston Seal
10	Wear Ring
11	O-ring
12	Backup Ring
13	Rod Seal
14	Wiper Ring
15	O-ring

1. Install the replacement seal and wiper ring in the inside of the head.
2. Install the replacement O-rings and the backup ring on the outside of the head.
3. Install the replacement O-ring in the inside of the piston.
4. Install the wear ring and piston seal on the outside of the piston.
5. Lubricate the rod with clean hydraulic oil.
6. Slide the head, wiper ring end first, onto the rod.
7. Install the spacer on the rod.
8. Screw the piston onto the rod tightly.
9. 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.

10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
11. Install new gasket material to the cylinder head retainer ring flange as follows.
12. Screw the head into the barrel.
13. Using a spanner wrench, continue to screw the head into place in the barrel.
14. Repeat steps 1 through 13 for the remaining rod assembly.

CAUTION

Do not use air pressure to cycle or pressurize the cylinder.

15. Pressurize and cycle the cylinder with hydraulic oil pressure. Static test the cylinder at 3000 psi (20,685 kPa). Check for proper operation and any leakage. Make repairs as needed.

AXLE OSCILLATION LOCKOUT CYLINDER (CE OPTION)

Description

The lockout cylinders Figure 2-56 have 5 in (12.7 cm) diameter bores. The retracted length of each cylinder is 19.25 in (48.8 cm) from the center of the lug holes to the center of the barrel bushing. The extended length of each cylinder from the center of the lug holes to the center of the barrel bushing is 25.8 in (65.5 cm). Its stroke is 6.62 in (16.8 cm). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 102 lb (45.3 kg).

Maintenance

Disassembly

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

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

WARNING

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

CAUTION

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

2. Drain the oil from the cylinder.
3. Secure cylinder barrel in a vise.
4. Remove the grease fitting from the rod.
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 when the rod assembly is extended. Make provisions to contain the oil.

6. Using a hoist, extend the rod assembly slowly until the piston is free of the barrel.
7. 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.

8. Remove the lip seals and wear ring 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.

9. Remove the hydrolock seals and guide lock ring from the outside of the piston.
10. Remove the head from the rod.
11. Remove the O-ring and backup ring from the outside of the head.
12. Remove the wear ring, 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.
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.

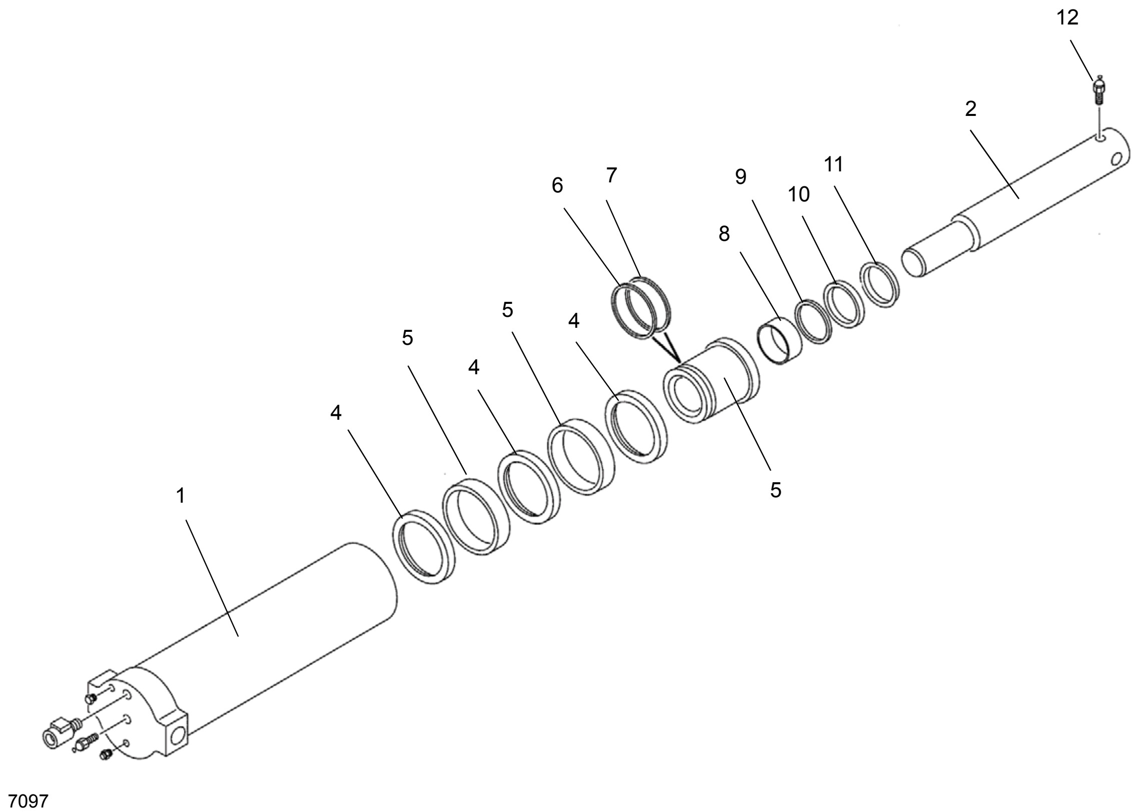

FIGURE 2-56

Item	Description
1	Barrel
2	Rod
3	Hydrolock Seal
4	Guidelock Ring
5	Head
6	O-ring
7	Backup Ring
8	Wear Ring
9	Buffer Seal
10	Rod Seal
11	Wiper Ring
12	Grease Fitting

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 hydraulic oil.

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

5. Slide the head, onto the rod. Tap the head with a rubber mallet to engage the seals. Push the head about half way down the length of the rod assembly.
6. Remove the cover from the barrel.

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.

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

CAUTION

Do not use air pressure to cycle or pressurize the cylinder.

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 3750 psi (25,856 kPa). Check for proper operation and any leakage. Make repairs as needed.

PARK BRAKE CYLINDER

Description

The park brake cylinder, mounted on the front axle, releases and applies the park brake. The park brake cylinder consists of a hydraulic cylinder and a lever. When the operator positions the Park Brake Switch to ON, the park brake solenoid valve de-energizes and closes the valve, removing hydraulic force from the cylinder’s piston. This allows the cylinder’s spring to extend, retracting the cylinder lever, and applying the park brake to hold the crane in place. When the operator positions the Park Brake Switch to OFF, the park brake solenoid valve energizes and opens the valve to apply hydraulic force to the cylinder’s piston. This allows the piston to compress the spring, extend the cylinder lever, and release the park brake.

SECTION 3
ELECTRIC SYSTEM

SECTION CONTENTS

3

DESCRIPTION

General

The electrical system is 12-volt operation with 12-volt starting, consisting of an alternator and three lead-acid batteries. The system is single wire negative ground return type.

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 *Electrical Swivel*, page 6-16.

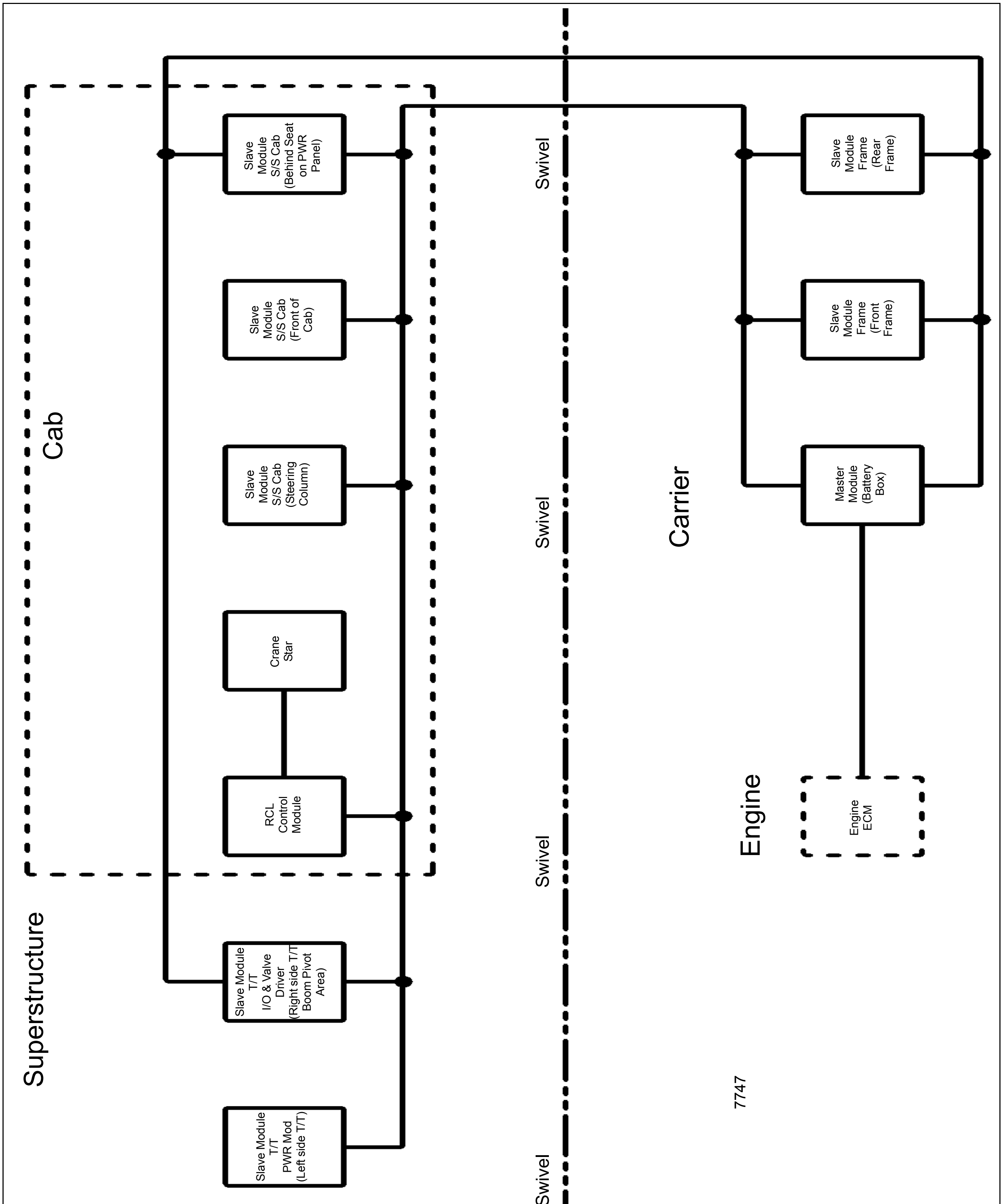
Superstructure
Cab
Slave Module S/S Cab (Behind Seat on PWR Panel)
Slave Module S/S Cab (Front of Cab)
Slave Module S/S Cab (Steering Column)
Crane Star
RCL Control Module
Slave Module T/T I/O & Valve Driver (Right side T/T Boom Pivot Area)
Slave Module T/T PWR Mod (Left side T/T)
Swivel
Swivel
Swivel
Swivel
Carrier
Slave Module Frame (Rear Frame)
Slave Module Frame (Front Frame)
Master Module (Battery Box)
Engine
Engine ECM
7747

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.

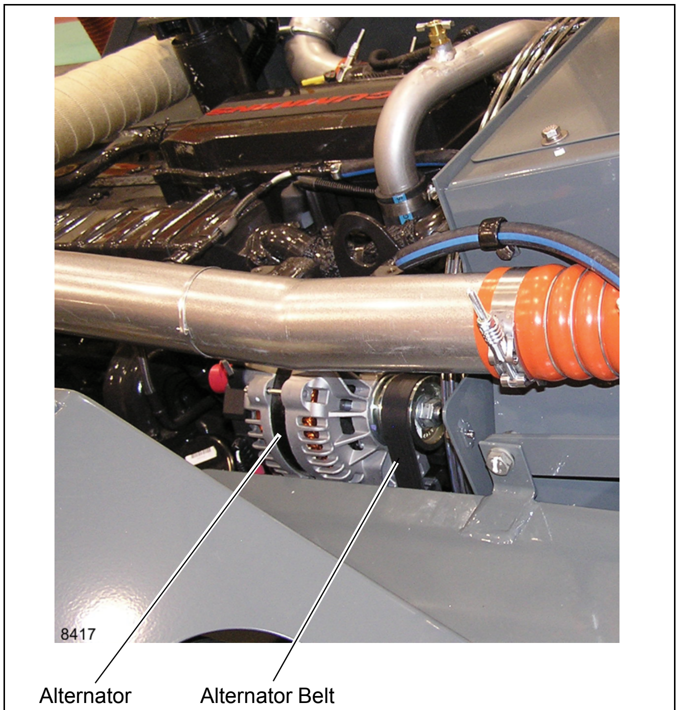

FIGURE 3-2

Batteries

The batteries are located in a box on the left side of the crane behind the hydraulic oil cooler. 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.

A Battery Disconnect Switch is located on the side of the battery box (Figure 3-3). To disconnect the batteries, wait two minutes after turning Ignition Switch OFF and then turn the Battery Disconnect Switch to OFF. Turn the switch to ON to connect the batteries.

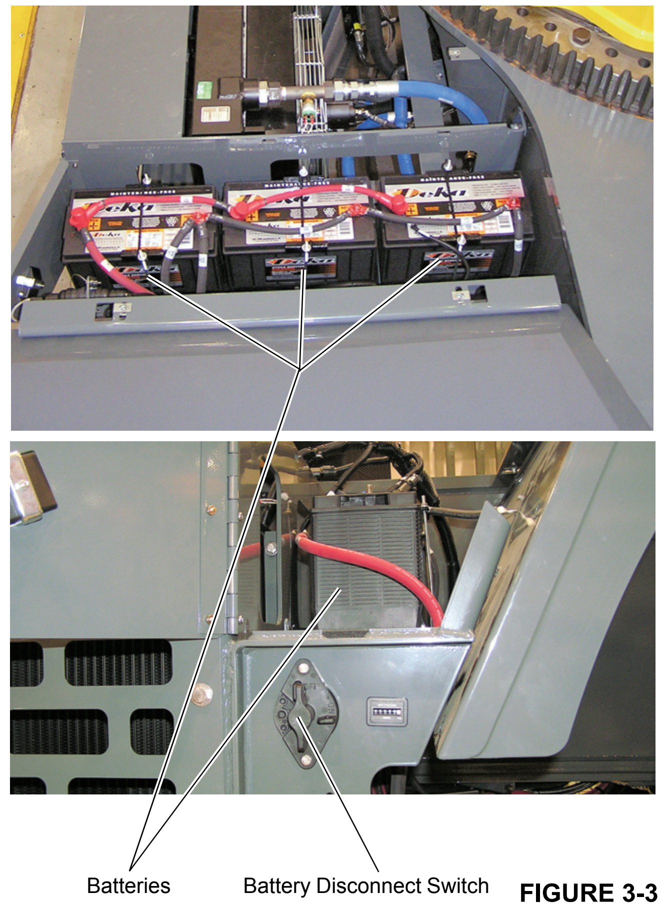

FIGURE 3-3

Cab Electrical Panel

The cab electrical panel (7, 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 (4) (Figure 3-4) securing the panel cover.

The two accessory relays (10, 11) (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 (3) (Figure 3-4) in the cab electrical panel contains twenty fuses. Fuses 1 - 5 are energized when the battery is connected. When the battery is connected and the ignition switch is at the RUN position, fuses 6 - 8 are energized, fuses 9-12 are energized through ACC relay #1, and 13-20 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.

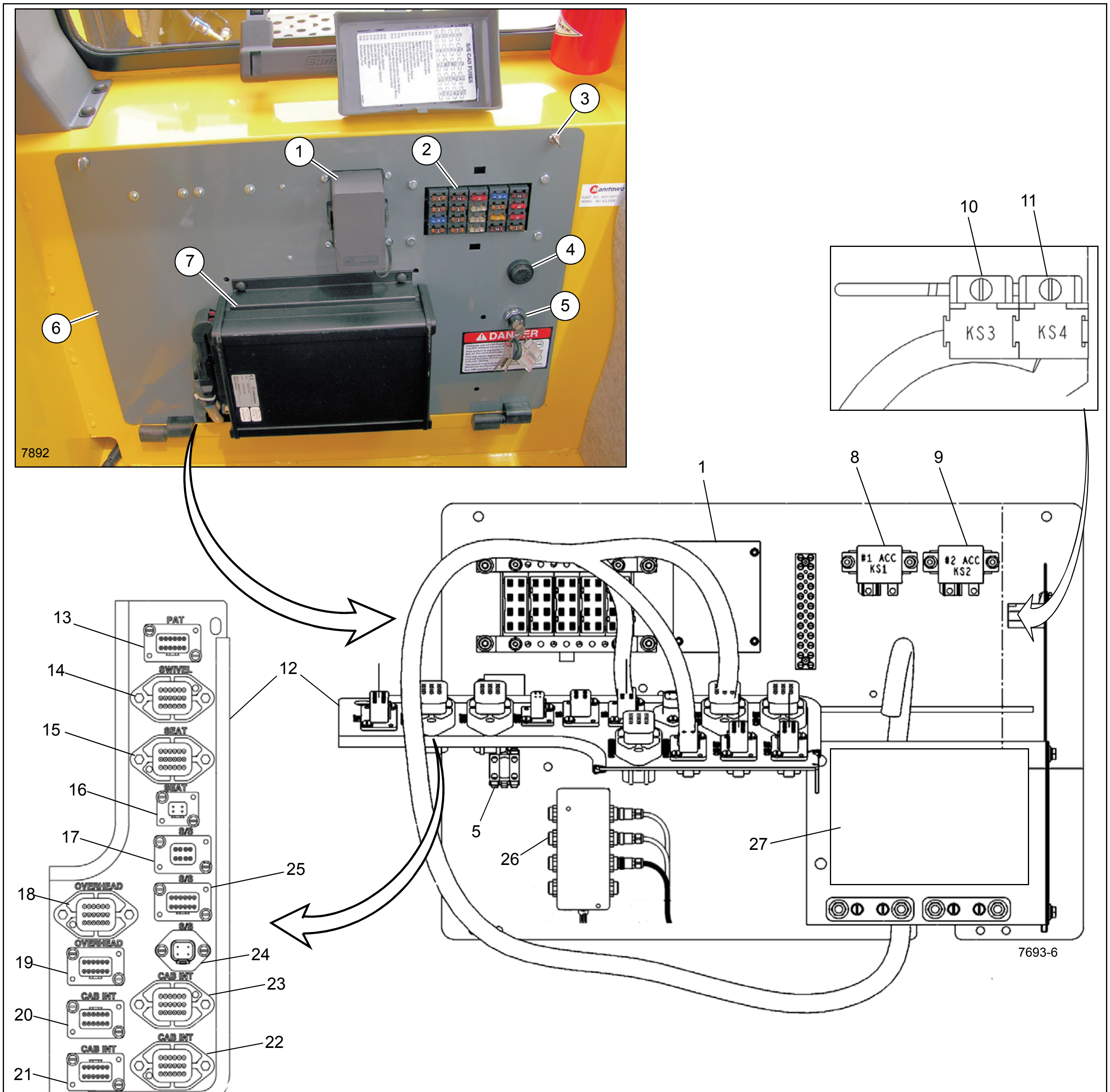

FIGURE 3-4

Figure 3-4 Item Numbers

Item	Component
1	Diode Box
2	Fuse Box (see Figure 3-5)
3	Panel Screw
4	Fast Pulse Buzzer Alarm
5	RCL Override Switch
6	Electrical Panel
7	RCL Controller
8	ACC Relay, Cab Modules & T/T Modules Power
9	ACC Relay, Jib Stow, RCL, Jib Option
10	Relay, Windshield Wiper Low Speed
11	Relay, Windshield Wiper High Speed

Item	Component
12	Connector Bulkhead
13	Cab Interior Harness
14	Swivel Harness
15	Seat Harness
16	Seat Harness
17	Superstructure Harness
18	Overhead Harness
19	Overhead Harness
20	Cab Interior Harness
21	Cab Interior Harness
22	Cab Interior Harness
23	Cab Interior Harness
24	Superstructure Harness
25	Superstructure Harness
26	CAN Junction Box (125K)
27	Cab Module

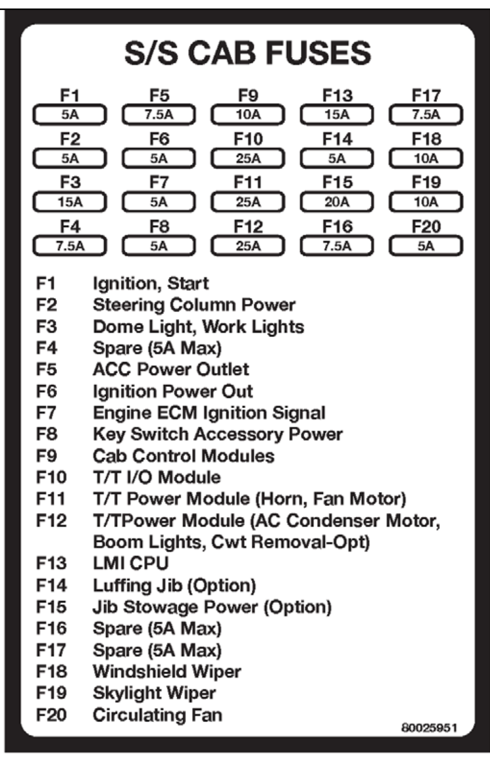

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FIGURE 3-5

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
- 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
- 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 (3) (Figure 3-6) is located on the fuel tank side of the crane, under the battery box assembly.

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

The coil of the start relay (7) (Figure 3-6) is energized when the batteries are connected, the start message from the steering column is present, the emergency stop switch is not activated, the engine is not running, and if the crane is equipped with a Tier 4 engine, the starter lockout signal from engine ECM must be present.

The coil of the grid heater relay (8) (Figure 3-6) is energized when the batteries are connected, the ignition switch is in the RUN position, and the output from the engine ECM to the grid heater coil must be energized.

The 250A fuse (10) (Figure 3-6) protects the batteries, the alternator, and the battery/alternator charge line. The 100A fuse (9) (Figure 3-6) protects those circuits that receive power when the battery disconnect switch is closed. The 250A fuse (5) (Figure 3-6) and the three 100A fuses (13, 14, 15) (Figure 3-6) receive power when the main power relay is energized. The 250A (5) protects the grid heater circuit and the three 100A fuses (13, 14, 15) protect the main feeds to all other circuits.

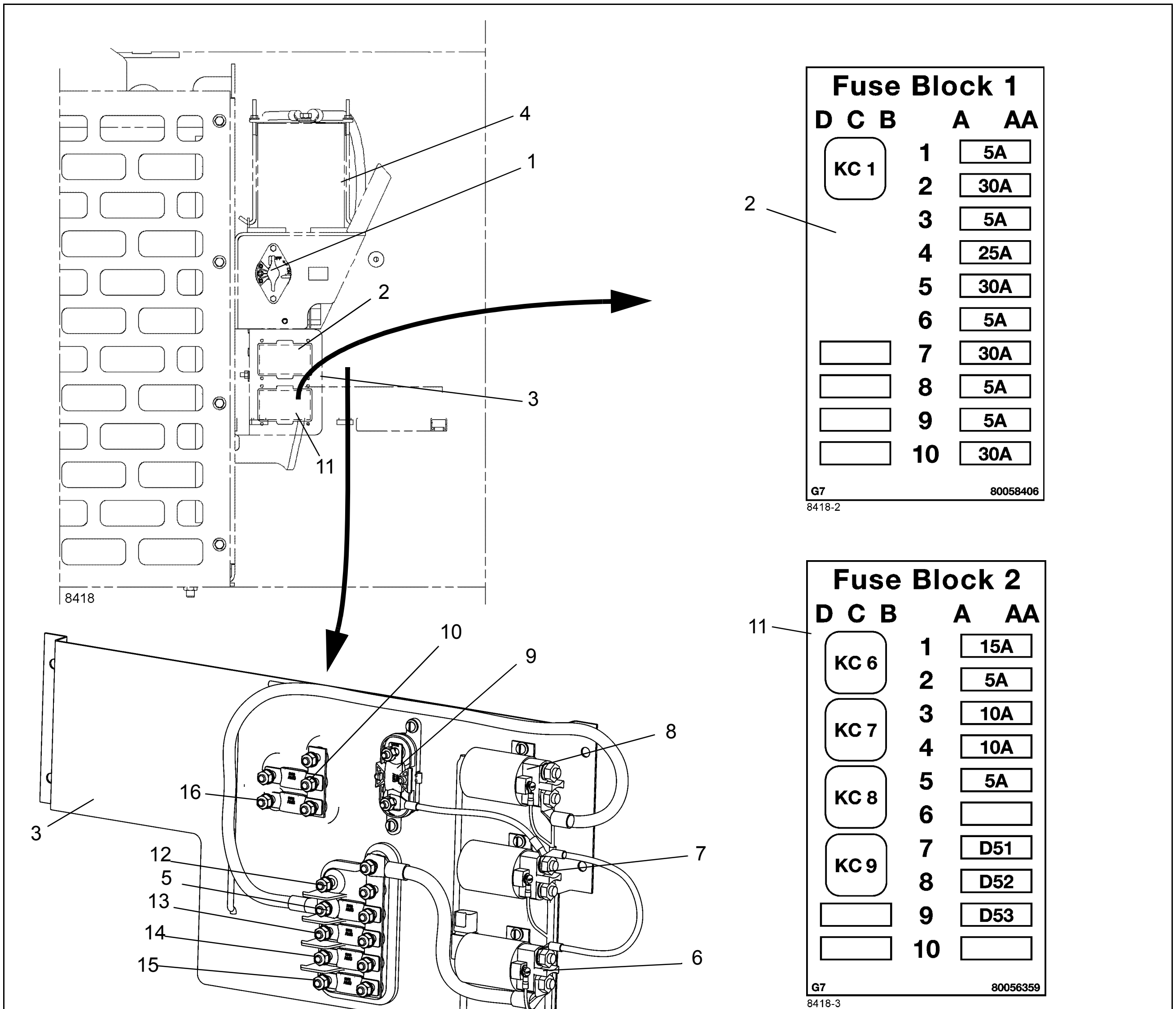

FIGURE 3-6

Figure 3-6 Item Numbers

Item	Description
1	Battery Disconnect Switch
2	Fuse Block 1 (See Table)
3	Fuse Panel Assembly
4	Battery Box
5	250 Amp Fuse, Grid Heater
6	Main Power Relay (K301)
7	Starter Relay (K303)
8	Grid Heater Relay (K302)
9	100 Amp Fuse, Starter Relay/Engine
10	250 Amp Fuse, Alternator
11	Fuse Block 2 (See Table)
12	Fuse Holder
13	100 Amp Fuse, Cab KS1 Relay
14	100 Amp Fuse, Cab KS2 Relay
15	100 Amp Fuse, Battery Fuse Box
16	100 Amp Fuse, DEF Line Heater

Fuse Block 1 (Figure 3-6)

Fuse Number	Description
1	5 Amp, 12 V Battery
2	30 Amp, 12 V Engine ECM
3	5 Amp, Starter Lockout Relay
4	25 Amp, Carrier Center Module Power Outputs
5	30 Amp, Carrier Center Module Outputs
6	5 Amp, Spare
7	30 Amp, Carrier Front Module Outputs
8	5 Amp, Diagnostic Connector
9	5 Amp, Power Relay
10	30 Amp, Spare
KC1	Power Relay

Fuse Block 2 (Figure 3-6)

Number	Description
1	15 Amp, KC6 DEF Lines Heater
2	5 Amp, KC6 Relay
3	10 Amp, KC7 DEF Supply Module
4	10 Amp, KC9 A/T Sensors
5	5 Amp, A/T Sensor Relay
KC6	DEF Lines Heater Relay
KC7	DEF Supply Module Relay
KC8	Starter Lockout Relay
KC9	A/T Sensor Relay
D51	Hose Heating Pressure Line
D52	Hose Heating Return Line
D53	Hose Heating Suction Line

MAINTENANCE

General

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

WARNING

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 harnesses 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.

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.

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
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	Grove 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	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT48-00	9999100808
4, 6, 8, 10 gauge wire	HDT 04-08	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	Grove 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.
- If alternator charge lamp is illuminated on steering column display while engine is running, check alternator fuse.

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 ma) 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 14V.

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 145A, so the meter should read 130A to 135A.

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 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 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 off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. 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 to 27 lb-ft (36.6 Nm).
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 10 to 13 mm (3/8 to 1/2 inch) with your thumb. (Or, using a belt tension gauge, verify there is 267 to 578 N (60 to 130 lb) 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. Turn battery disconnect switch to the connected position.
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 off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the starter.

7. Remove the bolts holding the starter to the mounting pad. Remove the starter.

Installation

1. Place the starter on its mounting pad. Secure the starter with the bolts. Torque the bolts to 32 lb-ft (43 Nm).
2. Connect the electrical leads to the terminals as tagged during removal.
3. Connect the batteries.
4. Install the ECM power fuse.
5. Turn the battery disconnect switch to the ON position.
6. Close the engine compartment.

Check

1. Try to start the engine. Verify the starter starts the engine.
2. Start engine again, and listen for starter noises. Verify there is no abnormal noise indicating the starter's gear is meshing 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.

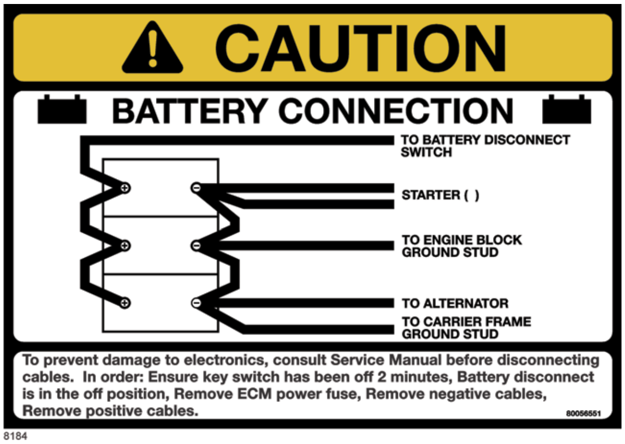

FIGURE 3-7

1. Ensure that the key switch has been off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove negative battery cables.
5. Remove positive battery cables.
6. 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. Turn the ignition switch to the OFF position.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Working behind the operator's seat, remove the hardware securing the panel cover and remove the cover.
5. Tag and disconnect the electrical leads from the suspect relay.
6. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
7. Install replacement relay on relay panel and secure it with attaching hardware.
8. Connect the electrical leads to the relay as tagged during removal.
9. Position the cover on the panel and secure with the attaching hardware.
10. Connect the batteries.
11. Turn the battery disconnect switch to the ON position.
12. 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 3-8 when removing/installing the gauge cluster.

Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the steering wheel by doing the following:
    a. Remove the steering wheel cap (1) using a twisting motion by pushing on the side of the cap closest to you with your thumbs while simultaneously pulling on the side of the cap farthest from you with your fingers.
    b. Remove the securing nut from the steering column shaft and remove the steering wheel (2).
7. Remove the four screws (13) securing the left and right side covers (8, 9) together.
8. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
9. Remove the left side cover (8) from the steering column.
10. Disconnect the wire harness from the back of the ignition switch (10).
11. Remove the right side cover (9) from the steering column.
12. Disconnect the wire harness from the bottom of the gauge cluster (5).
13. Remove the gauge cluster (5) from the gauge/switch cover (6) by pushing in on the left and right sides of the gauge cluster (5), then pushing the gauge cluster (5) up through the gauge/switch cover (6).

Installation

1. Install the gauge cluster (5) in the top of the gauge/switch cover (6) by pushing the gauge cluster (5) down through the top of the gauge/switch cover (6) until the gauge cluster's retaining clips click in place.
2. Connect the wire harness to the bottom of the gauge cluster (5).
3. Install the right side cover (9) on the steering column.
4. Connect the wire harness to the ignition switch (10).
5. Install the left side cover (8) on the steering column.
6. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
7. Secure the left and right side covers (8, 9) together using four screws (13).
8. Install the steering wheel (2); torque the securing nut to 30 lb-ft ±4 (40 Nm ±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 3-8 when removing/installing a switch.

Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).

5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the four screws (13) securing the left and right side covers (8, 9) together.
7. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
8. Remove the left side cover (8) from the steering column.
9. Disconnect the wire harness from the back of the ignition switch (10).
10. Remove the right side cover (9) from the steering column.
11. Disconnect the wire harness from the bottom of the switch (4) that must be replaced. Remove the switch by squeezing the retaining clips on each side of switch and pushing upwards until switch is free of cover.

Inspection

1. Visually check the switch for evidence of cracks, damaged connections, or other damage. Replace damaged switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Check all connectors for corrosion. Replace corroded components as needed.
4. Perform the following check to determine switch serviceability.
   a. Using an ohmmeter, check for continuity between the switch terminals with switch at ON or activated position(s). Ohmmeter should register zero ohms (continuity).
   b. Place switch at OFF or deactivated position. Ohmmeter should register infinity (no continuity).
   c. Replace switch if it fails either part of the check.

Installation

1. Remove the rocker (3) from the old switch by holding the switch by its sides in one hand and then squeezing the left and right sides of the rocker with the other hand and pulling up.
2. Orient the rocker (3) correctly relative to the new switch (4), then install rocker in switch.
3. Install the switch (4) in the gauge/switch cover (6) by pushing the switch (4) down through the top of the gauge/switch cover (6) until the switch's retaining clips click in place.
4. Connect the wire harness to the bottom of the switch (4).
5. Install the right side cover (9) on the steering column.
6. Connect the wire harness to the ignition switch (10).
7. Install the left side cover (8) on the steering column.
8. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
9. Secure the left and right side covers (8, 9) together using four screws (13).
10. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
11. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
12. Turn the battery disconnect switch to the ON position.

Check

1. Operate the switch per the Operator 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 3-8 when removing/installing the ignition switch.

Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the four screws (13) securing the left and right side covers (8, 9) together.
7. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
8. Remove the left side cover (8) from the steering column.
9. Disconnect the wire harness from the back of the ignition switch (10).
10. Remove the right side cover (9) from the steering column.
11. Remove the locking nut that secures the ignition switch (10) to the right cover (9) and remove the ignition switch (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 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 3-8 when removing/installing the turn signal lever or transmission shift lever.

Removal

1. Turn the ignition switch to the OFF position and remove the ignition key.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
5. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
6. Remove the steering wheel by doing the following:
   a. Remove the steering wheel cap (1) using a twisting motion by pushing on the side of the cap closest to you with your thumbs while simultaneously pulling on the side of the cap farthest from you with your fingers.
   b. Remove the securing nut from the steering column shaft and remove the steering wheel (2).
7. Remove the four screws (13) securing the left and right side covers (8, 9) together.
8. Remove the six screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
9. Remove the left side cover (8) from the steering column.
10. Disconnect the wire harness from the back of the ignition switch (10).
11. Remove the right side cover (9) from the steering column.
12. Disconnect the wire harness from the bottom of the gauge cluster (5).
13. Tag and disconnect the wire harness from the bottom of each switch (4).
14. Remove the gauge/switch cover (6) from the steering column.
15. Disconnect the wire harnesses from the bottom of the turn signal and transmission shift levers (7).
16. Remove the two bolts and nuts securing the two levers (7) together.

Installation

1. Align the location pins of the turn signal and transmission shift levers (7) with the holes in the steering column.
2. Secure the two levers (7) together using the two bolts and nuts.
3. Connect the wire harnesses to the levers (7).
4. Install the gauge/switch cover (6) on the steering column.

5. Connect the wire harness to the bottom of the gauge cluster (5).
6. Install the wire harnesses on the switches (4) as tagged during removal.
7. Install the right side cover (9) on the steering column.
8. Connect the wire harness to the ignition switch (10).
9. Install the left side cover (8) on the steering column.
10. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using six screws (14).
11. Secure the left and right side covers (8, 9) together using four screws (13).
12. Install the steering wheel (2); torque the securing nut to 30 lb-ft ±4 (40 Nm ±5).
13. Install the steering wheel cap (1).
14. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
15. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
16. Turn the battery disconnect switch to the ON position.

Check

1. Operate the turn signal lever or transmission shift lever per the Operator 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.

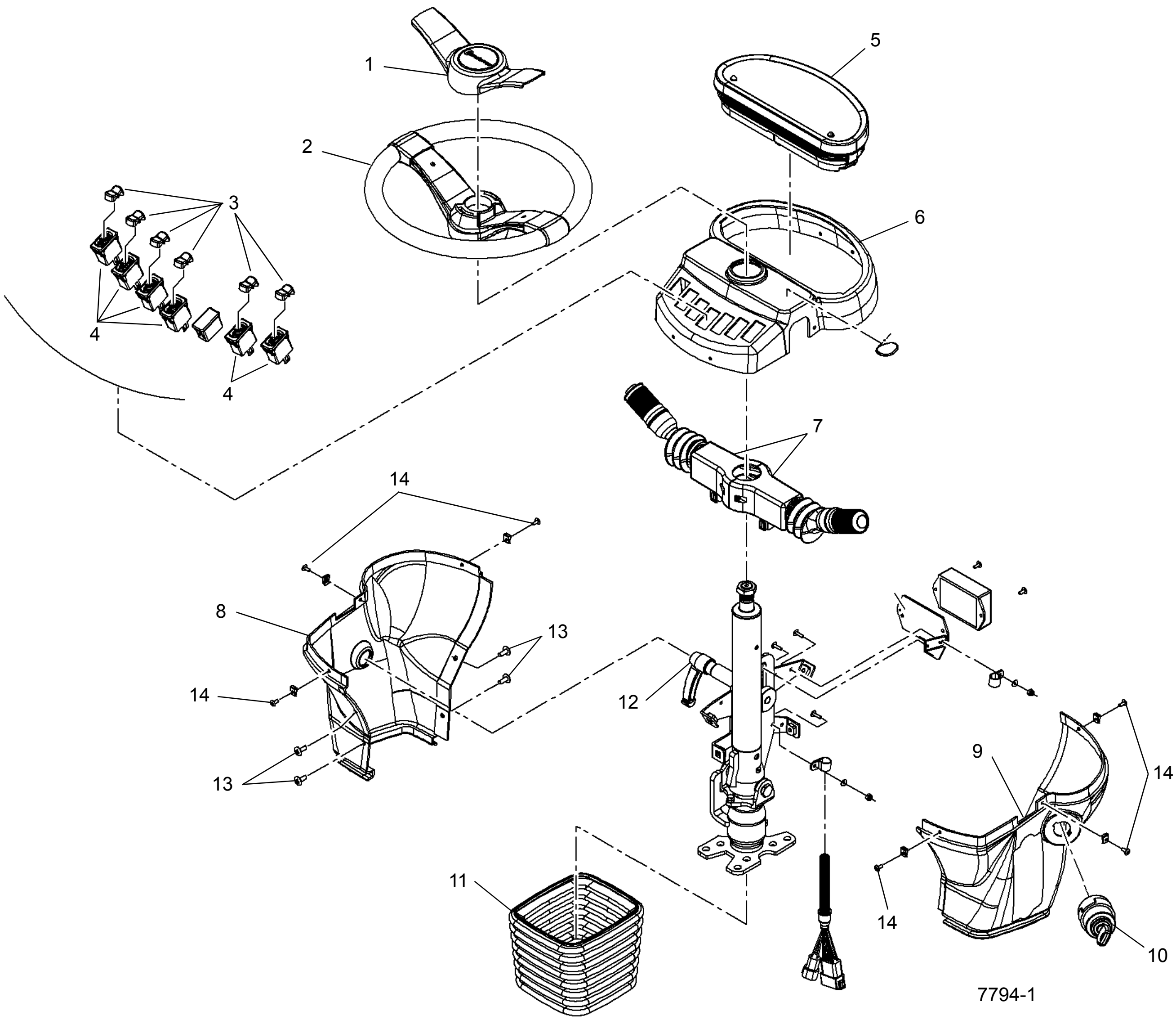

FIGURE 3-8

Windshield Wiper Assembly Replacement

Removal

1. Turn the ignition switch to the OFF position.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Tag and disconnect the electrical leads from the motor.
5. Disconnect the washer hose on the wiper arm (also called the pantograph arm assembly) from the washer nozzle fitting assembly.
6. 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.)
7. Remove the wiper arm from the pantograph adapter kit and the pivot shaft kit.
8. 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.)
9. 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.
10. Remove attaching hardware to free the windshield wiper motor bracket from the cab interior. Remove the bracket, with motor and pivot shaft connected, from the cab.

NOTE: You may have to remove or move other parts to get the bracket and attached parts around the steering column. Take care not to damage any parts.

11. Remove the nut to free the wiper motor's shaft from the wiper motor 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 3-9). 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.

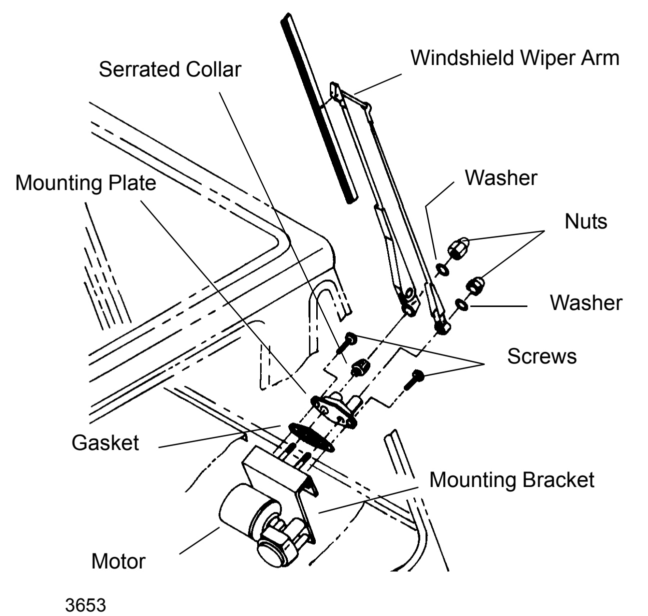

FIGURE 3-9

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. Turn the ignition switch to the OFF position.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
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. Turn the ignition switch to the OFF position.
2. Wait two minutes.
3. Turn the battery disconnect switch to the OFF position.
4. Tag and disconnect the electrical leads from the motor.
5. Remove the wiper arm from the motor shaft.
6. Remove the nut, spacer, leather washer, and nylon flat washer from the motor shaft outside the cab roof.
7. Remove the nut and lockwasher securing the motor bracket to the cab roof and remove the motor from the cab roof. Remove large nylon flat washer from motor shaft and flat washer and smaller nylon flat washer from mounting screw.
8. Remove mounting screw and nylon flat washer from outside cab roof.
9. Clean any sealing material from around holes in cab roof.

Inspection

1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts for damage. Replace as needed.

Installation

1. Install sealant material around both holes in cab roof, both inside and outside.
2. Install screw with nylon flat washer (from outside) through mounting hole in cab roof.
3. Install flat nylon washer on motor shaft and insert motor shaft through hole in cab roof. Position small nylon washer and flat washer on screw between mounting bracket and cab roof. Secure with lockwasher and nut.
4. Install nylon flat washer, leather washer, spacer, and nut on motor shaft. Tighten nut.
5. Install wiper arm and blade on motor shaft.

6. Connect the electrical leads to the wiper motor as marked before removal.
7. Turn the battery disconnect switch to the ON position.

Check

1. Operate the skylight wiper. Verify it works. (Replace wiper blade as needed if it streaks or otherwise wipes poorly.)

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 RT880E4. 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

Description

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. The light is illuminated anytime the ignition switch is in the on position.

Boom Mounted Floodlights

The boom lights switch is located in the cab overhead console panel. The switch is an On/Off rocker switch that will illuminate the lamps located on the underside of the boom.

Rear View Mirror

The rear view mirror installation consists of a rear view mirror mounted on the right side of the turntable. 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 Manual* 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 *Arctic Lubricants and Conditions*, page 9-3.)

Individual crane functions should be operated to ensure they are sufficiently warmed prior to performing a lift.

Operation of cranes at full rated capacities in ambient temperatures between -9°C and -40°C (15°F and -40°F) or lower should be accomplished only by competent operators who possess the skill, experience, and dexterity to ensure smooth operation.

Component Coolant Heater

A diesel fueled coolant heater circulates warm coolant through engine and crane components when operating during arctic temperatures. The coolant heater should be activated 2 hours before starting the crane to allow sufficient time to preheat fluids and assist with easy start-up conditions.

WARNING

Explosion Hazard!

Before switching on, check if the heater can be operated at the current site of the crane. There is a danger of explosion when using the heater around combustible objects! Do not park the vehicle near objects that are flammable.

Use caution near the exhaust tailpipe as it will also become very hot.

To activate the heater, ensure the fuel supply valve from the heater fuel reservoir is turned to the ON position. Ensure the battery disconnect switch is turned to the ON position and push the activation button at the heater control panel. A green light will illuminate indicating the system is activated. The start-up and shutdown cycles may take approximately 2 minutes for initialization. Ensure the coolant, transmission heater, swivel, battery heater, in-line fuel pump, in-line fuel heater, and hydraulic reservoir heater are heating properly.

To de-activate the heater, push the button at the heater control panel. The green light will turn off indicating the system is de-activated. The shutdown cycle may take approximately 2 minutes.

NOTE: Accelerated discharging of battery will occur when the crane engine is switched off. If you run the heater while the crane engine is stopped, the batteries voltage will need to be recharged after short periods of time.

Troubleshooting

In case of faults, please check the following points:

- If the heater does not start after being switched on:
  - switch the heater off and on again.
- If the heater still does not start, check whether:
  - There is fuel in the tank?
  - The fuses are OK?
  - The electrical cables, connections etc. are OK?
  - Anything is clogging the combustion air supply or exhaust system?
- Check the openings of the combustion air supply and exhaust system after longer standstill periods, clean if necessary!
- If the heater remains faulty even after these points have been checked, or another malfunction occurs in your heater, contact an authorized Manitowoc distributor or Manitowoc Crane Care.

Maintenance Instructions

- Switch the heater on once a month for about 10 minutes, even outside the heating period.
- Before the heating period starts, the heater should undergo a trial run. If persistent extreme smoke develops, unusual burning noise or a clear fuel smell can be perceived or if electric / electronic parts heat up, the heater must be switched off and put out of service by removing the fuse. In this case, the heater should not be started up again until it has been checked by qualified staff who have been properly trained.

SECTION 4
BOOM

SECTION CONTENTS

4

DESCRIPTION

One boom is available on the crane; a four section, full power, sequenced and synchronized, 41 to 128 ft (12.6 to 39.0 m) boom (see Figure 4-1). The boom assembly utilizes a mega form design. The boom utilizes two sequenced telescope cylinders for telescoping and retracting of the boom plus cable synchronization for the extension and retraction of the fly section. Boom lift is provided by a single lift cylinder and boom elevation is from - 3 degrees to +78 degrees.

A standard auxiliary boom nose (rooster sheave) is available for the boom to simplify single part cable usage. The rooster sheave is installed on the main boom nose and is secured by pins that pass through the rooster sheave and main boom nose.

Lattice Extension

A 33 to 56 ft (10.1 to 17.1 m) offsettable bi-fold lattice swingaway extension, offsets 0°, 20°, and 40° and stows alongside the base boom section.

Optional Lattice Extension Inserts

Two optional 20 ft (6.1 m) lattice extension inserts are available. The non-stowable inserts install between the boom nose and bi-fold extension.

THEORY OF OPERATION

Boom Extension

Boom extension and retraction is accomplished with two telescope cylinders, five extension cables, and two retraction cables. The lower telescope cylinder rod is secured to the rear of the boom base section and the barrel is secured to the inner mid boom section by a trunnion. The upper telescope cylinder rod is secured to the rear of the inner mid boom section and the barrel is secured to the outer mid boom section by a trunnion. The extension cables are secured to the back of the fly section and run around extension sheaves on the cylinder mounted fly sheave mount to the cable anchor at the lower cylinder.

The hydraulic fluid in both lower and upper telescope cylinders is routed through the rods so that the barrels can extend. There are two cam operated check valves which control flow to the telescope cylinders. With both cylinders retracted, the check valve for the lower telescope cylinder is open and the check valve for the upper cylinder is closed allowing the lower cylinder to extend. When the lower cylinder is fully extended, the check valve for the upper cylinder opens allowing the upper cylinder to extend. The check valve for the lower cylinder closes after the upper cylinder starts to extend and shuts off the flow to the lower cylinder. As the upper telescope cylinder barrel extends, the extend cables around the extend sheaves push on the extend cables to pull the fly section out at the same time the outer mid is extending.

Boom Retraction

The upper telescope cylinder retracts the outer-mid and two retract cables pull the fly section in at the same time. When the upper cylinder is fully retracted, the check valve for the lower telescope cylinder is opened and the lower cylinder starts to retract. The check valve for the upper cylinder is closed as the lower cylinder starts to retract. The outer mid and fly retract first and then the inner mid.

MAINTENANCE

Removal

NOTE: The boom weighs approximately 22,090 lb (10,020 kg). Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached.

1. Extend and set the outriggers to level the crane and ensure the boom is fully retracted and in a horizontal position over the front of the crane.
2. If equipped, remove the swingaway boom extension and auxiliary nose according to the removal procedures in this section.

CAUTION

Cuts and Abrasion Hazard!

Wear gloves when handling wire rope. Cuts and metal slivers are possible if gloves are not worn.

3. Remove the hook block or headache ball and wind all the wire rope onto the hoist drum.
4. Position the boom to make sure that the lift cylinder is resting securely in the lift cylinder support.

DANGER

Ensure the lifting device is capable of supporting the boom assembly.

5. Attach a lifting device to the boom to provide for equal weight distribution.
6. Tag and disconnect any electrical wiring from the boom.
7. Tag and disconnect the hydraulic lines to the lower telescope cylinder.

DANGER

Crushing Hazard!

Ensure the boom lift cylinder is properly supported before disconnecting it from the boom. Serious injury or death may result from a falling lift cylinder.

8. Block the lift cylinder.
9. Remove the bolt, locknut and shim securing the upper lift cylinder shaft to the side of the attach fitting on the boom.
10. Remove upper lift cylinder shaft.
11. Take up the slack on the boom lifting device.
12. Remove clip pin and cross pin securing boom point pin to base section.
13. Remove boom pivot pin.
14. Raise the boom clear of the crane and lower to ground and set cribbing to support the boom and prevent tipping.

Boom Disassembly

1. Remove the boom in accordance with the *Removal* procedures outlined in this section.
2. If necessary, on the left side of the boom remove the two bolts and washers securing the RCL cable angle brackets to the base, inner mid and outer mid.

NOTE: The boom weighs approximately 22,090 lb (10,020 kg) without the swingaway boom extension attached.

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

CAUTION

Possible Equipment Damage!

A rollover fixture with webbing is recommended to rotate boom and sections. Chains are not recommended. If a rollover fixture is not available, rotate sections using adequate support with webbing. Damage to the boom may result from improper rotation.

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

3. On the top front of the base section, remove the capscrews, flatwashers and cable pad.
4. Repeat step 3 on the inner mid.
5. Repeat step 3 on outer mid.
6. On the right side of the base section, remove the capscrew, two nuts, and the trigger weld from the brackets.
7. Remove the bolt, bolt insert and clamps securing the two hydraulic tubes to the rear of the base section. Tag and disconnect the two hydraulic tubes from the lower telescope cylinder. Cap or plug all openings.
8. Remove the capscrews and washers securing the lower telescope cylinder rod to the trunnion mounting plate at the rear of the base section.

NOTE: The combined weight of the boom inner mid, outer mid, and fly sections, including the telescope cylinders, is approximately 21,342 lb (9680 kg).

9. Slide the assembly out of the base part way.
10. Remove the bolts and washers and the two set screws and locknuts securing each front top wear pad to base section. Remove two bolts and washers securing each adjusting plate to top of base section. Remove two adjusting plates. Remove upper wear pad assembly. If necessary, remove four bolts securing front upper wear pad to pad plate.
11. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to the bottom of the base section. Remove the keeper plates.
12. Remove the capscrews and washers securing each front top wear pad to the base section. Remove the wear pads.
13. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to the inner mid. Remove the keeper plates.
14. Lift up on the front of the inner mid and remove the bottom and side wear pads and shims from the base section, noting quantity, size, and location of shims.
15. Continue to pull the assembly from the base section removing the top rear wear pads from the inner mid section as they clear the base section. Support remaining assembly on cribbing.
16. Remove the capscrews securing the rear side wear pads to the inner mid section. Remove the wear pads and shims, noting quantity and size of shims.
17. Remove the mounting plates from the lugs on the lower cylinder rod.
18. Tag and disconnect the hydraulic hoses and tubes from the telescope cylinders and the two cam valves. Cap or plug all openings.
19. Remove the capscrews and washers securing each cam valve to its mounting plate and remove the valves.
20. Place blocking under the lower cylinder barrel.
21. Remove the bolts and washer securing the lower cylinder barrel mounting plates to the inner mid.
22. Remove the capscrews and washers securing the upper cylinder rod mounting plates to the inner mid.
23. On the left side of the inner mid, remove the valve pusher rod.
24. On the right side of the inner mid, remove the valve pusher rod. Disassemble as necessary.
25. Slide the assembly out of the inner mid part way.
26. Remove the bolts and washers and the two set screws and locknuts securing each front top wear pad to base section. Remove two bolts and washers securing each adjusting plate to top of base section. Remove two adjusting plates. Remove upper wear pad assembly. If necessary, remove four bolts securing front upper wear pad to pad plate.
27. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to the inner mid. Remove the keeper plates.
28. Remove the capscrews and washers securing each front top wear pad to the inner mid. Remove the wear pads.
29. Continue to pull the assembly from the inner mid, removing the top rear wear pads from the outer mid as they clear the inner mid. Support remaining assembly on cribbing.
30. Remove the capscrews securing the rear side wear pads to the outer mid section. Remove the wear pads and shims, noting quantity and size of shims.

31. Remove the capscrews and washers securing the bottom rear wear pad to the inner mid and remove the wear pad and spacer.
32. If necessary, remove both grease fittings, connectors, and grease lines from the rear of the inner mid.
33. Continue to pull the assembly from the center mid, removing the top rear wear pads from the outer mid section as they clear the inner mid.
34. Remove the capscrews and washers securing each retract cable sheave mount in the rear of the outer mid. Remove the retract cable sheave mounts from the rear of the outer mid section; remove retract sheaves.
35. Place blocking under the lower and upper cylinder barrel.
36. Remove the capscrews and washer securing each upper cylinder barrel trunnion mounting plate to the outer mid.
37. Slide the assembly out of the outer mid part way.
38. Remove the bolts and washers and the two set screws and locknuts securing each front top wear pad to base section. Remove two bolts and washers securing each adjusting plate to top of base section. Remove two adjusting plates. Remove upper wear pad assembly. If necessary, remove four bolts securing front upper wear pad to pad plate.
39. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to the outer mid. Remove the keeper plates.
40. Lift up on the front of the fly section and remove the bottom and side wear pads and shims from the outer mid, noting quantity, size, and location of shims.
41. Continue to pull the assembly from the outer mid, removing the top rear wear pads from the fly section as they clear the inner mid.
42. Remove the capscrews securing the rear side wear pads to the fly section. Remove the wear pads and shims, noting quantity and size of shims.
43. Remove the capscrews and washers securing the bottom wear pad to the outer mid and remove the wear pad and shim.
44. If necessary, remove both grease fittings, connectors, and grease lines from the rear of the outer mid.

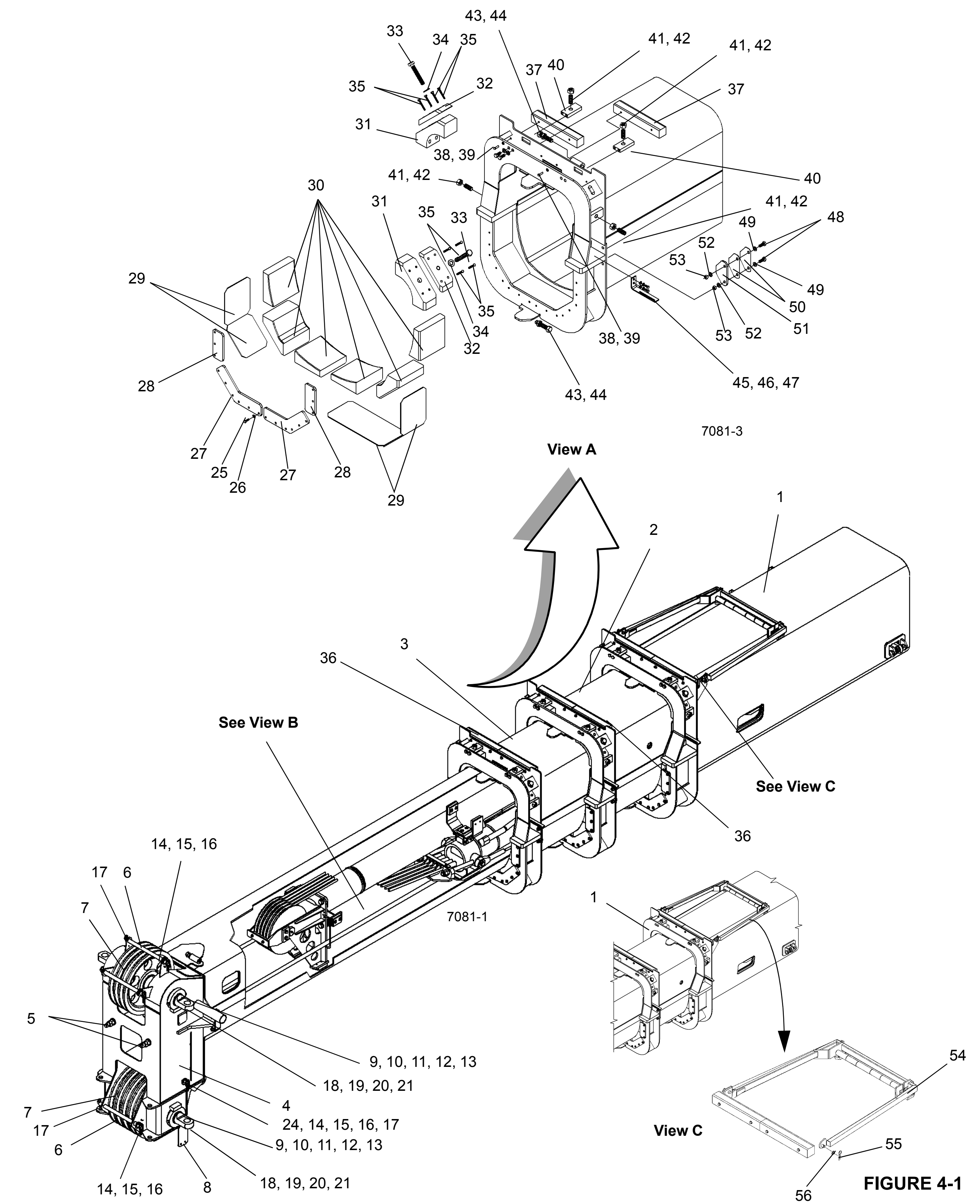
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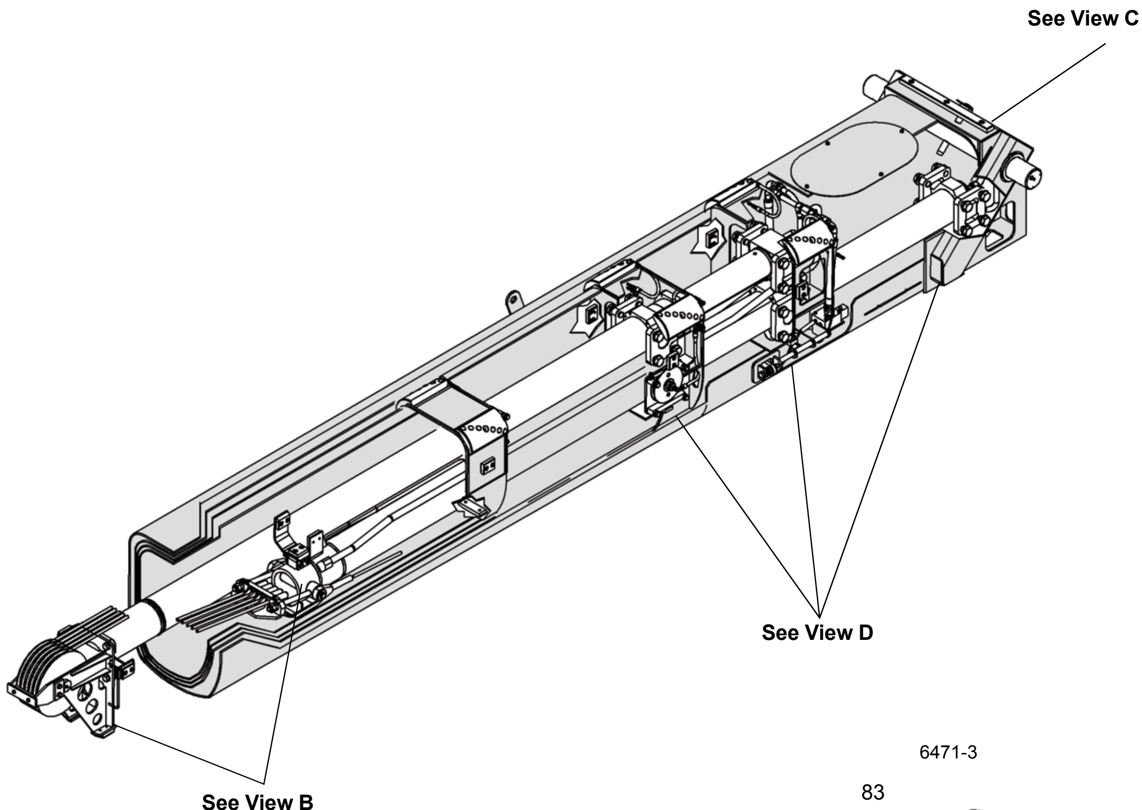
FIGURE 4-1

Item	Description
1	Base Section
2	Inner Mid Section
3	Outer Mid Section
4	Nose To Fly Section
5	Retract Cables
6	Cable Retainer Pin
7	Sheave Assembly
8	Anti-Two Block Plate
9	Spacer
10	Capscrew
11	Shim
12	Hex Nut
13	Lock Collar
14	Hook
15	Chain
16	Cotter Pin
17	Hitch Pin Clip
18	Shaft
19	Spacer
20	Locknut
21	Washers
22	Shim
23	Spacer
24	Pin
25	Capscrew
26	Washer
27	Keeper Plate
28	Keeper Plate

Item	Description
29	Shim
30	Lower Wear Pad
31	Front Upper Pad
32	Top Front Pad Support
33	Capscrew
34	Flatwasher
35	Capscrew
36	Cable Pad
37	Cable Pad
38	Capscrew
39	Flatwasher
40	Top Front Adjusting Block
41	Hex Nut
42	Socket Setscrew
43	Capscrew
44	Nut
45	Mounting Angle
46	Capscrew
47	Washers
48	Capscrews
49	Flatwasher
50	Stop Block Shim
51	Stop Block Plate
52	Washer
53	Nut
54	Cable Guide Assembly
55	Hitch Pin Clip
56	Washer



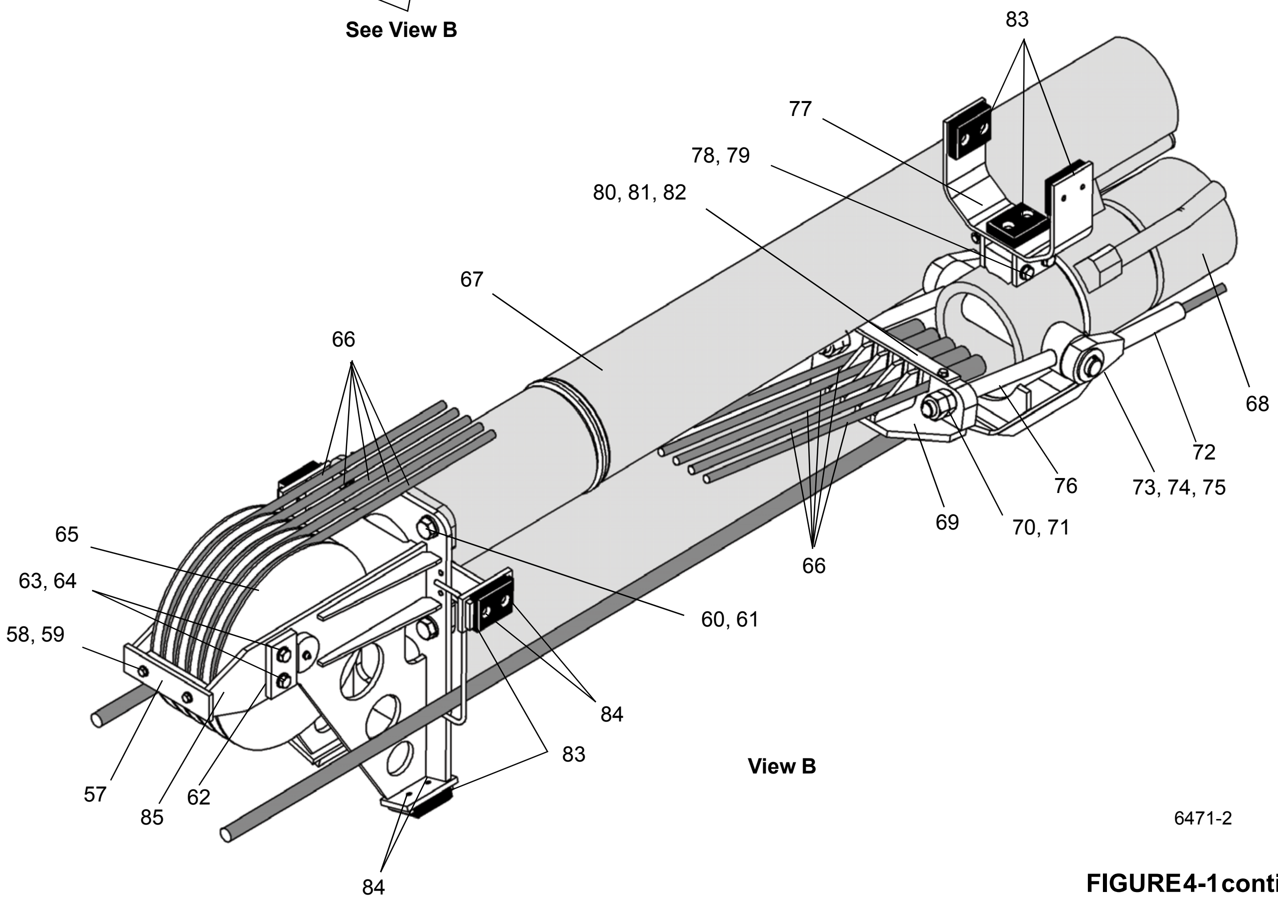
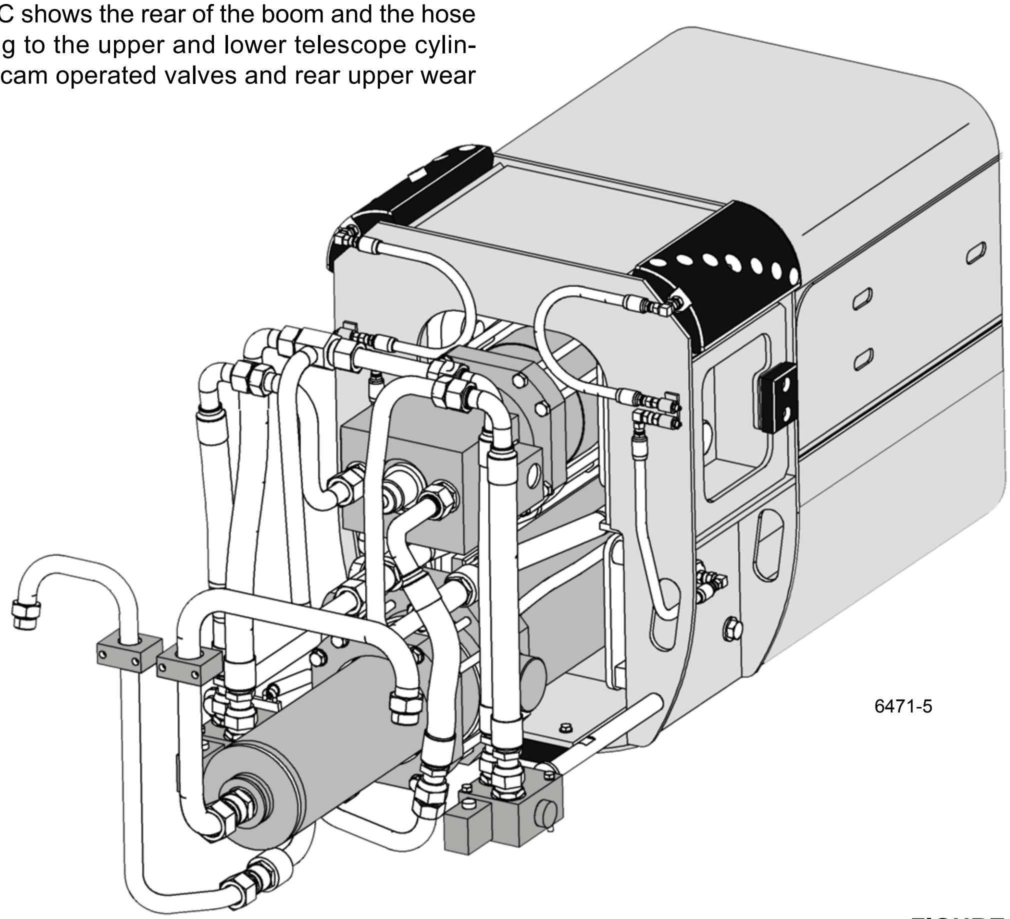


FIGURE 4-1 continued

Item	Description
57	Cable Retainer
58	Capscrew
59	Washer
60	Capscrew
61	Washer
62	Plate
63	Capscrew
64	Washer
65	Sheave Assembly
66	Extend Cables
67	Upper Telescope Cylinder
68	Lower Telescope Cylinder
69	Cable Anchor
70	Swivel Nut

Item	Description
71	Hex Nut
72	Retract Cable
73	Cotter Pin
74	Washer
75	Pin Cylinder Mount
76	Bolt
77	Cylinder Support
78	Capscrew
79	Washer
80	Plate Cover
81	Capscrew
82	Washer
83	Wear Pad
84	Capscrew
85	Sheave Mount

NOTE: View C shows the rear of the boom and the hose routing to the upper and lower telescope cylinders, cam operated valves and rear upper wear pads.



View C

FIGURE 4-1 continued

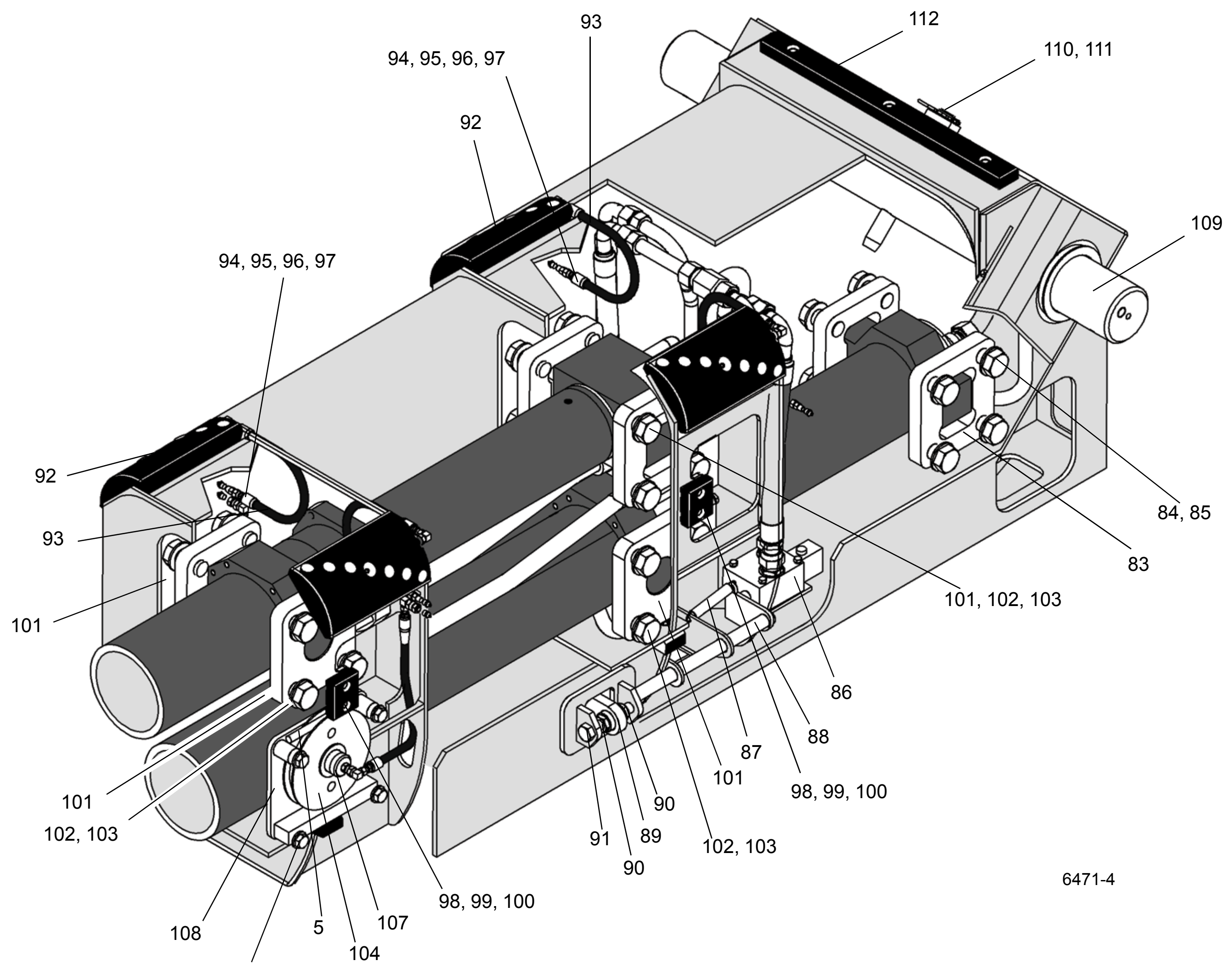


FIGURE 4-1 continued

Item	Description
86	Cam Operating Plate
87	Spring
88	Pusher Weld
89	Trigger Weld
90	Nut
91	Capscrew
92	Rear Upper Pad
93	Hose
94	Elbow
95	Adapter
96	Connector

Item	Description
97	Grease Fitting
98	Side Wear Pad
99	Capscrew
100	Shim
101	Trunnion Mounting Plate
102	Capscrew
103	Washer
104	Sheave Assembly
105	Capscrew
106	Washer
107	Thrust Washer

Item	Description
108	Sheave Mount
109	Boom Pivot
110	Pin
111	Clip Pin
112	Cable Wear Pad
113	Trunnion Mounting Plate
114	Capscrew
115	Washer

45. Remove the mounting plates from the upper cylinder barrel mounting lugs.

DANGER

Ensure the telescope cylinders are securely blocked and some means used to hold them together to prevent any accidental movement. Severe injury can occur if the cylinders drop.

46. Slide the telescope cylinder assembly out the rear of the fly until access to the wear pad holders on each side of the upper telescope cylinder support foot is obtained. Remove the two bolts and washers securing each holder and remove the holders.

47. If necessary, remove the two screws securing the wear pad to each holder and remove the wear pad.

48. Remove the two capscrews and washers securing the extend cable keeper plate to the rear of the fly. Remove the keeper plate and remove the five extend cable ends from the slots in the fly.

49. Continue to slide the telescope cylinder assembly out of the fly section. Lowering the rear of the fly section and raising the rod end of the cylinders will aid in removal.

50. Remove the cotter pin and washer securing the retract cable lug ends to the telescope pin cylinder mount.

51. Remove the two nuts and swivel nuts that attach the sled weld to the two adjusting bolts at the end of the lower cylinder.

52. Slide the sled weld off the two adjusting bolts and remove the adjusting bolts from the shaft on the lower cylinder.

NOTE: The upper telescope cylinder weighs approximately 1950 lb (1000 kg) and the lower telescope cylinder weighs approximately 2160 lb (1357 kg).

53. Remove the shaft from the lower telescope cylinder.

54. Using an adequate lifting device, remove the upper cylinder from the lower cylinder.

55. On the front of the fly section, remove the nut and washer from the end of each retract cable and remove the retract cables from the fly section.

56. Remove the capscrews securing the rear bottom wear pad on the fly section and remove the wear pad.

57. If necessary, remove both grease fittings, connectors, and grease lines from the rear of the fly section.

58. If necessary, remove the capscrews securing the skid pad to the cylinder mount and remove the skid pad.

59. Remove the capscrews and washers securing the extend cable retainer plate to the front of the upper telescope cylinder. Remove the retainer plate.

60. Remove the extend cables from the sheave assembly.

61. Remove the capscrews and flatwashers securing each plate to the sheave mounting assembly. Remove the sheave shaft and the sheave assembly from the mounting assembly.

62. Remove the capscrews and washers securing the sheave mount to the upper telescope cylinder. Remove the sheave mount.

63. If necessary, remove the two bolts securing each wear pad to the support foot and remove the wear pads.

64. If removal of the boom nose sheaves are required, refer to Boom Nose Sheaves - Removal in this section.

65. Refer to *Boom Extension and Retraction Cable*, page 4-16 for cable inspection.

Boom Nose Sheaves

Removal

1. Remove the hitch pin clip from the hitch pin and remove the pin from the upper and lower part of the boom nose.
2. Remove the capscrew, and nut securing the upper boom nose sheave shaft. Remove the lock collar and shim.
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, washers, 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.

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.

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 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 capscrew 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 to eliminate all play in bearings.
4. Install the cable retainer hitch pin into the upper and lower part of the boom nose and secure in place with the hitch pin clip.

Boom Assembly

DANGER

Boom assembly must be rotated 180° upside down before performing any assembly or disassembly procedures.

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

CAUTION

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

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

NOTE: Apply medium strength threadlocking adhesive/ sealant 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.

1. Install wear pads on the sheave mount/support with the capscrews.
2. Install the sheave mount to the front of the upper telescope cylinder assembly with capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
3. Using the sheave shaft, install the sheave assembly in the sheave mounting assembly. Secure the shaft with a plate and two capscrews and washers on each side of the sheave mounting assembly. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
4. Route the lug end of the extension cables up and around the upper telescope cylinder sheaves about one foot on to cylinder. To aid in assembly, secure the cables to the end of the cylinder by wrapping tape around the cylinder.
5. Position the cable retainer plate on the front of the sheave mounting assembly and secure with the capscrews and lockwashers.
6. Install the skid pad to the bottom of the lower telescope cylinder mount with the capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
7. Install the other ends of the extension cables into the sled weld, making sure the extension cables are not crossed and twisted.
8. Install the plate cover on the sled weld and secure with two bolts and washers.
9. Turn the lower telescope cylinder rod so the trunnion is vertical.
10. At the rear of the fly section, install the upper wear pad grease line, connector and grease fitting on each side.

NOTE: The grease lines are designed to be used only on one side or the other (i.e. RH or LH).

11. Install the bottom rear wear pad on the fly section with the capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
12. Route the two retract cables (threaded ends) through the fly section to the front. Insert the threaded ends through the holes on the front of the fly section and install a washer and two nuts on each cable end.

DANGER

Ensure the telescope cylinders are securely blocked and some means used to hold them together to prevent any accidental movement. Severe injury can occur if the cylinders drop.

13. Install the wear pads in the upper telescope cylinder support with the capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
14. Position the cylinder support on lower telescope cylinder and secure with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
15. Using an adequate lifting device, position the upper telescope cylinder onto the lower telescope cylinder.
16. Position the sheave end of the telescope cylinder assembly at the rear of the fly section.
17. Lay the retract cable sheave mounts out behind the fly section as they will be installed in the outer mid. Route the lug end of the retract cables through the sheave mounts (top to bottom) so the lug end will come off the bottom of the sheave. Place the retract sheave, with one thrust washer on each side, in the mount.
18. Install the lug end of each retract cable to the telescope pin cylinder mount and secure with the washer and cotter pin.
19. Install the adjusting bolts through the holes in the lower mount shaft.
20. Install the sled assembly onto the adjusting bolts and install both swivel nuts and regular nuts, making sure that the extension cables are not crossed and twisted.
21. Slide telescope cylinder assembly into the rear of the fly section until sheave mount clears the fly end plates at the rear of the fly section. Lowering the rear of the fly and raising the rod end of the cylinders will aid in sliding these together.
22. Place the extend cable lug ends in the slots at the top of the fly section and secure them with the keeper plate and two capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
23. Install a wear pad on the two upper telescope cylinder wear pad holders.
24. Position the wear pad holders on each side of the upper telescope cylinder support foot and secure each with two bolts and hardened washers.
25. Slide the telescope cylinder assembly all the way in. Place blocking under the rear of the telescope cylinders to aid in assembly.
26. Place the mounting plates on the upper telescope cylinder barrel mounting lugs.
27. Using tape or ty-wraps, fasten the extend cable ends to the telescope cylinder to aid in assembly.
28. Place the retract cable sheave mounts in the rear of the fly section to aid in assembly.
29. At the rear of the outer mid section, install the upper wear pad grease line, connector and grease fitting on each side.
30. Install the bottom rear wear pad on the outer mid section with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
31. Position the front end of the outer mid at the rear of the fly/telescope cylinder assembly.
32. Slide the fly/telescope cylinder assembly into the outer mid section installing top rear wear pads in pockets of fly section. Stop and install rear side wear pads and shims on fly section with capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

NOTE: Use shims as necessary to adjust wear pad so it is within 0.078 in (2 mm) of the outer mid section side plate. Use equal number of shims on each side.

33. Continue to slide together being careful not to damage cables.
34. Lift up on the front of the fly and install the bottom and side front wear pads in the outer mid. Install shims as necessary.
35. Install outer mid front top wear pads as noted during disassembly. Secure each with a bolt and washer. Install two adjusting blocks and secure each with two bolts and washers. Install adjusting screws and lock nuts. (Two each on top and two each on side).
36. Install bottom and side wear pad keeper plate on each side of the outer mid and secure with the capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
37. Continue to completely slide together.
38. Lift up on end of the upper cylinder to align barrel trunnion mounting plate holes with holes in outer mid. Secure each with four capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
39. Remove any blocking under cylinder.

40. Remove the retract cable sheave mounts from the fly section and attach them to the rear of the outer mid with capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

41. Place the trunnion mounting plates on the lower cylinder barrel mounting lugs.

42. Place the trunnion mounting plates on the upper cylinder rod mounting lugs.

43. At the rear of the inner mid section, install the upper wear pad grease line, connector and grease fitting on each side.

44. Install the bottom rear wear pad on the inner mid section with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

45. Position the front end of the inner mid at the rear of the outer mid/fly/telescope cylinder assembly.

46. Slide the outer mid/fly/telescope cylinder assembly into the inner mid section installing top rear wear pads in pockets of outer mid section (cutout should align with grease line). Stop and install rear side wear pads and shims on outer mid section with the capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

NOTE: Use shims as necessary to adjust wear pad so it is within 0.078 in (2 mm) of the inner mid section side plate. Use equal number of shims on each side.

47. Continue to slide together being careful not to damage cables.

48. Lift up on the front of the outer mid and install the bottom and side front wear pads in the inner mid. Install shims as necessary.

49. Install inner mid front top wear pads as noted during disassembly. Secure each with a bolt and washer. Install two adjusting blocks and secure each with two bolts and washers. Install adjusting screws and lock nuts. (Two each on top and two each on side).

50. Install bottom and side wear pad keeper plate on each side of the inner mid and secure with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

51. Continue to completely slide together.

52. Install nut and washer in right side valve tapped pusher rod. Install the rod assembly through hole on right side of inner mid.

53. Install left side valve pusher rod on outer left side of inner mid.

54. Align upper cylinder rod trunnion mounting plates holes with holes in inner mid. Secure with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

55. Lift up on end of the lower cylinder to align barrel mounting plate holes with holes in inner mid. Secure each with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

56. Remove any blocking under cylinder.

57. Install the cam valves on the mounting plates on each side of the inner mid using capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

58. If removed, install hydraulic fittings in the ports of the valves and the cylinders as tagged during disassembly.

59. Connect the hydraulic hoses and tubing to the valves and cylinders as tagged during disassembly.

60. Place the trunnion mounting plates on the lower cylinder rod mounting lugs.

61. Position the front end of the base at the rear of the inner mid/outer mid/fly/telescope cylinder assembly.

62. Slide the inner mid/outer mid/fly/telescope cylinder assembly into the base section installing top rear wear pads in pockets of inner mid section (cutout should align with grease line). Stop and install rear side wear pads and shims on inner mid section with the capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

NOTE: Use shims as necessary to adjust wear pad so it is within 0.078 in (2 mm) of the base section side plate. Use equal number of shims on each side.

63. Continue to slide together.

64. Lift up on the front of the inner mid and install the bottom and side front wear pads in the base section. Install shims as necessary.

65. Install base section front top wear pads as noted during disassembly. Secure each with a bolt and washer. Install two adjusting blocks and secure each with two bolts and washers. Install adjusting screws and lock nuts. (Two each on top and two each on side).

66. Install bottom and side wear pad keeper plate on each side of the base section and secure with the capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

67. Continue to completely slide together.

68. Align lower cylinder rod trunnion mounting plates holes with holes in base section. Secure with the capscrews and washers.Torque capscrews; refer to *Fasteners and*

Torque Values, page 1-15 for proper torque value.

69. Connect hydraulic tubes to the lower cylinder as tagged during disassembly. Install tubes in clamps on rear of base section. The clamps are larger than the tubes and only support the tubes vertically allowing the tubes to slide up and down with any movement of the lower cylinder.

70. Through the access hole on the left side of the base section, install the capscrew, two nuts, and the trigger weld in the brackets. One nut goes on each side of the trigger weld. See *Cam Operated Check Valve Adjustment*, page 4-15.

71. On the top front of the base section, install the cable pads with the flatwashers and capscrews. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

72. Repeat step 68 on the inner mid.

73. Repeat step 68 on the outer mid.

74. On the left side only, install a RCL cable angle bracket on the base, inner mid, and outer mid using capscrews and washers.

75. Install the boom in accordance with the Boom Installation procedures outlined in this section

Installation

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

DANGER

Ensure blocking and lifting devices are capable of supporting the boom assembly.

1. Attach an adequate lifting device to the boom and suspend the boom over the machine.

2. Lower the boom into position and align the boom pivot shaft mounting holes for installation of the pivot shaft to the superstructure assembly.

3. Lubricate the pivot shaft bushings in the superstructure assembly.

DANGER

Crushing Hazard!

Block the boom before doing any work under the boom.

4. Block the boom in place.

5. The boom may need to be raised or lowered to aid in the installation of the pivot shaft. Install pivot shaft.

6. Install anti-rotation pin and lock in place with clip pin.

DANGER

Crushing Hazard!

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

7. 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.

DANGER

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.

8. Lubricate the upper lift cylinder pin. Install upper lift cylinder pin. The lift cylinder may need to be raised or lowered to aid in the installation of the lift cylinder pin.

9. Secure the upper lift cylinder pin with the bolt and locknut to the attached fitting on the boom.

10. Lower the jack on the lift cylinder support.

11. Remove the boom lifting device.

12. Activate the hydraulic system and remove the boom and lift cylinder blocking devices. Lower the boom to horizontal. Shut down the crane.

13. Connect the hydraulic lines to the lower telescope cylinder as tagged prior to removal.

14. Install the base cover on top of the boom base section, then secure with four bolts and washers.

15. Connect any electrical wires as tagged prior to removal.

16. Refer to *Boom Extension and Retraction Cable*, page 4-16 for cable adjustments.

17. Refer to *Cam Operated Check Valve Adjustment*, page 4-15 for valve adjustment.

Functional Check

1. Activate the hydraulic system and check for proper operation and any leaks.

2. Ensure the boom will extend and retract properly.

3. Ensure the lift cylinder will not allow the boom to drift down until the operator lowers it.

4. Ensure all electrical components disconnected during removal are operating properly.

Inspection

Visually inspect telescoping sections for adequate lubrication of all wear surfaces. Observe extended sections for evidence of cracks, warping, or other damage. Periodically check security of boom wear pads. Check boom nose sheaves for security and freedom of movement.

Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. Refer to *Boom*, page 9-23.

Boom Alignment and Servicing

Refer to *Boom*, page 9-23 for the proper lubricant.

Boom alignment is done as the boom sections are being assembled into one another. A check and fine adjustment is as follows.

1. Fully extend the boom horizontally.
2. Lubricate the boom bottom channels and top corners.
3. Adjust 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 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 section(s).

4. Retract and extend the boom; check for the high point where the boom has brushed the wear pads at the widest point.
5. Retract the boom sections to align the high point on the boom section with the adjacent wear pads.
6. Add or subtract shims as necessary.
7. Attach a weight and extend the boom full length. Check for side deflection.

Example: If the boom deflects to the left, the top left wear pad would have shims added and the top right wear pad would have shims removed.

Cam Operated Check Valve Adjustment

There are two cam operated valves mounted on the back of the inner mid section. When the boom is fully retracted or the inner mid is fully extended, the valve on the right side of the boom is held open to supply flow to the lower telescope cylinder. When the inner mid is fully extended, the valve on the left side of the boom opens to supply flow to the upper telescope cylinder. For a short period of time, both valves are open because the lower cylinder is fully extended before the upper cylinder starts to extend. As the outer mid starts to extend, the valve on the right side closes to shut off the flow to the second stage of the lower cylinder.

1. Ensure the extend and retract cables are adjusted.
2. Extend boom out so that inner mid section is fully extended and outer mid is bottomed out on stop block of inner mid.
3. Access the check valves through the hole on right side of base section.
4. Left side valve (extend side): Adjust nuts to move the trigger weld until it just makes the pusher weld contact the valve stem on the cam valve. Move nuts until the pusher weld depresses the valve stem of the cam valve (10 mm). Tighten the nuts.
5. Right side valve (retract side): through the access hole on right side of base, tighten the bolt until the pusher bar contacts the valve stem on the cam valve. Adjust bolt to depress the valve stem of the cam valve 0.4 in (10 mm). Tighten the nut.

Stop Block Adjustment

Add or remove shims as required so that stop blocks on a given boom section (both sides) bottom out on the stop blocks of the next section at the same time.

Front Upper Pad Adjustment

1. Using setscrews, adjust front upper wear pads so that the wear pad is just touching or is no more than 0.07 in (2 mm) away from contacting the next outer section at the side surfaces, and is 0.15 to 0.23 in (4 to 6 mm) away from contacting the next outer section at the top surfaces.
2. Lock setscrews in place with locknut.
3. Tighten capscrews until pad support plate is held in place against setscrews.

Read Side Wear Pad Adjustment

1. Using shims, adjust wear pad so that the wear pad is within 0.07 in (2 mm) from the side plate of the next inner section. Equal number of shims should be on both sides.

4

BOOM EXTENSION AND RETRACTION CABLE

MAINTENANCE

NOTE: For more detailed information concerning maintenance of the extension and retraction cables, refer to *Wire Rope*, page 1-20.

Inspection

CAUTION

Never handle wire rope with 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. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
2. Evidence of any heat damage from any cause.
3. Reductions from nominal diameter of more than 5%.
4. In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
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.
6. In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
7. Severe corrosion as evidenced by pitting.
8. Manitowoc recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
9. Manitowoc recommends for cable extended booms, that boom extension cables be replaced every seven (7) years.

CAUTION

Any cutting of this specific wire rope is not recommended. If 35x7class wire rope must be cut for any reason, it is necessary to follow the instructions at Installing 35x7 Class Wire Rope, page 1-24. Also, unlike other types of wire rope, the ends on this wire rope must be welded to retain the rotation resistant characteristics.

Adjustment

At near fully extended boom length, during sudden extension after retracting the boom some distance, and with high telescoping speeds, the extension cables may slap the inside of the boom section. This will make a somewhat audible noise, however this will not cause any damage and is acceptable. If the cables do not make a slapping noise under these conditions, it is an indication that the extension cables may be too tight and should be readjusted. Be aware that there may also be a similar noise made by the telescope cylinder rod mount at the rear of the base section and center mid section and confusion between the two could be experienced.

CAUTION

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

NOTE: The extension cables must be adjusted properly before the retract cables can be adjusted.

1. Extend and set the outriggers, ensuring the crane is level.
2. Ensure the boom is over the front and at a horizontal position (boom angle elevation 0 degrees or lower).
3. Extend boom until the front end of the lower telescope cylinder is accessible through the holes in the outer and inner mid sections.
4. With the front of the boom in the above position, extend the boom approximately 1 in (25 mm) to relieve the tension in the retract cables. Access the retract cables from the front of the boom nose and view the slack of the retract cables through the hole in the back plate of the boom nose. Using the nuts on the retract cables, remove slack evenly, until both retract cables are at least 1 in (25 mm) above the lower leg of the cable retainer bars on the sheave mount on the upper telescope cylinder.
5. Retract the boom approximately 1 in (25 mm) to relieve tension on the extension cables. Shut down the crane. Evenly tighten the swivel nuts on the adjusting bolts, until the extension cables are up 6 in (150 mm) off the top of the bottom pad plate at the back of the fly section. Look through the holes in the boom sections to see the slack in cables.
6. Lock the adjustments with the jam nuts.
7. Extend the boom until the outer mid/fly extends several cm (in).
8. Adjust retract cables so that fly section stop block bottoms out 0.12 to 0.19 in (3 to 4 mm) before the stop block outer mid bottoms out.

9. If stop block on the fly cannot be properly adjusted without excessive thread 4.5 in (32 mm) protruding out from the jam nuts, backoff the nuts on the retract cables 1 in (25 mm), and backoff the swivel nuts 1 in (25 mm).

CAUTION

Overtightening of the retract cable will damage the cable. Take care when retracting the boom fully, while adjusting the cable, to avoid full boom retraction if the fly section contacts its stop block more than 0.125 in (3 mm) before the outer mid section contacts its stop block on the center mid.

10. Adjust retract cables until stop block on fly bottoms out properly. Install jam nuts.
11. If the retract cables can still not be adjusted properly, remove all the tension in the retract and extension cables and return to step 4. In step 5, adjust the extension cable to 5 in (127 mm) and continue with procedure.

NOTE: If grease fittings are not fully accessible at full boom extension, make the following adjustments.

12. Retract boom approximately one foot and tighten extend cables one full turn each.
13. Extend boom to make sure grease fittings line up with hole. If not lined up with hole, retract boom slightly and add one additional turn on each of the extend cables.
14. Once grease fittings lines up with boom at full extension, fully retract boom at Hi speed. When boom initially begins to retract, extension cables should become slack enough to hit the boom section. If this does not happen, reduce tension on retract cables until they do become slack.
15. Just as the boom begins to bottom out, observe that the fly still bottoms out before the outer mid. If so, all adjustments are correct.

TELESCOPE CIRCUIT

Description

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

The telescope control valve is the closed spool type and is described under *Directional Control Valves*, page 2-7.

Refer to *Hydraulic Remote Control Valve*, page 2-47 for a complete description of the hydraulic remote controller.

The boom telescope system has a lower and an upper telescope cylinder. Both the lower and upper telescope cylinder has a 7.0 in (17.7 cm) bore. Foreign material is prevented from entering the cylinder by a wiper seal during rod retraction. O-ring seals prevent internal and external leakage. Refer to *Cylinders*, page 2-71 for a complete description of the telescope cylinders.

A holding valve is threaded into a port block on the rod end of the upper telescope cylinder. The holding valve for the second stage of the lower telescope cylinder is mounted into the port block on the barrel end of the second stage barrel. The holding valves function during the retraction, extension, or holding operation. When holding the boom section at a given length, oil is trapped in the cylinder by the holding valve. Refer to *Holding Valves*, page 2-57 for a complete description of the holding valve.

Theory of Operation

Flow from the pump travels to the telescope directional control valve. Movement of the foot pedal for telescope functions from neutral sends a pilot pressure signal to the directional control valve to shift the spool in the directional control valve. This aligns the appropriate passages in the control valve to route oil to the telescope cylinders.

Also refer to *Boom - Theory of Operation* in this Section.

Maintenance

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Erratic operation of extending telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Damaged relief valves.	**b.** Repair or replace relief valves.
	c. Air in telescope cylinder.	**c.** Bleed by lowering telescope cylinder below horizontal.
	d. Low engine rpm.	**d.** Increase engine rpm to recommended setting.
	e. Lack of lubrication on boom sections.	**e.** Properly lubricate all boom sections.
	f. Extremely tight boom extension sheaves.	**f.** Inspect and properly lubricate boom extension sheaves.
	g. Improper boom alignment caused from side loading.	**g.** Reduce and properly hoist load.
	h. Worn boom wear pads.	**h.** Replace wear pads and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Damaged telescope cylinder.	**j.** Repair or replace cylinder.
	k. Clogged, broken, or loose hydraulic lines or fittings.	**k.** Clean, tighten, or replace lines or fittings.
	l. Damaged control valve.	**l.** Repair or replace control valve.

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Erratic operation of retracting telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	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).
3. Telescope cylinder will not extend.	**a.** Low hydraulic oil level.	**a.** Replenish oil to proper level.
	b. Relief valve malfunctioning.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load.
	d. Clogged hose and fittings.	**d.** Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	e. Broken valve spool.	**e.** Replace valve.
	f. Damaged piston seals.	**f.** Replace all cylinder seals.
	g. Damaged piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Bent boom section(s).	**h.** Replace damaged boom section(s).
	i. Broken hydraulic pump coupling.	**i.** Replace broken hydraulic pump coupling.
	j. Worn or damaged hydraulic pump section.	**j.** Repair or replace pump section.

SYMPTOM	PROBABLE CAUSE	SOLUTION
4. Telescope cylinder will not retract.	**a.** Low hydraulic oil level.	**a.** Replenish oil to proper level.
	b. Relief valve damaged.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load. (Refer to load chart).
	d. Inoperative check valve.	**d.** Replace check valve.
	e. Clogged hose and fittings.	**e.** Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	f. Broken valve spool.	**f.** Replace valve section.
	g. Broken piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Damaged piston seals.	**h.** Replace all cylinder seals.
	i. Bent boom section(s).	**i.** Replace damaged boom section(s).
	j. Broken hydraulic pump coupling.	**j.** Replace broken hydraulic pump coupling.
	k. Worn or damaged hydraulic pump.	**k.** Repair or replace pump.
	l. Broken hydraulic pump shaft.	**l.** Replace pump shaft.
5. Inner mid will not extend.	**a.** Right side check valve blocked.	**a.** Readjust, repair, or replace valve.
6. Inner mid will not retract.	**a.** Right side check valve closed.	**a.** Readjust valve.
7. Outer mid will not extend.	**a.** Left side check valve is closed.	**a.** Readjust valve.
8. Inner mid retracts before outer mid.	**a.** Right side check valve is open or hosed backwards.	**a.** Install hoses properly.
9. Outer mid extends only a short distance then stops.	**a.** Left check valve is open or hosed backwards.	**a.** Install hoses properly.

Removal and Installation

Removal and installation of the telescope cylinder from the boom is described under disassembly and assembly of the boom. Refer to Boom Maintenance in this Section.

Disassembly and Assembly

Disassembly and assembly procedures of the telescope cylinder and control valve are provided in Section 2 under Cylinders and Valves 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 under *Directional Control Valves*, page 2-7.

Refer to *Hydraulic Remote Control Valve*, page 2-47 for a complete description of the hydraulic remote controller.

The lift cylinder has a 12.0 in (30.48 cm) bore. The cylinder is a double acting type. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage by a wiper seal during rod retraction. Oil seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage. Refer to *Cylinders*, page 2-71 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.

4

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Boom raises erratically.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper level.
	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.** Replenish hydraulic oil to proper oil level.
	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.** Replenish hydraulic oil to proper level.
	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.** Replenish hydraulic oil to proper level.
	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 Parts Manual).
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals worn.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
	k. Piston rod broken (loose from piston).	**k.** Replace piston rod and all cylinder seals.
5. Boom will not raise.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper level.
	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.** Replenish hydraulic oil to proper level.
	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 Section 2 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).

DANGER

Crushing Hazard!

Ensure any blocking or cribbing used is capable of supporting the boom.

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.
4. Remove the capscrew and washers securing the lift cylinder upper pivot shaft to the boom.
5. Remove the bolt, locknut and shim securing the lift cylinder lower pivot shaft to the turntable.

DANGER

Crushing Hazard!

Ensure the lifting/supporting device is capable of supporting the lift cylinder.

6. Attach an adequate lifting/supporting device to the lift cylinder.
7. Remove the upper lift cylinder pivot shaft. 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 procedures of the lift cylinder holding valve, and control valve are provided in Section 2 under *Cylinders* and *Valves* respectively.

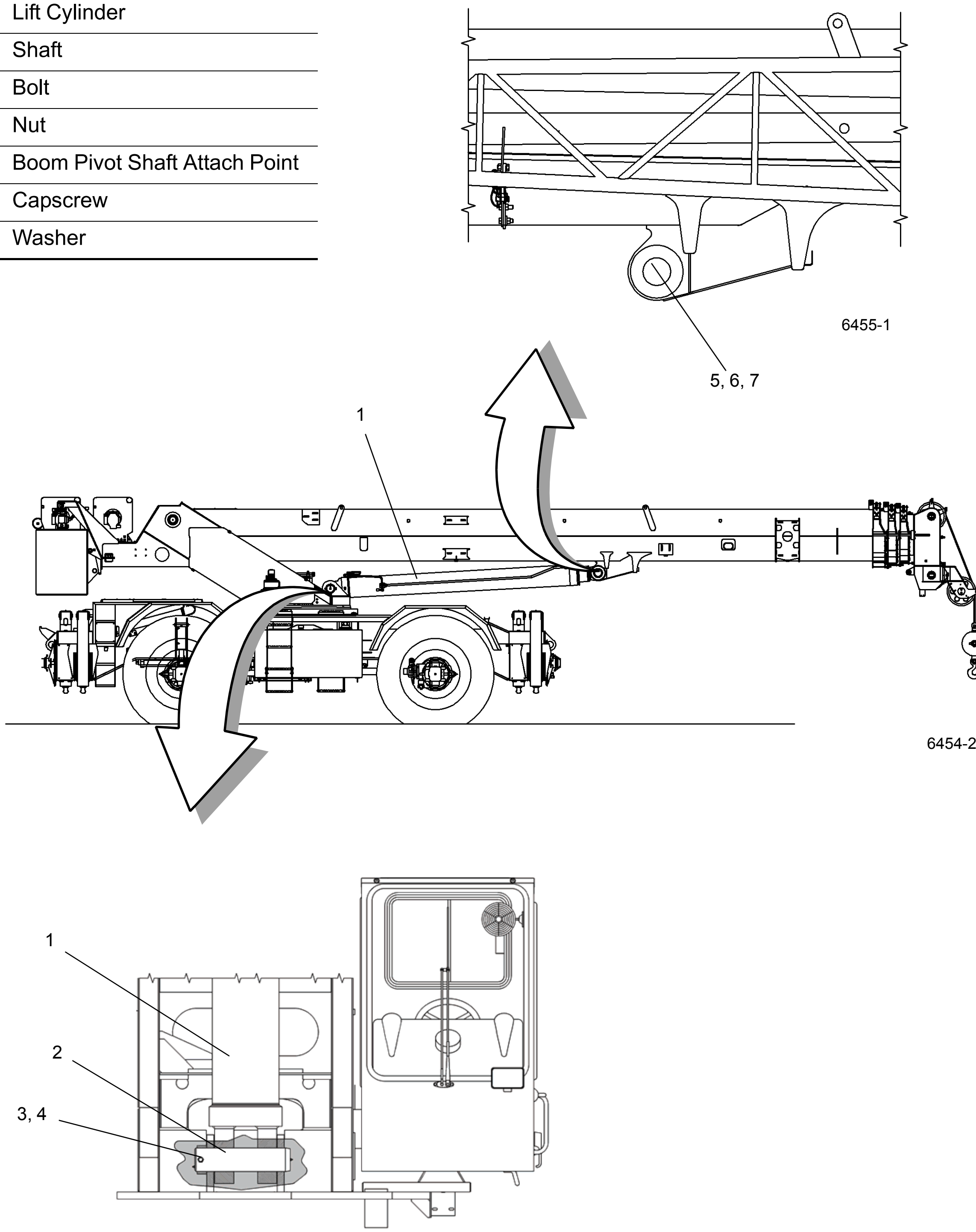
Lift Cylinder Installation

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, side opposite the cab.

3. Install the lift cylinder lower pivot shaft and secure with the shim, bolt and locknut. Torque bolt; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
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. Secure the upper pivot shaft to the boom with the capscrew and washers. Torque capscrew; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
6. 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.
7. Lubricate the pivot shafts.

Item	Description
1	Lift Cylinder
2	Shaft
3	Bolt
4	Nut
5	Boom Pivot Shaft Attach Point
6	Capscrew
7	Washer



Cutaway Shown For Clarity

Lift Cylinder Installation

FIGURE 4-2

AUXILIARY BOOM NOSE

Description

The auxiliary boom nose (rooster sheave) (see Figure 4-3) is used on the boom to simplify single part and maximum part cable usage. The rooster sheave is installed on the main boom nose and is secured by attach pins that pass through the rooster sheave and the main boom nose.

Item	Description
1	Auxiliary Boom Nose
2	Sheave Assembly
3	End Cap
4	Screw
5	Hitch Pin
6	Hitch Pin Clip
7	Lock Pin
8	Chain
9	Cotter Pin
10	S-Hook
11	Main Boom Nose

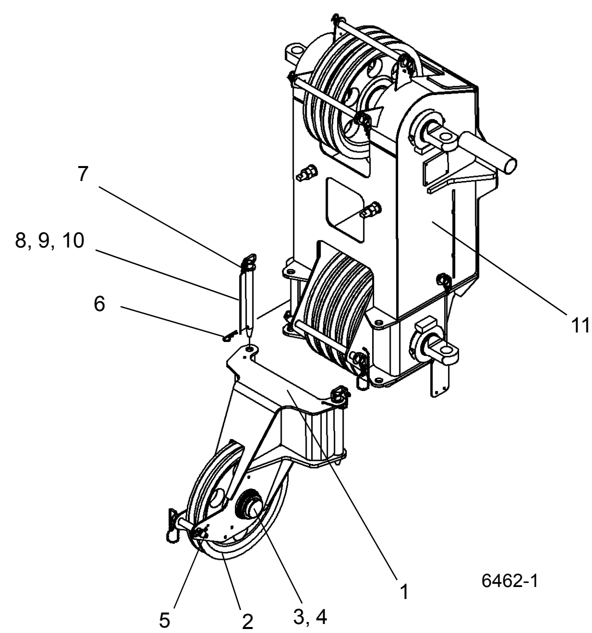


FIGURE 4-3

INSTALLING THE BI-FOLD MANUAL BOOM EXTENSION

DANGER

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

1. Before installing the boom extension make sure the crane is set up on outriggers using normal setup procedures. Refer to *Section 3 - Operating Controls and Procedures* in the *Operator Manual*.

NOTE: An auxiliary crane with sling is required to install the bi-fold boom extension.

2. Check the transport condition of the bi-fold extension.
3. Using an auxiliary crane, attach sling to the bi-fold extension.
4. Lift the bi-fold extension in front of the main boom with the auxiliary crane and lock the 33 ft (10.1 m) section to the right of the main boom head (Figure 4-4).

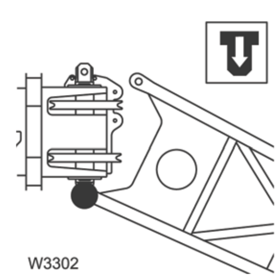
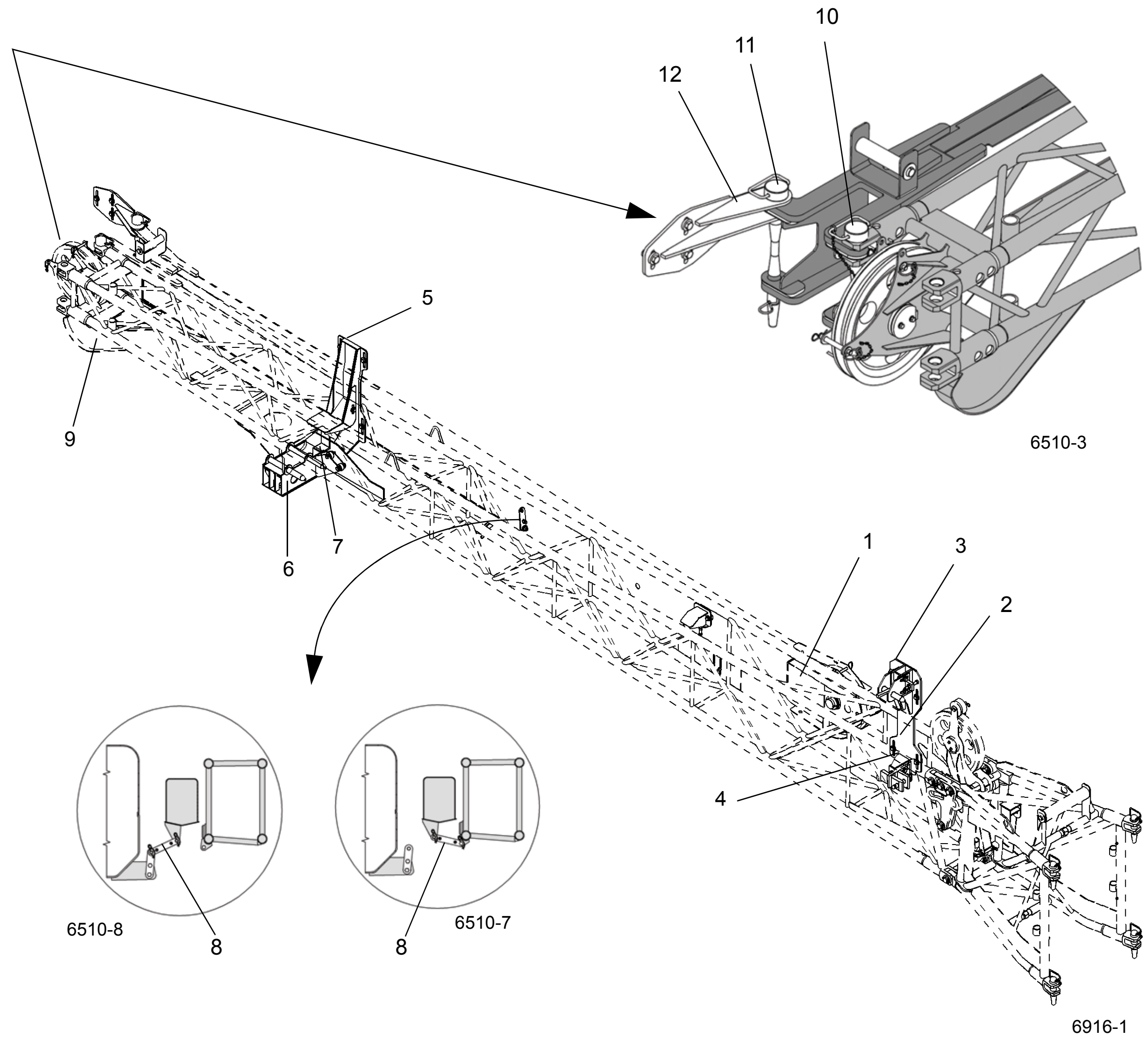


FIGURE 4-4

5. Pin the left side to the boom nose.
6. Establish electrical connection between the extension and the main boom.
7. For units equipped with hydraulic luffing boom extension, establish hydraulic connections between the extension and the main boom.

NOTE: You can also install the bi-fold swingaway boom extension in front of a 16 ft (4.9 m) section when you are changing directly from the 56 ft (17.1 m) bi-fold swingaway extension to a boom insert.



Item	Description
1	Stinger
2	Front Mount
3	Upper Hangar
4	Lower Support
5	Rear Hangar
6	Carrier

Item	Description
7	Bumper Pad
8	Holding Plate
9	Boom Extension
10	Pin
11	Pin
12	Bracket

FIGURE 4-5

Checking the Transport Condition

For transportation you must establish certain connections between both parts of the lattice extension. The connections which need to be established depend on whether the lattice extension:

- is folded up at the side of the main boom for transportation or
- is completely removed for transportation.

CAUTION

Be careful not to damage the lattice extension and the main boom. Always put the lattice extension into transport condition when folded at the side or working with the main boom. Only then is the lattice extension secured against slipping. This way you prevent the partly fastened lattice extension hitting the main boom or the individual components of the lattice extension hitting each other and becoming damaged.

You must check transport condition:

- After stowing the lattice extension, before you drive the crane with the lattice extension folded at the side or work with the main boom.
- Before installation and before erecting the lattice extension.

Transport Condition with Lattice Extension Folded at the Side

The transport condition with the lattice extension folded at the side is created when all of the following connections are established.

- Check the connections and establish them if necessary (Figure 4-5).

If 23 ft (7 m) Section and 33 ft (10.1 m) Section are Folded at the Side:

If the 23 ft (7 m) Section Only is Folded at the Side:

- The 33 ft (10.1 m) section is locked at the front mount (2) on the main boom (Figure 4-5).
- The pins (4) are inserted on the pivot point between the 23 ft (7 m) section and the 33 ft (10.1 m) section (Figure 4-5).
- The connection (8) in the middle area is between the 23 ft (7 m) section/33 ft (10.1 m) section (Figure 4-5).
- The connection (8) between 23 ft (7 m) section and main boom in the rear area is established (Figure 4-5).

If the 23 ft (7 m) Section Only is Folded at the Side:

- The connection (8) in the middle area is between the 23 ft (7 m) section and the main boom (Figure 4-5).
- The connection (5) between the 23 ft (7 m) section and the main boom in the rear area is established.

BOOM EXTENSION ERECTING AND STOWING PROCEDURE

For instructions on erecting and stowing the boom extension(s) and/or using additional equipment refer to Section 4 in the *Operator Manual*.

MONTHLY MAINTENANCE WORK

Pins

Lubricate all attach, securing and retaining pins:

- the pins for the connection on the lattice extension,
- the retaining pins on the return pulleys,
- the retaining pins used for fastening the lattice extension sections for transport,
- the spring latch on the run-up rail.

NOTE: The maintenance interval applies to average operation. Also, lubricate the pins after high-pressure cleaning and generally at an interval that will prevent them from being lubricated.

HOOK BLOCK

Description

A 75 ton (68 metric ton) hook block and a 10 ton (9 metric ton) top headache 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 the quick reeve design.

Maintenance

Periodic Maintenance

It is recommended that the hook block and/or headache ball be inspected every 50 hours. A complete assembly 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 area by brush or hand to prevent corrosion.

For hook blocks and other load handling devices not manufactured by Manitowoc Cranes, Inc.; follow the manufacturer's inspection and testing recommendations to assure an adequate preventative maintenance program is established.

SECTION 5
HOISTS AND COUNTERWEIGHT

SECTION CONTENTS

5

DESCRIPTION

One hoist is available, the HP30-19C (Figure 5-1 and Figure 5-4). 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 load 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

The hoist assembly is controlled by hydraulic remote controllers located in the cab. When the control lever in the cab is moved from neutral, it causes the main hoist section of the directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve is used to stop or slow the hoist when the load is trying to drive the hoist down too quickly. The motor control valve is piloted open by the hoist down pressure. If the load lowers faster than the flow of oil in the hoist down line, the pilot pressure decreases and the motor control valve partially closes to restrict the oil leaving the motor until a balance occurs. This results in the load lowering at a uniform speed based on the position of the hoist control lever.

During stopping, when the hoist down flow ceases, the pilot pressure holding the motor control valve open decays to zero and the motor control valve spool closes, thus blocking all flow of oil out of the hoist motor. This same pressure decay allows the spring applied pressure released hoist brake to apply when the load is fully stopped. This brake acts as a “parking brake” and holds the load in the stopped position.

MAINTENANCE

Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below +40°F (4°C).

The engine should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

DANGER

Crushing Hazard!

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

Routine Maintenance and Inspection

Hoisting gear assemblies must receive proper maintenance and inspection in order to provide satisfactory long term operation. It is extremely important that maintenance personnel recognize that deterioration of critical internal components within the hoist reduction unit can occur. The service life and reliability of the hoist can be substantially reduced by such factors as the following:

- High cycle operation
- Operating in high ambient temperatures
- High external contamination, such as dusty or sandy conditions
- Level of maintenance

Weekly or at 40 Hours of Operation (whichever comes first)

1. Check the hoist oil level. Use only the manufacturer's recommended oil when filling.
2. Inspect for any oil leaks from the hoist gearbox.

Every Three Months or 300 Hours of Operation (whichever comes first)

Lubricate the hoist cable follower and idler arm bearings. Refer to *Hoist*, page 9-29 for recommended grease.

Annually

1. Replace the oil in the hoist gearbox, refer to *Hoist*, page 9-29. We recommend having the used hoist oil tested by a hydraulic oil analysis provider, which can give advance warning of developing wear patterns. Any sign of abnormal contamination should be treated seriously, with an examination of the internal components of the hoist conducted at the earliest opportunity.
2. Check for correct function of the hoist brake by carrying out a high line pull load test, see *Functional Check*, page 5-4. Ensure the brake holds without creeping and that the hoist control is correct.

NOTE: The function of the hoist brake should be checked more often under extreme or abnormal operating conditions.

Every Ten Years or 10,000 Hours (whichever comes first)

As part of a preventative maintenance program, we recommend that hoist assemblies be opened in a properly controlled workshop environment. The major internal components (gears, spline couplings, shafts, etc.) should be examined for damage and/or wear. New components should be installed if any are found to be worn or if there is evidence of heat or other damage. Reassemble the hoist 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 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 Grove Distributor or Manitowoc Crane Care to order replacements.

DANGER

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.

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

Item	Description
1	Main Hoist
2	Auxiliary Hoist
3	Counterweight Cylinder
4	Cable Follower
5	Idler Drum
6	Shims
7	Capscrew
8	Nut
9	Washer
10	Counterweight
11	Counterweight Cylinder Pin

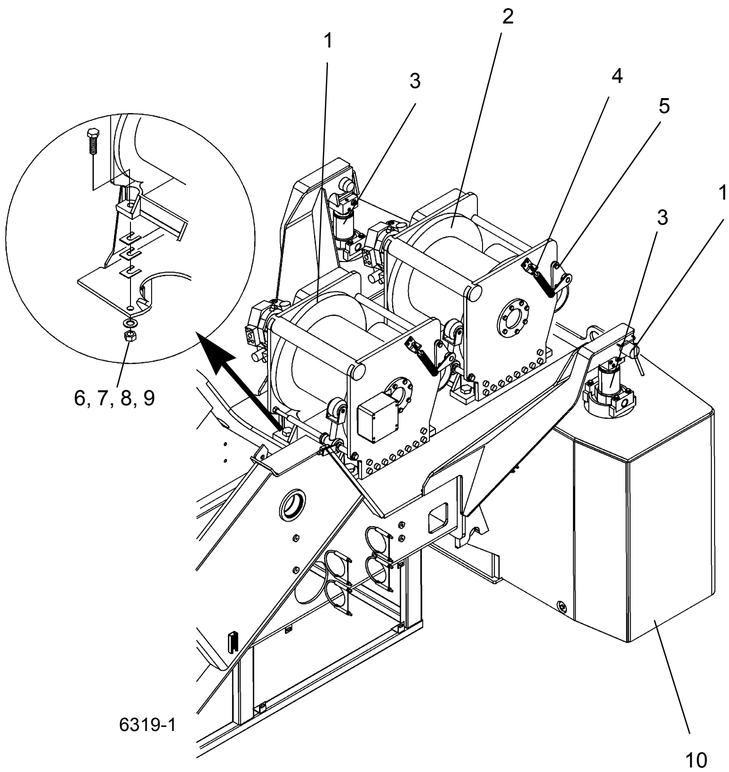


FIGURE 5-1

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 1485.9 lb (674 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 5-5 procedure in this section.
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 and torque 1047 to 1134 lb-ft (1420 to 1538 Nm).
9. Remove the lifting device from the hoist.
10. Connect the hydraulic lines to the hoist ensuring the proper lines are connected to the correct ports as marked during removal.
11. Connect the electrical wires to the hoist hi speed solenoid valve as marked during removal.
12. Connect the electrical wires to the hoist rotation indicator sensor box as tagged during removal.
13. Install the cable, following the procedures outlined under *Installing Cable on the Hoist*, in the *Operator 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 5-2 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 5-2.

   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).

Compare your reading with Table 5-1 below and take the required action.

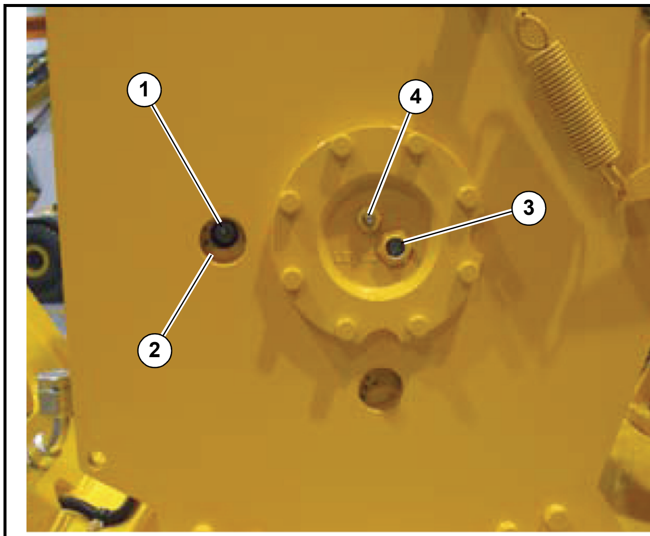


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FIGURE 5-2

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 1/8” (3 mm) from the top of the site glass. Refer to *Hoist*, page 9-29 for the correct type of oil.
Oil is visible in the sight glass and the level is no more than 1/8” (3 mm) from the top of the sight glass.	The oil level is correct.	No action is required.
Oil level is more than 1/8” (3 mm) 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 1/8” (3 mm) from the top of the sight glass.

HOIST TO BOOM ALIGNMENT

Preparation

Boom alignment must be completed before attempting hoist alignment. If the hoist is not properly aligned, the cable can be damaged or fine control could be affected.

The crane must be set on outriggers fully extended and the crane must be leveled. The boom must be over the rear on TM/TMS models and over the front on RT/Industrial models.

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 Figure 5-3.

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.

5

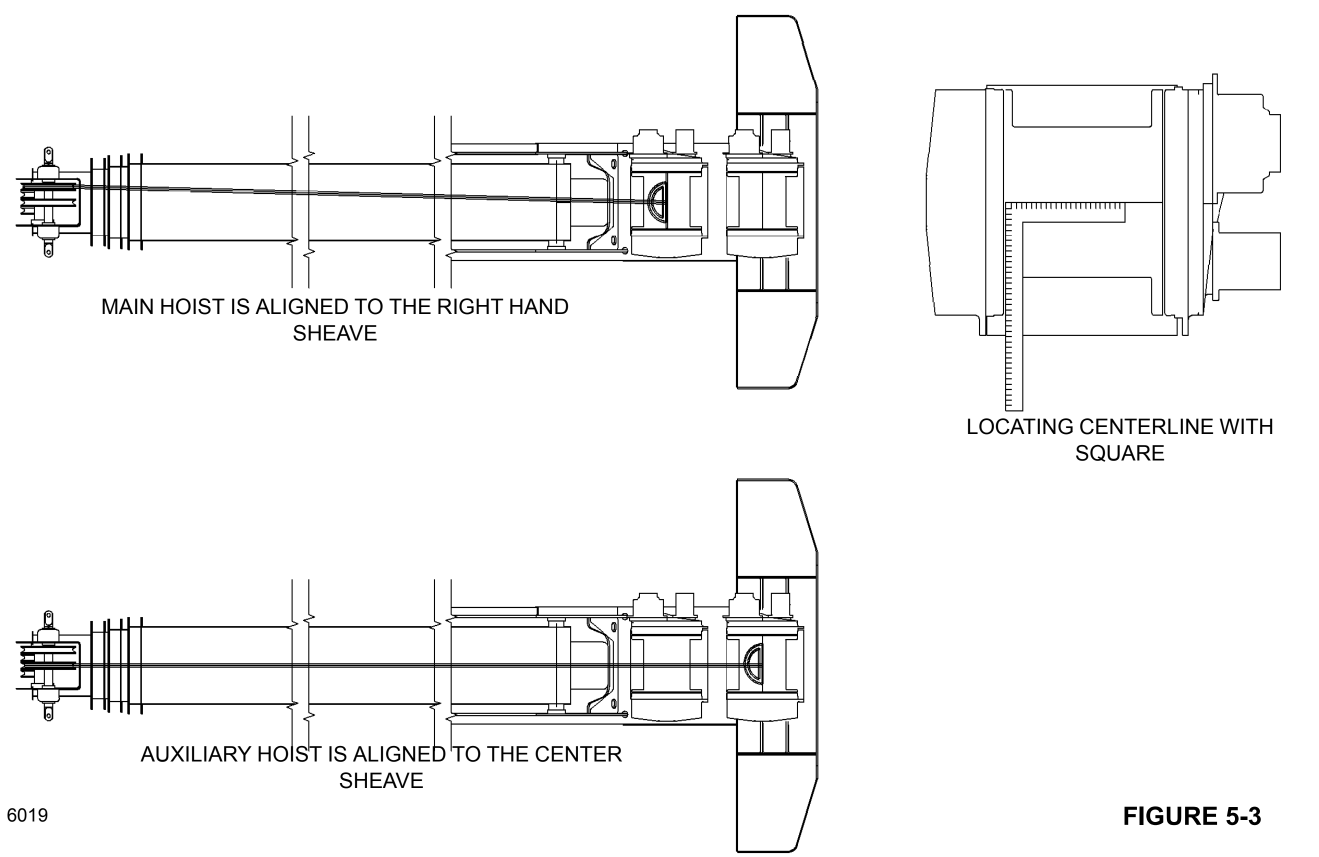


FIGURE 5-3

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 overcorrection.

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.

PISTON MOTOR AND CONTROL VALVE

Description

The piston motor is a bent axis, bidirectional, variable displacement heavy-duty motor. The motor is bolted to the hoist and is geared directly to the hoist planetary.

The motor control valve is bolted to the motor.

Maintenance

Removal

1. Thoroughly clean the external surfaces of the drum and motor with steam or clean solvent and blow dry.
2. Tag and disconnect the hydraulic lines connected to the hoist motor and the motor control valve.
3. Remove the capscrews and lockwashers that secures the motor and motor control valve to the hoist.
4. Place the motor and motor control valve in a clean, dry suitable work area.

Installation

NOTE: Care must be taken to assure the primary thrust plate remains properly located in its counterbore when the motor is re-installed. If the hoist is operated 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 components could result.

1. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil. Engage the motor shaft with the brake clutch inner race and lower into place.
2. Apply Loctite® No. 243 to the mounting bolts, and install the bolts and lockwashers. Torque the bolts to 102 Nm (75 pounds-foot).
3. Connect the hydraulic lines as tagged during removal.
4. Fill the drum with oil. Refer to *Lubrication*, page 9-1 in this manual.

IDLER DRUM AND CABLE FOLLOWER

Description

The main and auxiliary hoists are 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 rear side of it's respective hoist. The cable follower applies a downward spring pressure against the cable onto the hoist drum, to ensure that the cable will be uniformly wound onto the hoist drum, and also prevent cable from jumping under abnormal line conditions.

Maintenance

Idler Drum

Removal and Disassembly

1. Remove the bolt, washer, and lockwasher from the right side of the idler roller (Figure 5-4).
2. Support the idler roller and withdraw the shaft from the left side. Take care not to lose the dowel pin on the end.
3. Remove the roller from between the side plates.

Cleaning and Inspection

1. Clean all rust and dirt from the shaft.
2. Inspect the shaft and roller for cracks, scoring, or grooving. Replace if necessary.

Assembly and Installation

1. Position the roller between the side plates
2. Install the shaft through the left side plate and the roller. Ensure the flat on the shaft end aligns with the stop welded on the side plate, align the dowel pin.
3. Secure the shaft to the right side plate with a bolt, washer and lockwasher. Apply Loctite 243 to the bolt threads.

Cable Follower

Removal and Disassembly

1. Loosen the adjusting nuts and remove the tension spring and adjusting rod from both sides of the hoist (Figure 5-4).
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.

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 the left arm through the bushing on the left side plate. Install left spring attaching lever on the arm and secure with a bolt and locknut. Apply Loctite 243 to the bolt threads.
2. Repeat step 2 on the right side.
3. 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 at least one shim on each end.
   c. Position the angle on the right side of the shaft and secure with two bolts and washers. Apply Loctite 243 to the bolt threads.
4. 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.
5. 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.
6. Using a grease gun, apply grease to the fittings on each side plate bushing.
7. Adjust the roller as follows.
   a. With one layer of cable on the hoist drum, adjust the bolts on the front of each side plate (that push against each arm) so the roller applies pressure on the layer of cable, and does not interfere with filler/riser protrusions on the hoist drum flanges. Tighten jam nuts to secure setting.
   b. 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.

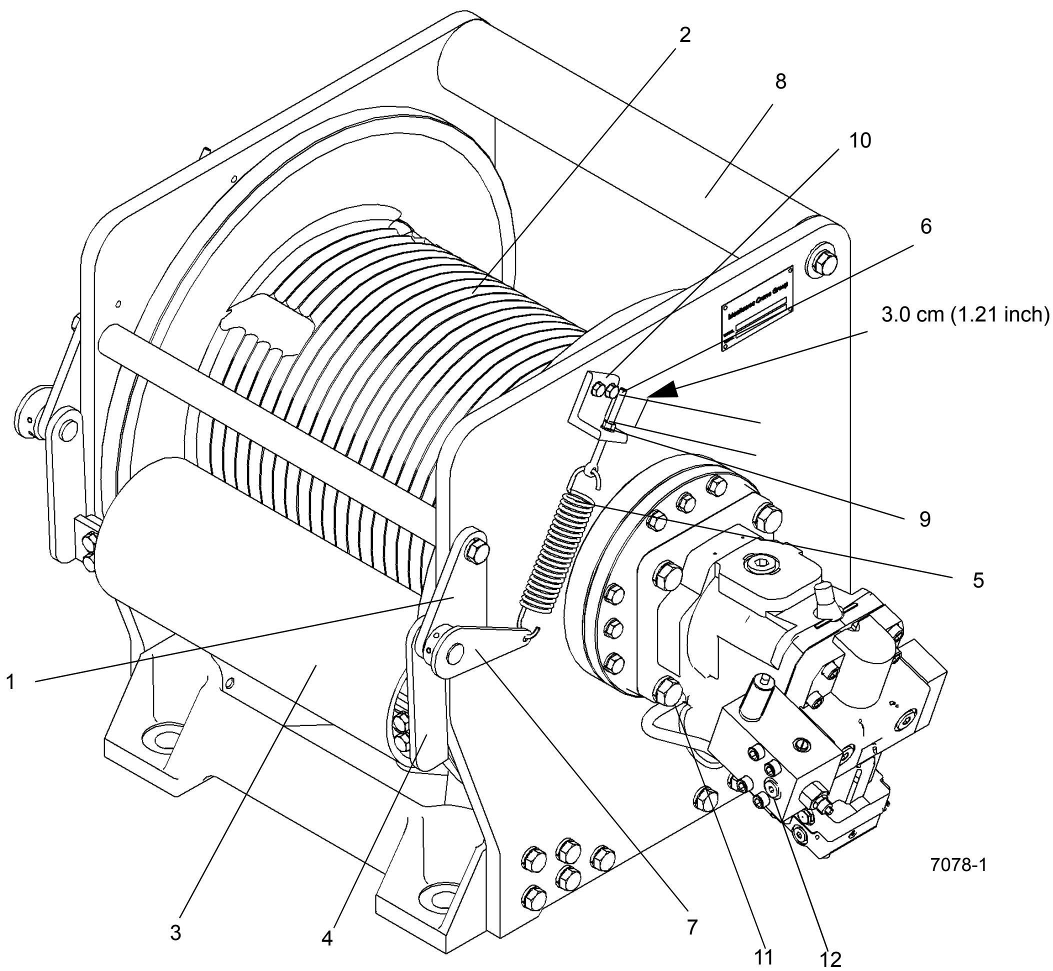
Complete Assembly

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 5-7.



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	Rotation Sensor
12	Hydraulic Motor

FIGURE 5-4

HOIST DRUM ROTATION INDICATOR SYSTEM

Description

The hoist drum rotation indicator system (Figure 5-6) 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 5-6) 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 5-6). 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 5-5).

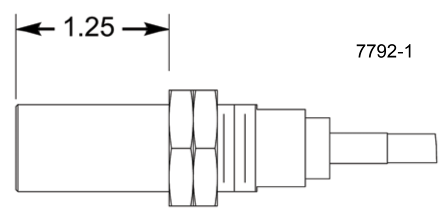


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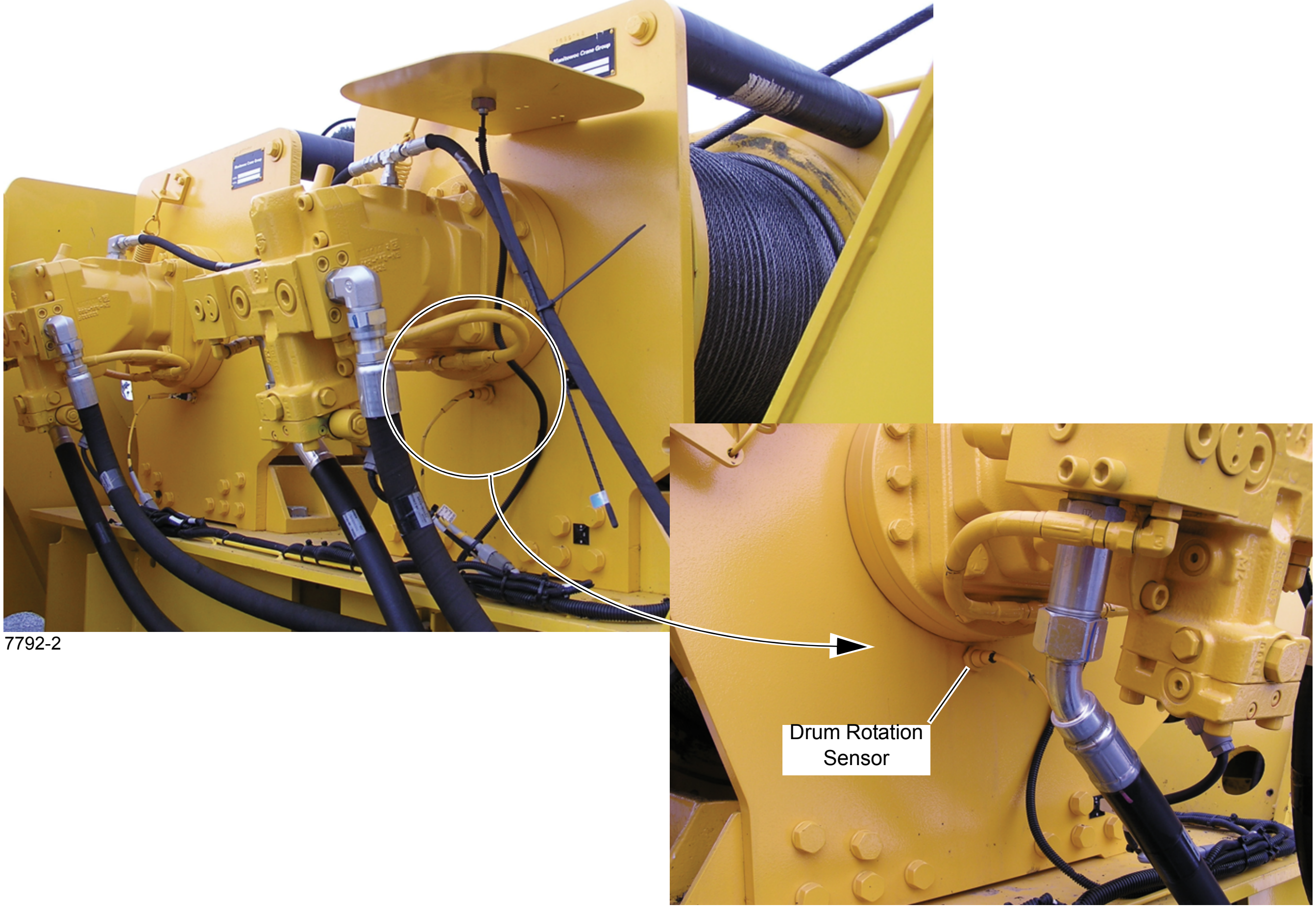
FIGURE 5-5

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.



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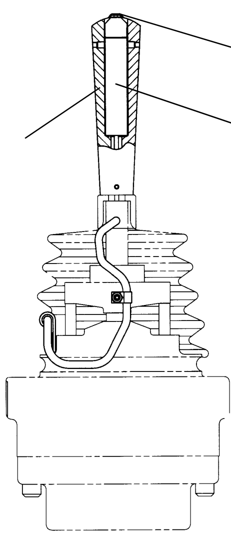


FIGURE 5-6

COUNTERWEIGHT REMOVAL

Removal of Standard Counterweight and Auxiliary Hoist

1. Position the crane on a firm, level surface. Fully extend and set the outriggers. Level the crane.
2. Position the superstructure over the front of the machine and engage the turntable lock.
3. Remove any load and handling device from the auxiliary hoist cable and retract all cable onto the hoist drum. Secure the cable.
4. Disconnect and secure the auxiliary hoist hydraulic lines and electrical harness.
5. Remove the ball detent pins which secure the counterweight mounting pins.

NOTE: It may be necessary to retract the counterweight removal cylinders to relieve weight from the counterweight mounting pins.

6. Ensure the counterweight removal cylinder support pins are securely attaching the counterweight to the turntable wing/support brackets. Disengage the counterweight mounting pins using the pinning control lever (center).
7. Using the control levers (left and right), simultaneously extend (lower) the counterweight onto the frame counterweight supports. Feather individual controls as required to lower the counterweight in a level position.
8. Remove the counterweight removal cylinder support pins from turntable wing/support brackets and using the control levers (left and right) retract the counterweight removal cylinders fully.
9. Disconnect and secure the counterweight removal cylinder hydraulic lines and replace the counterweight removal cylinder support pins on the turntable wing/support brackets.
10. Properly attach the supplied slings to the counterweight lifting holes and use a crane to carefully transfer the counterweight and auxiliary hoist to the ground or a suitable transport vehicle.

Installation of Standard Counterweight and Auxiliary Hoist Mounting Structure

1. Position the crane on a firm, level surface. Fully extend and set the outriggers. Level the crane.
2. Position the superstructure over the front of the machine and engage the turntable lock.

DANGER

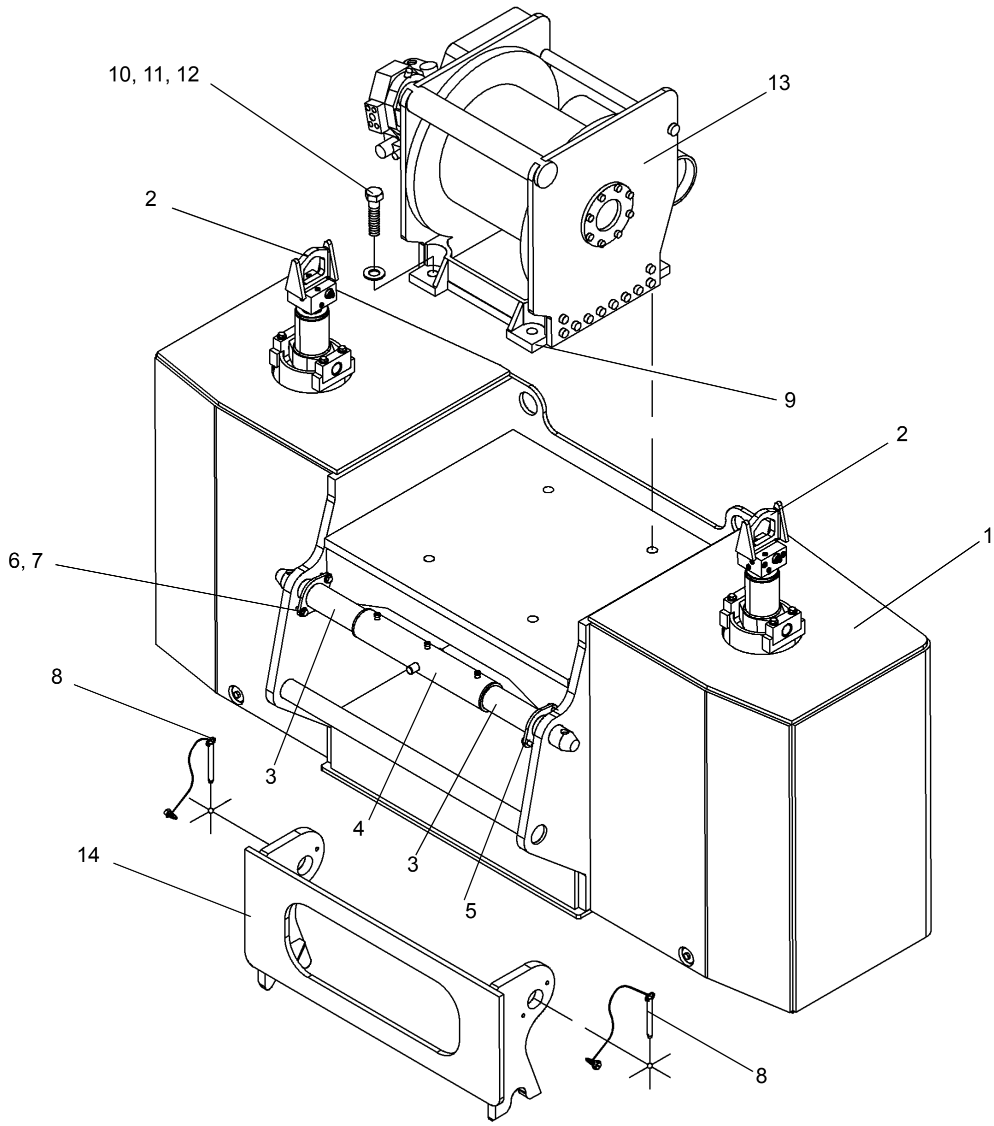
Assemble the counterweight and auxiliary hoist structure on the ground or on a suitable transport vehicle. Do not attempt to assemble on the counterweight stand, the auxiliary hoist structure may hit the counterweight and knock it off the stand.

3. Properly attach the slings to the counterweight lifting holes and use a crane to carefully transfer the counterweight and auxiliary hoist to the frame counterweight supports over the rear outrigger box.
4. Attach the counterweight removal cylinder hydraulic lines.
5. Using the control levers (left and right) extend the counterweight removal cylinders, one at a time, guiding them into the turntable wing/support brackets and pin securely.
6. Using the control levers (left and right) simultaneously retract (raise) the counterweight removal cylinders until the counterweight round bar engages the lugs on the turntable and the counterweight pinning holes are aligned with the counterweight mounting pins. Feather individual controls as required to raise the counterweight in a level position.
7. Engage the counterweight mounting pins using the control lever (center).
8. Attach the ball detent pins securing the counterweight mounting pins.
9. Relieve pressure on the counterweight removal cylinder so that weight is fully supported by the counterweight mounting pins.
10. Attach the auxiliary hoist hydraulic lines and electrical harness.

Removal of Counterweight without Auxiliary Hoist

1. Position the crane on a firm, level surface. Fully extend and set the outriggers. Level the crane.
2. Position the superstructure over the front of the machine and engage the turntable lock.
3. Remove the ball detent pins which secure the counterweight mounting pins.

NOTE: It may be necessary to retract the counterweight removal cylinders to relieve weight from the counterweight mounting pins.



Item	Description
1	Counterweight
2	Counterweight Cylinder Assembly
3	Cylinder Support
4	Pin Removal Cylinder
5	Capscrew
6	Washer
7	Capscrew

Item	Description
8	Ball Detent Pin
9	Shim
10	Capscrew
11	Washer
12	Nut
13	Hoist
14	Superstructure Weldment

FIGURE 5-7

4. Ensure that the counterweight removal cylinder support pins are securely attaching the counterweight to the turntable wing/support brackets. Disengage the counterweight mounting pins using the pinning control lever (center).
5. Using the control levers (left and right), simultaneously extend (lower) the counterweight onto the frame counterweight supports. Feather individual controls as required to lower the counterweight in a level position.
6. Remove the counterweight removal cylinder support pins from turntable wing/support brackets and using the control levers (left and right), fully retract the counterweight removal cylinders.
7. Disconnect and secure the counterweight removal cylinder hydraulic lines and replace the counterweight removal cylinder support pins on the turntable wing/support brackets.
8. Properly attach the slings to the counterweight lifting holes and use a crane to carefully transfer the counterweight to the ground or a suitable transport vehicle.

Installation of Counterweight Without Auxiliary Hoist

1. Position the crane on a firm, level surface. Fully extend and set the outriggers. Level the crane.
2. Position the superstructure over the front of the machine and engage the turntable lock.
3. Properly attach the slings to the counterweight lifting holes and use a crane to carefully transfer the counterweight to the frame counterweight supports over the rear outrigger box.
4. Attach the counterweight removal cylinder hydraulic lines.
5. Using the control levers (left and right), extend the counterweight removal cylinders, one at a time, guiding them into the turntable wing/support brackets. Pin securely.
6. Using the control levers (left and right) simultaneously retract (raise) the counterweight removal cylinders until the counterweight round bar engages the lugs on the turntable and the counterweight pinning holes are aligned with the counterweight mounting pins. Feather individual controls as required to raise the counterweight in a level position.
7. Engage the counterweight mounting pins using the control lever (center).
8. Attach the ball detent pins securing the counterweight mounting pins.
9. Relieve pressure on the counterweight removal cylinder so that weight is fully supported by the counterweight mounting pins.

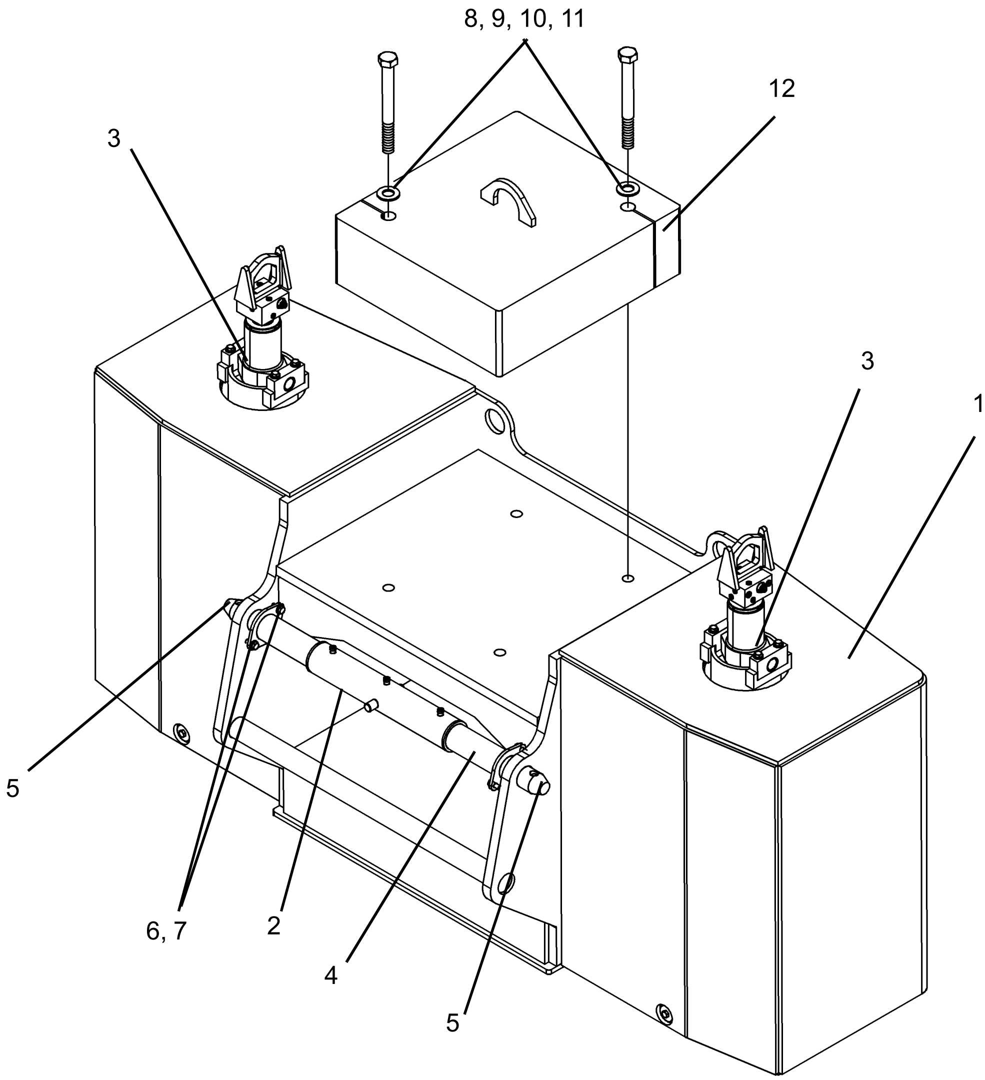


FIGURE 5-8

Item	Description
1	Counterweight
2	Counterweight Pin Cylinder
3	Counterweight Removal Cylinder
4	Cylinder Support Weld
5	Ball Detent Pin
6	Screw

Item	Description
7	Washer
8	Capscrew
9	Flatwasher
10	Lockwasher
11	Hex Nut
12	IPO Counterweight

THIRD WRAP INDICATOR (OPTIONAL—STANDARD ON CE)

Description

The third wrap indicator (Figure 5-9) 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, a lockout valve is actuated to stop hoist down operation.

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.

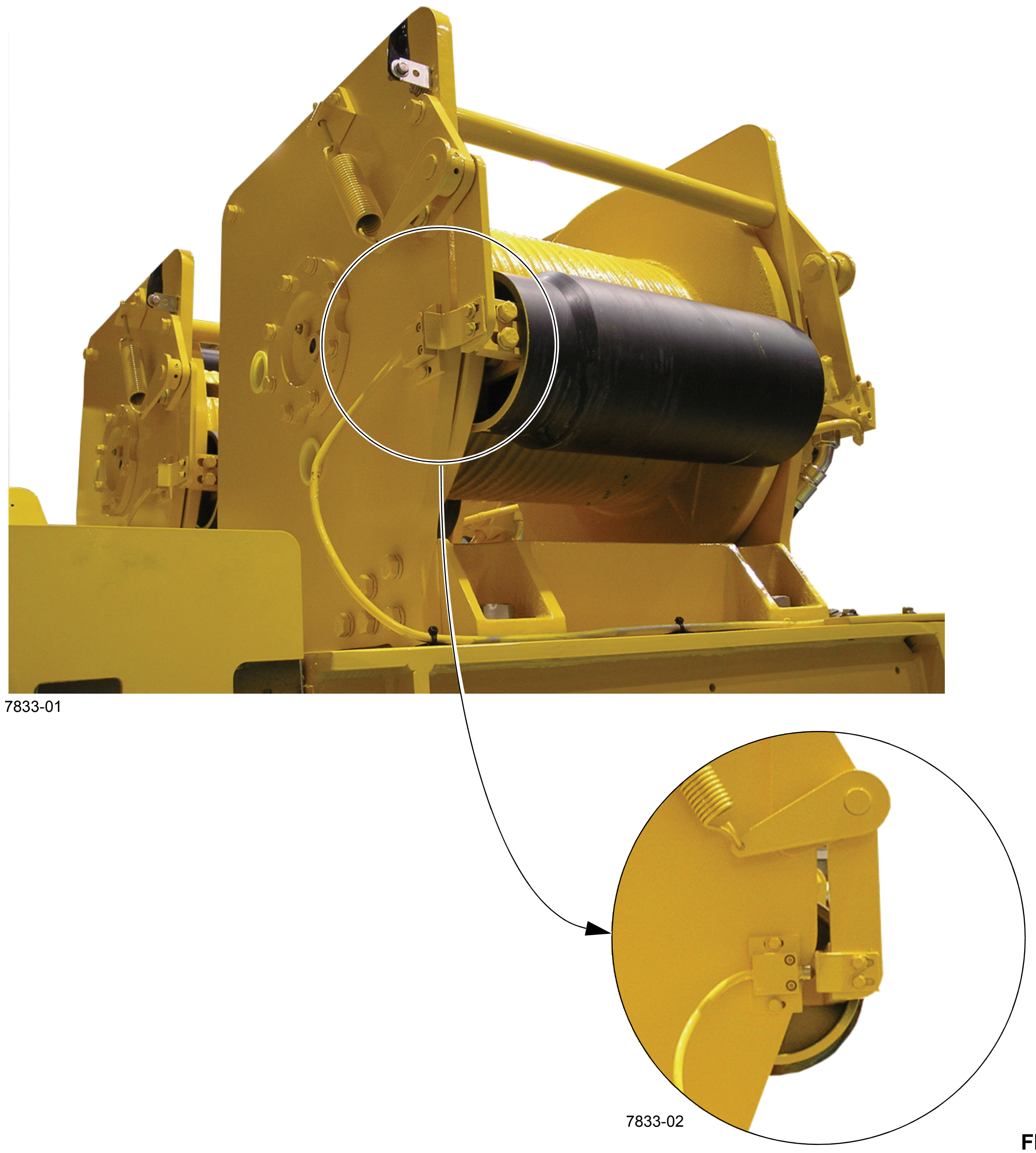


FIGURE 5-9

SECTION 6
SWING SYSTEM

SECTION CONTENTS

INTRODUCTION

Description

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term free swing means that, with the Swing Brake Switch in the OFF position, the superstructure will swing freely after the Swing Control Lever is released until it coasts to a stop or the glide swing brake pedal is depressed.

Swing is activated using the control lever in the cab. When the swing lever is actuated, hydraulic pressure is routed to the swing 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. Swing speed can be controlled by the control lever and a High/Low Swing Speed Switch on the front console. The maximum rotation speed is 2.5 rpm in HIGH speed and 1.25 rpm in LOW speed. Braking is accomplished by depressing a glide swing brake pedal which is a proportionate control valve that provides a controlled braking of the swing motion.

The swing system consists of a hydraulic remote controller, swing speed switch, series/parallel selector valve, a directional control valve, the swing drives, the swing brake assemblies, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The crane is equipped with a pin type turntable lock as standard and a standard 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type turntable lock will only lock the turntable in a straight ahead position over the front of machine. Both swing locks are operated from the cab.

Theory of Operation

Swing Drive

The hydraulic power for the swing drive is supplied by the engine driven hydraulic Pump No. 1, Section 2 mounted on the torque converter. Oil flows from the pump to the hydraulic Port 5 swivel. Flow from the swivel is routed to the front steering flow divider valve in the swing directional control valve. Bypass flow from the flow divider valve is used to supply the swing directional control valve.

When the hydraulic remote control is positioned to select right or left swing, the flow through the control valve is directed to the series/parallel valve, and then routed to the swing motors. If the Swing Brake Selector Switch is in the OFF position, the superstructure will rotate in the desired direction. Shifting the control to neutral and depressing the brake pedal will stop the swing.

Swing Brake

The hydraulic power for the swing brake is supplied by the pressure reducing/sequence valve in the swing brake and armrest lockout manifold. With the Swing Brake Selector Switch positioned to ON, the swing brake release valve blocks the regulated flow to the brake release 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.

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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.

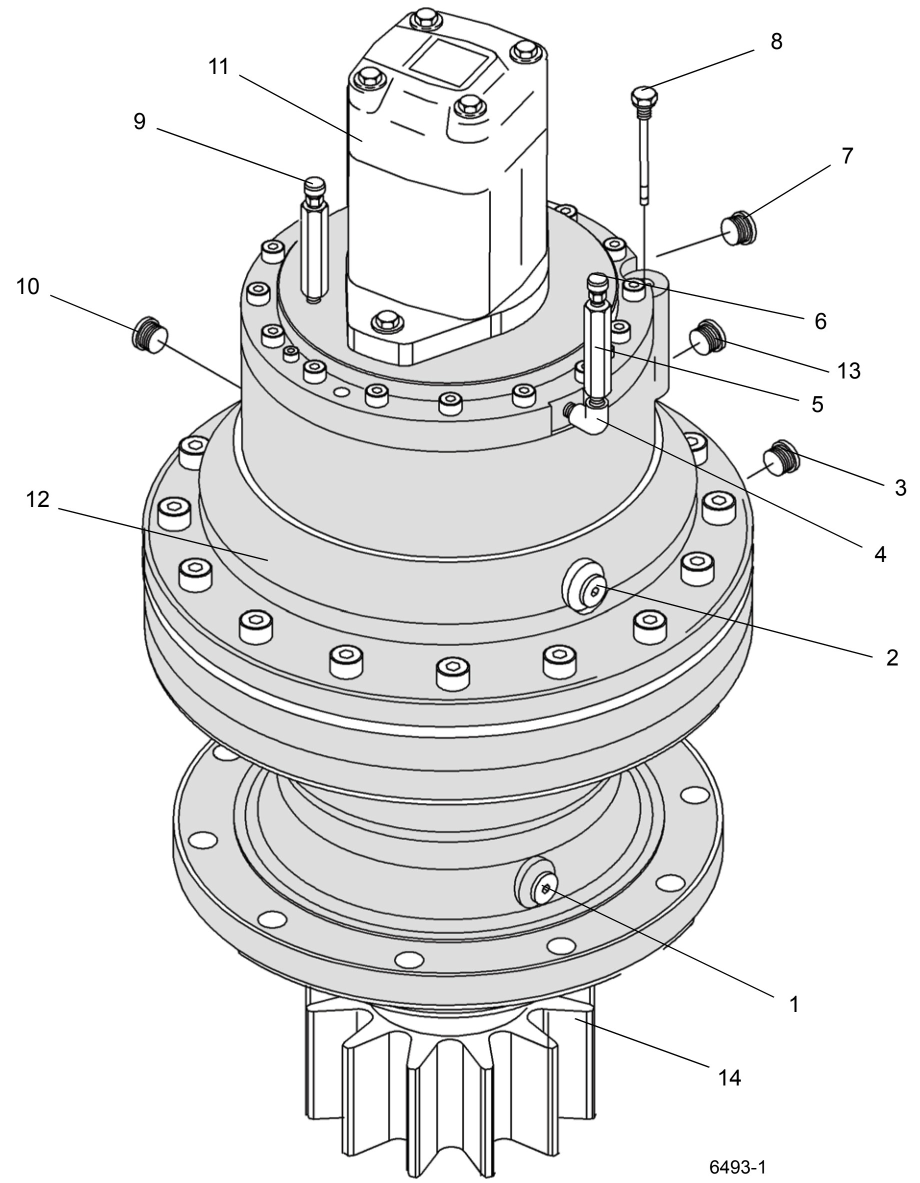

FIGURE 6-1

Item	Description
1	Plug
2	Plug
3	Plug
4	Elbow
5	Pipe
6	Breather
7	Plug

Item	Description
8	Dipstick
9	Breather
10	Plug
11	Motor
12	Gearbox and Brake
13	Plug
14	Pinion

Maintenance

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.** Replenish hydraulic oil to proper level.
	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 *Turntable*, page 9-17.
	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.
	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.
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.

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Symptom	Probable Cause	Solution
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 in *Turntable*, page 9-17.
	e. Improper size hose and/or fittings installed.	**e.** Refer to the 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.
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.

Symptom	Probable Cause	Solution
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.
12. Swing motor turning in wrong direction.	**a.** Improper port connections.	**a.** Reverse port connection.
13. Swing motor noisy.	**a.** Air in system.	**a.** Refer to *Removing Air from the Hydraulic System*, page 2-6, for removal of air from the system.
	b. Motor binding.	**b.** Repair or replace motor.

SWING MOTOR

Description

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

Maintenance

Removal

1. 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.

CAUTION

Oil can be hot and cause burns.

3. Unscrew the drain plug, remove the breather and dipstick to ensure that all oil has been removed. After the oil has been drained, replace the drain plug and any other plugs that may have been removed.

CAUTION

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

4. Remove the capscrews securing the motor and lift the swing motor free of the motor support plate. Remove and discard the O-ring from the groove in the swing brake.

Installation

CAUTION

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

1. Install a new O-ring in the groove of the swing brake. Position the swing motor on the swing brake, engaging the shaft with the brake input shaft.
2. Apply Loctite® 243 to the capscrew threads. Install the capscrews and secure the motor to the brake housing. Torque the capscrews 44 to 72.2 lb-ft (85 to 103.2 Nm).
3. 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.

SWING GEARBOX AND BRAKE

Description

The swing gearbox and brake, 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 gearboxes are 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 removal procedures found under *Swing Motor*, page 6-6.

CAUTION

Use care when removing the capscrews securing the brake, as there is tension on the bolts due to internal brake springs.

4. While observing tension on the bolts, unscrew the socket head capscrews securing the brake to the gearbox. Remove the brake assembly in one piece with the motor support plate.
5. Remove the bolts and washers securing the brake to the gearbox. Remove the brake assembly.
6. Remove and discard the O-ring from the brake housing.
7. 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.
2. Place motor support plate on brake housing.
3. Apply Loctite 270 to socket capscrews. Install motor support and brake onto gearbox and secure with the socket capscrews. Torque the capscrews 34.9 to 42.4 lb-ft (49.9 to 60.6 Nm).
4. Install the swing motor into the swing brake according to the installation procedures found under *Swing Motor*, page 6-6.
5. Connect the hydraulic lines to the motor and brake.
6. 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 capscrews and lockwashers securing the pinion guard. Remove the guard.
4. Remove the three bolts and plate attaching the pinion gear to the output shaft and remove the pinion gear.

NOTE: The complete gearbox assembly with motor weighs approximately 375 lb (170 kg).

5. Attach a suitable lifting device to the swing gearbox. Remove the capscrews, washers and spacers securing the gearbox to the mounting plate.

NOTE: Take note of the swing motor port orientation to ensure proper installation.

6. Remove the swing gearbox.
7. If necessary, remove the swing motor according to the removal procedures found under *Swing Motor*, page 6-6.
8. If necessary, remove the swing brake according to the removal procedures found under *Swing Gearbox and Brake*, page 6-6.
9. 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 installation procedures found under *Swing Gearbox and Brake*, page 6-6.
2. If removed, install the swing motor according to the installation procedures found under *Swing Motor*, page 6-6.
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 spacers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
5. Install the pinion gear on the output shaft and secure with three bolts. Torque 34.9 to 42.4 lb-ft (49 to 60.6 Nm).
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*, page 6-7.

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 SSGL-5 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.

1. Unscrew the drain plug; remove the breather and dipstick to ensure all oil has been removed.
2. After oil is drained, replace the drain plug and any other plugs that were removed to drain the oil.
3. 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.

4. To refill with oil (see Figure 6-2), make sure the breather is open. Insert oil through breather, fill until it reaches proper location on dipstick.
5. Tighten the breather and dipstick.

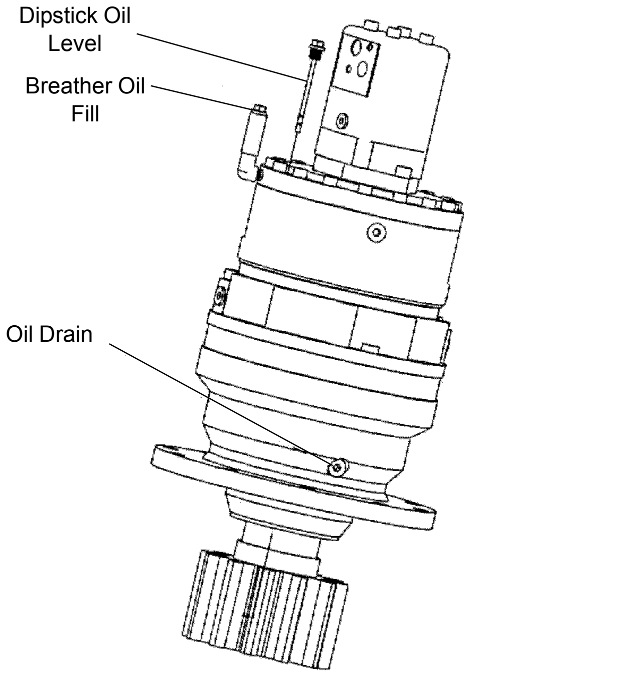


FIGURE 6-2

Checking the Oil Level

1. Check the level on the dipstick on the swing gearbox.
2. If no oil is visible on the dipstick, add SSGL-5 weight oil until the level is between min and max on the dipstick.
3. 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.

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 hosed to two fittings at the front right side of the turntable center section.

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

DANGER

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. Refer to *Fasteners and Torque Values*, page 1-15 for information on the use of a torque wrench and torque values or fasteners.

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 and metric grade 10.9), 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.

DANGER

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.

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 cranes' capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

The inner race of the bearing is secured to the turntable by 72, M24 Grade 10.9 bolts. The outer race of the bearing is secured to the carrier frame by 72, M24 Grade 10.9 bolts.

Tools Required

Figure 6-4 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: 1, 40, 22, 58, 16, 52, 34, and 70; refer to *Fasteners and Torque Values*, page 1-15 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 specified. The same tools are used as in Step 1.

Outer Race Torquing

Same as inner race.

NOTE: Bolt pattern numbering is the same for the inner and outer race

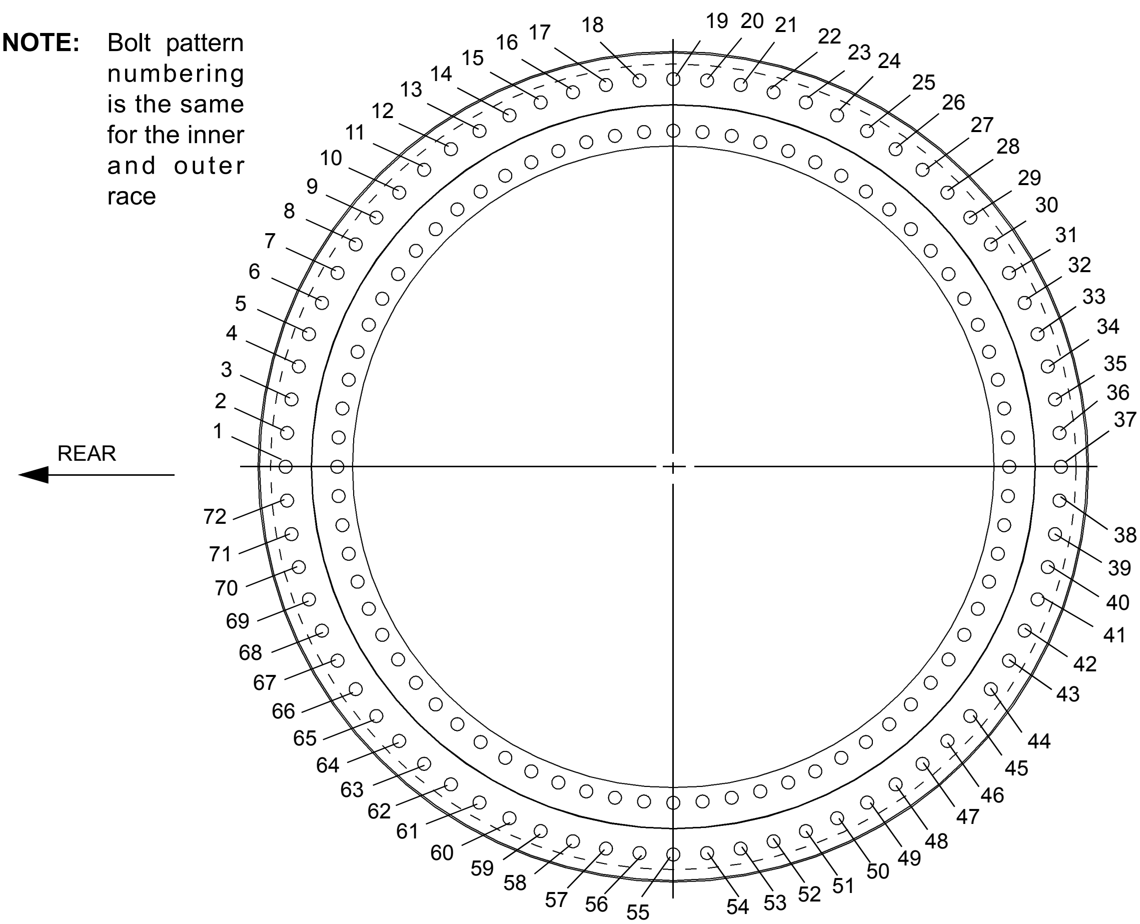
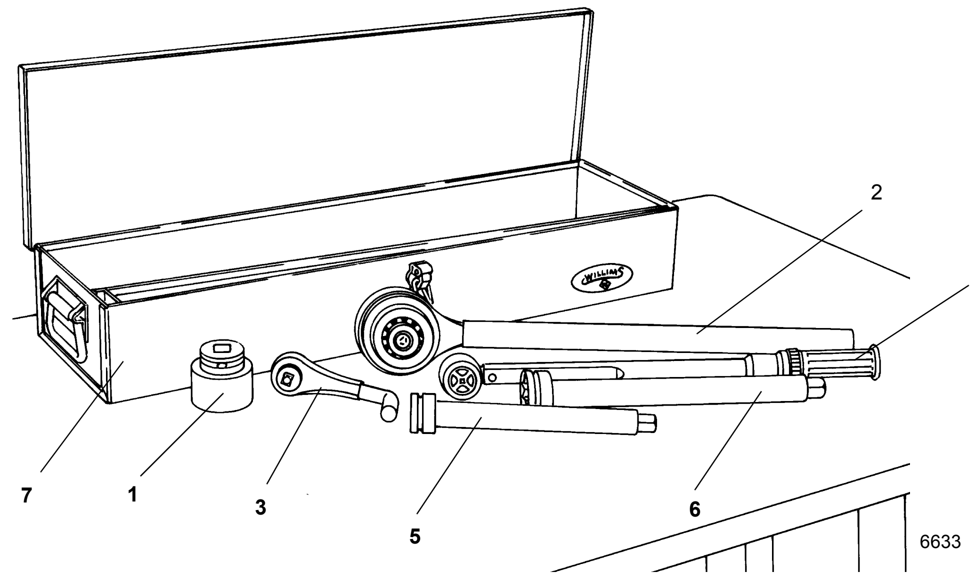


FIGURE 6-3



Orders for special tools shall be referred to:

Manitowoc Crane Care
Customer Support
1565 Buchanan Trail East
Shady Grove, PA 17256
Phone: (717) 597-8121
Fax: (717) 593-5929

Description	Manitowoc Part Number	Quantity Required
1. M24 Socket 3/4” Drive	9-999-101798	1
2. 4 to 1 Torque Multiplier (1/2” Input 3/4” Output)	9-999-100134	1
3. Backlash Adapter	9-999-100141	1
4. 1/2” Drive Torque Wrench	9-999-100136	1
5. 10” Extension 3/4” Drive	9-999-100138	A/R
6. 13” Extension 3/4” Drive	9-999-100137	A/R
7. Tool Box (Optional)	9-999-100146	1

Special Turntable Bolt Torquing Tools

FIGURE 6-4

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. Refer to *Batteries*, page 3-3.

NOTE: The boom assembly weighs approximately 36,610 lb (16606 kg) with stowed boom extension. Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached. The lift cylinder weighs approximately 3900 lb (1769 kg).

5. Remove the boom and lift cylinder following the procedures outlined in the section titled *Boom*, page 4-1.

NOTE: The counterweight/auxiliary hoist and structure weighs approximately 24,398 lb (11067 kg).

6. Remove the counterweight and auxiliary hoist following procedures outlined in *Removal of Standard Counterweight and Auxiliary Hoist*, page 5-11.

7. Tag and disconnect all water and oil lines from the bottom of the swivel. Cap or plug all lines and openings.

8. Locate the connectors and ground wire that joins the swivel wiring harness to the receptacles and ground stud on the carrier.

9. Disconnect the swivel wiring harness connectors from the carrier wiring receptacles. Remove the ground wire from the ground stud.

10. Remove the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.

11. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turntable removal.

12. On the bottom of the hydraulic swivel, bend the retainer tabs away from the bolt heads. Remove the eight bolts and four bolt retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: The swivel assembly will be removed with the turntable.

DANGER

Ensure the lifting device is capable of fully supporting the weight of the superstructure. Ensure the superstructure will not tilt or slide during lifting and moving. Failure to do so may result in death or injury to personnel and damage to equipment.

NOTE: If a lifting device capable of lifting the entire superstructure is not available, superstructure weight may be reduced by removing various components such as the hoist(s).

13. Attach a suitable lifting device to the four superstructure lifting lugs (two near the boom pivot shaft bushings and two near the lower lift cylinder pivot shaft bushings). Take in cable or chain to remove slack. Do not pull up on the superstructure.

DANGER

Ensure the superstructure is fully supported before proceeding.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be removed from the swing drive side of the turntable.

14. Remove the 72 bolts and washers securing the turntable bearing outer race to the carrier.

DANGER

Ensure that any blocking material used is capable of fully supporting the weight of the superstructure and will not allow it to tilt or shift. Failure to do so may result in death or injury to personnel.

15. Carefully lift the superstructure, using care not to damage the swivel assembly, and set it on blocking that will not allow the superstructure to tilt or shift, or rest on the swivel. Leave the lifting device attached.

NOTE: If the same bearing is to be used again, mark the position of the bearing on the superstructure so it can be installed in the exact position it was before removal.

NOTE: The bearing weighs approximately 1550 lb (703 kg). Ensure the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 72 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

DANGER

Anytime a turntable bolt has been removed, it must be replaced with a new bolt.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

NOTE: 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 72 new bolts and washers securing the bearing to the superstructure. Refer to *Inner Race Torquing*, page 6-9.
3. Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the swing drive side of the turntable.

4. Install 72 new bolts and washers. Refer to *Outer Race Torquing*, page 6-9.

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.

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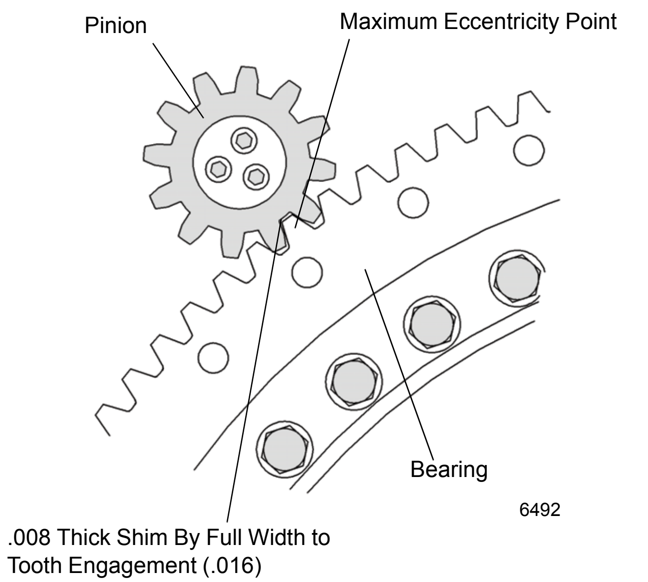


FIGURE 6-5

5. Orient ring gear such that its point of max eccentricity ("high point") is located between the swing drives. Position swing drives so that pinion is centered within cutout in base plate and motor ports face towards the outboard side as shown.

CAUTION

Do Not Clamp Over Pinion.

- Using shims, set backlash by moving the swing drive assemblies toward the bearing in order to mesh the pinion with the ring gear teeth (see Figure 6-5).
- Check tooth engagement squareness and vertical tooth engagement.
- Remove backlash shims and recheck backlash.

6. Position the two retainer plates on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure them to the spool with four bolt retainers and eight bolts. Torque the bolts to 199 ft-lb (270 Nm). 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 the section titled *Boom*, page 4-1.

NOTE: The counterweight/auxiliary hoist and structure weighs approximately 24,398 lb (11067 kg).

11. Install the counterweight and auxiliary hoist following procedures outlined in *Installation of Standard Counterweight and Auxiliary Hoist Mounting Structure*, page 5-11.
12. Reconnect the batteries.
13. Check the slew potentiometer in the electrical swivel for proper orientation. Refer to *Swivels*, page 6-12.

Testing

Activate the crane and check for proper function.

NOTE: If the superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

SWIVELS

Description

The swivel assembly (Figure 6-6) consists of a 12 port hydraulic swivel, 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. 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 integral with the hydraulic swivel. The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case engages to hydraulic case by four dowel pins.

The electrical swivel center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.

Item	Description
1	Nut and Washer
2	Electric Swivel
3	Capscrew and Washer
4	Spacer Bushing
5	Frame Mounting Lugs
6	Hex Head Screw and Jam Nut
7	Retainer Plate
8	Hydraulic Swivel
9	Mounting Bolts
10	Water and Hydraulic Case
11	Turntable Base Plate
12	Carrier Top Plate
13	Bolt and Bolt Retainer Plate
14	Tubing Clamp, Bolt, Lockwasher, Flatwasher
15	Electric Swivel Harness

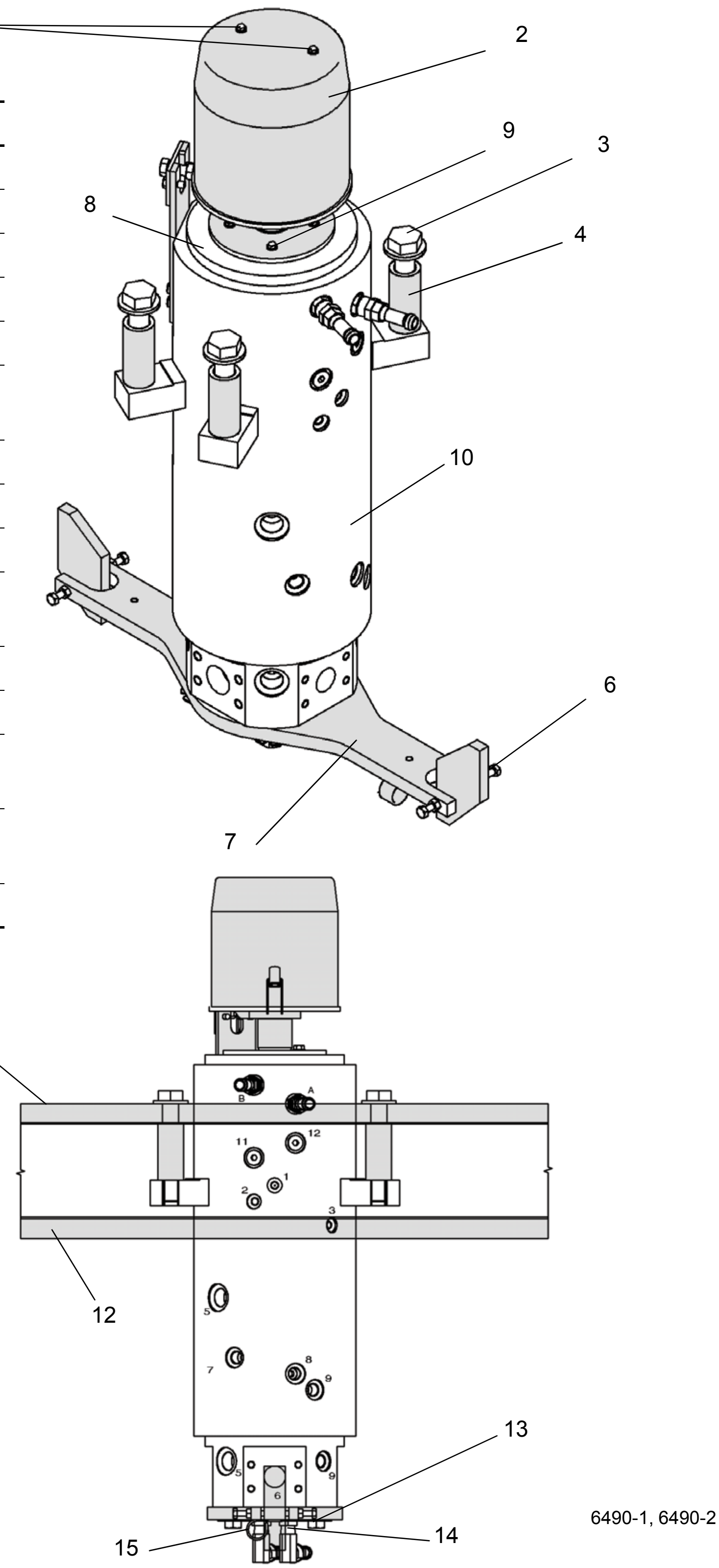


FIGURE 6-6

Hydraulic Swivel

Description

Each of the ports on the spool and case of the swivel is stamped with the port number. The function of each port is described below.

Port #	Standard Working Pressure psi (kPa)	Function
1	2901 (20000)	Brake - Front
2	2901 (20000)	Brake - Rear
3	2901 (20000)	Load Sense
4	508 (3500)	Dual Return
5	3553 (24500)	Swing/Steer
6	3553 (24500)	Lift/Tele/Hoist
7	2901 (20000)	Pilot/Accessory
8	2901 (20000)	Front Steer-Left
9	2901 (20000)	Front Steer-Right
10	508 (3500)	Drain
11	29 (200)	A/C
12	29 (200)	A/C
A	29 (200)	Heater Supply (Coolant)
B	29 (200)	Heater Return (Coolant)

Theory of Operation

The hydraulic swivel allows oil to flow from the pumps to various crane functions on the superstructure. All oil is routed into the spool portion of the swivel where, through a series of internally drilled passages, oil is transferred to circumferential channels on the spool exterior. These channels correspond with a mating port on the outer case of the swivel. Each channel is separated by a series of nylon and O-ring seals that prevent transfer of oil and pressure. Return flow from the crane superstructure is accomplished in the same manner through another set of ports.

Maintenance

Removal

1. Extend and set the outriggers. Ensure the crane is level and the boom is over the front.
2. Elevate the boom and note at what boom angle, you have the most clearance between the lift cylinder and the turntable side plate. Shut down the engine.
3. Measure the distance from the top of the lift cylinder to the base of the boom section where the lift cylinder attaches. Cut two pieces of 4 x 4 in (10 x 10 cm) oak to fit.

NOTE: It might be necessary to raise the boom slightly to allow installation of the blocking.

NOTE: This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use the oak blocking to block between the barrel of the lift cylinder and the boom base section.
5. Tag and disconnect the hydraulic lines from the case of the hydraulic swivel. Cap or plug all lines and openings.
6. Tag and disconnect the hydraulic lines and water lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
7. Tag and disconnect the water lines from the case of the water swivel. Cap or plug all lines and openings.
8. Disconnect the swivel wiring harness connectors from the carrier receptacles and the yellow ground wire from the connector mounting bracket on the carrier frame. If necessary, remove the electrical swivel. Refer to *Electrical Swivel*, page 6-16.

NOTE: The hydraulic swivel weighs approximately 213 lb (97 kg). The hydraulic, water, and electrical swivel combined weigh approximately 239 lb (108 kg).

9. On the bottom of the swivel, bend the retainer tabs away from the bolt heads. Remove the capscrews and capscrew retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: It may be necessary to remove some drive line components to remove the swivel.

10. Position an adequate supporting device beneath the swivel.

11. Remove the capscrews, washers, and bushings securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

Installation

NOTE: The hydraulic swivel weighs approximately 213 lb (97 kg). The hydraulic, water, and electrical swivel combined weigh approximately 239 lb (108 kg).

1. Raise the swivel into position.

2. Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews and washers. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.

NOTE: Allow a 1/32' (1 mm) max gap between bolt and the retaining lug on the frame. Do not tighten bolt against lug (Figure 6-7).

3. Position the two retainer plates on the hydraulic swivel spool ensuring they engage the lugs on the carrier frame. Secure the retainer plates with the capscrews and capscrew retainers. Apply Loctite® 271 to the bolt threads. Torque the bolts 199 lb-ft (270 Nm). Bolt head flats must align with retainer tabs. Bend all the retainer tabs to make contact with the bolt heads. Snug the retainer plate capscrews against the lugs on the carrier frame and tighten the locking nuts.

4. If removed, install the electrical swivel. Refer to *Electrical Swivel*, page 6-16. Connect the swivel wiring harness connectors to the carrier receptacles and the ground wire to the mounting bracket on the carrier frame. Use the bolt and star washers taken off at removal. Make sure the ground connection is clean and has good metal to metal contact. Spray the connection with a battery terminal protectant such as Deka Battery Terminal Protection spray, Grove P/N 9999102423.

5. Install the clamp, lockwasher, flat washer and capscrew to the bottom of the swivel retainer plate securing the wiring harness.

6. Connect the hydraulic lines and water lines to the spool of the hydraulic swivel as tagged during removal.

7. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.

8. Connect the water lines to the water swivel case as tagged during removal.

9. Remove the blocking material from the lift cylinder.

10. Activate all systems; cycle all functions and observe for proper operation and any leakage.

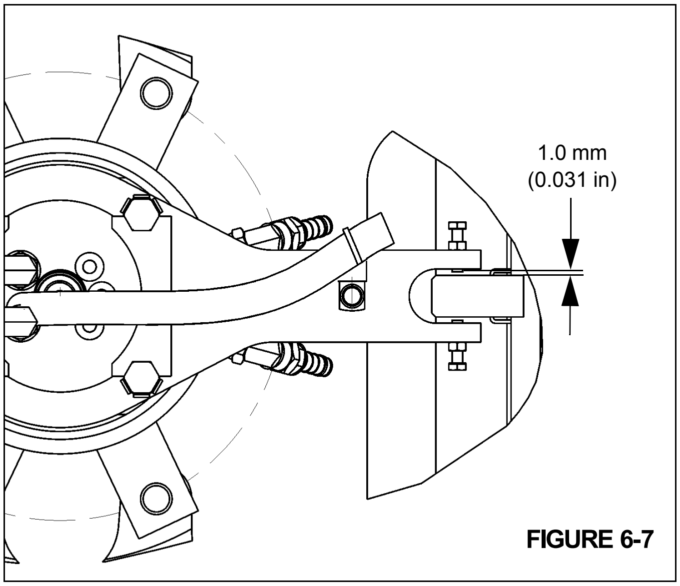


FIGURE 6-7

Two Port Water Swivel

Description

The two port water swivel allows engine coolant to flow from the carrier-mounted engine to the hot water heater in the operator's cab. Through an internally drilled passage in the 14 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/telflon 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 the removal procedure under *Hydraulic Swivel*, page 6-14.

2. Remove the electrical swivel. Refer to removal procedure under *Electrical Swivel*, page 6-16.

3. Tag and disconnect the lines from the case of the water swivel. Cap or plug all lines and openings.

4. Remove the four bolts and washers securing the water swivel and electrical swivel center post to the hydraulic swivel. Remove the water swivel case and center post.

Disassembly

NOTE: Any maintenance requiring disassembly of the water swivel should include replacement of all seals and rings.

CAUTION

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

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

1. Remove the seals and rings from the spool.

Cleaning and Inspection

DANGER

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid prolonged skin contact, inhalation of vapors, or smoking. Failure to comply can result in injury or death to personnel.

1. Clean the spool and case with a suitable solution and dry with compressed air. Plug all ports with plastic caps.
2. Check the spool and inside of the case for scratches, grooves, scoring, etc. If any grooves have developed with a depth of 0.005 in (0.127 mm) the unit should be replaced.

Assembly

NOTE: Lubricate the interior of the swivel to prevent rusting from condensation.

1. Lubricate the spool, seals, and rings.

CAUTION

When installing seals and rings, avoid stretching seals or scratching grooved or gland surfaces.

2. Install new seals and rings on the spool.

CAUTION

Proper alignment when installing the case is required. Do not force the spool into the case.

3. Insert the spool into the barrel.

Installation

1. Install the water swivel on top of the hydraulic swivel. Secure the water swivel and the electrical swivel center post with the capscrews and washers.
2. Connect the lines to the swivel case as tagged during removal.
3. Install the electrical swivel. Refer to the installation procedure under *Electrical Swivel*, page 6-16.
4. Perform steps 8 and 9 of the installation procedure under *Hydraulic Swivel*, page 6-14.
5. Activate all systems, cycle all functions, and observe for proper operation and any leakage.

Electrical Swivel

Description

The swivel assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes, leads, and clips which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the swivel. The collector ring leads are formed into one harness which is routed downward through the center of the hydraulic swivel. Extending from the base of the hydraulic swivel, the collector ring leads are also formed into connectors which plug into receptacles from the chassis power supply.

The swivel cover is secured with a seal and bolts

The electrical swivel also incorporates a slew potentiometer. The potentiometer controls functions in the rated capacity limiter, working area definition, and rear axle oscillation lockout systems.

Theory of Operation

The electrical swivel is located on top of the water swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity between the carrier and superstructure.

Maintenance

Removal

1. Perform steps 1 through 4 of the removal procedure under *Hydraulic Swivel*, page 6-14.

WARNING

Disconnect the batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

2. Disconnect the batteries. (Refer to *Batteries*, page 3-3.)
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.
5. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.
6. Secure the connectors and wires from each of the numbered connectors so the harness can be withdrawn through the center of the hydraulic swivel.
7. Tag and disconnect the connectors from the receptacles on the cab bulkhead mounting plate.
8. Remove the capscrews and washers, and remove the cover from the electrical swivel.
9. Loosen the setscrews securing the electrical swivel mounting tube to the center post on the water swivel.
10. Remove the capscrew and jam nut securing the electrical swivel case to the plate on the case of the water swivel.

CAUTION

When withdrawing the wiring harness through the center of the hydraulic and water swivels, ensure the wires do not get caught and damaged.

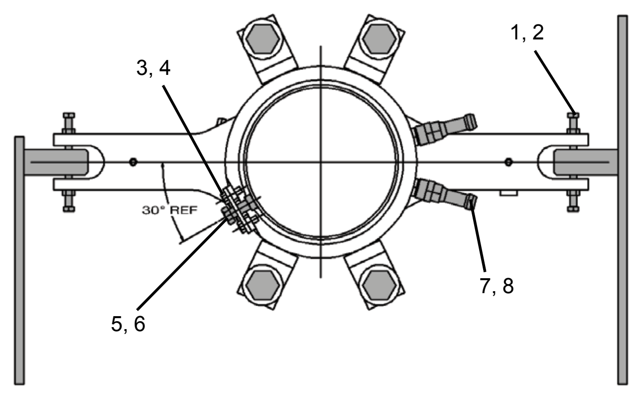
11. Remove the swivel and wiring harness from the crane. If necessary, remove the spacer bushing from the center post.

Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic and water swivels.

NOTE: The boom should be centered directly over the front of the crane before adjustment is made to the slew potentiometer.

2. Slide the electrical swivel mounting shaft onto the center post.
3. Ensure the threaded hole on the bottom of the electrical swivel base is aligned with the mounting hole in the plate on the water swivel case. Install the capscrew through the hole in the plate and install the jam nut. Screw the capscrew into the hole in the electrical swivel base until the capscrew head is approximately 0.23 in (6.0 mm) from the bracket. Tighten the nut against the electrical swivel (Figure 6-8).
4. Apply medium strength Loctite® to the setscrews securing the electrical swivel to the center post and tighten them 44 to 53 lb-in (5 to 6 Nm).
5. Install the swivel cover and secure with capscrews and washers.
6. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal.



TOP OF SWIVEL

FIGURE 6-8

Item	Description
1	Hex Nut
2	Capscrew
3	Capscrew
4	Flatwasher
5	Capscrew
6	Jam Nut
7	Nipple
8	Adapter

7. Plug the connector into the carrier wiring receptacle, connect the wires as tagged during removal. Install the yellow ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken off at removal. Make sure the ground connection is clean and has good metal to metal contact. Spray the connection with a battery terminal protectant such as Deka Battery Terminal Protection spray, Grove P/N 9999102423.
8. Install the clamp securing the harness to the retainer plate on the bottom of the hydraulic swivel assembly.
9. Connect the batteries.

6

CAUTION

It is imperative that the slew potentiometer be adjusted anytime work is done to the electrical swivel.

10. Activate all systems, cycle all functions, and observe for proper operation. Adjust the slew potentiometer in accordance with the procedures under *Slew Potentiometer Adjustment*, page 6-18.

Preventive Maintenance

It is recommended that a normal inspection of the electrical swivel collector ring and brush assembly be established. An example of this could be at approximately 100 to 150 engine operating hours. When this time limit is reached, perform the following.

1. Check the collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check the collector ring setscrews and ensure they are tight.
3. Check the brush and arm assembly springs. Ensure they are holding the brushes firmly against the collector rings.

Slew Potentiometer Adjustment

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 PAT Rated Capacity Limiter BCS Operator's Handbook for detailed instructions.

- Complete the RCL console setup according to the crane's current operating configuration.
- Press limits LIM.
- Press 4 for slew angle/work area definition limits.
- Press 1 for slew angle.
- Press 2 or 3 to display slewing angle.

3. Remove the electrical swivel cover.

CAUTION

Do not attempt to rotate the slotted shaft in the center of the slew potentiometer.

4. Disengage the house lock pin and swing the superstructure approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 4 must be repeated.

5. Loosen the three screws that secure the slew potentiometer to the mounting plate.
6. Rotate the body of the slew potentiometer until the slew angle indicates 0.6 ± 0.1 degree.

NOTE: The slew angle indication in step 6 may not be obtainable due to limited wire length on the potentiometer, or the electrical terminals interference with one of the three mounting screws. If this occurs, reposition the collar set screwed to the potentiometer shaft and repeat steps 4 thru 6.

7. Tighten the three screws that secure the slew potentiometer to the mounting plate. Install the electrical swivel cover.
8. Disengage the house lock pin and swing approximately 10 degrees to the left (counterclockwise). Slowly swing back to the right and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 8 must be repeated.

9. If the angle indicated on the console does not exceed ± 1.0 degree, proceed to step 10. If the indicated angle exceeds ± 1.0 degree, return to step 3.
10. Disengage the house lock pin and swing approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 10 must be repeated.

11. If the angle indicated on the console does not exceed ± 1.0 degree, proceed to step 12. If the indicated angle exceeds ± 1.0 degree, return to step 3.
12. Disengage the house lock pin and swing approximately 10 degrees to the left (counterclockwise). Slowly swing back to the right and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, step 12 must be repeated.

13. Verify the angle indicated on the console does not exceed ± 1.0 degree. If the indicated angle exceeds ± 1.0 degree, return to step 3.

SECTION 7
POWER TRAIN

SECTION CONTENTS

ENGINE

Description

The engine is a Cummins QSB6.7 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 accelerator 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 *Operator Manual* for details on the operation of the idle switch). The foot accelerator pedal and idle switch are electrically connected to the superstructure control module which sends the signal to the engine ECM via the 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 rear of the right rear fender. The exhaust system is mounted on the left side of the frame behind the rear fender.

DANGER

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 the 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 after-treatment assembly. 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*, page 7-25.
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 2400 lb (1100 kg).

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. Install the hydraulic hoses.
6. Install the radiator. Refer to *Radiator Removal and Installation.*, page 7-22. Connect all hoses and electrical harnesses to the radiator as tagged during removal.
7. Connect the drive shafts between the transmission/torque converter and the axles. Refer to *Drive Lines*, page 7-25.
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 after-treatment assembly. On Tier IV engines, replace the exhaust tube gaskets with new ones.
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 Belt

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.

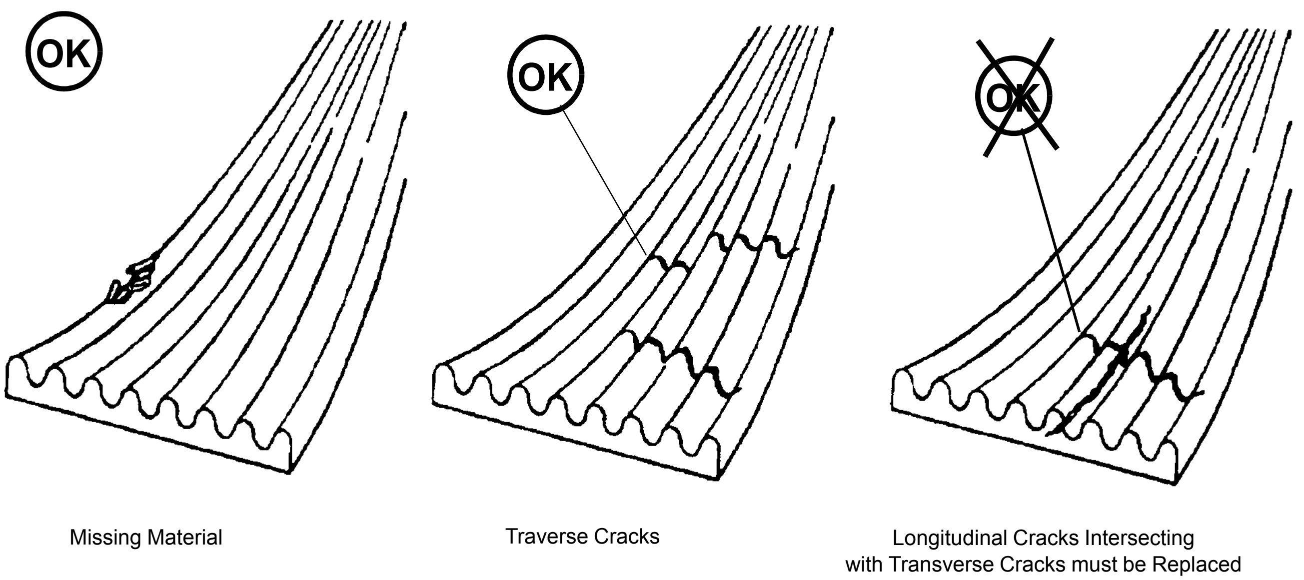


FIGURE 7-1

ELECTRONIC CONTROL SYSTEM

The engine control system is an electronically operated fuel control system that also provides many operator and vehicle features, as well as, reducing 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 control panel display or with the correct service tools. The ECM communicates with service tools supplied by Cummins through a SAE J1939 data link.

The ECM also monitors the condition of the Decomposition Tube and illuminate an indicator when it is getting filled with urea and needs to be cleaned out. When the Decomposition Tube becomes clogged, the ECM will control the exhaust system cleaning process to clean the tube of urea.

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.

In addition to alerting the operator of system faults, the Engine Stop Light, in conjunction with the Engine Warning Light, is used in the diagnostic operation of the engine control system.

NOTE: When not using the diagnostic system, turn the Engine Diagnostic Test Mode Switch to the OFF position.

To check for active fault codes, turn the keyswitch to the OFF position, and move the Engine Diagnostic Test Mode Switch to the ON position. Turn the vehicle keyswitch to the ON position. If no active fault codes are recorded, both lamps stay off. If active fault codes are recorded, both lamps will come on momentarily, then begin to flash one code of the recorded faults.

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.

In addition to alerting the operator of system faults, the Engine Warning Light, in conjunction with the Engine Stop Light, is used in the diagnostic operation of the engine control system.

NOTE: When not using the diagnostic system, turn the Engine Diagnostic/Speed Control Switch to the speed control position.

To check for active fault codes, the keyswitch must be in the OFF position, and move the Engine Diagnostic/Speed Control Switch to the engine diagnostic position. Turn the vehicle keyswitch to the ON position. If no active fault codes are recorded, both lamps stay off. If active fault codes are recorded, both lamps will come on momentarily, then begin to flash one code of the recorded faults.

Fault Code Flashing Sequence

The Engine Warning Light (amber) flashes at the beginning of a fault code sequence. There will be a short 1- or 2-second pause after which the number of the recorded fault code will flash in the Engine Stop Light (red). To interpret the flash code, count the first sequence of red flashes for the first digit and after a two second delay, count the second sequence of red flashes for the second digit. When the number has finished flashing in red, the Engine Warning Light (amber) flashes again. The lamps flash each fault code 3 times before advancing to the next code. To skip to the next fault code, move the Increment/Decrement Switch in either position (**+**/**-**) to see other fault codes. If only one active fault is recorded, the control system will continuously display the same fault code when pressing the Increment/Decrement Switch. Reference the engine manufacturers service manual for explanation and correction of the fault codes.

Exhaust System Cleaning Indicator

The Exhaust System Cleaning Indicator is located in the steering column gauge display. This indicator illuminates amber when the Decomposition Tube is getting filled with urea and needs to be cleaned out.

When the indicator illuminates or flashes, start the manual exhaust system cleaning process at the next opportune time.

The indicator will be lit continuously during the early stages of clogging. If the system continues to clog, the lamp will begin to flash and slight engine derate will occur.

If even more clogging occurs, the engine warning light (14) will illuminate in addition to the indicator (15) and severe engine derate will occur.

WARNING

Extreme Heat Hazard!

During the exhaust system cleaning process the exhaust becomes very hot. Do not park the vehicle near flammable objects.

Use caution near the exhaust tailpipe during exhaust system cleaning as it will become very hot.

The exhaust system cleaning process can take place in three different modes:

Passive: the exhaust is hot enough during normal working operation to burn off any accumulation.

Active: Active self-exhaust system cleaning occurs when there is not sufficient heat in the exhaust to convert all the urea being collected in the decomposition tube. Exhaust temperatures are raised by injecting a small amount of fuel. The resulting chemical reaction raises exhaust gas temperatures high enough to remove the urea from the decomposition tube. This is all done without any operator intervention.

Manual: Manual, or stationary, exhaust system cleaning is the same as active exhaust system cleaning but takes place while the equipment is not being operated. It offers the equipment operator the option, if needed, of performing exhaust system cleaning outside the normal duty cycle.

Exhaust System Cleaning Switch

WARNING

Fire or Burn Hazard!

During the exhaust system cleaning process the exhaust becomes very hot. Do not park the vehicle near flammable objects.

Use caution near the exhaust tailpipe during exhaust system cleaning as it will become very hot.

The Exhaust System Cleaning Switch is located on the right side of the overhead control panel. This switch is a three position switch, Inhibit Cleaning/Permit Cleaning/Start Cleaning. Press this switch to start exhaust system cleaning or to disable exhaust system cleaning:

- Start Exhaust System Cleaning  (7649-10)
- Inhibit Exhaust System Cleaning  (7649-11)

To manually clean, set the crane parking brake, the crane transmission must be in neutral and have all pedals released. Refer to *Exhaust System Cleaning Indicator*, page 7-5 for a description of when manual exhaust system cleaning is needed.

Set up a safe area around the crane's exhaust; remove tools, rags, grease or any debris from the engine exhaust area.

With the engine idling push the Exhaust System Cleaning Switch to initiate exhaust system cleaning.

As a warning, the light above the exhaust pipe will blink during exhaust system cleaning.

Pressing accelerator pedal during exhaust system cleaning or activating the Inhibit Exhaust System Cleaning Switch will interrupt the exhaust system cleaning process.

Make sure the crane and surrounding area are monitored during manual exhaust system cleaning. If any unsafe condition occurs, shut off the engine immediately.

During this period the sound of the engine may change. When exhaust system cleaning is complete the engine will return to it's normal idle speed.

Inhibit Exhaust System Cleaning Indicator

The Inhibit Exhaust System Cleaning Indicator is located in the steering column gauge display. When the Exhaust System Cleaning Switch is in the inhibit exhaust system cleaning position, this amber indicator is illuminated and active and manual exhaust system cleaning is prevented.

High Exhaust System Temperature

The High Exhaust System Temperature (HEST) Indicator is located in the steering column gauge display.

During exhaust system cleaning it is possible for the engine exhaust to reach temperatures exceeding 1200° F. The HEST indicator will illuminate red to warn the operator when temperatures reach 1247°F (675°C) and will stay on until the temperatures falls below 1157°F (625°C).

The HEST Lamp does not indicate a fault, and is provided for the operator's information and warning for bystanders.

Warning lights near the tailpipe will flash during exhaust system cleaning when high exhaust temperatures exist.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, fuel-water separator, secondary filter, 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 74 gal (280 l). A connection on the bottom of the tank provides for fuel supply to the engine. Surplus fuel from the engine is provided to the bottom of the fuel tank below the fuel level. The tank is equipped with a non-vented filler cap, chain-attached to the tank, and a fuel quantity sender unit which provides a signal to a fuel quantity gauge on the instrument panel in the cab. The fuel tank for the CE units has a lockable vented filler cap.

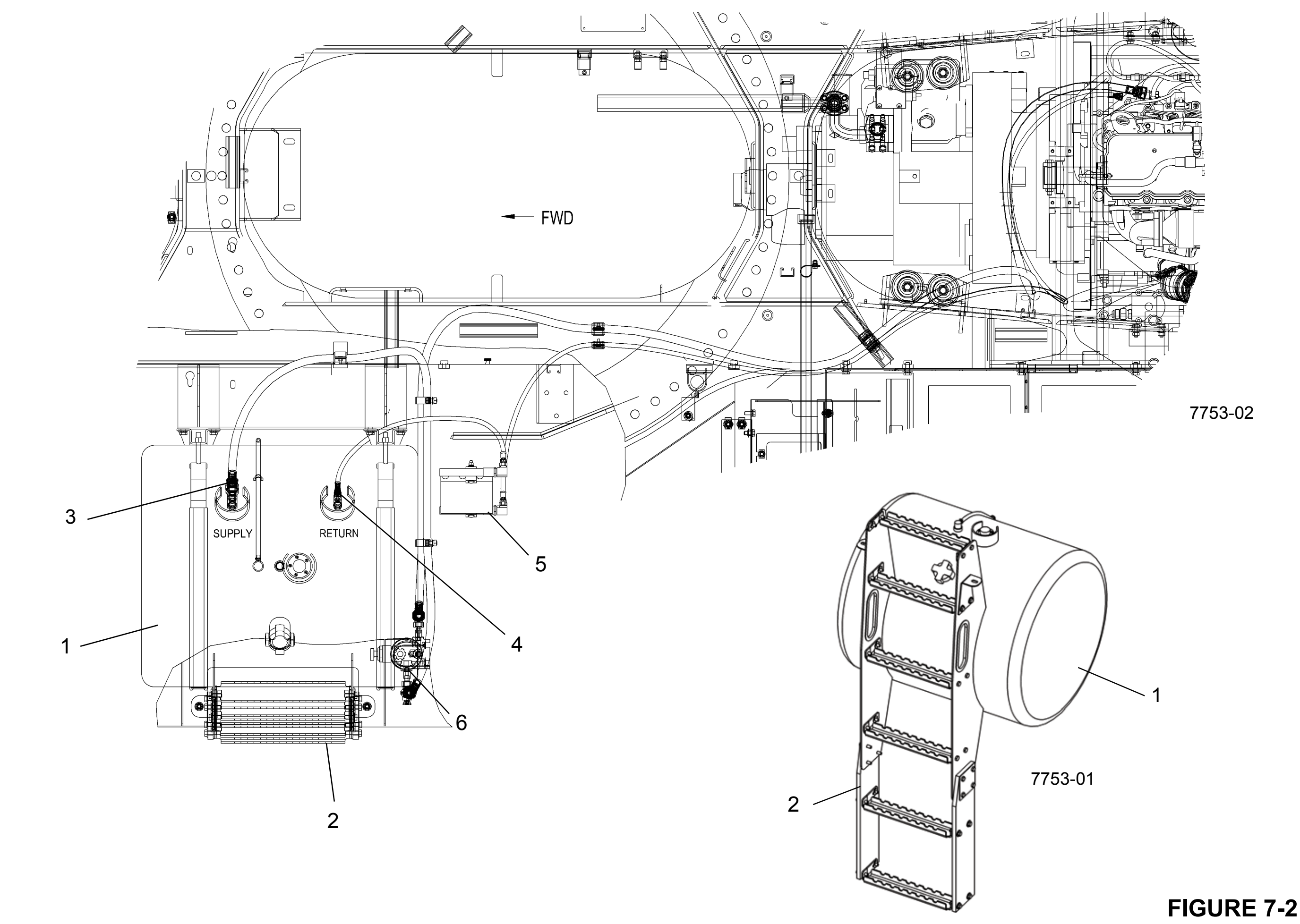


FIGURE 7-2

Item	Description
1	Fuel Tank
2	Steps
3	Fuel Supply
4	Fuel Return
5	Oil Cooler
6	Fuel Filter-Water Separator

Injection Fuel Pump

The fuel is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is metered during 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 to the hydraulic oil cooler bracket 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 on the right side of the crane. 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 Engine Warning light 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 capscrews 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 capscrews and washers on the two straps. Torque capscrews; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
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.

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 Gas Recirculation. 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 into the aftertreatment system and into the atmosphere.

The Air Cleaner (Figure 7-3) is the dry-type with a replaceable element and is located on the right rear fender. An Air Intake Restriction Monitor (AIRM) system is designed to calculate real-time air filter restriction at operational flow rate using the temperature and pressure input from the TBAP sensor installed on the air cleaner housing.

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 can cause rapid engine wear. All connections between the air cleaner and the engine must be tight and sealed. If these connections are well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Ensure the element gasket washer is not damaged and the washer's rubber face seals against the element.
3. Inspect the element gasket for damage.
4. Check for structural failures and replace damaged parts.

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 kilopascals or 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. Cummins allows a vacuum of 6.2 kPa (25 inches of water) maximum with a dirty air cleaner at maximum governed RPM.

A TBAP sensor attached to the air cleaner housing provides input to the Air Intake Restriction Monitor (AIRM) system to activate a fault code when the filter needs to be replaced. The Engine Warning Indicator will blink at engine start for fault code 5576 indicating the air cleaner is becoming clogged. The indicator will be on solid for fault code 3341 indicating the filter is clogged and must be changed. If the TBAP's accuracy is suspect, a water manometer connected to the filtered pressure tap 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 rated 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.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items:

- Ensure the air cleaner inlet is not plugged.
- Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.
- Ensure the correct size connections are used between the air cleaner and the engine.
- Ensure all inlet accessories are the correct size and are not plugged by any foreign object.

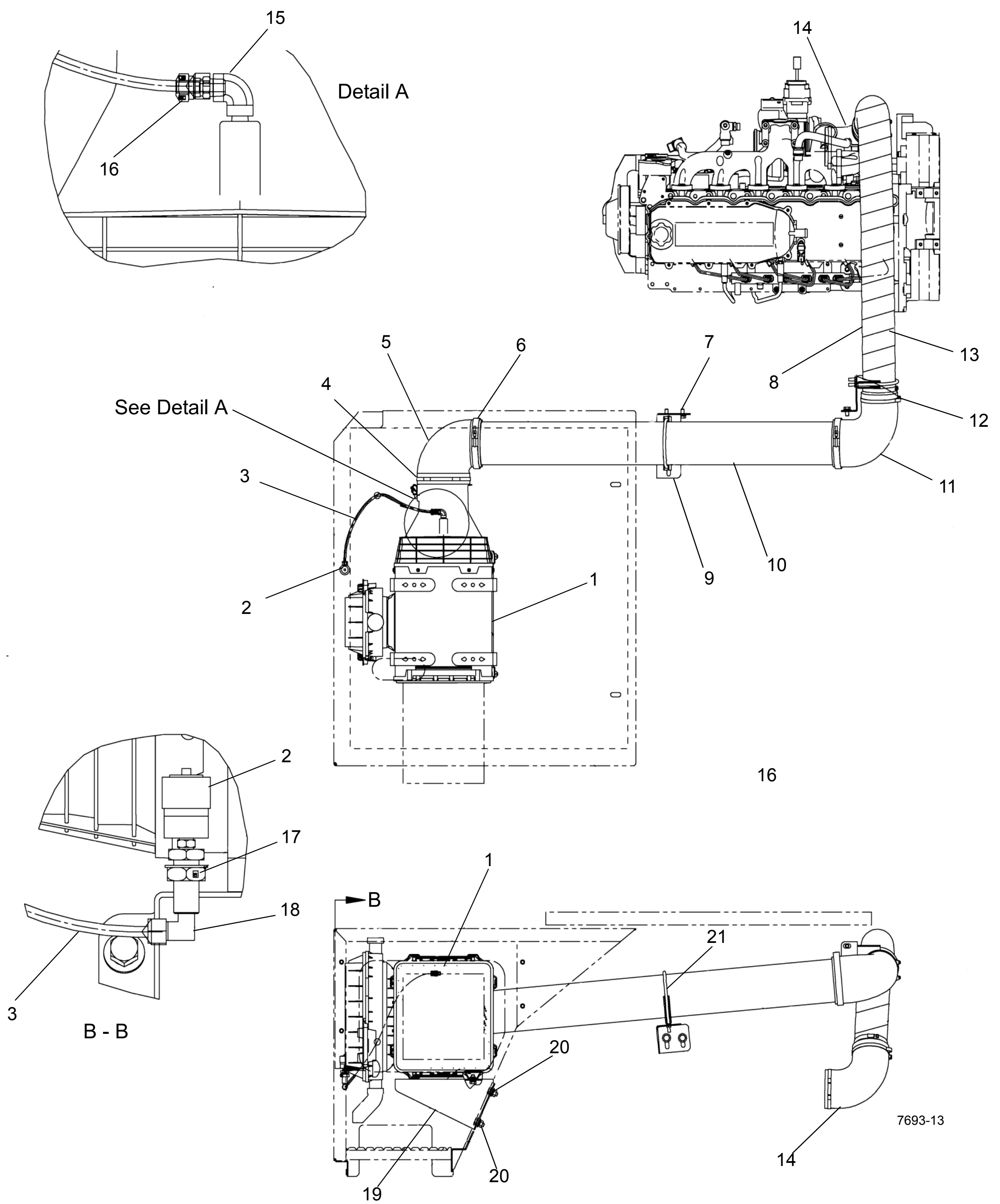


FIGURE 7-3

Air Intake Installation - Typical

Figure 7-4 Item Numbers

Item	Description
1	Air Cleaner
2	Service Indicator*
3	Nylon Tube*
4	Clamp T-Bolt 6.25-6.66
5	Elbow, Reducing 6” - 5”
6	Clamp 5.75”
7	Clamp Hardware
8	Intake Tube
9	Support Intake Bracket
10	Intake Tube
11	Elbow 5” - 4”
12	Muffler Clamp 4”
13	Exhaust Wrap
14	Elbow 4”
15	Elbow, 90°*
16	Male Connector*
17	Coupling, 1/8”*
18	Elbow, 90°*
19	Bracket
20	Bracket Hardware
21	Clamp 5”

* Tier 3 only

Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

1. Remove upper step/access plate from side of crane.
2. Lift the clips (1) (Figure 7-4) securing the cover to the air cleaner body and remove the cover.

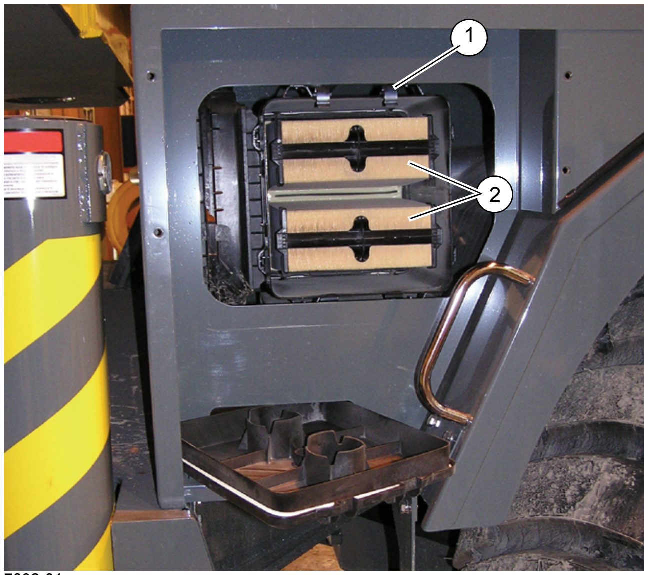


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FIGURE 7-4

3. Remove primary filter from the air cleaner and inspect for foreign material and marks of dust.
4. Remove secondary filter (not shown) from the air cleaner every third primary filter change.
5. Thoroughly clean the sealing surface and inside of the air filter housing. Inspect all parts of the intake system and air cleaner.
6. Install new filters.
7. Place the cover back on the air cleaner housing and secure with clips (1).
8. 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.
9. Replace decking access plate.

Element Cleaning

It is not recommended that filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.

Air Cleaner Body

Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for 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.

7

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.

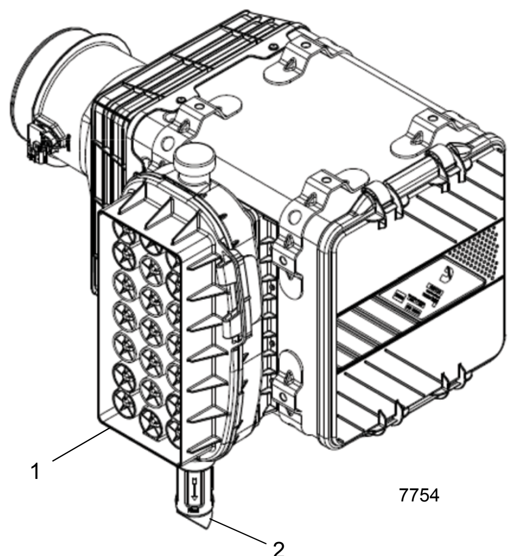


FIGURE 7-5

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.

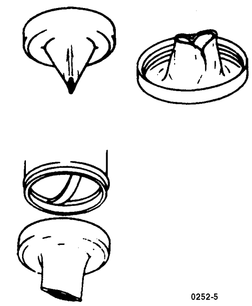


FIGURE 7-6

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.

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 an engine 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.

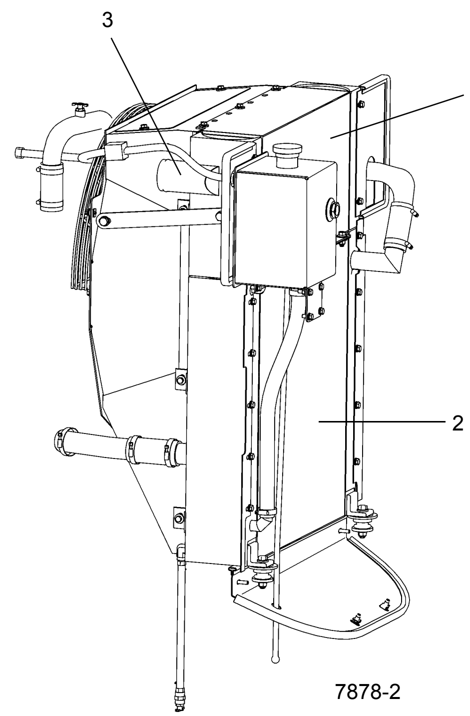
Maintenance

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.



Charge-Air Cooler Assembly

FIGURE 7-7

Item	Description
1	CAC
2	Engine Coolant Radiator
3	CAC Hot Tube

7

Exhaust System

Tier 3

The Tier 3 exhaust system (Figure 7-8) is made of tubing, elbows, and a muffler.

Removal

CAUTION

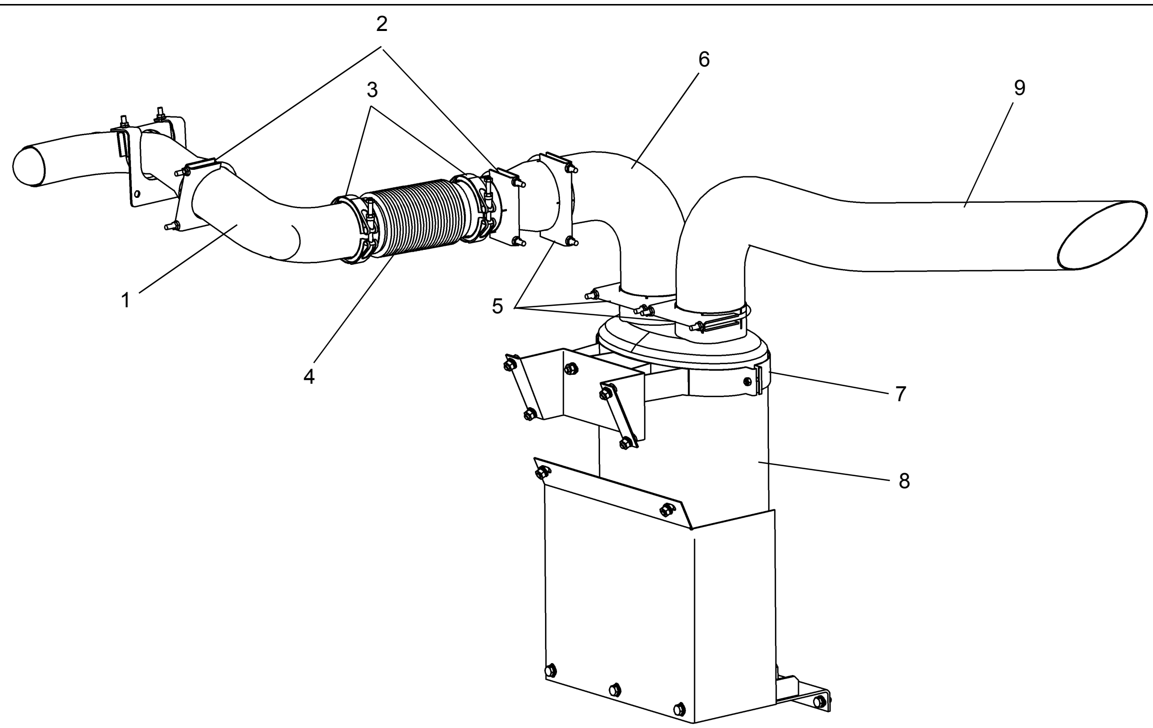
Burn Hazard!

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. Remove mounting bands to free muffler from muffler mounting bracket.
5. 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. Install sheet metal guard.



Tier 3 Muffler **FIGURE 7-8**

Item	Description
1	Exhaust Tube
2	Muffler Clamp 4”
3	V-Band Clamp
4	Bellows
5	Muffler Clamp 5”

Item	Description
6	Elbow
7	Mounting Band
8	Muffler
9	Tailpipe

Tier 4

The Tier 4 exhaust system (Figure 7-9) is made of a diesel oxidation catalyst (DOC), decomposition reactor tube, a selective catalytic reduction (SCR) unit and various tubes, elbows and clamps.

Removal

NOTE: The down pipe insulation is an emissions component and must be replaced if removed for service or if damaged.

The exhaust aftertreatment components are bolted to a single weldment that can be removed by a properly rated lifting device. The subassembly weighs approximately 300 lb (136 kg).

CAUTION

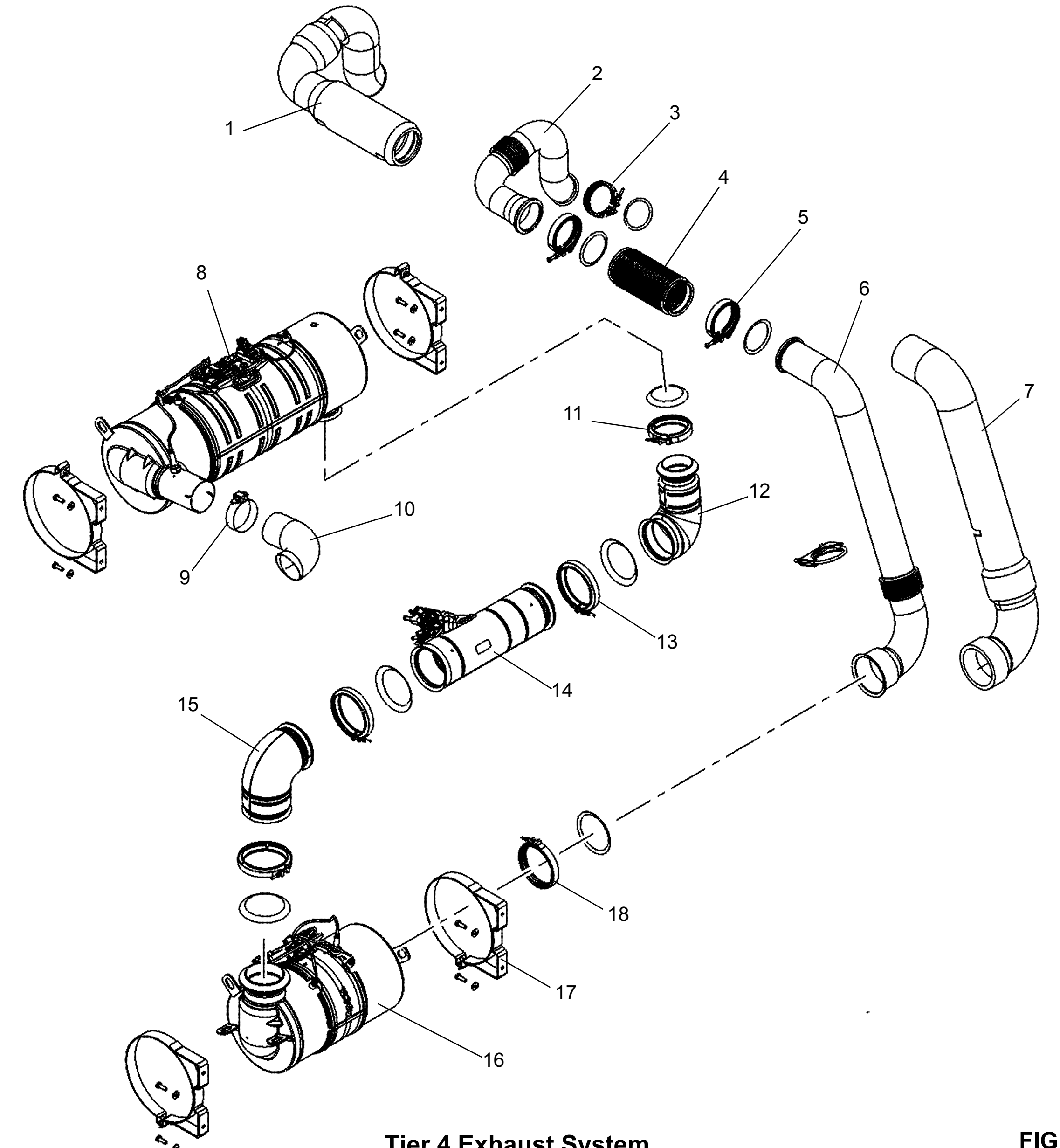
Burn Hazard!

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 exhaust system.
2. Tag and disconnect electrical and DEF connections.
3. Remove clamp to free exhaust tailpipe from the SCR.
4. Remove the mounting bands to free the SCR.
5. Loosen the V-band clamps to remove the elbows and decomposition reactor tube.
6. Remove mounting bands to free DOC from the mounting bracket.
7. Loosen the V-band clamps to remove the exhaust tube and flex hose.
8. If necessary loosen the V-band clamp and remove the exhaust tube from the turbocharger.
9. Inspect the parts of the exhaust system and repair or replace if damaged or missing.

Installation

1. Install the exhaust tube on the turbocharger with the V-band clamp.
2. Attach the flex hose to the exhaust tube with the V-band clamp.
3. Attach the exhaust tube to the flex hose with the V-band clamp.
4. Secure the DOC to the mounting bracket.
5. Attach the exhaust tube to the DOC with the V-band clamp.
6. Install the elbow to the DOC with a V-band clamp.
7. Install the decomposition reactor tube to the elbow with a V-band clamp.
8. Install the elbow to the decomposition reactor tube with a V-band clamp.
9. Secure the SCR to the mounting bracket and connect to the elbow with a V-band clamp.
10. Install the exhaust tailpipe on the SCR. Secure the exhaust tailpipe to the SCR with clamp.
11. Connect electrical connections and DEF line as tagged during disassembly.
12. Install sheet metal guard.



Tier 4 Exhaust System

FIGURE 7-9

Item	Description
1	Insulation
2	Exhaust Tube
3	V-Band Clamp
4	Flex Hose
5	V-Band Clamp
6	Exhaust Tube
7	Insulation
8	Selective Catalytic Reduction (SCR) unit
9	Muffler Clamp

Item	Description
10	Tail Pipe
11	V-Band Clamp
12	Elbow
13	V-Band Clamp
14	Decomposition Reactor Tube
15	Elbow
16	Diesel Oxidation Catalyst (DOC)
17	Mounting Band
18	V-Band Clamp

Diesel Exhaust Fluid (DEF) System

Diesel Exhaust Fluid (DEF) is an emissions control liquid required by modern diesel engines. It is injected into the exhaust stream. DEF is never added to diesel fuel. It is a non-hazardous solution of 32.5% urea in 67.5% de-ionized water. DEF is used by Selective Catalytic Reduction (SCR) technology to remove harmful NO_x emissions from diesel engines.

WARNING

Toxic Fluid Hazard!

Diesel exhaust fluid (DEF) contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow. In the event the diesel exhaust fluid is ingested, contact a physician immediately.

DEF Tank

The DEF tank is located in front of the right rear outrigger jack cylinder.

Removal

1. Drain the DEF into a suitable container (Figure 7-10). Reinstall the drain plug and torque to 40-60 lb-in (4.5-6.8 Nm).
2. Tag and disconnect the hoses from the tank.
3. Tag and disconnect the electrical connections.
4. Remove the hardware attaching the tank straps.
5. Remove the tank.

Installation

1. Position the tank on the mounting bracket.
2. Attach the tank straps and secure with the hardware.
3. Connect the electrical connectors as tagged during removal.
4. Connect the hoses as tagged during removal.
5. Fill the tank with DEF.

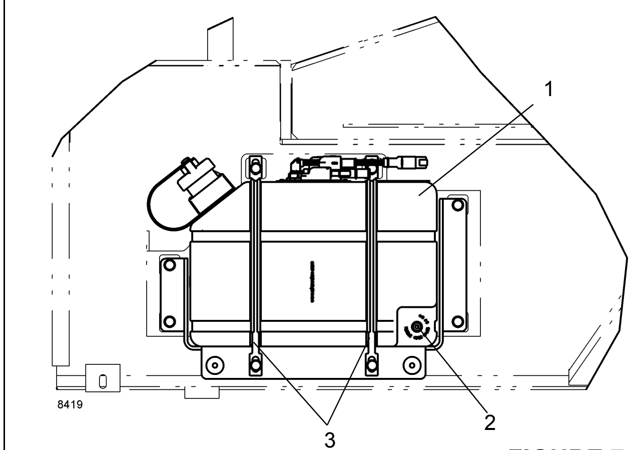


FIGURE 7-10

Item	Description
1	DEF Tank
2	Tank Drain
3	Tank Straps

DEF Supply Module

The DEF supply module is located behind the DEF tank.

CAUTION

Spraying Fluid Hazard!

The DEF line connecting the aftertreatment DEF dosing unit to the aftertreatment DEF dosing valve is under low pressure and should not be disconnected while the engine is running or before the system has completed the purge process after engine shutdown. Disconnecting the DEF line while under low pressure could cause DEF to spray.

Removal

NOTE: Do not disconnect the electrical connector until the DEF dosing system has completed the purge cycle. Before beginning to remove and/or disconnect any components, wait at least five minutes after the keyswitch is turned OFF for the aftertreatment DEF dosing system to purge the DEF from the system. The purge cycle is an automatic process and does not require intervention to occur. The aftertreatment DEF dosing unit will create an audible pumping noise during the purging process.

Do not power wash or steam clean this unit. Use compressed air to remove any loose debris.

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1. Disconnect the electrical connection from the supply module (Figure 7-11).
2. Tag and disconnect the hoses from the supply module.
3. Remove the hardware attaching the supply module to the frame.
4. Remove the supply module.

Installation

1. Place the supply module on the frame and secure with the hardware.
2. Connect the hoses as tagged during removal.
3. Connect the electrical connector.
4. Start the engine and perform a manual exhaust system cleaning, check for leaks, repair as necessary.

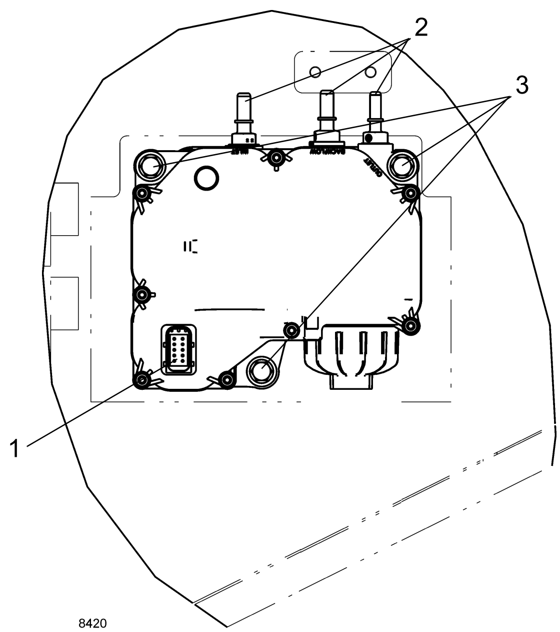

FIGURE 7-11

Item	Description
1	Electrical Connector
2	Hose Connectors
3	Mounting Hardware

Filter Replacement

Inspect the area around the seal and vent of the aftertreatment DEF dosing unit filter cap for signs of leakage. DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section following this procedure.

NOTE: There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

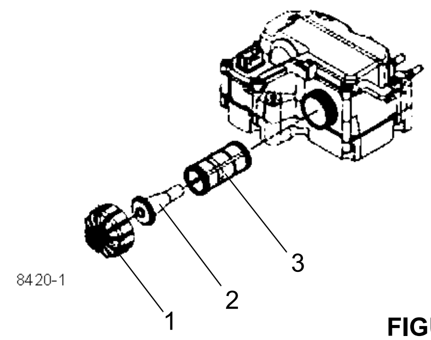

FIGURE 7-12

Item	Description
1	DEF Filter Cap
2	Equalizing Element
3	Filter Element

1. Unscrew the DEF filter cap (1, Figure 7-12).
2. Remove the aftertreatment DEF filter equalizing element (2).
3. Remove the old aftertreatment DEF dosing unit filter element (3).

NOTE: If removing the aftertreatment DEF dosing unit filter as part of a maintenance interval, discard the equalizer element and filter.

Clean and Inspect for Reuse

If there is the possibility that contaminated DEF has gone through the DEF dosing system, check the filter prior to discarding the filter.

Check the diesel exhaust filter for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.

Inspect the diesel exhaust filter for debris. If debris is evident, also check:

- DEF tank pick up screen.
- The aftertreatment DEF dosing unit inlet connector.

Discard the filter element and equalizing element.

Inspect the aftertreatment DEF dosing unit filter cap for cracks or holes that could create a DEF leak path.

Check the condition of the threads on the aftertreatment DEF dosing unit cap.

NOTE: Never operate the vehicle with the DEF cap removed.

Clean the aftertreatment DEF dosing unit cap with warm water and a clean cloth.

Filter Installation

1. Slide the DEF filter equalizing element (2) into the DEF filter cartridge (3).
2. Insert the assembly into the aftertreatement DEF dosing unit.
3. Install and tighten the cap (1). Torque to 177 lb-in (20 Nm).

NOTE: The aftertreatment DEF dosing system will not prime until the correct SCR temperatures are reached. To verify that there are no DEF leaks, initiate a stationary exhaust system cleaning to get the SCR system up to temperature.

4. Connect the electrical connector.
5. Operate the engine and check for leaks.

WATER COOLING SYSTEM

Description

The cooling system consists of a radiator (Figure 7-13), surge tank, engine cooling circuit, charge air cooler circuit, the connecting hoses and connecting tubes. Cooling system capacity is approximately 50 qt (47 l). The radiator consists of two sections; the top section is the charge air cooler, the bottom section is the engine water cooler. The temperature is controlled by a 181°F (83°C) thermostat located at the top of the engine. 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.

Coolant lines that go from the engine to the aftertreatment system serve two purposes – they thaw (heat) the DEF tank, and they cool the decomposition reactor tube.

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 right side of the transmission forward of 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 right 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:

- Burned valves.
- Pinging or knocking.
- Excessive fuel consumption.
- Poor lubrication - increased engine wear.
- Sticking valves.
- Short injector life.
- Engine hot spots.
- Need for higher grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

- Excessive fuel consumption.
- Sludge formation in crankcase.
- Corrosive acids formed in crankcase.
- Excessive fuel deposits in the exhaust system.

Rust Prevention

To keep engines operating at newness 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.

For maximum rust, freeze, and boiling point protection, an AFC-50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times.

Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. “Floating ball” type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

Engine Antifreeze/Coolant Fill Procedure

This procedure is for when the cooling system has been drained or most of the coolant has been removed. For daily maintenance procedures refer to *Engine Cooling System*, page 9-13.

1. Open air bleed valve on top radiator inlet tube, to allow trapped air to bleed.
2. Slowly fill the system with an AFC-50/50 blended, fully formulated extended life antifreeze/coolant. Fill to the bottom of the surge tank filler neck.

NOTE: A fill rate exceeding 3 gpm (12 l/min) can give a false reading.

3. Close the air bleed valve.
4. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 2.
5. Run the engine through two (2) thermal cycles and recheck the antifreeze/coolant level. Refill as necessary repeating step 2.

Cooling/SCA Maintenance Summary

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

6 Months or 500 Hours

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

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

1 Year or 1000 Hours

- Test coolant for contamination.

  Condemning 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 mixture of sodium carbonate and water or an equivalent commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Engine Cooling System*, page 9-13.

NOTE: Remove the radiator cap and open the air bleed valve when draining the system to ensure proper draining.

Cleaning

DANGER

The cooling system is pressurized and injury can result when removing the radiator cap at operating temperature. Use proper protection to remove the radiator cap.

1. Coolant shut-off valves to heaters and other accessories should be open to allow complete circulation during cleaning, flushing, and draining. Run the engine with radiator covered if necessary until temperature is up to operating range 160 to 180°F (71 to 82°C). Stop the engine, remove the radiator cap, and drain the system by opening the drain cocks on the radiator.
2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 180°F (82°C) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 180°F (82°C) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see Pressure Flushing) and repeat the cleaning operation.
8. If clogging of the core, indicated by low temperature spots on core, is not relieved, the radiator core must be removed for mechanical cleaning.

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. For badly clogged water jackets that do not respond to regular pressure flushing, remove the engine cylinder head and core hole plugs, and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through the openings.
9. 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.
10. 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.
11. 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 soldered to the core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler Neck - The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Ensure the overflow tube is not plugged.
3. Radiator Cap - This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

When removing the pressure type cap, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 0.13 in (3 mm). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.

CAUTION

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 become easily 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 has one or more drain plugs. These should receive seasonal care and be kept free of rust and scale.
3. Gaskets - 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

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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 Belt*, 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.

Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. “Floating ball” type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. Fill the system with a AFC-50/50 blended, fully formulated extended life antifreeze/coolant at all times. Refer to *Lubrication*, page 9-1. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

Radiator Removal and Installation.

Removal

1. Set the outriggers and position the boom to over the side.
2. Open the drain cock at the 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. Remove the bolts and nuts 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.
5. Tag and disconnect the hoses from the surge tank to the engine and from the surge tank to the radiator.
6. Remove the four bolts, washers, lockwashers and nuts holding the surge tank to the frame.
7. Remove the baffles on the rear side of the radiator assembly.
8. Remove the hose clamps and bellows connecting the radiator to the charge air cooler tubes.
9. Remove the hose clamps and radiator hose connecting the radiator to the radiator tubes.
10. Disconnect the coolant level harness from the engine harness.
11. Remove the bolts and washers attaching the fan guard to the shroud ring. Remove the fan guard.
12. Remove the bolts, washers and lockwashers that connect the plates to the top of the radiator and the top of the frame rail.

NOTE: The radiator assembly weighs approximately 271 lb (123 kg).

13. Attach an adequate lifting device to the radiator assembly.
14. Remove the two bolts, washers, lockwashers, nuts and mounting bushings securing the radiator flange to the frame mounting brackets. Remove the radiator assembly from the carrier.
15. Remove the six bolts, washers, lockwashers and six bushings securing the shroud ring to the radiator.
16. 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.

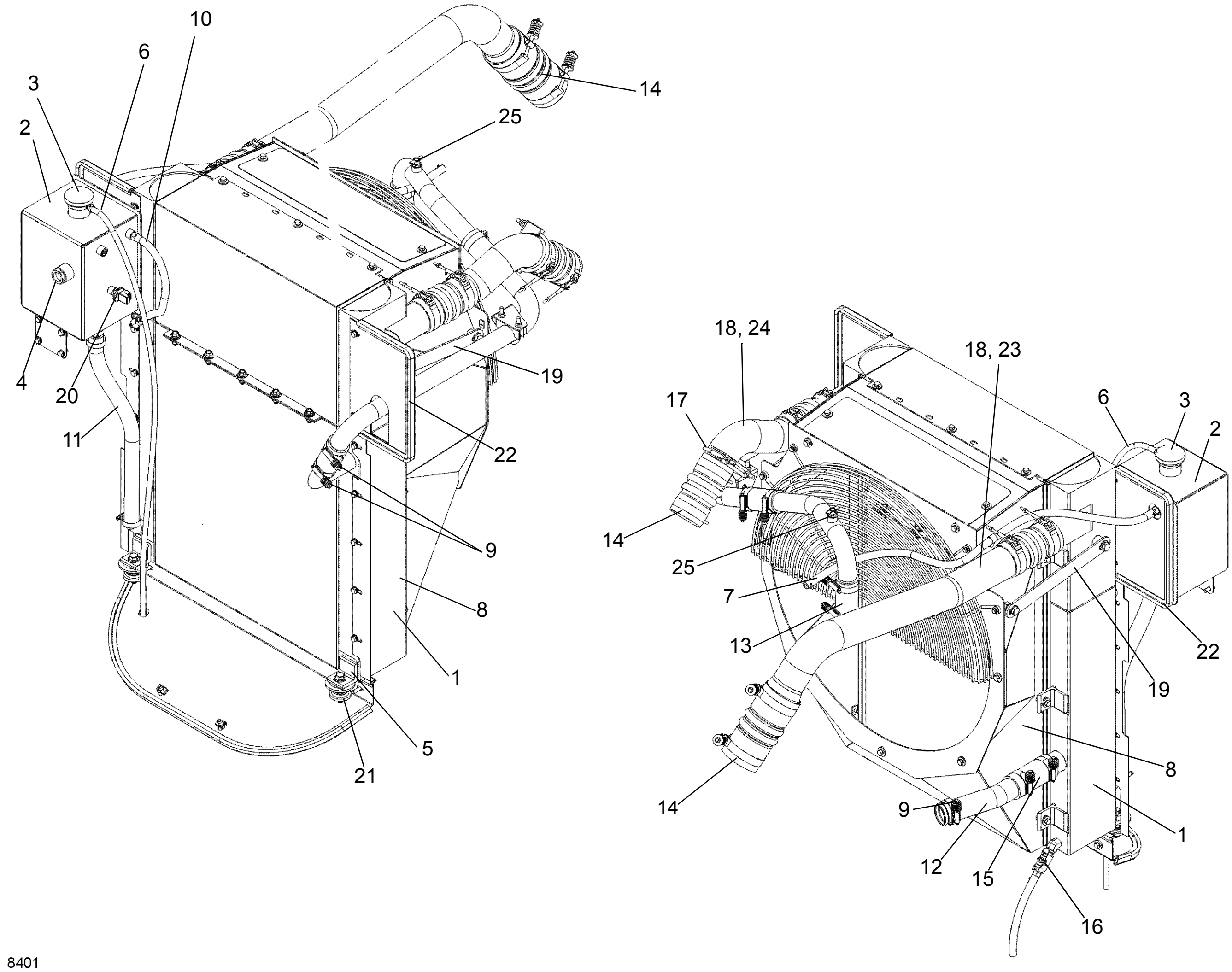
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FIGURE 7-13

Item	Description
1	Radiator
2	Surge Tank
3	Radiator Cap
4	Window Gauge
5	Mounting Bracket
6	Overflow Hose
7	Engine Block Vent Hose Connection
8	Shroud
9	Hose Clamps
10	Vent Hose
11	Coolant Fill Hose
12	Radiator Out
13	Radiator In
14	Bellows
15	Radiator Hose
16	Drain Cock
17	Muffler Clamp
18	Charge Air Cooler Tube
19	Plate
20	Radiator Coolant Level Switch
21	Mounting Bushings
22	Rubber Molding
23	Charge Air Cooler In
24	Charge Air Cooler Out
25	Air Bleed Valve

Installation

1. Ensure all fittings and hoses are installed on the radiator.
2. Position the radiator assembly in the carrier using a lifting device. Secure the radiator flange to the frame mounting brackets using two bolts, washers, lockwashers, nuts and mounting bushings.
3. Reconnect the two plates between the top of the radiator and the top of the frame rail using bolts, washers, lockwashers and nuts.
4. Adjust the shroud face to have equal clearance between fan and face opening on opposite sides.
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. Install baffles to rear side of the radiator assembly.
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 tubes to the radiator using hose clamps and bellows. The recommended installation torque of the spring loaded hose clamp is 100 lb-in (11.3 Nm). Do not compress spring completely, clamp may be damaged from thermal expansion of CAC tube.
10. Tighten the drain cock at the bottom of the radiator.
11. Install the hood assembly.
12. Mount the surge tank to the frame using the four bolts, washers, lockwashers and nuts.
13. Connect the hoses between the surge tank and engine and the surge tank and the radiator.
14. Fill the engine coolant system, refer to *Engine Antifreeze/Coolant Fill Procedure*, page 7-20. Start the engine, operate all systems and check for leaks.
15. Install the bolts and nuts holding the rear engine hood panel to the engine hood.
16. Install the hood top door assembly.

DRIVE TRAIN

Description

The drive train consists of the transmission/torque converter assembly and three drive lines (Figure 7-14).

The transmission/torque converter is mounted on and driven by the engine. The torque converter assembly provides for mounting and driving the piston 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 fuel tank. An oil filter is located on the left side of the frame bottom rail.

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

Drive Lines

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 line being removed so it does not fall when disconnected.
2. Remove the bolts from the bearing cap on each end of the drive line.
3. Remove the drive line.

Installation

1. Position the drive line, install the bearing cap bolts and tighten bolts securely.
2. Torque the bearing cap bolts 110 to 121 lb-ft (149 to 164 Nm).

Lubrication

The drive line slip joints require lubrication. Refer to *Lubrication*, page 9-1.

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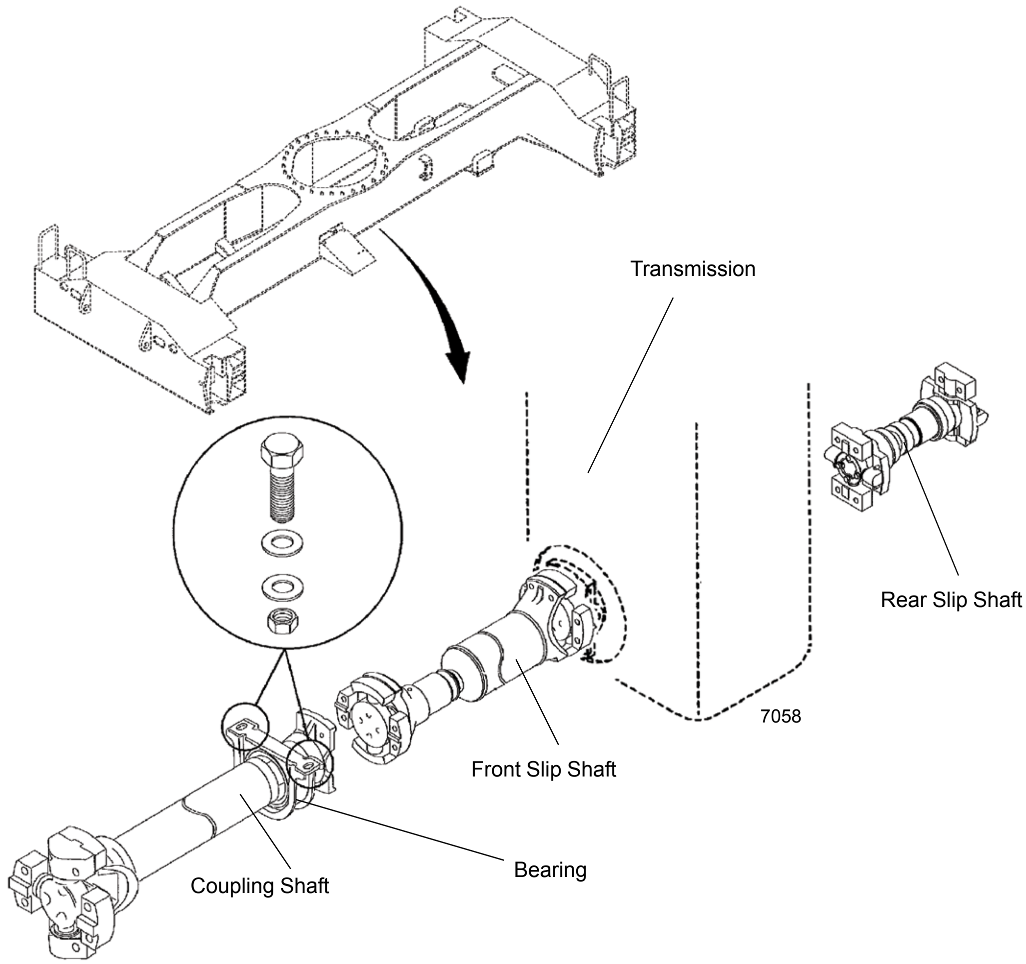

Transmission
Rear Slip Shaft
7058
Front Slip Shaft
Bearing
Coupling Shaft

FIGURE 7-14

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 two 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 sump 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 is mounted on the side of the converter housing. Its function is to direct pressurized oil to the appropriate direction and speed clutches to achieve the desired gear ratio. The valve consists of solenoid operated valves which direct oil to operate the larger spool valves that pass or block oil flow to a specific clutch.

NOTE: On this machine, the reverse clutch is energized for forward motion of the crane.

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.

Troubleshooting Procedures

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.
	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.
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.”

Hydraulic Checks

Before checking the transmission/torque converter and associated hydraulic system for pressures and rate of oil flow, it is essential that the following preliminary checks be made.

1. Check oil level in transmission. This should be done with oil temperature at 180 to 200° F (82 to 93° C). Do not attempt these checks with cold oil.
2. To bring the oil temperature to this level, it is necessary to either work the machine or stall out the converter. When it is impractical to work the machine, stall out the converter as follows.
   a. Apply the parking brake and service brakes.
   b. Position the shift lever to forward and high speed.
   c. Accelerate the engine to between half and three-quarter throttle.

CAUTION

Full throttle stall speeds for an excessive length of time will overheat the torque converter. Only stall the converter for 30 seconds and then idle for 15 seconds, repeat as necessary.

   d. Stall the converter until desired temperature is reached.

NOTE: Always make all troubleshooting checks with the converter outlet temperature at least 180 to 200°F (82.3 to 93.3°C).

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 piston and single section hydraulic pumps from the transmission/torque converter. Cover all openings. Refer to *Hydraulic Pumps*, page 2-13 for removal of the pump.

NOTE: The transmission/torque converter weighs approximately 990 lb (450 kg) dry.

5. Attach an adequate lifting device to the transmission/torque converter and take up any slack.
6. Remove the screws and hardened flatwashers 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 990 lb (450 kg) 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 piston and single section hydraulic pumps on the transmission/torque converter. Refer to *Hydraulic Pumps*, page 2-13 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.
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 4.00 in (101.6 mm) long drive plate locating stud 0.3750-24 fine thread 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 30 lb-ft (40.7 Nm).
9. Remove the drive plate locating stud. Install one drive plate attaching screw and hardened flatwasher. Snug the screw 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 screws. Rotate the engine flywheel and install the remaining seven flywheel to drive plate attaching screws and hardened flatwashers. Snug the screws but ***do not tighten***. After all eight screws and lockwashers have been installed, torque the screws to 28 lb-ft (38 Nm). This will require torquing each screw, then rotating the engine flywheel until all eight screws have been torqued.
10. Measure the engine crankshaft end play after the transmission/torque converter has been completely installed on the engine flywheel. This value must be within 0.001 in (0.025 mm) of the end play recorded in step 5.
11. Install the engine and transmission/torque converter in the crane as an assembly. Refer to *Power Train*, page 7-1.
12. Service the crane as required in *Servicing the Crane After Transmission/Torque Converter Overhaul*, page 7-32.
13. Cycle all functions and observe for proper operation.

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.

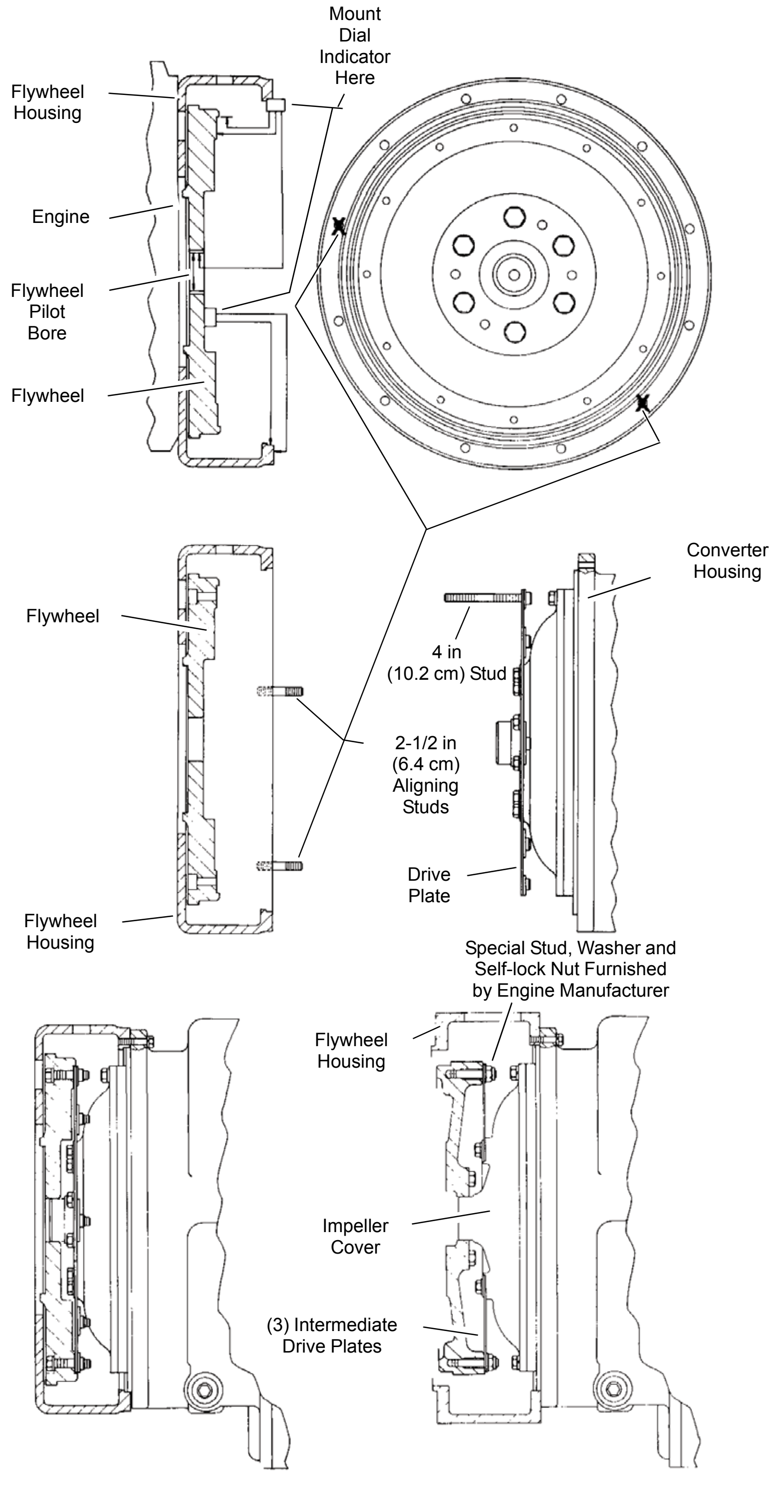

Mount
Dial
Indicator
Here
Flywheel
Housing
Engine
Flywheel
Pilot
Bore
Flywheel
Converter
Housing
Flywheel
4 in
(10.2 cm) Stud
2-1/2 in
(6.4 cm)
Aligning
Studs
Drive
Plate
Flywheel
Housing
Special Stud, Washer and
Self-lock Nut Furnished
by Engine Manufacturer
Flywheel
Housing
Impeller
Cover
(3) Intermediate
Drive Plates

FIGURE 7-15

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 (1200 rpm) to prime the torque converter and hydraulic lines. Recheck the level of oil in the transmission with the engine running at idle (1200 rpm). Add oil as necessary to bring the level to the LOW mark on the dipstick. After the oil temperature reaches 180 to 200°F (82 to 93°C), add oil to bring the level to the FULL mark on the dipstick.
7. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

Lubrication

Type of Oil

Hydraulic Oil (HYDO) or equivalent. Refer to *Lubrication*, page 9-1.

Capacity

System Capacity (includes torque converter, lines, and transmission) - Approximately 40 qt (37.9 l).

Check Period

Check oil level every 10 hours or DAILY with engine running at 1200 rpm and oil at 180 to 200°F (83 to 94°C). Maintain oil level to FULL mark.

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.

Every 500 hours, change oil filter element. Every 1000 hours or 6 months, drain and refill system as follows: Drain with oil at 150 to 200°F) (66 to 93°C).

NOTE: It is recommended that filter elements be changed after 50 and 100 hours of operation on new and rebuilt or repaired units, then at normal intervals thereafter.

a. Drain transmission and remove pump screen. Clean screen thoroughly and replace, using a new gasket.
b. Remove and discard oil filters. Clean filter housing and install new filters.
c. Refill transmission to LOW mark.
d. Run engine at 1200 rpm to prime converter and lines.
e. Recheck level with engine running at 1200 rpm and add oil to bring level to LOW mark. When oil temperature is hot (180 to 200°F) [83 to 94°C]), make final oil level check. BRING OIL LEVEL TO FULL MARK.

ENGINE BLOCK HEATER

The pre-heater is an 120 volt (240 volt, optional) immersion type heater. The immersion heater is installed in the engine block to preheat the coolant water. The immersion heater is provided with a short power cord equipped with a three prong ground plug. The heater is 1500 watts.

SECTION 8
UNDERCARRIAGE

SECTION CONTENTS

AXLES

Description

To provide maximum maneuverability, both the front and rear axles are steerable. The rear axle is mounted on a pivoting cradle (fifth wheel) which allows the axle to oscillate while traversing uneven terrain. The front axle is bolted directly to the frame. All four wheels utilize a hydraulic braking system. The axles are equipped with disc type brakes. A disc-type parking brake is mounted on the front axle input shaft.

Each axle incorporates a single reduction carrier with hypoid gearing mounted in the axle center. The final reduction is of planetary design spur gearing built into the wheel hubs.

The design of these axles permits the hypoid gearing of the differential carrier and the axle shafts to carry only a nominal torsional load while at the same time providing the highest practical numerical gear reduction at the wheels.

The hypoid pinion and differential assembly of the first reduction are supported by tapered roller bearings. The pinion bearing preload is adjusted and maintained by a hardened precision spacer between the inner and outer bearing. The differential tapered bearing preload is adjusted and maintained by the positioning of the threaded adjusting rings in the carrier leg and cap bores.

In the planetary wheel ends, the spur teeth of the sun gear mesh with teeth of the planet spur gears. The planet spur gears rotate on planet pins which are mounted in a spider. The planet spur gear teeth in turn mesh with teeth of the floating ring gear.

Power is transmitted by the hypoid gear set in the differential carrier to the axle shafts and the sun gear of the final reduction, through the revolving planet gears, and into the planetary spider which drives the wheel hub.

As an option, the front axle and rear axle may be provided with a differential lock. When in the locked mode, the axle shafts and the differential are locked together and there is no differential action between the wheels.

Maintenance

NOTE: The axles do not have to be removed from the crane to remove the planetary wheel ends or the drive units.

Removal

1. Using the outriggers, raise the wheels off the ground.
2. Install blocking under the frame at the outboard ends of the four outrigger boxes.

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

3. Disconnect and remove the drive line from the applicable axle. Do not disassemble the drive lines.
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 assembly weighs approximately 1651 lb (749 kg).

8. Remove the wheels from the axle.

NOTE: Each axle weighs approximately 3825 lb (1735 kg) with oil.

9. Position jacks, which are capable of handling the weight of the axle, under the axle for support.
10. Remove the eight nuts, washers, 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 8-14.

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 8-14.
2. Position the axle under the crane on jacks which are capable of handling the weight of the axle.
3. Raise the axle into place and secure with the eight attaching bolts, washers and nuts. The front axle has washers and nuts and the rear axle has tapped holes in the fifth wheel. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
4. Install the wheels onto the axle. Refer to *Mounting Wheel Assemblies*, page 8-4.
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 in accordance with *Rear Wheels Not Centered Switch Adjustment Procedure*, page 8-3.
9. Connect the drive line to the applicable axle. Refer to *Drive Lines*, page 7-25.
10. Refer to *Bleeding the Brake System*, page 8-15 in this section and bleed the hydraulic brake system.
11. Remove the blocking under the outrigger beams and retract the outriggers to lower the wheels to the ground.

Wheel Alignment Check Procedure

1. Check the axle for wheel alignment. The wheels are to be straight ahead with no toe-in or toe-out. Adjust if necessary by turning the tie rod ends in the direction necessary.
2. Turn the wheels to the extreme left. Check the clearance between the inside of the tire and the nearest object. If the clearance is less than 1.0 in (25 mm), adjust the axle stop to provide clearance. Do not adjust axle stop if clearance is greater than 1.0 in (25 mm). With the axles set at a 1.0 in (25 mm) 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 0.12 in (3.0 mm).
3. Turn the wheels to the extreme right and repeat step 2 for the right side.

Rear Wheels Not Centered Switch Adjustment Procedure

1. Ensure the wheels are straight ahead.

NOTE: Refer to (Figure 8-1) to perform the following adjustments.

2. Ensure proximity sensor switch is centered in the slot of the sensor plate bolted to the top of the axle trunnion cap. Adjust by moving the sensor mounting bracket.
3. Ensure a maximum gap of 0.2 in (5 mm) exists between the sensor switch and the sensor plate. Adjust by loosening switch mounting bolts and moving switch up or down on the mounting bracket. Tighten the mounting bolts.
4. Turn the rear wheels to verify proper operation. Rear Wheels Not Centered Light in cab should be out when rear wheels are centered and the sensor switch is centered in the slot of the sensor plate.

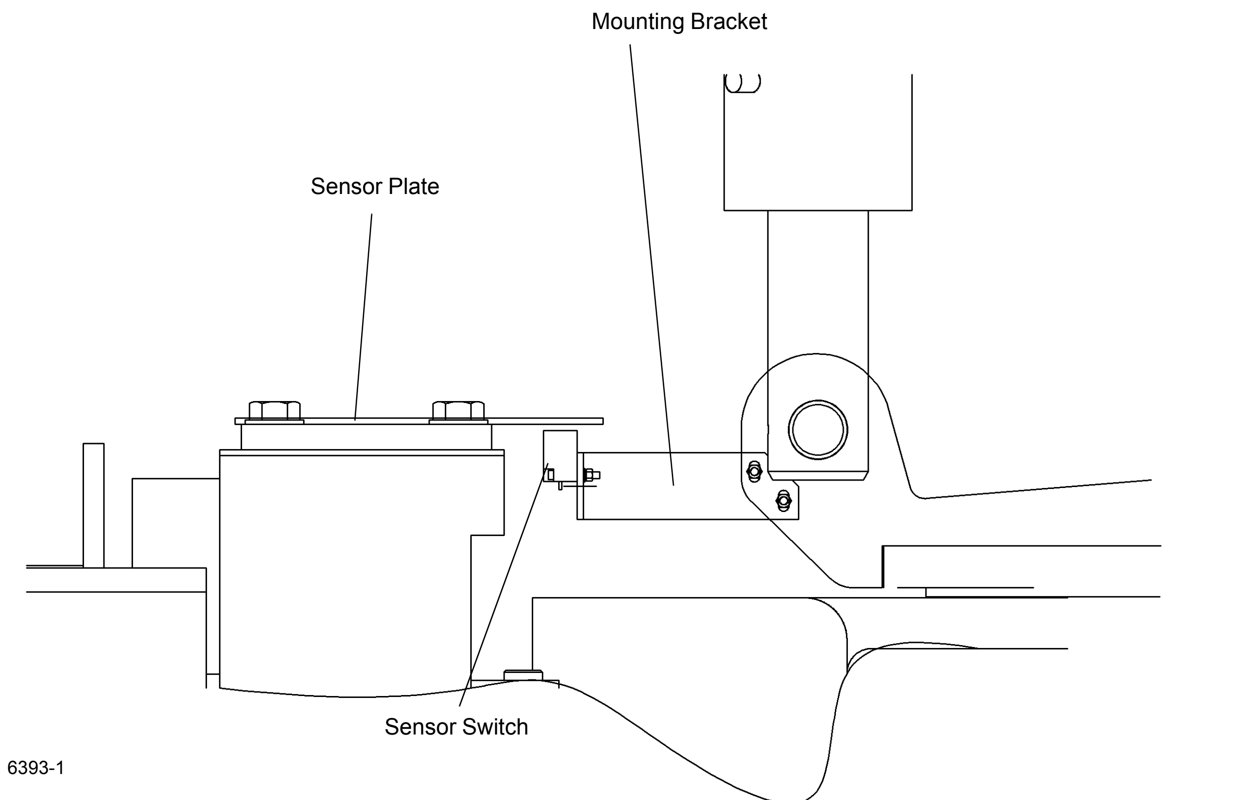


FIGURE 8-1

Wheels and Tires

Description

The standard tire size for this unit is 29.5 x 25-34 ply.

CAUTION

Do not mix tires and rims of different manufacturers.

Each wheel assembly (tire and rim) is mounted on the planetary hub with 24 grade 8 lug nuts.

NOTE: The tire diameters, widths, and weights may vary slightly depending on the tire manufacturer.

Off-highway tires are designed to operate with a certain sidewall deflection or bulge. Correct air pressure ensures prior deflection which, in turn, ensures proper traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lowered rim life.

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.

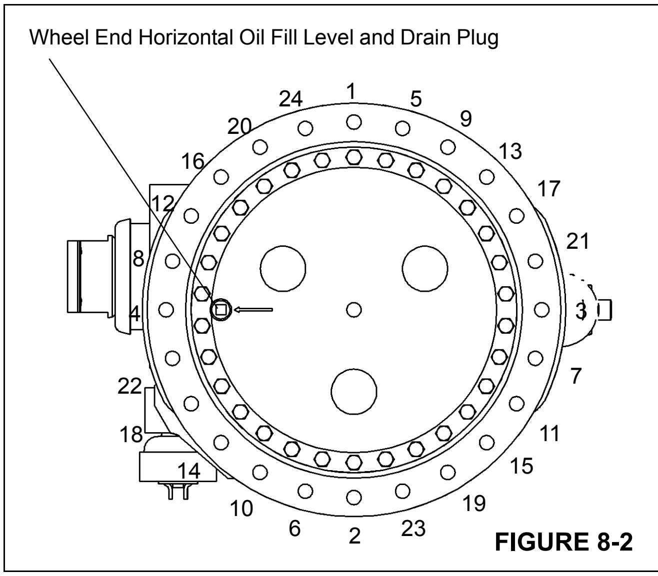


FIGURE 8-2

Mounting Wheel Assemblies

NOTE: Do not lubricate the wheel studs or lug nuts.

1. Position the wheel assembly on the mounting studs. Install the lug nuts and tighten them to 50 lb-ft (70 Nm) in the sequence shown in (Figure 8-2).
2. Ensure the wheel assembly is positioned properly on the hub.
3. Torque the lug nuts 340 to 360 lb-ft (461 to 488 Nm) in the sequence shown in Figure 8-2.
4. Retorque lug nuts after approximately one hour of travel.

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.

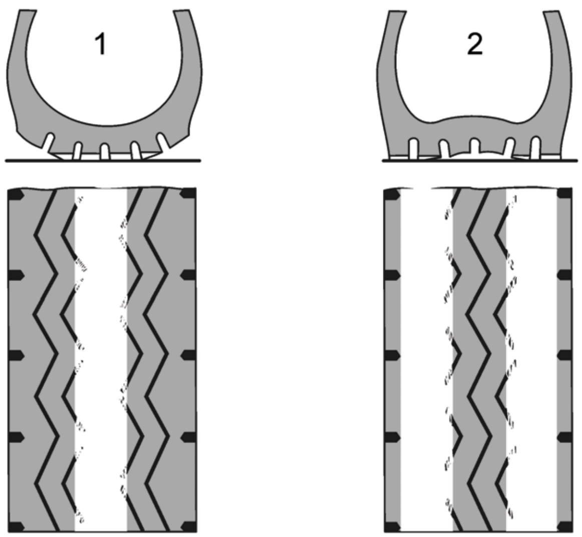


FIGURE 8-3

Incorrect Camber

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

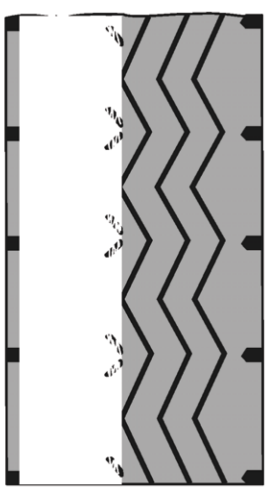


FIGURE 8-4

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.

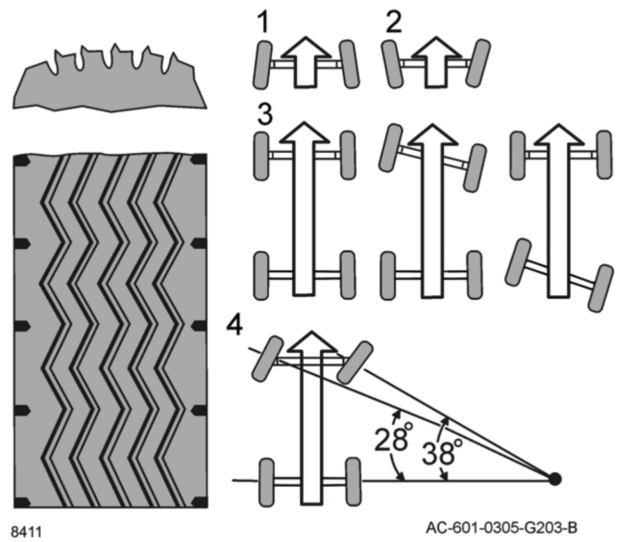


FIGURE 8-5

Item	Description
1	Incorrect Toe-In
2	Incorrect Toe-Out
3	Out-of-line Axles
4	Steering Arm Defect

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.

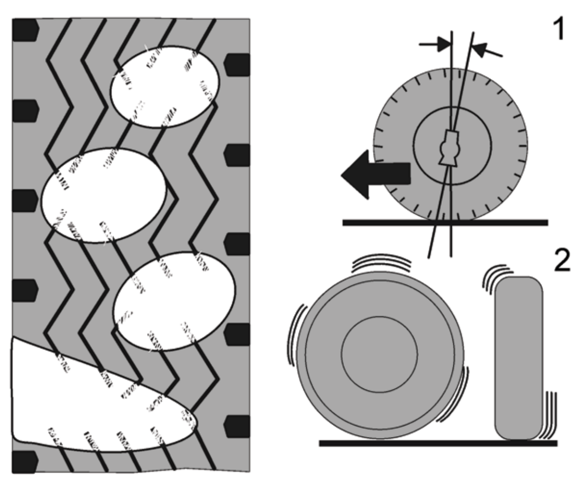


FIGURE 8-6

8

Cuts in the Tire Tread

Cuts are due to poor roads, air pressure too high or incorrect tire type for the application.

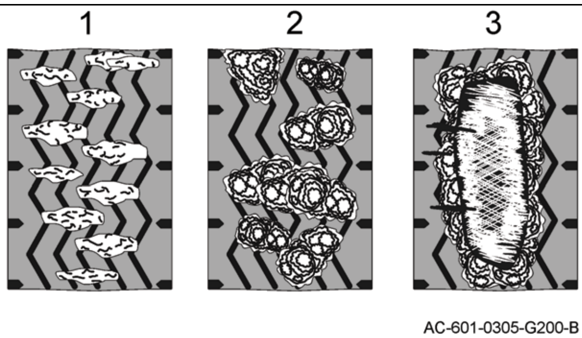


FIGURE 8-7

Item	Description
1	Cuts
2	Flaking Cuts
3	Rubber Flaking

Spot Wear

Sudden braking or locking brakes give spot wear.

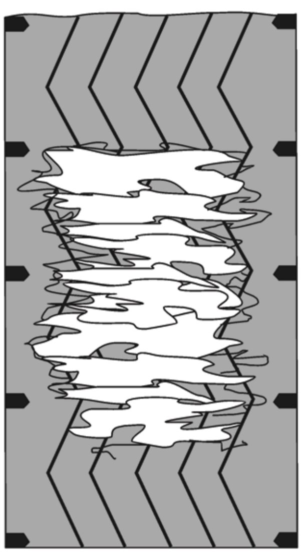


FIGURE 8-8

Feathered Edges

Normal occurrence on non-driving wheels on good roads and high mileage.

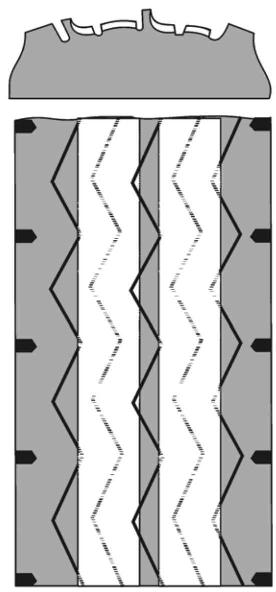


FIGURE 8-9

Cupping

Cupping is a normal occurrence that depends on the tread pattern - the higher the load, the greater the wear.

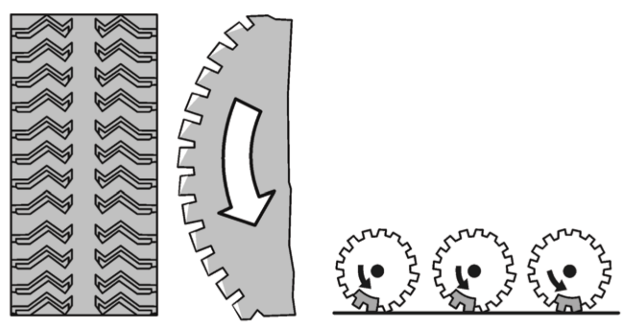


FIGURE 8-10

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 38.9 gpm (147 l/min) to the load sense steering priority flow divider. The load sense steer priority flow divider valve provides 12 gpm (45 l/min) to the load sense steering control valve and the remainder 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 right 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 pump number 1 is directed through the integrated outrigger valve to the rear steer/fan drive 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 125 psi (862 kPa) standby pressure in the steering load sense line. When a minimum 125 psi (862 kPa) 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 125 psi (862 kPa), 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 100 psi (689 kPa), 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

Symptom	Probable Cause	Solution
1. Hard to steer left and right.	**a.** Hydraulic oil low.	**a.** Refill hydraulic 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.** Refill hydraulic 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.
	b. Suction line plugged or too small.	**b.** Clean line and check for size.
5. Hydraulic pump shaft seal leakage.	**a.** Worn shaft seal.	**a.** Replace shaft seal.
	NOTE: If replacing the shaft seal does not stop leakage, the pump should be disassembled and checked for the following:	
	b. Broken diaphragm seal or backup gasket.	**b.** Replace seal or gasket.
	c. Bearing out of position.	**c.** Replace bearing.
	d. Excessive internal wear.	**d.** Replace pump.

Functional Check

A normal periodic functional check of the entire steering system will generally be adequate to ensure satisfactory service.

1. Check all fittings for leakage. An accumulation of moist, black dirt is a good indication of leakage.
2. With the engine running at idle and at full throttle, and with the machine standing still and moving, turn the steering wheel through the full range of travel. Note any speed irregularities and sticky sensation. This may indicate dirt in the fluid. If the steering wheel continues to rotate when started and released, a condition known as Motoring exists. This may also indicate dirty fluid in the system.
3. Ensure the system has adequate power. If there is an indication of hard steering, this can be caused by either a reduced oil flow to the control valve or a reduced system relief pressure. Adequate oil flow under all conditions can best be checked by timing the full travel of the cylinder with the steered axle unloaded and loaded. If there is a great difference at low engine speed and slight difference at high engine speeds this may indicate a defective pump. Adequate oil pressure can only be determined by connecting a pressure gauge [3500 psi (24 MPa) full scale recommended] at the swing/steer/ pressure gauge test port (GP2). 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 2600 psi (17.9 MPa).

REAR STEERING SYSTEM

Troubleshooting

Symptom	Probable Cause	Solution
1. Rear steering inoperative.	**a.** Hydraulic oil low.	**a.** Refill hydraulic 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.** Refill hydraulic 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.** Refill hydraulic reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.

Hydraulic Pumps

Description

Front Steer

The hydraulic pump is mounted off of drive pads of the torque converter 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 a flow of approximately 38.9 gpm (147 l/min).

Rear Steer

The hydraulic pump is mounted to the torque converter and is driven by the engine. Pump number 1 provides the hydraulic flow necessary to power all crane function except front steer and swing. The pump is a piston type pump that provides a flow of approximately 98.7 gpm (373 l/min).

Front Steering Control Valve

Description

The steering control valve is located under the dash and is actuated by a conventional steering wheel and steering column, providing precise, full hydraulic steering. Precise steering is accomplished by a metering system within the valve that is directly connected to the steering column and wheel.

Maintenance

Removal

1. Thoroughly clean the steering control valve and the surrounding area before removing the hydraulic hoses from the valve.
2. Tag and disconnect the five hydraulic hoses from the steering control valve. Cap or plug each hose and the five ports of the valve.
3. Remove the four bolts, lockwashers, and flat washers securing the valve to the bracket and the steering column. Remove the control valve, leaving the steering column in the cab.

Installation

1. Position the control valve to the bracket and steering column and install the four flat washers, lockwashers, and bolts. Torque bolts; refer to *Fasteners and Torque Values*, page 1-15 for proper torque value.
2. Connect the five hydraulic hoses to the control valve as tagged during removal.
3. Start the engine and check for proper operation and any leakage.

Rear Steer/ Axle Lockout/Fan Drive Valve

Description

The rear steer valve/axle lockout/fan drive directionally controls the outrigger circuit, outrigger pin circuit, and the rear steer circuit. The valve is mounted on the front face of the carrier frame member forward of the swivel.

The valve is made up of three sections. The inlet section contains a solenoid valve and a 2000 psi (13.8 MPa) relief valve. The relief valve is the main relief for both systems. The solenoid valve is normally open, bypassing oil to the reservoir. Operation of either system energizes the solenoid valve to close it and route oil to the applicable circuit.

The second section is the rear steer section and contains a three position four-way solenoid valve. The solenoid valve is controlled by the rear steer switch in the operator's cab. A bolt on manifold that contains work port double pilot operated check valves.

The third section is the outrigger section and contains two bolt-on three position four-way solenoid valves, a bolt on manifold that contains work port double pilot operated check valves with integral 300 psi (2.1 MPa) rod side and 3000 psi (20 MPa) piston side thermal relief valves. The solenoid valve is controlled by the extend/retract switch in the operator's cab.

The second and third sections both contain a double pilot operated check valve.

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the rear steer/axle lockout/fan drive valve.
2. Tag and disconnect the hydraulic lines to the rear steer/ axle lockout/fan drive valve. Cap or plug the lines and ports.
3. Remove the four bolts and nuts securing the rear steer/ axle lockout/fan drive valve to the crane. Remove the valve as a complete assembly.

Installation

1. Position the rear steer/axle lockout/fan drive valve on its mount. Secure the valve with the four nuts and bolts.
2. Connect the hydraulic lines to the rear steer/axle lockout/fan drive valve as tagged during removal.
3. Connect the electrical connectors to the rear steer/axle lockout/fan drive valve as tagged during removal.

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.

NOTE: For further information on the rear steer/axle lockout/fan drive valve, refer to *Axle Lockout, Rear Steer and Oil Cooler Fan Motor Control Manifold*, page 2-64.

Steer Cylinders

Description

The steer cylinders are mounted on the axles, two cylinders on each axle. The barrel end of each cylinder is attached to the axle housing and the rod end is attached to the steering lug on the axle end. The cylinders are controlled hydraulically by the steering control valve.

Maintenance

NOTE: For Disassembly and Assembly procedures, refer to *Steer Cylinder*, page 2-88.

Removal

1. Tag and disconnect the hydraulic lines going into the steer cylinder. Cap or plug all openings.
2. Remove the bolt, washer, and lockwasher securing each pin weldment in the rod end and barrel end of the cylinder.

NOTE: Steer cylinder weighs approximately 44 lb (20 kg).

3. Remove both pin weldments and two thrust washers (rod end only), and remove the cylinder from the axle.

Installation

1. Position the cylinder onto the attachment fittings on the axle and install both pin weldments. On the rod end, install a thrust washer on the top and bottom of lug.
2. Secure each pin weldment with the bolt, washer, and lockwasher.
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 consists of two lockout cylinders, a lockout valve, an axle oscillation relay, and an area definition potentiometer (see Figure 8-11 and 8-12). The lockout cylinders are mounted between a cradle (fifth wheel) and the carrier frame. The lockout valve is mounted on the left inner center frame rail and hydraulically controls the oscillating abilities of the lockout cylinders. The axle oscillation relay is located on the relay panel under the front console cover in the cab and the area definition potentiometer is located in the electrical swivel assembly.

Theory of Operation

The rear axle is mounted on a cradle (fifth wheel) allowing maximum oscillation of 10 in (25 cm) total while traveling over uneven terrain. Oscillation is provided only when the superstructure is within 6 degrees left or right of directly over the front. When the superstructure is within 6 degrees left or right of directly over the front, the area definition potentiometer energizes the axle oscillation relay which in turn energizes the solenoids on the lockout valve. When the solenoids are energized, the valve spools are shifted to allow hydraulic transfer between the two lockout cylinders. As one side of the axle is forced up by traveling over uneven terrain, the hydraulic oil flows from the rod end of cylinder A to the barrel end of cylinder B and from the rod end of cylinder B to the barrel end of cylinder A. The system is not pressurized and oil is moved from one cylinder to the other by the action of the axle moving the cylinder.

When the superstructure is more than 6 degrees left or right of directly over the front, the area definition potentiometer deenergizes the axle oscillation relay. This deenergizes the solenoids on the lockout valve and allows the springs in the valve to shift the valve spools to the closed position to prevent hydraulic oil flow between the cylinders. By stopping the flow of oil, a hydraulic lock is created and the axle is held rigid in that position.

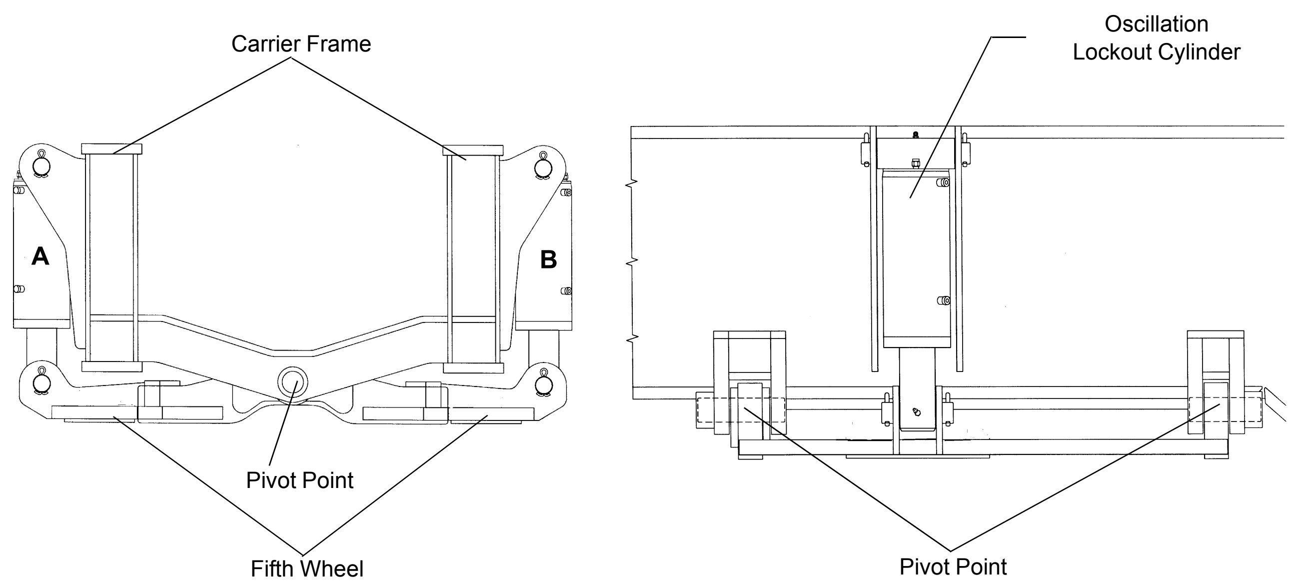


FIGURE 8-11

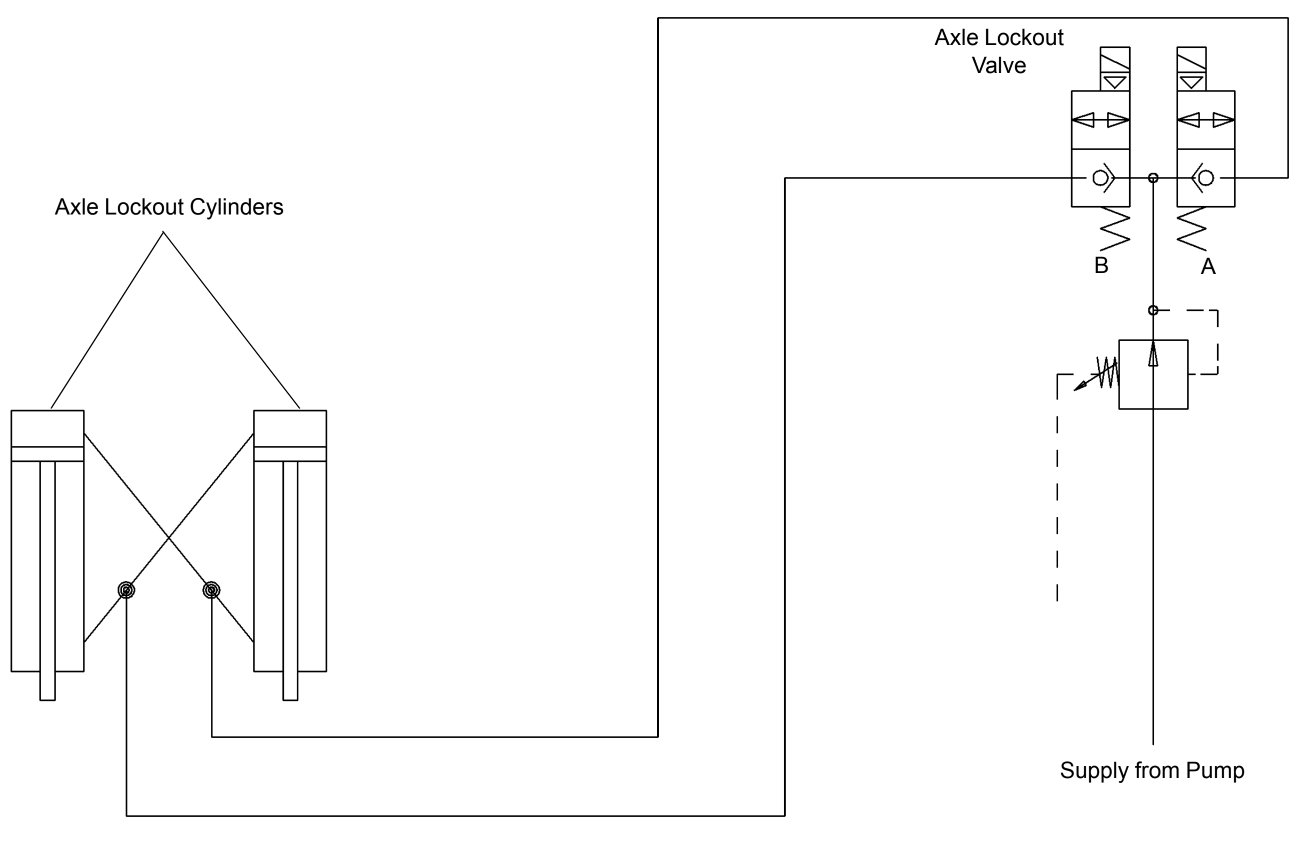


FIGURE 8-12

Axle Oscillation Lockout Cylinders

Description

Two 5.0 in (12.7 cm) hydraulic lockout cylinders are installed on the rear axle, one left side and one right side. The barrel end of each cylinder is attached to each side of the carrier frame and the rod ends are attached to each side of the cradle (fifth wheel). The lockout cylinders are connected hydraulically so that hydraulic oil flows from the rod side of the left cylinder to the barrel side of the right cylinder and from the rod side of the right cylinder to the barrel side of the left cylinder.

Each cylinder weighs approximately 88 lb (40 kg).

Maintenance

NOTE: For disassembly and assembly procedures, refer to *Axle Oscillation Lockout Cylinder*, page 2-85.

Removal

1. Raise the crane up on outriggers.
2. Rotate the turntable more than 6 degrees in either direction from directly over the front to lock out the oscillation cylinders.
3. Remove the wheel and tire assembly from the axle.
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 in accordance with the procedure in *Wheels and Tires*, page 8-4.
7. Lubricate both ends of the cylinder using the fittings provided.
8. Function test the axle oscillation system in accordance with the Operator 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 consists of a valve body and two solenoid valves, which keep the lockout cylinders from oscillating unless the superstructure is within 6 degrees left or right of directly over the front. The lockout valve is located on the left side of the frame in front of the front rear axle cross member.

When the superstructure is within 6 degrees left or right of directly over the front, the area definition potentiometer energizes the axle oscillation relay which energizes the solenoids on the axle oscillation lockout valve. This allows hydraulic oil to flow in and out of the lockout cylinders, allowing the axle to oscillate.

When the superstructure is more than 6 degrees left or right of directly over the front, the area definition potentiometer deenergizes the axle oscillation relay which deenergizes the solenoids on the axle oscillation lockout valve. This keeps the axle from oscillating because hydraulic oil cannot leave the cylinders.

Maintenance

Removal

1. Tag and disconnect the electrical connector to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the two screws and nuts securing the valve to the carrier frame.

Installation

1. Secure the valve to the carrier frame using two screws and nuts.
2. Connect the hydraulic hoses to the applicable valve ports as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Function test the axle oscillation system in accordance with the *Operator Manual* to ensure proper operation.
5. Check the valve and hoses for signs of leakage. Tighten fittings as required.

BRAKE SYSTEM

Description

The brake system includes all the components necessary for the application of the service brakes and the parking brake.

Service Brakes

The service brakes are full power hydraulic disc brakes which are hydraulically controlled and are used to apply the brake assemblies on all four wheels. The system consists of the tandem brake valve with treadle pedal, the dual accumulator charge valve, two hydraulic accumulators, the brake assemblies, and all the associated hoses and tubing. The operator depresses the pedal on the tandem brake valve, located on the cab floor, and the valve modulates the brake line pressure to the brake assemblies at each wheel. The full powered brake system supplies a high brake system pressure with relatively low reactive pedal forces, while controlling the maximum brake line pressure. The service brake dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve.

Parking Brake

The parking brake is a hydraulic release, spring apply, disc-type brake, located on the front axle. The system consists of a two-position switch, a three-way solenoid valve, actuator, a brake assembly, and all the associated hardware and tubing. The selector switch, located on the front console in the cab, is used to activate the solenoid valve which controls the park brake actuator, which applies and releases the park brake. There is one brake actuator on the front axle.

NOTE: For description and maintenance of the tandem brake valve with treadle pedal, the accumulators, and the dual accumulator charge valve, refer to *Hydraulic System*, page 2-1.

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 Pump No. 1 flows to swivel port 7 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 regulated maximum pressure setting. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve. The charged accumulators supply pressurized fluid to the closed tandem brake valve.

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

Symptom	Probable Cause	Solution
1. Brakes are poor.	**a.** Lining thickness less than 0.125 in (3mm).	**a.** Replace lining.
	b. Brake pedal operation.	**b.** Free mechanical linkage.
	c. Restriction or leaks in lines.	**c.** Check all lines for leaks and restrictions.
	d. Low hydraulic oil flow.	**d.** Check the hydraulic oil level in reservoir and check flow from the tandem brake valve.
	e. Air in brake lines.	**e.** Bleed the brakes.
	f. Brake pads/linings are grease-soaked.	**f.** Replace pads/linings.
	g. Engine not running.	**g.** Start engine. Due to the operation, the engine must be running to provide full brake power.
	h. Brake relief valve stuck open.	**h.** Replace the relief valve.
	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 35 psi (241 kPa) 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 to 100 to 120 lb-in (11.3 to 13.6 Nm).
7. Repeat steps 5 and 6 for the remaining wheel calipers/ actuators.
8. Remove the air supply from the bleeder tank.

NOTE: Close the bleeder tank valve and disconnect the hose and the bleeder adapter.

9. Remove the bleeder tank and hose.
10. 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 to 100 to 120 lb-in (11.3 to 13.6 Nm).
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 axles are hydraulic disc-type brakes. Two brake assemblies are used at each wheel end on the front axle. One brake assembly is used at the wheel end on the rear 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 *Wheels and Tires*, page 8-4.

Removal

Linings

1. Remove the bolts securing the end plates to one side of the caliper housing. Remove the end plates.
2. Loosen the bleeder screws to release hydraulic pressure in the caliper.

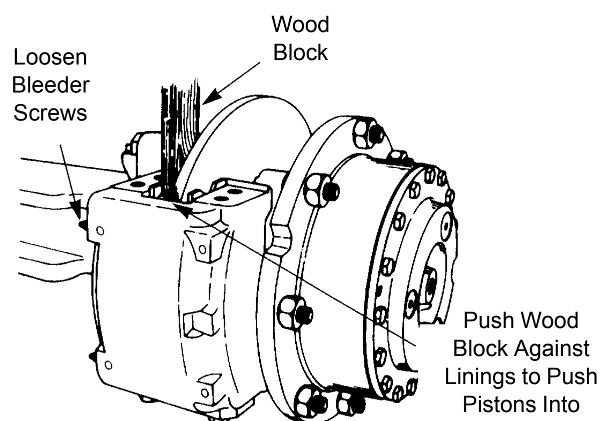


FIGURE 8-13

3. Use a piece of wood against the linings as a pry bar to push the pistons completely into the housing. Tighten the bleeder screws (Figure 8-13).
4. Remove the linings from the caliper housing. If necessary, discard the linings.

Caliper

1. Disconnect the hydraulic brake line from the inlet fitting on the caliper. Cap or plug all openings.
2. Remove the linings as described previously.
3. Remove the bolts securing the caliper housing to the mounting bracket. Remove the caliper housing from the

mounting bracket. If shims are used mark the position of the shims.

Disassembly

Caliper

1. Remove the inlet fitting and O-ring from the cylinder cap.
2. Drain and discard the 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 0.5 in (12.7 mm) 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 (Figure 8-14).

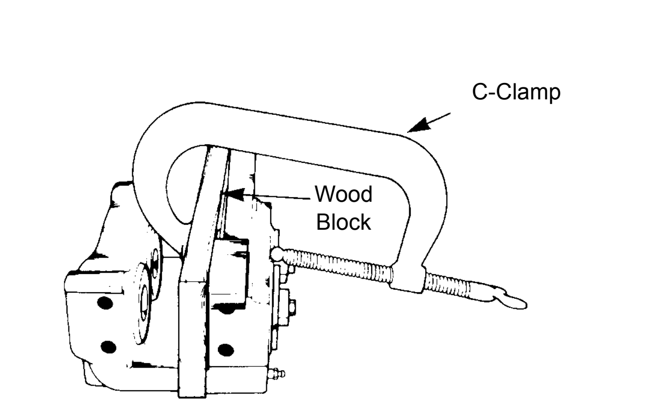


FIGURE 8-14

DANGER

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 (Figure 8-15).

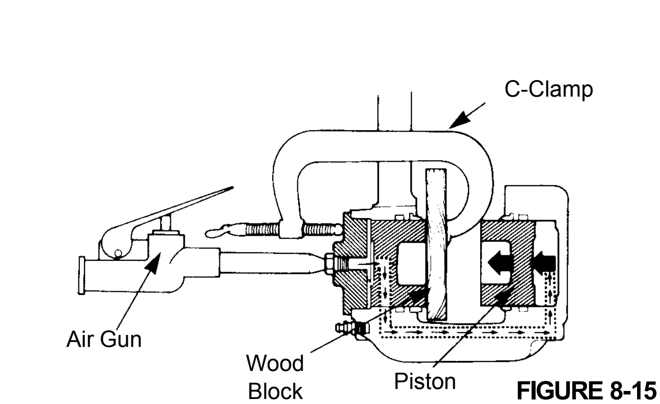


FIGURE 8-15

   - **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 cylinder caps from the housing using an open end wrench. Remove and discard the O-rings (Figure 8-16).

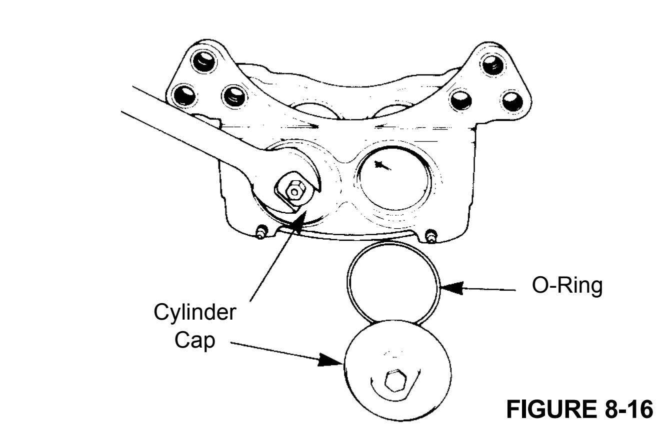


FIGURE 8-16

7. 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 (Figure 8-17).

8

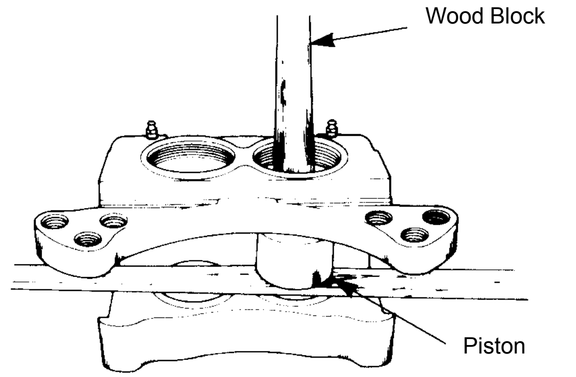


FIGURE 8-17

8. Remove the dust seals from the housing.

9. Remove and discard the O-ring and the backup rings (Figure 8-18).

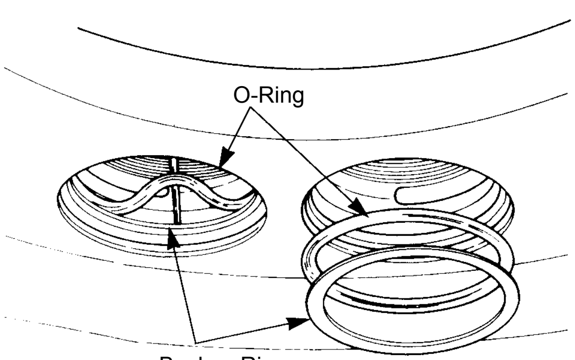


FIGURE 8-18

10. 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 Inspection - Caliper Parts.

11. 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.

Inspection

Periodic On-Vehicle

Inspect the caliper, linings, and disc for any damage.

Shoes, Linings, and End Plates

Remove the shoes and linings. To help prevent abnormal lining wear, replace worn, bent, or cracked end plates and distorted backing plates. Inspect end plate bolts for wear. Replace the bolts if worn. Inspect the linings for:

- Lining Wear. Replace the linings when the thickness of the lining is less than 0.125 in (3.2 mm) from the back plate (Figure 8-19).
- 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 (Figure 8-19).

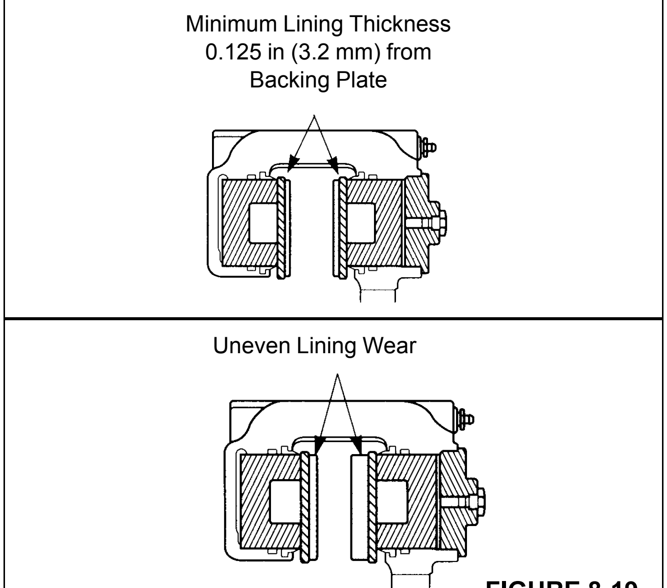


FIGURE 8-19

- 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 (Figure 8-20).

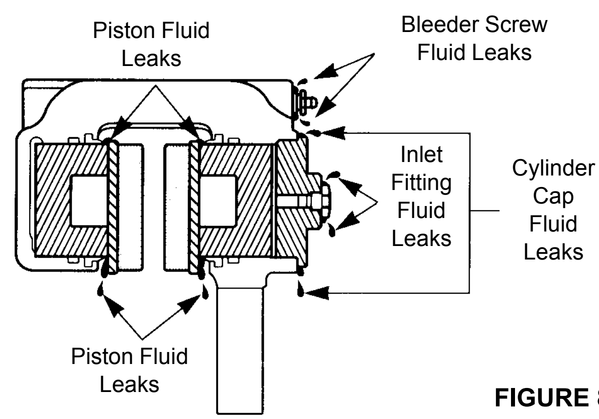


FIGURE 8-20

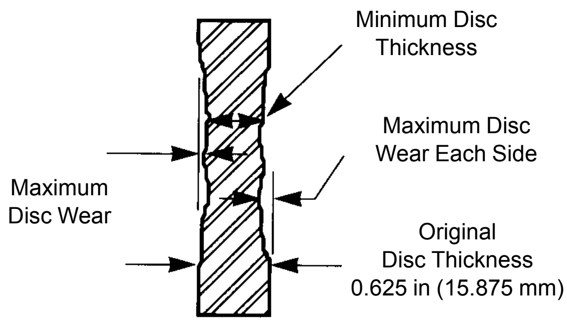
- **Pistons.** If fluid leaks at a piston, disassemble the caliper. Inspect the piston, the bore, the O-rings, and back-up rings. Service as necessary.
- **Cylinder Cap.** If fluid leaks at a cylinder cap, tighten the cylinder cap, the inlet fitting, and the plug. If the leak continues, disassemble the 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 (Figure 8-21).



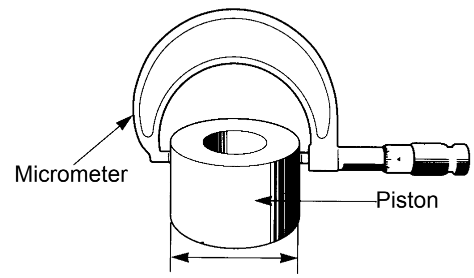
Typical Section Through Disc Showing Recommended Maximum Wear Limits

Lining Backing Plate Thickness	Maximum Disc Wear Each Side	Minimum Disc Thickness
0.28 in (7.1 mm)	0.06 in (1.5 mm)	0.50 in (12.7 mm)
0.34 in (8.6 mm)	0.09 in (2.3 mm)	0.44 in (11.2 mm)

FIGURE 8-21

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 2.995 in (76.073 mm) (Figure 8-22).



Replace Piston if Outer Diameter is Worn to Less than 2.995 in (76.073 mm)

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) (Figure 8-23).

Replace Housing if Bore is Worn to More than 3.003 in (76.276 mm)

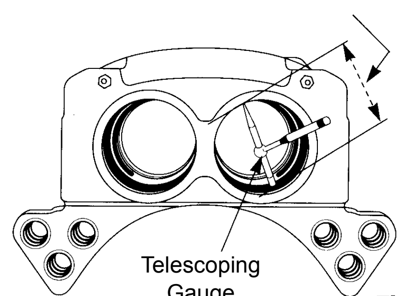


FIGURE 8-23

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.

8

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.

CAUTION

Use only solvent cleaners to clean ground or polished metal parts. Hot solution tanks or water and alkaline solutions will damage these parts. Isopropyl alcohol, kerosene, or diesel fuel can be used for this purpose.

- Use solvent cleaners to clean all metal parts that have ground or polished surfaces. Examples of ground or polished parts are the piston and the piston bore in the caliper.
- Metal parts with rough surfaces can be cleaned with solvent cleaners or with 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 (Figure 8-24).

CAUTION

Do not use silicone grease on the dust seal.

3. Install a new dust seal in the top groove of the bore (Figure 8-24).

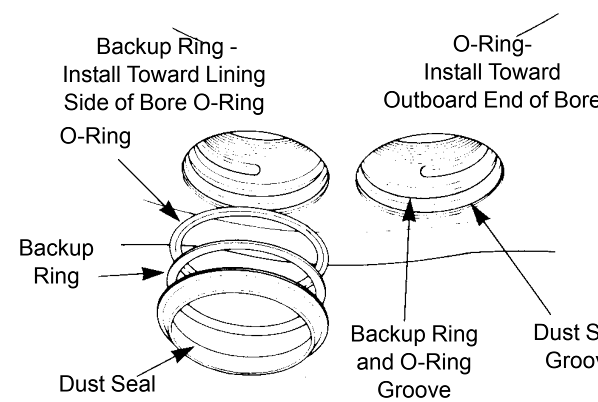


FIGURE 8-24

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 (Figure 8-25).

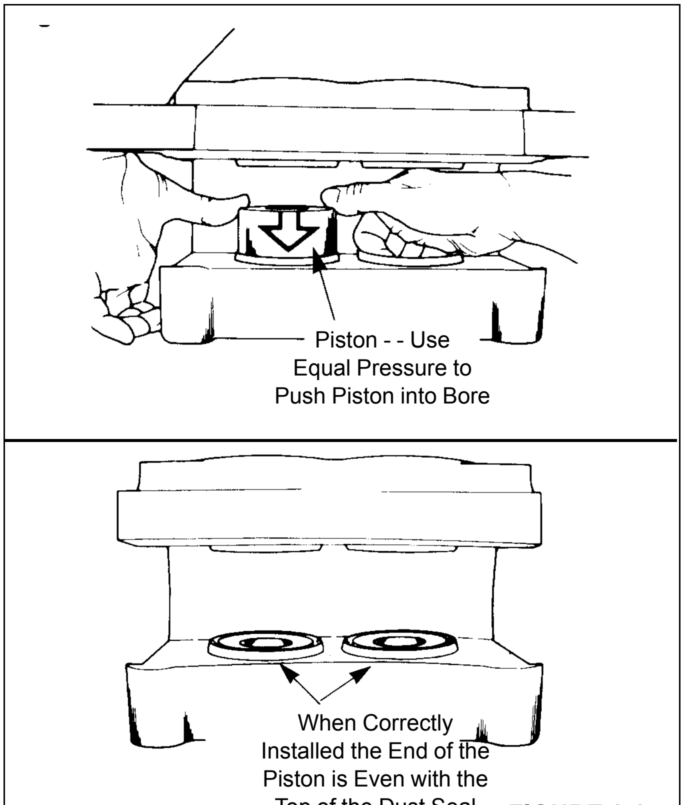


FIGURE 8-25

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 75 lb-ft (102 Nm) minimum as shown in (Figure 8-26).

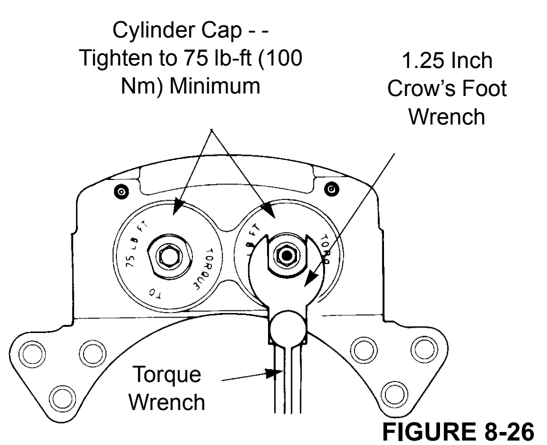


FIGURE 8-26

7. Install the bleeder screws in the housing. Tighten to 100 to 120 lb-in (11.3 to 13.6 Nm).
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. Install the linings in the caliper housing.
2. Position the end plates on the housing and secure with bolts. Apply Loctite® 271 or equivalent to the bolt threads. Tighten the bolts to 165 to 210 lb-ft (224 to 285 Nm).
3. Ensure the linings move freely in the housing.
4. Bleed the brake system.
5. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

Caliper

1. Position the caliper housing on the mounting bracket. If shims were used, place them as marked during removal.
2. Secure the caliper housing with the bolts and tighten them to 500 to 600 lb-ft (678 to 813 Nm).
3. Install the linings. Refer to *Linings*, page 8-21.
4. Ensure the housing is installed correctly on the mounting bracket. The disc must be within ±0.06 in (±1.5 mm) of being centered between the lining end plates.
   a. To increase outboard clearance and decrease inboard clearance, install a shim either between the housing and mounting bracket or between the hub and disc.
   b. The shims must be steel, ground flat, and parallel and must cover the entire mounting surface of the hub or housing. The linings must move freely in the housing and between the end plates (Figure 8-27).

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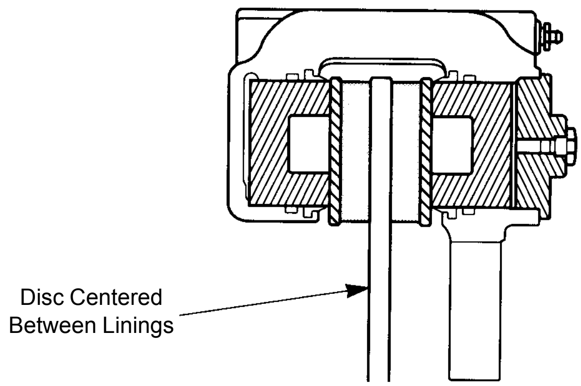

FIGURE 8-27

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 270 psi (1862 kPa/18.6 bar) 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 270 psi (1862 kPa/18.6 bar) 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 270 psi (1862 kPa/18.6 bar) 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 270 psi (1861.5 kPa) hydraulic pressure to avoid damage to the brake; 170 psi (1172.1) 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 0.015 in (0.381 mm).

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 0.07 in (1.778 mm) more. This puts the proper amount of pre-load on the urethane springs.
5. Tighten jam nut/sleeves (35) against mounting surface and torque 200 lb-ft (271.1 Nm).

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 270 psi (1861.5 kPa) hydraulic pressure to avoid damage to the brake; 170 psi (1172.1) 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 (0.016 in/0.406 mm).
   - **e.** Hold the socket head cap screw (38) in place while tightening the outer hex nut (39) against the inner hex nut (39) to 30 - 35 lb-ft (40.7 - 47.5 Nm).
   - **f.** Back off the socket set screw (12) 1/2 turn (0.028 in/ 0.711 mm).
   - **g.** Hold the socket set screw (12) in place and torque coupling nut (13) to 50 - 55 lb-ft (67.8 - 74.6 Nm).
   - **h.** Replace plug. Torque plug 45 - 50 lb-ft (61.0 - 67.7 Nm).

NOTE: Re-adjust the brake when running clearance reaches a total of 0.10 in (2.54 mm).

9. Position the Park Brake Switch to ON and shut down the engine.

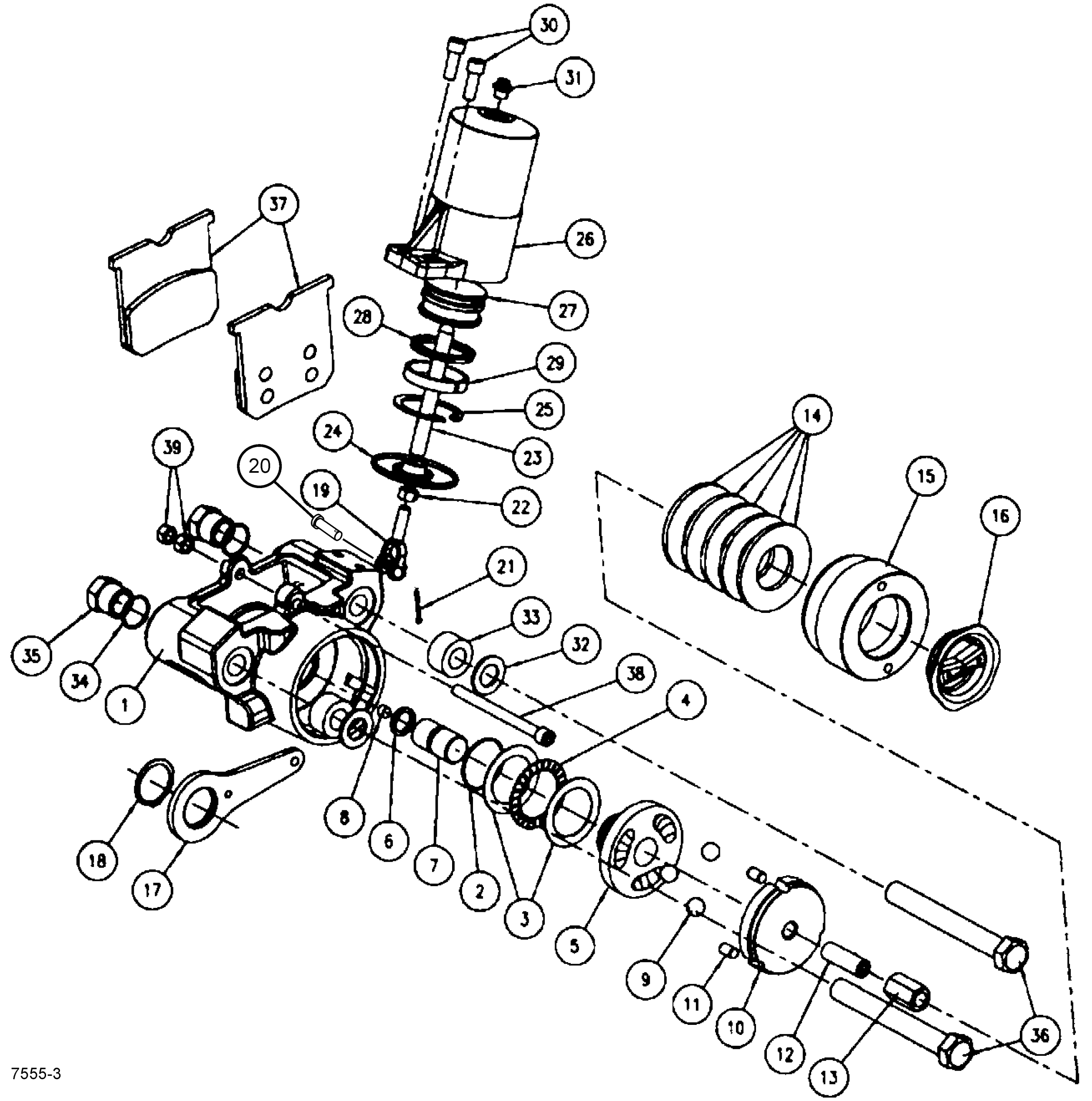
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FIGURE 8-28

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

PARK BRAKE SOLENOID VALVE

Description

The park brake solenoid valve (Figure 8-29) 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 on the switch.When the park brake is released, pressure buildup opens the switch, which turns off the indicator.

Maintenance

Removal

1. Tag and disconnect the 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.

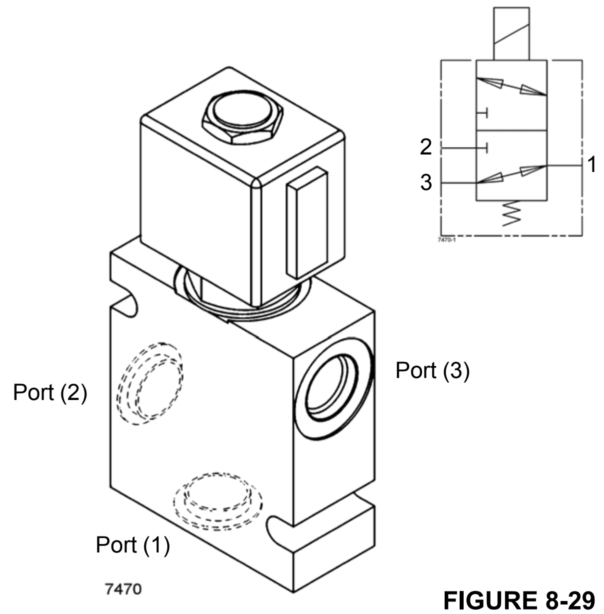

FIGURE 8-29

OUTRIGGERS

Outrigger Circuit

The outrigger circuit consists of four extension cylinders, four jack cylinders, an integrated outrigger/rear steer valve, front and rear outrigger control manifolds, pilot operated check valves and four Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometers. The front two extension cylinders are mounted in the front outrigger beams and the rear two extension cylinders are mounted in the rear outrigger beams. The front and rear outrigger beams are mounted in their respective outrigger boxes; in turn a jack cylinder is mounted on the end of each outrigger beam. The integrated outrigger/rear steer valve is mounted on the front face of the carrier frame front cross member. The front and rear outrigger control manifolds are mounted on the inside center of their respective outrigger box. An OMS string potentiometer (if equipped) is mounted inside each outrigger box. The potentiometer is connected by a cable to the outrigger beam to monitor the beam's position—fully retracted, mid-extend, or full extended.

The outrigger selector controls are located in the cab on the front console. Both the integrated outrigger valve and the manifold solenoid valves are electrically actuated from these controls. The solenoid switches must be held depressed to actuate the solenoid valve. The integrated outrigger valve switch is spring loaded to the off position. The console is 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 three relief valves. The main relief is set at 2000 psi (13,789 kPa). Thermal relief protection is provided on the extend side by a 3000 psi (20,684 kPa) relief valve and the retract side by a 300 psi (2068 kPa) relief valve.

8

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	**a.** Damaged relief valve.	**a.** Remove relief valve; clean or replace.
	b. Low hydraulic oil.	**b.** Replenish oil to proper level.
	c. Sticking solenoid valve spool.	**c.** Repair or replace valve spool.
	d. Improper ground to base of solenoid.	**d.** Ground properly.
2. Slow or erratic operation of outrigger extension cylinders (continued).	**a.** Directional selector switch sticking.	**a.** Clean or replace switch.
	b. Collector ring dirty or glazed.	**b.** Clean and deglaze collector ring.
	c. Damaged wiring to solenoid.	**c.** Replace wiring.
	d. Weak brush springs on collector ring.	**d.** Replace brush springs.
	e. Damaged extension cylinder (internal parts).	**e.** Remove extension cylinder and repair as necessary.
	f. Bent cylinder rods.	**f.** Replace piston rods and seals.
	g. Excessive material on outrigger beams.	**g.** Clean outrigger beams.
	h. Binding outrigger beam.	**h.** Repair or replace outrigger beam.
	i. Damaged outrigger valve.	**i.** Repair or replace valve.
	j. Damaged valve coil.	**j.** Replace coil.
	k. Main hydraulic pump cavitation.	**k.** Replace or tighten hose or fitting.
	l. Partially shifted hydraulic spool in selector valve or manifolds.	**l.** Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	m. Insufficient voltage for operation of solenoid valve.	**m.** Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical coupling collector rings.
	n. Damaged piston seals.	**n.** Replace all cylinder seals.
	o. Worn or damaged hydraulic pump section.	**o.** Repair or replace pump section.
	p. Scored cylinder barrel.	**p.** Repair or replace extension cylinder.
	q. Cracked or damaged piston.	**q.** Replace rod weld and all cylinder seals.

Symptom	Probable Cause	Solution
3. Sticking spool.	**a.** Dirt in the system.	**a.** Change oil and flush system.
	b. Distortion caused by tie bolts being overtorqued.	**b.** Retorque tie bolts.
	c. Flow in excess of valve rating.	**c.** Limit flow through valve to that recommended. Check pump output and cylinder ratio.
	d. Pressure in excess of valve rating.	**a.** Check relief valve setting or pump compensation with that recommended.
	e. Electrical failure.	**b.** Check wiring and solenoids.
4. 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.
5. 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.
6. Outrigger jack cylinder slow or erratic.	**a.** Low in hydraulic oil.	**a.** Replenish oil to proper level.
	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
7. 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.
8. 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.
9. Outrigger system will not activate (from stowed or extended and down position).	**a.** Hydraulic oil low.	**a.** Replenish system.
	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.
10. 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.
11. Outriggers will not set.	**a.** Improper sequence of activation.	**a.** Activate individual control switch; then activate system control switch.
12. Two outriggers activate from single control switch.	**a.** Damaged solenoid valves.	**a.** Repair or replace.
13. The two outriggers will not stow.	**a.** Hydraulic lock.	**a.** Recycle individual outrigger(s).
14. 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), 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) string potentiometer (if equipped) is mounted inside the outrigger box and is connected to the outrigger beam by a cable. The string potentiometer identifies whether an extension beam is at the fully retracted, mid-extend, or fully extended position. The OMS communicates the position of each outrigger beam to the Rated Capacity Limiter (RCL), aiding the operator in accurately programming the crane's configuration.

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

1. On the jack cylinder end of the beam, remove the set screw from the side adjustable wear pad and back off the wear pad from the outrigger box.
2. Remove the cover from the opposite end of the outrigger box. Remove the setscrew from the side adjustable wear pad and back off the wear pad from the beam.
3. Remove the setscrews from the bottom adjustable wear pads and back off the wear pads leaving approximately 0.125 in (3.2 mm) protruding
4. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.

WARNING

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

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 OMS string potentiometer caused by over-range of cable.

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

NOTE: Do not allow the end of the outrigger extension cylinder to fall when the cylinder mounting shaft is removed. Use blocking to limit the drop to prevent damage to the OMS string potentiometer (if equipped).

OMS string potentiometer may be easily removed to avoid damage during extension cylinder pin removal. Refer to *Outrigger Monitoring System (Optional—Standard in North America)*, page 8-36.

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 8-31).

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.

WARNING

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

NOTE: The outrigger beam assembly weighs approximately 1474 lb (669 kg).

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.

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Installation

1. Apply grease (EPMPG) to the bottom of the outrigger beam.
2. If removed, install the side adjustable wear pad in the outrigger beam.
3. Install the bottom wear pads with approximately 0.125 in (3.2 mm) 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 8-36.

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*, page 8-32.
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 Wear Pad Adjustment (Figure 8-32).

1. Adjust the bottom wear pads (approximately 1/4 turn) until a gap of 0.06 in (1.5 mm) 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 0.06 in (1.5 mm) 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 0.06 in (1.5 mm) is obtained between shim welded on beam and side of box. Install and lock set screw against wear pad.

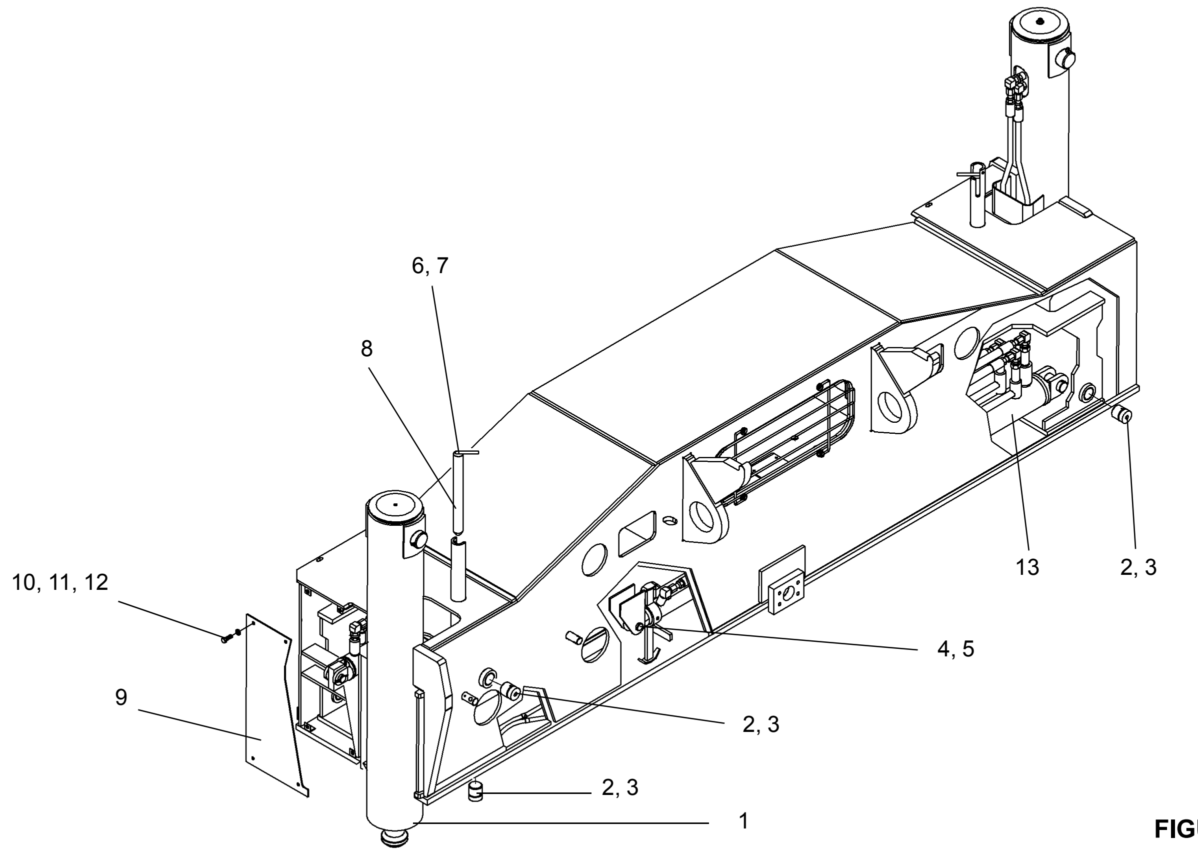

FIGURE 8-30

Item	Description
1	Outrigger Beam Assembly
2	Wear Pad
3	Setscrew
4	Clevis Pin
5	Cotter Pin
6	Capscrew
7	Hex Nut

Item	Description
8	Pin
9	Cover Plate
10	Screw
11	Lockwasher
12	Retaining Nut
13	Extension Cylinder

NOTE: Outrigger removal and installation similar for both front and rear outriggers.

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.

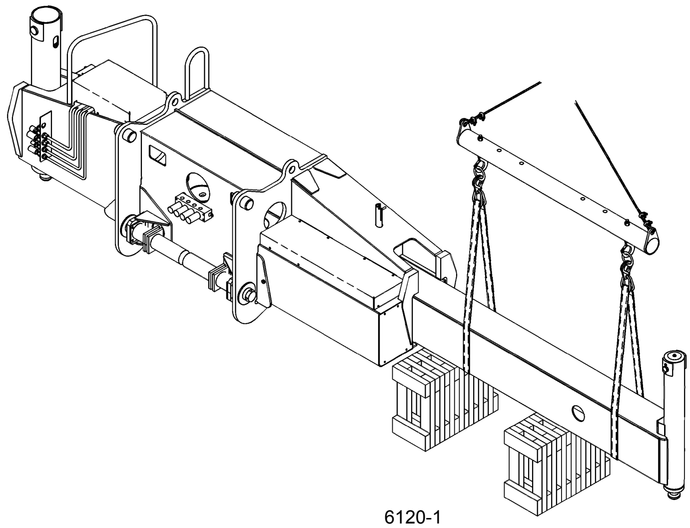

FIGURE 8-31

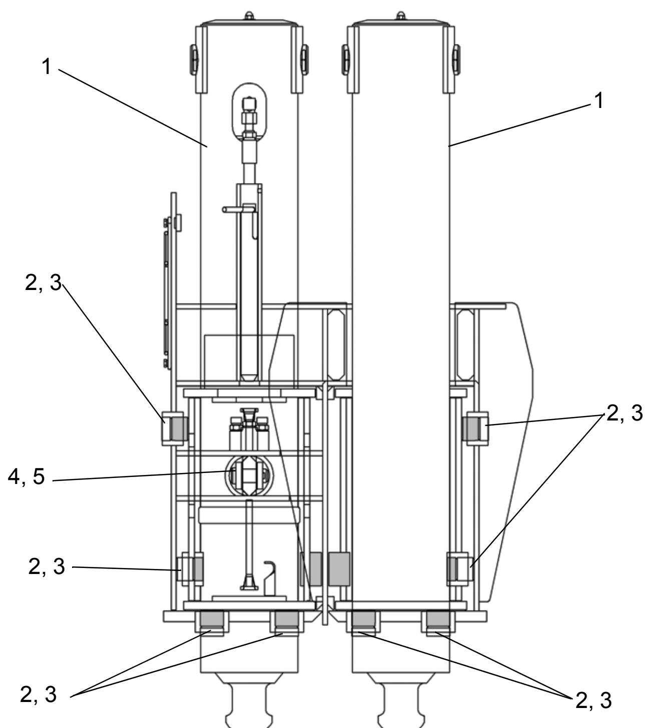

FIGURE 8-32

Item	Description
1	Outrigger Beam Assembly
2	Wear Pad
3	Setscrew
4	Clevis Pin
5	Cotter Pin

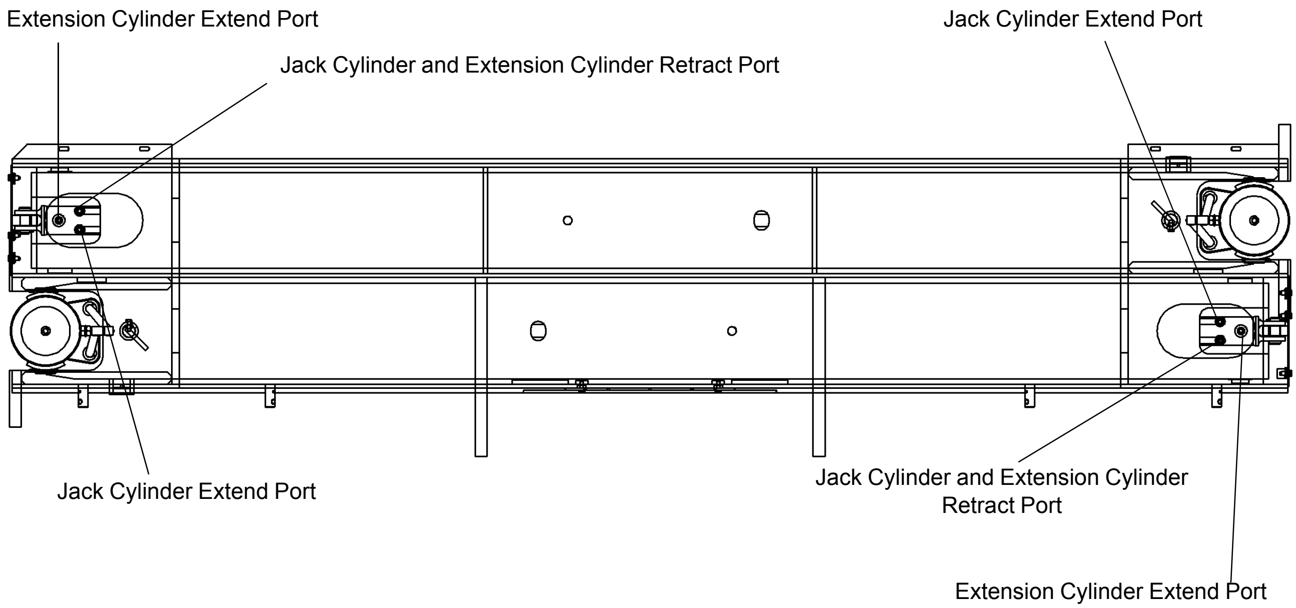

FIGURE 8-33

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 100 lb (45.3 kg).

Maintenance

NOTE: Refer to *Outrigger Extension Cylinder*, page 2-91 for Disassembly and Assembly of the cylinder.

Removal

1. Remove the outrigger beam. Refer to *Outrigger Beam*, page 8-31.
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 (Figure 8-34) 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.

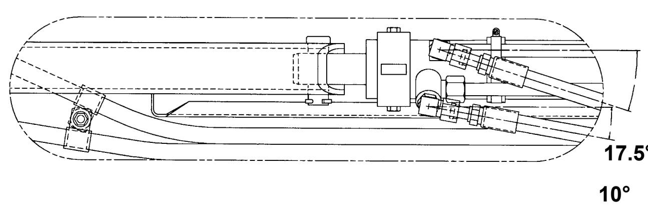

FIGURE 8-34

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.
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 8-31.

Functional Check

1. Activate the hydraulic system; extend and retract the outrigger.
2. Observe the operation of the outrigger beam.

3. Check the hydraulic connections for any evidence of leakage.

Outrigger Monitoring System (Optional—Standard in North America)

Description

The Outrigger Monitoring System (OMS) aids the operator in accurately programming the Rated Capacity Limiter (RCL) by automatically identifying the position of each outrigger beam. The OMS uses four sensors, one per outrigger beam, to identify when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

Removal

1. Extend the outrigger beam slightly for improved access and shut down the engine.
2. Remove the outer access cover plate from outrigger box.
3. Remove the OMS string potentiometer connector (1, Figure 8-35) from the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to 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.
7. Remove OMS string potentiometer from inside outrigger beam.

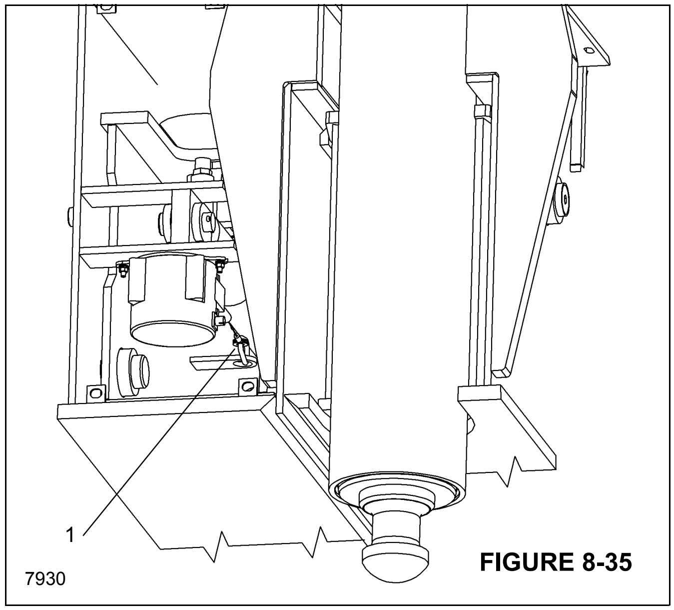

FIGURE 8-35

Installation

1. Install string potentiometer inside outrigger beam.
2. Install the OMS string potentiometer enough to engage slotted hole with top mounting hardware.
3. Install the lower mounting hardware.
4. Attach the OMS string potentiometer connector to the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to the OMS string potentiometer.

5. Connect electrical harness connector to string potentiometer.
6. Install access cover plate to outrigger box.

Jack Cylinder

Description

Four jack cylinders are used on the crane, one at the end of each outrigger beam. The jack cylinders provide the force for the outrigger beam’s vertical movement. The cylinder weighs approximately 229 lb (104 kg).

Maintenance

NOTE: Refer to *Outrigger jack Cylinder*, page 2-94 for disassembly and assembly of the cylinders.

Removal

1. Extend the outrigger beam slightly for improved access to the jack cylinder; shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder. Remove the fittings from the ports. Cap or plug all openings.

3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
6. Jack the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure the pin in place with the cotter pins.

CAUTION

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

Installation

1. Apply grease (EPMPG) to the ID of the jack cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under Removal, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.
5. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam.
6. Apply anti-seeze compound to the retaining pin. Secure the cylinder and cylinder cap retaining bracket to the support tube with the retaining pin and cotter pins.
7. Install the cylinder cap.
8. Install the fittings in the cylinder ports and connect the hoses as tagged during removal.

Functional Check

1. Activate the hydraulic system.
2. Extend and retract the jack cylinder.
3. Check for smooth operation of the cylinder.
4. Check all hydraulic connections and hoses for evidence of leakage.

Outrigger Jack Cylinder Internal Leak Test

Use the following procedure to troubleshoot and diagnose an internal leak, a leaking pilot operated check valve or a thermal contraction on an outrigger jack cylinder.

DANGER

Perform the following procedures with the crane positioned on a firm level surface with outriggers fully extended and set, and the crane in the travel position

Remove hoses from one cylinder at a time.

Checking Cylinder for Internal Piston Seal Leak

1. Fully extend and set the outriggers.

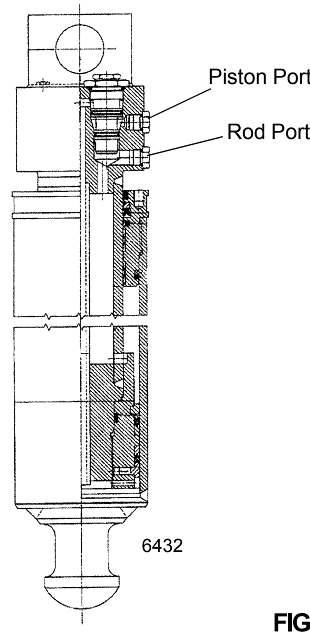

FIGURE 8-36

CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the rod side cylinder hose from the suspected leaking jack cylinder (see Figure 8-36). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the rod side port.

   Check for the following conditions:

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a. If oil stops flowing, the cylinder's internal piston seal is sealing properly.

b. If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking.

3. After determining the condition of the cylinders internal piston seal, leave the rod side hose disconnected and continue to test the pilot operated check valve.

Testing Pilot Operated Check Valve For Leakage

1. Fully extend and set the outriggers.

CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the piston side cylinder hose from the suspected leaking jack cylinder (see Figure 8-36). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the piston side port.

a. If oil stops flowing, the cylinder's pilot operated check valve is sealing properly.

b. If oil continues to flow out the piston port, the cylinder's pilot operated check valve is leaking.

If oil flow is not noticed from either port, the cylinder and pilot operated check valve are functioning properly, and any cylinder contraction during normal operation can be attributed to thermal contraction of the oil.

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 *Valves*, page 2-31.

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 jack cylinder.

Integrated Outrigger/Rear Steer Valve

The integrated outrigger/rear steer valve is mounted on the rear face of the carrier frame front cross member. The outrigger portion of the valve consists of a 4-way two position solenoid valve. The inlet section contains the main relief valve.

Outrigger Control Manifold

The front and rear outrigger control manifolds are located on the respective outrigger boxes. Each manifold consists of four 12 volt solenoid valves and an assembly mounting kit.

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.

Pintle Hook

A conventional pintle hook with safety pinned latch can be installed on the front and/or back of the crane. It is bolted onto a plate which is welded onto the front or rear outrigger boxes of the crane.

Secondary Front Steer (CE Option)

A secondary front steering system for the CE option consists of a hydraulic pump, load sense steer priority flow divider valve (part of the swing directional control valve), load sense steering control valve, two steer cylinders, dual accumulator charge valve, pressure switches, pilot operated valve and two accumulators.

The hydraulic pump is driven by the engine and supplies hydraulic flow to the load sense steering priority flow divider. The load sense steer priority flow divider valve provides flow to the load sense steering control valve. 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 front steer cylinders.

The two accumulators allow for emergency steering should there be a loss of hydraulic pressure.

SECTION 9
LUBRICATION

SECTION CONTENTS

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.

LUBRICATION INTERVALS

The service intervals specified are for normal operation where moderate temperature, humidity, and atmospheric conditions prevail. In areas of extreme conditions, the service periods and lubrication specifications should be altered to meet existing conditions. For information on extreme condition lubrication, contact your local Manitowoc Cranes distributor or Manitowoc Crane Care.

Lube intervals are to be used as a guideline only. Actual lube intervals should be formulated by the operator to correspond according to conditions such as continuous duty cycles and/or hazardous environments.

CAUTION

Chassis grease lubricants must not be applied with air pressure devices, as this lubricant is used on sealed bearings.

The multipurpose grease installed during manufacture is of a lithium base. Use of a noncompatible grease could result in damage to equipment.

STANDARD LUBRICANTS

TABLE 9-1: Standard Lubricants [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Axle/Swing Box Gear Oil	6829012964	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO	80W-90	
Engine Oil	6829104182	Conoco Fleet Supreme EC Mobil Delvac 1300 Super	15W-40	CJ-4
Hydraulic/Transmission Oil	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	
Hoist Gear Oil	6829100213	Mobil: Mobilfluid 629 Texaco: Meropa 150		AGMA No. 4 EP
Grease, Multipurpose	6829003477	Citgo Lithoplex MP# 2 Texaco Starplex Moly # 2 Phillips 66 Philube M Mobil Mobilgrease XHP 222 Special Chemtool Inc, Lube-A-Boom	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		

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 9-1) and -40°C (-40°F) (Table 9-2). 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 air 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

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Table 9-1: Cold Weather Lubricants [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant Type	Grade	Classification
Axle Gear Oil	6829014058	Petro-Canada Traxon E Synthetic CITGO, Syntetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	
Tier 3/Tier 4 Engine Oil	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
Hoist Gear/Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Hydraulic Oil	6829006993	Exxon Mobil Univis HVI	26	
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III Product #1	#1	NLOCK08

Table 9-2: Cold Weather Lubricants [Down to -40°C (-40°f)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Axle Gear Oil	6829014058	Petro-Canada Traxon E Synthetic CITGO, Syntetic Gear Lube Eaton, Roadranger EP Mobil, Mobilube SCH Shell, Spirax S Sunoco Duragear EP	75W-90	
Tier 3/Tier 4 Engine Oil	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20c & J20d
Hoist Gear/Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829104212	Old World Industries, Inc. Fleet Charge SCA Pre-charged Fleetguard Compleat EG Petro-Canada	Mix 60/40	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Hydraulic Oil	6829006993	Exxon Mobil Univis HVI	26	
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III	#1	NLOCK08

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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. cans by ordering part number 9999101803 through your authorized Manitowoc Cranes distributor.

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* in *Section 1- INTRODUCTION* in the Service Manual.

LUBRICATION POINTS

A regular frequency of lubrication must be established for all lubrication points. Normally, this is based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log indicating crane usage. The log must use the engine hourmeter to ensure coverage of lube points that will receive attention based on their hours operated. Other lubrication requirements must be made on a time interval basis, i.e. daily, weekly, monthly, etc.

All oil levels are to be checked with the crane parked on a level surface in transport position, tires on the ground, and the suspension set at the proper ride height.

Lubrication checks must be performed while the oil is cool and has not been operated within the past 30 minutes, unless otherwise specified.

On plug type check points, the oil levels are to be at the bottom edge of the fill plug hole.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease non-sealed bearings until grease is seen extruding from the bearing. One ounce (28 grams) of EP-MPG equals one pump on a standard one pound (0.45 kg) grease gun.

Over lubrication on non-sealed bearings will not harm the bearings or components, but under lubrication will definitely lead to a shorter lifetime.

On sealed U-joints, care must be exercised to prevent rupturing seals. Fill only until expansion of the seals first becomes visible.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, levers, etc., should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to ensure complete lubrication of the entire wear area.

CraneLUBE

Manitowoc highly recommends the use of CraneLUBE lubricants to increase your crane's reliability and performance. Contact your Manitowoc Distributor for information about the Manitowoc's CraneLUBE lubrication program.

Safety

To lubricate many of the locations, the engine will need to be started. After positioning areas of the unit for lubrication the engine must be turned off and the moved areas stable before approaching.

WARNING

Crushing Hazard!

Movement of the superstructure and the boom may create a crushing and/or pinching hazard. Failure to observe this warning could result in death or serious injury.

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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
5	Tie Rod Pivot Pins	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	4 grease fittings

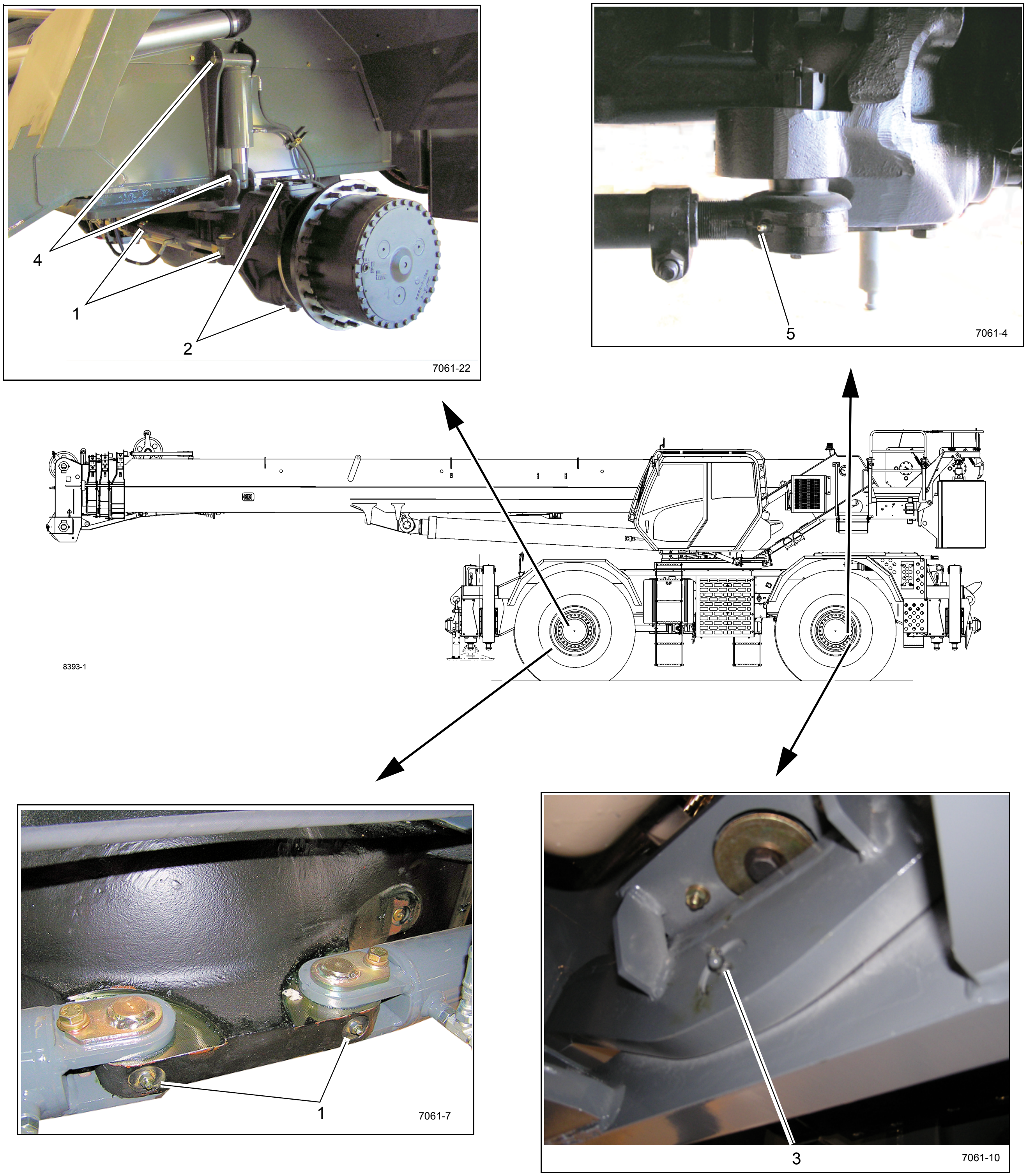

FIGURE 9-1

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Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Axles						
11	Differentials	Figure 9-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	52.0 pt 24.6 l	• Check level every 500 hours or 3 months • Drain and fill every 4000 hours or 2 years	Fill to bottom of hole in housing on the steer cylinder side.
NOTE: 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. **CAUTION:** Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals. **CAUTION:** If the makeup amount is substantially more than 0.5 pt (0.23 l), check for leaks.						
12	Planetary Hubs and Wheel Bearings	Figure 9-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	13.9 pt 6.6 l	• Check level every 500 hours or 3 months • Drain and fill every 4000 hours or 2 years	Fill to the bottom of the level hole in the housing with the fill plug and the oil level mark horizontal.
CAUTION: Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.						

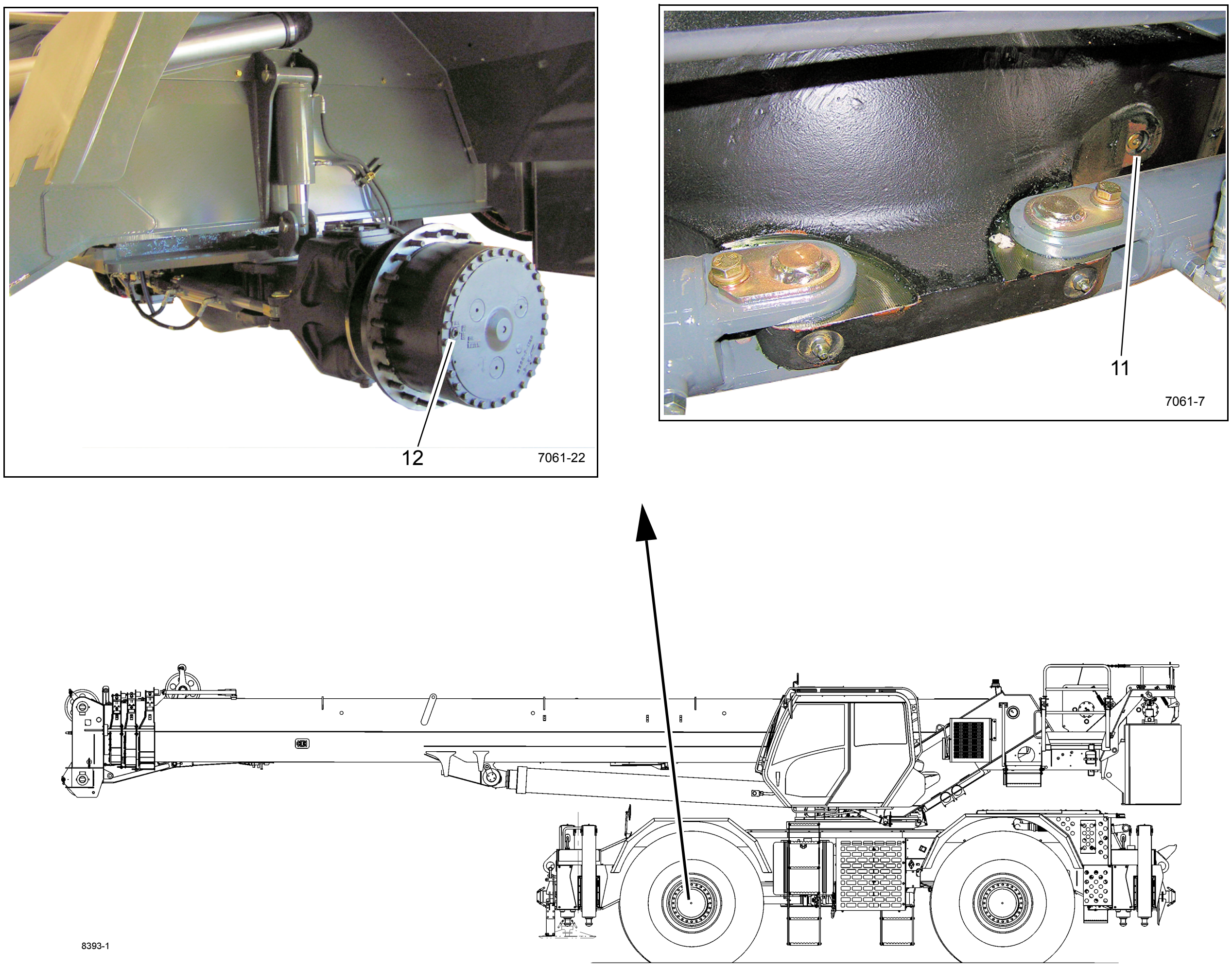


FIGURE 9-2

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Drive Train						
20a **20b**	a. Engine Crankcase b. Filter	Figure 9-3	EO-15W/40 Engine Oil SAE 15W-40 6829104182	21.1 qt 20 l	• Check level every 10 hours or daily • Drain, fill and replace filter every 250 hours	• Through valve cover to FULL mark on dipstick • Filter located on top left frame rail
21a **21b**	a. Transmission, Torque Converter Dipstick b. Filter	Figure 9-3	HYDO Hydraulic Oil 6829006444	40 qt 37.9 l	• Check level every 10 hours or daily • Drain and refill every 1000 hours or 6 months • Change transmission filter after first 50 and 100 hours of service, then every 500 hours thereafter	Through fill pipe to FULL mark on dipstick

NOTE:

- Check fluid level with engine running at 1200 rpm idle and the oil at 150 to 200° F (65 to 93°C). Do not attempt an oil level check with cold oil. To bring the oil temperature to this range, it is necessary to either work the crane or stall the converter. Converter stall should be accomplished by engaging shift lever in forward high range with the brakes applied and then accelerating the engine to half or three-quarter throttle. Hold the stall until the required converter temperature is reached and stabilized.

  Do not operate the converter at stall condition for longer than 30 seconds at one time. Shift to neutral for 15 seconds and repeat the procedure until the desired temperature is reached. Excessive temperature, i.e, 250°F (120°C) maximum will cause damage to transmission clutches, fluid, converter and seals.
- Drain and fill with the oil at 150 to 200°F (65 to 93°C).
- Transmission filters are located on the outside left hand frame in the area of the hydraulic oil cooler.
- To add fluid:

  a. Fill to FULL mark on dipstick

  b. Run engine at 1200 rpm to prime torque converter and lines

  c. Check oil level with engine running at 1200 rpm and oil at 180 to 200°F (82 to 93°C). Add oil to bring oil level to FULL mark on dipstick.

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
22a **22b**	Engine Cooling System	Figure 9-3	AFC 50/50 50/50 Blended Fully Formulated Antifreeze Coolant 6829101130	50 qt 47.3 l	• Check coolant level every 10 hours or daily	• Fill surge tank to bottom of filler neck. • Run engine through two (2) thermal cycles. • Check coolant level in sight gauge and refill as required.
			Supplemental Coolant Additive 6829012858	1 pt (.47 l) or as needed	• Check SCA level every 500 hours	• Add SCA if level is low as indicated by Coolant Test Kit, Grove P/N 9414101675

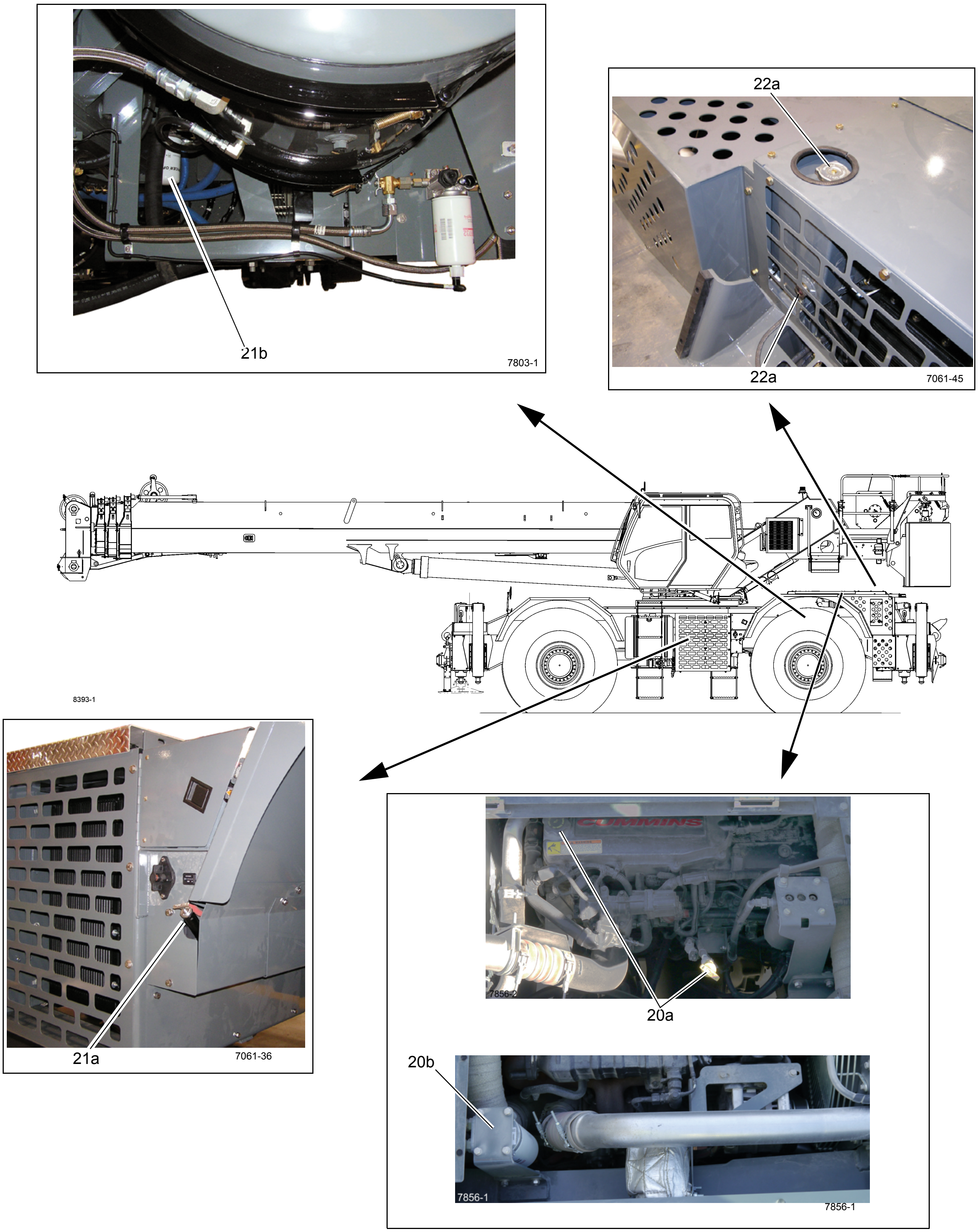

21b
7803-1
22a
22a
7061-45
8393-1
21a
7061-36
CUMMINS
7856-2
20a
20b
7856-1
7856-1

FIGURE 9-3

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Drive Train (continued)						
23	Coolant Strainer (Cab Heater)	Figure 9-4	---	---	Clean strainer screen after first 100 hours and every 2000 hours or 12 months thereafter.	Close shutoff valves. Unscrew hex plug to clean filter.
24	Air Cleaner Filter	Figure 9-4	---	---	• Replace primary filter element when Engine Warning Light blinks when ignition key is turned on or fault code 5576 or 3341 is displayed. • Replace secondary filter every third time primary filter is replaced.	Remove panel behind ladder to access air filter. Refer to Service Manual
25	Fuel/Water Separator Filter	Figure 9-4	---	---	• Drain water trap every 10 hours or daily. • Change filter every 500 hours or 6 months.	Separator filter is located below the fuel tank.
26	Driveline - Slip Joints	Figure 9-4	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings
27	Fuel Filter	Figure 9-4	---	---	Change filter every 500 hours or 6 months	Fuel filter is located on the top right frame rail.

NOTE: During replacement of the fuel filter, take note of the direction of the arrow. The arrow must point towards the fuel filter

9

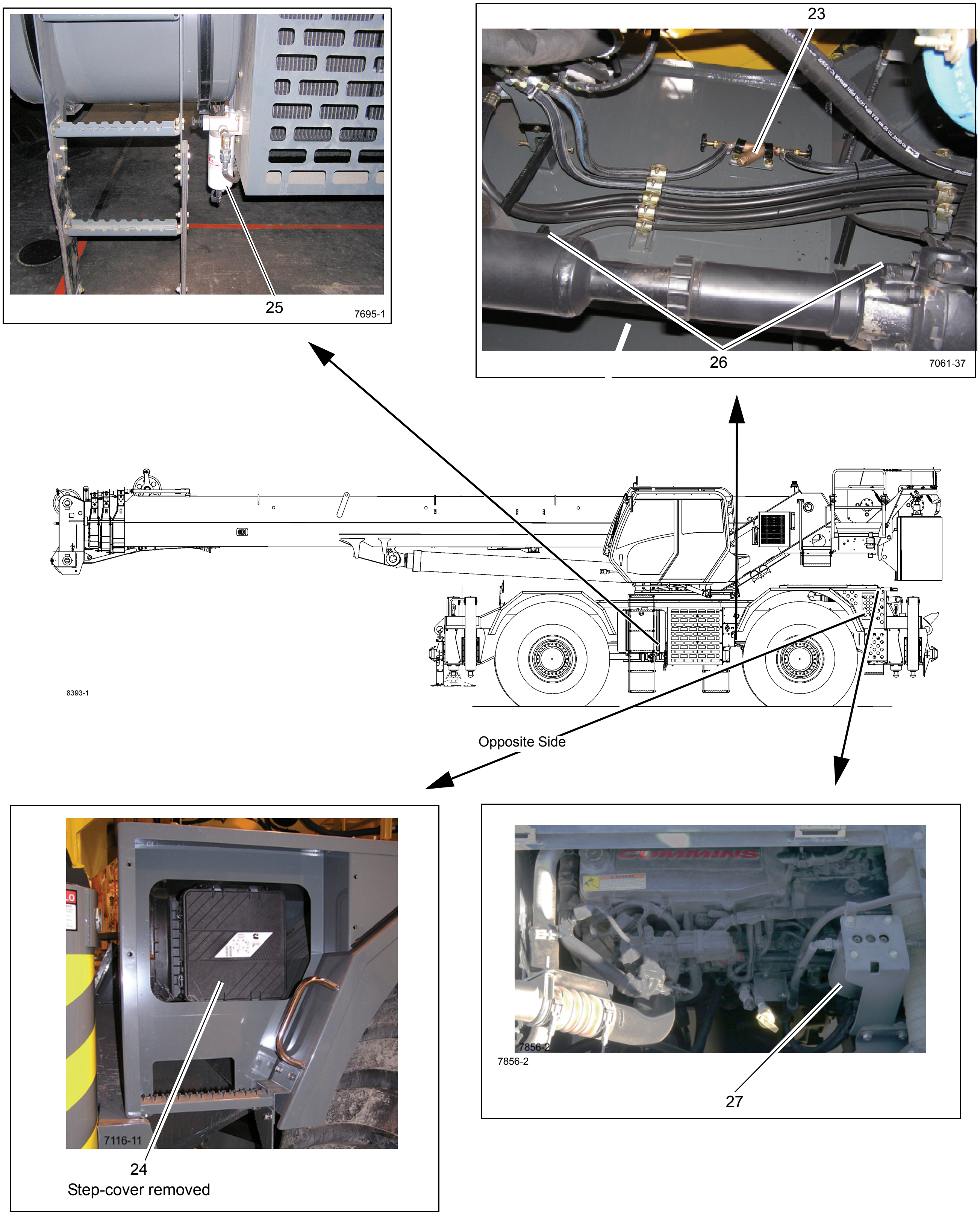

23
26
7061-37
25
7695-1
8393-1
Opposite Side
24
Step-cover removed
7116-11
27
7856-2

FIGURE 9-4

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Turntable						
30	Turntable Gear Box	Figure 9-5	GL-5 Extended Service Interval Gear Lubricant 6829012964	5.7 qt 5.4 l	• Check and fill every 50 hours • Drain and fill after first 250 hours and every 500 hours or 12 months thereafter.	Use Dipstick
31	Turntable Gear and Drive Pinion	Figure 9-5	EP-OGL Open Gear Lubricant 6829102971	Coat all teeth	500 hours or 6 months	Spray on
32	Turntable Bearing	Figure 9-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes the whole circumfer-ence of the bearing	500 hours or 6 months	2 grease fittings at the front of the turntable.
NOTE: Rotate the turntable 90° and apply grease to fittings. Continue rotating 90° and grease the fittings until the whole bearing is greased.						
33	Turntable Lock Pin	Not Shown	EP-OGL Open Gear Lubricant 6829102971	Coat pin	500 hours or 6 months	Spray on

9

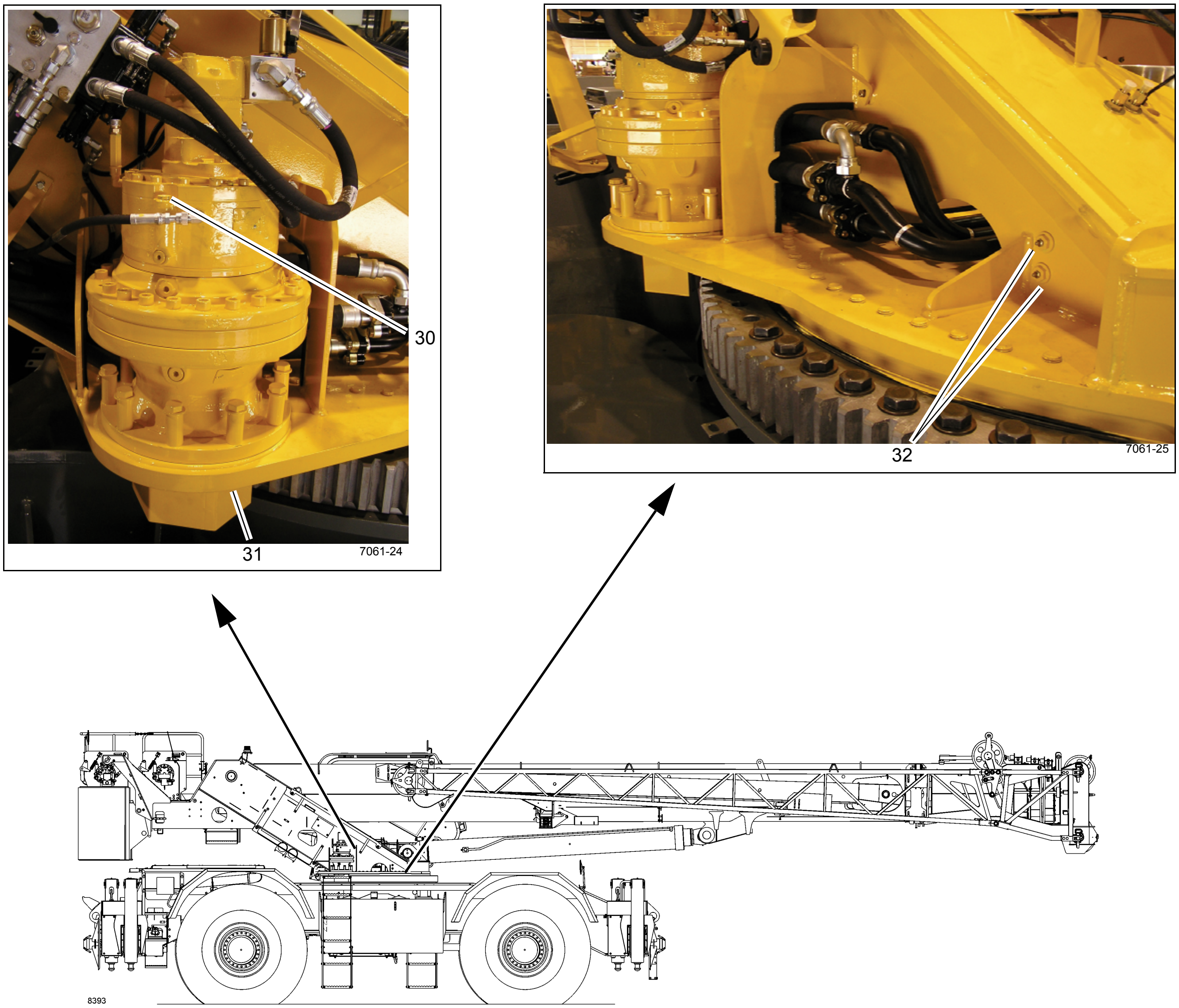


FIGURE 9-5

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Cab Tilt						
40	Cab Tilt Cylinder Pivot Pins	Figure 9-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 3 months	2 grease fittings
41	Pillow Block	Figure 9-6	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrude	500 hours or 3 months	2 grease fittings

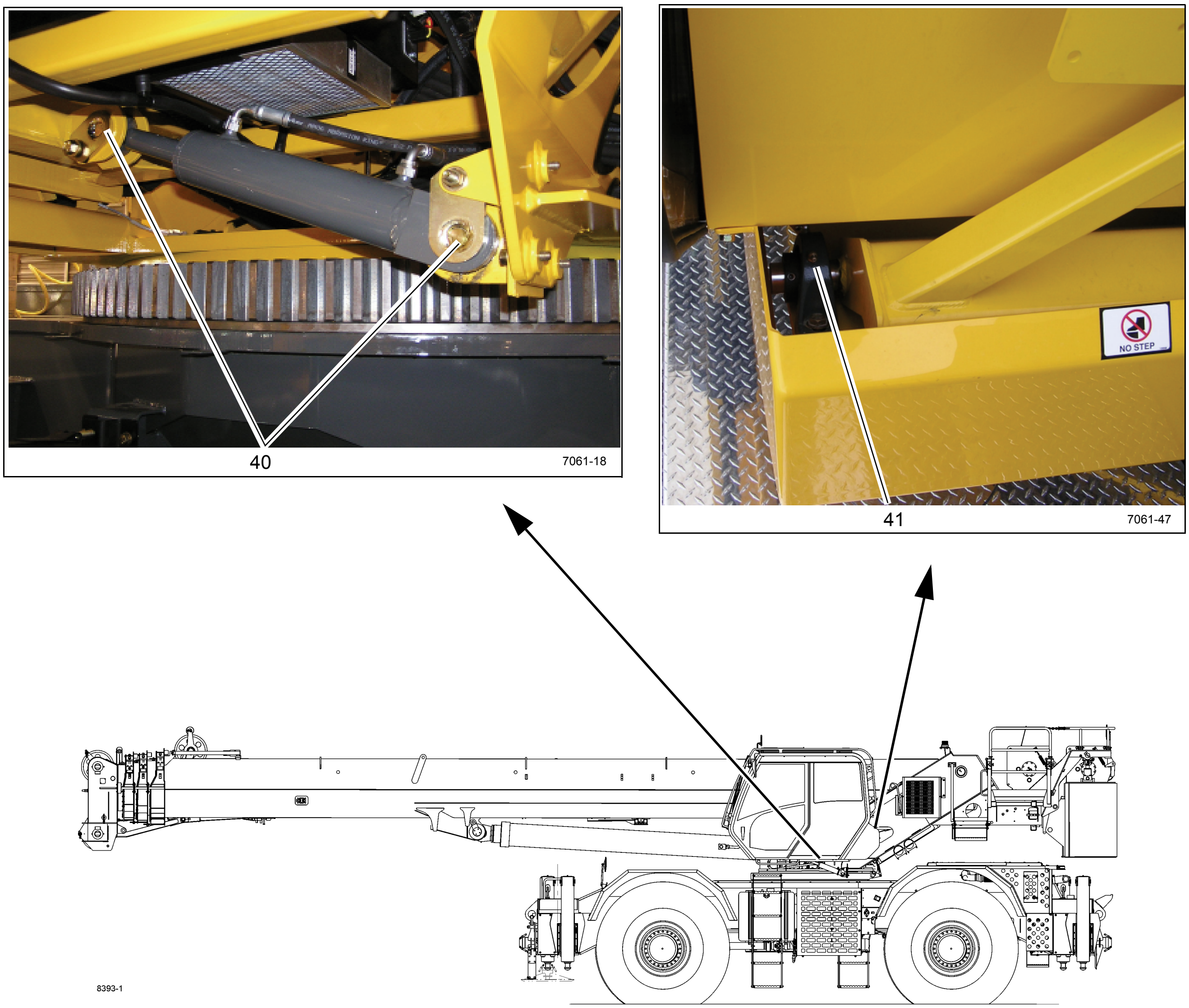


FIGURE 9-6

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Outriggers						
50	Outrigger Beams	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on bottom of outrigger beams
51	Jack Cylinder Support Tubes	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on ID of jack cylinder support tubes (4) places before installing jack cylinders
52	Jack Cylinder Barrels	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	---	50 hours or 1 week	Brush lubricant on OD of jack cylinder (4) places before installing jack cylinders

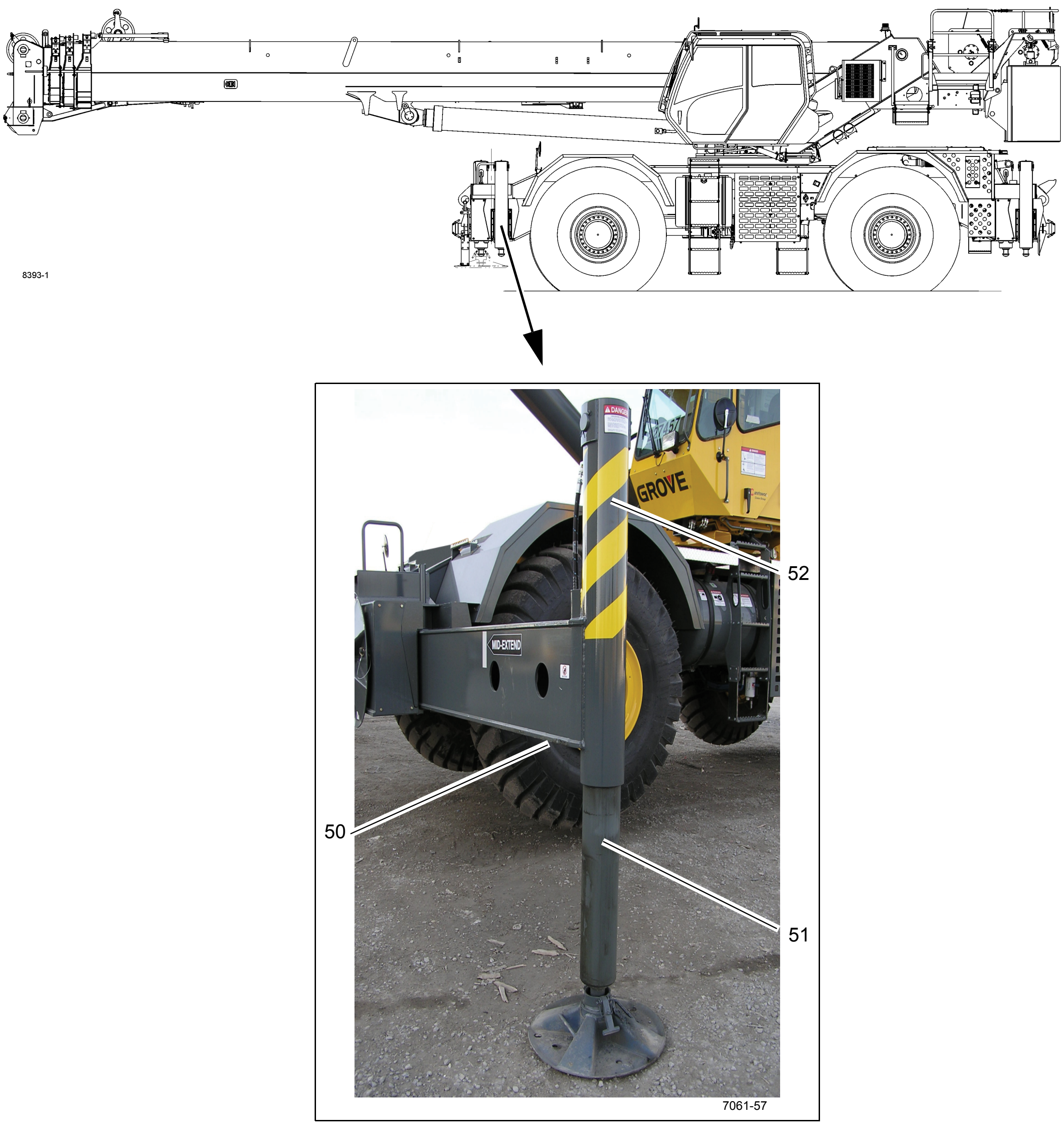


FIGURE 9-7

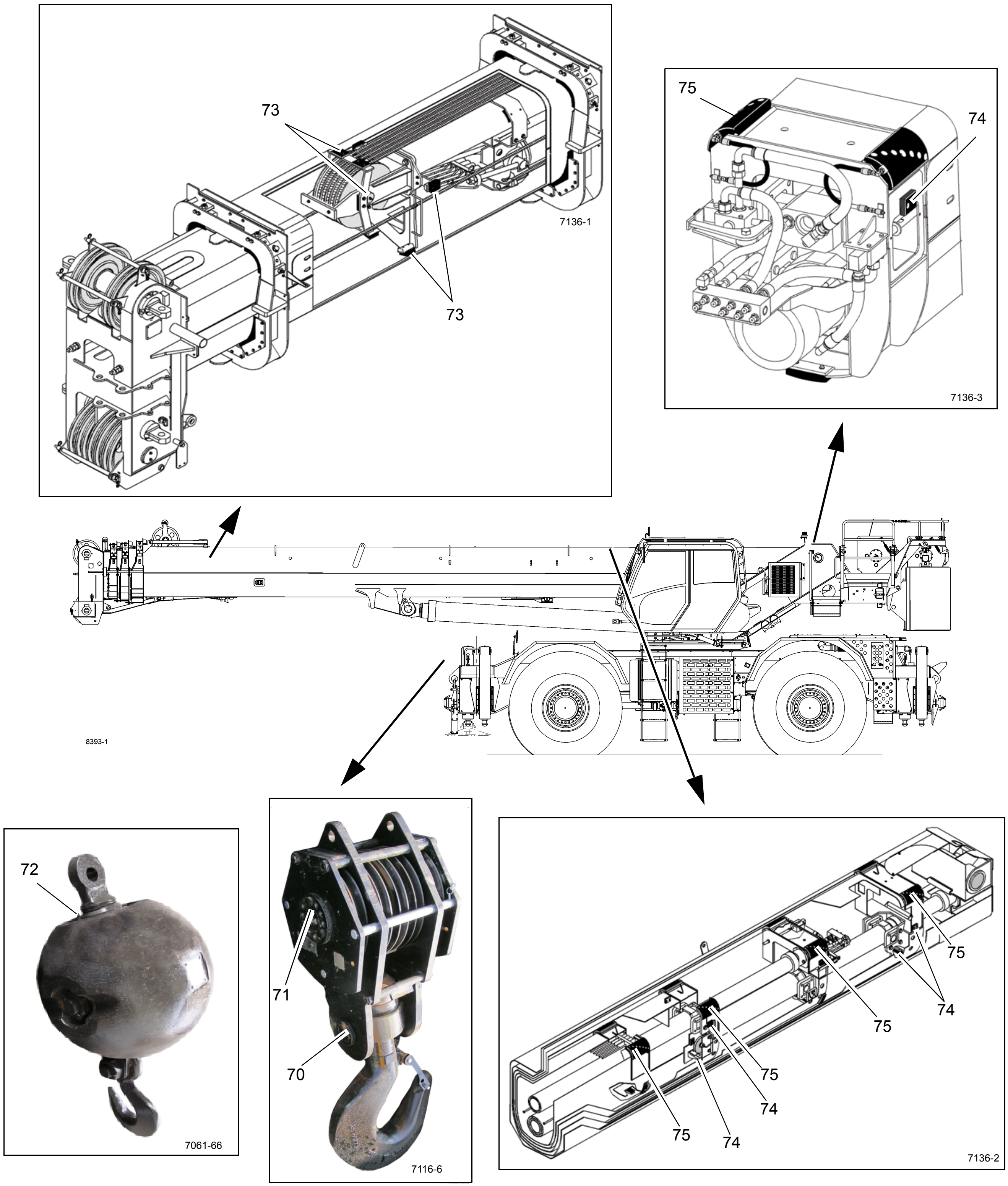
Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom						
70	Hook Block Swivel Bearing	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
71	Hook Block Sheaves	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting per sheave (5 fittings total)
72	Headache Ball	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
73	Telescope Cylinder Wear Pads	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat	Every boom teardown	5 places by brush

NOTE:

- For service of the boom, that is to be extended greater than 120 ft, the counterweight must be installed on the turntable and the outriggers must be fully extended. Superstructure could be in any slew position. No rigging, no hookblock nor overhaul ball may be installed on the nose of the boom. Extend boom to desired length at a boom angle of 20°. Lower boom until RCL limits the boom lower function. Override RCL per RCL operators manual and lower boom to desired angle.
- Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. By adding an extension adapter to a grease gun the wear pads and wear areas can be reached through the lubrication access holes in the side of the boom and through the access hole in the boom nose between the sheaves.
- Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
74	Internal Side and Bottom Wear Pads (Inner Sections)	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease A6-829-003477	Thoroughly coat all areas the wear pad moves on	250 hours or 3 months	14 places by brush; with boom in extended position through access holes in inner-mid and outer-mid sections
75	Boom Section Upper Wear Pads	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease A6-829-003477	Until grease extrudes	50 hours or 1 week	8 grease fittings; with boom in extended position through access holes

- For service of the boom, that is to be extended greater than 120 ft, the counterweight must be installed on the turntable and the outriggers must be fully extended. Superstructure could be in any slew position. No rigging, no hookblock nor overhaul ball may be installed on the nose of the boom. Extend boom to desired length at a boom angle of 20°. Lower boom until RCL limits the boom lower function. Override RCL per RCL operators manual and lower boom to desired angle.
- Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.


73
73
7136-1
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74
7136-3
8393-1
72
7061-66
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7116-6
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75
75
74
75
74
7136-2

FIGURE 9-8

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom (continued)						
76	Boom Section Upper and Lower Wear Pads	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat all areas the wear pad moves on	50 hours or 1 week	12 places by brush; with boom in extended position

NOTE:
- For service of the boom, that is to be extended greater than 120 ft, the counterweight must be installed on the turntable and the outriggers must be fully extended. Superstructure could be in any slew position. No rigging, no hookblock nor overhaul ball may be installed on the nose of the boom. Extend boom to desired length at a boom angle of 20°. Lower boom until RCL limits the boom lower function. Override RCL per RCL operators manual and lower boom to desired angle.
- Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
77	Extend Cable Sheaves	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting

NOTE:
- Access through holes in front of outer mid section at boom length of 128 ft (39 m).
- Access through slotted holes in front of inner-mid section at boom length of 45 to 70.2 ft (13.7 to 21.4 m).
- For service of the boom, that is to be extended greater than 120 ft, the counterweight must be installed on the turntable and the outriggers must be fully extended. Superstructure could be in any slew position. No rigging, no hookblock nor overhaul ball may be installed on the nose of the boom. Extend boom to desired length at a boom angle of 20°. Lower boom until RCL limits the boom lower function. Override RCL per RCL operators manual and lower boom to desired angle

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
78	Retract Cable Sheaves	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings (1) on each side

NOTE:
- Access through slotted holes in front of inner mid section at boom length of 128 ft (39 m).
- For service of the boom, that is to be extended greater than 120 ft, the counterweight must be installed on the turntable and the outriggers must be fully extended. Superstructure could be in any slew position. No rigging, no hookblock nor overhaul ball may be installed on the nose of the boom. Extend boom to desired length at a boom angle of 20°. Lower boom until RCL limits the boom lower function. Override RCL per RCL operators manual and lower boom to desired angle.

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
79	Boom Pivot Shaft	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings (1) on each side
80	Upper Boom Nose Sheave	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings (1) per sheave

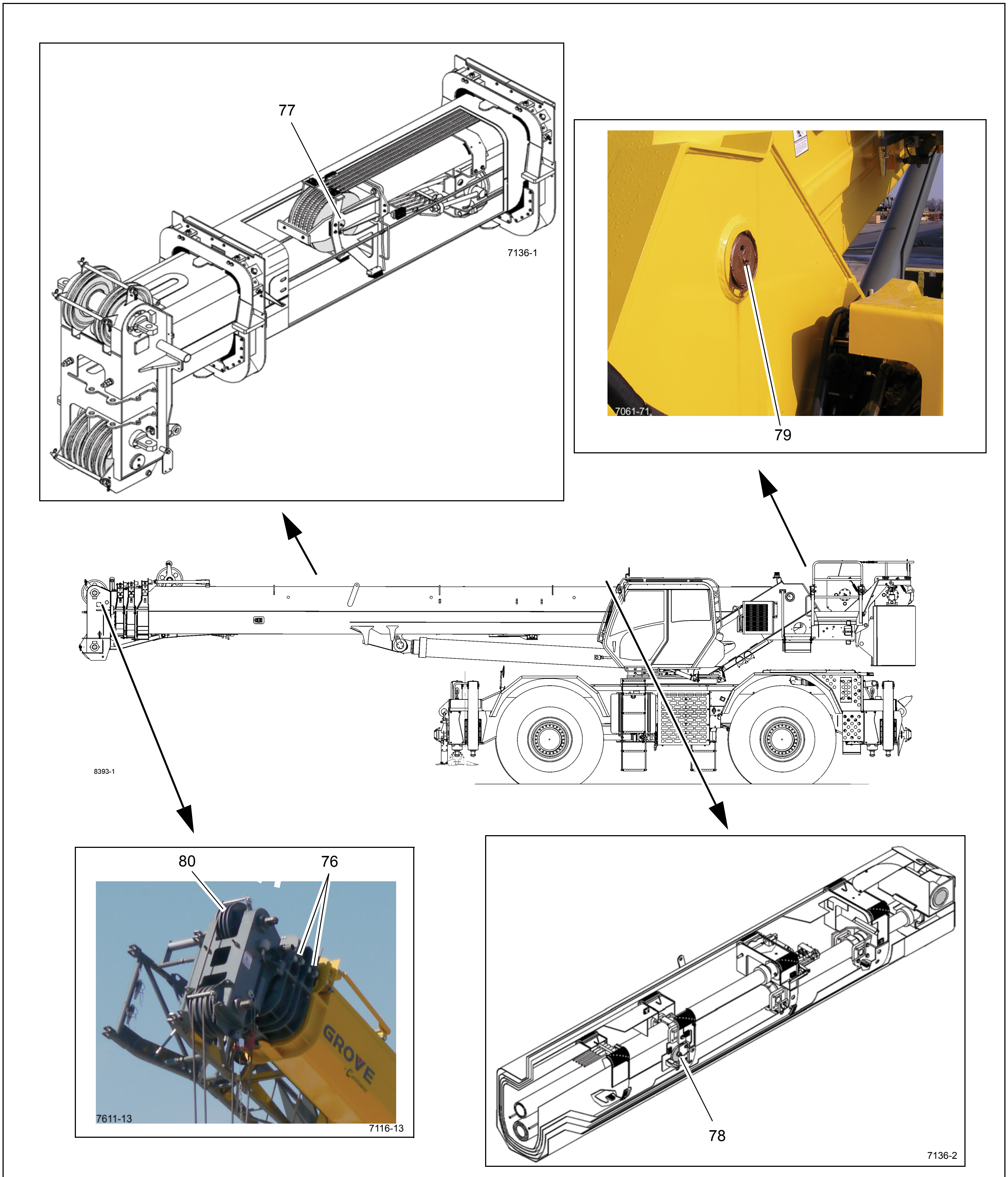


FIGURE 9-9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom (continued)						
81	Lower Boom Nose Sheave	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting per sheave (5 sheaves) total
82	Auxiliary Boom Nose Sheave	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	1 grease fitting
83	Mast Sheave	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	500 hours or 12 months	1 grease fitting
84	Boom Extension Sheaves	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Until grease extrudes	250 hours or 3 months	2 grease fittings

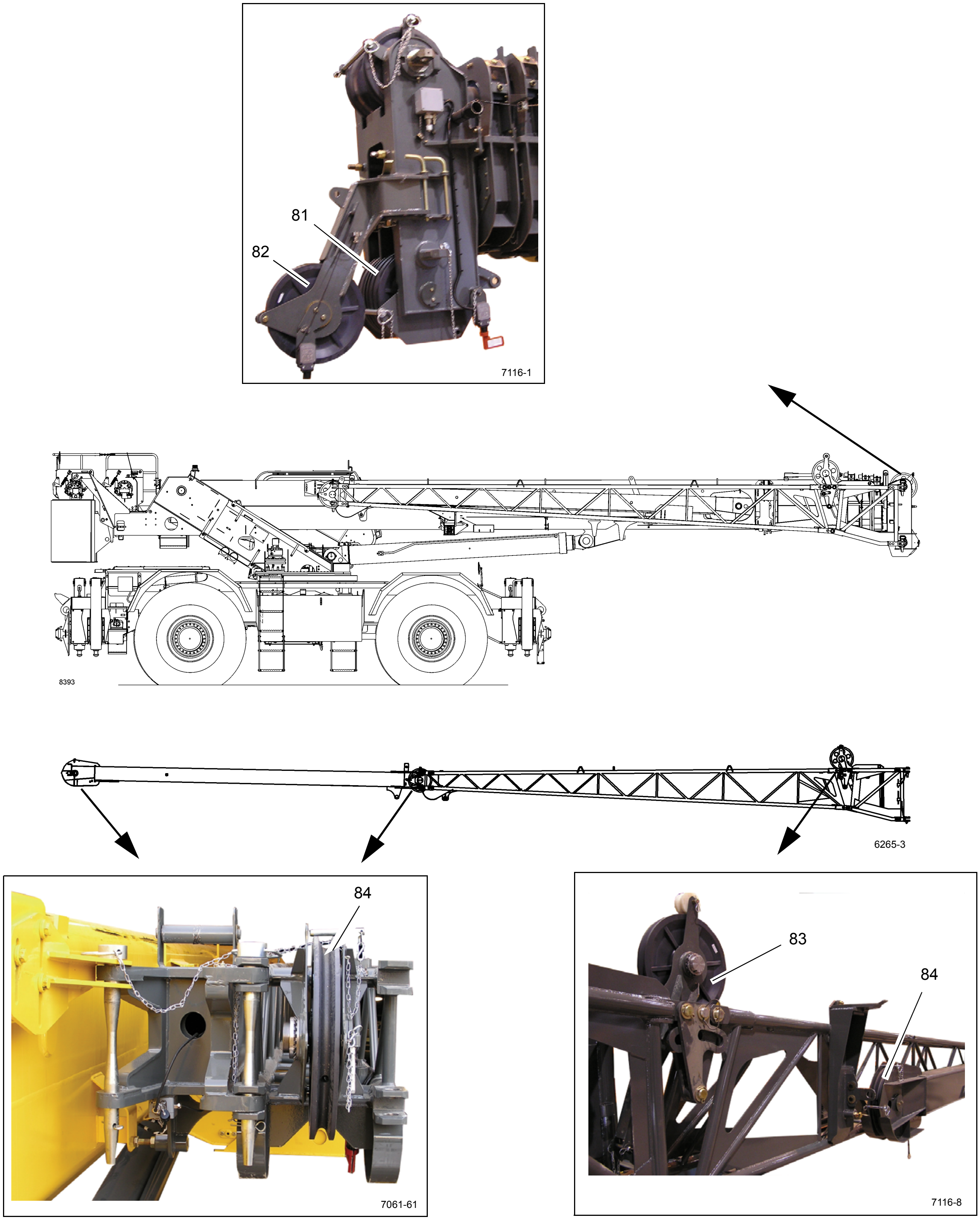
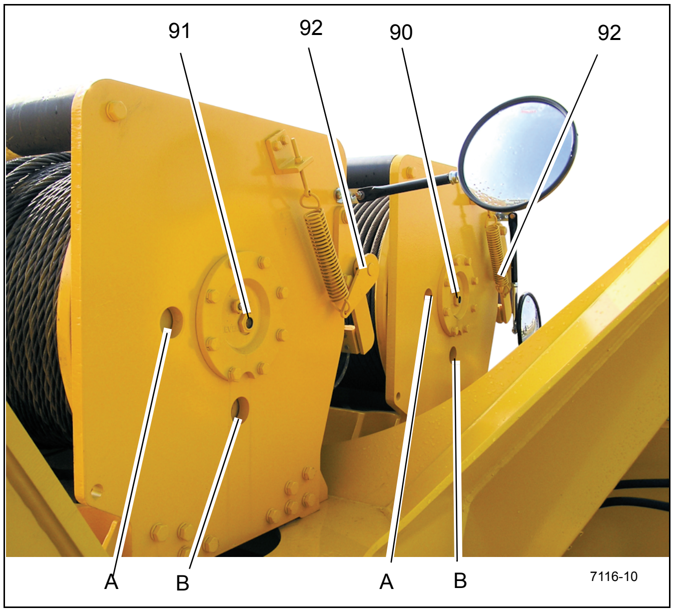


FIGURE 9-10

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Hoist						
90	Main Hoist	Figure 9-11	AGMA Extreme Pressure Gear Lubricant 6829100213	15.5 qt 14.7 l	• Check and fill every 50 hours or weekly • Drain and fill every 1000 hours or 12 months	Oil level must be visible in the sight glass
91	Auxiliary Hoist	Figure 9-11	AGMA Extreme Pressure Gear Lubricant 6829100213	15.5 qt 14.7 l	• Check and fill every 50 hours or weekly • Drain and fill every 1000 hours or 12 months	Oil level must be visible in the sight glass
NOTE: Line up the Fill/Drain Plug with the upper cutout hole (A). Let hoist sit idle for 20 minutes for an accurate reading. If oil level is not visible in sight glass, the hoist may be under filled. Oil escaping from vent plug is an indication the hoist may be over filled. If hoist is over filled move the Fill/Drain Plug to the lower cutout hole (B) and drain until oil level falls within the sight glass.						
92	Cable Follower (Arms)	Figure 9-11	EP-MPG Extreme Pressure Multipurpose Grease 6829003477	Thoroughly coat	250 hours or 3 months	Spray on
NOTE: Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.						

9



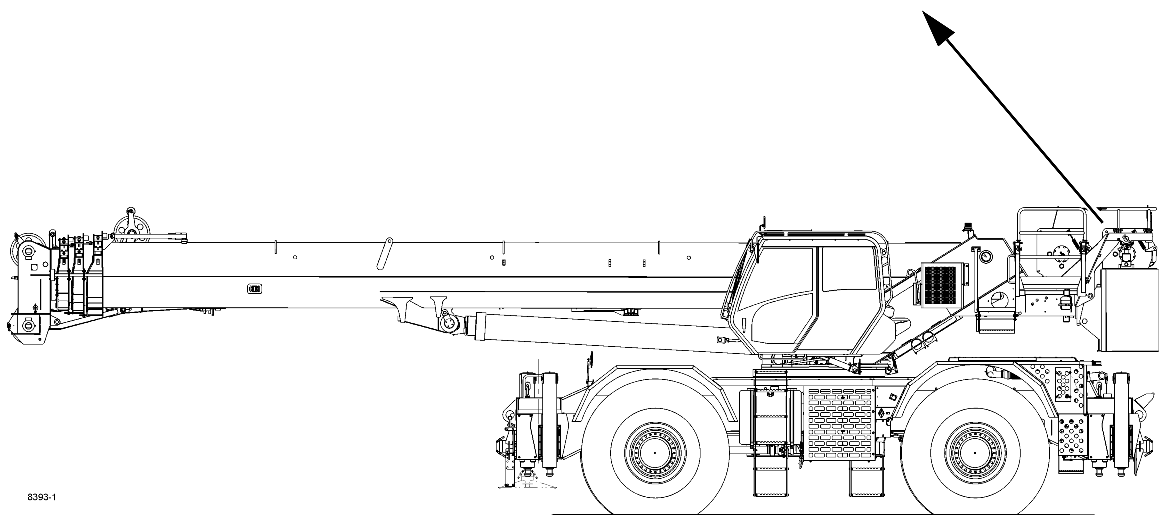


FIGURE 9-11

<table>
<tr><th>Item</th><th>Lube Point Description</th><th>Figure No.</th><th>Approved Lubricant</th><th>Lube Capacity</th><th>Lube Interval</th><th>Application</th></tr>
<tr><td colspan="7">Hydraulic</td></tr>
<tr><td>100</td><td>Hydraulic Tank</td><td>Figure 9-12</td><td>HYDO
Hydraulic Oil
6829006444</td><td>236 gal
894 l</td><td>Check fluid level every 10 hours or daily.</td><td>• Oil visible in sight gauge on side of tank, with boom down and all outrigger cylinders retracted.
• Drain and refill as necessary</td></tr>
<tr><td colspan="7">NOTE:
• 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.
• 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.
• 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.
• The hydraulic oil shall meet or exceed ISO #4406 class 19/17/14 cleanliness level.</td></tr>
<tr><td>101</td><td>Hydraulic Filter</td><td>Figure 9-12</td><td>HYDO
Hydraulic Oil
A6-829-006444</td><td>---</td><td>Change filter when the indicator is red</td><td>---</td></tr>
</table>

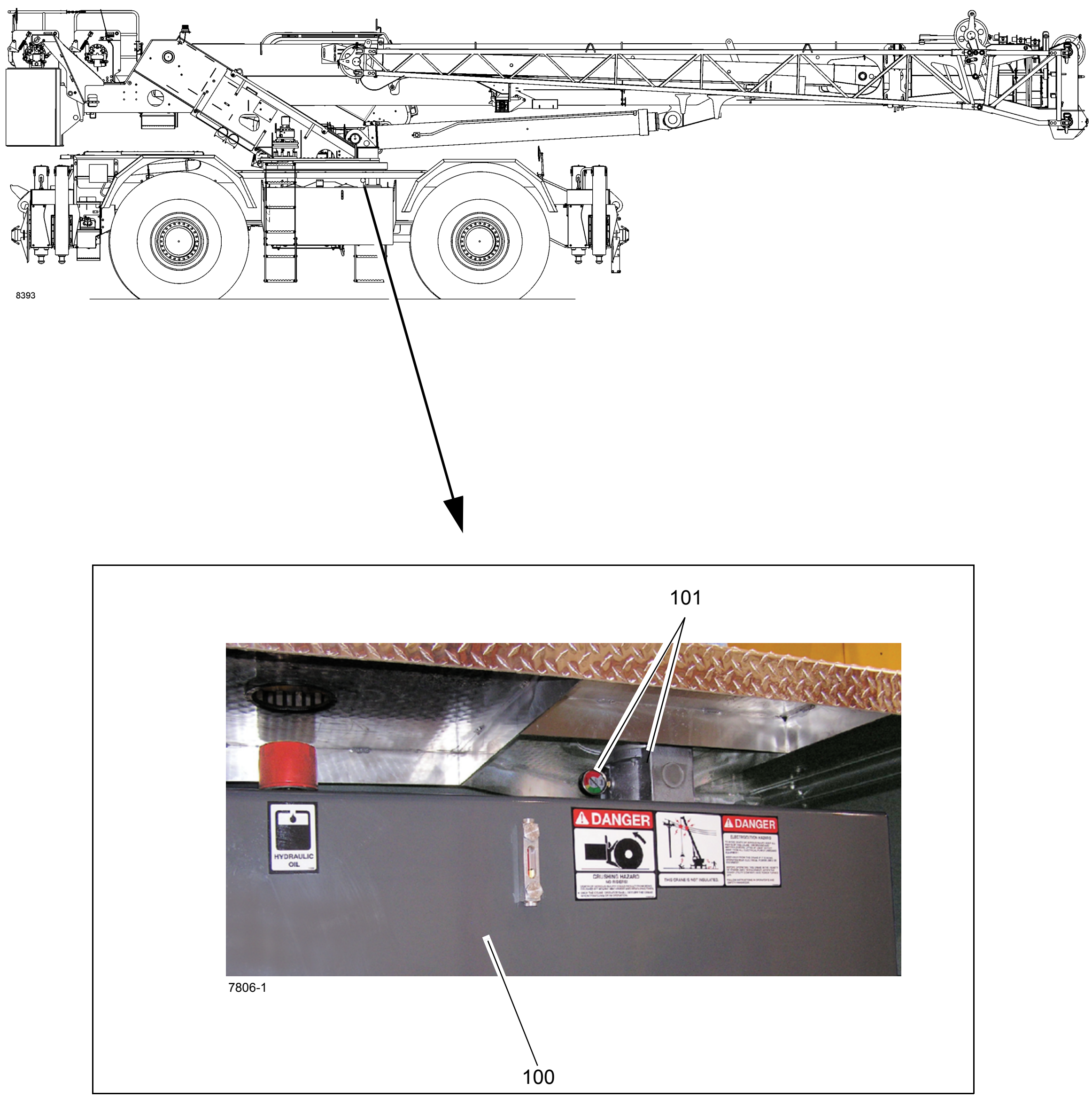


FIGURE 9-12

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Diesel Exhaust Fluid (DEF)						
110	DEF Tank	Figure 9-13	DEF 80019225	5 gal (19 l)	Fill when level is low per indicator.	---

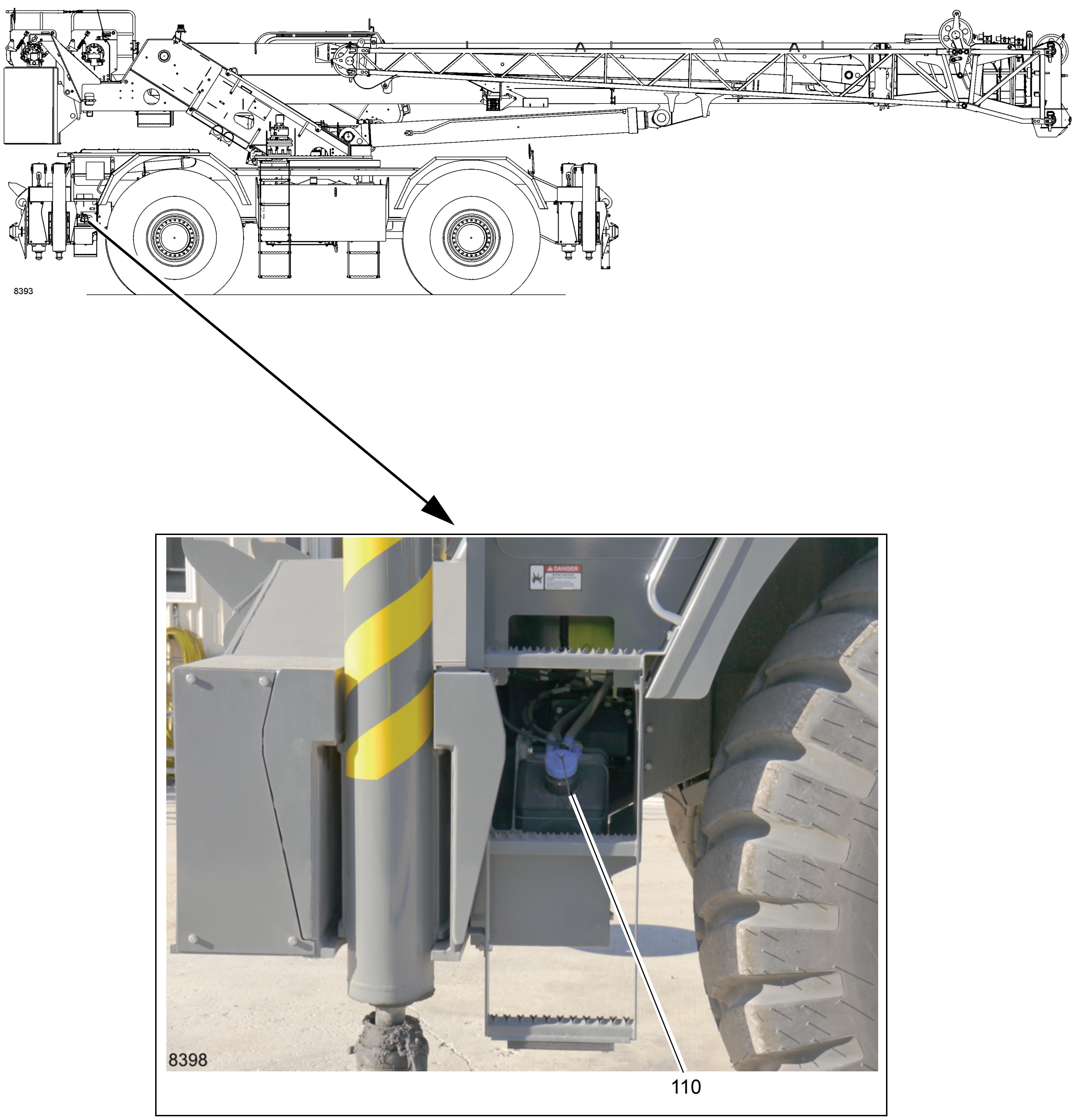


FIGURE 9-13

CARWELL® RUST INHIBITOR

Protecting Cranes From Rusting

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell® T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CRF-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 cleaning may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 9-14 and Figure 9-15.

- 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 9-14

7650-14

Figure 9-15

Item	Description
1	Pivot Shaft
2	Boom Extension Pins, Clips
3	Boom Nose Pins, Clips
4	Boom Extension Hanger Hardware
5	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
6	Hose Connections inside turntable
7	Turntable Bearing Fasteners
8	O/R Hose Connections
9	Hookblock Tiedown Cable
10	O/R Pins, Clips
11	O/R Beam Wear Pad Adjustment Hardware

Item	Description
12	Mirror Mounting Hardware
13	Entire underside of unit
14	Valve Bank
15	Powertrain Hardware Inside Compartment
16	Counterweight Mounting Hardware
17	Hoist Hose Connections
18	Tension Spring
19	Wire Rope
20	Counterweight Cylinder Pins
21	Counterweight Cylinder Hose Connections
22	Hose Connections
23	Hook Block/Headache Ball (Not Shown)

9

ALPHABETICAL INDEX