Grove RT9150E

Service/Maintenance Manual

Grove Manitowoc National Crane Potain

Manitowoc

Grove

SERVICE MANUAL

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

RT9150E

Crane Model Number

Crane Serial Number

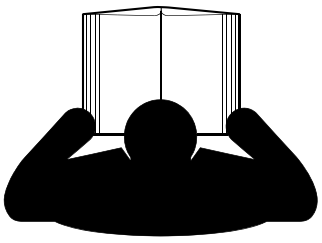
This Manual is Divided into the following Sections:

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

NOTICE

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

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



⚠DANGER

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

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

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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.

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SECTION 1
INTRODUCTION

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GENERAL

This manual provides important information concerning your Grove Crane.

Overview of Manuals

Before servicing the crane, 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 operating procedures and routine operation 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's Manual Section #2* for other safety related issues.

Delivery Report

A Delivery Report must be filled out by the Grove distributor, signed by the purchaser, and returned to Manitowoc Cranes once the crane is sold, leased or rented. This report activates the warranty period, assuring that your claims during the warranty period will be honored and processed expediently. To guarantee full warranty service, make sure your Grove distributor has returned the report to Manitowoc Cranes. An engine warranty form must also be filled out, signed and returned to the engine manufacturer for full warranty coverage.

Customer Support

Manitowoc and our dealer network want to ensure your satisfaction with our products and customer support. Your local dealer 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 dealer's service management to coordinate the contact on your behalf.

New Owners

If you are the new owner of a Grove crane, please register it with Manitowoc Crane Care so we have the ability to contact you if the need arises.

Go to: http://www.manitowoccranes.com/MCG_CARE/Includes/EN/changeofownership.cfm and complete the form.

Safety Information

A Safety CD which includes sections on operation, safety and maintenance for crane operators and owners is supplied when the crane is purchased new. Additional copies are available from your local distributor.

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

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

The superstructure is capable of 360° rotation in either direction. All crane functions are controlled from the fully-enclosed cab mounted on the superstructure.

The crane is equipped with a six-section, pinned boom. Additional reach is obtained by utilizing an optional swingaway boom extension. Lifting is provided by a main and 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

See Figure 1-1 for your crane's serial number location; stamped on left side of front frame (1), on manual holder in superstructure cab (2), and inside the cab in front of the seat on the right side (3).

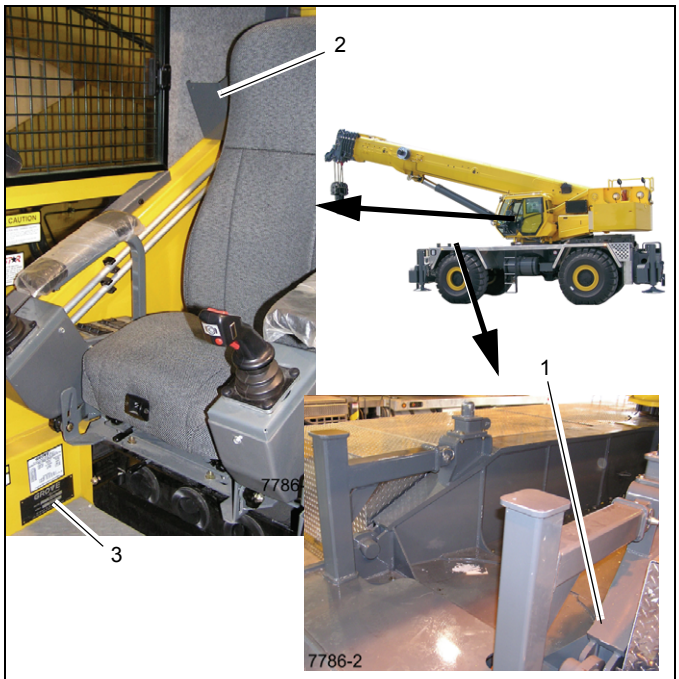


FIGURE 1-1

Transportation and Lifting Data

Transporting and lifting information is located on the hydraulic tank on the right side of the crane. For transportation and lifting data see Table 1-1.

LIST OF SPECIFICATIONS

General

Model . . . . . RT9150E Series
Rated Capacity . . . . . See Load Chart in cab
Drive . . . . . 4 x 4 x 4
Gross Weight . . . . . See Axle Weight Distribution Table

Dimensions

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

Wheelbase . . . . . 16 ft 2.5 in (4.94 m)
Overall Crane Length . . . . . 51 ft (15.545 m)
Overall Crane Width . . . . . 12 ft 5.5 in (3.80 m)
Overall Crane Height . . . 13 ft 8.2 in (4.17 m) (Std)
Tail-Swing . . . . . 15 ft 3.8 in (4.64 m)
Outrigger Spread
- Retracted . . . . . 11 ft 8 in (3.56 m)
- Mid Extend . . . . . 19 ft 9 in (6.02 m)
- Fully Extended . . . . . 27 ft 10 in (8.49 m)

Capacities

Fuel Tank . . . . . 100 gal (378 l)
Coolant System . . . . . See Engine Specifications
Engine Lubrication System . . . . . See Engine Specifications
Hydraulic Tank (Reservoir Capacity)
- Total . . . . . 198 gal (750 l)
- at Full Level . . . . . 173 gal (655 l)
- at Low Level . . . . . 163 gal (617 l)
- Expansion Space . . . . . 25 gal (95 l)

Hoists . . . . . 4.2 qt (4 l)
Swing Gearbox . . . . . 1 qt (0.9 l)
Axle Planetary Hubs . . . . . 7.2 qt (6.8 l)
Axle Differentials . . . . . 65.1 qt (61.6 l)
Transmission (Includes Torque Converter) . . . . . 34 qt (32 l)

Torque Converter

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

Transmission

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

Reverse
- 1st 7.87
- 2nd 2.98
- 3rd 0.95

Engine

Cummins QSC

HP Rating . . . . . 300 hp @ 2200 rpm
Peak Torque . . . . . 1000 pounds @ 1400 rpm
Lube Amount . . . . . 21 qt (19.9 l)
Coolant System . . . . . 36 qt (34.1 l)

Axles

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

Brakes

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

Wheels and Tires

Lugs 24
Torque . . . . . 380 - 400 lb-ft (515 to 542 Nm)
Tire Size
- Standard . . . . . 33.25 x 29-38 ply rating

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

Swing Gearbox

Reduction Ratio 63:1
Output Torque . . . . . 4071 lb-ft

Boom

Length
- Retracted . . . . . 42 ft (12.9 m)
- Extended . . . . . 196.8 ft (60 m)

Power . . . . . 6 Section, Full Power
Elevation . . . . . -3 to +82 degrees
Extensions
- Fixed* . . . . . 36.1 ft (11 m)
- Folding* . . . . . 36.1 or 59.1 ft (11 or 18 m)
- *Extensions are offsettable at 0, 20, or 40 degrees.

Extension Insert . . . . . 26.2 ft (8 m)
Extension Insert . . . . . 19.7 ft (6 m)

Swivel Assembly

Electrical . . . . . 46 Slip Rings
Hydraulic . . . . . 10 ports
Water . . . . . 2 ports
Air Conditioning . . . . . 2 ports

Hydraulic Pumps

NOTE: Pump output figures are theoretical.

Pump #1

Type . . . . . Piston
Sections 1
Output @ 2513 rpm
w/no load . . . . . 64.2 gpm (243 l/min)

Pump #2

Type . . . . . .Piston
Sections 1
Output @ 2513 rpm
w/no load . . . . . .46.7 gpm (176.8 l/min)

Pump #3

Type . . . . . .Gear
Sections 1
Output @ 2513 rpm
w/no load . . . . . 16.9 gpm (64 l/min)

Pump #4

Type . . . . . .Gear
Sections 1
Output @2712 rpm
w/no load . . . . . .18.3 gpm (69.3 l/min)

Hoists

Drum Dimensions
Length. . . . . 22.5 in (569 mm)
Diameter . . . . . .15 in (381 mm)
Cable
Diameter . . . . . 0.75 in (19 mm)
Length-Main . . . . . .837 ft (255 m)
Length-Aux. . . . . .738 ft (225 m)
Max. Permissible Line Pull
. . . . . 15,700 lb (7121 kg)
Max. Single Line Speed . . . .394 fpm (120.1 m/min)
Hoist Motor Displacement
. . . . . 90 cc per revolution
Oil Capacity . . . . . .4.2 qt (4 l)

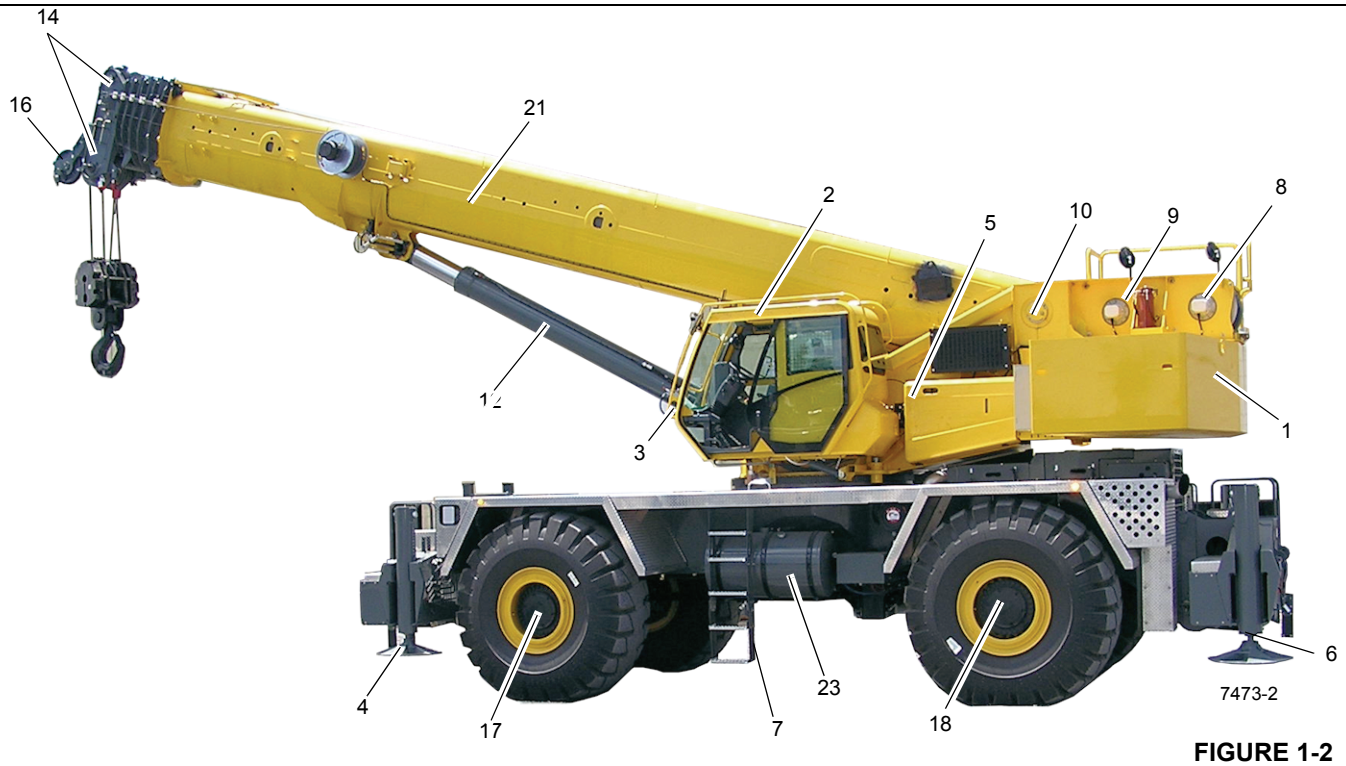


FIGURE 1-2

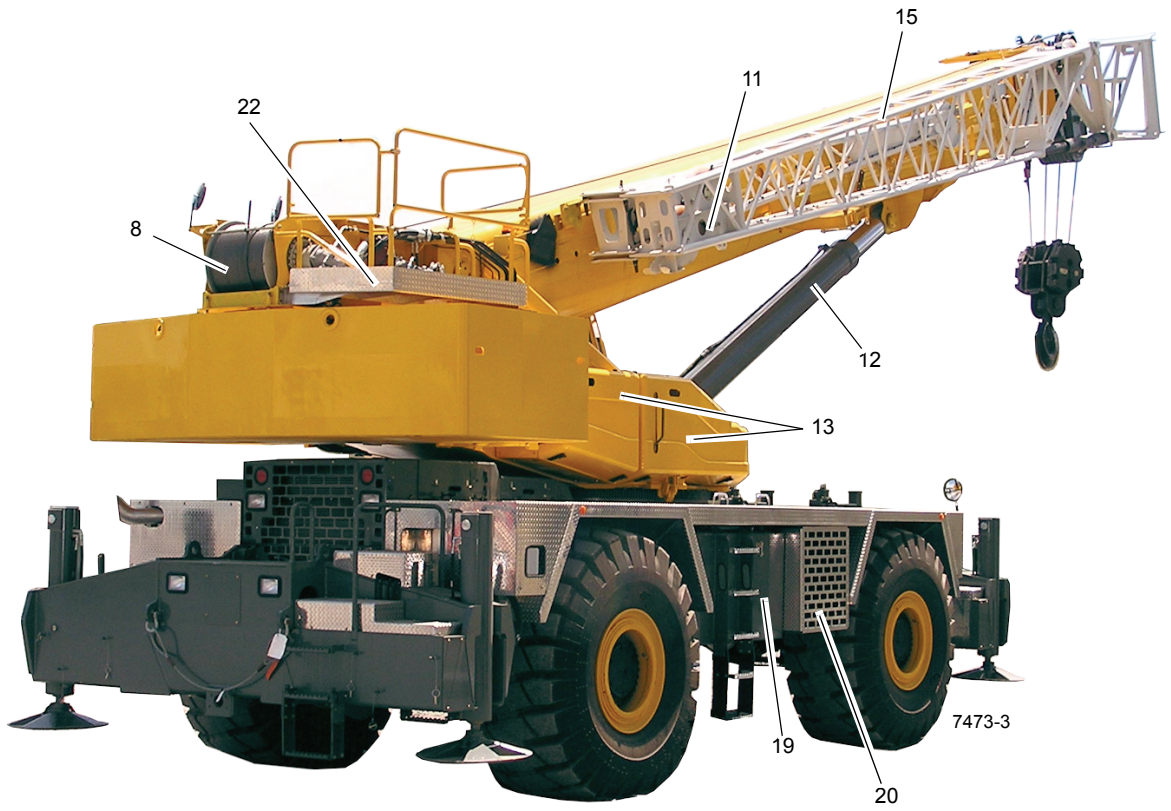


FIGURE 1-2 continued

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

Item	Description
13	Right Hand Valve Covers
14	Boom Nose Sheaves
15	Swingaway
16	Auxiliary Boom Nose
17	Front Axle
18	Rear Axle
19	Hydraulic Tank
20	Hydraulic Fluid Cooler
21	Boom Assembly
22	Hoist Access Platform
23	Fuel Tank

Table 1-1: Axle Weight Distribution Table

Description	CG in (cm)		Weight lb (kg)		Front Axle lb (kg)		Rear Axle lb (kg)	
Maximum Tire Loads Allowed at 15 mph (With no Cwt. Installed)	-		-		90000	40823	90000	40823
Maximum Tire Loads Allowed at 10 mph (With Standard Cwt. Installed)	-		-		98832	44829	98832	44829
Maximum Tire Loads Allowed at 2.5 mph (With Heavy Cwt. Installed)	-		-		130640	59257	130640	59257
Carrier 4x4 with all Fluids	83.13	211.15	52293	23720	22350	10138	29943	13582
Front outrigger box and beam assembly	266.00	675.64	9427	4276	12892	5848	-3465	-1572
Rear outrigger box and beam assembly	-82.00	-208.3	9427	4276	-3974	-1803	13401	6079
Superstructure with cable on both hoists	21.10	53.59	16177	7338	1755	796	14422	6542
Superstructure with cable on main hoist only	26.50	67.31	15300	6940	2085	946	13215	5994
Install Standard Counterweight	-52.17	-132.51	39000	17690	-10461	-4745	49461	22435
Install Heavy Counterweight	-52.17	-132.51	63000	28576	-16898	-7665	79898	36241
Main Boom	239.87	609.27	33438	15167	41238	18705	-7800	-3538
Lift Cylinder at 0º	201.91	512.85	2883	1308	2993	1358	-110	-50
Complete basic machine, including all of the above with the standard counterweight and cable on main hoist only.	80.70	204.98	161767	73376	67119	30445	94648	42932
Add To Basic Unit								
11-18 m (36 to 59 ft.) Bi-fold Boom Ext. (includes brackets on boom)	286.92	728.78	3477	1577	5129	2327	-1652	-749
11-18 m (36 to 59 ft.) Bi-fold Hydraulic Boom Ext. (includes brackets and hydraulic components on boom)	305.46	775.87	4023	1825	6318	2866	-2295	-1041
11-18 m (36 to 59 ft.) Bi-fold Heavy Hydraulic Boom Ext. (includes brackets and hydraulic components on boom)	312.63	794.08	4547	2062	7309	3315	-2762	-1253
Brackets and hydraulic components on boom for hydraulic boom ext.	358.30	910.08	666	302	1227	557	-561	-254
Brackets for manual boom ext.	247.31	628.17	251	114	319	145	-68	-31
10 ton (9.0 mt) Headache Ball (Swivel) attached to outrigger box	310.00	787.40	727	330	1159	526	-432	-196
100 Ton Domestic Hookblock - Stowed in trough	185.00	469.90	2535	1150	2411	1094	124	56
130 Ton Domestic Hookblock - Stowed in trough	185.00	469.90	2530	1148	2406	1092	124	56
90 Metric Tonne CE Hookblock - Stowed in trough	185.00	469.90	2555	1159	2430	1102	125	57
120 Metric Tonne CE Hookblock - Stowed in trough	185.00	469.90	2544	1154	2420	1098	124	56
Auxiliary Boom Nose Installed	513.75	1304.9	133	60	351	159	-218	-99

Description	CG in (cm)		Weight lb (kg)		Front Axle lb (kg)		Rear Axle lb (kg)	
Driver	92.00	233.68	250	113	118	54	132	60
Rear mounted pintle hook	-83.50	-212.09	30	14	-13	-6	43	19
Remove tires for transport	97.25	247.02	-9520	-4318	-4760	-2159	-4760	-2159
Remove main hoist cable	-38.31	-97.31	-884	-401	174	79	-1058	-480
Lift cylinder travel support	221.00	561.34	117	53	133	60	-16	-7
Counterweight stand (pinned to carrier)	247.00	627.38	170	77	216	98	-46	-21

GENERAL MAINTENANCE

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

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

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

Cleanliness

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

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

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

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

After Cleaning

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

CAUTION

Eye Injury Hazard!

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

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

Removal and Installation

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

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

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

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

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

Disassembly and Assembly

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

Pressing Parts

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

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

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

Locking Devices

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

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

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

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

Wires and Cables

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

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

Shims

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

Hoses and Tubes

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic fluid is hot, it can cause severe burns.

Pressurized hydraulic fluid can cause death or serious injury.

Stay clear of all hydraulic fluid 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 hydraulic fluid flow and the operation of the parts being served. Fittings showing signs of movement from their original position have failed and must be replaced.

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

Replace hoses if any of the following is evident (Figure 1-3):

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

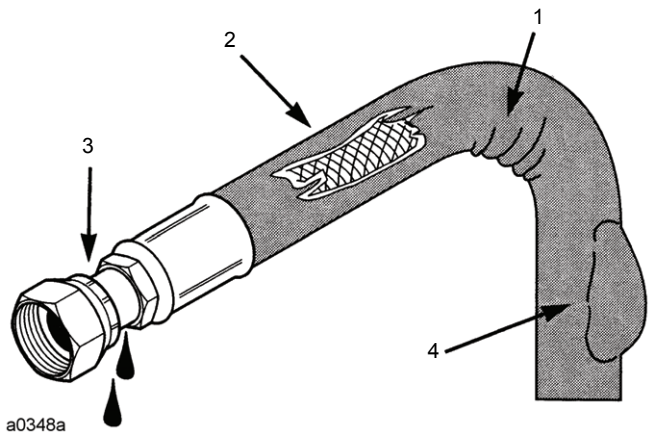


FIGURE 1-3

Installation

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

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

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

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

Sleeve Bearings

Do not install sleeve bearings with a hammer. Use a press and be sure to apply the pressure directly in line with the bore. If it is necessary to drive a bearing into place, use a bearing driver or a bar with a smooth flat end. If a sleeve bearing has an oil hole, align it with the oil hole in the mating part.

Gaskets

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

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

Batteries

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

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

Hydraulic Systems

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic fluid is hot, it can cause severe burns.

Pressurized hydraulic fluid can cause death or serious injury.

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

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

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

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

Visual Inspection of Hoses and Fittings

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

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

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

If any of these conditions exist, address them appropriately.

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

Table 1-2: Climate Zones

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

Hydraulic Fittings

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

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

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

Follow these steps when tightening all fitting connections:

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

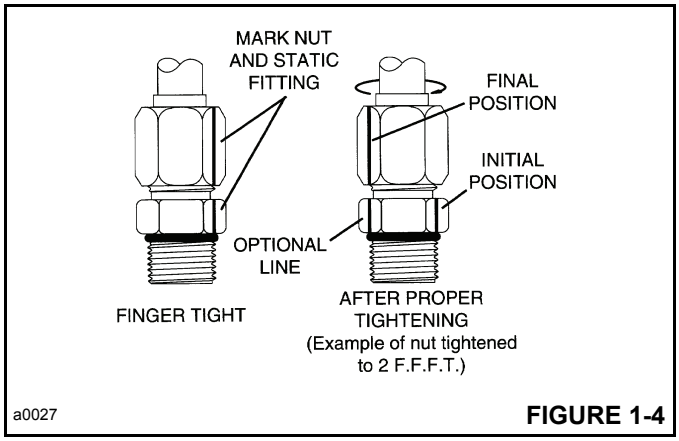


FIGURE 1-4

5. Tighten the joint by the number of flats as specified in Table 1-3 and 1-4 for size and type of fitting.
6. Optionally for future tightening of the same connection: extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-4).

37° Flared Steel Fitting: Tube or Hose to Fitting

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

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

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

T-2-5

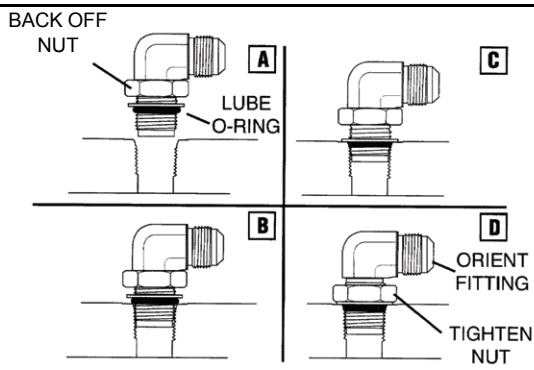
Adjustable Straight Thread O-ring Fittings

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

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

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

T-2-6



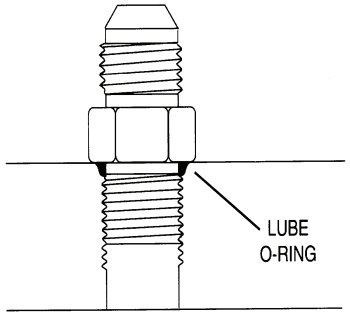
a0030 Adjustable Fitting to Port **FIGURE 1-5**

1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean hydraulic fluid.
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 hydraulic fluid (Figure 1-6).



a0032 Non-Adjustable Fitting to Port **FIGURE 1-6**

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

Table 1-5: Straight Thread Fittings

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

T-2-7

Table 1-6: BSPP (Thread G) Port Assembly fitting Torque Chart

Series	Tube OD	Metric Thread Size	Straight Male Form E with ED Sealing Torque (ft-lbs)	Straight Male O-ring With Retaining Ring Torque (ft-lbs)
S	6	G 1/4A	41	26
S	8	G 1/4A	41	26
S	10	G 3/8A	59	52
S	12	G 3/8A	59	52
S	14	G 1/2A	85	66
S	16	G 1/2A	85	66
S	20	G 3/4A	133	133
S	25	G 1A	229	229
S	30	G 1 1/4A	332	332
S	38	G 1 1/2A	398	398

Electrical System

Harnesses, Wires, and Connectors

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

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

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

The climate in which the crane operates affects the service life of the electrical components. The climate zones are defined in (Table 1-2). Recommended replacement of harness and cables is as follows:

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

Fatigue of Welded Structures

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

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

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

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

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

Loctite

⚠ CAUTION

Skin and/or Eye Hazard!

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

Always follow the directions on the Loctite container, as not all Loctite types are suitable for all applications.Various types of Loctite are specified throughout the Service Manual. The following types of Loctite brand adhesives are available from the Parts Department of the local Manitowoc distributor.

Application of Medium Strength Loctite

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

The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant (Loctite #242) and primer (Locquic Primer T7471).

Primer Application

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

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

Adhesive/Sealant Application

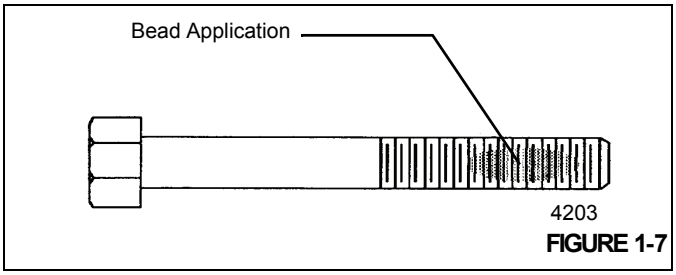


FIGURE 1-7

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

Fasteners and Torque Values

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

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

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

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

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

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

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

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

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

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

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

Torque Wrenches

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

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

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

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

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

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

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

Torque Values

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

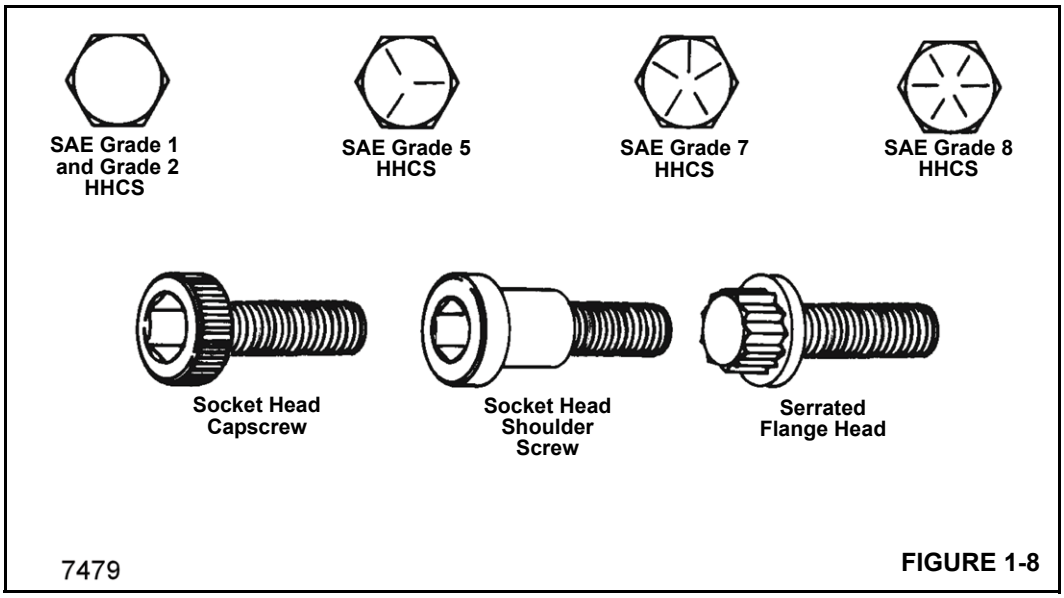


FIGURE 1-8

Table 1-7: UNC (Course) 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 1-8: 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 1-9: Metric Fasteners, Coarse Thread, Zinc-Flake Coating

	Bolt Diameter - Metric															
	Torque Values (Nm)															
Grade	**M4 0.157**	**M5 0.197**	**M6 0.236**	**M8 0.315**	**M10 0.394**	**M12 0.472**	**M14 0.551**	**M16 0.630**	**M18 0.709**	**M20 0.787**	**M22 0.866**	**M24 0.945**	**M27 1.06**	**M30 1.18**	**M33 1.18**	**M36 1.18**
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 1-10: Metric Fasteners, Coarse Thread, Untreated

	Bolt Diameter - Metric														
	Torque Values (Nm, Maximum/Minimum)														
Grade	**M4 0.157**	**M5 0.197**	**M6 0.236**	**M7 0.276**	**M8 0.315**	**M10 0.394**	**M12 0.472**	**M14 0.551**	**M16 0.630**	**M18 0.709**	**M20 0.787**	**M22 0.866**	**M24 0.945**	**M27 1.06**	**M30 1.18**
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 1-11: Metric Fasteners, Fine Thread, Zinc-Flake Coating

	Bolt Diameter - Metric													
	Torque Values (Nm)													
Grade	**M8x1 0.157**	**M10x1 0.197**	**M10x1.25 0.236**	**M12x1.5 0.315**	**M14x1.5 0.394**	**M16x1.5 0.472**	**M18x1.5 0.551**	**M20x1.5 0.630**	**M22x1.5 0.709**	**M24x2 0.787**	**M27x2 0.866**	**M30x2 0.945**	**M33x2 1.06**	**M36x3 1.18**
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 1-12: Metric Fasteners, Fine Thread, Untreated

	Bolt Diameter - Metric													
	Torque Values (Nm, Maximum/Minimum)													
Grade	**M8x1 0.157**	**M10x1 0.197**	**M10x1.25 0.236**	**M12x1.5 0.315**	**M14x1.5 0.394**	**M16x1.5 0.472**	**M18x1.5 0.551**	**M20x1.5 0.630**	**M22x1.5 0.709**	**M24x2 0.787**	**M27x2 0.866**	**M30x2 0.945**	**M33x2 1.06**	**M36x3 1.18**
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 1-13: UNC (Course) 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 1-14: Metric Course 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 1-15: Weld Stud Torque Values

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

T-2-4

WIRE ROPE

General

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

Environmental Conditions

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

Dynamic Shock Loads

Subjecting wire rope to abnormal loads beyond the endurance limit will shorten the wire 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 rope.
- It should be of a viscosity capable of penetrating the interstices between wires and strands.
- It should not be soluble in the medium surrounding it under the actual operating conditions (i.e. water).
- It should have a high film strength.
- It should resist oxidation.

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

Precautions and Recommendations During Inspection or Replacement

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

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

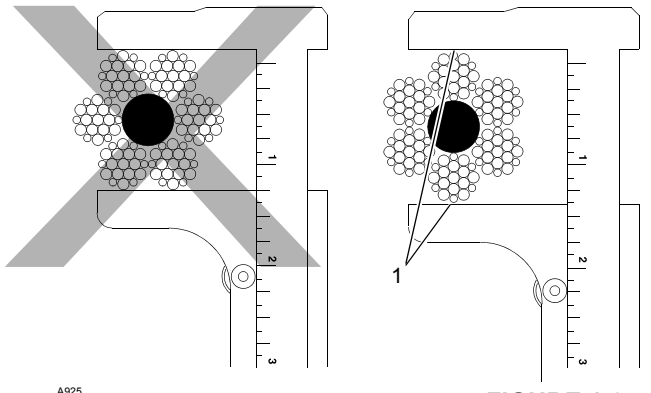


FIGURE 1-9

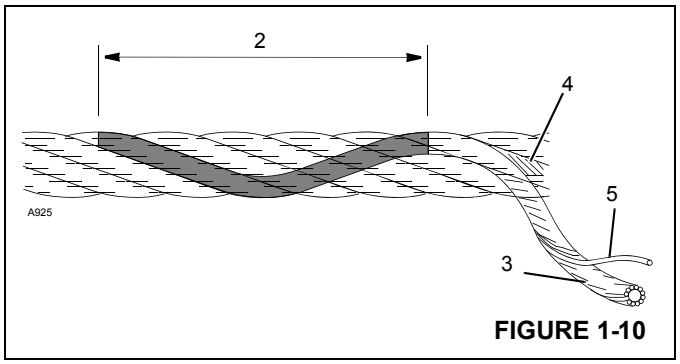


FIGURE 1-10

Wire Rope Inspection (Running Ropes and Pendant Cables)

Wire rope should be inspected frequently/daily and periodically/yearly in accordance with the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies. Recommended inspection intervals may vary from machine to machine and may vary based on environmental conditions, frequency of lifts, and exposure to shock loads. The inspection time intervals may also be predetermined by state and local regulatory agencies.

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

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

Keeping Records

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

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

Frequent Inspection

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

- Distortion, kinking, crushing, un-stranding, birdcaging, reduction of diameter, etc.

- General corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- End fitting wear/abrasion.

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

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

Periodic Inspection

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

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

Wire Rope Inspection/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:

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- Wear of one-third the original diameter of outside individual wires. Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than:
  - 1/64 inch for diameters up to and including 5/16 inch.
  - 1/32 inch for diameters 3/8 and 1/2 inch inclusive.
  - 3/64 inch for diameters 9/16 to 3/4 inch inclusive.
  - 1/16 inch for diameters 7/8 to 1 1/8 inches inclusive.
  - 3/32 inch for diameters 1/14 to 1 1/2 inches inclusive.
- 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 1-11), place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

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

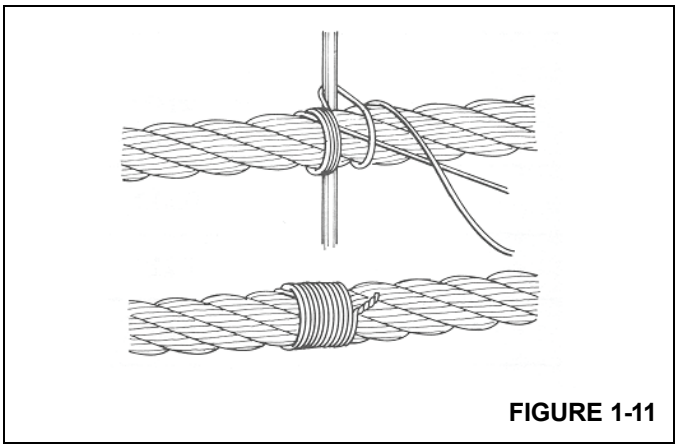


FIGURE 1-11

Method 2

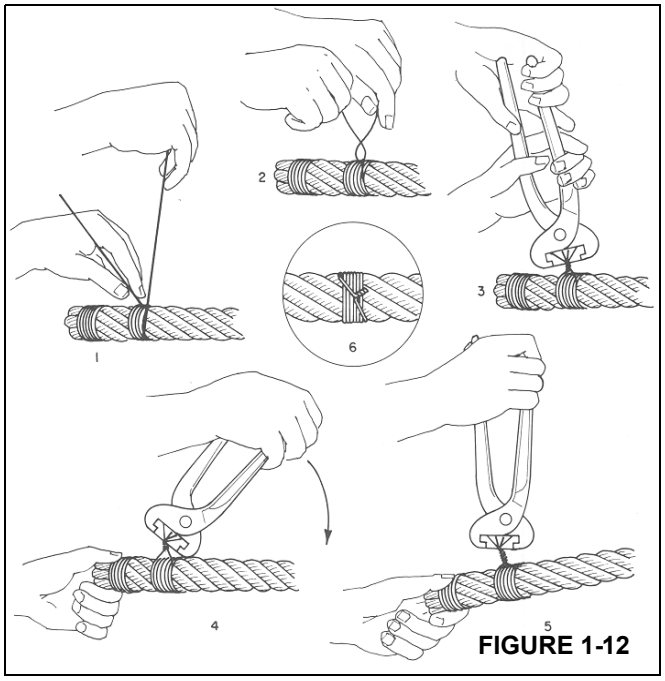


FIGURE 1-12

Wind a length of soft annealed wire (Figure 1-12) around the wire rope at least seven times. The two ends should be twisted together in the center of the seizing. Tighten the seizing by alternately prying and twisting. Cut off both ends of the wire and pound the twist flat against the rope.

NOTE: Non-preformed wire rope (1) (Figure 1-13) should have three seizings (3) located on each side of the cut (4) as compared to preformed wire rope (2).

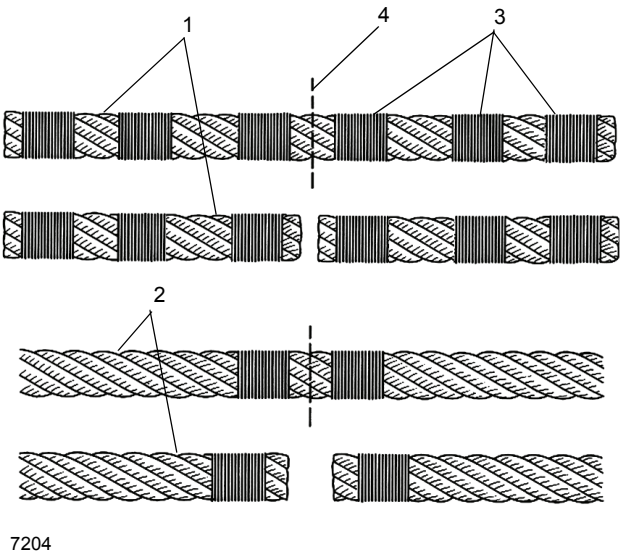


FIGURE 1-13

Installing Low Rotation Class Wire Rope

CAUTION

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

1. Unload properly and relieve any twists. Pull the rope off the shipping reel or unroll it from a shipping coil. (If done improperly, you may kink the rope, which will result in permanent damage to the rope.) Then, lay the rope on the ground in direct line with the boom. This helps release any twist in the rope.
2. Pull the rope over the point sheave and attach the end to the hoist drum. Be sure not to remove the welded end.
3. Wind rope onto drum slowly and carefully. At this point, it isn't necessary to provide additional load other than the weight of the rope being pulled across the ground.
4. Spool first layer tightly. It is essential on smooth-faced drums that the first layer is spooled with wraps tight and close together since the first layer forms the foundation for succeeding layers. If need be, use a rubber, lead or brass mallet (but never a steel hammer) to tap the rope into place.

5. Spool multiple layers with sufficient tension. It's very important to apply a tensioning load to the ropes during the rope breaking-in process. (If not, the lower layers may be loose enough that the upper layers become wedged into the lower layers under load, which can seriously damage the rope.) The tensioning load should range from 1 to 2% of the rope's minimum breaking force.
6. For ropes in multi-part systems: Reeve the traveling block and boom tip sheaves so the rope spacing is maximized and the traveling (hook) block hangs straight and level to help assure block stability.
7. Breaking in new Low Rotation Class Wire Rope—After installation, properly break in the rope, which allows the rope's component parts to adjust themselves to the operating conditions:

   With the boom fully raised and fully extended, attach a light load at the hook and raise it a few inches off the ground. Allow to stand for several minutes. Then cycle the load between the full "up" and "down" positions several times. Observe the drum winding and rope travel for any potential problems.

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

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

Procedures for Cutting and Preparing Low Rotation Class Wire Rope

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

1. The welded ends prepared by the manufacturer are not to be removed.
2. Before cutting the rope, make three separate bands with seizing strand on each side of where the cut is to be made (total of six bands for each cut). Each band is to have a minimum length of one and one half times the rope diameter. The two bands closest to the cut should be located at a distance equal to one rope diameter away from the cut. The four remaining bands should be evenly spaced at a distance equal to three rope diameters.

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

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.

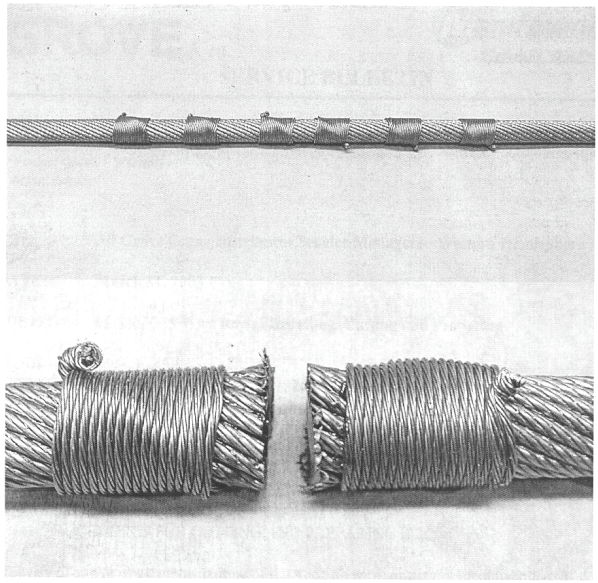


FIGURE 1-14

SECTION 2
HYDRAULIC SYSTEM

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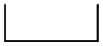
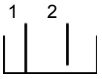
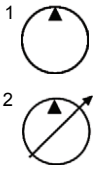
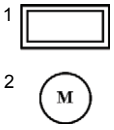
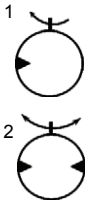
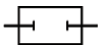
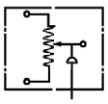
DESCRIPTION

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

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

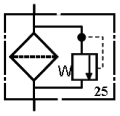
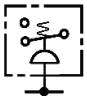
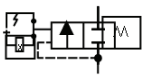
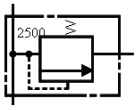
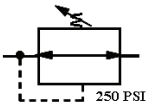
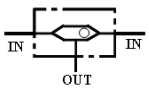
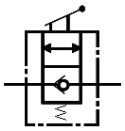
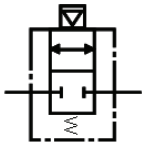
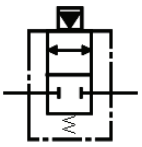
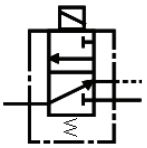
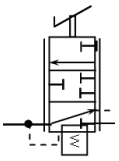
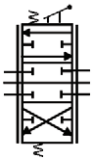
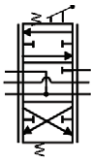
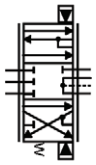
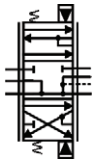
Description	Symbol
Filter - Removes contamination from hydraulic fluid.	
Filter with Bypass Valve - Bypass valve allows hydraulic fluid to bypass the filter if the filter becomes clogged.	
Accumulator - Used to either develop flow or absorb shock.	
Check Valve - Creates back pressure.	
Orifice - In-line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

FIGURE 2-1

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

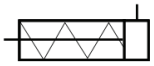
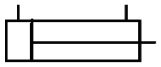
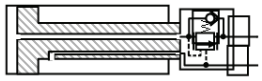
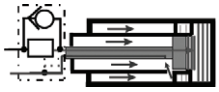
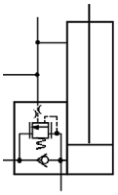
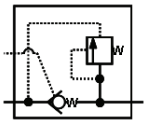
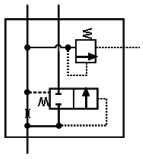
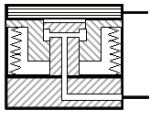
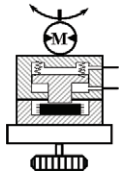
Description	Symbol
Single Acting Cylinder - Extended hydraulically and retracted with a spring.	
Double Acting Cylinder - Extended and retracted hydraulically.	
Double Acting Telescope Cylinder - Anchored rod pushes barrel out when check valve is unseated. 	
MultiStage Telescope Cylinder - Used in multi-section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

FIGURE 2-2

MAINTENANCE

Preparation

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

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

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

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

Hydraulic System Maintenance Precautions

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

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

Disassemble and reassemble hydraulic components on a clean surface.

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

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

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

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

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

Label Parts when Disassembling

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

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

Hydraulic Fluid Recommendations

For the hydraulic fluid specifications, refer to *Lubrication, pg 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.

NOTE: Improperly disposing of waste can threaten the environment.

Handle and dispose of waste according to local, state, and federal environmental regulations.

When filling and draining crane components: 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 wipe up any spills.

1. Remove the reservoir drain plug. Allow about three minutes after hydraulic fluid 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 fluid.
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 fluid.

CAUTION

Hydraulic fluid 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 fluid 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 fluid level as necessary.
9. Repeat Steps 7 and 8 for the remaining outriggers.

DANGER

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

10. Disconnect the return lines from a pair of outrigger stabilizer cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger stabilizer cylinders to the stowed position. Replenish the reservoir hydraulic fluid 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 fluid 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 fluid 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 fluid level as necessary.
24. Disconnect the return line from the main hoist motor and fully hoist up the wire rope.
25. Connect the return line to the main hoist motor and hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic fluid level as necessary.
26. Repeat Steps 24 and 25 for the auxiliary hoist as necessary.
27. Disconnect one of the lines from each of the swing motors and drive the motors in the direction they will go.
28. Connect the lines to the swing motors, then drive the swing motors in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic fluid level as necessary.

DANGER

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

When hydraulic fluids are changed, recheck the reservoir hydraulic fluid level after brief system operation and add hydraulic fluid as required. Reservoir total capacity is 198.27 gal (752.2 l) or 172.92 gal (654.5 l) full level. Low level is 162.90 gal (616.6 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 fluid as required.

Removing Air from the Hydraulic System

Air entering the hydraulic fluid will normally be removed automatically by passage of the hydraulic fluid 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 fluid, it may be

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

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

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

DANGER

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

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

DANGER

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

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

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

Parts Replacement

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

Directional Control Valves

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

Inspection

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

Valve Leakage

Dripping hydraulic fluid 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 fluid). Scored or severely worn valve components must be replaced.

Check valves in the control valves are designed to permit a flow of hydraulic fluid 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 fluid. 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 fluid, or warped mountings. When scorched, deteriorated hydraulic fluid or contamination is the cause, flushing the system and replenishing with clean hydraulic fluid 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 hydraulic hoses are depressurized before loosening the connections.

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

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

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

If any of these conditions exist, address them appropriately.

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

therefore, it is recommended these hoses be inspected and addressed accordingly.

Table 2-1

Zone	Classification
A	Tropical Moist: All months average above 18°C. Latitude: 15° - 25 ° North & South
B	Dry or Arid: deficient precipitation most of the year. Latitude: 20° - 35° North & South
C	Most 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 and South

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

The supply pressure and return circuit is made up of several circuits which route hydraulic fluid from the four hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, four hydraulic pumps, a hydraulic fluid cooler, and a ten port hydraulic swivel. Refer to Hydraulic Pumps in this section for descriptions and maintenance instructions for each hydraulic pump. Refer to *Swivels, pg 6-15* for description and maintenance instructions for the ten port hydraulic swivel.

The supply pressure and return circuit uses Ports 2 and 3 for pump supply and the dual Port 1 for return. Each operating circuit's description and components begin with the circuit's directional control valve.

Hydraulic Reservoir and Filter

The reservoir (Figure 2-3), attached to the right side of the carrier frame, has a total capacity of 198.27 gal (752.2 l) or 172.92 gal (654.5 l) full level. Low level is 162.90 gal (616.6 l). The all-steel reservoir has an internally mounted full-flow filter and integral baffles that help cool the hydraulic fluid and prevent hydraulic fluid foaming.

Hydraulic fluid flows through four tubes at the lower rear of the reservoir to the four hydraulic pumps. Almost all of the return flow goes through the filter at the top of the reservoir. The return line that goes directly into the reservoir (instead of through the filter) is from the No. 4 port (drain) of the 10-port swivel.

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

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

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

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

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

A gauge on the filter head indicates how restricted (clogged) the filter element is. When back pressure caused by a dirty filter element exceeds 25 psi (172 kPa), the filter assembly's bypass feature functions to allow hydraulic fluid to bypass the filter element and flow into the reservoir through the bypass valve instead. (Filter changing instructions are in *Air Intake and Exhaust System, pg 7-10*.)

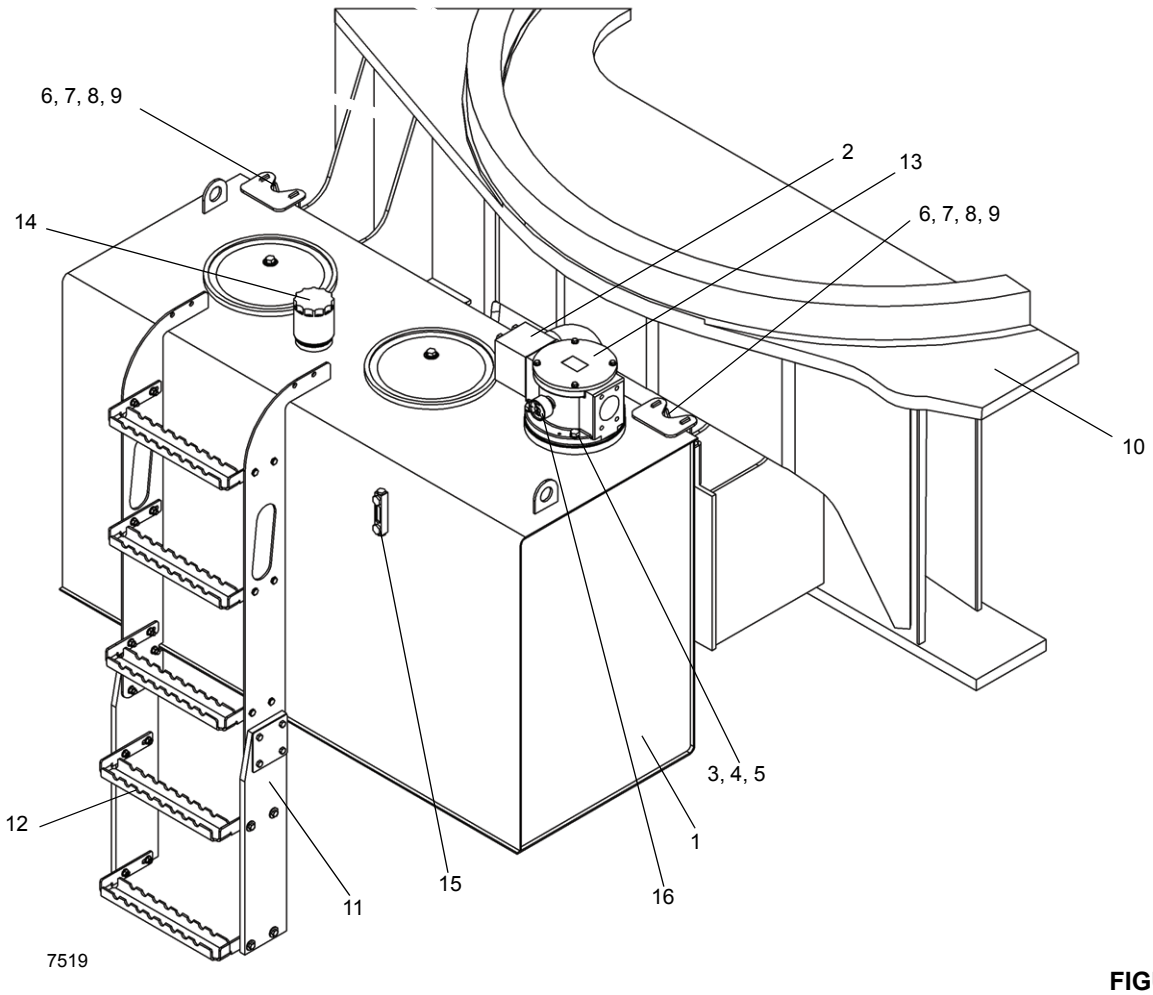


FIGURE 2-3

Item	Description
1	Reservoir
2	Return Manifold Tube Assembly
3	O-ring
4	Capscrew
5	Lockwasher
6	Capscrew
7	Lockwasher
8	Nut
9	Flatwasher
10	Frame
11	Extension

Item	Description
12	Steps
13	Return Filter
14	Breather
15	Oil Level Gauge
16	Oil Bypass Indicator Gauge

Pump Distribution

Pump No. 1

The torque converter drives Pump No. 1.

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

Pump No. 1 also supplies the counterweight removal, counterweight removal pin, boom removal pin, and cab tilt functions, and when installed, the luffing jib function.

Pump No. 2

The torque converter drives pump No. 2.

Hydraulic pump No. 2 supplies the integrated outrigger/ rear steer valve, the pressure reducing sequence valve and the steer/brake/load sense accessory manifold.

Pump No. 3

The torque converter drives Pump No. 3.

Pump No. 3 supplies the swing directional control valve.

Pump No. 4

The engine drives Pump No. 4.

Pump No. 4 priority port supplies flow to drive the oil cooler motor. Pump No. 4 secondary port returns oil to the reservoir.

MAINTENANCE

Troubleshooting

Table 2-2

Symptom	Probable Cause	Solution
1. No hydraulic fluid flows in systems.	**a.** Low hydraulic fluid level.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Reservoir-to-pump suction lines broken or restricted. Air entering at suction lines. Pump not priming.	**b.** Clean, repair, or replace lines as necessary. Check lines for security, absence of cracks, and proper attachment. Tighten, repair, or replace parts as necessary.
	c. Internal contamination.	**c.** Drain, flush with recommended oil mixture, then drain and refill system with recommended hydraulic fluid.
2. Slow response.	**a.** Low hydraulic fluid level.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Hydraulic fluid 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.	**c.** Repair or replace pump.
3. Pump noise accompanied by hydraulic fluid foaming in reservoir.	**a.** Low hydraulic fluid level.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Excessive engine speed.	**b.** Regulate engine speed.
	c. Air entering at suction lines.	**c.** Check all lines for security and proper repair. Tighten, repair, or replace as needed.
4. Excessive pressure buildup.	**a.** System relief valve(s) set too high.	**a.** Using adequate pressure gauge, adjust system relief valve(s) as necessary.
	b. Restricted pump-to-control valve supply line.	**b.** Clean, repair, or replace line as necessary.

Symptom	Probable Cause	Solution
5. Specific hydraulic system (lift, hoist, telescope, swing) not working.	**a.** Leak in system.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Faulty hydraulic remote control valve.	**b.** Adjust or replace valve.
	c. Faulty directional control valve.	**c.** Replace valve.
	d. Poorly adjusted control in circuit.	**d.** Troubleshoot circuit with schematic. Adjust hydraulic component per schematic.
	e. Faulty hydraulic cylinder, motor, or valve.	**e.** Replace faulty component.

Troubleshooting Aids

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

Troubleshooting Procedures

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

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

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

Remember:

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

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

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

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

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

Filter Maintenance

Maintenance Interval

Change filter when the bypass indicator gauge on the filter head is in the 'red'.

Under normal operating conditions, it is recommended that hydraulic filters be inspected and oils sampled at least every 3 to 6 months, or 500 hours, and more frequently for severe operating conditions, refer to *Lubrication, pg 9-1*.

Filter Element Removal

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.

1. Shut down all hydraulic systems.
2. Wipe any dirt from the filter head and cap (Figure 2-4).
3. Remove the capscrews and lockwashers and disconnect the return manifold tube from the filter. Discard O-ring.
4. Remove the bolts and washers and remove the filter assembly from the reservoir. Discard the gasket. If necessary, the filter can be disassembled without removing the entire filter from the reservoir.
5. Remove the capscrews securing the cap to the filter head. Remove the cap and spring. Take care when removing the spring as it may be under pressure. Discard O-ring.
6. Unscrew the filter gauge from the filter head.
7. Remove the filter head and discard the O-ring.
8. Remove the bypass valve from the filter tube on the filter bowl.
9. Remove the filter element.
10. Ensure the new filter element is correct by comparing their part numbers with the part numbers of the used filter element.
11. Discard the used filter element.
12. If not done earlier, unbolt the filter bowl from the reservoir. Remove the filter bowl. Discard gasket.

Filter Element Installation

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

Fill Cap Breather

Removal and Replacement

CAUTION

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

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

1. Wipe any dirt from the fill cap breather (Figure 2-3).
2. Unscrew the fill cap breather from the fill neck.
3. Screw the replacement fill cap breather into the fill neck.

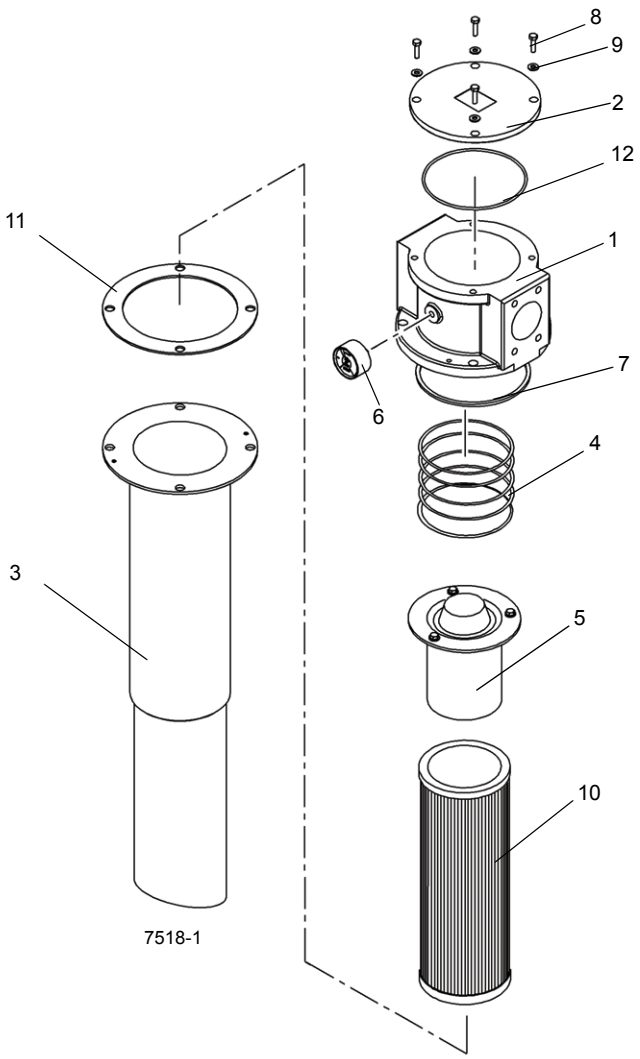


FIGURE 2-4

Item	Description
1	Head
2	Cap Assembly
3	Bowl Assembly
4	Spring
5	Bypass Valve Assembly
6	Gauge

Item	Description
7	O-ring
8	Capscrew
9	Washer
10	Element
11	Cap
12	O-ring

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.

Hydraulic Reservoir Removal

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

Hydraulic Reservoir Installation

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

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.

OIL COOLER

Description

An air cooled hydraulic fluid cooler is the right rear portion of the hydraulic/transmission oil cooler (Figure 2-5). The oil cooler is installed on the right side of the carrier beside the hydraulic reservoir.

When the oil temperature reaches 120°F (48.9°C), the oil cooler solenoid valve is de-energized, via a normally closed temperature switch, to allow pressurized oil from pump No. 4 to the oil cooler motor which drives the oil cooler fan.

The oil cooler fan pulls cool air through the cooling fins on the cooler. Normally, most hydraulic fluid 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 65 psi (448 kPa), the normally closed check valve in the return line (in parallel with the return line through the hydraulic fluid cooler) will open, letting some hydraulic fluid bypass the hydraulic fluid cooler and flow directly into the reservoir filter.

When fewer functions are being used, the pressure in the system will decrease below 45 psi (310 kPa) and the check valve will close again.

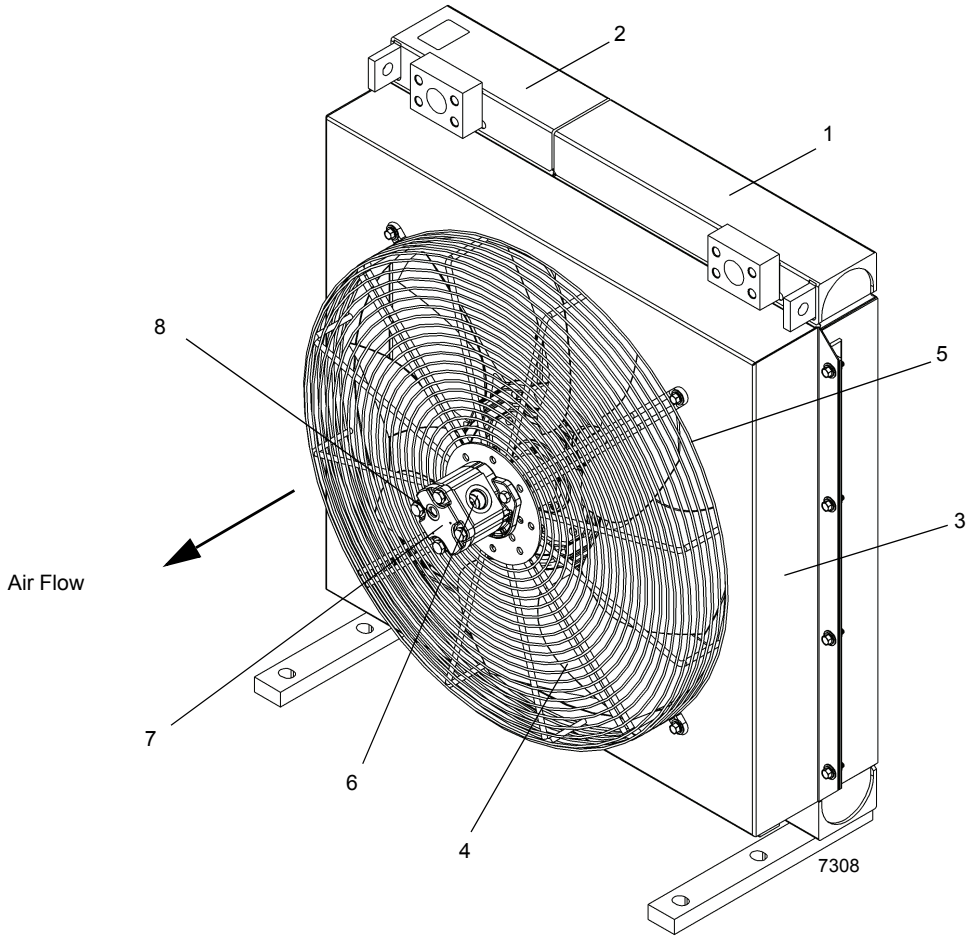


FIGURE 2-5

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

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

HYDRAULIC PUMPS

Description

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

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

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

Pump No. 1

Pump no. 1 is a piston pump with a displacement of 6.71 in^3/rev (110 cm^3/rev) and a cut-off pressure of 4640 psi (31992 kPa).

Pump No. 2

Pump No. 2 is a piston pump with a displacement of 4.88 in^3/rev (80 cm^3/rev) and a cut-off pressure of 4640 psi (31992 kPa).

Pump No. 3

Pump No. 3 is a gear pump with a displacement of 1.77 in^3/rev (29 cm^3/rev) section with a theoretical flow of 16.9 gpm (64 l/min) at 2512 rpm.

Pump No. 4

Pump No. 4 is a gear pump with a displacement of 1.77 in^3/rev (29 cm^3/rev) pump with a theoretical flow of 18.3 gpm (69.3 l/min) at 2712 rpm.

Maintenance

Pump No. 1 Removal

CAUTION

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

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

CAUTION

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

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

Pump No. 1 Installation

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

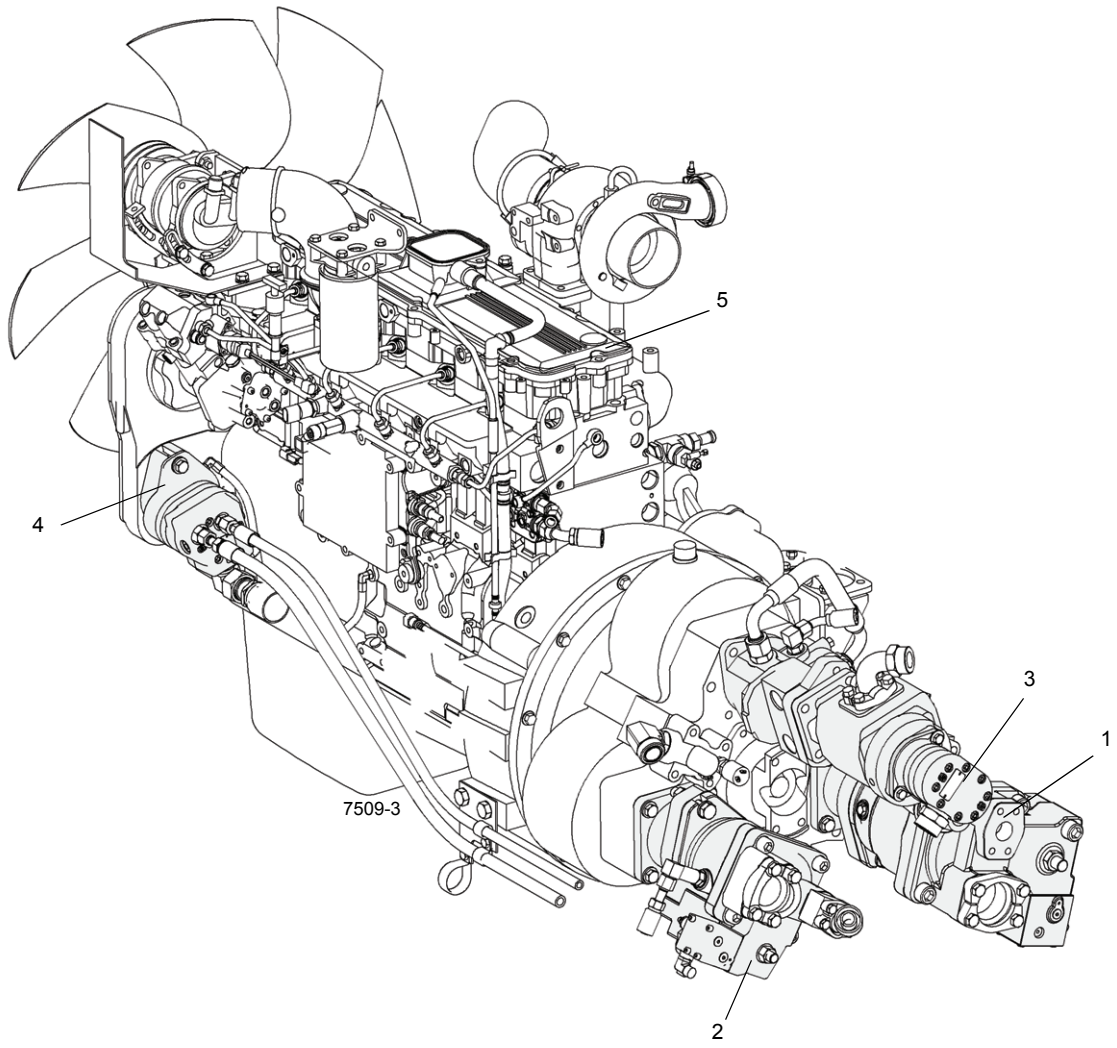


FIGURE 2-6

Item	Description
1	Hydraulic Pump No. 1
2	Hydraulic Pump No. 2
3	Hydraulic Pump No. 3

Item	Description
4	Hydraulic Pump No. 4
5	Engine

Pump No. 2 Removal

CAUTION

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

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

CAUTION

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

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

Pump No. 2 Installation

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

No. 3 Pump Removal

CAUTION

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

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

CAUTION

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

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

No. 3 Pump Installation

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

No. 4 Pump Removal

CAUTION

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

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

CAUTION

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

4. Remove the capscrews and washers attaching the pump to the drive pad of the engine. Remove the pump.
5. Cover the drive pad's opening to prevent dirt from entering.

No. 4 Pump Installation

1. Clean the pump and the engine drive pad with Loctite cleaning solvent 7070 or similar non chlorinated solvent. Likewise clean both surfaces of the new rubber/steel gasket, the spacer, and the new vellomoid gasket.
2. Apply a light coating of Loctite primer N7649 to Pump No. 4's mounting surface, but do not apply any to the engine's drive pad.
3. Apply a light coating of Loctite Master Gasket 518 to both surfaces of the gasket. Do not coat either side of the rubber/steel gasket or the facing sides of the parts that will touch it. (This material partially cures in 4 hours and fully cures in 48 hours.)
4. Install pump and gasket on drive pad with capscrews and washers. Make sure the splines mesh properly.
5. Torque capscrews to recommended torque.
6. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old o-ring and install a new o-ring in its place.

CAUTION

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

Piston Pump Start-up Procedure

CAUTION

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

1. Ensure the reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge.
2. Ensure no air is entering the pump inlet, and that the pump suction or inlet fluid is not bleeding back to the reservoir when the engine is stopped, by making sure all suction or inlet lines are air tight.
3. Remove the case drain hose and adapter from the "DR" port (Figure 2-7) on both pumps and fill the housing with the same hydraulic fluid that was used to fill the hydraulic reservoir to the bottom of the o-ring case drain port. Re-install the case drain adapter and hose running to the hydraulic reservoir.

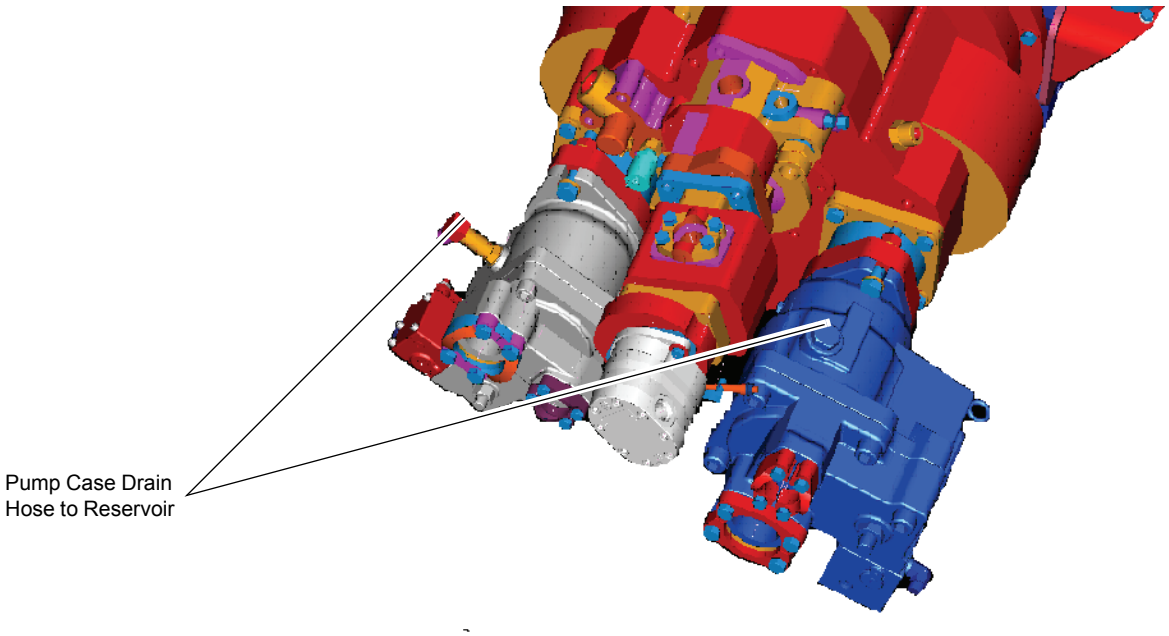


FIGURE 2-7

4. Start the engine and idle it for two or three minutes without running any hydraulic functions. Check for leaks; as needed, stop the engine and make repairs.
5. Place your hand on the pump to check for excessive heat buildup caused by binding or other problems. If the pump is too hot to keep a hand on, stop the engine.
6. Listen for abnormal noises indicating low hydraulic fluid level or internal pump problems. If the pump is making excessive noise, it is probably sucking air into its inlet, keeping it from priming. In case of abnormal noise, stop engine, and inspect the pump and the suction line for a loose connection, a leak, or a damaged or missing O-ring.
7. If the pump seems to be running properly, increase the rpm to 1500 to 1800 rpm for one to two minutes while operating no hydraulic functions. Repeat checks in steps 4, 5, and 6.
8. Increase engine speed in steps to full RPM. Repeat checks in steps 4, 5, and 6.
9. Cycle the components the pump sections power to verify the pump sections drive them properly. Verify there is no leaking.
10. Check pressure settings. Refer to Pressure Setting Procedures in this section.

PRESSURE SETTING PROCEDURES

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

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

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

NOTE: When checking 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.

The number after G (gauge port) corresponds to the gauge port number on the hydraulic system schematic (G1 through G3).

All valve settings can be obtained by adjusting the valve “in” to increase or “out” to decrease the pressure accordingly.

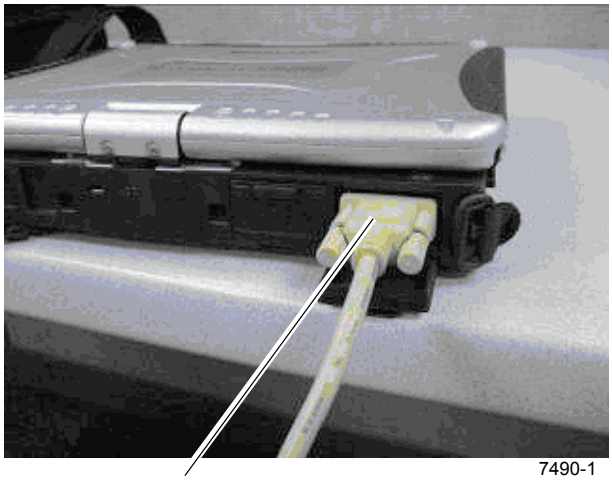
Table 2-3
Valve Pressure Setting Table

Valve To Be Set	Pressure Setting PSI (bar)	Tolerance PSI (bar)	Gauge Port (GPX) and Adjustment Location (MCV - Main Control Valve) (CCV - Compact Control Valve
NOTE: Reservoir oil temperature to be approximately 100° F (38° C)			
Outrigger/Rear Steer/Axle Lockout Pressure	3000 (33.1)	± 50 (0.4)	G - Carrier mounted outrigger/rear steer control manifold (Figure 2-11)
Outrigger Beam Extend Pressure	2000 (138)	± 50 (0.4)	G - Carrier mounted outrigger/rear steer control manifold (Figure 2-11)
Piston Pump # 1 Differential Pressure (Delta P)	350 (24)	± 25 (0.2)	G1 - Carrier mounted outrigger/rear steer control manifold (Figure 2-10) and (Figure 2-11)
Piston Pump # 2 Differential Pressure (Delta P)	375 (26)	± 25 (0.2)	G1 - Carrier mounted outrigger/rear steer control manifold (Figure 2-10) and (Figure 2-11)
Steer Pressure Setting	2500 (172)	± 50 (0.4)	GPS Superstructure mounted accessory manifold (Figure 2-25)
Control Pressure	508 (35)	± 25 (0.2)	MSt Adjust at DM MCV (Figure 2-22)
Main Hoist Raise Pressure	4351 (300)	± 50 (0.4)	MA3 MCV Adjust at D3 MCV (Figure 2-15) and (Figure 2-17)
Main Hoist Lower Pressure	1740 (120)	± 50 (0.4)	MB3 MCV Adjust at D6 MCV(Figure 2-15) and (Figure 2-17)
Auxiliary Hoist Raise Pressure	4351 (300)	+50 (0.4)	MA1 on MCV control valve. Adjust at D1 on the auxiliary hoist control valve (Figure 2-15) and (Figure 2-17)
Auxiliary Hoist Lower Pressure	1740 (120)	± 50 (0.4)	MB1 on MCV Adjust at D4 on the auxiliary hoist control valve (Figure 2-15) and (Figure 2-17)
Telescope Pressure Setting	2901 (200)	± 50 (0.4)	MB2 MCV. Adjust at D2 on MCV (Figure 2-17)
Telescope Pinning Pressure	1450 (100)	+25 (0.2)	MA6 on MCV Adjust at DBV (telescope locking) (Figure 2-20)
Lift Raise Pressure	4351 (300)	± 50 (0.4)	MA1 MCV. Adjust at D1on MCV (Figure 2-15)

Valve To Be Set	Pressure Setting PSI (bar)	Tolerance PSI (bar)	Gauge Port (GPX) and Adjustment Location (MCV - Main Control Valve) (CCV - Compact Control Valve
Counterweight Raise Pressure	4351 (300)	± 50 (0.4)	MP CCV. Adjust at DBV (counterweight raise) on CCV (Figure 2-19) and (Figure 2-23)
Counterweight Lower Pressure	1523 (105)	±25 (0.2)	MLs CCV. Adjust at DBV (counterweight lower) on CCV (Figure 2-19) and (Figure 2-21)
Counterweight Lock Pressure	2393 (165)	± 50 (0.4)	MLs CCV. Adjust at DBV (counterweight lock) on CCV (Figure 2-19) and (Figure 2-20)
Counterweight Unlock Pressure	2393 (165)	± 50 (0.4)	MLs CCV. Adjust at DBV (counterweight unlock) on CCV (Figure 2-19) and (Figure 2-21)
Cab Lower Pressure	798 (55)	± 25 (0.2)	MLs CCV. Adjust at DBV (cab lower) on CCV (Figure 2-19) and (Figure 2-21)
Cab Raise Pressure	1378 (95)	± 25 (0.2)	MLs CCV. Adjust at DBV (cab raise) on CCV (Figure 2-19) and (Figure 2-20)
Luffing Boom Extension Lower Pressure	4134 (285)	±50 (0.4)	MLs CCV. Adjust at DBV (luffing jib lower) on CCV (Figure 2-19) and (Figure 2-21)
Luffing Boom Extension Raise Pressure	4134 (285)	±50 (0.4)	MLs CCV. Adjust at DBV (luffing jib raise) on CCV (Figure 2-19) and (Figure 2-20)
Swing Pressure	3988 (275)	+50 (0.4)	MP Swing control valve. Adjust at Slewing relief on swing control valve (Figure 2-23)
Counterweight Pin Pressure	1378 (95)	± 25 (0.2)	MLs CCV. Adjust at DBV (counterweight un-pin) on CCV (Figure 2-19) and (Figure 2-21)
Counterweight Un-pin Pressure	1378 (95)	± 25 (0.2)	MLs CCV. Adjust at DBV (counterweight pin) on CCV (Figure 2-19) and (Figure 2-20)
Service Brake Pressure	3000 (207)	± 50 (0.4)	GPB Superstructure mounted accessory manifold (Figure 2-25)
Service Brake High Charge Limit	2320 (160)	+72, -145 (5), (10)	GPB Superstructure mounted accessory manifold non-adjustable (Figure 2-25)
Service Brake Low Charge Limit	1950 (135)	± 145 (10)	GPB Superstructure mounted accessory manifold non-adjustable (Figure 2-25)
Service Brake Accumulator Pre-Charge Pressure	1400 (97)	± 100 (7)	Accumulator (Figure 2-26)

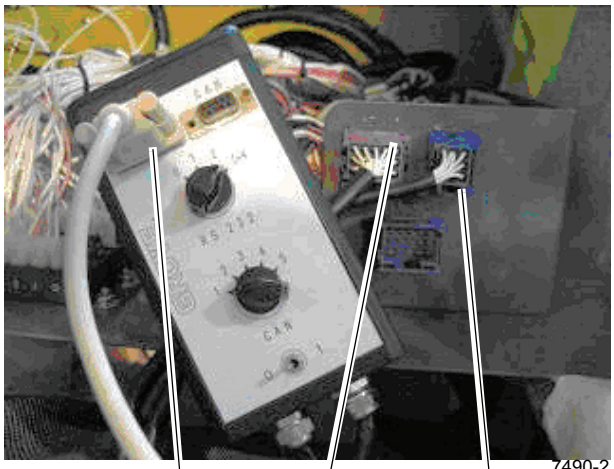
Connecting laptop to Crane Service Junction

When connecting laptop to the service junction in superstructure, refer to (Figure 2-8) and (Figure 2-9).



Connect switch box (junction RS232) and laptop with a 9-pole cable. Set the rotary RS232 switch to position 3 + 4.

FIGURE 2-8



Connect switch box (junction RS232) and laptop with a 9-pole cable. Set the rotary RS232 switch to position 3 + 4.

Connect switch box to the ESX-D1 junction

Connect switch box to the ESX-D2 junction

FIGURE 2-9

NOTE: Procedures A through M in the following text correlate with (Figure 2-10) through (Figure 2-26).

Procedure A - Checking/Setting Piston Pump Differential and Cut-off Pressures

1. Install pressure check diagnostic quick disconnect with gauge onto the test fitting at the G1 port of the integrated outrigger/rear steer/axle lockout manifold (Figure 2-11).
2. Assure piston pump “cut-off” max (Figure 2-10) factory setting is correct. Loosen the jam nut on the “cut-off” max adjusting screw and turn it “in” until it softly seats or bottoms out. Back the adjusting screw “out” 2 turns and lock in place with jam nut. This will ensure that full system pressure of 4351 psi (300 bar) can be obtained.
3. Assure piston pump delta P (stand-by) factory setting is correct. With diagnostic quick disconnect still installed @ the G1 port of the integrated outrigger/rear steer/axle lockout manifold (Figure 2-11), start engine and @ idle RPM adjust the piston pump #1 differential setting screw “in” to increase or out to decrease so that a gauge reading of 375 ±25 psi (26 ±2 bar) is achieved (Figure 2-10).
4. Stop engine. Remove the diagnostic coupler.

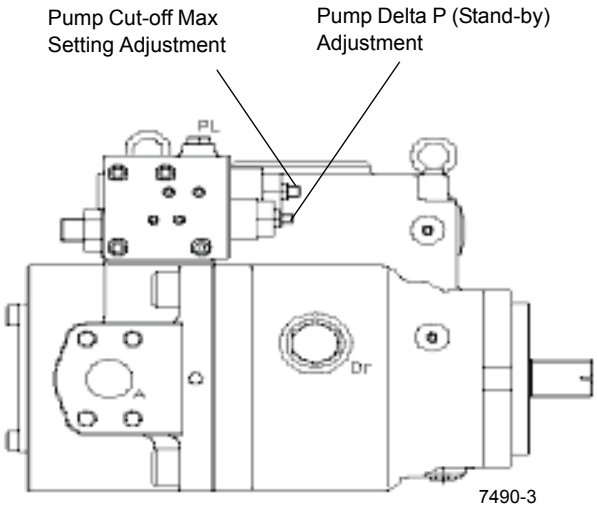
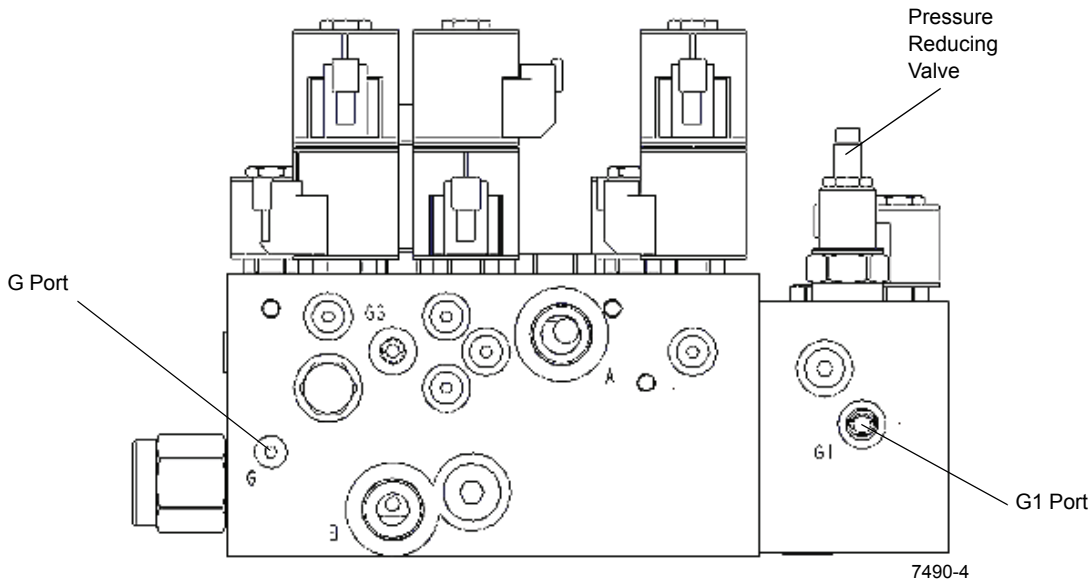


FIGURE 2-10

Procedure B - For Checking/Setting the Outrigger/Rear Steer/Axle Lockout Pressures

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the G port of the outrigger control manifold (Figure 2-11).



Outrigger/Rear Steer/Axle Lockout Manifold

FIGURE 2-11

2. Start engine and select and hold the outrigger “retract” and an outrigger “jack” or “beam” switch on the superstructure controls. Raise engine speed to full RPM. Adjust the pressure reducing valve for pressure beyond in the outrigger control manifold “in” to increase or “out” to decrease so that the gauge pressure of 3000 ±50 psi (207 ±4 bar) is achieved (Figure 2-11).

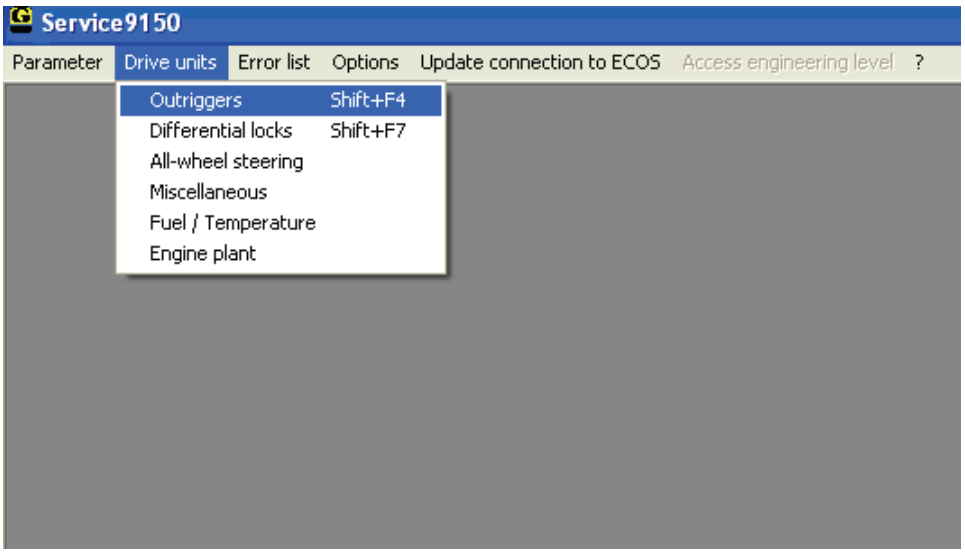
3. Select the outrigger “extend” and an outrigger “beam” switch on the superstructure controls. Fully extend and hold. Adjust the electric relief valve using the service software (Figure 2-12) through (Figure 2-14) to limit load sense pressure so that a gauge pressure of 2000 ±50 psi (138 ±4 bar) is achieved. Increasing the I-min value increases the pressure. The I-max value should not be changed.

4. Stop engine. Remove the diagnostic coupler.

- Once connected to the service junction, turn on the laptop and select the RT9150E service software icon (Figure 2-12).
- Select “OK” once connected to the ESX 3.

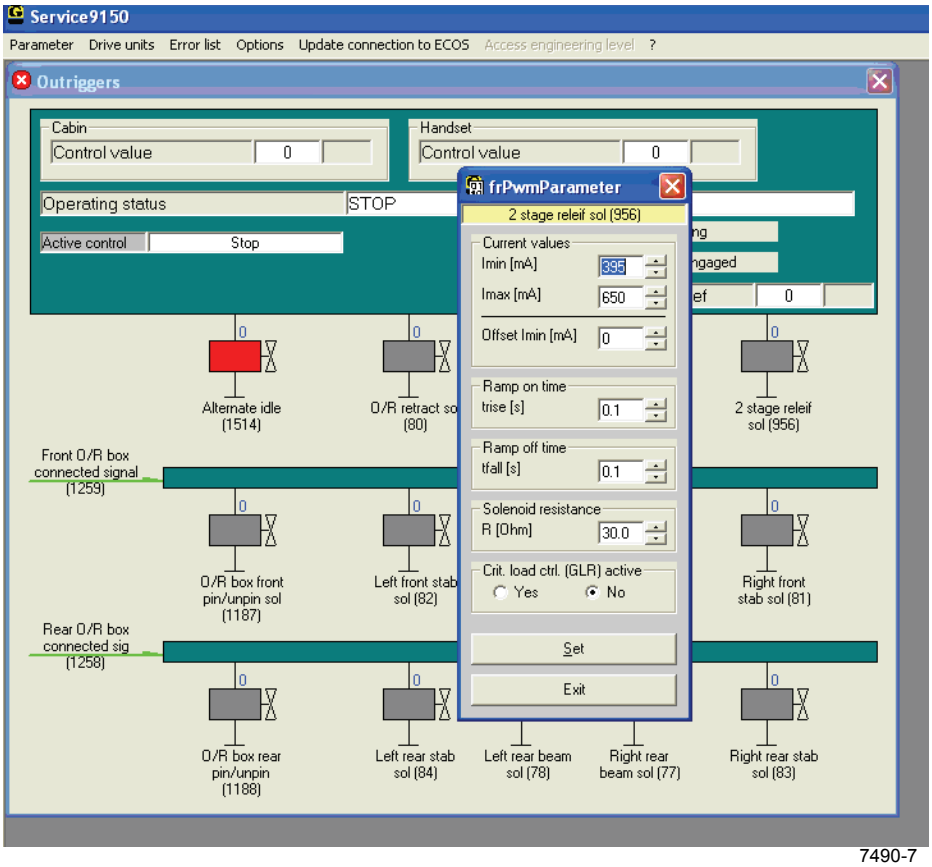
Service9150.exe

FIGURE 2-12



7490-6 **FIGURE 2-13**

- Under the Drive Units menu, select “Outriggers” (Figure 2-13).
- Click on the 2-stage relief solenoid symbol (956 to open the parameters menu.
- Adjust the “I-min” value accordingly and click “set”, then “exit”. Repeat until the correct pressure is obtained.
- Exit “outriggers” menu when finished.



7490-7

FIGURE 2-14

Superstructure Hydraulic System

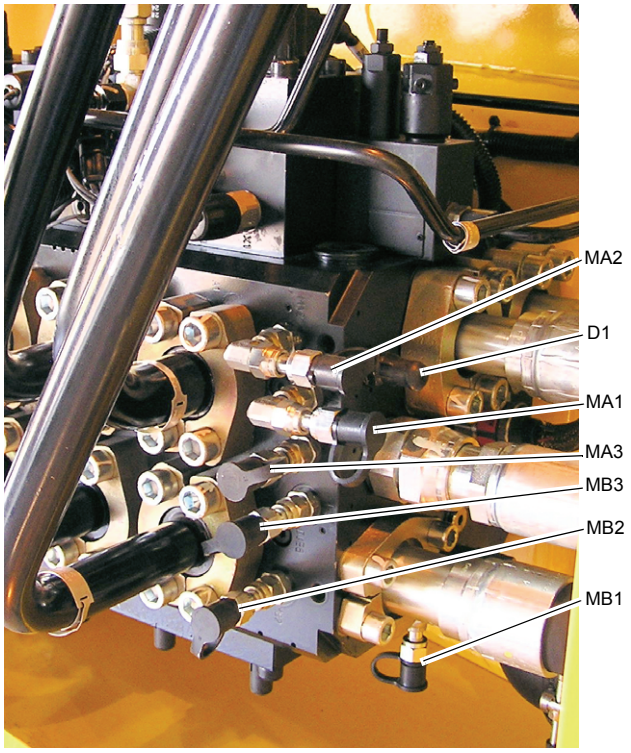
- It is absolutely essential that the hydraulic system is carefully bled to ensure that the superstructure hydraulics operate correctly. This applies in particular to the following control circuits;
  - Brake release lines of the slewing gear brake
  - Brake release lines of the hoist brake
- The following pressure values are read on the pressure gauge. For measuring points indicted (M...), refer to the hydraulic schematic.
- The hydraulic fluid temperature should be approximately 86 - 104°F (30 - 40° C) during adjustments.
- The following pressures do not have to be checked”

DBV1	5221 psi (360 bar)	Primary pressure control valve
DV2	653 psi (45 bar)	Control pressure
D4		Derricking out, not in service

- The pressure values which are read at measuring point MLs (Figure 2-19) of the compact control valve must be 73 psi (5 bar) higher than the values indicated on the circuit diagram. The function speeds must be present. The set pressure changes with the volume adjustment.
- All valve settings can be obtained by adjusting the valve “in” to increase or “out” to decrease the pressure.

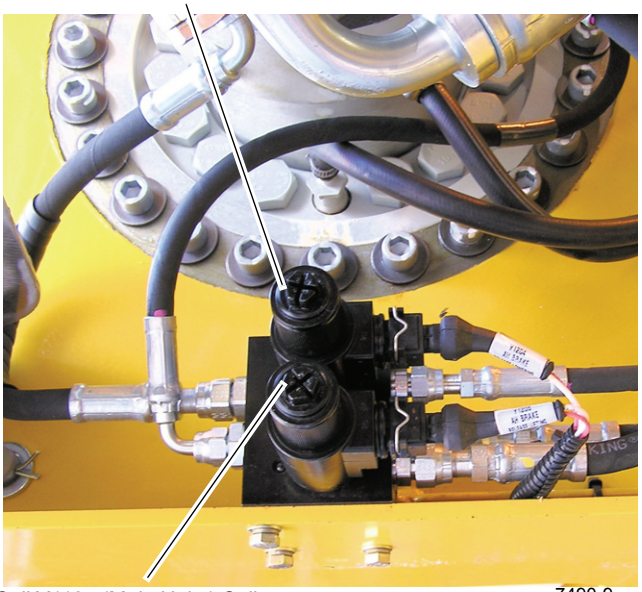
Procedure C - Checking/Setting Main Hoist Lower Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple @ the MB3 port of the main directional control valve (Figure 2-15).
2. Remove solenoid coils Y1104/Y1105 from main hoist brake control block (Figure 2-16). Start engine and lower hoist at average engine speed.
3. If necessary, adjust pressure at D6 (Figure 2-17) to 1740 ±50 psi (120±4 bar).
4. Stop engine. Reassembly solenoid coils Y1104/Y1105 and remove the diagnostic coupler.



Main Directional Control Valve 7490-8

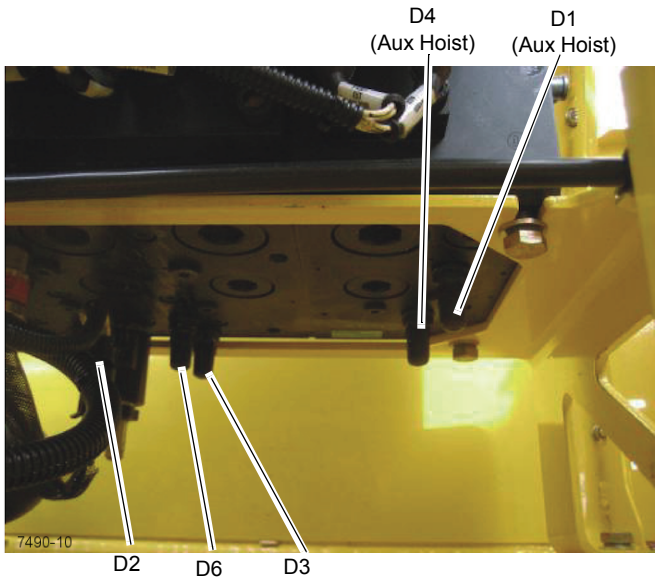
FIGURE 2-15



7490-9

Hoist Brake Control Block

FIGURE 2-16



Main Directional Control Valve (Rear)

FIGURE 2-17

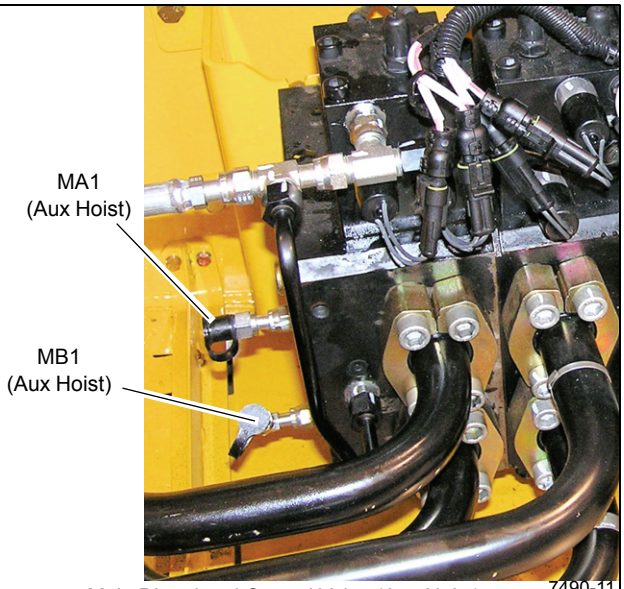
Procedure D - Checking/Setting Main Hoist Raise Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple @ the MA3 port of the main directional control valve (Figure 2-15).
2. Remove solenoid coils Y1104/Y1105 from main hoist brake control block (Figure 2-16). Start engine and raise hoist at average engine speed.
3. If necessary, adjust pressure at D3 (Figure 2-17) to 4351 ±50 psi (300 ±4 bar).
4. Stop engine. Reassemble solenoid coils Y1104/Y1105 and remove the diagnostic coupler.

Procedure E - Checking/Setting Auxiliary Hoist Lower Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple @ the MB1(Aux Hoist) port of the main directional control valve (Figure 2-18).
2. Remove solenoid coils Y1204/Y1205 from aux hoist brake control block (Figure 2-16). Start engine and lower hoist at average engine speed.
3. If necessary, adjust pressure at D4 (Aux Hoist) (Figure 2-17) to 1740 ±50 psi (120 ±4 bar).
4. Stop engine. Reassemble solenoid coils Y1204/Y1205 and remove the diagnostic coupler.

Procedure F - Checking/Setting Auxiliary Hoist Raise Pressure



Main Directional Control Valve (Aux Hoist)

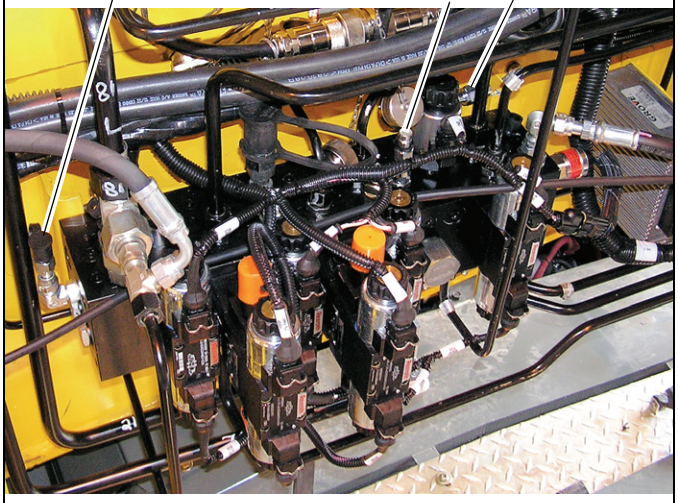
FIGURE 2-18

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple @ the MA1(Aux Hoist) port of the main directional control valve (Figure 2-18).
2. Remove solenoid coils Y1204/Y1205 from auxiliary hoist brake control block (Figure 2-16). Start engine and raise hoist at average engine speed.
3. If necessary, adjust pressure at D1 (Aux Hoist) (Figure 2-17) to 4351 ±50 psi (300 ±4 bar).
4. Stop engine. Reassemble solenoid coils Y1204/Y1205 and remove the diagnostic coupler.

Procedure G - Checking/Setting Telescope Pressure

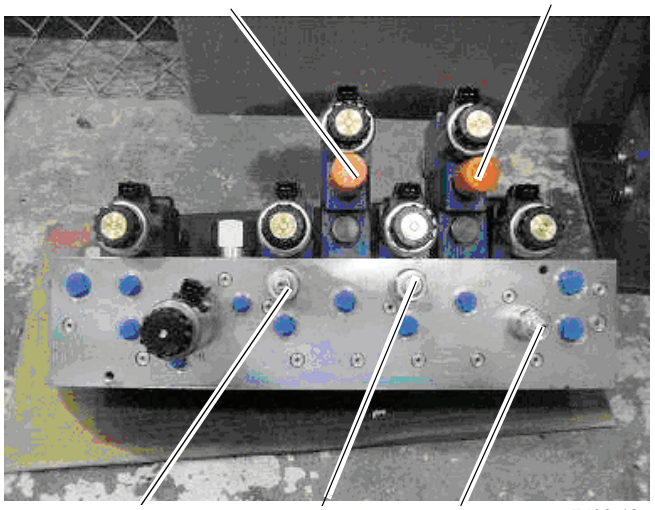
1. A laptop with the service software is required to adjust the pressures of the telescoping gear.
2. Connect pressure gauge to MA2 and MB2 on the main directional control valve (Figure 2-15).
3. Start engine and lock telescope section 1 at 50%.
4. In the service software, select the menu item to adjust the pressure or go into emergency operation.
5. Retract telescoping gear in the locked condition.
6. Adjust the pressure at D2 on the main directional control valve (Figure 2-17) to 2901 ±50 psi (200 ±4 bar).
7. Carefully extend the telescoping cylinder in the locking pin hole.

8. Connect pressure gauge to MA6 on the compact control valve (Figure 2-19).
9. Carefully retract the telescoping cylinder again in the locking pin hole.
10. Create a pressure build-up by activating the boom section unlocking device. This process can be repeated by activating the boom section locking device and then the boom section unlocking device. The pressure build-up only occurs for a few seconds.
11. Adjust the pressure at DBV (telescope locking) on the compact control valve (Figure 2-20) to 1450 ±25 psi (100 ±2 bar).
12. If an adjustment has been made with the aid of emergency operation, turn engine off and restart. Re-enter the current telescope status in ECOs.
13. The pressurizing valve Y2115 can only be adjusted via the service software.
14. If the pressure cannot be adjusted to greater than approximately 2175 psi (150 bar), valve Y2115 is not energized. In this case, there is an error in the control system.



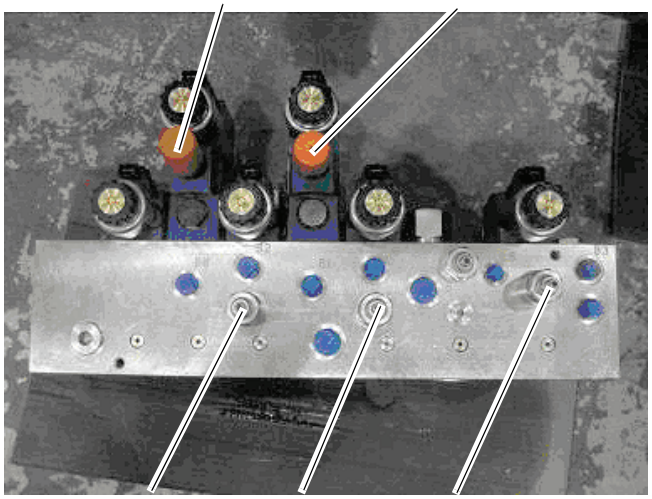
Compact Control Valve 7490-12

FIGURE 2-19



Compact Control Valve (Top)

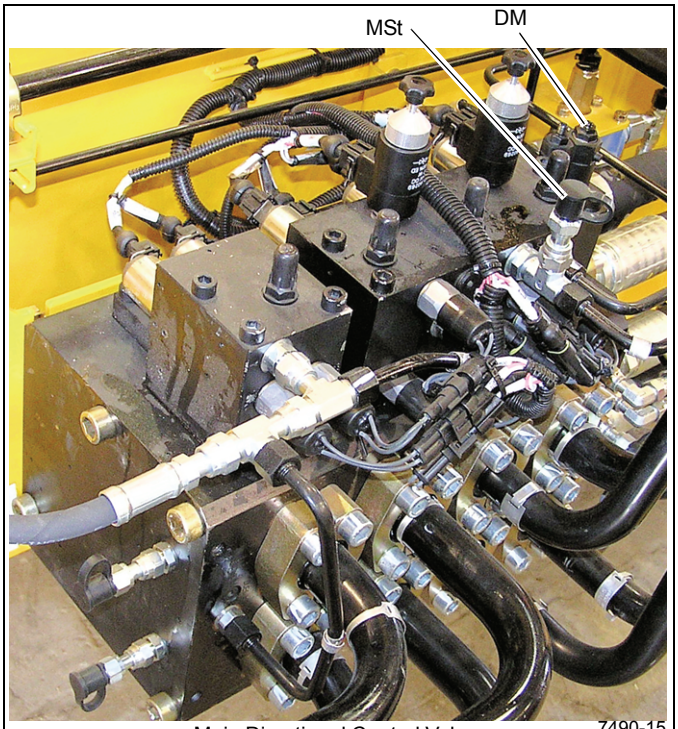
FIGURE 2-20



Compact Control Valve (Bottom)

FIGURE 2-21

Procedure H - Checking/Setting Control Pressure



Main Directional Control Valve

FIGURE 2-22

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MSt port of the main directional control valve (Figure 2-22).
2. Start engine and activate a function (pump pressure greater then 725 psi (50 bar)) at average engine speed.
3. If necessary, adjust pressure at DM to 508 ±25 psi (35 ±2 bar) (Figure 2-22).
4. Stop engine and remove the diagnostic coupler.

Procedure I - Checking/Setting Raise Boom (Derricking) Pressure

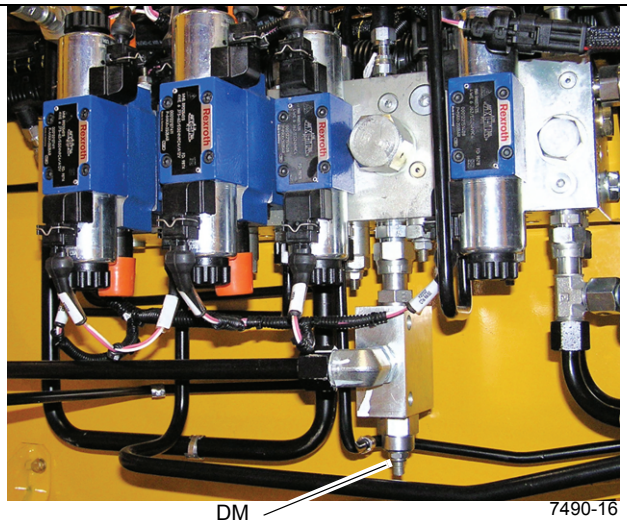
1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MA1 port of the main directional control valve (Figure 2-15).
2. Start engine and lift up (derrick in) against the stop at average engine speed. During this, slightly move the control lever and hold.
3. If necessary, adjust pressure at D1 to 4351 ±50 psi (300 ±4 bar) (Figure 2-15).
4. Stop engine and remove the diagnostic coupler.

Procedure J - Checking/Setting Counterweight Raise Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MP port of the compact control valve (Figure 2-19).
2. Start engine and lift up (derrick in) against the stop at average engine speed. During this, only move the control lever slightly and hold.
3. If necessary, adjust pressure at the pressure reducing valve DM to 4351 ±50 psi (300 ±4 bar) (Figure 2-23).
4. Stop engine and remove the diagnostic coupler.

Procedure K - Checking/Setting Counterweight Lower Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MLs port of the compact control valve (Figure 2-19).
2. Start engine and lower the counterweight cylinders against the stop at average engine speed and hold.
3. If necessary, adjust pressure at DBV (counterweight lower) to 1523 ±25 psi (105 ±2 bar) (Figure 2-21).
4. Stop engine and remove the diagnostic coupler.



Compact Control Valve

FIGURE 2-23

Procedure L - Checking/Setting Counterweight Locking/Unlocking Pressures

1. Check the speed setting.
2. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MLs port of the compact control valve (Figure 2-19).

3. Start engine and completely lower the counterweight and, if necessary, lay down counterweight, ensure that locking device is running freely.
4. Activate “Unlock Counterweight”.
5. If necessary, adjust pressure at DBV (counterweight unlock) to 2393 ±50 psi (165 ±4 bar) (Figure 2-21).
6. Activate “Lock Counterweight”.
7. If necessary, adjust pressure at DBV (counterweight lock) to 2393 ±50 psi (165 ±4 bar) (Figure 2-20).
8. Raise counterweight up against the stop.
9. Stop engine and remove the diagnostic coupler.

Procedure M - Checking/Setting Cab Tilt Pressures

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MLs port of the compact control valve (Figure 2-19).
2. Start engine and lower the cab against the stop at average engine speed and hold.
3. If necessary, adjust pressure at DBV (cab lower) to 798 ±25 psi (55 ±2 bar) (Figure 2-21).
4. Raise the cab against the stop at average engine speed and hold.
5. If necessary, adjust pressure at DBV (cab raise) to 1378 ±25 psi (95 ±2 bar) (Figure 2-20).
6. Stop engine and remove the diagnostic coupler.

Procedure N - Checking/Setting Luffing Jib Pressures

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MLs port of the compact control valve (Figure 2-19).
2. Start engine and lower the luffing jib against the stop at average engine speed and hold.
3. If necessary, adjust pressure at DBV (luffing jib lower) to 4134 ±50 psi (285 ±4 bar) (Figure 2-21).
4. Raise the luffing jib against the stop at average engine speed and hold.
5. If necessary, adjust pressure at DBV (luffing jib raise) to 4134 ±50 psi (285 ±4 bar)(Figure 2-20).
6. Stop engine and remove the diagnostic coupler.

Procedure O - Checking/Setting Slewing Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MLs port of the compact control valve (Figure 2-19).
2. Start engine and activate “Counterweight Pin” at average engine speed and hold.
3. If necessary, adjust pressure at DBV (counterweight pin) to 1378±25 psi (95 ±2 bar) (Figure 2-21)
4. Activate “Counterweight un-pin” at average engine speed and hold.
5. If necessary, adjust pressure at DBV (counterweight un-pin) to 1378±25 psi (95 ±2 bar) (Figure 2-20).
6. Stop engine and remove the diagnostic coupler.

Procedure P - Checking/Setting Slewing Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the MDr port of the slewing control valve (Figure 2-24).
2. Start engine and activate slewing gear brake, swing against the brake and hold.
3. If necessary, adjust pressure at DBV (slewing) to 3989 ±50 psi (275 ±4 bar) (Figure 2-24).
4. Stop engine and remove the diagnostic coupler.

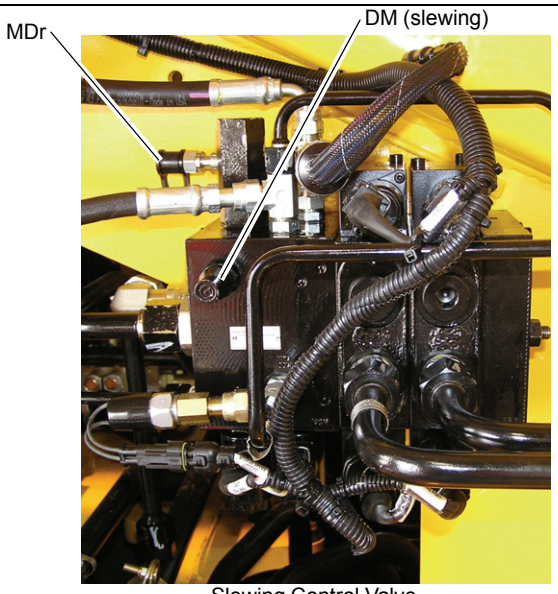
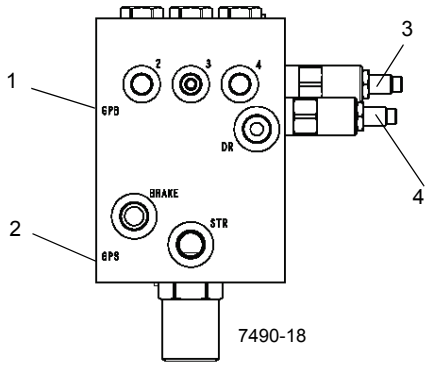


FIGURE 2-24

Procedure Q - Checking/Setting Steering Pressure



Accessory Manifold **FIGURE 2-25**

Item	Description
1	Gauge Port B (GPB)
2	Gauge Port S (GPS)
3	Brake Pressure Reducing Valve
4	Steering Relief Valve

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the GPS port of the accessory manifold (Figure 2-25).
2. Start engine, steer completely left or right at average engine speed and hold.
3. If necessary, adjust pressure at the steering relief valve to 2500 ±50 psi (172 ±4 bar) (Figure 2-25).
4. Stop engine and remove the diagnostic coupler.

Procedure R - Checking/Setting Service Brake Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at the GPB port of the accessory manifold (Figure 2-25).
2. Start engine and lift up (derrick in) against the stop at average engine speed. During this, only move the control lever slightly and hold.
3. If necessary, adjust pressure at the brake pressure reducing valve to 3000 ±50 psi (207 ±4 bar) (Figure 2-25).
4. Stop engine and remove the diagnostic coupler.

Procedure S - Checking Service Brake Accumulator Charge Pressures

1. With engine off, discharge all of the pressurized fluid stored in the accumulators by depressing the service brake pedal on the cab floor 8-10 times.
2. Install a pressure check diagnostic quick disconnect with gauge onto test fitting at GPB port of the accessory manifold (Figure 2-25).
3. Start engine and idle. The charging valve will immediately start to charge the accumulators. Watch the pressure gauge, the high charge limit should read 2320 +72, -145 psi (160 +5,-10 bar)—when the pressure stops rising.

NOTE: This accumulator charge valve is non-adjustable.

4. With the engine still at idle, repeatedly depress the service brake pedal on the cab floor until the gauge pressure reads approximately 2100 psi (145 bar). Once you have found this pressure, push the brake pedal 1-2 additional times to recharge. Watch the gauge and verify the low charging limit to be 1950 ±145 psi (134±10 bar)—when it starts to recharge.

NOTE: This accumulator charge valve is non-adjustable.

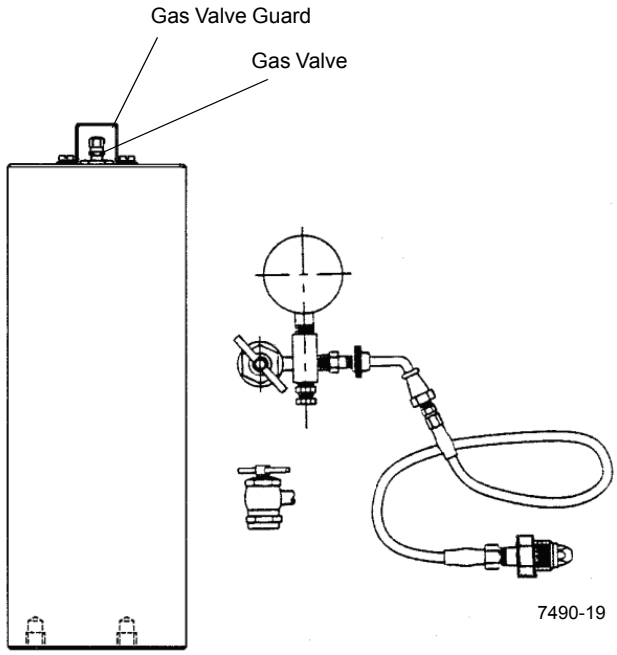
5. Stop engine and remove the diagnostic coupler.

Procedure T - Checking Service Brake Accumulator Pre-Charge Pressures

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4 – 6 times. Remove the gas valve guard and cap on the accumulator (Figure 2-26).
2. Before attaching the gas charging assembly (Figure 2-26) onto the gas valve, back out 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 (10-15 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. The gauge should read 1400 ±100 PSI (97 ±7 bar).
6. If the pressure is within the specified tolerance, remove the charging valve assembly by turning the “T” handle all the way out on the gas chuck and then opening the bleed valve (Figure 2-26).
7. Secure the gas valve, loosen the swivel nut and remove the charging assembly. Replace the gas valve cap and guard.

Procedure for Pre-Charging the Service Brake Accumulators, If Required

1. With the engine off, discharge all of the pressurized oil stored in the accumulators by depressing the service brake pedal on the cab floor 4 – 6 times. Remove the gas valve guard and cap on the accumulator (Figure 2-26).
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 to 10-15 lb-in.
5. Turn the gas chuck “T” handle all the way down (clockwise) which will depress the core in the gas valve.



Accumulator Check/Charge Valve

FIGURE 2-26

6. Slowly open the nitrogen bottle valve and fill the accumulator. Close the valve when the pre-charge is 1400 +50, -0 psi (97 +3.5, -0 bar).
7. If the pre-charge is higher than specified in step #6, close the nitrogen bottle and slowly open the bleed valve on the charging assembly (Figure 2-26) until the pressure is to specification.
8. Remove the charging valve 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.

VALVES

General

This subsection provides descriptive information for hydraulic valves used on this crane. For a listing of valves, the circuit they are used in, and their physical location, refer to Table 2-4. Refer to Figure 2-27 for location of valves installed on the superstructure and carrier frame.

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

Table 2-4: Valve Usage Table

Valve Name	Circuit Used In	Physical Location
Carrier		
Outrigger/Rear Steer/Outrigger Box Pin Removal Valve	Outrigger/Rear Steer	Front Face of Carrier Frame Member
Outrigger Control Manifold	Outrigger	Inside of Front & Rear Outrigger Box
Park Brake Axle Disconnect Valve	Park Brake/Two or Four Wheel Drive	Carrier Right Hand Side Rail
Axle Oscillation Lockout Valve	Rear Axle Lockout	Left Rear Face of Carrier Frame
Pressure Bleed-off Valve	Outrigger	In Line
Superstructure		
Main Directional Control Valve	Boom Lift/Telescope(s)/Hoist(s)	Superstructure Right Side Plate
Swing Directional Valve	Swing	Outside Right Superstructure Side Plate
Compact Block Manifold	Counterweight, Boom Extension, Cab Tilt and Telescope	Left Side Superstructure
Accessory Manifold	Steer/Brake/Load Sense	On Bracket Center of Superstructure
Case Drain Manifold	System	On Bracket Center of Superstructure
Dual Accumulator Charge Valve	Service Brakes	Superstructure Inside Left Side Plate
Control Block (Hoist Circuit)	Hoist	Beneath Hoists on Turntable
Tandem Brake Valve With Treadle Pedal	Service Brake	Cab Floor
Accumulator(s)	Service Brake	Outside Left Superstructure Side Plate

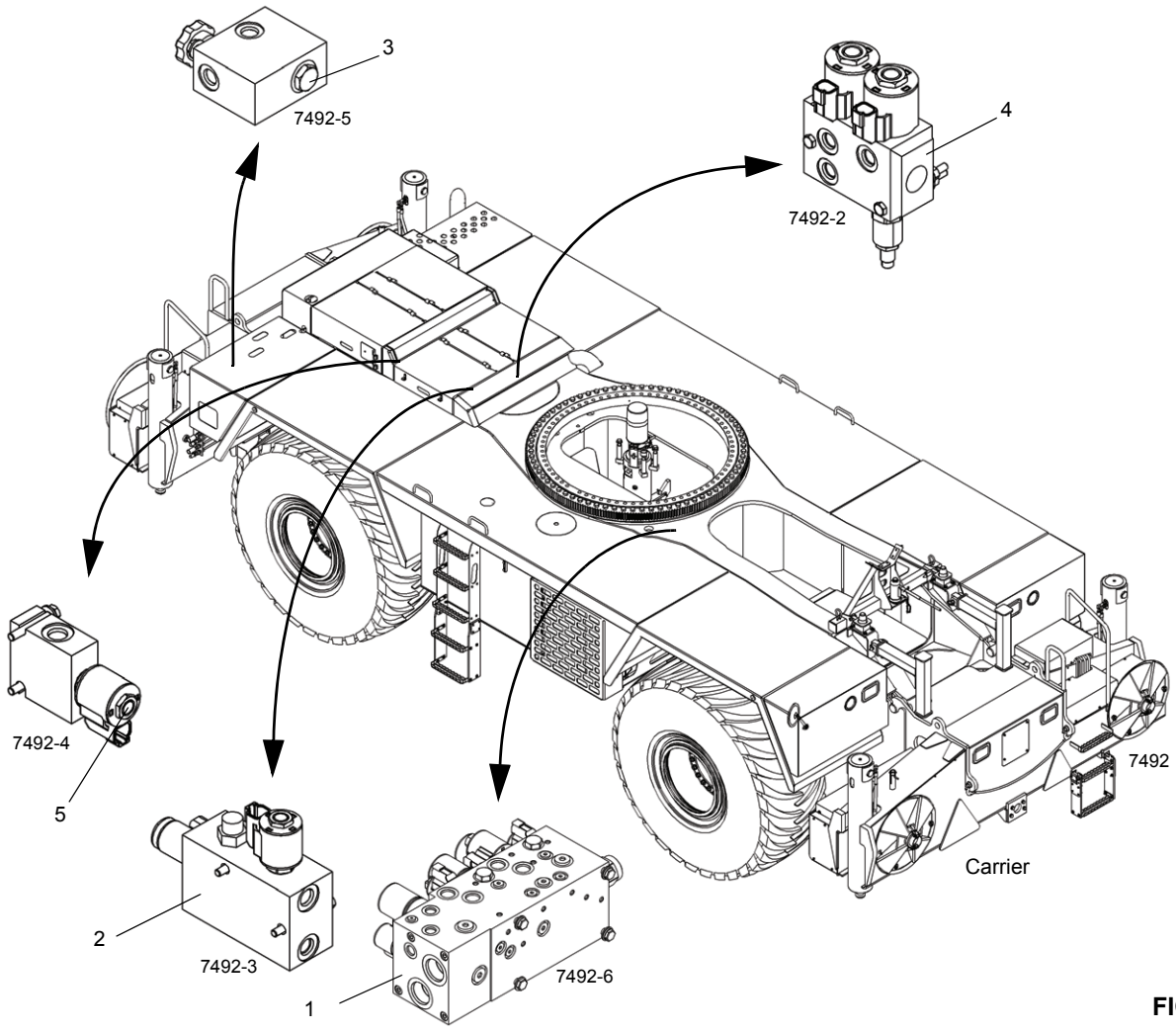


FIGURE 2-27

Item	Description
	CARRIER
1	Outrigger/Rear Steer Valve
2	Park Brake Axle Disconnect Valve
3	Manual Bleed Off Pressure Valve
4	Axle Lockout Valve
5	Differential Lock Valve (Optional)
6	Outrigger Control Manifold

Item	Description
	SUPERSTRUCTURE
7	Main Directional Control Valve (Telescope/ Lift/Hoist)
8	Swing Directional Control Valve
9	Compact Block Manifold
10	Accessory Manifold (Steer/Brake/Load Sense)
11	Case Drain Manifold
12	Dual Accumulator Charge Valve
13	Hoist Brake Control Valve
14	Manual Bleed Off Valve
15	Pilot Operated Solenoid Valve (Optional)

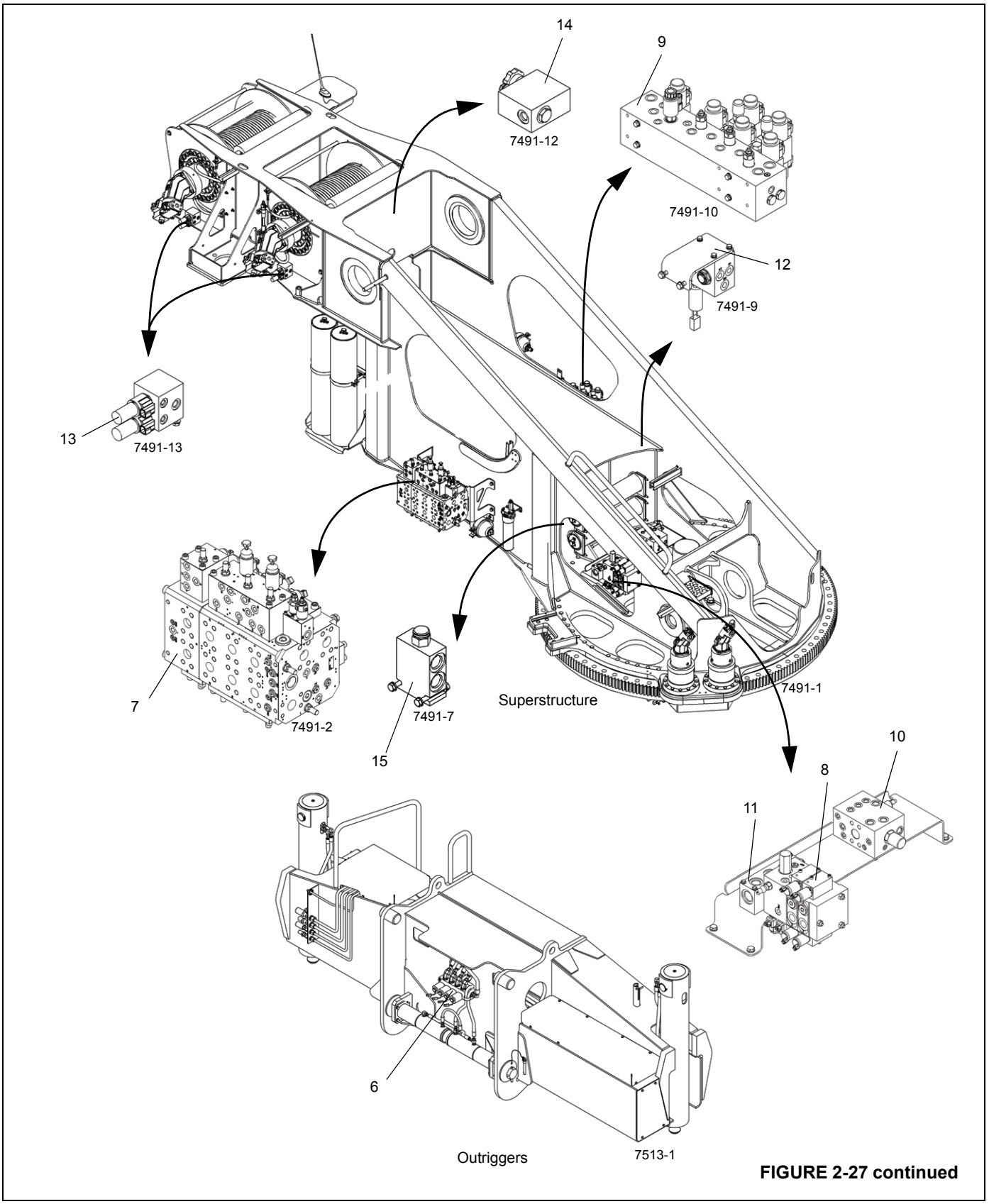


FIGURE 2-27 continued

OUTRIGGER/REAR STEER/OUTRIGGER BOX PIN REMOVAL VALVE

Description

The integrated outrigger/rear steer/outrigger removal valve (Figure 2-28) directional controls the outrigger circuit, rear steer circuit, and the pin cylinders that remove the front and rear outrigger boxes. The valve is mounted on the front face of the carrier frame member forward of the swivel. The manifold valve has five stations, an inlet, and four working stations.

The inlet station contains a 3000 psi (20684 kPa) relief valve and a two position two way solenoid valve that is normally open bypassing oil from the inlet port to the pressure beyond port.

Activation of either outriggers, rear steer, or removal pin stations will energize the solenoid valve to close, pressurizing the working sections.

The outrigger extend and retract section of the valve contains a four way solenoid directional control valve internally connected in parallel, two pilot operated check valves, a 2000 psi (13789 kPa) relief valve and two solenoid valves.

The rear steer section of the valve contains a three position four way solenoid controlled directional control valve cartridge and two pilot operated check valve cartridges.

The outrigger box pin removal portion of the valve contains a three position four way solenoid controlled directional control valve cartridge.

Maintenance

Removal

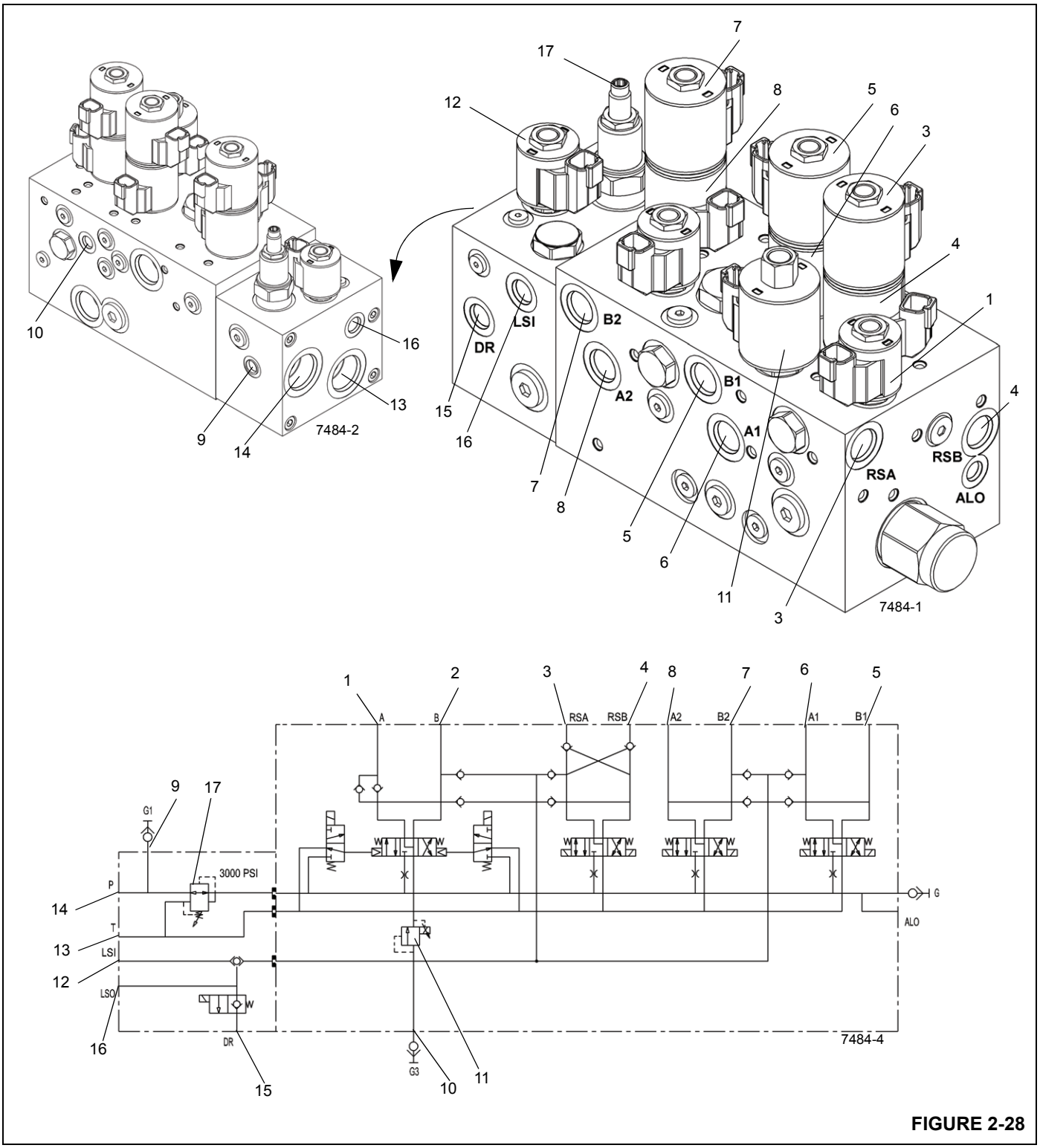
1. Tag and disconnect the electrical connectors to the integrated outrigger/rear steer valve. Tape the lead ends.
2. Tag and disconnect the hydraulic lines to the valve. Cap or plug the lines and ports.
3. Remove the capscrews and washers securing the valve to the frame. Remove the valve as a complete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

Installation

1. Install the integrated outrigger/rear steer valve to the frame. Secure the valve with the capscrews and washers. Torque capscrews to recommended torque.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.

Functional Check

1. Cycle an outrigger cylinder several times. Verify the cylinder extends and retracts properly.
2. Rear steer the crane to the left and to the right several times. Verify the crane steers properly in both directions.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RSB
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ALO
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7484-4

FIGURE 2-28

Item	Description
1	Outrigger Solenoid - A Port Extend
2	Outrigger Solenoid - B Port Retract
3	RSA Port to Steer Right Solenoid Valve
4	RSB Port to Steer Left Solenoid Valve
5	B1 Port to Front Outrigger Pin Extend
6	A1 Port to Front Outrigger Pin Retract
7	B2 Port to Rear Outrigger Pin Extend
8	A2 Port to Rear outrigger Pin Retract
9	Gauge Port G1

Item	Description
10	Gauge Port G3
11	Two Stage Relief
12	Load Sense In Port
13	Tank Port
14	Pressure Port
15	Drain Port
16	Load Sense Out Port
17	Pressure Reducing Valve

OUTRIGGER CONTROL MANIFOLD

Description

There are two outrigger control manifolds utilized on the crane; one for the front outriggers and one for the rear outriggers (Figure 2-29). Each manifold consists of four normally closed two position two way solenoid valves. They are mounted inside the frame on their respective outrigger box.

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

Maintenance

Removal

1. Tag and disconnect the hydraulic lines to the solenoid valves. Cap all lines and openings.
2. Tag and disconnect the electrical connectors.
3. Remove the capscrews and washers securing the manifold to the outrigger box. Remove the manifold.

Inspection

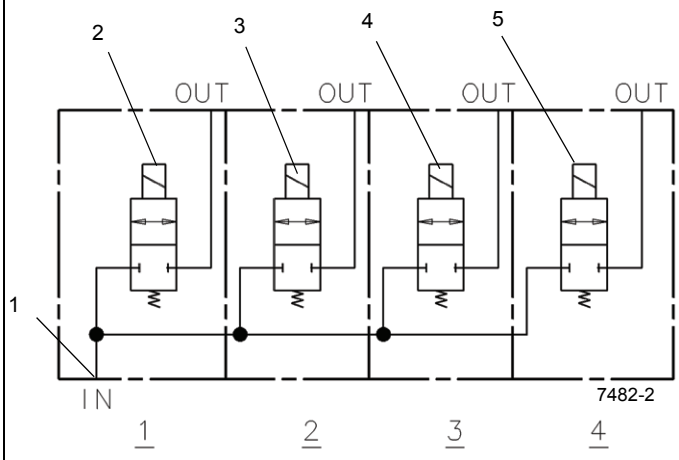
Visually inspect the valves and hydraulic connections for any evidence of leaks or other damage. Check security of the electrical connections. Inspect the wiring for any evidence of cracks or breaks.

Installation

1. Install the manifold and secure with the capscrews and washers. Torque capscrews to recommended torque.
2. Connect the electrical connectors to the solenoids as marked during removal.
3. Connect the hydraulic lines to the valves as marked during removal.

Functional Check

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



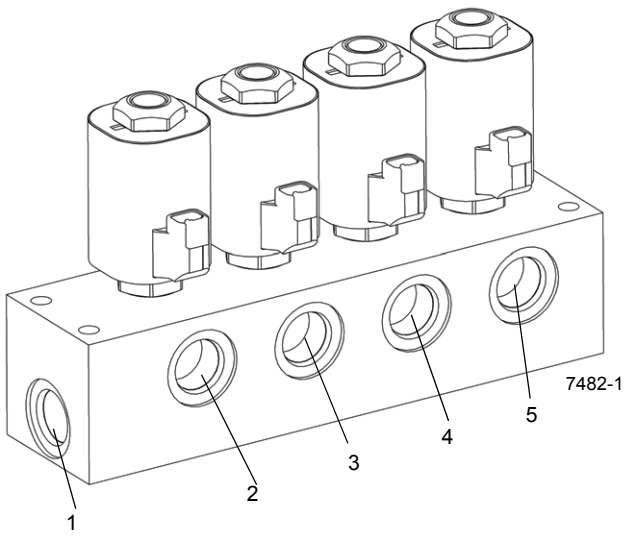


FIGURE 2-29

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

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

PARK BRAKE/AXLE DISCONNECT VALVE

Description

The two position three way parking brake/axle solenoid valve (Figure 2-30) is mounted off of the carrier right hand side rail. In its de-energized position, the inlet port is blocked and the parking brake and axle disconnect actuators are drained to the reservoir. When the solenoid is energized, the reservoir port is blocked and pressurized oil is directed to the parking brake or axle disconnect actuators.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines to the solenoid valves. Cap all lines and openings.
2. Tag and disconnect the electrical connectors.
3. Remove the capscrews and washers securing the valve to the frame. Remove the valve.

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. Install the valve the frame and secure with the capscrews and washers. Torque capscrews to recommended torque.
2. Connect the electrical connectors to the solenoids as marked during removal.
3. Connect the hydraulic lines to the valves as marked during removal.

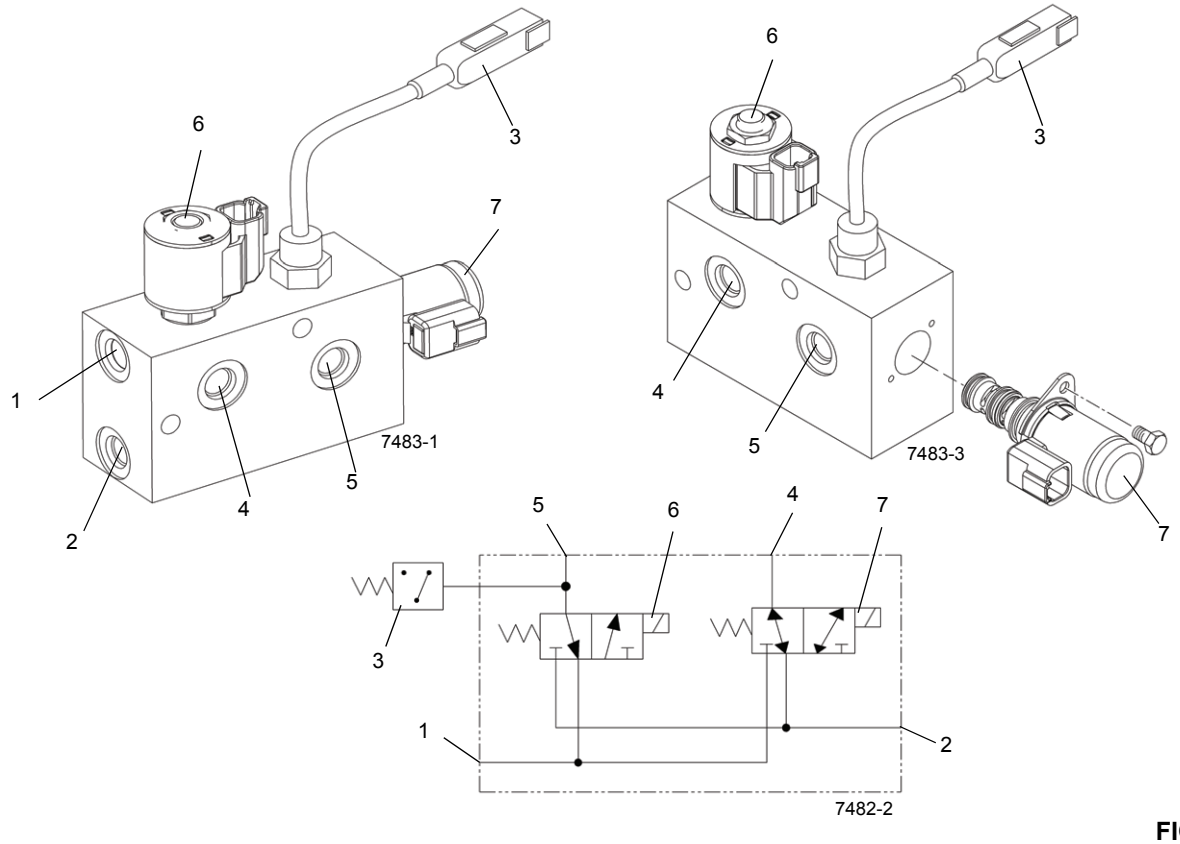


FIGURE 2-30

Item	Description
1	Tank Port
2	Pressure Port
3	Pressure Switch
4	Port A - Axle Disconnect

Item	Description
5	Port PB - Power Beyond
6	Axle Disconnect Solenoid Valve
7	Park Brake Solenoid Valve

AXLE OSCILLATION LOCKOUT VALVE

Description

The axle oscillation lockout valve (Figure 2-31) is used in the rear axle oscillation lockout circuit. The valve is mounted on the left rear face of the carrier frame forward of the rear axle. It consists of a valve body and two normally-closed, two-way, two-position solenoid valves. It keeps the lockout cylinders from oscillating unless the turntable is centered forward.

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

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

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

Maintenance

Removal

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

Installation

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

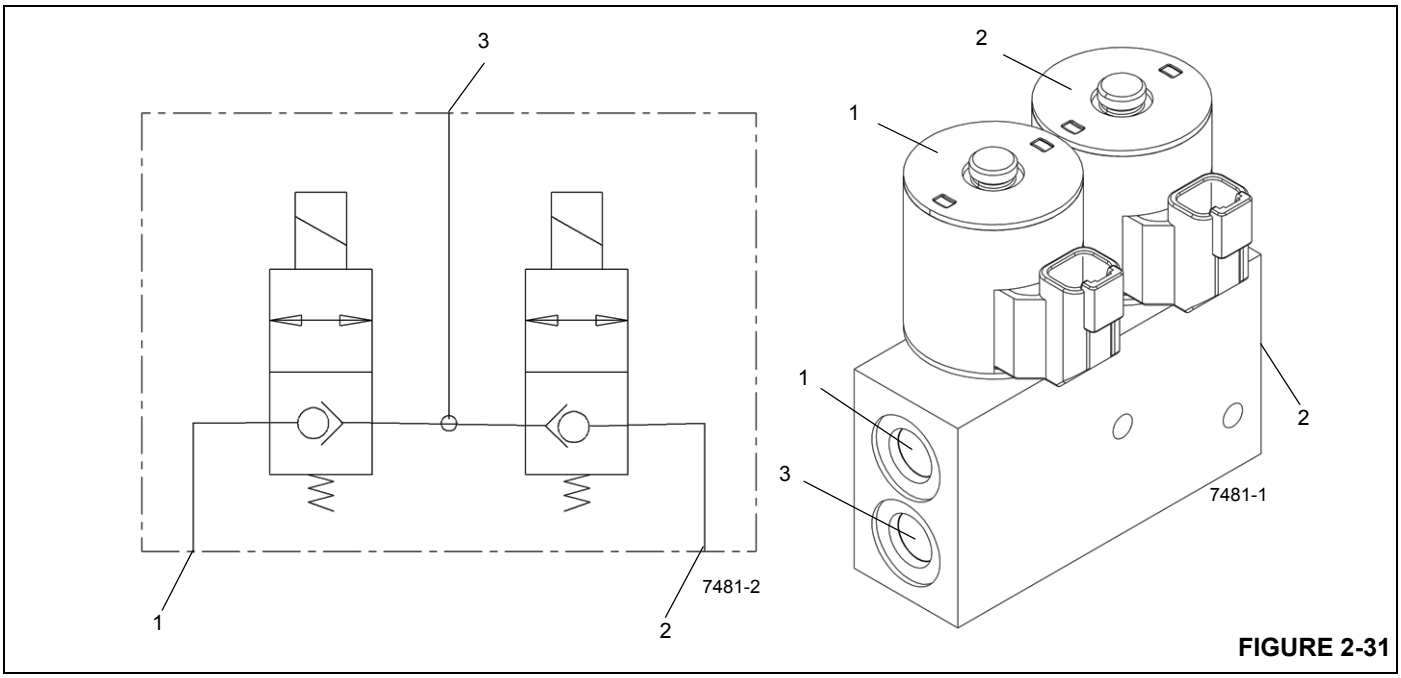


FIGURE 2-31

Item	Description
1	B Port - to Lockout Cylinder
2	A Port - to Lockout Cylinder

Item	Description
3	C Port from Outrigger Rear Steer valve

PRESSURE BLEED-OFF VALVE

Description

The pressure bleed-off valve (Figure 2-32) is used to manually drain to reservoir any trapped pressure from behind the outrigger box removal quick disconnects or the telescope boom removal quick disconnects.

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

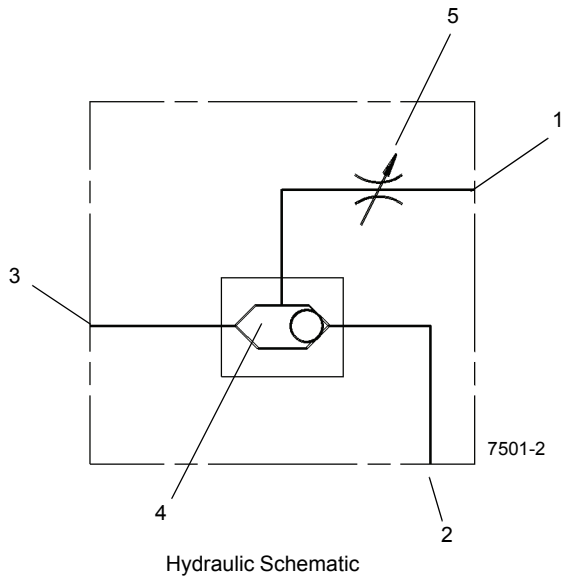
Maintenance

Removal

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

Installation

1. Install the valve and secure with the capscrews and washers. Torque capscrews to recommended torque.
2. Connect the hydraulic lines to the valve as tagged during removal.



Hydraulic Schematic

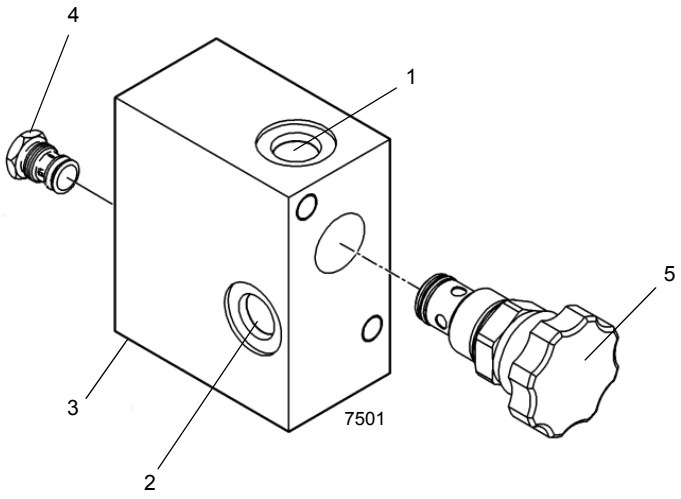


FIGURE 2-32

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

Item	Description
4	Shuttle Valve
5	Adjustable Flow Control Valve

MAIN DIRECTIONAL CONTROL VALVE

Description

General

The main directional control valves (Figure 2-33) direct and control hydraulic fluid flow from the pumps to the boom lift and telescope cylinders and the hoist motors. The valve is located on the outside of the right superstructure side plate. The valve bank is removed and installed as an assembly.

Maintenance

CAUTION

Weight of the valve is 388 lb (176 Kg), use an appropriate lifting device to move the valve.

Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Tag and disconnect the electrical leads from the valves.
3. Remove the capscrews and washers securing the valve to the bracket. Remove the valve.

Installation

1. Place the valve on the bracket and secure with the capscrews and washers. Torque capscrews to recommended torque.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valve as tagged during removal.

NOTE: Hydraulic solenoids must be calibrated to the software. This must be done by a Manitowoc Crane Care certified technician.

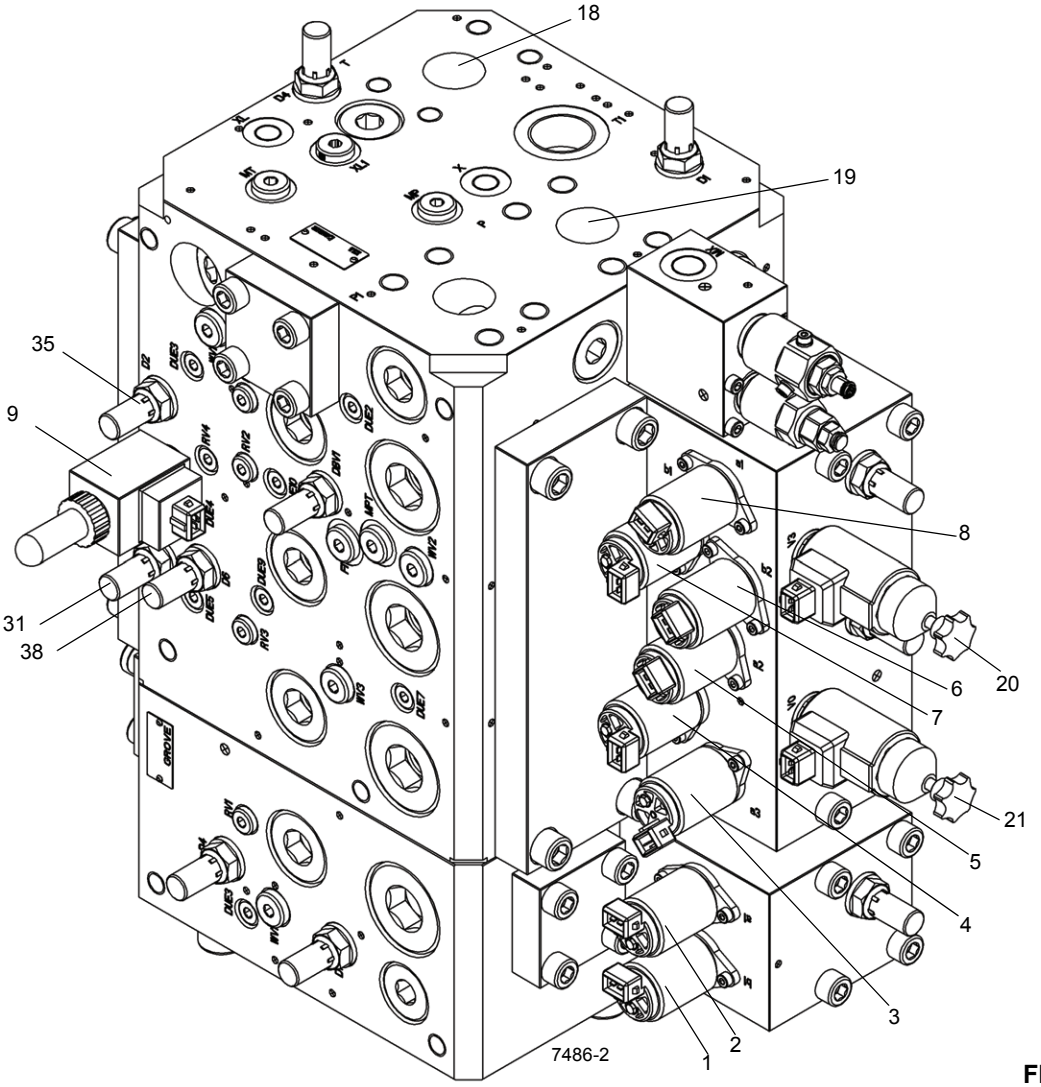


FIGURE 2-33

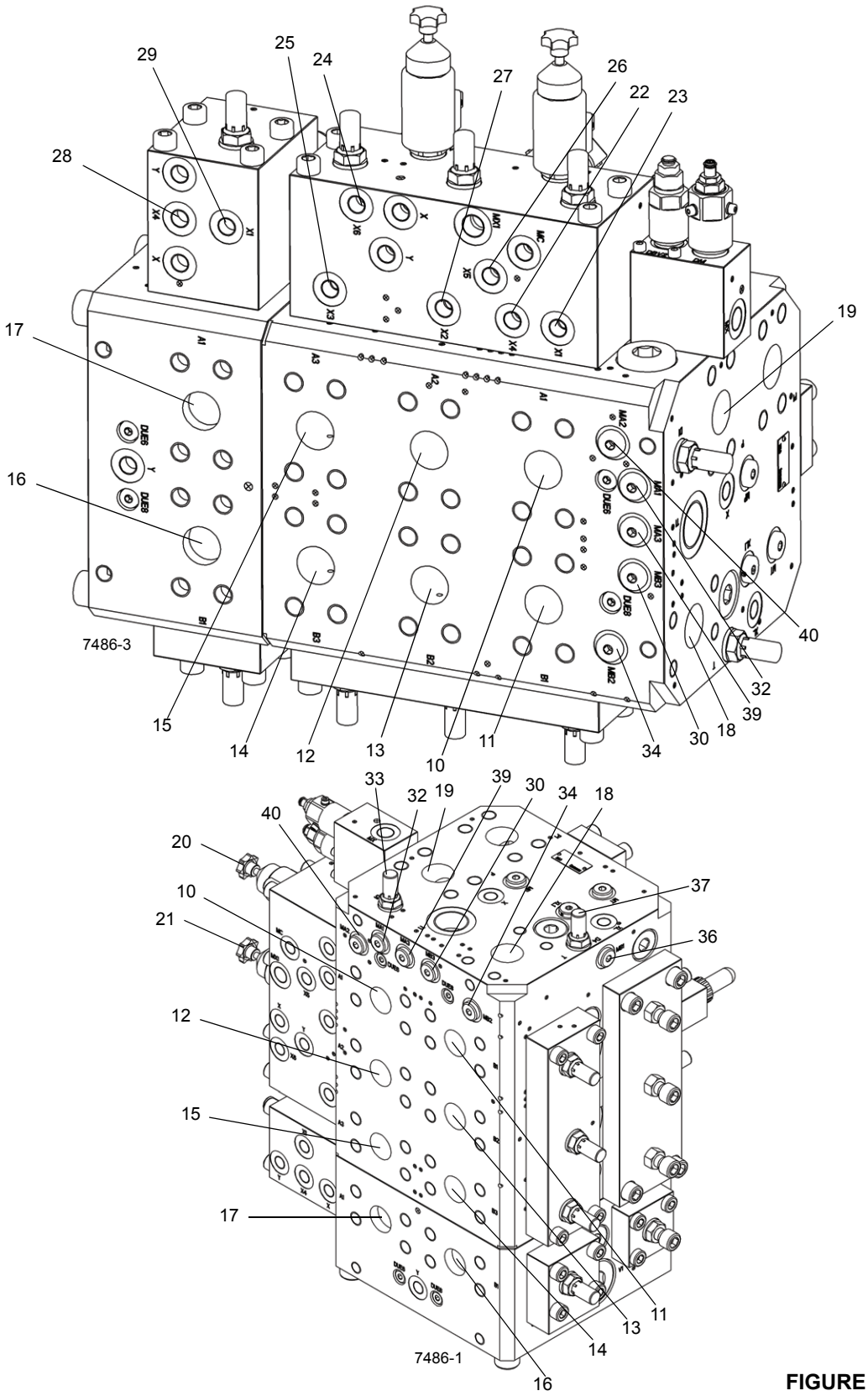


FIGURE 2-33 continued

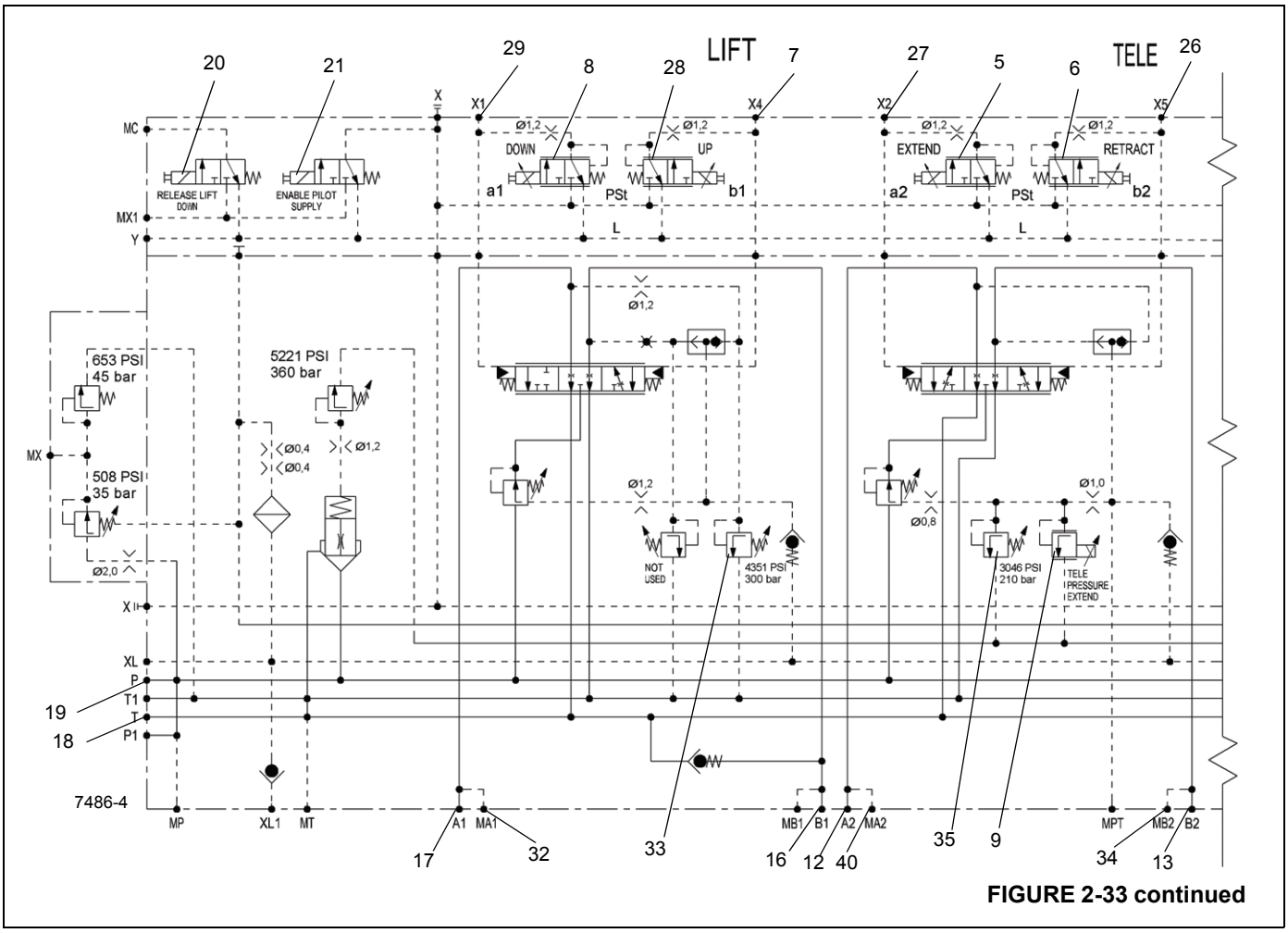


FIGURE 2-33 continued

Item	Description
1	Auxiliary Hoist Up Solenoid b1
2	Auxiliary Hoist Down Solenoid a1
3	Main Hoist Down Solenoid a3
4	Main Hoist Up Solenoid b3
5	Telescope Out Solenoid a2
6	Telescope In Solenoid b2
7	Lift Up Solenoid b1
8	Lift Down Solenoid a1
9	Telescope Extend Pressure
10	Port A1 - Auxiliary Hoist Raise
11	Port B1 - Auxiliary Hoist Lower
12	Port A2 - Telescope Retract
13	Port B2 - Telescope Extend
14	Port B3 - Main Hoist Lower

Item	Description
15	Port A3 - Main Hoist Raise
16	Port B1 - Lift Retract
17	Port A1 - Lift Extend
18	Tank Port - To Swivel Port 1
19	Pressure Port - To Swivel Port 3
20	Release Lift Down
21	Enable Pilot Supply
22	Port X4 to Pressure Switch (Aux Hoist Raise)
23	Port X1 to Pressure Switch (Aux Hoist Lower)
24	Port X6 to Pressure Switch (Main Hoist Raise)
25	Port X3 to Pressure Switch (Main Hoist Lower)
26	Port X5 to Pressure Switch (Telescope Retract)

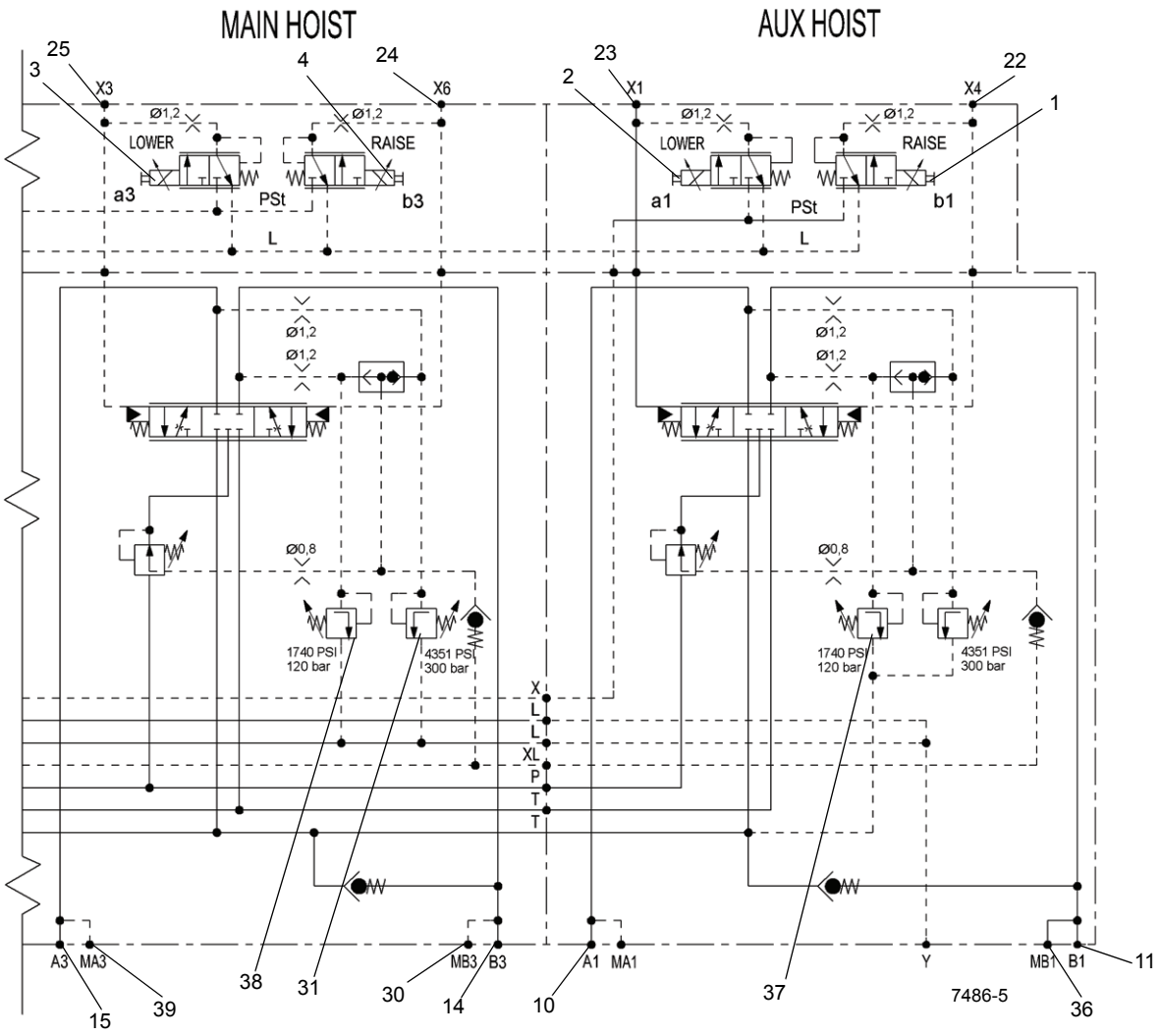


FIGURE 2-33 continued

Item	Description
27	Port X2 to Pressure Switch (Telescope Extend)
28	Port X4 to Pressure Switch (Lift Up)
29	Port X1 to Pressure Switch (Lift Down)
30	Port MB3 for Test Nipple
31	D3 - Pressure Check
32	Port MA1 for Test Nipple
33	D1 - Pressure Check

Item	Description
34	Port MB2 for Test Nipple
35	D2 - Pressure Check
36	Port MB1 for Test Nipple
37	D4 - Pressure Check
38	D6 - Pressure Check
39	Port MA3 for Pressure Check
40	Port MA2 for Pressure Check

SWING DIRECTIONAL CONTROL VALVE

Description

General

The swing directional control valve (Figure 2-34) directs and controls hydraulic fluid flow from the pump to each swing motor. The valve is located on the outside of the right superstructure side plate. The valve bank is removed and installed as an assembly.

Maintenance

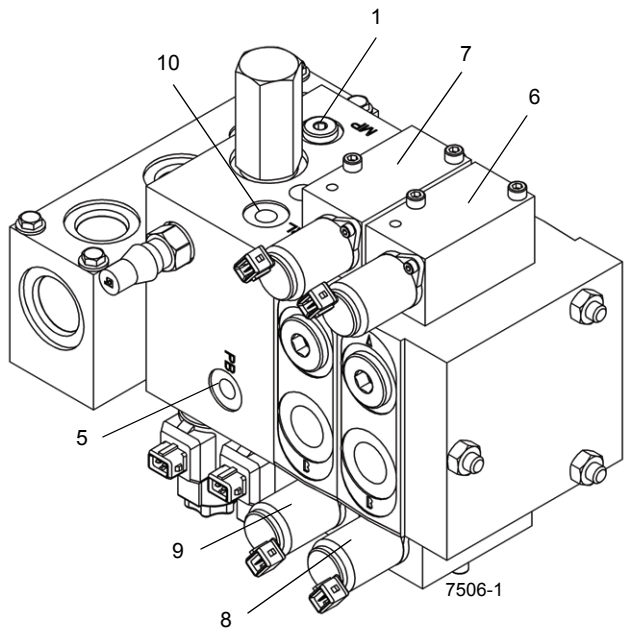
Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Tag and disconnect the electrical leads from the valves.
3. Remove the capscrews and washers securing the valve to the bracket. Remove the valve.

Installation

1. Place the valve on the bracket and secure with the capscrews and washers. Torque capscrews to recommended torque.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valve as tagged during removal.

NOTE: Run auto-teach in service software to calibrate software to valve solenoids. This must be done by a Manitowoc Crane Care certified technician.



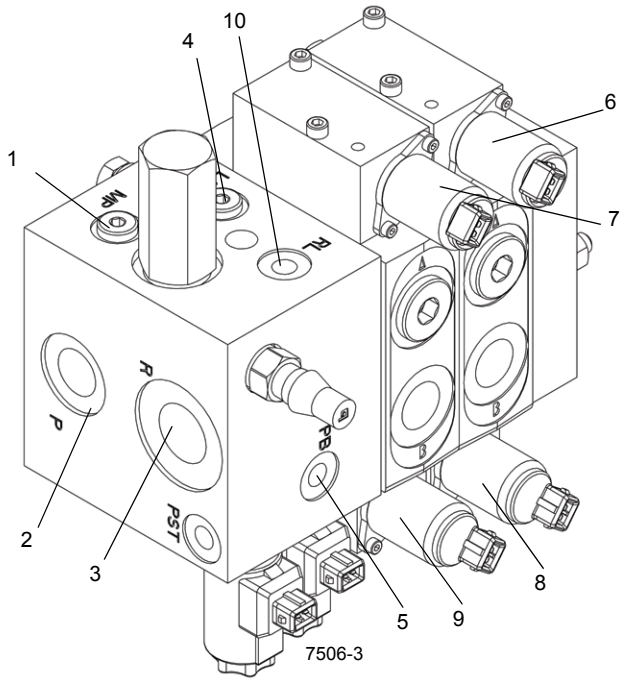


FIGURE 2-34

Item	Description
1	Port MP for Test Nipple
2	Port P - Pressure from Swivel Port 5
3	Port R - To Swivel Drain to Tank
4	Load Sense
5	Port PB - Pressure Beyond - Pressure Switch to Swing Motor

Item	Description
6	Swing Left Solenoid Valve
7	Swing Right Solenoid Valve
8	Brake Right Solenoid Valve
9	Brake Left Solenoid Valve
10	Port RL - Brake Release - Drain

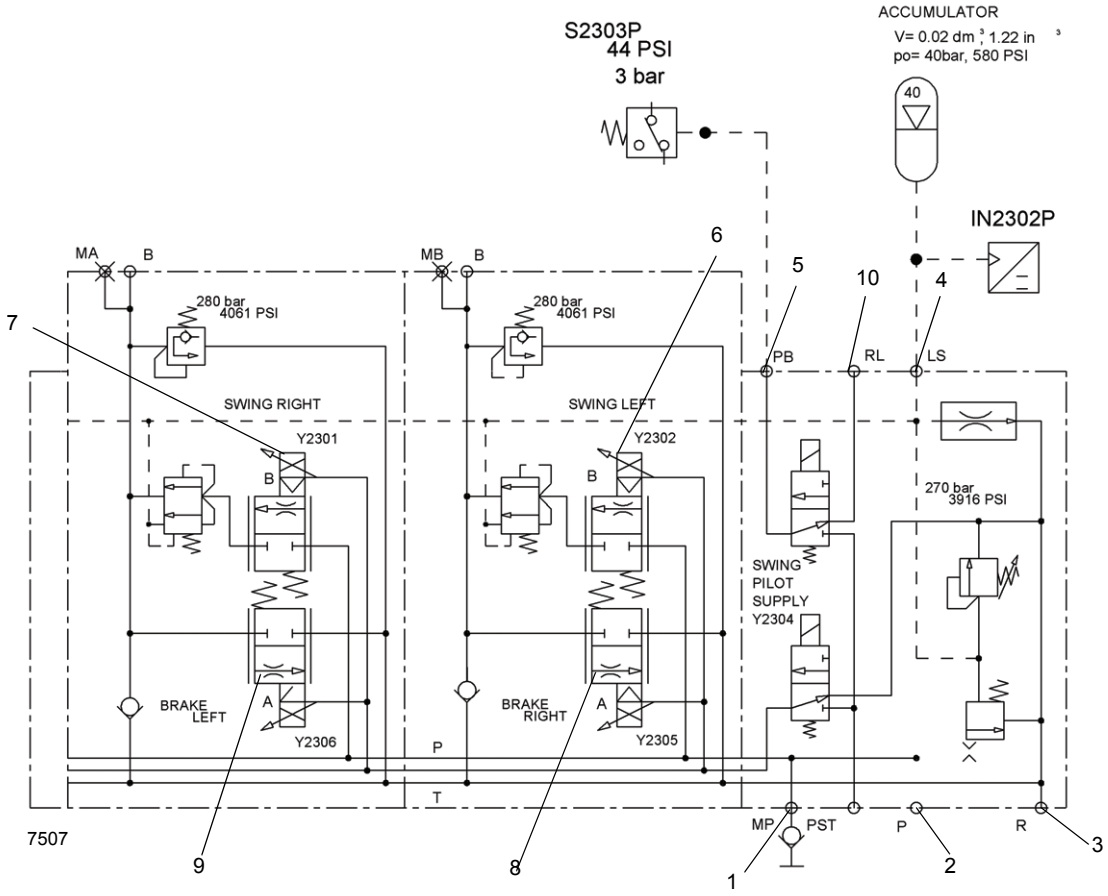


FIGURE 2-34 continued

COMPACT BLOCK MANIFOLD

Description

The compact block manifold (Figure 2-35) directs and controls hydraulic fluid flow for the counterweight pin lock, counterweight raise/lower, counterweight lock/unlock, boom extension cylinder, cab tilt and telescope pinning lock/unlock functions. The valve is located on the left side of the superstructure. The valve bank is removed and installed as an assembly.

Maintenance

Removal

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

Installation

1. Install the valve and secure with the capscrews, and washers. Torque capscrews to recommended torque.
2. Connect the hydraulic lines to the valves as tagged during removal.

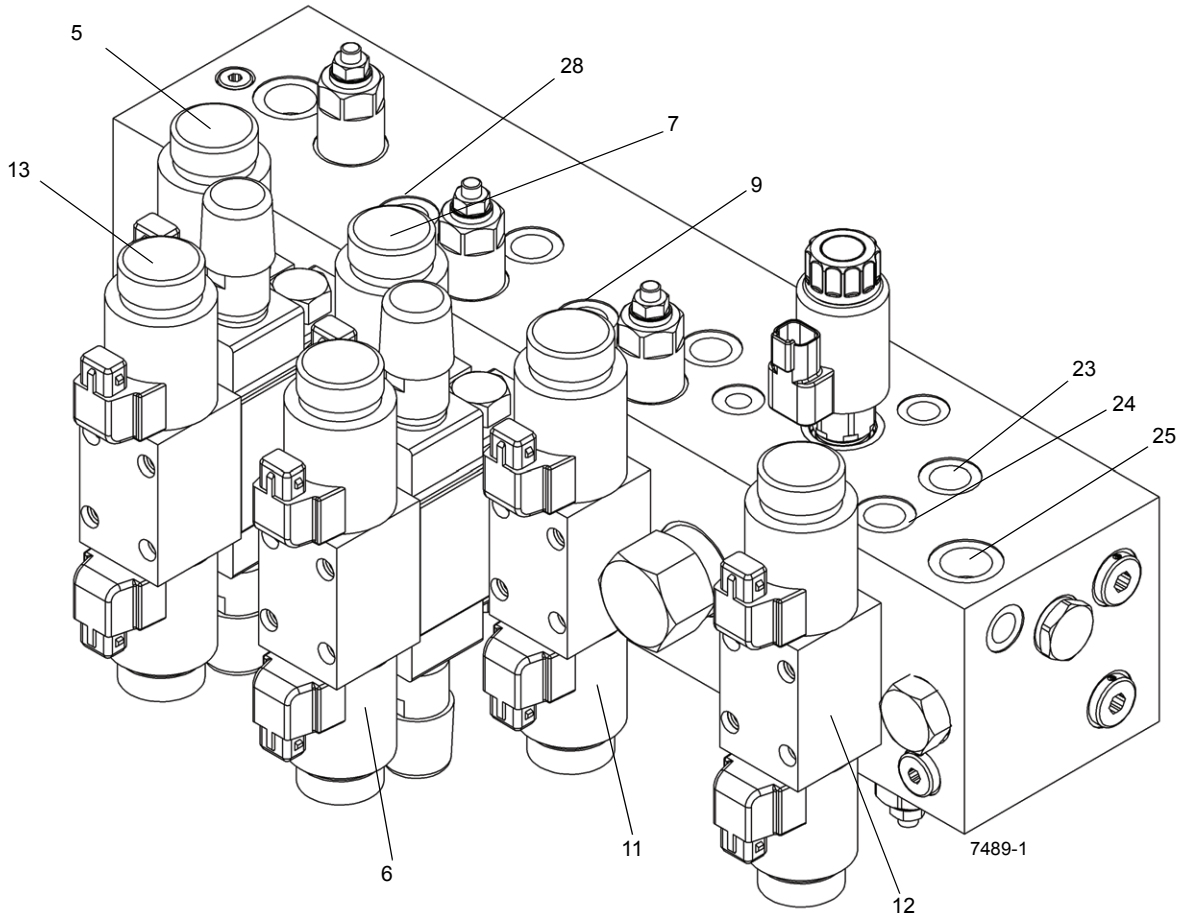


FIGURE 2-35

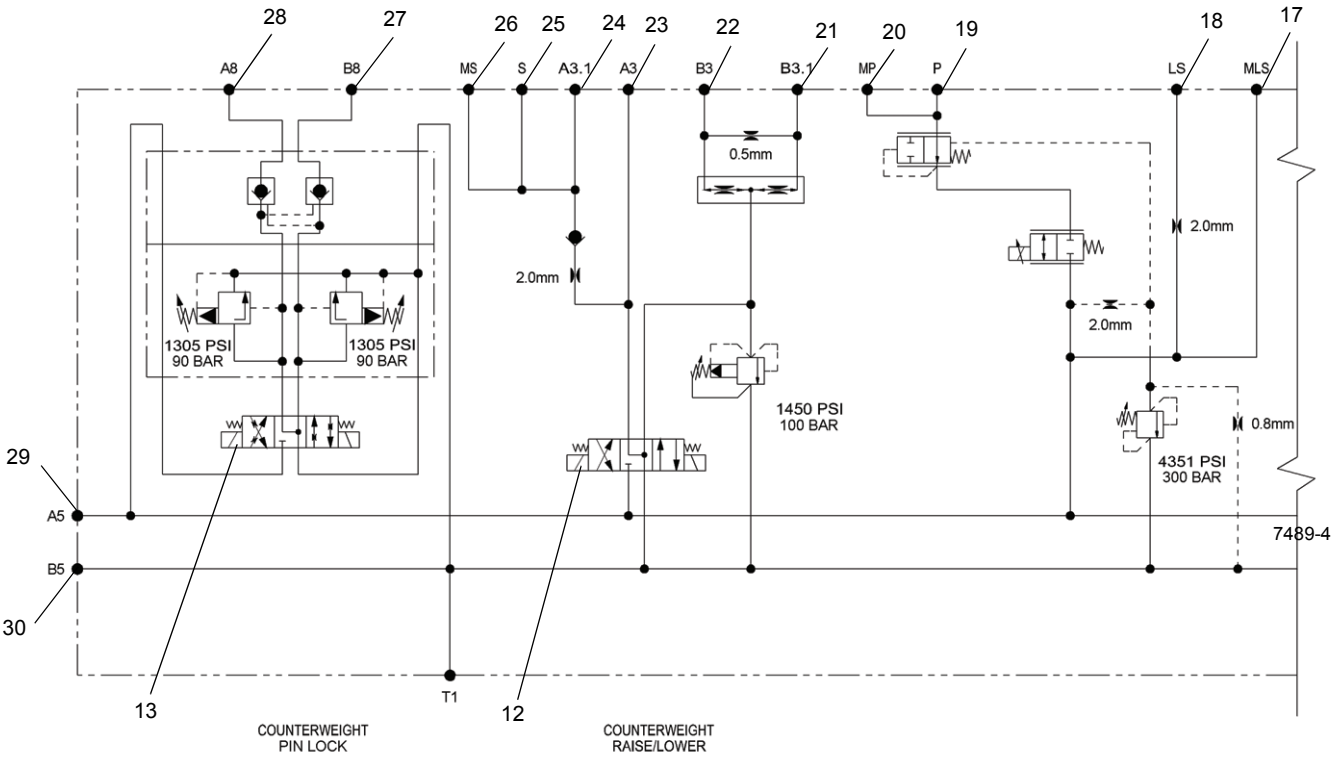


FIGURE 2-35 continued

Item	Description
1	Port MA6 for Pressure Gauge (Tele Locking)
2	Load Sense Port
3	Port A6 - Fill Passage Pipe
4	Tank Port
5	Telescope Pinning Lock/Unlock Solenoid
6	Cab Tilt Lower/Raise Solenoid Valve
7	Boom Extension Cylinder Solenoid Valve
8	Port B1 - Cab Tilt Lower
9	Port A1 - Cab Tilt Raise
10	Port B2 - Boom Extension Cylinder - Tank
11	Counterweight Lock/Unlock Solenoid Valve
12	Counterweight Raise/Lower Solenoid Valve
13	Counterweight Pin Lock Solenoid Valve
14	Port A2 - Boom Extension Cylinder- Pressure
15	Port B4 - Counterweight Lock

Item	Description
16	Port A4 - Counterweight Unlock
17	Port MLs - for Pressure Gauge
18	Load Sense Port
19	Port P - Pressure Valve
20	Port MP - for Pressure Gauge
21	Port B3.1 Counterweight Lower
22	Port B3 - Counterweight Lower
23	Port A3 - Counterweight Raise
24	Port A3.1 - Counterweight Accumulator
25	Port S - Accumulator
26	Port MS - Pressure Transducer
27	Port B8 - Counterweight Unpin
28	Port A8 - Counterweight Pin
29	Port A5 - Counterweight Pin - Tank
30	Port B5 - Counterweight Unpin - Tank

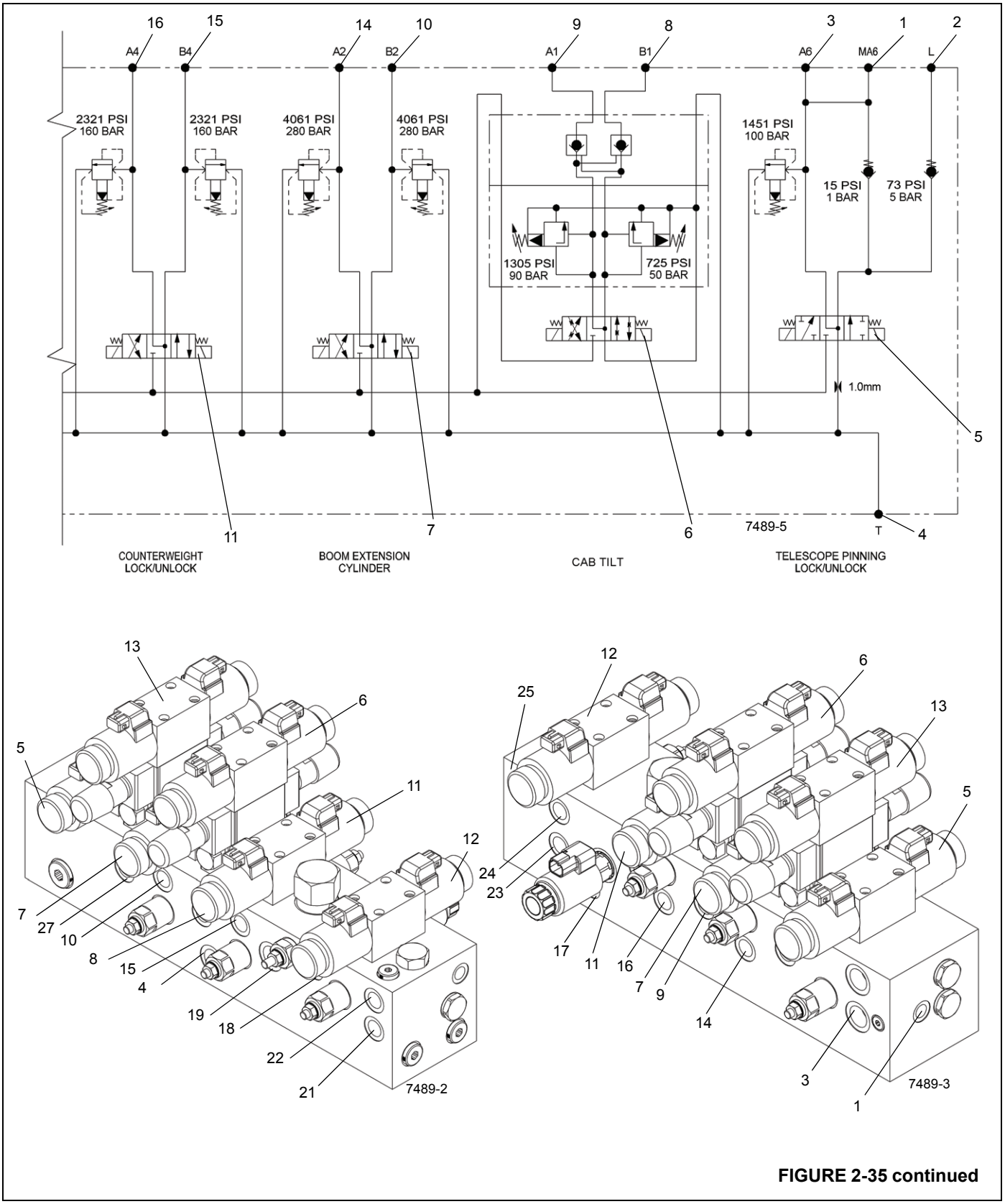


FIGURE 2-35 continued

ACCESSORY MANIFOLD

Description

The steer/brake/load sense accessory manifold (Figure 2-36) directs flow for the front steer and service brake circuits. The valve is located on a bracket in the center of the superstructure. The valve bank is removed and installed as an assembly.

Maintenance

Removal

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

Installation

1. Install the valve and secure with the capscrews, and washers. Torque capscrews to recommended torque.
2. Connect the hydraulic lines to the valves as tagged during removal.

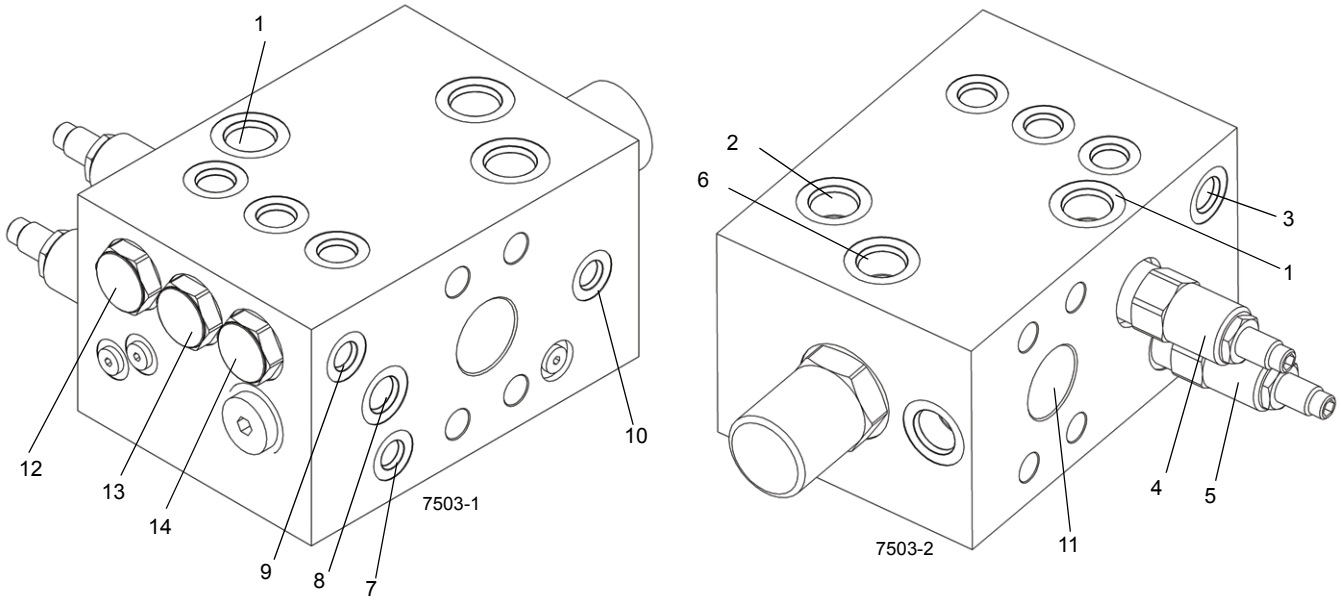


FIGURE 2-36

Item	Description
1	Port DR - Drain to Swivel Port 4 to tank
2	BRAKE Port - To Dual Accumulator Charge Valve
3	LS PUMP Port - to Swivel Port 8
4	RV1 - Relief Valve
5	PR1 - Pressure Reducing Relieving Valve
6	Port STR - To Front Steer Valve
7	Port GPB - Gauge Port for Test Nipple
8	Port 1 - Load Sense

Item	Description
9	Port GPLS - Gauge Port for Test Nipple
10	Port GPS - Gauge Port for Test Nipple
11	Port P - Pressure Port
12	Check Valve CV4 - Load Sense - Front Steer Valve
13	Check Valve - CV3 - Load Sense Dual Accumulator Valve
14	Check valve CV2 - Load Sense - to Compact Control Valve

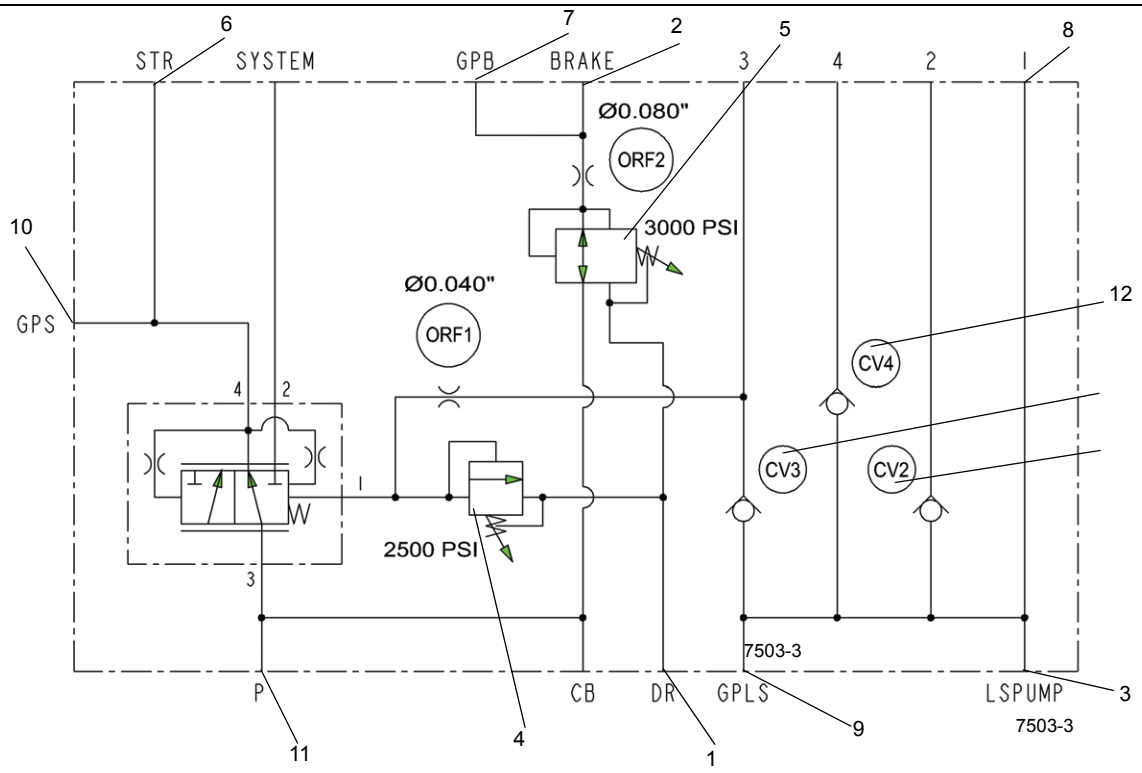


FIGURE 2-36 continued

CASE DRAIN MANIFOLD

Description

The case drain manifold (Figure 2-37) directs drain from various superstructure valves and cylinders to the reservoir. The valve is located on a bracket in the center of the superstructure. The valve bank is removed and installed as an assembly.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the manifold. Cap or plug the lines and ports.
2. Remove the capscrews, washers and nuts securing the manifold. Remove the manifold.

Installation

1. Install the manifold and secure with the capscrews, washers and nuts. Torque capscrews to recommended torque.
2. Connect the hydraulic lines to the valves as tagged during removal.

FIGURE 2-37

Item	Description
1	Drain to Reservoir
2	Drain from Hoist Motor, Swing Motor and Main Directional Control Valve
3	Drain from Dual Accumulator Charge Valve and Compact Control Block

Item	Description
4	Drain from Lift Cylinder and Main Directional Control Valve
5	Drain from Steer/Brake/Load Sense Accessory Manifold and Tandem Brake Valve

DUAL ACCUMULATOR CHARGE VALVE

Description

The load sensing dual accumulator charging valve (Figure 2-38) 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 an inlet main check valve, a load sense control section with a pilot spool that controls the pump stroke and an inverted shuttle that controls the accumulator charging (Figure 2-38).

When the valve is charging the accumulators, the load sense control section is in neutral position, connecting the load to the pump by way of the load sense line. This brings the piston pump No. 1 on stroke to supply fluid for charging. Fluid passes through the main check valve connecting to the pilot end and through the spool onward to the inverted shuttle that connects the accumulators.

When the control pilot spool bias spring senses the low limit pressure of 1950 psi (13,445 kPa), the spool shifts to the neutral position, allowing the pump to charge the accumulators to a maximum of 2320 psi (15,996 kPa). The inverted shuttle cartridge senses the pressure in the accumulators to pilot the cartridge closed when maximum charge pressure is reached. Maximum charge pressure also pilots the control pilot spool to open the load sense line to tank, de-stroking the piston pump No. 1.

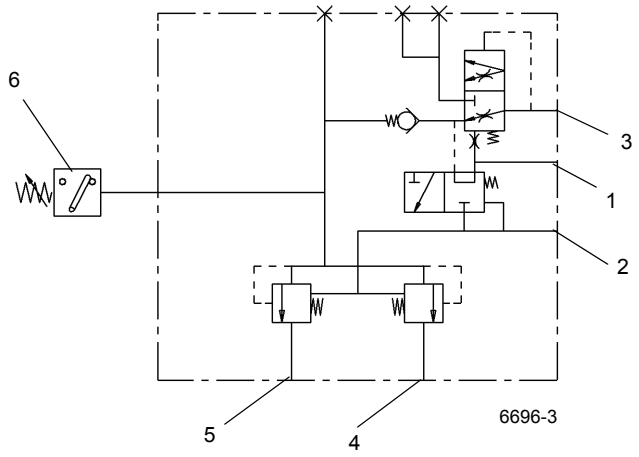
Maintenance

Removal

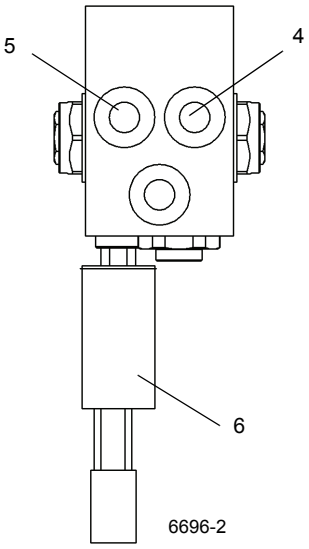
1. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
2. Remove the capscrews, flatwashers and lockwashers securing the valve to the turntable. Remove the valve.

Installation

1. Position the valve on the turntable and secure with the capscrews, flatwashers, and lockwashers. Torque capscrews to recommended torque.
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.



Valve Hydraulic Schematic



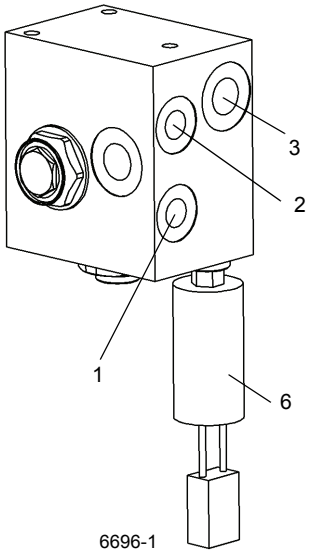


FIGURE 2-38

Item	Description
1	Port LS - Load Sense Port - To Port 3 of Steer/Brake/Load Sense Accessory Manifold
2	Port T - Tank Port - To Compact Control Block and Port 4 of Case Drain Manifold
3	Port P - Pressure Port - To Brake Port of Steer/Brake/Load Sense Accessory Manifold

Item	Description
4	Accumulator Port A1 - To Accumulator and Tandem Brake Valve
5	Accumulator Port A2 - To Accumulator and Tandem Brake Valve
6	Pressure Switch

CONTROL BLOCK

Description

The control block (Figure 2-39) is used in the main and auxiliary hoist circuit. The valve bank is removed and installed as an assembly.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the manifold. Cap or plug the lines and ports.
2. Remove the capscrews and washers securing the manifold. Remove the manifold.

Installation

1. Install the manifold and secure with the capscrews, washers and nuts. Torque capscrews to recommended torque.
2. Connect the hydraulic lines to the valves as tagged during removal.

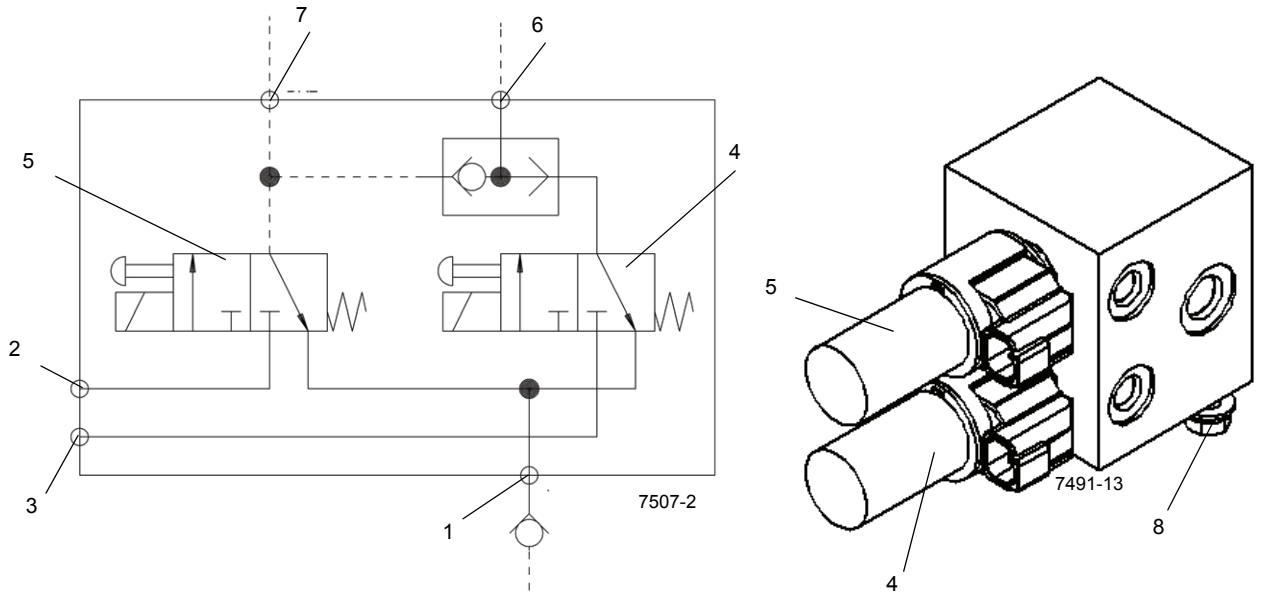


FIGURE 2-39

TANDEM BRAKE VALVE W/ TREADLE PEDAL

Description

The tandem brake valve with treadle pedal (Figure 2-40) 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 to the brake actuators.

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

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

The tandem brake valve consists of a tandem valve body, a closed center spool, a treadle pedal, an integral proximity switch and a mechanical spring assembly.

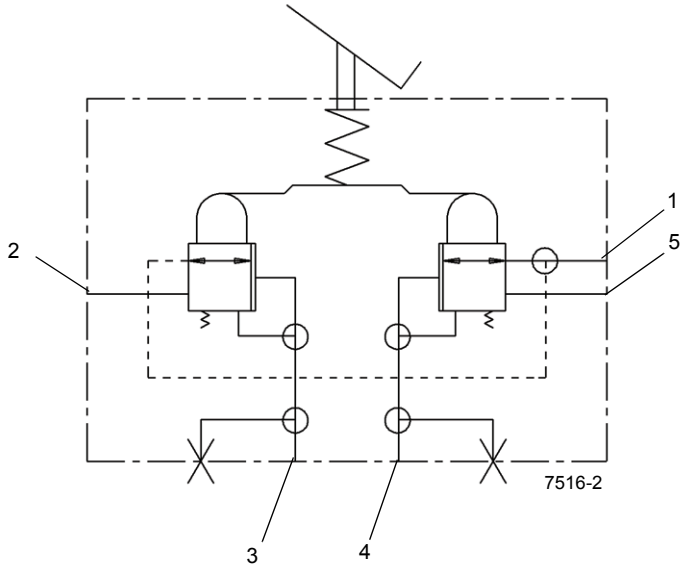
Maintenance

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 hardware securing the valve to the cab floor. Remove the valve.

Installation

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



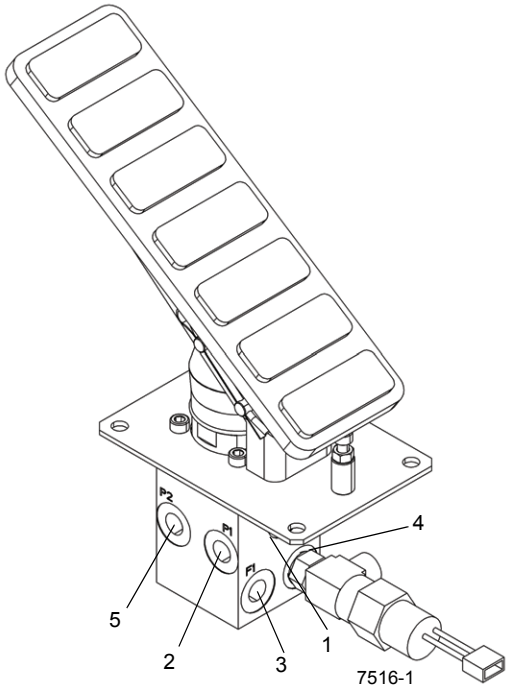


FIGURE 2-40

Item	Description
1	Port P2 from Port A1 of Dual Accumulator Charge valve
2	Port P1 from Port A2 of Dual Accumulator Charge Valve

Item	Description
3	Port F1 to Swivel Port 10 to Rear Disc Brakes
4	Port F2 to Swivel Port 9 to Front Disc Brakes

HYDRAULIC ACCUMULATOR SERVICE BRAKE

Description

The service brake hydraulic accumulators are located on the center of superstructure in the swivel area. The purpose of each accumulator is to provide stored energy, an oil volume of 231 cu in (3.8 liters) at a maximum pressure of 2320 psi (15,996 kPa), to actuate the service brake circuits. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits.

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

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

Maintenance

Removal

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

Installation

1. Position the accumulator in the clamps and secure with the removable clamp halves and nuts.
2. Connect the hydraulic hose to the port on the accumulator as tagged during removal.
3. Pre-charge the accumulator. Refer to *Procedure for Pre-Charging the Service Brake Accumulators, If Required, pg 2-33*.
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

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 (Table 2-5). In addition, each wear ring gap is to be located as follows: Divide 360 degrees by the number of wear rings on the component. The resulting value is the number of degrees each wear ring gap is to be located with respect to each other.

The approximate wear ring gaps are as follows:

Table 2-5
Wear Ring Gap

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

Surface Protection For Cylinder Rods

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

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

CAUTION

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

Leakage Check

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

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

DANGER

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

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

DANGER

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

4. Apply hydraulic pressure to the retract (rod) side of the cylinder and observe the open cylinder port for leakage.

If leakage is observed, the seals in the cylinder must be replaced.

5. Reconnect all cylinder ports.

Temperature Effects on Hydraulic Cylinders

Hydraulic fluid 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 fluid is approximately 0.00043 cubic inches per cubic inch of volume for 1°F of temperature change. **Thermal contraction will allow a cylinder to retract as the hydraulic fluid which is trapped in the cylinder cools.** The change in the length of a cylinder is proportional to the extended length of the cylinder and to the change in temperature of the oil in the cylinder. For example, a cylinder extended 25 feet in which the oil cools 60°F would retract approximately 7 3/4 inches (see chart below). A cylinder extended 5 feet in which the oil cools 60°F would only retract approximately 1 1/2 inches. The rate at which the oil cools depends on many factors and will be more noticeable with a larger difference in oil temperature verses the ambient temperature.

Thermal contraction coupled with improper or inadequate lubrication or improper wear pad adjustments and operation at low boom angles may, under certain conditions, cause a “stick-slip” condition in the boom. This “stick-slip” condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement, of the boom may be undetected by the operator unless a load is suspended for a long period of time. To minimize the effects of thermal contraction of “slip stick” it is recommended that the telescope control lever is activated periodically in the extend position to mitigate the effects of the cooling oil.

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

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

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

CAUTION

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

Table 2-6

BOOM DRIFT CHART (Cylinder length change in inches)

Coeff. = 0.00043 (in^3/in^3/ °F)

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

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

Temperature Effects on Hydraulic Cylinders

FIGURE 2-41

Table 2-7 BoomDrift 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

AXLE OSCILLATION LOCKOUT CYLINDER

Description

The two oscillation lockout cylinders (Figure 2-42) each have 7.0 in (17.7 cm) diameter bores. The retracted length of each cylinder is 26.31 in (66.8 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 33.93 in (86 cm). Its stroke is 7.62 in (19.3 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 192.0 lb (87.1 kg).

Maintenance

Disassembly

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

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

CAUTION

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

CAUTION

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

2. 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.

3. Remove the seal and wear rings from the outside of the piston.
4. Remove the nut from the rod and remove the piston from the rod.

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

Inspection

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

CAUTION

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. Damage to the cylinder or unexpected operation may result.

NOTE: Lubricate seals and rings with clean hydraulic fluid.

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

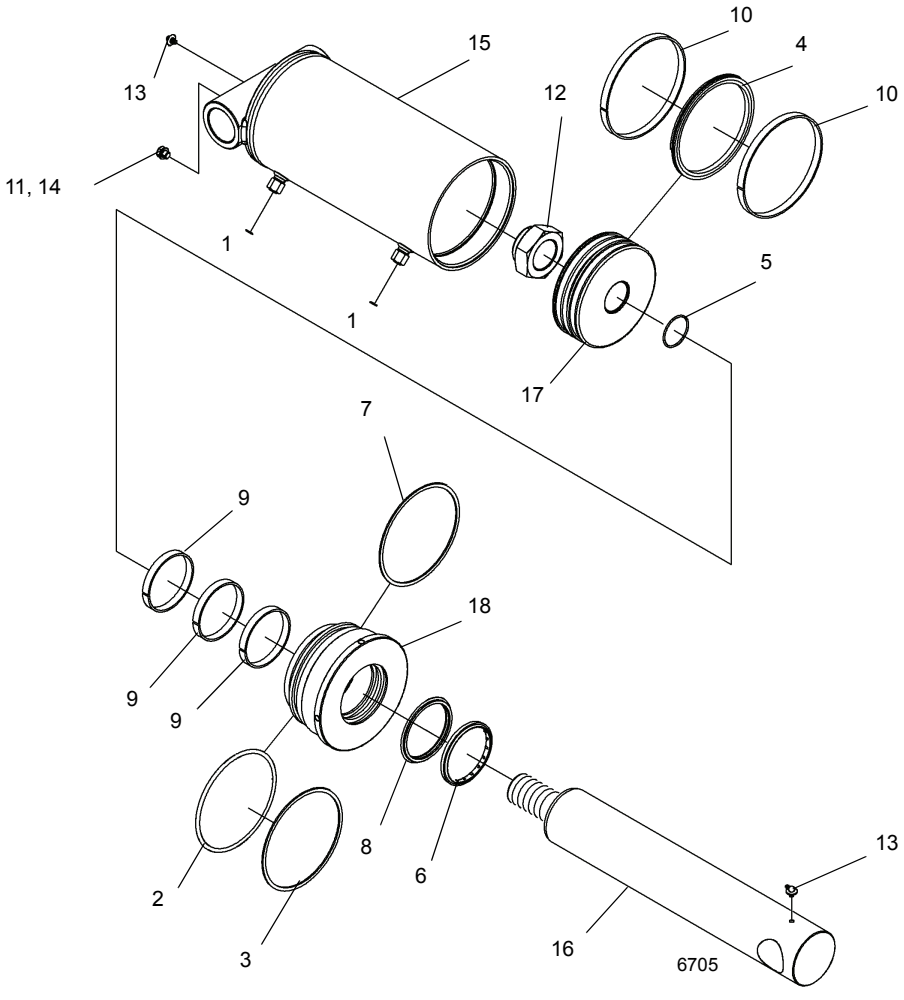


FIGURE 2-42

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

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

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

CAUTION

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

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

CAUTION

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

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

STEER CYLINDER

Description

The steer cylinders (Figure 2-43) are mounted on the axles, two cylinders on each axle.

The steer cylinder has a 3.5 inch (8.89 cm) diameter bore. The steer cylinder has a retracted length of 28 in (711.2 mm) from bushing center to bushing center. The steer cylinder has an extended length of 42.25 in (1073.2 mm) from bushing center to bushing center. Each cylinder has a stroke of 14.25 in (362 mm).

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

The cylinder weighs approximately 40 lb (20 kg).

Maintenance

Disassembly

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

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

CAUTION

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

CAUTION

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

3. Remove 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.

4. Remove the piston 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.

5. Loosen and remove the nut securing the piston. Remove the piston from the rod.
6. Remove the O-ring from the inside of the piston.
7. Remove the spacer and head from the rod.
8. Remove the O-ring and backup ring from the outside of the head and the wiper ring and rod seal from the inside of the head.
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 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. Damage to the cylinder or unexpected operation may result.

NOTE: Lubricate seals and rings with clean hydraulic fluid.

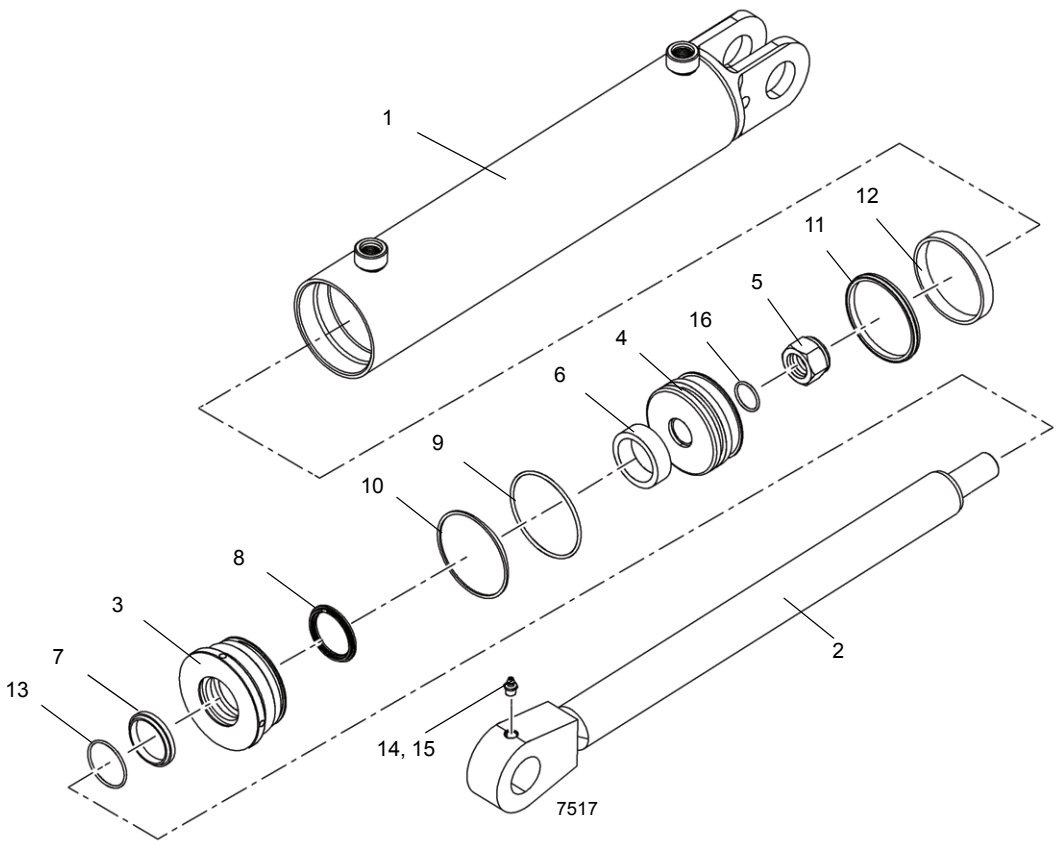


FIGURE 2-43

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

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

1. Install the O-ring onto the rod.
2. Install the replacement wiper ring and rod seal in the inside of the head. Make sure the lips of the seal face the piston.
3. Install the replacement O-ring and the backup ring on the outside of the head.
4. Install the replacement O-ring in the inside of the piston.
5. Lubricate the rod with clean hydraulic fluid.
6. Slide the head, larger OD end first, onto the rod.
7. Install the piston onto the rod. Secure the piston with the nut.
8. Install the replacement piston seal and wear ring on the outside of the piston.
9. Lubricate all parts freely with clean hydraulic fluid.

CAUTION

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

10. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
11. Thread the head into the barrel and using a spanner wrench or chain wrench, tighten the head.

CAUTION

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

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

OUTRIGGER EXTENSION CYLINDER

Description

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

Each cylinder (Figure 2-44) has a retracted length of 108.88 ± 0.12 in (276.5 cm) from the center of the rod bushing to the center of the barrel bushing. Each cylinder's extended length is 205.9 ± 0.12 in (523 ± 0.30 cm). The stroke of each cylinder is 97 in (246 mm).

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

The cylinder weighs approximately 104.9 lb (47.6 kg).

Maintenance

Disassembly

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

CAUTION

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

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

1. Using a spanner wrench or chain wrench, unscrew the head from the cylinder barrel.
2. Rapidly pull the rod against the head to free it. Remove rod and attached parts from the barrel.

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

4. Remove the nut and piston from the rod.
5. Remove the head from the rod.
6. Remove the O-ring and backup ring from the outside of the head and the wear ring, rod seal and wiper ring from the inside of the head.
7. 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. Damage to the cylinder or unexpected operation may result.

NOTE: Lubricate seals and rings with clean hydraulic fluid.

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

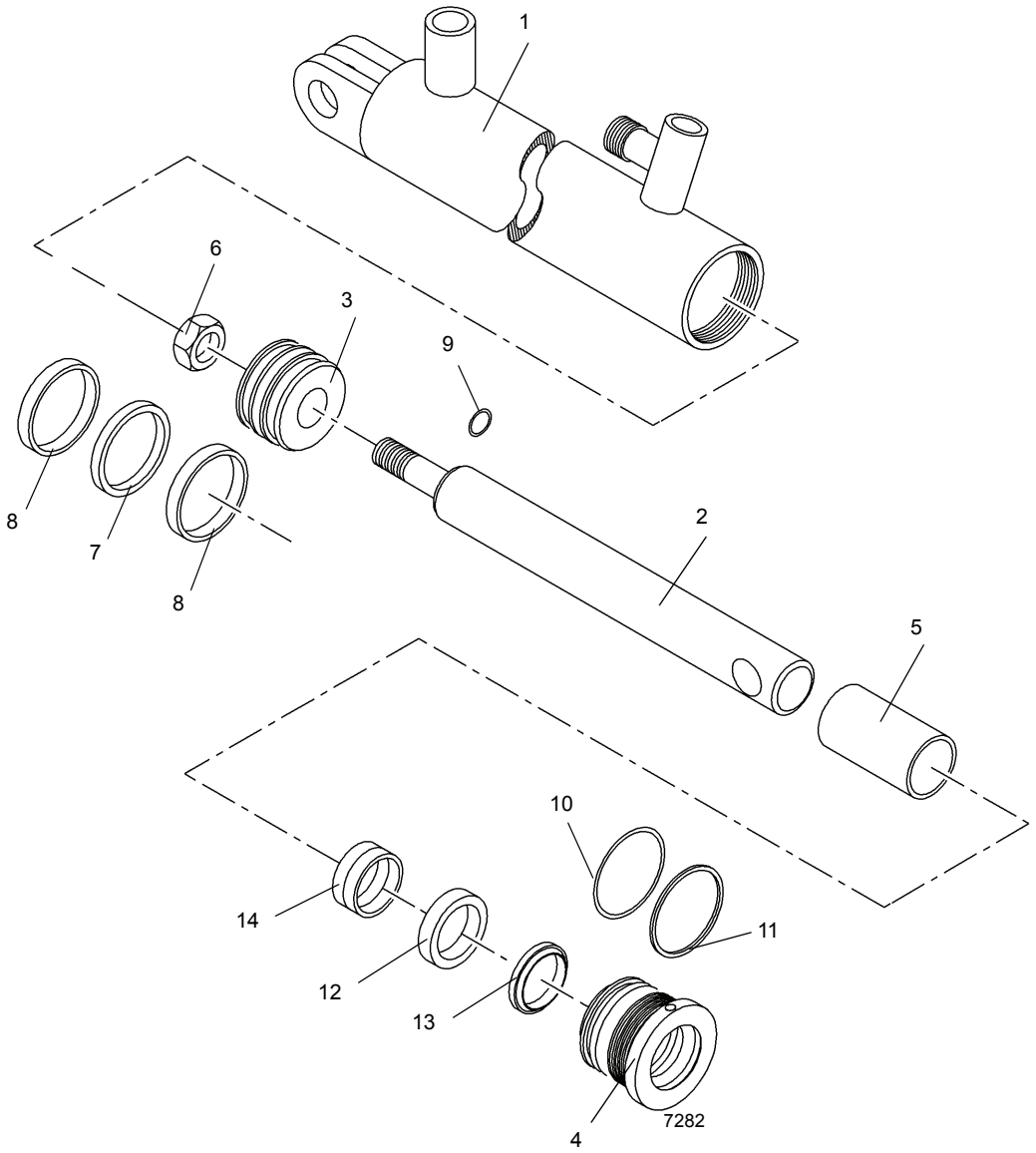


FIGURE 2-44

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

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

5. Slide the head, wear ring end first, onto the rod.
6. Install the replacement wear rings and seal on the outside of the piston.
7. Lubricate all parts freely with clean hydraulic fluid.

CAUTION

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

8. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
9. Push the head into the barrel.Install the nut on the rod.

CAUTION

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

10. Pressurize and cycle the cylinder with hydraulic fluid pressure. Static pressure test the cylinder at 20684 kPa/ 20.6 bar (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER STABILIZER CYLINDER

Description

The four outrigger stabilizer cylinders each have a hollow rod for internal porting (Figure 2-45). Each cylinder has a 6.5 in (165.1 mm) diameter bore. A port block is welded to the rod of each cylinder and a pilot operated check valve is threaded into each port block.

The retracted length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 55.75 ± 0.12 in (142 ± 0.30 cm). The extended length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 88 ± 0.12 in (223.5 cm). Its stroke is 32.25 in (82 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 331 lb (150 kg).

Maintenance

Disassembly

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

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

CAUTION

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

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

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

Inspection

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

CAUTION

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

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

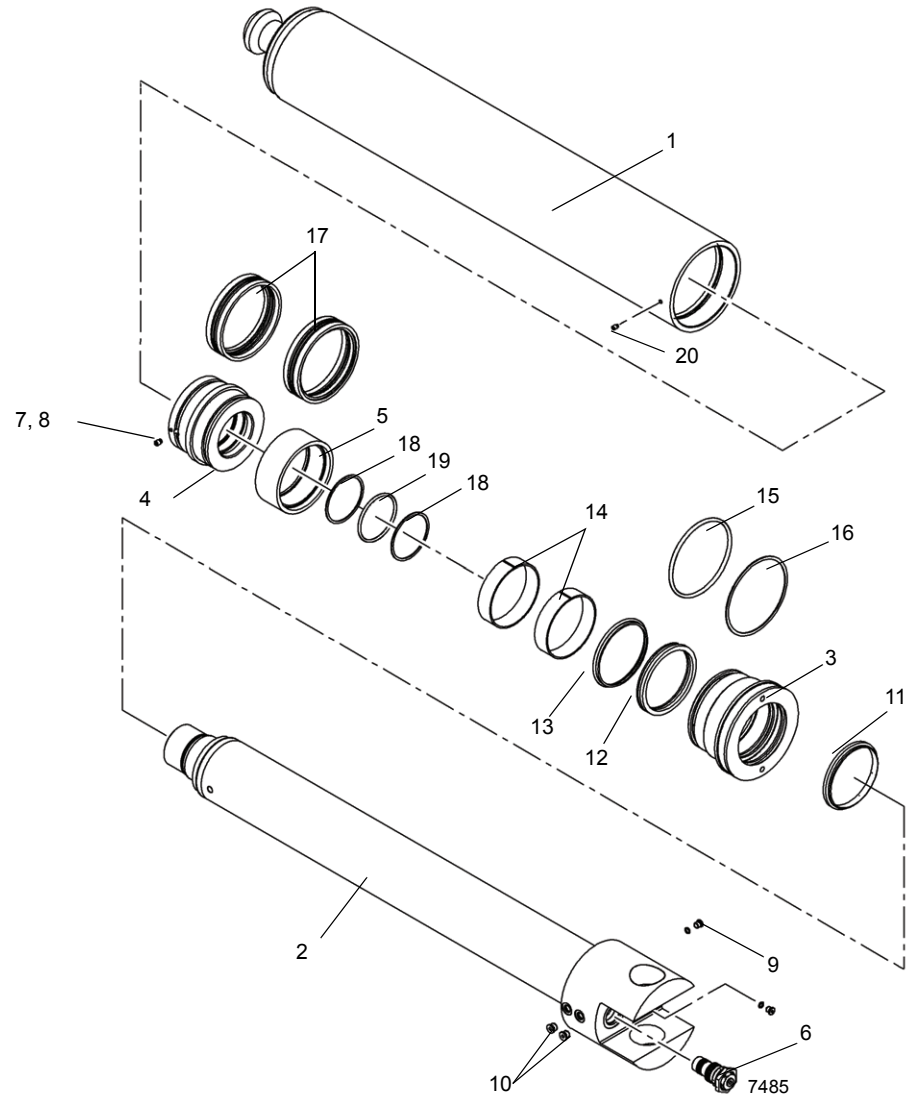


FIGURE 2-45

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	Rod Seal
13	Buffer Seal
14	Wear Ring
15	O-ring
16	Backup Ring
17	Seal Assembly
18	O-ring
19	Backup Ring
20	Setscrew

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic fluid.

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

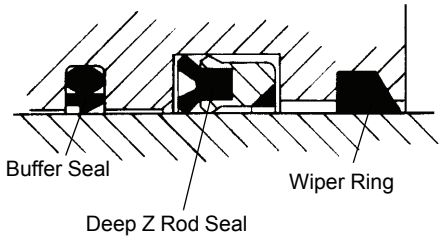


FIGURE 2-46

1. Install the replacement wear rings, buffer seal, rod seal and wiper ring in the inside of the head (Figure 2-46). Make sure the buffer seal's step is away from the wear rings. Make sure the deep Z rod seal rim groove is closer to the wear rings.
2. Install the replacement O-ring and the backup ring on the outside of the head.
3. Install the replacement O-ring and backup rings in the inside of the piston.

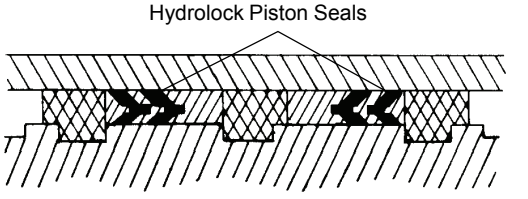


FIGURE 2-47

4. Install one replacement hydrolock seal on the outside of the piston (Figure 2-47). Leave the other hydrolock seal off for now so there is still access to the piston's set screw hole.
5. Lubricate the rod with clean hydraulic fluid.
6. Slide the head, larger OD end first, onto the rod.
7. Slide the spacer onto the rod.
8. Screw the piston onto the rod until it can go no farther. Hold the piston in place with the set screw.
9. Install the other replacement hydrolock seal on the outside of the piston over the setscrew. Make sure the "vees" on the two hydrolock seals point at each other.
10. Lubricate all parts freely with clean hydraulic fluid.

CAUTION

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

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

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.

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

CAUTION

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

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

CAB TILT CYLINDER

Description

The cab tilt cylinder (Figure 2-48) installed beneath the cab has a 2.5 in (6.3 cm) diameter bore.

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

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

The cylinder weighs approximately 19.9 lb (9.07 kg).

Maintenance

Disassembly

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

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

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

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

CAUTION

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

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.
11. Remove the O-ring and backup ring from the outside of the head. Remove the wiper ring and the rod seal from the inside of the head.

Inspection

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

CAUTION

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

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

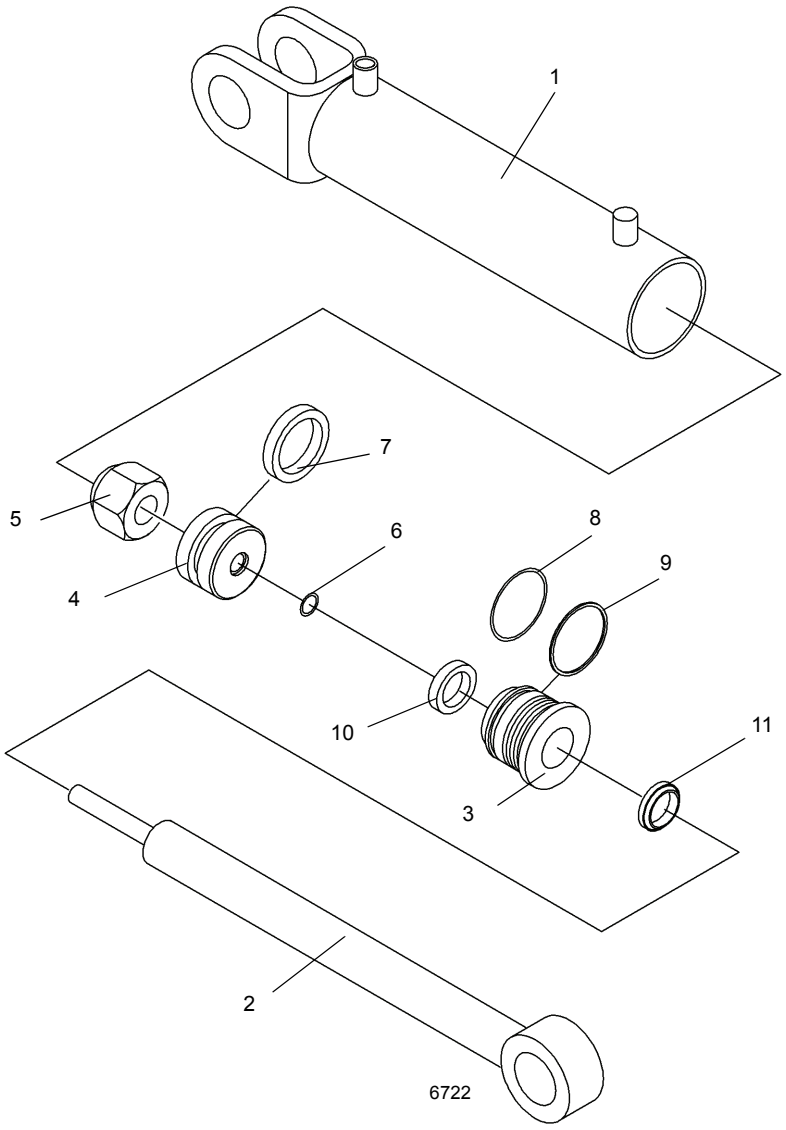


FIGURE 2-48

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

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

Assembly

CAUTION

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

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

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.
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 fluid.
6. Slide the head, larger outside diameter 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 fluid.

CAUTION

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

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 to 20 lb-ft (27.1 Nm).

CAUTION

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

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

POWER PIN CYLINDER

Description

The power pin cylinders (Figure 2-49) are installed in the outrigger box assemblies have a 4.0 in (10.1 cm) diameter bores.

The cylinder has a retracted length of 20.31 in (51.5 cm) and an extended length of 26.43 in (67.1cm). Each cylinder has a stroke of 6.12 in (15.5 cm).

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

The cylinder weighs approximately 60.1 lb (27.3 kg).

Maintenance

Disassembly

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

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

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

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

CAUTION

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

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

8. Unscrew the rod end from the rod.
9. Remove the seal and wear rings from the outside of the piston.

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

10. Loosen and remove the nut securing the piston. Remove the piston from the rod.
11. Remove the O-ring from the inside of the piston.
12. Remove the head from the rod.
13. Remove the O-ring, backup ring and wire wrap from the outside of the head.
14. Remove the wiper ring and rod seal from the inside of the head.

Inspection

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

CAUTION

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

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

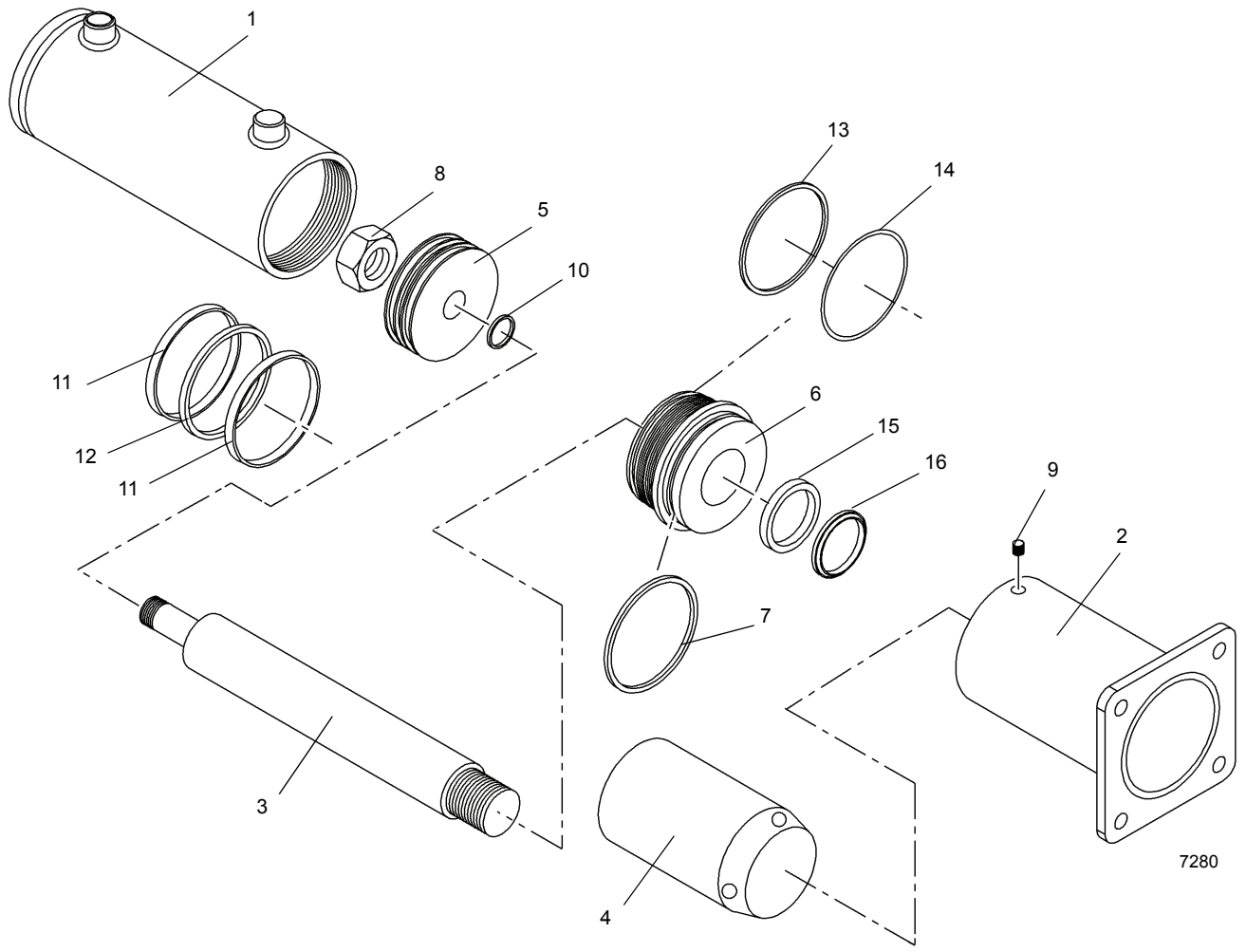


FIGURE 2-49

Item	Description
1	Barrel
2	Flange
3	Rod
4	Rod End
5	Piston
6	Head
7	Wire Wrap
8	Nut

Item	Description
9	Setscrew
10	O-ring
11	Wear Ring
12	Piston Seal
13	O-ring
14	Backup RIng
15	Rod Seal
16	Wiper Ring

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 new seals and rings with clean hydraulic fluid.

1. Install the replacement wiper ring and rod seal into the inside of the head.
2. Install the O-ring, backup ring and wire wrap on the outside of the head.
3. Install the O-ring in the inside of the piston.
4. Lubricate the rod with clean hydraulic fluid.
5. Install the head onto the rod. Torque to 200 ± 20 lb-ft (271.1 ± 27.1 Nm).
6. Install the piston onto the rod. Secure the piston with the nut. Lubricate the threads and torque the nut to 245 ± 15 lb-ft (332.1 ± 20.3 Nm).
7. Install the seal and wear rings on the outside of the piston.
8. Lubricate all parts freely with clean hydraulic fluid.
9. Apply 0.13 in (3 mm) bead of Loctite thread adhesive #277 or equivalent across the length of the threads on the rod end side of the rod. Install the rod end on the rod and torque to 375 to 450 lb-ft (508.4 to 610.1 Nm).

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.

CAUTION

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

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

COUNTERWEIGHT PIN CYLINDER

Description

The counterweight pin cylinder (Figure 2-50) has a 2.0 in (5.08 cm) diameter bore. The cylinder has a retracted length of 20.53 in (52.15 cm) from end to end and an extended length of 32.53 in (82.63 cm) from end to end. Each cylinder has a stroke of 12.0 in (30.48 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 13.2 lb (6.0 kg).

Maintenance

Disassembly

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

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

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

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

CAUTION

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

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. Using a chain wrench, unscrew the head from the barrel.
7. 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 grooved and gland surfaces.

8. 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.

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

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 new seals and rings with clean hydraulic fluid.

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.
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 fluid.
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 ± 6.7Nm).
8. Install the seal on the outside of the piston.
9. Lubricate all parts freely with clean hydraulic fluid.

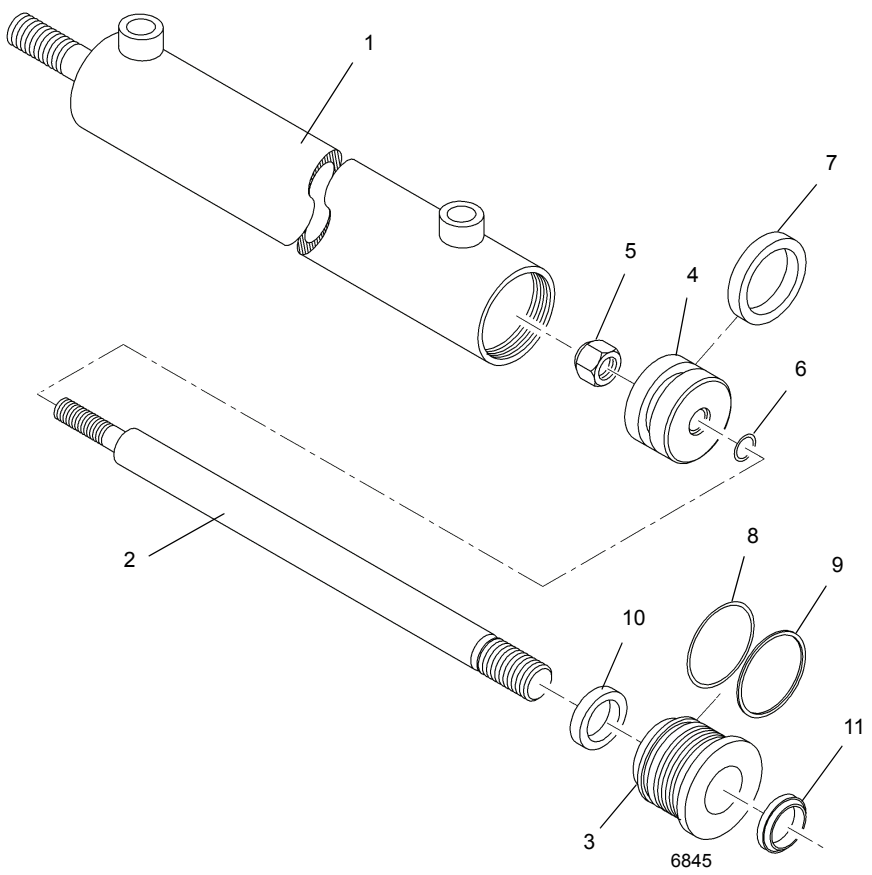


FIGURE 2-50

Item	Description
1	Barrel
2	Rod
3	Rod Head
4	Piston
5	Nut
6	O-ring
7	Seal Piston Ring
8	O-ring
9	Backup Ring
10	Seal Rod Ring
11	Wiper Ring

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. Torque the head to 20 lb-ft (27.1 Nm).

CAUTION

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

12. Pressurize and cycle the cylinder with hydraulic fluid pressure. Test the cylinder at 24,115 kPa/241.15 bar (3500 psi). Check for proper operation and any leakage. Make repairs as needed.

LIFT CYLINDER

Description

The lift cylinder has a retracted length of 194.4 in (4940 mm) and an extended length of 357.8 in (9090 mm). The cylinder has a stroke of 163.3 in (4150 mm).

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

The cylinder weighs approximately 2764 lb (1254 kg).

Maintenance

Disassembly

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

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.
3. Disconnect the tubing from the valves on the outside of the barrel. Remove the valves.
4. Disconnect the tubing from the barrel.
5. Remove the cap and screw from the barrel.

CAUTION

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

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

6. 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 grooved and gland surfaces.

7. Remove the seal and wear rings from the rod.

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

Assembly

CAUTION

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

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

1. Install the replacement wiper ring into the head.
2. Install the seals and wear rings in the inside of the head.
3. Install the O-ring onto the outside of the head.
4. Install the seals and wear rings onto the rod.
5. Lubricate the rod with clean hydraulic fluid.

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.

6. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
7. Install the screw and cap into the barrel.
8. Install the valves and tubing to the outside of the barrel.

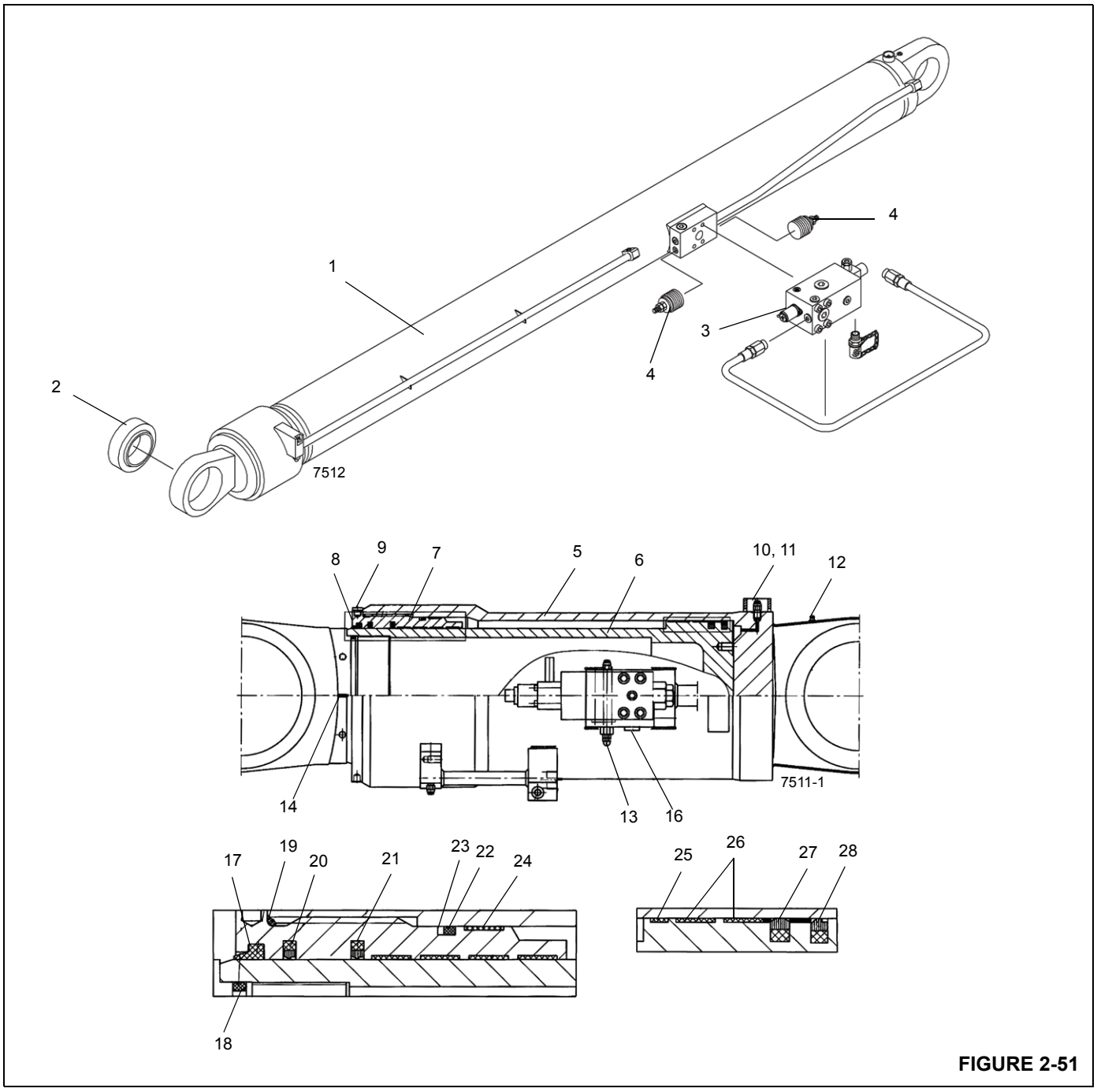


FIGURE 2-51

Item	Description
1	Lift Cylinder
2	Bearing
3	Stop Brake Valve
4	Pressure Pick-Off valve
5	Barrel
6	Rod

Item	Description
7	Bushing
8	Head
9	Safety Cam
10	Screw
11	Cap
12	Grease Fitting

Item	Description
13	Relief valve
14	Thread Pin
15	Lockscrew
16	Check Valve
17	Wiper Ring
18	O-ring
19	O-ring
20	Seal
21	Step Seal
22	O-ring
23	Backup Ring
24	Wear Ring
25	Guide Ring
26	Wear Ring
27	Seal
28	Step Seal

CAUTION

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

9. Pressurize and cycle the cylinder with hydraulic fluid pressure. Test the cylinder at 3500 psi (24,115 kPa). Check for proper operation and any leakage. Make repairs as needed.

SECTION 3
ELECTRICAL SYSTEM

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DESCRIPTION

General

The electrical system is 24-volt operation with 24-volt starting, consisting of an alternator and four lead-acid batteries. The system is the single wire ground return type, using the machine's structure as ground.

Electrical power is transferred to and from the superstructure through the electrical swivel. For more detailed information on the electrical swivel, refer to *Electrical Swivel, page 6-19*.

The superstructure control module is located behind the front console in the cab and the carrier control module is located near the hydraulic fluid tank.

Alternator

The alternator (Figure 3-1) is mounted on the engine and is belt driven. It is a 70 ampere alternator with an integral transformer - rectifier unit. When the engine is running, and the alternator is turning, the alternator's 24-volt output terminal supplies the crane's electrical circuits. The output terminal also supplies the voltage to recharge the batteries and maintains them at a full state of charge.

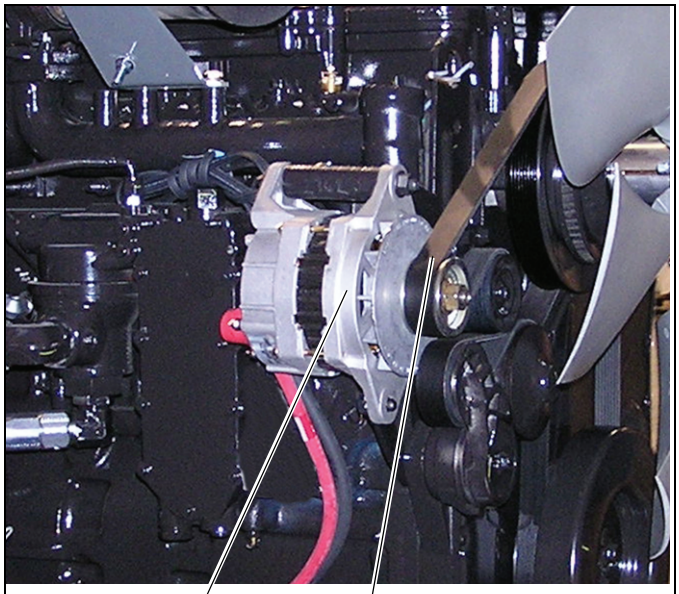


FIGURE 3-1

Batteries

The batteries (Figure 3-2) are located in the battery box on the left side of the crane behind the fuel tank. Each battery is the maintenance free type and is completely sealed except for a small vent hole in the side. The vent hole allows what small amount of gases that are produced in the battery to escape. On some batteries, a test indicator located on the top of the battery is used to determine if the battery can be tested in case of a starting problem.

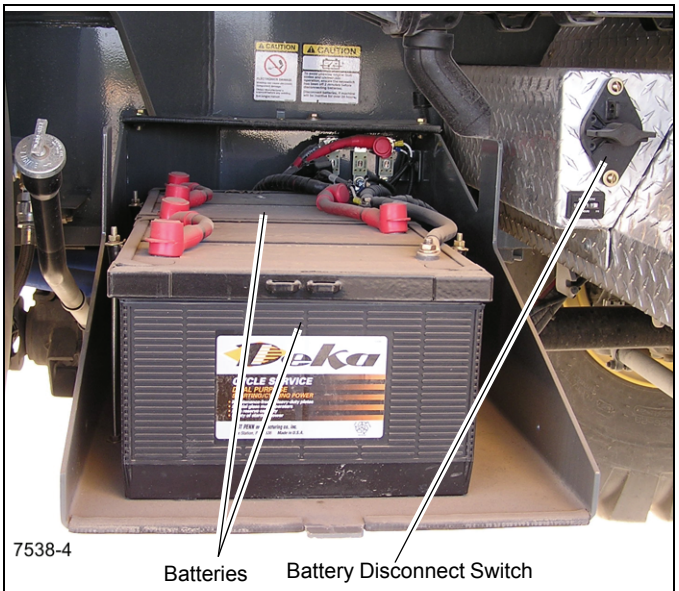


FIGURE 3-2

CAUTION!

Possible Equipment Damage!

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

The battery disconnect switch is located to the right side of the battery box below the air filter (Figure 3-2).To disconnect the batteries, turn the battery disconnect switch to OFF. Turn the switch to ON to connect the batteries.

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

Fuses/Relays

Fuses protect the electrical circuits and components of the crane from shorts and overloads. Relays are used to control various circuits and/or components. The four main locations for the fuses and relays are:

- The battery box
- The engine compartment
- The cab fuse/relay panel
- The junction box fuse/relay panel.

Battery Box

The battery box is located to the right of the fuel tank. The fuses are located at the rear of the battery box behind the batteries, refer to Figure 3-3 and Table 3-1 for specific information on each fuse.

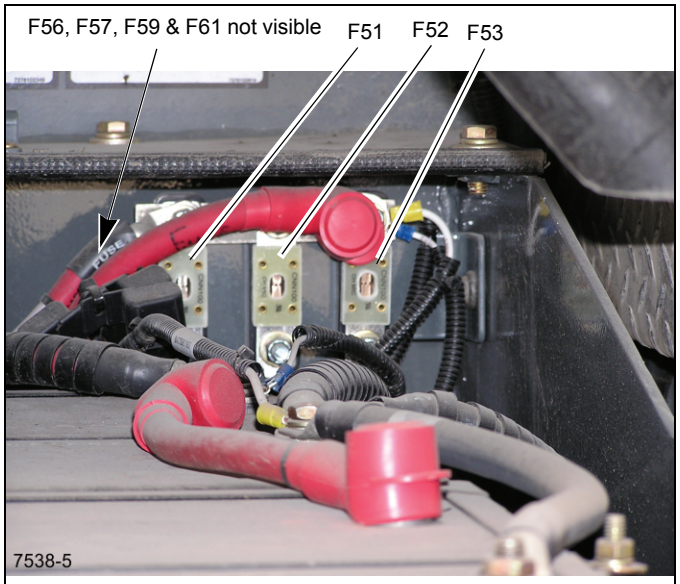


FIGURE 3-3

Table 3-1: Battery Box Fuses (Figure 3-3)

Fuse	Amp	Fuse Circuit	Supply
F51	100	Superstructure Power	B+
F52	100		
F53	100		
F56	30	Engine ECM Power	
F57	5	Diagnostic Connector Power	
F59	5	CraneSTAR Power	
F61	5	ESX-3 Power	

Engine Compartment

The fuses and relays are located at the front of the engine compartment to the left of pumps #1 and #3, refer to Figure 3-4, Table 3-2 and Table 3-3 for specific information on each component.

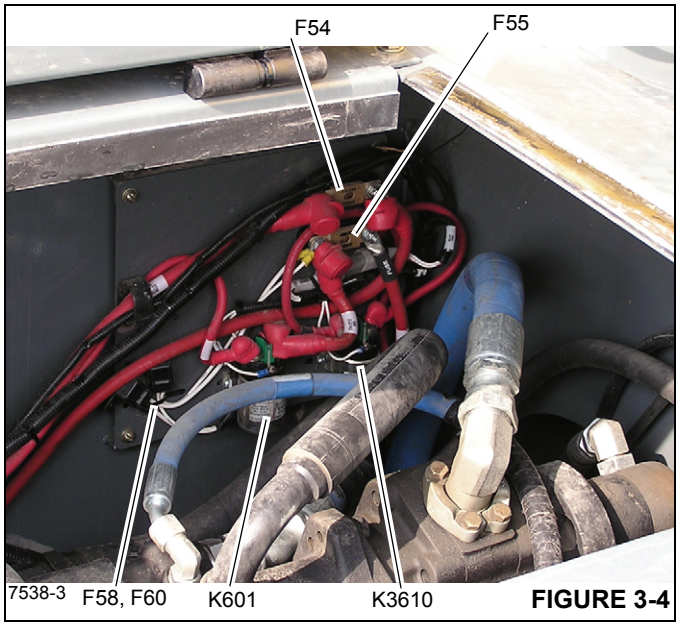


FIGURE 3-4

Table 3-2: Battery Box Fuses (Figure 3-4)

Fuse	Amp	Fuse Circuit	Supply
F54	125	Grid Heater Relay	B+
F55	125	Alternator Charge Circuit	
F58	30	ESX-3 Power	F55
F60	15	I/O-0 Power	

Table 3-3: Battery Box Relays (Figure 3-4)

Relay	Function
K601	Grid Heater
K3610	Engine Starter

Cab Relay/Fuse Panel

The panel is located behind the driver's seat. The fuses are easily accessible. To access the relays and other electronics the two retaining screws must be removed and the panel tilted forward. Refer to Figure 3-5, Figure 3-6, Figure 3-7, Table 3-4 and Table 3-5 for specific information on each component.

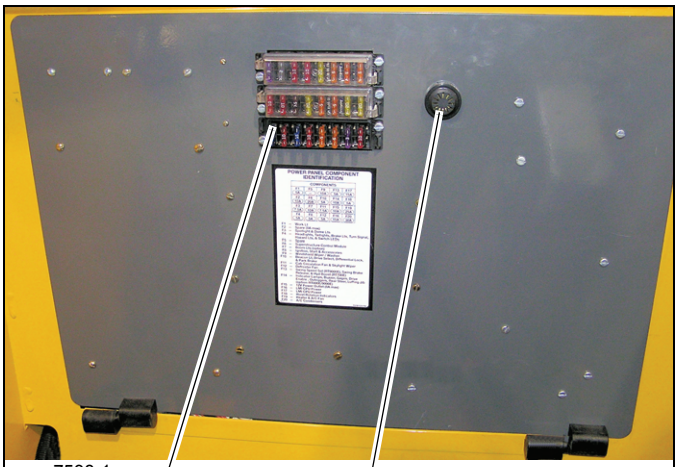


FIGURE 3-5

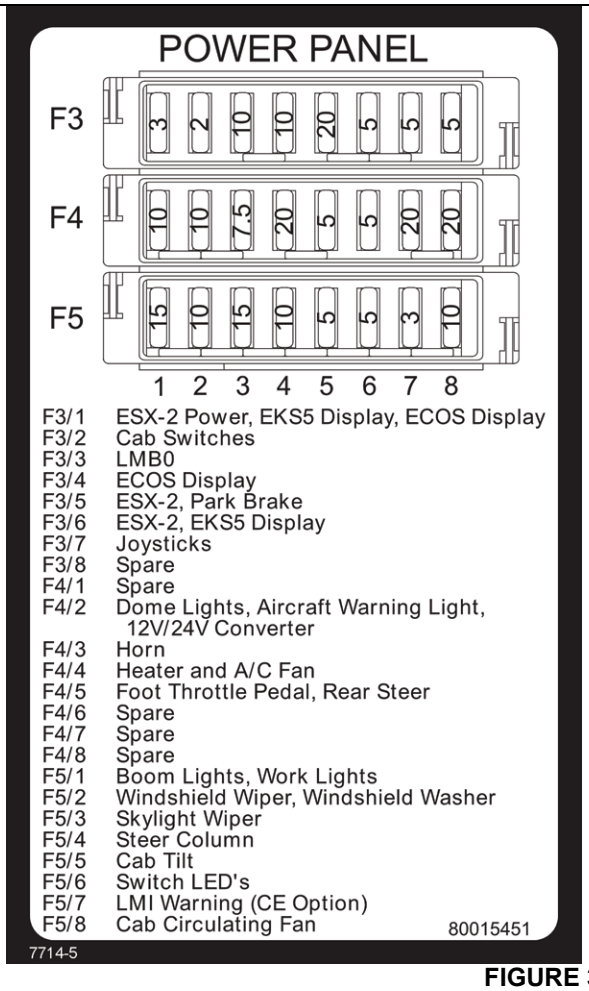
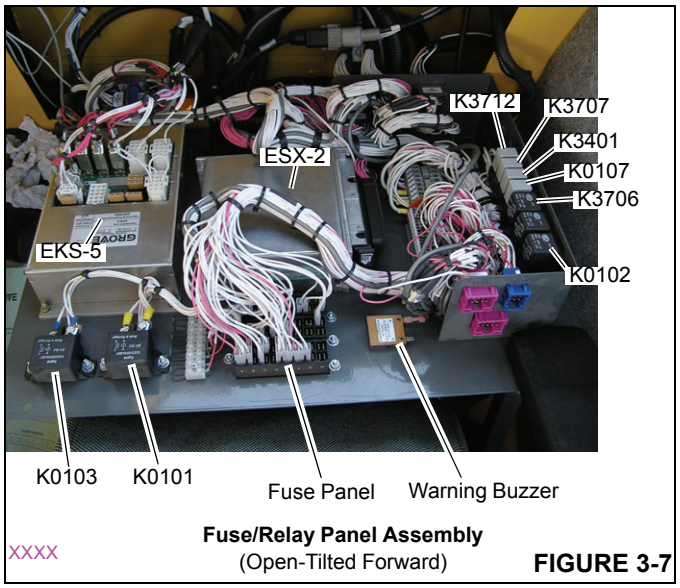


FIGURE 3-6

Table 3-4: Cab Fuse Panel (Figure 3-6)

Fuse	Amp	Fuse Circuit	Supply
F3-1	3	ESX-2 Power, EKS5 Display, ECOS Display	B+
F3-2	2	Cab Switches	ESX2
F3-3	10	LMI Controller Power	K0102 K0103
F3-4	10	ECOS Display	
F3-5	20	ESX-2, Park Brake	K3706
F3-6	5	ESX-2, EKS5 Display	
F3-7	5	Joysticks	
F3-8	5	Open	
F4-1	10	Open	B+
F4-2	10	Dome Light, Aircraft Warning Light, 12V/24V Converter	
F4-3	7.5	Horn	
F4-4	20	Heater and A/C Fan	K0102 K0103
F4-5	5	Foot Throttle Pedal, Rear Steer	
F4-6	5	Open	
F4-7	20	Open	B+
F4-8	20	Open	
F5-1	15	Boom Lights, Work Lights	K0101
F5-2	10	Windshield Wiper, Windshield Washer	
F5-3	15	Skylight Wiper	
F5-4	10	Steer Column	
F5-5	5	Cab Tilt	
F5-6	5	Switch LEDs	
F5-7	3	LMI Warning (CE Option)	
F5-8	10	Cab Circulating Fan	



Fuse/Relay Panel Assembly
(Open-Tilted Forward)

FIGURE 3-7

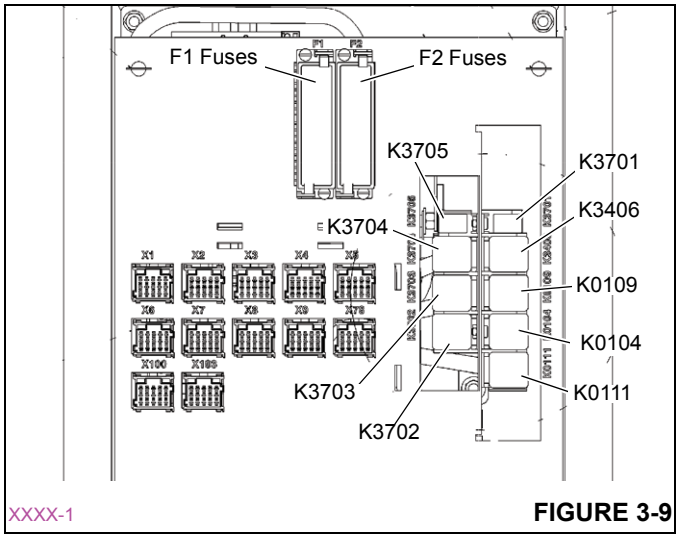
Table 3-5: Cab Relay Panel (Figure 3-7)

Relay	Function
K0101	Accessory #1 Position
K0102	Accessory #2 Position (Ignition ON)
K0103	Ignition ON
K0107	Heater and A/C
K3401	Horn
K3706	LMI Bypass
K3707	LMI Bypass
K3712	LMI Warning (CE Option)

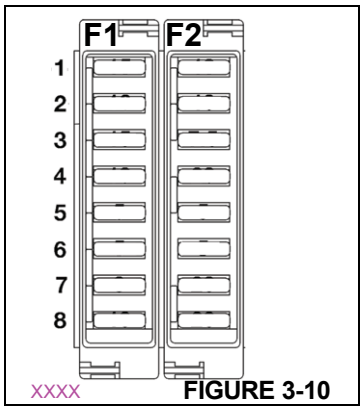
Junction Box Fuse/Relay Panel

The junction box fuse/relay panel is located behind the cab in front of the counterweight.To open the cabinet use the special key provided. Refer to Figure 3-8, Figure 3-9, Figure 3-10 and Table 3-6 for specific information on each component. The relays in this panel function as interlocks.

XXXX Junction Box **FIGURE 3-8**



XXXX-1 **FIGURE 3-9**



XXXX **FIGURE 3-10**

Table 3-6: Junction Box Fuses (Figure 3-10)

Fuse	Amp	Fuse Circuit	Supply
F1-1	20	Swing Brake Static Press. Sw., I/O-3, Filter Feed Press. Sw., ESX-1	K0104
F1-2	20	I/O-4 Power	
F1-3	10	Luffing Jib Switch	K0109 K3704
F1-4	20	Open	
F1-5	5	Flashing Beacon	Ign. Sw.
F1-6	3	Open	K3704
F1-7	3	I/O-3 Power, Cable Reel	
F1-8	5	Open	
F2-1	2	Hydraulic Boom Extension	ESX-0
F2-2	20	ESX-0	K0111
F2-3	20	ESX-1	
F2-4	5	Bypass Power	B+
F2-5	15	A/C Relay	
F2-6	3	Emergency Operation Hand Held Control	
F2-7	20	Open	
F2-8	20	Open	

3

MAINTENANCE

General

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

CAUTION

Burning hazard!

If it is necessary to perform electrical maintenance on live or hot circuits, remove all rings, watches, and other jewelry before performing maintenance.

Serious burns may result from accidental grounding or shorting circuits.

Damage to the machine or test equipment possible!

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

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

Visual Inspection and Replacement of Electrical Harnesses and Cables

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

- Damaged, cut or deteriorated harness loom covering.
- Damaged, cut or abraded individual wires or cable insulation.
- Exposed bare copper conductors.
- Kinked, crushed, flattened harnesses or cables.
- Blistered, soft, degraded wires and cables.
- Cracked, damaged, or badly corroded battery terminal connections.
- Inspect all machine ground connections for damaged terminals or excessive corrosion.
- Other signs of significant deterioration.

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

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

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

If any of these conditions exist, address them appropriately.

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

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

Table 3-1

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

General Troubleshooting

Troubleshoot per the following guidelines:

CAUTION

Electric Shock Hazard!

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

NOTE: This machine incorporates a CAN-Bus Multiplex system. In order to effectively troubleshoot the electrical system, contact an authorized Manitowoc Cranes distributor and/or Manitowoc Crane Care.

Make voltage checks at terminations when components are installed and operating. Make continuity checks (with batteries disconnected) when components are isolated or removed.

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

Tools for Troubleshooting

This machine Incorporates a CAN bus Multiplex system. In order to effectively troubleshoot the electrical system, you need a Windows-based PC, CAN-link service software and a connection cable. The CAN-link service software and connection cable are available through Crane Care to those service technicians who have attended the Grove New Technology training course.

Troubleshooting Engine Starting Problems

1. Verify the battery terminals are connected and clean, the transmission is in neutral, and the machine is fueled.
2. Try to turn on the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights to verify the batteries have at least some charge. If none of these lights come on, suspect the batteries. Charge batteries as needed, or replace the batteries if you can jump-start the crane from another crane.
3. If you hear the starter relay clicking repeatedly, power is reaching the starter, but not enough. Suspect the batteries. Charge batteries as needed, or replace the batteries if you can jump-start the crane from another crane.
4. Check Fuse 53 (100 amp) inside battery box. If fuse is blown, replace it.
5. Turn the ignition switch to RUN (1). Check the voltmeter. If it doesn't move (but the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights will come on), suspect the ignition switch and the power circuit to it starting at the ignition switch fuse. Repair or replace circuit, switch, or fuse as needed.
6. If the battery, fuses, ignition switch, and power circuit to the ignition switch check out, do one of the following:
   a. If you hear no noise when you try to turn the starter, troubleshoot the start circuit (ignition switch, electric shifter, and wiring from ignition switch to superstructure control module (connector A) through carrier control module (connector A) to starter relay. Make repairs as needed.
   b. If the engine still won't start, and you hear no noise or just a single click, suspect the starter. Troubleshoot the start circuit from the starter relay through the starter solenoid to the starter motor and ground. Make repairs as needed. If the starter solenoid or the starter motor is faulty, replace the starter.
   c. If the starter engages but can't turn the engine (and the lights dim, signaling power drain during start attempt), check the starter's feed circuit from the batteries for resistance. If the resistance is high, make repairs. If the circuit checks out, replace the starter. If the engine still won't start, suspect a seized engine.
   d. If the starter turns the engine, but it still won't start, check fuses F51, F52, F53 and F56 in the battery box. Replace if required. Ensure fuel system can draw fuel from the tank and pump it to the engine; make repairs as needed.
7. Refer to the engine manual for further instructions.

NOTE: If the starter won't disengage during running, verify the starter is mounted properly so its gear won't mesh with the engine's flywheel when not trying to start engine. Troubleshoot the starter relay and ignition switch for closed contacts. If these components check out, replace the starter.

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.

Engine Off Tests

Batteries

CAUTION

Burning hazard!

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 24.4 V or above, perform the following load test. If the voltage is lower than 24.4 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 other 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 24.6 V 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 26V.

NOTE: Amperage should be 15 amps or less.

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 25 volts.
4. Amperage should be within 10 to 15 amps of alternator rating; this alternator is rated at 70A, so the meter should read 55A to 60A.

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.

Troubleshooting Accessories

If the crane's engine starts and charges properly, but none of its components except the horn or lights work, the accessory circuitry may be faulty. Check as follows:

1. Turn the ignition switch to the ACC (3) position. Try to turn on the cab circulating fan, the heater fan, the defroster fan, or the windshield wipers or washer. If none of these come on (but the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights will come on), there is an accessory circuitry problem.
2. Check the primary power circuit to the accessory relays. Make circuit repairs as needed.
3. If the problem remains, check the ignition switch and the accessory control circuit from the ignition switch through the coil of the accessory relays K0101 and K0103 to ground. Turn the ignition switch to the ACC (3) position and listen for audible click of relays K0101 and K0103. If neither relay clicks, then there is no power through the switch when it is in the ACC (3) position. Replace ignition switch if there is no power through it when in the ACC (3) position. If one relay clicks and the other does not, check continuity of the coil of the relay that does not click. If there is no continuity through its coil, replace the relay. Make circuit repairs to accessory control circuit as needed.
4. If the problem remains, check the accessory relay contacts and the accessory power circuit. Replace relay if its contacts stay open when the coil is energized. Make circuit repairs as needed.

Troubleshooting Swivel-Caused Electrical Problems

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

Connector Troubleshooting

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

After cutting the pin or socket off, the wire will most likely be too short. Using a wire that is too short will allow pressure to be applied to the pin or socket and wire where they are crimped when the pin or socket is inserted in the plug or receptacle. Add a short length of the same size wire to the short wire by crimp splice or solder. Use heat shrinkable tubing or other suitable material to insulate the splice.

Table 3-2
Deutsch Extraction Tool Table

Description	Deutsch Part Number	Grove Part Number
12 gauge wire	114010	9-999-100194
16 gauge wire	0411-204-1605	9-999-100195
8-10 gauge wire	114008	7-902-000012
4-6 gauge wire	114009	7-902-000009
20-24 gauge wire	0411-240-2005	9-999-102084

Table 3-3
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20, 22, 24 gauge wire	HDT-48-00	9-999-100808
4, 6, 8, 10 gauge wire	HDT-04-08	9-999-100842

ECOS Control Panel

The ECOS control panel is located on the right side console. Various menus are displayed on the ECOS display. The individual buttons have a different function in each menu. The display shows various indicators about the crane; the engine, outriggers, boom, etc. All the indicators concerning the crane's functions are shown on the ECOS display except for information about a lift, which is controlled and shown on the LMI display. Refer to Section 3 of the Operator's Manual for complete information on the ECOS controller.

After the ignition has been switched on, a lamp test is conducted. Check that the lamps indicated in Figure 3-11 and Figure 3-12 light up briefly.

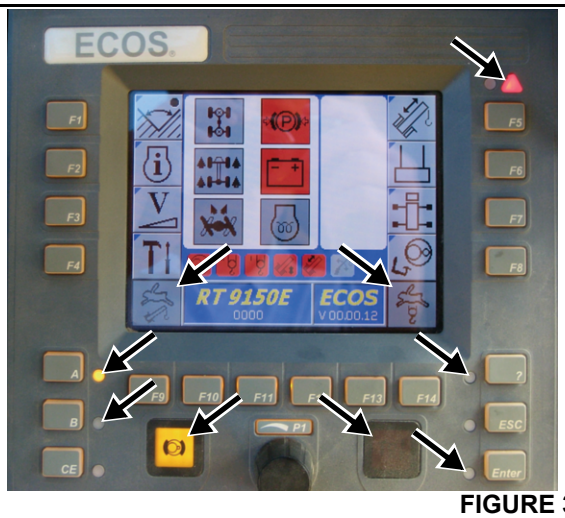


FIGURE 3-1

FIGURE 3-1

If the specified time is insufficient, switch on the ignition again or you can perform a manual lamp test, as follows:

1. If necessary, in the ECOS display, open the main menu and press the F4 button (1) (Figure 3-13). The Settings submenu (Figure 3-14) opens.

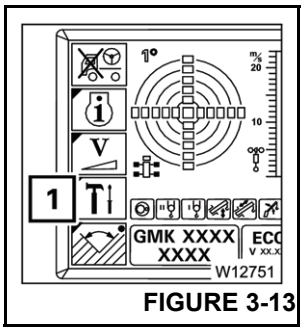


FIGURE 3-13

2. Press the F5 button (1) (Figure 3-14).

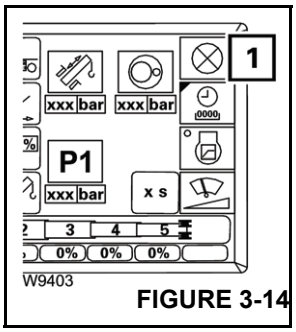


FIGURE 3-14

The lamps indicated in Figure 3-11 and Figure 3-12 light up until you let go of the button.

Contact Crane Care if one or more lamps do not light up.

Warning Messages

ECOS differentiates between warning messages and error messages, see *Error Messages*, in the following section. A warning message indicates that certain values do not correspond to a set value.

In the event of a warning message, the following lamps flash:

- the Warning/Error indicator (1) (Figure 3-15)
- the **A** button lamp (2).

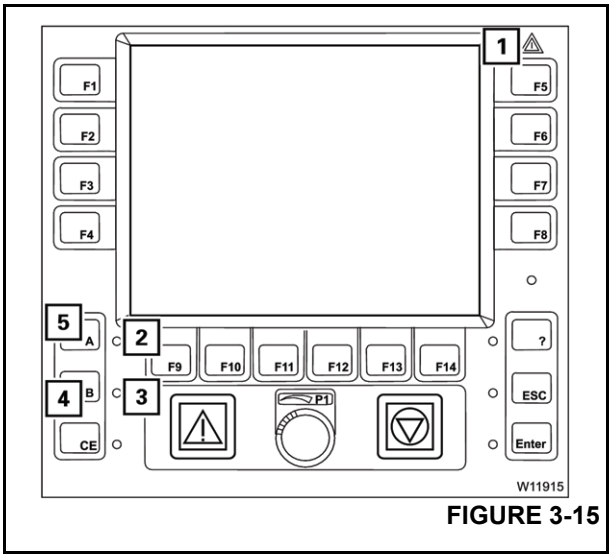


FIGURE 3-15

Press the **A** button (5) next to the flashing lamp to open the Warning submenu. Refer to Section 3, Warning Messages in the Operator's Manual for more information.

The warning message is acknowledged, lamp (2) lights up (does not flash any longer).

When all warning messages have been acknowledged, lamp (1) and lamp (2) lights up.

Both lamps start to flash again as soon as a new warning occurs.

Error Messages

If ECOS detects an error, an error message is indicated by two flashing lamps, (Figure 3-16):

- The Warning/Error indicator lamp (1)
- The **?** button lamp (2).

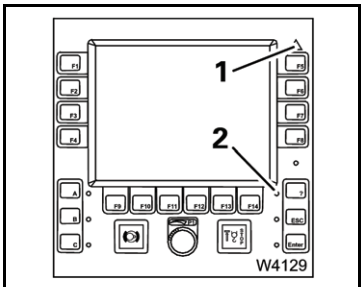


FIGURE 3-16

When all error messages have been acknowledged, lamp (1) and lamp (2) lights up.

Both lights start to flash again as soon as a new error occurs.

To determine what the error is, you must open the Error submenu by pressing the **?** button (2) (Figure 3-17). The button is only active when the lamp (1) flashes or lights up.

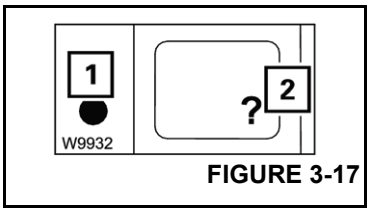


FIGURE 3-17

Each error is defined by an error code (5) and the symbols (1) to (4).

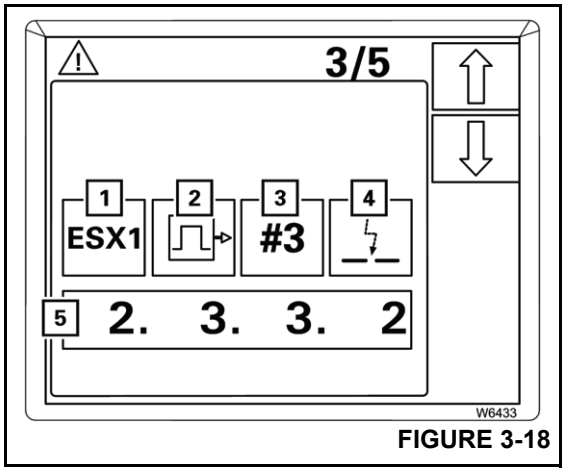


FIGURE 3-18

The symbols stand for:

(1) The faulty device
(2) The error group
(3) The index within the group
(4) The type of error

The error code (5) consists of 4 digits, e.g. 2332.

Refer to Section 3, Error Messages in the Operator's Manual for more information.

Always note down the error code before contacting Crane Care.

To exit the Error submenu, press the **Esc** button (1) (Figure 3-19) once. The same menu opens that was open before the Error submenu opened.

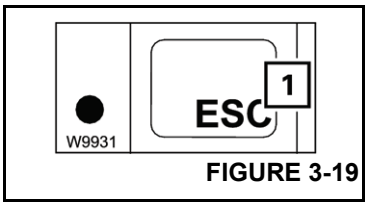


FIGURE 3-19

NOTE: All errors remain saved until you switch off the ignition, even those errors of which the cause has been eliminated in the meantime. All existing errors are treated as new errors and displayed again after turning on the ignition.

Diagnostic Connector and Equipment

The electrical diagnostic connector is located on the right side console. It can be used for troubleshooting electrical system and engine faults and conditions.

The connector is designed to connect a laptop computer with appropriate cable and engine or electrical system software to the crane for diagnostic work.

Besides the ECOS Controller and LMI this machine incorporates a CAN-bus Multiplex system for data communications.

To effectively troubleshoot the electrical CAN-bus system, contact an authorized dealer or Manitowoc Crane Care.

CAUTION!

Possible Equipment Damage!

When welding on the crane, turn battery disconnect off to prevent damage to the CAN-bus system.

Troubleshooting Vehicle Lights

1. Check the lamp first. Replace any defective lamp.
2. If all lamps in a circuit do not work, check the fuse, the switch and ground circuit. Replace fuse if blown.
3. Check the switch and circuit for continuity, loose connections and faulty grounds. Replace any faulty switch or other component. Repair wiring if faulty.

Troubleshooting Alarms, Indicators, and Emergency Components

1. If an alarm or emergency component doesn't work as expected, check and replace the fuse, especially when all other components downstream from the fuse are not working.
2. Check the component, its sensing device, and circuit for continuity, including the ground circuit. Repair or replace any faulty component or its sensing device. Repair wiring if faulty.

Troubleshooting Crane Components and Accessories

1. If a crane component or accessory won't work when it is supposed to, check and replace fuse. Also check and replace its relay, as needed.
2. Check the component or accessory, its control or triggering component, and its circuit for continuity problems and other problems. Repair any faulty component or accessory or trigger. Repair wiring if faulty.

Alternator Replacement

Removal

1. Disconnect the batteries.
2. Open the engine compartment.
3. Tag and disconnect the electrical leads from the terminals on the alternator.
4. Turn the tensioner above 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.
5. Remove and tag all wires. Remove the alternator link capscrew and the mounting capscrew. Remove the alternator.

Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.

NOTE: Install alternator on the mounting bracket with head towards turbocharger.

2. To assemble the alternator, the mounting components must be tightened in the following sequence.
   - **a.** Alternator-to-alternator bracket capscrew.
   - **b.** Lower brace-to-alternator capscrew.
   - **c.** Lower alternator brace-to-water pump capscrew.
   - **d.** Torque fasteners to recommended torque.

3. Install the belt on all engine pulleys except the alternator pulley for now.
4. Turn the tensioner clockwise. Slip the belt onto the alternator pulley, then carefully return the tensioner to its normal position so it puts tension on the belt. Make sure the belt is centered on the tensioner.
5. Check belt tension at the belt's longest span (longest distance between pulleys). At the center point of the longest span, push in on the belt with your thumb. Verify you can deflect the belt no more than 3/8 to 1/2 inch (10 to 13 mm). Or, using a belt tension gauge, verify there is 60 to 130 pounds (267 to 578 N) of tension on the belt in the middle of its longest span. Replace belt if it is too loose (overstretched).
6. Verify tensioner bolt is torqued to recommended torque.
7. Connect the electrical leads to the terminals as tagged during removal.
8. Close the engine compartment. Connect the batteries.

Check

1. Run engine. Verify reading of voltmeter on front console is 24 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. Disconnect the batteries.
2. Open the engine compartment.
3. Tag and disconnect the electrical leads from the terminals on the starter.
4. 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 recommended torque.
2. Connect the electrical leads to the terminals as tagged during removal.
3. Close the engine compartment. Connect the batteries.

Check

1. Try to start the engine. Verify the starter starts the engine.
2. Start engine again, and listen for starter noises. Verify there is no abnormal noise indicating the starter's gear is meshing improperly with the flywheel, that the starter's gear hasn't disengaged from the flywheel after the ignition switch is in the ignition. (run) position, or some other problem. Install starter properly as needed.

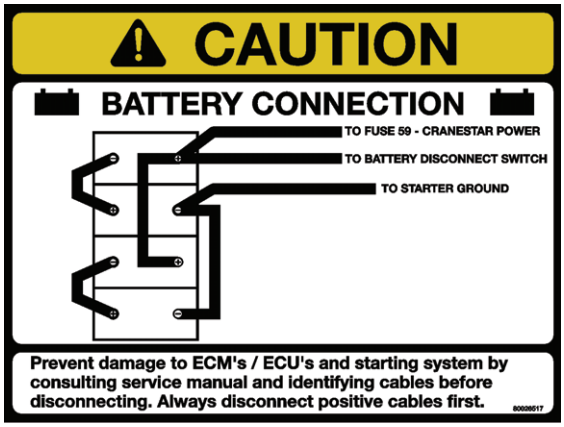
Battery Replacement

Removal

7010-1

FIGURE 3-20

1. Open the battery box cover.
2. Tag and disconnect leads from the battery terminals starting with the positive terminals (Figure 3-21).



7010-4

FIGURE 3-21

3. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
4. Remove the batteries.

Installation

1. Place the batteries in the battery box.
2. Install the hold down bracket so it can secure 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 negative terminals.
4. Close the battery box cover.
5. Verify replacement batteries work by starting crane's engine and operating various crane components.

Relay Panel Component Replacement

Accessory Relay

1. Disconnect the batteries.
2. Remove the hardware securing the console front cover and remove the cover.
3. Tag and disconnect the electrical leads from the suspect relay.
4. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
5. Install replacement relay on relay panel and secure it with attaching hardware.
6. Connect the electrical leads to the relay as tagged during removal.
7. Position the console front cover on the console and secure with the attaching hardware.
8. Connect the batteries.
9. Verify proper installation by operating all components involved with the replacement relay verifying they all work.

Buzzer Replacement

1. Remove the hardware securing the console front 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.

Switch Replacement

Rocker Switch Replacement

Use the following procedures and refer to Figure 3-22 when removing/installing a switch.

Removal

1. Disconnect the batteries and remove the ignition key.
2. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
3. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
4. Remove the four screws (13) securing the left and right side covers (8, 9) together.
5. Remove the four screws (14) securing the left and right side covers (8, 9) to the switch cover (6).
6. Remove the left side cover (8) from the steering column.
7. Disconnect the wire harness from the back of the ignition switch (10).
8. Remove the right side cover (9) from the steering column.
9. 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 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. Connect the batteries.

Check

1. Operate the switch per the *Operator's Manual*. Verify each of its functions works.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

Turn Signal Indicator Replacement

Use the following procedures and refer to Figure 3-22 when removing/installing a turn signal indicator.

Removal

1. Disconnect the batteries and remove the ignition key.
2. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
3. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
4. Remove the four screws (13) securing the left and right side covers (8, 9) together.
5. Remove the four screws (14) securing the left and right side covers (8, 9) to the switch cover (6).
6. Remove the left side cover (8) from the steering column.
7. Disconnect the wire harness from the back of the ignition switch (10).
8. Remove the right side cover (9) from the steering column.
9. Disconnect the wire from the bottom of the turn signal indicator (15) that must be replaced. Remove the indicator by squeezing the retaining clips on each side and pushing upwards until indicator is free of cover.

Inspection

1. Check wiring for damaged insulation or damaged connectors. Repair as needed.
2. Check all connectors for corrosion. Replace corroded components as needed.

Installation

1. Orient the indicator (15) correctly in the cover.
2. Install the indicator (15) in the switch cover (6) by pushing down through the top of the switch cover (6) until the retaining clips click in place.
3. Connect the wire harness to the bottom of the indicator (15).
4. Install the right side cover (9) on the steering column.
5. Connect the wire harness to the ignition switch (10).
6. Install the left side cover (8) on the steering column.
7. Secure the gauge/switch cover (6) to the left and right side covers (8, 9) using screws (14).
8. Secure the left and right side covers (8, 9) together using four screws (13).
9. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
10. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).
11. Connect the batteries.

Check

1. Operate the turn signal and emergency flashers per the *Operator's Manual* and verify the light illuminates.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the indicator.

Ignition Switch Replacement

Use the following procedures and refer to Figure 3-22 when removing/installing the ignition switch.

Removal

1. Disconnect the batteries and remove the ignition key.
2. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
3. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
4. Remove the four screws (13) securing the left and right side covers (8, 9) together.
5. Remove the screws (14) securing the left and right side covers (8, 9) to the switch cover (6).
6. Remove the left side cover (8) from the steering column.
7. Disconnect the wire harness from the back of the ignition switch (10).
8. Remove the right side cover (9) from the steering column.
9. 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 switch cover (6) to the left and right side covers (8, 9) using 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. Connect the batteries.

Check

1. Operate the ignition switch per the *Operator's Manual*. Verify each of its functions works.
2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

Turn Signal Lever and Transmission Shift Lever Replacement

Use the following procedures and refer to Figure 3-22 when removing/installing the turn signal lever or transmission shift lever.

Removal

1. Disconnect the batteries and remove the ignition key.
2. Pull the rubber boot (11) off the bottom of the left and right side covers (8, 9).
3. Remove the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.
4. 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).
5. Remove the four screws (13) securing the left and right side covers (8, 9) together.
6. Remove the screws (14) securing the left and right side covers (8, 9) to the gauge/switch cover (6).
7. Remove the left side cover (8) from the steering column.
8. Disconnect the wire harness from the back of the ignition switch (10).
9. Remove the right side cover (9) from the steering column.
10. Disconnect the wire harness from the bottom of the gauge cluster (5).
11. Tag and disconnect the wire harness from the bottom of each switch (4).

12. Remove the switch cover (6) from the steering column.

13. Disconnect the wire harnesses from the bottom of the turn signal lever (5) or transmission shift lever (7).

14. Remove the two bolts (16) and nuts (17) securing the shift lever (7) and the turn signal lever (5) together.

Installation

1. Align the location pins of the turn signal and transmission shift levers (5, 7) with the holes in the steering column.

2. Secure the two levers (5, 7) together using the two bolts (16) and nuts (17).

3. Connect the wire harnesses to the levers.

4. Install the switch cover (6) on the steering column.

5. Install the wire harnesses on the switches (4) as tagged during removal.

6. Install the right side cover (9) on the steering column.

7. Connect the wire harness to the ignition switch (10).

8. Install the left side cover (8) on the steering column.

9. Secure the switch cover (6) to the left and right side covers (8, 9) using screws (14).

10. Secure the left and right side covers (8, 9) together using four screws (13).

11. Install the steering wheel (2); torque the securing nut to 30 lb-ft ±4 (40 Nm ±5).

12. Install the steering wheel cap (1).

13. Install the lever (12) and spacer that locks/unlocks the steering column tilt/telescope function.

14. Pull the rubber boot (11) up and over the bottom of the left and right side covers (8, 9).

15. Connect the batteries.

Check

1. Operate the turn signal lever or transmission shift lever per the *Operator's Manual*. Verify each of its functions work.

2. As needed, troubleshoot further any system or circuit malfunction not corrected by repair or replacement of the switch or associated wiring.

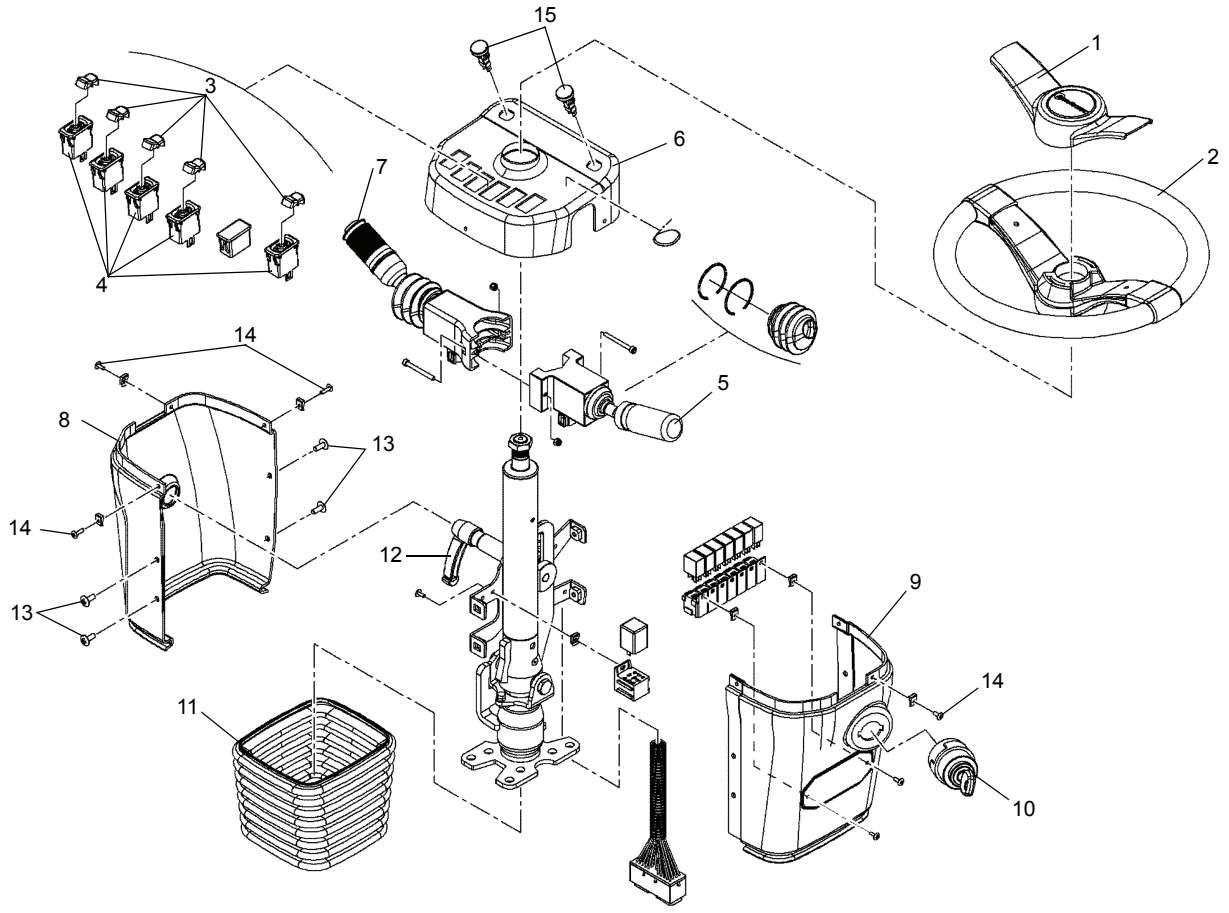


FIGURE 3-22

Windshield Wiper Assembly Replacement

Removal

1. Disconnect the batteries.
2. Tag and disconnect the electrical leads from the motor.
3. Disconnect the washer hose on the wiper arm (also called the pantograph arm assembly) from the washer nozzle fitting assembly (Figure 3-23).

NOTE: The nut and washer are part of the pantograph adapter kit. The nut, washer and sleeve are part of the pivot shaft kit.

4. Remove the cap nut and washer securing the wiper arm to the pantograph adapter kit. Remove the cap nut, washer, and tapered sleeve securing the wiper arm to the pivot shaft kit.
5. Remove the wiper arm from the pantograph adapter kit and the pivot shaft kit.
6. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft kit.
7. 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.
8. 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.

9. 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.

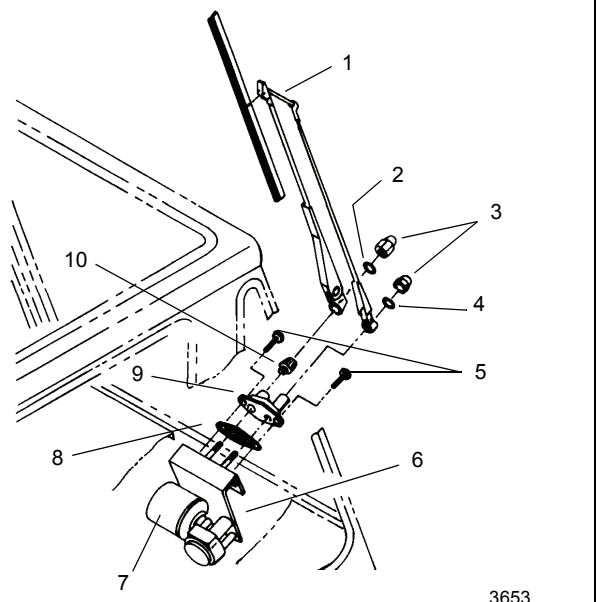


FIGURE 3-23

Item	Description
1	Windshield Wiper Arm
2	Washer
3	Nut
4	Washer
5	Screw
6	Mounting Bracket
7	Motor
8	Gasket
9	Mounting Plate
10	Serrated Collar

Installation

1. Verify the pivot shaft and the wiper motor 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. Connect the wiper motor's shaft to the wiper motor kit crank with the nut and washer. Secure the adapter and the gasket of the pantograph adapter kit to the cab exterior with capscrews and lockwashers.
3. Install the motor bracket and attached parts in the cab interior with attaching hardware. Ensure the pivot shaft sticks through the hole in the pantograph adapter kit.

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

4. Secure the pivot shaft to the pantograph adapter with the pivot shaft kit's nut and washers. Install the flanged sleeve on the pivot shaft.
5. 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.
6. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
7. Connect the electrical leads to the wiper motor as marked before removal.
8. Connect the batteries.

Check

1. Squirt some cleaning fluid onto the windshield with the windshield washer.
2. Operate the windshield wiper and verify it works. Replace wiper blade as needed if it streaks or otherwise wipes poorly.

Windshield Washer Assembly Replacement

Removal

1. Disconnect the batteries.
2. Locate the windshield washer container and pump on the left rear side of the cab.
3. Tag and disconnect the pump's electrical lead and ground wire.

4. 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.
5. Remove four self tapping screws securing the windshield washer container to the cab. Remove the windshield washer container and pump.
6. 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. Connect the batteries.
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. Disconnect the batteries.
2. Tag and disconnect the electrical leads from the motor.
3. Remove the wiper arm from the motor shaft.
4. Remove the nut, spacer, leather washer, and nylon flat washer from the motor shaft outside the cab roof.
5. 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.
6. Remove mounting screw and nylon flat washer from outside cab roof.
7. 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. Connect the batteries.

Check

1. Operate the skylight wiper and verify it works. Replace wiper blade as needed if it streaks or otherwise wipe poorly.

SECTION 4
BOOM

SECTION CONTENTS

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4

DESCRIPTION

Main Boom

A six section 42 to 196.8 ft (12.9 to 60 m) boom is installed on this crane. The boom uses one telescope cylinder for telescoping and retracting of the boom and a pinning system for the sequenced extension and retraction of the sections. A single lift cylinder provides boom lift; boom elevation is from -3 degrees to +82 degrees.

NOTE: The boom is comprised of the following sections: Base, 1, 2, 3, 4, and 5.

Mechanical Luffing Lattice Extension

The 36 to 59 ft (11 to 18 m) offsettable bifold lattice swingaway extension (mechanical luffing jib) stows alongside the base boom section. Offsets are 0°, 20°, and 40°.

Optional Hydraulic Luffing Lattice Extension

The 36 to 59 ft (11 to 18 m) hydraulically offsettable bifold lattice swingaway extension (hydraulic luffing jib) stows alongside the base boom section. Offsets are from 0° to 40°.

Optional Boom Equipment

The 19.7 ft (6 m) or 26.2 ft (8 m) lattice extension inserts install between the boom nose and bifold extension.

An auxiliary boom nose (rooster sheave) is available for the boom to simplify single part cable usage.

Boom Controls

The boom is controlled by the ECOS Controller and the LMI Controller in conjunction with the joystick controllers. Refer to Section 3 of the *Operator's Manual* for more information.

DESCRIPTION AND THEORY OF OPERATION

NOTE: At the end of this section (Figure 4-3) is an animation that shows how this Twin-Lock Telescope System functions. Use Adobe Acrobat® Reader 9 or above to view and control this animation.

Extension and retraction of the boom is controlled by a telescope cylinder and a pinning system. The telescope cylinder rod (1) (Figure 4-1) is secured to the rear of the boom's base section (2). The telescope cylinder barrel is free to ride inside the boom sections. The pinning system consists of a pinning block (3) that rides on the telescope cylinder barrel (4) and section locking pin assemblies (section pins) (5) located in the rear of each moveable boom section.

The pinning block consists of two separate hydraulic circuits. One circuit operates the slave cylinder (6) which actuates the butterfly (7). The butterfly is used to retract the section pins in the boom sections to allow the selected section to be moved. The other circuit operates the cylinder pins (8) on the sides of the pinning block. The cylinder pins are used to connect the cylinder to a boom section for extending or retracting that section

All functions on the pinning block are single acting hydraulic controlled, meaning the pins will return to the safe position using springs when pressure is released. The section pins in the boom are spring loaded to the locked position. The butterfly pulls the pins in and the pins are held by pressure, when the pressure is released, the pins go back to the engaged position. The same is true for the cylinder to section pins. The pins are spring loaded out, and the pinning block retracts the pins to permit motion of the cylinder between boom sections.

Two solenoid pinning valves are located on the cylinder barrel forward of the pinning head. The pressure holding valve (1) (Figure 4-2) maintains or locks hydraulic pressure in the pinning system. The cylinder pin unlock/boom section pin unlock valve (2) directs fluid to either the butterfly or the cylinder pin functions

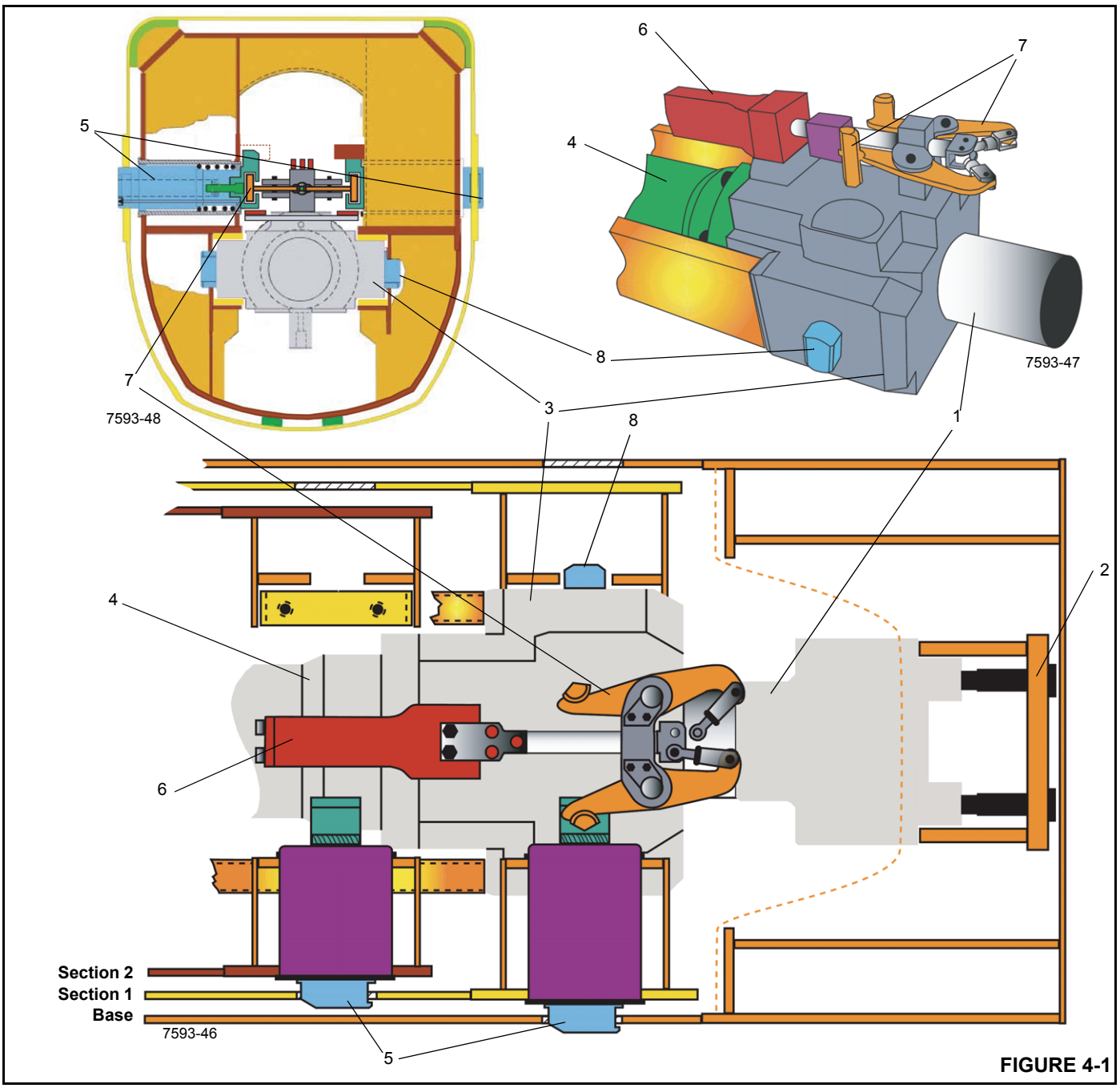

FIGURE 4-1

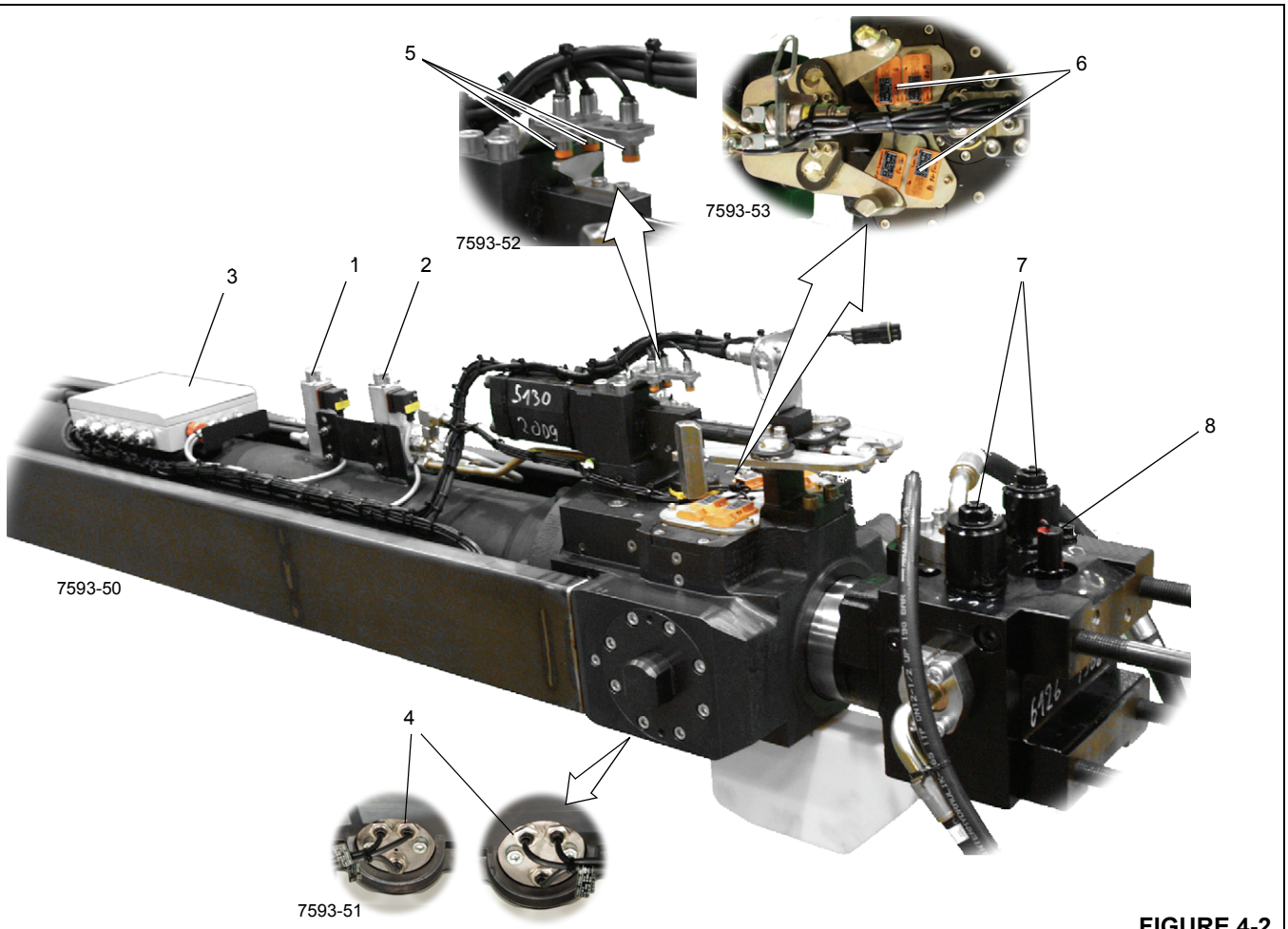

FIGURE 4-2

Each hydraulic circuit of the pinning block (butterfly and cylinder pins) is governed by interlocks. The interlocks function first and then the butterfly or cylinder pins function. In each case, the interlock engages and does not allow the other option to function. The interlocks work by having hydraulic pressure move a pin within the pinning block; the pin locks one component function in place and then opens a path for oil to reach the other component.

- When operating the butterfly, the interlocks for the cylinder to section pins engage to not allow the cylinder pins to retract, then the butterfly will function. This guarantees the cylinder is holding the section when the section pins are retracted.
- When operating the cylinder pins, the interlock for the butterfly engages to not allow the butterfly to function. This guarantees the sections are pinned when the cylinder is not.

The section pins are located in the rear of each moveable boom section. The section pins lock the rear of the inner section to one of three pinning locations on the next outer boom section. The pinning locations are located at the front (100%), middle (50%) and rest position (0%) of the boom section. At the 50% and 100% pinning location, the pins carry the structural load. The base section has no pinning locations, therefore the cylinder pins on the pinning block are always engaged to Section 1 when it is not at the 0% location.

Sensors in the boom and the boom control system synchronize movement of the cylinder, pinning system, and boom sections. As a result, the boom will extend or retract the sections per the chosen control mode. A control module (3) atop the cylinder barrel behind the valves aids in controlling telescope cylinder extension and retraction and cylinder pin and section pin locking and unlocking. Sensors feed signals to the telescope cylinder control module. The data is then sent to the overall control system.

- Sensors on the bottom of the pinning block (4) are used to verify the position (extended or retracted) of each cylinder pin. The butterfly mechanism will not function unless both cylinder pins are verified in the extended position.
- Proximity switches (5) in the butterfly mechanism sense the positions (extended or retracted) of the section pins.

- Four proximity sensors (6) on the pinning head sense the position of the pinning head in relation to the section pins. When the pinning head is in the proper position, the cylinder pins may be extended to connect the cylinder to the individual boom section. After verifying the cylinder pins are extended, the butterfly mechanism may be operated to retract the section pins. After a lift off sequence used to remove any load from the section pins, the cylinder may extend or retract the boom section.

The boom telescope hydraulic circuit consists of the telescope directional control valve, pinning circuit supply valve, holding valve, telescope cylinder, and pinning system.

The pressure and return line ports plus a holding valve are in the cylinder's valve block. This valve block is part of the cylinder's rod weldment.

When the pressure line applies pressure, the valve block routes fluid through the rod weldment and piston to the ID of the barrel. This fluid applies pressure on the cylinder barrel to extend while the seals on the OD of the piston keep fluid pressure from equalizing and stalling the cylinder.

When the return line applies pressure, the valve block routes fluid through a tube in the rod weldment to the OD of the rod weldment. This fluid applies pressure on the rear of the seals on the piston OD to keep the cylinder barrel from extending, while the return line provides a path for fluid to leave the cylinder barrel forward of the piston, and leave the inside of the rod weldment to drain through the pressure line. These forces cause the cylinder barrel to retract.

The rod that slides within the ID of the rod weldment routes fluid from the valve block through the cylinder to the solenoid valves in front of the pinning block.

Two holding valves (7) are threaded into the port block on the rod end of the telescope cylinder. The holding valves function during the retraction, extension, or holding operation. When holding the boom section at a given length, these valves trap oil in the cylinder. A differential valve (8) is installed to ensure the valves do not open together.

MAINTENANCE

Boom Removal

NOTE: The boom, without any boom extension, weighs about 33,000 lb (15,000 kg).

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. Counterweight must be removed from the crane.
3. Rotate turntable so boom is over the front of the crane and engage the turntable lock pin.
4. Fully retract and lock the telescopic sections.
5. If installed, remove the boom extension and auxiliary nose.

CAUTION

Injury Hazard!

Wear gloves when handling wire rope, metal slivers and/or cuts may result.

6. Remove the hook block or headache ball and wind all the wire rope onto the hoist drum.
7. Elevate boom to allow access to the telescope hose disconnects.
8. Disconnect main telescope hydraulic lines (Figure 4-3).

7850-1 **FIGURE 4-3**

9. Tag and disconnect the telescopic hydraulic lines from the compact block, if equipped, also disconnect the hydraulic boom extension hydraulic lines from the compact block (Figure 4-4).

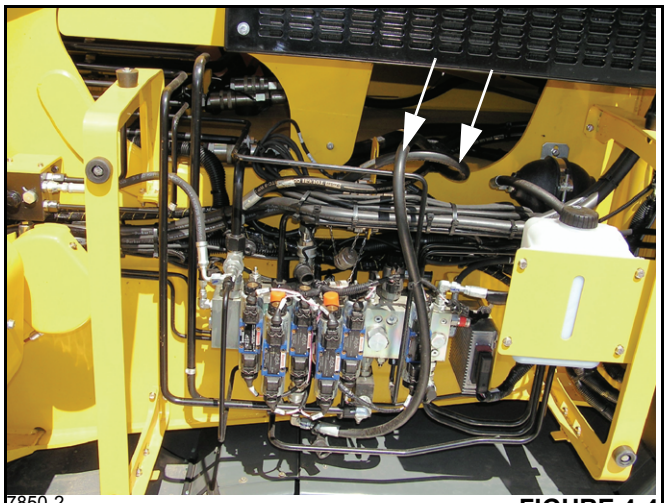
7850-2

FIGURE 4-4

NOTE: At this point you can continue to remove the boom or choose to remove the equipment that is attached to the boom to prevent it from being damaged. You can also choose to remove the attached equipment after the boom has been removed and is supported on cribbing.

10. Install lift cylinder support on carrier frame.

11. Lower the boom to zero degrees.

12. Close the valve on the lift cylinder (Figure 4-5), rotate as indicated.

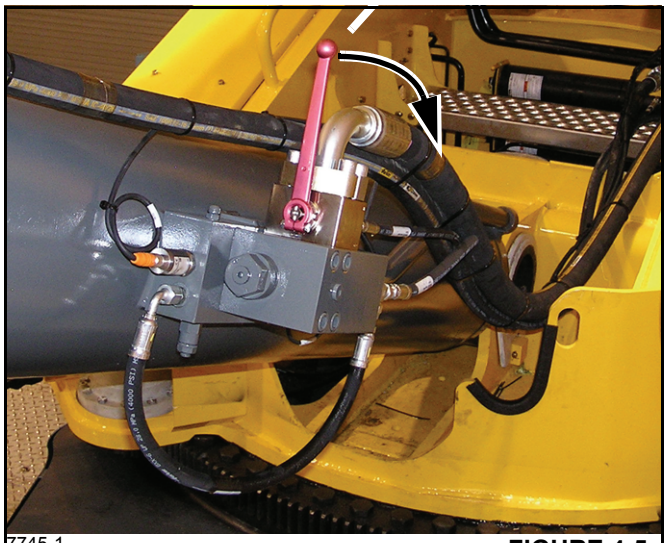
7745-1

FIGURE 4-5

13. Using a wood block between the lift cylinder and the bottle jack, raise the jack so it just touches the lift cylinder barrel.

14. Tag and disconnect electrical wiring from the hydraulic block on the left hand side of the lift cylinder (Figure 4-6).

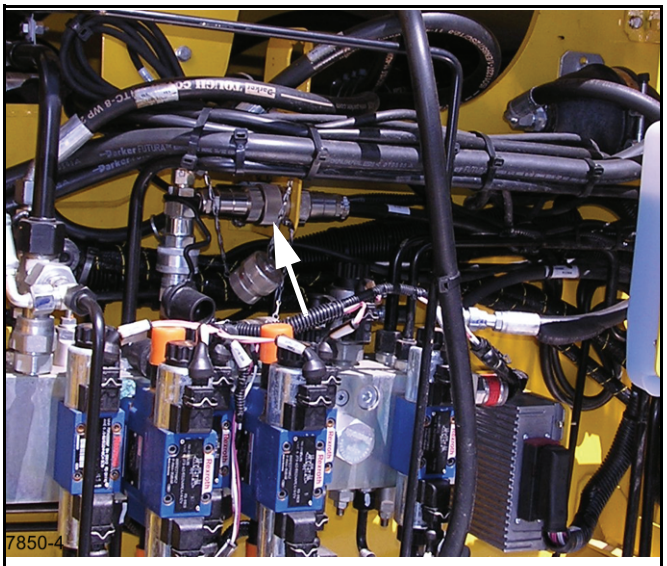
7850-4

FIGURE 4-6

15. Identify and mark locations of the shims installed at the upper lift cylinder pin.

WARNING

Crushing Hazard!

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

Ensure the boom lift cylinder is properly supported before disconnecting it from the boom.

Severe injury or death may result.

16. Attach the lifting rigging, P/N 03125617, to the boom to provide for equal weight distribution (Figure 4-7).

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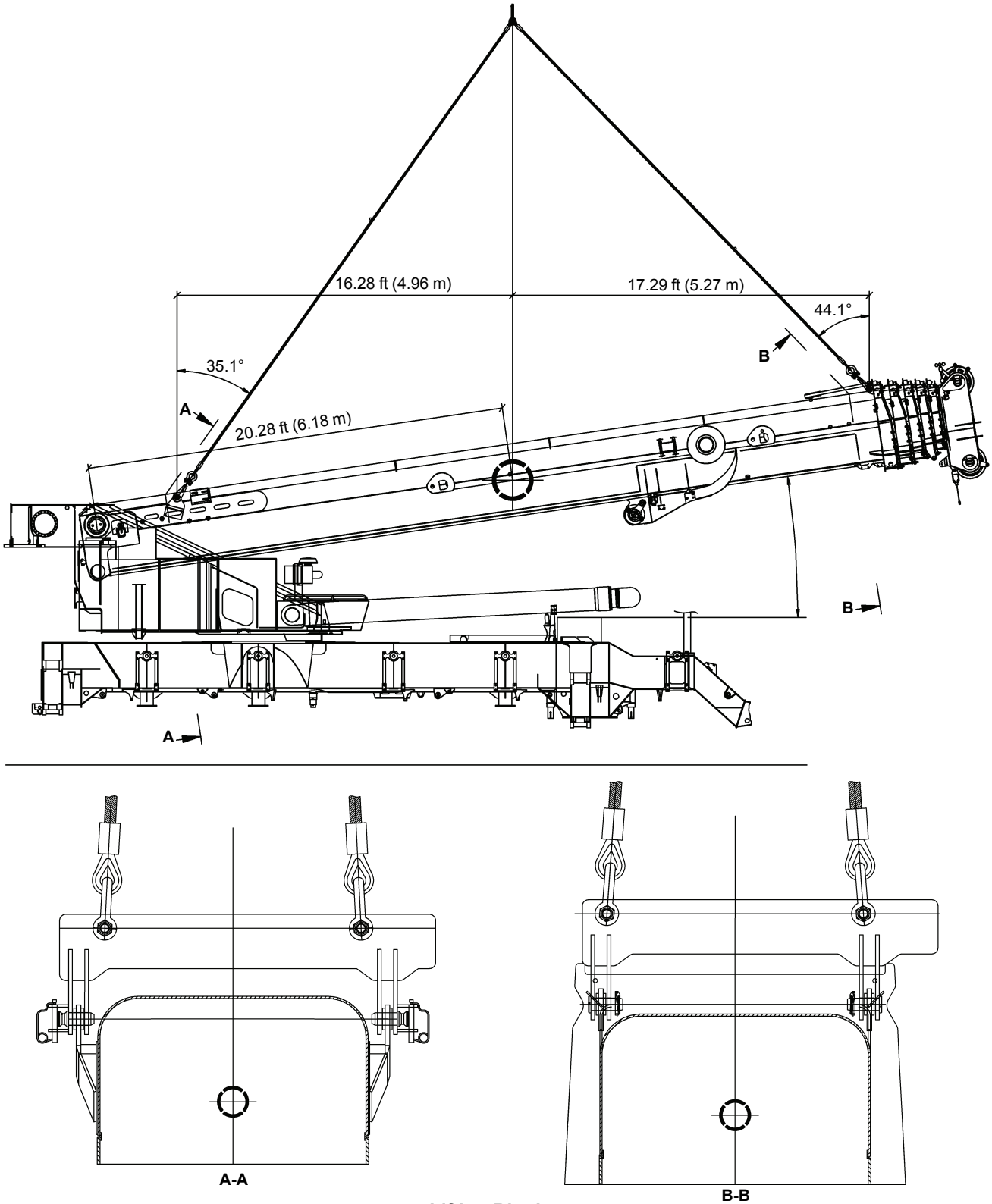


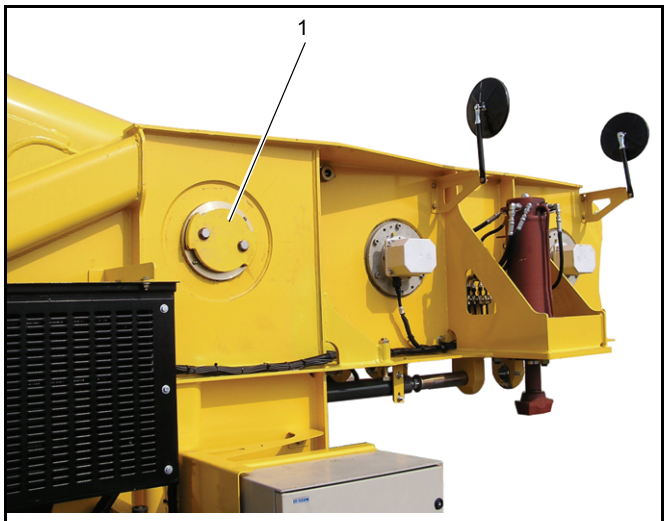
Lifting Rigging
P/N 03125617

FIGURE 4-7

17. Attach wire rope slings to support crane.

18. Lift the boom slightly to reduce the load on the pivot points.

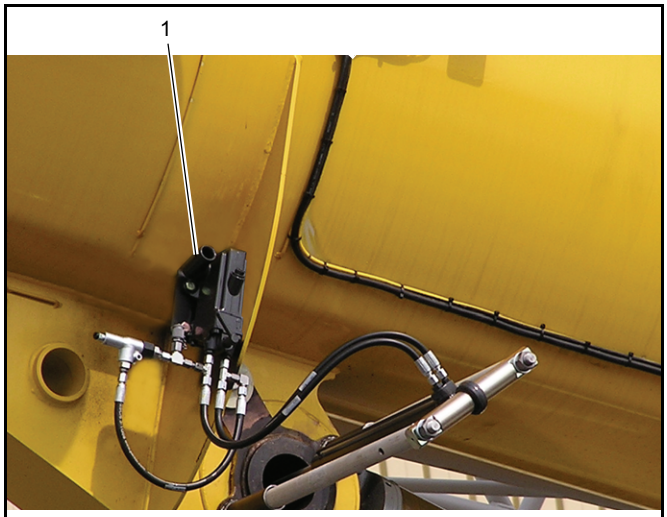
19. Remove boom pivot cap plates (Figure 4-8).



7745-2 **FIGURE 4-8**

20. Remove any hardware that would prevent the removal of the lift cylinder rod pin from the lift cylinder rod end and the boom base section.

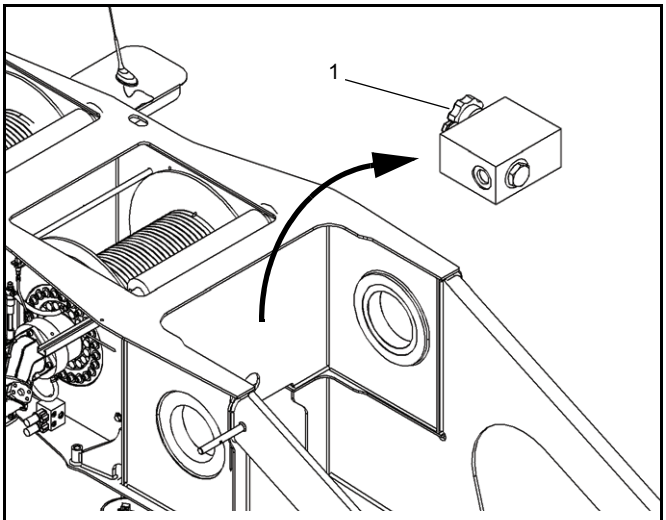
21. Use the hand pump (1) (Figure 4-9) to pull the lift cylinder rod pin free from the lift cylinder and boom.



7745-2 **FIGURE 4-9**

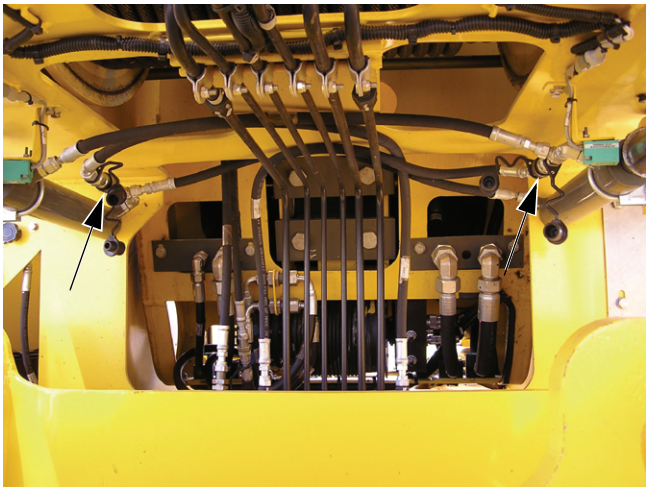
22. Remove any hardware that would prevent the removal of the two boom pivot pins from the boom base section.

23. Open pressure bleed valve on superstructure, behind the boom pivot (1) (Figure 4-10).



7745-2 **FIGURE 4-10**

24. Disconnect hoses from counterweight pin cylinders (Figure 4-11) and connect to boom pin cylinder. Hoses from the boom pivot cylinder are accessible at the back of the boom (Figure 4-12).



7745-2 **FIGURE 4-11**

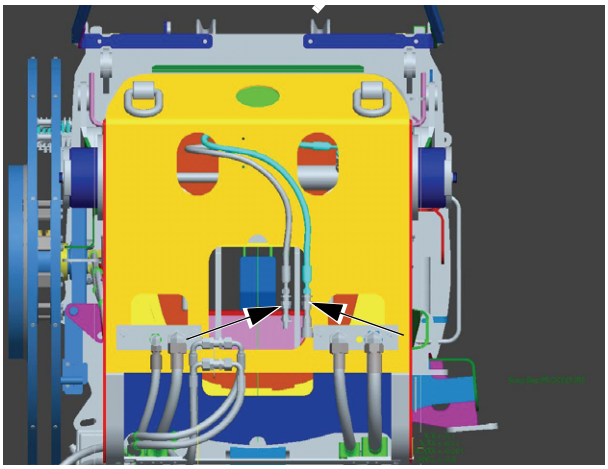


FIGURE 4-12

25. Close the pressure bleed valve on the superstructure, behind the boom pivot (1) (Figure 4-10).
26. Using the ECOS display, “Counterweight” menu, actuate the locking cylinder to retract the boom pivot pins.
27. The weight of the boom is now held by the support crane.
28. Disconnect the hydraulic hoses from the boom pivot cylinder and reconnect to the counterweight lock cylinders.
29. Raise the boom clear of the crane and lower it to the ground or trailer. Set cribbing to support the boom and prevent tipping.
30. Remove rigging and wire rope slings from the boom.
31. Lower the lift cylinder to the lift cylinder support using the bottle jack.

Boom Disassembly

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

CAUTION

Equipment Damage Hazard!

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 sections may result.

WARNING

Crushing Hazard!

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

Failure to properly secure a boom section may cause serious injury or death.

NOTE: Tag parts as you remove them and note the numbers and sizes of shims as you remove them from each of the sections. Consult the Manitowoc Cranes drawing or Parts Manual for each section to verify the part number.

Initial Disassembly

NOTE: The following sections describe the removal of equipment that may be attached to the boom base. It is not mandatory to remove this equipment but it may make disassembly of the boom easier or protect the equipment from damage when disassembling the boom.

Some equipment mentioned is optional and may not be installed on the boom.

1. After the boom has been removed: Tag the wires to the wind speed indicator and the flight warning light before disconnecting or removing them. Remove the wind speed indicator and the flight warning light from the boom nose on section 5. Disconnect and remove the wires from the boom nose terminal box.
2. Tag all wires to the boom nose terminal box before disconnecting or removing any of them. Remove boom nose terminal box and related wires from the boom.
3. Tag all wires to the boom lights before disconnecting or removing any of them. Remove boom lights from base section.
4. Tag and remove other electrical components and their wires from the boom.
5. Tag and disconnect the hose reel hoses.

6. Tag the hose assemblies connected to the hose reel hoses and remove them.

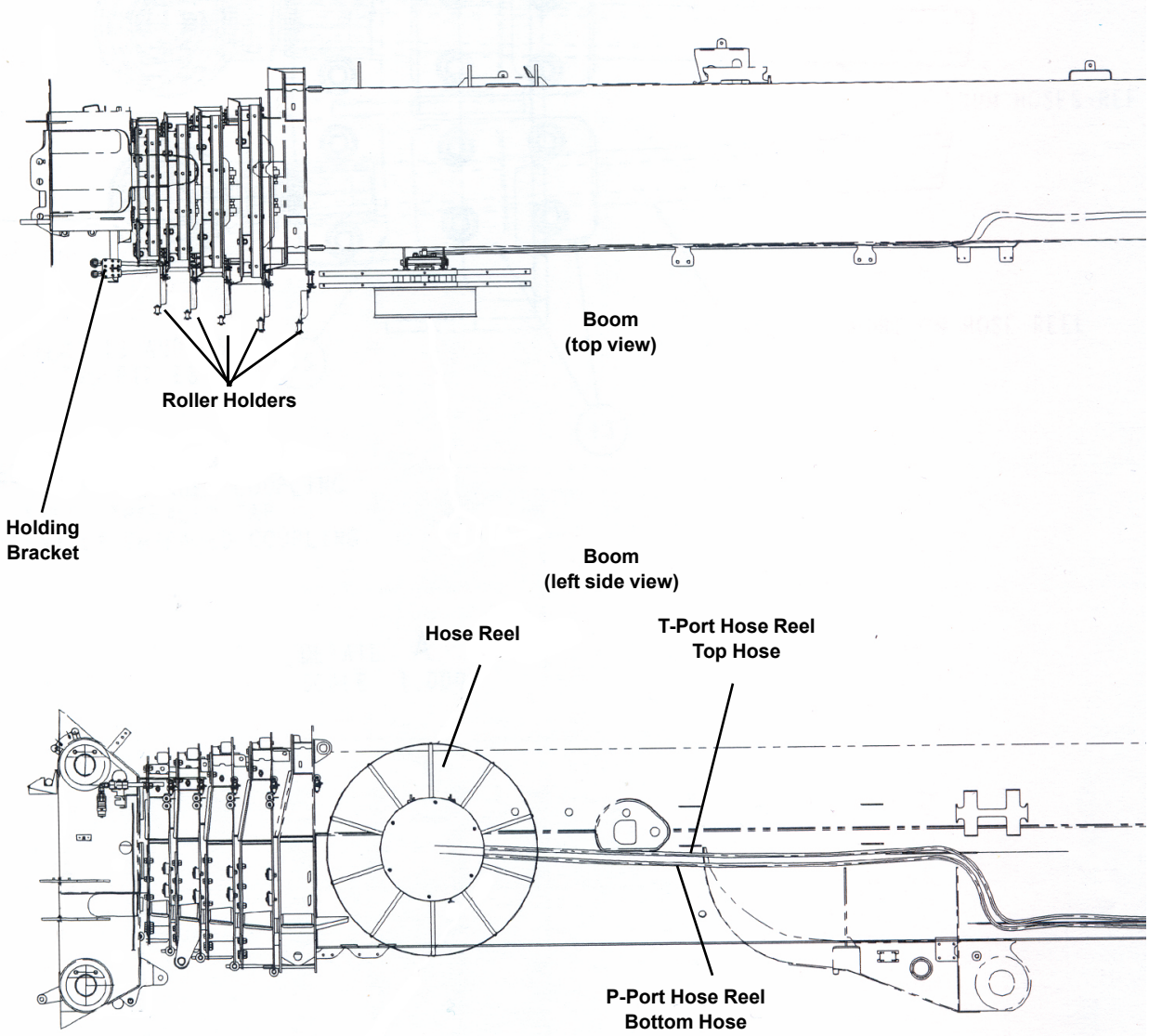


FIGURE 4-13

7. Remove the hardware securing the hoses to section 5.

8. Wrap the hoses around the hose reel.

9. Remove the holding bracket from section 5.

10. Remove the hose guides from the other boom sections.

11. Remove the hose reel from the base section.

12. Remove the cover assembly from the top rear of the base section.

13. Tag all wires to the boom cable length measuring unit (1) (Figure 4-14) in the top rear of the base section, then remove the wires.

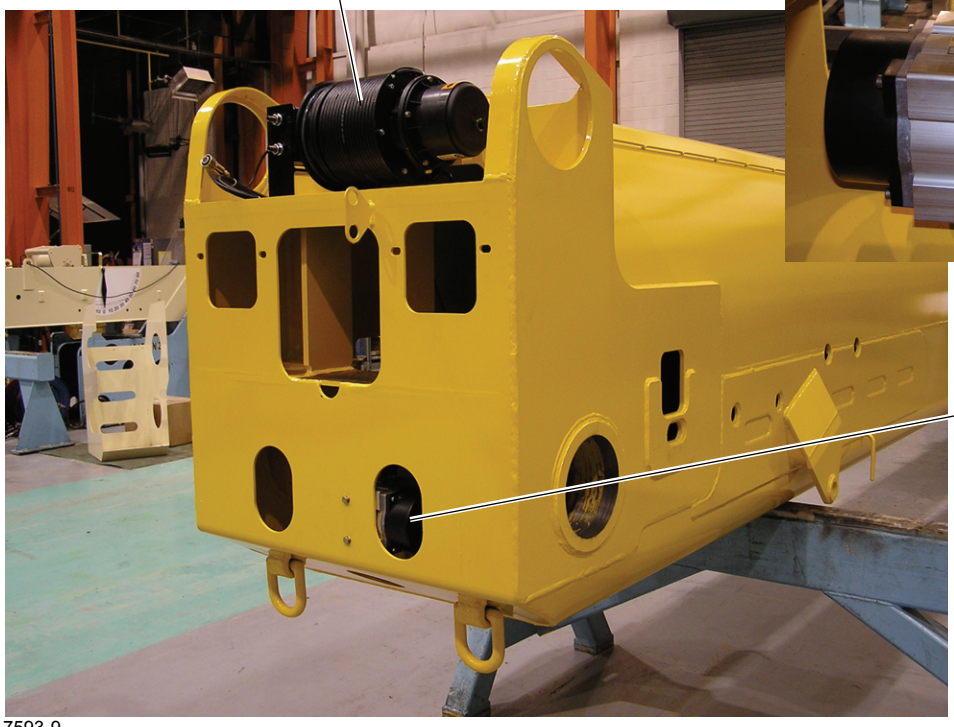
14. Provide adequate support to the boom cable length measuring unit before removing its attaching hardware. Remove attaching hardware and then remove the boom cable length measuring unit from the base section.

15. Tag all wires to the boom cable reel at the bottom rear of the base section before disconnecting or removing any of them. Provide adequate support to the boom cable reel before removing its attaching hardware.

16. Disconnect and remove wires from the boom cable reel (2). Then remove these wires from the base section.

17. Remove attaching hardware to free and remove the boom cable reel.

18. Remove roller holders from the sections.



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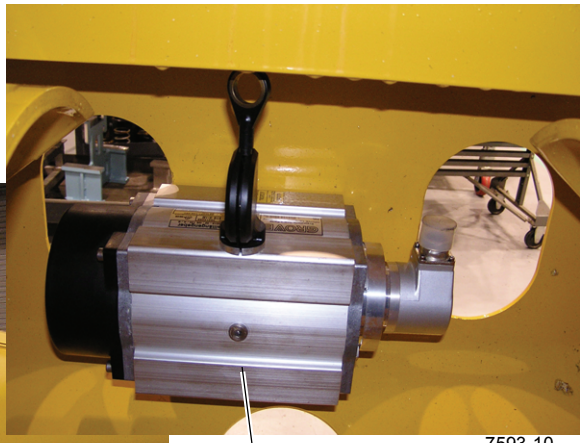

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P1070073

Base Section
(shown upside-down)

FIGURE 4-14

Remove Telescope Sections and Cylinder from Base Section

1. Have fixtures in place for resting disassembled boom sections.

CAUTION

Equipment Damage Hazard!

Apply no more than 1400 psi, seals in the butterfly can be damaged and leak.

2. Connect hoses to the A, R, K1, and K2 ports of the rod end valve block (Figure 4-15).
3. Connect the other end of the hoses to a hydraulic or air pressure source.

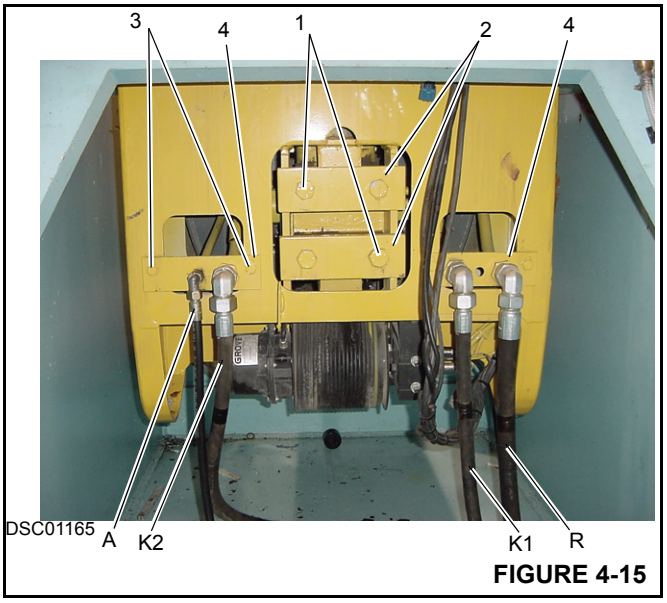


FIGURE 4-15

4. Connect a 24 VDC source (1) to the emergency/service mode plug (2) of the pinning head of the cylinder (Figure 4-16).

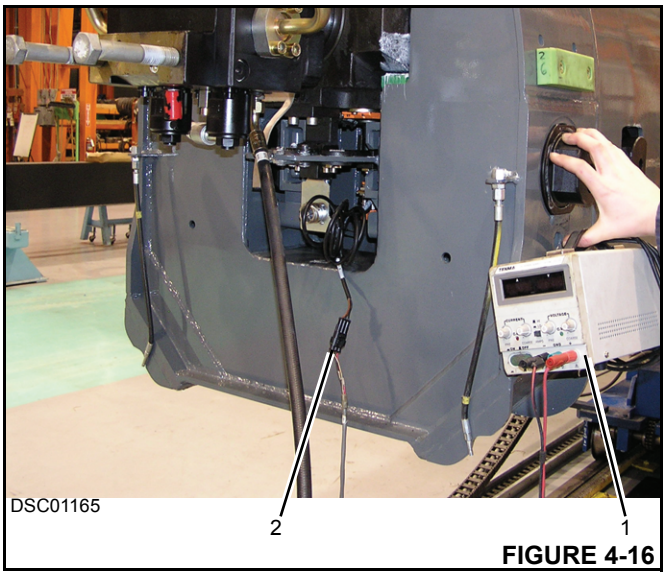


FIGURE 4-16

5. Use the 24 VDC source to actuate the section pins and hydraulic/air pressure to actuate the cylinder pins.
6. Engage the cylinder pins with the cutouts in section 1. This pins the cylinder assembly to section 1.
7. Unlock the section pins so section 1 is free from the base section.
8. Pin sections 2, 3, 4, and 5 to section 1.
9. Move the butterfly arms in to avoid engaging the C-clamps of the section pins. Disconnect electrical plug. Disconnect hydraulic/air pressure from hoses attached to the rod end valve block.
10. Remove the four bolts (1) (Figure 4-15) and both cylinder mounting plates (2) from cylinder assembly's rod end valve block.
11. Slide the five sections away from the base section until the section pins of section 1 are well away from the cutouts in the base section.
12. Remove the top and bottom retainer plates from front of base section.
13. Remove bottom corner inner wear pads and bottom inner wear pad and related shims from between bottom inner walls of base section and bottom outer walls of section 1.
14. Remove the side inner wear pads and their plates from the base section.
15. Remove side inner wear pads and shims from between side inner walls of the base section and side outer walls of section 1.
16. Remove the top corner inner wear pads and shims from the base section.
17. Slide sections 2, 3, 4, and 5 out the front of the base section.

18. Remove the two top corner outer wear pad assemblies from the outside top corners of section 1.
19. Remove the two bottom corner outer wear pads from the outside bottom corners of section 1.
20. Rest the pinned-together sections on an appropriate fixture.
21. Verify the cylinder pins are not connected to any telescope section and the butterfly arms are retracted.
22. Disconnect the 24 VDC supply and hydraulic hoses attached to the rod end valve block.
23. Remove the capscrews (3) (Figure 4-15) securing the hose brackets (4) to the rear of the section and route the brackets through the cutouts in the base section so the tele-cylinder can be removed.
24. Use appropriate lifting device to remove telescope cylinder assembly from telescope sections. Slowly remove the cylinder from the sections; take care not to damage any hydraulic or electrical parts, or mechanical parts while removing the cylinder. Ensure proper clearance for the pinning valve, the tubes, the wiring harness, the pinning head, and other attached parts of the cylinder assembly. Adjust and secure all parts as needed to ensure clearance.
25. Place cylinder assembly on a suitable fixture. Tag and remove hoses from cylinder assembly. Tag and remove wear pads from cylinder assembly as needed.

Remove Sections 2, 3, 4, and 5 from Section 1

1. Have fixtures in place for resting disassembled boom sections.
2. Unlock section 2's section pins using set screws (1) (Figure 4-17) to release them from the cutouts in section 1.

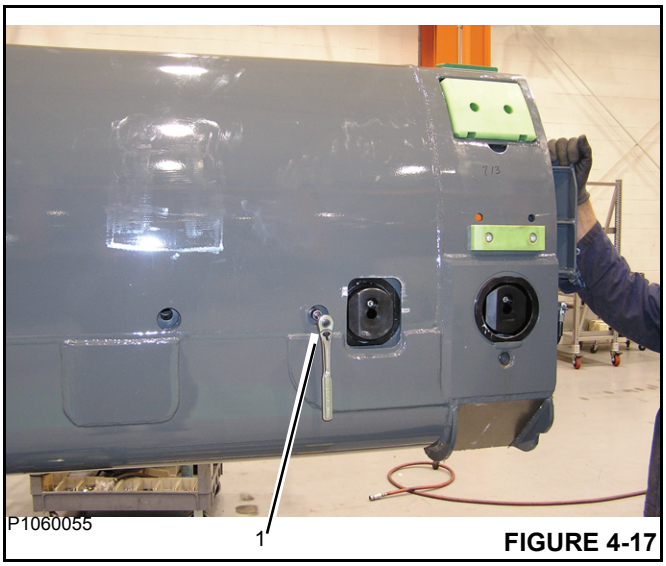


FIGURE 4-17

3. Slide section 2 and the other sections until section pins of section 2 are well away from the cutouts in section 1.
4. Remove top and bottom retainer plates from front of section 1.
5. Remove bottom corner inner wear pads and bottom inner wear pad and shims from between bottom inner walls of section 1 and bottom outer walls of section 2.
6. Remove the side inner wear pads and plates from section 1. Remove side inner wear pads and shims from between side inner walls of section 1 and side outer walls of section 2.
7. Remove top corner inner wear pads and shims from section 1.
8. Slide sections 2, 3, 4, and 5 out the front of section 1. Remove the two top corner outer wear pad assemblies from the outside top corners of section 2.
9. Remove the two bottom corner outer wear pads from the outside bottom corners of section 2.
10. Place boom sections on suitable fixtures for further teardown.

Remove Sections 3, 4, and 5 from Section 2

1. Have fixtures in place for resting disassembled boom sections.
2. Unlock section 3's section pins using set screws to release them from the cutouts in section 2 (Figure 4-17).
3. Slide section 3 and the other sections until section pins of section 3 are well away from the cutouts in section 2.
4. Remove the top and bottom retainer plates from front of section 2.
5. Remove bottom corner inner wear pads and bottom inner wear pad and shims from between bottom inner walls of section 2 and bottom outer walls of section 3.
6. Remove the side inner wear pads and their plates from section 2. Remove side inner wear pads and related shims from between side inner walls of section 2 and side outer walls of section 3.
7. Remove the top corner inner wear pads from section 2. Remove wear pads and shims.
8. Slide sections 3, 4, and 5 out the front of section 2. Remove the two top corner outer wear pad assemblies from the outside top corners of section 3.
9. Remove the two bottom corner outer wear pads from the outside bottom corners of section 3.
10. Place boom sections on suitable fixtures for further teardown.

Remove Sections 4 and 5 from Section 3

1. Have fixtures in place for resting disassembled boom sections.
2. Unlock section 4 section pins using set screws to release them from the cutouts in section 3.
3. Slide section 4 and section 5 until section pins of section 4 are well away from the cutouts in section 3.
4. Remove the top and bottom retainer plates from front of section 3.
5. Remove bottom corner inner wear pads and bottom inner wear pad and related shims from between bottom inner walls of section 3 and bottom outer walls of section 4.
6. Remove side inner wear pads and shims from between side inner walls of section 3 and side outer walls of section 4.
7. Remove the top corner inner wear pads and shims from section 3.
8. Slide sections 4 and 5 out the front of section 3.
9. Remove the two top corner outer wear pad assemblies from the outside top corners of section 4.
10. Remove the two bottom corner outer wear pads from the outside bottom corners of section 4.
11. Place boom sections on suitable fixtures for further teardown.

Remove Section 5 from Section 4

1. Have fixtures in place for resting disassembled boom sections.
2. Unlock section 5 section pins using set screws to release them from the cutouts in section 4.
3. Slide section 5 until section pins of section 5 are well away from the cutouts in section 4.
4. Remove top and bottom retainer plates from front of section 4.
5. Remove bottom corner inner wear pads and bottom inner wear pad and shims from between bottom inner walls of section 4 and bottom outer walls of section 5.
6. Remove the side inner wear pads and shims from between side inner walls of section 4 and side outer walls of section 4.
7. Remove top corner inner wear pads and shims from section 4.
8. Slide section 5 out the front of section 4.
9. Remove the two top outer wear pad assemblies from the outside top corners of section 5.
10. Remove the two bottom corner outer wear pads from the outside bottom corners of section 5.
11. Place boom sections on suitable fixtures for further teardown.

Disassembly of Sections

Section 5

1. Place the section upside down on roller jacks or other appropriate supports.

FIGURE 4-18

2. Remove the round button pads (1) (Figure 4-18) from the related holes in the rear portion of the section.
3. Remove the four sliders (2) and shims from the upper and lower rails in the rear portion of the section.
4. Remove the two bottom outer wear pads (3) and shims from the section.
5. Remove the two side outer wear pads (4) from the section.
6. Remove the two section pin assemblies (5):
   a. Remove connecting link (C-link) (6).
   b. Remove snap ring (7) in the OD groove of the guide tube. Remove pin assembly from the outside of the section.
   c. As needed, disassemble section pin.

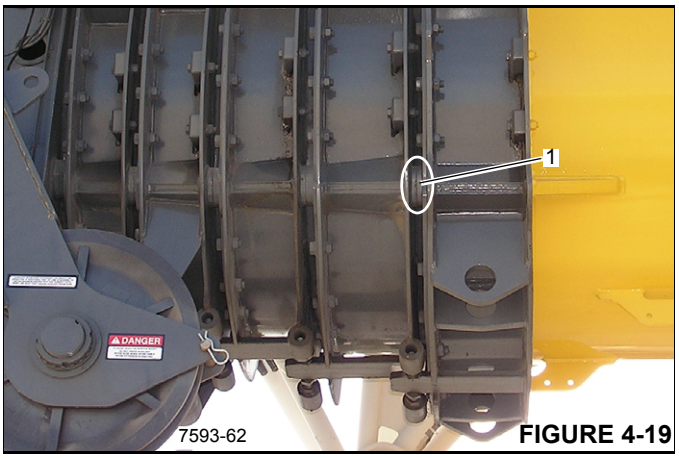


FIGURE 4-19

7. Remove stop block plates (1) and shims from the stop block mounting bosses on each side.
8. Remove top and bottom centering bolts and jam nuts from both sides.
9. For boom nose disassembly, refer to *Boom Nose Disassembly, page 4-16*.

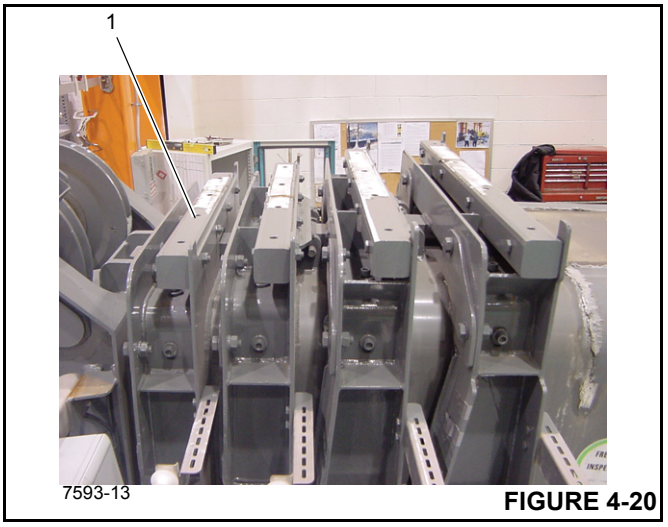


FIGURE 4-20

Section 4

1. Place the section upside down on roller jacks or other appropriate supports.
2. Remove the round button pads (1) (Figure 4-18) from the related holes in the rear portion of the section.
3. Remove the four sliders (2) and shims from the upper and lower rails in the rear portion of the section.
4. Remove the two bottom outer wear pads (3) and shims from the section.
5. Remove the two side outer wear pads (4) from the section.
6. Remove the two section pin assemblies (5):
   a. Remove connecting link (C-link) (6).
   b. Remove snap ring (7) in the OD groove of the guide tube. Remove pin assembly from the outside of the section.
   c. As needed, disassemble section pin.
7. Remove stop block plates (1) (Figure 4-19) and shims from the stop block mounting bosses on each side.
8. Remove cable protection strip (1) (Figure 4-20) from the top front of the flange in the front of the section.
9. Remove top and bottom centering bolts and jam nuts from both sides.

Section 3

1. Place the section upside down on roller jacks or other appropriate supports.
2. Remove the round button pads (1) (Figure 4-18) from the related holes in the rear portion of the section.
3. Remove the four sliders (2) and shims from the upper and lower rails in the rear portion of the section.
4. Remove the two bottom outer wear pads and shims from the section.
5. Remove the two side outer wear pads from the section.
6. Remove the two section pin assemblies:
   a. Remove connecting link (C-link).
   b. Remove snap ring in the OD groove of the guide tube. Remove pin assembly from the outside of the section.
   c. As needed, disassemble section pin.
7. Remove stop block plates and shims from the stop block mounting bosses on each side.
8. Remove cable protection strip from the top front of the flange in the front of the section.
9. Remove top and bottom centering bolts (1) (Figure 4-21) and jam nuts (2) from both sides.

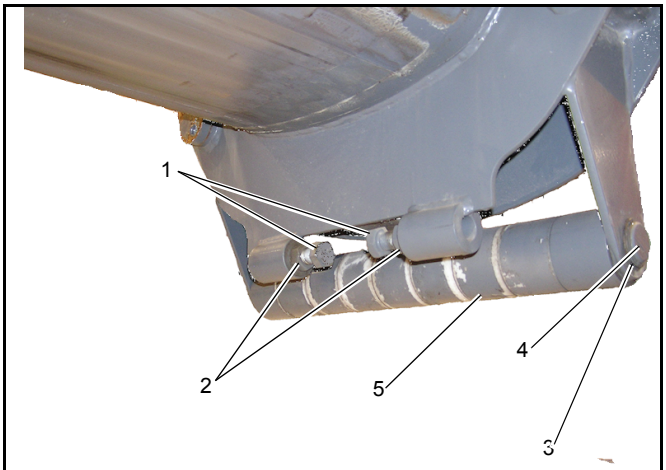


FIGURE 4-21

10. Remove two snap rings (3) (Figure 4-21) and axle shaft (4) and rollers (5) from the roller holder on the bottom of the section.

Section 2

1. Place the section upside down on roller jacks or other appropriate supports.
2. Remove the round button pads (1) (Figure 4-18) from the related holes in the rear portion of the section.
3. Remove the four sliders (2) and shims from the upper and lower rails in the rear portion of the section.
4. Remove the two bottom outer wear pads and shims from the section.
5. Remove the two side outer wear pads from the section.
6. Remove the two section pin assemblies:
   a. Remove connecting link (C-link).
   b. Remove snap ring in the OD groove of the guide tube. Remove pin assembly from the outside of the section.
   c. As needed, disassemble section pin.
7. Remove stop block plates and shims from the stop block mounting bosses on each side.
8. Remove remove cable protection strip from the top front of the flange in the front of the section.

Remove top and bottom centering bolts and jam nuts from both sides.

Section 1

1. Place the section upside down on roller jacks or other appropriate supports.
2. Remove the round button (1) (Figure 4-18) pads from the related holes in the rear portion of the section.
3. Remove the four sliders (2) and shims from the upper and lower rails in the rear portion of the section.
4. Remove the two bottom outer wear pads and shims from the section.
5. Remove the two side outer wear pads from the section.
6. Remove the two section pin assemblies:
   a. Remove connecting link (C-link).
   b. Remove snap ring in the OD groove of the guide tube. Remove pin assembly from the outside of the section.
   c. As needed, disassemble section pin.
7. Remove stop block plates and shims from the stop block mounting bosses on each side.
8. Remove remove cable protection strip from the top front of the flange in the front of the section.
9. Remove top and bottom centering bolts and jam nuts from both sides.

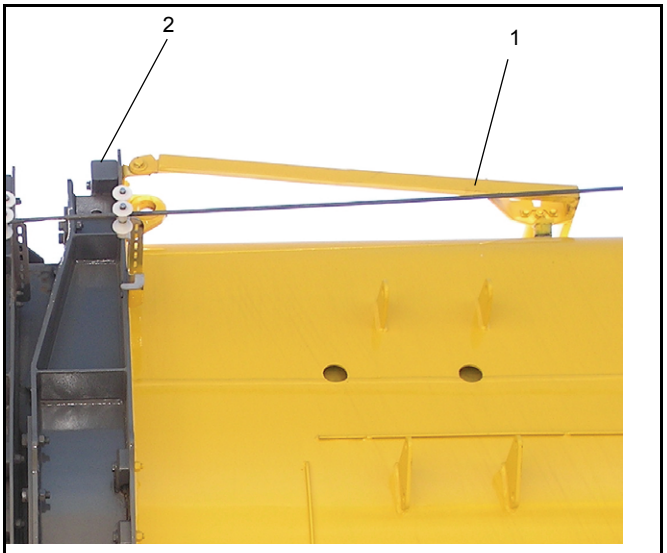


FIGURE 4-22

Base Section Disassembly

Removal of most parts on the outside of the base section takes place during initial disassembly.

1. Remove the linch pins and rope grab (1) (Figure 4-22) assembly from the top front of the base section.
2. Remove the cable protection strip (2) and two holder assemblies from the top front of the higher of the two flanges in the front of the base section.
3. Remove cable protection strip from the top rear surface of base section—above area where boom cable length measuring unit mounts.

Boom Nose Disassembly

Refer to (Figure 4-23) for the following procedure.

1. Remove the limit switch weight from the shackle.
2. Remove the linch pin and shackle from the post on the bottom left hand side of the nose.
3. Remove the cover from nose.
4. For each rope protection holder, remove securing pin and pin from the holder. Then remove the rope protection holder from the top of the nose.
5. Remove two linch pins and remove the lock pin from the boom nose above the pulleys.
6. Remove two linch pins and remove the lock pin from the boom nose forward of the pulleys.
7. Remove the two axle guards from the upper axle. Remove the axle, four spacer rings, or three and one spacers, both rope pulleys, two spacer rings, six spacer rings, and shim rings.
8. Remove the two axle guards from the lower axle. Remove the axle, four spacer rings, eight pulleys and seven spacer rings, and shim rings.

Assembling the Boom

Perform the assembly with the boom sections upside-down, preferably on roller jacks or similar fixtures appropriate for the buildup.

NOTE: Apply medium strength threadlocking adhesive/sealant to the threads of all attaching hardware.

Apply Mobil XHP222 lithium grease or Grove-approved equivalent to the section pins' springs, locking pins' shafts, and insides of guide tubes. Apply Bechem 9012329202 Berulub PAL 1 lubricant or Grove-approved equivalent to all wear surfaces, and to the outsides of section pins' guide tubes and portions of locking pins that are outside of the guide tubes.

Use metric grade 8.8,10.9 or 12.9 torque values specified in Section 1 of this manual unless otherwise specified.

The basic approach of assembling the boom is as follows:

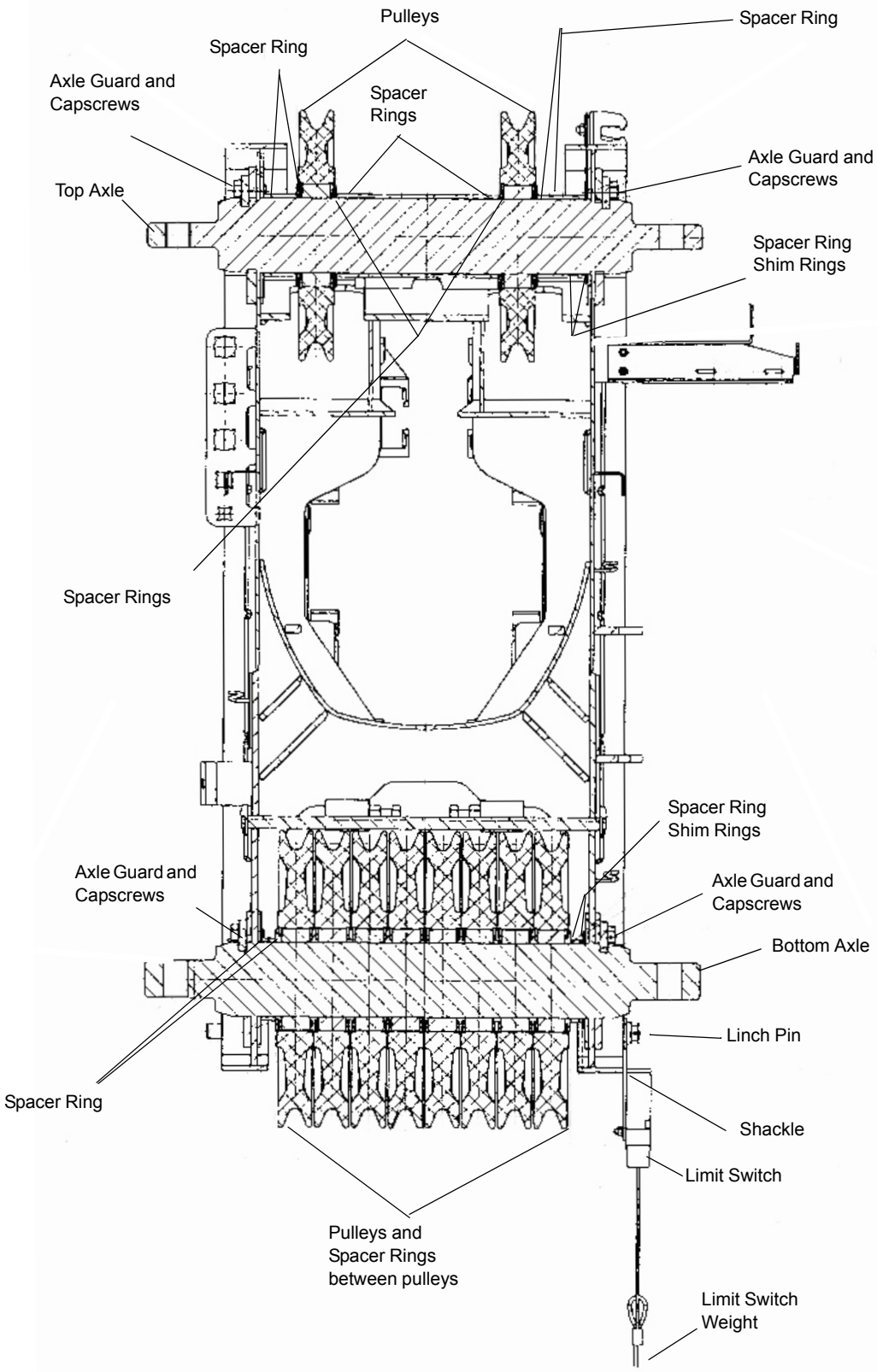
1. Build up each of the sections. This includes installing sheaves and related hardware onto the nose of section 5.
2. Install each section into the next larger section—section 5 into section 4, section 4 into section 3, section 3 into section 2, section 2 into section 1.
3. Install the telescope cylinder into the assembled sections.
4. Install the boom sections with telescope cylinder into the base section. Secure the telescope cylinder to the base section.
5. Install the remaining parts onto the assembled boom.

NOTE: To aid in assembly contact Manitowoc Crane Care to obtain a copy of the engineering drawings of the boom. Always consult the engineering drawings for each section to verify part numbers and to aid in assembly.

Boom Nose Assembly

Refer to Figure 4-23 for the following procedure.

1. Insert the bottom axle into the right side bottom axle hole in the nose of section 5.
2. Install a spacer ring (63) and a spacer ring (nylatrin single lip ring) (54) on the axle so they will keep the right hand pulley from rubbing against the inside right surface of the nose. Make sure lip of spacer ring (54) touches the right hand pulley and its flat side faces away from the pulley.
3. Install eight pulleys and seven spacer rings (double lip rings) (55), one between each pair of pulleys, on the axle.
4. Install a single lip spacer ring (62) and a spacer ring (66) on the axle so they will keep the left hand pulley (40) from rubbing against the inside left surface of the nose. Make sure lip of spacer ring (62) touches left hand pulley; make sure its flat side points away from the pulleys.
5. Shim the bottom axle as needed outside of spacers (63 and/or 66) with shim rings (68) until none of the spacers or pulleys will be able to move side to side on the axle.
6. Turn the bottom axle so the slots face up. Install the axle so the slots are visible on each side. Install an axle retainer into the slot of the axle on each side and secure it to the nose with two capscrews. Verify none of the spacers or pulleys can move side to side on the axle.
7. Tighten the capscrews until there is 0.04 to 0.08 in (1 to 2 mm) of end play on the bottom axle and there is no play in the pulleys' bearings.
8. Insert the top axle through the left side axle hole in the boom nose.
9. Install three spacer rings—lip must touch pulley and flat side must face away from the pulley—and a pulley on the axle. Verify the spacers prevent the pulley from rubbing against the inside left surface of the nose.
10. Install a spacer ring next to the left side pulley on the axle; make sure lip touches pulley and flat side faces away from the pulley. Install five spacer rings on the axle. Install another spacer ring on the axle so its lip will touch the right side pulley when it is installed; make sure its flat side faces away from the right side pulley.
11. Install a pulley, a spacer ring, and a spacer ring on the axle; the spacer ring lip touching pulley and flat side facing away from the pulley. Then install the spacer ring so it will keep the pulley from rubbing against the inside right surface of the nose.
12. Shim the top axle as needed on the outside of spacers with shim rings until none of the spacers or pulleys will be able to move side to side on the axle.
13. Turn the top axle so its slots face up. Install an axle guard on each side into the slots of the axle and secure with two capscrews. Verify none of the spacers or pulleys can move side to side on the axle.
14. Tighten the capscrews until there is 0.04 to 0.08 in (1 to 2 mm) of end play on the top axle and there is no play in the pulleys' bearings.
15. Install a retainer pin through the holes in the bottom of the boom nose in front of the lower pulleys. (This pin helps keep the cables on the sheaves.) Secure the retainer pin with two linch pins.
16. Install a retainer pin through the holes in the bottom of the boom nose above the pulleys. (This pin helps keep the cables on the sheaves.) Secure the lock pin with two linch pins.
17. For each of the two pulleys on the top axle, secure a rope retainer holder on the nose above the pulley. Each holder goes inside a nose bracket; the nuts go on the inside surface of the holder.
18. Install a pin in each sleeve of the rope retainer holders above the pulleys. Secure each pin to its holder with a retaining clip.
19. Secure cover to nose with capscrews.
20. Install the shackle onto the post on the bottom left hand side of the boom nose. Secure the shackle with a linch pin.
21. Secure the limit switch weight to the shackle with two nuts and capscrews.



nose 1

FIGURE 4-23

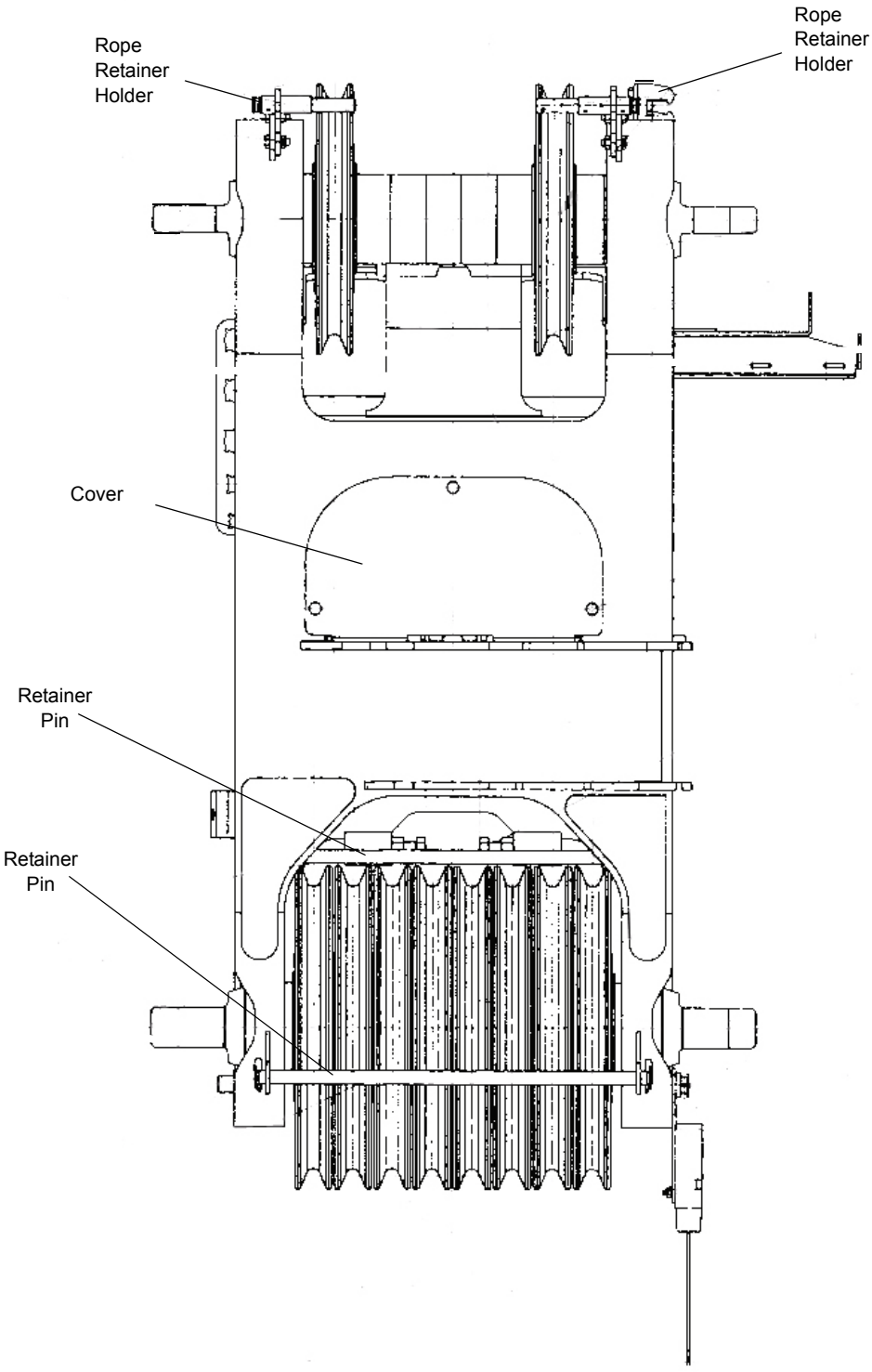


FIGURE 4-23 continued

Boom Nose (and Section 5) shown upside-down

FIGURE 4-23 continued

Section 5 Assembly

1. Install round button pads (1) (Figure 4-24) in the holes in the rear portion of the section.
2. Install four sliders (2) on the upper and lower rails in the rear portion of the section, shim as needed. Note the thick end of each slider; install sliders so the thick ends are opposite each other and the thin ends are at the rear of the section. Use shims to attain a gap between the thick ends of 6.73 to 6.74 in (171 mm).
3. Put two top corner outer wear pad assemblies (Figure 4-25) in place on the top outside corners of the section (the top outside corners are at the bottom of the upside-down section). Secure lube hoses in lugs provided on the rear of the section using the nuts. The wear pads “float” in their mountings on the section; section 4 will hold them in place.
4. Verify for each bottom corner outer wear pads (4) (Figure 4-24), a capscrew holds a plate in its recess. Route two set screws through holes in the curved surface of each wear pad and screw them into the plate. Put the wear pads in place on the bottom outside corners of the section with the two slots facing down to clear the screws holding the sliders.
5. Install two bottom wear pads (3) on the bottom of the section with shims and countersunk screws. The wear pads go on the top of the upside-down section. Use shims as needed to make these pads just touch the bottom inside of section 4 when installing section 5 into section 4.
6. Install two side outer wear pads (5) on the sides of the section with capscrews. Use wear pads of the proper size so they just touch the inside of section 4 when installing section 5 into section 4.

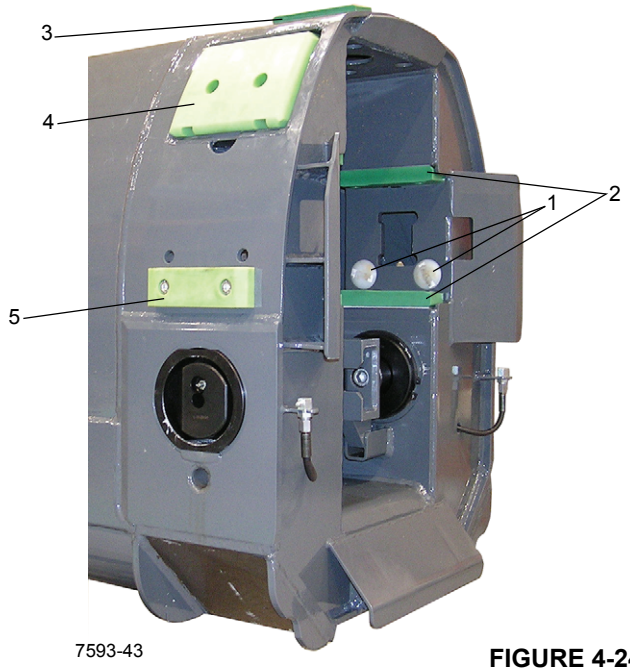
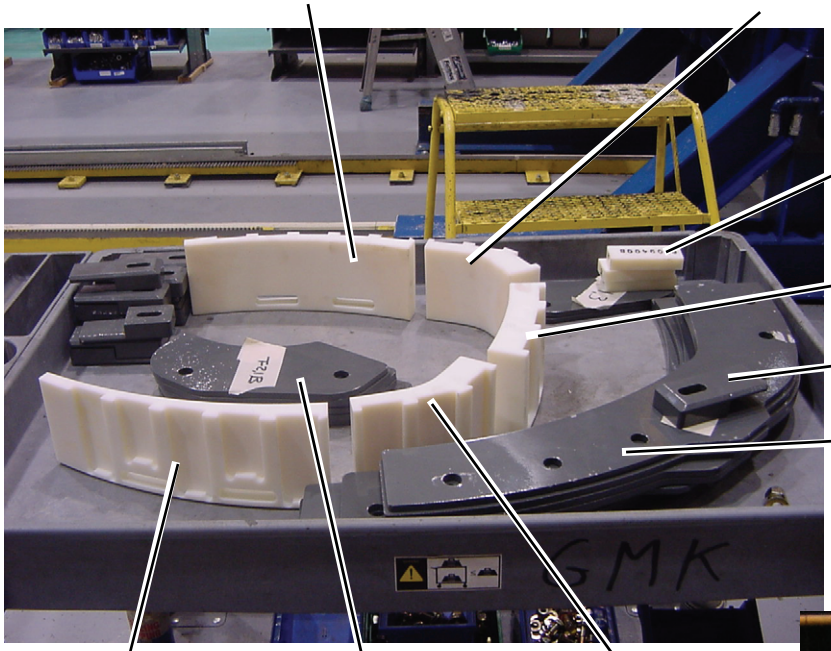
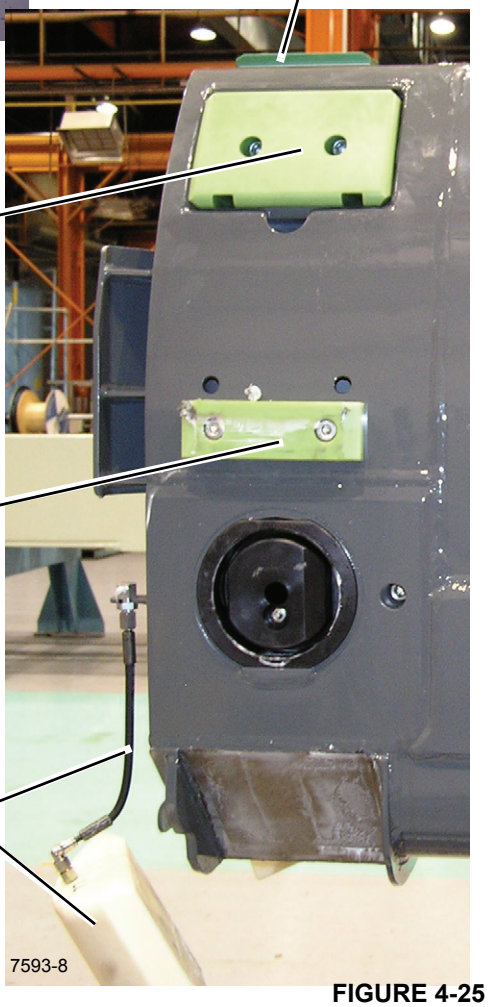
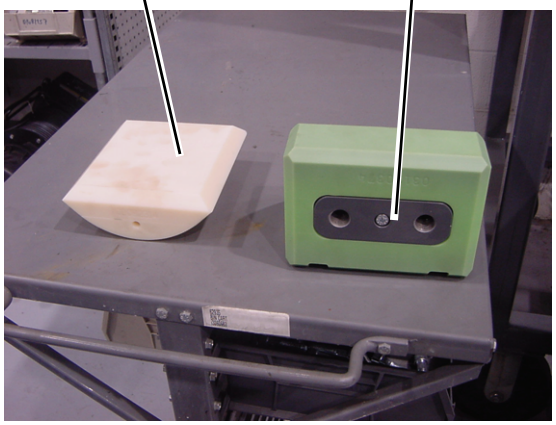


FIGURE 4-24







Note: Parts are similar for each section, but are of different sizes. Consult parts list or print as needed.

FIGURE 4-25

7. Install the section pins as follows:
   - **a.** Install a grease fitting into the threaded hole of a locking pin.
   - **b.** Put a spring around the shaft of the locking pin.
   - **c.** Grease the spring and the inside of a guide tube with approved lithium grease.
   - **d.** Insert the locking pin and spring into the guide tube.
   - **e.** Install the guide tube and attached parts in the rear of the section from the outside.
   - **f.** Place a retaining ring in the OD groove of the guide tube to prevent it from going too far into the hole in the section.
   - **g.** Install connecting link (C-clamp) with the triangular end in inside the tabs on the section wall and secure to guide tube and locking pin with a capscrew. Make sure the C-clamp's attached triangular flange points forward and covers the related set screw hole in the section.Tighten the capscrew until the flange of the guide tube touches the matching surface on the outside of the section, and the retaining ring around the guide tube touches the matching surface on the inside of the section.

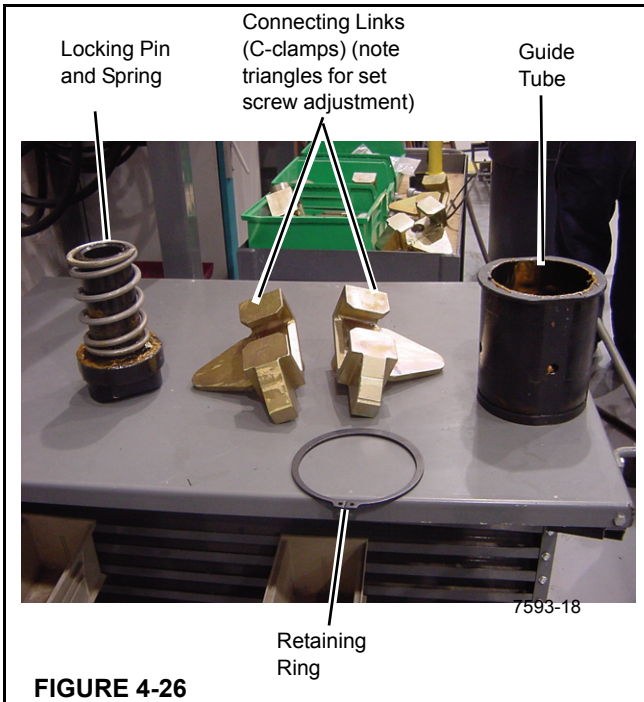


FIGURE 4-26

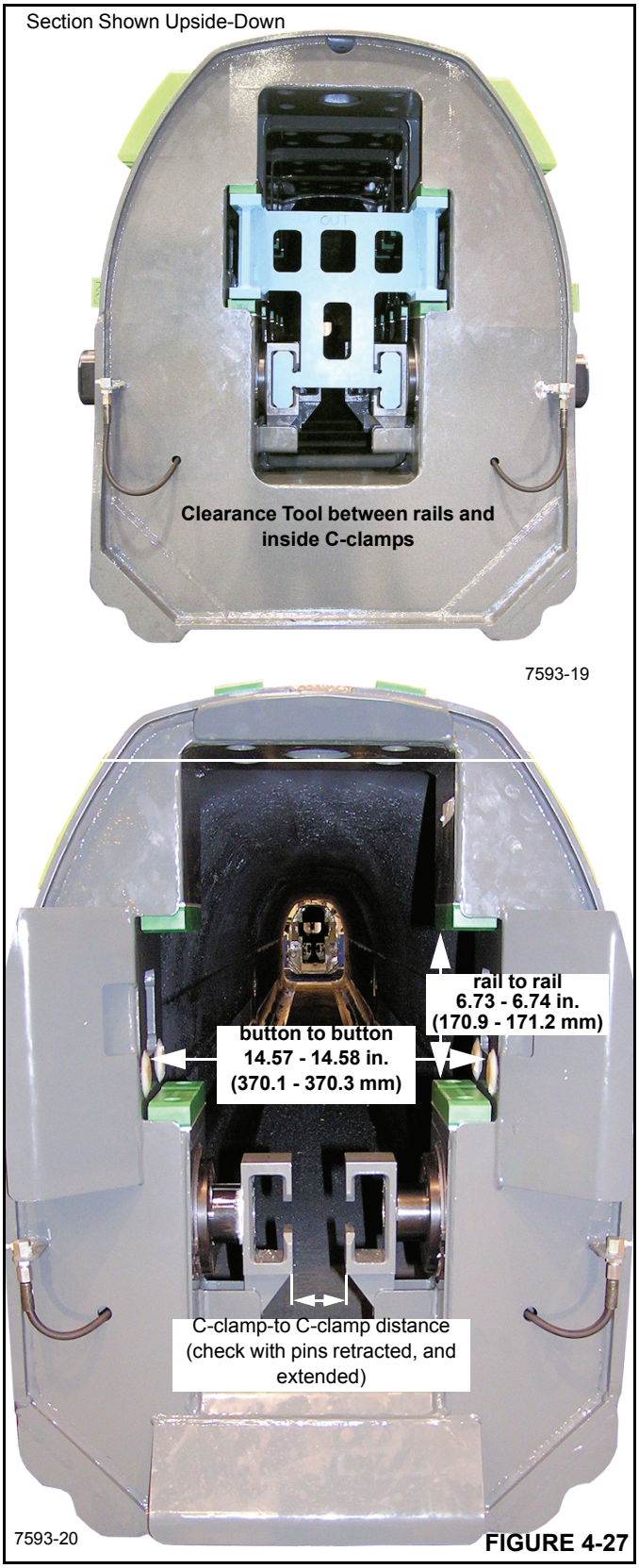


FIGURE 4-27

4

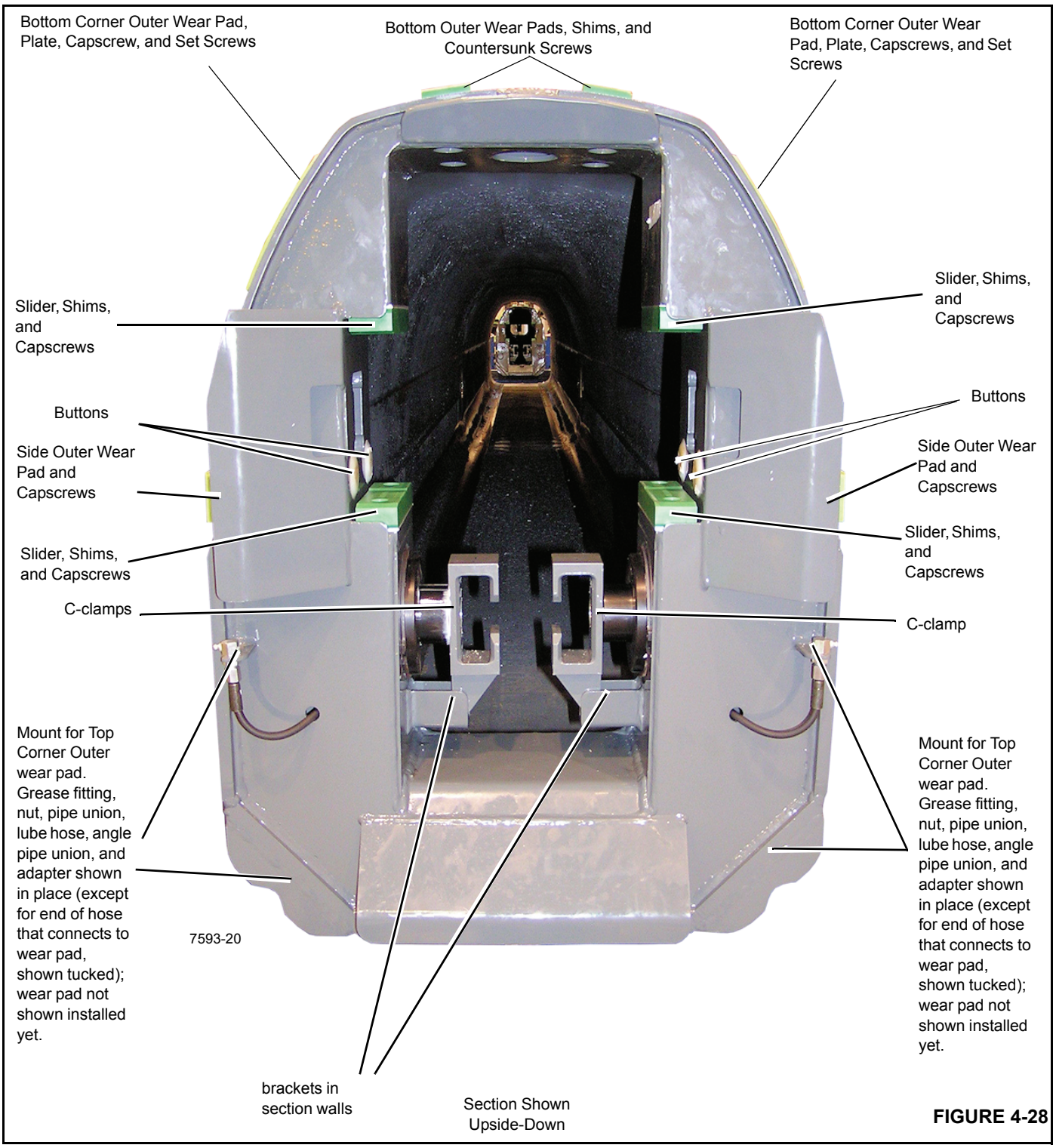


FIGURE 4-28

8. Test clearance between C-clamps and test clearances between interior wear pads with clearance tool CT100941. This test tool is essentially a go/no go gauge; it lets the mechanic know roughly how accurate the part installations are. The tool should slide easily without hanging if parts are installed properly. Refer to Table 4-1 for the proper dimensions.

Table 4-1: Assembly dimensions:

Item	Dimension
C-clamps, fully extended	5.27 to 5.28 in (134 mm)
C-clamps, fully retracted	2.20 to 2.21 in (56 mm)
Button pads	14.57 to 14.58 in (370 mm)
Thick ends of sliders	6.73 to 6.74 in (171 mm)

Make adjustments as needed.

NOTE: To fully retract the section pin assemblies, install a set screw in the hole provided forward of each of the two section pin assemblies. Thread set screw into hole until it is flush with the triangular flange of the C-clamp inside the section. Keep tightening the set screw against the C-clamp to retract the section pin until the locking pin face is flush with the flange of the guide tube. When done measuring, remove the set screw.

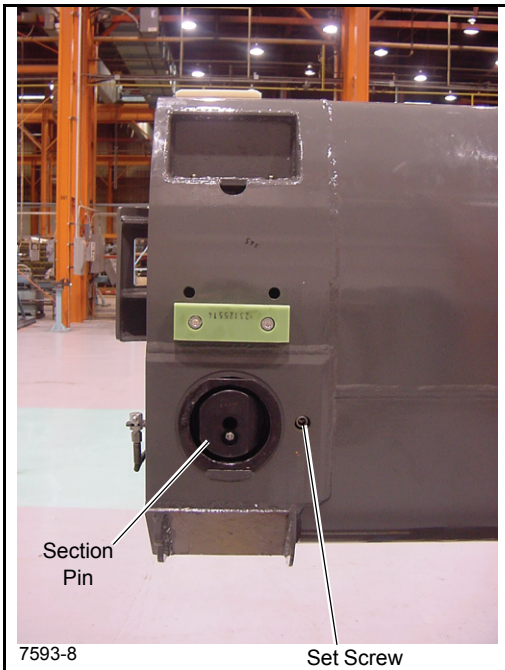


FIGURE 4-29

9. Install stop block plates and shims on the stop block mounting surfaces on each side of section 5 to the rear of the nose.

10. Install bolts and jam nuts into place on lugs on the top side and on the bottom side of section 5, near the rear of the nose portion. Nominal gap for each pair of bolt heads is 3.15 to 3.16 in (80 mm). These will need adjustment with anti-roll bars of section 4.

Section 4 Assembly

1. Install round button pads in the holes in the rear portion of the section.

2. Install four sliders on the upper and lower rails in the rear portion of the section, shim as needed. Note the thick end of each slider; install sliders so the thick ends are opposite each other and the thin ends are at the rear of the section. Use shims to attain a gap between the thick ends of 6.73 to 6.74 in (171 mm).

3. Put two top corner outer wear pad assemblies in place on the top outside corners of the section (the top outside corners are at the bottom of the upside-down section). Secure lube hoses in lugs provided on the rear of the section using the nuts. The wear pads “float” in their mountings on the section; section 4 will hold them in place.

4. Verify for each bottom corner outer wear pads, a capscrew holds a plate in its recess. Route two set screws through holes in the curved surface of each wear pad and screw them into the plate. Put the wear pads in place on the bottom outside corners of the section with the two slots facing down to clear the screws holding the sliders.

5. Install two bottom wear pads on the bottom of the section with shims and countersunk screws. The wear pads go on the top of the upside-down section. Use shims as needed to make these pads just touch the bottom inside of section 4 when installing section 4 into section 3.

6. Install two side outer wear pads on the sides of the section with capscrews. Use wear pads of the proper size so they just touch the inside of section 4 when installing section 4 into section 3.

7. Install the section pins as follows:

a. Install a grease fitting into the threaded hole of a locking pin.

b. Put a spring around the shaft of the locking pin.

c. Grease the spring and the inside of a guide tube with approved lithium grease.

d. Insert the locking pin and spring into the guide tube.

e. Install the guide tube and attached parts in the rear of the section from the outside.

f. Place a retaining ring in the OD groove of the guide tube to prevent it from going too far into the hole in the section.

g. Install C-clamp with the triangular end in inside the tabs on the section wall and secure to guide tube and locking pin with a capscrew. Make sure the C-clamp’s attached triangular flange points forward

and covers the related set screw hole in the section.Tighten the capscrew until the flange of the guide tube touches the matching surface on the outside of the section, and the retaining ring around the guide tube touches the matching surface on the inside of the section.

8. Test clearance between C-clamps and test clearances between interior wear pads with clearance tool CT100941. This test tool is essentially a go/no go gauge; it lets the mechanic know roughly how accurate the part installations are. The tool should slide easily without hanging if parts are installed properly. Refer to Table 4-1 for the proper dimensions.

NOTE: To fully retract the section pin assemblies, install a set screw in the hole provided forward of each of the two section pin assemblies. Thread set screw into hole until it is flush with the triangular flange of the C-clamp inside the section. Keep tightening the set screw against the C-clamp to retract the section pin until the locking pin face is flush with the flange of the guide tube. When done measuring, remove the set screw.

9. Install stop block plates and shims on the stop block mounting surfaces on each side of section 5 to the rear of the nose.

7593-13 Boom sections are shown assembled. All but section 5 have a cable protection strip.

FIGURE 4-30

10. Install cable protection strip on the top front of the flange in the front of the section (Figure 4-30).

11. Install bolts and jam nuts into place on lugs on the top side and on the bottom side of section 5, near the rear of the nose portion. Nominal gap for each pair of bolt heads is 3.15 to 3.16 in (80 mm). These will need adjustment with anti-roll bars of section 4.

Section 3 Assembly

Assemble section 3 the same as section 4 plus install axle pin and nine roller segments on the roller holder on the bottom of the section. Secure axle pin with two retaining rings.

Section 2 and 1 Assembly

Assemble section 2 and 1 the same as section 4.

Base Section Assembly

1. Install the cable protection strip on the top front of the higher of the two flanges in the front of the base section.
2. Install the two holder assemblies on the top rear of this same flange.
3. Secure rope grab assembly to holder assemblies with linch pins.
4. Install cable protection strip to top rear surface of base section (above area where boom cable length measuring unit mounts).
5. Installation of the remainder of parts on the outside of the base section takes place during boom final assembly.

Boom Assembly

NOTE: In the assembly procedures that follow, “consolidate shims” to shrink a shim stack as needed. Use fewer thicker instead of more thinner shims to adjust distances. This shrinks the actual distance because the more shims in the stack, the greater the dimension due to some warping or other abnormalities of shims.

Assemble Section 5 Into Section 4

1. Grease all section 5 sliding surfaces corresponding surfaces on section 4.
2. Install set screws in section 5 section pins and retract the pins so they won’t lock into holes in section 4.
3. Slide rear of section 5 into front of section 4. Shim the bottom wear pads (1) (Figure 4-31) to have the pads just touch the section 4 inner wall. Remove and install section 5, as necessary, to adjust these pads.
4. Push the top corner outer wear pads (2) into place as they go into section 4, adjust set screws in wear pads as

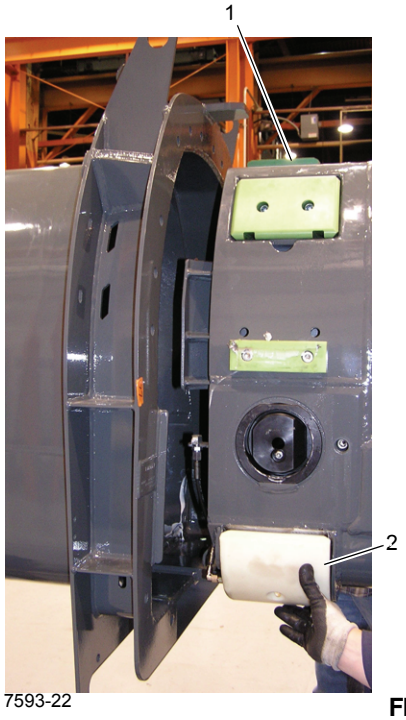


FIGURE 4-31

5. Slide section 5 into section 4 about midway.
6. Measure gap between outer side wall of section 5 and inner side wall of section 4, refer to (Figure 4-32). Do this for both sides of section 5. Note measurements.
7. Measure gap between outer bottom wall of section 5 and inner bottom wall of section 4. Measure gap between outer top wall of section 5 and inner top wall of section 4. Note measurements.
8. Slide section 5 into section 4 until one of the set screws of each of the bottom corner outer wear pads on section 5 is visible through the access holes of section 4 (Figure 4-32). Tighten each set screw (Figure 4-32) to force its wear pad to touch the inside wall of section 4. Then back off the set screw one-half turn. Repeat this for the other set screw in each wear pad.

FIGURE 4-32

FIGURE 4-33

9. Install bottom inner wear pad (1) (Figure 4-34), and bottom corner inner wear pads (2) between walls of section 4 and section 5.

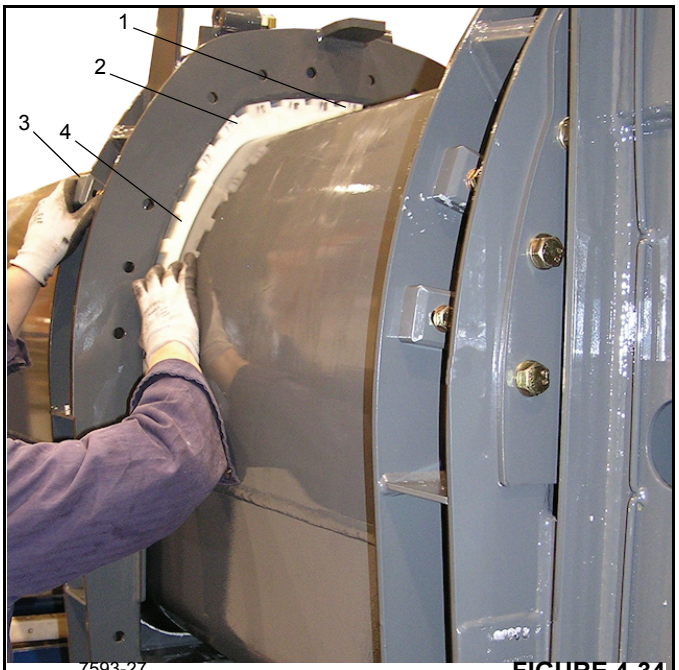


FIGURE 4-34

10. Install retainer plates (3) in slots behind front flange in section 4 with 0.25 in (6 mm) gap between plate and wear pads. Temporarily secure each plate with a capscrew, flat washer, and lock nut.
11. Install the side inner wear pads (4) and retaining plates.
12. Install wear strips (1) (Figure 4-35) under the wear pads to ensure bottom, corner, and side wear pads are tight against section 5 without jamming or interfering with normal movement. Wear strips must be same thickness on left and right to keep boom centered during extension and retraction.
13. Move the retainer plates tight against the wear pads and tighten the capscrews.
14. Install top corner inner wear pads (1) (Figure 4-36) between walls of section 4 and section 5. Shim under wear pads as needed using shims on each side. Shims must be same thickness on left and right.

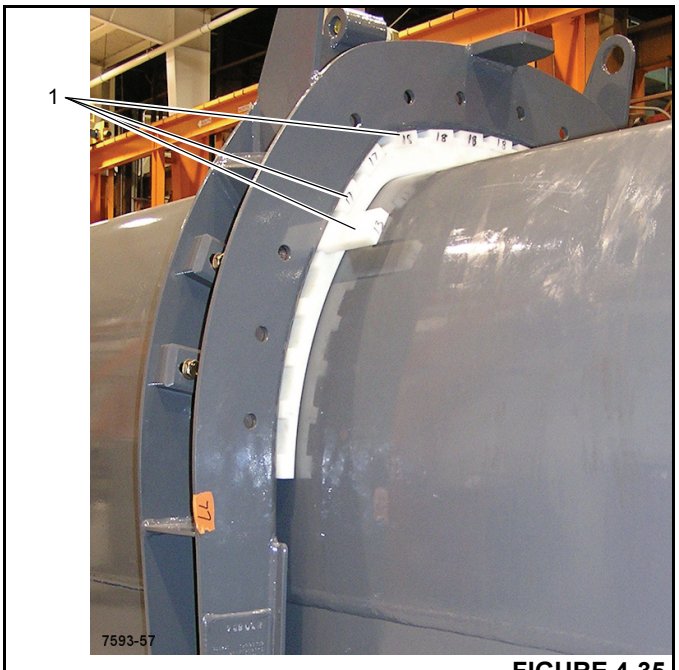


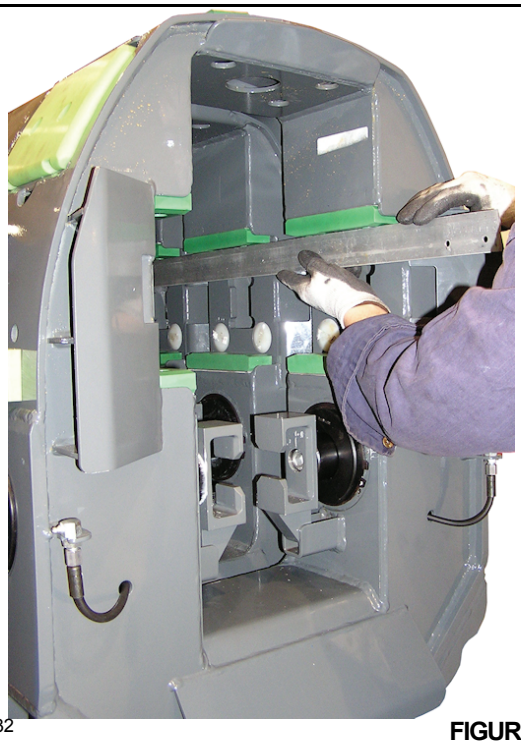
FIGURE 4-35

15. Tighten capscrews so the wear pads just touch section 5 outer wall. Don't tighten capscrews any more for now.

FIGURE 4-36

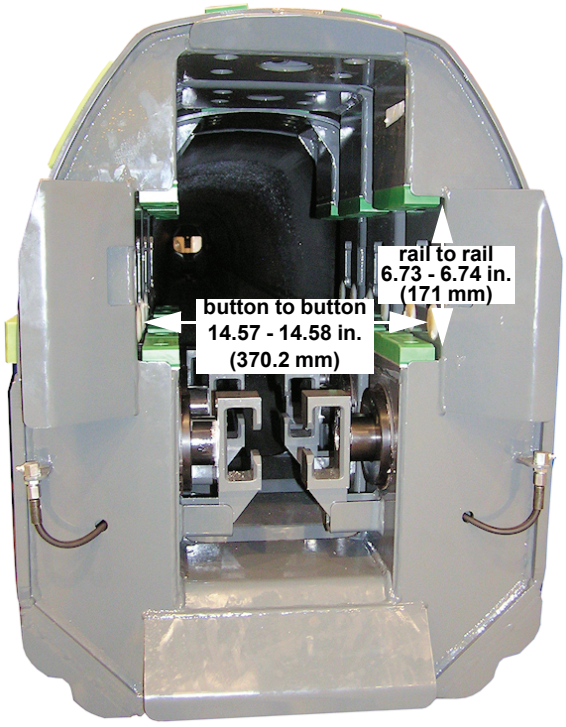
16. Tighten side outer wear pad screws on both sides of section 5 so the pads just touch section 4 inner walls. This aligns section 5 during extension or retraction.
17. Move section 5 inside section 4 until the lube hoses of its top corner outer wear pads are accessible. Lube wear pads with proper grease.

18. Retract section 5 into section 4 until section pins of section 5 align with cutouts in rear of section 4. Unscrew set screws to allow section pins to extend into section 4. Remove set screws.
19. Check each matching set of sliders in section 5 and in section 4 with a straight edge (Figure 4-37). Shim sliders as needed if not aligned per straightedge check.
20. Verify button pads of section 5 and section 4 are 14.57 to 14.58 in (370 mm) apart (Figure 4-38).
21. Verify the distance between the facing thick ends of each set of sliders on the upper and lower rails of section 5 and section 4 is 6.73 to 6.74 in (171 mm). Add or subtract shims as needed to achieve this distance.



7593-32

FIGURE 4-37



7593-33

FIGURE 4-38

22. Bring the sections together so the anti-roll bars (1) (Figure 4-39) of section 4 are between the adjusting bolts (2) of section 5. With section 5 centered in section 4 adjust the bolts until there is a gap of 0.125 in (3 mm) between each bolt head and its related anti-roll bar. Secure each bolt with its jam nut. Repeat for the other anti-roll bar.
    The purpose of the two anti-roll bars is to keep the boom from twisting during swinging of the jib.

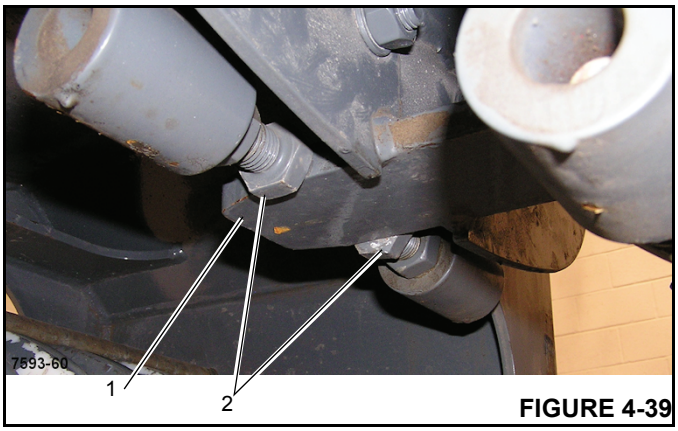
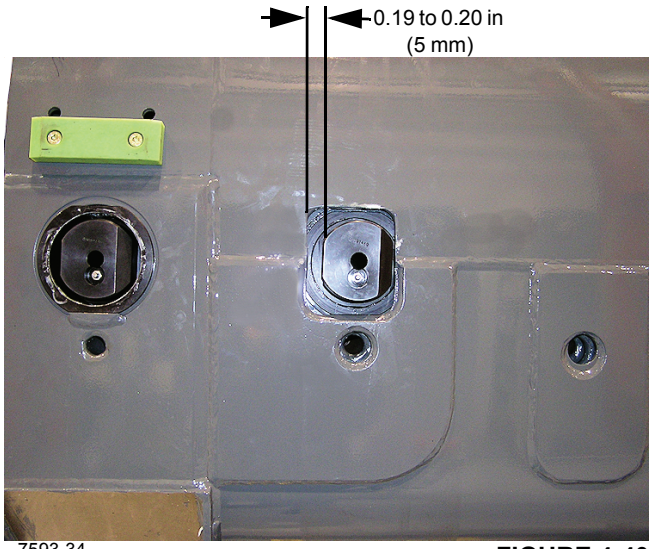


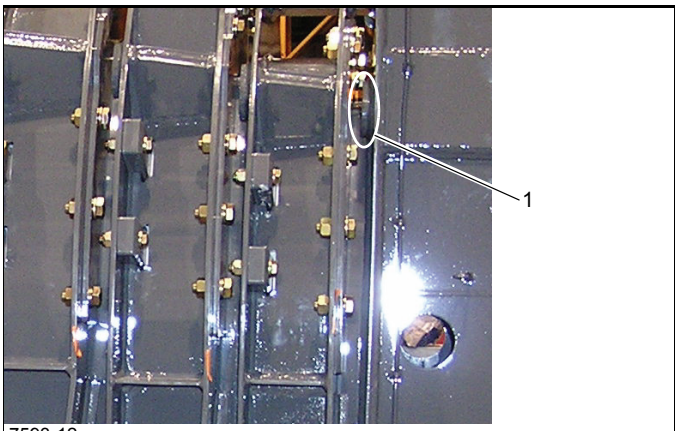
FIGURE 4-39

23. Measure from the rear edge of each section 4 cutout to the corresponding rear surface of the section pin on each side of section 5 (Figure 4-40). Distance must be 0.19 to 0.20 in (5 mm). Adjust by adding or subtracting

stop block shim(s) behind the stop block (1) (Figure 4-41) at the front of section 5.



7593-34 **FIGURE 4-40**



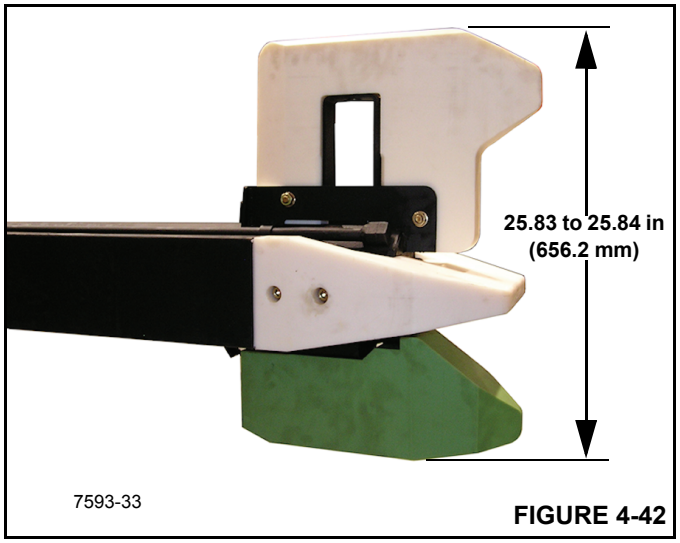
7593-12 **FIGURE 4-41**

Assembly of Remaining Sections

The procedure to insert the sections into the next is the same as the assembly of section 5 into section 4.

Install Telescope Cylinder Assembly into Sections

1. Inspect the telescope cylinder and assembled parts as follows:
   - Verify the pinning head (the butterfly and related parts) are installed on the pinning block on the back end of the barrel.
   - Verify the two-solenoid pinning valves and the control module are in place on the barrel forward of the pinning head.
   - Verify all hoses and tubing of the cylinder assembly are undamaged and all fittings are tight.
   - Verify the top, bottom and side wear pads are secured to the front end of the cylinder barrel.
   - Verify the bottom wear pad is secure to the underside of the pinning block of the cylinder barrel.
   - Verify the wiring harness, the electrical parts of the pinning head, and other electrical parts are undamaged. Verify these parts will not hang up on other parts during installation and normal cylinder movement.
   - Verify the faces of the proximity switches above the target on the butterfly are 0.156 to 0.159 in (4.0 mm) above the target.
   - Verify the distance between the top of the top wear pad on the front of the cylinder assembly and the bottom of the bottom wear pad on the front of the cylinder assembly is 25.83 to 25.84 in (656 mm) (Figure 4-42). As needed, shim between the bottom wear pad and the cylinder's bottom wear pad mount to maintain this dimension.



7593-33 **FIGURE 4-42**

2. Verify the top, side, and bottom pads are in place on the barrel end of the cylinder. Verify the pad is in place on

the bottom of the pinning block. Liberally grease these blocks attached to the cylinder assembly.

3. Turn the cylinder upside-down; the pinning head is on the bottom.

4. Apply 24 VDC to the emergency/service mode plug with the testing unit. Verify the LEDs on the proximity sensors in the pinning head light to verify they are in working order. If all the sensors do not all light, contact Manitowoc Crane Care. Disconnect the testing unit.

CAUTION

Equipment Damage Hazard!

Apply no more than 1400 psi or you will cause seals in the butterfly to suffer damage and leak.

5. Connect hydraulic/air supply hoses to the A, R, K1, and K2 ports of the rod end valve block (Figure 4-43).

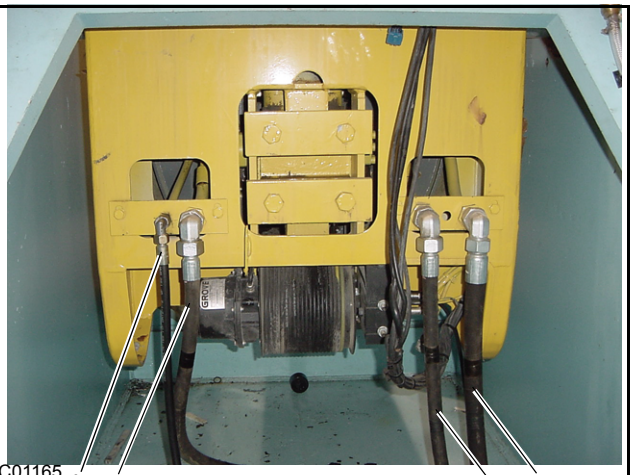


FIGURE 4-43

6. Use the 24 VDC control and hydraulic/air pressure to pivot the butterfly arms in so they won't be damaged during installation.

7. Disconnect electrical wires and hoses.

8. Use appropriate lifting device to install telescope cylinder assembly, barrel end first, into rear of section 1.

FIGURE 4-44

9. Slowly insert the cylinder into the sections (Figure 4-44); take care not to damage any hydraulic, electrical or mechanical parts while installing the cylinder. Ensure proper clearance for the pinning valve, tubes, wiring harness, pinning head, and other attached parts of the cylinder assembly. Verify they will all clear the interior parts of the five telescoping sections, and there will be no damage to them during extension or retraction. Adjust and secure them as needed to ensure clearance.

10. Stop when the cylinder pins in the pinning block of the cylinder align with the mating cutouts in section 1.

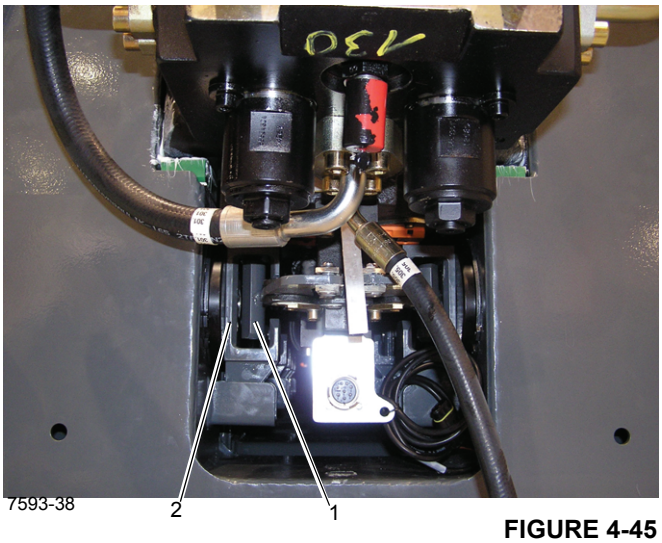


FIGURE 4-45

11. Reconnect the 24 VDC testing unit's plug to the matching emergency/service mode plug of the pinning head. Reconnect hoses to the rod end valve block.

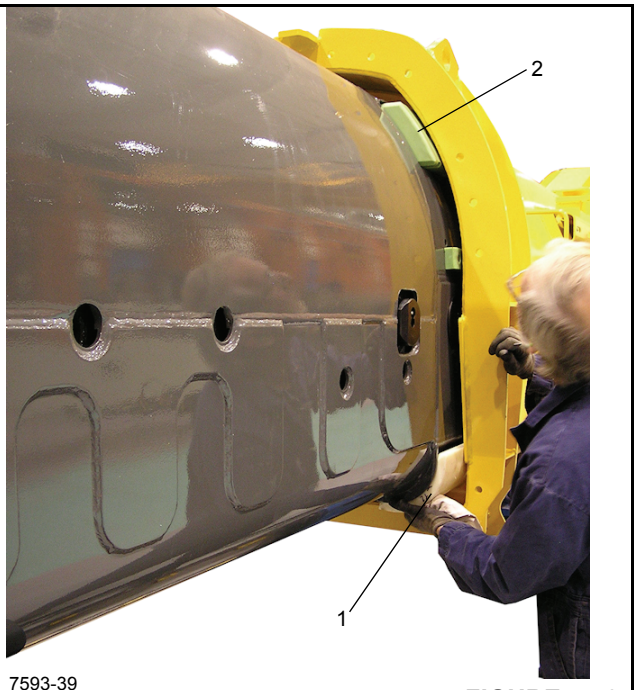
12. Use electrical control and hydraulic/air pressure to extend the cylinder pins to engage the mating cylinder

pin holes in section 1. This pins the cylinder to section 1. Keep the butterfly linkage of the cylinder assembly IN to avoid engaging the C-clamps. Then disconnect electrical plug and disconnect hoses from the rod end valve block.

NOTE: The links (1) (Figure 4-45) on the ends of the butterfly arms fit inside the C-clamps (2) without touching any sides.

Assemble Telescope Assembly and Base Section

1. Grease all section 1 sliding surfaces and mating base section surfaces.
2. Install set screws in the section 1 section pins and retract the pins so they won't lock into holes in the base section.
3. Lube all wear pads and lube the sliders on the cylinder rails.
4. Insert rear of section 1 into front of base section. As needed, extend out section 1 and install the right mix of shims under bottom outer wear pads of section 1 so the pads just touch the base section inner wall.



7593-39

FIGURE 4-46

5. Push the top corner outer wear pads (1) (Figure 4-46) into place as they go into the base section. Adjust the set screws in the bottom corner outer wear pads (2) to allow for assembly.
6. Slide section 1 into base section midway.
7. Measure gap between outer side wall of section 1 and inner side wall of base section. Do this for both sides of section 1. Note measurements.
8. Measure gap between outer bottom wall of section 1 and inner bottom wall of base section. Measure gap between outer top wall of section 1 and inner top wall of base section. Note measurements.
9. Slide sections into base section until one of the set screws of each of the bottom corner outer wear pads on section 1 is visible through the access holes in the base section. Tighten each set screw to force its wear pad to touch the related inside wall of the base section. Then back off the set screw one-half turn. Repeat this for the other set screw in each wear pad.
10. Install bottom inner wear pad and bottom corner inner wear pads.
11. Install retainer plates in slots behind front flange in base section with 0.25 in (6 mm) gap between plate and wear pads. Temporarily secure each plate with a capscrew, flat washer, and lock nut.
12. Install the side inner wear pads and retaining plates.
13. Install wear strips under the wear pads to ensure bottom, corner, and side wear pads are tight against section 5 without jamming or interfering with normal movement. Wear strips must be same thickness on left and right to keep boom centered during extension and retraction.
14. Move the retainer plates tight against the wear pads and tighten the capscrews.
15. Install top corner inner wear pads. Adjust capscrews for top corner inner wear pads so the wear pads are snug against section 1 but not jammed. Shim under wear pads as needed using shims on each side and on top. Shims must be same thickness on left and right to keep boom straight during extension and retraction. Divide total shimming distance by 2 to shim properly.
16. Secure top corner inner wear pads to forward top corners of base section inner walls with capscrews and flat washers through holes in corners. Tighten capscrews so the wear pads just touch section 1 outer wall.
17. Tighten screws so side outer wear pads on both sides of section 1 just touch base section inner walls. This adjustment protects section 1 from moving left or right during extension or retraction.
18. Install retainer plates to hold wear pads in place.
19. Move section 1 into the base section until the lube hoses of its top corner outer wear pads are accessible. Lube wear pads with proper grease.
20. Move section 1 into the base section until section pins of section 1 align with cutouts in rear of base section.

Unscrew set screws to allow section pins to extend and lock into base section. Remove set screws.

21. With section 1 centered in the base section adjust the bolts on either side of the top and bottom anti-roll bars until there is a gap of 0.125 in (3 mm) between each bolt head and its related anti-roll bar. Secure each bolt with its jam nut. Repeat for the other anti-roll bar.

22. Measure from the rear edge of each base section cutout to the corresponding rear surface of the section pin on each side of section 1. Distance must be 0.19 to 0.20 in (5 mm). Adjust by adding or subtracting stop block shim(s) at flange of section 1. Secure stop block and shims with capscrews.

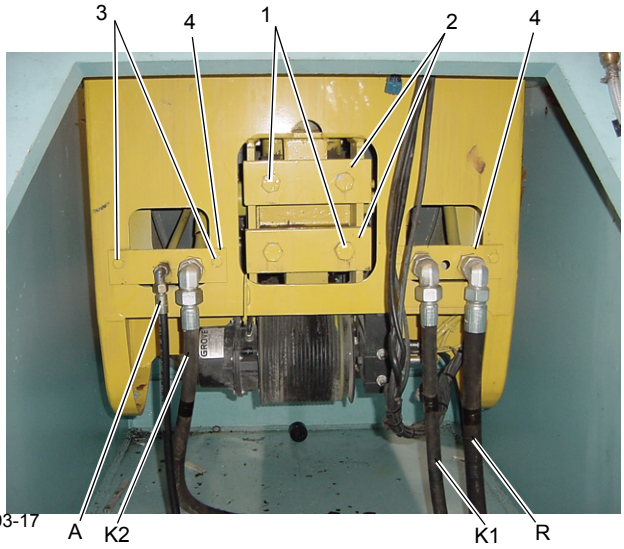


FIGURE 4-47

23. Install four anchor bolts (1) (Figure 4-47) through cylinder mounting bars (2) into the cylinder mounting holes in the rear of the base section. Tighten bolts in a star pattern to the proper torque.

24. Route the A hose (the cylinder pins lock/unlock hose from the small “A” port on the top of the cylinder rod end) through the hole (outside left, looking forward) on the left hose bar.

25. Route the R hose (the return hose from the larger “R” port on the top of the cylinder rod end) through the related hole (outside right, looking forward) on the right hose bar.

26. Route the K2 hose (the left extend hose from the “K2” port on the left of the cylinder rod end) through the related hole (inside left, looking forward) on the left hose bar.

27. Route the K1 hose (the right extend hose from the “K1” port on the right of the cylinder rod end) through the related hole (inside left, looking forward) on the left hose bar.

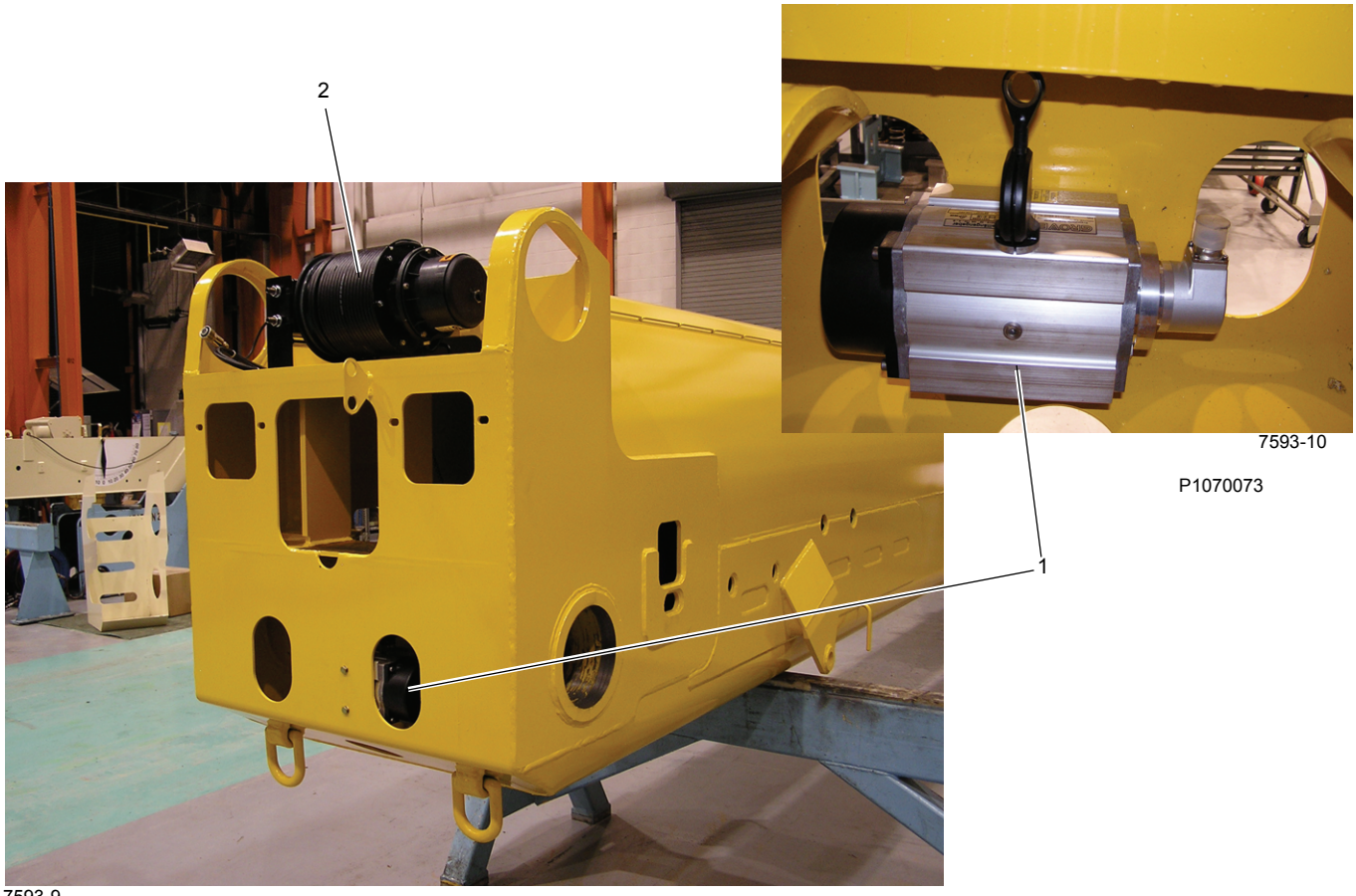
28. Secure each of the hoses to its related hose bar with nuts on its fitting.

29. Grease each of the five sections’ pairs of section pins. Their grease fittings should be accessible through the access holes in the base section and the sections.

30. Verify the emergency/service mode plug is secured to the cylinder above the cylinder control connector on the pinning block. Roll up the cable and secure it here with a cable tie so it will not be damaged or interfere with cylinder operation. Verify plug is covered to protect it.

Final Assembly and Test

1. Install the boom cable reel mounts in the bottom rear of the base below the cylinder rod end with attaching hardware.
2. Install the boom cable reel (1) (Figure 4-48) in its mount with attaching hardware.
3. Install the boom cable length measuring unit (2) in the top rear of the base above the cylinder rod end with attaching hardware.
4. Secure the D-ring (part of the cable reel) to the power connector bracket on the pinning block.



Base Section
(shown upside-down)

FIGURE 4-48

5. Plug wiring harness into cylinder control connector on bracket in rear of pinning block.
6. Secure the top rear cover plate to the top of the base section with capscrews.
7. Connect the hoses and electrical connector to the crane using extension hoses and electrical cable.
8. Using the ECOS controls in the crane, verify the cylinder pins are retracted to allow the cylinder barrel to extend.
9. Lock the cylinder pins to the cutouts in the rear of section 5. Verify the cylinder extends section 5 smoothly, stop section 5 when the cylinder pins align with the cutouts in the front of section 4.
10. Extend the section pins of section 5 to lock it to the front of section 4.
11. Extend the other sections, in turn, and verify the following:
    - As the telescope cylinder extends, it rides on the wear pads on the bottom of the front of the barrel and on the bottom of the pinning block. Side and top wear pads on the front of the barrel also help guide the cylinder.
    - The butterfly linkage works properly and locks the section pins properly. Likewise, both section pins work properly, extend, and lock section to section.
12. Engage the telescope cylinder to retract section 1. Verify the cylinder pins retract to allow the cylinder barrel to retract, then lock the cylinder pins to the cutouts in the rear of section 1.
13. Retract the section pins of section 1 to unlock it from the base section, then retract section 1. Verify the cylinder

retracts section 1 smoothly, then stop section 1 when the cylinder pins align with the cutouts in the rear of the base section. Extend the section pins of section 1 to lock it to the rear of the base section.

14. Retract the other sections to verify the following:

- As the telescope cylinder retracts, it rides on the wear pads on the bottom of the front of the barrel and on the bottom of the pinning block. Side and top wear pads on the front of the barrel also help guide the cylinder.
- The butterfly linkage works properly and locks the section pins properly. Likewise, both pins work properly, extend, and lock section to section.

15. Install the rollers to the left side of the stop flanges on the front of the sections.

16. Install the brackets and cable and connect it to its related fitting on the nose with a snap link.

17. Install optional boom lights on boom, as required.

18. Attach other removed parts, such as the flight traffic warning indicator, the wind speed indicator, and the boom angle unit components, and their related wiring and other electrical parts, on the boom. Pay attention to tagging done earlier when these parts and wires were removed.

19. Install the boom per Boom Installation procedure following in this section.

Boom Installation

NOTE: The following procedure applies to the entire boom assembly that has been totally removed from the crane.

The boom, without any boom extension, weighs about 33,000 lb (15,000 kg).

DANGER

Crushing Hazard!

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

Block the boom before doing any work under the boom.

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

1. With the machine properly set up on outriggers, attach an adequate lifting device to the boom and suspend the boom over the machine (Figure 4-7).

2. Lower the boom into position. Align the boom pivot mounting holes with mounting holes in the turntable.

3. Lubricate the pivot bushings in the turntable.

4. Block the boom in place.

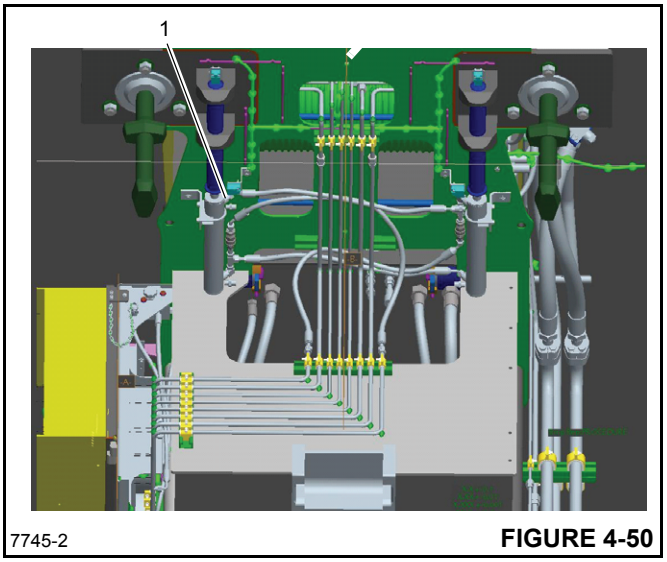
NOTE: The boom may need to be raised or lowered to aid in the installation of the boom pivot shafts.

5. Apply antiseize compound to the boom pivot shafts.

6. Open pressure bleed valve on superstructure, behind the boom pivot (1) (Figure 4-10).

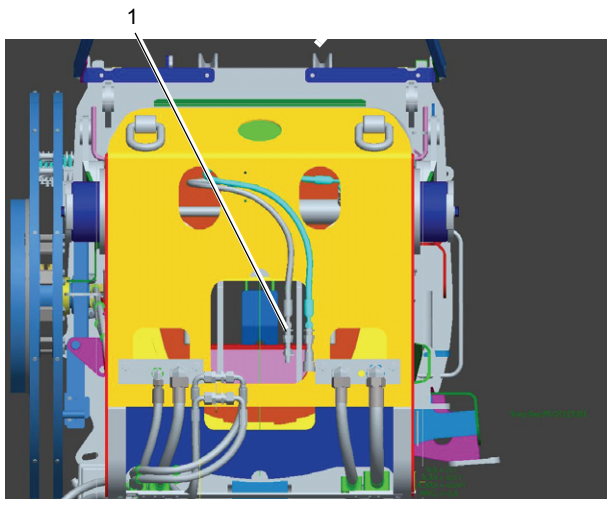
7890 **FIGURE 4-49**

7. Disconnect hoses from counterweight pin cylinders (Figure 4-50) and connect to boom pin cylinder (Figure 4-51). Hoses from the boom pivot cylinder are accessible at the back of the boom.



7745-2 **FIGURE 4-50**

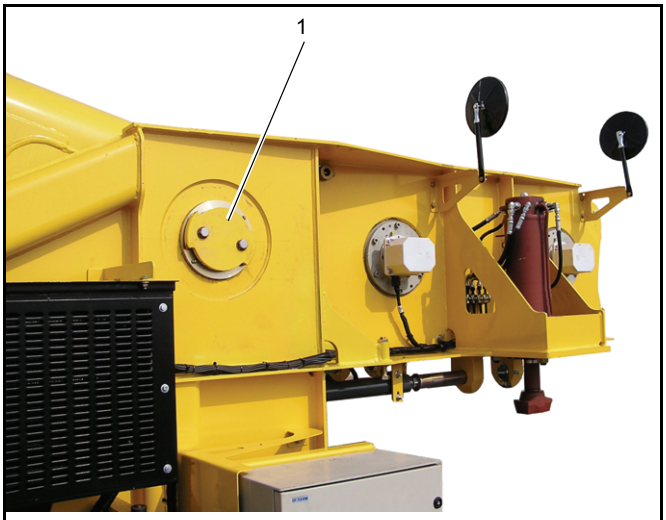
8. Close pressure bleed valve on superstructure, behind the boom pivot (1) (Figure 4-10).



7745-2 **FIGURE 4-51**

9. Using the ECOS display, “Counterweight” menu, actuate the locking cylinder to extend the boom pivot pins.

10. Install hardware removed earlier to secure the boom pivot shafts (Figure 4-52). For the proper torque values, refer to *Fasteners and Torque Values, page 1-17*.



7745-2 **FIGURE 4-52**

11. Disconnect hydraulic lines from boom pivot cylinder and connect to counterweight lock cylinders.

12. Using the lifting device attached to the boom, lower the boom onto the lift cylinder rod end.

The lift cylinder may be positioned by using the bottle jack on the lift cylinder support. Use a block of wood between the bottle jack and the lift cylinder barrel to prevent damage to the cylinder.

Extend the lift cylinder as necessary to align the rod end with the lugs in the base section. Using the valve on the lift cylinder as a control valve.

NOTE: This should be carefully controlled. If the lift cylinder rod is extended too far, it cannot be retracted using the main directional control valve.

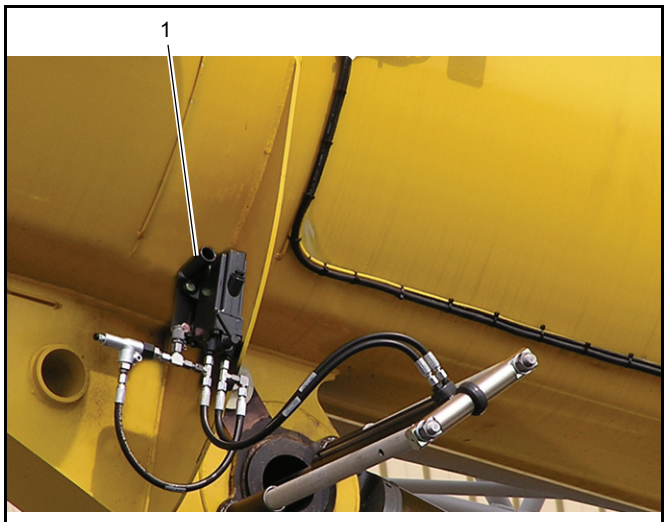
CAUTION

Equipment Damage Hazard!

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 pivot.

13. Apply antiseize compound to the upper lift cylinder pivot pin.

14. Use the hand pump (1) (Figure 4-53) to install the upper lift cylinder pivot pin. The lift cylinder may need to be raised or lowered to aid in the installation of the pivot pin.



7745-2 **FIGURE 4-53**

15. Install hardware removed earlier to secure the lift cylinder pivot pin. For the proper torque values, refer to *Fasteners and Torque Values, page 1-17*.

16. Adjust the top and bottom bolts (1) (Figure 4-54) to 0.04 in (1 mm) gap between the bolt and the lift cylinder rod end pivot (2). Ensure the rod end is centered in the pivot. Lock the centering bolt into place with the jam nut.

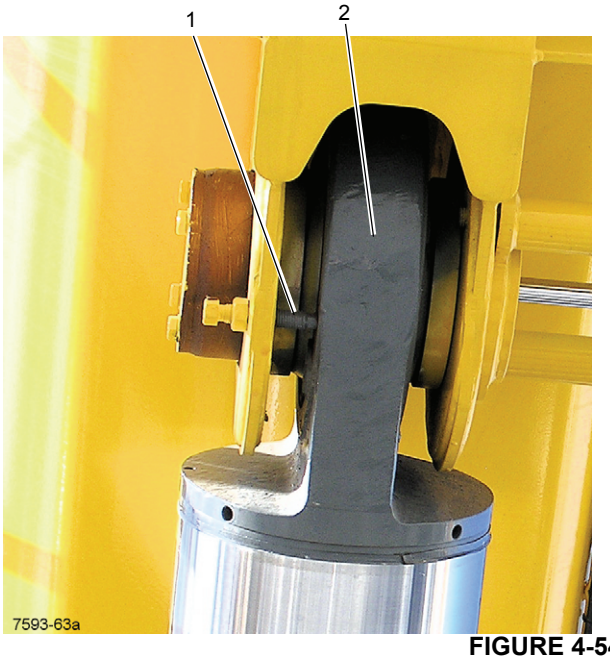


FIGURE 4-54

17. Lower the bottle jack after making sure the boom is properly supported.
18. Remove the boom lifting device.
19. Activate the hydraulic system and remove the boom and lift cylinder support devices.
20. Elevate boom to allow access to the telescope hose disconnects. Connect telescope hydraulic lines from the compact block.

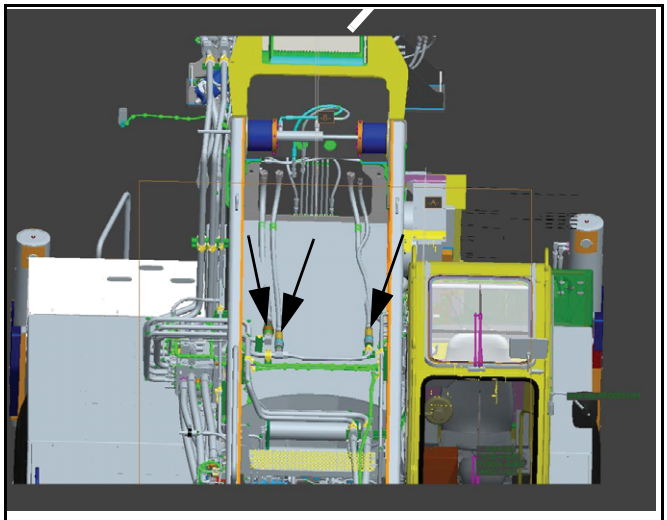


FIGURE 4-55

21. If unit is equipped with hydraulic boom extension, connect hydraulic lines from compact block.
22. Connect the hydraulic hoses as tagged before removal (Figure 4-56).

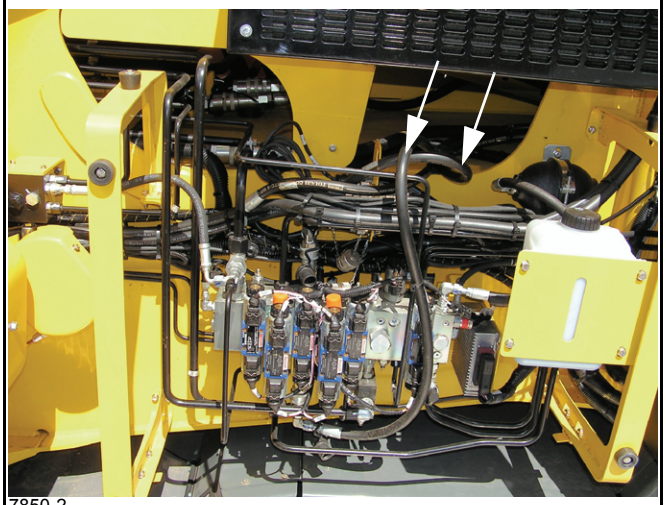


FIGURE 4-56

23. Connect electrical wires as tagged before removal (Figure 4-57).

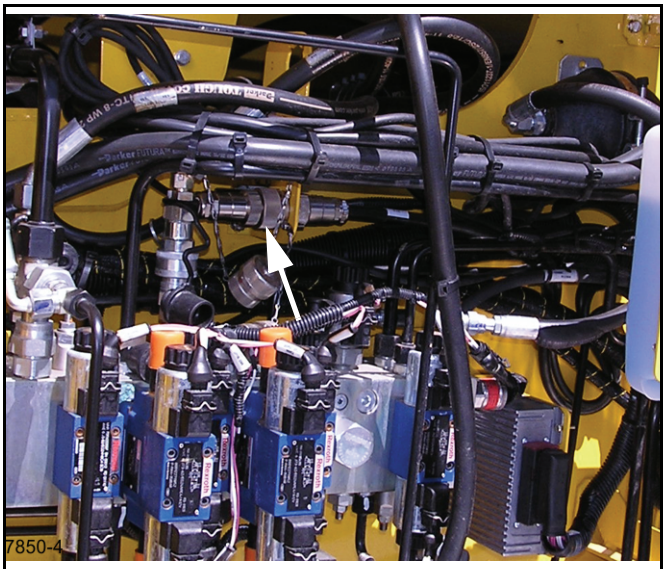


FIGURE 4-57

24. Install LMI components per LMI manual.
25. Remove the lift cylinder support from the carrier and place in the stowage tray, or remove from the crane.

Functional Check

1. Activate the hydraulic system and check for proper operation and leaks.
2. Ensure the boom will extend and retract properly.

NOTE: Cycle the boom several times to evacuate air from the telescope cylinder.

3. Ensure the lift cylinder does not allow the boom to drift down.

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

Inspection

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

Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. Refer to *Lubrication, page 9-1*.

Boom Alignment and Servicing

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

Boom alignment is 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 bottom corners and top corners of the outside of each inner boom section. Likewise, grease across the outer wall of each inner boom section at regular intervals.
3. Grease each section's pair of top corner outer wear pads using the grease fittings provided.
4. Adjust the top corner inner wear pads such that wear pad is just touching the next section both at the top and side surfaces of the top radius.

CAUTION

Equipment Damage Hazard!

When extending and retracting the boom during alignment, stop movement if there is any restriction. Adjust wear pads as necessary to provide free travel of the affected boom section(s).

5. Retract and extend the boom. Check for the high point where the boom has brushed the wear pads at the widest point.
6. Retract the boom sections to align the high point on the boom section with the adjacent wear pads.
7. Add or subtract shims under the wear pads as necessary. Adjust screws on the top corner inner wear pads, and adjust screws on the bottom corner outer wear pads. Shim evenly on opposite sides.
8. Attach a weight and fully extend the boom. Check for side to side deflection. Shim bottom wear pads as needed; adjust screws on top corner inner wear pads as needed. Shim evenly on opposite sides.

BI-FOLD SWINGAWAY BOOM EXTENSION

Description

A 59 ft (18 m) offsetable swingaway boom extension is provided to obtain additional boom reach. The fly swingaway section is 23 ft (7 m). The base section is 36 ft (11 m).

The boom extension mounts directly to the boom nose utilizing a four point attachment. In addition, the swingaway can be stowed on the right side of the boom base section.

The boom extension can be rotated and stowed on the right side of the boom base section.

The 23 ft (7m) section weighs approximately 882 lb (400 kg) and the 36 ft (11 m) section weighs approximately 2205 lb (1000 kg), for a combined weight of 3087 lb (1400 kg).

The serial number of the crane is also stamped on the boom extensions. The extensions are aligned at the factory for use with this specific crane. Before installing the boom extensions verify that the serial numbers match that of the crane. Figure 4-58 indicates where the serial numbers are stamped.

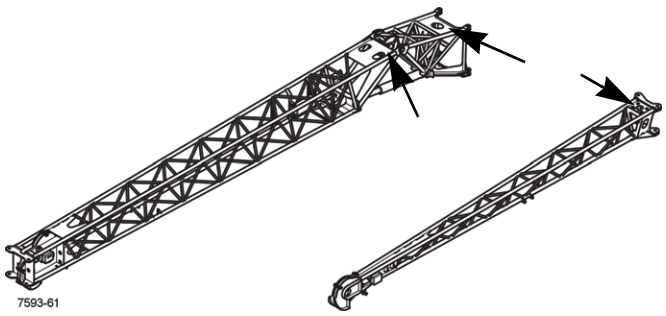


FIGURE 4-58

For instructions on installing, removing or deployment of the boom extension(s) refer to the Operator's Manual.

HOOK BLOCK/OVERHAUL BALL

DANGER

Crushing Hazard!

Before attempting to erect or stow the boom extension, read and strictly adhere to all warning decals installed on the swingaway and stowage brackets.

To prevent uncontrolled swinging of boom extension, always secure the extension with a guide rope on the main boom before removing any connections.

Description

A 130 ton (118 metric ton) hook block, a 100 ton (90 metric ton) hook block, and a 10 ton (9 metric ton) top swivel overhaul ball is available for the crane. The hook blocks utilizes a one-piece pivot block and the hook is equipped with a safety latch. Both hook blocks are the quick reeve design.

Maintenance

It is recommended that the hook block and/or headache ball be inspected every 50 hours. A complete disassembly inspection of the hook, hex nut, and threaded areas, for corrosion and proper fit, should be conducted every quarter or 500 hours. After assembly of the hook, a liberal coating of multipurpose grease should be applied to the nut and threaded areas by brush or hand to prevent corrosion.

For hook blocks and other load handling devices; follow the manufacturer's inspection and testing recommendations to assure an adequate preventative maintenance program is established.

SECTION 5
HOIST AND COUNTERWEIGHT

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5

DESCRIPTION

The hoist is installed on the superstructure and incorporates an axial piston motor, drive unit, gearbox and lowering limit switch.

THEORY OF OPERATION

Each hoist is controlled by controls in the cab.

When the main hoist control lever in the cab is moved from neutral, it causes the main hoist section of the directional control valve to shift the valve spool to route hydraulic flow to the main hoist motor control valve. The hoist motor control valve routes the hydraulic flow to the hoist motor. The motor turns one direction to hoist up, and turns the other direction to hoist down, depending on whether the hoist controls route fluid to the hoist up or hoist down port of the hoist motor control valve.

When the auxiliary hoist control lever in the cab is moved from neutral, it causes the auxiliary hoist section of the directional control valve to shift the valve spool to route hydraulic flow to the auxiliary hoist motor control valve. The hoist motor control valve routes the hydraulic flow to the hoist motor. The motor turns one direction to hoist up, and turns the other direction to hoist down, depending on whether the hoist controls route fluid to the hoist up or hoist down port of the hoist motor control valve.

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 prime mover should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic fluid, and to circulate gear lubricant through the planetary gear sets.

WARNING

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

Hoist Access Area

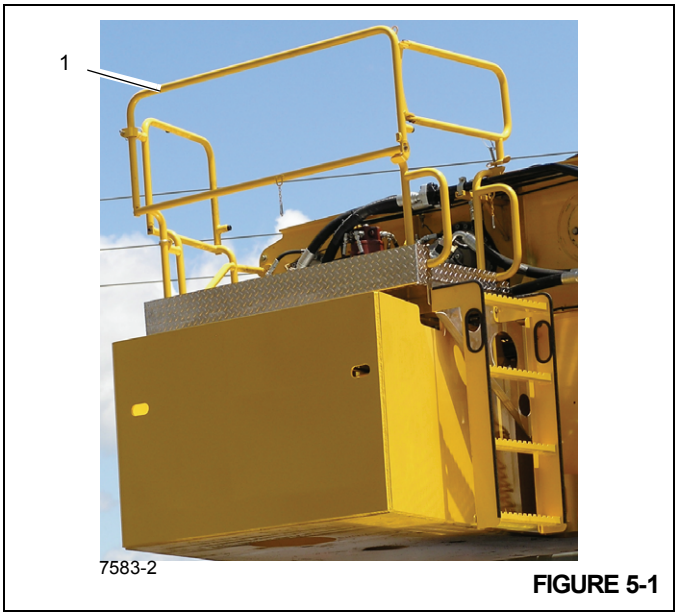


FIGURE 5-1

Use the hoist access platform (1) (Figure 5-1) when working in the hoist area.

WARNING

Platform must not be used for hauling passengers. No storage of components are allowed on the platform. Only one person at a time is allowed on the platform.

Hoist Removal

1. Remove all cable from the hoist drum. Refer to *Section 4, Set-up and Installation* in the Operator's manual.
2. Tag and disconnect all hydraulic lines to the hoist assembly. Cap or plug all lines and openings.
3. Drain the oil from the oil line on the hoist as follows:
   a. Place a receptacle under the tube (3) (Figure 5-3).
   b. Unscrew the bolts (1) and (6) (Figure 5-3) and let the oil drain out.
   c. If removing the oil tube, remove the capscrews (7), flatwashers (8) and nuts (9) (Figure 5-3) and remove the oil tube from superstructure.
4. Tag and disconnect the electrical wires to the lowering limit switch (1) (Figure 5-2 continued). Remove the screws and washers securing the limit switch (Figure 5-2 continued). Remove the limit switch (1) (Figure 5-2 continued).

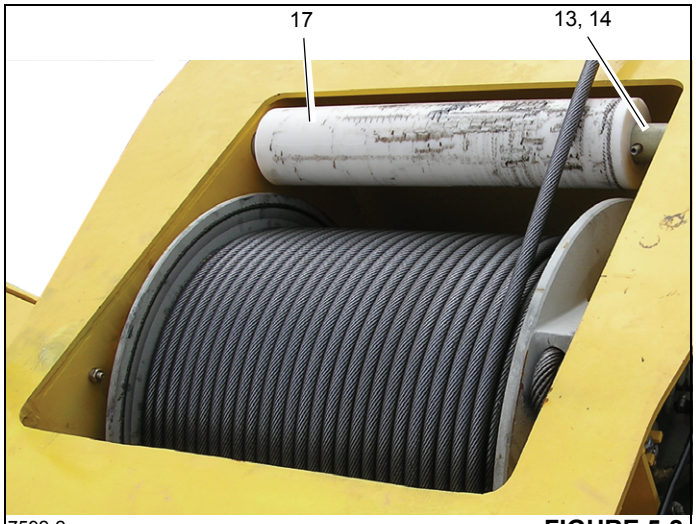
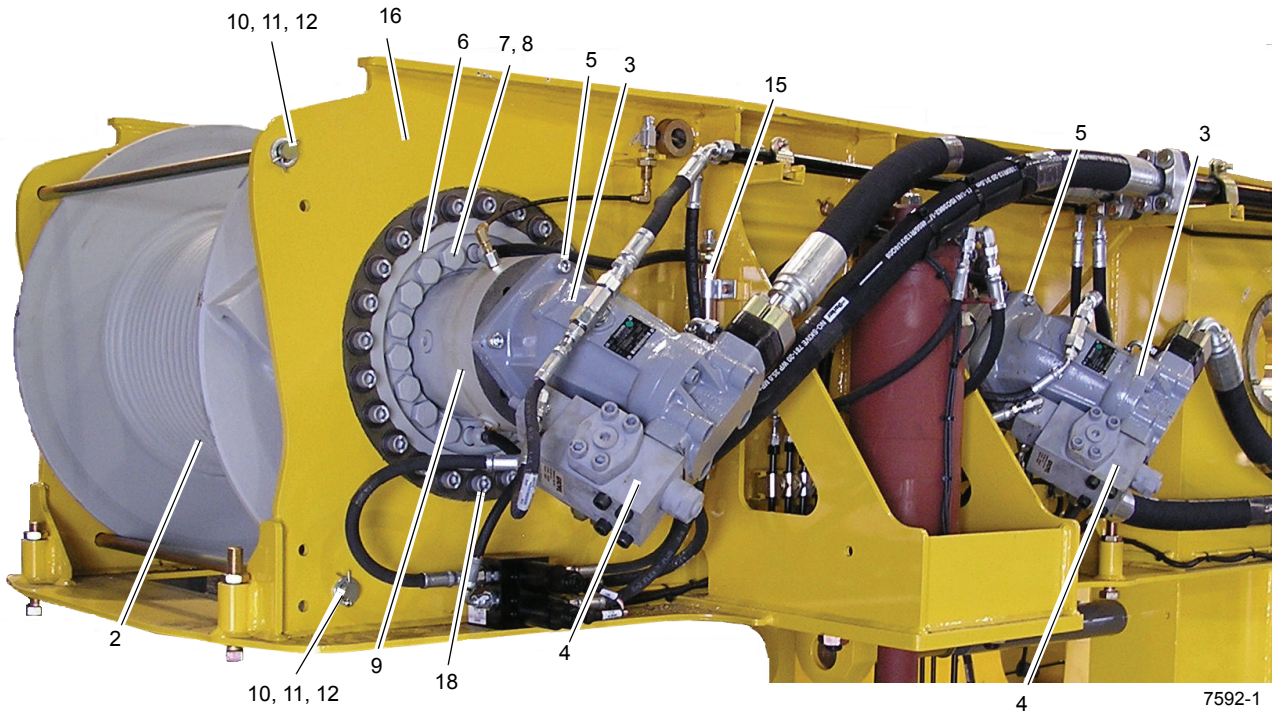


FIGURE 5-2

Item	Description
1	Lowering Limit Switch
2	Hoist Drum
3	Axial Motor
4	Stop Brake
5	Socket Head Capscrew
6	Mounting Gear
7	Hex Head Capscrew
8	Spring Washers
9	Multiple Disk Brake
10	Cotter Pin
11	Washer
12	Rod
13	Roll Pin
14	Roller
15	Oil Tube
16	Superstructure
17	Idler Roller
18	Socket Head Capscrew



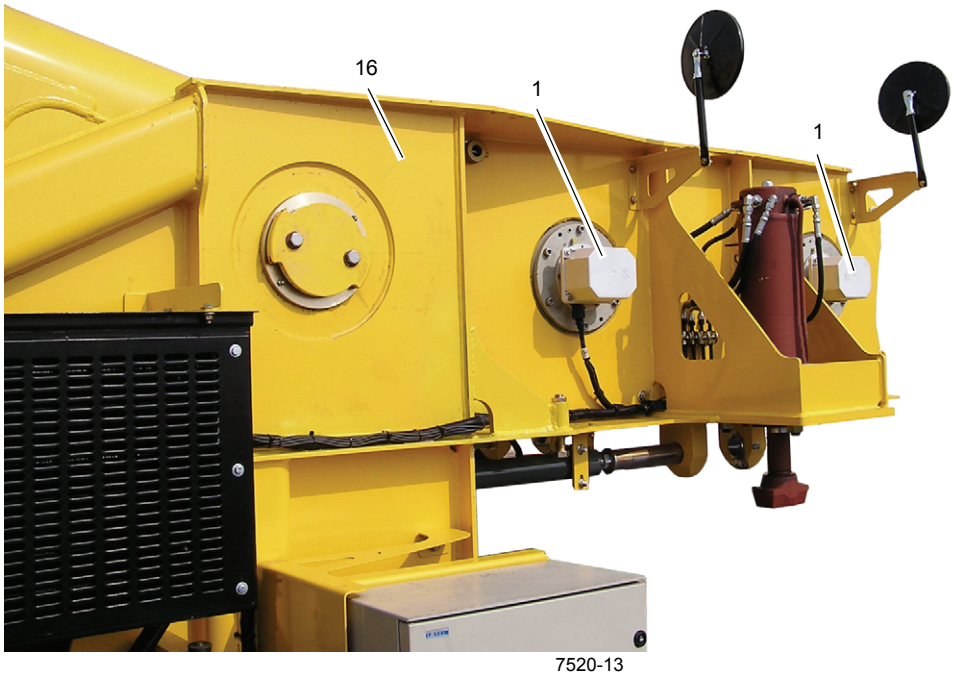


Figure 5-2 continued

5. Attach an adequate lifting device to the hoist.
6. Ensure the hydraulic lines have been disconnected from the hoist motor. Remove the socket head capscrews (5) (Figure 5-2 continued) securing the motor to the brake. Remove the motor (3).
7. Remove the socket head capscrews (7) and spring washers (8) (Figure 5-2 continued) securing the mounting gear (6) to the hoist flange.
8. Using a lifting device, remove the mounting gear (6) and brake (9). Separate the brake (9) from the mounting gear (6).
9. Ensure the lifting device is securing the hoist drum. Remove the cotter pins (13) (Figure 5-2 continued) and remove the idler rollers (17).
10. Remove the roll pins (10), washers (11) and rods (12) (Figure 5-2 continued) from the superstructure.
11. Using the lifting device remove the hoist drum from the superstructure.

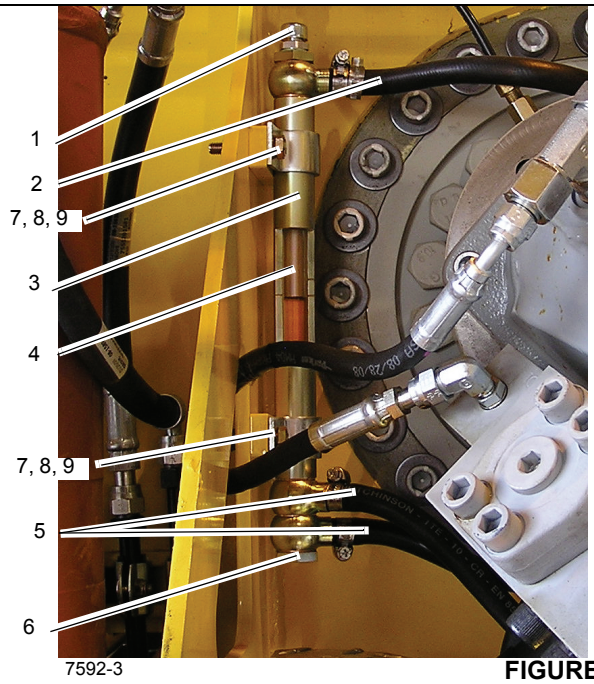


FIGURE 5-3

Item	Description
1	Breather
2	Hose
3	Sight Gauge/Fill Tube
4	Max Oil Fill Mark
5	Hose
6	Bolt
7	Capscrew
8	Flatwasher
9	Nut

Installation

1. With the hoist supported by a suitable lifting device, install the hoist drum.
2. Install the rods (12), washers (11) and cotter pins (Figure 5-2 continued) in the superstructure.
3. Place a level between the boom pivot shaft bushings.
4. Install the idler rollers (17) and secure with the cotter pins (13) (Figure 5-2 continued).
5. Using a lifting device, install the mounting gear (6) in the hoist flange and secure with the socket head capscrews (7) and spring washers (8) (Figure 5-2 continued). Torque the capscrews to recommended torque.
6. Remove the lifting device from the hoist.
7. Install the brake (9) (Figure 5-2 continued) to the mounting gear (6) and secure with the socket head capscrews.
8. Install the motor (3) to the brake and secure with the socket head capscrews (5) (Figure 5-2 continued). Torque the capscrews to recommended torque.
9. Install the limit switch (1) (Figure 5-2 continued) and secure with the screws and washers. Torque the screws to recommended torque. Connect the electrical wires to the lowering limit switch.
10. Connect the hydraulic lines to the hoist ensuring the proper lines are connected to the correct ports as marked during removal.
11. If the oil tube (3) (Figure 5-3) was removed, install and secure with the nuts (9), flatwashers (8) and capscrews (7). Ensure the max marking on the oil level tube is positioned at middle of hoist.
12. Fill the oil through the oil tube (3) (Figure 5-3) up to the max mark (4). Refer to *Lubrication, page 9-1*. Replace the gaskets and secure the hoses (2) with the bolt (1) (Figure 5-3).

13. Install the cable on the hoist following the procedures outlined in *Section 4, Set-up and Installation* in the *Operator's Manual*.
14. Adjust the Lowering Limit Switch, refer to *Setting the Lowering Limit Switch, page 5-6*.

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.

Preventive Maintenance

It is extremely important to be aware of the possibility that deterioration of internal critical components within the hoist reduction unit can occur. Hoist reduction units incorporate planetary gears, multi-disc brake assemblies, and sprag clutches which do not have an infinite life span. Although these components have been designed to achieve long service life, reliability can be substantially reduced by a variety of influencing factors such as:

- High cycle operation.
- Operating in high ambient temperatures.
- High external contaminations, such as dusty or sandy conditions.
- Level of maintenance.

Refer to the *Section 6, Preventive Maintenance* in the *Operator's Manual* and *Lubrication, page 9-1* for more information.

HOIST CABLE (WIRE ROPE)

Check the Position on the Hoist Drums

DANGER

Rick of Accidents when the rope drum is turning!

Keep away from the turning rope drum.

This will prevent your limbs from being drawn in and getting crushed.

1. Check the position of the ropes on at least one full turn of the rope drum for the hoist gears.
2. Slowly carry out the lowering movement and check the rope.
   - The rope needs to be evenly wound.
   - The rope turns on the drum must be evenly spaced at a distance of 0 to 0.08 in (0 to 2 mm).
   - The cross-over points must be at an angle of about 180°
   - The ropes of the top layer lie over the ropes of the bottom layer at the crossover points.

Check the Rope

1. Start the engine.
2. Unreel the rope and check that the rope is not damaged or improperly reeled. When five turns are left on the drum, the lowering limit switch must shut off.
3. If the lowering limit switch does not shut off or shuts off too late it must be reset. Refer to *Setting the Lowering Limit Switch, page 5-6*.
4. Check that the clamp (1) (Figure 5-4) is properly fastened, is not damaged and is properly seated. Torque the fasteners to recommended torque.
5. The free end of the rope must not extend out beyond the flanged wheel.
6. The rope wedge must be in the pouch (2) (Figure 5-4).
7. The rope end on the rope wedge must not show any signs of wear.

FIGURE 5-4

8. Reel in the rope. Inspect the rope at the same time, the rope may not show any signs of kinking or being flattened.
9. Check the end of the rope and all parts of the rope end clamp.

10. Make sure the rope is correctly fitted in the rope end and clamp. Refer to *Section 4, Installing Cable on the Hoist* in the *Operator's Manual*.

ADJUSTING THE LOWERING LIMIT SWITCH

A lowering limit switch is mounted on the main hoist and on the auxiliary hoist.

Setting the Lowering Limit Switch

DANGER

Risk of accidents due to rope end fitting being overloaded!

The lowering limit switch must always be reset after repair work to the hoisting gear and after rope replacement. A faulty lowering limit switch must always be replaced.

Prerequisites

- The hookblock is reeved 4-fold.
- The main boom is fully raised and extended.
- The hookblock is lowered until only five turns of the rope remain on the hoist drum.

1. Remove the cover (1) (Figure 5-5).
2. Turn the bolt (2) until you hear the switch activate.
3. Screw the cover on again. Replace the gasket, if necessary.
4. Check whether the lowering limit switch shuts off the hoist correctly.

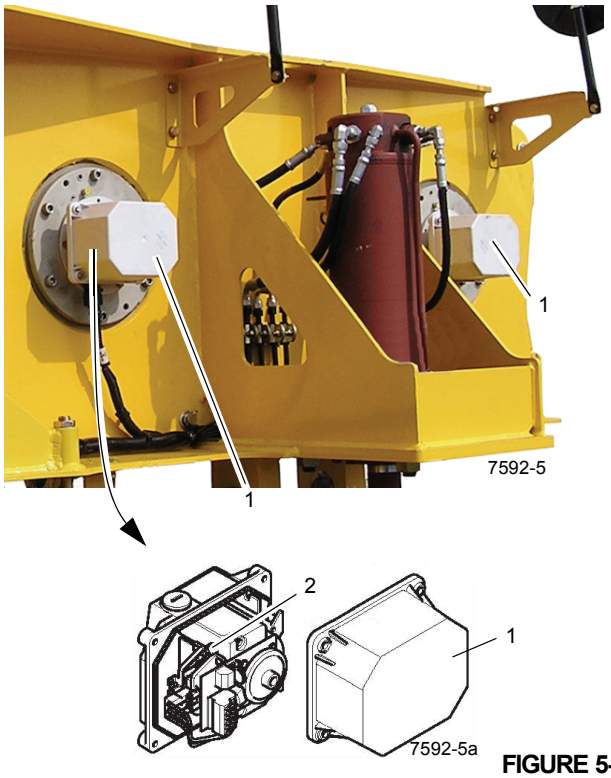


FIGURE 5-5

Check the Lowering Limit Shuts Off

1. Raise the hookblock until there are about 10 turns on the hoist drum.
2. Lower the hookblock and check whether the lowering limit switch shuts off properly.
3. The lowering limit switch must shut off the hoisting gear when five rope turns are still on the hoist drum. Correct the setting of the lowering limit switch, if necessary.

CHECKING THE HOIST BRAKE

Check that the hoist brake is working correctly on the main hoist and the auxiliary hoist.

1. Suspend the hookblock on the singly reeved hoist rope.
2. Lift a load of approximately 7.1 tons (15,653 lb) to approximately 1.0 ft (30 cm) above the ground.
3. Measure the distance from the ground when the load is hanging completely still.
4. Turn off the engine.

If the load has not lowered after approximately 2 minutes, the brake is currently in working order.

If the load lowers, contact Manitowoc Crane Care or your authorized Manitowoc dealer.

GENERAL INSPECTION

- Investigate any unusual noises from the hoist.
- Check the hoists and the connections for leaks.
- Check that hoses and fittings are tightly connected and not damaged.
- If any damage is found, contact Manitowoc Crane Care or your local Manitowoc dealer.

COUNTERWEIGHT REMOVAL AND INSTALLATION

Counterweight Stand Installation

NOTE: The counterweight stands must be installed on the front of the carrier before installing or removing the a counterweight.

1. Using an adequate lifting device, install the counterweight stands (1) (Figure 5-6) to the front of the carrier frame (2) (Figure 5-6) and secure with the hitch pins (3) (Figure 5-6).

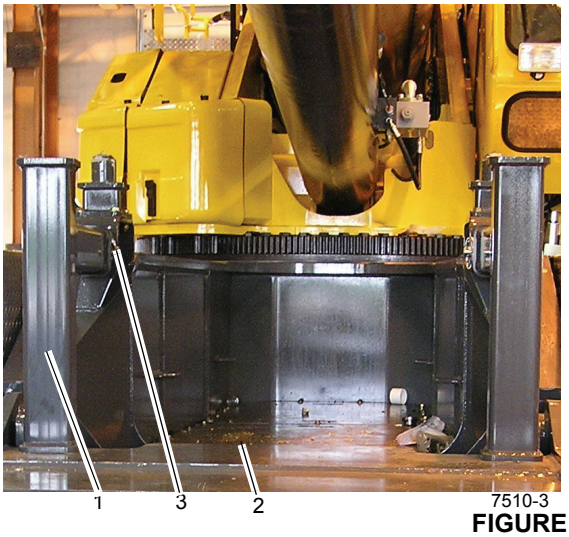


FIGURE 5-6

DANGER

Adjustment of the counterweight stand (1) (Figure 5-6) supports is prohibited when the counterweight is resting on them.

Standard 39,000 lb (17,690 kg) Counterweight Installation

DANGER

Read and understand the following when removing and installing the counterweight or counterweight stands, to avoid serious injury or death.

- Outriggers must be fully extended and set and crane level before installation or removal of counterweight.
- Lifting operations are not permitted with any counterweight on the carrier deck except for the removal or installation of the counterweight.
- Boom is not permitted over carrier deck when the boom angle is less than 30° and any counterweight is positioned on deck.
- Hookblock is not permitted to come in contact with counterweight during removal or installation.
- Travel is not permitted with any counterweight on carrier deck.

1. Rig the crane with three parts of line.
2. The standard 39,000 lb (17,690 kg) counterweight may be lifted in one of the following boom configurations.

Boom Configuration		
0-0-0-0-0 (30 ft radius)	0-0-0-0-50	0-0-0-50-0

3. Enter LMI code 1100. Refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.
4. Connect sling assembly to the standard counterweight using the installation lifting holes (Figure 5-7 and Figure 5-8).
5. Lift and place the counterweight onto the carrier stands.
6. Swing turntable to place the boom over the rear of the crane.
7. Set the turntable lock pin in the down position.
8. Using the ECOS display lower the counterweight cylinders into the tubes on the counterweight, refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.
9. Rotate the cylinders to lock into the counterweight.
10. Raise the counterweight until the display indicates the counterweight is pre-tensioned.

5

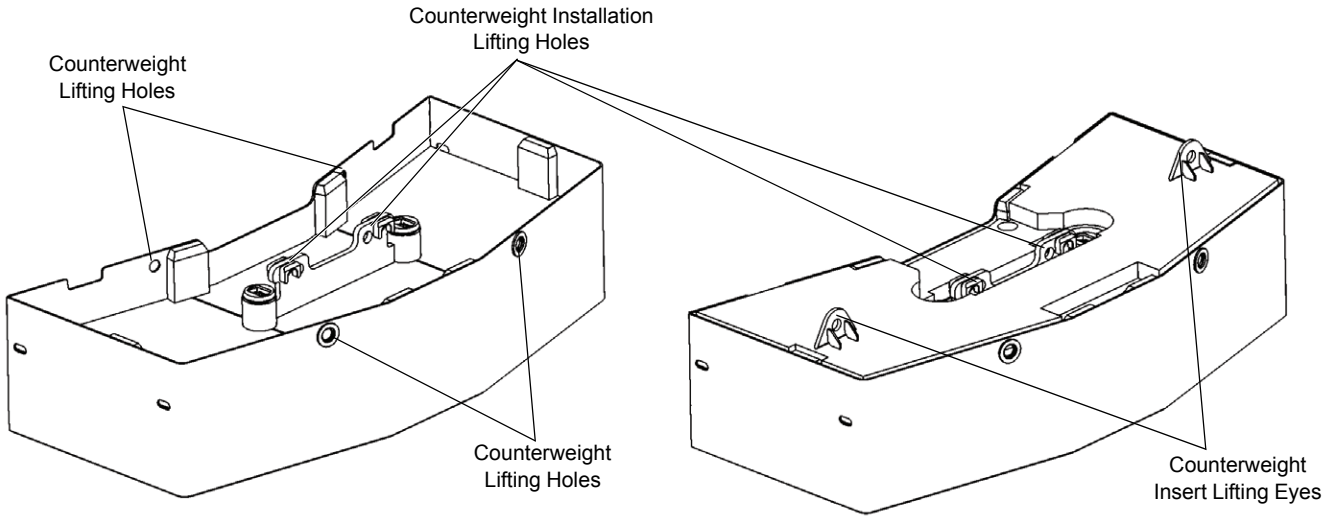
11. Using the ECOS display, extend the locking cylinders until the display indicates the counterweight is locked in place.

Standard 39,000 lb (17,690 kg) Counterweight Removal

1. Rig the crane with three parts of line (Figure 5-7 and Figure 5-8).
2. The standard counterweight may be lifted in one of the following boom configurations.

Boom Configuration		
0-0-0-0-0 (30 ft radius)	0-0-0-0-50	0-0-0-50-0

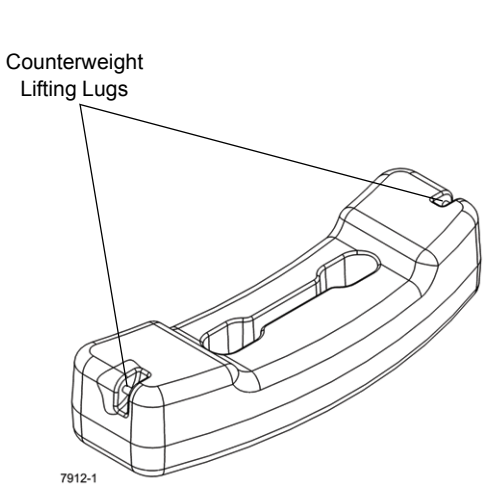
3. Enter LMI code 1100. Refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.
4. Swing turntable to place the boom over the rear of the crane.
5. Set the turntable lock pin in the down position.
6. Using the ECOS display, retract the locking cylinders until the display indicates the cylinders are fully retracted.
7. Lower the counterweight onto the carrier stands until the display indicates the counterweight is fully lowered.
8. Rotate the cylinders to unlock from the counterweight.
9. Using the ECOS display raise the counterweight cylinders from the tubes on the counterweight.
10. Connect sling assembly to the standard counterweight using the installation lifting holes (Figure 5-7 and Figure 5-8).
11. Lift and place the counterweight onto the ground.



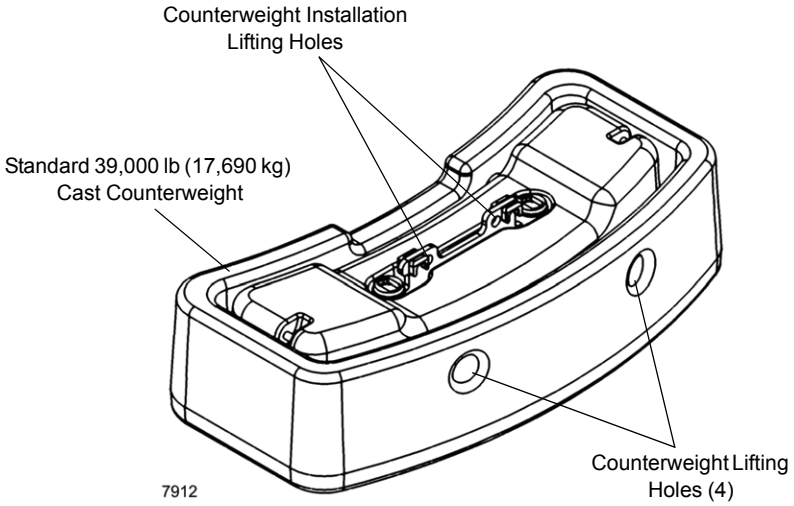
Standard 39,000 lb (17,690 kg) Counterweight

Heavy 63,000 lb (28,577 kg) Counterweight

FIGURE 5-7



24,000 lb (10,886 kg) Cast Counterweight Insert



Heavy 63,000 lb (28,577 kg) Cast Counterweight

FIGURE 5-8

Heavy 63,000 lb (28,576 kg) Counterweight Installation

DANGER

Read and understand the following when removing and installing the counterweight or counterweight stands, to avoid serious injury or death.

- Outriggers must be fully extended and set and crane level before installation or removal of counterweight.
- Lifting operations are not permitted with any counterweight on the carrier deck except for the removal or installation of the counterweight.
- Boom is not permitted over carrier deck when the boom angle is less than 30° and any counterweight is positioned on deck.
- Hookblock is not permitted to come in contact with counterweight during removal or installation.
- Travel is not permitted with any counterweight on carrier deck.

CAUTION

Counterweight assembly must be completed on the ground; not on the carrier counterweight stand.

Outrigger boxes must be installed and outrigger beams must be fully extended.

1. Rig the crane with five parts of line.
2. The heavy 63,000 lb (28,576 kg) counterweight may be lifted in one of the following boom configurations.

Boom Configuration		
0-0-0-0-0	0-0-0-0-50 (20 ft radius)	0-0-0-50-0

3. Enter LMI code 1100. Refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.
4. Connect sling assembly to the 24,000 lb (10,886 kg) counterweight insert using the lifting eyes/lugs on the insert.
5. Lift and place the counterweight insert into the standard counterweight.
6. Connect sling assembly to the heavy counterweight assembly using the installation lifting holes (Figure 5-7 and Figure 5-8).
7. Lift and place the counterweight assembly onto the carrier stands.
8. Swing turntable to place the boom over the rear of the crane.
9. Set the turntable lock pin in the down position.
10. Using the ECOS display lower the counterweight cylinders into the tubes on the counterweight, refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.
11. Rotate the cylinders to lock into the counterweight.

12. Raise the counterweight until the display indicates the counterweight is pre-tensioned.
13. Using the ECOS display, extend the locking cylinders until the display indicates the counterweight is locked in place.

Heavy 63,000 lb (28,576 kg) Counterweight Removal

1. Rig the crane with five parts of line (Figure 5-7 and Figure 5-8).
2. The 63,000 lb (28,576 kg) heavy counterweight may be lifted in one of the following boom configurations.

Boom Configuration		
0-0-0-0-0	0-0-0-0-50 (20 ft radius)	0-0-0-50-0

3. Enter LMI code 1100. Refer to *Section 3, Operating Controls and Procedures* in the *Operators Manual*.
4. Swing turntable to place the counterweight over the front of the crane.
5. Set the turntable lock pin in the down position.
6. Using the ECOS display, retract the locking cylinders until the display indicates the cylinders are fully retracted.
7. Lower the counterweight until the display indicates the counterweight is fully lowered.
8. Rotate the cylinders to unlock from the counterweight.
9. Raise the counterweight cylinders from the tubes on the counterweight.
10. Connect sling assembly to the heavy counterweight assembly using the installation lifting holes.
11. Lift and remove the counterweight from the carrier stands.
12. Place the counterweight on the ground.
13. Disassemble the counterweight, if necessary.

Counterweight Stand Removal

DANGER

The main boom must not be lowered below horizontal while swinging over the front while the counterweight supports are installed.

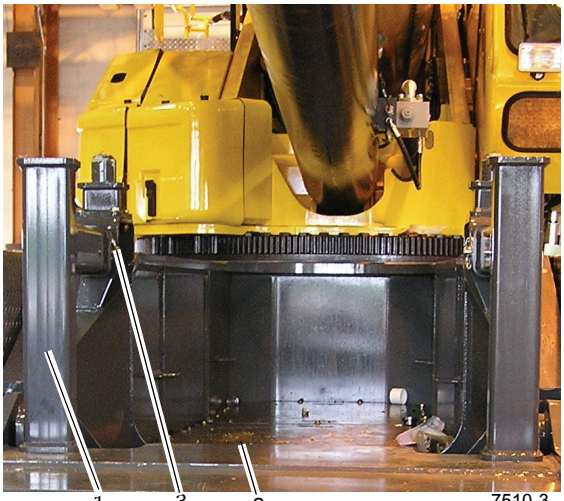


FIGURE 5-9

1. Attach an adequate lifting device with slings to the counterweight stands (1) (Figure 5-9).
2. Remove the hitch pins (3).

DANGER

Crushing Hazard

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

3. Using the lifting device, remove the counterweight stands (1) (Figure 5-9).

SECTION 6
SWING SYSTEM

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DESCRIPTION

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term free swing means that, with the swing brake switch in the off position, the superstructure will swing freely after the swing controller is released until it coasts to a stop or the swing brake pedal is depressed.

Swing is activated using the control lever in the cab. When the swing lever is actuated, hydraulic pressure is routed to the swing motors to drive the swing gearboxes in the appropriate direction. As the gearboxes rotate, their pinion gears mesh with the teeth on the swing bearing and rotate the superstructure. Swing speed can be controlled by the control lever and a HIGH/LOW swing speed switch on the front console. The maximum rotation speed is 2.5 rpm in HIGH speed and 1.25 rpm in LOW speed. Braking is accomplished by depressing a glide swing brake pedal which is a proportionate control valve that provides a controlled braking of the swing motion.

The swing system consists of a hydraulic remote controller, swing speed switch, series/parallel selector valve, a directional control valve, the swing drives, the swing brake assemblies, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The crane is equipped with a pin type swing lock as standard and a standard 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type swing lock will only lock the turntable in a straight ahead position over the front or rear of machine. Both swing locks are operated from the cab.

THEORY OF OPERATION

Swing Drive

The hydraulic power for the swing drive is supplied by the torque converter driven hydraulic Pump No. 3. Oil flows from the pump to the hydraulic Port 5 swivel. Flow from the swivel is routed to the front steering flow divider valve in the swing directional control valve. Bypass flow from the flow divider valve is used to supply the swing directional control valve.

When the hydraulic remote control is positioned to select right or left swing, the flow through the control valve is directed to the series/parallel valve, and then routed to the swing motors. If the Swing Brake Selector Switch is in the OFF position, the superstructure will rotate in the desired direction. Shifting the control to neutral and depressing the brake pedal will stop the swing.

Swing Brake

The hydraulic power for the swing brake is supplied by the pressure reducing/sequence valve in the swing brake and armrest lockout manifold. With the Swing Brake Selector Switch positioned to ON, the swing brake release valve blocks the regulated flow to the brake release ports and spring pressure in the swing brakes applies the brakes.

When the Swing Brake Selector Switch is positioned to OFF, the regulated flow is directed from the pressure reducing/sequence valve to the brake release ports, overcoming the brake spring pressures and releasing the swing brakes.

Regulated flow from the pressure reducing/sequence valve is also provided to the power brake valve where it is available for the activation of the swing brake when the pedal is depressed.

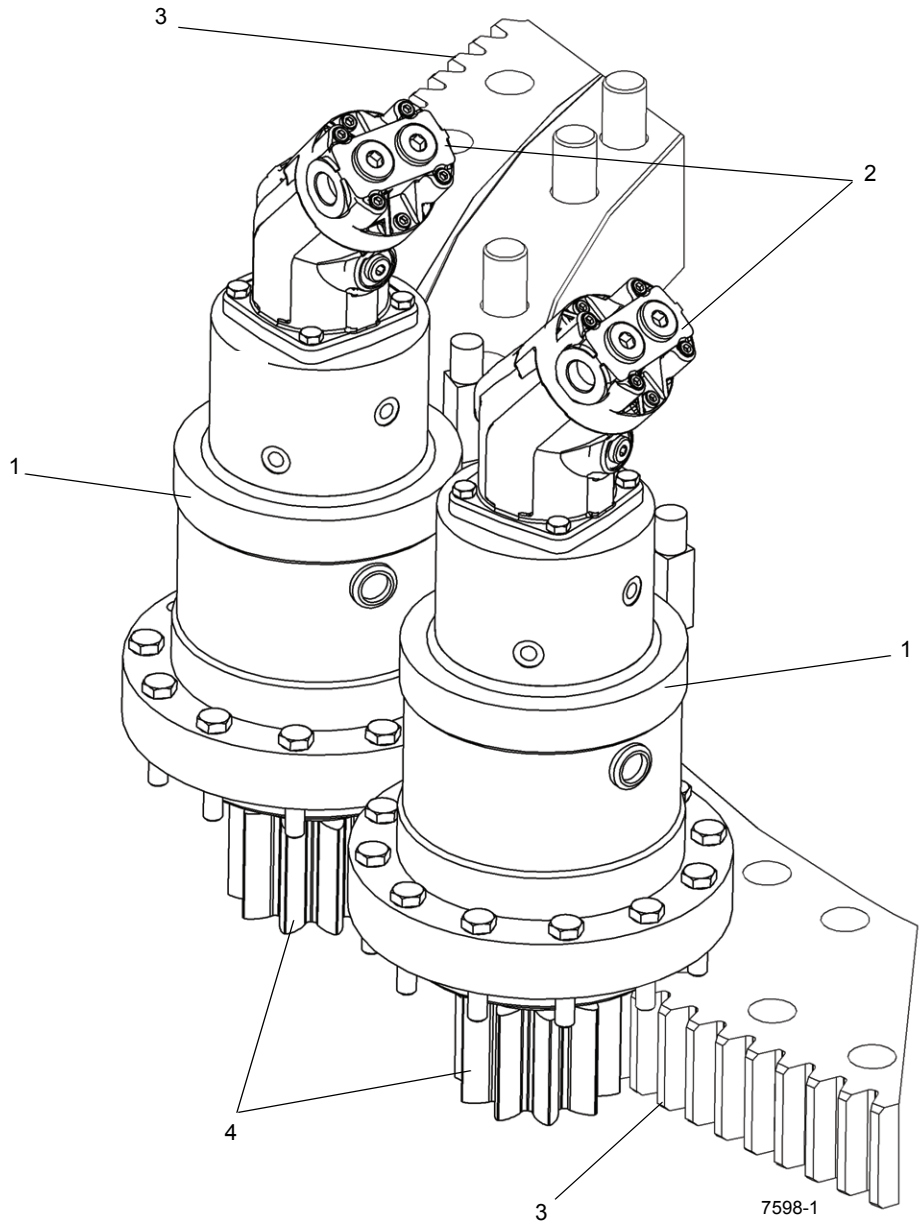


FIGURE 6-1

Item	Description
1	Swing Drive
2	Axial Piston Motor

Item	Description
3	Turntable Bearing
4	Pinion Gear

MAINTENANCE

Troubleshooting

Table 6-1

Symptom	Probable Cause	Solution
1. Boom swing operation erratic in either direction.	**a.** Damaged relief valve.	**a.** Replace relief valve.
	b. Swing brake dragging (not releasing properly).	**b.** Readjust and/or replace necessary parts.
	c. Low engine rpm.	**c.** Increase engine rpm to obtain smooth swing operation.
	d. Low hydraulic fluid.	**d.** Check system for leaks. Make repairs as needed. Fill reservoir. Refer to *Lubrication, page 9-1*.
	e. Improper movement of control to neutral.	**e.** Feather controls to neutral to maintain smooth stopping action.
	f. Insufficient lubricant on swing bearing.	**f.** Lubricate bearing properly. Refer to *Lubrication, page 9-1*.
	g. Crane not level.	**g.** Level crane using outriggers.
	h. Damaged swing motor.	**h.** Repair or replace swing motor.
	i. Excessive overload.	**i.** Reduce load. Refer to load capacity chart.
	j. Restricted or partly clogged hydraulic hose or fittings.	**j.** Replace hose or fittings. Refer to the Manitowoc Crane Care Parts Manual.
	k. Pump cavitation in swing section.	**k.** Tighten suction hose or replace any damaged fitting. Check hydraulic tank level.
	l. Improperly torqued turntable bolts.	**l.** Torque turntable bolts evenly.
	m. Excessive preload on upper and lower pinion shaft bearing.	**m.** Adjust as necessary.
	n. Improperly torqued swing motor attachment bolts.	**n.** Torque swing motor attachment bolts.
	o. Malfunction of the swing box.	**o.** Remove swing box and make necessary repairs.
	p. Worn or damaged pump.	**p.** Repair or replace damaged pump.
	q. Damaged swing directional control valve.	**q.** Repair or replace swing directional control valve.
	r. Damaged swing pinion.	**r.** Replace pinion.
	s. Damaged turntable bearing.	**s.** Replace turntable bearing.
	t. Controller settings.	**t.** Check settings.
	u. Electrical connection.	**u.** Inspect wiring and connections.

Symptom	Probable Cause	Solution
2. Boom swing operation erratic in one direction only.	**a.** Crane not level.	**a.** Level crane using outriggers.
	b. Turntable bearing binding due to continuous limited swing. (Example: concrete pourer.)	**b.** Rotate machine 360 degrees in both directions several times and lubricate bearing.
	c. Restricted hose or fitting.	**c.** Replace hose or fitting.
Boom swing operation erratic in one direction only.	**d.** Damaged swing directional control valve.	**d.** Replace swing directional control valve.
	e. Damaged swing pinion.	**e.** Replace pinion.
	f. Damaged turntable bearing.	**f.** Replace turntable bearing.
3. Boom will not swing in either direction.	**a.** Damaged relief valve.	**a.** Remove, clean, and repair or replace relief valve.
	b. Damaged swing motor.	**b.** Repair or replace swing motor.
	c. Swing brake not releasing properly.	**c.** Repair as necessary.
	d. Damaged hydraulic remote control valve.	**d.** Replace hydraulic remote control valve.
	e. Internal damage to swing box.	**e.** Remove swing box and repair.
	f. Worn or damaged hydraulic pump.	**f.** Replace pump section.
	g. Damaged swing directional control valve.	**g.** Replace swing directional control valve.
	h. Damaged swing pinion.	**h.** Replace pinion.
	i. Damaged turntable bearing.	**i.** Replace turntable bearing.
	j. Excessive overload.	**j.** Reduce load. Refer to load capacity chart.
4. Swing operation slow in either direction.	**a.** Damaged relief valve.	**a.** Adjust, repair or replace valve.
	b. Improperly adjusted swing brake.	**b.** Readjust.
	c. Damaged hydraulic remote control valve.	**c.** Replace hydraulic remote control valve.
	d. Improperly lubricated swing bearing.	**d.** Lubricate bearing per *Lubrication, page 9-1*.
	e. Improper size hose and/or fittings installed.	**e.** Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	f. Clogged or restricted hydraulic hoses or fittings.	**f.** Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	**g.** Replace bearings.
	h. Worn or damaged swing motor.	**h.** Repair or replace motor.
	i. Worn or damaged hydraulic pump.	**i.** Repair or replace pump.
	j. Crane not level.	**j.** Level crane.
	k. Damaged swing directional control valve.	**k.** Replace swing directional control valve.

Symptom	Probable Cause	Solution
5. Swing operation slow in one direction only.	**a.** Crane not level.	**a.** Level crane.
	b. Damaged hydraulic remote control valve.	**b.** Replace hydraulic remote control valve.
	c. Damaged swing directional control valve.	**c.** Replace the swing directional control valve.
	d. Clogged or restricted hose.	**d.** Replace hose or fitting.
	e. Improperly torqued turntable bearing.	**e.** Torque turntable bearing.
6. Swing brake operation erratic.	**a.** Improper brake adjustment.	**a.** Adjust brake.
	b. Air in swing brake system.	**b.** Bleed brake system.
	c. Brake pedal not fully retracted.	**c.** Check brake pedal return spring; repair or replace spring.
	d. Dirty or glazed brake disc.	**d.** Clean or replace disc.
	e. Malfunction of the glide swing power brake valve.	**e.** Repair or replace glide swing power brake valve.
	f. Kinked or bent lines and/or hoses and fittings.	**f.** Straighten or replace as required.
7. Swing brake system will not operate.	**a.** Damaged swing brake release valve.	**a.** Replace release valve.
	b. Damaged glide swing power brake valve.	**b.** Repair or replace glide swing power brake valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace lines and fittings.
8. Swing brake pedal is spongy.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Loose or restricted brake lines or fittings.	**b.** Tighten or replace brake lines and fittings.
9. Swing brake drags.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Damaged swing brake release valve.	**b.** Replace release valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace brake lines and fittings.
10. Boom swings slowly.	**a.** Insufficient hydraulic volume.	**a.** Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	b. Damaged relief valve.	**b.** Adjust, repair, or replace valve.
	c. Damaged swing motor.	**c.** Repair or replace motor.
11. Swing motor continues to operate when swing control is in neutral.	**a.** Hydraulic remote control valve sticking or valve otherwise damaged.	**a.** Repair or replace valve.
	b. Control valve sticking or valve otherwise damaged.	**b.** Repair or replace valve.

Symptom	Probable Cause	Solution
12. Swing motor turning in wrong direction.	**a.** Improper port connections.	**a.** Reverse port connection.
	b. Improper wiring connection	**b.** Inspect wiring and connections. Make repairs as needed.
13. Swing motor noisy.	**a.** Air in system.	**a.** Refer to *Hydraulic System, page 2-1*, for removal of air from the system.
	b. Motor binding.	**b.** Repair or replace motor.

SWING BOX ASSEMBLIES

Description

There are two swing box assemblies (Figure 6-1) for turning and stopping the turntable and superstructure. Each swing box assembly consists of a hydraulic motor on top, a brake assembly, and a swing gearbox on the bottom. Each swing motor on the swing gearbox gear pinion output shaft applies turning force to the turntable bearing's gear teeth to turn the turntable. Operator-applied hydraulic power applies the brake assemblies to stop their swing box assemblies.

Each swing motor runs on hydraulic power to drive its gearbox. Each swing motor has three ports (A, B and Tank) for connection to the hydraulic system.

Each swing brake assembly is between the swing motor and the swing gearbox. Each brake assembly's mechanism is a disc pack that is hydraulically released and spring applied. The operator steps on a pedal on the cab floor to trigger the swing brake assemblies to stop the swing boxes from turning. The Swing Brake Switch prevents the swing brake assemblies from releasing when ON; this prevents inadvertent swing during travel or other situations when the superstructure should not turn.

Each gearbox bolts to the superstructure base plate. Each gearbox uses double reduction planetary gearing. Each gearbox's pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

A filling plug in the side of the swing brake system assembly housing allows the operator to add gear oil to the swing gearbox and swing brake assembly. There is one drain plug for draining gear oil from the gearbox housing.

There are hydraulic lines to each swing brake assembly; these lines are in a system sealed from gear oil. The hydraulic lines are only for applying or releasing the brake, not providing brake or gearbox lubrication.

There are hydraulic lines to the swing motor; these lines are also in a system sealed from gear oil. The hydraulic lines are for driving the motor in the chosen rotation. There is one drain plug for draining hydraulic fluid from the swing motor.

Swing Motor Maintenance

NOTE: Each swing motor can be removed and disassembled independently of the swing brake assembly.

Removal

1. Engage the swing brake and the swing lock pin.

CAUTION

Hydraulic fluid can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

2. Clean the port area around the swing motor. Tag and disconnect the hydraulic hoses from the swing motor. Cap or plug all openings.
3. Unscrew the drain plug, and drain the oil. After oil is drained, reinstall the drain plug

.

CAUTION

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

4. Remove the fasteners securing the swing motor to the swing brake assembly housing flange. Remove and discard the O-ring from the groove in the swing brake assembly housing.

Installation

CAUTION

Use care when engaging the swing motor drive gear; do not force the shaft to engage. Damage to the gears may result

1. Install a new O-ring in the groove of the swing brake assembly's housing. Position the swing motor on the swing brake.
2. Secure the swing motor to the swing brake assembly housing with the capscrews. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
3. If needed, fill the swing gear box with gear oil. Refer to *Lubrication, page 9-1*.
4. Connect the hydraulic lines to the swing motor as tagged during removal.

Testing

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

Swing Brake Assembly Maintenance

NOTE: Each swing brake assembly can be removed and disassembled independently of the swing gearbox.

Removal

1. Engage the swing lock pin.

CAUTION

Hydraulic fluid can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

2. Tag and disconnect the hydraulic lines connected to the swing motor and the swing brake assembly. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake assembly per the procedure in this section.
4. While observing tension on the bolts due to internal brake springs, unscrew socket head capscrews securing the swing brake assembly to the gearbox. Remove the brake assembly.
5. Remove and discard the O-ring from the swing brake assembly housing.
6. Cover the opening of the swing gearbox to ensure no dirt, dust or other foreign material get into the gearbox.

Installation

1. Install a new O-ring onto the brake assembly's housing and insert the brake assembly into the gearbox.
2. Secure the brake assembly with the socket head capscrews.
3. Install the swing motor on the swing brake assembly per the procedure in this section.
4. Connect the hydraulic lines to the swing motor and swing brake assembly.
5. Bleed all air from the swing brake assembly.

Testing

1. With the Swing Brake Switch in the ON position, move the swing control lever in both directions. Superstructure rotation should not occur.
2. Put the Swing Brake Switch to OFF and swing the superstructure in both directions. Use the swing brake pedal to stop rotation.
3. Check for hydraulic leaks and repair as necessary.

Swing Gearbox Maintenance

Removal

1. Engage the swing lock pin.

CAUTION

Hydraulic fluid can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

2. Tag and disconnect the hydraulic lines from the swing motor and the swing brake assembly. Cap and/or plug all openings.
3. If necessary, remove the swing motor per instructions in this section. Or, do so after removing entire swing box assembly from superstructure.
4. If necessary, remove the swing brake assembly per instructions in this section. Or, do so after removing entire swing box assembly from superstructure.

NOTE: The swing gearbox with swing brake assembly and swing motor attached weighs about 335 pounds (about 150 kg).

5. Attach a suitable lifting device to the swing gearbox.
6. Remove the capscrews and flatwashers securing the swing gearbox to the superstructure base plate. Remove the swing gearbox.
7. Remove the bolts and bottom plate attaching the pinion gear to the swing gearbox shaft. Remove the pinion gear.
8. Cover the opening of the swing gearbox to ensure no dirt, dust, or foreign material gets into the gearbox.

Installation

1. Install the pinion gear and bottom plate on the swing gearbox splined shaft. Secure pinion gear with the bolts.
2. Install the swing brake assembly on the swing gearbox per instructions in this section.
3. Install the swing motor on the swing brake assembly per instructions in this section.
4. Attach a suitable lifting device to the swing gearbox and position the swing gearbox on the superstructure base plate.
5. Install the capscrews and washers removed earlier to secure the swing gearbox to the superstructure base plate.
6. Connect the hydraulic lines to the swing brake.
7. Connect the hydraulic lines to the swing motor.
8. Service the gearbox per the following instructions.

Servicing

Normal maintenance should only consist of proper lubrication and a periodic check of mounting bolt torque values. Lubrication consists of maintaining the gearbox oil level. Oil in a new gearbox should be drained and flushed out after approximately 250 hours of operation, and replaced with premium quality SGL-5 after about 500 hours of operation or each year, whichever occurs first. Operation in high humidity or polluted air areas will require more frequent changes to minimize moisture or contaminate accumulation.

Oil Changing

Change the oil as follows:

1. Unscrew drain plug; remove breather and dipstick. Ensure all oil has been removed.
2. Flush the case with a light flushing oil. Flushing of the gearbox with a solvent helps prevent an accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the vent of the swing bearing.
3. After oil is drained, reinstall the drain plug and any other plugs that were removed to drain the oil.
4. To refill with oil, make sure the breather is open. Fill until proper location on dipstick.
5. Tighten breather and dipstick.

Checking Oil Level

1. Check level on dipstick
2. If no lubricant is visible on dipstick, add SGL-5 until between minimum and maximum on dipstick. Refer to *Lubrication, page 9-1*.
3. Reinstall the dipstick in the brake housing.

Testing

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

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the superstructure to the carrier. The bearing inner race is bolted to the superstructure and the outer race is bolted to the carrier. The inner race contains grease fittings for lubrication of the bearing which are hosed to two fittings at the front of the turntable center section. The outer race has gear teeth that mesh with the pinion gear of the swing gearbox to provide rotation.

Maintenance

General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the superstructure and carrier. Therefore, proper care of the bearing and periodic maintenance of the turntable-to-bearing attach bolts IS A MUST to ensure safe and efficient operation.

Torquing Turntable Bolts

General

WARNING

Failure to maintain proper torque of the turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the superstructure from the carrier.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 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.

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

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

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

If it is reported by the crane operator or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the cranes' capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

Turntable bolts should be torqued according to the procedures outlined in this section.

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

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

The inner race of the bearing is secured to the turntable by 71 M27x10.9 Class bolts. The outer race of the bearing is secured to the carrier frame by 72 M27x10.9 Class bolts.

Torque Values

Torque all turntable bolts to a final torque of 1083 to 1173 lb-ft (1469 to 1591 Nm) in two steps.

Using the 4 to 1 multiplier and no step wrenches, set the torque wrench for 550 lb-ft (746 N-m).

Tools Required

Special Turntable Bolt Torquing Tools (Figure 6-3) illustrates and lists the complete set of special tools required to torque the turntable bolts.

Inner Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.

   Using a star pattern torque the bolts to 80% of the full torque value.

2. Torque eight bolts to 867 to 939 lb-ft (1176 to 1273 Nm) using the following sequence star pattern: 18, 54, 36, 1, 27, 63, 45, and 9 (Figure 6-2). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Tighten the other 65 bolts, working to the same star pattern, until all of them are torqued to 867 to 939 lb-ft (1176 to 1273 Nm).
4. Return to bolt 1 and torque all 71 bolts sequentially in a clockwise direction to the final torque of 1083 to 1173 lb-ft (1469 to 1591 Nm).

Outer Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts to 867 to 939 lb-ft (1176 to 1273 Nm) using the following sequence pattern: 18, 54, 36, 1, 27, 63, 45, and 9 (Figure 6-2). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Tighten the other 64 bolts, working to the same star pattern, until all of them are torqued to 867 to 939 lb-ft (1176 to 1273 Nm).
4. Return to bolt 1 and torque all 72 bolts sequentially in a clockwise direction to the final torque of 1083 to 1173 lb-ft (1469 to 1591 Nm).

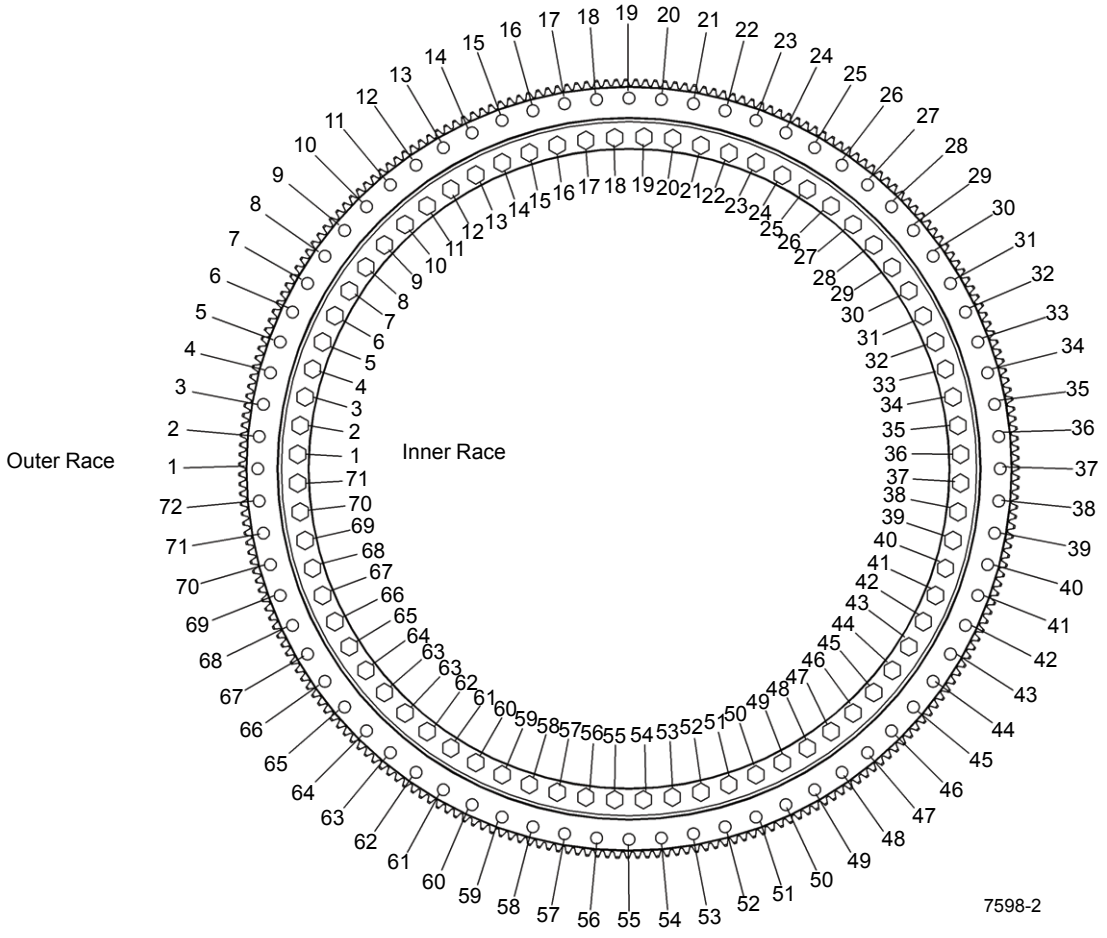
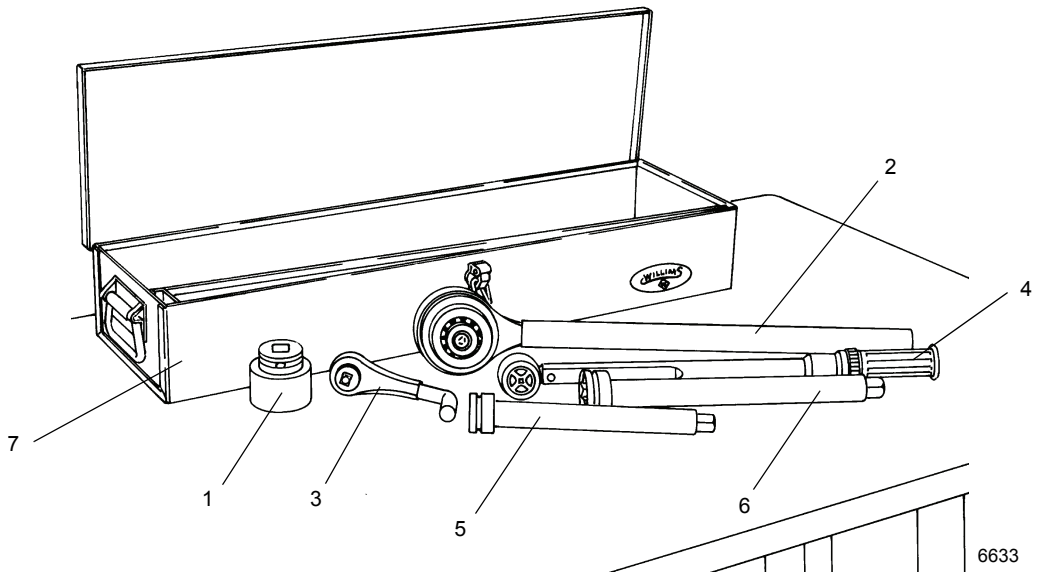


FIGURE 6-2



Orders for special tools shall be referred to your Manitowoc dealer or Manitowoc Crane Care.

Description	Grove Part Number	Quantity Required
1. 1 13/16 “Socket 3/4” Drive	9-999-101988	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

FIGURE 6-3

Removal

1. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

2. Ensure the boom is in the travel position and the turntable lock pin is engaged.
3. Elevate the boom slightly and shut down the engine.
4. Tag and disconnect the battery cables from the batteries.

NOTE: The boom assembly weighs approximately 32,758 lb (14,859 kg) without stowed boom extension. Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached. The lift cylinder weighs approximately 2765 lb (1254 kg).

5. Remove the boom and lift cylinder following the procedures outlined in *Boom, page 4-1*.

NOTE: The counterweight weighs approximately 63,000 lb (28,576 kg).

6. Remove the counterweight following procedures outlined in *Counterweight Removal and Installation, page 5-7*.
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 2030 lb (921 kg). Ensure the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 73 bolts and washers securing the turntable bearing to the superstructure.

17. Using the lifting device, remove the turntable bearing from under the superstructure.

Inspection

Check the bearing teeth for chipping or cracking. If any evidence of these are found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

Installation

DANGER

Anytime a grade 10.9 turntable bolt has been removed, it must be replaced with a new grade 10.9 bolt.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

1. Using an appropriate lifting device, position the turntable bearing under the superstructure. If the same bearing is being used, position it as marked prior to removal.

2. Install 73 new bolts and washers to secure the bearing to the superstructure. Refer to Inner Race Torquing in this Sub-Section.

3. Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the swing drive side of the turntable.

4. Install 72 new bolts and washers to secure the bearing to the carrier. Refer to *Outer Race Torquing, page 6-11*.

NOTE: If a new bearing is being installed, a new pinion gear must also be used. Align the high point (maximum eccentricity) on the bearing with the new pinion gear high point.

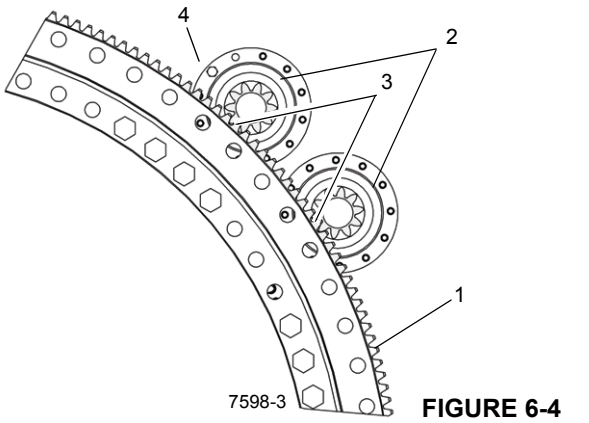


FIGURE 6-4

Item	Description
1	Bearing
2	Swing Gearbox
3	Backlash Check Point
4	Turntable

5. Orient ring gear such that its point of max eccentricity (“high point”) is located between the swing drives. Position swing drives so that pinion is centered within cutout in base plate and motor ports face towards the outboard side (Figure 6-4).

CAUTION

Do not clamp over pinion. Damage to the gear teeth may result.

a. Using shims, set backlash by moving the swing drive assemblies toward the bearing in order to mesh the pinion with the ring gear teeth.

b. Check tooth engagement squareness and vertical tooth engagement.

c. Remove backlash shims and recheck backlash.

NOTE: Adjust the tooth engagement (3) (Figure 6-4) for a backlash of 0.25 in (6.4 mm). Rotate the bearing (1) one revolution while checking the backlash at 90° increments.

6. Position the retainer plate 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 four bolts. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*. Bend all the retainer tabs to make contact with the bolt heads.

7. Plug the swivel wiring harness connectors into the carrier receptacles. Secure the ground wire to the ground stud using a washer, lockwasher, and nut.

8. Install the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel.

9. Connect all water and hydraulic lines to the ports on the bottom of the swivel as tagged during removal.

10. Install the boom and lift cylinder following the procedures outlined in *Boom, page 4-1*.

11. Install the counterweight following procedures outlined in *Counterweight Removal and Installation, page 5-7*.

12. Reconnect the batteries.

13. Check the slew potentiometer mounted outside of the bearing under the cab.

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 dealer.

SWIVELS

Description

The swivel assembly consists of a 14 port hydraulic, air conditioning, water swivel and 46 conductor slip ring assy (2) (Figure 6-5). Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts (3), washers (4) and bushings (6) (Figure 6-5), which connect to mounting lugs (7) on the case. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier by bolts, and bolt retainer plates attached to the swivel retainer plate (9) which engages the carrier frame lugs with bolts and jam nuts (10). This allows the spool to remain stationary with the carrier as the case rotates with the superstructure.

The spool portion of the water swivel is attached to the spool of the hydraulic swivel by four bolts. The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case contains a lug which is keyed to a corresponding lug on the hydraulic swivel case, causing the water swivel to rotate with the superstructure.

The electrical swivel center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.

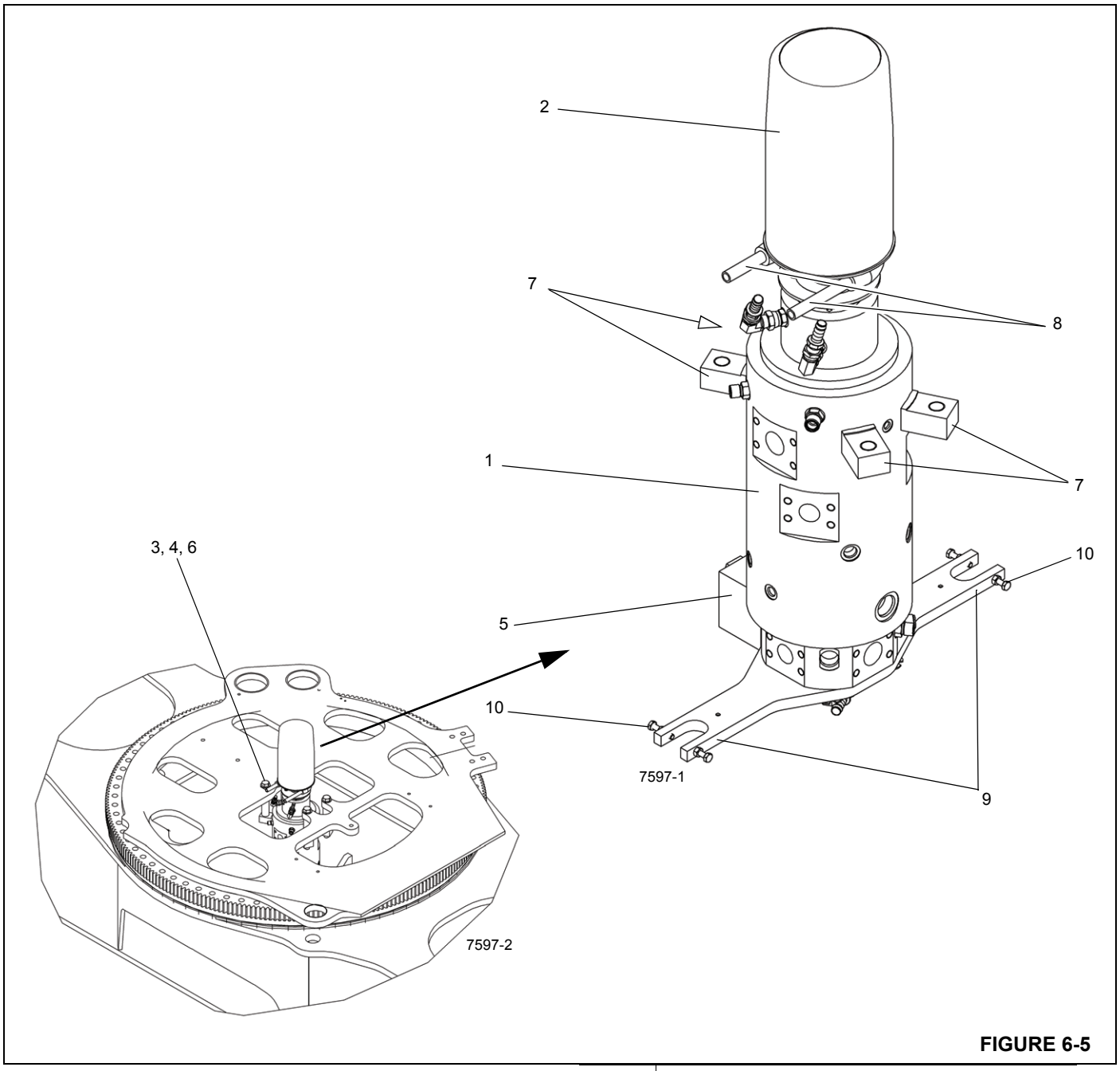


FIGURE 6-5

Item	Description
1	14 Port Hydraulic, AC, Water Swivel
2	46 Conductor Slip Ring Assy
3	Bolt
4	Washer
5	45 PSI Inline Check Valve

Item	Description
6	Bushing
7	Mounting Lug
8	Harness
9	Swivel Retainer Plate
10	Screw and Jam Nut

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 #	Function
1	Return
2	Supply - Piston Pump #1
3	Supply - Piston Pump #2
4	Case Drain
5	Swing
6	Steer, Front-Left
7	Steer, Front-Right
8	Load Sense
9	Brakes, Front
10	Brakes, Rear
11	A/C Supply
12	A/C Return
A&B	Heater

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) hardwood timbers.

NOTE: It might be necessary to raise the boom slightly to allow installation of the blocking.

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 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 ground wire from the connector mounting bracket on the carrier frame. If necessary, remove the electrical swivel. Refer to *Electrical Swivel, page 6-19*.

NOTE: The hydraulic swivel weighs approximately 430 lb (195 kg). The hydraulic, water, and electrical swivel combined weigh approximately 520 lb (236 kg).

9. On the bottom of the swivel, bend the retainer tabs away from the capscrew heads. Remove the eight capscrews and four capscrew retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: It may be necessary to remove some drive line components to remove the swivel.

10. Position an adequate supporting device beneath the swivel.
11. Remove the four capscrews, washers, and bushings securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

Installation

NOTE: The hydraulic swivel weighs approximately 430 lb (195 kg). The hydraulic, water, and electrical swivel combined weigh approximately 520 lb (236 kg).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews, and washers. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
3. Position the two retainer plates on the hydraulic swivel spool ensuring they engage the lugs on the carrier frame. Secure the retainer plates with eight capscrews and four capscrew retainers.

   Apply Loctite 271 to the capscrew threads. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*. Bend all the retainer tabs to make contact with the capscrew heads. Tighten the four 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 6-19*. Connect the swivel wiring harness connectors to the carrier receptacles and the ground wire to the mounting bracket on the carrier frame. Use the bolt and star washers taken off at removal and refer to Grove Engineering Specification A-829-100386 for proper electrical termination of grounds.
5. Install the clamp, lockwasher, flat washer and capscrew to the bottom of the swivel retainer plate securing the wiring harness.
6. Connect the hydraulic lines and water lines to the spool of the hydraulic swivel as tagged during removal.
7. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.
8. Connect the water lines to the water swivel case as tagged during removal.
9. Remove the blocking material from the lift cylinder.
10. Activate all systems; cycle all functions and observe for proper operation and any leakage.

Two-Port Water Swivel

Description

The two-port water swivel allows engine coolant to flow from the carrier-mounted engine to the hot water heater in the operator's cab. Through an internally drilled passage in the 11 port hydraulic swivel spool, coolant is transferred to a circumferential groove on the water spool exterior. This groove corresponds with a mating port on the outer case of the water swivel. The spool grooves are separated by a quad ring/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 *Hydraulic Swivel, page 6-17*.
2. Remove the electrical swivel. Refer to *Electrical Swivel, page 6-19*.
3. Tag and disconnect the lines from the case of the water swivel. Cap or plug all lines and openings.
4. Remove the bolt and shim(s) from the water/hydraulic swivel keying lugs.
5. Remove the four capscrews and washers securing the water swivel and electrical swivel center post to the hydraulic swivel. Remove the water swivel and center post.

Disassembly

NOTE: Any maintenance requiring disassembly of the water swivel should include replacement of all seals and rings.

1. Withdraw the spool from the case.
2. Place the spool on a clean work surface in a dust-free area and block the spool to prevent movement during disassembly.

CAUTION

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

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

3. Remove the seals and rings from the spool.

Cleaning and Inspection

WARNING

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid prolonged skin contact, inhalation of vapors, or smoking. Failure to comply can result in injury or death to personnel.

1. Clean the spool and case with a suitable solution and dry with compressed air. Plug all ports with plastic caps.
2. Check the spool and inside of the case for scratches, grooves, scoring, etc. If any grooves have developed with a depth of 0.005 in (0.127 mm) the unit should be replaced.

Assembly

NOTE: Lubricate the interior of the swivel to prevent rusting from condensation.

1. Lubricate the spool, seals, and rings.

CAUTION

When installing seals and rings, avoid stretching seals or scratching grooved or gland surfaces.

2. Install new seals and rings on the spool.

CAUTION

Proper alignment when inserting the spool is required. Do not force the spool into the case.

3. Insert the spool into the barrel.

Installation

1. Install the water swivel on top of the hydraulic swivel aligning the keyed lug on the water swivel with the lug on the hydraulic swivel. Secure the water swivel and the electrical swivel center post with the four bolts and washers.
2. Install the shim(s) on the keying lug to provide a snug fit and secure with a bolt.
3. Connect the lines to the swivel case as tagged during removal.
4. Install the electrical swivel. Refer to *Electrical Swivel, page 6-19*.
5. Perform steps 8 and 9 of *Hydraulic Swivel - Installation* in this Section.
6. Activate all systems, cycle all functions, and observe for proper operation and any leakage.

Electrical Swivel

Description

The swivel assembly consists of a 46 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.

Theory of Operation

The electrical swivel is located on top of the water swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity between the carrier and superstructure.

Maintenance

Removal

1. Perform steps 1 through 4 of *Hydraulic Swivel - Removal* in this section.

CAUTION

Disconnect the batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

2. Disconnect the batteries. Refer to *Batteries, page 3-2*.
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.

NOTE: If the connectors are too large to go through the center of the hydraulic swivel, they must be removed. Conditional instructions will follow.

5. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.

NOTE: If connectors are too large to go through the center of the hydraulic swivel, tag each wire on each of the connectors. Using the appropriate pin removal tools, remove the pins, with wires still attached, and mark each wire with the pin socket number in the connector. Collect the wires and secure into one bundle. Mark the bundle with the connector number. For a list of the appropriate pin removal tools, refer to *Connector Troubleshooting, page 3-9*.

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 junction box on the turntable.
8. Remove the nuts and washers, and remove the cover from the electrical swivel.
9. Loosen the setscrews securing the electrical swivel mounting tube to the center post on the water swivel.
10. Remove the bolt and nut securing the electrical swivel case to the bracket on the case of the water swivel.

CAUTION

When withdrawing the wiring harness through the center of the hydraulic and water swivels, ensure the wires do not get caught and damaged.

11. Remove the swivel and wiring harness from the crane. If necessary, remove the spacer bushing from the center post.

Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic and water swivels.
2. Slide the electrical swivel mounting shaft onto the center post.
3. Ensure the threaded hole on the bottom of the electrical swivel base is aligned with the mounting hole in the bracket on the water swivel case. Install the bolt through the hole in the bracket and install the nut. Screw the bolt into the hole in the electrical swivel base until the bolt head is approximately 0.25 in (6.4 mm) from the bracket. Tighten the nut against the electrical swivel (Figure 6-6).

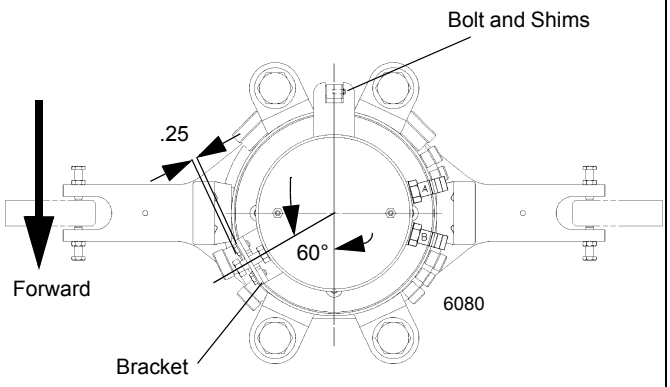


FIGURE 6-6

4. Apply Loctite to the set screws securing the electrical swivel to the center post and tighten them to 45 to 55 in-lb (5 to 6 Nm)
5. Install the swivel cover and two over-center latches.
6. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal.
7. Plug the connector into the carrier wiring receptacle, connect the wires as tagged during removal. Install the ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken off at removal and refer to Grove Engineering Specification A-829-100386 for proper electrical termination of grounds.
8. Install the clamp securing the harness to the retainer plate on the bottom of the hydraulic swivel assembly.
9. Connect the batteries.
10. Activate all systems, cycle all functions, and observe for proper operation.

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.

SWING LOCK PIN

Description

The purpose of the swing lock pin is to lock the superstructure in position directly over the front or the rear of the carrier. The swing lock pin installation consists of a large pin, a control handle in the right side of the cab, and a control cable and control linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front, pushing the control handle in inserts the swing lock pin into a socket on the carrier frame, locking the superstructure in place. Pulling the control handle out pulls the pin out of the socket, unlocking the superstructure.

Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify pin, the turntable bushing the pin passes through, and the sockets on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage and cable are adjusted properly. If they are, the pin bottom will stick out about 4.00 inches (10.16 cm) from the bottom of its bushing in the turntable. (If it is too far in, it might not lock properly. If it is too far out, it might hang up). Using the jam nuts on the linkage parts and cable, adjust the linkage and cable so the pin bottom will be flush with the bottom of its bushing in the turntable when not applied, and the pin will stick out about 4.00 inches (10.16 cm) from the bottom of its bushing in the turntable when applied. Verify the superstructure can lock properly when the pin is applied and the superstructure can rotate without pin hangup when the pin is not applied.

360° SWING LOCK CONTROL (POSITIVE LOCK TYPE)

Description

The purpose of the swing lock is to secure the superstructure in position at one of the positions in its rotation. There are roughly 247 spots about 1.45 degrees apart for the superstructure to lock to in its 360 degree of rotation. The 360 degree swing lock control pedal is on the left side of cab. Pushing the swing lock foot pedal engages the lock between the teeth of the swing gear. Pulling the swing lock control lever up disengages the lock.

Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify swing lock assembly is undamaged and working properly. Verify springs are undamaged and have enough strength to pull blade of swing lock assembly completely out of the gear teeth when the control pedal is up. Verify the linkage can put the blade of the swing lock assembly as far as possible between the gear teeth when the control pedal is down.

Verify all attaching hardware is secure and undamaged. Make adjustments as needed.

If the swing lock assembly is damaged, install a replacement. Align the blade of the swing lock assembly so it will fall between gear teeth. Use the shim and the related attaching hardware (two M8x16 screws and M8 lockwashers) to ensure the swing lock assembly cannot move side to side, and can lock up the superstructure. Torque the four M24x100 mounting bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.

As needed, adjust the swing lock control and cable per above instructions. Then operate the control lever several times to verify the swing lock blade assembly engages and disengages properly. Adjust cable as required.

SECTION 7
POWER TRAIN

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DESCRIPTION

The engine is either a Cummins QSC (Tier 3) or a QSX (Tier 4) diesel engine (Figure 7-1). This Service Manual does not include detailed information on the engine itself. A separate manual as prepared in detail by the engine manufacturer, is supplied with this Service Manual. However, a short description and maintenance of certain components of the fuel system, air intake system, and water cooling system is provided in this section.

The engine is electronically controlled by the Electronic Control Module (ECM), it is the control center of the system. It processes all of the inputs and sends commands to the fuel systems as well as vehicle and engine control devices.

Engine speed is controlled by the foot throttle pedal in the cab. It controls engine RPM which increases or decreases proportionately with the amount of foot pressure applied to the pedal. Engine speed is also controlled by a momentary rocker switch on the steering column. An increase in engine rpm occurs when the top of the switch is pushed. A decrease in engine rpm occurs when the bottom of the switch is pushed. The foot throttle pedal and Engine Increase/ Decrease Switch are electrically connected to the superstructure control module which sends the signal to the engine ECM.

The engine and its components are enclosed in a hood assembly with a grill in the rear of the hood for adequate air circulation. Access to the engine is gained through a door assembly in the top of the hood that opens from both sides.

The air intake filter is mounted on the front of the left rear fender. The muffler is mounted on the left side of the frame behind the left rear fender.

WARNING

Do not spray starting fluid into the air inlet. The spray will contact the heater elements and could explode, causing personal injury.

The engine is equipped with electric air heating elements that are located in the engine's intake air stream to aid in cold starting and reduce white smoke at start-up. In the preheat mode, the engine should not be cranked until the Wait-to-Start Lamp turns off. The Wait-to-Start Lamp is illuminated during the preheat time that takes place when the ignition switch is in the ON position during cold weather starting. The ECM checks intake manifold temperature to determine how long to energize the air heater before extinguishing the Wait-to-Start Lamp. Once the engine is started, the electric air heating element will be energized again for a time period determined by intake air temperature.

MAINTENANCE

Engine Removal

1. Fully extend and set the outriggers and position the boom over the side to provide working clearance.
2. Disconnect the battery.
3. Open the hood top door assembly.
4. Disconnect the air filter tubing at the engine and air cleaner (Figure 7-4). Remove and lay aside.
5. Disconnect the exhaust tubing at the engine and muffler. Remove and lay aside.
6. Tag and disconnect the hourmeter wiring, the engine electrical harness connector from the carrier harness connector, the starter and grid heater relay harness from the carrier harness and the battery cables from the batteries and the engine.
7. Tag and disconnect the left and right rear backup lights, stop lights and the backup alarm from the carrier harness. Remove the clamps holding the harness to the engine hood.
8. Remove the capscrews and washers securing the remote secondary fuel filter and mounting bracket to the engine hood. Tie strap the filter and bracket to the engine so it is out of the way for removal of the engine.
9. Remove the engine hood assembly and pump cover from the machine.
10. Drain the engine coolant system into a suitable container.
11. Drain the engine lubrication system into a suitable container.
12. Drain the transmission/torque converter oil system into a suitable container.
13. Tag and disconnect the oil lines from the torque converter. Cap or plug all openings.
14. Remove the driveline between the torque converter and the transmission. Refer to *Drive Lines, page 7-26*.

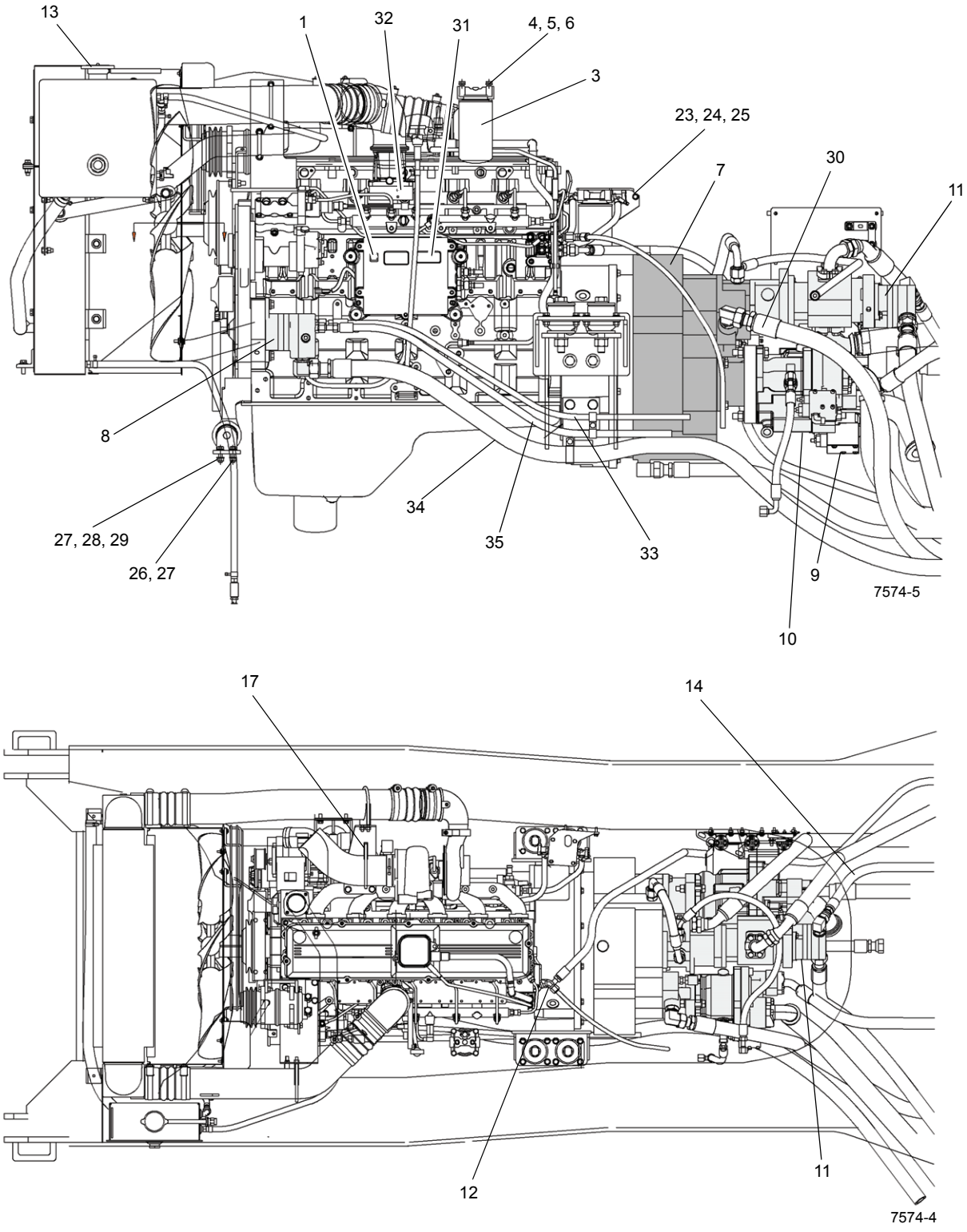
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FIGURE 7-1

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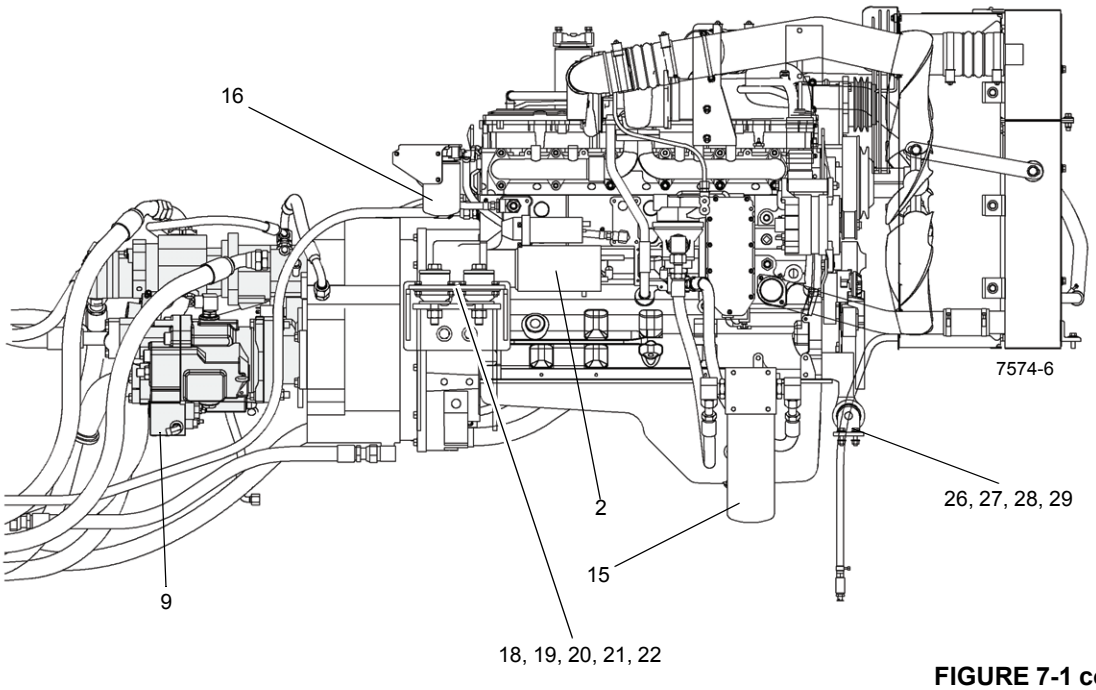


FIGURE 7-1 continued

Item	Description
1	Carrier Harness Connector
2	Starter
3	Remote Secondary Fuel Filter
4	Capscrew
5	Flatwasher
6	Lockwasher
7	Torque Converter
8	Hydraulic Pump # 4
9	Hydraulic Pump # 1
10	Hydraulic Pump # 2
11	Hydraulic Pump # 3
12	Fuel Return Line
13	Radiator Assembly
14	Swivel Port Hose
15	Remote Oil Filter
16	Remote Coolant Filter
17	Exhaust and CAC Tube Support

Item	Description
18	Rear Mount
19	Locknut
20	Flatwasher
21	Dockwasher
22	Capscrew
23	Capscrew
24	Lockwasher
25	Flatwasher
26	Hex Nut
27	Flatwasher
28	Capscrew
29	Lockwasher
30	Trans Oil Cooler Line
31	Carrier Harness Connection
32	Grid Header Connection
33	Primary, Oil Cooler Fan Hose
34	Hydraulic Reservoir Hose
35	Secondary, Return Hose

15. Tag and disconnect all lines from hydraulic pump No. 4 on the right side of the engine. Place a suitable container under the hydraulic pumps to catch any oil that is spilled. Cap or plug all openings. Position the hydraulic lines so the disconnected end is higher than the hydraulic tank. Refer to *Hydraulic Pumps, page 2-17*.
16. Remove the capscrews and flatwashers securing the three hydraulic pumps to the torque converter. Remove the pumps from the torque converter and position them so they do not interfere with removing the engine.
17. Tag and disconnect all lines from the radiator. Cap or plug all openings. Disconnect the coolant level sensor harness from the engine harness and tie up excess harness so it is out of the way.
18. Remove the fan guard and fan ring. Refer to *Radiator Removal and Installation, page 7-23*.
19. Tag and disconnect all fuel lines at the engine. Place a suitable container under the fuel line connection to catch any spills. Cap or plug all openings. Position the fuel lines so the disconnected end is higher than the fuel tank.
20. Tag and disconnect all lines and tubing from the engine. Cap or plug all openings.
21. If equipped with optional engine block heater, tape and stow the electrical plug to the engine so it is out of the way for engine removal.
22. Remove the capscrews, flatwashers and lockwashers securing the remote engine oil filter bracket to the side of the frame. Tie strap the oil filter and mounting bracket to the side of the engine so it is out of the way for removal of the engine.
23. Remove the three capscrews attaching the remote water conditioner to the left side frame rail. Tie strap the filter and mounting bracket to the engine so it is out of the way for removal of the engine.

DANGER

The lifting device must be able to support the combined weight of the engine and torque converter.

NOTE: The engine and torque converter assembly weighs approximately 2579 lb (1170 kg).

24. Attach a lifting device capable of supporting the weight of the engine, to the engine and torque converter.
25. With the lifting device supporting the weight of the engine, remove the four capscrews, nuts and washers securing the front of the engine to the frame. Remove the capscrews, nuts, washers, shock mounts, and dock washers (one set on each side) securing the rear of the engine to the frame.
26. Using the lifting device, lift the engine and torque converter as an assembly from the crane.
27. Remove the torque converter from the engine. Refer to *Torque Converter, page 7-27*.
28. If a new engine is to be installed, remove all components, fittings, etc., from the old engine and install them on the new engine in the same location.

Engine Installation

NOTE: Use the same grade hardware, torque values, and Loctite used by the factory.

DANGER

The lifting device must be able to support the combined weight of the engine and torque converter.

NOTE: The engine and torque converter assembly weighs approximately 2579 lb (1170 kg).

1. Install the torque converter on the engine. Refer to *Torque Converter, page 7-27*.
2. With all components and fittings installed on the engine, lift the engine into the crane.
3. With the engine in position, secure the rear of the engine with the capscrews, nuts, washers, shock mounts, and dock washers (one set on each side). Torque the capscrews, refer to *Fasteners and Torque Values, page 1-17*.

   At the front of the engine secure the engine mount to the frame with the four capscrews, nuts and washers. Torque the capscrews, refer to *Fasteners and Torque Values, page 1-17*.
4. Remove the lifting device.
5. Secure the remote engine oil filter and mounting bracket to the side of the engine frame with the capscrews, flatwashers and lockwashers. Torque the capscrews, refer to *Fasteners and Torque Values, page 1-17*.
6. Secure the remote water conditioner filter and mounting bracket to the side of the frame with three capscrews. Torque the capscrews, refer to *Fasteners and Torque Values, page 1-17*.
7. Install the three hydraulic pumps on the torque converter. Refer to *Hydraulic Pumps, page 2-17*.
8. Connect the hydraulic lines to hydraulic pump No.4 as marked at removal. Remove all caps or plugs placed on openings during removal so no blockage can occur in

the hydraulic system. Refer to *Hydraulic Pumps, page 2-17*.

9. Connect the fuel lines to the engine as tagged during removal. Remove all caps or plugs placed on openings during removal so no blockage can occur in the fuel system.
10. Connect all lines and tubing to the engine, torque converter, and all other components in accordance with the identification marks made during removal. Remove all caps or plugs placed on openings during removal so no blockage can occur.

CAUTION

Do not apply sealant to the inside of the hydraulic suction hoses.

11. Install the hydraulic hoses as tagged during removal.
12. Install the radiator. Refer to *Radiator Removal and Installation, page 7-23*. Connect all hoses and electrical harnesses to the radiator as tagged during removal. Remove all caps or plugs placed on openings during removal so no blockage can occur in the radiator system.
13. Connect the drive shaft between the torque converter and the transmission. Refer to *Drive Lines, page 7-26*.
14. Install the hood assembly. Install the pump cover.
15. Secure the remote secondary fuel filter to the engine hood with four capscrews, washers, and lockwashers. Torque the capscrews, refer to *Fasteners and Torque Values, page 1-17*.
16. Connect the left and right rear backup lights, stop lights and left side backup alarm at the rear of the engine hood. Use clamps acquired during removal to route harness along engine hood.
17. Connect the start and grid heater relay panel to the carrier harness.
18. Connect all electrical connections as tagged during removal.
19. Reconnect battery cables as tagged during removal.
20. If equipped with engine block heater, reroute the cord for the heater.
21. Connect the muffler exhaust piping to the engine.
22. Connect the air filter tubing at the engine and the air filter.
23. Service the transmission, engine lubrication system, and engine cooling system.
24. Start the engine. Check all hoses and fittings for leaks. Recheck all fluid levels. Refer to *Lubrication, page 9-1*.

Engine Drive Belts

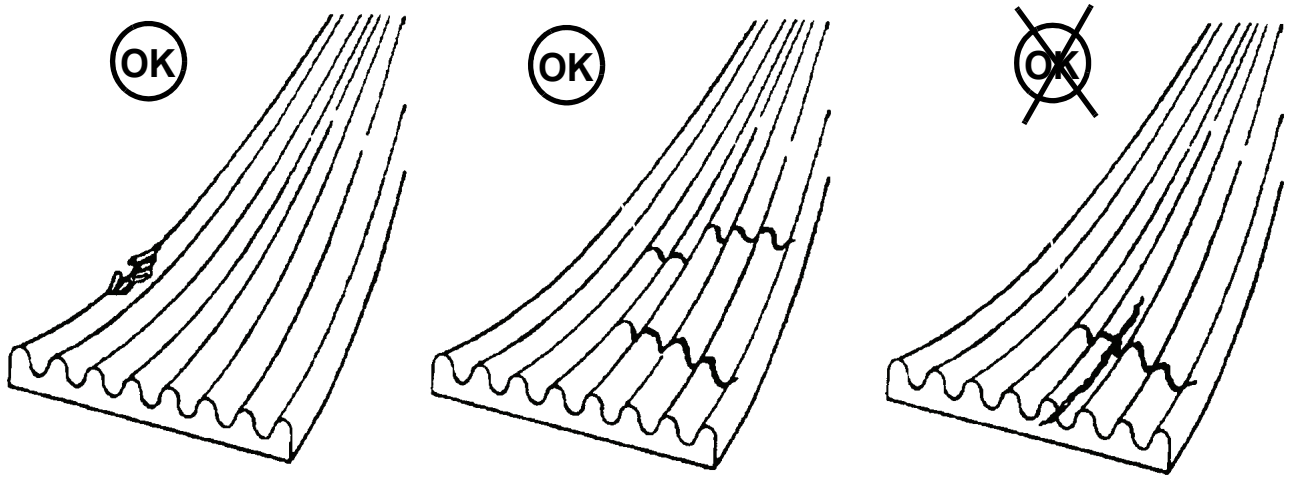
The proper operation of engine belt-driven components such as the alternator, fan, and water pump depend on the proper condition and tension of the engine drive belt.

NOTE: Belt tension is maintained with an automatic belt tension device.

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

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

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



Missing Material

Traverse Cracks

Longitudinal Cracks Intersecting with Transverse Cracks must be Replaced

FIGURE 7-2

ELECTRONIC CONTROL SYSTEM

The engine control system is an electronically operated fuel control system that also provides many operator and vehicle features as well as reducing exhaust emissions while optimizing engine performance.

The ECM performs diagnostic tests on most of its circuits and will activate a fault code if a problem is detected in one of these circuits. Along with the fault code identifying the problem, a snapshot of engine operating parameters at the time of fault activation is also stored in memory. Some fault codes will cause a diagnostic lamp to activate to signal the driver. The fault codes can be read using the fault lamps in the cab panel or with the correct service tools. The ECM communicates with service tools through a SAE J1939 datalink.

Engine diagnostics, warning lights and fault codes are displayed on the ECOS controller. For more information, refer to Section 3 of the *Operator's Manual*.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, primary fuel filter with water separator, secondary fuel filter with water separator and water in fuel sensor, lift pump, injection fuel pump, fuel injectors, and return fuel cooler. All components except the fuel tank and primary fuel filter are installed on the engine or supplied with the engine for remote mounting.

Fuel Tank

The fuel tank (Figure 7-3) is a steel cylinder-type tank located on the left side of the machine. The fuel tank has a draw capacity of 100 gal (379 l). A connection on the bottom of the tank provides for fuel supply to the engine. Surplus fuel from the engine is routed 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 gauge on the ECOS display.

Injection Fuel Pump

The fuel oil is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is also metered before injection, to meet the load requirements imposed upon the engine. Surplus fuel, returning from the injectors, is bypassed back to the fuel tank or to the inlet side of the pump. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

Fuel Filter-Water Separator

Both fuel filters have water separators that remove impurities from the fuel and also remove water from the fuel before it reaches the engine. The primary fuel filter is located on the frame beside the fuel tank. The secondary fuel filter is mounted on the right side of the engine hood.

The fuel mixture passes through the outer wrap of the first stage of the filter paper, where large droplets of water are formed as it is stripped from the fuel. The water falls out into the void between the two paper elements and goes to a reservoir in the bottom of the housing, where it can be drained through a drain plug at the bottom of the housing.

The water in fuel sensor is located in the secondary fuel filter housing on the right side of the engine hood. Once the storage space in the bottom of the filter housing fills with a certain amount of water, the sensor will signal the ECM.

Electric Lift Pump

The ECM controls the electric lift pump located between the fuel tank and the injection pump. Whenever the keyswitch is turned to the ON position, the lift pump will be energized for a few seconds to make sure the low pressure fuel lines are fully primed. The electric lift pump shuts off after the engine is started.

Maintenance

NOTE: The entire fuel system must be maintained air tight to prevent loss of prime.

Fuel Tank

The fuel tank should be kept filled, especially overnight, to reduce condensation to a minimum. Refer to the applicable engine manual for the recommended schedule for draining any water or sediment from the tank.

Removal

1. Position a suitable container under the fuel tank and drain all fuel from the tank.
2. Tag and disconnect the two lines from the bottom of the tank.
3. Disconnect the electrical lead from the fuel quantity sender unit.
4. Support the weight of the tank, loosen and remove the nuts, washers and capscrews securing the straps to the mounting brackets. Remove the tank and steps.
5. If a new tank is to be installed, remove the two fittings, the fuel quantity sender, and steps from the tank and install them in the new tank.

Installation

1. Position the new tank on the mounting brackets and install the nuts, washers and capscrews on the three straps. Torque the capscrews, refer to *Fasteners and Torque Values, page 1-17*.
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. Install the steps.
5. Service the tank.

Fuel Filter-Water Separator

Draining

The sump of the fuel filter-water separators should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure:

1. Open the drain plug.
2. Drain into suitable container until fuel appears.
3. Close the drain plug.

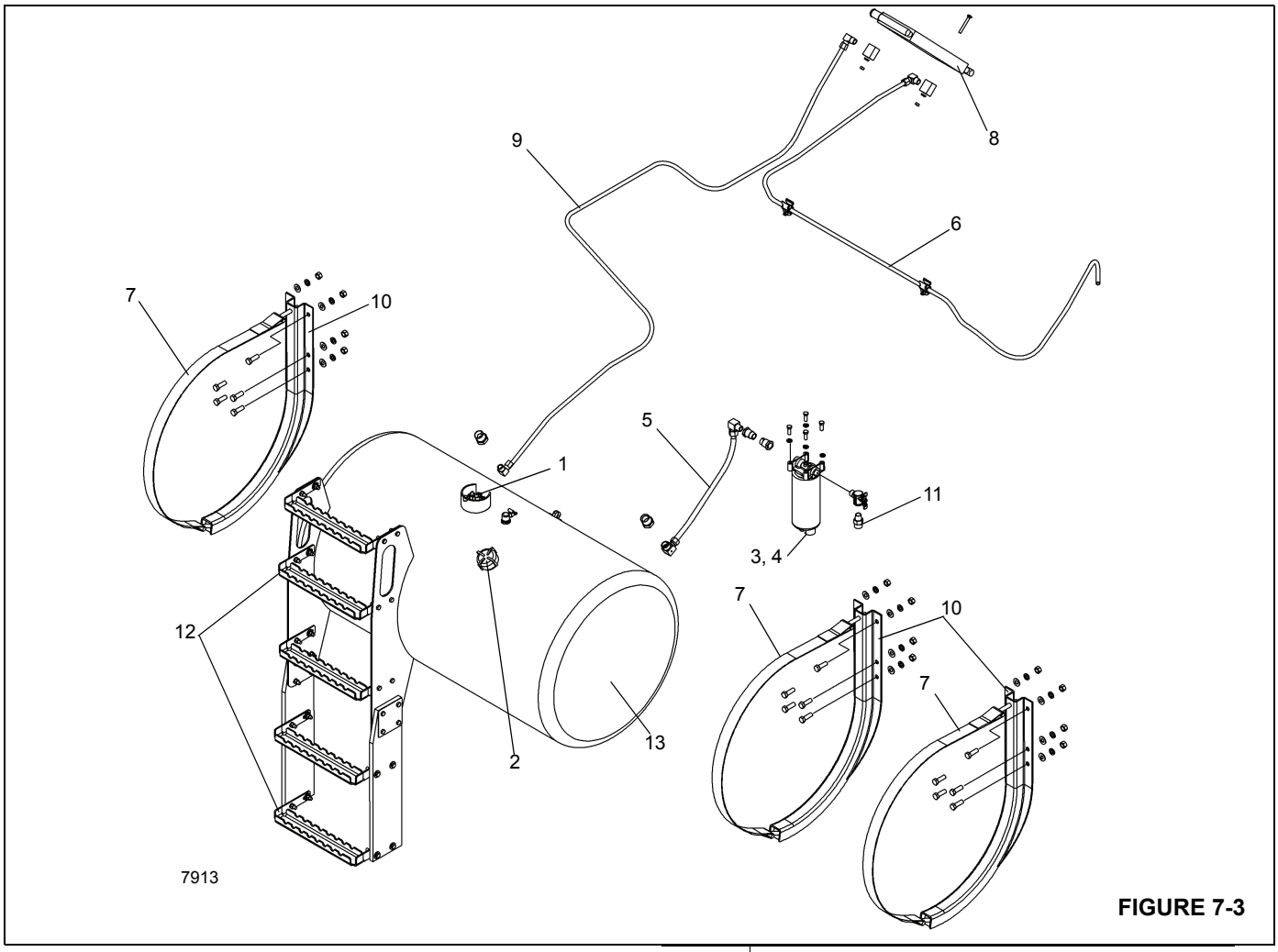


FIGURE 7-3

Item	Description
1	Fuel Quantity Sending Unit
2	Filler Cap
3	Fuel Filter
4	Fuel-Water Separator
5	Fuel Supply
6	Fuel Return

Item	Description
7	Strap Assembly
8	Fuel Cooler
9	Line To Return Port On Tank
10	Bracket
11	Line To Engine
12	Steps
13	Fuel Tank

AIR INTAKE AND EXHAUST SYSTEM

Description

The air intake system (Figure 7-4) controls the quality and amount of air available for combustion. System components are the air cleaner, turbocharger, charge air cooler, cylinder head, and exhaust manifold. Inlet air is pulled through the air cleaner, compressed and heated in the compressor side of the turbocharger. The air is pushed through the air-to-air 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 valve opens and exhaust is expelled through the exhaust port into the exhaust manifold.

The exhaust gases from the exhaust manifold enter the turbine side of the turbocharger and cause the turbine to turn driving the compressor. Exhaust from the turbocharger pass through the exhaust pipe and muffler into the atmosphere.

The air cleaner is the dry-type with a replaceable element and is located on the left rear fender. A service indicator, designed to indicate red when servicing is required, is installed in the left center deck and is connected to the air cleaner by plastic air line.

On the Cummins QSC 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 an intake air heater. A Wait-to-Start Lamp is located on the ECOS display to indicate when to crank the engine.

Maintenance

Air Cleaner Checks

Dust passing the air cleaner can cause rapid engine wear. All connections between the air cleaner and the engine must be tight and sealed. If these connections are well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Ensure the element gasket washer is not damaged and the washer's rubber face seals against the element.
3. Inspect the element gasket for damage.
4. Check for structural failures and replace damaged parts.
5. Inspect the restriction indicator tap for leaks.

Check for Filter Restriction

As a dry cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (at the air cleaner outlet) increases.

The vacuum is generally measured as restriction in 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 replaced. Cummins allows a vacuum of 25 inches of water (6.2 kPa) maximum with a dirty air cleaner at maximum governed RPM.

A service indicator on the air cleaner housing will indicate when the filter needs to be cleaned or replaced. Reset the indicator each time the air cleaner is serviced. If the indicator's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring vacuum.

To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters, is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up. If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Ensure the air cleaner inlet is not plugged.
2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.
3. Ensure the correct size connections are used between the air cleaner and the engine.
4. Ensure all inlet accessories are the correct size and are not plugged by any foreign object.

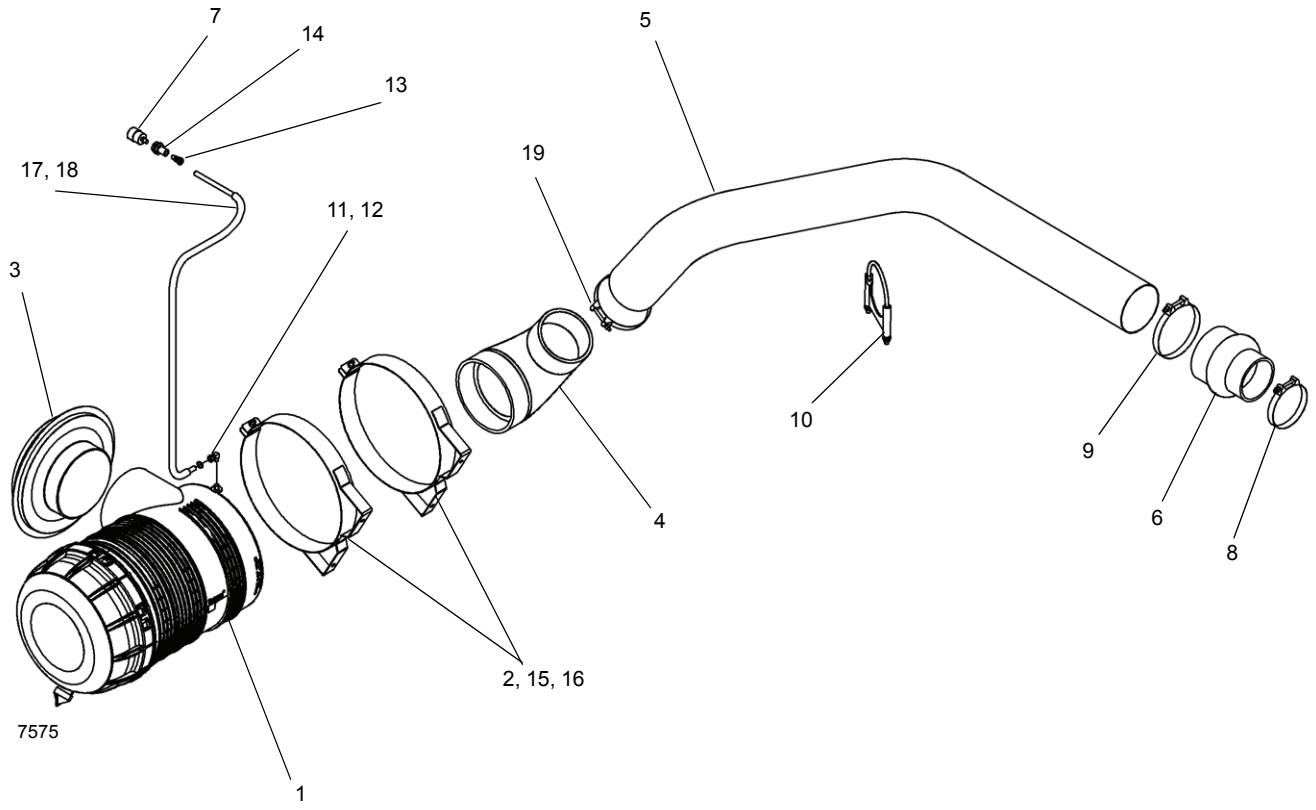
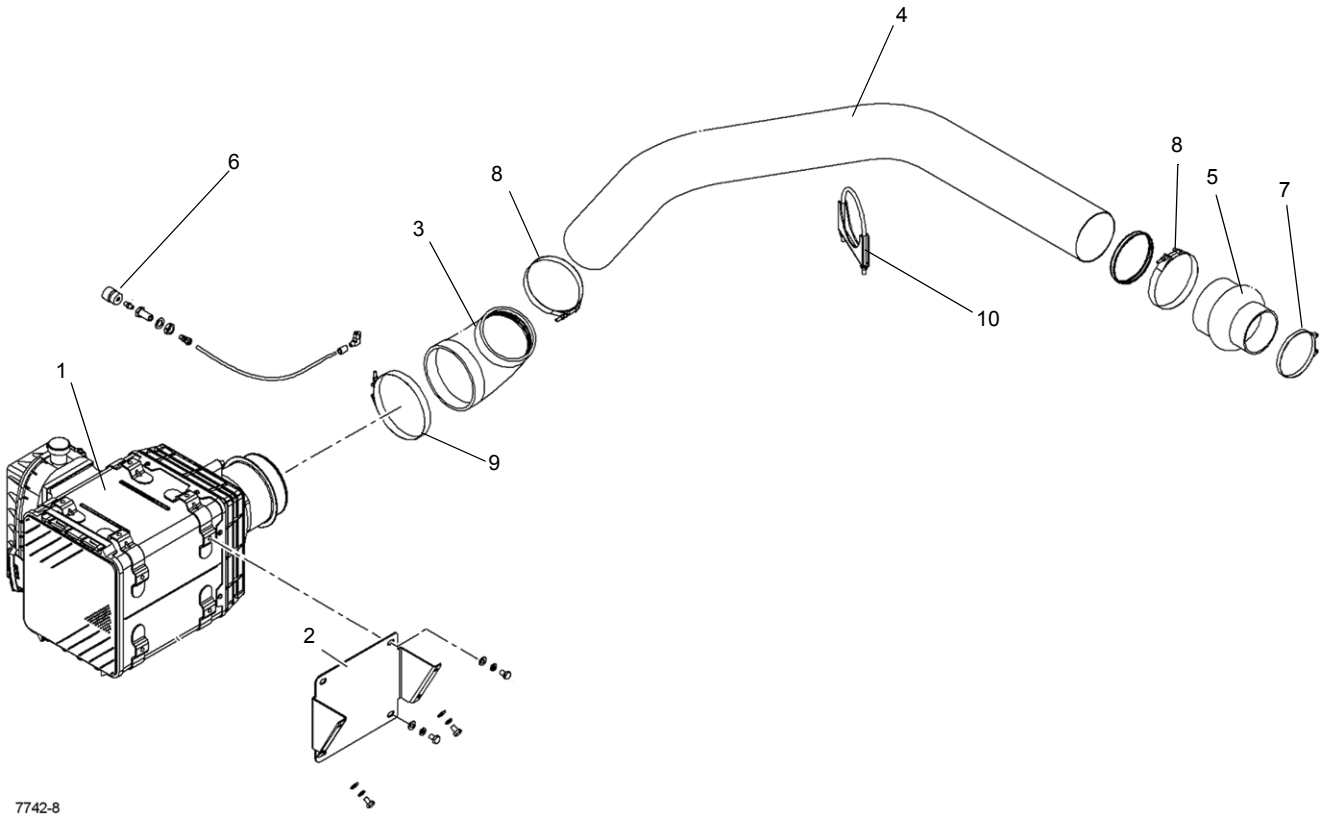


FIGURE 7-4

Item	Description
1	Air Cleaner
2	Mounting Bands
3	Air Inlet Hood
4	Elbow
5	Intake Tube
6	Reducer
7	Restriction Indicator
8	T-Bolt Clamp
9	T-Bolt Clamp
10	Muffler Clamp

Item	Description
11	Elbow
12	Connector
13	Fitting
14	Bulkhead Coupling
15	Flange Screw
16	Locknut
17	Tubing
18	Flex Guard
19	Clamp



Tier 4 Air Cleaner Assembly

FIGURE 7-5

Item	Description
1	Air Cleaner
2	Mounting Bracket
3	Elbow
4	Intake Tube
5	Reducer
6	Restriction Indicator
7	T-Bolt Clamp
8	T-Bolt Clamp
9	T-Bolt Clamp
10	Muffler Clamp

Tier 3 Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

1. Unlatch the latches, open the air cleaner body and withdraw the element as follows (Figure 7-6):

a. RELEASE THE SEAL GENTLY. The filter element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the filter endcap. The filter should be removed gently to reduce the amount of dust dislodged. There will be some initial resistance, similar to breaking the seal on a jar.

FIGURE 7-6

b. AVOID DISLODGING DUST FROM THE FILTER. Gently pull the filter off the outlet tube and out of the housing. Avoid knocking the filter against the housing (Figure 7-7).

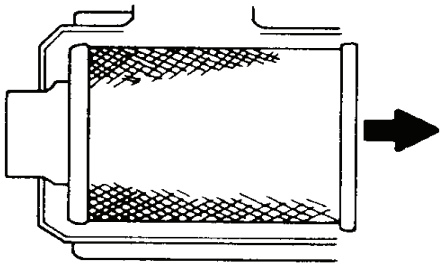


FIGURE 7-7

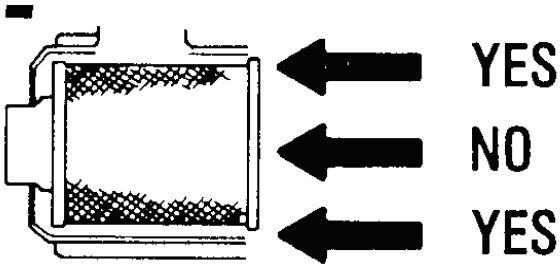


FIGURE 7-8

2. Inspect all parts of the intake system and air cleaner. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube.
3. Install the new element into the air cleaner body as follows:
   a. INSPECT THE FILTER FOR DAMAGE. Always look for filter damage, even if a new filter element is being installed. Pay special attention to the inside of the open end (sealing area). Do not install a damaged filter.
   b. INSERT THE FILTER PROPERLY. The seal area is on the inside of the open end of the primary filter. A new filter has a dry lubricant to aid installation. The critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly. To complete a tight seal, apply pressure at the outer rim of the filter, not the flexible center. No cover pressure is required to hold the seal (Figure 7-8).
4. Install the cover on the air cleaner body with the two arrows pointing up. Secure the cover with the latches.
5. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.

Air Cleaner Body

Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for dents or other damage that would interfere with air flow or with the fins on the element or inside the body. Repair any body dents, being careful not to damage the sealing surfaces. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

Tier 4 Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

Remove decking access plate behind steps. Unlatch the latches, open the air cleaner body and withdraw the element as follows:

1. Lift the clips (1) (Figure 7-9) securing the cover to the air cleaner body and remove the cover.

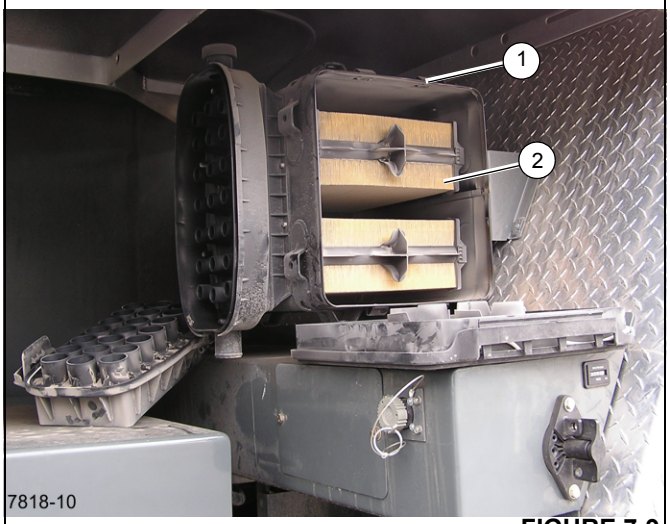


FIGURE 7-9

2. Remove Primary Filter (2) from the Air Cleaner and inspect for foreign material and marks of dust. Replace as necessary.
3. Remove Secondary Filter from behind the Primary Filter (not shown) from the Air Cleaner. Replace the Secondary Filter every third time the primary filter is change.
4. Thoroughly clean the sealing surface and inside of the air filter housing. Inspect all parts of the intake system and air cleaner.
5. Place the cover back on the air cleaner housing and secure with clips (1).
6. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.
7. Replace decking access plate.

Element Cleaning

It is not recommended that filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.

Air Cleaner Body

Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for damage that would interfere with air flow or with the fins on the element or inside the body. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

Precleaner

The Precleaner (1) (Figure 7-10) 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.

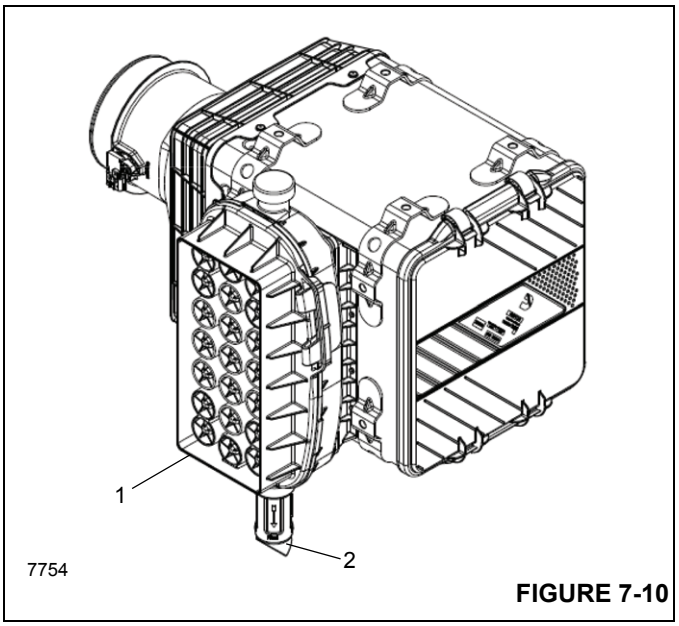


FIGURE 7-10

Vacuator Valve

Vacuator valves 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 7-11).

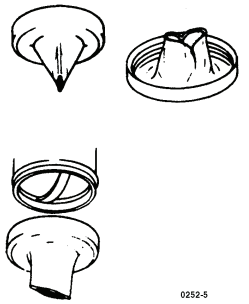


FIGURE 7-11

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 inside out, 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

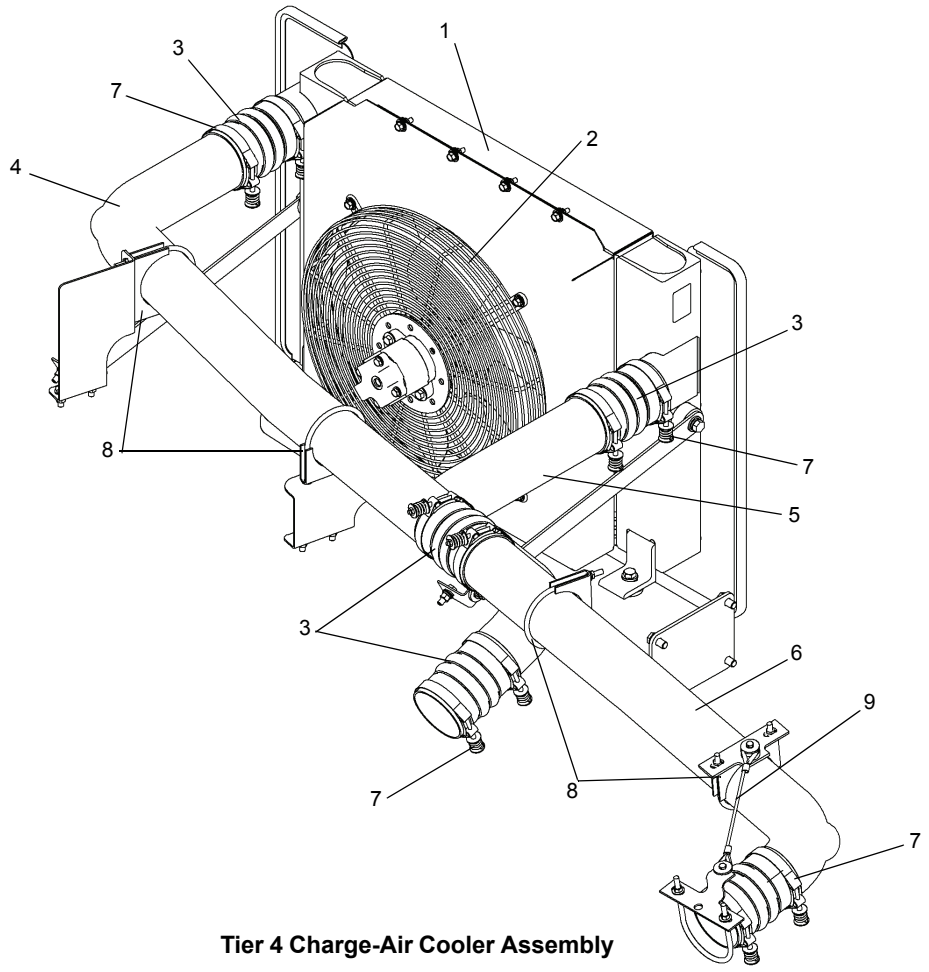
1. Check the intake pipe cap and screen for accumulation of leaves, trash, and other debris that could restrict air flow. Repair the screen or replace the cap if any large holes are found in the screen.
2. Check all mounting hardware for security to eliminate possible vibration of intake piping. Such 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 7-12) is used to cool engine air after it has passed through a turbocharger, but before it enters the engine. The charge-air cooler provides better horsepower, increased fuel efficiency, and reduces engine emissions.

The CAC system consists of the ducting to and from the charge-air cooler and a hydraulically driven fan. The charge-air cooler system must be air-tight in order to work efficiently.

The ducting consists of metal tubing, hose clamps and bellows. The recommended installation torque of the spring loaded T-bolt clamps is 100 lb-in (11.3 Nm). Do not compress the spring completely, the bellows and/or clamp may be damaged from thermal expansion of the CAC tube.



Tier 4 Charge-Air Cooler Assembly

FIGURE 7-12

Item	Description
1	Charge-air Cooler Assembly
2	Fan Assembly
3	Bellows
4	Tube
5	Tube
6	Tube
7	T-Bolt Clamp
8	Muffler Clamp
9	Strain Relief Cable

Maintenance

Check the hose clamps for proper torque.

Inspect the bellows for cracks or holes.

Clean the charge-air cooler, removing any dirt or debris.

Verify the fan is operating correctly and there are no hydraulic leaks.

MUFFLER

NOTE: Standard muffler and CE muffler are similar in removal and installation (Figure 7-13) despite the differences in the two mufflers, the exhaust tailpipes, and the mounting bracket weldments.

NOTE: Tier 3 muffler and Tier 4 muffler are similar in removal and installation (Figure 7-13) despite the differences in the two mufflers, the exhaust tailpipes, and the mounting bracket weldments.

The Tier 4 muffler (diesel particulate filter) is different in that it has sensors and electrical connections and mounts horizontally.

Removal

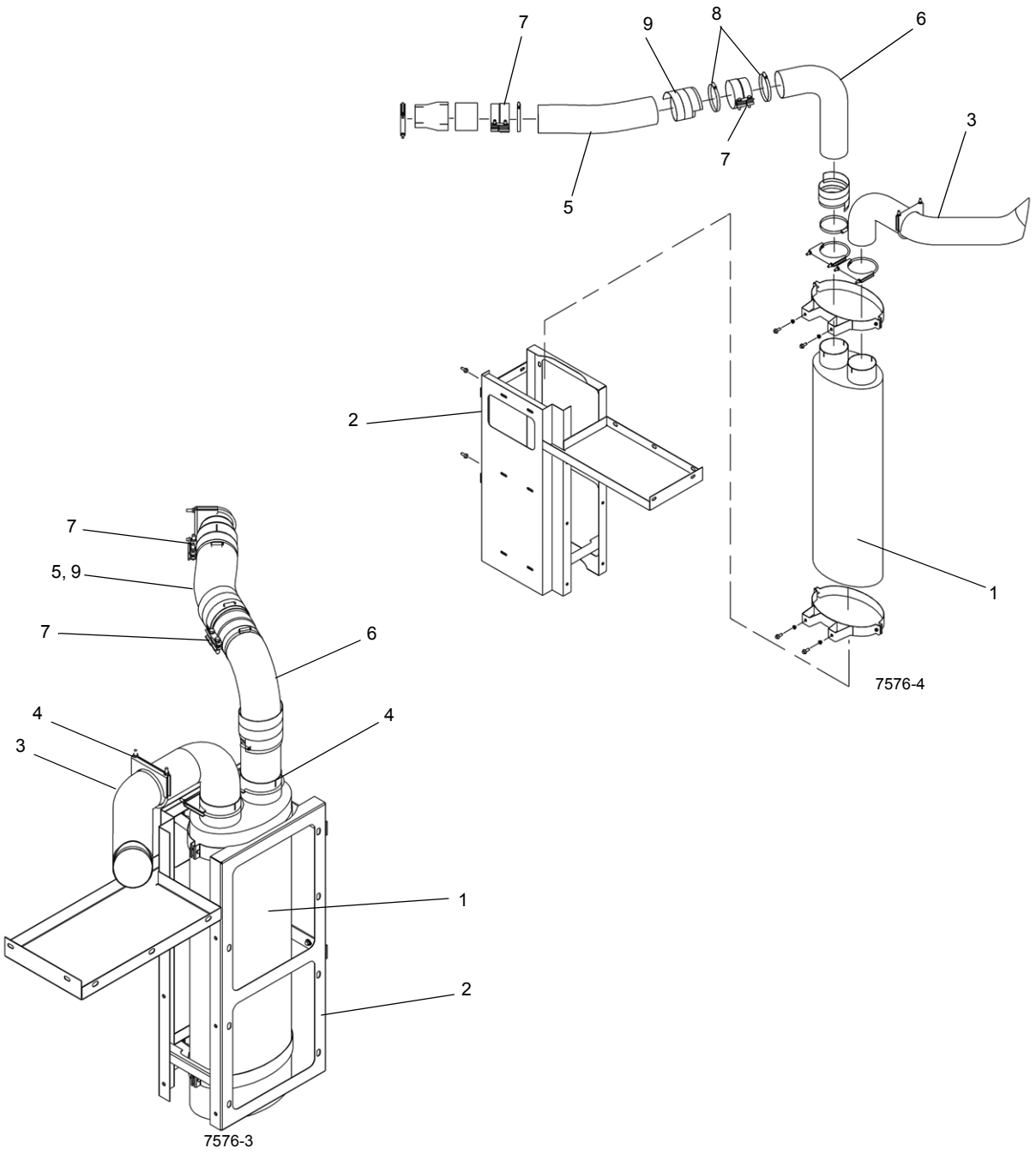
DANGER

Do not touch muffler or exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove muffler clamps to free exhaust tailpipe from muffler and muffler mounting bracket.
2. Remove seal clamp to free muffler from exhaust tube.
3. Remove mounting bands to free muffler from muffler mounting bracket. As needed, remove capscrews and nuts to free muffler mounting bracket from its mountings.
4. Inspect muffler, exhaust tailpipe, exhaust tubes, bracket, and attaching hardware. Repair or replace any of these parts if damaged or missing.

Installation

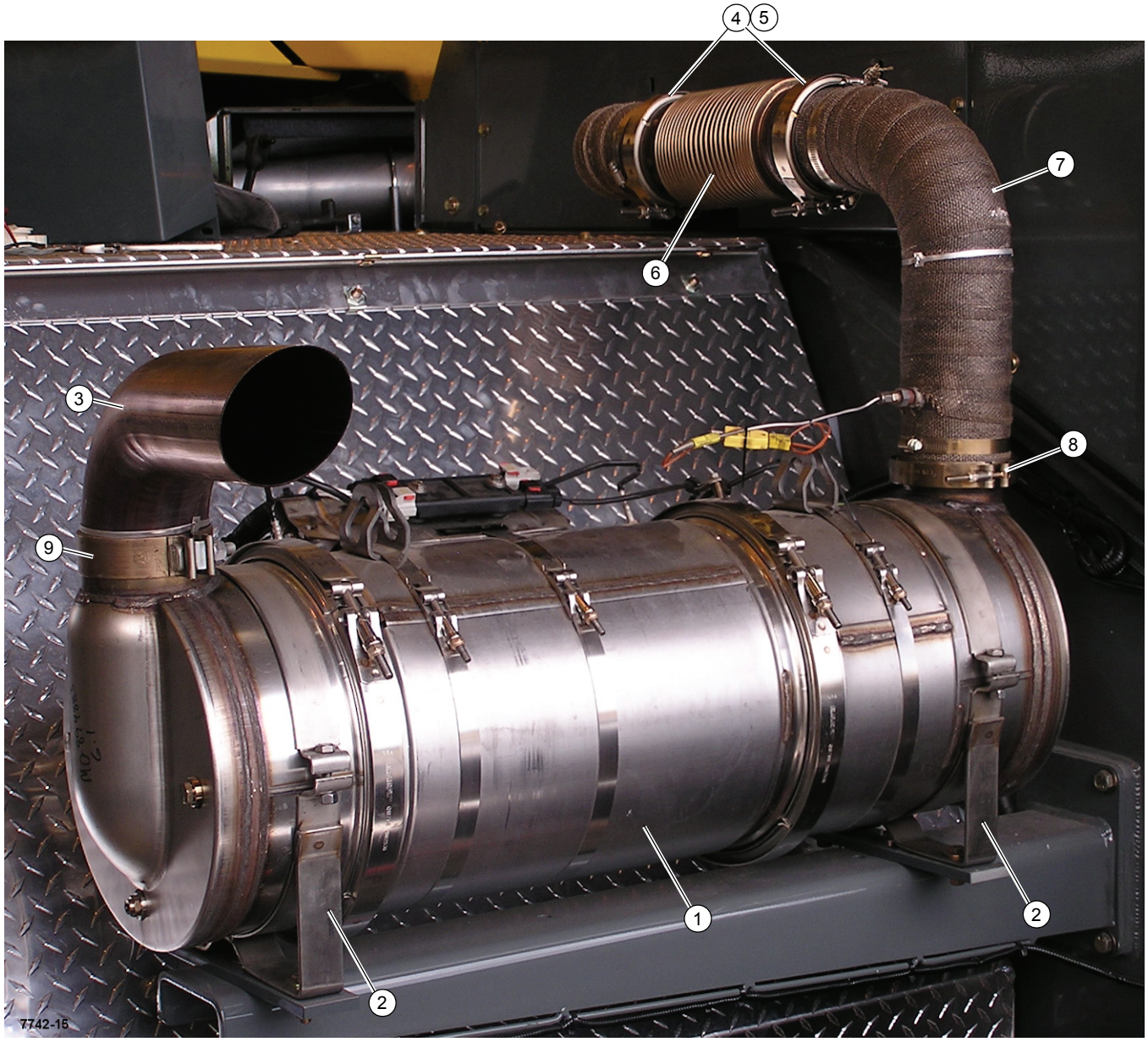
1. Secure the muffler to the exhaust tube with a seal clamp.
2. Install the exhaust tailpipe on the muffler. Secure the exhaust tailpipe to the muffler and muffler mounting bracket with muffler clamps. Adjust the seal clamp as needed.
3. Secure the muffler mounting bracket to its mountings with capscrews and nuts as needed. Secure the muffler to the muffler mounting bracket with mounting bands.



Tier 3 Muffler **FIGURE 7-13**

Item	Description
1	Muffler
2	Bracket
3	Tail Pipe
4	Muffler Clamp

Item	Description
5	Hose Exhaust
6	Reducer Exhaust
7	Seal Clamp
8	Clamp
9	Heat Tape



Tier 4 Diesel Particulate Filter/Muffler

FIGURE 7-14

Item	Description
1	Muffler—Diesel Particulate Filter
2	Bracket w/mounting bands
3	Tail Pipe
4	Clamp

Item	Description
5	Gasket
6	Bellows
7	Tube w/Exhaust Wrap
8	Clamp
9	Clamp

WATER COOLING SYSTEM

Description

The cooling system consists of a radiator, surge tank, engine cooling circuit, charge air cooler circuit, the connecting hoses and connecting tubes. Cooling system capacity is approximately 36 qt (34.1 liters). 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 between the top of the engine and the top of the radiator. At all times, the antifreeze/coolant should be properly inhibited against corrosion. It is recommended that a mixture of 50/50 blended ethylene-glycol, low silicate, fully formulated, extended life engine antifreeze/coolant mixture which does not require a pre-charge of supplemental coolant additives (SCA) be used for fill of heavy duty liquid cooled internal combustion engines.

The crane is equipped with a cab hot water heater. Hot water is supplied by the engine coolant system through a strainer and two port water swivel to the cab heater. The strainer is a cleanable type and is located on the left side of the transmission by the 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:

1. Burned valves.
2. Pinging or knocking.
3. Excessive fuel consumption.
4. Poor lubrication - increased engine wear.
5. Sticking valves.
6. Short injector life.
7. Engine hot spots.
8. Need for higher grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids formed in crankcase.
4. Excessive fuel deposits in the exhaust system.

Rust Prevention

To keep engines operating at like new efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times.

For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times.

Engine Antifreeze/Coolant Fill Procedure

1. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant. Fill to the bottom of the surge tank filler neck. Fill slowly. Flow exceeding 5 gpm (19 l/min) can give a false reading.

NOTE: If the engine coolant is changed, the coolant filters must also be changed.

2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.
3. Run the engine for 5 minutes and recheck the antifreeze/coolant level. Refill as necessary repeating step 1. Refer to *Lubrication, page 9-1*.

Cooling/SCA Maintenance Summary

The cooling system level should be checked every 10 hours of operation or daily, whichever comes first. Refer to *Lubrication, page 9-1*.

Supplemental Coolant Additives (SCA)

Supplemental coolant additives (SCA) are recommended for this cooling system. Antifreeze alone does not provide sufficient protection for heavy-duty diesel engines.

DCA4

DCA4 is the recommended SCA. Other brands can be used if they provide adequate engine protection and do not cause seal or gasket degradation or corrosion/fouling.

SCA Level Check/Coolant Filter Change Interval

6 months or 500 hours

- Check SCA Levels (use only the DCA4 Coolant Test Kit, Grove Service Part Number 9414101675, to check the coolant additive concentration in the cooling system).

  The Coolant Filter contains molybdate. Therefore, it is important to use the Grove Coolant Test Kit, which checks the molybdate level, regardless of whether the SCA used to replenish the coolant system contains molybdate or not.

If SCA levels are less than 1.2 Units/Gal, add Cummins DCA4 to maintain desired level.

NOTE: Inadequate concentration of the coolant additive can result in major corrosive damage to the cooling system components. Overconcentration can cause formation of a “gel” that can cause restriction, plugging of coolant passages, and overheating.

- Change coolant filter.

  Install charged filter if SCA levels are normal or below normal; install non-charged filter if SCA levels are above normal (contact Manitowoc Crane Care for filter part number).

1 year or 1000 hours

- Test coolant for contamination.

Condemning limits are:

- Sulfate level greater than or equal to 1500 ppm.
- Chloride level greater than or equal to 200 ppm.
- The ph level is less than 6.5
- Oil or fuel contamination can be identified by odor or color.

If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Lubrication, page 9-1*.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Cleaning

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 and engine block.

NOTE: Use a cleaning compound that is not corrosive to aluminum to prevent damage to the radiator.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 180°F (82°C) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 180°F (82°C) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*) and repeat the cleaning operation.
8. If problem persists, replace radiator.

Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of

hose to the radiator inlet opening to carry away the flushing stream.

3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill the core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
9. After completing the flushing operation, clean out the surge tank overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
10. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

Component Inspection

Radiator/Surge Tank

1. Side Tanks - Look for leaks, particularly where the tank is 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.

DANGER

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 - All gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

Water Pump

The pump should be checked carefully for leaks and proper lubrication. Replace or rebuild if leaking, cracked, or worn.

Fans and Belts

The fan should be checked for cracked or broken blades.

Refer to *Engine Drive Belts, page 7-6*.

Thermostat

The thermostat is of the nonadjustable type and is incorporated in the cooling system for the purpose of retarding or restricting the circulation of coolant during engine warm up. Engine overheating and loss of coolant is sometimes due to an inoperative thermostat. To check for this condition, remove the thermostat and test by submerging it in hot water and noting the temperature at which the thermostat opens and closes. Use an accurate high temperature thermometer for making this test.

Hoses and Clamps

Hoses and their connections must be checked regularly because they are often the source of hidden trouble. Hoses may often times appear in good condition on the outside while the inside will be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. The clamps should be inspected to make sure they are strong enough to hold a tight connection.

Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. “Floating ball” type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant at all times. Refer to *Lubrication, page 9-1*. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

Radiator Removal and Installation

Removal

1. Set the outriggers and position the boom to over the side.
2. Open the drain cock at the end of drain hose and drain the coolant into a suitable container. 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. Tag and disconnect the hourmeter wiring.
5. Remove the hardware securing the rear engine hood panel to the engine hood. This will gain access to the rear of the radiator.
6. Remove the engine hood assembly.
7. Remove the hose clamps and bellows connecting the charge air cooler to the charge air cooler tubes.
8. Tag and disconnect the hoses from the surge tank to the engine and from the surge tank to the radiator. Remove surge tank assembly.
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 capscrews and flatwashers attaching the fan guard to the shroud ring. Remove the fan guard.
12. Remove the hardware securing the shroud ring to the shroud box and slide the shroud ring back onto the engine fan.
13. Remove the capscrews, flatwashers and lockwashers that connect the plates to the middle of the radiator and the frame rail.

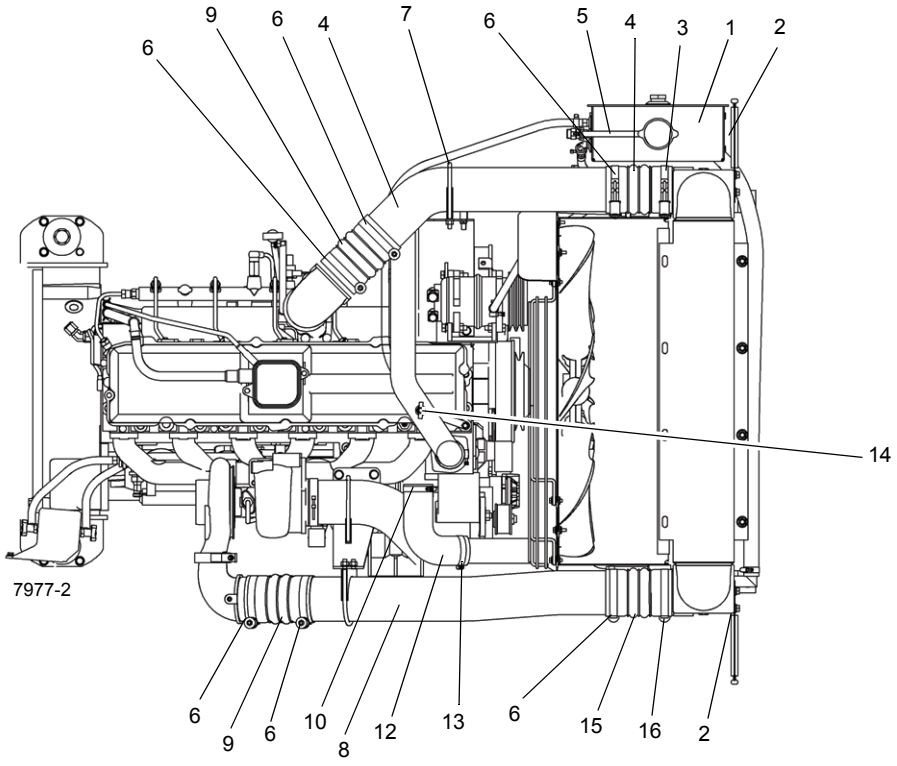
NOTE: The radiator assembly weighs approximately 240 lb (109 kg).

14. Attach an adequate lifting device to the radiator assembly.
15. Remove the capscrews and washers securing the radiator flange to the frame mounting brackets. Remove the radiator assembly from the carrier.
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.

Installation

1. Ensure all fittings and hoses are installed on the radiator.
2. Position the radiator assembly in the carrier using a lifting device. Take caution not to tear or misplace the rubber molding around the radiator assembly. Secure the radiator flange to the frame mounting brackets using capscrews and washers.
3. Reconnect the two plates between the middle of the radiator and the frame rail using capscrews, flatwashers, lockwashers and nuts.
4. Connect the shroud ring to the shroud box using the hardware taken off during removal.
5. Position the fan guard on the shroud ring and secure with bolts and washers.
6. Reconnect the coolant level harness to the engine harness.

Top View of Radiator Assembly



Left Side View of Radiator Assembly

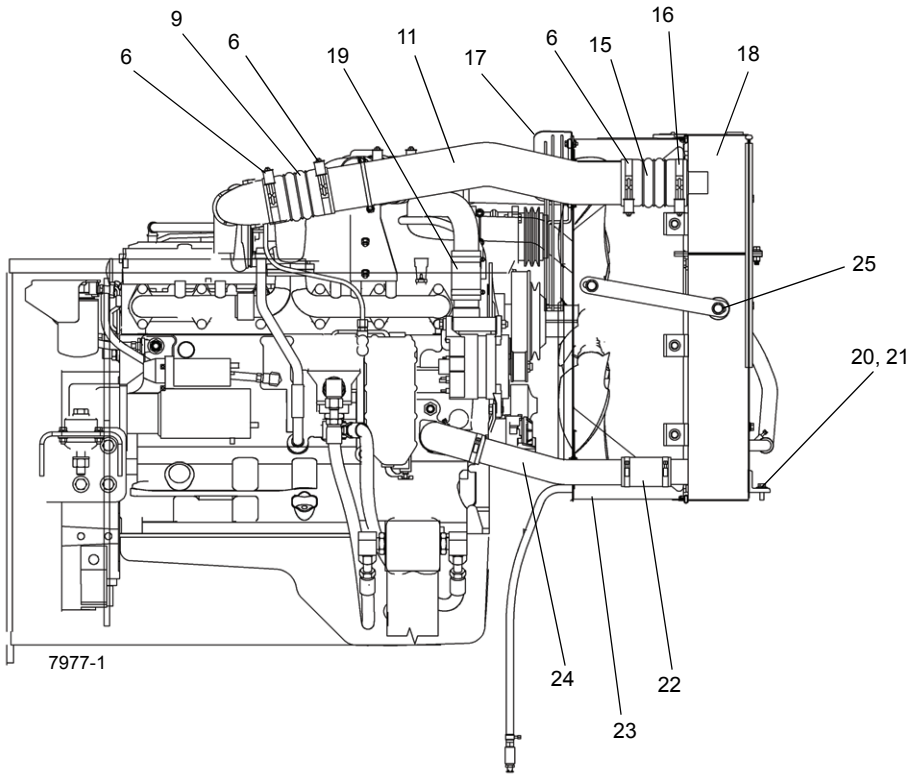


FIGURE 7-15

Item	Description
1	Surge Tank
2	Baffle
3	Clamp
4	Bellows
5	Overflow Hose
6	Clamp
7	Muffler Clamp
8	CAC Tube - Hot
9	Bellows
10	Hose Clamp
11	CAC Tube - Cold
12	Hose
13	Clamp
14	Drain Cock
15	Bellows
16	Clamp
17	Fan Guard
18	Radiator
19	Radiator Hose
20	Flange Screw
21	Flatwasher
22	Radiator Hose
23	Shroud
24	Lower Radiator Hose
25	Plate

7. Connect the two radiator tubes to the radiator with hose clamps and the radiator hose.
8. Secure the radiator return tube to the top of the engine using nuts, washers and a muffler clamp.
9. Reinstall surge tank and connect the hoses between the surge tank and engine and the surge tank and the radiator.
10. Reconnect the charge air cooler tubes to the charge air cooler using hose clamps and bellows.
11. Tighten the drain cock at the bottom of the radiator drain hose.
12. Install the hood assembly.
13. Install the hardware holding the rear engine hood panel to the engine hood.
14. Connect the hourmeter wiring.
15. Install the hood top door assembly.
16. Service the engine coolant system, as necessary. Refer to *Lubrication, page 9-1*. Start the engine, operate all systems and check for leaks.

DRIVE TRAIN

Description

The drive train consists of the torque converter, transmission, and four drive shafts.

The torque converter is mounted on and driven by the engine. The torque converter provides for mounting and driving hydraulic pumps No. 1, No. 2, and No. 3.

The transmission is a Spicer R36000 Series (R36626) powershift with six forward speeds and three reverse speeds. The transmission is controlled electrically by a shift lever located on the right side of the steering column and an axle drive mode selector rocker switch located on the steering column.

The torque converter and transmission oil is cooled by passing the oil through an externally mounted transmission cooler. The cooler is mounted on the right side of the machine in front of the hydraulic reservoir. An oil filter is located on the left side of the frame behind the fuel tank.

Four drive shafts are used. One drive shaft is connected between the torque converter and the transmission. The other three drive shafts are connected between the transmission and the front and rear axles.

Maintenance

Drive Lines

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

Removal

1. Support the drive shaft being removed so it does not fall when disconnected. If removing the coupling shaft or the front slip shaft, support the other shaft also.
2. If removing the coupling shaft, free its bearing from its bracket by removing two bolts, two nuts, and four washers.
3. Remove the bolts from the bearing cap on each end of the drive shaft. Note the lengths of the bolts and if they have lockwashers. Remove the drive shaft.

Installation

1. For any drive shaft which has mating marks (arrows), align these mating marks to ensure proper phasing of coupler yokes.
2. Position the drive shaft between the couplers on the two components it is joining.
3. For the coupling shaft, secure its bearing to its bracket with two bolts, two nuts, and four washers.
4. Secure the drive shaft to the coupler with bolts. For the coupling shaft, torque the bolts connecting it to the front axle installation's differential to 110 to 120 ft-lb (149 to 163 Nm). For the coupling shaft's connection to the front axle slip shaft, and for the other connections of the front axle slip shaft, rear axle slip shaft, and torque converter slip shaft, torque the bolts to 90 to 100 ft-lb(122 to 136 Nm).

Lubrication

The drive line slip joints require lubrication. Refer to Section *Lubrication, page 9-1*.

TORQUE CONVERTER

Description

The torque converter assembly is mounted on and driven by the engine. The torque converter provides for mounting and driving hydraulic pumps No. 1, No. 2, and No. 3.

Theory of Operation

The transmission and torque converter function together and operate through a common hydraulic system. Therefore, it is necessary to consider both units in discussing operation.

With the engine running, the converter charging pump draws oil from the transmission pump through the removable oil suction screen and directs it through the pressure regulating valve and oil filter.

The pressure regulating valve maintains pressure to the transmission control for actuating the direction and speed clutches. This requires a small portion of the total volume of oil used in this system. The remaining volume of oil is directed through the torque converter circuit to the oil cooler and returns to the transmission for positive lubrication. This regulator valve consists of a hardened valve spool operating in a closely fitted bore. The valve spool is spring loaded to hold the valve in a closed position. When a specific pressure is achieved, the valve spool works against the spring until a port is exposed along the side of the bore. This sequence of events provides the proper system pressure.

After entering the converter housing, the oil is directed through the reaction member support to the converter blade cavity and exits in the passage between the turbine shaft and reaction member support. The oil then flows out of the converter to the oil cooler. After leaving the cooler, the oil is directed to a fitting on the transmission. Through a series of tubes and passages, the transmission bearings and clutches are lubricated. The oil then drains to the transmission sump by gravity.

The torque converter consists basically of three elements and their related parts to multiply engine torque. The engine power is transmitted from the engine flywheel to the impeller element through the impeller cover. This element is the pump portion of the hydraulic torque converter and is the primary component which starts the oil flowing to the other components which results in torque multiplication. This element can be compared to a centrifugal pump, in that it picks up fluid at its center and discharges at its outer diameter.

The torque converter turbine is mounted opposite the impeller and is connected to the output shaft of the torque converter. This element receives fluid at its outer diameter and discharges at its center. Fluid directed by the impeller out into the particular design of blading in the turbine and reaction member is the means by which the hydraulic torque converter multiplies torque.

The reaction member of the torque converter is located between and at the center of the inner diameters of the impeller and turbine elements. Its function is to take the fluid which is exhausting from the inner portion of the turbine and change its direction to allow correct entry for recirculation into the impeller element.

The torque converter will multiply engine torque to its designed maximum multiplication ratio when the output shaft is at zero rpm. Therefore, as the output shaft is decreasing in speed, the torque multiplication is increasing.

The shift control valve assembly consists of a valve body with selector valve spools. A detent ball and spring in the selector spool provides one position for each speed range. A detent ball and spring in the direction spool provides three positions, one each for forward, neutral, and reverse.

With the engine running and the directional control lever in the neutral position, oil pressure from the regulating valve is blocked at the control valve, and the transmission is in neutral. Movement of the forward and reverse spool will direct oil, under pressure, to either the forward or reverse direction clutch, as desired. When either directional clutch is selected, the opposite clutch is relieved of pressure and vents back through the direction selector spool. The same procedure is used in the speed selector.

The direction or speed clutch assembly consists of a drum with internal splines and a bore to receive a hydraulically actuated piston. The piston is oil tight by the use of sealing rings. A steel disc with external splines is inserted into the drum and rests against the piston. Next, a friction disc with splines at the inner diameter is inserted. Discs are alternated until the required total is achieved. A heavy back-up plate is then inserted and secured with a snap ring. A hub with OD splines is inserted into the splines of discs with teeth on the inner diameter. The discs and hub are free to increase in speed or rotate in the opposite direction as long as no pressure is present in that specific clutch.

To engage the clutch, the control valve is placed in the desired position. This allows oil under pressure to flow from the control valve, through a tube, to a chosen clutch shaft. This shaft has a drilled passageway for oil under pressure to enter the shaft. Oil pressure sealing rings are located on the clutch shaft. These rings direct oil under pressure to the desired clutch. Pressure of the oil forces the piston and discs against the heavy back-up plate. The discs, with teeth on the outer diameter, clamping against discs with teeth on the inner diameter, enables the hub and clutch shaft to be locked together and allows them to drive as a unit.

There are bleed balls in the clutch piston which allow quick escape for oil when the pressure to the piston is released.

Maintenance

General Information

1. Always check the oil level with the engine idling, and the transmission in neutral and at normal operating temperature—180 to 200°F (82 to 93°C).
2. Change the oil filter element every 500 hours. Drain and refill the system every 1000 hours or 6 months. Refer to *Lubrication, page 9-1*.

Troubleshooting

The following data is presented as an aid to locating the source of difficulty in a malfunctioning unit. It is necessary to consider the torque converter charging pump, transmission, oil cooler, and connecting lines as a complete system when checking for the source of trouble, since the proper operation of any unit therein depends greatly on the condition and operation of the others. By studying the principles of operation together with the data in this section, it may be possible to correct any malfunction which may occur in the system. Troubleshooting procedures basically consist of hydraulic checks.

Hydraulic Checks

Before checking the transmission/torque converter and associated hydraulic system for pressures and rate of oil flow, it is essential that the following preliminary checks be made.

1. Check oil level in transmission. This should be done with oil temperature at 180 to 200 °F (82 to 93 °C). Do not attempt these checks with cold oil.
2. To bring the oil temperature to this level, it is necessary to either work the machine or stall out the converter. When it is impractical to work the machine, stall out the converter as follows.
   a. Apply the parking brake and service brakes.
   b. Position the shift lever to forward and high speed.
   c. Accelerate the engine to between half and three-quarter throttle.

CAUTION

Full throttle stall speeds for an excessive length of time will overheat the torque converter.

   d. Hold converter stalled until desired temperature is reached.

NOTE: Always make all troubleshooting checks with the converter outlet temperature at least 180 to 200 °F (82.3 to 93.3 °C).

Troubleshooting Procedures

Table 7-1

SYMPTOM	PROBABLE CAUSE	REMEDY
1. Low clutch pressure.	a. Low oil level.	a. Fill to proper level. Refer to *Lubrication, page 9-1*.
	b. Clutch pressure regulating valve spool stuck open.	b. Clean valve spool and housing.
	c. Faulty charging pump.	c. Replace pump. Refer to your Manitowoc Crane Care Parts Manual.
	d. Broken or worn clutch shaft or piston sealing rings.	d. Replace clutch shaft or sealing rings, as applicable.
	e. Clutch piston bleed valve stuck open.	e. Clean bleed valves thoroughly.
2. Low converter charging pump pressure.	a. Low oil level.	a. Fill to proper level. Refer to *Lubrication, page 9-1*.
	b. Suction screen plugged.	b. Clean suction screen.
	c. Defective oil pump.	c. Replace pump. Refer to your Manitowoc Crane Care Parts Manual.

SYMPTOM	PROBABLE CAUSE	REMEDY
3. Overheating.	**a.** Worn oil sealing rings.	**a.** Remove, disassemble, and rebuild converter assembly.
	b. Worn oil pump.	**b.** Replace pump. Refer to your Manitowoc Crane Care Parts Manual.
	c. Low oil level.	**a.** Fill to proper level. Refer to *Lubrication, page 9-1*
4. Noisy converter.	**a.** Worn oil pump.	**a.** Replace pump.
	b. Worn or damaged bearings.	**b.** A complete disassembly will be necessary to determine what bearing is faulty.
5. Lack of power.	**a.** Low engine RPM at converter stall.	**a.** Tune engine and check governor.
	b. See “Overheating” and make same checks.	**b.** Make corrections as explained in “Overheating.”

Removal

1. Extend and set the outriggers just enough to take up the slack in the outrigger pads. Chock the wheels.
2. Position the boom over the side and stop the engine.
3. Remove the front section of the engine hood.
4. Refer to *Drive Lines, page 7-26* in this section and disconnect the drive line from the torque converter.
5. Tag and disconnect all hydraulic lines from the torque converter to the transmission and the transmission oil cooler. Cap all lines and openings.
6. Remove the two-section and single section hydraulic pumps from the transmission/torque converter. Cover all openings. Refer to *Hydraulic Pumps, page 2-17* for removal of the pump.

NOTE: The torque converter weighs approximately 500 lb (225 kg) dry.

7. Attach an adequate lifting device to the torque converter and take up any slack.
8. Remove the screws and lockwashers securing the drive plate assembly to the flywheel.
9. Remove the bolts and washers securing the torque converter housing to the engine flywheel housing.

Installation

NOTE: The torque converter assembly weighs approximately 500 lb (225 kg) dry.

1. If a new torque converter is to be installed, remove all fittings and brackets from the original converter and install them in the same locations on the new torque converter.
2. Position the torque converter to the engine with the lifting device.
3. Remove all burrs from the flywheel mounting face and nose pilot bore. Clean the drive plate surface with solvent.

NOTE: Refer to Figure 7-16 for a typical transmission/ torque converter installation.

4. Check the engine flywheel and housing for conformance to standard S.A.E. No. 1-S.A.E. J-927 tolerance specifications for bore size, pilot bore runout and mounting face flatness. Measure and record engine crankshaft end play.
5. Rotate the engine flywheel to align a drive plate mounting screw hole with the flywheel housing front access hole.
6. Install a 4.00 in (101.6 mm) long drive plate locating stud 7/16-20 UNF thread in a drive plate nut.
7. Rotate the torque converter to align the locating stud in the drive plate with the flywheel drive plate mounting screw hole positioned in step 5. Locate the torque converter on the flywheel housing. Install the torque converter to the flywheel housing nuts and washers. Tighten the bolts to 29 to 32 lb-ft (39 to 43 Nm).

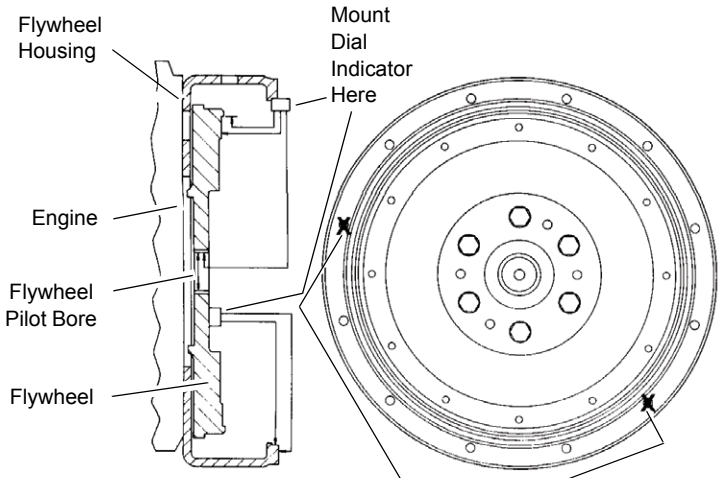


Figure 1

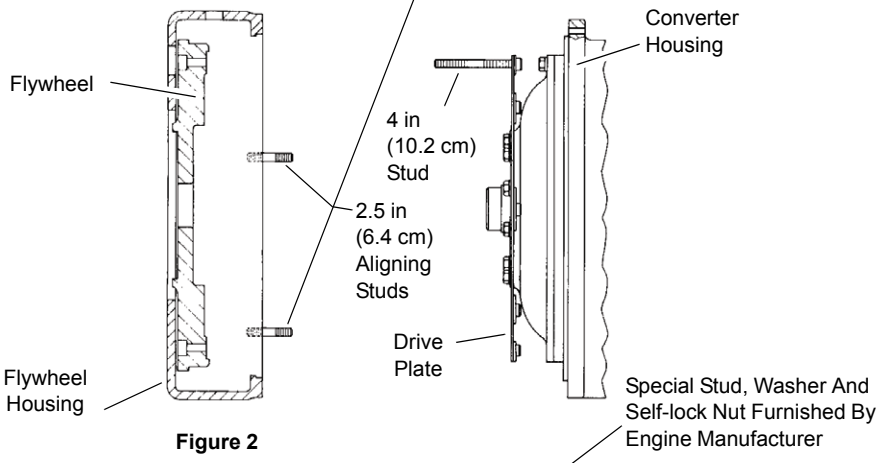


Figure 2

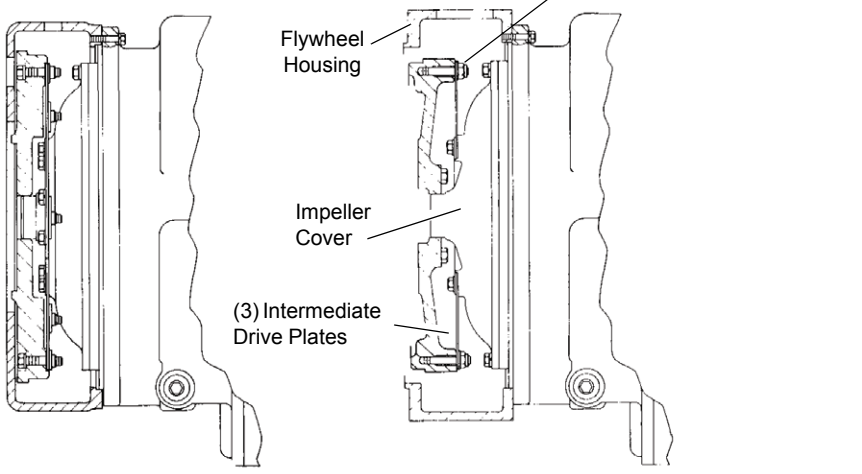


Figure 3

Figure 4

FIGURE 7-16

8. Remove the drive plate locating stud. Install one drive plate attaching bolt. Snug the bolt but ***do not tighten***.

   NOTE: Some engine flywheel housings have a hole located on the flywheel housing circumference in-line with the drive plate bolt access hole. A screwdriver or pry bar used to hold the drive plate against the flywheel will facilitate installation of the drive plate bolts. Rotate the engine flywheel and install the remaining seven flywheel to drive plate attaching bolts and washers. Snug the bolts but ***do not tighten***. After all eight bolts and washers have been installed, torque the bolts to 28 to 30 ft-lb (37 to 41 Nm). This will require torquing each bolt, then rotating the engine flywheel until all eight bolts have been torqued.

9. Measure the engine crankshaft end play after the torque converter has been completely installed on the engine flywheel. This value must be within 0.001 in (0.025 mm) of the end play recorded in step 4.

10. Install the two section hydraulic pumps and the single section hydraulic pump on the torque converter. Refer to *Hydraulic Pumps, page 2-17* for installation of the hydraulic pumps.

11. Install the hydraulic lines to the torque converter.

12. Connect the drive line to the torque converter. Refer to *Drive Lines, page 7-26* for installation of the drive line.

13. Install the front section of the engine hood.

14. Service the crane. Refer to *Servicing The Crane After Transmission/Torque Converter Overhaul* in this section.

15. Cycle all functions and observe for proper operation.

Servicing the Crane after Transmission/Torque Converter Overhaul

The transmission/torque converter and its allied hydraulic system are important links in the drive line between the engine and the wheels. The proper operation of either the unit or the system depends greatly on the condition and operation of the other; therefore, whenever repair or overhaul of the transmission/torque converter is performed, the balance of the system must be considered before the job can be considered completed.

After the overhauled or repaired transmission/torque converter has been installed in the crane, the oil cooler and connecting hydraulic system must be thoroughly cleaned. This can be accomplished in several ways, and a degree of good judgement must be exercised as to the method employed.

The following are considered the minimum steps to be taken:

1. Drain the entire system thoroughly.

2. Disconnect and clean all hydraulic lines. Where feasible, hydraulic lines should be removed from the machine for cleaning.

3. Replace oil filter elements, cleaning out the filter cases thoroughly.

4. The oil cooler must be thoroughly cleaned. The cooler should be back flushed with oil and compressed air until all foreign material has been removed. Flushing in the direction of normal oil flow will not adequately clean the cooler. If necessary, the cooler assembly should be removed for cleaning, using oil, compressed air and a steam cleaner for that purpose.

CAUTION

Do not use flushing compounds for cleaning purposes.

5. Remove the drain plug from the transmission/torque converter and inspect the interior of the unit housing, gears, etc. If the presence of considerable foreign material is noted, it will be necessary for the unit to be removed, disassembled, and cleaned thoroughly. It is realized this entails extra labor, however, such labor is a minor cost compared to the cost of difficulties which can result from the presence of such foreign material in the system.

6. Assemble all components and use only the type oil recommended. Fill the transmission through the fill pipe until fluid is at the top of the fill range on the dipstick. Run the engine for two minutes at idle (950 rpm) to prime the torque converter and hydraulic lines. Recheck the level of oil in the transmission with the engine running at idle (950 rpm). Add oil as necessary to bring the level to the LOW mark on the dipstick. After the oil temperature reaches 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 Fluid (HYDO) or equivalent. Refer to *Lubrication, page 9-1*.

Capacity

System Capacity (includes torque converter, lines, and transmission) - Approximately 34 qt (32 l).

Check Period

8. Check oil level every 10 hours or DAILY with engine running at 1000 RPM and oil at 150 to 200°F (82 to 93°C). Maintain oil level to FULL mark. Refer to *Lubrication, page 9-1*.

Normal Drain Period

NOTE: Normal drain periods and filter change intervals are for average environmental and duty-cycle conditions. Severe or sustained high operating temperatures or very dusty atmospheric conditions will cause accelerated deterioration and contamination. For extreme conditions, judgment must be used to determine the required change intervals.

9. Change oil filter element. Refer to *Lubrication, page 9-1*.

NOTE: It is recommended that filter elements be changed after 50 and 100 hours of operation on new and rebuilt or repaired units, then at normal intervals thereafter.

a. Drain transmission and remove pump screen. Clean screen thoroughly and reinstall it, using a new gasket.

b. Remove and discard both filter elements. Clean filter housing and install new filter elements.

c. Refill transmission to LOW mark.

d. Run engine at 800 RPM to prime converter and lines.

e. Recheck level with engine running at 800 RPM and add oil to bring level to LOW mark. When oil temperature is hot (150 to 200°F (82 to 93°C)), make final oil level check. Bring oil level to full mark.

TRANSMISSION

Description

The transmission is a powershift with six forward and three reverse speeds.

The transmission is controlled electrically by a shift lever located on the right side of the steering column and an axle drive mode selector rocker switch located on the steering column.

Maintenance

Removal

1. Extend and set the outriggers just enough to take up the slack in the outrigger pads. Chock the wheels.
2. Refer to *Drive Lines, page 7-26* and disconnect the three drive lines from the torque converter and axles.
3. Tag and disconnect the electrical leads and connectors from the valve body.
4. Tag and disconnect all hydraulic lines to the transmission. Cap all lines and openings.
5. Remove the bolt attaching the oil fill tube to the frame mount.

NOTE: The transmission weighs approximately 1,303 lb (591 kg) dry.

6. Position a transmission jack or some other means of support that is capable of supporting the weight of the transmission, under the transmission.
7. With the weight of the transmission on the supporting device, remove the capscrews, washers and nuts securing the transmission mounts to the frame mounts.
8. Using the support device, lower and remove the transmission.

Installation

NOTE: The transmission weighs approximately 1,303 lb (591 kg) dry.

1. If a new transmission is to be installed, remove all fittings and brackets from the old transmission and install them in the same locations on the new transmission.
2. Using a transmission jack or suitable device capable of supporting the transmission weight, position the transmission under the frame and raise it into position.
3. Install the capscrews, washers and nuts and secure the transmission mount to the frame mount. Refer to *Fasteners and Torque Values, page 1-17* for recommended torque.
4. Remove the supporting device from under the transmission.
5. Connect all the transmission oil lines to appropriate fittings.
6. Connect all electrical leads and connectors to the valve body.
7. Connect the oil fill tube to the frame mount.
8. Connect the three drive lines to the transmission. Refer to *Drive Lines, page 7-26* for installation of the drive line.
9. Service the crane. Refer to *Servicing The Crane After Transmission/Torque Converter Overhaul* in this section.
10. Cycle all functions and observe for proper operation.

Towing or Pushing

Before towing the crane, disconnect both front and rear drive lines. The engine cannot be started by pushing or towing because of the design of the hydraulic system.

SECTION 8
UNDERCARRIAGE

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AXLES

Description

To provide maximum maneuverability, both the front and rear axles are steerable. The rear axle is mounted on a pivoting cradle (fifth wheel) which allows the axle to oscillate while traversing uneven terrain. The front axle is bolted directly to the frame. All four wheels utilize a hydraulic braking system. Cranes are equipped with disc type brakes. A disc-type parking brake is mounted on the front axle input shaft.

Each axle incorporates a single reduction carrier with hypoid gearing mounted in the axle center. The final reduction is of planetary design spur gearing built into the wheel hubs.

The design of these axles permits the hypoid gearing of the differential carrier and the axle shafts to carry only a nominal torsional load while at the same time providing the highest practical numerical gear reduction at the wheels.

The hypoid pinion and differential assembly of the first reduction are supported by tapered roller bearings. The pinion bearing preload is adjusted and maintained by a hardened precision spacer between the inner and outer bearing. The differential tapered bearing preload is adjusted and maintained by the positioning of the threaded adjusting rings in the carrier leg and cap bores.

In the planetary wheel ends, the spur teeth of the sun gear mesh with teeth of the planet spur gears. The planet spur gears rotate on planet pins which are mounted in a spider. The planet spur gear teeth in turn mesh with teeth of the floating ring gear.

Power is transmitted by the hypoid gear set in the differential carrier to the axle shafts and the sun gear of the final reduction, through the revolving planet gears, and into the planetary spider which drives the wheel hub.

As an option, the front axle and rear axle may be provided with a differential lock. When in the locked mode, the axle shafts and the differential are locked together and there is no differential action between the wheels.

MAINTENANCE

NOTE: The axles do not have to be removed from the crane to remove the planetary wheel ends or the drive units.

Removal

1. Using the outriggers, raise the wheels off the ground.
2. Install blocking under the frame at the outboard ends of the four outrigger boxes.

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

3. Disconnect and remove the drive line from the applicable axle. Do not disassemble the drive lines. Refer to *Drive Lines, page 7-26*.
4. Tag, disconnect, and cap the hydraulic brake line at each wheel.
5. Tag, disconnect, and cap the hydraulic lines to the steer cylinders.
6. On the front axle only, tag and disconnect the hydraulic line from the park brake actuator.
7. On the right side of the rear axle only, tag and disconnect the electrical wires from the rear wheels not centered switch.
8. On machines equipped with cross-axle differential locks remove hoses and wires from the differentials.

NOTE: Each tire and wheel assembly weighs approximately 2400 lb (1089 kg).

9. Remove the wheels from the axle.

NOTE: Each axle weighs approximately 6050 lb (2750 kg) with oil. Refer to *Wheels and Tires, page 8-4*.

10. Position jacks, which are capable of handling the weight of the axle, under the axle for support.
11. Remove the eight nuts, washers, and bolts securing the axle to the frame/cradle.
12. Lower the axle to the ground and remove it to a clean working area.

Cleaning

Completely assembled axles may be steam cleaned on the outside only, to facilitate initial removal and disassembly, providing all openings are closed. Breathers, vented shift units, and all other openings should be tightly covered or closed to prevent the possibility of water entering the assembly.

Installation

1. If a new axle is to be installed, remove the following from the old axle and install them on the new one.
   a. The steer cylinders.
   b. The rear wheels not centered switch actuator bracket (rear axle only).
   c. The parking brake actuator (front axle only). Refer to *Brake System, page 8-12*.
2. Position the axle under the crane on jacks which are capable of handling the weight of the axle.
3. Raise the axle into place and secure with the eight attaching bolts, washers, and nuts. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
4. Install the wheels onto the axle. Refer to *Wheels and Tires, 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 right side of the rear axle only, connect the electrical wires to the rear wheels not centered switch. Refer to *Rear Wheels Not Centered Switch Adjustment Procedure* in this section and adjust the switch.
9. Connect the drive line to the applicable axle. Refer to *Drive Lines, page 7-26*.
10. Reconnect differential lock hoses and wires if applicable.
11. Refer to *Brake System, page 8-12* and bleed the hydraulic brake system.
12. Remove the blocking under the outrigger beams and retract the outriggers to lower the wheels to the ground.

Wheel Alignment Check Procedure

1. Check the axle for wheel alignment. The wheels are to be straight ahead with no toe-in or toe-out. Adjust if necessary by turning the tie rod ends in the direction necessary.
2. Check pre-set axle stop by turning the wheels to the extreme left. Check the clearance between the inside of the tire and the nearest object. If the clearance is less than 25.4 mm (1.0 inch), adjust the axle stop to provide clearance.
3. Turn the wheels to the extreme right and repeat step 2 for the right side.

Rear Wheels Not Centered Switch Adjustment Procedure

1. Ensure the wheels are straight ahead.

NOTE: Refer to (Figure 8-1) for rear wheels not centered switch adjustment.

2. Ensure a maximum gap of 0.19 in (4.8 mm) exists between the sensor switch (1) and the sensor plate (3). Adjust by loosening the jam nut (2) on the switch and rotating the switch. Tighten the jam nut.
3. Turn the rear wheels to verify proper operation. Rear Wheels Not Centered Light in cab should be out when rear wheels are centered.

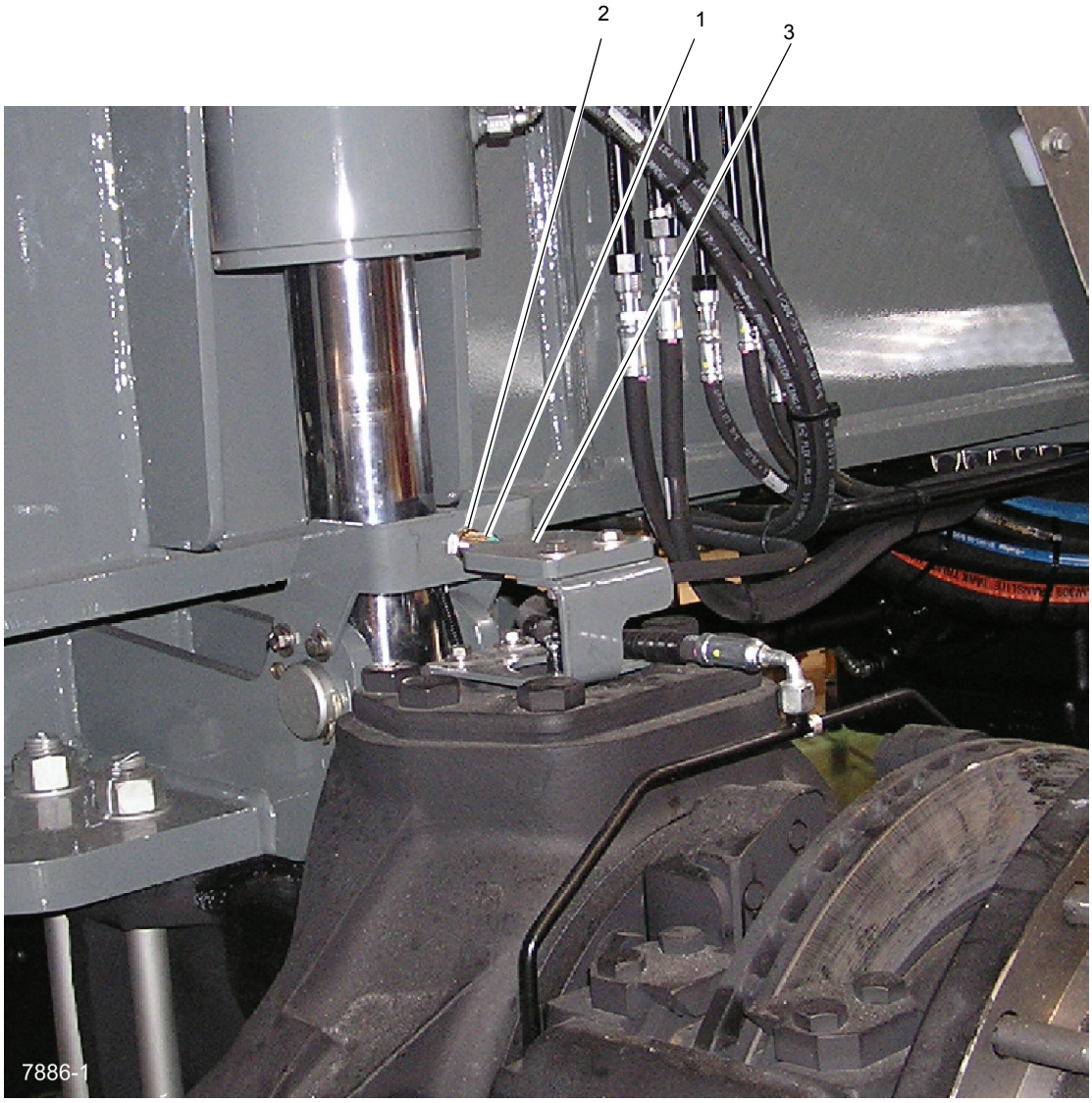


FIGURE 8-1

8

WHEELS AND TIRES

WARNING

Possible equipment damage and/or personal injury!

Driving the crane with a tire under inflated at 80% or less of its recommended pressure can cause the wheel and/or tire to fail. Per OSHA Standard 1910.177(f)(2), when a tire has been driven under inflated at 80% or less of its recommended pressure, it must first be completely deflated, removed from the axle, disassembled, and inspected before re-inflation.

Description

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* in the crane cab.

Maintenance

DANGER

Do not attempt to demount or mount tires without proper training. The high pressures involved can cause tire and rim parts and tools to fly with explosive force, if proper procedures are not used, causing severe injury or death to personnel and damage to the crane and surrounding area.

Mounting Wheel Assemblies

NOTE: Do not lubricate the wheel studs or lug nuts.

1. Raise the crane on outriggers so the wheels are off the ground.
2. Install the wheel assembly on the mounting studs. Install the lug nuts and tighten them to 50 lb-ft (68 Nm) in the sequence shown in (Figure 8-2).
3. Ensure the wheel assembly is properly on the hub.
4. Torque the lug nuts to 380 to 400 lb-ft (515 to 542 Nm) in the sequence shown in (Figure 8-2).
5. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.
6. Road test the tire, then retorque to 380 to 400 lb-ft (515 to 542 Nm). Maintain proper torque on wheel lugs and check for proper wheel mounting. Retorque the lug nuts after about an hour of travel after the wheels are removed and reinstalled. This will reseat the lug nuts. Check the torque every 250 hours for normal crane operation and more frequently if the crane does a lot of roading/travel or frequent on-rubber lifting.

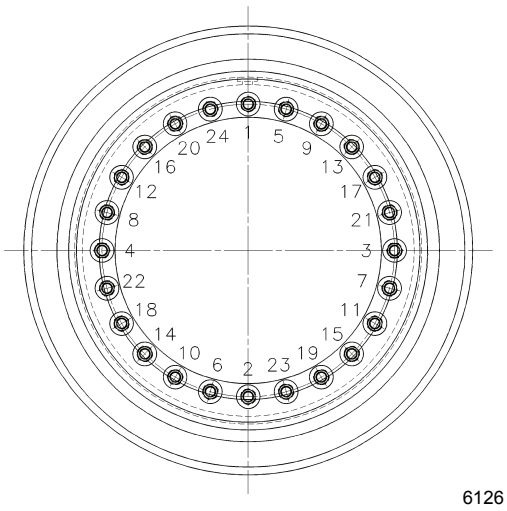


FIGURE 8-2

STEERING SYSTEMS

Description

To maximize maneuverability, the crane can be steered by the front axle, the rear axle, or by the front and rear axles simultaneously. The crane utilizes two separate steering systems, one to control front axle steering and one for rear axle steering.

Front Steering System

The front steering system consists of a hydraulic pump, load sense steer priority flow divider valve, load sense steering control valve, and two steer cylinders. The hydraulic pump is driven by the engine and supplies a hydraulic flow of 33.0 gpm (125 l/min) to the load sense steering priority flow divider. The load sense steer priority flow divider valve provides 0 to 18.5 gpm (0 to 70 l/min) to the front steering control valve and 14.5 to 33.0 gpm (55 to 125 l/min) to the swing system. When the steering wheel is turned, the load sense steering control valve sends a load sense signal to the load sense steer priority flow divider. As the load sense pressure increases, the priority flow divider spool shifts to direct oil from the hydraulic pump to the steering control valve, and to direct oil from the L port and R port of the steering control valve to the steer cylinders.

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 in the ECOS display and a switch located on the right side of the rear axle. When the rear wheels are turned to the left or right, the red indicator will illuminate.

Theory of Operation

Front Steering System

Hydraulic fluid flow from pump number 2 flows through port 3 of the hydraulic swivel to the steer/brake accessory manifold. Regulated flow from the steer priority flow divider valve is routed to the front steering control valve upon turning of the steering wheel and pressurizing of the load sense line. The front steering control valve routes the oil to the appropriate ends of the front steer cylinders to turn the wheels in the desired direction.

Rear Steering System

Hydraulic flow from the second section of pump number 2 is directed to the integrated outrigger/rear steer valve. When the Rear Steer Control Switch in the cab is positioned to left (L) or right (R), a signal is sent to the rear steer solenoid, shifting the control valve spool, routing the supply pressure to the appropriate ends of the rear steer cylinders to turn the wheels in the desired direction.

Maintenance

Front Steering System

Table 8-1
Troubleshooting

Symptom	Probable Cause	Solution
1. Hard to steer left and right.	**a.** Hydraulic fluid low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective flow divider valve(s).	**c.** Repair or replace valve(s).
	d. Defective steering control valve.	**d.** Repair or replace valve. Refer to your Manitowoc Crane Care Parts Manual.
	e. Defective hydraulic pump.	**e.** Repair or replace pump.
2. Hard to steer either left or right.	**a.** Clogged or loose hydraulic lines or fittings.	**a.** Clean or tighten lines or fittings.
	b. Defective steer cylinder.	**b.** Repair or replace cylinder.

Symptom	Probable Cause	Solution
3. Steering is erratic left and right.	**a.** Hydraulic fluid low.	**a.** Refill hydraulic reservoir. Refer to *Lubrication, page 9-1*.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.
4. Noisy hydraulic pump caused by cavitation.	**a.** Hydraulic fluid low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Suction line plugged or too small.	**b.** Clean line and check for size.
5. Hydraulic pump shaft seal leakage.	**a.** Worn shaft seal. **NOTE:** If replacing the shaft seal does not stop leakage, the pump should be disassembled and checked for the following:	**a.** Replace shaft seal. Refer to your Manitowoc Crane Care Parts Manual.
	b. Broken diaphragm seal or backup gasket.	**b.** Replace seal or gasket.
	c. Bearing out of position.	**c.** Replace bearing.
	d. Excessive internal wear.	**d.** Replace pump.

Functional Check

A periodic functional check of the power 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. Turn the steering wheel through the full range with the engine running at both idle and full throttle. Do this with the machine stationary and moving. 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 dirt 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 control valve bank pressure gauge test port. With the engine running at a medium speed, turn the steering wheel to one end of the travel and hold the cylinders at the travel limit briefly, just long enough to read the pressure gauge. Never hold the system at relief pressure for more than a few seconds at a time. The pressure gauge should indicate 2500 psi (17.2 MPa).

Rear Steering System

Table 8-2
Troubleshooting

Symptom	Probable Cause	Solution
1. Rear steering inoperative.	**a.** Hydraulic fluid low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged, broken, or loose hydraulic lines or fittings.	**b.** Clean, tighten, or replace lines or fittings.
	c. Steer cylinder locked.	**c.** Repair or replace cylinders. Refer to your Manitowoc Crane Care Parts Manual.
	d. Defective control valve.	**d.** Repair or replace valve.
	e. Defective steer cylinder(s).	**e.** Repair or replace cylinder(s).
	f. Lack of electrical signal	**f.** Check electrical connections/ wiring.
2. Hard to steer left and right.	**a.** Hydraulic fluid low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.
	e. Clogged or loose hydraulic lines or fittings.	**e.** Clean or tighten lines or fittings.
	f. Defective steer cylinder.	**f.** Repair or replace cylinder.
	g. Damaged relief.	**g.** Replace relief valve.
3. Steering is erratic left and right.	**a.** Hydraulic fluid low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.

Hydraulic Pump

Pump #2

Pump #2 provides the hydraulic flow necessary to power the front and rear steer cylinders, the outrigger circuit, the front and rear pairs of outrigger box pin cylinders, and the rear axle oscillation lockout system. The pump is a piston type pump, it provides a flow of approximately 46.7 gpm (177 l/min).

Front Steering Control Valve

Description

The steering control valve is located under the dash and is actuated by a conventional steering wheel and steering column, providing precise, full hydraulic steering. Precise steering is accomplished by a metering system within the valve that is directly connected to the steering column and wheel.

Maintenance

Removal

1. Thoroughly clean the steering control valve and the surrounding area before removing the hydraulic hoses from the valve.
2. Tag and disconnect the five hydraulic hoses from the steering control valve. Cap or plug each hose and the five ports of the valve.
3. Remove the capscrews, lockwashers, and flat washers securing the valve to the bracket and the steering column. Remove the control valve, leaving the steering column in the cab.

Installation

1. Position the control valve to the bracket and steering column and install the flat washers, lockwashers, and capscrews. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
2. Connect the five hydraulic hoses to the control valve as tagged during removal.
3. Start the engine and check for proper operation and any leakage.

Integrated Outrigger/Rear Steer Control Valve

Description

The integrated outrigger/rear steer valve directionally controls the outrigger circuit, outrigger pin circuit, and the rear steer circuit. The valve is mounted on the rear of the carrier frame front cross member.

The inlet section of the valve contains two solenoid valves and two relief valves. The solenoid valve is normally open, bypassing oil to the reservoir. Operation of either system energizes the solenoid valve to close it and route oil to the applicable circuit.

The valve also contains four three position four-way solenoid valves that control the following:

- The rear steer solenoid valve is controlled by the Rear Steer Switch in the operator's cab through port RSA and RSB of the valve.
- The removal pin solenoid valve for the front outrigger box is controlled by the Pin Unlock Switch in the outrigger control box in front of the left front fender through ports A1 and B1 of the valve.
- The removal pin solenoid for the rear outrigger box is controlled by the Pin Unlock Switch in the outrigger control box behind the right rear fender through ports A2 and B2 of the valve.
- The outrigger section solenoid valve is controlled by the Extend/Retract Switch on the ECOS display through ports A and B of the valve.

The valve also contains double pilot operated check valves in the rear steer and outrigger lines.

Maintenance

Removal

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

Installation

1. Position the integrated outrigger/rear steer valve on the frame. Secure the valve with the capscrews, nuts and washers. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
2. Connect the hydraulic lines to the integrated outrigger/rear steer valve as tagged during removal.
3. Connect the electrical connectors to the integrated outrigger/rear steer valve as tagged during removal.

Functional Check

1. Cycle each outrigger cylinder several times. Verify each cylinder extends and retracts properly.
2. Activate the rear steer function and steer to the left and right several times. Verify the crane steers properly in both directions.
3. Check the valve and lines for leakage. Make repairs as needed.

NOTE: For further information on the integrated outrigger/ rear steer valve, refer to *Outrigger/Rear Steer/ Outrigger Box Pin Removal Valve, page 2-37*.

Steer Cylinders

Description

The steer cylinders are mounted on the axles, two cylinders on each axle. The barrel end of each cylinder is attached to the axle housing and the rod end is attached to the steering lug on the axle end. The front steer cylinders are controlled hydraulically by the front steer control valve through the steer directional valve. The rear steer cylinders are controlled by a solenoid valve located in the integrated outrigger /rear steer valve.

Maintenance

NOTE: For Disassembly and Assembly procedures, refer to *Cylinders, page 2-62*.

Removal

1. Tag and disconnect the hydraulic lines going into the steer cylinder. Cap or plug all openings.
2. Remove the capscrew, flatwasher, and lockwashers securing each pin weld in the rod end and barrel end of the cylinder.

NOTE: Steer cylinder weighs approximately 44 lb (20 kg).

3. Remove both pin weldments and two thrust washers (rod end only), and remove the cylinder from the axle.

Installation

1. Position the cylinder onto the attachment fittings on the axle and install both pin weldments. On the rod end, install a thrust washer on the top and bottom of lug.
2. Secure each pin weldment with the capscrew, flatwasher and lockwasher. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
3. Connect the hydraulic lines to the cylinder as tagged during removal.
4. Operate the steering system and check the cylinder for proper operation and any leakage.

Rear Axle Oscillation Lockout System

Description

The rear axle oscillation system (Figure 8-3) consists of two lockout cylinders, a lockout valve, an axle oscillation relay, and an area definition potentiometer. The lockout cylinders are mounted between a cradle (fifth wheel) and the carrier frame. The lockout valve is mounted on the left inner center frame rail and hydraulically controls the oscillating abilities of the lockout cylinders.

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 fluid flows from the rod end of cylinder A to the barrel end of cylinder B and from the rod end of cylinder B to the barrel end of cylinder A (Figure 8-4). The system is not pressurized and oil is moved from one cylinder to the other by the action of the axle moving the cylinder.

When the superstructure is more than 6 degrees left or right of directly over the front, the area definition potentiometer de-energizes the axle oscillation relay. This de-energizes the solenoids on the lockout valve and allows the springs in the valve to shift the valve spools to the closed position to prevent hydraulic fluid flow between the cylinders. By stopping the flow of oil, a hydraulic lock is created and the axle is held rigid in that position.

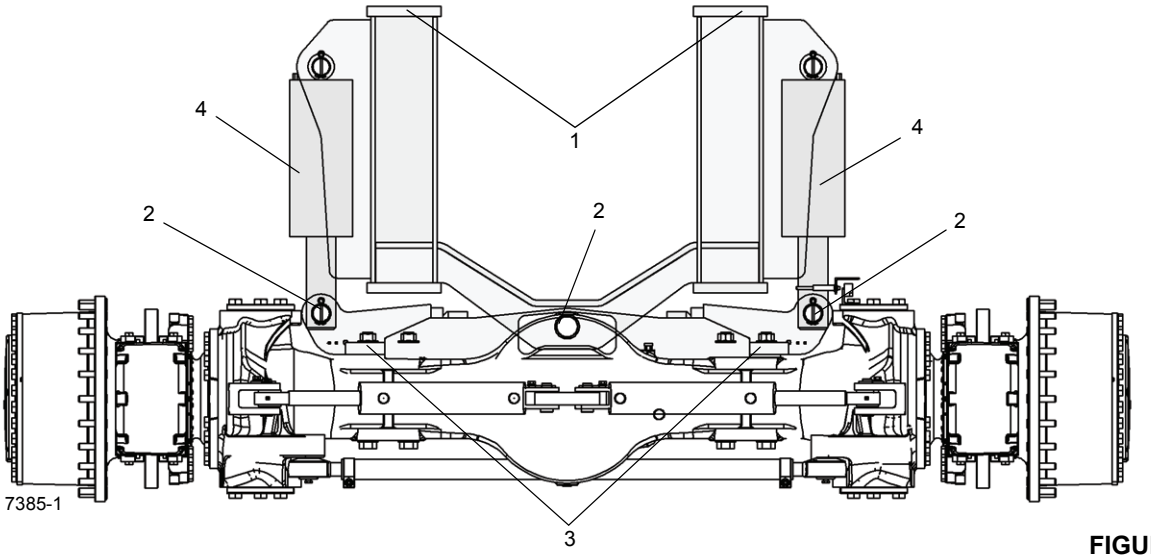


FIGURE 8-3

Item	Description
1	Carrier Frame
2	Pivot Point

Item	Description
3	Fifth Wheel
4	Oscillation Lockout Cylinder

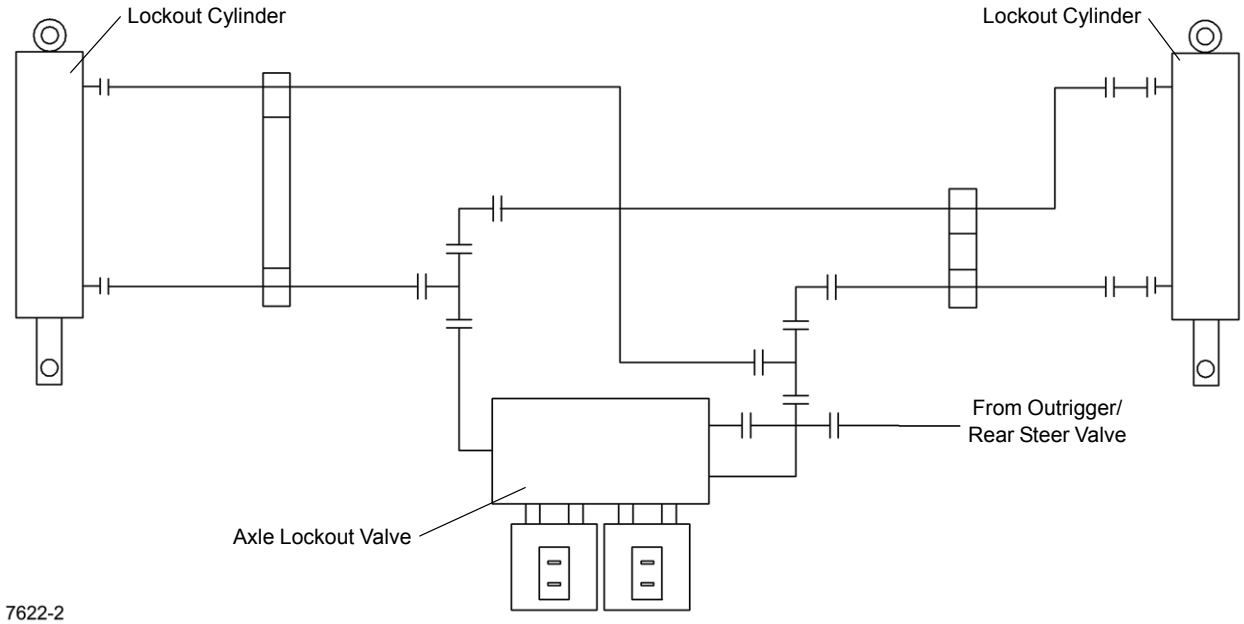


FIGURE 8-4

Axle Oscillation Lockout Cylinders

Description

Two 7.0 in (17.8 cm) hydraulic lockout cylinders are installed on the rear axle, one left side and one right side. The barrel end of each cylinder is attached to each side of the carrier frame and the rod ends are attached to each side of the cradle (fifth wheel).

The lockout cylinders are connected hydraulically so that hydraulic fluid flows from the rod side of the left cylinder to the barrel side of the right cylinder and from the rod side of the right cylinder to the barrel side of the left cylinder.

Each cylinder weighs approximately 192 lb (87 kg).

Maintenance

NOTE: For disassembly and assembly procedures, refer to *Axle Oscillation Lockout Cylinder, page 2-64*.

Removal

1. Raise the crane up on outriggers.
2. Rotate the turntable more than 6 degrees in either direction from directly over the front to lock out the oscillation cylinders.
3. Remove the wheel and tire assembly from the axle. Refer to *Wheels and Tires, page 8-4*.
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 install the retaining pin.
2. Secure the retaining pin with the cotter pin.
3. Align the rod end of the cylinder in the cradle attach fitting and install the retaining pin.
4. Secure the retaining pin with the cotter pin.
5. Remove the caps or plugs from the two hydraulic hoses and the cylinder ports and connect the hoses to the appropriate cylinder ports as tagged during removal.
6. Install the wheel and tire assembly on the axle. Tighten the lug nuts using the procedure under *Wheels and Tires, page 8-4*.
7. Lubricate both ends of the cylinder using the fittings provided.
8. Function test the axle oscillation system. Refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.

Axle Oscillation Lockout Valve

Description

The axle oscillation lockout valve, also called the double solenoid valve, is used in the rear axle oscillation lockout circuit. The valve consists of a valve body and two solenoid valves, which keep the lockout cylinders from oscillating unless the superstructure is within 6 degrees left or right of directly over the front. The lockout valve is located on the left side of the frame in front of the front rear axle cross member.

When the superstructure is within 6 degrees left or right of directly over the front, the area definition potentiometer energizes the axle oscillation relay which energizes the solenoids on the axle oscillation lockout valve. This allows hydraulic fluid 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 fluid cannot leave the cylinders.

Maintenance

Removal

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

Installation

1. Secure the valve to the carrier frame using two capscrews, washers and nuts. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-17*.
2. Connect the hydraulic hoses to the applicable valve ports as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.

4. Function test the axle oscillation system. Refer to *Section 3, Operating Controls and Procedures* in the *Operator's Manual*.
5. Check the valve and hoses for signs of leakage. Tighten fittings as required.

BRAKE SYSTEM

Description

The brake system includes all the components necessary for the application of the service brakes and the parking brake.

Service Brakes

The service brakes are full power hydraulic disc brakes which are hydraulically controlled and are used to apply the brake assemblies on all four wheels. The system consists of the tandem brake valve with treadle pedal, the dual accumulator charge valve, two hydraulic accumulators, the brake assemblies, and all the associated hoses and tubing.

The operator depresses the pedal on the tandem brake valve, located on the cab floor, and the valve modulates the brake line pressure to the brake assemblies at each wheel. The full powered brake system supplies a high brake system pressure with relatively low reactive pedal forces, while controlling the maximum brake line pressure. The service brake dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve.

NOTE: For Description and Maintenance of the tandem brake valve with treadle pedal, the accumulators, and the dual accumulator charge valve, refer to *Valves, page 2-34*.

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, two brake assemblies, and all the associated hardware and tubing. The selector switch, located on the steering column, is used to activate the solenoid valve which controls the park brake actuator, which applies and releases the park brake. There are two brake actuators on the front axle.

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 fluid from hydraulic pump number 2 flows to swivel port 3 to the dual accumulator charge valve. The dual accumulator charge valve charges the accumulators from the open center circuit upon demand and within its present operating charge rate and the high limit pressure setting. When the open center circuit pressure reaches the brake relief setting, which is higher than the high accumulator charge limit, the accumulators will be charged to the regulated maximum pressure setting. The dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve. The charged accumulators supply pressurized fluid to the closed tandem brake valve.

After the accumulators are fully charged, the high limit check opens and all of the pump flow is directed to the excess flow port and on to the front steer and swing circuits. When pressure to the steering or swing circuit becomes greater than accumulator pressure, the main check valve opens and charges the accumulator without the aid of the charging valve. In this condition, the maximum accumulator pressure is the brake circuit relief valve setting of 2320 psi (15,996 kPa).

Once the operator depresses the brake pedal, the tandem brake valve modulates fluid out to the brakes to provide the means of braking. The tandem brake valve will modulate the pressure in the brake system by increasing or decreasing pressure as required in proportion to the input force from the operator via the brake pedal. The hydraulic force acts within the brake assemblies to force the brake pads against the brake discs, acting to slow wheel rotation. Fully powered separate primary (front) and secondary (rear) braking circuits are provided with independent accumulators. A low pressure warning switch is used to sense the accumulator pressures and warn the operator through visual brake warning indicator light on the cab console in the event the pressure in the accumulators drops to an unsafe operating level. In the event of engine failure, the accumulators are pre-charged with dry nitrogen gas and properly sized to provide power-off stopping capacity for secondary braking.

Parking Brake

Hydraulic flow from the transmission charge pump is routed to the parking brake control valve. When the Park Brake Switch is in the ON position, the parking brake solenoid valve shifts to route flow from the hydraulic parking brake actuator back to the transmission sump. The actuator spring pulls on the lever on the brake assembly, applying the parking brake.

Maintenance

Troubleshooting

Table 8-3

Symptom	Probable Cause	Solution
1. Brakes are poor.	**a.** Lining thickness less than 0.125 in (3 mm).	**a.** Replace lining.
	b. Brake pedal operation.	**b.** Free mechanical linkage.
	c. Restriction or leaks in lines.	**c.** Check all lines for leaks and restrictions.
	d. Low hydraulic fluid flow.	**d.** Check the hydraulic fluid level in reservoir and check flow from the tandem brake valve.
	e. Air in brake lines.	**e.** Bleed the brakes.
	f. Brake pads/linings are grease-soaked.	**f.** Replace pads/linings.
	g. Engine not running.	**g.** Start engine. Due to the operation, the engine must be running to provide full brake power.
	h. Brake relief valve stuck open.	**h.** Replace the relief valve. Refer to your Manitowoc Crane Care Parts Manual.
	i. Dual accumulator charge valve not charging	**i.** Check valve operation and repair or replace valve.
	j. Accumulators not pre-charged.	**j.** Check accumulator pre-charge.
2. Hard brake pedal with engine running.	**a.** Pedal travel being interfered with.	**a.** Check all pedal linkage and ensure it is free and adjusted properly.
3. Brakes lock up.	**a.** Too much hydraulic flow.	**a.** Check the flow from the flow divider. Too much flow will cause the brakes to be applied by the oil trapped in the power boost chamber.
	b. Brake pedal push rod improperly adjusted, causing brakes to be always applied.	**b.** Adjust the push rod linkage so the brake pedal and push rod fully return.
4. Uneven braking or pad wear.	**a.** Lining thickness less than 0.125 in (3 mm).	**a.** Replace the lining.
	b. Grease on the pads/linings.	**b.** Replace the pads/linings.

General

A schedule for the periodic adjustment, cleaning, inspection, and lubrication of brake equipment should be established by the operator on the basis of past experience and severity of operation.

The disc brakes are not adjustable. Brakes should be cleaned, inspected, and linkage lubricated periodically to assure maximum performance.

Bleeding the Brake System

The brake system should be bled whenever air becomes entrapped within the brake system (usually characterized by

a spongy feeling during brake pedal application), whenever any brake system line has been opened, or whenever any brake component has been replaced.

Always start at the point in the system that is furthest from the tandem brake valve and work back toward the tandem brake valve. Bleed every bleeder screw on every caliper/actuator on every wheel. When you complete a bleeder screw, go to the next closest bleeder screw on the same caliper/actuator. When you complete a wheel, go to the furthest bleeder screw on the next closest wheel.

Service Brakes

Description

The brakes utilized are hydraulic disc-type brakes. Two brake assemblies are used at the end of each axle. The action of the brake pads riding against the brake discs acts to slow the rotation of the wheels.

Maintenance

NOTE: To perform maintenance on the brake caliper, remove the tire and wheel assembly. Refer to *Axles, page 8-1*.

Removal

Linings

1. Remove the bolts securing the end plates to one side of the caliper housing. Remove the end plates.
2. Loosen the bleeder screws to release hydraulic pressure in the caliper (Figure 8-5).

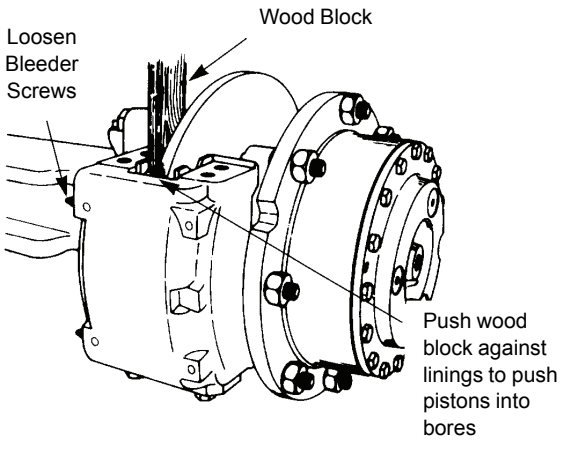


FIGURE 8-5

3. Use a piece of wood against the linings as a pry bar to push the pistons completely into the housing. Tighten the bleeder screws.
4. Remove the linings from the caliper housing. If necessary, discard the linings.

Caliper

NOTE: To lighten caliper weight, remove the brake linings from the caliper before removing the caliper from the vehicle.

1. Disconnect the hydraulic brake line from the inlet fitting on the caliper. Cap or plug all openings.
2. Remove the linings as described previously.
3. Remove the bolts securing the caliper housing to the mounting bracket. Remove the caliper housing from the mounting bracket. If shims are used mark the position of the shims.

Disassembly

Caliper

1. Remove the inlet fitting and o-ring from the cylinder cap.
2. Drain and discard the hydraulic fluid.
3. Clean the outside of the housing with isopropyl alcohol. Dry the housing with a clean cloth.
4. If installed, remove the bolts that secure the end plates to the housing. Remove the end plates and linings.
5. Remove the pistons from the side of the housing opposite the mounting plate according to the following procedure.
   a. Use a C-clamp to hold a 0.5 in (12.7 mm) block of wood against three pistons on the mounting side of the housing. Ensure the C-clamp is not in the area in front of the piston bore (Figure 8-6).

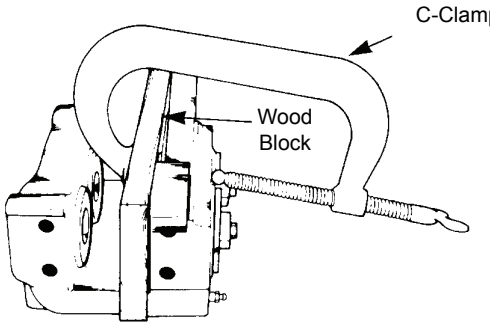


FIGURE 8-6

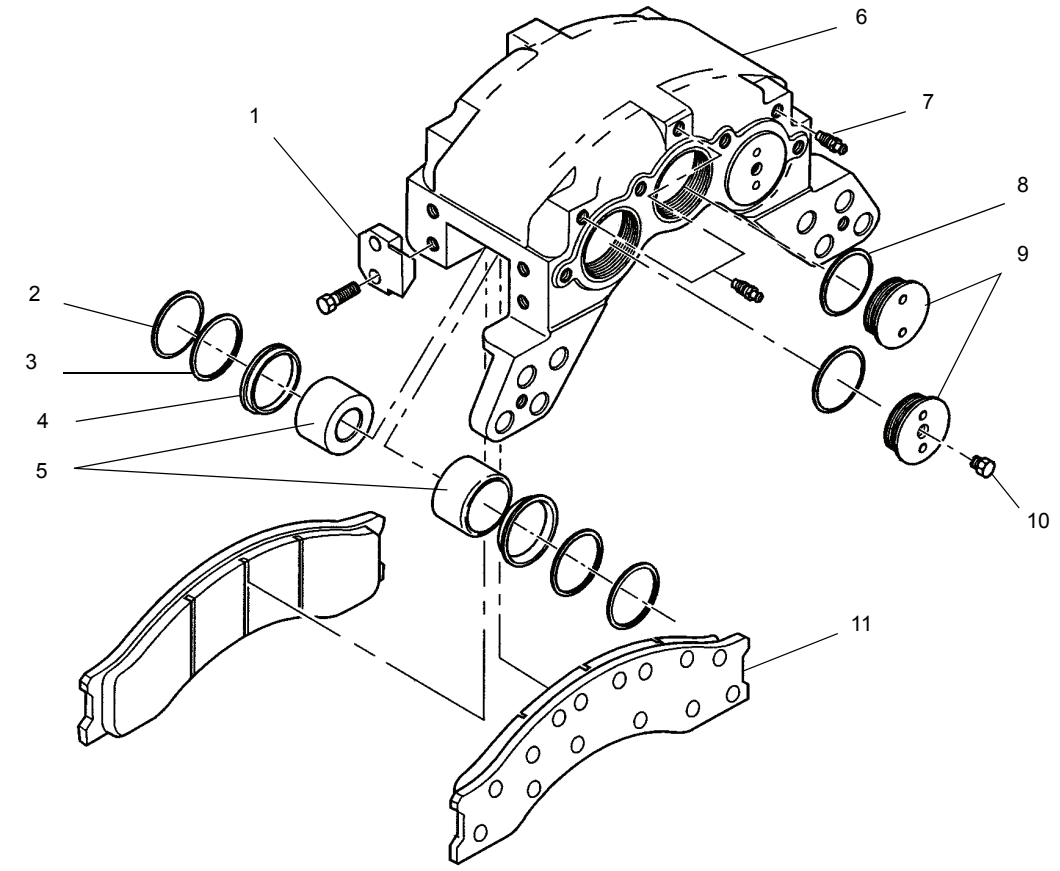


FIGURE 8-7

Item	Description
1	End Plate
2	O-ring
3	Backup Ring
4	Dust Seal
5	Pistons
6	Housing
7	Bleeder Screw
8	O-ring
9	Cylinder Caps
10	Cap
11	Lining Assembly

WARNING

Do not place hand in front of pistons when forcing them out. Serious personal injury may occur.

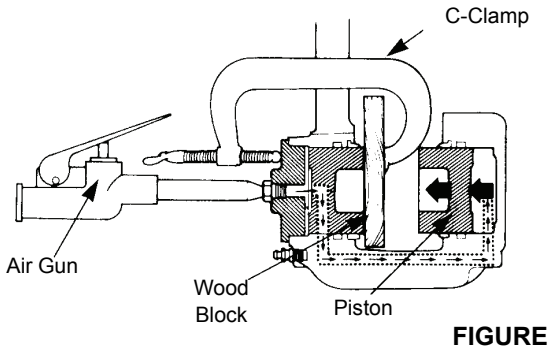


FIGURE 8-8

b. Apply compressed air to the inlet fitting to force the pistons out of the other housing. If one piston comes out before the other piston, put a piece of wood in front of the piston that comes out first. Apply compressed air to force the other piston out of the housing (Figure 8-8).

c. Remove the wood block and the C-clamp from the housing.

d. Remove the pistons (Figure 8-7) from the bores that are opposite from the mounting plate.

8

6. Remove the cylinder caps from the housing. Remove and discard the O-rings (Figure 8-9).

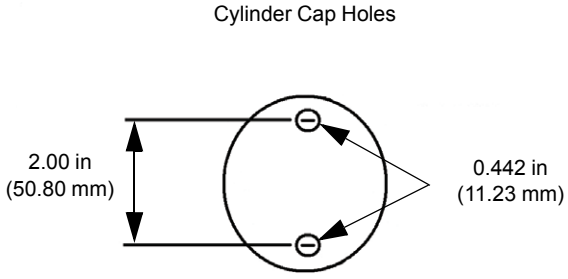


FIGURE 8-9

7. Remove the pistons from the mounting plate side of the housing. Push on the cap ends of the pistons to force them out of the disc side of the housing.

8. Remove the dust seals from the housing.

9. Remove and discard the O-ring and the backup rings (Figure 8-10).

NOTE: Use a soft tool to prevent scratching the housing and grooves.

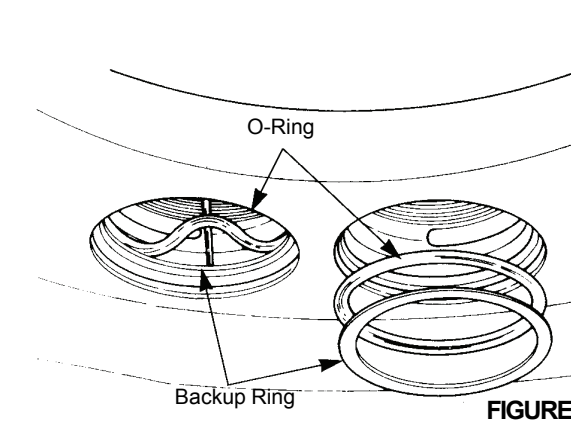


FIGURE 8-10

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 *Caliper Parts, page 8-17*.

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 8-17*.

Inspection

Periodic On-Vehicle

Inspect the caliper, linings, and disc for any damage.

Linings, and End Plates

Remove the linings. To help prevent abnormal lining wear, replace worn, bent, or cracked end plates and distorted backing plates. Inspect end plate bolts for wear. Replace the bolts if worn. Inspect the linings for:

- Lining Wear. Replace the linings when the thickness of the lining is less than 0.125 in (3.2 mm) from the back plate (Figure 8-11).
  - Lining Wear Not Even. Replace the linings if the thickness of the two linings is significantly different. Check the pistons for correct operation. Replace the piston and/or housing if a piston is cocked in the bore. Check that the disc surface is flat and parallel to the linings (Figure 8-11).

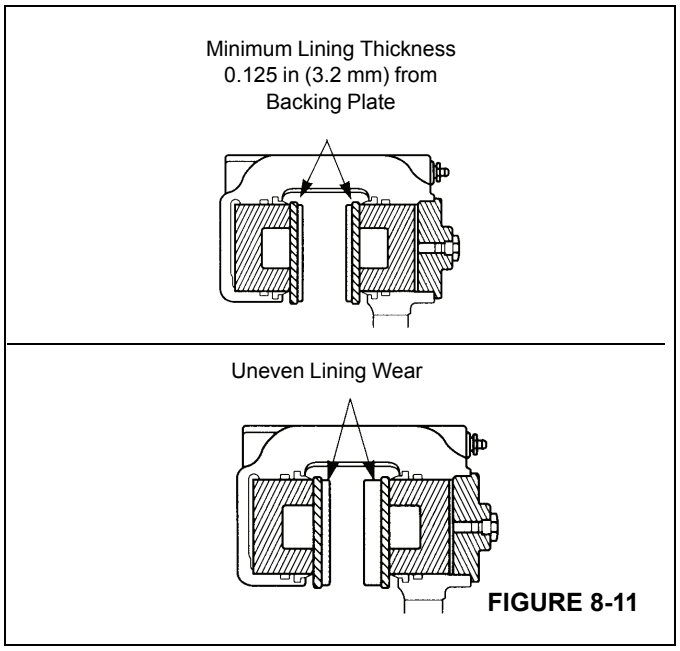


FIGURE 8-11

- Oil or Grease on Linings. Replace the linings.
- Cracks on Linings. Replace linings that have large or deep cracks.

NOTE: Small, tight cracks on the surface of the lining are normal when the caliper is used under high temperature conditions.

Caliper For Leaks

Inspect the following areas for fluid leaks (Figure 8-12).

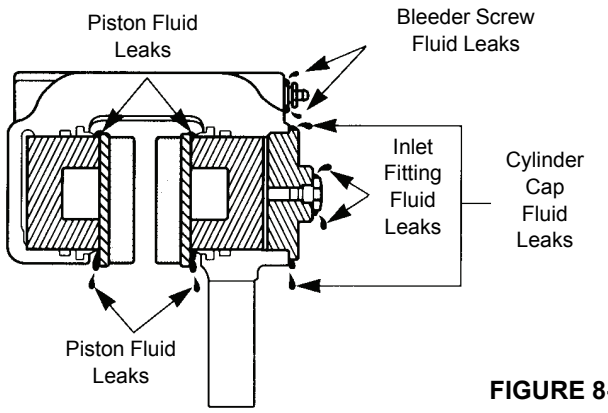


FIGURE 8-12

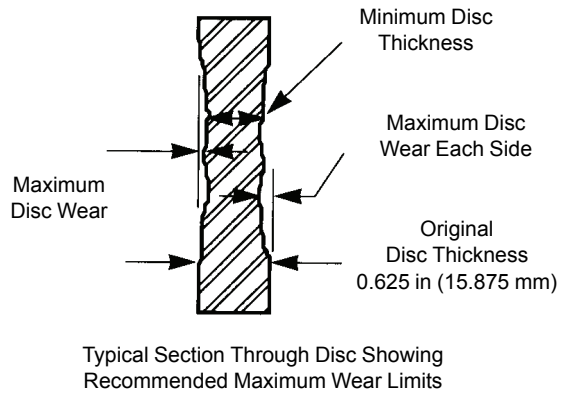
- **Pistons.** If fluid leaks at a piston, disassemble the caliper. Inspect the piston, the bore, the O-rings, and back-up rings. Service as necessary.
- **Cylinder Cap.** If fluid leaks at a cylinder cap, tighten the cylinder cap, the inlet fitting, and the plug. If the leak continues, disassemble the caliper. Inspect the cylinder cap threads, the housing threads, and the O-ring. Service as necessary.
- **Bleeder Screw.** If fluid leaks at the bleeder screw, tighten the bleeder screw. If the leak 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 8-13).



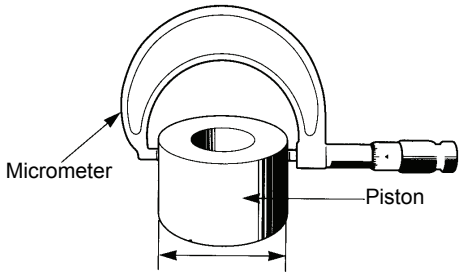
Typical Section Through Disc Showing Recommended Maximum Wear Limits

FIGURE 8-13

Lining Backing Plate Thickness	Maximum Disc Wear Each Side	Minimum Disc Thickness
0.28 in (7.1 mm)	0.06 in (1.5 mm)	0.50 in (12.7 mm)
0.34 in (8.6 mm)	0.09 in (2.3 mm)	0.44 in (11.2 mm)

Caliper Parts

1. Inspect the pistons, housing bores, and O-ring grooves for scratches or corrosion. Remove small scratches or corrosion with fine emery cloth. Replace the components if they are worn beyond wear limits or if there are large scratches or large amount of corrosion.
2. Measure the diameter of the piston. Replace the piston if the outer diameter is worn to less than 2.995 in (76.073 mm) (Figure 8-14).



Replace Piston if Outer Diameter is Worn to Less than 2.995 in (76.073 mm)

FIGURE 8-14

8

3. Measure the diameter of the housing bore. Replace the housing if the diameter is worn to more than 3.003 in (76.276 mm) (Figure 8-15).

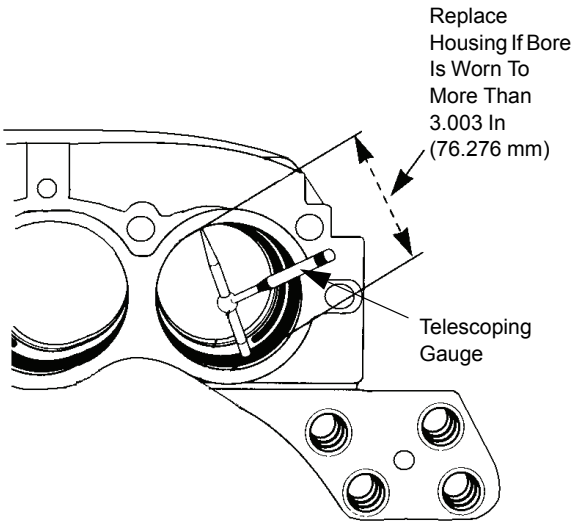


FIGURE 8-15

4. Inspect the linings as described previously.
5. Inspect the threads of the caliper, cylinder caps, and all fittings. Replace any component that has thread damage that cannot be repaired.
6. Discard all back-up rings, O-rings, and dust seals. Use new ones when assembling the caliper.

Cleaning

WARNING

Use of cleaning solvents, hot solution tanks, or alkaline solutions incorrectly, can cause serious personal injury. To prevent serious personal injury, follow the instructions supplied by the manufacturer of these products. Do not use gasoline to clean parts. Gasoline can explode and cause serious personal injury.

CAUTION

Use only solvent cleaners to clean ground or polished metal parts. Hot solution tanks or water and alkaline solutions will damage these parts. Isopropyl alcohol, kerosene, or diesel fuel can be used for this purpose.

- Use solvent cleaners to clean all metal parts that have ground or polished surfaces. Examples of ground or polished parts are the piston and the piston bore in the caliper.
- Metal parts with rough surfaces can be cleaned with solvent cleaners or with weak alkaline solutions.
- Use a wire brush to clean the threads of fasteners and fittings.
- Use soap and water to clean parts that are not made of metal.
- Scrape away build-ups of mud and dirt on the linings. Replace all linings contaminated with oil or grease.
- Immediately after cleaning, dry all parts with clean rags.

Corrosion Protection

Apply brake system fluid to the cleaned and dried parts that are not damaged and are to be immediately assembled. **Do Not** apply fluid to the brake linings or the disc.

If parts are to be stored, apply a special material that prevents corrosion to all surfaces. **Do Not** apply the material to the brake linings or the disc. Store the parts inside special paper or other material that prevents corrosion.

Assembly

Caliper

CAUTION

Use only specified components when assembling the calipers. Do not mix components from other calipers. Installing the wrong components may cause the caliper not to operate correctly and may cause damage to equipment. Use of non manufacturer's parts can cause damage, loss of braking, and serious personal injury.

NOTE: The O-rings, back-up rings, pistons, and bores must be lubricated before installing the pistons.

1. Lubricate all pistons, bores, O-rings, and back-up rings with silicone grease. If silicone grease is not available, use the same type of fluid that is used in the brake system.
2. Install new O-ring and a new back-up ring in the groove in the middle of the bore. The O-ring is installed toward the outboard end of the bore. The back-up ring is installed toward the lining side of the bore. Refer to the following figure.

CAUTION

Do not use silicone grease on the dust seal.

3. Install a new dust seal in the top groove of the bore (Figure 8-16).

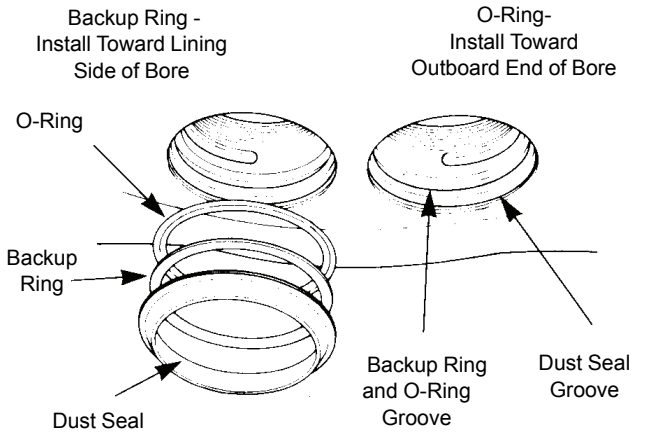


FIGURE 8-16

NOTE: Take care when you install the O-ring, so that the cylinder cap threads do not cut the O-ring.

4. Install the pistons in the housing. Push the pistons in from the lining side of the housing. Ensure the pistons are straight in the bores. Push each piston into the bore until the top of the piston is even with the top of the dust seal (Figure 8-17).

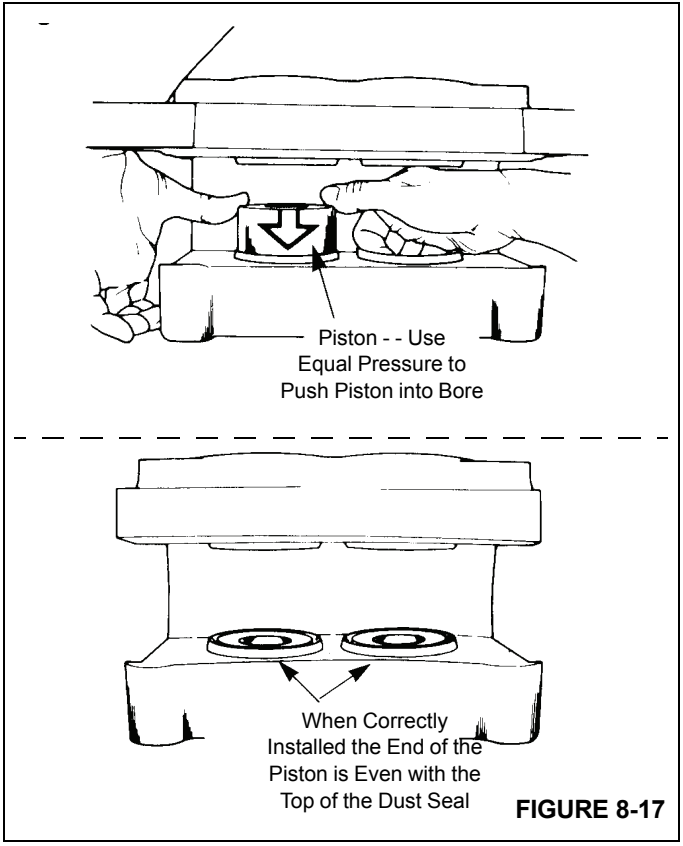


FIGURE 8-17

5. Install a new O-ring in the groove of the cylinder cap. Ensure the O-ring is not cut by the threads on the cylinder cap.

NOTE: Apply extra grease on O-ring before installing cylinder caps. this will keep O-ring from catching on threads as cylinder cap is threaded into housing.

6. Install the cylinder caps in the caliper housing. Tighten the cylinder caps to 680 Nm (500 foot-pounds) minimum as shown in the following figure.

7. Install the bleeder screws in the housing. Tighten to 100 to 180 lb-in (11.3 to 20.3 Nm).

8. Install the O-ring and the inlet fitting in the cylinder cap.

Installation

Caliper

1. Position the caliper housing on the mounting bracket. If shims where 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 8-20*.

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 8-18).

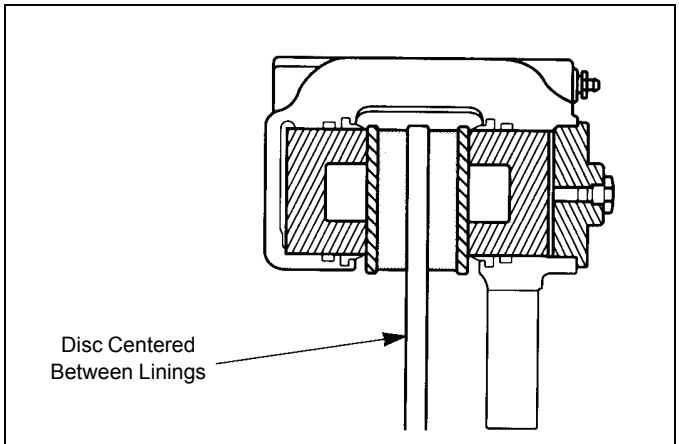


FIGURE 8-18

5. Connect the hydraulic brake line to the inlet fitting.
6. Bleed the brake system.
7. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

Linings

CAUTION

Always replace both linings. if only one lining is replaced, possible disc damage can occur.

1. Install the linings in the caliper housing with the metal backing against the piston and not toward the disc.
2. Position the end plates on the housing and secure with bolts. Apply Loctite 271 or equivalent to the bolt threads. 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.

Parking Brake Actuator

Description

The spring-applied, hydraulically-released parking brake actuators are located on the front axle and are used to apply and release the parking brake.

Maintenance

Removal

1. Chock the wheels to prevent crane movement.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake switch to OFF. This will pressurize the brake actuator to release the brake. Engine must remain running. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator.
3. Remove the washer and nut securing the brake actuator rod ball joint to the brake linkage lever.
4. Remove the nuts, washers, and lockwashers securing the brake actuator to the mounting bracket and tilt the actuator so the ball joint will clear the linkage lever bolt.
5. Position the Park Brake switch to ON and shut down the engine.
6. Disconnect the hydraulic line from the brake actuator, then cap or plug all openings.

Installation

1. Connect the hydraulic line to the brake actuator.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the brake. Engine must remain running. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator.
3. It will be necessary to tilt the actuator so the ball joint will clear the linkage lever bolt. Position the brake actuator on the mounting bracket and secure in place with the attaching nuts, washers, and lockwashers.
4. Secure the brake actuator rod ball joint to the brake linkage lever with the washer and nut.
5. Position the Park Brake Switch to ON and shut down the engine.

Adjustment

1. Chock the wheels to prevent crane movement.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the tension on the brake linkage. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator. Screw the caging nut up under the actuator chamber.
3. Install the rod ball joint until the ball joint will just connect to the brake linkage with the brake lever in a horizontal position.
4. Lock the rod ball joint with the jam nut and back off the caging nut.
5. Position the Park Brake Switch to ON and shut down the engine.

Parking Brake

Description

The parking brake is mounted on the front axle. The brake is a disc-type brake that is controlled by a switch on the steering column and is spring-applied and hydraulically released by an actuator.

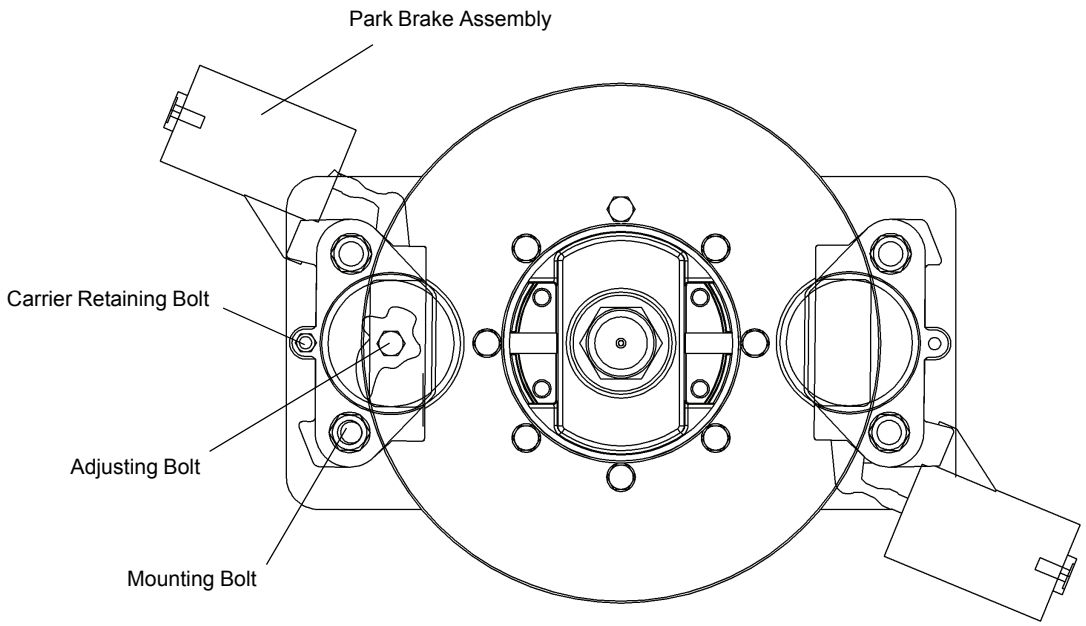


FIGURE 8-19

Maintenance

Removal

1. Chock the wheels to prevent crane movement.
2. Start the engine, ensure the transmission is in neutral, and position the Park Brake Switch to OFF. This will pressurize the brake actuator to release the tension on the brake linkage. Air pressure of 170 to 270 psi (1172 to 1862 kPa) may be used to pressurize the actuator. Screw the caging nut up under the actuator chamber.
3. Position the Park Brake Switch to ON and shut down the engine.
4. Tag and disconnect the hydraulic hose from the actuator. Cap or plug all openings.
5. Unthread the two mounting bolts securing the brake assembly to the mounting bracket, then carefully remove the brake assembly from the mounting bracket and the brake disc.
6. Repeat steps 4 and 5 for second caliper.

Installation

1. Slide the brake over the disc and align with mounting bracket holes.

NOTE: Mount the brake so that the linings are parallel with the disc within 0.015 in (0.381 mm).

2. Start the hex mounting bolts into the mounting bracket far enough to just support the brake.
3. Remove plug, loosen the coupling nut and tighten socket setscrew until linings are clamped to the disc. This locates and holds the brake in the proper position to set the hex mounting bolts and hex nuts.
4. Tighten hex mounting bolts until they make contact with the urethane springs, then tighten 4 flats (approximately 0.07 inch) more. This puts the proper amount of pre-load on the urethane springs.
5. Tighten jam nut/sleeves against mounting surface. Torque 200 lb-ft (271 Nm) dry.

CAUTION

Brake linings are susceptible to contamination. When installing or servicing brakes, keep all oil and fluids away from the linings. Poor brake performance may result if linings are contaminated.

6. Attach brake line to inlet port located on the top of the hydraulic cylinder.

CAUTION

To avoid damage to the brake, do not exceed 270 psi (1861kPa) hydraulic pressure.

7. Apply hydraulic pressure to the brake.
8. With plug removed, loosen coupling nut and set running clearance to 0.020 to 0.030 in (0.508 to 0.762 mm) total by adjusting the socket setscrew. Torque the coupling nut to 50 to 55 lb-ft (67.7 to 74.5 Nm) while holding the socket setscrew in position.
9. Replace plug. Torque to 45 to 50 lb-ft (61 to 67.7 Nm).
10. Even up the running clearance of the pads 0.010 to 0.015 in (0.254 to 0.381 mm) each side by adjusting the socket head capscrew.
11. Readjust the brake when running clearance reaches a total of 0.10 in (2.54 mm).

Park Brake Solenoid Valve

Description

The park brake solenoid valve is located on the right side frame rail in front of the rear axle. The valve is a three-way, two position solenoid valve. The park brake valve is used to control the application of the crane's spring-applied, hydraulically-released parking brake.

Positioning the Park Brake Switch to OFF shifts the three-way, two-position solenoid valve so hydraulic fluid 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 fluid can drain from the actuator. The parking brake actuator's rod retracts, forcing hydraulic fluid 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 fluid pressure keeps the pressure switch closed, which turns on the red LED indicator on the ECOS display.When the park brake is released, pressure buildup opens the switch, which turns off the indicator.

Maintenance

Removal

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

Installation

1. Secure the valve to the frame and secure with the washers, nuts and capscrews. Refer to *Fasteners and Torque Values, page 1-17*.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Connect the electrical connector to the valve as tagged during removal.
4. Apply and release the park brake several times. Verify the park brake holds the crane when applied. Verify the park brake doesn't drag when released.
5. Check for leaks. Make repairs as needed.

OUTRIGGERS

Description

The outriggers, when properly extended and set, provide a rigid four point platform which is capable of supporting the crane and its maximum load capacity. The outrigger circuit consists of four extension cylinders, four stabilizer cylinders, an integrated outrigger/rear steer valve, front and rear outrigger control manifolds, and pilot operated check valves. The front two extension cylinders are mounted in the front outrigger beams and the rear two extension cylinders are mounted in the rear outrigger beams. The front and rear outrigger beams are mounted on their respective outrigger boxes; in turn the stabilizer cylinders are mounted on the end of each outrigger beam. The integrated outrigger/rear steer valve is mounted on the rear face of the carrier frame front cross member. The front and rear outrigger control manifolds are mounted on the inside center of their respective outrigger box.

The outrigger selector controls are located on the ECOS display. 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.

A sight bubble level is mounted on the right side of the cab. The sight bubble level provides the operator with a visual indication of crane level attitude.

Theory of Operation

The outriggers are controlled by the ECOS display. Activating an outrigger function causes the solenoid valve to open, the integrated outrigger valve spool shifts allowing flow to either the extend or retract line as applicable. When the extend function is activated, the flow continues through the open solenoid valve to the piston side of the cylinder. If the stabilizer 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 retract function is activated, 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 stabilizer 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 3000 psi (20,684 kPa). Thermal relief protection is provided on the extend side by a 2000 psi (13,790 kPa) relief valve and the retract side by a 4000 psi (27,580 kPa) relief valve.

Maintenance

Table 8-4
Troubleshooting

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	**a.** Damaged relief valve.	**a.** Remove relief valve; clean or replace.
	b. Low hydraulic fluid level.	**b.** Check system for leaks. Make repairs as needed. Fill reservoir. Refer to *Lubrication, page 9-1*.
	c. Sticking solenoid valve spool.	**c.** Repair or replace valve spool.
	d. Improper ground to base of solenoid.	**d.** Ground properly.
	e. Directional selector switch sticking.	**e.** Clean or replace switch.
	f. Collector ring dirty or glazed.	**f.** Clean and deglaze collector ring.
	g. Damaged wiring to solenoid.	**g.** Replace wiring.
	h. Weak brush springs on collector ring.	**h.** Replace brush springs. Refer to your Manitowoc Crane Care Parts Manual.

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders. (continued)	**i.** Damaged extension cylinder (internal parts).	**i.** Remove extension cylinder and repair as necessary.
	j. Bent cylinder rods.	**j.** Replace piston rods and seals.
	k. Excessive material on outrigger beams.	**k.** Clean outrigger beams.
	l. Binding outrigger beam.	**l.** Repair or replace outrigger beam.
	m. Damaged outrigger valve.	**m.** Repair or replace valve.
	n. Damaged valve coil.	**n.** Replace coil.
	o. Main hydraulic pump cavitation.	**o.** Replace or tighten hose or fitting. Refer to your Manitowoc Crane Care Parts Manual.
	p. Partially shifted hydraulic spool in selector valve or manifolds.	**p.** Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	q. Insufficient voltage for operation of solenoid valve.	**q.** Solenoids require a minimum of 19 volts to energize. Check outrigger wiring and electrical coupling collector rings.
	r. Damaged piston seals.	**r.** Replace all cylinder seals.
	s. Worn or damaged hydraulic pump section.	**s.** Repair or replace pump section.
	t. Scored cylinder barrel.	**t.** Repair or replace extension cylinder.
	u. Cracked or damaged piston.	**u.** Replace rod weldment and all cylinder seals.
2. 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.	**d.** Check relief valve setting or pump compensation with that recommended.
	e. Electrical failure.	**e.** Check wiring and solenoids.
3. External leakage.	**a.** Damaged O-ring or quad rings.	**a.** Check for chipped packings and replace.
	b. Loose tie bolts.	**b.** Retorque tie bolts.
	c. Damaged solenoid.	**c.** Replace damaged parts.

Symptom	Probable Cause	Solution
4. Solenoid failure.	**a.** No current.	**a.** Check power source of at least 85% of coil rating.
	b. Damaged solenoid assembly.	**b.** Replace solenoid.
	c. Short in solenoid.	**c.** Replace coil.
	d. Loss of solenoid force.	**d.** Decrease time of solenoid energization, decrease cycle rate.
5. Outrigger stabilizer cylinder slow or erratic.	**a.** Low in hydraulic fluid.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Damaged main relief valve.	**b.** Repair or replace valve.
	c. Damaged holding valve seals.	**c.** Replace holding valve seals.
	d. Bent cylinder rod.	**d.** Replace cylinder rod and seals.
	e. Bent outrigger housing.	**e.** Repair or replace outrigger housing.
	f. Excessive material on beams.	**f.** Clean outrigger beams.
	g. Sticking solenoid valve spool.	**g.** Repair or replace valve spool.
	h. Damaged wiring to solenoid.	**h.** Repair or replace wiring.
	i. Weak brush springs on collector rings.	**i.** Replace brush springs.
	j. Collector ring dirty or glazed.	**j.** Clean or deglaze collector ring.
	k. Directional selector switch sticking.	**k.** Clean or replace switch.
	a. Main hydraulic pump cavitation.	**l.** Replace or tighten hose and fittings.
	b. Worn or damaged hydraulic pump section.	**m.** Repair or replace pump section.
6. Outrigger stabilizer cylinder retracts under load.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Damaged holding valve seals.	**b.** Replace seals.
	c. Damaged holding valve.	**c.** Replace valve assembly.
	d. Scored cylinder barrel.	**d.** Repair or replace cylinder.
	e. Cracked or damaged piston.	**e.** Replace piston and all cylinder seals.
7. Outrigger stabilizer cylinder extends while machine is traveling.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Scored cylinder barrel.	**b.** Replace jack cylinder.
	c. Cracked or damaged piston.	**c.** Replace piston and seals.
	d. Piston loose on cylinder rod.	**d.** Replace seal and retorque.

Symptom	Probable Cause	Solution
8. Outrigger system will not activate (from stowed or extended and down position).	**a.** Hydraulic fluid low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Loose or broken wire on switch.	**b.** Repair or replace wiring.
	c. Clogged, broken, or loose lines or fittings.	**c.** Clean, tighten, or replace lines or fittings.
	d. Damaged relief valve or damaged control valve.	**d.** Repair or replace valve.
9. Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	**a.** Clogged, broken, or loose hydraulic lines or fittings.	**a.** Clean, tighten, or replace lines or fittings.
	b. Loose or broken wire on control switch or solenoid valve.	**b.** Repair or replace wiring.
	c. Damaged solenoid valve.	**c.** Repair or replace valve.
	d. Damaged control switch.	**d.** Replace switch.
	e. Damaged hydraulic cylinder.	**e.** Repair or replace cylinder.
10. Outriggers will not set.	**a.** Improper sequence of activation.	**a.** Activate individual control switch; then activate system control switch.
11. Two outriggers activate from single control switch	**a.** Damaged solenoid valves.	**a.** Repair or replace.
12. The two outriggers will not stow.	**a.** Hydraulic lock.	**a.** Recycle individual outrigger(s).
13. Individual outrigger will not set or stow.	**a.** Damaged piston seals.	**a.** Replace seals.
	b. Damaged check valve.	**b.** Repair or replace valve.
	c. Loosen or broken wire on control switch or solenoid valve.	**c.** Repair or replace wiring.
	d. Damaged solenoid valve.	**d.** Repair or replace valve.

Outrigger Beam

Description

The outrigger beam assembly (Figure 8-20) consists of an outrigger beam, a stabilizer cylinder, an extension cylinder, and the required hoses and mounting hardware.

Theory of Operation

When 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 stabilizer 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 stabilizer 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. Disconnect the OMS sensor, refer to *OMS String Potentiometers, page 8-32*.

4. Remove the setscrews from the bottom adjustable wear pads and back off the wear pads leaving approximately 0.125 in (3.2 mm) protruding.

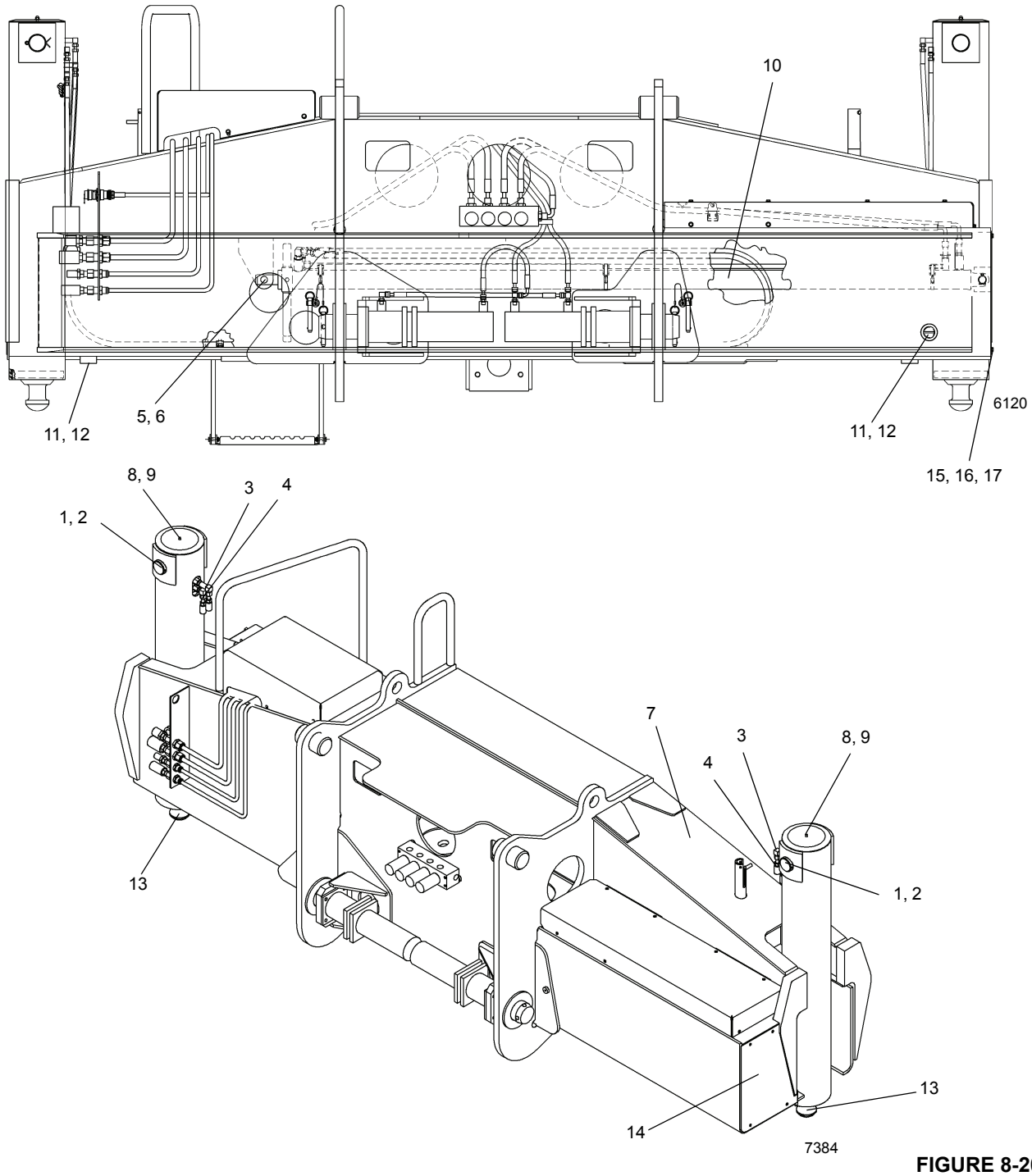
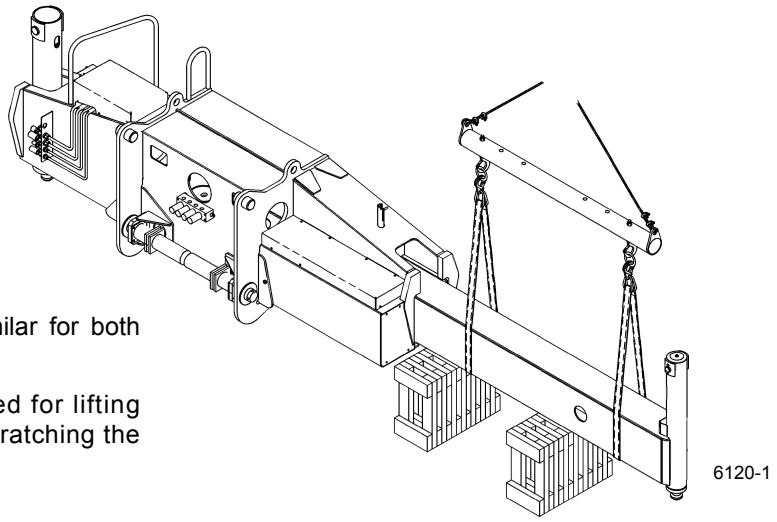


FIGURE 8-20

Item	Description
1	Retainer Pin
2	Cotter Pin
3	Extend Port
4	Retract Port
5	Clevis Pin
6	Cotter Pin
7	Outrigger Box
8	Locknut
9	Lockwasher

Item	Description
10	Extension Cylinder
11	Wear Pad
12	Setscrew
13	Stabilizer Cylinder
14	Cover Plate
15	Nut
16	Cotter Pin
17	Capscrew



NOTE: Outrigger removal and installation similar for both front and rear outriggers.

Lifting belts or straps should be used for lifting purposes so as to avoid nicking or scratching the bottom edges of the outrigger beam.

FIGURE 8-21

CAUTION

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. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
6. Place blocking material under the outrigger beam (Figure 8-21).
7. 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.

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.
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.

CAUTION

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

NOTE: The outrigger beam assembly weighs approximately 2132 lb (967 kg).

10. Position the outrigger beam on the blocking material.

Inspection

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

Installation

1. Apply grease (EP-MPG) to the bottom of the outrigger beam.

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

3. Install the bottom wear pads with approximately 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-seize compound to the clevis pin. Secure the cylinder barrel to the housing with the clevis pin and cotter pin.

CAUTION

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

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

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

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

9. Adjust the wear pads, refer to *Wear Pad Adjustment* in this Sub-Section.

10. Connect the OMS sensor, refer to *OMS String Potentiometers, page 8-32*.

11. Install the end cover.

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

Wear Pad Adjustment

NOTE: When adjusting wear pads, refer to (Figure 8-22).

1. Adjust each of the bottom wear pads (about 1/2 turn) until there is a gap of 0.12 to 0.18 in (3.0 to 4.5 mm) between the top of the beam and the top of the outrigger box. Install and lock set screws against wear pads.

2. Adjust outrigger box side wear pad until there is a gap of 0.12 to 0.18 in (3.0 to 4.5 mm) between beam and shims welded in top and bottom of box. Install and lock set screw against wear pad.

3. Adjust outrigger beam side wear pad until there is a gap of 0.12 to 0.18 in (3.0 to 4.5 mm) between shim welded on beam and side of box. Install and lock set screw against wear pad.

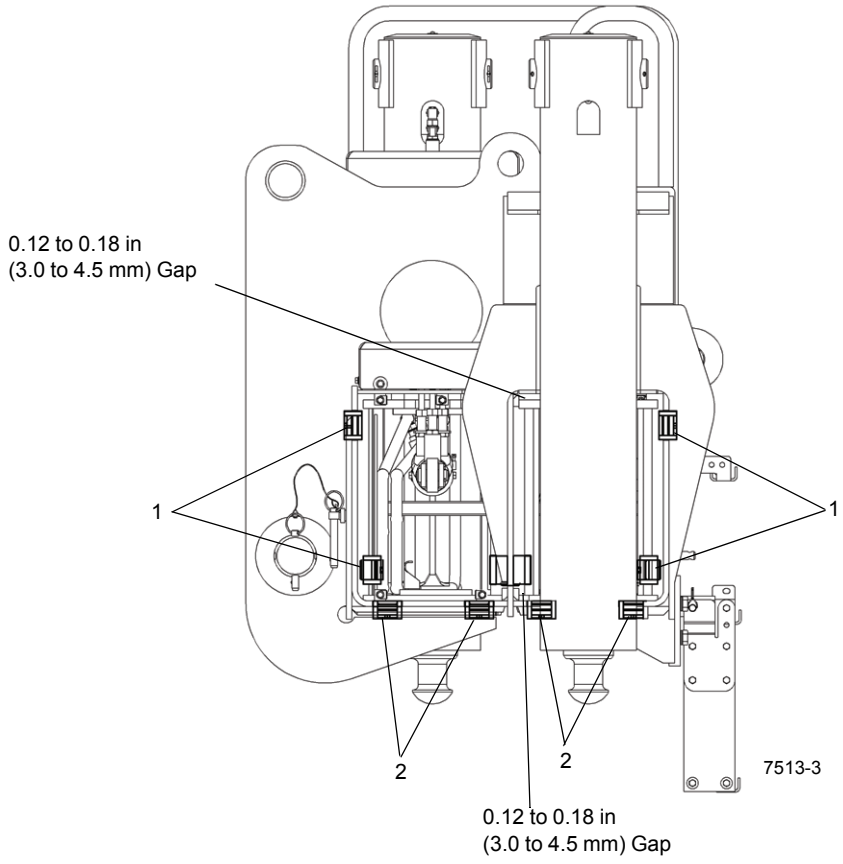


FIGURE 8-22

Item	Description
1	Side Wear Pads and Setscrews
2	Bottom Wear Pads and Setscrews

Extension Cylinder

Description

Two outrigger extension cylinders are utilized within each outrigger box assembly. The extension cylinders provide the force for the outrigger beam's horizontal movement. The cylinder weighs approximately 104.9 lb (47.6 kg).

Maintenance

NOTE: Refer to *Cylinders, page 2-62* for disassembly and assembly of the cylinder.

Removal

1. Remove the outrigger beam. Refer to *Outrigger Beam, page 8-26*.
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: Position hydraulic fittings and hoses to prevent rubbing with the beam top plate and side plate, and for proper tracking during beam extension and retraction.

2. Position the extension cylinder so the hydraulic ports on the rod end of the cylinder can be accessed. Connect the hydraulic hoses to the ports as tagged during removal. Verify the piston side of the extension cylinder is connected to the solenoid valve bank to prevent damage.
3. Push the cylinder into the outrigger beam. Align the cylinder rod with the clevis in the beam. Apply anti-seize compound to the clevis pin and secure in place with the clevis pin and cotter pin.

4. Install the outrigger beam. Refer to *Outrigger Beam, page 8-26*. Verify no stabilizer cylinder hose will be trapped by full outrigger beam retraction.

Functional Check

1. Activate the hydraulic system; extend and retract the outrigger.
2. Observe the operation of the outrigger beam.
3. Check the hydraulic connections for any evidence of leakage.

Stabilizer Cylinder

Description

Four stabilizer cylinders are used on the crane, one at the end of each outrigger beam. The stabilizer cylinders provide the force for the outrigger beam's vertical movement. The cylinder weighs approximately 220.4 lb (100 kg).

Maintenance

NOTE: Refer to *Cylinders, page 2-62* for disassembly and assembly of the cylinders.

Removal

1. Extend the outrigger beam slightly for improved access to the stabilizer cylinder; shut down the engine.
2. Tag and disconnect the hydraulic hoses from the stabilizer 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 stabilizer 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 stabilizer 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 stabilizer cylinder out of the tube on the beam assembly.

Installation

1. Apply grease (EP-MPG) to the ID of the stabilizer cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on stabilizer cylinder.
3. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under Removal, lower the stabilizer cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.
5. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam.
6. Apply anti-seize compound to the retaining pin. Secure the cylinder and cylinder cap retaining bracket to the support tube with the retaining pin and cotter pins.
7. Install the cylinder cap.
8. Install the fittings in the cylinder ports and connect the hoses as tagged during removal. Verify the piston side of the stabilizer cylinder is connected to the solenoid valve bank to prevent damage. Verify no stabilizer cylinder hose will be trapped by full outrigger beam retraction.

Functional Check

1. Activate the hydraulic system.
2. Observe the operation of the stabilizer cylinder. If hydraulic lines are reversed, stop immediately and connect lines properly per instructions. Verify no stabilizer cylinder hose is trapped by full outrigger beam retraction; if any is, stop immediately and install lines properly to avoid trapping.
3. Check the hydraulic connections and hoses for evidence of leakage. Make repairs as needed.

Outrigger Control Valves

Description

There are four valve assemblies responsible for controlling the outrigger system, the integrated outrigger/rear steer valve, the front and rear outrigger control manifolds, and the pilot operated check valves.

NOTE: For a more detailed description and maintenance of the valves, refer to *Valves, page 2-34*.

Pilot Operated Check Valve

The pilot operated check valves are located in the outrigger stabilizer port blocks. The check valve provides two functions; the first function is a holding valve, the second function provides a thermal relief of the stabilizer.

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 three 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 24 volt solenoid valves and an assembly mounting kit.

Outrigger Monitoring System (Optional—Standard in North America)

Description

The Outrigger Monitoring System (OMS) aids the operator 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.

If the crane is setup on outriggers and “On Outriggers” is chosen when programming the LMI, then the OMS indicates to the LMI the position of each of the four outrigger beams. The operator must confirm the outrigger positions and rigging code. Refer to the *Operator’s Manual* for more information.

OMS String Potentiometers

Removal

1. Remove the rear access cover plate from outrigger box.
2. Remove the OMS string potentiometer spring clip (1) (Figure 8-23) from the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer.

3. Tag and disconnect the electrical connector and secure to avoid damage.
4. Remove the mounting hardware.
5. Remove the OMS string potentiometer (2).

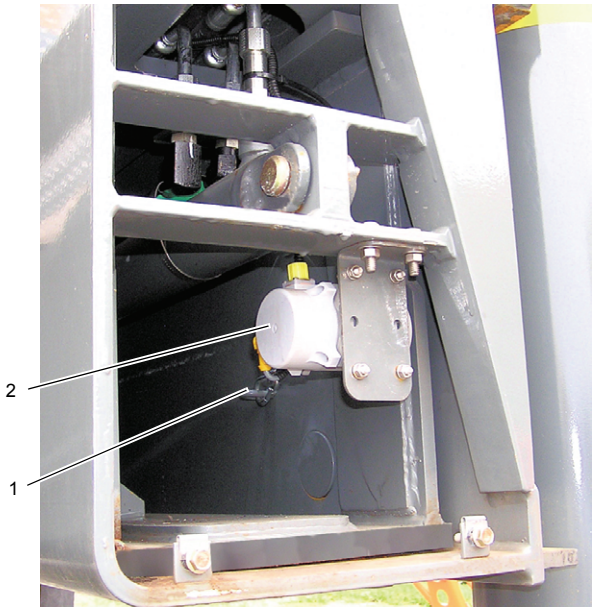


FIGURE 8-23

Installation

1. Install string potentiometer inside outrigger beam (Figure 8-23).
2. Install the mounting hardware.
3. Attach the OMS string potentiometer spring clip (1) to the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to the OMS string potentiometer.

4. Connect electrical connector, as tagged during removal, to string potentiometer.
5. Install access cover plate to outrigger box.

SECTION 9
LUBRICATION

SECTION CONTENTS

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GENERAL

Following the designated lubrication procedures is important in ensuring maximum crane lifetime and utilization. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information.

Environmental Protection

Dispose of waste properly! Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Manitowoc cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

Handle and dispose of waste according to local, state, and federal environmental regulations.

When filling and draining crane components, observe the following:

- Do not pour waste fluids onto the ground, down any drain, or into any source of water.
- Always drain waste fluids into leak proof containers that are clearly marked with what they contain.
- Always fill or add fluids with a funnel or a filling pump.
- Immediately clean up any spills.

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 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 accordingly to conditions such as continuous duty cycles and/or hazardous environments.

CAUTION

Possible Equipment Damage Hazard!

Chassis grease lubricants must not be applied with air pressure devices as this lubricant is used on sealed fittings.

The multipurpose grease installed during manufacture is of a lithium base. Use of a noncompatible grease could result in damage to equipment.

9

STANDARD LUBRICANTS PACKAGE

The following table lists all the lubricants and coolant recommended for this Grove crane.

Table 9-1Standard Lubricants

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Axle Gear Oil	6829012964	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO	80W-90	
Engine Oil				
QSC Tier 3	6829003483	Exxon XD-3 Conoco Fleet Supreme	15W-40	CI-4
QSX Tier 4	6829104182	Conoco Fleet Supreme EC Mobil Delvac 1300 Super		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	02313611	ARAL Synthetik API	75W-90	GL 4
Grease, Multipurpose	6829003477	Citgo Lithoplex MP# 2 Texaco Starplex Moly # 2 Phillips 66 Philube M Mobil Mobilgrese XHP 222 Special Chemtool Inc, Lube-A-Boom	NLGI 2	
Open Gear Lube	6829104478	LPS Dry Force 842 Moly Lube		
Swing Box Gear Oil	02313611	ARAL Synthetik API	75W-90	GL 4
Boom Telescopic Sections, Upper and Lower Faces	02310394	Sliding-paste		
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		

ARCTIC CONDITIONS

Below 0°F (–18°C)

In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, might not be compatible with hydraulic system seals and wear bands. If you are in doubt about the suitability of a specific fluid, check with your authorized Manitowoc distributor or Manitowoc Crane Care.

NOTE: All fluids and lubricants may be purchased by contacting the Manitowoc Crane Care Parts Department.

Regardless of temperature and oil viscosity, always use suitable start-up procedures to ensure adequate lubrication during system warm-up.

Down to –40°F

ALL Weather Package & Lubricants

Engineering recommends the following lubricants for components for ambient temperatures to -40F. Special lubricants alone are not sufficient to operate at extreme low temperatures. We also recommend the use of appropriately sized heaters for the hydraulic tank, engine oil pan, engine jacket water and batteries. The operator needs to follow the guide lines as stated in the operator's manual. We assume that the customer has taken steps for use of an appropriate engine antifreeze coolant, have taken care of the fuel, fuel system and starting system. And has done whatever they feel necessary to add insulation for under hood temperatures to meet the engine manufacture's intake air temperature. Other lubricants may be used if they meet the specification of the lubricant that is requested. Please consult factory.

Table 9-2: All Weather Lubricants

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Axle/Swing Box 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	GL-5
Engine Oil	6829104412	Citgo Citgard® Syndurance® Synthetic Engine Oil Maxtron® DEO Synthetic Blend Diesel Engine Oil ConocoPhillips Triton® ECT Full Synthetic Motor Oil Shell Rotella® T Synthetic Motor Oil Mobil Delvac 1 ESP SW-40 Chevron Delo® 400 LE Synthetic SAE 5W-40	5W-40	CJ-4
Hydraulic/Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20C
Hoist Gear Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Grease, Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829104478	LPS Dry Force 842 Moly Lube		
Antifreeze Coolant	6829104212	Petro-Canada AFC Old World Industries, Inc Fleet Charge SCA Fleetguard Compleat EG Antifreeze/Coolant	Premix 60/40	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		

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 fluid is too thick to penetrate these cracks. Normal machine operating temperatures will allow hydraulic fluid 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 that can be ordered through the Parts Department.

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

WIRE ROPE LUBRICATION

Wire rope is lubricated during manufacturing so that the strands, and individual wires in strands, may move as the rope moves and bends. A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added periodically throughout the life of a rope to replace factory lubricant which is used or lost. For more detailed information concerning the lubrication and inspection of wire rope, refer to *Wire Rope*, page 1-21.

LUBRICATION POINTS

A regular frequency of lubrication must be established for all lubrication points. Normally, this is based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log indicating crane usage. The log must use the engine hourmeter to ensure coverage of lube points that will receive attention based on their readings. Other lubrication requirements must be made on a time basis, i.e. weekly, monthly, etc.

All oil levels are to be checked with the crane parked on a level surface in transport position, 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. The hoists have an oil level indicator.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. 28 grams (one ounce) of EP-MPG equals one pump on a standard one pound (0.45 kg) grease gun.

Over lubrication on non-sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.

On sealed U-joints, care must be exercised to prevent rupturing seals. Fill only until expansion of the seals first becomes visible.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, levers, etc., should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to ensure complete lubrication of the entire wear area.

CraneLUBE

Manitowoc highly recommends the use of CraneLUBE lubricants to increase your crane's reliability and performance. Contact your Manitowoc distributor for information about the Manitowoc's CraneLUBE lubrication program.

Safety

To lubricate many of the locations the engine will need to be started. After positioning areas of the crane for lubrication the engine must be turned off and the areas to be lubricated made stable before preceding.

WARNING

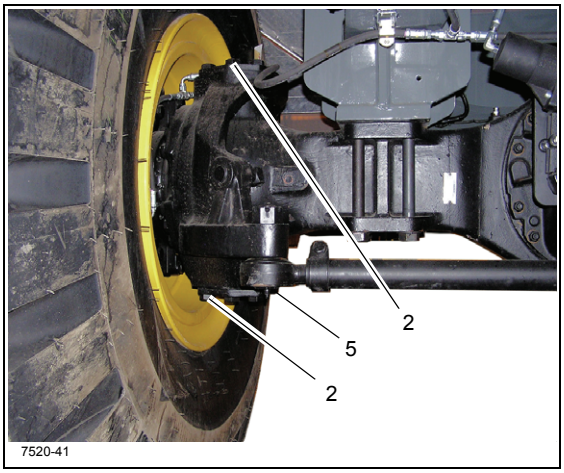
Crushing Hazard!

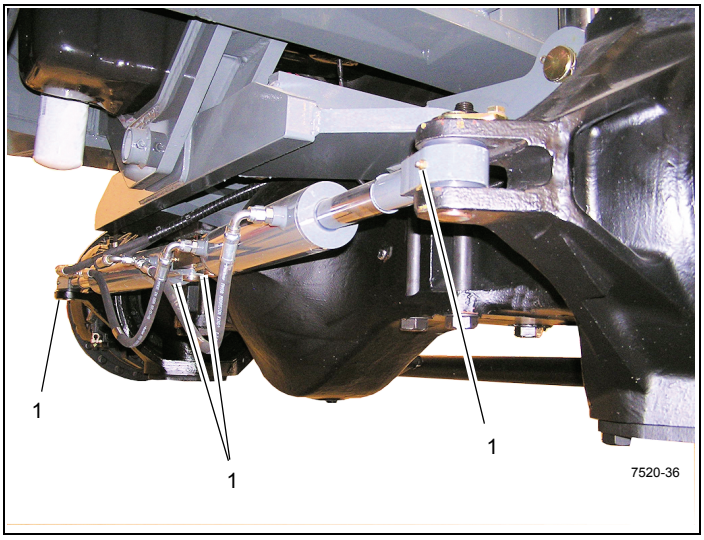
Movement of the superstructure and the boom may create a crushing and/or pinching hazard. Failure to observe this warning could result in death or serious injury.

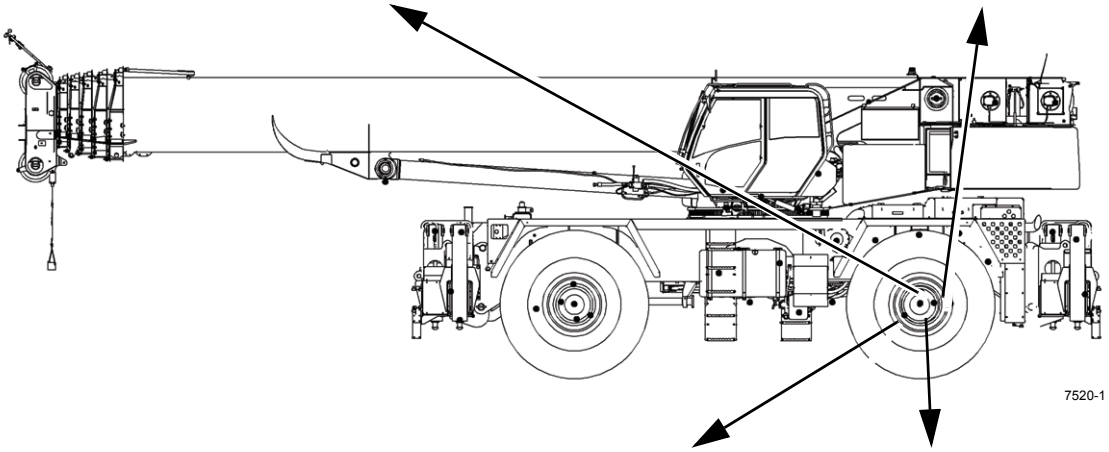
9

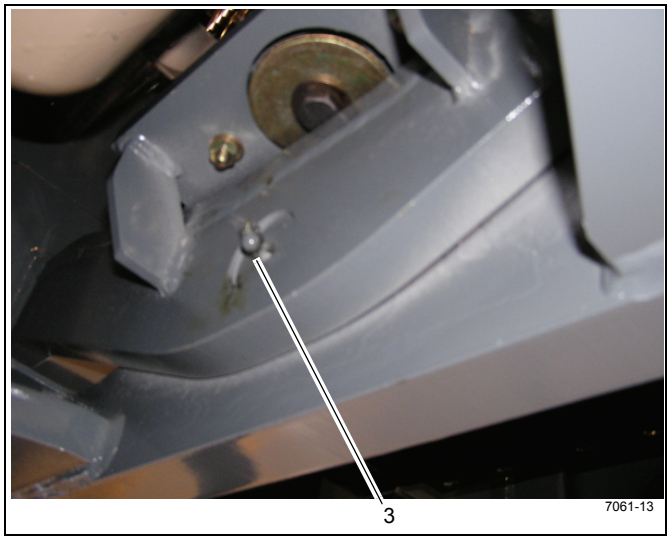
Steering and Suspension

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
NOTE:	Standard fluids good to -15° C (5° F) - Cold weather fluids good to -29° C (-20° F) The standard fluid part number in Approved Lubricant column in this chart appears first and cold weather part number is listed second. If only one part number is listed, it is the standard fluid.					
1	Steer Cylinder Pivot Pins	Figure 9-1	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	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 6829104275	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 6829104275	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 6829104275	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 6829104275	Until grease extrudes	500 hours or 3 months	4 grease fittings









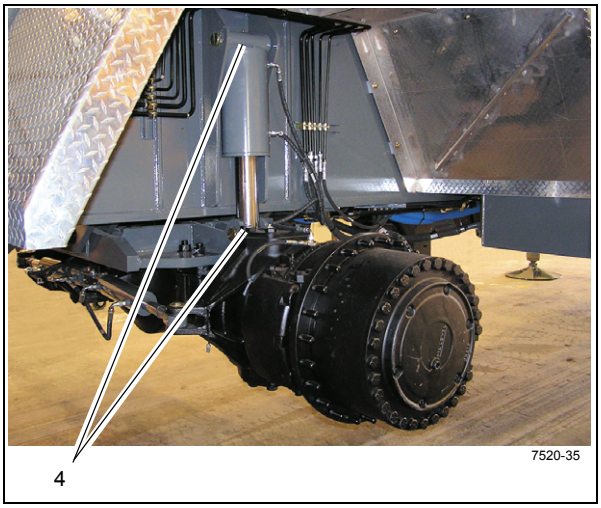
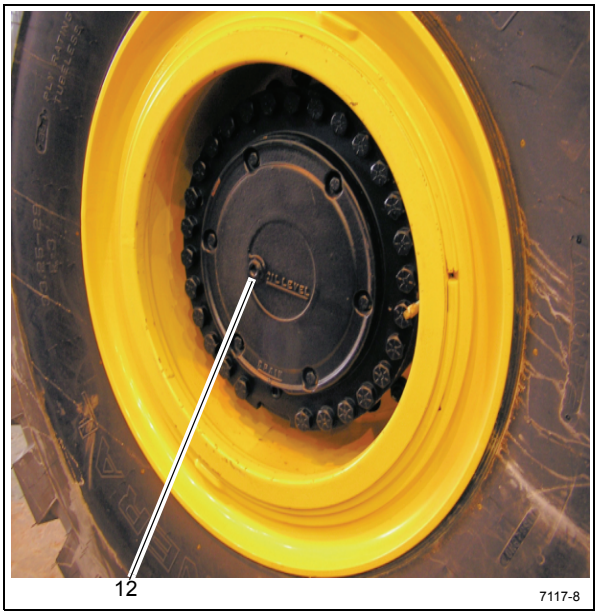
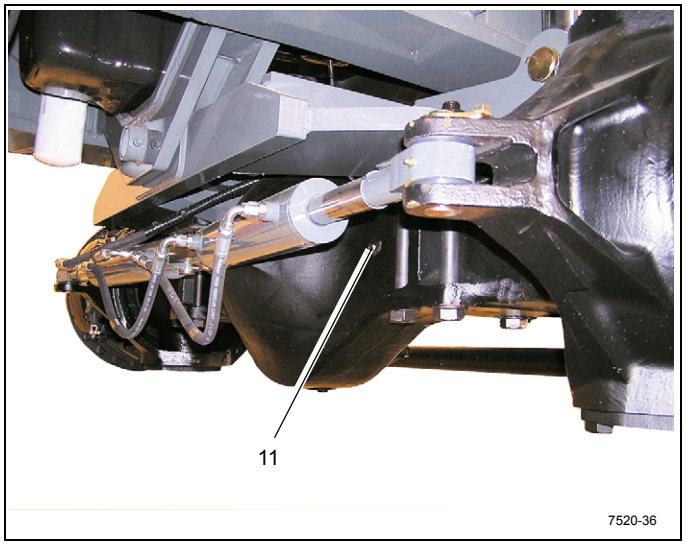


FIGURE 9-1

9

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	130.2 pints (61.6 liters)	• 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 (2 places)
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 semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals. **CAUTION:** If the makeup amount is substantially more than 0.23 liter (0.5 pint), check for leaks.						
12	Planetary Hubs and Wheel Bearings	Figure 9-2	GL-5 Extended Service Interval Gear Lubricant 6829012964	14.4 pints (6.8 liters)	• 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 (4 places)
CAUTION: Use of non synthetic lubricant may damage components and/or invalidate published lubricant intervals.						





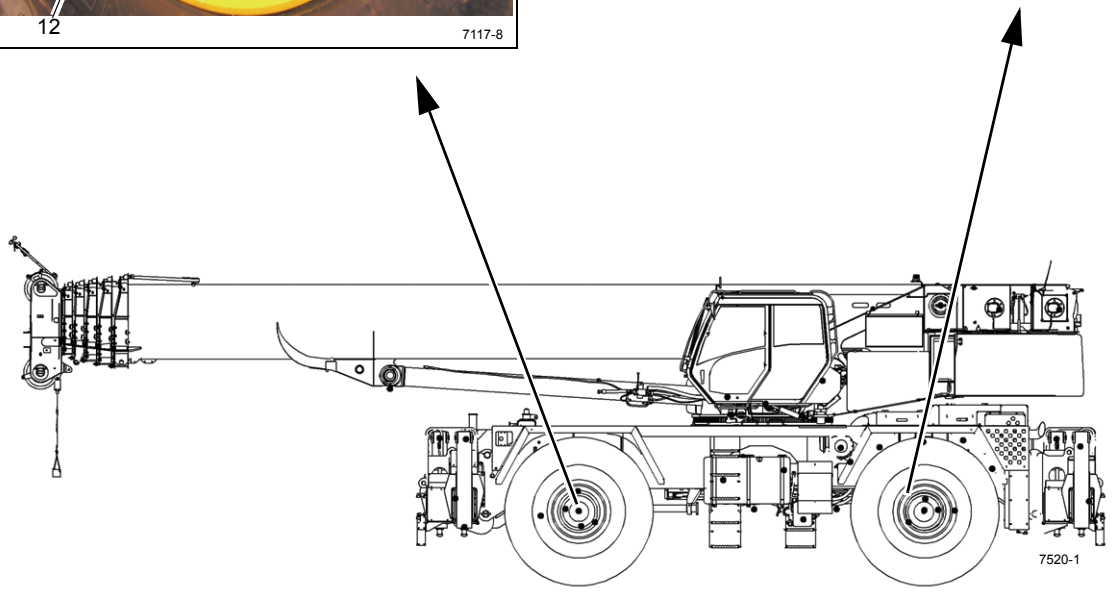


FIGURE 9-2

9

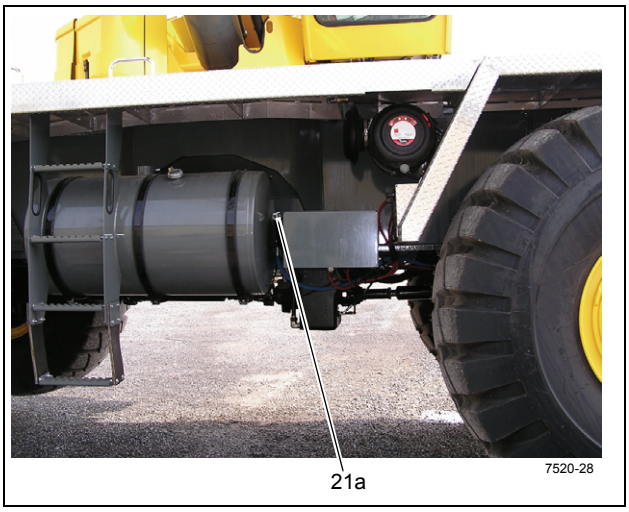
Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Drive Train						
20a **20b**	a. Engine Crankcase b. Filter	Figure 9-3	EO-15W/40 Engine Oil SAE 15W-40 Tier3-6829003483 Tier4-6829104182 EO-15W/40 EO-5W/40 Engine Oil SAE 5W-40 6829104412	21 quarts (19 liters)	• Check level every 10 hours or daily • Drain, fill and replace filter every 500 hours	• Through fill cap to FULL mark on dipstick • Filter located under radiator
21a **21b**	a. Transmission, Torque Converter b. Filter	Figure 9-3	HYDO Hydraulic Fluid 6829006444 Hydraulic/ Transmission Oil 6829101559	34 quarts (32 liters)	• 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 1000 rpm idle and the oil at 150 to 200° F (65 to 90° 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 90° C).
- Transmission filters are located on the outside left hand frame in the area of the hydraulic fluid cooler.
- Do not operate the machine in two wheel drive while the machine is up on outriggers. Serious transmission damage could result.
- To add fluid:
  - **a.** Fill to FULL mark on dipstick
  - **b.** Run engine at 800 rpm to prime torque converter and lines
  - **c.** Check oil level with engine running at 800 rpm and oil at 180 to 200° F (82 to 93° C). Add oil to bring oil level to FULL mark on dipstick.

22a **22b**	a. Engine Cooling System and SCA Levels b. Coolant Filter	Figure 9-3	AFC 50/50 50/50 Blended Fully Formulated Antifreeze Coolant 6829101130 SCA 6829012858	36 quarts (34 liters)	• Check coolant level every 10 hours or daily • Change filter and check SCA levels every 500 hours • Check coolant for contamination every 1000 hours	See *Water Cooling System*, page 7-20.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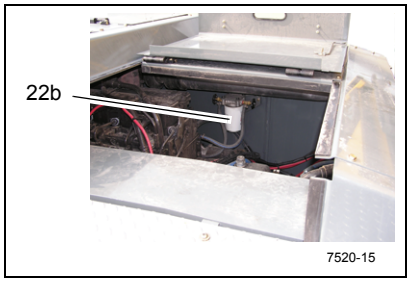
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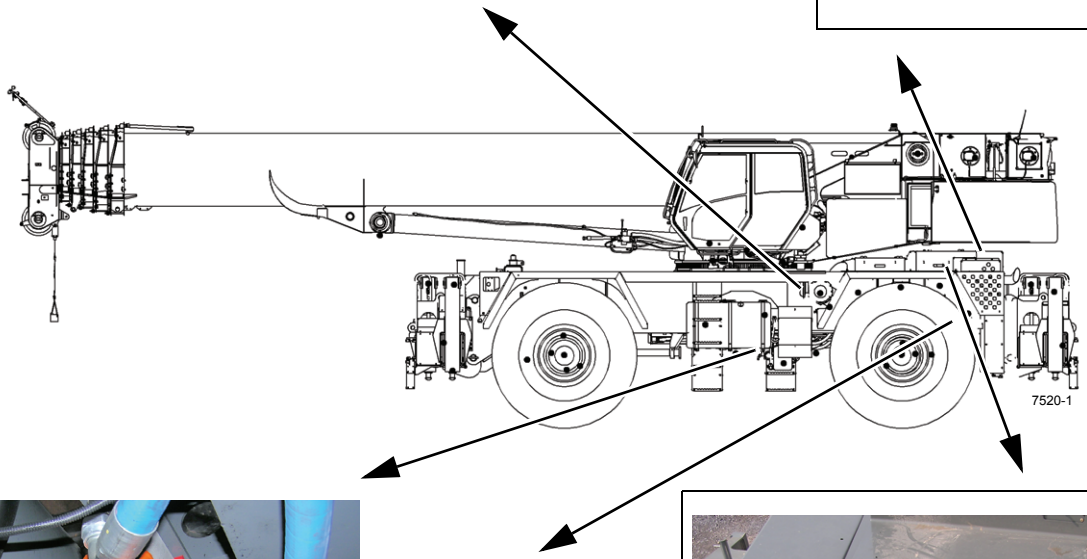
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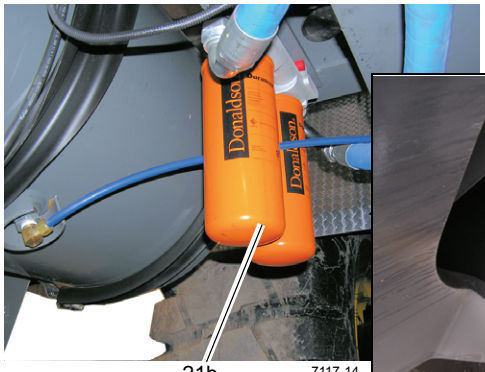
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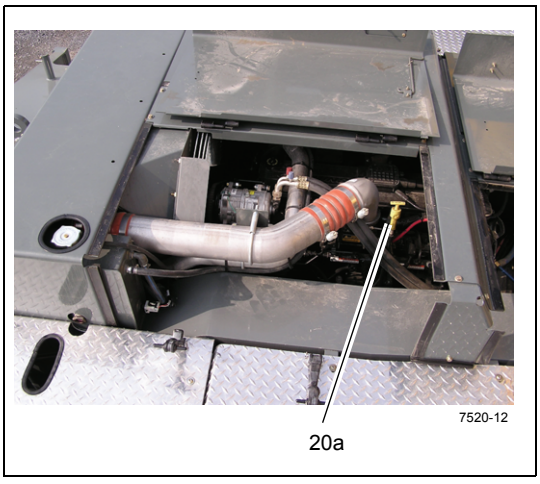
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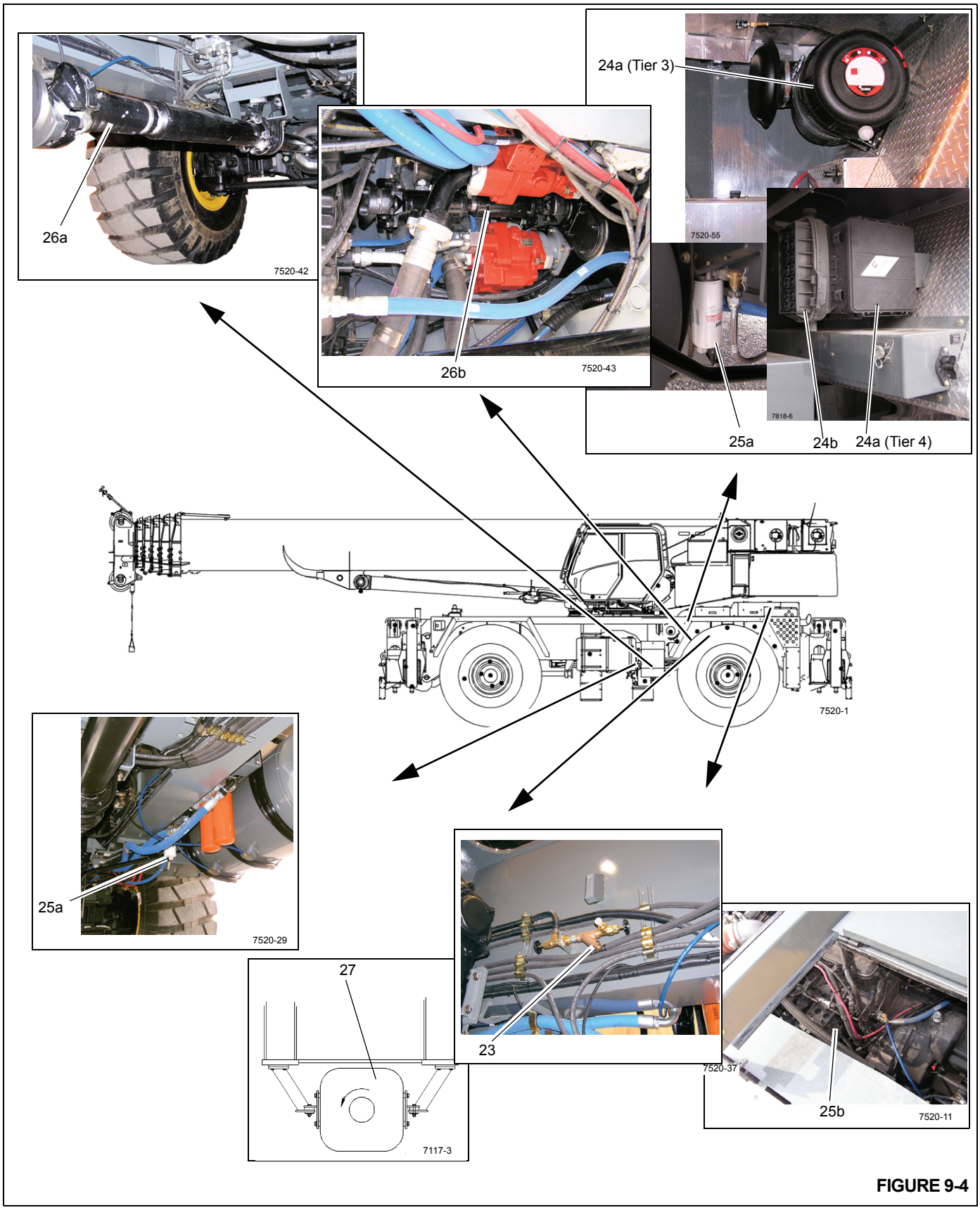
FIGURE 9-3

9

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.
24a **24b**	Air Cleaner Filters Pre-cleaner	Figure 9-4	---	---	• Replace primary filter element when indicator shows red (25 in of H_20). Replace secondary filter every third time primary filter is replaced. • In severe dust conditions the pre-cleaner may need to be serviced.	Right hand side of engine hood.
25a **25b**	Water Separator Fuel Filter	Figure 9-4	---	---	• Drain water trap every 10 hours or daily. • Change filter every 500 hours or 6 months.	Primary fuel/water separator is located beside the fuel tank. Fuel filter is located on the right side of the engine
26a **26b**	Driveline - Slip Joints	Figure 9-4	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	500 hours or 3 months	3 grease fittings
27	Retarder (Optional)	Figure 9-4	---	---	After 2000 hours	Grease using hand grease gun

NOTE: Grease using hand grease gun until grease comes out of vent tube outlet located near grease nipple.
CAUTION: Do not mix synthetic oil with mineral based oil.


26a
7520-42
26b
7520-43
24a (Tier 3)
7520-55
25a
24b
24a (Tier 4)
7818-6
7520-1
25a
7520-29
23
7520-37
27
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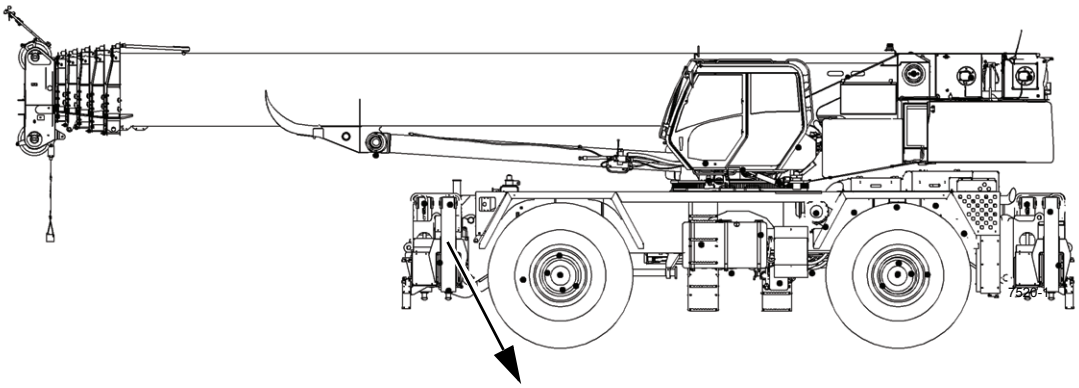
25b
7520-11

FIGURE 9-4

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Outriggers						
30	Outrigger Beams	Figure 9-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	---	50 hours or 1 week	Brush lubricant on bottom of outrigger beams
31	Jack Cylinder Support Tubes	Figure 9-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	---	50 hours or 1 week	Brush lubricant on ID of jack cylinder support tubes and wear bands (4) places before installing jack cylinders
32	Jack Cylinder Barrels	Figure 9-5	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	---	50 hours or 1 week	Brush lubricant on ID of jack cylinder support tubes and wear bands (4) places before installing jack cylinders and on outside of support tubes at regular intervals



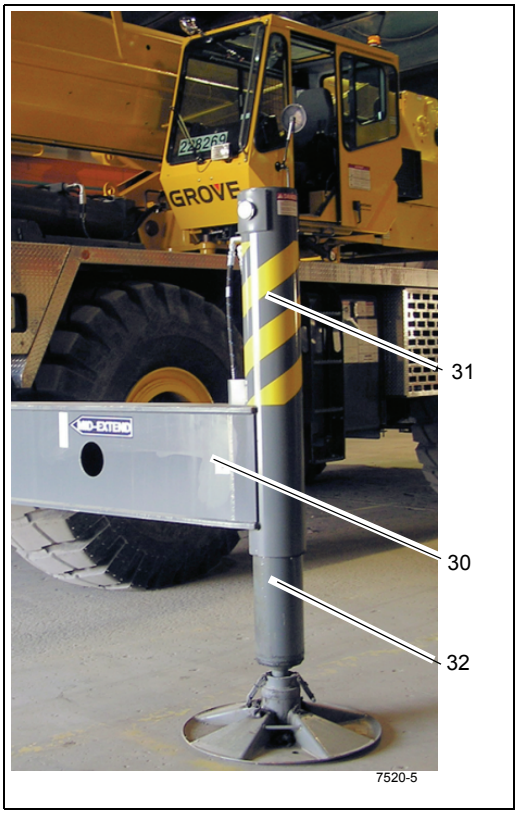


FIGURE 9-5

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Hydraulic						
40	Hydraulic Reservoir	Figure 9-6	HYDO Hydraulic Fluid 6829006444 6829101559	173 gallons (655 liters)	• Check fluid level every 10 hours or daily. • Drain and refill every 4000 hours or four years	• Use sight gauge on side of tank, with boom down and all outrigger cylinders retracted. • Drain and refill as necessary

NOTE:

- Environmental and other conditions can dramatically affect the condition of hydraulic fluid and filters. Therefore, specific intervals for servicing/changing hydraulic fluid, 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 fluid filters and tank breathers.
- Under normal operating conditions, it is recommended that hydraulic fluid, filters and breathers be inspected and fluids 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., fluid 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 fluid 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 fluid, fill a small glass container with a sample of reservoir fluid and another glass container with fresh fluid. Let the samples stand, undisturbed, for one to two hours and then compare the samples. If the reservoir fluid is heavily contaminated with water the sample will appear “milky” with only a small layer of transparent fluid on top. If the “milky” appearance was due to air foaming, it will dissipate and the fluid should closely match the fresh fluid. Should you have any questions, please contact your local authorized Manitowoc distributor.
- The hydraulic fluid shall meet or exceed ISO #4406 class 19/17/14 cleanliness level.

Fill Procedure for Hydraulic Reservoir (Refer to *Draining and Flushing*, page 2-5 for cleaning the hydraulic system)

1. Park crane with parking brake applied on level ground. Fully retract all cylinders and turn engine off.

NOTE: To assure an accurate reading, check reservoir fluid level only when the hydraulic fluid is cold (ideal temperature is 65-70°F (18-21°C)). Use only approved fluid listed above and never mix brands/viscosity fluids.

2. Check the level of the fluid in the sight gauge on the side of the reservoir. The level should be between the LOW and HIGH indicators.

3. If the fluid is nearing or below the LOW level, remove the breather and add fluid to bring the level no higher than the HIGH mark on the sight gauge.

NOTE: If the fluid level is above the HIGH mark on the sight gauge, drain the fluid until it is at a proper level.

41	Hydraulic Filter	Figure 9-6	---	---	Change filter when the indicator is red	---

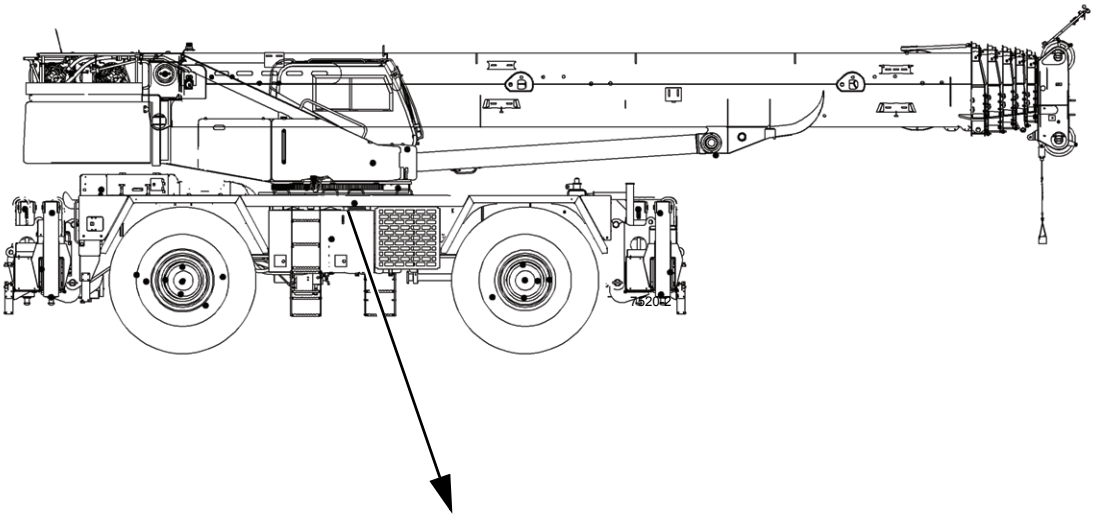
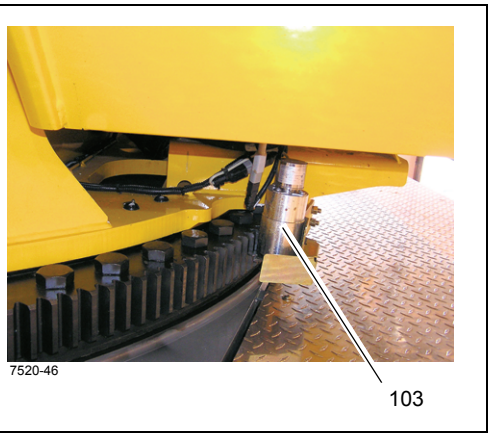


FIGURE 9-6

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Turntable						
100	Swing Drives	Figure 9-7	SGL-5 Synthetic Gear Lube - API GL4+ SAE75W-90 02313611	1.0 qt (0.9 l)	• Check and fill every 50 hours • Drain and fill every 1000 hours or 12 months thereafter.	Fill to level on sight gauge
CAUTION: Do not mix synthetic oil with mineral based oil.						
101	Turntable Gear and Drive Pinion	Figure 9-7	EP-OGL Open Gear Lubricant 6829104478	Coat all teeth	500 hours or 6 months	Spray on
102	Turntable Bearing	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes the whole circumfer-ence of the bearing	500 hours or 6 months	4 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.						
103	Slew Angle Sensor	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	5000 hours or 60 months	1 grease fittings
104	Boom Pivot Pin	Figure 9-7	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	300 hours or 3 months	4 grease fittings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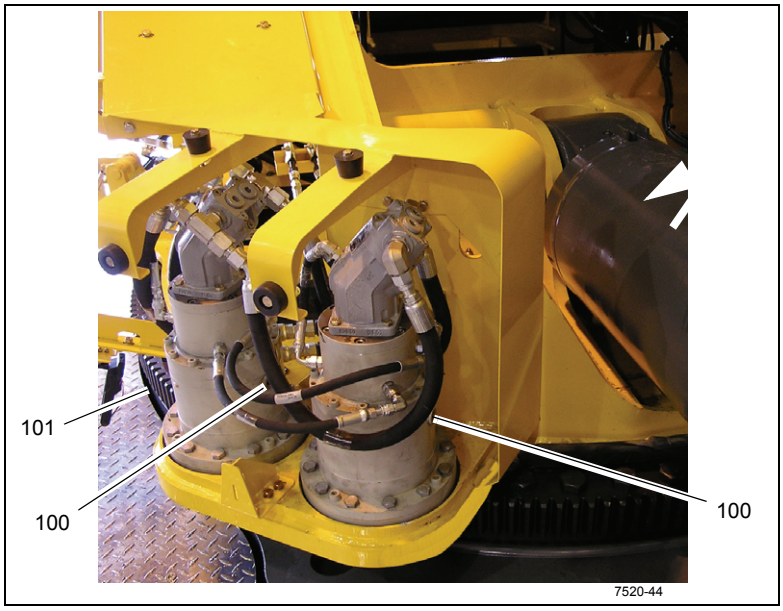
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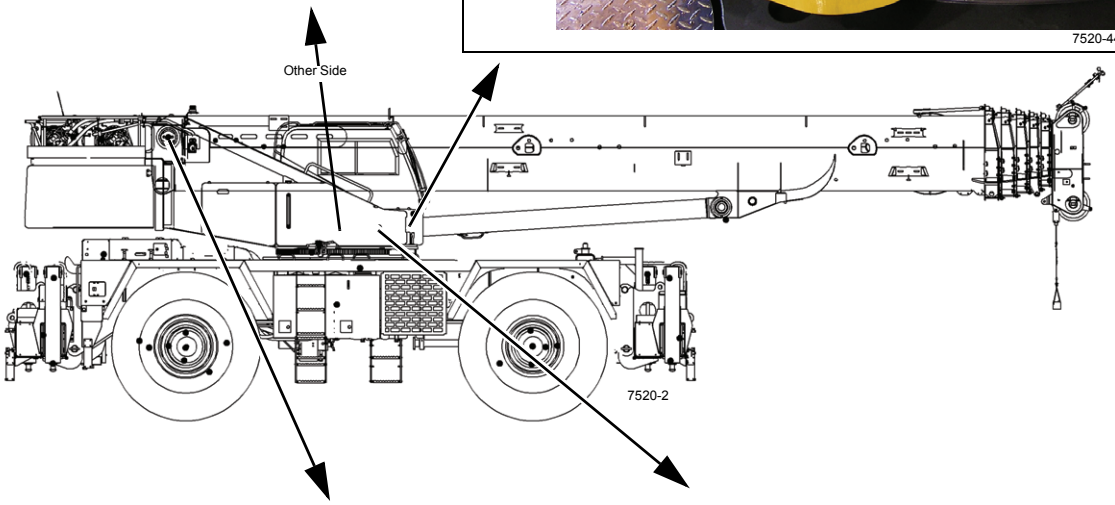
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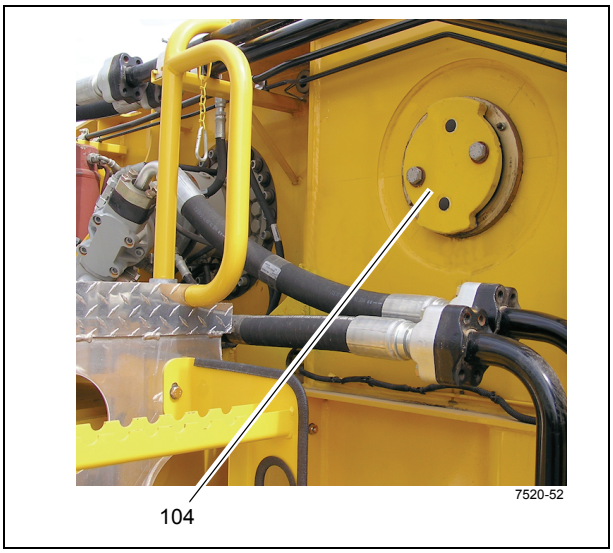
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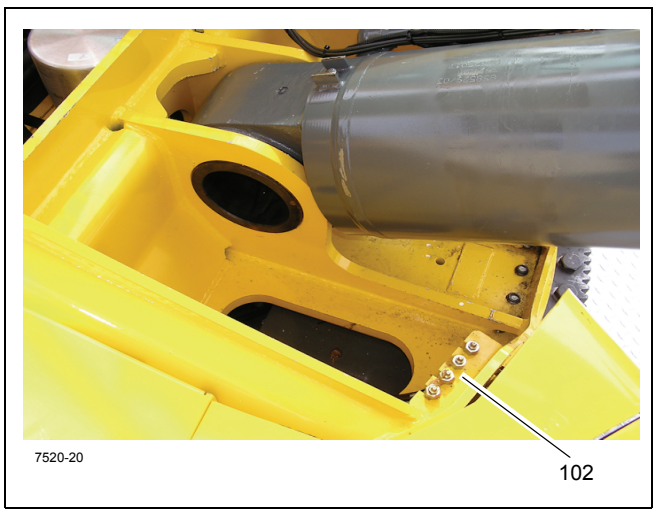
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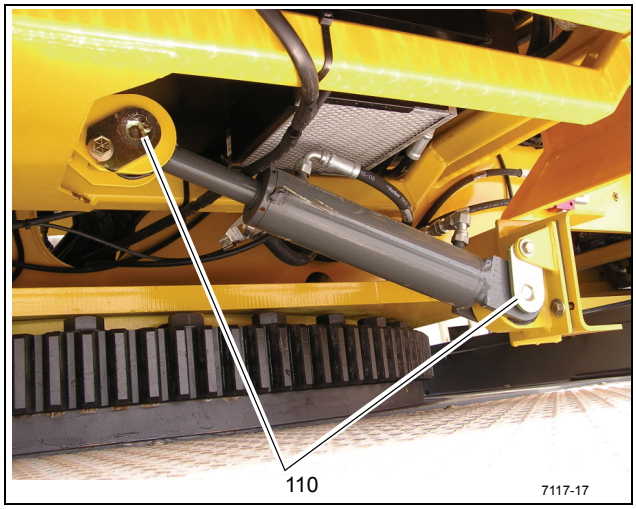
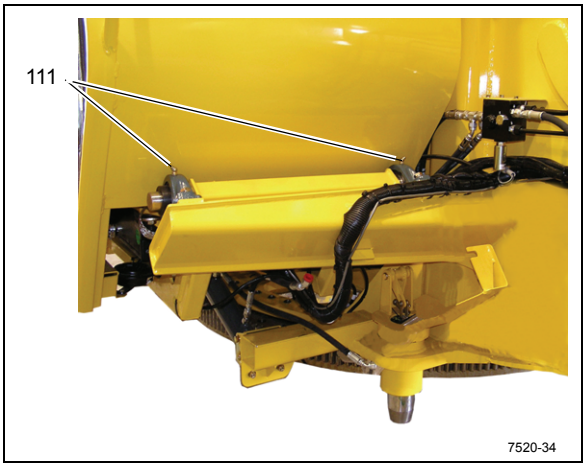
FIGURE 9-7

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Cab Tilt						
110	Cab Tilt Cylinder Pivot Pins	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	500 hours or 3 months	2 grease fittings
111	Cab Tilt Pivot Bearings	Figure 9-8	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	500 hours or 3 months	2 grease fittings





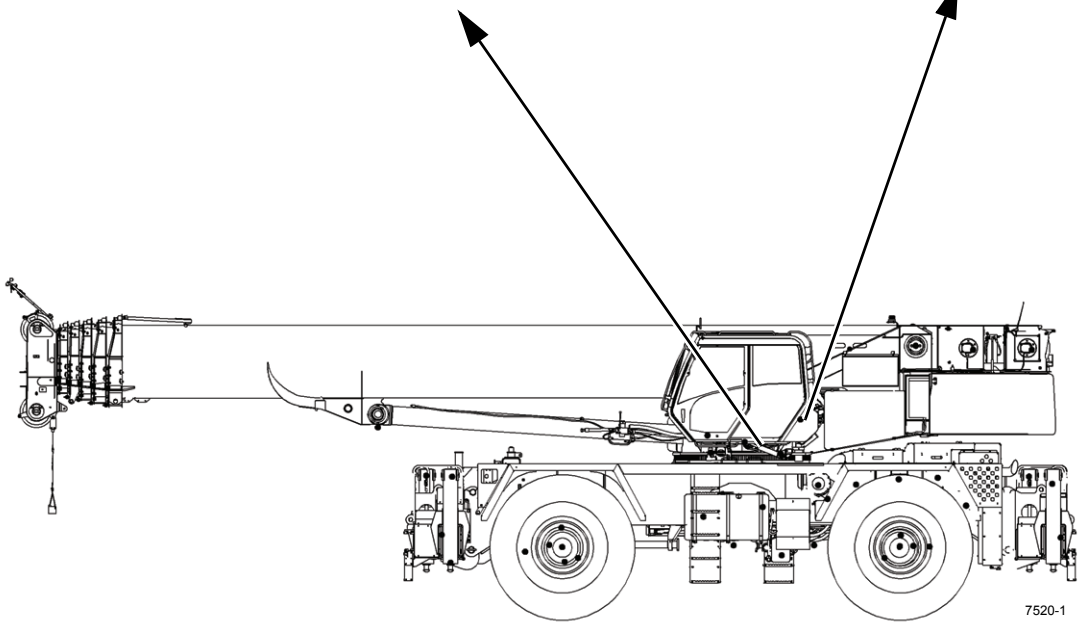
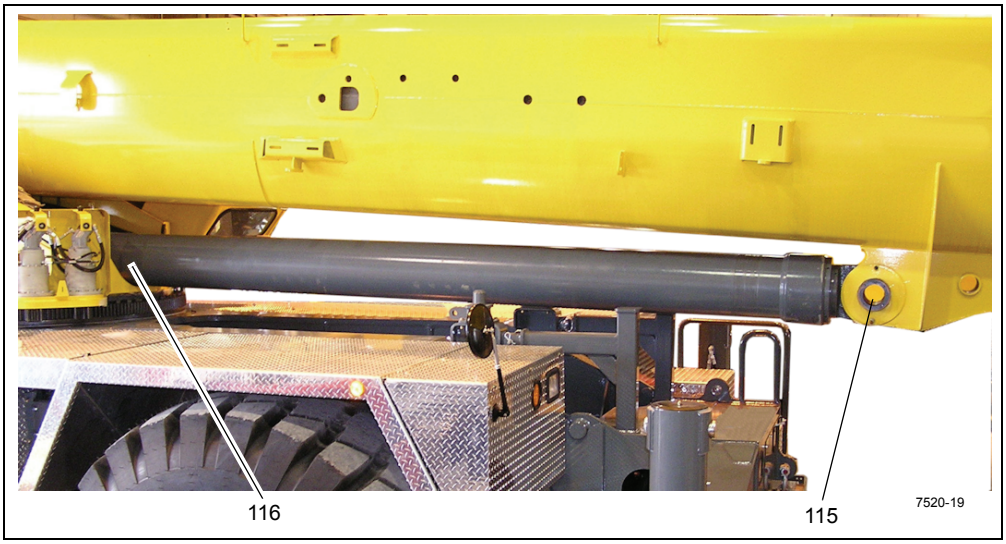


FIGURE 9-8

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Lift Cylinder						
115	Upper Lift Cylinder Pivot Pin	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	100 hours or 1 months	1 grease fitting
116	Lower Lift Cylinder Pivot Pin	Figure 9-9	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	100 hours or1 months	1 grease fitting



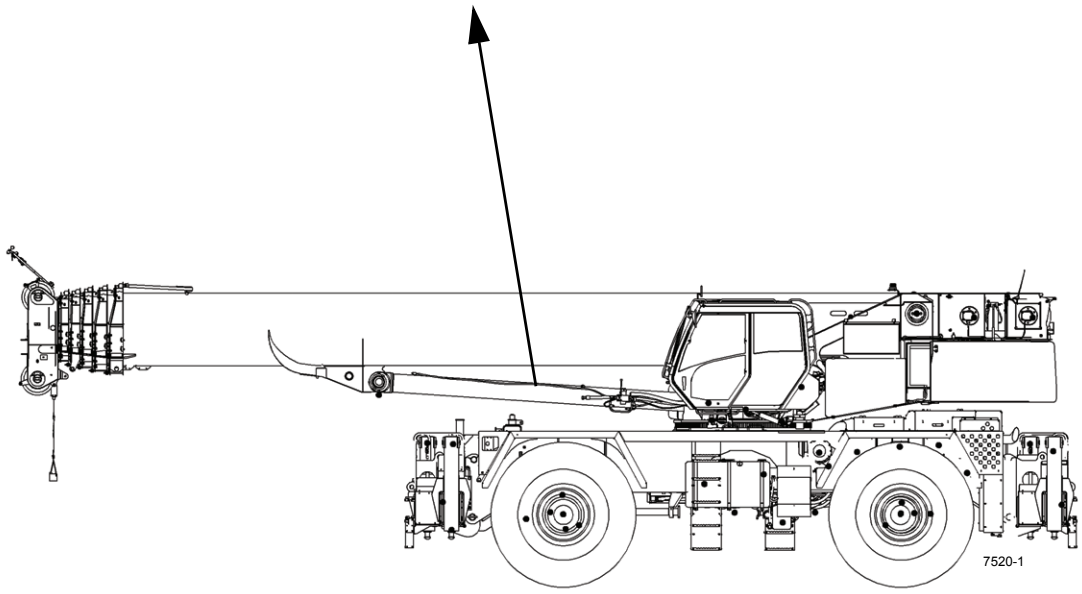
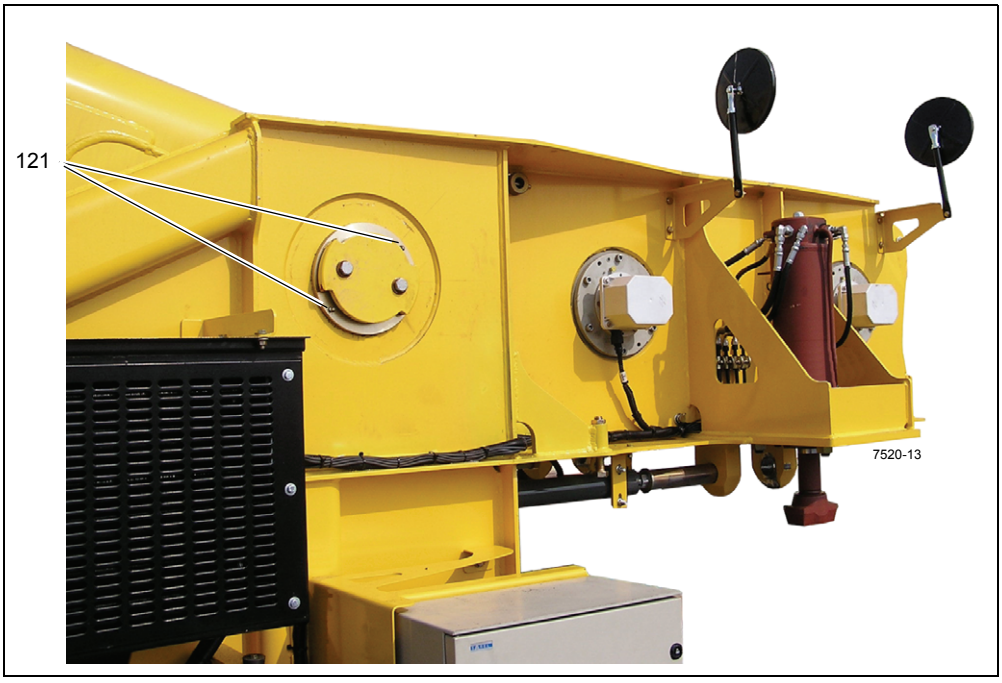
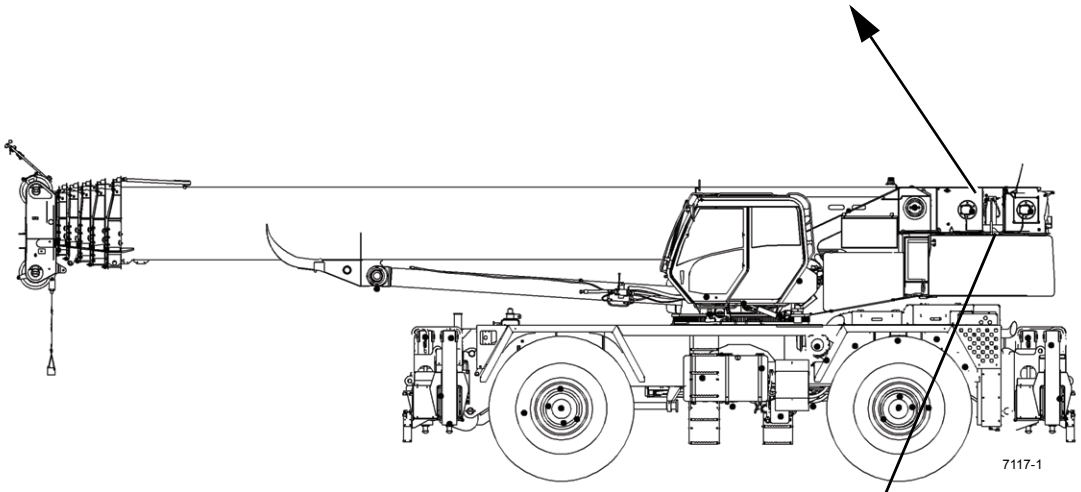


FIGURE 9-9

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Hoist						
120	Hoist Drum	Figure 9-10	SGL Synthetic Gear Lube - API GL4 + SAE 75W-90 02313611	4 qt (4 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
CAUTION: Do not mix synthetic oil with mineral based oil.						
121	Boom Pivot Bearing	Figure 9-10	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	500 hours or 6 months	4 grease fittings, 2 on each side





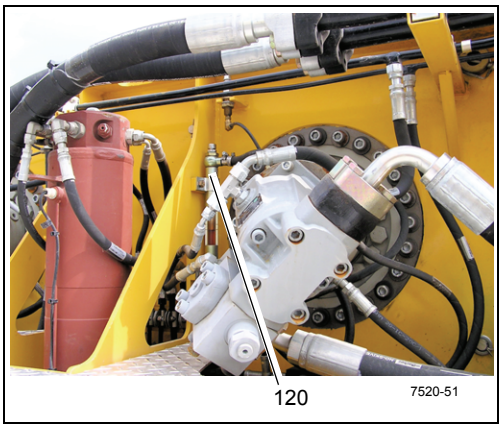


FIGURE 9-10

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom						
130	Telescope Sections - Lower Faces	Figure 9-11	Grease 02310394	Thoroughly coat	300 hours or 3 months	5 places by brush. Refer to Boom Lubrication Procedure.
131	Telescope Sections - Upper Faces	Figure 9-11	Grease 02310394	Thoroughly coat	300 hours or 3 months	10 places by brush. Refer to Boom Lubrication Procedure.

Boom Lubrication Procedure

Telescope Section 1

- Extend telescope section 1 to 100%.
- Using a brush or roller, apply grease to lower slide faces.
- Apply grease to the upper wear pads at fitting (item 131).
- Lubricate locking pins at fitting (item 132).
- Lock and unlock the section to distribute the grease.
- Extend section 1 to 50%
- Apply grease to the upper wear pads at fitting (item 131).

Fully retract section.

Telescope Section 2 - 5

- Extend telescope section 5 to 100% and telescope section 4 to approximately 25%.
- Using a brush or roller, apply grease to the lower slide faces.
- Apply grease to the upper wear pads at fitting (item 131).
- Lubricate locking pins at fitting (item 132).
- Raise the main boom to 15 degrees.
- Retract telescope section 4 to 0% and telescope section 5 to approximately 50%.
- Lock and unlock telescope section 5 several times to distribute the grease.
- Lower the main boom to 0 degrees. Do not lower less than 0 degrees.
- Extend telescope section 4 to approximately 75%.
- Apply grease to the upper wear pads at fitting (item 131)
- Raise the main boom to 15 degrees.
- Retract telescope sections 4 and 5 to 0%,
- Fully extend and retract telescope section 5 to distribute the grease.
- Lower the main boom to 0 degrees.
- Lubricate telescope sections 2, 3 and 4 in the same method.

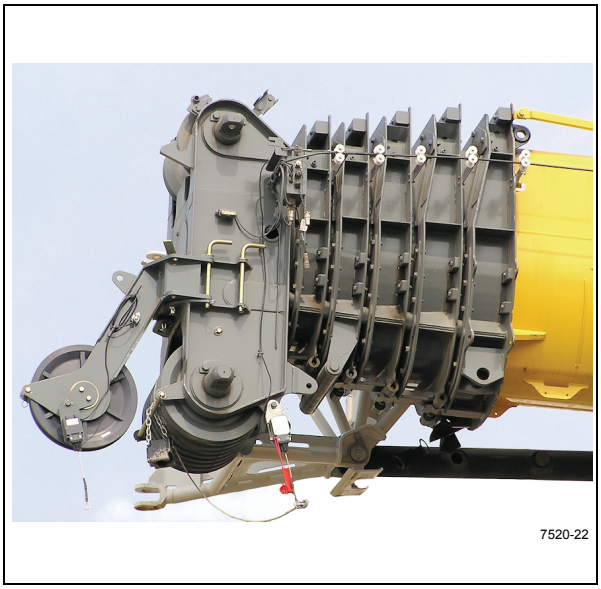
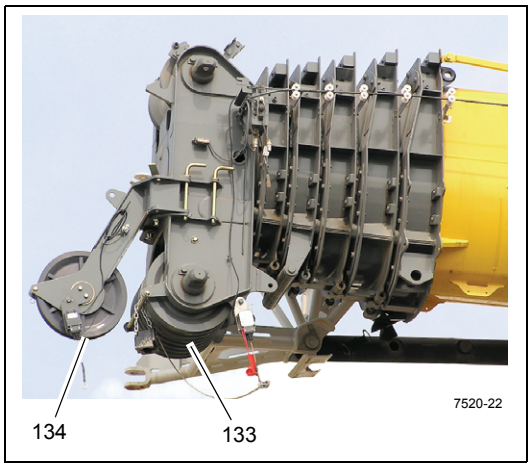
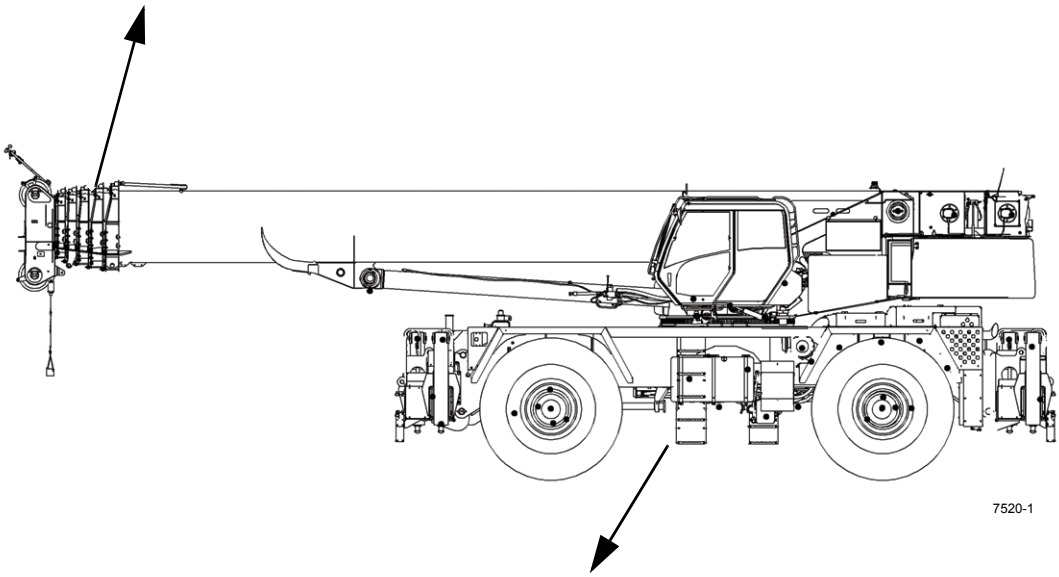


FIGURE 9-11

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom (continued)						
132	Locking Pins	Figure 9-12	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	300 hours or 3 months	Refer to Boom Lubrication Procedure on page 26.
133	Boom Nose Sheaves	Figure 9-12	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	---	Apply grease at assembly and/or teardown	10 service points
134	Auxiliary Boom Nose Sheave	Figure 9-12	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	1 grease fitting





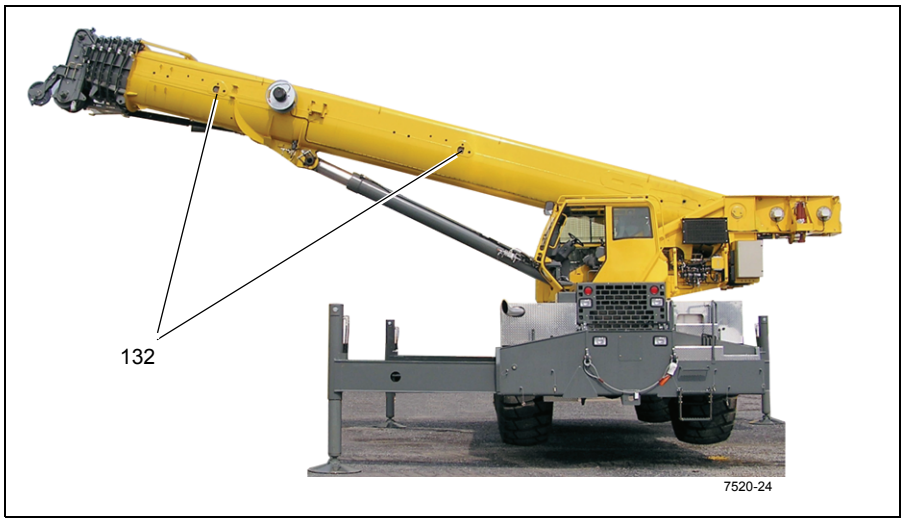
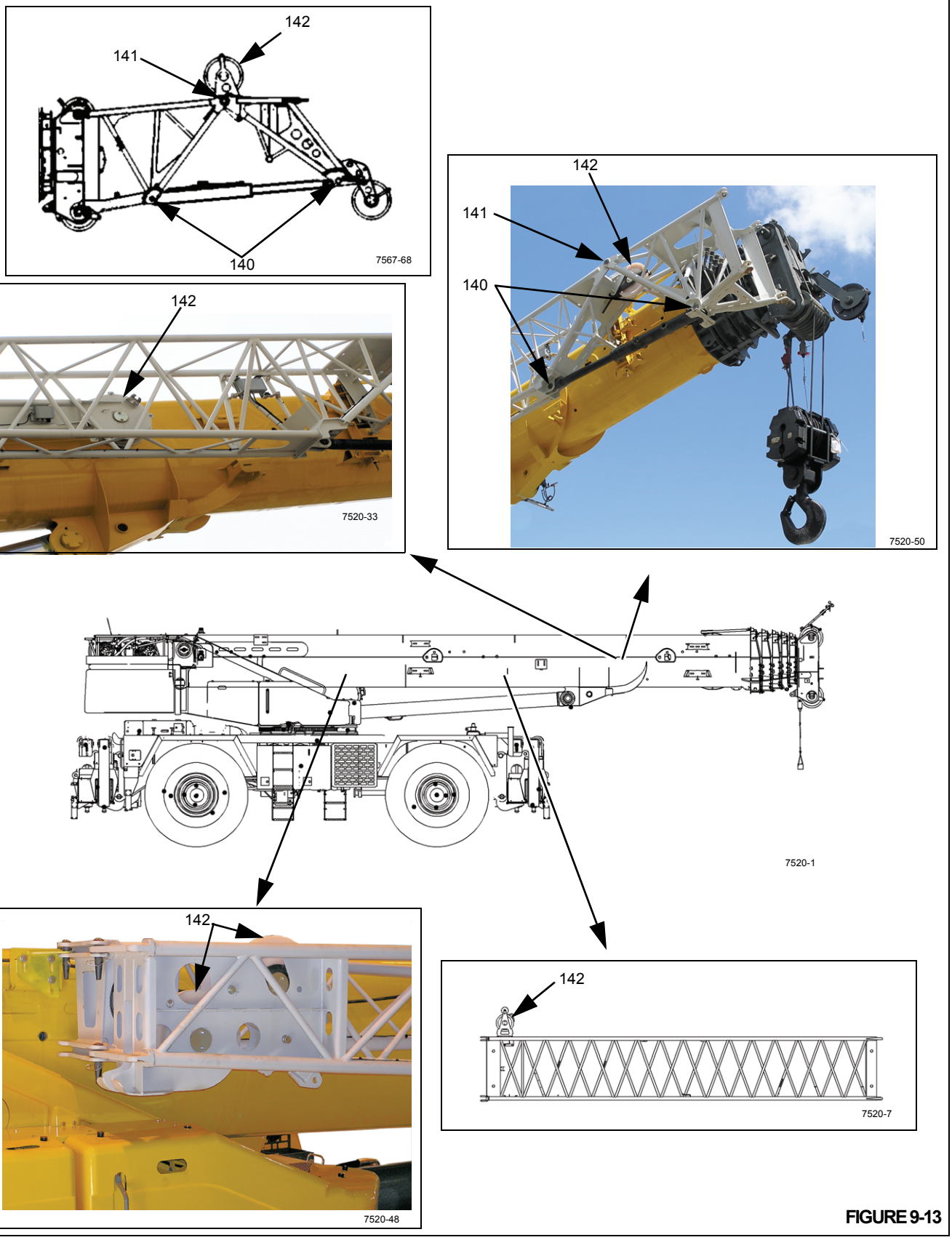


FIGURE 9-12

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom Extension						
140	Luffing Cylinder/ Adjustment Pivot Pins	Figure 9-13	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	2 grease fittings
141	Luffing Extension Pivot Pins	Figure 9-13	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	2 grease fittings
142	Extension Sheaves	Figure 9-13	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	1 grease fitting per sheave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7567-68
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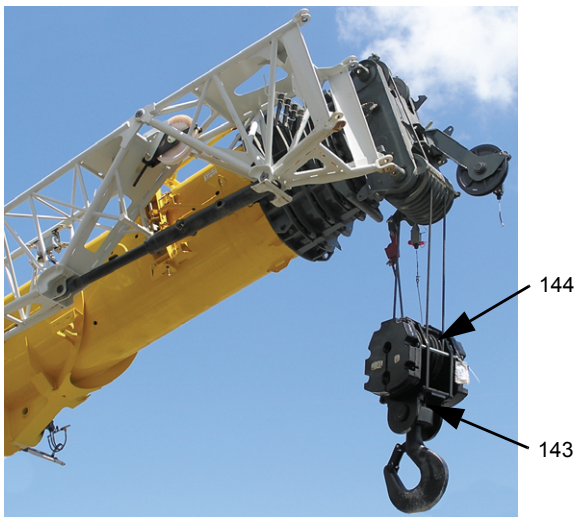
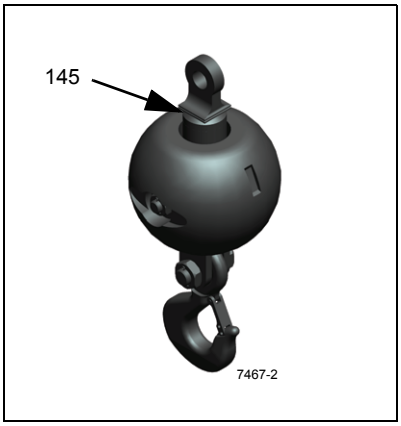
141
140
7520-50
142
7520-33
7520-1
142
7520-48
142
7520-7

FIGURE 9-13

9

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Boom						
143	Hook Block Swivel Bearing	Figure 9-14	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	1 grease fitting
144	Hook Block Sheaves	Figure 9-14	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	1 grease fitting per sheave
145	Headache Ball	Figure 9-14	EP-MPG Extreme Pressure Multipurpose Grease 6829003477 6829104275	Until grease extrudes	250 hours or 3 months	1 grease fitting





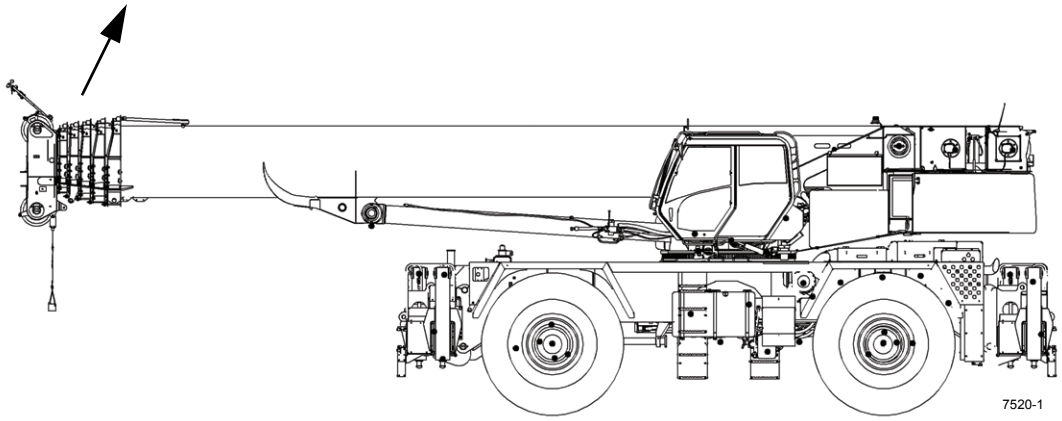


FIGURE 9-14

CARWELL® RUST INHIBITOR

Description

Manitowoc Crane's are manufactured to the highest quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, Grove is dedicated to help prevent premature corrosion of its cranes.

Grove cranes are treated with Carwell® T32-CP-90 rust inhibitor. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes when 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 indicate coverage during application. This red tint will turn clear within approximately 24 hours after application.

Once applied, the 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 fluid leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it can be removed using standard steam-cleaning techniques.

This treatment works in various ways:

- It eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface;
- The film creates a barrier to repel further moisture from coming into contact with the metal;
- It penetrates crevices.

In addition to this 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 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;
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleanings if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness—especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain crane parts may become corroded even though other parts remain dry; or
- in high humidity, or when temperatures are just above the freezing point.

Cleaning Procedures

To help protect against corrosion of Grove cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleanings may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

Equipment Damage Hazard!

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, sealed bearings, 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 strong 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

Structural Damage Hazard!

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 Manitowoc paint 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 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.

Carwell 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 onto the crane.
- Use of pressure paint pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 9-15.

- The underside of the crane should have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; valves, hose ends and fittings, swivel, pumps, axles, drivelines, transmission, slew ring gear fasteners and all interior surfaces of the frame.

- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope, hoist rollers, tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring gear fasteners and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, and hose connections not painted should have treatment applied.

FIGURE 9-15

Item	Description
1	O/R Hose Connections
2	Counterweight Removal Hoses
3	Hoist Tension Springs
4	Mirror Mounting Hardware
5	Hoist Hose Connections
6	Powertrain Hardware (Inside Compartment)
7	Valve Bank
8	Boom Extension Pins, Clips
9	Hose Connections inside turntable
10	Lift Cylinder Pivot Shafts
11	Boom Extension Hanger Hardware

Item	Description
12	Boom Nose Pins, Clips
13	O/R Pins, Clips
14	Hook block Tiedown Cable
15	O/R Beam Wear Pad Adjustment Hardware
16	Hook Block\Headache Ball
17	Entire underside of unit
18	Turntable Bearing Fasteners
19	All Hardware, Clips, Pins, Hose Connections not painted, O/R Pins, Clips
20	Wire Rope
21	Counterweight Mounting Hardware
22	Hose Connections

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