Grove TMS700E

Service/Maintenance Manual

Grove Manitowoc National Crane Potain

WARNING

California Proposition 65

Breathing diesel engine exhaust exposes you to chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

- Always start and operate the engine in a well-ventilated area.
- If in an enclosed area, vent the exhaust to the outside.
- Do not modify or tamper with the exhaust system.
- Do not idle the engine except as necessary.

For more information, go to www.P65warnings.ca.gov/diesel

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

California Spark Arrestor

Operation of this equipment may create sparks that can start fires around dry vegetation. A spark arrestor may be required. The owner/operator should contact local fire agencies for laws or regulations relating to fire prevention requirements.

The original language of this publication is English.

Manitowoc Cranes
1565 Buchanan Trail East PO Box 21
Shady Grove, PA 17256-0021
T 717 597 8121 F 717 593 5999
www.manitowoc.com

X Information Only

Service Manual Supplement

Date
Month/day/year

To:
Mobile Crane Distributor Service Managers
Mobile Crane Field Support Personnel

Subject:
Suspension Alignment Supplement; **Rev 2**

Model(s) Affected:
TMS700E, TMS800E, & TMS9000-2

PURPOSE: To provide guidance for issues related to tire wear, suspension and/or steering performance.

RECOMMENDED PROCEDURE FOR REPAIRING TIRE WEAR, SUSPENSION, AND/OR STEERING PERFORMANCE ISSUES: Have a qualified alignment specialist inspect the machine for compliance with the following machine specifications:

- **Tire pressure (front & rear): 130 psi**
  (If experiencing tire wear due to over-inflation contact Crane Care for alternate tire inflation solutions.)
- **Tire/Wheel lateral & radial run-out: 0.060” maximum**
  Note: For Runout Tolerances Use the 30/60/90 Rule
  0.000" - 0.030": Excellent
  0.031" - 0.060": Good
  0.061" - 0.090": Use 3R’s - Rotate tire 180 degrees
  - Re-lubricate tire and wheel
  - Re-inflate with tire laying flat (5 psi. max)
  0.091" - Higher: Inspect all wheel end components
- **Ride Height–both tandems: 1.80° open +/- 0.50°; max. 0.50° difference on any one tandem.**
- **Steer and Drive axles offset: 0.00” +/- 0.19”**
- **Steer and Drive axles parallelism: 0.00” +/- 0.13”**
- **Drive tandem thrust: 0.75” maximum**
- **Steer axles toe: +0.03” +/- 0.03”**
- **Steer axle wheel ends caster: 3.00° +/- 0.50°**
- **Steer axle wheel ends camber: +0.06° +/- 0.19° (not adjustable)**

ALTERNATIVE PROCEDURE: To enable a customer's service department to make axle and front-end alignment adjustments when suspension, tire, and/or steering performance is poor:

STEP 1. When an issue with tire, suspension, and/or steering performance is identified, the customer should fill out a "Field Alignment Worksheet" (attached to this document) and submit it to Crane Care for evaluation and instruction.

STEP 2. Crane Care will evaluate the worksheet and provide a list of adjustments that are required.

STEP 3. The customer's service department will make the required adjustments per the instructions on the following pages and test the machine to validate improved performance. Test results should be submitted to Crane Care.

FIELD ALIGNMENT INSTRUCTIONS: **Instructions for each adjustment are on the following pages. Crane Care to check-mark those that are required:**

- [X] **Machine Preparation.**
- [ ] **Inflate tire to 130 psi. Position/s:** ______
- [ ] **Breakdown and re-mount tire/wheel assy. Position/s:** ______ **Re-check axial & radial run-out.**
- [ ] **Adjust axle offset. Position/s:** ______
- [ ] **Adjust steer axle skew.**
- [ ] **Adjust steer axle parallelism.**
- [ ] **Adjust steering linkage.**
- [ ] **Adjust steer axle turning stops.**
- [ ] **Adjust steer wheel-end caster. Position/s:** ______
- [ ] **Steer wheel-end camber is not adjustable. Crane Care is to advise remedy.**
- [ ] **Adjust steer wheel-end toe. Position/s:** ______
- [ ] **Adjust drive axle thrust.**
- [ ] **Adjust drive axle parallelism.**
- [X] **Test and report result to Manitowoc Crane Care.**

Tools (other than miscellaneous wrenches):

Camber/Caster alignment tool (if available)	**Dial Indicator/s**
Thrust alignment tool (if available)	**4 foot level or straight edge**
Trammel bar (if available)	**Can of white spray paint**
Toe bar	**Tire Scribe**
(4) Alignment turntables	**(2) Wheel chocks**
Digital angle gauge/s	**(2) Ø21/64” (0.8mm) rig pin or drill**
Tape measure (1/32” graduations)	**Tape measure (1 mm graduations)**
Porta-power (if available)	**Laser pointer w/mtg for 22.5” wheel**
Air pressure >130 psi	**Air hose with chuck**

Machine Preparation:

NOTE: Alignments should be performed on a level surface. Height of tire patches should be within 1/8" of each other.

- **For field alignment configure the machine in the most common roading condition and inflate all tires to 130 psi.**
- **Drive vehicle straight into inspection site, at least 3 full tire rotations to ensure it's straight into site. Driving into and backing out of the work area several times will ensure the vehicle's suspension components remain relaxed to achieve proper measurements.**
- **For final positioning, shift transmission to neutral and allow vehicle to roll forward to a stop without using the brakes.**
- **Engage parking brake**. *(Note: Outriggers do not function unless park brake is engaged.)*

Machine Preparation continued:

- **Adjust ride height - front and rear.**

  Note: When setting ride height and measuring alignment settings be certain that the air system is at full system pressure; re-charge frequently.

  - **Place wheel chocks on drive axles and release the park brake.**
  - **Place a calibrated digital angle gauge on the flat surface of the trailing arm and adjust the ride height valve to achieve a 1.8° +/-0.5° angle, open to the rear. Repeat the process on all four tandems and maintain a 0.5° tolerance between left and right on the same tandem.**

  Note: Calibrate/zero digital angle gauges to the bottom frame rail, positioned in the same orientation that each is being applied on the suspension.

- **Prepare for toe adjustment if it is required:**
  - **Raise the machine on outriggers until the tires are just off the ground.**
  - **Prepare the steer tires for toe measurement by highlighting (white spray paint) a section/row of tread around each tire and scribing a line into the highlight around the tires as they are rotated.**

  - **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

Adjust axle offset.

- **Measure the distance between the frame side plate to the edge of the tire tread <u>centered over the axle</u>, left and right; these measurements should be within 3/16 in. (4.8 mm).**

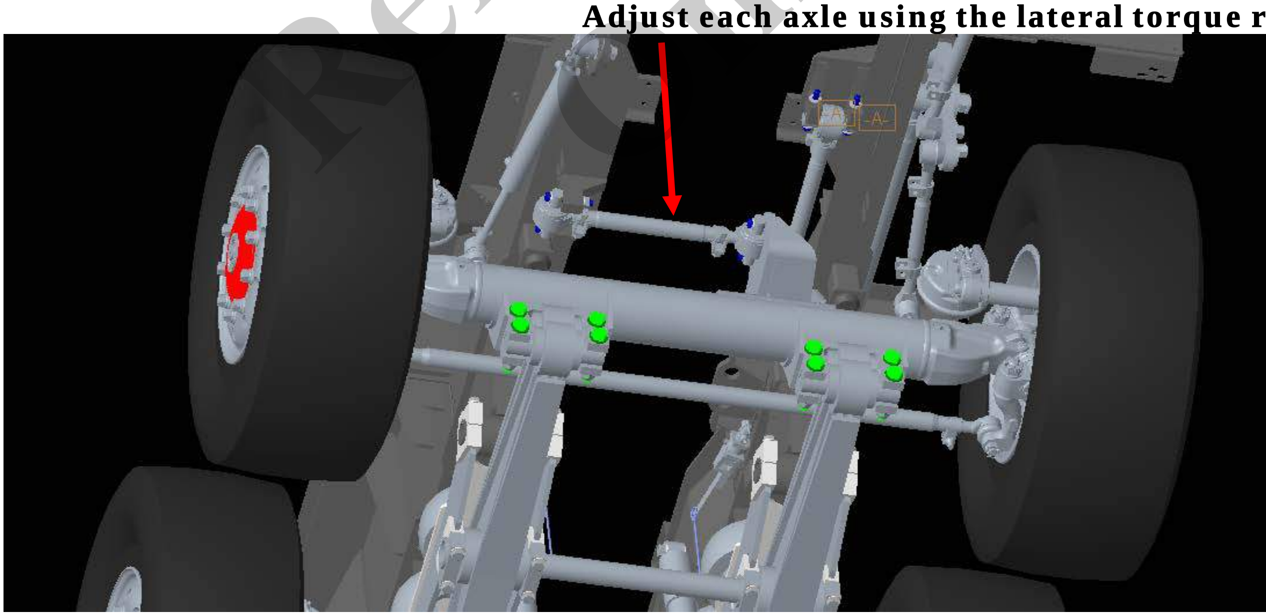
Note: steering axle and drive axle measurements will be different; axle lengths and frame widths are different.

Measure to edge of tread

- **Adjust side to side using lateral torque rods. Re-torque bolts 2 to 3 turns into the locking feature of the nut.**

Note: Machine should be on outriggers to perform this adjustment.

Adjust each axle using the lateral torque rod.



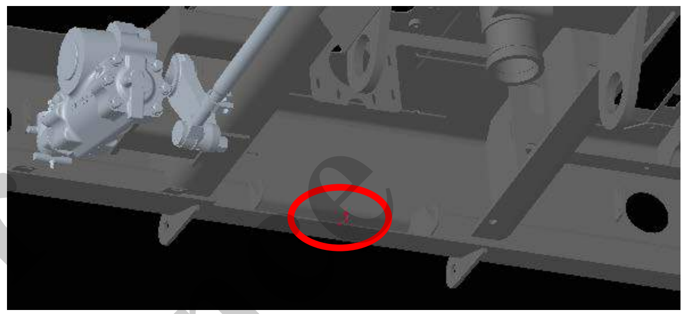
- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

Adjust steer axle skew.

- **Raise the machine on outriggers and place an alignment turntable under each of the steer tires. Lower the machine making certain not to bottom-out the turntables or put them in a bind.**

- **Measure the distance between the "center hook" on the frame to the corner of the front steer axle mount, left and right; each axle's left and right measurements should be within 3/16 in. (4.8 mm) of the other.**

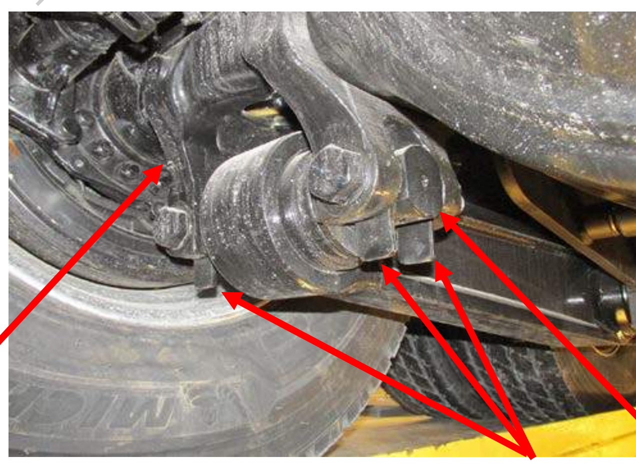
#1 axle



Center hook location

- **Adjust axle mounting shims to achieve squareness. Reposition the shim/s to the front of the bar pin to move the axle forward, or to the back of the bar pin to move the axle toward the rear. Slight adjustments might be achieved by adjusting shims on one side of the axle. Larger adjustments will be achieved by adjusting both sides in opposite directions. Re-torque hardware to 450-600 lbf*lb. (610-813 N*m).**

  Note: Raise the machine on outriggers to take weight off the suspension in order to reposition the mounting shims. A Porta Power can be used to support the suspension. Be sure to lift the outriggers and put full weight on the suspension prior to taking subsequent measurements.



Bar pin

Measure to outside edge of mounts **Shims**

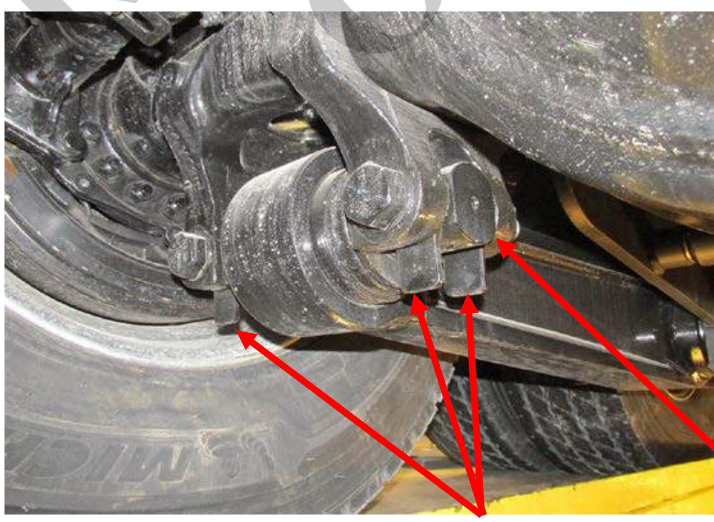
- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

Adjust steer axle parallelism.

- **Distance between the steer axle hub centers on the left and right side of the machine should be within 1/8 in. (3.2 mm). This can be measured, or the process can be simplified by use of a Trammel bar if available.**

- **Adjust rear steer axle mounting shims to achieve parallelism. Reposition the shim/s to the front of the bar pin to move the axle forward, or to the back of the bar pin to move the axle toward the rear. Slight adjustments might be achieved by adjusting shims on one side of the axle. Larger adjustments will be achieved by adjusting both sides in opposite directions. Re-torque hardware to 450-600 lbf*ft. (610-813 N*m).**

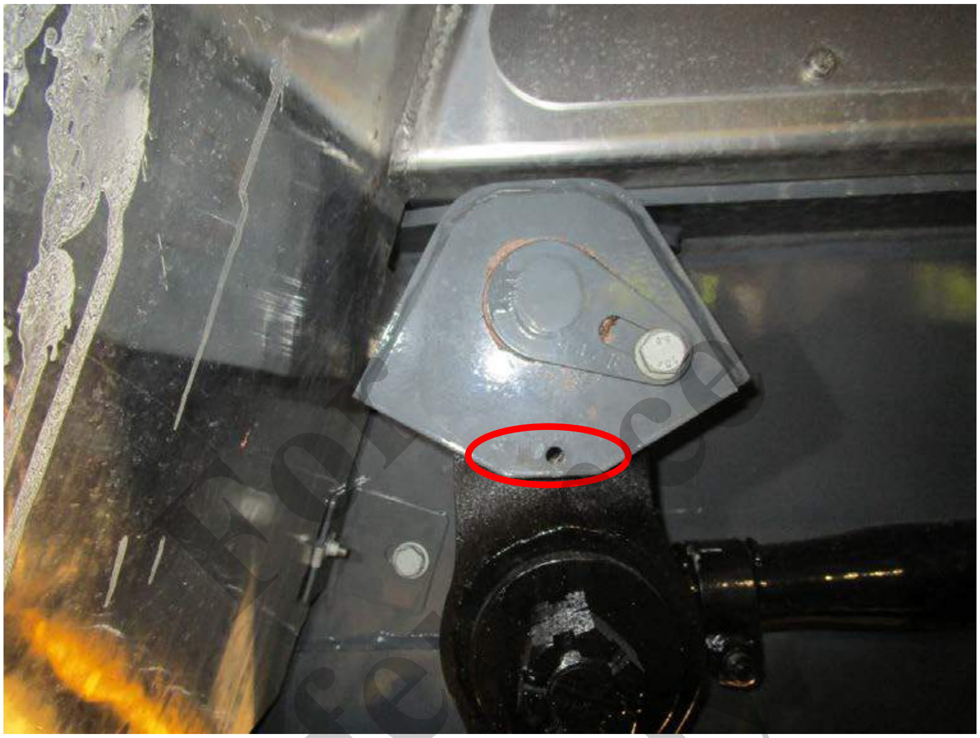
Note: Raise the machine on outriggers to take weight off the suspension in order to reposition the mounting shims. A Porta Power can be used to support the suspension. Be sure to lift the outriggers and put full weight on the suspension prior to taking subsequent measurements.



- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

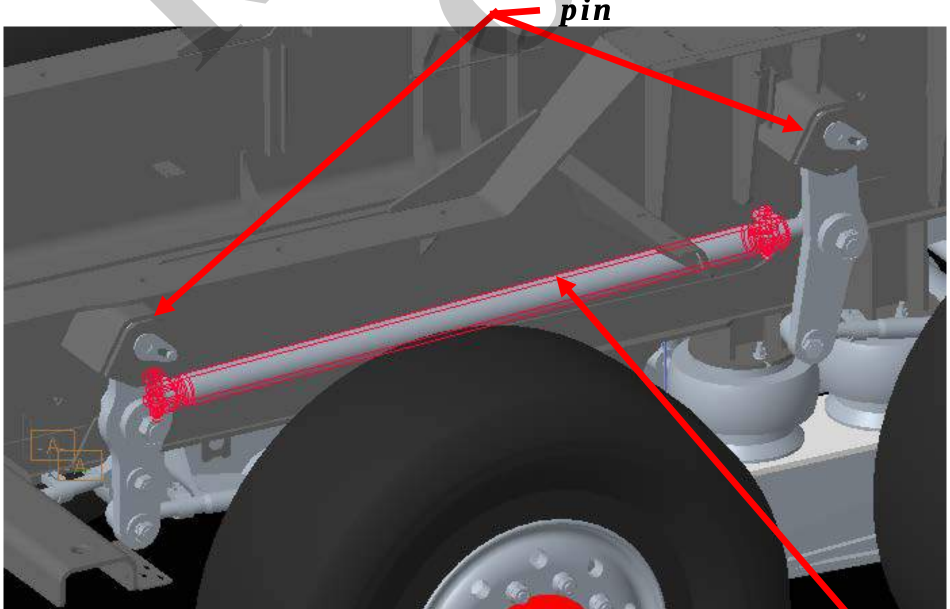
Adjust steering linkage.

- **Rotate the steering wheel to center the front relay arm and pin it with a Ø 21/64 in. (0.8 mm) rig pin or drill bit.**



- **Adjust the intermediate drag link to center the rear relay arm and pin it with a Ø 21/64 in. (0.8 mm) rig pin or drill bit. Apply Loctite 243 to clamp bolts and re-torque to 110-130 lbf*ft. (149-176 N*m).**

pin



Adjust intermediate drag link

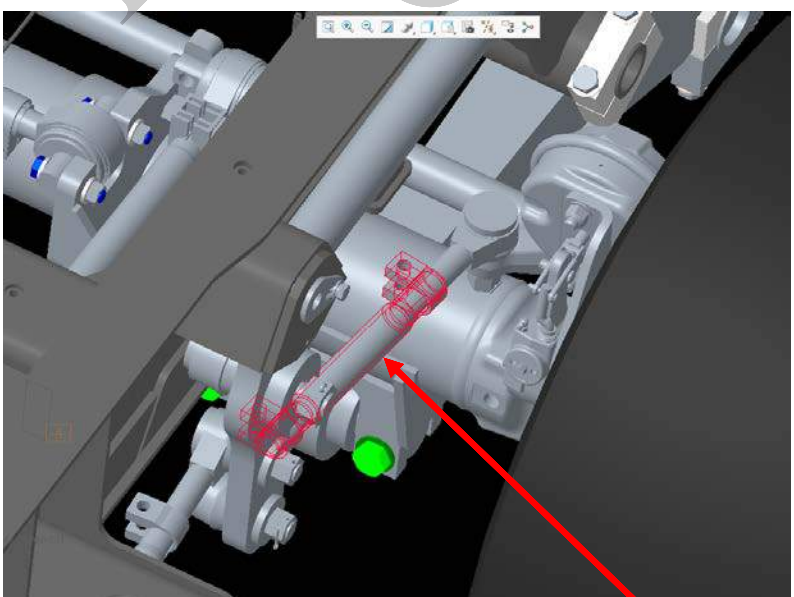
Driver side front steer axle.

Adjust steering linkage continued.

Note: Steer tires should be on alignment turntables for this step.

- **Adjust the front steer axle to "straight ahead."**
    - **Using a 4 ft. (1.2 meter) or longer straight edge measure the <u>front steer axle</u> driver's side tire, front and rear, to the frame side plate.**

-
    - **Adjust <u>front steer axle</u> drag link until front and rear measurements are equal. Apply Loctite 243 to clamp bolts and re-torque to 50-60 lbf*ft. (68-81 N*m).**

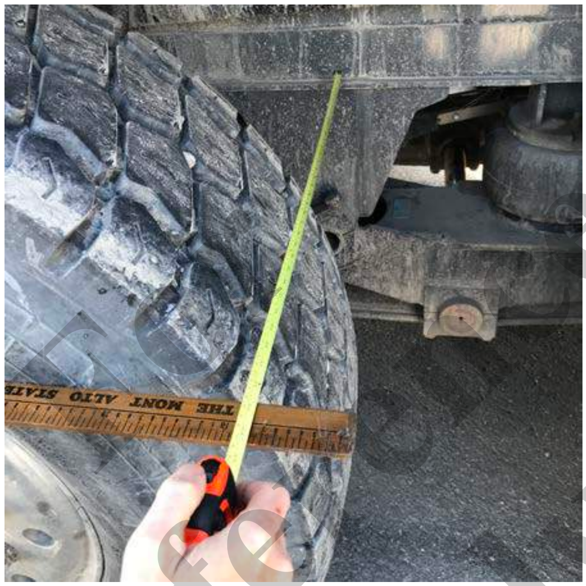


Front steer axle drag link

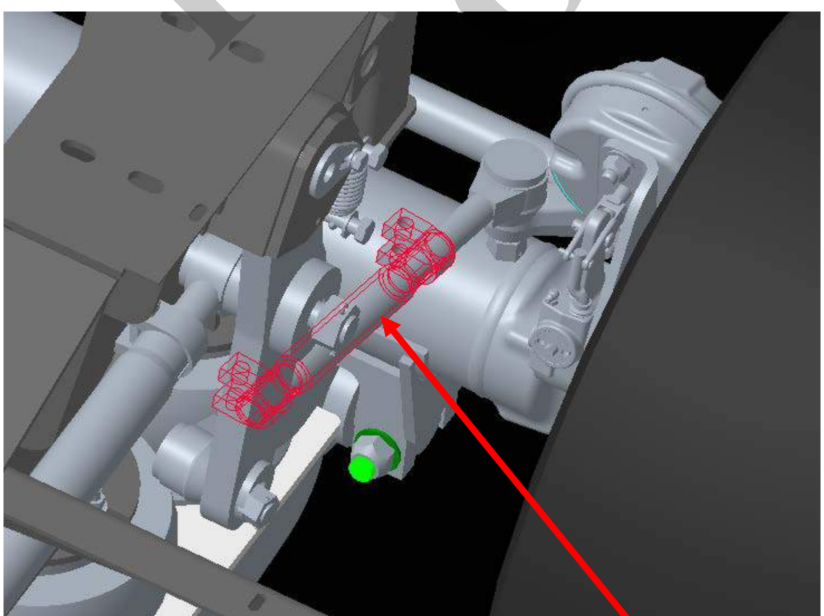
Adjust steering linkage continued.

Note: Steer tires should be on alignment turntables for this step.

- **Adjust rear steer axle to "straight ahead."**
  - **Using a 4 ft. (1.2 m) or longer straight edge measure <u>rear steer axle</u> driver side tire, front and rear, to the frame side plate.**



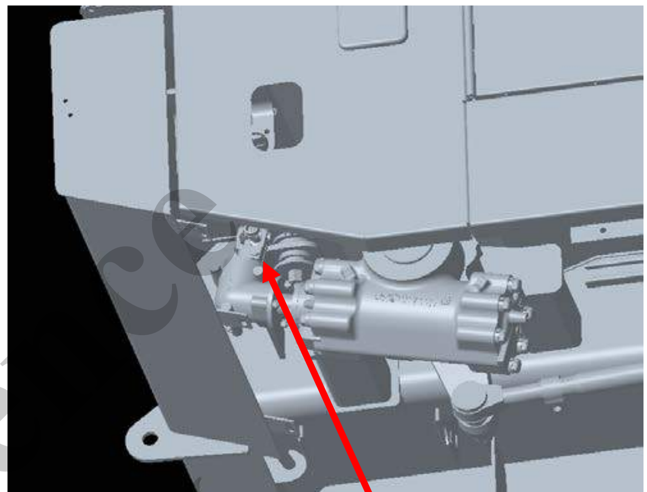
  - **Adjust <u>rear steer axle</u> drag link until front and rear measurements are equal. Apply Loctite 243 to clamp bolts and re-torque to 110-130 lbf*ft. (149-176 N*m).**



Rear steer axle #2 drag link

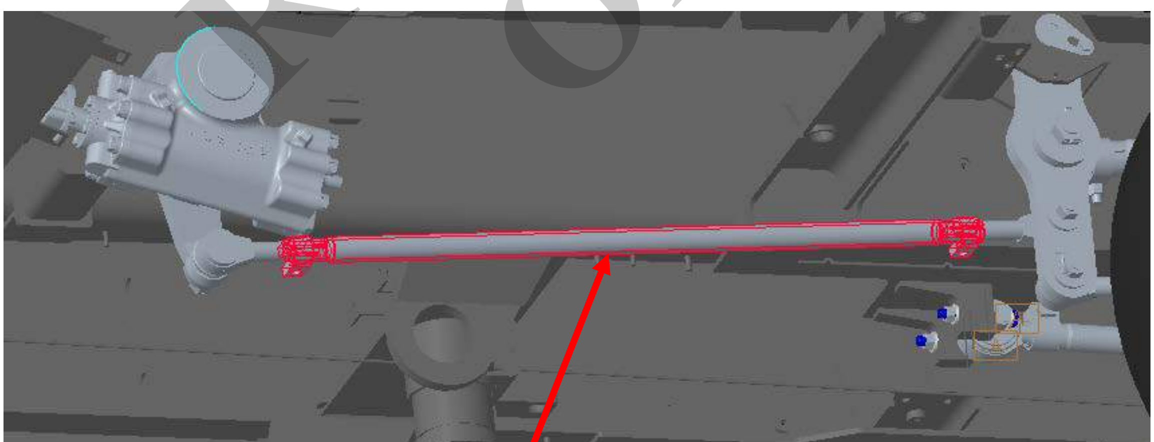
Adjust steering linkage continued.

- **Adjust steering wheel orientation.**
    - **For major adjustments of the steering wheel, loosen the bolt on the steering column splined coupling, slide the coupling off the steering gear 90° Miter and rotate until the steering wheel is straight ahead. Slide the coupling back onto the Miter and retighten the bolt.**



Splined coupling

- **For minor/fine adjustment of the steering wheel loosen the clamp bolts and rotate the steering link to orient the steering wheel straight ahead. Apply Loctite 243 to clamp bolts and re-torque to 50-60 lbf*ft. (68-81 N*m).**



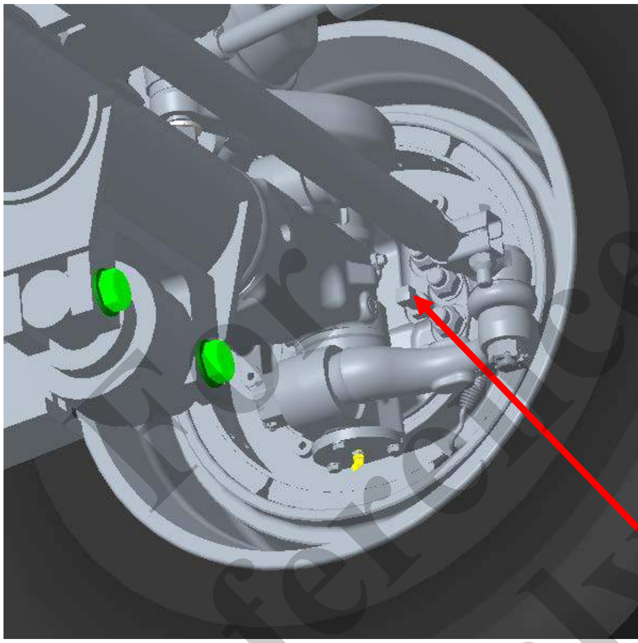
Steering link

- **Remove rig pins from relay arms.**

Adjust steer axle turning stops.

- **Steering stops should be set to provide 1.00 in. (25.4 mm) of clearance to closest object for any tire.**

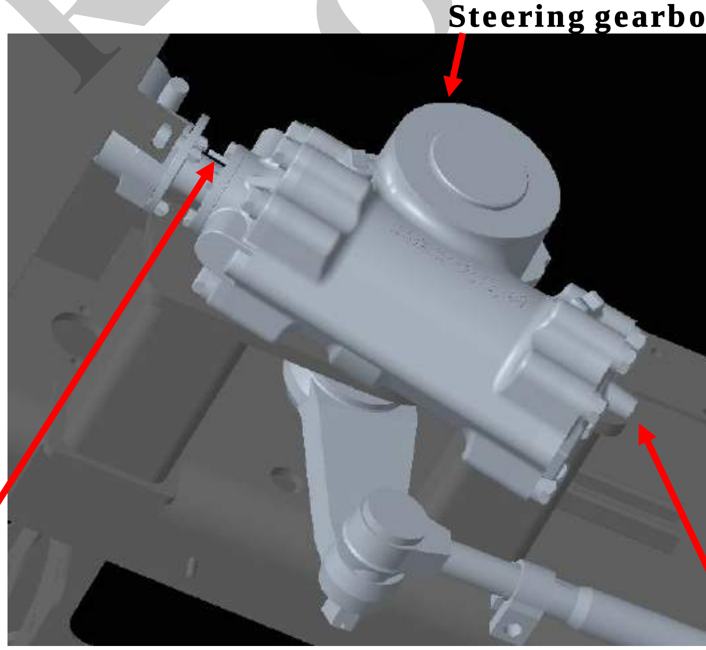
Note: steering stops are located on the front steer axle only.
Note: steer tires should still be on alignment turntables for this step.



Steering stop

- **Steering gearbox relief plungers should actuate 1/16 in. (1.6 mm) prior to contact with steering stops.**

Steering gearbox



Left turn relief
Screw in to decrease travel
Screw out to increase travel

Right turn relief
Screw in to decrease travel
Screw out to increase travel

Adjust steer wheel-end caster.

Caster should be positive 3.0° +/-0.5°.

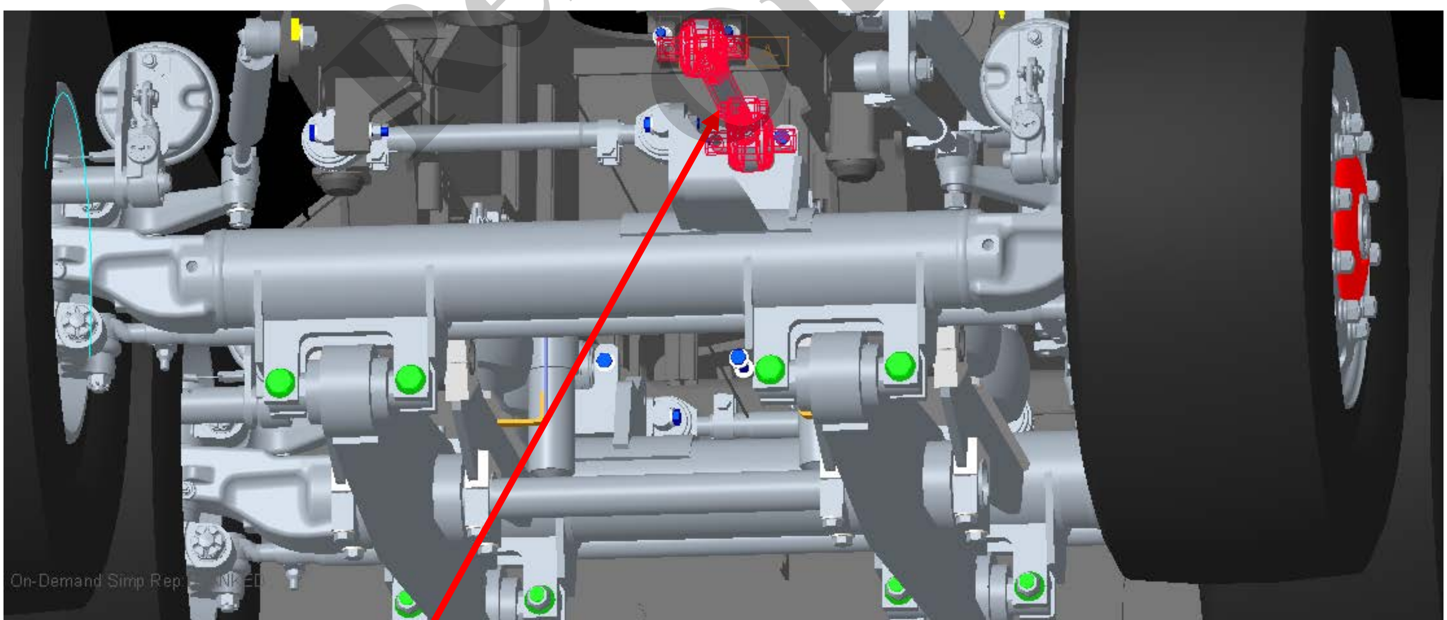
Note: Steer tires should be on alignment turntables for this step.

- **Use professional alignment caster tool if available, otherwise place a digital angle gauge, calibrated/zeroed to the bottom frame rail, on the bottom of the king pin housing, longitudinally.**

Caster gauge

Digital angle gauge

- **Adjust the longitudinal torque rods to achieve this. Re-torque clamp bolts to 2 to 3 turns into the locking feature of the nut.**



Adjust longitudinal torque rod

Steer wheel-end camber is not adjustable.

- **Camber should be 1/16° +/- 3/16°; if camber is out of tolerance it's a sign of a part defect, wear, or improper installation. Manitowoc Crane Care will provide direction.**

Adjust steer wheel-end toe.

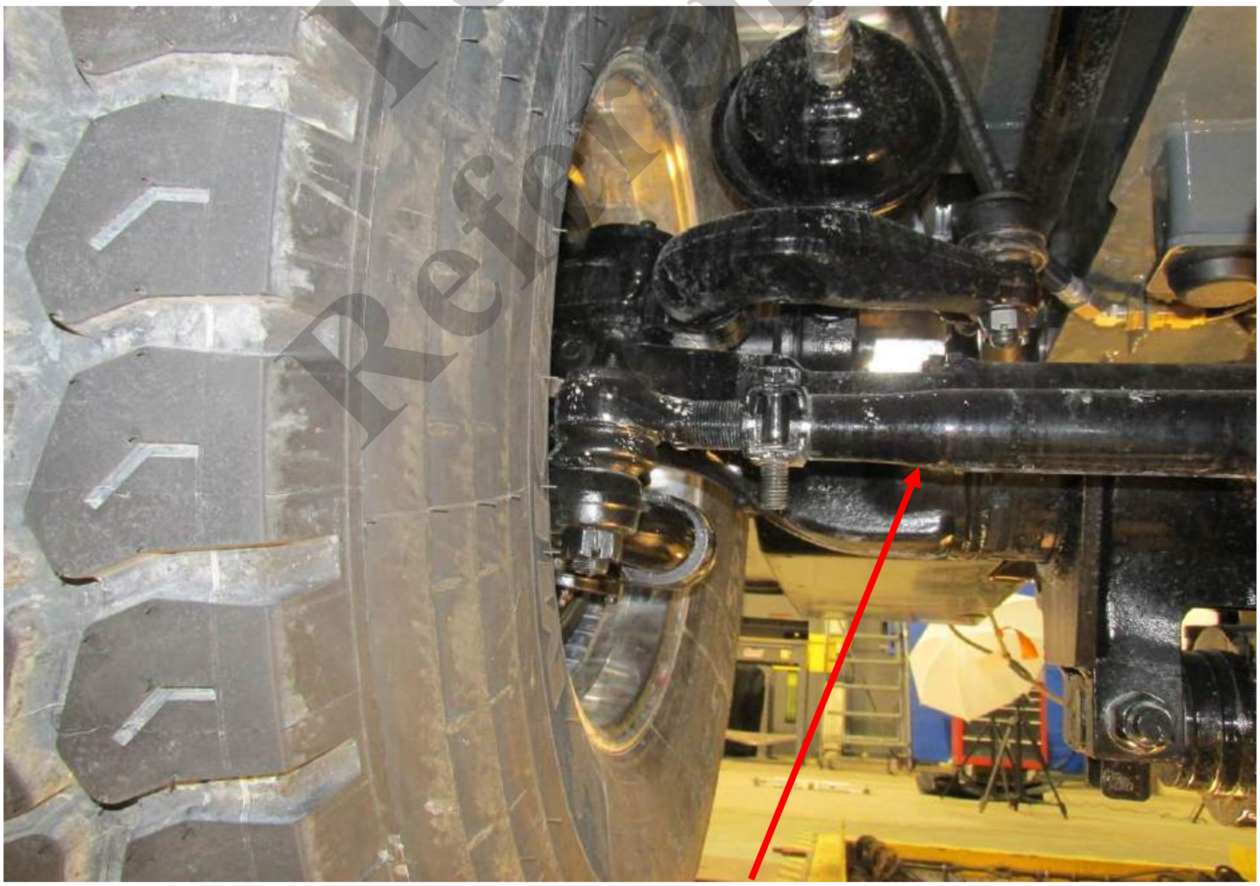
- **Toe should be +1/32 in. (0.8 mm) +/-1/32 in. (0.8 mm).**

  Note: Steer tires should be on alignment turntables for this step.

- **On the front steer axle measure the distance between the scribed lines (see "machine preparation for toe adjustment") at hub height on the rear of the tires and then on the front of the tires. Subtract the front value from the rear. Positive result is "toe in" and negative is "toe out." The use of a "toe bar" provides greater accuracy.**

  Adjust the front steer axle tie rod to achieve this. Apply Loctite 243 to clamp bolts and re-torque to 115-125 lbf*ft. (156-169 N*m).

- **Repeat this process for the rear steer axle.**



Tie rod

Adjust drive axle thrust.

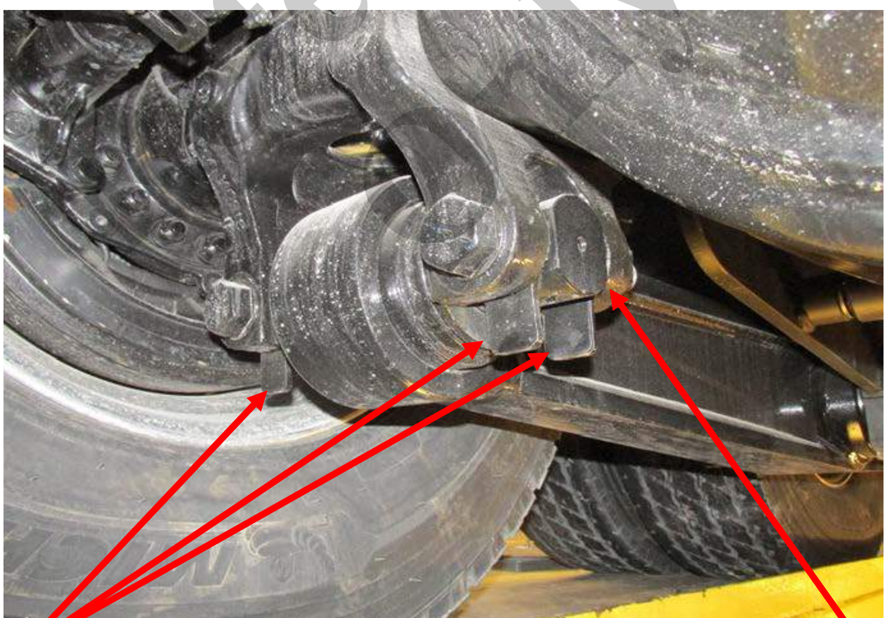
- **Acceptable thrust misalignment is 0.75 in. (19 mm) maximum.**

  (Note: Machine should be driven on a straight line for approximately 3 tire rotations prior to executing this step.)

- **If professional alignment equipment is not available, measure drive axle thrust by mounting a laser pointer parallel to the front drive wheel with the beam directed at the rear steer wheel and measure the distance between the rear steer wheel and beam. Repeat this process on the opposite side of the machine. Compare left and right; any difference is the misalignment.**

- **If adjustment is required, make the adjustment to the <u>front drive axle</u> mounting shims. Reposition the shim/s to the front of the bar pin to move the axle forward, or to the back of the bar pin to move the axle toward the rear. Slight adjustments might be achieved by adjusting shims on one side of the axle. Larger adjustments will be achieved by adjusting both sides in opposite directions. Re-torque hardware to 450-600 lbf*lb. (610-813 N*m).**

  Note: Raise the machine on outriggers to take weight off the suspension in order to reposition the mounting shims. A Porta Power can be used to support the suspension. Be sure to lift the outriggers and put full weight on the suspension prior to taking subsequent measurements.



Shims ***Bar pin***

- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

Adjust drive axle parallelism.

- **Distance between the drive axle hub centers on the left and right side of the machine should be within 1/8 in. (3.2 mm). This can be measured, or the process can be simplified by use of a Trammel bar if available.**

- **If adjustment is required, make the adjustment to the <u>rear drive axle</u> mounting shims. Reposition the shim/s to the front of the bar pin to move the axle forward, or to the back of the bar pin to move the axle toward the rear. Slight adjustments might be achieved by adjusting shims on one side of the axle. Larger adjustments will be achieved by adjusting both sides in opposite directions. Re-torque hardware to 450-600 lbf*lb. (610-813 N*m).**

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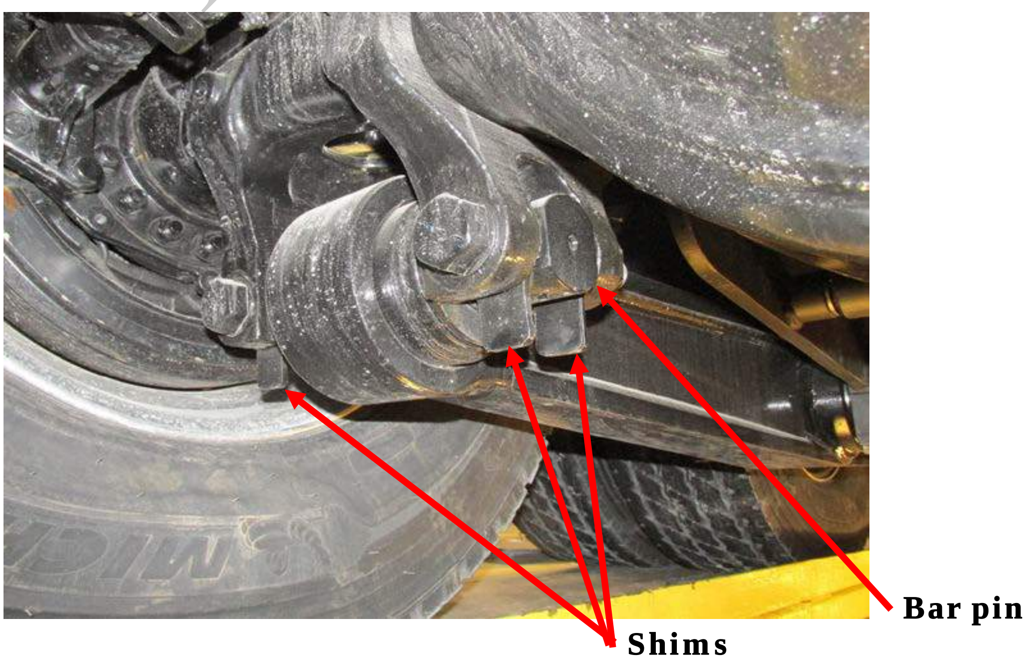


Test and report result to Manitowoc Crane Care.

- Perform a straight-line test for acceptable tracking.
- Perform a road test to assess steering performance and ride comfort.
- If necessary, re-adjust to achieve desired performance and retest.
- Advise Manitowoc Crane Care that the adjustments did or did not resolve your issues.

SERVICE MANUAL

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

TMS700E13

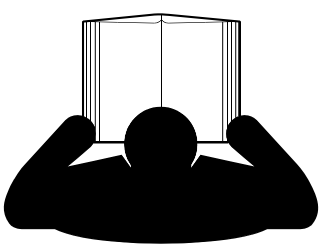
Crane Model Number

This Manual is Divided into the following Sections:

NOTICE

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

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



DANGER

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

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

Published 01-29-2015, Control # 512-01

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SECTION 1
INTRODUCTION

SECTION CONTENTS

Description

This Manual provides information for the maintenance of the Model TMS700E13 Series Grove Crane (see Figure 1-1).

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

The carrier incorporates a high strength, low alloy steel, all welded triple box section steel frame. The 8x4x4 carrier utilizes two drive axles and two steer axles. Axle steering is power assist controlled and controlled by the steering wheel. The engine is mounted at the front of the crane carrier and provides motive power through an 11-speed forward and three speed reverse manual transmission.

The outriggers are single stage, double box, telescopic beam type outriggers. The outriggers have three positions; fully extended, intermediate (50%) extended, and fully retracted.

The superstructure is capable of 360 degree rotation in either direction. All crane functions, with exception of counterweight removal, are controlled from the fully enclosed cab mounted on the superstructure.

One boom is available on the crane; a four section, full power, synchronized, 10.84 to 33.5 m (35 to 110 ft) boom. Additional reach is obtained by utilizing one of two optional boom extensions; a 9.75 m (32 ft) fixed length offsettable swingaway and a 9.75 to 17.07 m (32 to 56 ft) folding offsettable swingaway. A 6.1 m (20 ft) and a 12.2 m (40 ft) lattice insert is also available for use between the boom nose and the swingaway.

NOTE: Throughout this manual, reference is made to left, right, front, and rear when describing locations. When operating the crane, these reference locations are to be considered as those viewed from the operator's seat with the superstructure facing forward over the front of the carrier frame.

List Of Specifications

General

Model ... TMS700E13 Series
Rated Capacity ... See Load Chart in cab
Drive ... 8 x 4 x 4
Gross Weight ... 43,956 kg (96,906 lb)

Dimensions

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

Wheelbase ... 5639 mm (222 in)
Overall Crane Length ... 13,538 mm (533 in)
Overall Crane Width ... 2591 mm (102 in)
Overall Crane Height ... 3586 mm (141 in)
Tail-Swing ... 4102 mm (162 in)
Outrigger Spread
- Retracted ... 2429 mm (96 in)
- Mid Extend ... 4262 mm (168 in)
- Fully Extended ... 6096 mm (240 in)

Capacities

Fuel Tank ... 367 l (97 gal)
Coolant System ... See Engine Specifications
Engine Lubrication System ... See Engine Specifications
Hydraulic Tank (Reservoir Capacity)
- Total ... 564 l (149 gal)
- at Full Level ... 507 l (134 gal)
- at Add Level ... 477 l (126 gal)
- Expansion Space ... 57 l (15 gal)

Hoists ... 14.7 l (15.5 qt)
Swing Gearbox ... 1.30 l (2.75 pt)
Front Axle Hubs ... 0.95 l (1 qt)
Front Rear Axle Differentials ... 27 l (57 pt)
Rear Rear Axle Differentials ... 17.5 l (37 pt)
Transmission ... 19 l (20 qt)
Pump Drive ... 2.4 l (2.5 qt)

Transmission

Speeds ... 11 forward - 3 reverse
Gear Ratios
- LL2 ... 11.85
- Low ... 16.30
- LL1 ... 26.08

Low
- First ... 7.41
- Second ... 5.23
- Third ... 3.79
- Fourth ... 2.77

High ...
- Fifth ... 1.95
- Sixth ... 1.38
- Seventh ... 1.00
- Eighth ... 0.73

Reverse ...
- Low ... 13.03
- High ... 3.43

Clutch

Type ... 2 plate pull type dry disc

Engine

Cummins ISX12-2013 or QSMT3 inline 6 cyl. Turbo-Charged

Displacement ... 11.9 l (729 cu in)(ISX)
... 10.9 l (665 cu in)(QSM)
Firing Order ... 1-5-3-6-2-4
Lube Amount ... 41.6 l (11 gal)(ISX)
... 34 l (36 qt)(QSM)
Coolant System ... 54 l (57 qt)

Axles

Front

Type ... Non-drive steer

Rear

Type ... Single reduction tandem
Ratio ... 5.38:1

Brakes

Type ... Air operated S-Cam
Size ... 419 x 178 mm (16.5 x 7.0 in)

Wheel and Tires

Lugs ... 10
Torque ... 610 to 678 Nm (450 to 500 lb-ft)
Tire Size
- Front ... 445/65R22.5
- Rear ... 315/80R22.5

For roading and lifting pressures, refer to the Tire Inflation Decal.

Swing Gearbox

Reduction Ratio ... 36:2
Output Torque ... 5.54 Nm (49,825 lb-in)

Boom

Length ... 10.84 to 33.5 m (35 to 110 ft)
Power ... 4 Section, Full Power
Elevation ... -3 to +78 degrees
Extensions
- Fixed* ... 9.75 m (32 ft)
- Folding* ... 9.75 or 17.07 m (32 or 56 ft)
- Lattice Extension ... 20 and 6.1 and 12.2 m (40 ft)

*Extensions are offsettable at 0 or 45 degrees

Swivel Assembly

Electrical ... 49 Slip Rings
Hydraulic ... 5 ports
Water ... 2 ports

Hydraulic Pumps

NOTE: Pump output figures are theoretical.

Pump #1

Type . . . . .Gear
Sections 3
Output - @ engine speed 1800 rpm
Section 1 . . . . 184.3 lpm (48.7 gpm)
Section 2 . . . . 70.4 lpm (18.6 gpm)
Section 3 . . . . 88.9 lpm (23.5 gpm)

Pump #2

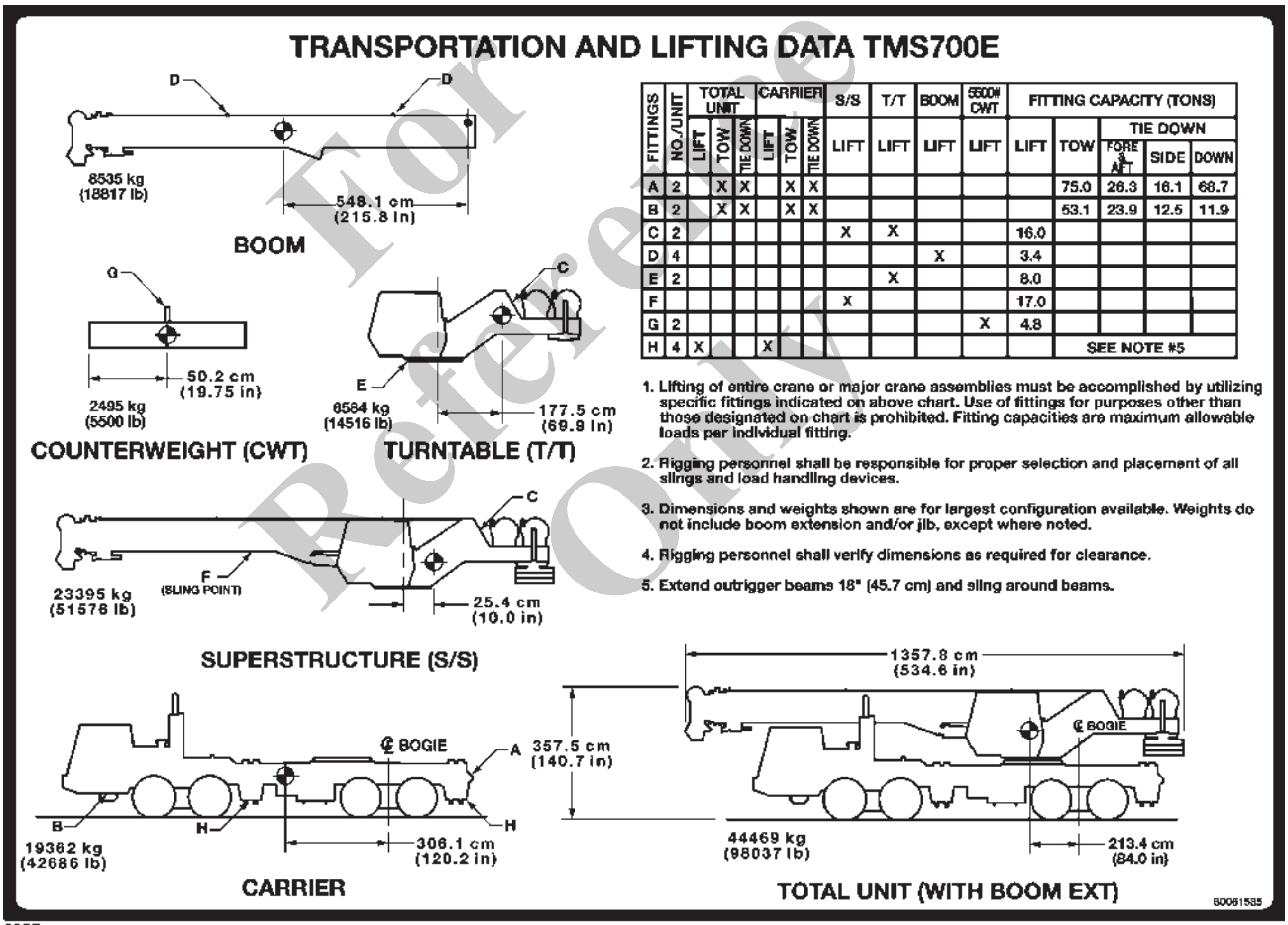
Type . . . . .Gear
Sections 1
Output - @ 1800 rpm
Section 1 . . . . 88.2 lpm (23.3 gpm)
Priority flow of 37.9 lpm (10 gpm) at 2175 psi

Pump #3

Type . . . . .Gear
Sections 1
Output - @ 1800 rpm
Section 1. . . . . .78.7 lpm (20.8 gpm)

Hoists

Drum Dimensions
Diameter . . . . .381 mm (15 in)
Length. . . . . .467 mm (18-3/8 in)
Cable
Diameter . . . . 19 mm (3/4 in)
Length-Main . . . . .153 m (500 ft)
Length-Aux. . . . . .153 m (500 ft)
Max. Permissible Line Pull (6x36)
. . . . 90.1 kN (20,250 lb)
Hoist Motor Displacement
. . . . .110 cm^3 (6.7 in^3) per revolution (low)
. . . . .61 cm^3 (3.7 in^3) per revolution (high)



FITTINGS	NO./UNIT	TOTAL UNIT			CARRIER			S/S	T/T	BOOM	5500# CWT	FITTING CAPACITY (TONS)				
														TIE DOWN		
		LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN	LIFT	LIFT	LIFT	LIFT	LIFT	TOW	FORE & AFT	SIDE	DOWN
A	2		X	X		X	X						75.0	26.3	16.1	68.7
B	2		X	X		X	X						53.1	23.9	12.5	11.9
C	2							X	X			16.0				
D	4									X		3.4				
E	2								X			8.0				
F								X				17.0				
G	2										X	4.8				
H	4	X			X								SEE NOTE #5			

1. Lifting of entire crane or major crane assemblies must be accomplished by utilizing specific fittings indicated on above chart. Use of fittings for purposes other than those designated on chart is prohibited. Fitting capacities are maximum allowable loads per individual fitting.
2. Rigging personnel shall be responsible for proper selection and placement of all slings and load handling devices.
3. Dimensions and weights shown are for largest configuration available. Weights do not include boom extension and/or jib, except where noted.
4. Rigging personnel shall verify dimensions as required for clearance.
5. Extend outrigger beams 18" (45.7 cm) and sling around beams.

8357

FIGURE 1-1

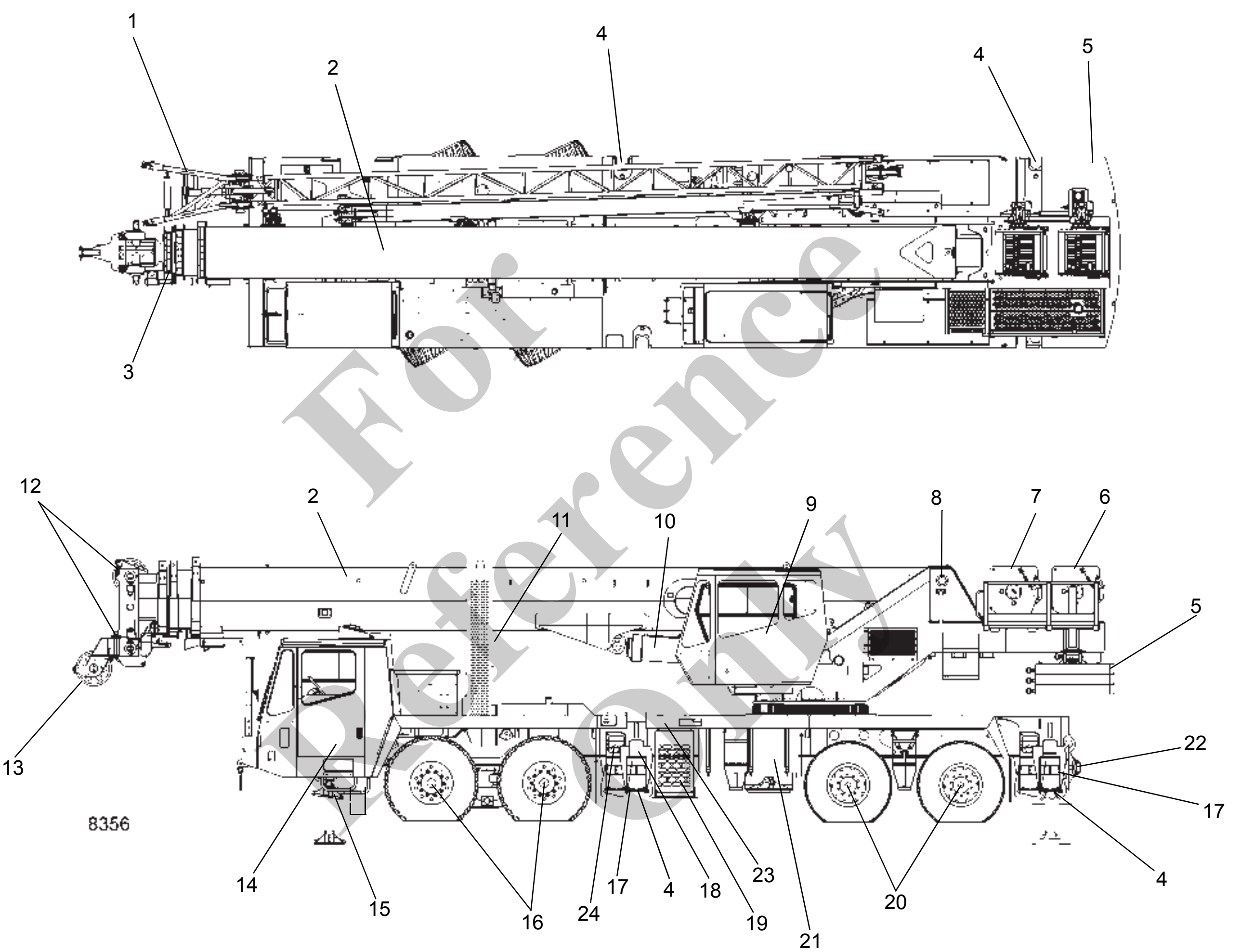


FIGURE 1-1 continued

Item	Description
1	Folding Swingaway
2	Boom
3	Section 4
4	Outrigger cylinder
5	Removable Counterweight
6	Auxiliary Hoist
7	Main Hoist
8	Boom Pivot
9	Superstructure Cab
10	Lift Cylinder
11	Boom Rest
12	Boom Nose Sheaves

Item	Description
13	Auxiliary Boom Nose
14	Carrier Cab
15	Center Front cylinder
16	Front Axles
17	Outrigger Beam
18	Outrigger
19	Hydraulic Oil Cooler
20	Rear Tandem Axles
21	Fuel Tank
22	Outrigger Float
23	Diesel Exhaust Fluid (DEF) Tank
24	Fuel Filter, Primary

Table 1-1 Axle Weight Distribution Table

Description	CG To CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Maximum Tire & Wheel Loads Allowed			23224(51200)	27216(60000)
Maximum Axle Loads Allowed			23224(51200)	27216(60000)
Standard Carrier Assy (8x4x4)	304.60(119.92)	18919(41708)	10220(22530)	8699(19178)
Superstructure Assy with main and aux hoists, w/cables	-51.69(-20.35)	6422(14157)	-589(-1298)	7010(15455)
Boom Assy w/pivot pins, 2 over 3 sheaves, RCL	489.46(192.70)	8241(18169)	7154(15771)	1088(2398)
Lift Cylinder and lower shafts	210.82(83.00)	791(1743)	296(652)	495(1091)
Complete Basic Machine: Carrier Ass'y, S/S Ass'y, 4-Section Boom, Cummins ISX 11.9 2010 Engine, 445/65R22.5 Goodyear Front Tires, 315/80R22.5 Goodyear Rear Tires, Full Fuel and Hydraulic Oil, cable on both hoists	280.21(110.32)	34372(75777)	17080(37655)	17292(38122)
	Boom Extensions			
10 - 17 m (33 - 56 ft) Bi-fold Boom Extension	571.30(224.92)	1132(2495)	1147(2528)	-15(-33)
Boom Extension Carrier Brackets	467.36(184.00)	133(293)	110(243)	23(50)
Aux Boom Nose	1097.28(432.00)	59(130)	115(253)	-56(-123)
6.1 m (20') Boom Extension Insert w/RCL (pinned at boom nose)		407(898)		
	Counterweights			
5500 lb counterweight on superstructure - master	-227.03(-89.38)	2495(5500)	-1004(-2214)	3499(7714)
5500 lb counterweight on superstructure - slab	-227.03(-89.38)	2495(5500)	-1004(-2214)	3499(7714)
5500 lb counterweight on superstructure - slab	-227.03(-89.38)	2495(5500)	-1004(-2214)	3499(7714)
5500 lb counterweight stowed on deck - master	481.03(189.38)	2495(5500)	2128(4692)	367(808)
5500 lb counterweight stowed on deck - slab	481.03(189.38)	2495(5500)	2128(4692)	367(808)
5500 lb counterweight stowed on deck - slab	481.03(189.38)	2495(5500)	2128(4692)	367(808)
	Rigging Equipment			
7.5 t (8.3 ton) Headache Ball (Swivel) - in stowage tray	830.58(327.00)	161(355)	237(523)	-76(-168)
7.5 t (8.3 ton) Headache Ball (Swivel) - tied to front bumper	942.34(371.00)	161(355)	269(593)	-108(-238)
36 t (40 ton) Hookblock (3 sheave) - tied to front bumper	955.04(376.00)	373(823)	632(1394)	-259(-571)
45 t (50 ton) Hookblock (3 sheave) - tied to front bumper	955.04(376.00)	458(1010)	776(1711)	-318(-701)
55 t (60 ton) Hookblock (5 sheave) - tied to front bumper	955.04(376.00)	581(1280)	983(2168)	-403(-888)
Rigging	170.18(67.00)	45(100)	14(30)	32(70)

Description	CG To CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Cribbing (in rear troughs)	-35.56(-14.00)	181(400)	-11(-25)	193(425)
	Optional Equipment			
Rear Mounted Pintle Hook	-218.44(-86.00)	12(26)	-5(-10)	16(36)
Air Conditioning - Carrier	695.96(274.00)	24(53)	29(65)	-5(-12)
Air Conditioning - S/S	20.32(8.00)	90(198)	3(7)	87(191)
Tow Rope	825.50(325.00)	9(20)	13(29)	-4(-9)
Driver	762.00(300.00)	91(200)	122(270)	-32(-70)
Trailing Boom Components - Carrier	-86.36(-34.00)	32(70)	-5(-11)	37(81)
Trailing Boom Components - S/S	154.94(61.00)	31(69)	9(19)	23(50)
	Substitutions, Deletions, and Removals			
SUB: Main Hoist Only (replace aux hoist & cable with IPO counterweight)	-210.82(-83.00)	-270(-595)	101(222)	-371(-817)
REM: Main Hoist Cable (500' of 3/4” 6x37)	-147.32(-58.00)	-236(-520)	62(136)	-298(-656)
REM: Aux Hoist Cable (502' of 19mm 35x7)	-231.14(-91.00)	-278(-612)	114(251)	-391(-863)
SUB: Optional cable on Main Hoist (502' of 19mm 35x7)	-147.32(-58.00)	42(92)	-11(-24)	53(116)
SUB: Aluminum Outrigger Floats	-63.50(-25.00)	-33(-72)	4(8)	-36(-80)
SUB: Cummins QSM Off Highway Engine	632.46(249.00)	-322(-709)	-361(-795)	39(86)
SUB: 2 over 4 boom nose sheaves	1043.74(410.92)	11(25)	21(46)	-10(-21)

GENERAL MAINTENANCE

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

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

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

Cleanliness

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

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

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

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

Removal and Installation

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

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

CAUTION

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

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

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

Disassembly and Assembly

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

Pressing parts

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

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

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

Locks

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

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

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

When installing lockwashers on housings made of aluminum, 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.

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

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

Sleeve Bearings

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

Gaskets

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

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

Batteries

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

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

Hydraulic Systems

DANGER

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.

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

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

Visual Inspection of Hoses and Fittings

CAUTION

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

1. Visually inspect hoses and fittings once a month or every 250 hours for the following:

- Leaks at hose fitting or in hose
- Damaged, cut, or abraded cover
- Exposed reinforcement
- Kinked, crushed, flattened, or twisted hose
- Hard, stiff, heat cracked, or charred hose
- Blistered, soft, degraded, or loose cover
- Cracked, damaged, or badly corroded fittings
- Fitting slippage on hose
- Other signs of significant deterioration

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

2. At the same service interval, visually inspect all other hydraulic components and valves for the following:

- Leaking Ports
- Leaking valve sections or manifolds and valves installed into cylinders or onto motors.
- Damaged or missing hose clamps, guard, or shields.
- Excessive dirt and debris around the hose assemblies.

If any of these conditions exist, address them appropriately.

3. 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” Table 1-2 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” Table 1-2 cold climates should expect a degrade of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

Table 1-2

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

Electrical System

Connectors, Harnesses, Wires, and Cables

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

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

If any of the above conditions exist, evaluate 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 8,000 hours of service.
- Climate zones D and E after 10,000 hours of service.
- Salt water conditions after 8,000 hours of service.

Fatigue of Welded Structures

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

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

- Power Telescope Boom - wear pad retaining structures, hydraulic cylinder attaching points, boom pivot shaft retaining structures.
- Outrigger pads, beams, boxes and attachment structures.
- Main frames - generally in the area of doubler plates and 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 distributor.

Loctite®

DANGER

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 Manitowoc Crane Care Parts Department or your local distributor.

Application of Medium Strength Loctite

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

The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant, Loctite #243, which does not require a primer or 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

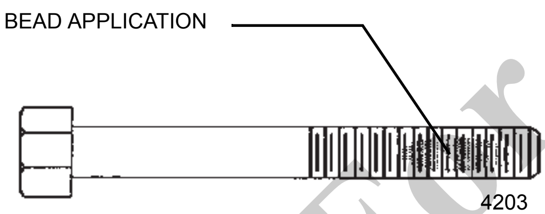


FIGURE 1-2

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-2).
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.

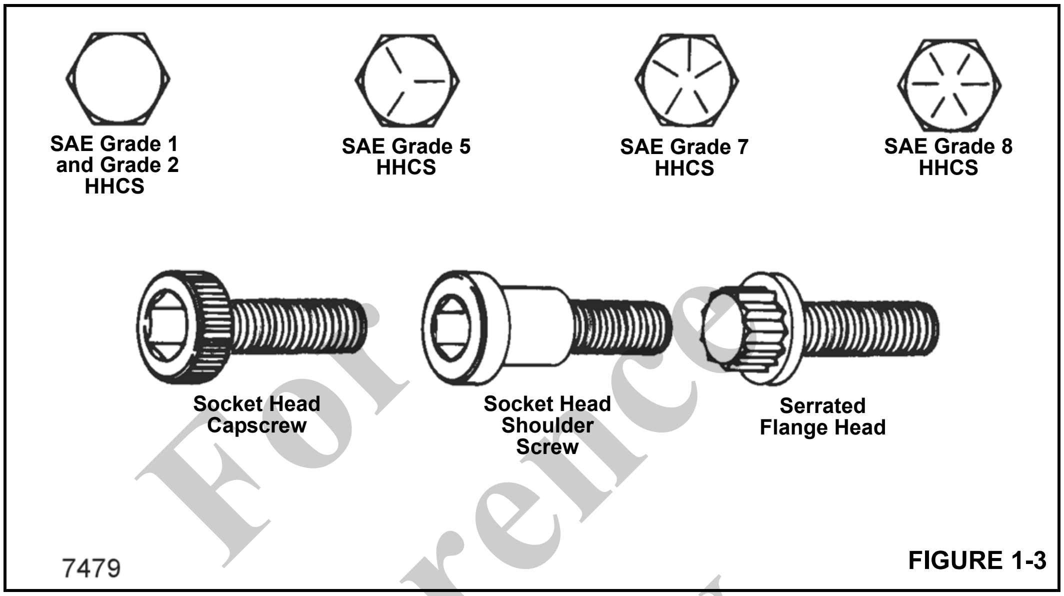


FIGURE 1-3

Table 1-3: 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 1-4: 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 1-5: Metric Fasteners, Coarse Thread, Zinc-Flake Coating

Bolt Diameter - Metric

Torque Values (Nm)

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

Table 1-6: Metric Fasteners, Coarse Thread, Untreated

Bolt Diameter - Metric

Torque Values (Nm, Maximum/Minimum)

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

Table 1-7: Metric Fasteners, Fine Thread, Zinc-Flake Coating

Bolt Diameter - Metric

Torque Values (Nm)

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

Table 1-8: Metric Fasteners, Fine Thread, Untreated

Class	M8x1	M10x1	M10x1.25	M12x1.5	M14x1.5	M16x1.5	M18x1.5	M20x1.5	M22x1.5	M24x2	M27x2	M30x2	M33x2	M36x3
	Bolt Diameter - Metric / Torque Values (Nm, Maximum/Minimum)													
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 1-9: UNC (Course) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

Size	Torque Value lb-in	Torque Value 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 1-10: 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 1-11: Weld Stud Torque Values

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

T-2-4

Wire Rope

General

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

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

Lubrication

A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added throughout the life of a rope to replace factory lubricant which is used or lost. It is important that lubricant applied as part of a maintenance program shall be compatible with the original lubricant, and to this end, the rope manufacturer should be consulted. Lubricant applied shall be of the type which does not hinder visual inspection. Those sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention when lubricating rope. The object of rope lubrication is to reduce internal friction and to prevent corrosion.

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

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

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

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

Precautions and Recommendations During Inspection or Replacement

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

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

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.

Frequent Inspection

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

- Distortion, Kinking, Crushing, Un-stranding, Bird caging, Reduction of diameter, etc.
- General corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- End fitting wear/abrasion.

Periodic Inspection

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

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

Wire Rope Inspection (Boom Extension and Retraction Cables)

Periodic Inspection

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

- Inspect for reduction of rope diameter below nominal diameter.
- Inspect for severely corroded or broken wires at end connections.

- Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
  - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
  - Sections of wire rope in contact with stationary surfaces where abrasion or chafing may take place as a result of equipment vibration.
- Inspect for damaged or wobbly boom extension and retraction sheaves that may cause rapid deterioration of the wire rope.
- Inspect for unusual cable sag/stretch and be sure cables used in sets all have an equal tension applied. Repeated need for adjustment of an individual cable is evidence of cable stretch and indicates the need for additional and more thorough inspection in order to determine and correct the cause.

Wire Rope 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 Cranes. 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, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than 5%.
- In 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.
- Manitowoc Cranes recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Manitowoc Cranes 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, place one end in the groove between two strands of the wire rope (see Figure 1-4). 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.

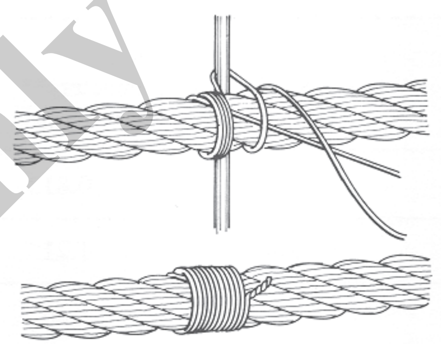


FIGURE 1-4

Method 2

Wind a length of soft annealed wire around the wire rope at least seven times (see Figure 1-5 thru 1-6). 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 should have two seizings located on each side of the cut.

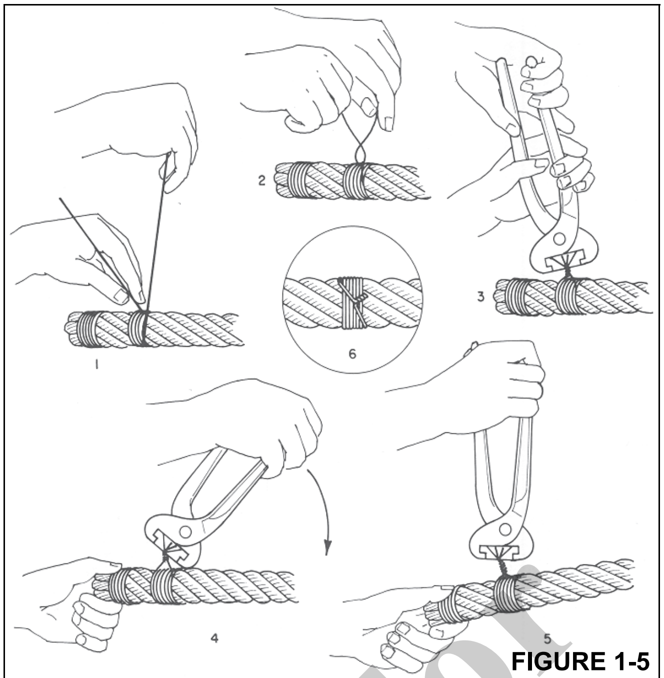


FIGURE 1-5

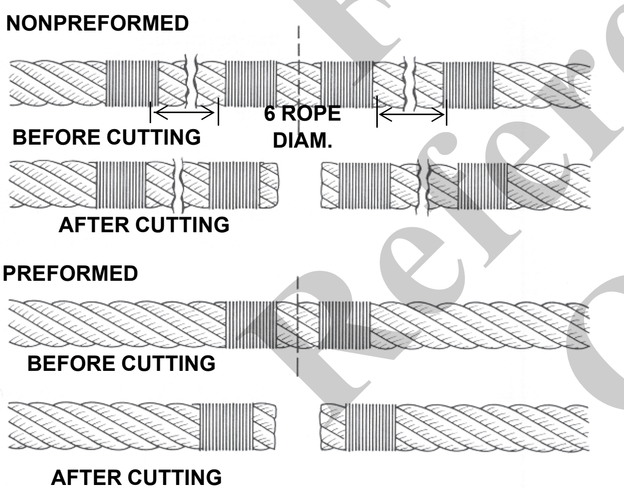


FIGURE 1-6

Installing 35x7 Class Wire Rope

CAUTION

Any cutting of this specific wire rope is not recommended. If 35x7 class wire rope must be cut for any reason, it is necessary to follow the attached instructions. Also, unlike other types of wire rope, the ends on this wire rope must be welded.

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

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

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

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

Procedures for Cutting and Preparing 35x7 Class Wire Rope

35x7 class wire rope is a special wire rope that must be handled differently than any other rope. 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.
3. Cutting the rope:
   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.

4. Once the cuts have been completed, the seizing bands are to be left in place for shipment of the rope.
5. Attach a “Do not remove welded ends” tag on each reel flange.

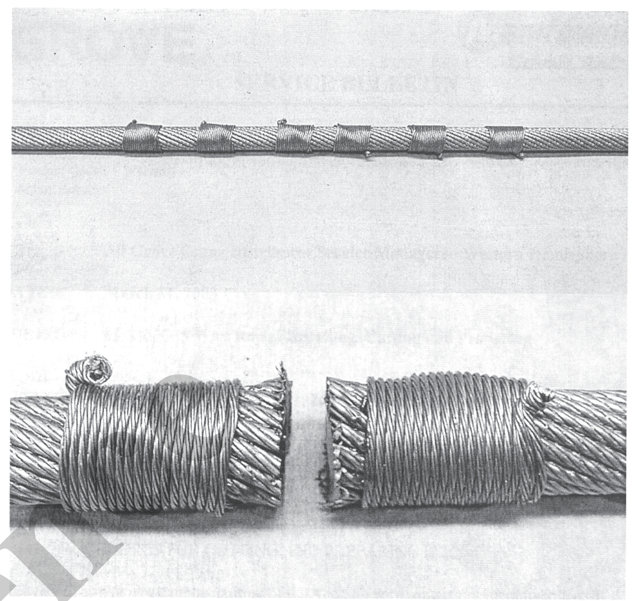


FIGURE 1-7

Synthetic Hoist Rope

For detailed information concerning synthetic hoist rope, refer to KZ100 Synthetic Crane Hoist Line Manual, P/N 9828100734 available by contacting Manitowoc Crane Care.

SECTION 2
HYDRAULIC SYSTEM

SECTION CONTENTS

DESCRIPTION

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

MAINTENANCE

Hydraulic Oil Recommendations

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

Draining and Flushing

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

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

CAUTION

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

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

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

CAUTION

When draining the outrigger 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 cylinders and the center front jack cylinder and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders and the center front jack cylinder to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.

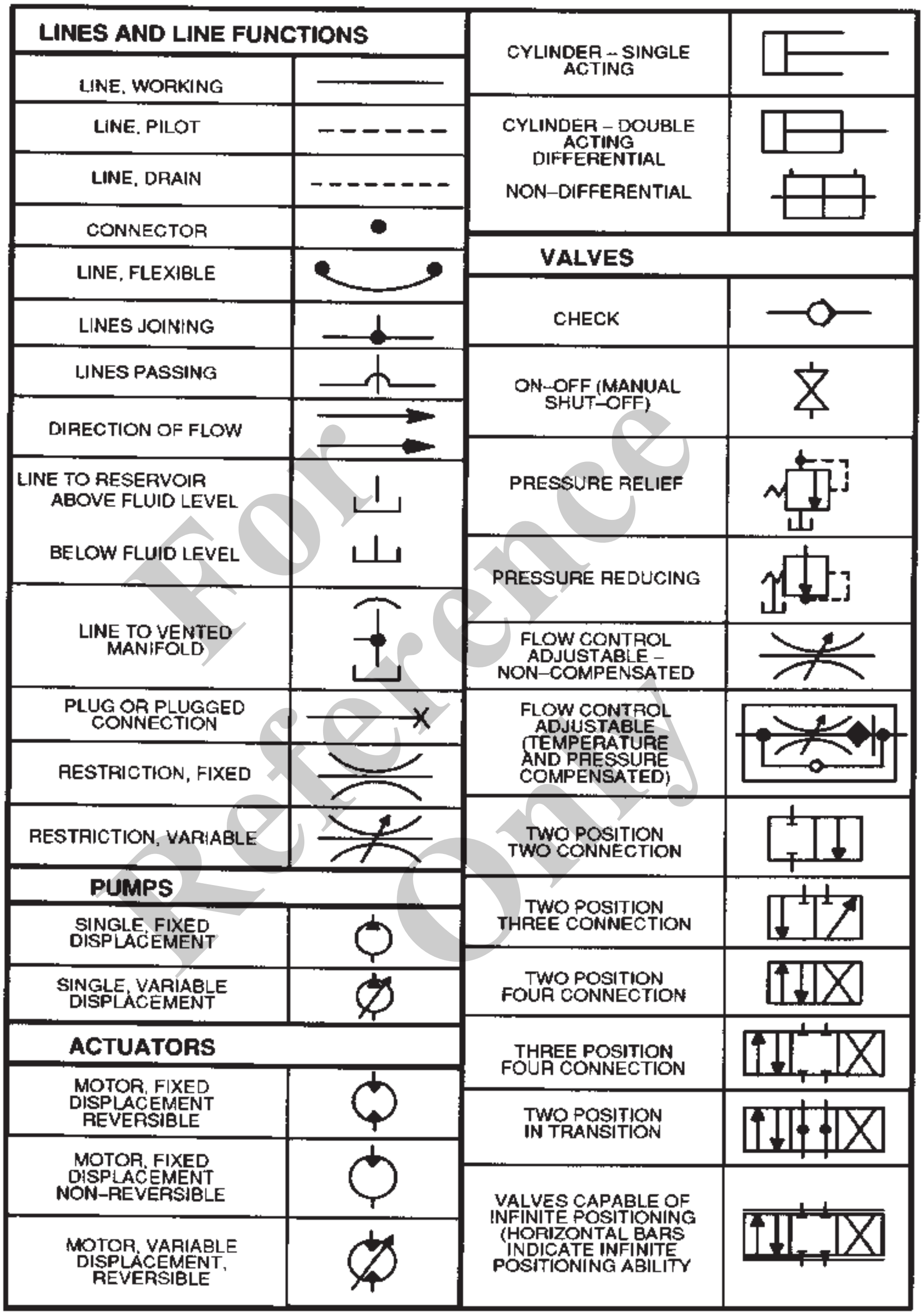

LINES AND LINE FUNCTIONS
LINE, WORKING
LINE, PILOT
LINE, DRAIN
CONNECTOR
LINE, FLEXIBLE
LINES JOINING
LINES PASSING
DIRECTION OF FLOW
LINE TO RESERVOIR
ABOVE FLUID LEVEL
BELOW FLUID LEVEL
LINE TO VENTED MANIFOLD
PLUG OR PLUGGED CONNECTION
RESTRICTION, FIXED
RESTRICTION, VARIABLE
PUMPS
SINGLE, FIXED DISPLACEMENT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

FIGURE 2-1

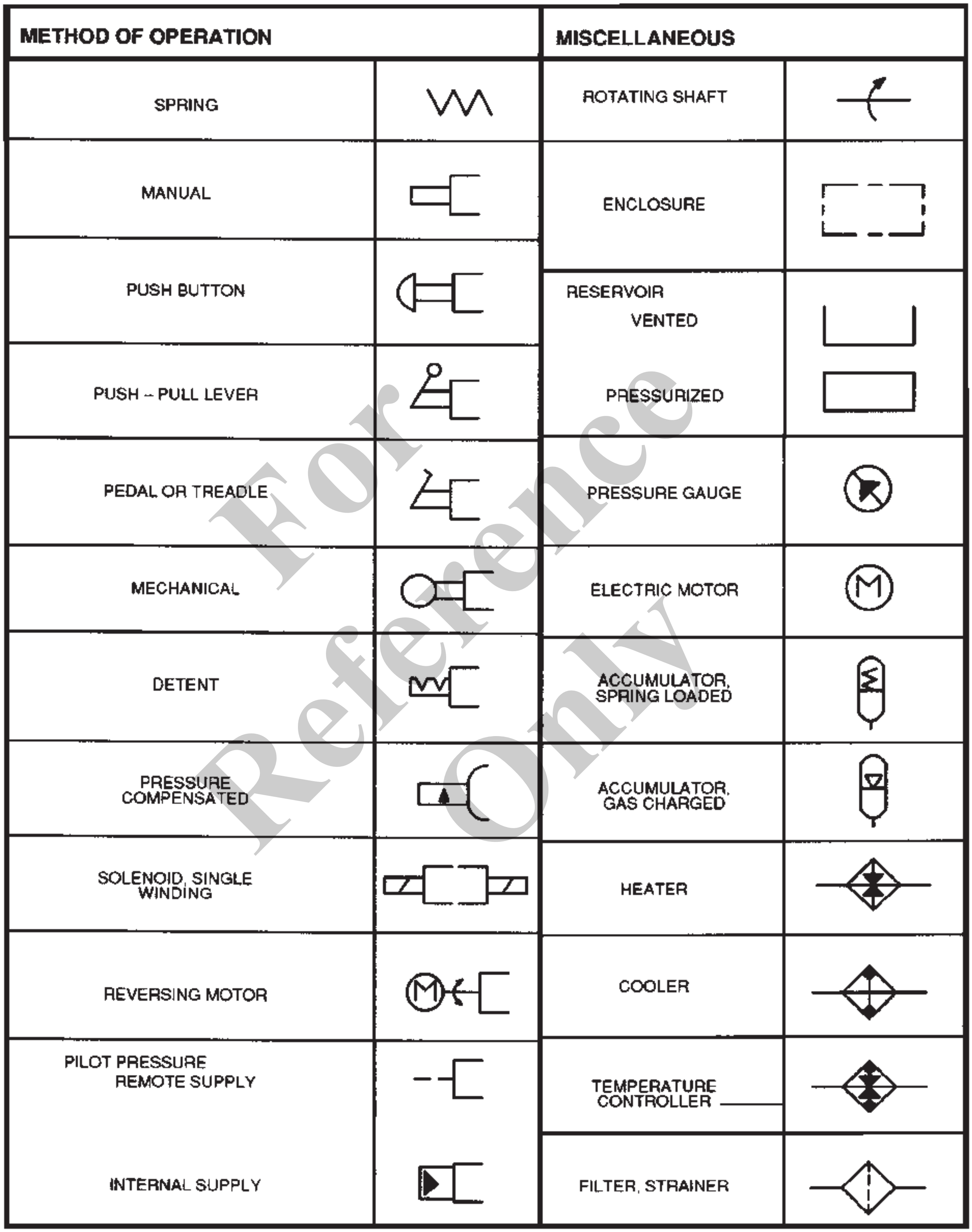


FIGURE 2-1 continued

14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from both front steer cylinders and turn the front wheels to the extreme right.
16. Connect the return lines and turn the front wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
18. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
19. Repeat Steps 17 and 18 for the auxiliary hoist as necessary.
20. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
21. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

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

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Working reservoir capacity (to full mark) is 507 l (134 U.S. gal). Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge. After the reservoir is filled, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

Removing Air from the Hydraulic System

Air entering the hydraulic oil will normally be removed automatically by passage of the hydraulic oil over the baffles in the hydraulic reservoir. If a component has been replaced, the reservoir level is too low, or a leak develops in the suction lines to the pumps, air can enter the system. If air becomes entrapped in the hydraulic oil, it may be detectable in pumps and motor operated components such as the swing mechanism and hoist(s), because it can cause these units to become noisy during operation. If noisy operation occurs, first check the level of the hydraulic reservoir and replenish as necessary. Then inspect for leaks in the suction lines leading to the pumps.

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

- Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 0.138 to 0.276 bar (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.
- This action should return any entrapped air to the reservoir where it can be removed from the hydraulic oil by the baffles.

DANGER

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

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

DANGER

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

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

DANGER

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

- In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw type fittings may become necessary.
- If the above procedures fail to eliminate air entrapment, contact your distributor.

Parts Replacement

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

Directional Control Valves

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

Inspection

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

Valve Leakage

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

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

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

Binding Spools

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

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

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

Visual Inspection of Hoses and Fittings

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

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

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

If any of these conditions exist, address them appropriately.

- Hydraulic hose assemblies operating in climate zone “C” are recommended to be replaced after 8000 hours of service life.
- Hydraulic hose assemblies operating in climate zones “A” or “B” with high ambient temperatures, could see hose service life reduced by 40% - 50%. Therefore, it is recommended to replace these hoses after 4000 - 5000 hours of service life.
- Hydraulic hose assemblies operating in climate zones “D” and “E” cold climates should expect a degrade of mechanical properties such as elasticty.Therefore it is recommended that these hoses be inspected and addressed accordingly.

Zone	Classification
A	Tropical Moist: All months average above 18°C (64.4°F). 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 oil from the three hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, three hydraulic pumps, a hydraulic oil cooler, and a 5-port hydraulic swivel. Refer to *Hydraulic Pumps*, page 2-14 in this section for descriptions and maintenance instructions for each hydraulic pump. Refer to *Swing System*, page 6-1 for description and maintenance instructions for the 5-port hydraulic swivel.

The supply pressure and return circuit uses Ports 1, 3, and 4 for pump supply and the dual Port 2 for return. Each operating circuit’s description and components begin with the circuit’s directional control valve.

Hydraulic Reservoir and Filter

The reservoir (Figure 2-2), attached to the right side of the carrier frame, has a capacity of 564 liters (149 gal) total, 507 liters (134 gal) to the full mark. The all-steel reservoir has an internally mounted full-flow filter and integral baffles that help cool the hydraulic oil and prevent hydraulic oil foaming.

Hydraulic oil flows through the manifold at the lower rear of the reservoir to the three hydraulic pumps. Almost all of the return flow goes through the filter at the top of the reservoir. The return line that goes directly into the reservoir (instead of through the filter) is from the No. 5 port (drain) of the 5-port swivel.

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

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

A filler cap on the top of the reservoir is for filling the reservoir. The filler cap includes a strainer for catching contaminants and gaskets to prevent leaking. A breather cap (vent) is located on top of the reservoir to allow air to enter or exhaust from the reservoir. It is most important that the breather be kept clean to prevent damage to the reservoir.

A large access cover on the top of the reservoir provides access for cleaning. The cover is secured to the top of the reservoir with a band clamp and has a gasket to prevent leaking.

An oil temperature gauge is located on the end of the reservoir to indicate oil temperature.

The hydraulic oil filter (Figure 2-3) is located in the reservoir. It bolts to the top of the reservoir, and its bypass outlet fits into a tube welded in the reservoir. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element, and into the reservoir.

A gauge installed in the filter head indicates how restricted (clogged) the filter element is. When back pressure caused by a dirty filter element exceeds 1.70 bar (25 psi), the filter head’s bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead. (Filter changing instructions are in *Return Hydraulic Filter Assembly*, page 2-10.)

Pump Distribution

No. 1 Pump

The engine PTO driven pump drive drives the No. 1 pump. The pump drive converts the PTO shaft’s 2070 rpm at engine speed of 1800 rpm to 2604 rpm. (The engine speed is limited to 1800 rpm when operating crane functions; the PTO spins at 1.15 times the engine speed; the pump drive output shaft speed is 1.258 times the PTO speed.) The pump drive has a disconnect to stop power transfer to the No. 1 pump.

Section One of the No. 1 hydraulic pump supplies the hoist, lift, and telescope directional control valve. The valve sections control the following functions: main hoist, boom lift, boom telescope, and, when equipped, auxiliary hoist.

Hydraulic oil flowing from this valve bank returns to the reservoir filter.

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

Section Two of the No. 1 hydraulic pump supplies the integrated outrigger valve, and all outrigger functions and the center front jack functions as well.

Output from Section Two passes through the high speed boost selector valve. When the valve is de-energized, the oil flows to the integrated outrigger valve. When the valve is energized, it closes to cut off flow to the integrated outrigger valve. Oil flow from Section Two combines with the output of Section One to provide additional hydraulic force to the Section One functions.

Section Three of the No. 1 hydraulic pump supplies the optional superstructure cab air conditioning compressor motor. If the crane does not have this feature, the section's output returns to the reservoir.

No. 2 Pump

The engine drives the No. 2 pump at 1.16 times engine rpm.

Priority flow of 37.9 lpm (10 gpm) goes to the front steering gear and the remainder goes to the auxiliary cooler circuit.

No. 3 Pump

The engine drives the No. 3 pump off the back of the air compressor at 1.16 times engine rpm.

Output supplies the swing directional control valve and swing drive motor.

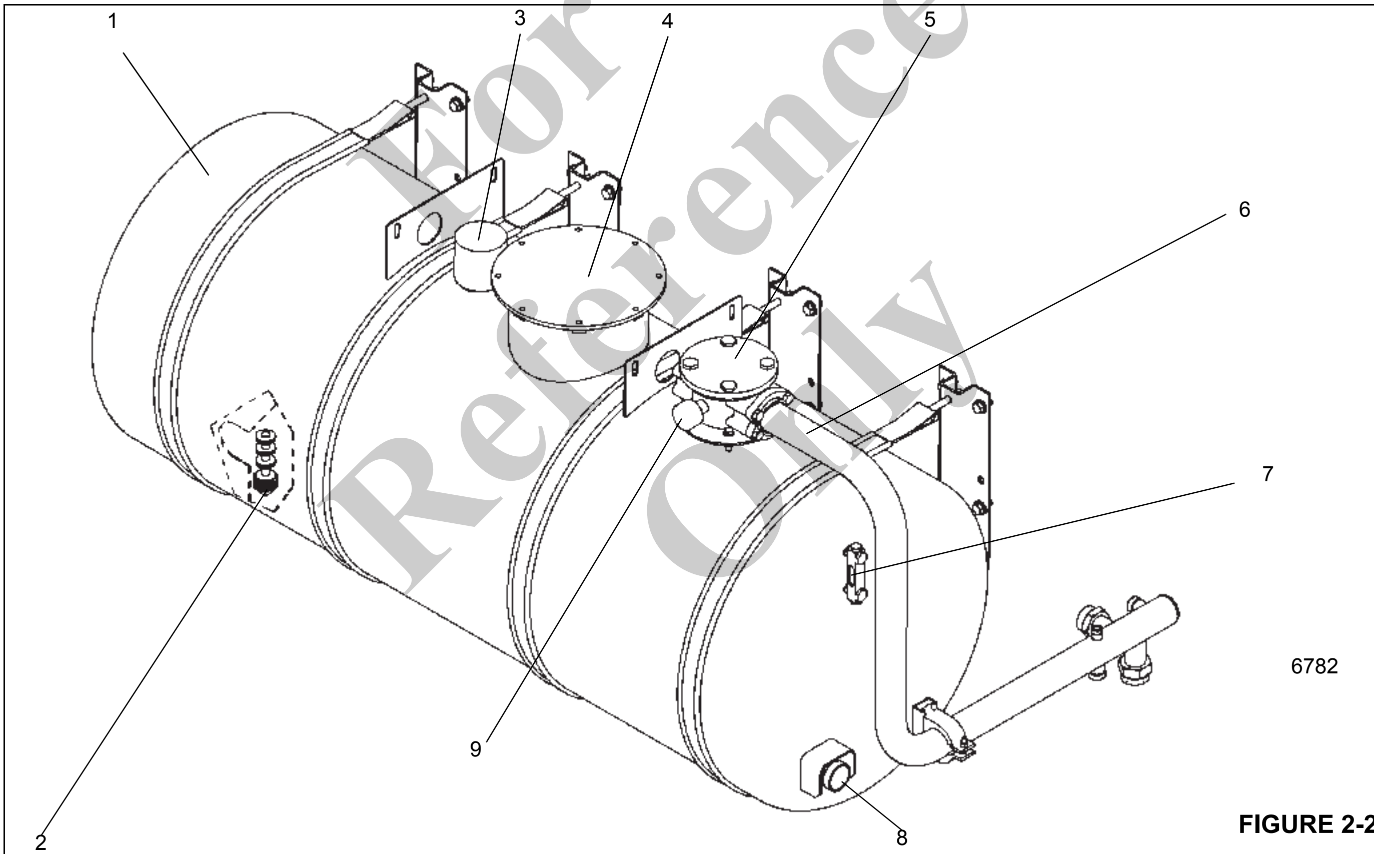


FIGURE 2-2

Item	Description
1	Reservoir Assembly (Hydraulic Tank)
2	Drain Plug
3	Breather and Fill Neck
4	Access Cover

Item	Description
5	Return Filter Assembly
6	Return Manifold Tube Assembly
7	Oil Level Gauge
8	Temperature Gauge
9	Bypass Gauge

2

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. No hydraulic oil flows in systems.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Add hydraulic oil to proper level.
	b. Reservoir-to-pump suction lines broken or restricted. Air entering at suction lines. Pump not priming.	**b.** Clean, repair, or replace lines as necessary. Check lines for security, absence of cracks, and proper attachment. Tighten, repair, or replace parts as necessary.
	c. Pump shaft sheared or disengaged.	**c.** If drive shaft is damaged or sheared, remove and repair or replace as necessary
	d. Internal contamination.	**d.** Drain, flush with recommended oil mixture, then drain and refill system with recommended hydraulic oil.
2. Slow response.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Add hydraulic oil to proper level.
	b. Hydraulic oil temperature too high (watery thin oil) or too low (thick sluggish oil).	**b.** If too low, warm up system. As needed, troubleshoot cooler circuit. If too high, troubleshoot cooler circuit. Likely suspects are in-line check valve and related hydraulic circuits.
	c. Faulty pump section(s).	**c.** Repair or replace pump section(s) or entire pump.
3. Pump noise accompanied by hydraulic oil foaming in reservoir.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Add hydraulic oil to proper level.
	b. Excessive engine speed.	**b.** Regulate engine speed.
	c. Air entering at suction lines.	**c.** Check all lines for security and proper repair. Tighten, repair, or replace as needed.
4. Excessive pressure buildup.	**a.** System relief valve set too high.	**a.** Using adequate pressure gauge, adjust system relief valve as necessary.
	b. Restricted pump-to-control valve supply line.	**b.** Clean, repair, or replace line as necessary.
5. Specific hydraulic system (lift, hoist, telescope, swing) not working.	**a.** Leak in system.	**a.** Repair leak.
	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.

Return Hydraulic Filter Assembly

Element Removal

DANGER

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

1. Shut down all hydraulic systems.
2. Wipe any dirt from the return filter assembly's head.
3. Remove the split flange halves and four bolts to separate the return manifold tube assembly from the filter. Cap or plug return manifold tube assembly. Discard the O-ring removed with the return manifold tube assembly.
4. Remove the four bolts and lockwashers securing the return filter assembly to the hydraulic tank. Remove the return filter assembly and its gasket from the hydraulic tank. Discard the gasket.
5. Remove the four bolts securing the cap to the head. Remove the cap and its O-ring from the head.
6. Remove the larger diameter spring from the head.
7. Remove the filter element and the smaller diameter spring from the bowl (housing). Remove the O-ring that fits between the cap and the filter element.
8. Ensure the new filter element is correct by comparing its part number with the part number of the used filter element.
9. Discard the used filter element. Discard the O-ring removed earlier from around the cap. Also discard the O-ring from between the head and the bowl.

Element Installation

1. Install a new O-ring between the head and the bowl (housing).
2. Install the new element and the smaller diameter spring into the bowl (housing). Ensure the spring seats properly.
3. Install a new O-ring on the cap.
4. Install the larger diameter spring on top of the filter element. Seat the spring properly.
5. Install the cap on the head and secure the cap to the head with four bolts.
6. Install the return filter assembly and new gasket over its mounting holes in the hydraulic tank. Secure the return filter assembly with four bolts and lockwashers.
7. Connect the return manifold tube assembly to the filter. Seal the return manifold tube assembly-to-filter connection with the O-ring and secure the return manifold tube assembly with the split flange halves and the bolts.
8. Activate the hydraulic system and check for leaks. Make repairs as needed.

Reservoir Breather

Removal and Replacement

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

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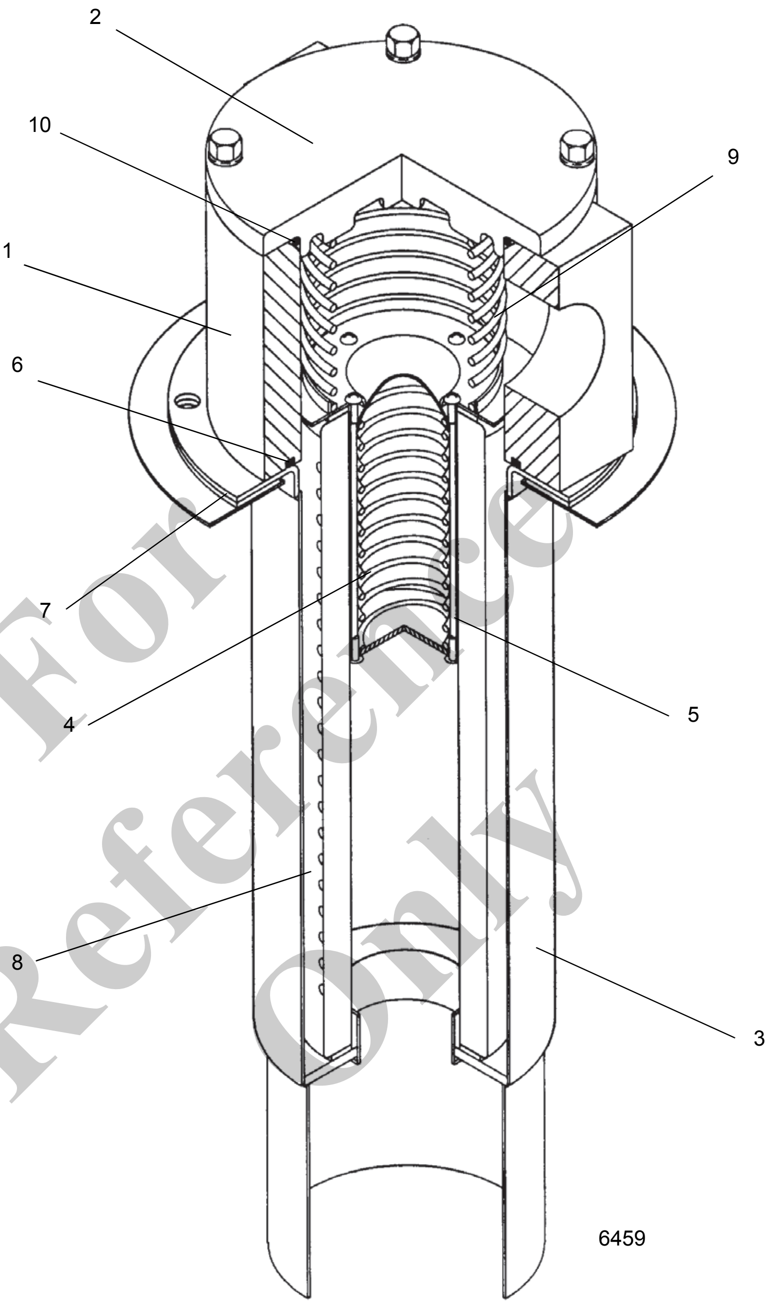


FIGURE 2-3

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

Item	Description
6	O-ring
7	Gasket
8	Filter Element
9	Spring
10	O-ring

OIL COOLER

Description

An air cooled hydraulic oil cooler (Figure 2-4) is mounted on the left side of the carrier forward of the fuel tank. The oil cooler consists of a hydraulic radiator, an electric motor, and a fan. The fan is driven by the motor and pulls air through the cooling fins on the cooler. All hydraulic oil returns from the major functions to two return lines which go to the reservoir. One return line leads directly to the hydraulic reservoir filter and bypasses the oil cooler. This line has a 448 kPa (65 psi) inline check valve which is normally closed and does not permit flow. Therefore, all oil is routed through the other line, through the oil cooler, and to the oil filter in the hydraulic reservoir. When several hydraulic functions are being used at one time (that is, hoisting, lifting, and telescoping), more oil has to flow through this one line, causing a pressure buildup in the return lines. When this pressure reaches 448 kPa (65 psi), the normally closed check valve will open and permit some oil to bypass the oil cooler and flow directly into the reservoir filter.

A temperature switch in the return line senses hydraulic oil temperature to control the fan motor. When the temperature reaches 64°C (120°F), the temperature switch closes its contacts to start the fan motor. When the temperature decreases to approximately 44°C (112°F), the contacts will open to stop the fan motor.

Maintenance

Removal and Disassembly

1. Tag and disconnect the hydraulic lines from the oil cooler. Cap or plug all openings.
2. Tag and disconnect the electrical connector from the motor.
3. Remove the bolts, washers, lockwashers, and nuts securing the front cover. Remove the cover.
4. Remove the bolts, washers, and lockwashers securing the cooler shroud and the cooler core to the front cover. Remove the shroud and cooler core.
5. If necessary, remove the bolts and washers securing the fan guard/motor assembly to the shroud. Remove the assembly.

Assembly and Installation

1. If removed, position the fan guard/motor assembly on the shroud and secure with the bolts and washers.
2. Position the shroud and cooler core on the cover and secure with the bolts, washers, and lockwashers.
3. Position the front cover and secure with the bolts, washers, lockwashers, and nuts.
4. Connect the motor electrical connector.
5. Connect the hydraulic lines to the oil cooler as tagged during removal.

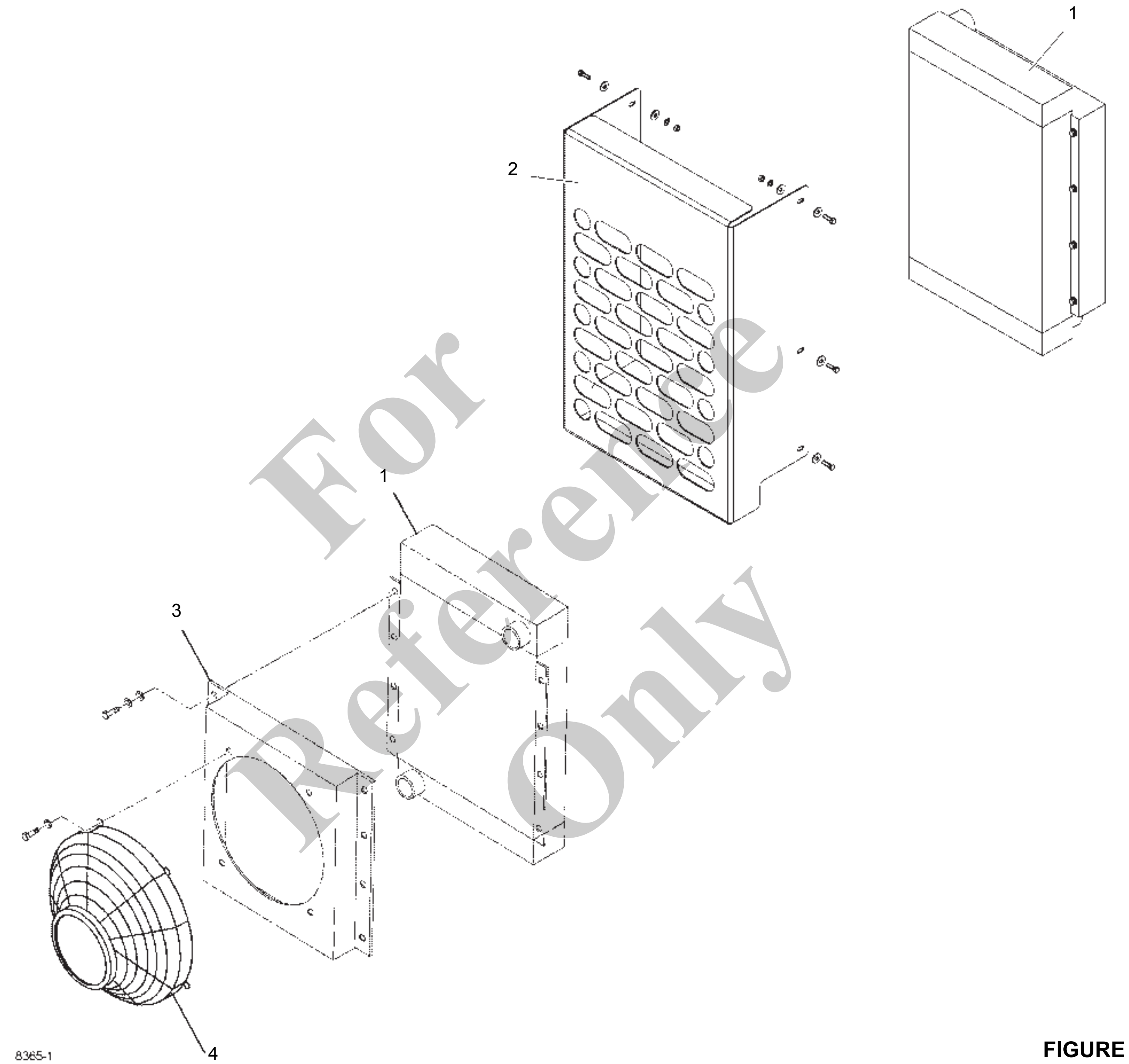


FIGURE 2-4

Item	Description
1	Cooler Core
2	Front Cover
3	Shroud
4	Fan/Motor Assembly

HYDRAULIC PUMPS

Description

The engine PTO driven pump drive drives the No. 1 pump. The No. 1 hydraulic pump mounts on the pump drive. Each of its three sections is a gear pump. The first section of the pump, the one closest to the mounting face, is a 73.7 cm^3 (4.50 cu in) section with a theoretical output of 184.3 lpm (48.7 gpm) at 2604 rpm (engine speed of 1800 rpm). The second section of the pump is a 28.2 cm^3 (1.72 cu in) section with a theoretical output of 70.4 lpm (18.6 gpm) at 2604 rpm. The third section is a 35.6 cm^3 (2.17 cu in) section with a theoretical output of 88.9 lpm (23.5 gpm) at 2604 rpm.

The No. 2 hydraulic pump is mounted on the engine and is directly driven by the engine at 1.16 times engine rpm. The gear pump displacement is 44.1 cm^3/rev (2.69 in^3/rev). The pump pumps at a theoretical rate of 88.2 lpm (23.3 gpm) at 2088 rpm. An integral flow divider/relief valve ensures a constant 37.9 l/min (10 gpm) at 13,800 kPa (2175 psi) at the primary port.

The No. 3 hydraulic pump is mounted on the air compressor and is driven by the engine at 1.16 times engine rpm. The gear pump displacement is 39.3 cm^3/rev (2.40 in^3/rev). The pump pumps at a theoretical rate of 78.7 lpm (20.8 gpm) at 2088 rpm.

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

Maintenance

No. 1 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 parts as needed to gain access to the pump. It is bolted to the pump drive.
2. Tag the supply lines to the pump and tag the distribution lines from the pump, then disconnect them. Cap or plug the lines and ports. \

CAUTION

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

3. Remove the bolts and hardened washers attaching the No. 1 pump to the pump drive. Remove the pump.
4. Discard the gasket. Clean the gasket compound and any gasket residue from the pump drive and the No. 1 pump.
5. Cover the pump drive's opening to prevent dirt from entering.

No. 1 Pump Inspection and Repair

Refer to the Shop Reference and Maintenance Guide for repair instructions as applicable.

No. 1 Pump Installation

1. Remove the pump drive temporary cover.
2. Apply gasket compound (Spec. 6829013865, Loctite Master Gasket 518) to the No. 1 pump's gasket's faces. Place the gasket on the mounting flange of the pump.
3. Install the No. 1 pump on pump drive with bolts and hardened washers. Make sure gear teeth mesh properly. Tighten bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the pump mounting bolts. Make sure gasket seals properly.
4. Connect the distribution and supply lines as tagged during removal. Apply medium strength thread locking compound (Spec. 6829012418, Loctite 243) to the bolts that attach the lines to the pump; discard old O-rings and use new ones with the lines, bolts, and flange halves.

No. 2 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 parts as needed to gain access to the pump. It is bolted to the engine.
2. Tag the supply lines to the pump and tag the distribution lines from the pump, then disconnect them. Cap or plug the lines and ports.
3. Remove nut and lockwasher to free the No. 2 pump from the pump support plate. As needed, loosen or remove the 3/8-16 bolt and its washer to move or remove the pump support plate.

CAUTION

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

4. Remove the bolts and washers attaching the No. 2 pump to the drive pad on the engine. Remove the pump.

5. Discard the gasket. Clean the gasket compound and any gasket residue from the engine drive pad and the No. 2 pump.
6. Cover the drive pad's opening to prevent dirt from entering.

No. 2 Pump Inspection and Repair

Refer to the Shop Reference and Maintenance Guide for repair instructions as applicable.

No. 2 Pump Installation

1. Remove the drive pad temporary cover.
2. Apply gasket compound (Spec. 6829013865, Loctite Master Gasket 518) to the No. 2 pump's gasket's faces. Place the gasket on the mounting flange of the pump.
3. Install the No. 2 pump on engine drive pad with bolts and washers. Make sure gear teeth mesh properly. Tighten bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the pump mounting bolts. Make sure gasket seals properly.
4. Secure the No. 2 pump to the pump support plate with the nut and lockwasher. Torque nut.
5. If you loosened or removed the 3/8-16 bolt to move or remove the pump support plate, reinstall and/or tighten this bolt and its washer.
6. Connect the distribution and supply lines as tagged during removal. Apply medium strength thread locking compound (Spec. 6829012418, Loctite 243) to the bolts that attach the lines to the pump; discard old O-rings and use new ones with the lines, bolts, and flange halves.

Pump Startup Procedure and Test Procedure After Repair or Replacement

CAUTION

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

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

CAUTION

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

5. Place your hand on the pump to check for excessive heat buildup. If the pump is too hot to keep a hand on, stop the engine. Each section should feel about the same warmth, but pressure drops in each pump section's circuit would explain some difference between sections.
6. Listen for abnormal noises indicating low hydraulic oil level or internal pump problems. If the pump is making excessive noise, it is probably sucking air into its inlet, keeping it from priming. In case of abnormal noise, stop engine, and inspect the pump and the suction line for a loose connection, a leak, or a damaged or missing O-ring.
7. If the pump seems to be running properly, increase the RPM to 1500 to 1800 rpm for one to two minutes while operating no hydraulic functions. Repeat checks in steps 4, 5, and 6.
8. Increase engine speed in steps to full RPM. Repeat checks in steps 4, 5, and 6.
9. Cycle the components the pump sections power to verify the pump sections drive them properly. Verify there is no leaking.
10. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-22.

PUMP DRIVE

Description

The hydraulic pump drive (Figure 2-5) is mounted on top of the transmission. The engine powers the pump drive through the use of a prop shaft mounted between the pump drive and the engine PTO. The pump drive is used to transmit engine power to the hydraulic pumps. The pump drive incorporates a disconnect that is operated by an air cylinder.

CAUTION

The engine must not be cranked to engage the pump. It is acceptable to "jog" the engine for proper gear engagement, but it cannot be cranked or damage may occur.

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Oil overflow from the breather.	**a.** Overfilled.	**a.** Drain to the proper level.
	b. The hydraulic pump shaft seal is leaking oil.	**b.** Repair the hydraulic pump.
2. Seals leaking.	**a.** Overfilled.	**a.** Drain to the proper level.
	b. The hydraulic pump shaft seal is leaking oil.	**b.** Repair the hydraulic pump.
3. Vibration.	**a.** Loose drive shaft.	**a.** Tighten the flange bolts (on both ends).
	b. Bad bearings in either the input shaft, the pinion gear, or the output pinion gear(s).	**b.** Inspect and replace as necessary.
	c. Engine malfunction.	**c.** Repair as necessary.
	d. Bent drive line or worn universals.	**d.** Repair or replace as necessary.
	e. Driveline out of balance.	**e.** Balance the drive shaft.
	f. Worn gears.	**f.** Replace as necessary.
4. Noise.	**a.** Worn gears or bearings.	**a.** Replace as necessary.

Removal

1. Remove the No. 1 pump per instructions in this section.
2. Tag and disconnect the air lines from the disconnect controls. Cap or plug air lines and ports as needed to protect against contamination.
3. Tag and disconnect the electrical connector to the air solenoid valves and the indicator light switch.
4. Disconnect the prop shaft from the pump drive.
5. Remove the hardware securing the support straps to each side of the pump drive and rear engine mounts.

NOTE: The pump drive with the mounting plate weldments weighs approximately 70 kg (154 lb).

6. Support the weight of the pump drive and remove the bolts and hardened washers securing the pump drive mounting plate to the top and rear of the transmission. Remove the assembly from the transmission.
7. If installing a new pump drive, remove the pump drive mounting plate, the pump drive upper support, and the air shift components (air cylinder, solenoid valves, linkage).
8. If the pump drive is to be installed on a new transmission, the bolts that secure the bottom support weldment on the transmission replace existing bolts in the transmission.

Installation

1. If the pump drive is to be installed on a new transmission, remove the bolts mentioned in step 8 of *Removal* from the new transmission and install them in the old transmission.
2. Secure the pump drive to the pump drive mounting plate with four bolts and hardened washers after applying medium strength thread locking compound (Specification 6829012418, Loctite 243) to the bolts' threads. Secure the pump drive upper support to the pump drive with four bolts and hardened washers after applying Loctite 243 to the bolts' threads. Tighten all eight bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the mounting bolts.
3. Install the air shift components on the pump drive. Refer to Figure 2-5. For the solenoids, apply medium strength thread locking compound (Specification 6829012418, Loctite 243) to the threads of the screws that secure the solenoids to their mounting bracket. Verify the air cylinder is pinned securely to the pump drive with a clevis pin and a cotter pin. Verify the disconnect lever is connected to the air cylinder's attached ball joint (upper), the bracket, and the ball joint (lower) near the lower side of the pump; verify there are enough 3/8 inch flat washers at its pivot connection to the bracket to minimize side play and verify each ball joint can move freely. Adjust ball joints' nuts as needed.

4. Place the pump drive mounting plate and attached parts on the transmission. Secure the pump drive mounting plate to the transmission with bolts and hardened washers.
5. Place the support straps on each side of the pump drive. Secure them to the rear engine mounts and the pump drive upper support with attaching hardware.
6. Connect the prop shaft to the pump drive with four 1/2-20 bolts and washers. If the prop shaft was also disconnected from the engine's PTO shaft, reconnect them using four 7/16-14 screws, nuts, and washers. Torque the 7/16-14 screws according to *Fasteners and Torque Values*, page 1-12.
7. Connect the electrical connectors to the air solenoids and the indicator light switch as tagged during *Removal*.
8. Connect the air lines to the disconnect controls as tagged during *Removal*.
9. Install the No. 1 Pump per installation instructions in this section.
10. Service the pump drive. Refer to *Lubrication*, page 9-1.
11. Operate all components and check for leaks and proper operation. Also verify the air-powered disconnect function works. Make adjustments or repairs as needed.

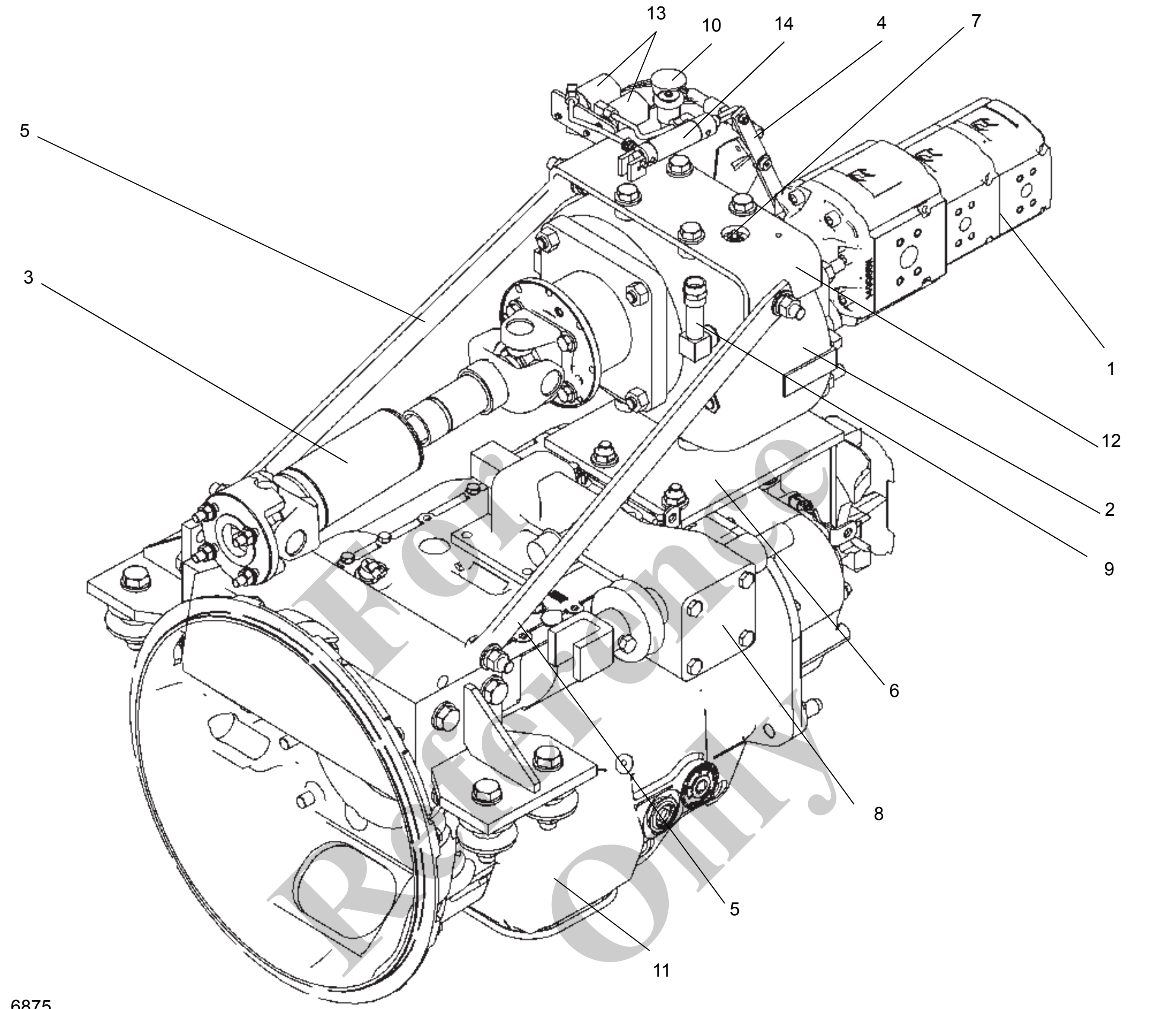


FIGURE 2-5

Item	Description
1	Hydraulic Pump
2	Pump Drive
3	Pump Drive Shaft
4	Disconnect Lever
5	Pump Drive Support Straps
6	Pump Drive Mounting Plate
7	Disconnect Indicator Light Switch

Item	Description
8	Transmission Shift Control
9	Breather
10	Pump Drive Dipstick
11	Transmission
12	Pump Drive Upper Support
13	Disconnect Air Solenoids
14	Disconnect Air Cylinder

VALVES

General

This subsection provides descriptive information for all the hydraulic valves used on this crane. For a listing of all valves, the circuit they are used in, and their physical location, refer to the Valve Usage Table, below. Also, refer to the following table for valve locations. 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 2-1
Valve Usage Table

Valve Name	Circuit Used In	Physical Location
Directional Control Valves	Boom Lift/Telescope/Hoist(s) Swing Counterweight Removal	Superstructure right side Superstructure right side Superstructure under hoists
Manifold • Swing brake release • Crane function	Swing HRC lockout (crane functions)	Superstructure right side
Hydraulic Remote Control Valve	Boom lift Telescope Main hoist Auxiliary hoist Swing	Cab seat arm rests (2)
Swing Power Brake Valve	Swing	Superstructure cab floor
Holding Valves	Boom lift Telescope (2) Counterweight removal (2)	Lift cylinder (bolt on manifold) Telescope cylinder (cartridge style) Removal cylinder (cartridge style)
Hoist Motor Control Valve (1 of 2)	Hoist(s)	Both hoists (see Hoist Section)
Check Valves (2)	Return circuit Return circuit	One on swing outlet One in parallel with oil cooler
Outrigger Selector Valve	Outrigger	On front face of carrier frame front cross member forward of hydraulic swivel
Outrigger Control Manifold (2)	Outriggers	4 stack on rear outrigger box; 5 stack on front outrigger box
Pilot Operated Check Valve	Outrigger	Port block of each jack cylinder (4)
Swing Speed Flow Control Valve	Swing	In-line between swing work port lines
Priority Flow Divider Valve	Optional air conditioner	Rear frame tunnel forward of hydraulic swivel
High Speed Boost Selector Valve	Hoist, boom lift and telescope	On swivel port #4
Front Center Jack Relief Valve	Outrigger	Front outrigger box under left rear frame rail
Pump Mounted Relief Valve	Outrigger/Main Crane Circuit	Mounted on the outlet of hydraulic pump #2 section #2
Needle Valve (2)	Trailing boom option	Boom lift cylinder

Valve Name	Circuit Used In	Physical Location
Flow Control Valve	Trailing boom option	Boom lift cylinder
Swing Brake Release Valve	Trailing boom option	Superstructure right side
Auxiliary Cooler Flow Control Valve	Auxiliary Water Jacket (Radiator) Cooler	Left side of Auxiliary Cooler support brace
Auxiliary Radiator Valve	Auxiliary radiator motor	Left side of auxiliary radiator

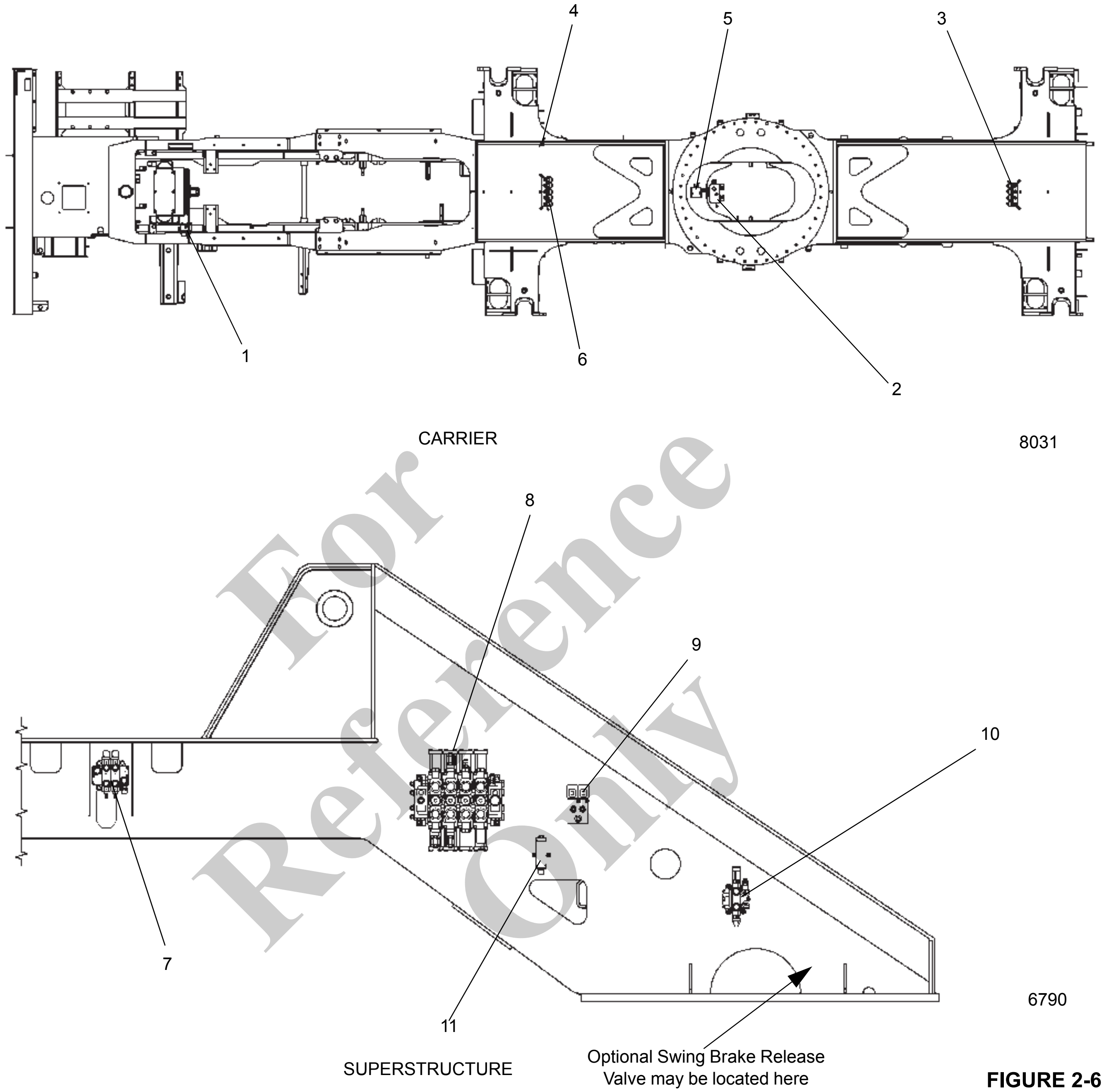


FIGURE 2-6

Item	Description
1	Auxiliary Cooler Control Valve
2	Outrigger Selector Valve
3	Rear Outrigger Manifold Valve
4	Center Jack Relief Valve
5	Flow Control Valve
6	Front Outrigger Manifold Valve (5 section)

Item	Description
7	Counterweight Removal Directional Control Valve
8	Telescope/Lift/Hoist Directional Control Valve
9	Swing Brake & Armrest L/O Manifold
10	Swing Control Valve
11	Accumulator

PRESSURE SETTING PROCEDURES

Description

The hydraulic valves in the hydraulic system must be properly adjusted to protect a component, a circuit, or a system from over pressurization (relief valves) or to ensure the components receive the appropriate pressure and flow for proper operation. Most of the relief valves are located in the directional control valves, but some are located in line between components, while others are part of a component.

Maintenance

General

Relief valves are checked and adjusted by causing a given circuit to reach its prescribed pressure limit (stall). At this point the relief valve opens, returning hydraulic oil to the reservoir. Hydraulic motor circuits may be stalled by preventing rotation of the motor shaft prior to actuating the control valve. Cylinder circuits may be stalled by extending or retracting a cylinder to its limit of travel.

A reading of a pressure gauge placed in the proper line or test port indicates when the relief valve opens. The gauge's needle climbs until it reaches the relief valve setting. Then the needle stops climbing and fluctuates, showing the relief valve is open and returning hydraulic oil to the reservoir.

Correct relief valve adjustment is mandatory if any hydraulic circuit is to function properly. Settings must be within tolerances. Only qualified technicians using the correct equipment should make pressure adjustments when pressure adjustments are needed.

The hydraulic system uses two valve banks. The hoist/lift/telescope valve bank directs hydraulic oil flow for operation of the main hoist, lift, and telescope circuits. RCL lockout solenoids are located in the hoist up, lift down, and telescope out functions. (If the crane has an auxiliary hoist, its auxiliary hoist control valve will be in this valve bank.) A single section valve bank serves the swing circuit.

The swing brake/armrest lockout valve (also called the swing brake/armrest lockout manifold) directs hydraulic oil flow to the swing brake release valve and pilot pressure for the remote controllers.

The Hoist/Lift/Telescope directional control valve bank has one main load sense relief valve limiting maximum operating pressure of the components in related circuits. There are also port relief valves in some circuits which limit operating pressures as required by circuit design. The pilot generator metering capsule located in the inlet section controls the pilot pressure and flow to the swing brake/armrest lockout manifold.

The following table and test procedures contain main and port relief valve settings. If the pressure setting of the main relief valve or a port relief valve is not within 3.45 bar (50 psi) of the listed setting, adjustment is necessary.

CAUTION

Do not overtighten the adjustment screw or locknut.

Do not hold the relief valve open for more than one minute at a time.

NOTE: Use an accurate 0 to 345 bar (0 to 5000 psi) pressure gauge when adjusting relief valves. For most circuits, utilize the gauge ports on the circuit valves or pumps. On a circuit without a gauge port, locate a suitable pressure test port elsewhere in the circuit.

To adjust a relief valve, turn the adjustment screw (in to increase or out to decrease) until the proper setting is reached.

Release the control lever after taking each reading and while making adjustments. When the proper pressure setting has been attained, tighten the adjustment screw locknut and recheck the pressure. It is possible that the setting may change while tightening the locknut.

It is only necessary to hold hydraulic pressure long enough (usually a few seconds) in the circuit to gain an accurate reading. Do not overload the hydraulic circuits for long periods of time.

If a question arises concerning pressure setting values, always refer to the crane hydraulic schematic supplied.

Reservoir oil temperature is to be 60° to 71°C (140° to 160°F).

Preparation

1. Start and warm up the engine until the hydraulic oil temperature reaches a minimum of 60° to 71°C (140° to 160°F).

DANGER

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

Table 2-2
Valve Pressure Setting Table

VALVE TO BE SET	PRESSURE SETTING Bar (PSI)	TOLERANCE Bar (PSI)	ADJUSTMENT LOCATION
Load Sense Relief*	276 (4000)	±4 (50)	Main Control Valve Inlet Gauge Port
Lift Down Relief	138 (2000)	+48/-0 (+700/-0)	See step #10 - Procedure For Checking Main Directional Control Valve Relief
Tele Retract Relief	241 (3500)	±4 (50)	Main Control Valve Tele Retract Port
Tele Extend Relief	186 (2700)	±4 (50)	Main Control Valve Tele Extend Port
Hoist Raise	241 (3500)	±4 (50)	Main Control Valve Hoist Raise Port
Hoist Lower	241 (3500)	±4 (50)	Main Control Valve Hoist Lower Port
Pilot Pressure Supply	22 to 31 (325 to 450)	See Range	Main Control Valve Inlet
Swing Brake Pilot Supply	17 (250)	+4/-0 (+50/-0)	Pressure Reducing Valve
Front Steer Relief	15 (2175)	±4 (50)	Steering Pump
Swing Relief	152 (2200)	±4 (50)	Swing Control Valve
Counterweight Relief	121 (1750)	±4 (50)	Counterweight Control Valve
Outrigger Relief	228 (3300)	±4 (50)	Outrigger Valve Inlet
Air Conditioning Relief	104 (1500)	±4 (50)	Air Conditioning Flow Divider
Front Jack Relief	14 (200)	+4/-0 (+50/-0)	Front Jack Relief Valve
*This setting is for Boom Lift "UP" circuit.			

Procedure for Checking Main Directional Control Valve Reliefs

NOTE: "When checking the directional control valve relief settings, start with the engine at idle RPM and move the controller to it's fully stroked position. Then slowly accelerate the engine to the specified RPM. Read gauge and make adjustment to specified setting.

1. Remove cap and install pressure gauge on the main directional control valve inlet gauge port. (See Figure 2-8.)
2. Completely extend the lift cylinder (or cap hose from port A to the lift cylinder), and attempt to lift up with the engine running at full rpm. Adjust the load sense relief to 276 ± 4 bar (4000 ± 50 psi).
3. Remove pressure gauge and reinstall plug.
4. Remove cap and install pressure gauge on the main directional control valve load sense relief test port. (See Figure 2-8.)
5. Disconnect and cap the hose running from the main directional control valve to the hoist(s) port A of the hoist motor control valve. (See Figure 2-7.) Disconnect the hoist brake release line at the hoist, cap fitting, and plug hose.

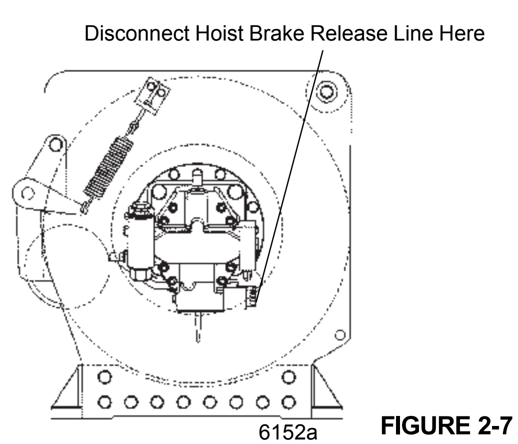


FIGURE 2-7

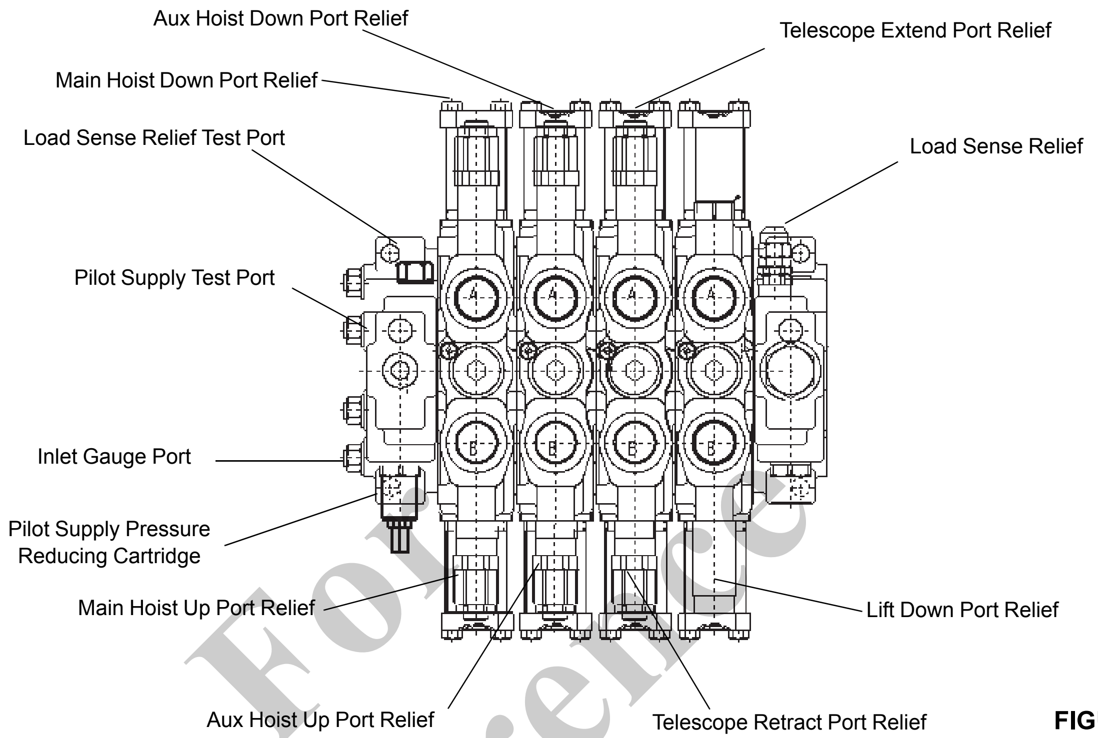


FIGURE 2-8

6. With the boost switch on, attempt to hoist up with the engine running at full RPM. Adjust the main directional control valve hoist up, port relief B, to 241 ± 4 bar (3500 ± 50 psi).

7. With the boost switch on, attempt to hoist down with the engine running at full RPM. Adjust the main directional control valve hoist down, port relief A, to 241 ± 4 bar (3500 ± 50 psi).

8. Reconnect the hose to port A of the hoist motor control valve and reconnect the hoist brake release line on the hoist.

9. If the auxiliary hoist is installed, repeat steps 3 through 8 for the auxiliary hoist and its port reliefs.

10. Completely retract the lift cylinder, attempt to lift down with the engine running at full RPM. The gauge should read 138 + 48/-0 bar (2000 +700/-0 psi). **This relief valve is non-adjustable.**

11. Completely retract the boom. Try to telescope in with engine running at full RPM. Adjust the main directional control valve telescope, port B relief, to 241 ± 4 bar (3500 ± 50 psi).

12. Completely extend the boom. Try to telescope out with engine running at full RPM. Adjust the main directional control valve telescope, port A relief, to 186 ± 4 bar (2700 ± 50 psi).

13. Remove pressure gauge from the load sense test port and reinstall cap.

Procedure for Checking Main Directional Control Valve Pilot Supply Pressure

1. Remove cap and install pressure gauge on pilot supply test port per Figure 2-8.

2. Adjust the pressure reducing cartridge located in the inlet of the hoist/lift/telescope directional control valve to 22 to 31 bar (325 to 450 psi). Turn adjustment clockwise to increase or counterclockwise to decrease the pressure setting.

3. Remove pressure gauge from the pilot supply test port and reinstall cap.

Procedure for Checking Swing Brake Pilot Supply Pressure

1. Remove and install pressure gauge on the swing brake pilot supply valve test port per Figure 2-9.

2. Adjust pressure reducing valve cartridge to 17 +4/-0 bar (250 +50/-0 psi). At idle, pressure should read a minimum of 17 bar (250 psi) to ensure brake is released for swing operation at idle.

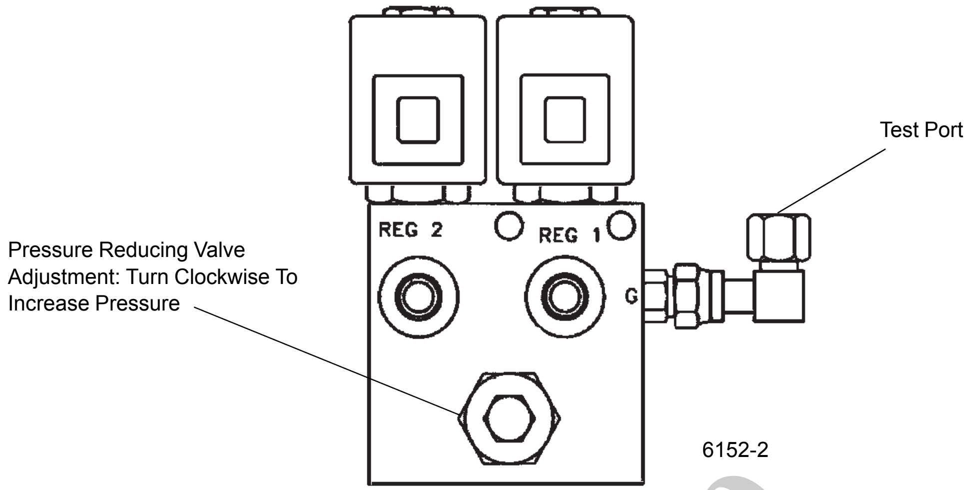


FIGURE 2-9

3. Remove pressure gauge from the test port and reinstall cap.

Procedure for Checking Swing Valve Main Relief Pressure

1. Remove cap and install pressure gauge on swing inlet test port per Figure 2-10. Locate needle valve plumbed between work ports A and B. Loosen locking nut and rotate knob clockwise until it bottoms out, and retighten locking nut.
2. With the swing lock pin engaged and the engine running at full RPM, swing left or right and adjust the main relief to 152 ± 4 bar (2200 ± 50 psi).
3. Remove pressure gauge from swing test port and reinstall cap.

Procedure for Checking Relief Setting for Counterweight Supply Control Valve

1. Remove cap and install gauge on load sense relief test port on the main directional control valve per Figure 2-8.
2. Operate the counterweight directional control valve by fully raising or lowering the counterweight cylinders. Adjust the counterweight removal directional control valve's LS relief valve (clockwise to increase pressure) on the counterweight directional control valve to 121 ± 4 bar (1750 ± 50 psi). See Figure 2-11.
3. Remove gauge, reconnect plumbing, and reinstall cap.

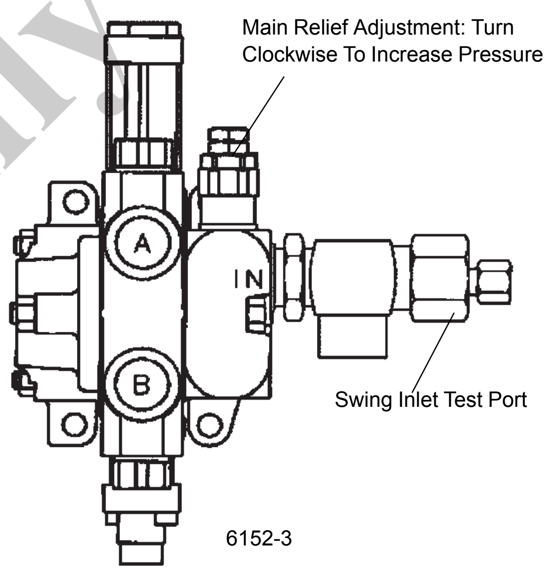


FIGURE 2-10

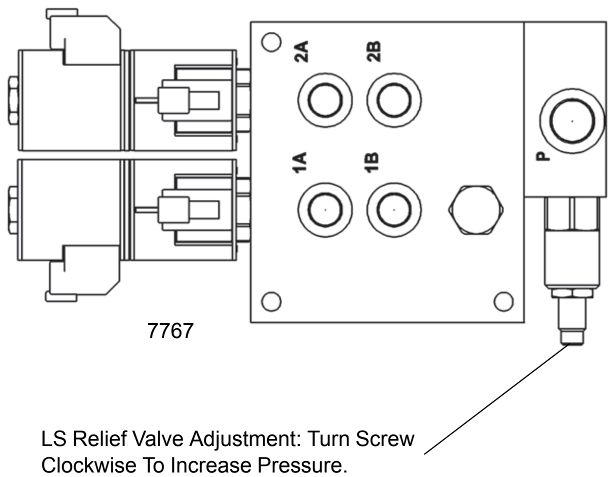


FIGURE 2-11

Procedure for Checking Outrigger Selector Valve Relief Pressure

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

1. Remove cap and install pressure gauge on outrigger selector valve pressure check port labeled GP (see Figure 2-12).
2. With the boost switch off and the engine running at full RPM, press the extend switch and adjust the outrigger selector relief valve to 228 ± 4 bar (3300 ± 50 psi).
3. Remove pressure gauge from outrigger selector valve and reinstall cap.

Procedure for Checking the Air Conditioning Circuit Relief Valve Pressure

1. Disconnect hose assembly at motor port P, coming from port A of flow divider (Figure 2-13). Install a pressure gauge on port GP of the flow divider.
2. Run the engine at 1000 rpm. Adjust the air conditioning flow divider relief (see Figure 2-14) to 104 ± 4 bar (1500 ± 50 psi). Hold adjustment with jam nut. If this step needs to be repeated, make sure pump is not hot to the touch. If it is, allow to cool before proceeding.
3. Remove pressure gauge and reconnect the pressure line.

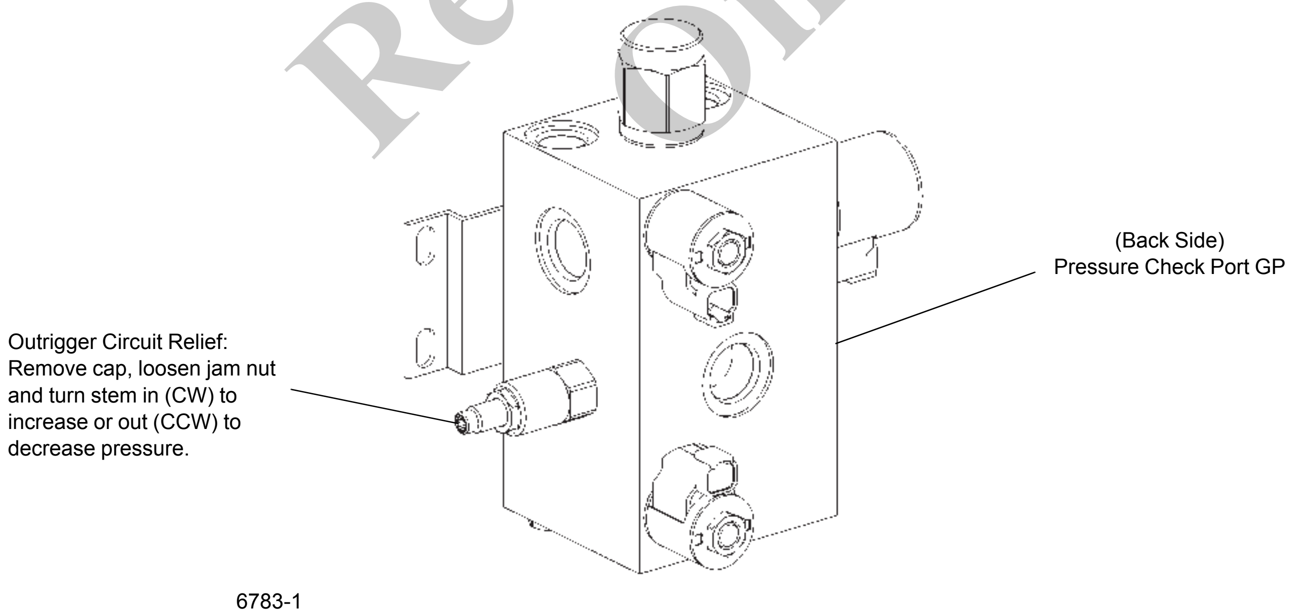


FIGURE 2-12

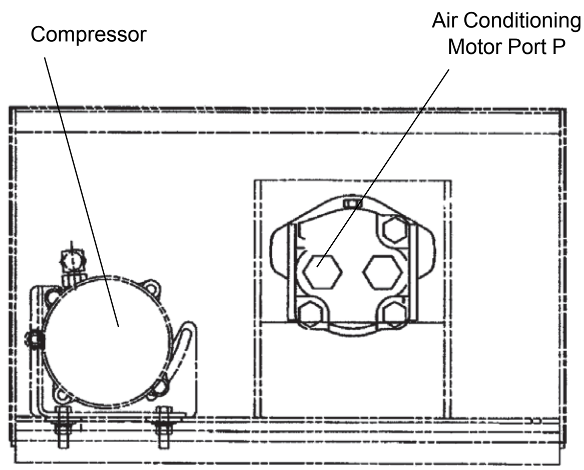


FIGURE 2-13

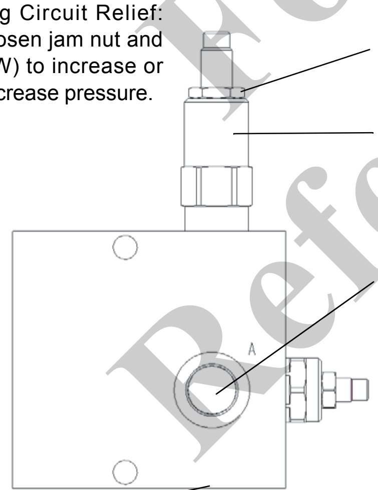


FIGURE 2-14

Procedure for Checking Center Front Jack Cylinder (Fifth Jack) Relief Valve Pressure

1. Remove hose from Port 1 on the Center Front Jack Cylinder Relief Valve. (See Figure 2-15.)
2. Install a tee fitting, reducer, and pressure gauge. Reinstall hose onto tee fitting on Port 1.
3. With the engine running at idle RPM, fully extend the center front jack cylinder (fifth jack).
4. While pressing the extend switch and the front jack activate switch on the outrigger control box, check the pressure and adjust the relief valve to 14 +4/-0 bar (200 +50/-0 PSI) (Figure 2-15).
5. Remove pressure gauge and adapters from Port 1 and reinstall hose.

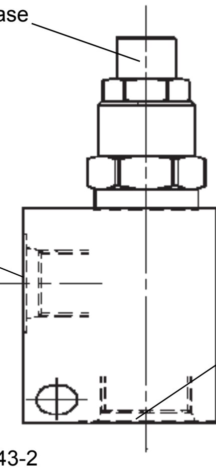


FIGURE 2-15

Procedure for Checking Pump Mounted Relief Valve Pressure

This relief valve is factory set at 310 ± 4 bar (4500 ± 50 psi). As long as the relief settings on both the outrigger and main crane functions are achievable, there is NO need to check or set it. If there is a problem with either relief setting, contact Manitowoc Crane Care for assistance. (See Figure 2-16.)

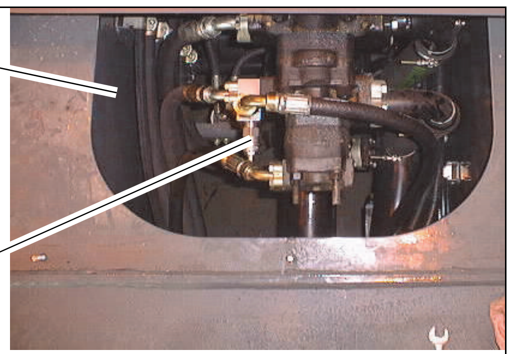


FIGURE 2-16

Procedure For Checking Front Steering Relief Valve Pressure

1. Install pressure check diagnostic quick disconnect with gauge on test nipple at the inlet of the power steering gear box. (See Figure 2-17)

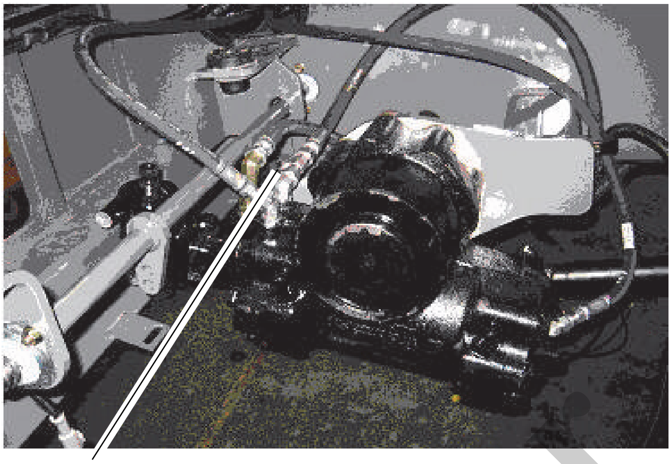


FIGURE 2-17

2. Disconnect hose from right front steer cylinder. Plug hose. Plug or cap cylinder port also. (See Figure 2-18.)

FIGURE 2-18

CAUTION

To prevent pump damage or failure due to heat buildup, run the engine at full RPM in this configuration for a maximum of 15 to 30 seconds.

3. Start engine and throttle up to full RPM. Attempt to turn the steering wheel left or right.
4. Adjust the priority flow relief valve (Figure 2-19) in the pump in to increase or out to decrease to attain a pressure of 150 ± 4 bar (2175 ± 50 psi).

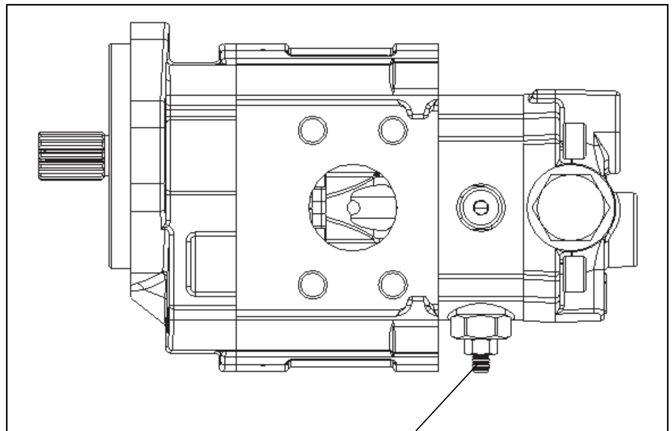


FIGURE 2-19

5. Stop engine. Remove quick disconnect and gauge. Connect steer hose to right front steer cylinder.

DIRECTIONAL CONTROL VALVES

Description

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

The boom lift/telescope/hoist directional control valve (Figure 2-21) is a sectional, hydraulic remote pilot actuated three position four way, pressure compensated, closed center directional valves. The inlet section contains a pump unloading valve and load sense relief valve set at 275.80 bar (4000 psi) protecting the main and auxiliary hoist and boom lift sections. The unloading valve has a 20.69 bar (300 psi) standby or pump margin pressure setting. The boom lift retract has a thermal relief set at 255 bar (3700 psi). The telescope section has port relief's set at 206.90 bar (3500 psi) for retract and 186.21 bar (2700 psi) for extend. All working sections have a two position two way solenoid RCL lockout valve in each pilot end cap.

The swing valve (Figure 2-22) is a sectional, hydraulic remote pilot actuated three position four way open center directional control valve. The inlet section has a 151.69 bar (2200 psi) relief valve. Both working sections have anti void check valves to provide make-up oil to the swing motor for motor over-run when the valve is centered.

The counterweight removal/cab tilt directional control valve (Figure 2-23) is a sectional, hydraulic remote pilot actuated three position four way, pressure compensated, closed center directional valve. It is plumbed in parallel with the boom lift/telescope/hoist directional control valve. The inlet section contains a load sense relief valve set at 103.43 bar (1500 psi) protecting all four working sections.

The auxiliary water jacket cooler directional valve is a solenoid operated two position, two-way valve. It is plumbed in parallel with the auxiliary water jacket cooler motor. When it is in the normal (de-energized) position, the valve is closed forcing all of the oil flow to run through the auxiliary water jacket cooler motor. When the valve is energized, oil can flow through the valve allowing it to bypass the motor. Energizing of the valve is controlled by the engine ECM.

Maintenance

Swing Valve Bank Removal

1. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.
2. Remove the three bolts, flatwashers, and spring lockwashers securing the valve bank and remove the valve bank.

Swing Valve Bank Installation

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

Hoist/Lift/Telescope Valve Bank Removal

1. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.
2. Tag and disconnect electrical connectors from the valve.
3. Remove the three bolts, flatwashers, and spring lockwashers securing the valve bank and remove the valve bank.

Hoist/Lift/Telescope Valve Bank Installation

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

Counterweight Removal Valve Bank Removal

1. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.
2. Tag and disconnect the wires from the valves.
3. Remove the three bolts and nuts securing the valve bank to the mounting bracket and remove the valve bank.

Counterweight Removal Valve Bank Installation

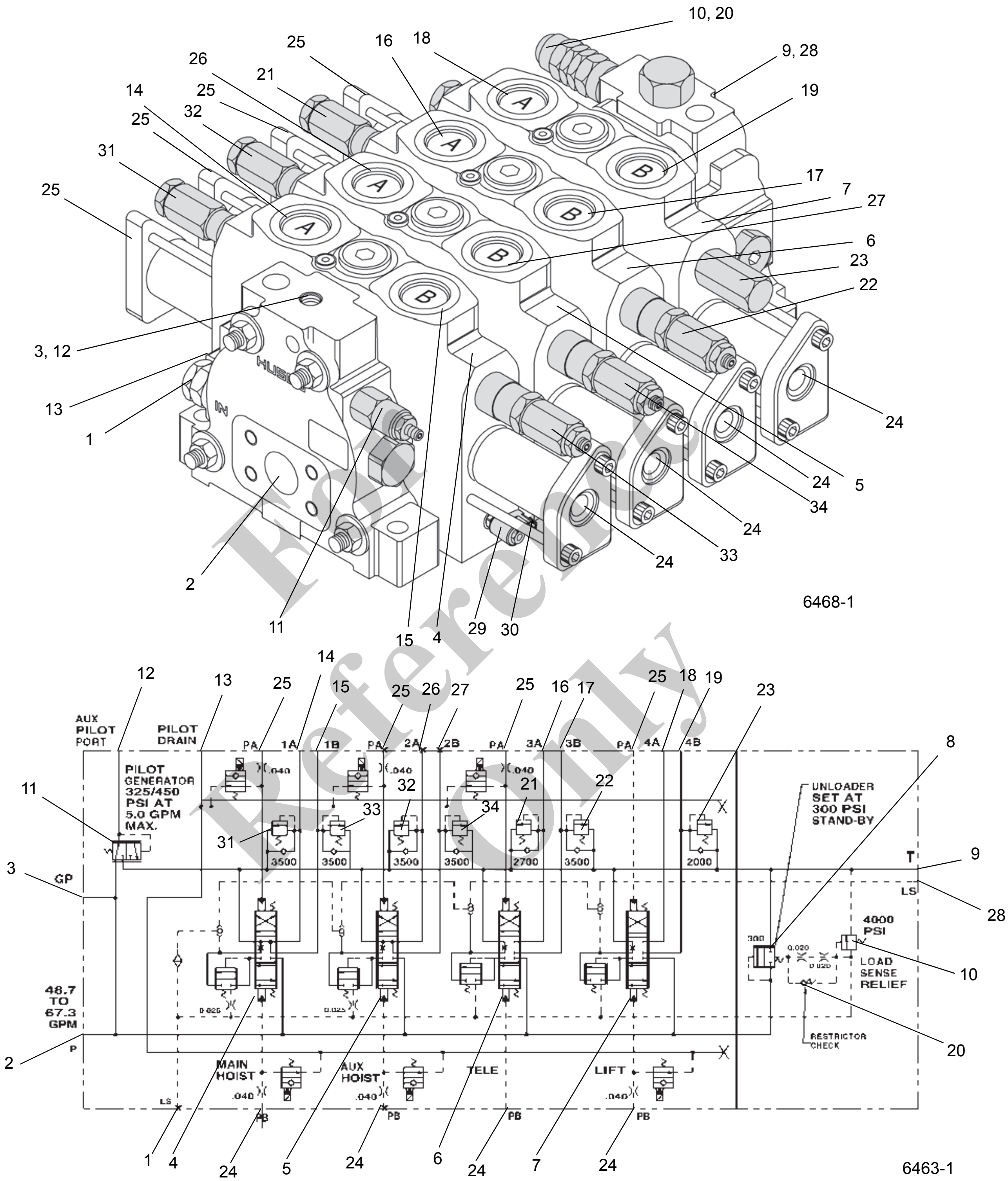
1. Position the valve bank on the mounting bracket and secure with the three bolts and nuts.
2. Connect the wires to the valves as tagged during removal.
3. Connect the hydraulic lines to the valves as tagged during removal.

Functional Check (All Valve Banks)

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

Functional Check (RCL Lockout Valves)

1. Remove circuit breaker CB11 from the circuit breaker panel in the superstructure cab. This cuts off power to the RCL.
2. Start the engine.
3. Try to telescope the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify none of these functions work.
4. Shut down the engine. Reinstall CB11.
5. Telescope the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify all of these functions work.
6. Check for leaks. Make repairs as needed.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3, 12
13
1
24
24
5
24
34
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6468-1
AUX PILOT PORT
PILOT DRAIN
PILOT GENERATOR 325/450 PSI AT 5.0 GPM MAX.
GP
48.7 TO 67.3 GPM
P
PA
1A
1B
2A
2B
3A
3B
4A
4B
.040
3500
2700
2000
T
LS
UNLOADER SET AT 300 PSI STAND-BY
4000 PSI
LOAD SENSE RELIEF
RESTRICTOR CHECK
MAIN HOIST
AUX HOIST
TELE
LIFT
PB
6463-1

FIGURE 2-20

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

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

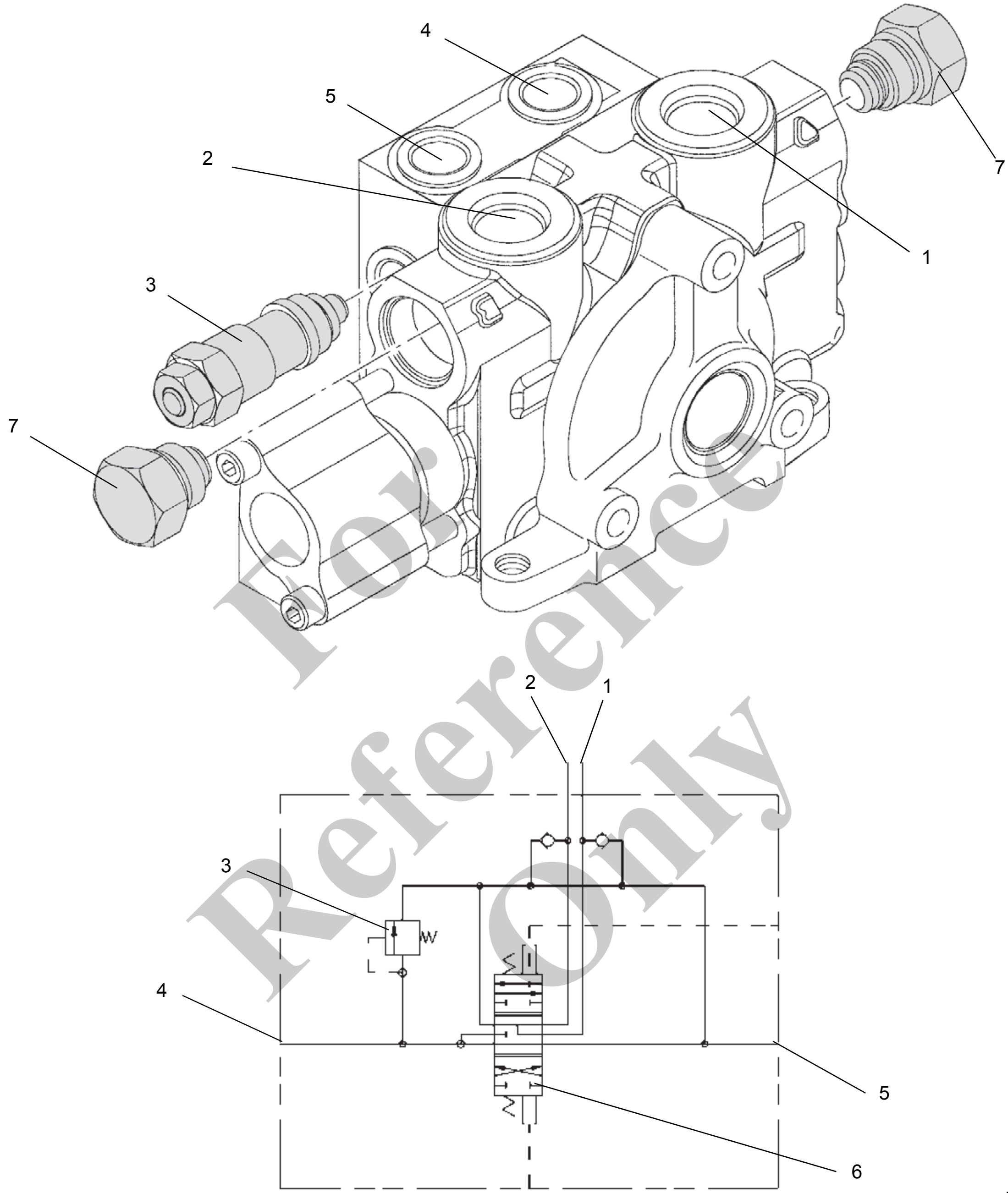
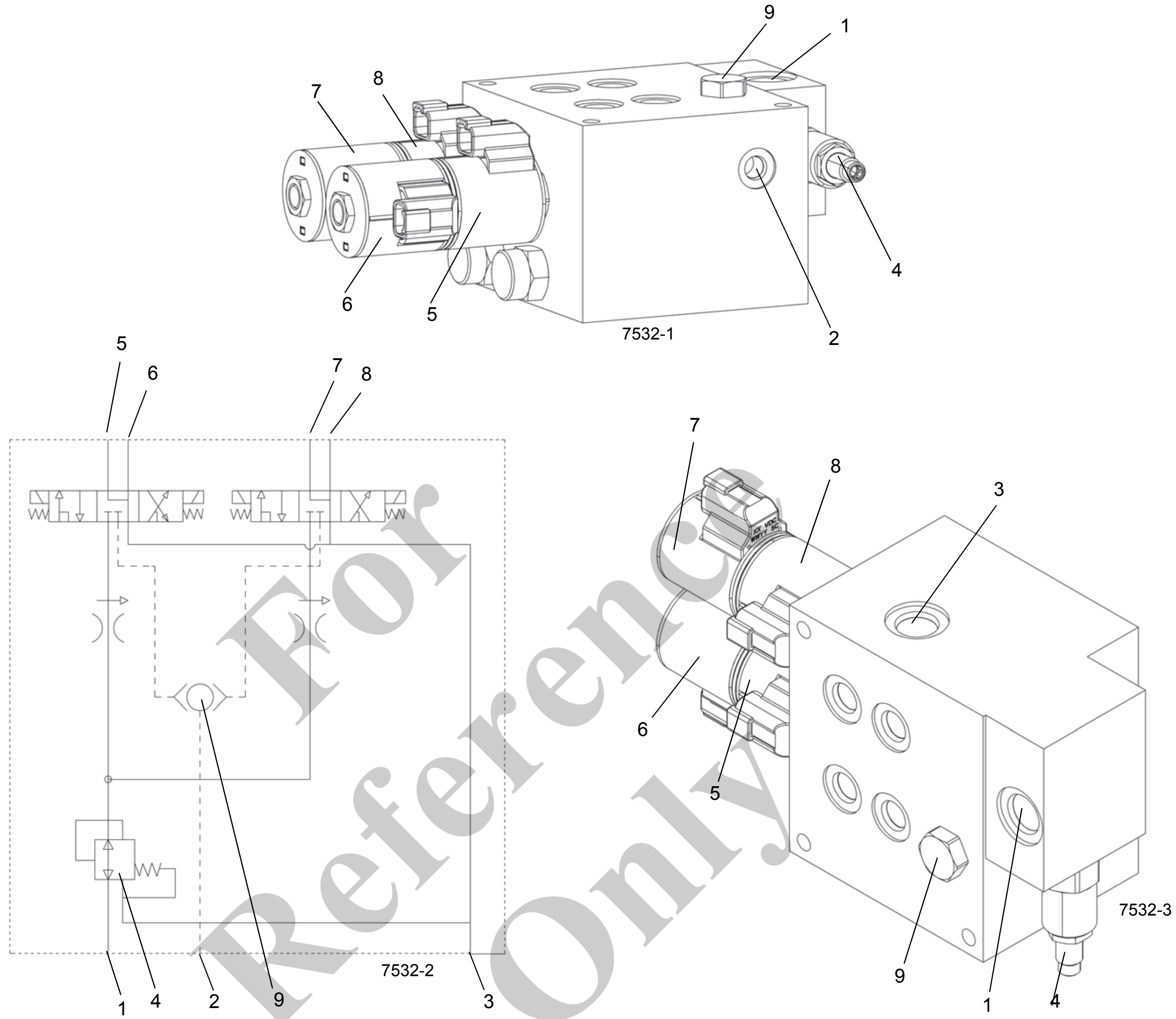


FIGURE 2-21

Item	Description
1	Port B - Swing Left
2	Port A - Swing Right
3	Relief Valve
4	Inlet

Item	Description
5	Outlet
6	Swing Directional Valve
7	Anti-Void Assembly



Counterweight Removal Manifold

FIGURE 2-22

Item	Description
1	Port P - Pressure to Directional Valve
2	Port LS - Load Sense
3	Port T - Tank to Swivel Port #4
4	Pressure Compensated Regulator
5	Port 1A - Solenoid Valve SV2
6	Port 1B - Solenoid Valve SV1
7	Port 2B - Solenoid Valve SV3
8	Port 2A - Solenoid Valve SV4
9	Load Shuttle

CHECK VALVES

Description

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

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

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

Maintenance

Removal

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

Installation

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

HYDRAULIC REMOTE CONTROL VALVE

Description

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

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

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

When the armrests are up, the crane function switch is off, or the operator is not seated, the controller lockout valve is de-energized and the functions are disabled.

Maintenance

Armrest Control Valve Removal

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

Armrest Control Valve Installation

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

Armrest Control Valve Functional Check

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

Telescope Pedal Control Valve Removal (with Auxiliary Hoist Option)

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

Telescope Pedal Control Valve Installation (with Auxiliary Hoist Option)

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

Telescope Pedal Control Valve Functional Check (with Auxiliary Hoist Option)

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

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

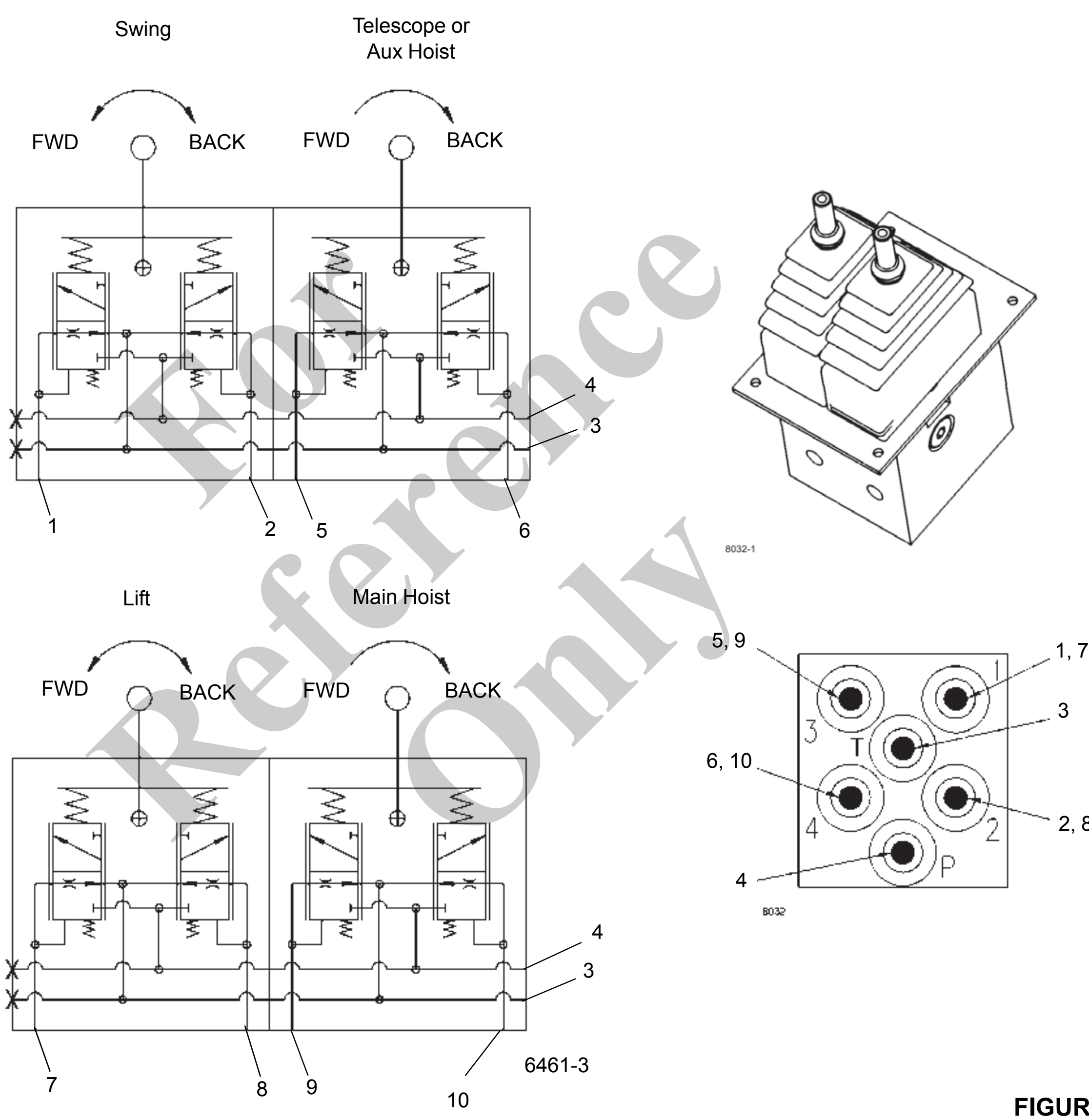


FIGURE 2-23

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

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

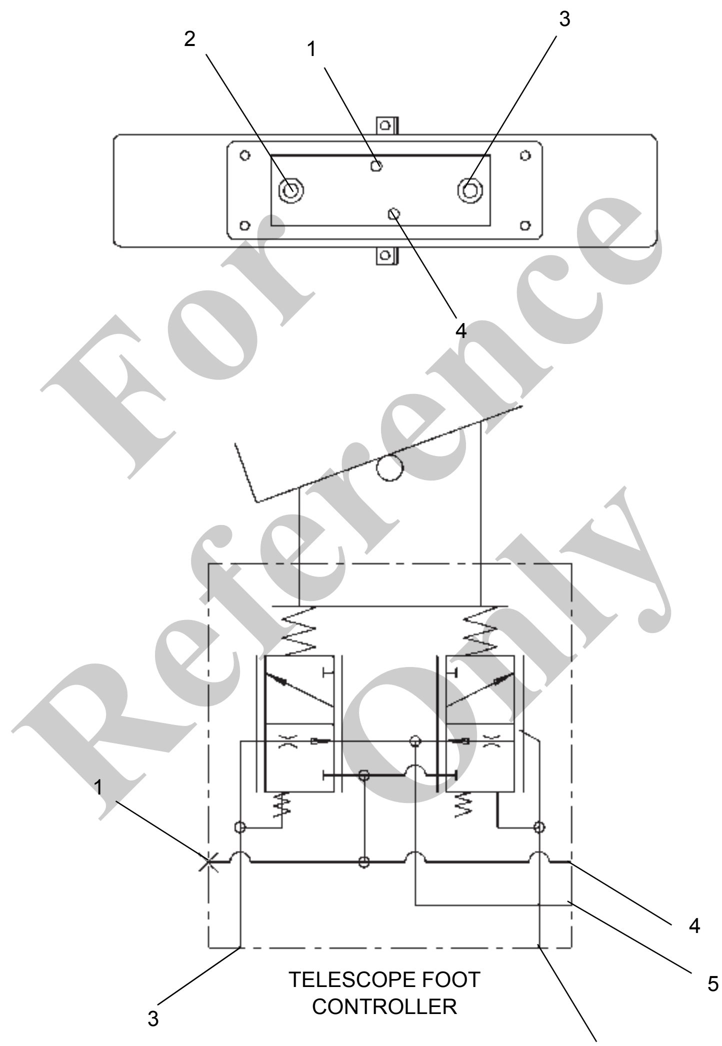


FIGURE 2-23 continued

Item	Description
1	Port P - Pressure
2	Port 1 - Telescope Out
3	Port 2 - Telescope In

Item	Description
4	Port T - Tank
5	Case Drain - Manifold

OUTRIGGER SELECTOR VALVE

Description

The outrigger selector valve (Figure 2-24) directionally controls the outrigger circuit, rear steer circuit, and the pin cylinders that remove the front and rear outrigger boxes. The valve is mounted on the rear face of the carrier frame front cross member forward of the swivel. The valve has two sections, an inlet and a working station

The inlet station contains a 228 bar (3300 psi) relief valve and a two position two way solenoid valve that is normally open by-passing oil from the inlet port to the tank port. Activation of the outriggers will energize the solenoid valve to close, pressurizing the working sections. The second section controls the outrigger extend and retract. It contains a three position four way solenoid directional control valve and a bolt on two pilot operated check valves with integral thermal relief valves, one for the extend set at 262 bar (3800 psi) and one for the retract set at 20.7 bar (300 psi).

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the integrated outrigger valve.
2. Tag and disconnect the hydraulic lines to the integrated outrigger valve. Cap or plug the lines and ports.
3. Remove the four bolts, nuts and washers securing the integrated outrigger valve to the crane. Remove the valve as a complete assembly.

Installation

1. Put the integrated outrigger valve on its mount. Secure the valve with the washers, nuts and bolts.
2. Connect the hydraulic lines to the integrated outrigger valve as tagged during removal.
3. Connect the electrical connectors to the integrated outrigger valve as tagged during removal.

Functional Check

Cycle an outrigger cylinder several times. Verify the cylinder extends and retracts properly.

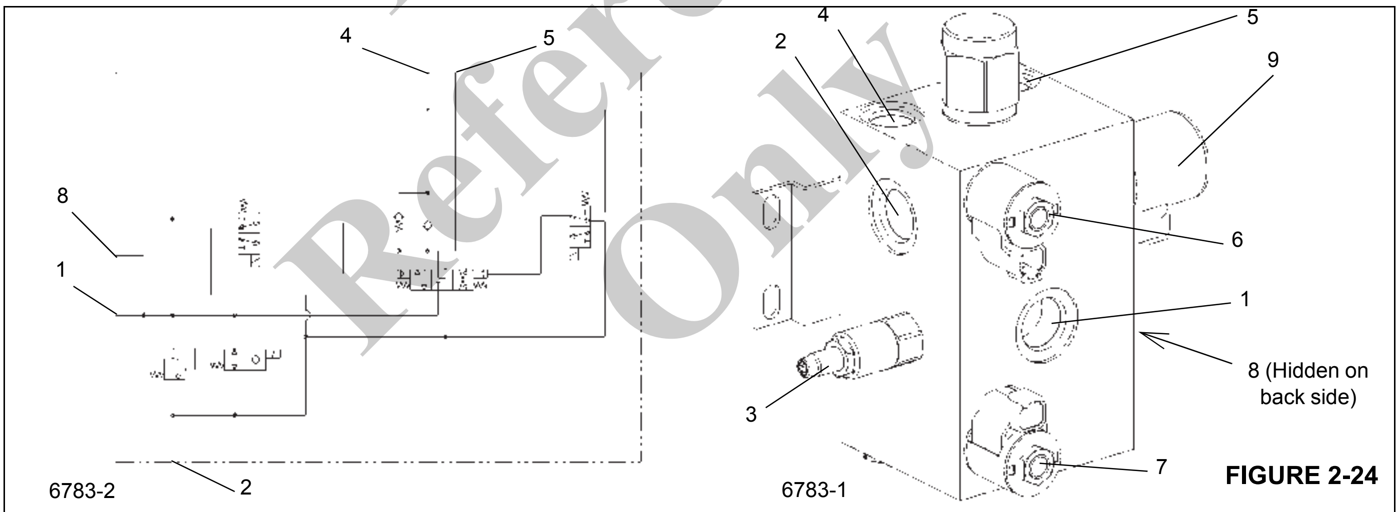


FIGURE 2-24

Item	Description
1	Port P (SAE - 12 ORB)
2	Port T (SAE - 12 ORB)
3	Outrigger Relief Valve (3100 PSI)
4	Port A - Retract (SAE - 10 ORB)
5	Port B - Extend (SAE - 10 ORB)
6	SV1 Coil (12V, 1.4A, 16.8W, IP69K Rated)

Item	Description
7	SV2 Coil (12V, 1.4A, 16.8W, IP69K Rated)
8	Port GP (Pressure Check) SAE - 4 ORB
9	SV3 Coil (10V, 1.6A, 15.9W, IP69K Rated)

OUTRIGGER CONTROL MANIFOLD

Description

There are two outrigger control manifolds utilized on the crane, one for the front outriggers (Figure 2-25) and one for the rear outriggers (Figure 2-26). The front manifold consists of five normally closed two position two way solenoid valves and the rear consists of four normally closed two position two way solenoid valves. They are mounted inside the frame of their respective outrigger box.

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

Maintenance

Removal

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

Inspection

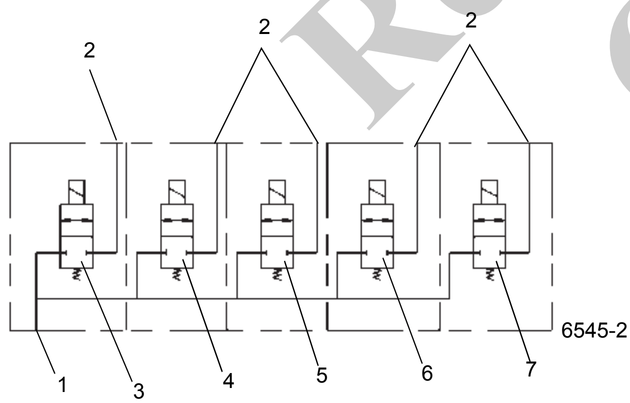
Visually inspect the valves and hydraulic connections for any evidence of leaks or other damage. Check security of the electrical connections. Inspect the wiring for any evidence of cracks or breaks.

Installation

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

Functional Check

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



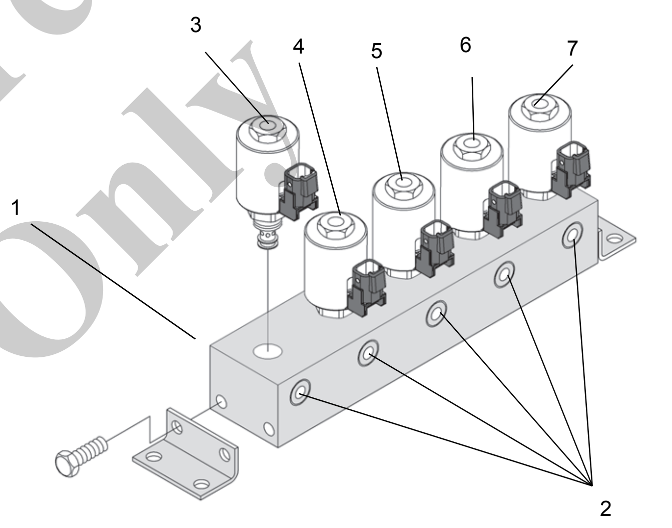


FIGURE 2-25

Item	Description
1	In Port Side
2	Out Ports Side
3	Center Front Jack Cylinder
4	Left Front Extension Cylinder
5	Left Front Jack Cylinder
6	Right Front Jack Cylinder
7	Right Front Extension Cylinder

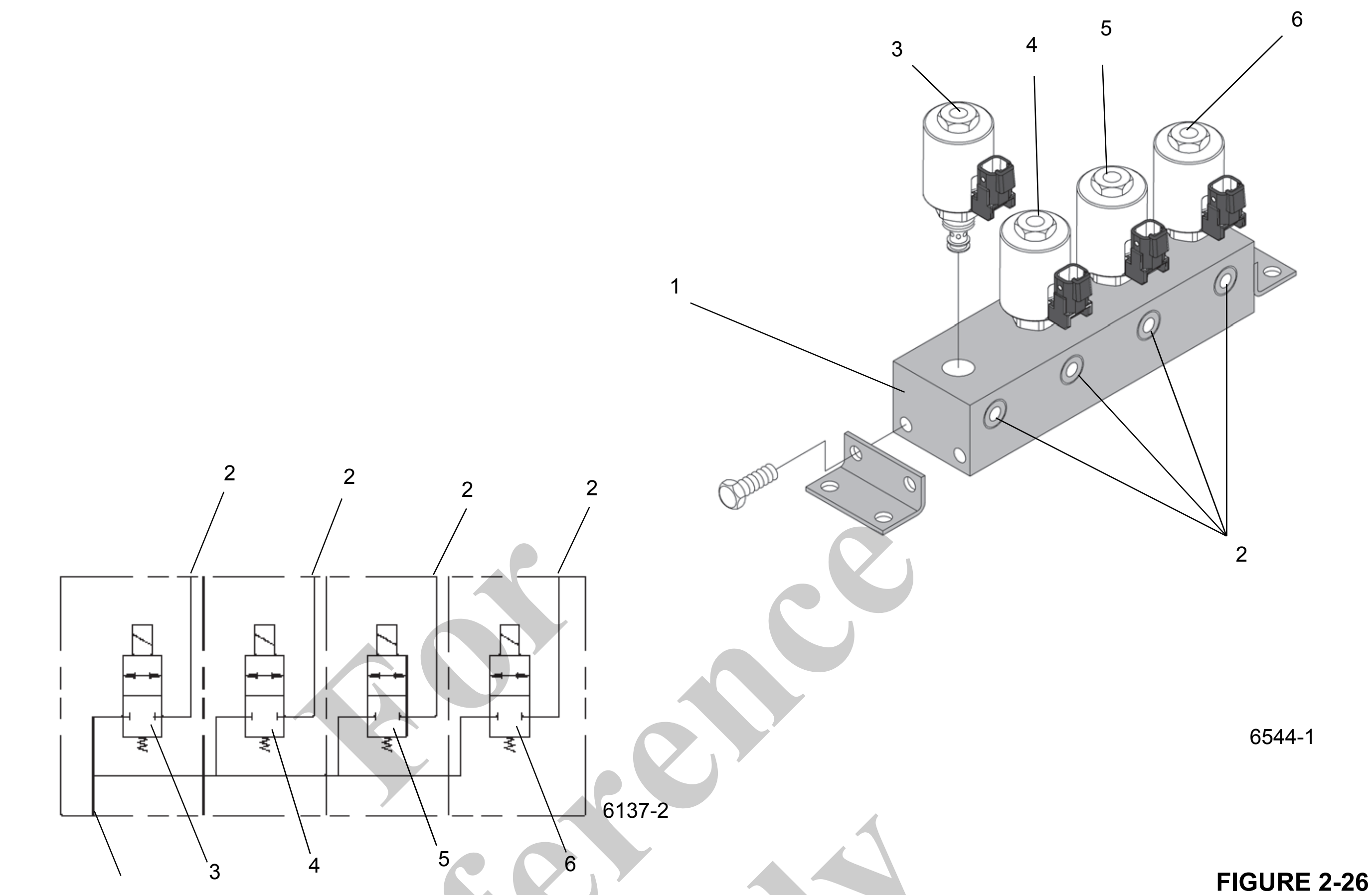


FIGURE 2-26

Item	Description
1	In Port
2	Out Ports
3	Left Rear Extension Cylinder
4	Left Rear Jack Cylinder
5	Right Rear Jack Cylinder
6	Right Rear Extension Cylinder

PILOT OPERATED CHECK VALVE

Description

A pilot operated (PO) check valve (Figure 2-27) is located in each outrigger jack cylinder port block. The check valve functions as a holding valve for the jack cylinder. Oil flow is directed from the "V" port to the "C" ports, while blocking flow in the opposite direction. Flow is reversed from "C" to "V" when pressure pilot oil is applied to the opposite side "V" port.

Maintenance

Removal

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

Installation

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

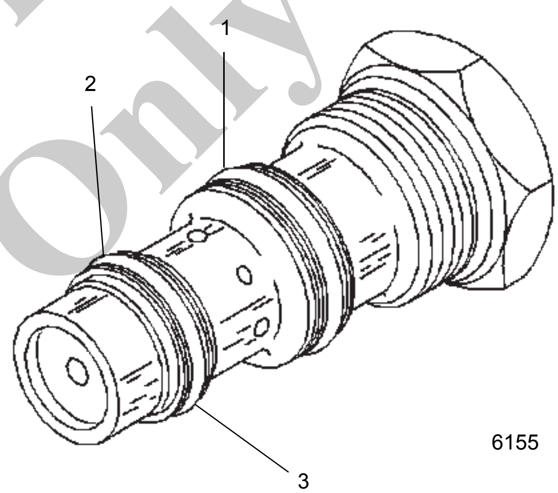
CAUTION

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

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

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

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



6155 **FIGURE 2-27**

HOLDING VALVES

Description

A bolt-on manifold style holding valve is installed on the boom lift cylinder and a cartridge style holding valve (Figure 2-29) in each of the two telescope cylinders. The holding valve installed on the outlet of the cylinder provides meter out control, will lock the cylinder in place, prevents a load from running ahead of the oil supply, and relieves excess pressure caused by thermal expansion.

Maintenance

Removal

DANGER

Pinch Point Hazard!

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

1. Lower the boom to below horizontal.
2. Extend the boom to align the access holes in second and third boom sections.
3. Install the telescope hold valve tool, P/N 80041761, see Figure 2-28. While holding the tool in position have a helper retract section 3 to lock the tool into place.

WARNING

Flying Object Hazard!

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

FIGURE 2-28

4. From the access holes in the opposite side of the boom, relieve the pressure in the lower telescope cylinder by loosening the bleed plug, (Figure 2-29).

FIGURE 2-29

5. Unscrew holding valve from its port block. (See Figure 2-28 and Figure 2-39.)

Installation

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

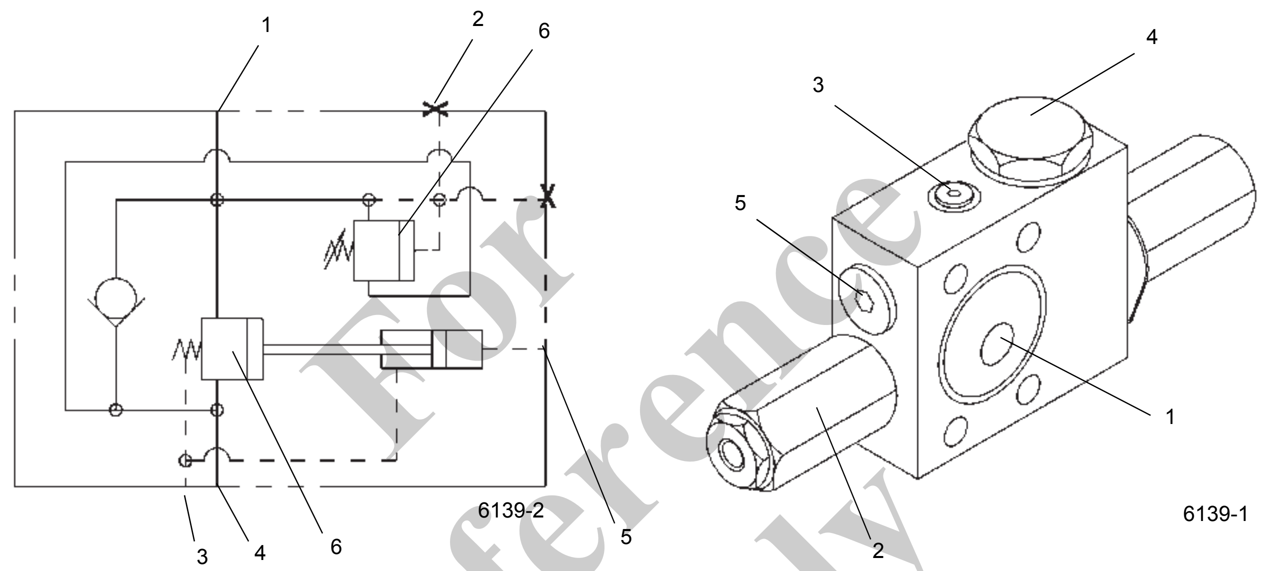
CAUTION

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

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

4. Carefully install the holding valve into the port block until fully seated.

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



Item	Description
1	Cylinder Port
2	Gauge Port
3	Drain
4	Valve Port
5	Pilot
6	Thermal Relief

FIGURE 2-30

SWING BRAKE AND ARMREST LOCKOUT VALVE MANIFOLD

Description

The swing brake and armrest lockout valve manifold (Figure 2-31) is located on the right side of the turntable. The manifold contains a pressure reducing valve, a 100 mesh filter screen in the inlet port, and two three-way, two position solenoid valves.

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

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

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

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

Maintenance

Removal

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

Installation

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

Functional Check - Swing Brake Release Valve

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

Functional Check - Crane Function Valve

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

Inlet Filter Screen Replacement

NOTE: The filter screen should be replaced every 2000 hours or sooner under severe conditions.

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

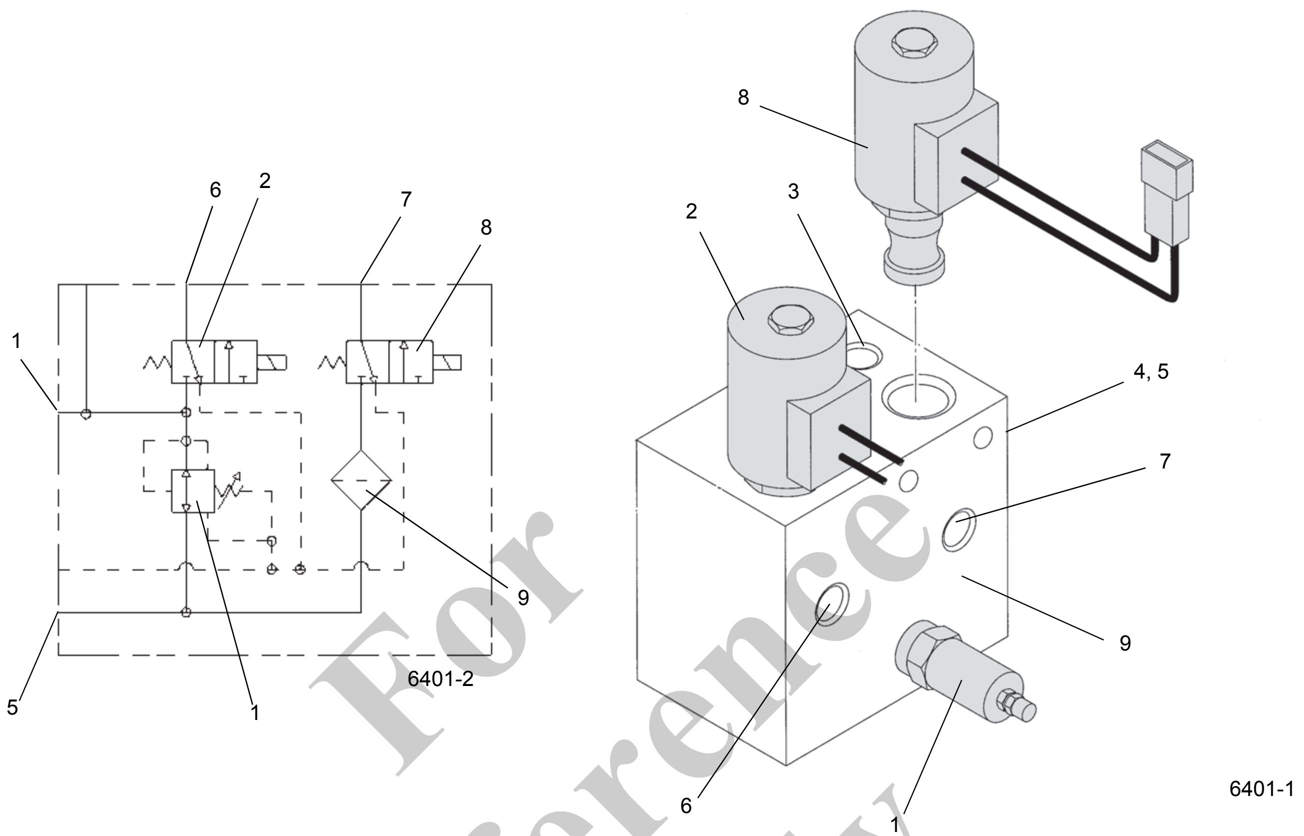


FIGURE 2-31

Item	Description
1	Pressure Reducing Valve - Swing Brake
2	Solenoid Valve - Swing Brake Release
3	Port B
4	Port G - Gauge (Not Shown)
5	Port P - Pressure (Not Shown)

Item	Description
6	Port REG1 - Swing Brake Release
7	Port REG2 - Crane Function
8	Solenoid Valve - Crane Function Lockout Valve
9	100 Mesh Screen Filter (Not Shown)

HIGH SPEED BOOST SELECTOR VALVE

Description

The high speed boost selector valve (Figure 2-32) is located on port #4 of the hydraulic swivel spool. Output from pump number 1, section 2 passes through the high speed boost selector valve. When the valve is de-energized, the oil flows to the normal delivery. When the valve is energized, the oil is combined with the output of pump number 1, section 1 to provide additional oil capacity to the section 1 functions. With the valve in the energized position, the outriggers are inoperative.

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

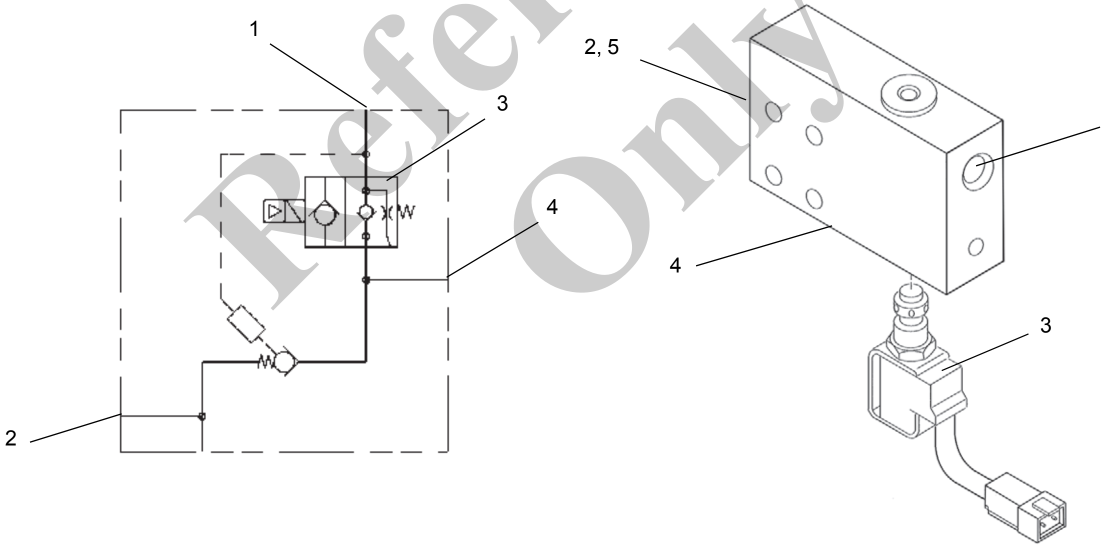
Maintenance

Removal

1. Tag and disconnect the electrical connectors to the valve.
2. Tag and disconnect the hydraulic hoses from the valve. Cap or plug the lines and ports.
3. Remove the hydraulic fitting securing the valve to the #4 port of the hydraulic swivel spool. Remove the valve.

Installation

1. Install the valve to the #4 port of the hydraulic swivel spool and tighten the fitting.
2. Connect the hydraulic hoses to the ports on the valve as tagged during removal.
3. Connect the electrical connectors to the valve as tagged during removal.
4. Start the engine and check valve and hoses for leaks. Make repairs as needed.



Item	Description
1	Port B
2	Port P1 - From Pump No. 1 (Not Shown)
3	Solenoid Valve
4	Port P2 (Not Shown)
5	Outlet Port - To Swivel Port 4

FIGURE 2-32

FRONT CENTER JACK RELIEF VALVE

Description

The pilot operated relief valve (Figure 2-33) is installed on the right inside frame of the front outrigger box under the right bottom side rail. Its purpose is to limit the piston pressure of the front center jack not allowing it to raise the crane.

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

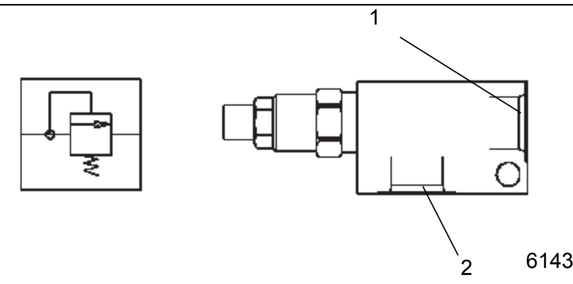
Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the valve and cap or plug all openings.
2. Remove the bolts, nuts and washers and remove valve.

Installation

1. Install the valve and secure with the washers, nuts and bolts.
2. Connect the hydraulic lines as tagged during removal.
3. Check the valve and hydraulic connections for leaks. Make repairs as needed.



Item	Description
1	Port 1 - Pressure Inlet
2	Port 2 - To Reservoir

FIGURE 2-33

PUMP MOUNTED RELIEF VALVE

Description

The in-line plumbed direct acting relief valve (Figure 2-34) is installed onto the second section of pump #1. Its purpose is to protect the pump section from over pressurization.

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

Maintenance

Removal

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

Installation

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

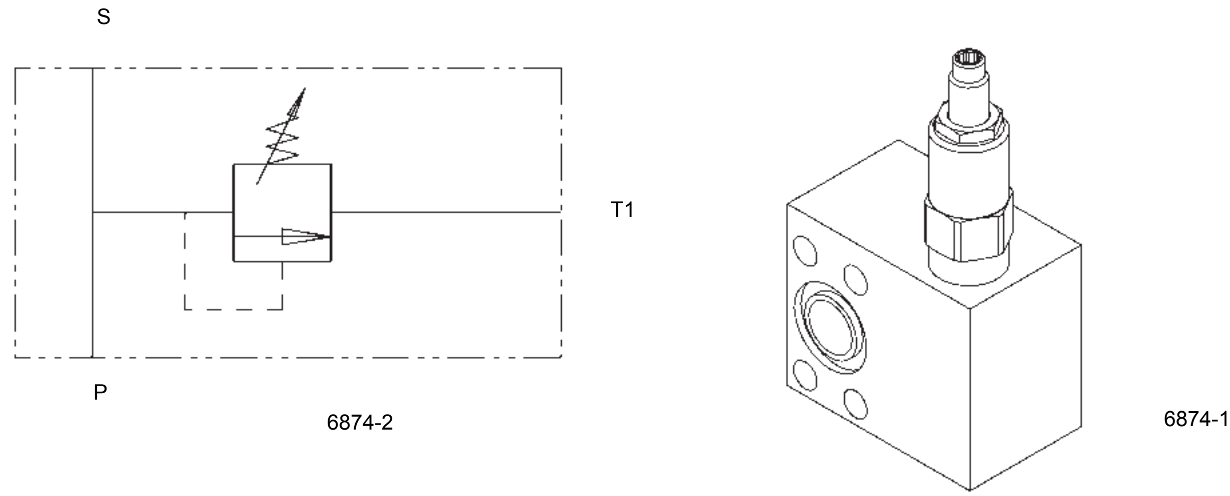


FIGURE 2-34

NEEDLE VALVE

Description

The two lift cylinder mounted needle valves are used to connect the rod and piston sides of the boom lift cylinder together to allow the boom to float when the boom is in the trailing boom mode.

The knob adjustable needle valve is installed into a manifold. Turning the knob counterclockwise opens the valve to allow the boom flotation and clockwise rotation closes the valve to return to normal boom lift cylinder operation.

Maintenance

Removal

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

Installation

1. Connect the hydraulic lines as tagged during removal.

NEEDLE VALVE WITH REVERSE FREE FLOW CHECK

Description

A needle valve with a reverse free flow check is used to prevent pressurization of the lift cylinder when the boom lift cylinder is in the trailing boom mode.

The knob adjustable needle valve and check valve is installed into a manifold. Turning the knob counterclockwise opens the valve to allow the normal boom lift operation and clockwise rotation closes the valve for trailing boom mode.

Maintenance

Removal

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

Installation

1. Connect the hydraulic lines as tagged during removal.

SWING POWER BRAKE VALVE

Description

The swing power brake valve (Figure 2-35) is used to provide hydraulic pressure to the piston of the swing brake to apply the brake. The valve receives its supply of oil from the main directional control valve pilot generator port. Depressing the brake pedal causes hydraulic oil to flow to the top of the brake piston where, combined with spring tension, the total force overcomes the brake release pressure and applies the brake. When the valve is released, excess hydraulic oil flows from the valve to the case drain manifold and back to the reservoir.

Maintenance

Removal

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

Installation

DANGER

Engage the swing lock before installing the swing brake valve.

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

Functional Check

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

DANGER

Engage the swing lock before adjusting the swing brake valve.

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

Item	Description
1	Tank Port - To Case Drain Manifold
2	Pressure Port From Main valve
3	Regulated Output Port - To Swing Drive

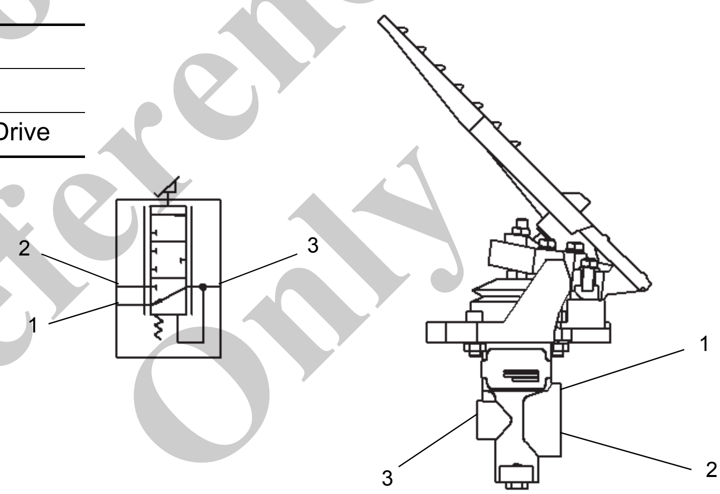


FIGURE 2-35

SWING BRAKE RELEASE VALVE (OPTIONAL)

Description

The swing brake release valve (Figure 2-36) is used when the crane is equipped with the trailing boom option. It is located on the right side of the turntable, near the front. The valve is used to keep the swing brake released when the boom is in the trailing mode which is necessary to allow the boom to swing for roading. This is done in the valve internally by routing oil from the accumulator to the brake release port keeping the brake released.

Incorporated within the valve is a check valve, two manually operated valve cartridges, an accumulator, a pressure gauge, and a pressure switch.

The two manually operated valves (FC1 and FC2) are used to route pressure to the swing brake release port for either craning or trailing boom operation. In the trailing boom mode, FC1 is open and FC2 is closed. In the craning mode, FC1 is closed and FC2 is open.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the swing brake release valve. Cap or plug all openings.
2. Tag and disconnect the electrical connector from the pressure switch.
3. Remove the bolts, lockwashers, and washers securing the valve in place and remove the valve.

Installation

1. Position valve on the turntable and secure with the bolts, lockwashers, and washers.
2. Connect the electrical connector to the pressure switch.
3. Connect the hydraulic lines to the valve as tagged during Removal.

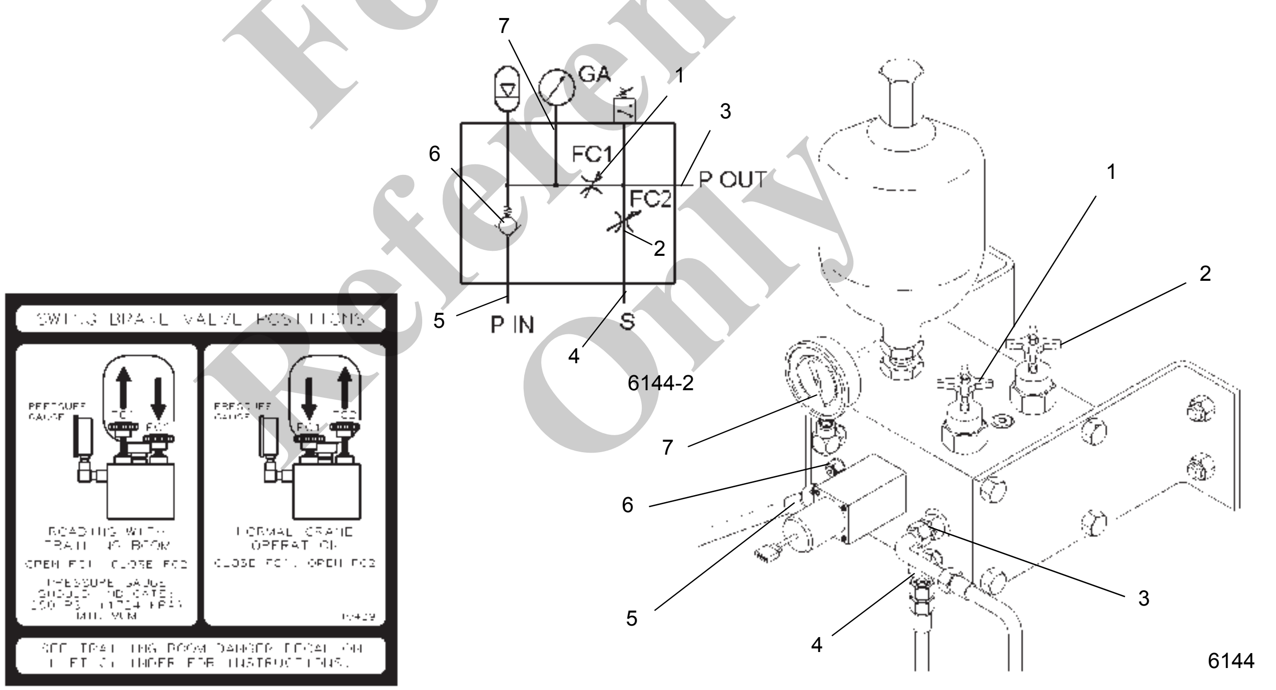


FIGURE 2-36

Item	Description
1	Needle Valve FC1
2	Needle Valve FC2
3	Port P - To Swing Brake Release
4	Port S - From Swing Brake Manifold

Item	Description
5	Port P - Pressure In
6	Check Valve - CK 1
7	Pressure Gauge

PRIORITY FLOW DIVIDER VALVE

Description

The priority flow divider (Figure 2-37) is located on the right inside carrier frame forward of the front outrigger box. It provides a controlled flow of oil to the optional air conditioning compressor motor. The excess flow is passed via a hydraulic swivel to the inlet of the swing directional control valve.

On units not equipped with air conditioning, the regulated flow is returned to the hydraulic reservoir.

Maintenance

Removal

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

Installation

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

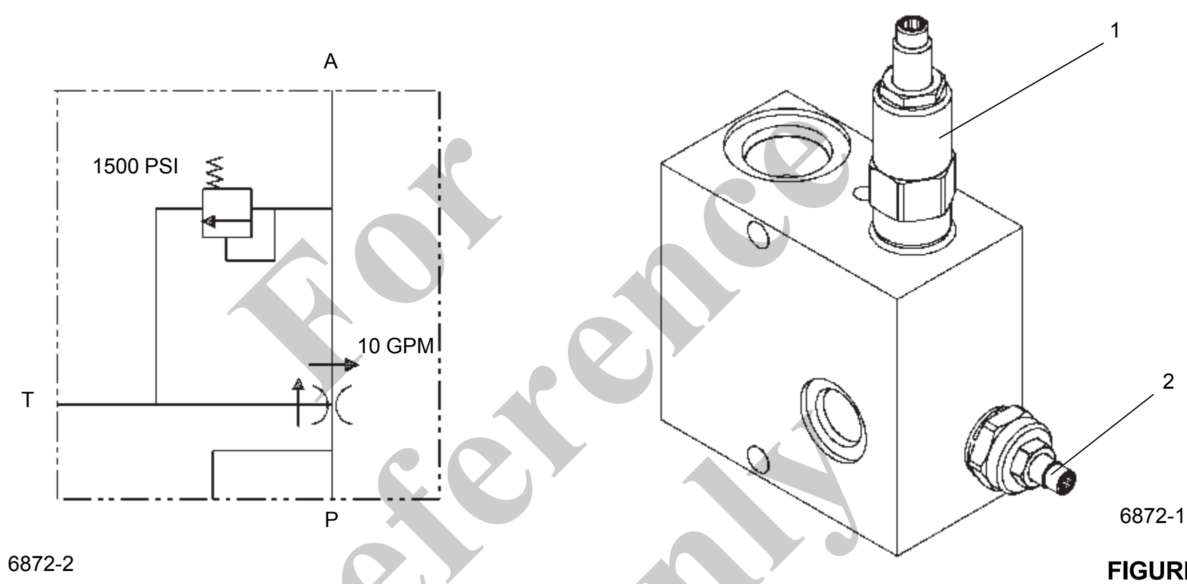


FIGURE 2-37

Item	Description
1	Adjustable Relief Valve (103.42 bar [1500 PSI])

Item	Description
2	Adjustable Bypass Flow (37.85 lpm [10GPM])

AUXILIARY WATER JACKET COOLER FLOW CONTROL VALVE

Description

The auxiliary water jacket cooler flow control valve (Figure 2-38) is located on the left side of the auxiliary water jacket radiator. It provides a maximum flow of 9 gpm of oil to the auxiliary jacket water cooler motor/bypass loop. The excess flow is returned to the hydraulic reservoir.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the valve. Cap or plug all openings.
2. Disconnect the wires from the control valve.
3. Remove the two bolt/nut assemblies that hold the valve to the support bracket.

Installation

1. Position the valve on the support bracket and secure with the two bolt/nut assemblies.
2. Connect the hydraulic lines to the valve as marked during removal.
3. Connect the wires to the control valve.
4. Check valve and hydraulic connections for leaks. Make repairs as necessary.

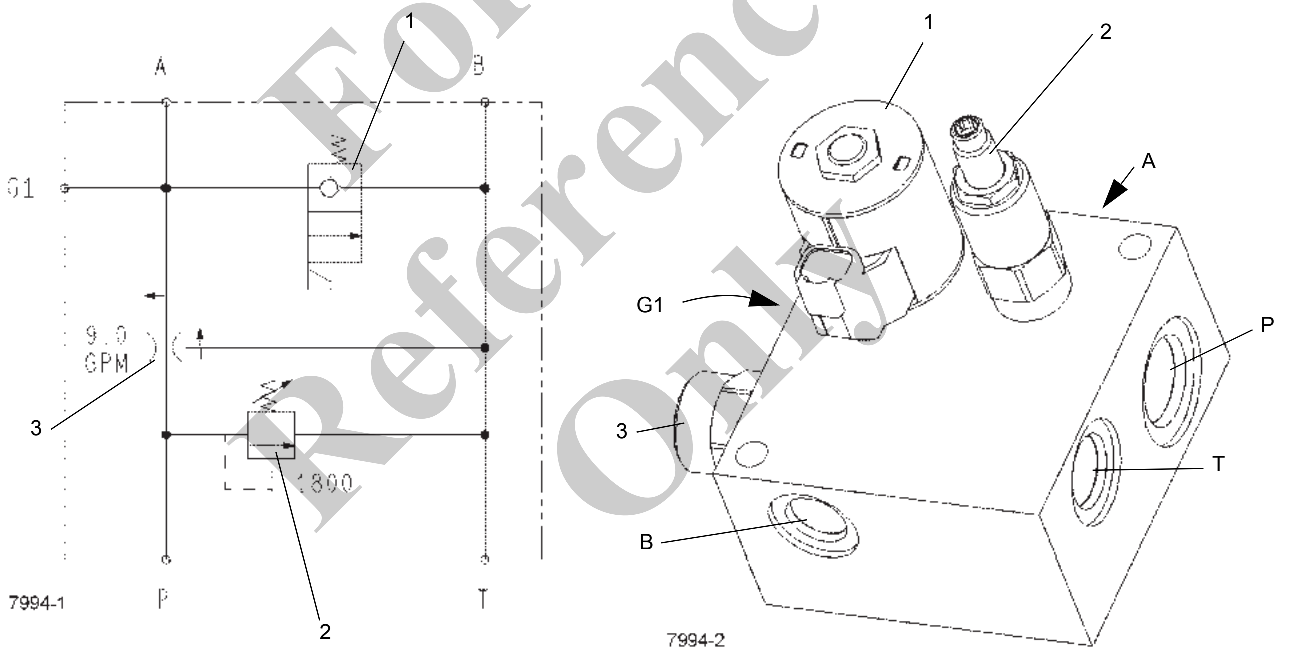


FIGURE 2-38

Item	Description
1	Flow Control Cartridge

Item	Description
2	Relief Valve (124.11 bar [1800 PSI])
3	Flow Divider

CYLINDERS

General

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

Maintenance

General

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

The approximate wear ring gaps are as follows:

Table 2-3
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

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. 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 that the extend hose is capped.

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

NOTE: Piston seal trouble may be due to either worn or damaged seals or to a scored cylinder. A scored cylinder is usually caused by abrasive contaminants in the hydraulic oil and is likely to reoccur unless the system is drained, thoroughly cleaned, and filled with clean, filtered hydraulic oil.

Temperature Effects on Hydraulic Cylinders

Hydraulic oil expands when heated and contracts when cooled. This is a natural phenomena that happens to all liquids. The coefficient of expansion for API Group 1 hydraulic oil is approximately 0.00043 cubic inches per cubic inch of volume for 1°F of temperature change. **Thermal contraction will allow a cylinder to retract as the hydraulic fluid which is trapped in the cylinder cools.** The change in the length of a cylinder is proportional to the extended length of the cylinder and to the change in temperature of the oil in the cylinder. For example, a cylinder extended 7.62 m (25 ft) in which the oil cools 15.6°C (60°F) would retract approximately 196.9 mm (7 3/4 in) (see charts below). A cylinder extended 1.5 m (5 ft) in which the oil cools 15.6°C (60°F) would only retract approximately 38.1 mm (1 1/2 in). 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 lubrication or improper wear pad adjustments may, under certain conditions, cause a “stick-slip” condition in the boom. This “stick-slip” condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement, of the boom may be undetected by the operator unless a load is suspended for a long period of time.

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

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

The charts (Table 2-4 and Table 2-5) have been prepared to assist you in determining the approximate amount of retraction/extension that may be expected from a hydraulic cylinder as a result of change in the temperature of the hydraulic oil inside the cylinder. The chart is for dry rod cylinders. If the cylinder rod is filled with hydraulic oil, the contraction rate is somewhat greater.

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

Table 2-4 Boom Drift Chart (Cylinder length change in inches)

Coeff. = 0.00043 ($in^3/in^3/$ °F)

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

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

Table 2-5 Boom Drift Chart (Cylinder length change in millimeters)

Coeff. = 0.000774 (1/ °C)

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

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

LIFT CYLINDER

Description

The lift cylinder (Figure 2-39) has a bore of 30.48 cm (12.0 in). The retracted length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 294.6 cm (116.0 in). The extended length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 520.9 cm (205.06 in). Its stroke is 226.2 cm (89.06 in). A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 787 kg (1735 lb).

Maintenance

Disassembly

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

1. Disconnect the tube assembly from the holding valve.
2. Remove the four bolts and washers securing the holding valve and remove the holding valve from the cylinder barrel.
3. Remove the two socket head cap screws securing the head retainer ring to the head.
4. Using a spanner wrench or chain wrench, unscrew the head retainer ring from the barrel.

DANGER

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

CAUTION

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

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

Inspection

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

CAUTION

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

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

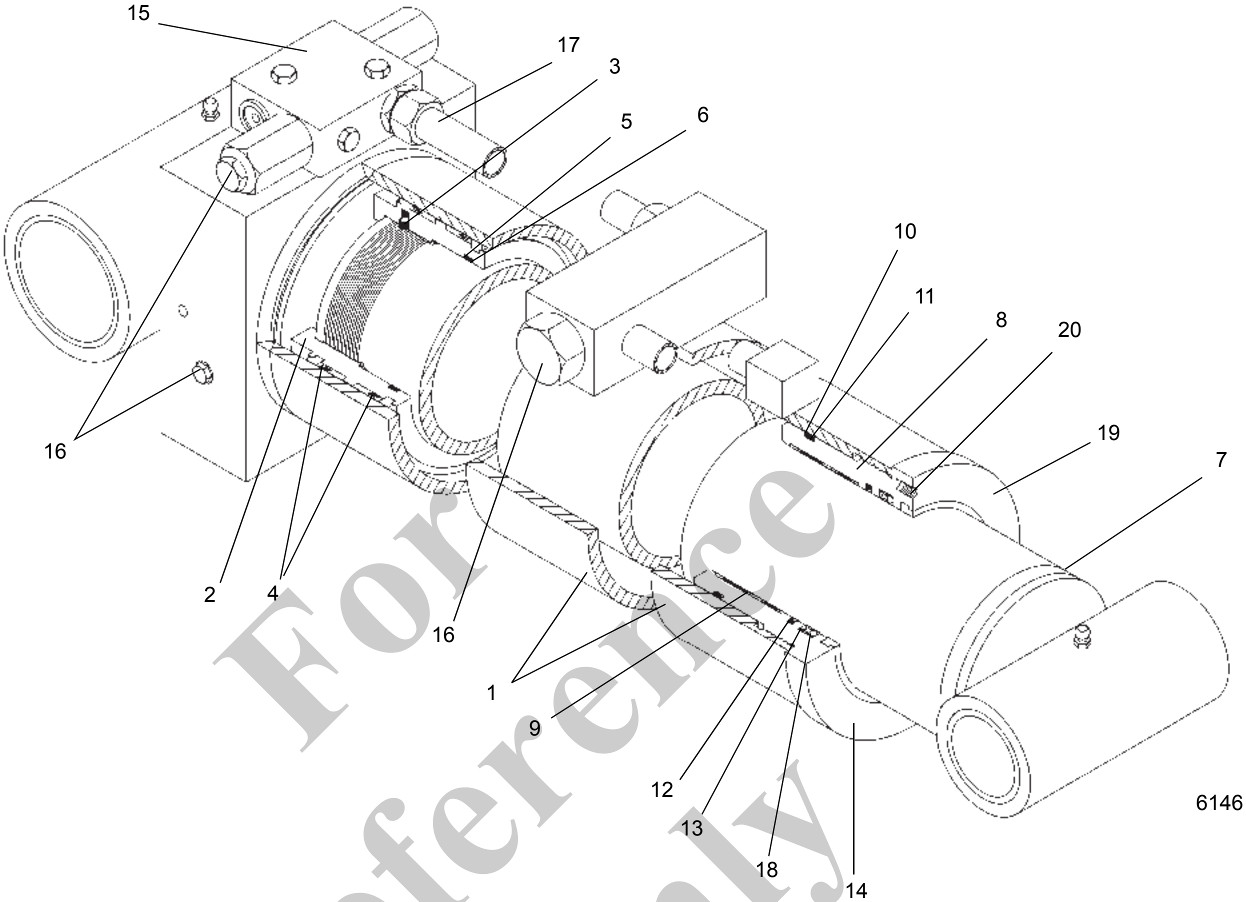


FIGURE 2-39

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

Item	Description
11	Backup Ring
12	Buffer Seal
13	Deep Z Rod Seal
14	Wiper Ring
15	Holding Valve
16	Plugs
17	Tube Assembly
18	Backup Ring
19	Head Retainer Ring
20	Socket Head Capscrew

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

1. Install the backup ring and wiper ring into the retaining ring (Figure 2-41).
2. Install head retainer ring on rod.
3. Install two new threaded inserts into head.

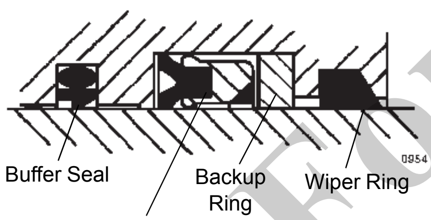


FIGURE 2-40

4. Install the replacement wear rings, buffer seal and deep Z rod seal in the inside of the head (Figure 2-40). Make sure the buffer seal's step is closer to the deep Z rod seal. Make sure the deep Z rod seal's rim groove is closer to the buffer seal.
5. Install the replacement O-ring and the backup ring on the outside of the head.
6. Install the replacement O-ring and backup rings in the inside of the piston.
7. Lubricate the rod with clean hydraulic oil.
8. Slide the head, onto the rod.
9. Screw the piston onto the rod tightly. Secure the piston with the set screw.

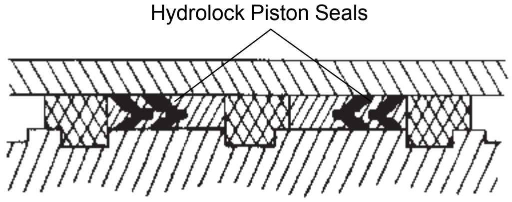


FIGURE 2-41

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

CAUTION

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

12. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
13. Install new gasket material to the cylinder head retainer ring flange as follows.
    - **a.** Clean the barrel and retainer ring with Loctite cleaning solvent 7070 or similar non- chlorinated solvent.
    - **b.** Apply a light coating of Loctite primer N7649 to both surfaces. Allow primer to dry for one to two minutes. Primer must be dry. Mating of parts should occur within five minutes.
    - **c.** Apply gasket material Loctite Master Gasket 518 to one surface. Partial cure is obtained in four hours, with full cure in 48 hours.
14. Screw the head retainer ring into the barrel and align holes in retainer ring with holes in head. Secure the head retainer ring to the head with two socket head capscrews. Torque screws to 60 to 65 Nm (44 to 48 lb-ft).
15. Using a spanner wrench or chain wrench, continue to screw the retainer ring/head into place in the barrel.

CAUTION

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

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

LOWER TELESCOPE CYLINDER

Description

The boom lower telescope cylinder (Figure 2-42) has a 152 mm (6 in) bore, a 127 cm (5 in) hollow rod, and is internally ported. Oil from the telescope control valve is routed to the cylinder by external lines. Oil is routed to the upper telescope cylinder by a 50.8 mm (2 in) hollow rod inside the 127 mm (5 in) rod. Foreign material is prevented from entering the cylinder rod during retraction by a wiper ring in the head. O-ring seals prevent internal and external leakage. The retracted length of the cylinder from the center of the support block to the center of the cylinder mounting pin is 895.9 cm (352.72 in). The cylinder has a stroke of 758.7 cm (298.69 in) which gives an extended length of 1654.6 cm (651.41 in).

The cylinder weighs 937 kg (2066 lb).

Maintenance

Disassembly

NOTE: Replace all seals and O-rings any time the cylinder is disassembled.

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

DANGER

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

CAUTION

Do not damage the cylinder rod chrome surface.

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

3. Using a chain wrench, unscrew the cylinder head from the barrel. Remove the rod from the barrel and cover the opening in the barrel to keep contaminates out of the barrel.

CAUTION

Do not scratch or damage the grooved and gland surfaces.

4. Remove the guide lock ring from the piston to gain access to the setscrew.
5. Remove the setscrew and unscrew the piston from the rod.
6. Remove the remaining guide lock ring, the hydrolock seals, and wear rings from the outside of the piston. Remove the O-ring and two backup rings from the inside of the piston.
7. Remove the spacer from the rod and the wear rings from the spacer.
8. Remove the cylinder head from the rod.
9. Remove the wear rings, buffer seal assembly, deep Z rod seal, and back-up ring from the inside of the head.
10. Remove the O-ring and backup ring from the outside of the cylinder head.
11. Slide the inner rod out from the outer rod. The seal retainer will slide out with the inner rod. Remove the guide lock ring from the inner rod end.
12. Remove the seal retainer from the inner rod.
13. Remove the wear rings and deep Z rod seals from the inside of the seal retainer.
14. Remove the O-ring and backup ring from the outside of the seal retainer.

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 ring. Replace all damaged or worn parts.

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

Assembly

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

CAUTION

Improper seal installation can cause faulty cylinder operation.

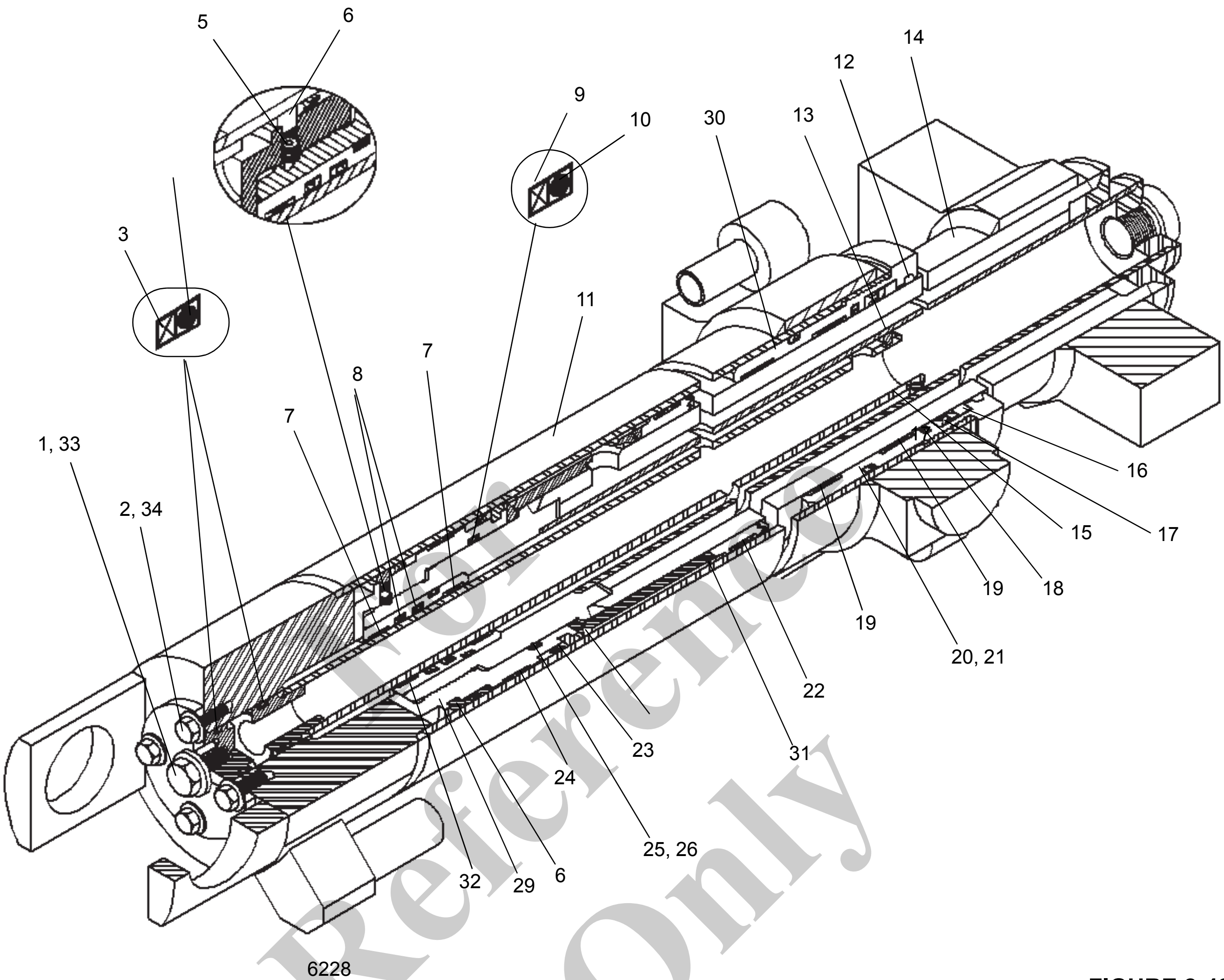


FIGURE 2-42

Item	Description
1	Rod End Bolt (Inner Rod)
2	Retaining Plate Bolt
2	Backup Ring
4	Low Temperature O-ring
5	Setscrew (Self-Locking)
6	Guide Lock Ring
7	Wear Ring
8	Deep Z Rod Seals
9	Backup Rings
10	Low Temperature O-ring
11	Barrel

Item	Description
12	Wiper Ring
13	Guide Lock Ring
14	Outer Rod
15	Inner Rod
16	Backup Ring
17	Deep Z Rod Seal
18	Buffer Seal Assembly
19	Wear Ring
20	Low Temperature O-ring
21	Backup Ring
22	Piston Wear RIng

Item	Description
23	Piston Hydrolock Seal Assembly
24	Piston Wear Ring
25	Backup Ring
26	Low Temperature O-ring
27	Rod End (Inner Rod)
28	Rod Retaining Plate (Inner Rod)
29	Piston
30	Cylinder Head
31	Spacer
32	Seal Retainer
33	Flatwasher
34	Flatwasher
35	Holding Valve

1. If removed, install the holding valve. Refer to *Holding Valves*, page 2-41 in this section.

CAUTION

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

2. Install the O-ring and backup rings on the outside of the seal retainer and the deep Z rod seals and wear rings in the inside of the seal retainer (Figure 2-43).

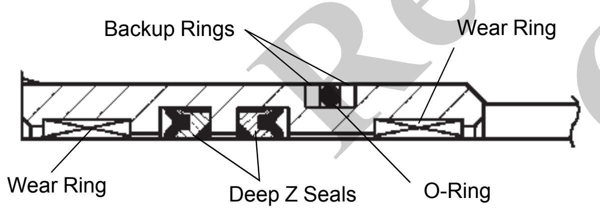


FIGURE 2-43

3. Slide the seal retainer onto the inner rod.
4. Install the guide lock ring onto the inner rod and slide the inner rod and seal retainer into the outer rod.

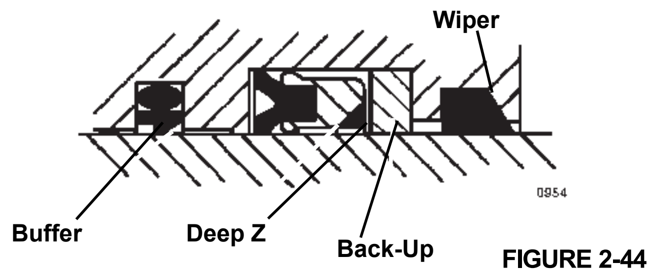


FIGURE 2-44

5. Install the wiper ring, backup ring, deep Z rod seal, buffer seal assembly, and wear rings into the inside of the cylinder head (Figure 2-44).
6. Slide the spacer and head onto the outer rod.
7. Install the O-rings and backup rings in the inside of the piston.

NOTE: Use a new setscrew.

8. Screw the piston onto the outer rod and secure with a new setscrew.
9. Install the guide lock rings, hydrolock seal assemblies, and wear rings to the outside of the piston (Figure 2-45).

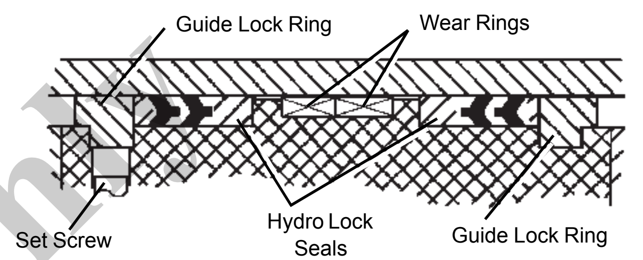


FIGURE 2-45

10. Install the wear rings on the outside of the spacer.
11. Install the O-ring and backup ring on the outside of the cylinder head.
12. Install the backup ring and O-ring on the outside of the inner rod end.
13. Clean all oil from the threads of the cylinder head and apply Loctite #290 to the threads.
14. Slide the rod assembly into the cylinder barrel and screw the cylinder head into the barrel.
15. Coat the threads of the bolts with Loctite #290. Install the rod end plate and bolt the plate to the inner rod end with the bolts and washer. Torque the bolts 195 - 211 Nm (144 - 156 lb-ft).
16. Bolt the rod retaining plate to the cylinder barrel with the three 7/16 in. bolts and washers. Torque the bolts 65 - 70 Nm (48 - 52 lb-ft).

CAUTION

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

17. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 361.70 bar (5250 psi). Check for proper operation and any leakage. Make repairs as needed.

UPPER TELESCOPE CYLINDER

Description

The upper boom telescope cylinder (Figure 2-46) has a 15.2 cm (6 in) bore and is internally ported (rod ported). Oil from the telescope control valve is routed to the cylinder by external lines. Foreign material is prevented from entering the cylinder during rod retraction by a wiper ring in the head and O-ring seals prevent internal and external leakage. The retracted length of the telescope cylinder is 883.3 cm (347.75 in) and a extended length of 1642.0 cm (646.44 in) from the end of the barrel to the center of the cylinder block.

The cylinder weighs 756 kg (1667 lb).

Maintenance

Disassembly

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

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

DANGER

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

CAUTION

Do not damage the cylinder rod chrome surface.

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

CAUTION

Do not scratch the grooved and gland surfaces.

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

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

4. Remove the set screw and discard.

5. Unscrew the piston from the rod.

6. Remove the remaining guide lock ring, the hydrolock seal assembly, and the wear rings from the outside of the piston.

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

8. Remove the spacer from the rod and the wear rings from the spacer.

9. Remove the cylinder head from the rod.

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

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

12. If necessary, remove the holding valve.

Inspection

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

CAUTION

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

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

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

4. Inspect the barrel for scoring.

Assembly

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

CAUTION

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

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

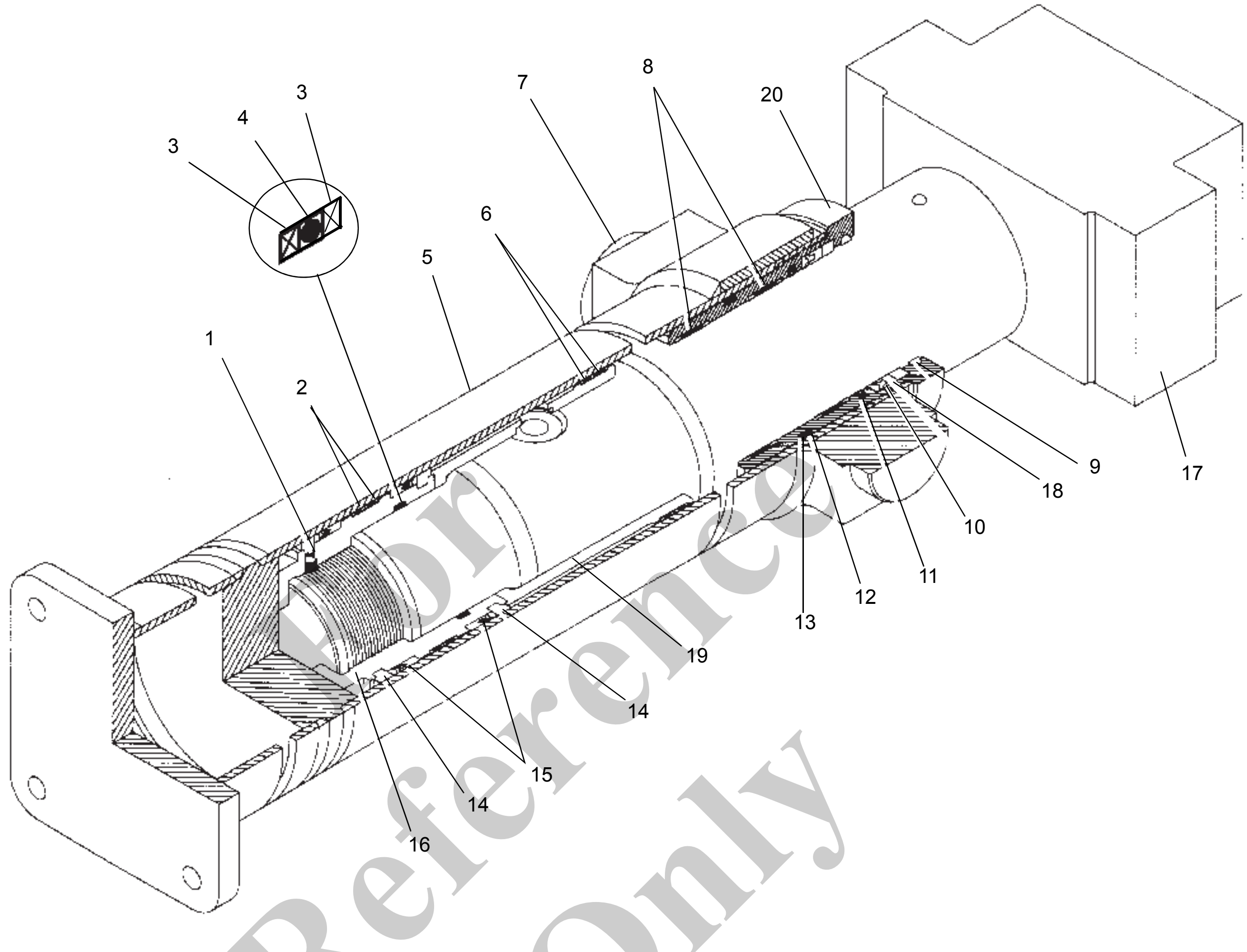


FIGURE 2-46

Item	Description
1	Setscrew
2	Piston Wear Ring
3	Backup Ring
4	O-ring
5	Barrel
6	Piston Wear Ring
7	Trunnion
8	Wear Rings
9	Wiper Ring
10	Deep Z Rod Seal

Item	Description
11	Buffer Seal
12	Backup Ring
13	O-ring
14	Guide Lock Ring
15	Piston Hydrolock Seal
16	Piston
17	Support Block
18	Backup Ring
19	Spacer
20	Head

NOTE: When installing seals in step 2 through 4, (Figure 2-47).

2. Install the wiper ring and wear rings on the inside of the cylinder head.
3. Install the buffer seal assembly and neutron backup ring on the inside of the cylinder head.
4. Install the deep Z rod seal inside the head. Make sure the seals are properly assembled and installed in the correct direction.
5. Install the low temperature O-ring and backup rings onto the outside of the head.
6. Install the cylinder head onto the cylinder rod.
7. Install the spacer onto the cylinder rod.

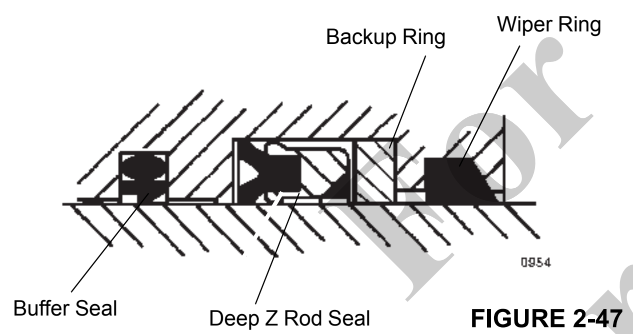


FIGURE 2-47

CAUTION

Improper seal installation could cause faulty cylinder operation.

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

NOTE: Use a new setscrew.

9. Screw the piston onto cylinder rod and secure with a new setscrew.
10. Install the guide lock rings, hydrolock seals and wear rings onto the outside of the piston (Figure 2-42).

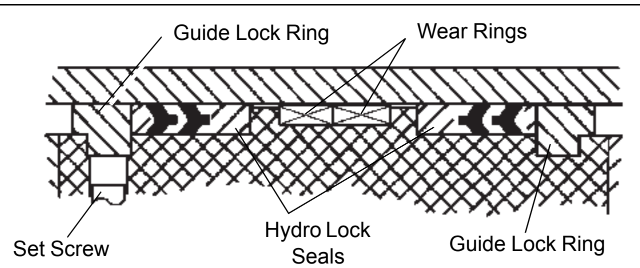


FIGURE 2-48

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

CAUTION

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

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

CAUTION

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

15. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 362 bar (5250 psi). Check for proper operation and any leakage. Make repairs as needed.

Bleeding Procedure

This procedure will specify procedures for bleeding the air from the retract side of the cylinders. There are (2) different scenarios for bleeding air from these cylinders.

- A cylinder on a test bench.
- A cylinder installed on crane.

Cylinder on Test Bench

1. Install all plugs/valves, extend and retract hoses, etc. as normal.
2. Attach EMA type hose assembly (p/n 80044628) to retract bleeder fitting and route to hydraulic tank or drain tray.
3. Apply retract pressure to cylinder, allowing cylinder to fill up under atmospheric conditions (no pressure buildup on retract side). Air will push out through bleeder during this step.
4. Continue to fill retract side until hydraulic oil starts to come out of bleeder hose.
5. Stop the retract function, and remove the bleeder hose.
6. Finish testing cylinder as normal.

Cylinder Installed on Crane

1. Extend boom so that the rear of the upper tele cylinder is accessible through the side access hole. Stop engine.
2. Attach bleeder hoses (2X p/n 80044629) to both tele cylinder bleeder fittings and route to catch pan, tank, etc. The lower tele cylinder bleeder fitting is located on the rod endcap. The upper tele cylinder bleeder fitting is located on the barrel, just in front of the trunnion.
3. Start engine. Low pressure will push oil/air out of the retract side of the cylinder.
4. Continue until all air is expelled from the cylinder followed by clean hydraulic oil.
5. Stop the engine and remove the hoses.

STEER CYLINDER

Description

The steer cylinders (Figure 2-49) are mounted on the front axles. The steer cylinders each have a 5.08 cm (2.0 in) diameter bore. The steer cylinders each have a retracted length of 52.15 cm (20.53 in) from end to end. The steer cylinders each have an extended length of 82.63 cm (32.53 in) from end to end. Each cylinder has a stroke of 30.48 cm (12.0 in). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 6.0 kg (13.2 lb).

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.

DANGER

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

CAUTION

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

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. With the cylinder secured, pull the rod to full extension to remove additional oil. Keep the rod supported and tap the rod back 25.4 mm (1 in) after all oil is drained.
7. Remove the head as follows:
    a. Remove the setscrew from the head.
    b. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.
    c. Insert a spanner wrench into the 6 mm (1/4 inch) holes provided.
    d. Turn the head until the beveled end of the retaining ring is visible in the mill slot.
    e. If the head is difficult to turn or moves erratically, tap the barrel adjacent to the head with a brass or plastic mallet while turning it.
    f. Pry the end of the retaining ring up with a thin blade screwdriver or chisel and rotate the ring out through the slot.
    g. Tap the head out with a rubber mallet and allow any excess fluid to drain into catch pan.
8. With the rod still supported, gently pull the piston from the barrel assembly being careful not to cock the piston in the barrel.
9. Place the rod assembly on a surface that will not damage the chrome or allow the rod assembly to drop.
10. Remove the piston as follows:
    a. Secure the rod assembly by clamping on the rod mount. Do not clamp on the chrome surface.
    b. Remove the locknut and slide the piston off over the threads. Use a rubber mallet only if the piston will not pull or turn off.
    c. Remove the head from same end as the piston being careful not to pull across the threads.

CAUTION

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

11. Remove the wear ring, seal and O-ring from the outside of the piston.
12. Remove the O-ring 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.

13. Remove the O-ring, backup ring and retaining ring from the outside of the head. Remove the seal and wiper ring from the inside of the head.

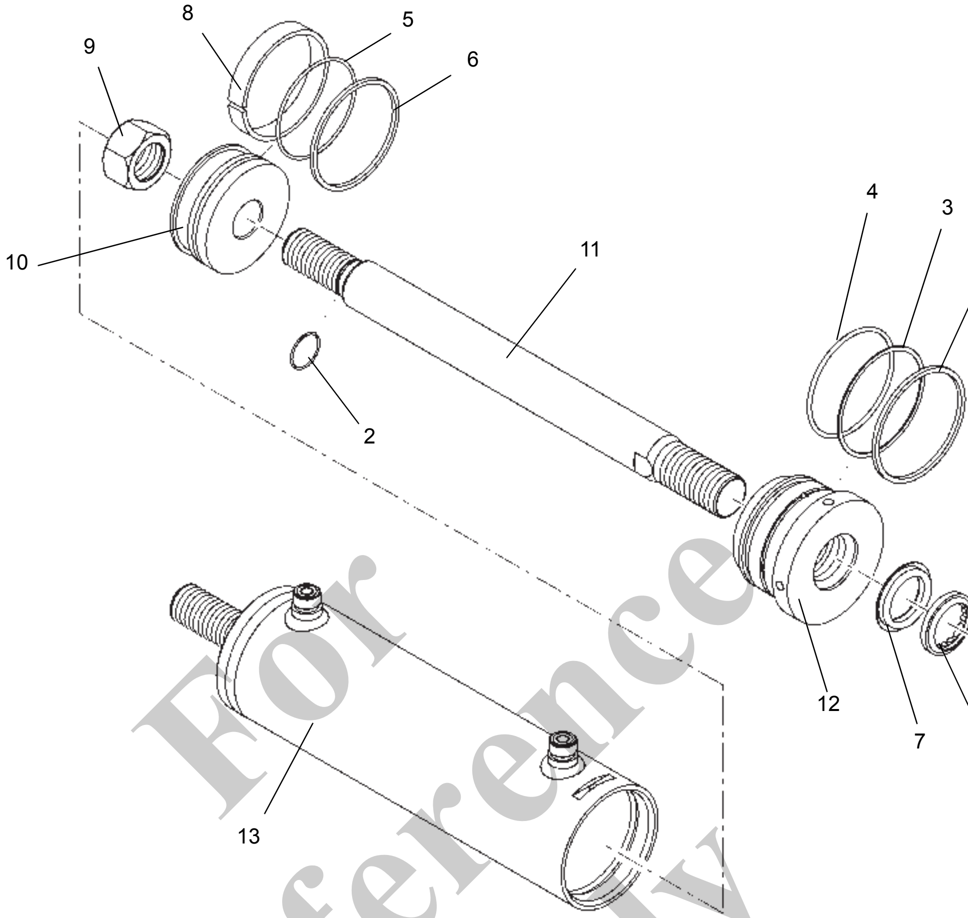


FIGURE 2-49

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

Inspection

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

CAUTION

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

Assembly

CAUTION

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

NOTE: Lubricate head and all seals and rings with clean hydraulic oil.

1. Install head seals as follows:
   - **a.** Using round-nose pliers or special installation tools, twist the dual lip u-cup seal into a “C” shape and allow it to snap into groove.
   - **b.** Using a similar method as in step no. 1, install the wiper.
   - **c.** Install the static O-ring and backup ring into the static seal groove verifying that the backup ring is closest to the retaining ring groove.
   - **d.** If possible, the head/seal assembly should sit for at least one hour to allow the seals to elastically restore (Figure 2-50).

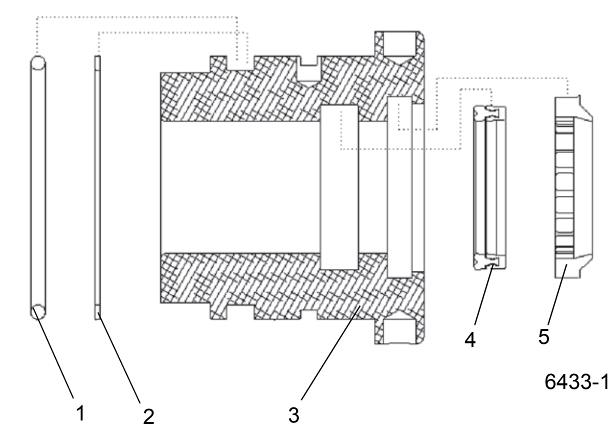


FIGURE 2-50

Item	Description
1	Static O-ring
2	Static Backup Ring
3	Head
4	Rod Seal
5	Rod Wiper

2. Install piston seals (Figure 2-51) as follows:
   - **a.** Separate the two components of the piston seal assembly (Teflon outer ring and expander).
   - **b.** For easiest installation, warm the Teflon outer ring in 49° to 66°C (120° to 150°F) hydraulic fluid or water.
   - **c.** Lubricate the piston and all components with hydraulic fluid.
   - **d.** Stretch the inner rubber expander into the seal groove. Do not use sharp edged tools and verify that it has not twisted.
   - **e.** Stretch the Teflon outer ring into the groove. This can be done without tools by using a piece of string or a clean used O-ring to work the Teflon seal around the piston and into the groove. Be careful not to damage the seal grooves during installation. Scratching the groove may cause by-pass leakage.
   - **f.** The Teflon ring will have a memory and may take as long as 24 hours to return to the correct size. This can be accelerated by pushing the piston/seal assembly through a honed or polished tube with an ID equal to the nominal cylinder bore to plus 0.254 mm (0.010 in).
   - **g.** Install the wear ring in the wear ring groove.

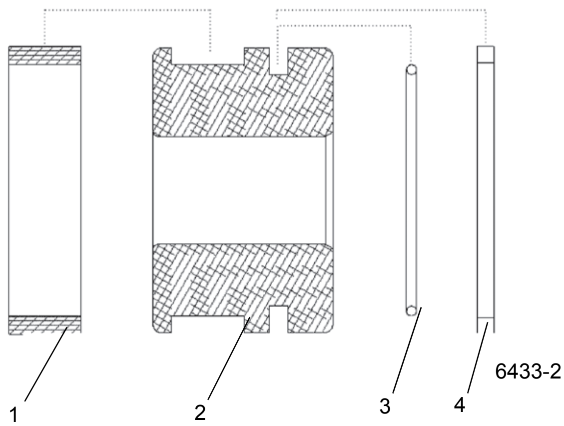


FIGURE 2-51

Item	Description
1	Wear Ring
2	Piston
3	O-ring (Energizer)
4	Piston Seal

3. Place the rod on a clean table
4. Install the head and then the piston onto the rod noting the proper orientation of each component. Torque the piston locknut.
5. Install the setscrew in the head.
6. Brush piston seals and head seals with hydraulic oil.

CAUTION

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

7. Install the rod assembly into the barrel. Alignment is critical. Watch the seals as they pass into the barrel to ensure that they are not nicked or cut.
8. Slide the head into the barrel and align the retaining ring drilled hole on the head with the barrel mill slot. Insert the blunt, curved end of the retaining ring into the hole and slowly work the head around, using the spanner wrench until no part of the ring protrudes from the slot.
9. Install the remaining port plugs.

WARNING

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

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 241 bar (3500 psi). Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER EXTENSION CYLINDER

Description

The four extension cylinders (Figure 2-52) have 6.4 cm (2.5 in) diameter bores. Each cylinder has a retracted length of 213.3 cm (84.0 in) from the center of the rod bushing to the center of the barrel bushing. Each cylinder's extended length is 396.72 cm (156.19 in). The stroke of each cylinder is 183.36 cm (72.19 in). A wiper ring prevents foreign material from entering each cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 42 kg (92 lb).

Maintenance

Disassembly

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

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

DANGER

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

CAUTION

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

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 the grooved and gland surfaces.

3. Remove the two wear rings and 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. Loosen and remove the locknut securing the piston. Remove the piston from the rod.
5. Remove the O-ring from the inside of the piston.
6. Remove the spacer from the rod.
7. Remove the head from the rod.
8. Remove the O-ring, backup ring and retaining ring from the outside of the head. Remove the seal and wiper ring from the inside of the head.

Inspection

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

CAUTION

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

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

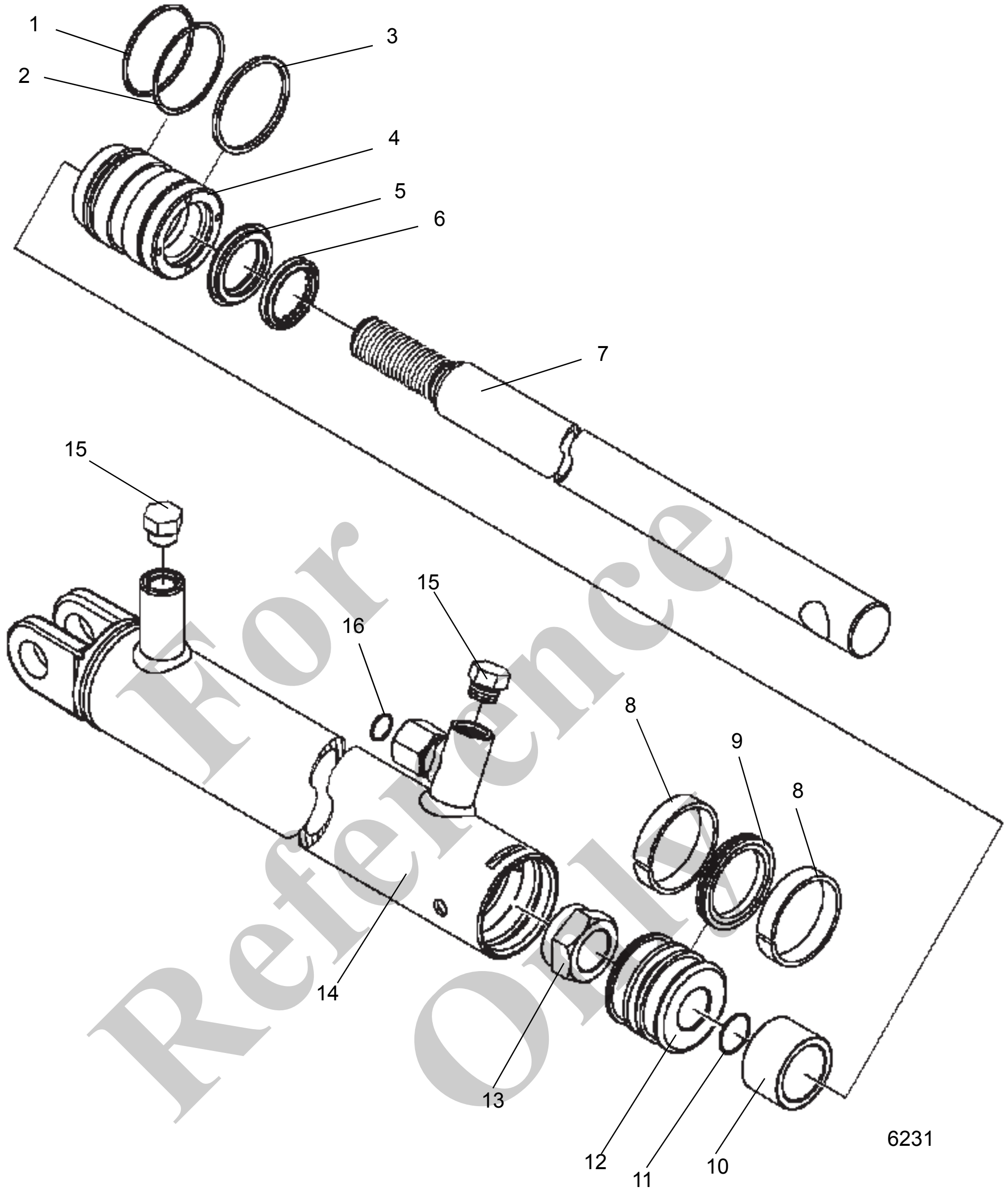


FIGURE 2-52

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

Item	Description
9	Seal
10	Spacer
11	O-ring
12	Piston
13	Locknut
14	Barrel
15	Plug
16	O-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 seals and rings with clean hydraulic oil.

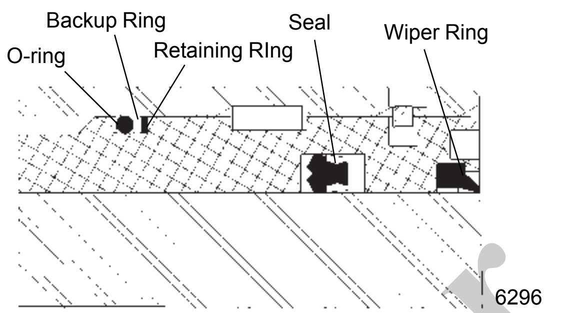


FIGURE 2-53

1. Install the replacement seal and wiper ring in the inside of the head (Figure 2-53).
2. Install the replacement O-ring, backup ring and retaining ring on the outside of the head (Figure 2-53).
3. Lubricate the rod with clean hydraulic oil.
4. Slide the head, retaining ring end first, onto the rod.

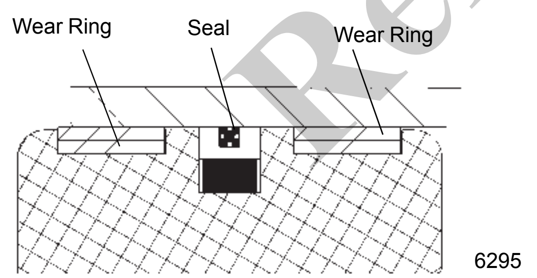


FIGURE 2-54

5. Install the replacement wear rings and seal on the outside of the piston (Figure 2-54), and the O-ring on the inside of the piston.
6. Install the piston on the rod and secure with the locknut.
7. Lubricate all parts freely with clean hydraulic oil.

CAUTION

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

8. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
9. Push the head into the barrel. Use a spanner wrench and tighten the head.

CAUTION

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

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 207 bar (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER JACK CYLINDER

Description

The four outrigger jack cylinders (Figure 2-55) each have a hollow rod for internal porting. Each cylinder has a 11.4 cm (4.5 in) diameter bore. A port block is welded to the rod of each cylinder and a pilot operated check valve is threaded into each port block. The retracted length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 112.06 ± 0.030 cm (44.12 ± 0.12 in). The extended length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 165.4 ± 0.030 cm (65.12 ± 0.12 in). Its stroke is 53.34 cm (21.0 in). A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 63.30 kg (139.5 lb).

Maintenance

Disassembly

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

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

DANGER

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

CAUTION

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

2. Retract the cylinder fully to avoid damaging the rod during removal.
3. Support the base of the cylinder to avoid sudden extension. Secure cylinder in work area with clamps or a chain vise to prevent rolling.

NOTE: Excessive wear due to side load or binding is a possibility. Mark or note the piston and head relationship to the rod and barrel.

4. Position the rod mount with the ports facing down. Use a means of collecting the oil, remove the port plugs and the check valve and allow cylinder to drain.
5. Support the rod with a hoist sling and pull the rod to full extension to remove additional oil. Keeping the rod supported, tap the rod back in 1 inch after all oil has drained.
6. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.
7. Insert a spanner wrench into the holes provided and turn the head counter clockwise to remove. If the head is difficult to remove, tap the head with a plastic mallet while turning.
8. With the rod still supported, gently pull the piston from the barrel being careful not to damage the internal threads. Place the rod on a surface that will not damage the chrome.
9. Remove the setscrews located near the top of the piston.
10. Insert a spanner wrench into the holes on the face side of the piston.
11. Turn the piston counter clockwise to remove.

CAUTION

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

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

12. Remove the wear rings and ring seal from the piston.
13. Remove the O-rings, backup ring, wear rings, ring seal and wiper ring from the head.

Inspection

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

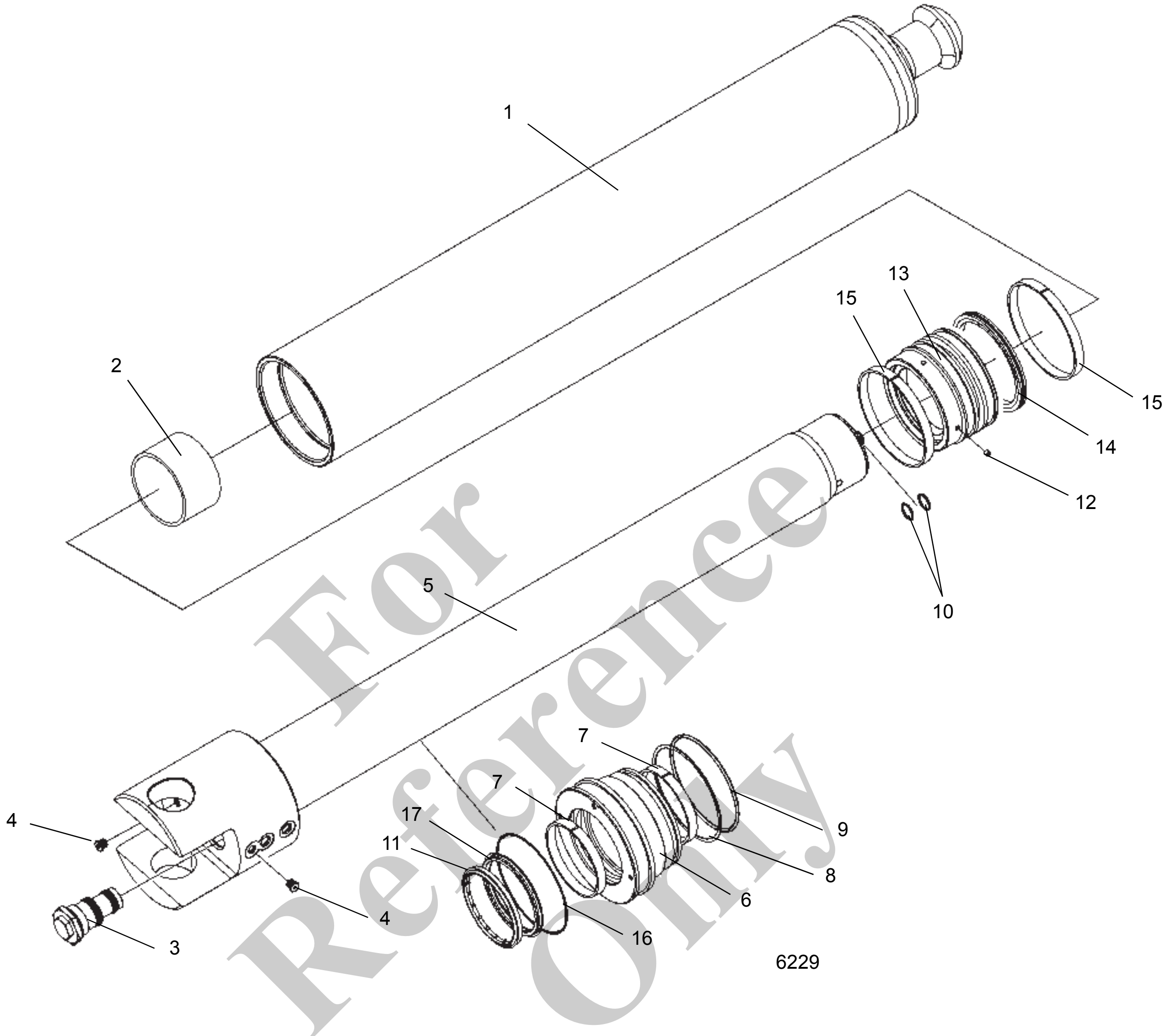


FIGURE 2-55

Item	Description
1	Barrel
2	Spacer
3	Pilot Check Valve
4	Plug
5	Rod
6	Head
7	Wear Ring
8	Backup Ring
9	O-ring

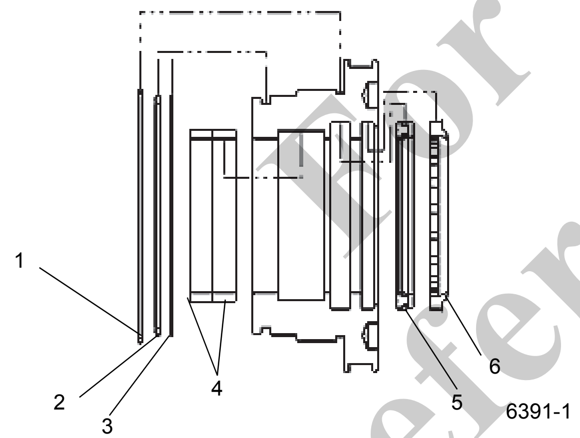
Item	Description
10	O-ring
11	Wiper Ring
12	Setscrew
13	Piston
14	Ring Seal
15	Wear Ring
16	O-ring
17	Ring Seal

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

CAUTION

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

Assembly



Item	Description
1	Sealing O-ring
2	Static O-ring
3	Static Backup Ring
4	Wear Rings
5	Rod Seal
6	Wiper

FIGURE 2-56

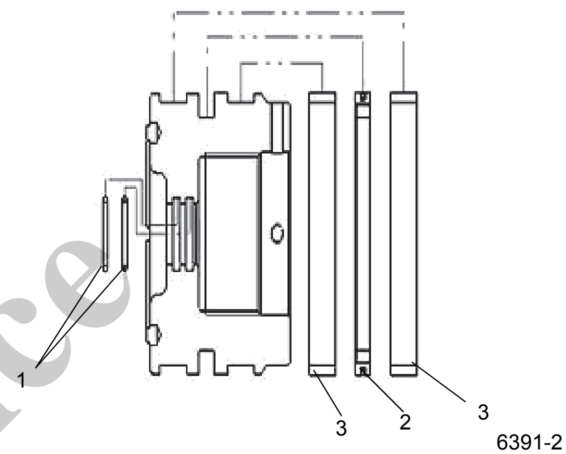
CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

For head and piston seal installation, (Figure 2-56) and (Figure 2-57).

1. Using round nose pliers or special installation tools, twist the dual lip u-cup seal into a "C" shape and allow it to snap into groove.
2. Use a similar technique to install the wiper.



Item	Description
1	Sealing O-rings
2	Piston Seal
3	Wear Ring

FIGURE 2-57

3. Install the static O-ring and backup ring into the static seal groove verifying that the backup ring is closest to the threads.
4. Install the sealing O-ring into the groove between the threads and the flange lip.

NOTE: If possible, the head/seal assembly should sit for at least one hour to allow the seals to elastically restore.

5. For easiest installation of the piston seal assembly, warm the teflon outer ring in 49° to 66°C (120° to 150°F) hydraulic oil or water. Lubricate the piston and all components with hydraulic fluid.
6. Stretch the inner ring into the seal groove. Do not use sharp edged tools and verify that it is not twisted.
7. Repeat step 6 for the outer ring.
8. Install the wear rings into wear ring grooves.

9. Place the rod on a clean table.
10. Install the head followed by the spacer, then the piston onto the rod. Note proper orientation of each component.
11. Torque the piston 406 to 474.5 Nm (300 to 350 lb-ft).
12. Install the piston setscrews.
13. Apply anti-seize lubricant to the head outer threads.
14. Brush piston seals and head seals with hydraulic oil and install rod assembly into barrel. Alignment is critical. Make sure the seals are not damaged during rod installation. If necessary use a sleeve to cover the seals.
15. Slide the head into the barrel and engage the threads. Turn the head counter clockwise until the first thread just passes the engagement point, then turn the head clockwise until it is hand-tight or fully seated. When the head becomes tight, use a mallet or dead blow hammer to knock the spanner wrench an extra 1/8 of a turn.
16. Brush the check valve with hydraulic oil and thread into cavity. Torque to 135.5 to 149.1 Nm (100 to 110 lb-ft).
17. Install the plugs.

Test

1. Set test stand pressure to 241.32 bar (3500 psi).
2. Attach hose fittings to cylinder.
3. Connect a ball valve to the “test extend” port (marked “PC” on rod mount) so that the pressure can be released after testing and is not trapped in the valve. Test cylinder through working ports with ball valve closed.
4. The cylinder shall be stroked its full length in both directions to fill it with oil and remove trapped oil.
5. Pressurize to recommended test pressure at each end, beginning with the rod end for a minimum of 10 seconds per end. While under pressure, cylinder shall be checked for leaks at weld, SAE fittings, valve, and all external static and dynamic seals (refer to *Outrigger Jack Cylinder*, page 8-71 for outrigger jack cylinder Internal Leak Testing). Cycle cylinder completely (retract and extend) three times under pressure.
6. When testing is complete, relieve pressure on working ports. Slowly open ball valve on PC port to relieve trapped oil pressure. Plug the extend port (marked “EXT”) and retract the cylinder with air using a regulator at the RET port and a return line connected to the PC port. Reclaim all oil. Carefully bleed off air pressure once cylinder is fully retracted.
7. Seal ports with port plugs to prevent contamination from entering cylinder.

CENTER FRONT JACK CYLINDER

Description

The center front jack cylinder (Figure 2-58) has a 8.9 cm (3.5 in) bore and is double acting. A port block is welded to the end of the cylinder rod and a pilot operated check valve is threaded into the port block. Internal seals are used to prevent leaks and a wiper ring in the cylinder head wipes dirt from the rod as it is retracted. The cylinder has a retracted length of 115.6 ± 0.30 cm (45.5 ± 0.012 in) and an extended length of 179.1 ± 0.30 cm (70.5 ± 0.012 in) from the center of the mounting fixture to the end of the ball on the barrel. The cylinder weighs approximately 42.5 kg (93.6 lb) dry.

Maintenance

Disassembly

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

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

DANGER

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

CAUTION

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

2. Retract the cylinder fully to avoid damaging the rod during removal.
3. Support the base of the cylinder to avoid sudden extension. Secure cylinder in work area with clamps or a chain vise to prevent rolling.

NOTE: Excessive wear due to side load or binding is a possibility. Mark or note the piston and head relationship to the rod and barrel.

4. Position the rod mount with the ports facing down. Use a a means of collecting the oil, remove the port plugs and the check valve and allow cylinder to drain.
5. Support the rod with a hoist sling and pull the rod to full extension to remove additional oil. Keeping the rod supported, tap the rod back in 1 inch after all oil has drained.
6. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.

7. Insert a spanner wrench into the holes provided and turn the head counter clockwise to remove. If the head is difficult to remove, tap the head with a plastic mallet while turning.
8. With the rod still supported, gently pull the piston from the barrel being careful not to damage the internal threads. Place the rod on a surface that will not damage the chrome.
9. Remove the setscrews located near the top of the piston.
10. Insert a spanner wrench into the holes on the face side of the piston.
11. Turn the piston counter clockwise to remove.

CAUTION

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

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

12. Remove the wear rings and ring seal from the piston.
13. Remove the O-rings, backup ring, wear rings, ring seal and wiper ring from the head.

Inspection

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

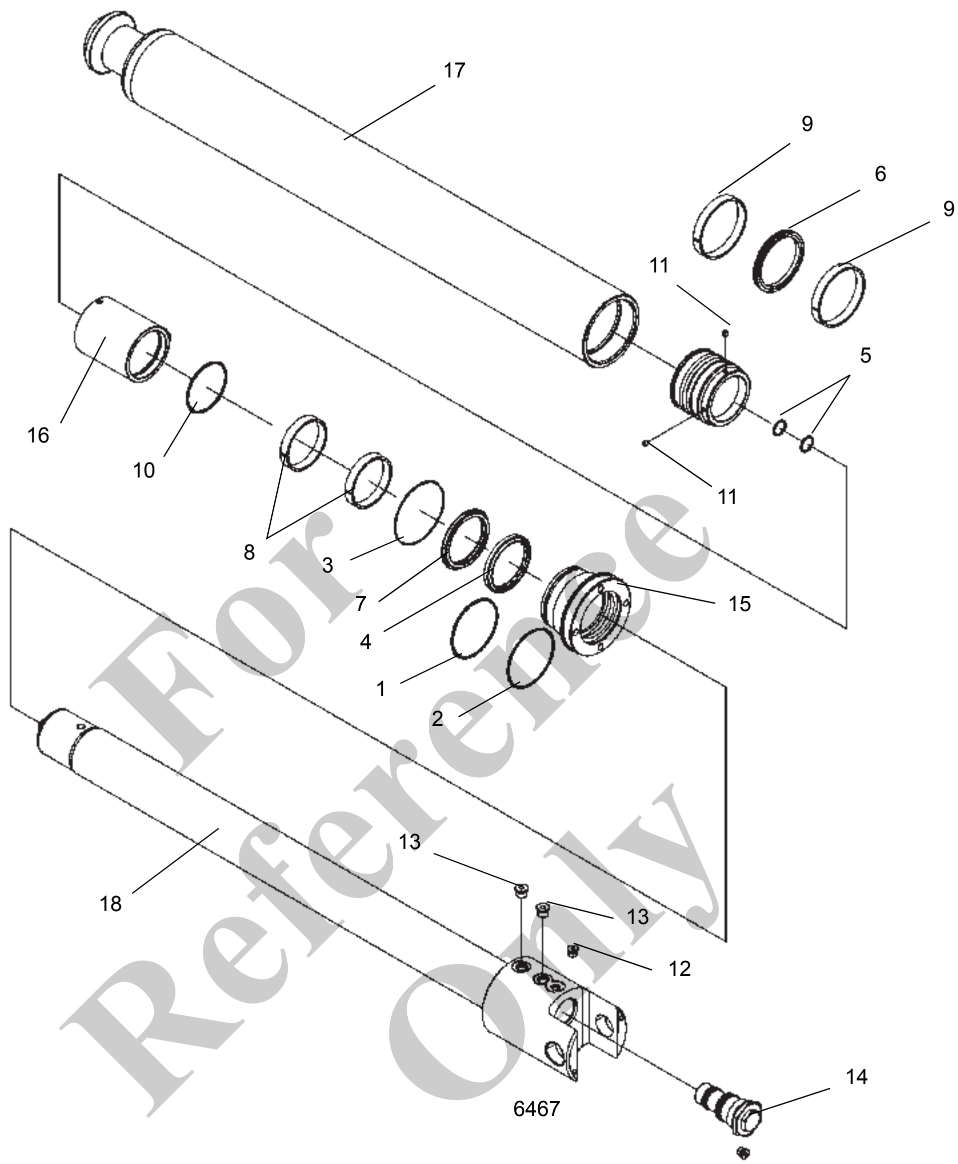


FIGURE 2-58

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

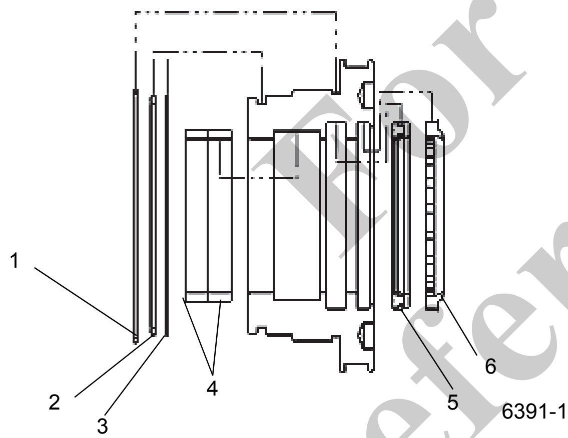
Item	Description
10	O-ring
11	Setscrew
12	Plug
13	Plug
14	Pilot Check Valve
15	Head
16	Spacer
17	Barrel
18	Rod

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

CAUTION

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

Assembly



Item	Description
1	Sealing O-ring
2	Static O-ring
3	Static Backup Ring
4	Wear Rings
5	Rod Seal
6	Wiper

FIGURE 2-59

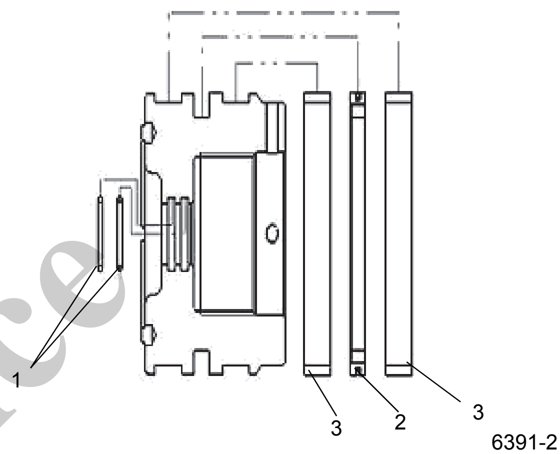
CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

For head and piston seal installation, refer to Figure 2-59 and Figure 2-60.

1. Using round nose pliers or special installation tools, twist the dual lip u-cup seal into a “C” shape and allow it to snap into groove.
2. Use a similar technique to install the wiper.



Item	Description
1	Sealing O-rings
2	Piston Seal
3	Wear Ring

FIGURE 2-60

3. Install the static O-ring and backup ring into the static seal groove verifying that the backup ring is closest to the threads.
4. Install the sealing O-ring into the groove between the threads and the flange lip.

NOTE: If possible, the head/seal assembly should sit for at least one hour to allow the seals to elastically restore.

5. For easiest installation of the piston seal assembly, warm the teflon outer ring in 49° to 66°C (120° to 150°F) hydraulic oil or water. Lubricate the piston and all components with hydraulic fluid.
6. Stretch the inner ring into the seal groove. Do not use sharp edged tools and verify that it is not twisted.
7. Repeat step 6 for the outer ring.
8. Install the wear rings into wear ring grooves.

9. Place the rod on a clean table.
10. Install the head followed by the spacer, then the piston onto the rod. Note proper orientation of each component.
11. Torque the piston 406 to 474.5 Nm (300 to 350 lb-ft).
12. Install the piston setscrews.
13. Apply anti-seize lubricant to the head outer threads.
14. Brush piston seals and head seals with hydraulic oil and install rod assembly into barrel. Alignment is critical. Make sure the seals are not damaged during rod installation. If necessary use a sleeve to cover the seals.
15. Slide the head into the barrel and engage the threads. Turn the head counter clockwise until the first thread just passes the engagement point, then turn the head clockwise until it is hand-tight or fully seated. When the head becomes tight, use a mallet or dead blow hammer to knock the spanner wrench an extra 1/8 of a turn.
16. Brush the check valve with hydraulic oil and thread into cavity. Torque to 135.5 to 149.1 Nm (100 to 110 lb-ft).
17. Install the plugs.

Test

1. Set test stand pressure to 241.32 bar (3500 psi).
2. Attach hose fittings to cylinder.
3. Connect a ball valve to the “test extend” port (marked “PC” on rod mount) so that the pressure can be released after testing and is not trapped in the valve. Test cylinder through working ports with ball valve closed.
4. The cylinder shall be stroked its full length in both directions to fill it with oil and remove trapped air.
5. Pressurize to recommended test pressure at each end, beginning with the rod end for a minimum of 10 seconds per end. While under pressure, cylinder shall be checked for leaks at weld, SAE fittings, valve, and all external static and dynamic seals (refer to *Outrigger Jack Cylinder*, page 8-71 for outrigger jack cylinder Internal Leak Testing). Cycle cylinder completely (retract and extend) three times under pressure.
6. When testing is complete, relieve pressure on working ports. Slowly open ball valve on PC port to relieve trapped oil pressure. Plug the extend port (marked “EXT”) and retract the cylinder with air using a regulator at the RET port and a return line connected to the PC port. Reclaim all oil. Carefully bleed off air pressure once cylinder is fully retracted.
7. Seal ports with port plugs to prevent contamination from entering cylinder.

COUNTERWEIGHT REMOVAL CYLINDER

Description

The counterweight cylinder (Figure 2-61) has a 8.9 cm (3.5 in) diameter bore. The retracted length of the cylinder from the end of the barrel to the center of the rod lug is 99.5 ±0.22 cm (39.19 ± 0.09 in). The extended length of the cylinder from the end of the barrel to the center of the rod lug is 170.66 ±0.22 cm (67.19 ± 0.09 in). Its stroke is 71.12 cm (28.0 in). A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs approximately 42 kg (92 lb).

Maintenance

Disassembly

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

1. Remove the holding valve from the port block.
2. Remove the bolts, washers, and nuts securing the rod end lug to the cylinder rod and remove the lug.
3. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent damaging the chrome during head removal. Using a spanner wrench, unscrew the head from the barrel.

DANGER

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

CAUTION

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

5. Loosen and remove the locknut securing the piston. Remove the piston from the rod.
6. Remove the O-ring from the inside of the piston.
7. Remove the wear ring and seal from the outside of the piston.
8. Remove the head from the rod. Remove the O-rings and the backup ring from the outside of the head. Remove the two 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 piston for damage. If piston is damaged, determine if it can be repaired or must be replaced.
4. Inspect rod for straightness. Determine if it can be straightened or must be replaced. Verify internal passages and ports are clean and undamaged.

CAUTION

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

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

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

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

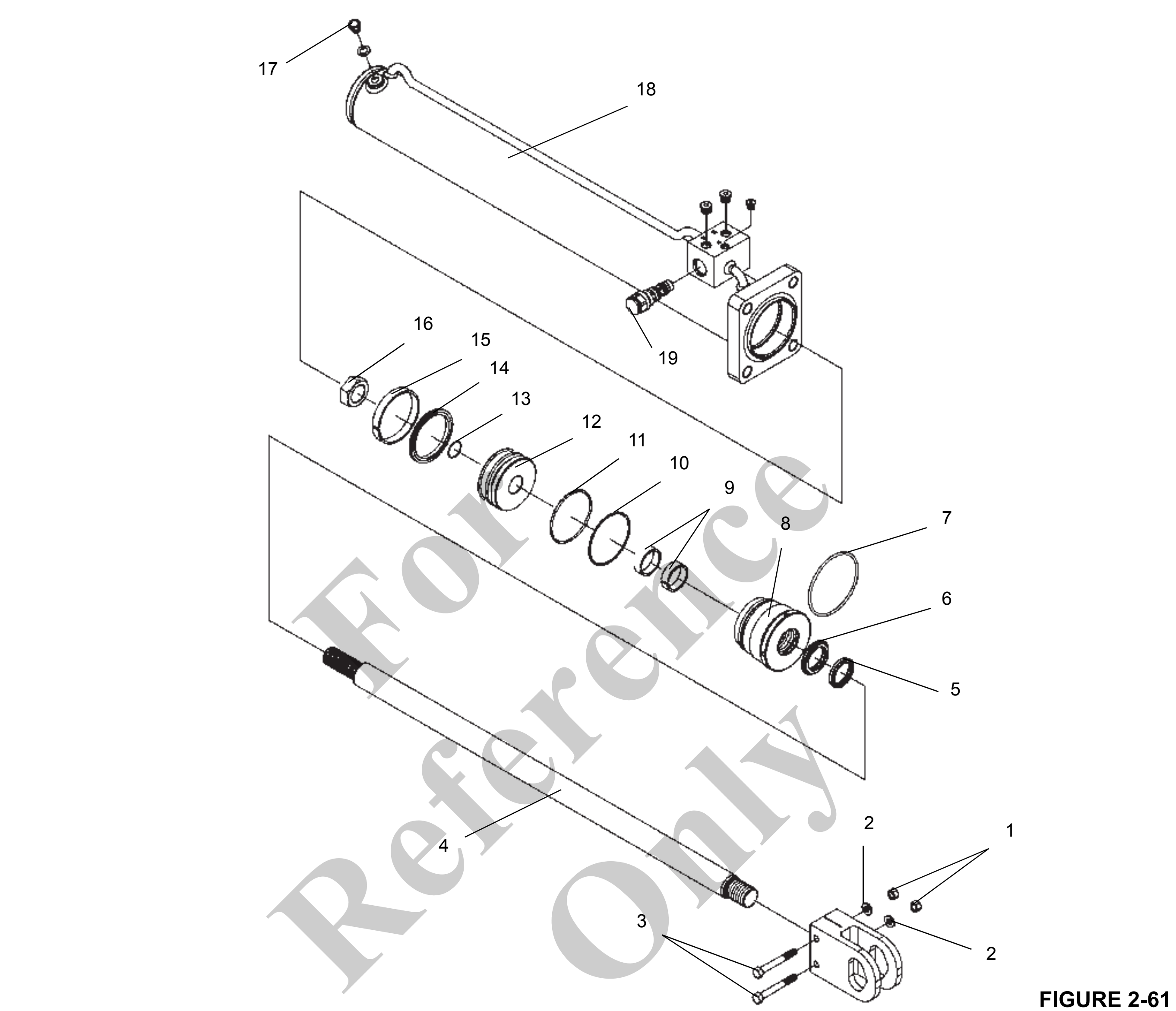


FIGURE 2-61

Item	Description
1	Nut
2	Washer
3	Capscrew
4	Rod
5	Wiper Ring
6	Seal
7	O-ring
8	Head
9	Wear Ring
10	Backup Ring

Item	Description
11	O-ring
12	Piston
13	O-ring
14	Seal
15	Wear Ring
16	Locknut
17	Bleeder Plug
18	Barrel
19	Holding Valve

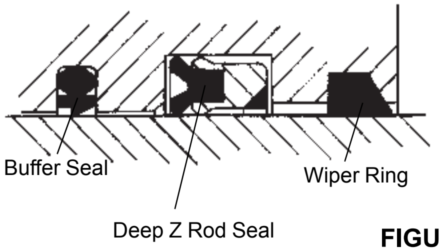


FIGURE 2-62

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

CAUTION

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

7. Remove the cover from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
8. Clean all oil from the threads of the head. Coat the threads with Loctite 271. Using a spanner wrench, screw the head into place in the barrel.
9. Check the inside of the port block for any sharp edges or burrs and remove as necessary with emery cloth.
10. Install new O-rings onto the holding valve.
11. Lubricate the holding valve and O-rings with clean hydraulic oil.

CAUTION

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

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

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

CAUTION

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

14. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 206.70 bar (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

SECTION 3
ELECTRIC SYSTEM

SECTION CONTENTS

DESCRIPTION

General

The electrical system is 12-volt operation with 12-volt starting, consisting of an alternator and three lead-acid batteries. The system is the single wire ground return type, using the machine's structure as ground.

Electrical power is transferred to and from the carrier and superstructure through the electrical swivel. For more detailed information on the electrical swivel, refer to *Swivels*, page 6-13.

Alternator

A 145 ampere alternator is mounted on the engine and is belt driven. When the engine is running, and the alternator is turning, the alternator's 12-volt output terminal supplies the crane's electrical circuits. The output terminal also supplies the voltage to recharge the battery and maintains it at a full state of charge.

Battery

The batteries are located in a box on the right front side of the carrier. The batteries are the maintenance free type and are 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.

In addition to the batteries, the battery box also contains a manual disconnect switch, four 100 amp fuses, one 250 amp fuse and one 30 amp circuit breaker. The fuses and circuit breaker protect all electrical circuits except the starter circuit.

Carrier Relay and Circuit Breaker Panel

Most carrier electrical circuits are protected by the components of the relay and the circuit breaker panel located to the rear of the side console in the carrier cab. Access is gained by removing the cover.

The relay and fuse panel contains 18 relays, a flasher, a buzzer and 24 fuses. A decal in the cover identifies each fuse and it's function (Table 3-1 and Figure 3-1).

Fuses

Fuses 2, 3, 9, 10, 11, 12, 13, and 14 are energized when the battery is connected and the battery disconnect is closed. Fuses 4, 19, 20, and 21 thru 24 are energized when the battery is connected and the headlights switch is ON. Fuses 5, 6, 7, 8, and 15 thru 18 are energized when the battery is connected and the ignition switch is in the ignition RUN (1) or accessory power position. F18 is a spare, 5 amp fuse.

NOTE: Fuse 1 is energized when the batteries are connected and the ignition switch is in the ignition (RUN) and (START) positions.

The following carrier fuse assignments (Table 3-1) apply:

Table 3-1

Fuse	Amp	Fuse Assignment
F1	5	ECM Ignition Signal
F2	10	Ignition
F3	20	Outrigger Solenoids, Daytime Running Lights
F4	5	Gauge Lights
F5	10	Console Lamps, Gauges, Buzzer, SW LEDS
F6	5	Horn
F7	10	Windshield Wiper/Washer Beacon Light
F8	5	Cab Circulating Fan, Heater Valve
F9	10	Air Dryer
F10	5	Dome Light
F11	8	12 Volt Power Outlet (8 A Max)
F12	30	Hydraulic Oil Cooler Fan
F13	20	Turn Signals, 4 Ways
F14	15	Stop Lights
F15	7.5	Backup Lights and Alarm
F16	20	Fan Motor, A/C CLutch
F17	30	A/C Condensor Fans
F18	3	Spare (3 A Max)
F19	10	Carrier Marker and Clearance Lights
F20	10	Carrier Marker and Clearance Lights
F21	10	Left Head Light Lo Beam
F22	10	Right Head Light Lo Beam
F23	10	Right Head Light Hi Beam
F24	10	Left Head Light Hi Beam and Hi Beam Ind
F25	5	S/S Ignition ON Relays
F26	5	ACC1, ACC2, Daytime Running Lights Relay
F27	5	DEF Level Gauge
F28	5	Spare

A 30 amp circuit breaker is installed inside the battery box compartment. It protects the headlights, marker lights, and gauge lights circuits.

Fuses 51, 52, 53, 54 and 55 are inside the battery box compartment. These fuses protect the electrical power system.

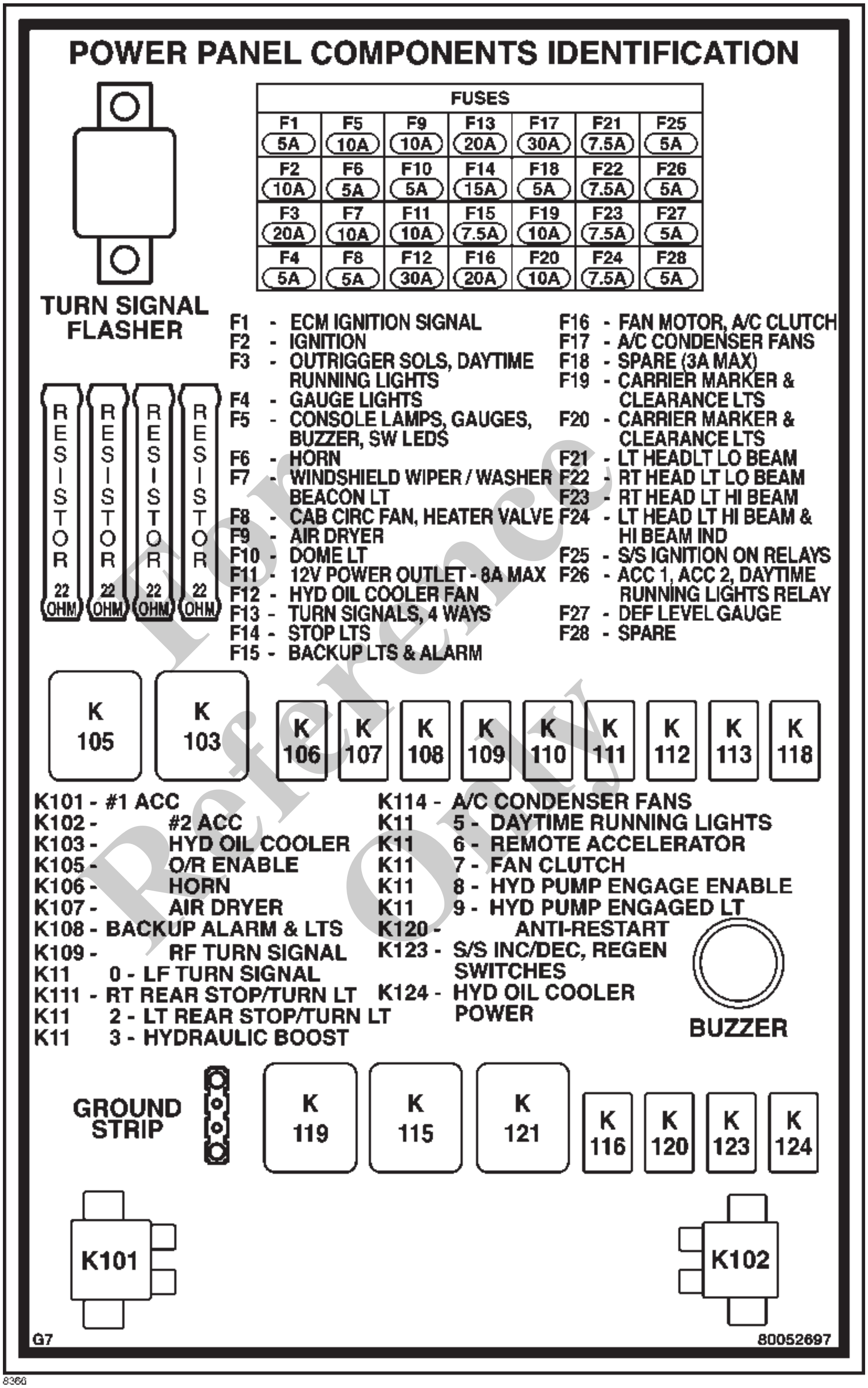

POWER PANEL COMPONENTS IDENTIFICATION
FUSES
F1 5A F5 10A F9 10A F13 20A F17 30A F21 7.5A F25 5A
F2 10A F6 5A F10 5A F14 15A F18 5A F22 7.5A F26 5A
F3 20A F7 10A F11 10A F15 7.5A F19 10A F23 7.5A F27 5A
F4 5A F8 5A F12 30A F16 20A F20 10A F24 7.5A F28 5A
TURN SIGNAL FLASHER
RESISTOR 22 OHM
RESISTOR 22 OHM
RESISTOR 22 OHM
RESISTOR 22 OHM
F1 - ECM IGNITION SIGNAL
F2 - IGNITION
F3 - OUTRIGGER SOLS, DAYTIME RUNNING LIGHTS
F4 - GAUGE LIGHTS
F5 - CONSOLE LAMPS, GAUGES, BUZZER, SW LEDS
F6 - HORN
F7 - WINDSHIELD WIPER / WASHER BEACON LT
F8 - CAB CIRC FAN, HEATER VALVE
F9 - AIR DRYER
F10 - DOME LT
F11 - 12V POWER OUTLET - 8A MAX
F12 - HYD OIL COOLER FAN
F13 - TURN SIGNALS, 4 WAYS
F14 - STOP LTS
F15 - BACKUP LTS & ALARM
F16 - FAN MOTOR, A/C CLUTCH
F17 - A/C CONDENSER FANS
F18 - SPARE (3A MAX)
F19 - CARRIER MARKER & CLEARANCE LTS
F20 - CARRIER MARKER & CLEARANCE LTS
F21 - LT HEADLT LO BEAM
F22 - RT HEAD LT LO BEAM
F23 - RT HEAD LT HI BEAM
F24 - LT HEAD LT HI BEAM & HI BEAM IND
F25 - S/S IGNITION ON RELAYS
F26 - ACC 1, ACC 2, DAYTIME RUNNING LIGHTS RELAY
F27 - DEF LEVEL GAUGE
F28 - SPARE
K 105
K 103
K 106
K 107
K 108
K 109
K 110
K 111
K 112
K 113
K 118
K101 - #1 ACC
K102 - #2 ACC
K103 - HYD OIL COOLER
K105 - O/R ENABLE
K106 - HORN
K107 - AIR DRYER
K108 - BACKUP ALARM & LTS
K109 - RF TURN SIGNAL
K11 0 - LF TURN SIGNAL
K111 - RT REAR STOP/TURN LT
K11 2 - LT REAR STOP/TURN LT
K11 3 - HYDRAULIC BOOST
K114 - A/C CONDENSER FANS
K11 5 - DAYTIME RUNNING LIGHTS
K11 6 - REMOTE ACCELERATOR
K11 7 - FAN CLUTCH
K11 8 - HYD PUMP ENGAGE ENABLE
K11 9 - HYD PUMP ENGAGED LT
K120 - ANTI-RESTART
K123 - S/S INC/DEC, REGEN SWITCHES
K124 - HYD OIL COOLER POWER
BUZZER
GROUND STRIP
K 119
K 115
K 121
K 116
K 120
K 123
K 124
K101
K102
G7
80052697
8366

FIGURE 3-1

Relays

The carrier has 22 relays (Table 3-2) which control many of its functions. Relays K101 through K124 are located in the cab circuit breaker and relay panel assembly. When any relay coil is energized, its contacts either close or open. This allows power to go to or be removed from the related circuits.

For any relay coil to energize, the battery must be connected.

Table 3-2

Relay	Relay Assignment
K101	#1 ACC
K102	#2 ACC
K103	Hydraulic Oil Cooler
K105	Outrigger Enable
K106	Horn
K107	Air Dryer
K108	Backup Alarm and Lights
K109	Right Front Turn Signal
K110	Left Front Turn Signal
K111	Right Rear Stop/Turn Light
K112	Left Rear Stop/Turn Signal
K113	Hydraulic Boost
K114	A/C Condenser Fans
K115	Daytime Running Lights
K116	Remote Accelerator
K117	Fan Clutch
K118	Hydraulic Pump Engage Enable
K119	Hydraulic Pump Engage Lamp
K120	Anti-Restart
K123	S/S Inc./Dec., Regen Switches
K124	Hyd Oil Cooler Power

The coil of the accessory relays (K101 and K102) are energized when the ignition switch is at the RUN (1) or ACC (3) position.

The coil of the hydraulic oil cooler relay (K103) is energized when the hydraulic oil temperature switch closes.

The coil of the outrigger enable relay (K105) is energized when the park brake on indicator pressure switch contacts are closed.

The coil of horn relay (K106) is energized when the horn button is depressed.

The coil of the air dryer heater relay (K107) is energized when the contacts of accessory relay (K101) are closed.

The coil of back up relay (K108) is energized when the contacts of accessory relay (K102) and back up switch are closed.

The coils of turn signal relays (K109 thru K112) are energized and de-energized by the turn signal flasher.

Superstructure Relay Panel and Fuse Panel

NOTE: Refer to Figure 3-3 for electrical connections

Most superstructure electrical circuits are protected by the components of the relay panel assembly (Figure 3-4) and the fuse panel (see Figure 3-2).

The relay panel assembly contains 6 relays. It is located on the outside rear wall of the superstructure cab. Access is gained by removing the cover that covers the rear outside of the cab.

Fuses

The fuse panel is located on the rear wall of the cab behind the seat and contains 20 fuses. To gain access to the fuses, loosen the thumb screws and remove the cover. A decal (Figure 3-4) in the cover identifies each fuse, its function and its amperage. Fuses 1, 2, 3, 4, 5, and 6 are energized when the battery is connected. Fuse 7 thru 16 are energized when the battery is connected and the ignition switch is in the RUN (1) or ACC (3) position.

The following superstructure fuse assignments (Table 3-3) apply:

Table 3-3

Fuse	Amp	Fuse Assignment
F1	10	Boom Flood Lights
F2	10	Cab Work Lights
F3	10	12V Dash Outlet (8A Max)
F4	5	Horn
F5	10	Radio (Opt), B+ Spare (8A Max)
F6	10	Dome LT, Gauge LTS
F7	10	Ignition
F8	5	Acc. Relay Coils
F9	10	Gauges, Warning Lights
F10	5	Swing Brake
F11	15	RCL/Unlock Solenoids
F12	10	Main Hoist Down, Aux Hoist Down
F13	5	Skywiper, Cab Fan

Fuse	Amp	Fuse Assignment
F14	10	Crane Function SOLS, Hyd Boost SOL
F15	5	Main, Aux Hoist Rotation Indicators
F16	25	Heater, A/C Evap Fans, A/C Clutch Solenoid
F17	30	A/C Condenser Fan Motor
F18	10	Beacon LT, Wiper, Washer, Switch LEDS
F19	5	Buzzer, DEF Level Gauge
F20	20	Outriggers, Counterweight Solenoids

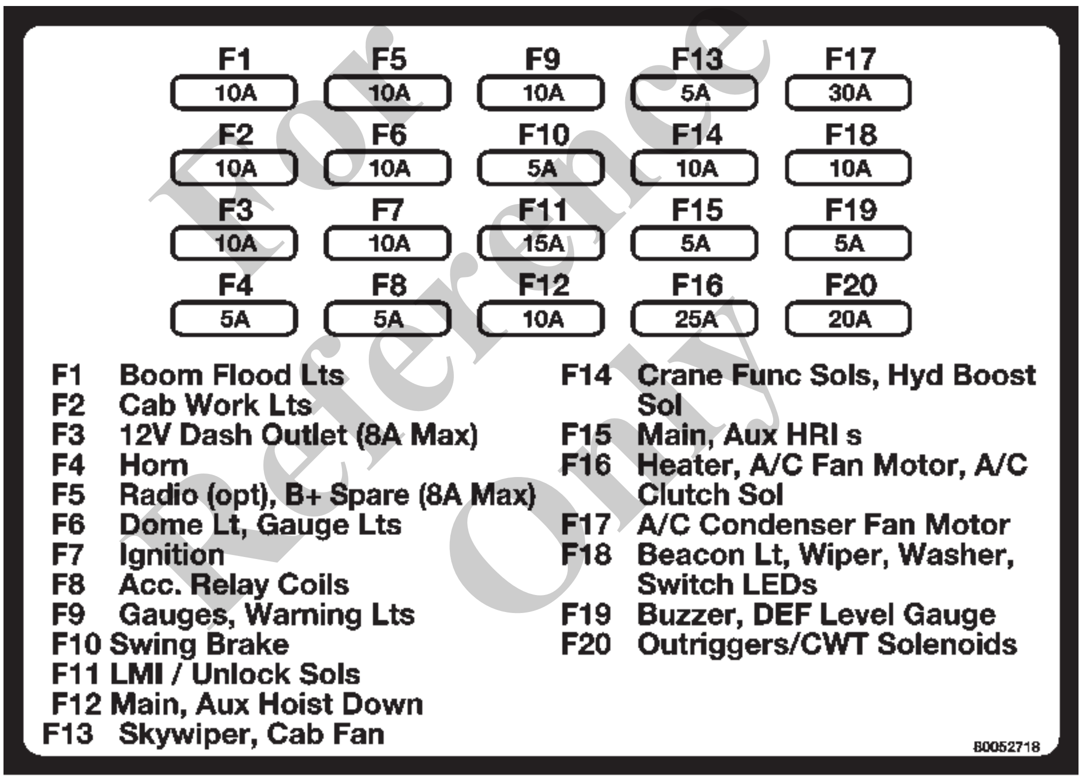


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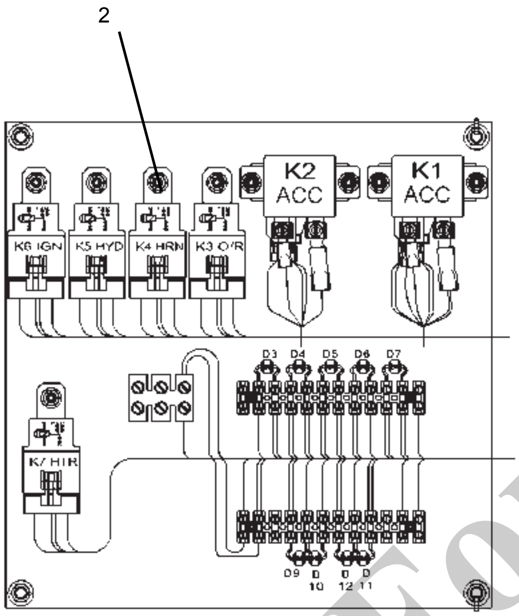
FIGURE 3-2

NOTE: Refer to (Figure 3-2, 3-3, and 3-4), and Table 3-3 and 3-4 for fuse and relay identification.



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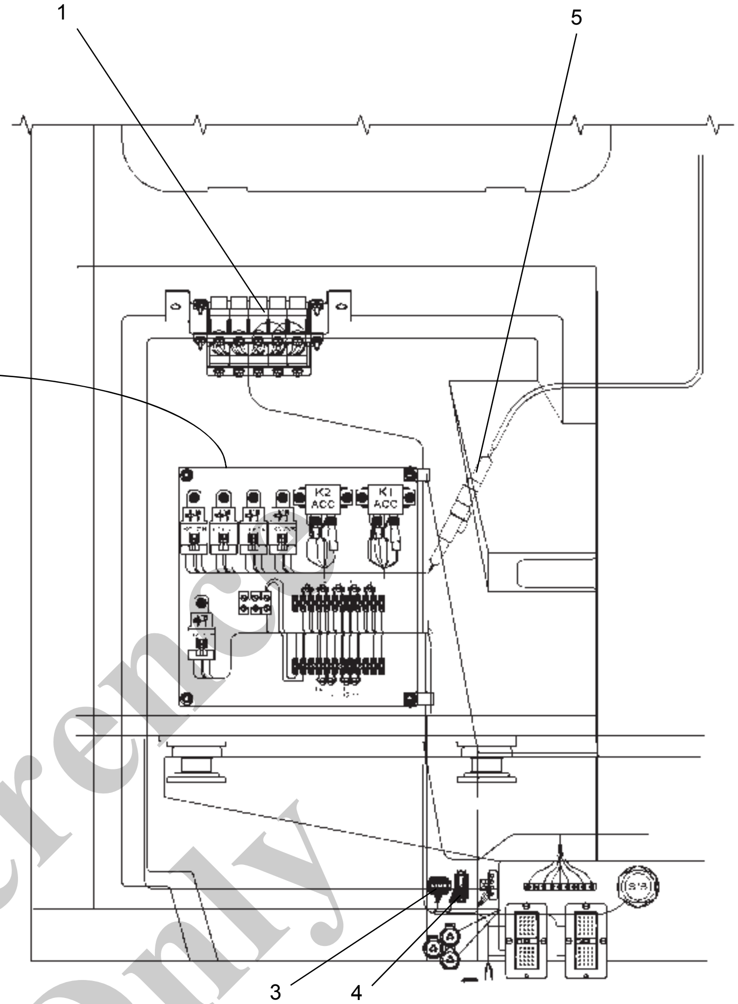


Partial Rear View Of Cab

6871-1

Item	Description
1	Fuse Installation
2	Fuse and Relay Panel
3	Harness Connector
4	Harness Connector
5	RCL Cable

FIGURE 3-3

Relays

The superstructure has 7 relays (Table 3-4) (Figure 3-3 and 3-4) which control many of its functions. The relays are located on the superstructure relay panel assembly (Figure 3-4).

When any relay coil is energized, its contacts either close or open. This allows power to go to or be removed from the related circuits. For any relay coil to energize, the battery must be connected.

Table 3-4

Relay	Relay Assignment
K1	ACC 1 Relay
K2	ACC 2 Relay
K3	Outriggers
K4	Horn
K5	Hyd Crane Function
K6	Ignition Relay
K7	Heater Control

The coil of the accessory relays (K1 and K2) are energized when the ignition switch is in the RUN (1) or ACC (3) position.

The coil of the ignition relay (K6) is energized when the carrier ignition switch is positioned to START (2) or ACC (3) and held energized when ignition switch is released to RUN (1). The coil of the swing horn relay (K4) is energized when the swing horn button is depressed.

The coil of the crane function relay (K5) is energized when the crane function switch is positioned to ON, the operator is in the seat, and the left armrest is down.

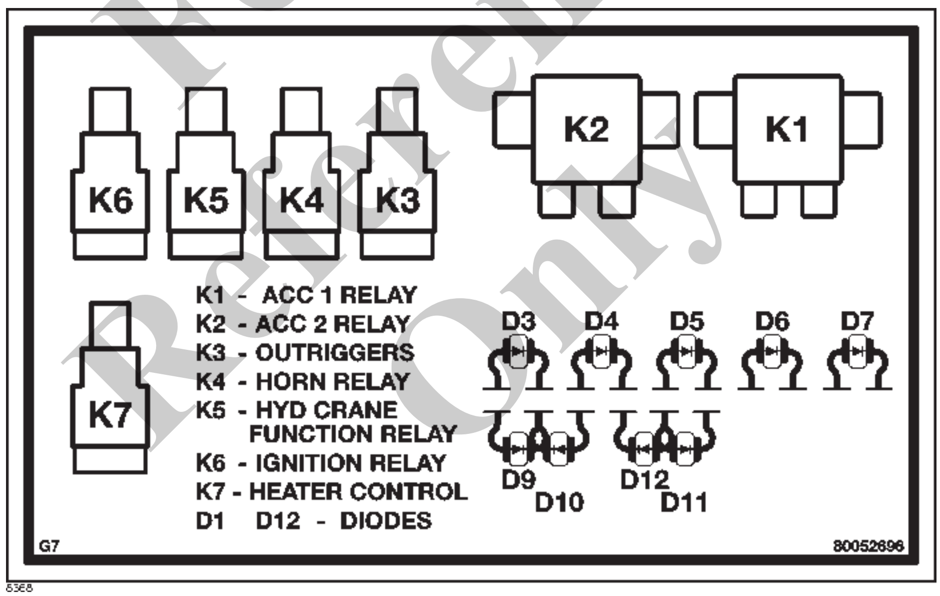


FIGURE 3-4

MAINTENANCE

General

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

CAUTION

If it is necessary to perform electrical maintenance on live or hot circuits, remove all rings, watches, and other jewelry before performing maintenance as serious burns result from accidental grounding or shorting circuits.

Ensure the battery is disconnected before performing any maintenance on an electrical circuit which is not fused.

CAUTION

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

General Troubleshooting

CAUTION

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

NOTE: Make voltage checks at terminations when components are installed and operating. Make continuity checks when components are isolated or removed. Troubleshoot per the following guidelines:

1. First, use reported symptoms to identify a problem or a suspect component.
2. Test the suspect component per instructions in this section. The instructions identify the circuit breakers 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 diameter.
5. After troubleshooting, test and repair the repaired circuit. Verify the circuit works properly.

Troubleshooting Engine Starting Problems

1. Verify the battery terminals are connected and clean, the transmission is in neutral, and the machine is fueled.
2. Try to turn on the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights to verify the battery has at least some charge. If none of these lights comes on, suspect the battery. Charge battery as needed, or replace the battery 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 battery. Charge battery as needed, or replace the battery if you can jump-start the crane from another crane.
4. Verify the anti-restart relay, K120, is working properly.
5. If the problem remains, suspect Fuse 53. Replace Fuse 53 and make repairs to the circuit.
6. Turn the ignition switch(es) 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(es) and the power circuit to it starting at the ignition switch(es) circuit breaker (CB 2). Repair or replace circuit, switch, or fuse as needed.
7. If the battery, fuses, ignition switches, and power circuit to the ignition switch check out, do one of the following:
   a. If you hear no noise when you try to engage the starter, troubleshoot the start circuit (ignition switch, electric shifter, neutral start relay K110, the anti-restart relay K120 and wiring from ignition switch 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, suspect a faulty engine control system. Refer to the engine manual for further instructions.

e. If the engine starts, then shuts down, suspect a faulty engine control system. Refer to the engine manual for further instructions.

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

Troubleshooting Engine Charging Problems

1. Verify battery terminals are connected and clean and all wires in the charging system are in good repair and are connected properly.
2. Verify the alternator belt is properly installed and is under proper tension.
3. Verify the battery puts out 12 volts minimum. Charge battery as needed so the battery can supply a minimum excitation voltage to the engine's charging system.
4. Verify there is a minimum of 12 volts at the alternator from the battery, and that the alternator is properly grounded.
5. Replace the alternator if the other conditions check out.
6. Refer to the engine manual for further instructions.

NOTE: If the alternator runs noisily, check belt tension. If problem persists, replace alternator.

If the alternator overcharges (voltmeter reads high, light bulbs burn out quickly), look for a ground where one shouldn't exist. If external wiring checks out, replace alternator. (The alternator probably has an internal ground or a faulty internal voltage regulator.)

Troubleshooting Accessories

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

1. Turn the ignition switch to the ACC (3) position. Try to turn on the cab circulating fan, the 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 circuit problem.

NOTE: Steps 2 thru 4 are referring to the carrier accessory circuits. They also apply to the superstructure except the relays are K1 and K2.

2. Check the primary power circuit to the accessory relays K101 and K102. 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 K101 and K102 to ground. Turn the ignition switch to the ACC (3) position and listen for audible click of relays K101 and K102. 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 K101 or K102 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 replacement 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.

Refer to Table 3-5 through 3-8 for listing of tools necessary for connector maintenance.

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

Table 3-5
Amp Extraction Tool Table

Description	Amp Part Number	Grove Part Number
14 gauge wire (connectors)	305183	9999100176
12 to 8 gauge wire (connectors)	91019-3	9999100175
4 to 9 circuit (in-line connectors)	453300-1	N/A
15 circuit (in-line connectors)	458944-1	N/A

Table 3-6
Amp Crimping Tool Table

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

Table 3-7
Deutsch Extraction Tool Table

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

Table 3-8
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT48-00	9999100808
4, 6, 8, 10 gauge wire	HDT 04-08	9999100842

Troubleshooting Lights

1. Check lamp first. Replace any damaged lamp.
2. If all lamps in a circuit do not work, suspect the fuse and switch. Replace fuse if necessary.
3. Check the switch and circuit for continuity problems and other problems. Repair any faulty switch or other component. Repair wiring if faulty.

Carrier

The following carrier circuit designs apply (Table 3-9) (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

Table 3-9

Lights	Circuit
Head Lights	HEADLIGHTS switch, dimmer switch, F21, F22, F23, or F24, lamps, grounds
Tail Lights	HEADLIGHTS switch, F19 or F20, lamps, grounds
Marker Lights	HEADLIGHTS switch, F19 or F20, lamps, ground
Gauge Lights	HEADLIGHTS switch, F4, lamps, grounds
Turn Signal Lights	F13, flasher, turn signal switch, relays K109, K110, K111, or K112, lamps, grounds. Suspect turn signal switch if hazard light circuit functions properly.
Hazard Lights	F13, flasher, hazard lights switch, relays K109, K110, K111, or K112, lamps, grounds. Suspect hazard lights switch if turn signal lights circuit functions properly.
Stop Lights	F14, stop light switches, turn signal switch, K109, K110, K111, or K112, lamps (suspect stop circuit problem if turn signal or tail light function works), grounds
Beacon Light	F7, BEACON light switch, lamp, ground. Parallel circuit to LED indicator in switch to ground
Cab Dome Light	F10, switch on dome light, parallel circuit through door switch, lamp, ground

Superstructure

The following superstructure circuit designs apply (Table 3-10) (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

Table 3-10

Lights	Circuit
Boom Flood Lights	F1, BOOM light switch, lamps, grounds. Parallel circuit to LED indicator in switch to ground
Work Lights	F2, WORK light switch, lamp, grounds. Parallel circuit to LED indicator in switch to ground
Cab Dome Light	F3, switch on dome light, lamp, grounds
Gauge Lights	F3, PANEL DIM control, lamps, grounds
Beacon Light	F8, lamp, ground. Parallel circuit to LED indicator in switch to ground

Troubleshooting Gauges and Meters

NOTE: When operating from either cab, the gauges and meters in the other cab will function also. The gauges share a common sender and therefore both gauges must be powered, When operating from the carrier, F5 supplies the power and when operating from the superstructure, F9 supplies the power.

1. Check all other gauges and meters (besides the suspect). If none of them are working, check or replace F5 (carrier) or F9 (superstructure).
2. Check the gauge or meter, its sensing component, and circuit for continuity problems and other problems. A sender is probably at fault when it shows infinite resistance, or resistance out of specifications for condition. Repair any faulty gauge, meter or other component. Repair wiring if faulty.

The following carrier and superstructure circuit designs (Table 3-11) apply (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

Table 3-11

Gauge/Meter	Circuit
Voltmeter	F5/F9, voltmeter, ground
Fuel Level Gauge	F5/F9, gauge. Gauge is grounded. Branch from gauge to sending unit in fuel tank to ground
Engine oil Pressure Gauge	F5/F9, gauge. Gauge is grounded. Branch from gauge to oil pressure sending unit to ground
Engine Coolant Temperature Gauge	F5/F9, gauge. Gauge is grounded. Branch from gauge to coolant temperature sending unit to ground

Gauge/Meter	Circuit
Tachometer	F5/F9, tachometer. Meter is grounded. Branch from tachometer to tachometer sender to ground
Speedometer	F5, gauge. Gauge is grounded. Branch from speedometer to engine ECM and back to speedometer

3. Repair is straightforward.
   a. For a gauge or meter, check or replace fuse, remove gauge or meter, install new gauge or meter, then test gauge or meter.
   b. For a sender, check or replace fuse, remove sender, install new sender, then test sender and gauge or meter. See *Instrument Replacement*, page 3-17 in this section for details on removing and installing gauges and meters.

Troubleshooting Alarms, Indicators, and Emergency Components

1. If an indicator won't work when it is supposed to, check its lamp first. Replace any damaged lamp. Then check and replace fuse as applicable, especially if all other components downstream from the fuse are not working. Also, check and replace its relay as applicable.
2. If an alarm or an emergency component won't work when it is supposed to, check and replace its fuse, especially when all other components downstream from the fuse are not working. Also, check and replace its relay as applicable.
3. Check the alarm or indicator or emergency component, its sensing component, and circuit for continuity problems and other problems. Repair any faulty alarm or indicator or emergency component or sensing device (switch, relay, sending unit). Repair wiring if faulty.

The following carrier circuit designs apply (Table 3-12) (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

Table 3-12

Component	Circuit
Backup Light and Backup Alarm	F15, backup switch, relay K108, then to backup light in parallel with backup alarm; then from light and alarm to grounds
Park Brake Indicator	F5, indicator, normally closed park brake pressure switch on cab front console control valve, ground
Steering Wheel Horn	F6, horn relay K106 coil, horn switch, ground. Parallel branch from horn relay contacts, horn, ground
Low Air Pressure Indicator	F5, to indicator or buzzer to two parallel normally closed pressure switches on the dual brake valve
Tire Inflation On Indicator	F5, to indicator or buzzer to the normally open pressure switch on the cab front console control valve to ground.
Swing Brake On Indicator	F5, to indicator or buzzer to the normally open pressure switch on the cab front console mounted trailer brake control valve to normally open pressure switch on the trailing boom swing valve on the superstructure to ground
Hydraulic Pump Engaged Indicator	F5 to indicator to switch on pump disconnect lever to ground
Cross Axle Differential Lock On Indicator	F5 to indicator to switch on axle to ground
Inter-Axle Differential Lock On Indicator	F5 to indicator to normally open pressure switch on cab front console control valve to ground
Suspension Deflated Indicator	F5 to indicator to four (one at each air bag suspension) normally closed pressure switches connected in series to ground
Engine Stop Indicator	F5 to indicator or buzzer to engine ECM
Engine Warning Indicator	F5 to indicator to engine ECM
Engine Service Indicator	F5 to indicator to engine ECM

The following superstructure circuit designs apply (Table 3-13) (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

Table 3-13

Component	Circuit
Swing Horn	F4 to horn relay (K4) coil to horn switch to ground. Parallel branch from horn relay contacts to horn to ground
Center Front Jack Overloaded Indicator	F9 to indicator to normally open pressure switch on cylinder to ground
Engine Stop Indicator	(F9 to indicator) and (F2 in carrier to power select relay (K104) contacts to superstructure ignition switch to buzzer) to engine ECM

4. Repair is straightforward.

- **a.** ALARM: check or replace fuse, or replace faulty alarm or faulty sensor (switch, relay, sending unit), install new alarm or sensor, test alarm.
- **b.** INDICATOR: check and/or replace fuse, or remove faulty light or faulty sensor (switch, relay, sending unit), install new light or sensor, test indicator.
- **c.** BACKUP LIGHT: check and/or replace fuse, or remove faulty relay, light, or faulty sensor (electric shifter), install new light or sensor, test lights.
- **d.** HORN: check and/or replace fuse or remove faulty horn or faulty trigger (switch, relay), install new horn or trigger, test horn.
- **e.** BUZZER: check and/or replace fuse or remove buzzer, install new buzzer, test buzzer.

Troubleshooting Crane Components and Accessories

1. If a crane component or accessory won't work when it is supposed to, check and/or 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.

Carrier

The following carrier circuit designs apply (Table 3-14) (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

Table 3-14

Component	Circuit
Windshield Wiper Motor and Windshield Washer Pump Motor	F7, wiper/washer switch, motors in parallel, grounds
Heater Fan	F16, heater switch, fan motor, ground. Parallel circuit to LED indicator in switch to ground
Cab Circulating Fan	F8, switch, motor, ground
Defroster Fan	F17, defrost switch, motor, ground. Parallel circuit to LED indicator in switch to ground
Air Dryer Heater	F9 to air dryer relay (K107) contacts to air dryer temperature switch, to heating element to ground. Branch circuit from carrier F5/superstructure F9 to air dryer relay (K107) coil to ground
Hydraulic Oil Cooler Fan Motor	Fuse F12 to hydraulic oil cooler relay (K103) contacts to fan motor to ground. Branch circuit from superstructure ignition switch to superstructure ignition relay (K3) contacts to oil cooler temperature switch contacts to relay (K103) coil to ground
Outrigger Enable Circuit	Carrier F5/superstructure F9 to outrigger enable relay (K105) coil to park brake on indicator circuit pressure switch contacts to ground
Outrigger Control functions	F3 to outrigger enable relay (K105) contacts to selector switches in superstructure control box or carrier optional remote mounted control boxes extend/retract switches to engine ECM for throttle control

Superstructure

The following superstructure circuit designs apply (Table 3-15) (connecting wiring and passage through swivel slip ring -- as applicable -- is understood):

3

Table 3-15

Component	Circuit
Windshield Wiper Motor and Windshield Washer Pump Motor	F18, wiper/washer switch, motors in parallel, grounds
Heater or A/C Fan	F16, FAN switch, fan motor, ground
Cab Circulating Fan	F13, switch, motor, ground
A/C Control Functions	F16 to FAN switch to A/C ON-OFF switch to fans relay coil to ground. Parallel circuit to LED indicator in A/C ON-OFF switch to ground. Parallel circuit to thermostat contacts to binary pressure switch contacts to A/C compressor clutch to ground
A/C Condensor Fan Motors	Fuse F17 to fans relay contacts to condensor fan motors in parallel to ground
Crane Function	F14, crane function switch, seat switch, left armrest switch, crane function relay (K5) coil, ground. Branch in parallel from crane function switch to crane function relay contacts to crane function solenoid valve to ground. Parallel circuit to LED indicator in switch to ground
Main and Auxiliary Hoist Rotation Indicators	F15, branch for each hoist (driver assembly, sensor, driver assembly, ground). Parallel branch through thumper to driver assembly
RCL	F11, RCL CPU and RCL crane components, grounds
Lockout Function	F11, RCL CPU, three or four lockout solenoid valves in parallel, grounds
Swing Brake Release Function	F10, swing brake release switch, swing brake release solenoid valve, ground. Parallel circuit to LED indicator in switch to ground
Hydraulic Boost Function	From upstream of crane function relay contact (see crane function circuit) to hydraulic boost switch to hydraulic boost solenoid to ground. Parallel circuit to LED indicator in switch to ground
Main Hoist High Speed Function	F12 to main hoist high speed switch to hoist speed solenoid valve on hoist to ground. Parallel circuit to LED indicator in switch to ground
Auxiliary Hoist On/Off function	For hoist up, F11 to RCL CPU to aux hoist switch to auxiliary hoist up solenoid valve to ground. For hoist down, CB12 to aux hoist switch to auxiliary hoist down solenoid valve to ground. Parallel circuit to LED indicator in switch to ground
Skylight Wiper Motor	F13, wiper switch (on motor), motor, grounds
Beacon Light	F18 to beacon light to ground
Switch LED's	F18 to seven parallel LED's to ground

3. Repair is straightforward.
   a. MOTOR: check and/or replace fuse, remove faulty motor or faulty trigger (switch, relay), install new motor or trigger, test motor. For further information, see the applicable section in this manual.
   b. SOLENOID VALVE: check and/or replace fuse, remove faulty valve or solenoid, install new valve or solenoid, fill fluid system, test valve.
   c. RCL: check and/or replace fuse, repair per RCL manual, test per RCL manual.
   d. ROTATION INDICATOR: check and/or replace fuse, remove driver assembly or sensor, install driver assembly or sensor, test thumper. For further information on rotation indicator, see *Hoist Drum Indicator System*, page 5-10 or the applicable SM package.

Alternator Replacement

NOTE: On cranes with air conditioning it may be necessary to move the compressor to gain access to the alternator.

Removal

CAUTION

To prevent damage to electronics, in order: Ensure keyswitch has been off 2 minutes, Battery disconnect is in the off position, Remove ECM power fuse, Remove negative cables, Remove positive cables (if required).

1. Turn the ignition switch off two minutes before proceeding to the next step.
2. Turn the battery disconnect switch to OFF.
3. Remove the ECM power fuse.
4. Disconnect the batteries starting with the negative terminals.
5. Open the engine compartment.

6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. 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.
8. Remove the alternator attaching bolt. Remove the alternator.

Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. Install the alternator with the alternator attaching bolt. Torque bolt; refer to *Fasteners and Torque Values*, page 1-12.
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. Verify tensioner bolt is properly torqued to 43 Nm (32 lb-ft).
6. Connect the electrical leads to the terminals as tagged during removal.
7. Connect the batteries starting with the positive terminals.
8. Install the engine ECM fuse.
9. Turn the battery disconnect switch to the ON position.
10. Close the engine compartment.

Check

1. Run engine. Verify reading of voltmeter on front console is 12 volts or greater. Make repairs as needed.
2. Continue troubleshooting charging system as needed if replacement of alternator did not correct problem in charging system.

Starter Replacement

Removal

CAUTION

To prevent damage to electronics, in order; Ensure key switch has been off 2 minutes, Battery disconnect is in the off position, Remove ECM power fuse, Remove negative cables, Remove positive cables (if required).

1. Turn the ignition switch off two minutes before proceeding to the next step.
2. Turn the battery disconnect switch to OFF.
3. Remove the ECM power fuse.
4. Disconnect the batteries starting with the negative terminals.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the starter.
7. Remove the hex nuts and washers securing the starter. Remove the starter.

Installation

1. Install the starter and secure with the hex nuts and washers.
2. Connect the electrical leads to the terminals as tagged during removal.
3. Connect the batteries starting with the positive terminals. Install ECM power fuse. Turn the battery disconnect switch to the on position.
4. Close the engine compartment.

Check

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

Battery Replacement

Removal

CAUTION

To prevent damage to electronics, in order: Ensure key switch has been off 2 minutes, Battery disconnect is in the off position, Remove ECM power fuse, Remove negative cables, Remove positive cables

1. Ensure that the key switch has been off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove negative battery cables.
5. Remove positive battery cables.
6. Tag and disconnect leads from the battery terminals starting with the positive terminals.
7. Remove the nuts and washers from the bracket hold down rods. Remove the hold down bracket.
8. Remove the batteries.

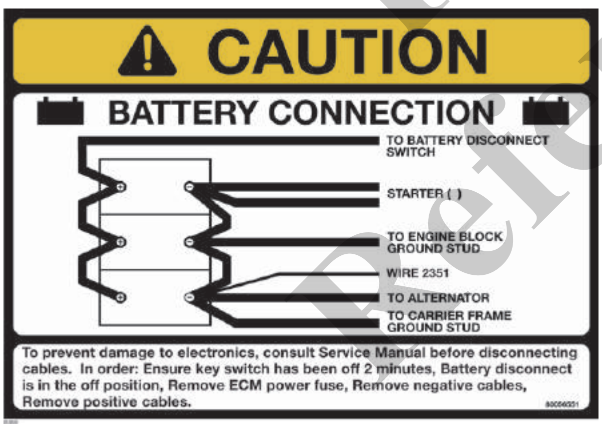


FIGURE 3-5

Installation

1. Place the batteries in the battery box.
2. Install the hold down bracket so it can hold down the batteries. Secure the bracket (and batteries) to the bracket hold down rods with nuts and washers.
3. Connect leads to the battery terminals starting with the positive terminals.
4. Close the battery box cover.
5. Install the ECM power fuse.
6. Turn the battery disconnect switch to ON.
7. Verify replacement batteries work by starting crane's engine and operating various crane components.

Relay Panel Component Replacement

Accessory Relay and Flasher Replacement

1. Disconnect the battery.
2. Remove the cover from the relay panel.
3. Tag and disconnect the electrical leads from the suspect relay or flasher.
4. Remove the hardware securing the suspect relay or flasher to the relay panel assembly. Remove suspect relay or flasher.
5. Install replacement relay or flasher on relay panel and secure it with attaching hardware.
6. Connect the electrical leads to the relay or flasher as tagged during removal.
7. Install the cover.
8. Connect the battery.
9. Verify proper installation by operating all components involved with the replacement relay and verifying they all work. Verify proper operation of the flasher by operating the turnsignals or hazard lights.

Buzzer Replacement

1. Remove the cover from the relay panel.
2. Tag and disconnect the electrical leads from the buzzer.
3. Unscrew the plastic collar ring from back of 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. Install the cover.
7. Verify proper operation by positioning the ignition switch to RUN (1). Buzzer should sound when engine is not running.

Plug-in Relays Replacement

1. Remove the cover from the relay panel.
2. Unplug the suspect relay from the receptacle.
3. Plug replacement relay into receptacle.
4. Install the cover.

5. Verify proper installation by operating all components involved with the replacement relay and verifying they all work.

Instrument Replacement

Removal

1. Disconnect the battery.
2. Remove the hardware securing the console cover and remove the cover.
3. Tag and disconnect the electrical wiring or air lines from the instrument.
4. Remove the hardware securing the instrument to the console panel. (Typically, remove nuts and lockwashers, and then a bracket or clamp.) Pull the instrument through the front of the console panel and remove it.

Inspection

1. Examine the instrument for cracked and broken lenses. Check instrument terminals, bracket or clamp, and mounting studs for damage. Replace damaged instrument; repair or replace damaged connecting hardware.
2. Check wiring for damaged insulation or damaged connectors. Make repairs as needed.

Installation

1. Put the instrument in place on the console panel and secure it with the attaching hardware.
2. Connect the electrical wiring or air lines to the instrument as marked during removal.
3. Position the console cover on the console and secure with the attaching hardware.
4. Connect the battery.

Check

1. Start the engine and verify that the instrument works. (Refer to *Operator's Manual*.)
2. As needed, troubleshoot further any system malfunction not corrected by repair or replacement of the instrument or associated wiring.

Switch Replacement

Rocker Switch

Removal

1. Disconnect the battery.
2. Remove the hardware securing the console cover and remove the cover.
3. Disconnect the electrical connector from the switch.
4. Depress the plastic tabs on top and bottom of switch and pull the switch through the front of the console panel to remove it.

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. 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. Place the switch on the console panel and secure it by pushing the switch into the panel, until it snaps into place.
2. Connect the electrical connector to the switch.
3. Position the console cover on the console and secure with the attaching hardware.
4. Connect the battery.

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.

All Other Switches

Removal

1. Disconnect the battery.
2. Remove the hardware securing the console cover and remove the cover.
3. Tag and disconnect the electrical leads from the switch.
4. On the front of the console panel, remove the nut securing the switch to the panel. As necessary, remove the knob from the switch first.
5. Remove the switch from the hole in the panel.

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. 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. Place the switch through the hole in the front console panel and secure to the front of the panel with the nut. Install the knob on switch as necessary.
2. Connect the electrical leads to the switch as tagged during removal.
3. Position the console cover on the console and secure with the attaching hardware.
4. Connect the battery.

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.

Windshield Wiper Assembly Replacement

Removal

1. Disconnect the battery.
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 (see Figure 3-7).
4. Remove the cap nut and washer securing the wiper arm to the pantograph adapter assembly. (The nut and washer are part of the pantograph adapter assembly.) Remove the cap nut, washer, and tapered sleeve securing the wiper arm to the pivot shaft assembly. (The nut, washer, and sleeve are part of the pivot shaft assembly.)
5. Remove the wiper arm from the pantograph adapter assembly and the pivot shaft assembly.
6. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft assembly. (The sleeve, nut, and washers are part of the pivot shaft assembly.)
7. Remove the two capscrews and lockwashers securing the pantograph adapter assembly's adapter to the cab exterior. Remove the pantograph adapter assembly'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 assembly 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 assemblies (pantograph adapter assembly, pivot shaft assembly, wiper motor assembly link and crank, wiper motor bracket) for damage. Replace as needed.

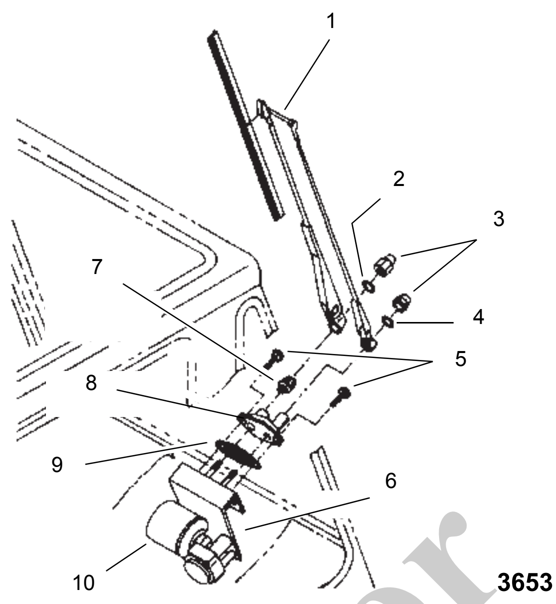


FIGURE 3-6

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

Installation

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

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

5. Secure the pivot shaft to the pantograph adapter with the pivot shaft assembly's nut and washers. Install the flanged sleeve on the pivot shaft.
6. Install the wiper arm on the shafts of the pantograph adapter assembly and the pivot shaft assembly. Secure the wiper arm to the pantograph adapter assembly shaft with the assembly's own washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft assembly's own tapered sleeve, washer, and cap nut.
7. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
8. Connect the electrical leads to the wiper motor as marked before removal.
9. Connect the battery.

Check

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

Windshield Washer Assembly Replacement

Removal

1. Disconnect the battery.
2. Locate the windshield washer container and pump.
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. 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. 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 battery.
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 battery.
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 battery.

Check

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

SECTION 4
BOOM

SECTION CONTENTS

DESCRIPTION

A four section 10.84 to 33.5 m (35.6 to 110 ft), full power, sequenced, and synchronized boom is installed on this crane.

The boom utilizes two telescope cylinders to extend and retract Section 2 and Section 3 with a synchronized cable system to extend and retract Section 4. The telescoping sections are supported on graphite impregnated nylatron wear pads. Side wear pads prevent metal to metal contact between the sections.

Boom assembly lift is provided by one lift cylinder. The lift cylinder has a 30.48 cm (12 in) bore. Boom elevation is from -3 to 78 degrees.

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

A 9.75 m (32 ft) fixed offsetable or a 9.75 to 17.07 m (32 to 56 ft) folding offsetable swingaway boom extension is provided to obtain additional boom reach. A 6.1 m (20 ft) and a 12.2 m (40 ft) lattice insert are also available for use between the boom nose and the swingaway.

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 boom Section 1.

THEORY OF OPERATION

Boom Extension

Boom extension and retraction is accomplished with two telescope cylinders, four extension cables, and two retraction cables. The lower telescope cylinder rod is secured to the rear of the boom Section 1 and the barrel is secured to Section 2 boom section by a trunnion. The upper telescope cylinder rod is secured to the rear of Section 2 boom section and the barrel is secured to the Section 3 boom section by a trunnion. The extension cables are secured to the back of Section 4 and run around extension sheaves on the front of the upper telescope cylinder to the rear of Section 2.

The hydraulic fluid in both lower and upper telescope cylinders is routed through the rods so that the barrels can extend. There are two cam operated check valves which control flow to the telescope cylinders. With both cylinders retracted, the check valve for the lower telescope cylinder is open and the check valve for the upper cylinder is closed allowing the lower cylinder to extend. When the lower cylinder is fully extended, the check valve for the upper cylinder opens allowing the upper cylinder to extend. The check valve for the lower cylinder closes after the upper cylinder starts to extend and shuts off the flow to the lower cylinder. As the upper telescope cylinder barrel extends, the sheaves on the end of the cylinder barrel push on the extend cables to pull Section 4 out at the same time Section 3 is extending.

Boom Retraction

The upper telescope cylinder retracts the Section 3 and two retract cables pull Section 4 in at the same time. When the upper cylinder is fully retracted, the check valve for the lower telescope cylinder is opened and the lower cylinder starts to retract. The check valve for the upper cylinder is closed as the lower cylinder starts to retract.

MAINTENANCE

Removal

NOTE: The boom may be disassembled with Section 1 left on the crane if repair of Section 1 is not necessary.

The boom weighs approximately 8246 kg (18,179 lb). Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached.

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

CAUTION

Wear gloves when handling wire rope.

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

DANGER

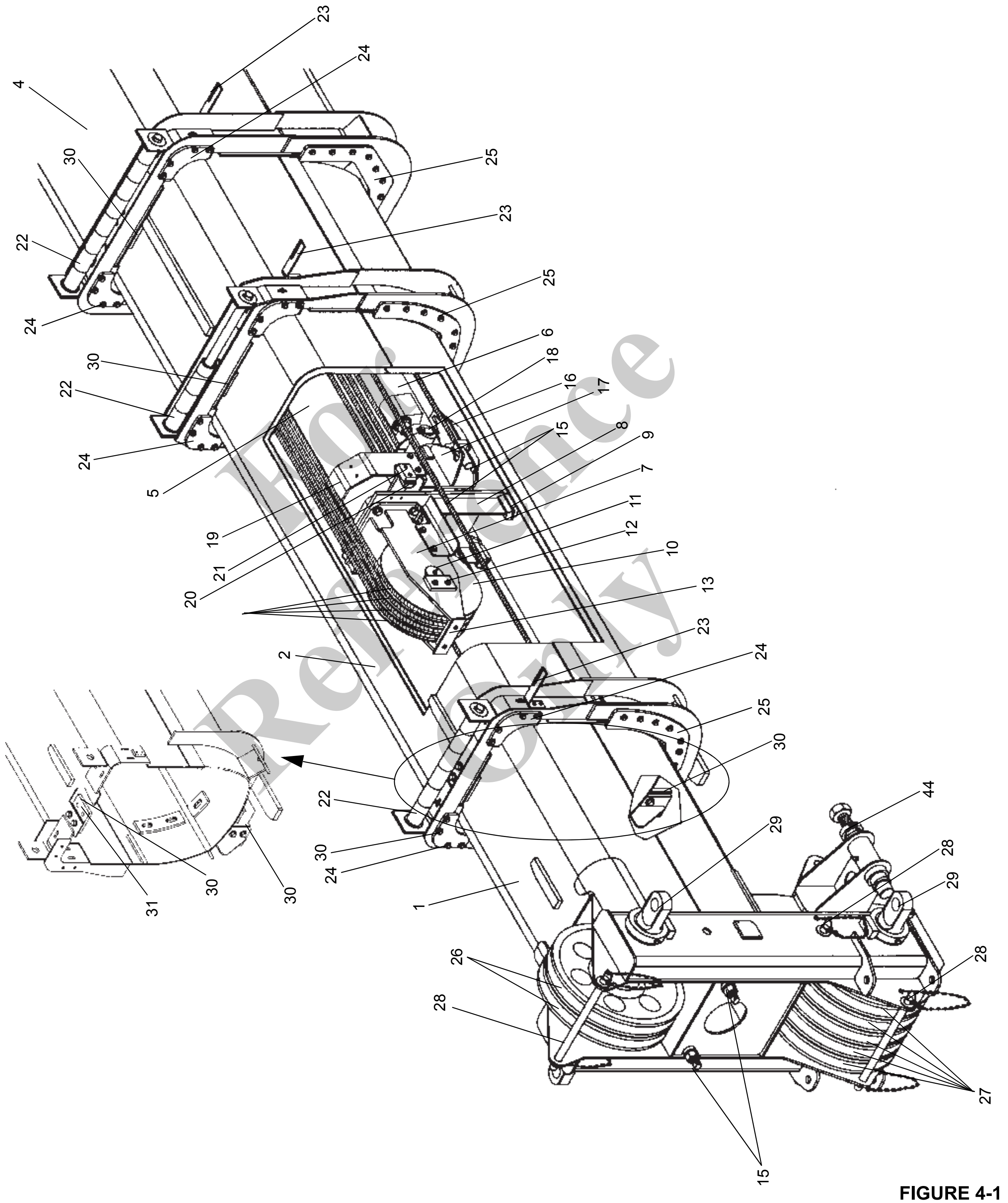
Ensure all blocking and lifting devices are capable of supporting the boom assembly.

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

DANGER

Ensure the boom lift cylinder is properly supported before disconnecting it from the boom.

8. Block the lift cylinder.
9. Remove the bolts, washers, and stop plate securing the upper lift cylinder shaft to the side of the attach fitting on the boom.
10. Remove the upper lift cylinder shaft and two thrust washers.
11. Activate the hydraulic system and withdraw the lift cylinder rod enough to clear the attach fitting. For removal of the lift cylinder from the crane refer to the removal procedures outlined in *Lift Circuit*, page 4-18 - *Removal* in this section.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For Reference Only

FIGURE 4-1

Item	Description
1	Section 4
2	Section 3
3	Section 2
4	Section 1
5	Upper Telescope Cylinder
6	Lower Telescope Cylinder
7	Sheave Mounting Assembly
8	Upper Cylinder Support Foot
9	Wear Pad
10	Sheave Assembly
11	Sheave Shaft
12	Sheave Shaft Plate
13	Cable Retainer
14	Extend Cables
15	Retract Cables
16	Skid Pad
17	Lower Cylinder Mount
18	Shaft
19	Upper Cylinder Support
20	Wear Pad Support
21	Wear Pad
22	Cable Roller
23	RCL Cable Mounting Angle
24	Upper Wear Pad Keeper Plate
25	Lower and SIde Wear Pad Keeper Plate
26	Upper Boom Nose Sheaves
27	Lower Boom Nose Sheaves
28	Cable Retainer Pin
29	Sheave Shaft/Swingaway Anchor Lugs
30	Guide Block
31	Shim

WARNING

Shut down the crane and disconnect the batteries before proceeding.

12. Take up the slack on the boom lifting device.
13. Remove the bolt, lockwasher, nut, and retaining pin securing the boom pivot shaft. Remove the grease fittings from the pivot shaft. Remove the boom pivot shaft.
14. Raise the boom clear of the crane and lower to ground level for service.

Disassembly

1. Remove the boom in accordance with the *Removal*, page 4-2 procedures outlined in this section.
2. If necessary, on the left side of the boom remove the two bolts and washers securing the RCL cable angle brackets to the base, Section 2, and Section 3.
3. On the top front of Section 1, remove the cotter pins, four spacers, shaft, and eight cable rollers.
4. Repeat step 3 on Section 2, removing seven rollers.
5. Repeat step 3 on Section 3, removing six rollers.
6. On the left side of Section 1, remove the bolt, two nuts, and the trigger weldment from the brackets.
7. Remove the clamp halves securing the two hydraulic lines to the rear of Section 1. Tag and disconnect the two hydraulic lines from the lower telescope cylinder. Cap or plug all openings.
8. Remove the five bolts and hardened washers securing each lower telescope cylinder rod mounting plate to the rear of Section 1.

NOTE: The combined weight of the boom Section 2, Section 3, and Section 4, including the telescope cylinders, is approximately 9939 kg (20,911 lb).

9. Slide the assembly out of the base part way.

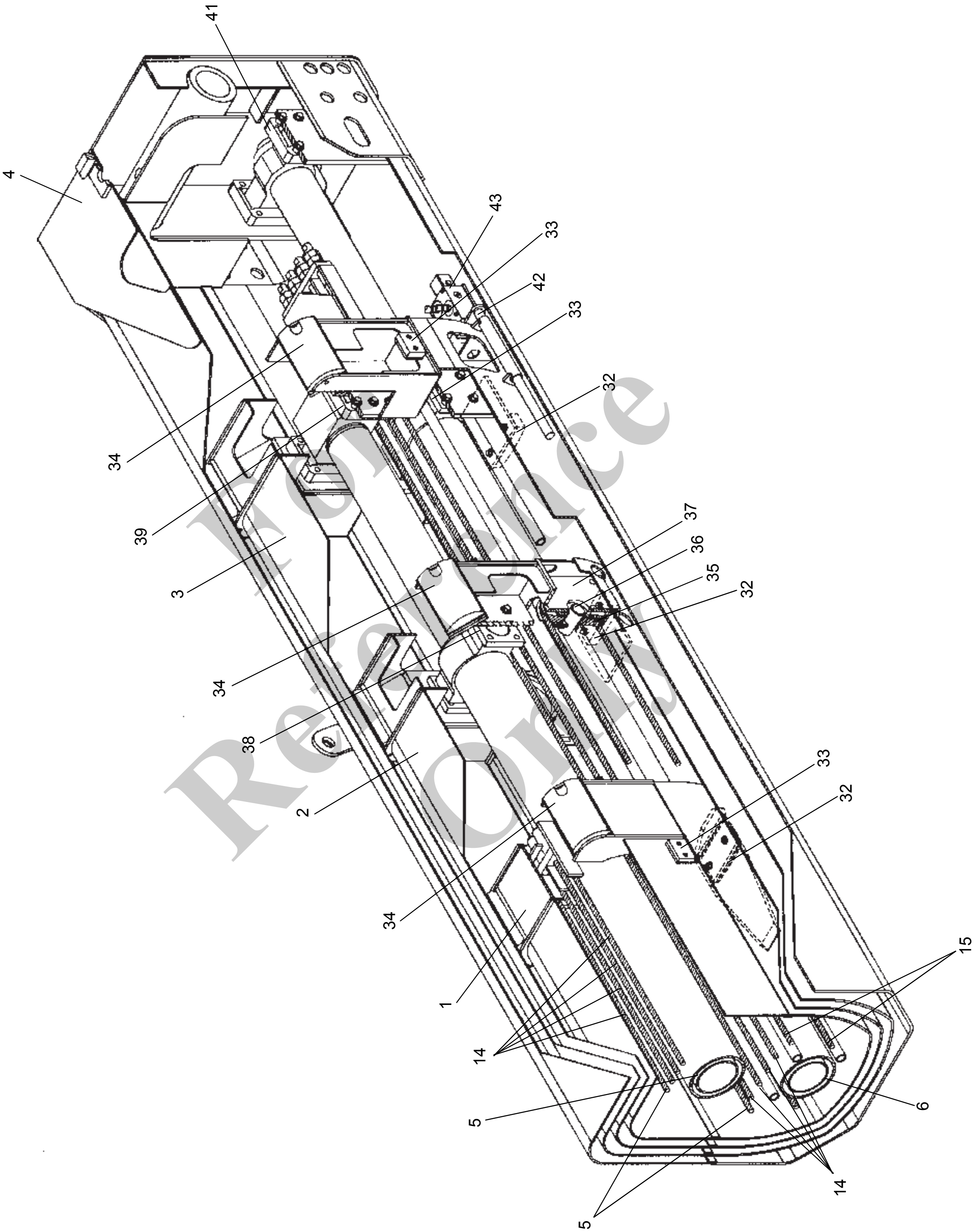
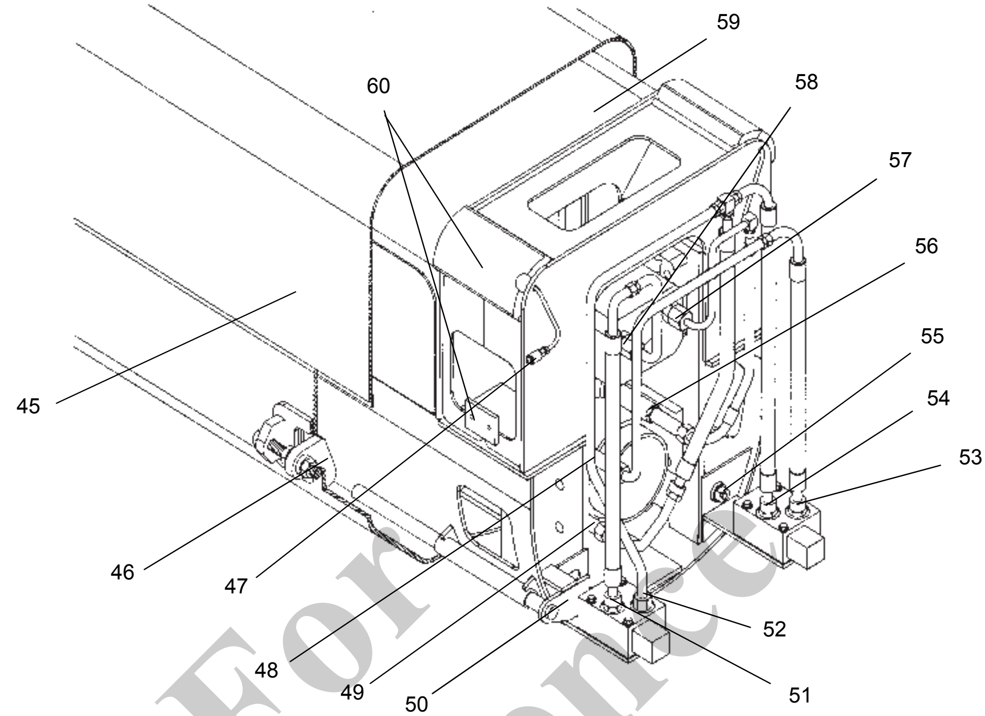


FIGURE 4-1 continued



NOTE: Section 2 extend cable anchor plate not shown for clarity.

FIGURE 4-1 continued

Item	Description
32	Bottom Wear Pad and Shims
33	Rear Side Wear Pads
34	Top Rear Wear Pads
35	Retract Cable Sheave
36	Retract Cable Sheave Shaft
37	Retract Cable Shave Mount
38	Upper Cylinder Barrel Mounting Plate
39	Upper Cylinder Rod Mounting Plate
40	Lower Cylinder Barrel Mounting Plate
41	Lower Cylinder Rod Mounting Plate
42	Pusher Rod
43	Cam Operated Check Valve
44	Boom Extension Alignment Device
45	Section 1
46	Trigger Weldment

Item	Description
47	Grease Liner
48	Port A
49	Port B
50	Pusher Bar
51	Port B
52	Port A
53	Port A
54	Port B
55	Tapped Pusher Bar
56	Port C
57	Port R
58	Port P
59	Section 2
60	Wear Pad

10. Remove the four bolts and hardened washers securing the guide block to the inner top of Section 1. Remove the guide block and shim(s), noting quantity of shims.
11. Remove the four bolts, hardened washers, and nuts securing each top wear pad keeper plate to Section 1. Remove the keeper plates.
12. Remove the eight bolts and hardened washers securing the bottom and side wear pad keeper plates to Section 1. Remove the keeper plates.
13. Remove the four bolts and hardened washers securing each front top wear pad to Section 1. Remove the wear pads and shims, noting quantity, size, and location of shims.
14. Lift up on the front of Section 2 and remove the bottom and side wear pads and shims from Section 1, noting quantity, size, and location of shims.
15. Continue to pull the assembly from Section 1 removing the top rear wear pads from Section 2 as they clear Section 1.
16. Remove the two flat head screws securing the rear side wear pads to Section 2. Remove the wear pads and shims, noting quantity and size of shims.
17. Remove the mounting plates from the lugs on the lower cylinder rod.
18. Tag and disconnect the hydraulic hoses and tubes from the telescope cylinders and the two cam valves. Cap or plug all openings.
19. Remove the three bolts, hardened washers, and nuts (early models only) securing each cam valve to its mounting plate and remove the valves.
20. Place blocking under the lower cylinder barrel.
21. Remove the four bolts and hardened washers securing each lower cylinder barrel mounting plate to Section 2.
22. Remove the five bolts and hardened washers securing each upper cylinder rod mounting plate to Section 2.
23. Remove the nuts and hardened washers from the four extend cable threaded ends. Remove them from the mounting bracket. Tape or ty-wrap the ends of the cables to the telescope cylinder to prevent damage to the cables.
24. On the left side of Section 2, remove the valve pusher rod from the tube.
25. On the right side of Section 2, remove the valve pusher rod. Disassemble as necessary.

NOTE: Together boom Section 3 and Section 4, and telescope cylinders weigh approximately 4861 kg (10,717 lb).

26. Slide the assembly out of Section 2 part way.
27. Remove the four bolts and hardened washers securing the guide block to the inner top of Section 2. Remove the guide block and shim(s), noting quantity of shims.
28. Remove the four bolts and hardened washers securing each top wear pad keeper plate to Section 2. Remove the keeper plates.
29. Remove the seven bolts and hardened washers securing the bottom and side wear pad keeper plates to Section 2. Remove the keeper plates.
30. Remove the four bolts, hardened washers, and nuts securing each front top wear pad to Section 2. Remove the wear pads and shims, noting quantity, size, and location of shims.
31. Lift up on the front of Section 3 and remove the bottom and side wear pads and shims from Section 2, noting quantity, size, and location of shims.
32. Continue to pull the assembly from Section 2, removing the top rear wear pads from Section 3 as they clear Section 2.
33. Remove the two flat head screws securing the rear side wear pads to Section 3. Remove the wear pads and shims, noting quantity and size of shims.
34. Remove the two bolts and hardened washers securing the bottom wear pad to Section 2 and remove the wear pad.
35. If necessary, remove both grease fittings, connectors, and grease lines from the rear of Section 2.
36. Remove the mounting plates from the lugs on the lower cylinder barrel and from the upper cylinder rod.
37. Remove four bolts and hardened washers securing each retract cable sheave mount in the rear of Section 3. Lay the sheave mounts in the rear of Section 4.
38. Place blocking under the upper cylinder barrel.
39. Remove the four bolts and hardened washers securing each upper cylinder barrel mounting plate to Section 3.

NOTE: Together boom Section 4 and telescope cylinders weigh approximately 3225 kg (7110 lb).

40. Slide the assembly out of Section 3 part way.
41. Remove the four bolts and hardened washers securing the guide block to the inner top of Section 3. Remove the guide block and shim(s), noting quantity of shims.
42. Remove the four bolts, hardened washers, and nuts securing each top wear pad keeper plate to Section 3. Remove the keeper plates.
43. Remove the seven bolts and hardened washers securing the bottom and side wear pad keeper plates to Section 3. Remove the keeper plates.

44. Remove the four bolts and hardened washers securing each front top wear pad to Section 3. Remove the wear pads and shims, noting quantity, size, and location of shims.

45. Remove the four bolts and hardened washers securing the guide block to the bracket on the bottom front of Section 3.

46. Lift up on the front of Section 4 and remove the bottom and side wear pads and shims from Section 3, noting quantity, size, and location of shims.

47. Continue to pull the assembly from Section 3, removing the top rear wear pads from Section 4 as they clear Section 2.

48. Remove the two flat head screws securing the rear side wear pads to Section 4. Remove the wear pads and shims, noting quantity and size of shims.

49. Remove the two bolts and hardened washers securing the bottom wear pad to Section 3 and remove the wear pad.

50. If necessary, remove both grease fittings, connectors, and grease lines from the rear of Section 3.

51. Remove the retract cable sheave mounts from the rear of Section 4.

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

WARNING

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

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53. Slide the telescope cylinder assembly out the rear of Section 4 until access to the wear pad holders on each side of the upper telescope cylinder support foot is obtained. Remove the two bolts and hardened washers securing each holder and remove the holders.

NOTE: The upper telescope cylinder weighs approximately 756 kg (1667 lb) and the lower telescope cylinder weighs approximately 937 kg (2066 lb).

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

55. Remove the two bolts and hardened washers securing the extend cable keeper plate to the rear of Section 4. Remove the keeper plate and remove the four extend cable ends from the slots in Section 4.

56. Continue to slide the telescope cylinder assembly out of Section 4. Lowering the rear of Section 4 and raising the rod end of the cylinders will aid in removal.

57. Remove the retract cable lug ends from the slot on each side of the lower telescope cylinder mount.

58. At each retract cable sheave mount, remove the grease fitting from the shaft. Remove the two bolts and hardened washers securing the shaft and remove the shaft, sheave, and two thrust washers from each mount. Remove the retract cable from each mount.

59. Remove the four bolts and hardened washers securing the upper telescope cylinder support to the lower telescope cylinder mount. Remove the cylinder support from the upper cylinder.

60. If necessary, remove the flat head screws securing each wear pad to the cylinder support and remove the wear pads.

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

62. On the front of Section 4, remove the two nuts and a hardened washer from the end of each retract cable and remove the retract cables from Section 4.

63. Remove the four bolts and hardened washers securing the guide block to the bracket on the bottom front of Section 4.

64. Remove the two flat head screws securing the rear bottom wear pad on Section 4 and remove the wear pad.

65. If necessary, remove both grease fittings, connectors, and grease lines from the rear of Section 4.

66. On the lower telescope cylinder mount, remove the two bolts and hardened washers securing plates that secure the shaft. Remove the plates, shaft, and mount from the lower telescope cylinder.

67. If necessary, remove four flat head screws securing the skid pad to the cylinder mount and remove the skid pad.

68. Remove the two bolts and lockwashers securing the extend cable retainer plate to the front of the upper telescope cylinder. Remove the retainer plate.

69. Remove the four extend cables from the sheave assembly.

70. Remove the grease fitting from the shaft. Remove the two bolts and hardened washers securing each plate to the sheave mounting assembly. Remove the sheave shaft and the sheave assembly from the mounting assembly.

71. Remove the four bolts and hardened washers securing the sheave mounting assembly to the support foot.

72. Remove the four bolts and hardened washers securing the sheave mounting assembly and the support foot to the front of the telescope cylinder. Remove the sheave mounting assembly and the support foot.

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

74. If removal of the boom nose sheaves are required, refer to *Boom Nose Sheaves*, page 4-9 - *Removal*.

75. Refer to *Boom Extension and Retraction Cable*, page 4-14 for cable inspection.

Boom Nose Sheaves

Removal

1. Remove the clip pins from the cable retainer pins and remove the cable retainer pins from the upper and lower part of the boom nose.

2. Remove the bolt, washer, and nut securing the upper boom nose sheave shaft. Remove the collar.

NOTE: The boom nose sheave shafts weigh approximately 63 kg (138 lb) each. The boom nose sheaves weigh approximately 13 kg (28 lb) apiece.

3. Carefully pull the upper boom nose sheave shaft from the boom nose, removing the spacers, shims, and boom nose sheaves.

4. Repeat steps 2 and 3 and remove the lower boom nose sheave shaft.

5. Remove the shim, keyed washer, washer, and locknut from both sheave shafts.

Installation

CAUTION

Do not install the boom nose sheaves over the threaded end of the boom nose sheave shaft.

NOTE: The boom nose sheave shafts weigh approximately 63 kg (138 lb) each. The boom nose sheaves weigh approximately 13 kg (28 lb) apiece.

1. Install the spacers and sheaves onto the sheave shaft while installing the sheave shafts into the boom nose.

NOTE: The lockwasher can be used more than once but must be replaced if not in good condition.

Install the lockwasher onto the sheave shaft with the tabs facing out.

2. Install the locknut, washer, keyed washer, and shims (if necessary) onto the boom nose sheave shaft with the chamfer side out. Install the collar onto the opposite end of the sheave shafts and secure in place with the bolt, washer, and nut.

NOTE: If more than one shim is required, install an equal amount on each side of the boom nose.

3. Tighten the locknut until the play in the entire assembly is within 0.79 mm (0.03 in) total. Install shims as necessary to achieve the correct dimension. Bend the lockwasher tabs to secure the locknut in place.

4. Install the cable retainer pins into the upper and lower part of the boom nose and secure in place with the hitch pins.

Assembly

CAUTION

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

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

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

Apply multipurpose grease (MPG) to all wear surfaces.

Use standard Grade 5 and/or 8 torque values specified in *Fasteners and Torque Values*, page 1-12 of this manual unless otherwise specified.

1. Install wear pads on the bottom of the upper telescope cylinder support foot using two screws each.

2. Install the support foot and the sheave mounting assembly on the front of the upper telescope cylinder assembly, with four bolts and hardened washers. Attach the support foot and the sheave mounting assembly together using four bolts and hardened washers.

NOTE: The sheave shaft should be installed with grease fitting hole to the left side.

3. Using the sheave shaft, install the sheave assembly in the sheave mounting assembly. Secure the shaft with a plate and two bolts and hardened washers on each side of the sheave mounting assembly. Install grease fitting in shaft and apply grease.

4. Route the lug end of the four extension cables up and around the upper telescope cylinder sheaves about 1 ft (.3 m) on to cylinder. To aid in assembly, secure the cables to the end of the cylinder by wrapping tape around the cylinder.

5. Position the cable retainer plate on the front of the sheave mounting assembly and secure with two bolts and lockwashers.
6. Install the skid pad to the bottom of the lower telescope cylinder mount with four flat head screws.
7. Install the cylinder mount to the lugs on the front of the lower telescope cylinder using the shaft. Secure the shaft with a plate and two bolts and hardened washers on each side of the cylinder mount.
8. Turn the lower telescope cylinder rod so the trunnion is vertical.
9. At the rear of Section 4, install the upper wear pad grease line, connector and grease fitting on each side.

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

10. Install the bottom rear wear pad on Section 4 with two flat head screws.
11. Position the guide block on the bracket at the bottom front of Section 4. Secure with four bolts and hardened washers. Do not tighten bolts at this time.
12. Route the two retract cables (threaded ends) through Section 4 to the front. Insert the threaded ends through the holes on the front of Section 4 and install a hardened washer and two nuts on each cable end.

WARNING

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

13. Using an adequate lifting device, position the upper telescope cylinder onto the lower telescope cylinder.
14. Install two wear pads in the upper telescope cylinder support using two flat head screws each.
15. Position the cylinder support over the upper telescope cylinder and secure to the lower telescope cylinder mount with four bolts and hardened washers.
16. Position the sheave end of the telescope cylinder assembly at the rear of Section 4.
17. Lay the retract cable sheave mounts out behind Section 4 as they will be installed in Section 3. Route the lug end of the retract cables through the sheave mounts (top to bottom) so the lug end will come off the bottom of the sheave. Place the retract sheave, with one thrust washer on each side, in the mount and secure with the shaft. Secure each shaft with two bolts and hardened washers. Install grease fitting in each shaft and apply grease.
18. Install the lug end of each retract cable in the slots on each side of the lower telescope cylinder mount.
19. Slide telescope cylinder assembly into the rear of Section 4 until foot support clears the gussets at the rear of Section 4. Lowering the rear of Section 4 and raising the rod end of the cylinders will aid in sliding these together.
20. Place the four extend cable lug ends in the slots at the top of Section 4 and secure them with the keeper plate and two bolts and hardened washers.
21. Install a wear pad on the two upper telescope cylinder wear pad holders using two flat head screws.
22. Position the wear pad holders on each side of the upper telescope cylinder support foot and secure each with two bolts and hardened washers.
23. Slide the telescope cylinder assembly all the way in. Place blocking under the rear of the telescope cylinders to aid in assembly.
24. Place the mounting plates on the upper telescope cylinder barrel mounting lugs.
25. Using tape or ty-wraps, fasten the extend cable ends to the telescope cylinder to aid in assembly.
26. Place the retract cable sheave mounts in the rear of Section 4 to aid in assembly.
27. At the rear of Section 3, install the upper wear pad grease line, connector and grease fitting on each side.

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

28. Install the bottom rear wear pad on Section 3 with two bolts and hardened washers.
29. Position the front end of Section 3 at the rear of the Section 4/telescope cylinder assembly.
30. Slide the Section 4/telescope cylinder assembly into Section 3 installing top rear wear pads in pockets of Section 4 (cutout should align with grease line). Stop and install rear side wear pads and shims on Section 4 with two flat head screws each.

NOTE: Use shims as necessary to adjust wear pad so it is within 2 mm (0.078 in) of Section 3 side plate. Use equal number of shims on each side.

31. Continue to slide together being careful not to damage cables.
32. Lift up on the front of Section 4 and install the bottom and side front wear pads in Section 3. Install shims as necessary.

33. Position the guide block on the bracket at the bottom front of Section 3. Secure with four bolts and hardened washers. Do not tighten bolts at this time.

34. Install Section 3 front top wear pads and shims as noted during disassembly. Secure with four bolts and hardened washers each.

NOTE: Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 2 mm (0.078 in) of Section 4 side plate at both the top and side surfaces of the top radius.

35. Install bottom and side wear pad keeper plate on each side of Section 3 and secure with seven bolts and hardened washers each.

36. Install top wear pad keeper plate on each side of Section 3 and secure with four bolts, hardened washers, and nuts each.

37. Position the guide block and shims as noted during disassembly in the top inside of Section 3. Secure with four bolts and hardened washers. Do not tighten bolts at this time.

NOTE: Use shims as necessary to adjust guide block so that the guide block is within 3 to 5 mm (0.118 to 0.197 in) of the top of Section 4.

38. Continue to completely slide together.

39. Lift up on end of the upper cylinder to align barrel mounting plate holes with holes in Section 3. Secure each with four bolts and hardened washers.

40. Remove any blocking under cylinder.

41. Remove the retract cable sheave mounts from Section 4 and attach them to the rear of Section 3 with four bolts and hardened washers each.

42. Ensure upper cylinder rod is turned so holding valve is on top.

43. Place the mounting plates on the lower cylinder barrel mounting lugs.

44. Place the mounting plates on the upper cylinder rod mounting lugs, three holes facing the rear.

45. At the rear of Section 2, install the upper wear pad grease line, connector and grease fitting on each side.

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

46. Install the bottom rear wear pad on Section 2 with two bolts and hardened washers.

47. Position the front end of Section 2 at the rear of the Section 3/Section 4/telescope cylinder assembly.

48. Slide the Section 3/Section 4/telescope cylinder assembly into Section 2 installing top rear wear pads in pockets of Section 3 (cutout should align with grease line). Stop and install rear side wear pads and shims on Section 3 with two flat head screws each.

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

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

50. Lift up on the front of Section 3 and install the bottom and side front wear pads in Section 2. Install shims as necessary.

51. Install Section 2 front top wear pads and shims as noted during disassembly. Secure with four bolts and hardened washers each.

NOTE: Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 2 mm (0.078 in) of Section 3 side plate at both the top and side surfaces of the top radius.

52. Install bottom and side wear pad keeper plate on each side of Section 2 and secure with seven bolts and hardened washers each.

53. Install top wear pad keeper plate on each side of Section 2 and secure with four bolts, hardened washers, and nuts each.

54. Position the guide block and shims as noted during disassembly in the top inside of Section 2. Secure with four bolts and hardened washers. Do not tighten bolts at this time.

NOTE: Use shims as necessary to adjust guide block so that the guide block is within 3 to 5 mm (0.118 to 0.197 in) of the top of Section 3.

55. Continue to completely slide together.

56. Install bolt, nut, and hardened washer in right side valve tapped pusher rod. Install the rod assembly through hole on right side of Section 2.

57. Install left side valve pusher rod in tube on outer left side of Section 2.

58. Insert the threaded ends of the four extend cables through the holes in the mounting bracket on the rear of Section 2. Ensure the cables are not crossed. Install a hardened washer and two nuts on each cable end.

59. Align upper cylinder rod mounting plates' holes with holes in Section 2. Secure each with five bolts and hardened washers.

60. Lift up on end of the lower cylinder to align barrel mounting plate holes with holes in Section 2. Secure each with four bolts and hardened washers.

61. Remove any blocking under cylinder.

62. Install the cam valves on the mounting plates on each side of Section 2 using three bolts, hardened washers, and nuts (early models only) each.

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

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

65. Place the mounting plates on the lower cylinder rod mounting lugs, three holes facing the rear.

66. Position the front end of the base at the rear of the Section 2/Section 3/Section 4/telescope cylinder assembly.

67. Slide the Section 2/Section 3/Section 4/telescope cylinder assembly into Section 1 installing top rear wear pads in pockets of Section 2 (cutout should align with grease line). Stop and install rear side wear pads and shims on Section 2 with two flat head screws each.

NOTE: Use shims as necessary to adjust wear pad so it is within 2 mm (0.078 in) of Section 1 side plate. Use equal number of shims on each side.

68. Position the guide block and shims as noted during disassembly in the top inside of Section 1. Secure with four bolts and hardened washers. Do not tighten bolts at this time.

NOTE: Use shims as necessary to adjust guide block so that the guide block is within 3 to 5 mm (0.118 to 0.197 in) of the top of Section 2.

69. Continue to slide together.

70. Lift up on the front of Section 2 and install the bottom and side front wear pads in Section 1. Install shims as necessary.

71. Install Section 1 front top wear pads and shims as noted during disassembly. Secure with four bolts and hardened washers each.

NOTE: Use shims as necessary to adjust wear pad so that the wear pad is just touching or is within 2 mm (0.078 in) of Section 2 side plate at both the top and side surfaces of the top radius.

72. Install bottom and side wear pad keeper plate on each side of Section 1 and secure with eight bolts and hardened washers each.

73. Install top wear pad keeper plate on each side of Section 1 and secure with four bolts, hardened washers, and nuts each.

74. Continue to completely slide together.

75. Align lower cylinder rod mounting plates holes with holes in Section 1. Secure each with five bolts and hardened washers.

76. Connect hydraulic tubes to the lower cylinder as tagged during diassembly. Install tubes in clamps on rear of Section 1. The clamps are larger than the tubes and only support the tubes vertically allowing the tubes to slide up and down with any movement of the lower cylinder.

77. On the left side of Section 1, install the bolt, two nuts, and the trigger weldment in the brackets. One nut goes on each side of the trigger weldment.

78. On the top front of Section 1, install eight cable rollers using a shaft, four spacers, and two cotter pins. One spacer goes on each side of the mounting bracket.

79. Repeat step 78 on Section 2 using seven rollers.

80. Repeat step 78 on Section 3 using six rollers.

81. On the left side only, install a RCL cable angle bracket on the base, Section 2, and Section 3 using two bolts and washers each.

82. Install the boom in accordance with the *Installation* procedures outlined in this section.

Installation

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

DANGER

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

1. Attach an adequate lifting device to the boom and suspend the boom over the machine.
2. Lower the boom into position and align the boom pivot shaft mounting holes for installation of the pivot shaft to the superstructure assembly.
3. Lubricate and install the boom pivot shaft. Secure in place with the retaining pin, bolt, lockwasher, and nut. Install the grease fitting in each end of the shaft.

DANGER

Block the boom before doing any work under the boom.

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

DANGER

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

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

WARNING

If the hydraulic system must be activated to extend or retract the lift cylinder, ensure the rod end is properly aligned with the lift cylinder attach fitting.

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

CAUTION

If removed, ensure the large access covers on each side of the boom Section 1 are installed before extending the boom.

12. Refer to *Boom Extension and Retraction Cable*, page 4-14 for cable adjustments.
13. Refer to *Cam Operated Check Valve Adjustment*, page 4-14 for valve adjustment.

Functional Check

1. Activate the hydraulic system and check for proper operation and any leaks.
2. Ensure the boom will extend and retract properly.
3. Ensure the lift cylinder will not allow the boom to drift down until the operator lowers it.
4. Ensure all electrical components disconnected during removal are operating properly.

Inspection

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

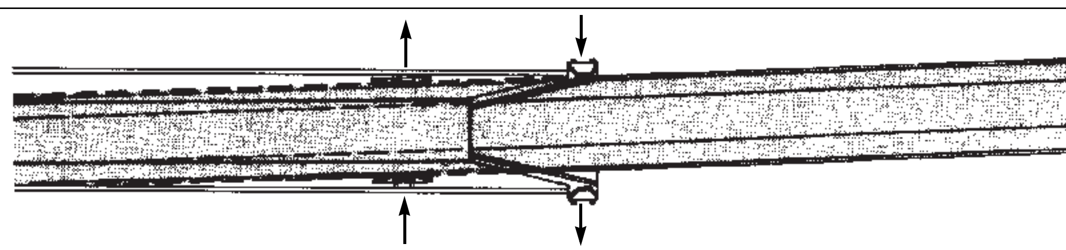
Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. Refer to *Lubrication*, page 9-1.

Boom Alignment and Servicing

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

Boom alignment (see Figure 4-2) is achieved by adjustment of the wear pads located at various points in the boom assembly. Adjustment of the wear pads is as follows:

1. Fully extend the boom horizontally.
2. Lubricate the boom bottom plates (sides and bottom).
3. Shim the front top wear pads such that wear pad is just touching or is no more than 2 mm (0.078 in) from contacting the next section both at the top and side surfaces of the top radius.



NOTE: Deflection exaggerated for illustration purposes

FIGURE 4-2

CAUTION

When extending and retracting the boom during alignment, movement should be stopped if a restriction is encountered, and wear pads adjusted as necessary to provide free travel of the affected boom section(s).

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

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

Cam Operated Check Valve Adjustment

There are two cam operated check valves mounted on the back of Section 2 boom section. When the boom is fully retracted or Section 2 is fully extended, the valve on the right side of the boom is held open to supply flow to the lower telescope cylinder. When Section 2 boom section is fully extended, the valve on the left side of the boom opens to supply flow to the upper telescope cylinder. For a short period of time, both valves are open because the bottom cylinder is fully extended before the upper cylinder starts to extend. As Section 3 starts to extend, the valve on the right side closes to shut off the flow to the lower telescope cylinder.

1. Ensure the extend and retract cables are adjusted.
2. Extend the boom until Section 2 is fully extended and Section 3 is against the stop block of Section 2.
3. Access the check valves through the hole on each side of Section 1.
4. Left side valve: on the left side of Section 1, adjust the nuts on the adjusting bolt to move the trigger weldment causing the pusher bar to just contact the valve stem. Continue to adjust the nuts until the pusher bar depresses the valve stem approximately 10 mm (0.39 in). Tighten the nuts.
5. Right side valve: through the access hole in Section 1 on the right rear of Section 2, loosen the lock nut and adjust the bolt until it just contacts the valve stem. Continue to adjust the bolt until it depresses the valve stem approximately 10 mm (0.39 in). Tighten the lock nut.

Guide Block Adjustment

1. Align and service the boom per *Boom Alignment and Servicing*, page 4-13.
2. Rotate the guide block at the top of Section 1, Section 2, and Section 3 so that the guide block is within 0 to 2 mm (0 to 0.078 in) of the welded block on the top of the next section.

NOTE: The guide block hole pattern is so designed that the guide block has four mounting positions which provide 3.175 mm (0.125 in) incremental settings.

3. After obtaining proper clearance, tighten the four bolts.
4. Rotate the guide block at the bottom of Section 4 and Section 3 so that the guide block is within 0 to 2 mm (0 to 0.078 in) of the welded guide rail on the front of the next section. These guide blocks are the same as the ones used on top. After obtaining proper clearance, tighten the four bolts.

BOOM EXTENSION AND RETRACTION CABLE

Maintenance

NOTE: For more detailed information concerning maintenance of the extension and retraction cables, refer to *Wire Rope*, page 1-16.

Inspection

CAUTION

Never handle wire rope with bare hands.

The following information is taken from a National Consensus standard as referenced by Federal Government Agencies, and as recommended by Manitowoc Cranes.

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, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than 5%.

- In 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.

Adjustment

At near fully extended boom length, during sudden extension after retracting the boom some distance, and with high telescoping speeds, the extension cables may slap the inside of the boom section. This will make a somewhat audible noise, however this will not cause any damage and is acceptable. If the cables do not make a slapping noise under these conditions, it is an indication that the extension cables may be too tight and should be readjusted. Be aware that there may also be a similar noise made by the telescope cylinder rod mount at the rear of Section 1, and confusion between the two could be experienced.

CAUTION

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

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

1. Extend and set the outriggers, ensuring the crane is level.
2. Ensure the boom is over the rear and at a horizontal position (boom angle elevation 0 degrees).
3. With Section 2 extended and Section 3 retracted, extend the boom approximately 15 cm (6 in). This will cause a slack condition in the retract cables.
4. Tighten the retract cable adjusting nuts at the front of Section 4 to approximately 1.4 Nm (1.0 ft-lb).
5. Extend the boom approximately 15 cm (6 in) and then retract the boom completely. This will create the loosest condition for the extension cables.
6. Using the adjusting nuts on extension cable ends, adjust the cables so they are approximately 15 mm (0.56 in) off the top of the telescope cylinder.

NOTE: Step 6 should be performed with the boom horizontal and by visually looking through the back of Section 1 or through the access holes on Section 1.

7. Lock the adjustments with the jam nuts.

NOTE: During retract cable adjustments, Section 2 must remain fully extended.

8. Extend the boom until the Section 3/Section 4 extends several centimeters (inches).
9. Retract the boom until either Section 4 just contacts Section 3 stop block or Section 3 just contacts Section 2 stop block.
10. Check the gap between the stop blocks and the boom sections. If there is a gap between Section 2's stop block and Section 3 of more than 3 mm (0.125 in), loosen the retract cable. If there is gap between Section 3's stop block and Section 4, tighten the retract cable slightly.

CAUTION

Over tightening of the retract cable will damage the cable. Take care when retracting the boom fully, while adjusting the cable, to avoid full boom retraction if Section 4 contacts its stop block more than 3 mm (0.125 in) before Section 3 contacts its stop block on Section 2.

11. Extend the boom approximately 15.2 cm (6 in). Retract the boom again until one of the stop blocks just contacts its boom section.
12. Again check the gap as in step 10 and if necessary, make further adjustments.
13. Repeat steps 11 and 12 until there is a 3 mm (0.125 in) gap at Section 3's stop block when Section 4's stop block has just made contact.
14. Lock the retract cable adjustments with the jam nut.

TELESCOPE CIRCUIT

Description

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

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

The telescope control valve is the closed spool type and is described under *Valves*, page 2-19.

Refer to *Hydraulic Remote Control Valve*, page 2-34 for a complete description of the hydraulic remote controller.

Both boom telescope cylinders have a 15.2 cm (6.0 in) bore. Foreign material is prevented from entering the cylinder by a wiper seal during rod retraction. O-ring seals prevent internal and external leakage. Refer to *Cylinders*, page 2-52 for a complete description of the telescope cylinder.

A holding valve is threaded into a port block on the rod end of the upper telescope cylinder. A holding valve is threaded into the port block on the barrel end of the lower telescope cylinder. The holding valves function during the retraction, extension, or holding operation. When holding the boom section at a given length, oil is trapped in the cylinder by the holding valve. Refer to *Hydraulic Remote Control Valve*, page 2-34 for a complete description of the holding valve.

Theory of Operation

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

Also refer to *Theory of Operation*, page 4-1 in this Section.

Maintenance

Troubleshooting

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

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Erratic operation of retracting telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Damaged relief valve.	**b.** Repair or replace relief valve.
	c. Air in cylinder.	**c.** Bleed by lowering telescoping cylinder below horizontal and cycle telescope cylinder.
	d. Low engine rpm.	**d.** Increase engine rpm to recommended setting.
	e. Lack of lubrication.	**e.** Properly lubricate all boom sections.
	f. Check valve malfunctioning.	**f.** Repair or replace check valve.
	g. Improper boom alignment caused from side loading.	**g.** Reduce and properly hoist load.
	h. Very tight boom retraction sheave.	**h.** Inspect and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Worn boom wear pads.	**j.** Replace wear pads and properly lubricate.
	k. Bent cylinder rod(s).	**k.** Replace cylinder rod(s) and all cylinder seals.
	l. Scored cylinder barrel.	**l.** Repair or replace cylinder barrel.
	m. Damaged piston seals.	**m.** Replace all cylinder seals.
	n. Loose or damaged piston(s).	**n.** Replace all seals and re-torque or replace piston(s).
3. Telescope cylinder will not extend.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Replenish oil to proper level.
	b. Relief valve malfunctioning.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load.
	d. Clogged hose and fittings.	**d.** Replace hose or fittings. (Refer to Grove Parts Manual).
	e. Broken valve spool.	**e.** Replace valve.
	f. Damaged piston seals.	**f.** Replace all cylinder seals.
	g. Damaged piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Bent boom section(s).	**h.** Replace damaged boom section(s).
	i. Broken hydraulic pump coupling.	**i.** Replace broken hydraulic pump coupling.
	j. Worn or damaged hydraulic pump section.	**j.** Repair or replace pump section.

SYMPTOM	PROBABLE CAUSE	SOLUTION
4. Telescope cylinder will not retract.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Replenish oil to proper level.
	b. Relief valve damaged.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load. (Refer to load chart).
	d. Inoperative check valve.	**d.** Replace check valve.
	e. Clogged hose and fittings.	**e.** Replace hose or fittings. (Refer to Grove Parts Manual).
	f. Broken valve spool.	**f.** Replace valve section.
	g. Broken piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Damaged piston seals.	**h.** Replace all cylinder seals.
	i. Bent boom section(s).	**i.** Replace damaged boom section(s).
	j. Broken hydraulic pump coupling.	**j.** Replace broken hydraulic pump coupling.
	k. Worn or damaged hydraulic pump.	**k.** Repair or replace pump.
	l. Broken hydraulic pump shaft.	**l.** Replace pump shaft.
5. Section 2 will not extend.	**a.** Right side check valve blocked.	**a.** Readjust, repair, or replace valve.
6. Section 2 will not retract.	**a.** Right side check valve closed.	**a.** Readjust valve
7. Section 3 will not extend.	**a.** Left side check valve is closed	**a.** Readjust valve
8. Section 2 retracts before Section 3.	**a.** Right side check valve is open or hosed backwards.	**a.** Install hoses properly
9. Section 3 extends only a short distance, then stops.	**a.** Left check valve is open or hosed backwards	**a.** Install hoses properly.

Removal and Installation

Removal and installation of the telescope cylinder from the boom is described under disassembly and assembly of the boom. Refer to *Maintenance*, page 4-2.

Disassembly and Assembly

Disassembly and assembly procedures of the telescope cylinder and control valve are provided in *Hydraulic System*, page 2-1 under *Cylinders* and *Valves* respectively.

LIFT CIRCUIT

Description

The boom lift circuit consists of the lift hydraulic remote controller, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -3 to +78 degrees from horizontal.

The lift directional control valve is the closed spool type and is described under *Valves*, page 2-19.

Refer to *Hydraulic Remote Control Valve*, page 2-34 for a complete description of the hydraulic remote controller.

The lift cylinder has a 30.48 cm (12.0 in) bore and is the double acting type. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage by a wiper seal during rod retraction. Oil Seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage. Refer to *Lift Cylinder*, page 2-54 for a complete description of the lift cylinder.

The holding valve is a balanced poppet type hydraulic valve. It is threaded into the port block which is an integral portion of the lift cylinder barrel. The holding valve functions when booming up (cylinder rod extended), booming down (cylinder rod retracted), or holding (cylinder rod stationary).

Theory of Operation

The directional control valve bank housing the lift control valve is supplied by flow from the hydraulic pump.

When booming up, oil unseats the poppet (check) valve in the holding valve, letting oil flow to the piston side of the cylinder. Pressure is applied to the piston, forcing the rod to extend, raising the boom.

When booming down, oil enters the retract port of the port block and flows to the cylinder rod side. When pilot pressure reaches a pre-determined value, the main poppet unseats and oil flows from the piston side of the cylinder to the reservoir.

All return flow from the control valve goes to the reservoir.

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Boom raises erratically.	**a.** Low hydraulic oil.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase engine rpm to recommended setting.
	c. Main relief valve damaged.	**c.** Replace relief valve.
	d. Air in cylinder rod.	**d.** Bleed cylinder rod.
	e. Bent boom pivot shaft.	**e.** Replace pivot shaft.
2. Boom lowers erratically.	**a.** Low hydraulic oil.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase engine rpm to recommended level.
	c. Circuit and/or relief valve inoperative.	**c.** Repair or replace relief valve.
	d. Air in hydraulic cylinder.	**d.** Bleed air from cylinder.
	e. Damaged hydraulic pump section.	**e.** Repair or replace pump section.
3. Boom raises slowly.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase and maintain engine rpm.
	c. Damaged relief valve.	**c.** Repair or replace relief valve.
	d. Extremely cold hydraulic oil.	**d.** Operate unit to bring oil to operating temperature.
	e. Improper hose or fittings, installed.	**e.** Replace hose or fittings. (Refer to Grove Parts Manual).
	f. Operating two functions within the same control valve bank assembly.	**f.** Feather controls to obtain desired speed of both functions.
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals leaking.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.

Symptom	Probable Cause	Solution
4. Boom lowers slowly.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Low engine rpm.	**b.** Increase rpm to recommended level.
	c. Damaged relief valve.	**c.** Repair or replace relief valve.
	d. Operating two functions within the same control valve bank assembly.	**d.** Feather controls to obtain desired speed of both functions.
	e. Extremely cold hydraulic oil.	**e.** Operate unit to bring oil to operating temperature.
	f. Improper hose or fittings installed.	**f.** Replace hose or fittings. (Refer to Grove Manitowoc Parts Manual).
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals worn.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
	k. Piston rod broken (loose from piston).	**k.** Replace piston rod and all cylinder seals.
5. Boom will not raise.	**a.** Low hydraulic oil.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Main relief valve or circuit relief valve damaged.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load as required.
	d. Worn or damaged hydraulic pump section.	**d.** Repair or replace pump section.
	e. Broken pump shaft.	**e.** Replace pump shaft and seals.
	f. Broken pump drive coupling.	**f.** Replace drive coupling.
	g. Broken control valve spool.	**g.** Replace control valve.
6. Boom will not lower.	**a.** Low hydraulic oil.	**a.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	b. Main relief valve or circuit relief valve damaged.	**b.** Repair or replace relief valve.
	c. Worn or damaged hydraulic pump section.	**c.** Repair or replace pump section.
	d. Broken pump shaft.	**d.** Replace pump shaft and seals.
	e. Broken pump drive coupling.	**e.** Replace drive coupling.
	f. Broken control valve spool.	**f.** Replace control valve.

NOTE: Refer to Section 2 for lift cylinder Disassembly and Assembly procedures. Maintenance not requiring removal of the cylinder barrels, such as packing, may be performed without removing the cylinder from the turntable. However, all disassembly and assembly should be conducted in a clean dust-free area.

Removal

1. Extend and set the outriggers and level the crane.
2. Elevate the boom slightly so that the lift cylinder is extended approximately 0.3 m (1 ft).

DANGER

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

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.
4. Remove the bolts, washers, and stop plate securing the lift cylinder's upper pivot shaft to the boom.
5. Remove the bolt, lockwasher, and nut to free the pin from the lift cylinder's lower pivot shaft. Remove pin.

DANGER

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

6. Attach an adequate lifting/supporting device to the lift cylinder.
7. Remove the upper pivot shaft. Activate the hydraulic system and retract the lift cylinder enough to clear the boom's lift cylinder lugs. Save the thrust washers removed.
8. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.
9. Remove the lower lift cylinder pivot shaft from the lift cylinder and its lugs on the turntable. Remove the cylinder. Save the thrust washers removed.
10. Move the lift cylinder to a clean work area.

Disassembly and Assembly

Disassembly and assembly procedures of the lift cylinder holding valve, and control valve are provided in *Hydraulic System*, page 2-1 under *Cylinders* and *Valves* respectively.

Installation

1. Attach an adequate lifting device to the lift cylinder and place the cylinder barrel end between the lift cylinder attach lugs on the turntable.
2. Align the cylinder's barrel end hole with the attaching lugs on the turntable.
3. Install the lower lift cylinder pivot shaft, with one or more thrust washers on each side as required between the turntable attach lugs and the cylinder.
4. Apply medium strength thread locking compound (Spec. 6829012418, Loctite® 243) to the bolt and nut used to secure the pin. Secure the lift cylinder lower pivot shaft to the cylinder with the pin. Secure the pin with the bolt, lockwasher, and nut.
5. Connect the extend and retract hoses to the lift cylinder.
6. Activate the crane's hydraulic system and align the lift cylinder rod end with the attaching lugs on the boom. Install the lift cylinder upper pivot shaft, with one or more thrust washers as required between the cylinder and the boom attach lug(s). Shut down the engine.
7. Apply medium strength thread locking compound (Spec. 6829012418, Loctite® 243) to the bolts used to secure the stop plate. Secure the upper pivot shaft to the boom with the stop plate, two bolts and two washers.
8. Remove the lifting and supporting devices from the boom and lift cylinders. Activate the hydraulic system and check the lift cylinder for proper operation and any leaks. Repair any leaks.
9. Lubricate the pivot shafts using their grease fitting(s).

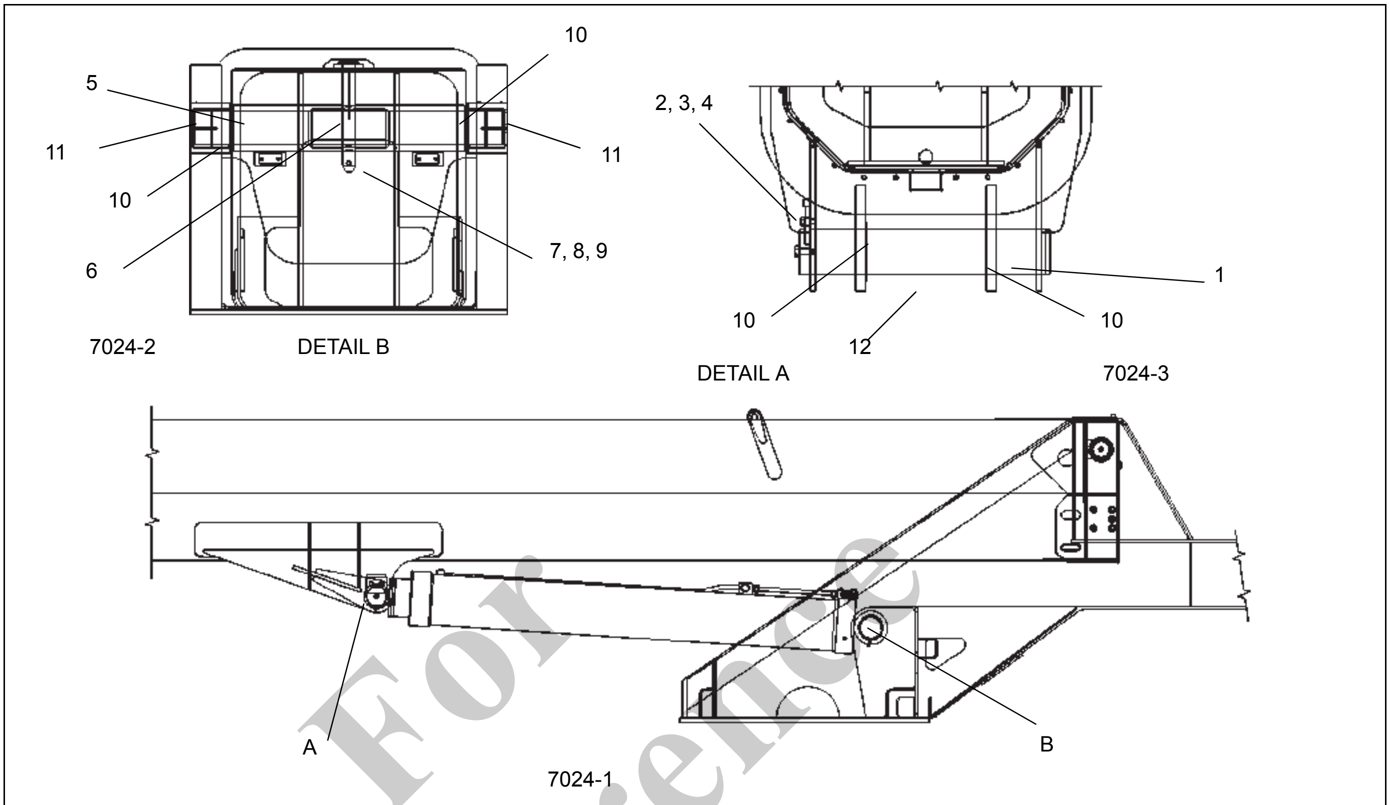


FIGURE 4-3

Item	Description
1	Upper Pivot Shaft
2	Bolts
3	Washers
4	Stop Plate
5	Lower Pivot Shaft
6	Pin
7	Nut
8	Bolt
9	Washer
10	Thrust Washers
11	Grease Fitting
12	Grease Fitting on Cylinder (ref.)

SWINGAWAY BOOM EXTENSION

Description

A 9.45 m (31 ft) fixed offsettable or a 9.45 to 17.07 m (31 to 56 ft) folding offsetable swingaway boom extension is provided to obtain additional boom reach.

The boom extension mounts directly to the boom nose utilizing a four point attachment. In addition, the swingaway can be stowed on the right side of the boom Section 1.

Removing the attach pins from the attach points on the left side of the boom nose allows the swingaway to be rotated and stowed on the right side of the boom Section 1.

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

Maintenance

DANGER

Before attempting to erect or stow the swingaway, read and strictly adhere to all danger decals installed on the swingaway and stowage brackets.

Removal

NOTE: If an adequate lifting device is available, the swingaway boom extension can be dismounted directly from the side of the boom.

See Figure 4-5 for swingawy boom extension removal and installation illustration.

1. Fully extend and set the outriggers.
2. Position the boom over the rear.
3. If extended, fully retract all the boom sections and lower the boom to minimum elevation to permit ease of installation of pins and access to the boom nose.

NOTE: The auxiliary boom nose (rooster sheave) does not have to be removed.

4. Extend the boom enough to disengage the spring loaded boom extension stop block (refer to Figure 4-4).
5. Pull down on the handle to disengage the spring loaded boom extension stop block. Place the end of the handle in the retainer plate. Fully retract the boom.

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

7921 FIGURE 4-4

6. Remove the retainer clips from the attach pins stowed in the base of the swingaway and insert the attach pins through the attach and anchor fittings on the right side of the boom nose. Install the retainer clips in the attach pins.

CAUTION

If swingaway stinger is not to be removed, it should remain on the stowage brackets on the side of the boom.

Item	Description
1	Base To Section 4 Attach Pins
2	Section 1
3	Section 4 Section
4	Rear Stowage Bracket
5	Section 4 Section Front Stowage Bracket
6	Front Stowage Bracket
7	Swingaway Base Sheave
8	Mast Assembly
9	Boom Nose To Swingaway Attach Fitting
10	Boom Nose To Swingaway Attach Pins
11	Offset Links
12	Offset Pivot Point
13	Section 4 Sheave

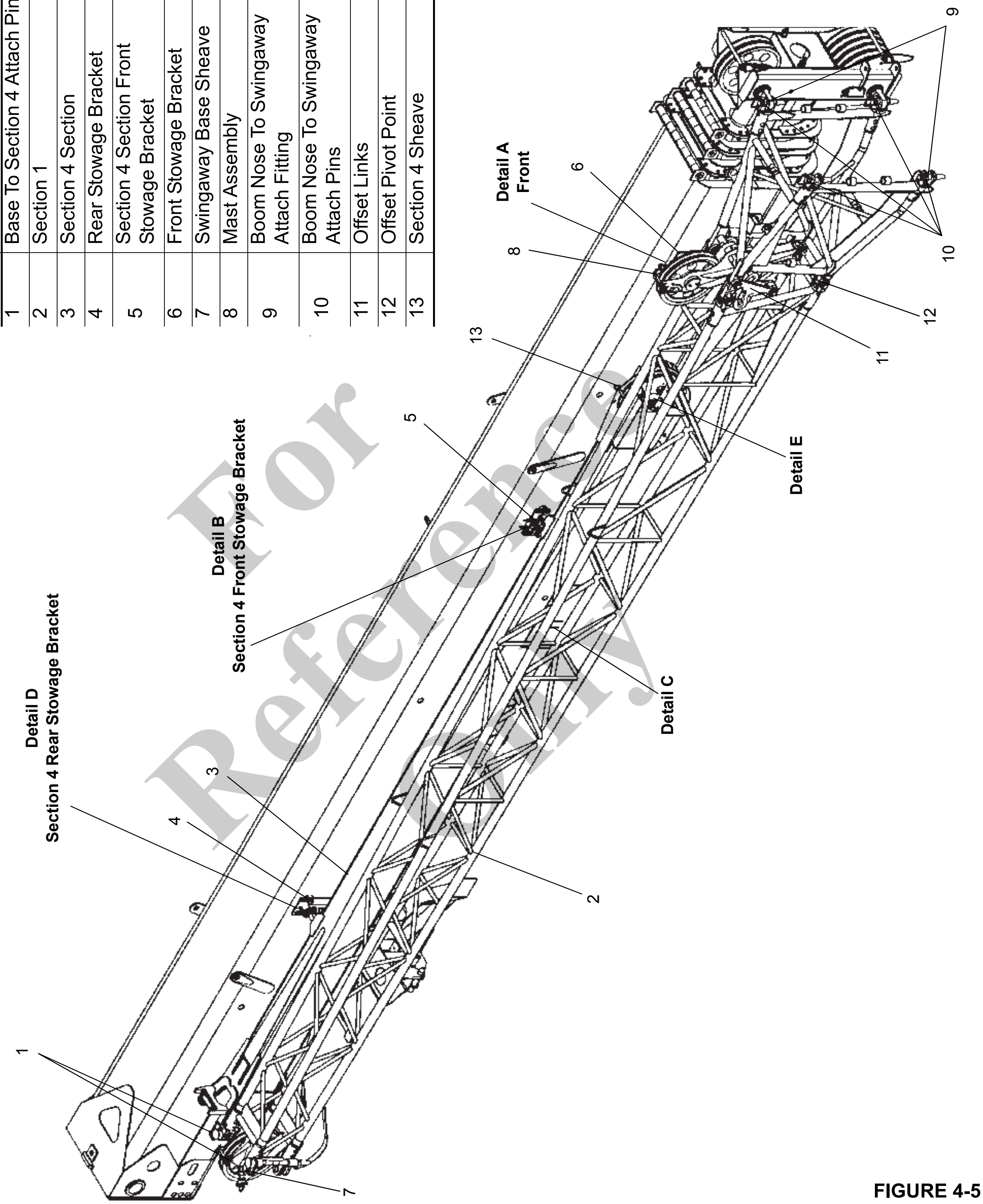
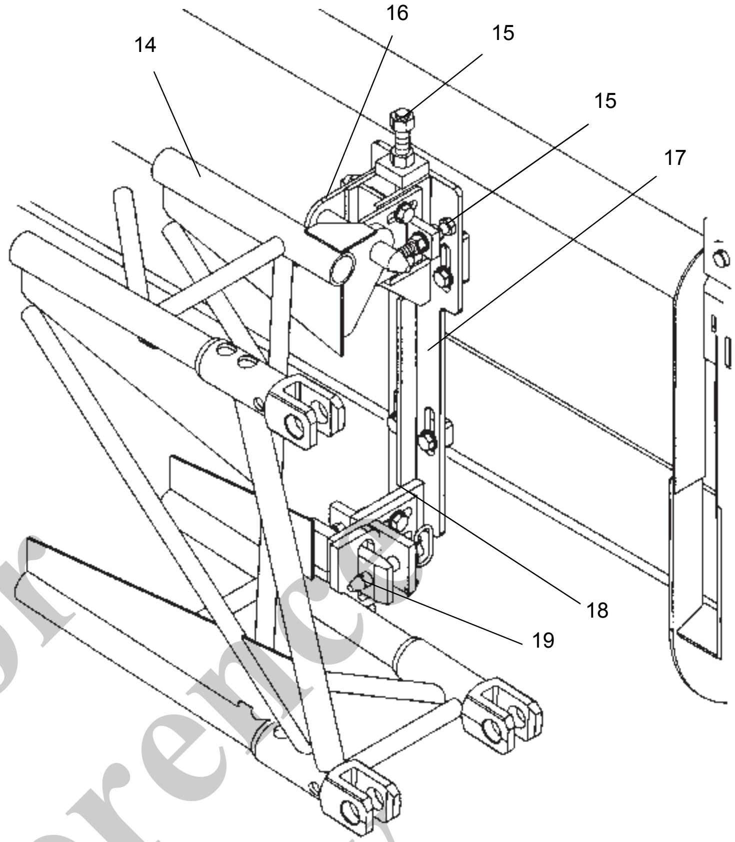


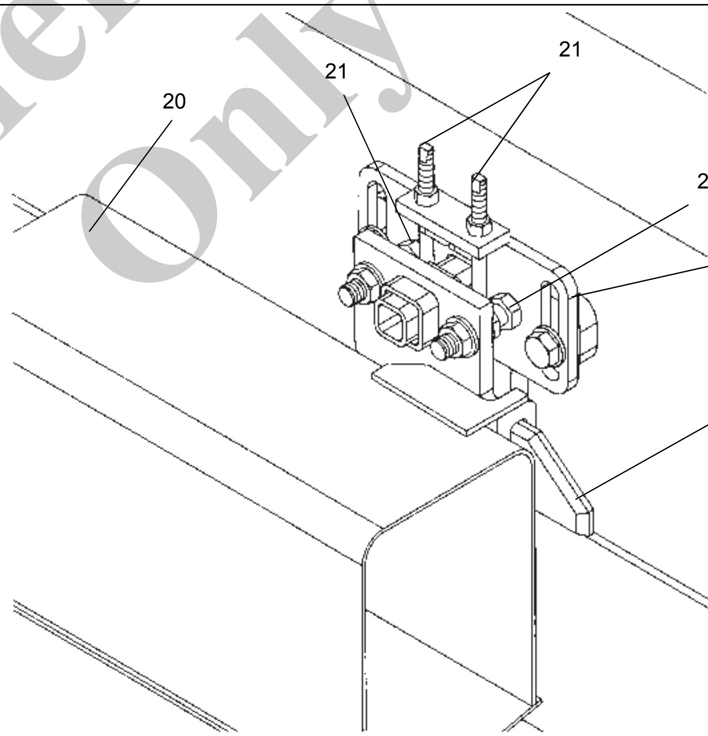
FIGURE 4-5

Item	Description
14	Swingaway Base
15	Adjusting Bolt
16	Upper Hanger
17	Main Hanger
18	Lower Support
19	Lock Hitch Pin



DETAIL A

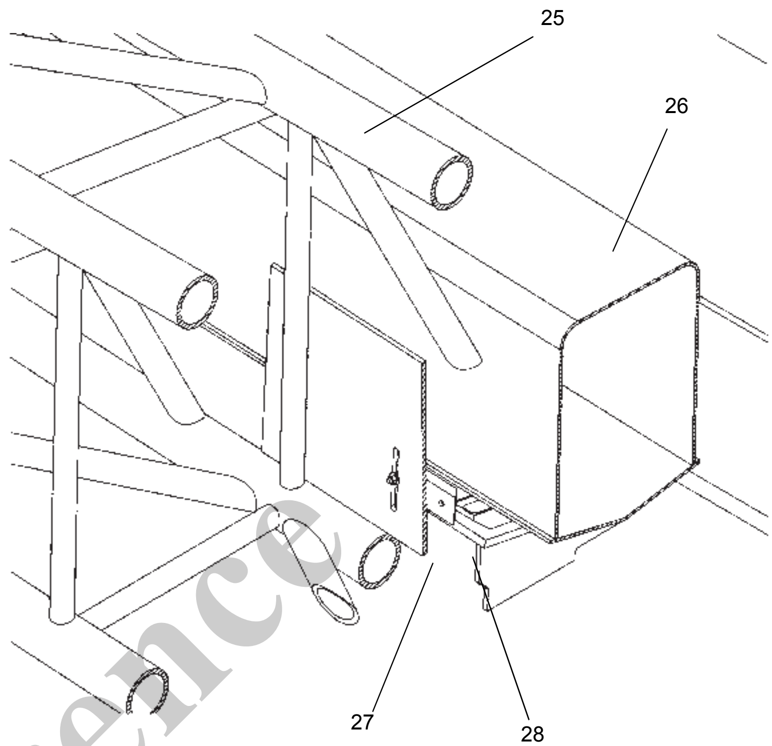
Item	Description
20	Swingaway Stinger
21	Adjusting Bolts
22	Adjusting Bolts
23	Front Mount
24	Hanger



DETAIL B

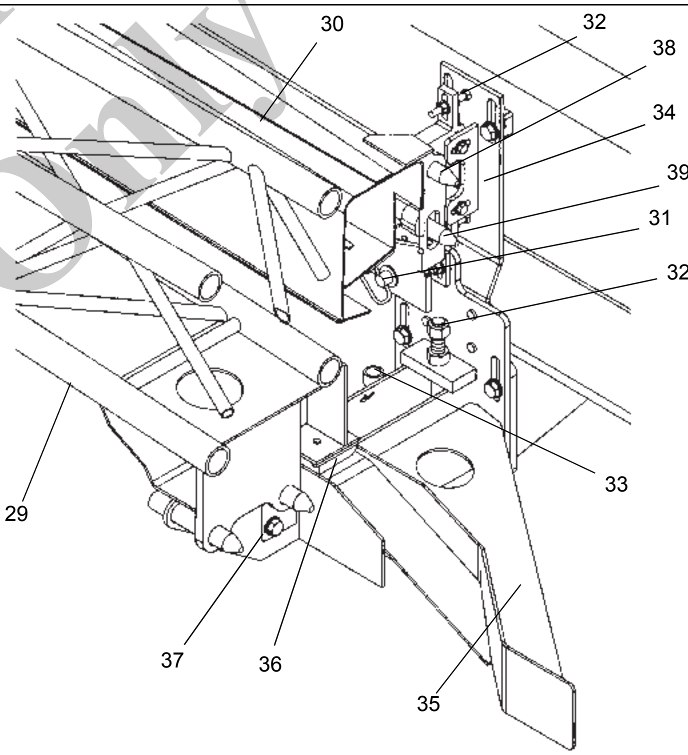
FIGURE 4-5 continued

Item	Description
25	Swingaway Base
26	Swingaway Stinger
27	Shock Wear Pad and Shim
28	Ramp Wear Pad and Shim



DETAIL C

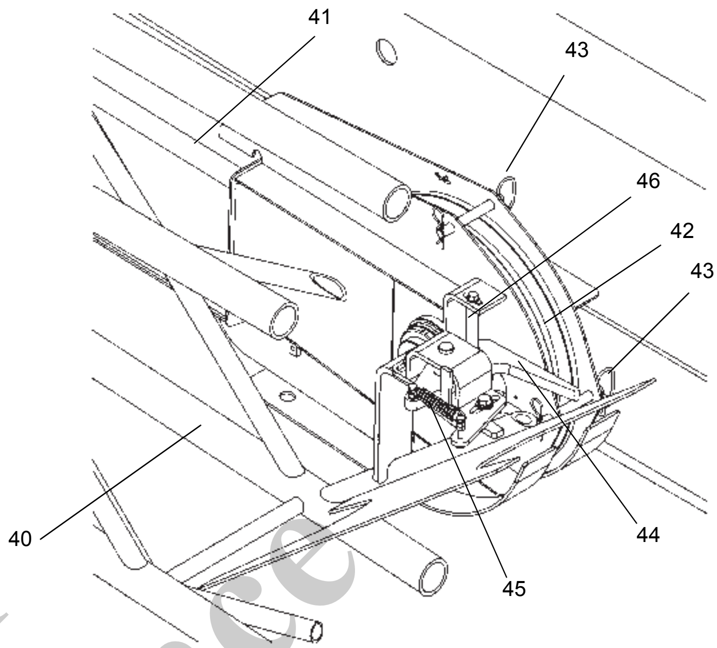
Item	Description
29	Swingaway Base
30	Swingaway Stinger
31	Stinger Attach Pin and Hitch Pin
32	Adjusting Bolts
33	Pin Stowage Lug
34	Upper Support
35	Lower Mount
36	Wear pad
37	Pin Mount
38	Upper Hanger
39	Lower Hanger



DETAIL D

FIGURE 4-5 continued

Item	Description
40	Swingaway Base
41	Swingaway Stinger
42	Stinger Sheave
43	Cable Retainer Pin
44	Latch Hook
45	Spring
46	Latch Bar



DETAIL E

Item	Description
47	Boom Nose Upper Sheaves
48	Mast Assembly
49	Offset Link
50	Offset Pivot Points
51	Offset Link Pins Stowage Lugs
52	Mast Assembly Pin
53	Boom Nose Lower Sheaves
54	Swingaway Attachment Pins
55	Swingaway Attachment Pins Stowage Lugs
56	Offset Link Pins
57	Zero Degree Offset Hole

NOTE: Offset shown at 25 degrees. To obtain 45 degree offset, remove pin (item 56) and stow in lug.

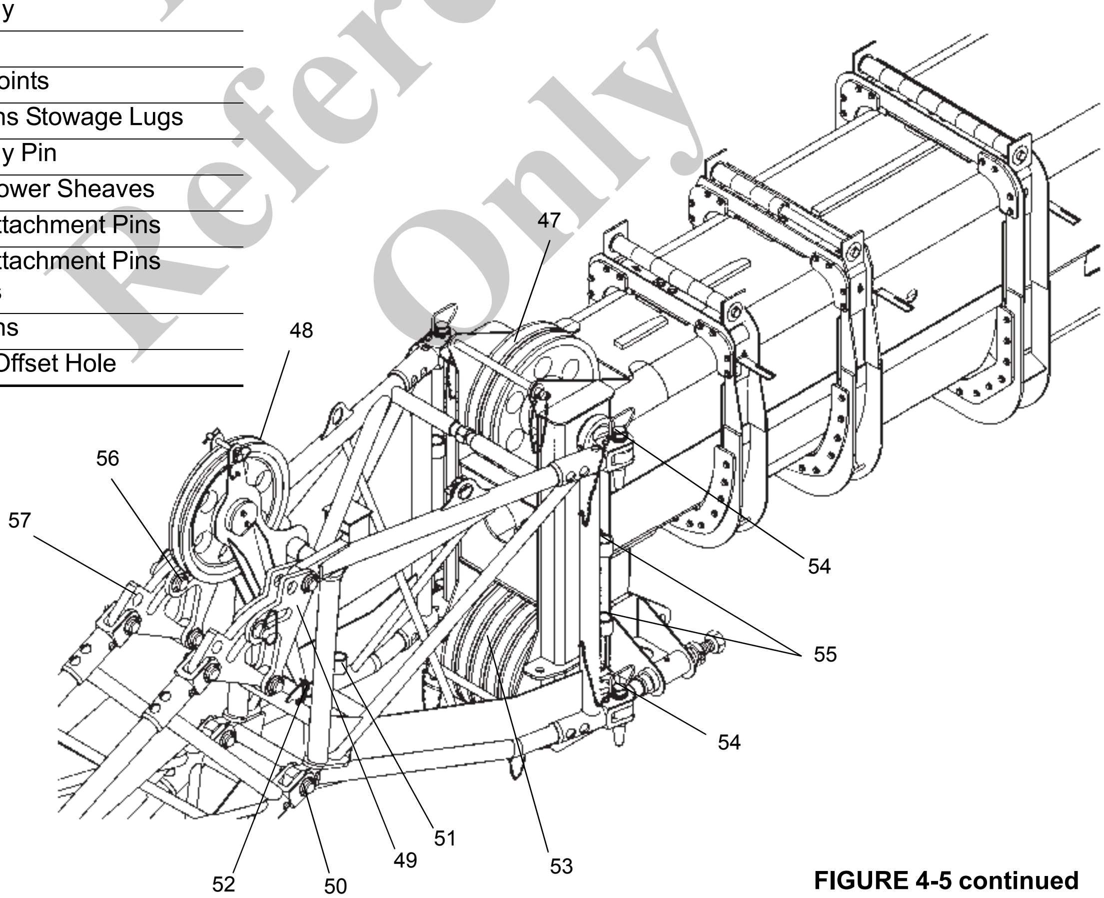
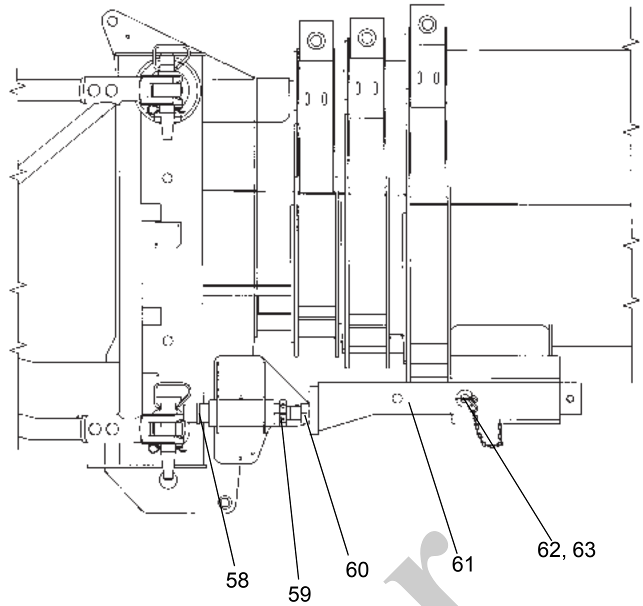


FIGURE 4-5 continued



Item	Description
58	Pusher Bar
59	Collar Clamp
60	Adjustment Bar
61	Push Bar Assembly
62	Hitch Pin
63	Clip Pin

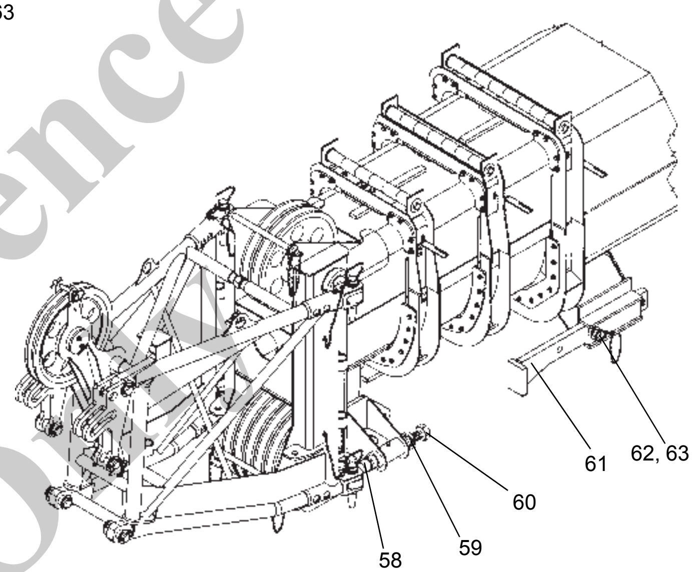


FIGURE 4-5 continued

NOTE: If not removing the swingaway stinger perform steps 7 thru 10.

7. Remove retainer clip from attach pin and remove attach pin from Section 1 to Stinger attach fittings.

8. Stow the pin in the opposite attach fitting or the stowage lug.

9. Ensure the pin attaching Stinger to the boom Section 1 rear stowage bracket (see detail D) is in place.

10. At Stinger sheave end (see detail E) push in on spring loaded latch hook to release latch, allowing the Swingaway Base to separate from Stinger.

11. Remove the pin attaching Stinger to the boom Section 1 rear storage bracket (see detail D).

12. Remove lock hitch pin securing the Swingaway Base to the front stowage bracket (see detail A). Stow lock hitch pin in lug provided.

13. Attach a length of rope to the swingaway tip to aid in swinging the swingaway into place ahead of the boom nose.

CAUTION

If Stinger remains on the Swingaway Base, do not extend the swingaway to far, as the nose of the Stinger could contact the front stowage bracket and cause damage.

14. Raise the boom to horizontal and extend the boom just enough to clear the swingaway stowage lugs from the guide ramps and stowage pins on the front and rear stowage brackets.

15. Remove the pin and clip pin securing the boom extension alignment device in the stowed position. Pull the alignment device out to the working position and secure it in place with the pin and clip pin.

DANGER

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

16. Slightly raise and/or lower the boom to help control the swingaway. Using the rope attached to the tip of the swingaway, swing the swingaway into place ahead of the boom nose, engaging the anchor fittings with the attach fittings on the left side of the boom nose.

DANGER

Do not modify the attachment points to permit the installation of the attachment pins.

17. Install the attach pin into the upper anchor and attach fitting on the left side of the boom nose. Install retainer clip in attach pin.

NOTE: It may not be necessary to install the lower attach pin. If not, proceed to step 19.

18. Fully retract the boom until the bottom swingaway anchor fitting is against the boom extension alignment device and install the attach pin in the lower anchor and attach fittings on the left side of the boom nose. Install the retainer clip in the attach pin.

19. Extend and lower the boom until blocking can be placed under the swingaway. Remove the rope from the tip of the Swingaway Base.

20. Lower the swingaway onto the cribbing. Remove and stow the pins securing the swingaway to the boom nose.

21. Retract the boom, freeing the swingaway from the boom nose.

Installation

1. Position the crane so the swingaway lies to the rear of the crane with the Swingaway Base facing the crane. Fully extend and set the outriggers.

2. Extend and lower the boom to engage the anchor and attach fittings on the swingaway.

3. Install the attach pins and retainer clips to secure the swingaway to the boom nose. Raise the boom, lifting the swingaway from the cribbing on which it was resting.

4. Remove the pin and clip pin securing the boom extension alignment device in the stowed position. Pull the alignment device out to the working position and secure it in place with the pin and clip pin.

5. Lower the boom to minimum elevation.

6. Attach a length of rope to the swingaway tip.

7. Raise the boom to horizontal.

8. Remove the retainer clips and attach pins from the anchor and attach fittings on the left side of the boom nose and stow them in the base of the swingaway.

9. Extend the boom enough so that the Swingaway Base and Section 4 stowage lugs will line up in front of the guide ramps and pins on the stowage brackets when the swingaway is positioned to the side of the boom.

DANGER

When stowing the swingaway, ensure that all personnel and equipment are kept clear of the swing path.

CAUTION

Do not allow the swingaway to slam into the stowage brackets when swinging into the stowed position.

10. Raise and/or lower the boom to help control the swingaway and using the rope attached to the tip of the swingaway, swing the swingaway to the side of the boom.

11. Elevate the boom and push in on the swingaway to align the stowage lugs on the swingaway with the guide ramps and pins on the stowage brackets and fully retract the boom

.

DANGER

During disengagement of the stop block, extend the boom only enough to free the block. Extending the boom too far will cause the swingaway to slide off the guide ramps and allow the swingaway to swing.

12. Lower the boom and extend the boom only enough to disengage the spring loaded boom extension stop block (see Figure 4-6).

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

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

7921 **FIGURE 4-6**

14. Ensure that all the stowage lugs on the base and Section 4 are fully engaged with the pins on the stowage brackets.

15. Insert lock hitch pin. Install the pin securing the swingaway base to the front stowage bracket (see detail A). Ensure the lock hitch pin is pushed all the way in.

16. Install the pin attaching the Stinger to the boom Section 1 stowage bracket (see Detail D).

NOTE: If the swingaway Stinger remained on the boom stowage brackets, perform steps 17 thru 20.

17. Remove retainer clip and attach pin from the bushing on Section 1.

18. Insert the attach pin into Section 1 to Stinger attach fittings and install the retainer pin.

19. Ensure the spring loaded latch hook is engaged on Stinger sheave end (see Detail E).

20. Ensure the pin attaching Stinger to the boom Section 1 stowage bracket (see Detail D) is in place.

21. Remove the retainer clips and attach pins from the anchor and attach fittings on the right side of the boom nose and stow them in the base of the swingaway.

22. Remove the clip pin and pin securing the boom extension alignment device. Place the boom extension alignment device in the stowed position and secure it in place with the pin and clip pin.

DANGER

Failure to maintain the proper clearance between the swingaway anchor fittings and the boom nose attach fittings could cause these fittings to contact each other during operation of the boom.

23. Extend the boom enough to engage the boom stop block.

24. Rig the boom nose and hoist cable as desired and operate the crane using normal operating procedures.

BOOM EXTENSION ALIGNMENT DEVICE ADJUSTMENT

1. Ensure the boom extension and retraction cables are properly adjusted. If necessary, adjust the cables.
2. Fully retract the boom.
3. Following the boom erection procedures, install the pins into the boom extension lugs on the right side of the boom nose and secure in place with the clip pins.
4. Following the boom erection procedures, swing the boom extension around and install the pin in the upper left boom extension lug and secure in place with the clip pin.
5. If the pin cannot be installed in step 4 because of lateral misalignment, adjust the upper cross strut adjustment screw on the swingaway adapter to align the holes.
6. Extend the boom approximately 15 cm (6 in).
7. Remove the pin securing the push bar assembly in the stowed position and slide the push bar to the forward position. Secure the push bar in place with the pin and clip pin.
8. Retract the boom fully. Adjust the pusher bar, using the adjustment bolt, until the holes in the lower left lug of the boom extension align with the boom nose shaft holes. Install the retaining pin in the swingaway lug and secure the pin with the clip pin.
9. If the pin cannot be installed in step 8 because of lateral misalignment, adjust the lower cross strut adjustment screw on the swingaway adapter to align the holes.
10. Secure the adjustment bolt in place by tightening the collar clamp.
11. When the boom extension is not in use, the boom extension alignment device should be placed in the stowed position.

4

Swingaway Mounting Adjustment

The following procedures may be used to adjust the existing installation or for installing a new swingaway and/or stinger. For the referenced details, refer to Figure 4-5.

1. With the swingaway base laying on the ground or cribbing, use an adequate lifting device to place stinger on the side of the base and install the one attach pin.
2. Raise the sheave end of stinger until the attach pin installed in step 1 is loose. Install the ramp wear pad (see Detail C) on the bottom of stinger and shim to provide a clearance of 12 mm (0.5 in) between wear pad and ramp on swingaway base.
3. Install the shock wear pad (see Detail C) on the swingaway base bracket. Shim the wear pad to provide a clearance of 3 mm (0.125 in) between shock wear pad and ramp wear pad installed in step 2.
4. With stinger supported on the base ramp wear pad and held tight against the shock wear pad, adjust stinger latch hook (see Detail E) so that a 4 mm (0.156 in) clearance is maintained between the hook and the latch bar.
5. Remove Section 4 from the side of the swingaway base.
6. Disengage the boom stop and fully retract the boom.
7. Mount the swingaway base on the right side on the boom base and install the pins attaching the swingaway base to the boom nose.
8. Loosen the front and rear stowage bracket attaching hardware.
9. Lift the sheave end of the swingaway base until the attachment pins installed in step 7 are loose. Refer to Detail D (rear stowage bracket) and adjust the lower mount and the pin mount to maintain a loose condition of the attachment pins. Tighten all rear stowage bracket attaching hardware.
10. Refer to Detail A (front stowage bracket) and adjust the main hanger, upper hanger, and lower support to maintain a loose condition of the attachment pins.
11. Move the swingaway base away from the boom base and mount stinger on the swingaway base using one attach pin. Position swingaway base on stowage brackets on side of boom.
12. Lift up on sheave end of stinger until attachment pin is loose and stinger is 3 mm (0.125 in) from shock wear pad at the ramp (see Detail C).
13. Refer to Detail B (stinger front stowage bracket) and adjust the front mount and hanger to maintain the attachment pin in a loose condition.
14. Refer to Detail D (rear stowage bracket) and adjust stinger upper hanger and lower hanger to maintain the attachment pin in a loose condition.
15. Some final adjustment of stinger latch may be required. With the swingaway base and stinger in the final stowed position on the stowage brackets, ensure there is approximately a 3 mm (0.125 in) clearance between the shock wear pad and the ramp wear pad on stinger (see Detail C). In addition, stinger latch must be free (approximately a 1.5 mm (0.059 in) clearance) between the surfaces of the latch hook and the latch bar.

HOOK BLOCK

Description

A 55 metric ton (60 ton) hook block, a 45 metric ton (50 ton) hook block, and a 8.3 metric ton (7.5 ton) headache ball are available for the crane. The hook blocks utilize a one-piece pivot block and the hook is equipped with a safety latch. Both hook blocks are the quick reeve design. Grease fittings are provided to ensure lubrication of all moving parts.

There are two types of headache balls available for this crane. One is provided for use with the main hoist when standard 6 x 37 WS wire rope is used. This headache ball has a top swivel. A non-swivel type headache ball is provided with the optional auxiliary hoist or when 18 x 19 wire rope is provided on the main hoist.

CAUTION

Do not use a swivel type headache ball with 18 x 19 wire rope.

Maintenance

Periodic Maintenance

It is recommended that the hook block and/or headache ball be inspected every 50 hours. A complete disassembly inspection should be conducted every quarter or 500 hours in the area of the hook, hex nut, and threaded areas for corrosion and proper fit. After assembly of the hook, a liberal coating of multipurpose grease should be applied to the nut and threaded areas by brush or hand to prevent corrosion.

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

SECTION 5
HOIST AND COUNTERWEIGHT

SECTION CONTENTS

5

DESCRIPTION

One standard hoist is available for both the main and auxiliary; the GHP 30A model hoist.

An overrunning clutch will allow the hoist to be raised without releasing the brake while holding the load until there is sufficient pressure to release the brake when hoisting down.

Each hoist has a hydraulic motor, a brake valve, a brake cylinder and piston, and a brake clutch which controls motion of the hoist's drum. These parts mount on one of the support end brackets of the hoist.

The hoist speed switch on the armrest in the superstructure cab controls hoist speed. When at the low speed position, it does not energize the solenoid valve (hoist motor control valve) on the hoist motor. This keeps the hydraulic piston and hydraulic cylinder applied to the brake clutch, allowing the motor to turn the hoist drum at low speed. When in the high speed position, this switch energizes the solenoid valve (hoist motor control valve) on the hoist motor. This causes the hydraulic piston and hydraulic cylinder to release the brake clutch, which allows the motor to turn the hoist drum at high speed. For further description of the hoist, read its component manual.

THEORY OF OPERATION

Flow from Section 1 of Pump No. 1 is routed through the swivel to the directional control valve bank.

When the main hoist control lever in the cab is moved from neutral, it sends a pilot pressure signal to the main hoist directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve internally routes the hydraulic flow to the hoist motor as selected by the operator.

When the auxiliary hoist control lever in the cab is moved from neutral, it sends a pilot pressure signal to the auxiliary hoist directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve internally routes the hydraulic flow to the hoist motor as selected by the operator.

Additional flow (high speed boost) above and beyond the positioning of the hoist motor control valve is obtained by using the hydraulic boost switch. Positioning the switch to HI allows the flow from Section 2 of Pump No. 1 to combine with flow from Section 1 of Pump No. 1 to provide extra flow to the hoist.

MAINTENANCE

Removal

1. Remove all cable from the hoist drum.
2. Tag and disconnect the hydraulic lines to the hoist. Cap or plug all lines and openings.

3. Tag and disconnect the electrical wires to the hoist rotation indicator sensor box.
4. Tag and disconnect the electrical wires to the hoist motor control valve.
5. Remove the hoist mounting nuts, bolts, washers, and shims (if shims are used, mark their location).

NOTE: The GHP 30A model hoist assembly, less the cable, weighs approximately 650 kg (1430 lb). If there is only one hoist on the superstructure, there will be an extra counterweight plate weighing about 672 kg (1480 lb) in place of the auxiliary hoist.

6. Using an adequate lifting device, remove the hoist from the crane.

Installation

1. Ensure the mounting plate and hoist pads are clean and free from debris and the hoist has not been damaged during handling.
2. With the hoist supported by a suitable lifting device, position the hoist on the mount.
3. Check the hoist to boom alignment according to *Hoist to Boom Alignment*, page 5-6.
4. Place a level between the boom pivot shaft bushings.
5. Place a level across the top of the hoist drum and determine if the hoist is sitting in the same plane in relation to the level positioned between the boom pivot shaft bushings.
6. With the hoist level, check to determine if all the hoist mounting pads are in contact with the mounting plate by rocking the hoist.
7. Keeping the hoist level, use a feeler gauge to determine the amount of gap existing between the pads and the mounting plate.
8. Add shims to satisfy any existing gaps. Altering the shim thickness to fit a tapering gap is acceptable. Install the bolts, washers, and nuts. Tighten bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the hoist mounting bolts.
9. Remove the lifting device from the hoist.
10. Connect the hydraulic lines to the hoist. Ensure the proper lines are connected to the correct ports as marked during removal.
11. Connect the electrical wires to the hoist motor control valve as marked during removal.
12. Connect the electrical wires to the hoist drum rotation indicator sensor box as tagged during removal.
13. Install the cable, following the procedures outlined under *Installing Cable on the Hoist*, in the *Operator's Manual*.

Functional Check

1. Attach a test weight to the hook and raise and lower the load several times.
2. Check the hoist for smooth operation of the hoist motor and brake system.
3. Ensure the hydraulic connections are secure and free from leaks.

Usage and Inspection

Inspection procedures for hoists are divided into five general categories based upon their usage or duty cycle, which in turn determines appropriate intervals for inspections. The usage categories must be assigned by the crane user on a consistent crane-by-crane basis. The five crane/hoist usage categories are as follows:

Idled - The crane/hoist has not been used for three months.

Infrequent Usage - The crane/hoist is used less than ten hours per month based on a three month average

Moderate Usage - Crane/hoist used 10 - 50 hours per month based on a three month average.

Heavy Usage - Crane/hoist used 50 - 200 hours per month.

Severe Usage - Crane/hoist is operated more than 200 hours per month OR where 50% of the lifts exceed 75% of the rated capacity for the hoist.

The following chart lists the inspections that are required for each type of usage category.

USAGE CATEGORY \ INSPECTION	PRE-USE DAILY INSPECTION	QUARTERLY INSPECTION	SEMI-ANNUAL INSPECTION	ANNUAL INSPECTION
IDLED Not used for 3 months or longer	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	----
INFREQUENT USAGE less than ten hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
MODERATE USAGE 10-50 hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
HEAVY USAGE 50-200 hours per month	REQUIRED	REQUIRED MONTHLY	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)
SEVERE USAGE 200+ hours per month or 50% of lifts exceed 75% rated capacity	REQUIRED	REQUIRED	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)

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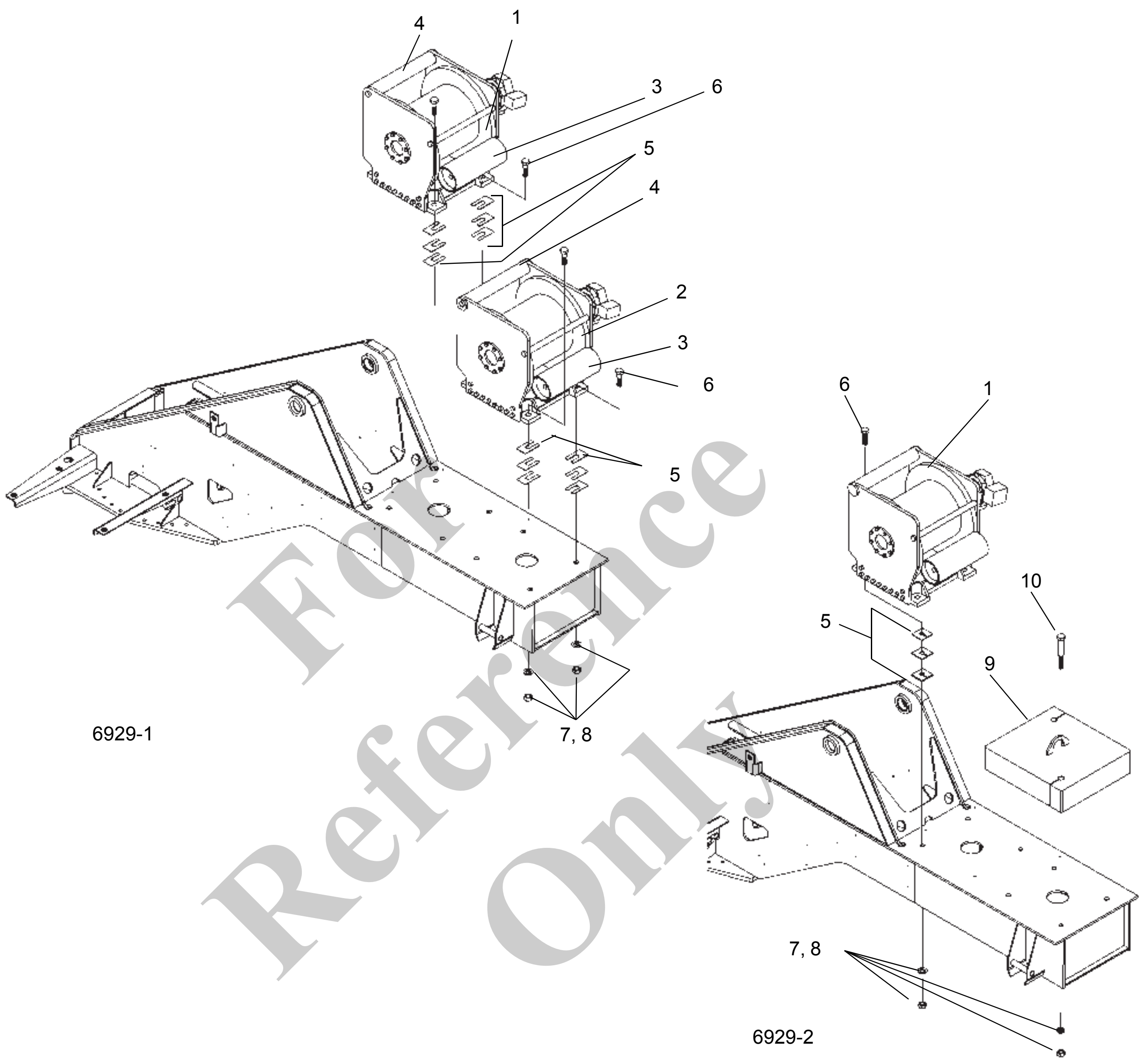

FIGURE 5-2

Item	Description
1	Main Hoist
2	Auxiliary Hoist
3	Cable Guard Roller
4	Cable Guide Roller
5	Shims (different thicknesses)

Item	Description
6	Bolts for Hoist(s)
7	Nuts
8	Washers
9	Counterweight
10	Bolts for Counterweight

Preventative Maintenance

It is extremely important to be aware of the possibility that deterioration of internal critical components within the hoist reduction unit can occur. Hoist reduction units incorporate planetary gears, multi-disc brake assemblies, and sprag clutches which do not have an infinite life span. Although these components have been designed to achieve long service life, reliability can be substantially reduced by a variety of influencing factors such as:

- High cycle operation.
- Operating in high ambient temperatures.
- High external contaminations, such as dusty or sandy conditions.
- Level of maintenance.

The following should be carried out following instructions in *Lubrication*, page 9-1 and/or manufacturers instructions.

1. Pre-Use or Daily Inspection.

Must include but is not limited to the following inspections that will be performed prior to placing the crane into service and then as necessary during extended operation. This inspection must be performed by a qualified crane operator or qualified crane technician.

- Check for external oil leaks and repair as necessary. This is extremely important due to the accelerated wear that will result from insufficient lubricating oil in the hoist. Hoists with a sight glass; check oil level daily. Hoists without a sight glass; check oil level monthly if no external oil leaks are detected. Lubricant level must be maintained between the minimum and maximum levels; midway up sight glass or at bottom of level plug port as equipped. Use ONLY the recommended type of lubricant. Refer to *Lubrication*, page 9-1.
- Check hydraulic fittings and hoses for chaffing, deterioration or corrosion and repair as necessary.
- Visually inspect for corroded, loose or missing bolts, pins or other fasteners and replace or tighten as necessary.
- Visually inspect rotation indicator transmitters, anti-two-blocking switches and other safety equipment and repair as necessary.

2. Quarterly Inspection (every three months).

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

- Perform the pre-use inspection.
- Inspect for corrosion of fasteners, hoist base, drum, etc. and repair/replace as required to maintain the structural integrity of the hoist.
- Check the hoist oil level. Inspect for any oil leaks from the hoist gearbox.

3. Every 250 hours or 3 months.

- If applicable, lubricate the cable guide roller and cable guard roller bearings.

4. Semi-Annual Inspections (every six months).

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

- Perform the Pre-Use and Quarterly inspections.
- Take a sample of the lubricant from the hoist gear cavity as described in *Gear Oil Sampling and Analysis*, page 5-5 and analyze it for wear metals content, correct viscosity, lubricant deterioration, moisture and other contaminants. If the oil sample contains a high amount of metallic particles, the hoist must be taken out of service to undergo a tear down inspection.

NOTE: Oil analysis alone cannot detect nor warn against a fatigue failure.

5. Annual Inspection.

This inspection must be carried out by a qualified crane technician. The annual inspection MUST include, but not be limited, to the following:

- Perform the Pre-Use/Daily Inspection, Quarterly inspection and Semi-Annual Inspection.
- Change the lubricating oil in the hoist gear cavity after an oil sample has been taken as described in *Gear Oil Sampling and Analysis*, page 5-5. Refill the hoist to the proper level with recommended lubricant. Refer to *Lubrication*, page 9-1.

WARNING

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury or death. Some gear lubricants contain large amounts of EP (extreme pressure) and anti-friction additives which may contribute to brake clutch slippage or damage to brake friction discs or seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Our tests indicate that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

- Check for correct function of the hoist brake by conducting a high line pull load test, ensuring the brake holds without creeping and that the hoist control is correct. The function of the hoist brake should be checked more often if abnormal operating conditions or characteristics exist.

6. Every 10,000 hours or every ten years, it is recommended that the hoist assembly be disassembled and that all major components be examined for damage and/or wear, i.e. gears, spline couplings, shafts, etc. New components must be installed if any are found to be worn or if there is evidence of heat or other damage. The hoist should be reassembled using all new seals, bearings, fasteners, washers, brake discs, brake stators, sprag clutch, and springs. A comprehensive hoist line pull and load holding test must be conducted following the repair work.

Oil Change

The hoist gear oil must be changed after the first 100 operating hours then on an annual basis, at a minimum thereafter. In severe duty applications, the gear oil should be changed every six months. Use the recommended lubricants. Refer to *Lubrication*, page 9-1.

Gear Oil Sampling and Analysis

Proper gear oil sampling and analysis is a vital part of a comprehensive preventive maintenance program. Information obtained from the oil analysis allows the maintenance technician to substitute preventive maintenance for more costly unscheduled down time or a far more dangerous failure. Early detection of accelerated component wear allows the scheduling of corrective maintenance.

CAUTION

Hot oil may cause personal injury and/or burns to unprotected skin. Make certain the oil has cooled to a safe temperature (typically less than 110°F or 43°C) before taking an oil sample, changing oil or servicing the hoist.

Prepare the hoist by cleaning the drain plug area and drain extension tube in order to obtain an uncontaminated sample. Operate the hoist in both directions for one or two minutes to thoroughly mix the gear oil then take the sample from the midstream flow of the oil to obtain an accurate representation of the oil condition. After taking the oil sample continue with the oil change or refill the hoist gear cavity to the proper level with recommended lubricant.

General Guidelines for Iron Contaminant Level

100-500 ppm

Normal

500-800 ppm

Caution - Abnormal Sample. Change oil and retake sample after 50 hours of operation. If second sample is above 500 ppm, remove hoist from service and perform tear-down inspection to determine source of contamination.

800+ ppm

Unacceptable. Remove hoist from service and perform tear-down inspection to determine source of contamination.

Iron contaminant levels will be on the high side of "Normal' during initial break-in.

Equally important as the level of contamination is the change in level of contamination. An effective oil analysis program should provide the technician with a view of the progression of wear or a trend. If a sample shows a sudden rise in contaminant level action should be taken to determine what has changed.

NOTE: Oil analysis alone cannot detect nor warn against a fatigue failure.

Brake Test Procedure

The planetary hoists have a spring applied, hydraulically released, multiple disc brake inside the hoist housing. This brake holds a suspended load when the directional control valve is in neutral, or when hydraulic power is lost. An over-running brake clutch assembly permits the power train and drum to rotate in the direction to lift a load, while the brake remains fully applied. A load cannot be lowered, however, without applying hydraulic pressure to the release port and releasing the brake.

(Test to be performed with no load on the hoist)

Remove and cap or plug the brake release line from fitting in the hoist brake release port.

With the hydraulic power unit running, move the directional control valve handle slowly to the full open, lowering position.

Increase the engine speed, if necessary, to bring system pressure up to the relief valve setting. The hoist drum should remain stationary.

If the hoist drum rotates, the hoist should be disassembled and the brake components should be examined for wear. In addition, the brake springs should be measured for the correct free length in those hoists using helical compression springs.

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Replace any parts showing excessive wear and any spring whose length is shorter than the minimum shown in the applicable hoist Service Manual.

Reassemble the brake and hoist and repeat the above steps.

When testing is complete, reattach the brake release line to the brake release port.

HOIST TO BOOM ALIGNMENT

Preparation

Boom alignment must be completed before attempting hoist alignment. If the hoist is not properly aligned, the cable can be damaged or fine control could be affected.

The crane must be set on outriggers fully extended and the crane must be leveled. The boom must be over the rear.

Tools Required

- Two foot square
- Mason cord or cat gut fishing line
- Chalk
- Protractor

Procedure

The hoist mounting location will determine the alignment procedure used. Shift one side of the hoist back or forward to align the hoist with the boom sheave for cranes that have the hoist mounted either directly to the boom or on a mount attached to the boom. It may be necessary to shim under one side of the hoist to make it level.

The hoist must be checked in two directions, one at 0 degree and the other is above 45 degrees boom angle on any crane that the hoist is not mounted directly to the boom, stationary mounted.

Check the hoist at 0 degree to see if the hoist is aligned to the boom nose sheave. The main hoist is aligned to the right hand sheave and the auxiliary hoist is aligned to the center sheave.

NOTE: The hoist cable will have gaps in it during spooling if the alignment is not correct.

The hoist is not level if the cable is piling up on one side of the drum.

1. The boom must be extended one half of full extension on all hoist alignments. This length is used because when the main hoist cable is positioned on the top right hand boom nose sheave, the cable must leave the center of the drum at a 90 degree angle. The boom has the ability to extend, retract, and change the angle of departure from the drum. Extend the boom half way to provide a center point of adjustment to check the fleet angle of the cable.
2. All the cable must be removed from the hoist drum to check the fleet angle. Using mason cord or cat gut fishing line you will be able to pull the line tight to make an accurate measurement of the fleet angle. Find the centerline of the hoist drum by using a square and drawing a line horizontal on the drum. Put a line vertical to the horizontal line on the absolute center of the drum by using a tape measure. With the boom at 0 degree, tie the line tight to the boom nose and have it in the center of the right hand boom nose sheave.

NOTE: If this special equipment is not available, sufficient accuracy in locating a center line may be obtained by using a steel square against the machine’s inner surfaces of both flanges. It is advisable to avoid using any cast surfaces in this procedure unless a check from both flanges indicates that the resultant line is straight.

3. Tie the line around the hoist drum so that the line is very tight and the line is crossing the absolute center of the drum at the centerline mark you put on the drum.
4. Using a protractor, lay it on the vertical line on the hoist drum so the string line is in the center of the protractor. The string line will be at the 90 degree mark on the protractor if the hoist is straight with the boom nose sheave. If it is not at the 90 degree mark, the hoist mounting bolts will have to be loosened and the hoist moved so it is.

NOTE: This test is for cable piling up while spooling.

CAUTION

Do not alter holes or stop blocks on the crane mounting plate, as very small adjustments result in large angular changes. Extreme care should be taken to avoid over-correction.

5. Elevate the boom above 45 degrees boom angle to check if the hoist is level. Reposition the hoist drum and tighten the cord so you can have the cord in the center of the protractor at the 90 degree mark. If the cord is not at the 90 degree mark, the hoist will have to be shimmed until the cord is at the 90 degree mark.

NOTE: This test is for cable piling up on one side of the hoist drum.

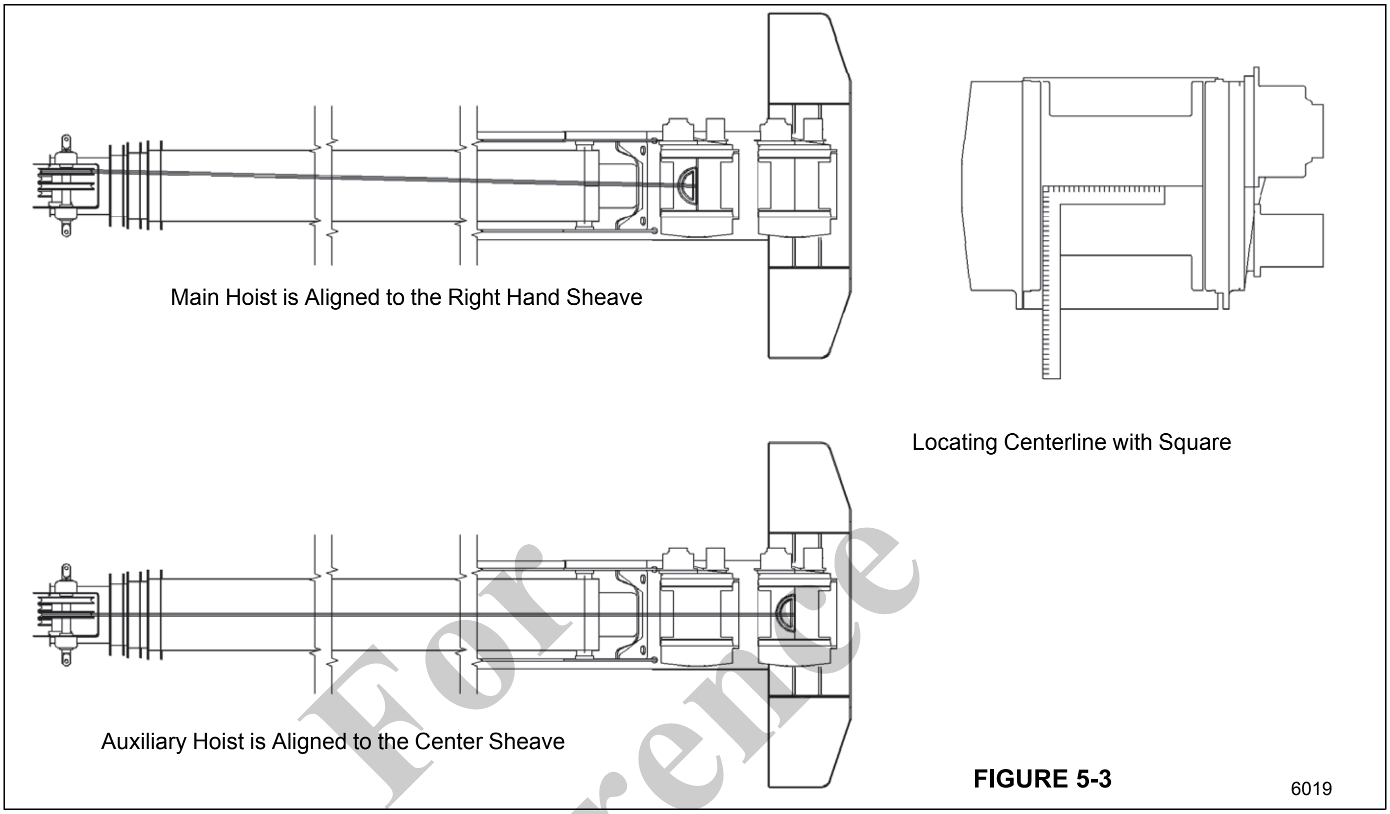

Main Hoist is Aligned to the Right Hand Sheave
Locating Centerline with Square
Auxiliary Hoist is Aligned to the Center Sheave
6019

FIGURE 5-3

MOTOR AND BRAKE

Description

Each hoist has a hydraulic motor, a brake valve, a brake cylinder, and a brake clutch which control motion of the hoist's drum. These parts mount on one of the support end brackets of the hoist. The hydraulic motor connects to the hoist's brake clutch, which in turn connects to the gear train of the hoist.

Maintenance

Removal

1. Drain the oil from the hoist drum by removing the plugs. Reinstall the plugs when the drum is finished draining.
2. Power-wash the hoist on the motor side to wash away potential contaminants from the drive components of the hoist.
3. If needed, tag and disconnect wires from the hoist drum indicator parts. Then remove these parts from the hoist.
4. Tag and disconnect the hydraulic lines from the motor and the brake valve. Cap or plug all lines and openings.
5. Remove the four bolts and washers to free the motor and brake valve from the brake cylinder and brake clutch on the support end bracket. Remove the motor and brake valve as a unit. Discard the O-ring.
6. Cover the motor opening in the brake cylinder to protect drive components inside the hoist drum. As needed, secure the brake clutch from inside the brake cylinder.

Installation

NOTE: Assure the primary thrust plate remains properly located in its counterbore when installing the motor. If operating the hoist with the primary thrust plate wedged between the primary gears and the planet carrier, or with a thrust washer out of position severe damage to internal hoist parts could result.

1. Uncover the motor opening in the brake cylinder. Verify the brake clutch is secure in the brake cylinder. Verify these parts are clean.
2. Install a replacement O-ring on the motor's pilot after lubricating it with gear oil or petroleum jelly.
3. Engage the motor shaft to the inner race of the brake clutch when installing the motor and attached brake valve. Apply Loctite No. 243 to the bolts for the motor. Secure the motor and brake valve to the brake cylinder with bolts and washers. Torque bolts to 382 Nm (282 lb-ft).
4. Connect the hydraulic lines to the motor and brake valve as tagged during removal.
5. Reinstall any hoist drum rotation indicator parts removed earlier, if done. Connect electrical wires as tagged during removal. Torque CPU bolt according to *Fasteners and Torque Values*, page 1-12. Adjust sensor per instructions in *Hoist Drum Indicator System*, page 5-10.
6. Fill the drum with oil. Refer to *Lubrication*, page 9-1 in this manual.

CABLE GUARD ROLLER AND CABLE GUIDE ROLLER

Description

The main and auxiliary hoists are equipped with a cable guard roller on the forward side of the hoist and a cable guide roller on the top rear of the hoist. The main hoist cable guide roller is used to keep the hoist cable from coming in contact with the boom. When the crane is also equipped with an auxiliary hoist, the cable guide roller is used to keep the hoist cable from the auxiliary hoist from otherwise coming in contact with the main hoist.

The cable guard roller on each hoist aids in rolling up the cable smoothly and paying it out smoothly without tangling. A pair of cable tension brackets holds each cable guard roller to the cable so the related cable guard roller can apply a downward spring pressure against the cable onto the hoist drum. This ensures the cable will be uniformly wound onto the hoist drum, and will also prevent the cable from jumping under abnormal line conditions.

Maintenance

Refer to Figure 5-4.

Removal

1. Remove attaching hardware holding the shaft of the cable guard roller to the cable tension brackets. Remove shaft and cable guard roller from cable tension brackets. Account for any shims and other attaching hardware.
2. Loosen jam nuts and eyebolts to lessen tension of the springs for the cable tension brackets. Remove springs.
3. Remove attaching hardware to free each cable tension bracket from the hoist. Remove each cable tension bracket.
4. Remove attaching hardware holding the shaft of the cable guide roller to the hoist. Remove shaft and cable guide roller from the hoist.

Cleaning and Inspection

1. Clean all rust and dirt from the cable guard roller, springs, shaft, cable tension brackets, and attaching

hardware. Do likewise for the cable guide roller and shaft and attaching hardware.

2. Inspect each shaft and roller for cracks, scoring, or grooving. Replace if necessary.
3. Inspect the springs for proper length, tensile strength, and lack of damage. Replace both springs as a pair if either is defective.

Assembly

1. Secure the cable guide roller to the two support end brackets of the hoist with its shaft and attaching hardware.
2. Secure the cable tension brackets to the two support end brackets of the hoist with attaching hardware.
3. Secure the cable guard roller to the cable tension brackets with its shaft and attaching hardware.
4. Attach each of the two springs to its related eyebolt and jam nut that attach to the spring adjusting bracket on each of the two support end brackets of the hoist. Attach the other end of each spring to the spring hole of its related cable tension bracket.
5. Adjust each spring's jam nut and eyebolt until there is a distance of 42 mm (1.7 in) between the jam nut and the threaded end of the eyebolt.
6. Ensure the cable guide roller can turn, and that it touches the cable along its cable-touching length.
7. If the cable guard roller's bearings have grease fittings, apply EP-MPG grease to them. If the cable guide roller's bearings have grease fittings, apply EP-MPG grease to them.

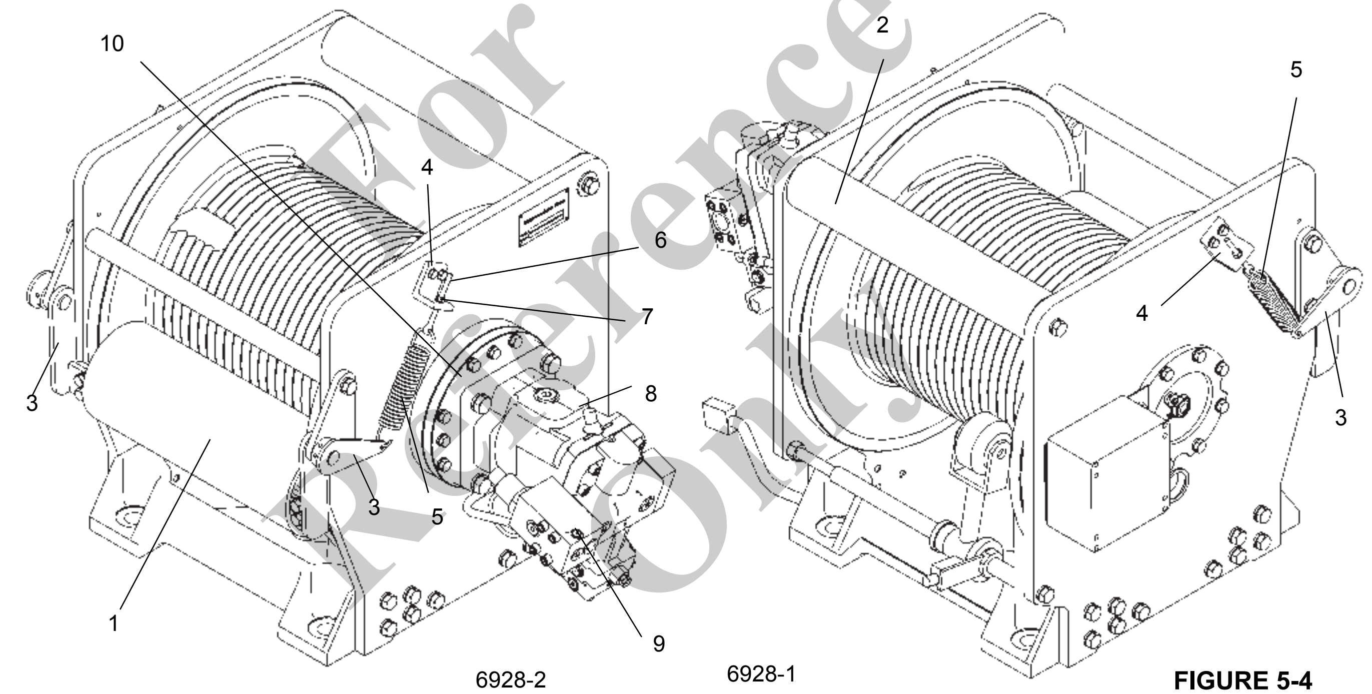


FIGURE 5-4

Item	Description
1	Cable Guard Roller
2	Cable Guide Roller
3	Cable Tension Bracket
4	Spring Adjusting Bracket
5	Spring
6	Eyebolt
7	Jam Nut
8	Motor

Item	Description
9	Brake Valve
10	Brake Clutch and Brake Cylinder

5

HOIST DRUM INDICATOR SYSTEM

Description

The hoist drum rotation indicator system (see Figure 5-4) is an electrically operated system that provides the operator with a touch indication of drum rotation so he will know if and at what speed the hoist drum is rotating, even under the most distracting conditions.The system also includes a visual display located in the front overhead panel that indicates hoist rotation direction.

The rotation indicator system consists of three separate electrical components; the rotation indicator sensor, drum rotation indicator control module (CPU), and thumb thumper solenoid. The rotation sensor and control module (CPU) are located on the hoist. The pulsing thumb thumper solenoid is located in the applicable hoist control lever handle.

Maintenance

General

CAUTION

Disconnect the batteries before performing any maintenance on this system. Serious burns may result from accidental shorting or grounding of live circuits.

Proper circuit operation can be checked for each individual electrical component. If a malfunction occurs within the system, repairs should be limited to finding and replacing the faulty component(s). To determine which component is at fault, use the self diagnostic LEDs on the CPU. If difficulty persists, contact your distributor for additional troubleshooting aid.

Rotation Sensor

The rotation sensor is screwed into the hoist support end bracket that holds the hydraulic motor. It senses the rotation of the drum. When installing the sensor, ensure its sensing end is 31 mm (1.21 in) from the first lock nut. (This is the length of the sensor from its sensing end through to the outside surface of the hoist support end bracket.) If sensor will not work properly, loosen both lock nuts and turn the sensor counterclockwise up to one turn, then retighten lock nuts to hold sensor position. If sensor will still not work properly, ensure its sensing end is 31 mm (1.21 in) from the first lock nut, then turn the sensor clockwise up to one turn, then retighten lock nuts to hold sensor position.

Drum Rotation Indicator Control Module (CPU)

The control module (CPU) is bracket mounted to one of the hoist motor brake clutch attaching bolts. (Torque this CPU bolt according to *Fasteners and Torque Values*, page 1-12.) It provides LEDs for checking proper circuit operation, as well as providing power to the rotation sensor. It also sends a signal to the thumper solenoid proportional to the sensor.

Thumb Thumper Solenoid

The thumb thumper solenoid provides feedback proportional to the hoist line speed by pulsing the rubber button on top of the hoist control lever.

Troubleshooting

To troubleshoot the system, use the three diagnostic LEDs located on the control module (CPU). Under normal operating conditions (hoist drum rotating) the diagnostic LEDs function as shown in the Table below.

LED	OPERATION	DEFINITION
Green	On continuously	Current applied to sensor
Red	Pulses on, varies with speed	Sensor signal received
Amber	Pulses on, varies with speed	Solenoid pulse working

NOTE: The following paragraphs troubleshoot the system using the diagnostic LEDs. The hoist drum must be rotating during all troubleshooting.

Green LED

Turn the ignition switch on. Verify that the green LED is on. The LED should stay on as long as accessory power is on. If the green LED is not on, either the voltage did not power the CPU, or the CPU is worn or damaged and needs to be replaced. If the green LED repeatedly flashes once with the red and amber LEDs off, the solenoid circuit is shorted. If the green LED repeatedly flashes two times with the red and amber LEDs off, the CPU is worn or damaged. If the green LED repeatedly flashes three times with the red and amber LED's off, the CPU needs to be reprogrammed. The following should be used only after using the diagnostic LEDs.

1. Use a digital voltmeter or multimeter to measure if voltage is present on wire 27 at circuit breaker or fuse feed. Replace fuse, circuit breaker, or wire as needed.
2. Make sure 12 volts are measured across terminals A (red wire) and B (black wire) of connector DT3S. If there is no voltage present, check wiring and circuit breaker or fuse. Replace fuse, circuit breaker, or wire as needed.
3. If voltage is present but green LED does not light, replace the CPU.

Red LED

With the green LED on, and the hoist rotating, the red LED should be pulsing on and off and should stop pulsing when the hoist stops rotating. If the red LED does not pulse on and off, then either the CPU is damaged or the sensor is damaged. The following should be used only after using the diagnostic LEDs.

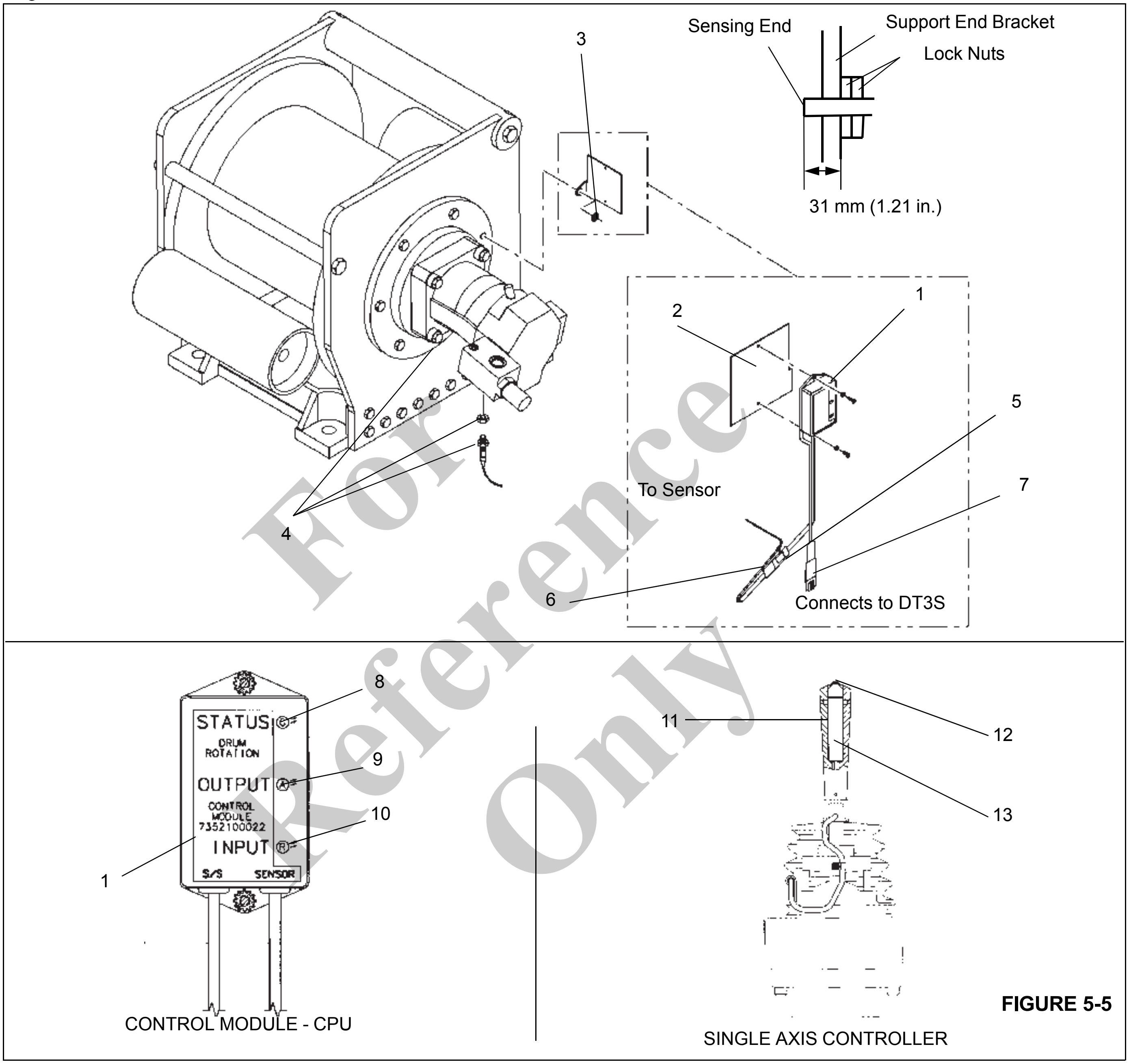


FIGURE 5-5

Item	Description
1	Control Module - CPU
2	Bracket
3	CPU Bolt (not shown) and Washer
4	Sensor (horizontal under brake clutch, through support end bracket, shown with lock nuts)
5	DTM3S

Item	Description
6	DTM3P
7	DT3P
8	Green LED
9	Amber LED
10	Red LED
11	Lever Handle

Item	Description
12	Button
13	Thumb Thumper Rotation Indicator Solenoid

1. Measure the sensor input voltage from +10V terminal 1 to ground terminal 3 on the DTM3S connector. Measure the pulsating return signal from +5V terminal 2 to ground terminal 3 on the DTM3S connector. If the +10V is applied to the sensor input and the +5V pulsating signal is applied to the DTM3S connector terminal 2 and the red LED still does not pulsate, the CPU is worn or damaged and should be replaced.
2. If the +5V signal on terminal 2 does not oscillate, the sensor is worn or damaged or the sensor adjustment air gap from the drum is too wide. Adjust the sensor position and retest. If oscillation does not occur, replace the sensor.

Amber LED

With the green LED on continuously, and the red LED pulsating (hoist is rotating), the amber LED should also be pulsating. If the amber LED does not pulse on and off, a worn or damaged CPU could be the problem. If the amber LED pulsates, but the thumb thumper solenoid does not, then the thumper solenoid is worn or damaged and should be replaced or there are broken or pinched wires in the system. The following should be used only after using the diagnostic LEDs.

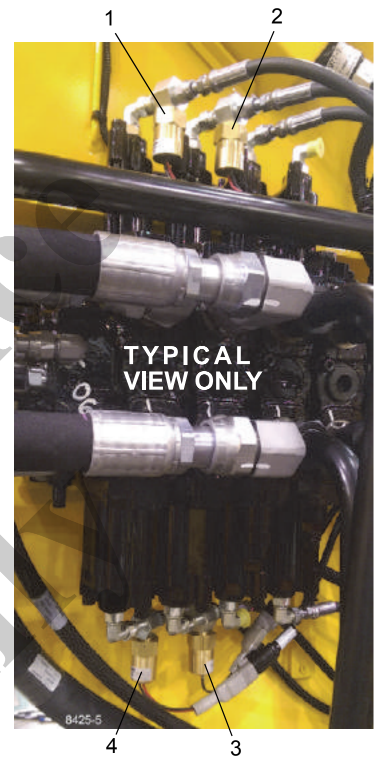
1. Using a digital voltmeter, check to see if the CPU is receiving 12 volts between terminals A (red wire) and B (black wire) of connector DT3S. If no voltage is present, check wiring and circuit breaker or fuse.
2. Using a digital ohmmeter, check to see if the thumper solenoid resistance is 12 ± 2 ohm. If the resistance does not measure correctly the solenoid is worn or damaged and should be replaced.
3. Using a digital voltmeter, measure the voltage on thumper solenoid white feed wire 27. The voltage should measure 12V. If voltage is not within ± 10 percent, check the voltage at the fuse or circuit breaker. If the voltage does not measure within ± 10 percent, trace the high or low voltage back to the source and repair the defect. If the voltage does measure within ± 10 percent, the thumper solenoid white feed wire 27 is pinched; replace it.
4. After disconnecting both ends of wire 508 (main hoist) or 509 (auxiliary hoist) between the thumper solenoid and the CPU, measure the resistance of wire 508 or 509. If the resistance measures more than 0.5 ohm, the wire is worn or damaged; replace it.

Hoist Rotation Indicator (HRI) Display System

The HRI Display consists of an LED display that indicates the direction the hoist(s) are rotating, pressure switches that monitor hydraulic pilot pressure, and a control module mounted in the cab.

Pressure Switches

The pressure switches are located on the main control valve Figure 5-6. The switch contacts close at 75 psi (5.17 bar).



8425-5

Item	Description
1	Main Hoist Down Switch
2	Auxiliary Hoist Down Switch
3	Auxiliary Hoist Up Switch
4	Main Hoist Up Switch

FIGURE 5-6

HRI Display

The display is located in the front overhead panel Figure 5-7.

To replace the display, remove the overhead panel. Disconnect the electrical connector and pry the display off of the panel. Clean the panel where the display was affixed with isopropyl alcohol, remove the paper from the adhesive back of the new display and stick it into the panel. Connect the wires to the display. Replace the panel and secure with the hardware.

FIGURE 5-7

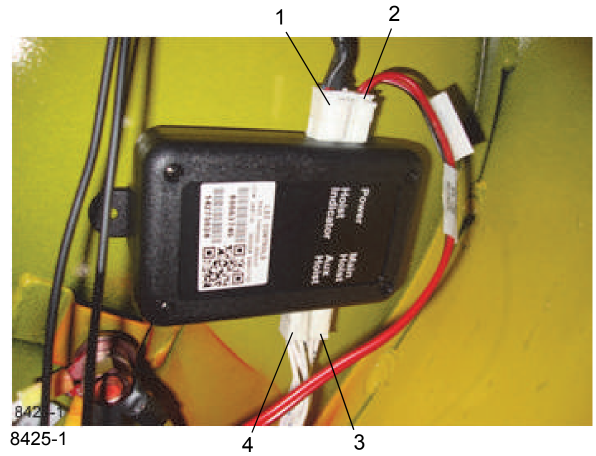
HRI Control Module

The control module is located in the fuse and relay panel behind the driver's seat in the cab Figure 5-8.

8425-2

FIGURE 5-8

To replace the control module, tag and disconnect the wires from the module Figure 5-9. The module is mounted to the bulkhead using double-sided adhesive tape. To remove the module, pry it off the bulkhead. Remove any residual tape from the bulkhead. Secure the replacement module to the bulkhead with the foam tape. Connect the wires as tagged during removal.



8425-1

Item	Description
1	To LED Indicator
2	Power and Ground
3	Main Hoist Pressure Switches
4	Auxiliary Hoist Pressure Switches

FIGURE 5-9

HOIST CONTROL VALVES

Description

NOTE: For more detailed information, refer to *Valves*, page 2-19.

Hydraulic Hoist Motor Control Valve

The hydraulic hoist motor control valve is mounted on the hoist and is designed to provide an even flow of oil to the hoist motor in both directions. This is a different valve than the hoist motor control valve that applies and releases the hydraulic piston and hydraulic cylinder.

Hoist Directional Control Valve

The hoist directional control valve is used to control the operation of the hoist. It is a four-way, pilot operated valve and is mounted on the right side of the turntable.

COUNTERWEIGHT

Description

The removable counterweight (see Figure 5-5) is pinned to the rear of the turntable under the hoist mounting. The counterweight consists of one standard box and maximum of two slabs, each weighing 2495 kg (5500 lb). This provides counterweight configurations of 4990 kg (11000 lb) and 7485 kg (16500 lb). The standard box contains lugs for

5

attachment to the removal cylinders and lugs to pin it under the hoist mounting. The two additional slabs pin to the standard box and to each other. The counterweights can be pinned to the carrier deck and are transferred between the turntable and the carrier deck by two hydraulic removal cylinders. The cylinders are controlled from a valve assembly located under the hoist mounting. The valve contains an inlet section, an outlet section with relief valve, and two working sections (one for each cylinder). The valve is controlled by switches on a control panel on each side.

For cranes without an auxiliary hoist, an additional 862 kg (1900 lb) counterweight is bolted to the hoist mounting area in lieu of the auxiliary hoist.

Maintenance

NOTE: For removal and installation of the counterweight, refer to the *Operator Manual*.

Cylinders

Removal

1. Set the counterweight on the carrier deck. Refer to procedures in the *Operator Manual*.
2. Tag and disconnect the hydraulic lines from the cylinder. Cap or plug all openings.

NOTE: The cylinder weighs approximately 42 kg (92 lb).

3. Remove the four bolts and lockwashers securing the cylinder to the mounting plate. Remove the cylinder and spacer.

Installation

1. Position the cylinder and spacer on the mounting plate and secure with four bolts and lockwashers. Tighten the bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the bolts.
2. Connect the hydraulic lines to the cylinder as marked during removal.

Jack Screws

There are four jack screws with jam nuts under the mounting structure and six on the slabs. With the counterweight properly pinned to the mounting structure (turntable) adjust the jackscrews to level the counterweight pieces to eliminate any relative movement between each piece and the mounting structure (turntable). Secure the adjustment with the jam nuts.

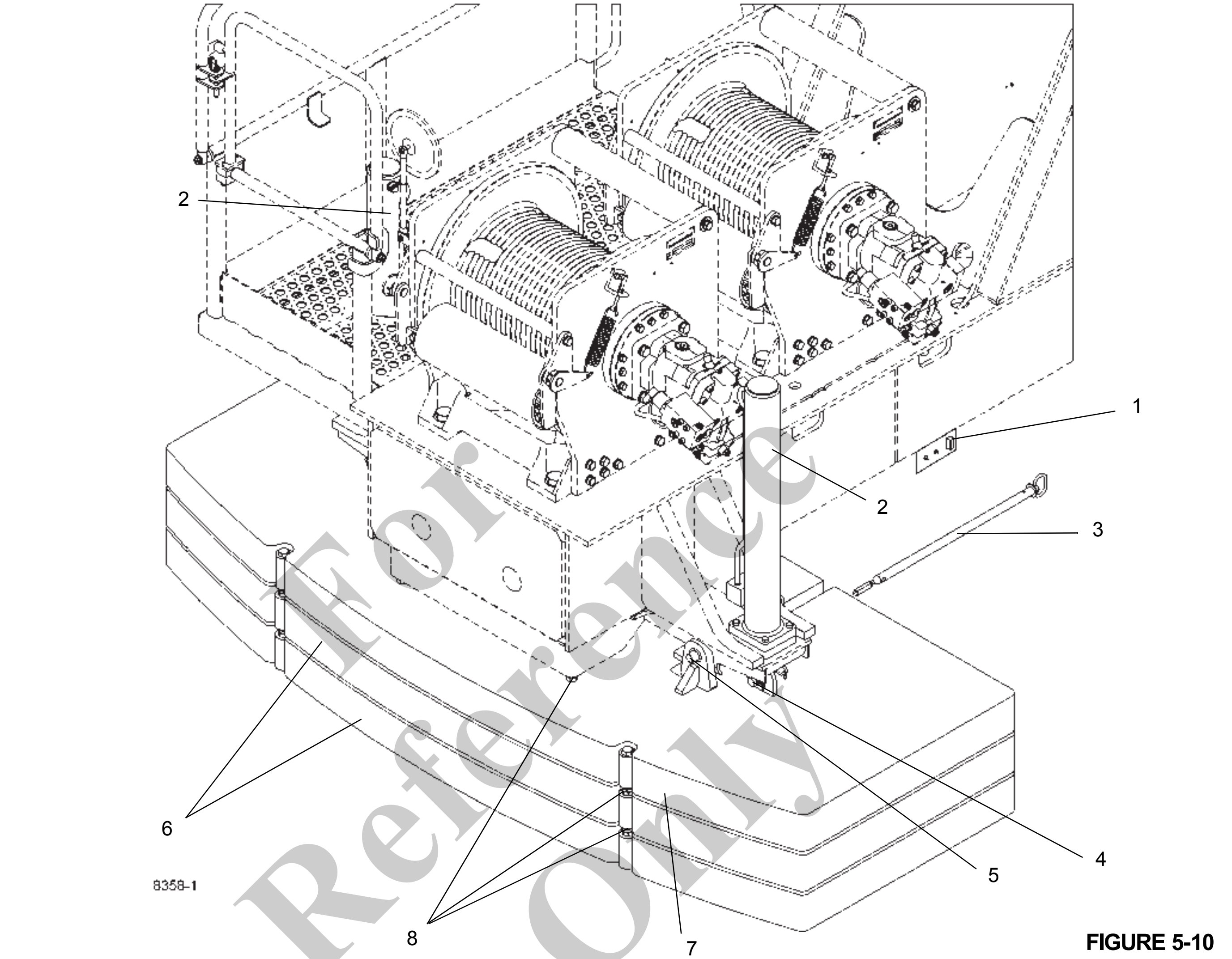


FIGURE 5-10

Item	Description
1	CWT Removal Panel
2	Removal Cylinder
3	Slab Attach Pin
4	Cylinder Attach Pin

Item	Description
5	Box Attach Pin
6	2495 kg (5500 lb) Slabs
7	2495 kg (5500 lb) Standard Box
8	Jack Screws

SECTION 6
SWING SYSTEM

SECTION CONTENTS

DESCRIPTION

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term free swing means that, with the Swing Brake switch in the OFF position, the superstructure will swing freely after the Swing control lever is released until it coasts to a stop or the glide swing brake pedal is depressed.

Swing is activated using the control lever in the cab. When the swing lever is actuated, hydraulic pressure is routed to the swing motor to drive the gearbox in the appropriate direction. As the gearbox rotates, the pinion gear meshes with the teeth on the swing bearing and rotates the superstructure. The maximum rotation is 2.5 rpm. 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, a directional control valve, the swing drive, the swing brake assembly, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The crane is equipped with a pin type swing lock as standard and an optional 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type swing lock will lock the turntable in the over the front and over the rear positions. Both swing locks are operated from the superstructure cab.

THEORY OF OPERATION

Swing Drive

The hydraulic power for the swing drive (see Figure 6-1) is supplied by the engine driven hydraulic pump. Oil flows from the pump to the hydraulic swivel. Flow from the swivel is routed to the swing directional control valve.

When the hydraulic remote controller is positioned to select right or left swing, the flow through the control valve is directed to the swing motor. If the Swing Brake selector switch is in the OFF position, the superstructure will rotate in the desired direction. Shifting the control to neutral and depressing the brake pedal will stop the swing.

Swing Brake

Hydraulic power for the swing brake control and swing brake cooling is supplied by the pilot generator capsule in the hoist/telescope/lift directional control valve to the swing brake and armrest lockout manifold, swing power brake valve, and through an orifice to the cooling IN port on the swing brake.

The hydraulic power for the swing brake release is supplied by the pressure reducing/sequence valve in the swing brake and armrest lockout manifold. With the Swing Brake selector switch positioned to ON, the swing brake release valve blocks the regulated flow to the brake release port and spring pressure in the swing brake applies the brake. When the Swing Brake selector switch is positioned to OFF, the regulated flow is directed from the pressure reducing/sequence valve to the brake release port, overcoming the brake spring pressure and releasing the swing brake.

Hydraulic flow from the pilot generator capsule is provided to the swing power brake valve where it is available for the activation of the swing brake when the pedal is depressed.

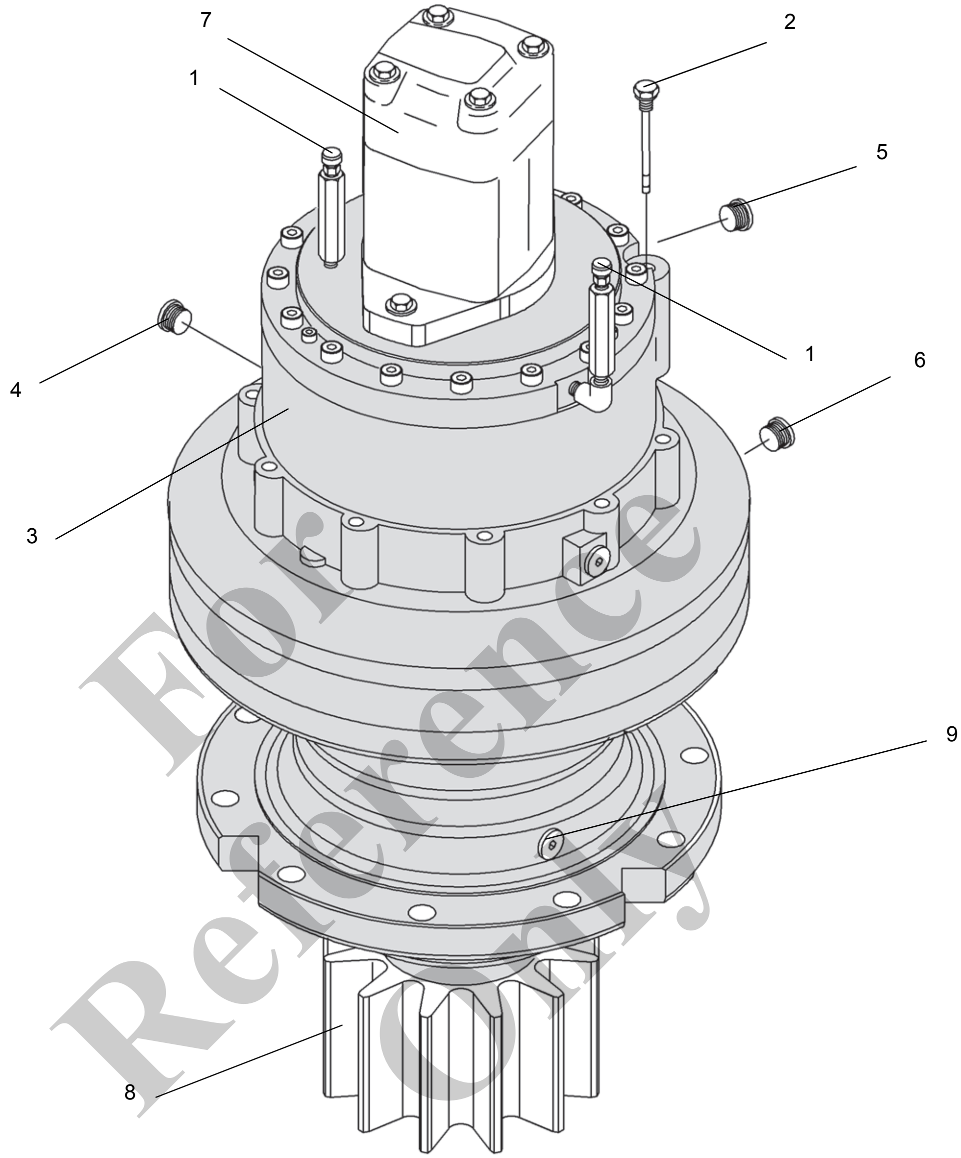


FIGURE 6-1

Item	Description
1	Breather Plug
2	Filler Plug
3	Swing Drive and Brake
4	Hydraulic Apply Brake Port
5	Hydraulic Release Brake Port

Item	Description
6	Level Plug
7	Motor
8	Pinion
9	Drain Plug

MAINTENANCE

Troubleshooting

Symptom	Probable Cause	Solution
1. Boom swing operation erratic in either direction.	**a.** Low engine rpm.	**a.** Increase engine rpm to obtain smooth swing operation.
	b. Low hydraulic oil.	**b.** Check for leaks. Repair any found. Replenish hydraulic oil to proper level.
	c. Damaged relief valve.	**c.** Replace relief valve.
	d. Swing brake dragging (not releasing properly).	**d.** Readjust and/or replace necessary parts.
	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.
	k. Pump cavitation in swing section.	**k.** Tighten suction hose or replace any damaged fitting. Check hydraulic tank level.
	l. Improperly torqued turntable bolts.	**l.** Torque turntable bolts evenly.
	m. Excessive preload on upper and lower pinion shaft bearing.	**m.** Adjust as necessary.
	n. Improperly torqued swing motor attachment bolts.	**n.** Torque swing motor attachment bolts.
	o. Malfunction of the swing box.	**o.** Remove swing box and make necessary repairs.
	p. Worn or damaged pump.	**p.** Repair or replace damaged pump.
	q. Damaged swing directional control valve.	**q.** Repair or replace swing directional control valve.
	r. Damaged swing pinion.	**r.** Replace pinion.
	s. Damaged turntable bearing.	**s.** Replace turntable bearing.
2. Boom swing operation erratic in one direction only.	**a.** Crane not level.	**a.** Level crane using outriggers.
	b. Turntable bearing binding due to continuous limited swing. (Example: concrete pourer.)	**b.** Rotate machine 360 degrees in both directions several times and lubricate bearing.
	c. Restricted hose or fitting.	**c.** Replace hose or fitting.
	d. Damaged swing directional control valve.	**d.** Replace swing directional control valve.
	e. Damaged swing pinion.	**e.** Replace pinion.
	f. Damaged turntable bearing.	**f.** Replace turntable bearing.

Symptom	Probable Cause	Solution
3. Boom will not swing in either direction.	**a.** Damaged relief valve.	**a.** Remove, clean, and repair or replace relief valve.
	b. Damaged swing motor.	**b.** Repair or replace swing motor.
	c. Swing brake not releasing properly.	**c.** Repair as necessary.
	d. Damaged hydraulic remote control valve.	**d.** Replace hydraulic remote control valve.
	e. Internal damage to swing box.	**e.** Remove swing box and repair.
	f. Worn or damaged hydraulic pump.	**f.** Replace pump section.
	g. Damaged swing directional control valve.	**g.** Replace swing directional control valve.
	h. Damaged swing pinion.	**h.** Replace pinion.
	i. Damaged turntable bearing.	**i.** Replace turntable bearing.
	j. Excessive overload.	**j.** Reduce load. Refer to load capacity chart.
4. Swing operation slow in either direction.	**a.** Damaged relief valve.	**a.** Adjust, repair or replace valve.
	b. Improperly adjusted swing brake.	**b.** Readjust.
	c. Damaged hydraulic remote control valve.	**c.** Replace hydraulic remote control valve.
	d. Improperly lubricated swing bearing.	**d.** Lubricate bearing per recommendations.
	e. Improper size hose and/or fittings installed.	**e.** Refer to the *Grove Parts Manual*.
	f. Clogged or restricted hydraulic hoses or fittings.	**f.** Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	**g.** Replace bearings.
	h. Worn or damaged swing motor.	**h.** Repair or replace motor.
	i. Worn or damaged hydraulic pump.	**i.** Repair or replace pump.
	j. Crane not level.	**j.** Level crane.
	k. Damaged swing directional control valve.	**k.** Replace swing directional control valve.
5. Swing operation slow in one direction only.	**a.** Crane not level.	**a.** Level crane.
	b. Damaged hydraulic remote control valve.	**b.** Replace hydraulic remote control valve.
	c. Damaged swing directional control valve.	**c.** Replace the swing directional control valve.
	d. Clogged or restricted hose.	**d.** Replace hose or fitting.
	e. Improperly torqued turntable bearing.	**e.** Torque turntable bearing.

Symptom	Probable Cause	Solution
6. Swing brake operation erratic.	**a.** Improper brake adjustment.	**a.** Adjust brake.
	b. Air in swing brake system.	**b.** Bleed brake system.
	c. Brake pedal not fully retracted.	**c.** Check brake pedal return spring; repair or replace spring.
	d. Dirty or glazed brake disc.	**d.** Clean or replace disc.
	e. Malfunction of the glide swing power brake valve.	**e.** Repair or replace glide swing power brake valve.
	f. Kinked or bent lines and/or hoses and fittings.	**f.** Straighten or replace as required.
7. Swing brake system will not operate.	**a.** Damaged swing brake release valve.	**a.** Replace release valve.
	b. Damaged glide swing power brake valve.	**b.** Repair or replace glide swing power brake valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace lines and fittings.
8. Swing brake pedal is spongy.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Loose or restricted brake lines or fittings.	**b.** Tighten or replace brake lines and fittings.
9. Swing brake drags.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Damaged swing brake release valve.	**b.** Replace release valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace brake lines and fittings.
10. Boom swings slowly.	**a.** Insufficient hydraulic volume.	**a.** Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	b. Damaged relief valve.	**b.** Adjust, repair, or replace valve.
	c. Damaged swing motor.	**c.** Repair or replace motor.
11. Swing motor continues to operate when swing control is in neutral.	**a.** Hydraulic remote control valve sticking or valve otherwise damaged.	**a.** Repair or replace valve.
	b. Control valve sticking or valve otherwise damaged.	**b.** Repair or replace valve.
12. Swing motor turning in wrong direction.	**a.** Improper port connections.	**a.** Reverse port connection.
13. Swing motor noisy.	**a.** Air in system.	**a.** Refer to *Hydraulic System*, page 2-1, for removal of air from the system.
	b. Motor binding.	**b.** Repair or replace motor.

SWING MOTOR

Description

The swing motor is mounted on the swing brake housing and drives the swing gearbox through the brake assembly (see Figure 6-1). The motor has two ports for connection to the hydraulic system.

Maintenance

Removal

1. Ensure the swing brake and swing lock are engaged.
2. Clean the port area around the motor. Tag and disconnect the hydraulic hoses from the motor assembly. Cap or plug all openings.

CAUTION

Oil can be hot and cause burns.

3. Unscrew the drain plug, filler and level plugs, and drain the oil. After oil is drained, replace the drain plug.

CAUTION

Pull straight up on the motor assembly to avoid damaging the splined shaft.

4. Remove the two screws and separate the motor from the brake flange. Remove and discard the O-ring from the groove in the swing brake.

Installation

CAUTION

Use care when engaging the swing motor drive gear; do not force the shaft to engage.

1. Install a new O-ring in the groove of the swing brake. Position the swing motor on the swing brake.
2. Apply Loctite 243 on the two screws. Install the screws and secure the motor to the brake housing. Torque the screws, refer to *Fasteners and Torque Values*, page 1-12.
3. Replace plugs, extensions, and fill the assembly with oil. Refer to *Lubrication*, page 9-1.
4. Connect the hydraulic lines to the swing motor as tagged during removal.

Test

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING GEARBOX AND BRAKE

Description

The swing gearbox and brake (see Figure 6-1), used in conjunction with the swing motor, rotates and stops the superstructure. A pedal on the cab floor is used to activate the swing brake. The swing gearbox is bolted to the superstructure base plate, and its pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

The swing gearbox utilizes double reduction planetary gearing. The multi-disc swing brake assembly is an integral part of the swing gearbox and is located between the swing motor and the swing gearbox. The brake mechanism is a disc pack that is hydraulically released and spring applied.

Maintenance

NOTE: The swing brake can be removed and disassembled independently of the swing gearbox.

Swing Brake

Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines connected to the swing motor and the brake. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake according to the procedures found in this Section under *Swing Motor*, page 6-7, *Removal*.
4. Remove the capscrews securing the brake to the gearbox. Lift the brake from the gearbox using the flange.
5. Remove and discard the O-ring from the brake housing.
6. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

Installation

1. Install a new O-ring onto the brake housing.
2. Apply Loctite 243 to the brake mounting screws. Install the screws into the brake housing.
3. Install the swing motor into the swing brake according to the procedures found in this Section under *Swing Motor*, page 6-7, *Installation*.
4. Connect the hydraulic lines to the motor and brake.

5. Bleed all air from the brake assembly.

Testing

1. With the Swing Brake Switch in the ON position, position the swing control lever in both directions. Superstructure rotation should not occur.
2. Position the Swing Brake Switch to OFF and swing the superstructure in both directions. Use the swing brake pedal to stop rotation.
3. Check for hydraulic leaks and repair as necessary.

Gearbox

Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines from the swing motor and swing brake. Cap and/or plug all openings.
3. Remove the three bolts securing the pinion gear to the output shaft and remove the pinion gear.

NOTE: The complete gearbox assembly with motor weighs approximately 155 kg (342 lb).

4. Attach a suitable lifting device to the swing gearbox. Remove the hex head screws, washers and bushings securing the gearbox to the mounting plate.
5. Remove the swing gearbox.
6. If necessary, remove the swing motor according to the procedures found in this Section under *Swing Motor*, page 6-7, *Removal*.
7. If necessary, remove the swing brake according to the procedures found in this Section under *Swing Brake*, page 6-7, *Removal*.
8. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

Installation

1. If removed, install the swing brake according to the procedures found in this Section under *Swing Brake*, page 6-7, *Installation*.
2. If removed, install the swing motor according to the procedures found in this Section under *Swing Motor*, page 6-7, *Installation*.
3. Attach a suitable lifting device to the swing gearbox and lift and position the swing gearbox in place on the mounting plate.
4. Install the hex head screws, washers and bushings. Tighten screws; refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the mounting screws.
5. Install the pinion gear on the output shaft and secure with three bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value.
6. Connect the hydraulic lines to the swing brake.
7. Connect the hydraulic lines to the swing motor.
8. Service the gearbox as indicated under *Servicing*.

Servicing

As with all highly stressed mechanisms, reasonable operating procedures are always required. Normal maintenance should only consist of proper lubrication and a periodic check of mounting bolt torque values. Lubrication consists of maintaining the gearbox oil level. Oil in a new gearbox should be drained, flushed out and replaced after approximately 250 hours of operation, and replaced with premium quality SSGL-5 after approximately 500 hours of operation or each year, whichever occurs first. Refer to *Lubrication*, page 9-1. Operation in high humidity or polluted air areas will require more frequent changes to minimize moisture or contaminate accumulation. Change the oil as follows.

1. Unscrew the drain plug; and to ensure all oil has been removed, unscrew filler and level plugs.
2. After oil is drained, replace the drain plug and insert oil through filler plug until it begins to flow out of level plug.
3. Install and tighten the level and filler plugs.

Testing

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the Superstructure to the Carrier. The bearing inner race is bolted to the Superstructure and the outer race is bolted to the Carrier. The inner race contains two grease fittings for lubrication of the bearing which are hosed to two fittings at the front of the turntable center section. The outer race also contains two grease fittings and incorporates gear teeth that mesh with the pinion gear of the swing gearbox to provide rotation.

Maintenance

General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the superstructure and carrier. Therefore, proper care of the bearing and periodic maintenance of the turntable-to-bearing attach bolts -IS A MUST -to ensure safe and efficient operation.

Torquing Turntable Bolts

General

DANGER

Failure to maintain proper torque of the turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the superstructure from the carrier.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.

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! Refer to *Torque Wrenches*, page 1-12 for more information.

Torque Values

Refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the turntable bolts.

Tools Required

Figure 6-3 illustrates and lists the complete set of special tools required to torque the turntable bolts.

Inner Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts to 80% of their specified torque value using the following sequence pattern; 1, 23, 12, 34, 9, 28, 19, and 42 (see Figure 6-2). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to their final torque value specified. The same tools are used as in step 2 (see Figure 6-2).

Outer Race Torquing

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts to 80% of their specified torque value using the following sequence pattern; 1, 21, 11, 31, 6, 26, 16, and 36 (see Figure 6-2). Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to their final torque value specified. The same tools are used as in step 2 (see Figure 6-2).

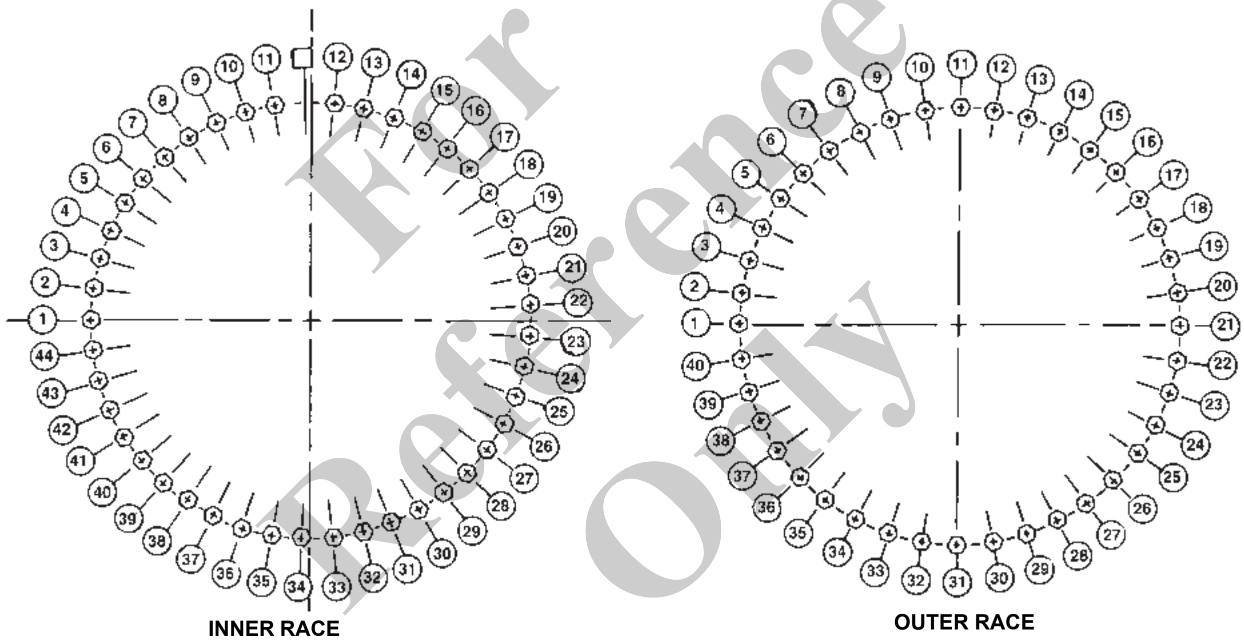
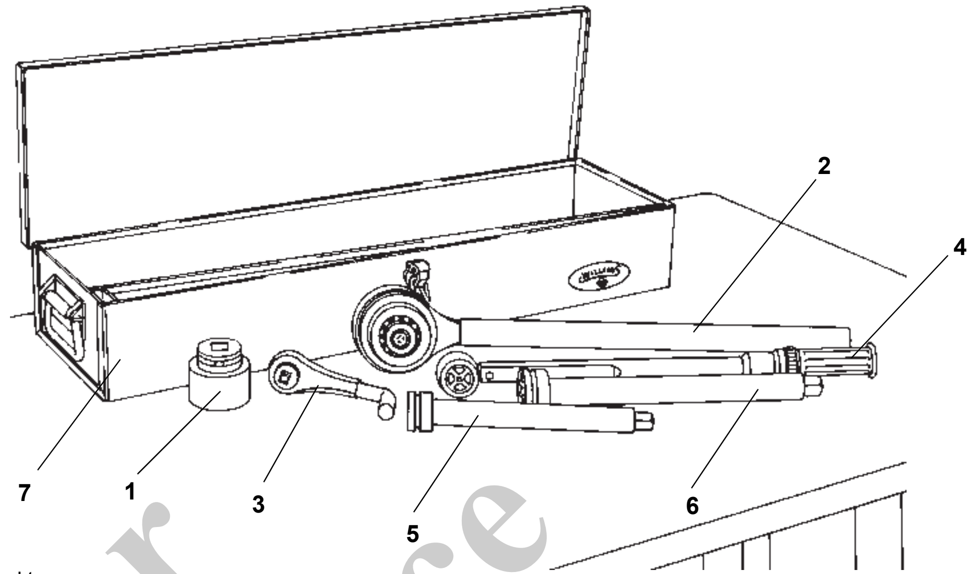


FIGURE 6-2



Orders for special tools shall be referred to:
Manitowoc Crane Care
1565 Buchanan Trail East
P.O. Box 21
Shady Grove, PA 17201
Phone: 717-598-8121
Fax: 717-597-4062

FIGURE 6-3

Description	Grove Part Number	Quantity Required
1. 1 1/2” Socket 3/4” Drive	9999100143	1
2. 4 to 1 Torque Multiplier (1/2” Input 3/4” Output)	9999100134	1
3. Backlash Adapter	9999100141	1
4. 1/2” Drive Torque Wrench	9999100136	1
5. 10” Extension 3/4” Drive	9999100138	A/R
6. 13” Extension 3/4” Drive	9999100137	A/R
7. Tool Box (Optional)	9999100146	1

Removal

1. Remove the counterweight. Refer to the *Operator Manual*.
2. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

3. Ensure the boom is in the travel position and the turntable lock pin is engaged.
4. Elevate the boom slightly and shut down the engine.
5. Tag and disconnect the battery cables from the batteries.
6. Remove the boom and lift cylinder following the procedures outlined in *Boom*, page 4-1.
7. Tag and disconnect all water and oil lines from the bottom of the swivel. Cap or plug all lines and openings.
8. Locate the connectors and ground wire that joins the swivel wiring harness to the receptacles and ground stud on the carrier.

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 at the boom pivot shaft bushings and two at the lower lift cylinder pivot shaft bushings). Take in cable or chain to remove slack. Do not pull up on the superstructure.

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 front or from under the cab.

14. Remove the 40 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.

The bearing weighs between 585 kg (1290 lb) and 642 kg (1415 lb) depending on the bearing used. Ensure the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 44 bolts and washers securing the turntable bearing to the superstructure.
17. Using the lifting device, remove the turntable bearing from under the superstructure.

Inspection

Check the bearing teeth for chipping or cracking. If any evidence of these is found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

Installation

DANGER

Anytime a grade 8 turntable bolt has been removed, it must be replaced with a new grade 8 bolt.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

1. Using an appropriate lifting device, position the turntable bearing under the superstructure. If the same bearing is being used, position it as marked prior to removal.
2. Install 44 new bolts and washers securing the bearing to the superstructure. Refer to *Inner Race Torquing*, page 6-10.

3. Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the front or from under the cab.

4. Install 40 new bolts and washers. Refer to *Outer Race Torquing*, page 6-10.

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 (see Figure 6-4).

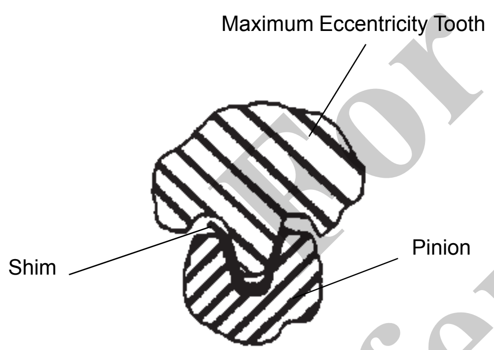


FIGURE 6-4

5. Install the gearbox pinion aligning the high point (maximum eccentricity) on the turntable bearing. Using a 0.203 mm (0.008 in) thick shim, check the backlash (see figure). If the pinion must be moved to achieve proper backlash, contact your distributor.
6. Position the two retainer plates on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure them to the spool with four bolt retainers and eight bolts. Bend all the retainer tabs to make contact with the bolt heads.
7. Plug the swivel wiring harness connectors into the carrier receptacles. Secure the ground wire to the ground stud using a washer, lockwasher, and nut.
8. Install the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel.
9. Connect all water and hydraulic lines to the ports on the bottom of the swivel as tagged during removal.
10. Install the boom and lift cylinder following the procedures outlined in *Boom*, page 4-1.
11. Reconnect the batteries.
12. Check the slew potentiometer in the electrical swivel for proper orientation. Refer to *Swivels* in this section.
13. Install the counterweight. Refer to the *Operator Manual*.

Testing

Activate the crane and check for proper function.

NOTE: If the superstructure does not turn freely after bearing and pinion replacement, contact your distributor.

SWIVELS

Description

The swivel assembly (see Figure 6-5) consists of a 5 port hydraulic swivel, a 2 port water swivel, and a 49 conductor slip ring electrical swivel. Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts, washers and bushings, which connect to mounting lugs on the case. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier by bolts, and bolt retainer plates attached to the swivel retainer plate which engages the carrier frame lugs with bolts and jam nuts. This allows the spool to remain stationary with the carrier as the case rotates with the superstructure.

The spool portion of the water swivel is attached to the spool of the hydraulic swivel by four bolts. The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case contains a lug which is keyed to a corresponding lug on the hydraulic swivel case, causing the water swivel to rotate with the superstructure.

The electrical swivel center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.

6

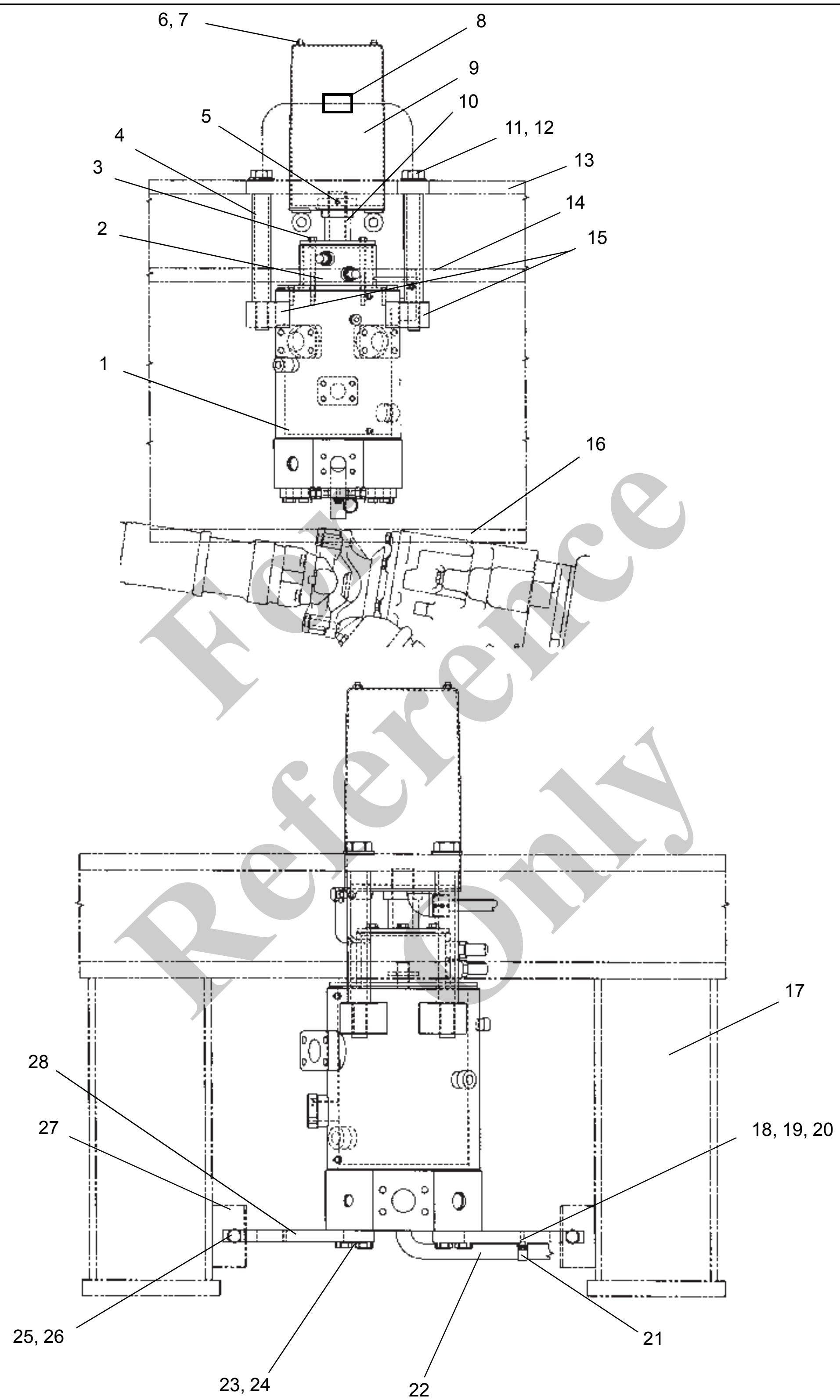


FIGURE 6-5

Item	Description
1	Hydraulic Swivel
2	Water Swivel
3	Mounting Bolts
4	Spacer Bushing
5	Setscrew
6	Nut
7	Washer
8	Slew Potentiometer
9	Electrical Swivel
10	Spacer Bushing
11	Mounting Bolt
12	Washer
13	Turntable Base Plate
14	Carrier Top Plate
15	Mounting Lugs
16	Carrier Bottom Plate
17	Frame
18	Bolt
19	Flatwasher
20	Lockwasher
21	Tubing Clamp
22	Electric Swivel Harness
23	Bolt
24	Bolt Retainer Plate
25	Hex Head Screw
26	Jam Nut
27	Frame Mounting Lugs
28	Retainer Plate

HYDRAULIC SWIVEL

Description

Each of the ports on the spool and case of the swivel is stamped with the port number (see Table 6-1). The function of each port is described below. The hydraulic swivel has four grease fittings on the case. These fittings allow water pump grease (WPG) to fill the channel in the spool and provide a barrier to keep water out of the swivel.

Theory of Operation

The hydraulic swivel allows oil to flow from the pumps to various crane functions on the superstructure. All oil is routed into the spool portion of the swivel where, through a series of internally drilled passages, oil is transferred to circumferential channels on the spool exterior. These channels correspond with a mating port on the outer case of the swivel. Each channel is separated by a series of nylon and O-ring seals that prevent transfer of oil and pressure. Return flow from the crane superstructure is accomplished in the same manner through another set of ports.

Maintenance

Removal

1. Extend and set the outriggers. Ensure the crane is level and the boom is over the front.
2. Elevate the boom and note at what boom angle, you have the most clearance between the lift cylinder and the turntable side plate. Shut down the engine.
3. Measure the distance from the top of the lift cylinder to the base of the boom section where the lift cylinder attaches. Cut two pieces of 10 x 10 cm (4 x 4 in) oak to fit.

NOTE: It might be necessary to raise the boom slightly to allow installation of the blocking.

Table 6-1

Port #	Test Pressure bar (psi)	Function
1	170 (2500)	Air Conditioning
2	34 (500)	Dual Return
3	240 (3500)	Swing
4	240 (3500)	Lift/Tele/Hoist
5	34 (500)	Drain
A	2.1 (30)	Heater Supply (Coolant)
B	2.1 (30)	Heater Return (Coolant)

NOTE: This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use the oak blocking to block between the barrel of the lift cylinder and the boom Section 1.
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 and superstructure receptacles and the yellow ground wire from the weld stud on the carrier and superstructure frame. If necessary, remove the electrical swivel. Refer to *Electrical Swivel*, page 6-18.

NOTE: The hydraulic swivel weighs approximately 117 kg (258 lb). The hydraulic, water, and electrical swivel combined weigh approximately 142 kg (313 lb).

9. On the bottom of the swivel, bend the retainer tabs away from the bolt heads. Remove the eight bolts and four bolt retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: It may be necessary to remove some drive line components to remove the swivel.

10. Position an adequate supporting device beneath the swivel.
11. Remove the 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 117 kg (258 lb). The hydraulic, water, and electrical swivel combined weigh approximately 142 kg (313 lb).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews, and washers. Properly torque the bolts, refer to *Fasteners and Torque Values*, page 1-12.
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 bolts and four bolt retainers. Apply Loctite 271 to the bolt threads. Refer to *Fasteners and Torque Values*, page 1-12 for the torque value for the eight retainer plate bolts. Bend all the retainer tabs to make contact with the bolt heads. Tighten the four retainer plate capscrews, leaving a maximum 0.79 mm (1/32 in) gap between each bolt and lug on carrier frame, then tighten the locking nuts.
4. If removed, install the electrical swivel. Refer to *Electrical Swivel*, page 6-18. Connect the swivel wiring harness connectors to the carrier and superstructure receptacles and the yellow ground wire to the weld stud on the carrier and superstructure frame. Secure ground wire with washer, lockwasher and nut.
5. Install the clamp, lockwasher, flat washer and hex head bolt 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 2 port water swivel allows engine coolant to flow from the carrier-mounted engine to the hot water heater in the operator's cab. Through an internally drilled passage in the 5 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 6-15, *Removal* in this section.
2. Remove the electrical swivel. Refer to *Electrical Swivel*, page 6-18, *Removal* in this section.
3. Tag and disconnect the lines from the case of the water swivel. Cap or plug all lines and openings.
4. Remove the bolt and shim(s) from the water/hydraulic swivel keying lugs.
5. Remove the four bolts 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

DANGER

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid prolonged skin contact, inhalation of vapors, or smoking. Failure to comply can result in injury or death to personnel.

1. Clean the spool and case with a suitable solution and dry with compressed air. Plug all ports with plastic caps.
2. Check the spool and inside of the case for scratches, grooves, scoring, etc. If any grooves have developed with a depth of 0.127 mm (0.005 in) the unit should be replaced.

Assembly

NOTE: Lubricate the interior of the swivel to prevent rusting from condensation.

1. Lubricate the spool, seals, and rings.

CAUTION

When installing seals and rings, avoid stretching seals or scratching grooved 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 6-18, *Installation* in this Section.
5. Perform steps 8 and 9 of *Hydraulic Swivel*, page 6-15, *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 49 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 harnesses which are routed downward through the center of the hydraulic swivel. Extending from the base of the hydraulic swivel, the collector ring leads are also formed into connectors which plug into receptacles from the chassis power supply.

The swivel cover is secured with a seal and bolts

The electrical swivel also incorporates a slew potentiometer. The potentiometer controls functions in the rated capacity limiter and working area definition systems.

Theory of Operation

The electrical swivel is located on top of the water swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity between the carrier and superstructure.

Maintenance

Removal

1. Perform steps 1 through 4 of *Hydraulic Swivel*, page 6-15, *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 *Battery*, page 3-1.
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.

NOTE: The large flat connector is too large to go through the center of the hydraulic swivel. It must be removed.

5. Disconnect the yellow ground wire from the weld stud on the carrier frame.
6. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.
7. Tag each wire on the large flat connector. 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. For a list of the appropriate pin removal tools, refer to *Electric System*, page 3-1.
8. Secure the wires from step 7 together so the harness can be withdrawn through the center of the hydraulic swivel.
9. Tag and disconnect the connectors from the receptacles on the cab bulkhead mounting plate. Disconnect the yellow ground wire from the weld stud on the superstructure frame.
10. Remove the nuts and washers, and remove the cover from the electrical swivel.
11. Loosen the setscrews securing the electrical swivel mounting tube to the center post on the water swivel.
12. 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.

13. Remove the swivel and wiring harness from the crane. If necessary, remove the spacer bushing from the center post.

Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic and water swivels.

NOTE: The boom should be centered directly over the front of the crane before adjustment is made to the slew potentiometer.

2. Slide the electrical swivel mounting shaft onto the center post.
3. Ensure the threaded hole on the bottom of the electrical swivel base is aligned with the mounting hole in the bracket on the water swivel case. Install the bolt through the hole in the bracket and install the nut. Screw the bolt into the hole in the electrical swivel base until the bolt head is approximately 6.4 mm (0.25 in) from the bracket. Tighten the nut against the electrical swivel (see Figure 6-6).

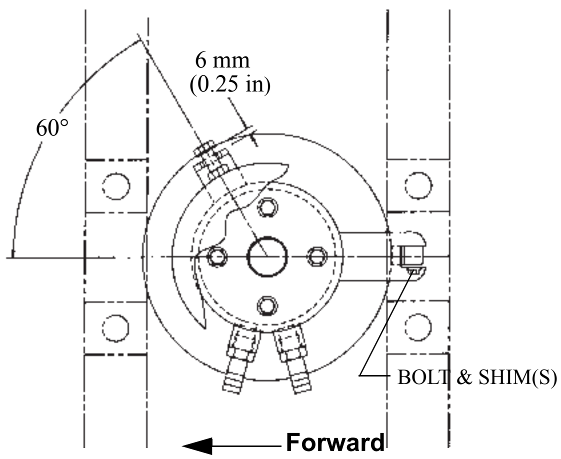


FIGURE 6-6

4. Apply Loctite to the set screws securing the electrical swivel to the center post and tighten.
5. Install the swivel cover and secure with two nuts and washers.
6. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal. Attach the yellow ground wire to the weld stud on the superstructure frame. Secure ground wire with washer, lockwasher and nut.
7. Unbundle the wires of the collector core wiring harness. Install the pins, with wire attached, to the large flat connector as tagged during removal.
8. Plug the large flat connector into the carrier wiring receptacle, connect red, black, and white wire connectors and install the yellow ground wire to the weld stud on the carrier frame. Secure the yellow ground wire using a washer, lockwasher, and nut.
9. Install the clamp securing the harness to the retainer plate on the bottom of the hydraulic swivel assembly.
10. Connect the batteries.

CAUTION

It is imperative that the slew potentiometer be adjusted anytime work is done to the electrical swivel.

11. Activate all systems, cycle all functions, and observe for proper operation. Adjust the slew potentiometer in accordance with *Slew Potentiometer Adjustment* procedures in this Sub-Section.

Preventative Maintenance

It is recommended that a normal inspection of the electrical swivel collector ring and brush assembly be established. An example of this could be at approximately 100 to 150 engine operating hours. When this time limit is reached, perform the following.

1. Check the collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check the collector ring setscrews and ensure they are tight.
3. Check the brush and arm assembly springs. Ensure they are holding the brushes firmly against the collector rings.

Slew Potentiometer Preliminary Zero Adjustment Procedure

1. Rotate the superstructure over the front and engage the lock pin.

NOTE: Refer to the *PAT Rated Capacity Limiter Operator's Handbook* for detailed instructions. Complete the RCL console setup according to the crane's current operating configuration.

2. Press the 1 keypad button on the RCL console.
3. Press the CTRL keypad button on the RCL console.
4. Enter authorization code 64356, then press the return keypad button on the RCL console.
5. Press the return keypad button two more times to display the slew adjustment screen.
6. Press the + and the - keypad buttons on the RCL console simultaneously. Note the indicator line moves to zero on the bar graph on the slew adjustment screen.
7. Press the ESC keypad button on the RCL console.

Slew Potentiometer Adjustment

1. Rotate the superstructure over the front and engage the lock pin.
2. Set the RCL console to read slewing angle as follows:

NOTE: Refer to the *PAT Rated Capacity Limiter Operator's Handbook* for detailed instructions.

- Complete the RCL console setup according to the crane's current operating configuration.
- Press limits LIM.
- Press 4 for slew angle/work area definition limits.
- Press 1 for slew angle.
- Press 2 or 3 to display slewing angle.

3. Remove the electrical swivel cover.

6

CAUTION

Do not attempt to rotate the slotted shaft in the center of the slew potentiometer.

4. Disengage the swing lock pin and swing the superstructure approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the swing lock pin.

NOTE: If the superstructure swings past the swing lock pin engaged position, step 4 must be repeated.

5. Loosen the three screws that secure the slew potentiometer to the mounting plate.
6. Rotate the body of the slew potentiometer until the slew angle indicates 0.6 ± 0.1 degree.

NOTE: The slew angle indication in step 6 may not be obtainable due to limited wire length on the potentiometer, or the electrical terminals interference with one of the three mounting screws. If this occurs, reposition the collar set screwed to the potentiometer shaft and repeat steps 4 thru 6.

7. Tighten the three screws that secure the slew potentiometer to the mounting plate. Install the electrical swivel cover.
8. Disengage the swing lock pin and swing approximately 10 degrees to the left (counter clockwise). Slowly swing back to the right and engage the swing lock pin.

NOTE: If the superstructure swings past the swing lock pin engaged position, step 8 must be repeated.

9. If the angle indicated on the console does not exceed ± 1.0 degree, proceed to step 10. If the indicated angle exceeds ± 1.0 degree, return to step 4.
10. Disengage the swing lock pin and swing approximately 10 degrees to the right (clockwise). Slowly swing back to the left and engage the swing lock pin.

NOTE: If the superstructure swings past the swing lock pin engaged position, step 10 must be repeated.

11. If the angle indicated on the console does not exceed ± 1.0 degree, proceed to step 12. If the indicated angle exceeds ± 1.0 degree, return to step 3.
12. Disengage the swing lock pin and swing approximately 10 degrees to the left (counter clockwise). Slowly swing back to the right and engage the swing lock pin.

NOTE: If the superstructure swings past the swing lock pin engaged position, step 12 must be repeated.

13. Verify the angle indicated on the console does not exceed ± 1.0 degree. If the indicated angle exceeds ± 1.0 degree, return to step 3.

SWING LOCK PIN

Description

The purpose of the swing lock pin is to lock the superstructure in position directly over the front or over the rear. The pin swing lock installation consists of a large pin, a control handle in the right side of the superstructure cab, and control linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front or rear, pushing the control handle down drops the swing lock pin into a socket on the carrier frame, locking the superstructure in place. Pulling the control handle up pulls the pin out of the socket, unlocking the superstructure.

Maintenance

Verify linkage is installed to avoid damage from superstructure rotation and is undamaged. Verify pin, turntable bushing pin passes through, and both sockets on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage is adjusted properly. If it is, the pin bottom will stick out about 5.8 cm (2.3 in) from the bottom of its bushing in the turntable. (If it is too far in, it might not lock properly. If it is too far out, it might hang up). Using the jam nuts on the linkage parts, adjust the linkage so the pin bottom will stick out about 5.8 cm (2.3 in) from the bottom of its bushing in the turntable; verify the superstructure can lock properly and the superstructure can rotate without lock pin hangup.

360° SWING LOCK CONTROL (POSITIVE LOCK TYPE) (OPTIONAL)

Description

The purpose of the swing lock is to secure the superstructure in position at one of the positions in its rotation. There are roughly 120 spots about 3.0 degrees apart for the superstructure to lock to in its 360 degree of rotation. The 360 degree swing lock control pedal is on the left side of the superstructure cab floor, left of the swing brake pedal. Pushing the swing lock control pedal down engages the lock between the teeth of the swing gear. Pulling up on the release lever allows the swing lock control pedal up disengaging the lock.

Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify swing lock assembly is undamaged and working properly. Verify spring is undamaged and has enough strength to pull blade of swing lock assembly completely out of the gear teeth when the control pedal is allowed 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 pushed down. Verify all attaching hardware is secure and undamaged. Make adjustments as needed.

If the swing lock assembly is damaged, install a replacement. Align the blade of the swing lock assembly so it will fall between gear teeth. Use the shim and the related attaching hardware (two 5/16-18 screws and 5/16 ID lockwashers) to ensure the swing lock assembly stays in place and can lock up the superstructure. Tighten the four mounting bolts; refer to *Fasteners and Torque Values*, page 1-12 for the torque value.

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SECTION 7
POWER TRAIN

SECTION CONTENTS

DESCRIPTION

The carrier engine (see Figure 7-1) is a Cummins ISX 11.9 EPA OBD II 2013 on-highway emissions certified engine or a Cummins QSM EPA Tier 3 certified engine.

This Service Manual does not include detailed information on these individual engines. 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 are provided in this section.

Engine speed is controlled from the carrier cab by a foot throttle pedal connected electronically to the engine Electronic Control Module (ECM). Speed is electronically controlled in the same manner from the superstructure cab by either a foot throttle pedal or hand throttle. The ECM 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.

The engine and its components are enclosed within a hood assembly. The hood has openings in the front and rear to allow for adequate air flow over the engine. A door on the top left and right side of the hood may be opened to provide easier access to the engine.

The air intake filter is located on the right side of the engine on the fender. The muffler is located on the left side behind the cab. It is mounted to the boom rest support.

To aid in starting the engine in cold weather, an automatic cold weather starting aid injection system is provided. When the engine ECM determines the need the automatic cold start solenoid is activated when the engine is started, providing an injection of starting fluid to the engine. The system consists of a solenoid valve, starting aid container, and the necessary connecting tubing and wiring from the ECM. The solenoid and container are mounted inside the hood on the left side. An immersion type engine block heater is also provided.

MAINTENANCE

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 left and right hood access doors.
4. Disconnect the air filter tubing at the engine and air cleaner. Remove and lay aside.
5. Tag and disconnect charge air cooling hoses from the engine and the charge air cooler. Cap or plug all openings.
6. Drain the engine lubricating systems.
7. Drain the transmission lubricating systems.
8. Drain the engine coolant system.
9. Tag the starting aid (ether) tubing. Disconnect the tubing from the injector nozzle on the engine intake manifold. Cap or plug the openings of the tubing and the injector. As needed, remove ether cylinder to prevent ether discharge.
10. Remove the bolts, washers, lockwashers, and nuts securing the start relay to the hood. Lay the relay with the harness on the engine.
11. Disconnect the muffler exhaust tubing at the engine and after treatment assembly (muffler). Remove the tubing clamp bracket and exhaust bracket from the rear of the engine and remove the tubing from the engine.
12. Unplug after treatment assembly wiring harness from carrier harness and after treatment assembly, and unstrap from boom rest tie bars.
13. Remove the engine hood assembly, counterweight stowage frame work and decking over transmission.
14. Leave the pump drive and Pump No. 1 in place on the engine and transmission.

NOTE: After treatment assembly weighs approximately 102 kg (224 lb). Ensure lifting device is sufficient to lift the boom rest and after treatment assembly.

15. Attach an adequate lifting device and remove the boom rest and after treatment assembly.
16. Tag and disconnect the engine electrical connections from the starter and the alternator, the starting aid valve connector, and the battery cables.
17. Tag and disconnect the transmission oil lines to the filter and oil cooler. Cap or plug all openings.
18. Disconnect and remove the drive line from the transmission. Refer to *Drive Train* on page 7-29.
19. Tag and disconnect all lines to the radiator and air cooler. Remove the radiator assembly and fan. Cap or plug all openings.

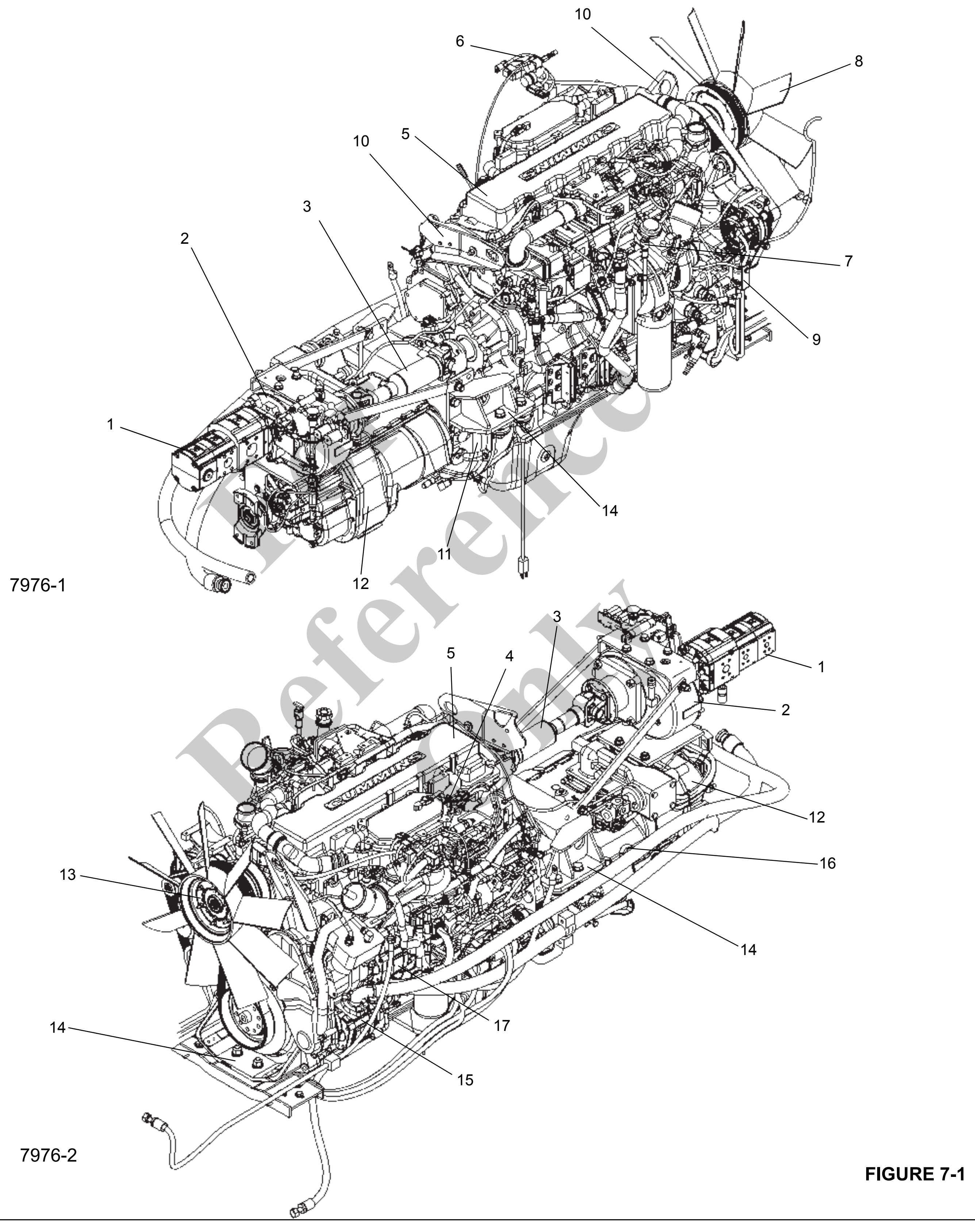


FIGURE 7-1

Item	Description
1	Three Section Pump
2	Pump Drive
3	Prop Shaft
4	Pressure Switch Assembly
5	Engine Assembly
6	Fan Clutch Sol
7	Dipstick
8	Fan
9	Oil Pressure Sender
10	Lifting Lug
11	Clutch Assembly
12	Transmission
13	Fan Clutch
14	Engine Mount
15	Two Section Pump
16	Transmission Check Plug
17	Steering Pump

20. Tag and disconnect the heater hoses. Cap or plug all openings.
21. Tag and disconnect the fuel lines to the engine. Cap or plug all openings.
22. Tag and disconnect all air lines to the engine components, transmission, and pump drive. Cap or plug all openings. Move the tubing out of the way so it is not damaged during the removal of the engine and transmission assembly.
23. Tag and disconnect the hydraulic lines to Pump No. 1 and to Pump No. 2 on the transmission and on the engine. Cap or plug all lines and openings.
24. Tag and disconnect all linkages and cables to the engine, engine components, and transmission.
25. Attach an adequate lifting device to the engine and transmission sufficient to lift and support both the engine, transmission, and pump drive. Locate the rear engine lifting bracket bolted to the exhaust tube support bracket and install it where the tubing clamp bracket was removed. Use the hardware from the exhaust bracket and torque the bolts to 113 Nm (83 lb ft).

NOTE: The engine, transmission, and pump drive assembly weighs approximately 1800 kg (3960 lb).

26. With the lifting device supporting the weight of the engine, transmission, and pump drive, remove the bolts, washers, lockwashers, nuts and bonded mounting centers from the front engine mounting support and the transmission mounting brackets.
27. Carefully lift the engine assembly from the crane and move it to a clean work area.
28. If a new engine is to be installed, remove the pump drive, both pumps, the transmission, and all engine installed components, fittings, etc. from the old engine and install them on the new engine in the same locations. Refer to *Manual Transmission* on page 7-42 for transmission removal and installation. Refer to *Pump Drive* on page 2-15 for pump drive removal and installation.

Ensure that the same grade hardware, torque values, and loctite as were installed by the factory are used.

Installation

1. Attach adequate lifting device to the engine and transmission sufficient to lift and support both the engine and transmission. With all components and fittings installed on the engine, lift the engine assembly (including the transmission and pumps and pump drive) into the crane.
2. With the engine assembly in position, install the bolts, washers, lockwashers, nuts, and bonded mounting centers on the front engine mounting support and on the transmission mounting brackets. Torque the bolts to factory specifications as defined in *Fasteners and Torque Values* on page 1-12.
3. Remove the lifting device from engine and transmission.
4. Connect all linkages and cables to the engine, engine components, and transmission as tagged during removal.
5. Connect all hydraulic lines to Pump No. 1 and Pump No. 2 as tagged during removal.
6. Connect charge air cooling hoses to engine and charge air cooler as tagged during removal.
7. Connect all air lines to the engine components, transmission, and pump drive as tagged during removal.
8. Connect the fuel lines to the engine as tagged during removal.
9. Connect the heater hoses as tagged during removal.
10. Install the radiator assembly and fan. Connect all lines to the radiator and air cooler as tagged during removal.
11. Connect the drive line to the transmission. Refer to *Drive Train* on page 7-29.
12. Connect the filter and oil cooler oil lines to the transmission as tagged during removal.

13. As needed, install ether cylinder if removed earlier.
14. Connect the battery cables, starting aid valve connector, and engine electrical connections as marked during removal.
15. Attach lifting device to and install the boom rest and after treatment assembly.
16. Install the engine hood assembly, counterweight stowage frame work, and the removed decking.
17. Plug after treatment wiring harness to carrier harness and after treatment assembly and install straps to the boom rest tie bars.
18. Remove the rear engine lifting bracket from the engine and bolt it on the exhaust tubing clamp mounting bracket (Figure 7-2). Install the exhaust tubing clamp mounting bracket where the lifting bracket was removed. Install the exhaust tubing and connect it to the engine.

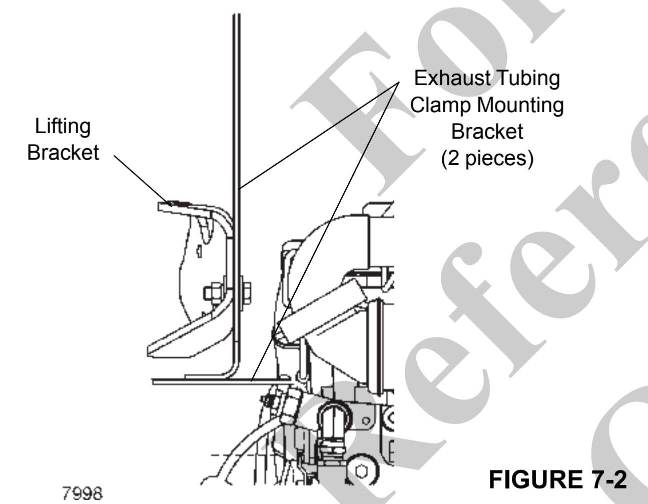


FIGURE 7-2

19. Connect the starting aid tubing to the nozzle in the intake manifold. Verify the nozzle orifice points upstream.
20. Connect the air cleaner tubing at the engine and air cleaner.
21. Service the engine lubricating system, hydraulic reservoir, and the engine cooling system.
22. Connect the battery.
23. Position the start relay on the inside of the hood and secure with the bolts, washers, lockwashers, and nuts.
24. Fill the transmission with SAE GRADE 50 synthetic gear lubricant (Spec. 6829013433).
25. Prime the fuel system and hydraulic pumps and start the engine. Check all hoses for leaks.
26. Run the engine and transmission to fill the transmission cooler and its lines to and from the transmission. Stop the engine, check the transmission fluid level again, and add SAE GRADE 50 synthetic gear lubricant to fill the transmission to the full mark.
27. Shut down the engine and check all fluid levels.

7

Engine Drive Belts

The proper operation of engine belt-driven components such as the alternator, fan clutch, and water pump depend on the proper condition and tension of the engine drive belts.

NOTE: Belt tension is maintained with an automatic belt tension device.

The engine drive belt should be inspected visually (Figure 7-3) 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 belts, or by oil, grease, or hydraulic fluid on the belt.

Refer to the engine manufacturer's manual for any special tools or belt tension specifications.

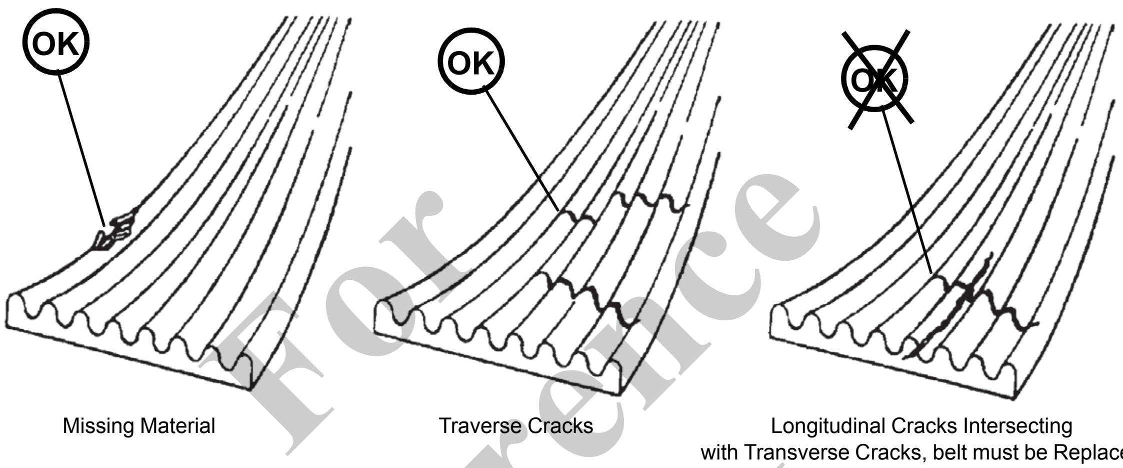


FIGURE 7-3

ENGINE CONTROL SYSTEM

Description

The engine control system is an electronically operated fuel injection system that optimizes fuel economy and reduces exhaust emissions. It accomplishes this by controlling the torque and horsepower curve, air fuel control function, engine high speed, low idle and road speed. The system monitors critical engine temperatures and pressures, and will log diagnostic faults when an abnormal operating condition occurs. If an out of range condition exists, and engine derate action is to be initiated, the operator will be alerted by an in-cab warning light. The warning light will flash when out-of-range conditions continue to get worse.

NOTE: See Operator Manual for additional information on “Engine Controls and Indicators”

Functional Operation

Five key switch phases govern the operation of the engine control system:

1. Ignition switch in the on position, engine diagnostics idle switch off, engine not cranking or running.
2. Ignition switch in the on position, engine diagnostics idle switch on, engine not cranking or running.
3. Ignition switch in the on position, engine cranking.
4. Ignition switch in the on position, engine running, engine diagnostics idle switch off.
5. Ignition switch in the on position, engine running, engine diagnostics idle switch on.

With the ignition switch on, the diagnostic test switch off and the engine not cranking or running, the Electronic Control Module (ECM) performs diagnostic and status operations. It reads the logic inputs from the brake, clutch, and cab switches and analog inputs from sensors such as the engine coolant temperature sensor and the manifold boost pressure sensor. During this phase the data link is active and can be accessed by the applicable service tools. The ECM opens the fuel shutoff valve so the engine is ready to be started.

Additionally when the key switch is turned on but the diagnostic switch remains off, the indicator lights illuminate for approximately two seconds to verify they are working and then go out. This is part of the normal operation of the power-up sequence. However, if an active fault is present, one of the lights remains illuminated, determined by the type of fault being sensed.

When the engine diagnostics idle switch is turned on, the red and amber indicator lights illuminate and remain illuminated if there is no active fault. If there is an active fault, the lamps flash in a sequence of pulses to indicate that specific fault code.

During the cranking phase, with the ignition switch in the start position, the ECM commands all of the fuel needed to start the engine. There is no need to use the throttle pedal while cranking the engine.

While the engine is cranking the ECM is performing additional diagnostic and status operations. An active fault causes one of the two indicator lamps to illuminate and remain lit. Which lamp is illuminated depends on the severity of the fault.

Normal operation occurs when the engine is running and the engine diagnostics idle switch is off.

Engine Control System Switches and Indicator Lights

Engine Diagnostics/Idle Switch (+/-)

This switch is a two position (+/-) momentary rocker switch on the right side panel in the carrier cab. It provides idle-control inputs that increase and decrease the engine idle during normal operating mode, or diagnostic code inputs when in diagnostic mode.

Regen Initiate/Inhibit Switch

This switch, located on the right side of the front console in the carrier cab, is used to initiate or inhibit a stationary exhaust regeneration. The switch must be cycled on and off to initiate regeneration. The Regen Inhibit Switch is a maintained ON switch, when selected to manually override the regen process.

The clutch and brake pedals must also be released. The engine will automatically change speed as needed. The cycle will take approximately 20 minutes.

If regeneration (active or stationary) is not desired, press the inhibit side (bottom) of the switch. The regeneration inhibit indicator should illuminate. When the switch is in the center position, the engine will perform an active regeneration as it requires and is able.

Hand Throttle Switch (Engine Increment/ Decrement Switch)

This switch, located on the right side console in the superstructure cab, is used to set the engine operating speed. It is a two position (+/-) momentary switch.

Pushing the top of the switch quickly increases (+) engine RPM to the maximum allowed operating speed. Pushing the bottom of the switch quickly decreases (-) engine RPM to idle speed. Pushing and holding either side of the switch will increase or decrease engine speed. Releasing the switch will hold the engine at the current speed. Pressing the foot pedal will increase engine speed above the “hold” speed. Releasing the foot pedal causes the engine to return to the “hold” speed.

Engine Stop Light

The engine stop light is located at the top of the front console in the carrier cab. It is a red indicator light that illuminates to signify a serious engine problem that requires the vehicle and the engine to be stopped as soon as safely possible.

In addition to alerting the operator of system faults, the engine stop light, along with the engine warning light, is used in the diagnostic operation of the engine control system.

NOTE: When not using the diagnostic system, turn the engine diagnostic switch to the OFF position.

The diagnostic mode begins when the ignition and engine diagnostic switches are on and the engine is not running. The amber light flashes at the beginning of a fault code sequence, the red light flashes the three- or four-digit code for the active fault and the amber light flashes again to separate the previous red light sequence from the next one. Each code will be flashed once before moving to the next code. When all codes have been flashed, the sequence will begin again. If no codes are present, both the warning and stop lights will remain on.

Engine Warning Light

The engine warning light is located at the top of the front console in the carrier cab. It is an amber indicator light that is a part of the engine's electronic control system and when illuminated, gives the operator a signal that there is an engine problem which must be corrected.

In addition to alerting the operator of system faults, the engine warning light, along with the engine stop light, is used in the diagnostic operation of the engine control system.

NOTE: When not using the diagnostic system, turn the engine diagnostic switch to the OFF position.

The diagnostic mode begins when the ignition and engine diagnostic switches are on and the engine is not running. The amber light flashes at the beginning of a fault code sequence, the red light flashes the three- or four-digit code for the active fault and the amber light flashes again to separate the previous red light sequence from the next one. Each code will be flashed once before moving to the next code. When all codes have been flashed, the sequence will begin again. If no codes are present, both the engine warning and engine stop lights will remain on.

Fault Code Flashing Sequence

The amber engine warning light flashes at the beginning of a fault code sequence. There will be a short 1- or 2-second pause after which the number of the recorded fault code will flash in the red engine stop light. To interpret the flash code, count the first sequence of red flashes for the first digit and after a two second delay, count the second sequence of red flashes for the second digit. when the number has finished flashing in red, the amber engine warning light flashes again. The lamps flash each fault code one time before advancing to the next code. To skip to the next fault code, move the engine diagnostics idle switch in either position (+/-) to see other fault codes. If only one active fault is recorded, the control system will continuously display the same fault code when pressing the engine diagnostics idle switch. Refer to the engine manufacturers service manual for explanation and correction of the fault codes.

Regen Needed/Inhibit Indicator

This dual lamp indicator is located on the right side of the front console in the carrier cab.The upper lamp is used to indicate when the first level of exhaust regeneration is needed. The Inhibit Indicator is illuminated when Regen Inhibit Switch has been activated.

High Exhaust Temp Indicator

The high exhaust temp indicator lights when an active exhaust regeneration has been initiated and the exhaust temperatures will be elevated above normal levels for the vehicle operating conditions This can occur while driving or during a manually initiated “stationary regeneration”.

WARNING

While regenerating, ensure the exhaust is not aimed at any surface or material that will melt, burn, or explode.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, fuel filter-water separator, injection fuel pump, the fuel injectors, and fuel cooler.

Fuel Tank

The fuel tank is located on the left side of the crane. The tank has a capacity of about 380 liters (100 gal). Two connections on the tank provide for fuel supply to the engine and return of surplus fuel from the engine. The tank is equipped with a spin-type filler cap and a fuel quantity sender unit which provides a signal to a quantity indicator on the instrument panels.

Injection Fuel Pump

The fuel oil is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is metered also, before injection, to meet the load requirements imposed upon the engine.

Surplus fuel, returning from the injectors, is bypassed back through the fuel cooler, to the fuel tank. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

Fuel Filter-Water Separator

The fuel filter-water separator (Figure 7-4) removes impurities from the fuel and also removes water from the fuel before it reaches the engine.

The fuel mixture passes through the outer wrap of the first stage of the filter paper, where large droplets of water, removed from the fuel, are formed. The water droplets drain into a void between the two paper elements and to a reservoir in the bottom of the housing, where it can be drained through a petcock.

The fuel level will initially only rise to a low level in the clear filter bowl, as the filter becomes dirty the fuel level will rise. When the fuel level reaches the indicated mark, filter replacement is required.

Draining

The sump of the fuel filter-water separator should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure.

1. Place a suitable container under the filter and open the drain plug.
2. Drain until fuel appears.
3. Close the drain plug.

Filter Replacement

When the filter is clean, fuel will be seen at a very low level through the transparent filter cover. As the filter element plugs, the fuel level will rise. When the fuel level reaches the top of the cover it is time to change the filter element.

Maintenance

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. Place a suitable container under the fuel tank and drain all fuel from the tank.
2. Tag and disconnect the two lines from the tank.
3. Disconnect the electrical lead from the fuel quantity sender unit.
4. Remove the hardware securing the tank in place and using a suitable lifting device, remove the fuel tank.
5. If a new tank is to be installed, remove the two fittings, the fuel quantity sender, and steps from the tank and install them on the new tank.

Installation

1. Position the tank and install the hardware securing the tank in place.
2. Connect the electrical lead to the fuel quantity sender unit.
3. Connect the two lines to the fittings on the tank in accordance with the identification marks made during removal.

NOTE: ISX engines require the fuel return line be connected to the lower port on the side of the tank, QSM engines require the fuel return line be connected to the top port.

4. Service the tank.

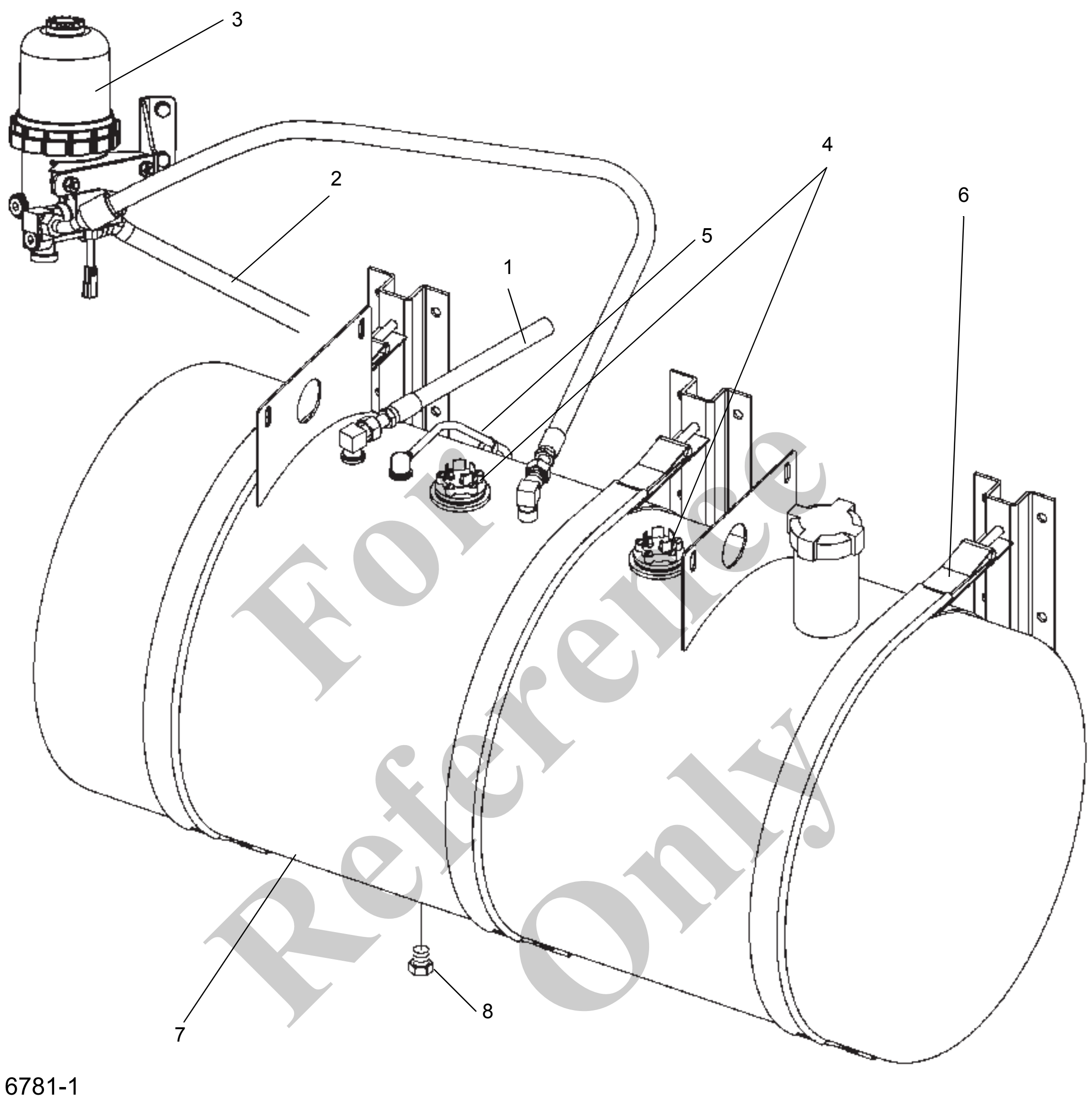


FIGURE 7-4

Item	Description
1	Fuel Return Line - From Fuel Cooler (QSM shown)
2	Fuel Supply Line - To Engine
3	Fuel Filter-Water Separator
4	Fuel Level Senders

Item	Description
5	Vent Tube
6	Mounting Strap
7	Fuel Tank
8	Plug

AIR INTAKE SYSTEM

Description

The engine air intake system (Figure 7-8) consists of an air cleaner and associated piping for channeling the air from the atmosphere to the engine intake manifold.

The air cleaner is the dry-type with a replaceable element. It is located on the right front fender. A service indicator, designed to indicate red when servicing is required, is installed at the air cleaner outlet.

The automatic cold weather starting system consists of ECM wiring, valve assembly, and starting fluid bottle and tubing. The quick start system is activated to facilitate engine starting during cold temperatures. When activated, the system actuates the valve assembly, passing starting fluid from the bottle through the atomizer into the air intake manifold where it mixes with the intake air to facilitate engine combustion.

Maintenance

Troubleshooting

Dust passing the air cleaner, even through small holes, can cause rapid engine wear. Ensure all connections between the air cleaner and the engine are tight and sealed. If these connections are all well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Ensure the element 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. Any damaged parts must be replaced.
5. Inspect the restriction indicator tap for leaks.

Check For Filter Restriction

As a dry cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (at the air cleaner outlet) increases.

The vacuum is generally measured as restriction in inches of water. The engine manufacturer places a recommended limit on the amount of restriction the engine will stand without loss in performance before the element must be cleaned or replaced. Cummins allows a vacuum of 0.062 bar (25 inches of water) 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.

Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

1. Release the latch and open the air cleaner body, and withdraw the element as follows:
   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. Gently move the end of the filter up and down and side to side or twist to break the seal.

FIGURE 7-5

b. AVOID DISLODGING DUST FROM THE FILTER. Gently pull the filter off the outlet tube and out of the housing. Avoid knocking the filter against the housing.

c. Carefully remove the safety element from the housing.

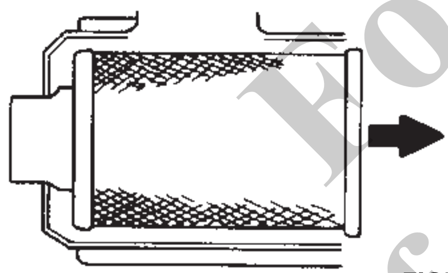


FIGURE 7-6

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 elements into the air cleaner body as follows:

a. INSPECT THE FILTER FOR DAMAGE. Always look for filter damage, even if a new filter element is being installed. Pay special attention to the inside of the open end (sealing area). Do not install a damaged filter.

b. INSERT THE FILTER PROPERLY. The seal area is on the inside of the open end of the primary filter. A new filter has a dry lubricant to aid installation. The critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly. To complete a tight seal, apply pressure at the outer rim of the filter, not the flexible center. No cover pressure is required to hold the seal.

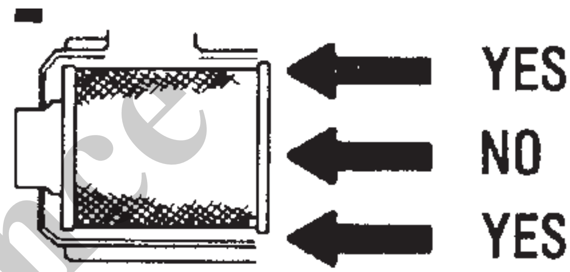


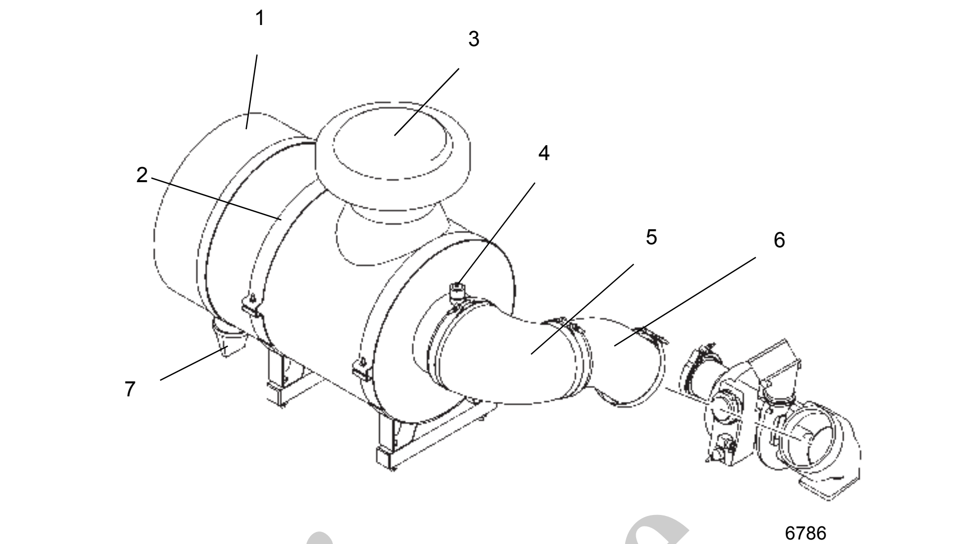
FIGURE 7-7

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.

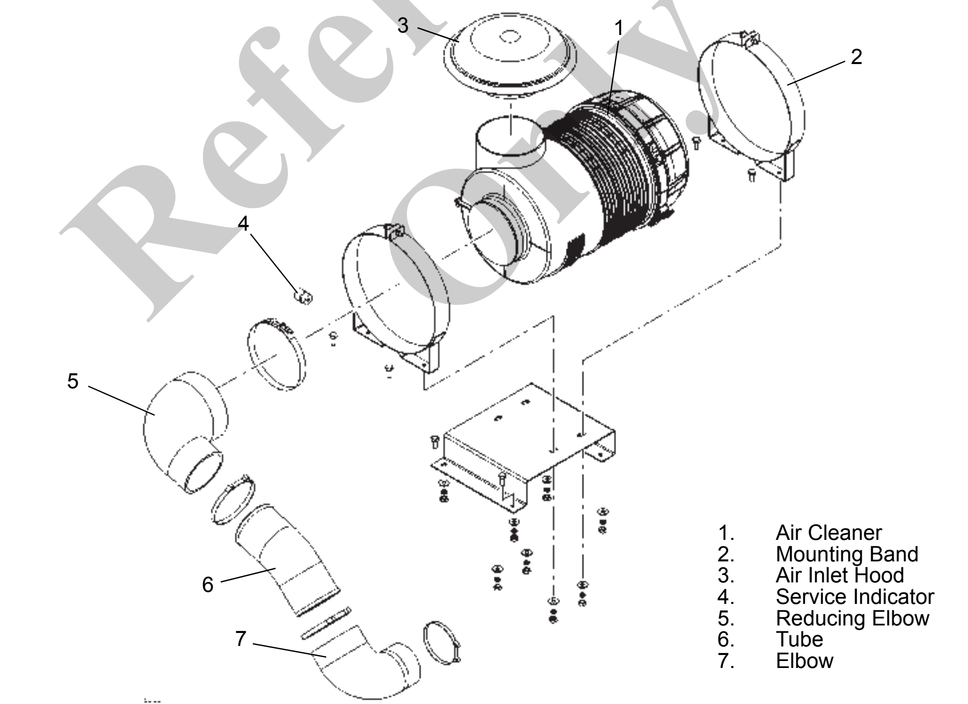
Element Cleaning

It is not recommended that either filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.



1. Air Cleaner
2. Mounting Band
3. Air Inlet Hood
4. Service Indicator
5. Reducing Elbow
6. Tube
7. Vacuator Valve

QSM AIr Intake Installation



1. Air Cleaner
2. Mounting Band
3. Air Inlet Hood
4. Service Indicator
5. Reducing Elbow
6. Tube
7. Elbow

ISX AIr Intake Installation

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.

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.

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 non-filtered air into the engine air intake.
3. Check hoses for cracks, chafing, or deterioration, and replace at the first sign of probable failure.

EXHAUST SYSTEM

Description

The ISX exhaust system incorporates a diesel particulate filter (DPF) to remove soot, a diesel exhaust fluid (DEF) dosing section (decomposition pipe) to inject the DEF and a selective catalytic reduction (SCR) assembly.

The QSM exhaust system is much simpler, it incorporates just one muffler.

ISX System Removal

CAUTION

Do not touch exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove capscrews, lockwashers, flat washers, and nuts to free exhaust system guards. Remove guards.
2. Tag and disconnect all wires and hoses.
3. Disconnect clamps securing Decomposition Pipe to the DPF and SCR. Remove Decomposition Pipe.
4. Remove clamp from inlet of DPF.
5. Remove capscrews, lock washers, flat washers, and nuts to free DPF mounting bands.
6. Using a suitable lifting device remove the DPF (approximate weight 54 kg (120 lb)).
7. Attach a suitable lifting device to the SCR (approximate weight 73 kg (160 lb)).
8. Remove capscrews, lock washers, flat washers, and nuts to free SCR mounting bands and remove the SCR.
9. Inspect exhaust tubing, exhaust wrap, outlet sensors and wire leads, and attaching hardware.
10. Inspect the crane's sensor harness wiring that connects to sensor wiring of the exhaust system. Repair or replace any of these components if damaged or missing.

ISX System Installation

1. Install mounting bands on SCR.
2. Install the SCR leaving the mounting hardware slightly loose to allow for proper alignment.
3. As needed, loosen the clamps on the SCR so it can rotate. Rotate the inlet section of the SCR so it will align with the Decomposition Pipe.
4. Install the DPF, leave the hardware loose to aid in aligning the Decomposition Pipe.
5. Install the Decomposition Pipe, install new gaskets as necessary.
6. Secure all exhaust tubing with appropriate clamps.
7. Tighten the mounting hardware for all the components.
8. Attach the crane's sensor harness wires, as tagged during removal, to the sensor wire leads of the system.
9. Attach the tubing as tagged during removal.
10. Secure all wiring and tubing to prevent damage from heat and abrasion.
11. As needed, install a replacement exhaust wrap around the exhaust tube.
12. Install exhaust system guards and secure with capscrews, lock washers, flat washers, and nuts.

QSM System Removal

CAUTION

Do not touch exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove capscrews, lockwashers, flat washers, and nuts to free exhaust system covers and guards. Remove covers/guards.
2. Disconnect clamps securing tubes.
3. Remove capscrews, lock washers, flat washers, and nuts to free the mounting bands.
4. Using a suitable lifting device remove the muffler (approximate weight 26 kg (57 lb)).

QSM System Installation

1. Install mounting bands on muffler.
2. Install the muffler leaving the mounting hardware slightly loose to allow for proper alignment.
3. Install the tubes, install new gaskets as necessary.
4. Secure all exhaust tubing with appropriate clamps.
5. Tighten the mounting hardware for all the components.
6. As needed, install a replacement exhaust wrap around the exhaust tube.
7. Install exhaust system covers/guards and secure with capscrews, lock washers, flat washers, and nuts.

Slip Joint Exhaust Connectors

Slip joint exhaust couplers require tightening to avoid exhaust leaks. Perform the following procedures at the appropriate intervals.

After 1000 Hours, or One Year

Visually inspect the exhaust connector. If necessary, tighten the V-clamps by one full turn of the nuts.

2000 Hours or 2 Years

Tighten the V-clamps by 1 ½ turns of the nuts.

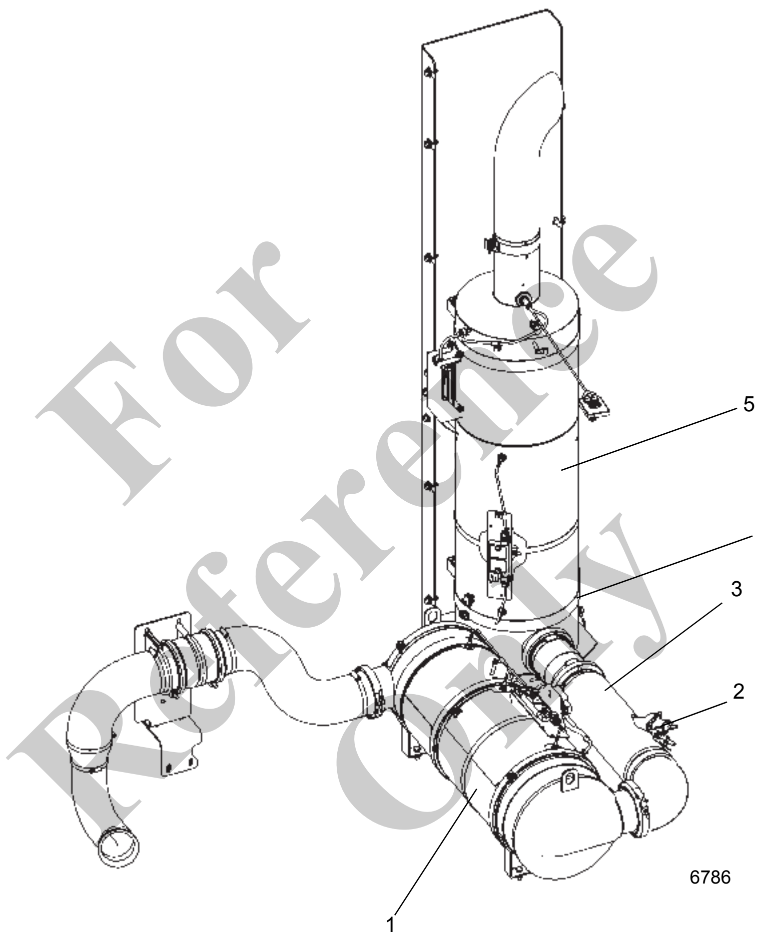
4000 Hours or 4 Years

Tighten the V-clamp by 1 ½ turns of the nuts.

5000 Hours or 5 Years

Remove the V-clamps and gaskets, and replace them with new gaskets and clamps. Tighten the V-clamps to 9.6 to 11.3 Nm (85 to 100 lb-in) of torque.

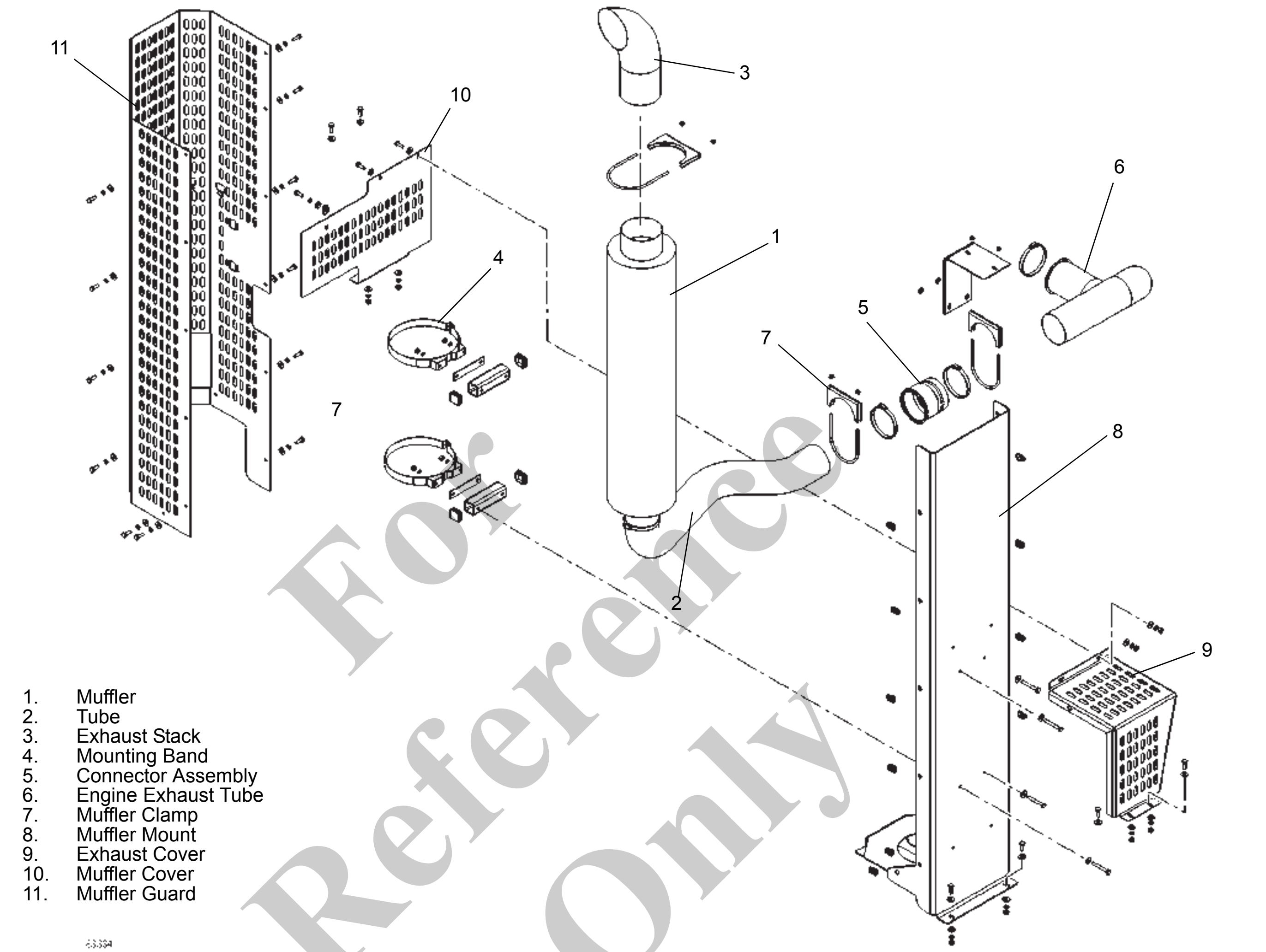
ISX Exhaust System



1. Diesel Particulate Filter (DPF)
2. Diesel Exhaust Fluid (DEF) Injector
3. Decomposition Pipe
4. Mounting Band
5. Selective Catalytic Reduction (SCR) Stack

ISX Exhaust System

QSM Exhaust System



QSM Exhaust System

AFTERTREATMENT DIESEL EXHAUST FLUID (DEF)

DEF Tank

Description

This engine uses a Selective Catalytic Reduction (SCR) system. SCR is a technology that uses a urea based DEF and a catalytic converter to significantly reduce oxides of nitrogen (NOx) emissions.

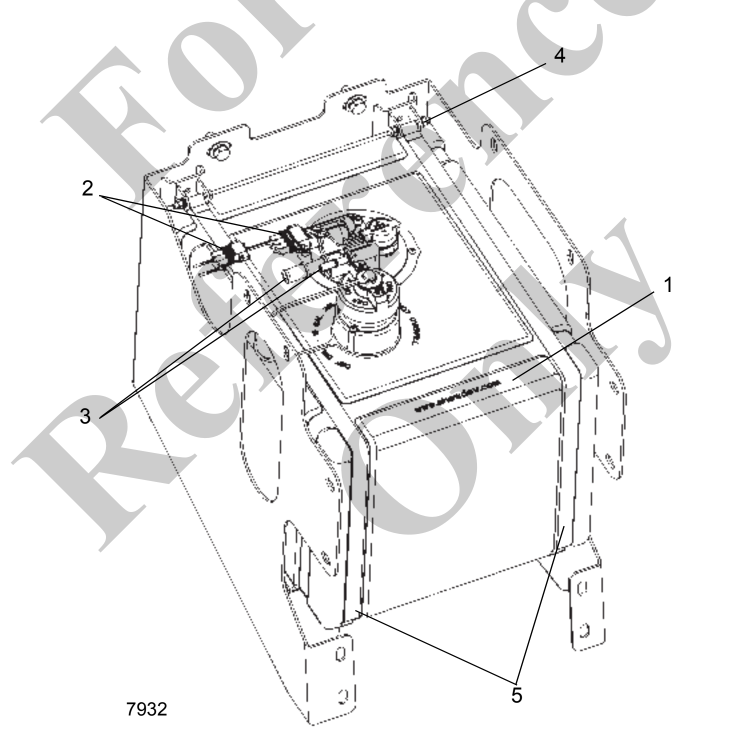
The DEF tank incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

Removal

1. Tag and disconnect the electrical connectors on the DEF tank.
2. Tag and disconnect the fluid lines on the tank.
3. Remove the hardware holding the tank straps in place.
4. Remove the tank.

Installation

1. Place the DEF tank onto the location on the frame.
2. Place the tank straps around the tank and secure with the hardware.
3. Connect the fluid lines as tagged during removal.
4. Connect the electrical connectors as tagged during removal.



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1. DEF Tank
2. Electrical Connectors
3. DEF Fluid Connectors
4. Tank Strap Mounting Hardware
5. Tank Straps

DEF Tank

DEF Dosing Unit Filter

The DEF dosing unit filter is a 10-micron filter designed to prevent foreign objects, that may be suspended in the DEF, from entering the dosing system.

Debris can cause permanent damage and premature failure to either the aftertreatment DEF dosing unit or the aftertreatment DEF dosing valve.

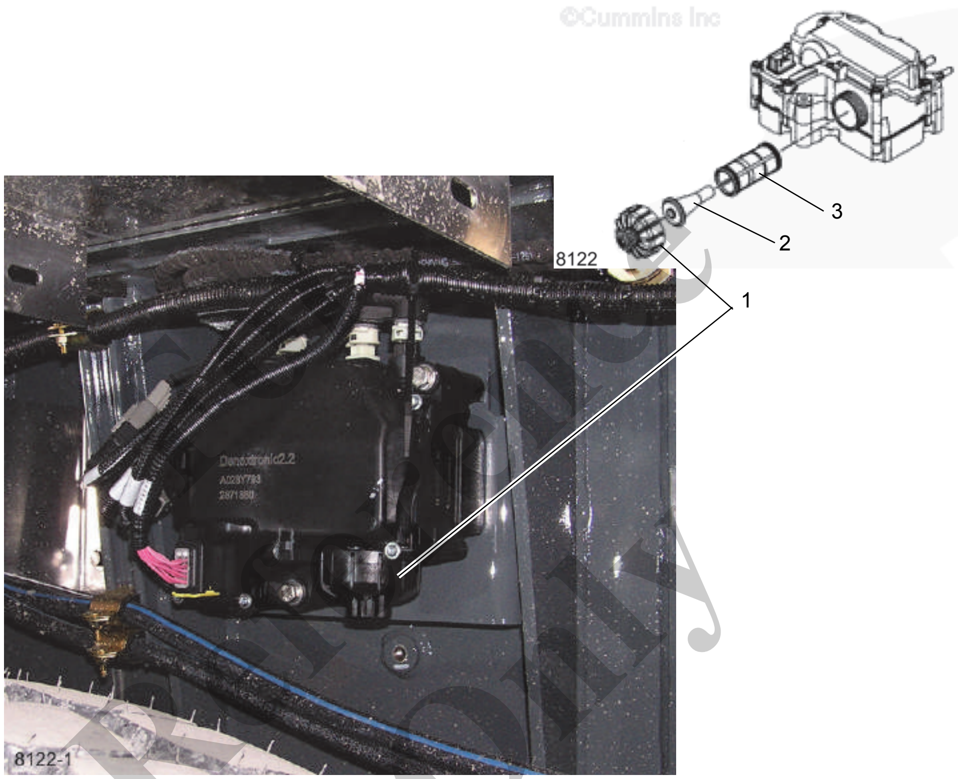
The filter should be replaced every 200,000 miles or 4500 hours of crane operation.

The aftertreatment DEF dosing unit filter consists of the following components:

(1) Aftertreatment DEF Dosing Unit Filter Cap

(2) Aftertreatment DEF Dosing Unit Filter Equalizing Element

(3) Aftertreatment DEF Dosing Unit Filter Element.



1. DEF Filter Cap
2. DEF Filter Equalizing Element
3. DEF Filter Element

DEF Dosing Unit

Initial Check

Inspect the area around the seal and vent of the aftertreatment DEF dosing unit filter cap for signs of leakage.

DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section in this procedure.

Preparatory Steps

WARNING

DEF contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of15 minutes. Do not swallow. In the event the DEF is ingested, contact a physician immediately. Reference the Materials Safety Data Sheet (MSDS) for additional information.

NOTE: Do not disconnect the vehicle batteries until the DEF dosing system has completed the purge cycle. Before beginning to remove and/or disconnect any components, wait at least five minutes after the key switch is turned OFF for the aftertreatment DEF dosing system to purge the DEF from the system. The purge cycle is an automatic process and does not require intervention to occur. The aftertreatment DEF dosing unit will create an audible pumping noise during the purging process.

NOTE: Do not power wash or steam clean this unit. Use compressed air to remove any loose debris.

Turn the battery disconnect switch to OFF to disconnect the batteries.

Removal

NOTE: There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

1. Unscrew the DEF filter cap (1).
2. Remove the aftertreatment DEF filter equalizing element (2).
3. Remove the old aftertreatment DEF dosing unit filter element (3).

NOTE: If removing the aftertreatment DEF dosing unit filter as part of a maintenance interval, discard the equalizer element and filter.

Clean and Inspect for Reuse

If there is the possibility that contaminated DEF has gone through the DEF dosing system, check the DEF filter prior to discarding the filter.

1. Check the DEF for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.
2. Inspect the DEF filter for debris. If debris is evident, also check:
   - DEF tank pick up screen.
   - The aftertreatment DEF dosing unit inlet connector.
3. Discard the filter element and equalizing element.
4. Inspect the aftertreatment DEF dosing unit filter cap for cracks or holes that could create a DEF leak path.
5. Check the condition of the threads on the aftertreatment DEF dosing unit cap. If the threads are damaged, replace the aftertreatment DEF dosing unit filter cap.
6. Inspect the aftertreatment DEF dosing unit threads. This is especially important if the aftertreatment DEF dosing unit cap was damaged. If the aftertreatment DEF dosing unit threads are damaged, replace the entire aftertreatment DEF dosing unit.

NOTE: Never operate the vehicle with the DEF cap removed.

7. Clean the aftertreatment DEF dosing unit cap with warm water and a clean cloth.

Install

NOTE: Lubrication of the DEF filter O-rings is not required.

1. Slide the DEF filter equalizing element (2) into the DEF filter cartridge (3).
2. Insert the assembly into the aftertreatment DEF dosing unit.
3. Install and tighten the cap (1). Torque Value: 20 Nm (177 lb-in).

Finishing Steps

CAUTION

Do not use the flow test portion of the INSITE™ electronic service tool Diesel Exhaust Fluid Doser Pump Override Test to check the system for leaks. This will spray diesel exhaust fluid into the exhaust system at too low of temperatures to evaporate, resulting in deposit formations in the exhaust system.

NOTE: The aftertreatment DEF dosing system will not prime until the correct SCR temperatures are reached. To verify that there are no DEF leaks, initiate a manual regeneration to get the SCR system up to temperature.

1. Connect the batteries by turning the battery switch to ON.
2. Operate the engine and check for leaks.

WATER COOLING SYSTEM

Description

The cooling system consists of the radiator, coolant recovery tank, engine cooling circuit, and the connecting hoses. Cooling system capacity is approximately 37.9 liters (52 quarts). The temperature is controlled by a 83°C (181°F) 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 50/50 fully formulated antifreeze coolant be used at all times.

The radiator assembly consists of the engine water cooler, charge air cooler, and the shroud.

A radiator coolant level switch is installed in the top portion of the radiator. Coolant level high/low signals are supplied to the engine ECM.

The crane is equipped with cab hot water heaters. Hot water is supplied by the engine coolant system through cable operated shutoff valves to each heater. The hot water to the superstructure heater also passes through a strainer and two port water swivel. The strainer is a cleanable type and is located on the right side of the carrier frame at the front corner of hydraulic reservoir. Refer to *Lubrication*, page 9-1 for service of the strainer.

Maintenance

General

The cooling system includes the radiator, coolant recovery 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 top radiator tank. Then the water flows down through the radiator core and is cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

Effects Of Cooling System Neglect

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the part directly responsible is not a part of the cooling system. Most of these problems can be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating

An engine that is overheating may lead to troubles such as the following:

- Burned valves.
- Pinging or knocking.
- Excessive fuel consumption.
- Poor lubrication - increased engine wear.
- Sticking valves.
- Short injector life.
- Engine hot spots.
- Need for higher grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

- Excessive fuel consumption.
- Sludge formation in crankcase.
- Corrosive acids formed in crankcase.
- Excessive fuel deposits in the exhaust system.

Rust Prevention

To keep engines operating at newness efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times.

For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times. Failure to use and maintain the fully formulated coolant will increase maintenance needs.

Engine Antifreeze/Coolant Fill Procedure (when level is low)

1. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant. Fill to the bottom of the surge tank filler neck. Fill slowly. Flow exceeding 19 l/min (5 gpm) can give a false reading.

NOTE: If the engine coolant is changed, the coolant filter must also be changed.

2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.

3. Run the engine for 5 minutes and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.

Engine Antifreeze/Coolant Fill Procedure (after a complete draining of the system)

NOTE: If the engine coolant is changed, the coolant filter must also be changed.

1. Open cab heater line valves and SCR cooling line valves.
2. Open petcocks at the Diesel Exhaust Fluid (DEF) Tank (1,2) (Figure 7-8), Decomposition Pipe enclosure (3) and Top Radiator Tube to allow trapped air to bleed.
3. Slowly fill the system at 11 l/min (3.0 gpm) to the bottom of the surge tank fill neck.

NOTE: A fill rate faster than 11 l/min (3.0 gpm) can give a false reading.

4. Verify a steady stream of fluid (no more than 1 l (1 qt)) at DEF tank petcocks (1 and 2) then close.
5. Verify a steady stream of fluid (no more than 1 l (1 qt)) at the decomposition pipe enclosure petcock (3) then close.
6. Verify a steady stream of fluid (no more than 1 l (1 qt)) at the top radiator tube petcock then close.
7. Start the engine and run at idle for 10 seconds. Accelerate to high idle for 1 minute and return to idle.
8. Top off the surge tank.
9. Operate the engine through two (2) thermal cycles and re-check the fluid level. Re-fill as necessary repeating Step #3.

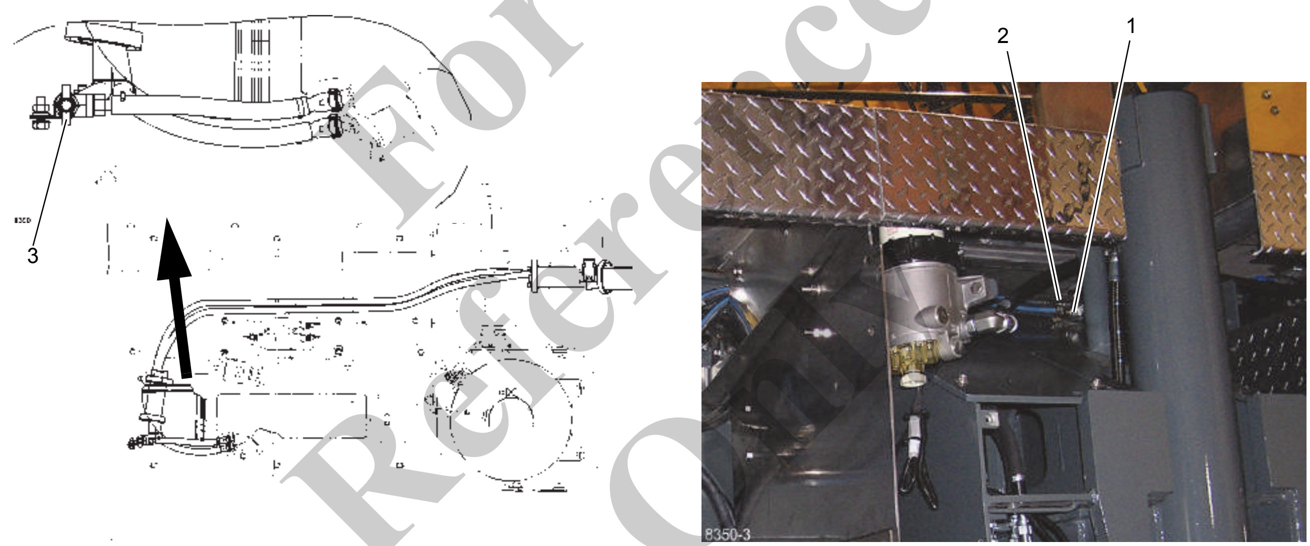


FIGURE 7-8

Antifreeze/Supplemental Coolant Additives Maintenance Summary

Cooling System Level Check Interval

Daily or 10 hours

The cooling system level should be checked every 10 hours of operation or daily, whichever comes first. Refer to *Lubrication*, page 9-1.

SCA Level Check/Coolant Filter Change Interval

6 months or 500 hours

- Check SCA Levels (use only Coolant Test Kit, Grove P/N 9414101675, to check the coolant additive concentration in the cooling system).

The Coolant Filter contains molybdate. Therefore, it is important to use the Grove Coolant Test Kit, which checks the molybdate level, regardless of whether the SCA used to replenish the coolant system contains molybdate or not.

Only add coolant additive if levels are less than 1.2 units/gal.

NOTE: An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Over concentration can cause formation of a “gel” that can cause restriction or plugging of coolant passages, and overheating.

- Change coolant filter.

Install charged filter if SCA levels are normal or below normal; install non-charged filter if SCA levels are above normal (contact Manitowoc Crane Care for filter part number).

1 year or 1000 hours

- Test antifreeze/coolant for contamination.

  Condemning limits are:

  - Sulfate level greater than or equal to 1500 ppm.
  - Chloride level greater than or equal to 200 ppm.
  - The pH level is less than 6.5
  - Oil or fuel contamination can be identified by odor or color.

  If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Cleaning

CAUTION

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 71 to 82°C (160 to 180°F). Stop the engine, remove the radiator cap, and drain the system by opening the drain cocks on the radiator and engine block.
2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 82°C (180°F) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 82°C (180°F) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*, page 7-23) and repeat the cleaning operation.
8. If clogging of the core, indicated by low temperature spots on core, is not relieved, the radiator core must be removed for mechanical cleaning. Mechanical cleaning requires removal of the upper and lower tanks, and rodding out the accumulated rust and scale from the water passages of the core.

Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.
3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill the core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. For badly clogged water jackets that do not respond to regular pressure flushing, remove the engine cylinder head and core hole plugs, and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through the openings.
9. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
10. After completing the flushing operation, clean out the overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.

11. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

Component Inspection

Radiator/Recovery Tank

1. Top and Bottom 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 3 mm (0.13 in). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.

CAUTION

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

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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.

- 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.
- 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.
- 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 in this Section.

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 section. 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.

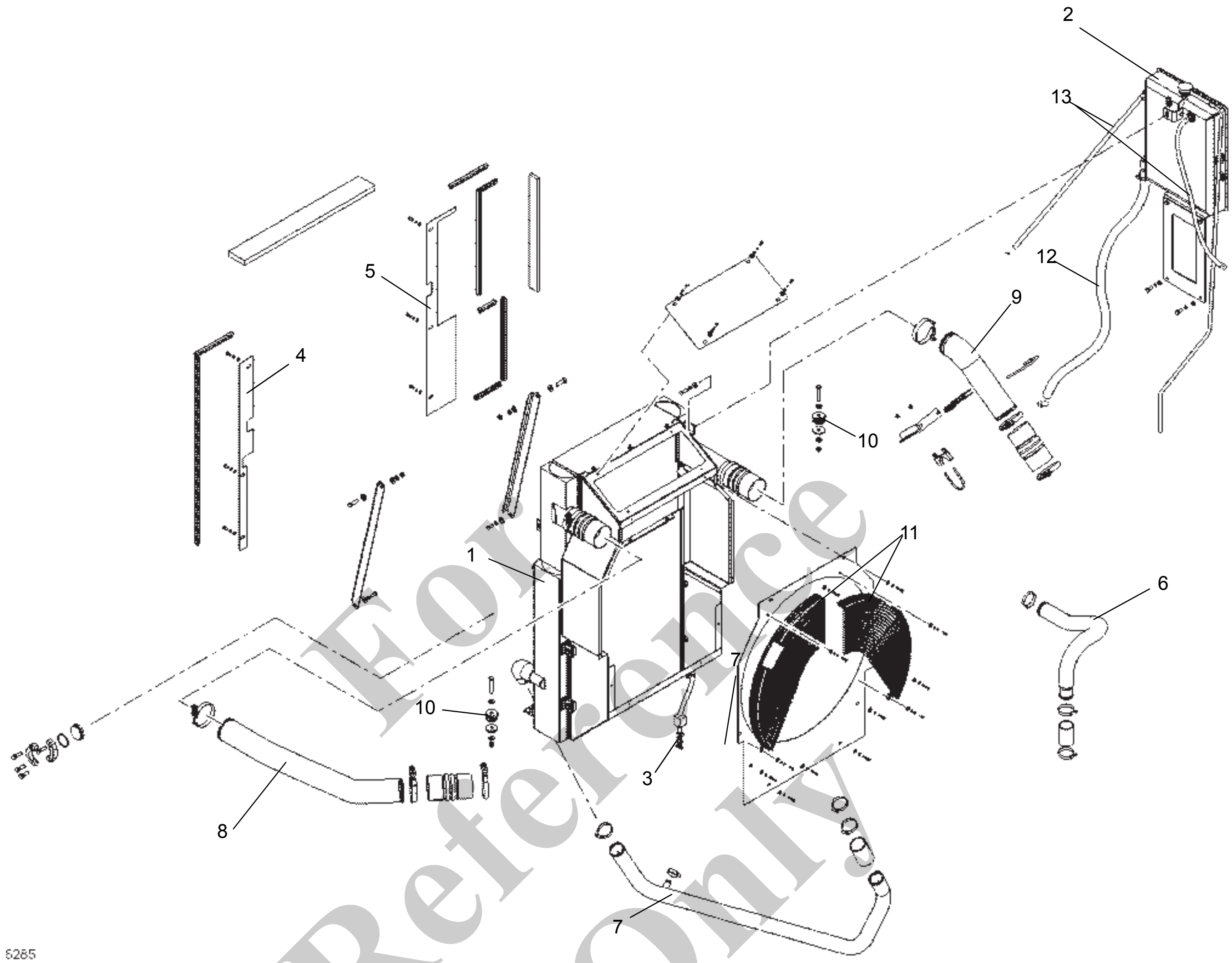
Coolant Filter

The engine has a coolant filter of the canister or spin-on type that requires periodic servicing. It is suggested that this be done when engine oil and filter are changed. Refer to *Antifreeze/Supplemental Coolant Additives Maintenance Summary*, page 7-22. There is a shut off valve located on the coolant filter head. Turn it to the OFF position before removing the filter. After changing filter, be sure the valve is positioned to the ON position.

Radiator Assembly Removal and Installation

Removal

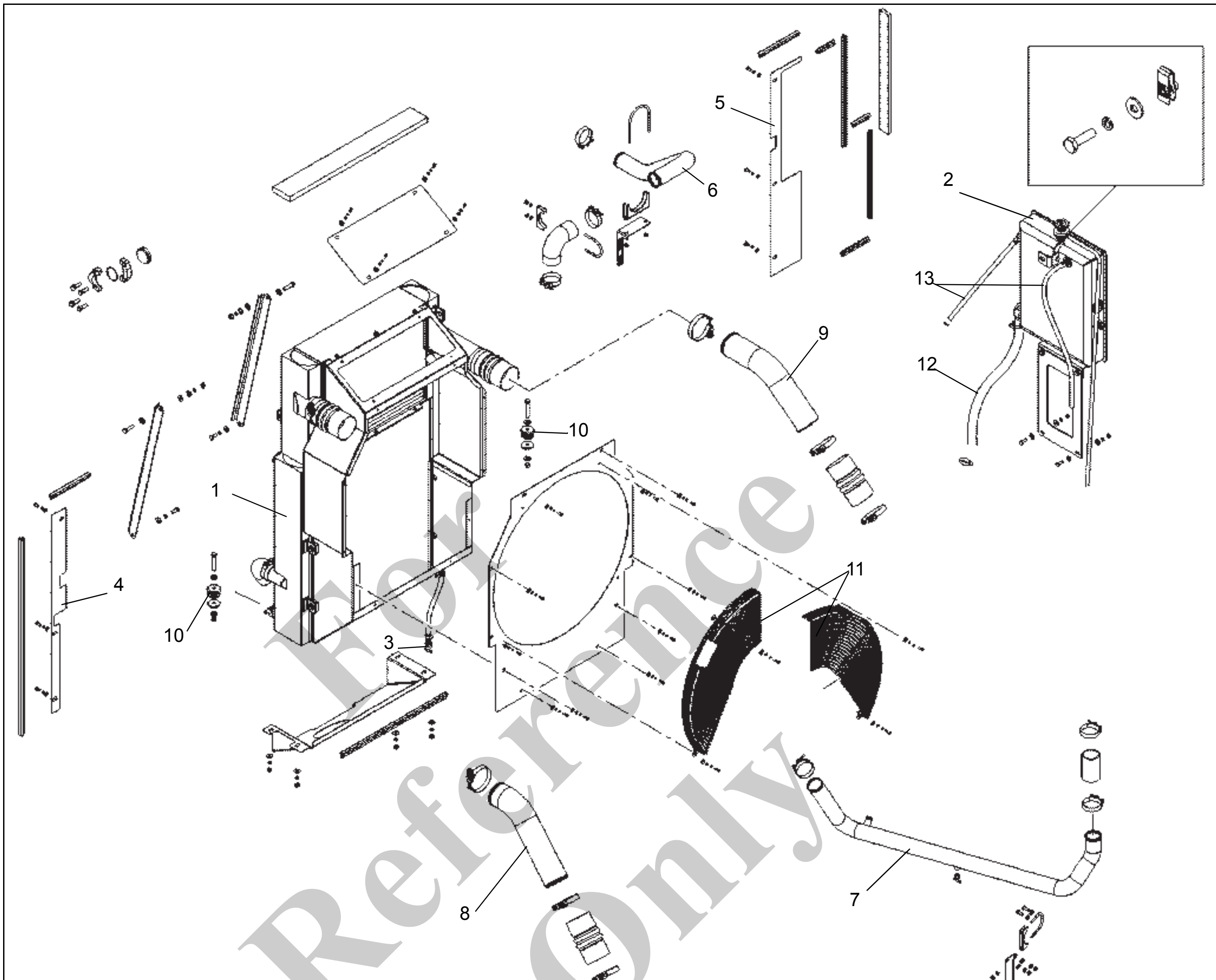
1. Set the outriggers and position the boom to over the side.
2. Disconnect the battery.
3. Open the drain cocks at the bottom of the radiator and drain the coolant into a suitable container. Dispose of the coolant in accordance with local and EPA regulations.
4. Open the left and right hood access doors.
5. Disconnect the hoses from the coolant recovery tank and remove the tank.



QSM Engine Radiator/Charge Air Cooler Assembly

Item	Description
1	Radiator/Charge Air Cooler
2	Recovery Tank
3	Drain Cock
4	Left Hand Baffle
5	Right Hand Baffle
6	Top Radiator Tube (QSM)
7	Bottom Radiator Tube (QSM)
8	Cold CAC Tube (QSM)
9	Hot CAC Tube (QSM)
10	Radiator Mount
11	Fan Guards
12	Coolant Recovery Hose
13	Vent Hoses

FIGURE 7-9



ISX Engine Radiator/Charge Air Cooler Assembly

Item	Description
1	Radiator/Charge Air Cooler
2	Recovery Tank
3	Drain Cock
4	Left Hand Baffle
5	Right Hand Baffle
6	Top Radiator Tube (ISX)
7	Bottom Radiator Tube (ISX)
8	Cold CAC Tube (ISX)
9	Hot CAC Tube (ISX)
10	Radiator Mount
11	Fan Guards
12	Coolant Recovery Hose
13	Vent Hoses

FIGURE 7-10

6. Remove the hardware securing the top center hood panel to the front and rear cowls and remove the panel with doors from the crane.
7. Remove the hardware securing the left and right lower side panels to the front cowl.
8. Remove the hardware securing the front grill panel to the front cowl and remove the grill.
9. Remove the hardware securing the front cowl and remove the front cowl.
10. Disconnect the CAC hoses from the air cooler assembly.
11. Disconnect the hoses from the top and bottom of the radiator assembly.
12. Remove the bolts, washers, and lockwashers attaching the fan guard to the shroud. Remove the fan guard.

NOTE: The radiator assembly weighs approximately 116 kg (256 lb).

13. Attach an adequate lifting device to the radiator/air cooler assembly.
14. Remove the nuts, hardened washers and mounts securing the radiator/air cooler assembly to the mounting brackets and remove the assembly from the carrier.

Installation

1. Position the radiator/air cooler assembly in the carrier using a lifting device and secure to the mounting brackets using the mounts, hardened washers, and nuts.
2. Position the fan guard on the shroud and secure with bolts, washers, and lockwashers.
3. Connect the air cooler tubes to the air cooler using the bellows and clamps. Tighten the clamps to 4 to 5 Nm (35 to 45 in-lb).
4. Connect the hoses to the top and bottom of the radiator.
5. Ensure the drain cock is closed
6. Position the front cowl on the frame and secure with the attaching hardware
7. Position the front grill panel on the front cowl and secure with the attaching hardware.
8. Attach the left and right side lower panels to the front cowl with the attaching hardware.
9. Position the top center panel, with doors attached, on the front and rear cowl and secure with the attaching hardware.
10. Install the coolant recovery tank. Connect the hoses to the tank.
11. Service the engine coolant system as necessary, *Engine Antifreeze/Coolant Fill Procedure (after a complete draining of the system)*, page 7-22. Start the engine, operate all systems and check for leaks.

DRIVE TRAIN

Description

The drive train consists of the manual transmission, clutch, and drive lines (see Figure 7-12).

A two-plate clutch is used between the engine and the transmission.

The transmission is an 11-speed forward and 3-speed reverse transmission controlled through a shifter with mechanical linkage. Range shift is air controlled. The transmission oil is cooled by an oil cooler mounted in front of the radiator.

There are three drive shafts. The coupling shaft assembly with center bearing connects the output shaft of the transmission to the forward slip shaft assembly. The forward slip shaft assembly then connects to the input shaft of the front differential of the rear tandem axles. The rear tandem axles have a drive shaft that connects the output shaft of the rear front axle differential to the input shaft of the rear rear axle differential.

Maintenance

Transmission

Refer to the Cummins engine and Eaton transmission manuals and other portions of this section for removal, scheduled maintenance and corrective maintenance, and installation.

Drive Shafts

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 assembly or the forward slip shaft assembly, support the other shaft also.
2. If removing the coupling shaft assembly, free its bearing from the frame by removing two bolts, two locknuts, and four washers.
3. Remove the bolts from the bearing cap on each end of the drive line. Remove the drive line.

Installation

1. For the coupling shaft assembly, verify the center bearing nut is torqued according to *Fasteners and Torque Values* on page 1-12.
2. For any drive shaft which has mating marks (arrows), align these mating marks to ensure proper phasing of coupler yokes.
3. Position the drive shaft between the couplers on the two components it is joining.
4. For the coupling shaft assembly, secure its bearing to the frame with two bolts, two locknuts, and four washers. Torque these locknuts according to *Fasteners and Torque Values* on page 1-12.
5. Secure the drive shaft to the coupler with bolts. For the rear tandem axles' shaft (the shaft between the differentials), torque the bolts according to *Fasteners and Torque Values* on page 1-12. For the other drive shafts, torque according to *Fasteners and Torque Values* on page 1-12.

Lubrication

The drive line slip joints require lubrication. Refer to *Lubrication* on page 9-1.

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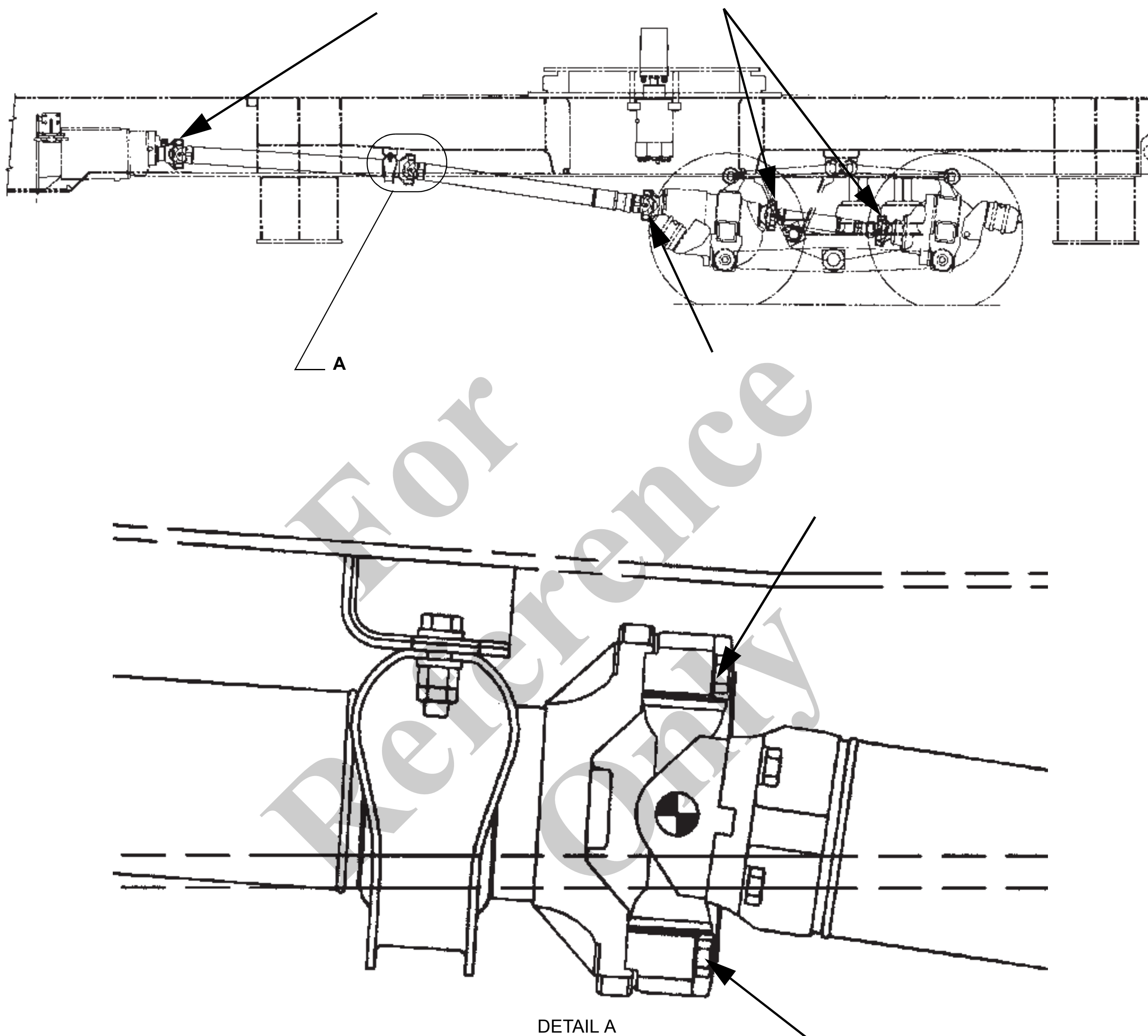

Torque all fasteners according to
Fasteners and Torque Values on page 1-12
A
DETAIL A

FIGURE 7-11

CLUTCH

Description

The clutch (Figure 7-12) is a 15-1/2 in (39.4 cm), 2-plate, pull-type heavy duty unit. Refer to the *Operator Manual* for operation instructions.

The clutch is the device that interrupts shaft power from the engine flywheel to the transmission. When starting the engine, the clutch is disengaged, disconnecting the transmission and the rest of the drive train from the rotation of the flywheel. This allows the engine flywheel to turn freely during startup.

When the clutch is engaged, it connects the engine drive shaft to the transmission and the rest of the drive train.

The clutch assembly has a clutch brake that stops the rotation of the transmission gears to aid quick engagement on engine start. It also slows down the gears on the upshift to allow engagement of the next higher gear without gear clash. Pressing the clutch pedal through the last one inch of pedal travel engages the clutch brake.

Clutch pedal adjustment provides for approximately 2.5 cm (1 in) of free travel movement of the pedal after the first free travel of 1.3 cm (0.5 in) is passed before engaging the release bearing fully. It is important that this free travel be maintained to avoid possible excessive wear on the bearing and/or clutch slippage. Approximately the last one inch of downward clutch pedal travel engages the clutch brake which overcomes the tendency of the clutch to rotate at high speed when the clutch is disengaged. A slight but definite resistance to clutch pedal downward movement will be felt at the last one inch of travel. THE CLUTCH BRAKE MUST NOT BE USED WHEN MAKING A DOWNSHIFT.

The clutch assembly has a cover, a pressure plate, an intermediate plate, two driven discs, a throw-out bearing and carrier, and springs and other linkage that allow the throw-out bearing to press the pressure plate against the driven discs, or pull it away.

The clutch assembly mounts inside the clutch housing of the transmission. The clutch assembly bolts to the engine flywheel and rotates with the flywheel. The pressure plate, the intermediate plate, and both driven discs are inside the clutch assembly. The pressure plate connects to the clutch assembly with driving lugs that extend into the mating slots. Drive pins in the engine flywheel mate with holes in the intermediate plate to drive it.

The driven plates rotate inside the clutch assembly but are not fastened to the clutch assembly. The driven discs' splined center holes mate with the transmission input shaft, but unless the flywheel pressure plate contacts them, they will not rotate, nor will the transmission input shaft.

The throw-out bearing mounts on a sleeve that fits through the rear of the clutch assembly. The transmission input shaft fits through this sleeve; this allows the throw-out bearing to be stationary while the clutch assembly rotates and allows the throw-out bearing to move fore and aft with respect to the clutch assembly and the transmission. The clutch release shaft and yoke, which connect to the crank and the linkage from the clutch pedal, connect to the throw-out bearing. This connection keeps the throw-out bearing from turning with the clutch and allows the yoke to move the throw-out bearing aft and fore when the clutch pedal is stepped on or released.

Stepping on the clutch pedal causes the clutch release yoke to pull the throw-out bearing toward the transmission. The throw-out bearing, being connected to the release levers, retracts the pressure plate from contact with the driven disc assembly. This relieves the pressure on the intermediate plate and the forward driven disc assembly, which disengages the clutch. This stops the rotation of the flywheel from rotating the transmission input shaft. The clutch release yoke also holds the throw-out bearing against the clutch brake pad of the transmission; this brakes the clutch instead of letting it rotate on built-up energy.

Releasing the clutch pedal allows the throw-out bearing to move toward the engine. This permits the pressure plate, under powerful spring pressure, to move toward the flywheel, gripping the driven discs and causing engagement. This means the engine drive shaft output connects through the flywheel and in the clutch's pressure plate pressing on the driven discs, to the transmission input shaft.

CAUTION

Never fully depress the clutch pedal before the transmission is put in neutral. If the clutch brake is applied with the transmission still in gear, a reverse load will be put on the gears, making it difficult to get the transmission out of gear. At the same time it will have the effect of trying to stop or decelerate the vehicle with the clutch brake, with resultant rapid wear and generation of excessive heat, necessitating frequent replacement of the brake friction discs.

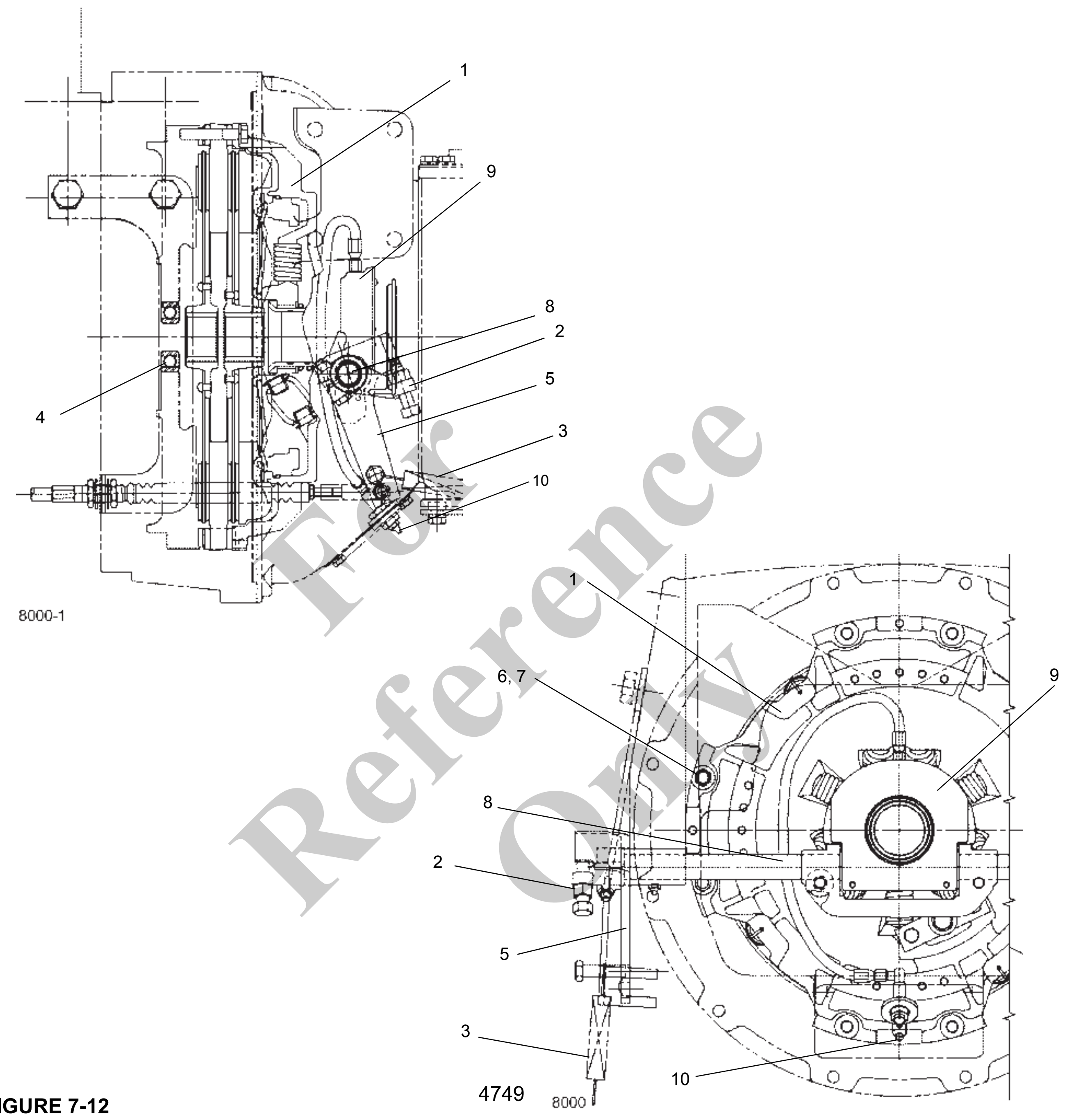


FIGURE 7-12

Item	Description
1	Clutch Assembly
2	Clutch Pedal Adjusting Lever
3	Governor Spring
4	Pilot Bearing (ref.)
5	Crank

Item	Description
6	Lockwasher
7	Bolt
8	Clutch Release Shaft and Yoke
9	Throw Out Bearing
10	Throw-Out Bearing Grease Fitting

Maintenance

Troubleshooting

Table 7-1

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Chatter.	**a.** Loose, broken, or worn engine mounts.	**a.** Tighten or replace mounts.
	b. Loose or cracked clutch housing.	**b.** Tighten or replace.
	c. Rear axle attach bushings worn.	**c.** Replace bushings.
	d. Misalignment.	**d.** Align.
	e. Oil or grease on facings.	**e.** Install new facings or disc assembly.
	f. Warped or bent driven disc assembly.	**f.** Replace.
	g. Improper disc facing thickness.	**g.** Install proper disc assembly.
	h. Worn pilot bearing.	**h.** Replace.
	i. Wrong spring pressure in the cover assembly.	**i.** Adjust or replace springs in cover assembly.
	j. Cross shaft bushings worn.	**j.** Replace the bushings.
	k. Release levers not parallel.	**k.** Recheck installation.
2. Aggressive (grabby).	**a.** Excessive backlash in the power train.	**a.** Worn parts. Make repairs.
	b. Warped driven disc.	**b.** Install a new disc assembly.
	c. Worn driven disc hub splines.	**c.** Install a new disc assembly.
	d. Worn splines on transmission input shaft.	**d.** Replace shaft.
	e. Improper facing material.	**e.** Install proper driven disc assembly.
3. Insufficient release.	**a.** Broken or loose engine mounts.	**a.** Tighten or replace.
	b. Excessive idling speed.	**b.** Adjust to factory specifications.
	c. Loose or worn facings.	**c.** Replace.
	d. Improper facing thickness.	**d.** Install the proper driven disc assembly.
	e. Drive lugs binding.	**e.** Check pressure plate drive lugs for proper clearance 0.15 mm (0.006 in).
	f. Pressure plate return springs bent or stretched.	**f.** Replace springs.
	g. Insufficient amount of release travel.	**g.** Adjust for proper release travel.
	h. Lever nose out of groove in release sleeve retainer.	**h.** Disassemble and repair as necessary.

SYMPTOM	PROBABLE CAUSE	SOLUTION
Insufficient release. (continued)	**i.** Driven disc distorted or warped.	**i.** Driven disc assembly must be straight within 0.38 mm (0.015 in) total indicator reading. Replace discs. Damage to driven disc can be caused by poor installation methods. Do not force transmission input shaft into disc hubs. This will distort or bend driven disc, causing poor release. Replace the drive disc.
	j. Transmission input shaft splines worn or rusty.	**j.** Replace input shaft and check driven disc hubs for excessive wear. If worn, replace disc. Check flywheel housing alignment of engine and transmission. Make sure driven discs slide freely on transmission input shaft splines.
	k. Internal clutch adjustment not correct.	**k.** Readjust clutch for standard release travel.
	l. Flywheel pilot bearing fitting too tight in flywheel or on end of drive gear.	**l.** Free pilot bearing to a light push. Fit in flywheel and on drive gear pilot. If bearing is rough, replace.
	m. Facings gummed with oil or grease.	**m.** Replace facings or entire driven disc assembly.
	n. Damaged clutch release bearing (throw-out bearing).	**n.** Replace bearing.
	o. Clutch release shaft projecting through clutch release yoke.	**o.** Relocate release shaft so it does not project. Check bell housing bushings and clutch release yoke for wear.
	p. Clutch release yoke contacting cover assembly at full release position.	**p.** Replace clutch release yoke with proper yoke.
	q. Clutch release yoke will not align with release bearing (throw-out bearing) properly.	**q.** Flywheel has been resurfaced more than the recommended 1.52 mm (0.060 in) removal. Replace flywheel.
	r. Broken intermediate plate.	**r.** Replace damaged intermediate plate.
	s. Intermediate plate sticking on clutch cover.	**s.** Intermediate plate lugs should have 1.52 mm (0.060 in) clearance in driving slots of clutch assembly cover.
	t. Warped or bent driven disc assembly.	**t.** Replace.
	u. Lever settings wrong.	**u.** Recheck installation.
	v. Worn driven disc hub splines.	**v.** Replace driven disc assembly.
4. Hard pedal.	**a.** Excessive spring pressure on cover.	**a.** Install proper cover correctly.
	b. Contact pad of throw-out bearing carrier worn by clutch release yoke.	**b.** Replace carrier and yoke. Also check for proper installation to provide the best linkage operating positions.
5. Slippage.	**a.** Oil or grease on the facing.	**a.** Replace facing or install a new driven disc assembly.

SYMPTOM	PROBABLE CAUSE	SOLUTION
6. Noisy clutch.	**a.** Clutch release bearings dry or damaged.	**a.** Lubricate bearing. Replace if damaged.
	b. Flywheel pilot bearing dry or damaged.	**b.** Lubricate bearing. Replace if damaged.
	c. Clutch release bearing housing striking flywheel ring.	**c.** Adjust clutch. Also check wear on cross shafts, bell housing bushings, and clutch release yoke fingers. If badly worn, replace parts.

Removal

CAUTION

The fully assembled clutch assembly weighs approximately 66.5 kg (146 lb). Avoid the risk of injury; use proper equipment when lifting a clutch.

1. Remove the transmission following the procedures in this section under *Manual Transmission* on page 7-42, *Removal*.

2. Install two 19 mm (0.75 in) blocks of wood between the clutch assembly cover and the clutch release bearing housing (throw-out bearing) as the clutch mounting bolts are loosened around the flywheel.

3. Remove the bolts and washers mounting the clutch to the flywheel.

4. Remove the clutch assembly.

5. If necessary, remove the setscrews and drive pins from the flywheel.

Inspection

NOTE: Failure to perform inspection may result in low mileage disc/damper failure.

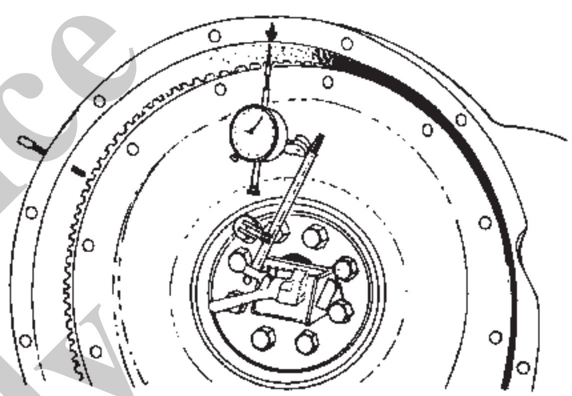
1. Begin by wiping all surfaces before gauging.

2. Secure the dial indicator to the flywheel housing with the gauge finger on the flywheel near the outer edge. Rotate flywheel.

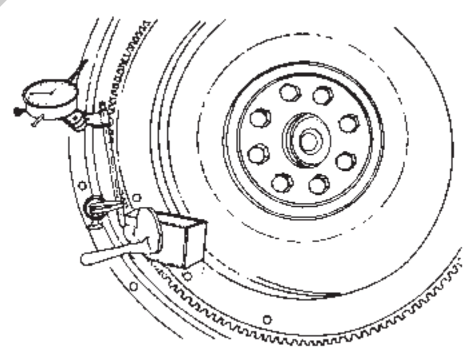
3. The total indicated difference between the high and low joints must be 0.18 mm (0.007 in) or less for a 35.6 cm (14 in) clutch, or 0.20 mm (0.008 in) or less for a 39.4 cm (15.5 in) clutch.

4. Secure a dial indicator to the crankshaft (Figure 7-13). With the gauge finger against the housing pilot, rotate the crankshaft. Use a marker or soapstone to mark the high and low points.

Total difference between high and low points should not exceed 0.20 mm (0.008 in).



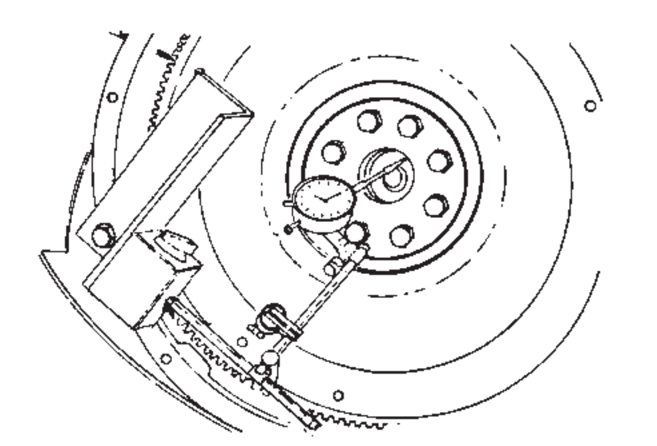
4863-1 **FIGURE 7-13**



4863-2 **FIGURE 7-14**

5. Move the gauge finger to contact the face of the engine flywheel housing (Figure 7-14).

Again, rotate the crankshaft and then mark high and low points. The total difference between the high and low points should not exceed 0.20 mm (0.008 in).

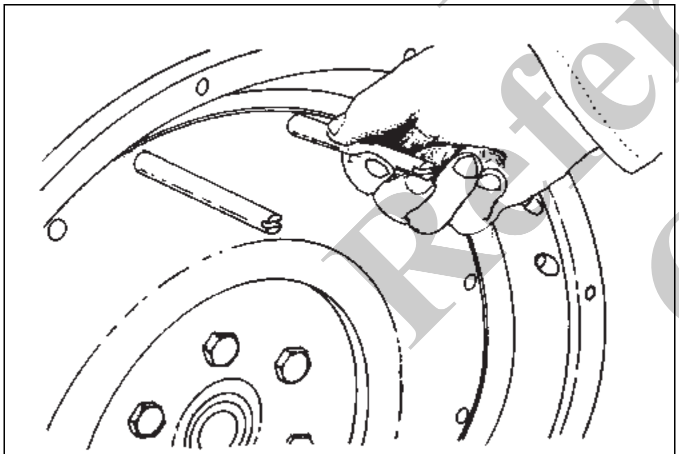


4863-4 FIGURE 7-15

6. Move the gauge finger to contact the pilot bearing bore surface. Again, rotate the flywheel (Figure 7-15).

The maximum total allowable runout is 0.13 mm (0.005 in). If these limits are exceeded, the problem must be corrected or misalignment will cause premature wear to the drive train components

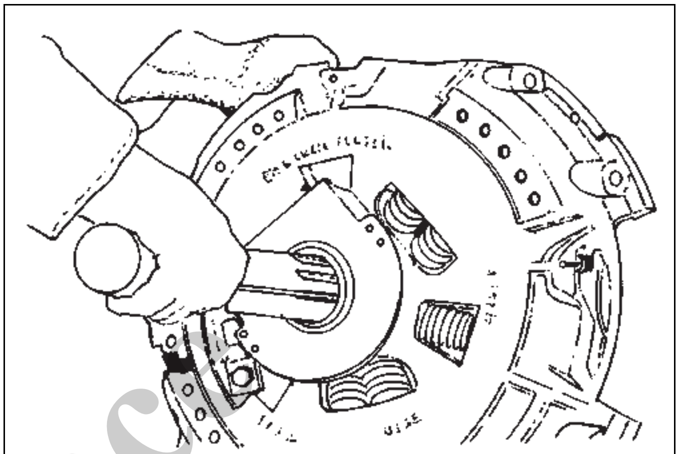
Installation



4863-4 FIGURE 7-16

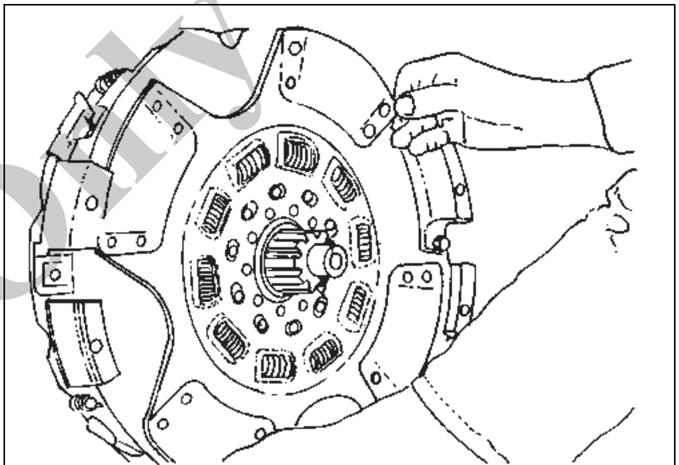
1. Insert two 13 cm (5 in) long 7/16 inch - 14 UNC guide studs into the two upper mounting holes of the flywheel (Figure 7-16).
2. Verify flywheel cavity.
   - 8 Springs need 18.4 cm (7.25 in) bore
   - 10 Springs need 21.7 cm (8.56 in) bore.
   - 7 Springs need 24.8 cm (9.75 in) bore.
   - 9 Springs need 24.8 cm (9.75 in) bore.

Insert the aligning tool through the release bearing sleeve in the new clutch (Figure 7-17).



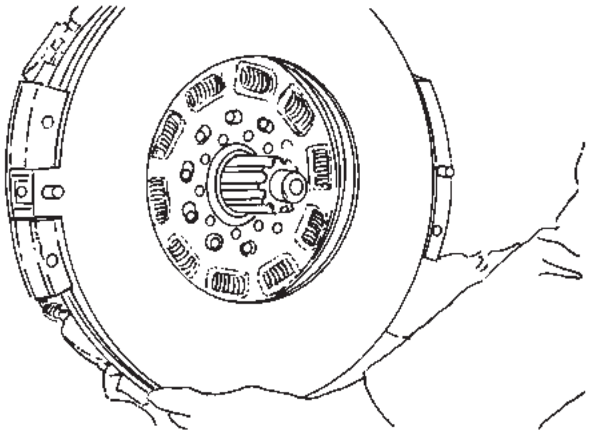
4863-5 FIGURE 7-17

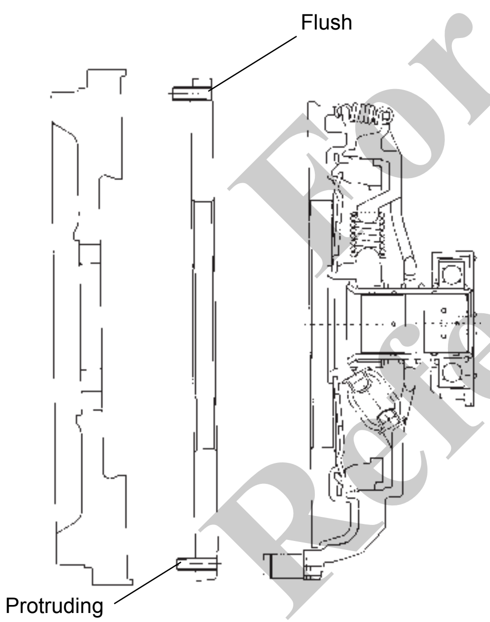
3. Put the rear driven disc on the aligning tool with the side stamped "pressure plate" facing the pressure plate (Figure 7-18).



4863-6 FIGURE 7-18

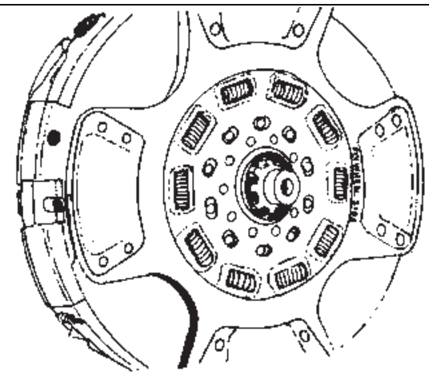
4. Place the intermediate plate in the clutch cover and align the driving lugs of the plate with the slots provided (Figure 7-19).


4863-7 FIGURE 7-19



4863-8 FIGURE 7-20

5. Positive separator (roll) pins should be flush on the clutch side, protruding on flywheel side (Figure 7-20).

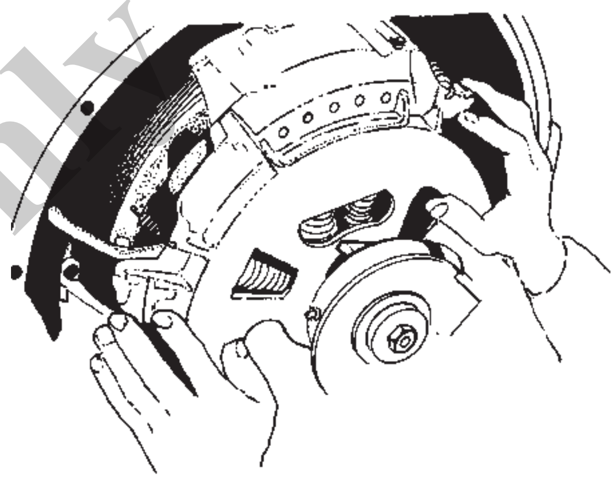

4863-9 FIGURE 7-21

6. Install the front disc on the aligning tool with the side stamped “flywheel” facing the engine (Figure 7-21).

NOTE: It’s imperative that the side stamped “flywheel” faces the engine and the side stamped “pressure plate” faces the transmission.

The relative position of the buttons on the front and rear driven discs is not important.

NOTE: Ensure the adjustment mechanism will be aligned with the opening in the bell housing of the transmission.


4863-10 FIGURE 7-22

7. Position the clutch over the guide studs and slide it forward until contact is made with the flywheel surface. The clutch assembly weighs approximately 66.5 kg (146 lb), so a hoist may be required to lift it into place (Figure 7-22).

8. Start the eight 7/16 inch bolts with lock washers and tighten them finger tight.

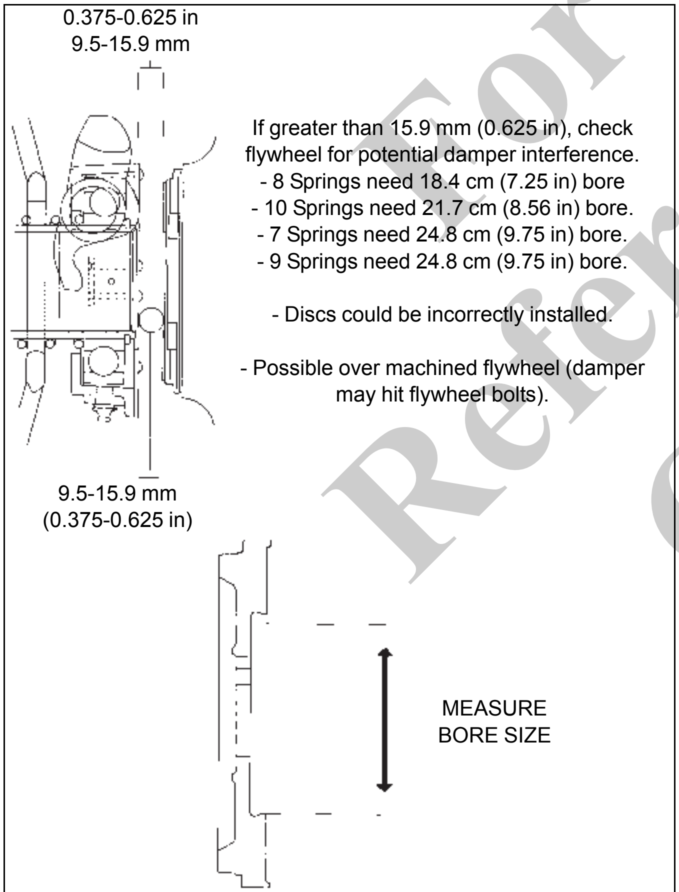
CAUTION

Failure to tighten the bolts in this manner can cause permanent damage to the clutch or create an out-of-balance condition.

9. Tighten the bolts in the criss-cross sequence to pull the clutch into its proper position in the flywheel pilot. You must start with the lower left-hand bolt.
10. To achieve the final torque, progressively tighten all bolts 61 to 68 Nm (45 to 50 lb-ft).

As the bolts are tightened, the wooden spacers should fall out. If they do not fall free, remove them. If necessary, lightly tap on the aligning tool with a mallet to remove it.

Bearing position should be approximately 9.5 to 15.9 mm (0.375 to 0.625 in) from the clutch cover (Figure 7-23).

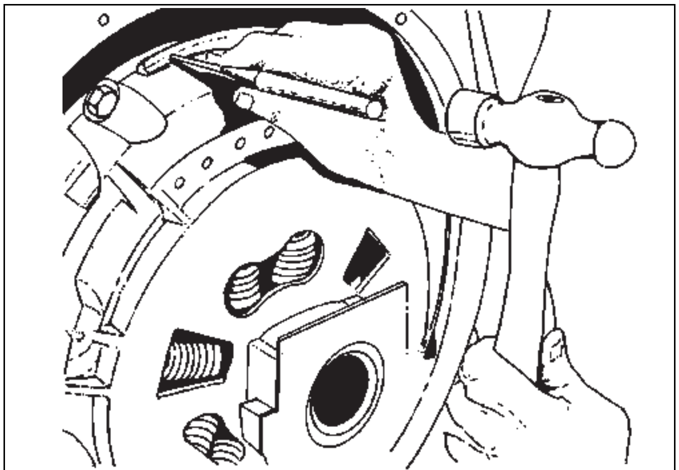


4863-12 **FIGURE 7-23**

If greater than 15.9 mm (0.625 in) check possible disc to flywheel bore interference.

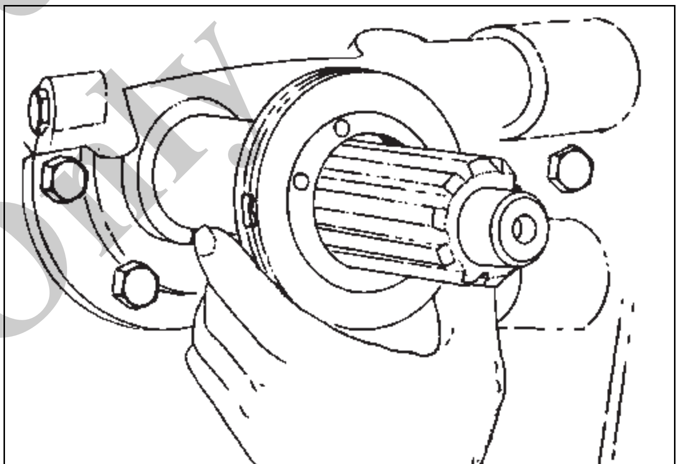
11. Check Positive Separators.

Using a 6 mm (0.25 in) diameter flat nose drift, lightly tap each of the four positive separator pins toward the flywheel. After tapping, the pins should be flush against the flywheel (Figure 7-24).



4863-13 **FIGURE 7-24**

- Remove rust and contamination from input shaft.
- Replace the shaft if any wear is noticed. The clutch won't release if the shaft is notched.
- Do not coat the shaft with grease or never seize. Install discs dry or wipe on a light coat of oil.



4863-14 **FIGURE 7-25**

If a clutch brake is used, be sure to install it on the input shaft of the transmission at this time (Figure 7-25).

12. Refer to *Manual Transmission* on page 7-42, *Installation* in this Section, and install the transmission.

Clutch Adjustment Procedure

Remove the inspection plate from the bottom of the clutch housing and make the following inspections and adjustments if required.

The release levers of new or factory exchange cover assemblies are properly adjusted and locked at assembly and will not require further adjustment. However, after the transmission has been securely attached to the engine, the release sleeve must be adjusted until the correct distance between the surface of the release bearing housing and the front brake disc is obtained.

1. Clutch brake squeeze should begin 25 mm (1.0 in) above the pedal stroke. This is controlled by adjusting the rod end bearings evenly at each rod end. Lengthen the rod to squeeze closer to end of pedal stroke.
2. Visually check the travel of the release bearing after working the pedal several times. Release travel should be 13 to 14 mm (1/2 to 9/16 in).
3. Make internal clutch adjustment for proper clearance as follows.
    a. Insert a 3/4 inch socket (12 points) or a 3/4 inch box end wrench through the inspection hole and depress the square headed bolt to adjust the clutch.
    b. Turning the bolt 2-1/3 rotations changes the adjustment 3 mm (1/8 in). The Kwik-Adjust will reengage at a quarter of a turn. The flat of the bolt will align with the flat edge of the bracket.
4. Set the clutch pedal free travel to 25 to 38 mm (1.0 to 1.5 in) using the adjusting screw on the clutch pedal adjusting lever.
5. After all adjustments are made, tighten all jam nuts to lock rod end bearings to the control rods and pivot arms.
6. Install the inspection plate on the bottom of the clutch housing and road test the crane for proper clutch operation.
7. After installing transmission, perform *Clutch Adjustment Procedure* on page 7-46.

Clutch Adjustment Inspection Procedure

1. Remove inspection plate from bottom of clutch housing.
2. Depress the clutch pedal several times and check for the 13 to 14 mm (1/2 to 9/16 in) throw-out bearing travel. Readjust if necessary.
3. Verify there is 25 to 38 mm (1.00 to 1.50 in) of free travel of the clutch pedal. Make adjustments as needed.
4. Reinstall the inspection plate on the bottom of the clutch housing.
5. Road test the machine to verify proper clutch operation.

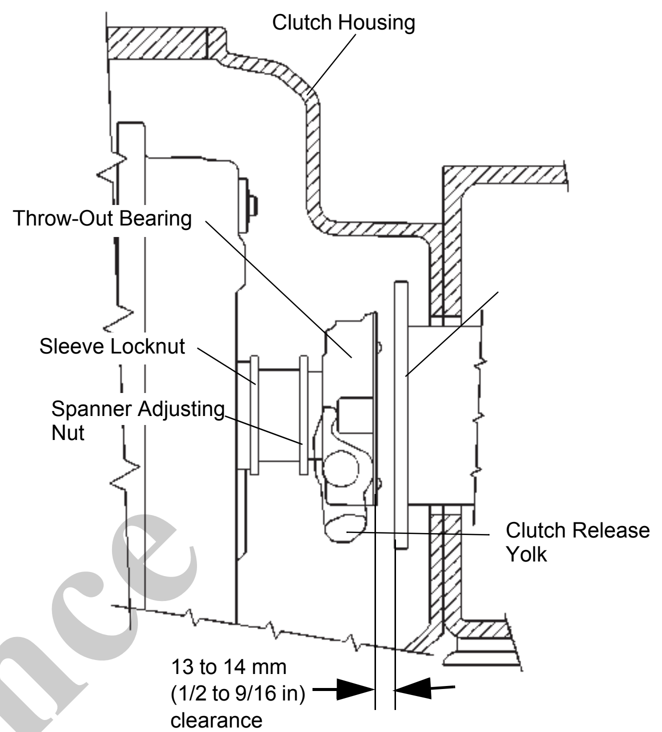


FIGURE 7-26

General Maintenance

1. Never underestimate the necessity of perfect clutch balance. For example, just 3 ounces of clutch unbalance at 300 rpm is enough to fracture a crankshaft!
2. Pressure plates dished as much as 1.5 mm (0.060 in) are reground by some rebuilders! Not enough metal remains to dissipate heat. That means quick failure.
3. You should never wait for a clutch to slip before adjusting! Regular inspection of the release bearing clearance insures proper adjustment.
4. Misalignment will cause chatter, grab, drag, or vibration, or all four! Alignment of clutch and all other drive-line parts should be checked before putting crane into service.

Lubrication

Perform periodic free-travel checks and adjustment, and lubrication of the clutch's throw-out bearing with high temperature grease for trouble-free clutch operation. Do not use chassis grease on the throw-out bearing. Lubricate clutch pedal to clutch linkage grease fittings with chassis grease. Refer to *Lubrication* on page 9-1.

GEARSHIFT AND TRANSMISSION SHIFT AIR SYSTEM

Description

The remote location of the transmission from the shift lever in the carrier cab requires a mechanical linkage between the cab and transmission case. A master control unit is attached to the bottom of the gearshift lever under the cab floor and is mechanically connected by a universally jointed rod to a slave shifter unit on top of the transmission case. All of the motions of the gearshift lever are in this way transmitted to the shift fingers that engage the shift bars and locks of the transmission case. Range shifts for the transmission are controlled by air operated master and slave valves.

The shift air system controls the selection of the transmission ranges and is comprised of an air valve, air regulator, air filter, range control valve, a range shift cylinder, and the necessary connecting piping.

The range control valve is located on the shift lever in the carrier cab, and the other valves and cylinders are mounted on the transmission.

Refer to the *Operator Manual* for operation instructions.

Theory of Operation

The range control valve has two positions: HIGH (switch up) and LOW (switch down). There are two air lines connected between it and the air valve. One of these is the supply line from the regulator, while the other is the air return to the air valve.

When the range control valve is in the LOW position, air is exiting the range control valve and enters the slave air valve where it shifts the piston. This allows the air from the regulator to exit the bottom port of the air valve, enter the low range air port of the auxiliary shift cylinder, and shift the low speed gear.

When the range control valve is in the HIGH position, air is prevented from exiting the range control valve. This allows the air entering the slave air valve from the regulator to move the piston, routing the air out of the valve to the high range port of the auxiliary shift cylinder. This moves the shift bar shifting the high speed gear.

In addition to the range control switch, a LO-LO (deep reduction) switch allows the operator to select two extra low gears. This switch has a forward (IN) position for being in deep reduction, and a rearward (OUT) position for being out of deep reduction.

Shifting Gears

The manual transmission's gear shift has six drive locations and the neutral locations. The gear shift has a finger switch (range control switch) for high range and low range, and a thumb switch (deep reduction switch) for deep reduction (Figure 7-27). These switches route air under pressure to shift in high, low, or deep reduction ranges.

To change gears, the operator has to step on the clutch pedal, use the finger or thumb switch to pick proper range, use the gear shift to pick the chosen speed and direction, and then step off of the clutch pedal (Figure 7-28).

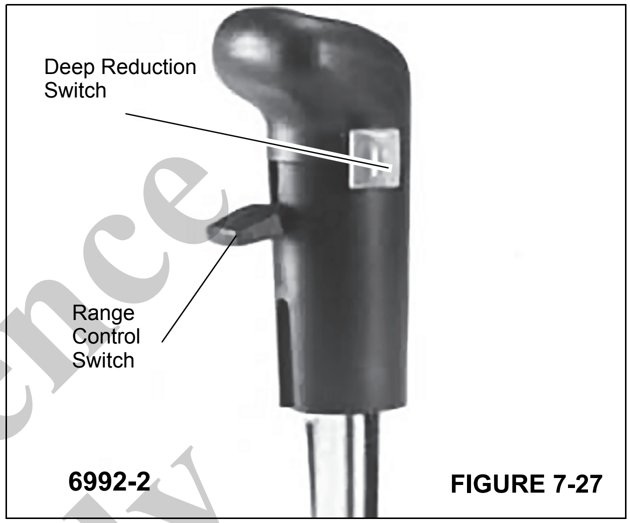


FIGURE 7-27

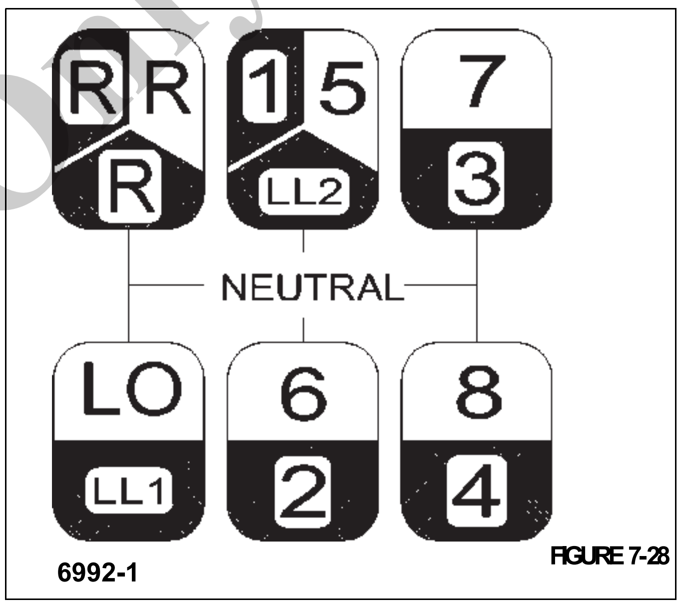


FIGURE 7-28

Maintenance

Troubleshooting

Table 7-2

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Excessive lever travel or sloppy feel when shifting.	**a.** Setscrews loose in control shaft universal joints or shift fingers.	**a.** Tighten or replace setscrews.
2. Hard shifting.	**a.** Bent shift bar in transmission. Damaged cross shaft or bushings in master or slave unit.	**a.** Disassemble and repair as necessary
3. Transmission locked in gear or in neutral; gearshift lever moves freely; no detent feel.	**a.** Shift control shaft broken, U-joints loose or disconnected, cross shaft in slave unit broken, or shift fingers loose.	**a.** Disassemble and repair as necessary.
4. Gearshift lever positions do not correspond to transmission gear ranges.	**a.** Lever in master unit and cross shaft in slave unit out of phase.	**a.** Shift transmission to neutral. Disconnect U-joints at shift control slave unit; place gear shift lever in neutral position. Connect U-joints and tighten setscrews.

Removal

1. Shift the transmission to neutral. Bleed the air reservoirs and tag and disconnect the nylon tubing at the range shift valve on the gearshift lever. Tag and disconnect the tubing at the splitter valve.

NOTE: The range shift valve may be removed from the gearshift lever without disconnecting the nylon tubing from the valve, if so desired. This is recommended if no service is to be performed on the air shift piping or valves.

2. Loosen the setscrews in the universal joints on the shift control shaft (at both ends of the shaft) and remove the shift control shaft.
3. Remove the capscrews securing the master control unit to the bracket.
4. Loosen the locknuts on the slave control unit mounting flange studs. Loosen the hex nuts on the mounting studs, remove all nuts, and lift off the slave control unit.

Installation

1. Route the gear shift up through the cutout in the cab floor and secure the master unit to the plate with the capscrews.
2. Install the slave unit onto the studs in the transmission shift bar cover, ensuring the shift fingers engage properly with the shift bars inside the transmission.
3. Position the gearshift lever to the neutral (perpendicular) position and install the shift control shaft, being careful to maintain the exact position of the slave unit input shaft and the gearshift lever.
4. After installing the shift control shaft and ensuring the master and slave unit are synchronized in the exact neutral position, tighten the setscrews on the shift control shaft universal joint yokes. There are two setscrews on each yoke mounted at 90 degrees to each other. Lockwire these setscrews after tightening.
5. Connect the nylon tubing to the range shift valve if disconnected.
6. Connect the nylon tubing to the splitter valve.

Lubrication

Lubricate the U-joints with chassis grease. Lubricate the master unit with chassis grease. Refer to *Lubrication* on page 9-1.

7

MANUAL TRANSMISSION

Description

The transmission is a manual transmission. It has a gearshift and a clutch pedal in the carrier cab. Refer to the *Operator Manual* for operation instructions.

The transmission provides 11 forward speeds and three reverse speeds. The transmission has a five speed front section and a three speed auxiliary section. The auxiliary section contains the low and high range ratios, plus the three deep reduction gears. The range switch is used once during an upshift sequence and once during a downshift sequence. Deep reduction ratios are selected using the deep reduction button on the gear shift.

Theory of Operation

One ratio in the front section is used only in low range as a starting gear. The remaining four ratios in the front section are used once through the reduction (low) gear in the range section and once through direct (high) in the range section.

The twin countershaft design splits torque evenly between two countershafts, reducing gear tooth pressure and wear. The floating mainshaft gears of this design eliminate gear bushings and sleeves as gears float between mating gears on the countershafts.

Maintenance

Troubleshooting

Before attempting to determine a cause of transmission noise or trouble, note what position the gearshift lever is in when the trouble occurs. If the noise is evident in only one gear position, the cause of the trouble is generally traceable to the gears in operation. There are times, however, due to abnormal conditions in other parts of the crane, when noises are transmitted from the engine, power train, frame, or body to the transmission and will appear to originate there. All such sources should be checked out before removing and disassembling the transmission.

Another source of trouble could be a faulty air system or in the actuating parts of the transmission's shifting bar housing. This will be noticed when the transmission fails to make a range shift, or shifts too slowly.

Diagnostics

NOTE: Refer to the Eaton Manual Transmission Troubleshooting Guide on the Roadranger web site for diagnostic procedures. If these cannot be retrieved, contact your distributor or Manitowoc Crane Care.

If there is a problem with the transmission, the operator should do the following:

1. Verify there is enough fluid in the transmission and there is no damage to the transmission and lines.
2. Note the driving condition under which the problem occurred.
3. Note the condition of the transmission under which the problem occurred (i.e. direction, range, and gear) and engine speed.
4. Contact a service facility to have the vehicle and transmission system evaluated.

Table 7-3

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Noise (from other sources).	**a.** Fan bent or out of balance.	**a.** Replace fan.
	b. Damaged vibration damper.	**b.** Replace damper.
	c. Flywheel out of balance.	**c.** Check balance. Replace flywheel if necessary.
	d. Unbalanced clutch assembly.	**d.** Check clutch and clutch housing for proper alignment.
	e. Loose engine mountings.	**e.** Tighten mountings.
	f. Worn U-joints.	**f.** Replace U-joints.

SYMPTOM	PROBABLE CAUSE	SOLUTION
2. Noisy transmission (in neutral).	**a.** Transmission misaligned.	**a.** Align engine and transmission (assembled) with rear axle so as to correct angles of U-joints.
	b. Worn transmission pinion bearing.	**b.** Replace bearing.
	c. Worn or scored countershaft bearing.	**c.** Replace bearings.
	d. Damaged second speed mainshaft gear bushing.	**d.** Replace bushing.
	e. Unmatched gears.	**e.** Replace unmatched gears.
	f. Worn or rough reverse-idler gear.	**f.** Replace gear.
	g. Eccentric countershaft gear assembly.	**g.** Replace gear.
	h. Sprung or worn countershaft.	**h.** Replace countershaft.
	i. Excessive backlash in gears.	**i.** Replace worn gears.
	j. Excessive end play in countershaft.	**j.** Adjust to reduce end play.
	k. Worn main shaft pilot bearing.	**k.** Replace pilot bearing.
	l. Scuffed gear tooth contact surface.	**l.** Replace gear.
	m. Insufficient lubrication.	**m.** Check for leaks; fill to proper level.
3. Sticking in gear.	**a.** Clutch operating improperly.	**a.** Adjust clutch. Check alignment.
4. Jumping out of gear.	**a.** Sliding gear tight on main shaft splines.	**a.** Check for galling. Replace as necessary.
	b. Improper adjustment of linkage	**b.** Adjust linkage.
	c. Misaligned transmission.	**c.** Check alignment.
	d. Shift rail poppet springs broken.	**d.** Replace poppet springs.
	e. Worn main shaft pilot bearing.	**e.** Replace pilot bearing.
	f. Shift forks sprung or loose on shift rail.	**f.** Replace sprung fork or tighten setscrew in shift fork.
	g. Linkage and rods between shift lever and transmission not properly adjusted.	**g.** Check and adjust linkage and rods to make sure transmission is shifting full into gear.
	h. Clutch gear teeth worn tapered.	**h.** Replace worn parts.
	i. Bearings worn.	**i.** Replace bearings.
	j. Transmission mounting in carrier puts strain on case.	**j.** Line up front mounting bracket so it does not cause strain on front main shaft bearing retainer.

SYMPTOM	PROBABLE CAUSE	SOLUTION
5. Oil leakage.	**a.** Transmission over filled.	**a.** Drain to proper level.
	b. Breather stopped up.	**b.** Clean breather assembly.
	c. Use of transmission oil that foams and expands when hot.	**c.** Drain and refill with proper grade and type of lubricant.
	d. Drain back holes between bearing retainers and main case stopped up.	**d.** Check drain holes and gaskets to ensure openings are clean.
	e. Broken gaskets.	**e.** Replace gaskets and use gasket cement.
	f. Loose drain plug in transmission.	**f.** Tighten drain plug.
	g. Cracked transmission housing.	**g.** Replace transmission.
	h. Cover not properly tightened.	**h.** Tighten cover.
6. Noisy transmission (in gear).	**a.** Gears worn and pitted due to lugging engine with transmission in too high a gear range.	**a.** Replace gears.
	b. Bearings worn due to lugging engine with transmission in too high a gear range, or to chips and dirt in oil.	**b.** Replace worn or rough bearings.
	c. Worn, chipped, or tapered sliding gear teeth.	**c.** Replace gears.
	d. Noisy speedometer gears.	**d.** Replace gears.
	e. Transmission not lined up properly with carrier.	**e.** Line up transmission with rear axle so as to correct angles of U-joints.
7. Difficult shifting.	**a.** Improperly operating clutch.	**a.** Adjust clutch. Check alignment.
	b. Sliding gear tight on shaft splines.	**b.** Check for galling. Replace as necessary.
	c. Burred main shaft splines.	**c.** Replace main shaft.
	d. Improper adjustment of shifting linkage. Worn or bent shifter rails.	**d.** Check and adjust linkage and rods to ensure that transmission is shifting fully into gear.
	e. Insufficient lubricant.	**e.** Fill to proper level.
8. Range shift inoperative or malfunctioning.	**a.** Air lines crossed between control valve on shift lever and air valve on transmission (steady leakage from exhaust port on range shift control valve with switch in the up position).	**a.** Disconnect crossed air lines and connect properly.
	b. Lines crossed between air valve on transmission and the shift cylinder.	**b.** Disconnect crossed air lines and connect properly.
	c. Low range (down position) on switch results in high range gear engagement, and vice versa.	**c.** Disassemble control valve and replace O-ring seals.
	d. Range shift control valve leaking due to poor O-ring seals. Leakage from exhaust port of regulator due to ruptured diaphragm or clogged regulator piston.	**d.** Disassemble, clean, and repair regulator.

SYMPTOM	PROBABLE CAUSE	SOLUTION
9. Bearing failure.	**a.** Use of wrong lubricant or grade of lubricant.	**a.** Drain transmission; flush and refill with proper grade and type of lubricant.
	b. Bearings adjusted too tight or too loose.	**b.** Obtain correct adjustment.
	c. Lack of cleanliness in overhaul of transmission resulting in damaged gearing due to foreign matter in oil.	**c.** Properly clean transmission.

Transmission Removal

1. Refer to *Engine Removal* in this section and remove the engine and transmission as an assembly from the crane.

CAUTION

Ensure any lifting device used is capable of supporting the transmission in a level position during removal.

2. Remove the bolts and washers securing the transmission housing to the engine housing.
3. Carefully pull back on the transmission, keeping it level until the input shaft is clear of the clutch assembly.
4. Continue to pull back and remove the transmission.

Special Procedure for Changing Transmission Input Shaft

In some cases in field repair it may be necessary to replace only the transmission input shaft due to clutch wear on the splines.

In these instances the input shaft can be removed without disassembling the transmission other than removing the shifting bar housing. Removal of the clutch housing is optional.

NOTE: The below instructions are for changing the input shaft only. To change the drive gear, complete disassembly of the front section must be made.

Disassembly

1. Remove the gear shift lever housing and shift bar housing from the transmission.
2. Remove the front bearing cover.
3. Engage the mainshaft sliding clutches in two gears and remove the drive gear bearing nut.
4. Move the drive gear assembly as far forward as possible and remove the drive gear bearing.
5. Remove the washer from the input shaft.
6. From the front, remove the snap ring from the ID of the drive gear.
7. Pull the input shaft forward and from the splines of the drive gear.

Assembly

1. Install the new input shaft into the splines of the drive gear just far enough to expose the snap ring groove in the ID of the drive gear.
2. Install the snap ring in the ID of the drive gear.
3. Install the washer on the shaft.
4. Move the forth-fifth speed sliding clutch gear forward to contact the end of the input shaft in the hub of the drive gear. Block between the rear of the sliding clutch and the front of the fourth speed gear. When installing the bearing this will hold the input shaft in position to seat the bearing properly.
5. Install the drive gear bearing on the shaft and into the case bore. Ensure the blocking remains in place.
6. Remove the blocking from the mainshaft and install the drive gear bearing nut (left-hand thread). Use Loctite sealant on the threads of the nut and shaft.
7. Peen the nut into the milled slots in the shaft.
8. Install the front bearing cover, shifting bar housing and gear shift lever housing.

Transmission Installation

1. Refer to *Clutch* on page 7-31 and install the clutch as well as perform the required clutch maintenance.
2. Put a very light film of wheel bearing grease on the input shaft of the transmission.
3. Attach an adequate lifting device to the transmission and position the transmission so the transmission housing aligns with the engine flywheel housing.

CAUTION

Ensure the input shaft or clutch release yoke does not bind on the release bearing.

4. Carefully move the transmission forward, ensuring the shaft aligns with the splines on the clutch discs and the

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clutch release yoke rides up and over the release bearing (throw-out bearing) while the shaft goes into the pilot bearing.

5. Install the 12 bolts and washers mounting the transmission's clutch housing to the engine flywheel housing. Tighten the bolts; refer to *Fasteners and Torque Values* on page 1-12 for the torque value.
6. Refer to *Engine - Installation* in this section and install the engine and transmission.

Clutch Adjustment Procedure

1. Remove the inspection plate from bottom of the clutch housing.
2. Verify the following:
    - Clutch lever is properly installed, the adjusting screw on clutch pedal adjusting lever is equally adjusted in either direction.
    - The adjusting screw is set to 1.6-3.2 mm (1/16-1/8 in) wear clearance, as shown, (Figure 7-29).
    - That all rod end bearings and jam nuts on control rods are tight and have sufficient thread engagement (4 threads min) on each rod.
    - Cable is set to the middle of its adjustment range at both ends.

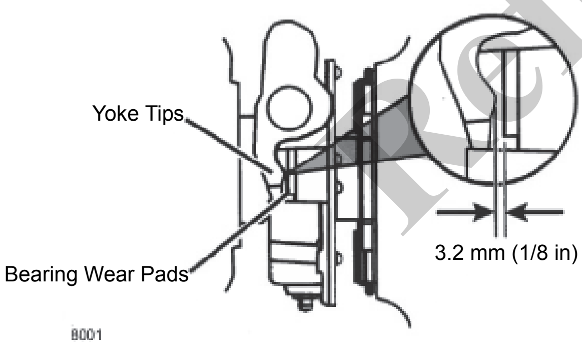


FIGURE 7-29

3. Visually check the travel of the release bearing after working the pedal several times. Measure the distance between the release bearing and the clutch brake. The correct distance should be 12.7-14.2 mm (0.500-.560 in) (Figure 7-30).

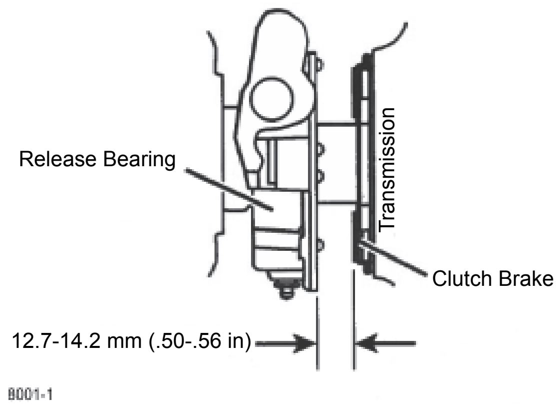


FIGURE 7-30

4. To adjust, remove cover plate and disassemble grease hose/fitting inside.
5. Depress clutch and turn adjusting nut. Clockwise moves the bearing toward transmission, (Figure 7-31)

NOTE: 2-1/3 rotations = 3 mm (1/8 in)

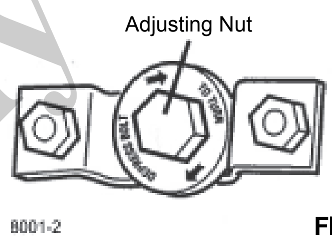


FIGURE 7-31

6. Clutch brake squeeze should begin 12.7-25.4 mm (0.50-1.00 in) above the end of pedal stroke. Insert a 0.25 mm (0.010 in) feeler gauge between the release bearing and the clutch brake (Figure 7-32). Press the pedal down to clamp the gauge. If the gauge does not clamp, adjust linkage to achieve clutch brake squeeze then repeat this step.

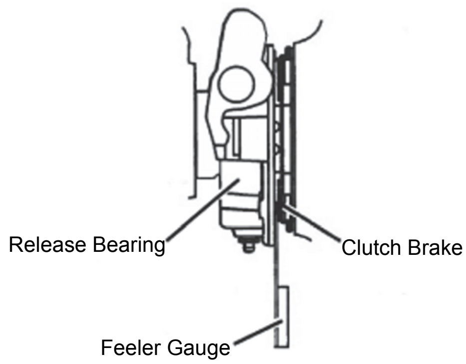


FIGURE 7-32

7. Slowly let up on the pedal and check the measurement from the floor to the pedal at the moment the gauge can be removed. Measurement should be 12.7-25.4 mm (0.50-1.00 in). Adjust as necessary and repeat measurement.
8. For rod linkage, adjust the rod end bearings evenly at each rod end. Lengthen rod to squeeze closer to end of pedal stroke.
9. For cable linkage, adjust cable inside frame rail near cab by loosening jam nuts and turning cable assembly. Approximately 44.5 mm (1.75 in) total adjustment available (22.4 mm (.88 in) each way from center). If more adjustment is needed, obtain by adjusting cable at transmission end. Clevis at either end may be adjusted if adjusting both cable ends does not provide enough travel.
10. Set the clutch pedal free travel to 12.7-25.4 mm (0.50-1.00 in) using the adjusting screw on the clutch pedal adjusting lever.
11. Verify free-play: Check distance between yoke tips and bearing wear pads. This should be 3.2 mm (0.125") (Figure 7-29). To change clearance, adjust upper pedal stop in cab.
12. Grease the yoke fingers, cross shaft bushings, linkage pivot points, and release bearing per instructions in *Lubrication* on page 9-1. Apply anti seize to spline shaft.

Lubrication

General

The transmission is designed so the internal parts operate in a bath of oil circulated by the motion of gears and shafts. Gray iron parts have built-in channels where needed, to help lubricate bearings and shafts. Thus, all parts will be amply lubricated if these procedures are closely followed.

1. Maintain the oil level. Inspect regularly.
2. Change the oil regularly.
3. Use the correct grade and type of oil.
4. Buy from a reputable dealer.

Draining Oil

Drain the transmission while the oil is warm. Remove the drain plug at the bottom of the case. Clean the drain plug before installation.

Refilling Oil

Clean the area around the filler plug and remove the plug from the left side of the case. Fill the transmission to the level of the filler opening. The exact amount of oil will depend on the transmission inclination; always fill to the proper level according to the dipstick. Do not overfill. This will cause oil to be forced out of the case through the main shaft opening.

Adding Oil

It is recommended that types and brands of oil not be intermixed because of possible incompatibility.

Operating Temperature

It is important the transmission operating temperature does not exceed 120°C (250°F) for an extended period of time. Operating temperatures above 120°C (250°F) will cause breakdown of the oil and shorter transmission life.

The following conditions in any combination can cause operating temperatures of over 120°C (250°F).

1. Operating consistently at road speeds under 32 km/h (20 mph).
2. High engine RPM.
3. High ambient temperature.
4. Restricted air flow around the transmission.
5. Exhaust system too close to the transmission.
6. High horsepower, overdrive operation.

High operating temperatures may require more frequent oil changes.

Proper Lubrication

If the transmission operating angle is more than 12 degrees, improper lubrication can occur. The operating angle is the transmission mounting angle in the chassis plus the percent of upgrade (expressed in degrees).

Preventive Maintenance

The following checks can be performed without disassembly:

- **Air System and Connections**. Check for leaks, worn air lines, loose connections, and capscrews.

7

- **Clutch Housing Mounting.** Check all capscrews in the bolt circle of the clutch housing for looseness.
- **Throw-out Bearing.** Remove the hand hole cover and check radial and axial clearances in the bearing. Check the relative position of the thrust surface of the bearing with the thrust sleeve.
- **Clutch Pedal Shaft and Bores.** Pry upward on the shafts to check wear. If excessive movement is found, remove the clutch release mechanism and check the bushings in the bores and wear on the shafts.
- **Gear Lubricant.** Change at the specified service intervals. Use only gear oils as recommended.
- **Filler and Drain Plugs.** Remove the filler plugs and check the level of lubricant at specified intervals. Tighten the filler plug and drain plug securely.

The following check can be made with the drive line dropped.

Universal Joint Companion Flange Nut. Check for tightness. Tighten to recommended torque.

The following checks can be made with the universal joint companion flange removed:

- **Output Shaft.** Check splines for wear from movement and chucking action of the universal joint companion flange.
- **Main Shaft Rear Bearing Cover.** Check oil seal for wear.

SECTION 8
UNDERCARRIAGE

SECTION CONTENTS

FRONT AXLE AND SUSPENSION

Description

Front Axle

The carrier has two non-driving front steer axles (see Figure 8-1). The front axle centers are built of tempered seamless steel tube center sections with heat treated steel forged knuckle pin ends.

Each front axle is bolted to the walking beam of the suspension system. Each axle is anchored against forward, rearward, and side ways movement by adjustable torque rods attached to the axles and to brackets on the carrier frame.

Suspension

The front axle suspension uses air bags with walking beams. The air bags along with shock absorbers are mounted on saddle assemblies above the walking beams. They provide for cushioning of road shock. The saddle assemblies are connected at the front by pivot blocks to carrier mounted brackets. The air bags and shock absorbers are bolted to the rear of the saddle assemblies and to carrier mounted brackets. A walking beam center is attached to each saddle assembly with the ends attached to each front axle.

Rubber bushings in the walking beam centers and ends, and torque rod ends, restrict excessive movement but allows enough movement to relieve stresses on metal parts. The rubber joints allow a certain amount of in and out axle movement which permits each axle to follow its own natural course more closely through turns. Once a straight line is resumed, the bushings square off the tandem so that the leading tires set the tracking pattern. Torque rods along with the walking beam creates a parallelogram style linkage that assure positive axle alignment.

Air for the suspension system is controlled by a control valve on the side console in the carrier cab and by two height control valves mounted on each side of the frame by the air bags. Each height control valve is mechanically actuated by a control lever attached to its respective saddle assembly. The valve controls the amount of air in each set of air bags thus controlling the height of the frame. To deflate the entire air suspension system (front and rear), position the suspension control valve on the carrier cab side panel to DEFLATE. This causes the four height control valves to shift and dump all air from the suspension air bags. Four pressure switches sense the air pressure in each set of air bags. Low air pressure in any of the four sets of air bags will trip the respective pressure switch to illuminate the Deflated Indicator on the side console.

Maintenance

General

Proper preventive maintenance will help control repair costs and downtime. If a major overhaul is required, remove the tandem suspension and axle assemblies from the carrier. However, torque rods, air bags, shock absorbers, walking beams, and other components can be removed separately as required with the axles remaining on the carrier. Refer to *Lubrication*, page 9-1 for specified lubrication intervals. Check the torque on all bolts at least once a year.

Beam Center Cap Fasteners

Periodically check the bolts on the saddle cap to prevent wear of the beam center bushing into the saddle assembly. Check bolt torque. Torque should be 305 to 372 Nm (225 to 275 lb-ft).

Beam End Connections and Bushings

Every 16,090 km (10,000 mi) check the torque of the beam end bolts. Torque 610 to 813 Nm (450 to 600 lb-ft). Jack up under each beam end and check for movement of the rubber end bushing. Worn bushings will allow movement and the bushings should be replaced. Periodically inspect the beam for a lowering in the hanger and distorted or frayed rubber. A gap on each side of the visible rubber at the lower end of the end bushing is normal because the end bushings are in compression.

Saddle Assembly End Cap Fasteners

Periodically check the bolt torque on the saddle assembly end caps. Torque should be 305 to 372 Nm (225 to 275 lb-ft).

Beam Center Bushings

The beam center bushings control lateral movement of the axles during cornering. Normal wear is evidenced by rubber shredding from each end of the bushing. Worn bushings result in increased lateral movement on turns, causing the inside walls of the tires to rub on the suspension saddle assemblies during turns. Replace the bushings before serious tire damage results.

Beam Center Cross Tube

The center cross tube connects the two walking beams and maintains axle alignment in turns. Inspect the cross tube for damage and, if bent, it must be replaced. A bent tube will result in axle misalignment and cause abnormal tire wear.

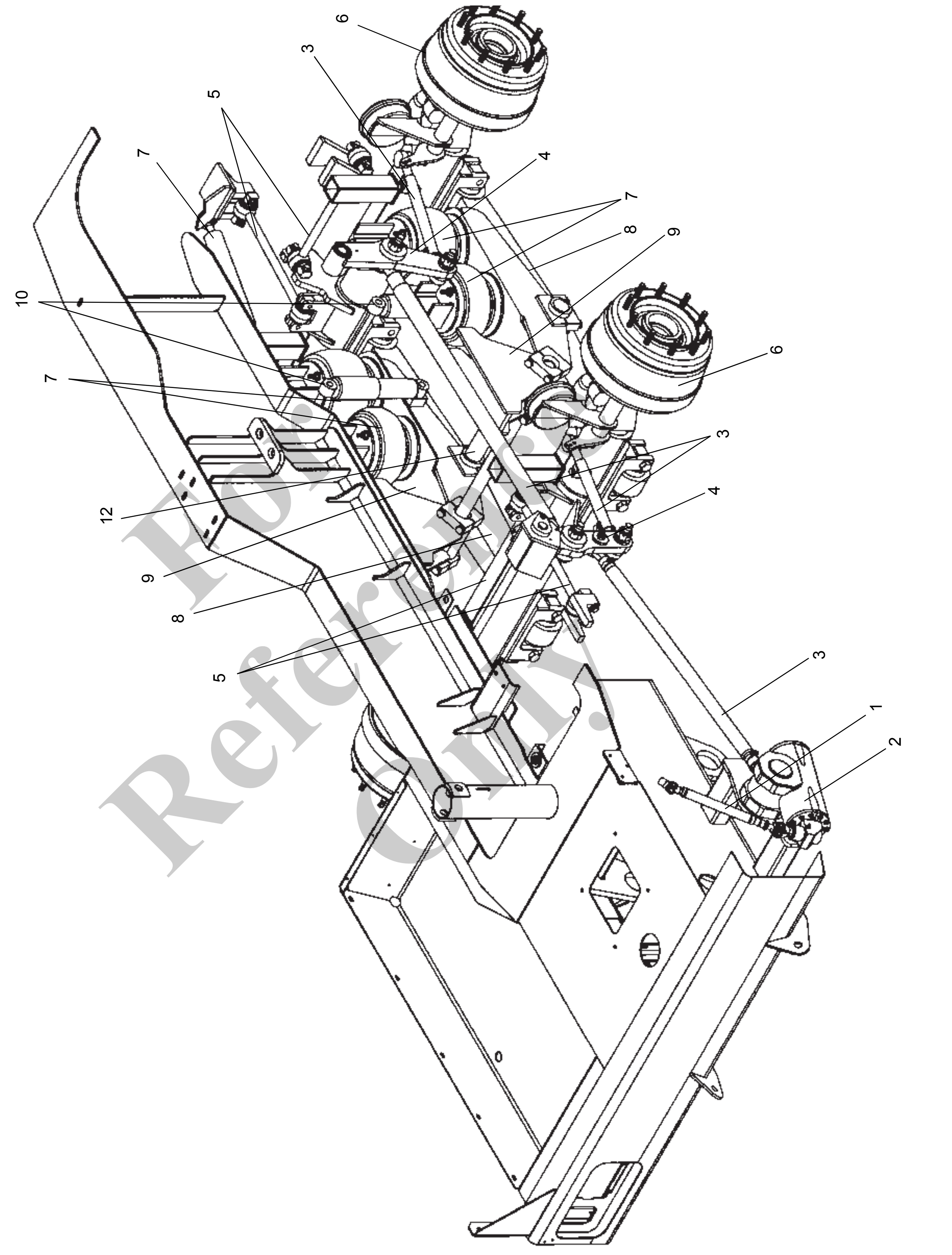


FIGURE 8-1

Item	Description
1	Steering Column
2	Steering Gearbox
3	Vertical Socket Drag Link
4	Relay Arm
5	Torque Rod
6	Steer Axle
7	Suspension Air Bag
8	Walking Beam
9	Suspension Saddle Assembly
10	Shock Absorber
11	Steer Cylinder
12	Trunnion Tube

Air Bags

Check for wear or road damage. Check for air leaks. Check tightness of nuts and bolts. Torque to 41 Nm (30 lb-ft).

Height Control Valves

Check valve, fittings, and air lines for leaks. Check actuating linkage for bent or damaged condition.

Shock Absorbers

Check the shock absorbers for leakage and wear.

Removal

NOTE: The axle does not have to be removed from the crane for maintenance.

1. Raise the crane on outriggers until the weight is off the tires and place jack stands under the carrier frame.
2. Completely drain the air pressure from both systems.
3. Remove the tire and wheel assemblies from both sides of the axles.
4. Place an adequate lifting/supporting device under the axles and suspension system.

NOTE: The axle and suspension system weighs approximately 1700 kg (3750 lb).

5. Tag and disconnect the air lines to the four brake chambers and the four air bags. Remove the fittings from the air bag connections. Cap all hoses and openings.

NOTE: Do not change the torque rod or vertical socket drag links dimensions. This will make wheel alignment easier when the axle is reinstalled.

6. Remove the bolts, hardened washers, and nuts securing each of the torque rods to the carrier frame.
7. Remove the cotter pin and nut securing each vertical socket drag link to its axle.
8. Remove the cotter pin and nut (and washers if any) securing each steer cylinder to the axles. Free each steer cylinder from the axles; take care not to damage hydraulic lines. Secure each steer cylinder to protect it and the hydraulic lines.
9. Remove the hardware securing the linkage rod of each height control valve to its respective saddle assembly.
10. Remove the nut, lockwasher, and hardened washer securing each shock absorber to the carrier frame.
11. With the axles and suspension fully supported, remove the two nuts and washers securing each of the four air bags to the carrier frame brackets.
12. Remove the two bolts and washers securing each of the four saddle assemblies' cap blocks to the carrier frame brackets.
13. Remove the axles and suspension assembly from under the carrier.

Disassembly

Disassemble the axle and suspension assembly as necessary using the following procedures.

NOTE: Do not change the torque rod dimensions. This will make wheel alignment easier when the axle is reinstalled.

1. Remove the bolts, hardened washers, and nuts securing each torque rod to the axle brackets.
2. Remove each shock absorber from the suspension saddle assembly by removing the nut and two washers securing each. Remove the shock absorber(s).
3. Remove each axle from the walking beams by removing the two bolts, washers, and nuts securing each end of the axle to the walking beam end bushings. Remove the axle(s).
4. Remove the saddle assemblies from the walking beams by removing two bolts and washers from each pivot block cap. Remove the caps. Remove the saddle assemblies and the trunnion tube from the walking beams.
5. Remove each air bag from the saddle assembly by removing the bolt and lockwasher. Remove the air bag(s).

Assembly

As necessary, assemble the axle and suspension assembly using the following procedures.

1. Position the air bag(s) on the saddle assembly and secure each with a bolt and lockwasher.
2. Position the trunnion tube through the center bushing on each walking beam. Position each saddle assembly over the center bushing and secure with the pivot block cap and two bolts and lockwashers. Torque the bolts 305 to 373 Nm (225 to 275 lb-ft).
3. Position the axle(s) under the walking beams aligning the axle brackets with the bar end bushings on the walking beams. Secure each end with two bolts, washers, and nuts. Torque the bolts 610 to 814 Nm (450 to 600 lb-ft).
4. Position the shock absorber(s) on the saddle assembly and secure each with a nut and two washers. Torque the nuts 305 to 373 Nm (225 to 275 lb-ft).
5. Position the torque rods in the axle brackets and secure each with two bolts, hardened washers, and nuts.

Installation

1. Position the axle and suspension assembly under the carrier.
2. Raise the assembly into position under the carrier aligning the saddle assemblies pivot blocks and air bags with the mounting brackets on the carrier.
3. Install the four saddle assemblies' cap blocks and secure each with the two bolts and washers. Torque the bolts to 305 to 373 Nm (225 to 275 lb-ft).
4. Secure the four air bags to the carrier brackets with two nuts and washers. Torque the nuts to 41 Nm (30 lb-ft).
5. Secure each shock absorber to the carrier frame with a nut, lockwasher, and hardened washer.
6. Secure the linkage rod of each height control valve to its respective saddle assembly with the attaching hardware.
7. Attach each steer cylinder's attached ball socket to the axle using the ball socket's slotted nut and a cotter pin. Add hardened flat washers as needed to ensure proper seating of cotter pin in slotted nut. Torque nut 136 to 170 Nm (100 to 125 lb-ft). Tighten to nearest cotter pin hole and insert cotter pin. Take care not to damage hydraulic lines.
8. Attach the vertical socket drag links to each axle using the slotted nut and cotter pin. Torque nut 136 to 170 Nm (100 to 125 lb-ft). Tighten to nearest cotter pin hole and insert cotter pin.
9. Attach the four torque rods to the carrier frame using two bolts, hardened washers, and nuts each.
10. Install the air fittings in the inlet of the air bags. Connect the air lines to the air bags and brake chambers as tagged during removal.
11. Service the axles and suspension system. Refer to *Lubrication*, page 9-1.
12. Build up air pressure in the systems and check for leaks. Check operation of brakes and air suspension system.
13. Install the tire and wheel assemblies. Refer to *Wheels and Tires*, page 8-21.
14. Retract the outriggers and check the axles for proper operation.

Axle Alignment Procedure

1. Place wood blocks between the saddle assemblies and the frame so that the top surfaces of the saddle assemblies are parallel to the bottom of the carrier frame.
2. Measure the longitudinal distance from the center of the rear axle saddle blocks to the center of the king pin on the last front axle (see Figure 8-2). If necessary, adjust the shims in the walking beam ends. The correct side to side location is achieved by adding or removing shims at the lateral rods.
3. Measure diagonally from the center of the rear axle saddle blocks to the center of the opposite king pin on last front axle (see Figure 8-2). If the diagonal measurements are not within 12.7 mm (0.50 in), check the location of the suspension hangers and air bag hangers and adjust as necessary.
4. Double check all measurements made in steps 1 thru 3 and readjust the shims if necessary.
5. Repeat steps 2 thru 4 to align the first front axle. Use the king pin centers of the last front axle for making the necessary longitudinal and diagonal king pin measurements to the first front axle. If the diagonal distance from one side to the other is not within 6.35 mm (0.25 in), check the location of the suspension hangers and air bag hangers and adjust as necessary.

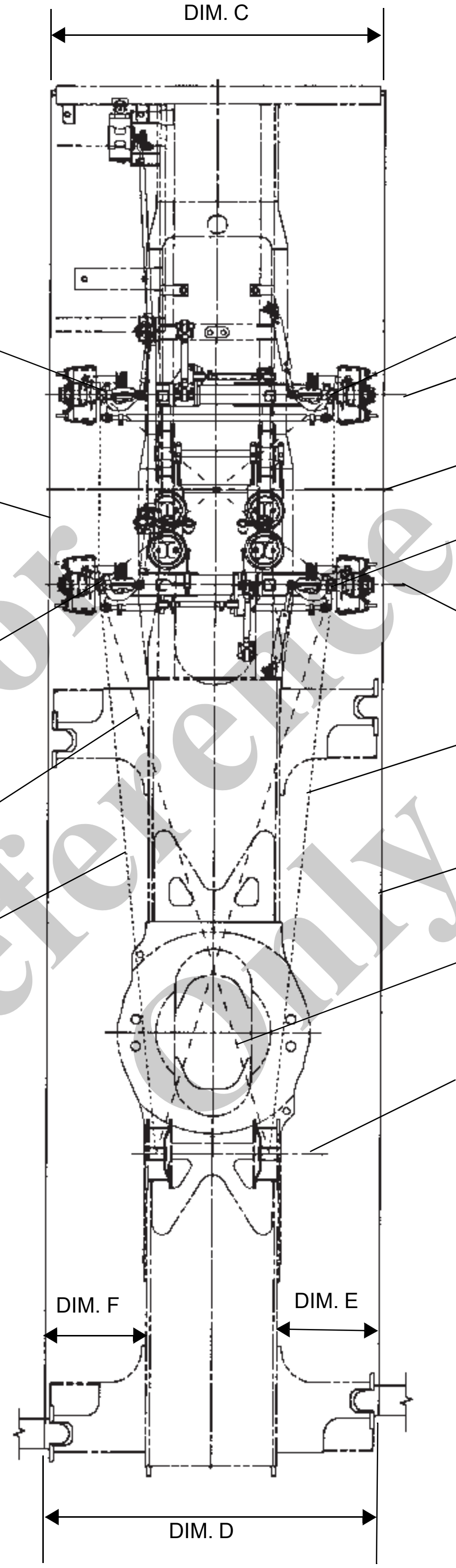

DIM. C
King Pin Center
King Pin Center
C/L Of First Front Axle
C/L Of Front Bogie
String Line
King Pin Center
C/L Of Last Front Axle
King Pin Center
Longitudinal Measurement
Diagonal Measurement
String Line
Longitudinal Measurement
Diagonal Measurement
C/L Of Rear Axle Saddle Block
DIM. F
DIM. E
DIM. D

FIGURE 8-2

Toe-In Adjustment

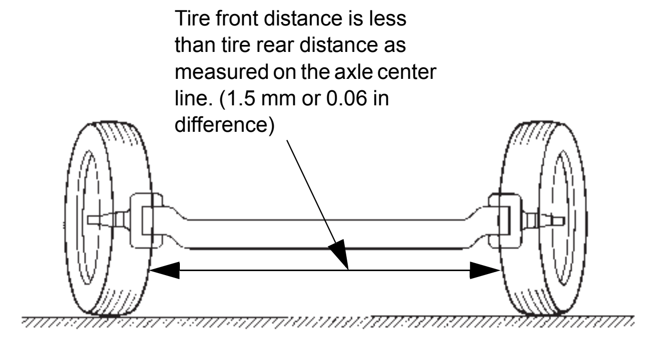


FIGURE 8-3

Toe-in (see Figure 8-3) is having the wheels of a steerable axle closer together in the front than in the rear. Toe-in is necessary for both tire wear and to keep the wheels from weaving side to side.

1. Position the wheels straight ahead.
2. Loosen the clamps on the tie rods.
3. Adjust the tie rod as needed to provide between 0.0 to 1.5 mm (0 to 0.06 in) of toe-in for each wheel. Double check to ensure both wheels have the correct toe-in.
4. Position the clamps on the tie rod beams so that they clear the axle when the wheels are turned. Tighten the clamps and recheck toe-in measurement.

Axle Stop Settings

1. Remove and discard the axle stop bolts on the last front axle.
2. Adjust the axle stop bolts (see Figure 8-4) on the first front axle, the bolts should be adjusted in or out as needed to obtain a measurement of 3.0 mm (0.12 in) minimum from the rigid axle stop to the top of the bolt head (see Figure 8-4).

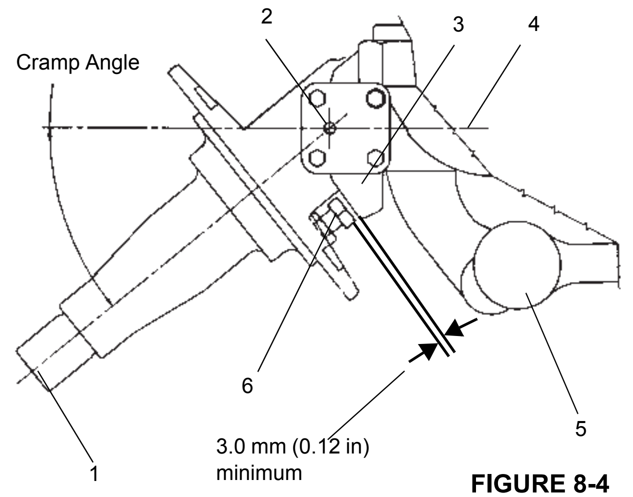


FIGURE 8-4

Item	Description
1	Spindle
2	King Pin Center
3	Rigid Axle Stop
4	C/L Of Axle
5	Tie Rod
6	Axle Stop Bolt

Drag Link Installation and Axle Synchronization

NOTE: All detail numbers are in reference to Figure 8-5.

1. Assemble front relay arm (Detail #9) and drag link (Detail #7). Install the assembly on the carrier frame.
2. Attach rear relay arm (Detail #8) to the opposite end of drag link (Detail #7) and then install the relay arm on the carrier frame.

NOTE: It is acceptable to use a 21/64 drill bit as the rig pin(s).

3. Install a 8.33 mm (0.328 in) diameter rig pin through the front relay arm mounting bracket and the front relay arm. Adjust drag link (Detail #7) so that a 8.33 mm (0.328 in) rig pin can be installed through the rear relay arm mounting bracket and the rear relay arm.
4. Check that the front wheels are aligned to the straight ahead position by using a straight edge long enough to lay across the wheel mounting surfaces of both front axles. Adjust drag links (Detail #5) to fit between the relay arms (Details #8 and #9) and the axle steer arms.
5. Check the position of the pitman arm on the steering gearbox and adjust if necessary. Attach drag link (Detail #6) to the pitman and adjust its length as needed to fit between the pitman arm and the front relay arm (Detail #9) while keeping the pitman arm position fixed.

6. Remove the relay arm rig pins and secure all drag links.
7. Check that the rod ends on all drag links are within the limits shown in Figure 8-5.

Final Adjustments

1. Inflate tires to the pressure specified on the tire inflation chart located on the carrier cab door.
2. Start the engine and allow both air systems to reach full system pressure. Ensure the crane is on a flat level surface. Ensure the top surface of each saddle assembly is parallel with the bottom surface of the carrier frame by measuring the distance at the front and rear of the saddle assemblies. If necessary, adjust the height control valves to raise or lower the saddle assemblies into a parallel position.

CAUTION

Do not attempt to adjust the axle drag links or the tie rod ends while the full weight of the crane is on the axles unless the tires are on greased plates or the crane is on outriggers. Failure to do so may cause component damage.

3. To ensure proper adjustment, drive the front wheels onto greased plates or a suitable turntable so that the friction between the tires and ground is reduced.
4. If greased plates are not available, raise the crane 3.75 cm (1.5 in) from the static height by lowering the outrigger jack cylinders. This will allow adjustment of the drag links without damage, but will require rechecking the alignment after the axles are fully loaded
5. Slightly open the fittings on each steer cylinder and turn the steering wheel from stop to stop, bleeding the cylinders until there is no air. Tighten fittings.
6. Install the relay arm rig pins. Refer to paragraph titled *Drag Link Installation and Axle Synchronization*, page 8-7.
7. Partially extend the outrigger beams. Attach a string line to front and rear outrigger beams per Figure 8-2. Ensure the string line is taut and level.
8. Referring to Figure 8-2, ensure that Dimension C equals Dimension D and that Dimension E equals Dimension F.
9. Referring to Figure 8-5, adjust the drag links (Detail 5) as required so that the distance from the string line to the front of each wheel is the same as the distance from the string line to the rear of the same wheel within 1.5 mm (0.06 in). Check that the rod ends of the drag links are within limits specified in Figure 8-5.
10. Remove the rig pins.

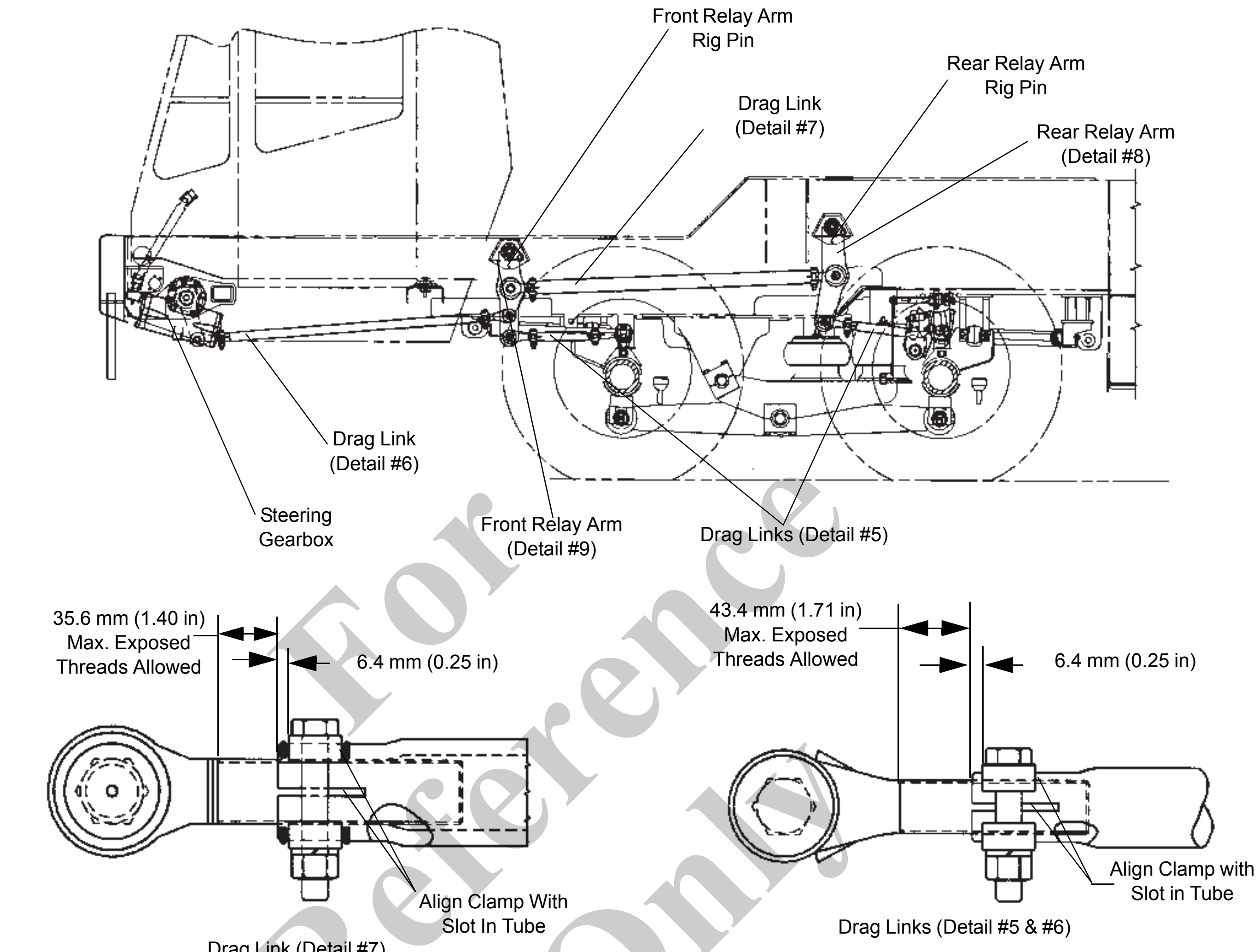
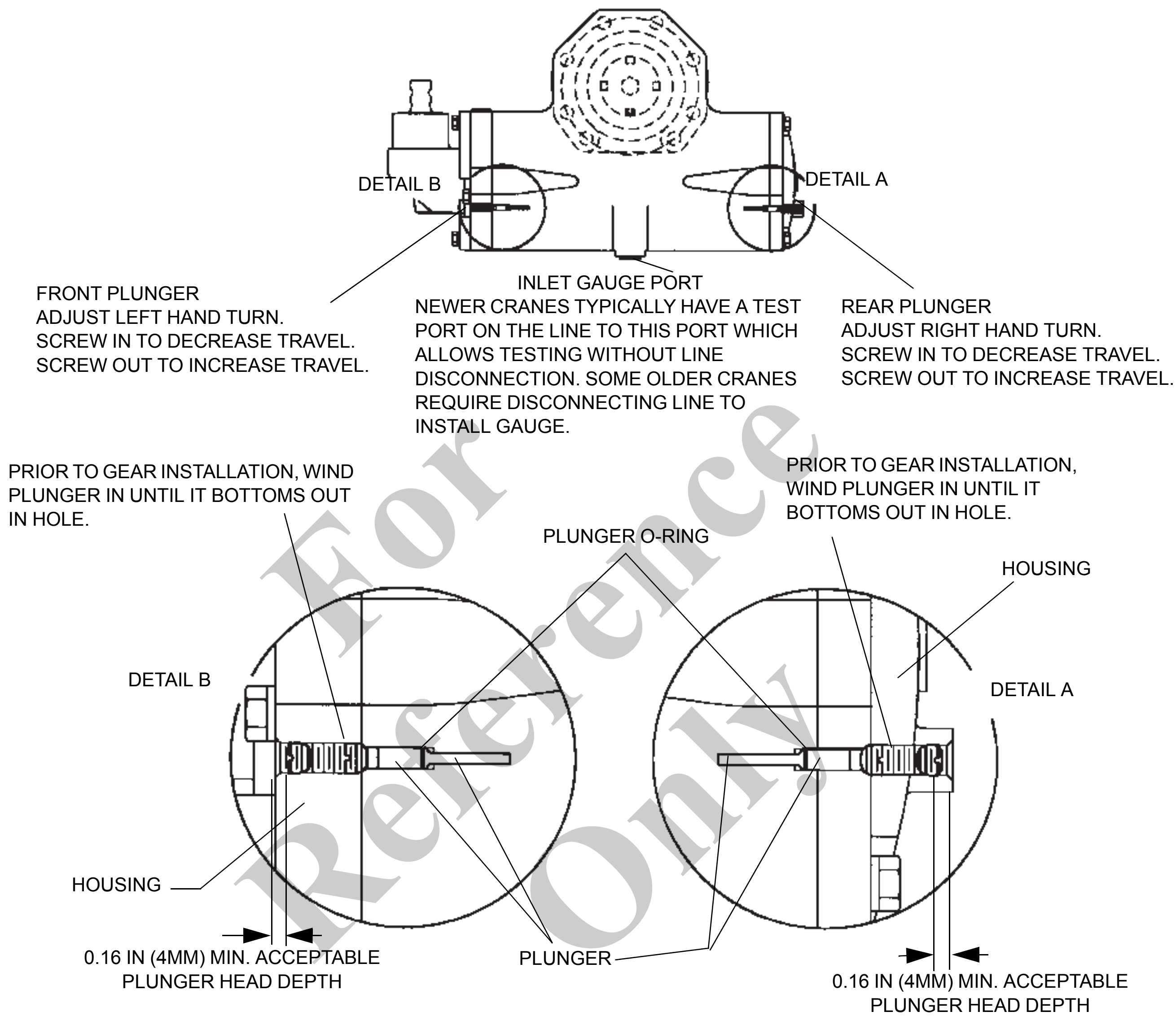


FIGURE 8-5

Setting Axle Stops and Steering Gear Relief Plungers

1. Start the engine and run at idle.
2. With the wheels on greased plates, turn the wheels in both directions and check for clearances between all moving parts. The clearances should be at least 1.00 in (25 mm).
3. Adjust the axle stop as necessary to get the maximum cramp angle and proper clearances.
4. Put the full weight of the machine on properly inflated tires and on a hard firm surface.

8



NOTE: PLUNGER(S) MUST NOT BE WOUND OUT BEYOND THIS DEPTH. DAMAGE COULD RESULT.

FIGURE 8-6

5. Install a pressure check diagnostic quick disconnect with gauge on the test port upstream of the inlet gauge port of the power steering gearbox. (On older cranes, disconnect the hydraulic line to the inlet gauge port, cap or plug it, and temporarily install the gauge on the test port.)

CAUTION

To prevent pump damage/failure due to heat build up, run the engine in this configuration for a maximum of 30 seconds to 1 minute.

6. Start engine. Slowly drive the crane forward and turn the wheels to full left turn against the axle stop. Verify solid contact against axle stop; screw in the power steering gearbox's front plunger to decrease travel or screw it out to increase travel as needed. Check pressure; it should not exceed 62 bar (900 psi).

7. If the pressure is too high or the axle stop is not making contact with the axle, adjust the front plunger so the axle stop makes contact with the axle and the pressure reading does not exceed 62 bar (900 psi). Screw the front plunger in to decrease travel or screw it out to increase travel so pressure reading does not exceed 62 bar (900 psi).

NOTE: Do not attempt to set the relief pressure with the tires off the ground.

8. Slowly drive the crane forward and turn the wheels to full right turn against the axle stop. Verify solid contact against axle stop; screw in the power steering gearbox's rear plunger to decrease travel or screw it out to increase travel as needed. Check pressure; it should not exceed 62 bar (900 psi).

9. If the pressure is too high or the axle stop is not making contact with the axle, adjust the rear plunger so the axle stop makes contact with the axle and the pressure reading does not exceed 62 bar (900 psi). Screw in the rear plunger to decrease travel or screw it out to increase travel so pressure reading does not exceed 62 bar (900 psi).

NOTE: Do not attempt to set the relief pressure with the tires off the ground.

10. Stop engine. Verify both plungers are screwed into the gearbox far enough so the head of each plunger is at least 4 mm (0.16 in) below the top of its threaded hole. A plunger screwed in less deeply than this could cause or suffer damage.

11. Remove diagnostic gear and reinstall cap on test port. (On older cranes, re-connect the hydraulic line to the inlet gauge port.)

12. Ensure the top surface of each saddle assembly is parallel with the bottom surface of the carrier frame by measuring the distance at the front and rear of the saddle assemblies. If necessary, adjust the height control valves to raise or lower the saddle assemblies into a parallel position.

Front Air Ride Adjustment

NOTE: This model is equipped with an air ride front and rear suspension. It is necessary to periodically inspect the suspension for proper adjustment. Operating this machine with incorrect ride height adjustments could result in poor ride quality or possible damage to suspension and axle components.

1. Start unit and charge the air system until the air compressor shuts off and the air pressure gauges read 130 +/- 10 psi.

2. Turn suspension inflation switch on.

3. Install digital level on bottom of frame rail above the trailing arm and zero level.

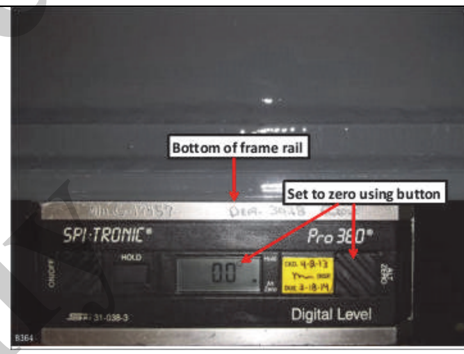


FIGURE 8-7

4. Next set digital level on top of the trailing arm and adjust the ride height until a reading of 0.0° ± 0.5° is achieved.

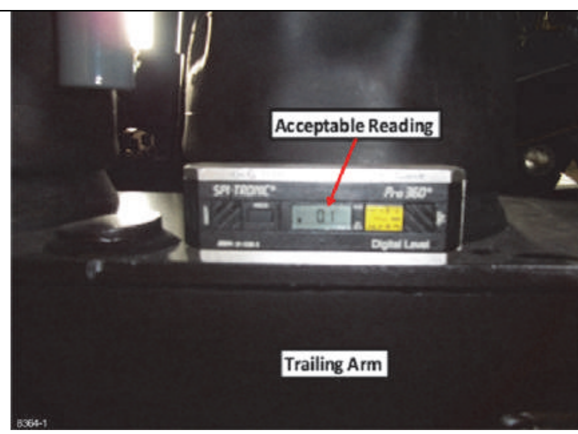


FIGURE 8-8

5. Repeat procedure on frame and trailing arm on the other side of the frame.

6. Once all four corners are adjusted, drive the machine forward at a slow speed and “tap” the brake pedal to bounce the machine. Do this 3 times going forward, then 3 times in reverse.
7. Repeat steps 3 through 5 until all the trailing arms remain adjusted within 0.5° of level.

STEERING SYSTEM

Description

The steering system is comprised of the steering gearbox, steer pump, and two steer cylinders. The steering gearbox provides for full time hydraulic steering, but still allows for manual steering in the event of a system malfunction.

Maintenance

Troubleshooting

Table 8-1

Symptom	Probable Cause	Solution
1. Oil leaking at output shaft of steering gear.	**a.** Damaged sector shaft seal.	**a.** Replace sector shaft.
2. Oil leaking at actuating shaft of steering gear.	**a.** Worn or damaged oil seal. **b.** Damaged actuating shaft seal surface.	**a.** Replace actuating shaft seal. **b.** Replace bearing cap, actuating shafts assembly.
3. Oil leaking at supply pump drive shaft.	**a.** Damaged oil seal. **b.** Oil seal-heat damaged. **c.** Loose or damaged bushing on pump drive shaft.	**a.** Replace oil seal. **b.** Check operating temperature. **c.** Repair pump per pump service instruction.
4. Lubricant milky or white in appearance.	**a.** Water entry through reservoir venting system.	**a.** Clean vent system or replace cap assembly.
5. Oil forced out of reservoir or foaming.	**a.** Clogged oil filter. **b.** Air in system. **c.** Relief plungers of steering gear not adjusted properly creating high operating temperatures. **d.** Air leak in suction side of supply pump. **e.** Pump cavitation. **f.** Oil overheating.	**a.** Change oil and oil filter. **b.** Bleed air from the system. Check for air leak on suction side of supply pumps. **c.** Adjust relief plungers. **d.** Reference pump servicing instruction. **e.** Check for restriction in pump supply. **f.** Check for restriction in steering gear return.
6. Engine oil in power steering reservoir (gear driven pump).	**a.** Faulty seal at pump drive shaft. **b.** Faulty seal at accessory shaft driving supply pump.	**a.** Repair pump. **b.** Repair accessory drive.

Published 01-29-2015, Control # 512-01

Symptom	Probable Cause	Solution
7. Lubricating oil discolored or smells bad.	**a.** Operating temperatures too high. **b.** Change intervals too long. **c.** Incorrect lubricant used.	**a.** Check and correct cause of overheating. **b.** Change oil more often. **c.** Drain, flush, and refill with recommended lubricant.
8. High operating temperatures.	**a.** Oil flow restriction. **b.** Oil flow too high.	**a.** Check back pressure. **b.** Check maximum oil flow.
9. Excessive pump pressure with steering gear in neutral.	**a.** Pinched oil return line, high back pressure. **b.** Binding steering column.	**a.** Relocate line. **b.** Repair steering column.
10. Wheel turning restricted.	**a.** Relief plungers not adjusted properly.	**a.** Adjust relief plungers.
11. Erratic steering or mechanical steering only.	**a.** Insufficient volume of oil. **b.** Sticking pressure relief valve in steering gear.	**a.** Refer to pump servicing instructions. **b.** Repair or replace relief valve as required.
12. Hard steering.	**a.** Faulty supply pump. **b.** Steering out of alignment. **c.** High operating temperature.	**a.** Check pump flow. **b.** Align front end. **c.** Locate and correct cause of overheating.
13. Wheel turns hard in one or both directions.	**a.** Dirt or foreign matter trapped in piston relief. **b.** Bent or damaged king pins and tie rods. **c.** Front end load too great. **d.** Low oil level in steering system.	**a.** Check pressure relief. **b.** Repair or replace king pins and tie rods. **c.** Lighten load. **d.** Fill oil reserve as required.
14. Wheel turns hard in one or both directions.	**a.** Air in system. **b.** Caster degree incorrect.	**a.** Bleed system and check for cause of air. **b.** Correct to specified degree.
15. Wheel turns hard in one direction.	**a.** Metal or foreign material in relief ball seat in piston of steering gear.	**a.** Remove and clean relief valve seats or replace damaged parts.
16. No attempt to return straight ahead from turns/should also be hard steering complaint.	**a.** No positive caster. **b.** Steering column bind. **c.** Steering gear mounting distorted. **d.** Linkage ball sockets seized or binding.	**a.** Set caster to specified degree. **b.** Check and repair U-joints and support bearings. **c.** Shim mounting pads to correct piston to bore interference. Make sure correct bolt length is used on the base mount gears. **d.** Check and repair or replace.

Symptom	Probable Cause	Solution
	e. King pins seized or binding.	**e.** Repair or replace.
	f. Oil flow rate incorrect.	**f.** Check and correct supply pump.
17. Darting, wandering, oversteering.	**a.** Oil flow too high.	**a.** Supply pump not to specifications.
	b. Air trapped in steering gear.	**b.** Bleed system.
Darting, wandering, oversteering. (continued)	**c.** Looseness, worn front end parts.	**c.** Check and repair as required.
	d. Front end alignment not correct.	**d.** Align front end - Caster.
	e. Overloading.	**e.** Reduce loads.
	f. Rear axle not parallel.	**f.** Check and repair as required.
	g. Tight tie rod ends and drag link sockets.	**g.** Check rotational torque and replace if necessary.
18. Excessive backlash, freeplay.	**a.** Worn universal joint.	**a.** Replace universal joint.
	b. Rack on piston damaged.	**b.** Replace steering gear.
	c. Damaged sector shaft/ splines.	**c.** Replace steering gear.
	d. Worn or damaged pitman arm splines.	**d.** Replace pitman arm and/or sector shaft.
	e. Universal joint yoke loose on actuating shaft.	**e.** Repair or replace damaged parts.
19. Steering input not smooth.	**a.** Worn universal joint.	**a.** Check and replace as required.
	b. Lack of lubrication.	**b.** Lubricate per lube chart.
	c. Universal joints not phased properly.	**c.** Re-phase columns.
	d. Low oil flow.	**d.** Idle speed to slow or supply pump not to specifications.
	e. Pump cavitation.	**e.** Correct pump supply.
	f. Overheating.	**f.** Correct cause of overheating.

NOTE: *With the vehicle stationary and engine at idle, place the torque wrench on the steering wheel retaining nut and steer from lock to lock. A reading of more than 1.7 Nm (15 lb-in) means improper phasing. To correct, rotate the intermediate steering shaft one spline at a time until the torque reads the same throughout the 360 degree rotation.

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. 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 fluid.
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 pressure can only

be determined by connecting a pressure gauge at the pump outlet port or at the steering gear inlet port. With the engine running at a medium speed, turn the steering wheel to one end of travel and hold at the travel limit just long enough to get a pressure reading. Never hold the system relief pressure for more than a few seconds at a time. The pressure gauge should indicate 137.9 bar (2000 psi) at the pump outlet.

STEERING PUMP

Description

The steering pump is mounted on and driven by the engine. The pump is located on the left side of the engine and provides the hydraulic flow necessary to power the steering gearbox. The pump is a gear type pump and provides a priority flow of approximately 38 lpm (10 gpm) at 137.9 bar (2000 psi). For additional information on the pump, refer to *Pressure Setting Procedures*, page 2-22.

STEERING GEARBOX

Description

The steering gear box is attached to the frame and is located on the left side beneath the cab. The gearbox provides full-time hydraulic steering and only enough manual effort to overcome the torsion bar and turn the rotate valve is required. With the engine running, there is a constant oil flow through the steering gear which provides an instant response and absorbs road shock. There is mechanical back-up steering so that the vehicle can be steered to the side of the road in the event of hydraulic pressure loss.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the steering gearbox. Cap or plug all openings.
2. Remove the steering shaft from the steering gearbox input shaft.
3. Remove the cotter pin and slotted nut securing the drag link vertical socket to the pitman arm.
4. Remove the pitman arm as follows.
   a. Using a punch and hammer, bend the retainer tab(s) out of the pitman arm retainer nut.
   b. Using an allen head socket, remove the retainer nut, friction washer, and retainer tab washer.
   c. Using a 3-jaw puller, remove the pitman arm from the gearbox shaft.

NOTE: The steering gearbox weighs approximately 79 kg (176 lb).

5. Support the weight of the gearbox. Remove the eight bolts and hardened washers which secure the gearbox to the frame and remove the gearbox.

Installation

CAUTION

Deviation from the following step could result in seal damage and/or leakage.

1. Prior to installation, wind the relief plungers located at both ends of the gearbox until they bottom out. Do not remove or wind out the plungers to a depth of less than 4 mm (0.16 in).
2. Position the gear box on the mounting and secure with eight bolts and hardened washers. Apply Loctite #243 to the gear box mounting bolts. Torque bolts to 306 Nm (225 lb-ft).
3. Turn the input shaft on the gearbox in one direction until it bottoms out.
4. Turn the input shaft in the opposite direction while counting the number of turns until it bottoms out.
5. Divide the number of turns by two, then turn the input shaft back that number of turns to center the steering gearbox output shaft.
6. After centering the steering gearbox output shaft, locate the pitman arm on the output shaft by aligning the timing marks (arrow on shaft and letter ‘B’ on pitman arm).

NOTE: The pitman arm must be at the angle shown in Figure 8-9. If the position varies more than 2 degrees, double check the center of travel and timing mark alignment.

7. Install the retainer nut, friction washer and tab washer onto the gear box shaft and secure the pitman arm. Torque the nut to 613 Nm (450 lb-ft).
8. After specified torque is reached, continue to torque until the notches in the retainer nut are aligned with the next bend tab of the tab washer. Bend two opposing tabs of the washer into the notches of the retainer nut.
9. Attach the steering column to the steering gearbox input shaft.
10. Connect the drag link vertical socket to the pitman arm using a slotted nut. Torque the nut to 136 to 170 Nm (100 to 125 lb-ft). Tighten the nut to the next cotter pin hole and install the cotter pin.
11. Connect the hydraulic lines to the steering gearbox as tagged during removal.

8

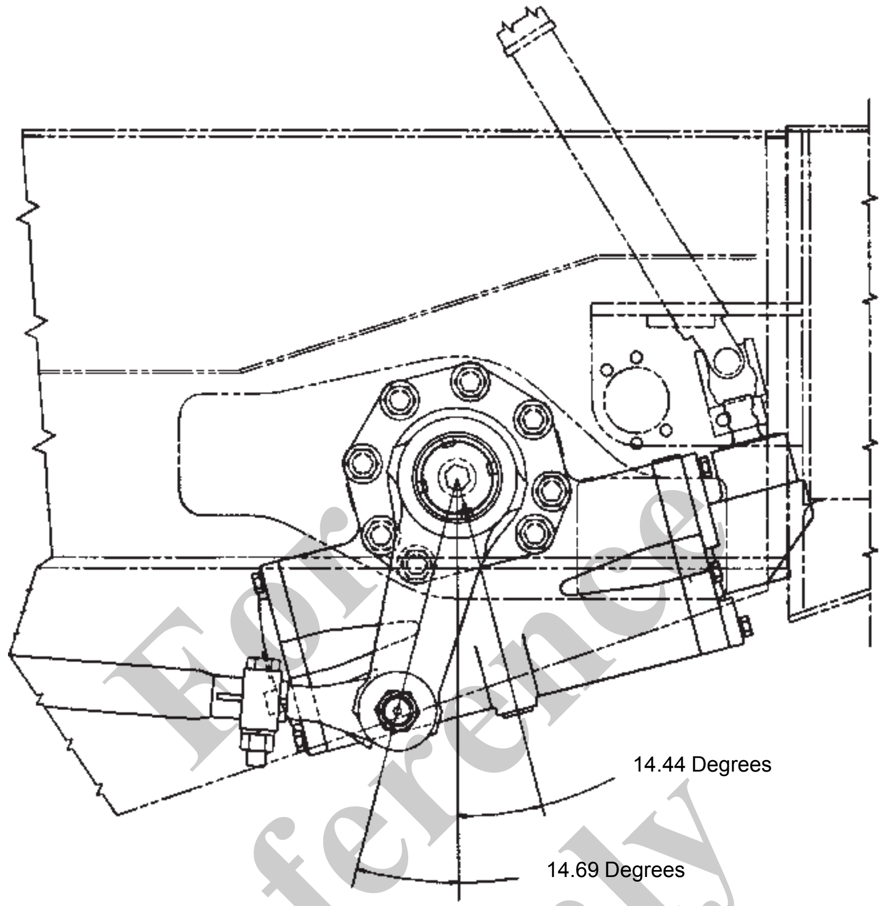


FIGURE 8-9

STEER CYLINDER

Description

The steer cylinders are double acting hydraulic cylinders and are controlled by a steering control valve located in the steering gearbox. The barrel of each cylinder is attached to the carrier frame. The cylinder shaft is attached to a steering arm on the axle spindle. The hydraulic oil entering one end or the other of the cylinder pushes or pulls the tie rod to turn the wheels left or right.

Maintenance

NOTE: For Disassembly and Assembly of the steer cylinder, refer to *Cylinders*, page 2-52.

Removal

1. Tag and disconnect the hydraulic lines to the cylinder. Cap or plug all lines and openings.
2. Remove the cotter pin, washer, and the retaining nut from each end of the cylinder.
3. Remove the cylinder.

Installation

1. Install the cylinder in position and secure it with the attaching nut and washers. Torque the nut 136 to 170 Nm (100 to 125 lb-ft). Tighten the nut to the nearest cotter pin hole and install the cotter pin. Add additional washers as necessary to ensure proper seating of cotter pin in nut.
2. Connect the hoses as per removal tags.

REAR AXLE AND SUSPENSION

Description

Rear Axle

The rear axles (see Figure 8-10) have single reduction differentials. The differentials have hypoid drive pinions, ring gear sets, and bevel gears. A straight roller bearing is mounted on the head of the drive pinion and all other bearings are tapered roller bearings. If equipped with a differential lock, the differential has the same gears and bearings as the standard differential. An air actuated shift collar moves toward the center of the differential and when the splines of the shift collar and axle shafts are meshed the differential is locked.

Suspension

The rear axle suspension (see Figure 8-10) uses air bags with walking beams. The air bags along with shock absorbers are mounted on saddle assemblies above the walking beams. They provide for cushioning of road shock. The saddle assemblies are connected at the front by pivot blocks to carrier mounted brackets. The air bags and shock absorbers are bolted to the rear of the saddle assemblies and to carrier mounted brackets. A walking beam center is attached to each saddle assembly with the ends attached to each rear axle.

Rubber bushings in the walking beam centers and ends, and torque rod ends, restrict excessive movement but allows enough movement to relieve stresses on metal parts. The rubber joints allow a certain amount of in and out axle movement which permits each axle to follow its own natural course more closely through turns. Once a straight line is resumed, the bushings square off the tandem so that the leading tires set the tracking pattern. Torque rods along with the walking beam creates a parallelogram style linkage that assure positive axle alignment.

Air for the suspension system is controlled by a control valve on the side console in the carrier cab and by two height control valves mounted on each side of the frame by the air bags. Each height control valve is mechanically actuated by a control lever attached to its respective saddle assembly. The valve controls the amount of air in each set of air bags thus controlling the height of the frame. To deflate the entire air suspension system (front and rear), position the Suspension Control Valve on the carrier cab side panel to DEFLATE. This causes the four height control valves to shift and dump all air from the suspension air bags. Four pressure switches sense the air pressure in each set of air bags. Low air pressure in any of the four sets of air bags will trip the respective pressure switch to illuminate the DEFLATED indicator on the side console.

Maintenance

General

Proper preventive maintenance will help control repair costs and downtime. If a major overhaul is required, remove the tandem suspension and axle assemblies from the carrier. However, torque rods, air bags, shock absorbers, walking beams, and other components can be removed separately as required with the axles remaining on the carrier. Refer to *Lubrication*, page 9-1 for specified lubrication intervals. Check the torque on all bolts at least once a year.

Beam Center Cap Fasteners

Periodically check the bolts on the saddle cap to prevent wear of the beam center bushing into the saddle assembly. Check bolt torque. Torque should be 305 to 372 Nm (225 to 275 lb-ft).

Beam End Connections and Bushings

Every 16,090 km (10,000 mi) check the torque of the beam end bolts. Torque 610 to 813 Nm (450 to 600 lb-ft). Jack up under each beam end and check for movement of the rubber end bushing. Worn bushings will allow movement and the bushings should be replaced. Periodically inspect the beam for a lowering in the hanger and distorted or frayed rubber. A gap on each side of the visible rubber at the lower end of the end bushing is normal because the end bushings are in compression.

Saddle Assembly End Cap Fasteners

Periodically check the bolt torque on the saddle assembly end caps. Torque should be 305 to 372 Nm (225 to 275 lb-ft).

Beam Center Bushings

The beam center bushings control lateral movement of the axles during cornering. Normal wear is evidenced by rubber shredding from each end of the bushing. Worn bushings result in increased lateral movement on turns, causing the inside walls of the tires to rub on the suspension saddle assemblies during turns. Replace the bushings before serious tire damage results.

Beam Center Cross Tube

The center cross tube connects the two walking beams and maintains axle alignment in turns. Inspect the cross tube for damage and, if bent, it must be replaced. A bent tube will result in axle misalignment and cause abnormal tire wear.

Air Bags

Check for wear or road damage. Check for air leaks. Check tightness of nuts and bolts. Torque to 41 Nm (30 lb-ft).

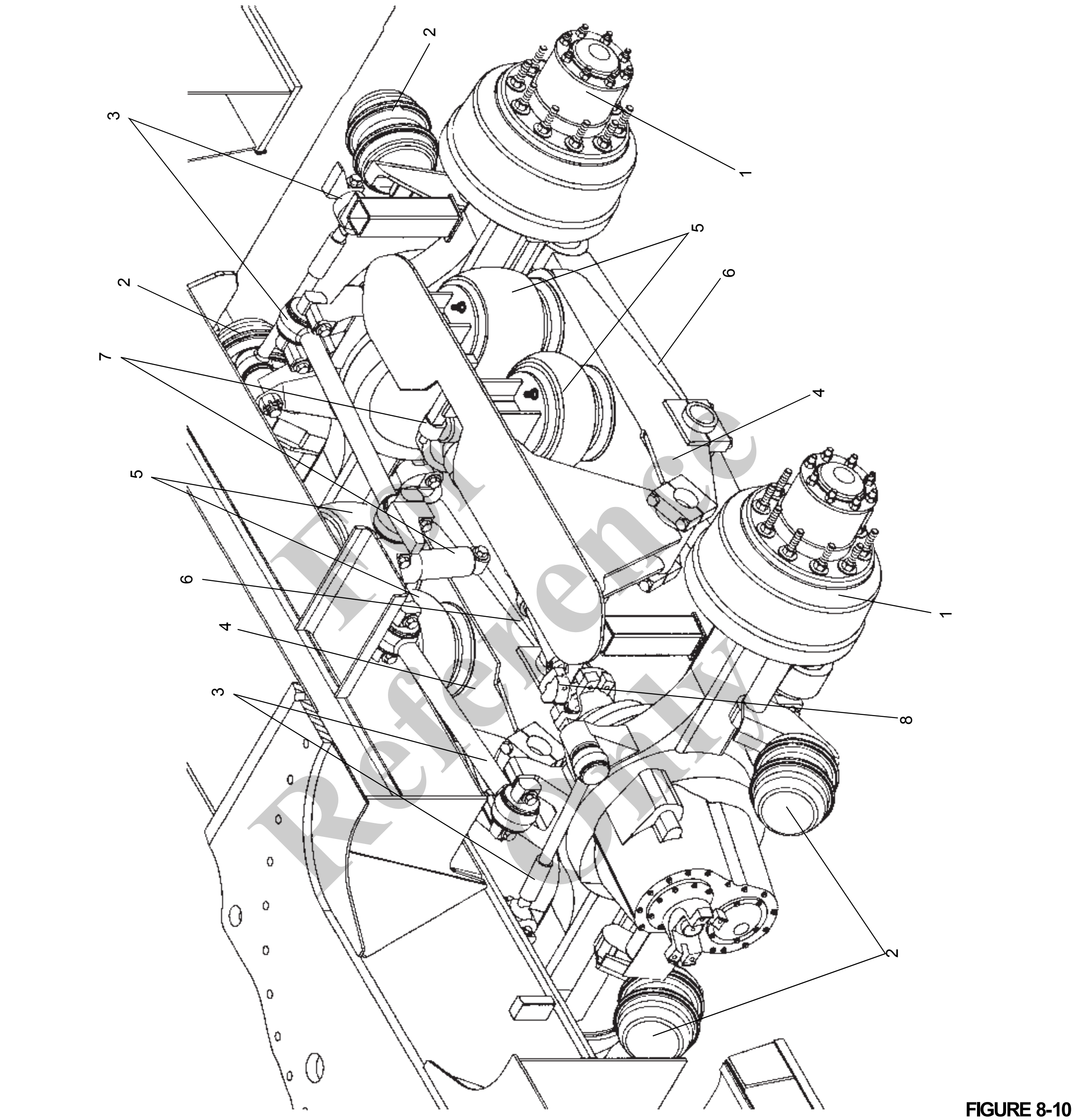


FIGURE 8-10

Item	Description
1	Drive Axle
2	Air Brake Chamber
3	Torque Rod
4	Lower Saddle Assembly

Item	Description
5	Air Bags
6	Walking Beam
7	Shock Absorber
8	Drive Line

Height Control Valves

Check valve, fittings, and air lines for leaks. Check actuating linkage for bent or damaged condition.

Shock Absorbers

Check the shock absorbers for leakage and wear.

Removal

NOTE: The axle does not have to be removed from the crane for maintenance.

1. Raise the crane on outriggers until the weight is off the tires and place jack stands under the carrier frame.
2. Completely drain the air pressure from both systems.
3. Remove the tire and wheel assemblies from both sides of the axles.
4. Place an adequate lifting/supporting device under the axles and suspension system.

NOTE: The axle and suspension system weighs approximately 2232 kg (4921 lb).

5. Tag and disconnect the air lines to the four brake chambers and the four air bags. Remove the fittings from the air bag connections. Cap all hoses and openings.
6. Disconnect the drive shaft from the front rear axle.
7. Remove the bolts, hardened washers, and nuts (lateral torque rod only) securing each of the torque rods to the carrier frame.
8. Remove the hardware securing the linkage rod of each height control valve to its respective saddle assembly.
9. Remove the nut, lockwasher, and two washers securing each shock absorber to the carrier frame.
10. With the axles and suspension fully supported, remove the two nuts and washers securing each of the four air bags to the carrier frame brackets.
11. Remove the two bolts and washers securing each of the four saddle assemblies' cap blocks to the carrier frame brackets.
12. Remove the axles and suspension assembly from under the carrier.

Disassembly

Disassemble the axle and suspension assembly as necessary using the following procedures.

1. Remove the drive line between the two rear axles.
2. Remove the bolts, hardened washers, and nuts securing each fore and aft torque rod to the axle brackets. Remove the torque rod(s).
3. Remove the nut securing each lateral torque rod to the axle brackets. Remove the torque rod(s).
4. Remove each shock absorber from the suspension saddle assembly by removing the nut and two washers securing each. Remove the shock absorber(s).
5. Remove each axle from the walking beams by removing the two bolts, washers, and nuts securing each end of the axle to the walking beam end bushings. Remove the axle(s).
6. Remove the saddle assemblies from the walking beams by removing two bolts and washers from each pivot block cap. Remove the caps. Remove the saddle assemblies and the trunnion tube from the walking beams.
7. Remove each air bag from the saddle assembly by removing the bolt and lockwasher. Remove the air bag(s).

Assembly

As necessary, assemble the axle and suspension assembly using the following procedures.

1. Position the air bag(s) on the saddle assembly and secure each with a bolt and lockwasher.
2. Position the trunnion tube through the center bushing on each walking beam. Position each saddle assembly over the center bushing and secure with the pivot block cap and two bolts and washers. Torque the bolts 305 to 373 Nm (225 to 275 lb-ft).
3. Position the axle(s) under the walking beams aligning the axle brackets with the bar end bushings on the walking beams. Secure each end with two bolts, washers, and nuts. Torque the bolts to 610 to 814 Nm (450 to 600 lb-ft).
4. Position the shock absorber(s) on the saddle assembly and secure each with a nut and two washers. Torque the nuts to 305 to 373 Nm (225 to 275 lb-ft).
5. Position the fore and aft torque rods in the axle brackets and secure each with two bolts, hardened washers, and nuts. Place two additional hardened washers on each side between torque rod and bracket. Torque the nuts to 769 to 834 Nm (567 to 615 lb-ft).
6. Position the lateral torque rods in the axle brackets and secure each with a nut and cotter pin. Torque the nuts to 237 to 305 Nm (175 to 225 lb-ft).
7. Connect the drive shaft between the two rear axles.

Installation

1. Position the axle and suspension assembly under the carrier.
2. Raise the assembly into position under the carrier aligning the saddle assemblies' pivot blocks and air bags with the mounting brackets on the carrier.
3. Install the four saddle assemblies' cap blocks and secure each with the two bolts and washers. Torque the bolts to 305 to 373 Nm (225 to 275 lb-ft).
4. Secure the four air bags to the carrier brackets with two nuts and washers. Torque the nuts to 41 Nm (30 lb-ft).
5. Secure each shock absorber to the carrier frame with a nut, lockwasher, and hardened washers.
6. Secure the linkage rod of each height control valve to its respective saddle assembly with the attaching hardware.
7. Attach the fore and aft torque rods to the carrier frame using two bolts and hardened washers each. Torque the bolts 769 to 834 Nm (567 to 615 lb-ft).
8. Attach the lateral torque rods to the carrier frame using two bolts, hardened washers, and nuts. Use additional hardened washers between torque rod and bracket to aid in properly centering axle.
9. Connect the drive shaft to the front rear axle.
10. Install the air fittings in the inlet of the air bags. Connect the air lines to the air bags and brake chambers as tagged during removal.
11. Service the axles and suspension system. Refer to *Lubrication*, page 9-1.
12. Build up air pressure in the systems and check for leaks. Check operation of brakes and air suspension system.
13. Install the tire and wheel assemblies. Refer to *Wheels and Tires*, page 8-21.
14. Retract the outriggers and check the axles for proper operation.

Rear Air Ride Adjustment

NOTE: This model is equipped with an air ride front and rear suspension. It is necessary to periodically inspect the suspension for proper adjustment. Operating this machine with incorrect ride height adjustments could result in poor ride quality or possible damage to suspension and axle components.

1. Start crane and charge the air system until the air compressor shuts off and the air pressure gauges read 130 ± 10 psi.
2. Turn suspension inflation switch on.
3. Install digital level on bottom of frame rail above the trailing arm and zero level.

FIGURE 8-11

4. Next set digital level on top of the trailing arm and adjust the ride height until a reading of 0.0° ± 0.5° is achieved.

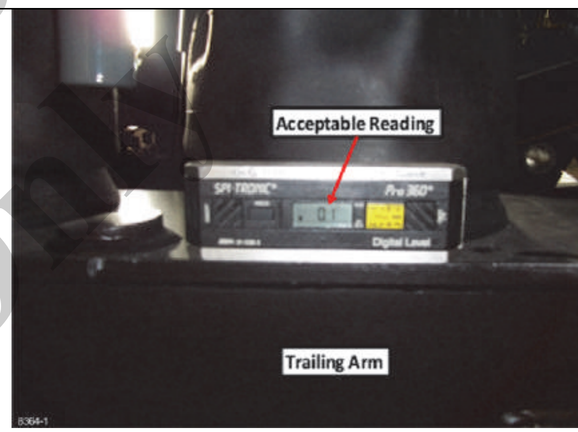


FIGURE 8-12

5. Repeat procedure on frame and trailing arm on the other side of the frame.
6. Once all four corners are adjusted, drive the machine forward at a slow speed and "tap" the brake pedal to bounce the machine. Do this 3 times going forward, then 3 times in reverse.
7. Repeat steps 3 through 5 until all the trailing arms remain adjusted within 0.5° of level.

WHEELS AND TIRES

Description

The following tire size is available for the axles:

- Front axle; size 445/65R22.5
- Rear axle: size 315/80R22.5.

NOTE: Tire diameter, width, and weight may vary slightly depending upon the manufacturer.

CAUTION

Do not mix tires or rims from different manufacturers.

Tires are designed to operate with a certain sidewall deflection or bulge. Correct air pressures ensures proper deflection which, in turn ensures proper traction, flotation, support of load and prevents excessive flexing of the tire. Overinflation increases rim stresses which results in lower rim life.

Inflate tires to the pressure specified on the tire inflation decal on the crane.

Unmatched tires on either tandems will cause wear, scuffing, and possible damage to drive units. It is recommended that tires be matched to within 3.2 mm (0.13 in) of the same rolling radius and 19.0 mm (0.75 in) of the same rolling circumference.

CAUTION

Do not install the largest tires on one driving axle and the smallest on the other driving axle. This will cause axle “fight” and high lubricant temperatures resulting in premature lubricant breakdown and costly axle service.

In addition to matching individual tire rolling radii and circumference, the total tire circumference of one driving axle should match the other driving axle.The result will be satisfactory axle lubricant temperatures.

Maintenance

DANGER

Do not dismount or mount tires on rims without proper training. High pressures can cause tire and rim parts to fly apart with explosive force and cause injury or death.

Mounting the Wheels on the Front Axle

NOTE: Do not lubricate the wheel studs or lug nuts or the wheel face or the hub. On aluminum wheels, lubricate the wheel pilot or hub pads only with an antiseize compound or synthetic lubricant with teflon. Do not lubricate wheel or hub faces.

1. Raise the crane on outriggers so the front wheels are off the ground.
2. Generously coat the wheel pilot or hub pads with antiseize compound. Do not apply antiseize compound to the face of the wheel or the hub.
3. Place the wheel assembly on the mounting studs. Take care not to damage the studs.
4. Install hub cover if applicable.
5. Install the lug nuts and tighten them until they are just snug. Rotate the wheel while installing each nut so the nut being tightened is in the top position. Do not lubricate the nuts or studs.
6. Tighten the lug nuts in the sequence shown to a preliminary torque of 68 Nm (50 lb-ft) (see Figure 8-13).
7. Keep tightening the lug nuts in the sequence shown until all 10 are torqued to 610 to 678 Nm (450 to 500 lb-ft) (see Figure 8-13).
8. Install lug nut covers on lug nuts.

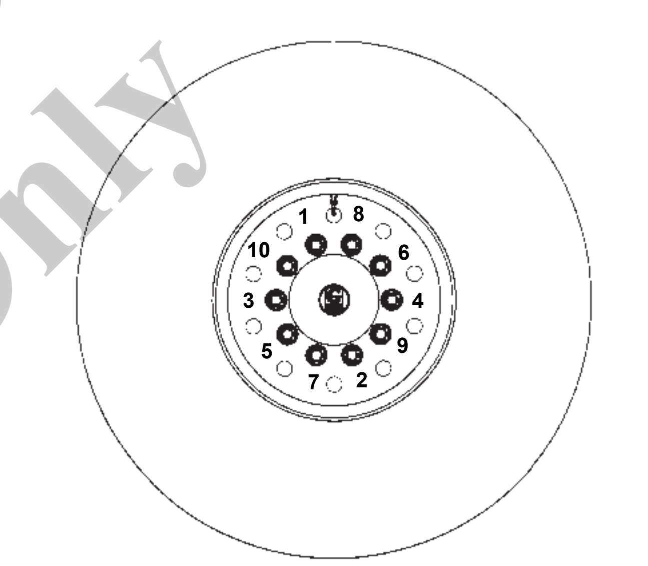


FIGURE 8-13

9. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.
10. Road-test the tire, then retorque to 610 to 678 Nm (450 to 500 lb-ft).

Maintain proper torque on wheel lugs and check for proper wheel mounting. Retorque the lug nuts 80 to 160 km (50 to 100 miles) after the wheels are removed and reinstalled. This will reseat the lug nuts. Check the torque every 800 km (500 miles) thereafter.

Mounting the Wheels on the Rear Axle

NOTE: Do not lubricate the wheel studs or lug nuts or the wheel face or the hub. On aluminum wheels, lubricate the wheel pilot or hub pads only with an antiseize compound or synthetic lubricant with teflon. Do not lubricate wheel or hub faces.

1. Raise the crane on outriggers so the rear wheels are off the ground.
2. Generously coat the wheel pilot or hub pads with antiseize compound. Do not apply antiseize compound to the face of the wheel or the hub.
3. Place the inside steel wheel assembly on the mounting studs. Take care not to damage the studs. Verify the valve extension is in place on the inside wheel assembly.
4. Align the outside aluminum wheel assembly so the valve extension from the inside tire can fit through the hole provided for it. (In Figure 8-14, the hole in question is between the stud labeled “5” and the stud labeled “7”. Place the outside wheel assembly on the mounting studs. Take care not to damage the studs.
5. Place three spring clips (mounted evenly on the axle flange) with the fingers extending inward toward the wheel base. Slide hub cover over clips.
6. Install the lug nuts and tighten them until they are just snug. Rotate the wheels while installing each nut so the nut being tightened is in the top position. Do not lubricate the nuts or studs.
7. Slide the valve stem stabilizer over the valve extension and press it into its hole in the wheel. The stabilizer should be against the wheel surface when properly installed.
8. Tighten the lug nuts in the sequence shown to a preliminary torque of 68 Nm (50 lb-ft) (see Figure 8-14).
9. Keep tightening the lug nuts in the sequence shown until all 10 are torqued to 610 to 678 Nm (450 to 500 lb-ft) (see Figure 8-14).

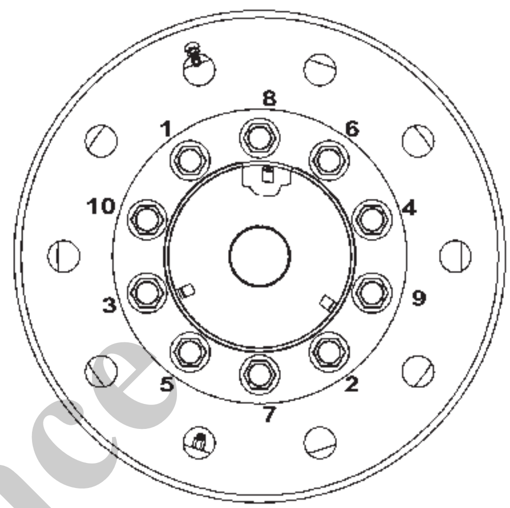


FIGURE 8-14

10. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.
11. Road-test the tire, then retorque to 610 to 678 Nm (450 to 500 lb-ft).

Maintain proper torque on wheel lugs and check for proper wheel mounting. Retorque the lug nuts 80 to 160 km (50 to 100 miles) after the wheels are removed and reinstalled. This will reseat the lug nuts. Check the torque every 800 km (500 miles) thereafter.

BRAKES

Description

The front brakes (see Figure 8-15) are air actuated brakes which are cam operated. Each brake shoe employs two 19 mm (0.75 in) tapered block liners. The shoes are fabricated of steel, mounted on individual anchor pins, and supported by open type spiders. Automatic slack adjusters maintain the proper adjustment for the pushrod stroke and lining-to-drum clearance. The cam is actuated by the air chamber.

The rear brakes are air actuated brakes which are cam operated. Each brake shoe employs two 19 mm (0.75 in) liners. The shoes are fabricated of steel, mounted on individual anchor pins, and supported by open type spiders. Automatic slack adjusters maintain proper adjustment of the pushrod stroke and lining-to-drum clearance. The brake actuator is a conventional chamber with an emergency (parking) brake mechanism.

Maintenance

Non-Asbestos Warning

Most brake linings no longer contain asbestos fibers. These fibers may be glass, mineral wool, aramid, ceramic, or carbon. Current regulations do not cover non-asbestos fibers. Medical experts do not agree about the possible long term risks of working with and breathing non-asbestos fibers. But some experts think that long term exposure to some non-asbestos fibers could cause pneumoconiosis, fibrosis, and cancer. Therefore, it is recommended that workers use caution to avoid dust when working on brakes.

1. Whenever possible, work on brakes in a separate area away from other operations.
2. Always wear a respirator approved by NIOSH or MSHA during all brake service procedures. Wear the respirator from removal of the wheels through assembly.
3. NEVER use compressed air or dry brushing to clean brake parts or assemblies. OSHA recommends that you use cylinders that enclose the brake. These cylinders have vacuums with high efficiency (HEPA) filters and workmans' arm sleeves. If such equipment is not available, carefully clean parts and assemblies in the open air.
4. Clean brake parts and assemblies in the open air. During disassembly, carefully place all parts on the floor to avoid getting dust into the air. Use an industrial vacuum cleaner with a HEPA filter system to clean dust from the brake drums backing plates and other brake parts. After using the vacuum, remove any remaining dust with a rag soaked in water and wrung until nearly dry.
5. Grinding or machining brake linings. If it is necessary to grind or machine brake linings, additional precautions should be taken because contact with fiber dust is higher during these operations. In addition to wearing an approved respirator, such work should be done in an area with exhaust ventilation.
6. Cleaning the work area. NEVER use compressed air or dry sweeping to clean the work area. Use an industrial vacuum with a HEPA filter and rags soaked in water and wrung until nearly dry. Used rags should be disposed of with care to avoid getting dust into the air. Use an approved respirator when emptying vacuum cleaners and handling used rags.
7. Worker clean-up. Workers should wash their hands before eating or drinking. Working clothes should not be worn home. They should be vacuumed after use and then should be laundered separately, without shaking, to prevent fiber dust from getting into the air.

FRONT BRAKES

Description

The front brakes are air actuated and cam operated. The brake shoes employ 19 mm (0.75 in) tapered block liners. The shoes are fabricated of steel and mounted on individual anchor pins which are supported by cast spiders. Automatic slack adjusters maintain proper pushrod stroke and lining-to-drum clearance during normal service.

Maintenance

Table 8-2

Troubleshooting

Symptom	Probable Cause	Solution
1. Brakes are poor or do not apply.	**a.** Insufficient air pressure.	**a.** Check for the correct pressure at the compressor and brake air chambers.
	b. Restriction or leak in lines, valves, etc.	**b.** Check all lines, valves, etc., for leaks or restrictions.
	c. Brakes out of adjustment.	**c.** Adjust the brakes.
	d. Leaking diaphragm.	**d.** Replace the diaphragm.
2. Uneven braking or uneven lining wear.	**a.** Ruptured diaphragm.	**a.** Replace the Diaphragm.
	b. Brakes out of adjustment.	**b.** Adjust the brakes.
	c. Grease on the lining.	**c.** Replace the lining.
	d. Glazed lining.	**d.** Replace the lining.
	e. Shoes installed backwards.	**e.** Reverse the shoes.
	f. Combination linings.	**f.** Remove the linings and replace with the correct style.

Brakes

Disassembly

DANGER

Do not work under a crane supported by only outrigger jacks. Use jack stands to support the carrier.

1. Set the parking brakes and block the wheels.
2. Raise the carrier so that the front wheels are off the ground.
3. Install jack stands under the carrier.
4. Back off the automatic slack adjuster until the brake shoes are clear of the drum.
5. Remove the hub cap, axle spindle nut, and washer.

DANGER

Do not strike the axle shaft flange with a hammer. Do not use chisels or wedges to loosen shaft or dowels.

6. Rock the drum and pull outward until the outer wheel bearing can be removed.

CAUTION

Do not force the drum. Excessive force may damage brake components.

7. To remove the drum, pull outboard while rocking from side to side.

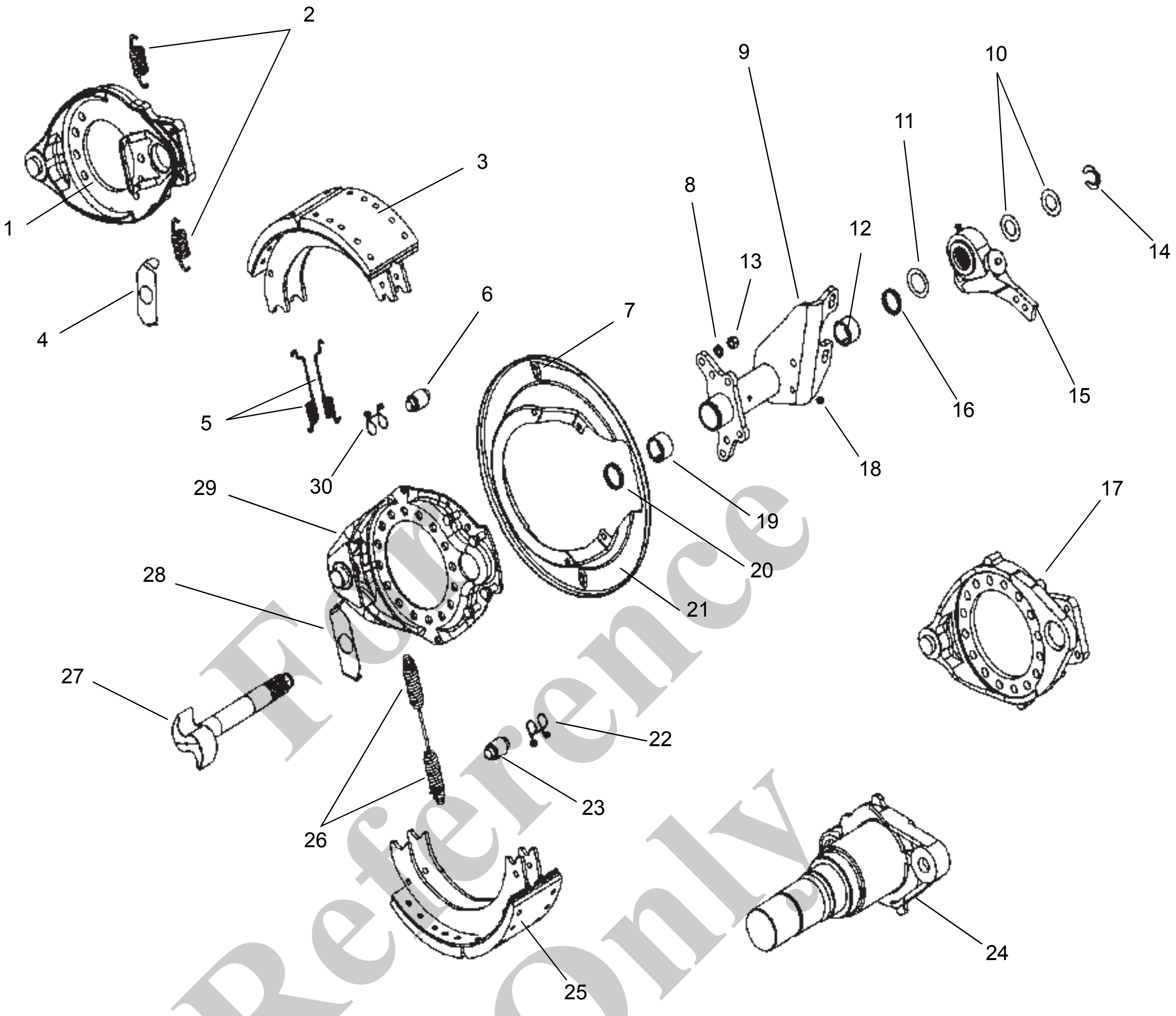


FIGURE 8-15

Item	Description
1	Cast Spider With Horse Collar
2	Shoe Retainer Springs (Color-Orange)
3	Shoe Assembly
4	Cam Head Washer
5	Shoe Return Springs (Color-Red)
6	Roller
7	Inspection Hole Plug
8	Lockwasher
9	Bracket Assembly

Item	Description
10	Camshaft Shim Washers
11	Slack Adjuster Inner Washer
12	Camshaft Bushing
13	Nut
14	Camshaft Retainer Snap Ring
15	Slack Adjuster
16	Grease Seal
17	Cast Spider
18	Grease Fitting

8

Item	Description
19	Camshaft Bushing
20	Grease Seal
21	Dust Shield
22	Retainer
23	Roller
24	Forged Spider
25	Shoe Assembly
26	Shoe Return Springs (Color-Grey)
27	Camshaft
28	Cam Head Washer
29	Spider (Steel Stamped)
30	Retainer

8. Pry the roller retainer loops out of the shoe web holes (see Figure 8-16). Pivot the roller retainer to swing the loops clear of shoe webs.

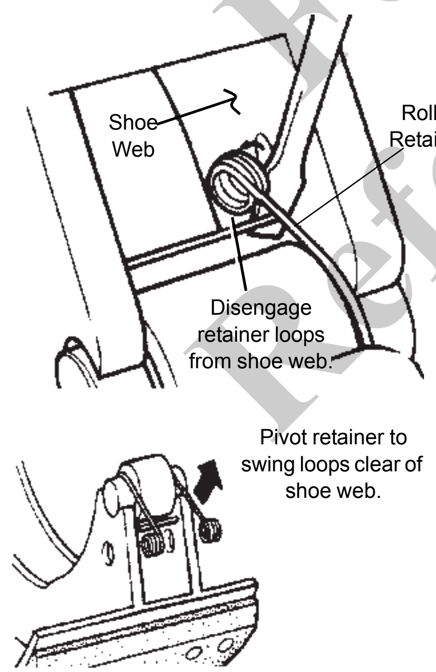


FIGURE 8-16

9. With a large screwdriver or lever, lift the upper shoe and remove the roller and retainer as a unit (see Figure 8-17).

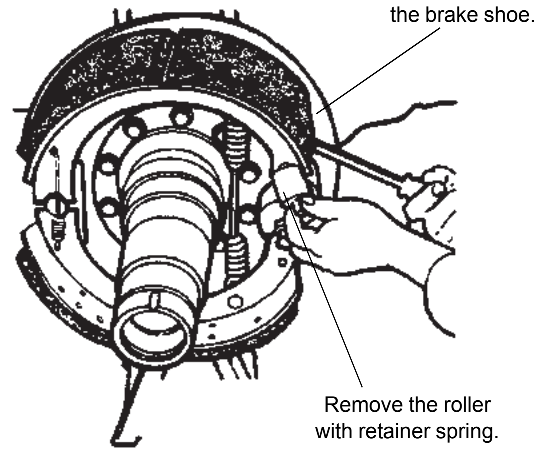


FIGURE 8-17

10. If springs are connected by spring post (horse collar), push cam end of upper shoe toward the cam. Otherwise push cam end of both shoes toward cam. With a spring removal tool, hook onto the spring and pry to unhook the upper shoe return spring (see Figure 8-18). Remove the spring and discard.

11. Do the same for the lower return spring.

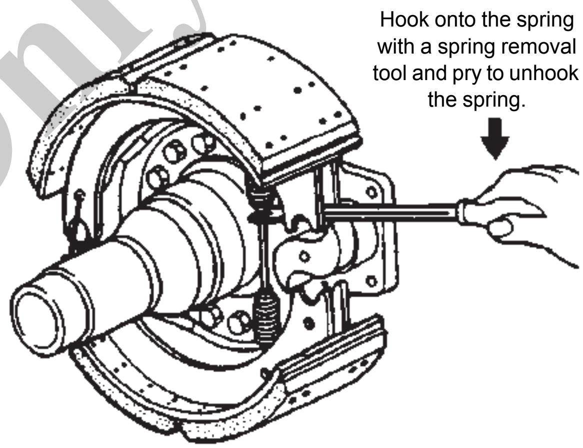


FIGURE 8-18

12. Repeat step 8 for the lower shoe roller and retainer.

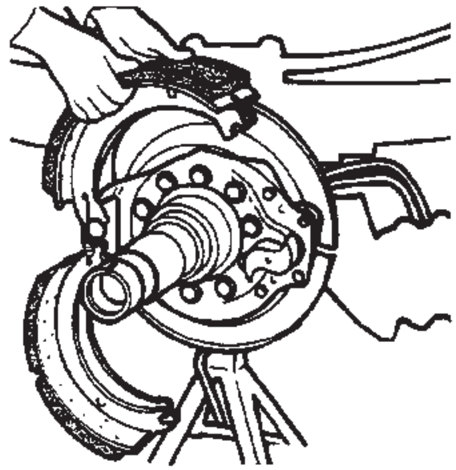


FIGURE 8-19

13. Remove the shoes from the axle (see Figure 8-19).
14. Remove the slack adjuster. Refer to *Automatic Slack Adjuster*, page 8-30.
15. Remove the camshaft by grasping the camshaft head and pulling outboard.
16. Remove the bolts attaching the air chamber bracket to the spider and pull it away from the spider.
17. Remove spider-to-axle attaching nuts and bolts and remove the spider (see Figure 8-20).

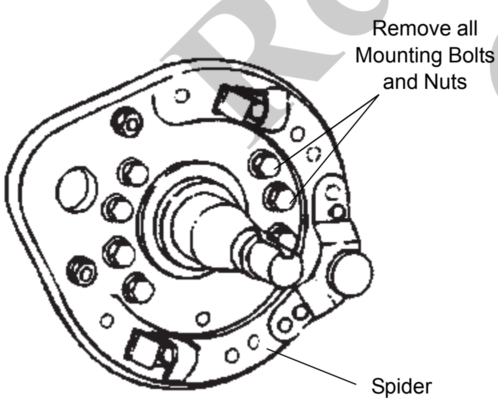


FIGURE 8-20

18. Remove screws and retaining clip securing dust shield to spider and remove dust shield (see Figure 8-21).

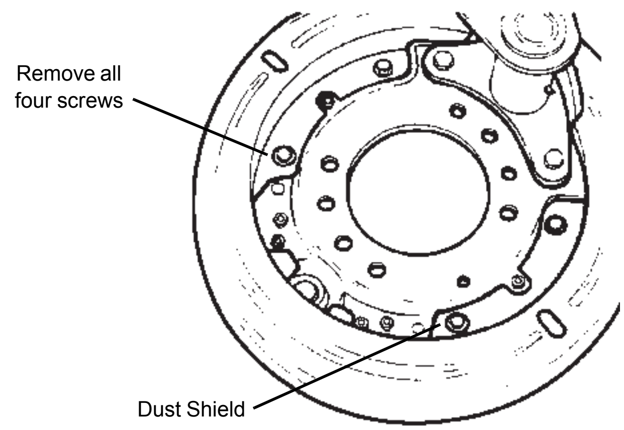


FIGURE 8-21

19. Clean brake parts as outlined below:

CAUTION

Oxidation and dirt on the outside of brake drum acts as an insulator and may hinder heat dissipation. Remove with a wire brush.

a. Wire brush all parts exposed to mud, road dirt, and salt, to include the spider, air chamber bracket, dust shield, and exterior of drum.
b. Following the recommendations at the beginning of this section, use a vacuum cleaner to remove brake dust from drums. Wipe interior of drums with a greaseless solvent to remove any spilled oil.
c. Clean all other brake parts thoroughly with a suitable shop solvent. Wipe dry with a clean, lint-free cloth.

Inspection

1. Check drum for cracks, glazing, grooving, run-out and out-of-round. Cracked drums must be replaced. Drums which are glazed, grooved, out-of-round, etc., may be returned to service if they can be reworked without exceeding the manufacture's specifications.

CAUTION

Do not use drum if it exceeds maximum diameter or run-out specifications.

2. Inspect the shoes for bent or cracked webs or table, broken welds, loose rivets, or elongated rivet holes. Replace shoes if any are found.
3. Check the anchor pin and cam roller contact areas in the shoe webs for elongation or wear. Replace the shoe if the diameter of the roller end exceeds 21.33 mm (0.835 in) or the diameter of the anchor pin end exceeds 35.56 mm (1.4 in).

4. Check the linings and replace the shoes if contaminated, cracked, or worn to less than 6.35 mm (0.25 in) thickness at any point.
5. Inspect the spider for cracks around mounting bolt holes, cam area, or anchor pin and replace if cracked.
6. Check the anchor pin and replace if loose or grooved more than 0.787 mm (0.031 in) below original surface.
7. Each time the brake shoes are removed, check camshaft radial play as outlined below:
   a. Mount a dial indicator plunger on the cam head at the roller contact area.
   b. Zero the dial indicator.
   c. Move the cam head up and down and note the maximum reading.
   d. If play exceeds 0.9 mm (0.035 in), rebush the air chamber bracket. Refer to Repair/Replacement in this Section.
   e. After rebushing, recheck radial play. Replace the camshaft if play is still excessive.
8. Check spline on the end of the camshaft for cracks and worn or deformed splines. Replace as necessary.
9. Check the camshaft bushing journals for wear or corrosion. If the camshaft shows visible wear or if roughness is felt in the journal, replace the camshaft.
10. Check the camshaft head for brineling, cracking or flat spots. Replace the camshaft if a ridge can be felt between the worn areas and surface of the cam head.

NOTE: The camshaft bushings and seals are mounted in the air chamber bracket assembly.

11. Check the camshaft bushings for deterioration or wear. The inner surface must be smooth. Replace the bushing if surface is rough or abrasive.
12. Check the grease seals and replace if nicked, cut, or distorted.
13. Check the air chamber bracket for a bent, broken, or cracked arm and welds. Replace as necessary.
14. Check the air chamber bracket mounting studs for looseness, damaged threads, or bent studs. Replace as necessary.
15. Check the air chamber for leaks, cracked housing, bent pushrod, loose clamp ring, clogged vent holes, or loose air fittings. Repair or replace as necessary.
16. If the air chamber is replaced or repaired, check the distance from the clevis pin hole centerline to the air chamber face. Reference *Automatic Slack Adjuster*, page 8-44 for adjustment.
17. If a new air chamber is installed, ensure that the cutoff pushrod does not project too far into the clevis. Minimum clearance from the clevis centerline to pushrod end is 22.2 mm (0.875 in).
18. Check air chamber clevis pin for cracks and wear.
19. Check the automatic slack adjuster. Reference *Automatic Slack Adjuster*, page 8-44.

Repair/Replacement

Routinely replace lower cost items such as springs, seals, bushings, and heavily worn parts. Damage caused by failure of worn parts is much more expensive than the cost of the parts.

Camshaft bushing and/or grease seal replacement is as follows:

1. Remove the air chamber bracket.
2. Drive out the old bushing and grease seal with a suitable driver.
3. Clean and inspect the air chamber bracket. Reference *Inspection* in this subsection.
4. Install the new bushings in the air chamber bracket with a piloted driver. Both bushings are nonmetallic and are labeled on one end. Install them with the labeled ends facing each other. The cam head end is recessed 7.1 mm (0.281 in) and the slack adjuster end is recessed 17.5 mm (0.688 in) from the ends of the tube (see Figure 8-22).

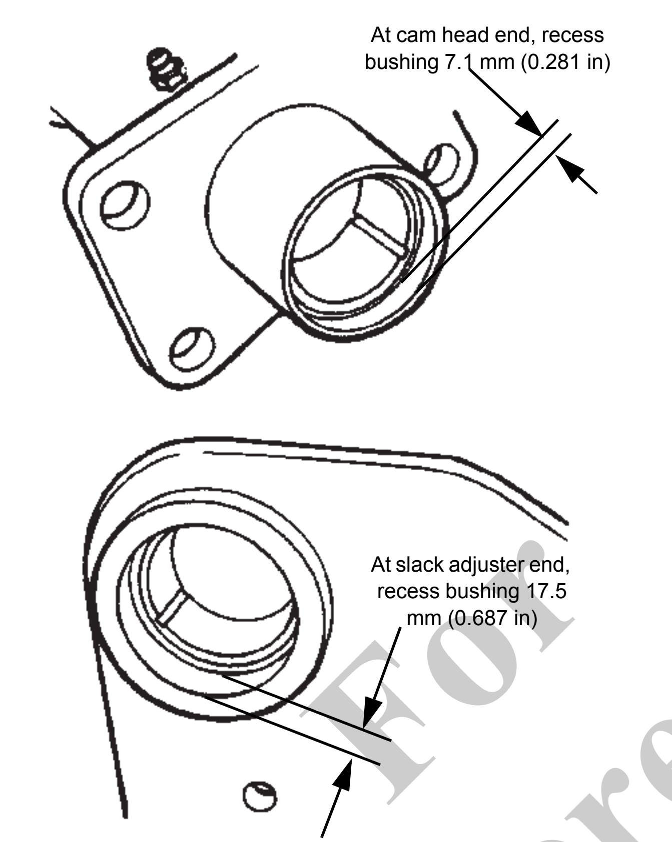


FIGURE 8-22

CAUTION

Seals must be installed with the lip side (spring side) of both seals facing toward the slack adjuster end of the bracket. Improperly oriented seals may allow grease to exit the camshaft head end of air chamber bracket and contaminate lining material.

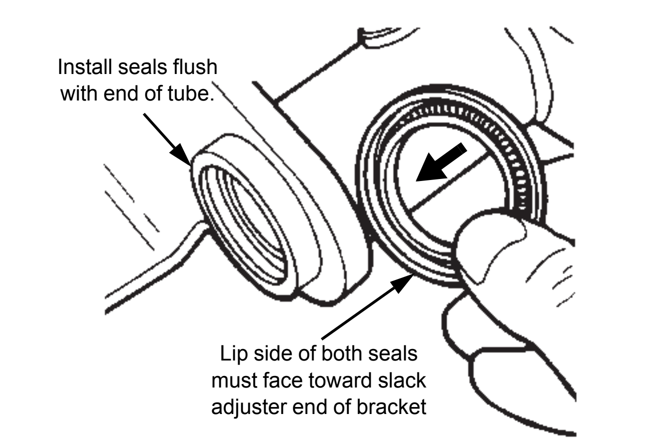


FIGURE 8-23

5. Install new grease seals with a piloted driver so the seals are flush with the end of the air chamber bracket tube (see Figure 8-21).

Assembly

1. Position the spider on the axle flange and install attaching bolts and nuts. Place hardened washers under the bolt head.
2. Position the dust shield against the spider. Install all attaching screws finger tight. Torque screws 16.9 to 20.3 Nm (150 to 180 lb-in).
3. Align the air chamber bracket with the holes on the spider and secure with the bolts and lock washers. Torque 88 to 115 Nm (65 to 85 lb-ft).
4. Installation of camshaft is as follows:
   - **a.** Check for correct camshaft by rotating the camshaft in the direction of the air chamber push rod extension. The roller should start to ride up on the convex side of the cam head.

CAUTION

Do not get grease on cam head surface. The cam surface must be free of oil, grease, and other contaminants for efficient operation.

   - **b.** Apply a thin film of chassis grease on the inside of the camshaft bushing, seals, and spline area.
   - **c.** Place the cam head washer on the camshaft under the cam head with the cast spider arrow pointing toward the center of the spider.
   - **d.** Carefully slip the camshaft into the mounting position.
5. Install the slack adjuster. Refer to *Automatic Slack Adjuster*, page 8-44.
6. Installation of brake shoes is as follows:
   - **a.** Lubricate the shoe roller recess with chassis grease. Do not get grease on the cam head surface.
   - **b.** Hook the ends of the new retainer springs into the holes on both shoe webs with the hooks pointing out.
   - **c.** Position the upper and lower shoes around the anchor pin. Install a new shoe return spring.
   - **d.** Assemble the roller retainer on both ends of the roller.
   - **e.** Stretch the return spring and insert the roller and retainer on the lower shoe web.
   - **f.** Position the roller assembly in the recess. Squeeze the loops of the retainer and rotate to snap loops

into the web holes. Make sure that both loops are engaged in the web holes.

g. Repeat steps (d) thru (f) on the upper shoe.

7. Install the drum and axle spindle nut(s) and washers.

AUTOMATIC SLACK ADJUSTER

Description

The automatic slack adjuster compensates for normal wear in the brake shoe linings by maintaining a nominal clearance between the lining and drum. They are preset at the manufacturer's facility.

When the brake is applied the slack adjuster's rotation moves the shoes and linings into contact with the brake drum. This movement also lifts the actuation rod through a pre-set, free travel dimension that is normal lining to drum clearance. Continuing the brake application rotates a one-way clutch in its over riding mode, and at the same time causes the large coil spring to deflect at a specific force. This spring deflection allows the worm to move axially. The clutch movement is restricted by a machine step. This movement fully disengages the drive clutch from the worm and prevents unwanted brake adjustment from occurring.

When the brake is released, the large coil spring resumes its original load and position, which allows the drive clutch to re-engage. Simultaneous to drive clutch re-engagement, if any lining wear has occurred, the actuation rod rotates the one way adjuster clutch an amount proportional to lining wear. This motion rotates the worm, worm wheel, and the S-cam shaft resulting in adjustment of the brakes.

Maintenance

Alternative 1

NOTE: If your slack adjuster is as pictured in Figure 8-24, use the removal, installation and adjustment procedures that follow. Refer to *Alternative 2*, page 8-34 for the other type of slack adjuster.

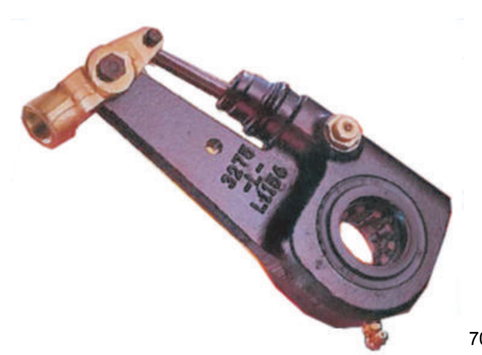


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FIGURE 8-24

Removal

CAUTION

You must disengage a pull pawl before rotating the manual adjusting nut, or you will damage the pawl teeth.

1. Disengage the pull pawl. Use a screwdriver or equivalent tool to pry the pull pawl at least 0.8 mm (0.0313 in) to disengage the teeth from the actuator.

2. Use a wrench to turn the manual adjusting nut clockwise until the brake shoes are fully retracted and the lining clears the drum.

CAUTION

When you remove a clevis pin that has a spring, hold the spring with pliers. The spring can disengage from the clevis with enough force to cause serious personal injury.

CAUTION

Always replace used clevis pin retainer clips with new ones when you service an automatic slack adjuster. Do not reuse retainer clips. When you remove a retainer clip, it can bend out of shape and lose retention. Damage to components can result.

3. Remove both clevis pins and retainer clips or cotter pins.

4. Move the slack adjuster away from the clevis.

5. Discard the retainer clips and cotter pins and replace them with new ones.

CAUTION

Do not use a hammer to remove the slack adjuster. Damage to the slack adjuster and/or camshaft splines may result.

NOTE: Note the orientation of the slack adjuster with reference to the push rod before removal to ensure proper orientation at installation.

6. Remove the slack adjuster with a suitable puller.

Installation

1. Verify that the pushrod is fully retracted.

2. Install the inner washer on the camshaft. The inner washer has a larger hole.

3. Apply Anti-Seize type lubricant to the camshaft splines. Install the slack adjuster onto the camshaft with the adjusting shaft hex pointing away from the air brake

chamber. Secure with outer shim washer(s) and snap ring.

4. Rotate the adjusting shaft hex nut clockwise until the slack adjuster arm and actuator rod holes line up with the clevis holes.
5. Install the clevis pins and the cotter pins.
6. Adjust the brakes by turning the adjusting shaft hex clockwise until the lining contacts the drum. Then rotate the adjusting shaft hex counterclockwise 1/2 turn.

Adjustment Procedures

Brake Applied Stroke Measurement

Ensure that the brake applied stroke is within required values as outlined below.

1. Chock the wheels.
2. Charge air tanks. Refer to *Air System*, page 8-47.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures to 6.21 to 6.89 bar (90 to 100 psi). Refer to *Air System*, page 8-47.
5. With service brakes released, measure distance from slack adjuster clevis pin to chamber mounting face on each brake. Refer to Dimension “A” in (Figure 8-25).

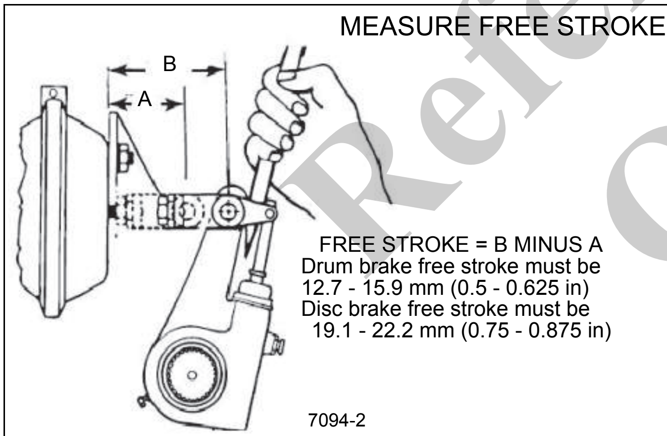

FIGURE 8-25

6. Starting with 6.21 to 6.89 bar (90 to 100 psi) air tank pressure in both primary and secondary systems, fully apply service brakes and hold brakes on. Do not pump the brakes. Measure between the same points as in step 5 on each brake. This is Dimension “B” in (Figure 8-25).
7. Subtract Dimension “A” from Dimension “B” for each brake position (Figure 8-25). This value cannot exceed 5 cm (2 in) on the front brakes or 6.3 cm (2.5 in) on the rear brakes.
8. If any brake exceeds values shown in step 7, the brake must be re-adjusted per the *Brake Free Play Measurement and Adjustment* procedure that follows in this section.
9. If after adjustment the requirements in step 7 cannot be met, contact your distributor or Manitowoc Crane Care. The crane cannot be driven on public roads until repaired.

Brake Free Play Measurement and Adjustment

The following procedure is required to ensure that the free play of the brakes is within required values.

NOTE: If the brake is equipped with a spring type parking chamber the spring must be caged before taking measurements.

1. Chock the wheels and release the parking brakes.
2. Remove the plastic end cap from the spring brake chamber (Figure 8-26).

7092-1

FIGURE 8-26

NOTE: If the items referred to in step 3 and 4 are not stored on the chamber, they must be obtained from the vehicle tool box or Manitowoc Crane Care, as the piggyback spring brake cannot be manually released without them.

3. Using a 3/4 inch wrench, unscrew the release-nut and remove the nut, flatwasher and release-bolt from their storage pocket on side of chamber (Figure 8-27).

8

FIGURE 8-27

4. Insert the release-bolt into the center hole of the head. Ensure the formed end of the bolt has entered the hole in the piston inside the chamber. Continue to insert the bolt until it bottoms out (Figure 8-28).

FIGURE 8-28

If not absolutely sure of correct bolt-to-piston engagement, repeat step 5 until sure.

5. Turn the release-bolt 1/4 turn clockwise and pull the bolt out to lock the formed end into the piston. If the bolt does not lock into the piston in less than 1/2 inch outward movement, repeat steps 4 and 5 until it locks.

6. Holding the bolt locked into the piston, install the flatwasher and the release nut on the end of the release-bolt, and turn down the nut against the flatwasher until finger tight (Figure 8-29).

FIGURE 8-29

CAUTION

Do not exceed the length as stated in step 7. Do not exceed 67.7 Nm (50 lb-ft) torque on release nut at any time or damage may occur which could prevent any future correct manual-releasing of the piggyback spring brake chamber.

7. Using a 3/4 inch hand wrench turn the release-nut clockwise until 8.2 cm (3.25 in) length of bolt extends above the nut (Figure 8-30). Do not use an impact wrench.

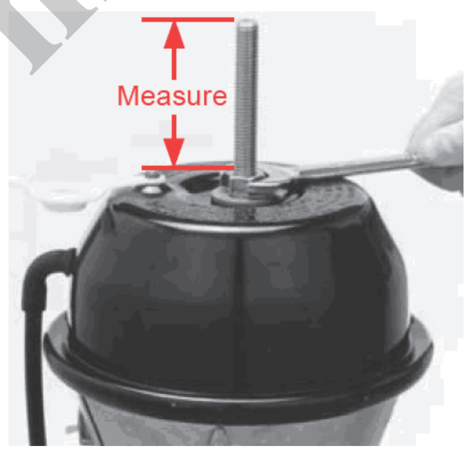

FIGURE 8-30

8. For easier manual-releasing, apply 6.20 - 8.61 bar (90 - 125 psi) air pressure to inlet port marked “SPRING BRAKE” before step 4, but make sure to exhaust all air pressure after step 7 and 8.

9. To reactivate the piggyback/spring brake from its manually-released position, reverse the order of steps 8 through 1.

10. When re-installing the release-bolt, flatwasher and release-nut into the storage pocket, apply 13.5 Nm (10 lb-ft) torque on nut against the flatwasher (Figure 8-31).

FIGURE 8-31

DANGER

There are no serviceable parts inside the spring brake chamber. Never attempt to disassemble the spring brake chamber as serious personal injury could result from accidental sudden release of the high energy spring.

11. Measure the distance from the center of the large clevis to the air chamber mounting face with the brake fully released. This is dimension “X” in (Figure 8-32).

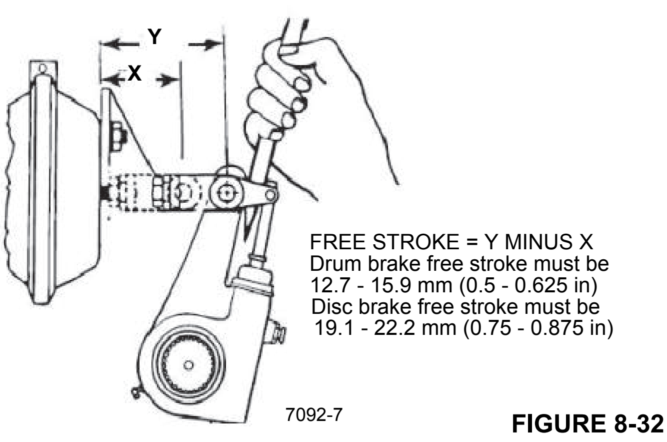

FIGURE 8-32

12. Using a pry bar, move the slack adjuster so that the linings contact the drum. Measure the distance between the same points as in step 11. This dimension is “Y” in Figure 8-32.

CAUTION

See Figure 8-32 and Figure 8-33, Free Stroke Measurement. Pull pawl must be disengaged before rotating adjusting nut. Pawl teeth will be damaged if not disengaged. Pry on the pull pawl at least 0.8 mm (0.0313 in) to disengage the teeth. When the pry bar is removed, the pull pawl will re-engage immediately.

13. Subtract dimension “X” from dimension “Y” (Figure 8-32). The difference should be 12.7 to 15.9 mm (0.5 to 0.625 in). If the stroke falls within these limits, no adjustment is required. If it falls outside these limits, proceed to step 14 through step 16.

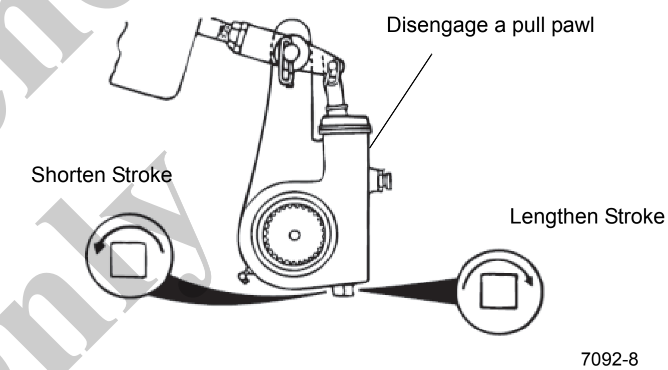

FIGURE 8-33

14. Disengage the pull pawl (Figure 8-33).

15. Turn the adjusting nut approximately 3.1 mm (0.1250 in) turn in the direction required and re-measure the stroke. Continue this process until the stroke is within limits (Figure 8-33).

16. Release the pawl and uncage the spring brake, if required.

8

Alternative 2

NOTE: If your slack adjuster is as pictured in Figure 8-34, use the removal, installation and adjustment procedures that follow.

FIGURE 8-34

REMOVAL

CAUTION

Do not use an impact wrench or permanent internal damage will occur.

1. Block wheels to prevent crane from moving. Ensure system tank pressure is above 6.89 bar (100 psi).
2. Use a wrench to turn the manual adjusting nut counterclockwise until the brake shoes are fully retracted and the lining clears the drum.

NOTE: Note the orientation of the slack adjuster with reference to the push rod before removal to assure proper orientation at installation.

3. Remove the brake adjuster from the camshaft.

Installation

1. Block wheels to prevent crane from moving. Ensure system tank pressure is above 6.89 bar (100 psi).
2. Check that the push rod is fully retracted and apply air to release spring brake. If air is not available, spring brake must be manually caged back.
3. Install anchor bracket loosely.
4. Do not tighten anchor bracket fasteners at this time.
5. Apply Anti-Seize type lubricant to camshaft splines.
6. Install the brake onto the camshaft with the adjusting hex pointing away from the brake chamber.

NOTE: Do not pull push rod out to meet the brake adjuster.

7. Secure the brake adjuster on the camshaft. Use at least one inner washer and enough outer washers to allow no more than 1.5 mm (0.060 in) movement of adjuster on camshaft.
8. Rotate the adjusting hex nut clockwise until the clevis hole lines up with the brake adjuster arm hole.
9. Apply anti-seize to clevis pin. Install and secure with cotter pin.
10. The control arm can be placed anywhere within the range of the bracket slot for automatic adjustment to take place. Rotate the control arm towards the axle until they come to a complete stop and secure in that position.
11. Tighten all anchor bracket fasteners.
12. Rotate the adjusting hex clockwise until the lining lightly contacts the drum.

CAUTION

Do not use an impact wrench or permanent internal damage will occur.

13. Back-off the adjuster by turning the adjusting hex counterclockwise 1/2 of a turn.

Adjustment Procedures

Brake Applied Stroke Measurement

Ensure that the brake applied stroke is within required values as outlined below.

1. Chock the wheels.
2. Charge air tanks. Refer to *Air System*, page 8-47.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures to 6.21 to 6.89 bar (90 to 100 psi). Refer to *Air System*, page 8-47.
5. With service brakes released, measure distance from slack adjuster clevis pin to chamber mounting face on each brake. Refer to Dimension “A” in (Figure 8-35).

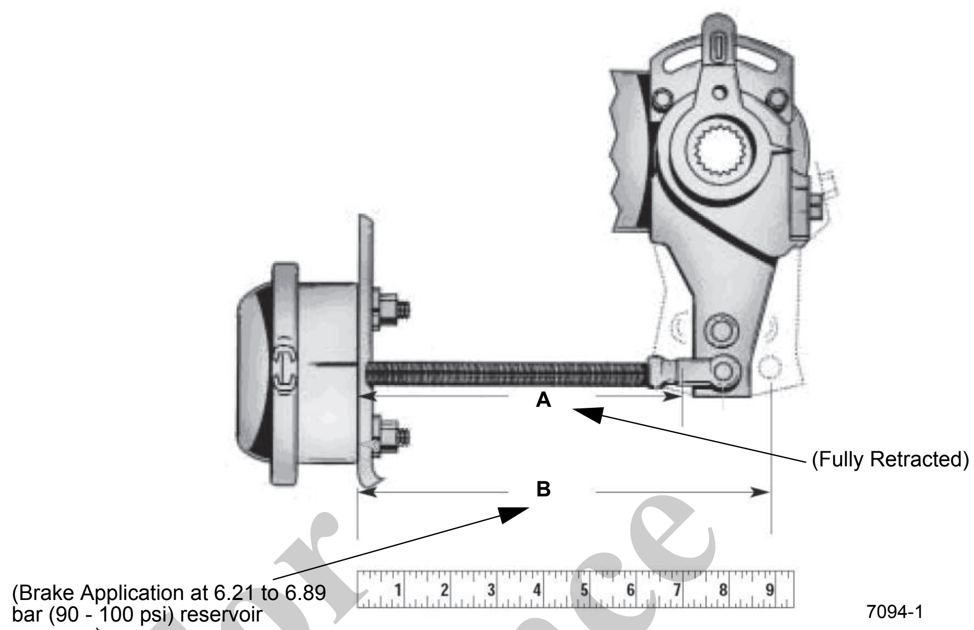

FIGURE 8-35

6. Starting with 6.21 to 6.89 bar (90 to 100 psi) air tank pressure in both primary and secondary systems, fully apply service brakes and hold brakes on. Do not pump the brakes. Measure between the same points as in step 5 on each brake. This is Dimension “B” (Figure 8-35).
7. Subtract Dimension “A” from Dimension “B” for each brake position (Figure 8-35). This value cannot exceed 5 cm (2 in) on the front brakes or 6.3 cm (2.5 in) on the rear brakes.
8. If any brake exceeds values shown in step 7, the brake must be re-adjusted per the *Brake Free Play Measurement and Adjustment* procedure that follows in this section.
9. If after adjustment the requirements in step 7 cannot be met, contact your distributor or Manitowoc Crane Care. The crane can not be driven on public roads until repaired.

Brake Free Play Measurement and Adjustment

The following procedure is required to ensure that the free play of the brakes is within required values.

CAUTION

If the brake is equipped with a spring type parking chamber the spring must be caged before taking measurements.

1. Chock the wheels and release the parking brakes.

CAUTION

Do not use an impact wrench on bolt.

For easier turning of the release bolt, apply 6.55 to 8.62 bar (95 to 125 psi) air pressure to the air inlet port marked “Spring”. After caging, completely exhaust air from the spring chamber.

2. Turn the integral release bolt counterclockwise using a 3/4 inch socket wrench (Figure 8-36), until the power spring is fully caged or compressed. Full cage position requires approximately 22 to 23 turns for 76 mm (3.00 in) stroke units.

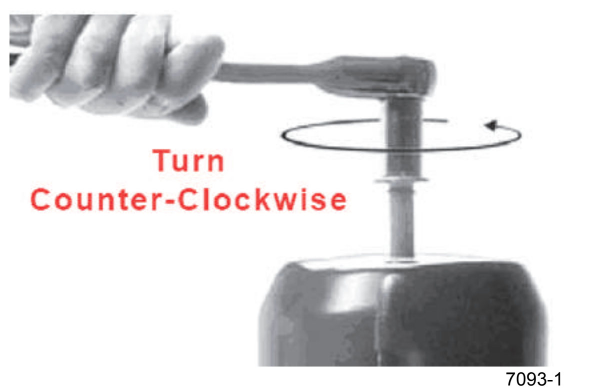

FIGURE 8-36

CAUTION

Do not exceed the length stated in step 3 and do not exceed 68 Nm (50 lb-ft) torque on release bolt at any time or damage may occur which could prevent any further correct manual release of the spring brake chamber.

3. The dual thread release bolt which reduces the travel of the release bolt by a factor of 2.4 in a 76 mm (3.00 in) stroke unit, for instance, the parking spring is fully caged when the release bolt is up approximately 33 mm (1.3 in) from the run position (Figure 8-37). After caging, completely exhaust air from the spring chamber.

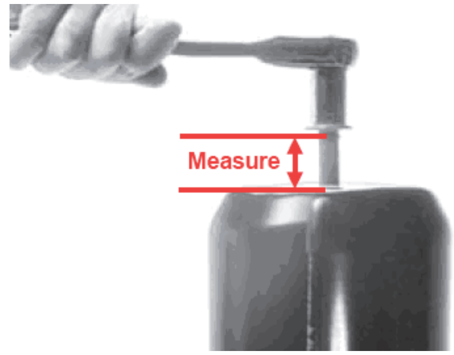

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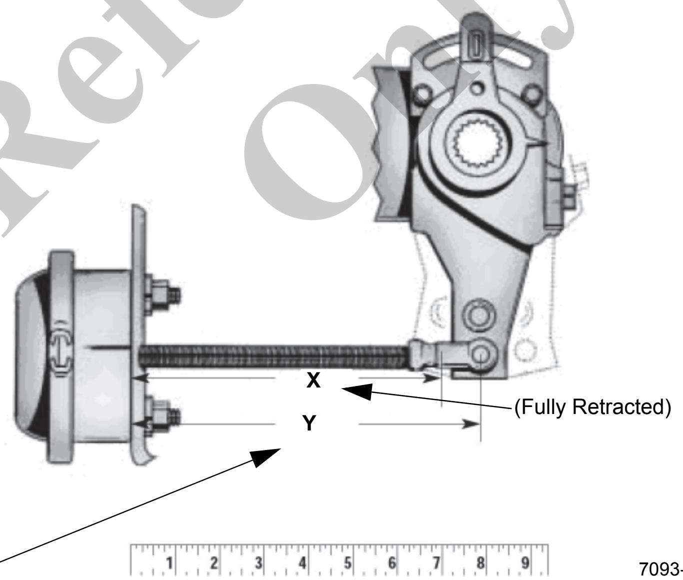
FIGURE 8-37

DANGER

There are no serviceable parts inside the spring brake chamber. Never attempt to disassemble the spring brake chamber as serious personal injury could result from accidental sudden release of the high energy spring.

4. Measure the distance from the center of the large clevis to the air chamber mounting face with the brake fully released. This is dimension “X” in (Figure 8-38)



7093-6

FIGURE 8-38

5. Using a pry bar, move the slack adjuster so that the linings contact the drum. Measure the distance between the same points as in step 4. This dimension is “Y” in (Figure 8-38).

6. Subtract dimension “X” from dimension “Y”. The difference should be 12.7 to 15.9 mm (0.5 to 0.625 in). If the stroke falls within these limits, no adjustment is required. If it falls outside these limits, proceed to step 7.

7. Rotate the adjusting hex approximately 1/8 turn in the direction required and re-measure the stroke. Continue this process until the stroke is within limits. A minimum of 17.6 Nm (13 lb-ft) of torque is required to turn the hex and overcome the internal clutch. A ratcheting noise will be heard. Do not use an impact wrench or internal damage will occur (Figure 8-39).

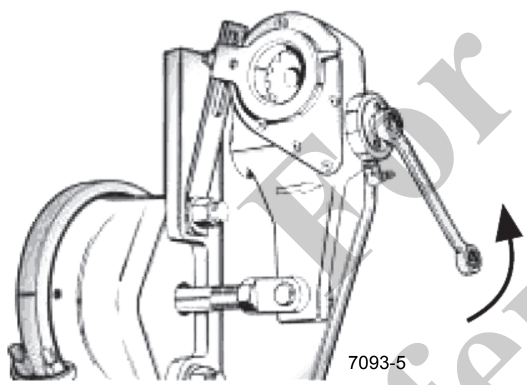


FIGURE 8-39

8. With brakes released, check installation indicator Figure 8-38 and Figure 8-39 to determine proper adjustment.

9. If installation indicator is not positioned properly, refer to Figure 8-39. Loosen fastener holding indicator to anchor bracket, rotate indicator as required and retighten fastener.

10. Uncage spring brake if so equipped.

REAR BRAKES

Description

Brakes

The rear brakes are air actuated and cam operated. Each shoe, which is steel fabricated, employs two 19 mm (0.75 in) tapered block liners. The shoes are mounted on individual anchor pins and supported by open type spiders. Automatic slack adjusters maintain proper adjustment of the push rod stroke and lining to drum clearance.

The brake actuator is a conventional brake air chamber with an emergency (parking) brake spring mechanism incorporated into the air brake chamber. The brake chamber has an aluminum body and pressure plate with a steel non-pressure plate that houses a service/emergency diaphragm, piston, and two springs.

Spring Brake Actuator

The spring brake actuator, which is the upper part of the air brake chamber, is spring applied and air released. When an air pressure of 4.82 bar (70 psi) or more is applied against the piston, the spring is compressed and braking is done with the service brakes. When the air pressure is removed, the spring pushes against the piston and diaphragm plate to apply the brake. Internal venting works in conjunction with a one-way breather cap that allows system air to fill the vacuum behind the piston to keep out atmospheric air and contamination. The unit is equipped with a manual caging bolt to permit safe handling and service work.

8

Maintenance

Table 8-3

Troubleshooting

Symptom	Probable Cause	Solution
1. Brakes are poor or do not apply.	**a.** Insufficient air pressure.	**a.** Check for correct pressure at compressor and brake chambers.
	b. Restriction or leak in lines, valves, etc.	**b.** Check all lines, valves, etc., for leaks or restrictions.
	c. Brakes are out of adjustment.	**c.** Adjust the brakes.
	d. Leaking diaphragm.	**d.** Replace diaphragm.
2. Uneven braking or lining wear.	**a.** Ruptured diaphragm.	**a.** Replace diaphragm.
	b. Brakes are out of adjustment.	**b.** Adjust brakes.
	c. Grease on the lining.	**c.** Replace lining.
	d. Glazed lining.	**d.** Replace lining.
	e. Shoes are installed backwards.	**e.** Reverse shoes.
	f. Combination linings.	**f.** Replace with correct style.
3. Automatic adjusters are not working.	**a.** Adjusting pawl installed backwards.	**a.** Remove and properly install pawl.
	b. Pawl is collapsed or missing.	**b.** Replace spring.
	c. Bolt is frozen in adjusting sleeve.	**c.** Free-up or replace the bolt.
	d. Detent is damaged allowing the bolt to rotate with sleeve.	**d.** Replace damaged detent.
	e. Double lip seals are not installed correctly.	**e.** Remove and correctly install seals.
4. Spring brake is not holding.	**a.** Power spring is not fully released. (uncaged).	**a.** Turn caging bolt fully counterclockwise until stop is reached.
	b. Brakes are out of adjustment.	**b.** Readjust the brakes.
	c. Hold-off air is not releasing fully.	**c.** Check for faulty air system components.
	d. Power spring is broken.	**d.** Replace spring brake actuator.

Symptom	Probable Cause	Solution
5. Brake is dragging.	**a.** Low spring brake hold-off air pressure, 70 psi (482 kPa).	**a.** Check for minimum spring brake pressure, 4.82 bar (70 psi). Check for proper functioning of air system components.
	b. Improper connection of the service line at spring brake.	**b.** Check and connect line to proper port.
	c. Leaking lines or spring brake seals.	**c.** Tighten connections on air lines or replace spring brake unit seals.

Spring Brake Actuator

The upper part of the brake air chamber containing the large spring is not serviceable; however, the lower part of the assembly is serviceable.

WARNING

Spring brake unit is powerful enough to cause parts to fly apart with enough force to cause personal injury. The spring brake must be caged before removing or servicing brakes before returning the crane to service.

1. Remove the caging bolt and washer from its storage hole on the outside of the brake chamber.
2. Remove the dust cap from the bolt hole in the top of the chamber.
3. Insert the head of the caging bolt through the opening and turn bolt 1/4 turn clockwise.
4. Thread the nut and washer on the bolt and turn the nut clockwise about 18 to 21 turns. Air pressure can be applied to the spring brake chamber through the parking port to compress the spring while the nut is being tightened.
5. Do not force the nut beyond its normal stop. A torque of 40.6 Nm (30 lb-ft) is the maximum that should be required. Reverse the procedure to uncage the spring.

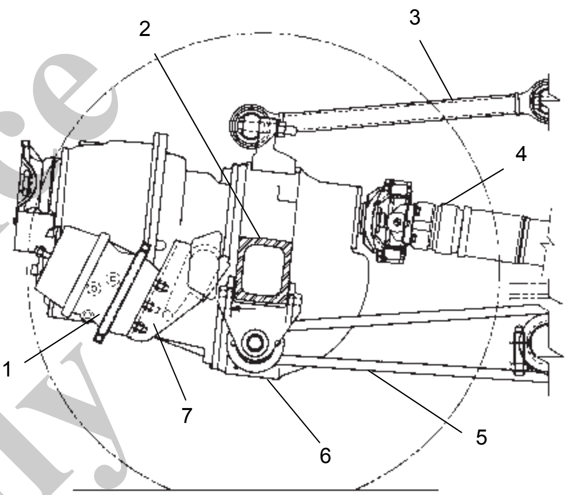


FIGURE 8-40

Item	Description
1	Brake Air Chamber
2	Axle No. 3
3	Torque Rod
4	Drive Shaft
5	Stabilizer Beam
6	Differential
7	Mounting Bracket

Removal

DANGER

Cage the spring brake before removal of air brake chamber.

1. Cage the spring brake.
2. Tag, remove, and cap the air lines to the brake air chamber.
3. Remove the pin(s) connecting the clevis to the slack adjuster.
4. Mark the position of the clevis on push rod so that the clevis can be reinstalled in the same position.

5. Unbolt the air brake chamber from the mounting bracket and remove the air brake chamber (see Figure 8-40).

Installation

1. Bolt the air brake chamber to the mounting bracket.
2. Install the pin through the clevis and slack adjuster.
3. Check brake adjustment.
4. Uncage the spring brake.

Disassembly

1. Remove the clamp securing the service brake chamber to the spring brake chamber (see Figure 8-41).
2. Separate the lower cover from the spring brake chamber.
3. If the push rod or spring needs to be removed, mark the position of the clevis on the push rod. Remove the clevis and jam nut.
4. Remove the push rod.

Assembly

1. Insert the push rod through the spring and cover.
2. Screw on the jam nut and clevis as per removal marks.
3. Position the diaphragm over the push rod (see Figure 8-41).
4. Push the lower cover assembly into the spring brake chamber and secure with the clamp.

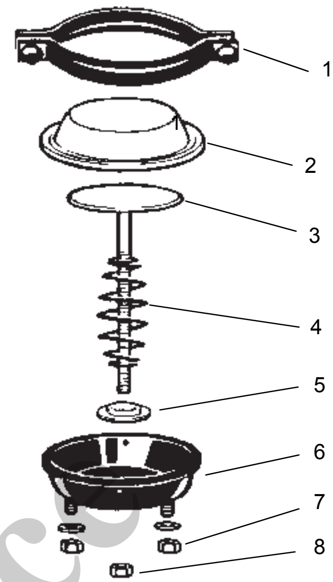


FIGURE 8-41

Item	Description
1	Clamp
2	Diaphragm
3	Push Rod
4	Spring
5	Shield
6	Cover
7	Mounting Nut
8	Jam Nut

Rear Brake Assembly

The rear brakes are air actuated and cam operated with two shoes. Each shoe is mounted on separate anchor pins and has open anchor pin ends for easy removal. There are two shoe retainer springs in addition to the shoe return springs.

Disassemble Brakes

1. Raise the crane on outriggers so that the rear wheels are off the ground.

CAUTION

Do not attempt to do any type of work under a crane that is supported by only the outriggers or jacks.

2. Place jack stands under the frame where the wheels are to be removed.
3. Cage the spring brake with the caging bolt provided.
4. Fully release the slack adjuster so that the shoes retract allowing the drums to clear the linings. To retract the slack adjuster, do the following:
    a. Remove the pawl assembly to keep the pawl teeth from being damaged.
    b. Turn the manual adjusting nut until the brake shoe is fully retracted.
    c. Install the pawl assembly into the slack adjuster.
5. Remove the brake drum.

Brake Shoe Removal

1. Push down on the bottom brake shoe and pull on the roller retaining clip to remove the bottom cam roller (see Figure 8-42).

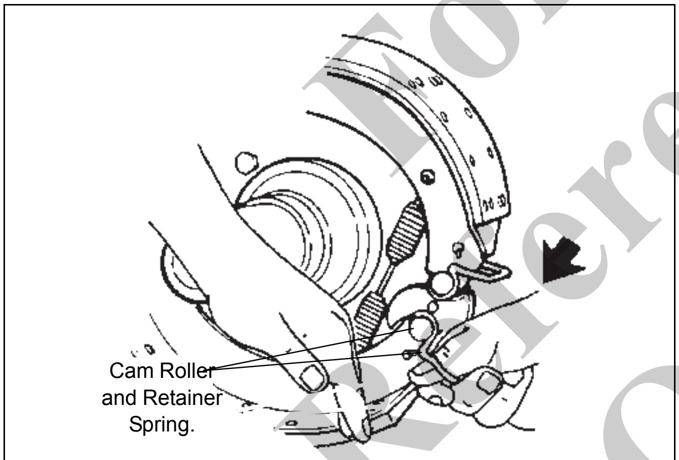


FIGURE 8-42

2. Lift the top shoe and pull on the roller retaining clip and remove the upper cam roller.
3. Lift the bottom shoe to release the tension on the brake return spring and remove the spring (see Figure 8-43).

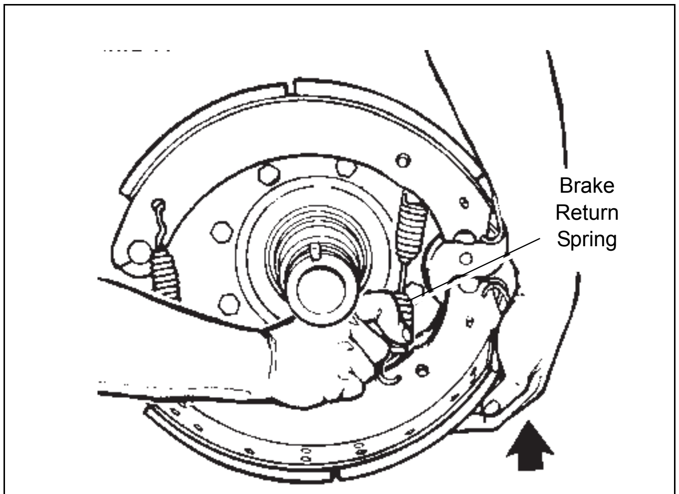


FIGURE 8-43

4. Rotate the bottom shoe to relieve tension on the retaining springs (see Figure 8-44). Remove the springs and brake shoes.

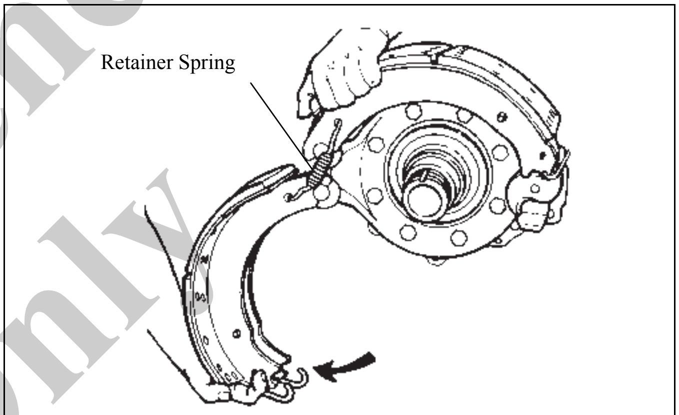


FIGURE 8-44

Clean and Inspect Parts

Clean all polished metal parts such as inner bore, gear, and worm with solvent cleaners.

WARNING

Solvent cleaners can be flammable, poisonous, and cause burns.

Use soap and water to clean all nonmetallic parts. Dry all parts with clean paper towel or cloth.

CAUTION

Do not use solvent cleaners on non-metallic parts.

Apply brake lubricant to all parts except the linings and drums to prevent rust.

Inspect Parts

1. Check the spider for expanded anchor pin holes and cracks. Replace damaged spiders and anchor pin bushings.
2. Check the camshaft bracket for broken welds, cracks, and correct alignment.
3. Check anchor pins for corrosion and wear. Replace damaged anchor pins.
4. Check brake shoes for rust expanded rivet holes, broken welds, and correct alignment. Anchor pin holes must not exceed 26 mm (1.03 in) in diameter. The distance from the center of the anchor pin hole to the center of the roller hole must not exceed 327 mm (12.875 in).
5. Check the camshaft for cracks, wear, and corrosion. Check the cam head, bearing journals, and splines.
6. Check the slack adjuster for the gap between the clevis and collar. If the gap exceeds 1.5 mm (0.060 in), replace the clevis. Check the clevis pins and bushing in the slack adjuster arm. Replace bushing if diameter exceeds 16.6 mm (0.65 in).
7. Rotate the slack adjuster adjusting nut through a 360 degree rotation (about 22 turns of the adjusting nut) with a torque wrench. Torque must be less than 2.8 Nm (25 lb-in) for a new or rebuilt slack adjuster.
8. Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting, and distortion.
9. Measure the inside diameter of the drum in several locations and replace if diameter exceeds manufacturers specifications.
10. Check dust shields for rust and distortion. Replace as necessary.

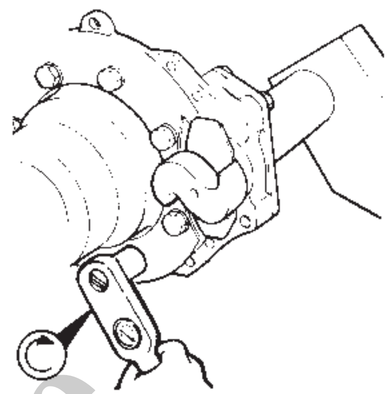
Assemble Brakes

Each time the brakes are relined, the following parts should also be replaced.

- Springs
- Rollers
- Anchor Pins
- Clevis Pins
- Camshaft Seals

Camshaft Installation

1. Check all spider bolts for the correct torque (see Figure 8-45).



Bolt Size	Nm	Pounds-Foot
7/16” - 20	85 - 102	60 - 75
1/2” - 20	115 - 156	85 - 115
9/16” - 18	176 - 224	130 - 165
1/8” - 18	244 - 312	180 - 230

FIGURE 8-45

2. Install new camshaft seals and, if required, bushings in both the spider and camshaft bracket. Use a seal driver to install the bushings.
3. If the camshaft bracket was removed, install the gasket and bracket to the spider. Torque per Table 8-4.

Table 8-4

Size and Grade	Torque Nm (pounds-foot)
1/2”-13 Grade 8	122 to 163 Nm (90 to120 lb-ft)
1/2”-13 Grade 5	88 to 136 Nm (65 to 100 lb-ft)
5/8”-18 Plain Nut	203 to 258 Nm (150 to 190 lb-ft)
5/8”-18 Lock Nut	176 to 224 Nm (130 165 lb-ft)

NOTE: Install both seals with lips toward slack adjuster (see Figure 8-46).

4. Put the cam head thrust washer on the camshaft. Apply O-617 - A or B chassis grease to the camshaft bushings or needle bearings and to the camshaft journals. Install

the camshaft through the spider and bracket so that the camshaft turns freely.

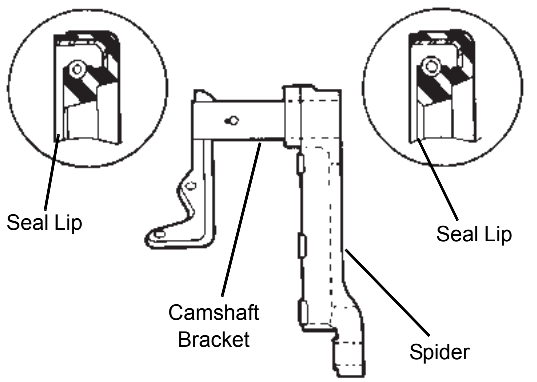


FIGURE 8-46

Brake Shoe Installation

1. Put the upper brake shoe in position on the top anchor pin. Hold the lower shoe on the bottom anchor pin and install the two new retainer springs.
2. Rotate the lower brake shoe forward and install a new brake shoe return spring (see Figure 8-47).

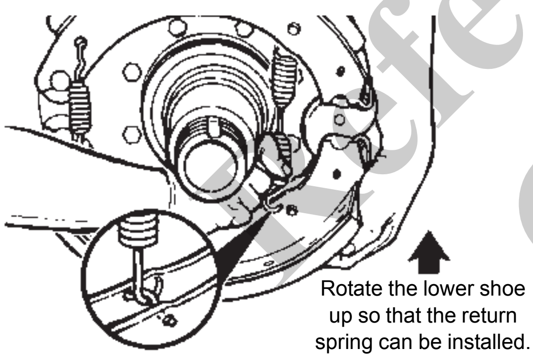


FIGURE 8-47

3. Pull each shoe away from the cam to permit enough space to install the cam rollers and retainers. Press the ears of the retainer together to permit the retainer to fit between the brake shoe webs (see Figure 8-48).

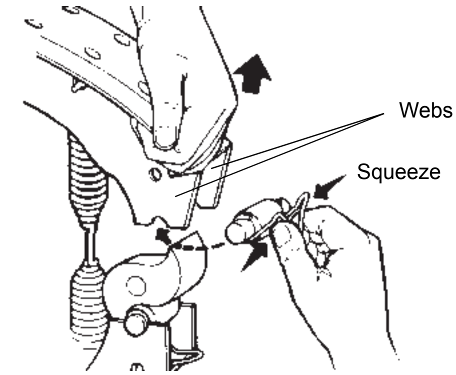


FIGURE 8-48

4. Push the retainer into the brake shoe until its ears lock into the holes in the shoe webs (see Figure 8-49).

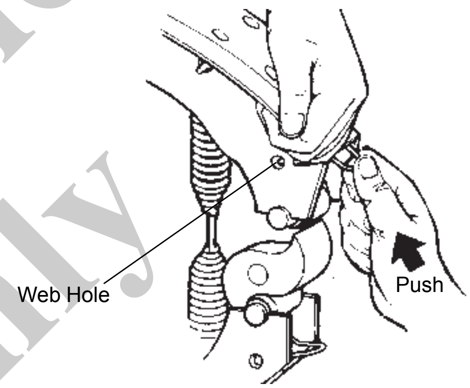


FIGURE 8-49

5. Install the slack adjuster and adjust brakes. Refer to *Automatic Slack Adjuster*, page 8-44.

8

AUTOMATIC SLACK ADJUSTER

Description

The automatic slack adjuster (see Figure 8-50) compensates for normal wear in the brake shoe linings by maintaining a nominal clearance between the lining and drum. The clearance notch in the rack corresponds to the normal lining-to-drum clearance.

When the brake is applied the rack moves upward and rotates the one way clutch to allow for slippage in this direction. Brake application torque presses the wormshaft against the coil spring which releases the cone clutch.

When the brake is released, the coil spring presses against the wormshaft and engages the cone clutch which pulls the rack back to its original position in the clearance notch. Lining wear causes the rack to turn the locked one-way clutch while rotating the wormshaft via the locked cone clutch. The wormshaft rotates the wormwheel and camshaft, which adjusts the brakes.

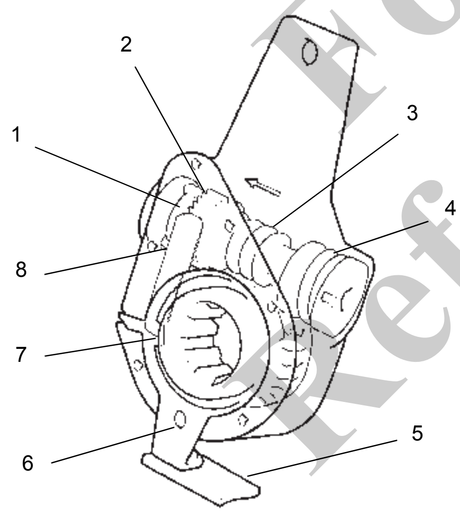


FIGURE 8-50

Item	Description
1	Cone CLutch
2	One-Way Clutch
3	Wormshaft
4	Coil Spring
5	Control Arm Anchor
6	Control Arm
7	Clearance Notch
8	Rack

Maintenance

Removal

NOTE: See Figure 8-51 for steps 1 through 5.

1. Remove the cotter pin and clevis pin from the push rod clevis.
2. Loosen the anchor bracket hardware.
3. Turn the adjuster nut until the slack adjuster is clear of the air chamber pushrod clevis.
4. Remove the snap ring and outer shim washer(s) from the camshaft.
5. Remove the slack adjuster with a suitable puller.

Installation

NOTE: See Figure 8-51 for steps 1 through 3.

1. Verify that the pushrod is fully retracted.
2. Install the anchor bracket loosely. Do not tighten the anchor bracket fasteners at this time.

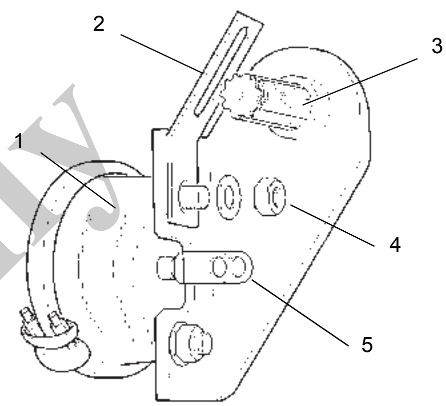


FIGURE 8-51

Item	Description
1	Air Chamber
2	Anchor Bracket
3	Camshaft
4	Mounting Nut
5	Clevis and Push Rod

3. Apply anti-seize type lubricant to the camshaft splines. Install the slack adjuster onto the camshaft with the adjusting hex pointing away from the air brake chamber. Secure with outer shim washer(s) and snap ring.

4. Rotate the adjusting hex nut clockwise until the slack adjuster arm hole lines up with the clevis hole (see Figure 8-52).
5. Install the clevis pin without the cotter pin at this time.

CAUTION

Excessive positioning force may damage control arm. Most adjusters will be equipped with an installation indicator which must fall within the slot for proper installation. Incorrect control arm position can cause tight or dragging brakes.

6. Rotate the control arm counterclockwise towards the air chamber until it comes to a definite internal stop. If necessary, use a plastic mallet to tap the control arm into position (see Figure 8-53).

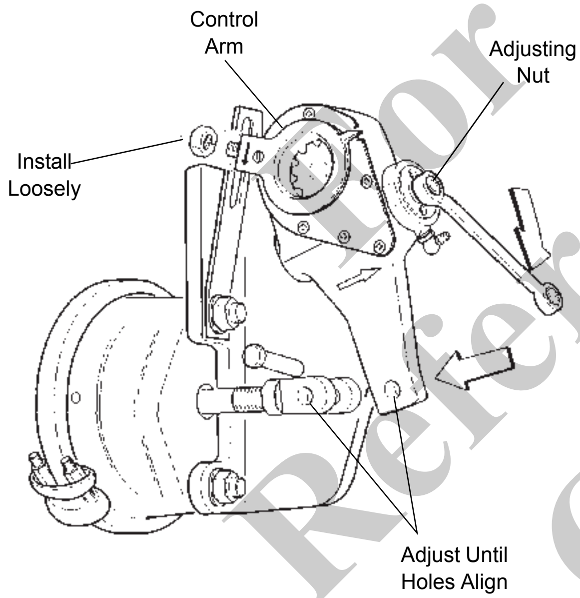


FIGURE 8-52

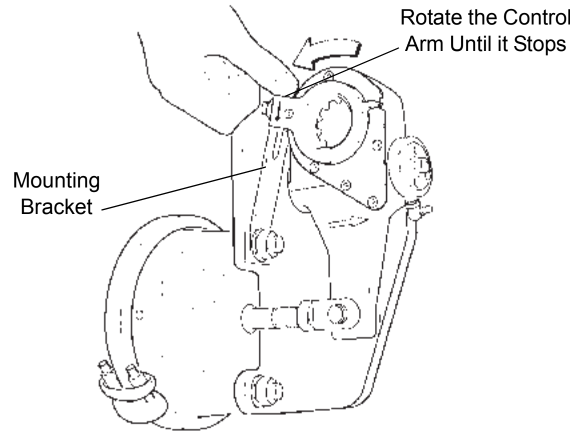


FIGURE 8-53

7. Tighten control arm anchor and bracket fastener.
8. Adjust the brakes by turning the adjusting hex clockwise until the lining contacts the drum. Then rotate the adjusting hex counterclockwise 1/2 turn. A minimum of 17.6 Nm (13 lb-ft) is necessary to overcome the clutch and a ratcheting sound will be heard.
9. With the brakes released, verify that the installation indicator is within the slot. Remove the clevis pin. The clevis hole and adjuster hole should remain in alignment. If the air chamber clevis pulls into the air chamber, repeat the installation procedure.
10. Install the clevis pin and cotter pin.

Brake Adjustment

NOTE: See Figure 8-54 for adjustment procedure.

1. Apply the brakes so that the air chamber is fully retracted. Measure from the face of the air chamber to the centerline of the clevis pin. Record the measurement as dimension ‘A’.
2. Pry the slack adjuster so that the brake shoes are in contact with the drum.
3. Measure between the face of the air chamber and the centerline of the clevis pin. Record this measurement as dimension ‘B’.
4. Subtract dimension ‘A’ from ‘B’ to find the free stroke distance. The minimum free stroke is 9.525 mm (0.375 in).
5. Spin the wheel by hand to check for drag. Tap the drum lightly with a hammer and listen for a sharp ringing sound. If drag is noted, back off the slack adjuster and recheck free stroke.
6. Apply and hold brakes (5.51 to 6.20 bar (80 to 90 psi)).
7. Measure the distance between the face of the air chamber and clevis pin centerline. Record as dimension ‘C’.
8. Subtract dimension ‘A’ from dimension ‘C’. The difference is the applied stroke. Maximum applied stroke is 5.08 cm (2 in).
9. If the applied stroke is equal to or exceeds the maximum, adjust the brakes. No adjustment is necessary if stroke is less than the maximum.

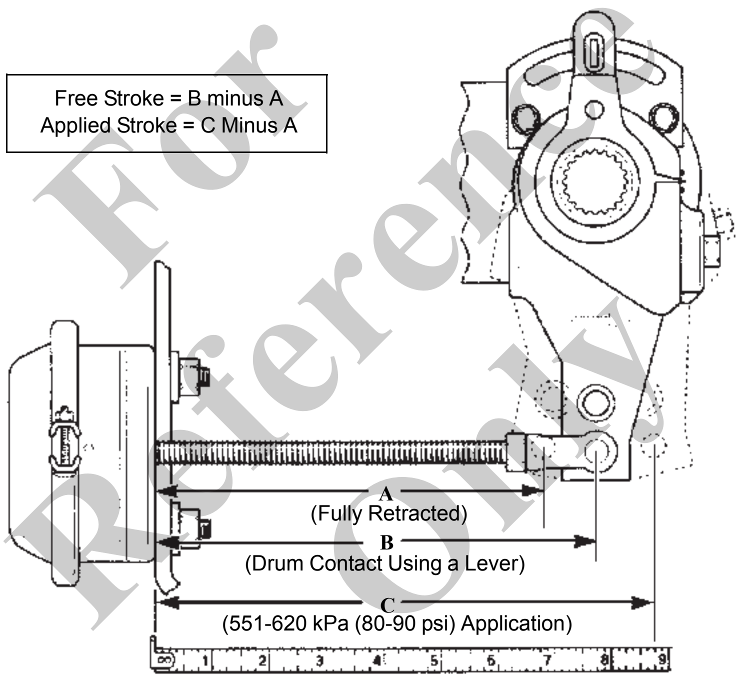


FIGURE 8-54

AIR SYSTEM

Description

The air system (see Figure 8-55) provides the air supply to operate the service brakes, parking brakes, air suspension system, inter axle and cross axle differential locks, tire inflation option, and other air accessories.

The air system is pressurized by an engine-mounted air compressor and the pressurized air is stored in six air reservoirs underneath the frame. The air system components are operated by the air that is stored in these reservoirs.

An air dryer is mounted on the left side of the carrier frame just behind the front bumper. It is connected between the outlet of the compressor and the front primary supply reservoir. Oil, water, and contaminates are removed from the air during the compression cycle and when the governor is unloading, the contaminates are removed from the dryer.

The air system is split into a primary system and a secondary system. The systems are isolated from each other so that in the event of a failure of one system, air is retained in the other system. By means of pressure protection valves, check valves, and spring brake valves, a reserve of air pressure remains to operate the spring brakes through normal use of the brake pedal. Any unusual loss of pressure should be investigated immediately and corrected, so as to restore the full backup capability of the system.

Theory of Operation

Through reciprocating motion, the piston in the compressor compresses air with every cycle. The compressed air passes through the air dryer and onto the primary front supply reservoir (tank #1). The primary front supply reservoir helps cool the heated air and contains an automatic drain valve to vent off condensed water. A 10.30 bar (150 psi) safety valve is installed on the supply reservoir for protection from excess pressure. The pressurized air flows to the primary rear service reservoirs (tanks #4 and #5) and secondary service reservoirs (tanks #2 and #3) from the primary front supply reservoir. Both primary and secondary air reservoirs provide the supply for the dual brake and spring brake control valves. Air to the service brakes on axles #2, #3, and #4 is supplied by both primary rear service reservoirs. The secondary reservoirs provide the supply for the service brakes on axle #1. The auxiliary air reservoir provides the air supply to operate all other air components.

The three pressure protection valves are set at 5.90 bar (85 psi) and are basically check valves. They open at 0.70 to 1.00 bar (10 to 15 psi) above their closing pressure. These valves protect a circuit if a line is ruptured to ensure a priority supply to the brakes.

The compressor, which is mounted on and driven by the engine, is regulated by an air governor which vents the compressor when a pressure of 9.30 bar (135 psi) is sensed in the air system. When pressure drops to 7.90 bar (115 psi), the governor will allow the compressor to supply the air system to maintain proper system pressure.

Braking

The top priority of the air system is to provide braking. Each rear wheel has a spring brake chamber and a service brake chamber. The spring brake is applied by a spring and released by pressurized air. The spring brakes on all four rear wheels are released by the parking brake push-pull knob on the right hand console in the cab. Pushing in on the parking brake causes air pressure to enter the spring brake chamber on each wheel and compress the spring, releasing the brakes. At least 2.80 bar (40 psi) is required to keep the parking brake valve engaged. If supply pressure to the valve drops below 2.80 bar (40 psi), the valve will release, applying the brakes.

The service brakes are applied by air pressure. Depressing the foot brake pedal on the cab floor causes pressurized air to enter the service brake chamber on each wheel and apply the brakes. In the event of a loss of supply pressure to the service brakes, the spring brake valve will allow the operator to release or bleed off the air pressure in the spring brake chamber by depressing the foot brake pedal to apply the brakes.

Maintenance

WARNING

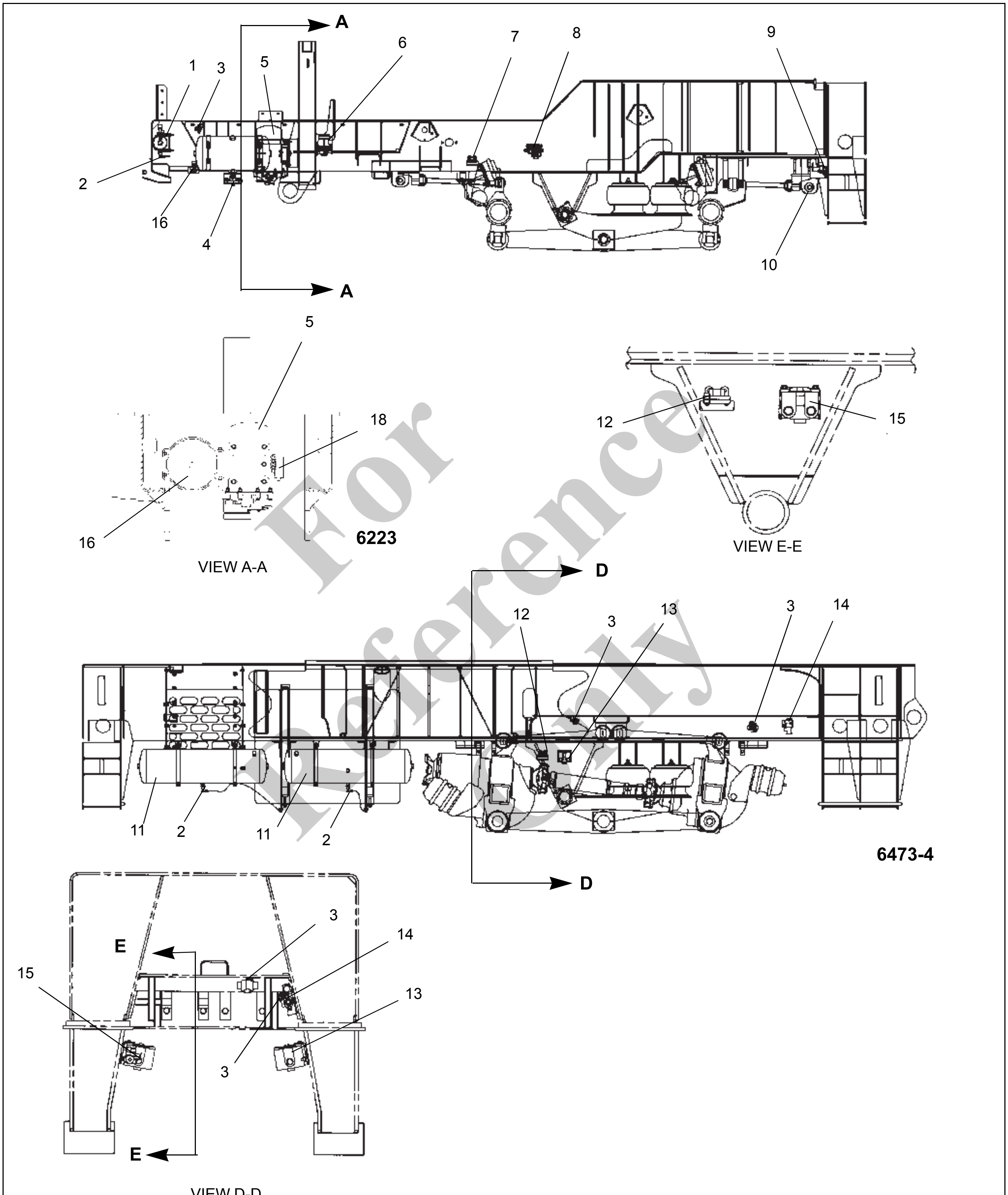
Depressurize both air systems completely before disconnecting air lines or components.

CAUTION

Do not expose nylon tubing to flames or heat. Replace tubing if outside covering shows white. Eliminate cause of chafing or other damage.

Leak Detection

If a leak is suspected, shut off the engine and note the air pressure reading of both circuits. Acceptable air pressure loss is 0.40 bar (6 psi) within 30 minutes. A hard to detect leak can be found by wetting the suspected area with a soap solution and observing for bubbles.


A
1
3
5
6
7
8
9
2
16
4
10
A
5
18
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6223
VIEW A-A
12
15
VIEW E-E
D
12
3
13
3
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6473-4
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13
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E
VIEW D-D

FIGURE 8-55

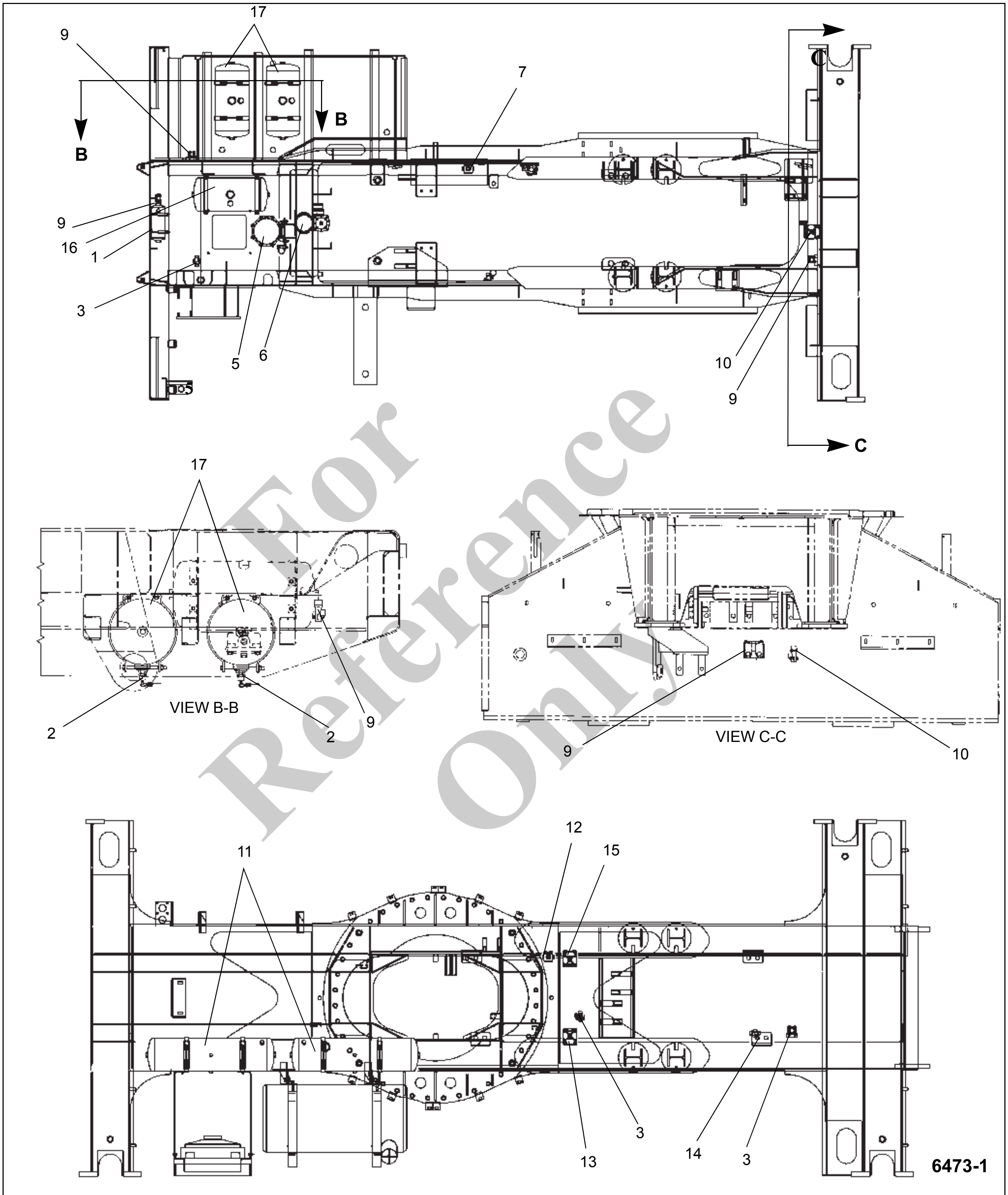

FIGURE 8-55 continued

8

Item	Description
1	Auxiliary Reservoirs
2	Cable Operated Drain Valve
3	Double Check Valve
4	Automatic Drain Valve
5	Air Dryer
6	Supply Dump Valve
7	Axle No. 1 Quick Release Valve
8	Spring Brake Control Valve
9	Pressure Protection Valve
10	Axle No. 2 Relay Valve
11	Primary Rear Service Reservoirs
12	Rear Axle (right Side Only) Park Brake Quick Release Valve
13	Park Brake Relay Valve
14	Trailing Boom Tractor Protection Valve
15	Service Brake Relay Valve
16	Front Primary Supply Reservoir
17	Secondary Service Reservoirs
18	Air Governor

Air System Operational Test

DANGER

Air pressure must not exceed 10.30 bar (150 psi).

1. Park the crane on a firm level surface and apply the parking brakes.
2. Position the Suspension Control Valve Lever to the DEFLATE position to deflate the air suspension bags. The amber Deflate Indicator Light should illuminate when the pressure in all air bags drops below 0.28 ± 0.14 bar (4 ± 2 psi).
3. Raise the crane on outriggers.
4. Shutdown the engine.
5. Open the manual drain valves on the main air reservoirs to depressurize both air circuits. If not already applied, the parking brake will be applied as the system is drained. Ensure the parking brakes are applied on all rear wheels.
6. Close the drain valves and start the engine.
    - a. The Air Pressure Low Light and warning buzzer should activate immediately.
    - b. The red (rear primary) needle on the dual air gauge should rise to about 5.90 bar (85 psi) at which time the green (front/secondary) needle will begin to rise.
    - c. The warning buzzer and light will stay on until both gauges show 4.10 to 4.80 bar (60 to 70 psi).
    - d. Release the parking brake.
    - e. Check that the outriggers cannot be operated with the parking brakes released.
    - f. Continue charging the system until the air dryer cycles and the compressor shuts off. All system gauges should read 9.30 bar (135 psi).
7. Turn off the engine and check that all wheels turn freely.
8. The air pressure should remain constant with no leaks. Any air pressure drop should be no more than 0.07 bar (1 psi) per minute.
9. Apply service brakes to full application and hold.
    - a. Check for a drop in air pressure and then an equalization in pressure with no loss (less than 0.14 bar (2 psi) per minute).
    - b. Check to see that all brakes are applied.
    - c. Release the service brakes and check that the reservoir pressure is maintained.
10. Start the engine and recharge the air system.
11. With the engine running, simulate a full air leak in the rear air system by opening the manual drain valve on the rear (primary) air reservoir.
    - a. The Air Pressure Low Warning Light and buzzer should come on when the pressure in the primary circuit drops below 5.17 ± 0.34 bar (75 ± 5 psi).
    - b. Air pressure in the front (secondary) system should not drop below 5.90 ± 0.34 bar (85 ± 5 psi).
    - c. Depressurize the rear (primary) system to zero.
12. With the park brakes released, check that all wheels turn freely.
13. Apply the service brakes and hold.
    - a. The front axle service brakes and the rear axles' spring brakes should be applied and the brake lights on the rear of the carrier should be on.
    - b. Release the brakes.
14. Close the drain cock on the rear (primary) reservoir and recharge the air system.
15. Simulate a full air leak in the front air system by opening the drain valve on the front (secondary) reservoir.

a. The Air Pressure Low Light and warning buzzer will come on when the secondary air pressure drops below 5.17 ± 0.34 bar (75 ± 5 psi).

b. The pressure in the secondary circuit should not drop below 5.90 ±0.34 bar (85 ±5 psi).

c. Depressurize the secondary system to zero.

16. Check that all the wheels can be rotated.

17. Apply the service brakes.

a. The rear front axle and the rear axles' service brakes should be applied and the brake lights on the rear of the carrier should be on.

b. Release the service brakes and check that all wheels turn freely.

c. Close the drain valves and recharge the system.

18. Apply the parking brakes.

19. Lower the crane to the ground off the outriggers.

20. With the engine running, position the Suspension Control Valve Lever to the INFLATE position to inflate the air suspension bags. The Amber Deflate Indicator light should go out when the pressure in the air bags goes above 0.28 ± 0.14 bar (4 ± 2 psi).

21. Continue charging the system until the air dryer cycles and the compressor shuts off. All system gauges should read 9.30 bar (135 psi).

22. Check that all suspension air bags are properly inflated. The top surface of each air bag saddle should be parallel with the bottom horizontal surface of the carrier frame.

AIR SYSTEM COMPONENTS

Description

Air Compressor

The air compressor is mounted on and driven by the engine. It provides the source of compressed air for the operation of the air system components. It is controlled (cycled on and off) by an air governor. The compressor has a capacity of 0.53 cm/m (18.7 cf/m).

Air Governor

The air governor is mounted on the left side of the air dryer. The governor senses the system pressure and when pressure reaches 9.30 bar (135 psi) the governor vents the compressor. When pressure drops to 7.90 bar (115 psi), the governor signals the compressor to start charging again.

Air Dryer

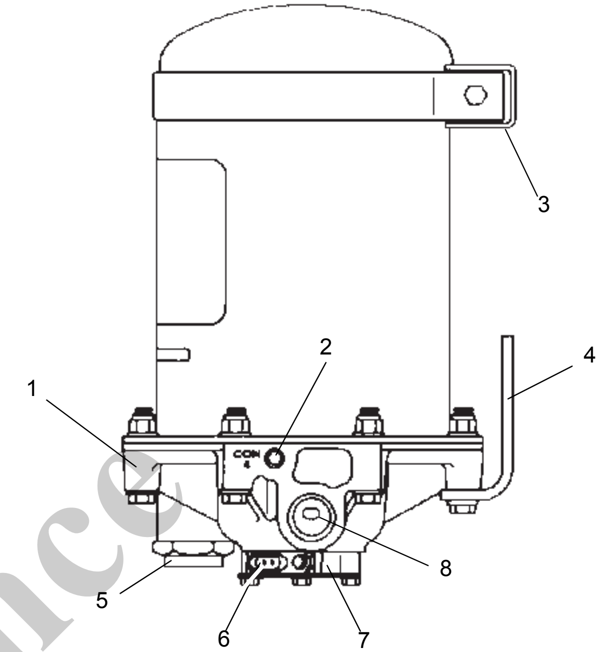

FIGURE 8-56

Item	Description
1	End Cover
2	Control Port
3	Upper Bracket
4	Lower Bracket
5	Delivery Port
6	Female Connector
7	Purge Valve Housing
8	Supply Port

The purpose of the air dryer (see Figure 8-40) is to collect and remove solid, liquid, and vapor contaminates from the air system. Clean dry air increases the life of the air system and reduces cost.

The dryer consists of a desiccant cartridge and die cast aluminum end cover secured to a cylindrical steel shell. The end cover contains a check valve, safety valve, three threaded connections and purge valve housing. The purge valve housing contains the purge valve and turbo charger cutoff. The turbo charger cutoff prevents loss of engine "turbo" boost pressure during the purge cycle of the air dryer

8

Reservoirs

Six air reservoirs store compressed air for braking and auxiliary air devices. The first reservoir in the system (front primary supply) also acts as a purge tank to remove additional moisture not removed by the air dryer. It contains an automatic drain valve. The other five reservoirs have a manual drain valve actuated by a cable lanyard accessible from the outside of the carrier.

Low Pressure Indicator Switches

The low pressure indicator switches (see Figure 8-57) are used to warn the operator of low pressure in the air systems. One switch is installed in each system and they are electrically connected in parallel to illuminate the Air Pressure Low Indicator on the front console in the cab. Observe the dual air pressure gauge to determine which system is low. The switch contacts close when the pressure in the system decreases to 5.17 bar (75 psi).

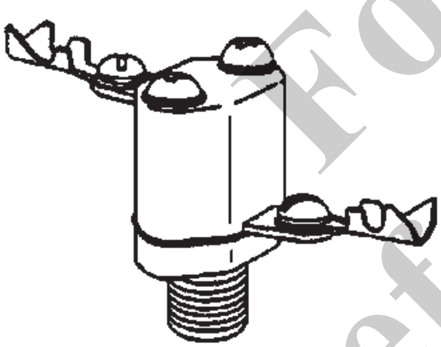

FIGURE 8-57

Stop Light Switch

The stop light switches (see Figure 8-58) are installed in the ports of the dual brake valve and are used to illuminate the stop lights on the rear of the carrier when the brakes are applied. There is one switch in each system (primary and secondary) and they are connected electrically in parallel.

Air Pressure Gauge

The dual air pressure gauge is located on the left side of the front console. The gauge is a direct reading pressure gauge with two indicating pointers, red for the primary system and green for the secondary system. The gauge has a dual scale calibrated from 0 to 150 psi and 1.00 to 10.00 bar.

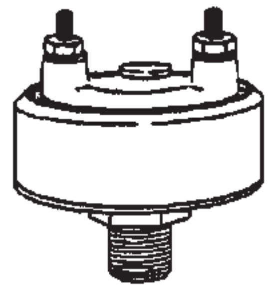

FIGURE 8-58

Safety Valve

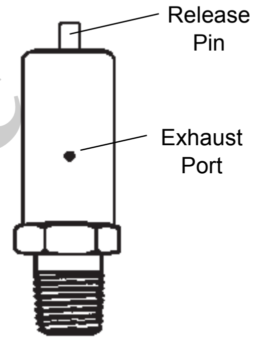

FIGURE 8-59

A safety valve (see Figure 8-59) is installed in the primary (front) supply reservoir to protect the air system against excessive air pressure buildup. The valve consists of a spring loaded ball which exhausts the system if the pressure rises above 10.30 bar (150 psi). A second safety valve is installed in the tire inflation circuit and is set at 12.07 bar (175 psi).

Automatic Drain Valve

The automatic drain valve (see Figure 8-60) is located in the bottom of the primary (front) supply reservoir and is designed to collect and eject moisture and contaminates from the reservoir. The valve is operated by a difference in air pressure between the tank and valve sump cavity. If the pressure in the tank is greater than in the sump cavity, the inlet valve opens and drains moisture into the sump cavity. If the sump cavity pressure is greater than the tank pressure, the exhaust valve opens and expels the moisture to the outside. Both valves are closed when the pressure is equalized.

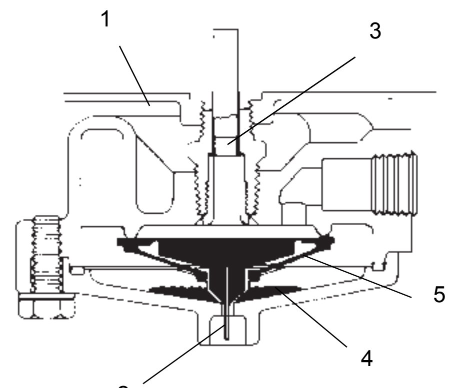

FIGURE 8-60

Item	Description
1	Pressure Regulating Spring
2	Outlet
3	Inlet

To manually drain the valve, push the wire in the exhaust port up and hold until the valve is drained. The valve has a die cast aluminum body and cover.

Pressure Protection Valve

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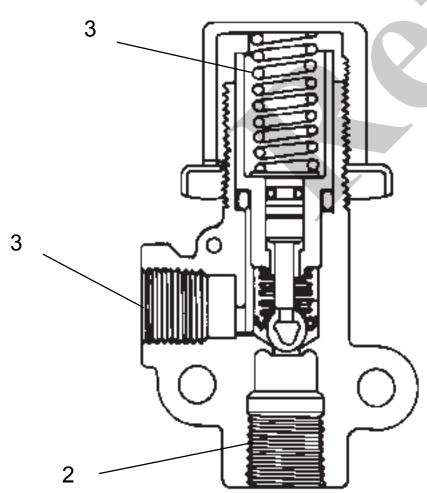

FIGURE 8-61

Item	Description
1	Delivery Port
2	Supply Port
3	Shuttle Valve

There are three pressure protection valves in the air system. The purpose of the pressure protection valve (see Figure 8-61) is to isolate one system from the other by closing at a preset pressure. One valve isolates the primary system from the secondary system, one valve isolates the auxiliary system from the primary system, and the other isolates the tire inflation system from the primary system. The valve is a normally closed valve which can also be referred to as a non-exhausting sequencing valve. The valve has two ports: a supply port and a delivery port. The closing pressure is 5.86 bar (85 psi) and opening pressure is about 1.00 to 1.40 bar (15 to 20 psi) higher than the closing pressure. The valve is preset to the specified opening and closing pressures.

Double Check Valve

There are three double check valves used in the air system. The double check valve (see Figure 8-62) is used when a function or component is controlled by either of two sources. The higher of the two pressures is transmitted to the output port.

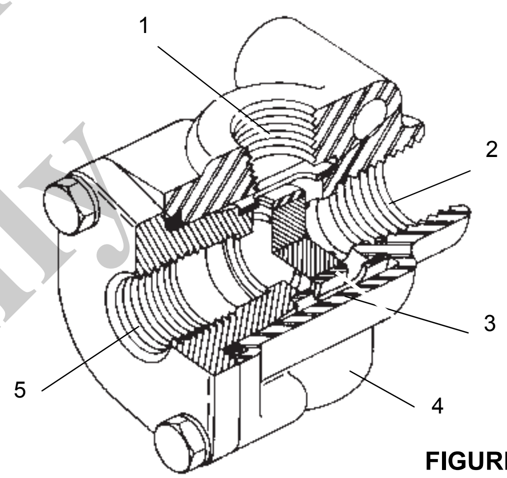

FIGURE 8-62

Item	Description
1	Delivery Port
2	Supply Port
3	Shuttle Valve
4	Delivery
5	Supply

Relay Valve

The purpose of the three relay valves (see Figure 8-63) is to speed up application of the parking and service brakes. The valve is remote mounted and delivers air to the brakes in response to signals from the parking and foot brake control valves. One valve controls the front #2 axle service brakes, one valve controls the rear axle service brakes, and the other valve controls the rear parking brakes. Air pressure, which controls the valve, enters through the service port to either deliver or exhaust air pressure from the circuits serviced by the relay valve.

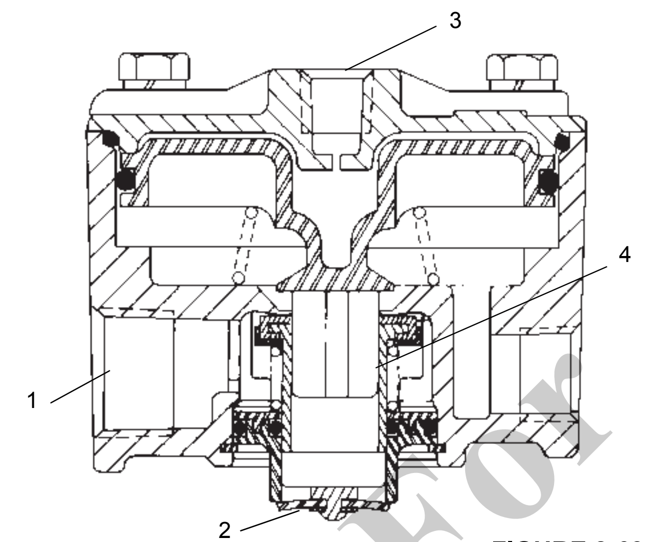

FIGURE 8-63

Item	Description
1	Supply Port
2	Exhaust Cover
3	Service Port
4	Inlet/Exhaust Valve

Dual Brake Valve

The dual brake valve is a suspended, pedal operated brake valve which has two separate supply and delivery circuits. The valve is located under the front console to the right of the steering column. The valve provides the driver with a graduated control for applying the service brakes or the parking brakes through the spring brake control valve.

Spring Brake Control Valve

The spring brake control valve is located on the right side of the carrier frame. The purpose of the valve is to supply a specific, limited hold off pressure to the spring brakes, and in the event of loss of primary pressure, to modulate the spring brakes through use of the dual brake valve.

Park Brake Control Valve

The park brake control valve is an on/off push/pull control valve located on the front console. When the air pressure reaches 3.40 bar (50 psi) and the button is pushed in, the park brakes are disengaged. The button will pop out when the air pressure falls below 2.80 bar (40 psi) exhausting the delivery line and engaging the brakes.

Quick Release Valve

There are two quick release valves (see Figure 8-64) used in the air system. One is used for front axle #1 service brakes, and the other is used for right side only rear spring brakes. The quick release valve is an air valve used to exhaust air pressure from the brake chambers to speed up the brake release by reducing the distance the air would have to travel back to the operating valve exhaust port.

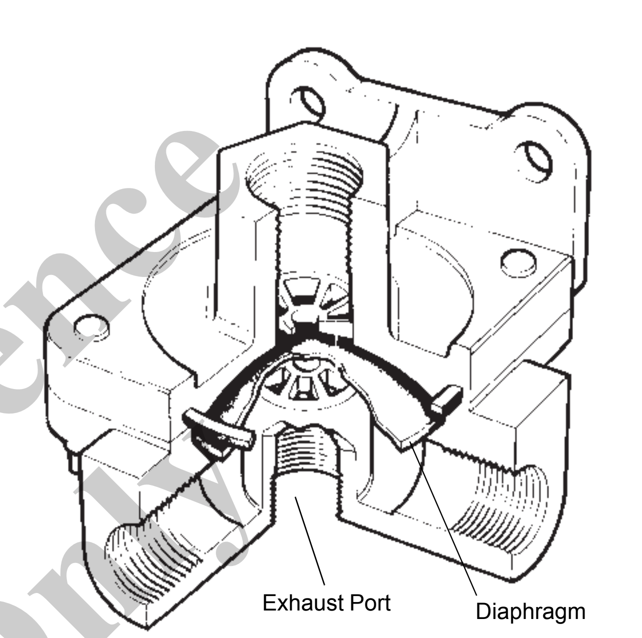

FIGURE 8-64

Maintenance

WARNING

Depressurize both air systems completely before disconnecting air lines or components.

Air Compressor

NOTE: Detailed maintenance instructions for the air compressor are contained in the Engine Service Manual.

Removal

1. Chock the wheels and depressurize both primary and secondary air circuits.
2. Open the engine compartment to gain access to the air compressor.

3. Disconnect and tag the air lines connected to the air compressor.
4. Unbolt and remove the compressor from the engine.

Installation

1. Bolt the air compressor to the engine.
2. Connect air lines as per removal tags.

Air Governor

Removal

1. Chock the wheels and depressurize both primary and secondary air circuits.
2. Access the air governor which is located beside the air dryer under the storage mat.
3. Tag and disconnect the air lines connected to the governor.
4. Remove the bolts, nuts and washers securing the air governor mounting plate to the engine. Remove the mounting plate and air governor.
5. Remove the washers and nuts securing the air governor to the mounting plate and remove the air governor.

Installation

1. Position the air governor on the mounting plate and secure with lockwashers and nuts.
2. Position the mounting plate on the engine and secure with bolts, nuts and lockwashers.
3. Connect air lines as per removal tags.

Operational Test

1. Start the engine and pressurize the system. Check the governor cut-out pressure with either the panel gauge or a test gauge (it should be 9.30 bar (135 psi)). At the cut-out pressure, the compressor is unloaded and the air dryer is purged.
2. Apply a series of brake applications with the engine running until the governor cuts-in. The cut-in pressure is 7.90 bar (115 psi). Governor adjustment is as follows:
    a. Unscrew the cover at the top of the governor.
    b. Loosen the adjusting screw locknut.
    c. Turn the adjusting screw counterclockwise to raise the setting or clockwise to lower the setting.
    d. Tighten the adjusting screw locknut to lock the adjustment.
3. Repeat step 2 as necessary.

Leakage Test

1. Leakage checks on the governor are made at the exhaust port with a soap solution in both the cut-in and cut-out positions. In the cut-in position, the leakage can be through either the inlet valve or bottom piston grommet. In the cut-out position, leakage can be through the exhaust valve seat or upper piston grommet. The soap solution test on the exhaust port is done to verify a leak and determine its location.
2. If the governor does not function properly or has excessive leakage, repair or replace the air governor. Check the applicable Grove Parts Manual.

Preventive Maintenance

Every 500 hours or 24,000 km (15,000 mi).

1. Clean or replace the governor filters.
2. If cleaning, use a cleaning solvent that will not have a detrimental effect on metal or rubber.
3. Always replace filters that are removed with new ones. Every operating 3,000 hours or 160,000 km (100,000 mi), disassemble the governor and clean all parts.

Air Dryer

Removal

1. Turn ignition switch off.
2. Turn the battery disconnect switch in the battery compartment to the OFF position.
3. Chock the wheels and completely depressurize the air system.
4. Tag and disconnect all air and electrical lines connected to the air dryer.
5. Remove the bolts, nuts and washers securing the dryer to the carrier frame and remove the dryer.
6. If the dryer is to be replaced with a new one, remove the fittings from the old dryer.

Installation

1. Install the fittings on the new dryer.
2. Position the air dryer on the mounting studs on the carrier frame and secure with the bolts, nuts and washers.
3. Connect the air and electrical lines as per removal tags. Run the lines downhill so that pockets of water don't collect in the lines and freeze.

Preventive Maintenance

The recommended desiccant cartridge change is 3 years but can be shorter or longer depending on conditions.

1. Every 900 hours, or 40,000 km (25,000 mi) check for moisture in the air system by opening the reservoir's drain cock or automatic drain valve.
2. Replacement of the desiccant cartridge may be necessary if moisture is present; however, the following conditions can also cause water accumulation and should be considered before changing the desiccant.
    a. An outside air source has been used to charge the system that has not been passed through a drying bed.
    b. Excessively high air demands, which is not normal, that do not allow the compressor to unload in a normal fashion. Check for air system leakage.
    c. The dryer has been installed in a system that has been previously used without an air dryer. The system is probably saturated with moisture and it may take several weeks to dry the system out.
    d. In areas where the temperature varies 15°C (30°F) or more daily, small amounts of water can accumulate in the air system due to condensation. This is normal and should not be considered as an indication that the dryer is not performing properly.
    e. Location of the air dryer is too close [less than 1.8 m (6 ft)] to the air compressor.
3. Check the electrical connections and mounting bolts for tightness.
4. With the ignition switch ON, unplug the electrical connector at the air dryer and check for power. If there is no power, check for tripped circuit breaker and broken wires.
5. Every 10,800 hrs, 500,000 km (300,000 mi), or 36 months rebuild the air dryer and replace the desiccant cartridge.

Check the heater and thermostat as follows:

a. Turn off the engine and let the air dryer end cover cool to below 4°C (40°F).
b. Check the resistance across the pins in the female connector on the bottom of the air dryer. The resistance should be 1.5 to 3 ohms for a 12 volt system.
c. Warm the end cover to over 32°C (90°F) and check the resistance again. The resistance should exceed 1000 ohms.
d. If the resistance is outside the specified limits, replace the purge valve housing assembly which includes the thermostat and heater.

Leak Tests

1. Test the outlet port check valve in the dryer by observing the pressure after the governor cuts out. A rapid loss in pressure indicates a possible failed check valve in the outlet port.
2. Test the purge valve by applying a soap solution to the exhaust. Observe for bubbles during the loading cycle.
3. Test the safety valve by pulling the stem while the compressor is loading. Air must exhaust while the stem is held and stop when the stem is released.
4. Test all lines and fittings leading to and from the air dryer with a soap solution for leaking.

Reservoirs

Removal

1. Chock the wheels and completely depressurize both systems.
2. Disconnect and tag all air lines connected to the reservoir.
3. Remove the clamping hardware and remove the reservoir from the clamping brackets. If a new reservoir is to be installed, remove the fittings from the old reservoir.

Maintenance

Maintenance of the reservoir is limited to inspecting the mounting hardware. If the tank is damaged and cannot be used, it is more economical to replace it with a new tank than to repair the old one.

Cleaning

If the inside of the reservoir has become excessively coated with sludge that cannot be drained off, remove the reservoir and clean with solvent, steam, or water. Aerate the reservoir before reinstalling.

Installation

1. If a new reservoir is being installed, install the fittings from the old reservoir on the new one.
2. Position the reservoir in the mounting brackets and install the clamp hardware.
3. Connect the air lines to the reservoir.

Low Pressure Indicator Switches

Maintenance is limited to leakage and pressure checks. Replace faulty switches.

Operating and Leakage Checks

1. Shut down the engine and slowly reduce the pressure.
2. The switch should activate at about 5.20 bar (75 psi). The air gauges and indicators in the cab can be used to test the switch.
3. With system pressurized, coat the switch with a soap solution and observe for bubbles. No leaking is permitted.

Removal

1. Chock the wheels and completely depressurize both systems.
2. Disconnect the electrical lead and unscrew the switch from the fitting.

Installation

1. Screw the switch into the fitting and connect the electrical leads.

Preventive Maintenance

Every 16,000 km (10,000 mi) or monthly do the procedures as outlined under Operating and Leakage Checks above.

Stop Light Switch

Operational Test

Depress the brake pedal and observe that the stop lights illuminate.

Leakage Test

With pressure applied, coat the switch with a soap solution and observe for bubbles. No leaks are permitted.

Removal

Disconnect the electrical leads and unscrew the switch from the dual brake valve with a wrench.

Installation

Screw the switch into the dual brake valve with a wrench and connect the electrical leads.

Air Pressure Gauge

Removal

1. Chock the wheels and completely depressurize both systems.
2. Remove the hardware securing the cover to the front console and remove the cover.
3. Gain access to the rear of the air pressure gauge. Tag and disconnect the nylon tubes from the rear of the gauge. Tag and disconnect the electrical connector.
4. Remove the hardware securing the gauge to the front console and remove the gauge.

Installation

1. Install the air pressure gauge in the front console with the attaching hardware.
2. Connect the two nylon tubes to the fittings in the rear of the gauge and connect the electrical connector as per removal tags.
3. Install the front console cover and secure with attaching hardware.

Functional Check

Start the engine and observe the air pressure gauge. The red arrow on the gauge (primary) should rise first until a pressure reading of about 5.90 bar (85 psi) at which time the green arrow (secondary) should begin to climb. Both arrows should level off at about 7.60 bar (110 psi).

Safety Valve

Removal

1. Chock the wheels and completely depressurize the system.
2. Using a wrench, unscrew the valve from the fitting.

Installation

Screw the valve into the fitting.

Operating and Leakage Checks

With the system pressurized, pull the valve stem and air should exhaust from the valve exhaust port. Release the stem and air flow should stop. Replace the safety valve if it does not pass the operation test.

Coat the valve and fitting with a soap solution and observe for leaks. Replace the valve if excessive leaking is present.

Check the valve every 160,000 km (100,000 mi), 3600 hrs, or yearly.

Automatic Drain Valve

Removal

1. Chock the wheels and completely depressurize both systems.
2. Unscrew the drain valve from the bottom of the reservoir.

Disassembly

1. Unscrew and remove the cover and sealing ring.
2. Remove the valve guide, inlet valve, and exhaust valve.
3. Remove the adaptor and filter assembly.
4. Remove the filter and retainer.

Cleaning

1. Clean all metal parts in cleaning solvent.
2. Wipe clean all rubber parts and replace the filter if clogged.

NOTE: Do not reinstall the valve without a clean filter.

3. Replace all worn parts.

Assembly

1. Apply a light film of grease on the inlet valve seat.

NOTE: Do not oil the inlet/exhaust valve.

2. Place the sealing ring in the groove of the cover.
3. Place the valve guide over the inlet/exhaust valve. The wire will project through the exhaust port.
4. Place the body on the cover and install the capscrews and lockwashers.
5. Install the filter and adapter. Screw in the filter retainer.
6. Install the adapter and filter assembly in the body and tighten.

Installation

1. Clean and flush the reservoir to prevent clogging of the drain valve filter.
2. Aerate the reservoir thoroughly if any solvents have been used to clean the reservoir.
3. Install the drain valve in the bottom port of the reservoir and tighten.

Preventive Maintenance

Every 1800 hrs, 80,000 km (50,000 mi) or 6 months remove, inspect, and clean the drain valve as described above.

Operating Leaks and Checks

Slightly depressurize the tank several times and check if air is exhausted through the drain valve exhaust port. If no air is exhausted, push up on the wire stem. If no air is exhausted, the filter is plugged. Remove the drain valve and clean the filter.

NOTE: Excessive leaking of the air system could result in constant exhausting of the drain valve.

Replace the drain valve if the valve does not function as described above.

Pressure Protection Valve

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect the two air lines from the pressure protection valve and remove the capscrews, nuts and washers securing the valve to the mounting studs.

NOTE: Step 3 is applicable to the pressure protection valve for the auxiliary air circuit.

3. Tag and disconnect the air lines from the valve. Unscrew the valve from the auxiliary air reservoir.

Installation

1. Install the valve on the mounting studs and secure with capscrews, nuts and washers or screw the valve into the auxiliary air reservoir.
2. Connect the air lines as per removal tags.

Operational Check

NOTE: Replace any pressure protection valve that does not operate properly.

1. Install a pressure gauge and drain valve at both the supply and delivery sides of the pressure protection valve.
2. Pressurize the system and shut off the engine.
3. Slowly exhaust the delivery side of the valve. The gauge on the supply side should stop while the gauge on the delivery side should continue to show a pressure loss. The closing pressure should be 5.90 ±0.35 bar (85 ±5 psi).

Leakage Test

1. Apply a soap solution around the cap of the valve with the system pressurized and observe for bubbles. A 25 mm (1 in) bubble in three seconds or longer is acceptable.
2. Disconnect the air line on the delivery side of the valve and apply a soap solution to the delivery port. A 25 mm (1 in) bubble in five seconds or more is acceptable.

Preventive Maintenance

Every 900 hrs, 40,000 km (25,000 mi) or 3 months check for operation and leakage as described above.

Double Check Valve

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect the air lines connected to the double check valve.
3. Remove the two nuts and washers securing the valve to the frame and remove the valve

Disassembly

1. Remove the end caps, O-rings, shuttle, and shuttle guide.

Cleaning

1. Clean metal parts in a cleaning solvent and inspect for cracks, wear, or deterioration. Replace all parts not considered serviceable.
2. Replace all rubber parts.

Assembly

1. Install the shuttle guide, shuttle, O-rings, and end caps.

Installation

1. Position valve on mounting studs on frame and secure with two nuts and washers.
2. Connect the air lines as per removal tags.

Operating Check

1. Connect two separately controlled air lines to the inlet ports and a pressure gauge to the outlet port.
2. Apply and release air to one of the inlet ports and observe that the gauge registers the pressure.
3. Repeat with the other line. Keep in mind that the outlet gauge will register pressure from the highest pressure line.

Leak Test

1. Disconnect one inlet port and apply a soap solution.
2. Apply air to the other inlet port and observe for bubbles. A 25 mm (1 in) bubble in five seconds is permissible.
3. Do the same to the other side. Replace any valve that does not function properly.

Preventive Maintenance

Every 3600 hours, 160,000 km (100,000 mi), or yearly remove disassemble, clean, and inspect the valve.

Relay Valve

CAUTION

Completely depressurize all reservoirs before removing the insert.

The inlet/exhaust valve assembly can be replaced without removing the valve. Replacement is as follows:

1. Remove the snap ring/exhaust cover assembly.
2. Pull the insert out and replace.
3. Reinstall the exhaust cover and snap ring.

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect all air lines connected to the relay valve.
3. Remove the two nuts and washers securing the valve to the frame and remove the valve.

Inspection

Inspect all air lines for kinks, cuts, chafing, or deterioration. Replace lines showing these defects.

Installation

1. Position the valve on the mounting studs on the frame and secure with two nuts and washers.
2. Connect the air lines as per removal tags.
3. Check operation as described under Operating and Leakage Tests.

Operating Test

1. Chock the wheels and pressurize both systems. Adjust the brakes.
2. Apply and release the brakes several times and check for prompt response of the brakes at all wheels.

Leakage Test

1. With dual brake valve released, coat the relay valve exhaust port with a soap solution to check for inlet valve and O-ring leakage. A 25 mm (1 in) bubble in five seconds is permissible.
2. With the dual brake valve applied, check the relay valve exhaust port for leakage of the exhaust valve.
3. Apply a soap solution around where the relay valve cover and body meet to check for seal ring leakage. A 25 mm (1 in) bubble in five seconds is permissible.

Preventive Maintenance

Every 300 hours, 16,000 km (10, 000 mi), or monthly.

1. Check the relay valve for leakage and proper operation.

Every 3600 operating hours, 160,000 km (100,000 mi), or annually.

Disassemble the valve, clean and inspect all parts. Repair and replace as necessary.

Dual Brake Valve

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect all air lines connected to the brake valve.
3. Remove the three nuts, washers, and lockwashers securing the valve to the mounting studs and remove the brake valve and pedal assembly.

Installation

1. Position the brake valve and pedal assembly onto the studs under the front console and secure with three nuts, washers, and lockwashers.
2. Connect all the air lines to the brake valve per removal tags.

Operating Test

CAUTION

A change in braking characteristics or low air pressure may be an indication of a malfunction in one of the brake circuits. Do not operate the vehicle until repairs have been made and both circuits are operating properly. Always check brakes after servicing.

1. Check the delivery pressure of both #1 and #2 circuits with a test gauge. Depress the treadle to several positions between fully released and applied. Check the pressure on the gauges to see if it varies equally and proportionately with the movement of the brake pedal.
2. After the brakes are released, the reading on the test gauges should fall off to zero. The delivery pressure in #1 circuit should be 0.30 bar (4 psi) greater than #2 circuit with both supply reservoirs at the same pressure.

Leakage Test

1. Make and hold a high pressure application of 5.50 bar (80 psi).
2. Coat the exhaust port and body of the brake valve with a soap solution. A leakage of a 25 mm (1 in) bubble in three seconds is permitted.

Preventive Maintenance

Every 300 operating hours, 16,000 km (10,000 mi), or three months.

1. Clean dirt away from the heal of the treadle, plunger boot, and mounting plate.
2. Lubricate the treadle roller, hinge pin, and roller pin using a barium base lubricant.
3. Check the rubber plunger boot for deterioration and replace as necessary.
4. Lubricate the plunger with a barium base lubricant.

Every 3600 operating hours, 160,000 km (100,000 mi), or yearly.

Replace inlet and exhaust valves, exhaust diaphragm, O-rings, and rubber graduating spring if worn or deteriorated.

Every 7200 operating hours, 320,000 km (200,000 mi) or two years.

Disassemble the brake valve and clean and inspect all parts.

Park Brake Control Valve

Removal

1. Chock the wheels and completely depressurize both systems.
2. Remove the hardware securing the front console cover and remove the cover.
3. Tag and disconnect the air lines connected to the park control valve. Tag and disconnect the electrical leads from the pressure switch screwed into the valve.
4. Drive out the roll pin securing the knob to the valve stem.
5. Loosen and remove the valve mounting nut and remove the valve from the console panel.
6. Unscrew pressure switch from the valve if new valve is to be installed.

Installation

1. If removed, install the pressure switch in the valve port.
2. Position the valve through the hole in the console and secure with the valve mounting nut.
3. Push the knob onto the valve stem and secure with the roll pin.
4. Connect the air lines to the valve and the electrical leads to the pressure switch as per removal tags.
5. Install the front console cover and secure with the attaching hardware.

Operating and Leakage Check

NOTE: Replace malfunctioning or leaking parking brake valve.

1. Chock the wheels and pressurize the air system.
2. With the park brake valve plunger pulled out (exhaust position), coat the exhaust port and plunger stem with a soap solution. A 25 mm (1 in) bubble in five seconds is permissible. No leakage is permitted between the upper and lower body.
3. Push the park brake valve plunger in (applied position). A 25 mm (1 in) bubble in three seconds is permitted.
4. Reduce the air pressure and observe the park brake valve plunger. It should pop out when the air pressure drops to about 2.80 bar (40 psi) exhausting the delivery line and engage the park brakes.

Preventive Maintenance

Every 300 hours, 16,000 km (10,000 mi) or 3 months. Perform the procedures under the Operating and Leakage Check.

Quick Release Valve

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect the air lines.
3. Remove the two nuts and washers securing the valve to the mounting studs on the frame and remove the valve.

Disassembly

1. Scribe an index mark across the cover so that the cover can be reinstalled in the same position.
2. Remove the four screws from the valve cover and remove the spring, spring seat, diaphragm and O-ring.

Cleaning and Inspection

1. Clean all parts and inspect the threads, body, and cover for damage.
2. Inspect the exhaust seat for scratches or pitting.

Assembly

1. Put the spring into the body and the diaphragm over the spring seat with the flat side of the diaphragm toward the body.
2. Install the O-ring and cover. Secure the cover with the four screws.
3. Do the tests as outlined in the *Operating and Leakage Tests*.

Installation

1. Position the valve on the mounting studs and secure with the two nuts and washers.
2. Connect the air lines as per removal tags.

Operating and Leakage Tests

1. Apply and release the brake several times and check for prompt response of brake chambers.
2. Remove the exhaust port fitting and coat the exhaust port with a soap solution then fully apply and hold the brakes. A 25 mm (1 in) bubble in five seconds is permissible.

Preventive Maintenance

Every 300 hours, 16,000 km (10,000 mi) or three months:

- Check that the air lines and valve mounting are secure. Check the air lines for chafing, kinking or corrosion and replace as necessary. Check for a clean exhaust port.

Every 7200 hours, 160,000 km (100,000 mi), or every two years:

- Remove the valve and replace the spring and all rubber parts.

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 outriggers consist of inverted jack cylinders with outrigger beams to allow for fully retracted, partial extension, and fully extended operation. A center front jack is provided for stabilization. The outriggers are fully hydraulic. The front outrigger box is mounted behind the front axles while the rear outrigger box is mounted behind the rear axles. The front jack is mounted on the center of a crossmember at the front of the crane.

The beam assembly (see Figure 8-65) contains the 6.4 cm (2.5 in) bore extension cylinder and the 11.4 cm (4.5 in) jack cylinder which is mounted in a tube at the end of the beam.

The outrigger circuit consists of an integrated outrigger selector valve, two outrigger manifold valves, four extension cylinders, five jack cylinders, a relief valve, a pressure switch, (pilot operated) check valves and four Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometers. The two front extension cylinders are mounted in the front outrigger beams and the two rear extension cylinders are mounted in the rear outrigger beams. The front and rear jack cylinders are mounted on their respective outrigger boxes; in turn the outrigger boxes are mounted on the end of each outrigger beam. The center front jack is mounted to the frame behind the front bumper. Each jack cylinder has a port block mounted on its side with the pilot operated check valve threaded into the port block. The pressure switch is mounted in a port on the center front jack cylinder. An OMS string potentiometer (if equipped) is mounted inside each outrigger box. The potentiometer is connected by a cable to the outrigger beam to monitor the beam's position—fully retracted, mid-extend, or full extended.

There are three outrigger control panels on the crane. One outrigger control panel is located in the superstructure cab at the front left corner of the cab. There is also an optional control panel on either side of the crane near the front outriggers. When using either of these control panels, the engine speed will be increased above idle when the outrigger Extend/Retract Switch is moved to either position.

A sight bubble level is mounted on the right side console in the cab and in each of the side control panels. The sight bubble level provides the operator with a visual indication of crane level attitude.

Theory of Operation

When the outrigger cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

The appropriate Extension/Jack Switch must be depressed before the outrigger Extend/Retract Switch is depressed. Depressing one of the outrigger selector switches causes that solenoid valve to open. As the outrigger Extend/Retract Switch is moved, the integrated outrigger valve spool shifts allowing flow to either the extend or retract line as applicable. If the switch is in the EXTEND position, the flow continues through the open solenoid valve to the piston side of the cylinder. If the jack is to be extended, the flow first unseats the cylinder check valve then extends the cylinder. The oil from the rod end flows through the integrated outrigger valve, and then to the reservoir.

When the outrigger switch is in the RETRACT position, the flow through the selector valve is directed to the rod side of the cylinder. The oil in the piston side flows through the open solenoid back to the integrated outrigger valve. If a jack cylinder is to be retracted, 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 valve contains three relief valves. The main relief is set at 172.40 bar (2500 psi) to protect the system. Thermal protection is provided on the extend side by a 241.30 bar (3500 psi) relief valve and the retract side by a 20.70 bar (300 psi) relief valve.

The front jack functions similar to any of the other outrigger cylinders. The front jack will retract when the outrigger Extend/Retract Switch is positioned to the RETRACT position. After operating the main outrigger control, the center front jack must be reset before operating the crane. A pressure switch is used to sense pressure in the barrel end of the cylinder after extension. When the pressure reaches 310.30 ± 1.38 bar (4500 ± 20 psi), the switch causes the red Front Jack Overloaded Indicator to be illuminated on the superstructure front console. This alerts the operator that the center jack circuit senses over pressurization indicating an overload condition. The inline relief valve prevents over pressurization of the center front jack cylinder. The valve is installed in line between the solenoid valve and the cylinder, and is set at 13.80 bar (200 psi).

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	**a.** Damaged relief valve.	**a.** Remove relief valve; clean or replace.
	b. Low hydraulic oil.	**b.** Check for leaks. Repair any found. Add hydraulic oil to proper level.
	c. Sticking solenoid valve spool.	**c.** Repair or replace valve spool.
	d. Improper ground to base of solenoid.	**d.** Ground properly.
	e. Damaged O-rings and swivel.	**e.** Remove swivel and replace O-rings.
	f. Directional selector switch sticking.	**f.** Clean or replace switch.
	g. Collector ring dirty or glazed.	**g.** Clean and deglaze collector ring.
	h. Damaged wiring to solenoid.	**h.** Replace wiring.
	i. Weak brush springs on collector ring.	**i.** Replace brush springs.
	j. Damaged extension cylinder (internal parts).	**j.** Remove extension cylinder and repair as necessary.
	k. Bent cylinder rods.	**k.** Replace piston rods and seals.
	l. Excessive material on outrigger beams.	**l.** Clean outrigger beams.
	m. Binding outrigger beam.	**m.** Repair or replace outrigger beam.
	n. Damaged outrigger valve.	**n.** Repair or replace valve.
	o. Damaged valve coil.	**o.** Replace coil.
	p. Main hydraulic pump cavitation.	**p.** Replace or tighten hose or fitting.
	q. Partially shifted hydraulic spool in selector valve or manifolds.	**q.** Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	r. Insufficient voltage for operation of solenoid valve.	**r.** Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical coupling collector rings.
	s. Damaged piston seals.	**s.** Replace all cylinder seals.
	t. Worn or damaged hydraulic pump section.	**t.** Repair or replace pump section.
	u. Scored cylinder barrel.	**u.** Repair or replace extension cylinder.
	v. Cracked or damaged piston.	**v.** Replace rod weld and all cylinder seals.
	w. Piston loose on piston rod	**w.** Replace all cylinder seals and torque piston lockout.

Symptom	Probable Cause	Solution
2. Sticking spool.	**a.** Dirt in the system.	**a.** Change oil and flush system.
	b. Distortion caused by tie bolts being 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.
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 vertical jack cylinder slow or erratic.	**a.** Low in hydraulic oil.	**a.** Check for leaks. Repair any found. Add hydraulic oil to proper level.
	b. Damaged main relief valve.	**b.** Repair or replace valve.
	c. Damaged holding valve seals.	**c.** Replace holding valve seals.
	d. Bent cylinder rod.	**d.** Replace cylinder rod and seals.
	e. Bent outrigger housing.	**e.** Repair or replace outrigger housing.
	f. Damaged O-rings in swivel.	**f.** Replace O-rings.
	g. Excessive material on beams.	**g.** Clean outrigger beams.
	h. Sticking solenoid valve spool.	**h.** Repair or replace valve spool.
	i. Damaged wiring to solenoid.	**i.** Repair or replace wiring.
	j. Weak brush springs on collector rings.	**j.** Replace brush springs.
	k. Collector ring dirty or glazed.	**k.** Clean or deglaze collector ring.
	l. Directional selector switch sticking.	**l.** Clean or replace switch.
	m. Main hydraulic pump cavitation.	**m.** Replace or tighten hose and fittings.
	n. Worn or damaged hydraulic pump section.	**n.** Repair or replace pump section.

Symptom	Probable Cause	Solution
6. Outrigger jack cylinder retracts under load.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Damaged holding valve seals.	**b.** Replace seals.
	c. Damaged holding valve.	**c.** Replace valve assembly.
	d. Scored cylinder barrel.	**d.** Repair or replace cylinder.
	e. Cracked or damaged piston.	**e.** Replace piston and all cylinder seals.
7. Jack cylinder extends while machine is traveling.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Scored cylinder barrel.	**b.** Replace jack cylinder.
	c. Cracked or damaged piston.	**c.** Replace piston and seals.
	d. Piston loose on cylinder rod.	**d.** Replace seal and retorque.
8. Outrigger system will not activate (from stowed or extended and down position).	**a.** Hydraulic oil low.	**a.** Check for leaks. Repair any found. Add hydraulic oil to proper level
	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. One/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. Loose or broken wire on control switch or solenoid valve.	**c.** Repair or replace wiring.
	d. Damaged solenoid valve.	**d.** Repair or replace valve.

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OUTRIGGER BEAM

Description

The outrigger beam assembly (see Figure 8-65) consists of an outrigger beam, a 11.43 cm (4.5 in) jack cylinder, a 6.35 cm (2.5 in) outrigger extension cylinder, an Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometer, and the required hoses and mounting hardware.

Theory of Operation

When the outrigger cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This provides for lifting and stabilizing the crane for operation.

The Outrigger Monitoring System (OMS) string potentiometer (if equipped) is mounted inside the outrigger box and is connected to the outrigger beam by a cable. The string potentiometer identifies whether an extension beam is at the fully retracted, mid-extend, or fully extended position. The OMS communicates the horizontal position of each outrigger beam to the Rated Capacity Limiter (RCL), aiding the operator in accurately programming the crane's configuration.

Maintenance

Removal

1. On the jack cylinder end of the beam, remove the set screw from the side adjustable wear pad and back off the wear pad from the outrigger box.
2. Remove the end cover and the top box cover from the opposite end of the outrigger box. Remove the setscrew from the side adjustable wear pad and back off the wear pad from the beam.
3. Remove the setscrews from the bottom adjustable wear pads and back off the wear pads leaving approximately 3.2 mm (0.125 in) protruding
4. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.

DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

5. Place blocking material under the outrigger beam (see Figure 8-66).
6. Tag and disconnect the hydraulic lines at the cylinder barrel end of the extension cylinder. Cap all lines and fittings.

NOTE: Do not allow the end of the outrigger extension cylinder to fall when the cylinder mounting shaft is removed. Use blocking to limit the drop or an adequate soft support to cushion any distance the rod will drop.

7. Remove the OMS string potentiometer cable (if equipped) from the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer caused by over-range of cable.

8. Remove the cotter pin and clevis pin securing the cylinder barrel end of the extension cylinder to the outrigger housing. Carefully extend the outrigger beam until the extension cylinder is free of the housing and carefully lay the end of the cylinder on the bottom of the outrigger beam or leave on blocking.

NOTE: OMS string potentiometer may be easily removed to avoid damage during extension cylinder pin removal. Refer to *Outrigger Monitoring System (Optional—Standard in North America)*, page 8-70.

9. After attaching a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam, pull the outrigger beam out of the outrigger box, re-adjusting the lifting attachment to prevent the extension cylinder from sliding out of the outrigger beam when the beam clears the outrigger box.

DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

NOTE: The outrigger beam assembly weighs approximately 384 kg (847 lb).

10. Position the outrigger beam on the blocking material.

Inspection

Inspect the outrigger beams for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder, loose connection, or damaged hydraulic line.

Installation

1. Apply grease (EP-MPG) to the bottom of the outrigger beam.
2. If removed, install the side adjustable wear pad in the outrigger beam.
3. Install the bottom wear pads with approximately 3.2 mm (0.125 in) protruding. This will prevent the beam side plates from riding on the bottom of the box.
4. Attach a suitable lifting device of straps or belts—instead of chains to prevent nicking the bottom edges of the outrigger beam.
5. Slide the beam into the outrigger housing and align the cylinder bushing with the mounting hole.
6. Apply anti-seeze compound to the clevis pin. Secure the cylinder barrel to the housing with the clevis pin and cotter pin.

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.

7. If the OMS string potentiometer was removed, install the potentiometer at this time. Refer to *Outrigger Monitoring System (Optional—Standard in North America)*, page 8-70.
8. Attach the OMS string potentiometer cable (if equipped) to the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer caused by over-range of cable.

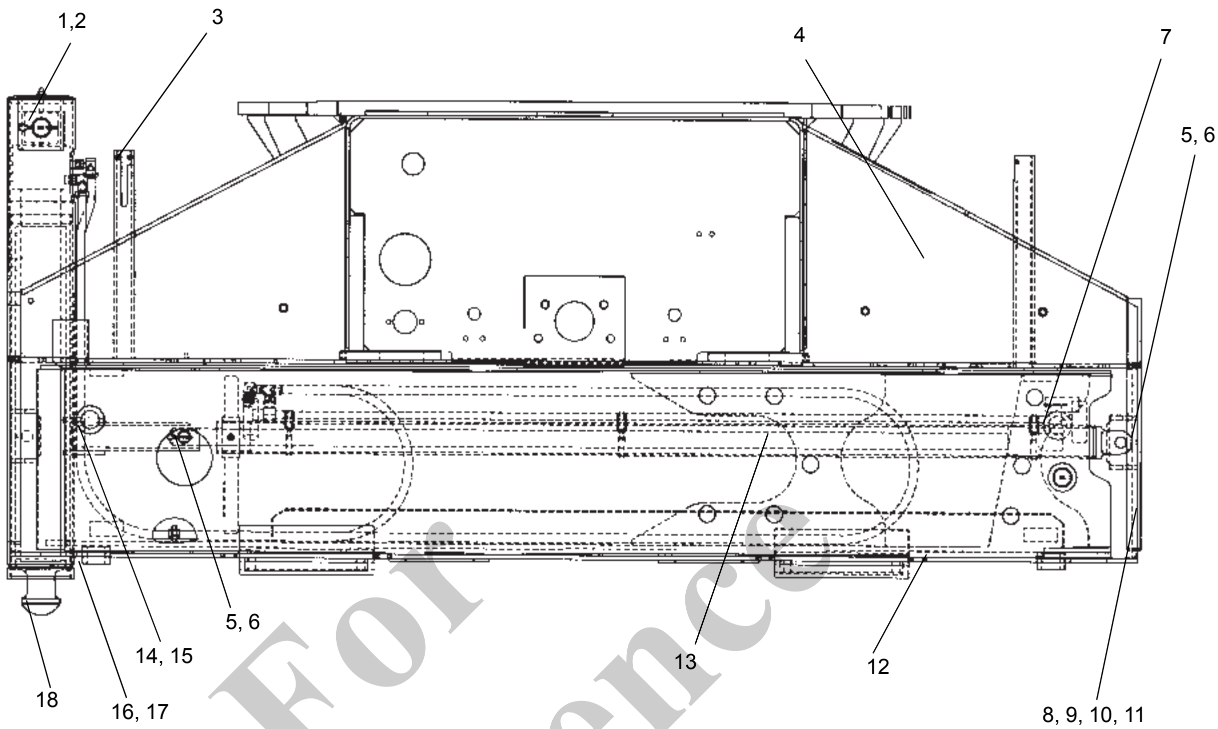


FIGURE 8-65

Item	Description
1	Retainer Pin
2	Cotter Pin
3	Mid Extension Lock
4	Outrigger Box
5	Clevis Pin
6	Cotter Pin
7	Tubing Clamp
8	End Cover Plate
9	Retainer Nut
10	Capscrew
11	Washer
12	Outrigger Beam
13	Extension Cylinder
14	Side Wear Pad
15	Setscrew
16	Lower Front Wear Pad
17	Setscrew
18	Jack Cylinder

CAUTION

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.

9. Connect the hydraulic lines as tagged prior to removal.

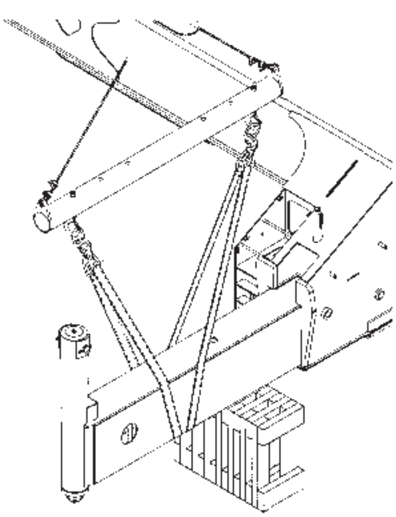
10. Install the side adjustable wear pad in the outrigger box.

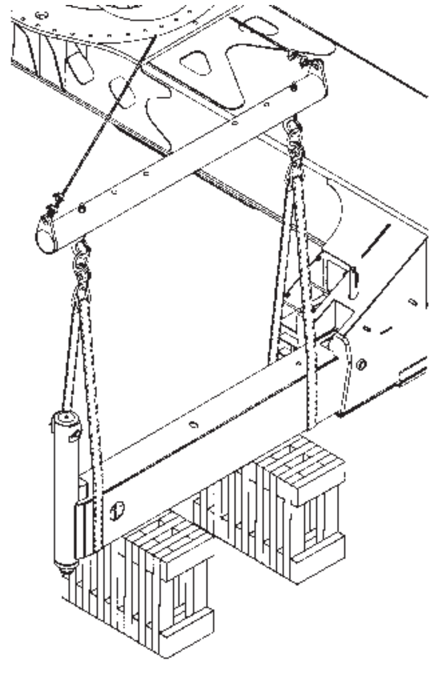
11. Adjust the wear pads, refer to *Wear Pad Adjustment*, page 8-69.

12. Install the end and top box covers.

NOTE: At installation, be sure that the outrigger jack cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

NOTE: Rear Outrigger Shown





NOTE: Outrigger removal and installation similar for both front and rear outriggers,

NOTE: Lifting belts or straps should be used for lifting purposes so as to avoid nicking or scratching the bottom edges of the outrigger beam.

FIGURE 8-66

Wear Pad Adjustment

1. Adjust the bottom wear pads (approximately 1/4 turn) until a gap of 1.5 mm (0.06 inch) is obtained 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 a gap of 1.5 mm (0.06 inch) is obtained between beam and shims welded in top and bottom of box. Install and lock set screw against wear pad.
3. Adjust outrigger beam side wear pad until a gap of 1.5 mm (0.06 inch) is obtained between shim welded on beam and side of box. Install and lock set screw against wear pad.

OUTRIGGER EXTENSION CYLINDER

Description

The four outrigger extension cylinders have 6.4 cm (2.5 in) diameter bores and are the double acting type. It is attached to the outrigger box by means of a pin through a clevis on the barrel end of the cylinder. Attachment of the rod end to the outrigger beam is by means of a clevis pin and cotter pins.

Each cylinder weighs approximately 49 kg (108 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-52 for Disassembly and Assembly of the cylinder.

Removal

1. Remove the outrigger beam. (Refer to *Outrigger Beam - Removal* in this Section).

NOTE: Step 2 is only required if hoses are also to be removed.

2. Remove the nut and two hose clamps securing the hoses to the inside of the beam.
3. Remove a cotter pin and clevis pin securing the rod end of the extension cylinder to the outrigger beam.
4. Withdraw the cylinder until the rod end is exposed.
5. Tag and disconnect the jack cylinder hoses from the end of the extension cylinder. Cap all lines and openings.

Installation

1. Place the cylinder in the beam.

NOTE: Keep hydraulic fittings and hoses close to angles shown (see Figure 8-67) and as low as possible to prevent rubbing with the beam top plate and side

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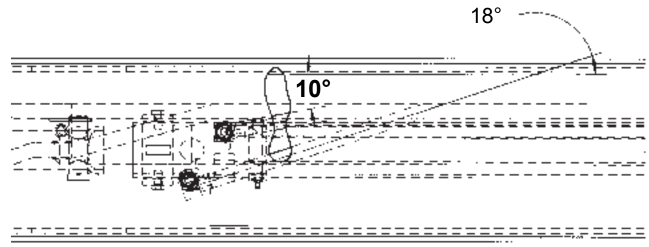
plate, and for proper tracking during beam extension and retraction.



NOTE: Keep hydraulic fittings and hoses close to angles shown & as low as possible to prevent rubbing with the beam top plate & side plate, and for proper tracking during beam extension and retraction.

FIGURE 8-67

2. Position the extension cylinder so the hydraulic ports on the rod end of the cylinder can be accessed. Connect the hydraulic hoses to the ports as tagged during removal.
3. Push the cylinder into the outrigger beam. Align the cylinder rod with the clevis in the beam. Apply anti-seeze to the clevis pin and secure in place with the clevis pin and cotter pin.
4. Install the outrigger beam. (Refer to *Outrigger Beam - Installation* in this Section).

Functional Check

1. Activate the hydraulic system; extend and retract the outrigger.
2. Observe the operation of the outrigger beam.
3. Check the hydraulic connections for any evidence of leakage.

OUTRIGGER MONITORING SYSTEM (OPTIONAL—STANDARD IN NORTH AMERICA)

Description

The Outrigger Monitoring System (OMS) aids the operator in accurately programming the Rated Capacity Limiter (RCL) by automatically identifying the horizontal position of each outrigger beam. The OMS uses four sensors, one per outrigger beam, to identify when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

Removal

1. Extend the outrigger beam slightly for improved access and shut down the engine.
2. Remove the outer access cover plate from outrigger box.
3. Remove the OMS string potentiometer (1, Figure 8-68) connector (2) from the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer.

4. Disconnect electrical harness connector and secure to avoid damage.
5. Loosen the mounting hardware enough to disengage OMS string potentiometer from the slotted mounting hole.
6. Completely remove the other mounting hardware.
7. Remove OMS string potentiometer from inside outrigger beam.

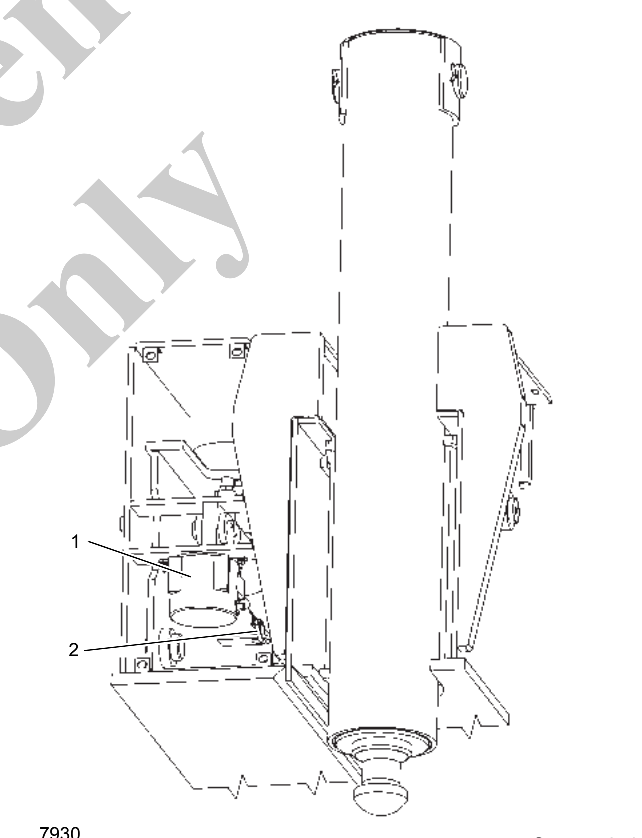


FIGURE 8-68

Installation

1. Install string potentiometer inside outrigger beam.
2. Install the OMS string potentiometer enough to engage slotted hole with the mounting hardware (Figure 8-68).
3. Install the remaining mounting hardware.
4. Attach the OMS string potentiometer connector to the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to the OMS string potentiometer.

5. Connect electrical harness connector to string potentiometer.
6. Install access cover plate to outrigger box.

OUTRIGGER JACK CYLINDER

Description

The jack cylinders have 11.43 cm (4.5 in) diameter bores and are the double acting type. The cylinders are pinned into tubes welded onto the end of the outrigger beams. A port block is welded to the end of the cylinder rod and a pilot operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

Each cylinder weighs approximately 76 kg (168 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-52 for Disassembly and Assembly of the cylinders.

Removal

1. Extend the outrigger beam slightly for improved access to the jack cylinder; shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
6. Jack the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

CAUTION

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

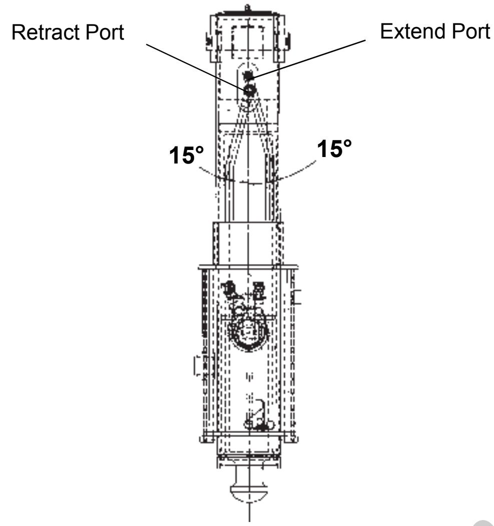
7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

Installation

1. Apply grease (EPMPG) to the ID of the jack cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under *Removal*, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.
5. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam.
6. Apply anti-seeze compound to the retaining pin. Secure the cylinder and cylinder cap retaining bracket to the support tube with the retaining pin and cotter pins.
7. Install the cylinder cap.

NOTE: Keep hydraulic fittings and hoses close to angles shown for proper tracking during extension and retraction (see Figure 8-69).

8. Install the fittings in the cylinder ports and connect the hoses as tagged during removal.



NOTE: Keep hydraulic fittings and hoses close to angles shown for proper tracking during extension and retraction.

FIGURE 8-69

Functional Check

1. Activate the hydraulic system.
2. Extend and retract the jack cylinder.
3. Check for smooth operation of the cylinder.
4. Check all hydraulic connections and hoses for evidence of leakage.

Outrigger Jack Cylinder Internal Leak Test

Use the following procedure to troubleshoot and diagnose an internal leak, a leaking pilot operated check valve or a thermal contraction on an outrigger jack cylinder.

WARNING

Perform the following procedures with the crane positioned on a firm level surface with outriggers fully extended and set, and the crane in the travel position

Remove hoses from one cylinder at a time.

Checking Cylinder for Internal Piston Seal Leak

1. Fully extend and set the outriggers.

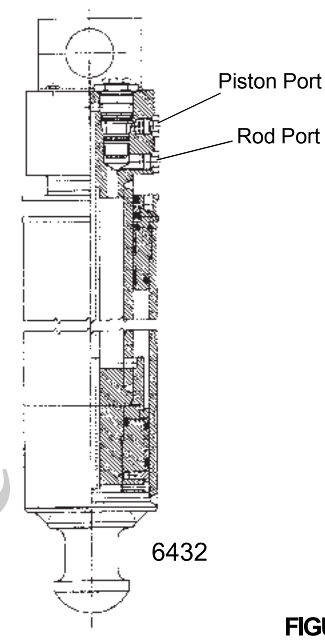


FIGURE 8-70

CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the rod side cylinder hose from the suspected leaking jack cylinder (see Figure 8-70). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the rod side port.

   Check for the following conditions:

   a. If oil stops flowing, the cylinder's internal piston seal is sealing properly.

   b. If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking.

3. After determining the condition of the cylinders internal piston seal, leave the rod side hose disconnected and continue to test the pilot operated check valve.

Testing Pilot Operated Check Valve for Leakage

1. Fully extend and set the outriggers.

CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

---

2. Remove the piston side cylinder hose from the suspected leaking jack cylinder (see Figure 8-70). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the piston side port.
   a. If <u>oil stops flowing</u>, the cylinder's pilot operated check valve is sealing properly.
   b. If <u>oil continues to flow</u> out the piston port, the cylinder's pilot operated check valve is leaking.

If oil flow is not noticed from either port, the cylinder and pilot operated check valve are functioning properly, and any cylinder contraction during normal operation can be attributed to thermal contraction of the oil.

OUTRIGGER SYSTEM VALVES

Description

There are five valve assemblies responsible for controlling the outrigger system, the integrated outrigger 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 2-19.

Pilot Operated Check Valve

The pilot operated check valves are located in the outrigger jack port blocks. The check valve provides two functions; the first function is a holding valve, the second function provides a thermal relief of the jack.

Integrated Outrigger Valve

The integrated outrigger valve is mounted on the front face of the carrier frame rear cross member. The valve consists of an enable solenoid valve, a three position four-way solenoid controlled directional control valve, a main relief valve, and two thermal relief valves.

Outrigger Control Manifold

The front and rear outrigger control manifolds are located inside the frame on the respective outrigger box. The rear manifold consists of four 12 volt solenoid valves and assembly mounting hardware. The front manifold consists of five 12 volt solenoid valves and assembly mounting hardware.

Center Front Jack Circuit Relief Valve

The center front jack circuit relief valve is mounted on the front outrigger box next to the front outrigger control manifold. The valve prevents over pressurization of the center front jack circuit.

CENTER FRONT JACK CYLINDER

Description

The center front jack cylinder has a 8.9 cm (3.5 in) diameter bore and is the double acting type. The cylinder is pinned into a tube which is welded onto a special crossmember on the front end of the carrier frame. A port block is welded to the end of the cylinder rod and a pilot operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is on the cylinder barrel to wipe dirt from the rod as it is retracted.

The cylinder weighs approximately 57 kg (126 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-52 for disassembly and assembly of the cylinder.

See Figure 8-71 for cylinder installation.

Removal

1. Remove the screws, washers, lockwashers, and nuts securing the tilt plate. Remove tilt plate.
2. Remove the bolts, lockwashers, and nuts securing the float pad to the cylinder ball and remove the float pad.
3. Remove the washer and nut securing the cylinder tube cap to the cap bracket.
4. Tag, disconnect, and cap the hydraulic lines to the cylinder.
5. Place a jack capable of supporting the weight of the cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
6. Remove the two cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap bracket.

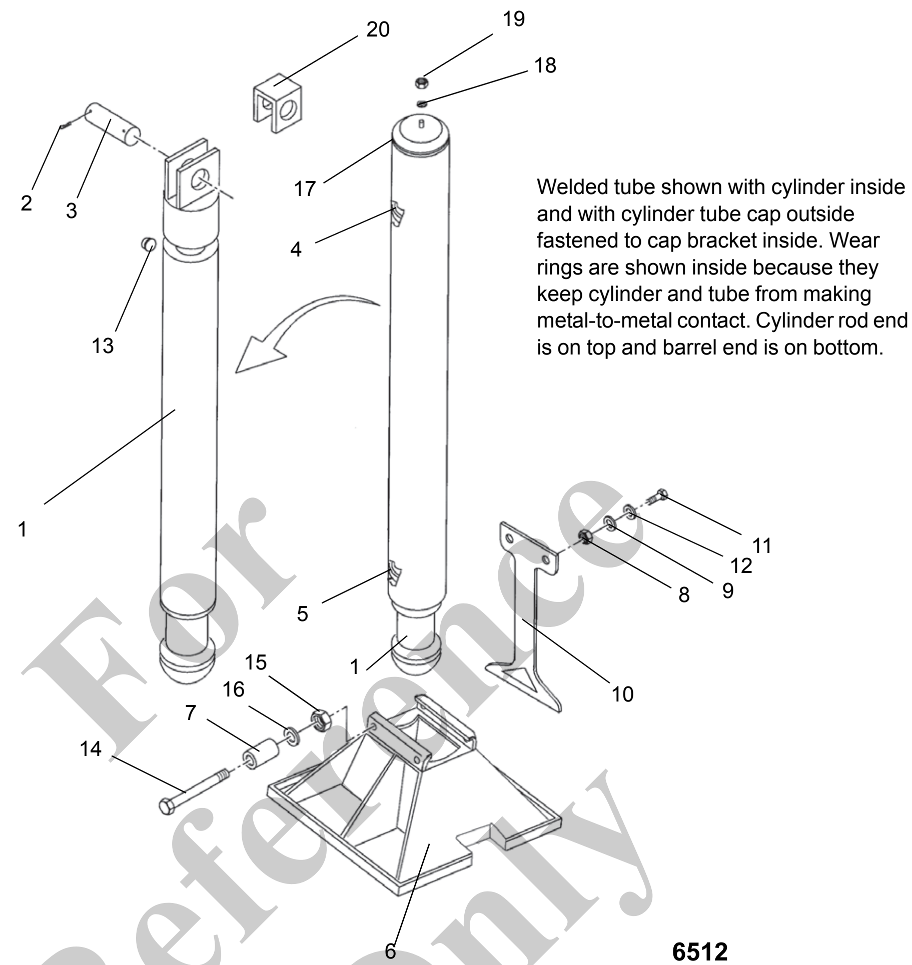


FIGURE 8-71

Item	Description
1	Jack Cylinder
2	Cotter Pins
3	Cylinder Retaining Pin
4	Cylinder Head Wear Ring
5	Piston Wear Ring
6	Jack Pad (Float Pad)
7	Bushing
8	Hex Nut
9	Lockwasher
10	Tilt Plate

Item	Description
11	Capscrew
12	Flatwasher
13	Plug
14	Capscrew
15	Locknut
16	Flatwasher
17	Cylinder Tube Cap
18	Washer
19	Acorn Nut
20	Cap Bracket

7. Jack the jack cylinder up just enough to insert the retaining pin back into the cylinder's lugs. Insert the retaining pin into the lugs on the cylinder and secure it in place with the cotter pins.

CAUTION

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

8. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube.
9. Remove the wear ring from the groove of the cylinder. Remove the wear ring from the groove in the bottom of the tube.

Installation

1. Apply grease (EP-MPG) to the ID of the jack cylinder support tube.
2. Install piston wear ring in groove in bottom of support tube and install cylinder head wear ring in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube. Using the same method as described under *Removal*, lower the jack cylinder into the cylinder tube 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.

CAUTION

When installing cylinder retaining pin, orient it so that when cotter pins are installed they will be horizontal.

5. Lower the jack until the holes in the cylinder rod align with the holes in the tube. Apply grease (EP-MPG) to the retaining pin. Secure the cylinder and cylinder cap bracket in place with the retaining pin and cotter pins.
6. Install the hydraulic lines as tagged prior to removal.
7. Secure the cylinder tube cap to the cylinder bracket with a replacement black nylon washer and the acorn nut.
8. Position the float pad on the cylinder ball and secure with bolts, bushings, lockwashers, and nuts. Tighten each nut until the washer contacts the pad and the nut. Do not tighten either nut onto their related bolts any further; this allows the pad to pivot.
9. Position the tilt bar on the mounting bracket and secure with the screws, washers, lockwashers, and nuts.

Functional Check

CAUTION

Extend and set the four main outriggers before extending the center front jack.

1. Extend and set the outriggers.
2. Activate the hydraulic system; extend and retract the outrigger.
3. Observe for proper operation of the center front jack cylinder.
4. Check the hydraulic connections for evidence of leakage.

SECTION 9
LUBRICATION

SECTION CONTENTS

GENERAL

Following the designated lubrication procedures is important in ensuring maximum crane lifetime and utilization. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information.

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 distributor or Manitowoc Crane Care.

CAUTION

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.

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.

ARCTIC CONDITIONS BELOW -9°C (15°F)

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 distributor or Manitowoc Crane Care.

Regardless of temperature and oil viscosity, always use suitable start-up procedures to ensure adequate lubrication during system warm-up.

ALL WEATHER PACKAGE & LUBRICANTS

Arctic Conditions Down to -40°C (-40°F)

Engineering recommends the following lubricants for components that will be operated in ambient temperatures to -40°C (-40°F). 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 water jacket 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, taken care of the fuel, fuel system and starting system, and has done whatever they feel necessary to add insulation for under hood temperatures and meet the engine manufacture's intake air temperature requirements. Other lubricants may be used if they meet the specifications of the lubricant that is requested. Please consult the factory.

Axles and Swing Box - Spec 6829014058:

- Petro-Canada Traxon E Synthetic 75W-90
- CITGO, Synthetic Gear Lube 75W-90
- Eaton, Roadranger EP75W-90
- Mobil, Mobilube SCH 75W-90
- Shell, Spirax S 75W-90
- Sunoco Duragear EP75W-90

Engine - Pre-2007 ISM engine burning non-ULSD fuel- Spec 6829101560:

- Petro-Canada Duron Synthetic CI-4 5W-40
- Mobil Delvac 1 5W-40

2007 ISM engine, 2010 ISX, 2013 ISX and QSM engines burning ULSD- Spec 6829104412:

- Citgo Citgard Syndurance Synthetic Engine Oil CJ-4 5W-40
- Maxtron DEO Synthetic Blend Engine Oil CJ-4 5W-40
- Conoco Phillips Triton® ECT Full Synthetic Motor Oil CJ-4 5W-40
- Shell Rootlet® T Synthetic Motor Oil CJ-4 5W-40
- Mobil Delvac 1 ESP SW-40 CJ-4 5W-40
- Chevron Delo® 400 LE Synthetic SAE 5W-40, Product #271207

Transmission:

- Use Standard Lubricants Package

Hydraulic tank - Spec 6829101559:

- Petro-Canada Duratran Synthetic THF
- Chevron All Weather THF
- Texaco TDH Oil SS

Hoist - Spec 6829103636:

- Petro-Canada Enduratex Synthetic EP 150
- Mobil SHC629

Grease - Spec 6829104275:

- Petro-Canada Precision Synthetic EP1
- Mobil: Mobilith SHC 220

Open Gear Lube (bearing/swingdrive teeth) - No Spec:

- Vultrex OGL Synthetic All Season

Antifreeze Coolant - Spec 6829104212:

- Petro-Canada Antifreeze/Coolant 60/40
- Old World Industries, Inc Fleet Charge SCA Pre-charged Antifreeze/ Coolant-60/40
- Fleetguard Compleat EG Antifreeze/Coolant Premix 60/40

Supplemental Coolant Additive (SCA) - Spec 6829012858:

- Fleetguard DCA4
- Fleetguard DCA2
- Penray Pencool 3000

Diesel Exhaust Fluid (DEF)– Spec 80019225:

- Fleetguard StableGuard™ Urea 32 Premix
- AdBlue®
- TerraCair Ultrapure® DEF

STANDARD LUBRICANTS PACKAGE

Axle and Swing Box - Spec 6829012964:

- Century Unigear Semi-synthetic SAE 80W-90
- Texaco Multigear SS 80W-90
- Chevron DELO 80W-90

Engine - Pre-2007 ISM and QSM engine burning non-ULSD fuel - Spec 6829003483:

- Engine Oil Exxon XD-3 CI-4 15W-40
- Conoco Fleet Supreme CI-4 15W-40

2007 ISM, 2010 ISX and QSM engines burning ULSD- Spec 6829104182:

- Conoco Fleet Supreme EC CJ-4 15W-40
- Mobil Delvac 1300 Super CJ-4 15W-40

Transmission - Fuller Manual - Spec 6829013433:

- Citgo Synthetic Gear Lubricant CD50
- Eaton Roadranger SAE50
- Mobil Delvac Synthetic Transmission Fluid 50
- Shell Spirax GSX SAE 50
- Texaco Syn-Star TL SAE 50

- Petro-Canada Traxon E Synthetic CD50
- Chevron Delo Transmission Fluid SAE 50
- Conoco/Phillips/Union 76 Triton Synthetic Transoil 50

Hydraulic Tank - Spec 6829006444:

- Hyken 052-10W-20
- Exxon Torque Fluid 56- 10W-20
- Esso Torque Fluid 56- 10W-20
- BP-Eldoran UTH & Trak-Tran 9 - 10W20
- BP- Blend- 7367 -10W20
- Exxon Mobil 424- 10W-30

Hoist - Spec 6829100213:

- AGMA No. 4 EP Extreme Pressure Gear Lube
- Mobil: 600XP 150 Gear Oil
- Texaco: Meropa 150

Grease - Spec 6829003477:

- Citgo Lithoplex MP # 2
- Texaco Starplex Moly # 2
- Phillips 66 Philube M Grease
- Mobil Mobilgrese XHP 222 Special, # 53055-0
- Chemtool Inc, Lube-A-Boom-Grease

Open Gear Lube (bearing/swingdrive teeth) - Spec 6829104478:

- LPS Dry Force 842 Moly Lube

Antifreeze Coolant - Spec 6829101130:

- AFC - 50/50 Old World Industries, Inc.
- Fleet Charge SCA Pre-charged Antifreeze/Coolant
- Caterpillar DEAC Antifreeze/Coolant
- Fleetguard Complete EG Antifreeze/Coolant

Supplemental Coolant Additive (SCA) - Spec 6829012858:

- Fleetguard DCA4
- Fleetguard DCA2
- Penray Pencool 3000

Diesel Exhaust Fluid (DEF)– Spec 80019225:

- Fleetguard StableGuard™ Urea 32 Premix
- AdBlue®
- TerraCair Ultrapure® DEF

LUBRICATION POINTS

A regular frequency of lubrication must be established for all lubrication points. Normally, this is based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log indicating crane usage. The log must use the engine hourmeter to ensure coverage of lube points that will receive attention based on their readings. Other lubrication requirements must be made on a time basis, i.e. weekly, monthly, etc.

All oil levels are to be checked with the crane parked on a level surface in transport position, and while the oil is cold, unless otherwise specified.

On plug type check points, the oil levels are to be at the bottom edge of the check port.

On all hoists with a check plug in the drum, the fill plug shall be directly on top of the hoist, and the check plug level.

All grease fittings are SAE Standard unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. A measure of 1 oz (0.28 kg) of EP-MPG equals one pump on a standard 1 lb (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.

Table 9-1: Standard Lube Symbol Chart

Symbol	Description
AFC	Antifreeze/Coolant - 50/50 Blended, Fully Formulated - SAE Grade J1941
EO	Engine Oil - SAE 15W-40, API Service Classification CJ-4. (CI-4 for pre-2007 ISM engines)
EP-MPG	Extreme Pressure Multipurpose Grease - Lithium Soap Base, NLGI Grade 2.
SGL-5	Synthetic Gear Lubricant - SAE Grade 50, API Gravity 23.
HYDO	Hydraulic Oil - Must meet John Deere Standard JDM-J20C, Allison C4, and ISO 4406 level.
SSGL-5	Semi-Synthetic Gear Lubricant - SAE Grade 80W-90, API Service Designation GL-5.
ASC	Anti-Seize Compound - Military Specifications MIL-A-907E.
EP-OGL	Open Gear Lubricant - LPS Dry Force 842 Moly Lube
EPGL-5H	Extreme Pressure Gear Lubricant - SAE Grade 80W-140
LCC	Liquid Coolant Conditioner
DEF	Diesel Exhaust Fluid
SCA	Supplemental Coolant Additive

Table 9-2
Lube Description

Lubrication Description	Lube Specification
50/50 Fully Formulated Anti-Freeze Coolant	6829101130
Engine Oil SAE 15W40, CJ4	6829104182
Engine Oil SAE 15W40, CI4	6829003483
Extreme Pressure Multi-Purpose Grease	6829003477
Synthetic Gear Lube	6829013433
Hydraulic Oil	6829006444
Semi-Synthetic Gear Lube	6829012964
Anti-Seize Compound	6829003689
Open Gear Lube	6829104478
EPGL Gear Lube	6829006240
Liquid Coolant Conditioner	6829012858
Diesel Exhaust Fluid	80019225
Wire Rope	See Service Manual

The following describe the lubrication points and gives the lube type, lube interval, lube amount, and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown on the Lubrication Chart (refer to Figure 9-1 through 9-3, Table 9-1 and Table 9-2).

CAUTION

The following lube intervals are to be used as a guideline only. Actual lube intervals should be formulated by the operator to correspond according to conditions such as continuous duty cycles and/or hazardous environments.

CARRIER LUBRICATION

1. Engine Crankcase

Lube Type - EO - 15W40

Lube Interval - Check fluid level every 10 hours or daily, whichever interval occurs first. Drain, fill and replace filter every 400 hours.

Lube Amount - Capacity

QSM Engine - 36 l (38 qt)
ISX Engine - 44 l (47 qt)

Application - Fill to full mark on dipstick.

2. Engine Cooling System

Lube Type - AFC

Lube Interval - Check coolant level every 10 hours or daily, whichever interval occurs first. Test and refresh per instructions in *Water Cooling System*, page 7-21.

Lube Amount - Capacity

QSM Engine - 54 l (57 qt)
ISX Engine - 75 l (79 qt)

CAUTION

Improper filling of the engine coolant system can result in engine damage.

Lube Type - SCA

Lube Interval - Change filter and check SCA levels every 500 hours. Check coolant for contamination every 1000 hours. Test and refresh per instructions in *Water Cooling System*, page 7-21.

3. Transmission

Lube Type - SGL-5

Lube Interval - Check fluid level every 500 hours, 6 months, or 14500 km (9,000 mi), whichever interval occurs first. Drain, fill, and replace filter every 80,000 km (50,000 mi) or 2 years, whichever interval occurs first.

Lube Amount - Capacity - 19 liters (20 quarts)

CAUTION

Axle fluid levels shall be adjusted to bottom of fill plug threads. Check with crane on level ground, at its normal ride height; cold or room temperature oil only.

Application - Final fluid levels shall be adjusted to indicating arrows, dipstick markings, or to bottom of fill plug threads.

4. Pump Drive

Lube Type - SSGL-5

Lube Interval - Check fluid level every 100 hours or monthly, whichever interval occurs first. Drain and fill every 500 hours.

Lube Amount - Capacity - 2.4 l (2.5 qt)

Application - Through fill pipe (dipstick pipe) to oil level mark on dipstick.

5. Pump Drive Shaft

a. U-Joints

Lube Type - EP-MPG

Lube Interval - 250 hours

Lube Amount - Until grease extrudes

Application - 2 grease fittings

b. Spline

Lube Type - EP-MPG

Lube Interval - 500 hours

Lube Amount - Until grease extrudes

Application - 1 grease fitting

DANGER

Ensure crane is on jacks and wheels are off ground, parking brakes are set, transmission is in neutral gear, and an assistant is depressing the clutch pedal before trying to grease the clutch throw-out bearing. Doing so allows the transmission input shaft -- shielded by the transmission's clutch housing -- to turn and distribute grease without the other drive shafts turning and posing further hazards to workers. Allowing crane to move could cause workers death or serious injuries.

6. Clutch Throw-Out Bearing

Lube Type - EP-MPG

Lube Interval - 250 hours

Lube Amount - Until grease extrudes

Application - 1 grease fitting, apply with engine running for equal distribution of grease

7. Clutch Linkage

Lube Type - EP-MPG

Lube Interval - 500 hours

Lube Amount - Until grease extrudes

Application - 5 grease fittings

8. Transmission

a. Shift U-Joints/Control Unit

Lube Type - EP-MPG

Lube Interval - 500 hours

Lube Amount - Until grease extrudes

Application - 3 grease fittings

b. Driveline Slip

Lube Type - EP-MPG

Lube Interval - 500 hours or 16,000 km (10,000 mi), whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 2 grease fittings

9. Power Steering Gearbox

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 1 grease fitting

10. Steering Relay Arms

Lube Type - EP-MPG

Lube Interval - 250 hours

Lube Amount - Until grease extrudes

Application - 2 grease fittings

11. Front Aluminum Wheel Pilots

Lube Type - ASC

Lube Interval - When wheels are removed for service.

Lube Amount - Generously coat the wheel pilot or hub pads with antiseize compound. Do not apply antiseize compound to the face of the wheel of the hub.

Application - Brush on. 4 places

CAUTION

Axle fluid levels shall be adjusted to bottom of fill plug threads. Check with crane on level ground, at its normal ride height; cold or room temperature oil only.

12. Front Axle Hubs

Lube Type - SSGL-5

Lube Interval - Check fluid level every 250 hours and refill as necessary.

Lube Amount - 0.95 l (1.0 qt)

Application - Fill to the oil level mark on the housing with the fill plug and the oil level mark horizontal. 4 places

13. Front Axle Tie Rod Ends

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

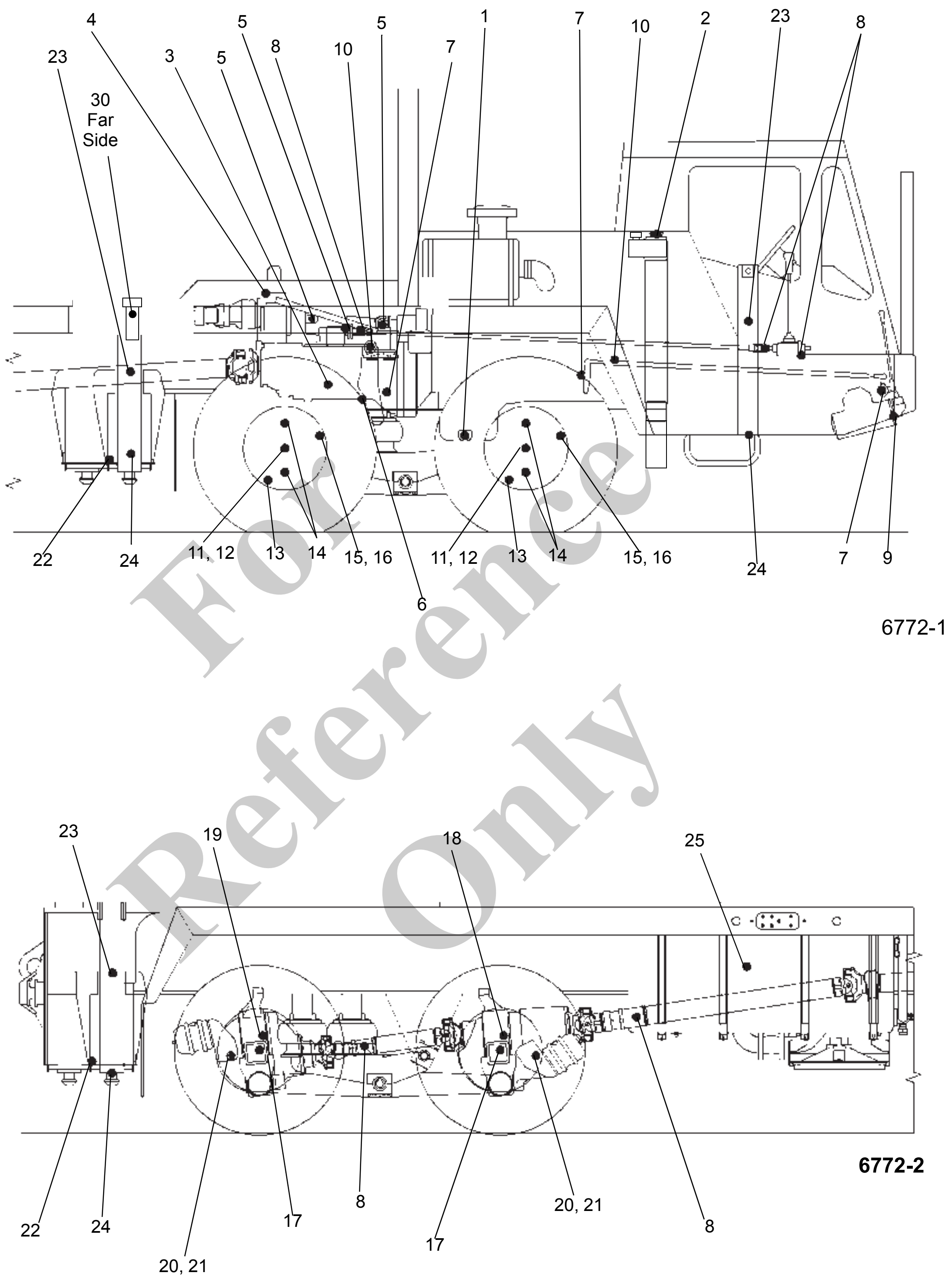
14. Front Axle King Pins

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 8 grease fittings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For Reference Only

FIGURE 9-1

Item	Description
1	Engine Crankcase
2	Engine Cooling System
3	Transmission
4	Pump Drive
5	Pump Drive Shaft U-Joints and Spline
6	Clutch Throw Out Bearing
7	Clutch Linkage
8	Transmission Shift U-Joints and Control Unit
9	Power Steering Gearbox
10	Steering Relay Arms
11	Front Aluminum Wheel Pilots
12	Front Axle Hubs
13	Front Axle Tie Rod Ends
14	Front Axle King Pins
15	Front Axle Brake Slack Adjusters
16	Front Axle Brake Camshafts
17	Rear Aluminum Wheel Pilot
18	Front Rear Axle Differential
19	Rear Rear Axle Differential
20	Rear Axle Brake Slack Adjusters
21	Rear Axle Brake Camshafts
22	Outrigger Beams
23	Jack Cylinder Support Tubes
24	Jack Cylinder Barrels
25	Hydraulic Reservoir
26	Hydraulic Filter
27	Fuel Filter
28	Air Cleaner
29	Coolant Strainer (Superstructure Cab Heater)
30	Fuel Filter

CAUTION

Axle fluid levels shall be adjusted to bottom of fill plug threads. Check with crane on level ground, at its normal ride height; cold or room temperature oil only.

15. Rear Aluminum Wheel Pilots

Lube Type - ASC

Lube Interval - When wheels are removed for service.

Lube Amount - Generously coat the wheel pilot or hub pads with antiseize compound. Do not apply antiseize compound to the face of the wheel of the hub.

Application - Brush on. 8 places

16. Front Axle Brake Slack Adjusters

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

17. Front Axle Brake Camshafts

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

18. Front Rear Axle Differential

Lube Type - SSGL-5

Lube Interval - Check lubricant level every 250 hours and refill as necessary. Drain, fill, change filter, and clean magnetic drain plug every 80,000 km (50,000 mi) or 2 years, whichever interval occurs first.

CAUTION

Use of non-semi-synthetic lubricant may damage components and/or invalidate published lubrication intervals.

Axle fluid levels shall be adjusted to bottom of fill plug threads. Check with crane on level ground, at its normal ride height, cold or room temperature oil only. A 30 minute drain-down time is required before checking fluid level if crane has been recently moved.

If the makeup amount is substantially more than 0.23 l (0.5 pt) check for leaks.

Lube Amount - Capacity - 27 l (57 pt) Normal makeup - less than 0.23 l (0.5 pt).

Application - Fill to bottom of fill plug threads

NOTE: Lube level (Figure 9-2) 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.

NOTE: Figure 9-2 pertains to the differentials and the planetary hubs and wheel bearings.

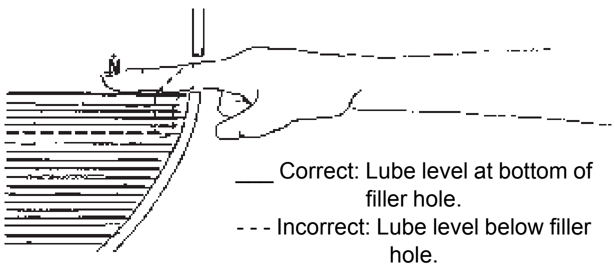


FIGURE 9-2

19. Rear Rear Axle Differential

Lube Type - SSGL-5

Lube Interval - Check lubricant level every 250 hours and refill as necessary. Drain, refill, and clean magnetic drain plug every 80,000 km (50,000 mi) or 2 years, whichever interval occurs first.

CAUTION

Use of non-semi-synthetic lubricant may damage components and/or invalidate published lubrication intervals.

Axle fluid levels shall be adjusted to bottom of fill plug threads. Check with crane on level ground, at its normal ride height, cold or room temperature oil only. A 30 minute drain-down time is required before checking fluid level if crane has been recently moved.

If the makeup amount is substantially more than 0.23 l (0.5 pt) check for leaks.

Lube Amount - Capacity - 17.5 l (37 pt) Normal makeup - less than 0.23 l (0.5 pt).

Application - Fill to bottom of fill plug threads.

20. Rear Axle Brake Slack Adjusters

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

21. Rear Axle Brake Camshafts

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

22. Outrigger Beams

Lube Type - EP-MPG

Lube Interval - 50 hours or 1 week, whichever interval occurs first

Lube Amount - Brush on bottom of outrigger beams.

Application - Brush on; 8 places

23. Jack Cylinder Support Tubes

Lube Type - EP-MPG

Lube Interval - 500 hours

Lube Amount - Brush lubrication on ID of jack cylinder support tubes and wear bands before installing jack cylinders.

Application -Brush on; 5 places

24. Jack Cylinder Barrels

Lube Type - EP-MPG

Lube Interval - 50 hours or 1 week, whichever interval occurs first

Lube Amount - Fully extend outriggers and brush lubricant onto cylinder barrels.

Application - Brush on; 5 places

25. Hydraulic Reservoir

Lube Type - HYDO

Lube Interval - Check fluid level every 10 hours or daily, using sight gauge on side of tank, with boom retracted and in boom rest and all outrigger cylinders retracted; drain and refill as necessary. Replace oil every 2000 hours or 2 years, whichever interval occurs first.

NOTE: Environmental and other conditions can dramatically affect the condition of hydraulic oil and filters. Therefore, specific intervals for servicing/changing hydraulic oil, filters and hydraulic tank breathers cannot be set. However, it is imperative for the continued satisfactory performance of Grove cranes that inspections be performed on the basis of how and where each crane is used. Air borne and ingested contaminants can significantly reduce the life of oil and the condition of hydraulic oil filters and tank breathers.

NOTE: Under normal operating conditions, it is recommended that hydraulic oil, filters and breathers be inspected and oils sampled at least every 3 to 6 months and more frequently for severe operating conditions. The inspections should be for air borne and/or ingested particles and water that deteriorate and contaminate the oil (e.g., oil appears "milky" or no longer has a transparent clear to amber color). The return filter by-pass indicator should be observed daily to determine if the contaminants content may be high. If the indicator reaches the red zone or indicates a by-pass condition, the hydraulic oil must be sampled. The hydraulic tank breather should also be inspected to assure that it is not restricting air flow into and out of the reservoir.

To inspect hydraulic oil, fill a small glass container with a sample of reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one to two hours and then compare the samples. If the reservoir oil is heavily contaminated with water the sample will appear "milky" with only a small layer of transparent oil on top. If the "milky" appearance was due to air foaming, it will dissipate and the oil should closely match the fresh oil. Should you have any questions, please contact your distributor or Manitowoc Crane Care.

After 2000 hours or 2 years of service, an oil sample should be taken and laboratory analyzed. If it continues to meet a minimum cleanliness level of ISO 16/13 (SAE J1165), the service interval can be increased to 3000 hours or 3 years.

Lube Amount - 134 gal (507 l) (tank only), to the FULL mark on sight gauge.

Application - Remove the breather; fill through the breather hole on top of tank; reinstall breather. When tank is drained, clean the magnetic pipe plug.

Replace breather every 500 hours or 6 months, whichever interval occurs first.

26. Hydraulic Filter

Drain water trap every 10 hours or daily and change filter when clear cover is full of fuel.

27. Fuel Filter

Drain water trap every 10 hours or daily and change filter every 500 hours or 6 months.

28. Air Cleaner Filter

Replace air cleaner filter element when indicator shows red (0.062 bar (25 inches of water) or indicator is red).

29. Coolant Strainer (Superstructure Cab Heater)

Close the shutoff valves. Unscrew the hex plug and clean the strainer screen after first 100 hours and every 2000 hours or 12 months thereafter.

SUPERSTRUCTURE LUBRICATION

30. Turntable Gear Box

Lube Type - SSGL-5

NOTE: Remove one valve to equalize the pressure before checking the swing gearbox oil level. This will keep the oil from pushing out.

Lube Interval - Check and fill every 50 hours. Drain and fill after first 250 hours and every 500 hours or 12 months thereafter, whichever interval occurs first.

Lube Amount -

Gearbox - 1.30 l (2.75 pt)

Application - Fill until oil level is at top of sight gauge

31. Turntable Gear and Drive Pinion

Lube Type - EP-OGL

Lube Interval - 500 hours or 6 months, whichever interval occurs first

Lube Amount - Coat all teeth

Application - Spray on

32. Turntable Bearing

Lube Type - EP-MPG

Lube Interval - 500 hours or 6 months, whichever interval occurs first

Lube Amount - Until grease extrudes the whole circumference of the bearing.

Application - 2 grease fittings at the front of the turntable. Rotate the turntable 90° and apply grease to fittings. Continue rotating 90° and grease the fittings until the whole bearing is greased.

32a. Swivel Lock Pin

Lube Type - EP-OGL

Lube Interval - 500 hours or 6 months, whichever interval occurs first

Lube Amount - Coat pin

Application - Spray on

33. Upper Lift Cylinder Pivot Pin

Lube Type - EP-MPG

Lube Interval - 500 hours or every 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

34. Lower Lift Cylinder Pivot Pin

Lube Type - EP-MPG

Lube Interval - 500 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 2 grease fittings

35. Main Hoist

Lube Type - EPGL-5H

Lube Interval - Check and fill every 50 hours or weekly, whichever interval occurs first. Verify drain plug is visible in upper cutout, the machine is level from side to side, the hoist has not been operated for at least 20 minutes and the temperature is 21°C ± 6.7°C (70°F ± 20°F). Drain and fill every 1000 hours or 12 months.

Lube Amount - Capacity - 14.7 l (15.5 qt)

Application - Fill until level is visible in sight gauge.

36. Auxiliary Hoist (Optional)

Lube Type - EPGL-5H

Lube Interval - Check and fill every 50 hours or weekly, whichever interval occurs first. Verify drain plug is visible in upper cutout, the machine is level from side to side, the hoist has not been operated for at least 20 minutes and the temperature is 21°C ± 6.7°C (70°F ± 20°F). Drain and fill every 1000 hours or 12 months.

Lube Amount - Capacity - 14.7 l (15.5 qt)

Application - Fill until level is visible in sight gauge.

37. Cable Guard Roller and Guide Roller

Lube Type - EP-MPG

NOTE: Rollers may or may not have bearings that need lubrication. Those that do will have grease fittings. Lubricate more frequently than interval indicated, if environmental conditions and/or operating conditions necessitate.

Lube Interval - 250 hours or 3 months, whichever interval occurs first.

Lube Amount - Until grease extrudes

Application - To each grease fitting.

BOOM, BOOM EXTENSION, AND BOOM ACCESSORIES LUBRICATION

38. Boom Pivot Shaft

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 2 grease fittings, one on each side

39. Extend Cable Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting; extend boom for entry through access holes in Section 4 and Section 3s.

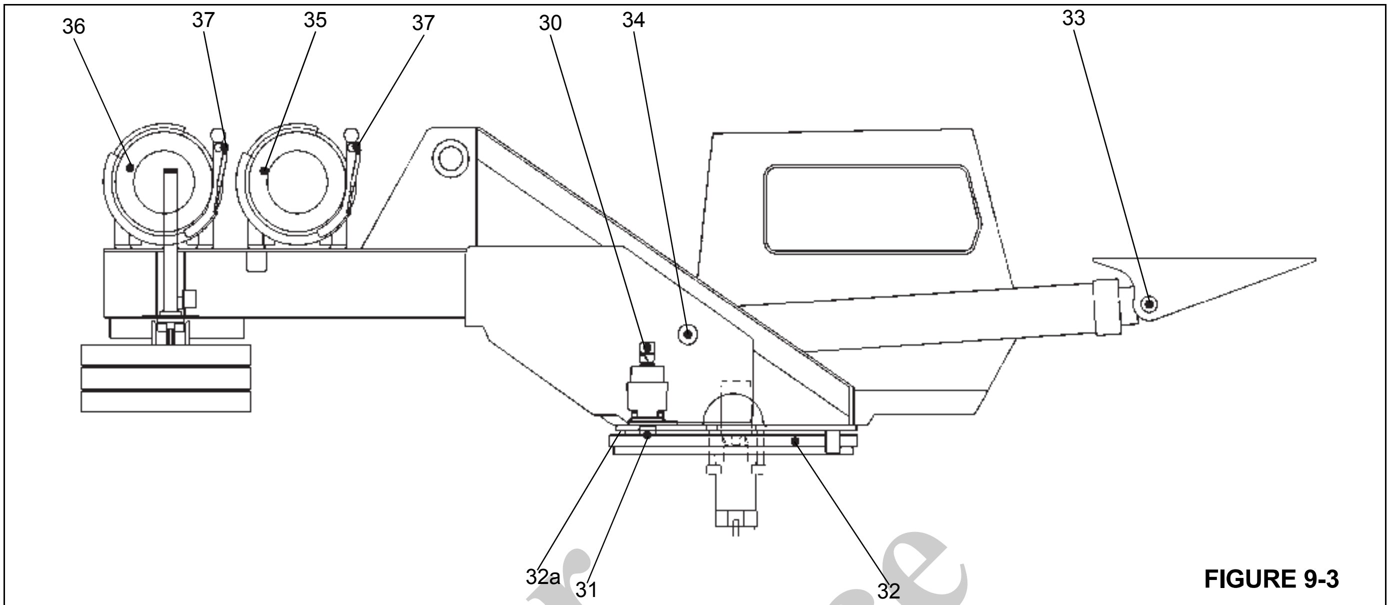


FIGURE 9-3

Item	Description
30	Turntable Gear Box
31	Turntable Gear and Drive Pinion
32	Turntable Bearing
32a	Swivel Lock Pin
33	Upper Lift Cylinder Pivot Pin
34	Lower Lift Cylinder Pivot Pin
35	Main Hoist
36	Auxiliary Hoist (Optional)
37	Cable Guard Roller and Guide Roller (possible)

40. Retract Cable Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 2 grease fittings; extend boom for entry through access holes in front of Section 2.

41. Telescope Cylinder Wear Pads

Lube Type - EP-MPG

Lube Interval - Every boom teardown.

Lube Amount - Thoroughly coat all areas the wear pads move on.

Application - By brush: 2 places.

NOTE: Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. By adding an extension adapter to a grease gun the wear pads and wear areas can be reached through the lubrication access holes in the side of the boom and through the access hole in the boom nose between the sheaves. Extend boom for access to holes as needed.

42. Section 2 Side Wear Pads

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Thoroughly coat all areas the wear pads move on.

Application - By brush: 2 places; with boom in extended position through access holes in Section 1.

43. Boom Section Upper Wear Pads

Lube Type - EP-MPG

Lube Interval - 50 hours or 1 week, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 6 grease fittings; with boom in extended position through access holes.

44. Boom Section Upper and Lower Wear Pads

Lube Type - EP-MPG

Lube Interval - 50 hours or 1 week, whichever occurs first

Lube Amount - Thoroughly coat all areas the wear pad moves on.

Application - By brush; 6 places; with boom in extended position.

45. Upper Boom Nose Sheave

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting per sheave (2 total)

46. Lower Boom Nose Sheave

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting per sheave (5 total)

47. Boom Extension Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

48. Boom Extension Mast Sheave

Lube Type - EP-MPG

Lube Interval - 500 hours or 6 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

49. Auxiliary Boom Nose Sheave

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

50. Hook Block Swivel Bearing

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

51. Hook Block Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting per sheave

(5 fittings total - 60 ton)

(4 fittings total - 50 ton)

(3 fittings total - 40 ton)

52. Headache Ball Swivel Top

Lube Type - EP-MPG

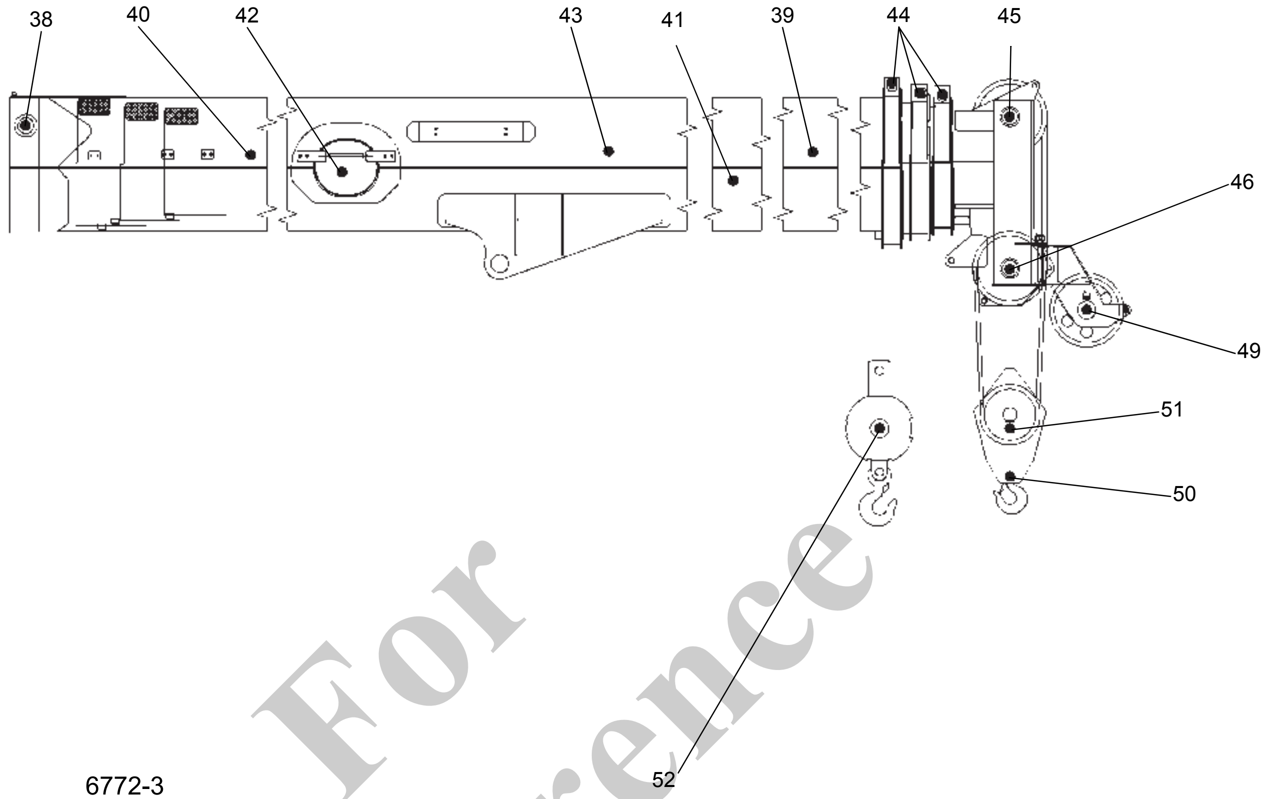
Lube Interval - 250 hours or 3 months, whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

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 1-16.



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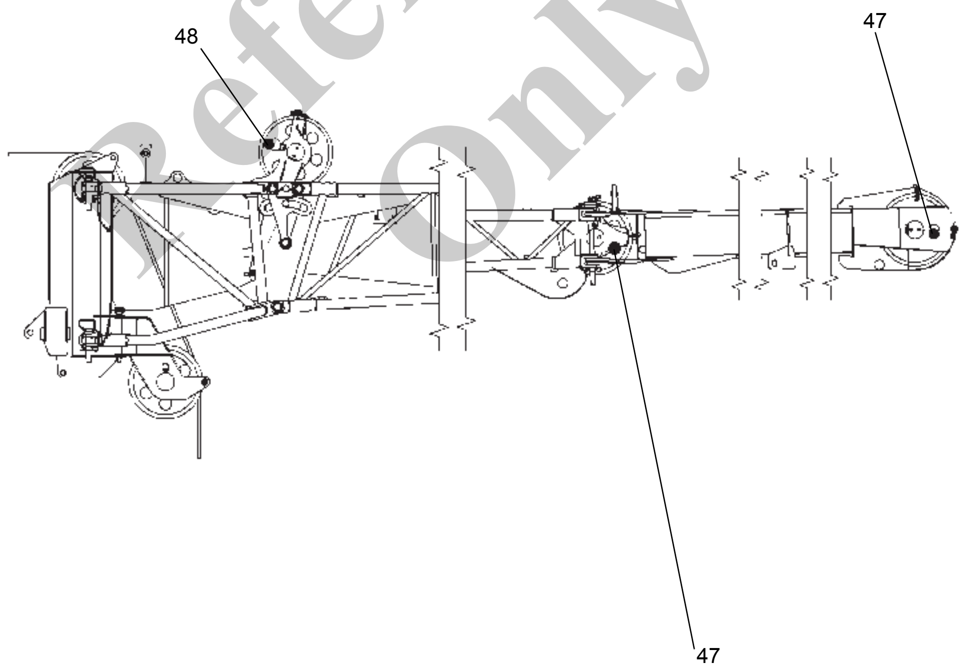

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FIGURE 9-3 continued

Item	Description
38	Boom Pivot Shaft
39	Extend Cable Sheaves
40	Retract Cable Sheave
41	Telescope Cylinder Wear pads
42	Section 2 Side Wear Pads
43	Boom Section Upper Rear Wear Pads
44	Boom Section Upper and Lower Wear Pads
45	Upper Boom Nose Sheave
46	Lower Boom Nose Sheave
47	Boom Extension Sheaves
48	Boom Extension Mast Sheave
49	Auxiliary Boom Nose Sheave
50	Hook Block Swivel Bearing
51	Hook Block Sheaves
52	Headache Ball Swivel Top

CARWELL® RUST INHIBITOR

Protecting Cranes From Rusting

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CRF-19-10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly "oily" residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it can be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleanings if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain crane parts may become corroded even though other parts remain dry; or
- in high humidity, or when temperatures are just above the freezing point.

Cleaning Procedures

To help protect against corrosion of Grove cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleanings may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

- For scratches and marks in highly visible areas:
  - Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.

- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 9-4

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose ends and fittings, Swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoist roller, tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.


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FIGURE 9-4

Item	Description
1	Hoist Hose Connections
2	Boom Extension Pins, Clips
3	Valve Bank
4	Hose Connections inside turntable
5	Boom Extension Hanger Hardware
6	Boom Nose Pins, Clips
7	Hook block Tiedown Cable
8	Headache Ball/Hook block
9	Mirror Mounting Hardware
10	O/R Hose Connections
11	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
12	Powertrain Hardware inside compartment
13	O/R Pins, Clips
14	Entire underside of unit
15	Turntable Bearing Fasteners
16	Counterweight Pins
17	Wire Rope
18	Tension Spring
19	Pivot Shaft
20	Outrigger Beam Wear Pad Adjustment Hardware

Alphabetical Index