Grove TMS800E

Service/Maintenance Manual

Grove Manitowoc National Crane Potain

Manitowoc

⚠ 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.

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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).**

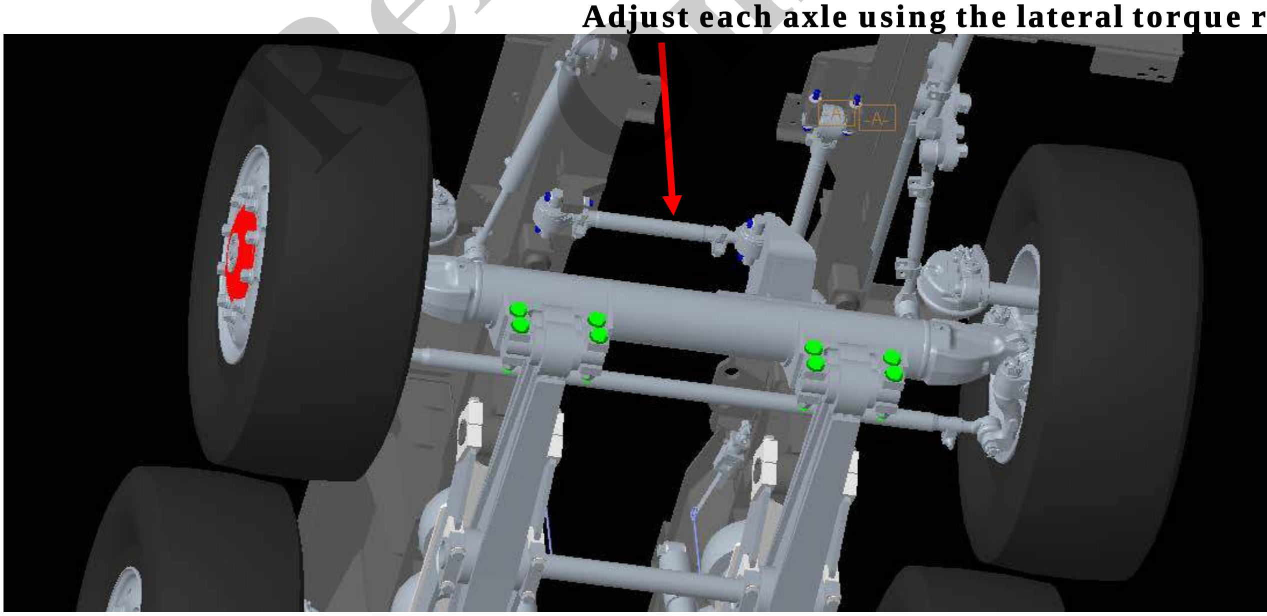
  Note: steering axle and drive axle measurements will be different; axle lengths and frame widths are different.

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.



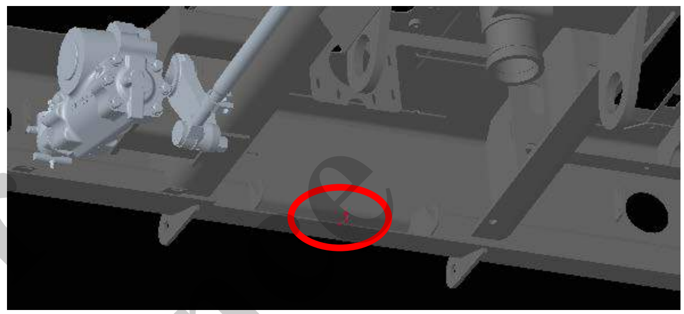
- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

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 <u>front steer axle</u> mount, left and right; each axle's left and right measurements should be within 3/16 in. (4.8 mm) of the other.**

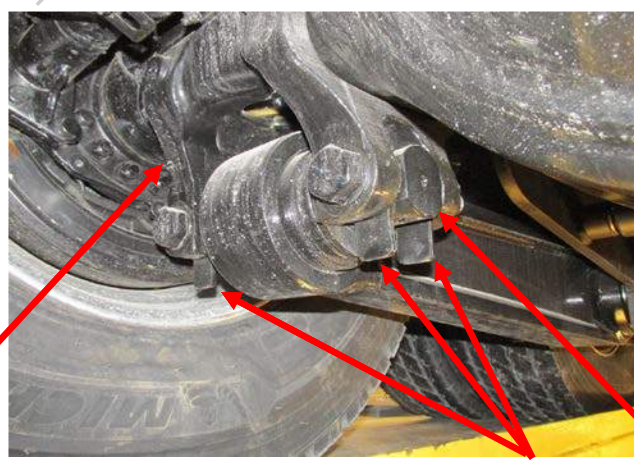
#1 axle



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**

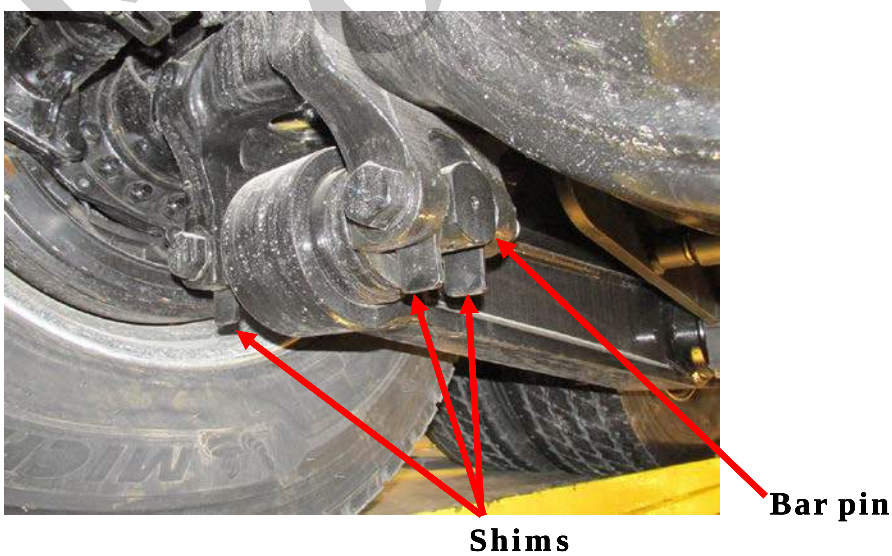
- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

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).**

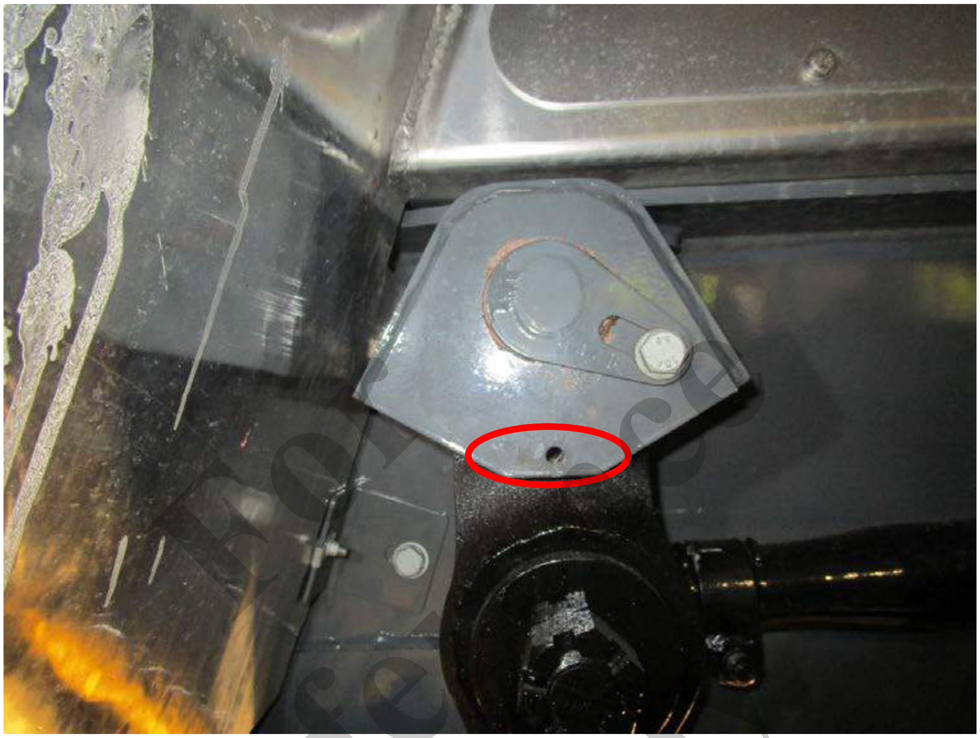
Note: Raise the machine on outriggers to take weight off the suspension in order to reposition the mounting shims. A Porta Power can be used to support the suspension. Be sure to lift the outriggers and put full weight on the suspension prior to taking subsequent measurements.



- **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.**

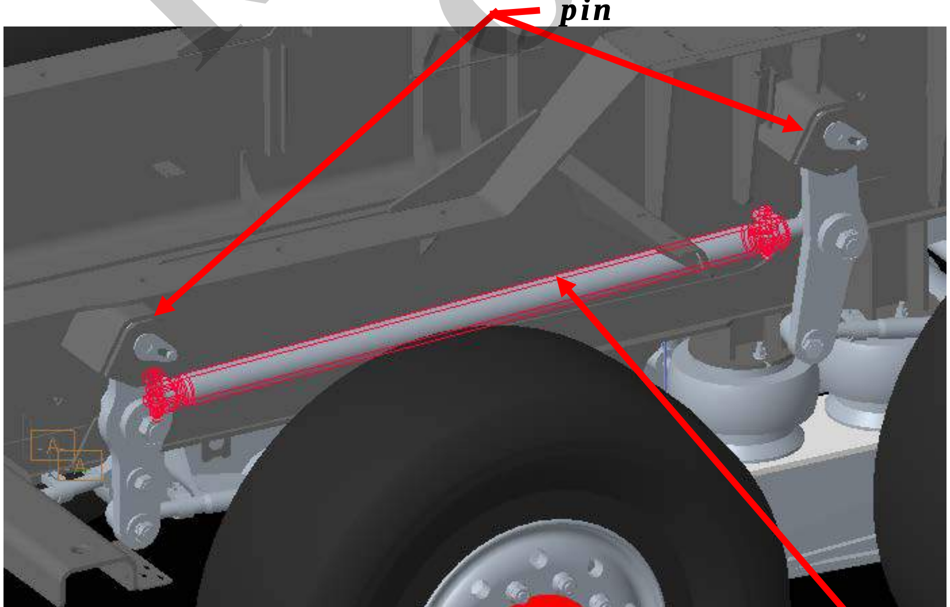
Adjust steering linkage.

- **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

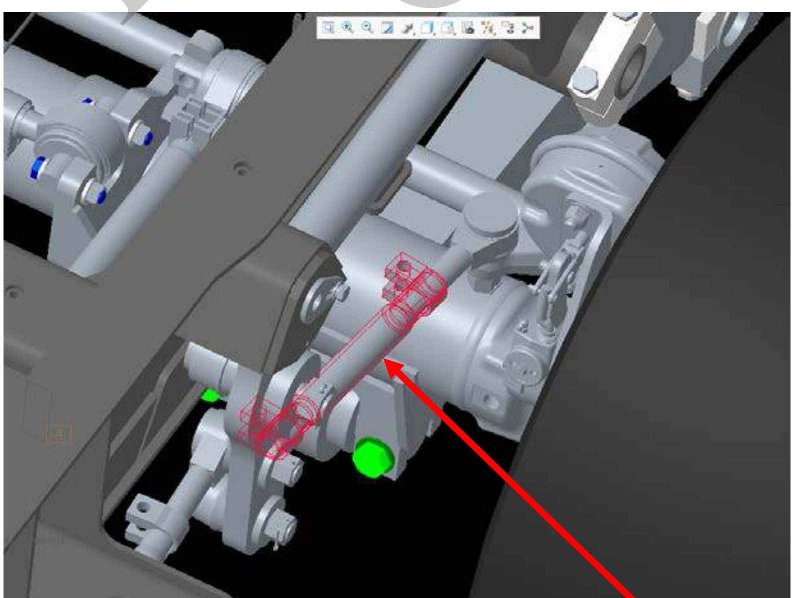
Driver side front steer axle.

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).**

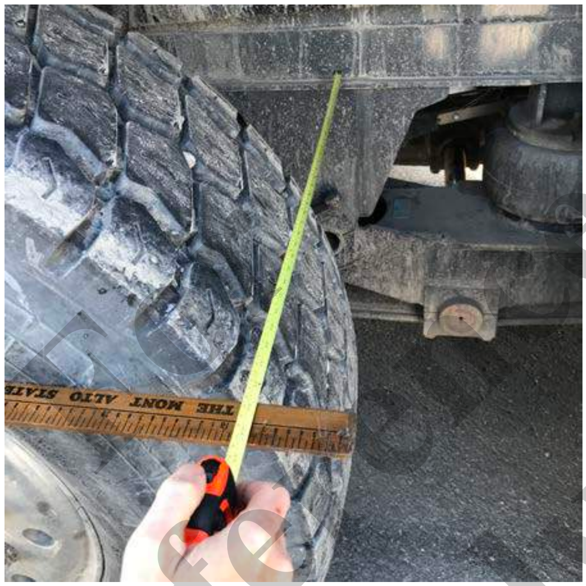


Front steer axle drag link

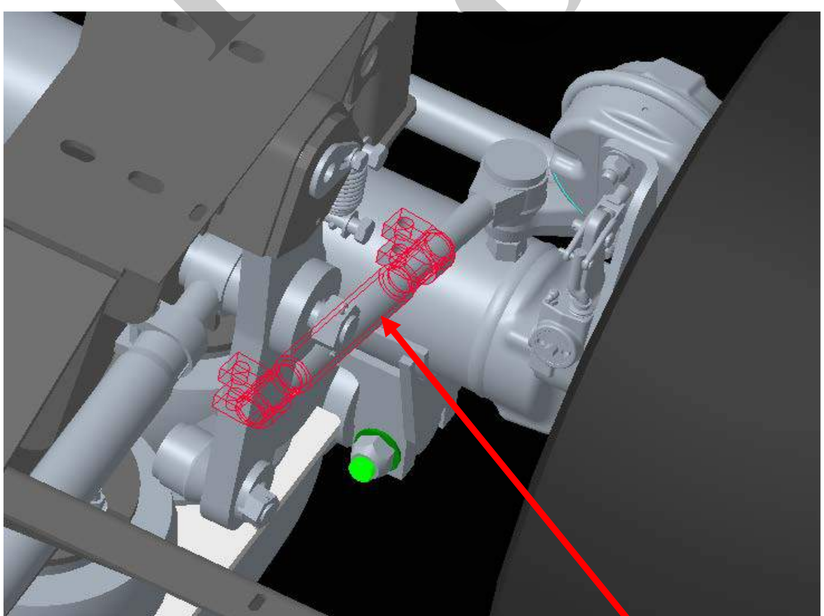
Adjust steering linkage continued.

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.**



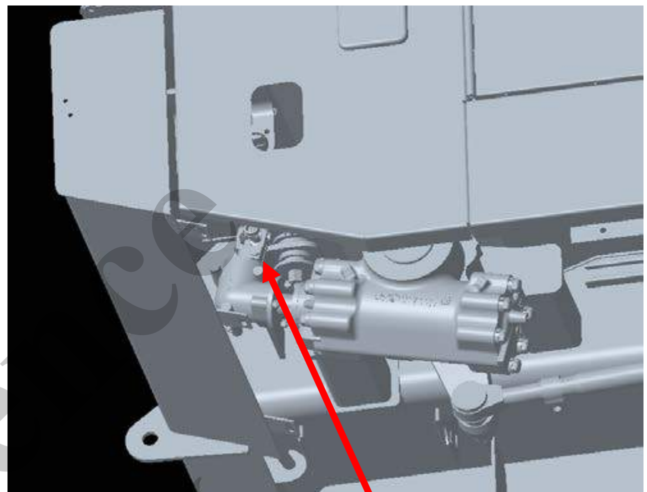
  - **Adjust <u>rear steer axle</u> drag link until front and rear measurements are equal. Apply Loctite 243 to clamp bolts and re-torque to 110-130 lbf*ft. (149-176 N*m).**



Rear steer axle #2 drag link

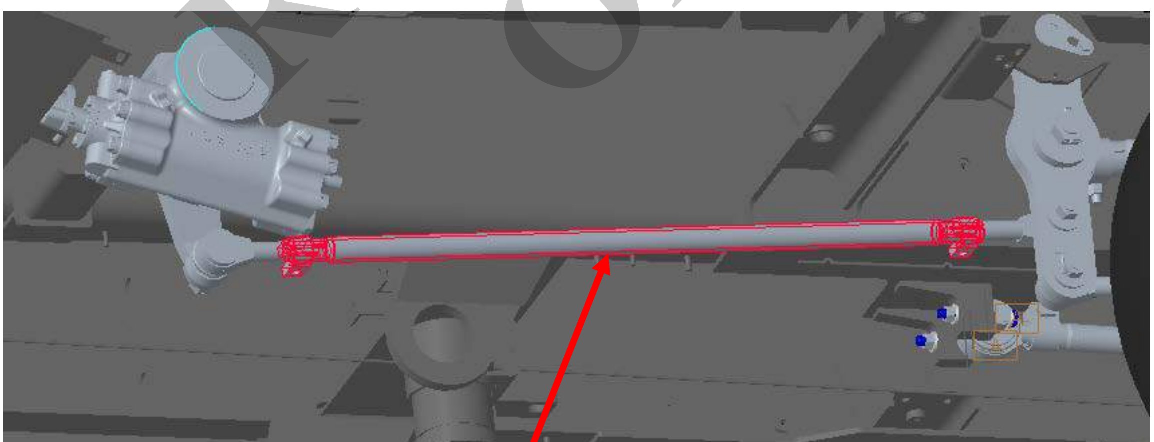
Adjust steering linkage continued.

- **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).**



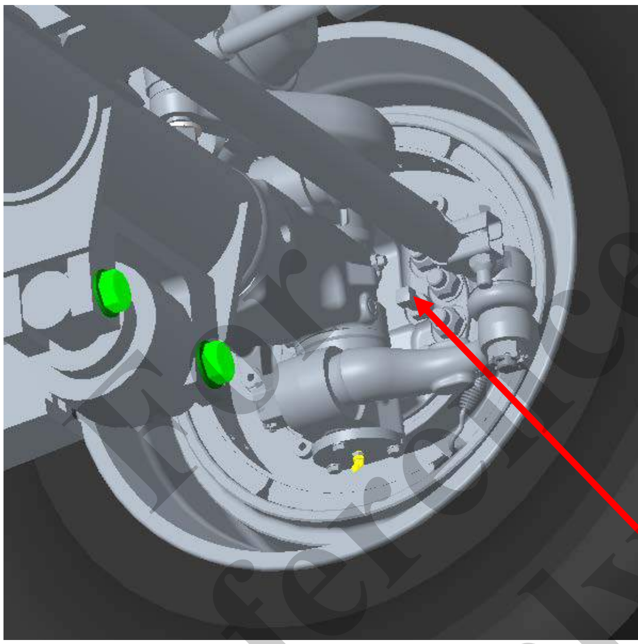
Steering link

- **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.**

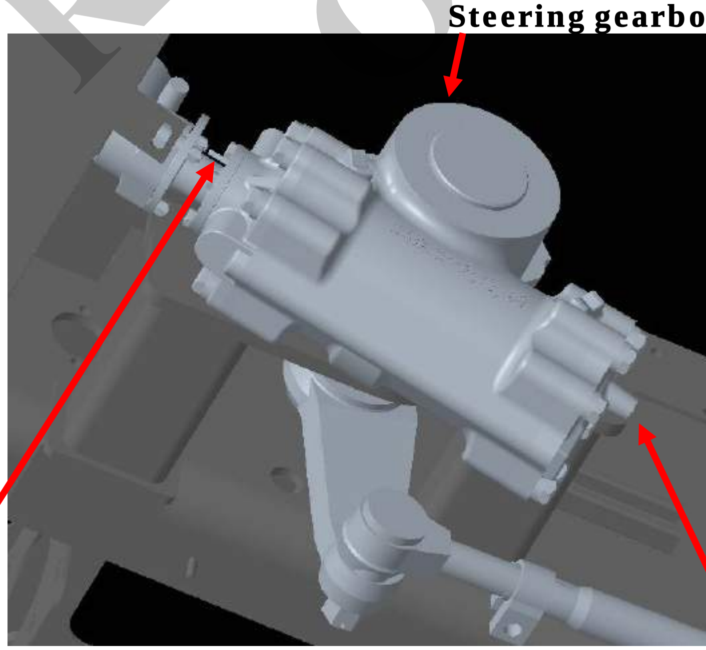
Note: steering stops are located on the front steer axle only.
Note: steer tires should still be on alignment turntables for this step.



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°.

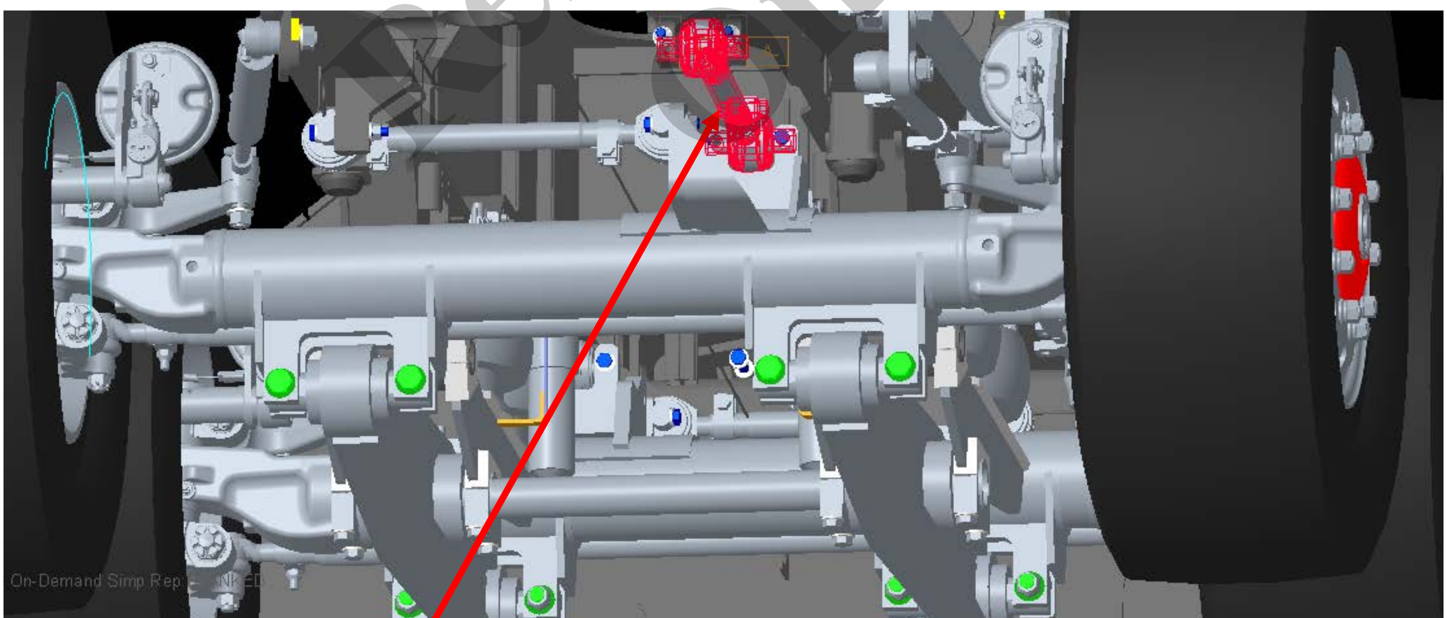
Note: Steer tires should be on alignment turntables for this step.

- **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.

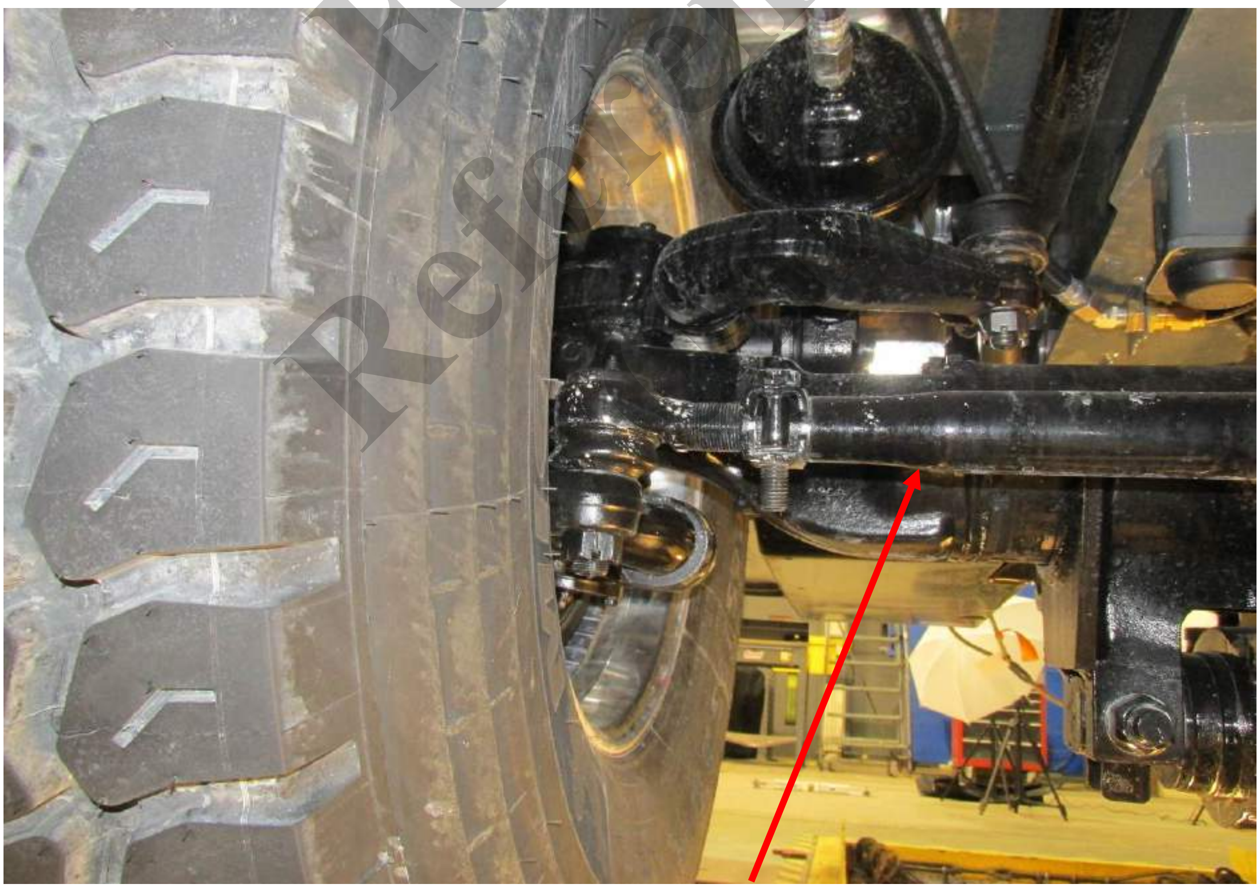
- **Toe should be +1/32 in. (0.8 mm) +/-1/32 in. (0.8 mm).**

  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.

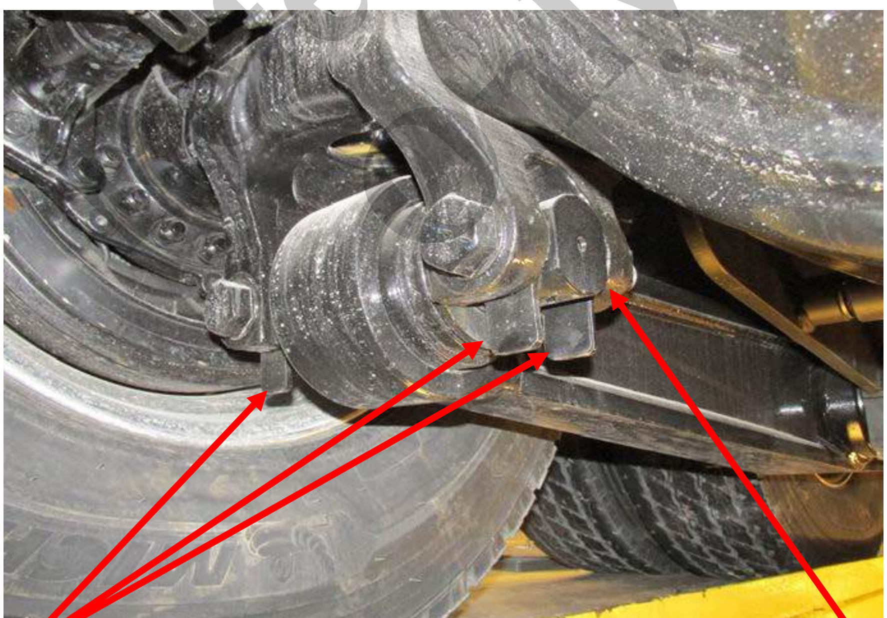
- **Acceptable thrust misalignment is 0.75 in. (19 mm) maximum.**

  (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.



- **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).**

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

Shims

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.**

TOC

GROVE
by Manitowoc

SERVICE MANUAL

This Manual has been prepared for and is considered part of

TMS800E

Crane Model Number

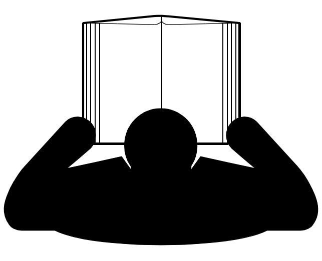
This Manual is Divided into the following Sections:

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

NOTICE

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

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



DANGER

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

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

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SECTION 1

INTRODUCTION

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Description

This Manual provides information for the maintenance of the Model TMS800E13 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 3 speed reverse manual transmission.

The outriggers are two 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, Mega Form, 12.6 to 39 meter (41 to 128 foot) boom. Additional reach is obtained by utilizing a 10 to 17 meter (33 to 56 foot) bi-fold jib. A 6.1 meter (20 foot) and a 12.2 meter (40 foot) 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 ... TMS800E Series
Rated Capacity ... See Load Chart in cab
Drive ... 8 x 4 x 4

Dimensions

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

Wheelbase ... (222 in) 5639 mm
Overall Crane Length ... (537 in) 13,640 mm
Overall Crane Width ... (102 in) 2591 mm
Overall Crane Height ... (142 in) 3606 mm
Tail-Swing ... (151 in) 3835 mm
Outrigger Spread
- Retracted ... (45.50 in) 1156 mm
- Mid Extend ... (92.50 in) 2350 mm
- Fully Extended ... (144 in) 3658 mm

Capacities

Fuel Tank ... (97 gal) 367 liters
Coolant System ... See Engine Specifications
Engine Lubrication System ... See Engine Specifications
Hydraulic Tank (Reservoir Capacity)
- Total ... (193 gal) 731 liters
- at Full Level ... (173.5 gal) 657 liters
- at Add Level ... (166.5 gal) 630 liters
- Expansion Space ... (19.5 gal) 74 liters

Hoists ... (31 pt) 14.7 liters
Swing Gearbox ... (5.7 qt) 5.4 liters
Front Axle Hubs ... (1 qt) 0.95 liters
Front Rear Axle Differentials ... (57 pt) 27 liters
Rear Rear Axle Differentials ... (37 pt) 17.5 liters
Transmission ... (13 qt)12 liters

Transmission

Speeds ... 11 forward and 3 reverse
Gear Ratios
High
- Eighth ... 0.73
- Seventh ... 1.00
- Sixth ... 1.38
- Fifth ... 1.95

Low
- Fourth ... 2.77
- Third ... 3.79
- Second ... 5.23
- First ... 7.41
- High-LL2 ... 11.85
- Low-Low ... 16.30
- Deep Reduction-LL1 ... 26.08

Reverse
- High ... 3.43
- Low ... 13.03
- Deep Reduction-LL ... 20.85

Clutch

Type ... 2 plate dry disc with centrifugal operation

Engine

Cummins ISX12-2013 Tier 4

Bore ... 130 mm (5.12 in)
Stroke ... 150 mm (5.91 in)
Displacement ... 11.9 liters (726 cu in)
Firing Order ... 1-5-3-6-2-4
Lube Amount ... 41.6 liters (11 gal)
Coolant System (w/radiator, hoses) ... 74.6 liters (19.7 gal)

Cummins QSM11 Tier 3

Bore ... 125 mm (4.92 in)
Stroke ... 147 mm (5.79 in)
Displacement ... 10.8 liters (659 cu in)
Firing Order ... 1-5-3-6-2-4
Lube Amount ... 38 liters (10 gal)
Coolant System (w/radiator, hoses) ... 64.4 liters (17 gal)

Axles

Front

Type ... Non-drive steer

Rear

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

Brakes

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

Wheel And Tires

- Lugs 10
- Torque .... (450 - 500 lb-ft) 610 to 678 Nm
- 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 33.6:1
- Output Torque .... 72,222 lb-in

Boom

- Length .... (41 to 128 ft) 12.5 to 39 meters
- Power .... 4 Section, Full Power
- Elevation .... -3 to +78 degrees
- Extensions
  - Fixed* .... (33 ft) 10 meters
  - Folding* .... (33 or 56 ft) 10 or 17 meters
  - Lattice Extension .... (20 and 40 ft) 6.1 and 12.2 meters

*Extensions are offsettable at 0, 20, or 40 degrees

Swivel Assembly

- Electrical .... 19 Slip Rings
- Hydraulic .... 6 ports
- Water .... 2 ports

Hydraulic Pumps

NOTE: Pump output figures are theoretical.

Pump #1 (QSM Engine)

- Type .... Piston/Piston
- Sections 2
- Output (at 2012 rpm)
  - Section 1 (piston) .... (57.1 gpm) 216.15 l/min
  - Section 2 (piston) .... (40.8 gpm) 154.4 l/min

Pump #2 (QSM Engine)

- Type .... Gear
- Sections 1
- Output (at 2012 rpm)
  - Section 1 .... (20.1 gpm) 76.1 l/min

Pump #3 (QSM Engine)

- Type .... Gear/Gear
- Sections 2
- Output (at 1750 rpm)
  - Section 1 .... (19.4 gpm) 73.4 l/min
  - Section 2 .... (19.4 gpm) 73.4 l/min

Pump #1 (ISX Engine)

- Type .... Piston/Gear
- Sections 2
- Output (at 1900 rpm)
  - Section 1 (piston) .... (96.3 gpm) 364.5 l/min
  - Section 2 (gear) .... (18.9 gpm) 71.5 l/min

Pump #2 (ISX Engine)

- Type .... Gear
- Sections 1
- Output (at 1670 rpm)
  - Section 1 .... (18.7 gpm) 70.8 l/min

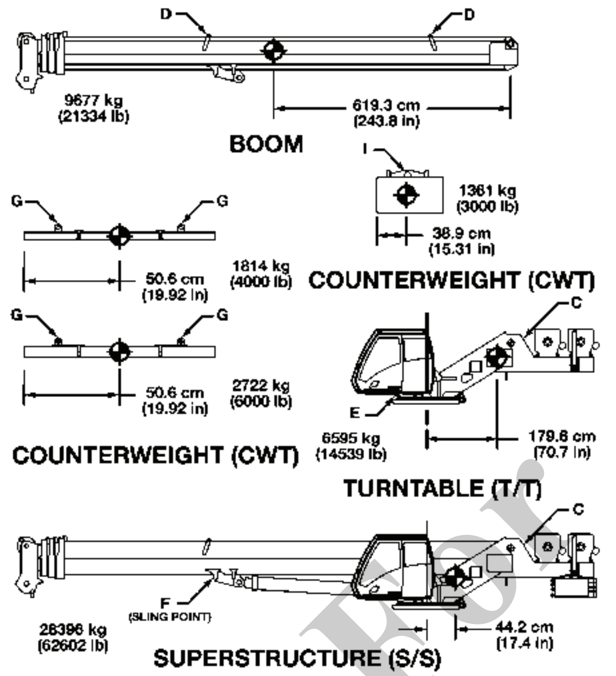
Pump #3 (ISX Engine)

- Type .... Gear
- Sections 1
- Output (at 1670 rpm)
  - Section 1 .... (16.7 gpm) 63.2 l/min

Hoists

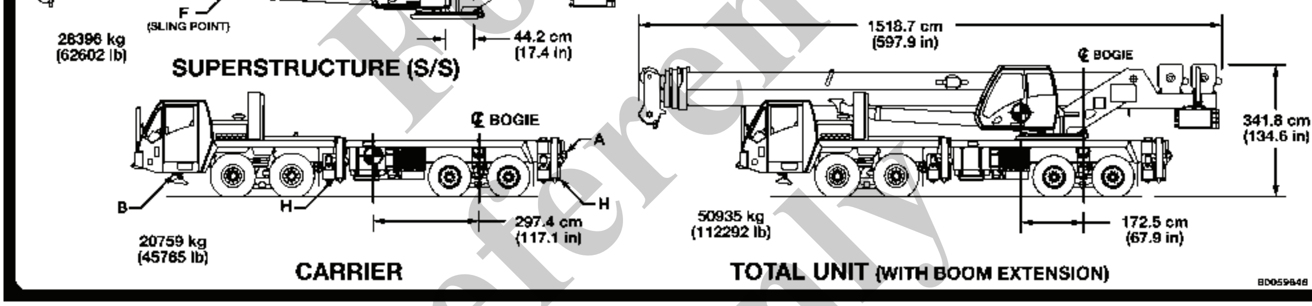
- Drum Dimensions
  - Diameter .... (15 in) 381 mm
  - Length (Standard) .... (18 in) 467 mm
- Cable
  - Diameter .... (3/4 in) 19 mm
  - Length-Main .... (600 ft) 183 m
  - Length-Aux. .... (607 ft) 185 m
- Max. Permissible Line Pull (6x36)
  - (16,800 lb) 7,620 kg
- Max. Single Line Speed .... (514 fpm) 157 m/min
- Hoist Motor Displacement
  - Low 6.53 in^3/rev (107 cm^3/rev)
  - High 3.72 in^3/rev (61 cm^3/rev)

TRANSPORTATION AND LIFTING DATA TMS800E



FITTINGS	NO./UNIT	TOTAL UNIT			CARRIER			S/S	T/T	BOOM	CWT	FITTING CAPACITY (TONS)				
		LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN	LIFT	LIFT	LIFT	LIFT	LIFT	TOW	TIE DOWN FORE & AFT	TIE DOWN SIDE	TIE DOWN DOWN
A	2		X	X		X	X						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			13.0				
D	4									X		3.4				
E	2								X			50.0				
F								X				14.0				
G	2										X	4.8				
H	4	X			X								SEE NOTE #5			
I	2										X	9.0				

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.



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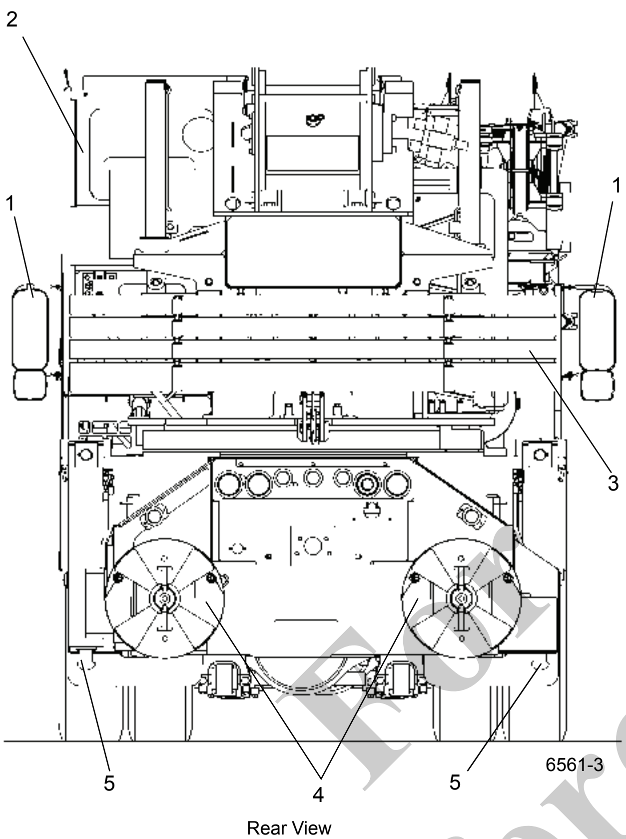
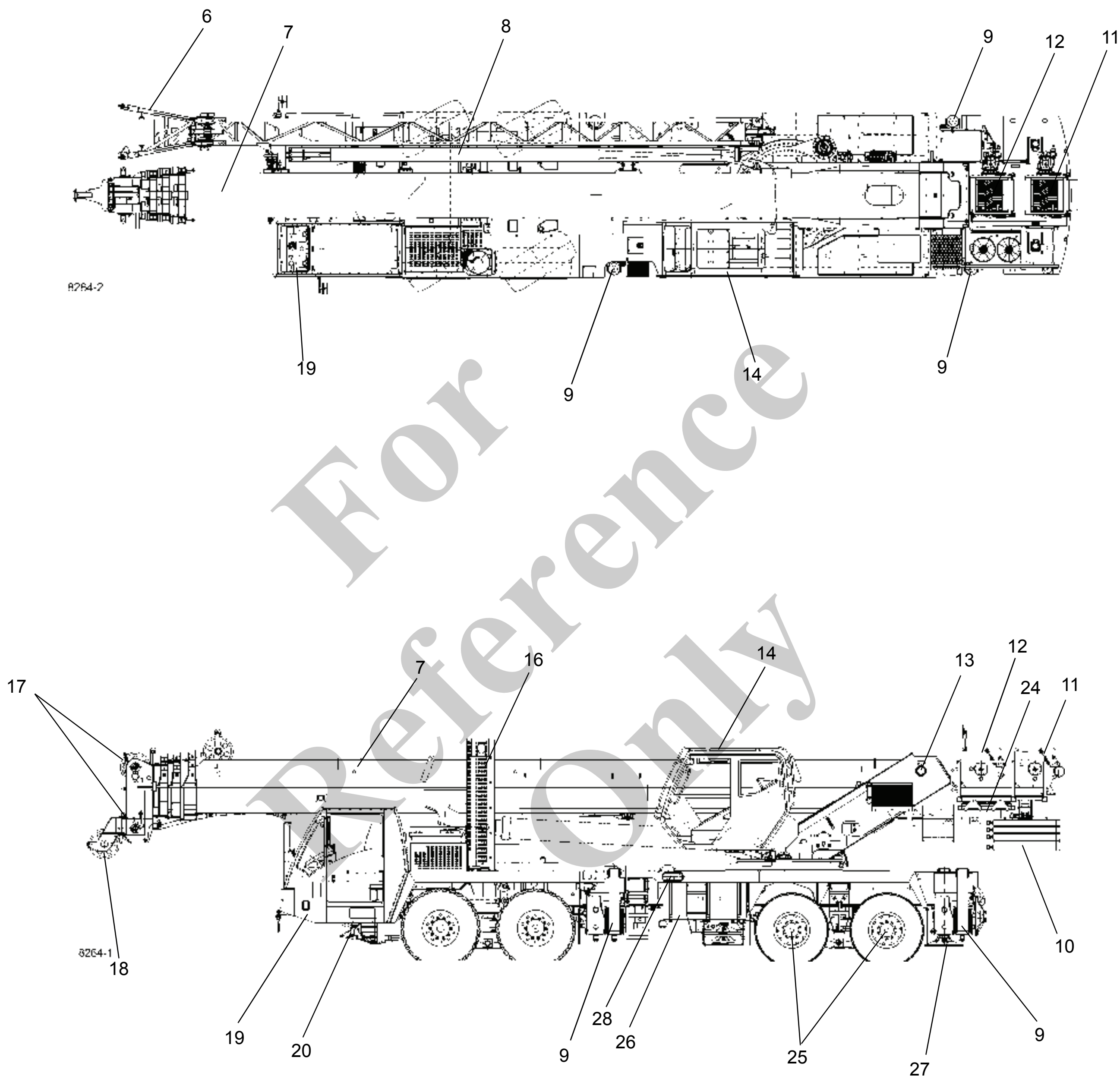


FIGURE 1-1

Item	Description
1	Rear View Mirror
2	Crane Cab
3	Counterweight
4	Outrigger Float
5	Outrigger Jack Cylinder



Left Side View

FIGURE 1-1 continued

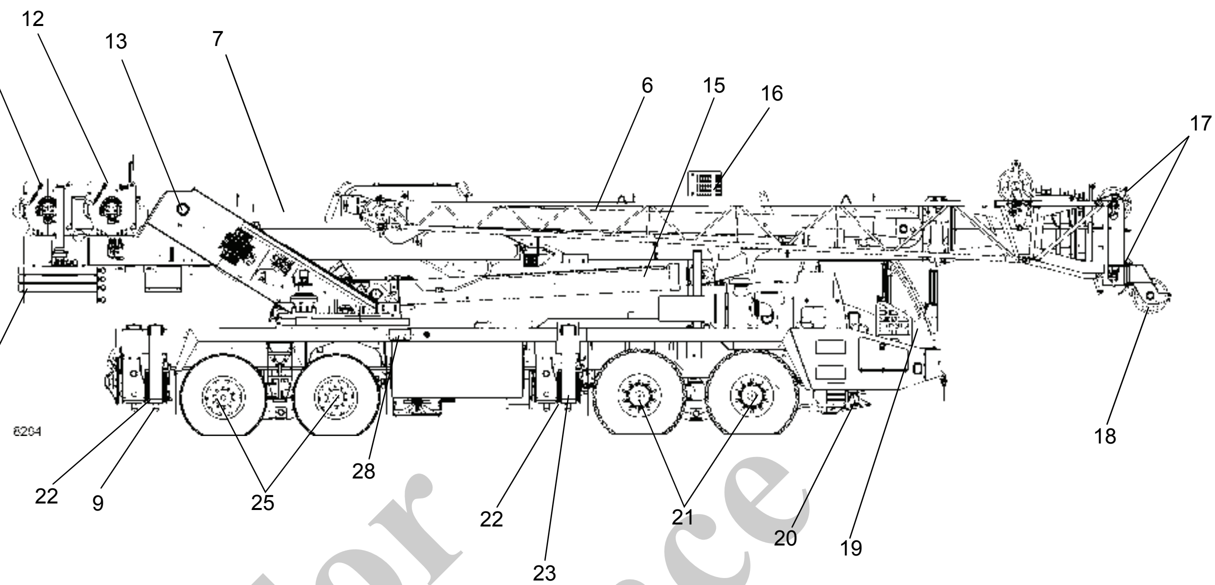


FIGURE 1-1 continued

Item	Description
6	Folding Jib
7	Boom
8	Stinger
9	Outrigger Stabilizer Cylinder
10	Removable Counterweights
11	Auxiliary Hoist
12	Main Hoist
13	Boom Pivot
14	Superstructure Cab
15	Lift Cylinder
16	Exhaust System
17	Boom Nose Sheaves

Item	Description
18	Auxiliary Boom Nose
19	Carrier Cab
20	Center Front Stabilizer
21	Front Axles
22	Outrigger Beam
23	Outrigger
24	Hydraulic Oil Cooler
25	Rear Axles
26	Fuel Tank
27	Outrigger Float
28	Carrier Outrigger Controls

Table 1-1: Axle Weight Distribution

DESCRIPTION	CG to CL REAR BOGIE cm (in)	WEIGHT kg (lb)	FRONT AXLE kg (lb)	REAR AXLE kg (lb)
Maximum Tire & Wheel Loads Allowed			22317 (49200)	27216 (60000)
Maximum Axle Loads Allowed			23224 (51200)	27216 (60000)
Carrier 8 x 4 x 4 (w/O/R Beams)	294.79 (116.06)	20158 (44441)	10568 (23299)	9590 (21142)
Superstructure (w/main & aux. hoists with cable)	-92.79 (-36.53)	6417 (14148)	-1059 (-2335)	7477 (16483)
Boom Assembly w/(2/4) sheaves, RCL, pivot pins	478.66 (188.45)	9354 (20621)	7962 (17554)	1391 (3067)
Lift Cylinder & Lower Shaft	314.73 (123.91)	1213 (2674)	679 (1497)	534 (1177)
Add: Aux boom nose, installed	1170.53 (460.84)	59 (130)	123 (271)	-64 (-141)
Complete Basic Machine TMS800E Carrier and S/S • 4-Section boom (13 - 39 m/41 - 128 ft) • 8 x 4 x 4 chassis; Cummins ISX 11.9 2013 Engine • Front and rear axles; 445/65R22.5 front & 315/80R22.5 rear Goodyear tires • Main hoist w/183 m (600 ft) of 3/4” cable • Aux hoist w/185 m (607 ft) of 3/4” cable • Full fuel and hydraulic oil • Steel Outrigger Floats	274.78 (108.18)	37142 (81884)	18150 (40014)	18992 (41870)
	Jibs			
10.1 to 17.1 m (33 to 56 ft) Folding Jib w/Mast	640.00 (251.97)	1200 (2645)	1365 (3010)	-166 (-365)
Add: 10.1 m (33 ft) Fixed Jib w/mast	718.85 (283.01)	829 (1827)	1060 (2336)	-231 (-509)
Jib Carrier Brackets (Bolt On)	499.82 (196.78)	159 (351)	142 (312)	18 (39)
Aux Boom Nose	1170.53 (460.84)	59 (130)	123 (271)	-64 (-141)
Add: 6.1 m (20 ft) Boom Ext. w/RCL (pinned to boom nose)		875 (397)		
	Counterweights			
1814 kg (4000 lb) counterweight on S/S (top piece with pins)	-298.73 (-117.61)	1822 (4016)	-968 (-2134)	2790 (6150)
Add: 1814 kg (4000 lb) counterweight on S/S (with pins)	-298.73 (-117.61)	1820 (4013)	-967 (-2132)	2787 (6145)
1814 kg (4000 lb) counterweight on carrier deck (with pins)	473.43 (186.39)	1820 (4013)	1533 (3379)	288 (634)
Add: 1814 kg (4000 lb) counterweight on S/S (with pins)	-298.73 (-117.61)	1820 (4013)	-967 (-2132)	2787 (6145)

DESCRIPTION	CG to CL REAR BOGIE cm (in)	WEIGHT kg (lb)	FRONT AXLE kg (lb)	REAR AXLE kg (lb)
Add: 1814 kg (4000 lb) counterweight on carrier deck (with pins)	473.43 (186.39)	1820 (4013)	1533 (3379)	288 (634)
Add: 2722 kg (6000 lb) counterweight on S/S (with pins)	-298.73 (-117.61)	2727 (6013)	-1449 (-3194)	4176 (9207)
Add: 2722 kg (6000 lb) counterweight on carrier deck (with pins)	473.43 (186.39)	2727 (6013)	2297 (5063)	431 (950)
Add: 2722 kg (6000 lb) wing cwt on S/S - 2 X 3000 lb (not roadable)	-287.66 (-113.25)	2722 (6000)	-1392 (-3069)	4114 (9069)
Add: 2722 kg (6000 lb) wing cwt on deck - 2 X 3000 lb (not roadable)	462.36 (182.030)	2722 (6000)	2238 (4934)	484 (1066)
	Rigging Equipment			
10.9 t (12 ton) Headache Ball (Swivel) in stowage tray	829.84 (326.71)	258 (568)	380 (838)	-122 (-270)
36 t (40 ton) Hookblock (3 sheave) - tied to front bumper	1010.92 (398.00)	373 (823)	671 (1480)	-298 (-657)
54 t (60 ton) Hookblock (5 sheave) - tied to front bumper	1010.92 (398.00)	581 (1280)	1044 (2301)	-463 (-1021)
70 t (77 ton) Hookblock (4 sheave) - tied to front bumper	1010.92 (398.00)	578 (1275)	1040 (2292)	-461 (-1017)
Rigging	170.82 (67.25)	45 (100)	14 (30)	32 (70)
Cribbing (in rear troughs)	-35.56 (-14.00)	181 (400)	-11 (-25)	193 (425)
	Optional Equipment			
Add: Air Conditioning - Carrier	716.28 (282.00)	25 (55)	32 (70)	-7 (-15)
Add: Air Conditioning - S/S	-82.83 (-32.61)	91 (200)	-13 (-29)	104 (229)
Trailing Boom - Carrier Components	-101.60 (-40)	31 (69)	-5 (-12)	37 (81)
Trailing Boom - S/S Components	181.33 (71.39)	34 (75)	11 (24)	23 (51)
Trailing Boom - Boom brackets (use with trailing boom with dolly option)	774.14 (304.78)	105 (232)	145 (319)	-39 (-87)
Driver	760.60 (299.45)	91 (200)	123 (271)	-32 (-71)
	Substitutions, Deletions, and Removals			
Sub: Main Hoist only (replace aux hoist and cable with IPO cwt	-288.57 (-113.61)	-128 (-283)	66 (145)	-194 (-428)
Del: Main Hoist cable (600’ of 3/4” 6x37)	-230.15 (-90.61)	-283 (-624)	116 (255)	-399 (-879)
Del: Aux hoist cable (607’ of 3/4” 35x7)	-316.51 (-124.61)	-336 (-740)	189 (417)	-525 (-1157)
Sub: Aluminum Outrigger Floats	5.08 (2.00)	-33 (-72)	0 (-1)	-32 (-71)
Sub: Michelin Tires	-17.78 (-7.00)	60 (132)	-2(-4)	62 (136)
Sub: Bridgestone Tires	17.78 (7.00)	56 (124)	2 (4)	54 (120)
Sub: Optional Cable on Main Hoist (607’ of 3/4” 35x7)	-230.15 (-90.61)	53 (116)	-21 (-47)	74 (163)
Sub: Cummins QSM Tier 3 Off Highway Engine	660.40 (260.00)	-281 (-620)	-330 (-728)	49 (108)

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

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

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

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

Removal and Installation

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

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

CAUTION

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

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

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

Disassembly and Assembly

When assembling or disassembling a component or system, complete each step in turn. Do not partially assemble one part and start assembling some other part. Make all adjustments as recommended. Always check the job after it is completed to see that nothing has been overlooked. Recheck the various adjustments by operating the crane 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 121°C (250°F). 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 pre-loaded 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-rings, gaskets, etc.) when disassembling and assembling the hydraulic system components. Installation of new elements is always recommended.

Hydraulic Lines

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

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 cranes, 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 plate is welded to the crane superstructure or chassis).
- Counterweight support structures.
- Chassis axle and suspension mounting structures.
- Hydraulic cylinder end connections.

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

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

Loctite®

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 Grove Manitowoc distributor.

Application of Medium Strength Loctite®

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

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

T7471).Loctite #243 is a replacement for #242 and does not need the primer.

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

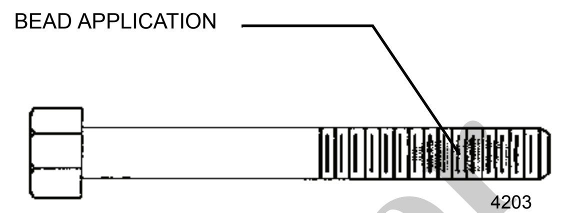


FIGURE 1-2

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.

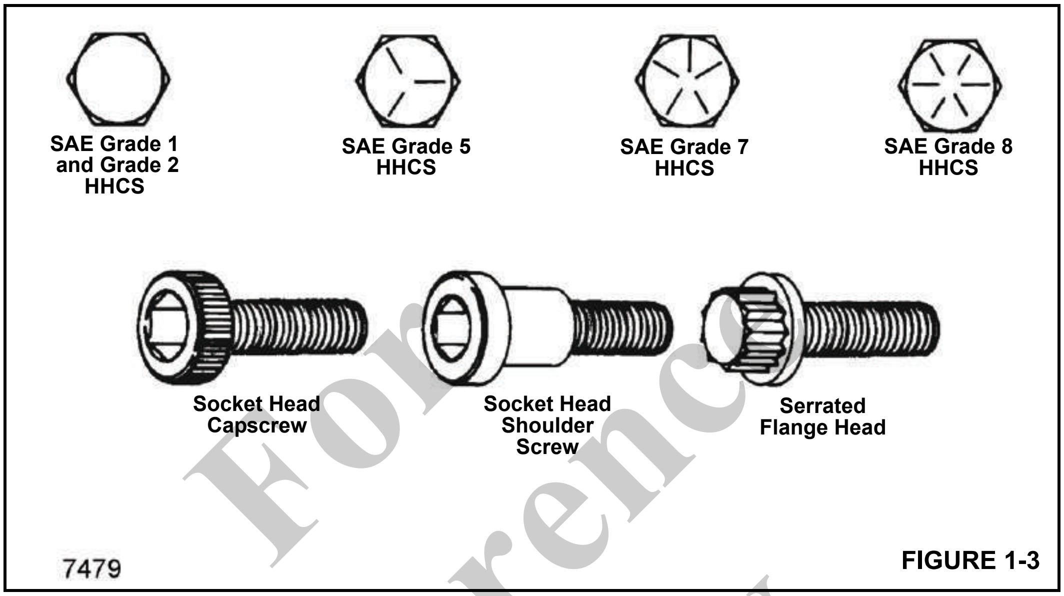


FIGURE 1-3

Table 1-2: 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 1-3: 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 1-4: Metric Fasteners, Coarse Thread, Zinc-Flake Coating

Bolt Diameter - Metric Torque Values (Nm)																
Grade	**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 1-5: Metric Fasteners, Coarse Thread, Untreated

Bolt Diameter - Metric Torque Values (Nm, Maximum/Minimum)															
Grade	**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 1-6: Metric Fasteners, Fine Thread, Zinc-Flake Coating

Bolt Diameter - Metric Torque Values (Nm)														
Grade	**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 1-7: Metric Fasteners, Fine Thread, Untreated

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

Table 1-8: UNC (Course) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

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

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

Table 1-9: 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 1-10: 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 Crane Group. The inspection interval shall be determined by a qualified person and shall be based on such factors as expected rope life as determined by experience on the particular installation or similar installations, severity of environment, percentage of capacity lifts, frequency rates of operation, and exposure to shock loads. Periodic Inspections need not be at equal calendar intervals and should be performed at shorter time intervals as the wire rope approaches the end of its useful life. A periodic inspection shall be performed at least once a year. The following provides inspection and maintenance procedures for wire ropes used on Grove products (for example, wire rope used as load lines [hoisting cables], jib extension and retraction cables, pendant cables, tow winch cables, and hook block tie down cables).

Environmental Conditions

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

Dynamic Shock Loads

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

1. High velocity movement e.g.; hoisting or swinging of a load followed by abrupt stops.
2. Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
3. Moving a load that is beyond the rated capacity of the lifting mechanism, that is, 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 (that is, 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 (for example, 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 crane to crane 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.

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, jib/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 (Jib Extension and Retraction Cables)

Periodic Inspection

It is recommended that a periodic inspection of all jib 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 jib 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.

NOTE: Wire rope may be purchased by contacting the Manitowoc Crane Care Parts Department.

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 Grove Manitowoc Crane Group. 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 Crane Group recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Manitowoc Crane Group recommends for cable extended booms, that jib 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 1-5). 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.

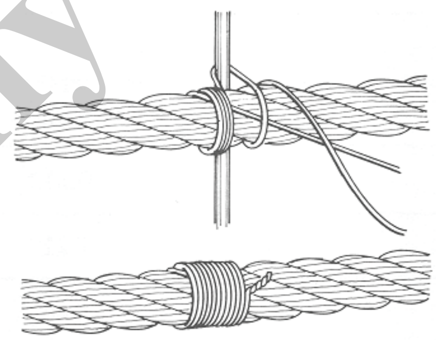


FIGURE 1-4

Method 2

Wind a length of soft annealed wire around the wire rope at least seven times (see Figure 1-6). 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 (see Figure 1-7).

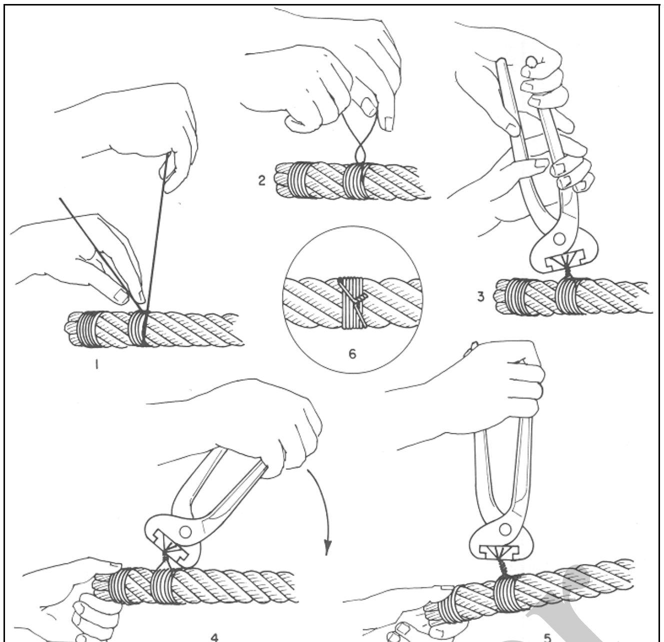


FIGURE 1-5

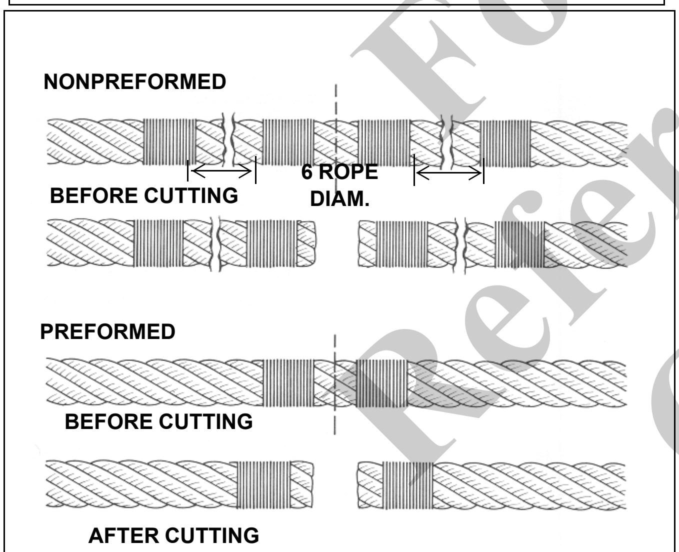


FIGURE 1-6

Installing 35x7 Wire Rope

CAUTION

Any cutting of this specific wire rope is not recommended. If 35x7 wire rope must be cut for any reason, it is necessary to follow the attached instructions (see Figure 1-7). 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: 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

35x7 is a special wire rope that must be handled differently than any other rope we use. 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 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) (see Figure 1-7). 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.
   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.

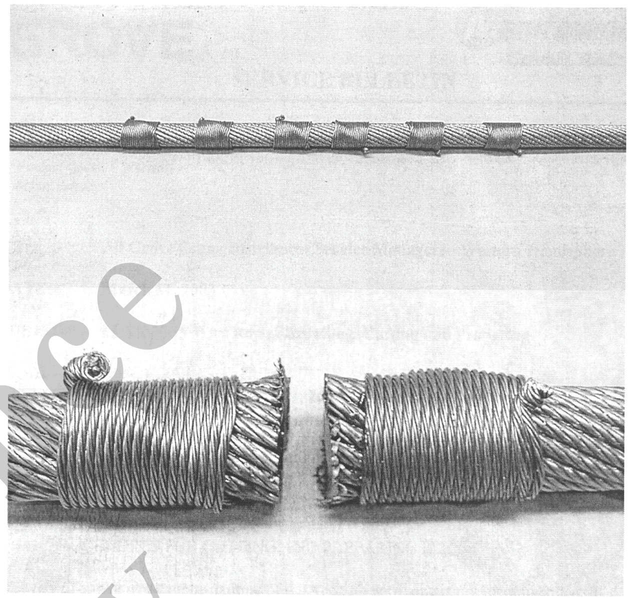


FIGURE 1-7

SECTION 2
HYDRAULIC SYSTEM

TABLE OF 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 titled A.N.S.I. Graphical Symbols provides hydraulic symbol information for this section.

MAINTENANCE

Hydraulic Oil Recommendations

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

Draining and Flushing

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

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

CAUTION

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

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

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

CAUTION

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

10. Disconnect the return lines from a pair of outrigger stabilizer cylinders and the center front stabilizer cylinder and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger stabilizer cylinders and the center front stabilizer 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.
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 (capacity to full mark) is 656.7 l (173.5 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.

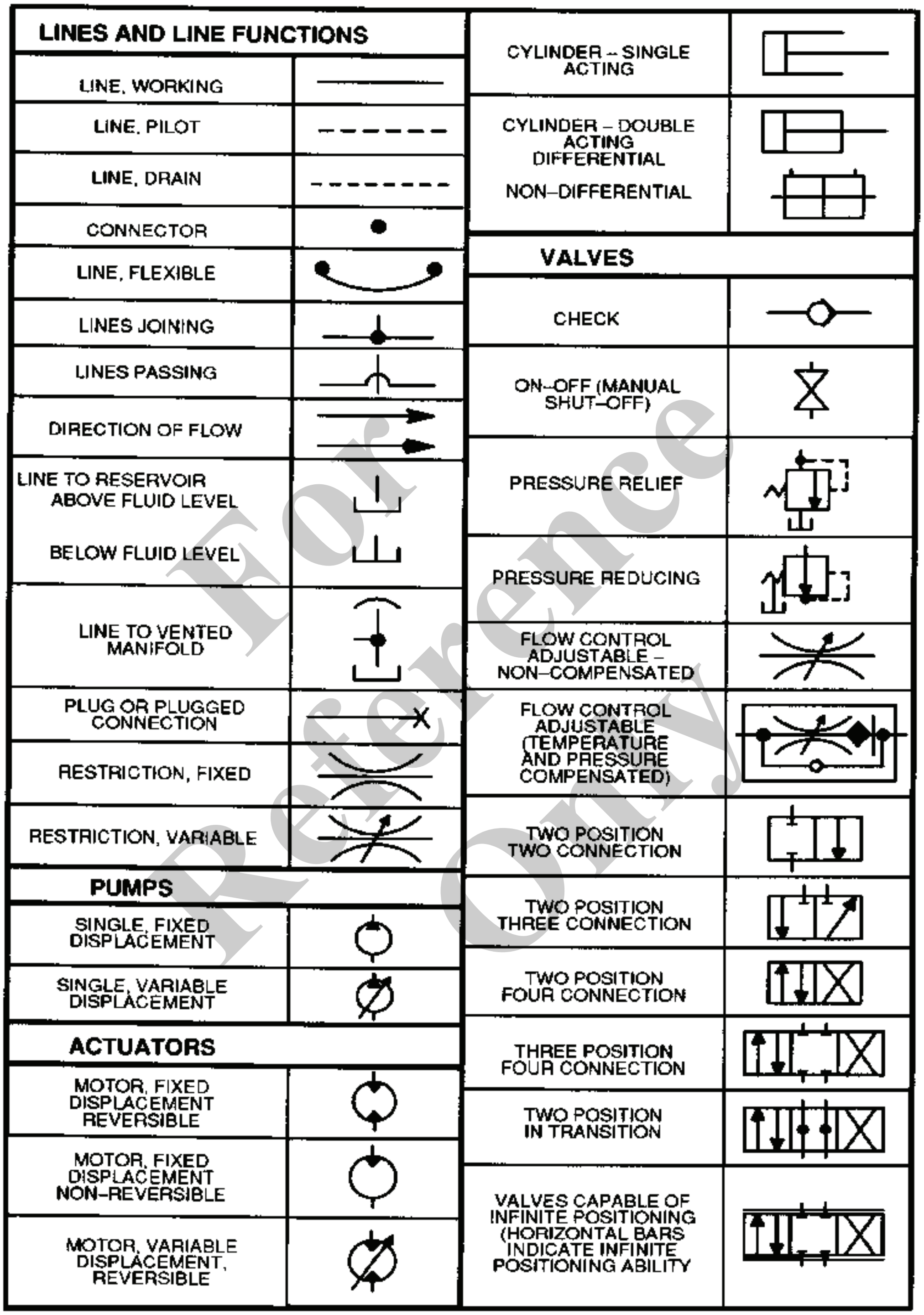

LINES AND LINE FUNCTIONS
LINE, WORKING
LINE, PILOT
LINE, DRAIN
CONNECTOR
LINE, FLEXIBLE
LINES JOINING
LINES PASSING
DIRECTION OF FLOW
LINE TO RESERVOIR
ABOVE FLUID LEVEL
BELOW FLUID LEVEL
LINE TO VENTED MANIFOLD
PLUG OR PLUGGED CONNECTION
RESTRICTION, FIXED
RESTRICTION, VARIABLE
PUMPS
SINGLE, FIXED DISPLACEMENT
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

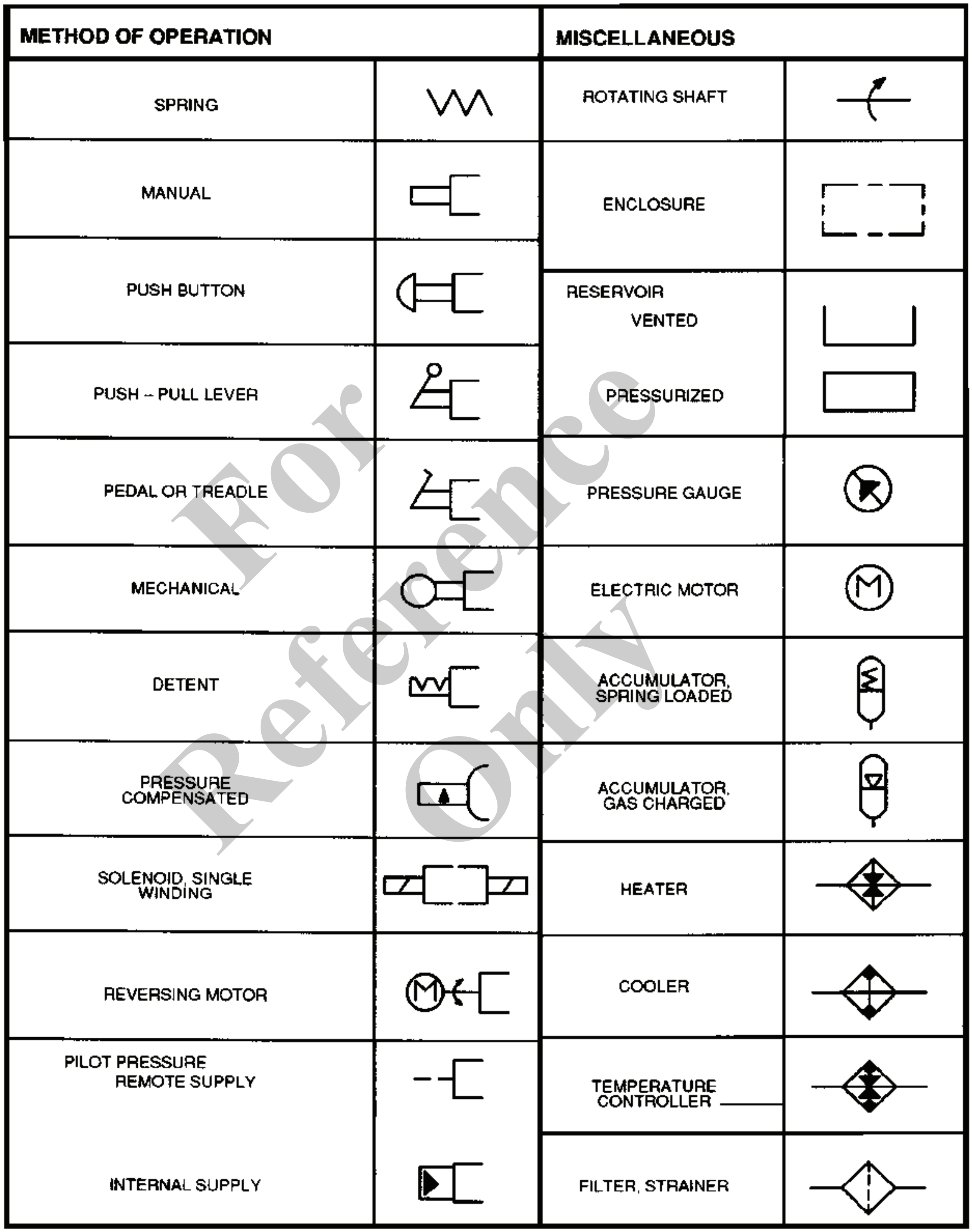

METHOD OF OPERATION
SPRING
MANUAL
PUSH BUTTON
PUSH -- PULL LEVER
PEDAL OR TREADLE
MECHANICAL
DETENT
PRESSURE COMPENSATED
SOLENOID, SINGLE WINDING
REVERSING MOTOR
PILOT PRESSURE
REMOTE SUPPLY
INTERNAL SUPPLY
MISCELLANEOUS
ROTATING SHAFT
ENCLOSURE
RESERVOIR
VENTED
PRESSURIZED
PRESSURE GAUGE
ELECTRIC MOTOR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

FIGURE 2-2

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 0.14 to 0.28 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.

WARNING

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

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

WARNING

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

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

WARNING

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

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

Parts Replacement

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

Directional Control Valves

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

Inspection

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

Valve Leakage

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

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

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

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

If any of these conditions exist, address them appropriately.

3. Hydraulic hose assemblies operating in climate zone "C" are recommended to be replaced after 8000 hours of service life.
4. 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.
5. Hydraulic hose assemblies operating in climate zones "D" and "E" cold climates should expect a degrade of mechanical properties such as elasticity. Therefore it is recommended that these hoses be inspected and addressed correctly.

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

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

The supply pressure and return circuit is made up of several circuits which route hydraulic 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, two hydraulic pumps, a hydraulic oil cooler, and a 6-port hydraulic swivel. Refer to *Hydraulic Pumps*, page 2-15 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 6-port hydraulic swivel.

The supply pressure and return circuit uses Ports 2, 3, and 5 for pump supply and the dual Port 4 for return. Each operating circuit's description and components begin with the circuit's directional control valve.

Hydraulic Reservoir and Filter

The reservoir (see Figure 2-3), attached to the right side of the carrier frame, has a capacity of 730.6 liters (193 gallons) total; 656.7 liters (173.5 gallons) 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 two hydraulic pumps. Almost all of the return flow goes through the filter at the top of the reservoir. The return line that goes directly into the reservoir (instead of through the filter) is from the No. 1 port (drain) of the 8-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 rear 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 located forward of the reservoir allows air to enter or exhaust from the reservoir. It is most important that the breather be kept clean to prevent damage to the reservoir.

A large access cover on the top of the reservoir provides access for cleaning. The access hole can also be used to fill the reservoir after it has been completely drained.

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

The hydraulic oil filter (see Figure 2-4) is located in the rear of the reservoir. It bolts to the top of the reservoir. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element, and into the reservoir.

A remote mounted gauge connected to the filter head indicates how restricted (clogged) the filter element is. When back pressure caused by a dirty filter element exceeds 1.7 bar (25 psi), the filter head's bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass valve instead. (Filter changing instructions are in Return Filter Assembly pg 2-11.)

Pump Distribution

No. 1 Pump

The engine PTO drives the No. 1 pump.

Section 1 of this pump is a piston pump. It supplies the hoist, lift, and telescope directional control valve. The valve sections control the following functions: main hoist, boom lift, boom telescope, counterweight removal, cab tilt, superstructure accessory manifold and swing directional control valve motor, and, when equipped, auxiliary hoist. Hydraulic oil flowing from this valve bank returns to the reservoir filter.

Section 2 of this pump is a smaller gear pump that supplies the integrated outrigger valve.

No. 2 Pump

The No. 2 hydraulic pump mounts directly on the engine. An engine accessory drive shaft directly drives this two-section gear pump.

Section 1 of this pump supplies the motor control manifold, hydraulic oil cooler, and optional superstructure air conditioner. (The compressor motor runs on hydraulic power.)

Section 2 of this pump supplies the front axle steering gear and cylinders and the charge air cooler fan motor.

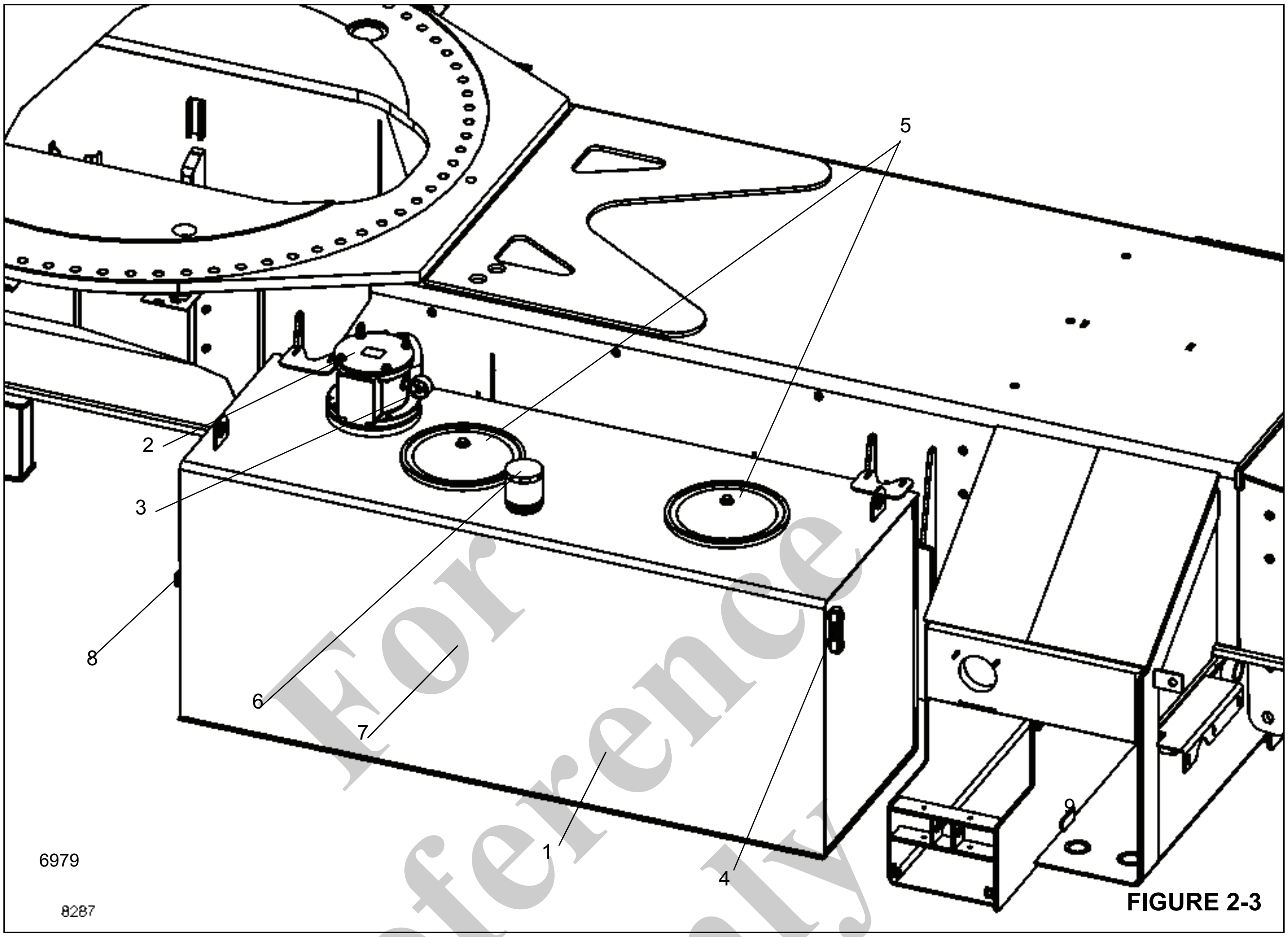


FIGURE 2-3

Item	Description
1	Reservoir
2	Return Filter
3	Return Manifold Inlet
4	Sight Gauge (Oil Level Gauge)

Item	Description
5	Access Cover
6	Filler Cap
7	Drain Plug (Not Shown)
8	Thermometer

Maintenance

Troubleshooting

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

Element Removal

CAUTION

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 filter element 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. Torque bolts, refer to Fasteners and Torque Values pg 1-13.
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. Torque the bolts, refer to Fasteners and Torque Values pg 1-13.
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 breather line elbow.
3. Screw the replacement reservoir breather into the breather line elbow.

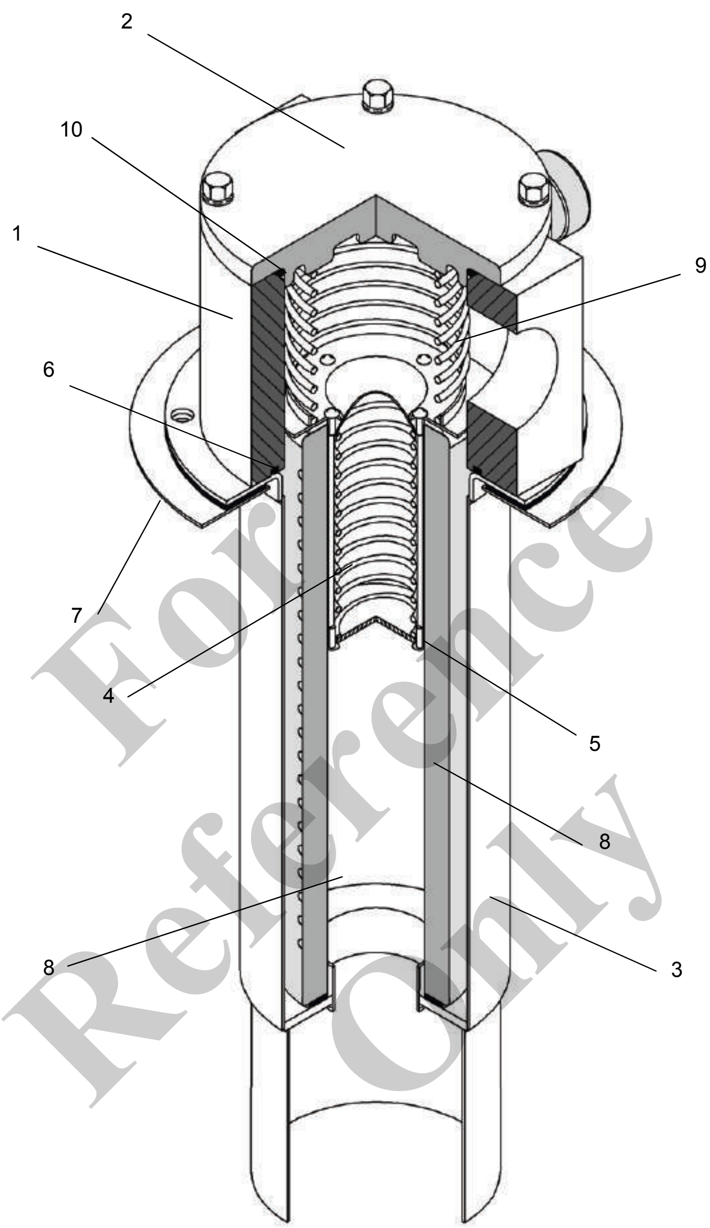


FIGURE 2-4

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 (see Figure 2-5) is mounted on the superstructure below the hoist platform. The oil cooler consists of a radiator, two electric motors, and two fans. The fans are driven by the motors 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 2.07 bar (30 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, through the hydraulic swivel and to the oil filter in the hydraulic reservoir. When several hydraulic functions are being used at one time (i.e., 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 2.07 bar (30 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 hydraulic tank senses hydraulic oil temperature to control the fan motors. The switch sends a signal to the CAN controller. The controller will turn the fans on and off based on that signal.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the oil cooler. Cap or plug all openings.
2. Tag and disconnect the electrical connectors to the fan motors.
3. Remove the bolts, flatwashers, spring lockwashers and nuts securing the hydraulic oil cooler brackets to the hoist platform.

Installation

1. Position the oil cooler assembly under the hoist platform and secure with the bolts, flatwashers, spring lockwashers, and nuts. Torque the bolts, refer to Fasteners and Torque Values pg 1-13.
2. Connect the electric motors.
3. Connect the hydraulic lines to the oil cooler as tagged during removal.

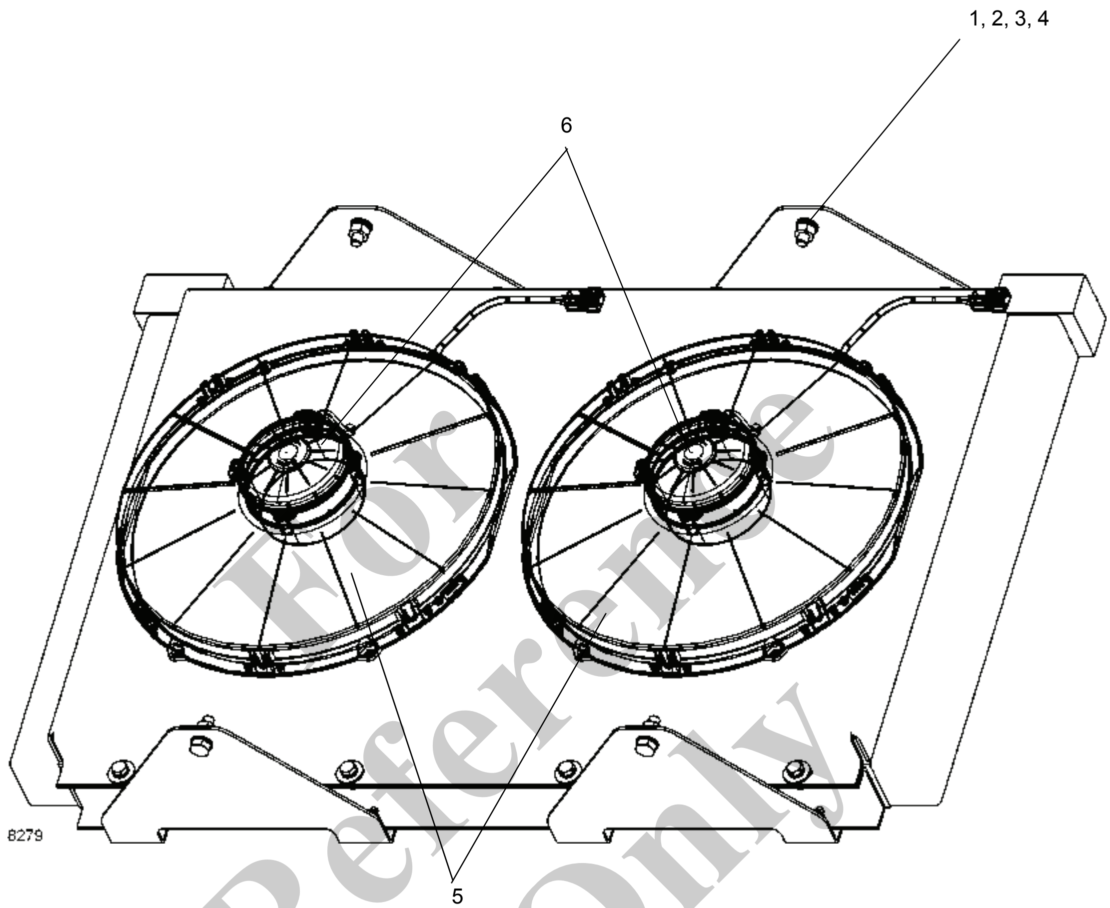


FIGURE 2-5

Item	Description
1	Hex Nut
2	Spring Lockwasher
3	Flatwasher
4	Bolt
5	Fans
6	Electric Motors

HYDRAULIC PUMPS

Description QSM Cranes

The No. 1 hydraulic pump is frame-mounted above the transmission. A drive shaft attached to the rear engine PTO drives this combination piston pump and gear pump. The piston pump has two sections, the first section displacement is 112 cm³/rev (6.8 inch³/rev) and pumps at a rate of 216.1 lpm (57.1 gpm). The second section displacement is 80 cm³/rev (4.9 inch³/rev) and pumps at a rate of 154.4 lpm (40.8 gpm). The gear pump displacement is 29 cm³/rev (2.4 inch³/rev) and pumps at a rate of 76.1 lpm (20.1 gpm).

The No. 2 hydraulic pump is mounted on the engine and is directly driven by the engine. Each section is a gear pump; each gear pump displacement is 43.8 cm³/rev (2.67 inch³/rev). Both sections pumps at a rate of 73.4 lpm (19.4 gpm).

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.

Description ISX Cranes

The No. 1 hydraulic pump is frame-mounted above the transmission. A drive shaft attached to the rear engine PTO drives this combination piston pump and gear pump through an air operated clutch. The piston pump displacement is 200 cm³/rev (12.2 inch³/rev) and pumps at a rate of 364.5 lpm (96.3 gpm). The gear pump displacement is 27.8 cm³/rev (2.4 inch³/rev) and pumps at a rate of 85.9 lpm (18.9 gpm).

The No. 2 hydraulic pump is mounted on the engine and is a gear pump; the pump displacement is 44 cm³/rev (2.69 inch³/rev). Both sections pumps at a rate of 73.4 lpm (22.7 gpm).

The No. 3 hydraulic pump is mounted on the air compressor and is a gear pump; the pump displacement is 27.8 cm³/rev (2.4 inch³/rev) and pumps at a rate of 76.8 lpm (20.3 gpm).

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 QSM Cranes

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 carrier parts as needed to gain access to the pump.
2. Tag the supply lines to the pump and tag the distribution lines from the pump, then disconnect them from the pump. Cap or plug the lines and ports.
3. Remove the four bolts and washers to free the pump from the PTO shaft. Secure the shaft so it doesn't damage other parts.

CAUTION

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

NOTE: The weight of the pump assembly is approximately 143kg (383lb).

4. Secure the pump so it won't fall when free. Remove the bolts, washers, and nuts to free the No. 1 pump from its support bracket. Remove the pump from the crane. Or if it is more convenient, remove the bolts, washers, nuts, and spacers to free the support bracket from the carrier, and lift the pump and its support bracket out together. Then remove the pump from the support bracket.

No. 1 Pump Inspection and Repair

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

No. 1 Pump Installation

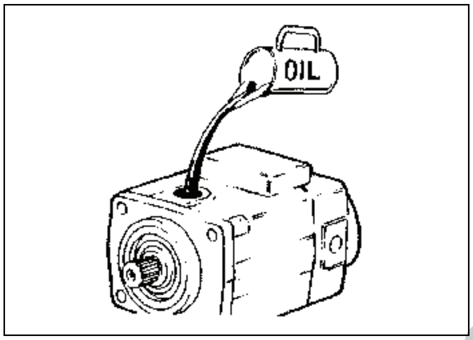
1. Secure the No. 1 pump to the support bracket with bolts, washers, and nuts. Torque bolts, refer to *Fasteners and Torque Values*, page 1-13. If reinstalling the support bracket also, secure the support bracket to the carrier with bolts, washers, nuts, and spacers. Torque these bolts, refer to *Fasteners and Torque Values*, page 1-13.
2. Connect prop shaft to pump assembly with bolts and washers. Torque bolts, refer to *Fasteners and Torque Values*, page 1-13.
3. Connect the distribution and supply lines as tagged during removal.
4. Install carrier parts removed for access earlier.

No. 1 Pump Piston Pump Section Startup Procedure

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.

NOTE: The following step can be done before the pump is installed by removing the plastic cap from "T1" port, and checking to ensure "T2" port on the opposite side of the pump is plugged. Fill housing full of hydraulic oil through “T1” port. Re-install the plastic cap and then install the pump.

3. Remove adapter and hose from “T1” port, and check to ensure “T2” port on the opposite side of the pump is plugged. Fill housing full of hydraulic oil through “T1” port. Re-install the adapter and hose into the “T1” port.



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 piston pump section to check for excessive heat build-up. If the piston pump section is too hot to keep your hand on, stop immediately. If the pump makes excessive noise it is probably sucking air, keeping the pump from priming. If this occurs, stop engine, and inspect all connections of the suction hose/ tube for a loose connection, or a missing or damaged O-ring. Re-start the engine and run until the pump takes prime for a maximum of 30 seconds. If the pump does not prime in 30 seconds, stop the engine and repeat until the pump primes.

6. Increase the RPM to 1500-1800 for 1 to 2 minutes with no functions actuated and make checks again per step 5. Incrementally increase throttle to full RPM and then cycle the functions that the pump section supples to verify proper speed. Verify pump flow. Verify there is no leaking.

7. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-24 in this section.

No. 1 Pump Gear Pump Section Startup Procedure

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 each pump section outlet hose. Fill each pump outlet port of the pump section with as much hydraulic oil as it will take. Then reinstall each outlet hose.

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 gear pump section to check for excessive heat buildup. If the gear pump section 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 the two.

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 section powers to verify the pump section drives them properly. Verify there is no leaking.

10. Check pressure settings. Refer to *Pressure Setting Procedures*, page 2-24 in this section.

No. 2 Pump Removal

CAUTION

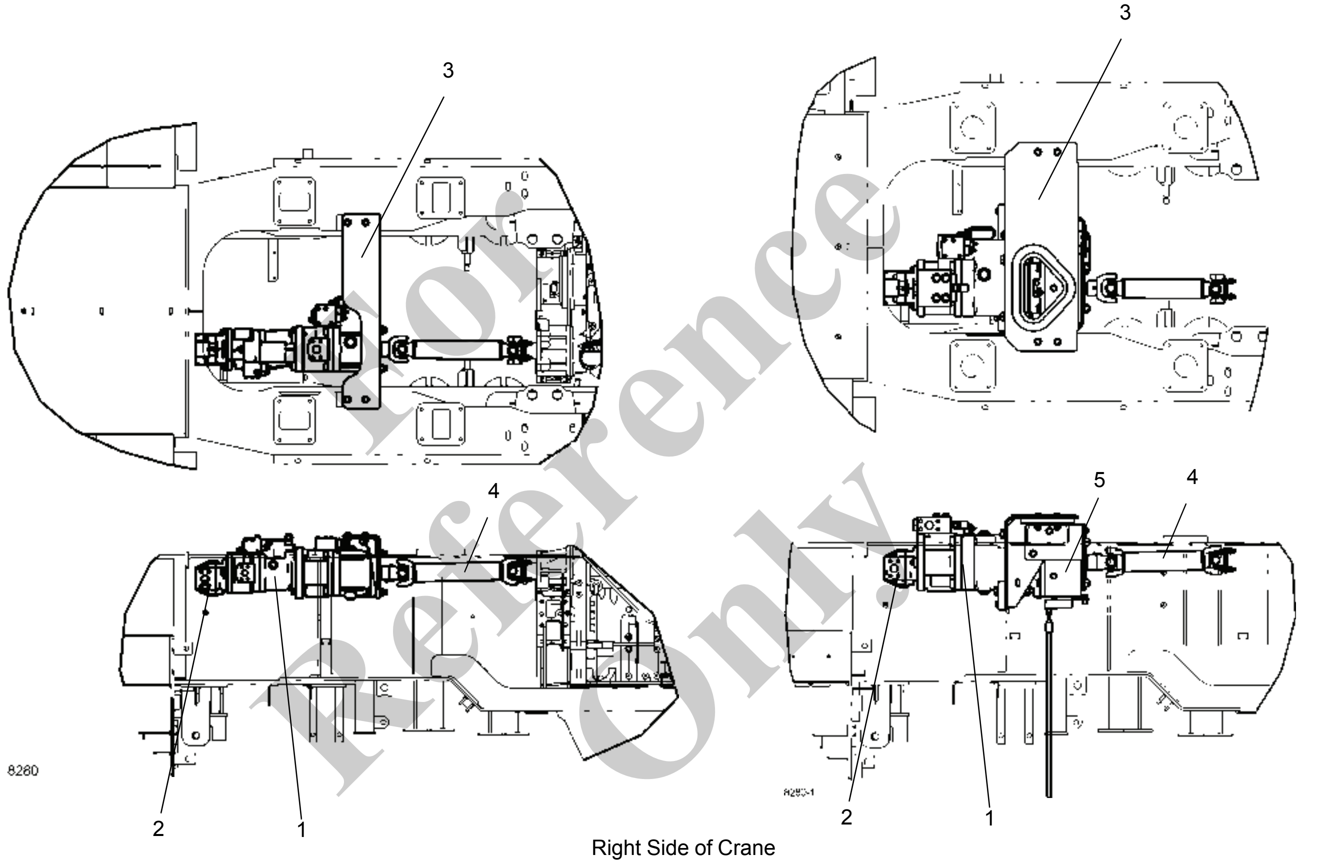
Absolute cleanliness is essential when working on the hydraulic pumps. The presence of dirt and foreign materials in the system can result in serious damage or inadequate operation.

1. Remove carrier 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.



QSM Pump Installation **ISX Pump Installation**

FIGURE 2-6

Item	Description
1	Pump No. 1 Piston Pump
2	Pump No. 1 Gear Pump
3	Support Bracket
4	Propeller Shaft (connects to engine)
5	Clutch (ISX only)

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 cover.
2. Apply gasket compound (Spec. 6829013865, Loctite Master Gasker 518) to the No. 2 pump's gasket. Place the gasket on the mounting flange of the pump.
3. Apply medium strength thread locking compound (Spec. 6829012418, Loctite 243) to the two pump mounting bolts. Install the No. 2 pump on engine drive pad with bolts and washers. Make sure gear teeth mesh properly. Torque bolts, refer to *Fasteners and Torque Values*, page 1-13. Make sure gasket seals properly.
4. Secure the No. 2 pump to the pump support plate with the nut and lockwasher. Torque nut, refer to *Fasteners and Torque Values*, page 1-13.
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. Torque bolts, refer to *Fasteners and Torque Values*, page 1-13.
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.

No. 2 Pump Startup Procedure

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 the two.
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 2-24 in this section.

Maintenance ISX Cranes

Pump/PTO Clutch Replacement

CAUTION

Damage could occur!

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

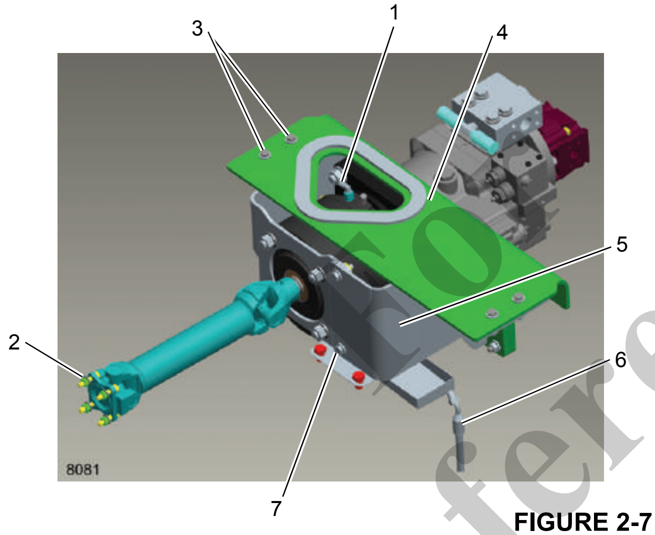


FIGURE 2-7

Removal

1. Depressurize the hydraulic system.
2. Depressurize the air system and disconnect the clutch air line (1, Figure 2-7) from the clutch.
3. Remove the cap screws, nuts and washers (2) connecting the PTO driveline to the engine. Remove the driveline.

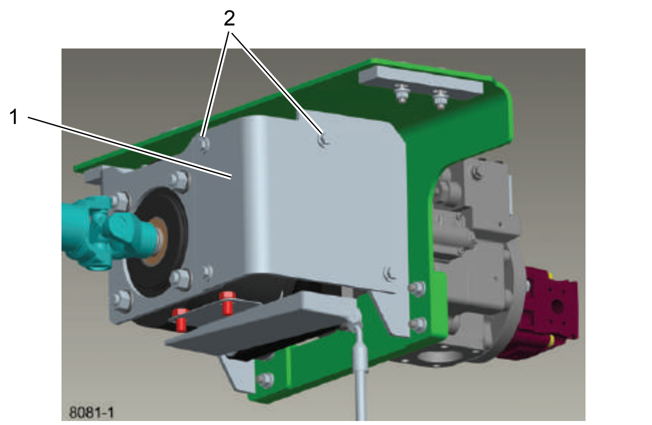


FIGURE 2-8

4. Remove the access cover (1, Figure 2-8) by removing the four cap screws and washers (2) and two “double-nut” plates.
5. Tag, disconnect and plug or cap the hydraulic hoses and ports on the pumps.
6. Tag and disconnect the electrical connectors to the pumps.
7. Remove the four cap screws, nuts and washers (3, Figure 2-7) securing the clutch mounting bracket (4) to the frame.
8. Attach a suitable lifting device to the PTO clutch/ mounting bracket/pump assembly—the clutch/mounting bracket/pump weighs approximately 215 kg (474 lb).
9. Remove the assembly and place on a suitable workbench.

Disassembly

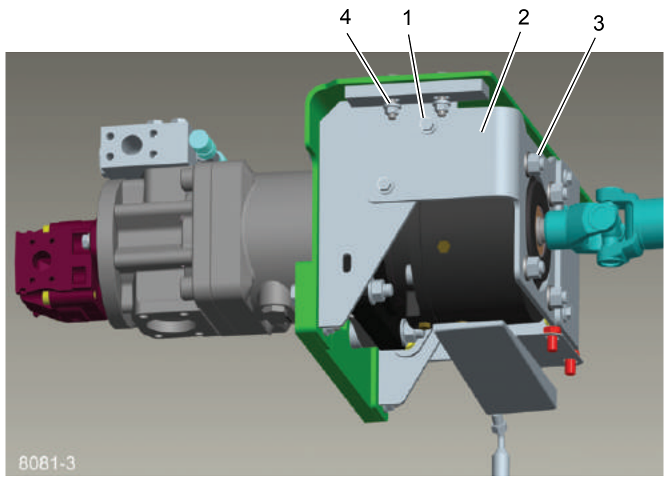


FIGURE 2-9

1. Remove the cap screws and washers (1, Figure 2-9) and double-nut plate securing the front support plate (2) to the mounting bracket.

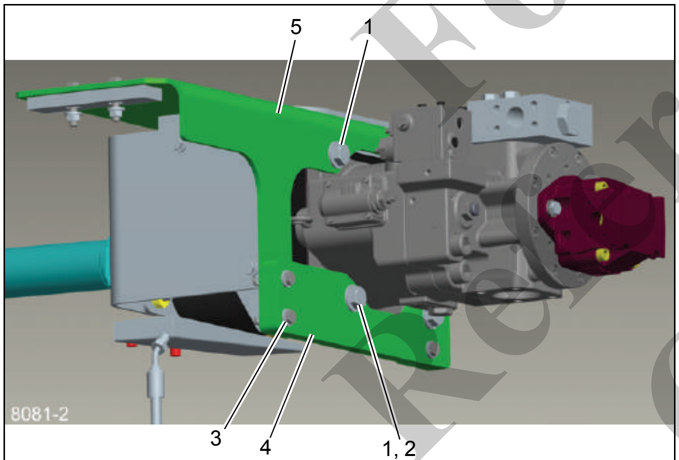


FIGURE 2-10

2. Remove the cap screws, nuts and washers (1, Figure 2-10) that fastens the clutch, mounting bracket and pump together. A bushing (2), on the lower left bolt, will fall out when the hardware is removed.
3. Remove the three cap screws, nuts and washers (3) that secure the mounting plate (4) to the mounting bracket (5).
4. Slide the clutch/front support plate off the pump spline.
5. Using a short Allen wrench or a tool, made by locking nuts on a 7/16 bolt, inserted into the socket head cap screws, and held with a wrench, remove the socket head cap screws, nuts and washers (3, Figure 2-9) that secures the front support plate to the clutch.

Assembly

1. Assemble bottom plate (4, Figure 2-10) to mounting bracket (5) around the pump body using the three bolts, washers, and nuts (3).
2. Slide the clutch onto the pump spline, install the bushing (2) removed in step 1 above and fasten the assembly together with the cap screws, nuts and washers (1, Figure 2-10). Torque hardware, refer to *Fasteners and Torque Values*, page 1-13.
3. Loosely attach the front support plate (2, Figure 2-9) to the front of the clutch using the nuts, washers and socket head cap screws (3). Secure the front support plate to the mounting bracket with the cap screws, washers and double-nut plate (1). Gently tighten hardware allowing assembly to settle into place. Torque all hardware according to *Fasteners and Torque Values*, page 1-13.

Installation

1. Using the lifting device place the clutch/mounting bracket/pump assembly onto the crane and loosely assemble with the cap screws, nuts and washers (4, Figure 2-9).
2. Connect the hydraulic hoses and air line to the clutch as tagged during removal. To prime the pumps, add hydraulic oil to the pumps and hoses before installation.
3. Attach the access cover (1, Figure 2-8) to the front support plate/clutch/mounting bracket with four cap screws and washers (2) and two double-nut plates. Torque all hardware, refer to *Fasteners and Torque Values*, page 1-13.
4. Install the driveline onto the clutch input shaft and transmission output. Secure the driveline to the transmission with the cap screws, nuts and washers. Torque hardware, refer to *Fasteners and Torque Values*, page 1-13.
5. Adjust the clutch/mounting bracket/pump assembly fore and aft to position the driveshaft between 6 to 14 mm (0.24 to 0.55 in) from the clutch face Figure 2-11.

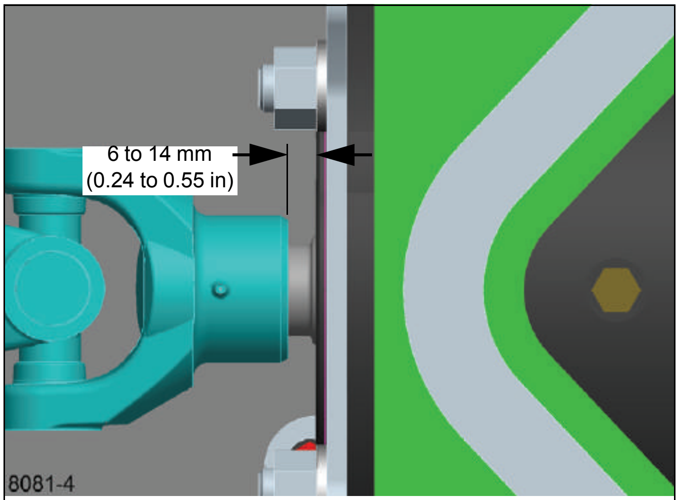


FIGURE 2-11

6. Torque hardware (4, Figure 2-9), refer to *Fasteners and Torque Values*, page 1-13.
7. Connect the electrical connectors and hoses to the pumps as tagged during removal.
8. Start the engine, engage the clutch and check for leaks.

PUMP/PTO CLUTCH ASSEMBLY

The pump PTO clutch is used on cranes with the ISX engine to engage/disengage pump 1 from the engine to aid in starting, especially in cold weather, and to prevent the pumps from over-speeding while traveling the crane. This clutch connects the PTO driveline to pump 1. The clutch assembly is air operated and electrically controlled.

PTO Clutch Lubrication

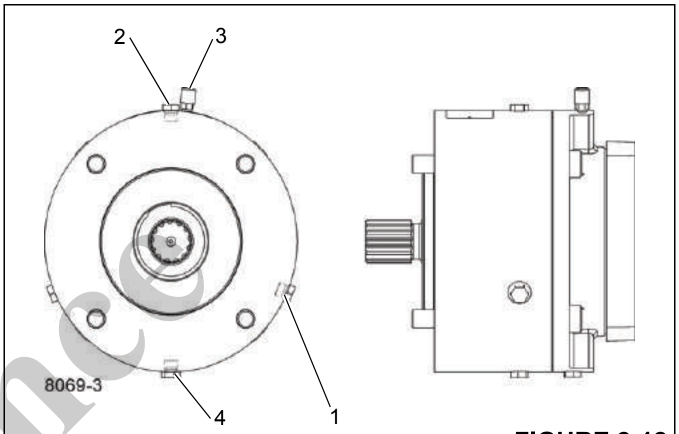


FIGURE 2-12

1. Remove access cover (5, Figure 2-7).
2. Open check plug (1, Figure 2-12) and check that oil is even with bottom of threads.
3. If necessary, remove fill plug (2) and add hydraulic oil until it is even with the bottom of the check plug threads.
4. Reinstall access cover (5, Figure 2-7) and secure with hardware (7). Refer to *Fasteners and Torque Values*, page 1-13.

When changing oil, place suitable container under drain pan hose (6, Figure 2-7) before removing drain plug (4, Figure 2-12). Remove and clean breather (3) and inspect and clean magnetic drain plug (4) for contamination or particles before reinstalling. For more information, refer to *Lubrication*, page 9-1.

VALVES

General

This subsection provides descriptive information for all the hydraulic valves used on this crane. For a listing of all valves, the circuit they are used in, and their physical location, refer to the Valve Usage Table. Refer to Figure 2-13 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/Cab Tilt	Superstructure right side Superstructure right side Superstructure under main hoists
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	Center of carrier frame in bearing area
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 stabilizer cylinder (4)
Accessory Manifold w/ Swing Directional Valve	Swing	Right side of turntable
Front Center Stabilizer Relief Valve	Outrigger	Front outrigger box under right frame rail
Motor Control Manifold	Hydraulic Oil Cooler/Superstructure Air Conditioner	Center of Carrier Frame
Needle Valve (2)	Trailing boom option	Boom lift cylinder
Flow Control Valve	Trailing boom option	Boom lift cylinder
Charge air cooler control manifold	Charge air cooler	Inside left front frame wall above transmission

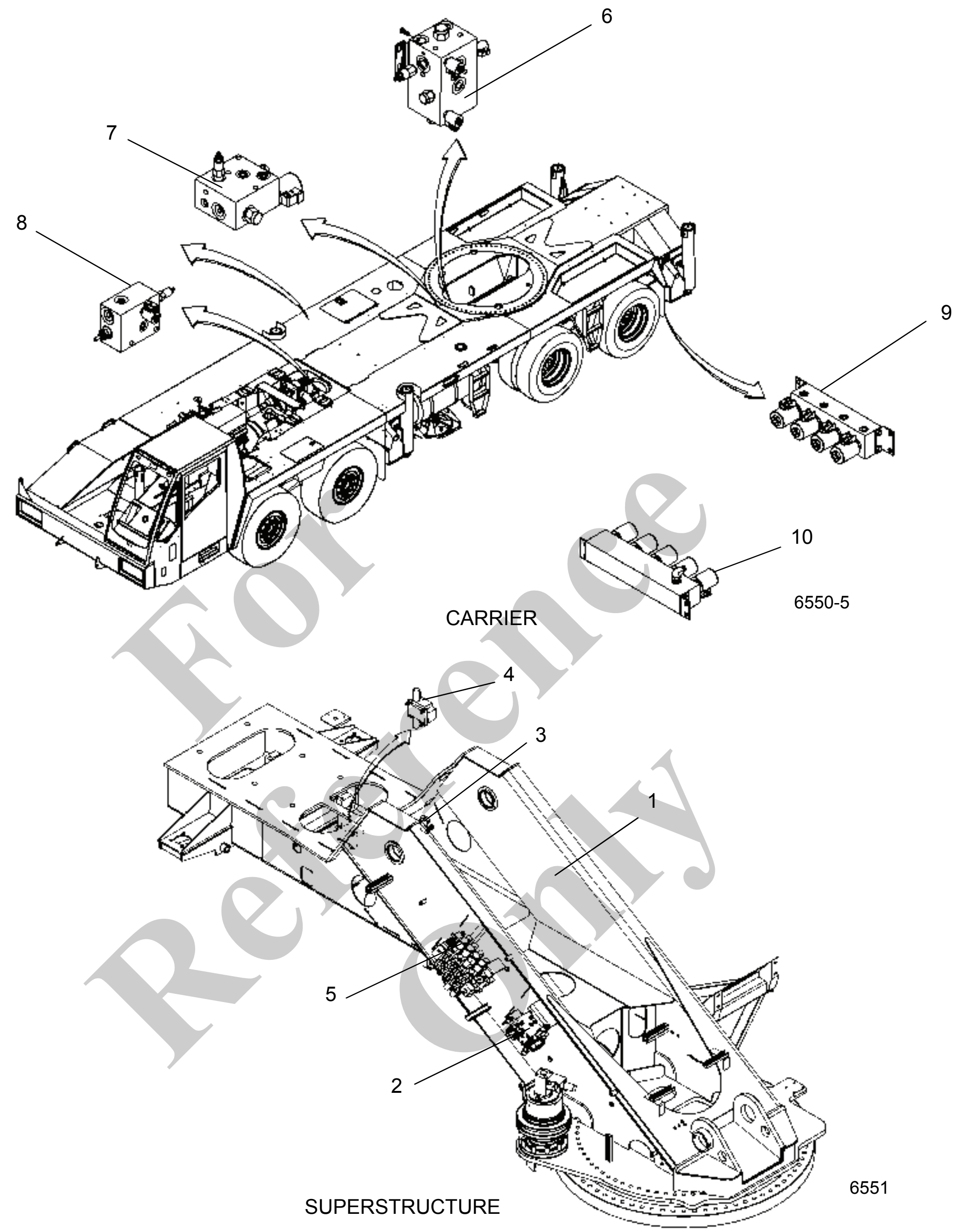


FIGURE 2-13

Item	Description
1	Turntable
2	Accessory Manifold with Swing Directional Valve
3	Pilot Operated Check Valve (Cab Tilt)
4	Counterweight Removal/Cab Tilt Directional Control Valve
5	Hoist/Telescope/Lift Directional Control Valve\
6	Outrigger Selector Valve
7	Motor Control Manifold
8	Charge Oil Cooler Control Manifold
9	Rear Outrigger Control Manifold
10	Front Outrigger Control Manifold

PRESSURE SETTING PROCEDURES

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

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

- Pressure Gauge
- Three dial gauge 0-345 bar (0-5000 psi)
- Diagnostic quick disconnect - Grove P/N 9999101806 and straight adapter fitting 7447040401
- ORFS reducers as required to attach work port hoses to the gauge.

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

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

Table 2-2
Valve Pressure Setting Table

Reservoir Oil Temperature to be Approximately 49°C (120°F

Valve To Be Set	Pressure Setting bar (PSI)	Tolerance bar (PSI)	Gauge Port (GPX) and Adjustment Location
Hoist(s), and Lift Pressure Setting	276 (4000)	± 4 (50)	GP2 Superstructure mounted accessory manifold with swing directional control valve (see Figure 2-14)
Telescope Extend Pressure	179 (2600)	± 4 (50)	GP5 Superstructure mounted main directional control valve port relief valve (see Figure 2-15)
Telescope Retract Pressure	239 (3460)	± 4 (50)	GP5 Superstructure mounted main directional control valve port relief valve (see Figure 2-15)
Outrigger Extend/Retract and Swing Left/ Right Pressure Setting	214 (1500)	± 4 (50)	GP7 Carrier mounted outrigger control manifold (see Figure 2-18)
Air Conditioning Circuit Relief Valve Pressure	103 (2000)	± 4 (50)	GP Carrier mounted flow control manifold (see Figure 2-17)
Steer Pressure Setting	150 (2175)	± 4 (50)	GP8 Carrier mounted Priority Flow Pump Relief (see Figure 2-19)
Swing Brake Supply Pressure Setting	18 - 20 (260 - 300)	See Range	GP4 Superstructure mounted accessory manifold with swing directional control valve (see Figure 2-14)
Pilot Supply Pressure Setting	28 - 31 (400 - 450)	See Range	GP3 Superstructure mounted accessory manifold with swing directional control valve (see Figure 2-14)
Counterweight Removal Extend/Retract and Cab Tilt Relief Pressure Setting	172 (2500)	± 4 (50)	GP2 Superstructure mounted accessory manifold with swing directional control valve (see Figure 2-14)

Valve To Be Set	Pressure Setting bar (PSI)	Tolerance bar (PSI)	Gauge Port (GPX) and Adjustment Location
Pump Differential Pressure Setting (ISX Engine)	26 (375)	± 4 (50)	GP2 Carrier mounted piston pump (see Figure 2-21)
Center Front Stabilizer Relief Setting	10 - 20 (150 - 300)	Not Adjustable	GP Carrier mounted in Outrigger 5 stack valve (see Figure 2-22)
Pump Differential Pressure Setting (GSM Engine)	26-29 (375-425)	See Range	GP2 Carrier mounted piston pump (see Figure 2-21)

Procedure A - For Checking/Setting the Main Directional Control Valve for Hoist(s) and Boom Lift

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

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at the GP2 port of the swing and accessory manifold (see Figure 2-14).
2. Ensure piston pump “P” max (see Figure 2-21) factory setting is correct. Loosen the jam nut on the “P” max adjusting screw and turn it “in” until it softly seats or bottoms out. Then back the adjusting screw “out” 1/4 to 1/2 turn and lock in place with jam nut. This will ensure that full system pressure of 276 bar (4000 psi) can be obtained in step # 4.
3. If the lift cylinder is not installed, plug the extend hose (the larger of the two). If lift cylinder is installed, omit this step and continue to step 4.
4. Start engine and throttle up to full RPM. Feather into the boom lift controller to full controller stroke (Up or down) and hold. If the boom is installed, boom up to max elevation and hold or boom down to minimum elevation and hold. Adjust the load sense relief valve “in” to increase or “out” to decrease so that a gauge pressure reading of 276 ± 4 bar (4000 ± 50 psi) is achieved (see Figure 2-15).
5. Stop engine and remove the diagnostic couplers from the test nipples.

Set the telescope extend and retract as follows:

Extend

6. If the boom is not installed, install a pressure check diagnostic quick disconnect with gauge onto test nipple at the GP5 port at the inlet of the main directional control valve (see Figure 2-15).
7. Cap hose (the larger of the two) running from port A, telescope section of the main directional control valve to the cylinder port block at the back of the base section.
8. Start engine and throttle up to full RPM. Attempt to extend boom by feathering into the controller to full controller stroke. Adjust the work port relief valve “in” to increase or “out” to decrease so that a gauge pressure reading of 179 ± 4 bar (2600 ± 50 psi) is achieved (see Figure 2-15).
9. If the boom is installed, start engine and throttle up to full RPM. Fully extend the boom and hold. Adjust the work port relief valve “in” to increase or “out” to decrease so that a gauge pressure reading of 179 ± 4 bar (2600 ± 50 psi) is achieved (see Figure 2-15)
10. Stop engine and remove pressure gauge and re-connect plumbing.

Retract

11. If the boom is not installed, install a pressure check diagnostic quick disconnect with gauge onto test nipple GP5 at the inlet of the main directional control valve (see Figure 2-15).
12. Cap hose (the smaller of the two) running from port B, telescope section of the main directional control valve to the cylinder port block at the back of the base section.
13. Start engine and throttle up to full RPM. Attempt to retract boom by feathering into the controller to full controller stroke. Adjust the work port relief valve “in” to increase or “out” to decrease so that a gauge pressure reading of 239 ± 4 bar (3460 ± 50 psi) is achieved (see Figure 2-15).
14. If the boom is installed, start engine and throttle up to full RPM. Fully retract the boom and hold. Adjust the work port relief valve “in” to increase or “out” to decrease so that a gauge pressure reading of 239 ± 4 bar (3460 ± 50 psi) is achieved (see Figure 2-15).
15. Stop engine and remove pressure gauge and re-connect plumbing.

Set the cab tilt and counterweight removal pressure as follows:

16. Install pressure check diagnostic quick disconnect with gauge onto test nipple at the GP2 port of the swing and accessory manifold (see Figure 2-14).

17. If the lift cylinder is not installed, plug the extend hose (the larger of the two). If lift cylinder is installed, omit this step and continue to step 18.
18. Start engine and throttle up to full RPM. Select and hold the cab tilt switch on the superstructure cab right arm rest in the down position and adjust the load sense relief valve of the counterweight removal and cab tilt directional control valve “in” to increase or “out” to decrease so that a gauge pressure reading of 172 ± 4 bar (2500 ± 50 psi) is achieved (see Figure 2-16).
19. Stop engine and remove the diagnostic couplers from the test nipples.

Procedure B - For Checking/Setting the Outrigger/Swing Pressures

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at GP7 port of the outrigger control manifold (see Figure 2-18).
2. Start engine and throttle up to full RPM. Select and hold either the outrigger “extend or retract” switch on the cab dash. Adjust the pressure reducing valve integrated in the outrigger control manifold “in” to increase or “out” to decrease so that a gauge pressure of 214 ± 4 bar (3100 ± 50 psi) is achieved (see Figure 2-18).
3. Stop engine. Remove the diagnostic coupler.

Procedure C - For Checking/Setting Air Conditioner Relief Valve Pressure

1. With engine off, install a pressure check diagnostic coupler with gauge onto the diagnostic nipple at GP port of the motor control manifold (see Figure 2-17).
2. Disconnect and cap hose running from the A2 port of the motor control manifold to hydraulic swivel port #6 (see Figure 2-17).
3. Start engine, throttle up to 1500 RPM. With the oil cooler motor off, adjust relief valve in the motor control manifold “in” to increase or “out” to decrease so that a gauge pressure of 103 ± 4 bar (1500 ± 50 psi) (see Figure 2-17).
4. Stop engine. Remove diagnostic couplers and re-connect plumbing.
5. Start engine and throttle up to 1500 rpm. Adjust the relief valve in the motor control manifold “in” to increase or “out” to decrease so that a gauge pressure of 221 ± 3 bar (3200 ±50 psi) is achieved (see Figure 2-17).
6. Stop engine. Remove diagnostic couplers and reconnect plumbing.

Procedure D - For Checking/Setting the Front Steer Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at GP8 port at the inlet of the power steering gearbox (see Figure 2-19).
2. Disconnect hose at right hand front steer cylinder (see Figure 2-20) and plug the hose. Cap or plug the steer cylinder connection to protect it from contamination.

CAUTION

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

3. Start engine and throttle up to full RPM. Fully turn the steering wheel to left or right against axle stop. Adjust the priority flow relief valve in the pump (see Figure 2-19) “in” to increase or “out” to decrease so that a gauge pressure of 150 ± 3 bar (2175 ± 50 psi) is achieved.
4. Stop engine. Remove diagnostic couplers and reconnect plumbing.

Procedure E - For Checking/Setting Swing Brake Release Pressure

1. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at GP4 port of the swing and accessory manifold (see Figure 2-14). Unplug connectors containing wire 50 and 1475. Plug connector containing wire 50 into the solenoid where wire 1475 was connected.
2. Start engine and idle, release swing brake and adjust the swing brake pressure reducing valve “in” to increase or “out” to decrease so that a gauge pressure of 18-20 bar (260-300 psi) is achieved. (see Figure 2-14).
3. If adjustment can’t obtain the setting in step 2, stop engine and install a pressure check diagnostic quick disconnect with gauge onto the test nipple at the GP 2 at the accessory manifold valve (see Figure 2-15). Follow Procedure G to set and then repeat this step.

Procedure F - For Checking/Setting the Pilot Supply Pressure

1. With engine off, install a pressure check diagnostic quick disconnect with gauge onto diagnostic nipple at GP3 of the swing and accessory manifold (see Figure 2-14).
2. Start engine and run at idle, lower left armrest, depress and hold the cab tilt lower switch, adjust the controller pressure reducing valve of the swing and accessory manifold “in” to increase or “out” to decrease so that the

gauge pressure of 28 - 31 bar (400 - 450 psi) is achieved (see Figure 2-14).

3. Stop engine. Remove diagnostic couplers and reconnect plumbing.

Procedure G - For Checking/Setting the Piston Pump (ISX Engine)

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at GP2 port of the swing and accessory manifold (see Figure 2-14).
2. Start engine and idle. Adjust the piston pump (P) differential pressure adjusting screw “in” to increase or “out” to decrease so that a gauge reading of 22 - 32 bar (325 - 425 psi) is achieved (see Figure 2-21).
3. Stop engine. Remove diagnostic couplers.

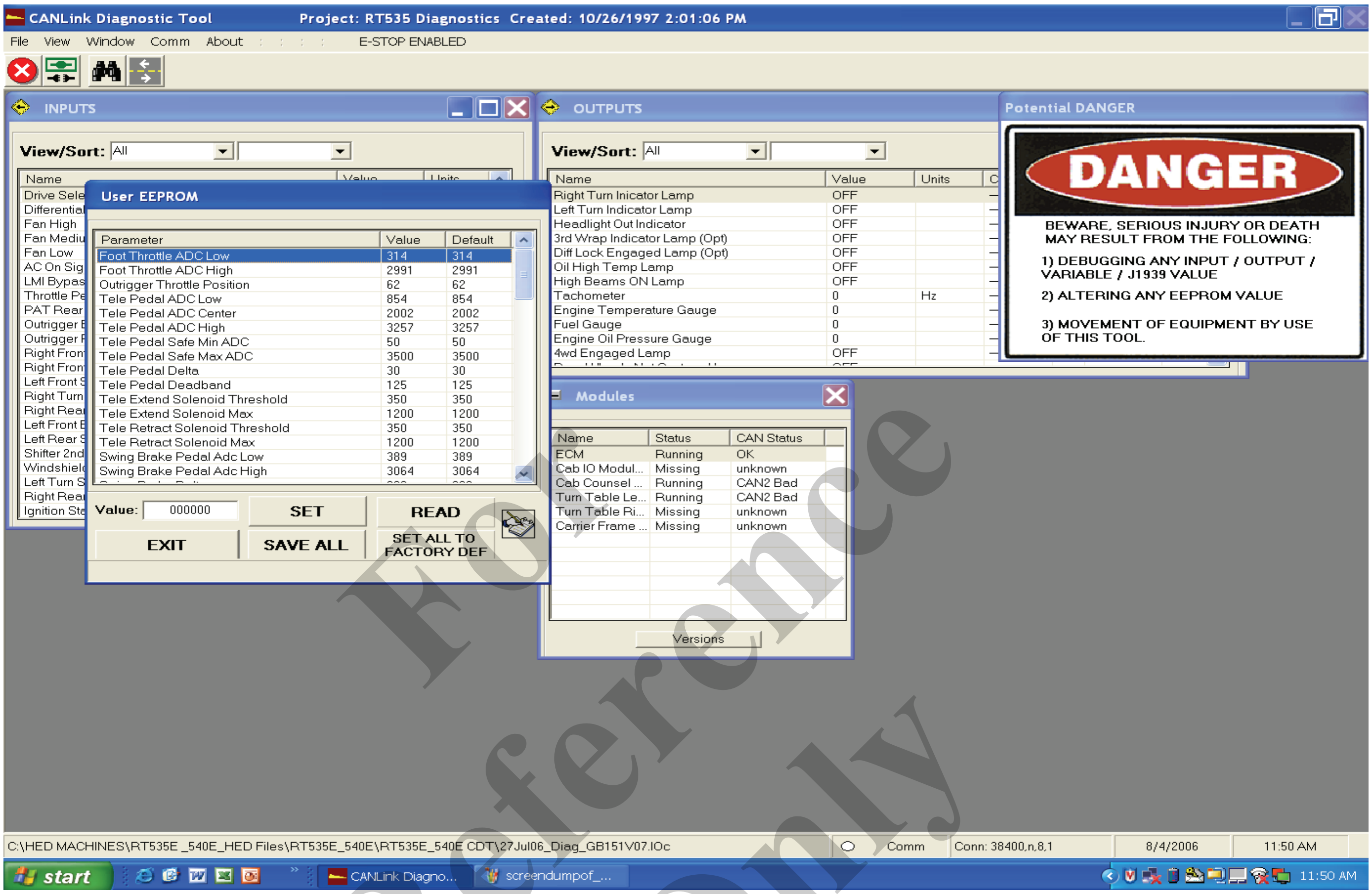
Procedure H - For Checking the Center Front Stabilizer Pressure

1. Install pressure check diagnostic quick disconnect with gauge onto test nipple at GP at the inlet of the center front stabilizer relief valve (see Figure 2-22).
2. Extend the center front stabilizer to the ground and hold switch. Verify that a gauge reading of 10-20 bar (150 - 300 psi) is achieved (see Figure 2-22). This valve is not adjustable.
3. Stop engine. Remove diagnostic couplers.

Procedure I - Procedures for Checking/ Setting the Piston Pumps (GSM Engine)

1. Install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple @ GP2 port of the swing and accessory manifold (see Figure 2-14).
2. Screw out pump #2 adjusting screw two turns to decrease its setting (see Figure 2-21). Start engine and @ idle RPM adjust the piston pump #1 differential setting screw “in” to increase or “out” to decrease so that a gauge reading of 325-375 PSI (22-26 bar) is achieved (see Figure 2-21). With the engine still @ idle RPM adjust the piston pump #2 differential setting screw “in” to increase so that a gauge reading of 375-425 PSI (26-29 bar) is achieved (see figure #8).
3. Stop engine. Remove diagnostic couplers.

Procedure J- For Setting Threshold on Electronic Controllers



1. Attach test fitting and pressure gage in the pilot end caps one at a time at GPA for Main Hoist Up, GPB for Aux Hoist Up, GPC Tele Retract, GPD Lift Down, GPA, and GPB Swing Left and Right.

2. Attach laptop to diagnostic connector in cab and bring up the EPROM settings (see screen above, for an example). Arrange windows so you can view the EPROM Window and Output Window values.

3. Start engine and run at idle RPMs; make sure to lower left armrest.

4. Start with GPA Main Hoist Up. View the pressure gauge and stroke the joystick just off center for Main Hoist in the up position. Watch the pressure gauge; stroke it until it reaches about 6.89 bar (100 psi), hold it there, and look at the value for Main Hoist Up in the Output Window. If the pressure gauge reading goes above 6.89 bar (100 psi), back the value down. To change the value, double-click the value you want to change in the EPROM Window and the value window will turn blue. Enter the value for the Main Hoist Up and select SET and change the Main Hoist Down value with the same setting. Repeat again and make sure it does not exceed 6.89 bar (100 psi). Do not change the default setting for the MAX. Repeat this process for ports GPB, GPC, GPD, and GPA and GPB Swing Left and Right, and enter values to respective functions. Make sure to select SAVE ALL after completing entering the value settings.

5. After setting all the functions and selecting SAVE ALL, select the File Down Load button. Save the file in a folder under the model designation (TMS800E13). Name the file as follows:

(Sales order number_Date). Sample: (123456_2013aug17)

K. Procedure for Setting Threshold and Max on Swing Brake Pedal

1. Attach laptop to diagnostic connector in cab and bring up the EPROM settings (shown in the Figure in section

J.). Arrange windows so you can view the EPROM window & Output Window values

2. Set swing brake center percentage X & Y counts to 500. Attach test fitting and pressure gage GP4 (see in figure #1) port with engine running at idle. Fully depress swing brake pedal. Monitor the pressure gauge and adjust the swing brake solenoid Max counts to reach 16.9 bar (245 psi). Then raise the counts up to reach 17.2 bar (250 psi).To set swing brake solenoid threshold. Slowly depress swing brake pedal down until you reach 1.7 bar (25 psi) on the gauge. Then looking at the swing brake output value, set the swing brake solenoid threshold 5 counts lower than the output value.

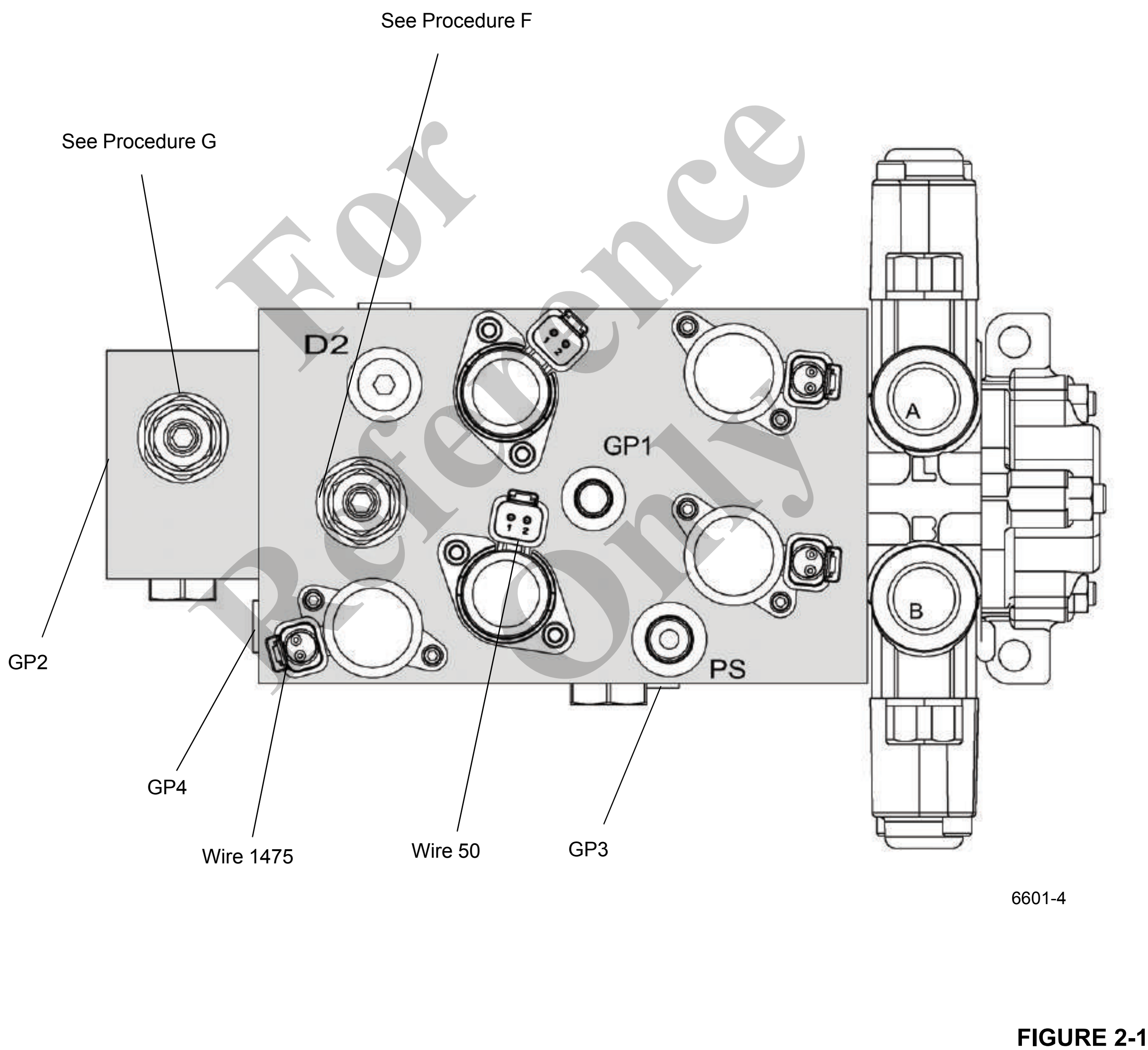


FIGURE 2-14

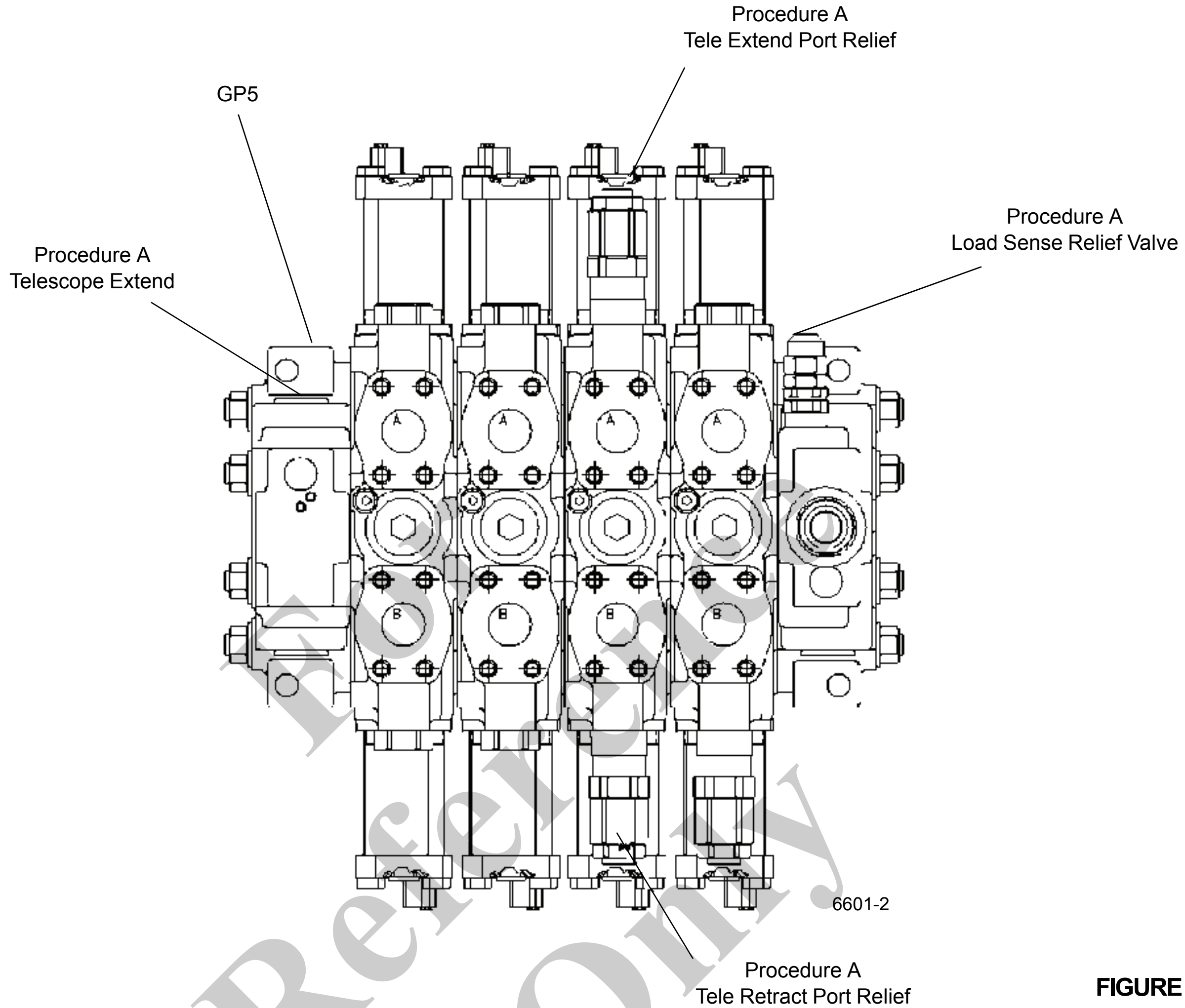


FIGURE 2-15

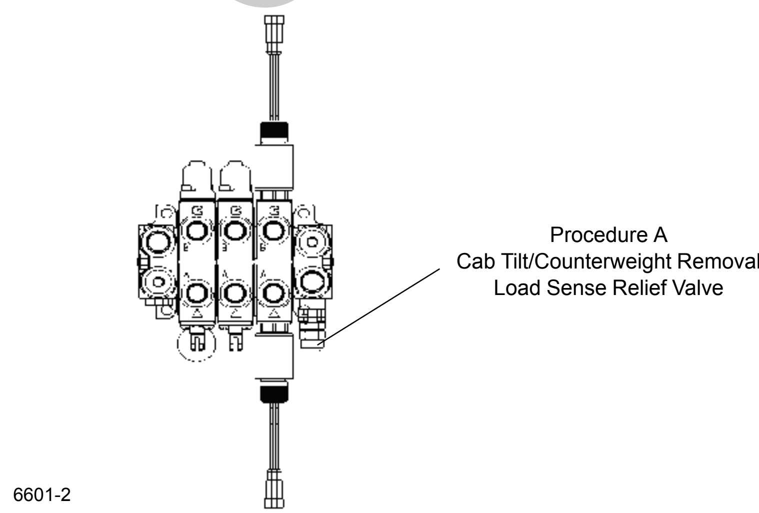


FIGURE 2-16

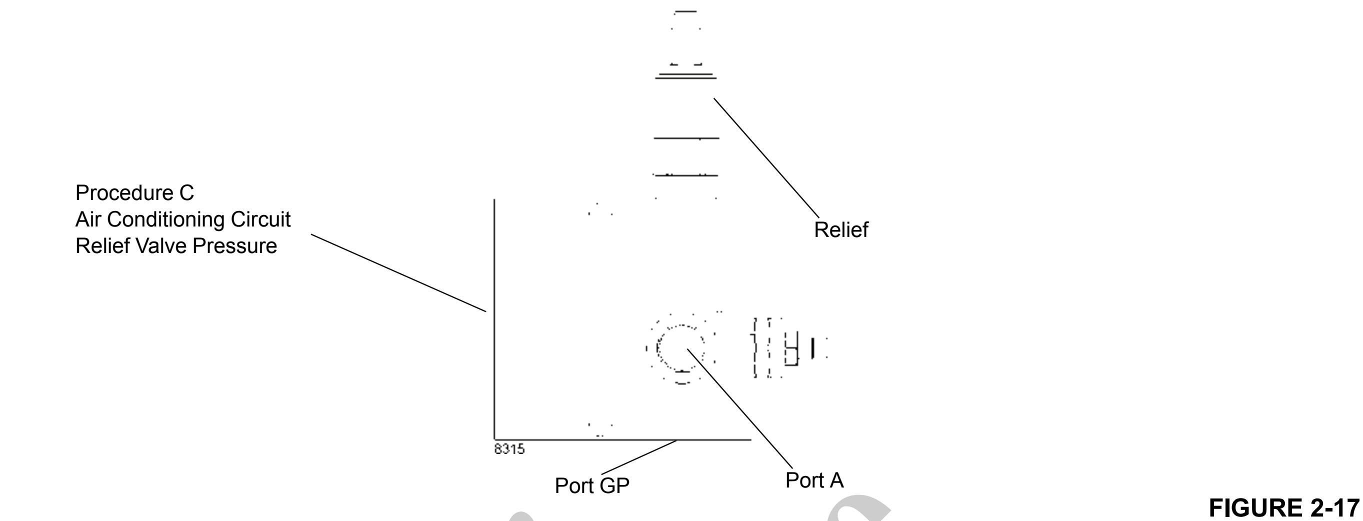


FIGURE 2-17

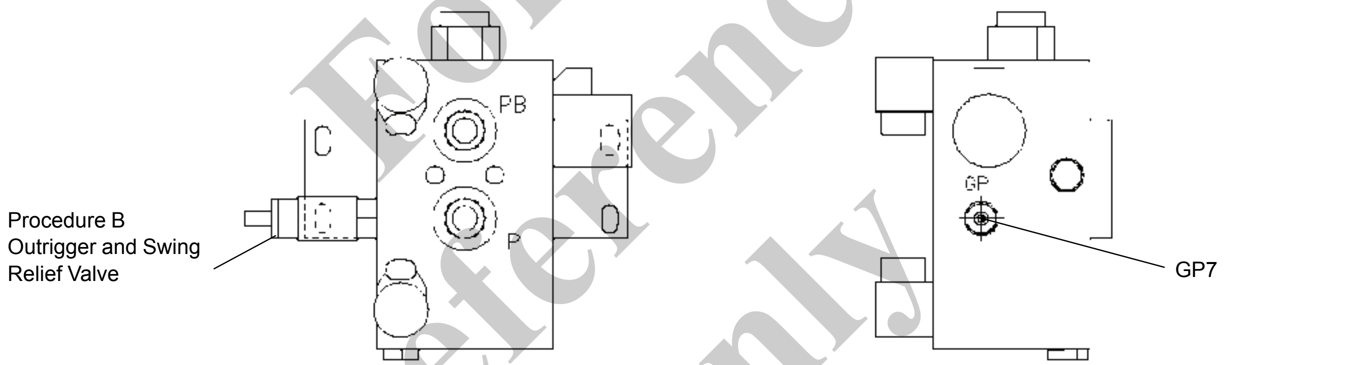


FIGURE 2-18

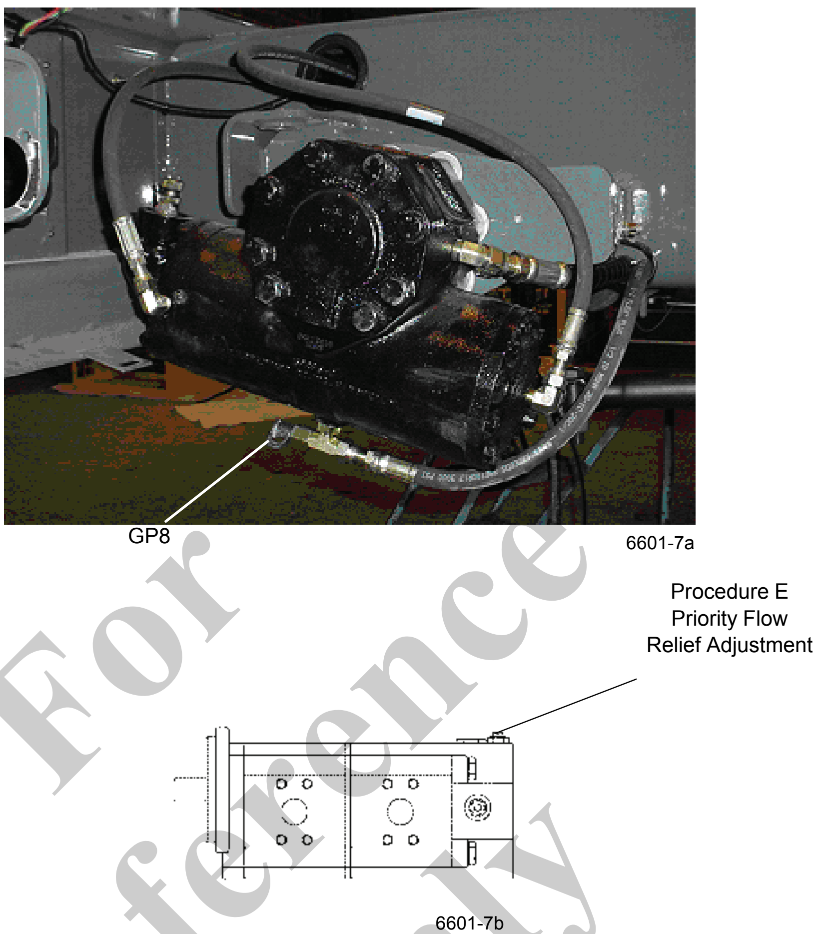


FIGURE 2-19

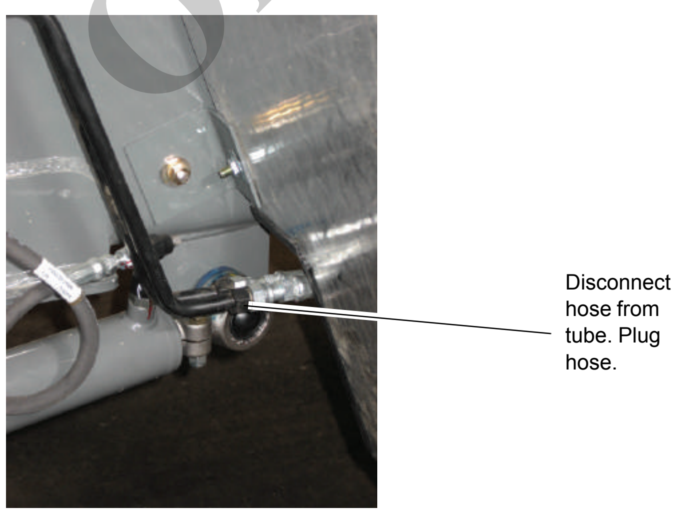


FIGURE 2-20

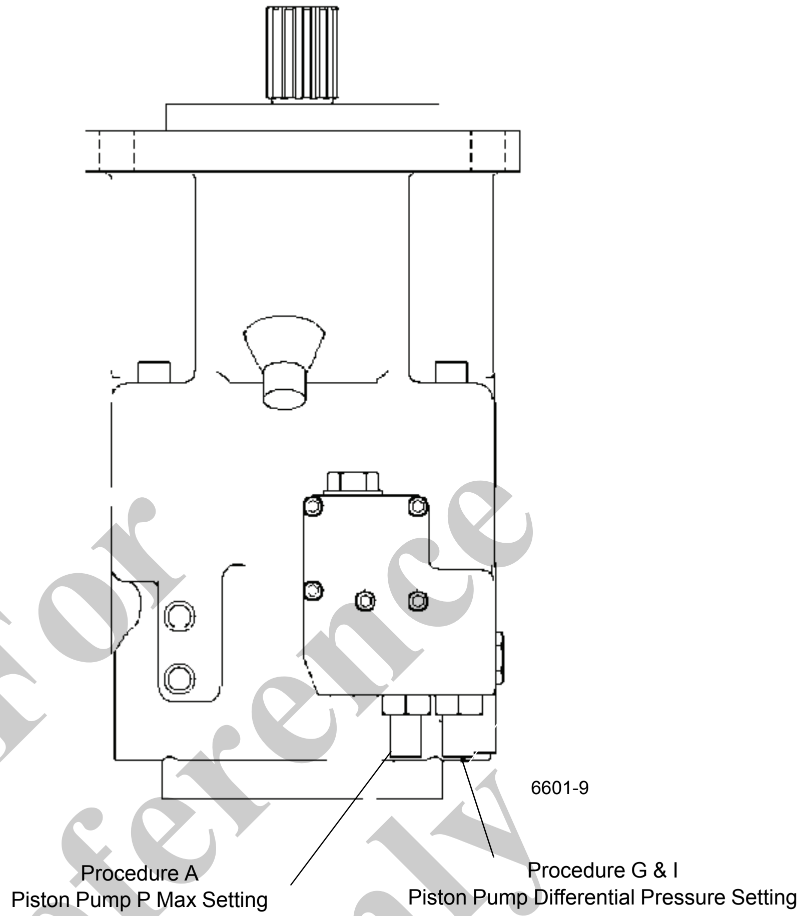


FIGURE 2-21

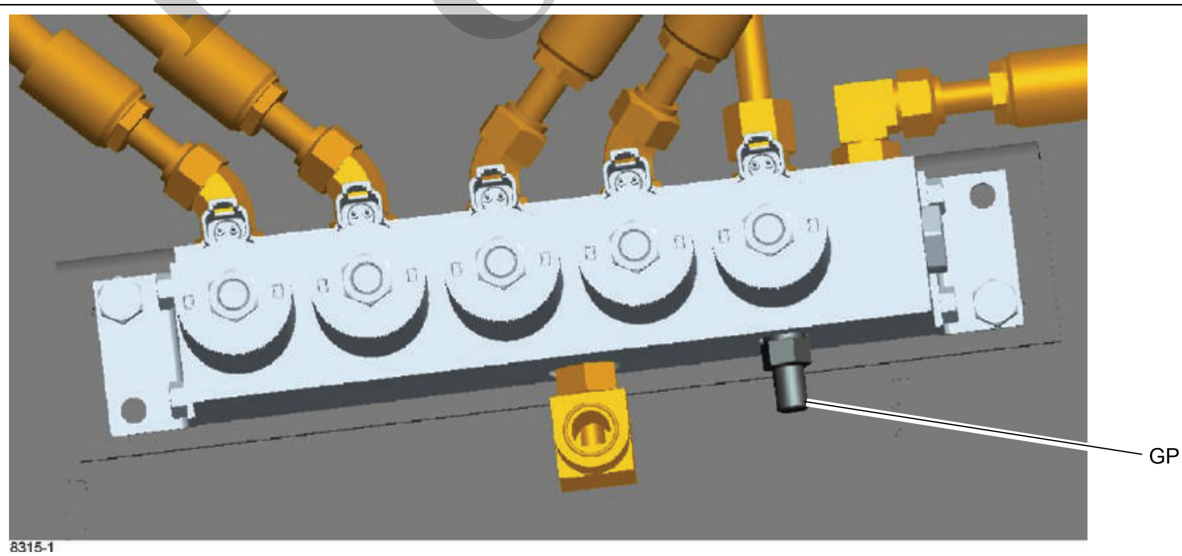


FIGURE 2-22

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, and the counterweight removal/cab tilt cylinders. 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 (see Figure 2-23) is a sectional, three position four way, pressure compensated, closed center directional valves. The inlet section contains a load sense relief valve set at 275.8 bar (4000 psi) protecting the main and auxiliary hoist and boom lift sections. The boom lift retract has a thermal port relief set at 296.5 bar (4300 psi). The telescope section has port relief's set at 238.6 bar (3460 psi) for retract and 179.3 bar (2600 psi) for extend. All working sections have a two position two way solenoid RCL lockout valve in each pilot end cap.

The counterweight removal/cab tilt directional control valve (see Figure 2-24) is a sectional, 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 172.4 bar (2500 psi) protecting all three working sections.

Maintenance

CAUTION

The approximate weight of the directional control valve is 81 kg (217 lb).

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 capscrews and washers 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 capscrews and washers. Torque capscrews refer to *Fasteners and Torque Values*, page 1-13.
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/Cab Tilt Valve Bank Removal

1. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.
2. Remove the cotter pins, clevis pins, and washers securing the control levers to the clevis on each valve.
3. Remove the locknut, bolt, and bushings securing each set of control levers to the bracket and remove the control levers.
4. Remove the capscrews, washers and nuts securing the valve bank to the mounting bracket and remove the valve bank.

Counterweight Removal/Cab Tilt Valve Bank Installation

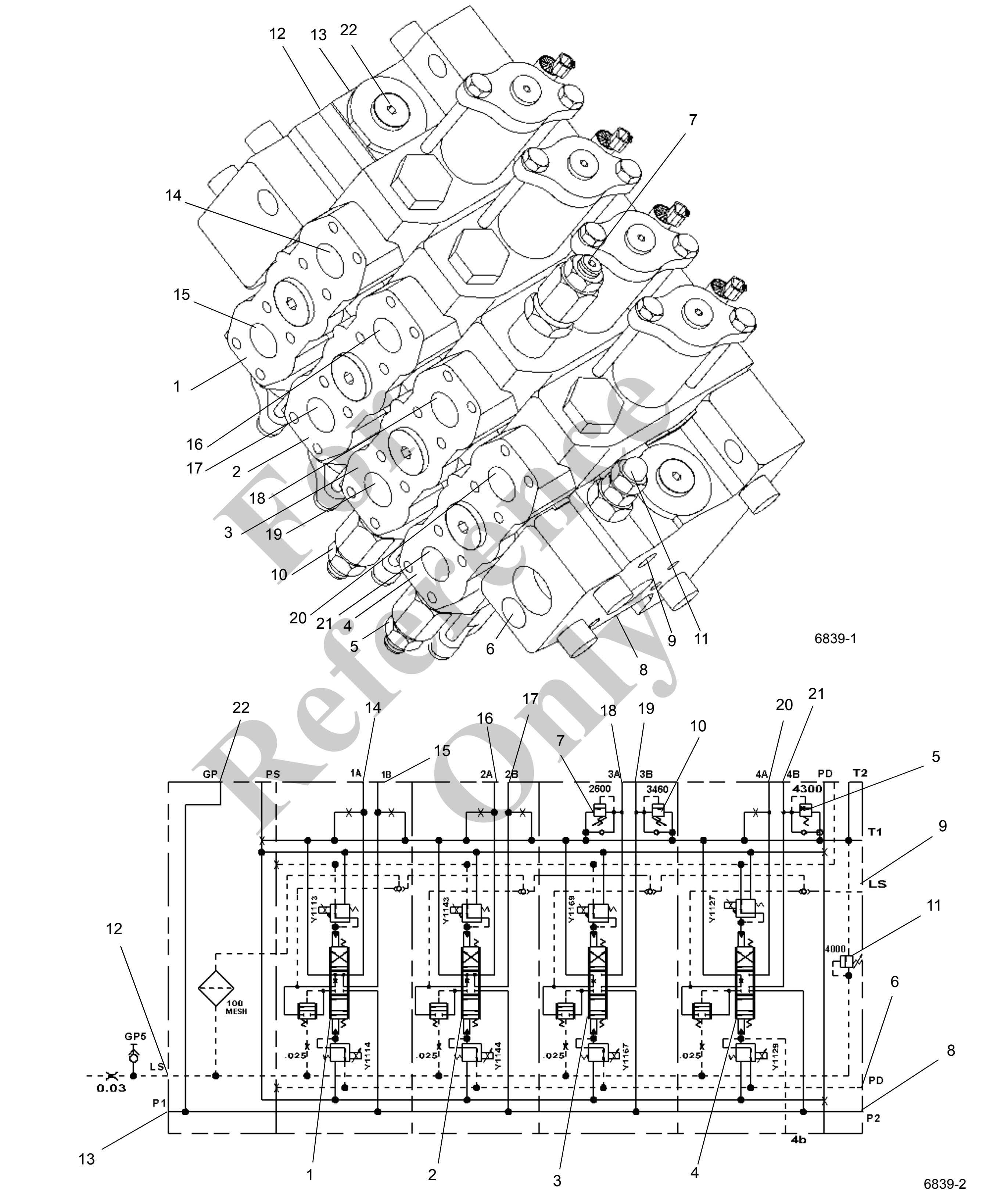
1. Position the valve bank on the mounting bracket and secure with the capscrews, washers and nuts. Torque the capscrews refer to *Fasteners and Torque Values*, page 1-13.
2. Attach the control levers to the bracket using the bushings, bolts, and locknuts.
3. Attach the control levers to the clevis on each valve with two washers, a clevis pin, and a cotter pin.
4. 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 levers of the valve bank(s). Check for smooth operation of cylinders and motors.
3. Check the valve bank(s) and lines for leakage. Make repairs as needed.

Functional Check (RCL Lockout Valves)

1. Remove fuse F12 from the circuit breaker panel in the superstructure cab. This cuts off power to the RCL.
2. Start the engine.
3. Try to extend the boom out, lower the boom, hoist up the main hoist, and hoist the auxiliary hoist up (if installed). Verify none of these functions work.
4. Shut down the engine. Reinstall fuse F12.
5. Extend the boom, 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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GP
PS
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1B
2A
2B
3A
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4A
4B
PD
T2
2600
3460
4300
T1
LS
Y1113
Y1143
Y1169
Y1127
11
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4000
6
100 MESH
GP5
.025
Y1114
Y1144
Y1167
Y1129
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LS
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6839-2

FIGURE 2-23

Item	Description
1	Main Hoist Directional Valve
2	Auxiliary Hoist Directional Valve
3	Telescope Directional Valve
4	Lift Directional Valve
5	Thermal Relief Valve
6	Pilot Drain Port (PD)
7	Telescope Extend Relief Valve
8	Inlet Port (P2)
9	Load Sense Input Port (LS)
10	Telescope Retract Relief Valve
11	Load Sense Relief

Item	Description
12	Load Sense Outlet (Not Shown)
13	Inlet Port (P1) (Not Shown)
14	Main Hoist Up (A Port)
15	Main Hoist Down (B Port)
16	Auxiliary Hoist Up (A Port)
17	Auxiliary Hoist Down (B Port)
18	Telescope Out (A Port)
19	Telescope In (B Port)
20	Lift Up (A Port)
21	Lift Down (B Port)
22	Gage Port (GP)

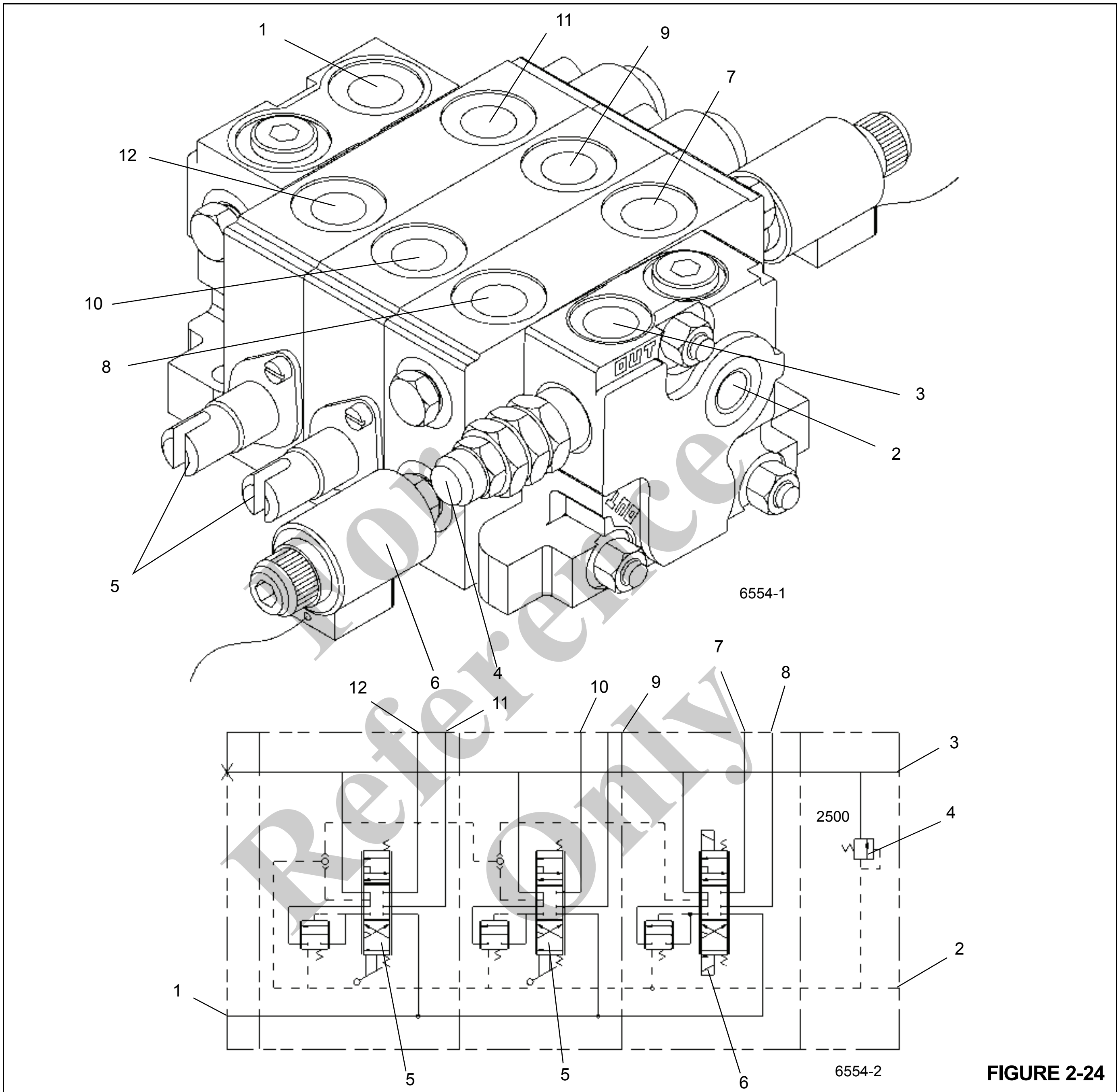


FIGURE 2-24

Item	Description	Item	Description
1	Inlet	7	Cab Tilt Up (A Port)
2	Load Sense Port (LS)	8	Cab Tilt Down (B Port)
3	Outlet	9	Port 2B (To L H Cwt Removal Cylinder (Retract)
4	Load Sense Relief	10	Port 2A (To L H Cwt Removal Cylinder (Extend)
5	Counterweight Removal Directional Valve	11	Port 1B (To R H Cwt Removal Cylinder (Retract)
6	Cab Tilt Directional Valve	12	Port 1A (To R H Cwt Removal Cylinder (Extend)

CHECK VALVES

Description

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

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

Maintenance

Removal

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

Installation

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

OUTRIGGER SELECTOR VALVE

Description

The outrigger selector valve (see Figure 2-25) directionally controls the outrigger circuit. The valve is mounted on the center of the carrier frame near the bearing. It receives pump flow from the gear pump outlet of pump #2.

The valve contains a 214 bar (3100 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. The valve also contains a three position four way solenoid directional control valve and 2 two-position, three way solenoid valves that controls outrigger extend and retract.

Maintenance

Removal

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

Installation

1. Attach the outrigger selector valve to the frame. Secure the valve with the washers and bolts. Torque bolts, refer to *Fasteners and Torque Values*, page 1-13.
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.

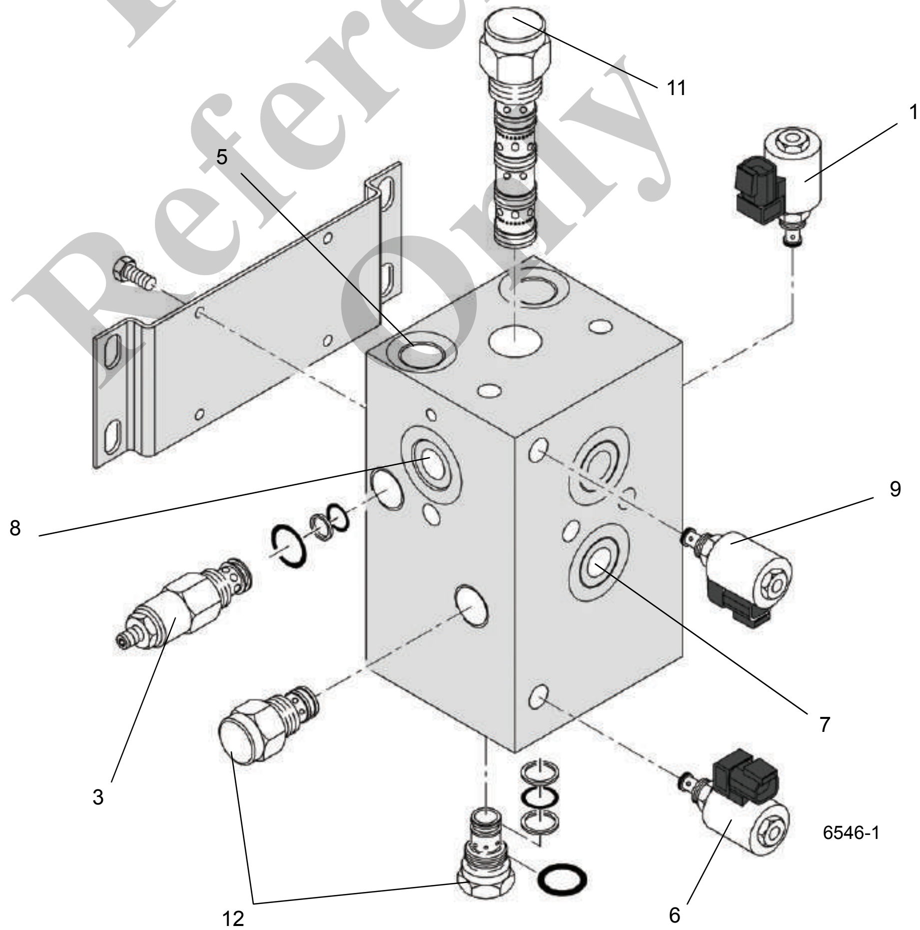


FIGURE 2-25

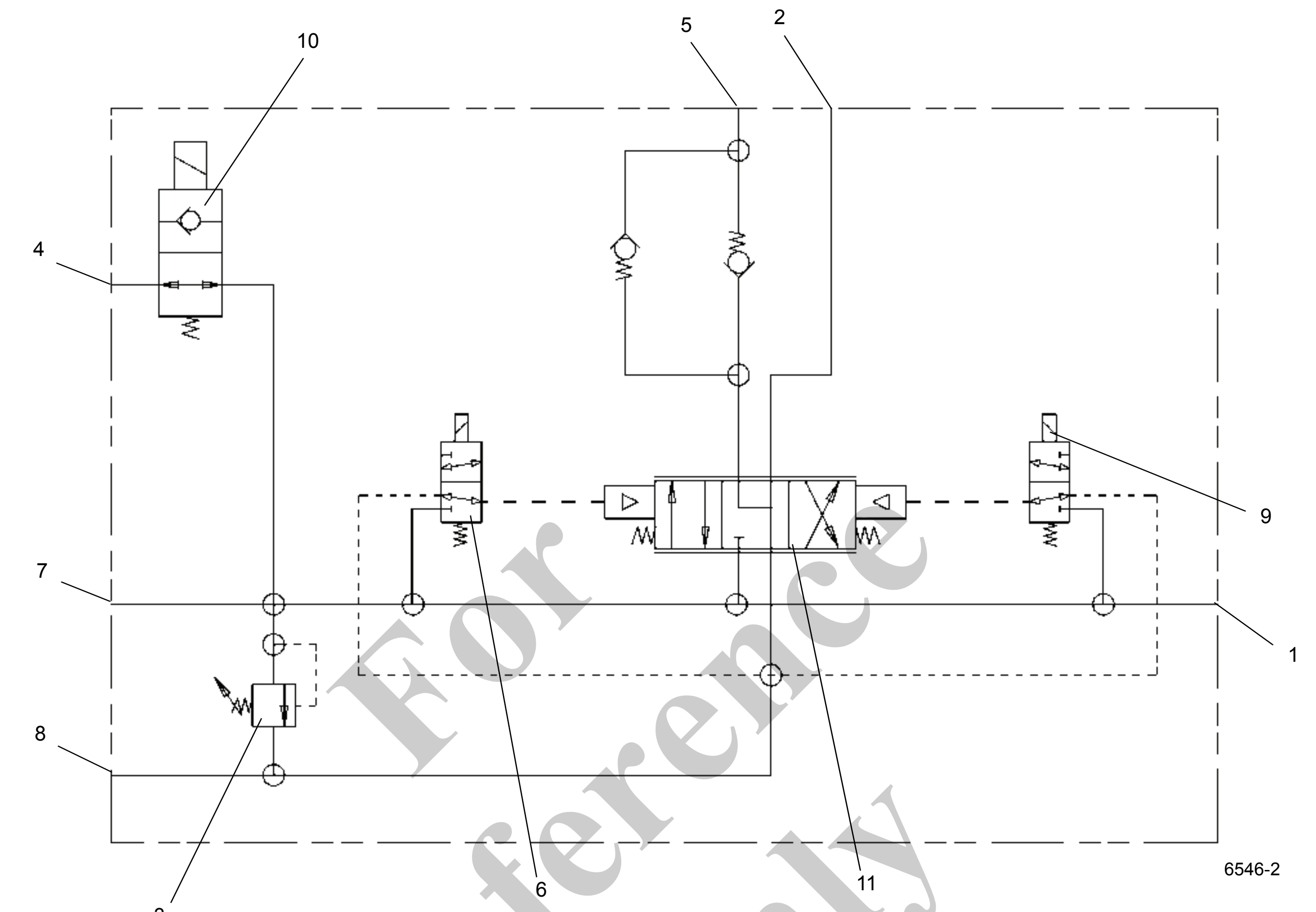


FIGURE 2-25 continued

Item	Description
1	Gauge Port (GP7)
2	Port B (To Front and Rear Outrigger Outrigger Control Manifolds
3	Relief Valve
4	Pressure Beyond Port (PB)
5	Port A (To Stabilizer Cylinders)
6	Solenoid Valve (Retract)

Item	Description
7	Inlet Port (P)
8	Tank Port (T)
9	Solenoid Valve (Extend)
10	Solenoid Valve (Pressure Beyond)
11	Directional Control Valve (Retract - Extend)
12	Check Valves (Cylinder Retract)

OUTRIGGER CONTROL MANIFOLD

Description

There are two outrigger control manifolds utilized on the crane, one for the front outriggers (see Figure 2-26) and one for the rear outriggers (see Figure 2-27). 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 mounting; secure with the washers, nuts and bolts. Torque bolts, refer to *Fasteners and Torque Values*, page 1-13.
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.

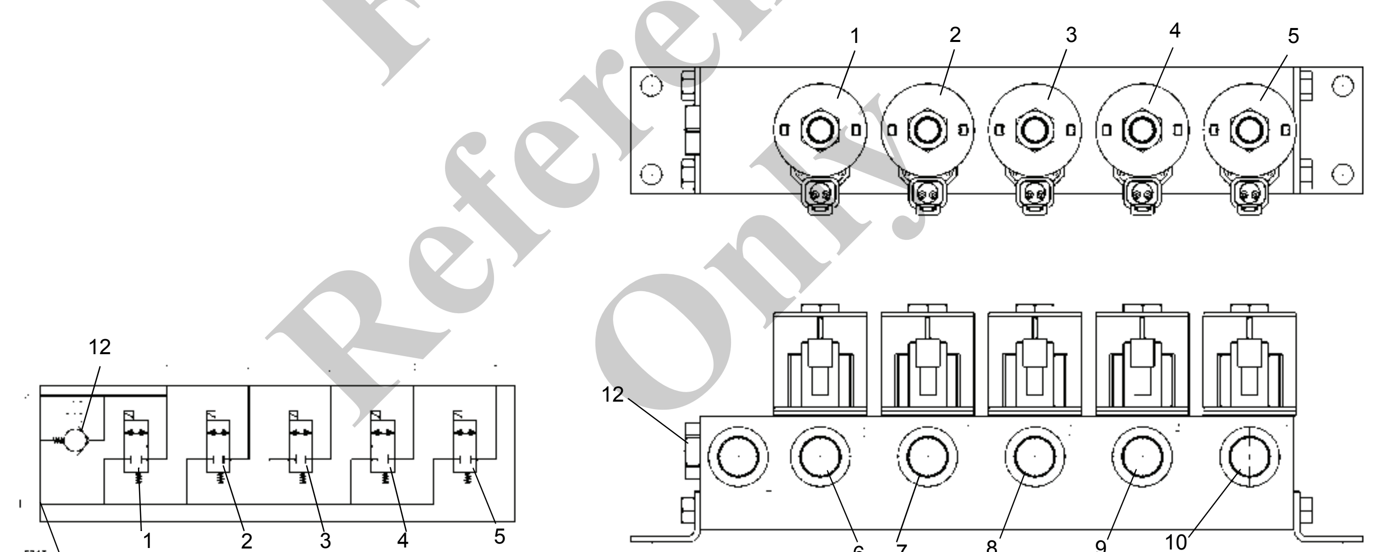


FIGURE 2-26

Item	Description
1	Solenoid Valve (Center Front Stabilizer Cyl)
2	Solenoid Valve (Left Front Extension Cyl)
3	Solenoid Valve (Left Front Stabilizer Cyl)
4	Solenoid Valve (Right Front Stabilizer Cyl)
5	Solenoid Valve (Right Front Extension Cyl)
6	Outlet Port (Center Front Stabilizer)

Item	Description
7	Outlet Port (Left Front Extension Cyl)
8	Outlet Port (Left Front Stabilizer Cyl)
9	Outlet Port (Right Front Stabilizer Cyl)
10	Outlet Port (Right Front Extension Cyl)
11	In Port (From Port B of Outrigger Selector Valve)
12	Check Valve

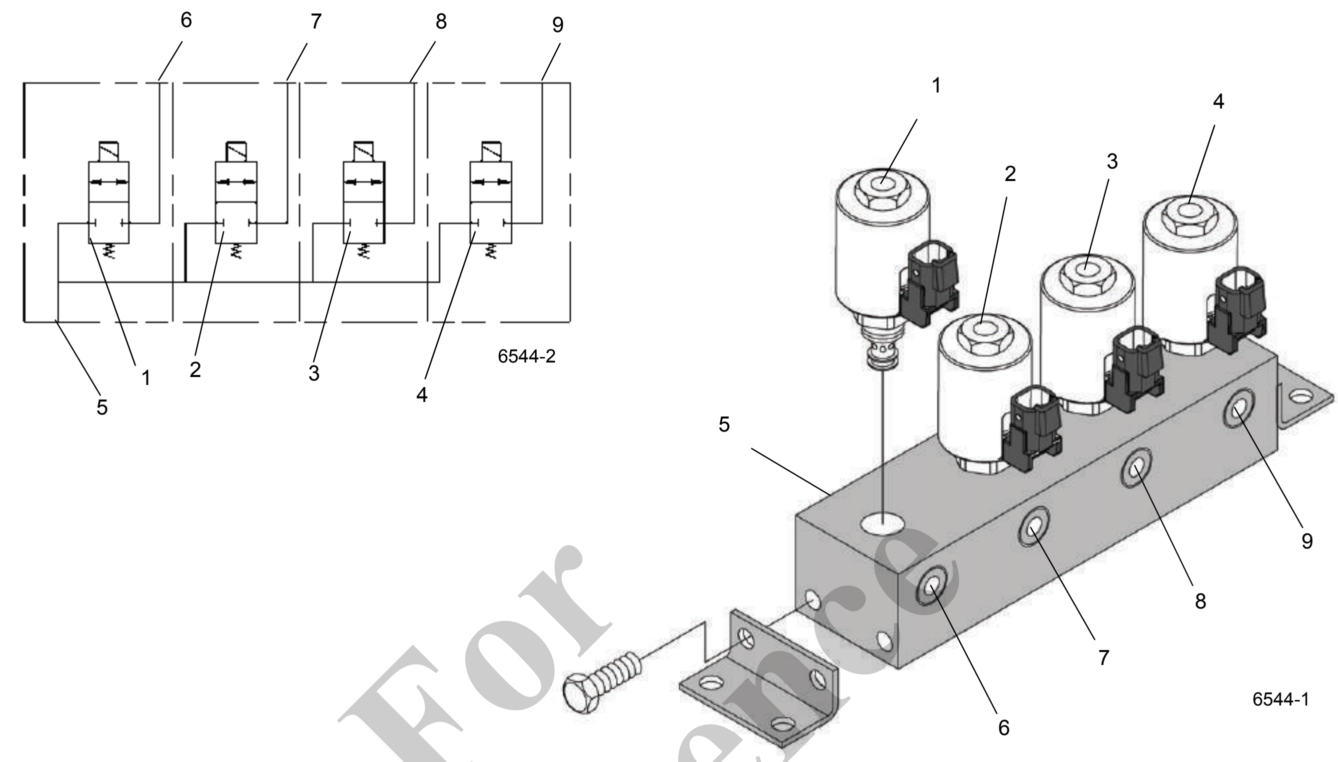


FIGURE 2-27

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

Item	Description
6	Outlet Port (Right Rear Extension Cylinder)
7	Outlet Port (Right Rear Stabilizer Cylinder)
8	Outlet Port (Left Rear Stabilizer Cylinder)
9	Outlet Port (Left Rear Extension Cylinder)

PILOT OPERATED CHECK VALVE

Description

A pilot operated (PO) check valve (see Figure 2-28) is located in each outrigger stabilizer cylinder port block. The check valve functions as a holding valve for the stabilizer cylinder. Oil flow is directed from the “V” port to the “C” ports, while blocking flow in the opposite direction. Flow is reversed from “C” to “V” when pressure pilot oil is applied to the opposite side “V” port.

Maintenance

Removal

DANGER

Do not remove check valve with load on cylinder.

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

Installation

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

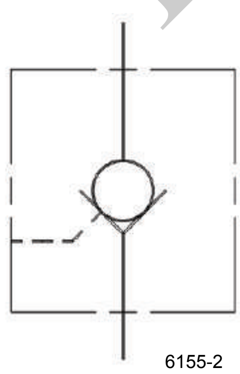
CAUTION

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 stabilizer 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



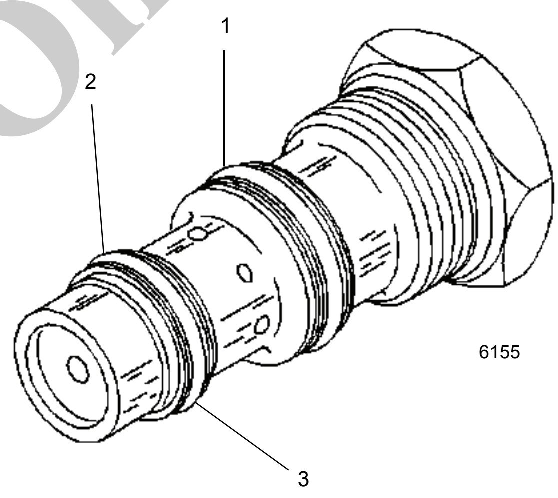


FIGURE 2-28

CAB TILT DOUBLE PILOT OPERATED CHECK VALVE

Description

The cab tilt double pilot operated (PO) check valve (see Figure 2-29) is located on the left side of the superstructure side plate. It is used to hold or lock the cab tilt cylinder in place. Oil flow is directed from the “V” ports to the “C” ports, while blocking flow in the opposite direction. Flow is reversed from “C” to “V” when pressure pilot oil is applied to the opposite side “V” port.

Maintenance

Removal

CAUTION

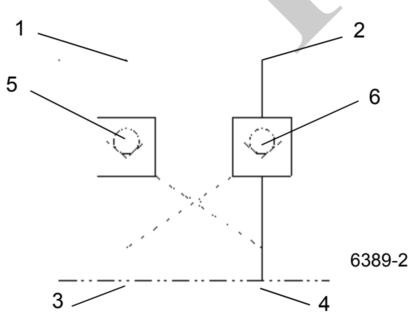
Completely lower the cab before disconnecting valve plumbing.

1. Tag and disconnect the hydraulic lines running to the valve. Cap or plug all openings.
2. Remove the capscrews and lockwashers securing the valve to the plate and remove the valve.

Installation

1. Install the valve to the plate and secure with the capscrews and lockwashers. Torque the capscrews refer to *Fasteners and Torque Values*, page 1-13.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Operate the applicable function and check the valve for proper operation and any leaks.
4. Test the check valve by operating the cab tilt cylinder. Verify it extends and retracts without problems; verify there is no leaking. Make repairs as needed.

Item	Description
1	Port C1 - To Cab Tilt Cylinder - Extend
2	Port C2 - To Cab Tilt Cylinder - Retract
3	Port V1- Cab Tilt Valve (Not Shown)
4	Port V2 - Cab Tilt valve (Not Shown)
5	Check Valve A Ports Of Directional Valve
6	Check Valve B Ports Of Directional Valve



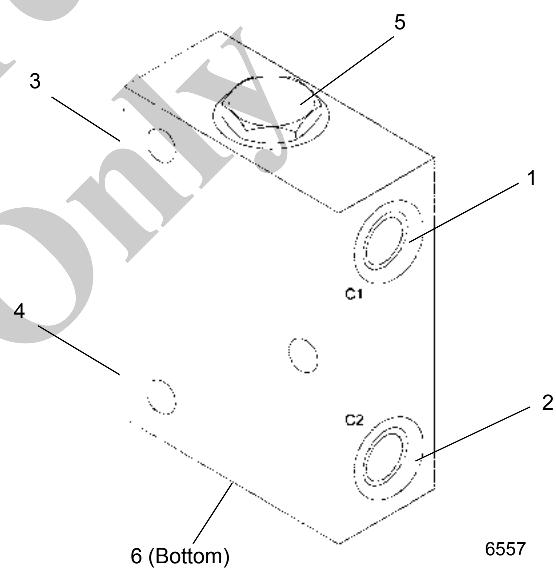


FIGURE 2-29

HOLDING VALVES

Description

A bolt-on manifold style holding valve is installed on the boom lift cylinder.

A cartridge style holding valve is used 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

DANGER

The trombone cylinder must be fully retracted and the conventional cylinder must be fully extended or retracted before removal.

Lower Lift Cylinder Holding Valve

Removal

WARNING

Pinch Point Hazard!

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

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

WARNING

Flying Object Hazard!

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

FIGURE 2-30

4. From the access holes in the opposite side of the boom, relieve the pressure in the lower telescope cylinder by loosening the bleed plug, (35, Figure 2-44).

FIGURE 2-31

5. Unscrew holding valve from its port block. (See Figure 2-31 and Figure 2-44.)

Installation

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

CAUTION

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

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

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

5. Remove the telescope hold valve tool.

6. Test the check valve and port block by operating the telescope cylinder. Verify telescope cylinder works without problems; verify there is no leaking. Make repairs as needed.

Cartridge Style Holding Valve

Removal

Unscrew holding valve from its port block. (See Figure 2-32.)

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.

Manifold Style Holding Valve

DANGER

The cylinder must be fully retracted before removal.

Removal

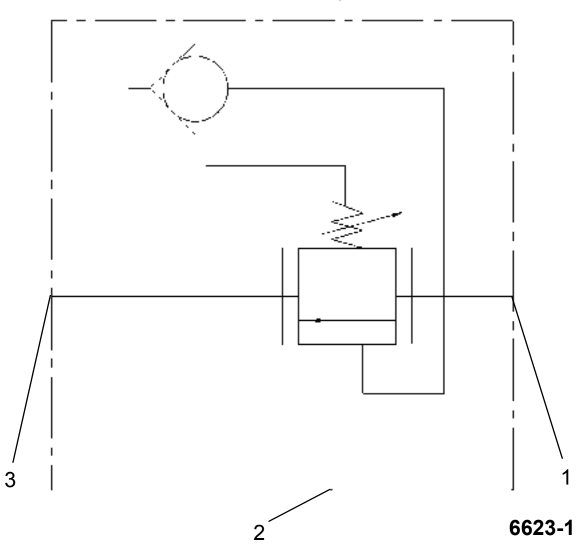
1. Disconnect the tubing from the manifold.

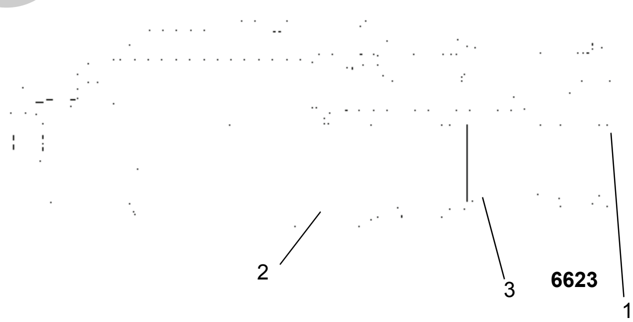
2. Remove the screws and washers securing the holding valve manifold.

Installation

1. Install the valve manifold and secure with the screws and washers. Torque the screws refer to *Fasteners and Torque Values*, page 1-13.

2. Connect the tubing to the valve.





Item	Description
1	Cylinder Port
2	Pilot
3	Valve Port

FIGURE 2-32

Published 01-29-2014, Control # 496-00

ACCESSORY MANIFOLD WITH SWING DIRECTIONAL CONTROL VALVE

Description

The accessory manifold with swing directional valve (see Figure 2-33) is located on the right side of the turntable. The manifold contains two adjustable pressure reducing valves, five 3-way two position solenoid valves, 3-way four position swing directional valve, and a check valve.

One pressure reducing valve provides 17.2 bar (250 psi) for operation of the swing brake. The other provides 31 bar (450 psi) for the pilot circuit.

Each solenoid valve is held in its normally closed 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 two position, three way solenoid valve serves as the swing brake release valve. This normally closed valve, when de-energized, prevents hydraulic oil pressure from releasing the swing brake. When the swing brake switch is off, this valve opens to allow hydraulic oil pressure to release the swing brake.

One proportional two position, three way solenoid valve actuated by the cab swing foot brake proportionally supplies pressurized oil to the swing drive brake.

The three position four-way swing directional valve is installed onto the manifold. Both swing working ports have check valves that are flooded by a 4.1 bar (60 psi) resistance check valve providing make-up oil to the swing motor for motor over-run when the valve is centered. It receives oil from pump #2 through swivel port 3. This section is controlled by two proportional two position, three way solenoid valves. These valves receive an electrical signal from the cab armrest controllers.

Maintenance

Removal

1. Tag and disconnect the electrical connectors to the manifold.
2. Tag and disconnect the hydraulic lines from the manifold. Cap or plug the lines and ports.
3. Remove the bolts, spring lockwashers, and flatwashers securing the manifold. Remove the manifold.

Installation

1. Install the manifold on turntable and secure with bolts, flatwashers and spring lockwashers. Torque bolts refer to *Fasteners and Torque Values*, page 1-13.
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 (push bottom of switch). Verify the LED indicator in the front console switch goes out.
2. Swing the turntable to verify the swing brake has released. Step on the swing brake pedal to stop the turntable.
3. Position the swing brake switch to ON (push top of switch). Verify the LED indicator in the front console 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.

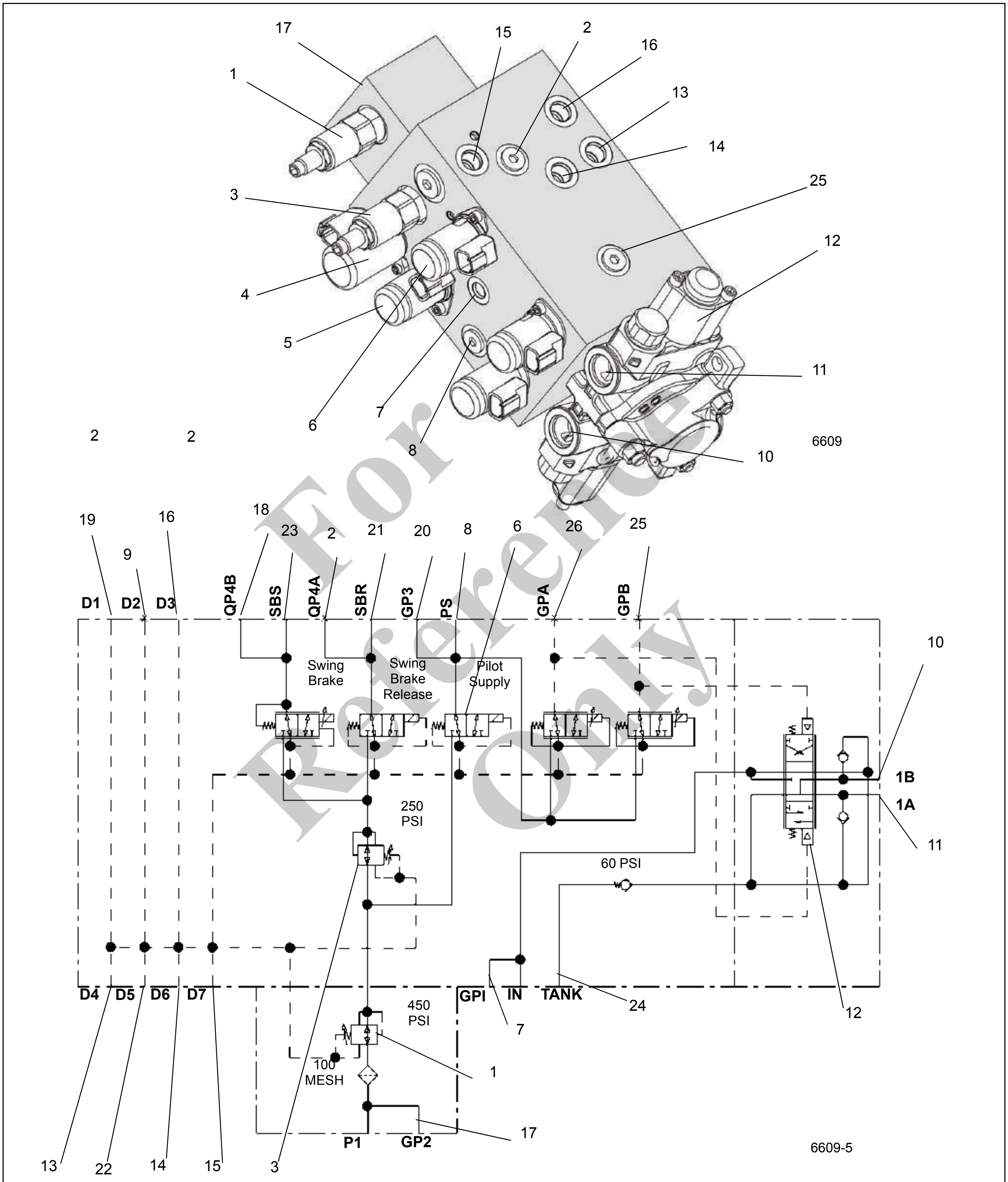
Functional Check - Crane Function Control

1. Turn the crane function switch to OFF (push bottom of 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 the crane function switch to ON (push top of 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 P1 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.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26
25
9
D1
D2
D3
QP4B
SBS
QP4A
SBR
GP3
PS
GPA
GPB
Swing
Brake
Swing
Brake
Release
Pilot
Supply
10
1B
1A
11
250
PSI
60 PSI
D4
D5
D6
D7
GPI
IN
TANK
24
12
450
PSI
7
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MESH
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17
P1
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FIGURE 2-33

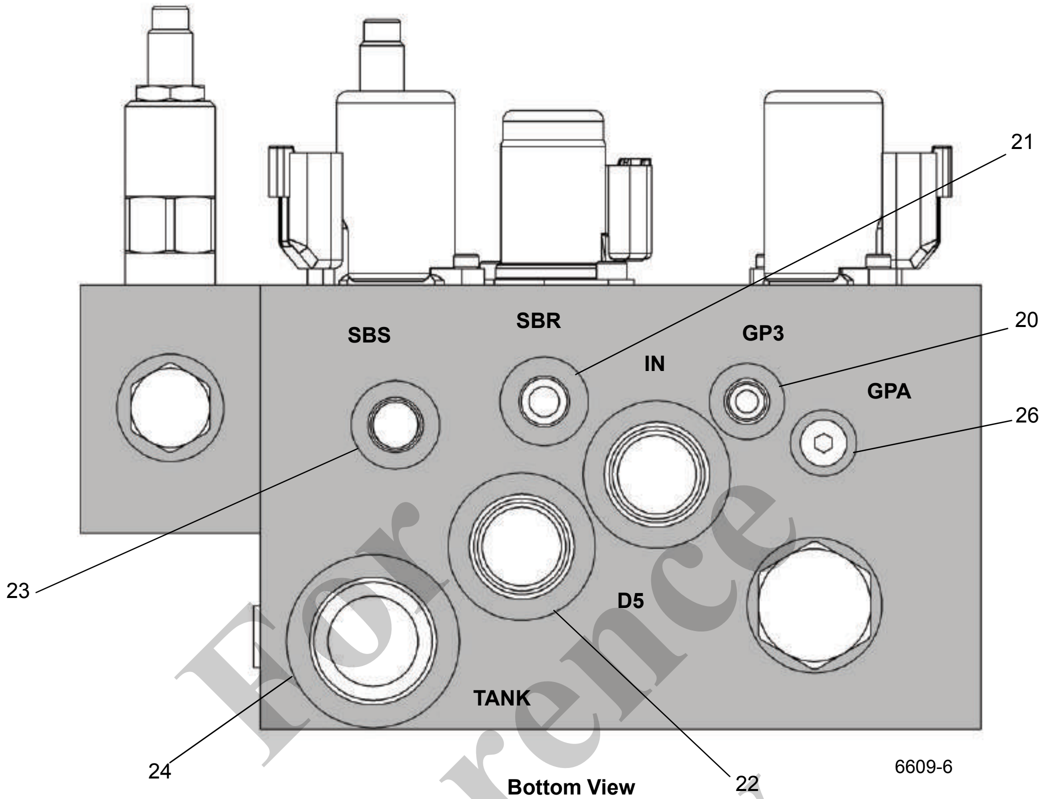

FIGURE 2-33 continued

Item	Description
1	Pilot Supply Relief Valve (450 psi)
2	Gauge Port (QP4A)
3	Swing Brake Relief Valve (250 psi)
4	Solenoid Valve (Swing Brake)
5	Solenoid Valve (Swing Brake Release)
6	Solenoid Valve (Pilot Supply)
7	Gauge Port (GP1)
8	Pilot Supply Port (PS)
9	Plugged (D2)
10	Port 1B (Swing Left)
11	Port 1A (Swing Right)
12	Swing Directional Valve

Item	Description
13	Drain Port D4 (Swing Motor Pilot Supply)
14	Drain Port D6 (Hoist/Tele/Lift Valve Pilot Supply)
15	Drain Port D7 (Swing Brake Lift Cylinder Pilot)
16	Drain Port D3 (Plugged)
17	Gauge Port (GP2)
18	Gauge Port (QP4B) (Not Shown)
19	Drain Port D1
20	Gauge Port (GP3)
21	Swing Brake Release Port (SBR)
22	Drain Port D5
23	Swing Brake Supply Port (SBS)
24	Tank Port
25	Gauge Port (GPB)
26	Gauge Port (GPA)

MOTOR CONTROL MANIFOLD

Description

The motor control valve manifold (see Figure 2-34) is installed in the center of the frame. The purpose of the valve is to provide simultaneously proportional control of the oil cooler motor and a constant flow to the optional superstructure air conditioner motor.

The manifold contains a two-position, 4 way solenoid valve, an adjustable relief valve and a proportional flow control cartridge.

Priority flow is from section 1 of pump #3 to a proportional solenoid valve in the manifold. The solenoid is energized sending flow to swivel port 6 to the air condition option. Excess flow is routed to the hydraulic oil cooler at 8.0 gpm by the proportional flow control valve in the manifold. If a signal is received from the oil cooler temperature sender, the other proportional valve is energized and priority flow is routed to the oil cooler motor.

Maintenance

Removal

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

Installation

1. Install the valve to the frame and secure with the bolts and washers. Torque the bolts refer to *Fasteners and Torque Values*, page 1-13.
2. Connect the hydraulic lines to the valve as tagged during removal.
3. Check valve and hydraulic connections for leaks. Make repairs as necessary.

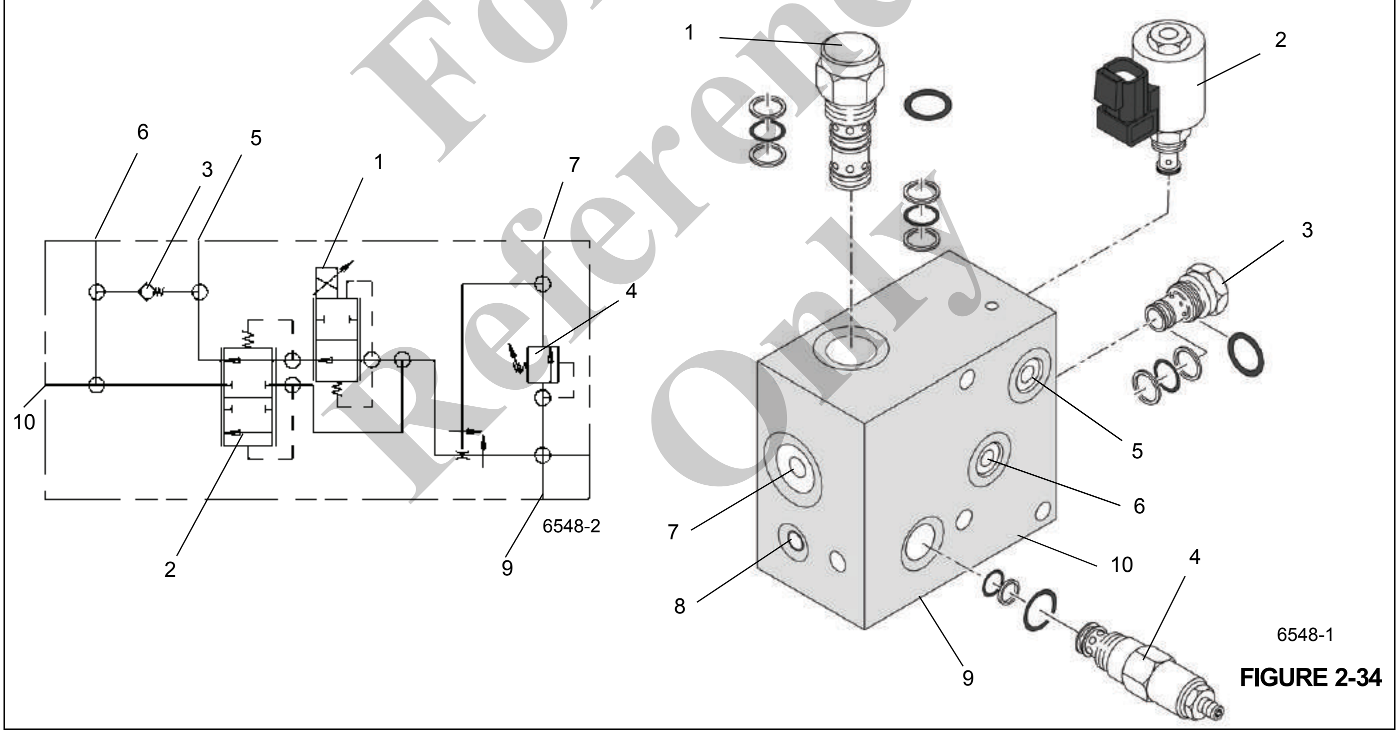

FIGURE 2-34

Item	Description
1	Proportional Flow Control Cartridge
2	Valve
3	Check Valve
4	Adjustable Relief Valve
5	Port A1 (Hydraulic Oil Cooler) - Motor Supply

Item	Description
6	Port B1 (Hydraulic Oil Cooler) - Motor Return
7	Tank Port (T)
8	Gauge Port (GP)
9	Pressure Port (P) (Not Shown)
10	Port A2 (To Swivel Port 6 Air Condition Option) (Not Shown)

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

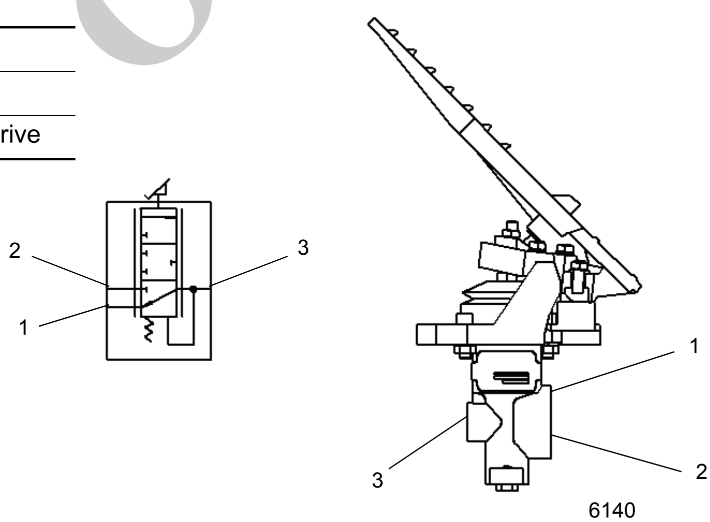

FIGURE 2-35

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.

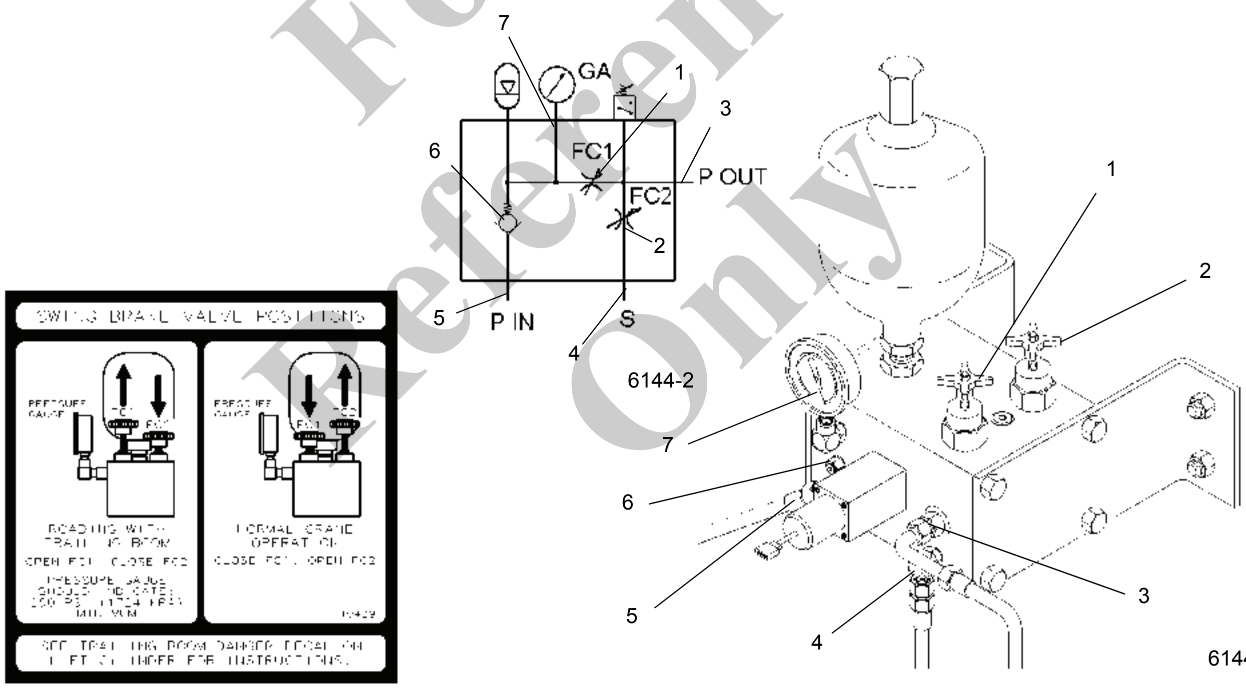

FIGURE 2-36

Item	Description
1	Needle Valve FC1
2	Needle Valve FC2
3	Port P - To Swing Brake Release
4	Port S - From Swing Brake Manifold
5	Port P - Pressure In
6	Check Valve - CK 1
7	Pressure Gauge

NEEDLE VALVE (OPTIONAL)

Description

The two lift cylinder mounted needle valves (1, Figure 2-37) 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 (OPTIONAL)

Description

A needle valve (2, Figure 2-37) 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.

FIGURE 2-37

CYLINDERS

General

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

Maintenance

General

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

The approximate wear ring gaps are as follows:

Table 2-3
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

Cylinder Rod-Surface Protection

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

It is recommended that all exposed cylinder rods be protected using Boeshield® T-9 Premium Metal Protectant. Manitowoc Crane Care has Boeshield® T-9 Premium Metal Protectant available in 12 oz. cans that can be ordered through the Parts Department.

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

Leakage Check

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

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

CAUTION

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

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

CAUTION

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

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

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 25 feet in which the oil cools 60°F would retract approximately 7 3/4 inches (see chart below). A cylinder extended 5 feet in which the oil cools 60°F would only retract approximately 1 1/2 inches. The rate at which the oil cools depends on many factors and will be more noticeable with a larger difference in oil temperature verses the ambient temperature.

Thermal contraction coupled with improper 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 tables (see 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 tables are for dry rod cylinders. If the cylinder rod is filled with hydraulic oil, the contraction rate is somewhat greater.

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

Table 2-4: 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 2-5Boom Drift Chart (Cylinder length change in millimeters)

Coeff. = 0.000774 (1/ °C)

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

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

LIFT CYLINDER

Description

The lift cylinder (see Figure 2-38) 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 438.7 cm (72.75 in). The extended length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 786.7 cm (309.75 in). Its stroke is 347.9 cm (137 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 1280 kg (3429.3 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 screws and washers securing the holding valve and remove the holding valve from the cylinder barrel.
3. Remove the two socket head capscrews securing the head retainer ring to the head.
4. Using a spanner wrench or chain wrench, unscrew the head retainer ring from the barrel.

CAUTION

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

CAUTION

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

7. Remove the setscrew securing the piston to the rod.
8. Unscrew the piston from the rod.
9. Remove the 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.

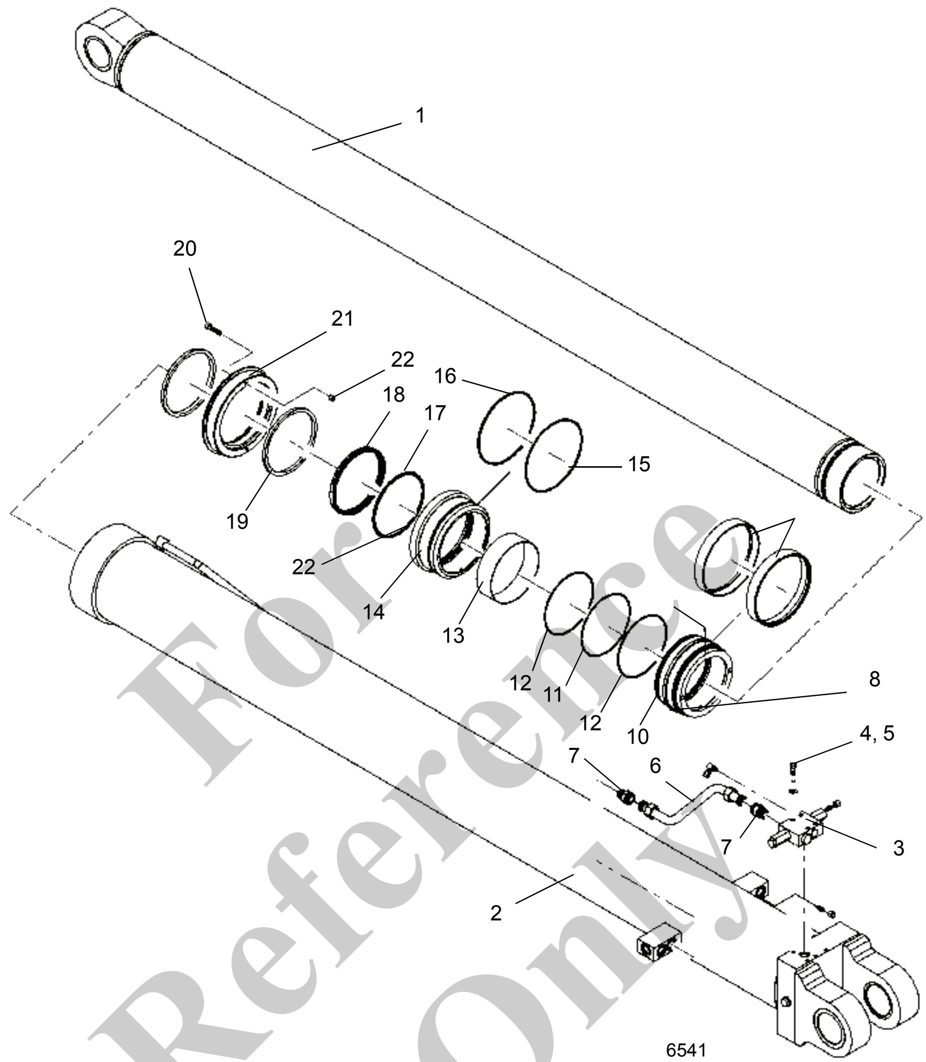

FIGURE 2-38

Item	Description
1	Rod
2	Barrel
3	Holding Valve
4	Screw
5	Washer
6	Tube
7	Adapter
8	Setscrew (Not Shown)
9	Seal Assembly
10	Piston
11	O-ring

Item	Description
12	Backup Ring
13	Backup Ring
14	Head
15	O-ring
16	Backup Ring
17	Buffer Seal
18	Rod Seal
19	Backup Ring
20	Capscrew
21	Retaining Ring
22	Insert

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

1. Install the backup ring and wiper ring into the retaining ring (see Figure 2-39).
2. Install head retainer ring on rod.
3. Install two new threaded inserts into head.

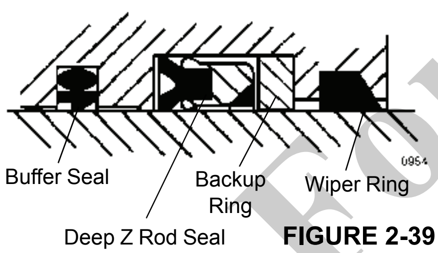

FIGURE 2-39

4. Install the replacement wear rings, buffer seal and deep Z rod seal in the inside of the head (see Figure 2-39). 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 setscrew.

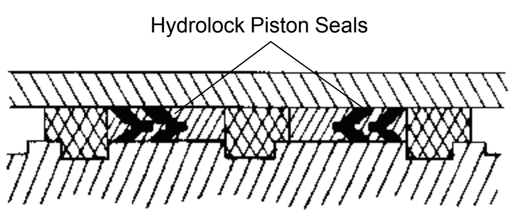

FIGURE 2-40

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 (see Figure 2-40).
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 head retainer ring to head with two socket head capscrews. Torque screws refer to *Fasteners and Torque Values*, page 1-13.
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 414 bar (6000 psi). Check for proper operation and any leakage. Make repairs as needed.
19. After successful pressure testing, re-torque screws holding retainer ring to head, refer to *Fasteners and Torque Values*, page 1-13.

LOWER TELESCOPE CYLINDER

Description

The boom lower telescope cylinder (see Figure 2-44) has a 16.5 cm (6.5 in) bore, a 13.9 cm (5.50 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 13.9 cm (5.50 in) rod. Foreign material is prevented from entering the cylinder rod during retraction by a wiper ring in the head retaining ring. 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 1014.9 cm (399.57 in). The cylinder has a stroke of 881.5 cm (347.05 in) which gives an extended length of 1896.3 cm (746.6 in).

The cylinder weighs 1149 kg (2533 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.

CAUTION

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 retaining ring and 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 and hydrolock seals 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 ring from the spacer.
8. Remove the cylinder head from the rod.
9. Remove the wear rings, buffer seal assembly, deep Z rod seal, and backup ring from the inside of the head.
10. Remove the O-ring and backup ring from the outside of the cylinder head.
11. Remove the retaining ring from the rod.
12. Remove the wiper ring from the inside of the retaining ring.
13. 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.
14. Remove the seal retainer from the inner rod.
15. Remove the wear rings and deep Z rod seals from the inside of the seal retainer.
16. 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.

1. If removed, install the holding valve. Refer to HOLDING VALVES 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 (see Figure 2-41).

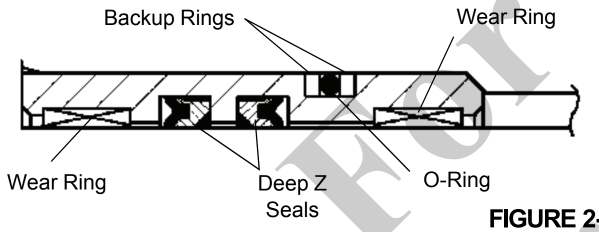

FIGURE 2-41

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.
5. Install the wiper ring into the inside of the retaining ring.

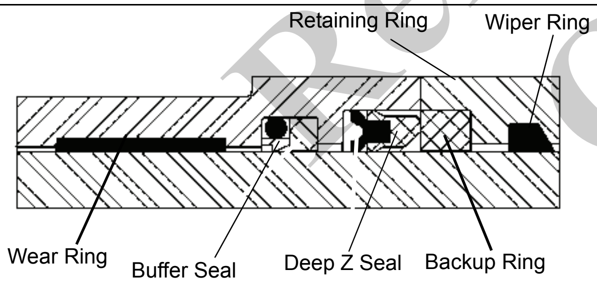

FIGURE 2-42

6. Install the backup ring, deep Z rod seal, buffer seal assembly, and wear rings into the inside of the cylinder head (Figure 2-42).
7. Slide the spacer, head and retaining ring onto the outer rod.
8. Install the O-rings and backup rings in the inside of the piston.

NOTE: Use a new setscrew.

9. Screw the piston onto the outer rod and secure with a new setscrew.
10. Install the guide lock rings and hydrolock seal assemblies on the outside of the piston (Figure 2-43).

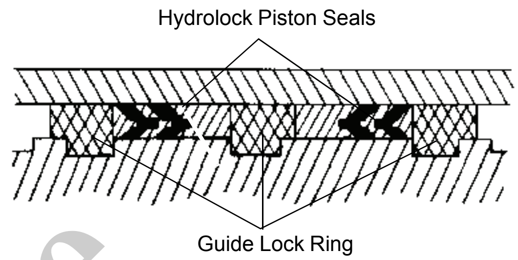

FIGURE 2-43

11. Install the wear ring on the outside of the spacer.
12. Install the O-ring and backup ring on the outside of the cylinder head.
13. Install the backup ring and O-ring on the outside of the inner rod end.
14. Clean all oil from the threads of the cylinder head and apply Loctite #290 to the threads.
15. Slide the rod assembly into the cylinder barrel and screw the cylinder head into the barrel.
16. 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 refer to *Fasteners and Torque Values*, page 1-13.
17. Bolt the rod retaining plate to the cylinder barrel with the three 7/16 in bolts and washers. Torque the bolts refer to *Fasteners and Torque Values*, page 1-13.

CAUTION

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

18. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 310.1 bar (4500 psi). Check for proper operation and any leakage. Make repairs as needed.

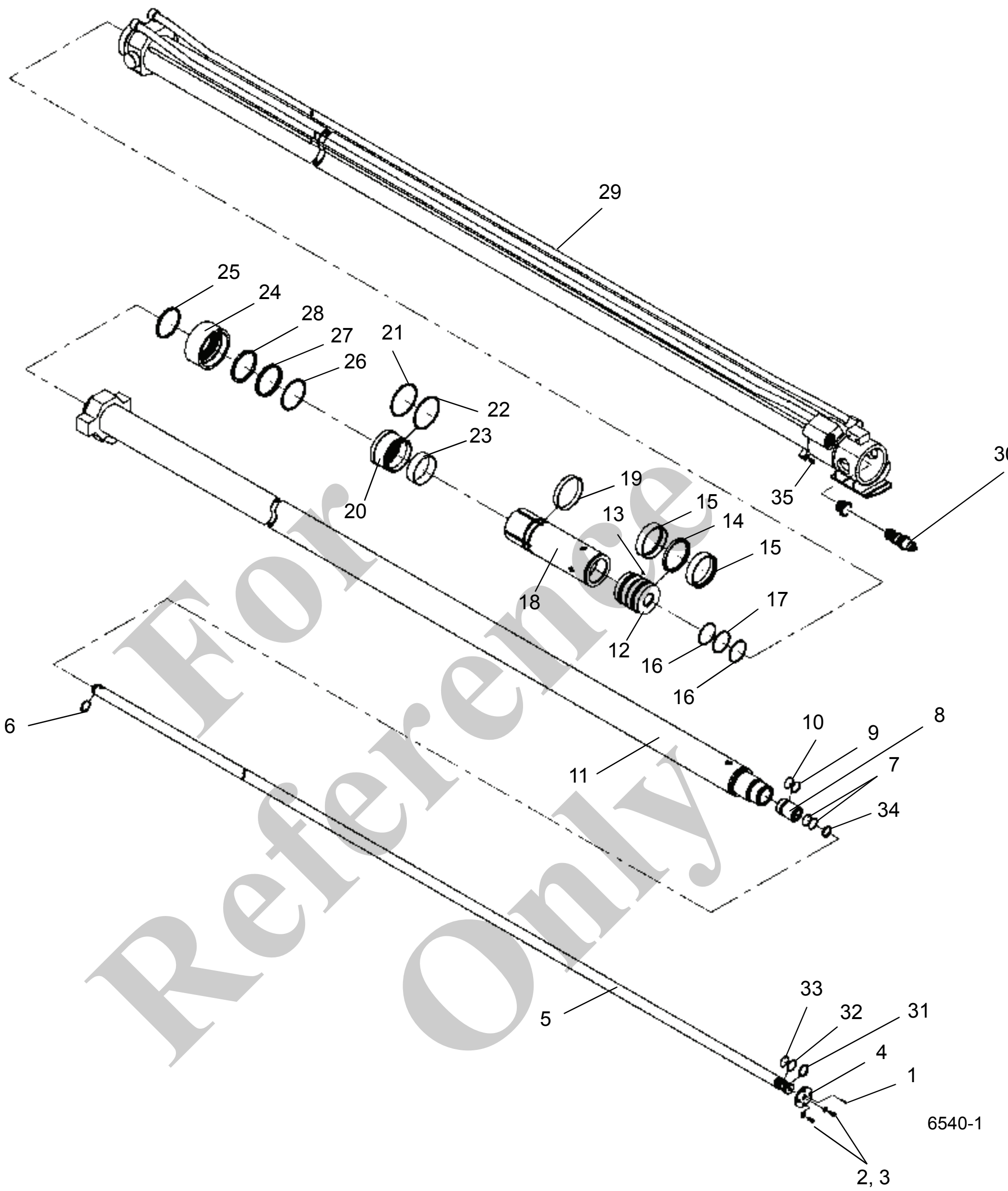

FIGURE 2-44

Item	Description
1	Dowel
2	Bolt
3	Flatwasher
4	Retaining Plate
5	Rod

Item	Description
6	Guidelock Ring
7	Lok-T Seal
8	Seal Retainer
9	O-ring
10	Backup Ring

Item	Description
11	Rod
12	Piston
13	Setscrew
14	Guidelock RIng
15	Seal Assembly
16	Backup Ring
17	O-ring
18	Spacer
19	Piston Wear Ring
20	Head
21	O-ring
22	Backup Ring

Item	Description
23	Wear Ring
24	Retaining Ring
25	Wiper Ring
26	Buffer Seal
27	Rod Seal
28	Backup Ring
29	Barrel
30	Holding Valve
31	Polyseal Ring
32	O-ring
33	Backup Ring
34	Wear Ring
35	Bleeder Plug

UPPER TELESCOPE CYLINDER

Description

The upper boom telescope cylinder (see Figure 2-45) has a 16.5 cm (6.50 in) bore and is internally ported (rod ported). Oil from the telescope control valve is routed to the cylinder by the lower cylinder. Foreign material is prevented from entering the cylinder during rod retraction by a wiper ring in the head retaining ring and O-ring seals prevent internal and external leakage. The retracted length of the telescope cylinder is 1013.5 cm (399.02 in) and the extended length is 1896.3 cm (746.58 in) from the end of the barrel to the center of the cylinder block.

The cylinder weighs 840 kg (1852 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 retaining ring and cylinder head from the cylinder barrel.

CAUTION

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 setscrew and discard.
5. Unscrew the piston from the rod.
6. Remove the remaining guide lock ring and hydrolock seal assembly from the outside of the piston.
7. Remove the O-ring and backup rings from the inside of the piston.
8. Remove the spacer from the rod 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 ring, buffer seal and rod seal from the inside of the head.
12. Remove the retaining ring from the rod.
13. Remove the wiper ring and backup ring from the inside of the retaining ring.
14. 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*, page 2-22.

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.

NOTE: When installing seals in step 2 through 4, see Figure 2-46.

2. Install the wiper ring and backup ring into the inside of the retaining ring.
3. Install the rod seal, buffer seal and wear ring in the inside of the cylinder head. Make sure the seals are properly assembled and installed in the correct direction.
4. Install the O-ring and backup ring onto the outside of the head.

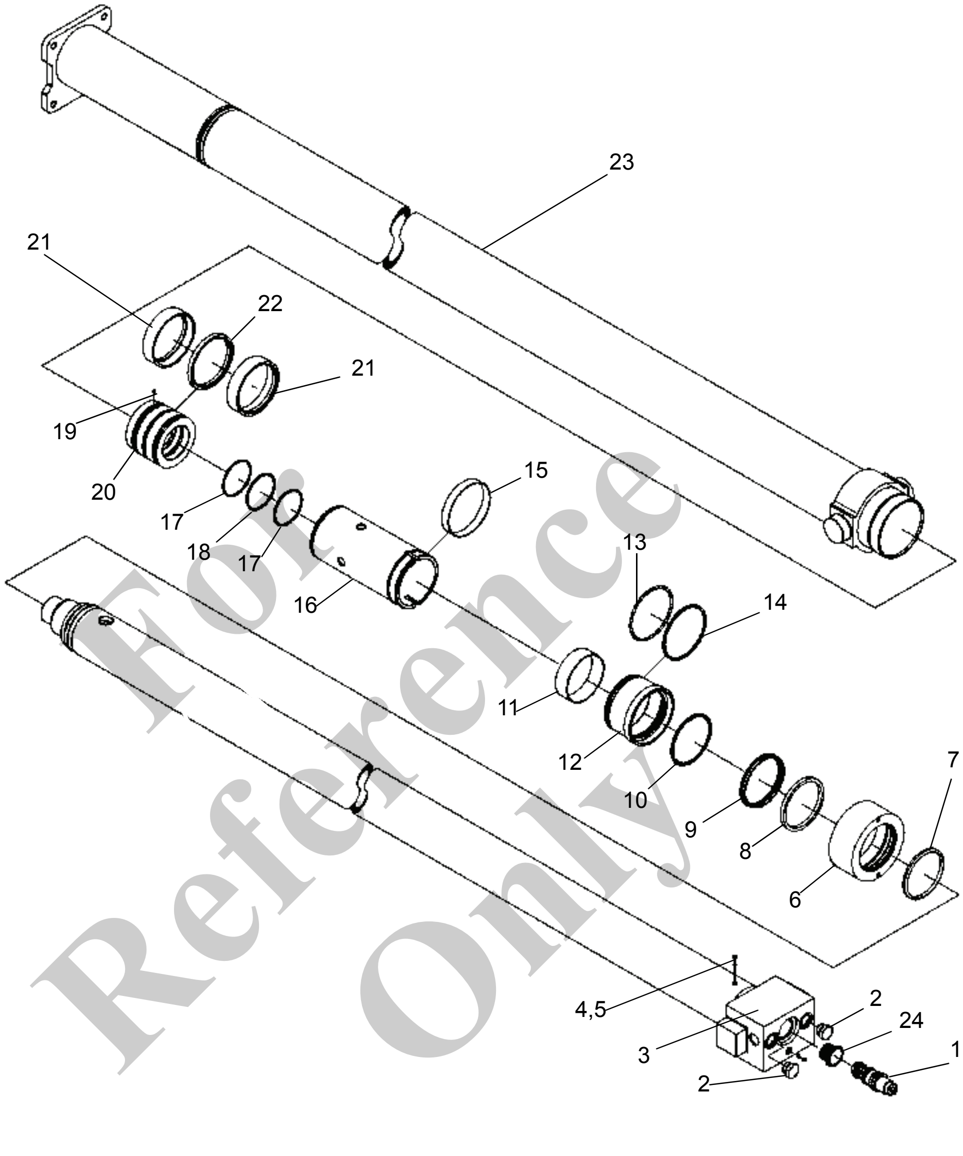

FIGURE 2-45

Item	Description
1	Holding Valve
2	Plug
3	Rod
4	Capscrew
5	Fastener
6	Retaining Ring
7	Wiper

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

Item	Description
15	Wear Ring
16	Spacer
17	Backup Ring
18	O-ring
19	Setscrew
20	Piston
21	Seal Assembly
22	Guidelock Ring
23	Barrel
24	Reducer

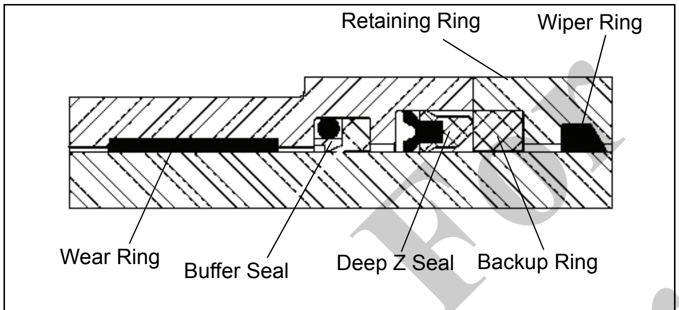

FIGURE 2-46

5. Install the retaining ring and head onto the cylinder rod.

6. Install the spacer onto the cylinder rod.

CAUTION

Improper seal installation could cause faulty cylinder operation.

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

NOTE: Use a new setscrew.

8. Screw the piston onto cylinder rod and secure with a new setscrew.

9. Install the guide lock rings and hydrolock seals onto the outside of the piston, see Figure 2-47.

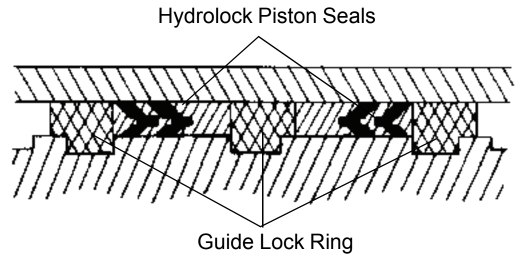

FIGURE 2-47

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

CAUTION

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

11. Clean all oil from the threads of the cylinder head and apply Loctite #290 to the threads.

12. Lubricate the piston and head with clean hydraulic oil and install the rod assembly into the cylinder barrel with a slight twisting motion.

13. Using a chain wrench, secure the cylinder head and retaining ring to the cylinder barrel.

CAUTION

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

14. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 331 bar (4800 psi). Check for proper operation and any leakage. Make repairs as needed.

STEER CYLINDER

Description

The steer cylinders (see Figure 2-48) are mounted on the front axles. The steer cylinders each have 5.08 cm (2.0 in) diameter bores. 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.

CAUTION

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

CAUTION

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

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

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

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

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

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

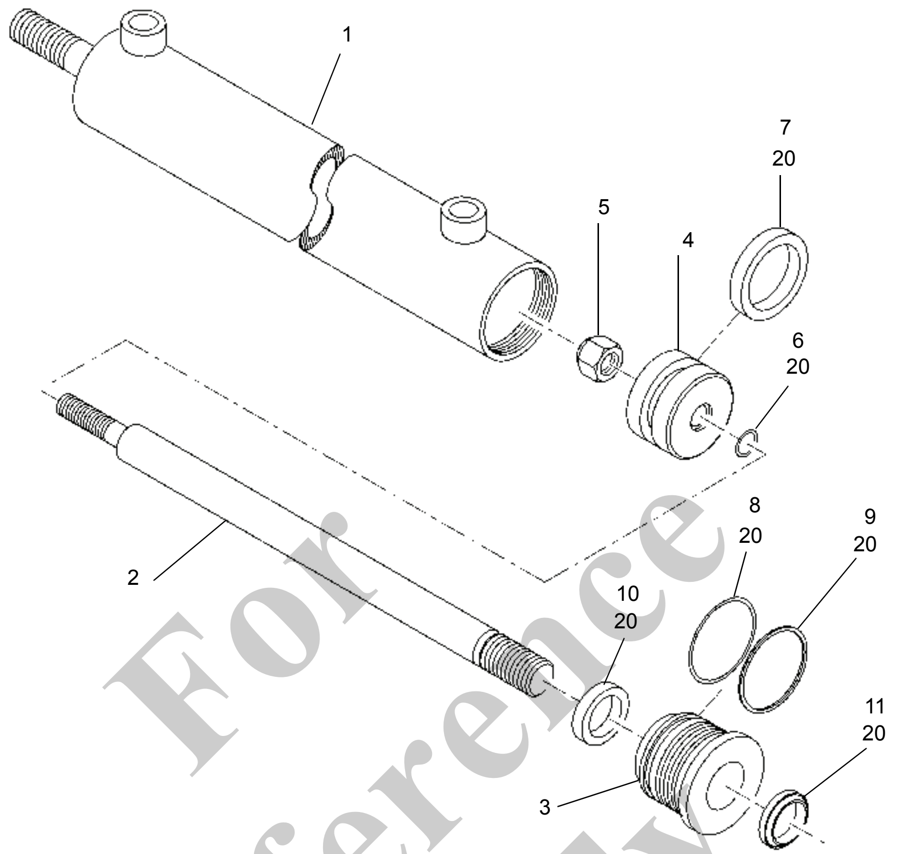

FIGURE 2-48

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

Inspection

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

CAUTION

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

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

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Assembly

CAUTION

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

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

1. Install the replacement wiper ring into the head.
2. Install the rod seal in the inside of the head. Make sure the lips of the seal face the piston.
3. Install the O-ring and backup ring onto the outside of the head.
4. Install the O-ring in the inside of the piston.
5. Lubricate the rod with clean hydraulic oil.
6. Slide the head, larger OD end first, onto the rod.
7. Install the piston onto the rod. Secure the piston with the nut. Lubricate the threads and torque the nut to 176.2 ± 6.7Nm (130 ± 5 pounds-foot).
8. Install the seal on the outside of the piston.
9. Lubricate all parts freely with clean hydraulic oil.

CAUTION

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

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

CAUTION

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

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

OUTRIGGER EXTENSION CYLINDER

Description

The four extension cylinders (see Figure 2-49) have 6.4 cm (2.5-in) diameter bores and are installed within the outrigger beams. The cylinders are a combination unit with two rods, one for extending each direction. Each half of the cylinder is a double-acting type cylinder.

Each cylinder has a retracted length of 182.7 ± 0.30 cm (71.94 ± 0.12 in) from the center of the rod mounting hole to the center of the other rod mounting hole. The cylinder's extended length is 432.8 cm (170.4 in). The stroke of the cylinder is 250.1 cm (98.50 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 70.3 kg (188.3 lb).

Maintenance

Disassembly

Upper Barrel

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

CAUTION

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

CAUTION

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

3. Remove the upper cylinder rod assembly from the cylinder barrel.

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

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

4. Remove the 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.

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

Lower Barrel

1. Using a spanner wrench, unscrew the cylinder head spacer from the lower barrel.
2. Remove the rod assembly from the lower barrel.

NOTE: Cover the cylinder barrel opening to prevent contamination from dust and dirt.

3. Remove the hydrolock seal assemblies from the outside of the piston.
4. Remove the setscrew and unscrew the piston from the cylinder rod and remove the piston from the rod.
5. Remove the O-rings and seal from the inside of the piston.
6. Remove the head and spacer from the rod.
7. Remove the O-ring and backup ring from the outside of the cylinder head and the wear rings and seal from the inside of the head.
8. Remove the wiper ring from the inside of the head spacer.

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.

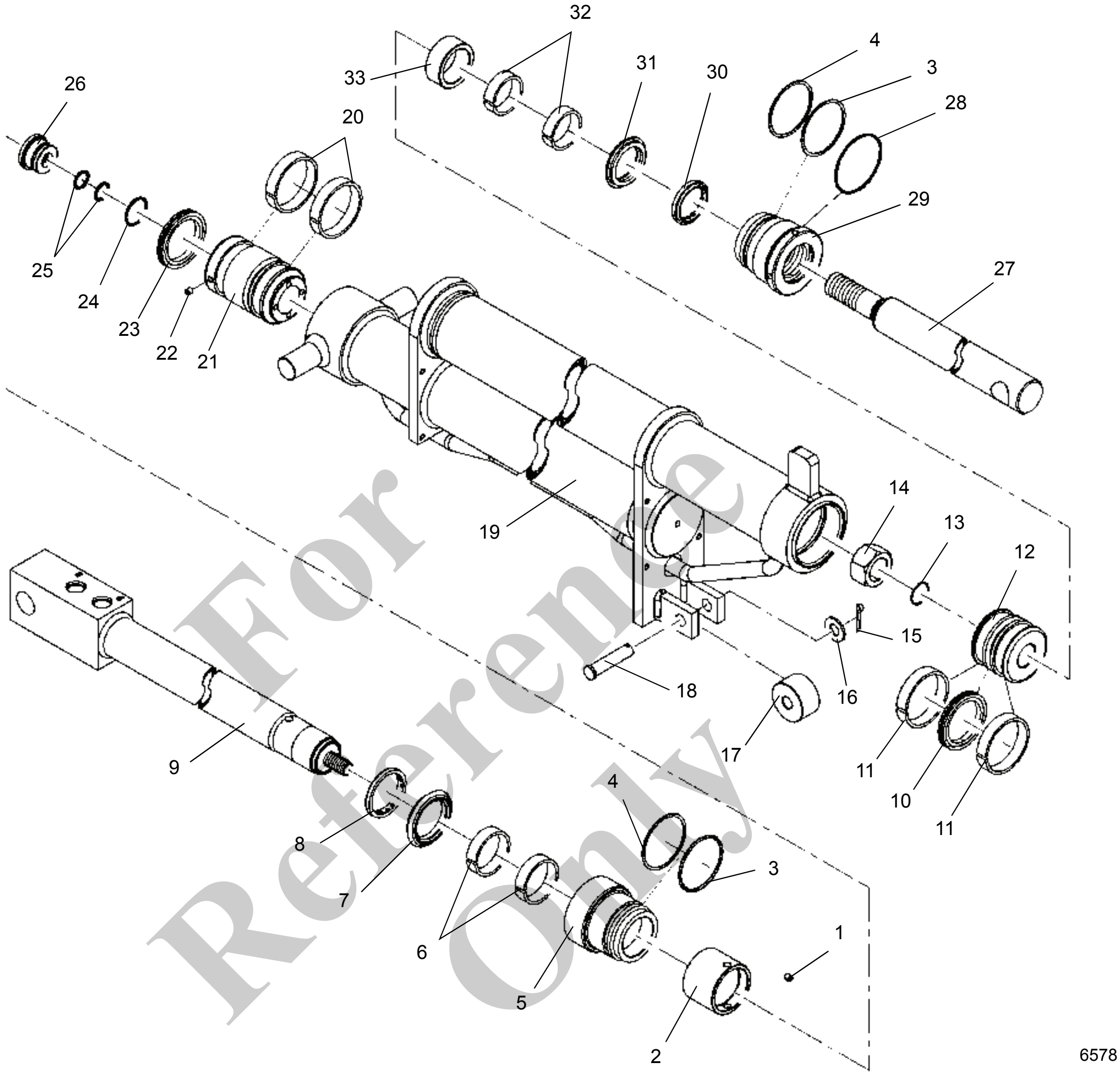


FIGURE 2-49

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

Item	Description
9	Rod
10	Seal
11	Wear Ring
12	Piston
13	O-ring
14	Locknut
15	Cotter Pin
16	Washer

Item	Description
17	Roller
18	Pin
19	Barrel
20	Wear Ring
21	Piston
22	Setscrew
23	Seal
24	O-ring
25	O-ring
26	Adapter
27	Rod
28	O-ring
29	Head
30	Wiper Ring
31	Seal
32	Wear Ring
33	Spacer

4. Inspect the barrel for scoring.

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

Lower Barrel

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.

Improper installation of seals could cause faulty cylinder operation.

NOTE: Lubricate seals and rings with clean hydraulic oil.

1. Install the wiper ring in the spacer.
2. Install the seal, and wear rings in the inside of the cylinder head. Make sure the seals are assembled properly and installed the correct direction.
3. Install the replacement O-ring and backup ring on the outside of the head.
4. Place the spacer and head onto the rod.

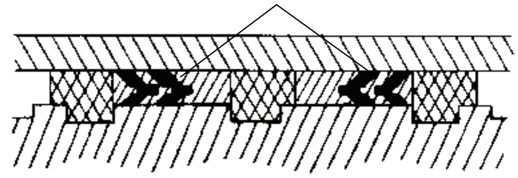


FIGURE 2-50

5. Install the hydrolock seals on the outside of the piston (see Figure 2-50).
6. Install the O-rings and seal in the inside of the piston.
7. Install the piston onto the rod and install the setscrew.

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. Clean all oil from the threads of the head spacer. Apply Loctite 271 to the threads.
9. Lubricate the piston seals and cylinder head O-ring with clean hydraulic oil.
10. Lubricate the rod with clean hydraulic oil.
11. Install the rod assembly into the lower cylinder barrel with a slight twisting motion.
12. Using a chain wrench or spanner wrench, screw the cylinder head retaining ring securely into the cylinder barrel.

Upper Barrel

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.

Improper installation of seals could cause faulty cylinder operation.

1. Install the wiper ring, seal and wear rings on the inside of the head. Make sure the seals are assembled properly and in the correct direction.
2. Install the O-ring and backup ring on the outside of the head.
3. Install the hydrolock seals and seal on the outside of the piston.
4. Install the spacer onto the rod.
5. Install the head onto the rod.
6. Lubricate the rod with clean hydraulic oil.
7. Lubricate the piston seals and head O-ring with clean hydraulic oil.
8. Remove the cover from the barrel. Insert the rod and attached part into the barrel with a slight twisting motion.
9. Using a chain wrench or spanner wrench, screw the head into the cylinder barrel.

CAUTION

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

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

OUTRIGGER STABILIZER CYLINDER

Description

The four outrigger stabilizer cylinders (see Figure 2-51) each have a hollow rod for internal porting. Each cylinder has a 13.9 cm (5.50 inch) 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 109.50 ±0.30 cm (43.12 ±0.12 inches). The extended length of the cylinder from the end of the barrel to the center of the rod's port block rod bushing is 160.30 cm (63.12 inches). Its stroke is 50.8 cm (20.0 inches).

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

The cylinder weighs approximately 100.2 kg (220.4 lb) dry.

Maintenance

Disassembly

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

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

CAUTION

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

CAUTION

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

2. Open ports on the side of the cylinder barrel and drain the oil from the cylinder.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube in the vertical position with the rod assembly up.
4. Remove the setscrew on the barrel OD at the head.

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

5. With the ports open, extend the rod assembly with a hoist enough to access the top of the head with spanner wrench. Do not extend completely.
6. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.
7. Extend the rod assembly slowly until the piston is free of the barrel assembly. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod.

NOTE: Cover the barrel opening to avoid contamination.

8. Remove the piston seal to gain access to the piston setscrew. Remove the setscrew from the piston.
9. Remove the piston by turning counterclockwise with a fitted spanner wrench.
10. Remove the spacer and head from the rod.

CAUTION

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

11. Remove the seal assembly from the outside of the piston and the O-ring and backup rings from the inside 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.

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

Inspection

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

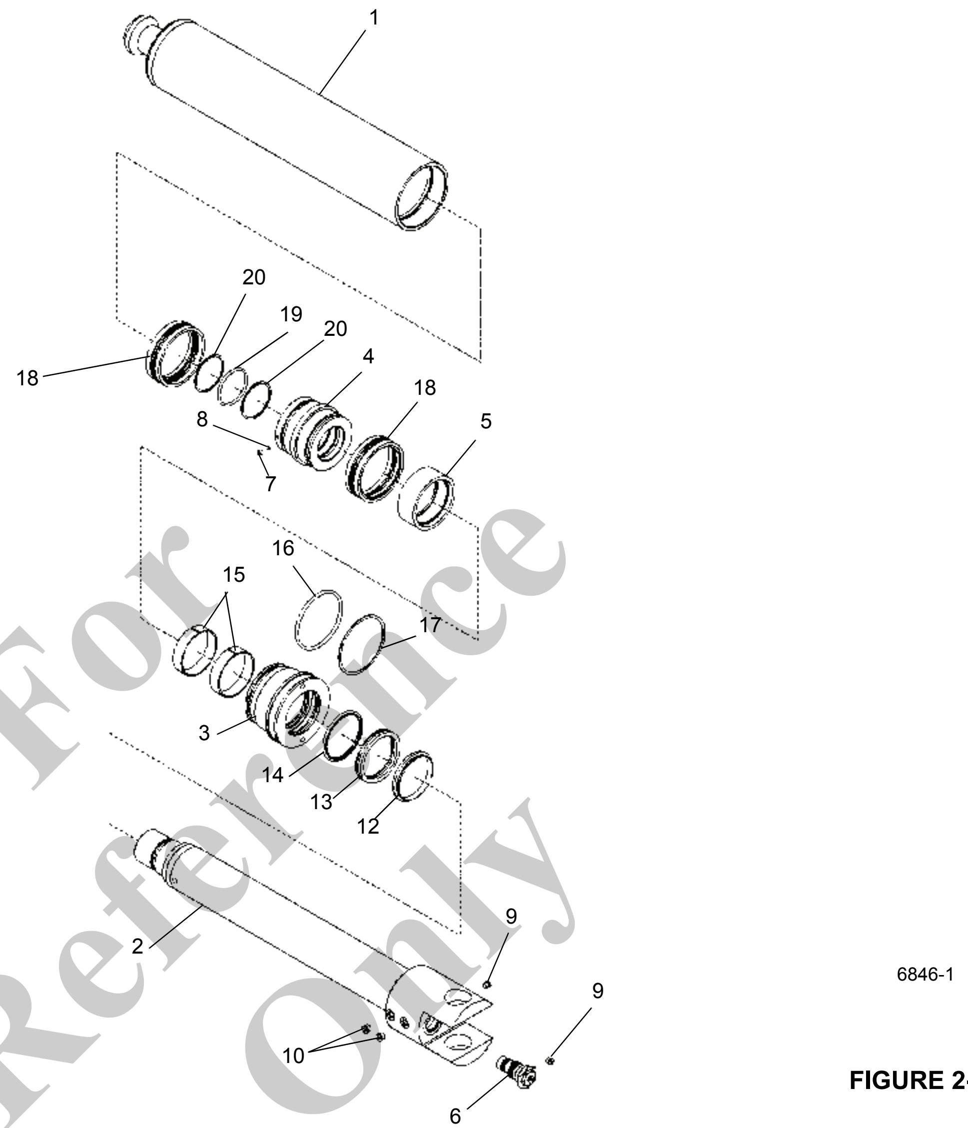


FIGURE 2-51

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

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

5. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
6. Thoroughly rinse parts, allow to drain, and wipe with a lint-free rag. Inspect all parts for serviceability.

CAUTION

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

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

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

NOTE: For head and piston seal installation, see Figure 2-52 and Figure 2-53.

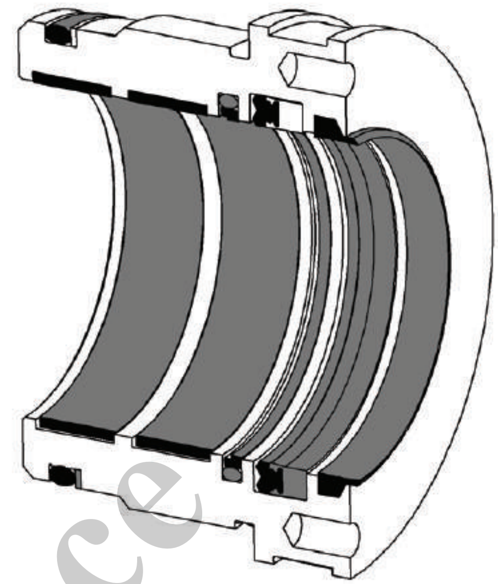


FIGURE 2-52

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

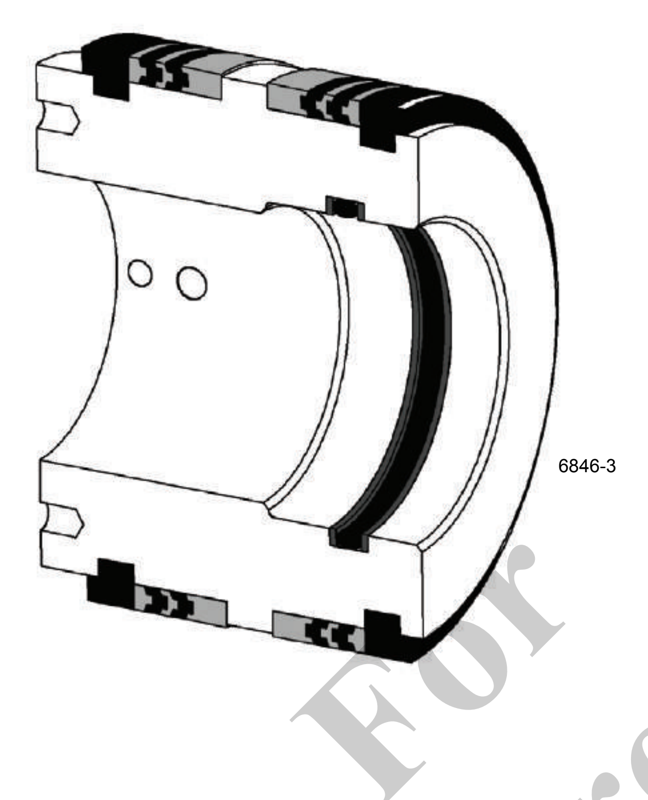


FIGURE 2-53

3. Lubricate the rod with clean hydraulic oil.
4. Slide the head onto the rod. Tap the head with a rubber mallet to engage the seals. Push the head about half way down the length of the rod assembly.
5. Install the spacer onto the rod with the inside diameter lip at the piston end.
6. Install the setscrew in the piston until hand tight. Install the seal assemblies onto the piston.
7. Remove the cover from the barrel.

CAUTION

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

8. With a hoist, raise the rod assembly back into a vertical position taking care not to damage the outside diameter seals on the head and piston.
9. Lubricate the outside diameter seals on the piston and head with clean light oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
10. Place a spanner wrench on the head and turn counterclockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the head shoulder and top of barrel.
11. Install the setscrew into the head until hand tight.
12. Slowly lower the rod down to the fully retracted position.

CAUTION

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

13. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 310.1 bar (4500 psi). Check for proper operation and any leakage. Make repairs as needed.

CENTER FRONT STABILIZER CYLINDER

Description

The center front stabilizer cylinder (see Figure 2-53) has a 8.9 cm (3.5 inch) bore. A port block is welded to the end of the cylinder rod and a pilot operated check valve is threaded into the port block.

The cylinder has a retracted length of 115.60 ± 0.30 cm (45.50 ± 0.012 inches) and a extended length of 179.10 ± 0.30 cm (70.50 ± 0.012 inches) from the center of the mounting fixture to the end of the ball on the barrel. The stroke of the cylinder is 63.5 cm (25.0 inches).

The cylinder weighs approximately 56.7 kg (124.7 lb) dry.

Maintenance

Disassembly

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

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

CAUTION

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

CAUTION

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

2. Open ports on the side of the cylinder barrel and drain the oil from the cylinder.
3. Secure cylinder barrel in a chain vise without putting pressure on the side feeder tube in the vertical position with the rod assembly up.
4. Remove the setscrew on the barrel outside diameter at the head.

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

5. With the ports open, extend the rod assembly with a hoist enough to access the top of the head with spanner wrench. Do not extend completely.
6. Turn the head counterclockwise with a fitted spanner wrench until the threads disengage.
7. Extend the rod assembly slowly until the piston is free of the barrel assembly. Place the rod assembly horizontally on a workbench taking care not to damage the surface of the rod.

NOTE: Cover the barrel opening to avoid contamination.

8. Remove the piston seal to gain access to the piston setscrew. Remove the setscrew from the piston.
9. Remove the piston by turning counterclockwise with a fitted spanner wrench.
10. Remove the spacer and head from the rod.

CAUTION

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

11. Remove the seal assembly from the outside of the piston and the O-ring and backup rings from the inside 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.

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

Inspection

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

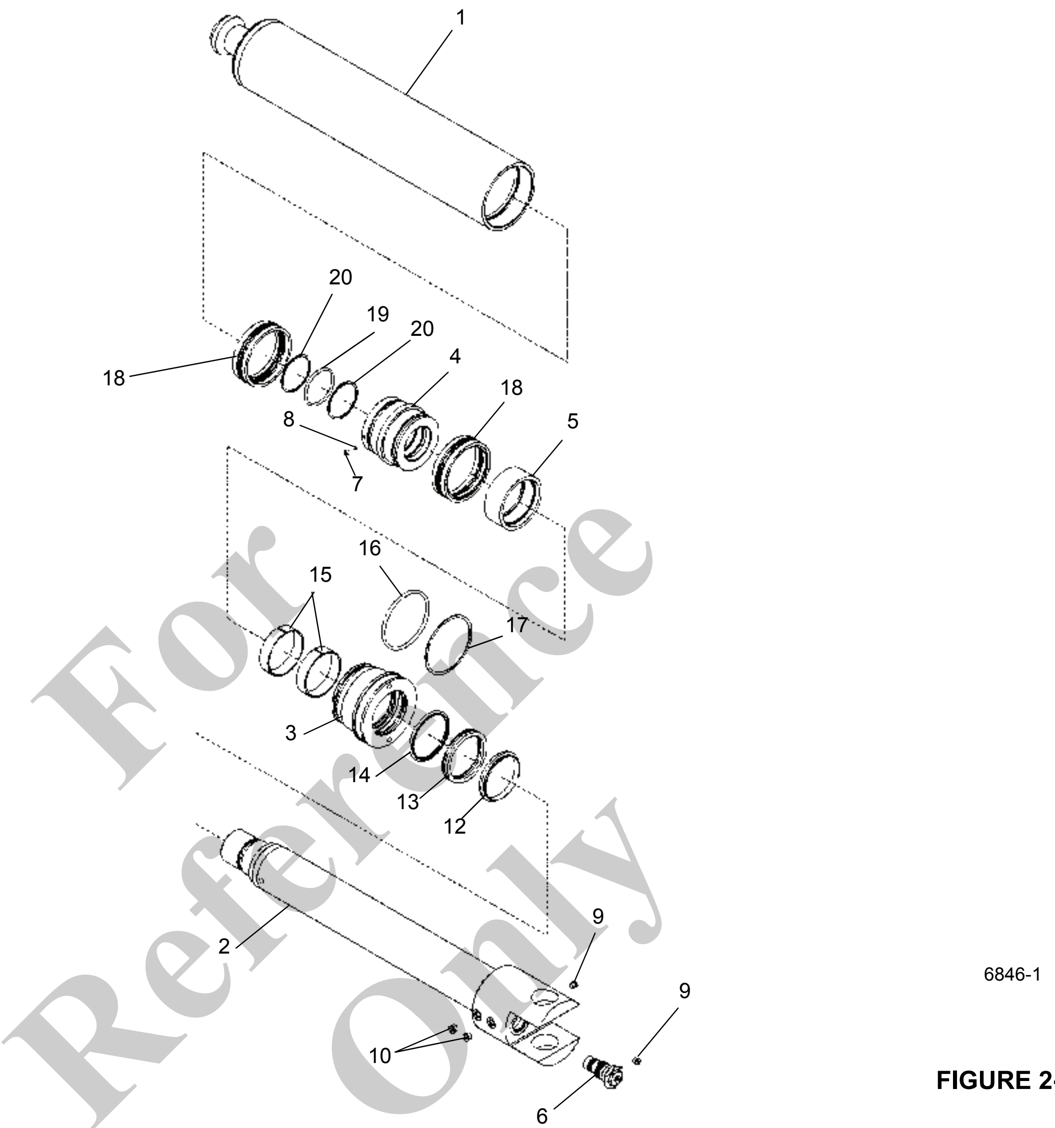


FIGURE 2-54

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

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

5. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
6. Thoroughly rinse parts, allow to drain, and wipe with a lint-free rag. Inspect all parts for serviceability.

CAUTION

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

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

Assembly

CAUTION

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

NOTE: Lubricate seals and rings with clean hydraulic oil.

NOTE: For head and piston seal installation, see Figure 2-48 and Figure 2-49.

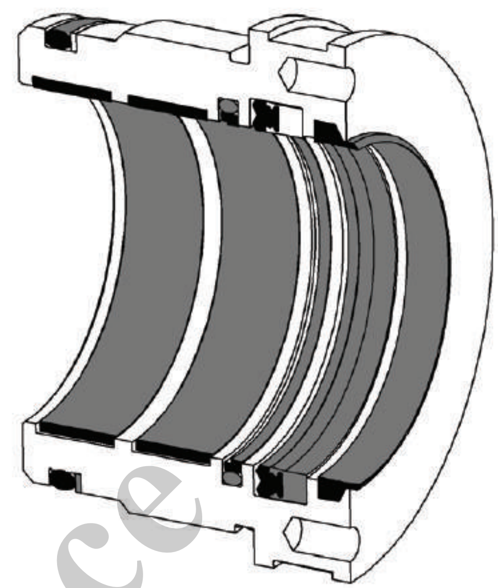


FIGURE 2-55

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

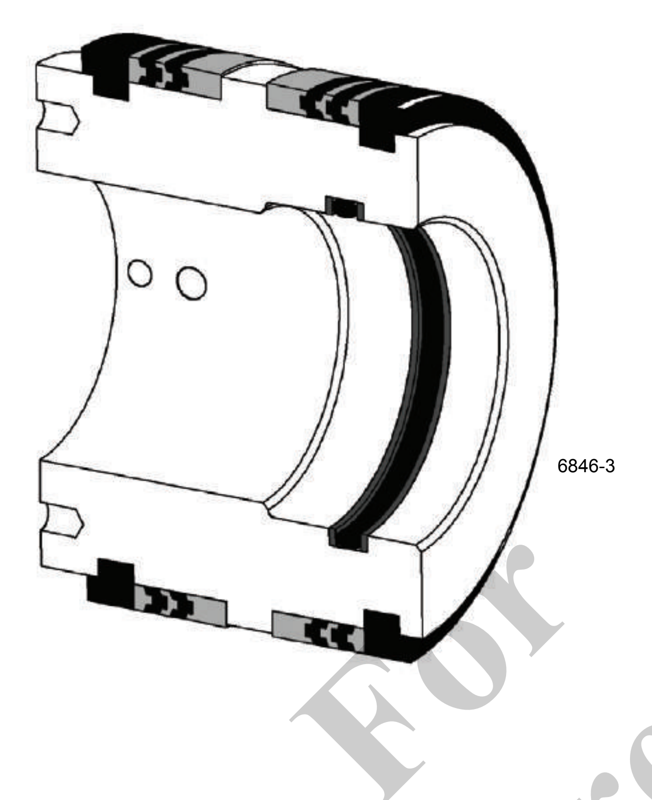


FIGURE 2-56

3. Lubricate the rod with clean hydraulic oil.
4. Slide the head onto the rod. Tap the head with a rubber mallet to engage the seals. Push the head about half way down the length of the rod assembly.
5. Install the spacer onto the rod with the inside diameter lip at the piston end.
6. Install the setscrew in the piston until hand tight. Install the seal assemblies onto the piston.
7. Remove the cover from the barrel.

CAUTION

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

8. With a hoist, raise the rod assembly back into a vertical position taking care not to damage the outside diameter seals on the head and piston.
9. Lubricate the outside diameter seals on the piston and head with clean light oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
10. Place a spanner wrench on the head and turn counterclockwise until the thread clicks, then reverse direction to clockwise and thread in until there is no gap between the head shoulder and top of barrel.
11. Install the setscrew into the head until hand tight.
12. Slowly lower the rod down to the fully retracted position.

CAUTION

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

13. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 310.1 bar (4500 psi). Check for proper operation and any leakage. Make repairs as needed.

COUNTERWEIGHT REMOVAL CYLINDER

Description

The counterweight cylinder (see Figure 2-57) 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 cylinders should include replacement of all seals and rings. A seal kit will supply the required items.

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

CAUTION

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.

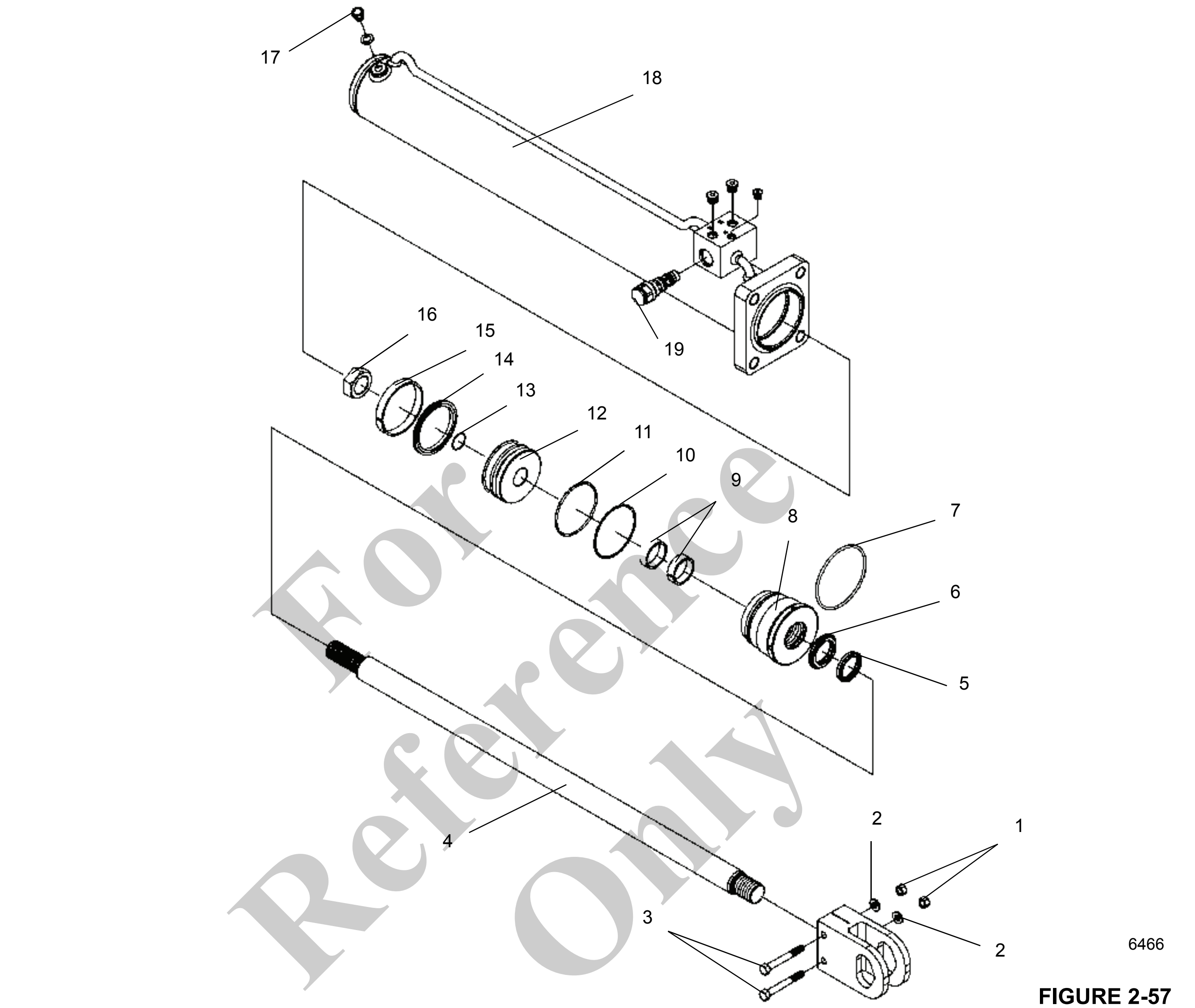


FIGURE 2-57

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

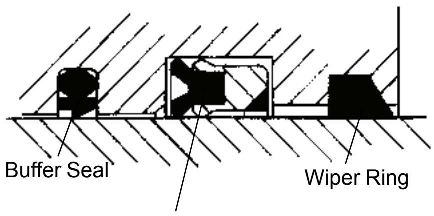


FIGURE 2-58

1. Install the replacement wear rings, seal, and wiper ring in the inside of the head (see Figure 2-58).
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 207 bar (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

CAB TILT CYLINDER

Description

The cab tilt cylinder (see Figure 2-59) is mounted beneath the superstructure cab. The cylinder has a 3.81 cm (1.50 in) diameter bore. The retracted length of the cylinder from bushing center to bushing center is 57.4 cm (22.62 in). The extended length of each cylinder from bushing center to bushing center is 84.6 cm (33.31 in). Its stroke is 27.1 cm (10.69 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 9.53 kg (25.5 lb) dry.

Maintenance

Disassembly

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

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

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

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

CAUTION

Do not use air pressure to remove the rod. Use only a source of controlled hydraulic 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 mm (1 in) after all oil is drained.
7. Remove the head as follows:
   a. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.
   b. Insert a spanner wrench into the 1/4 in holes provided.
   c. Turn the head until the beveled end of the retaining ring is visible in the mill slot.
   d. 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.
   e. Pry the end of the retaining ring up with a thin blade screwdriver or chisel and rotate the ring out through the slot.
   f. 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 and rod 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 seal and wear 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.

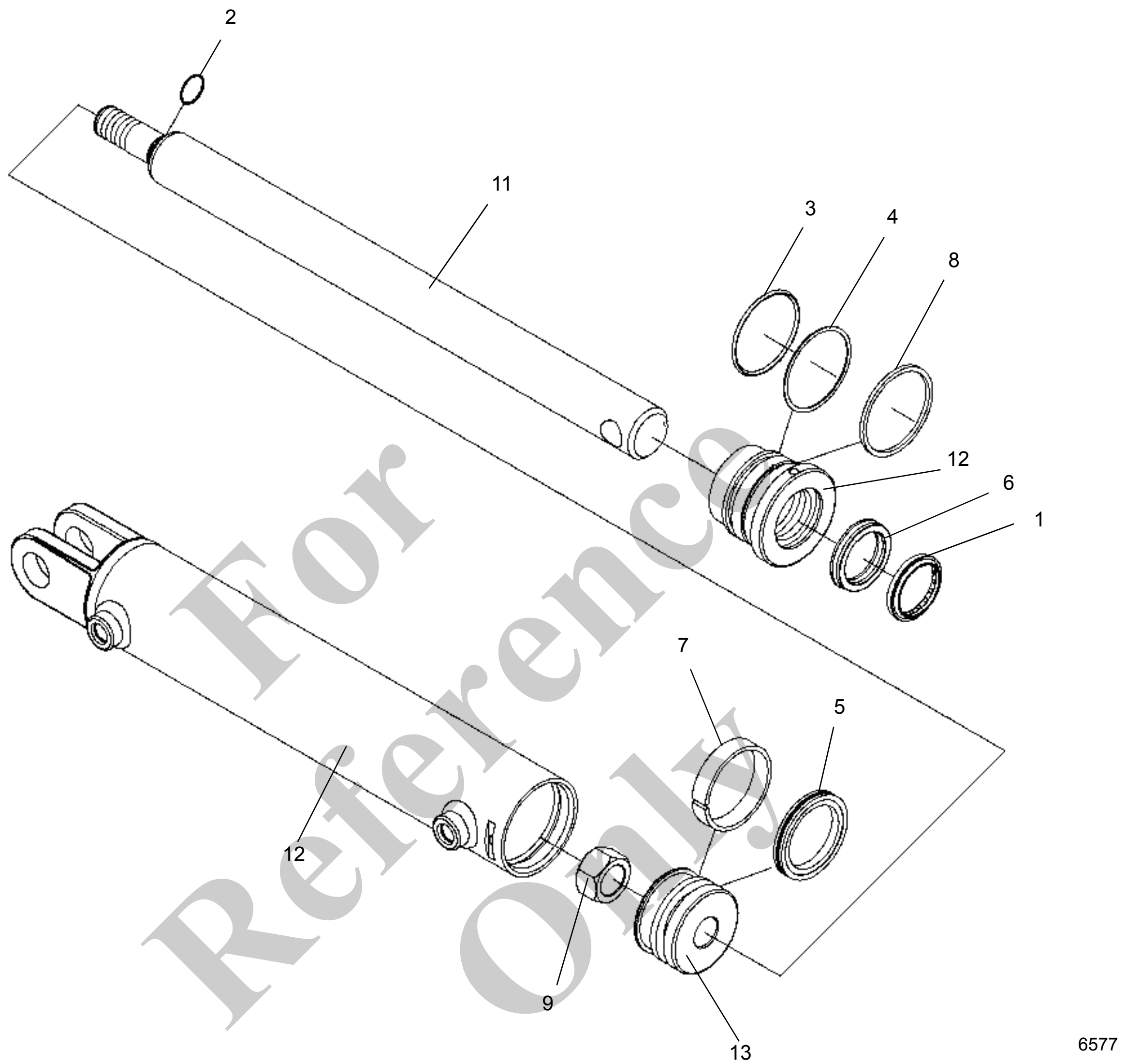


FIGURE 2-59

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

Item	Description
8	Retainer Ring
9	Locknut
10	Barrel
11	Rod
12	Head
13	Piston

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 (see Figure 2-60) 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.
   - **e.** Install wiper ring and seal in the inside of the head.

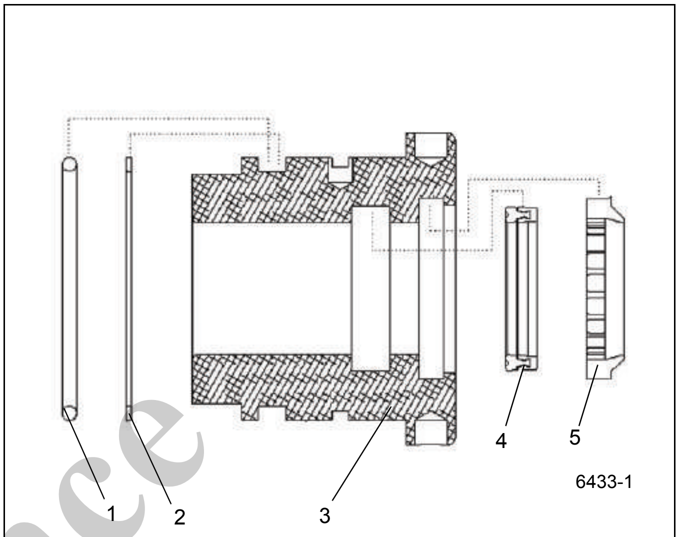


FIGURE 2-60

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

2. Install piston seals (see Figure 2-61) 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°C to 66°C (120°F 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 inside diameter equal to the nominal cylinder bore to plus 0.25 mm (0.010 in).

g. Install the wear ring in the wear ring groove.

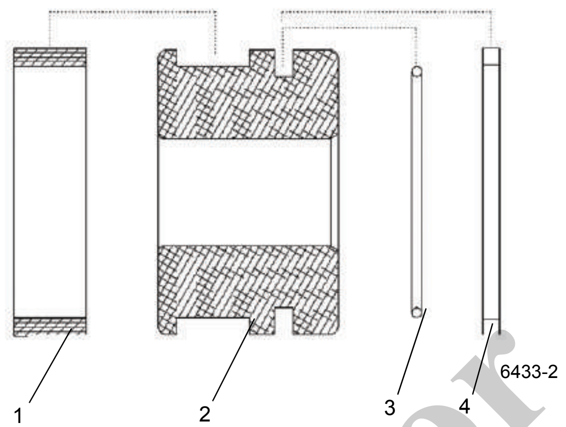


FIGURE 2-61

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. 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 inside diameter with hydraulic oil to ease the rod assembly installation.

6. 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.

7. 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.

8. 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.

9. Pressurize and cycle the cylinder with hydraulic oil pressure. Static pressure test the cylinder at 207 bar (3000 psi) in both directions. Check for proper operation and any leakage. Make repairs as needed.

SECTION 3
ELECTRIC SYSTEM

TABLE OF CONTENTS

DESCRIPTION

General

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

Electrical power is transferred to and from the carrier and superstructure through the electrical swivel. For more detailed information on the electrical swivel, refer to *Swivels*, page 6-16.

The carrier control module locations are shown in (Figure 3-1) and listed in (Table 3-1).

Table 3-1

Module	Location
1	Under the left side of the carrier front console
0 and 3	Rear of the carrier cab
4	Front right side of the frame
5	Center left side of the frame
6	Rear center frame

The superstructure control module locations are shown in (Figure 3-2) and listed in (Table 3-2).

Table 3-2

Module	Location
2	Inside rear of the superstructure cab
7	Left side of the turntable weldment
8	Right side of the turntable weldment

Alternator

A 150 ampere alternator is mounted on the engine and is belt driven. When the engine is running, and the alternator is turning, the alternator's 24-volt output terminal supplies the crane's electrical circuits. The output terminal also supplies the voltage to recharge the batteries and maintains them at a full state of charge.

Batteries

The batteries are located in a box on the left front side of the crane. 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 battery disconnect switch, a power relay, (2) fuse and relay modules, (3) 100A fuses, (1) 250A fuse and (1)

35A fuse all of which are explained in greater detail in *Carrier Fuse and Relays*, page 3-8.

Carrier Cab Power Panel

Most of the carrier cab electrical circuits and components are protected by the fuses mounted on the carrier cab power panel (Figure 3-3) located toward the rear of the cab, behind the driver's seat. Access to this panel is gained by removing plastic cover.

The power panel (Figure 3-3) contains 12 fuses, (2) terminal strips, (2) relays, a warning buzzer, a ground tab, and a USB diagnostic connector. A decal (Figure 3-4) located on the inside of this power panel cover identifies each fuse, relay and its function.

Fuses

Fuses 1 through 5 are energized while the batteries are connected.

Fuse 6 is energized when the batteries are connected and the carrier cab key switch is in the “ignition” or “accessory” position.

Fuses 7 through 8 are energized when the batteries are connected and the carrier cab key switch is in the “ignition” or “start” position.

Fuses 9 through 12 are energized when the batteries are connected and (either key switch is in the accessory, ignition, or start position) or (when any of the following switches are activated, headlight switch, hazard switch, or brake pressure switch.

The rating of each fuse and the function or circuit it protects can be found on the decal shown in Figure 3-4.

Relays

The carrier cab has 2 relays which are mounted on the cab's power panel assembly located behind the operator's seat. After removing the power panel's cover, relays K1 and K2 can be seen.

The description and function of these relays are listed on the power panel's component identification decal as shown in Figure 3-4.

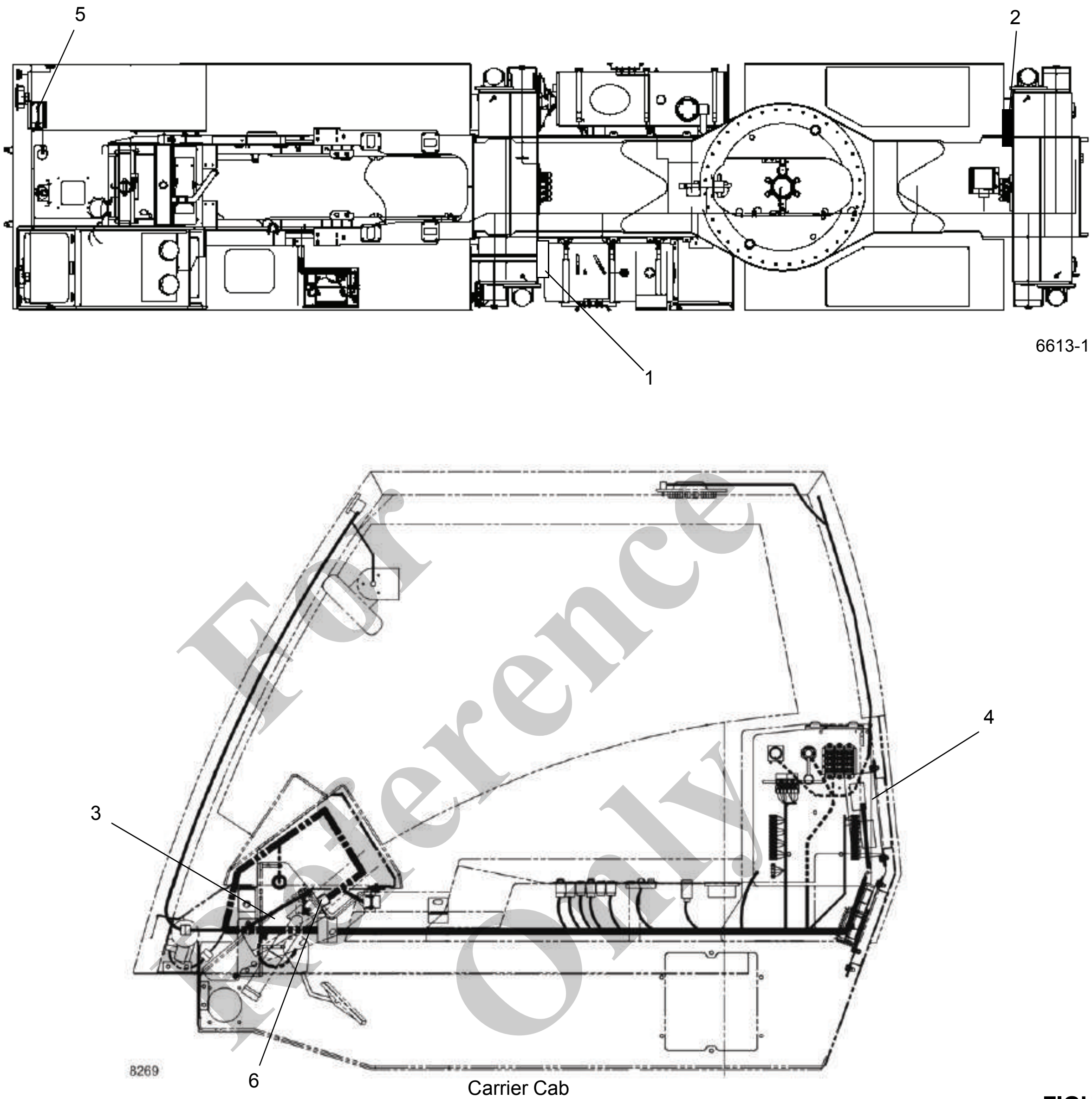
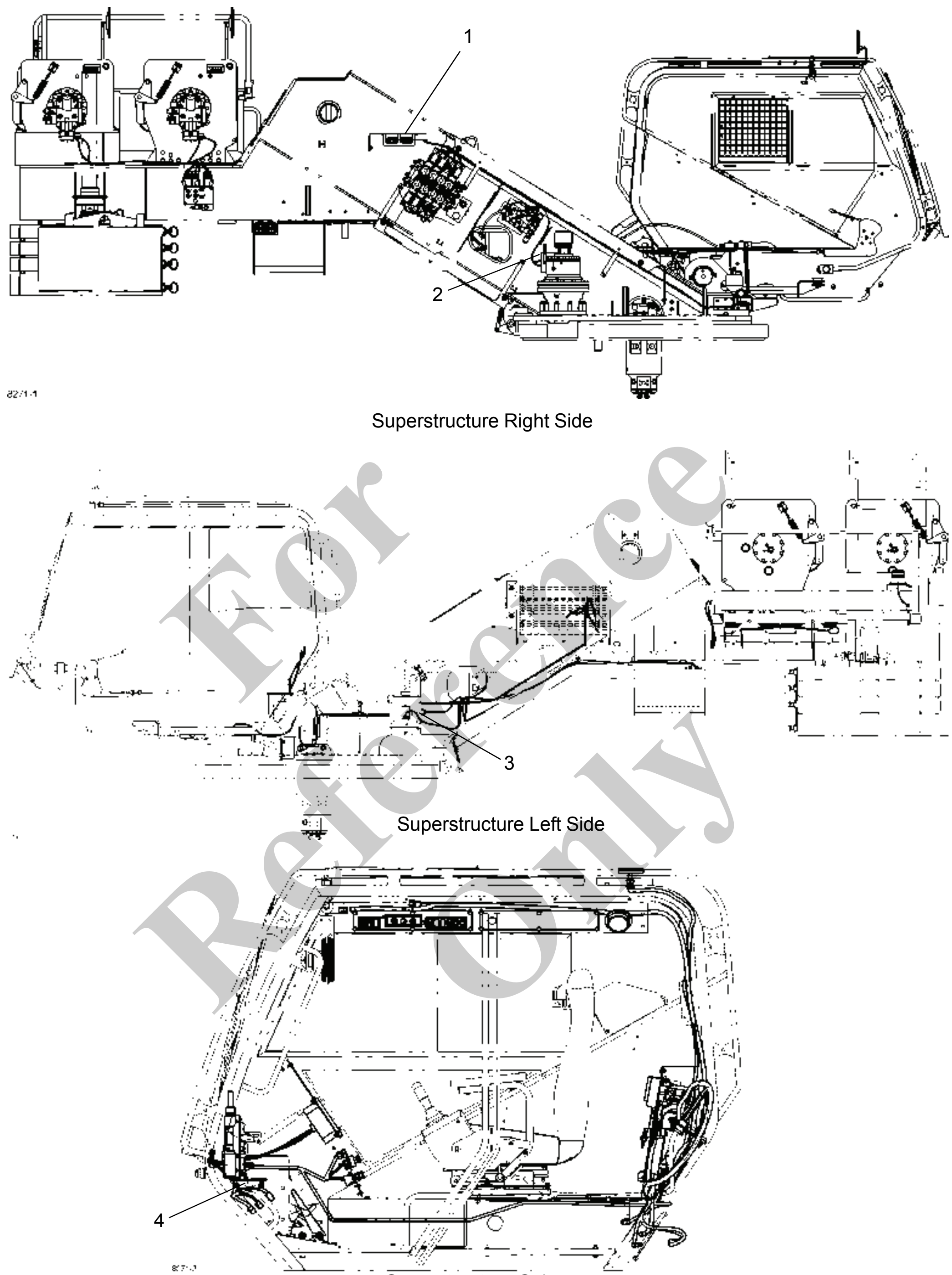


FIGURE 3-1

Item	Description
1	Carrier Frame Center Module
2	Carrier Frame Rear Module
3	Carrier Cab Console Module
4	Master Control Module

Item	Description
5	Carrier Frame Front Module
6	Engine Diagnostic Connector



Superstructure Right Side

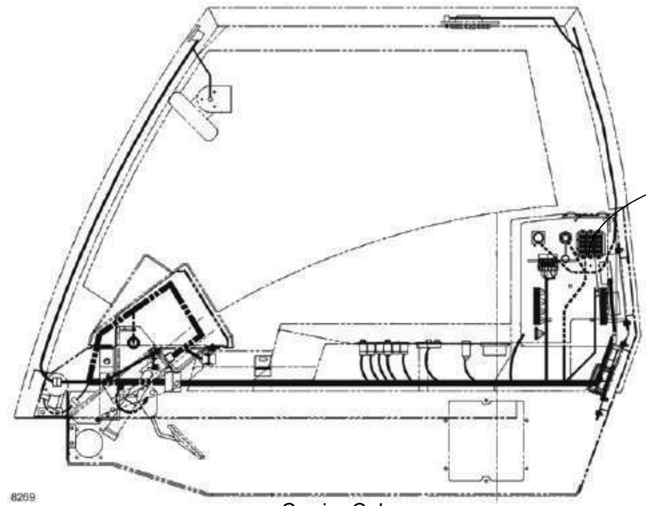
Superstructure Left Side

Superstructure Cab

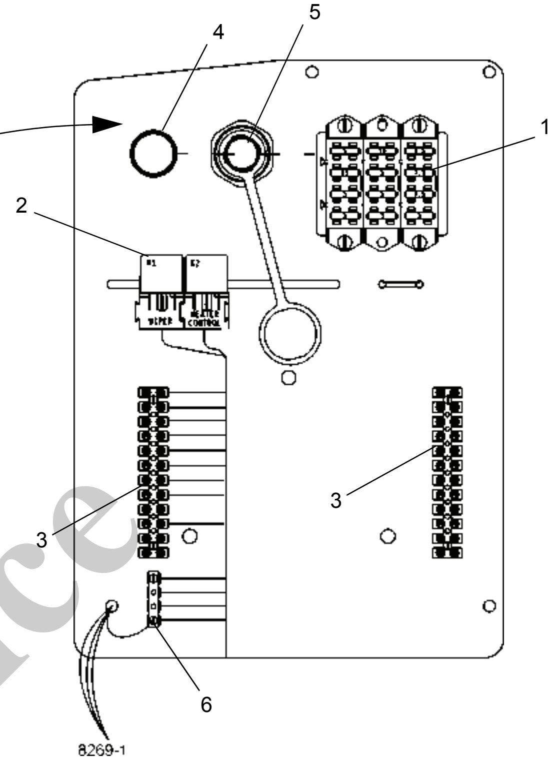
FIGURE 3-2

Item	Description
1	Right Side Control Module
2	CL-306 Control Module

Item	Description
3	CL-305 Control Module
4	IO Module



Carrier Cab



Item	Description
1	Fuse Panel
2	K1 and K2 Relays
3	Terminal Strip (2)
4	Buzzer
5	Crane USB Diagnostics Connector
6	Ground Tab

FIGURE 3-3

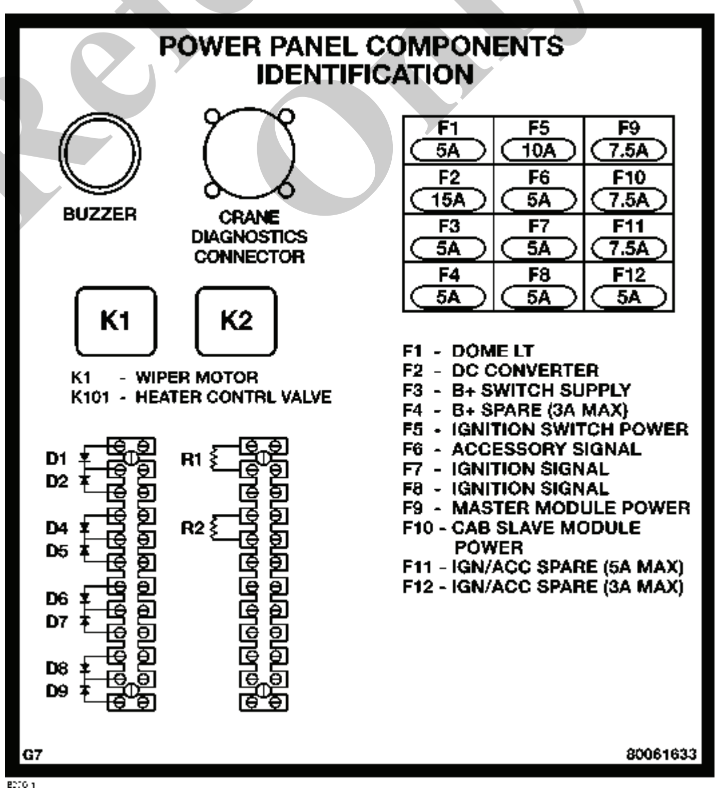


FIGURE 3-4

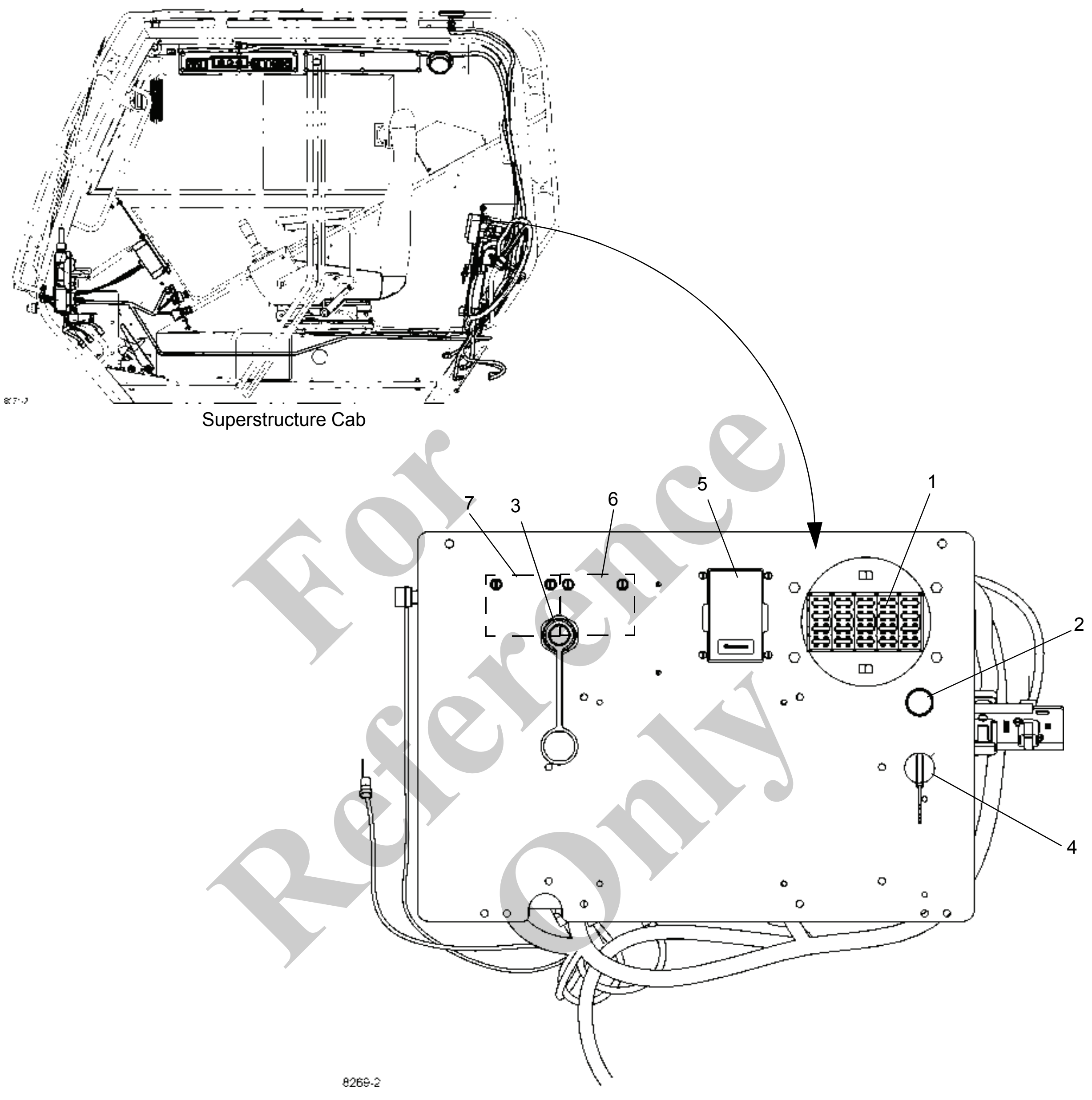
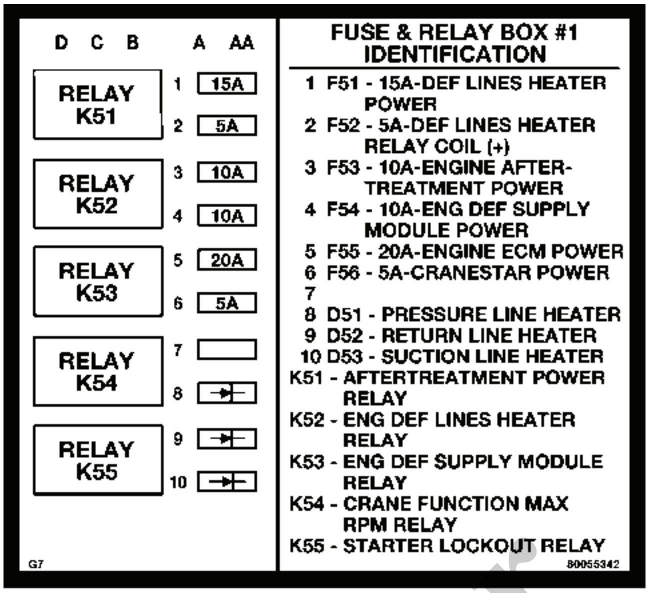


FIGURE 3-5

Item	Description
1	Fuse Panel
2	Buzzer
3	Crane USB Diagnostics Connector
4	RCL Override Switch
5	Relay and Diode Module
6	Relay K101 (on back side)
7	Relay K102 (on back side)



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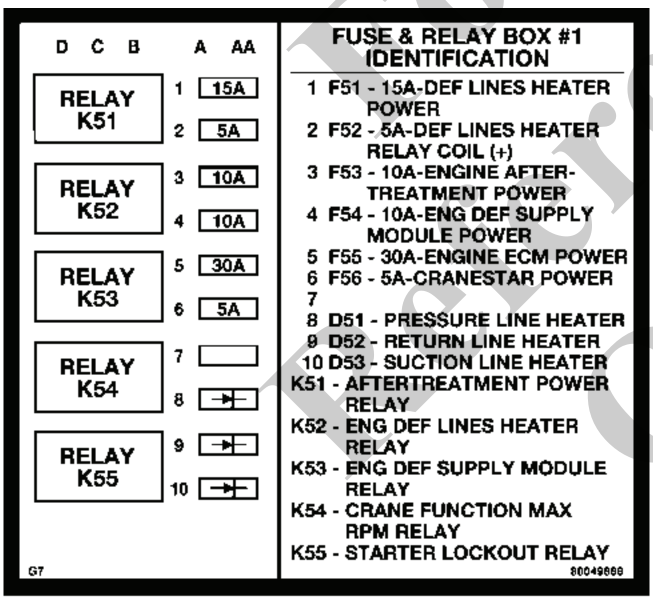
QSM Carrier Relay/Fuse Panel #1 FIGURE 3-6



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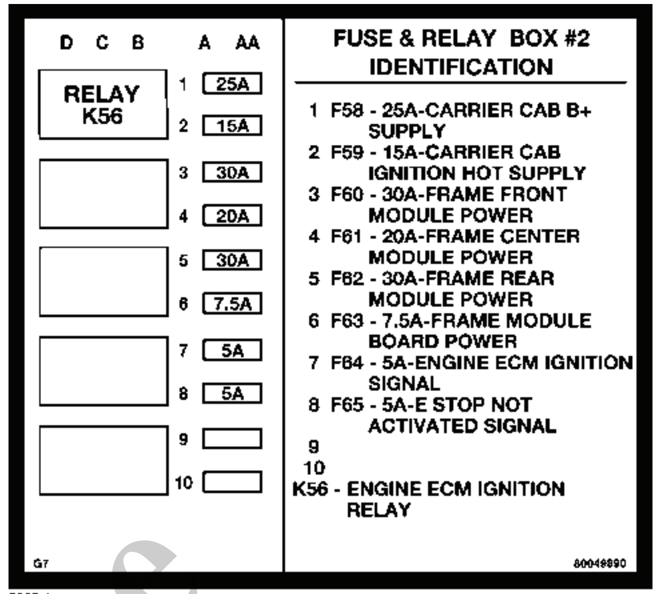
ISX Carrier Relay/Fuse Panel #1 FIGURE 3-7



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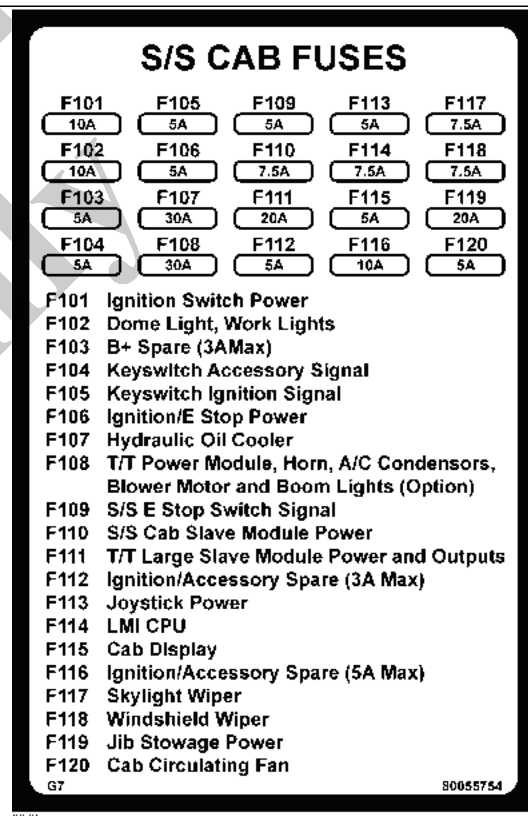
Carrier Relay/Fuse Panel #2 FIGURE 3-8



Superstructure Cab Fuse Panel FIGURE 3-9

3

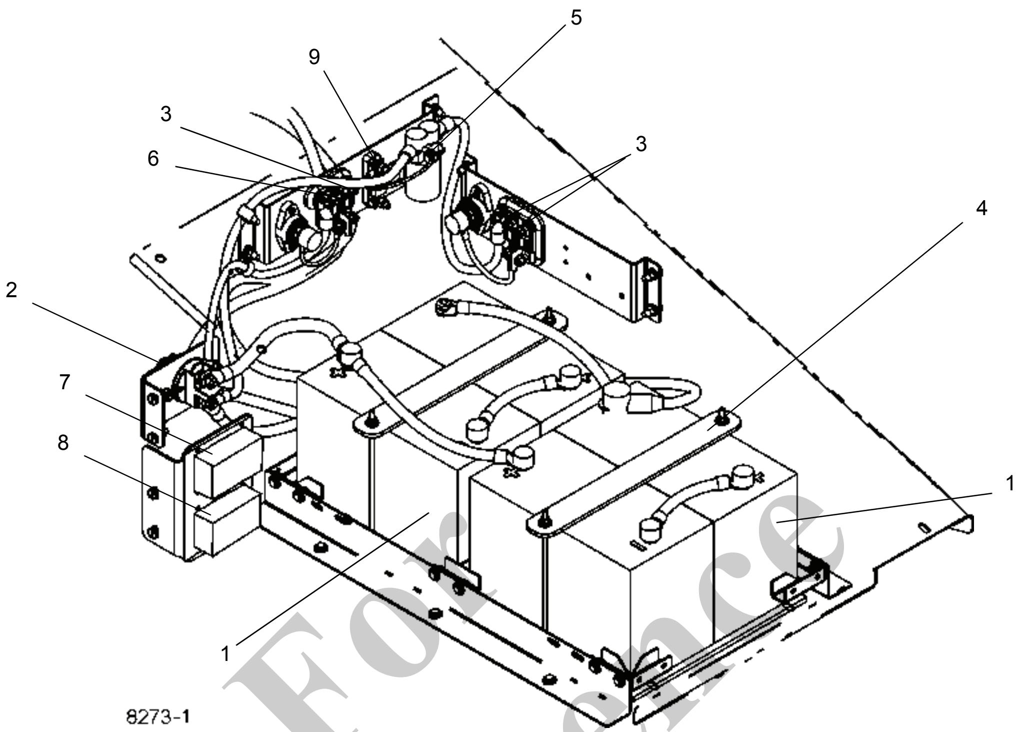


FIGURE 3-10

Item	Description
1	Battery
2	Battery Disconnect Switch
3	100 Amp Fuse
4	Battery Hold Down
5	Power Relay
6	250 Amp Fuse
7	Battery Box Fuse and Relay Module #1
8	Battery Box Fuse and Relay Module #2
9	35 Amp Fuse

Relays

The carrier cab has 2 relays which are mounted on the cab's power panel assembly located behind the operator's seat. After removing the power panel's cover, relays K1 and K2 can be seen.

The description and function of these relays are listed on the power panel's component identification decal as shown in Figure 3-4.

Table 3-3

Relay	Relay Assignment
K1	Wiper
K2	Heater Control Valve

Carrier Fuse and Relays

The carrier has 5 large ANL type fuses, (2) Fuse and Relay Modules containing 14 ATO mini style fuses and 7 relays, all located within the battery compartment as shown in Figure 3-10.

Fuses

Fuses F301 through F305 are the large ANL style fuses used to protect the batteries and large current carrying electrical circuits.

F301 (100A) is energized regardless of the battery disconnect switch and protects the electrical circuit supply power to the engine, engine ECM, and the aftertreatment components (if ISX engine is installed).

F302 (250A) is energized regardless of the battery disconnect switch and protects the batteries and the alternator charge circuit.

F303 (35A) is energized while the battery disconnect switch is closed and protects the electrical circuits supplying power to the superstructure cab and carrier cab.

F304 (100A) is energized when either key switch is in the ignition “RUN” or accessory position and protects the electrical circuits supplying power to the carrier and carrier cab.

F305 (100A) is energized when either key switch is in the ignition “RUN” or accessory position and protects the electrical circuits supplying power to the superstructure and superstructure cab.

Fuses F53 through F55 are located in the Fuse and Relay Module #1. The rating of each fuse and the function or circuit they protect can be found on the decal shown in (Figure 3-6 OR Figure 3-7).

F58 through F65 are located in the Fuse and Relay Module #2. The rating of each fuse and the function or circuit they protect can be found on the decal shown in (Figure 3-8).

Item 5 is the main power relay which provides power to most of the crane's electrical circuits with the exceptions being the engine ECM, starter, and all “battery hot” circuits. The relay's contacts will close providing power to the circuits mentioned above when its coil is energized. The coil will become energized when any of the following conditions are met: either key switch is turned to the ignition or accessory position, or when the headlight switch, brake pressure switch or hazard switch is actuated.

There are 6 additional relays, all located within the battery compartment's (2) fuse and relay modules items 7 and 8. Their descriptions and functions are listed on the fuse and relay module's decals as shown in Figure 3-6, 3-7 and 3-8.

Superstructure Fuse and Relay Panel

Most superstructure electrical circuits are protected by the components of the fuse and relay panel (Figure 3-5) located at the rear of the superstructure cab. Access to all the fuses may be gained by removing the small plastic cover on the front of the panel. Inside the small plastic fuse cover, a fuse decal as shown in Figure 3-9 can be found.

The fuse and relay panel contains 6 relays, 20 fuses (Items 1), a crane USB electrical diagnostic connector (Item 3), a buzzer (Item 2), a diode module (Item 5) and a RCL override key switch (Item 4).

Fuses

Fuses F101 through F103 are energized when the batteries are connected.

Fuse F104 is energized when the batteries are connected and the superstructure cab key switch is in the accessory position.

Fuses F105 through F106 are energized when the batteries are connected and the superstructure key switch is in the ignition (RUN) position.

Fuse F106 is energized when the batteries are connected and either the carrier cab or superstructure cab key switch is in the ignition (RUN) position and the superstructure cab emergency stop switch has not been activated.

Fuses F107 through F112 are energized when the batteries are connected and either the carrier cab or superstructure cab key switch is in the ignition (RUN) position or the accessory (ACC) position.

Fuses F113 through F120 are energized when the batteries are connected and the superstructure key switch is in the ignition (run) position or the accessory (ACC) position.

The rating of each fuse and the function or circuit they protect can be found on the decal shown in Figure 3-9.

Relays

Relay K101 provides power to fuses 107 through 112. This relay's coil is energized when either key switch is positioned to the ignition (RUN) position or the accessory position.

Relay K102 provides power to fuses 113 through 120. This relay's coil is energized when the superstructure key switch is positioned to the ignition (Run) position or the accessory position.

Relay K103 through K106 are mounted on the rear side of the fuse and relay panel.

Relay K103 is the superstructure key switch power supply relay.

Relay K104 is the superstructure cab heater control motor relay.

Relay K105 is the superstructure cab windshield wiper relay.

Relay K106 is the superstructure cab skylight wiper relay.

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.

CAUTION

When possible ensure the batteries are disconnected before performing any maintenance on an electrical circuit.

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 fuses and components and guide you from the easiest and most likely problems to the hardest and least likely problems.
3. Using a multimeter, test the circuit for continuity if you suspect a broken circuit or for voltage if you suspect a power problem. Check the electrical schematic 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 verify the repaired circuit works properly.

Troubleshooting Swivel-Caused Electrical Problems

Many crane component electrical troubles can be traced to the electrical swivel. Troubles common to the swivel are improper mounting, foreign material between the brushes and slip rings, incorrect wiring from the swivel to the components, incorrect wire size, worn brushes, improper spring tension on the brush assembly, and loose setscrews on the slip ring assembly. Refer to the electrical schematic 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 (Tables 3-4 through 3-7) 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 3-4
Amp Extraction Tool Table

Description	Deutsch Part Number	Grove Part Number
14 gauge wire (connectors)	305183	9-999-100176
12 to 8 gauge wire (connectors)	91019-3	9-999-100175
4 to 9 circuit (in-line connectors)	453300-1	N/A
15 circuit (in-line connectors)	458944-1	N/A

Table 3-5
Amp Crimping Tool Table

Description	Amp Part Number		Grove Part Number	
	Tool	Die	Tool	Die
14 to 12 gauge wire	69710-1	90145-1	9-999-100177	N/A
10 to 8 gauge wire	69710-1	90140-1	9-999-100177	9-999-100178
4 to 9 circuit (in-line connectors	69710-1	90306-1	9-999-100177	N/A
15 (in-line connectors	90299-1	--	N/A	--

Table 3-6
Deutsch Extraction Tool Table

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

Table 3-7
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT-48-00	9-999-100808
4, 6, 8, 10 gauge wire	HDT04-08	9-999-100842

Diagnostic Lights

The console indicator lights are located in the carrier cab console. Refer to Section 3 in the Operator's Manual. The lights are linked to various parts of the crane by the control modules and notify the operator when a certain condition occurs during the operation of the crane. When the ignition key is turned to the ON position, all indicators on the top row of the console will illuminate solid, all at the same time for approximately two seconds as a diagnostic test. For any lamp not illuminating during this period, following the steps in the General Troubleshooting Section to identify and repair the issue or replace the lamp if it is determined to be faulty.

Engine Stop Indicator Lamp - This lamp is the top portion of the first indicator lamp. It will illuminate red when it is commanded on by the engine ECM. This is accomplished by a J1939 CAN message from the engine ECM to the crane's master module. When this lamp is on, an engine fault condition is active. The engine's fault code(s) may be obtained by the Engine Stop Lamp and Warning Lamps as described below or the superstructure cab's operator's display. When this lamp is illuminated red after the two second pre-test, the warning buzzer will be sounding.

Engine Amber Warning Indicator Lamp - This lamp is the top portion of the second indicator lamp. It will illuminate amber when it is commanded on by the engine ECM. This is accomplished by a J1939 CAN message from the engine ECM to the crane's master module. When this lamp is on, it indicates there are critical operator messages and diagnostic fault codes which require prompt operator attention. It is also used to flash diagnostic fault codes. The engine's fault code(s) may be obtained by the Engine Stop Lamp and Warning Lamps as described below or the superstructure cab's operator's display.

Engine Malfunction Indicator Lamp (MIL) - This lamp is only installed on units with an ISX engine and will be located at the top portion of the third indicator. It will illuminate amber when it is commanded on by the engine ECM for any failure that could affect tail pipe emissions. This is accomplished by a J1939 CAN message from the engine ECM to the crane's master module. When this lamp is on, an engine fault condition is active. The engine's fault code(s) may be obtained by the Engine Stop Lamp and Warning Lamps as described below or the superstructure cab's operator's display.

In addition to alerting the operator of system faults, the warning light, in conjunction with the stop light, is used in the diagnostic operation of the engine control system. The diagnostic mode begins when the ignition and engine diagnostic switch is 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-, four-, or five-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 twice 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.

The engine fault codes, while active, may also be obtained by navigating to the service screen of the superstructure cab's operator's display.

Crane system Module Off Line Indicator Lamp - This lamp is the bottom portion of the first indicator lamp. It will illuminate red any time one of the crane control modules or the engine electronic control module (ECM) is not in communication with the crane's master module. The service tool may be connected to the Crane's USB diagnostic connector mounted on the carrier cab power panel to determine which module(s) is off line. Service tool components and software may be obtained by contacting Manitowoc Crane Care.

Crane system Electrical System Diagnostic Lamp - This lamp is the bottom portion of the second indicator lamp. It will illuminate red when there is fault condition on one of the crane module's outputs. The fault may be determined by accessing the code from the superstructure cab's operator's display or the service tool may be connected to the Crane's USB diagnostic connector mounted on the carrier cab power panel to determine output is faulty. Service tool components and software may be obtained by contacting Manitowoc Crane Care.

The bottom portion of the switch is the electrical system diagnostic indicator. There are three conditions for this indicator as follows:

- **a.** On solid with buzzer sounding - There is an interruption of communication over the main CAN bus control line between the crane's electronic control modules. Proper crane operating condition shall be restored as quickly as possible.
- **b.** Flashing with buzzer sounding - An undesirable condition with the crane's joysticks has been detected. Proper crane operating condition shall be restored before performing any hydraulic function.
- **c.** Flashing without buzzer - An undesirable component or electrical system condition has occurred.

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 1-13.
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 24 volts or greater. Make repairs as needed.
2. Continue troubleshooting charging system as needed if replacement of alternator did not correct problem in charging system.

Starter Replacement

Removal

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.

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

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

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

Installation

1. Place the batteries in the battery box.
2. Install the hold down bracket so it can hold down the batteries. Secure the bracket (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.

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

Relay Panel Component Replacement

Accessory Relay Replacement

CAUTION

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

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

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. Turn the battery disconnect switch to off.
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. Turn the battery disconnect switch to on.

Check

1. Start the engine and verify that the instrument works. Refer to Section 3 in the 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. Turn the battery disconnect switch to off.
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. Turn the battery disconnect switch to on.

Check

1. Refer to Section 3 in the Operator's Manual and verify switch operation. 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

CAUTION

To prevent possible engine fault codes and undesirable operation, in order: Ensure keyswitch has been off 2 minutes, Battery disconnect is in the off position.

1. Ensure that the key switch has been off for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the motor.

4. Disconnect the washer hose on the wiper arm (also called the pantograph arm assembly) from the washer nozzle fitting assembly (Figure 3-11).
5. Remove the cap nut and washer securing the wiper arm to the pantograph adapter kit. (The nut and washer are part of the pantograph adapter kit.) Remove the cap nut, washer, and tapered sleeve securing the wiper arm to the pivot shaft kit. (The nut, washer, and sleeve are part of the pivot shaft kit.)
6. Remove the wiper arm from the pantograph adapter kit and the pivot shaft kit.
7. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft kit. (The sleeve, nut, and washers are part of the pivot shaft kit.)
8. Remove the capscrews and lockwashers securing the pantograph adapter kit's adapter to the cab exterior. Remove the pantograph adapter kit's adapter and gasket.
9. Remove attaching hardware to free the windshield wiper motor bracket from the cab interior. Remove the bracket, with motor and pivot shaft connected, from the cab.

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

10. Remove the nut to free the wiper motor's shaft from the wiper motor kit crank. Remove the three screws and washers to free the wiper motor from its bracket. Remove the wiper motor from its bracket. Leave the other parts attached to the bracket for now.

Inspection

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

Installation

1. Verify the pivot shaft and the wiper motor kit link and crank are in place on the motor bracket. (Washers and clip springs fasten the link to the pivot pins on the crank and the pivot shaft. The pivot shaft's pivot pin mounts in the hole nearest the end of the pivot shaft's lever.)
2. Connect the wiper motor to the motor bracket with screws and washers. Connect the wiper motor's shaft to the wiper motor kit crank with the nut and washer.
3. Secure the adapter and the gasket of the pantograph adapter kit to the cab exterior with capscrews and lockwashers.
4. Install the motor bracket and attached parts in the cab interior with attaching hardware. Ensure the pivot shaft sticks through the hole in the pantograph adapter kit.

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

5. Secure the pivot shaft to the pantograph adapter with the pivot shaft kit's nut and washers. Install the flanged sleeve on the pivot shaft.
6. Install the wiper arm on the shafts of the pantograph adapter kit and the pivot shaft kit. Secure the wiper arm to the pantograph adapter kit shaft with the kit's own washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft kit's own tapered sleeve, washer, and cap nut.
7. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
8. Connect the electrical leads to the wiper motor as marked before removal.
9. Turn the battery disconnect switch to the ON position.

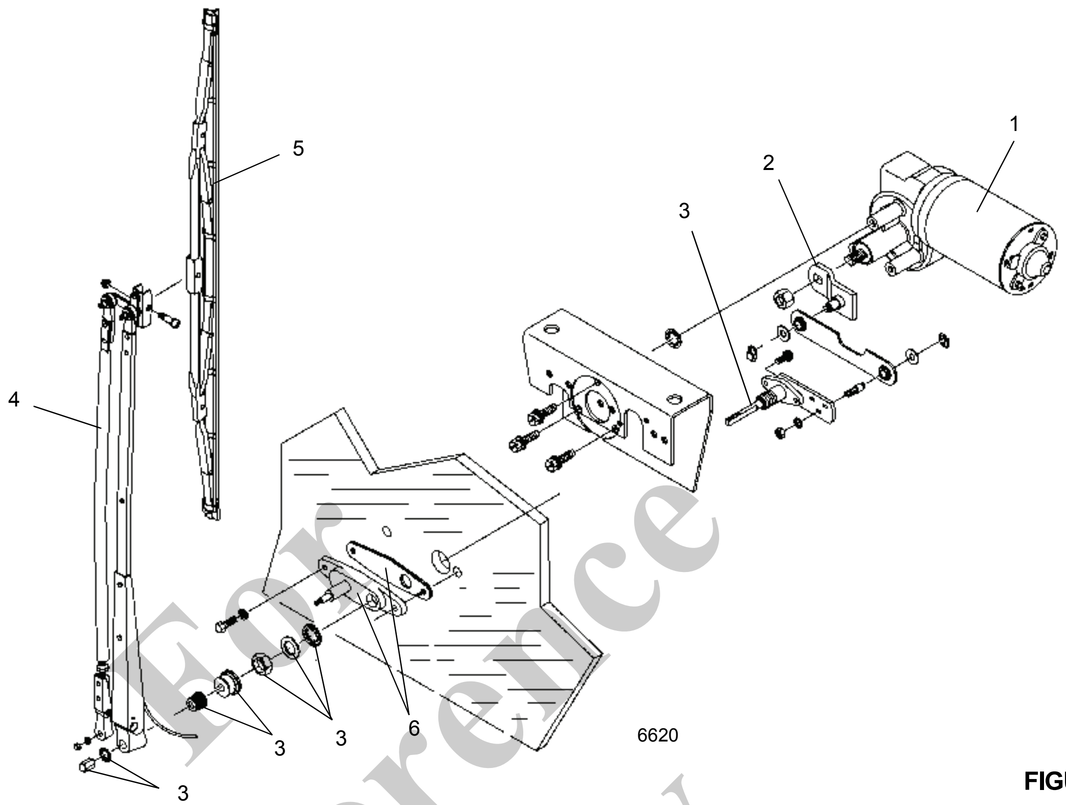


FIGURE 3-11

Item	Description
1	Motor
2	Arm Drive
3	Pivot Shaft
4	Wiper Arm
5	Wiper Blade
6	Adapter

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

CAUTION

To prevent possible engine fault codes and undesirable operation, in order: Ensure keyswitch has been off 2 minutes, Battery disconnect is in the off position.

1. Turn the battery disconnect switch to the off position.
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. Turn the battery disconnect switch to the on position.
6. Fill the container with cleaning fluid.

Check

1. Squirt some cleaning fluid onto the windshield with the windshield washer.
2. Make repairs if windshield washer doesn't work.

Skylight Wiper Assembly Replacement

Removal

CAUTION

To prevent possible engine fault codes and undesirable operation, in order: Ensure keyswitch has been off 2 minutes, Battery disconnect is in the off position.

1. Turn the battery disconnect switch to the off position.
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. Turn the battery disconnect switch to the on position.

Check

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

Troubleshooting

This machine incorporates a CAN bus Multiplex system. In order to effectively troubleshoot the electrical system, you need a Windows-based PC, Orchestra® software (999102409), a connection cable (9999102296) and a dongle (9999102587). The Orchestra® software, connection cable and dongle may be ordered from Crane Care.

NOTE: The software can only be purchased by technicians that have attended the Grove New Technology training course.

SECTION 4
BOOM

TABLE OF CONTENTS

4

DESCRIPTION

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

Lattice Extension

10m - 17m (33ft - 56ft) offsettable bifold lattice swingaway extension. Offsets 0°, 20°, and 40°. Stows alongside base boom section.

Optional Lattice Extension

6.1m (20ft) lattice extension inserts install between the boom nose and bifold extension are non-stowable. A standard auxiliary boom nose (rooster sheave) is available for the boom to simplify single part cable usage. The rooster sheave is installed on the main boom nose and is secured by pins that pass through the rooster sheave and main boom nose.

THEORY OF OPERATION

Extension

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 base section and the barrel is secured to tele 1 boom section by a trunnion. The upper telescope cylinder rod is secured to the rear of tele 1 boom section and the barrel is secured to tele 2 boom section by a trunnion. The extension cables are secured to the back of the tele 3 section and run around extension sheaves on the cylinder mounted tele 3 sheave mount to the cable anchor at the lower cylinder.

The hydraulic fluid in both lower and upper telescope cylinders is routed through the rods so that the barrels can extend. There are two cam operated check valves which control flow to the telescope cylinders. With both cylinders retracted, the check valve for the lower telescope cylinder is open and the check valve for the upper cylinder is closed allowing the lower cylinder to extend. When the lower cylinder is fully extended, the check valve for the upper cylinder opens allowing the upper cylinder to extend. The check valve for the lower cylinder closes after the upper cylinder starts to extend and shuts off the flow to the lower cylinder. As the upper telescope cylinder barrel extends, the extend cables around the extend sheaves push on the extend cables to pull the tele 3 section out at the same time tele 2 is extending.

Boom Retraction

The upper telescope cylinder retracts the tele 2 and two retract cables pull the tele 3 section in at the same time. When the upper cylinder is fully retracted, the check valve for the lower telescope cylinder is opened and the lower cylinder starts to retract. The check valve for the upper cylinder is closed as the lower cylinder starts to retract. Tele 2 and tele 3 retract first and then tele 1.

MAINTENANCE

Removal

NOTE: The boom weighs approximately 9570 kg (21098 lb). Removal of the swingaway jib will simplify boom removal, therefore, the above weight is for the boom without the swingaway jib attached.

1. Extend and set the outriggers to level the crane and ensure the boom is fully retracted and in a horizontal position over the front of the crane.
2. If equipped, remove the swingaway jib and auxiliary nose 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. Position the boom to make sure that the lift cylinder is properly supported.

DANGER

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

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

DANGER

Ensure the boom lift cylinder is properly supported before disconnecting it from the boom.

8. Block the lift cylinder.
9. Take up the slack on the boom lifting device.
10. Remove the capscrews, washers and end plate securing the upper lift cylinder shaft to the boom base section.
11. Remove upper lift cylinder shaft.
12. Remove clip pin and cross pin securing boom point pin to base section.

DANGER

Shut down the crane before proceeding.

13. Remove boom pivot pin.

NOTE: The boom nose sheave shafts weigh approximately 63 kg (139 lb) each.

14. Raise the boom clear of the crane and lower to ground and set cribbing to support the boom and prevent tipping.

Boom Disassembly

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

NOTE: The boom weighs approximately 9570 kg (21098 lb). The above weight is for the boom without the swingaway jib attached.

DANGER

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

DANGER

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

DANGER

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

3. On the top front of the base section, remove the cotter pins, shim, shaft and roller.
4. Repeat step 3 on tele 1.
5. Repeat step 3 on tele 2.
6. On the right side of the base section, remove the capscrew, two nuts, and the trigger weld from the brackets.
7. Remove the bolt, bolt insert and clamps securing the two hydraulic tubes to the rear of the base section. Tag and disconnect the two hydraulic tubes from the lower telescope cylinder. Cap or plug all openings.
8. Remove the capscrews and washers securing the lower telescope cylinder rod to the trunnion mounting plate at the rear of the base section.

NOTE: The combined weight of the boom tele 1, tele 2, and tele 3 sections, including the telescope cylinders, is approximately 7231 kg (15942 lb).

9. Slide the assembly out of the base part way.
10. Remove the capscrews and washers and the two set screws and hex nuts securing each front top wear pad to base section. Remove bolts and washers securing each adjusting plate to top of base section. Remove two adjusting plates. Remove upper wear pad assembly. If necessary, remove four capscrews securing front upper wear pad to pad plate.
11. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to the bottom of the base section. Remove the keeper plates.
12. Lift up on the front of tele 1 and remove the bottom and side wear pads and shims from the base section, noting quantity, size, and location of shims and pads.
13. Continue to pull the assembly from the base section removing the top rear wear pads from tele 1 as they clear the base section. Support remaining assembly on cribbing.
14. Remove the capscrews securing the rear side wear pads to tele 1. Remove the wear pads and shims, noting quantity and size of shims.
15. Remove the mounting plates from the lugs on the lower cylinder rod.

16. Tag and disconnect the hydraulic hoses and tubes from the telescope cylinders and the two cam valves. Cap or plug all openings.
17. Remove the capscrews and washers securing each cam valve to its mounting plate and remove the valves.
18. Place blocking under the lower cylinder barrel.
19. Remove the capscrews and washers securing the lower cylinder barrel mounting plates to tele 1.
20. Remove the capscrews and washers securing the upper cylinder rod mounting plates to tele 1.
21. On the left side of tele 1, remove the valve pusher rod.
22. On the right side of tele 1, remove the valve pusher rod. Disassemble as necessary.
23. Slide the assembly out of tele 1 part way.
24. Remove the capscrews and washers and the two set screws and hex nuts securing each front top wear pad to tele 1. Remove bolts and washers securing each adjusting plate to top of tele 1. Remove two adjusting plates. Remove upper wear pad assembly. If necessary, remove four capscrews securing front upper wear pad to pad plate.
25. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to tele 1. Remove the keeper plates.
26. Lift up on the front of tele 2 and remove the bottom and side wear pads and shims from tele 1, noting quantity, size and location of shims.
27. Continue to pull the assembly from tele 1, removing the top rear wear pads from tele 2 as they clear tele 1. Support remaining assembly on cribbing.
28. Remove the capscrews securing the rear side wear pads to tele 2. Remove the wear pads and shims, noting quantity and size of shims and pads.
29. Remove the capscrews and washers securing the bottom rear wear pad to tele 1 and remove the wear pad and spacer.
30. If necessary, remove both grease fittings, connectors, and grease lines from the rear of tele 1.
31. Continue to pull the assembly from tele 1, removing the top rear wear pads from tele 2 as they clear tele 1.
32. Remove the capscrews and washers securing each retract cable sheave mount in the rear of tele 2. Remove the retract cable sheave mounts from the rear of tele 2; remove retract sheaves.
33. Place blocking under the lower and upper cylinder barrel.
34. Remove the capscrews and washer securing each upper cylinder barrel trunnion mounting plate to tele 2.
35. Slide the assembly out of tele 2 part way.
36. Remove the capscrews and washers and the two set screws and hex nuts securing each front top wear pad to tele 2. Remove two bolts and washers securing each adjusting plate to top of tele 2. Remove two adjusting plates. Remove upper wear pad assembly. If necessary, remove four capscrews securing front upper wear pad to pad plate.
37. Remove the capscrews and washers securing the bottom and side wear pad keeper plates to tele 2. Remove the keeper plates.
38. Lift up on the front of the tele 3 section and remove the bottom and side wear pads and shims from tele 2, noting quantity, size, and location of shims.
39. Continue to pull the assembly from tele 2, removing the top rear wear pads from tele 3 section as they clear tele 1.
40. Remove the capscrews securing the rear side wear pads to tele 3 section. Remove the wear pads and shims, noting quantity and size of shims.
41. Remove the capscrews and washers securing the bottom wear pad to tele 2 and remove the wear pad and shim.
42. If necessary, remove both grease fittings, connectors, and grease lines from the rear of tele 2.
43. Remove the mounting plates from the upper cylinder barrel mounting lugs.

DANGER

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

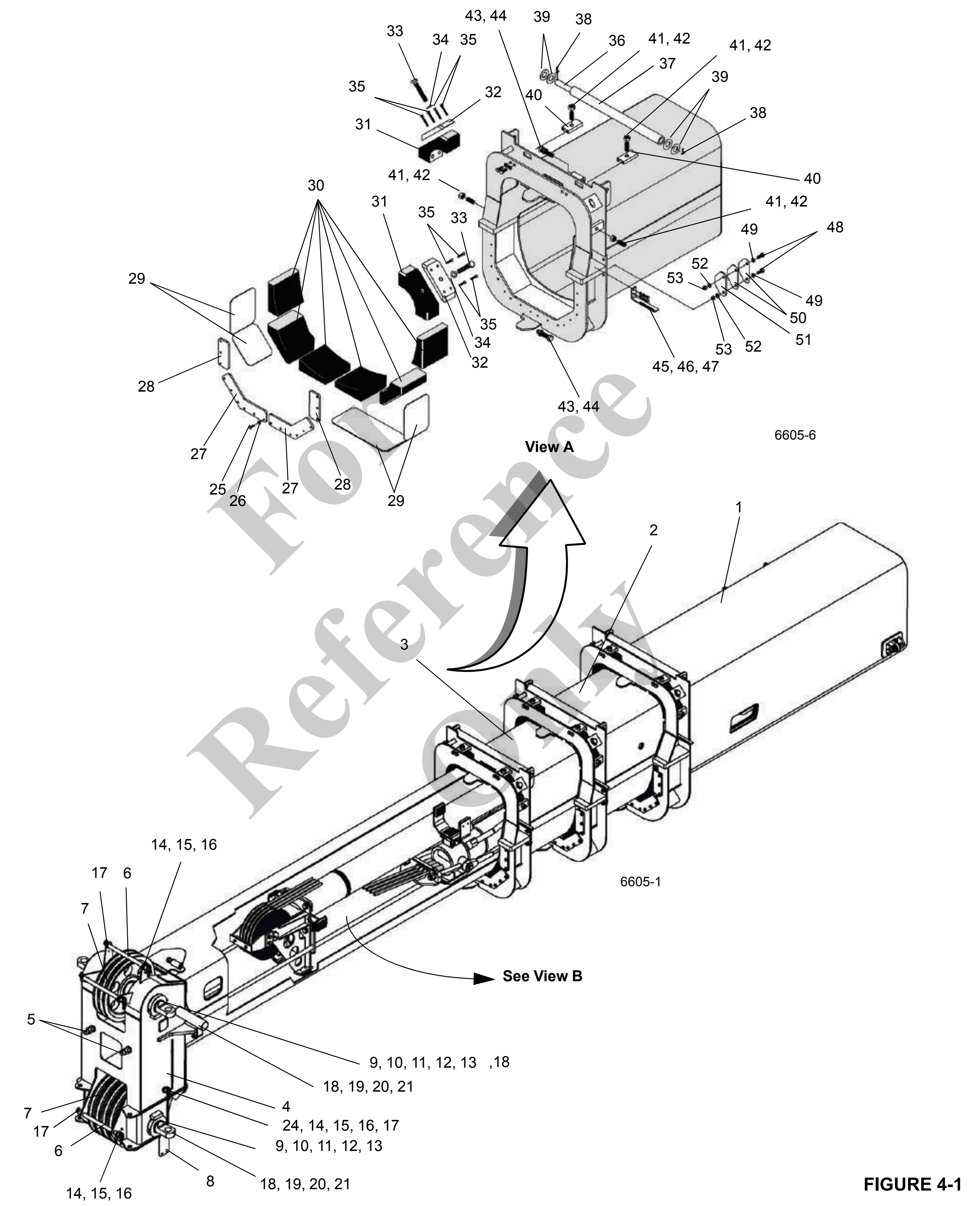

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FIGURE 4-1

4

Item	Description
1	Base Section
2	Tele 1
3	Tele 2
4	Nose To Tele 3 Section
5	Retract Cables
6	Cable Retainer Pin
7	Sheave Assembly
8	Anti-Two Block Plate
9	Spacer
10	Capscrew
11	Shim
12	Hex Nut
13	Lock Collar
14	Hook
15	Chain
16	Cotter Pin
17	Hitch Pin Clip
18	Shaft
19	Spacer
20	Locknut
21	Washers
22	Shim
23	Spacer
24	Pin
25	Capscrew
26	Washer
27	Keeper Plate
28	Keeper Plate
29	Shim
30	Lower Wear Pad
31	Front Upper Pad
32	Top Front Pad Support
33	Capscrew
34	Flatwasher
35	Capscrew
36	Shaft
37	Roller
38	Cotter Pin
39	Shim
40	Top Front Adjusting Block
41	Hex Nut
42	Socket Setscrew
43	Capscrew
44	Nut
45	Mounting Angle
46	Capscrew
47	Washers
48	Capscrews
49	Flatwasher
50	Stop Block Shim
51	Stop Block Plate
52	Washer
53	Nut

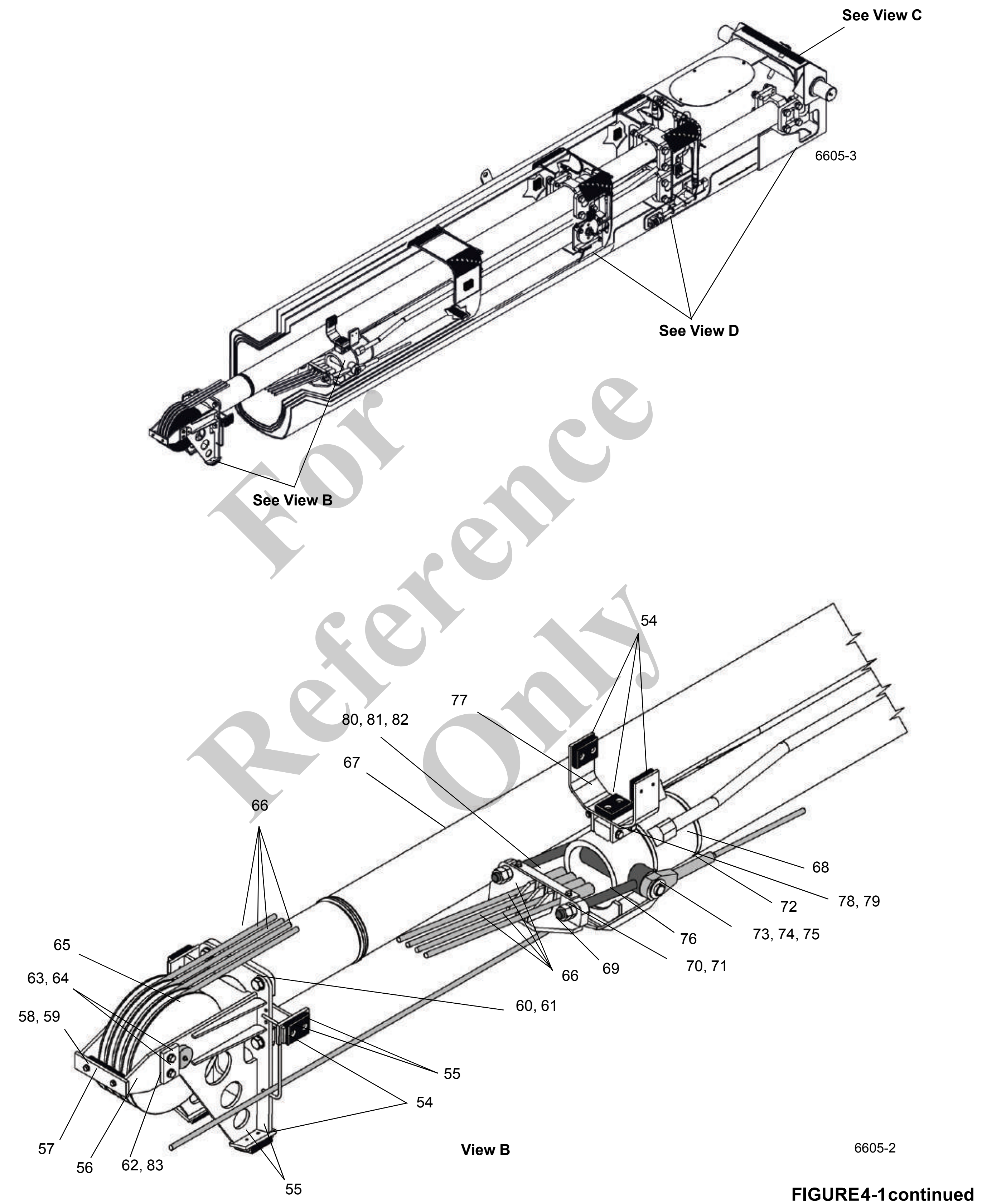


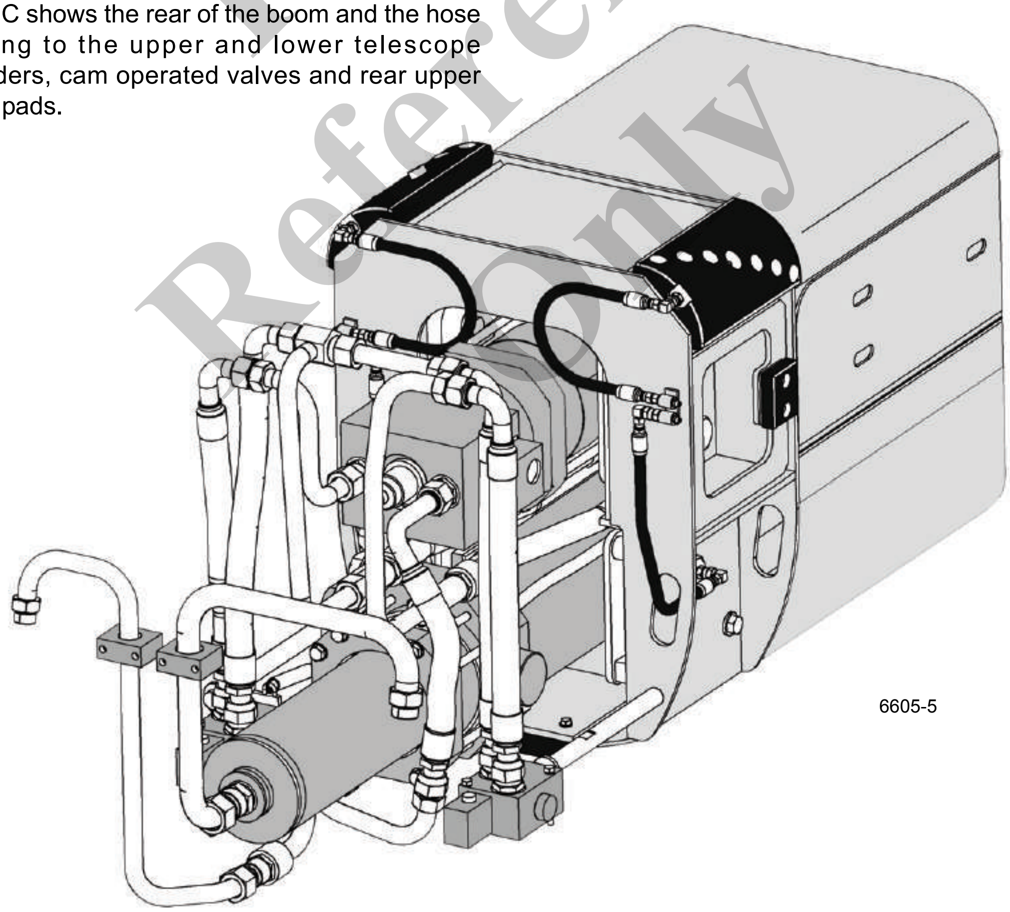
FIGURE4-1continued

4

Item	Description
54	Wear Pad
55	Capscrew
56	Sheave Mount
57	Cable Retainer
58	Capscrew
59	Washer
60	Capscrew
61	Washer
62	Plate
63	Capscrew
64	Washer
65	Sheave Assembly
66	Extend Cables
67	Upper Telescope Cylinder
68	Lower Telescope Cylinder

Item	Description
69	Cable Anchor
70	Swivel Nut
71	Hex Nut
72	Retract Cable
73	Cotter Pin
74	Washer
75	Pin Cylinder Mount
76	Bolt
77	Cylinder Support
78	Capscrew
79	Washer
80	Plate Cover
81	Capscrew
82	Washer
83	Spacer

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



View C

FIGURE 4-1 continued

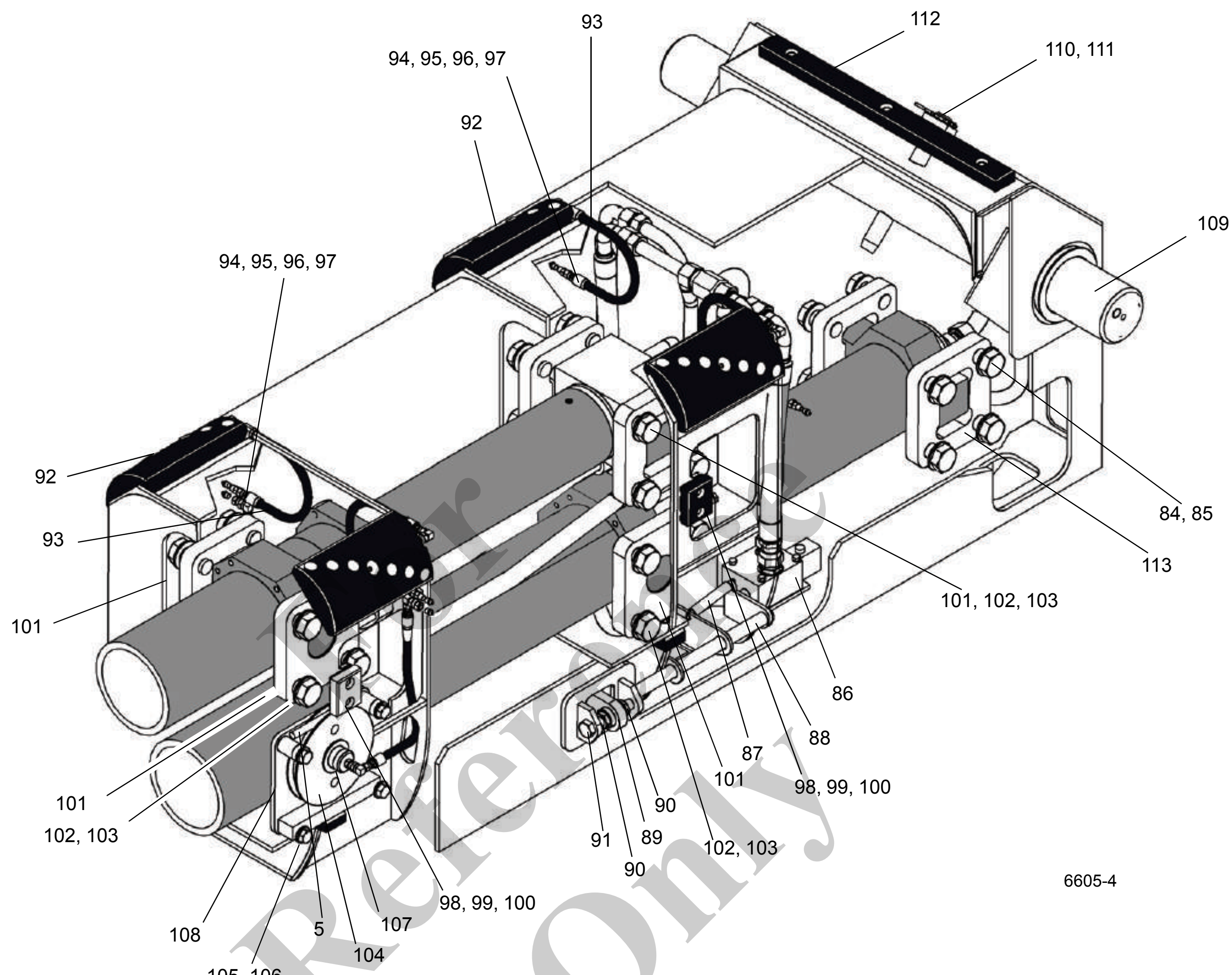


FIGURE 4-1 continued

Item	Description
84	Capscrew
85	Washer
86	Cam Operating Plate
87	Spring
88	Pusher Weld
89	Trigger Weld
90	Nut
91	Capscrew
92	Rear Upper Pad
93	Hose

Item	Description
94	Elbow
95	Adapter
96	Connector
97	Grease Fitting
98	Side Wear Pad
99	Capscrew
100	Shim
101	Trunnion Mounting Plate
102	Capscrew
103	Washer
104	Sheave Assembly

Item	Description
105	Capscrew
106	Washer
107	Thrust Washer
108	Sheave Mount
109	Boom Pivot
110	Pin
111	Clip Pin
112	Cable Wear Pad
113	Trunnion Mounting Plate

44. Slide the telescope cylinder assembly out the rear of tele 3 until access to the wear pad holders on each side of the upper telescope cylinder support foot is obtained. Remove the capscrews and washers securing each holder and remove the holders.

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

46. Remove the capscrews and washers securing the extend cable keeper plate to the rear of tele 3. Remove the keeper plate and remove the four extend cable ends from the slots in tele 3.

47. Continue to slide the telescope cylinder assembly out of tele 3 section. Lowering the rear of tele 3 section and raising the rod end of the cylinders will aid in removal.

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

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

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

NOTE: The upper telescope cylinder weighs approximately 410 kg (904 lb) and the lower telescope cylinder weighs approximately 1149 kg (2533 lb).

51. Remove the shaft from the lower telescope cylinder.

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

53. On the front of tele 3 section, remove the nut and washer from the end of each retract cable and remove the retract cables from tele 3 section.

54. Remove the capscrews and washers securing the rear bottom wear pad on the tele 3 section and remove the wear pad.

55. If necessary, remove the grease fittings, connectors, and grease lines from the rear of the tele 3 section.

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

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

58. Remove the extend cables from the sheave assembly.

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

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

61. If necessary, remove the capscrews securing each wear pad to the support foot and remove the wear pads.

62. If removal of the boom nose sheaves are required, refer to BOOM NOSE SHEAVES - Removal in this section.

63. Refer to *Jib and Retraction Cable*, page 4-15 in this section for cable inspection.

Boom Nose Sheaves

Removal

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

NOTE: The boom nose sheave shafts weigh approximately 63 kg (139 lb) each.

3. Carefully pull the upper boom nose sheave shaft from the boom nose, removing the spacers, shims, and boom nose sheaves. Note location of each.
4. Repeat steps 2 and 3 and remove the lower boom nose sheave shaft.
5. Remove the shim, washers, and locknut from both sheave shafts.

Installation

CAUTION

Do not install the boom nose sheaves over the threaded end of the boom nose sheave shaft.

1. Install the spacers and sheaves onto the sheave shaft while installing the sheave shafts into the boom nose.

Ensure that top spacer and sheaves are in proper orientation to lower sheaves.

NOTE: The lockwasher can be used more than once but must be replaced if not in good condition.

NOTE: Install the lockwasher onto the sheave shaft with the tabs facing out.

2. Install the locknut and shims (if necessary) onto the boom nose sheave shaft with the chamfer side out. Install the collar onto the opposite end of the sheave shafts and secure in place with the capscrew and nut.

NOTE: If more than one shim is required, install an equal amount on each side of the boom nose.

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

Assembly

DANGER

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

DANGER

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

CAUTION

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

CAUTION

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

NOTE: Apply medium strength threadlocking adhesive/ sealant to the threads of all attaching hardware except cable ends and cable lock nuts.

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

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

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

NOTE: The grease lines are designed to be used only on one side or the other (that is, RH - right hand or LH - left hand).

11. Install the bottom rear wear pad on the tele 3 section with the capscrews and washers. Torque the capscrews.
12. Route the two retract cables (threaded ends) through the tele 3 section to the front. Insert the threaded ends through the holes on the front of the tele 3 section and install a washer and two nuts on each cable end.

DANGER

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

13. Install the wear pads in the upper telescope cylinder support with the capscrews. Torque the capscrews.
14. Position the cylinder support on lower telescope cylinder and secure with the capscrews and washers. Torque the capscrews.
15. Using an adequate lifting device, position the upper telescope cylinder onto the lower telescope cylinder.
16. Position the sheave end of the telescope cylinder assembly at the rear of the tele 3 section.
17. Lay the retract cable sheave mounts out behind the tele 3 section as they will be installed in tele 2. Route the lug end of the retract cables through the sheave mounts (top to bottom) so the lug end will come off the bottom of the sheave. Place the retract sheave, with one thrust washer on each side, in the mount.
18. Install the lug end of each retract cable to the telescope pin cylinder mount and secure with the washer and cotter pin.
19. Install the adjusting bolts through the holes in the lower mount shaft.
20. Install the sled assembly onto the adjusting bolts and install both swivel nuts and regular nuts, making sure that the extension cables are not crossed and twisted.
21. Slide telescope cylinder assembly into the rear of the tele 3 section until sheave mount clears the tele 3 end plates at the rear of the tele 3 section. Lowering the rear of tele 3 and raising the rod end of the cylinders will aid in sliding these together.
22. Place the extend cable lug ends in the slots at the top of the tele 3 section and secure them with the keeper plate and two capscrews and washers. Torque the capscrews.
23. Install a wear pad on the two upper telescope cylinder wear pad holders.
24. Position the wear pad holders on each side of the upper telescope cylinder support foot and secure each with capscrews and washers.
25. Slide the telescope cylinder assembly all the way in. Place blocking under the rear of the telescope cylinders to aid in assembly.
26. Place the mounting plates on the upper telescope cylinder barrel mounting lugs.
27. Using tape or ty-wraps, fasten the extend cable ends to the telescope cylinder to aid in assembly.
28. Place the retract cable sheave mounts in the rear of the tele 3 section to aid in assembly.
29. At the rear of tele 2, install the upper wear pad grease line, connector and grease fitting on each side.
30. Install the bottom rear wear pad on tele 2 with the capscrews and washers. Torque the capscrews.
31. Position the front end of tele 2 at the rear of the tele 3/telescope cylinder assembly.
32. Slide the tele 3/telescope cylinder assembly into tele 2 installing top rear wear pads in pockets of tele 3 section. Stop and install rear side wear pads and shims on tele 3 section with capscrews. Torque the capscrews.

NOTE: Use shims as necessary to adjust wear pad so it is within 2 mm (0.079 in) of tele 2 side plate. Use equal number of shims on each side.

33. Continue to slide together being careful not to damage cables.
34. Lift up on the front of tele 3 and install the bottom and side front wear pads in tele 2. Install shims as necessary.
35. Install tele 2 front top wear pads as noted during disassembly. Secure each with a capscrew and washer. Torque the capscrews. Install two adjusting blocks and secure each with capscrews and washers. Install adjusting screws and lock nuts. (Two each on top and two each on side).
36. Install bottom and side wear pad keeper plate on each side of tele 2 and secure with the capscrews. Torque the capscrews.
37. Continue to completely slide together.
38. Lift up on end of the upper cylinder to align barrel trunnion mounting plate holes with holes in tele 2. Secure each with four capscrews and washers. Torque the capscrews.
39. Remove any blocking under cylinder.
40. Remove the retract cable sheave mounts from the tele 3 section and attach them to the rear of tele 2 with capscrews and washers. Torque the capscrews, refer to *Fasteners and Torque Values*, page 1-13.
41. Place the trunnion mounting plates on the lower cylinder barrel mounting lugs.
42. Place the trunnion mounting plates on the upper cylinder rod mounting lugs.
43. At the rear of tele 1, install the upper wear pad grease line, connector and grease fitting on each side.

44. Install the bottom rear wear pad on tele 1 with the capscrews and washers. Torque the capscrews.

45. Position the front end of tele 1 at the rear of the tele 2/ tele 3/telescope cylinder assembly.

46. Slide the tele 2/tele 3/telescope cylinder assembly into tele 1 installing top rear wear pads in pockets of tele 2 (cutout should align with grease line). Stop and install rear side wear pads and shims on tele 2 with the capscrews. Torque the capscrews.

NOTE: Use shims as necessary to adjust wear pad so it is within 2 mm (0.079 in) of tele 1 side plate. Use equal number of shims on each side.

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

48. Lift up on the front of tele 2 and install the bottom and side front wear pads in tele 1. Install shims as necessary.

49. Install tele 1 front top wear pads as noted during disassembly. Secure each with a capscrew and washer. Install two adjusting blocks and secure each with capscrews and washers. Install adjusting screws and lock nuts. (Two each on top and two each on side).

50. Install bottom and side wear pad keeper plate on each side of tele 1 and secure with the capscrews and washers. Torque the capscrews.

51. Continue to completely slide together.

52. Install nut and washer in right side valve tapped pusher rod. Install the rod assembly through hole on right side of tele 1.

53. Install left side valve pusher rod on outer left side of tele 1.

54. Align upper cylinder rod trunnion mounting plates holes with holes in tele 1. Secure with the capscrews and washers. Torque the capscrews.

55. Lift up on end of the lower cylinder to align barrel mounting plate holes with holes in tele 1. Secure each with the capscrews and washers. Torque the capscrews.

56. Remove any blocking under cylinder.

57. Install the cam valves on the mounting plates on each side of tele 1 using capscrews and washers. Torque the capscrews.

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

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

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

61. Position the front end of the base at the rear of tele 1/tele 2/tele 3/telescope cylinder assembly.

62. Slide tele 1/tele 2/tele 3/telescope cylinder assembly into the base section installing top rear wear pads in pockets of tele 1 (cutout should align with grease line). Stop and install rear side wear pads and shims on tele 1 with the capscrews. Torque the capscrews.

NOTE: Use shims as necessary to adjust wear pad so it is within 2 mm (0.079 in) of the base section side plate. Use equal number of shims on each side.

63. Continue to slide together.

64. Lift up on the front of tele 1 and install the bottom and side front wear pads in the base section. Install shims as necessary.

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

66. Install bottom and side wear pad keeper plate on each side of the base section and secure with the capscrews and washers. Torque the capscrews.

67. Continue to completely slide together.

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

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

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

71. On the top front of the base section, install the cable rollers using a shaft, shims, and two cotter pins. One shim goes on each side of the mounting bracket.

72. Repeat step 68 on tele 1.

73. Repeat step 68 on tele 2.

74. On the left side only, install a RCL cable angle bracket on the base, tele 1, and tele 2 using capscrews and washers.

75. Install the boom in accordance with the BOOM INSTALLATION procedures outlined in this section.

Installation

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

DANGER

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

1. Attach an adequate lifting device to the boom and suspend the boom over the machine.
2. Lower the boom into position and align the boom pivot shaft mounting holes for installation of the pivot shaft to the superstructure assembly.
3. Lubricate the pivot shaft bushings in the superstructure assembly.

DANGER

Block the boom before doing any work under the boom.

4. Block the boom in place.
5. The boom may need to be raised or lowered to aid in the installation of the pivot shaft. Install pivot shaft.
6. Install anti-rotation pin and lock in place with clip pin.

DANGER

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

7. Using the lifting device attached to the boom, lower the boom onto the lift cylinder rod end and extend the lift cylinder as necessary to align rod end with bore in base section.

DANGER

If the hydraulic system must be activated to extend or retract the lift cylinder, ensure the rod end is properly aligned with the lift cylinder attach fitting.

8. Lubricate the upper lift cylinder pin. Install upper lift cylinder pin. The lift cylinder may need to be raised or lowered to aid in the installation of the lift cylinder pin.
9. Secure the upper lift cylinder pin with the end plate, capscrews and washers. Torque the capscrews.
10. Lower the jack after making sure it is properly supported.
11. Remove the boom lifting device.
12. Activate the hydraulic system and remove the boom and lift cylinder blocking devices. Lower the boom to horizontal. Shut down the crane.
13. Connect the hydraulic lines to the lower telescope cylinder as tagged prior to removal.
14. Install the base cover on top of the boom base section, then secure with four bolts and washers.
15. Connect any electrical wires as tagged prior to removal.
16. Refer to *Jib and Retraction Cable*, page 4-15 in this section for cable adjustments.
17. Refer to *Cam Operated Check Valve Adjustment*, page 4-15 in this section 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.

NOTE: Cycle the boom several times to evacuate air from cylinders.

3. Ensure the lift cylinder will not allow the boom to drift down until the operator lowers it.
4. Ensure all electrical components disconnected during removal are operating properly.

Inspection

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

Should boom chatter or rubbing noises in the boom occur, it will be necessary to lubricate the telescope cylinder wear pads. Refer to *Lubrication*, page 9-1.

Boom Alignment and Servicing

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

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

1. Fully extend the boom horizontally.
2. Lubricate the boom bottom channels and top corners.
3. Adjust the front top wear pads such that wear pad is just touching or is no more than 2 mm (0.079 in) from contacting the next section both at the top and side surfaces of the top radius.

CAUTION

When extending and retracting the boom during alignment, movement should be stopped if a restriction is encountered, and wear pads adjusted as necessary to provide free travel of the affected boom section(s).

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

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

Cam Operated Check Valve Adjustment

There are two cam operated valves mounted on the back of tele 1. When the boom is fully retracted or tele 1 is fully extended, the valve on the right side of the boom is held open to supply flow to the lower telescope cylinder. When tele 1 is fully extended, the valve on the left side of the boom opens to supply flow to the upper telescope cylinder. For a short period of time, both valves are open because the lower cylinder is fully extended before the upper cylinder starts to extend. As tele 2 starts to extend, the valve on the right side closes to shut off the flow to the second stage of the lower cylinder.

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

Stop Block Adjustment

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

Front Upper Pad Adjustment

1. Using setscrews, adjust front upper wear pads so that the wear pad is just touching or is no more than 2 mm (0.079 in) away from contacting the next outer section at the side surfaces, and is 4 mm to 6 mm (0.16 in to 0.24 in) away from contacting the next outer section at the top surfaces.
2. Lock setscrews in place with locknut.
3. Tighten capscrews until pad support plate is held in place against setscrews.

Rear Side Wear Pad Adjustment

1. Using shims, adjust wear pad so that the wear pad is within 2 mm (0.079 in) from the side plate of the next inner section. Equal number of shims should be on both sides.

4

JIB AND RETRACTION CABLE

Maintenance

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

Inspection

CAUTION

Never handle wire rope with bare hands.

The following information is taken from a National Consensus standard as referenced by Federal Government Agencies.

All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall be taken out of service when any of the following conditions exist.

- 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 the base section and tele 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 front and at a horizontal position (boom angle elevation 0 degrees or lower).
3. Extend boom until the front end of the lower telescope cylinder is accessible through the holes in tele 2 and tele 1.
4. With the front of the boom in the above position, extend the boom approximately 25 mm (1.0 in) to relieve the tension in the retract cables. Access the retract cables from the front of the boom nose and view the slack of the retract cables through the hole in the back plate of the boom nose. Using the nuts on the retract cables, remove slack evenly, until both retract cables are at least 25 mm (1.0 in) above the lower leg of the cable retainer bars on the sheave mount on the upper telescope cylinder.
5. Retract the boom approximately 25 mm (1.0 in) to relieve tension on the extension cables. Shut down the crane. Evenly tighten the swivel nuts on the adjusting bolts, until the extension cables are up 150 mm (6 in) off the top of the bottom pad plate at the back of the tele 3 section. Look through the holes in the boom sections to see the slack in cables.
6. Lock the adjustments with the jam nuts.

NOTE: During retract cable adjustments, tele 1 must remain fully extended.

7. Extend the boom until tele 2/tele 3 extends several cm (in).
8. Adjust retract cables so that tele 3 section stop block bottoms out 3 mm (.12 in) before the stop block on tele 2 bottoms out.
9. If stop block on tele 3 cannot be properly adjusted without excessive thread 114 mm (4.5 in) protruding out from the jam nuts, back off the nuts on the retract cables 25 mm (1.0 in) and back off the swivel nuts 25 mm (1.0 in).

CAUTION

Overtightening of the retract cable will damage the cable. Take care when retracting the boom fully, while adjusting the cable, to avoid full boom retraction if the tele 3 section contacts its stop block more than 3 mm (.125 in) before tele 2 contacts its stop block on tele 1.

10. Adjust retract cables until stop block on tele 3 bottoms out properly. Install jam nuts.
11. If the retract cables can still not be adjusted properly, remove all the tension in the retract and extension cables and return to step 1.

TELESCOPE CIRCUIT

Description

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

The telescope control valve is the closed spool type and is described under *Valves*, page 2-22.

Refer to *Valves*, page 2-22 for a complete description of the hydraulic remote controller.

The boom telescope system has a lower and an upper telescope cylinder. Both the lower and upper telescope cylinder has a 16.5 cm (6.5 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 2-54 for a complete description of the telescope cylinders.

A holding valve is threaded into a port block on the rod end of the upper telescope cylinder. The holding valve for the second stage of the lower telescope cylinder is mounted into the port block on the barrel end of the second stage barrel. The holding valves function during the retraction, extension, or holding operation. When holding the boom section at a given length, oil is trapped in the cylinder by the holding valve. Refer to *Valves*, page 2-22 for a complete description of the holding valve.

Theory of Operation

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

Also refer to BOOM - THEORY OF OPERATION in this Section.

Maintenance

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Erratic operation of extending telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** 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 recommended setting.
	e. Lack of lubrication on boom sections.	**e.** Properly lubricate all boom sections.
	f. Extremely tight jib sheaves.	**f.** Inspect and properly lubricate jib 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. Extremely tight boom retraction sheave.	**h.** Inspect and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Worn boom wear pads.	**j.** Replace wear pads and properly lubricate.
	k. Bent cylinder rod(s).	**k.** Replace cylinder rod(s) and all cylinder seals.
	l. Scored cylinder barrel.	**l.** Repair or replace cylinder barrel.
	m. Damaged piston seals.	**m.** Replace all cylinder seals.
	n. Loose or damaged piston(s).	**n.** Replace all seals and re-torque or replace piston(s).
3. Telescope cylinder will not extend.	**a.** Low hydraulic oil level.	**a.** Check 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 Manitowoc Crane Care Parts Manual).
	e. Broken valve spool.	**e.** Replace valve.
	f. Damaged piston seals.	**f.** Replace all cylinder seals.
	g. Damaged piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Bent boom section(s).	**h.** Replace damaged boom section(s).
	i. Broken hydraulic pump coupling.	**i.** Replace broken hydraulic pump coupling.
	j. Worn or damaged hydraulic pump section.	**j.** Repair or replace pump section.
	k. Lack of electric control signal.	**k.** Replace control signal.

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 Manitowoc Crane Care Parts Manual).
	f. Broken valve spool.	**f.** Replace valve section.
	g. Broken piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Damaged piston seals.	**h.** Replace all cylinder seals.
	i. Bent boom section(s).	**i.** Replace damaged boom section(s).
	j. Broken hydraulic pump coupling.	**j.** Replace broken hydraulic pump coupling.
	k. Worn or damaged hydraulic pump.	**k.** Repair or replace pump.
	l. Broken hydraulic pump shaft.	**l.** Replace pump shaft.
	m. Lack of electric control signal.	**m.** Replace control signal.
5. Tele 1 will not extend.	**a.** Right side check valve blocked.	**a.** Readjust, repair, or replace valve.
6. Tele 1 will not retract.	**a.** Right side check valve closed.	**a.** Readjust valve.
7. Tele 2 will not extend.	**a.** Left side check valve is closed.	**a.** Readjust valve.
8. Tele 1 retracts before tele 2.	**a.** Right side check valve is open or hosed backwards.	**a.** Install hoses properly.
9. Tele 2 extends only a short distance then stops.	**a.** Left check valve is open or hosed backwards.	**a.** Install hoses properly.

Removal and Installation

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

Disassembly and Assembly

Disassembly and assembly procedures of the telescope cylinder and control valve are provided in *Cylinders*, page 2-54 and *Valves*, page 2-22.

LIFT CIRCUIT

Description

The boom lift circuit consists of the lift electric 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 2-22.

Refer to *Valves*, page 2-22 for a complete description of the hydraulic remote controller.

The lift cylinder has a 30.48 cm (12.0 in) bore. The cylinder is a double acting type. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage by a wiper seal during rod retraction. Oil seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage. Refer to *Cylinders*, page 2-54 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 oil level.
	b. Low engine RPM.	**b.** Increase engine RPM to recommended level.
	c. Circuit and/or relief valve inoperative.	**c.** Repair or replace relief valve.
	d. Air in hydraulic cylinder.	**d.** Bleed air from cylinder.
	e. Damaged hydraulic pump section.	**e.** Repair or replace pump section.

Symptom	Probable Cause	Solution
3. Boom raises slowly.	**a.** Low hydraulic oil level.	**a.** 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 Manitowoc Crane Care Parts Manual).
	f. Operating two functions with in the same control valve bank assembly.	**f.** Feather controls to obtain desired speed of both functions.
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals leaking.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
4. Boom lowers slowly.	**a.** Low hydraulic oil level.	**a.** Check 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 Manitowoc Crane Care Parts Manual).
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals worn.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
	k. Piston rod broken (loose from piston).	**k.** Replace piston rod and all cylinder seals.
5. Boom will not raise.	**a.** Low hydraulic oil.	**a.** Check 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.
	h. Lack of electrical control signal.	**h.** Replace control signal.

Symptom	Probable Cause	Solution
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.
	g. Lack of electrical control signal.	**g.** Replace control signal.

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.

Lift Cylinder Removal

1. Extend and set the outriggers and level the crane.
2. Elevate the boom slightly so that the lift cylinder is extended approximately 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 four M10 capscrews to free the end plate from the lift cylinder upper pivot shaft. Remove the M20 capscrew and washer to free the end plate from the boom (Figure 4-2).

DANGER

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

5. Attach an adequate lifting/supporting device to the lift cylinder.
6. Remove the lift cylinder upper pivot shaft. Activate the hydraulic system and retract the lift cylinder enough to clear the boom's lift cylinder attach lugs.
7. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.
8. Remove the bolt and locknut securing the lift cylinder lower pivot shaft to the turntable.
9. Remove the lift cylinder lower pivot shaft from the lift cylinder attach lugs on the turntable. Save the shim. Remove the lift cylinder.
10. Move the lift cylinder to a clean work area.

Lift Cylinder Disassembly and Assembly

Disassembly and assembly procedures of the lift cylinder holding valve, and control valve are provided in Section 2 under *Cylinders*, page 2-54 and *Valves*, page 2-22 respectively.

Lift Cylinder 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 lift cylinder barrel end bushing with the attach lug holes on the turntable.
3. Apply antiseize compound (Spec. 6829003689) to the lift cylinder lower pivot shaft. Install the pivot shaft into the attach lug holes so its tapped hole is on the right side, the side opposite the cab. Before driving the pivot shaft through the left side lug hole, put the shim in place on the left side. (In some instances the shim could be on the right side.) Secure the pivot shaft with the bolt and new locknut (Figure 4-2). Torque the bolt, refer to *Fasteners and Torque Values*, page 1-13.
4. Connect the extend and retract hoses to the lift cylinder.
5. Activate the crane's hydraulic system and align the lift cylinder rod end with the lift cylinder attach lugs on the boom.
6. Apply antiseize compound (Spec. 6829003689) to the lift cylinder upper pivot shaft. Install the pivot shaft into the attach lug holes so its tapped holes are on the left side.

7. Apply medium strength threadlocking compound (Spec. 6829012418) to the four M10 capscrews and to the M20 capscrew.

8. Attach the end plate to the lift cylinder upper pivot shaft with the four M10 capscrews. Attach the end plate to the boom with the M20 capscrew and washer. Torque the M20 capscrew, refer to *Fasteners and Torque Values*, page 1-13. Torque the M10 capscrews.

9. 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.

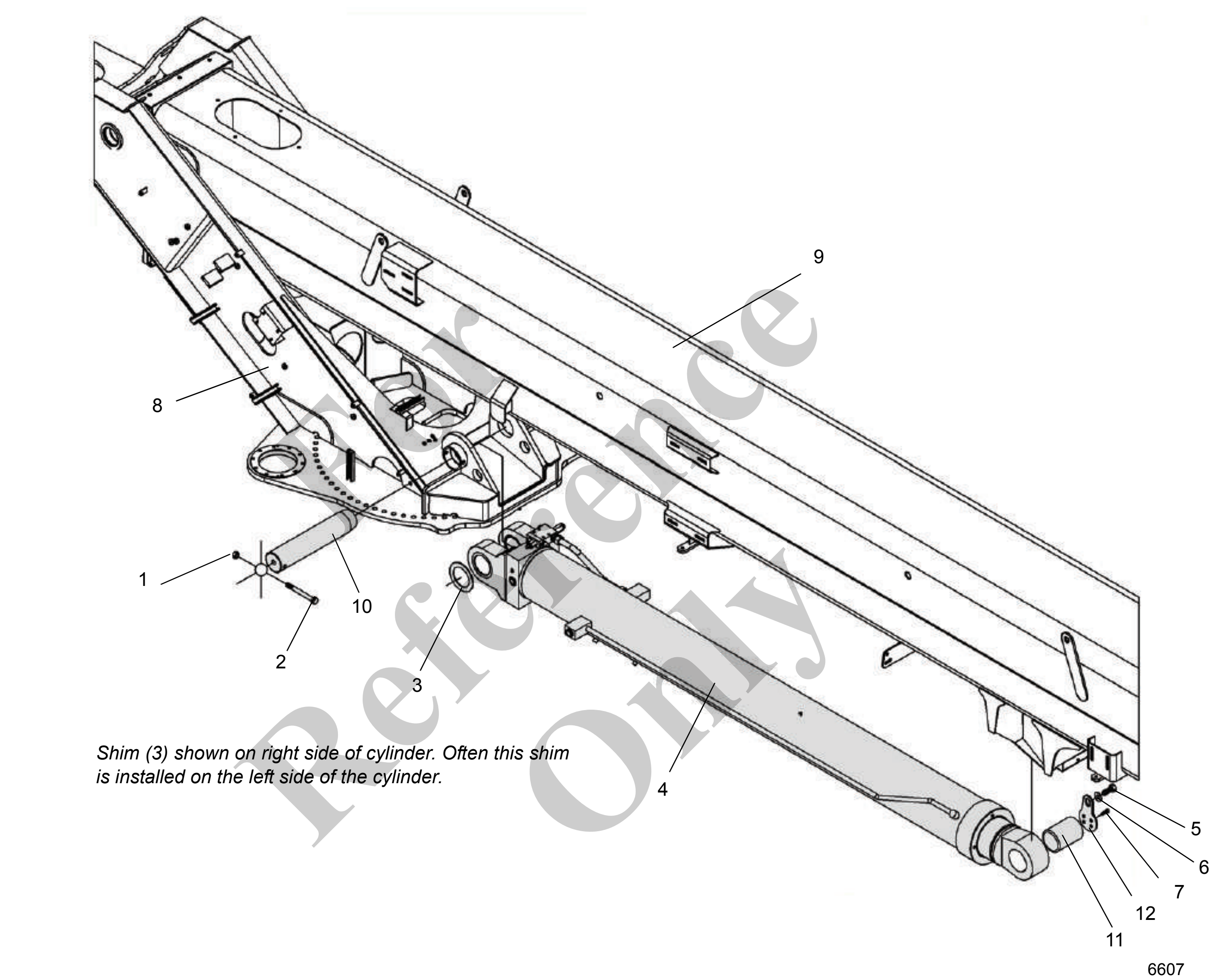


FIGURE 4-2

Item	Description
1	Locknut
2	Capscrew
3	Shim
4	Lift Cylinder
5	M20 Capscrew
6	Washer

Item	Description
7	M10 Capscrew
8	Turntable
9	Boom
10	Lower Pivot Shaft
11	Upper Pivot Shaft
12	End Plate

AUXILIARY BOOM NOSE

Description

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

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

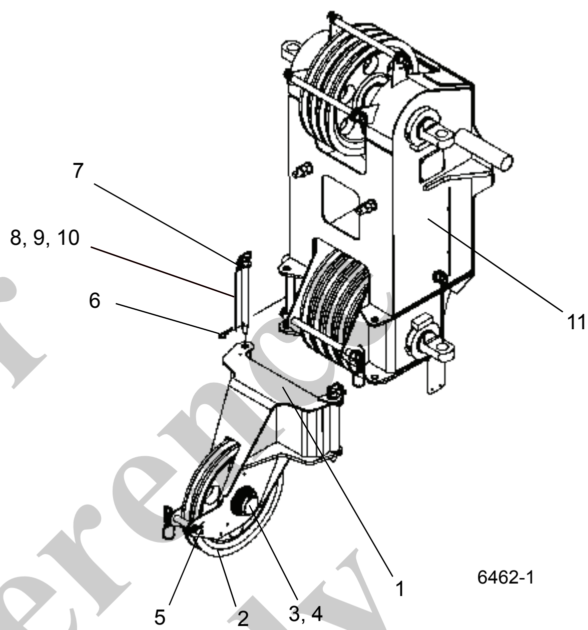


FIGURE 4-3

INSTALLING THE BI-FOLD MANUAL JIB

DANGER

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

1. Before installing the jib make sure the crane is set up on outriggers using normal setup procedures. Refer to Section 3 - OPERATING CONTROLS and PROCEDURES, in the Operator Manual.

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

2. Check the transport condition of the bi-fold extension.
3. Using an auxiliary crane, attach sling to the bi-fold extension.
4. Lift the bi-fold extension in front of the main boom with the auxiliary crane and lock the 33 ft (10 m) section to the right of the main boom head Figure 4-4.

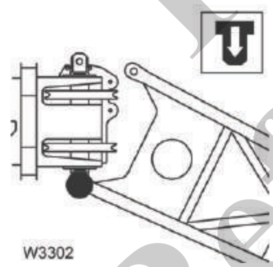


FIGURE 4-4

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

NOTE: You can also install the bi-fold swingaway jib in front of a 16 ft (5 m) section when you are changing directly from the 56 ft (17 m) bi-fold swingaway extension to a jib.

Checking the Transport Condition

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

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

DANGER

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

You must check transport condition:

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

Transport condition with lattice extension folded at the side

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

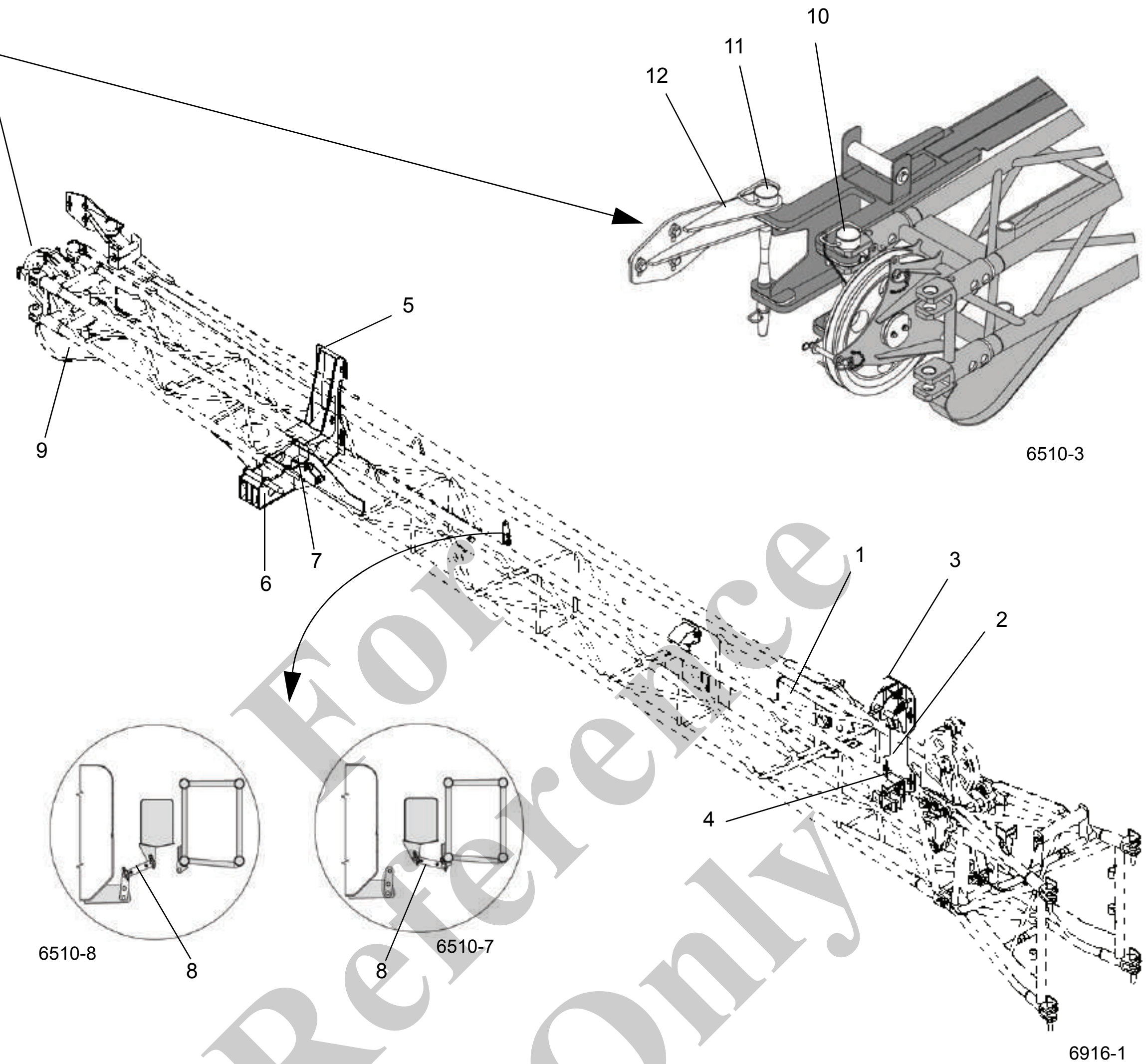
- Check the connections and establish them if necessary Figure 4-5.

If 7 m (23 ft) section and 10 m (33 ft) section are folded at the side

- The 10 m (33 ft) section is locked at the front mount (2) on the main boom (Figure 4-5).
- The pins (4) are inserted on the pivot point between the 7 m (23 ft) section and the 10 m (33 ft) section Figure 4-5.
- The connection (8) in the middle area is between the 7 m (23 ft) section/10 m (33 ft) section Figure 4-5.
- The connection (8) between 7 m (23 ft) section and main boom in the rear area is established Figure 4-5.

If the 7 m (23 ft) section only is folded at the side

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



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

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

FIGURE 4-5

JIB ERECTING AND STOWING PROCEDURE

General Warnings

DANGER

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

DANGER

Boom angles are used to control speed at which extensions swing during erecting and stowage. Improper boom angles will cause uncontrollable swing speeds of extension.

NOTE: Tag line used in these procedures is to control the movement of the jib.

Preparing the Crane for Jib Erection Procedure

Requirements for Jib Erection

Before you erect a lattice extension or the jib, the following requirements must be met:

- The swingaway lattice extension is mounted on the side of the main boom and is in transport condition.
- The crane is supported by the outriggers according to the *lifting capacity chart* for the planned operation with the lattice extension and is aligned horizontally.
- The main boom is completely retracted and has been lowered into horizontal position.
- If the crane is equipped with two hoists with additional equipment, the hook block is unreeved on the hoist, which is not used for working with the lattice extension.

Requirements for Stowing the Jib

Before you lower a lattice extension or the jib into a horizontal position, the following requirements must be met:

- No other load is raised apart from the hook block.
- The counterweight required according to the *lifting capacity chart* for the planned operation with the lattice extension is rigged.
- The crane is supported with the outriggers prescribed for operation with the erected lattice extension according to the *lifting capacity chart*.
- The main boom is fully retracted.

Securing Lattice Extension with Tag Line (Rope)

DANGER

Always secure the lattice extension with a tag line (rope) on the main boom before removing any connections. This will prevent the lattice extension from slipping off the run-up rail, swinging around and knocking you off the carrier or injuring other persons in the swing range.

The lattice extension may swing out on its own accord when the jib is removed from its stowage brackets.

You must therefore secure the lattice extension before you begin with the erection procedure.

Secure the lattice extension as follows:

- Attach a tag line (rope) at the front of the lattice extension.
- Guide the tag line (rope) underneath the lattice extension, via the holding rod on the main boom and back again.
- Secure the other end of the tag line (rope) on the crane (for example, on the steps of the access ladder to the carrier or to the hole in the superstructure). Leave enough play in the tag line (rope) that it is tight only when you swing the lattice extension towards the main boom head later on. Refer to ERECTION AND STOWING PROCEDURE.

Erecting Procedure

33 ft (10 m) Jib

DANGER

To prevent serious injury or death, do not stand on decking until extensions are secure.

1. Visually check to ensure all pins are installed.

2. Crane should be set up on outriggers using normal setup procedures Figure 4-6. Refer to Section 3 - OPERATING CONTROLS and PROCEDURES, in the Operator Manual.

6645-1

FIGURE 4-6

a. Fully retract boom.

b. Lower boom to horizontal for erecting over the front of the crane.

NOTE: Tag line is used to control movement of the jib during erecting procedure.

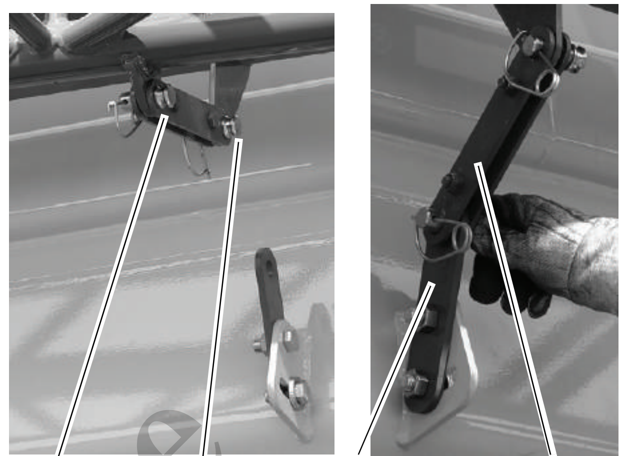
3. Attach tag line to tip of extension Figure 4-7 and to the superstructure.

6645-2

FIGURE 4-7

NOTE: If erecting the 10 m (33 ft) section without the 7 m (23 ft) section, perform steps 4 and 5, otherwise proceed to step 6.

4. If not using the bi-fold 7 m (23 ft) section, remove pin from the locking bar. Move locking bar to the base section attachment bar and install pin. Secure with retaining pin Figure 4-8.



6642-8 6642-9

FIGURE 4-8

5. If not using the bi-fold 7 m (23 ft) section, remove the retainer clip and bi-fold stowage pin at the base section connection Figure 4-9. Stow pin on bi-fold. Leave the pin attaching the 7 m (23 ft) section to the base section to retain the 7 m (23 ft) section Figure 4-9.

6642-41

FIGURE 4-9

NOTE: Steps 6, 7 and 8 apply when erecting the 7 m (23 ft) section together with the 10 m (33 ft) section. If not using the bi-fold 7 m (23 ft) section, proceed to step 11.

6. Remove retainer clip from the pin attaching the 7 m (23 ft) section to the base section Figure 4-10.

Retainer Clip

6642-5

FIGURE 4-10

7. Remove the stowage pin Figure 4-11.

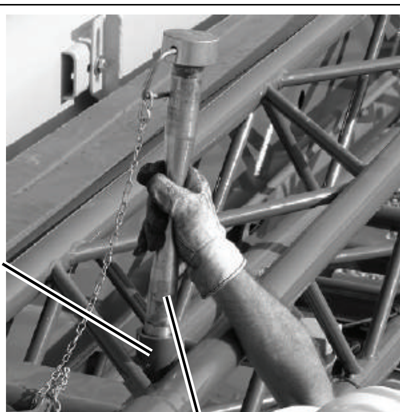
6642-6

Stowage Pin

FIGURE 4-11

8. Stow the pin in pin holder provided on the swingaway extension (Figure 4-12).

Pin Holder



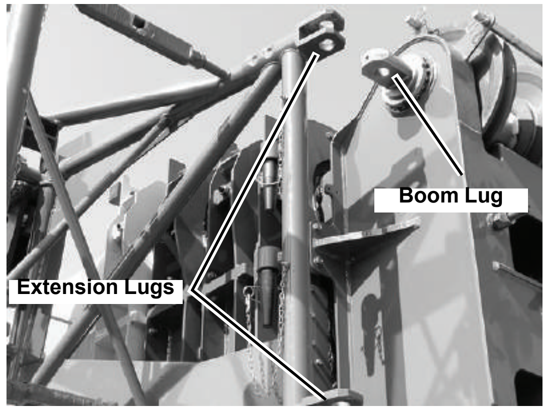
6642-7

Stowage Pin

FIGURE 4-12

9. Remove the jib stowage controller from behind the seat in the superstructure cab.

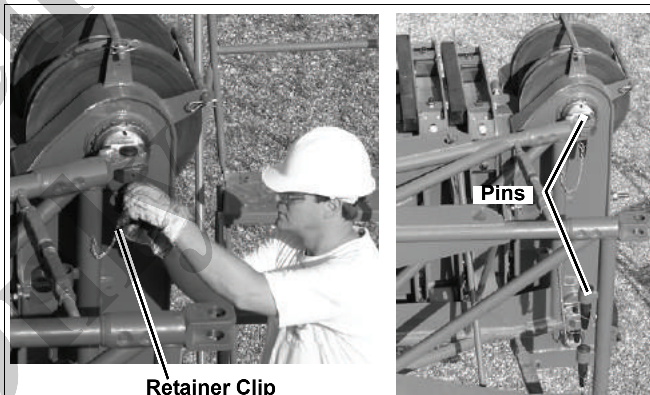
10. Use the controller to pivot the jib so that lugs on jib align with the holes in the lugs on the boom nose (Figure 4-13).



6642-11

FIGURE 4-13

11. Remove pins stowed in extension and install in holes (right side of boom nose) and secure with retainer clips Figure 4-14.



Retainer Clip

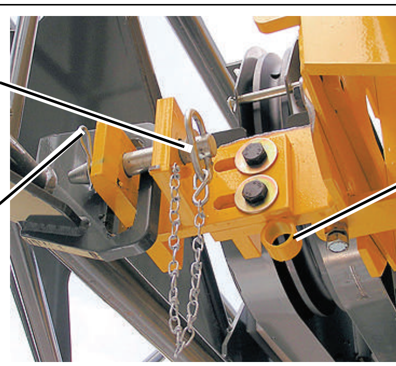
6642-13

FIGURE 4-14

12. Remove the clip pin from the stowage pin at the front mount. Unpin the stowage pin and store in holder (Figure 4-15).

Stowage Pin

Clip Pin



Pin Holder

6642-46

FIGURE 4-15

4

13. Extend the boom approximately 61 cm (2 ft) to move extension off of the ramp (Figure 4-16).

6642-47 **FIGURE 4-16**

14. Remove tag line from superstructure.

NOTE: Tag line is used to control movement of the jib during erecting procedure.

DANGER

To prevent serious injury or death, do not stand on the crane deck to pull extension off ramp.

NOTE: If erecting the 7 m (23 ft) section with the 10 m (33 ft) section, perform steps 18 and 19. If erecting the 10 m (33 ft) section without the 7 m (23 ft) section, proceed to step 17.

15. Using the tag line (rope), pull the extension away from the boom Figure 4-17.

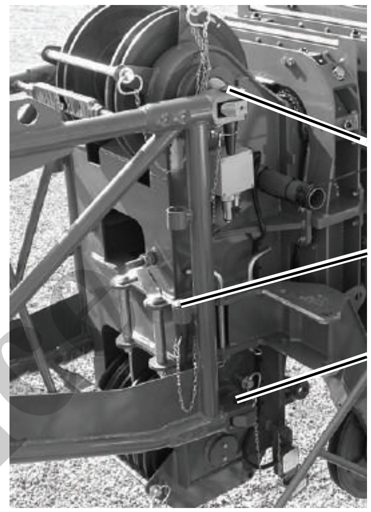
16. While maintaining control of the extension with the tag line, swing extension into position on boom nose Figure 4-17.

6645-3 **FIGURE 4-17**

NOTE: Step 17 is with the 7 m (23 ft) section stowed on boom.

17. While maintaining control with the tag line, swing extension into position on boom nose. The 7 m (23 ft) section will remain on the boom.

18. Remove pins from holders and install on left side of boom nose and secure with retainer clips Figure 4-18.



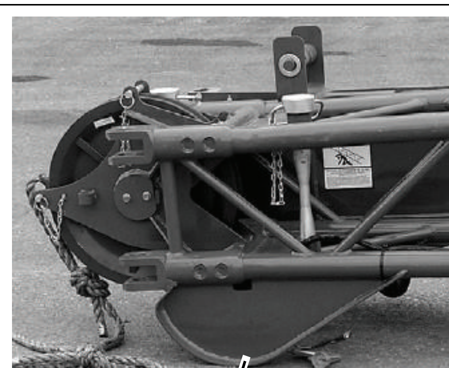
6642-18 **FIGURE 4-18**

Relieving the Load on Bearing Points

NOTE: The weight of the lattice extension can cause the bearing points on the left side to be misaligned or the pins to get weighted which makes it impossible to knock them out.

When establishing or disconnecting the connections, proceed as follows:

- Lower the lattice extension until it is on the ground with the supports (Figure 4-19). If necessary, override the lifting limit switch.
- Continue to lower carefully until the connecting points (Figure 4-20) align or until the load has been removed from the pins.



6642-44 **FIGURE 4-19**

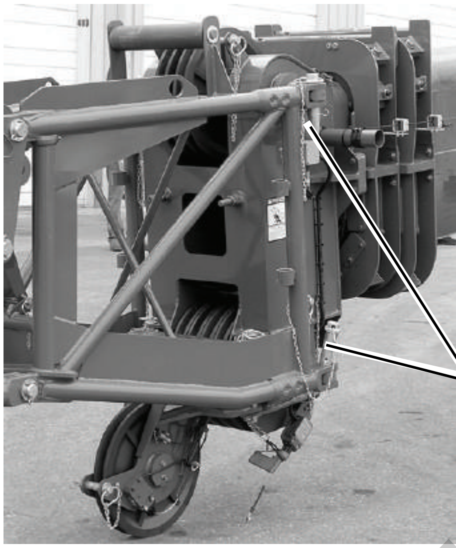


FIGURE 4-20

19. Connect RCL cables:

a. Remove RCL cable end connector from extension and route through jib Figure 4-21.

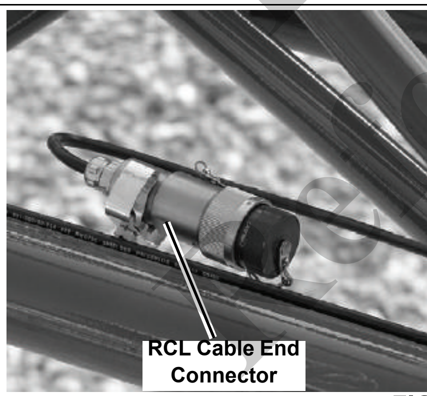


FIGURE 4-21

b. Remove dummy plug from junction box on boom nose Figure 4-22.

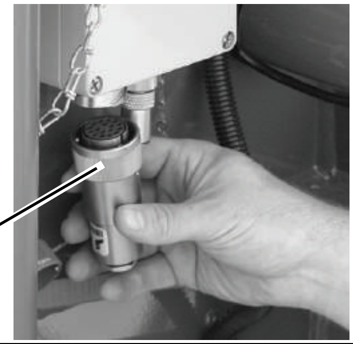


FIGURE 4-22

c. Install cable end connector from jib where dummy plug was removed Figure 4-23.

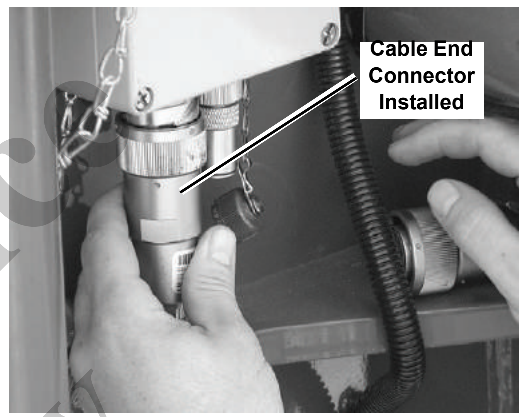


FIGURE 4-23

20. Lower boom and remove tag line from the tip of the extension. Figure 4-24 shows the 7 m (23 ft) and 10 m (33 ft) section together.

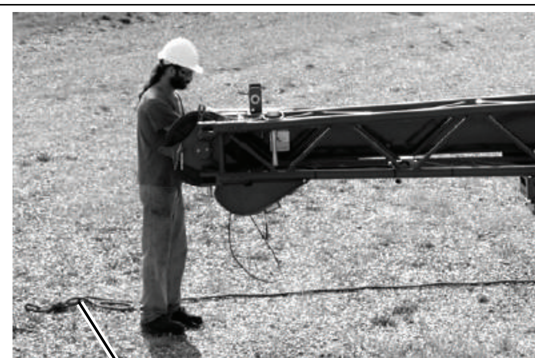


FIGURE 4-24

4

56 ft (17 m) Jib

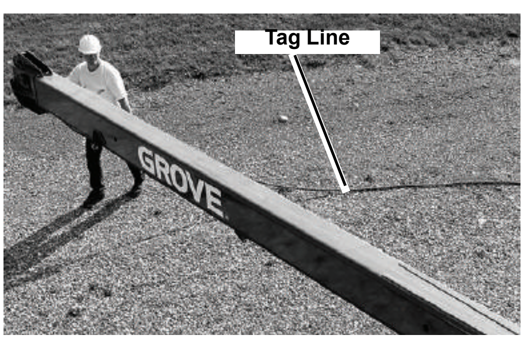
1. Secure tag line to stinger nose Figure 4-25.

6642-23 **FIGURE 4-25**

2. Raise boom slightly above horizontal.
3. Remove retainer clip and remove stinger stowage pin Figure 4-26.

6642-24 **FIGURE 4-26**

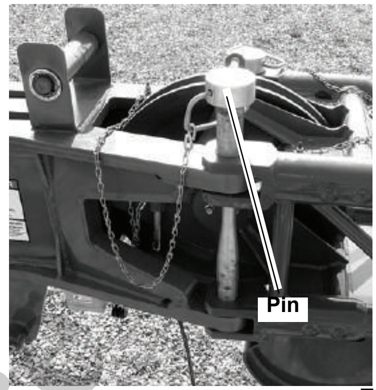
4. Using the tag line to maintain control of the bi-fold (stinger), swing stinger into erected position Figure 4-27.



6642-25 **FIGURE 4-27**

NOTE: Do not lower boom until stinger has been completely swung in front of the 10 m (33 ft) section.

5. Lower the boom.
6. Remove pin from swingaway. Install pin in stinger and retain with clip pin Figure 4-28.



6642-26 **FIGURE 4-28**

7. Connect RCL connector to RCL connection box Figure 4-29. The cable is stowed in the 7 m (23 ft) section.

6642-27 **FIGURE 4-29**

8. Remove tag line before operating crane.

NOTE: Reeve the hoist cable as described under rigging and unrigging procedure in this section.

Stowing Procedure

56 ft (17 m) Jib

DANGER

To prevent serious injury or death, do not stand on decking until extensions are secure.

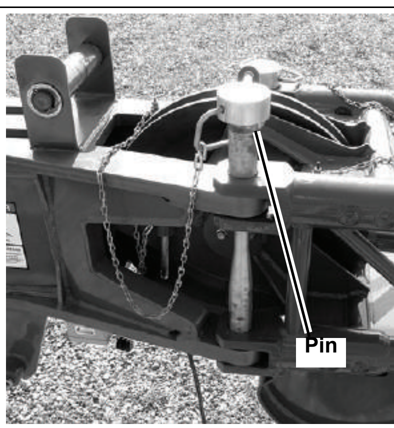
1. Lower boom below horizontal.
2. Attach tag line to stinger nose Figure 4-30.

6642-23 **FIGURE 4-30**

3. Disconnect RCL connection Figure 4-31. Stow the cable in the 7 m (23 ft) section.

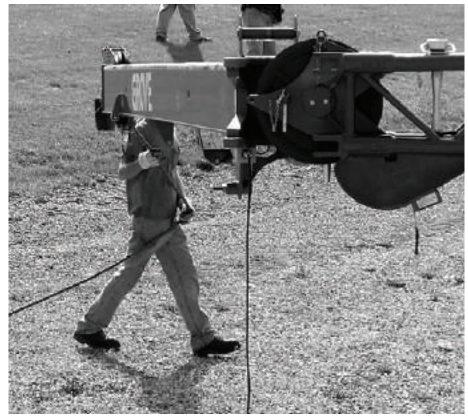
6642-28 **FIGURE 4-31**

4. Remove retainer clip and remove the left side stinger retaining pin Figure 4-32. Place pin in holder.



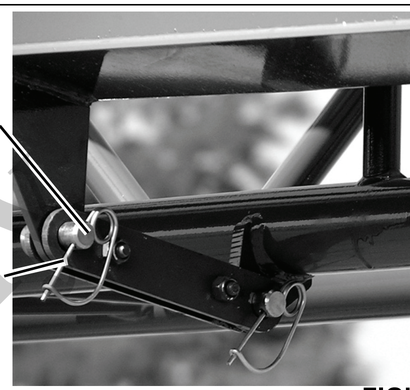
6642-26 **FIGURE 4-32**

5. Raise boom to slightly above horizontal.
6. Using tag line to control movement of stinger, swing stinger into stowed position Figure 4-33.



6642-29 **FIGURE 4-33**

7. Raise boom slightly above horizontal.
8. Connect stowage link to stinger and install retainer clip Figure 4-34.



6642-24 **FIGURE 4-34**

9. Remove tag line from stinger.

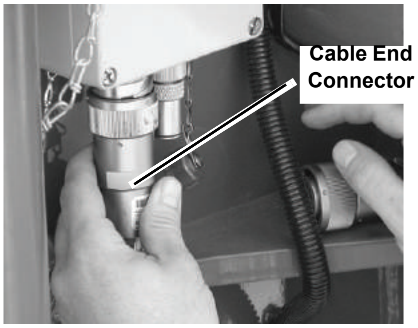
33 ft (10 m) Jib

1. Lower boom and secure tag line to tip of jib. Figure 4-35 shows the 7 m (23 ft) and 10 m (33 ft) extension together.

6642-30 **FIGURE 4-35**

2. Disconnect RCL Cable.

a. Remove connector from junction box on boom nose Figure 4-36.

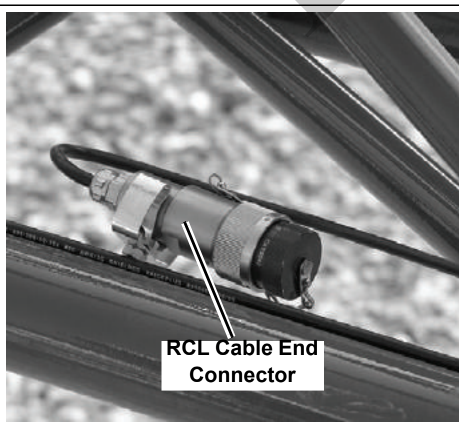


6642-21 **FIGURE 4-36**

b. Install dummy plug on junction box Figure 4-37.

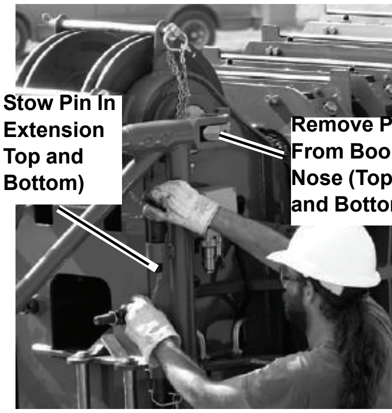
6642-20 **FIGURE 4-37**

c. Route cable through jib and stow connector Figure 4-38.



6642-19 **FIGURE 4-38**

3. Remove retainer clips and remove pins attaching the jib to the left side of boom nose. Stow the pins in the jib pin holders and install the retainer clips Figure 4-39.



6642-31 **FIGURE 4-39**

4. Completely retract boom.

5. Extend boom approximately 61 cm (2 ft).

6. Raise boom above horizontal.

NOTE: Step 7 is stowing with the 7 m (23 ft) section and 10 m (33 ft) section together. If the 7 m (23 ft) section remained on the boom, proceed to step 9.

7. Use the tag line to maintain control of the jib, and swing the extension into the stowed position Figure 4-40.

6645-5 **FIGURE 4-40**

NOTE: Step 8 is with the 7 m (23 ft) section stowed on boom. If stowing the 7 m (23 ft) section and 10 m (33 ft) section together, proceed to step 10.

8. Use the tag line to maintain control of the jib Figure 4-40, and swing the extension into stowed position until tag line can be attached to superstructure.

9. Raise the boom to ensure wear pad rests against bumper plate on ramp (Figure 4-41).

10. Completely retract boom so that the jib stows on the ramp and front stowage brackets Figure 4-41.

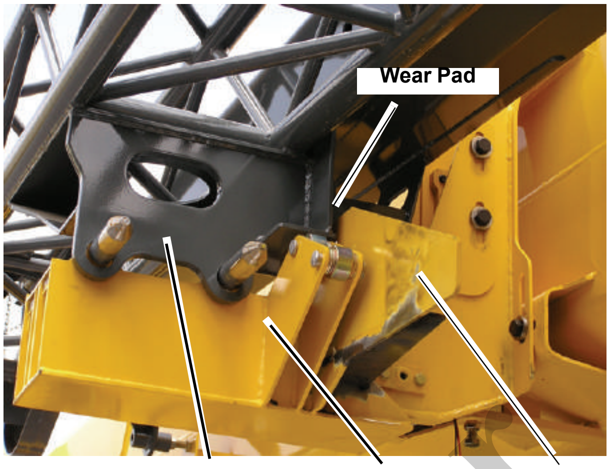


FIGURE 4-41

11. Lower the boom.

12. Remove the stowage pin from the holder at the front mount. Install stowage pin and secure extension to boom (Figure 4-42).

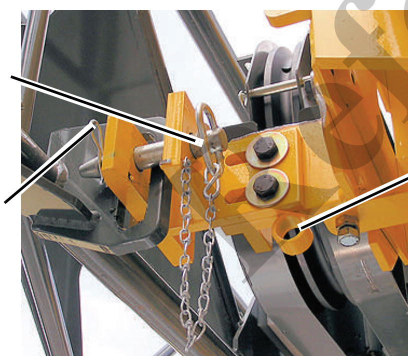


FIGURE 4-42

13. Remove pins from right side of the boom nose. Stow the pins in pin holders on jib and install retainer clips Figure 4-43.

   a. If the 7 m (23 ft) was left stowed, use controller to pivot jib in towards boom so that the lugs on 10 m (33 ft) section align with 7 m (23 ft) section.

   b. If using both the 10 m (33 ft) and 7 m (23 ft) sections, use the controller to pivot jib towards boom such that the lugs on the 7 m (23 ft) section align with rear stowage bracket.

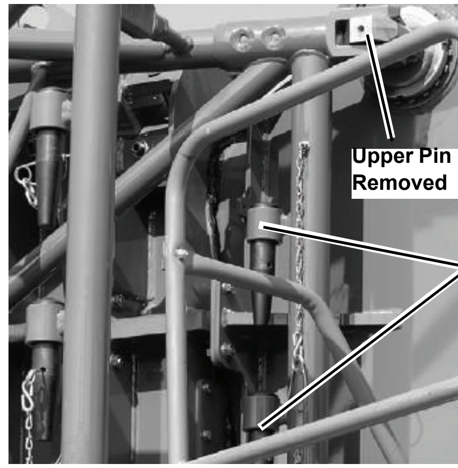


FIGURE 4-43

NOTE: Perform steps 14 and 15 if stowing the 10 m (33 ft) section when the 7 m (23 ft) section remained on the boom, otherwise proceed to step 19.

14. If the bi-fold 7 m (23 ft) section was not used, remove pin from the base section locking bar. Move locking bar to the 7 m (23 ft) section and install pin. Secure with retaining pin Figure 4-44.

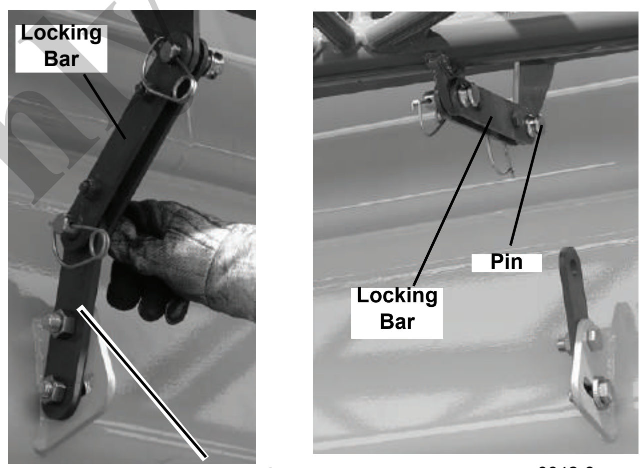


FIGURE 4-44

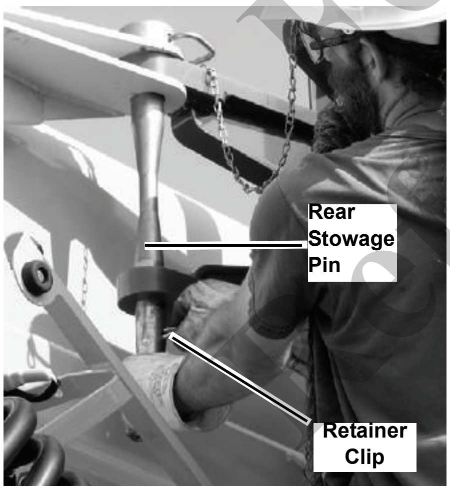
15. If the bi-fold 7 m (23 ft) section was not used, remove bi-fold stowage pin from bi-fold and install at the base section connection. Install retainer clip Figure 4-45.

4

6642-41 **FIGURE 4-45**

NOTE: Step 16 applies when the 7 m (23 ft) section was erected with the 10 m (33 ft) section.

16. Install rear stowage pin and retainer clip Figure 4-46.



6642-39 **FIGURE 4-46**

17. Lower boom.

18. Remove tag line.

NOTE: Reeve the hoist cable as described in this section.

Raising and Lowering the Hydraulic Jib

NOTE: For more information on operation of the jib switches, refer to Section 3 - Operating Controls and Procedures in the Operator Manual.

When Erecting

To remotely raise or lower the lattice extension when erecting there are two control units each with two push buttons on the 10 m (33 ft) section.

- Press the top push-button to raise the lattice extension (1).
- Press the bottom push-button to lower the lattice extension (2).

During Operation

During operation the lattice extension is raised or lowered from the crane cab. The lattice extension can be raised or lowered, only when the power for the lattice extension is switched on.

When the power is switched on:

- The indicator lamp in the on/off rocker switch on the lattice extension lights up brightly.
- Activation of the power is shown on the RCL display.

- If necessary, switch on the power of the lattice extension, by pressing the lattice extension on/off rocker switch.

To **raise**, press the switch to the rear.

To **lower**, press the switch to the front.

Transportation on a Separate Vehicle

DANGER

Risk of accidents from a falling lattice extension.

Only attach the lattice extension in such a way that it is positioned in the center of gravity and always use lifting gear with sufficient lifting capacity. This prevents the lattice extension from falling and injuring people while loading.

- Check if all the required connections for transport condition are established.
- For transportation, place the lattice extension on the skid at the front and onto the lower cross strut at the rear of the 10 m (33 ft) section.
- Always secure the lattice extension on the separate vehicle with belts as well as to prevent slipping and overturning.

CAUTION

Risk of damaging the lattice extension.

Always secure the lattice extension by tying it down with suitable belts when it is transported on the separate vehicle. This prevents the two-stage swingaway lattice extension tipping and becoming damaged during transportation.

Lifting Limit Switch on the Lattice Extension

The functions raise hoist, extend main boom and lower main boom are monitored during operation with the lattice extension by the lifting switch on the lattice extension and are switched off when the lifting limit switch is actuated.

NOTE: The same lifting limit switch is used for lattice extension and main boom.

Overriding Connection on Main Boom

For operation with the lattice extension you must remove the lifting limit switch on the main boom and override the connection.

- Insert the short-circuit plug (1) in the socket for the connection of the lifting limit switch Figure 4-47.

The connection is now overridden.

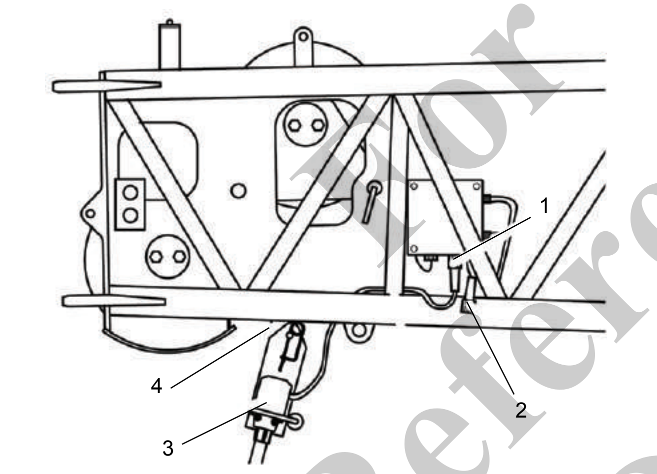


FIGURE 4-47

On 10 m (33 ft) swingaway lattice extension

- Attach the lifting limit switch (3) in the holder (4) and secure it with a retaining pin. See Figure 4-47.
- Remove the short-circuit plug (2) from the socket (1).
- Connect the lifting limit switch on the socket (1).
- When unrigging you must insert the short-circuit plug (2) back in the socket (1).

On the 17 m (56 ft) Two-Stage Swingaway Lattice Extension

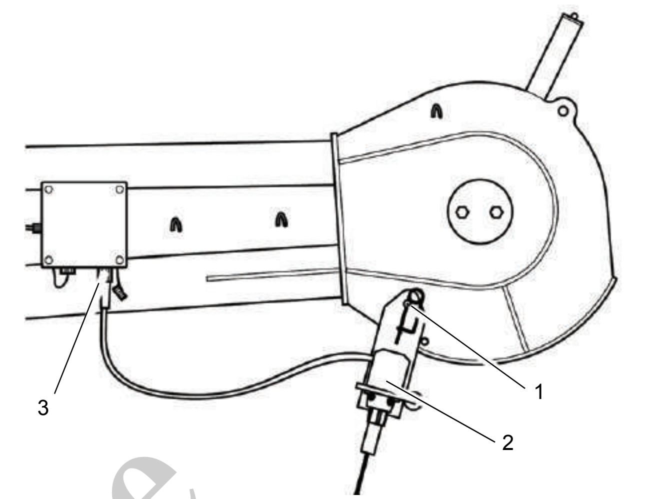


FIGURE 4-48

NOTE: For operation with the 17 m (56 ft) two-stage swingaway lattice extension the connection for the lifting limit switch on the 10 m (33 ft) section must be overridden with a short-circuit plug.

- Attach the lifting limit switch (2) on the shackle (1) and secure it with a retaining pin, Figure 4-48.
- Connect the lifting limit switch on the socket (3).
- When stowing, close the socket (3) with the protective cap.

Folding Out/In the Deflection Sheaves on the 10 m (33 ft) Section

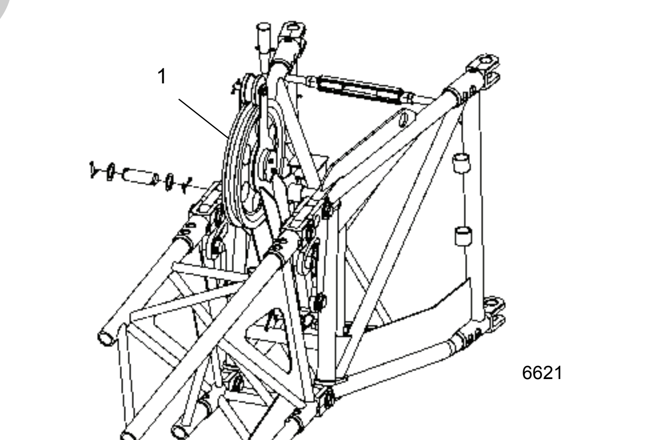


FIGURE 4-49

To prevent the hoist rope dragging on the main boom or lattice extension during operation with the lattice extension or jib, the hoist rope is guided via deflection sheaves.

On the 10 m (33 ft) section, there is a deflection sheave at the rear (1) Figure 4-49. Fold out the deflection sheave if the jib offset angle is 20° or 40°.

NOTE: For zero (0) degree offset, leave the mast assembly in the stowed position.

The sheave must be folded out:

- for operation with the swingaway lattice extension,
- for operation with the 17 m (56 ft) two-stage swingaway lattice extension.

For transportation the mast sheave must be folded in.

Folding Rear Deflection Sheave

DANGER

Risk of crushing.

Always hold the deflection sheave by the handle, when removing the pin. You might get your fingers crushed if you hold the sheave by the side plates.

Folding Out Deflection Sheave

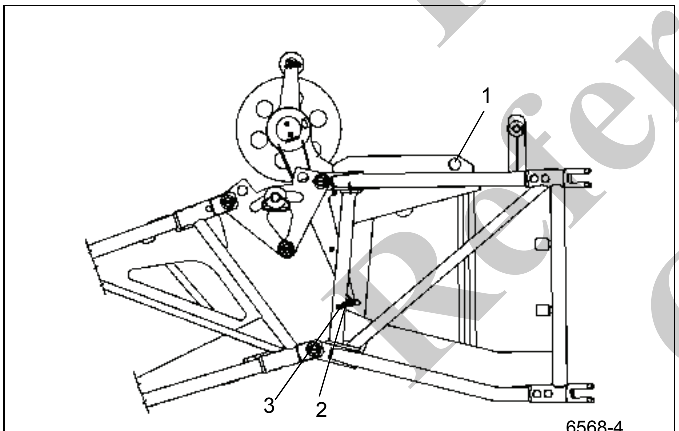


FIGURE 4-50

- Remove the pin (2) from the bore (1) per Figure 4-50.
- Fold the deflection sheave up and secure it with the pin in the bore (3).
- Secure the pin with a retaining pin.

Folding In Deflection Sheave

- Remove the pin (2) from the bore (3).
- Fold the deflection sheave down and insert the pin in the bore (1).
- Secure the pin with a retaining pin.

Positioning/Remove the Hoist Cable

DANGER

Risk of accidents due to falling parts.

Always secure the hoist cable holding rollers and rods with retaining pin. This prevents elements from coming loose, falling down and injuring people.

Positioning Hoist Cable

- Remove the hoist cable holding rollers and rod (1), Figure 4-51.
- Guide the hoist rope via the deflection sheaves (3) and via the head sheave (2) on the 10 m (33 ft) section or on the 7 m (23 ft) section. Put all hoist cable holding rollers and rods back in place and secure these with retaining pins.
- Attach the overhaul ball.
- Install the A2B weight assembly.

Removing Hoist Cable

- Unpin the overhaul ball.
- Remove the hoist cable holding rollers and rods (1).
- Take the hoist cable off the head sheave (2) and the deflection sheaves (3) and place it onto the ground on the left side.

Setting the Folding Swingaway Extension Offset

DANGER

Ensure any blocking material used is adequate to support the weight of the extension assembly without tipping or falling.

1. Extend and set the outriggers and swing the boom to over the front per Figure 4-52. Position the boom to above horizontal.
2. Block up under the tip of the extension assembly section.
3. To set the offset from a lesser degree to higher degree, perform the following procedures.

CAUTION

Do not overload the extension anchor fittings or the extension base section when lowering the boom.

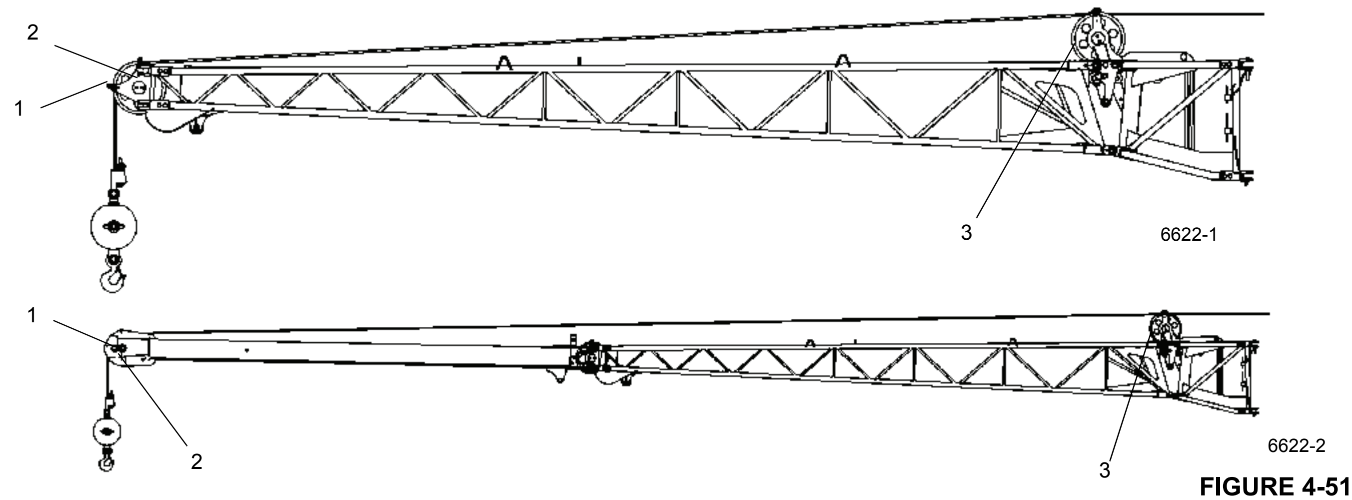


FIGURE 4-51

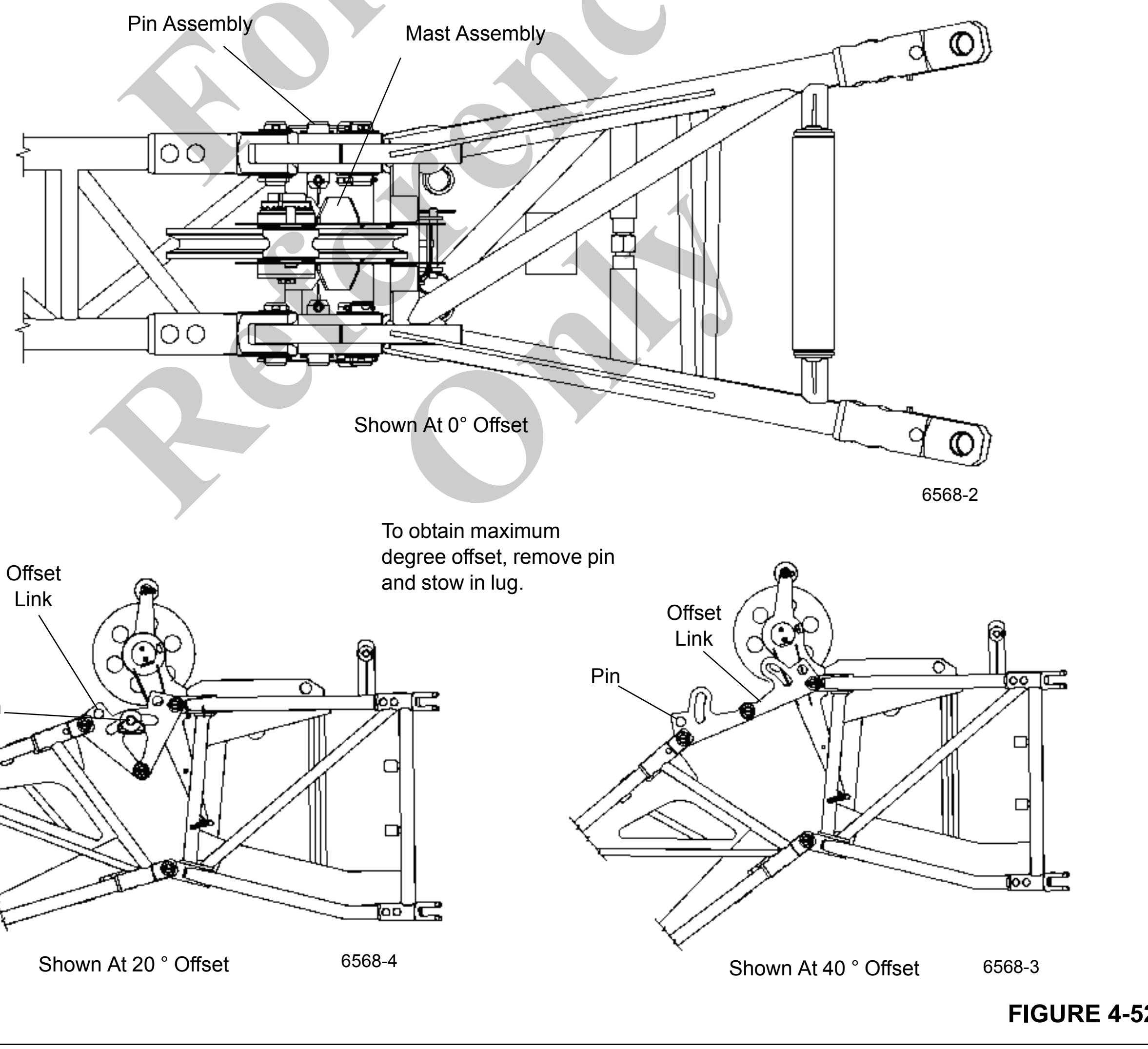


FIGURE 4-52

a. Slowly lower the boom until the pressure is relieved on the offset link pins.

NOTE: For 20 or 40 degree offset, make sure the mast is in the raised position.

b. Remove the offset link clip pins and attach pins securing the offset links in the lesser degree offset position. If going to maximum offset, stow them in the stowage lugs. If going to the intermediate (20 degree) offset, install them in the offset links for that degree of offset.

c. Slowly elevate and telescope the boom at the same time so that the extension does not move off of the blocking until the offset links take the full weight of the extension.

d. Reeve the hoist cable as described under normal erecting procedures.

REMOVING THE BI-FOLD MANUAL JIB

DANGER

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

1. Before removing the jib make sure the crane is set up on outriggers using normal setup procedures. Refer to Section 3 - OPERATING CONTROLS and PROCEDURES in the Operator Manual.

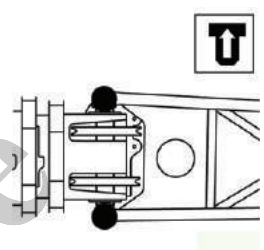
NOTE: An auxiliary crane with sling is required to remove the bi-fold jib.

1. Retract the main boom completely and lower it into the horizontal position.
2. Unreeve the hoist cable from the hook block and remove it from the jib.
3. Fold in the deflection sheave on the 10 m (33 ft) section.
4. Disconnect electrical connection between the lattice extension and the main boom.
5. Attach auxiliary crane sling to bi-fold swingaway extension.

WARNING

Lattice extension must be supported by an auxiliary crane before removing pins.

6. Remove locking pins Figure 4-53 on both sides between 10 m (33 ft) section and main boom head and remove the bi-fold swingaway extension.



w3303a
FIGURE 4-53

7. Check the transport condition of the bifold swingaway extension.

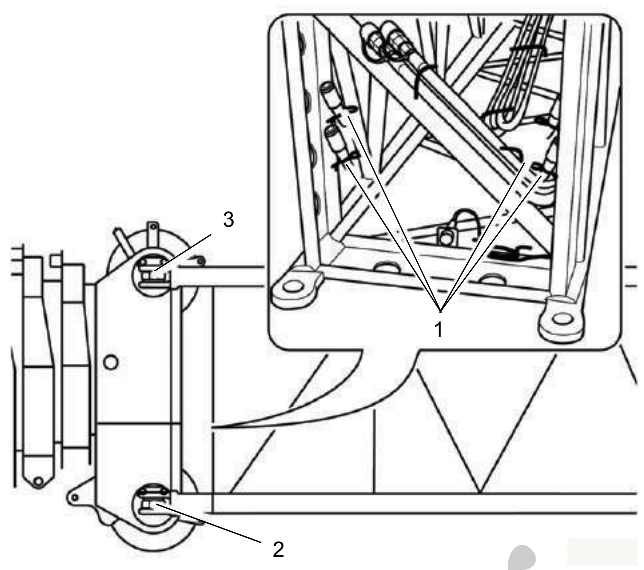
INSTALLING/REMOVING 5 M (16 FT) SECTIONS

- In order to rig the 22 m (72 ft) jib, you must install the 5 m (16 ft) section with support roller in front of the main boom head.
- In order to rig the 27 m (89 ft) jib, you must additionally install the 5 m (16 ft) section without support roller in front of the 5 m (16 ft) section with support roller.

NOTE: An auxiliary crane must be used to install and remove the 5 m (16 ft) sections.

Installing the 5 m (16 ft) Sections

The securing pins (1) for the connection are secured with retaining pins in the holders at the foot of the 5 m (16 ft) sections Figure 4-54.



w3361a
FIGURE 4-54

- Using an auxiliary crane with sling, lift the 5 m (16 ft) section with support roller on an auxiliary crane and lift it in front of the main boom head so that the bearing points (2) and (3) align on both sides.
- Insert the securing pins into the bearing points (2) and (3) on both sides.
- Secure all pins with retaining pins.
- Install the second 5 m (16 ft) section in front of the first 16 ft section for the 27 m (89 ft) jib in the same way.
- Install 17 m (56 ft) section in front of the respective 5 m (16 ft) section per previous instructions in this section.

Removing the 5 m (16 ft) Sections

- Using an auxiliary crane with sling, lift the 5 m (16 ft) section until the bearing points (2) and (3) are relieved.
- Release the pins and knock them out of the bearing points (2) and (3) on both sides.
- Insert the pins into the holders at the foot of the 5 m (16 ft) sections and secure them with retaining needles.

JIB (ADDITIONAL EQUIPMENT)

Identification and Slinging Points

Identification

The jib consists of the 56 ft (17 m) bi-fold swingaway lattice extension and two jib sections. The jib is designed for the crane it was delivered with. The parts which belong to the crane have the same serial number as the crane.

The following sections are identified by the serial number:

- All parts of the 17 m (56 ft) bi-fold swingaway lattice extension.
- Both sections of the insert 5 m (16 ft) sections

.

CAUTION

Operate the crane only with those sections of the jib which have the same serial number as the crane. This prevents malfunctions and damage.

NOTE: For technical reasons a crane may only be set with one jib.

If you wish to use the jib on several Manitowoc/Grove cranes, the parts of the jib must be adjusted for these cranes and labeled with all of the respective serial numbers.

CAUTION

Have the adjustment of the jib only carried out on site by Manitowoc Crane Care!

Serial numbers on the 5m (16ft) sections

The serial number is on a plate at the front of the 5 m (16 ft) inserts.

Slinging Points

CAUTION

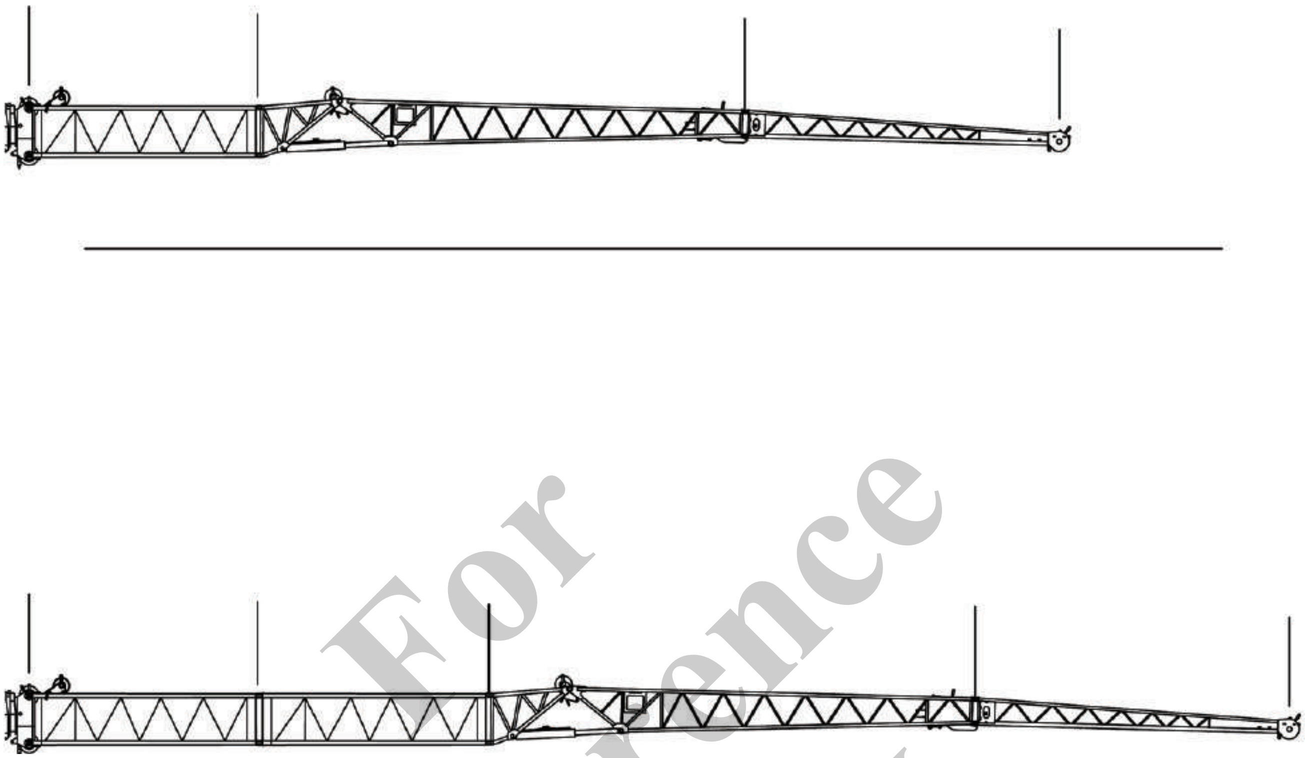
This section shows the slinging points of the 16 ft (5 m) sections. Attach the sections only to these slinging points because they will then automatically have the correct center of gravity. Use only lifting gear with sufficient load bearing capacity.

The 5 m (16 ft) sections have two slinging points (one slightly offset on each side).

NOTE: For electrical connections at the 5 m (16 ft) sections, refer to Electrical Connections at the Jib, in this section.

ASSEMBLY OF JIBS

NOTE: The lengths of 22 m (72 ft) and 27 m (89 ft) respectively equal the distance between the center of the locking pin (on the main boom head) and the front edge of the head sheave.



w3351a

FIGURE 4-55

The designation 10 m (33 ft) section, 7 m (23 ft) section, and 5 m (16 ft) section have been adjusted to these lengths.The total length of the individual sections is greater or smaller. (See FIGURE 4-55.)

Electrical Connection at the Jib

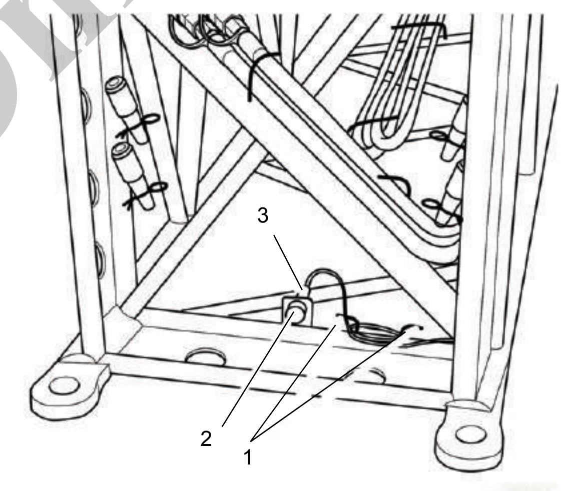
The following describes the electrical connections at the 5 m (16 ft) sections. Establish the electrical connection at the bi-fold swingaway lattice extension per the following procedures

Transport Condition of the Connection

For transport, bring the electrical connections always into the following condition.

There is a cable with a plug (3) at the rear of the 5 m (16 ft) sections Figure 4-56.

For transport, the cable is wound around the holders (1) and the plug is inserted in the dummy socket (2).



w3367a

FIGURE 4-56

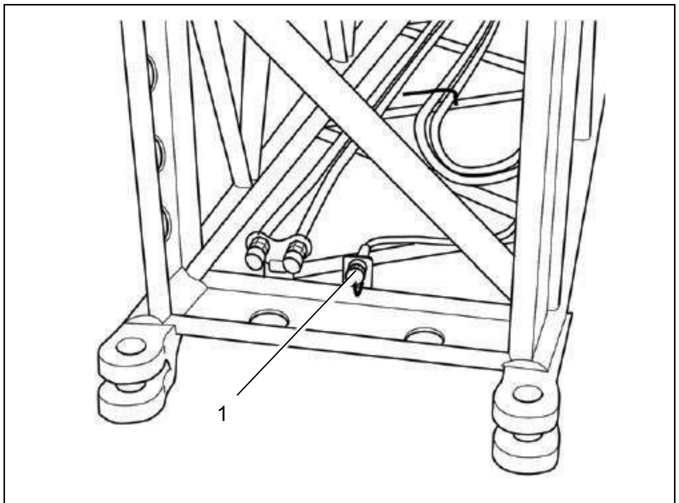


FIGURE 4-57

There is a plug socket (1) at the front of each 5 m (16 ft) section Figure 4-57.

For transport, the sockets are covered with protective caps.

At the 22 m (72 ft) Jib

Establishing a Connection

- Connect the cable of the 10 m (33 ft) section to the socket of the second 5 m (16 ft) section at the front.
- Connect the cable of the 5 m (16 ft) section to the socket at the main boom.

Disconnecting

- Detach the electrical connection between 10 m (33 ft) and 5 m (16 ft) section.
- Detach the electrical connection between 5 m (16 ft) section and main boom head.
- Prepare the electrical connections at the 10 m (33 ft) section for transport.

At the 27 m (89 ft) Jib

Establishing a Connection

- Connect the cable of the 10 m (33 ft) section to the socket of the second 5 m (16 ft) section at the front.
- Connect the cable of the second 5 m (16 ft) section to the socket of the first 5 m (16 ft) section at the front.
- Connect the cable of the first 5 m (16 ft) section to the socket at the main boom head.

Disconnecting

- Detach the electrical connection between the 10 m (33 ft) and front 5 m (16 ft) section.
- Detach the electrical connection between the two 5 m (16 ft) sections.
- Detach the electrical connection between the rear 5 m (16 ft) section and the main boom head.
- Prepare the electrical connections at the 5 m (16 ft) section for transport.
- Prepare the electrical connections at the 10 m (33 ft) section for transport.

Unfolding/Folding the Deflection Sheave on the 5 m (16 ft) Section

This section describes only the unfolding and folding of the deflection sheave on the 5 m (16 ft) section.

For work with the jib, you must fold out the deflection sheaves on the rear 5 m (16 ft) section.

Fold the deflection sheave for transport.

Folding Out Deflection Sheave

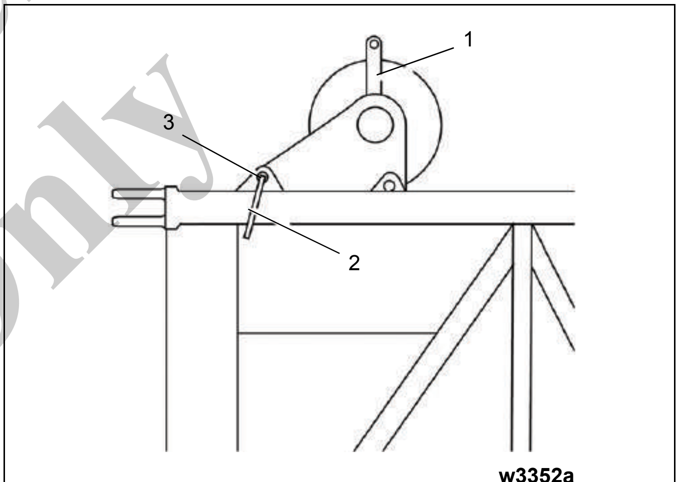


FIGURE 4-58

- Pull the pin (2) out of the bore (3) Figure 4-58.
- Fold the deflection sheave on the strut (1) upwards until the locking positions are aligned with the bore hole (3).
- Fasten the deflection sheave for transport.

4

Folding In Deflection Sheave

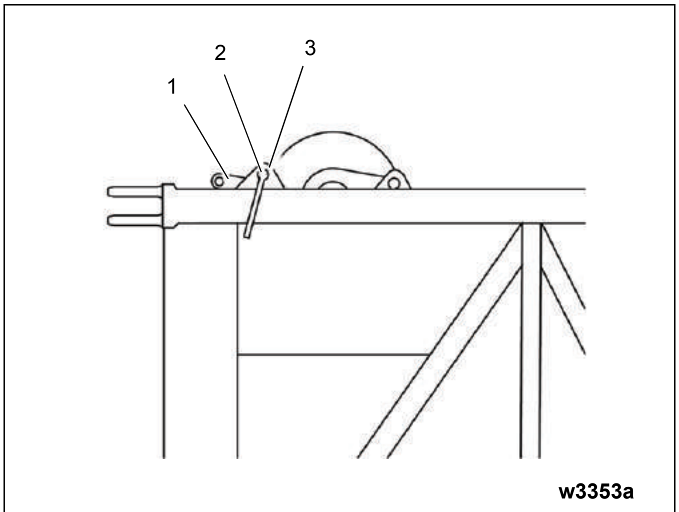


FIGURE 4-59

- Hold the deflection sheave by the strut (1) and remove the pin (2) from the bore (3) Figure 4-59.
- Fold the deflection sheave down as far as possible.
- Insert the pin in the bore hole (3) and secure it with a retaining clip.

Positioning/Removing the Hoist Cable

CAUTION

Risk of accidents due to falling parts.

Always secure the hoist cable holding rollers and rods with retaining pins. This prevents elements from becoming loose, falling down and injuring people.

Positioning Hoist Cable

- Remove the hoist rope holding rollers and rods (1) Figure 4-60.
- Guide the hoist rope via the deflection sheaves (3) and via the head sheave (2) on the 10 m (33 ft) section or on the 7 m (23 ft) section. Put all hoist cable holding rollers and rods back in place and secure these with retaining pins.
- Attach the overhaul ball.
- Install the A2B weight assembly.

Removing Hoist Cable

CAUTION

Risk of accidents due to falling parts.

Always secure the hoist cable holding rollers and rods with retaining pins. This prevents elements from becoming loose, falling down and injuring people.

- Unpin the overhaul ball.
- Remove the hoist rope holding rollers and rods (1) Figure 4-60.
- Take the hoist cable off the head sheave (2) and the deflection sheaves (3) and place it onto the ground on the left side.
- Put all hoist cable holding rollers and rods back in place and secure them with retaining pins.

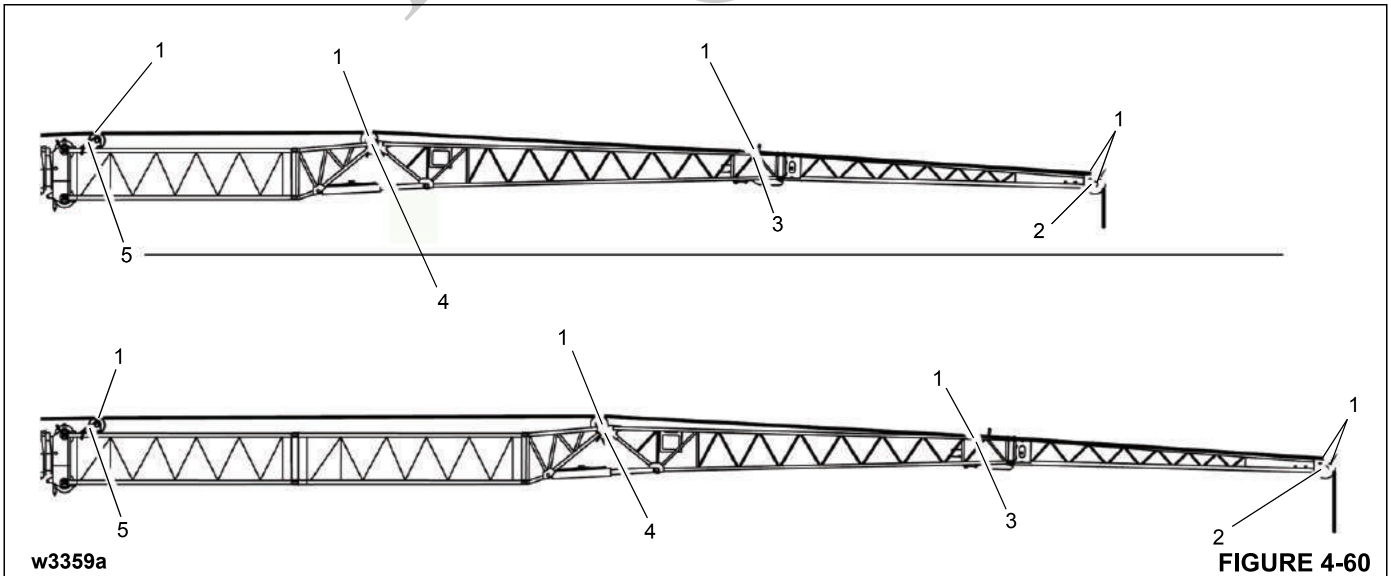


FIGURE 4-60

Traveling with Manually Offsettable Jib and/or Inserts Erected

10 m (33 ft)/17 m (56 ft) Extension Plus 5 m (16 ft) or 10 m (32 ft) Inserts

Travel is permissible under the following conditions.

- The 10 m (33 ft) or 17 m (56 ft) jib shall be erected at minimum offset.
- Jobsite travel only on firm, level surface.
- Main boom shall be fully retracted.
- Main boom angle: 0 degrees minimum, 40 degrees maximum.
- Maximum travel speed: 4 km/h (2.5 mph).
- Counterweight shall be installed.
- The boom shall be over the front.
- Swing lock and pin shall be engaged.
- Hookblock must be removed from main boom nose.
- Headache ball may be reeved over jib, hanging 0.9 m (3 feet) below sheave.
- The tires shall be properly inflated.

AUXILIARY SINGLE-SHEAVE BOOM NOSE (ADDITIONAL EQUIPMENT)

Identification

The auxiliary single-sheave boom nose is designed for the crane it was delivered with.

CAUTION

Operate the crane only with the auxiliary single-sheave boom nose that has the identical serial number.

If you wish to use the auxiliary single-sheave boom nose on several Manitowoc/Grove cranes, it needs to be adapted to the corresponding crane and marked with all the serial numbers.

CAUTION

The auxiliary single-sheave boom nose should only be adjusted by Manitowoc Crane Care at the particular location.

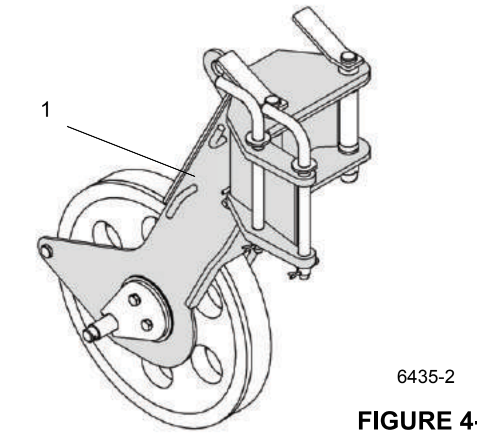


FIGURE 4-61

The serial number (1) is on a plate, in the front on the auxiliary single-sheave boom nose Figure 4-61.

Installing/Removing Auxiliary Single-Sheave Boom Nose

DANGER

Risk of accidents if boom nose should fall off! During installation and removal, always use the proper materials with sufficient load bearing capacities.

Installing Auxiliary Single-Sheave Boom Nose

- Loosen the retaining pin (4) and remove the pins (1) from the bearing point (2) Figure 4-62.

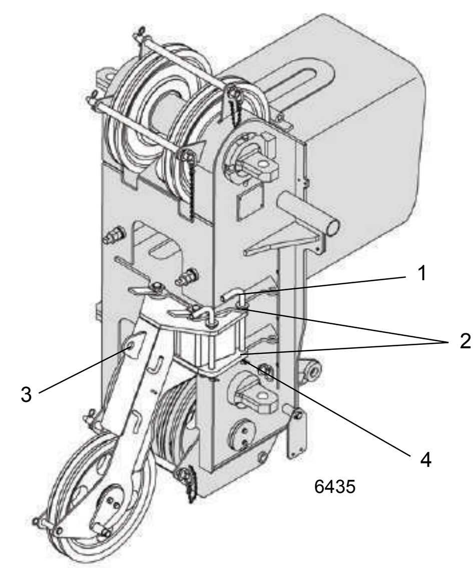


FIGURE 4-62

- Use an auxiliary crane to couple the holding device to the connection eyes (3) on the auxiliary boom nose and lift it to the left onto the main boom head.
- Align the auxiliary single-sheave boom nose so that the bearing point (2) lines up to the front bore holes in the holding device.
- Secure the auxiliary single-sheave boom nose to the holding device using a pin (1).
- Secure the pin (1) with a retaining pin (4).
- Depending on the application, bring the auxiliary single-sheave boom nose into transport position or working position.

Removing the Auxiliary Single-Sheave Boom Nose

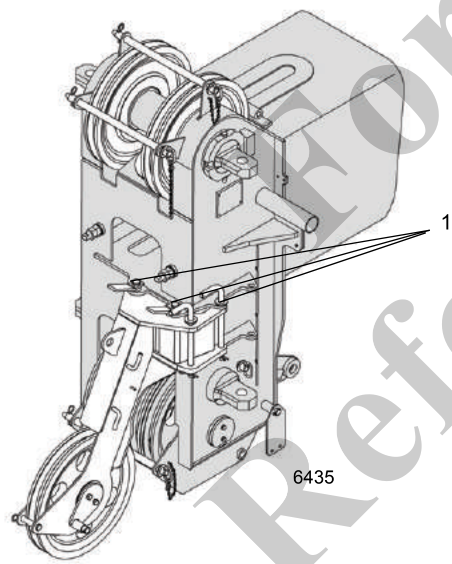


FIGURE 4-63

- Attach an auxiliary crane to the connection eyes of the boom nose.

In the working position, the auxiliary single-sheave boom nose is positioned in front of the main boom head and is fastened with three pins (1) Figure 4-63.

- Remove the retaining pins and draw all the pins out of the bores and bearing points.

In the transport position, the auxiliary single-sheave boom nose is positioned to the side of the main boom head and is fastened with two pins.

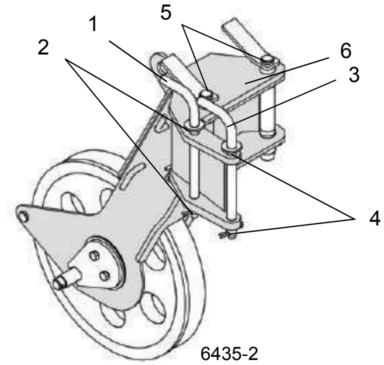


FIGURE 4-64

- Remove the retaining pins and draw all the pins out of the bores and bearing points.
- In the transport position, the auxiliary single-sheave boom nose is positioned to the side of the main boom head and is fastened with two pins.
- Lift the auxiliary single-sheave boom nose from the head of the main boom.
- Insert the two thin pins (1) and (3) into the bearing points (2) and (4) on the auxiliary single-sheave boom nose Figure 4-64.
- Insert the two pins (5) into the mounting brackets (6) in front on the auxiliary single-sheave boom nose.
- Secure all pins using retainer pins.

RIGGING THE AUXILIARY SINGLE-SHEAVE BOOM NOSE

Rigging in Transport Position

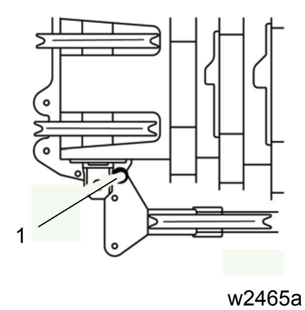


FIGURE 4-65

On the left side of the main boom head there is a holding device. In transport position, the boom nose is connected to the rear bore holes on the holding device, Figure 4-65.

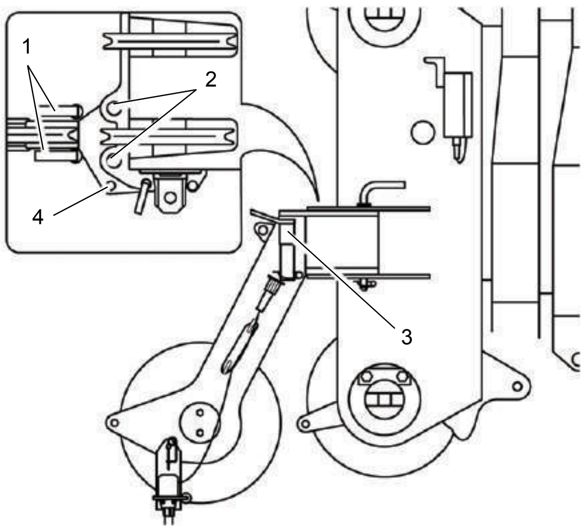


FIGURE 4-66

- Remove the retaining pins and take both pins (1) out of the bearing points (2) at the front of the main boom head Figure 4-66.
- Insert both pins into the holders (3) and secure them with retaining pins.
- Release the retaining pin and remove the thin pin from the bearing point (4).
- Rotate the auxiliary boom nose to the side of the main boom head.

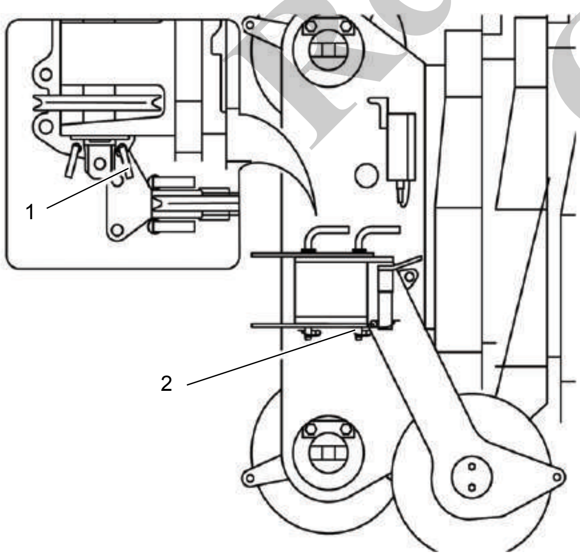


FIGURE 4-67

- Using the thin pin (1), fasten the auxiliary single-sheave boom nose to the bearing point (2) Figure 4-67.
- Secure the pin with a retaining pin.
- The auxiliary single-sheave boom nose is now in transport position.

Rigging in Working Position

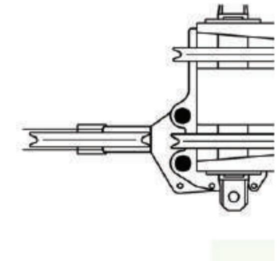


FIGURE 4-68

On the left side of the main boom head, there is a holding device. In working position, the auxiliary single-sheave boom nose is attached to the main boom head at both bore holes Figure 4-68.

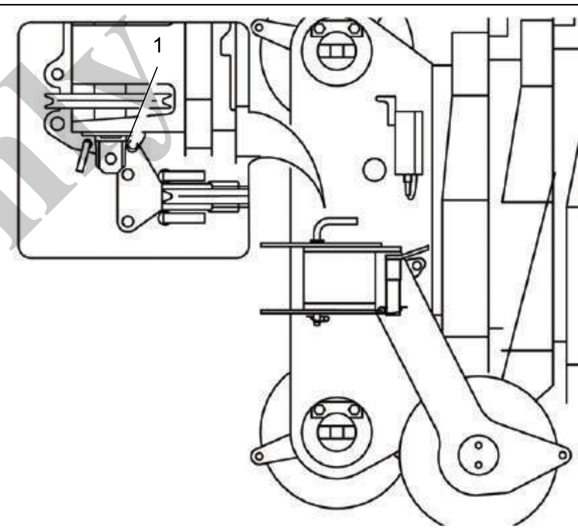


FIGURE 4-69

- Release the retaining pin and remove the thin pin from the bearing point Figure 4-69.
- Swing the auxiliary single-sheave boom nose in front of the main boom head.

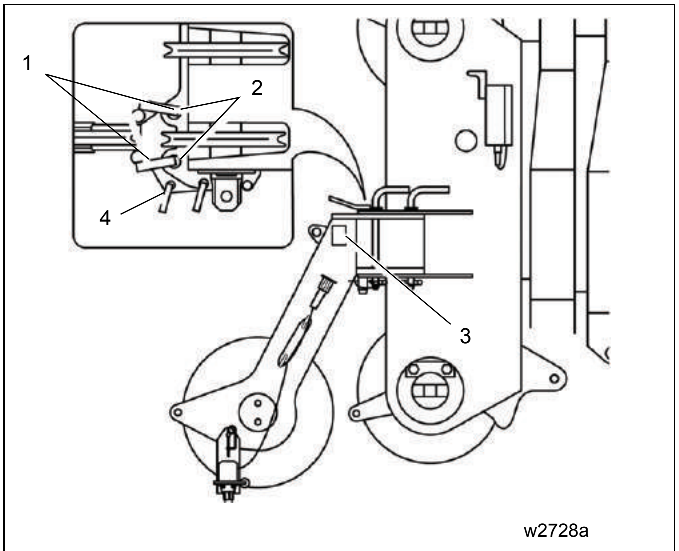


FIGURE 4-70

- Remove the retaining pin and take out both thick pins from the holders Figure 4-70.
- Insert both pins into the pivot points at the front of the main boom head and secure them with retaining pins.
- Insert the thin pin into the bearing point and secure it with a retaining pin.

The auxiliary single-sheave boom nose is now in working position.

Attaching and Removing Hoist Cable

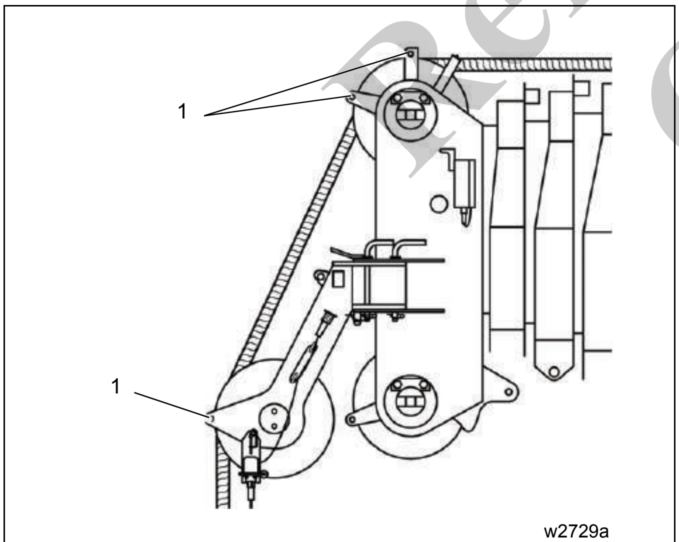


FIGURE 4-71

- Remove the cable holding rods from the head of the main boom and from the auxiliary single-sheave boom nose Figure 4-71.
- When reeving, guide the hoist cable over the left hand upper sheave of the main boom.
- Insert the rope holding rod into the appropriate bore holes and secure them with the corresponding retaining pins.
- Fasten the cable end clamp on the hook tackle or the hook block.

Reverse the sequence of operations to remove the hoist cable before rotating the auxiliary boom nose into transport position.

Possible Reeving Methods on the Auxiliary Single-Sheave Boom Nose

NOTE: The hoist cable may only be simply reeved (single drop).

Maximum load bearing capacity for single-reeving 7.3 t (16,000 lbs).

Lifting Limit Switch

In Operation

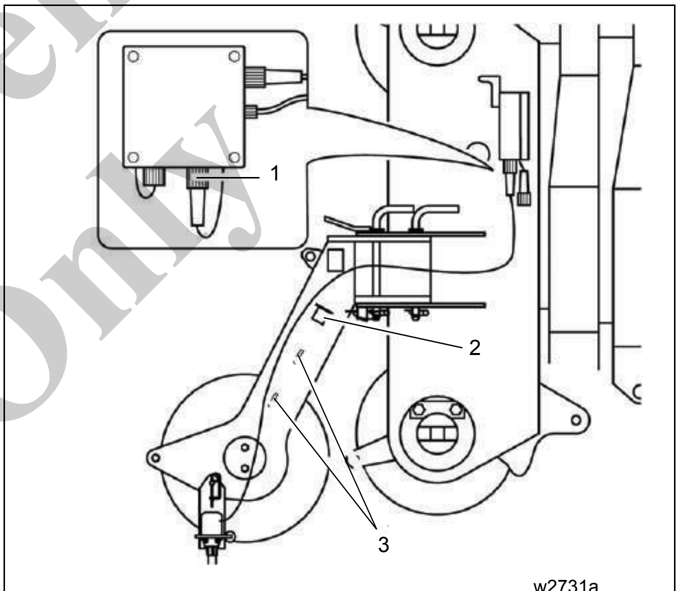


FIGURE 4-72

- Pull the plug of the connecting cable from the dummy socket (2) Figure 4-72.
- Unwind the connecting cable from the holders (3).
- Insert the plug of the connecting cable into the socket (1) on the main boom head.
- Guide the hoist cable through the lifting limit switch weight.

During Transport

- Insert the plug of the connecting cable into the dummy socket (2) Figure 4-73
- Wind the connecting cable onto the holders (3).
- Plug the short-circuit plug into the socket (1).

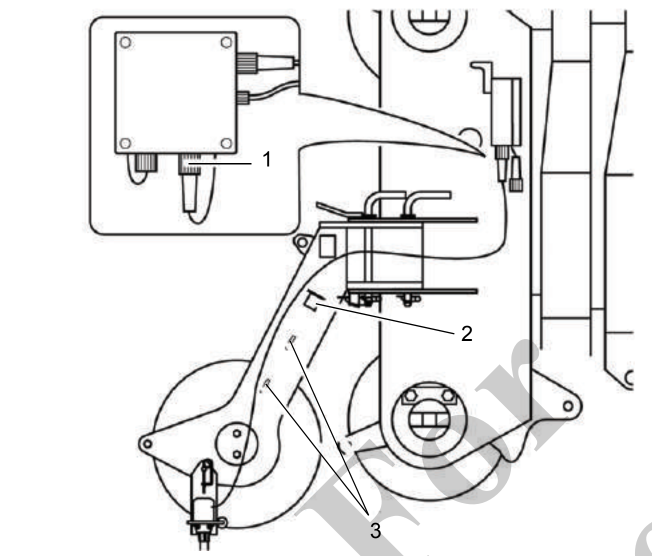


FIGURE 4-73

RAISING AND SETTING DOWN THE MAIN BOOM WITH RIGGED LATTICE EXTENSION

NOTE: The information in this section also applies for raising and setting down the main boom with a rigged jib.

To raise and lower the main boom with a rigged lattice extension, the main boom must be fully retracted.

For raising and lowering, the following prerequisites must be fulfilled:

- Apart from the hook block there is no load on the lattice extension.

TELESCOPING WITH RIGGED LATTICE EXTENSION

CAUTION

The main boom may become overloaded!

If you telescope the main boom with a rigged lattice extension or jib. You must not rotate the superstructure at the same time. This prevents the main boom being subjected to additional side forces and increased vibration and becoming overloaded.

NOTE: Do not actuate the slewing gear when telescoping.

OPERATING WITH THE LATTICE EXTENSION

NOTE: The information in this section also applies to operation with the jib. Observe the following safety instruction before working with the jib.

CAUTION

Risk of overturning when working with the jib!

When lifting over the swingaway and/or jib combinations, deduct the total weight of all load handling devices reeved over the main boom nose directly from the swingaway or jib capacity.

NOTE: The hoisting, lowering, swinging, lifting and telescoping movements are done in the same way as when operating with the main boom. Telescoping is permitted only at main boom angles of approximately 75° - 80°, depending on the length of the lattice extension.

Procedure if the Permissible Wind Speed is Exceeded

Strong winds can overstrain the crane. Therefore, closely observe the instructions in table.

If the maximum permissible wind speed according to the lifting capacity table is exceeded during the main boom operation, proceed as in Table 4-1:

Table 4-1

with wind speed up to 66 ft/s	with wind speed over 66 ft/s
• Set down the load. • Slew the superstructure so that the main boom creates as little wind resistance as possible.	• Set down the load. • Fully retract the main boom. • Set down the lattice extension.

NOTE: The information in Table 4-2 applies to malfunctions during operation with the 10/17 m (33/56 ft) lattice extension.

Table 4-2

Malfunction	Cause	Remedy
No function of the lifting limit switch	Lifting limit switch not connected	Connect the lifting limit switch.
	Electrical connection between the boom head and lattice extension and between 10 m (33 ft) section and 7 m (23 ft) section is not established.	Establish electrical connection.
	Lifting limit switch on the main boom head not overridden.	Override the lifting limit switch on the main boom head.
	When operating with a 17 m (56 ft) lattice extension or jib, the short-circuit plug is not inserted on the head of the 10 m (33 ft) section.	Insert short-circuit plug.
The main boom cannot be telescoped with the rigged lattice extension or jib.	The main boom is derricked to such an angle at which telescoping is not permissible	Derrick the main boom to the required angle.
The lattice extension can not be derricked.	Derricking gear of the lattice extension is switched off.	Switch on the derricking gear of the lattice extension.

MONTHLY MAINTENANCE WORK

Pins

Lubricate all attach, securing and retaining pins, in other words:

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

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

HOOKBLOCK

Description

A 68 metric ton (75 ton) or 36 metric ton (40 ton) hook block and a 9 metric ton (10 ton) top headache ball are available for the crane. The hook block utilizes a one-piece pivot block and the hook is equipped with a safety latch. The hook block is the quick reeve design.

Maintenance

Periodic Maintenance

It is recommended that the hook block and/or headache ball be inspected every 50 hours. A complete assembly inspection should be conducted every quarter or 500 hours in the area of the hook, hex nut, and threaded areas for corrosion and proper fit. After assembly of the hook, a liberal coating of multipurpose grease should be applied to the nut and threaded area by brush or hand to prevent corrosion.

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

SECTION 5
HOIST AND COUNTERWEIGHT

TABLE OF CONTENTS

DESCRIPTION

One standard hoist is available for both the main and auxiliary; the HP30A (see Figure 5-1). The hoist incorporates one dual displacement piston motor which drives a reduction unit within the hoist. The hoist utilizes planetary reduction with a multi-disc automatic brake that is spring applied and hydraulically released. An overrunning clutch allows the hoist to be raised without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down. The hoist motor controls both speed and torque of the hoist.

There are two modes in which the hoist operates. One mode is high speed. The pilot solenoid valve shifts the selector spool on the motor to provide minimum motor displacement. This gives high line speed and low torque.

The second mode is low speed. The pilot solenoid valve shifts the selector spool on the motor to provide maximum motor displacement. This gives low line speeds and high torque.

THEORY OF OPERATION

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

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

NOTE: For more detailed information on the hoist, refer to the Shop Reference and Maintenance Guide.

MAINTENANCE

Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below 4°C (+40°F).

The prime mover should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

DANGER

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

Removal

1. Remove all cable from the hoist drum.
2. Tag and disconnect the hydraulic lines to the hoist. Cap or plug all lines and openings.
3. Tag and disconnect the electrical wires to the hoist rotation indicator sensor.
4. Tag and disconnect the electrical wires to the hoist hi-speed solenoid valve.
5. Remove the hoist mounting nuts, capscrews, washers, and shims (if shims are used, mark their location).

NOTE: The HP30A hoist assembly, less the cable, weighs approximately 674 kg (1490 lb).

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.

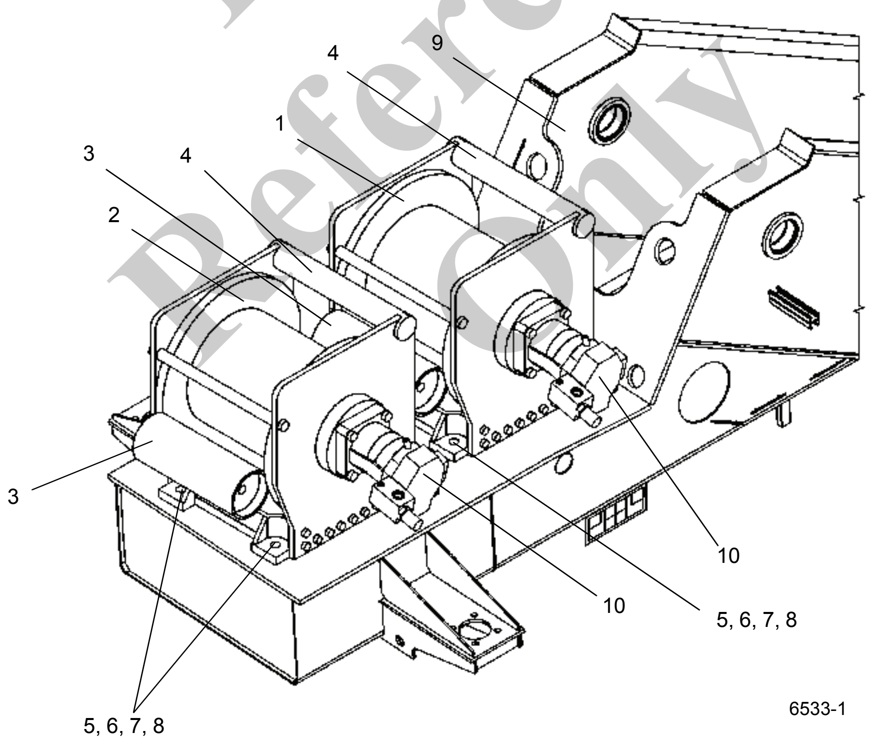


FIGURE 5-1

Item	Description
1	Main Hoist
2	Auxiliary Hoist
3	Cable Follower
4	Idler Drum
5	Shims
6	Capscrew
7	Nut
8	Washer
9	Turntable
10	Hoist Motor

3. Check the hoist to boom alignment according to the *Hoist to Boom Alignment*, page 5-4 procedure.
4. Place a level between the boom pivot shaft bushings.
5. Place a level across the top of the hoist drum and determine if the hoist is sitting in the same plane in relation to the level positioned between the boom pivot shaft bushings.
6. With the hoist level, check to determine if all the hoist mounting pads are in contact with the mounting plate by rocking the hoist.
7. Keeping the hoist level, use a feeler gauge to determine the amount of gap existing between the pads and the mounting plate.
8. Add shims to satisfy any existing gaps. Altering the shim thickness to fit a tapering gap is acceptable. Install the capscrews, washers and nuts and tighten, refer to *Fasteners and Torque Values*, page 1-13.
9. Remove the lifting device from the hoist.
10. Connect the hydraulic lines to the hoist ensuring the proper lines are connected to the correct ports as marked during removal.
11. Connect the electrical wires to the hoist hi-speed solenoid valve as marked during removal.
12. Connect the electrical wires to the hoist rotation indicator sensor as tagged during removal.
13. Install the cable, following the procedures outlined under INSTALLING CABLE ON THE HOIST, in the Operator Manual.

Functional Check

1. Attach a test weight to the hook and raise and lower the load several times.
2. Check the hoist for smooth operation of the hoist motor and brake system.
3. Ensure the hydraulic connections are secure and free from leaks.

Servicing

Remove the fill/check plug from the side of the final drive assembly. Fill with AGMA EP-4 lubricant until oil starts to flow out the plug hole. Check every 1,000 hours or 12 months; whichever occurs first.

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 (see Figure 5-2). 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.

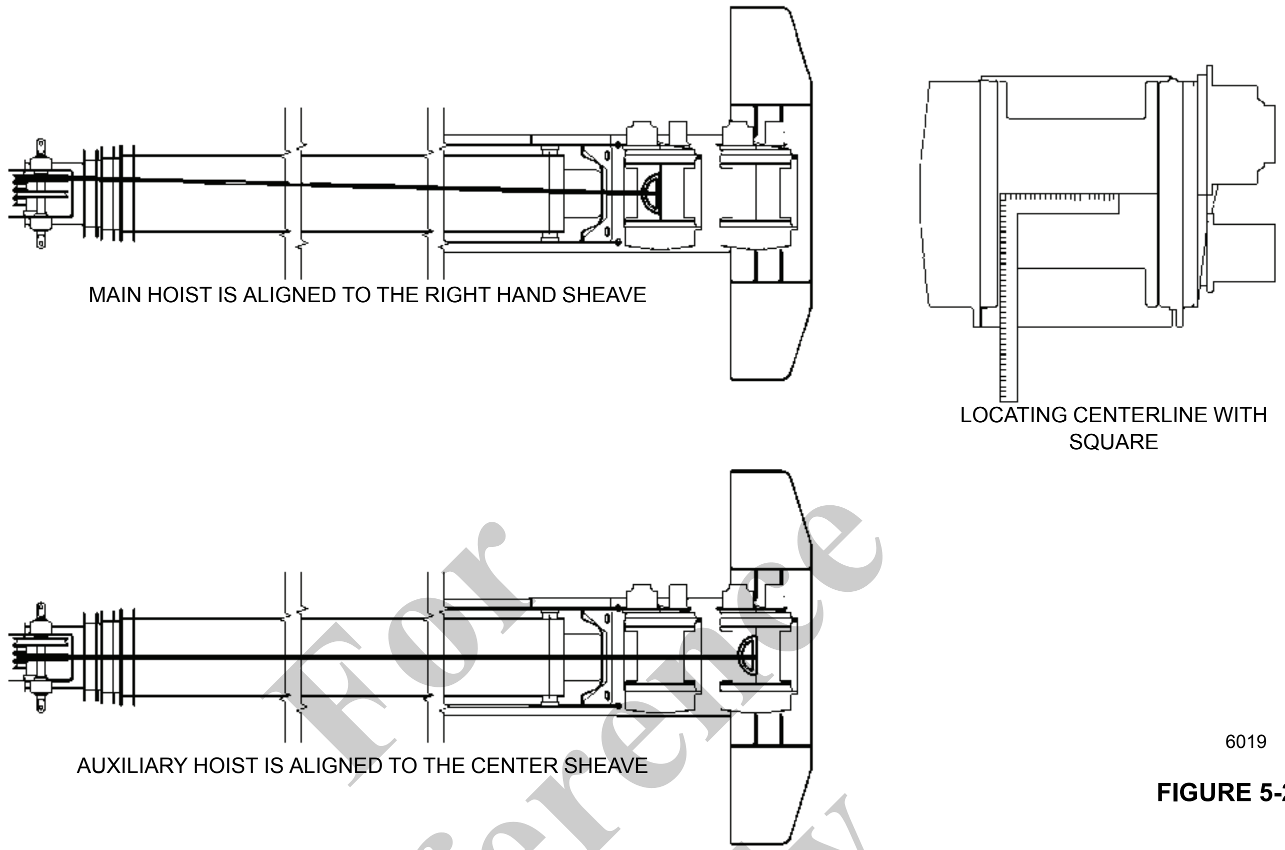


FIGURE 5-2

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.

6. Elevate the boom above 45 degrees boom angle to check if the hoist is level. Reposition the hoist drum and tighten the cord so you can have the cord in the center of the protractor at the 90 degree mark. If the cord is not at the 90 degree mark, the hoist will have to be shimmed until the cord is at the 90 degree mark.

NOTE: This test is for cable piling up on one side of the hoist drum.

PISTON MOTOR AND CONTROL VALVE

Description

The piston motor is a bent axis, bidirectional, variable displacement heavy-duty motor. The motor is bolted to the hoist and is geared directly to the hoist planetary.

The motor control valve is bolted to the motor.

Maintenance

Removal

NOTE: The motor weighs approximately 48.8 kg (107.6 lb).

1. Thoroughly clean the external surfaces of the drum and motor with steam or clean solvent and blow dry.
2. Tag and disconnect the hydraulic lines connected to the hoist motor and the motor control valve.
3. Remove the capscrews and lockwashers that secures the motor and motor control valve to the hoist.
4. Place the motor and motor control valve in a clean, dry suitable work area.

Installation

NOTE: Care must be taken to assure the primary thrust plate remains properly located in its counterbore when the motor is re-installed. If the hoist is operated with the primary thrust plate wedged between the primary gears and the planet carrier, or with a thrust washer out of position severe damage to internal hoist components could result.

1. Install a new O-ring on the motor pilot then lubricate with petroleum jelly or gear oil. Engage the motor shaft with the brake clutch inner race and lower into place.
2. Apply Loctite® No. 243 to the mounting capscrews, and install the capscrews and lockwashers. Tighten the capscrews, refer to *Fasteners and Torque Values*, page 1-13.
3. Connect the hydraulic lines as tagged during removal.
4. Fill the drum with oil. Refer to *Lubrication*, page 9-1 in this manual.

IDLER DRUM AND CABLE FOLLOWER

Description

The main and auxiliary hoists are equipped with an idler drum on the forward side of the hoist. The main hoist idler drum is used to keep the hoist cable from coming in contact with the boom. When the crane is also equipped with an auxiliary hoist, the idler drum on the auxiliary hoist is used to keep the hoist cable from coming in contact with the main hoist. The cable follower is mounted on the rear side of it's respective hoist. The cable follower applies a downward spring pressure against the cable onto the hoist drum, to ensure that the cable will be uniformly wound onto the hoist drum, and also prevent cable from jumping under abnormal line conditions.

Maintenance

Idler Drum

Removal and Disassembly

1. Remove the bolt, washer, and lockwasher from the right side of the idler roller (see Figure 5-3).
2. Support the idler roller and withdraw the shaft from the left side. Take care not to lose the dowel pin on the end.
3. Remove the roller from between the side plates.

Cleaning and Inspection

1. Clean all rust and dirt from the shaft.
2. Inspect the shaft and roller for cracks, scoring, or grooving. Replace if necessary.

Assembly and Installation

1. Position the roller between the side plates.
2. Install the shaft through the left side plate and the roller. Ensure the flat on the shaft end aligns with the stop welded on the side plate, align the dowel pin.
3. Secure the shaft to the right side plate with a bolt, washer and lockwasher. Apply Loctite® 243 to the bolt threads.

Cable Follower

Removal and Disassembly

1. Loosen the adjusting nuts and remove the tension spring and adjusting rod from both sides of the hoist (see Figure 5-3).
2. Remove the tack welds from the bolt heads securing the arm to the cable follower roller.
3. Support the cable follower roller and remove the bolts and washers securing the arms to the angles on each end of the roller. Remove the cable follower roller.
4. Disassemble the cable follower roller as follows.
   a. Remove the two bolts and washers securing the angle to the right side of the shaft.
   b. Remove the shims and roller from the shaft.
   c. If necessary, remove the bearing and bearing housing from both ends of the roller.
5. Remove the bolt and locknut securing the arm to the spring attaching lever on each side of the hoist. Remove arms and levers from the side plates.

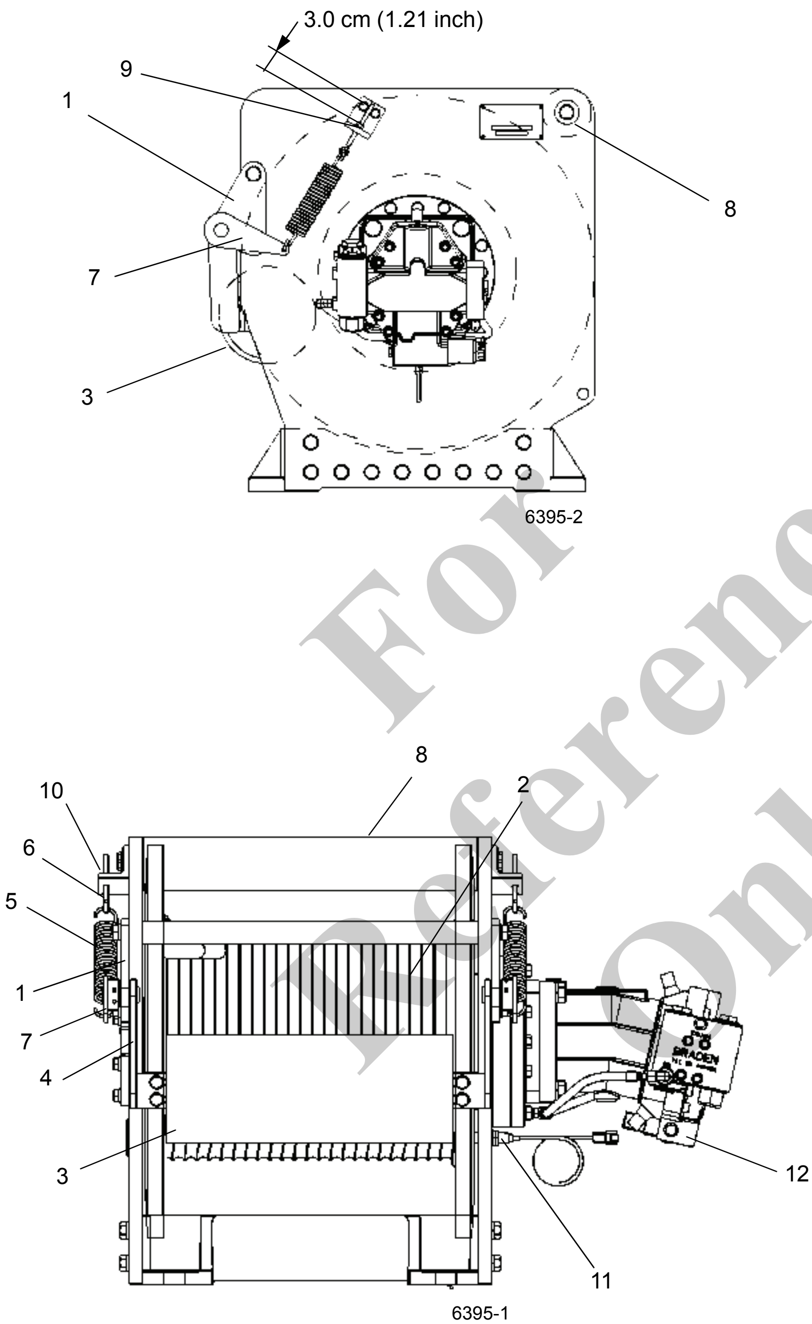
NOTE: Be sure to mark each arm and lever as to what side (left or right) they were removed from. This will be helpful during installation.

Cleaning and Inspection

1. Clean all grease from the shaft, bearing, and roller.
2. Check the shaft, roller, and bearings for cracks, scoring, or grooving. Replace if necessary.
3. Check the spring tension. If the springs will not provide sufficient tension when adjusted, replace them.

Assembly and Installation

1. Install the left arm through the bushing on the left side plate.
2. Install left spring attaching lever on the arm and secure with a bolt and locknut. Apply Loctite 243 to the bolt threads.
3. Repeat step 2 on the right side.
4. Assemble the cable follower roller as follows:
   a. Apply high strength retaining compound Loctite 680 to the bearing housings and the bearings. Install them in both ends of the roller.
   b. Install the shaft into the roller with at least one shim on each end.
   c. Position the angle on the right side of the shaft and secure with two bolts and washers. Apply Loctite 243 to the bolt threads.
5. Position the cable follower roller on the arms and secure with four bolts and washers. Center the roller between the hoist drum flanges and tighten the bolts. Tack weld the bolt heads.
6. Attach one end of the tension springs to the levers on each side. Install the adjusting rod through the lug on each side plate and connect to the other end of the spring. Install the adjusting nuts on each rod and tighten enough to take the slack out of the springs.
7. Using a grease gun, apply grease to the fittings on each side plate bushing.
8. Adjust the roller as follows:



Item	Description
1	Pivot Bracket
2	Drum
3	Follower Roller
4	Arm
5	Spring
6	Spring Adjusting Rod
7	Lever
8	Idler Roller
9	Nut
10	Bracket
11	Rotation Sensor
12	Hydraulic Motor

FIGURE 5-3

a. With one layer of cable on the hoist drum, adjust the bolts on the front of each side plate (that push against each arm) so the roller applies pressure on the layer of cable, and does not interfere with filler/ riser protrusions on the hoist drum flanges. Tighten jam nuts to secure setting.

b. With a full drum of cable, the adjusting spring length from eye to eye should not exceed 25.7 cm (10.12 in). Adjust rods as necessary and tighten jam nuts to secure this setting.

Complete Assembly

Removal

1. Remove all tension from the springs on each side by loosening the nuts and jam nuts.
2. Support the weight of the assembly and remove the two bolts and washers securing each side plate to the hoist. Remove the idler drum and cable follower assembly from the hoist.
3. If necessary to completely disassemble or remove any part of the assembly, refer to the applicable paragraphs in this Sub-section.

Installation

1. Position the idler drum and cable roller assembly on the hoist and secure each side plate to the hoist with two bolts and washers.
2. Adjust the tension on the cable follower. Refer to instructions in paragraph titled CABLE FOLLOWER - Assembly and Installation in this Sub-Section.

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 the operator will know if and at what speed the hoist drum is rotating, even under the most distracting conditions.

The rotation indicator system consists of the rotation indicator sensor and thumb thumper solenoid. The rotation sensor is located on the hoist. The pulsing thumb thumper solenoid is located in the applicable hoist control lever handle. Actuation of the thumb thumper is controlled by the CAN-bus system from input supplied by the rotation indicator sensor.

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, refer to the troubleshooting section of your CAN-bus CD.

Rotation Sensor

The rotation sensor is screwed into the hoist housing and senses the rotation of the primary drive end teeth. When installing the sensor, ensure it contacts the top land of a tooth and not between teeth. Screw the sensor in until contact is made, then back out 1/2 turn and tighten lock nut.

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 controller. The thumb thumper will cease operation at high line speeds to prevent damage to the solenoid.

Troubleshooting

NOTE: This machine incorporates a CAN bus Multiplex system. In order to effectively troubleshoot the electrical system, you need a Windows-based PC, Orchestra® software (999102409), a connection cable (9999102296) and a dongle (9999102587). The Orchestra® software, connection cable and dongle may be ordered from Crane Care.

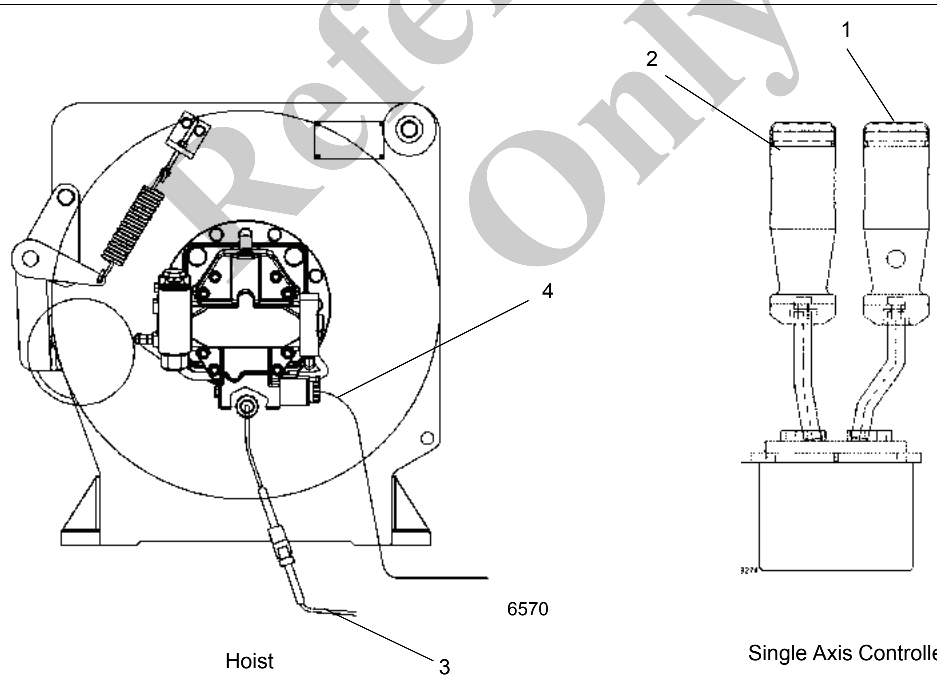


FIGURE 5-4

Item	Description
1	Thumb Thumper
2	Controller

Item	Description
3	To Rotation Indicators
4	High Speed Solenoid Connection

HOIST CONTROL VALVES

Description

NOTE: For more detailed information, refer to *Valves*, page 2-22.

Hoist Motor Control Valve

The hoist motor control valve is mounted on the hoist and is designed to provide an even flow of oil to the hoist motors in both directions.

Hoist Directional Control Valve

The hoist directional control valve is used to control the operation of the hoist. It 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:

- A 5443 kg (12,000 lb) removable counterweight consisting of three slabs, each weighing 1814 kg (4000 lb).
- A 8165 kg (18,000 lb) removable counterweight consisting of three slabs each weighing 1814 kg (4000 lb) and one slab weighing 2721 kg (6000 lb).
- An optional 10,885 kg (24,000 lb) removable counterweight consists of two 1,360 kg (3000 lb) “wing weights” that hang on the existing 8,165 kg (18,000 lb) counterweight stack.

NOTE: This extra counterweight is not roadable due to the overall width of the machine when installed, but you can move around the jobsite with the full counterweight installed.

The following procedures are applicable for removal and installation of any or all pieces (see Figure 5-5).

The counterweight contains lugs for attachment to the removal cylinders and lugs to pin it under the hoist mounting. The additional slabs pin the structure 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 a working section for each cylinder. The valve is electrically controlled by a control panel on the right side of the turntable.

Maintenance

Cylinders

Removal

1. Set the counterweight on the carrier deck.
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 1-13.
2. Connect the hydraulic lines to the cylinder as marked during removal.

Jackscrews

There are four jackscrews 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.

Mounting the Counterweight

1. Position the crane on a firm level surface. Fully extend and set the outriggers.
2. Rotate and align the rear of the superstructure above the removable counterweight stowed on the carrier deck. Engaging the pin type turntable lock will aid alignment.
3. Using the counterweight removal control panel located on the right side of the turntable, lower the counterweight cylinders. Pin the cylinders to the counterweight using the attach pins in the cylinders. Insert the retaining pins in the attach pins.
4. Push in, turn, and remove the long attach pins from the counterweight and carrier frame lugs.
5. Using the control panel, raise the counterweight up under the superstructure frame.

NOTE: It may be necessary to jog the counterweight with the removal control panel to install the upper attach pins.

6. Remove the upper attach pins from the stowage bushings and install them into the upper counterweight and superstructure frame lugs.

7. Push in on the pins and turn to lock pin in the notch.
8. Insert the long pins into the bottom of the counterweight. Push in on the pins and turn to lock pin in the notch.
9. The crane is now ready for operation with the counterweight installed.

Stowing the Counterweight

1. Position the crane on a firm level surface. Fully extend and set the outriggers.
2. Rotate the superstructure to align the counterweight with the stowage area. Engaging the pin type turntable lock will aid alignment.

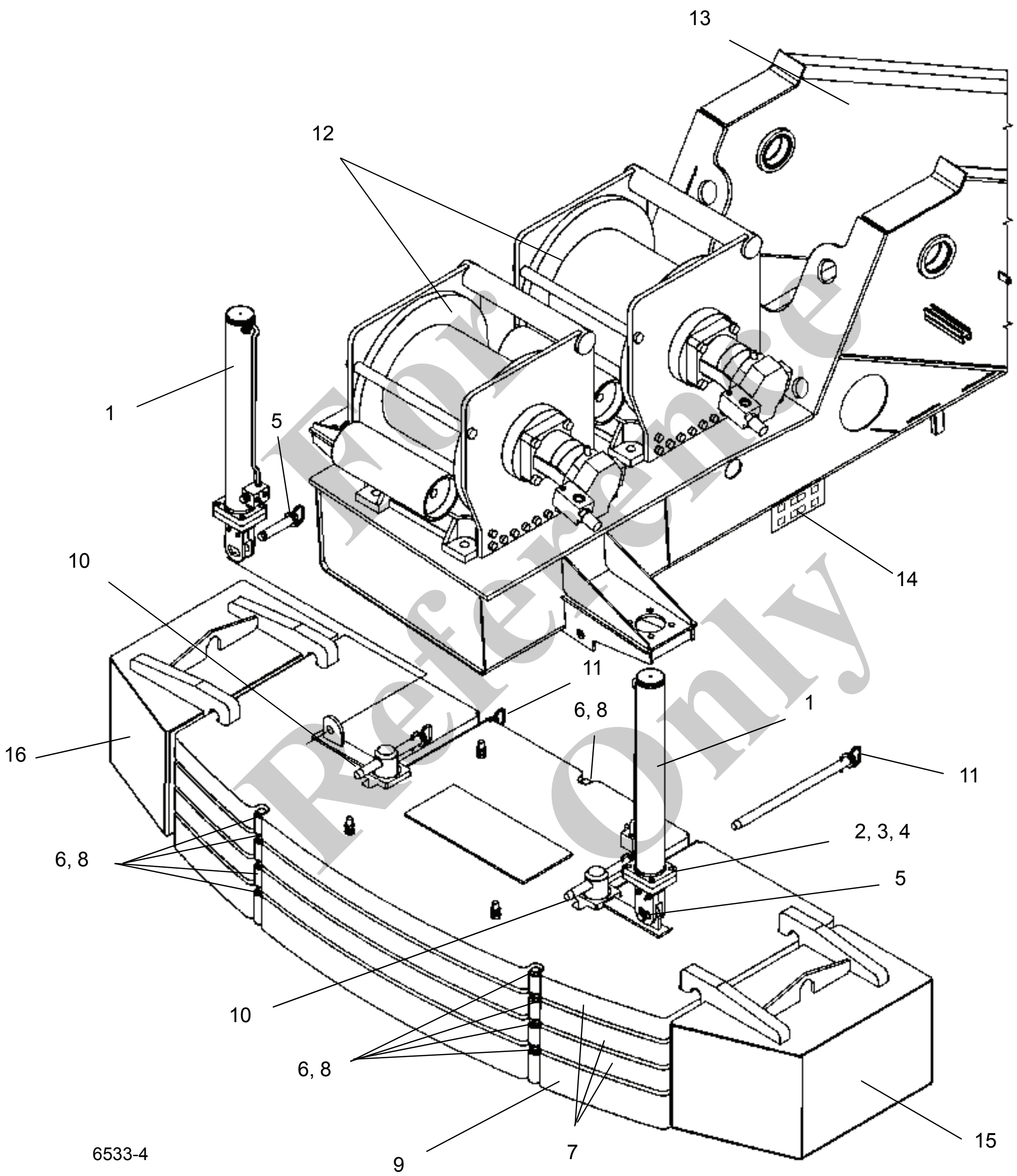


FIGURE 5-5

Item	Description
1	Counterweight Removal Cylinder
2	Spacer
3	Bolt
4	Washer
5	Cylinder Attach Pin Assembly
6	Capscrew
7	Counterweight Weldment
8	Nut
9	Counterweight Weldment (18,000# Only)
10	Box Attach Pin
11	Counterweight Weldment Attach Pin
12	Hoist(s)
13	Turntable
14	Counterweight Removal Control Panel
15	Counterweight Weld- LH (Optional)
16	Counterweight Weld - RH (Optional)

NOTE: It may be necessary to jog the counterweight with the removal control panel to remove the weight of the counterweight from the upper attach pins.

3. Using the counterweight removal control panel, raise the counterweight cylinders to relieve weight on the upper attach pins. Push in, turn, and remove the upper attach pins from the superstructure frame lugs and the counterweight
4. Stow the upper attach pins in the bushings on the side of the superstructure.
5. Push in, turn, and remove the long pins from the bottom of the counterweight.
6. Using the removal control panel, slowly lower the counterweight onto the carrier stowage area.
7. Insert the long pins through the carrier lugs and counterweight. Push in and turn to lock pin in the notch.
8. Remove the attach pins from the counterweight lugs and cylinder ends. Raise the cylinders and stow the attach pins in cylinder and insert retainer clip pins.
9. The carrier is now ready for highway travel with the counterweight stowed.

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SECTION 6
SWING SYSTEM

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6

DESCRIPTION

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term free swing means that, with the swing brake switch in the off position, the superstructure will swing freely after the swing controller is released until it coasts to a stop or the swing brake pedal is depressed.

Swing is activated using the controller in the cab. When the swing lever is actuated, hydraulic pressure is routed to the swing motor to drive the gearbox in the appropriate direction. As the gearbox rotates, the pinion gear meshes with the teeth on the swing bearing and rotates the superstructure. Swing speed can be controlled by the swing speed switch located on the left armrest. The maximum rotation is 2.5 rpm. Braking is accomplished by depressing a glide swing brake pedal which is an electric pedal that provides a controlled braking of the swing motion.

The swing system consists of an electric pedal controller, a directional control valve, the swing drive, the swing brake assembly, the brake pedal, and a swing brake release solenoid valve.

The crane is equipped with a pin type swing lock as standard and a standard 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type swing lock will lock the turntable in the over the front and over the rear positions. Both swing locks are operated from the cab.

THEORY OF OPERATION

Swing Drive

The hydraulic power for the swing drive (see Figure 6-1) is supplied by hydraulic pump #2. Oil flows from the pump to the outrigger selector manifold to the hydraulic swivel. Flow from the swivel is routed to the swing directional control valve.

When the 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 release is supplied by hydraulic pump #1 and the main directional control valve. With the swing brake selector switch positioned to on (push top switch), the swing brake release valve blocks the 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 flow is directed to the brake release port, overcoming the brake spring pressure and releasing the swing brake.

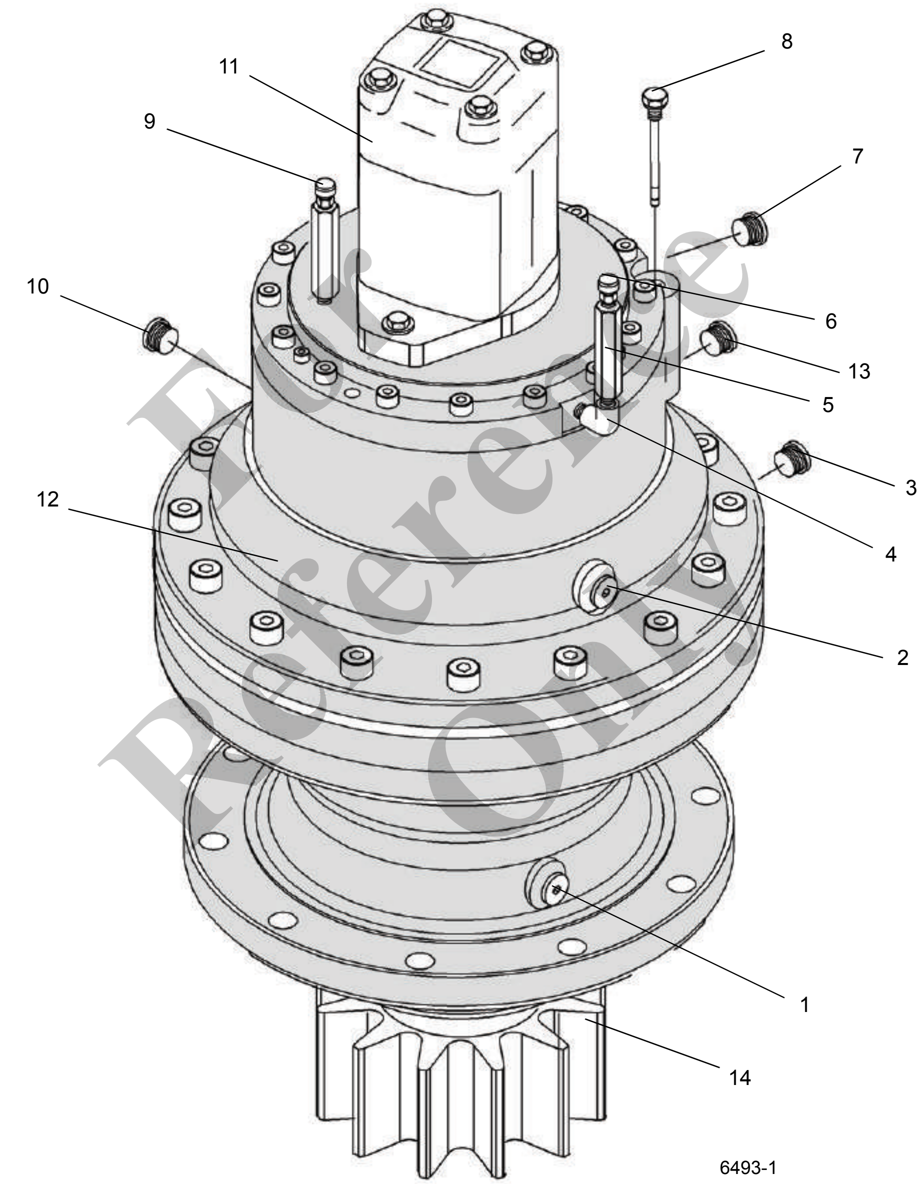

FIGURE 6-1

Item	Description
1	Plug
2	Plug
3	Plug
4	Elbow
5	Pipe
6	Breather
7	Plug
8	Dipstick

Item	Description
9	Breather
10	Plug
11	Motor
12	Gearbox and Brake
13	Plug
14	Pinion

MAINTENANCE

Troubleshooting

NOTE: CAN-bus service tool should be used to aid troubleshooting. Service tool can be ordered through the Manitowoc Technical Training Center.

Symptom	Probable Cause	Solution
1. Superstructure 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 Section 9 - LUBRICATION.
	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.
	t. Hydraulic pressures and EEPROMS not setup correctly.	**t.** See pressure setting procedure.

Symptom	Probable Cause	Solution
2. Superstructure 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.
	g. Electrical connections.	**g.** Inspect wiring and connectors.
	h. Controller settings.	**h.** Check settings. See item t. on previous page.
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 wiring/connectors.	**d.** Inspect wiring and connectors.
	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.

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Symptom	Probable Cause	Solution
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. Electrical connectors/wiring.	**c.** Inspect connectors and wiring.
	d. Improperly lubricated swing bearing.	**d.** Lubricate bearing per recommendations.
	e. Improper size hose and/or fittings installed.	**e.** Refer to the Manitowoc Crane Care Parts Manual.
	f. Clogged or restricted hydraulic hoses or fittings.	**f.** Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	**g.** Replace bearings.
	h. Worn or damaged swing motor.	**h.** Repair or replace motor.
	i. Worn or damaged hydraulic pump.	**i.** Repair or replace pump.
	j. Crane not level.	**j.** Level crane.
	k. Damaged swing directional control valve.	**k.** Replace swing directional control valve.
	l. Two speed swing valve adjustment.	**l.** Check adjustment. Repair or replace valve.
	m. Hydraulic pressures and EEPROMS not setup correctly.	**m.** See pressure setting procedure.
5. Swing operation slow in one direction only.	**a.** Crane not level.	**a.** Level crane.
	b. Damaged swing directional control valve.	**b.** Replace the swing directional control valve.
	c. Clogged or restricted hose.	**c.** Replace hose or fitting.
	d. Improperly torqued turntable bearing.	**d.** Torque turntable bearing.
	e. Hydraulic pressures and EEPROMS not setup correctly.	**e.** See pressure setting procedure.
6. Swing brake operation erratic.	**a.** Improper brake adjustment.	**a.** Adjust brake.
	b. Air in swing brake system.	**b.** Bleed brake system.
	c. Dirty or glazed brake disc.	**c.** Clean or replace disc.
	d. Kinked or bent lines and/or hoses and fittings.	**d.** Straighten or replace as required.
	e. Hydraulic pressures and EEPROMS not setup correctly.	**e.** See pressure setting procedure.
7. Swing brake system will not operate.	**a.** Damaged swing brake release valve.	**a.** Replace cartridge.
	b. Internal damage to the swing brake assembly.	**b.** Repair or replace affected parts.
	c. Loose or restricted brake lines or fittings.	**c.** Tighten or replace lines and fittings.
	d. Hydraulic pressures and EEPROMS not setup correctly.	**d.** See pressure setting procedure.

Symptom	Probable Cause	Solution
8. Swing brake drags.	**a.** Damaged swing brake release valve.	**a.** Replace cartridge.
	b. Internal damage to the swing brake assembly.	**b.** Repair or replace affected parts.
	c. Loose or restricted brake lines or fittings.	**c.** Tighten or replace brake lines and fittings.
	d. Hydraulic pressures and EEPROMS not setup correctly.	**d.** See pressure setting procedure.
9. Swing motor continues to operate when swing control is in neutral.	**a.** Control valve sticking or valve otherwise damaged.	**a.** Repair or replace valve.
10. Superstructure swings slowly.	**a.** Insufficient hydraulic volume.	**a.** Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump speed.
	b. Damaged relief valve.	**b.** Adjust, repair, or replace valve.
	c. Damaged swing motor.	**c.** Repair or replace motor.
11. Swing motor turning in wrong direction.	**a.** Improper port connections.	**a.** Reverse port connections.
	b. Improper wiring connections.	**b.** Inspect connections.
12. 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. The swing motor is a hydraulic piston type. The motor has two ports for connection to the hydraulic system.

Maintenance

Removal

1. Ensure the swing brake and swing lock are engaged.
2. Clean the port area around the motor. Tag and disconnect the hydraulic hoses from the motor assembly. Cap or plug all openings.

CAUTION

Oil can be hot and cause burns.

3. Unscrew the drain plug, remove the breather and dipstick to ensure that all oil has been removed. After the oil has been drained, replace the drain plug and any other plugs that may have been removed.

CAUTION

Pull straight up on the motor assembly to avoid damaging the splined shaft.

4. Remove the capscrews securing the motor and lift the swing motor free of the motor support plate. Remove and discard the O-ring from the groove in the swing brake.

Installation

CAUTION

Use care when engaging the swing motor drive gear, do not force the shaft to engage.

1. Install a new O-ring in the groove of the swing brake. Position the swing motor on the swing brake, engaging the shaft with the brake input shaft.
2. Apply Loctite® 243 to the capscrew threads. Install the capscrews and secure the motor to the brake housing. Tighten the capscrews, refer to Fasteners and Torque Values, page 1-13.
3. Connect the hydraulic lines to the swing motor as tagged during removal.

Test

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING GEARBOX AND BRAKE

Description

The swing gearbox and brake, used in conjunction with the swing motor, rotates and stops the superstructure. A pedal on the cab floor is used to activate the swing brake. The swing 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

CAUTION

Lock pin must be engaged or superstructure free swing will occur when brake or gearbox is removed.

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines connected to the swing motor and the brake. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake according to the procedures found in this Section under SWING MOTOR - REMOVAL.

CAUTION

Use care when removing the capscrews securing the brake, as there is tension on the bolts due to internal brake springs.

4. While observing tension on the bolts, unscrew the socket head capscrews securing the brake to the gearbox. Remove the brake assembly in one piece with the motor support plate.
5. Remove 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. Place motor support plate on brake housing.
3. Apply Loctite® 270 to socket capscrews. Install motor support and brake onto gearbox and secure with the socket capscrews. Tighten the capscrews, refer to Fasteners and Torque Values, page 1-13.
4. Install the swing motor into the swing brake according to the procedures found in this Section under SWING MOTOR - INSTALLATION.
5. Connect the hydraulic lines to the motor and brake.
6. Bleed all air from the brake assembly.

Testing

1. With the Swing Brake switch in the ON position, position the swing control lever in both directions. Superstructure rotation should not occur.
2. Position the Swing Brake switch to OFF and swing the superstructure in both directions. Use the swing brake pedal to stop rotation.
3. Check for hydraulic leaks and repair as necessary.

Gearbox

Removal

CAUTION

Lock pin must be engaged or superstructure free swing will occur when brake or gearbox is removed.

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines from the swing motor and swing brake. Cap and/or plug all openings.
3. Remove the capscrews and lockwashers securing the pinion guard. Remove the guard.
4. Remove the three bolts and plate attaching the pinion gear to the output shaft and remove the pinion gear.

NOTE: The complete gearbox assembly with motor weighs approximately 170 kg (375 lb).

5. Attach a suitable lifting device to the swing gearbox. Remove the capscrews, washers and spacers securing the gearbox to the mounting plate.

NOTE: Take note of the swing motor port orientation to ensure proper installation.

6. Remove the swing gearbox.

6

7. If necessary, remove the swing motor according to the procedures found in this Section under SWING MOTOR REMOVAL.
8. If necessary, remove the swing brake according to the procedures found in this Section under SWING GEARBOX AND BRAKE REMOVAL.
9. Cover the opening of the swing gearbox to ensure no dirt, dust, etc., gets into the gearbox.

Installation

1. If removed, install the swing brake according to the procedures found in this Section under SWING GEARBOX AND BRAKE INSTALLATION.
2. If removed, install the swing motor according to the procedures found in this Section under SWING MOTOR INSTALLATION.
3. Attach a suitable lifting device to the swing gearbox and lift and position the swing gearbox in place on the mounting plate.
4. Install the capscrews, washers and spacers. Tighten the bolts, refer to Fasteners and Torque Values, page 1-13.
5. Install the pinion gear on the output shaft and secure with three bolts. Tighten the bolts, refer to Fasteners and Torque Values, page 1-13.
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 checked and filled after 50 hours of operation, drained and flushed out after approximately 250 hours of operation, and replaced with premium quality SSGL-5 after approximately 500 hours of operation or each year, whichever occurs first. Operation in high humidity or polluted air areas will require more frequent changes to minimize moisture or contaminate accumulation. Change the oil as follows:

1. Unscrew the drain plug; remove the breather and dipstick to ensure all oil has been removed.
2. After oil is drained, replace the drain plug and any other plugs that were removed to drain the oil.
3. Flush the case with a light flushing oil.

NOTE: Cleaning of the gearbox with a solvent is recommended to prevent an accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the vent of the swing bearing.

4. To refill with oil (see Figure 6-2), make sure the breather is open. Insert oil through breather oil fill until it reaches proper location on dipstick.
5. Tighten the breather and dipstick.

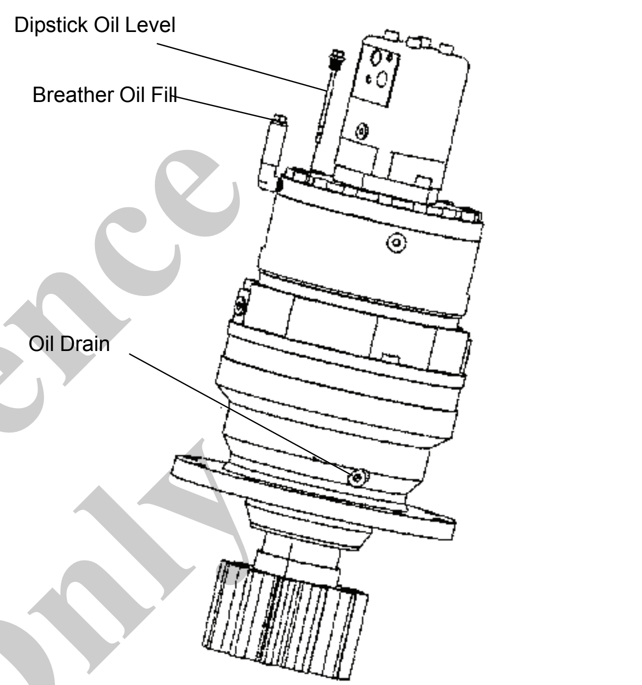


FIGURE 6-2

Checking the Oil Level

1. Check the level on the dipstick on the swing gearbox.
2. If no oil is visible on the dipstick, add SSGL-5 weight oil until the level is between min and max on the dipstick.
3. Replace the dipstick in the brake housing.

Testing

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the Superstructure to the Carrier. The bearing inner race is bolted to the Superstructure and the outer race is bolted to the Carrier. The inner race contains two grease fittings for lubrication of the bearing which are hosed to two fittings at the front 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.

Tightening Turntable Bolts

General

WARNING

Failure to maintain proper torque of the turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the superstructure from the carrier.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength metric bolt (grade 10.9), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high strength bolt is removed, or untorqued, the bolt must be replaced with a new bolt of the same classification.

DANGER

It is mandatory that bearing attaching bolts be inspected for lack of torque and retorqued, as required, after the first 300 hours of crane operation. The bolts may loosen in service due to vibration, shock-loads, and temperature changes, therefore, periodic inspection should be accomplished every 500 hours thereafter, ensuring the bolts are properly torqued.

KNOW YOUR TORQUE WRENCH! Flexible beam type wrenches, even though they might have a pre-set feature, must be pulled at 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 (see Figure 6-4) are used to reach hard to get at areas, ensure torque readings are accurate.

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

If it is reported by the crane operator or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the cranes' capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

Turntable bolts should be torqued according to the procedures outlined in this section.

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

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

The inner race of the bearing is secured to the turntable by 72, M24 Grade 10.9 bolts. The outer race of the bearing is secured to the carrier frame by 72, M24 Grade 10.9 bolts.

Torque Values

Torque all turntable bolts to a final torque of 1005 to 1089 Nm (741 to 803 lb-ft).

Tools Required

The Special Turntable Bolt Torquing Tools (see Figure 6-4) 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 804 to 871 Nm (593 to 642 lb-ft) using the following sequence pattern; 19, 55, 37, 1, 28, 64, 46, and 10 (see Figure 6-3). 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 the final torque of 1005 to 1089 Nm (741 to 803 lb-ft). The same tools are used as in step 1.

Outer Race Torquing

Same as inner race (see Figure 6-3).

NOTE: Bolt pattern numbering is the same for the inner and outer race

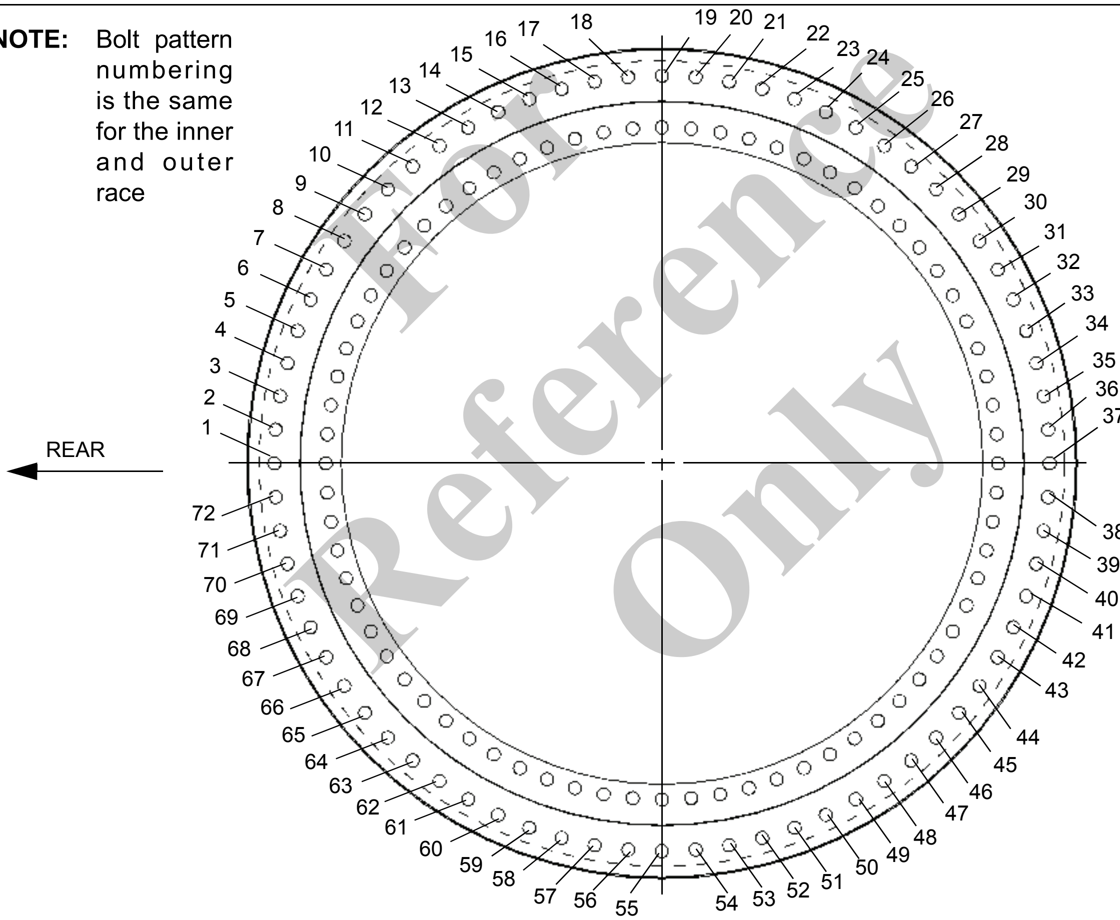
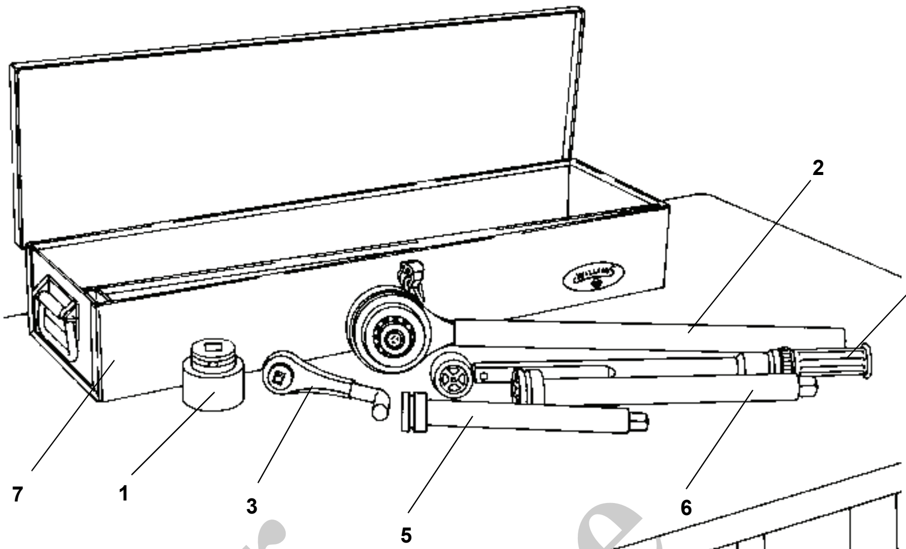


FIGURE 6-3



Orders for special tools shall be referred to:

Manitowoc Crane Care
1565 Buchanan Trail East
Shady Grove, PA 17256
Phone: (717) 597-8121
Fax: (717) 593-5929

Description	Grove Part Number	Quantity Required
1. M24 Socket 3/4" Drive	9-999-101798	1
2. 4 to 1 Torque Multiplier (1/2" Input 3/4" Output)	9-999-100134	1
3. Backlash Adapter	9-999-100141	1
4. 1/2" Drive Torque Wrench	9-999-100136	1
5. 10" Extension 3/4" Drive	9-999-100138	A/R
6. 13" Extension 3/4" Drive	9-999-100137	A/R
7. Tool Box (Optional)	9-999-100146	1

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FIGURE 6-4

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Removal

1. Remove the counterweight. Refer to Hoist and Counterweight, page 5-1.
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. Remove bolts that engage the bottom swivel plate to the carrier lugs.

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 72 bolts and washers securing the turntable bearing outer race to the carrier.

DANGER

Ensure that any blocking material used is capable of fully supporting the weight of the superstructure and will not allow it to tilt or shift. Failure to do so may result in death or injury to personnel.

15. Carefully lift the superstructure, using care not to damage the swivel assembly, and set it on blocking that will not allow the superstructure to tilt or shift, or rest on the swivel. Leave the lifting device attached.

NOTE: If the same bearing is to be used again, mark the position of the bearing on the superstructure so it can be installed in the exact position it was before removal.

NOTE: The bearing weighs approximately 704 kg (1886 lb) depending on the bearing. Ensure the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 72 bolts and washers securing the turntable bearing to the superstructure.

17. Using the lifting device, remove the turntable bearing from under the superstructure.

Inspection

Check the bearing teeth for chipping or cracking. If any evidence of these is found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

Installation

DANGER

Anytime a metric grade 10.9 turntable bolt has been removed, it must be replaced with a new grade 10.9 bolt.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

1. Using an appropriate lifting device, position the turntable bearing under the superstructure. If the same bearing is being used, position it as marked prior to removal.

2. Install 72 new bolts and washers securing the bearing to the superstructure. Refer to Inner Race Torquing in this Sub-Section.

3. Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the front or from under the cab.

4. Install 72 new bolts and washers. Refer to Outer Race Torquing in this Sub-Section.

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).

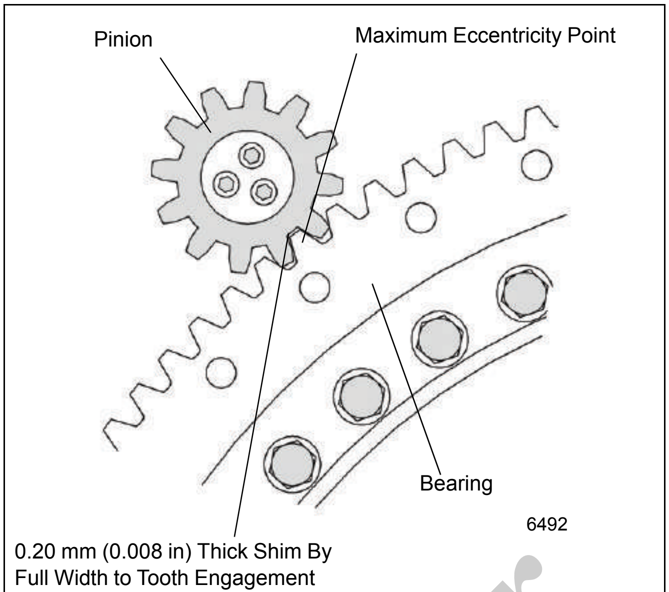


FIGURE 6-5

5. Install the gearbox pinion aligning the high point (maximum eccentricity) on the turntable bearing. Using - a 0.20 mm (0.008 in) thick shim, check the backlash (see figure). If the pinion must be moved to achieve proper backlash, contact your local distributor.

CAUTION

Do not clamp over pinion.

- Using shims, set backlash by moving the swing drive assemblies toward the bearing in order to mesh the pinion with the ring gear teeth (see Figure 6-5).
- Check tooth engagement squareness and vertical tooth engagement.
- Remove backlash shims and recheck backlash.

6. Engage swivel plate into the carrier lugs.

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 following procedures outlined in Hoist and Counterweight, page 5-1.

Testing

Activate the crane and check for proper function.

NOTE: If the superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

SWIVELS

Description

The swivel assembly (see Figure 6-6) consists of an 8-port hydraulic swivel, a 2 port water swivel, and a 20 conductor slip ring electrical swivel. Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts, washers and bushings. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier by bolts, and bolt retainer plate 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 water swivel case is engaged to the hydraulic case by four dowel pins causing the water swivel to rotate with the superstructure.

The electrical swivel center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.

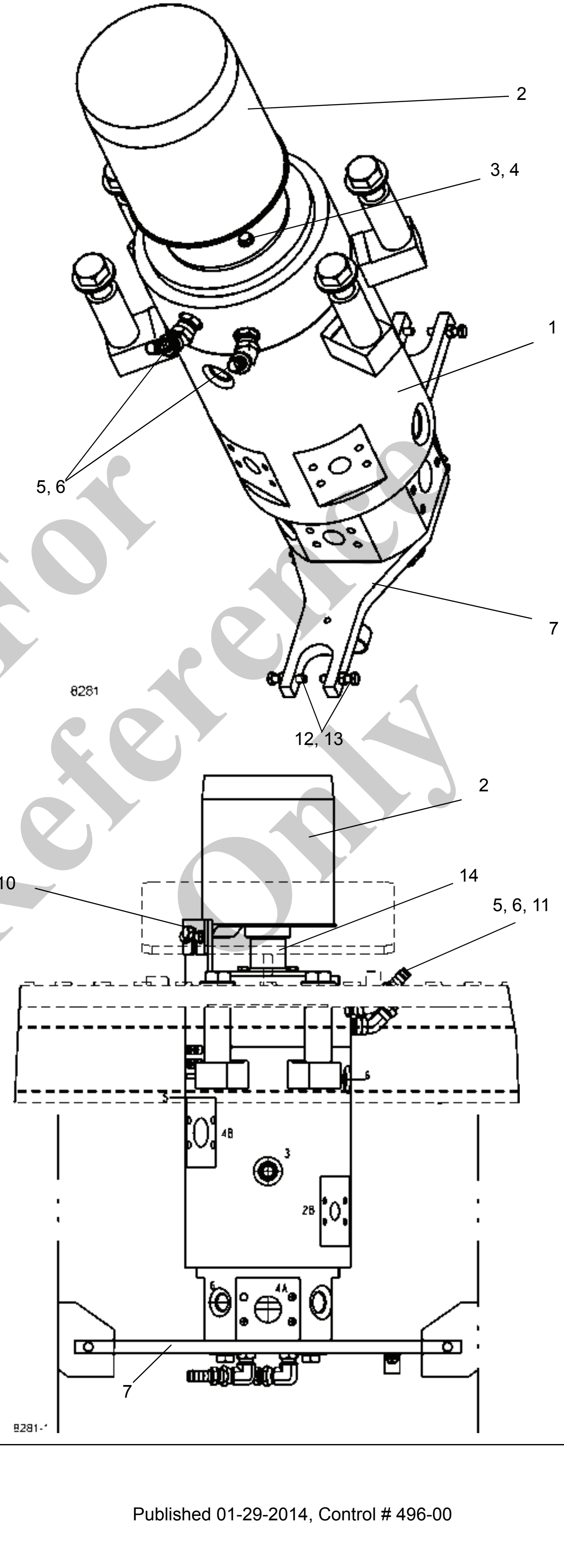


FIGURE 6-6

Item	Description
1	Hydraulic Swivel
2	Slip Ring Assembly
3	Capscrew
4	Washer
5	Swivel Adapter
6	Hose Nipple
7	Retainer Plate
8	Plate
9	Capscrew
10	Flatwasher
11	Swivel Adapter
12	Capscrew
13	Hex Nut
14	Center Post

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 in Table 6-1.

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 distance from top of the lift cylinder to base of 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.

This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use the oak blocking to block between the barrel of the lift cylinder and the boom base section.
5. Tag and disconnect the hydraulic lines from the case of the hydraulic swivel. Cap or plug all lines and openings.
6. Tag and disconnect the hydraulic lines and water lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
7. Tag and disconnect the water lines from the case of the water swivel. Cap or plug all lines and openings.
8. Disconnect the swivel wiring harness connectors from the carrier 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 6-20.

NOTE: The hydraulic swivel weighs approximately 163.2 kg (437 lb). The hydraulic, water, and electrical swivel combined weigh approximately 183 kg (490 lb).

It may be necessary to remove some drive line components to remove the swivel.

Boom needs to be in the air to remove swivel after it is loosened.

9. On the bottom of the swivel, bend the retainer tabs away from the bolt heads.
10. Place adequate supporting device beneath swivel.
11. Remove the capscrews, washers, and bushings securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

Table 6-1

Port #	Test Pressure bar (psi)	Function
1	50 (725)	Case Drain (Hydraulic Fluid)
2A	300 (4350)	Hydraulic Fluid Inlet
2B	300 (4350)	Hydraulic Fluid Inlet
3	300 (4350)	Swing (Hydraulic Fluid)
4A	50 (725)	Hydraulic Fluid Return
4B	50 (725)	Hydraulic Fluid Return
5	250 (3625)	Load Sense (Hydraulic Fluid)
6	250 (3625)	Air Condition (Hydraulic Fluid)
A	.5 (7.25)	Heater Supply (Water and Antifreeze)
B	.5 (7.25)	Heater Return (Water and Antifreeze)

Installation

NOTE: The hydraulic swivel weighs approximately 163 kg (437 lb). The hydraulic, water, and electrical swivel combined weigh approximately 183 kg (490 lb).

1. Lower the swivel into position.

   Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews, and washers. Torque the bolts, refer to Fasteners and Torque Values, page 1-13.

2. Position the retainer plate on the hydraulic swivel spool ensuring they engage the lugs on the carrier frame. Apply Loctite® 271 to the bolt threads. Torque the bolts, refer to Fasteners and Torque Values, page 1-13. Bend all the retainer tabs to make contact with the bolt heads. Snug the four retainer plate bolts against the lugs on the carrier frame and tighten the locking nuts.

3. If removed, install the electrical swivel. Refer to Electrical Swivel, page 6-20. 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.

4. Install the clamp, lockwasher, flat washer and hex head bolt to the bottom of the swivel retainer plate securing the wiring harness.

5. Connect the hydraulic lines and water lines to the spool of the hydraulic swivel as tagged during removal.

6. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.

7. Connect the water lines to the water swivel case as tagged during removal.

8. Remove the blocking material from the lift cylinder.

9. Activate all systems; cycle all functions and observe for proper operation and any leakage.

INTEGRAL W/HYDRAULIC WATER SWIVEL

Description

The integral w/hydraulic 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 - REMOVAL in this section.

2. Remove the electrical swivel. Refer to ELECTRICAL SWIVEL - REMOVAL in this section.

3. Tag and disconnect the lines from the case of the water swivel. Cap or plug all lines and openings.

4. Remove the four bolts and washers securing the water swivel and electrical swivel center post to the hydraulic swivel. Remove the water swivel case and center post.

Disassembly

NOTE: Any maintenance requiring disassembly of the water swivel should include replacement of all seals and rings.

1. Remove the case.
2. Place the spool on a clean work surface in a dust-free area and block the spool to prevent movement during disassembly.

CAUTION

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

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

3. Remove the seals and rings from the spool.

Cleaning and Inspection

WARNING

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid prolonged skin contact, inhalation of vapors, or smoking. Failure to comply can result in injury or death to personnel.

1. Clean the spool and case with a suitable solution and dry with compressed air. Plug all ports with plastic caps.
2. Check the spool and inside of the case for scratches, grooves, scoring, etc. If any grooves have developed with a depth of 0.127 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 installing the case is required. Do not force the spool into the case.

Installation

1. Install the water swivel on top of the hydraulic 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. Connect the lines to the swivel case as tagged during removal.
3. Install the electrical swivel. Refer to ELECTRICAL SWIVEL - INSTALLATION in this Section.
4. Perform steps 8 and 9 of HYDRAULIC SWIVEL - INSTALLATION in this Section.
5. Activate all systems, cycle all functions, and observe for proper operation and any leakage.

ELECTRICAL SWIVEL

Description

The swivel assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes, leads, and clips which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the swivel. The collector ring leads are formed into 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 encoder. The encoder 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 conducts electricity between the carrier and superstructure.

Maintenance

Removal

1. Perform steps 1 through 4 of HYDRAULIC SWIVEL - REMOVAL in this section.

DANGER

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 Electric System, page 3-1.
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.
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. Secure the wires from step 4 together so the harness can be withdrawn through the center of the hydraulic swivel.
8. Tag and disconnect the connectors from the receptacles on the cab bulkhead mounting plate. Disconnect the yellow ground wire from the weld stud on the superstructure frame.
9. Remove the nuts and washers, and remove the cover from the electrical swivel.
10. Loosen the setscrews securing the electrical swivel mounting tube to the center post on the water swivel.
11. 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.

12. 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 6-7).

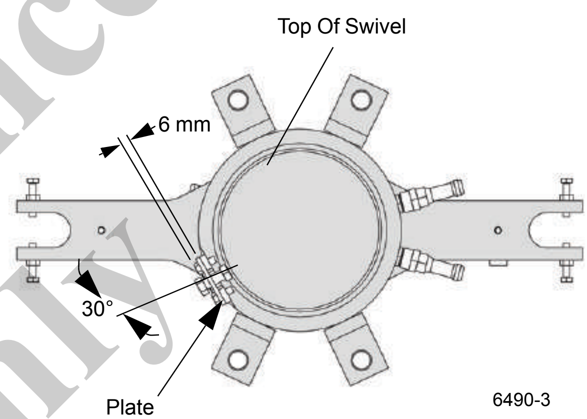


FIGURE 6-7

4. Apply Loctite® to the set screws securing the electrical swivel to the center post and tighten them 5 to 6 Nm (45 to 55 lb-in).
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 inside the superstructure cab. Secure ground wire with washer, lockwasher and nut
7. Unbundle the wires of the collector core wiring harness.
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 encoder 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 encoder in accordance with Slew Angle Zero Adjustment Procedure, page 6-22 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 Angle Zero Adjustment Procedure

1. Rotate the superstructure over the front and engage the lock pin.

NOTE: Refer to the Hirschmann Rated Capacity Limiter Operator's Handbook for detailed instructions. Complete the RCL console setup according to the crane's current operating configuration.

2. Select the Info icon.
3. Enter authorization code 64356, then select return.
4. Select return until the slew adjustment screen is displayed.
5. Select the Auto 0 (zero) icon. Note the indicator line moves to zero on the bar graph on the slew adjustment screen.
6. Press the ESC keypad button on the RCL console.

Slew Angle Verification

1. Rotate the superstructure over the front and engage the house lock pin.
2. Set the RCL console to read slewing angle as follows:

NOTE: Refer to the Hirschmann Rated Capacity Limiter Operator's Handbook for detailed instructions.

- Complete the RCL console setup according to the crane's current operating configuration.
- Select the Info icon.

3. Verify the angle indicated on the console does not exceed ± 1.0 degree.

SWING LOCK PIN

Description

The purpose of the swing lock pin is to lock the superstructure in position directly over the front for pick and carry loads. The pin swing lock installation consists of a large pin, a control handle in the right side of the cab, and control linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front 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 socket on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage is adjusted properly. If it is, the pin bottom will stick out about 5.89 cm (2.32 in) from the bottom of its bushing in the turntable. (If it is too far in, it might not lock properly. If it is too far out, it might hang up). Using the jam nuts on the linkage parts, adjust the linkage so the pin bottom will stick out about 5.89 cm (2.32 in) from the bottom of its bushing in the turntable; verify the superstructure can lock properly and the superstructure can rotate without lock pin hang up.

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 foot pedal is on the left side of the cab. Pushing the swing lock pedal down engages the lock between the teeth of the swing gear. Pulling the swing lock lever up disengages the lock.

Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify swing lock assembly is undamaged and working properly. Verify spring is undamaged and has enough strength to pull blade of swing lock assembly completely out of the gear teeth when the foot pedal is up. Verify the linkage can put the blade of the swing lock assembly as far as possible between the gear teeth when the foot pedal is down. Verify all attaching hardware is secure and undamaged. Make adjustments as needed. When the foot pedal is fully up, the top diagonal surface of the blade of the swing lock assembly (the beveled surface from the blade's top horizontal surface to its "ax blade" vertical surface should be 1.45 cm (0.57 in) from the tips of the gear teeth.

If the swing lock assembly is damaged, install a replacement. Align the blade of the swing lock assembly so it will fall between gear teeth. Use the shim and the related attaching hardware (two 5/16-18 screws and 5/16 inside diameter lockwashers) to ensure the swing lock assembly cannot move side to side, and can lock up the superstructure. Torque the four 3/4-10 mounting bolts to their specified torque found in Fasteners and Torque Values, page 1-13.

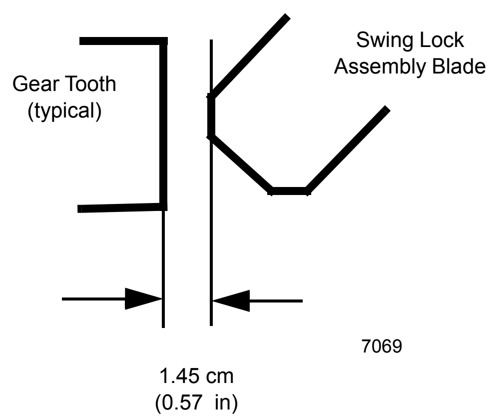


FIGURE 6-8

6

SECTION 7
POWER TRAIN

TABLE OF CONTENTS

DESCRIPTION

The carrier engine (Figure 7-1) is a Cummins ISX12 2013 or a QSM11 2010.

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 by the engine ECM and heavily based upon an accelerator pedal position message which is sent from the crane's master control module to the engine ECM by a J1939 CAN message. The percent pedal request is based upon actual throttle pedal position.

There are three methods of requesting engine speed, the carrier cab foot throttle pedal, the superstructure cab foot throttle pedal and the superstructure cab increment/ decrement switch.

The carrier cab foot throttle pedal is active while in driving mode (the carrier cab key switch is in the ignition “RUN” position). While in driving mode the superstructure cab foot throttle pedal and the increment/decrement switch are ignored.

The superstructure cab foot throttle pedal and the increment/decrement switch are active while in craning mode (the superstructure key switch is in the ignition "RUN" position). While in craning mode, the percent throttle will reflect which ever superstructure cab device is requesting the most RPM and the carrier cab foot pedal position is ignored.

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 exhaust system is located on the left side behind the cab. It is mounted to the decking and boom rest support.

To aid in starting the engine in cold weather, an automatic cold weather starting aid injection system is provided. When engine senses that the temperature is below 4°C (40°F), 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 an engine temperature switch, solenoid valve, starting aid container, and the necessary connecting tubing. 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 (Refer to *Electric System*, page 3-1).
3. Open the left and right hood access doors.
4. Disconnect and remove the air filter tubing from the engine and air cleaner.
5. Drain the engine lubricating systems.
6. Drain the transmission systems.
7. Drain the engine coolant system.
8. 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.
9. Disconnect the exhaust tubing at the engine and aftertreatment assembly (DPF). Remove the tubing clamp and exhaust bracket from the rear of the engine and remove the tubing from the engine.
10. Unplug aftertreatment assembly wiring harness from carrier harness and aftertreatment assembly. Unstrap this harness from boom rest tie bars.
11. Remove support brace between aftertreatment stack and boom rest weldment.
12. Remove the engine hood assembly, counterweight stowage frame work and decking over transmission.
13. Tag and disconnect hoses from the No. 1 pump and cap or plug all openings.
14. Unbolt the pump propeller shaft from the engine and pump coupler. Disconnect clutch air line and electrical harness (ISX engine only). Remove the No. 1 pump. Pump and clutch weighs approximately 213 kg (470 lb) (ISX engine). QSX pump installation weighs approximately 168 kg (370 lb).
15. Attach adequate lifting device to the engine and transmission sufficient to lift and support both the engine and transmission.

NOTE: Boom rest weighs approximately 68 kg (150 lb). Ensure lifting device is sufficient to lift the boom rest.

16. Attach an adequate lifting device and remove the boom rest.
17. Tag and disconnect the engine electrical connections from the starter and the alternator, the starting aid valve connector, and the battery cables.
18. Tag and disconnect the transmission oil lines to the transmission filter and the transmission oil cooler.
19. Disconnect and remove the drive line from the transmission. Refer to DRIVE TRAIN in this section.

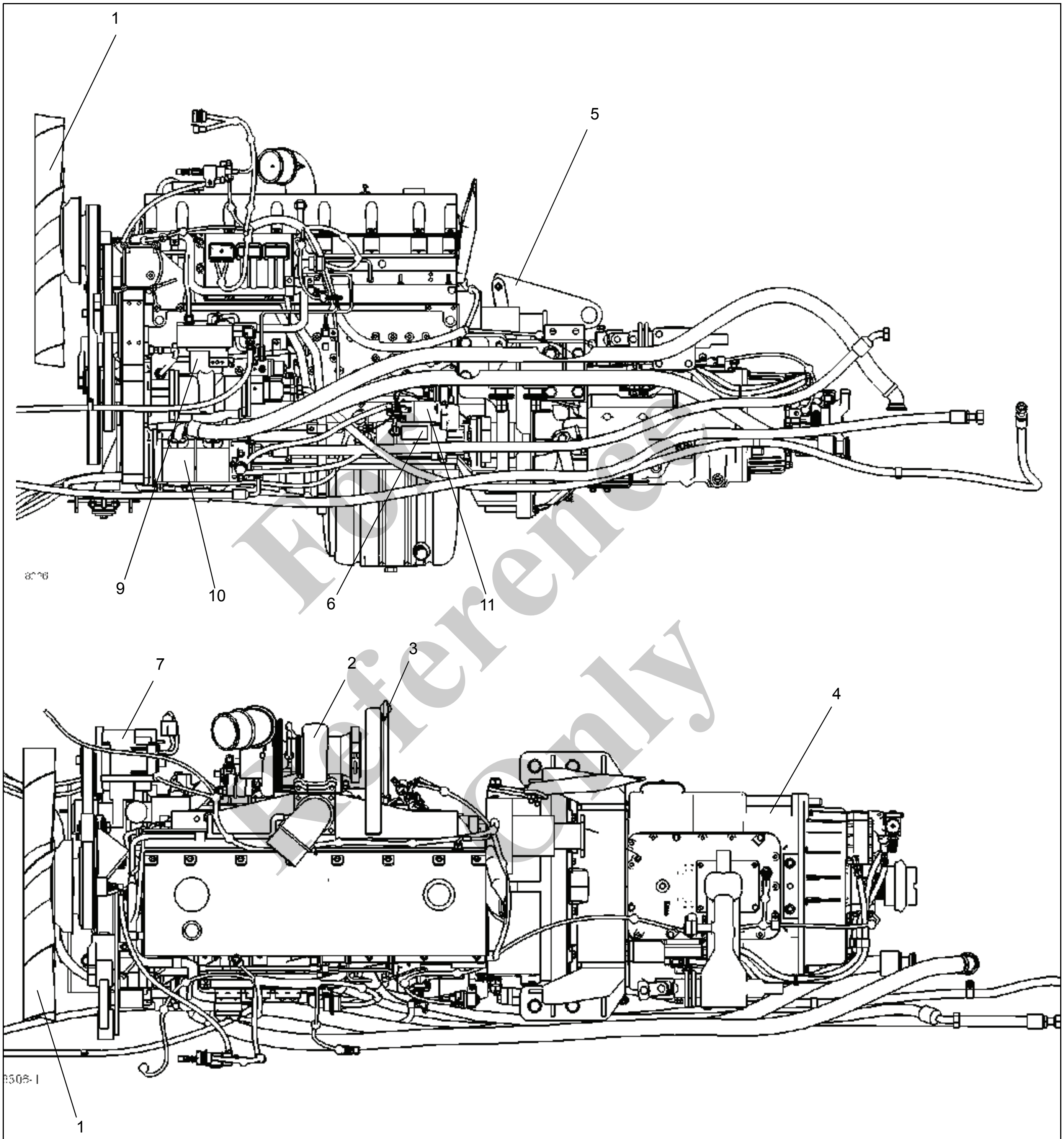
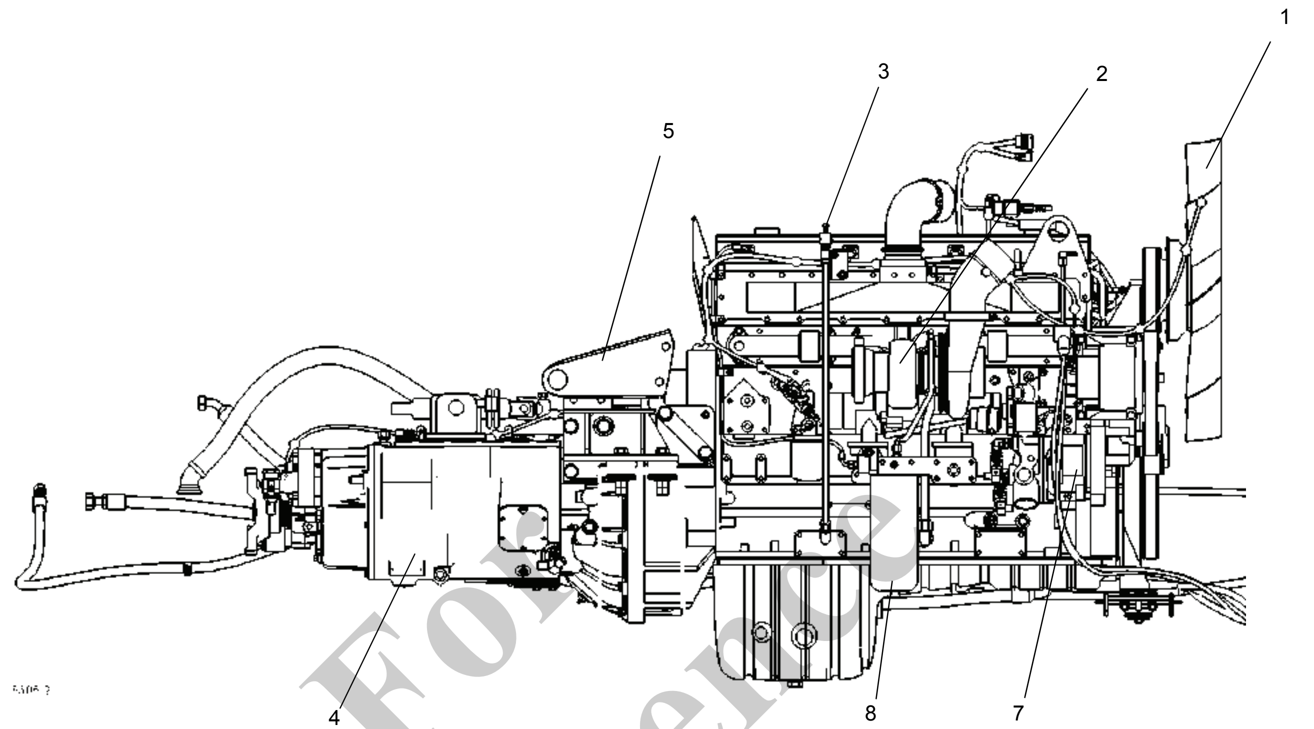


FIGURE 7-1

QSM Engine



QSM Engine

FIGURE 7-1 continued

Item	Description
1	Fan
2	Turbocharger
3	Engine Oil DIpstick
4	Transmission
5	Rear Engine Lift Bracket

Item	Description
6	Starter
7	Alternator
8	Oil Filter
9	Air Compressor
10	Piston Pump
11	IMS (Internal Magnetic Solenoid)

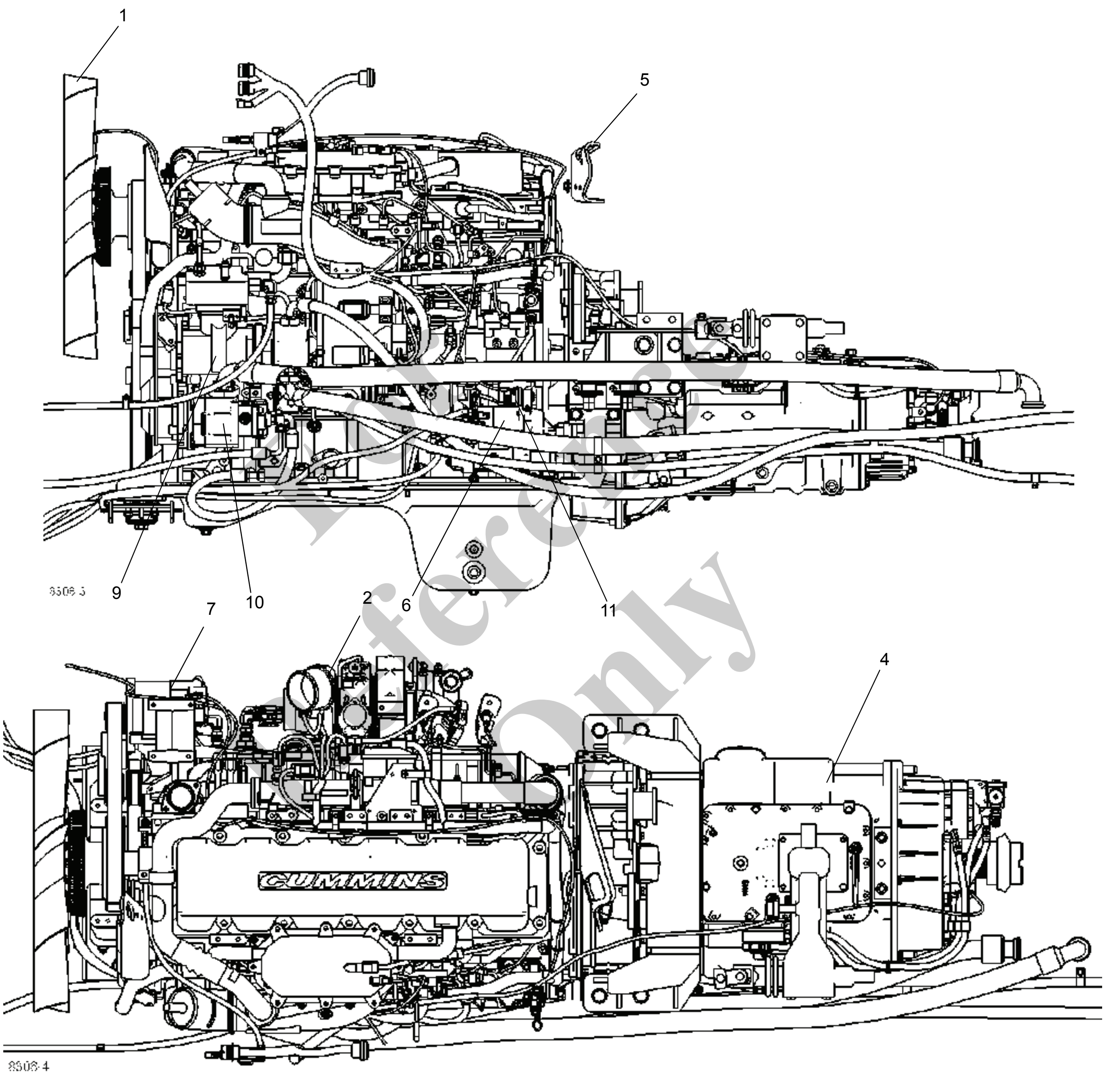
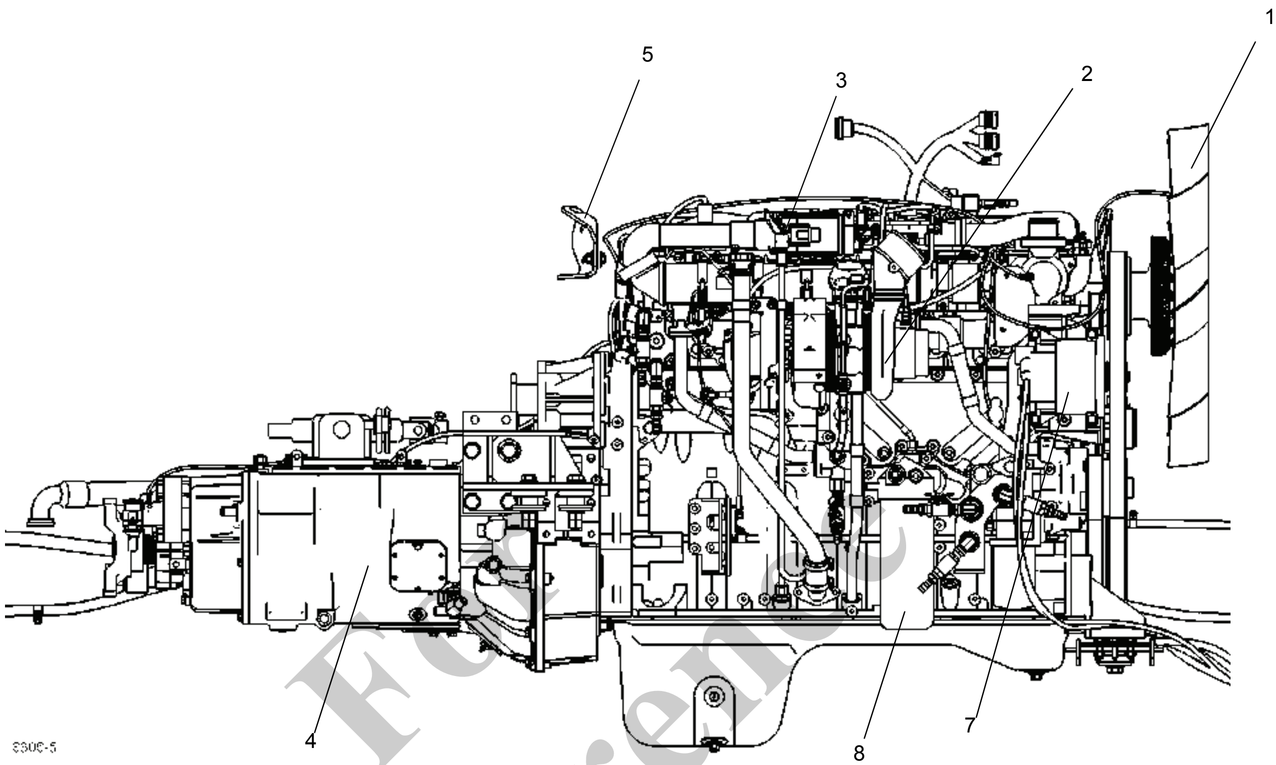


FIGURE 7-2

ISX Engine



ISX Engine

FIGURE 7-2 continued

Item	Description
1	Fan
2	Turbocharger
3	Engine Oil DIpstick
4	Transmission
5	Rear Engine Lift Bracket

Item	Description
6	Starter
7	Alternator
8	Oil Filter
9	Air Compressor
10	Piston Pump
11	IMS (Internal Magnetic Solenoid)

20. Tag and disconnect all lines to the radiator and air cooler. Remove the radiator assembly and fan. Cap or plug all openings.
21. Tag and disconnect the heater hoses.
22. Tag and disconnect the fuel lines to the engine. Cap or plug all openings.
23. Tag and disconnect all air lines to the engine components and the transmission. Cap or plug all openings.
24. Tag and disconnect the hydraulic lines to the No. 2 and 3 Pump (ISX) (or the two-section pump, QSM). Cap or plug all lines and openings.
25. Tag and disconnect all cables to the engine, engine components, and transmission.
26. Attach an adequate lifting device to the engine and transmission sufficient to lift and support both the engine and transmission. 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 and transmission weigh approximately 1800 kg (3968 lb).

27. With the lifting device supporting the weight of the engine and transmission, remove the bolts, washers, lockwashers and nuts from the front engine mounting support and the transmission mounting brackets.
28. Carefully lift the engine assembly from the crane and move it to a clean work area.
29. If a new engine is to be installed, remove the transmission, pumps, and all engine installed components, fittings, etc. from the old engine and install them on the new engine in the same locations. Refer to *Removal of the Transmission*, page 7-48 in this section for transmission removal and installation. Use the same grade hardware, torque values, and thread sealing compound as the engine factory's workers 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) 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 refer to *Fasteners and Torque Values*, page 1-13.
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. 2 (the pump on the engine) as tagged during removal.
6. Connect all air lines to the engine components and transmission as tagged during removal. Also connect the charge air cooler lines as tagged during removal.
7. Connect the fuel lines to the engine as tagged during removal.
8. Connect the heater hoses as tagged during removal.
9. Install the radiator assembly and fan. Connect all lines to the radiator and air cooler as tagged during removal.
10. Connect the drive line to the transmission. Refer to *Drive Train*, page 7-33.
11. Connect the filter and oil cooler oil lines to the transmission as tagged during removal.
12. As needed, install ether cylinder if removed earlier.
13. Connect the battery cables, starting aid valve connector, and engine electrical connections as marked during removal.
14. Attach lifting device to and install the boom rest and aftertreatment assembly.
15. Connect propeller shaft to No. 1 pump coupler with bolts and washers. Torque the bolts refer to *Fasteners and Torque Values*, page 1-13.
16. Install the engine hood assembly, counterweight stowage frame work, and the removed decking. If the No. 1 pump was removed, reinstall it.
17. Connect hydraulic lines to Pump No. 1 as tagged during removal.
18. Plug aftertreatment wiring harness to carrier harness and aftertreatment assembly and install straps to the boom rest tie bars.
19. Remove the rear engine lifting bracket from the engine and bolt it on the frame. Install the exhaust tubing clamp mounting bracket where the lifting bracket was removed. Install the exhaust tubing and connect it to the engine.
20. Connect the starting aid tubing to the nozzle in the intake manifold. Verify the nozzle orifice points upstream.
21. Connect the air cleaner tubing at the engine and air cleaner.
22. Service the engine lubricating system, hydraulic reservoir, and the engine cooling system.
23. Fill the transmission with SAE GRADE 50 synthetic gear lubricant (Spec. 6829013433).

24. Connect the battery.
25. Position the start relay and the max speed relay on the inside of the hood. Secure them with the bolts, washers, lockwashers, and nuts.
26. Prime the fuel system and hydraulic pumps and start the engine. Check all hoses for leaks. Shut down the engine and check all fluid levels. 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.

Engine Drive Belts

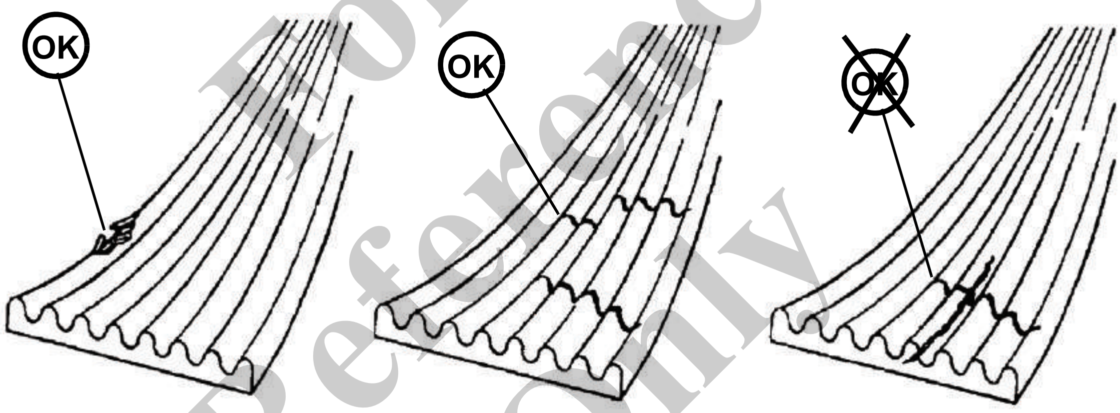
The proper operation of engine belt-driven components such as the alternator, fan clutch, and water pump depend on the proper condition and tension of the engine drive belts.

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.



Missing Material

Traverse Cracks

Longitudinal Cracks Intersecting
with Transverse Cracks must be Replaced

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.

Functional Operation

Three 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/start position, engine cranking.
3. Ignition switch in the on position, engine running.

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 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 runs the fuel lift pump so the engine is ready to be started.

Additionally, when the key switch is turned on, 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 will re-illuminate, determined by the type of fault being sensed.

The electronic subsystem will also engage the starter lockout relay to enable cranking. 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 a combination of the three indicator lamps (engine warning, engine stop, and malfunction indicator lamp (MIL)) to illuminate and remain lit. Which lamp is illuminated depends on the severity of the fault.

Normal operation occurs when the engine is running.

At this point the starter lockout relay will be disengaged.

Engine Control System Switches and Indicator Lights

Engine Idle/Increment-Decrement Switch

The Engine Diagnostic/Idle Switch, located on the left side of the carrier cab console, is a two position maintained on/off rocker switch used to access the engine fault codes or enable the control of the engine idle speed. Default idle speed will resume after each engine shutdown (70 seconds) and restart.

Diagnostic function - With the Ignition Switch in the RUN position and the engine off, press the top of the Engine Diagnostic/Speed Control Switch to view the engine fault codes. Fault codes will be flashed out using the Engine Stop Indicator Lamp and the Engine Warning Indicator Lamp. If there is more than one active engine fault code, use the Increment/Decrement Switch to toggle forward and backward through the fault codes. If there are no engine fault codes, both Engine Stop and Engine warning Lamps will be on solid.

Engine Idle Function - With the engine running and the bottom of the Engine Diagnostic/Idle Switch activated, the engine idle may be slightly increased or decreased by using the Increment/Decrement Switch.

Increment/Decrement Switch (Superstructure Cab)

The Increment/Decrement Switch is a three position momentary rocker switch with center maintained position being off. There is one located in the carrier cab and one in the superstructure cab.

In the carrier cab, use this switch in conjunction with the Engine Diagnostic/Idle switch as describe directly above.

In the superstructure cab, this switch is used to adjust engine RPM. Quickly press the top of the switch (+) once to go to full engine RPM; quickly press the bottom of the switch (-) once to return to low engine idle. If the engine speed is below the maximum RPM setting, pressing and holding the top of the switch (+) will cause the engine RPM to slowly increase; release the switch when the desired RPM is attained. If the engine speed is above the minimum RPM setting, pressing and holding the bottom of the switch (-) will cause the engine RPM to slowly decrease; release the switch when the desired RPM is attained.

Note: The engine RPM will be based on which ever device, the foot pedal throttle or the increment/decrement switch, is requesting the greater RPM.

Engine Regeneration Start Switch

This switch, located on the left side of the front console in the carrier cab, enables the operator to initiate a stationary exhaust regeneration is required and when engine RPM is greater than zero. The switch must be cycled on and off to initiate regeneration. The throttle, clutch and brake pedals must also be released. The engine will automatically change speed as needed. The cycle will take approximately 20 minutes.

Engine Stop Light

The engine stop light is located at the top left side 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.

Engine Warning Light

The engine warning light is located at the top left side 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.

Engine Regeneration Inhibit Switch

This switch located in the right side overhead control panel is used to stop an engine regeneration.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, fuel filter-water separator, low pressure fuel pump, secondary fuel filter, high pressure fuel filter, fuel injectors and fuel cooler (Figure 7-5).

Fuel Tank

The fuel tank is an aluminum round tank located on the left side of the crane. The tank has a capacity of 367 liters (97 gal). Two connections on the top of 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 two fuel quantity sender units. One sender provides a signal to the vehicle control module which then controls the quantity indicator. The other sender provides a signal directly to the engine ECM.

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 circulated 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 (see Figure 7-3) removes impurities from the fuel and also removes water from the fuel before it reaches the engine. It is mounted above the left front outrigger box.

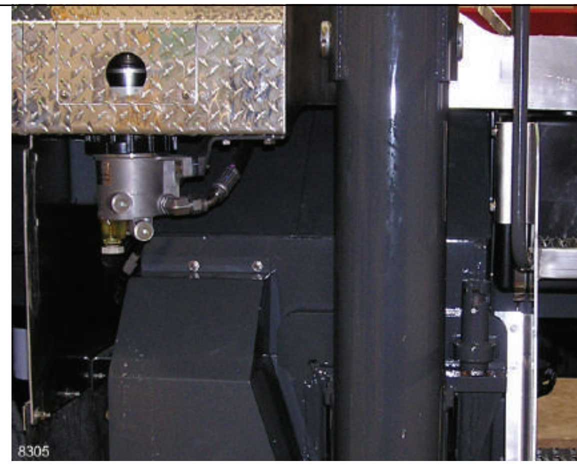


FIGURE 7-4

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.

As the filter becomes clogged the level of fuel will increase. When the filter looks full of fuel the filter should be changed.

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 leads from the fuel level sender units.
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 senders, 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 leads to the fuel quantity sender units.

3. Connect the two lines to the fittings on the tank in accordance with the identification marks made during removal.
4. Service the tank.

Fuel Filter-Water Separator

Draining

The sump of the fuel filter-water separator should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure.

1. Place a suitable container under the filter and open the drain plug.
2. Drain until fuel appears.
3. Close the drain plug.

Filter Change Procedure

1. Turn off the engine. Loosen the vent cap to break the air lock in the filter.
2. Open the drain valve and drain the fuel level below the collar, then close the drain valve.
3. Using the collar/vent cap wrench (Grove part number 90023151), remove the clear cover from the fuel processor by removing the collar. Discard the O-ring from the base of the cover. (A new O-ring seal is supplied with the new filter.) Remove the filter element from the filter body by pulling upward and twisting slightly. Be sure the sealing grommet is removed from the center stud.
4. Install the new filter element (supplied with a sealing grommet already inserted into the element) on the processor center stud by pushing down and twisting slightly. After checking to make sure the new O-ring seal (supplied with the filter) at the base of the cover is in place, install the cover and collar. Hand tighten the collar until seated. Do not use tools to tighten.
5. Remove the vent cap from the top of the clear cover by turning the vent cap counterclockwise. Fill the clear cover with enough clean fuel to cover the bottom half of the filter element. Make sure the new O-ring (supplied with the filter) is installed on the vent cap. Reinstall the vent cap and tighten by hand only.
6. Start the engine. When the lubrication system reaches its normal operating pressure, increase engine RPM for one minute.

NOTE: The clear filter cover will not fill completely during engine operation. It will gradually fill over time as the filter becomes clogged. The filter element does not need to be changed until the fuel level has risen to the top of the filter element.

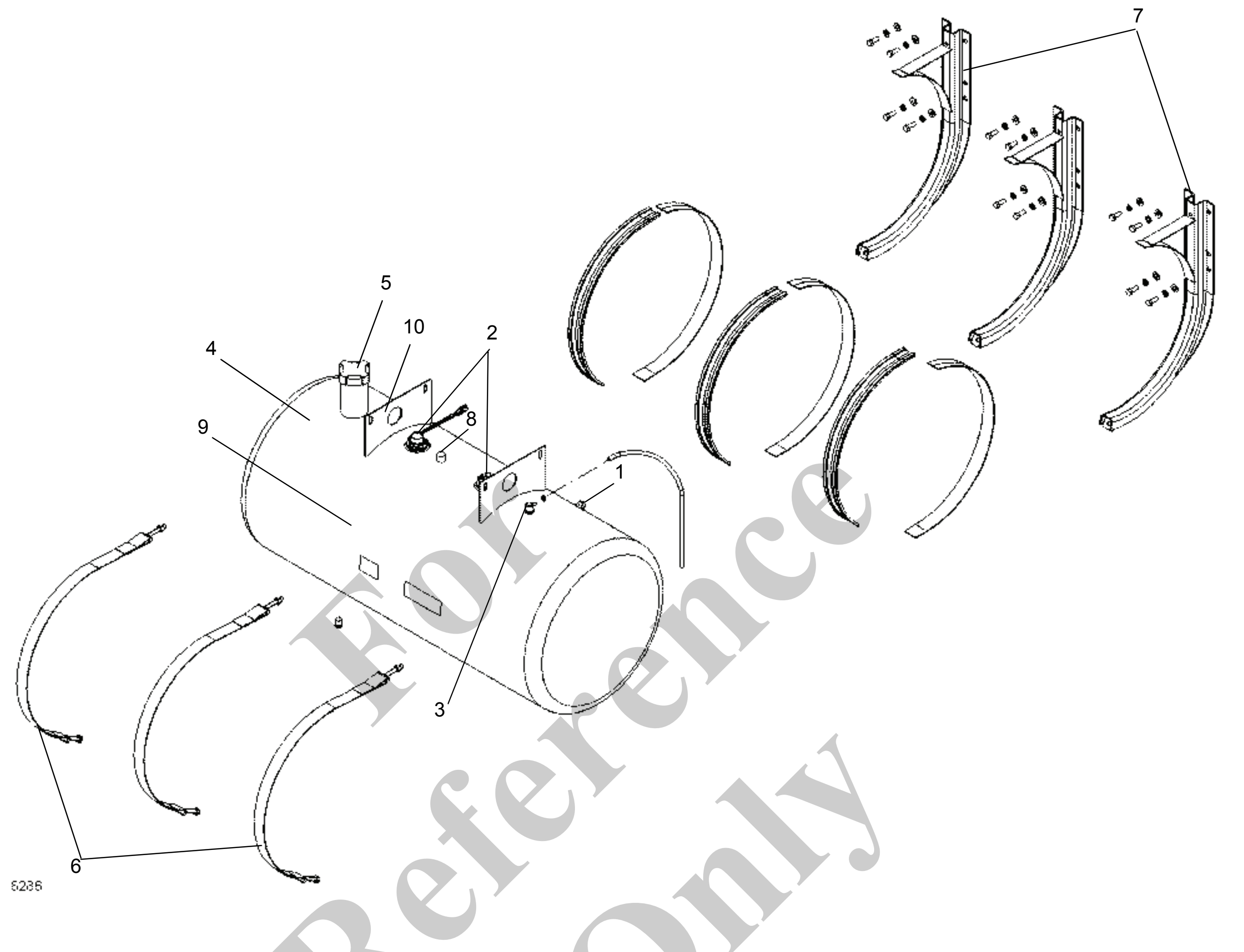


FIGURE 7-5

Item	Description
1	Fuel Return From Fuel Cooler
2	Fuel Level Sending Units
3	Tank Vent
4	Fuel Tank

Item	Description
5	Filler Cap
6	Mounting Straps
7	Fuel Tank Brackets
8	Fuel Supply To Engine
9	Fuel Return (ISX-Back Side)
10	Fuel Return (QSM)

AIR INTAKE SYSTEM

Description

The engine air intake system (see 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.

A gauge connected to the air cleaner housing will indicate when the filter needs to be cleaned. Reset the gauge each time the air cleaner is serviced. If the gauge's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring.

To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Ensure the air cleaner inlet is not plugged.
2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.
3. Ensure the correct size connections are used between the air cleaner and the engine.
4. Ensure all inlet accessories are the correct size and are not plugged by any foreign object.

Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

1. Unlatch the latches, open the air cleaner body, and withdraw the element as follows (Figure 7-6):
   a. RELEASE THE SEAL GENTLY. The filter element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the filter end cap. 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.

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FIGURE 7-6

b. AVOID DISLODGING DUST FROM THE FILTER. Gently pull the filter off the outlet tube and out of the housing. Avoid knocking the filter against the housing (Figure 7-7).

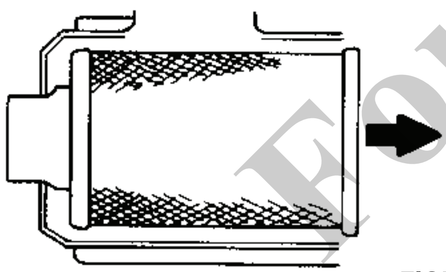

FIGURE 7-7

2. Clean the element as outlined in ELEMENT CLEANING. Replace the element after six cleanings or annually, whichever comes first.

3. Inspect all parts of the intake system and air cleaner. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube.

4. Install the cleaned or new element into the air cleaner body as follows:

- **a.** INSPECT THE FILTER FOR DAMAGE. Always look for filter damage, even if a new filter element is being installed. Pay special attention to the inside of the open end (sealing area). Do not install a damaged filter.
- **b.** INSERT THE FILTER PROPERLY. The seal area is on the inside of the open end of the primary filter. A new filter has a dry lubricant to aid installation. The critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly. To complete a tight seal, apply pressure at the outer rim of the filter, not the flexible center. No cover pressure is required to hold the seal (Figure 7-8).

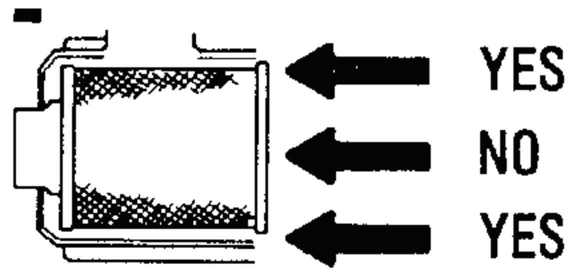

FIGURE 7-8

5. Install the cover on the air cleaner body with the two arrows pointing up. Secure the cover with the latches.

6. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.

Cleaning with Compressed Air

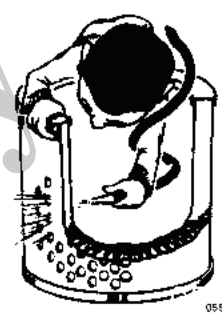

FIGURE 7-9

CAUTION

Pressure at the air nozzle must not exceed 6.9 bar (100 psi).

1. Direct a jet of clean, dry air from the inside of the filter element, perpendicular to the pleats (Figure 7-9).

2. Move the air jet up and down along the pleats, slowly rotating the element, until no more dust is being removed. Do not rupture the element with the nozzle or the air jet.

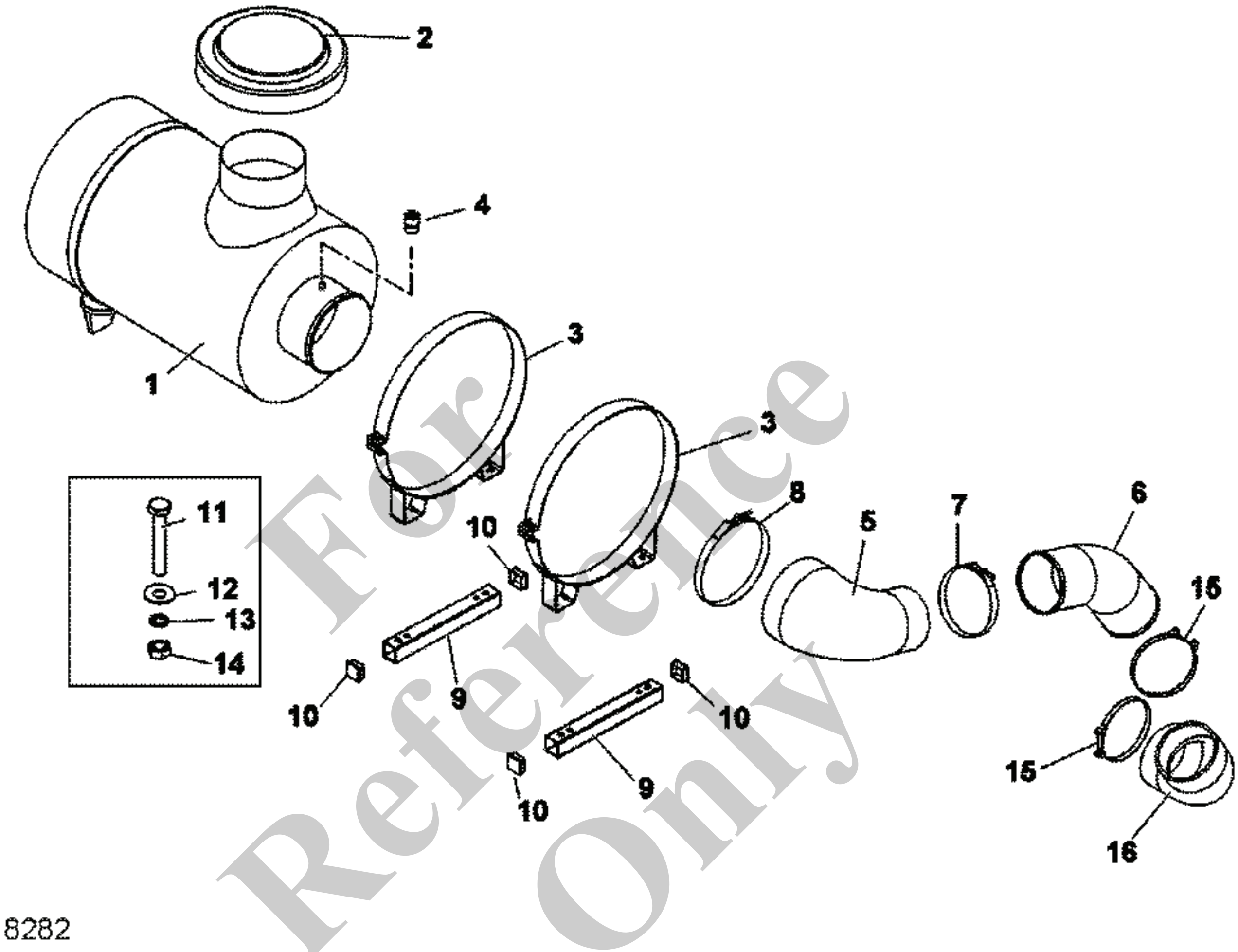

FIGURE 7-10

Item	Description
1	Air Cleaner (See Figure 7-11)
2	Air Inlet Hood
3	Mounting Band
4	Service Indicator
5	Reducing Elbow
6	Intake Tube
7	Clamp
8	T-bolt Clamp

Item	Description
9	Tube
10	End Cap Plug
11	Capscrew
12	Washer
13	Lock Washer
14	Hex Nut
15	Clamp
16	Adapter

CAUTION

Do not touch the inside of the filter with a bare light bulb.

After cleaning the filter element, inspect the element for damage. Look for dust on the clean air side, the slightest rupture, or damaged gaskets. A good method to use to detect ruptures in the element is to place a light inside the element and look toward the light from the outside. Any hole in the element will pass dust to the engine and cause unnecessary engine wear. Replace the element if holes are evident.

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.

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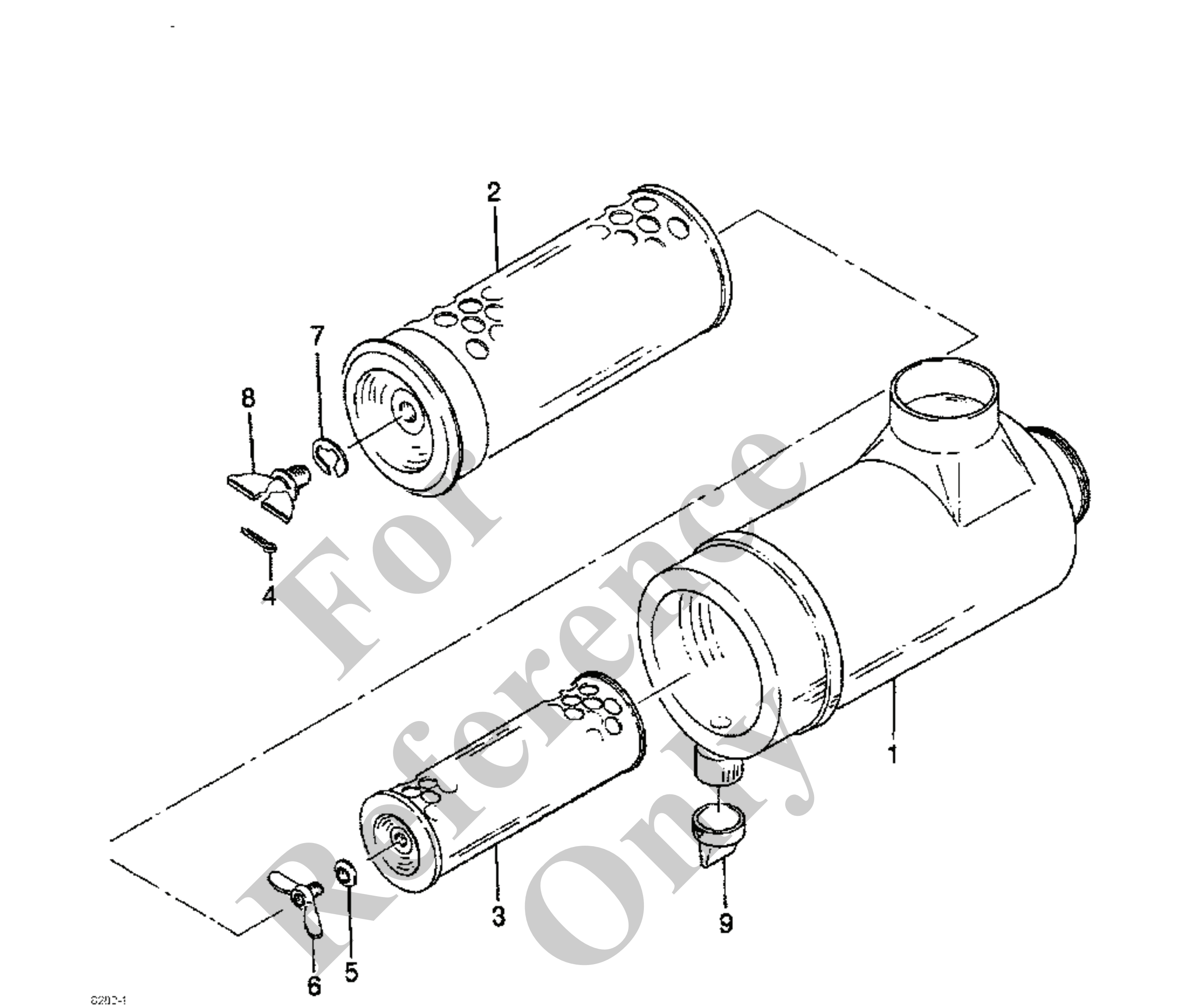

FIGURE 7-11

Item	Description
1	Body Assembly
2	Large Air Filter Element
3	Safety Air Filter Element
4	Cotter Pin
5	Air Cleaner Gasket

Item	Description
6	Wing Nut
7	Clip
8	Nut
9	Vacuator Valve

QSM ENGINE MUFFLER

Removal

CAUTION

Do not touch muffler or exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove capscrews, lockwashers, flat washers, and nuts to free muffler guard. Remove muffler guard.
2. Remove muffler cover and exhaust cover.
3. Remove muffler clamp. Remove exhaust connector assembly.
4. Remove muffler from mounting bands.
5. Remove capscrews, lock washers, flat washers, and nuts to free muffler mounting bands from muffler mount.

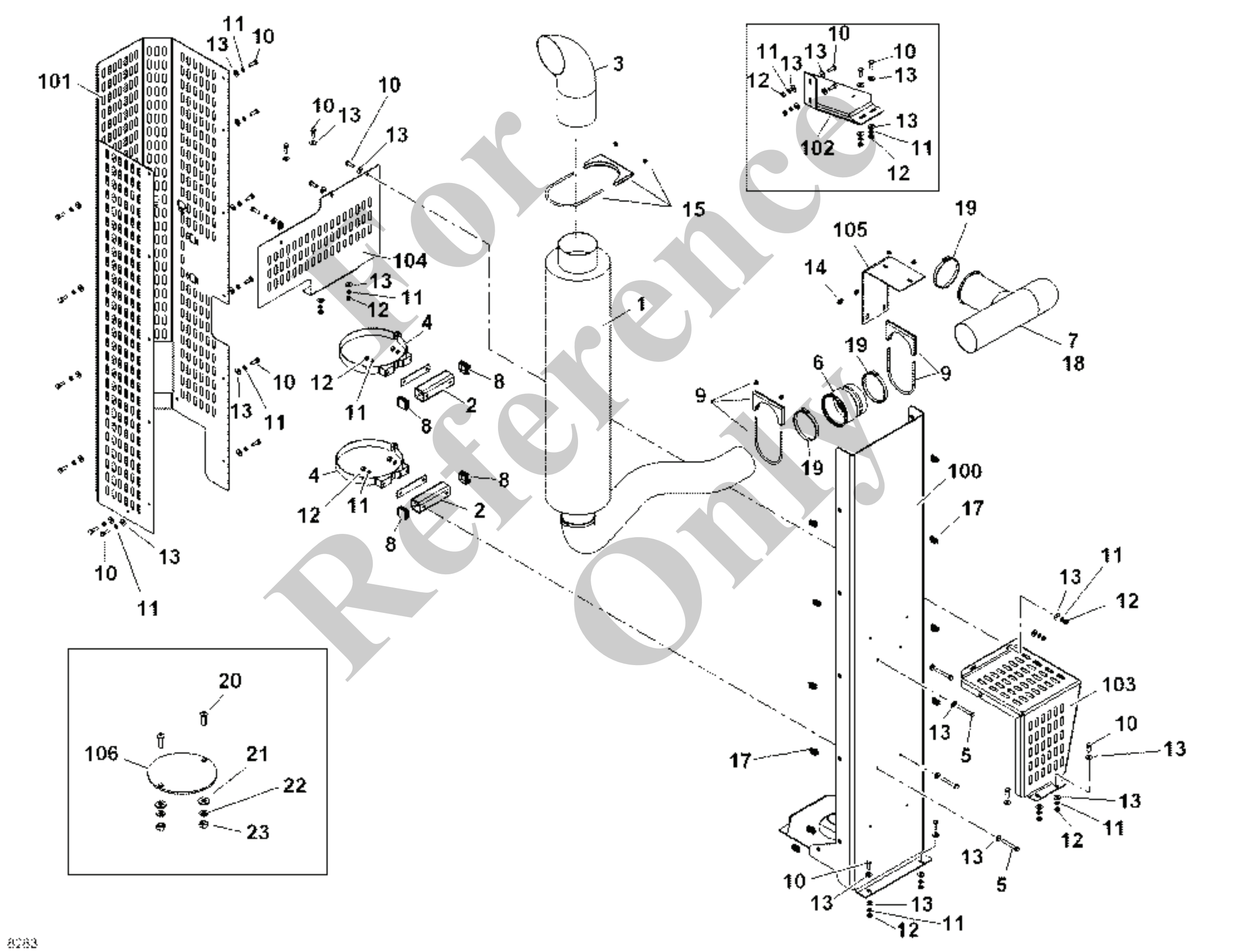

FIGURE 7-12

Item	Description
1	Muffler
2	Tube, Spacer
3	Exhaust Stack
4	Mounting Band
5	Capscrew
6	5” Slip Exhaust Connector Assembly

Item	Description
7	Engine Exhaust Tube
8	Square Cap
9	Muffler Clamp
10	Capscrew
11	Lock Washer
12	Hex Nut
13	Wide Flat Washer
14	Flat Washer
15	Muffler Clamp
16	Not Used
17	Retaining Nut
18	Exhaust Wrap
19	T-Bolt Clamp
20	Capscrew
21	Flat Washer
22	Lock Washer
23	Hex Nut
100	Muffler Mount
101	Muffler Guard
102	Muffler Support
103	Exhaust Cover
104	Muffler Cover
105	Bracket
106	Cover

Installation

1. Install muffler mounting bands on muffler mount
2. Install muffler to mounting bands.
3. Install exhaust connector assembly.
4. As needed, install a replacement exhaust wrap around the exhaust tube.
5. Install muffler cover to exhaust cover.
6. Install exhaust stack on muffler. Secure exhaust stack with clamp.
7. Install muffler guard to muffler mount.

ISX ENGINE DIESEL PARTICULATE FILTER/ SELECTIVE CATALYST REDUCTION ASSEMBLY

Removal

CAUTION

Do not touch muffler or exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove capscrews, lockwashers, flat washers, and nuts to all guards and covers.
2. Loosen the V-Band clamps to free the DPF from the exhaust tube and 90° elbow. Note the location of each clamp and gasket.
3. Remove hardware securing mounting bands to DPF and remove DPF assembly.
4. Loosen the V-Band clamp between the adapter tube and SCR. Note the location of each clamp and gasket.
5. Remove hardware securing mounting bands to the SCR and using an appropriate lifting device remove the SCR.

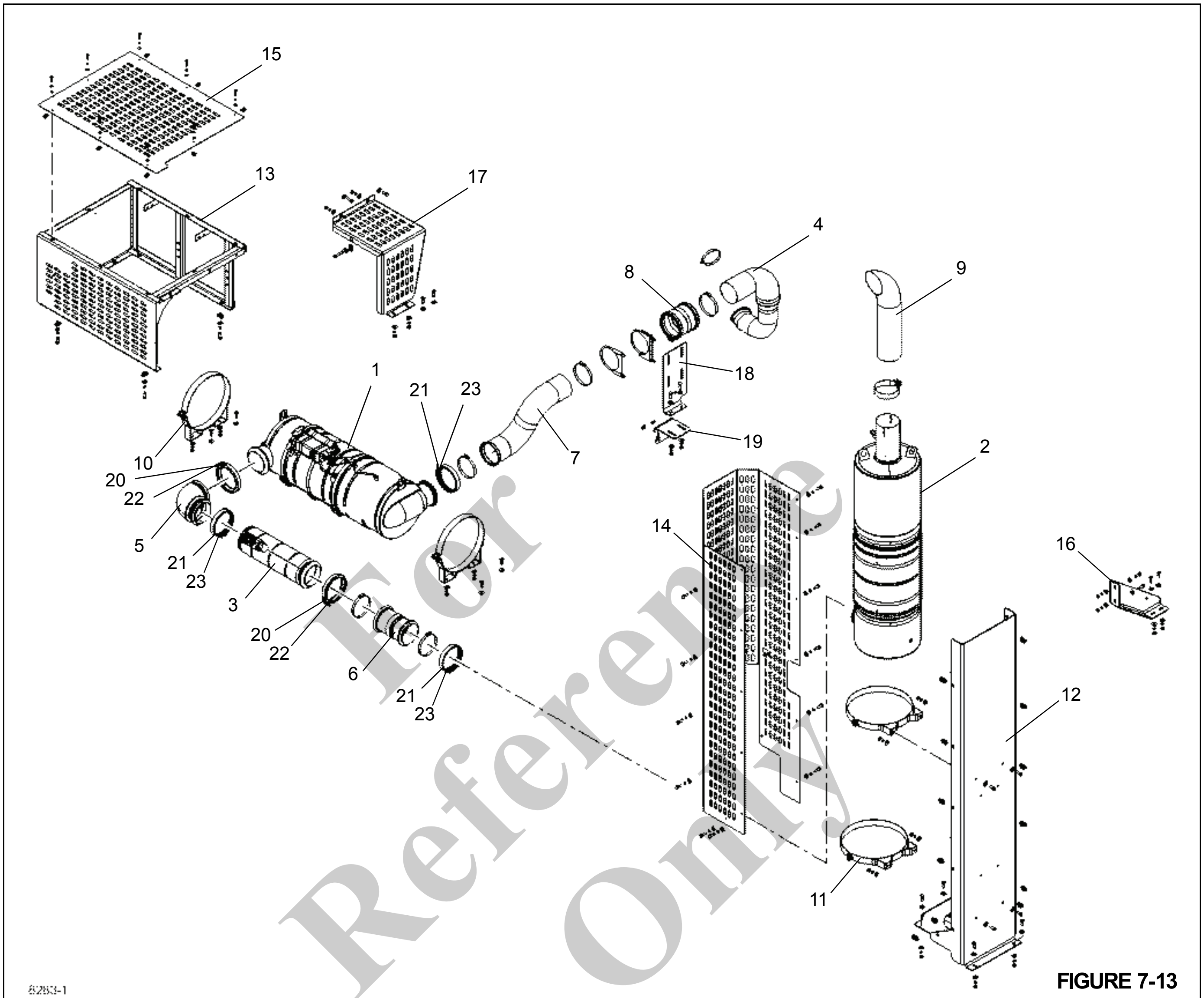

FIGURE 7-13

Item	Description
1	Diesel Particulate Filter (DPF) Assembly
2	Selective Catalytic Reduction (SCR) Assembly
3	Decomposition Pipe Assembly
4	Exhaust Tube
5	90° Elbow
6	Adapter Tube
7	Exhaust Tube
8	Flex Coupler
9	Exhaust Stack
10	Mounting Band
11	Mounting Band
12	Muffler Mount Weldment
13	Cover Weldment
14	Muffler Guard
15	Cover
16	Muffler Support
17	Exhaust Cover
18	Muffler Support
19	Bracket
20	Gasket, Spherical
21	Gasket, Flat
22	V-band Clamp, Spherical
23	V-band Clamp

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Installation

1. Install SCR to the muffler mount weldment with the mounting bands. Ensure there is a 3 mm (.13 in) gap between the SCR and the muffler mount weldment floor.
2. Connect the adapter tube to the SCR with a V-Band clamp and gasket.
3. Install the DPF and secure with the mounting bands.
4. Connect the elbow and decomposition tube to the DPF and adapter tube with the appropriate gaskets and V-Band clamps.
5. Connect the exhaust tube to the DPF with a V-Band clamp and gasket.
6. Install the covers and guards.

DIESEL EXHAUST FLUID (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.

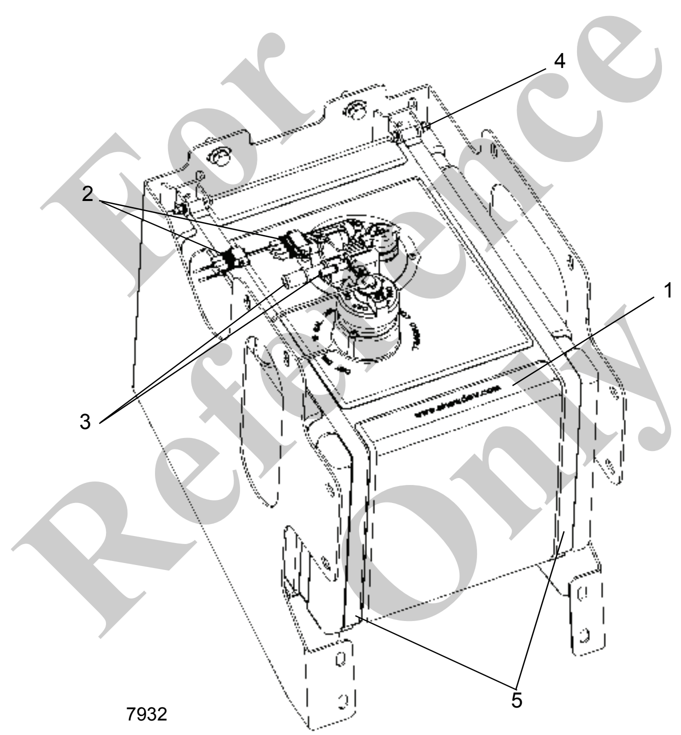
The DEF tank incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

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.



1. DEF Tank
2. Electrical Connectors
3. DEF Fluid Connectors
4. Tank Strap Mounting Hardware
5. Tank Straps

6786

DEF Tank

WATER COOLING SYSTEM

Description

The cooling system consists of the radiator, coolant recovery tank, engine cooling circuit, and the connecting hoses (Figure 7-14). Cooling system capacity is approximately 49.2 l (52 qt). The temperature is controlled by a 83°C (181°F) thermostat located between the top of the engine and the top of the radiator.

The water pump is located on the right side of the engine and is belt driven by the crankshaft pulley. Coolant enters the pump from the bottom inlet hose or bypass hose. Coolant flows from the water pump to the cylinder block, cylinder head, and into the thermostat housing. If the thermostat is closed the coolant enters the bypass hose and flows back to the water pump. If the thermostat is open, the bypass hose is blocked and most of the coolant flows back to the radiator.

At all times, the antifreeze/coolant should be properly inhibited against corrosion, It is recommended that 50/50 fully formulated antifreeze/coolant be used at all times.

The radiator assembly consists of the engine water cooler, and shroud.

A sight gauge is installed on the side of the surge tank to visually check coolant level. A coolant level sensor is also located in the surge tank. 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 electric operated shutoff valves to each heater. The hot water to the superstructure heater also passes through a strainer and a 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 cooling 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 engine 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:

- Low power.
- 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

An engine that is overcooled can lead to the following:

- Excessive fuel consumption.
- Sludge formation in crankcase.
- Corrosive acids formed in crankcase.
- Excessive fuel deposits in the exhaust system.

Antifreeze/Coolant

Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant at all times. Fully formulated coolants resist sentimentation and degradation, thus allowing longer replacement intervals. Refer to *Lubrication*, page 9-1. This antifreeze/coolant is intended to provide protection for a minimum of one (1) year in a properly maintained cooling system. It provides protection against freeze-up down to -36.6°C (-34°F) and boil-over up to 129.4°C (265°F) using a 15 psi pressure cap.

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 fully formulated 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

1. Fill the system with fully formulated antifreeze/coolant mixture. Fill to the bottom of the filler neck. Open petcock on top tube. Fill slowly. Flow exceeding 19 l/min (5 gpm) can give a false reading.
2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.
3. Run the engine through two (2) thermal cycles and recheck the antifreeze/coolant level. Refill as necessary repeating step 1.

Cooling/SCA Maintenance Summary

The cooling system level should be checked every 10 hours of operation or daily, whichever interval occurs first.

Supplemental Coolant Additives (SCA)

Supplemental coolant additives (SCA) are recommended for this cooling system. Antifreeze alone does not provide sufficient protection for heavy-duty diesel engines.

DCA4

DCA4 is the recommended SCA. Other brands can be used if they provide adequate engine protection and do not cause seals or gasket degradation or corrosion/fouling.

Coolant Filter

The Cummins engines have a coolant filter of the canister or spin-on type that requires periodic servicing. It is suggested that this be done when the coolant is changed.

Close the shut-off valves in the inlet and drain lines before disassembling the filter. Some engines may have a push-button valve on the rear of the water pump housing that must be closed (pushed in) when changing the water filter.

DCA4 Filter Change Interval

6 months or 500 hours

- Change coolant filter (replace with Coolant Filter DCA4 Corrosion Resistor Cartridge, GROVE Service Part Number 9414101675).
- Check SCA Levels (use only the DCA4 Coolant Test Kit, GROVE Service Part Number 9414101675, to check the coolant additive concentration in the cooling system).

If SCA levels are less than 1.2 Units/Gal, add Cummins DCA4 to maintain desired level.

NOTE: Inadequate concentration of the coolant additives can result in major corrosive damage to the cooling system components. Over-concentration can cause formation of a “gel” that can cause restriction, plugging of coolant passages, and overheating.

1 year or 1000 hours

- Change coolant filter (replace with Coolant Filter/DCA4 Corrosion Resistor Cartridge, GROVE Service Part Number 9414101675).
- Test coolant for contamination.

Condemning limits are:

- Sulfate level greater than or equal to 1500 ppm.
- Chloride level greater than or equal to 200 ppm.
- The pH level is less than 6.5.
- Oil or fuel contamination can be identified by odor or color.

If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Lubrication*, page 9-1.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Cleaning

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.

NOTE: Use a cleaning compound that is not corrosive to aluminum to prevent damage to the radiator.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.

3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 82°C (180°F) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 82°C (180°F) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, cautiously feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see Pressure Flushing) and repeat the cleaning operation.
8. If problem persists, replace radiator.

Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.
3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill the core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. 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. Flush the heaters following the same procedure as for the radiator core.
10. After completing the flushing operation, clean out the surge tank overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
11. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

Component Inspection

Radiator/Recovery Tank

1. Side Tanks - Look for leaks, particularly where the tank is soldered to the core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler Neck - The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Ensure the overflow tube is not plugged.
3. Radiator Cap - This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

When removing the pressure type cap, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 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 to the first detent to relieve pressure, then pause a moment to avoid possible burning by hot water or steam. Continue to turn the cap to the left until it can be removed.

4. Tubes are very small and can become easily clogged by rust and scale. The general condition of the cooling system and operating temperature are indications as to

whether or not tubes are clean. Another good test is to feel the core for cold spots.

5. Fins are thin metal sheets that dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw etc., so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged if the cooling system does not receive the proper maintenance.

1. Core Plugs - These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.
2. Drain Plugs - The water jacket of each engine has one or more drain plugs. These should receive seasonal care and be kept free of rust and scale.
3. Gaskets - Gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with 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 7-8.

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.

Radiator Assembly Removal and Installation

Refer to Figure 7-14 and Figure 7-15.

Removal

1. Set the outriggers and position the boom to over the side.
2. Open the drain cock at the bottom of the radiator and drain the coolant into a suitable container. Dispose of the coolant in accordance with local and EPA regulations.
3. Disconnect the battery (Refer to *Electric System*, page 3-1).
4. Open the left and right hood access doors.
5. Remove the hardware securing the top center hood panel to the front and rear cowls and remove the panel with doors from the crane.
6. Disconnect the surge tank hoses from the radiator.
7. Remove the hardware securing the radiator baffles to the front cowl and remove the baffles.
8. Remove the clamps securing the charge air cooler (CAC) tubes to the CAC and disconnect the CAC tubes from the CAC.
9. Disconnect the hoses from the top and bottom of the radiator assembly.
10. Remove the bolts, washers, and lock washers attaching the fan guards to the shroud. Remove the fan guards.

NOTE: The radiator assembly weighs approximately 93 kg (206 lb).

11. Attach an adequate lifting device to the radiator assembly.
12. Remove the two nuts, hardened washers and mounts securing the radiator assembly to the mounting brackets and remove the assembly from the carrier.

Installation

1. Position the radiator/CAC assembly in the carrier using a lifting device and secure to the mounting brackets using the two mounts, hardened washers, and nuts. As needed, use extra 1/2 inch inside diameter hard dock flat

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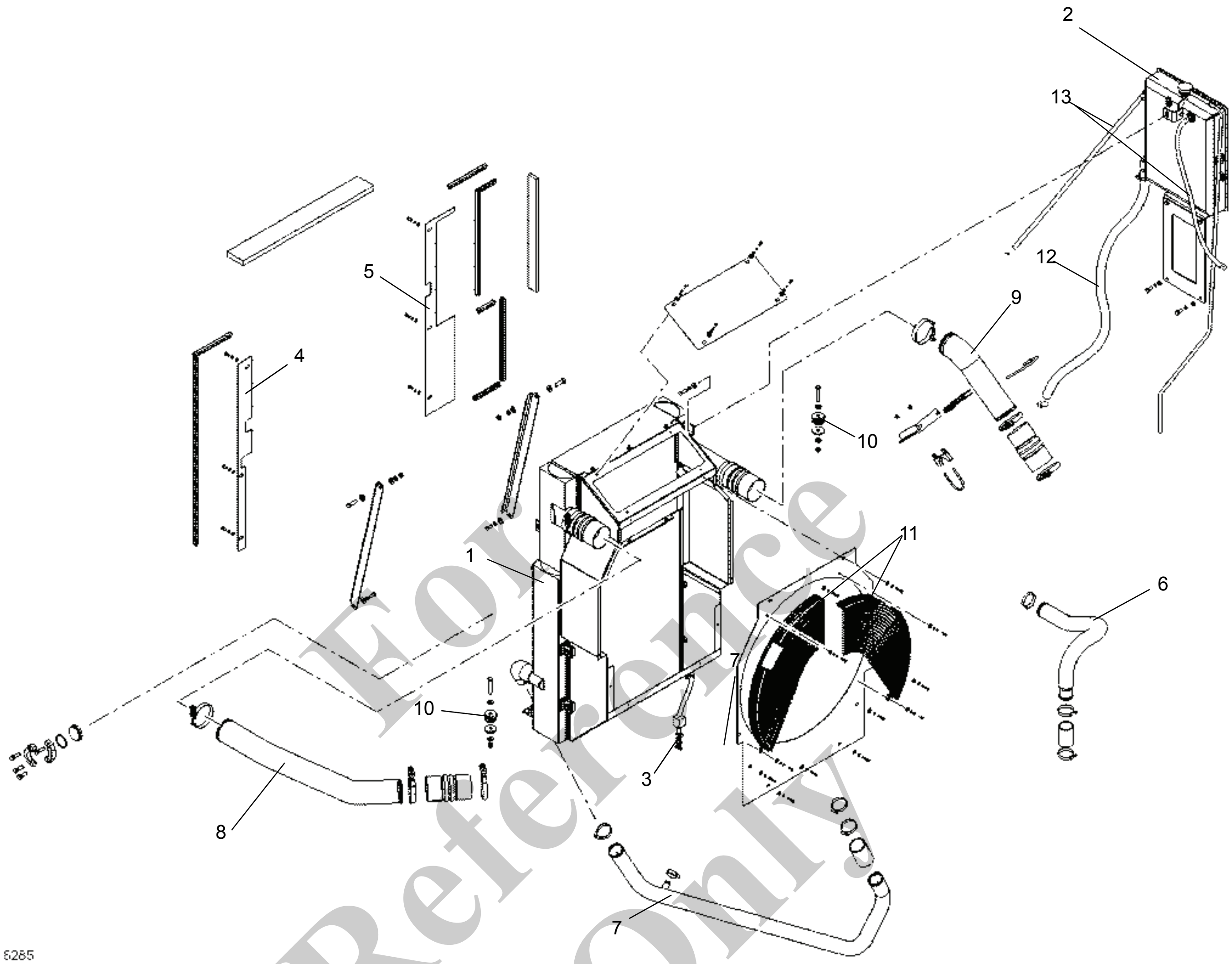
washers between the radiator and the mounts to adjust radiator height properly.

2. Position the fan guards on the shroud and secure with bolts, washers, and lock washers.
3. Attach the left and right side baffles to the front cowl with the attaching hardware.
4. Connect the hoses to the top and bottom of the radiator.
5. Ensure the drain cock is closed.
6. Connect the CAC tubes to the CAC.
7. Connect the coolant recovery hoses to the radiator.
8. Position the top center panel, with doors attached, on the front and rear cowl and secure with the attaching hardware.
9. Service the engine coolant system as necessary. Start the engine, operate all systems and check for leaks.
10. Position the front cowl on the frame and secure with the attaching hardware
11. Position the front grill panel on the front cowl and secure with the attaching hardware.

WINTER FRONT GRILL COVER

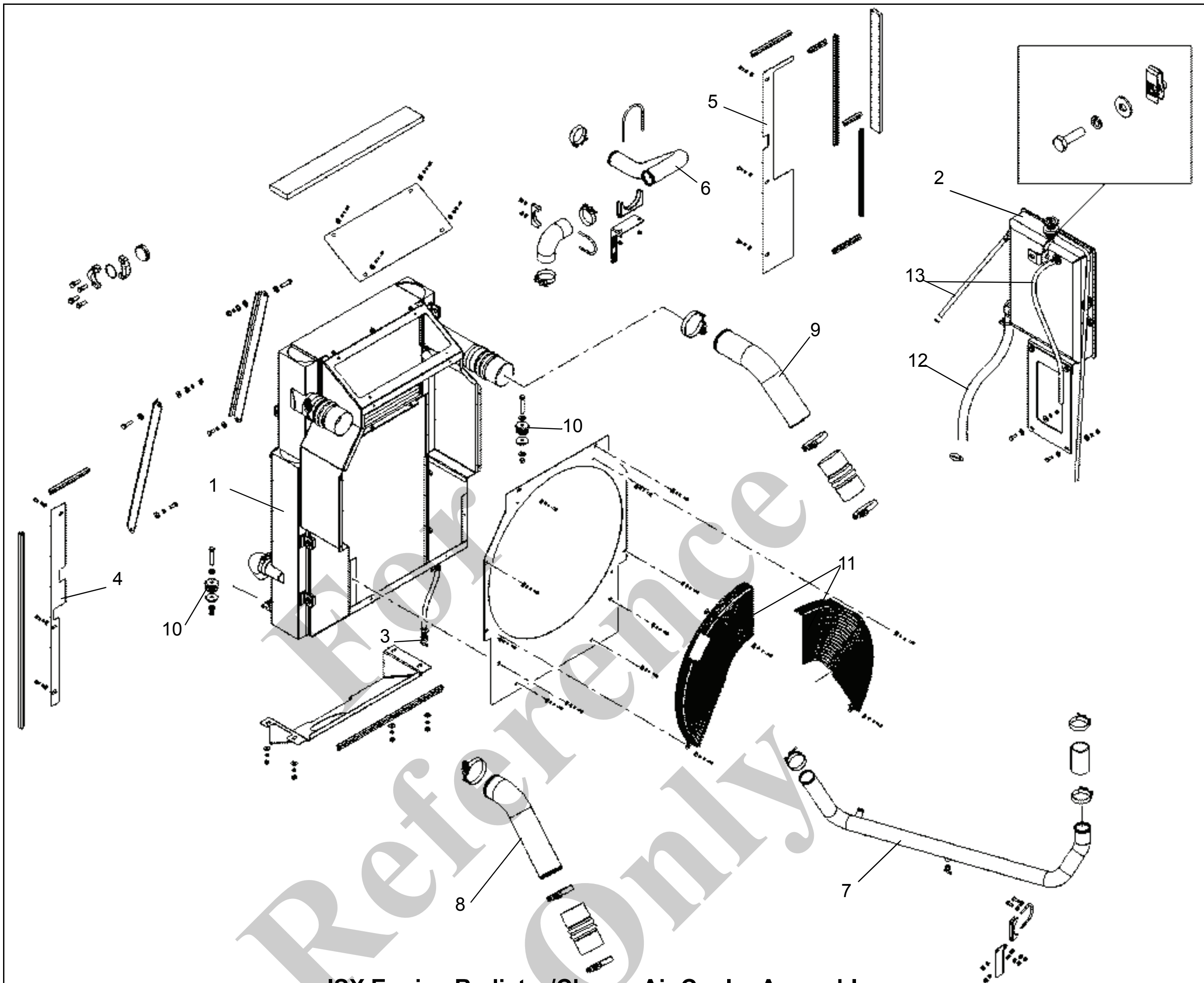
1. When coming into winter operation season, install the winterfront grill cover on the grill panel with ten 6-32 UNC SAE-2 hex nuts and ten No. 6 lock washers.
2. Clean cover with soap and water as needed during winter season operation. Blow cover dry with compressed air.
3. Remove and stow cover when not needed.



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 7-14



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 7-15

PUMP/PTO CLUTCH ASSEMBLY (ISX ENGINE)

The pump PTO clutch is used to engage/disengage pump 1 from the engine to aid in starting, especially in cold weather, and to prevent the pumps from over-speeding while traveling the crane. This clutch connects the PTO driveline to pump 1. The clutch assembly is air operated and electrically controlled.

PTO Clutch Lubrication

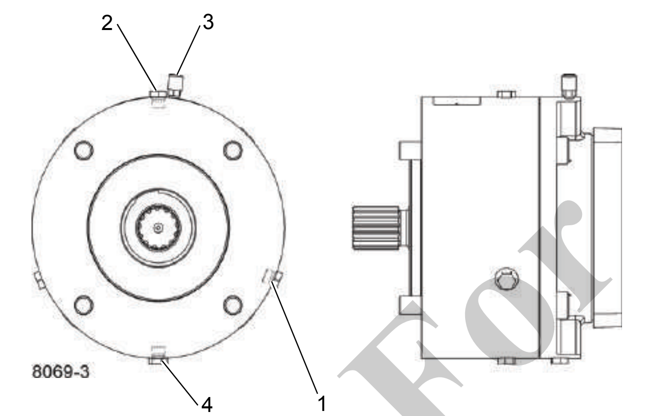


FIGURE 7-16

1. Remove access cover (5, Figure 7-17).
2. Open check plug (1, Figure 7-16) and check that oil is even with bottom of threads.
3. If necessary, remove fill plug (2) and add hydraulic oil until it is even with the bottom of the check plug threads.
4. Reinstall access cover (5, Figure 7-17) and secure with hardware (7). Refer to *Fasteners and Torque Values*, page 1-13.

When changing oil, place suitable container under drain pan hose (6, Figure 7-17) before removing drain plug (4, Figure 7-16). Remove and clean breather (3) and inspect and clean magnetic drain plug (4) for contamination or particles before reinstalling. For more information, refer to *Lubrication*, page 9-1.

Pump/PTO Clutch Replacement

CAUTION

Damage could occur!

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

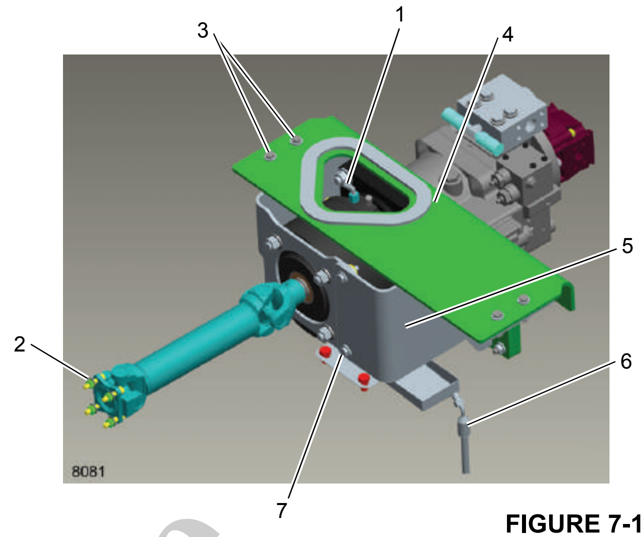


FIGURE 7-17

Removal

1. Depressurize the hydraulic system.
2. Depressurize the air system and disconnect the clutch air line (1, Figure 7-17) from the clutch.
3. Remove the cap screws, nuts and washers (2) connecting the PTO driveline to the engine. Remove the driveline.

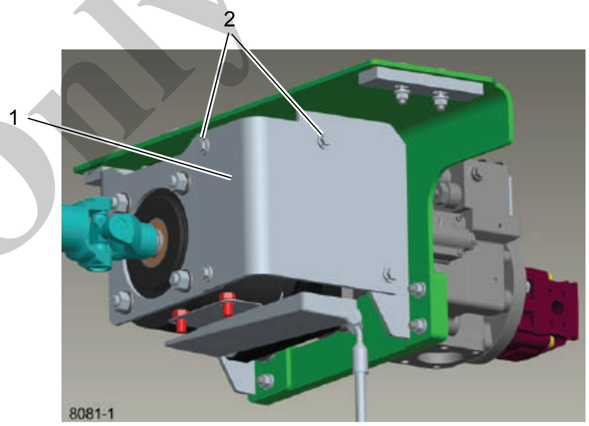


FIGURE 7-18

4. Remove the access cover (1, Figure 7-18) by removing the four cap screws and washers (2) and two “double-nut” plates.
5. Tag, disconnect and plug or cap the hydraulic hoses and ports on the clutch.
6. Tag, disconnect and plug or cap the hydraulic hoses and ports on the pumps.
7. Tag and disconnect the electrical connectors to the pumps.

8. Remove the four cap screws, nuts and washers (3, Figure 7-17) securing the clutch mounting bracket (4) to the frame.
9. Attach a suitable lifting device to the PTO clutch/mounting bracket/pump assembly—the clutch/mounting bracket/pump weighs approximately 215 kg (474 lb).
10. Remove the assembly and place on a suitable workbench.

Disassembly

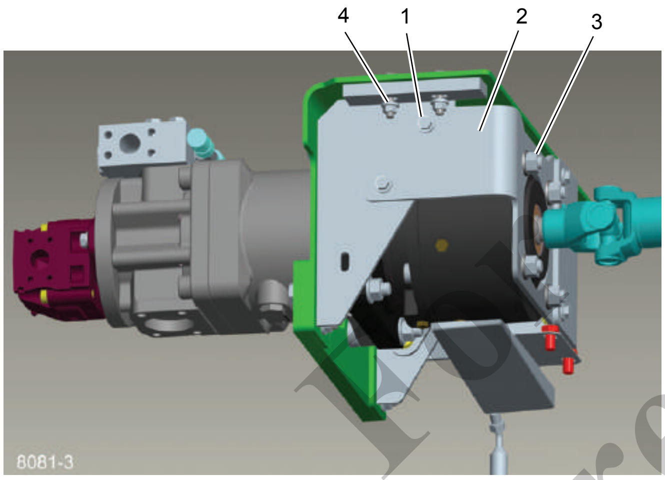


FIGURE 7-19

1. Remove the cap screws and washers (1, Figure 7-19) and double-nut plate securing the front support plate (2) to the mounting bracket.

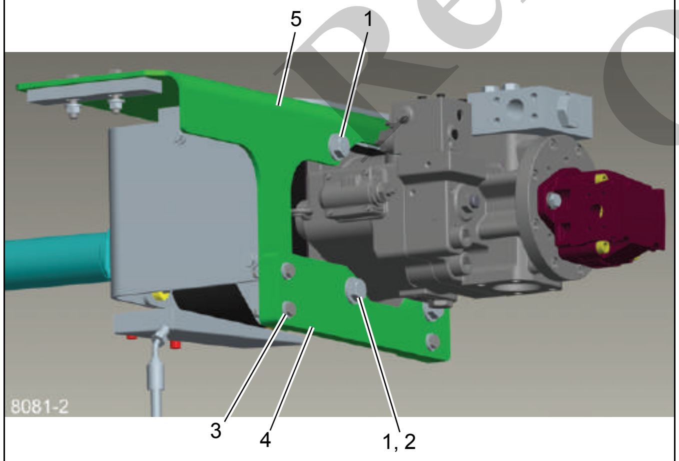


FIGURE 7-20

2. Remove the cap screws, nuts and washers (1, Figure 7-20) that fastens the clutch, mounting bracket and pump together. A bushing (2), on the lower left bolt, will fall out when the hardware is removed.
3. Remove the three cap screws, nuts and washers (3) that secure the mounting plate (4) to the mounting bracket (5).
4. Slide the clutch/front support plate off the pump spline.
5. Using a short Allen wrench or a tool, made by locking nuts on a 7/16 bolt, inserted into the socket head cap screws, and held with a wrench, remove the socket head cap screws, nuts and washers (3, Figure 7-19) that secures the front support plate to the clutch.

Assembly

1. Assemble bottom plate (4, Figure 7-20) to mounting bracket (5) around the pump body using the three bolts, washers, and nuts (3).
2. Slide the clutch onto the pump spline, install the bushing (2) removed in step 1 above and fasten the assembly together with the cap screws, nuts and washers (1, Figure 7-20). Torque hardware, refer to *Fasteners and Torque Values*, page 1-13.
3. Loosely attach the front support plate (2, Figure 7-19) to the front of the clutch using the nuts, washers and socket head cap screws (3). Secure the front support plate to the mounting bracket with the cap screws, washers and double-nut plate (1). Gently tighten hardware allowing assembly to settle into place. Torque all hardware according to *Fasteners and Torque Values*, page 1-13.

Installation

1. Using the lifting device place the clutch/mounting bracket/pump assembly onto the crane and loosely assemble with the cap screws, nuts and washers (4, Figure 7-19).
2. Connect the hydraulic hoses and air line to the clutch as tagged during removal. To prime the pumps, add hydraulic oil to the pumps and hoses before installation.
3. Attach the access cover (1, Figure 7-18) to the front support plate/clutch/mounting bracket with four cap screws and washers (2) and two double-nut plates. Torque all hardware, refer to *Fasteners and Torque Values*, page 1-13.
4. Install the driveline onto the clutch input shaft and transmission output. Secure the driveline to the transmission with the cap screws, nuts and washers. Torque hardware, refer to *Fasteners and Torque Values*, page 1-13.
5. Adjust the clutch/mounting bracket/pump assembly fore and aft to position the driveshaft between 6 to 14 mm (0.24 to 0.55 in) from the clutch face (Figure 7-21).

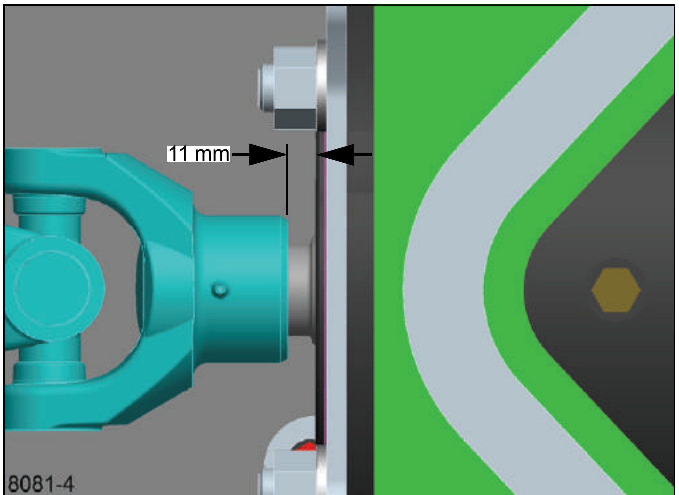


FIGURE 7-21

6. Torque hardware (4, Figure 7-19), refer to *Fasteners and Torque Values*, page 1-13.
7. Connect the electrical connectors and hoses to the pumps as tagged during removal.
8. Start the engine, engage the clutch and check for leaks.

Air Valve Replacement

The air valve is used to control the air to the PTO clutch.

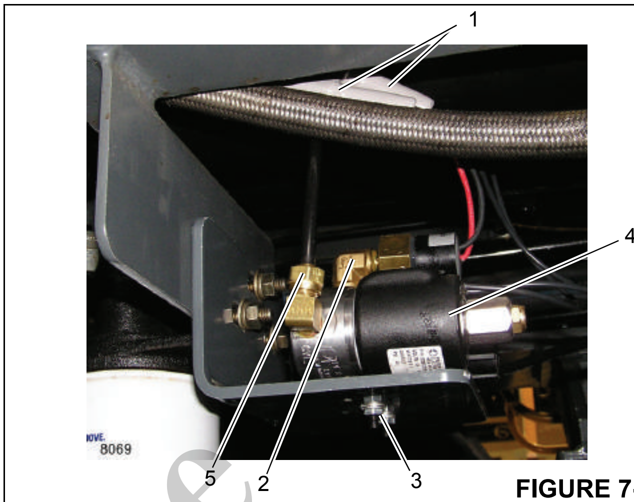


FIGURE 7-22

Removal

1. Drain the air system to remove any pressure.
2. Tag and disconnect the electrical connectors (1) (Figure 7-22).
3. Tag and remove air lines (2, 5).
4. Remove the hardware (3) securing the valve to the bracket and remove the air valve (4).

Installation

1. Install the air valve into position and secure with the hardware.
2. Connect the air lines to the valve.
3. Connect the electrical connectors.
4. Start the engine and charge the air system. Engage and disengage the pumps and check for proper operation of the clutch.

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DRIVE TRAIN

Description

The drive train consists of the manual transmission, clutch, and drive lines.

A 39.4 cm (15-1/2 in) - 2 plate pull type disc clutch is used between the engine and the transmission.

The transmission is an 11 speed forward and three speed reverse and is controlled through a remote 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 two drive shafts connected between the transmission and the front rear axle. An inter-axle shaft connects the rear axles.

Maintenance

Drive Lines

CAUTION

Do not disassemble drive lines when removing them from the crane!

Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

Removal

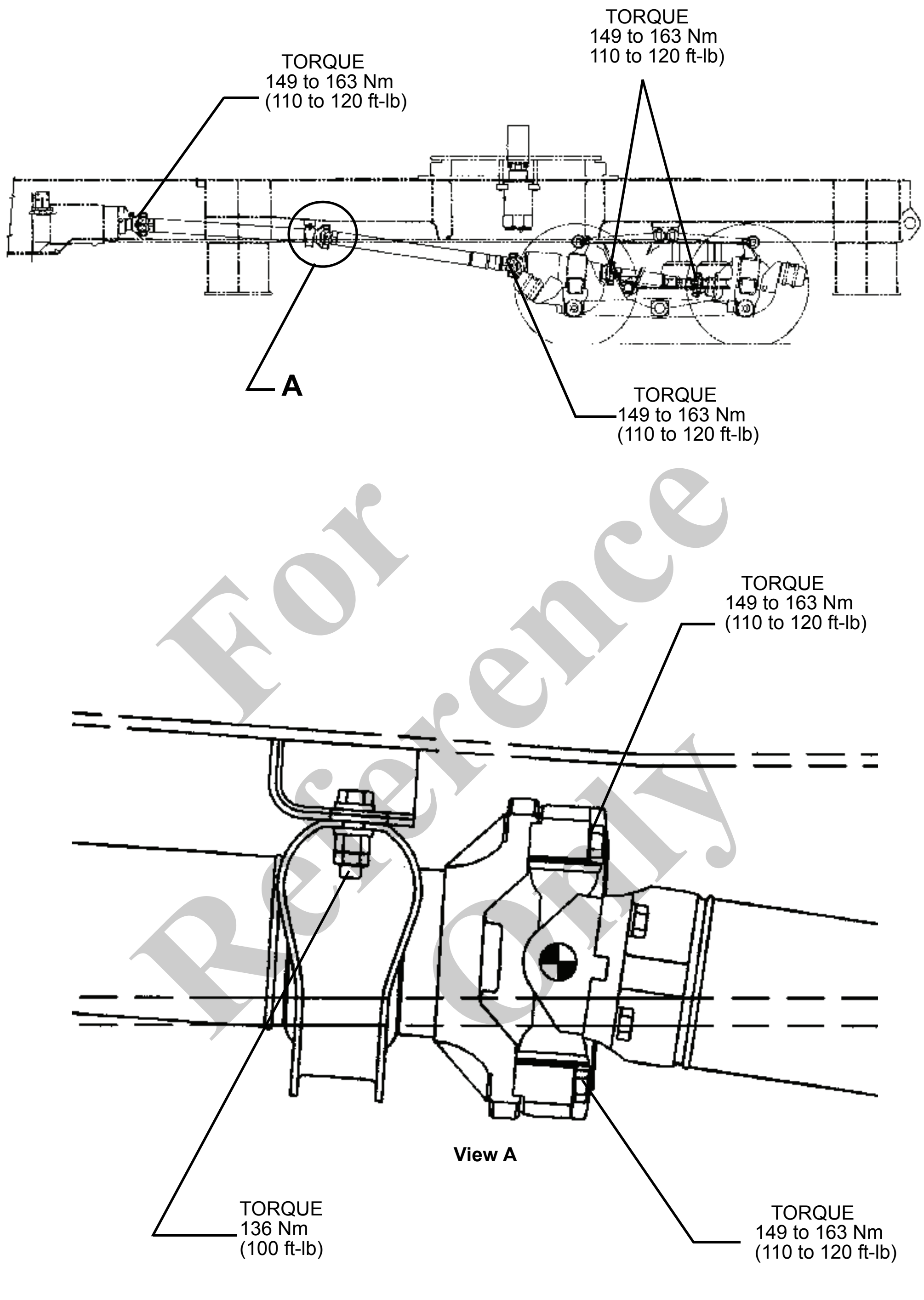
1. Support the drive line being removed so it does not fall when disconnected.
2. Remove the bolts from the bearing cap on each end of the drive line. Remove the drive line.

Installation

1. Position the drive line, install the bearing cap bolts and tighten bolts securely.
2. Torque the bearing cap bolts on the drive line 149 to 163 Nm (110 to 120 lb-ft).

Lubrication

Drive line U-joints are permanently lubricated and do not have any provisions for servicing.



Drive Line Installation

CLUTCH

Description

The clutch is a 39.4 cm (15-1/2 in), 2-plate, pull-type heavy duty unit. It incorporates a clutch brake that stops the rotation of the transmission gears to facilitate quick engagement on the initial start. It also slows down the gears on the upshift so the next higher gear can be engaged without gear clash. The clutch brake is engaged by pressing the clutch pedal through the last 25 mm (one inch) of pedal travel.

The lever on the shaft for the throwout bearing is actuated directly by mechanical linkage operated by the clutch pedal.

Periodic free-travel checks and adjustment, and lubrication of the throwout bearing with a small amount of high temperature grease should be scheduled for trouble free clutch operation. Do not use chassis grease. Refer to *Lubrication*, page 9-1.

Theory Of Operation

CAUTION

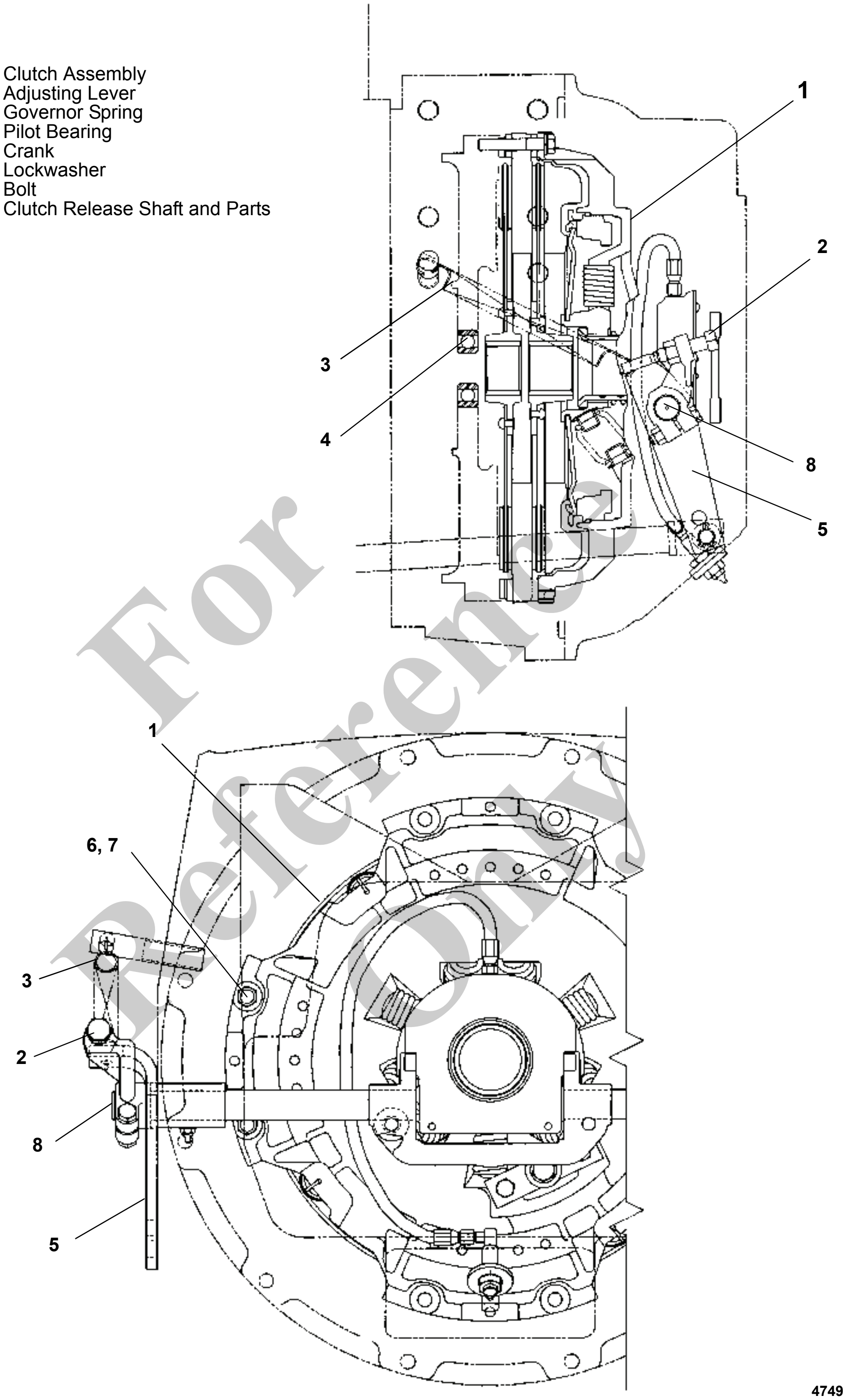
Never fully depress the clutch pedal before the transmission is put in neutral.

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.

The 39.4 cm (15-1/2 in) clutch flywheel ring (cover) is attached to the engine flywheel by eight 7/16-inch capscrews. The pressure plate is driven by driving lugs extending into mating slots in the flywheel ring (cover). The intermediate plate is driven by drive pins located in the engine flywheel.

Depressing the clutch pedal pulls the release bearing assembly toward the transmission. The release bearing, being connected to the release levers, thus 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. Releasing the clutch pedal allows the release bearing assembly to move toward the engine, permitting the pressure plate, under powerful spring pressure, to move toward the flywheel gripping the discs and causing engagement.

1. Clutch Assembly
2. Adjusting Lever
3. Governor Spring
4. Pilot Bearing
5. Crank
6. Lockwasher
7. Bolt
8. Clutch Release Shaft and Parts



Clutch Installation

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Manitowoc Crane Care

Maintenance

Troubleshooting

SYMPTON	PROBABLE CAUSE	SOLUTION
Chatter.	Loose, broken, or worn engine mounts.	Tighten or replace mounts.
	Loose or cracked clutch housing.	Tighten or replace.
	Rear axle attach bushings worn.	Replace bushings.
	Misalignment.	Align.
	Oil or grease on facings.	Install new facings or disc assembly.
	Warped or bent driven disc assembly.	Replace,
	Improper disc facing thickness.	Install proper disc assembly.
	Worn pilot bearing.	Replace.
	Wrong spring pressure in the cover assembly.	Use correct cover assembly.
	Cross shaft bushings worn.	Replace the bushings.
	Release levers not parallel.	Recheck installation.
Aggressive (grabby).	Excessive backlash in the power train.	Worn parts.
	Warped driven disc.	Install a new disc assembly.
	Worn hub splines.	Install a new disc assembly.
	Worn splines on splined shaft.	Replace shaft.
	Improper facing material.	Install proper driven disc assembly.
Insufficient release.	Broken or loose engine mounts.	Tighten or replace.
	Excessive idling speed.	Adjust to factory specifications.
	Loose or worn facings.	Replace.
	Improper facing thickness.	Install the proper driven disc assembly.
Insufficient release (continued).	Drive lugs binding.	Check pressure plate drive lugs for proper clearance 0.152 mm (0.006 in).

7

SYMPTON	PROBABLE CAUSE	SOLUTION
	Pressure plate return springs bent or stretched.	Replace springs.
	Insufficient amount of release travel.	Adjust for proper release travel.
	Lever nose out of groove in release sleeve retainer.	Disassemble and repair as necessary.
	Driven disc distorted or warped.	Driven disc assembly must be straight within 0.381 mm (0.015 in) total indicator reading. Replace discs. Damage to driven disc can be caused by poor installation methods. Do not force transmission drive gear into disc hubs. This will distort or bend driven disc causing poor release. Replace the drive disc.
	Splines worn on main drive gear of transmission.	Replace drive gear 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 drive gear splines.
	Internal clutch adjustment not correct.	Readjust clutch for standard release travel.
	Flywheel pilot bearing fitting too tight in flywheel or on end of drive gear.	Free pilot bearing to a light push. Fit in flywheel and on drive gear pilot. If bearing is rough, replace.
	Facings gummed with oil or grease.	Replace facings or entire driven disc assembly.
	Damaged clutch release bearing.	Replace bearing.
	Clutch release shaft projecting through release yoke.	Relocate release shaft so it does not project. Check bell housing bushings and release yoke for wear.
	Release yoke contacting cover assembly at full release position.	Replace release yoke with proper yoke.
Insufficient release (continued).	Release yoke will not align with release bearing properly.	Flywheel has been resurfaced more than the recommended 1.524 mm (0.060 in) removal. Replace flywheel.

SYMPTON	PROBABLE CAUSE	SOLUTION
	Broken intermediate plate.	Replace damaged intermediate plate driven disc assembly.
	Intermediate plate sticking on cover.	Intermediate plate lugs should have 0.1524 mm (0.006 in) clearance in driving slots of flywheel ring (cover).
	Warped or bent driven disc assembly.	Replace.
	Lever settings wrong.	Recheck installation.
	Worn splines.	Replace driven disc assembly.
	Worn or rusty splines on the splined shaft.	Repair or replace.
	Worn pilot bearing.	Replace.
Hard pedal.	Excessive spring pressure in the cover assembly.	Install the proper cover assembly.
	Contact pad of the release bearing carrier worn by the shifter shaft.	Replace the carrier and shifter yoke. Also check for proper installation to provide the best linkage operating positions.
Slippage.	Oil or grease on the facing.	Replace facing or install a new driven disc assembly.
	Loose or worn facings.	Replace facings or install a new driven disc assembly.
	Weak pressure springs.	Replace springs.
	No free pedal.	Readjust clutch.
	Release mechanism binding.	Free up mechanism and linkage, check clutch adjustment.
Noisy clutch.	Clutch release bearings dry or damaged.	Lubricate bearing. Replace if damaged.
	Flywheel pilot bearing dry or damaged.	Lubricate bearing. Replace if damaged.
	Clutch release bearing housing striking flywheel ring.	Adjust clutch. Also check wear on cross shafts, bell housing bushings, and release yoke fingers. If badly worn, replace parts.

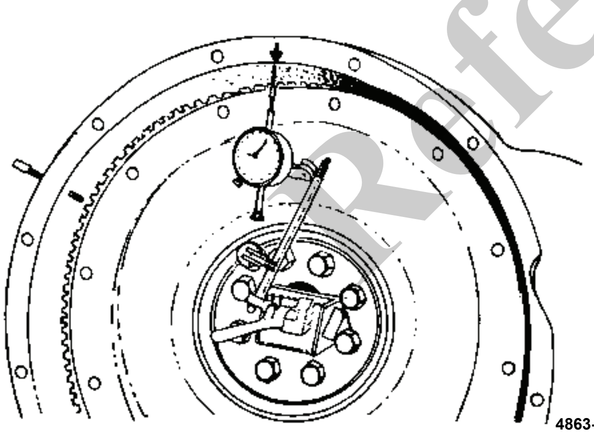
Removal

1. Remove the transmission following the procedures under *Removal of the Transmission*, page 7-48.
2. Install two 19 mm (0.75 in) blocks of wood between the clutch flywheel ring and the clutch release bearing housing 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.

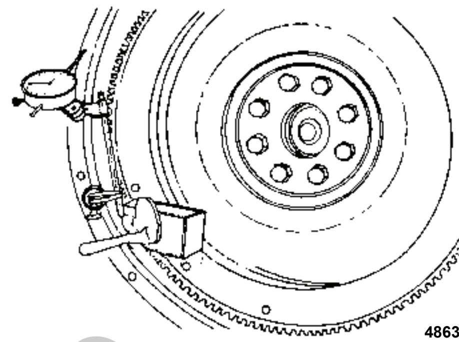
1. Begin by wiping all surfaces before gauging.
2. Secure the dial indicator to the flywheel housing with the gauge finger on the flywheel near the outer edge. Rotate flywheel.
3. The total indicated difference between the high and low joints must be 0.178 mm (0.007 in) or less for a 35.6 cm (14 in) clutch, 0.203 mm (0.008 in) or less for a 39.4 cm (15.5 in) clutch.



4863-1

4. Secure a dial indicator to the crankshaft. 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 0.203 mm (0.008 in).



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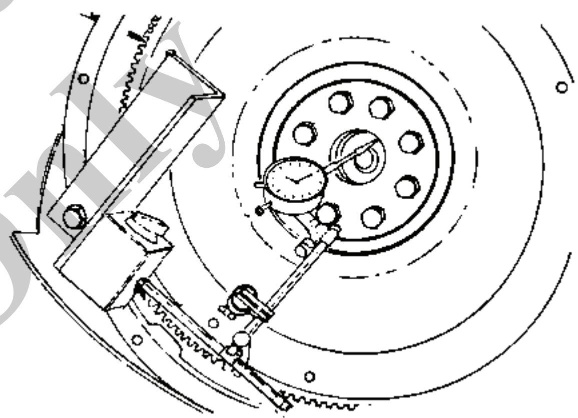
5. Move the gauge finger to contact the face of the engine flywheel housing.

   Again, rotate the crankshaft and then mark high and low points. The total difference between the high and low points should not exceed 0.203 mm (0.008 in).

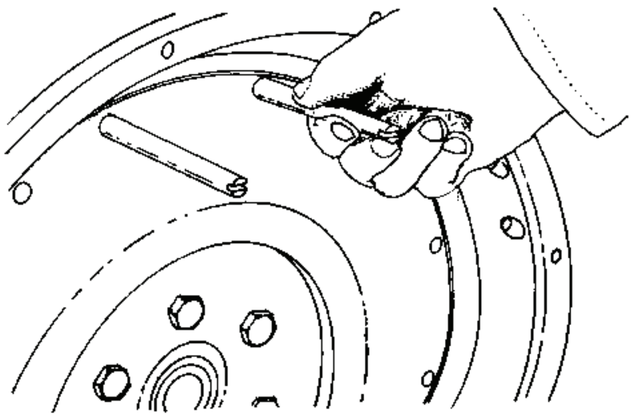


4863-4

6. Move the gauge finger to contact the pilot bearing bore surface. Again, rotate the flywheel.

   The maximum total allowable runout is 0.127 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



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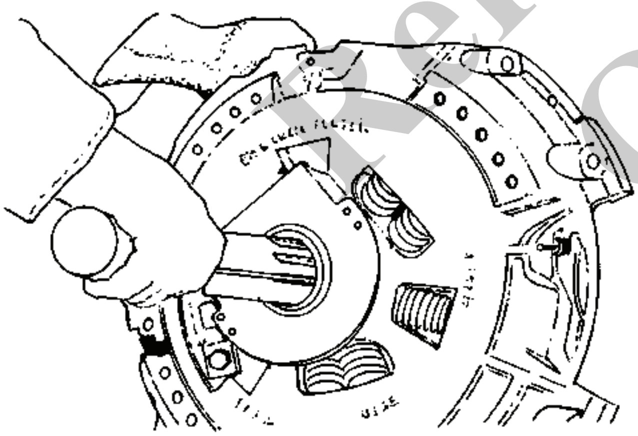
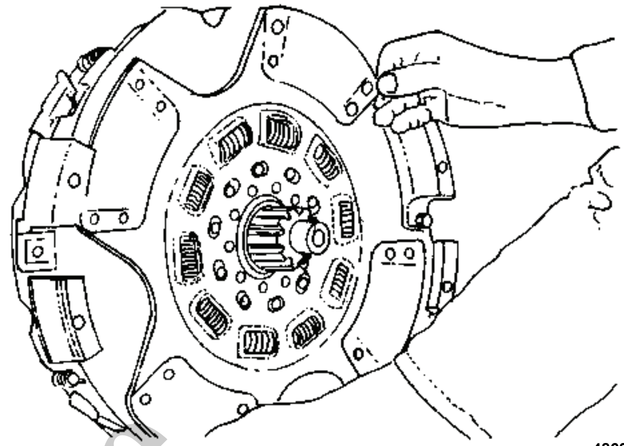
1. Insert two 12.7 cm (5 in) long 7/16 inch - 14 UNC guide studs into the two upper mounting holes of the flywheel.
2. Verify flywheel cavity.
   - - 8 Springs need 18.4 cm (7.25 in) bore.
   - - 10 Springs need 21.7 cm (8.56 in) bore.
   - - 7 Springs need 24.8 cm (9.75 in) bore.
   - - 9 Springs need 24.8 cm (9.75 in) bore.

   Insert the aligning tool through the release bearing sleeve in the new clutch.



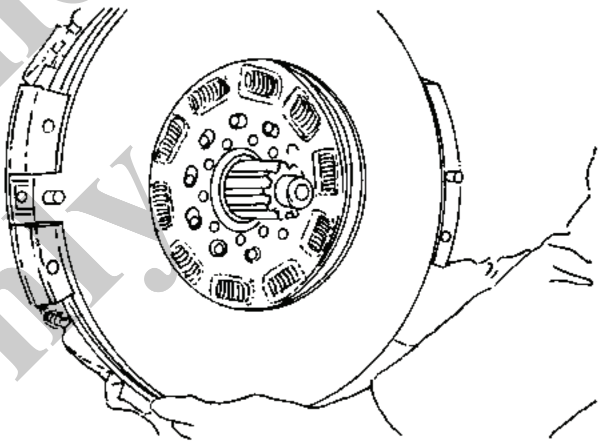
4863-5

3. Put the rear driven disc on the aligning tool with the side stamped "pressure plate" facing the pressure plate.



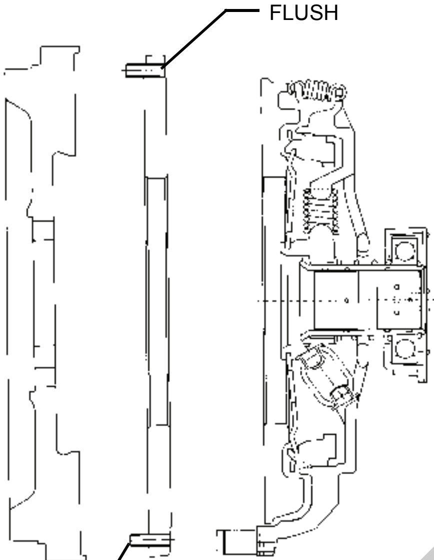
4863-6

4. Place the intermediate plate in the clutch cover and align the driving lugs of the plate with the slots provided.



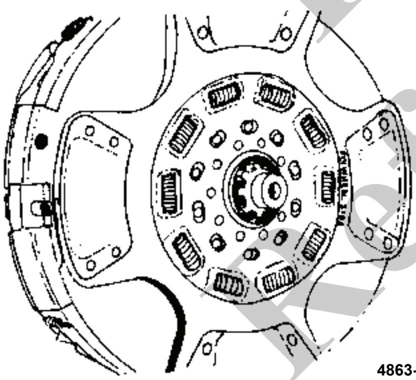
4863-7

7



4863-8

5. Positive Separator (Roll) pins should be flush on the clutch side, protruding on flywheel side.

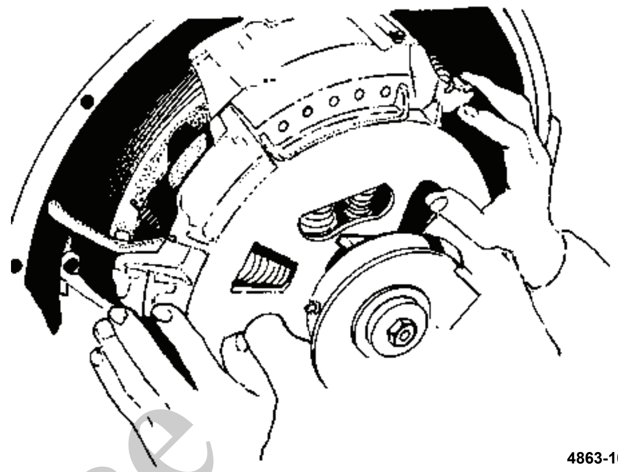

4863-9

6. Install the front disc on the aligning tool with the side stamped “flywheel” facing the engine.

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

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 68 kg (150 lb), so a hoist may be required to lift it into place.
8. Start the eight 7/16 inch bolts with lockwashers and tighten them finger tight.

CAUTION

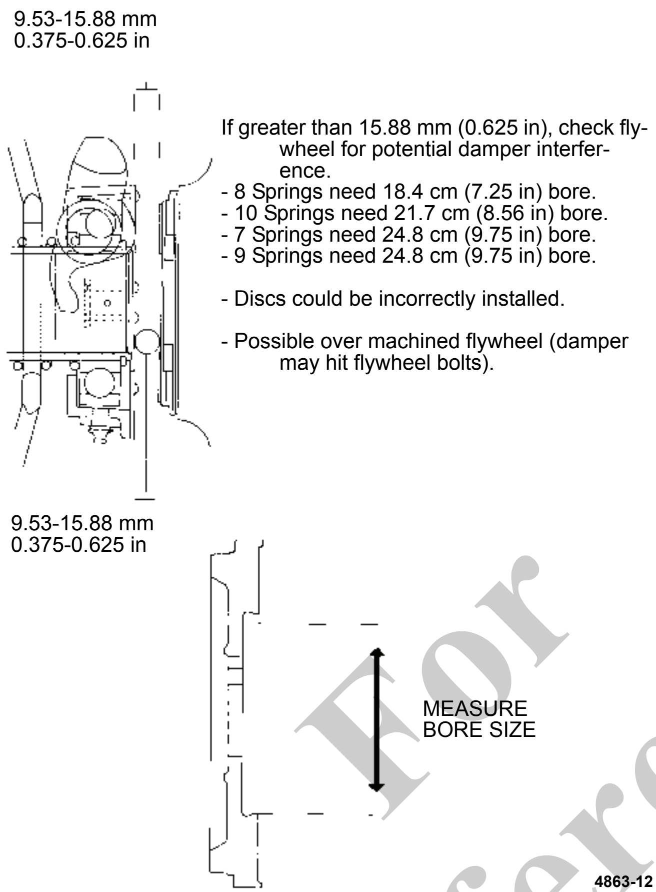
Risk of damage!

Failure to tighten the bolts in this manner can cause permanent damage to the clutch cover or create an out-of-balance condition.

9. Tighten the bolts in the crisscross 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 69 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 9.53 to 15.88 mm (0.375 to 0.625 in) from the clutch cover.

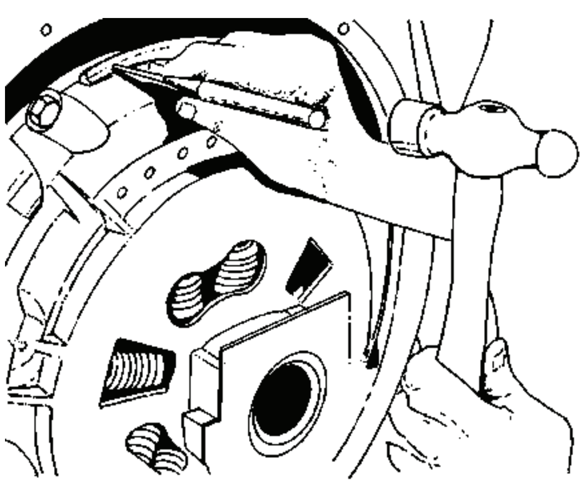


4863-12

If greater than 15.88 mm (0.625 in) check possible disc to flywheel bore interference.

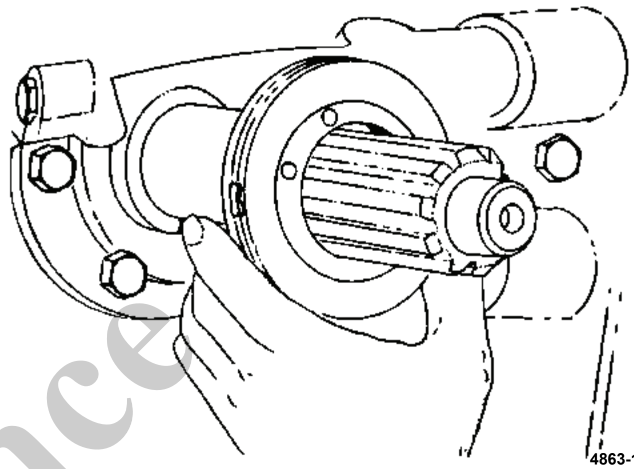
11. Check Positive Separators.

Using a 6.35 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.



4863-13

- - 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

If a clutch brake is used, be sure to install it on the input shaft of the transmission at this time.

12. Refer to *Installation of the Transmission*, page 7-49, 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 25.4 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 12.7 to 14.3 mm (0.5 to 0.5625 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.

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b. Turning the bolt 2-1/3 rotations changes the adjustment 3.175 mm (0.125 in). The Kwik-Adjust will re-engage 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 25.4 to 38.1 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.

Clutch Adjustment Inspection Procedure

1. Remove the inspection plate from the bottom of the clutch housing.
2. Depress the clutch pedal several times and check for the 9.525 to 12.7 mm (0.375 to 0.5 in) release bearing travel. Readjust if necessary.
3. Check the clutch pedal for 38.1 mm (1.5 in) of free travel. Readjust if necessary.
4. Install the inspection plate on the bottom of the clutch housing and road test the crane for proper clutch operation.

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 inch) are re-ground 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 taking crane off dead-line.

GEARSHIFT

Description

The remote location of the transmission from the shift lever in the 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.

NOTE: Range shifts for the transmission, are controlled by air operated master and slave valves.

Maintenance

Troubleshooting

SYMPTON	PROBABLE CAUSE	SOLUTION
Excessive lever travel or sloppy feel when shifting.	Setscrews loose in control shaft universal joints or shift fingers.	Tighten or replace setscrews.
Hard shifting.	Bent shift bar in transmission. Damaged cross shaft or bushings in master or slave unit.	Disassemble and repair as necessary
Transmission locked in gear or in neutral gearshift lever moves freely; no detent feel.	Shift control shaft broken, U-joints loose or disconnected, cross shaft in slave unit broken or shift fingers loose.	Disassemble and repair as necessary.
Gearshift lever positions do not correspond to transmission gear ranges.	Lever in master unit and cross shaft in slave unit out of phase.	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 bolts and washers 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 shift control tower up through the cut out in the cab floor. Apply Loctite to bolts. Install bolts and washers and secure the slave unit to the plate.
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. Lubricate the U-joints with chassis grease.
6. Connect the nylon tubing to the range shift valve if disconnected.
7. Connect the nylon tubing to the splitter valve.

MANUAL TRANSMISSION

Description

The transmission provides 11 forward speeds and three reverse, consisting of a five speed front section and a three speed auxiliary section. The auxiliary section contains the LO and HI range ratios, plus the three deep reduction gears. The range button 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 control knob.

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 shifting bar housing. This will be noticed when the transmission fails to make a range shift, or shifts too slowly.

SYMPTON	PROBABLE CAUSE	SOLUTION
Noise (from other sources).	Fan bent or out of balance.	Replace fan.
	Damaged vibration damper.	Replace damper.
	Flywheel out of balance.	Check balance. Replace flywheel if necessary.
	Unbalanced clutch assembly.	Check clutch and clutch housing for proper alignment.
	Loose engine mountings.	Tighten mountings.
	Worn U-joints.	Replace U-joints.
Noisy transmission (in neutral).	Transmission misaligned.	Align engine and transmission (assembled) with rear axle so as to correct angles of U-joints.
	Worn transmission pinion bearing.	Replace bearing.
	Worn or scored countershaft bearing.	Replace bearings.
	Damaged second speed mainshaft gear bushing.	Replace bushing.
	Unmatched gears.	Replace unmatched gears.
	Worn or rough reverse-idler gear.	Replace gear.
	Eccentric countershaft gear assembly.	Replace gear.
	Sprung or worn countershaft.	Replace countershaft.
	Excessive backlash in gears.	Replace worn gears.
	Excessive end play in countershaft.	Adjust to reduce end play.
	Worn main shaft pilot bearing.	Replace pilot bearing.
	Scuffed gear tooth contact surface.	Replace gear.
	Insufficient lubrication.	Check for leaks; fill to proper level.
Sticking in gear.	Clutch operating improperly.	Adjust clutch. Check alignment.
	Sliding gear tight on main shaft splines.	Check for galling. Replace as necessary.
	Improper adjustment of linkage	Adjust linkage.
Jumping out of gear.	Misaligned transmission.	Check alignment.
	Shift rail poppet springs broken.	Replace poppet springs.
	Shift rail poppet notch worn.	Replace shift rail.
	Shift forks sprung or loose on shift rail.	Replace sprung fork or tighten setscrew in shift fork.

SYMPTON	PROBABLE CAUSE	SOLUTION
	Linkage and rods between shift lever and auxiliary transmission not properly adjusted.	Check and adjust linkage and rods to make sure transmission is shifting full into gear.
	Clutch gear teeth worn tapered.	Replace worn parts.
	Bearings worn.	Replace bearings.
	Transmission mounting in carrier puts strain on case.	Line up front mounting bracket so it does not cause strain on front main shaft bearing retainer.
Oil leakage.	Transmission over filled.	Drain to proper level.
	Breather stopped up.	Clean breather assembly.
	Use of transmission oil that foams and expands when hot.	Drain and refill with proper grade and type of lubricant.
	Drain back holes between bearing retainers and main case stopped up.	Check drain holes and gaskets to ensure openings are clean.
	Broken gaskets.	Replace gaskets and use gasket cement.
	Loose drain plug in transmission.	Tighten drain plug.
	Cracked transmission housing.	Replace transmission.
	Cover not properly tightened.	Tighten cover.
Noisy transmission (in gear).	Gears worn and pitted due to lugging engine with transmission in too high a gear range.	Replace gears.
	Bearings worn due to lugging engine with transmission in too high a gear range, or to chips and dirt in oil.	Replace worn or rough bearings.
	Worn, chipped, or tapered sliding gear teeth.	Replace gears.
	Noisy speedometer gears.	Replace gears.
	Transmission not lined up properly with carrier.	Line up transmission with rear axle so as to correct angles of U-joints.
Difficult shifting.	Improperly operating clutch.	Adjust clutch. Check alignment.
	Sliding gear tight on shaft splines.	Check for galling. Replace as necessary.
	Burred main shaft splines.	Replace main shaft.
	Improper adjustment of shifting linkage. Worn or bent shifter rails.	Check and adjust linkage and rods to ensure that transmission is shifting fully into gear.
	Insufficient lubricant.	Fill to proper level.

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SYMPTON	PROBABLE CAUSE	SOLUTION
Range shift inoperative or malfunctioning.	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 button in the up position).	Disconnect crossed air lines and connect properly.
	Lines crossed between air valve on transmission and the shift cylinder.	Disconnect crossed air lines and connect properly.
	Low range (down position) on button results in high range gear engagement, and vice versa.	Disassemble control valve and replace o-ring seals.
	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.	Disassemble, clean, and repair regulator.
Bearing failure.	Use of wrong lubricant or grade of lubricant.	Drain transmission; flush and refill with proper grade and type of lubricant.
	Bearings adjusted to tight or too loose.	Obtain correct adjustment.
	Lack of cleanliness in overhaul of transmission resulting in damaged gearing due to foreign matter in oil.	Properly clean transmission.

Removal of the Transmission

1. Refer to *Engine Removal*, page 7-2 and remove the engine and transmission as an assembly from the crane.

CAUTION

Risk of damage!

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 Clutch (Input) Shaft

General

In some cases in field repair it may be necessary to replace only the 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. Engage the mainshaft sliding clutches in two gears and remove the drive gear bearing nut.
3. Move the drive gear assembly as far forward as possible and remove the drive gear bearing.
4. Remove the washer from the input shaft.
5. From the front, remove the snap ring from the inside diameter of the drive gear.
6. 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 inside diameter of the drive gear.
2. Install the snap ring in the inside diameter of the drive gear.
3. Install the washer on the shaft.

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4. Move the fourth-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.

Installation of the Transmission

1. Refer to *Clutch*, page 7-35 in this section 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

Risk of damage!

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 clutch release yoke rides up and over the release bearing while the shaft goes into the pilot bearing.
5. Install the 12 bolts and washers mounting the clutch housing to the engine flywheel housing. Torque per specifications *Fasteners and Torque Values*, page 1-13.
6. Install the bolts and washers securing the engine flywheel to the flywheel ring cover.
7. Refer to *Maintenance*, page 7-2 and install the engine and transmission.

Lubrication

General

The transmission is designed so the internal parts operate in a bath of oil circulated by the motion of gears and shafts. Grey 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.

- Maintain the oil level. Inspect regularly.
- Change the oil regularly.
- Use the correct grade and type of oil.
- 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 left side of the case. Fill the transmission to the level of the filler openings. The exact amount of oil will depend on the transmission inclination, always fill to the proper level using sight plug. Do not overfill. This will cause oil to be forced out of the case through the mainshaft 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 shorten transmission life.

The following conditions in any combination can cause operating temperatures of over 120°C (250°F).

- Operating consistently at road speeds under 32 k/h (20 mph).
- High engine rpm.
- High ambient temperature.
- Restricted air flow around the transmission.
- Exhaust system too close to the transmission.
- 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.
- **Clutch Housing Mounting.** Check all capscrews in the bolt circle of the clutch housing for looseness.
- **Clutch Release Bearing.** Remove the hand hole cover and check radial and axial clearances in the release bearing. Check the relative position of the thrust surface of the release 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 and drain plugs 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.

TRANSMISSION SHIFT AIR SYSTEM

Description

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 cab, and the other valves and cylinders are mounted on the transmission.

Theory of Operation

The range control valve has two positions HIGH (button up) and LOW (button 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 button, a LO-LO button is incorporated to select two extra low gears.

SECTION 8
UNDERCARRIAGE

TABLE OF 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. When the ignition switch is OFF and the crane is on rubber, the air bags will inflate. To deflate the entire air suspension system (front and rear), position the inflation control switch on the carrier cab right side panel to the right 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 suspension deflated indicator on the right side console.

Maintenance

NOTE: For more information on the axles, refer to Volume 2 - Service Maintenance Manual or the Arvinmeritor web site.

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 that bolt torque is 305 to 372 Nm (225 to 275 ft-lb).

Beam End Connections and Bushings

Every 16,090 km (10,000 mi) check the torque of the beam end bolts. Tighten to 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, 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.

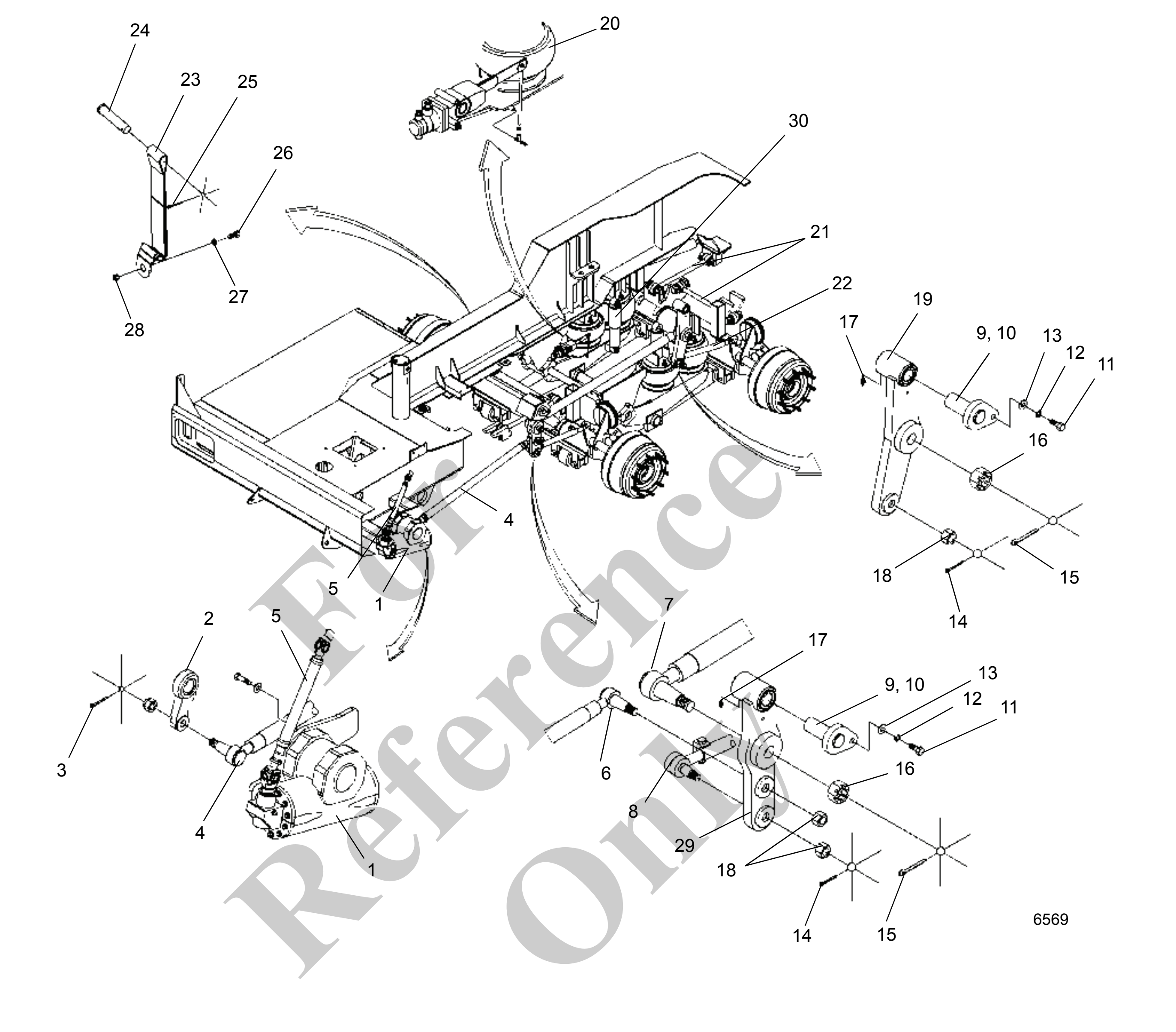


FIGURE 8-1

Item	Description
1	Power Steering Gear
2	Pittman Arm
3	Cotter Pin
4	Drag Link
5	Steering Shaft
6	Vertical Socket
7	Vertical Socket

Item	Description
8	Vertical Socket
9	Pin Weld
10	Shim
11	Bolt
12	Lockwasher
13	Flatwasher
14	Cotter Pin

8

15	Cotter Pin
16	Slotted Nut
17	Grease Fitting
18	Nut
19	Relay Arm
20	Suspension Air Bag
21	Torque Rod
22	Drag Link
23	Restraint Strap
24	Clevis Pin
25	Cotter Pin
26	Bolt
27	Lockwasher
28	Nut
29	Relay Arm
30	Shock Absorber

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.
6. Tag and disconnect the hydraulic lines from the steer cylinders.

NOTE: Do not change the torque rod or vertical socket drag links' dimensions. This will make wheel alignment easier when the axle is reinstalled.

7. Remove the bolts, hardened washers, and nuts securing each of the torque rods to the carrier frame.
8. Remove the cotter pin and nut securing each vertical socket drag link to its axle.
9. Remove the cotter pin, washer and nut securing each steer cylinder to its axle.
10. Remove the hardware securing the linkage rod of each height control valve to its respective saddle assembly.
11. Remove the bolts and washers securing each shock absorber to the carrier frame.
12. With the axles and suspension fully supported, remove the nuts and washers securing each of the four air bags to the carrier frame brackets.
13. Remove the bolts and flatwashers securing each of the four saddle assemblies' cap blocks to the carrier frame brackets.
14. Remove the cotter pin and clevis pin securing the restraint strap to the frame.
15. 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 bolt and flatwasher securing each. Remove the shock absorber(s).
3. Remove each axle from the walking beams by removing the two bolts, flatwashers, locknuts and shim securing each end of the axle to the walking beam end bushings. Remove the axle(s).

NOTE: Figure shown for reference only. Frame, axles and steer cylinder locations vary for each model.

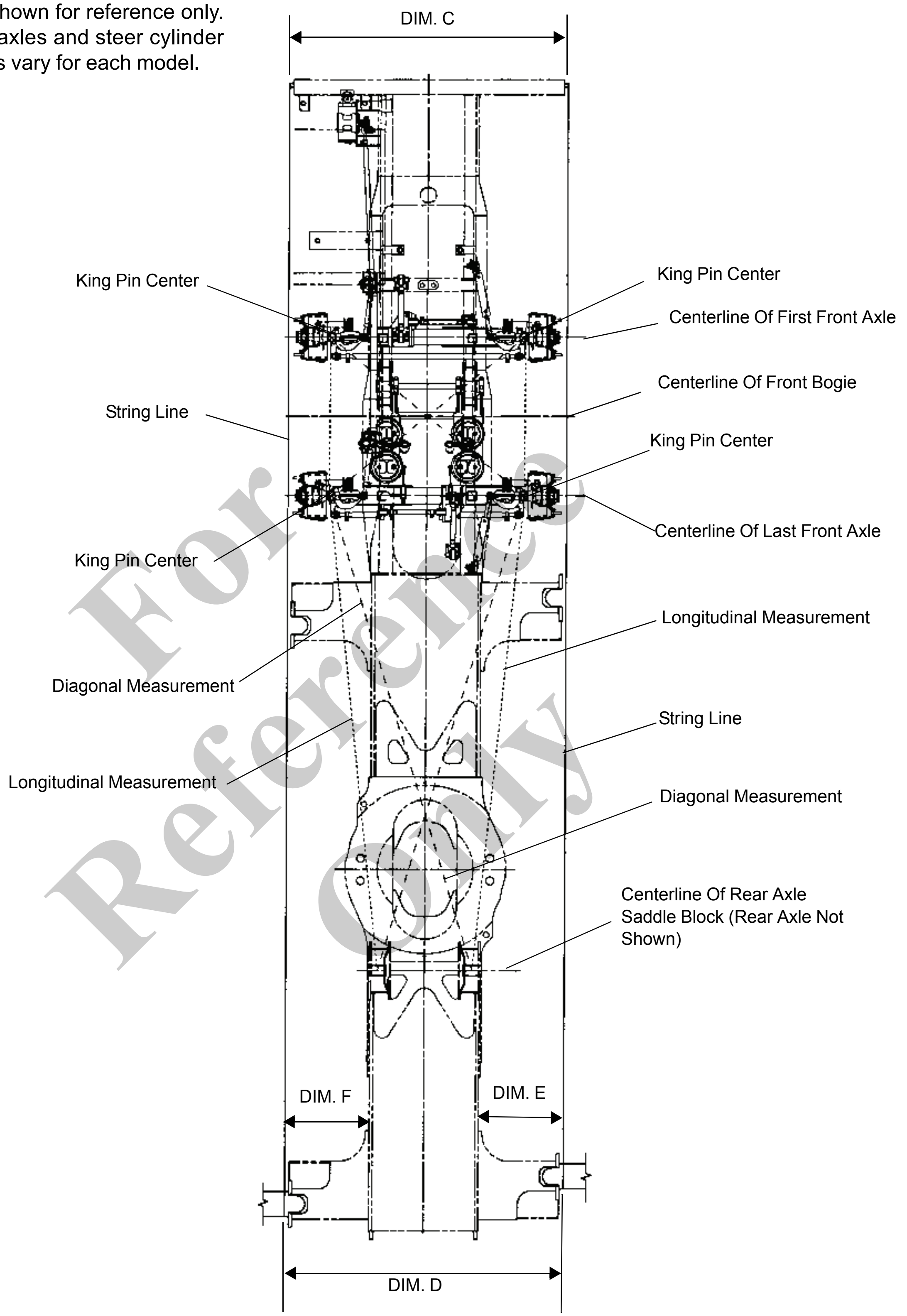


FIGURE 8-2

4. Remove the saddle assemblies from the walking beams by removing bolts and flatwashers 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 locknut and flatwasher. 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 locknut and flatwasher.
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 bolts and flatwashers. Torque the bolts to 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 the bolts, flatwashers, locknuts and shim. 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 bolt and flatwasher. Torque the nuts to 610 Nm (450 lb-ft).
5. Position the torque rods in the axle brackets and secure each with two bolts, hardened washers, and nuts. Torque bolts to 293 to 317 Nm (216 to 234 lb-ft).

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 bolts and flatwashers. Center the walking beam in saddle before tightening end caps. Torque the bolts to 305 to 373 Nm (225 to 275 lb-ft).
4. Secure the four air bags to the carrier brackets with the nuts and washers. Torque the nuts to 41 Nm (30 lb-ft).
5. Secure each shock absorber to the carrier frame with a bolt and flatwasher. Torque bolts to 610 Nm (450 lb-ft).
6. Secure the linkage rod of each height control valve to its respective saddle assembly with the attaching hardware.
7. Attach each steer cylinder ball socket to its axle using the slotted nut, washer and cotter pin. Torque each nut to 136 to 170 Nm (100 to 125 lb-ft). Tighten to nearest cotter pin hole and insert cotter pin.
8. Attach the vertical socket drag links to their axles using the slotted nuts and cotter pins. Torque each nut to 136 to 170 Nm (100 to 125 lb-ft). Tighten to nearest cotter pin hole and insert cotter pin.
9. Connect the hydraulic lines to the steer cylinders as tagged during removal.
10. Attach the four torque rods to the carrier frame using two bolts, hardened washers, and nuts each. Torque the bolts to 293 to 317 Nm (216 to 234 lb-ft).
11. 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.

NOTE: The front rear axle will need to be elevated to attach restraining strap.

12. Secure the restraint strap to the frame and secure with the cotter pin and clevis pin.
13. Service the axles and suspension system. Refer to *Lubrication*, page 9-1.
14. Build up air pressure in the systems and check for leaks. Check operation of brakes and air suspension system.
15. Install the tire and wheel assemblies. Refer to *Wheels and Tires*, page 8-19 in this Section.
16. 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 (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 (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 through 3 and readjust the shims if necessary.
5. Repeat steps 2 through 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.

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. Front Axle Ride Height - 298 mm (11.75 In) (Figure 8-3)

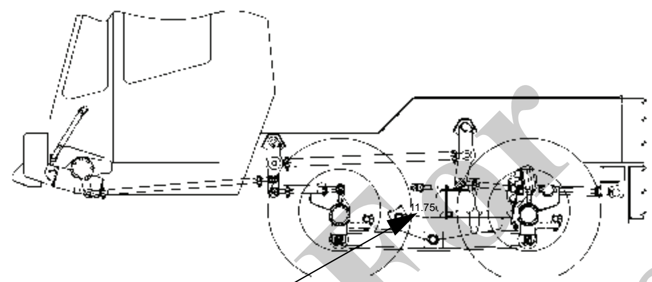


FIGURE 8-3

2. Rear Axle Ride Height - 387 mm (15.25 In) (Figure 8-4)

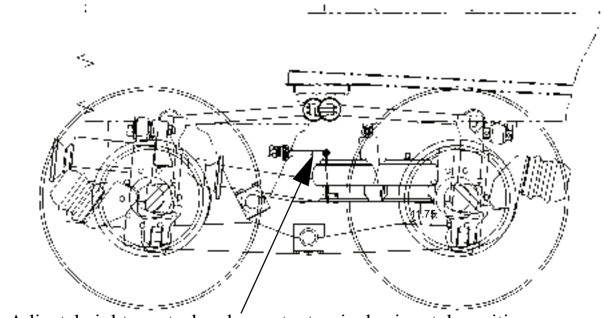


FIGURE 8-4

3. Adjust rod to achieve proper ride height setting (Figure 8-5) and torque P-clamp on P-boot to 1.13 to 1.7 Nm (10 - 15 in lbs).

NOTE: Over-tightening of the P-clamp will cut through the P-boot.

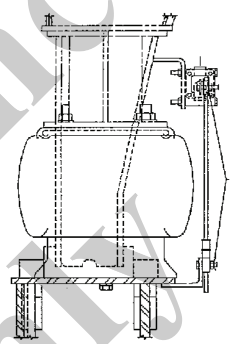


FIGURE 8-5

Toe-In Adjustment

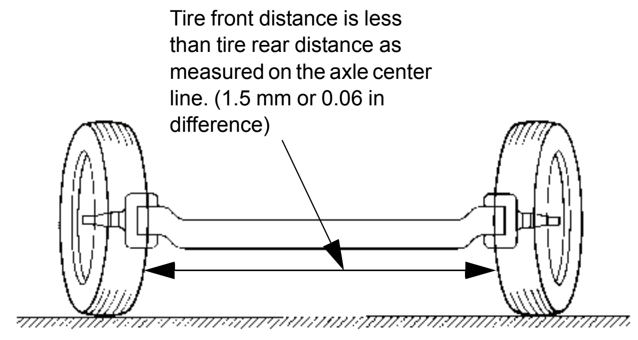


FIGURE 8-6

Toe-in (see Figure 8-6) 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 between tires. 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 8-7) on the first front axle the bolts should be adjusted in or out as needed to obtain a measurement of 3.2 mm (0.12 in) minimum from the rigid axle stop to the top of the bolt head (see Figure 8-7).

Drag Link Installation and Axle Synchronization

NOTE: All detail numbers are in reference to (Figure 8-8).

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 as the rig pin(s).

3. Install a 8.3 mm (0.33 in) diameter rig pin through the front relay arm mounting bracket and the front relay arm. Adjust drag link (Detail #7) so that a 8.3 mm (0.33 in) rig pin can be installed through the rear relay arm mounting bracket and the rear relay arm.

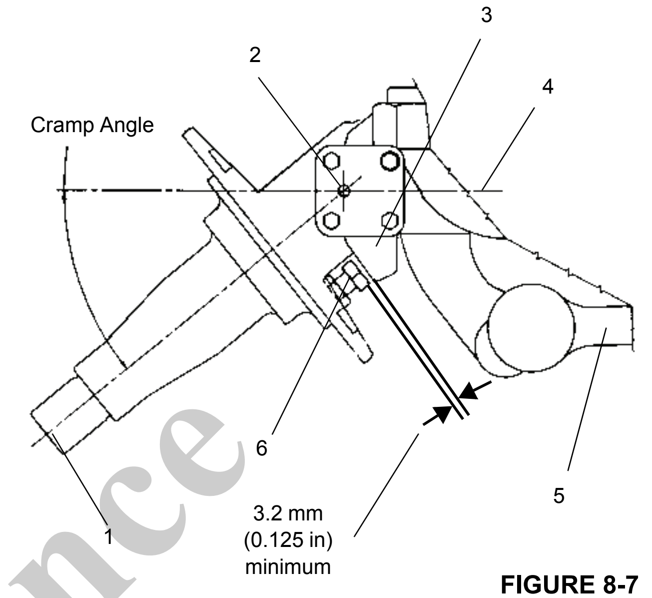


FIGURE 8-7

Item	Description
1	Spindle
2	King Pin Center
3	Rigid Axle Stop
4	C/L Of Axle
5	Tie Rod
6	Axle Stop Bolt

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 8-8.

Final Adjustments

1. Inflate tires to the pressure specified on the tire inflation chart located on the carrier cab door.

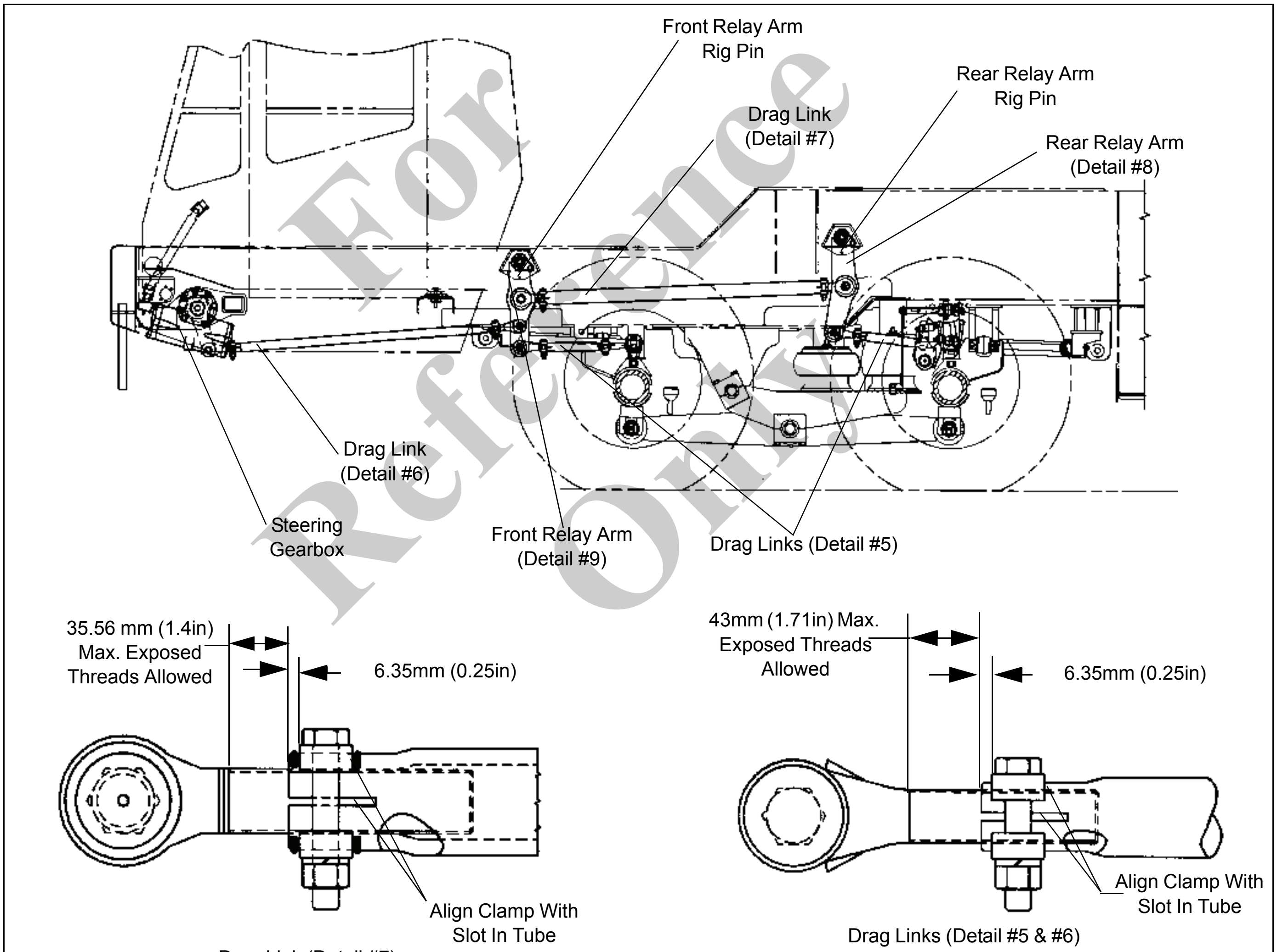


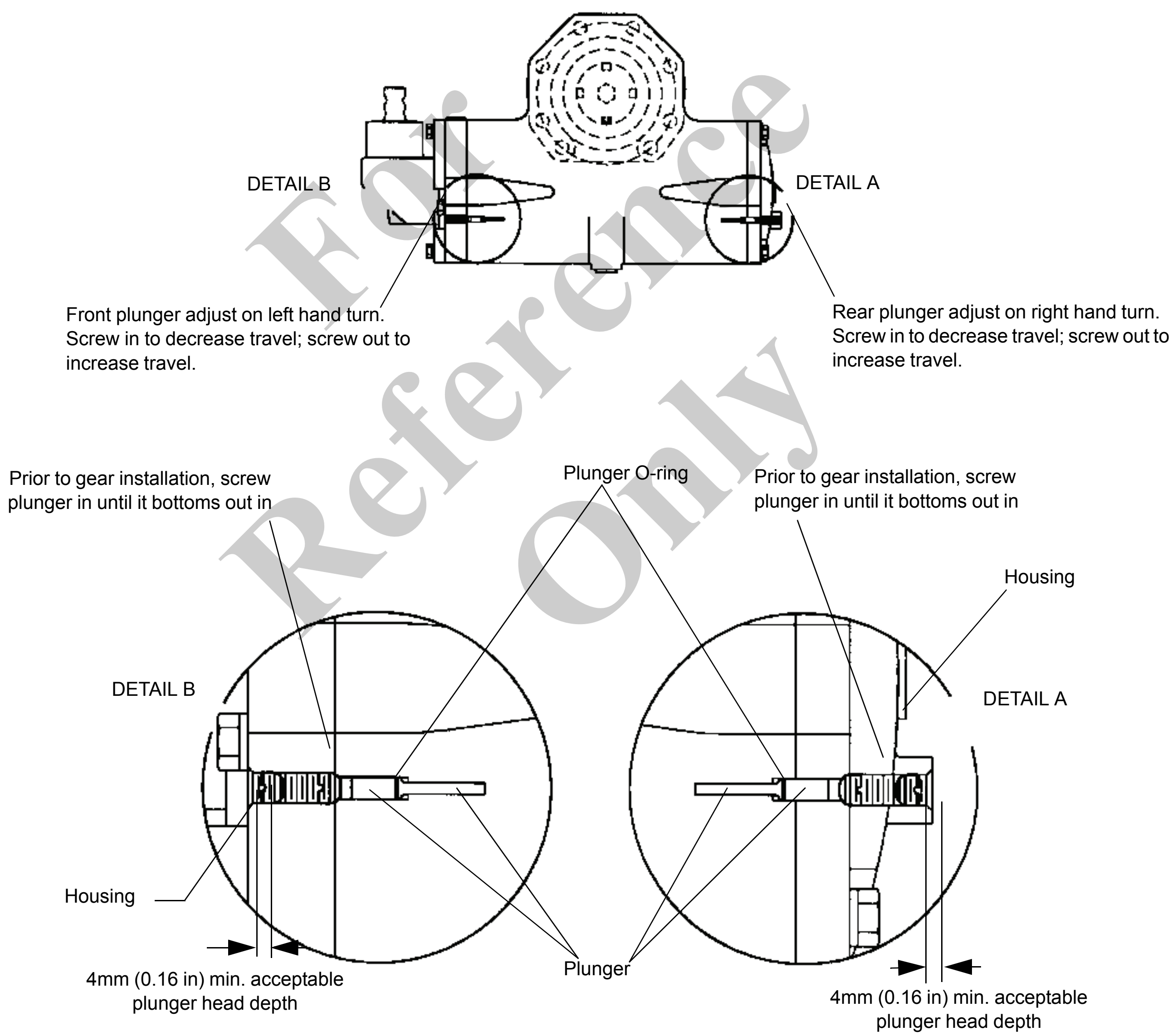
FIGURE 8-8

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. Crack 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 Drag Link Installation and Axle Synchronization in this section.



NOTE: Plunger(s) must not be screwed out beyond this depth. Damage could result.

FIGURE 8-9

7. Partially extend the outrigger beams. Attach a string line to front and rear outrigger beams as shown in Figure 8-2. Ensure the string line is taut and level.
8. Refer to Figure 8-2 and ensure that Dimension C equals Dimension D and that Dimension E equals Dimension F.
9. Refer to Figure 8-8 and 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.
10. Remove the rig pins.

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 between 25 mm (1.00 in) and 38 mm (1.50 in).
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.
5. Remove cap from test nipple at port GP8 upstream from the inlet of the power steering gearbox. Install a pressure check diagnostic quick disconnect with gauge onto test nipple at port GP8.

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 and 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). (Figure 8-9)
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 and 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. Remove diagnostic gear and reinstall cap on port GP8.
11. 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.

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

Table 8-1Troubleshooting

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.	**a.** Replace actuating shaft seal.
	b. Damaged actuating shaft seal surface.	**b.** Replace bearing cap, actuating shafts assembly.
3. Lubricating oil discolored or smells bad.	**a.** Operating temperatures too high.	**a.** Check and correct cause of overheating.
	b. Change intervals too long.	**b.** Change oil more often.
4. High operating temperatures.	**a.** Oil flow restriction.	**a.** Check back pressure.
	b. Oil flow too high.	**b.** Check maximum oil flow.
5. Excessive pump pressure with steering gear in neutral.	**a.** Pinched oil return line, high back pressure.	**a.** Relocate line.
	b. Binding steering column.	**b.** Repair steering column.
6. Wheel cuts restricted.	**a.** Relief plungers not adjusted properly.	**a.** Adjust relief plungers.
7. Erratic steering or mechanical steering only.	**a.** Insufficient volume of oil.	**a.** Refer to pump servicing instructions.
	b. Sticking pressure relief valve in steering gear.	**b.** Repair or replace relief valve as required.
8. Hard steering.	**a.** Faulty supply pump.	**a.** Check pump flow.
	b. Steering out of alignment.	**b.** Align front end.
	c. High operating temperature.	**c.** Locate and correct cause of overheating.
9. Wheel turns hard in one or both directions.	**a.** Dirt or foreign matter trapped in piston relief.	**a.** Check pressure relief.
	b. Bent or damaged king pins and tie rods.	**b.** Repair or replace king pins and tie rods.
	c. Front end load too great.	**c.** Lighten load.
	d. Low oil level in steering system.	**d.** Fill oil reserve as required.
10. Wheel turns hard in one or both directions.	**a.** Air in system.	**a.** Bleed system and check for cause of air.

Table 8-1Troubleshooting

Symptom	Probable Cause	Solution
	b. Caster degree incorrect.	**b.** Correct to specified degree.
11. 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.
12. No attempt to return straight ahead from turns/should also be hard steering complaint.	**a.** No positive caster.	**a.** Set caster to specified degree.
	b. Steering column bind.	**b.** Check and repair U-joints and support bearings.
	c. Steering gear mounting distorted.	**c.** Shim mounting pads to correct piston to bore interference. Make sure correct bolt length is used on the base mount gears.
	d. Linkage ball sockets seized or binding.	**d.** Check and repair or replace.
	e. King pins seized or binding.	**e.** Repair or replace.
	f. Oil flow rate incorrect.	**f.** Check and correct supply pump.
13. Darting, wandering, oversteering.	**a.** Oil flow too high.	**a.** Supply pump not to specifications.
	b. Air trapped in steering gear.	**b.** Bleed system.
	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.
14. 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.
15. 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.

Table 8-1Troubleshooting

Symptom	Probable Cause	Solution
	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: For more information on steering column and steering wheel maintenance, refer to Shop Reference and Maintenance Guide.

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 a 138 bar (2000 psi) at the pump outlet.

STEERING PUMP

Description

The steering pump is a gear type pump mounted on and driven by the engine. The pump provides the hydraulic flow necessary to power the steering gearbox. The pump provides a priority flow of approximately 38 lpm (10 gpm) at 137.90 bar (2000 psi). For additional information on the pump, refer to Hydraulic Pumps in Section 2 - HYDRAULIC AND PRESSURE SETTINGS.

STEERING GEARBOX

Description

The steering gearbox 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 six screws 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) (Figure 8-9).

2. Position the gearbox on the mounting and secure with eight screws and washers. Apply Loctite #243 to the gear box mounting bolts. Torque bolts to 520 Nm (384 ft-lb).
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 pittman arm must be at the angle shown in Figure 8-10. 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 gearbox shaft and secure the pittman 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 pittman 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.

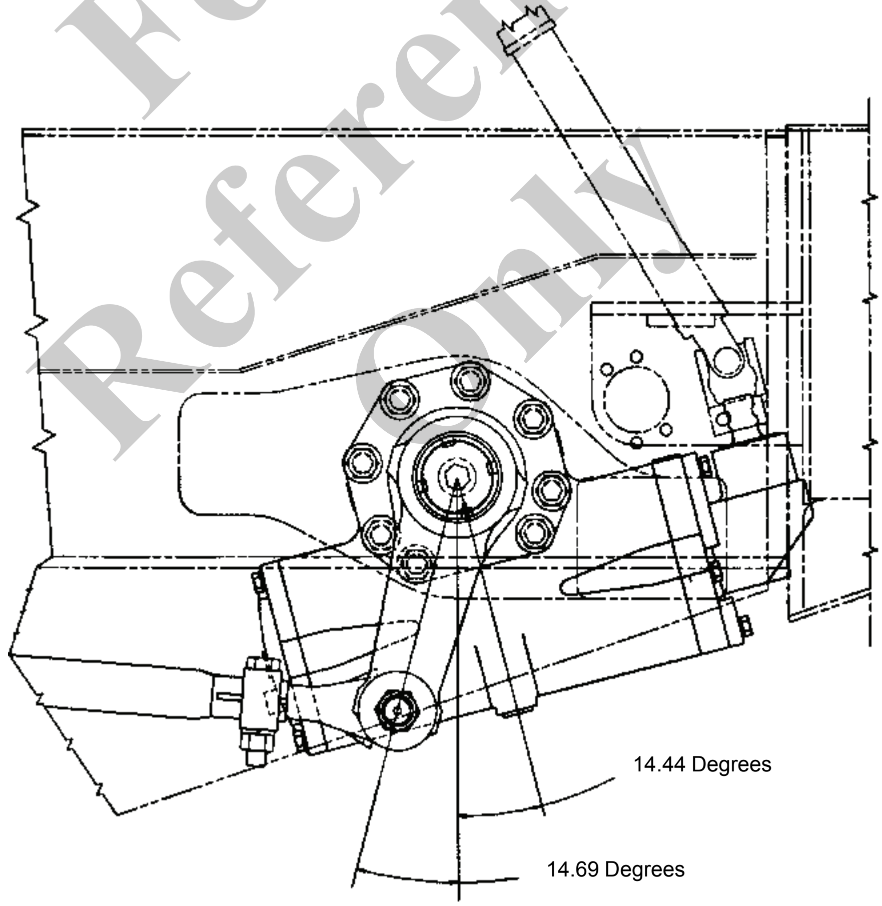


FIGURE 8-10

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 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 *Steer Cylinder*, page 2-67.

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 to 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 8-11) 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 8-11) 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 right 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 bushing is 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).

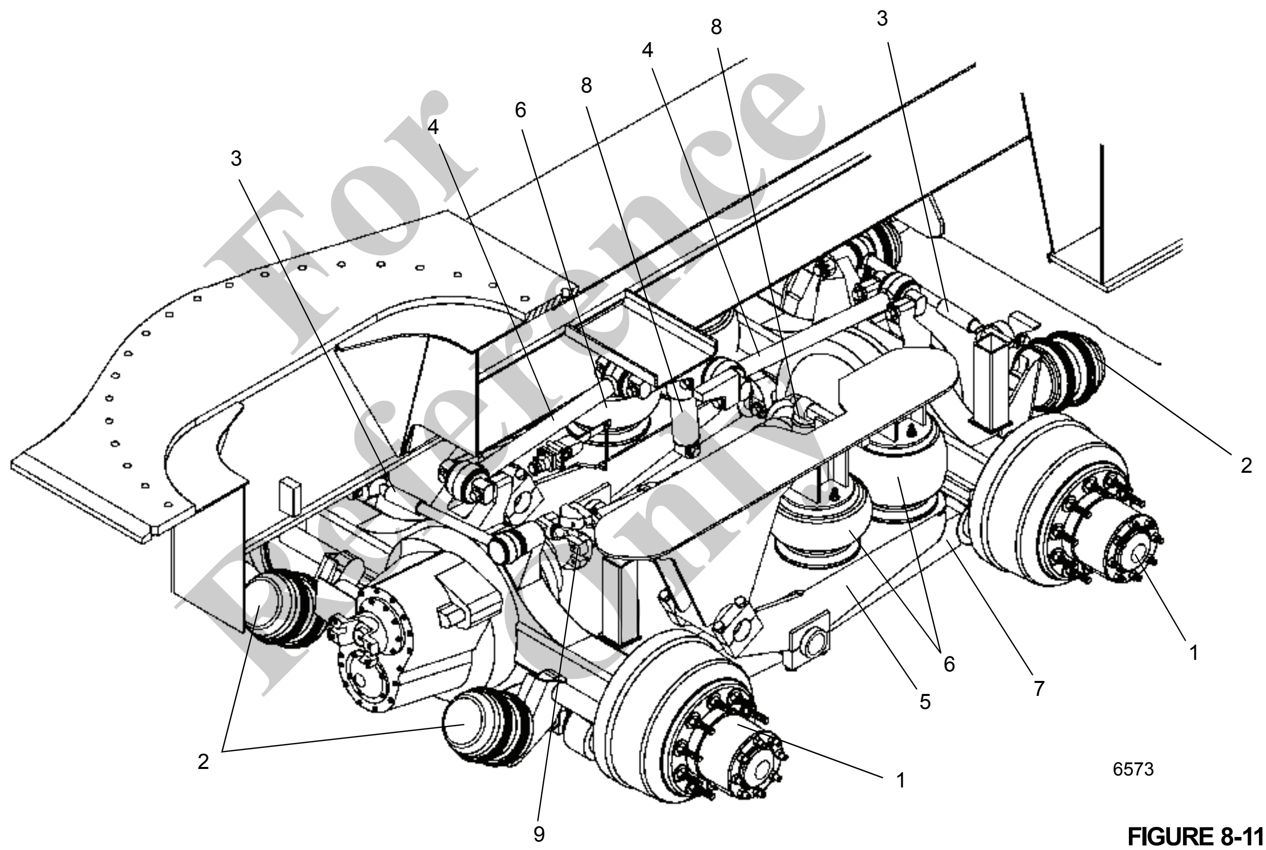


FIGURE 8-11

Item	Description
1	Rear Drive Axles
2	Air Brake Chambers
3	Lateral Torque Rod
4	Torque Rod Assembly
5	Saddle Assembly
6	Air Bags
7	Walking Beam
8	Shock Absorber
9	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.

NOTE: For more information on the axles, refer to Volume 2 - Service Maintenance Manual or the Arvinmeritor web site.

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 capscrews, washers, and hex 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 capscrew, washer, and hex nuts securing each shock absorber to the carrier frame.
10. With the axles and suspension fully supported, remove the nuts and washers securing each of the four air bags to the carrier frame brackets.
11. Remove the bolts and flatwashers 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 bolt and flatwashers securing each. Remove the shock absorber(s).
5. Remove each axle from the walking beams by removing the bolts, flatwashers, locknuts and shim 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 flatwashers 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 locknut and flatwasher. 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 locknut and flatwasher.
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 bolts and flatwashers. 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 the bolts, flatwashers, locknuts and shim. 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 bolt and flatwasher. Torque the nuts 610 Nm (450 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 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 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 bolts and flatwashers. Torque 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. Apply Loctite® 243 to attaching nut and secure each shock absorber to the carrier frame with a nut and washer. Torque nut to 610 Nm (450 lb-ft).
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 the capscrews, washers and hex nuts. Torque the capscrews 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 8-19 in this Section.
14. Retract the outriggers and check the axles for proper operation.

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, match 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 axle 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.

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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 8-12).
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 8-12).
8. Install lug nut covers on lug nuts.
9. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.

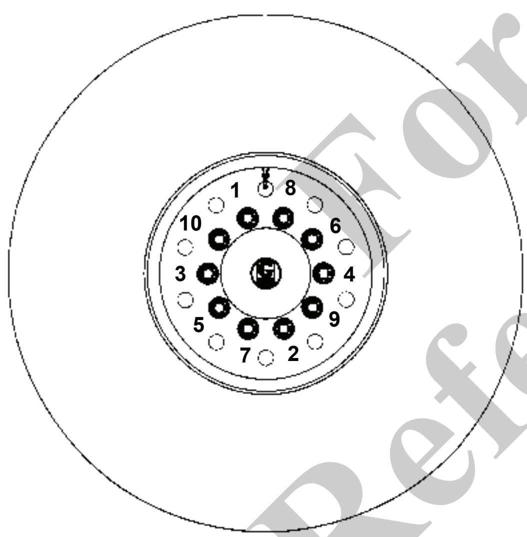

FIGURE 8-12

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 mi) after the wheels are removed and reinstalled. This will reseat the lug nuts. Check the torque every 800 km (500 mi) 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 axle 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. Place the wheel guard (aka the spacer) on the mounting studs so it can space the inside and outside wheel and tire assemblies.
5. Install the outside aluminum wheel assembly so the valve extension from the inside tire can fit through the hole provided for it. In Figure 8-13, 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.
6. Place three spring clips (mounted evenly on the axle flange with the fingers extending inward toward the wheel base. Slide hub cover over clips.
7. 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.
8. 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.
9. Tighten the lug nuts in the sequence shown to a preliminary torque of 68 Nm (50 lb-ft) (see Figure 8-13).
10. 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).
11. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.
12. 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 mi) after the wheels are removed and reinstalled. This will reseat the lug nuts. Check the torque every 800 km (500 mi) thereafter.

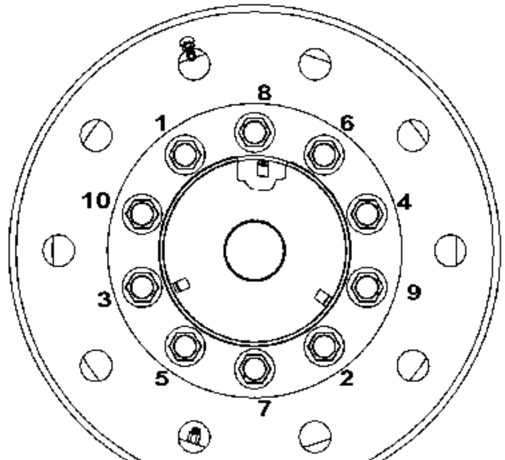

FIGURE 8-13

BRAKES

Description

The front and rear brakes are air actuated brakes which are cam operated and employ shoe and lining assemblies. 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.

NOTE: For more information on the brakes, refer to Volume 2 - Service Maintenance Manual or the Arvinmeritor web site.

Rear Brake 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.

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.

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.
3. Adjusted stroke is too long and no adjustment	**a.** Clevis installed at wrong angle	**a.** Install clevis correctly
	b. Excessive wear between clevis and collar	**b.** Replace clevis
	c. Loose jam nut at clevis	**c.** Tighten to specification
	d. Worn clevis pin bushing in slack arm.	**d.** Replace bushing
	e. Weak or broken return spring in air chamber	**e.** Replace return spring or air chamber
	f. Spring brake does not retract fully.	**f.** Repair or replace spring brake.
	g. Worn or stripped teeth on pawl or actuator.	**g.** Replace slack adjuster
	h. Excessive looseness between splines of camshaft.	**h.** Replace powershaft, gear or automatic slack adjuster as needed.
	i. Worn components in brake.	**i.** Replace worn component.
4. Adjusted stroke is too short or linings drag.	**a.** Clevis installed at wrong angle.	**a.** Install clevis correctly.
	b. Loose jam nut at clevis.	**b.** Tighten to specification.
	c. Spring brake does not retract fully.	**c.** Repair or replace spring brake.
	d. Wrong brake adjustment	**d.** Adjust brake
	e. Poor contact between linings and drum, or drum is out-of-round.	**e.** Repair or replace drums or linings.
	f. Brake temperature imbalance	**f.** Correct brake balance.

FRONT BRAKES

Description

The front brakes are air actuated brakes which are cam operated and that employ shoe and lining assemblies. Automatic slack adjusters maintain the proper adjustment for the pushrod stroke and lining-to-drum clearance. The cam is actuated by the air chamber.

Disassembly

DANGER

Do not work under a crane supported by only outrigger jacks. Use stands to support the carrier.

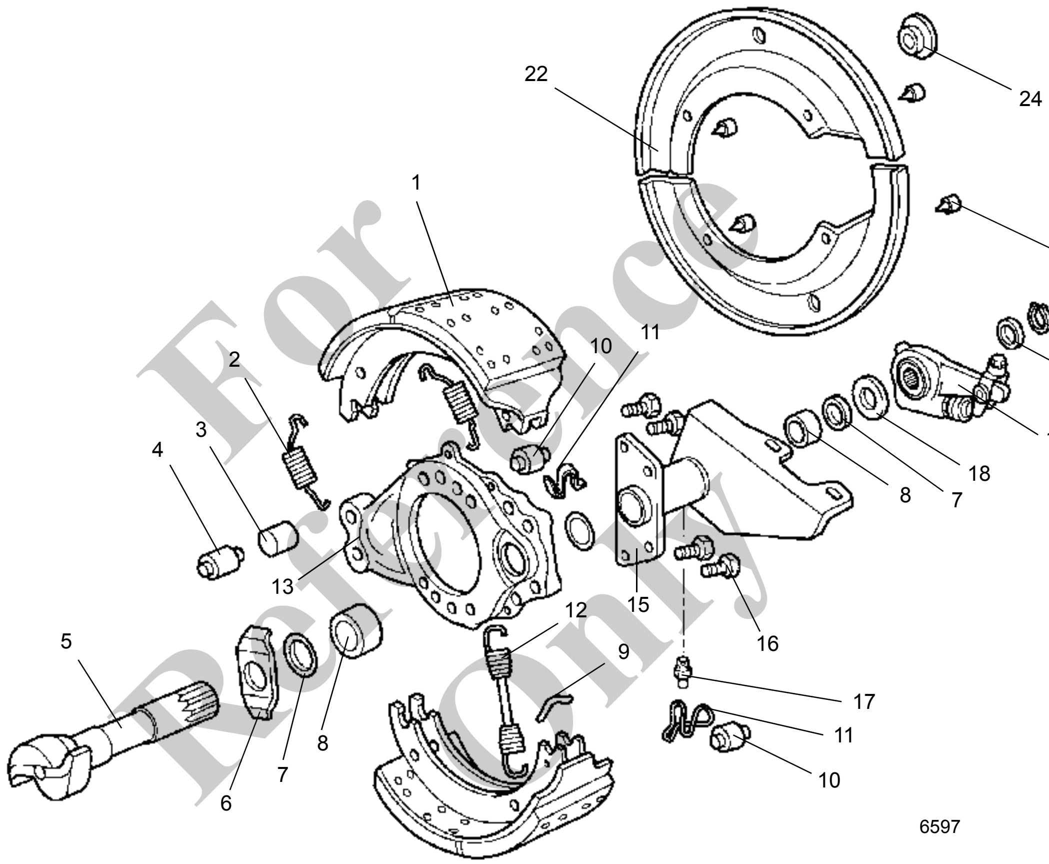

FIGURE 8-14

Item	Description
1	Shoe and Lining Assembly
2	Shoe Retaining Spring
3	Anchor Pin Bushing
4	Brake Shoe Anchor Pin
5	Camshaft
6	Cam Head Washer
7	Camshaft Grease Seal
8	Camshaft Bushing
9	Return Spring Pin
10	Brake Shoe Roller
11	Shoe Roller Retainer
12	Brake Shoe Return Spring

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Item	Description
13	Cast Brake Spider
14	Chamber Bracket Seal
15	Camshaft and Chamber Bracket
16	Chamber Bracket Capscrew
17	Grease Fitting
18	Thick Camshaft Washer
19	Automatic Slack Adjuster
20	Spacing Washer
21	Camshaft Snap Ring
22	Dust Shield
23	Dust Shield Capscrew
24	Plug

1. Set the parking brakes and block the wheels.
2. Raise the carrier so that the front wheels are off the ground. Support with safety stand.

WARNING

Sudden release of a compressed spring can cause serious personal injury.

3. If the brake has spring chambers, carefully cage and lock the spring so that the spring can not actuate during disassembly.
4. Fully release the automatic slack adjusters so that the brake shoes retract and the drum clears the linings.
5. Remove the hub cap, axle spindle nut, and washer.

CAUTION

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.
8. Pry the roller retainer loops out of the shoe web holes. Pivot the roller retainer to swing the loops clear of shoe webs (Figure 8-14).
9. Push down on the bottom brake shoe. Pull on the brake shoe roller retainer clip to remove the bottom roller (Figure 8-15).

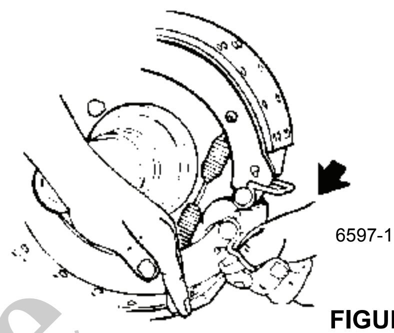

FIGURE 8-15

10. Lift the top brake shoe and pull on the brake shoe roller retainer clip to remove the top roller.
11. Lift the bottom shoe to release the tension on the brake shoe return spring (Figure 8-16).

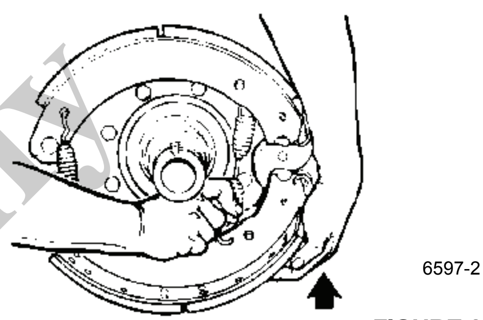

FIGURE 8-16

12. Rotate the bottom shoe to release the tension on the brake shoe retainer springs (Figure 8-17).

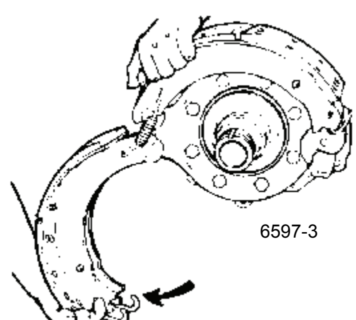

FIGURE 8-17

13. Remove the shoe retainer springs and the brake shoes.

14. Use the correct bushing driver tool to remove the anchor pin bushings from the spider.
15. Remove the slack adjuster. Reference Slack Adjuster Removal this Section.
16. Remove the camshaft by grasping the camshaft head and pulling outboard.
17. Remove the bolts attaching the air chamber bracket to the spider and pull it away from the spider.
18. Remove spider-to-axle attaching nuts and bolts and remove the spider.
19. Remove screws and retaining clip securing dust shield to spider and remove dust shield.

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.

1. Wire brush all parts exposed to mud, road dirt, and salt, to include the spider, air chamber bracket, dust shield, and exterior of drum.
2. 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.
3. 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. Check the spider for expanded anchor pin holes and for cracks. Replace damaged spiders and anchor pin bushings.
3. Check the camshaft bracket for broken welds, cracks and correct alignment. Replace damaged brackets.
4. Check the anchor pins for corrosion and wear. Replace worn or damaged anchor pins.
5. Inspect the shoes for rust, expanded rivet holes, broken welds and correct alignment. Replace a shoe with any of the conditions listed in steps 2 through 5.
6. Anchor pin holes must not exceed 25.63 mm (1.009 in) in diameter. The distance from the center of the anchor pin hole to the center of the roller hole must not exceed 32.46 cm (12.779 in). Replace brake shoes with measurements that do not meet these specifications (Figure 8-18).

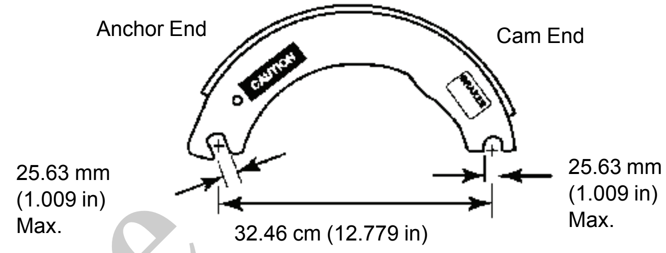

FIGURE 8-18

7. 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.
8. Each time the brake shoes are removed, check camshaft radial play as outlined below
   a. Mount a dial indicator with the 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.
9. Check the end of the camshaft for cracks and worn or deformed splines. Replace as necessary.
10. 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.
11. 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.

12. Check the camshaft bushings for deterioration or wear. The inner surface must be smooth. Replace the bushing if surface is rough or abrasive.

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13. Check the grease seals and replace if nicked, cut, or distorted.
14. Check the air chamber bracket for a bent, broken, or cracked arm and welds. Replace as necessary.
15. Check the air chamber bracket mounting studs for looseness, damaged threads, or bent studs. Replace as necessary.
16. Check the air chamber for leaks, cracked housing, bent push rod, loose clamp ring, clogged vent holes, or loose air fittings. Repair or replace as necessary.
17. 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 in this Section for adjustment.
18. If a new air chamber is installed, ensure that the cutoff push rod does not project too far into the clevis. Minimum clearance from the clevis centerline to push rod end is 22.2 mm (0.875 in).
19. Check air chamber clevis pin for cracks and wear.
20. Check the automatic slack adjuster. Reference automatic Slack Adjuster this Section.

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 8-19).

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.

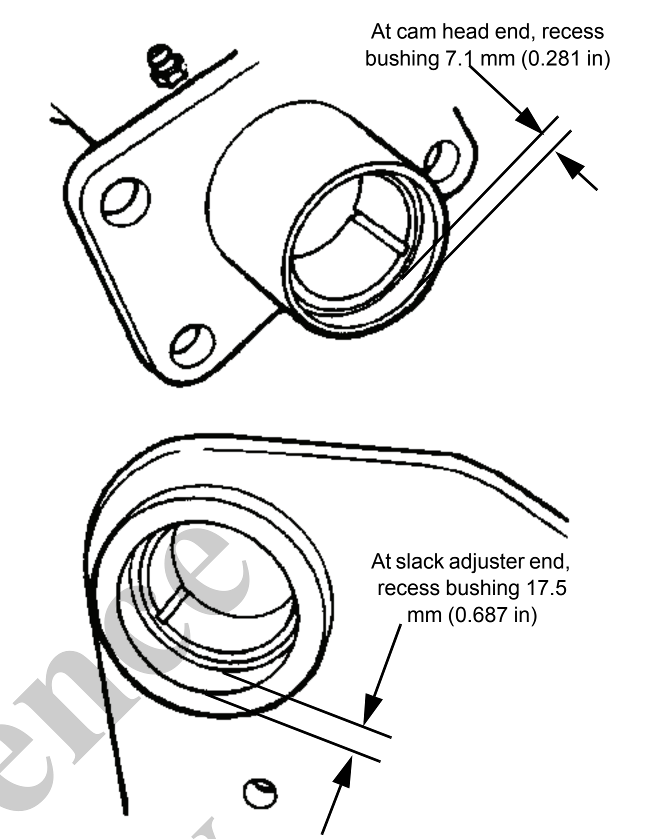


FIGURE 8-19

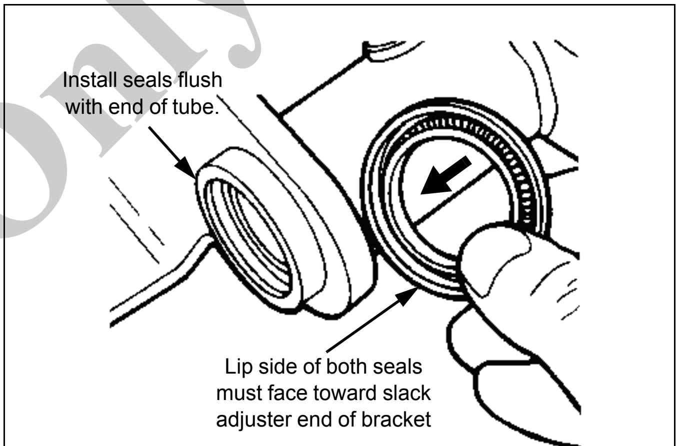


FIGURE 8-20

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 8-20).

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 lockwashers. 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. Reference Slack Adjuster Installation in this section.
6. Installation of brake shoes is as follows:
    a. Lubricate the brake shoe roller pin and anchor pin. Do not get grease on the cam roller pin center surface.
    b. Place the upper brake shoe into position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin. Install two new brake shoe retaining springs (Figure 8-21).

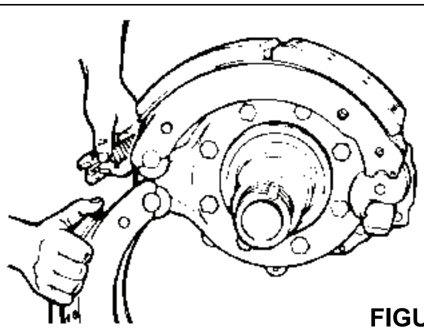


FIGURE 8-21

    c. Rotate the lower brake shoe forward. Install a new brake shoe return spring with the open end of the spring hooks toward the camshaft (Figure 8-22).

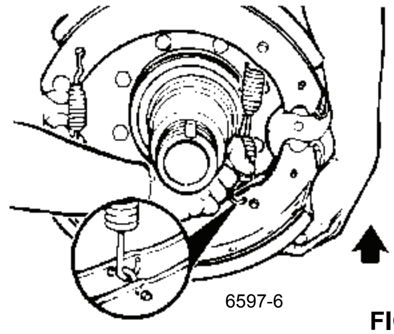


FIGURE 8-22

    d. Pull each brake shoe away from the camshaft to enable you to install the brake shoe roller retainer. Press the retainer ears to fit into the retainer between the brake shoe webs. (Figure 8-23).

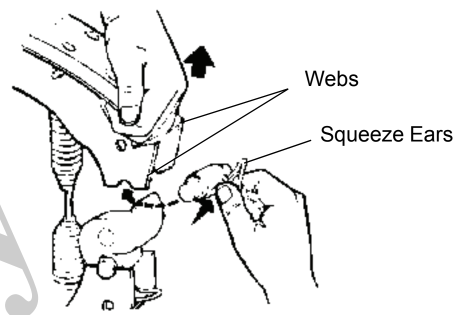


FIGURE 8-23

    e. Push the brake shoe roller retainer into the brake shoe until the ears lock into the shoe web holes (Figure 8-24).

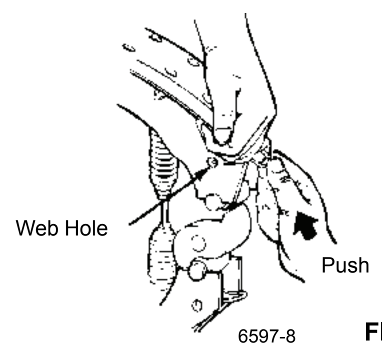
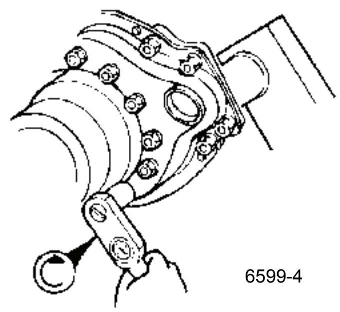


FIGURE 8-24

    f. Repeat steps (b) thru (e) on the upper shoe.
7. Install the drum and axle spindle nut(s) and washers.

Camshaft Installation

1. Check the camshaft for cracks, wear and corrosion. Check the cam head, bearing journals and splines. Replace worn or damaged camshafts
2. Install new camshaft bushings and seals whenever you install a new camshaft.
3. Tighten all spider bolts to the correct torque (Figure 8-25).



Bolt Size	Nm	lb-ft
7/16" - 20	81 - 102	60 - 75
1/2" - 20	115 - 156	85 - 115
9/16" - 18	176 - 224	130 - 165
5/8" - 18	244 - 312	180 - 230
7/8" - 9	598 - 789	440 - 580

FIGURE 8-25

4. Use a seal driver to install new camshaft seals and new bushings into the cast spider and camshaft bracket (Figure 8-26).

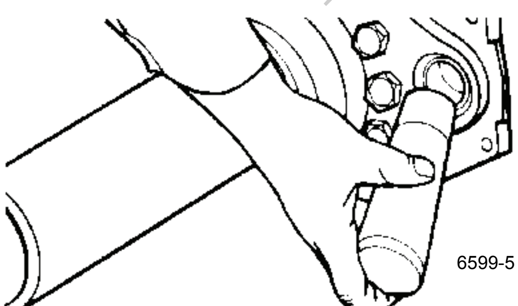


FIGURE 8-26

NOTE: Install the seals with the seal lips toward the slack adjuster to ensure grease purges at the slack end (Figure 8-27).

5. If the camshaft bracket has been removed, install the chamber bracket seal and bracket onto the spider. Tighten the capscrews to the correct torque (Figure 8-25).

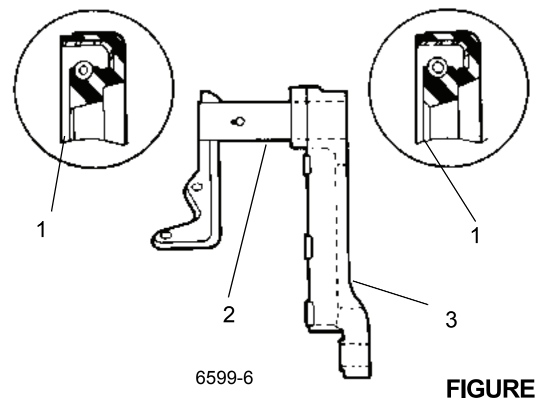


FIGURE 8-27

Item	Description
1	Seal Lip
2	Camshaft Bracket
3	Spider

REAR BRAKES

Description

The rear brakes are air actuated brakes which are cam operated and that employ shoe and lining assemblies. Automatic slack adjusters maintain the proper adjustment for the push rod stroke and lining-to-drum clearance. The cam is actuated by the air chamber.

Disassembly

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. Support with safety stand.
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. Refer to Slack Adjuster in this section.
5. Remove the brake drum.

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.

Removal

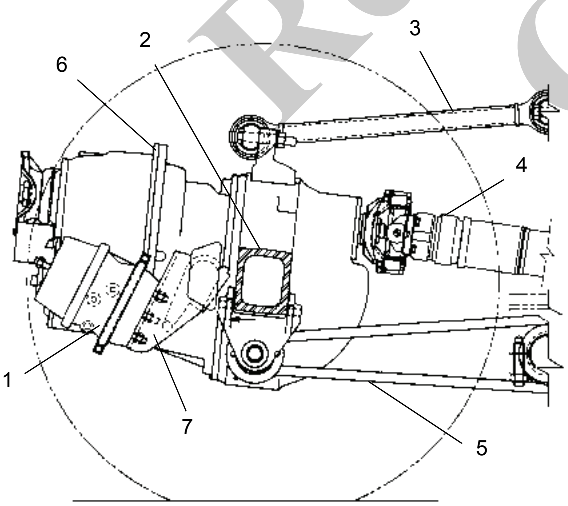


FIGURE 8-28

Item	Description
1	Brake Air Chamber
2	Axle No. 3
3	Torque Rod
4	Drive Shaft
5	Stabilizer Beam
6	Differential
7	Mounting Bracket

WARNING

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 8-28).

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 8-29).
2. Separate the lower cover from the spring brake chamber.
3. If the push rod needs the spring to be removed, mark the position of the clevis on the push rod. Remove the clevis and jam nut.
4. Remove the push rod (see Figure 8-30).

Assembly

1. Insert the push rod through the spring and cover.
2. Screw on the jam nut and clevis as per removal marks.

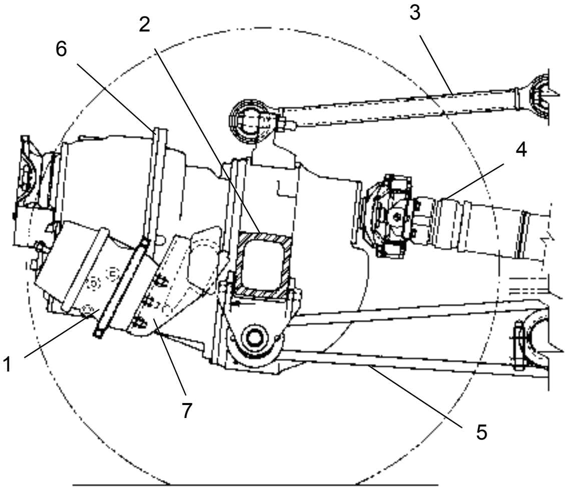


FIGURE 8-29

Item	Description
1	Brake Air Chamber
2	Axle No. 3
3	Torque Rod
4	Drive Shaft
5	Stabilizer Beam
6	Differential
7	Mounting Bracket

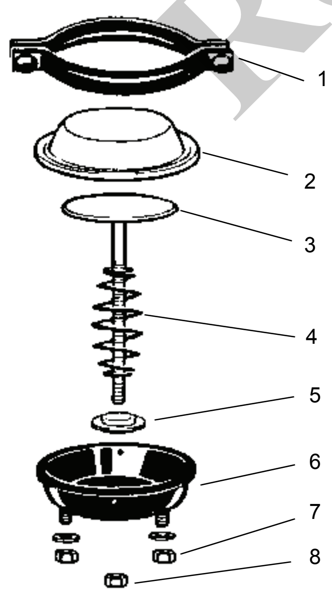


FIGURE 8-30

Item	Description
1	Clamp
2	Diaphragm
3	Push Rod
4	Spring
5	Shield
6	Cover
7	Mounting Nut
8	Jam Nut

3. Position the diaphragm over the push rod (see Figure 8-30).
4. Push the lower cover assembly into the spring brake chamber and secure with the clamp.

Rear Brake Shoe Removal

CAUTION

Use a brass or synthetic mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

1. Remove the anchor pin snap ring, washer, retainer, felts, seals or capscrews as required.
2. Use a brass drift to remove the top anchor pin (Figure 8-31).

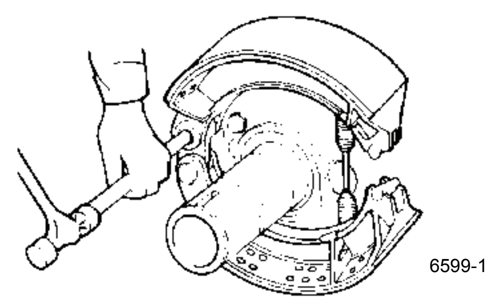


FIGURE 8-31

3. Rotate the top shoe to release the tension on the brake shoe return spring. Remove the shoe (Figure 8-32).

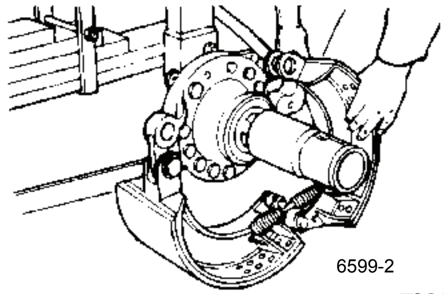


FIGURE 8-32

4. Use a brass drift to remove the bottom anchor pin. Remove the bottom shoe. If necessary, remove the rollers (Figure 8-33).

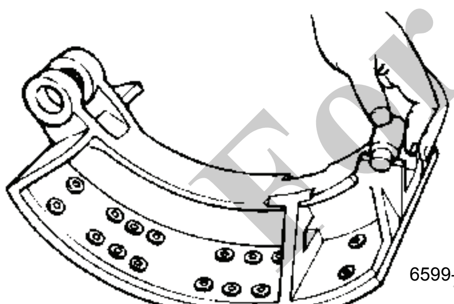


FIGURE 8-33

Clean and Inspect Parts

NOTE: Refer to Inspection under Front Brakes in this section.

Rear Brake Assembly

Each time the brakes are relined, the following parts should also be replaced.

- Springs
- Rollers
- Anchor Pins
- Clevis Pins
- Camshaft Seals

1. Lubricate the camshaft roller pin and anchor pin with grease.
2. Install the anchor pin bushings. If necessary, align the holes in the bushings with the holes in the spider.
3. Install a new cam roller and cam roller retainers.

Rear Brake Shoe Installation

1. Install the lower brake shoe in position on the spider.
2. Use a hammer and brass drift to install the anchor pin. If necessary, align the groove on the anchor pin with the holes in the spider and bushing.
3. Install the anchor pin washers, felts, seals, retainers and snap rings, if required. Install lock pins or lock screws, if required. Tighten the screws 13.6 to 20.3 Nm (10 to 15 lb-ft).
4. Install a new shoe return spring onto the brake shoe (Figure 8-34). Place the upper brake shoe into position over the spider. Repeat steps 1 and 2.

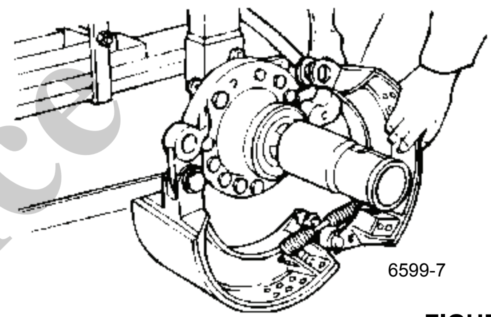


FIGURE 8-34

5. Install the slack adjuster and adjust brakes. Refer to Slack Adjuster in this section.

AUTOMATIC SLACK ADJUSTER (FRONT)

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.

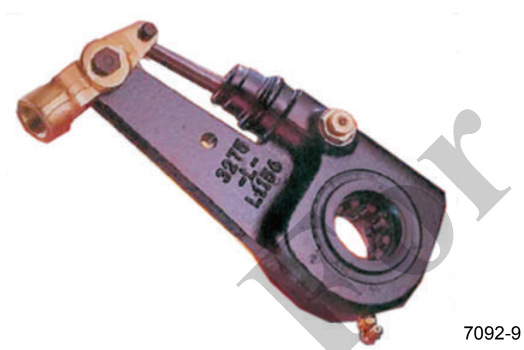
This motion rotates the worm, worm wheel, and the S-cam shaft resulting in adjustment of the brakes.

Maintenance

There are 2 different styles of slack adjusters used for this brake system. It is necessary to determine style applicable to this crane.

Slack Adjuster Style #1

NOTE: If your slack adjuster is as pictured in Figure 8-35 Style #1, use the removal, installation and adjustment procedures that follows. See *Slack Adjuster Style #2*, page 8-35.



7092-9

Style #1 **FIGURE 8-35**

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.
3. Release the parking brakes and shut down the engine.

4. Adjust the primary and secondary air tank pressures to 6.2 to 6.8 bar (90 to 100 psi).
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 8-36).

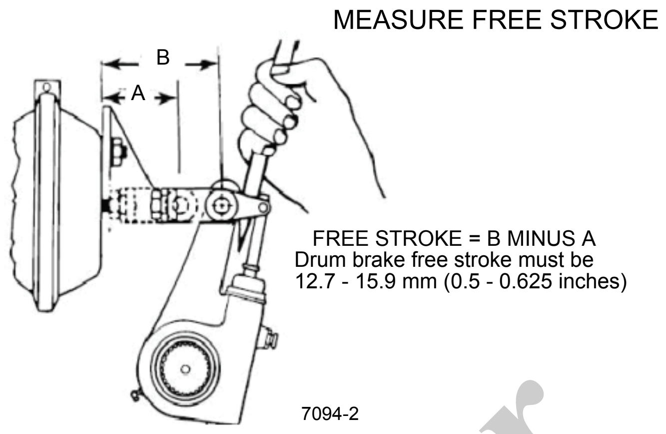


FIGURE 8-36

6. Starting with 6.2 to 6.8 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 8-36).
7. Subtract Dimension “A” from Dimension “B” for each brake position (Figure 8-36). 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 you Manitowoc Crane Care distributor. 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 8-37).

FIGURE 8-37

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 8-38).

FIGURE 8-38

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 8-39).

7092-3
FIGURE 8-39

If not absolutely sure of correct bolt-to-piston engagement, repeat step 5 until sure.

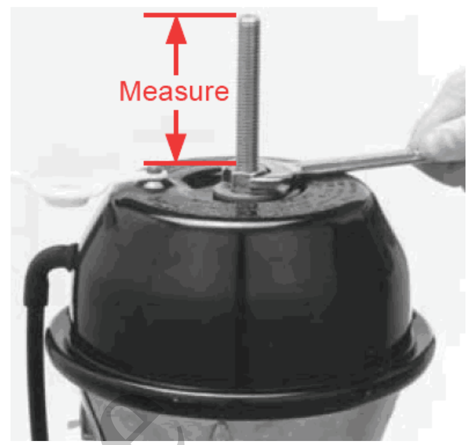
5. Turn the release-bolt 1/4 turn clockwise and pull the bolt out to lock the formed end into the piston. If the bolt does not lock into the piston in less than 13 mm (1/2 inch) outward movement, repeat steps 4 and 5 until it locks.
6. Holding the bolt locked into the piston, install the flatwasher and the release nut on the end of the release-bolt, and turn down the nut against the flatwasher until finger tight (Figure 8-40).

7092-4
FIGURE 8-40

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 8-41). Do not use an impact wrench.



7092-5
FIGURE 8-41

8. For easier manual-releasing, apply 6.2 - 8.6 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 8-42).

7092-6
FIGURE 8-42

CAUTION

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 8-43).

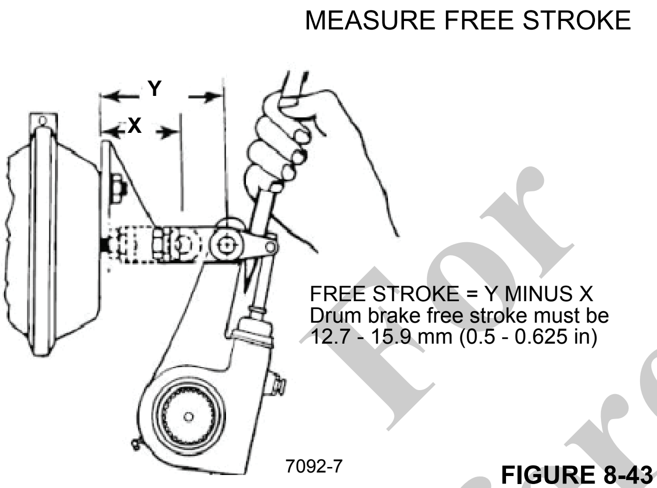


FIGURE 8-43

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 8-43).

CAUTION

See (Figure 8-43) and (Figure 8-44), 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 8-43). 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.

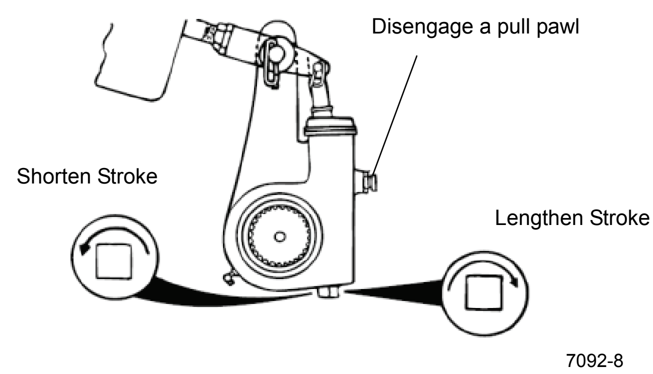


FIGURE 8-44

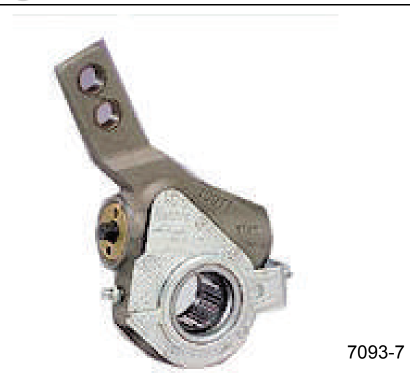
14. Disengage the pull pawl (Figure 8-44).

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 8-44).

16. Release the pawl and uncage the spring brake, if required.

Slack Adjuster Style #2

NOTE: If your slack adjuster is as pictured in (Figure 8-45) Style #2, use the removal, installation and adjustment procedures that follow.



Style #2 **FIGURE 8-45**

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 6.8 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 6.8 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.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures 6.2 to 6.8 bar (90 to 100 psi).
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 8-46).

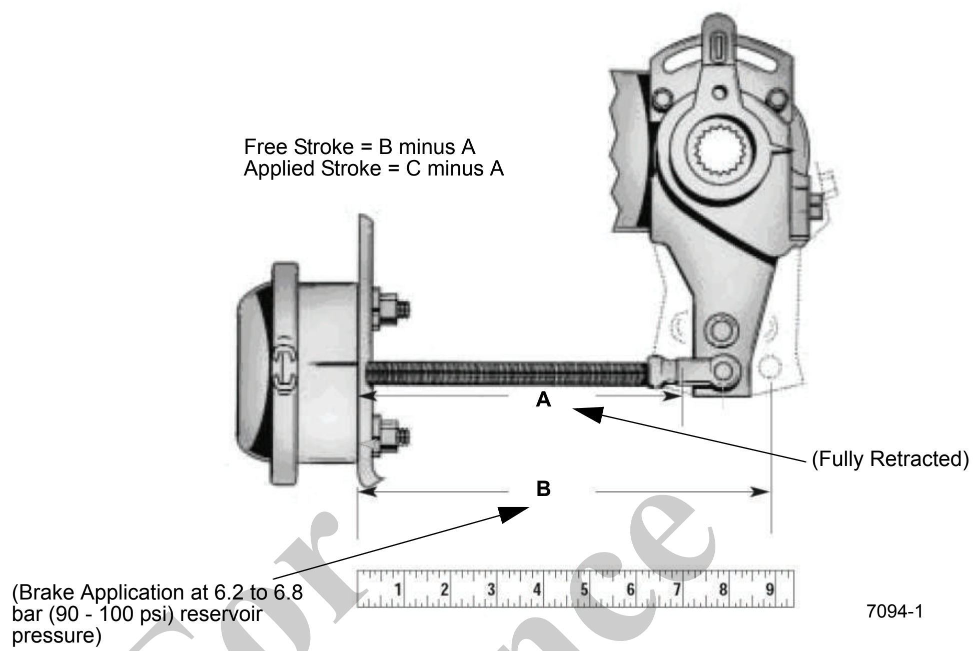


FIGURE 8-46

6. Starting with 6.2 to 6.8 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 8-46).
7. Subtract Dimension “A” from Dimension “B” for each brake position (Figure 8-46). 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 Manitowoc Crane Care distributor. 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.

CAUTION

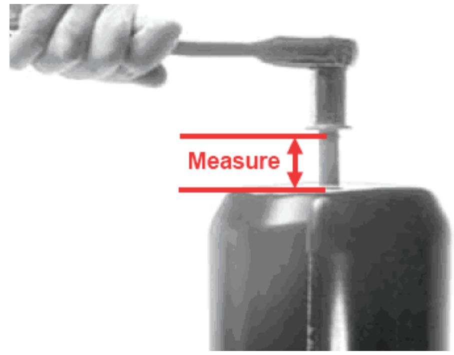
For easier turning of the release bolt, apply 6.5 to 8.6 bar (95 to 125 psi) air pressure to the air inlet port marked “Spring”. After caging, completely exhaust air from the spring chamber.

2. Turn the integral release bolt counterclockwise using a 3/4 inch (19 mm) socket wrench (Figure 8-47), 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.

8

7093-1

FIGURE 8-47



7093-2

FIGURE 8-48

CAUTION

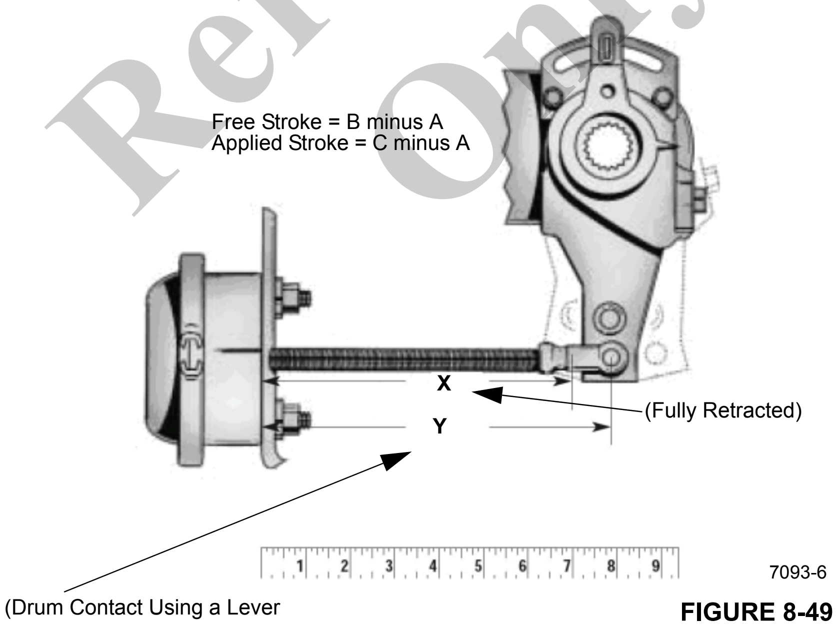
Do not exceed the length stated in step 3 and do not exceed 68 Nm (50 lb) torque on release bolt at any time or damage may occur which could prevent any further correct manual release of the spring brake chamber.

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 8-48). After caging, completely exhaust air from the spring chamber.

CAUTION

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 8-49)



7093-6

FIGURE 8-49

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 8-49).

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 8-50).

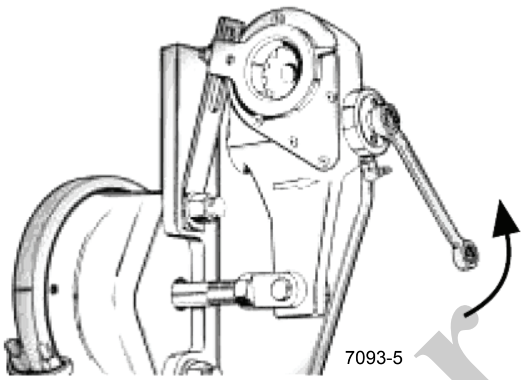


FIGURE 8-50

8. With brakes released, check installation indicator (Figure 8-49) and (Figure 8-50) to determine proper adjustment.
9. If installation indicator is not positioned properly, refer to (Figure 8-50). Loosen fastener holding indicator to anchor bracket, rotate indicator as required and retighten fastener.
10. Uncage spring brake if so equipped.

AUTOMATIC SLACK ADJUSTER (REAR)

Description

The automatic slack adjuster (see Figure 8-51) compensates for normal wear in the brake shoe linings by maintaining a nominal clearance between the lining and drum. These are preset at the manufacturer's factory.

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.

8

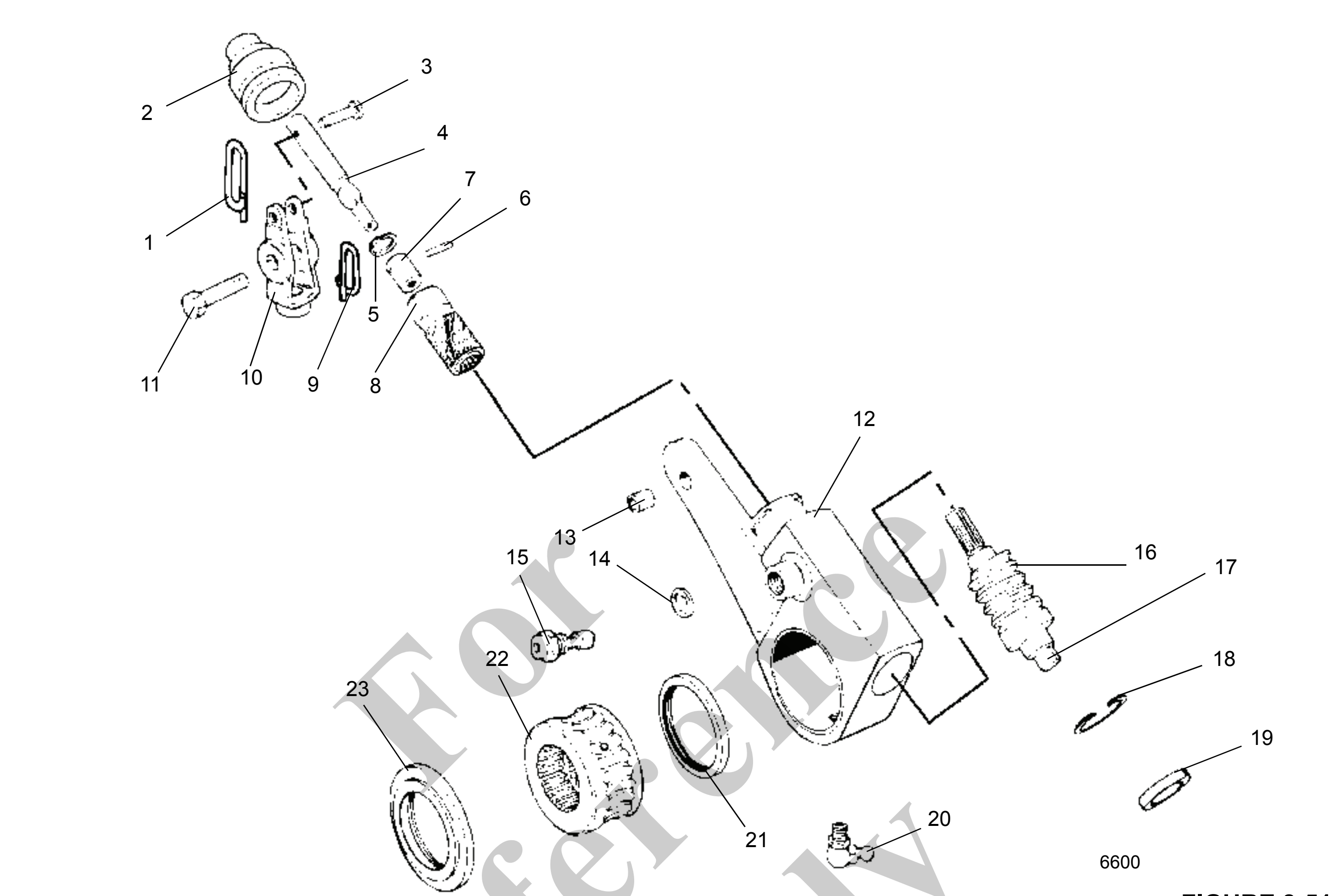


FIGURE 8-51

Item	Description
1	Retainer Clip
2	Boot
3	Clevis Pin
4	Actuator Rod
5	Retaining Ring
6	Roller Pin
7	Actuator Piston
8	Adjusting Sleeve
9	Retainer Clip
10	Clevis
11	Clevis Pin

Item	Description
12	Housing
13	Bushing
14	Gasket
15	Pull Pawl Assembly
16	Worm Gear
17	Manual Adjusting Nut
18	Retaining Ring
19	Worm Grease Seal
20	Grease Fitting
21	Face Seal
22	Gear
23	Retainer/Seal

Maintenance

Removal

CAUTION

You must disengage a pull pawl before rotating the manual adjusting nut, or you will damage the pawl teeth. A damaged pawl will not allow the slack adjuster to automatically adjust brake clearance.

1. Disengage the pull pawl. Use a screwdriver or equivalent tool to pry the pull pawl at least 0.8 mm (1/32 inch) 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 S spring, hold the spring with pliers. The spring can disengage from the clevis with enough force to cause serious personal injury.

3. Remove both clevis pins, retainer clips or cotter pins. Move the slack adjuster away from the clevis. Discard the retainer clips and cotter pins and replace with new ones.

Disassembly

1. Use a punch and hammer to tap the metal boot retaining ring from the slack adjuster housing.
2. Remove the boot from the housing. Pull the actuator assembly from the housing (Figure 8-52).

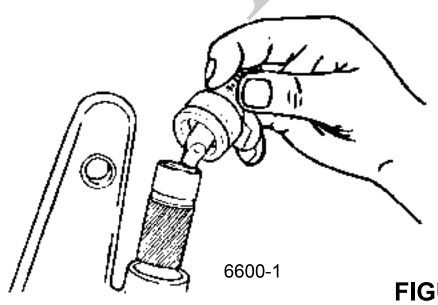


FIGURE 8-52

3. Use a small screwdriver to push down on one side of the piston retaining ring to force the ring out of the groove (Figure 8-53).
4. Extend the coils of the ring. Use pliers to unwind the ring and pull it out of the groove. Use a new ring when you assemble the slack adjuster (Figure 8-53).

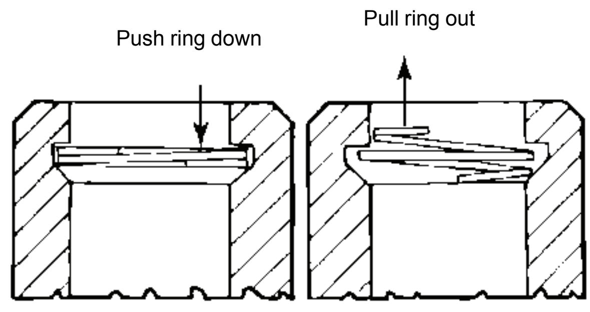


FIGURE 8-53

5. Pull the actuator rod, piston and pin from the actuator.
6. If necessary, remove the pin from the rod and piston (Figure 8-54).

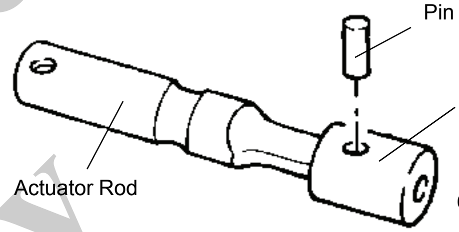


FIGURE 8-54

7. Inspect the clevis bushing in the slack adjuster arm for wear or damage. Replace a worn or damaged bushing. Check the bushing's diameter to ensure it does not exceed 13.5 mm (0.531 in) (Figure 8-55). If the bushing's diameter exceeds 13.5 mm (0.531 in), replace the bushing.

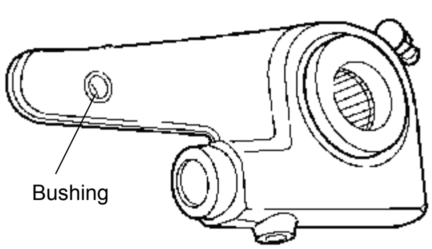


FIGURE 8-55

8. Use a small screwdriver to remove the grease seal from around the worm bore (Figure 8-56). Discard the seal. Install a new seal when you assemble the slack adjuster.

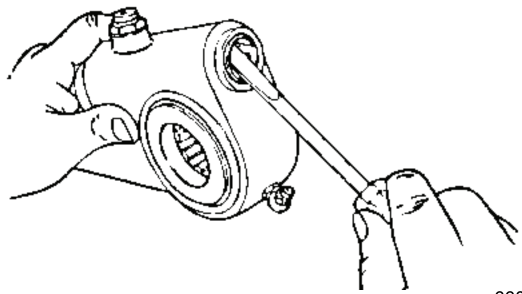

6600-5

FIGURE 8-56

Assembly

1. Use grease to lubricate the gear bore in the housing.
2. Lubricate the seal with grease. Press the seal into its groove. Push the gear into the housing.

CAUTION

Install the seal with the lips outside of the bore and the metal retainer inside of the bore to prevent contaminants from entering the slack adjuster housing. Damage to components can result.

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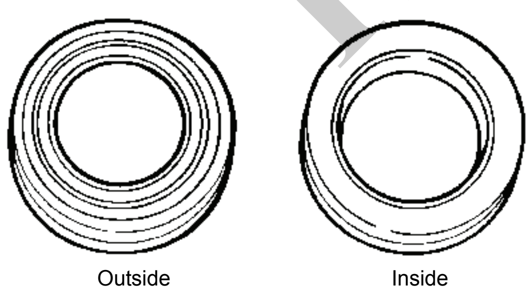
3. Place the seal directly over the worm bore with the seal lips outside of the bore and the metal retainer inside of the bore (Figure 8-57). Use a hammer and a 30.2 mm (1-3/16 inch) diameter seal driver to install the seal straight into the bore (Figure 8-58). Do not hit the seal after it reaches the bottom of the bore. Damage to the seal will result.



6600-6

FIGURE 8-57

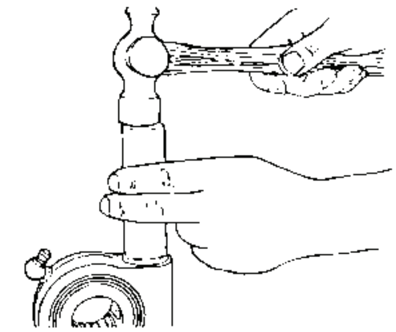
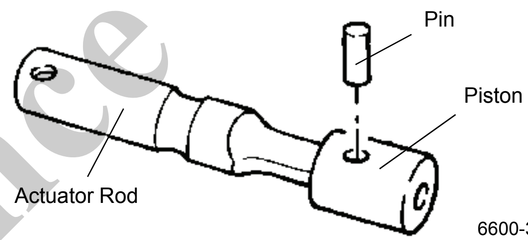

6600-7

FIGURE 8-58

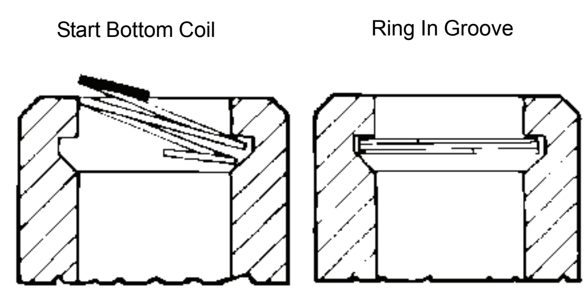
4. If the pin was removed, install it into the rod and piston (Figure 8-59).



6600-3

FIGURE 8-59

5. Apply a small amount of grease to the actuator piston and install the actuator rod and piston assembly into the actuator adjusting sleeve.
6. Slide the piston retaining ring over the rod.
7. Extend the coils of the ring.
8. Use a small screwdriver to press one end of the ring into the groove (Figure 8-60).



6600-8

FIGURE 8-60

9. Keep the coil extended. Press on the ring and work around the groove until the ring is in the groove completely.

10. Check to ensure that the ring is installed correctly in the groove. You cannot pull the piston out of the actuator if the retaining ring is installed correctly.
11. Disengage the pull pawl. Use a screwdriver or equivalent tool to pry the pull pawl at least 0.8 mm (1/32 inch) to disengage the teeth from the actuator.
12. Make sure the pull pawl is disengaged, and install the actuator assembly into the housing so that the actuator slides along the worn splines.
13. Fill the boot with grease and slip it over the actuator rod. Do not seal the boot to the tapered part of the actuator rod. The top of the boot must fit into the groove.
14. Press the boot metal ring into the slack adjuster housing.
15. Remove the screwdriver or equivalent tool from the pull pawl. The pull pawl will re-engage automatically.
16. Use a grease gun to lubricate the slack adjuster through the grease fitting. If necessary, install a camshaft into the slack adjuster gear to minimize the grease flow through the gear holes.
17. Apply lubrication until new grease purges from around the camshaft splines and from the pawl assembly.

Adjust the Brakes

NOTE: For more information on the brakes, refer to Volume 2 - Service Maintenance Manual or the Arvinmeritor web site.

Measure Free Stroke

When performing preventive maintenance on the brakes, check both the free stroke and adjusted chamber stroke. Free stroke sets the clearance between the linings and drum. The free stroke may be slightly longer than 12.7 to 15.9 mm (0.5 to 0.625 in). This is acceptable if the adjusted chamber stroke is within the limits outlined in the brake manufacturer's maintenance manual.

CAUTION

You must disengage a pull pawl before rotating the manual adjusting nut, or you will damage the pawl teeth. A damaged pawl will not allow the slack adjuster to automatically adjust brake clearance. Replace damaged pawls before putting vehicle in service.

1. Disengage a pull pawl. Use a screwdriver or equivalent tool to pry the pull pawl at least 0.8 mm (1/32 inch) to disengage the teeth.
2. Use a wrench to turn the adjusting nut counterclockwise until the brake shoe contacts the drum (Figure 8-61). Then back off the adjusting nut in the opposite direction 1/2 turn for drum brakes.

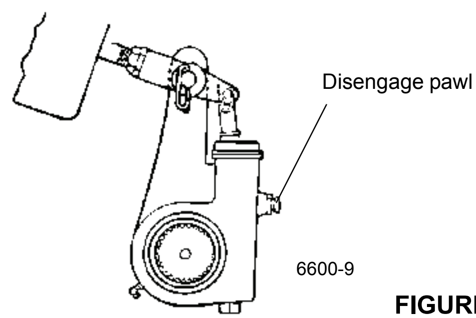


FIGURE 8-61

3. Measure the distance from the center of the large clevis pin to the bottom of the air chamber while the brake is released. The measurement is indicated with an "X" in (Figure 8-62).

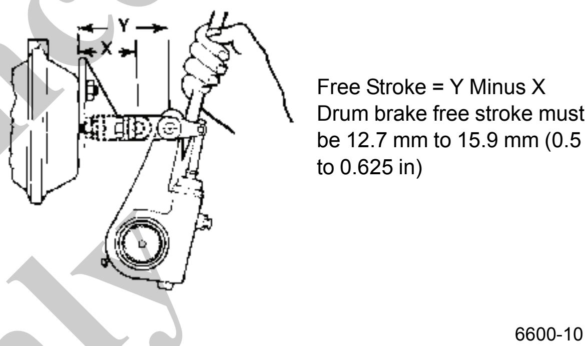


FIGURE 8-62

4. Use a pry bar to move the slack adjuster and position the linings against the drum, brakes applied. Measure the same distance again while the brakes are applied. The measurement is indicated with a "Y" in (Figure 8-62).

CAUTION

Do not set free stroke shorter than 12.7 to 15.9 mm (0.5 to 0.625 in) for drum brakes. If the measurement is too short, linings can drag. Damage to the components can result.

5. Subtract measurement "X" from "Y" (Figure 8-62) to obtain free stroke.
6. If the free stroke measurement is not within specification, turn the adjusting nut 1/8 turn in the direction shown in (Figure 8-63), and check the free stroke again. Continue to measure and adjust stroke until the measurement is within specification.

8

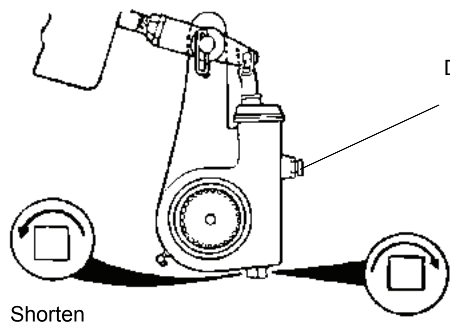


FIGURE 8-63

7. Re-engage the pull pawl by removing the screwdriver or equivalent tool. The pull pawl will re-engage automatically.
8. If the brakes have spring chambers, carefully release the springs. Test before returning vehicle to service.

Measure Push Rod Travel or Adjusted Chamber Stroke

Use the following procedure to check in-service push rod travel or adjusted chamber stroke on vehicle brakes.

1. The engine must be off. If the brake has a spring chamber, follow the procedure to release the spring. Verify that no air pressure remains in the service section of the chamber.
2. Verify that the pressure is 6.89 bar (100 psi) in the air tanks. Determine the size and type of the brake chambers on the vehicle.
3. With the brakes released, mark the push rod where it exits the chamber. Measure and record the distance. Have another person apply and hold the brakes on full application Figure 8-64. Hold a ruler parallel to the push rod and measure as carefully as possible. A measurement error can affect CVSA (Commercial Vehicle Safety Alliance) re-adjustment limits. CVSA states that “any brake 6.4 mm (1/4 in) or more past the readjustment limit, or any two brakes less than 6.4 mm (1/4 in) beyond the re-adjustment limit, will be cause for rejection.”

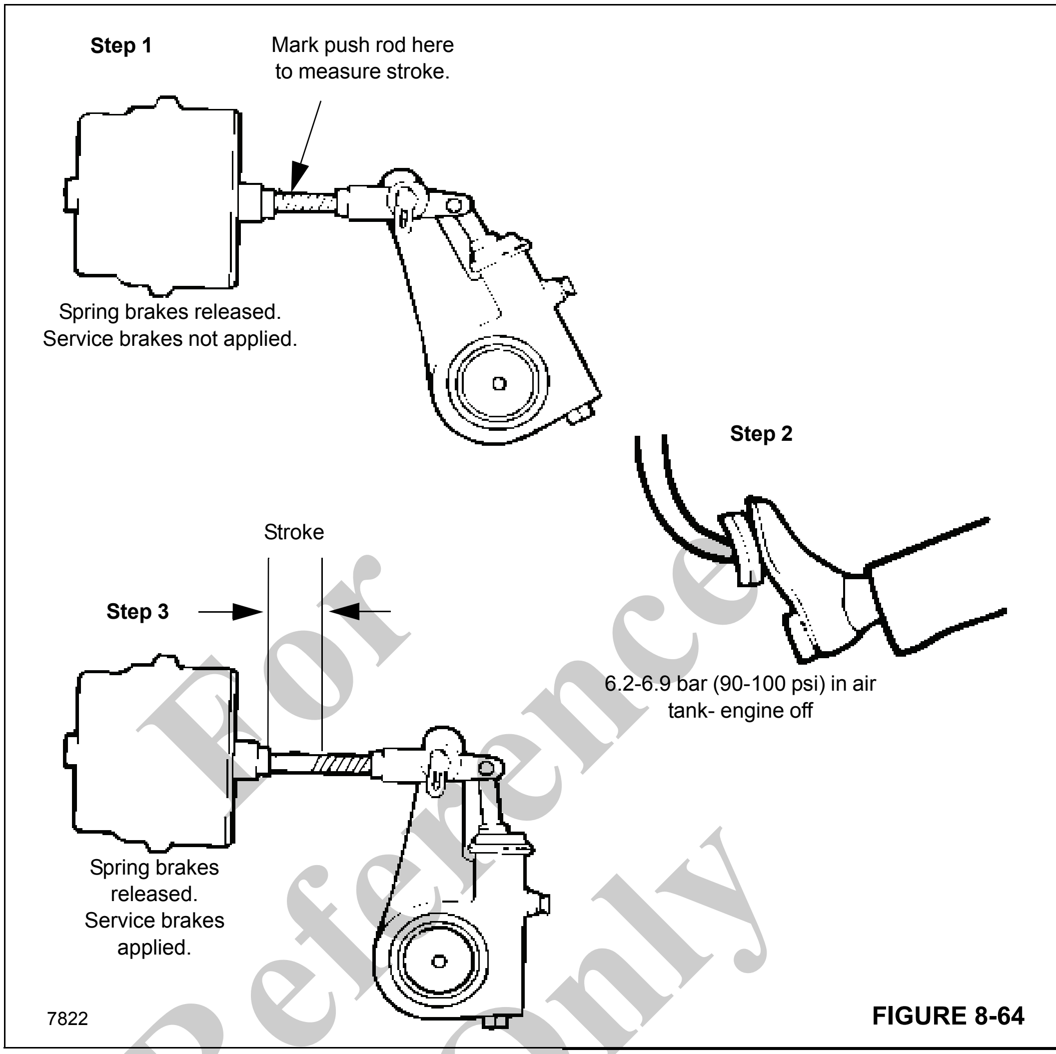


FIGURE 8-64

4. Measure the push rod travel or adjusted chamber stroke from where the push rod exits the brake chamber to the mark on the push rod. Measure and record the distance Figure 8-64 step 3.
5. Subtract the measurement recorded in step 3 from the measurement recorded in step 4. The difference is the push rod travel or adjusted chamber stroke.
6. Refer to Table 8-3 or Table 8-4 to verify that the stroke length is correct for the size and type of air chambers on the vehicle.

If push rod travel is greater than the maximum stroke shown in Table 8-3 or Table 8-4, inspect the slack adjuster and replace it if necessary.

Table 8-3 Standard-Stroke Clamp- Type Brake Chamber Data

Type	Outside Diameter (in)	Brake Adjustment Limits (in)	Brake Adjustment Limits (mm)
6	4 1/2	1 1/4	31.75
9	5 1/4	1 3/8	34.93
12	5 4/16	1 3/8	34.93
16	6 3/8	1 3/4	1 3/4
20	6 25/32	1 3/4	44.45
24	7 7/32	1 3/4	44.45
30	8 3/32	2	50.8
36	9	2 1/4	57.15

8

Table 8-4Long- Stroke Clamp- Type Brake Chamber Data

Type	Outside Diameter (in)	Brake Adjustment Limits (in)	Brake Adjustment Limits (in)
16	6 3/8	2.0	50.8
20	6 25/32	2.0	50.8
24	7 7/32	2.0	50.8
24[1]	7 7/32	2.5	63.5
30	8 3/32	2.5	63.5

[1] For 3 in maximum stroke type 24 chambers.

AIR SYSTEM

Description

The air system (Figure 8-65) 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 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 supply dump valve and air dryer and into the supply reservoirs. A 10.30 bar (150 psi) safety valve is installed on the air dryer module for protection from excess pressure. The pressurized air flows to the primary service reservoirs and secondary service reservoirs. 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 #3, and #4 is supplied by the primary reservoirs. The secondary reservoirs provide the supply for the service brakes on axle #1 and #2.

Pressure protection valves are set at 7.31 bar (106 psi) and are basically check valves. They open at 0.69 to 1.03 bar (10 to 15 psi) above it’s closing pressure. These valves protect a circuit if a line is ruptured to ensure a priority supply to the brakes. Pressure protection valve for tire inflation is set at 5.86 bar (85 psi).

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 8.96 bar (130 psi) is sensed in the air system. When pressure drops to 7.58 bar (110 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

CAUTION

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.

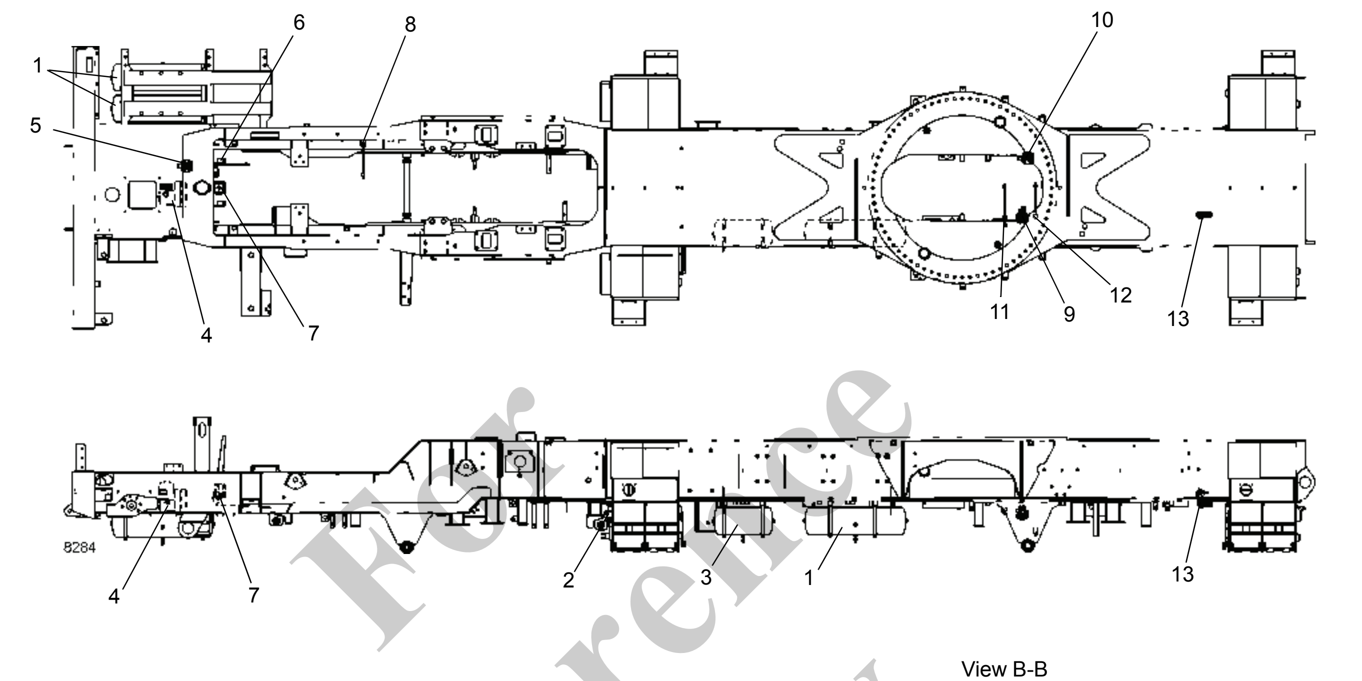


FIGURE 8-65

Item	Description
1	Air Reservoir
2	Pressure Protection Valve
3	Air Reservoir
4	Air Dryer
5	Front Service Brake Relay Valve
6	Tire Suspension Solenoid Valve
7	Supply Dump Valve
8	Air Suspension Valve
9	Spring Brake Relay Valve
10	Rear Service Brake Relay Valve
11	Inter-Axle Differential Lock Solenoid Valve
12	Cross Axle Differential Lock Valve (Optional)
13	Tractor Protection Valve (Optional)

Air System Operational Test

WARNING

Death or injury could occur!

Air pressure must not exceed 9.00 bar (130 psi).

NOTE: Refer to Figure 8-65 for air tank and valve installation.

1. Park the crane on a firm level surface and apply the parking brakes.

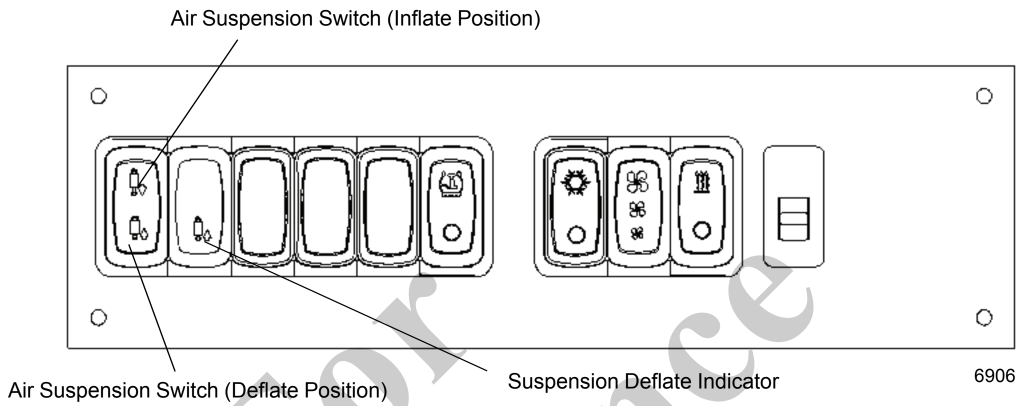


FIGURE 8-66

2. Push air suspension switch (Figure 8-66) in the carrier cab to deflate position to deflate the air suspension bags. The amber suspension 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.

Pressure Warnings and Pressure Build-up

1. Drain all reservoirs to zero (0) psi by opening the drain valves. 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.
2. Close the drain valves and start the engine. Set the engine speed to fast idle.
    a. The low air pressure indicator (Figure 8-67) should be on, and an audio warning should be on until both pressure gauges indicate 4.14 to 4.83 bar (60 to 70 psi) air pressure.
    b. Air will fill the primary (rear) or secondary (front) reservoirs first. The red needle on the gauge represents the primary air pressure. The green needle on the gauge represents the secondary air pressure. The primary or secondary gauge should rise until it reaches 7.31 ± 0.41 bar (106 ± 6 psi). At 7.31 ± 0.41 bar (106 ± 6 psi), the pressure protection valve will open and allow air to flow into the reservoirs. The pressure will level off, or momentarily fall as the next pressure protection valve opens for the other system. When the other systems reach 7.31 ± 0.41 bar (106 ± 6 psi), the pressure will level off, or momentarily fall as the third and fourth pressure protection valves open. Then the primary and secondary gauges should increase together until they reach their full pressure.

CAUTION

Damage could occur!

Do not attempt to adjust or service the pressure protection valves.

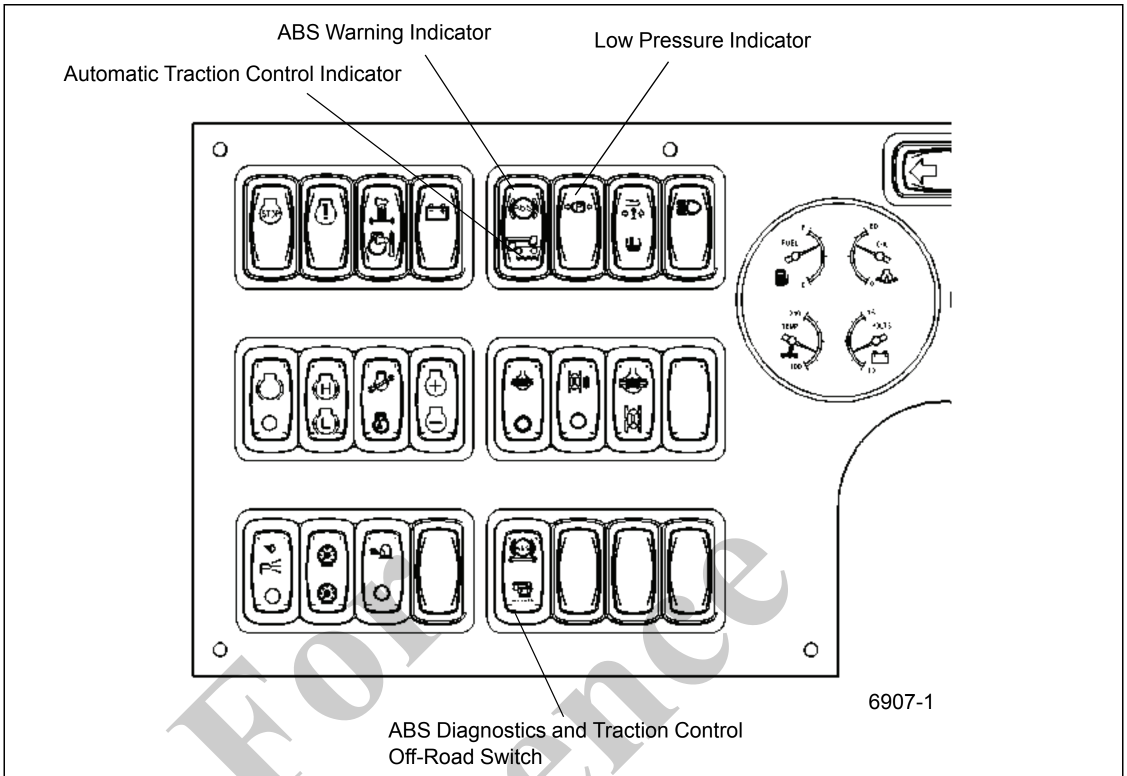


FIGURE 8-67

c. Record the amount of time to build air pressure from 5.86 to 6.89 bar (85 to 100 psi). This time should be less than 40 seconds.

d. Continue charging the air system until the air dryer cycles and the compressor shuts off. All system gauges should read 8.96 bar (130 psi).

e. Reduce air pressure by applying the service brakes until governor cut-in pressure is reached. The difference between governor cut-out and cut-in pressure should be 1.72 bar (25 psi) or less.

f. Release the park brakes by pushing the yellow knob on the front console.

g. Check that all wheels turn freely.

h. Attempt to operate the outriggers. The outriggers should not operate with the park brakes released.

i. Turn engine off.

Air Leakage Test

1. If necessary, start the engine and charge air system to governor cut-out pressure.
2. Turn engine off and allow the air pressure to stabilize for one minute.
3. Observe the air pressure gauge on the front console for two additional minutes without the service brakes applied. Any decrease in air pressure shall not exceed one (1) psi per minute.
4. Apply the service brakes to full application and hold. Allow the air pressure to stabilize. Continue holding the service brakes for two minutes. Any decrease in air pressure shall not exceed 0.138 bar (2 psi) per minute.

Loss of Primary (Rear) Air System

1. If necessary, start the engine and charge air system to governor cut-out pressure.
2. Turn engine off and allow the air pressure to stabilize for one minute.
3. Release the park brakes by pushing the yellow button on the front console (Figure 8-67). On units equipped with trailing boom, push the yellow button and the red button. Ensure the dummy glad hand is installed on the trailer supply and control disconnects before pushing red button.
4. Check that all wheels turn freely.
5. Simulate a full air leak by opening the drain valve in one of the two primary reservoirs.
6. The low air pressure indicator and warning buzzer should come on when the air pressure in the primary system drops below 5.17 ± 0.35 bar (75 ± 5 psi). Air

pressure in the secondary system should not drop below 6.89 bar (100 psi).

7. Continue draining the primary reservoirs to zero (0) psi.
8. Apply the service brakes.
9. All four front axle brakes and the four rear axle spring brakes should apply. The brake lights on the rear of the crane should illuminate.
10. On units equipped with trailing boom, the trailer supply line should not be evacuated.
11. Release the service brakes.

Loss of Secondary (Front) Air System

1. If necessary, start the engine and charge air system to governor cut-out pressure.
2. Turn engine off and allow the air pressure to stabilize for one minute.
3. Release the park brakes by pushing the yellow button on the front console. On units equipped with trailing boom, push the yellow button and the red button. Ensure the dummy glad hand is installed on the trailer supply and control disconnects before pushing red button.
4. Check that all wheels turn freely.
5. Simulate a full air leak by opening the drain valve in one of the two secondary reservoirs.
6. The Low Air Pressure indicator and warning buzzer should come on when the air pressure in the secondary system drops below 5.17 ± 0.35 bar (75 ± 5 psi). Air pressure in the primary system should not drop below 6.89 bar (100 psi).
7. Continue draining the secondary reservoirs to zero (0) psi.
8. Apply the service brakes.
9. All four rear axle brakes should apply. The brake lights on the rear of the crane should illuminate.
10. On units equipped with trailing boom, the trailer supply line should not be evacuated.
11. Release the service brakes.

Emergency Brake Application

1. If necessary, start the engine and charge air system to governor cut-out pressure.
2. Turn engine off and allow the air pressure to stabilize for one minute.
3. Release the park brakes by pushing the yellow knob on the front console.
4. Check that all wheels turn freely.
5. Simulate a full air leak by opening the drain valve in one of the two secondary reservoirs.
6. Slowly drain the primary reservoirs.
7. The yellow knob should automatically “pop” out when the pressure decreases below 1.38 to 2.07 bar (20 to 30 psi).
8. On units equipped with trailing boom, the trailer emergency supply line should be exhausted between 1.38 to 3.10 bar (20 to 45 psi).

AIR SYSTEM COMPONENTS

Description

Air Compressor

The air compressor (Figure 8-68) 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.

Air Governor

The air governor is mounted on the air dryer behind the front bumper under the center decking. The governor senses the system pressure and when pressure reaches 8.96 bar (130 psi) the governor vents the compressor. When pressure drops to 7.58 bar (110 psi), the governor signals the compressor to start charging again.*

Air Dryer

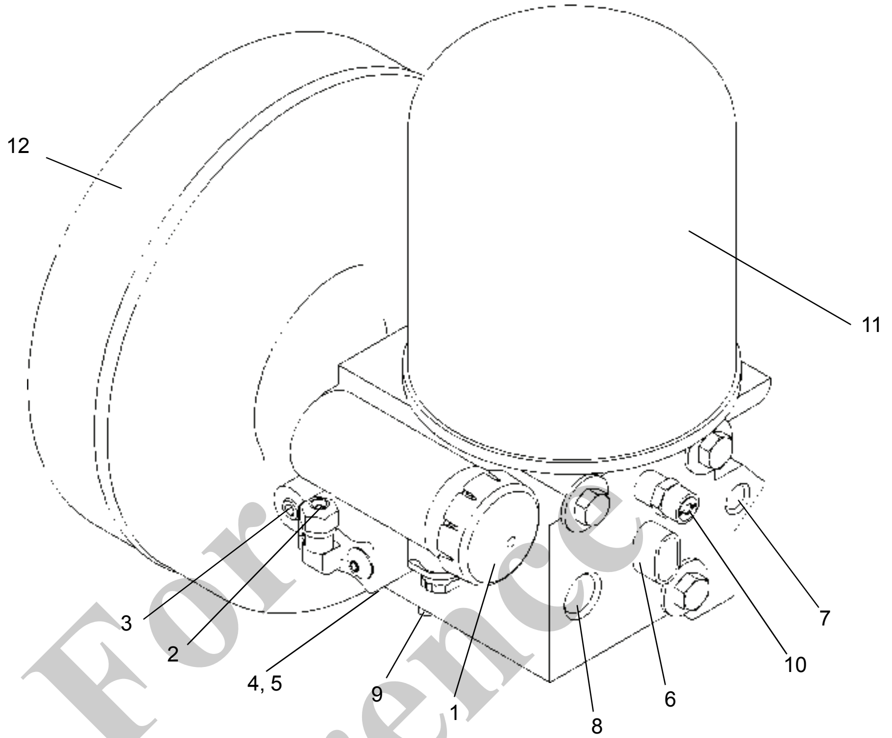


FIGURE 8-68

Item	Description	Item	Description
1	Governor	7	Auxiliary Delivery Port (Air Out)
2	Unloader Control Valve	8	Inlet Port (Supply From Compressor)
3	Common Reservoir Pressure	9	Pressure Protection Valves
4	Delivery Port Out (To Primary Reservoir) (Not Shown)	10	Safety Valve
5	Delivery Port Out (To Secondary Reservoir) (Not Shown)	11	Desiccant Cartridge
6	Heater/Thermostat Connection	12	Purge Reservoir

The purpose of the air dryer 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.

CAUTION

Do not attempt to adjust or service the pressure protection valves!

Incorrect pressure protection valve settings can result in automatic application of vehicle spring brakes without prior warning.

The dryer with integral governor (Figure 8-68) consists of a spin-on desiccant cartridge to collect and remove air system contaminants before they enter the brake system. The base contains a check valve, safety valve, heater and thermostat assembly, four pressure protection valves, threaded air connections and the purge valve assembly. 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.

Reservoirs

Four air reservoirs store compressed air for braking and auxiliary air devices. The first reservoir in the system (in air dryer module) also acts as a purge tank to remove additional moisture not removed by the air dryer. The reservoirs have manual drain valves.

Low Pressure Indicator Switches

The low pressure indicator switches (Figure 8-69) 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 Low Air Pressure 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).

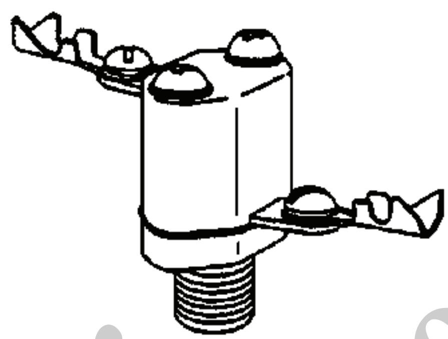


FIGURE 8-69

Stop Light Switch

The stop light switches (Figure 8-70) 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.

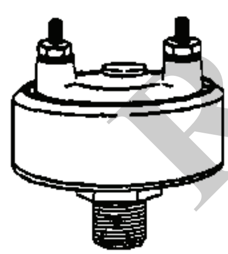


FIGURE 8-70

Air Pressure Gauge

The dual air pressure gauge is located on the right 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 100 to 1000 kPa.

Safety Valve

A safety valve (Figure 8-71) is installed in the air dryer module 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).

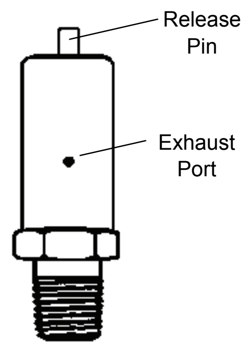


FIGURE 8-71

Pressure Protection Valve

The purpose of the pressure protection valve (Figure 8-72) 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. Refer to Pressure Protection Valve illustration.

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 1.03 to 1.38 bar (15 to 20 psi) higher than the closing pressure. The valve is preset to the specified opening and closing pressures.

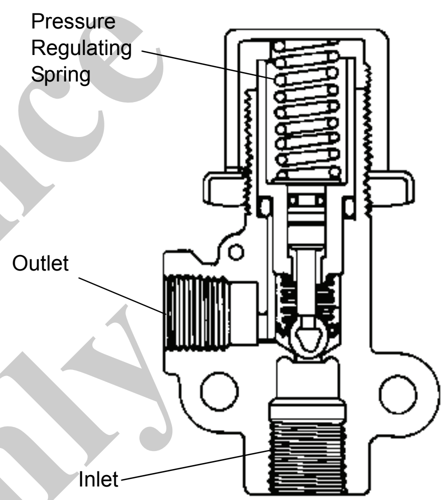


FIGURE 8-72

Relay Valve

The purpose of the two piston operated relay valves (Figure 8-73) is to speed up application of the service brakes. The valve is remote mounted and delivers air to the brakes in response to signals from the foot brake control valves.

One valve is mounted on the front of the frame for front service brakes and one is mounted on the rear of the frame for the rear service 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.

Item	Description
1	Service Port
2	Supply Port
3	Delivery

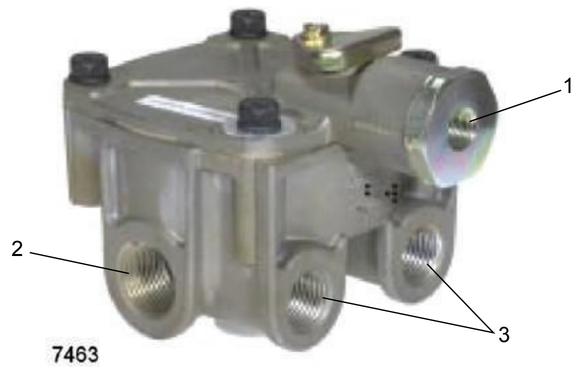


FIGURE 8-73

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 Figure 8-74 is located on the rear 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.

Port	Designation
1	Air Supply Port
2	Air Delivery Port
3	Air Exhaust Port
4	Park Control Port

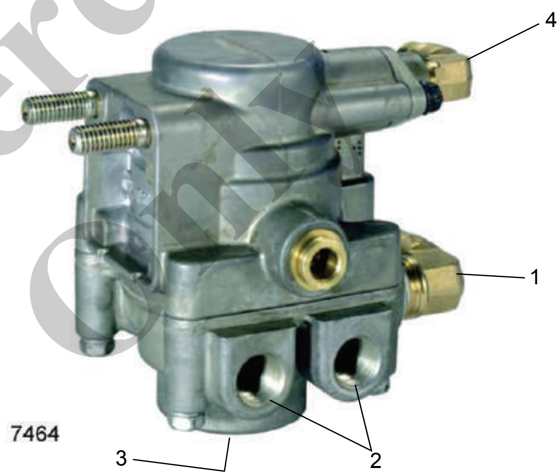


FIGURE 8-74

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.

Antilock Modulator

The quick release antilock system modulators are on/off air valves that incorporate a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface between the antilock controller electronics and the air brake system. The modulator is used to control the braking function on actuators during antilock activity.

Traction Control Valve

The traction control valve is installed on the right rear side of the frame. It is used in the air system to improve stability and traction during acceleration (at low speeds) and lateral stability while driving around curves.

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Maintenance

WARNING

Death or injury could occur!

Depressurize both air systems completely before disconnecting air lines or components.

NOTE: For more in depth information on Bendix system components go to the Bendix website and download the appropriate document: Bendix Service Literature.

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. Refer to engine manual for appropriate torque.
2. Connect air lines as tagged during removal.

Air Governor

Removal

1. Chock the wheels and depressurize both primary and secondary air circuits.
2. Disconnect the air line from the governor.
3. Remove the bolts, lockwashers and nuts securing the air governor to the air dryer module. Remove the air governor.

Installation

1. Position the air governor on the air dryer module and secure with bolts, lockwashers, and nuts.
2. Connect the air line to the governor.

Operational Test

Start the engine and pressurize the system. Check the governor cut-out pressure with either the panel gauge or a test gauge 8.96 bar (130 psi). At the cut-out pressure, the compressor is unloaded and the air dryer is purged.

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.

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 capscrews 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 carrier frame and secure with the capscrews and washers. Torque the capscrews. Refer to *Fasteners and Torque Values*, page 1-13.
3. Connect the air and electrical lines as tagged during removal. 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. 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.

3. Location of the air dryer is too close — less than 1.8 m (6 ft) — to the air compressor.
4. Check the electrical connections and mounting bolts for tightness.
5. 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.
6. Every 10,800 hrs, 500,000 km (300,000 mi), or 36 months rebuild the air dryer and replace the desiccant cartridge.
7. 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 6.0 to 9.0 ohms for a 24 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 capscrews, washers and nuts 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. It is not recommended that tanks be repaired. Damaged tanks need to be replaced.

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. Install the reservoirs to the brackets and secure with the nuts, washers and capscrews. Refer to *Fasteners and Torque Values*, page 1-13.
2. Connect all 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

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 590 kPa (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 and water 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.

Tire Inflation Pressure Protection Valve

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect the air lines from the pressure protection valve.
3. Remove the capscrews, nuts and washers securing the valve to the mounting studs.

Installation

1. Install the valve on the mounting studs and secure with the capscrews, nuts and washers. Refer to *Fasteners and Torque Values*, page 1-13.
2. Connect the air lines as tagged during removal.

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.

Relay Valve

WARNING

Death or injury could occur!

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 bolts 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 frame and secure with the bolts 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, 1600 km (1000 mi), or monthly:

Check the relay valve for leakage and proper operation.

Every 3600 operating hours, 16000 km (10000 mi), or annually:

Disassemble the valve, clean and inspect all parts. Repair and replace as necessary.

Spring Brake Control Valve

Removal

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect all air lines connected to the valve.
3. Remove the attaching hardware to free the valve. Remove the valve.

Inspection

Inspect all air lines for kinks, cuts, chafing, or deterioration. Replace lines showing these defects.

Installation

1. Secure the valve with attaching hardware.
2. Connect the air lines as per removal tags.
3. Check operation as described under Operating and Leakage Tests.

Operating Test

Block vehicle and hold by means other than vehicle brakes.

Charge air brake system to governor cut-out pressure.

1. Place parking control valve in “park” position. Observe that spring brake actuators apply promptly. Remove one line from delivery port of the valve and install test gauge.

Place parking control valve in “release” position. Observe that spring brake actuators release fully.

2. With parking control valve in “release” position, note gauge pressure reading. (Correct spring brake actuator hold-off pressure is 7.38 bar (107 psi) nominally.)
3. Place parking control valve in “park” position - gauge reading should drop to zero promptly. A lag (more than 3 seconds) in drop of pressure would indicate faulty operation.
4. With the parking control valve in the “park” position, gradually apply foot brake valve and note a pressure reading increase on the gauge installed in the delivery port.
5. Place parking control valve in “release” position.
6. Drain the reservoir, which supplies the rear service brake circuit, apply the foot brake valve several times and note that pressure reading on gauge decreases each time foot brake valve is applied (spring brake modulation). After the foot brake valve has been applied several times, pressure on gauge will drop to the point where release of the spring brake actuators will no longer occur.

Leakage Test

Place the park control valve in the “release” position; using a soap solution, coat all ports including the exhaust port. A 25 mm (1 in) bubble in 3 seconds is permitted (175 SCCM). If the valve does not function as described, or leakage is excessive, the valve should be replaced with a new or remanufactured unit.

WARNING

Death or injury could occur!

Do not attempt to disassemble the valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted!

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 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 the nuts, washers, and lockwashers.
2. Connect all the air lines to the brake valve as per removal tag.

Operating Test

CAUTION

Damage could occur!

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 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 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, 16,000 km (10,000 mi), or yearly.

Replace inlet and exhaust valves, exhaust diaphragm, O-rings, and rubber graduating spring if worn or deteriorated.

Every 7200 operating hours, 32,000 km (20,000 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. Remove mounting screws.
5. 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. Install mounting screws.
3. Connect the air lines to the valve and the electrical leads to the pressure switch as per removal tags.
4. 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.

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 stabilizer (jack) cylinders with outrigger beams to allow for fully retracted, partial extension, and fully extended operation. A center front stabilizer 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 stabilizer is mounted on the center of a crossmember at the front of the crane.

The beam assembly (see Figure 8-75) contains the 6.35 cm (2.5 in) bore extension cylinder and the 13.9 cm (5.50 in) stabilizer cylinder which is mounted in a tube at the end of the beam.

The outrigger circuit consists of an integrated outrigger selector manifold, two outrigger manifold valves, four extension cylinders, five stabilizer (jack) cylinders, a relief valve, a pressure switch, (pilot operated) check valves and eight 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 stabilizer cylinders are mounted on their respective stabilizer boxes; in turn the stabilizer boxes are mounted on the end of each outrigger beam. The center front stabilizer is mounted to the frame behind the front bumper. Each stabilizer 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 stabilizer cylinder. Two OMS string potentiometers (if equipped) are mounted inside each outrigger box. The potentiometers are connected by cables to the outrigger beams to monitor the beam's horizontal 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 on the right side console. There is also a standard control panel on either side of the crane near the front outriggers. When using either of these control panels, the engine speed will be automatically increased above idle when the outrigger extend/retract switch is moved to either position.

A sight bubble level is mounted on a bracket on the right side of the cab. Bubble levels are also mounted in the carrier 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.

NOTE: The park brake in the carrier cab must be set before the outrigger controls will operate.

The outrigger extend/retract momentary switch located on the right side console in the superstructure cab must be used in conjunction with the outrigger selector switch to control the operation of the stabilizer and extension cylinders. Push the top of the switch to select the extend function or bottom of switch to select the retract switch.

The integrated outrigger valve spool shifts allowing flow to either the extend or retract line as applicable. If the top of the switch is pushed down to extend, flow continues through the open solenoid valve to the piston side of the cylinder. If the stabilizer is to be extended, the flow first unseats the cylinder check valve then extends the cylinder. The oil from the rod end flows through the integrated outrigger valve, and then to the reservoir.

When the bottom of the outrigger switch is pushed to 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 stabilizer cylinder is to be retracted, then pilot pressure from the pressurized retract line unseats the cylinder check valve allowing oil to flow from the piston side through the open solenoid valve to the integrated outrigger valve. The integrated outrigger valve directs the flow to the reservoir.

The front stabilizer functions similar to any of the other outrigger cylinders. The front stabilizer will retract when the outrigger extend/retract switch is positioned to the retract position. After operating the main outrigger control, the center front stabilizer 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 310.26 ± 1.38 bar (4500 ± 20 psi), the switch causes the red center front stabilizer overloaded indicator to be illuminated on the superstructure operator’s display and a warning buzzer to sound. This alerts the operator that the center stabilizer circuit senses over pressurization indicating an overload condition. The inline relief valve prevents over pressurization of the center front stabilizer cylinder as the cylinder is being extended. The valve is installed in line between the solenoid valve and the cylinder, and is set at 13.79 bar (200 psi).

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Make any needed repairs. Fill reservoir to proper level.
	b. Damaged relief valve.	**b.** Remove relief valve; clean or replace.
	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.

Symptom	Probable Cause	Solution
Slow or erratic operation of outrigger extension cylinders. (continued)	**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.
2. Sticking spool.	**a.** Dirt in the system.	**a.** Change oil and flush system.
	b. Distortion caused by tie bolts being over torqued.	**b.** Retorque tie bolts.
	c. Flow in excess of valve rating.	**c.** Limit flow through valve to that recommended. Check pump output and cylinder ratio.
	d. Pressure in excess of valve rating.	**d.** Check relief valve setting or pump compensation with that recommended.
	e. Electrical failure.	**e.** Check wiring and solenoids.
3. External leakage.	**a.** Damaged O-ring or quad rings.	**a.** Check for chipped packings and replace.
	b. Loose tie bolts.	**b.** Retorque tie bolts.
	c. Damaged solenoid.	**c.** Replace damaged parts.
4. Solenoid failure.	**a.** No current.	**a.** Check power source of at least 85% of coil rating.
	b. Damaged solenoid assembly.	**b.** Replace solenoid.
	c. Short in solenoid.	**c.** Replace coil.
	d. Loss of solenoid force.	**d.** Decrease time of solenoid energization, decrease cycle rate.
5. Outrigger vertical jack cylinder slow or erratic.	**a.** Low hydraulic oil level.	**a.** Check for leaks. Make any needed repairs. Fill reservoir 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.

Symptom	Probable Cause	Solution
Outrigger vertical jack cylinder slow or erratic. (continued)	**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.
6. Outrigger stabilizer cylinder retracts under load.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Damaged holding valve seals.	**b.** Replace seals.
	c. Damaged holding valve.	**c.** Replace valve assembly.
	d. Scored cylinder barrel.	**d.** Repair or replace cylinder.
	e. Cracked or damaged piston.	**e.** Replace piston and all cylinder seals.
7. 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.** Replenish system.
	b. Loose or broken wire on switch.	**b.** Repair or replace wiring.
	c. Clogged, broken, or loose lines or fittings.	**c.** Clean, tighten, or replace lines or fittings.
	d. Damaged relief valve or damaged control valve.	**d.** Repair or replace valve.
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.
	f. Damaged relief valve.	**f.** Repair or replace relief valve.
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. Loosen or broken wire on control switch or solenoid valve.	**c.** Repair or replace wiring.
	d. Damaged solenoid valve.	**d.** Repair or replace valve.

OUTRIGGER BEAM

Description

The outrigger beam assembly (see Figure 8-75) consists of an outrigger beam, a 13.9 cm (5.50 in) stabilizer (jack) cylinder, a 6.35 cm (2.5 in) outrigger extension cylinder, two Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometers, 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 potentiometers (if equipped) are mounted inside the outrigger box and are connected to the outrigger beam by cables. The string potentiometers identify 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. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
2. From the opposite side of the outrigger housing, remove the end cover.
3. Tag and disconnect the hydraulic lines to the cylinder end of the extension cylinder. Cap all lines and fittings.
4. On the side of the outrigger housing, remove the setscrews from the side adjustable wear pads and back off the wear pads from the housing.
5. Remove the setscrews from the bottom adjustable wear pads and back off the wear pads leaving approximately 3.2 mm (0.125 in) protruding.
6. Remove the bolt, washer, lockwasher and nut securing each hydraulic tube to the outrigger housing.
7. Remove the OMS string potentiometer cables (if equipped) from the attaching points 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 rod of the extension cylinder to the outrigger housing.
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 beam from tipping.

NOTE: The outrigger beam assembly weighs approximately 776 kg (1710 lb).

Do not allow the end of the outrigger extension cylinder to fall when the cylinder mounting shaft is removed.

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.

10. Position the outrigger beam on the blocking material.
11. If necessary, remove the wear pads from the bottom of the outrigger box.

Disassembly

1. Remove the two cotter pins and clevis pins securing the extension cylinder barrel lugs to the brackets on the mid beam.

NOTE: Do not allow the end of the extension cylinder to fall when the cylinder barrel lugs are removed from the brackets. Use blocking to limit the drop or an adequate soft support to cushion any distance the cylinder will drop.

WARNING

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

2. 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 jack beam out of the outrigger mid beam, re-adjusting the lifting attachment to prevent the beam from tipping.

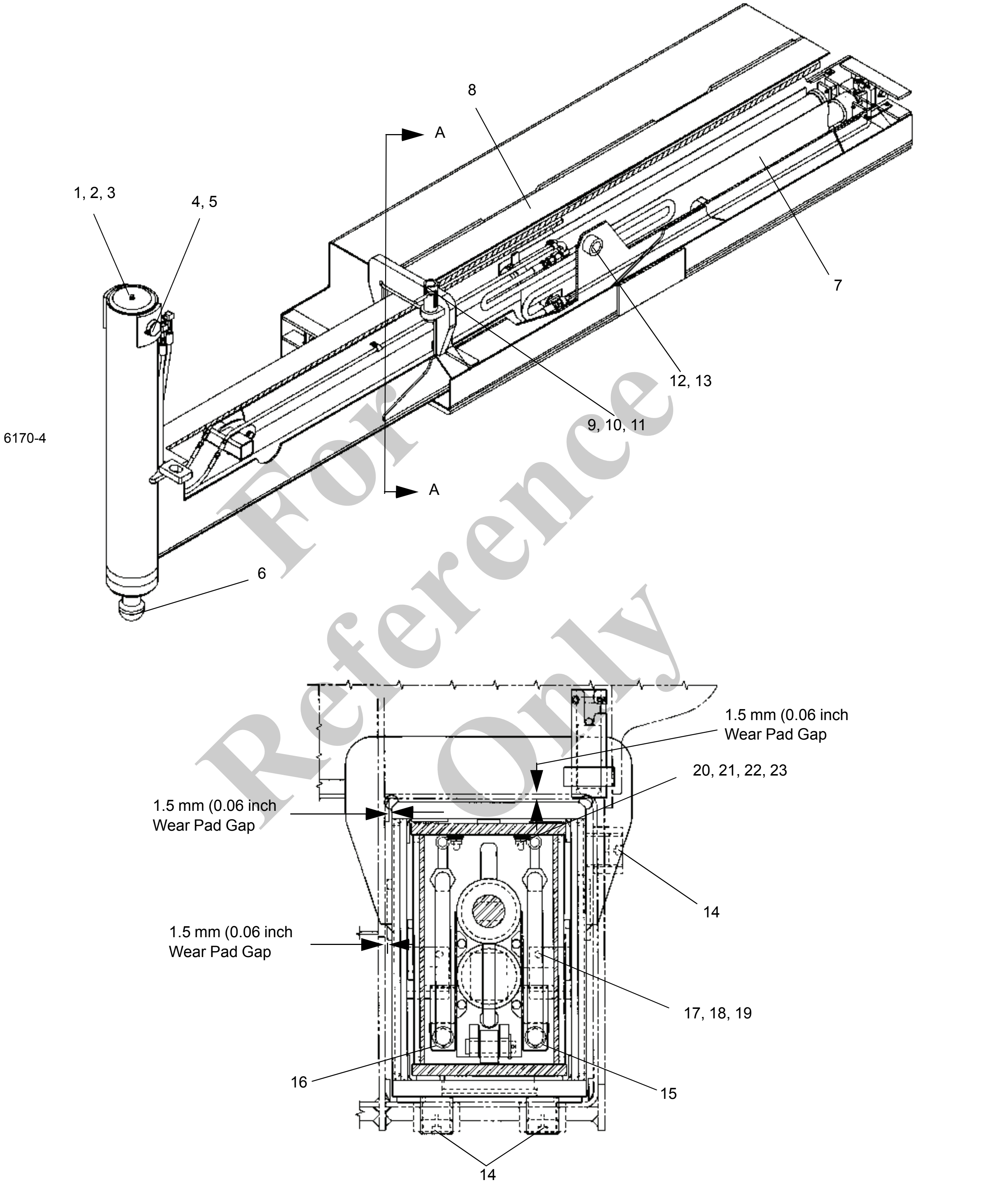
NOTE: The outrigger jack beam assembly weighs approximately 576 kg (1269 lb).

3. Position the outrigger jack beam on the blocking material.
4. Remove the wear pad from the bottom of the outrigger mid beam.
5. Remove the cotter pin and clevis pin securing the cylinder rod to the jack beam.

6. Slide the extension cylinder from the jack beam being careful not to damage the two hoses.
7. Tag and disconnect the hoses from the tubes in the top of the jack beam. Cap or plug all openings.
8. Remove the cylinder and lay it on suitable blocking.

NOTE: The extension cylinder weighs approximately 70.3 kg (154.9 lb).

9. Remove the two clamps, nuts, washers, and lockwashers securing each tube assembly to the top inside of the jack beam. Remove the tube assemblies.
10. Tag and disconnect the stabilizer cylinder hoses from the tube assemblies. Cap or plug all openings.
11. Tag and disconnect the hoses from the tubes in the trays on the extension cylinder. Cap or plug all openings.
12. Tag and disconnect the tubes from the cylinder ports and remove the tubes from the trays. Cap or plug all openings.



View A - A

FIGURE 8-75

Item	Description
1	Cap
2	Nut
3	Washer
4	Pin
5	Cotter Pin
6	Stabilizer Cylinder (Jack Cylinder)
7	Extension Cylinder
8	Outrigger Beam
9	Pin Weld
10	Cotter Pin
11	Pin
12	Wear Pad
13	Setscrew
14	Setscrew
15	Tray
16	Tray
17	Bolt
18	Flatwasher
19	Lockwasher
20	Clamp
21	Hex Nut
22	Lockwasher
23	Flatwasher

13. Remove the bolts, washers, and lockwashers securing the trays to the extension cylinder and remove the trays.
14. Tag and disconnect the hoses from the stabilizer cylinder. Cap or plug all openings.
15. Remove the stabilizer cylinder from the jack beam. Refer to Outrigger Stabilizer Cylinder - Removal in this Section.

Inspection

1. Inspect the hoses, couplings, and end fittings for cracks, chafing, cuts, or other damage.
2. 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 or damaged hydraulic line.

Assembly

NOTE: The mid beam and the jack beam are shimmed as a matched set and are identified by the stamped serial number ending in ‘A’ for the mid beam and ‘B’ for the jack beam. If one or the other is replaced, then the shims will have to be replaced and tolerances rechecked.

1. Install the stabilizer cylinder in the jack beam. Refer to Outrigger Stabilizer Cylinder - Installation in this Section.
2. Connect the hoses, as tagged during disassembly, to the stabilizer cylinder and route them into the jack beam.
3. Coat the inside of the tube trays with Never-Seeze. Attach the trays to the extension cylinder with bolts, washers, and lockwashers.
4. Install the tubes in the trays. Connect the hoses to the tubes as marked during disassembly. Connect the tubes to the extension cylinder ports.
5. Position the two tube assemblies in the top inside of the jack beam and secure each with two clamps, nuts, washers, and lockwashers.

NOTE: The stabilizer cylinder weighs approximately 100 kg (268 lb).

6. Position the extension cylinder at the end of the jack beam and connect the hoses to the tubes in the top of the jack beam as marked during disassembly.
7. Slide the extension cylinder into the jack beam using care not to damage or trap the hoses.
8. Secure the extension cylinder rod to the jack beam using the clevis pin and a cotter pin.
9. Position the wear pad in the pocket in the bottom of the mid beam.
10. After attaching a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam, slide the outrigger jack beam into the outrigger mid beam.
11. Place the extension cylinder barrel lugs in the brackets of the mid beam and secure each with a clevis pin and cotter pin.

Installation

1. Apply grease (EP-MPG) to the bottom of the outrigger beam assembly.
2. 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.
3. Attach a suitable lifting device of straps or belts instead of chains to prevent nicking the bottom edges of the outrigger beam.

4. Slide the beam into the outrigger housing and align the cylinder rod with the mounting hole.
5. Secure the cylinder rod to the housing with the clevis pin and cotter pin.
6. Secure the tube assemblies to the housing using bolts, washer, lockwashers and nuts.
7. Attach the OMS string potentiometer cables (if equipped) to the attaching point on the outrigger beams.

   If the OMS string potentiometers were removed, install the potentiometers at this time. Refer to *Outrigger Monitoring System (Optional—Standard in North America)*, page 8-70.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer caused by over-range of cable.

CAUTION

Make 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.

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.

8. Connect the hydraulic lines as tagged prior to removal.
9. Install the side adjustable wear pads in the outrigger box.
10. Adjust the wear pads. Refer to Wear Pad Adjustment.
11. Install the end cover.

NOTE: At installation, be sure that the outrigger stabilizer cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

Wear Pad Adjustment

NOTE: When adjusting wear pads, refer to Figure 8-75.

1. Adjust the bottom wear pads (approximately 1/4 turn) until a gap of 1.5 mm (0.06 in) is obtained at the tightest point during full extension. Install and lock setscrews against wear pads.
2. Adjust outrigger box side wear pads until a gap of 1.5 mm (0.06 in) is obtained at the tightest point during full extension. Install and lock setscrews against wear pads.

EXTENSION CYLINDER

Description

The outrigger extension cylinder is a combination unit with two rods, one for extending each beam section. Each “half” of the cylinder is a double-acting type cylinder. The barrel end is attached to the mid beam. The lower rod is attached to the outrigger box and the upper rod is attached to the jack beam.

Each barrel has a 6.4 cm (2.50 in) diameter bore. Internal seals are used to prevent internal and external leakage.

Each cylinder weighs approximately 70.3 kg (154.9 lb).

NOTE: Refer to *Cylinders*, page 2-54 for Disassembly and Assembly of the cylinder.

Removal

1. Remove the outrigger beam. Refer to Outrigger Beam Removal in this section.
2. Remove the bolts, pipe clamps, and bolt inserts, securing the hoses to the inside of the beam.
3. Remove the shaft 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 lines to the jack cylinder. Cap all lines and openings.

Installation

1. Install the extension cylinder into the outrigger beam.

NOTE: Keep hydraulic fittings and hoses as low as possible to prevent rubbing with the beam top plate and side plate, and for proper tracking during beam extension and retraction.

CAUTION

Make 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.

2. Connect the lines to the jack cylinder as marked during disassembly.

3. Secure the hoses in place with the bolts, pipe clamps and bolt inserts.
4. Install the shaft securing the rod end of the extension cylinder to the outrigger beam.
5. 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 eight sensors, two per outrigger beam, to identify when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

If the crane is setup on outriggers and “On Outriggers” is chosen when programming the RCL, then the OMS indicates to the RCL the horizontal position of each of the four outrigger beams. Based on this information, the RCL will choose the most conservative outrigger beam configuration (that is, If three outriggers are fully extended and one is retracted, the RCL will select retracted as the outrigger configuration). A confirmation of this outrigger configuration is all that is needed. Refer to the *Rated Capacity Limiter Operator’s Handbook* for detailed instructions.

Removal

1. Extend the outrigger beam slightly for improved access and shut down the engine.
2. Remove the outer access cover plate from outrigger box.
3. Remove the OMS string potentiometer connector (1, Figure 8-76) from the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer (2).

4. Disconnect electrical harness connector and secure to avoid damage.
5. Remove the mounting hardware.
6. Remove OMS string potentiometer from inside outrigger beam.

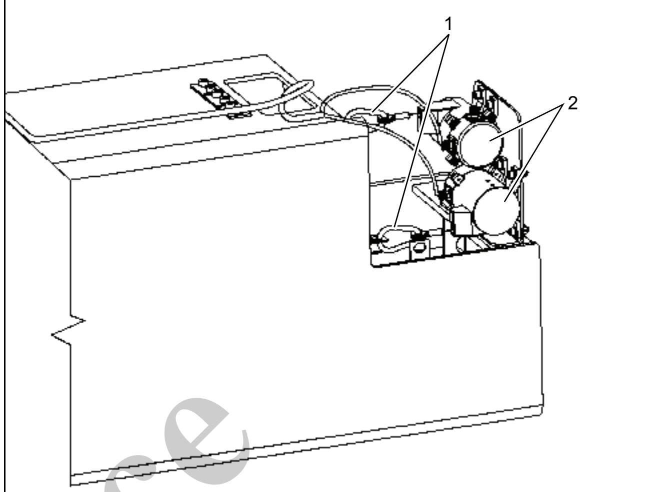


FIGURE 8-76

Installation

1. Install string potentiometer inside outrigger beam.
2. Install the mounting hardware.
3. 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.

4. Connect electrical harness connector to string potentiometer.
5. Install access cover plate to outrigger box.

OUTRIGGER STABILIZER CYLINDER

Description

The stabilizer cylinders have 14.0 cm (5.50 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 90.2 kg (198.8 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-54 for Disassembly and Assembly of the cylinders.

Removal

1. Extend the outrigger beam slightly for improved access to the stabilizer cylinder. Shut down the engine.
2. Tag and disconnect the hydraulic hoses from the stabilizer cylinder.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the stabilizer cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin.
6. Jack the stabilizer cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

CAUTION

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

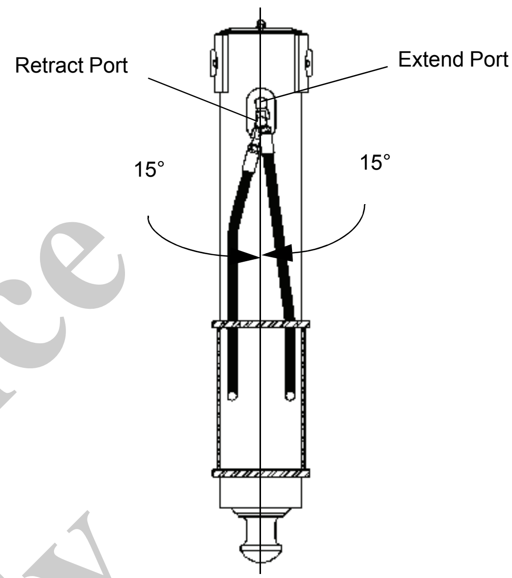
7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the stabilizer cylinder out of the tube on the beam assembly.

Installation

1. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under Removal, lower the stabilizer cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
2. Remove the retaining pin and cotter pins from the cylinder.
3. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam. Secure the cylinder in place with the retaining pin and cotter pins.
4. Install the cylinder cap.

CAUTION

Make 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.



NOTE: Keep hydraulic fittings and hoses close to angles shown for proper tracking during extension and retraction.

FIGURE 8-77

5. Connect the hydraulic hoses to the stabilizer cylinder as marked during disassembly.

NOTE: Keep hydraulic fittings and hoses close to angles shown in Figure 8-77 for proper tracking during extension and retraction.

Functional Check

1. Activate the hydraulic system.
2. Extend and retract the stabilizer cylinder.
3. Check for smooth operation of the cylinder.
4. Check all hydraulic connections and hoses for evidence of leakage.

8

Outrigger Stabilizer 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 stabilizer cylinder.

DANGER

Perform the following procedures with the crane positioned on a firm level surface with outriggers fully extended and set, and the crane in the travel position.

Remove hoses from one cylinder at a time.

Checking Cylinder for Internal Piston Seal Leak

1. Fully extend and set the outriggers.

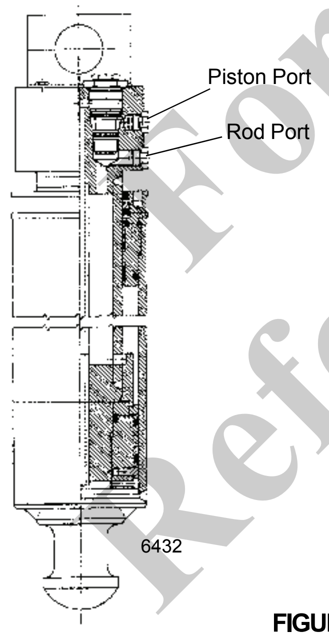


FIGURE 8-78

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 stabilizer cylinder (see Figure 8-78). 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 stabilizer cylinder (see Figure 8-78). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the piston side port.

a. If oil stops flowing, the cylinder's pilot operated check valve is sealing properly.

b. If oil continues to flow out the piston port, the cylinder's pilot operated check valve is leaking.

If oil flow is not noticed from either port, the cylinder and pilot operated check valve are functioning properly, and any cylinder contraction during normal operation can be attributed to thermal contraction of the oil.

OUTRIGGER SYSTEM VALVES

Description

There are five valve assemblies responsible for controlling the outrigger system, the outrigger selector 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 2-22.

Pilot Operated Check Valve

The pilot operated check valves are located in the outrigger stabilizer port blocks. The check valve provides two functions; the first function is a holding valve, the second function provides a thermal relief of the stabilizer.

Outrigger Selector Valve

The integrated outrigger is mounted on the center of carrier frame in bearing area. The valve contains a 214 bar (3100 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. The valve also contains a three position four way solenoid directional control valve that controls outrigger extend and retract.

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 24 volt solenoid valves and an assembly mounting kit. The front manifold consists of five 24 volt solenoid valves and an assembly mounting kit.

Center Front Stabilizer Circuit Relief Valve

The center front stabilizer 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 stabilizer circuit.

CENTER FRONT STABILIZER CYLINDER

Description

The center front stabilizer 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 mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

The cylinder weighs approximately 42.5 kg (93.6 lb) dry.

Maintenance

NOTE: Refer to *Cylinders*, page 2-54 for Disassembly and Assembly of the cylinder.

See Figure 8-79 for cylinder installation.

Removal

1. Remove the bolts, washers, flatwashers, and nuts securing the tilt plate. Remove the plate.
2. Remove the bolts, washers, locknuts, and bushings securing the float pad to the cylinder ball and remove the float pad.
3. Remove the washers and nuts securing the cylinder tube cap to the cylinder cap bracket.
4. Tag, disconnect, and cap the hydraulic lines to the cylinder.
5. Place a jack capable of supporting the weight of the stabilizer cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
6. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap bracket.
7. Jack the stabilizer 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 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 stabilizer 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 inside diameter of the stabilizer cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on stabilizer cylinder.
3. Place a jack beneath the cylinder tube. Using the same method as described under removal, lower the stabilizer 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.

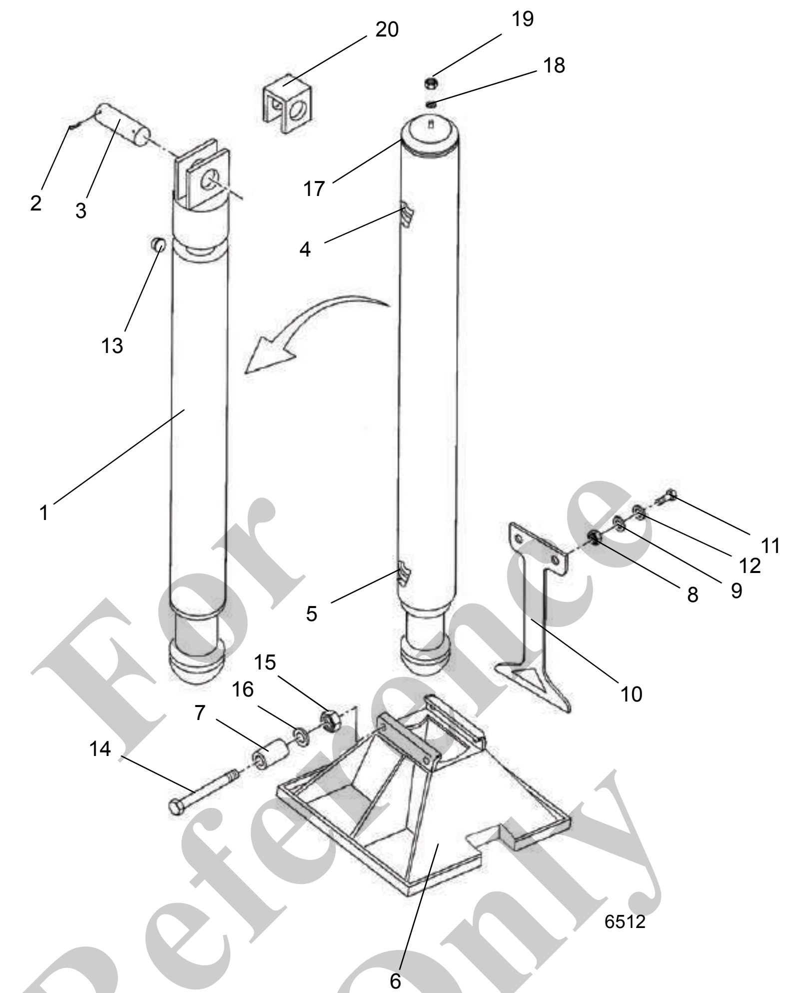


FIGURE 8-79

Item	Description	Item	Description
1	Stabilizer Cylinder	11	Capscrew
2	Cotter Pin	12	Flatwasher
3	Cylinder Retaining Pin	13	Plug
4	Cylinder Head Wear Ring	14	Capscrew
5	Piston Wear Ring	15	Locknut
6	Stabilizer Pad (Float Pad)	16	Flatwasher
7	Bushing	17	Cylinder Tube Cap
8	Hex Nut	18	Washer
9	Lockwasher	19	Acorn Nut
10	Tilt Plate	20	Cylinder Cap Bracket

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 Never-Seeze 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. Install the cylinder tube cap.
8. Position the float pad on the cylinder ball and secure with capscrews, washers, locknuts, and bushings. Tighten locknut until the washer just touches the pad. Do not tighten any further. Torque capscrews 97.6 to 105.7 Nm (72 to 78 lb-ft).
9. Position the tilt plate on the mounting bracket and secure with the capscrews, washers, flatwashers, and nuts. Torque capscrews 40.6 to 43.3 Nm (30 to 32 lb-ft).

Functional Check

CAUTION

Extend and set the four main outriggers before extending the center front stabilizer.

1. Extend and set the outriggers.
2. Activate the hydraulic system; extend and retract the outrigger.
3. Observe for proper operation of the cylinder.
4. Check the hydraulic connections for evidence of leakage.

CAUTION

When installing cylinder retaining pin, orient it so that when cotter pins are installed they will be horizontal.

SECTION 9
LUBRICATION

TABLE OF 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 local Grove 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.

CAUTION

The multipurpose grease installed during manufacture is of a lithium base. Use of a incompatible grease could result in damage to equipment.

Arctic Conditions Below -15°C (5°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 authorized Grove distributor or Manitowoc Crane Care.

NOTE: All fluids and lubricants may be purchased by contacting the Manitowoc Crane Care Parts Department.

Regardless of temperature and oil viscosity, always use suitable start-up procedures to ensure adequate lubrication during system warm-up.

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 jacket water and batteries. The operator needs to follow the guide lines as stated in the operator's manual. We assume that the customer has taken steps for use of an appropriate engine antifreeze coolant, 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 - 2013 ISX engine - Spec 80056036:

- Shell Rotella® T6 0W-40
- Mobil Delvac 1 ESP 0W-40
- Caterpillar Cat DE0-ULS Cold Weather

2013 QSM engine - Spec 6829104412:

- Citgo Citgard Syndurance Synthetic Engine Oil CJ-4 5W-40
- Maxtron DEO Synthetic Engine Oil CJ-4 5W-40

Transmission:

- Use Standard Lubricants Package

Auxiliary 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/swing drive teeth) - No Spec:

- Vultrex OGL Synthetic All Season

Antifreeze Coolant - Spec 6829104212:

- Petro-Canada AFC 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

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 - 2013 ISX engine - Spec 6829104182:

- Mobil delvac 1300 Super CJ-4 15W-40
- Conoco Fleet Supreme EC CJ-4 15W-40

2013 QSM engine - Spec 6829003483:

- Conoco Fleet Supreme CI-4 15W-40
- Exxon XD-3 CI-4 15W-40

Transmission - Fuller Manual & Automatic - 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

- Allison Automatic Spec 6829101690:

- Castrol - Allison Transynd TES295
- Mobil Delvac Synthetic ATF
- BP Autran Syn 295

Auxiliary Transmission - Spec 6829013433 also

Hydraulic Tank - Spec 6829006444:

- Hyden 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: Mobilfluid 629
- 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 6829102971:

- Ceplattyn 300 Spray 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

ENVIRONMENTAL PROTECTION

Dispose of waste properly! Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Manitowoc cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

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

When filling and draining crane components, observe the following:

- Do not pour waste fluids onto the ground, down any drain, or into any source of water.
- Always drain waste fluids into leak proof containers that are clearly marked with what they contain.
- Always fill or add fluids with a funnel or a filling pump.
- Immediately clean up any spills.

LUBRICATION 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. 0.28 kg (1 oz) of EP-MPG equals one pump on a standard 0.45 kg (1 lb) 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 re-lubricate to ensure complete lubrication of the entire wear area.

Surface Protection for Cylinder Rods

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

It is recommended that all exposed cylinder rods be protected using Boeshield® T-9 Premium Metal Protectant. Manitowoc Crane Care has Boeshield® T-9 Premium Metal Protectant available in 12 oz. cans that can be ordered through the Parts Department.

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

Table 9-1
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.
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
AGMA No. 4 EP	Extreme Pressure Gear Lube
SCA (LCC)	Supplemental Coolant Additive

Table 9-2
Lube Description

Lubrication Description	Lube Specification
50/50 Fully Formulated Anti-Freeze Coolant	A6-829-101130
Engine Oil SAE 15W40-ISX Engine	A6-829-104182
Engine Oil SAE 15W40-QSM Engine	A6-829-003483
Extreme Pressure Multi-Purpose Grease	A6-829-003477
Synthetic Gear Lube	A6-829-013433
Hydraulic Oil	A6-829-006444
Semi-Synthetic Gear Lube	A6-829-012964
Anti-Seize Compound	A6-829-003689
Open Gear Lube	6829102971
Extreme Pressure Gear Lube	A6-829-100213
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 accordingly 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 - 37 l (9.7 gal)

   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. Drain and refill cooling system every 2000 hours or 12 months.

   Lube Amount - Capacity - 49 l (52 qt)

CAUTION

Improper filling of the engine coolant system can result in engine damage.

   Application -

   a. Open petcock in upper radiator tube to vent air during initial fill.

      Fill slowly. Flows exceeding 12 l/min (3 gpm) can give a false level. When coolant squirts out, close petcock, then fill radiator to bottom of filler neck with mixture of 50% AFC and 50% water.

      Run engine through two (2) thermal cycles.

      Wait 1 minute and recheck coolant level and refill as required.

3. Transmission

   Lube Type - SGL-5

   Lube Interval - Check fluid level every 500 hours, 6 months, or 14,484 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 - 12 l (13 qt)

   Application - Fill to check plug on the left-hand side of the transmission.

4. 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

5. PTO Clutch

Lube Type - HYDO

Lube Interval - 500 hours or 3 months

Lube Amount - Capacity - 650 ml (22 fl.oz.)

Application - Fill until oil weeps from side port.

6. Drive line

Lube Type - EP-MPG

Lube Interval - 500 Hours or 16,093 km (10,000 mi) whichever interval occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fittings

7. Power Steering Gearbox

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 1 grease fitting

8. Steering Relay Arms

Lube Type - EP-MPG

Lube Interval - 250 hours

Lube Amount - Until grease extrudes

Application - 2 grease fittings

9. 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 anti-seize (ASC) compound. Do not apply anti-seize compound to the face of the wheel of the hub.

Application - Brush on

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.

10. 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.

11. Front Axle Tie Rod Ends

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

12. Front Axle King Pins

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 8 grease fittings

13. Front Axle Brake Slack Adjusters

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

14. Front Axle Brake Camshafts

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

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 anti-seize (ASC) compound. Do not apply anti-seize compound to the face of the wheel of the hub.

Application - Brush on; 8 places

16. 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

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 unit if the unit has been recently moved.

CAUTION

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 9-1) 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.

17. 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

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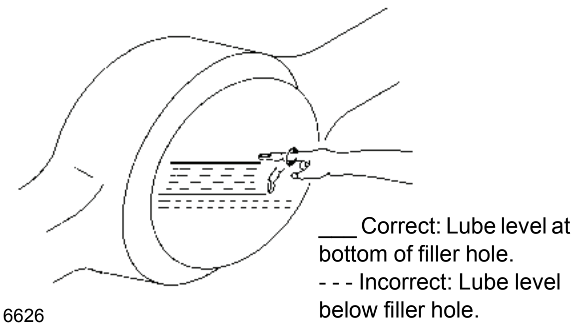

FIGURE 9-1

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. A 30 minute drain down time is required before checking unit if the unit has been recently moved.

CAUTION

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.

18. Rear Axle Brake Slack Adjusters

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

19. Rear Axle Brake Camshafts

Lube Type - EP-MPG

Lube Interval - 1000 hours

Lube Amount - Until grease extrudes

Application - 4 grease fittings

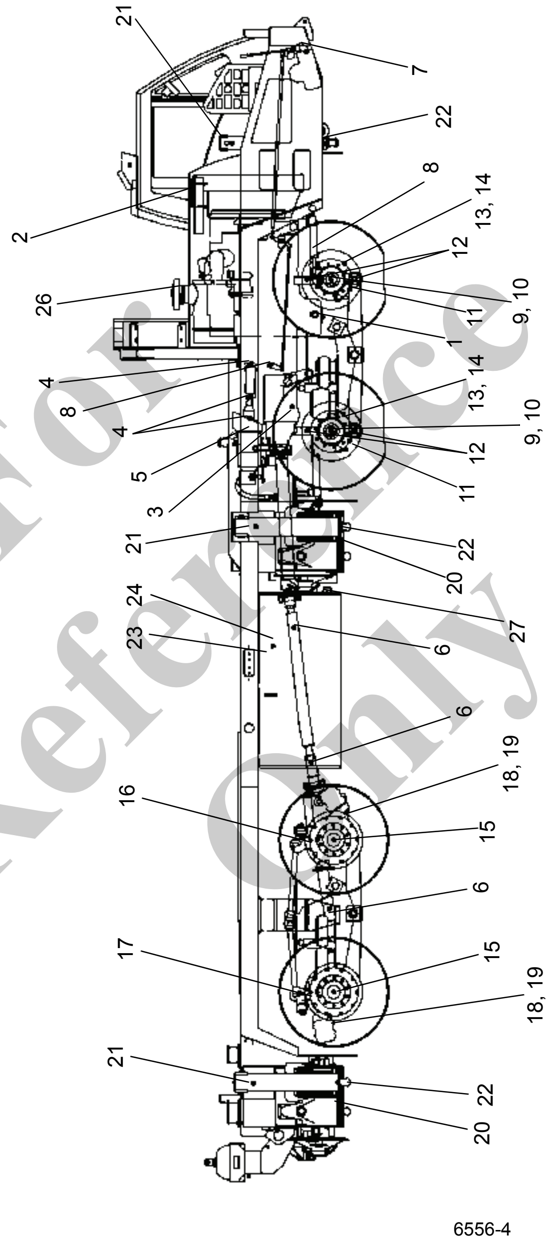
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FIGURE 9-2

Item	Description
1	Engine Crankcase
2	Engine Cooling System
3	Transmission
4	Pump Drive Shaft U-Joints and Spline
5	PTO Clutch
6	Driveline
7	Power Steering Gearbox
8	Steering Relay Arms
9	Front Aluminum Wheel Pilots
10	Front Axle Hubs
11	Front Axle Tie Rod Ends
12	Front Axle King Pins
13	Front Axle Brake Slack Adjusters
14	Front Axle Brake Camshafts
15	Rear Aluminum Wheel Pilot
16	Front Rear Axle Differential
17	Rear Rear Axle Differential
18	Rear Axle Brake Slack Adjusters
19	Rear Axle Brake Camshafts
20	Outrigger Beams
21	Jack Cylinder Support Tubes
22	Jack Cylinder Barrels
23	Hydraulic Reservoir
24	Hydraulic Filter
25	Fuel Filter
26	Air Cleaner
27	Coolant Strainer (Superstructure Cab Heater)

20. 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

21. Jack Cylinder Support Tubes

Lube Type - EP-MPG

Lube Interval - 500 hours

Lube Amount - Brush on inside diameter of jack cylinder support tubes and wear bands before installing jack cylinders.

Application -Brush on; 5 places

22. 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

HYDRAULIC LUBRICATION

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 (for example, 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.

NOTE: To inspect hydraulic oil, fill a small glass container with a sample of reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one to two hours and then compare the samples. If the reservoir oil is heavily contaminated with water the sample will appear “milky” with only a small layer of transparent oil on top. If the "milky" appearance was due to air foaming, it will dissipate and the oil should closely match the fresh oil. Should you have any questions, please contact your local Grove distributor or Manitowoc Crane Care.

23. Hydraulic Reservoir

Lube Type - HYDO

Lube Interval - Check fluid level every 10 hours or daily, using sight gauge on side of tank, with boom down and retracted and all outrigger cylinders retracted; drain and refill as necessary. Replace oil every 2000 hours or 2 years, whichever interval occurs first.

NOTE: 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, the service interval can be increased to 3000 hours or 3 years.

Lube Amount - 656.6 l (173.5 gal) (tank only), to the FULL mark on sight gauge.

Application - Fill through filler cap on top of tank. When tank is drained, clean the magnetic pipe plug.

Replace breather every 500 hours or 6 months, whichever interval occurs first.

24. Hydraulic Filter

Check filter every 500 hours or 6 months, whichever interval occurs first.

Change the filter when the indicator is red.

25. Fuel Filter

Drain water trap every 10 hours or daily and change filter every 500 hours or 6 months.

26. Air Cleaner Filter

Replace air cleaner filter element when indicator shows red (25" H2O).

27. 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.

28. Not used.

SUPERSTRUCTURE LUBRICATION

29. Turntable Gear Box

Lube Type - SSGL-5

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 -5.4 l (1.4 gal)

Application - Fill until oil level is at top of sight gauge

30. Turntable Gear and Drive Pinion

Lube Type - OGL

Lube Interval - 500 hours or 6 months, whichever interval occurs first

Lube Amount - Coat all teeth

Application - Spray on; 2 places

31. 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. Rotate the turntable 90° and apply grease to fittings. Continue rotating 90° and grease the fittings until the whole bearing is greased.

32. Main Hoist

Lube Type - AGMA EP-4

Lube Interval - Check and fill every 1000 hours or 12 months, whichever interval occurs first. Drain and fill annually.

Lube Amount - Capacity - 14.7 l (15.5 qt)

Application - Fill until level with the check plug opening.

33. Auxiliary Hoist

Lube Type - AGMA EP-4

Lube Interval - Check and fill every 1000 hours or 12 months, whichever interval occurs first. Drain and fill annually.

Lube Amount - Capacity - 14.7 l (15.5 qt)

Application - Fill until level with the check plug opening.

BOOM, JIB, AND BOOM ACCESSORIES LUBRICATION

NOTE: To service the boom at boom lengths longer than 36.6 m (120 ft) (to access grease fittings, grease the sections, or to change the holding valve), a minimum of 5443 kg (12,000 lb) of counterweight must be installed on the turntable and the outriggers must be fully extended. Boom must be positioned over the right-hand side of the machine. No rigging, no hook block, or overhaul ball may be installed on the nose of the boom.

Extend boom to desired length at a boom angle of 20 degrees. Lower boom until RCL limits the boom lower function. Override RCL per RCL Operator's Manual and lower boom to desired angle.

34. 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

35. 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 tele 3 and tele 2.

36. 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 tele 1 at boom length of 39 m (128 ft)

37. Telescope Cylinder Wear Pads

Lube Type - EP-MPG

Lube Interval - Every boom tear down.

Lube Amount - Thoroughly coat all areas the wear pads move on.

Application - By brush; 5 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.

38. Internal Side and Bottom Wear Pads (Inner Sections)

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever interval occurs first. Lubricate more frequently if environmental conditions and/or operating conditions necessitate.

Lube Amount - Thoroughly coat all areas the wear pads move on.

Application - By brush: 14 places; with boom in extended position through access holes in tele 1 and tele 2.

39. Boom Section Upper Wear Pads

Lube Type - EP-MPG

Lube Interval - 50 hours or 1 week, whichever interval occurs first. Lubricate more frequently if environmental conditions and/or operating conditions necessitate.

Lube Amount - Until grease extrudes

Application - 8 places; with boom in extended position through access holes.

40. Boom Section Upper and Lower Wear Pads

Lube Type - EP-MPG

Lube Interval - 50 hours or 1 week, whichever occurs first. Lubricate more frequently if environmental conditions and/or operating conditions necessitate.

Lube Amount - Thoroughly coat all areas the wear pad moves on.

Application - By brush; 12 places; with boom in extended position.

41. Upper Boom Nose Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 2 grease fittings per sheave

42. Lower Boom Nose Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 4 grease fittings per sheave

43. Jib Sheaves

Lube Type - EP-MPG

Lube Interval - 250 hours or 3 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 2 grease fittings

44. Jib Mast Sheave

Lube Type - EP-MPG

Lube Interval - 500 hours or 12 months, whichever occurs first

Lube Amount - Until grease extrudes

Application - 1 grease fitting

45. 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

46. 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

47. 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

(4 fittings total - 75 ton)

48. Overhaul 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

49. Turntable Swivel Lock Pin

Lube Type - OGL

Lube Interval - 500 hours or 6 months, whichever interval occurs first

Lube Amount - Coat points requiring periodic lubrication

Application - Spray on

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.

NOTE: Wire rope may be purchased by contacting the Manitowoc Crane Care Parts Department.

For more detailed information concerning the lubrication and inspection of wire rope, refer to Wire Rope, page 1-17.

Item	Description
29	Turntable Gearbox
30	Turntable Gear and Drive Pinion
31	Turntable Bearing
32	Main Hoist
33	Auxiliary Hoist
34	Boom Pivot Shaft
35	Extend Cable Sheaves
36	Retract Cable Sheaves
37	Telescope Cylinder Wear Pads
38	Internal Side and Bottom Wear Pads (Internal Sections)
39	Boom Section Upper Wear Pads
40	Boom Section Upper and Lower Wear Pads
41	Upper Boom Nose Sheaves
42	Lower Boom Nose Sheaves
43	Jib Sheaves
44	Jib Mast Sheave
45	Auxiliary Boom Nose Sheave
46	Hook Block Swivel Bearing
47	Hook Block Sheaves
48	Overall Ball Swivel Top
49	Turntable Swivel Lock Pin

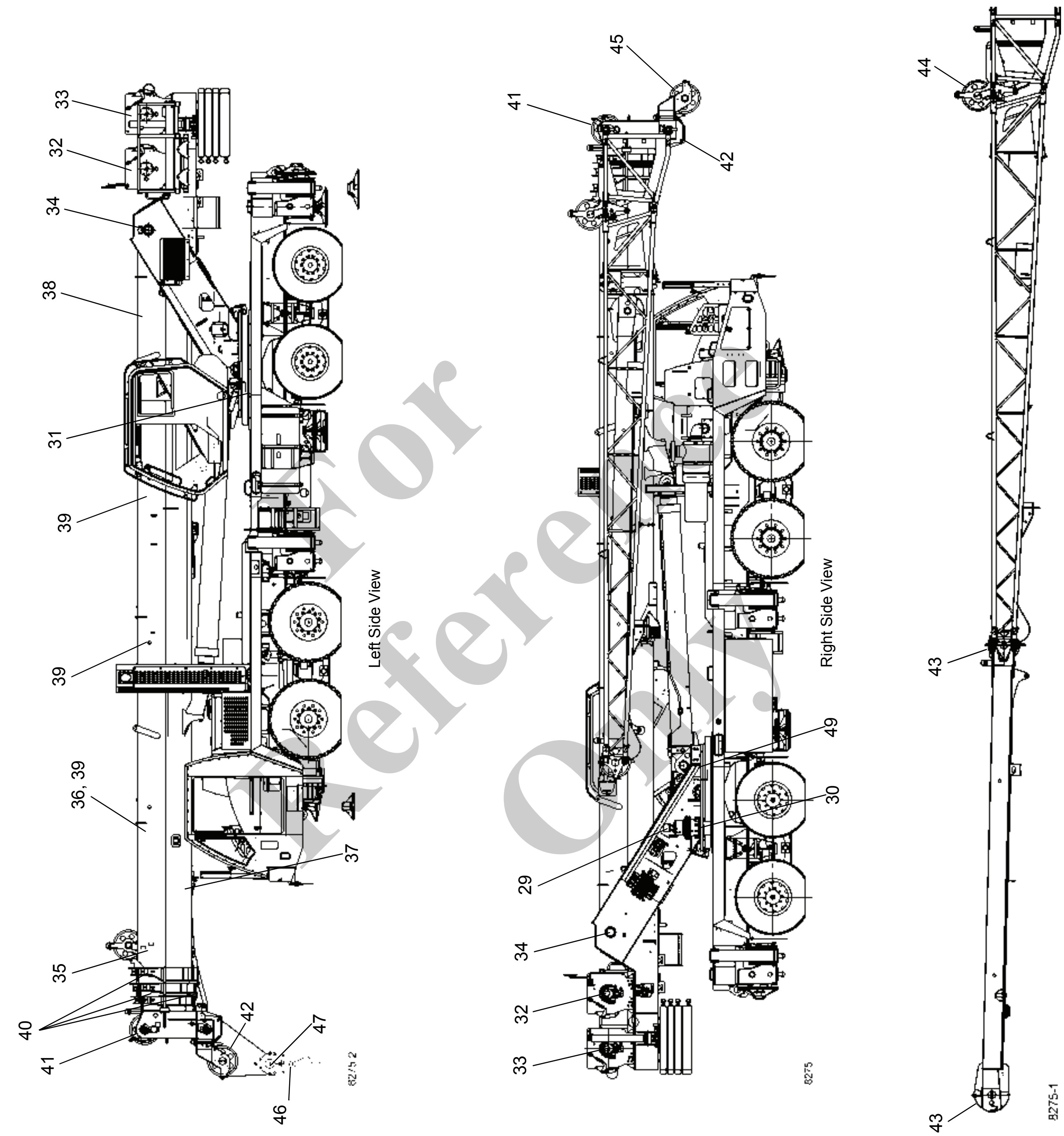

FIGURE 9-3

CARWELL® RUST INHIBITOR

Protecting Cranes From Corrosion

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CRF-19-10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly "oily" residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleaning if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain crane parts may become corroded even though other parts remain dry; or
- in high humidity, or when temperatures are just above the freezing point.

Cleaning Procedures

To help protect against corrosion of Grove cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleaning may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

- For scratches and marks in highly visible areas:
- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Refer to Figure 9-4

- 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 end and fittings, Swivel, pumps, axles, drive lines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose end and fittings, wire rope on hoist roller tensioning springs on hoists, all

unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.

- Boom application areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, headache ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.


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FIGURE 9-4

Item	Description
1	Hoist Hose Connections
2	Jib Pins, Clips
3	Valve Bank
4	Hose Connections inside turntable
5	Jib 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

Item	Description
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

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ALPHABETICAL INDEX