

Grove TMS9000-2

Service Manual





WARNING

California Proposition 65

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

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

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

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.

SERVICE MANUAL

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

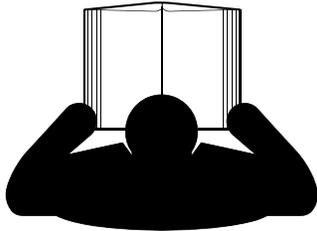
TMS9000-2

Crane Model Number

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.

	<h2>⚠ DANGER</h2> <p>An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:</p> <ul style="list-style-type: none">• You are trained in the safe operation of this crane. Manitowoc is not responsible for qualifying personnel.• You read, understand, and follow the safety and operating recommendations contained in the crane manufacturer's manuals and load charts, your employer's work rules, and applicable government regulations.• You are sure that all safety signs, guards, and other safety features are in place and in proper condition.• The Operator Manual and Load Chart are in the holder provided on the crane.
---	--

**For
Reference
Only**

This Page Blank

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.

For
Reference
Only

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

- 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.
- 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 $1.8^{\circ} \pm 0.5^{\circ}$ 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 centered over the axle, left and right; these measurements should be within 3/16 in. (4.8 mm).**

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

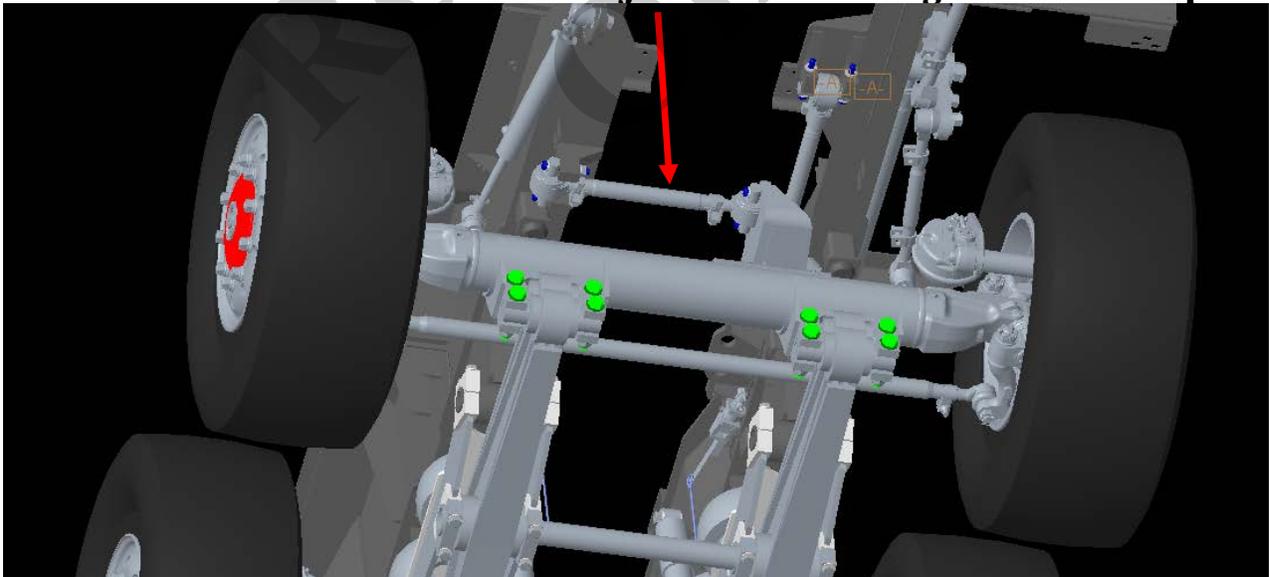


Measure to edge of tread

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

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

Adjust each axle using the lateral torque rod.



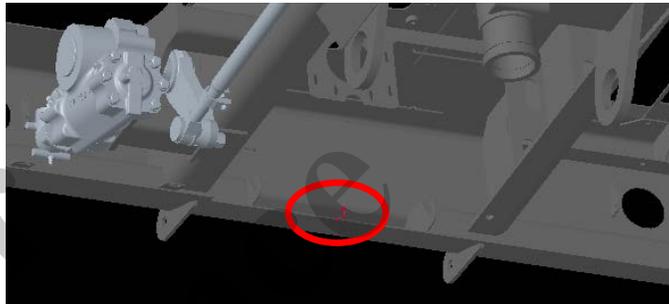
- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

Adjust steer axle skew.

- **Raise the machine on outriggers and place an alignment turntable under each of the steer tires. Lower the machine making certain not to bottom-out the turntables or put them in a bind.**
- **Measure the distance between the “center hook” on the frame to the corner of the front steer axle mount, left and right; each axle’s left and right measurements should be within 3/16 in. (4.8 mm) of the other.**



#1 axle



Center hook location

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

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



Measure to outside edge of mounts

Shims

Bar pin

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

Adjust 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.



Shims

Bar pin

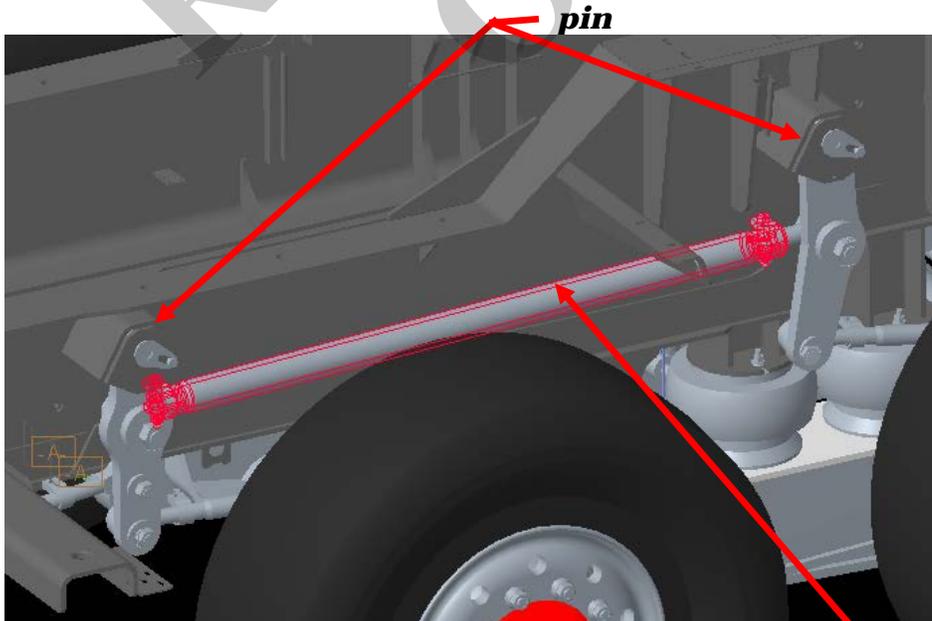
- **Lower the machine to the ground. Back out and drive straight into the work area several times to ensure the vehicle's suspension components remain relaxed and achieve proper measurements. Place wheel chocks on the drive axles.**

Adjust steering linkage.

- Rotate the steering wheel to center the front relay arm and pin it with a $\text{\O} 21/64$ 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 $\text{\O} 21/64$ 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).



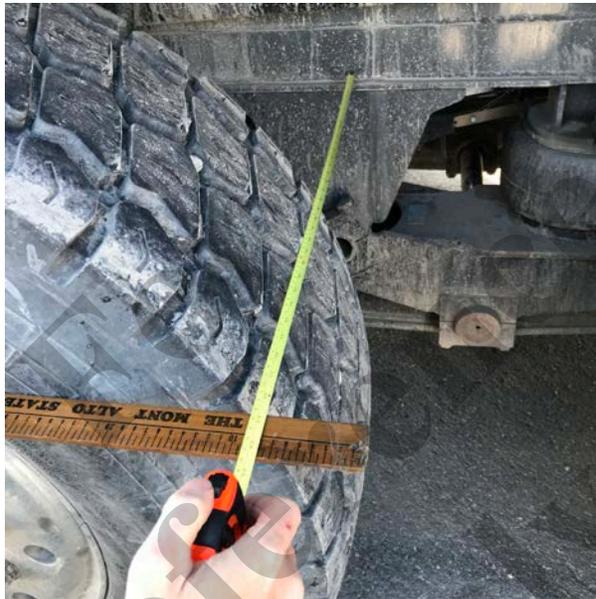
Driver side front steer axle.

Adjust intermediate
drag link

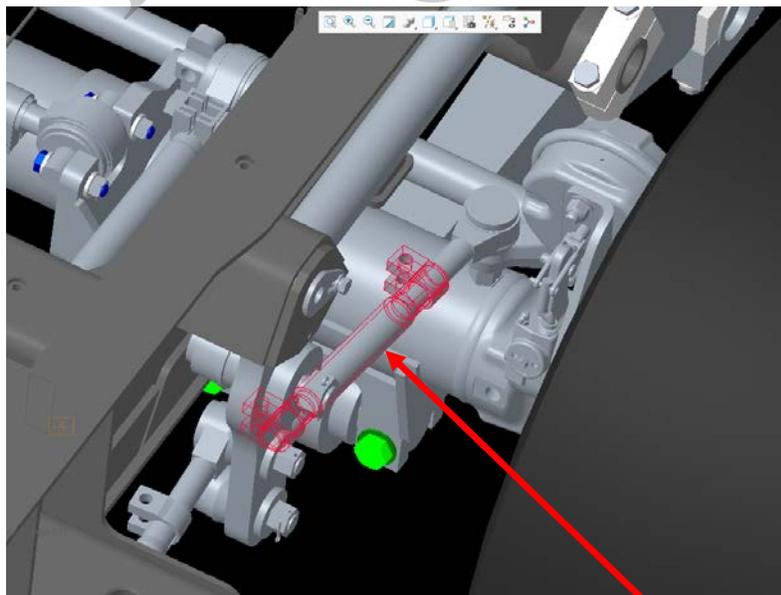
Adjust steering linkage continued.

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 front steer axle driver’s side tire, front and rear, to the frame side plate.**



- **Adjust front steer axle 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

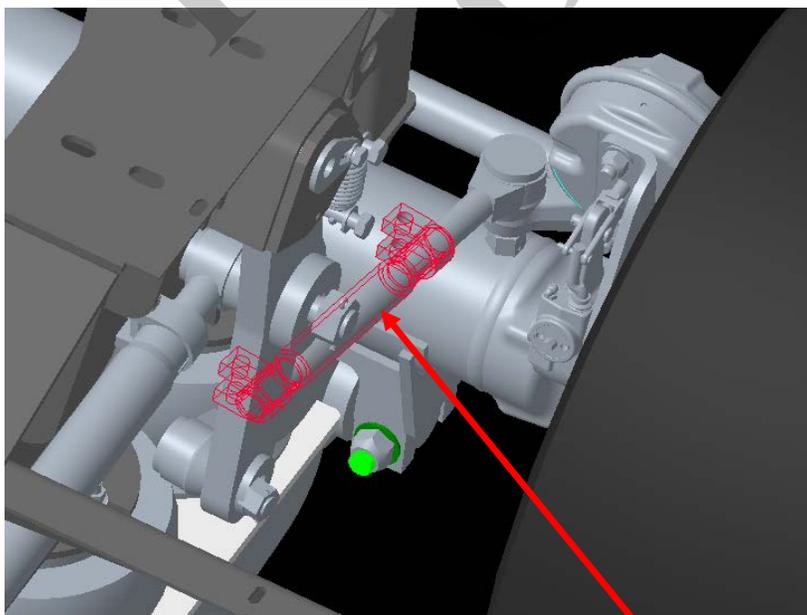
Adjust steering linkage continued.

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 rear steer axle driver side tire, front and rear, to the frame side plate.**



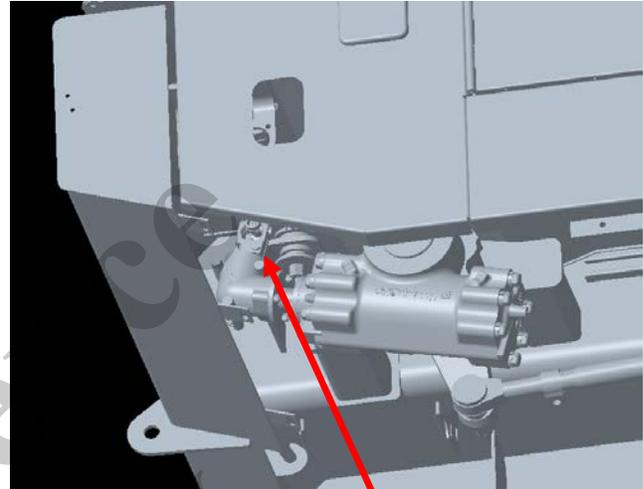
- **Adjust rear steer axle drag link until front and rear measurements are equal. Apply Loctite 243 to clamp bolts and re-torque to 110-130 lbf*ft. (149-176 N*m).**



Rear steer axle #2 drag link

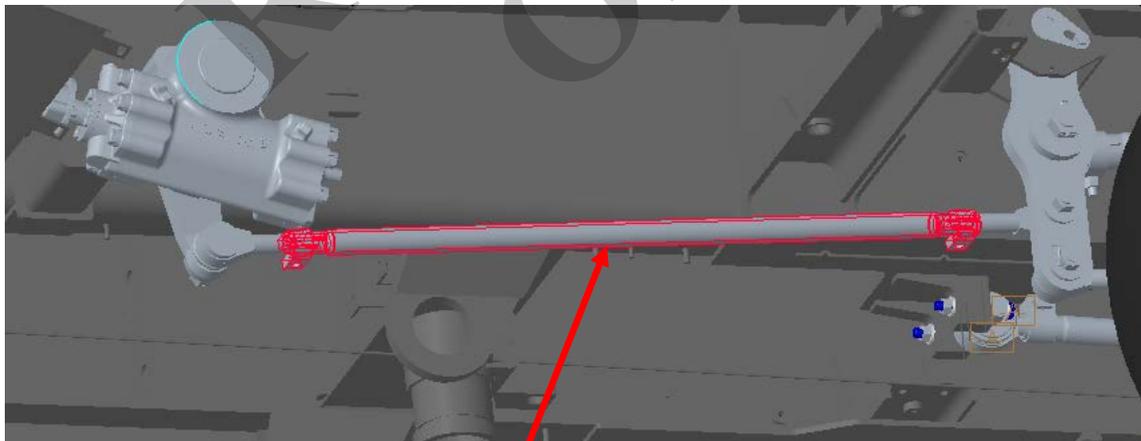
Adjust steering linkage continued.

- **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).**



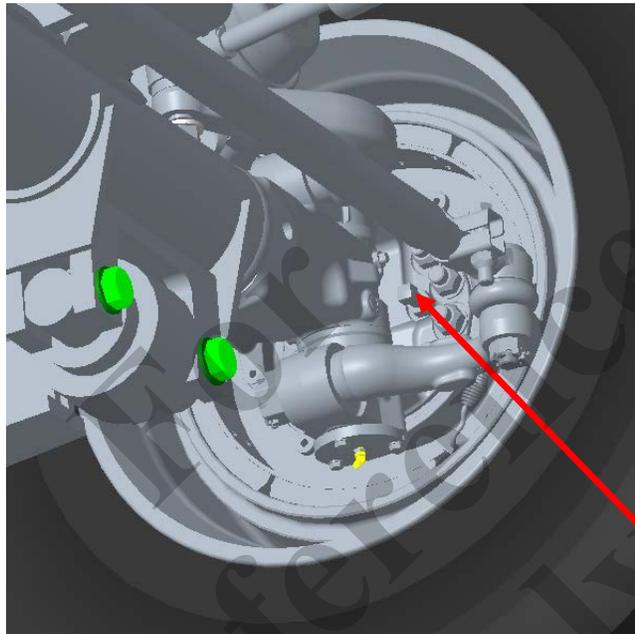
Steering link

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

Adjust steer axle turning stops.

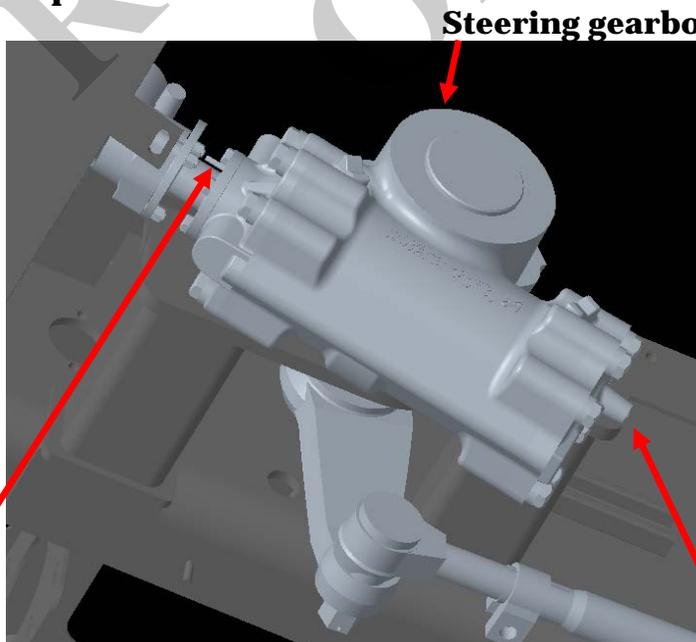
- **Steering stops should be set to provide 1.00 in. (25.4 mm) of clearance to closest object for any tire.**

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 $3.0^{\circ} \pm 0.5^{\circ}$.

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.

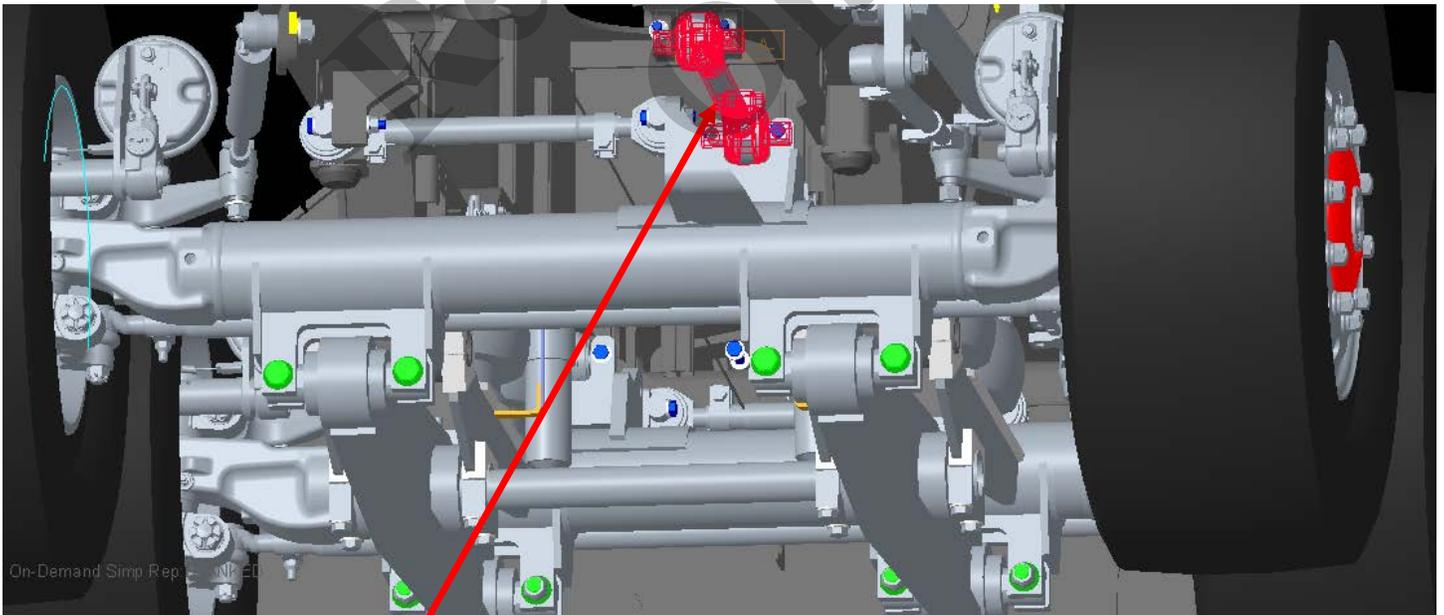


Caster gauge



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 $1/16^\circ$ +/- $3/16^\circ$; 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.

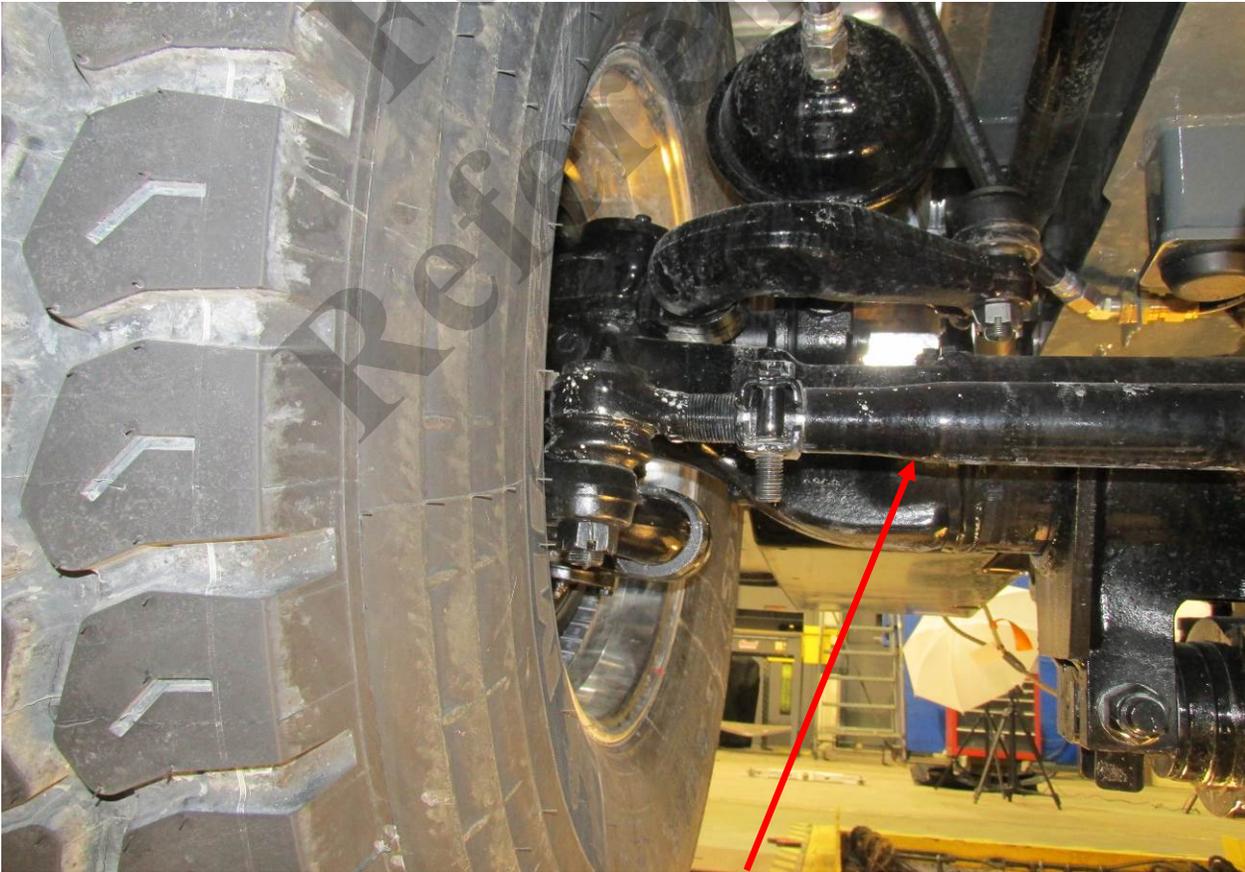
- Toe should be $+1/32$ in. (0.8 mm) $\pm 1/32$ in. (0.8 mm).

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

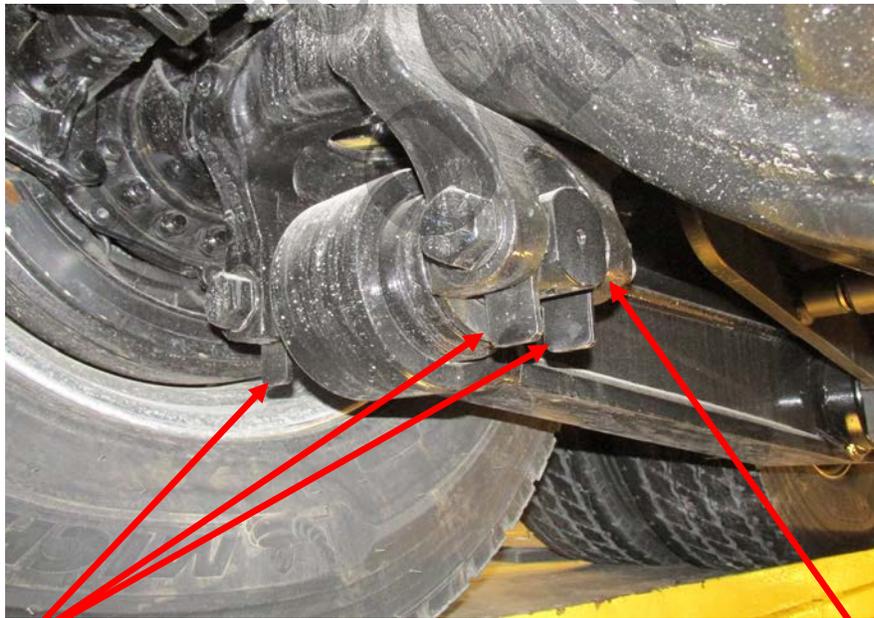
Adjust drive axle thrust.

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

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



Shims

Bar pin

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

Adjust drive axle parallelism.

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



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

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



Shims

Bar pin

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.**

For
Reference
Only

**For
Reference
Only**

TABLE OF CONTENTS

SECTION 1 General Instructions

- Using the Service Manual 1-1
- Safety Messages 1-1
 - General 1-1
 - Safety Alert Symbol 1-1
 - Signal Words 1-1
- Manitowoc CraneCare Service instructions 1-2
- Definitions of Stated Directions 1-2
- Breaking in a New Crane 1-2
- Safety Rules 1-3
- Handling Substances which are Harmful to the Environment 1-4
 - What do Environmentally Harmful Substances Include? 1-4
- Overview of the Operating and Display Elements 1-4
 - Axle Weight Distribution Table 1-5
- Cleaning 1-7
 - Boom Cleaning 1-7
- Overview of the Components that are Easily Damaged when Cleaning 1-8
 - On Truck Crane 1-8
- Fasteners and Torque Values 1-8
- Torque Wrenches 1-9
- Torque Values 1-9
 - Weld Studs 1-23

SECTION 2 Hydraulic System

- Description 2-2
 - Maintenance 2-4
 - Draining and Flushing 2-4
 - Removing Air from the Hydraulic System 2-5
 - Parts Replacement 2-6
- Supply Pressure and Return Circuit 2-6
 - Description 2-6
 - Hydraulic Reservoir and Filter 2-6
 - Pump Distribution 2-7
- Maintenance 2-9
 - Troubleshooting 2-9
- Return Hydraulic Filter Assembly 2-10
 - Element Removal 2-10
 - Element Installation 2-10
- Hydraulic Pumps 2-12
 - Description 2-12
 - Maintenance 2-12
- Carrier Valves 2-17
 - General 2-17
- Outrigger Selector-A/C Manifold Valve 2-19
 - Description 2-19
 - Maintenance 2-19
- Outrigger Control Manifold 2-21
 - Description 2-21
 - Maintenance 2-21
- Pilot Operated Check Valve 2-24
 - Description 2-24
 - Internal Leak Testing 2-24
 - Maintenance 2-25
- Superstructure Valves 2-26

T
O
C

Turntable Hydraulic Valves	2-26
Main Directional Valve Assembly	2-27
Access Manifold Assembly	2-28
Hydraulic System of the Superstructure	2-29
Checking for Leaks	2-29
Cylinders	2-29
General	2-29
Maintenance	2-29
Steer Cylinder	2-31
Description	2-31
Maintenance	2-31
Outrigger Extension Cylinder	2-34
Description	2-34
Maintenance	2-34
Outrigger Jack Cylinder	2-37
Description	2-37
Maintenance	2-37
Center Front Stabilizer Cylinder	2-41
Description	2-41
Maintenance	2-41
Lift Cylinder	2-44
Description	2-44
Maintenance	2-44
Counterweight Cylinder	2-47
Description	2-47
Telescope Cylinder	2-48
Description	2-48
Pressure Setting Procedures	2-49
Objective	2-49
Equipment	2-49
Valve Pressure Setting Table	2-49
Service Tool Notes	2-50
A. Procedure for Checking/Setting the Piston Pumps Cut-Off & Differential Pressures	2-50
B. Procedure for Checking/Setting the Pilot Supply Pressure	2-52
C. Procedure for Checking/Setting the Main Directional Control Valve, Load Sense, Lift and Telescope Pressures	2-53
D. Procedure for Checking/Setting Cab Tilt Raise and Lower Pressures	2-58
E. Procedure for Checking/Setting Counterweight (CWT) Raise and Lower Pressures	2-58
F. Procedure for Checking/Setting Swing Pressure	2-59
G. Procedure for Checking/Setting Outrigger Pressure	2-59
H. Procedure for Checking/Setting Air Conditioning Pressure	2-60
I. Procedure for Checking/Setting the Center Front Stabilizer Pressure	2-61
J. Procedure for Checking/Setting the Front Steer Pressure	2-62
K. Procedure for Adjusting Electronic Controllers (Meter-in Dead Band and/or Max Function Speeds)	2-63

SECTION 3. Electrical System

Description	3-1
Carrier	3-1
Maintenance	3-9
General	3-9
General Troubleshooting	3-9
Tools for Troubleshooting	3-9
Troubleshooting Engine Starting Problems	3-9

Troubleshooting Engine Charging Problems 3-10

Troubleshooting Slip Ring-Caused Electrical Problems 3-10

Connector Troubleshooting. 3-11

Di-Electrical Grease Application 3-12

Troubleshooting Lights 3-13

Troubleshooting Gauges and Meters 3-13

Troubleshooting Alarms, Indicators, and Emergency Components 3-14

Troubleshooting the Crane Control System (CCS). 3-14

ODM Error Code Viewer. 3-14

Troubleshooting Crane Components and Accessories. 3-15

Alternator Replacement 3-15

Starter Replacement 3-15

Battery Replacement 3-16

Relay Panel Component Replacement. 3-18

Instrument Replacement. 3-18

Switch Replacement 3-18

 Rocker Switch 3-18

 All Other Switches. 3-19

Windshield Wiper Assembly Replacement 3-19

Windshield Washer Assembly Replacement 3-21

Remote Controller (Optional). 3-22

 Receiver 3-22

 Battery Charger. 3-22

 Remote Controller Battery 3-23

Jump Starting the Crane 3-23

 Charging 3-23

SECTION 4 Superstructure

Description of Maintenance Work on the Superstructure 4-1

 Hoist 4-1

Boom Removal 4-9

Boom Installation 4-11

 Functional Check 4-13

Boom Nose Sheaves 4-13

 Boom Nose Sheaves Removal 4-13

 Boom Nose Sheaves Installation 4-17

Boom Disassembly 4-17

Boom Assembly. 4-18

 Telescope Section 5 Assembly. 4-18

 Telescope Section 4 Assembly. 4-22

 Telescope Section 3 Assembly. 4-25

 Telescope Section 2 Assembly. 4-28

 Telescope Section 1 Assembly. 4-31

 Telescope Base Section Assembly. 4-37

Pinning Boom Components 4-38

 Mechanical Locking Head Description 4-38

 Proximity Switch Descriptions 4-39

 Hydraulic Actuator Description 4-41

 Precision Length Sensor Description 4-42

 Pinned Boom Control System Description 4-42

Mechanical Emergency Unlocking and Locking of the Telescopic Sections 4-43

 Prerequisites 4-43

 Maintenance 4-43

New York House Lock 4-44

Bleeding the Telescoping Cylinders 4-44

 Prerequisites 4-44

Bleeding Procedure	4-44
Telescoping Status	4-45
Telescope Slide Pad Adjustment	4-46
Check the Locking System	4-46
Hoist Ropes	4-47
Checking the Position of Sheaves and Rope Drums	4-47
Wire Rope Inspection/Replacement (All Wire Rope)	4-47
Rated Capacity Limiter	4-52
Maintenance of the Slip Ring Assembly of the Cable Drum	4-52
Lubricating the Swing Angle Sensor	4-54
Superstructure Air Conditioning System (Additional Equipment)	4-55
Checking Hoses	4-55
Other Maintenance Work	4-55
Checking for Correct Operation of the Auxiliary Heater (Additional Equipment) ..	4-55
Lubricating the Piston Rod of the Lifting Cylinder	4-55

SECTION 5. Superstructure Maintenance

Superstructure Maintenance Overview	5-1
Maintenance Intervals	5-1
Maintenance Plans	5-3
Maintenance Plan W: Weekly	5-5
Maintenance Plan M 1: Monthly/After 100 Operating Hours/Approximately 2,000 km (1240 mi)	5-6
Maintenance Plan M 3: Every 3 Months/After 300 Operating Hours/ 5 000 - 6 000 km (3,100 - 3,730 mi)	5-6
Maintenance Plan M 6: Every 6 Months/After 500 Operating Hours/10 000 - 12 500 km (6,210 - 7,770 mi)	5-6
Maintenance Plan M 12: Every 12 Months/After 1,000 Operating Hours/20 000 - 25 000 km (12,430 - 15,530 mi)	5-7
Maintenance and Inspection Plan Y 2: Every 24 Months/After 100 000 - 125 000 km (62,150 - 77,800 mi)	5-7
Maintenance and Inspection Plan Y 3: Every 36 Months/After 3,000 Operating Hours	5-7
Maintenance and Inspection Plan Y 5: Every 60 Months/After 5,000 Operating Hours	5-8
Maintenance and Inspection Plan Y 6: Every 72 Months/After 6,000 Operating Hours	5-8
Periodic Inspections	5-9
Load Hook Inspection	5-9
Measures Required for Hoist Monitoring	5-10
Theoretical Service Life	5-10
Proportion of the Theoretical Service Life Used	5-10
Table Example to Determine the Remaining Theoretical Service Life on Hoist No. 1 (Main Hoist)	5-12

SECTION 6. Swing System

Description	6-1
Theory of Operation	6-1
Swing Drive	6-1
Swing Brake	6-1
Maintenance	6-3
Troubleshooting	6-3
Swing Box Assemblies	6-7
Description	6-7
Swing Motor Maintenance	6-7
Swing Gear Brake Function Check	6-8

Swing Brake Assembly Maintenance	6-8
Swing Gearbox Maintenance	6-8
Swing Bearing	6-10
Description	6-10
Maintenance	6-10
Swivels	6-15
Description	6-15
Hydraulic Swivel	6-17
Electrical Swivel	6-18
Swing Lock Pin	6-20
Description	6-20
Rotating the Turntable Swing Lock Handle	6-20
Maintenance	6-20
360° Swing Lock Control (Positive Lock Type)	6-20
Description	6-20
Maintenance	6-20

SECTION 7 Power Train

Engine	7-1
Description	7-1
Maintenance	7-2
Removal	7-2
Installation	7-4
Engine Drive Belts	7-4
Engine Control System	7-5
Description	7-5
Functional Operation	7-5
Engine Control System Switches and Indicator Lights	7-6
Fuel System	7-6
Description	7-6
Maintenance	7-7
Air Intake System	7-8
Description	7-8
Maintenance	7-9
Exhaust System	7-11
Description	7-11
Exhaust System Removal	7-11
System Installation	7-11
Slip Joint Exhaust Connectors	7-12
Exhaust System	7-12
After-Treatment Diesel Exhaust Fluid (DEF)	7-13
DEF Tank	7-13
DEF Dosing Unit Filter	7-14
Water Cooling System	7-16
Description	7-16
Maintenance	7-16
Cleaning	7-18
Component Inspection	7-19
Radiator Assembly Removal and Installation	7-20
Drive Train	7-22
Description	7-22
Maintenance	7-22
Drive Lines	7-22
Clutch	7-24
Description	7-24
Theory Of Operation	7-24

Maintenance	7-26
Clutch Adjustment Procedure	7-33
General Maintenance	7-33
Gearshift	7-33
Description	7-33
Maintenance	7-34
Manual Transmission	7-34
Description	7-34
Theory of Operation	7-34
Maintenance	7-35
Lubrication	7-38
Preventive Maintenance	7-39
Transmission Shift Air System	7-39
Description	7-39
Theory of Operation	7-39
Pump / PTO Assembly	7-40
Pump / PTO Replacement	7-40

SECTION 8. Carrier

Front Axle	8-2
Suspension	8-2
Maintenance	8-2
General	8-2
Removal	8-5
Disassembly	8-5
Assembly	8-5
Installation	8-6
Axle Alignment Procedure	8-6
Steering System	8-12
Description	8-12
Maintenance	8-13
Steering Pump	8-15
Description	8-15
Steering Gearbox	8-15
Maintenance	8-15
Steer Cylinder	8-16
Description	8-16
Maintenance	8-16
Wheels and Tires	8-17
Description	8-17
Maintenance	8-17
Rear Axle and Suspension	8-17
Rear Axle	8-17
Suspension	8-18
Maintenance	8-18
Removal	8-20
Disassembly	8-20
Assembly	8-20
Installation	8-21
Wheels and Tires	8-21
Description	8-21
Maintenance	8-21
Mounting the Wheels on the Axle	8-21
Air System	8-22
Description	8-22
Theory of Operation	8-22

Braking	8-24
Maintenance	8-25
Air System Components	8-27
Brakes	8-36
Description	8-36
Air Supply	8-36
Normal Braking	8-36
Vehicle Parking	8-36
Anti-lock Braking Systems (ABS)	8-36
Automatic Traction Control	8-37
Emergency Braking	8-37
Non-Asbestos Warning	8-37
Front Brakes	8-37
Description	8-37
Maintenance	8-38
Automatic Slack Adjuster	8-44
Description	8-44
Maintenance	8-44
Rear Brakes	8-52
Description	8-52
Maintenance	8-52
Rear Brake Assembly	8-55
Anti-Lock Brake System (ABS)/Automatic Traction Control (ATC)	8-57
ABS System Description	8-57
ATC System Description	8-59
ABS Troubleshooting	8-61
Troubleshooting Diagnostic Trouble Codes: Traction Control Valves	8-69
Power Supply Tests	8-71
Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications	8-71
Miscellaneous Troubleshooting	8-73
Troubleshooting Wiring	8-74
Special Tools	8-78
Tests, Repair and Adjustment	8-78
Component Removal and Installation	8-80
Outriggers	8-83
Description	8-83
Theory Of Operation	8-84
Maintenance	8-84
Extension Cylinder	8-92
Outrigger Jack Cylinders	8-92
Description	8-92
Maintenance	8-92
Center Front Jack Cylinder	8-93
Description	8-93
Maintenance	8-93
Functional Check	8-94
Outrigger Monitoring System (Optional—Standard in North America)	8-96
Description	8-96
OMS String Potentiometers	8-96

SECTION 9 Lubrication

General	9-1
Environmental Protection	9-1
Cummins Oil Registration List	9-1
Arctic Conditions Below -18° C (0° F)	9-2
Cylinder Rod Surface Protection	9-2

Lubrication Points 9-2

 Standard Lubricants 9-3

 Cold Weather Lubricants 9-5

 Arctic Lubricants and Conditions 9-7

 Drivetrain Lubrication 9-8

 Clutch Release Bearing Grease Interval 9-11

 Steering Lubrication 9-13

 Axle Lubrication 9-13

 Outrigger Lubrication 9-17

 Miscellaneous Lubrication 9-18

 Turntable & Cab Tilt Lubrication 9-19

 Hoist Lubrication 9-21

 Turntable Central Lubrication 9-22

 Boom Lubrication 9-23

 Monthly Lubrication Work 9-28

Carwell® Rust Inhibitor 9-29

 Protecting Cranes From Corrosion 9-29

 Cleaning Procedures 9-29

 Inspection and Repair 9-30

 Application 9-30

 Areas of Application 9-30

For Reference Only

SECTION 1 GENERAL INSTRUCTIONS

SECTION CONTENTS

<p>Using the Service Manual 1-1</p> <p>Safety Messages 1-1</p> <p style="padding-left: 20px;">General 1-1</p> <p style="padding-left: 20px;">Safety Alert Symbol 1-1</p> <p style="padding-left: 20px;">Signal Words 1-1</p> <p>Manitowoc CraneCare Service instructions 1-2</p> <p>Definitions of Stated Directions 1-2</p> <p>Breaking in a New Crane 1-3</p> <p>Safety Rules 1-3</p> <p>Handling Substances which are Harmful to the Environment 1-4</p> <p style="padding-left: 20px;">What do Environmentally Harmful Substances</p>	<p style="padding-left: 20px;">Include? 1-4</p> <p>Overview of the Operating and Display Elements 1-5</p> <p style="padding-left: 20px;">Axle Weight Distribution Table 1-6</p> <p>Cleaning 1-8</p> <p style="padding-left: 20px;">Boom Cleaning 1-8</p> <p>Overview of the Components that are Easily Damaged when Cleaning 1-9</p> <p style="padding-left: 20px;">On Truck Crane 1-9</p> <p>Fasteners and Torque Values 1-9</p> <p>Torque Wrenches 1-10</p> <p>Torque Values 1-10</p> <p style="padding-left: 20px;">Weld Studs 1-24</p>
--	--

USING THE SERVICE MANUAL

This manual is not designed to replace proper training and instruction!
 Truck crane maintenance personnel are required to have relevant specialized knowledge of proper safety procedures!
 Read this section carefully before beginning maintenance work.

SAFETY MESSAGES

General

The importance of safe operation and maintenance cannot be overemphasized. Carelessness or neglect on the part of operators, job supervisors and planners, rigging personnel, and job site workers can result in their death or injury and costly damage to the crane and property.

To alert personnel to hazardous operating practices and maintenance procedures, safety messages are used throughout the manual. Each safety message contains a safety alert symbol and a signal word to identify the hazard's degree of seriousness.

Safety Alert Symbol



This safety alert symbol means **ATTENTION!** Become alert - **your safety is involved!** Obey all safety messages that follow this symbol to avoid possible death or injury.

Signal Words



DANGER

Identifies **hazards** that will result in death or serious injury if the message is ignored.



WARNING

Identifies **hazards** that could result in death or serious injury if the message is ignored.

**CAUTION**

Identifies **hazards** that could result in minor or moderate injury if the message is ignored.

CAUTION

Without the safety alert symbol, identifies **hazards** that could result in property damage if the message is ignored.

NOTE: Highlights operation or maintenance procedures.

MANITOWOC CRANECARE SERVICE INSTRUCTIONS

This Service Manual is intended for maintenance personnel. The maintenance manual does not contain information on repair work. Repair work may only be carried out by qualified repair personnel (e.g. the local authorized distributor or Manitowoc Crane Care).

Repair work also requires:

- appropriate workshop equipment,
- special tools and
- replacement parts authorized by Manitowoc Crane Care.

It is your responsibility to maintain and service the truck crane regularly in order to lengthen its service life and keep it in good working order.

Please note that Manitowoc Crane Care can only uphold the warranty provided for the truck crane if the following conditions are met:

- proper use,
- prescribed care and maintenance,
- professional repair work / overhauling.

Failures can be caused by **improper maintenance** such as:

- lack of oil, grease or antifreeze,
- dirt,
- rope damage,
- damaged compressed air and hydraulic systems,
- hose damage or loose screw connections,
- malfunctioning or mis-adjusted brakes,
- worn or damaged tires or wheel rims,
- exceeded maintenance intervals.

For your safety and the safety of others, avoid these errors by carrying out maintenance work carefully within the specified intervals. Do not put off maintenance work that is due. Notify either your local Grove Crane distributor or your qualified repair personnel immediately should repair work become necessary. This work may only be carried out by trained, qualified personnel.

A few general maintenance instructions:

- Clean the parts of the truck crane that are to be serviced, particularly the area around oil filler, inspection, and drain openings and lubricating nipples.
- When changing the oil, let the oil run out at operating temperature.
- Ensure that only oils and lubricants specified in the *Lubrication Section* are used.
- Replace all filters within the specified period if cleaning is not explicitly permitted.
- Replace all seals before assembly. Clean the sealing surfaces.
- Only tighten loose screw connections on hydraulic systems when the system is depressurized.
- Keep brake and clutch linings free of grease.
- Replace hydraulic hoses immediately once damage or evidence of moisture becomes visible.
- When handling hydraulic oil, cleanliness is imperative. Even new hydraulic oil must be filtered.
- Check fastening and retaining elements (screws, nuts, lock washers) before re-using them and replace them if necessary.

Tightening torques may be found in *Torque Values*, page 1-9.

Our training center at our plant in Shady Grove, Pennsylvania offers specialized training programs. Your local Grove Crane distributor can provide you with any information you may need in this regard.

Ensure compliance with all applicable regulations regarding operation of the crane on public roads.

DEFINITIONS OF STATED DIRECTIONS

Some of the terms which are used to describe the location of components are defined in this section.

On the **carrier**, the driver's cab is always at the **front**. The terms **rear**, **right** and **left** are used in relation to the definition of the term "front" on the carrier.

On the **superstructure**, **front** is the direction facing forward when seated in the operators cab. The terms **rear**, **right** and **left** are used in relation to the definition of the term "front" on the superstructure.

BREAKING IN A NEW CRANE

Special running-in instructions must be observed for individual components (hoist, gearbox, etc.)

Special run-in instructions must be observed, i.e. additional maintenance work must be carried out on the carrier and the superstructure in certain intervals:

- after initial start-up or
- after part replacement or
- after a general inspection

Operating Hours (oh) ^{1,2)}	Travelled km (miles)	Additional Maintenance Work on the CARRIER
	after 50 (31.0)	Tighten wheel nuts. Refer to <i>Wheels and Tires</i> , page 8-17.
	after 150 (93.2)	Tighten wheel nuts. Refer to <i>Wheels and Tires</i> , page 8-17.
after 50		Tighten hose clamps on all coolant hoses.
during the first 100		Check the hydraulic oil filters weekly. Refer to Lubrication Section

- 1) Operating hours is the amount of time the engine has run.
 2) 1 oh corresponds to approximately 40 kilometers (24.8 miles) driven.

Please note the instructions concerning run-in times / run-in regulations / oil change intervals in the enclosed operating manual of the engine manufacturer and in the crane diesel engine maintenance booklet.

Operating Hours (oh)	Travelled km	Additional Maintenance Work on the SUPERSTRUCTURE
during the first 100		Check the hydraulic oil filters weekly.
after 100		Check tightness of retaining bolts; tightening torque.
after 200		Carry out first oil change on hoist gears (auxiliary hoist optional).
after 200		Carry out first oil change in slewing gear transmission.
after 1000 ¹⁾		Carry out second oil change on hoist gears (auxiliary hoist optional).

1) after 1000 operating hours, after 12 months at the latest.

SAFETY RULES

When carrying out maintenance work, it is imperative that you observe safe work practices. The following instructions are general safety rules for maintenance personnel:

- Familiarize yourself with the truck crane and its operation. Read the operating instructions carefully and request guidance from crane operator.
- Do not carry out maintenance work unless you are authorized to do so.

- Use personal protective equipment when performing maintenance (e.g., safety shoes, gloves, safety glasses, hard hats, fall protection, etc.)
- Observe all safety and warning signs on the truck crane.
- Observe all safety instructions contained in this maintenance manual.
- Familiarize yourself with the conditions under which the superstructure may be slewed and the boom may be extended into horizontal position.
- Do not carry out maintenance work unless the truck crane is standing on flat, stable ground and is prevented from rolling.

- Keep all handles, steps, landings and ladders free of dirt, grease, snow and ice.
- Use the proper access aids and working platforms when carrying out overhead work. Use personal fall protection when working at height.
- Walk only on those machine parts which are equipped with appropriate steps and railings. During rigging and maintenance work use ladders and/or other equipment to assist in reaching locations at height where other means of access are not provided, (e.g. when lubricating telescopic slide faces).
- Perform maintenance work only after the truck crane has been shut down. Always ensure that the truck crane is protected from unauthorized operation before beginning maintenance work. Remove the key and put up warning signs.

If, as an exception, the truck crane needs to be put into operation for certain types of maintenance work, great care must be taken where there are moving parts (superstructure, outrigger, drive shafts, swiveling connections, motors, tiltable crane cabs, superstructure lock). There is a risk of injury!

- Ensure that all hydraulic components are returned to their initial positions (e.g. the boom) or locked (e.g. the outrigger).

Escaping hydraulic fluid or compressed air can cause severe injury. Remember that hydraulic and compressed air systems of the truck crane are pressurized even when the crane is not in operation. Only tighten loose screw connections when the system is in depressurized condition. Always depressurize the hydraulic and compressed air systems before opening them.

- Do not allow hot materials to escape unchecked. Risk of scalding!
- Observe the applicable safety regulations when working with inflammable fluids.
- Observe the applicable safety regulations when working with process materials.
- Disconnect the earthing terminal and switch off all electrical consumers before removing any batteries.
- Keep the corroding effect of battery acid in mind.
- Note the fire alarm and fire fighting facilities on the site.
- Return the truck crane to proper working order once maintenance work is completed. Inform the crane operator accordingly.

HANDLING SUBSTANCES WHICH ARE HARMFUL TO THE ENVIRONMENT

What do Environmentally Harmful Substances Include?

When you carry out maintenance work on the truck crane you will occasionally work with substances which are considered to be harmful to the environment according to the current national and local regulations.

This includes, amongst others, oil, fuel, grease, used oil and fuel filters as well as cloths which have come into contact with these environmentally harmful substances.

- When handling these substances observe the current national and regional regulations as well as the instructions in this chapter.

Use Suitable Equipment

Substances harmful to the environment can be corrosive. Therefore only use containers, hoses, pumps, funnels etc. which are resistant to the respective substance.

Filling and Draining

- When filling and draining, make absolutely sure that no substances harmful to the environment seep into the earth, escape into the sewage system or pollute natural waters.
- Collect draining oil in a suitable container.
- Always use a drain hose when draining, a funnel or a filling pump and hose suitable for the respective substance when filling.

Collect and Store Separately

Substances which are environmentally harmful should always be collected separately from other waste.

- Also collect the environmentally harmful substances divided according to solid materials (e.g. filter elements) and liquids. Disposal costs will be reduced if you collect liquids separately according to certain categories.
- Ask your local environmental protection authority about the different categories for the substances.
- Only store environmentally harmful substances in approved containers and in locations which meet the regulations according to the current national and regional regulations.

Disposal

- Ask your local environmental protection authority about the prescribed disposal possibilities.

- Only have collected environmentally harmful substances disposed of by disposal companies which are approved by the national or regional authority responsible.

OVERVIEW OF THE OPERATING AND DISPLAY ELEMENTS

NOTE: Refer to the Operator Manual for the operating and display elements.

For
Reference
Only

Axle Weight Distribution Table

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
Maximum Tire & Wheel Loads Allowed					23224	(51200)	27216	(60000)
Maximum Axle Loads Allowed					23224	(51200)	27216	(60000)
Standard Carrier Assy (8x4x4)	282.58	(111.25)	18787	(41417)	9441	(20813)	9346	(20604)
Superstructure Assy with both hoists, cables, lwr lift cyl pin	-15.80	(-6.22)	5946	(13108)	-167	(-368)	6113	(13476)
Boom Assy w/pivot pins	454.36	(178.88)	10578	(23320)	8547	(18843)	2031	(4477)
Lift Cylinder	347.90	(136.97)	1005	(2216)	622	(1371)	383	(845)
Complete Basic Machine: Carrier Ass'y, S/S Ass'y, 6-Section Boom, Cummins X12 Engine, 445/65R22.5 Michelin Front Tires, 315/80R22.5 Michelin Rear Tires, Full Fuel and Hydraulic Oil, cable on both hoists	285.57	(112.43)	36315	(80061)	18443	(40659)	17873	(39402)
Boom Extensions								
10.5 - 17.6 m (34.5 - 57.6 ft) Manual Bi-fold Boom Extension	572.90	(225.55)	1529	(3370)	1557	(3433)	-29	(-63)
10.5 - 17.6 m (34.5 - 57.6 ft) Hydraulic Bi-fold Boom Extension	585.88	(230.66)	1603	(3535)	1671	(3683)	-67	(-148)
10.5 - 17.6 m (34.5 - 57.6 ft) Manual Integrated Heavy-Duty Bi-fold Boom Extension	584.23	(230.01)	1640	(3615)	1704	(3756)	-64	(-141)
10.5 - 17.6 m (34.5 - 57.6 ft) Hydraulic Integrated Heavy-Duty Bi-fold Boom Extension	595.86	(234.59)	1715	(3780)	1817	(4006)	-103	(-226)
Boom Extension Carrier Brackets	474.50	(186.81)	218	(480)	184	(405)	34	(75)
Boom Extension Carrier Brackets for Integrated Heavy Duty Extensions	497.36	(195.81)	235	(518)	208	(458)	27	(60)
Hose Reel for Hydraulic Boom Extension	738.66	(290.81)	212	(468)	279	(615)	-67	(-147)
Aux Boom Nose	1054.74	(415.25)	86	(190)	161	(356)	-75	(-166)
Counterweights								
3000 lb counterweight (pin on with pins) on S/S	-246.05	(-96.87)	1369	(3019)	-599	(-1321)	1969	(4340)
5000 lb counterweight (pin on with pins) on S/S	-246.05	(-96.87)	2277	(5019)	-996	(-2196)	3273	(7215)
5000 lb counterweight (pin on with pins) on S/S	-246.05	(-96.87)	2277	(5019)	-996	(-2196)	3273	(7215)

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
3000 lb counterweight (pin on with pins) on S/S	-246.05	(-96.87)	1369	(3019)	-599	(-1321)	1969	(4340)
2000 lb counterweight (pin on) on S/S	-246.05	(-96.87)	907	(2000)	-397	(-875)	1304	(2875)
3000 lb counterweight (pin on with pins) on carrier deck	481.97	(189.75)	1369	(3019)	1174	(2588)	196	(431)
3000 lb counterweight (pin on with pins) on carrier deck	481.97	(189.75)	1369	(3019)	1174	(2588)	196	(431)
2000 lb counterweight (pin on) on carrier deck	481.97	(189.75)	907	(2000)	777	(1714)	130	(286)
3000 lb counterweight (tray) on carrier deck	481.97	(189.75)	1361	(3000)	1166	(2571)	195	(429)
5000 lb counterweight (pin on with pins) on carrier deck	481.97	(189.75)	2277	(5019)	1951	(4302)	325	(717)
10000 lb counterweight (non pin on) on carrier deck	481.97	(189.75)	4536	(10000)	3888	(8571)	648	(1429)
Rigging Equipment								
11 t (12 USt) Overhaul Weight - in stowage tray	830.58	(327.00)	294	(648)	435	(958)	-140	(-309)
11 t (12 USt) Overhaul Weight - tied to front bumper	942.34	(371.00)	294	(648)	493	(1086)	-199	(-438)
10.9 t (12 USt) Overhaul Ball (Swivel) - in stowage tray	830.58	(327.00)	253	(558)	374	(824)	-121	(-266)
10.9 t (12 USt) Overhaul Ball (Swivel) - tied to front bumper	942.34	(371.00)	253	(558)	424	(935)	-171	(-377)
26 t (29 USt) Hookblock (1 sheave) - tied to front bumper	955.04	(376.00)	323	(712)	548	(1209)	-225	(-497)
45 t (50 USt) Hookblock (3 sheave) - tied to front bumper	955.04	(376.00)	560	(1235)	952	(2098)	-391	(-863)
75 t (83 USt) Hookblock (5 sheave) - tied to front bumper	955.04	(376.00)	722	(1592)	1227	(2704)	-504	(-1112)
100 t (112 USt) Hookblock (7 sheave) - tied to front bumper	955.04	(376.00)	1140	(2513)	1936	(4268)	-796	(-1755)
Rigging	170.18	(67.00)	45	(100)	14	(30)	32	(70)
Cribbing (in rear troughs)	-35.56	(-14.00)	181	(400)	-11	(-25)	193	(425)
Optional Equipment								
Driver	762.00	(300.00)	113	(250)	154	(339)	-40	(-89)
Rear Frame Counterweight Mount	-165.10	(-65.00)	39	(87)	-12	(-26)	51	(113)
Trailing Boom - Carrier Components	-83.82	(-33.00)	33	(73)	-5	(-11)	38	(84)
Trailing Boom - Boom Brackets (use with trailing boom w/dolly option)	822.40	(323.78)	87	(192)	127	(281)	-40	(-89)
Rear Access Ladder	-198.12	(-78.00)	28	(61)	-10	(-21)	37	(82)

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
360° Swing Lock	117.91	(46.42)	40	(88)	8	(18)	32	(70)
Substitutions and Removals								
REM: Main Hoist Cable (820' of 3/4" Bridon Dyform 34LR)	-176.91	(-69.65)	-483	(-1065)	152	(335)	-635	(-1400)
REM: Aux Hoist Cable (581' of 3/4" Bridon Dyform 34LR)	-271.91	(-107.05)	-342	(-754)	166	(365)	-508	(-1119)
SUB: Automated Manual Transmission	439.42	(173.00)	68	(149)	53	(116)	15	(33)

CLEANING

The paint on the truck crane will continue to harden for the first three months.

- During this period the truck crane may only be cleaned with cold water.
- Do not use high-pressure or steam-jet cleaning equipment during this period.
- Avoid water temperatures over 60°C (140°F), even after the first three months.
- Do not use corrosive cleaning agents that might corrode the paint.
- Never hold the spray nozzle of your cleaning unit at a right angle to the surface you are cleaning and ensure that you are standing at a sufficient distance away from the surface you are cleaning.

Boom Cleaning

The operator should ensure that each of the telescoping boom sections are clean during operation. Any dirt that is on the painted boom sections can get stuck in the wear pads, and this will lead to scoring of the paint. Eventually, the telescoping of a section with damaged paint will become more difficult to complete as the paint damage becomes more severe. Each of the telescoping boom sections should be cleaned with a nonabrasive, solvent free cleaning agent

at least once a month or as required. If the sections are pressure washed, caution should be used to not damage the paint.



CAUTION

High Pressure Water Jet Hazard!

When working with high-pressure and steam jet cleaners, the water jet will be deflected by crane parts and could spray into your face and eyes at great speed and high pressure.

Always wear a face guard when cleaning the truck crane with high-pressure and steam-jet cleaning equipment.

- Never point the nozzle at electrical equipment, relay and control boxes, suction and venting filters or control elements and lubricated surfaces.

NOTE: The components specified in section *Overview of the Components that are Easily Damaged when Cleaning*, page 1-8 are to be cleaned with particular care.

- After cleaning with a high-pressure device or a steam jet device, activate an intermediate lubrication at the centralized lubrication system. Lubricate all remaining lubrication points with a grease gun.

OVERVIEW OF THE COMPONENTS THAT ARE EASILY DAMAGED WHEN CLEANING

On Truck Crane



- | | | | |
|---|----------------------|---|-------------------------------------|
| 1 | Air Ride Suspension | 4 | Telescope slide faces |
| 2 | RCL connecting box | 5 | RCL length and angle measuring unit |
| 3 | Lifting limit switch | 6 | Angle sensor control box |

FASTENERS AND TORQUE VALUES

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

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

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

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

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

stressed component and the fastener should be torqued accordingly.

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

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

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

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

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

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

TORQUE WRENCHES

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

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

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

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

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

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

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

TORQUE VALUES

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

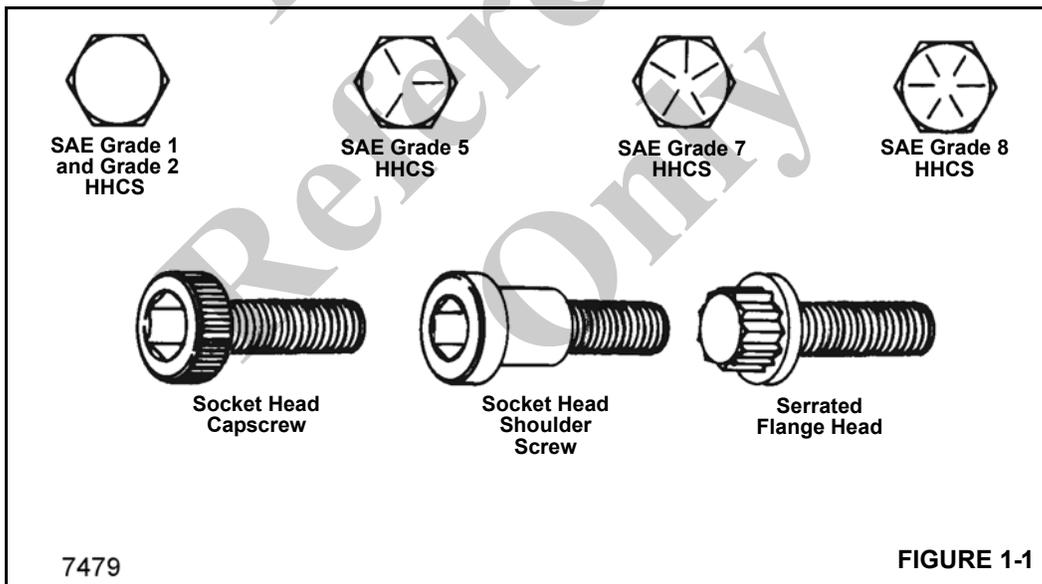


Table 1-1Inch Series with Coarse Threads (UNC) – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20 UNC	5	6.6	6.4	6.2
	8	9.3	9.0	8.8
5/16-18 UNC	5	13.5	13.2	12.8
	8	19.1	18.6	18.1
3/8-16 UNC	5	24.0	23.4	22.8
	8	33.9	33.1	32.2
7/16-14 UNC	5	38.4	37.4	36.5
	8	54.3	52.9	51.5
1/2-13 UNC	5	58.6	57.1	55.7
	8	82.8	80.7	78.6
9/16-12 UNC	5	84.5	82.4	80.3
	8	119.4	116.5	113.5
5/8-11 UNC	5	116.6	113.7	110.8
	8	164.8	160.7	156.6
3/4-10 UNC	5	206.8	201.7	196.5
	8	292.3	284.9	277.6
7/8-9 UNC	5	333.8	325.4	317.1
	8	471.6	459.8	448.0
1-8 UNC	5	500.3	487.8	475.3
	8	707.0	689.3	671.6
1 1/8-7 UNC	5	624.0	608.4	592.8
	8	1001.4	976.4	951.4
1 1/4-7 UNC	5	880.5	858.5	836.5
	8	1413.1	1377.8	1342.5
1 3/8-6 UNC	5	1154.5	1125.6	1096.7
	8	1852.8	1806.5	1760.2
1 1/2-6 UNC	5	1532.0	1493.7	1455.4
	8	2458.8	2397.3	2335.8

Table 1-2 Inch Series with Fine Threads (UNF) – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28 UNF	5	7.5	7.3	7.1
	8	10.6	10.4	10.1
5/16-24 UNF	5	15.0	14.6	14.2
	8	21.1	20.6	20.1
3/8-24 UNF	5	27.2	26.5	25.8
	8	38.4	37.5	36.5
7/16-20 UNF	5	42.9	41.8	40.7
	8	60.6	59.1	57.6
1/2-20 UNF	5	66.0	64.4	62.7
	8	93.3	90.9	88.6
9/16-18 UNF	5	94.3	91.9	89.6
	8	133.2	129.9	126.6
5/8-18 UNF	5	132.1	128.8	125.5
	8	186.7	182.0	177.3
3/4-16 UNF	5	231.0	225.2	219.4
	8	326.4	318.2	310.1
7/8-14 UNF	5	367.7	358.5	349.3
	8	519.6	506.6	493.6
1-12 UNF	5	547.4	533.7	520.0
	8	773.5	754.2	734.8
1 1/8-12 UNF	5	700.0	682.5	665.0
	8	1123.5	1095.4	1067.3
1 1/4-12 UNF	5	975.0	950.6	926.2
	8	1564.8	1525.7	1486.5
1 3/8-12 UNF	5	1314.4	1281.5	1248.6
	8	2109.5	2056.7	2004.0
1 1/2-12 UNF	5	1723.9	1680.8	1637.7
	8	2766.8	2697.6	2628.4

Table 1-3 Metric Series with Coarse Threads – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	10.9	3.6	3.5	3.4
	12.9	4.2	4.1	4.0
M5x0.8	10.9	7.2	7.0	6.8
	12.9	8.4	8.2	8.0

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M6x1.0	8.8	8.3	8.1	7.9
	10.9	12.2	11.9	11.6
	12.9	14.3	13.9	13.6
M8x1.25	8.8	20.2	19.7	19.2
	10.9	29.6	28.9	28.2
	12.9	34.7	33.8	33.0
M10x1.5	8.8	40.0	39.0	38.0
	10.9	58.7	57.2	55.8
	12.9	68.7	67.0	65.3
M12x1.75	8.8	69.7	68.0	66.2
	10.9	102.4	99.8	97.2
	12.9	119.8	116.8	113.8
M14x2	8.8	111.4	108.6	105.8
	10.9	163.6	159.5	155.4
	12.9	191.5	186.7	181.9
M16x2	8.8	172.8	168.5	164.1
	10.9	253.8	247.4	241.1
	12.9	296.9	289.5	282.1
M18x2.5	8.8	246.2	240.1	233.9
	10.9	350.7	341.9	333.2
	12.9	410.4	400.1	389.9
M20x2.5	8.8	348.0	339.3	330.6
	10.9	495.6	483.2	470.8
	12.9	580.0	565.5	551.0
M22x2.5	8.8	474.4	462.6	450.7
	10.9	675.7	658.8	641.9
	12.9	790.7	770.9	751.2
M24x3	8.8	601.3	586.3	571.3
	10.9	856.4	835.0	813.6
	12.9	1002.2	977.1	952.1
M27x3	8.8	881.6	859.6	837.5
	10.9	1255.7	1224.3	1192.9
	12.9	1469.4	1432.7	1395.9
M30x3.5	8.8	1195.3	1165.5	1135.6
	10.9	1702.5	1659.9	1617.3
	12.9	1992.3	1942.4	1892.6

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M36x4	8.8	2089.8	2037.6	1985.3
	10.9	2976.4	2902.0	2827.6
	12.9	3483.0	3395.9	3308.9

Table 1-4 Metric Series with Fine Threads – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1.0	8.8	21.6	21.1	20.5
	10.9	31.7	30.9	30.1
	12.9	37.1	36.2	35.3
M10x.75	8.8	46.8	45.6	44.4
	10.9	68.7	67.0	65.3
	12.9	80.4	78.4	76.4
M10x1.25	8.8	42.2	41.1	40.1
	10.9	62.0	60.4	58.9
	12.9	72.5	70.7	68.9
M12x1.0	8.8	79.5	77.5	75.5
	10.9	116.7	113.8	110.9
	12.9	136.6	133.2	129.8
M12x1.25	8.8	76.2	74.2	72.3
	10.9	111.8	109.0	106.3
	12.9	130.9	127.6	124.3
M12x1.5	8.8	72.9	71.1	69.2
	10.9	107.1	104.4	101.7
	12.9	125.3	122.1	119.0
M14x1.5	8.8	120.2	117.2	114.2
	10.9	176.5	172.1	167.7
	12.9	206.6	201.4	196.2
M16x1.5	8.8	184.4	179.8	175.2
	10.9	270.9	264.1	257.3
	12.9	317.0	309.1	301.2
M18x1.5	8.8	276.6	269.7	262.8
	10.9	394.0	384.2	374.3
	12.9	461.1	449.6	438.0
M20x1	8.8	405.7	395.5	385.4
	10.9	577.8	563.3	548.9
	12.9	676.1	659.2	642.3

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M20x1.5	8.8	386.0	376.3	366.7
	10.9	549.7	535.9	522.2
	12.9	643.3	627.2	611.1
M22x1.5	8.8	520.8	507.8	494.8
	10.9	741.7	723.2	704.7
	12.9	868.0	846.3	824.6
M24x2	8.8	655.8	639.4	623.0
	10.9	934.0	910.6	887.3
	12.9	1092.9	1065.6	1038.3
M27x2	8.8	951.4	927.6	903.8
	10.9	1355.0	1321.1	1287.2
	12.9	1585.6	1546.0	1506.3
M30x1.5	8.8	1369.2	1334.9	1300.7
	10.9	1950.0	1901.3	1852.5
	12.9	2281.9	2224.9	2167.8
M30x2	8.8	1324.6	1291.5	1258.4
	10.9	1886.6	1839.4	1792.2
	12.9	2207.7	2152.5	2097.3
M33x2	8.8	1784.5	1739.9	1695.3
	10.9	2541.6	2478.0	2414.5
	12.9	2974.2	2899.8	2825.4
M36x2	8.8	2340.1	2281.6	2223.1
	10.9	3332.8	3249.5	3166.2
	12.9	3900.2	3802.6	3705.1

Table 1-5 Metric Series Screws of STAINLESS STEEL A2-70/A4-70 with Coarse Threads

Size	Torque (Nm)
M2.5x0.45	0.4
M3x0.5	0.9
M4x0.7	1.5
M5x0.8	3.1
M6x1	5.3
M8x1.25	13
M10x1.5	27

Torque Values for fasteners **with lubrication** these torque values result in an 80% utilization of the yield strength.

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

Table 1-6 Inch Series Screws of STAINLESS STEEL 300 (18-8) with Coarse Threads

Size	Torque	
	lb-in	lb-ft
#5-40 (0.125)	6.9	-
#6-32 (0.138)	9	-
#8-32 (0.164)	18	-
#10-24 (0.190)	21	-
1/4-20	68	-
5/16-18	120	10
3/8-16	210	17.5

Torque Values for fasteners **with lubrication** these torque and preload values result in an 80% utilization of the yield strength.

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

Table 1-7 Inch Series Bearing Bolts – Untreated (Black Finish)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
5/8-11 UNC	8	234	225	216
5/8-18 UNF	8	250	240	230
3/4-10 UNC	8	385	370	355
7/8-9 UNC	8	615	591	567
1-8 UNC	8	929	893	857
1 1/4-7 UNC	8	2043	1964	1885

Table 1-8 Metric Series Bearing Bolts – Untreated (Black Finish)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (Nm)		
		Maximum	Nominal	Minimum
M20X2.5	12.9	756	727	698
M24X3	10.9	1089	1047	1005
M27X3	10.9	1591	1530	1469

For Reference Only

Table 1-9 Inch Series with Coarse Threads (UNC) – Untreated (Black Finish)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20	5	9.0	8.4	7.7
	8	12.5	12	11.5
5/16-18	5	19	18	17
	8	26	25	24
3/8-16	5	32	31	30
	8	48	46	44
7/16-14	5	52	50	48
	8	73	70	67
1/2-13	5	78	75	72
	8	120	115	110
9/16-12	5	114	110	106
	8	161	152	143
5/8-11	5	156	150	144
	8	234	225	216
3/4-10	5	270	259.5	249
	8	385	370	355
7/8-9	5	416	400	384
	8	615	591	567
1-8	5	606	583	560
	8	929	893	857
1 1/8-7	5	813	782	751
	8	1342	1288	1234
1 1/4-7	5	1141	1097	1053
	8	2043	1964	1885
1 3/8-6	5	1519	1461	1403
	8	2496	2396	2296
1 1/2-6	5	2028	1946.5	1865
	8	3276	3150	3024

Table 1-10 Inch Series with Fine Threads (UNF) – Untreated (Black Finish)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28	5	10	9.5	9
	8	14.5	14	13.5
5/16-24	5	21	20	19
	8	26	25	24
3/8-24	5	36	35	34
	8	53	51	49
7/16-20	5	57	55	53
	8	85	82	79
1/2-20	5	88	84.5	81
	8	125	120	115
9/16-18	5	126	121	116
	8	177	170	163
5/8-18	5	182	174.5	167
	8	250	240	230
3/4-16	5	312	299.5	287
	8	425	409	393
7/8-14	5	458	439.5	421
	8	672	646	620
1-12	5	658	632	606
	8	1009	970	931
1-14	5	670	644.5	619
	8	945	908.5	872
1 1/8-12	5	882	848	814
	8	1500	1440	1380
1 1/4-12	5	1251	1203	1155
	8	2092	2008.5	1925
1 3/8-12	5	1704	1638	1572
	8	2833	2719	2605
1 1/2-12	5	2288	2196.5	2105
	8	3640	3500	3360

Table 1-11 Metric Series with Coarse Threads – Untreated (Black Finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	8.8	3.1	2.9	2.8
	10.9	4.5	4.3	4.1
	12.9	5.4	5.2	4.9
M5x0.8	8.8	6.5	6.2	5.9
	10.9	9.2	8.9	8.5
	12.9	11	10.5	10
M6x1	8.8	11	10.5	10
	10.9	16	15	14
	12.9	19	18	17
M8x1.25	8.8	27	26	25
	10.9	38	36.5	35
	12.9	45	43.5	42
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144
M14x2	8.8	148	142	136
	10.9	212	203.5	195
	12.9	248	238	228
M16x2	8.8	230	221	212
	10.9	322	310	298
	12.9	387	372	357
M18x2.5	8.8	319	306.5	294
	10.9	455	436.5	418
	12.9	532	511	490
M20x2.5	8.8	447	430	413
	10.9	629	605	581
	12.9	756	727	698
M22x2.5	8.8	608	585	562
	10.9	856	823	790
	12.9	1029	989	949
M24x3	8.8	774	744	714
	10.9	1089	1047	1005
	12.9	1306	1256	1206

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M27x3	8.8	1134	1090	1046
	10.9	1591	1530	1469
	12.9	1910	1836.5	1763
M30x3.5	8.8	1538	1479	1420
	10.9	2163	2080	1997
	12.9	2595	2495	2395
M36x4	8.8	2681	2578.5	2476
	10.9	3964	3812	3660
	12.9	4639	4461	4283

For
Reference
Only

Table 1-12 Metric Series with Fine Threads – Untreated (Black Finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1	8.8	29	28	27
	10.9	41	39.5	38
	12.9	49	47	45
M10x0.75	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M10x1.25	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M12x1	8.8	101	97.5	94
	10.9	150	144	138
	12.9	175	168	161
M12X1.25	8.8	100	96	92
	10.9	147	141.5	136
	12.9	172	165.5	159
M12x1.5*	8.8	100	96	92
	10.9	140	135	130
	12.9	168	162	156
M14x1.5	8.8	160	153.5	147
	10.9	229	220	211
	12.9	268	257	246
M16x1.5	8.8	248	238.5	229
	10.9	348	335	322
	12.9	418	402	386
M18x1.5	8.8	345	331.5	318
	10.9	491	471	451
	12.9	575	552	529
M20X1	8.8	471	453	435
	10.9	694	667.5	641
	12.9	812	781	750
M20x1.5	8.8	483	464.5	446
	10.9	679	653	627
	12.9	816	785	754
M22x1.5	8.8	657	632	607
	10.9	924	888.5	853
	12.9	1111	1068	1025

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M24x2	8.8	836	803.5	771
	10.9	1176	1130.5	1085
	12.9	1410	1356	1302
M27x2	8.8	1225	1171.5	1130
	10.9	1718	1652.5	1587
	12.9	2063	1983.5	1904
M30x1.5	8.8	1530	1471.5	1413
	10.9	2253	2166.5	2080
	12.9	2637	2536	2435
M30x2	8.8	1661	1597.5	1534
	10.9	2336	2246.5	2157
	12.9	2800	2695	2590
M33x2	8.8	2141	2059	1977
	10.9	3155	3034	2913
	12.9	3692	3550.5	3409
M36x2	8.8	2795	2688	2581
	10.9	4118	3960	3802
	12.9	4818	4634	4450

For Reference Only

Table 1-13: UNC (Coarse) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

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

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

Table 1-14: Metric Coarse Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

Size	Torque Value Nm
M2.5	0.4
M3	0.9
M4	1.5

Size	Torque Value Nm
M5	3.1
M6	5.3
M8	13.0
M10	27.0
M12	45.0
M14	71.1
M16	109
M18	157
M20	220

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

Weld Studs

Unless otherwise specified the following grade 2 torque values (+/- 10%) apply.

Table 1-15: Weld Stud Torque Values

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

T-2-4

**SECTION 2
HYDRAULIC SYSTEM**

SECTION CONTENTS

Description	2-2	Description	2-34
Maintenance	2-4	Maintenance	2-34
Draining and Flushing	2-4	Outrigger Jack Cylinder	2-37
Removing Air from the Hydraulic System	2-5	Description	2-37
Parts Replacement	2-6	Maintenance	2-37
Supply Pressure and Return Circuit	2-6	Center Front Stabilizer Cylinder	2-41
Description	2-6	Description	2-41
Hydraulic Reservoir and Filter	2-6	Maintenance	2-41
Pump Distribution	2-7	Lift Cylinder	2-44
Maintenance	2-9	Description	2-44
Troubleshooting	2-9	Maintenance	2-44
Return Hydraulic Filter Assembly	2-10	Counterweight Cylinder	2-47
Element Removal	2-10	Description	2-47
Element Installation	2-10	Telescope Cylinder	2-48
Hydraulic Pumps	2-12	Description	2-48
Description	2-12	Pressure Setting Procedures	2-49
Maintenance	2-12	Objective	2-49
Carrier Valves	2-17	Equipment	2-49
General	2-17	Valve Pressure Setting Table	2-49
Outrigger Selector-A/C Manifold Valve	2-19	Service Tool Notes	2-50
Description	2-19	A. Procedure for Checking/Setting the Piston	
Maintenance	2-19	Pumps Cut-Off & Differential Pressures	2-50
Outrigger Control Manifold	2-21	B. Procedure for Checking/Setting the Pilot	
Description	2-21	Supply Pressure	2-52
Maintenance	2-21	C. Procedure for Checking/Setting the Main	
Pilot Operated Check Valve	2-24	Directional Control Valve, Load Sense, Lift	
Description	2-24	and Telescope Pressures	2-53
Internal Leak Testing	2-24	D. Procedure for Checking/Setting Cab Tilt	
Maintenance	2-25	Raise and Lower Pressures	2-58
Superstructure Valves	2-26	E. Procedure for Checking/Setting Counter-	
Turntable Hydraulic Valves	2-26	weight (CWT) Raise and Lower Pressures	2-58
Main Directional Valve Assembly	2-27	F. Procedure for Checking/Setting Swing	
Access Manifold Assembly	2-28	Pressure	2-59
Hydraulic System of the Superstructure	2-29	G. Procedure for Checking/Setting Outrigger	
Checking for Leaks	2-29	Pressure	2-59
Cylinders	2-29	H. Procedure for Checking/Setting Air	
General	2-29	Conditioning Pressure	2-60
Maintenance	2-29	I. Procedure for Checking/Setting the Center	
Steer Cylinder	2-31	Front Stabilizer Pressure	2-61
Description	2-31	J. Procedure for Checking/Setting the Front	
Maintenance	2-31	Steer Pressure	2-62
Outrigger Extension Cylinder	2-34	K. Procedure for Adjusting Electronic	
		Controllers (Meter-in Dead Band and/or	
		Max Function Speeds)	2-63

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. Figure 2-1 provides A.N.S.I graphical symbols and Figure 2-2 provides hydraulic symbol information for this section.

For
Reference
Only

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

1951-1

FIGURE 2-1

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

FIGURE 2-2

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.
- NOTE:** Hydraulic oil supply lines must be connected to the cylinders when flushing the system.
- Draining the various components will be aided by connecting a drain line in place of the disconnected return line.
5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.
 6. Connect the cylinder return line and lower the boom to its stowed position. Replenish the reservoir hydraulic oil level as required.
 7. Disconnect the return line from an outrigger extension cylinder and fully extend the outrigger.
 8. Connect the outrigger return line and retract the outrigger. Replenish the reservoir hydraulic oil level as necessary.
 9. Repeat Steps 7 and 8 for the remaining outriggers.
 17. Repeat Steps 15 and 16 for the rear steering cylinders.
 18. Raise the crane on outriggers.
 19. Disconnect the line from port A of the axle lockout valve.
 20. Using a jack under the rear wheel on one side of the crane, jack up the wheel to maximum travel.
 21. Connect the line to port A of the axle lockout valve and disconnect the line from Port B.
 22. Repeat step 19 using the other rear wheel.
 23. Connect the line to port B of the axle lockout valve. Energize the axle lockout valve. Replenish the reservoir hydraulic oil level as necessary.
 24. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
 25. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
 26. Repeat Steps 24 and 25 for the auxiliary hoist as necessary.
 27. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
 28. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

Machine Damage hazard!

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 jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from both front steer cylinders and turn the front wheels to the extreme right.
16. Connect the return lines and turn the front wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

Machine Damage!

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

Incompatible hydraulic oils can damage the components or system.

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

Removing Air from the Hydraulic System

Air entering the hydraulic oil will normally be removed automatically by passage of the hydraulic oil over the baffles in the hydraulic reservoir. If a component has been replaced, the reservoir level is too low, or a leak develops in the suction

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

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

Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 13.8 to 27.6 kPa (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

Projectile Hazard!

Plugs being removed when air is trapped in the hydraulic system can be ejected with significant force.

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

Skin Injection Hazard!

Fluid in the hydraulic system can be under enough pressure that it will penetrate the skin, causing serious injury or death.

Use a piece of cardboard, or piece of paper, to search for leaks. Wear gloves to protect your hands from spraying fluid. Do not use your hand or any part of your body to check for hydraulic fluid leaks when the engine is running or the hydraulic system is under pressure.

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 Crane 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.

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, two hydraulic pumps, a hydraulic oil cooler, and a 6-port hydraulic swivel. Refer to *Hydraulic Pumps*, page 2-12 in this section for descriptions and maintenance instructions for each hydraulic pump.

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

Hydraulic Reservoir and Filter

The reservoir Figure 2-3, attached to the right side of the carrier frame, has capacities listed in the following table.

Hydraulic Reservoir Capacities

Level	Capacity
Total Reservoir	624.6 L (165 gallon)
Full Level	556.5 L (147 gallons)
Low Level	514.8 L (136 gallons)
Expansion Volume	69.3 L (18.3 gallons)

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 hydraulic pumps. Almost all of the return flow goes through the filter at the top of the reservoir. The return line that goes directly into the reservoir (instead of through the filter) is from the No. 5 port (drain) of the 6-port swivel.

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

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

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

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

The hydraulic oil filter (Figure 2-4) is located in the reservoir. It is installed to the top of the reservoir, and its bypass outlet is integral to the filter housing. 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 restriction indicator connected to the filter head indicates the amount of filter restriction. When back pressure caused by a dirty filter element exceeds 170 kPa (25 psi), the filter head's bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead.

Hydraulic Reservoir Filling Breather Filter

This element filters the air in and out of the oil reservoir as the level changes. Remove the breather (2), (Figure 2-3) to add oil. The breather incorporates a filter to strain the oil

when adding to the tank. The breather should be replaced when the hydraulic oil filter is changed, 6 months or 500 hours.

Hydraulic Reservoir Thermistor and Temperature Switch

The thermistor and temperature switch can be damaged by over-torquing. Use the following torques when installing these devices:

- Thermistor - 47.5 ± 4.7 Nm (35 ± 3.5 lb-ft).
- Temperature switch - 10.8 ± 2.7 Nm (8 ± 2 lb-ft).

Pump Distribution

No. 1 and 2 Pump

Pump No. 1 is a gear pump mounted to the front gear accessory drive, it has a displacement of 39.3 cu cm (2.4 cu in). The No. 2 hydraulic pump is driven by the engine PTO. It is mounted to the carrier frame. The pump assembly consists of two variable displacement piston pumps. Each variable displacement pump has a displacement of 112 cu cm (6.83 cu in).

Pump No. 1 supplies the steering and swing. Pump No. 2 supplies the hoists, lift, telescope directional control valves, the counterweight lift and lower, cab tilt, and telescope in and out, and tele pinning. Hydraulic oil flowing from these valve banks returns to the reservoir filter through dual port 1 in the swivel.

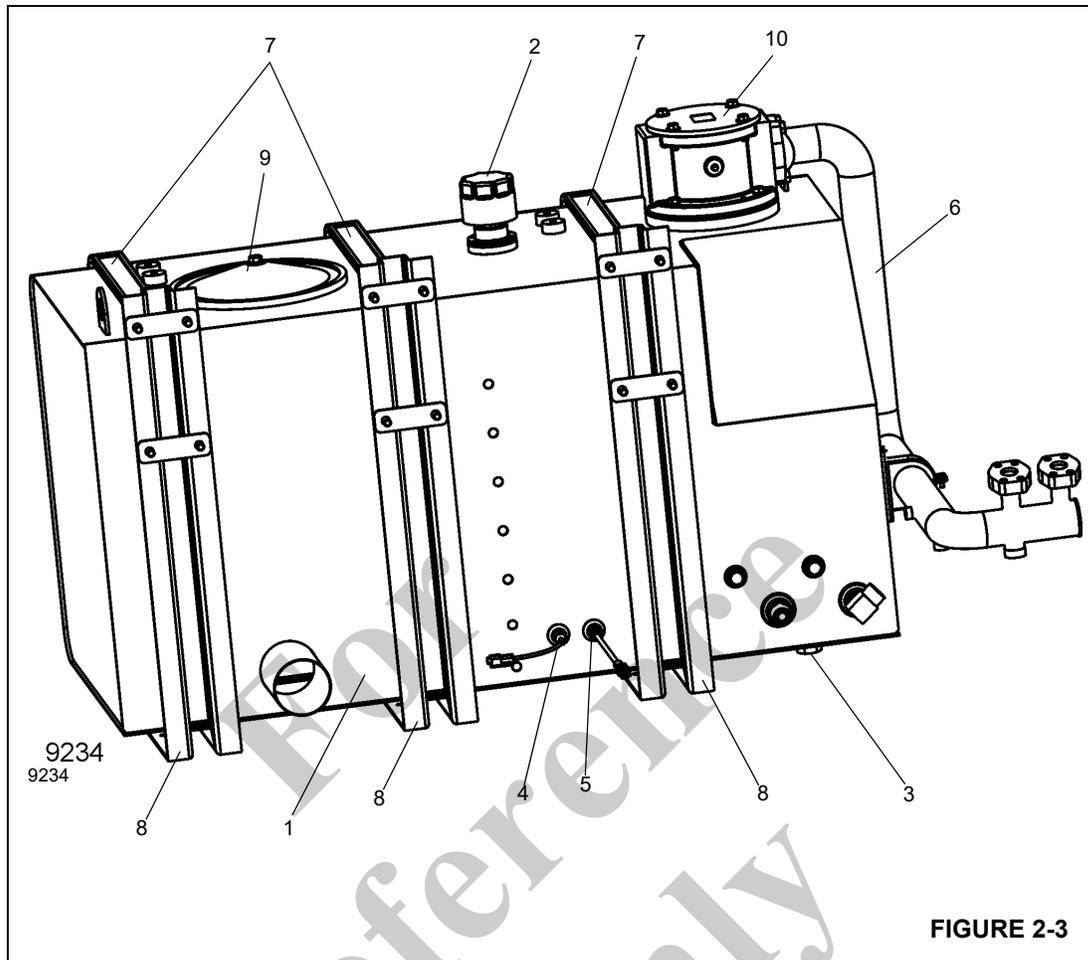


FIGURE 2-3

Item	Description	Item	Description
1	Reservoir	6	Return Manifold
2	Breather	7	Straps
3	Magnetic Plug	8	Mounting Bracket
4	Thermistor	9	Access Cover
5	Temperature Switch	10	Return Filter

MAINTENANCE

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
No hydraulic oil flows in systems.	<p>Low hydraulic oil level.</p> <p>Reservoir-to-pump suction lines broken or restricted. Air entering at suction lines. Pump not priming.</p> <p>Pump shaft sheared or disengaged.</p> <p>Internal contamination.</p> <p>Internal pump issue.</p>	<p>Fill reservoir.</p> <p>Clean, repair, or replace lines as necessary. Check lines for security, absence of cracks, and proper attachment. Tighten, repair, or replace parts as necessary.</p> <p>If drive shaft is damaged or sheared, remove and repair or replace as necessary</p> <p>Drain, flush with recommended oil mixture, then drain and refill system with recommended hydraulic oil.</p> <p>Repair or replace pump.</p>
Slow response.	<p>Low hydraulic oil level.</p> <p>Hydraulic oil temperature too high (watery thin oil) or too low (thick sluggish oil).</p> <p>Faulty pump section(s).</p> <p>Software settings.</p>	<p>Fill reservoir.</p> <p>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.</p> <p>Repair or replace pump section(s) or entire pump.</p> <p>Review and edit software settings.</p>
Pump noise accompanied by hydraulic oil foaming in reservoir.	<p>Low hydraulic oil level.</p> <p>Excessive engine speed.</p> <p>Air entering at suction lines.</p>	<p>Fill reservoir.</p> <p>Regulate engine speed.</p> <p>Check all lines for security and proper repair. Tighten, repair, or replace as needed.</p>
Excessive pressure buildup.	<p>System relief valve set too high.</p> <p>Restricted pump-to-control valve supply line.</p>	<p>Using adequate pressure gauge, adjust system relief valve as necessary.</p> <p>Clean, repair, or replace line as necessary.</p>

SYMPTOM	PROBABLE CAUSE	SOLUTION
Specific hydraulic system (lift, hoist, telescope, swing) not working.	Leak in system.	Repair leak.
	Faulty electric controls/signals.	Adjust or replace controls signals.
	Faulty directional control valve.	Replace valve.
	Poorly adjusted control in circuit.	Troubleshoot circuit with schematic. Adjust hydraulic component per schematic.
	Faulty hydraulic cylinder, motor, or valve.	Replace faulty component.
	Software settings.	Review and edit software settings.

RETURN HYDRAULIC FILTER ASSEMBLY

Element Removal



WARNING

Skin Injection Hazard!

Fluid in the hydraulic system can be under enough pressure that it will penetrate the skin, causing serious injury or death.

Wear gloves when working with hydraulic system components.

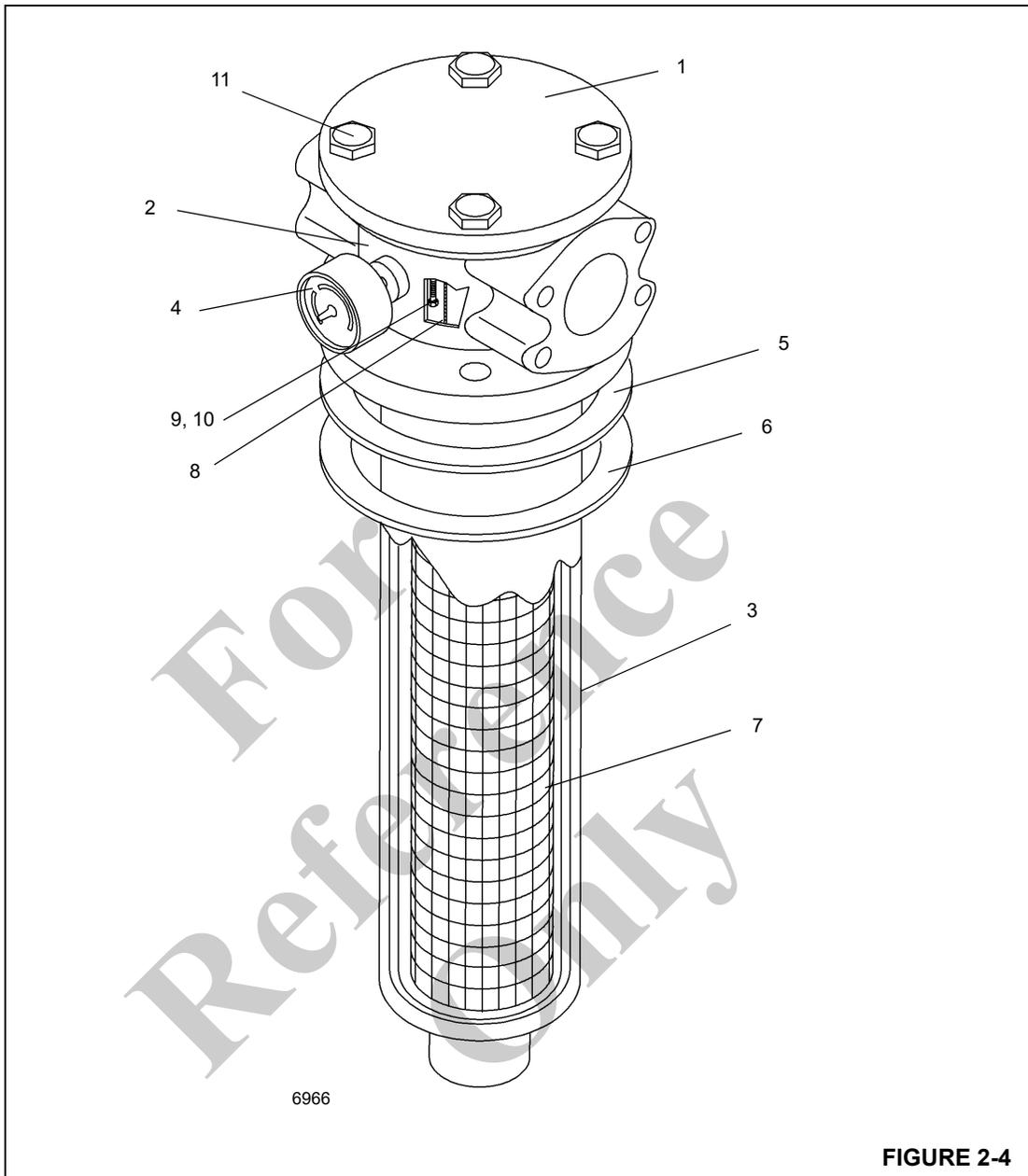
1. Shut down all hydraulic systems.
2. Wipe any dirt from the filter head and cap assembly.

NOTE: The bypass valve assembly is installed to the cap and is removed with the cap.

3. Remove the capscrews and lockwashers securing the cap assembly to the filter head and remove the cap assembly.
4. Remove the filter element from the filter bowl (housing).
5. Ensure the new filter element is correct by comparing their part numbers with the part numbers of the used filter element.
6. Discard the used filter element.

Element Installation

1. Install the new element into the filter bowl (housing).
2. Install new O-ring in the cap assembly.
3. Install the cap assembly on the filter head and secure the cap assembly to the filter head with the lockwashers and capscrews.
4. Activate the hydraulic system and check for leaks. Make repairs as needed.



Item	Description	Item	Description
1	Cap Assembly	7	Element
2	Filter Head	8	Bypass Valve
3	Filter Bowl	9	Spacer
4	Restriction Indicator	10	Capscrew
5	O-ring	11	Capscrew
6	Gasket		

HYDRAULIC PUMPS

Description

The engine drives the No. 1 gear pump Figure 2-23 mounted directly to the front cover accessory drive. No. 1 gear pump supplies the front axle power steering gear and the swing function.

The No. 2 hydraulic pump assembly (Figure 2-9) is frame mounted above the transmission and is driven by a driveshaft attached to the engine PTO. The pump assembly consists of two variable displacement pumps. The pumps supply the hoist, lift, telescope directional control valve and auxiliary hoist.

Maintenance

CAUTION Machine Damage!

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.

No. 1 Pump

Removal

1. Remove the engine cover to gain access to the pump.
2. Remove the cotter pin from the retaining pin (1, Figure 2-5) in the two piece shift rod.

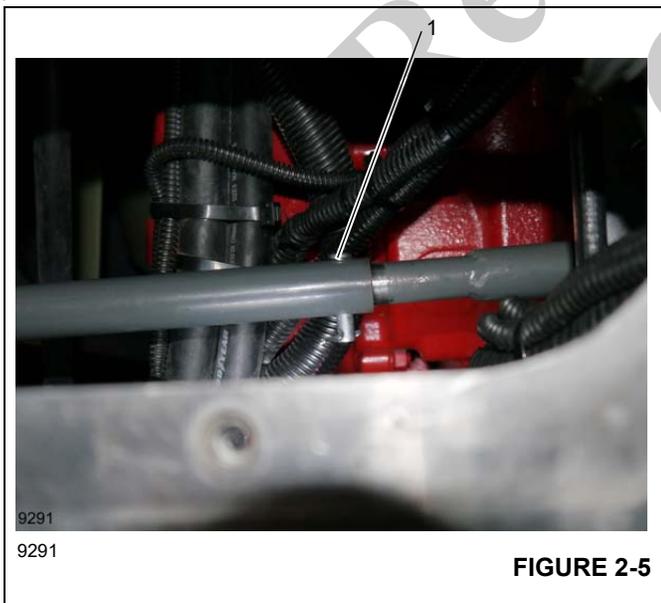


FIGURE 2-5

3. Separate the shift rod to gain access to pump no. 1.

4. Remove the capscrews, flatwashers and O-ring securing the hydraulic tank hose assembly to the pump.
5. Tag and disconnect all other lines from the pump. Cap all lines and ports.

CAUTION

Machine Damage!

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

6. Remove the capscrews and flatwashers securing the pump to the front cover accessory drive. Remove the pump.
7. Clean the gasket material from the drive pad and the pump.

Installation

1. Install a new gasket to the pump mounting flange.
2. Install No. 1 pump on the front cover accessory drive with capscrews and flatwashers. Make sure gear teeth mesh properly. Torque capscrews according to *Torque Values*, page 1-9.
3. Connect the distribution and supply lines as tagged during removal.
4. Install the hydraulic tank hose to the pump and secure with the capscrews, flatwashers and O-ring. Torque capscrews according to *Torque Values*, page 1-9.
5. Assemble the two piece shift rod and insert the retaining pin. Secure the retaining pin with a new cotter pin.
6. Before start-up the pump needs to be primed, refer to *Gear Pump Inlet Port Air Purge/Bleed*, page 2-13.

No. 2 Pump

Removal

1. Remove the pump cover to gain access to the pumps.
2. Remove the capscrews, flatwashers and O-ring securing the hydraulic hose assemblies to the pumps. Tag all hoses for reassembly. Cap all lines and ports.
3. Remove the capscrews and lockwashers attaching the pump mounting bracket to the frame. Remove the pump assembly.



CAUTION

Crushing Hazard!

The pump assembly weighs approximately 220 lbs (100 kg). Use an appropriate lifting device to lift the pump.

CAUTION**Machine Damage!**

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

4. Remove the capscrews and flatwashers securing the rear pump to the front pump. Remove the pump.
5. Remove the capscrews and flatwashers securing the front pump to the pump mounting bracket. Remove the pump.
6. Clean the gasket material from the mounting surface and the pumps.

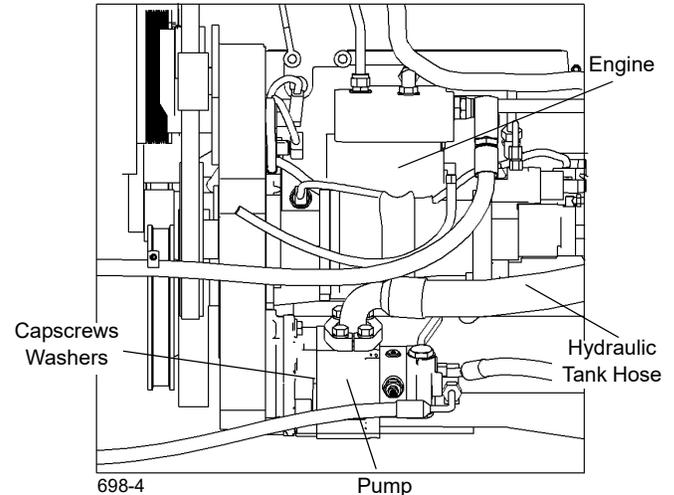
Installation

1. Install a new gasket to the pump mounting flange.
2. Install rear pump on front pump with capscrews and flatwashers. Make sure gear teeth mesh properly. Torque capscrews according to *Torque Values*, page 1-9.
3. Install the front pump to the mounting bracket.
4. Install the pump assembly onto the frame. Align the splines to the PTO driveline.

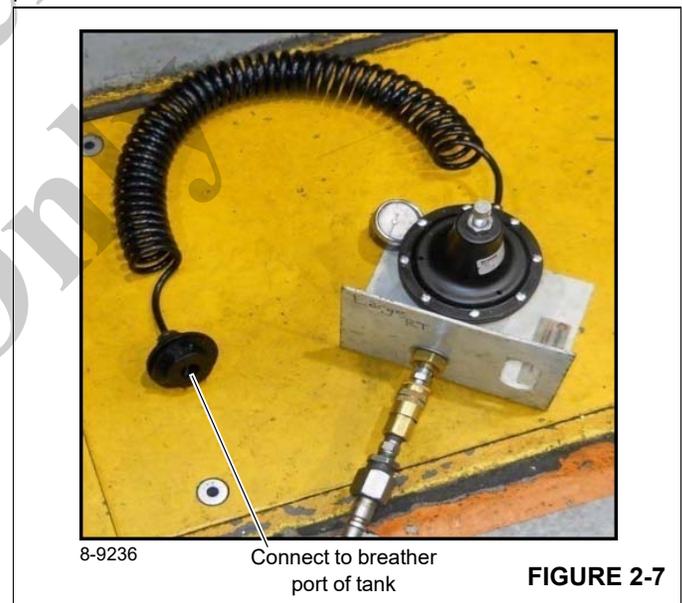
**CAUTION****Crushing Hazard!**

The pump assembly weighs approximately 220 lbs (100 kg). Use an appropriate lifting device to lift the pump.

5. Install the hydraulic hoses to the pump and secure with the capscrews, flatwashers and O-ring. Torque capscrews according to *Torque Values*, page 1-9.

**FIGURE 2-6****Pump Priming Tool**

The Pump Priming Tool (Figure 2-7), P/N 80030367, available from Manitowoc Crane Care is used to prime the pumps after they have been removed from the crane.

**FIGURE 2-7****Gear Pump Inlet Port Air Purge/Bleed**

Ensure the hydraulic reservoir is filled to the proper level and that the fluid is not aerated (aerated appearance: foamy white tint with bubbles). If so let the unit sit until air has escaped and the fluid is a dark solid color.

NOTE: Removing the top of the filter housing and filling the reservoir through the filter will deaerate the fluid and have the crane ready for initial start-up as soon as filling is complete.

1. Crack open the inlet port hose from the pumping section.
2. Remove the hydraulic reservoir mounted breather, install the Pump Priming Tool and connect it to a shop air source.
3. When a solid stream of fluid, free of air bubbles exits the hose, reinstall the hose to the pump while the fluid is still coming out.
4. Remove the shop air supply from the Pump Priming Tool.
5. Torque hose connections to the specified Manitowoc torque setting.

Gear Pump Outlet Port Air Bleeding

Gear pumps that do not start against high pressure (service brake charge circuits, sequence valve circuits) are able to prime at initial start up. Additional air bleeding steps below are not necessary for these applications.

Gear pumps that supply service brake charging or sequence valve circuits will be initially started as follows unless there is an air bleed start-up valve already designed into the circuit.

1. Install the pump priming tool and connect to a shop air source.
2. Bleeding to be done after fluid and inlet checks are made.
3. Remove the outlet hose from the pump.
4. Jog the engine starter until a solid stream of air free fluid exits the pump.
5. Remove the shop air supply from the pump priming tool and re-tighten the hose to the pump following the proper Manitowoc torque specifications.

Gear Pump Start-up Procedure (Pump No. 1)

1. Ensure the hydraulic reservoir is filled to the proper level and the fluid is not aerated. If so, let unit sit until air has escaped and the fluid is a dark solid color.
2. If the circuit includes an air conditioning compressor drive motor ensure it is in the OFF position before initial start up.
3. Start the engine and let idle for 2-3 minutes with NO crane functions actuated. If the pump outlet becomes too warm to keep your hand on comfortably, stop the engine immediately.
4. Slowly increase the engine speed to approximately 1500 rpm and hold for no longer than 1 minute and make the same checks as outlined previously.

5. Slowly increase engine speed to full RPM and hold for no longer than 1 minute while making the same checks as outlined previously.
6. At full engine RPM cycle all functions fully extending and retracting the cylinders to their stop position to verify operation and that the pump stays quiet and does not become excessively hot.

Testing After Rebuild or Replacement

CAUTION

Pump Damage!

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

1. Operate the pump for at least two minutes at zero pressure and moderate speed (not over 1500 rpm).

CAUTION

Pump Damage!

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.

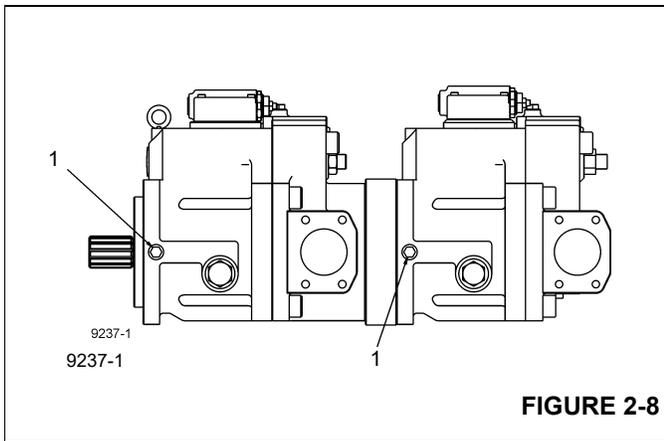
2. Touch pump to verify it has not become hot from binding. Listen for abnormal noises indicating low hydraulic oil level or internal pump problems. If the pump appears to be operating satisfactorily, increase the RPM by steps, until reaching governed RPM. Operate pump about five minutes while checking for proper operation and leakage. Fix leaks; make repairs as needed.
3. Cycle the components the pump powers to verify the pump drives them all properly.

Piston Pump Air Purge / Bleed and Case Filling

1. Ensure the hydraulic reservoir is filled to the proper level and the fluid is not aerated. If there is air in the oil let the unit sit until the air has escaped and the fluid is a dark solid color.

NOTE: Removing the top of the filter housing and filling the reservoir through the filter will deaerate the fluid and have the crane ready for initial start-up as soon as filling is complete.

2. Remove the adapter and hose from the Dr Port. Fill the pump casing with the same hydraulic fluid that was used to fill the reservoir. When full, re-install the adapter and hose using the specified Manitowoc torque setting.
3. Remove the plug from pump port T air (1), (Figure 2-8).



4. Remove the hydraulic reservoir mounted breather, install the Pump Priming Tool and connect it to a shop air source.
5. When a solid stream of fluid, free of air bubbles exits the T air port, reinstall the plug to port T air at 12Nm (9ft lbs) while fluid is still coming out.
6. Remove the shop air supply from the pump priming tool.
7. Remove the pump priming tool and reinstall the breather onto the vacated flange mount.

Piston Pump Start-up Procedure (Pump No. 2)

1. Ensure the hydraulic reservoir is filled to the proper level and that the fluid is not aerated. If it is aerated let the unit sit until the air has escaped and fluid is a dark solid color.
2. If the circuit includes an air conditioning compressor drive motor ensure it is in the OFF position before initial start up.
3. Start the engine and let idle for 2-3 minutes with NO crane functions actuated. If the pump outlet becomes too warm to keep your hand on comfortably, stop the engine immediately.

4. Slowly increase the engine speed to approximately 1500 rpm and hold for no longer than 1 minute and make the same checks as outlined previously.
5. Slowly increase engine speed to full RPM and hold for no longer than 1 minute while making the same checks as outlined previously.
6. At full engine RPM cycle all functions fully extending and retracting the cylinders to their stop position to verify operation and that the pump stays quiet and does not become excessively hot.
7. Proceed to the pressure setting procedure.

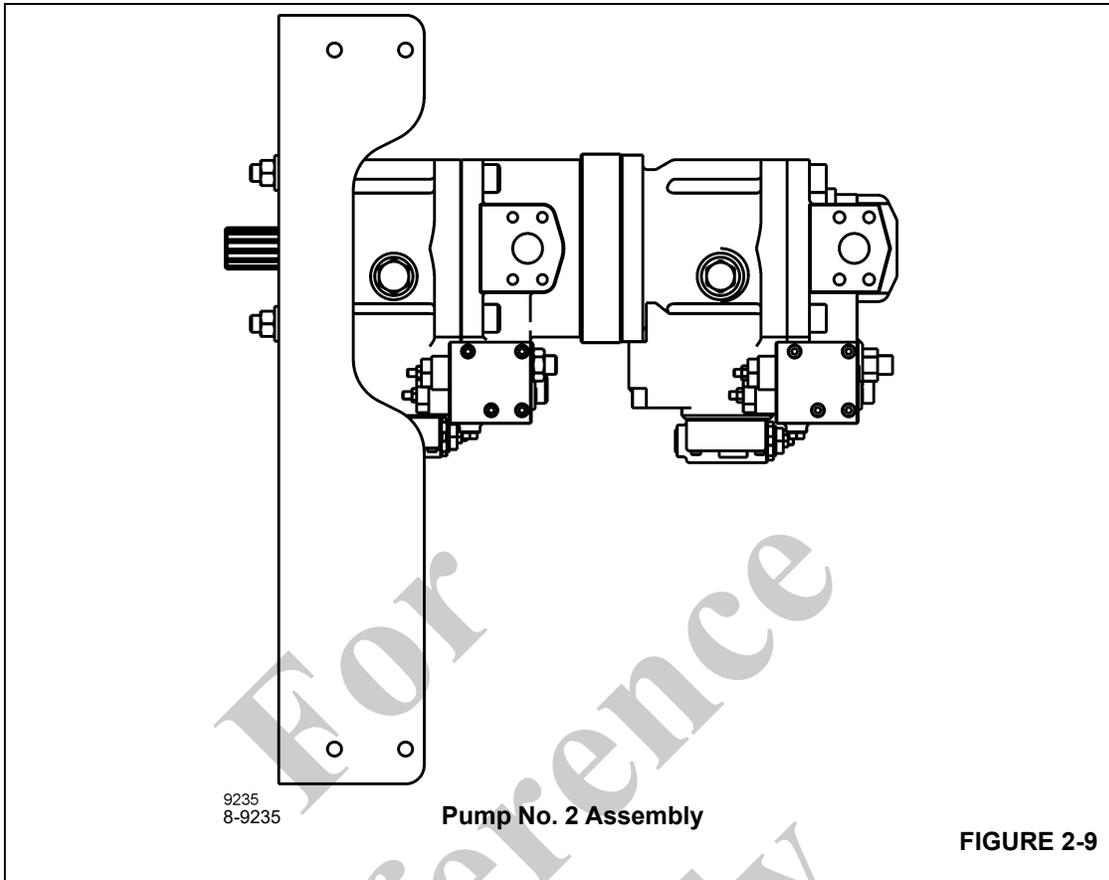
CAUTION

Pump or Reservoir Damage!

If the pump displays either excessive noise or vibration it is probably sucking air into the inlet keeping the pump from priming. (This is usually accompanied by the pump increasingly becoming hotter the longer it is being driven in this condition). If this occurs, stop the engine immediately and inspect all connections of the suction hose/tube for a loose connection, or for a missing or damaged O-ring. Repeat air bleeding and start-up procedure.

DO NOT retract cylinders with the pump priming tool connected to the reservoir. The relief function in the charging tool may not have enough volume to vent the reservoir due to the large differential area of the cylinder as it retracts. Irreparable damage to the reservoir may occur.

The Pump Priming Tool is factory set at 1–2 PSI to lift the fluid to the inlet of the pumps and to prevent the reservoir from being over-pressurized and damaged. DO NOT ATTEMPT TO ADJUST IT. It is necessary to monitor the pressure gauge to ensure that 2 PSI is not exceeded during air bleeding and pump start-up to prevent possible reservoir damage. Again, irreparable damage to the reservoir may occur.



CARRIER VALVES

General

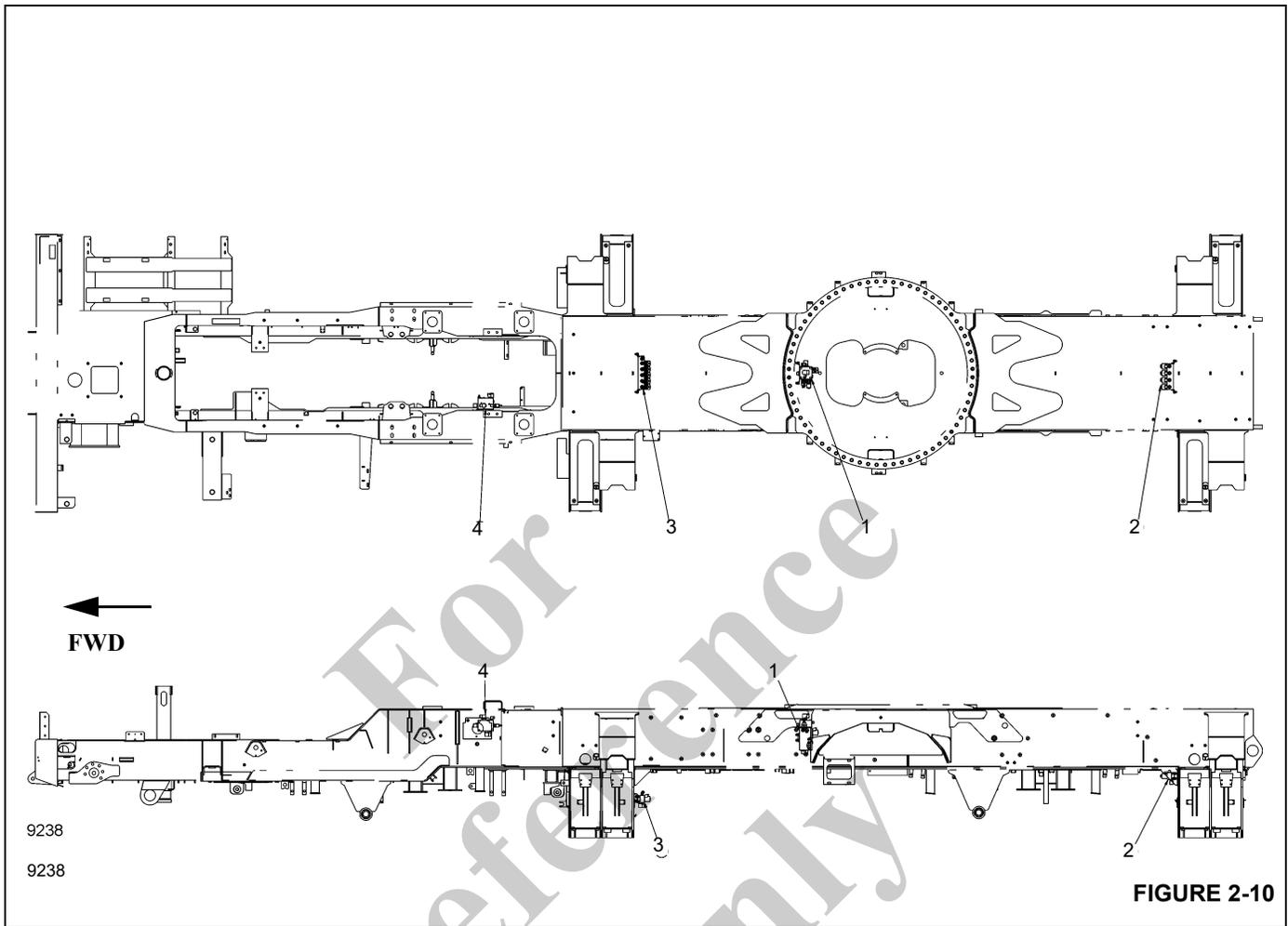
This subsection provides descriptive information for the hydraulic valves used on this crane. For a listing of the valves, the carrier circuit they are used in, and their physical location, refer to VALVE USAGE TABLE. Refer to Figure 2-10 for valve locations. The description of each valve given here 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.

For information on the superstructure hydraulic components, refer to Figure 2-16.

VALVE USAGE TABLE

Valve Name	Circuit Used In	Physical Location
Outrigger Selector and A/C manifold Valve	Outrigger	On front face of carrier frame front cross member forward of hydraulic swivel
Outrigger Control Manifold (2)	Outriggers	4 stack on rear outrigger box; 5 stack on front outrigger box
Pilot Operated Check Valve (Not Shown)	Outrigger	Port block of each jack cylinder (4)
Swing/Steer Selector Valve	Swing/Steer	Front frame of the carrier.

Reference Only



9238

9238

FIGURE 2-10

Item	Description	Item	Description
1	Outrigger Selector and AC Valve	3	Front Outrigger Manifold Valve
2	Rear Outrigger Manifold Valve	4	Swing Steer Valve

OUTRIGGER SELECTOR-A/C MANIFOLD VALVE

Description

The outrigger selector / A/C manifold (Figure 2-11) directionally controls the outrigger and air conditioning circuits. The valve is mounted on the rear face of the carrier frame member forward of the swivel.

The valve inlet contains a pilot operated pressure reducing valve with the pressure in the neutral position limited to approximately 120 psi via the bias spring. The pilot pressure supplied to this reducing valve is controlled by a solenoid operated proportional pressure relief valve. As current is increased to this relief valve the pressure allowed downstream of the reducing valve is increased.

The outrigger circuit contains two three position closed center four way valves. One is solenoid operated and controls the pilot supply to the other which is pilot operated. Activation of the outriggers will energize the solenoid operated relief valve and the solenoid operated four way sending a load sense pressure to the pump allowing it to supply flow to the circuit. This allows movement of the desired outrigger function while limiting the pressure based on the function selected. See the pressure setting procedure for specific pressures.

The A/C circuit contains a pressure reducing valve and two position two way flow control valve. The pressure reducing valve protects the A/C circuit in the event that a high pressure outrigger function is activated while the A/C circuit is also on. Activation of the A/C will energize the solenoid

operated relief valve and the solenoid operated two way flow control sending a load sense pressure to the pump allowing it to supply flow to the circuit. This allows a controlled amount of flow through the two way valve at the desired pressure controlled by the inlet pressure reducing valve.

Maintenance

Removal

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

Installation

1. Install the outrigger selector valve to the frame. Secure the valve with the washers, nuts and capscrews. Torque the capscrews. Refer to *Torque Values*, page 1-9.
2. Connect the hydraulic lines to the outrigger valve as tagged during removal.
3. Connect the electrical connectors to the outrigger selector valve as tagged during removal.

Functional Check

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

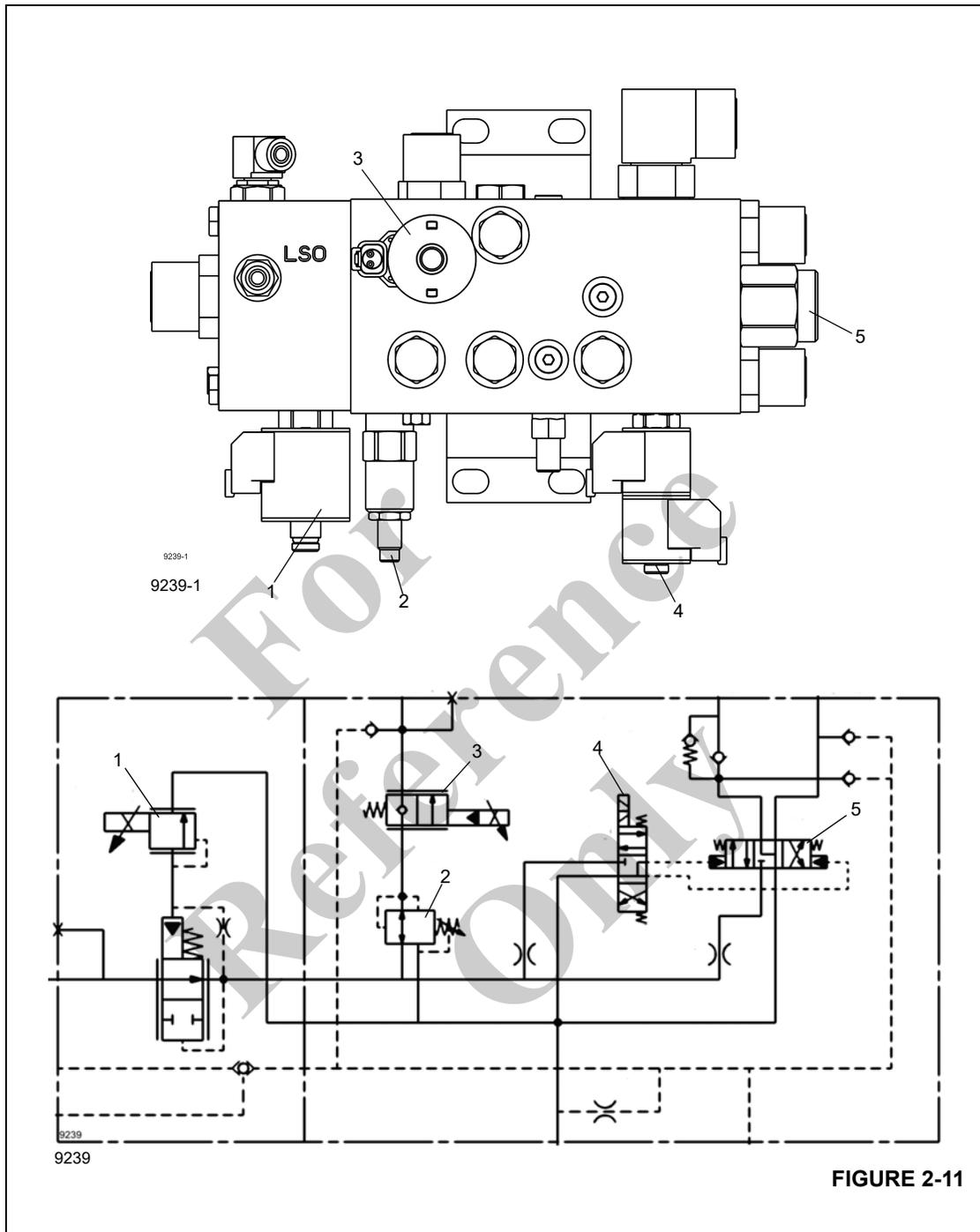


FIGURE 2-11

Item	Description
1	Solenoid Relief Valve
2	Adjustable Pressure Reducing Valve
3	Solenoid Flow Control Valve

Item	Description
4	4-way Solenoid Pilot Valve
5	4-way Outrigger Directional Valve

OUTRIGGER CONTROL MANIFOLD

Description

There are two outrigger control manifolds utilized on the crane, one for the front outriggers and one for the rear outriggers. The front manifold (Figure 2-12) consists of five normally closed two position two way solenoid valves and a 200 psi check valve for the fifth jack, the rear (Figure 2-13) 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 capscrews, 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 the capscrews. Refer to *Torque Values*, page 1-9.
2. Connect the electrical connectors to the solenoids as marked during removal.
3. Connect the hydraulic lines to the valves as marked during removal.

Functional Check

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

For Reference Only

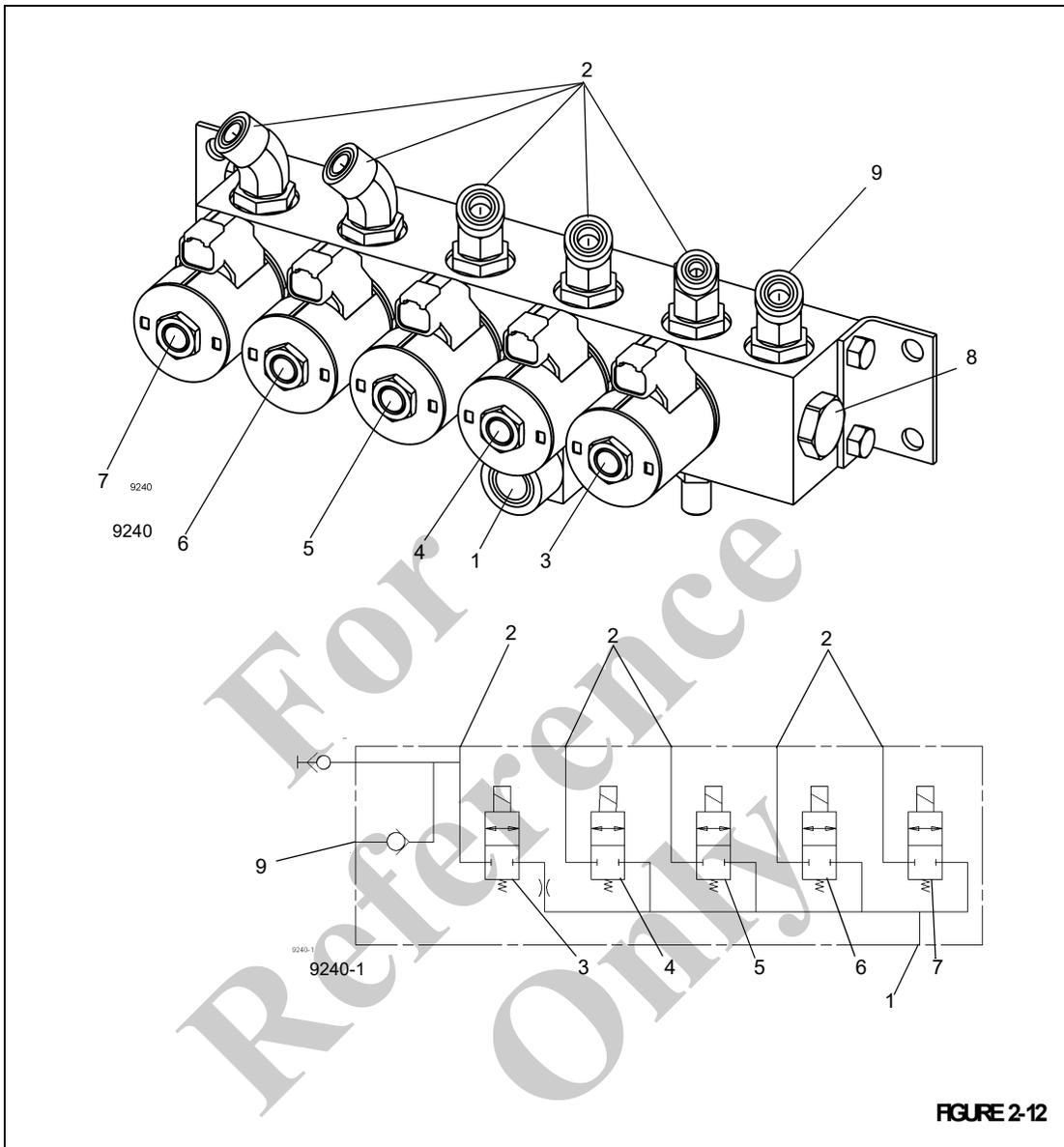


FIGURE 2-12

Item	Description
1	In Port
2	Out Ports
3	Center Front Jack Cylinder
4	Left Front Extension Cylinder

Item	Description
5	Left Front Jack Cylinder
6	Right Front Jack Cylinder
7	Right Front Extension Cylinder
8	Check Valve
9	Tank

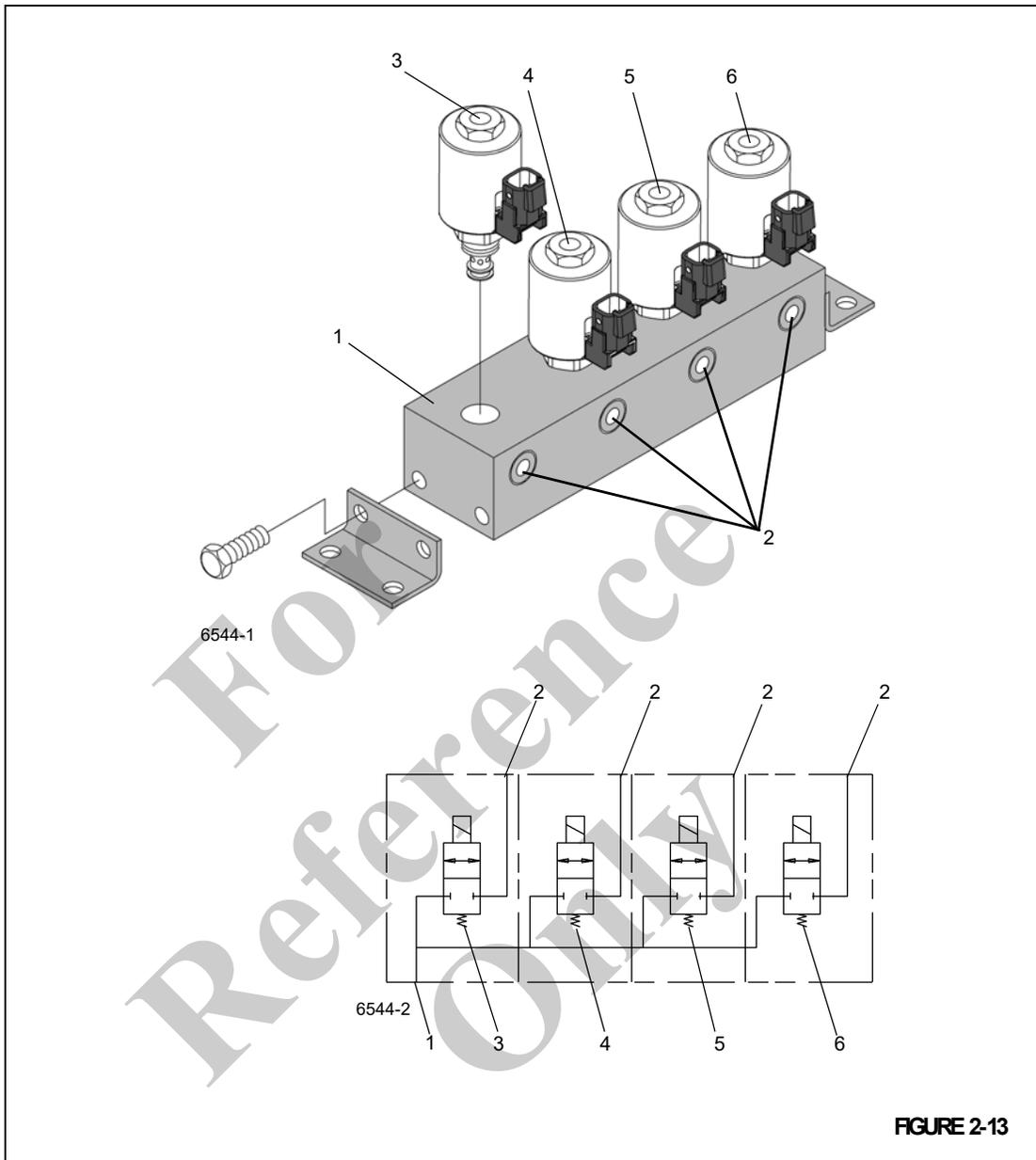


FIGURE 2-13

Item	Description
1	In Port
2	Out Ports
3	Left Rear Extension Cylinder

Item	Description
4	Left Rear Jack Cylinder
5	Right Rear Jack Cylinder
6	Right Rear Extension Cylinder

PILOT OPERATED CHECK VALVE

Description

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

Internal Leak Testing

This procedure is to be used to determine if the outrigger stabilizer cylinder has an internal seal leak, a leaking PO check valve or if it is thermal contraction.

CAUTION

Machine Damage!

Perform the following procedure with the crane set up on outriggers and the boom in the boom rest and the boom extension stowed. Only remove the hoses from one cylinder at a time.

Check Cylinder for Internal Piston Seal Leak

With machine set up on outriggers remove the rod side cylinder hose from the suspected leaking stabilizer cylinder. (See Figure 2-14).

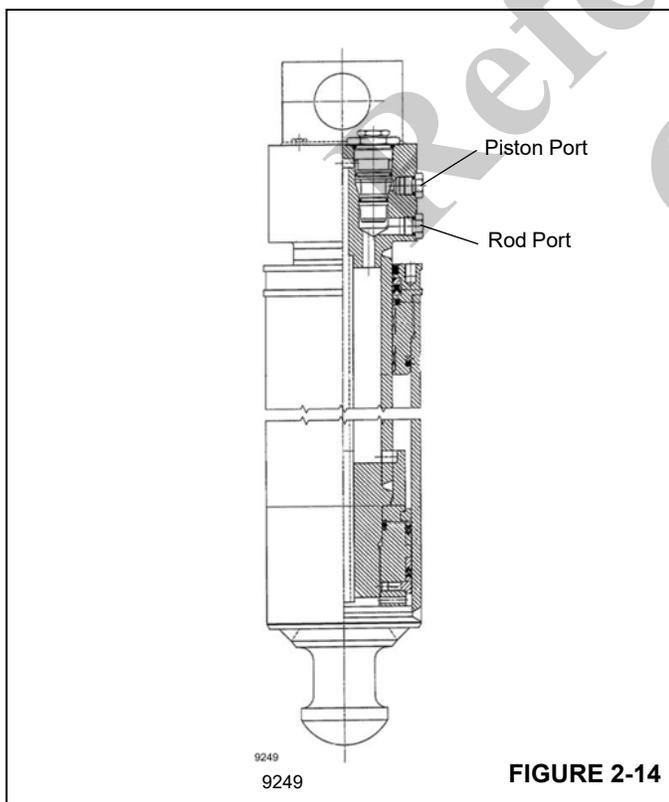


FIGURE 2-14



CAUTION

Personal Injury Hazard!

Release hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port PO check valves in the outrigger selector valve. Hydraulic oil is under pressure that can cut and inject into the skin.

Always wear gloves when working with hydraulic system components.

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.

If oil stops flowing, the cylinder's internal piston seal is sealing properly.

If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking.

After determining the condition of the cylinder's internal piston seal leave the rod side hose disconnected and continue to test the PO check valve.

Test PO Check Valve For Leakage

Remove the piston side hose from the port block of the cylinder. (See Figure 2-14).



CAUTION

Personal Injury Hazard!

Release hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port PO check valves in the outrigger selector valve. Hydraulic oil is under pressure that can cut and inject into the skin.

Always wear gloves when working with hydraulic system components.

A small amount of oil will flow out and then stop.

If oil stops flowing, the cylinder's PO check valve is sealing properly.

If oil continues to flow out the piston port, the cylinder's PO check valve is leaking.

If oil flow is not noticed from either port then the cylinder and PO check valve are functioning properly and any cylinder contraction during normal operation can be attributed to thermal contraction of the oil.

Maintenance

Removal



WARNING

Projectile Hazard!

There must not be any load on the jack cylinder when removing check valve to prevent the valve from becoming a projectile.

Unscrew the check valve from the jack cylinder port block.

Installation

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

3. Lubricate the check valve and O-rings with clean hydraulic oil.

CAUTION

Damage Could Occur!

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. Torque to 136-149 Nm (100-110 lb-ft).
5. Test the check valve and port block by operating the affected outrigger's jack cylinder. Verify it extends and retracts without problems; verify there is no leaking. Make repairs as needed.

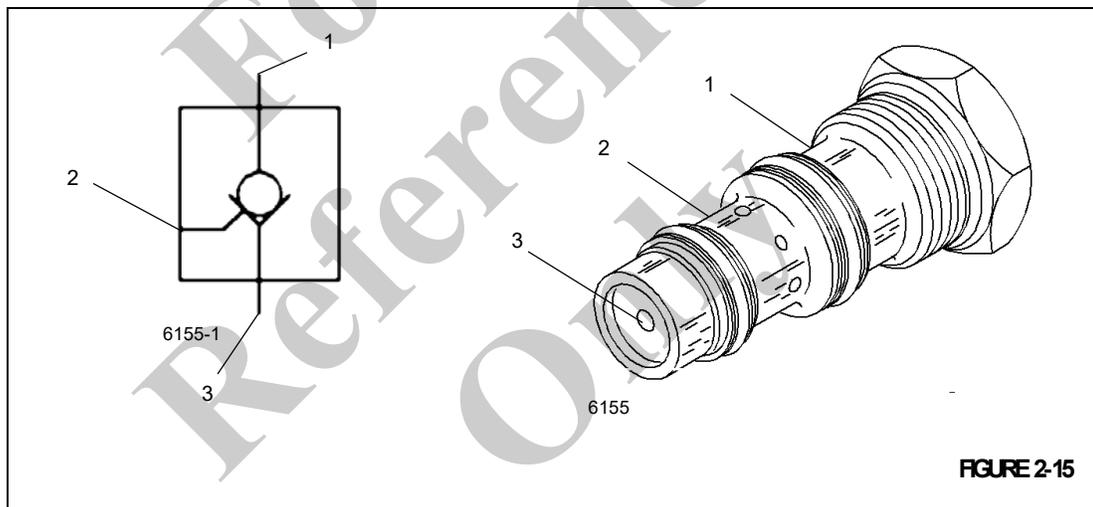


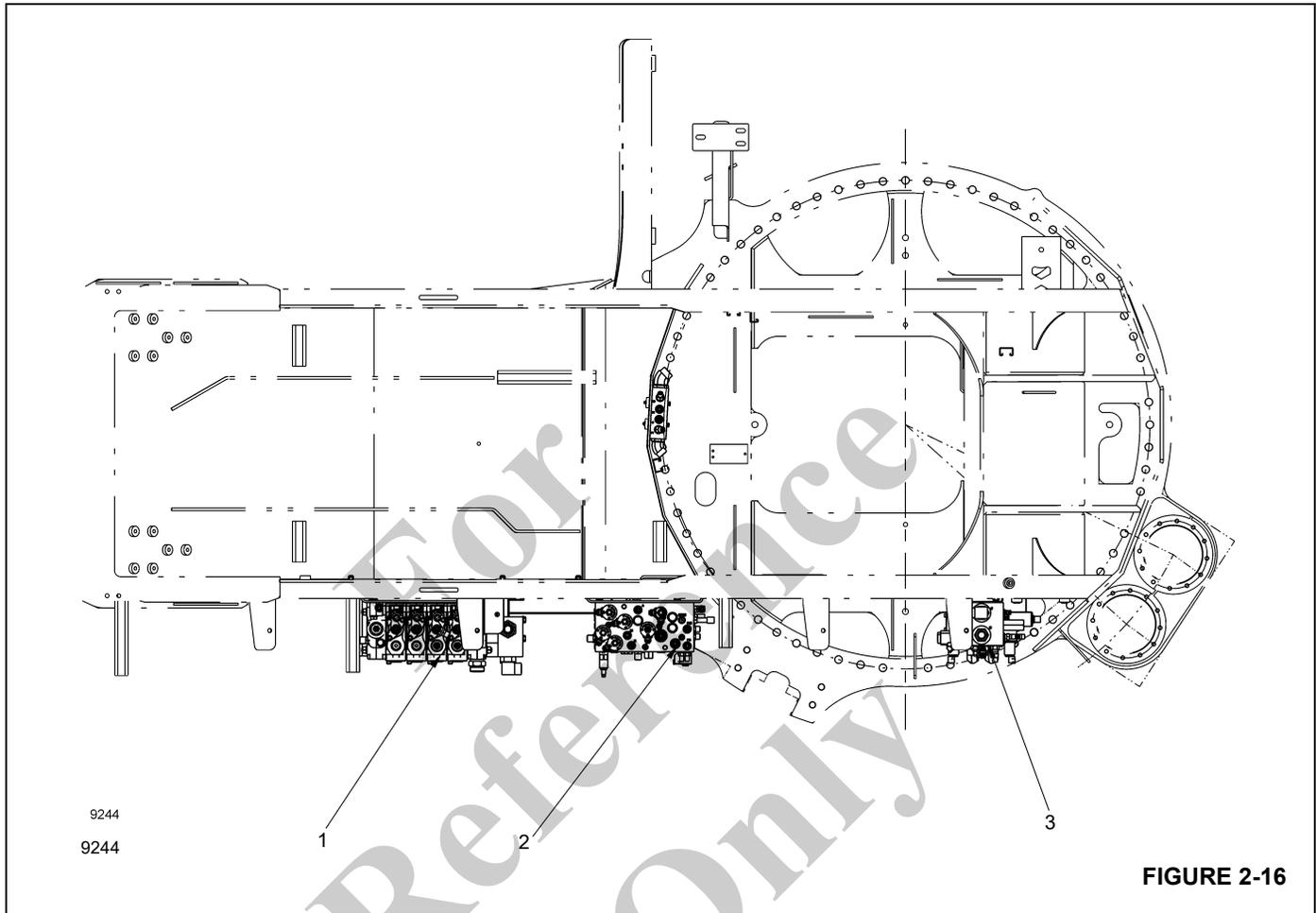
FIGURE 2-15

Item	Description
1	Port C - Cylinder
2	Port P - Pilot

Item	Description
3	Port V - Valve

SUPERSTRUCTURE VALVES

Turntable Hydraulic Valves



Item	Description
1	Assy Main Directional Valve
2	Assy Access Manifold
3	Assy Case Drain Manifold

Main Directional Valve Assembly

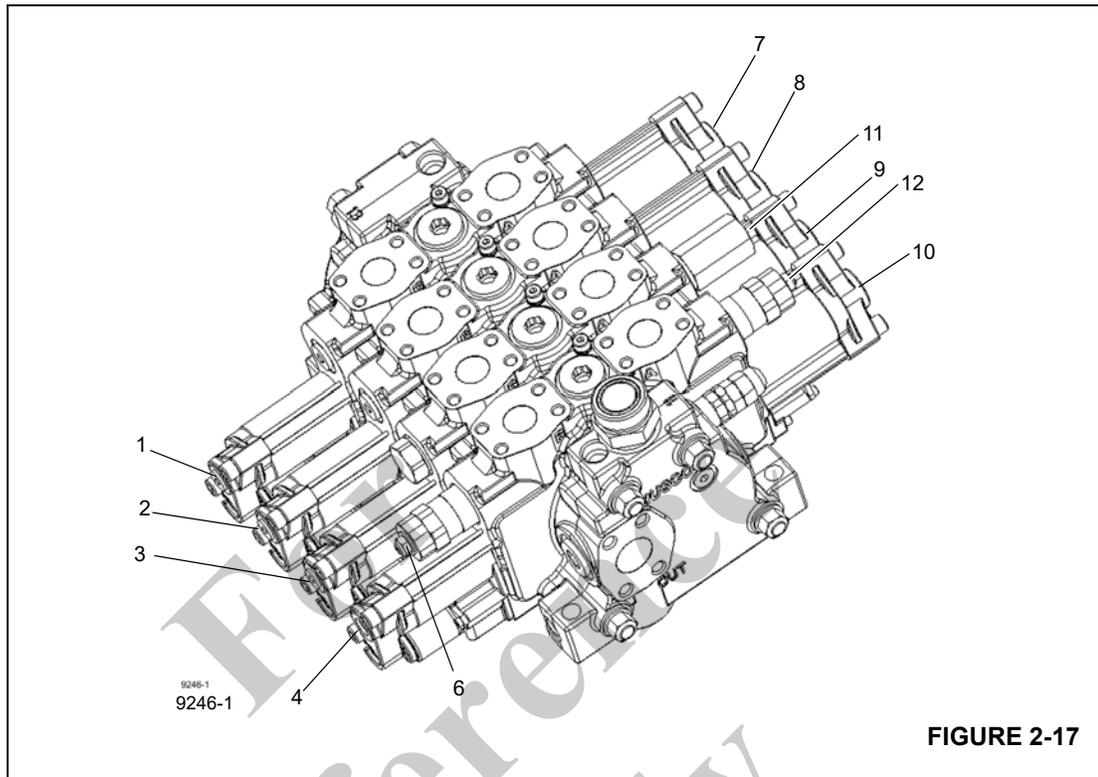


FIGURE 2-17

Item	Description	Item	Description
1	Solenoid operated pressure reducing valve (Aux hoist up)	7	Solenoid operated pressure reducing valve (Aux hoist down)
2	Solenoid operated pressure reducing valve (Main hoist up)	8	Solenoid operated pressure reducing valve (Main hoist down)
3	Solenoid operated pressure reducing valve (Lift up)	9	Solenoid operated pressure reducing valve (Lift Down)
4	Solenoid operated pressure reducing valve (Tele extend)	10	Solenoid operated pressure reducing valve (Tele Retract)
5	Not Used	11	Non-Adjustable port relief (Lift Down)
6	Adjustable port relief (Tele extend)	12	Adjustable port relief (Tele retract)

Access Manifold Assembly

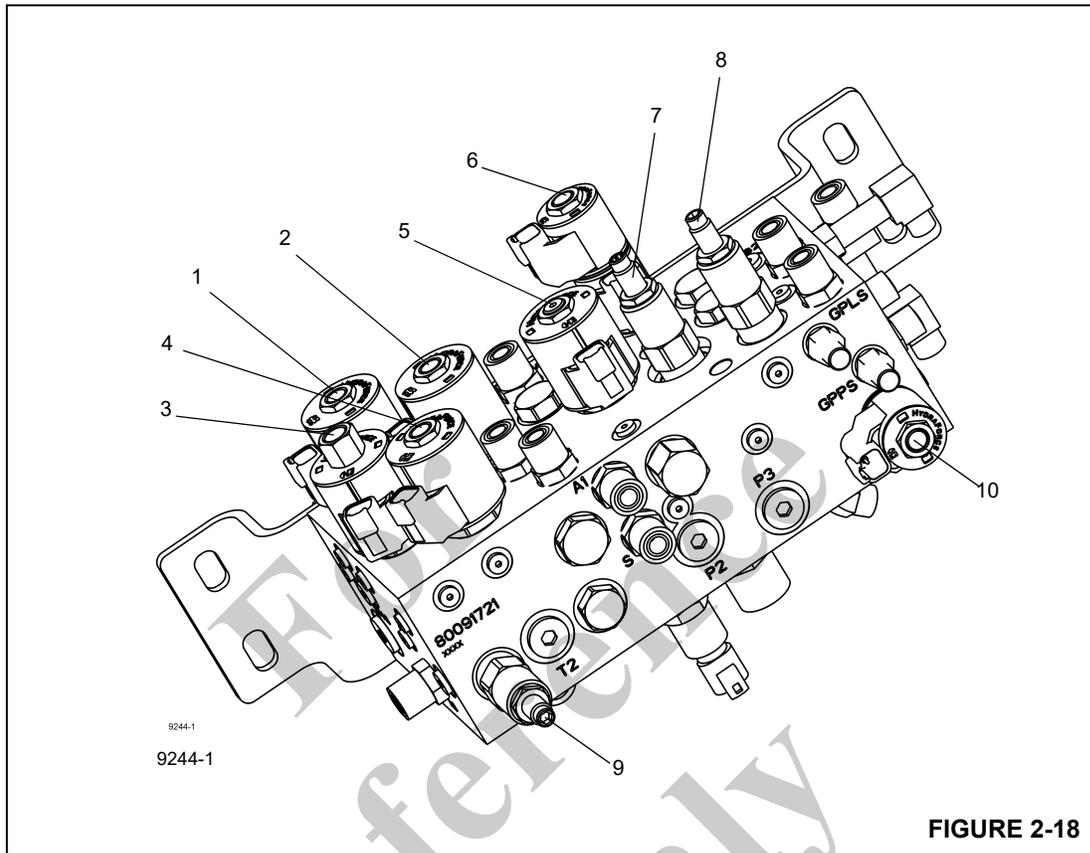


FIGURE 2-18

Item	Description	Item	Description
1	2 Position 3 Way Solenoid Valve (CWT Raise)	6	3 Position 4 Way Solenoid Valve (Cab Tilt)
2	2 Position 3 Way Solenoid Valve (Tele Pinning)	7	Adjustable Pressure Reducing Valve
3	Solenoid Operated Proportional Relief	8	Adjustable Pressure Reducing Valve (Pilot Supply)
4	2 Position 3 Way Solenoid Valve (CWT Lower)	9	Adjustable Pressure Relief Valve (Tele Pinning)
5	Solenoid Operated Proportional Flow Control Valve	10	2 Position 3 Way Solenoid Valve (Pilot Supply)

HYDRAULIC SYSTEM OF THE SUPERSTRUCTURE

Checking for Leaks

- With the diesel engine running, make a visual inspection for leaks and escaping hydraulic oil on the hydraulic components of the superstructure (hydraulic cylinders, lines, connections, hydraulic pumps, motors, valves, and control block).
- If leaks are detected, check the hydraulic oil level and top up if necessary.



WARNING

Pressurized Hydraulic Oil Hazard!

Never tighten leaking connections when the system is under pressure. Only change seals, pipes and hoses when the system is de-pressurized. Hydraulic oil can cut skin.

If damage cannot be rectified immediately further damage is likely:

- Inform Manitowoc Crane Care or your repair personnel.

CAUTION

Environmental Damage Hazard!

Immediately repair leakages in the hydraulic system or have them repaired to ensure that no hydraulic oil escapes, seeps into the ground or reaches waterways when the crane is being used.

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:

WEAR RING GAP

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

Leakage Check

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

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



WARNING
Injury Could Occur!

Make sure that 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.



WARNING
Injury Could Occur!

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

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

Table 2-1 Boom Drift Chart (Cylinder Length Change in Inches)

Coeff. = 0.00043 (in ³ /in ³ / °F)										
STROKE (FT.)	Temperature Change (°F)									
	10	20	30	40	50	60	70	80	90	100
5	0.26	0.52	0.77	1.03	1.29	1.55	1.81	2.06	2.32	2.58
10	0.52	1.03	1.55	2.06	2.58	3.10	3.61	4.13	4.64	5.16
15	0.77	1.55	2.32	3.10	3.87	4.64	5.42	6.19	6.97	7.74
20	1.03	2.06	3.10	4.13	5.16	6.19	7.22	8.26	9.29	10.32
25	1.29	2.58	3.87	5.16	6.45	7.74	9.03	10.32	11.61	12.90
30	1.55	3.10	4.64	6.19	7.74	9.29	10.84	12.38	13.93	15.48
35	1.81	3.61	5.42	7.22	9.03	10.84	12.64	14.45	16.25	18.06
40	2.06	4.13	6.19	8.26	10.32	12.38	14.45	16.51	18.58	20.64
45	2.32	4.64	6.97	9.29	11.61	13.93	16.25	18.58	20.90	23.22
50	2.58	5.16	7.74	10.32	12.90	15.48	18.06	20.64	23.22	25.80
55	2.84	5.68	8.51	11.35	14.19	17.03	19.87	22.70	25.54	28.38
60	3.10	6.19	9.29	12.38	15.48	18.58	21.67	24.77	27.86	30.96

Length change in inches = Stroke (Ft.) X Temperature Change (°F) X Coeff. (in³/in³/ °F) X 12 in/ft

Table 2-2 Boom Drift Chart (Cylinder Length Change in Millimeters)

Coeff. = 0.000774 (1/ °C)											
STROKE (m)	Temperature Change (°C)										
	5	10	15	20	25	30	35	40	45	50	55
1.5	5.81	11.61	17.42	23.22	29.03	34.83	40.64	46.44	52.25	58.05	63.86
3	11.61	23.22	34.83	46.44	58.05	69.66	81.27	92.88	104.49	116.10	127.71
4.5	17.42	34.83	52.25	69.66	87.08	104.49	121.91	139.32	156.74	174.15	191.57
6	23.22	46.44	69.66	92.88	116.10	139.32	162.54	185.76	208.98	232.20	255.42
7.5	29.03	58.05	87.08	116.10	145.13	174.15	203.18	232.20	261.23	290.25	319.28
9	34.83	69.66	104.49	139.32	174.15	208.98	243.81	278.64	313.47	348.30	383.13
10.5	40.64	81.27	121.91	162.54	203.18	243.81	284.45	325.08	365.72	406.35	446.99
12	46.44	92.88	139.32	185.76	232.20	278.64	325.08	371.52	417.96	464.40	510.84
13.5	52.25	104.49	156.74	208.98	261.23	313.47	365.72	417.96	470.21	522.45	574.70
15	58.05	116.10	174.15	232.20	290.25	348.30	406.35	464.40	522.45	580.50	638.55
16.5	63.86	127.71	191.57	255.42	319.28	383.13	446.99	510.84	574.70	638.55	702.41
18	69.66	139.32	208.98	278.64	348.30	417.96	487.62	557.28	626.94	696.60	766.26

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

STEER CYLINDER

Description

The steer cylinders (Figure 2-19) are mounted on the front axles. The steer cylinders each have a 5.08 cm (2.0 inch) diameter bores. The steer cylinders have a retracted length of 52.15 cm (20.53 in) from end to end. The steer cylinders 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 cylinders should include replacement of all seals. A seal kit will supply the required items.

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

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



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



WARNING
Injury Could Occur!

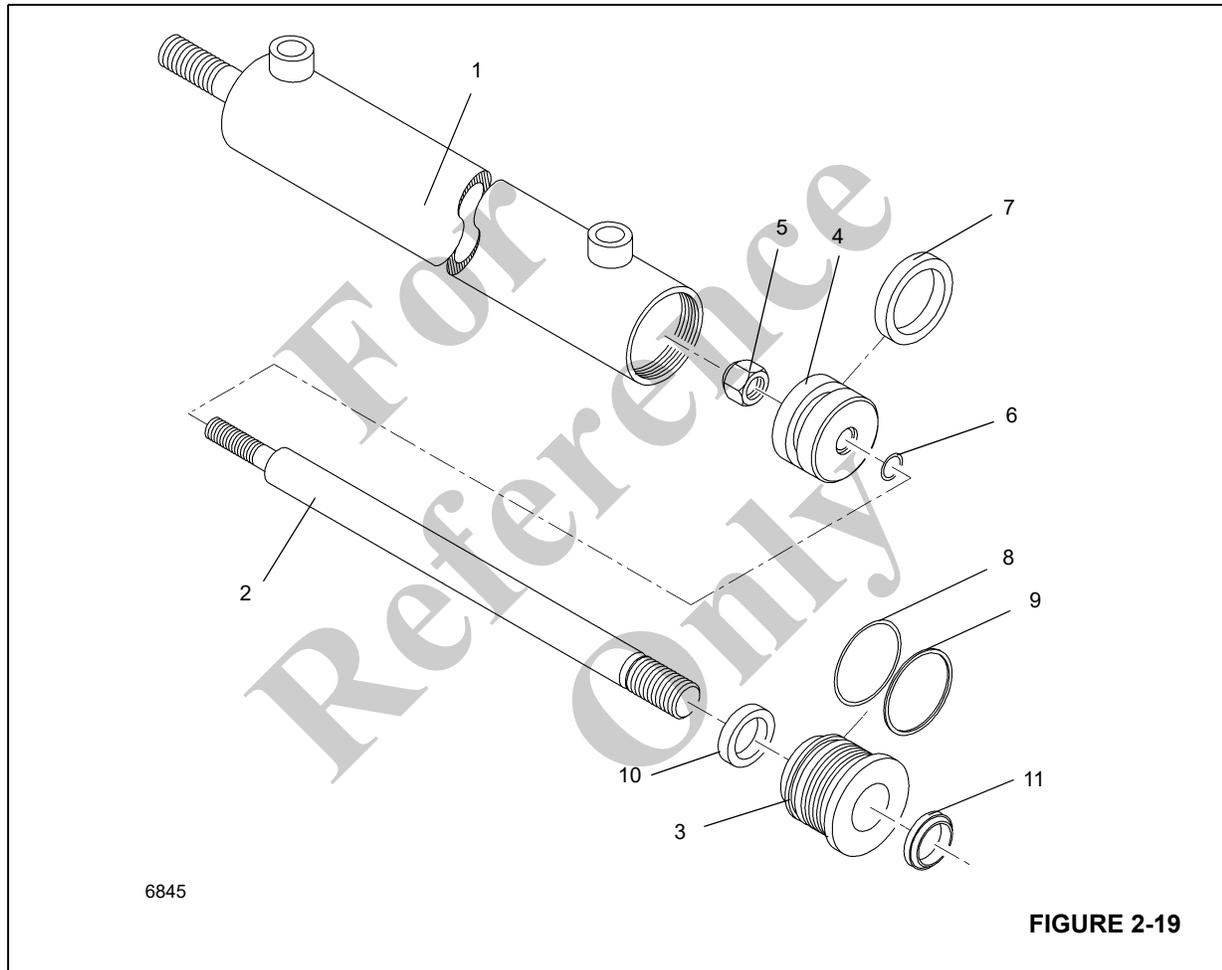
Do not use air pressure to remove the rod. Use only a source of controlled hydraulic oil pressure if the rod is hard to move.

CAUTION

Damage Could Occur!

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

- Position the cylinder with the ports facing down.
- Using a means of collecting the oil, remove the port plugs and allow cylinder to drain.



6845

FIGURE 2-19

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

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

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

Damage Could Occur!

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

1. 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.

2. Loosen and remove the nut securing the piston. Remove the piston from the rod.
3. Remove the O-ring from the inside of the piston.
4. Remove the head from the rod. Remove the O-ring and backup ring from the outside of the head.
5. Remove the wiper ring and the rod seal from the inside of the head.

Inspection

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

CAUTION

Damage Could Occur!

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

2. Stone out minor blemishes and polish with fine crocus cloth.
3. Clean all with solvent and dry with compressed air any parts that have been stoned and polished.
4. Inspect the barrel carefully for scoring. If barrel is scored, it must be repaired or replaced.
5. Check rod's piston area for damage. If it is damaged, determine if it can be repaired or must be replaced.
6. Inspect rod for straightness. Determine if it can be straightened or must 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

Damage Could Occur!

Before 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 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 ± 7 N-m (130 ± 5 lb-ft).
8. Install the seal on the outside of the piston.
9. Lubricate all parts freely with clean hydraulic oil.

CAUTION

Damage Could Occur!

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.

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 lb-ft)

CAUTION

Damage Could Occur!

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

12. Pressurize and cycle the cylinder with hydraulic oil pressure. Static test the cylinder at 24,132 kPa (3500 psi). Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER EXTENSION CYLINDER

Description

The four extension cylinders are installed in the outrigger beams. The cylinders are two stage, with the extend and retract ports on the rod end. Oil from the outrigger selector valve extends and retracts the cylinders.

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. 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.



WARNING

Death or Injury Could Occur!

Do not use air pressure to remove the rod. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure if the rod is hard to move.

CAUTION

Damage Could Occur!

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

Damage Could Occur!

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 rod seal, wiper and O-ring from the inside of the head.

Lower Barrel

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

2. Remove the rod assembly from the lower barrel.

NOTE: Cover the barrel opening to avoid contamination.

3. Remove the wear rings and seal from the outside of the piston.
4. Unscrew and remove the piston from the cylinder rod.
5. Remove the O-ring 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 head and the rod seal, wiper and O-ring from the inside of the head.

Inspection

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

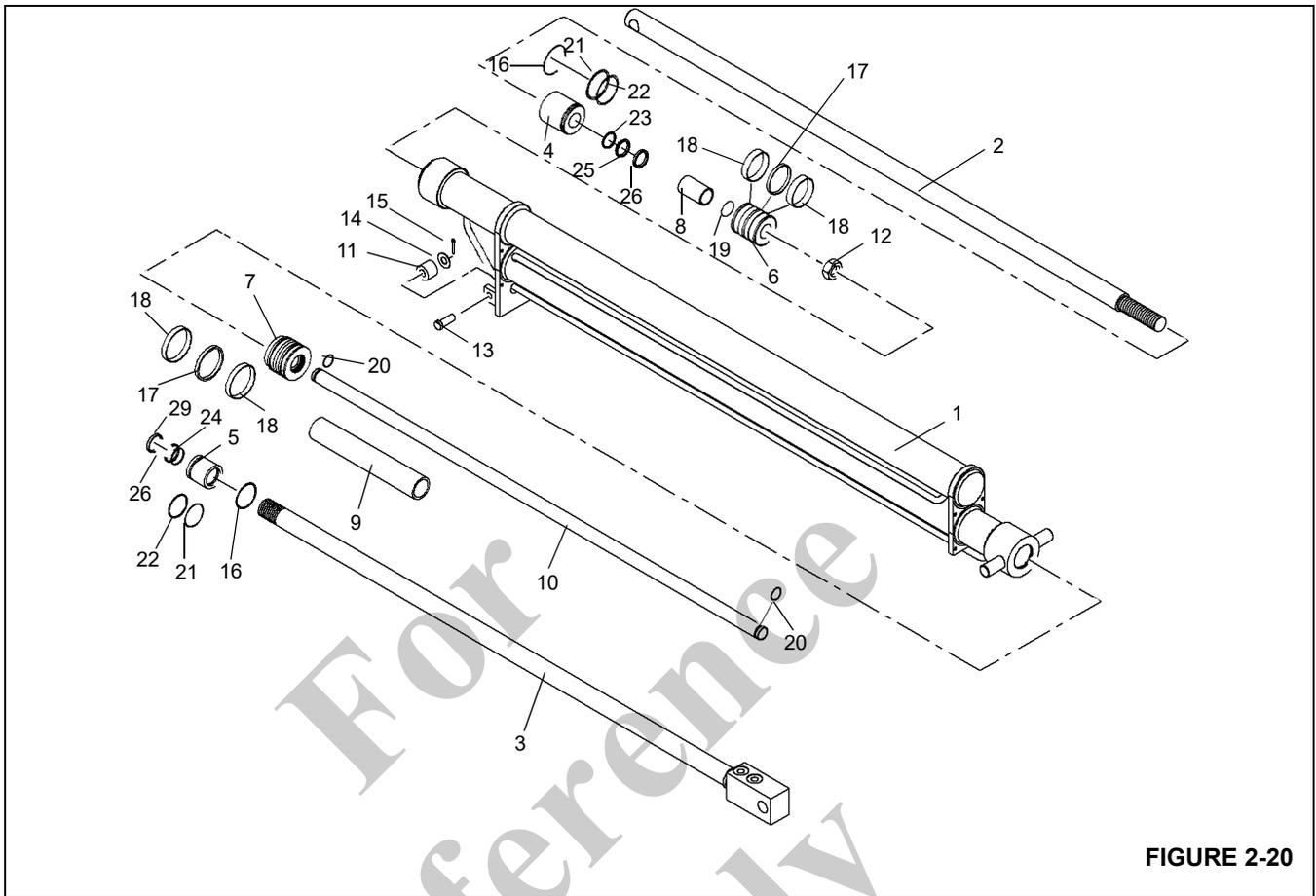


FIGURE 2-20

Item	Description	Item	Description
1	Barrel	16	Retaining Ring
2	Upper Rod	17	Piston Seal
3	Lower Rod	18	Wear Ring
4	Head	19	O-ring
5	Head	20	O-ring
6	Piston	21	O-ring
7	Piston	22	Backup Ring
8	Spacer	23	Rod Seal
9	Spacer	24	Rod Seal
10	Manifold Tube	25	Wiper
11	Roller Bearing	26	Wiper
12	Nut	27	Plug
13	Clevis Pin	28	O-ring
14	Washer	29	O-ring
15	Cotter Pin		

CAUTION**Damage Could Occur!**

Clean all surfaces and carefully remove 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.

CAUTION**Damage Could Occur!**

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****Damage Could Occur!**

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

5. Install the O-ring in the inside of the piston.
6. Install the piston onto the rod.

CAUTION**Damage Could Occur!**

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. Lubricate the piston seals and cylinder seals with clean hydraulic oil.
8. Lubricate the rod with clean hydraulic oil.
9. Install the rod assembly into the lower cylinder barrel with a slight twisting motion.

Upper Barrel**CAUTION****Damage Could Occur!**

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

**WARNING****Death or Injury Could Occur!**

Do not use air pressure to cycle or pressurize the cylinder. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure if the rod is hard to move.

10. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 20,700 kPa (3000 psi). Check for proper operation and any leakage. Make repairs as needed.

OUTRIGGER JACK CYLINDER**Description**

The four outrigger jack cylinders (Figure 2-3) each have a port block bolted to the piston end of the cylinder, containing a pilot operated (PO) check valve and the extend and retract ports. For the cylinder to extend oil passes across the PO check valve in the free flow direction while retracting requires the PO check to be piloted open by the retract side pressure.

The four outrigger jack cylinders (Figure 2-21) each have a hollow rod for internal porting. Each cylinder has a 12.7 cm (5.0 in) diameter bore. A port block is welded to the rod of each cylinder and a pilot operated check valve is threaded into each port block.

The retracted length of the cylinder from the end of the barrel to the end of the rod is 85.3 ±0.30 cm (33.60 ±0.12 in). The extended length of the cylinder from the end of the barrel to the end of the rod is 132.8 cm (52.3 in). Its stroke is 47.5 cm (18.7 in).

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 98.6 kg (217.4 lb).

Maintenance**Disassembly**

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

1. Clean away all dirt from the head. Place protective padding around the rod near the head to prevent

damaging the chrome. Using a spanner wrench, unscrew the head from the barrel.

**WARNING****Death or Injury Could Occur!**

Do not use air pressure to remove the rod. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure if the rod is hard to move.

CAUTION**Damage Could Occur!**

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

2. Secure cylinder barrel in a chain vise in the vertical position with the rod assembly up.

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

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

NOTE: Cover the barrel opening to avoid contamination.

6. Remove the socket head capscrew.
7. Unscrew the locknut and remove the piston.
8. Remove the spacer from the rod.

CAUTION**Damage Could Occur!**

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

9. Remove the seal assembly from the outside of the piston and the O-ring from the inside of the piston.

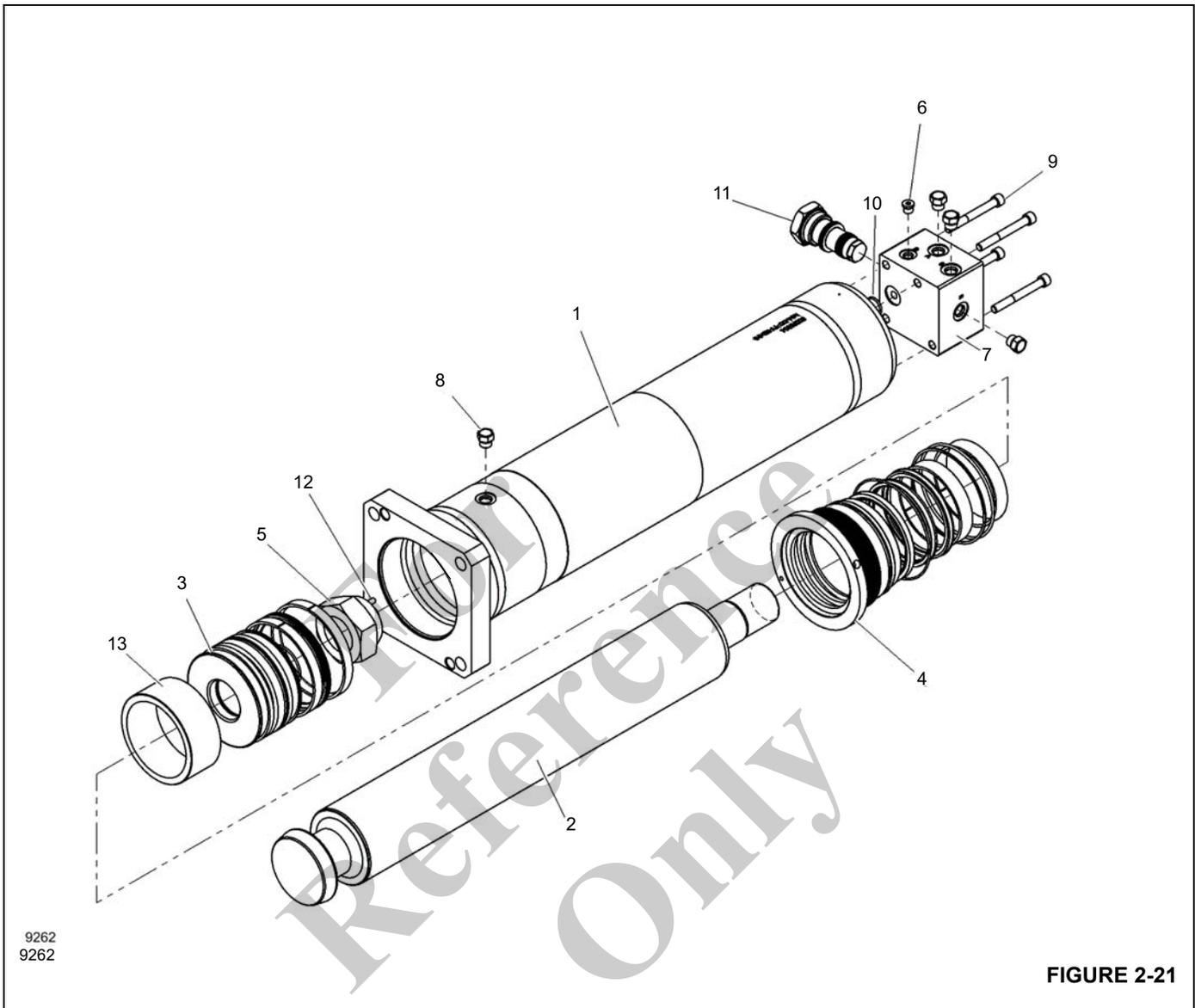


FIGURE 2-21

Item	Description
1	Barrel Assy.
2	Rod Assy.
3	Piston Assy.
4	Head Assy.
5	Locknut
6	Plug, O-ring
7	Valve Body Assy.

Item	Description
8	Plug, SAE #6
9	Capscrew
10	O-ring
11	Valve, Check PO
12	Capscrew, Socket Head
13	Spacer, Limiter

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

installed to avoid installing replacement seals and rings improperly.

10. Remove the 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.
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

Damage Could Occur!

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

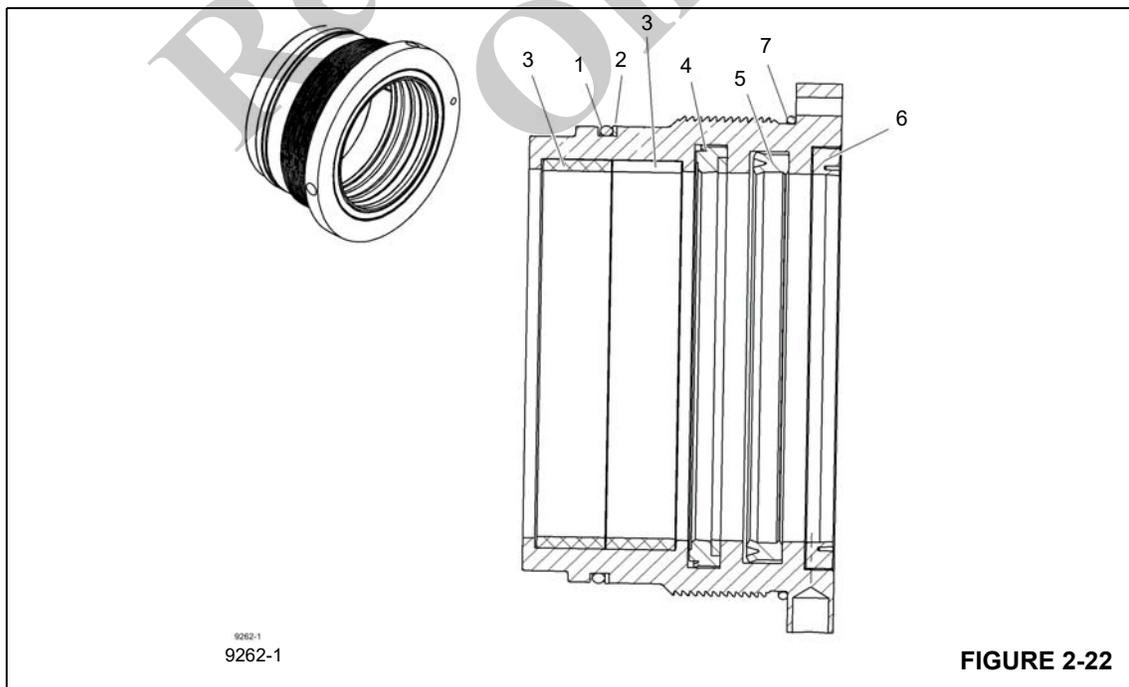
CAUTION

Damage Could Occur!

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.

Refer to head (Figure 2-22) and piston (Figure 2-23) seal installation illustrations when installing the seals.



Item	Description
1	O-ring
2	Backup Ring
3	Wear Ring
4	Buffer Seal

Item	Description
5	Rod Seal
6	Wiper Ring
7	O-ring

1. Install the replacement wiper ring, rod seal, buffer seal and wear rings in the inside of the head Figure 2-22.
2. Install the replacement O-ring and backup ring on the outside of the head.
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.

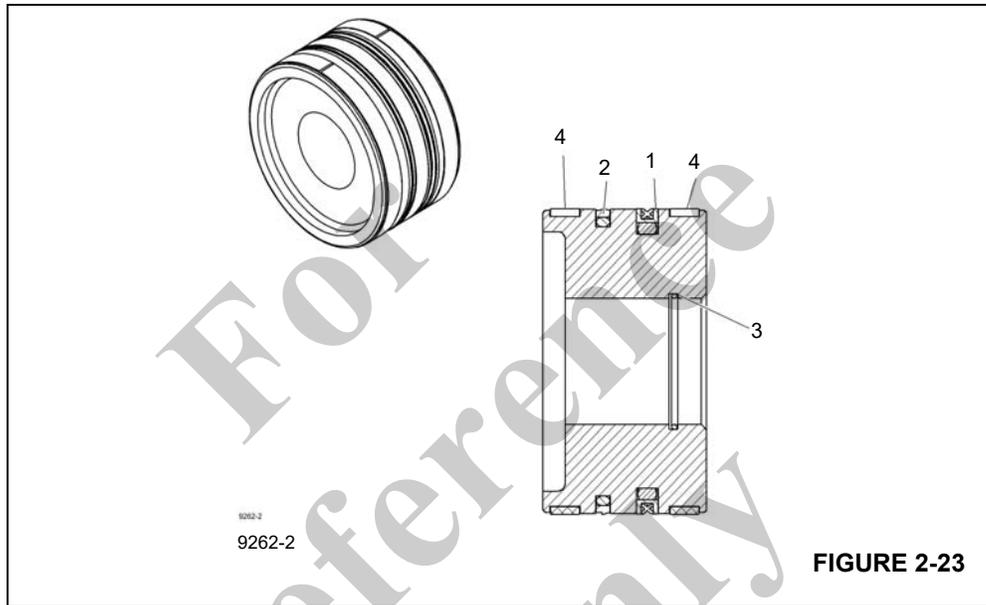


FIGURE 2-23

Item	Description
1	Seal Assembly
2	Backup Ring

Item	Description
3	O-ring
4	Wear Ring

5. Install the spacer onto the rod with the ID lip at the piston end.
6. Install the seal assemblies onto the piston.
7. Remove the cover from the barrel.
8. Lubricate the OD seals on the piston and head with clean light oil and lower the assembly into the barrel. Stop just before the head enters the barrel.
9. Place a spanner wrench on the head and turn 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.
10. Slowly lower the rod down to the fully retracted position.

CAUTION

Damage Could Occur!

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.

CAUTION

Do not use air pressure to cycle or pressurize the cylinder. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure.

11. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 4500 psi (31,026 kPa). Check for proper operation and any leakage. Make repairs as needed.

CENTER FRONT STABILIZER CYLINDER

Description

The center front jack cylinder (Figure 2-24) has a 8.9 cm (3.5 inch) bore and is double acting. A port block is welded to the end of the cylinder rod and a pilot operated check valve is threaded into the port block. Internal seals are used to prevent leaks and a wiper ring in the cylinder head wipes dirt from the rod as it is retracted.

The cylinder has a retracted length of 115.6 cm (45.5 in) and an extended length of 179.1 cm (70.5 in) from the center of the mounting fixture to the end of the ball on the barrel. The cylinder weighs approximately 42.5 kg (113.8 lb) dry.

Maintenance

Disassembly

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

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



WARNING

Death or Injury Could Occur!

Do not use air pressure to remove the rod. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure if the rod is hard to move.

CAUTION

Damage Could Occur!

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

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

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

4. Position the rod mount with the ports facing down. Use a means of collecting the oil, remove the port plugs and the check valve and allow cylinder to drain.
5. Support the rod with a hoist sling and pull the rod to full extension to remove additional oil. Keeping the rod supported, tap the rod back in 25 mm (1 in) after all oil has drained.
6. Place protective padding around the rod near the head to prevent damaging the chrome during head removal.
7. Insert a spanner wrench into the holes provided and turn the head counter clockwise to remove. If the head is difficult to remove, tap the head with a plastic mallet while turning.
8. With the rod still supported, gently pull the piston from the barrel being careful not to damage the internal threads. Place the rod on a surface that will not damage the chrome.
9. Remove the setscrews located near the top of the piston.
10. Insert a spanner wrench into the holes on the face side of the piston.
11. Turn the piston counter clockwise to remove.

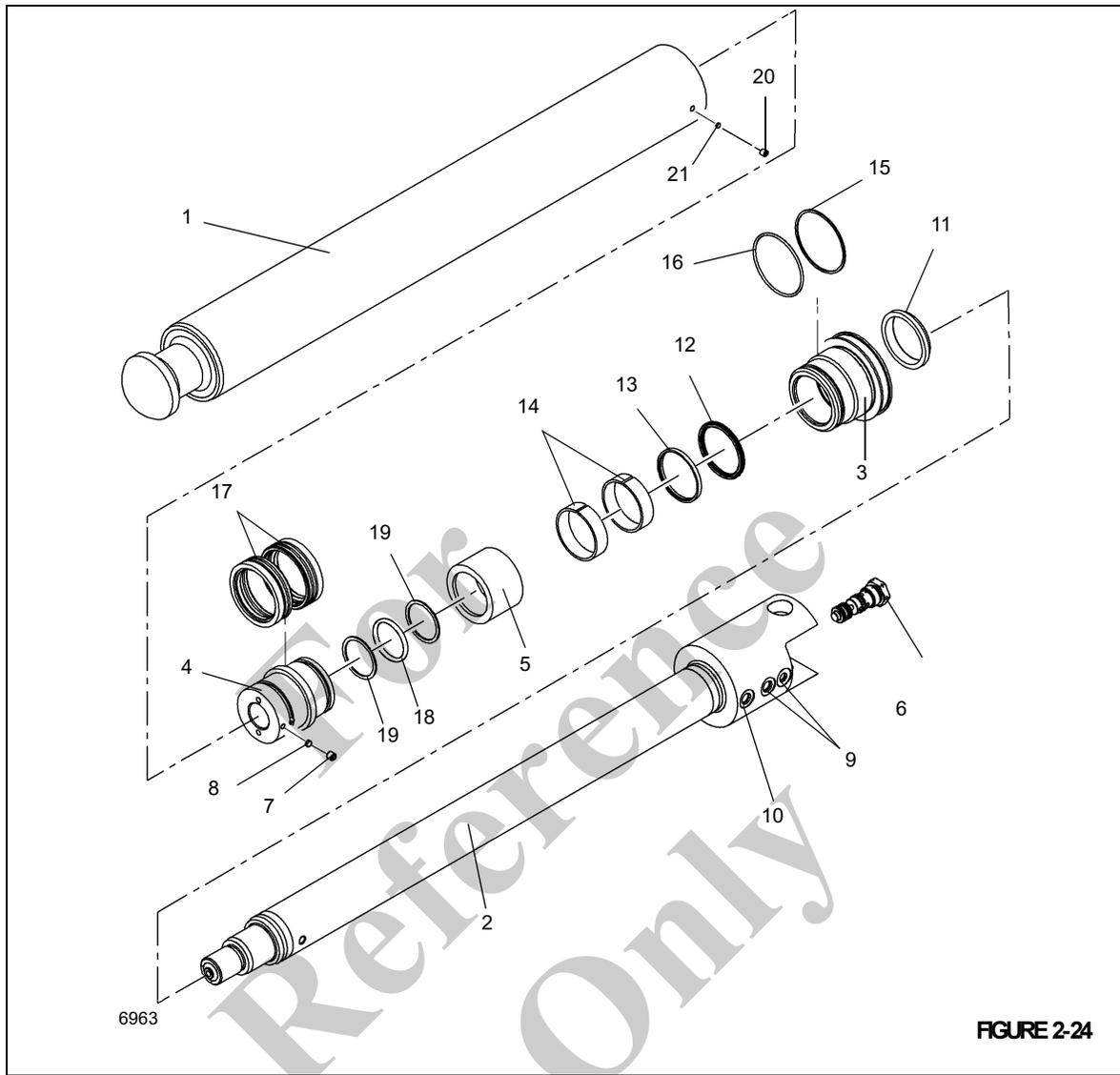


FIGURE 2-24

Item	Description	Item	Description
1	Barrel	12	Rod Seal
2	Rod	13	Buffer Seal
3	Head	14	Wear Ring
4	Piston	15	O-ring
5	Spacer	16	Backup Ring
6	Check Valve	17	Seal
7	Setscrew	18	O-ring
8	Insert	19	Backup Ring
9	Plug	20	Setscrew
10	Plug	21	Insert
11	Wiper Ring		

CAUTION**Damage Could Occur!**

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

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

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

Inspection

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

CAUTION**Damage Could Occur!**

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****Damage Could Occur!**

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 new seals and rings with clean hydraulic oil.

For head and piston seal installation, refer to figures titled, Head Seal Installation and Piston Seal Installation.

1. Using round nose pliers or special installation tools, twist the dual lip u-cup seal into a "C" shape and allow it to snap into groove.
2. Use a similar technique to install the wiper.
3. Install the static O-ring and backup ring into the static seal groove verifying that the backup ring is closest to the threads.
4. Install the sealing O-ring into the groove between the threads and the flange lip.

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

5. For easiest installation of the piston seal assembly, warm the teflon outer ring in 49°C to 66°C (120° to 150° F) hydraulic oil or water. Lubricate the piston and all components with hydraulic fluid.
6. Stretch the inner ring into the seal groove. Do not use sharp edged tools and verify that it is not twisted.
7. Repeat step 6 for the outer ring.
8. Install the wear rings into wear ring grooves.
9. Place the rod on a clean table.
10. Install the head followed by the spacer, then the piston onto the rod. Note proper orientation of each component.

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

Functional Check

1. Set test stand pressure to 24,132 kPa (3500 psi).
2. Attach hose fittings to cylinder.
3. Connect a ball valve to the "test extend" port (marked "PC" on rod mount) so that the pressure can be released after testing and is not trapped in the valve. Test cylinder through working ports with ball valve closed.
4. The cylinder shall be stroked its full length in both directions to fill it with oil and remove trapped oil.
5. Pressurize to recommended test pressure at each end, beginning with the rod end for a minimum of 10 seconds per end. While under pressure, cylinder shall be checked for leaks at weld, SAE fittings, valve, and all external static and dynamic seals. Cycle cylinder completely (retract and extend) three times under pressure.
6. When testing is complete, relieve pressure on working ports. Slowly open ball valve on PC port to relieve trapped oil pressure. Plug the extend port (marked "EXT") and retract the cylinder with air using a regulator at the RET port and a return line connected to the PC port. Reclaim all oil. Carefully bleed off air pressure once cylinder is fully retracted.

7. Seal ports with port plugs to prevent contamination from entering cylinder.

LIFT CYLINDER

Description

The lift cylinder Figure 2-25 has a bore of 27.94 cm (11.0 in). The retracted length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 454.4 cm (178.9 in). The extended length of the cylinder from the center of the barrel bushing to the center of the rod bushing is 848.5 cm (334.1 in). Its stroke is 394.11 cm (155.16 in). A wiper ring prevents foreign material from entering the cylinder. O-rings and other seals prevent internal and external leakage.

The cylinder weighs (dry) approximately 1021.2 kg (2251.4 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. Using a spanner wrench or chain wrench, unscrew the head retainer ring from the barrel.



WARNING

Death or Injury Could Occur!

Do not use air pressure to remove the rod. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure if the rod is hard to move.

CAUTION

Damage Could Occur!

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

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

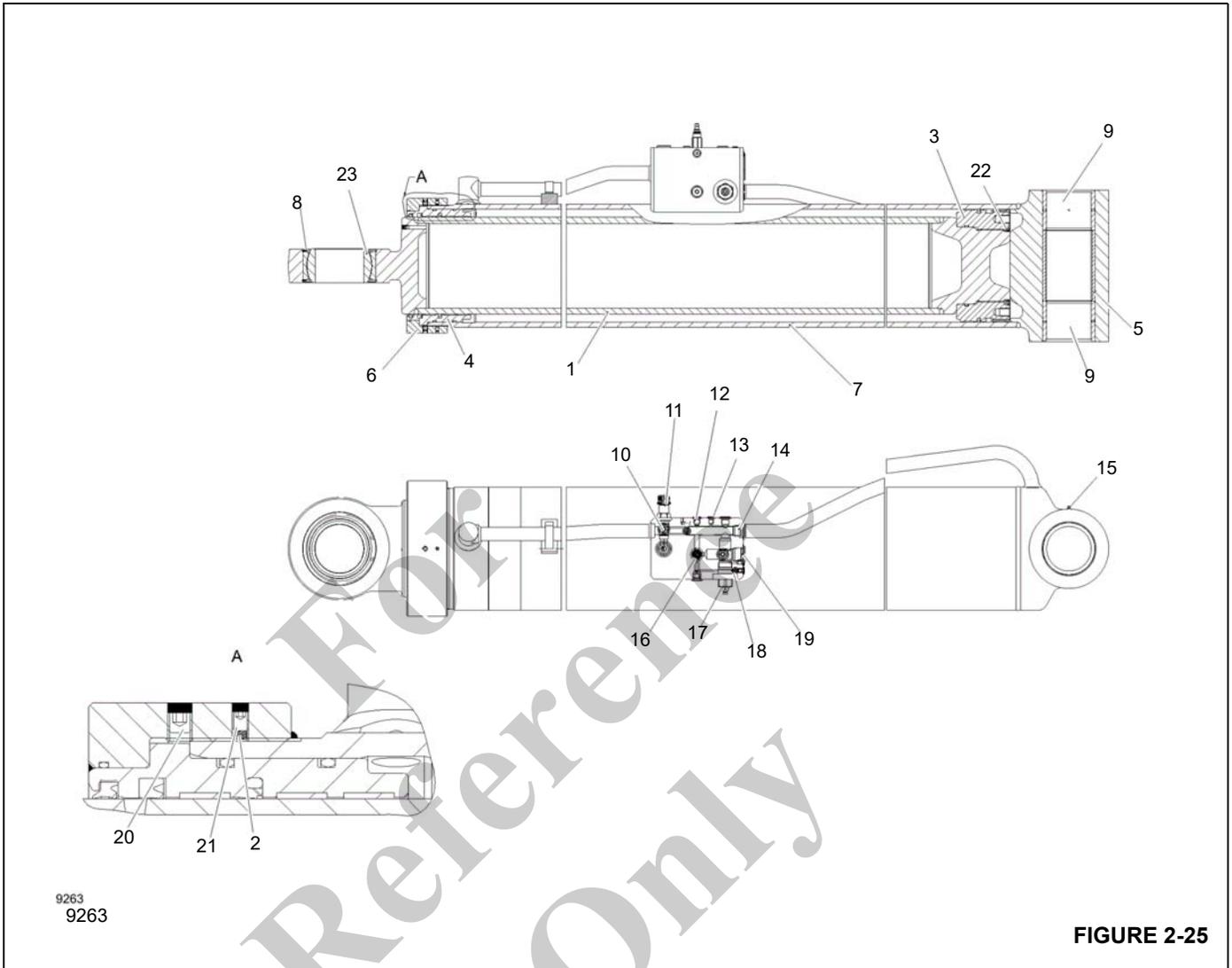


FIGURE 2-25

9263
9263

Item	Description	Item	Description
1	Rod Assy.	13	Plug, #4 SAE
2	Nylon Set	14	Plug, #12 SAE
3	Piston Assy.	15	Grease Fitting
4	Head Assy.	16	Valve Assy., Sequence
5	Bushing	17	Valve Assy., Overcenter
6	Cover	18	Plug, #2 SAE
7	Barrel Assy.	19	Plug, #16 SAE
8	Circlip Ring	20	Set Screw
9	Bushing, Copper	21	Set Screw
10	Plug, #8 SAE	22	Set Screw
11	Valve Assy., Cart. Flow Control	23	Bearing
12	Plug, #6 SAE		

NOTE: Cover the barrel opening to avoid contamination.

CAUTION

Damage Could Occur!

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

3. Remove the 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.

4. Remove the setscrew securing the piston to the rod.
5. Unscrew the piston from the rod.
6. Remove the O-rings and backup rings from the inside of the piston.
7. Remove the head from the rod. Remove the O-ring and the backup ring from the inside of the head. Remove the wear ring, buffer seal, and deep Z rod seal from the outside of the head.
8. Remove the backup ring and wiper ring from the inside of the retainer ring.
9. 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

Damage Could Occur!

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

Damage Could Occur!

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 new seals and rings with clean hydraulic oil.

1. Install the O-rings, backup rings and wear rings onto the head.
2. Install O-ring and retainer ring into the head.
3. Install the replacement O-ring and backup ring in the inside of the head.
4. Install the replacement O-ring, wear rings and seal rings in the inside of the piston.
5. Lubricate the rod with clean hydraulic oil.
6. Slide the head onto the rod.
7. Screw the piston onto the rod tightly. Secure the piston with the setscrew.
8. Lubricate all parts freely with clean hydraulic oil.

CAUTION

Damage Could Occur!

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.

9. Remove the cloth from the barrel. Insert the rod and attached parts into the barrel with a slight twisting motion.
 - a. Screw the cover onto the barrel tightly. Secure the cover with the setscrews.



WARNING

Death or Injury Could Occur!

Do not use air pressure to cycle or pressurize the cylinder. Cylinder parts could fly apart with explosive force. Use only a source of controlled hydraulic oil pressure

- 10. Connect the hoses to the valve block.
- 11. Pressurize and cycle the cylinder with hydraulic oil pressure. Test the cylinder at 36,107 KPa (5250 psi). Check for proper operation and any leakage. Make repairs as needed.

COUNTERWEIGHT CYLINDER

Description

The counterweight cylinder (Figure 2-26) has a retracted length of 90.9 cm (36 in). The extended length of the cylinder is 139.9 cm (55 in). Its stroke is 49 cm (19.3 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 88 kg (194 lb) wet.

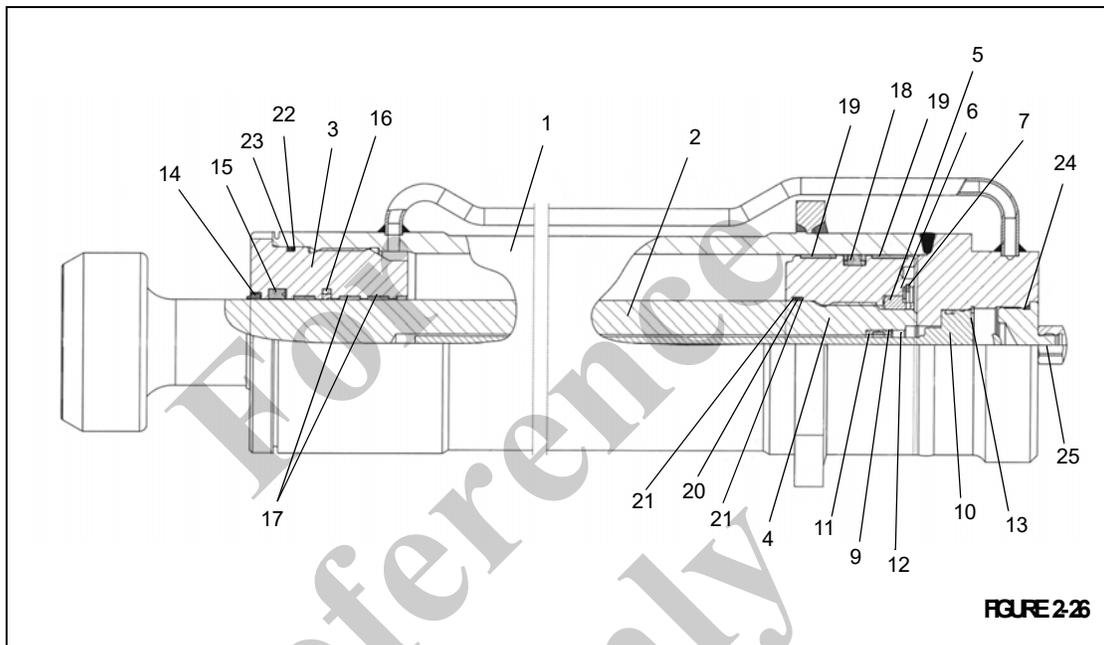


FIGURE 2-26

Item	Description	Item	Description
1	Barrel	14	Wiper
2	Rod	15	Rod Seal
3	Head	16	Step Seal
4	Piston	17	Wear Ring
5	Dowel Pin	18	Piston Seal
6	Washer	19	Wear Ring
7	Snap Ring	20	O-ring
8	Cover	21	Backup Ring
9	Distance Sleeve	22	O-ring
10	Linear Sensor	23	Backup Ring
11	Magnetic Bushing	24	O-ring
12	Snap Ring	25	Cap Nut
13	Snap Ring		

TELESCOPE CYLINDER

Description

The telescope cylinder (Figure 2-27) is installed in the boom.

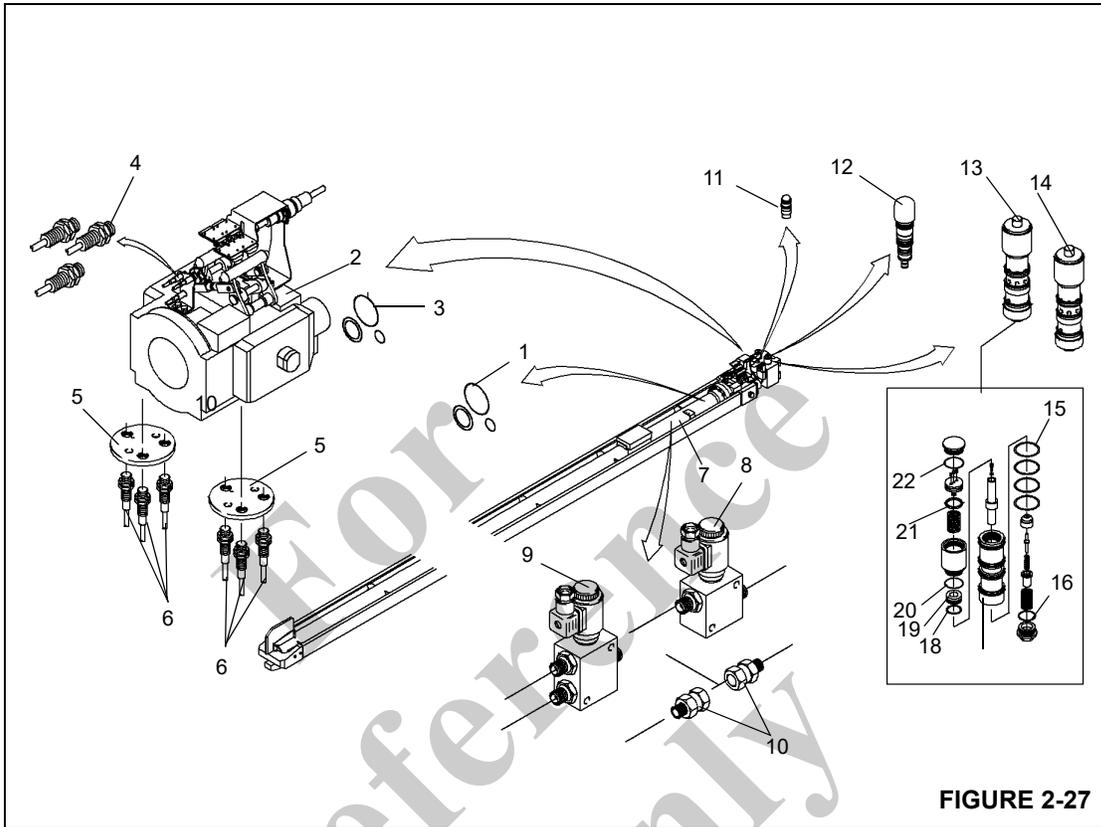


FIGURE 2-27

Item	Description	Item	Description
1	Gasket	12	Relief Valve
2	Cylinder Head	13	Stop Brake Valve
3	Gasket	14	Stop Brake Valve
4	Approximate Switch	15	O-ring
5	Control Unit	16	O-ring
6	Approximate Switch	17	Cartridge Valve
7	Piping Unit	18	O-ring
8	Valve	19	Gasket
9	Valve	20	O-ring
10	Back Pressure Valve	21	Retaining Slip Ring
11	Excess Pressure Valve	22	O-ring

PRESSURE SETTING PROCEDURES

Objective

To assist personnel in properly checking, adjusting and setting the hydraulic system pressures.

Equipment

Required pressure gauge analog or digital capable of reading 0-34.5 MPa (0-5000 psi). (1) Parker Diagnostic Quick Disconnect p/n PD240 for carrier and (1) Parker EMA gauge adapter for the superstructure.

Valve Pressure Setting Table

NOTE: Reservoir oil temperature to be approx. 120-140° F (49-60° C) to check pressures.

Set pressure to nominal value to account for tolerance of gauge.

The below values indicate what the pressure gauge must read at the pressure check ports therefore listed pressures may not match the values shown on the hydraulic schematic.

PRESSURE TO BE CHECKED	GAUGE PRESSURE PSI (bar)	TOLERANCE PSI (bar)	PROCEDURE
Pump section #1 differential pressure	475-525 (33-36)	See Range	A
Pump section #2 differential pressure.	525-575 (36-40)	See Range	A
Pilot supply pressure	600 (41)	± 50 (4)	B
Load sense (max system) pressure	4300 (296)	± 50 (4)	C
Lift down pressure	2350 (162)	± 150 (10)	C
Tele extend pressure	2900 (200)	± 100 (7)	C
Tele retract pressure	3250 (224)	± 100 (7)	C
Cab tilt lower pressure	725 (50)	± 100 (7)	D
Cab tilt raise pressure	1450 (100)	± 100 (7)	D
Counterweight lower pressure	1450 (100)	± 100 (7)	E
Counterweight raise pressure	3200 (221)	± 100 (7)	E
Swing pressure	2750 (190)	± 50 (4)	F
Outrigger beam extend pressure	750 (52)	± 50 (4)	G
Outrigger beam retract pressure	1600 (110)	± 100 (7)	G
Outrigger jack extend pressure	3000 (207)	± 50 (4)	G
Outrigger jack retract pressure	2250 (155)	± 150 (10)	G
A/C pressure	1000 (69)	± 150 (10)	H
Center front stabilizer pressure	150-300 (10-21)	See Range	I
Front steer pressure	2175 (150)	± 50 (4)	J

Service Tool Notes

Attach laptop to DIAG_1 connector in cab and make sure CAN C is selected (position 3 on CAN selector knob.)

Open the CCS Crane Service Tool. From the menu bar, select Settings->Crane Model->Auto Detect. The auto detection procedure should detect TMS->TMS9000E-1->Superstructure (C).

The current settings for each function can be found in the Crane Service Tool in the menu bar under Tools->EEPROM->View Parameters.

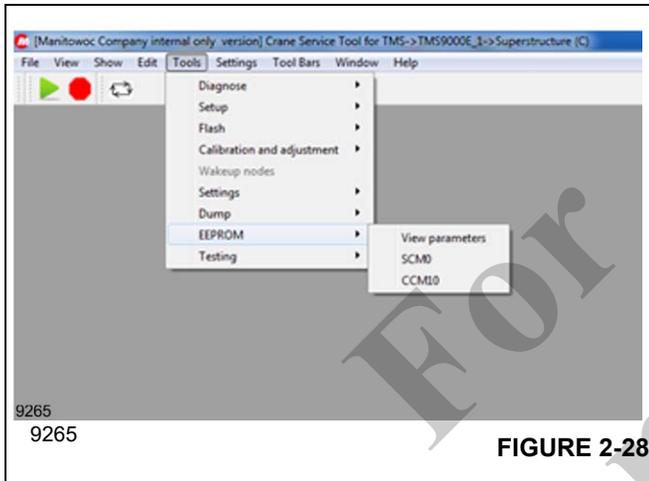
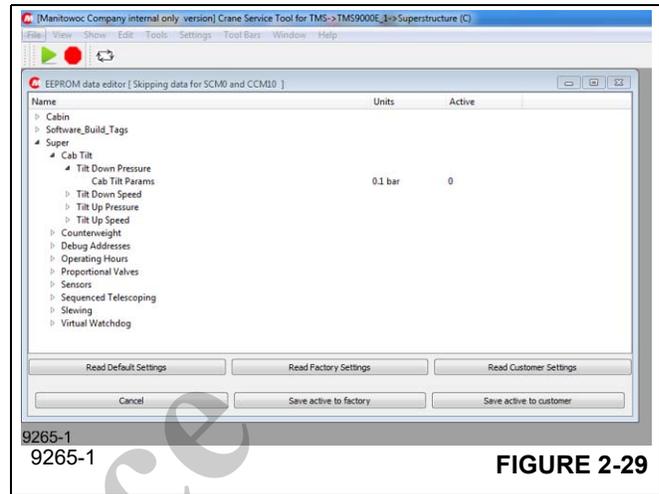


FIGURE 2-28

Next select the function which needs adjusted. Cab tilt is shown here. Main crane functions can be found under Proportional Valves and Carrier functions can be found under Cabin.



A. Procedure for Checking/Setting the Piston Pumps Cut-Off & Differential Pressures

1. With engine off, install a pressure check diagnostic quick disconnect (Parker PD240) with gauge onto the test nipple at GP gauge port on Main Directional Valve (MDV) (Figure 2-13).

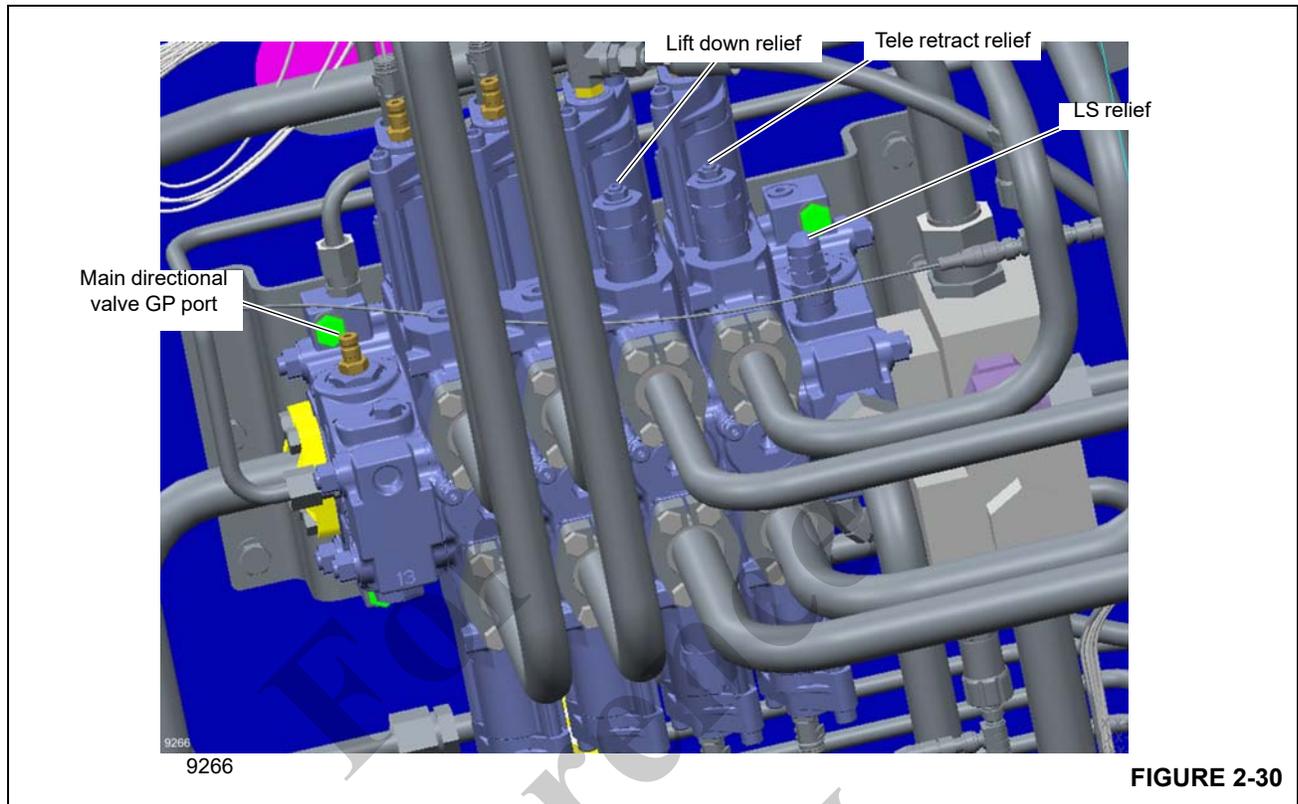


FIGURE 2-30

2. Adjust the differential pressure adjustment screw (see Figure 2-14) on pump #2 out "CCW" 2 to 3 turns.
3. Start engine and idle. Gauge port GP should read 475-525 PSI (33-36 bar). If it does not adjust the differential pressure adjustment screw. See (Figure 2-14) on pump #1 "in" to increase or "out" to decrease so that a gauge reading is achieved.
4. With the engine still at idle. Adjust the differential pressure adjustment screw. See (Figure 2-14) on pump #2 "in" to increase the pressure until the gauge reads 525-575 PSI (36-40 bar).

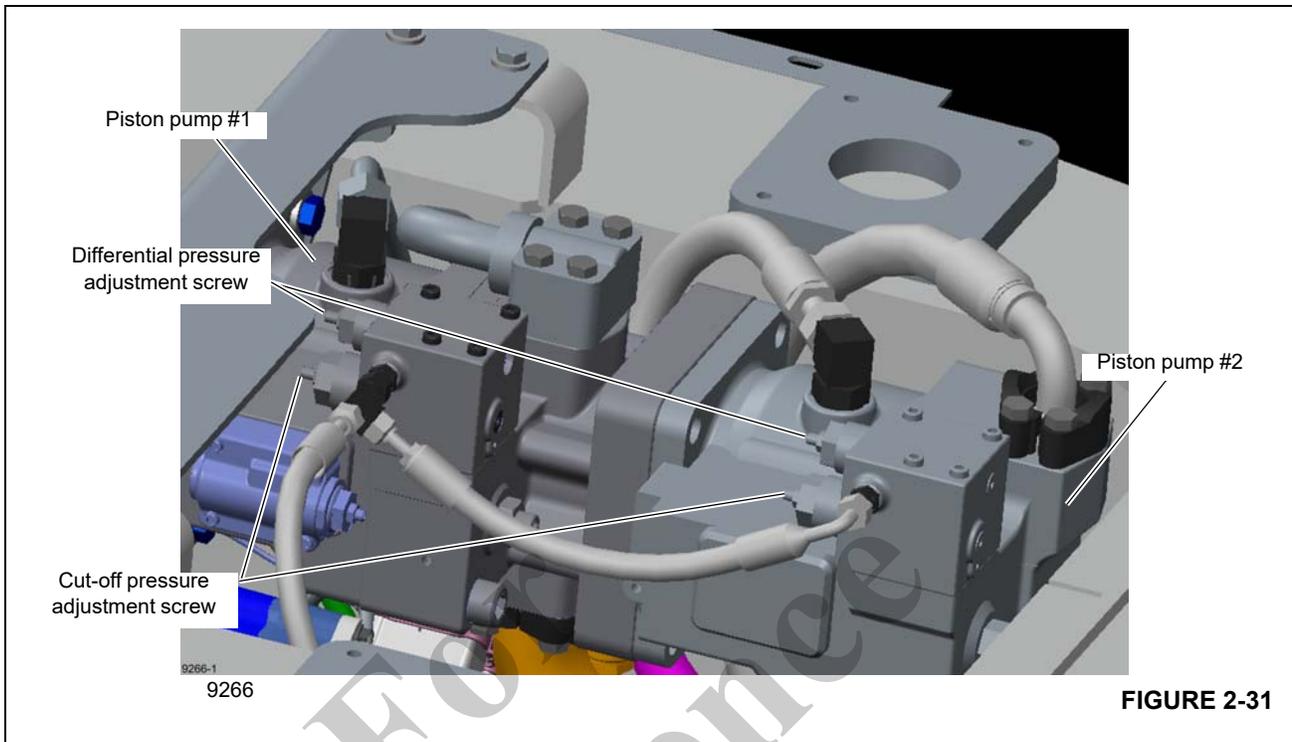


FIGURE 2-31

5. Stop engine and remove the diagnostic coupler.
6. Assure the piston pump “cut-off” max setting is correct. Loosen the jam nut on the cut-off pressure adjusting screw. See (Figure 2-14) and turn it “in” until it softly seats or bottoms out. Then back the adjusting screw “out” ½ turn and lock in place with the jam nut. Perform this step on both pumps.

B. Procedure for Checking/Setting the Pilot Supply Pressure

1. With the engine off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test

the nipple at GPPS port of the Accessory manifold. See (Figure 2-15).

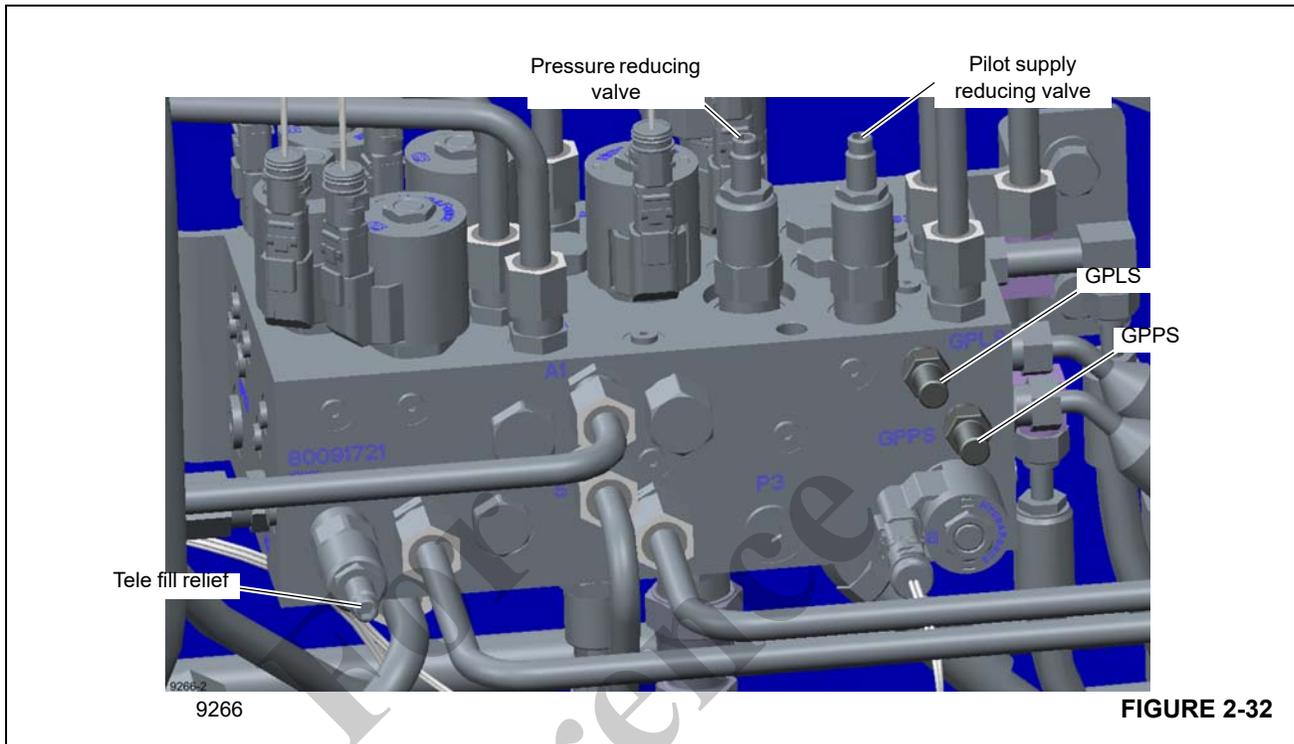


FIGURE 2-32

2. If the lift cylinder is not installed, plug the lift hoses. If the cylinder is installed, omit this step.
3. Start engine and idle.
4. Feather into lift up or down and hold. (If the cylinder is fully stroked in either direction the RCL over-ride switch will need to be active to assure that the pilot supply will not be cut off before the cylinder can be dead headed) The reading at GPPS should be 600 ± 50 PSI (41 ± 4 bar) if it is not adjust the pilot supply pressure reducing valve. See (Figure 2-15) "in" to increase or "out" to decrease until the reading is achieved.
5. Stop engine. Remove diagnostic couplers.

C. Procedure for Checking/Setting the Main Directional Control Valve, Load Sense, Lift and Telescope Pressures

Load Sense Relief (Max System Pressure)

1. With the engine off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto the test nipple at GP gauge port on Main Directional Valve (MDV). See (Figure 2-13).
2. If the lift cylinder is not attached assure the hoses are capped and move to Step 3.
3. The RCL override switch will need to be activated to do lift up and lift down functions if the hoses are attached to

the cylinder in order to assure that cylinder can reach full stroke in either direction. Make sure the machine is parked on a firm level surface, the park brake is set, the boom is fully retracted and positioned over the side away from the cab or engine cover.

4. **Lift Up:** Start engine and idle. Feather into the lift up function until full cylinder stroke is achieved and hold. Slowly accelerate the engine to full RPM. The reading at GP should be 4300 ± 50 PSI (296 ± 4 bar) if it is not adjust the LS relief (see Figure 2-13) "in" to increase or "out" to decrease until the reading is achieved.

NOTE: If the pressure can not be achieved assure the piston pump "cut-off" max setting is correct by loosening the jam nut on the cut-off pressure adjusting screw (see Figure 2-14) and turn it "in" until it softly seats or bottoms out. Then back the adjusting screw "out" $\frac{1}{2}$ turn and lock in place with the jam nut. Perform this step on both pumps. Then repeat Step 4.

Lift Down Relief Pressures

1. With the engine off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test the nipple at GPLS port of the Accessory manifold. See (Figure 2-15).
2. If the lift cylinder is not attached assure the hoses are capped and move to Step 3.

3. The RCL override switch will need to be activated to do lift up and lift down functions if the hoses are attached to the cylinder in order to assure that cylinder can reach full stroke in either direction. Make sure the machine is parked on a firm level surface, the park brake is set, the boom is fully retracted and positioned over the side away from the cab or engine cover.
4. **Lift Down:** Start engine and idle. Feather into the lift down function until full cylinder stroke is achieved and hold. Slowly accelerate the engine to full RPM. The reading at GPLS should be 2350 ± 150 PSI (162 ± 10 bar) this pressure is non-adjustable.
5. Turn the RCL override switch to it's normal position. Stop engine. Remove diagnostic couplers.

Tele Extend and Retract Relief Pressures

1. With the engine off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test the nipple at GPLS port of the Accessory manifold. See (Figure 2-15).
2. Start the engine and navigate to the boom recovery pinning screens. See (Figure 2-33, Figure 2-34 & Figure 2-35).
3. Navigate to the Lower display menu screen and select the Emergency Mode icon.
4. Use the "jog dial" and change the word "GELP" to "HELP" and then select the check box.

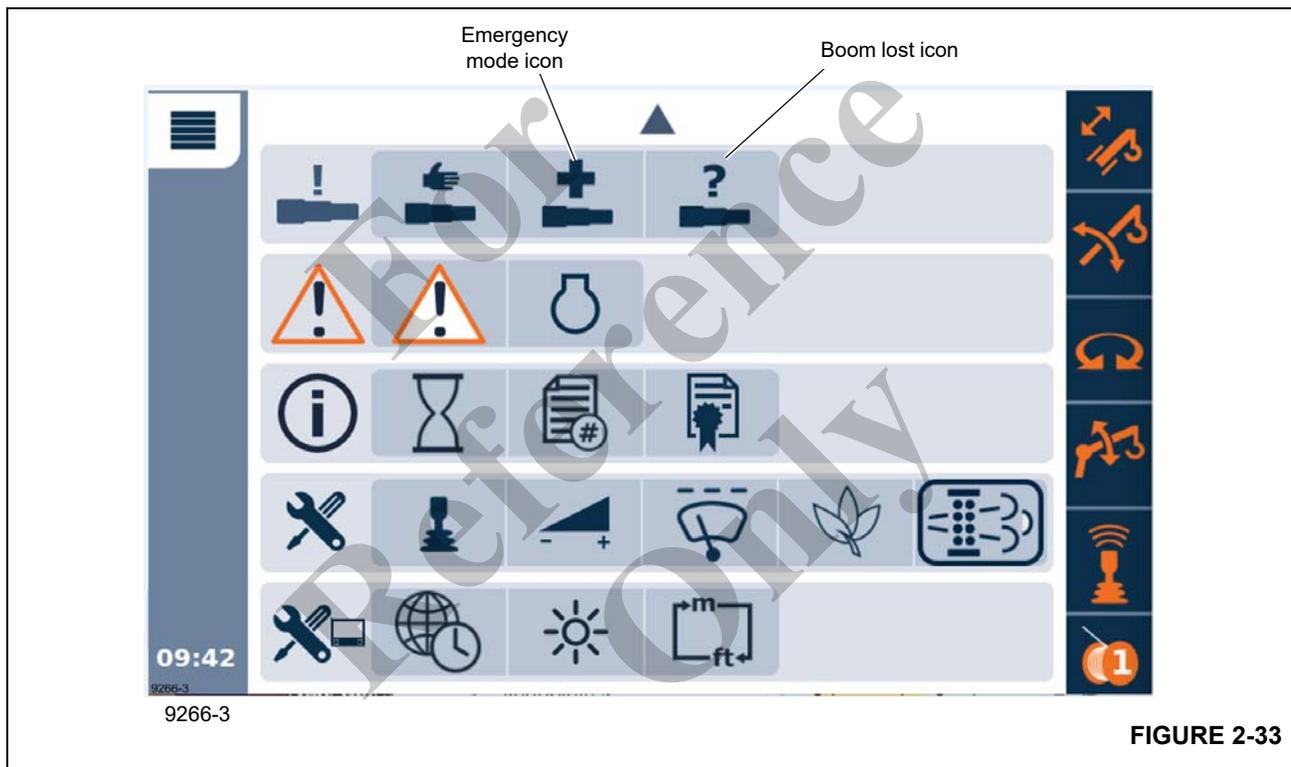


FIGURE 2-33

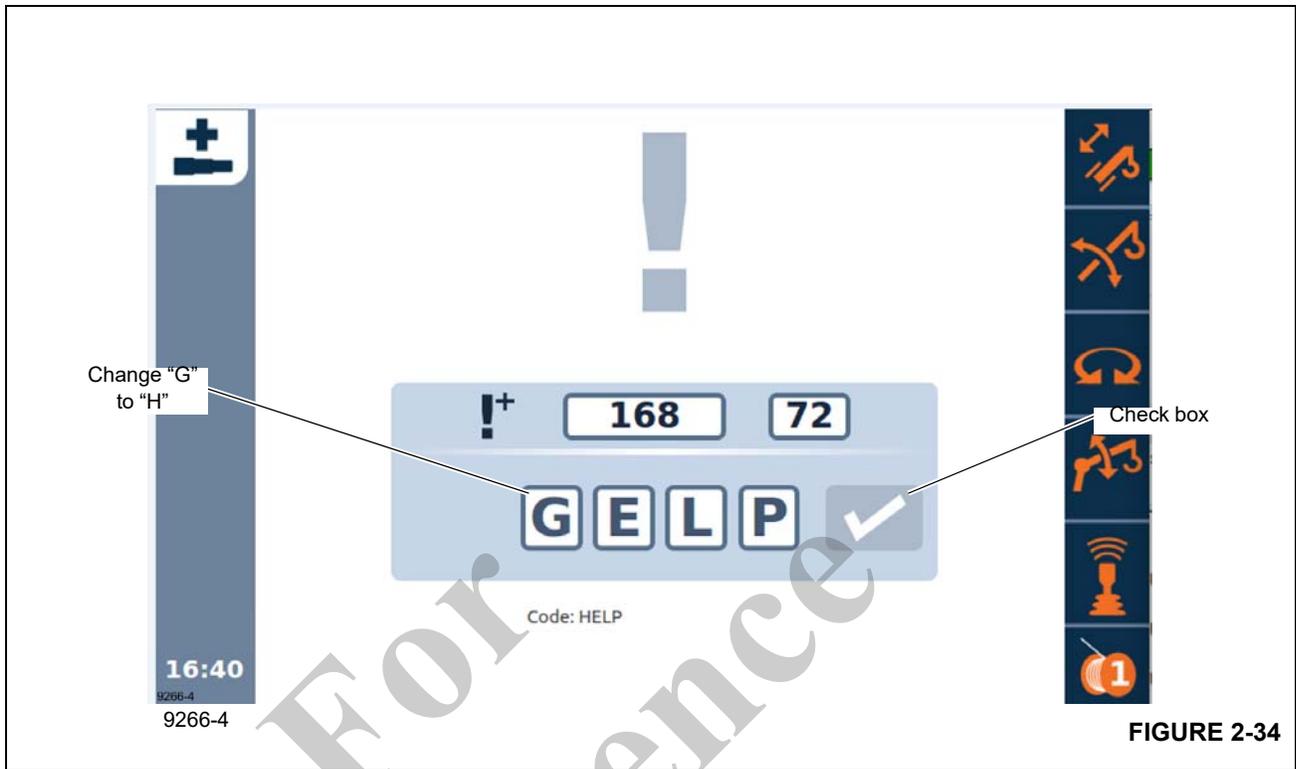


FIGURE 2-34

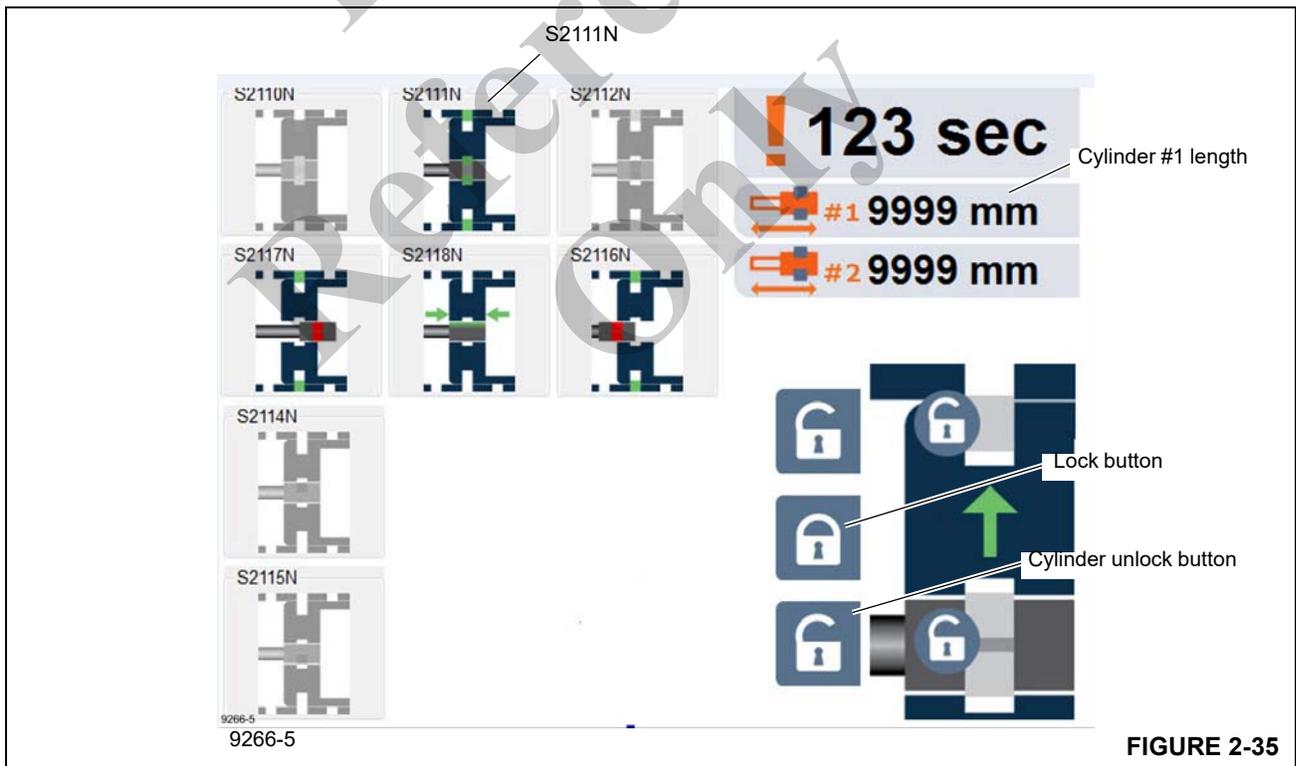
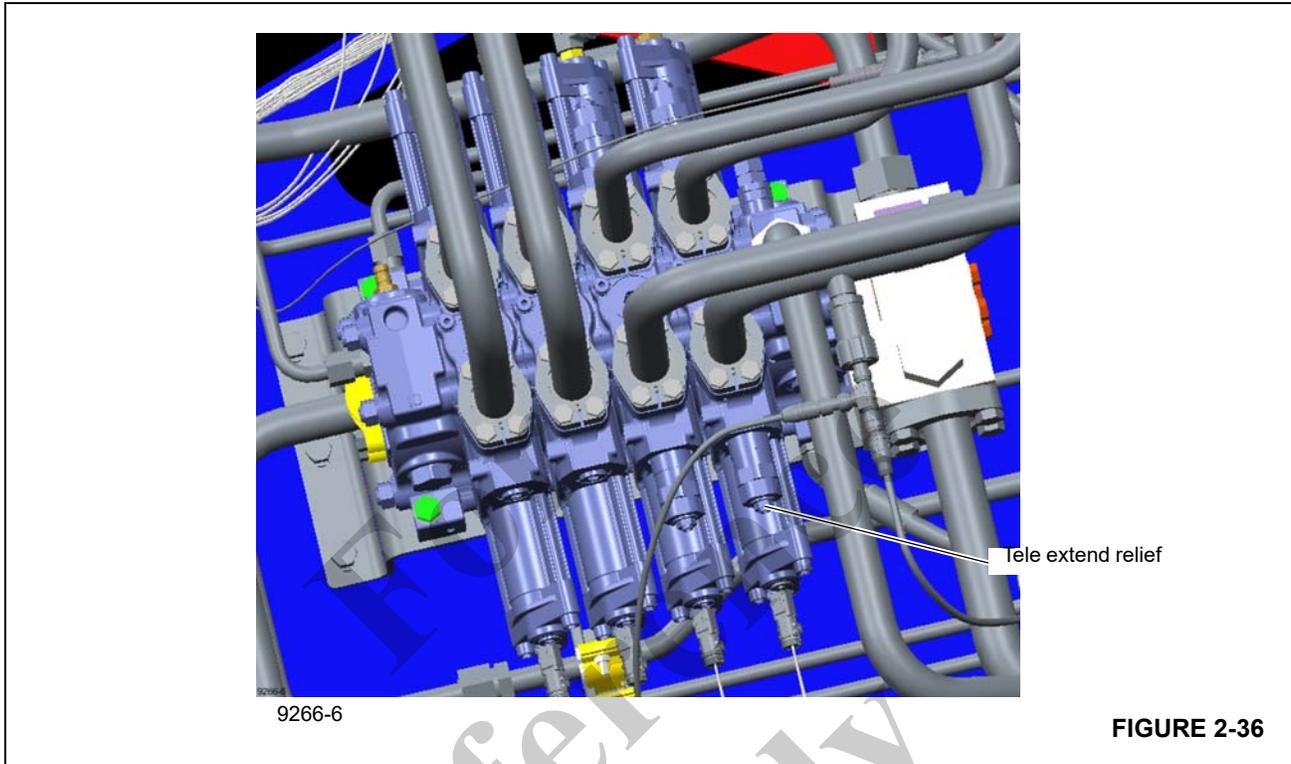


FIGURE 2-35

5. Make sure cylinder #1 is at 0 mm.
 - a. If it is not, unlock the cylinder using the cylinder unlock button and the jog dial selector.
 - b. Use the joystick and retract cylinder #1 until the length reads 0 mm.
6. Make sure that S2111N is green.

- a. If it is not, use lock button and the jog dial to lock the boom and verify that S2111N is green.
7. **Tele Extend:** Feather into the tele extend function until the cylinder is dead headed and hold. Slowly accelerate

the engine to full RPM. The reading at GPLS should be 2900 ± 100 PSI (200 ± 7 bar) if it is not adjust the Tele extend relief (Figure 2-18) "in" to increase or "out" to decrease until the reading is achieved.

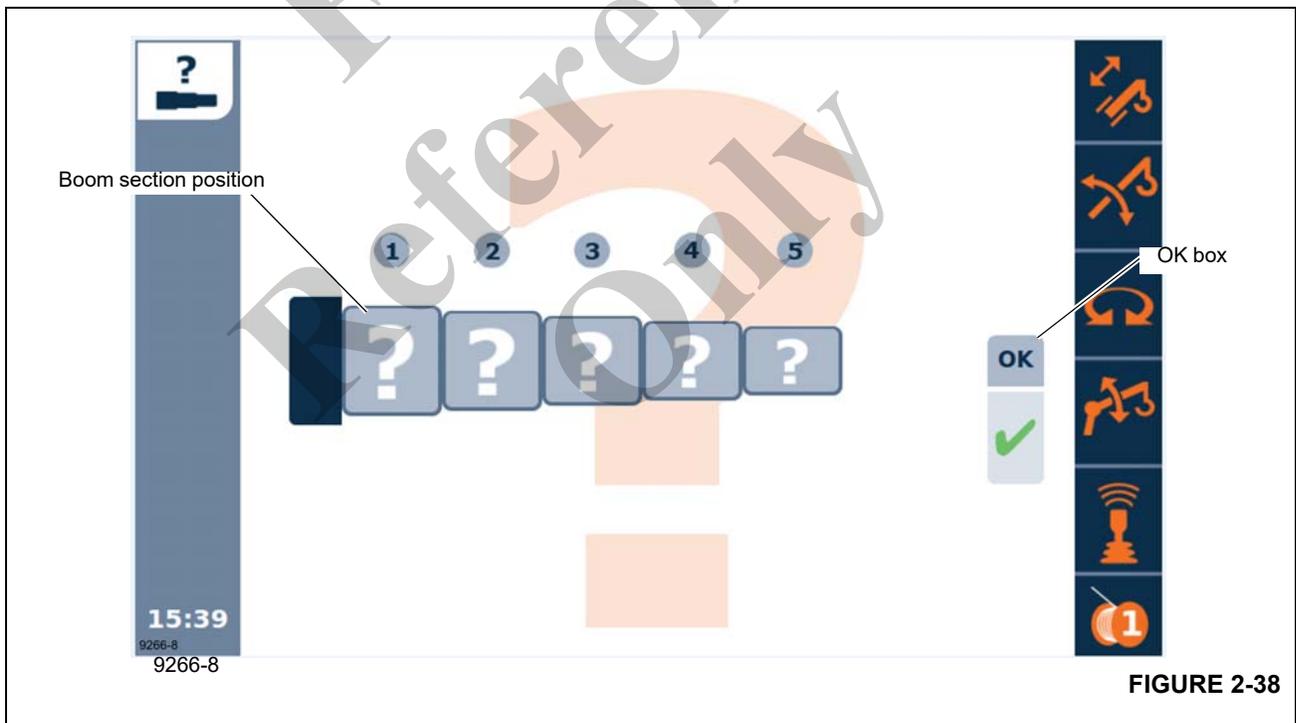
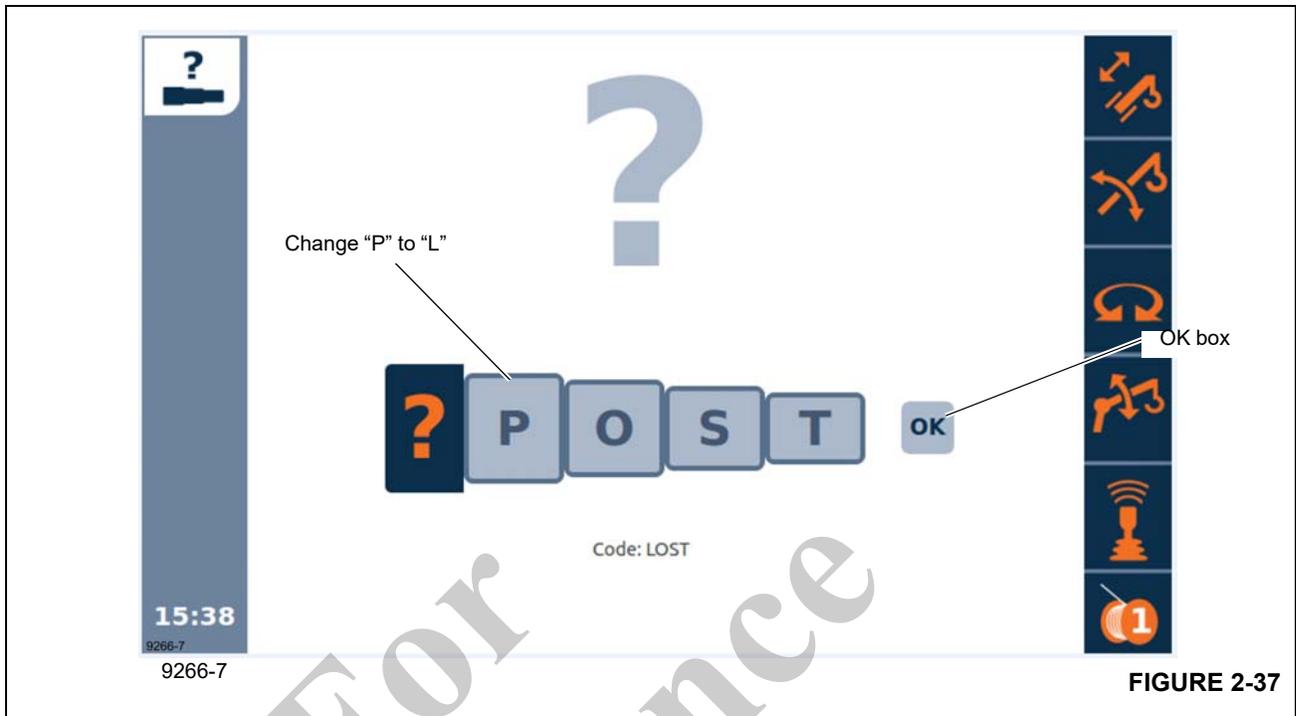


8. **Tele Retract:** Feather into the tele retract function until the cylinder is dead headed and hold. Slowly accelerate the engine to full RPM. The reading at GPLS should be 3250 ± 100 PSI (224 ± 7 bar) if it is not adjust the Tele retract relief (Figure 2-13) "in" to increase or "out" to decrease until the reading is achieved.

9. Make sure that cylinder is fully retracted, length reads 0 mm.

10. Return the boom pinning to it's normal state. See (Figure 2-33, Figure 2-37 & Figure 2-38).

Navigate to the Lower display menu screen and select the Boom lost icon. See (Figure 2-33).



Use the "jog dial" and change the word "POST" to "LOST" and then select the "OK" box.

NOTE: If the boom is not fully retracted enter appropriate pinning position for each section.

Navigate to each boom section and enter 0 for the pinning position.

Select the "OK" button

11. Stop engine. Remove diagnostic couplers.

D. Procedure for Checking/Setting Cab Tilt Raise and Lower Pressures

With the engine off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at GPLS port of the Accessory manifold (Figure 2-15).

12. Cab Tilt Lower: Start engine and idle. Activate the cab lower function until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at GPLS should be 725 ± 100 PSI (50 ± 7 bar) if it is not use the service tool as follows to adjust.

- In the Tools->EEprom->View Parameters->Super->Cab Tilt->Tilt Down Pressure params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjust by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusting by more than 100 mA there may be other issues in the circuit.
- Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"

13. Cab Tilt Raise: Start engine and idle. Activate the cab raise function until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at GPLS should be 1450 ± 100 PSI (100 ± 7 bar) if it is not use the service tool as follows to adjust.

- In the Tools->EEprom->View Parameters->Super->Cab Tilt->Tilt Up Pressure params row increase

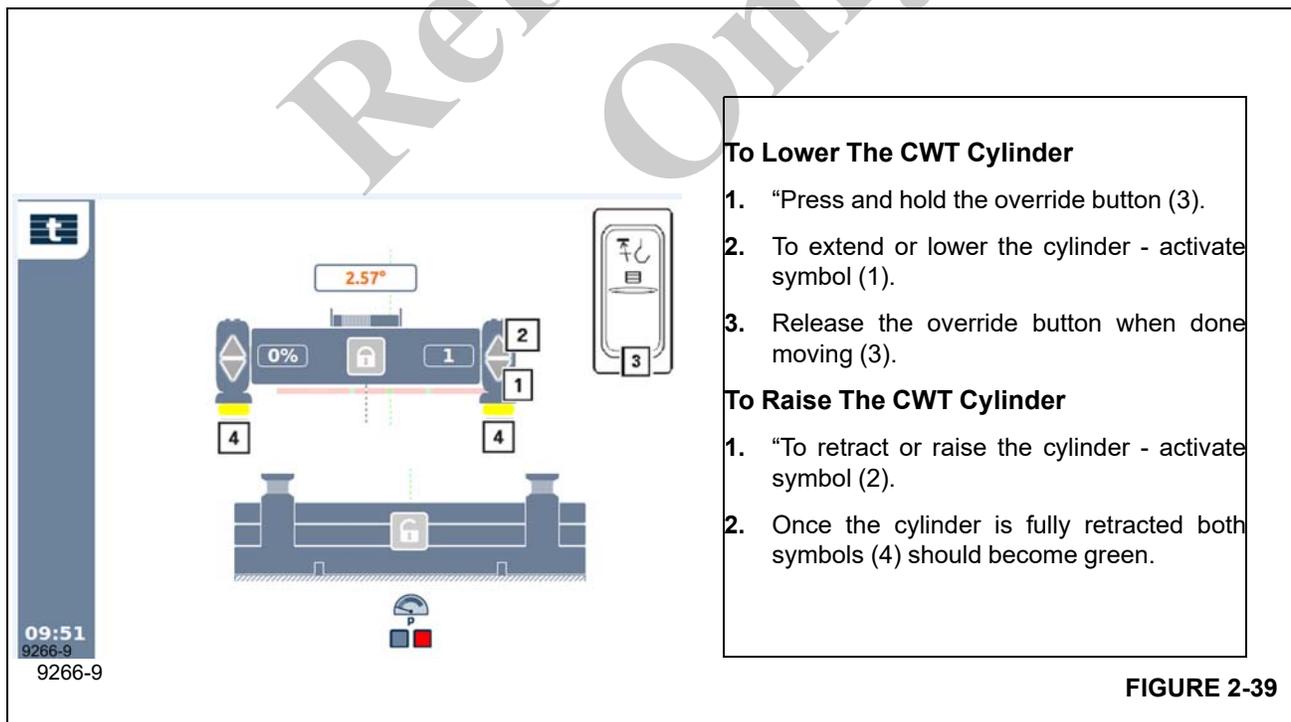
the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may other issues in the circuit.

- Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"

14. Stop engine. Remove diagnostic couplers.

E. Procedure for Checking/Setting Counterweight (CWT) Raise and Lower Pressures

- With the engine off, install pressure check diagnostic quick disconnect (Parker PD240) with gauge onto test nipple at GPLS port of the Accessory manifold (Figure 2-15).
- Assure that the CWT is not attached to the cylinders and the superstructure is in a position that the cylinders can be fully actuated in both directions.
- CWT Lower:** Start engine and idle. Activate the CWT lower function (Figure 2-39) until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at GPLS should be 1450 ± 100 PSI (100 ± 7 bar) if it is not use the service tool as follows to adjust.



- a. In the Tools->EEPROM->View Parameters->Super->Counterweight->Lower Pressure params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may be other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
4. **CWT Raise:** Start engine and idle. Activate the CWT raise function (Figure 2-39) until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at GPLS should be 3200 ± 100 PSI (221 ± 7 bar) if it is not use the service tool as follows to adjust.
- a. In the Tools->EEPROM->View Parameters->Super->Counterweight->Raise Pressure params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may be other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
5. Stop engine. Remove diagnostic couplers.

F. Procedure for Checking/Setting Swing Pressure

1. With the engine off, install a pressure check diagnostic coupler (Parker PD240) with gauge onto the diagnostic

nipple at the MP port of the swing control valve (see Figure 2-40).

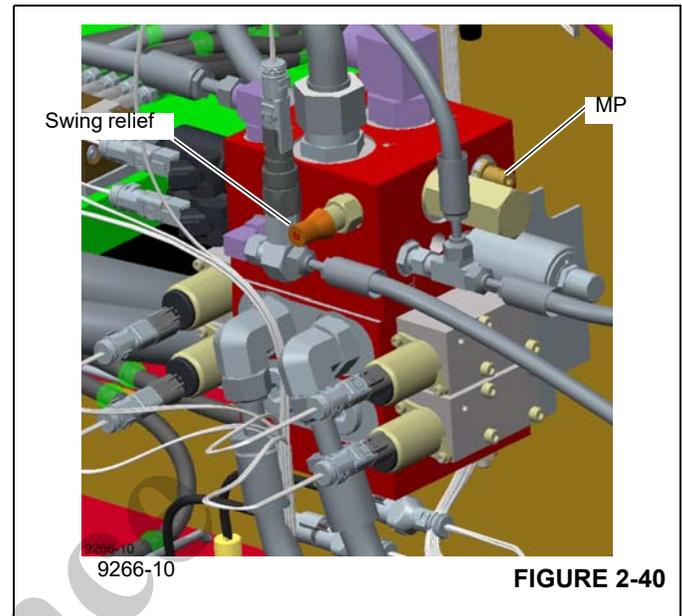


FIGURE 2-40

2. Start engine and idle. Depress and hold the swing brake pedal. Feather into the swing function (left or right) until full controller stroke is reached and hold. Slowly accelerate the engine to full RPM. The reading at MP should be 2750 ± 50 PSI (190 ± 4 bar) if it is not adjust the swing relief (Figure 2-40) "in" to increase or "out" to decrease until the reading is achieved.
3. Move controller to center position before disengaging the swing pedal.
4. Stop engine. Remove the diagnostic coupler.

G. Procedure for Checking/Setting Outtrigger Pressure

1. With the engine off, install a pressure check diagnostic coupler (Parker PD240) with gauge onto the diagnostic

nipple at the G2 port of the outrigger selector/ A/C manifold (Figure 2-41).

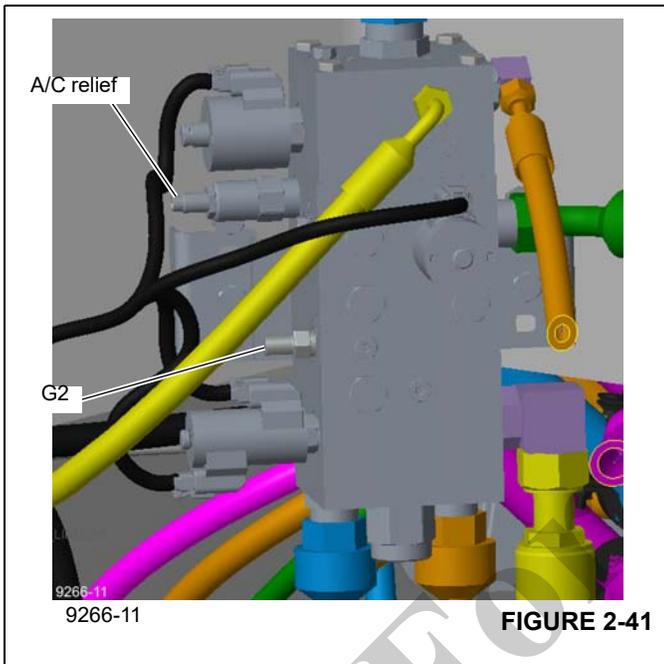


FIGURE 2-41

2. **Outrigger Beam Extend:** Start engine and idle. Ensure that the outrigger beams can be fully extended safely. Extend any outrigger beam until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 750 ± 50 PSI (52 ± 4 bar) if it is not use the service tool as follows to adjust
 - a. In the Tools->EEprom->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Beams Extend Target params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
3. **Outrigger Beam Retract:** Start engine and idle. Retract any outrigger beam until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 1600 ± 100 PSI (110 ± 7 bar) if it is not use the service tool as follows to adjust
 - a. In the Tools->EEprom->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Beams Retract Target params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
4. **Outrigger Jack Extend Pressure:** Start engine and idle. Extend any outrigger jack until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 3000 ± 50 PSI (207 ± 4 bar) if it is not use the service tool as follows to adjust.
 - a. In the Tools->EEprom->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Jacks Extend Target params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may be other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
5. **Outrigger Jack Retract Pressure:** Start engine and idle. Retract any outrigger jack until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 2250 ± 150 PSI (155 ± 10 bar) if it is not use the service tool as follows to adjust.
 - a. In the Tools->EEprom->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Jacks Retract Target params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
6. Stop engine. Remove diagnostic couplers.

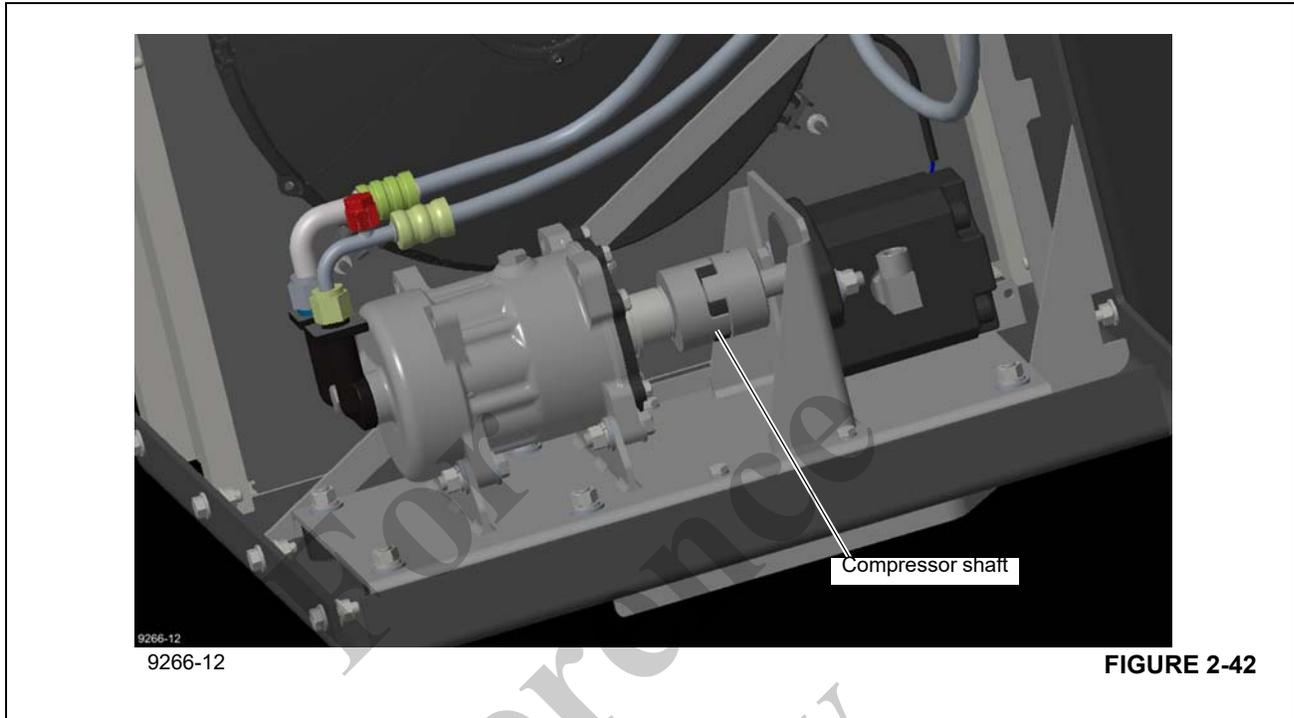
H. Procedure for Checking/Setting Air Conditioning Pressure

1. With the engine off, install a pressure check diagnostic coupler (Parker PD240) with gauge onto the diagnostic

nipple at the G2 port of the outrigger selector/ A/C manifold (Figure 2-41).

2. Start engine and idle. Turn on the A/C, listen to ensure that the compressor motor is running or verify by

removing the cover (Figure 2-42) and looking at the shaft. The reading at G2 should be 1000 ± 150 PSI (69 ± 10 bar) if it is not use the service tool as follows to adjust.



- a. In the Tools->EEprom->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol AC Only Target params row increase the value to increase the pressure or decrease the value to decrease the pressure (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may other issues in the circuit.
 - b. Once the pressure is achieved make sure to "Save active to customer" and "Save active to factory"
3. If the pressure is correct and the AC is still not working correctly remove the cover and check the shaft speed (Figure 2-42) with a photo tach. The shaft speed should be 1800 to 2000 rpm when the unit is running. If the shaft is not in this range use the service tool as follows to adjust.

NOTE: While doing this step the gauge from Step 2 should also be installed and if the pressure gets out of the

acceptable range Step 2 will need to be repeated once the RPMs are increased.

- a. In the Tools->EEprom->View Parameters->Cabin->Solenoid PWM Control (carrier)->Flow Sol A/C Target params row increase the value to increase the flow or decrease the value to decrease the flow (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings". Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA there may be other issues in the circuit.
 - b. Once the flow and pressure are achieved make sure to "Save active to customer" and "Save active to factory"
4. Stop engine. Remove diagnostic couplers.

I. Procedure for Checking/Setting the Center Front Stabilizer Pressure

1. With the engine off, install a pressure check diagnostic coupler (Parker PD240) with gauge onto the diagnostic

nipple at the GP port of the outrigger 5 stack valve (Figure 2-43).

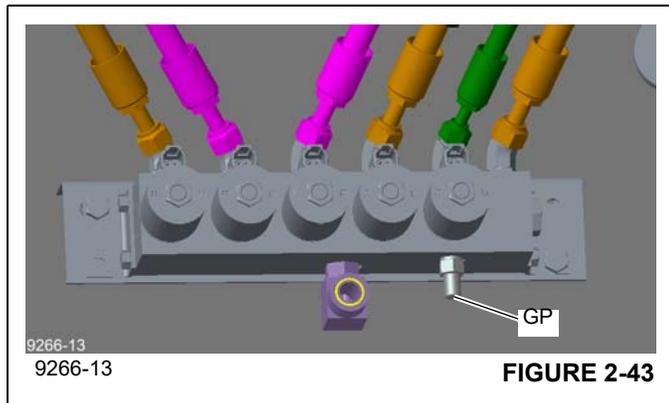


FIGURE 2-43

2. Extend the center front stabilizer to the ground and hold switch. The gauge should read 150-300 PSI (10-21 bar). If it does not, contact your distributor or Manitowoc Crane Care for assistance as this pressure is not adjustable.
3. Stop engine. Remove diagnostic couplers.

J. Procedure for Checking/Setting the Front Steer Pressure.

1. With the engine off, install a pressure check diagnostic coupler (Parker PD240) with gauge onto the diagnostic nipple at the GP port of the power steering gear box. (Figure 2-44).

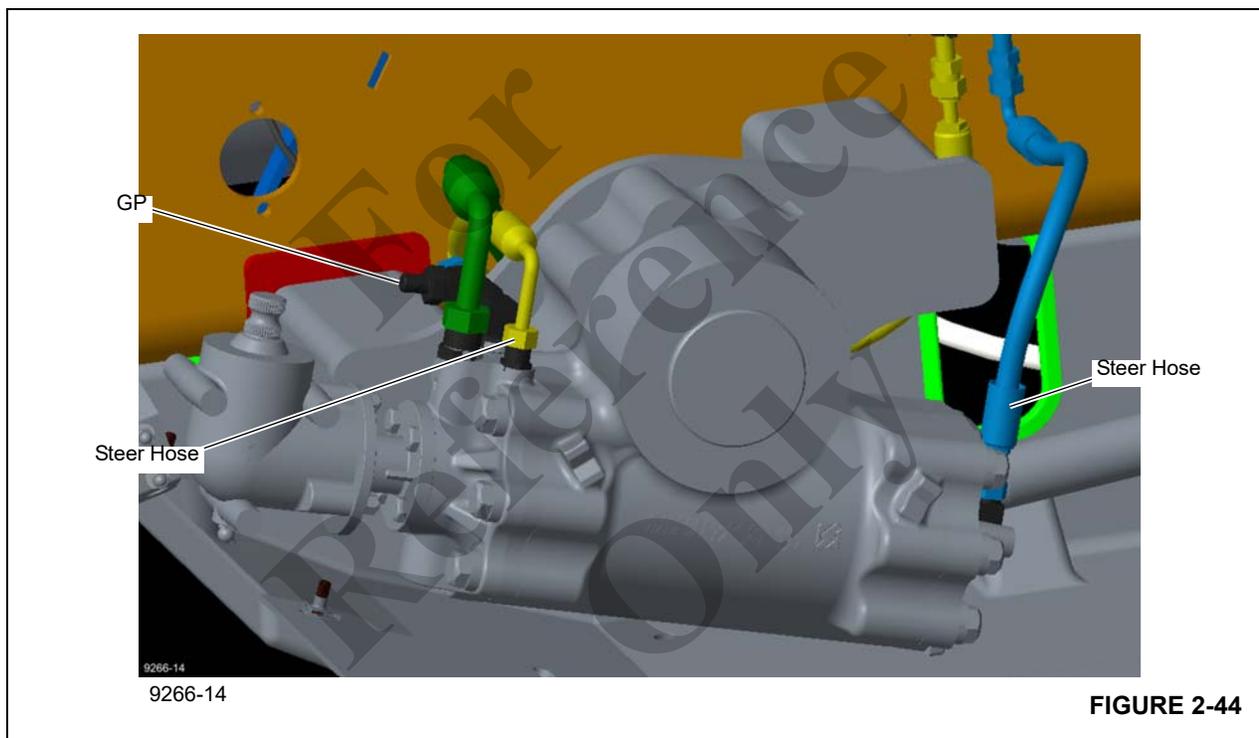


FIGURE 2-44

2. Disconnect and plug one steer hose and cap the fitting. (Figure 2-44).
3. Start engine and throttle up to full RPM. Fully turn the steering wheel to the left or right. The reading at GP

should be 2175 ± 50 PSI (150 ± 4 bar) if it is not adjust the steering relief (Figure 2-45) "in" to increase or "out" to decrease until the reading is achieved.

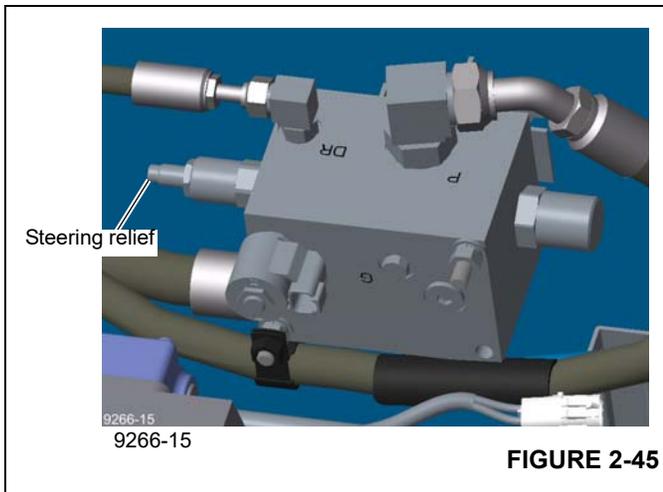


FIGURE 2-45

4. Stop engine. Remove diagnostic couplers.

K. Procedure for Adjusting Electronic Controllers (Meter-in Dead Band and/or Max Function Speeds)

All controller E-prom settings should be set to factory defaults specific to the crane model. This procedure should only be used if there is an issue with the crane controller functions and the following have been tried.

- All function pressure are set correctly per this procedure
- Operator has tried adjusting the function speed thru the CCS control screens
- Operator has tried adjusting the function control thru the CCS control screen selectable curves

Follow the steps listed below for any function which the operator feels the meter-in dead band in the controller is either too fast or slow, or if the max function speed is verified to be slower or faster than designed (see flows show on system schematic).

For meter-in too fast – lower Imin setting

For meter-in too slow – raise Imin setting

For low function flow– raise Imax setting (DO NOT EXCEED 1500 mA)

For high function flow – lower Imax setting

1. Follow the service tool notes then do the following.
2. Current range settings for each function can be found in the Crane Service Tool in the menu bar under Tools->EEprom->View Parameters->Super->Proportional Valves->Proportional Valve Params->Main Hoist Up Valve Params. An example is shown for Main Hoist Up.

Reference Only

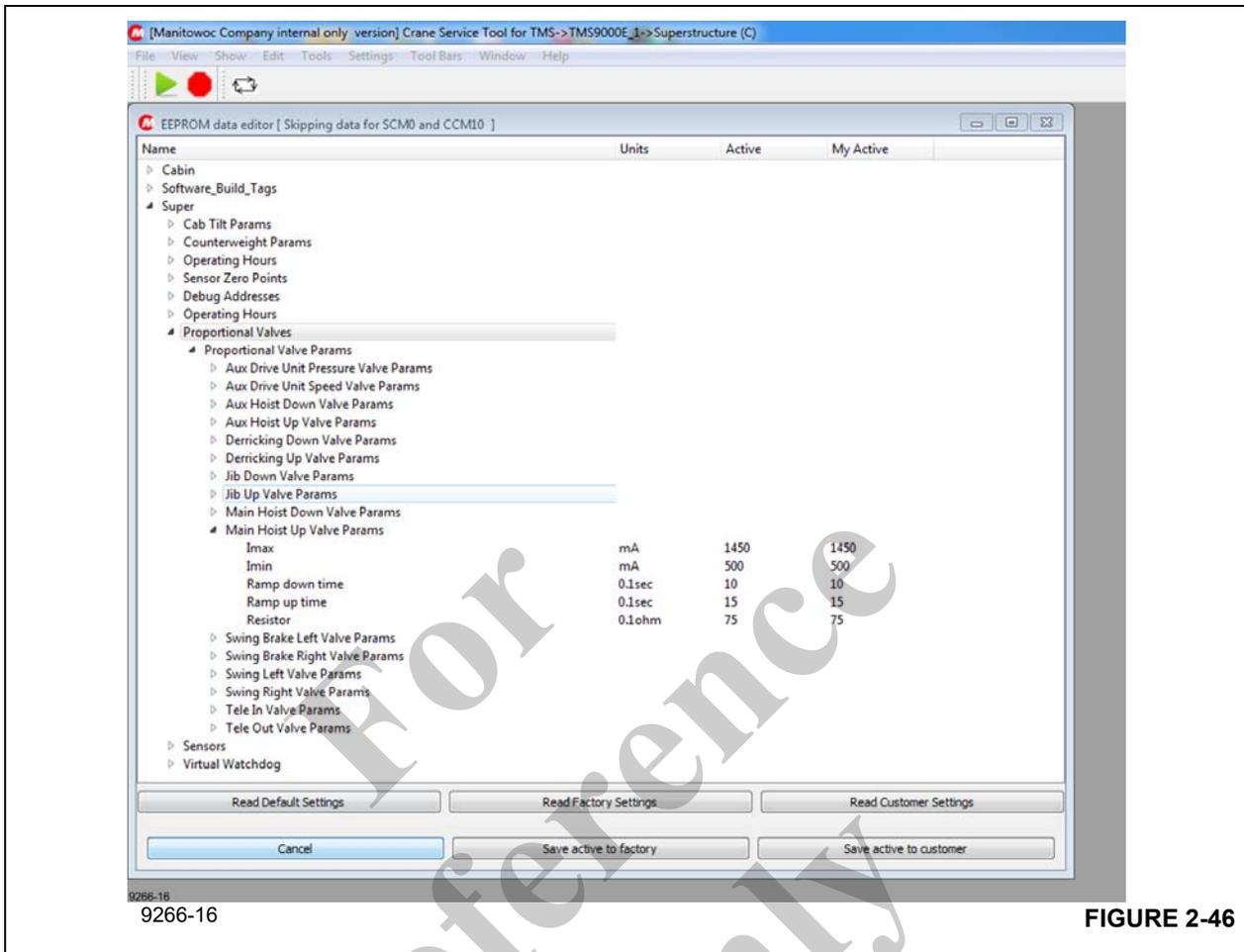


FIGURE 2-46

- Adjust the I-min or I-max per the information above (adjustment by 10 mA increments is suggested). Make sure to write column to "active settings".
 - Try function again. If it is now satisfactory continue to step 4 if not repeat step 3 until the results are satisfactory or until you have adjust by 100 mA. Adjustment of 100 mA in either direction is considered excessive and may indicate checks/trouble shooting may be needed in other components.
 - After setting all of the functions, save the EE configuration to the controller's Factory and Customer settings area. This is done by selecting Tools->Calibration and Adjustment->EEPROM and pressing the Save active to Customer and Save active to Factory buttons.
 - Next save the configuration to a file by right clicking on the 'Active' column and Write->Write column to file from the context menu. Save the file in a folder under the model designation (GRT8100). Name the file as follows: (Sales order number Date). Sample: (700287_2015june25).
- Contact Crane Care concerning any calibration requests that may involve the following, but are not limited to:
- Pedals
 - OMS
 - Level Sensors
 - RCL
 - Transducers
 - Real Time Clock (RTC)
 - Counterweight Cylinder Length
 - Ride Height

SECTION 3 ELECTRICAL SYSTEM

SECTION CONTENTS

<p>Description 3-1</p> <p>Carrier 3-1</p> <p>Maintenance 3-9</p> <p>General 3-9</p> <p>General Troubleshooting 3-9</p> <p>Tools for Troubleshooting 3-9</p> <p>Troubleshooting Engine Starting Problems 3-9</p> <p>Troubleshooting Engine Charging Problems ... 3-10</p> <p>Troubleshooting Slip Ring-Caused Electrical Problems 3-10</p> <p>Connector Troubleshooting 3-11</p> <p>Di-Electrical Grease Application 3-12</p> <p>Troubleshooting Lights 3-13</p> <p>Troubleshooting Gauges and Meters 3-13</p> <p>Troubleshooting Alarms, Indicators, and Emergency Components 3-14</p> <p>Troubleshooting the Crane Control System (CCS)..... 3-14</p> <p>ODM Error Code Viewer 3-14</p>	<p>Troubleshooting Crane Components and Accessories 3-15</p> <p>Alternator Replacement 3-15</p> <p>Starter Replacement 3-15</p> <p>Battery Replacement 3-16</p> <p>Relay Panel Component Replacement 3-18</p> <p>Instrument Replacement 3-18</p> <p>Switch Replacement 3-18</p> <p>Rocker Switch 3-18</p> <p>All Other Switches 3-19</p> <p>Windshield Wiper Assembly Replacement 3-19</p> <p>Windshield Washer Assembly Replacement ... 3-21</p> <p>Remote Controller (Optional) 3-22</p> <p>Receiver 3-22</p> <p>Battery Charger 3-22</p> <p>Remote Controller Battery 3-23</p> <p>Jump Starting the Crane 3-23</p> <p>Charging 3-23</p>
--	---

3

DESCRIPTION

Carrier

General

The electrical system is 24-volt operation with 24-volt starting, consisting of a 24-volt alternator and four 12-volt lead-acid batteries.

Electrical power is transferred to and from the carrier and superstructure through the electrical slip ring assembly.

Alternator

A 140 ampere 24 volt 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 right front side of the carrier next to the access ladder. 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 six 100 amp fuses. The fuses protect some electrical circuits except the starter circuit.

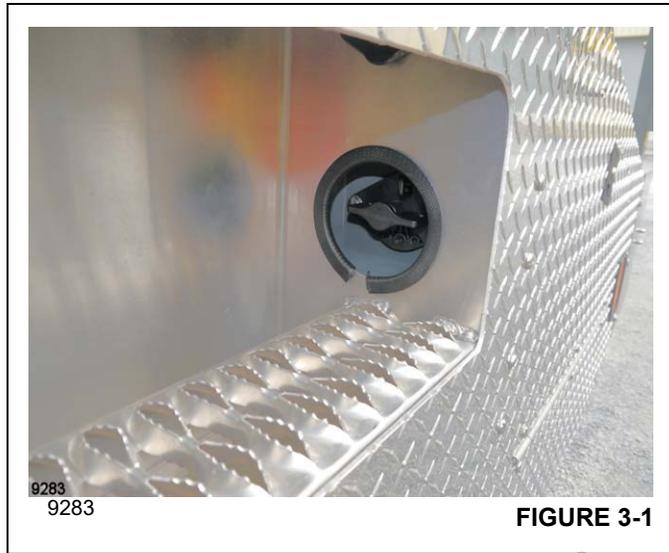


FIGURE 3-1

Carrier Power Panel

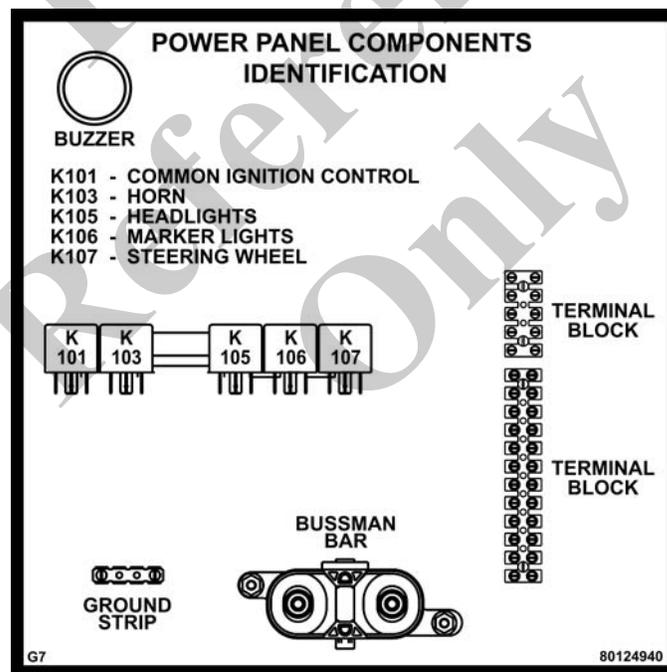
The carrier power panel (Figure 3-3) contains 5 relays and a buzzer. Refer to Power Panel and Power Panel Decal illustrations.

Relays

The carrier has 5 relays which control many of its functions. The relays are located on the power panel in the carrier cab. When any relay coil is energized, its contacts either open or close. This allows power to go to or be removed from the related circuits. For any relay coil to energize, the battery must be connected.

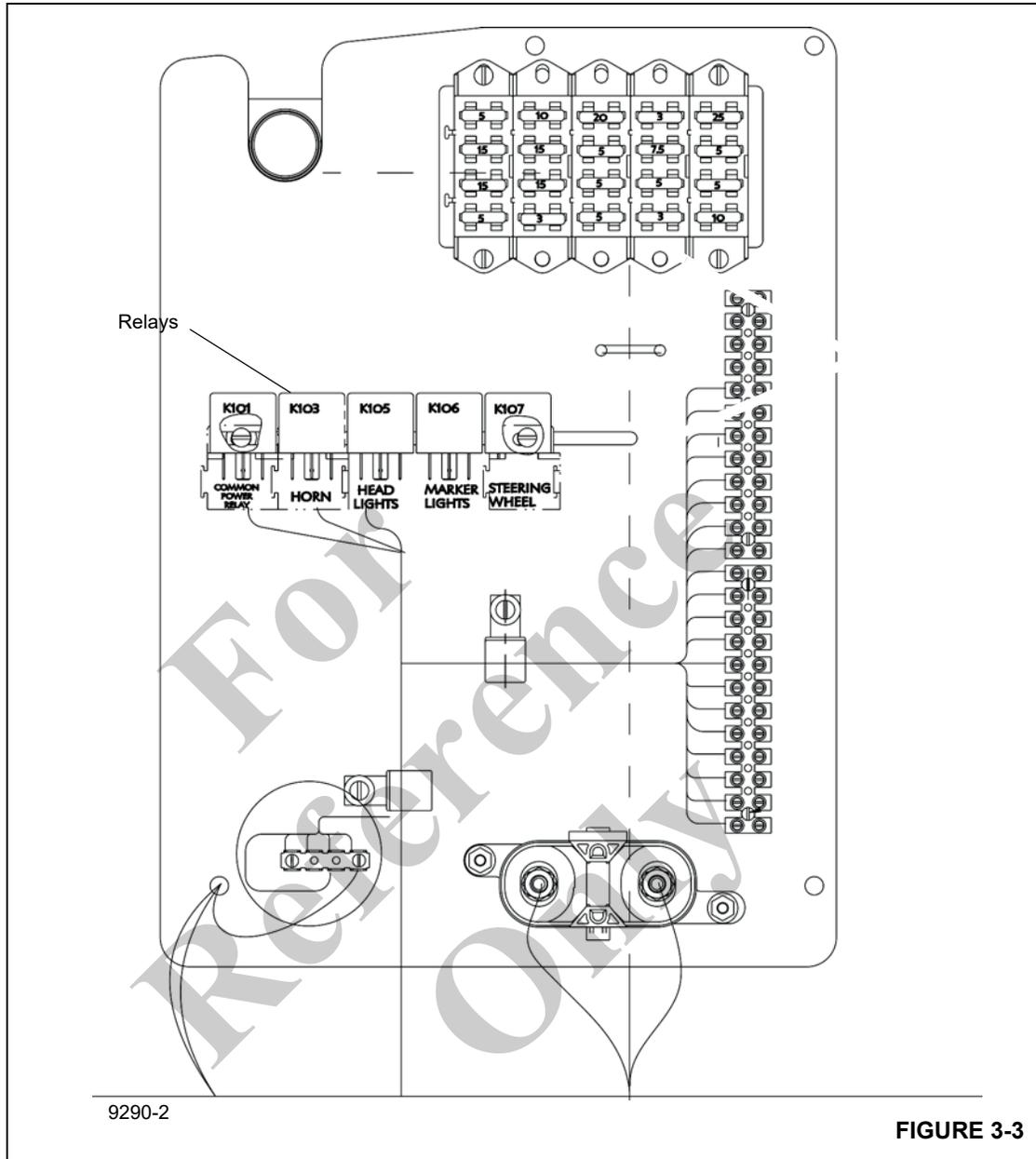
Carrier Power Panel and Fuse Panels

Most carrier electrical circuits are protected by the fuse panels located under the dash in the carrier cab. Access is gained by removing the covers.



9279-2

FIGURE 3-2

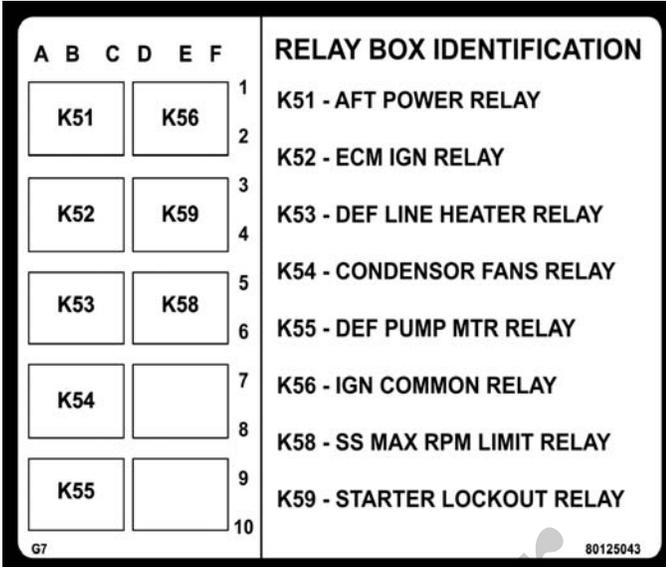


The coils of the accessory relay (K101) and charge air cooler relay (K103) is energized when the ignition switch is at the RUN (1) or ACC (3) position. The coil of the headlights on relay (K105) is energized when the headlights on switch contacts are closed. The coil of horn relay (K103) is energized when the horn button is depressed. The coil of the marker lights relay (K106) is energized when the headlight

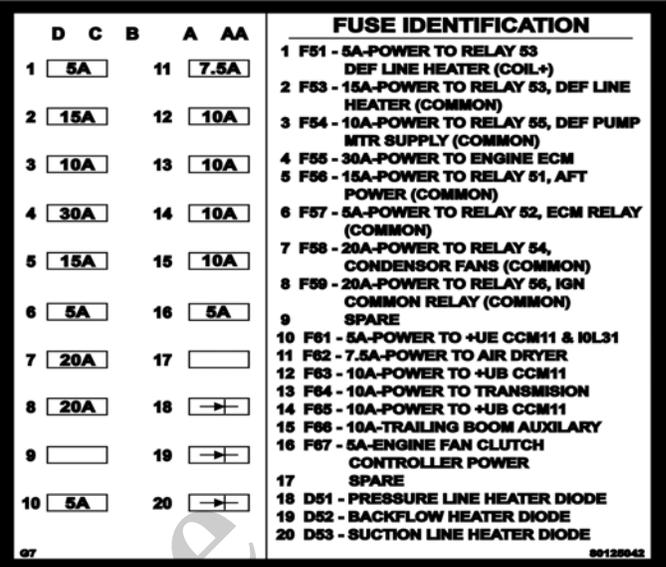
switch is in the park light or "ON" position. The coil of the steering wheel relay (K107) is energized when the contacts of ignition control relay K101 are closed.

Fuse and Fuse & Relay Panels

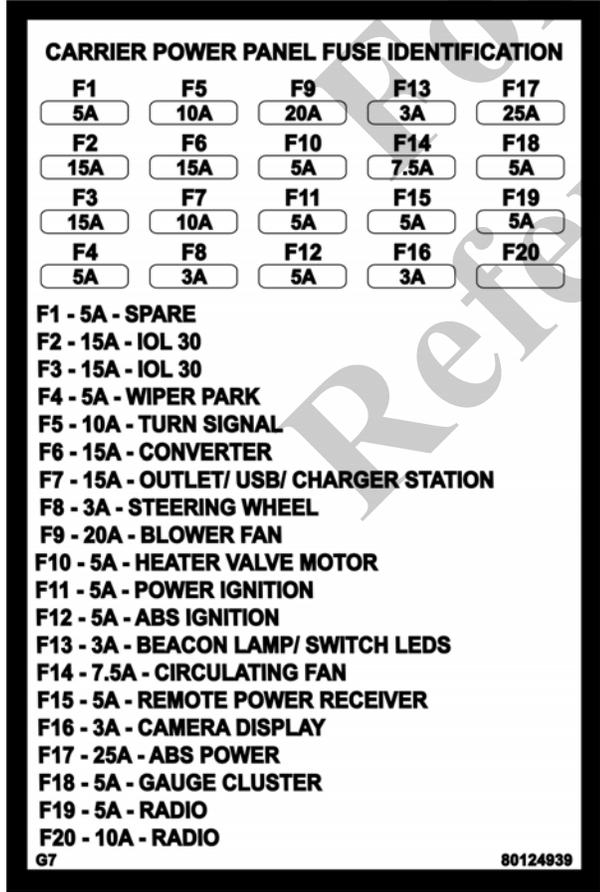
Refer to (Figure 3-4) for carrier fuse assignments.



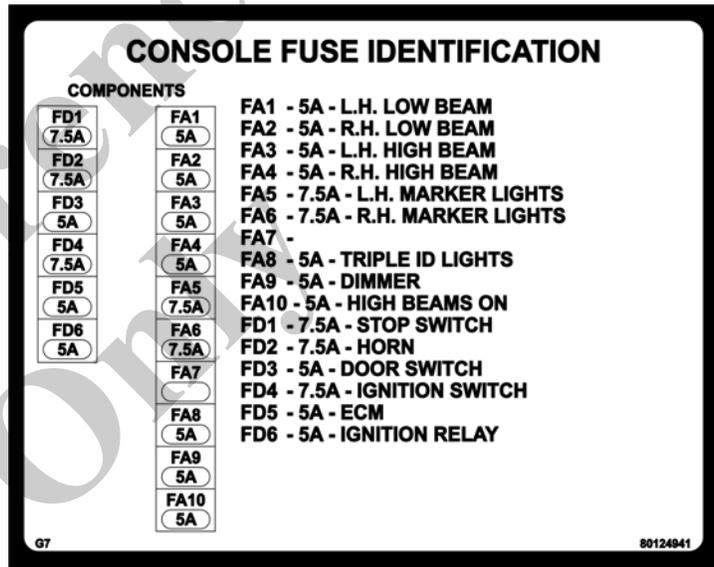
9280a



9280b



9280c



9280d

FIGURE 3-4

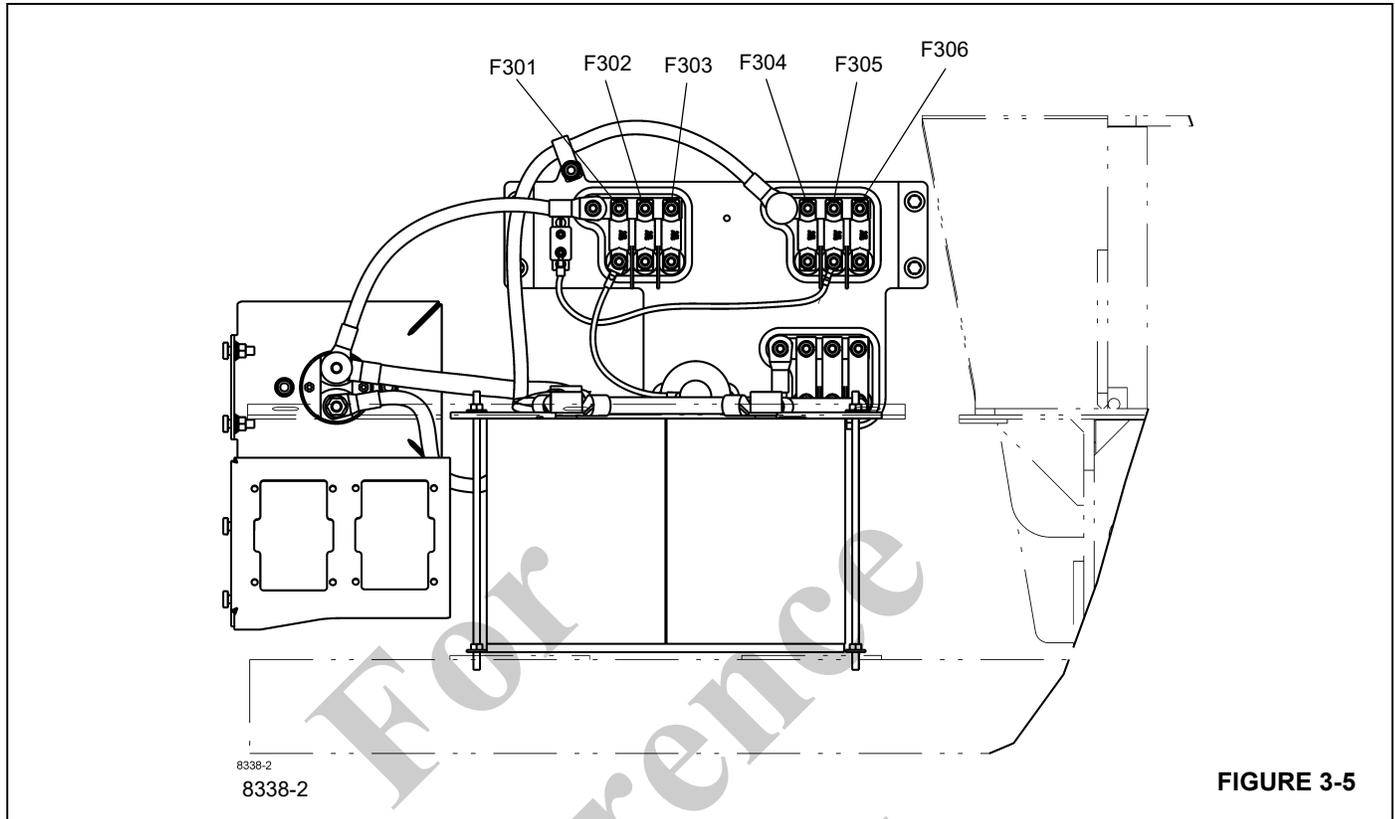


FIGURE 3-5

Superstructure Fuse and Relay Panel

S/S CAB FUSE & RELAY IDENTIFICATION

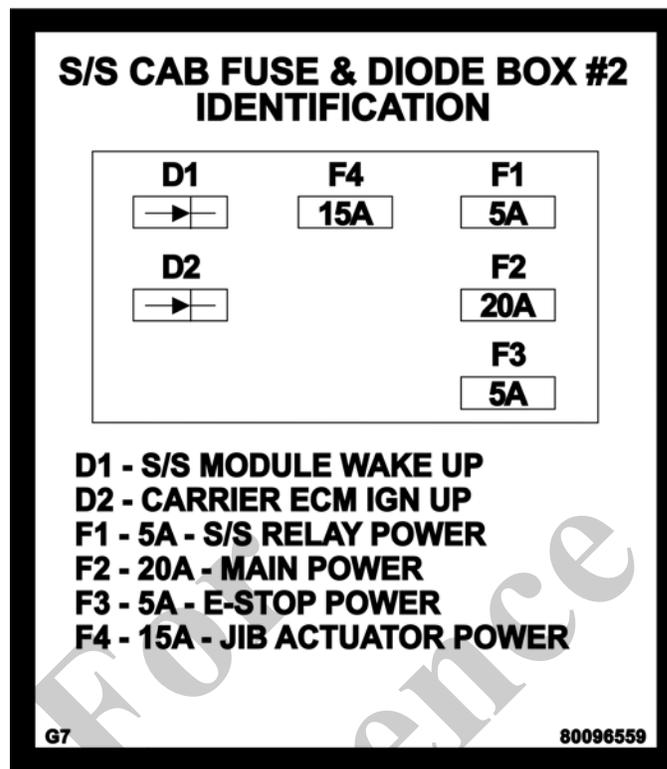
	FRONT VIEW FUSES	FUSE LINE 1	FUSE LINE 4
K 3701	F01 1 5 A	F01 - 15A - UB+ SCM	F01 - 10A - CIG LTR, DIA CONN
K 0401	F02 1 5 A	F02 - 15A - UB+ CCM10/2	F02 - 5A - CAMERA
K 3409	F03 1 5 A	F03 - 15A - UB+ CCM10/2	F03 - 5A - BEACON LT
K 3405	F04 1 5 A	F04 - 15A - UB+ IOL45/1	F04 - 3A - WIRELESS REMOTE, CRANESTAR
K 3404	F05 1 5 A	F05 - 15A - UB+ IOL45/1	F05 - 10A - NOT USED
K 0103	F06 1 0 A	F06 - 15A - UB+ IOL45/2	F06 - 3A - MOTOR WORK LTS
K 0102	F07 1 0 A	F07 - 15A - UB+ IOL45/2	F07 - 10A - RADIO/CONVERTER
K 0101	F08 3 A	F08 - 3A - ROOF LIGHT	F08 - 7.5A NOT USED
		FUSE LINE 2	FUSE LINE 5
		F01 - 5A - UB+ IOS/20	F01 - 20A - HEATER AIRTOP
		F02 - 15A - DISPLAY POWER	F02 - 5A - UE+ SCM, CRANESTAR
		F03 - 15A - UB+ IOS/22	F03 - 5A - UE+ IOS20
		F04 - 15A - A/C CONDENSER	F04 - 5A - UE+ IOL45/1
		F05 - 10A - UB+ IOS/21	F05 - 10A - RADIO KL30
		F06 - 10A - FAN HEAT	F06 - 5A - HANDSET
		F07 - 15A - NOT USED	F07 - 10A - NOT USED
		F08 - 2A - SWING BRAKE	F08 - NOT USED
		FUSE LINE 3	FUSE LINE 6
		F01 - 3A - SCM & RCL DISPLAY	F01 - 3A - SWITCH POWER (VCC)
		F02 - 5A - L & R JOYSTICK, JOGDAIL, SLEW SENSOR, PRESSURE TRANSDUCER	F02 - 3A - NOT USED
		F03 - 5A - SW IND LTS, WEBASTO HEAT CONTROL	F03 - NOT USED
		F04 - 5A - L & R JOYSTICK SUPPLY	F04 - NOT USED
		F05 - 10A - LUBE, WIPERS MOTORS	F05 - NOT USED
		F06 - 20A - WORK LTS CAB, WORK LTS BOOM	F06 - NOT USED
		F07 - 15A - A/C CONTROL PANEL	F07 - NOT USED
		F08 - NOT USED	F08 - NOT USED

REAR RELAYS SIDE

- K0101 - POWER SUPPLY F1 & F2
- K0102 - POWER SUPPLY F1 & F2
- K0103 - POWER SUPPLY F1 & F2
- K0401 - BEACON
- K3701 - HANDSET
- K3409 - A/C FAN
- K3405 - SKYLIGHT WIPER SW
- K3404 - FRONT WIPER SW

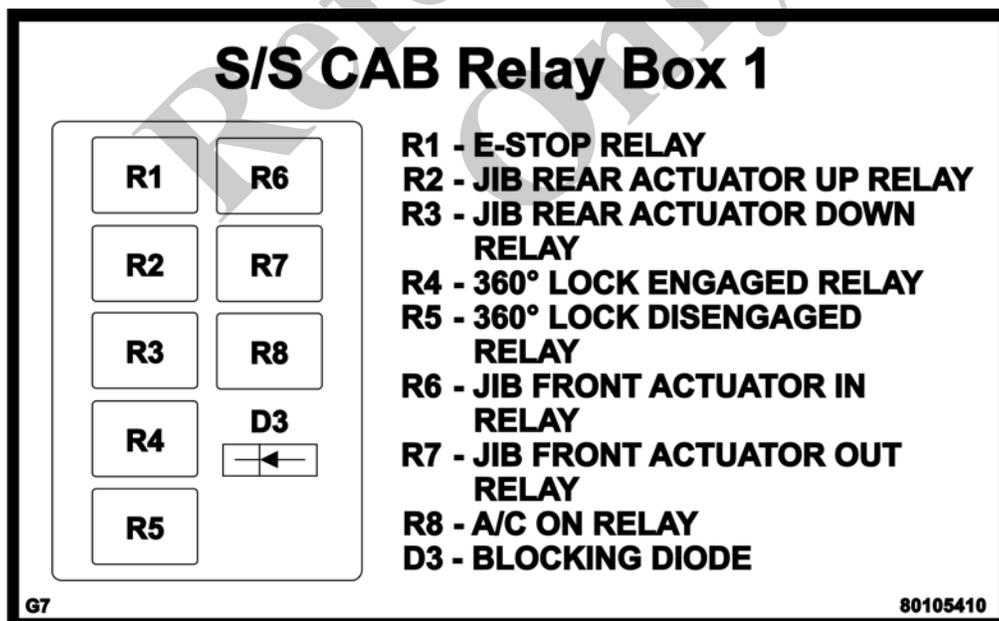
9280e
80116320

FIGURE 3-6



9280f

FIGURE 3-7



9280g

FIGURE 3-8

Anti-Lock Brake System (ABS)

Electronic Control Unit (ECU)

The ABS ECU (1), (Figure 3-9) is located inside the cab behind the seat. ABS wiring is combined with the main cab and engine harnesses.



FIGURE 3-9

Diagnostic Connector

The 9-pin on board diagnostic connector (1), (Figure 3-10) is located below the control panel on the left side of the dash.

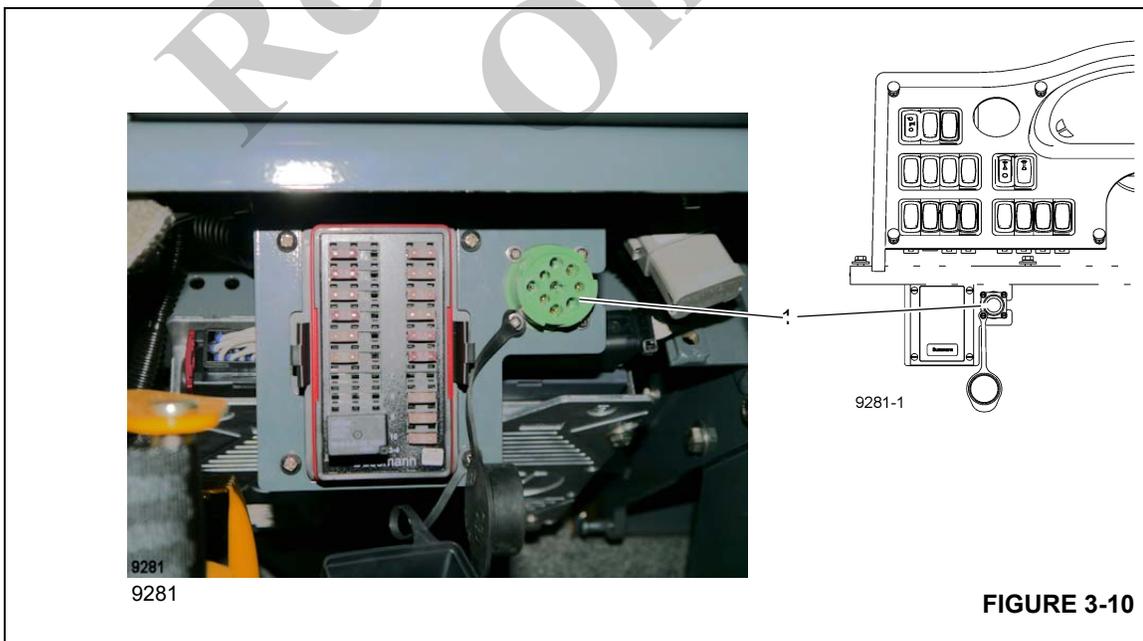
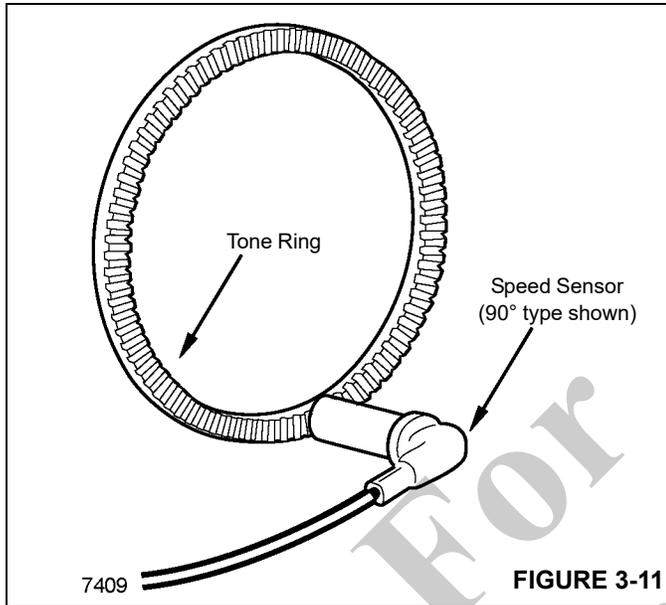


FIGURE 3-10

Wheel Speed Sensor and Tone Ring

An ABS wheel speed sensor and tone ring (Figure 3-11) is mounted in each monitored wheel. As the wheel spins, the sensor sends a fluctuating signal to the ABS ECU, which the ECU interprets as wheel speed.



Camera System

There are four cameras standard on the crane, two mounted on the carrier and two mounted on the superstructure. On the carrier, one is on the back of the crane used when backing up. The other is on the right side of the carrier, mounted on the right side mirror, used as a blind side camera when turning right. The back up camera is labeled Reverse and the right side camera is labeled Right.

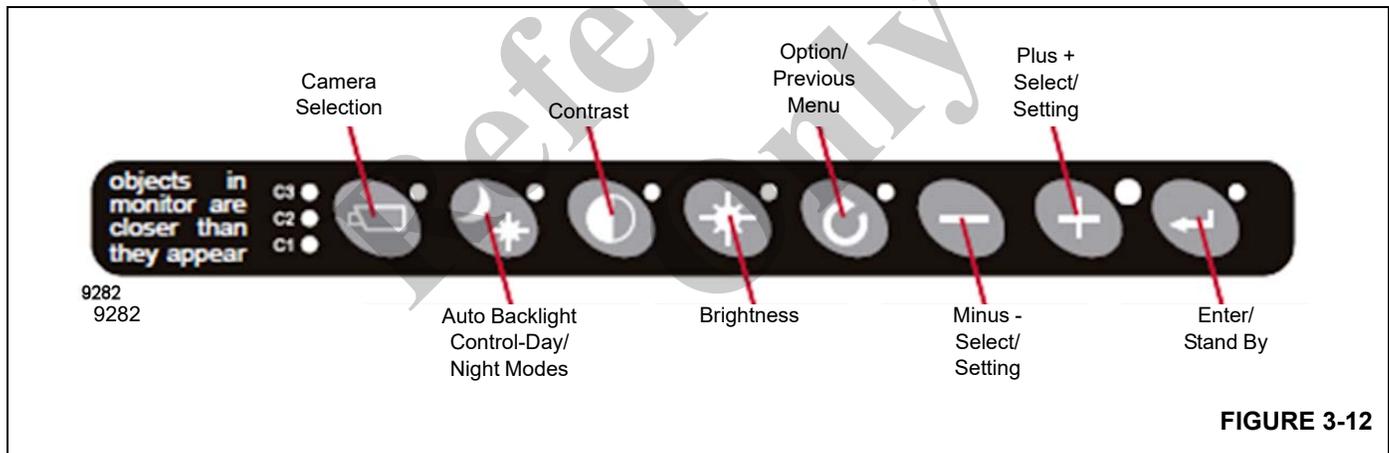
The camera display is located above the windshield in the center. The camera display can display just one camera image or both images.

On the superstructure, one is mounted on the left side of the crane on the hoist platform, used to monitor the hoists. The other is mounted on the right side of the crane next to the main hoist, and it monitors the right side of the crane. Both cameras display on the ODM. The superstructure cameras do not require alignment.

There is a fifth optional camera that is mounted on the rear of the optional trailing boom dolly and it displays on the carrier monitor.

Camera Alignment Carrier Right Side

1. Press the camera select button (Figure 3-12).
2. Press the + or - button to select the full screen view of "Right" camera.



3. **Horizontal:** The right-side camera should be adjusted horizontally so that the full length of the right side edge of the carrier can be seen on the left edge of the screen.
4. **Vertical:** The right-side camera should be adjusted vertically so that the ground below alongside the crane can be seen. Set a marker on the ground beside the front right tire. Adjust the camera vertically so that the marker can be seen on the bottom edge of the screen.
5. Recheck that both the horizontal and vertical requirements are met.

Camera Alignment Carrier Reverse

1. Press the camera select button or otherwise use the + or - buttons to select the full screen Reverse camera view.
2. **Horizontal:** Center the camera view horizontally.
3. **Vertical:** Set 2 markers on the ground at the very rear of the crane and to the outside corners. Point the camera down so that these markers can be seen.

MAINTENANCE

General

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



WARNING

Serious Injury Could Occur!

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

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

CAUTION

Damage Could Occur!

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

General Troubleshooting



WARNING

Serious Injury Could Occur!

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

Tools for Troubleshooting

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

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 and wiring diagram for most accurate wiring information.
4. If the component proves faulty, replace it with a known working component. If wiring proves faulty, replace it with wiring of equal wire gauge.
5. After troubleshooting, if the circuit proves faulty, repair and then test to ensure the circuit works properly.

Troubleshooting Engine Starting Problems

1. Verify the battery terminals are connected and clean, the transmission is in neutral, and the machine is fueled.
2. Check Fuse F61. Replace, if necessary.
3. Try to turn on the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights to verify the batteries have at least some charge. If none of these lights comes on, suspect the batteries. Charge batteries as needed, or jump-start the crane from another crane. Refer to *Jump Starting the Crane*, page 3-23. If the batteries will not take a charge replace them.
4. If you hear the starter relay clicking repeatedly, power is reaching the starter, but not enough. Suspect the batteries. Charge batteries as needed, or jump-start the crane from another crane. If the batteries will not take a charge replace them.
5. Turn the ignition switch(es) to RUN (1). Using a multimeter, check for 24 volts on the "I" post of ignition switch(es). If there is not 24 volts (but the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights will come on), suspect the ignition switch(es) and the power circuit to it starting at the ignition switch(es) fuse FD04. Repair or replace circuit, switch, or fuse as needed.
6. If the batteries, fuses, ignition switch(es), and power circuit to the ignition switch check out, do one of the following:
 - a. If you hear no noise when you try to turn the starter, troubleshoot the start circuit (ignition switch, electric shifter, neutral start switch and wiring from ignition switch to starter relay). Make repairs as needed.
 - b. If the engine still won't start, and you hear no noise or just a single click, suspect the starter. Troubleshoot the start circuit from the starter relay

through the starter solenoid to the starter motor and ground. Make repairs as needed. If the starter solenoid or the starter motor is faulty, replace the starter.

- c. If the starter engages but can't turn the engine (and the lights dim, signaling power drain during start attempt), check the starter's feed circuit from the batteries for resistance. If the resistance is high, make repairs. If the circuit checks out, replace the starter. If the engine still won't start, suspect a seized engine.
- d. If the starter turns the engine, but it still won't start, suspect a faulty engine control system. Refer to the engine manual for further instructions.
- e. If the engine starts, then shuts down, suspect a faulty engine control system. Refer to the engine manual for further instructions.

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

Troubleshooting Engine Charging Problems

1. Verify battery terminals are connected and clean and all wires in the charging system are in good repair and are connected properly.
2. Verify the alternator belt is properly installed and is under proper tension.

3. Verify the batteries put out 24 volts minimum. Charge battery as needed so the battery can supply a minimum excitation voltage to the engine's charging system.
4. Verify there is a minimum of 24 volts at the alternator from the batteries, and that the alternator is properly grounded.
5. Replace the alternator if the other conditions check out.
6. Refer to the engine manual for further instructions.

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

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

Troubleshooting Slip Ring-Caused Electrical Problems

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

Connector Troubleshooting

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

Refer to Table 3-1 Amp Extraction Tool Table, Table 3-2 Amp Crimping Tool Table, Table 3-3 Deutsch Extraction Tool Table and Table 3-4 Deutsch Crimping Tool Table for listing of tools necessary for connector maintenance.

Table 3-1
Amp Extraction Tool Table

Description	Amp 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 3-2
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 circuit (in-line connectors)	90299-1	—	N/A	—

Table 3-3
Deutsch Extraction Tool Table

Description	Deutsch Part Number	Grove Part Number
12 gauge wire	114010	9999100194
16 gauge wire	047-204-1605	9999100195
8-10 gauge wire	114008	7902000012
4-6 gauge wire	114009	7902000009

Table 3-4
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20 gauge wire	HDT48-00	9999100808

Description	Deutsch Part Number	Grove Part Number
4, 6, 8, 10 gauge wire	HDT 04-08	9999100842

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.

Di-Electrical Grease Application

Since March 2018 Manitowoc Cranes has been using Di-Electric Grease on all electrical connectors. All of the below electrical connection received Di-Electric Grease:

- All Deutsch Connectors.
- All Valve Solenoid connections on Hydraulic valves and Transmissions.
- All Harness Connections.
- CCS Module Connections.

When servicing electrical connections on Cranes, you should reapply Di-Electric Grease per the instructions below:

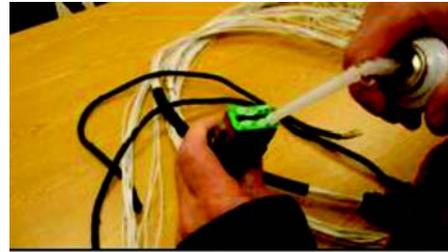
- Check connection for moisture before application of the grease.
- If moisture is found, please clean/replace connector accordingly.
- Apply material immediately prior to connection.
- Make sure that there is coverage to all terminal sockets.

Procedure

Required Material: Manitowoc P/N 90045471 - Di-Electric Grease.

1. Screw the tip/trigger assembly onto the can, if necessary.
2. Squeeze the trigger to dispense the material onto the female (socket) contact as shown in (Figure 3-13).

Grease Application



6862-41

FIGURE 3-13

3. Use a clean towel (or clean glove) to remove any excess material from the surface of the connector, and wipe material into the terminal sockets as shown in (Figure 3-14)

Clean off Excess Material



6862-42

FIGURE 3-14

4. Make sure that each socket has material. The towel with excess material can be used to fill empty terminal sockets as shown in (Figure 3-15).

Make sure Coverage in each Socket



6862-43

FIGURE 3-15

5. Make sure that grease is also applied to the entire surface of the rubber seal as shown in (Figure 3-16).

Make Sure Coverage of Rubber Seal



6862-44

FIGURE 3-16

6. Do not allow material to come in contact with any painted surface, or any other components as shown in (Figure 3-17).

Excessive Paste Must be Wiped Off



6862-45

FIGURE 3-17

7. If clean-up is necessary, contact cleaner or petroleum distillates can be used.
8. Secure the connectors when complete.

NOTE: EXCLUSIONS: The following items are excluded from the application of Di-Electric Grease (Figure 3-18):

- All connections inside the cab.
- M12 and M8 connectors.
- Pin Type contacts.



Pin Connectors

6862-40



M8/M12

FIGURE 3-18

Should you have any questions, please contact our Crane Care Office.

Troubleshooting Lights

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

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

- Head lights. CB01, HEADLIGHTS switch, dimmer switch, FA01-06 and FA08-FA10, lamps, grounds.
- Tail lights. CB01, HEADLIGHTS switch, FA01,FA02, FA03 and FA04, lamps, grounds.
- Marker lights. CB01, HEADLIGHTS switch, FA05, FA06, FA08 and FA09, lamps, grounds.
- Gauge lights. CB01, HEADLIGHTS switch, FA09, lamps, grounds.
- Turn signal lights. FA05, turn signal switch, lamps, grounds. Suspect turn signal switch if hazard light circuit functions properly.
- Hazard lights. Hazard lights switch, lamps, grounds. Suspect hazard lights switch if turn signal lights circuit functions properly.
- Stop lights. FD01, stop light switches, turn signal switch, lamps (suspect stop circuit problem if turn signal or tail light function works), grounds.
- Beacon light. F13, beacon light switch, lamp, ground. Parallel circuit to LED indicator in switch to ground.
- Cab dome light. FD03, switch on dome light, parallel circuit through door switch, lamp, ground.

Troubleshooting Gauges and Meters

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

1. Check all other gauges and meters (besides the suspect). If none of them are working, replace F18 (carrier fuse) or F02/02 (superstructure fuse).
2. Check the gauge or meter, its sensing component, and circuit for continuity problems and other problems. A sender is probably at fault when it shows infinite resistance, or resistance out of specifications for

condition. Repair any faulty gauge, meter or other component. Repair wiring if faulty.

Troubleshooting Alarms, Indicators, and Emergency Components

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

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

- Park brake indicator. Indicator, normally closed park brake pressure switch on cab front console control valve, ground.
- Steering wheel horn. FD02, Horn relay K103 coil, horn switch, ground. Parallel branch from horn relay contacts, horn, ground.
- Tire inflation on indicator. F11, to indicator or buzzer to the normally open pressure switch on the cab front console control valve to ground.

Troubleshooting the Crane Control System (CCS)

The Crane Control System (CCS) monitors the engine, transmission, and crane functions to ensure they are functioning properly. If a malfunction is detected within any of these areas, the crane control system display will illuminate the engine system warning icon for engine and transmission faults, or the crane error icon for any crane function faults. Both of these icons are located on the main menu screen of the CCS display.

NOTE: The description and resolutions of the error codes and software to interface with the ODM are available to those technicians that have attended the New Technology training course.

ODM Error Code Viewer

1. Open the fault list screen (Figure 3-19) or the engine faults screen (Figure 3-20) and highlight the fault you're interested in getting more information about.

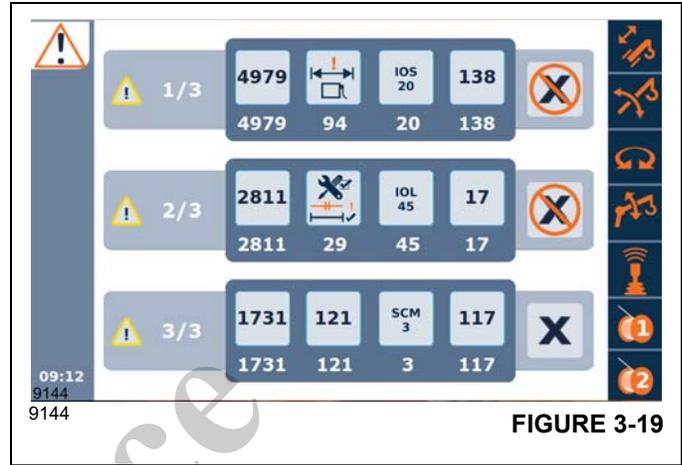


FIGURE 3-19

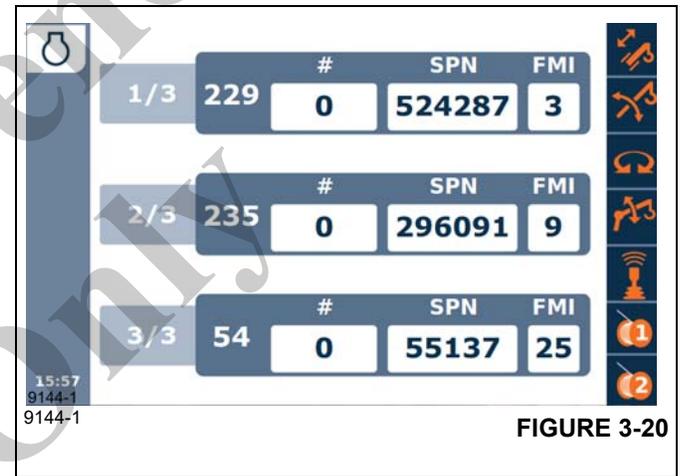


FIGURE 3-20

2. Press the upper right button (1), (Figure 3-21) on the jog dial panel or the control panel.

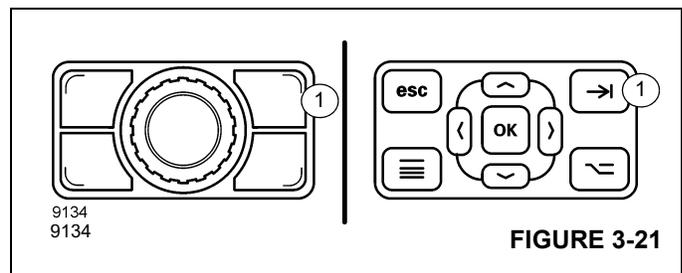


FIGURE 3-21

3. The ODM error code viewer (Figure 3-22) opens.

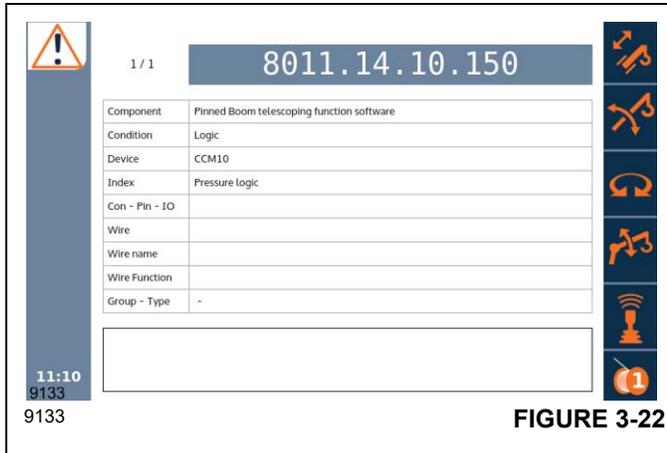


FIGURE 3-22

Troubleshooting Crane Components and Accessories

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

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

- Windshield wiper motor and windshield washer pump motor. F04, wiper/washer switch, motors in parallel, grounds.
- Heater/defroster fan. F09, heater switch, fan motor, ground.
- Cab circulating fan. F14, switch, motor, ground.
- Air dryer fuse is F62. Power goes straight from F62 to air dryer element to ground.

Alternator Replacement

Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables (Figure 3-24).
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 four bolts attaching the alternator to the mounting bracket. Remove the alternator.

Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. Place the alternator on the mounting bracket. Secure the alternator with the bolts. Torque mounting bolts. Refer to *Torque Values*, page 1-9.
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 torqued. Refer to *Torque Values*, page 1-9.
6. Connect the electrical leads to the terminals as tagged during removal.
7. Connect the batteries. Close the engine compartment.
8. Install the ECM power fuse.
9. Turn the battery disconnect switch to the ON position.

Check

1. Run engine. Verify reading of voltmeter on front console is 24 volts or greater. Make repairs as needed.
2. Continue troubleshooting charging system as needed if replacement of alternator did not correct problem in charging system.

Starter Replacement

Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables.
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the starter.
7. Remove the bolts holding the starter to the mounting pad. Remove the starter.

Installation

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

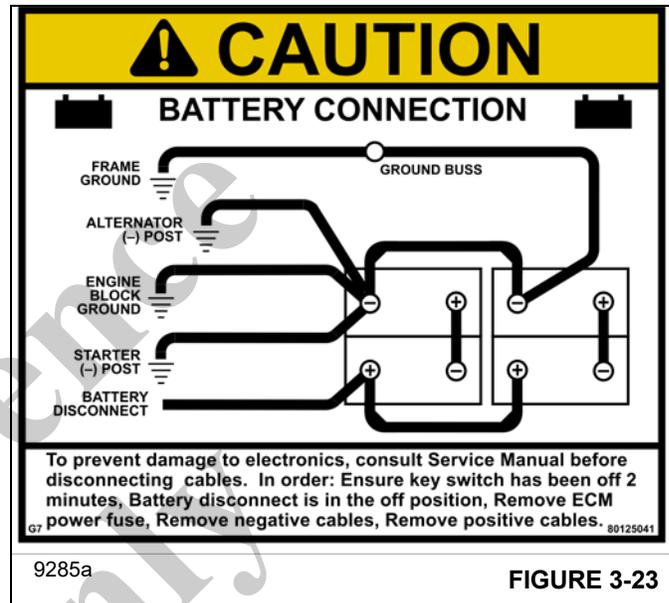
Check

1. Try to start the engine. Verify the starter starts the engine.
2. Start engine again, and listen for starter noises. Verify there is no abnormal noise indicating the starter's gear is meshing 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 key switch has been off 2 minutes before disconnecting batteries.

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



1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch(1, Figure 3-24) to the OFF position.
3. Remove the ECM power fuse.
4. Remove the negative battery cables (4, Figure 3-24).
5. Remove the positive battery cables (2).
6. Remove the nuts and washers from the bracket hold down rods (2). Remove the hold down brackets.
7. Remove the batteries.

Installation

1. Place the batteries in the battery compartment. Refer to (Figure 3-24).

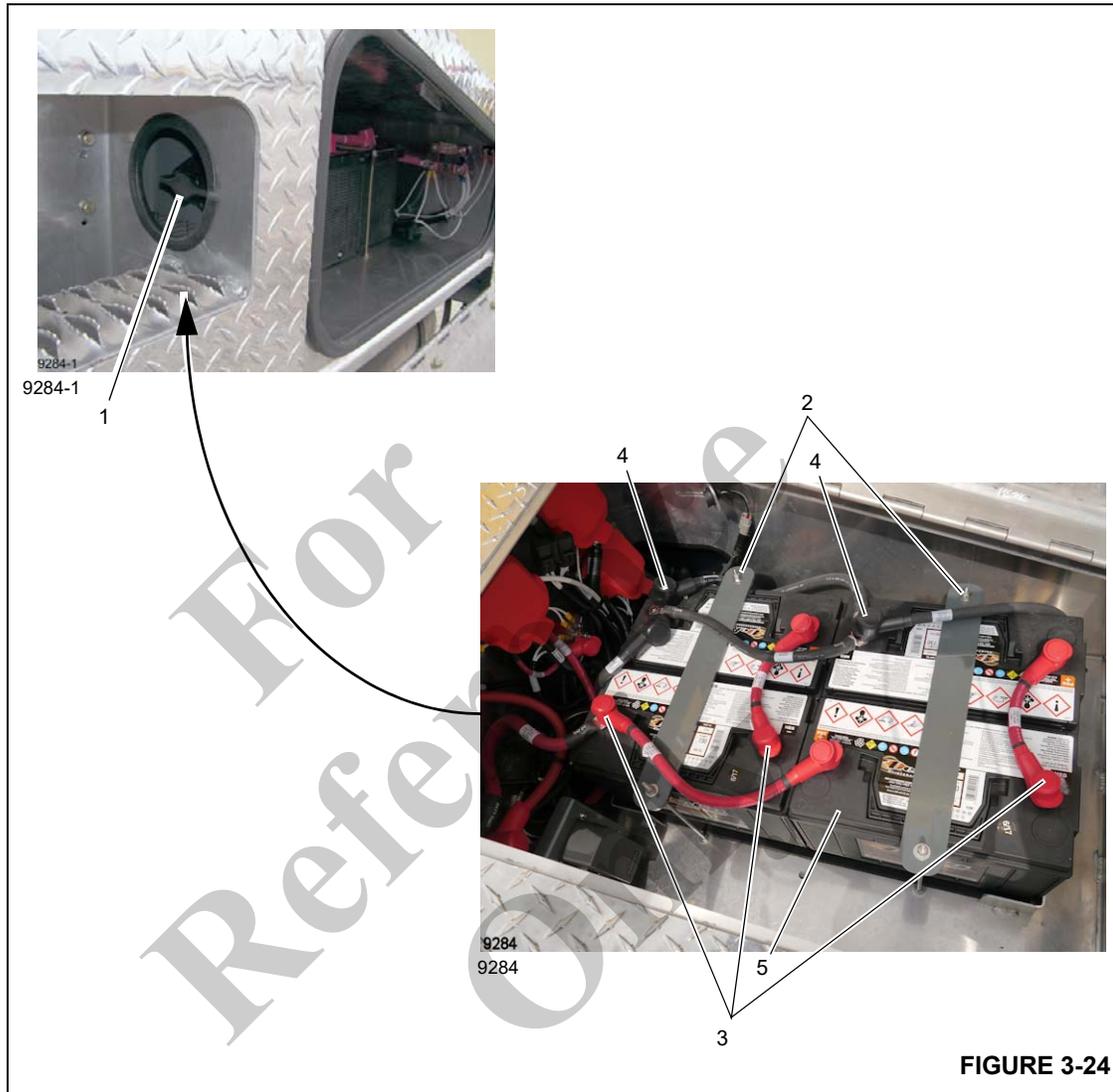


FIGURE 3-24

Item	Description
1	Battery Disconnect Switch
2	Battery Hold Down
3	Positive Cables

Item	Description
4	Negative Cables
5	Batteries (4)

2. Install the hold down brackets. Secure the brackets to the bracket hold down rods with nuts and washers.
3. Make sure the battery disconnect switch is in the disconnect position and all key switches are in the "OFF" position.
4. Connect cables to the battery terminals starting with the positive terminals.
5. Close the battery box cover.
6. Install the ECM power fuse.
7. Turn the battery disconnect switch to ON.
8. Verify replacement batteries work by starting crane's engine and operating various crane components.

Relay Panel Component Replacement

Accessory Relay and Flasher Replacement

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the cover from the relay panel.
4. Tag and disconnect the electrical leads from the suspect relay or flasher.
5. Remove the hardware securing the suspect relay or flasher to the relay panel assembly. Remove suspect relay or flasher.
6. Install replacement relay or flasher on relay panel and secure it with attaching hardware.
7. Connect the electrical leads to the relay or flasher as tagged during removal.
8. Install the cover.
9. Turn the battery disconnect switch to the ON position.
10. Verify proper installation by operating all components involved with the replacement relay and verifying they all work. Verify proper operation of the flasher by operating the turn signals or hazard lights.

Buzzer Replacement

1. Remove the cover from the relay panel.
2. Tag and disconnect the electrical leads from the buzzer.
3. Unscrew the plastic collar ring from back of the panel and remove the buzzer from the hole in the panel.
4. Install replacement buzzer through the hole in panel and secure with the plastic collar ring.
5. Connect the electrical leads to the buzzer as tagged during removal.
6. Install the cover.
7. Verify proper operation by positioning the ignition switch to RUN (1). Buzzer should sound when engine is not running.

Plug-in Relays Replacement

1. Remove the cover from the relay panel.
2. Unplug the suspect relay from the receptacle.
3. Plug replacement relay into receptacle.
4. Install the cover.
5. Verify proper installation by operating all components involved with the replacement relay and verifying they all work.

Instrument Replacement

Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the hardware securing the console cover and remove the cover.
4. Tag and disconnect the electrical wiring or air lines from the instrument.
5. Remove the hardware securing the instrument to the console panel. (Typically, remove nuts and lock washers, and then a bracket or clamp.) (The gauge cluster has two tabs on either side that must be pushed in.) 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 the ON position.

Check

1. Start the engine and verify that the instrument works. (Refer to *Operator 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. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.

remove the cover.

4. Disconnect the electrical connector from the switch.
5. 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 the ON position.

Check

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

All Other Switches

Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the hardware securing the console cover and remove the cover.
4. Tag and disconnect the electrical leads from the switch.

5. On the front of the console panel, remove the nut securing the switch to the panel. As necessary, remove the knob from the switch first.
6. Remove the switch from the hole in the panel.

Inspection

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

Installation

1. Place the switch through the hole in the front console panel and secure to the front of the panel with the nut. Install the knob on switch as necessary.
2. Connect the electrical leads to the switch as tagged during removal.
3. Position the console cover on the console and secure with the attaching hardware.
4. Turn the battery disconnect switch to the ON position.

Check

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

WINDSHIELD WIPER ASSEMBLY REPLACEMENT

Removal

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

4. Disconnect the washer hose on the wiper arm (also called the pantograph arm assembly) from the washer nozzle fitting assembly.
5. Remove the cap nut and washer securing the wiper arm to the pantograph arm assembly. Remove the cap nut, washer, and tapered sleeve securing the wiper arm to the pivot shaft assembly.
6. Remove the wiper arm from the pantograph arm assembly and the pivot shaft.
7. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft.
8. Remove the two capscrews and lock washers securing the pantograph arm assembly's adapter to the cab

exterior. Remove the pantograph arm assembly'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 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.

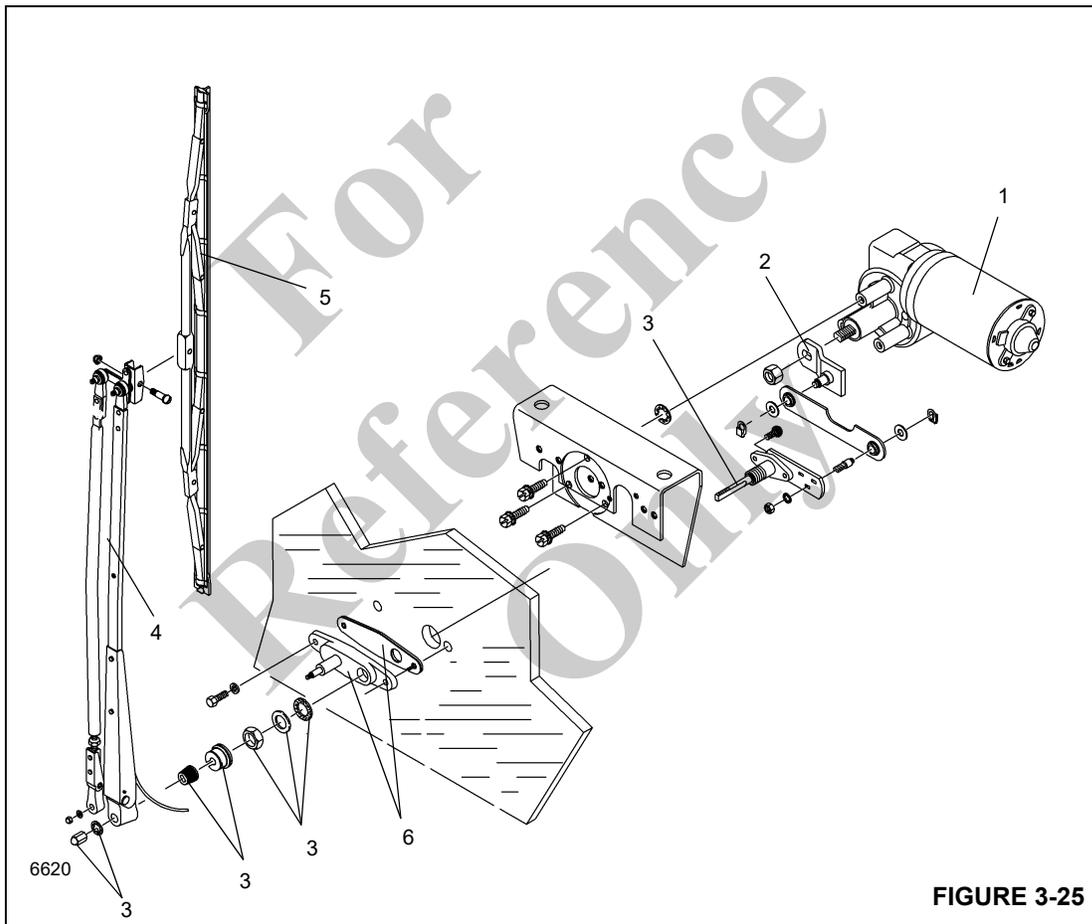


FIGURE 3-25

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

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 parts (pantograph adapter, pivot shaft assembly, wiper motor link and crank, wiper motor bracket) for damage. Replace as needed.

Installation

1. Verify the pivot shaft and the wiper motor 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 crank with the nut and washer.
3. Secure the adapter and the gasket of the pantograph to the cab exterior with capscrews and lock washers.
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.

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

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

Check

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

WINDSHIELD WASHER ASSEMBLY REPLACEMENT**Removal**

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Locate the windshield washer container and pump.
4. Tag and disconnect the pump's electrical lead and ground wire.
5. Disconnect the hose from the windshield washer pump. Point it so it won't spill cleaning fluid. Catch cleaning fluid from the windshield washer container with a suitable container.
6. Remove four self tapping screws securing the windshield washer container. Remove the windshield washer container and pump.
7. Remove pump and pump seal from container.

Inspection

1. Visually check the pump for evidence of cracks, leaks, or other damage. Replace pump if damaged.
2. Inspect the container for leaking. Replace pump seal if it is leaking. Replace container if it is damaged and leaking.
3. Inspect spray nozzle on the wiper arm. As needed, clean the nozzle with a fine piece of wire and compressed air.

Installation

1. Install pump and pump seal on container.
2. Install windshield washer container. 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.

REMOTE CONTROLLER (OPTIONAL)

The remote controller consists of the following:

- A hand held remote transmitter (1), (Figure 3-26)
- A receiver (2), (Figure 3-26) mounted behind the seat in the carrier cab.
- A battery charger (3), (Figure 3-26).
- A second battery (4), (Figure 3-26). The other battery is in the remote.
- The battery charger clip (5), (Figure 3-26) that holds the charger in place.



FIGURE 3-26

Receiver**Removal**

1. Tag and remove the cables from the receiver.
2. Remove the four screws holding the receiver to the panel.
3. Remove the receiver.

Installation

1. Align the receiver's four mounting holes with the holes in the panel.
2. Install the four screws and tighten.
3. Connect the cables as tagged during removal.

Battery Charger**Removal**

1. Unplug the wire from the battery charger.
2. Loosen the screw securing the battery charger clip (5).
3. Loosen the nuts securing the battery charger to the panel.
4. Slide the battery charger up and remove it.

Installation

1. Hold head of screws, that secure the battery charger, approximately 3 mm (0.13 in) off the panel and slide the battery charger over the screw heads.
2. Secure the screws with the nuts.
3. Slide the battery charger clip down onto the battery charger and secure with the screw.
4. Plug in the wire to the battery charger.

Remote Controller Battery

Remove/install the battery into the remote transmitter or charger by squeezing the tab on the base of the battery and pulling/pushing the battery out/in.

JUMP STARTING THE CRANE

Do not attempt to jump start the crane.

CAUTION

It is strongly recommended that the batteries not be “jumped” with a different vehicle, portable power pack, etc. The surge of power from these sources can irreparably damage the various electronic controls and computer systems. Jump starting the crane batteries with a different vehicle while the engine is running can damage the donor vehicle electronics as well if done improperly.

All crane models, particularly those produced since 2000, have multiple computer systems (crane control, RCL, engine

& transmission control) that are highly susceptible to voltage/ amperage surges in the electrical system.

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries.

Charging

When charging the batteries, do not turn on the battery charger until the charging leads have been connected to the battery(s). Also, if the battery(s) are found to be frozen, do not attempt to charge them. Remove the battery(s) from the crane, allow them to thaw, and then charge the battery(s) to full capacity.

“Slow charging” is preferred to “fast charging”. Fast charging saves time but risks overheating the battery(s). Slow charging at six (6) amps or less develops less heat inside the battery and breaks up the sulfate on the battery plates more efficiently to bring the battery up to full charge. The use of a “smart charger” that automatically adjusts the charging amperage rate should be used.

For Reference Only

For
Reference
Only

This Page Blank

SECTION 4 SUPERSTRUCTURE

SECTION CONTENTS

<p>Description of Maintenance Work on the Superstructure 4-1</p> <p style="padding-left: 20px;">Hoist 4-1</p> <p>Boom Removal 4-9</p> <p>Boom Installation 4-11</p> <p style="padding-left: 20px;">Functional Check 4-13</p> <p>Boom Nose Sheaves 4-13</p> <p style="padding-left: 20px;">Boom Nose Sheaves Removal 4-13</p> <p style="padding-left: 20px;">Boom Nose Sheaves Installation 4-17</p> <p>Boom Disassembly 4-17</p> <p>Boom Assembly 4-18</p> <p style="padding-left: 20px;">Telescope Section 5 Assembly 4-18</p> <p style="padding-left: 20px;">Telescope Section 4 Assembly 4-22</p> <p style="padding-left: 20px;">Telescope Section 3 Assembly 4-25</p> <p style="padding-left: 20px;">Telescope Section 2 Assembly 4-28</p> <p style="padding-left: 20px;">Telescope Section 1 Assembly 4-31</p> <p style="padding-left: 20px;">Telescope Base Section Assembly 4-37</p> <p>Pinning Boom Components 4-38</p> <p style="padding-left: 20px;">Mechanical Locking Head Description 4-38</p> <p style="padding-left: 20px;">Proximity Switch Descriptions 4-39</p> <p style="padding-left: 20px;">Hydraulic Actuator Description 4-41</p> <p style="padding-left: 20px;">Precision Length Sensor Description 4-42</p> <p style="padding-left: 20px;">Pinned Boom Control System Description 4-42</p> <p>Mechanical Emergency Unlocking and Locking of the Telescopic Sections 4-43</p>	<p style="padding-left: 20px;">Prerequisites 4-43</p> <p style="padding-left: 20px;">Maintenance 4-43</p> <p>New York House Lock 4-44</p> <p>Bleeding the Telescoping Cylinders 4-44</p> <p style="padding-left: 20px;">Prerequisites 4-44</p> <p style="padding-left: 20px;">Bleeding Procedure 4-44</p> <p style="padding-left: 20px;">Telescoping Status 4-45</p> <p>Telescope Slide Pad Adjustment 4-46</p> <p>Check the Locking System 4-46</p> <p>Hoist Ropes 4-47</p> <p style="padding-left: 20px;">Checking the Position of Sheaves and Rope Drums 4-47</p> <p>Wire Rope Inspection/Replacement (All Wire Rope) 4-47</p> <p>Rated Capacity Limiter 4-52</p> <p style="padding-left: 20px;">Maintenance of the Slip Ring Assembly of the Cable Drum 4-52</p> <p style="padding-left: 20px;">Lubricating the Swing Angle Sensor 4-54</p> <p>Superstructure Air Conditioning System (Additional Equipment) 4-55</p> <p style="padding-left: 20px;">Checking Hoses 4-55</p> <p>Other Maintenance Work 4-55</p> <p style="padding-left: 20px;">Checking for Correct Operation of the Auxiliary Heater (Additional Equipment) 4-55</p> <p style="padding-left: 20px;">Lubricating the Piston Rod of the Lifting Cylinder 4-55</p>
---	---



DESCRIPTION OF MAINTENANCE WORK ON THE SUPERSTRUCTURE

Hoist

Description

One standard hoist is available for both the main and auxiliary (Figure 4-2). The hoist incorporates one dual displacement piston motor which drives a reduction unit within the hoist. The hoist utilizes planetary reduction with a multi-disc automatic brake that is spring applied and hydraulically released. The hoist motor controls both speed and torque of the hoist. The hoists operate in two modes - High or Low Speed.

The main hoist and the auxiliary hoist of identical construction are located on the superstructure turntable. The auxiliary hoist is located behind the main hoist.

Theory of Operation

Flow from pump number one and two is routed through the swivel to the directional control valve bank.

When the main hoist joystick in the cab is moved from neutral, it sends an electrically controlled signal to the main hoist directional control valve to shift the valve spool to route hydraulic flow to the hoist motor or motor control valve.

When the auxiliary hoist joystick in the cab is moved from neutral, it sends an electrically controlled signal to the auxiliary hoist directional control valve to shift the valve spool

to route hydraulic flow to the hoist motor or motor control valve.

WARNING
Crushing Hazard!

If this inspection is not performed, there may be a risk of damage to the hoist gearbox which could lead to the load falling crushing personnel below. Always perform hoist inspections.

Carrying Out Partial Inspection of Hoists

Certain parts must be inspected for wear during the partial inspection:

- the multiple-disk brake
- the plug connections between the hydraulic motor and the multiple-disk brake
- the plug connections between the multiple-disk brake and the transmission unit (where applicable)

These parts must be replaced when worn.

NOTE: Inspections and part replacements may only be carried out by trained, qualified personnel.

Carrying Out General Inspection of Hoists

NOTE: When carrying out general inspection of the hoists, also observe the information contained in *Measures Required for Hoist Monitoring*, page 5-10.

The hoist gear is to undergo general inspection after the period of time indicated in the *Maintenance plan*. This inspection involves removing the transmission and sending it to the manufacturer for testing.

NOTE: The oil of new transmissions and transmissions which have undergone a general overhaul must be changed after 200 and 1000 operating hours, in accordance with run-in times, before the yearly interval can be implemented.

Installing Cable On Hoist

NOTE: To install synthetic rope refer to the K100™ manual.

Refer to (Figure 4-1).

CAUTION

If cable is wound from storage drum, rotate reel in same direction as hoist.

NOTE: Straighten cable before installing on hoist drum.

1. Place cable (1) over boom nose sheave and route to hoist drum (2).
2. Rotate hoist drum so cable slot located on left side of drum is easily accessible.
3. Insert cable through slot (3) and wedge block (4). Slowly wind the drum and rope tail in the hoist up direction until they are toward the top of the superstructure. Pull the rope up into the open space and loop around anchor wedge (6) and route back through wedge block to clamp (5). Make sure that the cable is routed over guide in side of drum. End of cable should extend approximately 50 mm (2 in) beyond clamp. Tighten clamp.
4. Adjust cable so clamp side is snug against guide. Position anchor wedge in wedge block. Slowly rotate the drum downward until cable entry hole is visible. Pull firmly on inside hoist side of cable to secure the wedge.
5. If wedge does not seat securely in slot, carefully tap cable and top of wedge (7) with a mallet.

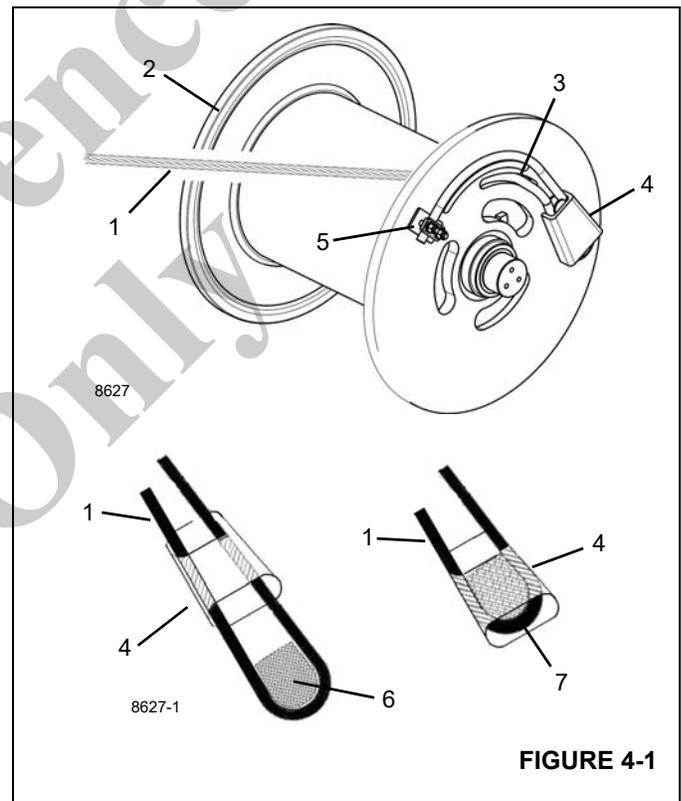


FIGURE 4-1

	<p>⚠ DANGER</p>
	<p>ENTANGLEMENT HAZARD Death or serious injury may result if entanglement occurs during hoist operation. Keep all body parts and loose clothing clear while hoist is running.</p>

7196

6. Slowly rotate drum and ensure cable lays immediately in the first groove.
7. Install remainder of cable as required.

Removing/Installing the Hoist

Refer to (Figure 4-2), on page 4-4.

Removing

1. Remove cable from hoist drum.
2. Tag and disconnect hoist hydraulic lines from motor and brake. Cap or plug all lines and openings.
3. Remove lower hose from sight glass. Collect oil as it drains.
4. Remove gearbox sight glass hoses and fittings from gearbox.
5. Tag and disconnect hoist control valve electrical wires.
6. Remove hydraulic motor (6).
7. Remove the hydraulic motor adapter plate and O-ring.
8. Remove standoff fitting from right side of hoist assembly.
9. Tag and disconnect hoist rotation indicator sensor electrical wires.
10. Remove hoist rotation indicator sensor (5).
11. Remove two shafts (7).
12. Remove hoist roller (11).
13. Using an adequate lifting device, slightly lift hoist assembly.

NOTE: Hoist assembly weighs approximately 412 kg (908 lb).

14. Remove bearing support (8) capscrews (6 long, 3 short). Install three long capscrews into the three short capscrew holes. Use capscrews as jack screws to pull the bearing support (8) off the drum shaft (1).
15. Remove the hoist mounting capscrews and washers, then remove the hoist assembly.

Installing

1. Ensure the hoist and superstructure mounting surfaces 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 inside the superstructure.

NOTE: Hoist assembly weighs approximately 412 kg (908 lb).

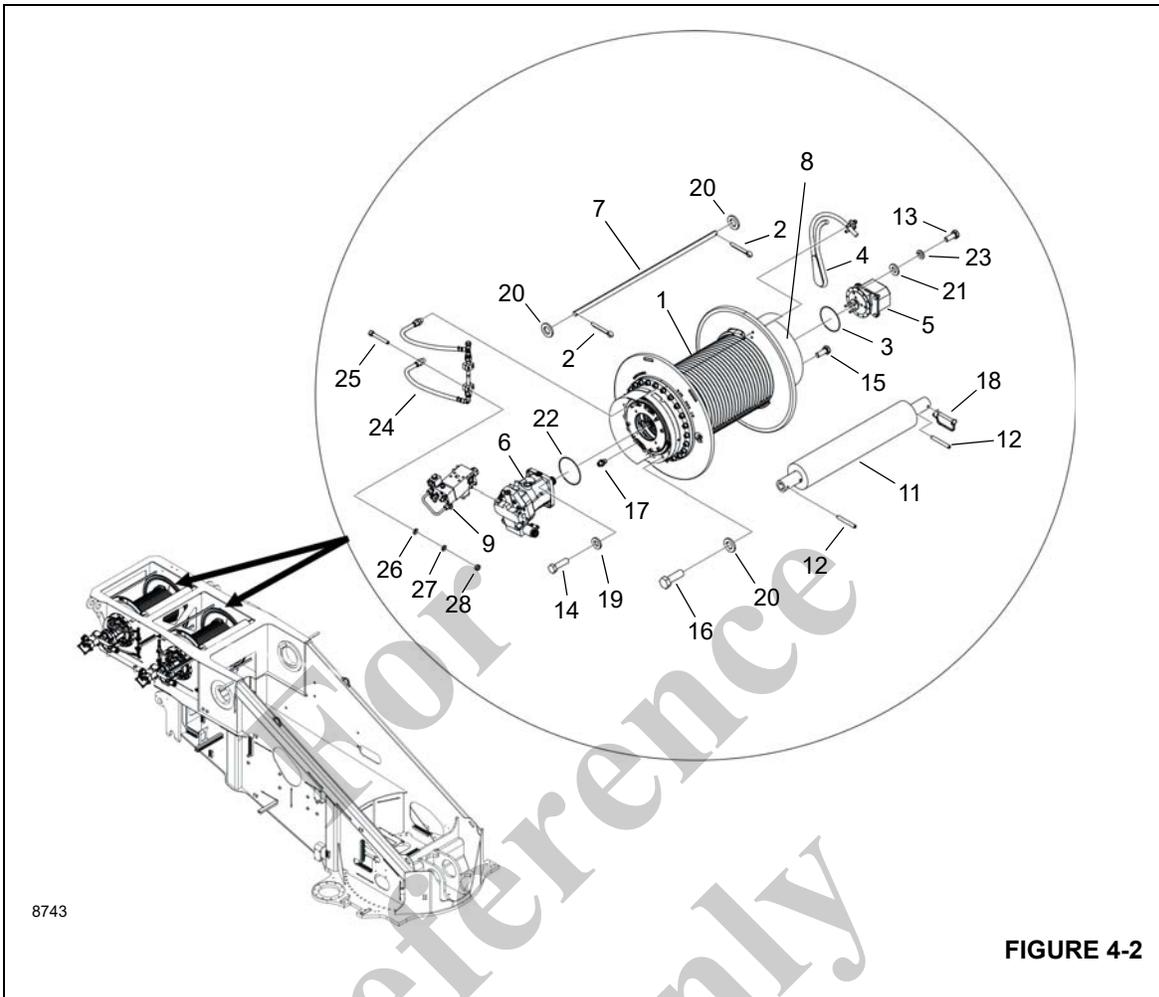
3. Secure the hoist assembly to the superstructure using the capscrews and washers. Torque the capscrews - refer to *Torque Values*, page 1-9 for proper torque value.
4. Install the bearing support assembly (8) to the drum shaft with grease fittings at the 11-o'clock position. Align and install the six long capscrews into the threaded turntable holes. Install the three short capscrews into the blind holes. Torque capscrews following specification under *Torque Values*, page 1-9
5. Install the hoist roller (11).
6. Install the two shafts (7)
7. Install the hoist rotation indicator sensor (5).
8. Connect the hoist rotation indicator sensor electrical connectors as tagged during removal.
9. Install the standoff fitting. Torque standoff fitting to 35 Nm (26 ft-lb).
10. Lubricate O-ring, then install O-ring and hydraulic motor adapter plate. Apply medium strength thread locker to the capscrews and torque to 42 Nm (31 ft-lb).
11. Install new O-ring (22). Lube O-ring, then install hydraulic motor.
12. Connect the hoist control valve electrical connectors as tagged during removal.
13. Reattach gearbox sight glass hoses and fittings.
14. Reattach lower hose to bottom of sight glass.
15. Connect the hydraulic lines to the motor and brake as tagged during removal.
16. Ensure the bearing is full of grease.
17. Ensure gear box is filled with oil to the proper level.
18. Install cable onto hoist assembly. Refer to *Installing Cable On Hoist*, page 4-2.
19. Adjust the minimum wrap switch, refer to *Adjusting Minimum Wrap Switch*, page 4-8.

Functional Check

1. Attach a test weight to the hook. Raise and lower the load several times.
2. Check for smooth operation of the hoist motor and brake system.
3. Ensure hydraulic connections are secure and free from leaks.

Hoist Fluid Level Check

Check the oil level in the sight glass.



8743

FIGURE 4-2

1	Hoist	10	Shaft	19	Flat Washer
2	Cotter Pin	11	Hoist Roller	20	Flat Washer
3	O-Ring	12	Roll Pin	21	Narrow Flat Washer
4	Cable Wedge	13	Capscrew	22	O-Ring
5	Limit Switch Assembly	14	Capscrew	23	Lockwasher
6	2 Speed Motor Piston	15	Capscrew	24	Sight Glass
7	Shaft	16	Capscrew	25	Socket Head Cap Screw
8	Bearing Support	17	Straight Thread Adapter	26	Washer
9	Motor Control Valve Assy	18	Pin	27	Lockwasher
				28	Nut

A comprehensive hoist line pull and load holding test must be carried out following any such repair work.

Manitowoc Crane Care offers prepackaged kits that include all seals, bearings, fasteners, washers, brake disks, brake stators, and springs required for reassembling hoist after inspection. If components not included in the kit are found to be worn or damaged, contact your Manitowoc Cranes distributor or Manitowoc Crane Care to order a replacement.

Usage and Inspection

Inspection procedures for hoists are divided into five general categories based on usage or duty cycle which determines appropriate intervals for inspections. Usage categories must be assigned by the crane user on a consistent crane-by-crane basis. The five crane/hoist usage categories are as follows:

- Idled** - The crane/hoist has not been used for three months.
- Infrequent Usage** - The crane/hoist is used less than ten hours per month based on a three month average
- Moderate Usage** - Crane/hoist used 10 - 50 hours per month based on a three month average.
- Heavy Usage** - Crane/hoist used 50 - 200 hours per month.
- Severe Usage** - Crane/hoist is operated more than 200 hours per month OR where 50% of the lifts exceed 75% of the rated capacity for the hoist.

The following chart lists inspections required for each type of usage category.

	PRE-USE DAILY INSPECTION	QUARTERLY INSPECTION	SEMI-ANNUAL INSPECTION	ANNUAL INSPECTION
IDLED Not used for 3 months or longer	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	REQUIRED BEFORE PLACED IN SERVICE	N/A
INFREQUENT USAGE Less than 10 hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
MODERATE USAGE 10-50 hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
HEAVY USAGE 50-200 hours per month	REQUIRED	REQUIRED MONTHLY	REQUIRED QUARTERLY (3 MONTHS)	REQUIRED SEMI-ANNUALLY (6 MONTHS)
SEVERE USAGE 200+ hours per month or 50% of lifts exceed 75% rated capacity	REQUIRED	REQUIRED	REQUIRED QUARTERLY (3 MONTHS)	REQUIRED SEMI-ANNUALLY (6 MONTHS)

Preventative Maintenance

It is extremely important to be aware of deterioration of internal critical components within the hoist reduction unit. Hoist reduction units contain planetary gears, and multi-disc brake assemblies, which do not have an infinite life span. Although these components are designed for long service life, reliability can be reduced by a variety of factors such as:

- High cycle operation.
- Operating in high ambient temperatures.
- High external contaminations, such as dusty or sandy conditions.
- Level of maintenance.



Failure to implement and adhere to a hoist inspection and maintenance program may result in damage to the crane, other property damage, and/or serious injury or death to persons working on or near the crane.

The following should be carried out following instructions in *Lubrication*, page 9-1 and/or manufacturers instructions.

1. Pre-Use or Daily Inspection, refer to the Operator Manual.
2. Quarterly Inspection (every three months).

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

- Perform pre-use inspection.
 - Inspect for corrosion of fasteners, hoist base, drum, etc. and repair/replace as required to maintain structural integrity of the hoist.
 - Check hoist oil level. Inspect hoist gearbox for oil leaks.
3. Every 250 hours or 3 months.
 - If applicable, lubricate cable guide roller and cable guard roller bearings.
 4. Semi-Annual Inspections (every six months).

Must include but is not limited to the following inspections that must be performed by a qualified crane operator or qualified crane technician.

- Perform Pre-Use and Quarterly inspections.
- Take a sample of lubricant from hoist gear cavity as described in *Gear Oil Sampling and Analysis*, page 4-6 and analyze it for wear metals content, correct viscosity, lubricant deterioration, moisture and other contaminants. If oil sample contains a high amount of

metallic particles, hoist must be taken out of service to undergo a tear down inspection.

NOTE: Oil analysis alone cannot detect or warn against a fatigue failure.

5. Annual Inspection.

This inspection must be carried out by a qualified crane technician. Annual inspection **MUST** include, but not be limited, to the following:

- Perform Pre-Use/Daily Inspection, Quarterly Inspection, and Semi-Annual Inspection.
- Change lubricating oil in hoist gear cavity after an oil sample has been taken as described in *Gear Oil Sampling and Analysis*, page 4-6. Refill hoist to proper level with recommended lubricant. Refer to *Lubrication*, page 9-1.



DANGER

Failure to use proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in death, serious injury or damage to property and equipment. Some gear lubricants contain large amounts of Extreme Pressure (EP) and anti-friction additives which may contribute to brake clutch slippage or damage to brake friction discs or seals. Oil viscosity with regard to ambient temperature is also critical to reliable brake clutch operation. Our tests indicate excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Ensure gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

- Check for correct function of hoist brake by conducting a high line pull load test. Ensure brake holds without creeping and hoist control is correct. Check hoist brake function more often if abnormal operating conditions or characteristics exist.
6. Every 10,000 hours or every ten years, it is recommended that the hoist assembly be disassembled and that all major components be examined for damage and/or wear, i.e. gears, spline couplings, shafts, etc. New components must be installed if any are found to be worn or if there is evidence of heat or other damage. The hoist should be reassembled using all new seals, bearings, fasteners, washers, brake discs, brake stators, and springs. A comprehensive hoist line pull and load holding test must be conducted following the repair work.

Oil Sampling

Oil Change

Hoist gear oil must be changed after the first 100 operating hours then on an annual basis, at a minimum thereafter. In

severe duty applications, the gear oil should be changed every six months. Use the recommended lubricants. Refer to *Lubrication*, page 9-1.

Gear Oil Sampling and Analysis

Proper gear oil sampling and analysis is a vital part of a comprehensive preventive maintenance program. Information obtained from the oil analysis allows the maintenance technician to substitute preventive maintenance for more costly unscheduled down time or a far more dangerous failure. Early detection of accelerated component wear allows the scheduling of corrective maintenance.



CAUTION

Hot oil may cause personal injury and/or burns to unprotected skin. Make certain the oil has cooled to a safe temperature (typically less than 110°F or 43°C) before taking an oil sample, changing oil or servicing the hoist.

Prepare hoist by cleaning drain area to obtain an uncontaminated sample. Operate hoist in both directions for one or two minutes to thoroughly mix the gear oil. Take sample from midstream flow of oil to obtain an accurate representation of the oil condition. After taking the oil sample, continue with oil change or refill hoist gear cavity to proper level with recommended lubricant.

General Guidelines for Iron Contaminant Level

100-500 ppm

Normal

500-800 ppm

Caution - Abnormal Sample. Change oil and retake sample after 50 hours of operation. If second sample is above 500 ppm, remove hoist from service and perform tear-down inspection to determine source of contamination.

800+ ppm

Unacceptable. Remove hoist from service and perform tear-down inspection to determine source of contamination.

NOTE: Iron contaminant levels will be on high side of "Normal" during initial break-in.

Equally important as level of contamination is a change in level of contamination. An effective oil analysis program should provide the technician with a view of the progression of wear or a trend. If a sample shows a sudden rise in contaminant level action should be taken to determine what has changed.

NOTE: Oil analysis alone cannot detect nor warn against a fatigue failure.

Brake Test Procedure

These planetary hoists have a spring applied, hydraulically released, multiple disc brake inside the hoist housing. This brake holds a suspended load when the directional control valve is in neutral, or when hydraulic power is lost. A load cannot be lifted or lowered, however, without applying hydraulic pressure to the release port and releasing the brake.

(Test to be performed with no load on the hoist)

Remove and cap or plug the brake release line from fitting in the hoist brake release port.

With hydraulic power unit running, move directional control valve handle slowly to the full open, lowering position.

Increase the engine speed, if necessary, to bring system pressure up to the relief valve setting. The hoist drum should remain stationary.

If the hoist drum rotates, the hoist should be disassembled and the brake components should be examined for wear. In addition, the brake springs should be measured for the correct free length in those hoist using helical compression springs.

Replace any parts showing excessive wear and any spring whose length is shorter than the minimum shown in the applicable hoist Service Manual.

Reassemble the brake and hoist and repeat the above steps.

When testing is complete, reattach the brake release line to the brake release port.

Motor, Motor Control Valve, and Brake

Description

Each hoist has a hydraulic motor, a motor control valve, a brake cylinder, and a brake clutch which controls motion of the hoist's drum. These parts mount on or in the gearbox. The hydraulic motor connects to the hoist's brake, which in turn connects to the gear train of the hoist. The entire hoist assembly must be removed from the crane to service the brake cylinder and clutch.

Removal

1. Power-wash the hoist on the motor side to wash away potential contaminants from the drive components of the hoist.
2. Drain the oil from the hoist gearbox. Once oil is drained, reinstall the plug or hose at bottom of sight glass.
3. Tag and disconnect the hydraulic lines from the motor and the motor control valve. Cap or plug all lines and openings.
4. Remove the bolts and washers to free the motor and motor control valve from the brake cylinder and brake

clutch, which are in the motor control valve gearbox. Remove the motor and motor control valve as a unit. Discard the O-ring.

5. Cover the motor opening in the brake cylinder to protect drive components inside the hoist drum. As needed, secure the brake clutch from inside the brake cylinder.

Installation

1. Uncover the motor opening in the gearbox. Verify these parts are clean.
2. Install a replacement O-ring on the motor's pilot after lubricating it with gear oil or petroleum jelly.
3. Engage the motor shaft to the input shaft of the gearbox. Secure the motor and brake valve to the gearbox with bolts and washers. Torque bolts to 40 Nm (29.5 lb-ft).
4. Connect the hydraulic lines to the motor and brake valve as tagged during removal.
5. Fill the gearbox with oil. Refer to the hoist filling procedures on page *Hoist Lubrication*, page 9-21.

Hoist Rotation and Minimum Wrap Indicator System

Description

The main and auxiliary hoists are each equipped with an encoder (Figure 4-3) and (Figure 4-4) that is part of the hoist rotation and minimum wrap indicator systems. The encoder is mounted to the end of each hoist and senses the rotation of the drum.

Hoist Rotation Indicator

The hoist rotation indicator system provides the operator with a touch indication of the hoist drum rotation so he or she knows if and at what speed the hoist drum is rotating. The system also displays symbols on the rated capacity limiter (RCL) display and crane control system (CCS) display indicating which hoist is operating and in what direction it is rotating (hoist up or hoist down).

The hoist rotation indicator system uses a solenoid to provide a physical indication to the operator of hoist operation. Actuation of the indicator is controlled by the CAN bus modules from input supplied by the hoist drum encoder. The pulsing solenoid is located in the main and auxiliary hoist joystick handles and provides feedback proportional to the hoist line speed by pulsing the back of the hoist joystick. The solenoid will cease operation at high line speeds to prevent damage to the solenoid.

Minimum Wrap Indicator

The minimum wrap indicator system uses the main and auxiliary hoist encoders to indicate when there are a minimum number of wraps of cable remaining on the respective hoist. When a minimum number of wraps of cable are reached on the main or auxiliary hoist, the crane control

system will sound a buzzer in the cab, cut-out the hoist down function, and display the minimum wrap symbol on the RCL display to indicate that a minimum number of wraps of cable remain on the respective hoist. The encoder must be properly adjusted for this system to function properly. Refer to *Adjusting Minimum Wrap Switch*, page 4-8.

NOTE: If using synthetic rope, the minimum wrap indicator system uses the hoist encoders to indicate when there are eight wraps of cable remaining on the respective hoist.

Maintenance

General



DANGER

Burn Hazard!

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.

Adjusting Minimum Wrap Switch

1. Install hoist rope on the hoist.
2. Reeve hook block with four parts of line from hoist to be adjusted.
3. Fully raise and extend boom.
4. Lower hook block until three wraps of rope remain on hoist drum.
5. Remove four screws and cover from switch.
6. Rotate adjustment screw (2) until switch activates. Service software may be used to monitor an indicator light on the appropriate display.
7. Raise hook block until there are ten rope wraps on hoist drum.
8. Lower hook block to verify lower limit switch actuates with a minimum number of rope wraps on hoist drum.
9. Correct setting of switch if necessary.
10. Install cover and secure with four screws.
11. Repeat for auxiliary hoist.

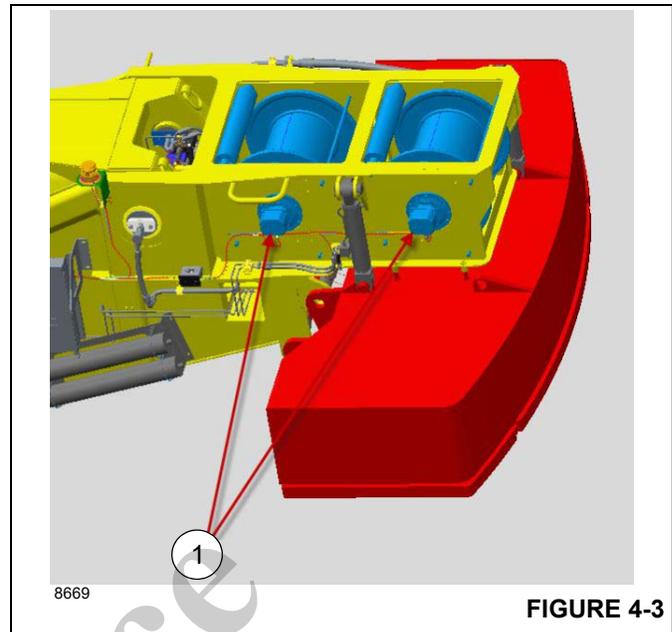


FIGURE 4-3

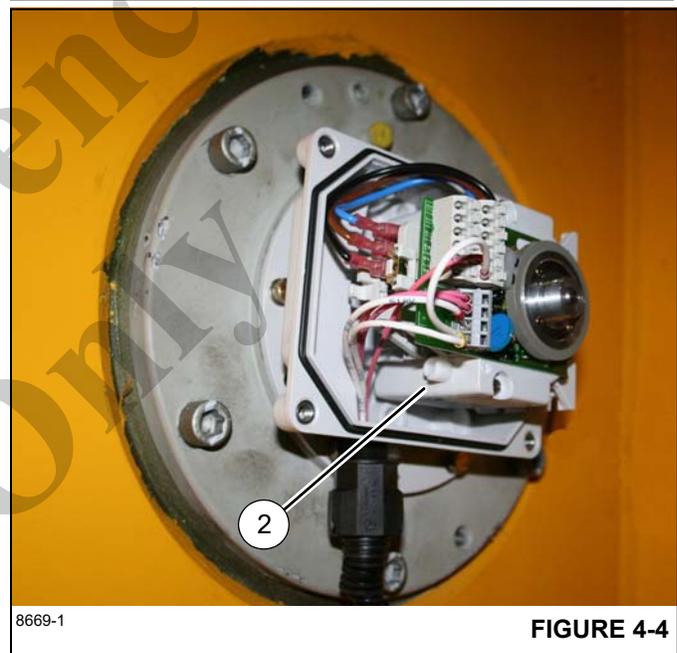


FIGURE 4-4

Hoist Control Valves

Description

NOTE: For more detailed information, refer to *Superstructure Valves*, page 2-26 in Section 2 - , page 2-28.

Hydraulic Hoist Motor Control Valve

The hydraulic hoist motor control valve is mounted on the hoist motor and is designed to provide an even flow of oil to the hoist motor in both directions. This is a different valve than the hoist brake valve that applies and releases the hydraulic piston and hydraulic cylinder.

Hoist Directional Control Valve

The hoist directional control valve is used to control the operation of the hoist. It is a four-way, pilot operated valve and is mounted on the right side of the turntable.

BOOM REMOVAL

NOTE: The boom, without any boom extension, weighs about 10,577 kg (23,320 lbs).

1. Extend and set the outriggers to level the crane and ensure the boom is fully retracted and in a horizontal position over the front of the crane.
2. Counterweight must be removed from the crane.
3. Rotate turntable so boom is over the front of the crane and engage the turntable lock pin.
4. Fully retract and lock the telescopic sections.
5. If installed, remove the boom extension and auxiliary nose.



CAUTION

Injury Hazard!

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

6. Remove the hook block or overhaul ball and wind all the wire rope onto the hoist drum.
7. Elevate boom to allow access to the telescope hose disconnects.
8. Disconnect main telescope hydraulic lines. Tag and disconnect the telescopic hydraulic lines from the compact block, if equipped, also disconnect the hydraulic boom extension hydraulic lines from the compact block.

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

9. Lower the boom to zero degrees.
10. Move a crane hook to the front above the lift cylinder. Attach a strap under the lift cylinder and lift it (Figure 4-5).

NOTE: Install a piece of wood to prevent damaging the electrical harness as shown in the red circle (Figure 4-5).

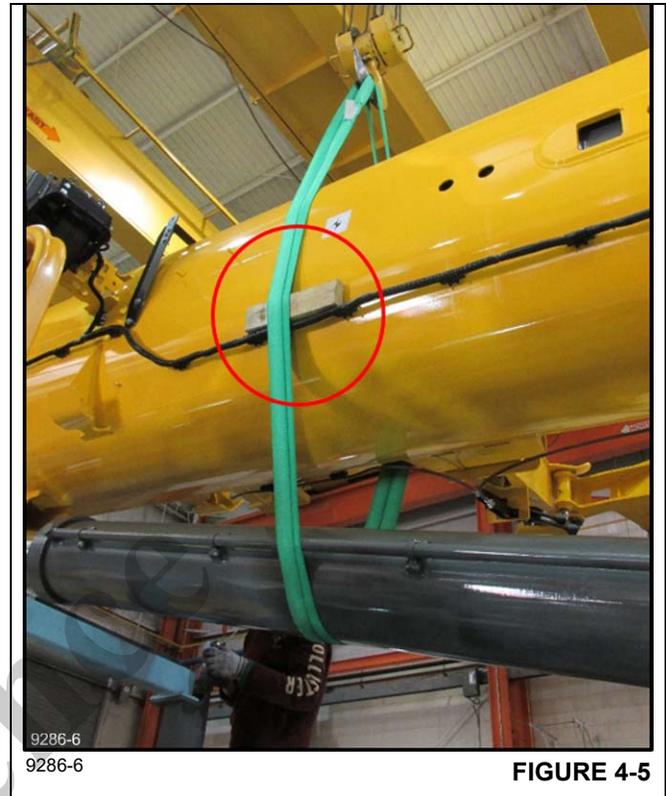


FIGURE 4-5

11. Prior to disconnecting the lift cylinder, install blocking under the lift cylinder.
12. Lower the boom so that the lift cylinder is supported on the blocking.
13. Remove the bolt that secures the pin (1), (Figure 4-6).
14. Unscrew stop bolts (1), (Figure 4-8) on the other side of boom.

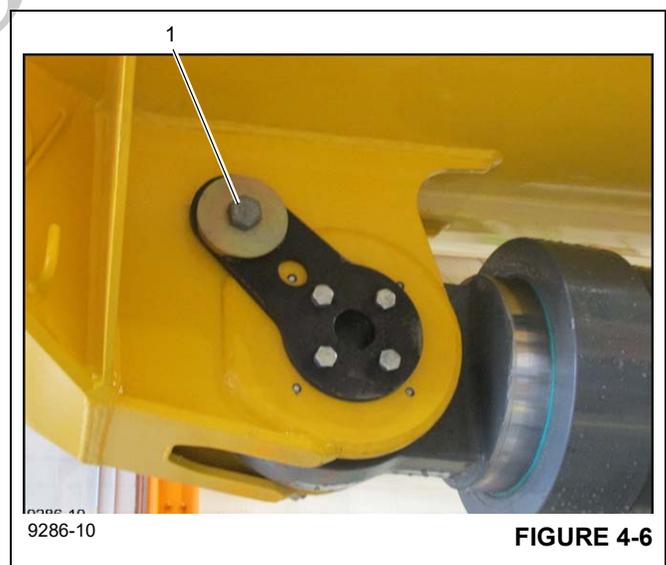


FIGURE 4-6

15. Attach two cranes to the boom (Figure 4-7).



9286



9286-1

FIGURE 4-7

16. Slightly lift the boom to remove weight on the pivot pins.
17. Pull lift cylinder pin (2), (Figure 4-8) far enough out that the cylinder (3), (Figure 4-8) will clear it. Tag and remove the shims and bushing/plates on the pin.



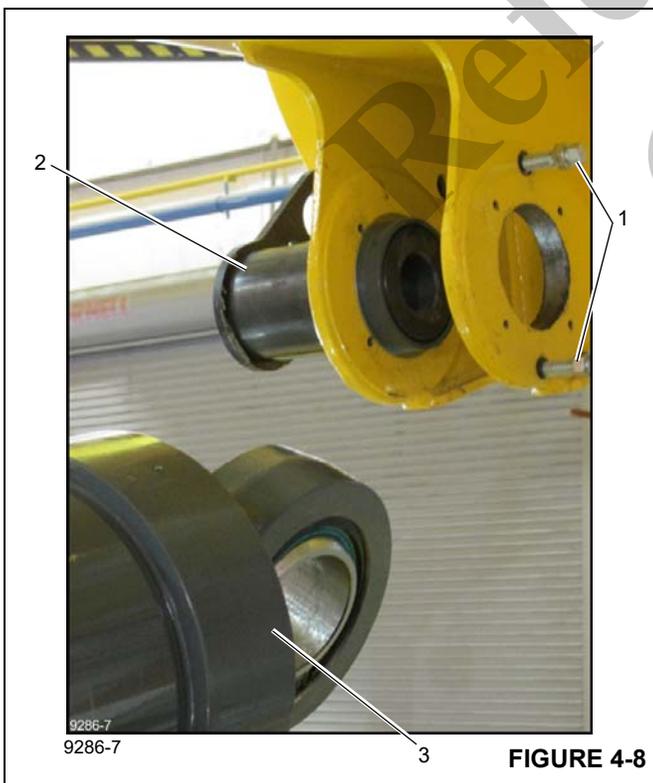
WARNING

Crushing Hazard!

Make sure that the lifting device is capable of supporting the boom assembly.

Severe injury or death may result.

18. Reach in access hole at top of boom, remove pins on stop plates (Figure 4-9).



9286-7

9286-7

3

FIGURE 4-8



9286-4

FIGURE 4-9

19. Using a mallet and block of wood drive the pivot pins fully in.
20. The weight of the boom is now held by the support cranes.
21. Raise the boom clear of the crane and lower it to the ground or trailer. Set cribbing to support the boom and prevent tipping.
22. Remove rigging and chains from the boom.

BOOM INSTALLATION

NOTE: The following procedure applies to the entire boom assembly that has been totally removed from the crane.

The boom, without any boom extension, weighs about 10,577 kg (23,320 lbs).



DANGER

Crushing Hazard!

Make sure that blocking and lifting devices are capable of supporting the boom assembly.

Block the boom before doing any work under the boom.

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

1. With the machine properly set up on outriggers, attach two cranes to the boom (Figure 4-7) and suspend the boom over the machine.
2. Make sure that the pins are pushed all the way in (Figure 4-10) and will not get caught up during lowering into the turntable.
3. Lower the rear of the boom into position. Align the boom pivot mounting holes with mounting holes in the turntable. Make sure that all hydraulic and electrical cables are out of the way so they will not be damaged.



9286-2

FIGURE 4-10

4. Lubricate the pivot bushings in the turntable.

NOTE: The boom may need to be raised or lowered to aid in the installation of the boom pivot shafts.

5. Apply anti-seize compound to the boom pivot shafts.
6. Using a long bar, insert through pin, and tap backside of opposite pin (Figure 4-11). Install pin on non-cab side first. Continue until pin comes through mounting bushing and is flush with the outside.

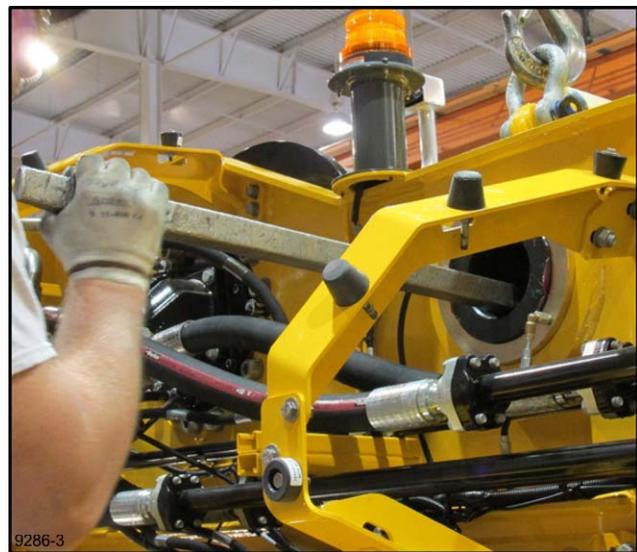
9286-3
9286-3

FIGURE 4-11

7. Reach in access hole at top of boom, install pins on stop plates already installed on back of mounting pins (Figure 4-12).

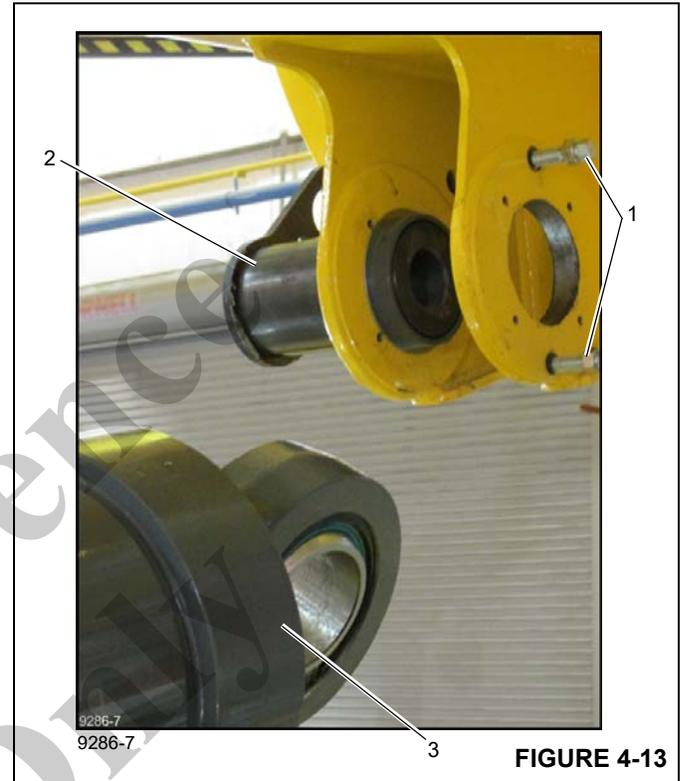
9286-4
9286-4

FIGURE 4-12

8. Prior to starting the lift cylinder to boom installation, make sure the lift cylinder is securely resting on the blocking.
9. Move the rear crane hook to the front above the lift cylinder. Attach a strap under the lift cylinder and lift it (Figure 4-5).

NOTE: Install a piece of wood to prevent damaging the electrical harness as shown in the red circle (Figure 4-5).

10. Run stop/adjustable bolts (1), (Figure 4-13) on the side of the weldment completely out.
11. Pull lift cylinder pin (2), (Figure 4-13) far enough out that the cylinder (3), (Figure 4-13) will clear it. Install shim and bushing/plate on the pin.

9286-7
9286-7

3

FIGURE 4-13

12. Have an operator in the crane extend the lift cylinder until aligned with boom mounting holes.

NOTE: This should be carefully controlled. If the lift cylinder rod is extended too far, it cannot be retracted using the main directional control valve.

NOTE: This may take a combination of both cranes lifting the boom and lifting the cylinder up and down and the operator in the crane moving the cylinder in and out.

CAUTION

Equipment Damage Hazard!

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

13. Install shims and bushing/plate in other side of lift cylinder.



CAUTION
Pinch Hazard!

Use caution when installing pin, high pinch point risk.

14. Tap lift cylinder pin all the way in, be sure pin is properly aligned with bolt hole on side of boom (Figure 4-14).



FIGURE 4-14

15. Install bolt to secure pin (1), (Figure 4-15).
16. Adjust stop bolts on other side of boom.

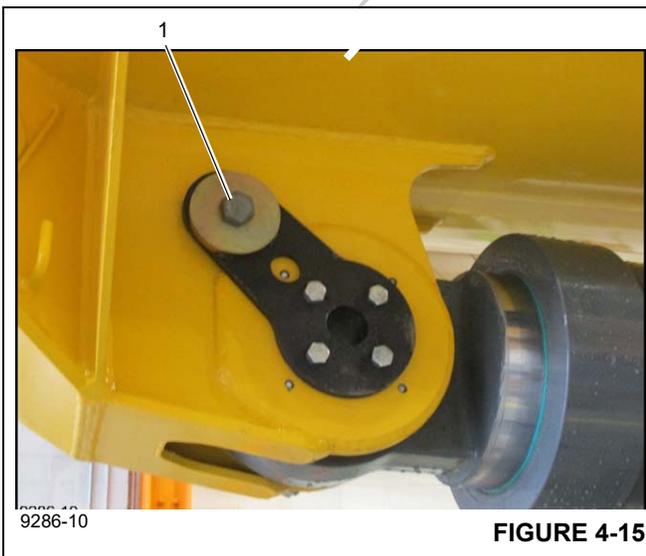


FIGURE 4-15

17. Connect the hydraulic lines as tagged before removal from the boom to the turntable.
18. Connect the electrical cables from the boom to the turntable.

Functional Check

1. Activate the hydraulic system and check for proper operation and leaks.
2. Make sure that the boom will extend and retract properly.

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

3. Make sure the lift cylinder does not allow the boom to drift down

BOOM NOSE SHEAVES

Do not attempt to work on the boom without experienced supervision.



DANGER
Accident Hazard!

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

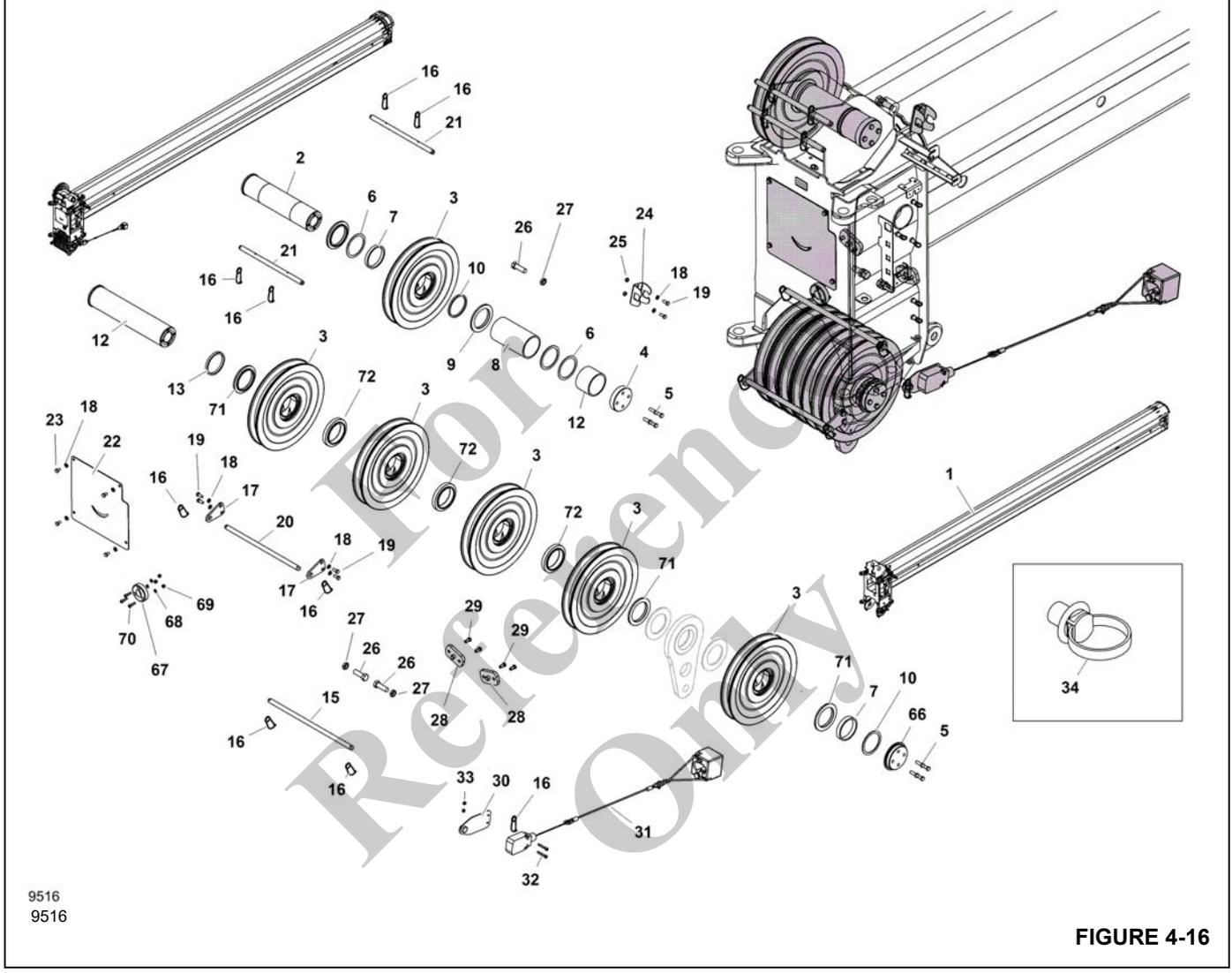
Boom Nose Sheaves Removal

1. Remove the securing pins (16), (Figure 4-16) from the cable retainer pins (15, 20, 21), (Figure 4-16) and remove the cable retainer pins from the upper and lower part of the boom nose.
2. Remove the two hex head screws (5), (Figure 4-16) securing the cover plate (4), (Figure 4-16) to the upper boom nose axle (2), (Figure 4-16). Remove the cover plate.

NOTE: The boom nose sheave shafts weigh approximately 12.5 kg (27.5 lb) each. The boom nose sheaves weigh approximately 17.4 kg (38 lb) each.

3. Carefully pull the upper boom nose sheave shaft (6), (Figure 4-16) from the boom nose, removing the spacers, and boom nose sheaves (4), (Figure 4-16). **Note** the quantity of the spacers for installation.
4. Repeat Steps 2 and 3 and remove the lower boom nose sheave shaft.
5. Remove the shim, washer, keyed washer and locknut from both sheave shafts.

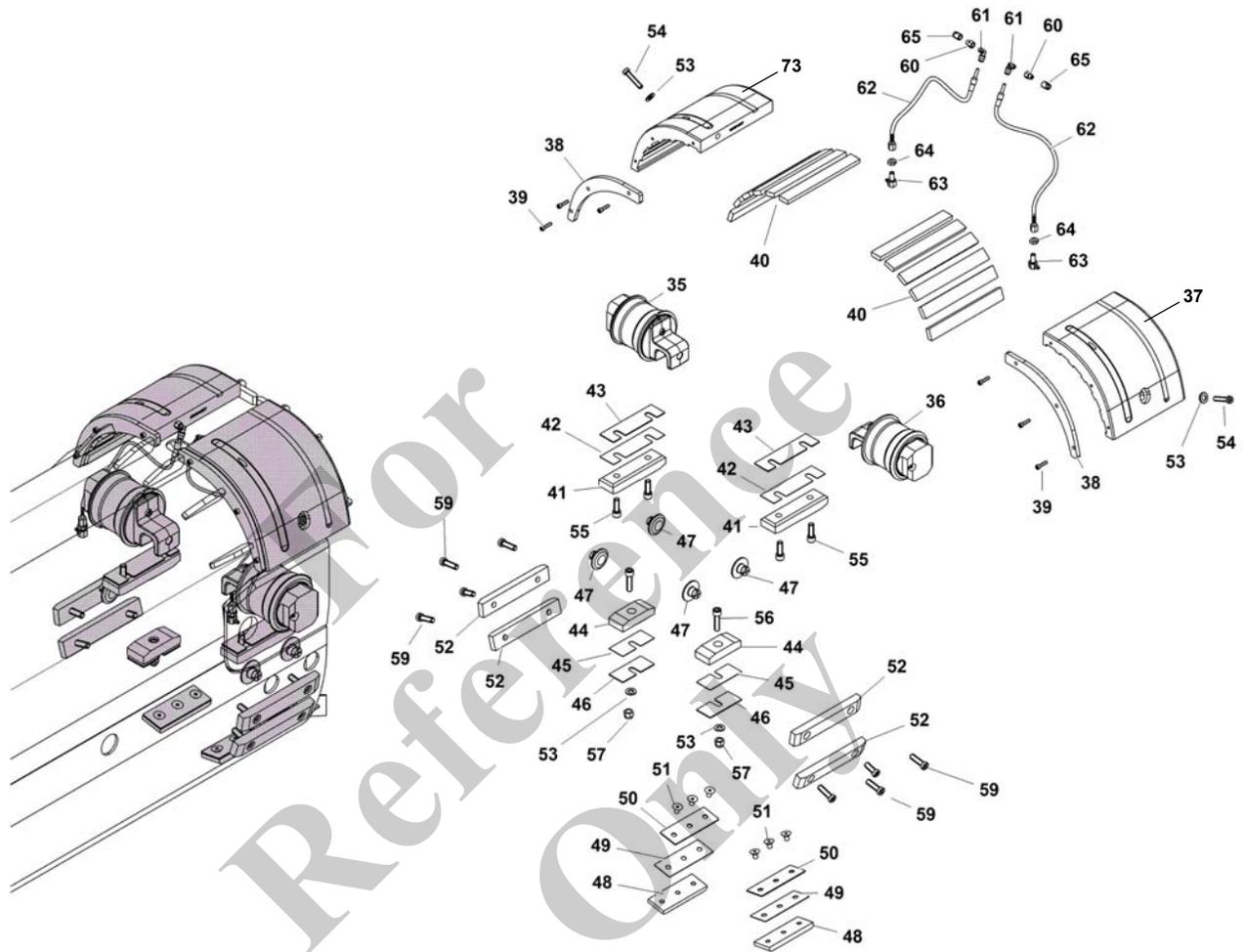
Telescope Section 5 Assembly



9516
9516

FIGURE 4-16

Telescope Section 5 Assembly (Continued)



9517
9517

FIGURE 4-16 continued

4

Item Number	Description
1	TELESCOPIC PART 5
2	AXLE
3	SHEAVE
4	COVER PLATE
5	HEX HEAD SCREW
6	SHIM,2MM
7	SPACER RING
8	RING, SPACER
9	SPACER RING
10	SHIM RING
11	SPACER RING
12	AXLE
13	SPACER RING
14	SPACER RING
15	PIN
16	SECURING PIN
17	PLATE
18	WASHER
19	HEXAGON HEAD SCREW
20	PIN
21	PIN
22	PLATE
23	HHCS M10X16 8.8
24	OUTER STOCK SUPPORT
25	HEX NUT
26	HEXAGON HEAD SCREW
27	HEXAGON THIN NUT
28	SPACER
29	SOCKET-HEAD SCREW
30	SHACKLE
31	LIMIT SWITCH - WEIGHT ASSEMBLY
32	SHCS M8x50 8.8
33	HEX NUT M8 8
34	CABLE CLIP
35	LOCKING UNIT ASSY
36	LOCKING UNIT ASSY
37	WEAR PAD TELE 5 ASSY.
38	PLATE

Item Number	Description
39	CAP SCREW
40	STRIP
41	SLIDER SUSTAGLIDE
42	PLATE
43	PLATE
44	SLIDER SUSTAGLIDE
45	PLATE
46	PLATE
47	GUIDE PILOT
48	SLIDER SUSTAGLIDE
49	FILL PLATE
50	FILL PLATE
51	SFS, M10X16
52	WEAR PAD SUSTAGLIDE
53	WASHER, 12 FLAT
54	SHCS M10X50
55	SHCS M12x35 8.8
56	CAP SCREW
57	HEX L NUT M12
58	SOCKET-HEAD SCREW
59	SOCKET-HEAD SCREW
60	ADAPTER
61	ANGLE PIPE UNION
62	LUBRICANT HOSE
63	PIPE UNION
64	NUT, THIN
65	INSERT
66	COVER
67	WEAR PAD
68	F WASHER
69	HEXAGON NUT M8
70	SHCS M8X30
71	DISTANCE RING
72	DISTANCE RING
73	WEAR PAD TELE 5 ASSY.

Boom Nose Sheaves Installation

Refer to (Figure 4-16) when performing this installation.

NOTE: This procedure can be greatly simplified if two technicians are used. One technician to hold the sheave in place and the other to insert the spacers and axle.

1. Install the rings (7, 10, 13), spacers (72) and sheaves (3) onto the axle (12) while installing the axle into the lower boom nose.
2. Secure the axle with the cover (66) and hex head screws (5).
3. Repeat Steps 1 and 2 for the upper boom nose sheaves and axle.
4. Install the cable retainer pins into the upper and lower part of the boom nose and secure in place with the securing pins.

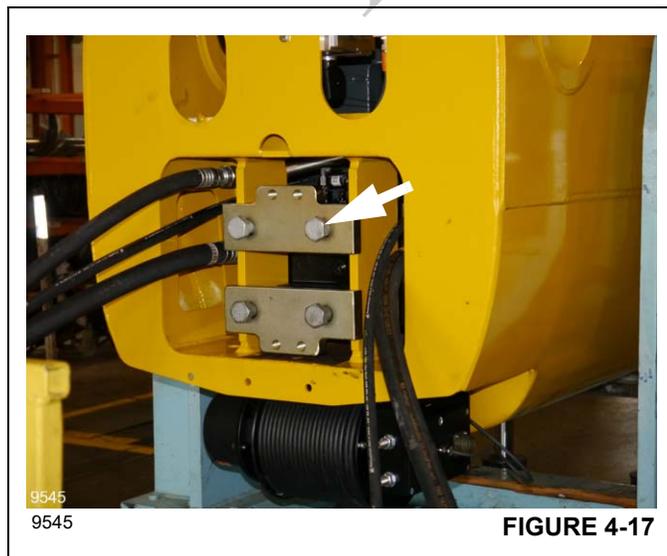
BOOM DISASSEMBLY

Do not attempt to work on the boom without experienced supervision.



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

1. Pin the cylinder to Tele 1.
2. Remove the four cylinder retaining bolts (Figure 4-17) and two retaining plates.



3. Climb into the base section and secure the hoses to the cylinder to keep them from being damaged when removing the tele cylinder.
4. Remove the sliders, strips and plates (28, 29, 34, 35, 36), (Figure 4-24 continued 2).
5. Remove the sliders, holders, strips and plates (30, 31, 32, 33, 66, 37, 38), (Figure 4-24 continued 2).
6. Remove Tele Section 1 from the Base Section (1), (Figure 4-24).
7. Remove the tele power plug (1), (Figure 4-18).
8. Remove the tele power cable strain relief (2), (Figure 4-18).



9. Remove the Tele cylinder.
10. Remove the wear pads, plates, and strips (29, 30, 32, 62), (Figure 4-23), as necessary.
11. Remove the sliders, fill plates, plates, and guide pilots (33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 45, 46, 47), (Figure 4-23) as necessary. Tag the plates and sliders as to their location for reassembly.
12. Remove the wear pads, holders, strips and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14), (Figure 4-23).
13. Remove the rope protection bar (2), (Figure 4-23).
14. Remove the guide (162), (Figure 4-23).
15. Remove Tele Section 2 (1), (Figure 4-22).
16. Remove the wear pads, holders, strips, and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14), (Figure 4-22).
17. Remove the sliders, fill plates, plates, and guide pilots (33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 45, 46, 47), (Figure 4-22) as necessary. Tag the plates and sliders as to their location for reassembly.

18. Remove the wear pads, plates, and strips (29, 30, 32, 59), (Figure 4-22) as necessary.
19. Remove the rope protection bar (2), (Figure 4-22).
20. Remove the guide (162), (Figure 4-22).
21. Remove Tele Section 3 (1), (Figure 4-21).
22. Remove the wear pads, holders, strips, and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14), (Figure 4-21).
23. Remove the sliders, fill plates, plates, and guide pilots (33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 45, 46, 47), (Figure 4-21) as necessary. Tag the plates and sliders as to their location for reassembly.
24. Remove the wear pads, plates, and strips (29, 30, 32, 59), (Figure 4-21) as necessary.
25. Remove the rope protection bar (2), (Figure 4-21).
26. Remove the guide (162), (Figure 4-21).
27. Remove Tele Section 4 (1), (Figure 4-20).
28. Remove the wear pads, holders, strips, and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14), (Figure 4-20).
29. Remove the sliders, fill plates, plates, and guide pilots (33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 44, 45, 46, 47), (Figure 4-20) as necessary. Tag the plates and sliders as to their location for reassembly.
30. Remove the wear pads, plates, and strips (29, 30, 32, 59), (Figure 4-20) as necessary.
31. Remove the rope protection bar (2), (Figure 4-20).
32. Remove the guide (162), (Figure 4-20).
33. Remove Tele Section 5 (1), (Figure 4-16).
34. Remove the wear pads, strips, and plates (37, 38, 40, and 73), (Figure 4-16).
35. Remove the sliders, plates, guide pilots, fill plates and wear pads (41, 42, 43, 44, 45, 46, 47, 48, 49, 50, and 52), (Figure 4-16). Tag the plates, sliders, fill plates, and wear pads as to their location for reassembly.

BOOM ASSEMBLY

Do not attempt to work on the boom without experienced supervision.



DANGER

Accident Hazard!

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

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

Apply multipurpose grease (MPG) to all wear surfaces.

Use standard torque values specified in Section 1 of this Manual unless otherwise specified.

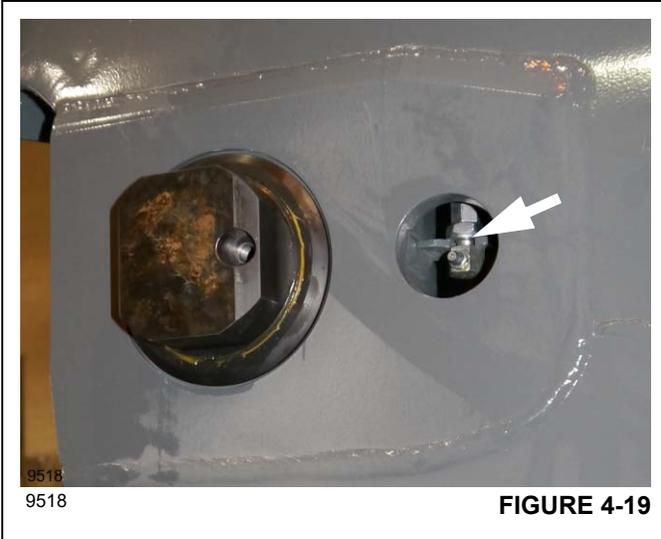
NOTE: Wear Pads. When installing upper and lower side wear pad, use shims as necessary so wear pad is within 1.52 mm (0.06 inch) from side plate of next inner section. Use equal number of shims on each side.

If wear pad shims were previously removed, place shims in same locations that was noted during removal.

Telescope Section 5 Assembly

Refer to (Figure 4-16) when assembling this section.

1. Install the plates (49, 50) and sliders (48).
2. Install the wear pads (52).
3. Install the plates (45, 46) and sliders (44).
4. Install the guide pilots (47).
5. Install the plates (42, 43) and sliders (41).
6. Place the wear pad (37) on the section and insert six strips (40) inside.
7. Secure the wear pad (37) with the plate (38).
8. Install the opposite wear pad (73), strips (40) and plate (38).
9. Assemble the lubrication hoses (60, 61, 62, 65) and connect to the wear pads (37, 73).
10. Attach the thin nuts (64) and pipe unions (63) to the lubrication hoses and secure the hoses to the tabs (Figure 4-19) inside the section.



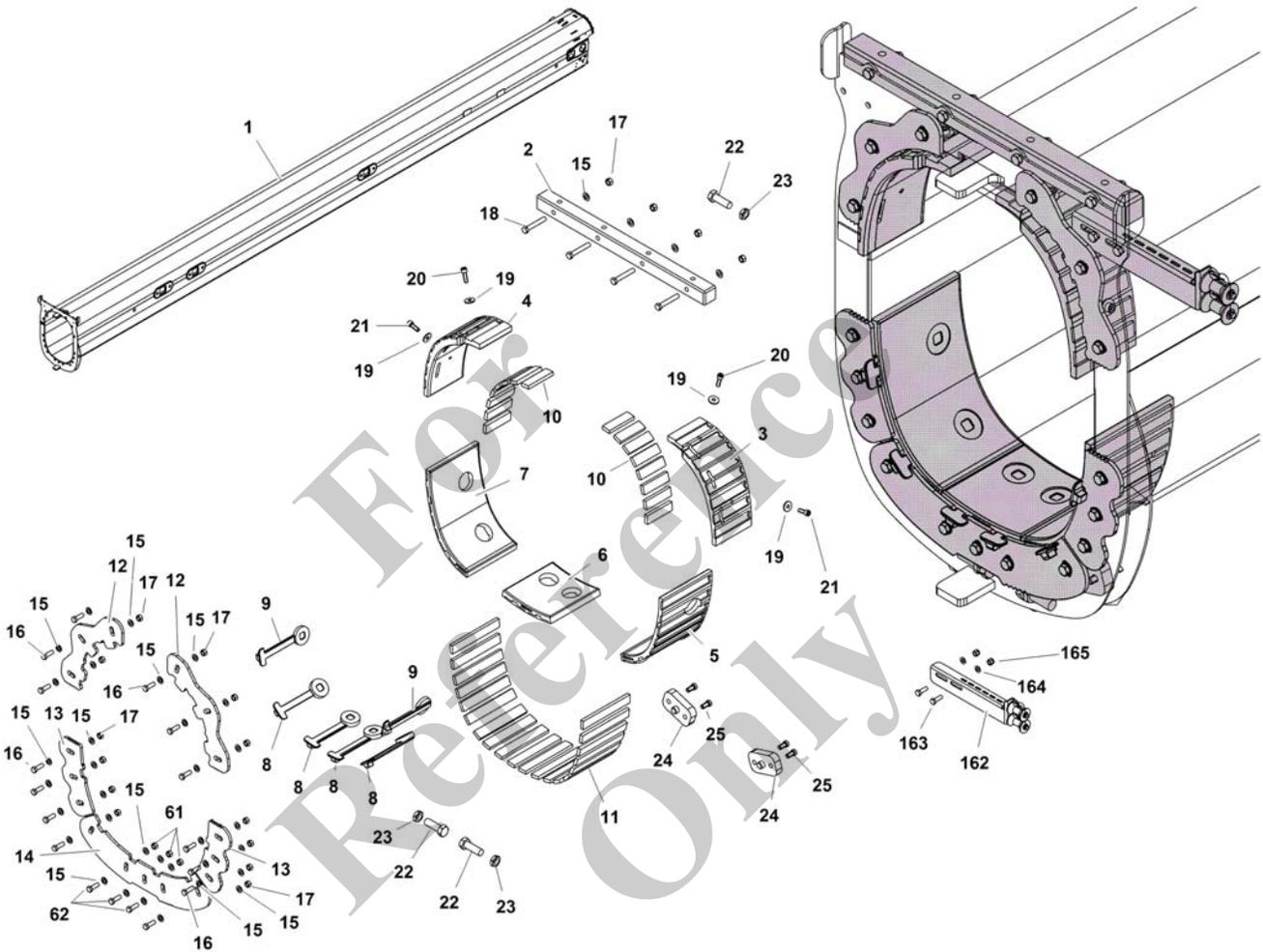
11. Install the locking unit assemblies (35, 36), (Figure 4-16).

12. Insert Section 5 into Section 4 just far enough to measure the gaps between the sliders and wear pads and Section 4. The gaps should be no greater than 1.52 mm (0.06 in). Adjust the gaps by adding or removing plates or using thicker or thinner sliders and wear pads.

13. Insert Section 5 into Section 4 half way.

For
Reference
Only

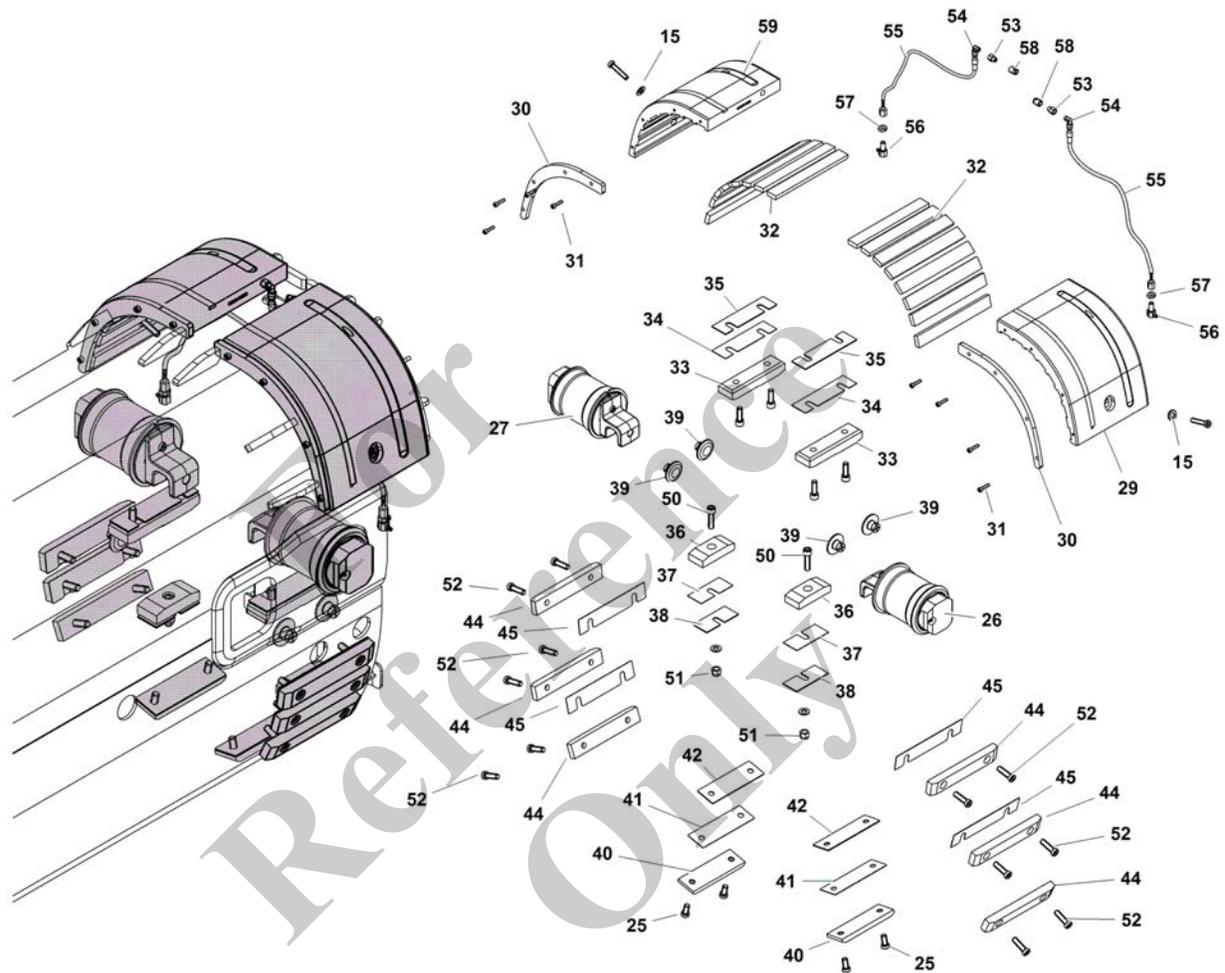
Telescope Section 4 Assembly



9519
9519

FIGURE 4-20

Telescope Section 4 Assembly (Continued)



9519-1
9519-1

FIGURE 4-20 continued

Item Number	Description
1	TELESCOPIC PART 4
2	ROPE PROTECTION
3	WEAR PAD - GREASELESS TELE 4
4	WEAR PAD - GREASELESS TELE 4
5	WEAR PAD - GREASELESS TELE 4
6	WEAR PAD - GREASELESS TELE 4
7	WEAR PAD - GREASELESS TELE 4
8	HOLDER
9	HOLDER
10	STRIP T=11
11	STRIP T=10
12	PLATE
13	PLATE
14	PLATE
15	WASHER, 12 FLAT
16	HHCS M12x35 8.8
17	HEX NUT M12
18	HEXAGON HEAD BOLT
19	WASHER
20	SHCS M10X35 8.8
21	SHCS M10X30 8.8
22	HEXAGON HEAD SCREW
23	HEXAGON THIN NUT
24	SPACER
25	SOCKET HEAD SCREW
26	LOCKING UNIT ASSY
27	LOCKING UNIT ASSY
29	WEAR PAD TELE 4 ASSY
30	PLATE
31	CAP SCREW
32	STRIP T=11
33	SLIDER SUSTAGLIDE
34	PLATE
35	PLATE
36	SLIDER SUSTAGLIDE
37	PLATE
38	PLATE
39	GUIDE PILOT
40	SLIDER

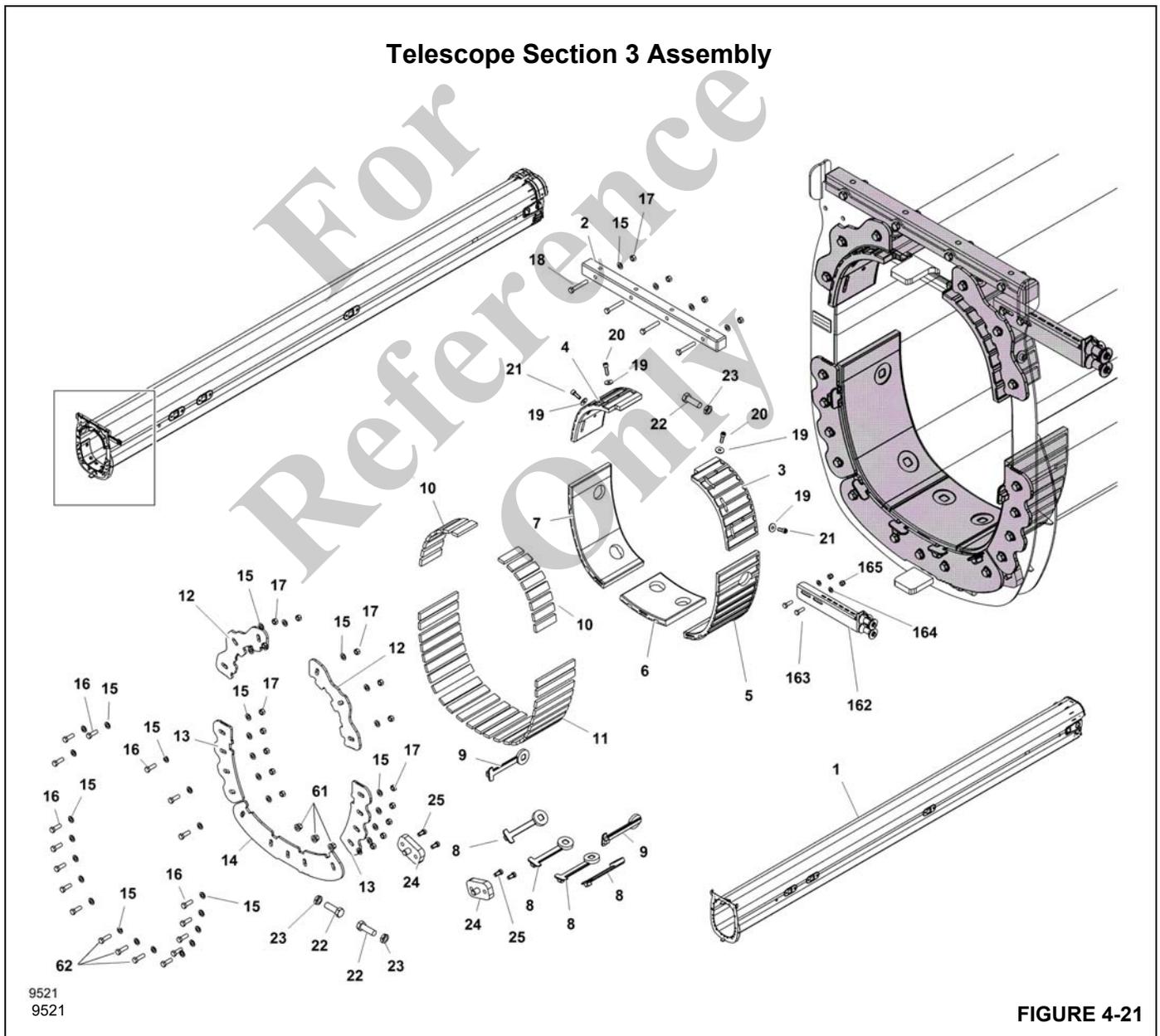
Item Number	Description
41	FILL PLATE - 1 MM
42	FILL PLATE - 2MM
44	WEAR PAD SUSTAGLIDE
45	PLATE
49	SHCS M12x35 8.8
50	CAP SCREW
51	HEX L NUT M12
52	SOCKET-HEAD SCREW
53	ADAPTER
54	ANGLE PIPE UNION
55	LUBRICANT HOSE
56	PIPE UNION, M12X1
57	NUT, THIN
58	INSERT
59	WEAR PAD TELE 4 ASSY
61	FLAT COLLAR NUT M12
62	HEXAGON HEAD SCREW
162	GUIDE
163	CAP SCREW
164	WASHER
165	HEXAGON NUT

Telescope Section 4 Assembly

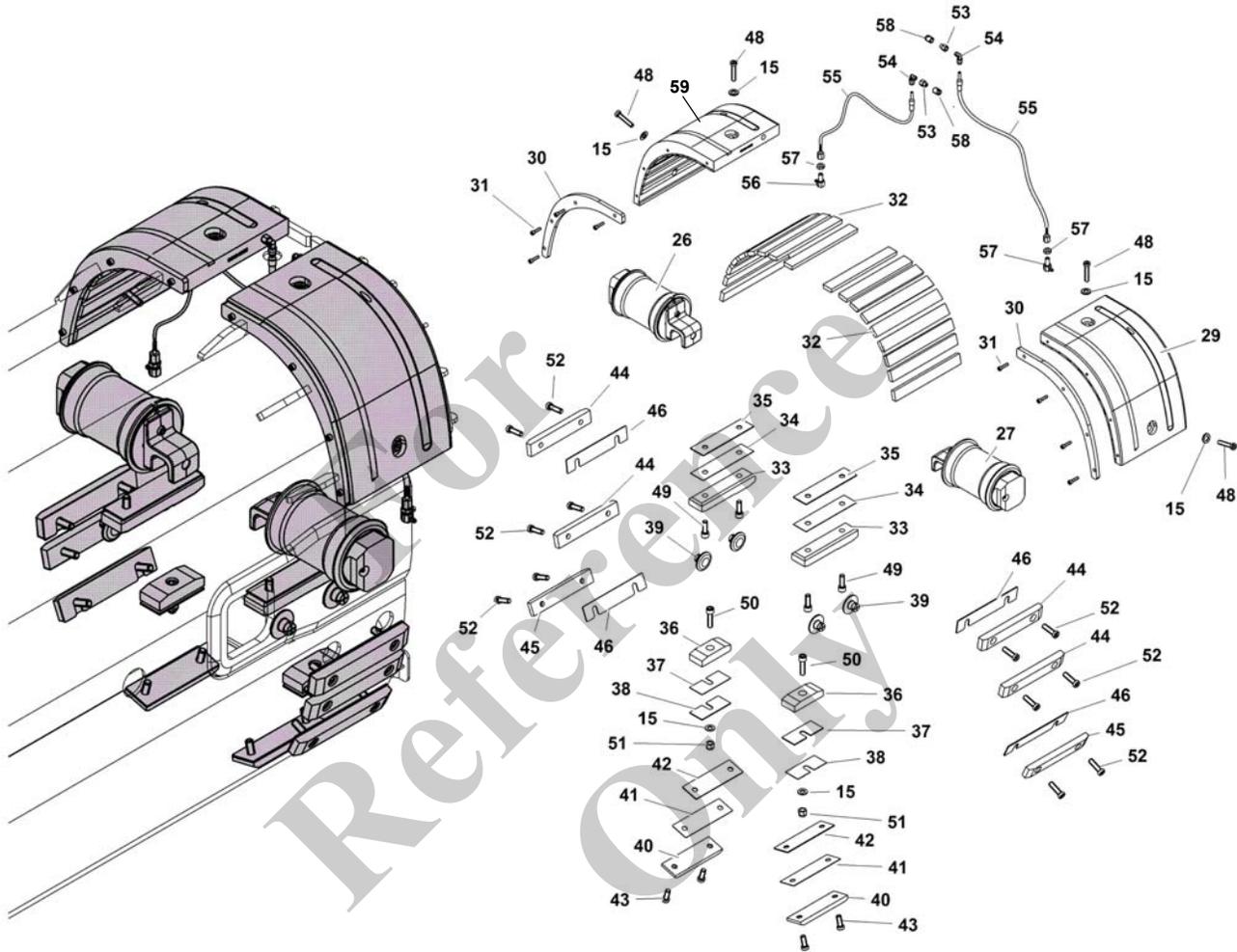
Refer to (Figure 4-20) when assembling this section.

1. Connect a strap to Tele 5, then using an overhead lifting device or another crane, lift Tele 5 so the strips (11), holders (8, 9) and wear pads (5, 6, 7) can be installed.
2. Install the hexagon head screws (22) and hexagon thin nuts (23).
3. Install the spacers (24).
4. Secure the strips and wear pads in place with the plates (13, 14).
5. Lower Tele 5.
6. Install the wear pads (3, 4).
7. Install the strips (10).
8. Secure the strips and wear pads with the plates (12).
9. Install the rope protection bar (2).
10. Install the guide (162).
11. On the opposite end of Tele 4, install sliders (40) and fill plates (41, 42).

12. Install wear pads (44) and plates (45).
13. Install sliders (36) and plates (37, 38).
14. Install the guide pilots (39).
15. Install the sliders (33) and plates (34, 35).
16. Place the wear pad (29) on the section and insert eight strips (32) inside.
17. Secure the wear pad (29) with the plate (30).
18. Install the opposite wear pad (59), strips (32) and plate (30).
19. Assemble the lubrication hoses (53, 54, 55, 58) and connect to the wear pads (29, 59).
20. Attach the thin nuts (57) and pipe unions (56) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (26, 27).
22. Insert Section 5 completely into Section 4.
23. Insert Section 4 into Section 3 just far enough to measure the gaps between the sliders and wear pads and Section 3. The gaps should be no greater than 1.52 mm (0.06 in). Adjust the gaps by adding or removing plates or using thicker or thinner sliders and wear pads.
24. Insert Section 4 into Section 3 half way.



Telescope Section 3 Assembly (Continued)



9521-1
9521-1

FIGURE 4-21 continued

Item Number	Description
1	TELESCOPIC PART 3
2	ROPE PROTECTION
3	WEAR PAD - GREASELESS TELE 3
4	WEAR PAD - GREASELESS TELE 3
5	WEAR PAD - GREASELESS TELE 3
6	WEAR PAD - GREASELESS TELE 3
7	WEAR PAD - GREASELESS TELE 3
8	HOLDER
9	HOLDER
10	STRIP T=11
11	STRIP T=10
12	PLATE
13	PLATE
14	PLATE
15	WASHER, 12 FLAT
16	HHCS M12x35 8.8
17	HEX NUT M12
18	HEXAGON HEAD BOLT
19	WASHER
20	SHCS M10X35 8.8
21	SHCS M10X30 8.8
22	HEXAGON HEAD SCREW
23	HEXAGON THIN NUT
24	SPACER
25	SOCKET-HEAD SCREW
26	LOCKING UNIT ASSY
27	LOCKING UNIT ASSY
29	WEAR PAD TELE 3 ASSY.
30	PLATE
31	CAP SCREW
32	STRIP T=11
33	SLIDER
34	FILE PLATE
35	FILL PLATE
36	SLIDER SUSTAGLIDE
37	PLATE
38	PLATE
39	GUIDE PILOT

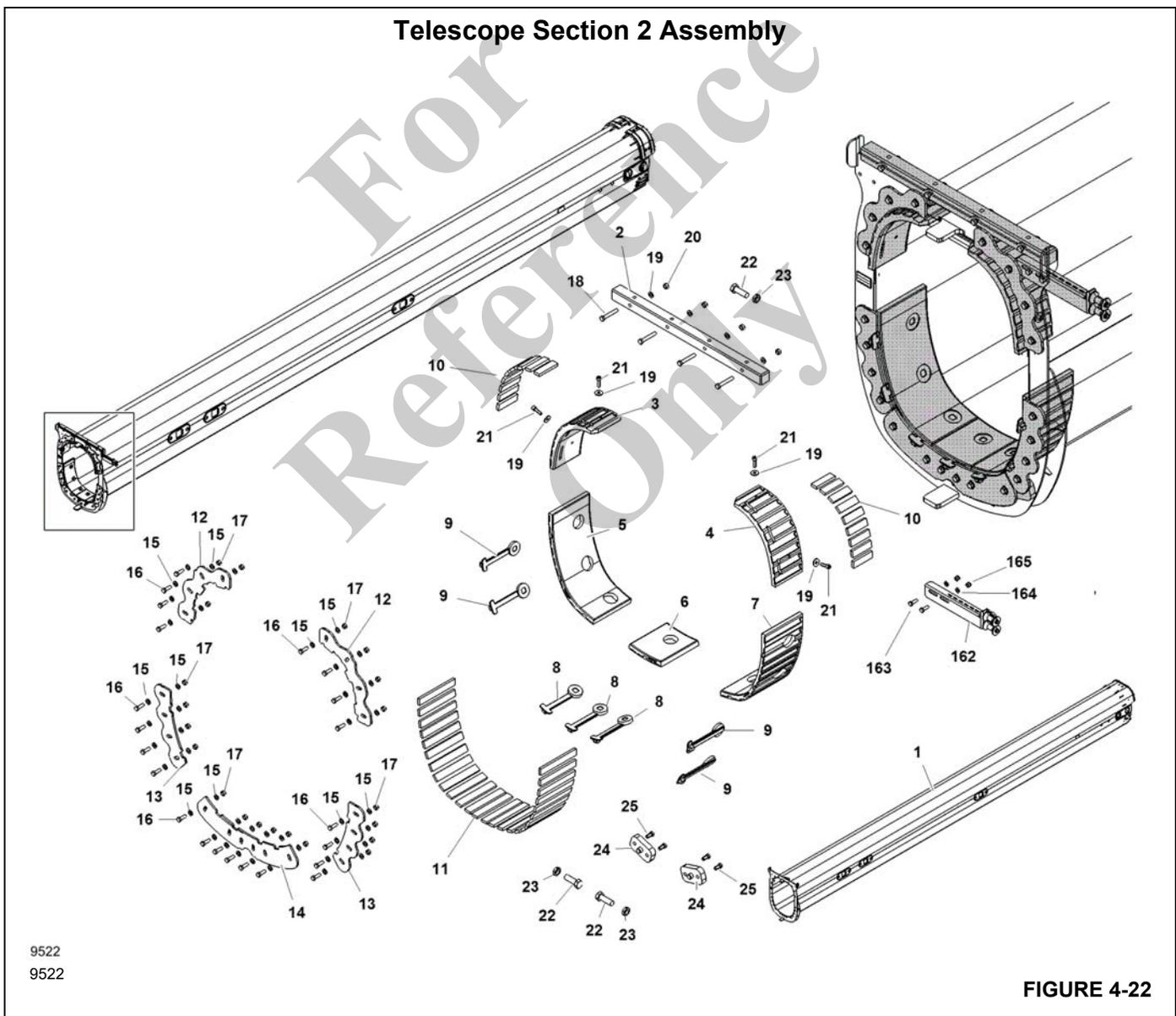
Item Number	Description
40	SLIDER
41	FILL PLATE - 1 MM
42	FILL PLATE - 2MM
43	SOCKET-HEAD SCREW
44	WEAR PAD SUSTAGLIDE
45	WEAR PAD SUSTAGLIDE
46	PLATE
48	SHCS M10X50
49	SHCS M12x35 8.8
50	CAP SCREW
51	HEX L NUT M12
52	SOCKET-HEAD SCREW
53	ADAPTER
54	ANGLE PIPE UNION
55	LUBRICANT HOSE
56	PIPE UNION, M12X1
57	NUT, THIN
58	INSERT
59	WEAR PAD TELE 3 ASSY.
61	FLAT COLLAR NUT M12
62	HEXAGON HEAD SCREW
162	GUIDE
163	CAP SCREW
164	WASHER
165	HEXAGON NUT

Telescope Section 3 Assembly

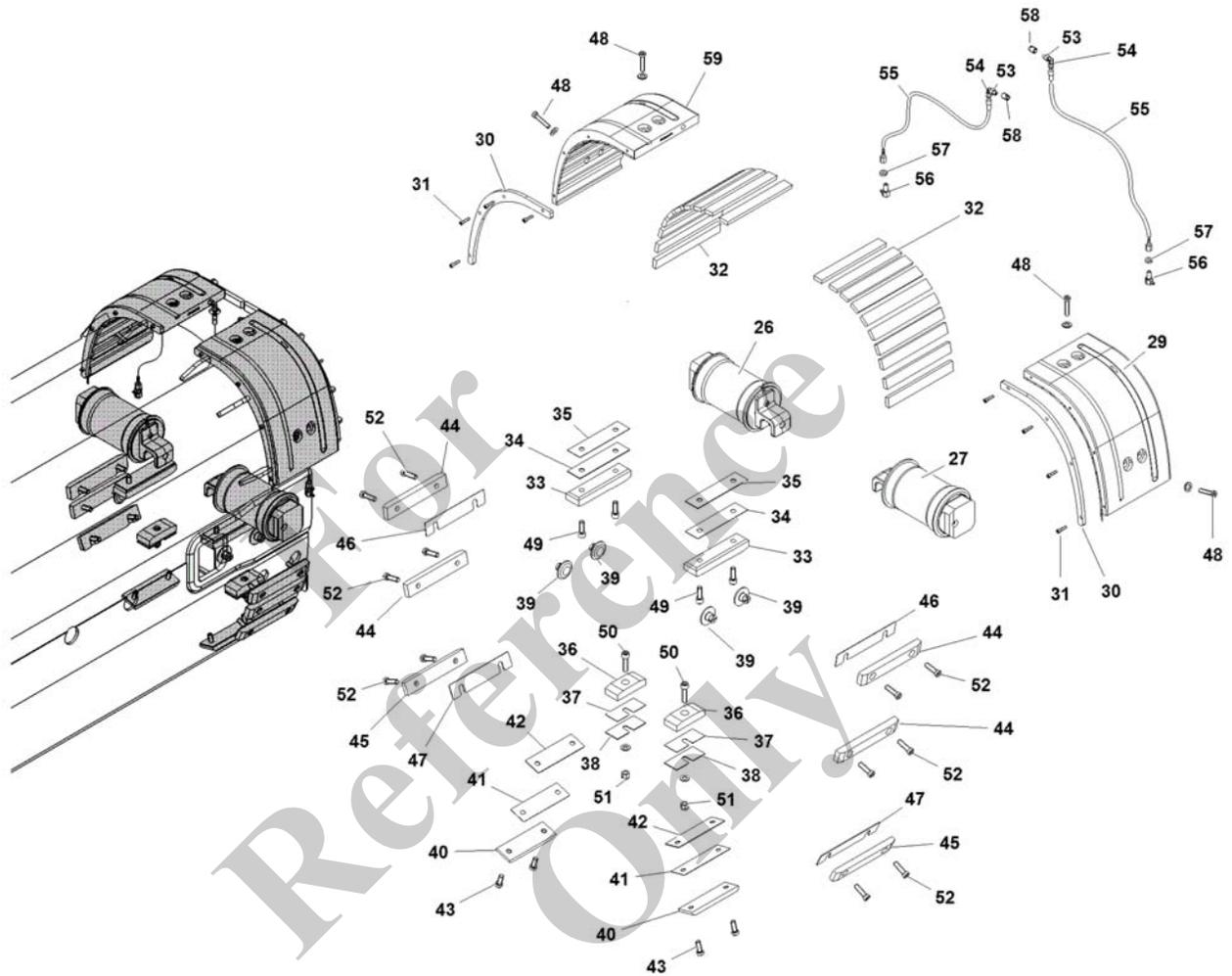
Refer to (Figure 4-21) when assembling this section.

1. Connect a strap to Tele 4, then using an overhead lifting device or another crane, lift Tele 4 so the strips (11), holders (8, 9) and wear pads (5, 6, 7) can be installed.
2. Install the hexagon head screws (22) and hexagon thin nuts (23).
3. Install the spacers (24).
4. Secure the strips and wear pads in place with the plates (13, 14).
5. Lower Tele 4.
6. Install the wear pads (3, 4).
7. Install the strips (10).

8. Secure the strips and wear pads with the plates (12).
9. Install the rope protection bar (2).
10. Install the guide (162).
11. On the opposite end of Tele 3, install sliders (40) and fill plates (41, 42).
12. Install wear pads (44) and plates (45).
13. Install sliders (36) and plates (37, 38).
14. Install the guide pilots (39).
15. Install the sliders (33) and plates (34, 35).
16. Place the wear pad (29) on the section and insert nine strips (32) inside.
17. Secure the wear pad (29) with the plate (30).
18. Install the opposite wear pad (59), strips (32) and plate (30).
19. Assemble the lubrication hoses (53, 54, 55, 58) and connect to the wear pads (29, 59).
20. Attach the thin nuts (57) and pipe unions (56) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (26, 27).
22. Insert Section 3 into Section 2 just far enough to measure the gaps between the sliders and wear pads and Section 2. The gaps should be no greater than 1.52 mm (0.06 in). Adjust the gaps by adding or removing plates or using thicker or thinner sliders and wear pads.
23. Insert Section 3 into Section 2 half way.



Telescope Section 2 Assembly (Continued)



9522-1
9522-1

FIGURE 4-22 continued

Item Number	Description
1	TELESCOPIC PART 2
2	ROPE PROTECTION
3	WEAR PAD - GREASELESS TELE 2
4	WEAR PAD - GREASELESS TELE 2
5	WEAR PAD - GREASELESS TELE 2
6	WEAR PAD - GREASELESS TELE 2
7	WEAR PAD - GREASELESS TELE 2
8	HOLDER
9	HOLDER
10	STRIP T=11
11	STRIP T=10
12	PLATE
13	PLATE
14	PLATE
15	WASHER, 12 FLAT
16	HHCS M12x35 8.8
17	HEX NUT M12
18	HEXAGON HEAD BOLT
19	WASHER
20	SHCS M10x35 8.8
22	HEXAGON HEAD SCREW
23	HEXAGON THIN NUT
24	SPACER
25	SOCKET-HEAD SCREW
26	LOCKING UNIT ASSY
27	LOCKING UNIT ASSY
29	WEAR PAD TELE 2 ASSY.
30	PLATE
31	CAP SCREW
32	STRIP T=11
33	SLIDER
34	FILE PLATE
35	FILL PLATE
36	SLIDER SUSTAGLIDE
37	PLATE
38	PLATE
39	GUIDE PILOT
40	SLIDER

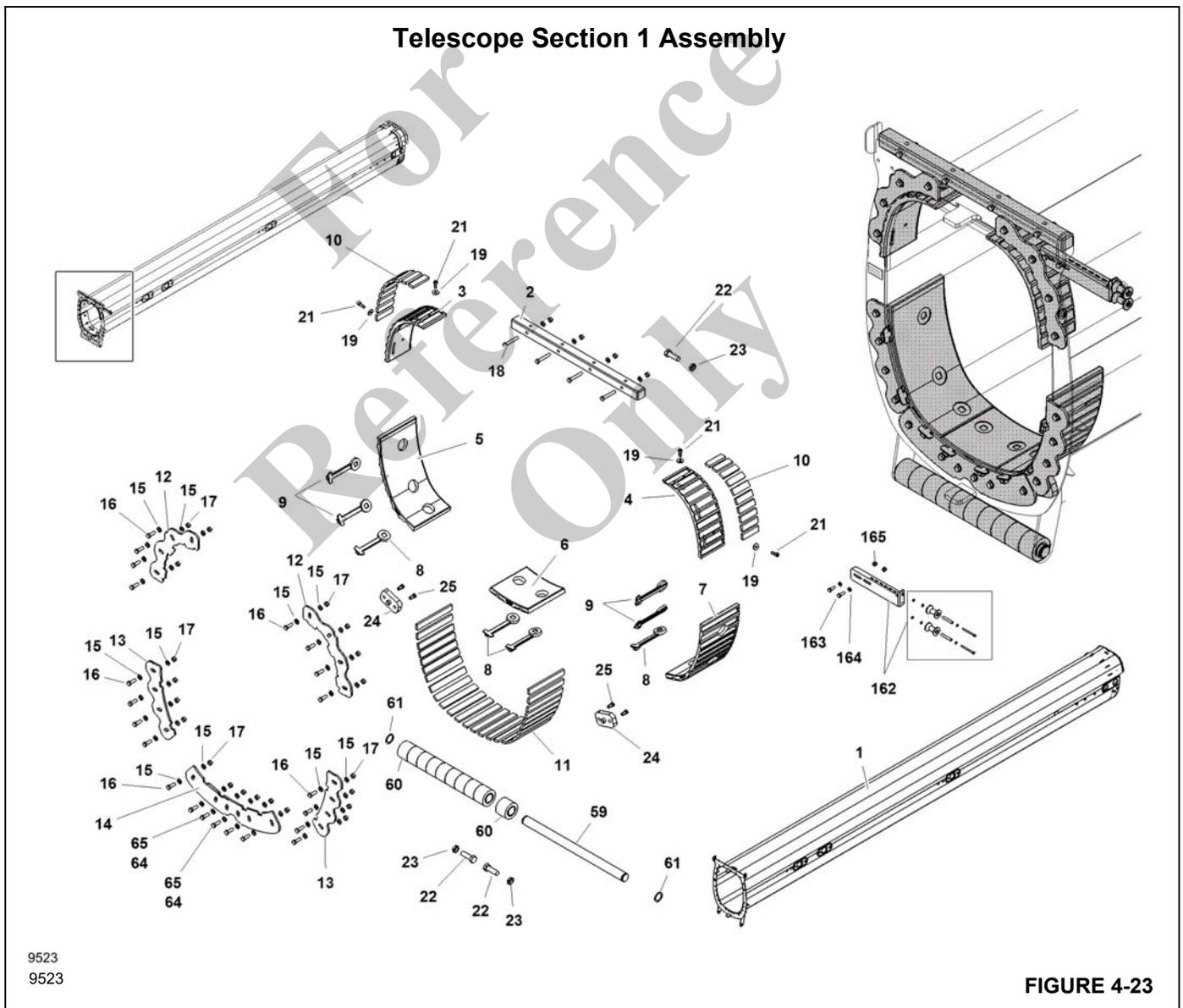
Item Number	Description
41	FILL PLATE - 1 MM
42	FILL PLATE - 2MM
43	SOCKET-HEAD SCREW
44	WEAR PAD SUSTAGLIDE
45	WEAR PAD SUSTAGLIDE
46	PLATE
47	PLATE
48	SHCS M10X50
49	SHCS M12x35 8.8
50	CAP SCREW
51	HEX L NUT M12
52	SOCKET-HEAD SCREW
53	ADAPTER
54	ANGLE PIPE UNION
55	LUBRICANT HOSE
56	PIPE UNION, M12X1
57	NUT, THIN
58	INSERT
59	WEAR PAD TELE 2 ASSY.
162	GUIDE
163	CAP SCREW
164	WASHER
165	HEXAGON NUT

Telescope Section 2 Assembly

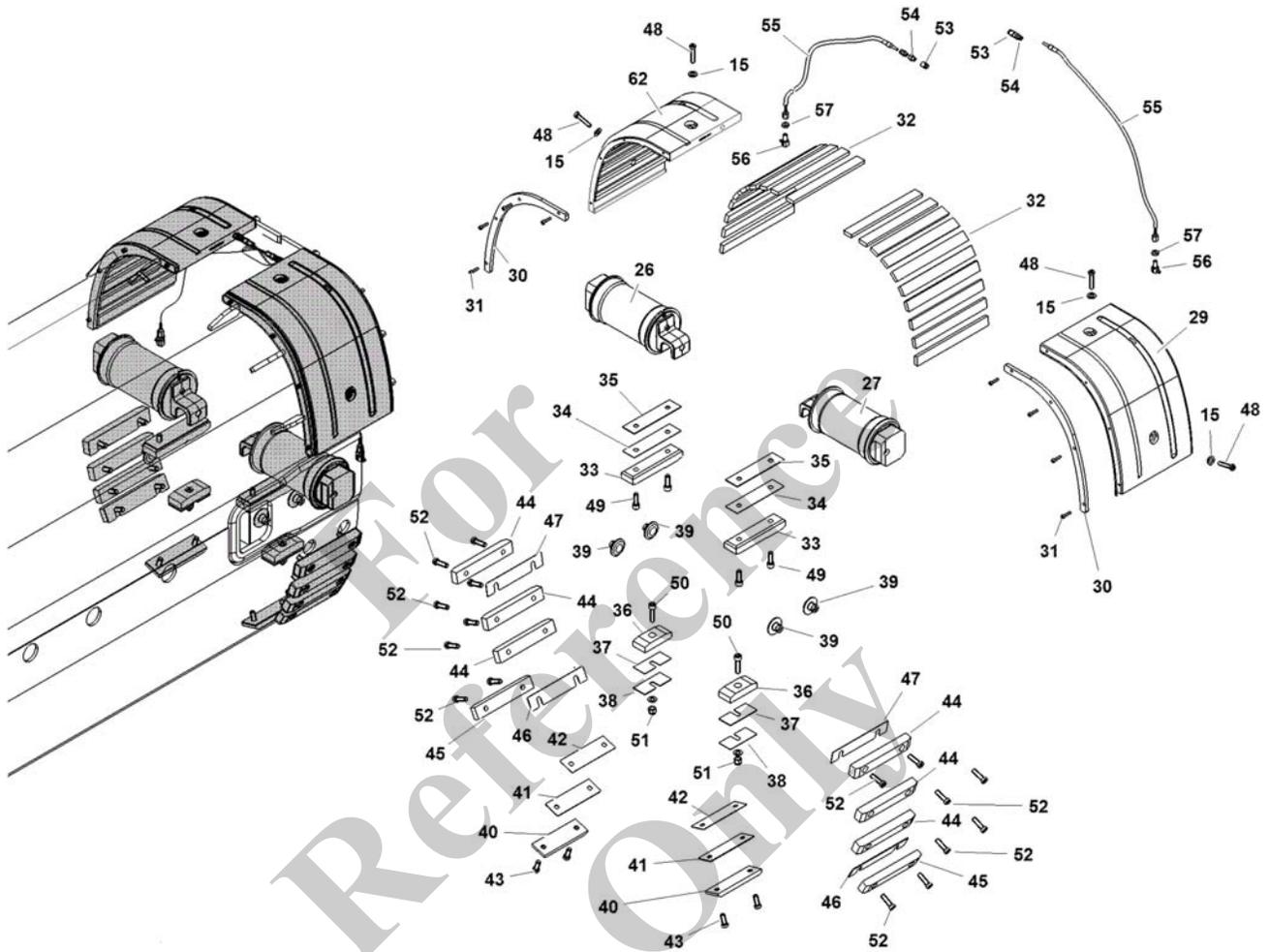
Refer to (Figure 4-22) when assembling this section.

1. Connect a strap to Tele 3, then using an overhead lifting device or another crane, lift Tele 3 so the strips (11), holders (8, 9) and wear pads (5, 6, 7) can be installed.
2. Install the hexagon head screws (22) and hexagon thin nuts (23).
3. Install the spacers (24).
4. Secure the strips and wear pads in place with the plates (13, 14).
5. Lower Tele 3.
6. Install the wear pads (3, 4).
7. Install the strips (10).
8. Secure the strips and wear pads with the plates (12).
9. Install the rope protection bar (2).

10. Install the guide (162).
11. On the opposite end of Tele 2, install sliders (40) and fill plates (41, 42).
12. Install wear pads (44) and plates (45).
13. Install sliders (36) and plates (37, 38).
14. Install the guide pilots (39).
15. Install the sliders (33) and plates (34, 35).
16. Place the wear pad (29) on the section and insert ten strips (32) inside.
17. Secure the wear pad (29) with the plate (30).
18. Install the opposite wear pad (59), strips (32) and plate (30).
19. Assemble the lubrication hoses (53, 54, 55, 58) and connect to the wear pads (29, 59).
20. Attach the thin nuts (57) and pipe unions (56) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (26, 27).
22. Insert Section 2 into Section 1 just far enough to measure the gaps between the sliders and wear pads and Section 1. The gaps should be no greater than 1.52 mm (0.06 in). Adjust the gaps by adding or removing plates or using thicker or thinner sliders and wear pads.
23. Insert Section 2 into Section 1 half way.



Telescope Section 1 Assembly (Continued)



9523-1
9523-1

FIGURE 4-23 continued

Item Number	Description
1	TELESCOPIC PART 1
2	ROPE PROTECTION
3	WEAR PAD - GREASELESS TELE 1
4	WEAR PAD - GREASELESS TELE 1
5	WEAR PAD - GREASELESS TELE 1
6	WEAR PAD - GREASELESS TELE 1
7	WEAR PAD - GREASELESS TELE 1
8	HOLDER
9	HOLDER
10	STRIP T=11
11	STRIP T=10
12	PLATE
13	PLATE
14	PLATE
15	WASHER, 12 FLAT
15	WASHER, 12 FLAT
16	HHCS M12x35 8.8
17	HEX NUT M12
18	HEXAGON HEAD BOLT
19	WASHER
21	SHCS M10X30 8.8
22	HEXAGON HEAD SCREW
23	HEXAGON THIN NUT
24	SPACER
25	SOCKET-HEAD SCREW
26	LOCKING UNIT ASSY
27	LOCKING UNIT ASSY
29	WEAR PAD TELE 1 ASSY.
30	PLATE
31	CAP SCREW
32	STRIP T=11
33	SLIDER
34	FILE PLATE
35	FILL PLATE
36	SLIDER SUSTAGLIDE
37	PLATE
38	PLATE

Item Number	Description
39	GUIDE PILOT
40	SLIDER
41	FILL PLATE - 1 MM
42	FILL PLATE - 2MM
43	SOCKET-HEAD SCREW
44	WEAR PAD SUSTAGLIDE
45	WEAR PAD SUSTAGLIDE
46	PLATE
47	PLATE
48	SHCS M10X50
49	SHCS M12x35 8.8
50	HEXAGON SOCKET HEAD CAP SCREW
51	HEX L NUT M12
52	SOCKET-HEAD SCREW
53	ADAPTER
54	FITTING
55	LUBRICANT HOSE
56	PIPE UNION, M12X1
57	NUT, THIN
58	INSERT
59	AXLE
60	ROLLER
61	RING, SNAP
62	WEAR PAD TELE 1 ASSY
64	FLAT COLLAR NUT M12
65	HEXAGON HEAD SCREW
162	GUIDE
163	CAP SCREW
164	WASHER
165	HEXAGON NUT

Telescope Section 1 Assembly

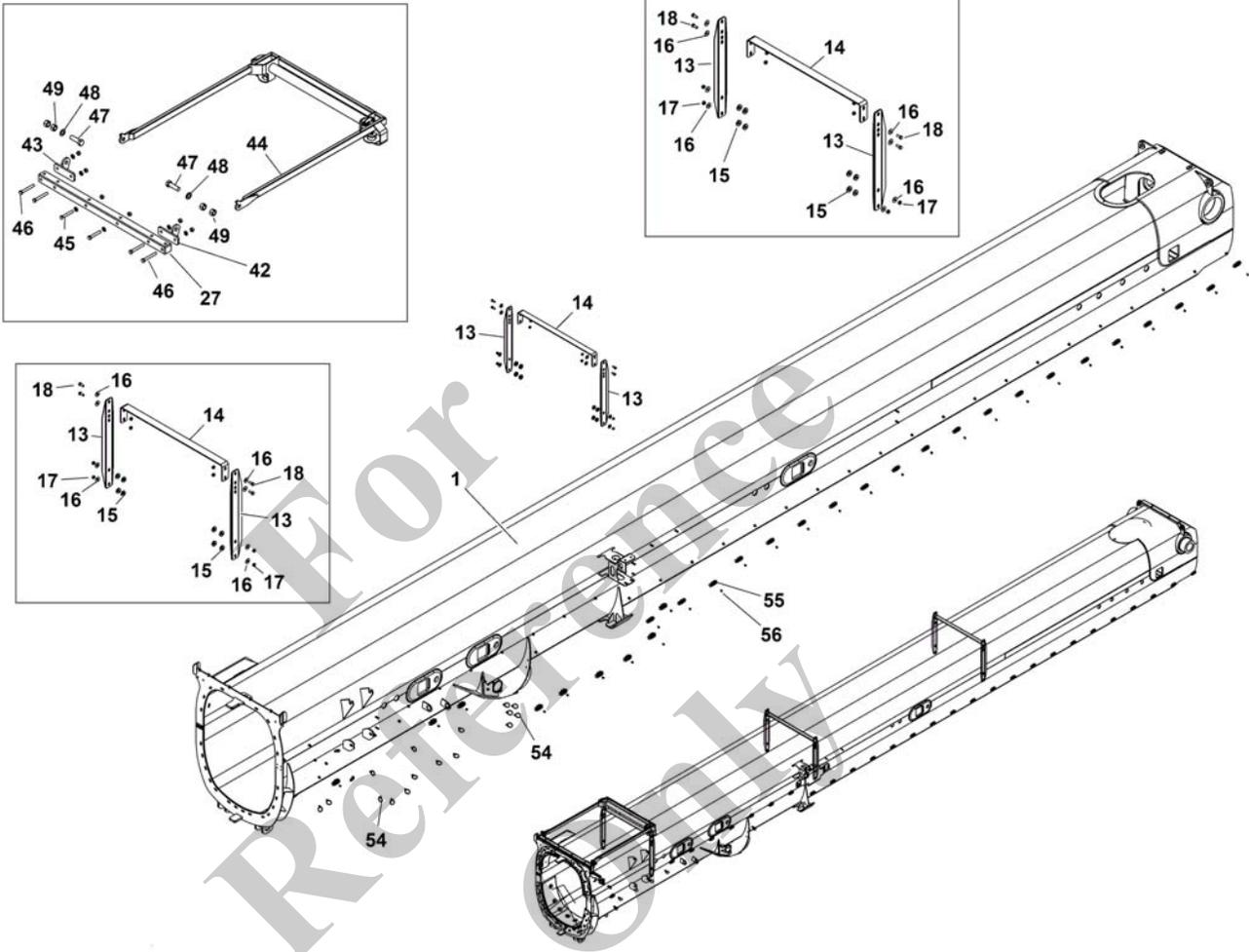
Refer to (Figure 4-23) when assembling this section.

1. Connect a strap to Tele 2, then using an overhead lifting device or another crane, lift Tele 2 so the strips (11), holders (8, 9) and wear pads (5, 6, 7) can be installed.
2. Install the hexagon head screws (22) and hexagon thin nuts (23).
3. Install the spacers (24).

4. Secure the strips and wear pads in place with the plates (13, 14).
5. Lower Tele 2.
6. Install the wear pads (3, 4).
7. Install the strips (10).
8. Secure the strips and wear pads with the plates (12).
9. Install the rope protection bar (2).
10. Install the guide (162).
11. On the opposite end of Tele 1, install sliders (40) and fill plates (41, 42).
12. Install wear pads (44, 45) and plates (46, 47).
13. Install sliders (36) and plates (37, 38).
14. Install the guide pilots (39).
15. Install the sliders (33) and plates (34, 35).
16. Place the wear pad (29) on the section and insert ten strips (32) inside.
17. Secure the wear pad (29) with the plate (30).
18. Install the opposite wear pad (62), strips (32) and plate (30).
19. Assemble the lubrication hoses (53, 54, 55) and connect to the wear pads (29, 62).
20. Attach the thin nuts (57) and pipe unions (56) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (26, 27).
22. Insert the telescope cylinder assembly into Section 1.
23. Install the tele power cable strain relief (2), (Figure 4-18).
24. Install the tele power plug (1), (Figure 4-18).
25. Insert Section 1 into the Base Section just far enough to measure the gaps between the sliders and wear pads and the Base Section. The gaps should be no greater than 1.52 mm (0.06 in). Adjust the gaps by adding or removing plates or using thicker or thinner sliders and wear pads.
26. Insert Section 1 into the Base Section half way.

For Reference Only

Telescope Base Section Assembly

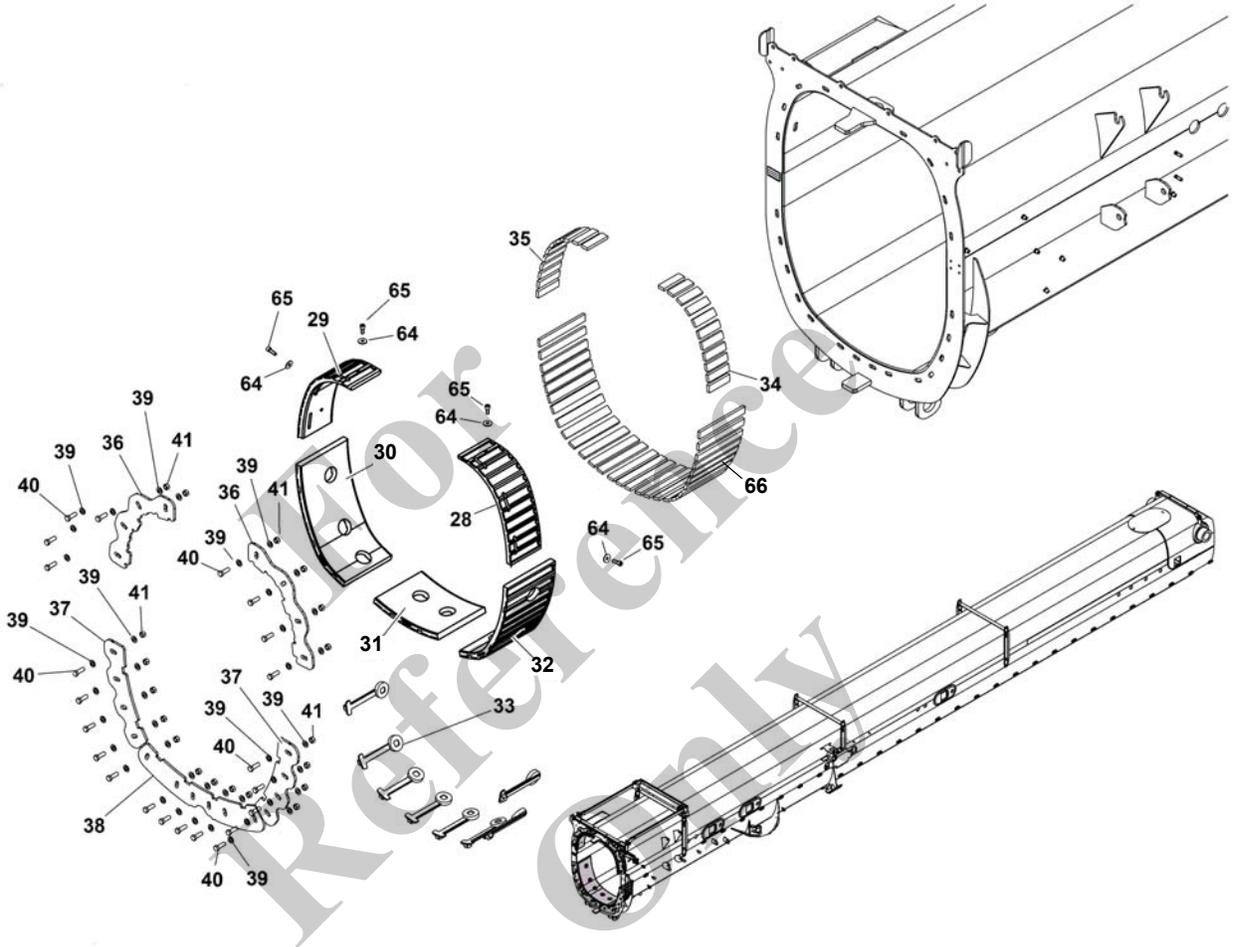


9546
9546

FIGURE 4-24

4

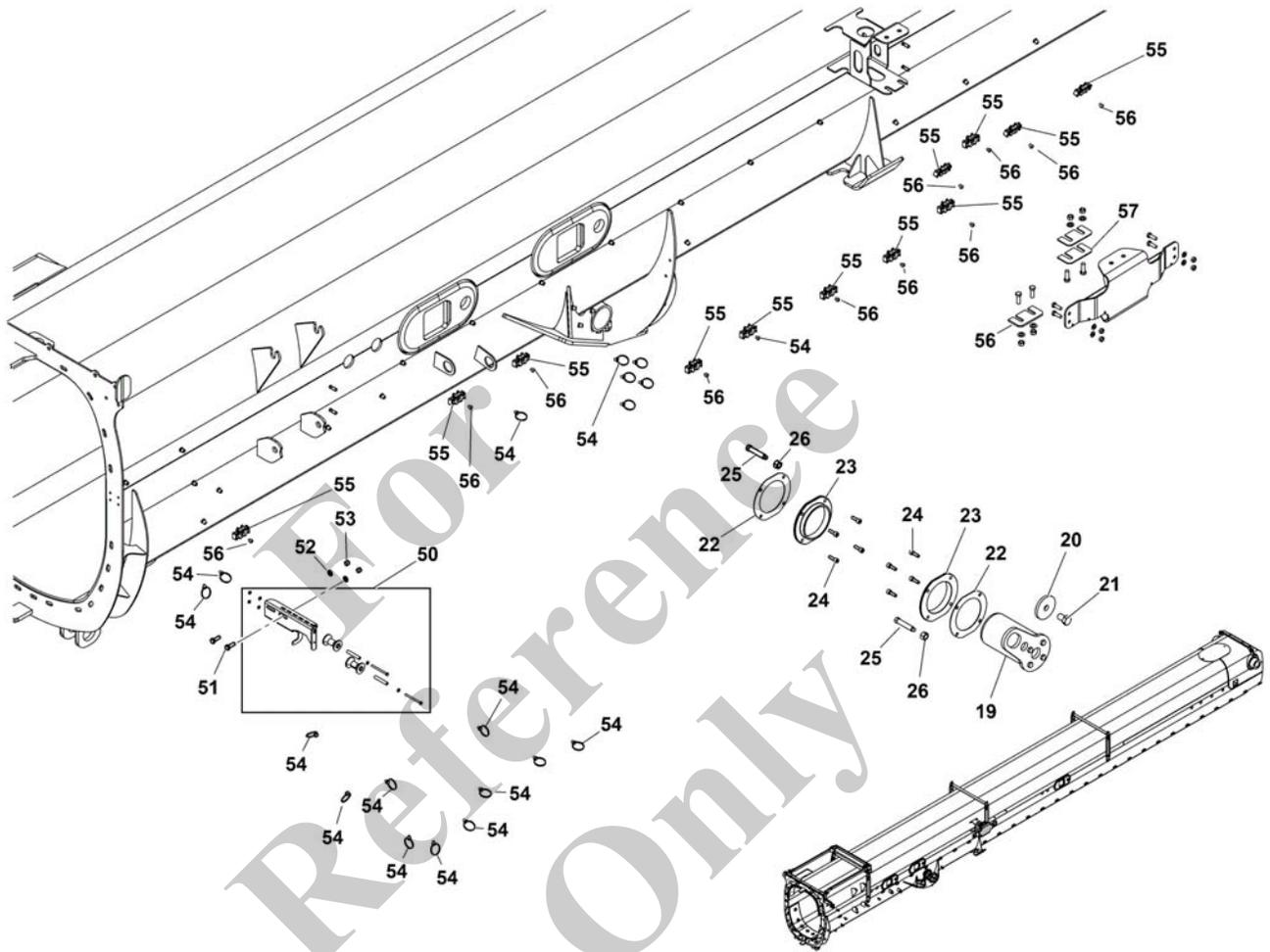
Telescope Base Section Assembly (Continued)



9546-1
9546-1

FIGURE 4-24 continued 2

Telescope Base Section Assembly (Continued)

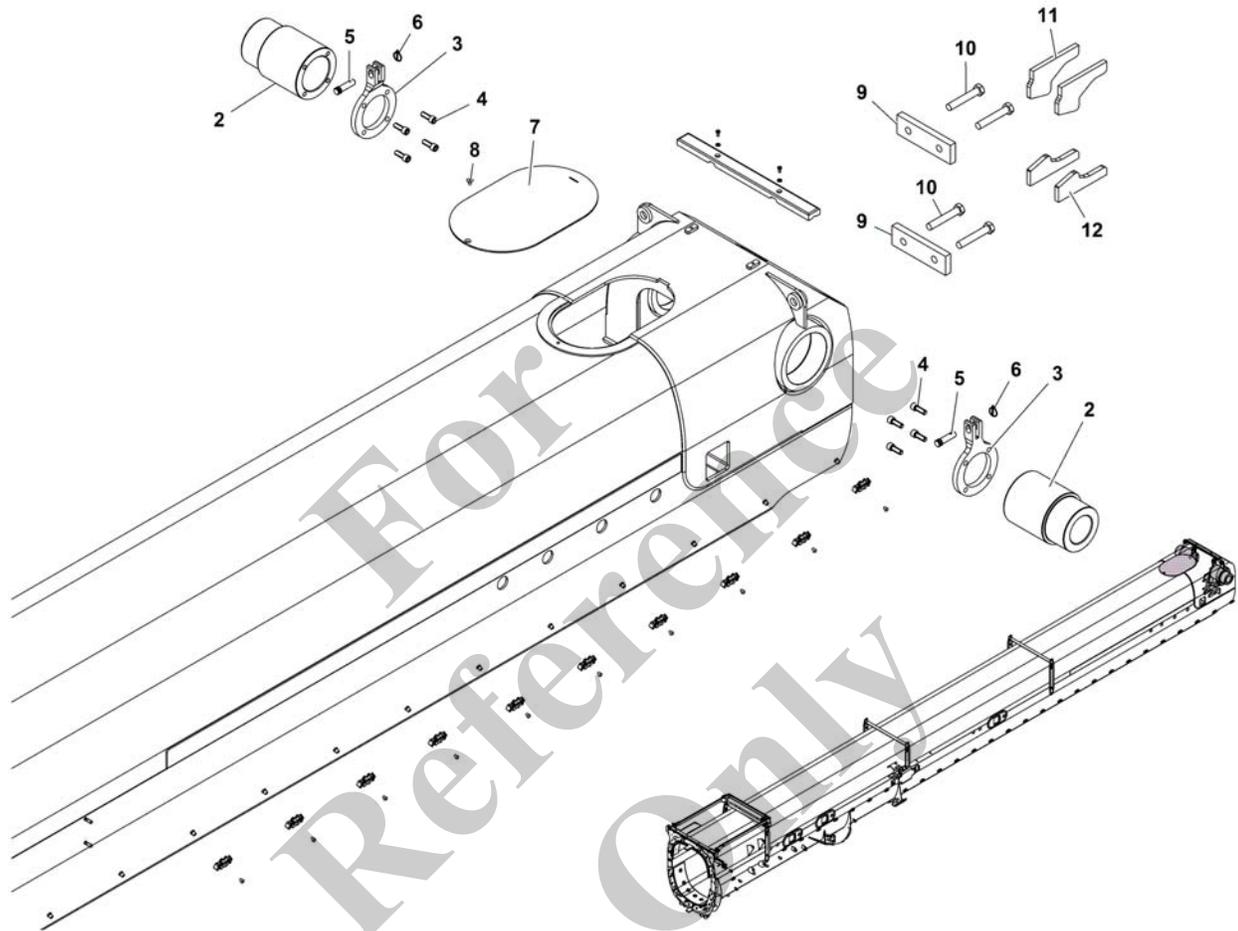


9546-2
9546-2

FIGURE 4-24 continued 3

4

Telescope Base Section Assembly (Continued)



9546-3
9546-3

FIGURE 4-24 continued 4

Item Number	Description
1	BASE SECTION
2	AXLE
3	PLATE
4	SOCKET-HEAD SCREW M16x45 8.8
5	PIN
6	COTTER PIN
7	COVER
8	SFS, M10X16
9	BAR
10	HHCS
11	PLATE
12	PLATE
13	PLATE
14	PLATE
15	WASHER
16	WASHER
17	HEX NUT M10
18	HEXAGON HEAD SCREW
19	AXLE ASSEMBLY
20	F WASHER 21X90X10
21	HHCS M20X30
22	PLATE
23	FLANGE
24	SHCS M10X30 8.8
25	HSS
26	HEXAGON NUT
27	ROPE PROTECTION
28	SLIDER
29	SLIDER
30	SLIDER
31	SLIDER
32	SLIDER
33	HOLDER
34	STRIP T=11
35	STRIP T=10
36	PLATE
37	PLATE
38	PLATE

Item Number	Description
39	WASHER, 12 FLAT
40	HHCS M12x35 8.8
41	HEX NUT
42	BRACKET
43	BRACKET
44	STIRRUP
45	HEXAGON HEAD BOLT
46	CAP SCREW M12X90 -8.8
47	HEXAGON HEAD SCREW
48	WASHER, FLAT
49	HEX NUT
50	GUIDE
51	CAP SCREW
52	WASHER
53	HEXAGON NUT
54	CABLE CLIP
55	CABLE CLIP FOR HEAVY DUTY APPL
56	SBCS
57	FILL PLATE
58	PLATE, FILL
59	PLATE
60	PLATE
61	SOCKET-HEAD SCREW
62	SHCS M10X35 8.8
64	WASHER
65	CAP SCREW
66	STRIP

Telescope Base Section Assembly

Refer to (Figure 4-24) when assembling this section.

1. Connect a strap to Tele 1, then using an overhead lifting device or another crane, lift Tele 1 so the strips (66), holders (33) and sliders (30, 31, 32) can be installed.
2. Secure the strips and sliders in place with the plates (37, 38).
3. Lower Tele 1.
4. Install the wear pads (28, 29).
5. Install the strips (34, 35).
6. Secure the strips and wear pads with the plates (36).

7. Climb inside the Base Section and remove the tie straps restraining the cylinder hoses. Route the hoses out the rear of the Base Section as shown in (Figure 4-25).
8. Secure the tele cylinder with the four cylinder retaining bolts (Figure 4-25) and two retaining plates.

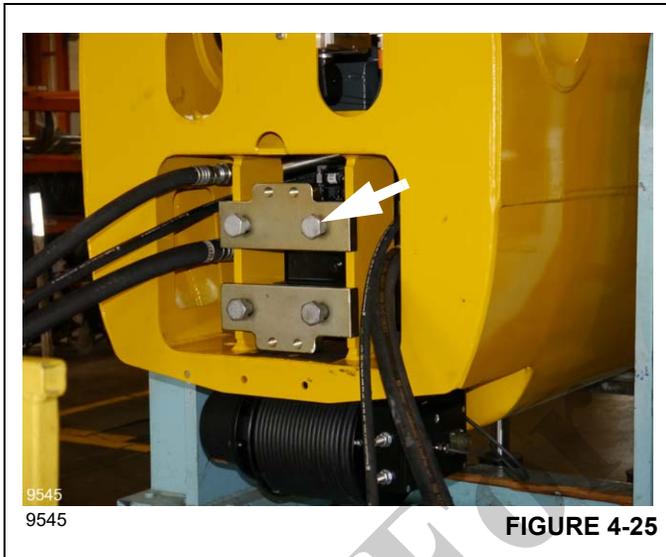


FIGURE 4-25

PINNING BOOM COMPONENTS

Mechanical Locking Head Description

It is important to understand that a pinned boom has a telescoping cylinder that can disconnect and reconnect (unlock/lock) to boom sections, as well as disconnect and connect (unlock/lock) boom sections to each other. This is

accomplished by a pinning mechanism or pinning “head” at the near end of the barrel of the telescoping cylinder (the rod is fixed to the Base Section and the barrel extends within the boom). This pinning mechanism has a set of sensors and an electronic module to communicate with the Crane Control System (CCS). Using these sensors, as well as a precision length sensor for the linear location of the telescoping cylinder within the boom, the Crane Control System commands the pinning mechanism to perform the locking operations.

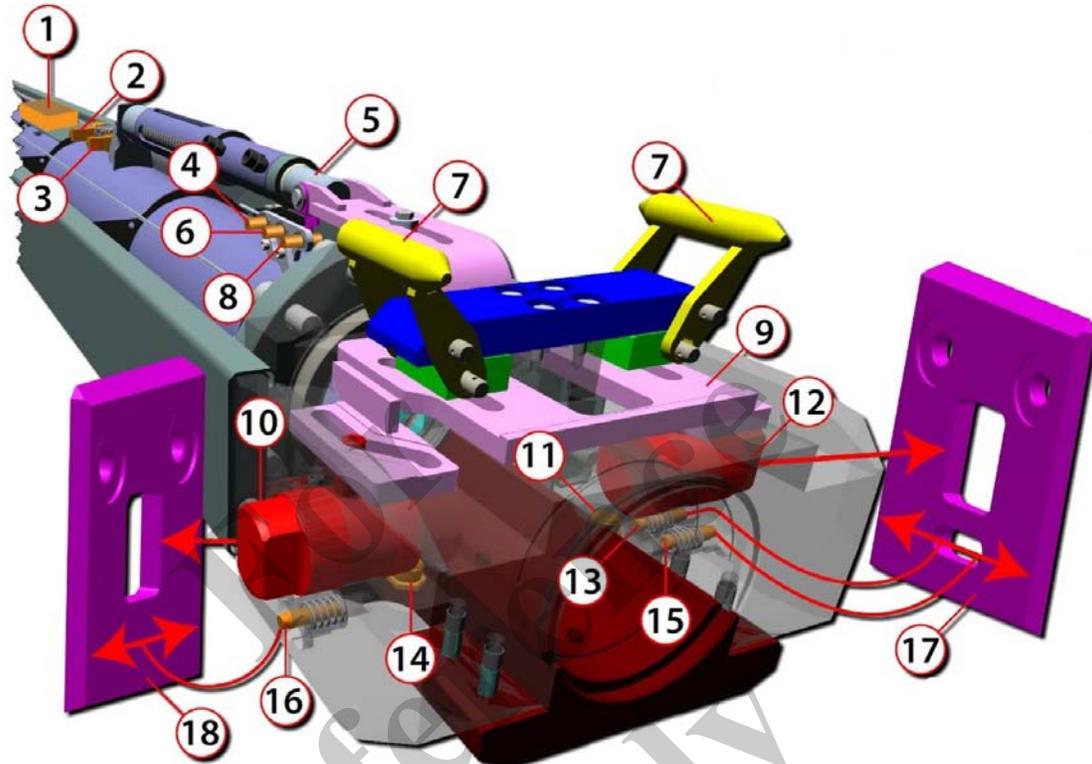
The key component for the pinned boom then is the pinning mechanism. For the TMS9000-2, this is referred to as the Mechanical Locking Head. Be aware that this pinning mechanism is quite different from a past design that was referred to as TwinLock.

(Figure 4-26) shows a layout for the Mechanical Locking Head design.

The actuator sliding plate (9), (Figure 4-26) has slots that guide the ends of small pins. The small pins are connected to components that can retract and release the pinned boom locking pins. The cylinder pins (10 and 12), (Figure 4-26) are directly connected to the small pins, and when the sliding plate slides in the direction of telescoping cylinder extending, the cylinder pins are retracted. The section pins (not shown in Figure 4-26) are moved by the butterfly levers (7), (Figure 4-26). The butterfly levers are moved as the sliding plate slides in the other direction (telescoping cylinder retracting direction).

The sliding plate is moved by the hydraulic actuator (5), (Figure 4-26).

Mechanical Locking Head Layout



9300
9300

FIGURE 4-26

Item Number	Description	Item Number	Description
1	I/O Module	13	Proximity Switch S2116N
2	Valve for pinning control	14	Proximity Switch S2114N
3	Valve for pinning control	15	Proximity Switch S2117N
4	Proximity Switch S2112N	16	Proximity Switch S2118N
5	Double-acting hydraulic actuator	17	Sample boom section plate in "foot area" that includes a slot
6	Proximity Switch S2111N	18	Sample boom section plate in "foot area" that is solid
7	Butterfly levers that engage with section pins		
8	Proximity Switch S2110N		
9	Actuator sliding plate		
10	Left side cylinder pin that engages with boom sections		
11	Proximity switch S2115N		
12	Right side cylinder pin that engages with boom sections		

Proximity Switch Descriptions

There are a number of proximity switches used in the pinning mechanism. Some of the switches confirm the location of components in the mechanism. Some are used to determine the alignment of the telescoping cylinder with boom sections.

Proximity Switches for Hydraulic Actuator Position

There are 3 proximity switches for confirming the position of the hydraulic actuator (5), (Figure 4-26). They detect a target

plate that is attached to one of the pieces that move with the sliding plate. These switches are the following:

- **S2110N** - (8), (Figure 4-26): This switch is expected to detect that the sliding plate has moved all the way in the direction that retracts the section pins via the butterfly levers.
- **S2111N** - (6), (Figure 4-26): This switch is expected to detect that the sliding plate has moved to the middle or neutral position which indicates that neither the cylinder pins or the section pins have been retracted.
- **S2112N** - (4), (Figure 4-26): This switch is expected to detect that the sliding plate has moved all the way in the direction that retracts the cylinder pins.

Proximity Switches for Cylinder Pins Retracted

There are 2 proximity switches for confirming the position of the cylinder pins (10 and 12), (Figure 4-26). They detect the pins themselves. These switches are the following:

- **S2114N** - (14), (Figure 4-26): This switch is expected to detect that the left side cylinder pin is in the retracted position.
- **S2115N** - (11), (Figure 4-26): This switch is expected to detect that the right side cylinder pin is in the retracted position.

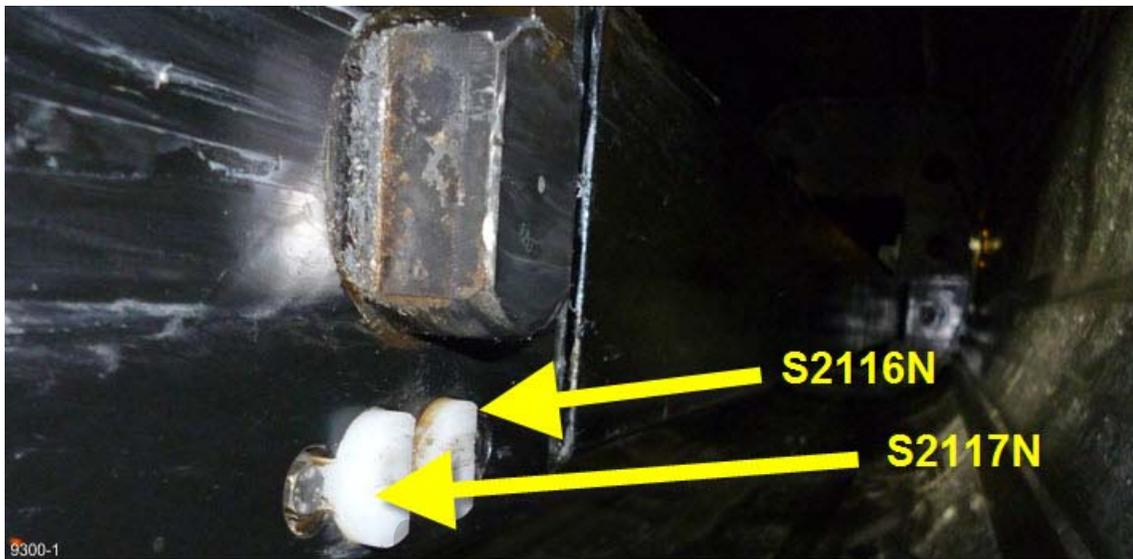
Proximity Switches for Cylinder Alignment to Boom Section

There are 3 proximity switches for confirming the position of the telescoping cylinder relative to a Boom Section. Two of these switches indicate the telescoping cylinder at a slot in a plate in the “foot area” of the Boom Section (13 and 15), (Figure 4-26). (Figure 4-27) shows these two switches, and

that they are located on spring-loaded cylindrical bodies that can ride in and out of slots in the Boom Sections. The third proximity switch is on the other side of the telescoping cylinder (16), (Figure 4-26).

As shown with the arrows for Items 17 and 18 in (Figure 4-27), when switches S2116N and S2117N are OFF, and switch S2118N is ON, then the telescoping cylinder can be considered aligned with a Boom Section. The telescoping cylinder would now be in position to connect to that Boom Section. The following provides identification of these proximity switches:

- **S2116N** - (13), (Figure 4-26): This switch is expected to detect slot in the “foot area”. When it turns ON, the telescoping cylinder has extended too far, so it can be described as the “too high” switch since the precision length sensor value is too high; the telescoping cylinder would be expected to be retracted so that it turns OFF.
- **S2117N** - (15), (Figure 4-26): This switch is expected to detect slot in the “foot area”. When it turns ON, the telescoping cylinder has not extended far enough, so it can be described as the “too low” switch since the precision length sensor value is too low; the telescoping cylinder would be expected to be extended so that it turns OFF.
- **S2118N** - (16), (Figure 4-26): This switch is expected to detect that the telescoping cylinder is in a region where S2116N and S2117N information would be valid. It is in this region when the switch is ON. When it is OFF, then the telescoping cylinder is not in the needed region and the S2116N and S2117N information can be ignored. The precision length sensor data would then be relied upon to move the telescoping cylinder to a desired location.



9300-1
9300-1

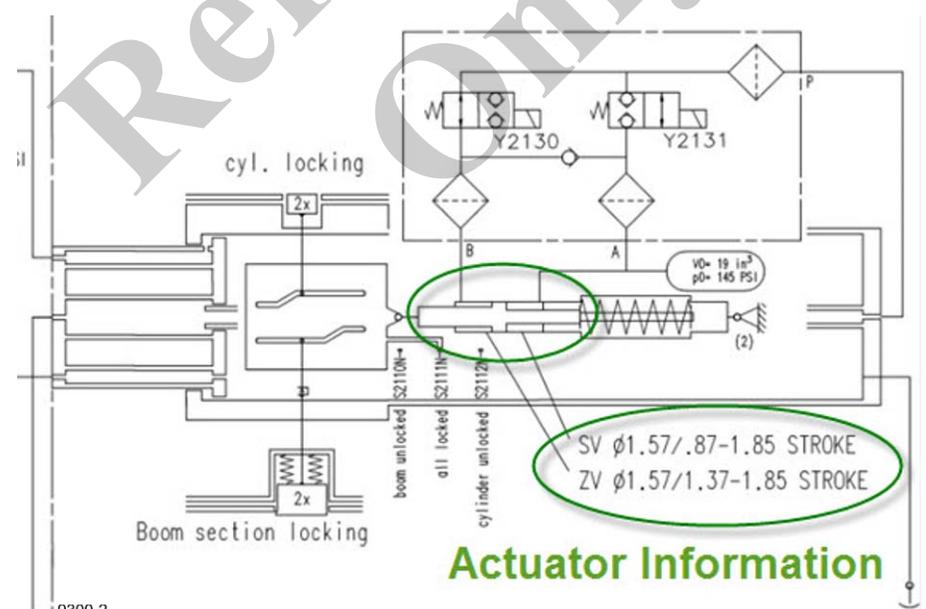
FIGURE 4-27

Hydraulic Actuator Description

Item 5, (Figure 4-26), indicates the hydraulic actuator for the pinning mechanism. This actuator is expected to move the sliding plate in either direction from its neutral position. The actuator utilizes pressure from a trombone-tube (or fill-tube or transfer-tube) in the center of the hollow rod of the

telescoping cylinder via a tube on the outer surface of the telescoping cylinder barrel.

There are two ON/OFF valves (2 and 3, (Figure 4-26) that control where pressure for the actuator is directed. These valves are designated Y2130 and Y2131.



9300-2
9300-2

FIGURE 4-28

(Figure 4-28) shows a region of a typical hydraulic schematic for the Mechanical Locking Head Design. In the schematic, the highlighted actuator is shown to have a piston with rods at both sides for the double-acting actuator. However, one rod diameter is larger than the other. The other highlighted area shows the rod diameters as 0.87" and 1.37". This difference gives an exposed area difference for the hydraulic pressure to act upon. If pressure is applied to just the left side of the piston, then the actuator will shift to the right, and this retracts the cylinder pins. If pressure is applied to both sides of the piston, then due to the area difference, the actuator will shift to the left, and this retracts the section pins.

As shown in (Figure 4-28), the setting of the Y2130 and Y2131 valves can be manipulated to have the pressure

applied to one side or both sides (with appropriate relieving of pressure where needed).

Precision Length Sensor Description

An important component of the pinned boom system is the precision length sensor. (Figure 4-29) shows a typical example highlighted in green with the back plates of the base section not shown. This sensor has a cable reel. The cable is attached to the pinning mechanism at the near end of the telescoping cylinder barrel. As the barrel extends, the sensor measures the distance. This distance is the most important data that is used by the Pinned Boom Control System. It allows motion to be monitored, and for the cylinder to be placed in the correct location for pinning operations.

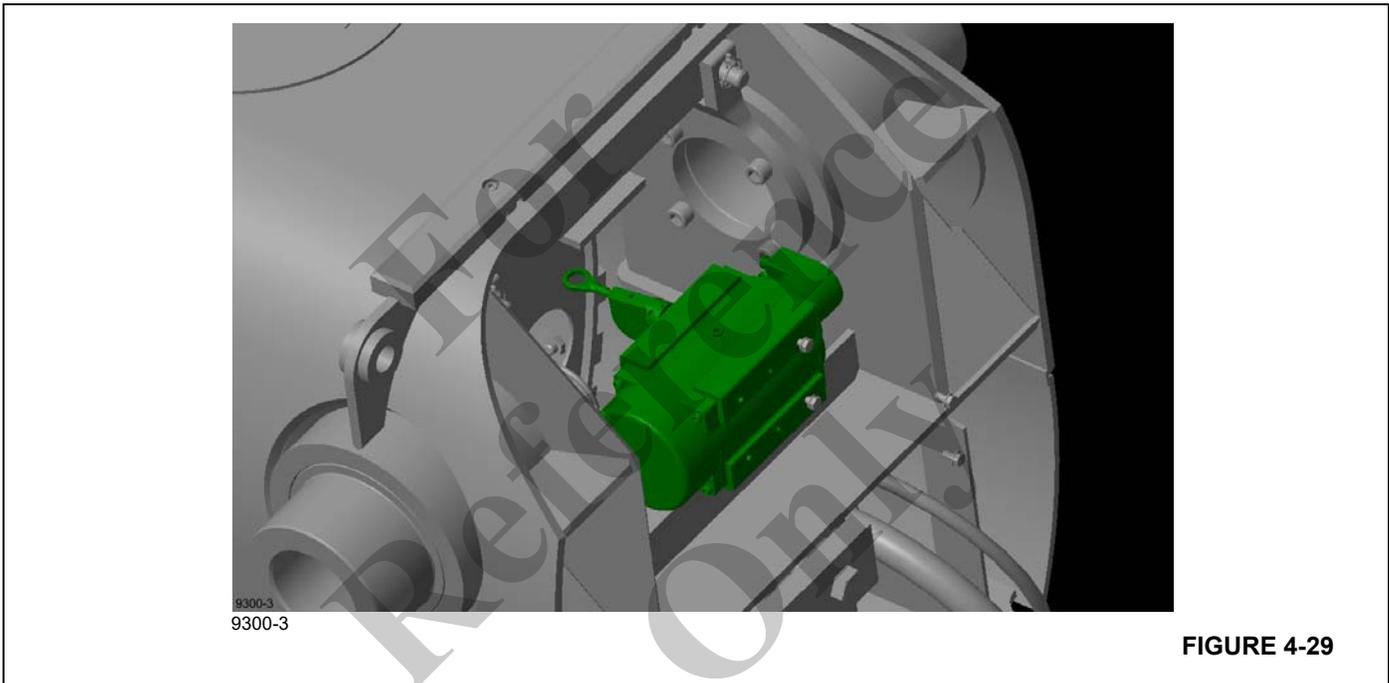


FIGURE 4-29

Pinned Boom Control System Description

The Pinned Boom Control System for the telescoping system manages the state of the sensors, switches, valves, and information to/from the display screens. There are a number of different approaches to using the telescoping system. These are referred to as the Semi-Auto Mode, the Manual Mode, and the Emergency Mode.

It is important to realize that for some of the modes the control system is performing automated motions within the boom at some point in the telescoping process. At other times, the operator is able to move the boom components. Then the automated motions can occur once again after the operator has indicated the appropriate next action for telescoping the boom.

The control system requires that the telescoping cylinder and pinning mechanism perform within expected parameters. For instance, if there is entrapped air within the trombone-tube, the hydraulic pressure will initially move the hydraulic actuator as expected, but after the pressure is trapped in the actuator and the pressure in the trombone-tube is reduced, there may be motion of the components that is not expected by the control system. If there is unexpected friction in the sliding components, then the pressure may not be sufficient to move the components within the time allotted by the control system. If the boom is at a very low angle, the boom sections may drift with respect to each other and then the telescoping cylinder will not align with boom sections in the expected range of the data from the precision length sensor.

Therefore, it is essential that the telescoping cylinder and boom sections be maintained properly so that the control system can work properly.

MECHANICAL EMERGENCY UNLOCKING AND LOCKING OF THE TELESCOPIC SECTIONS

The mechanical emergency operation must be used whenever the telescoping cylinder can no longer be moved.

For manual unlocking and locking of the telescopic sections, a screw is inserted into each side in the locking pins. When screwed in, the screw collapses the spring internal to the locking pin, thus pulling the locking pin which pulls the locking pin into the telescopic section and thus unlocks the section.

The screw is screwed out again to lock the section manually.

The main boom is designed in such a way that the locks can be operated in emergency mode from the outside for most fixed lengths.

NOTE: If the telescoping cylinder is in the foot section of a telescopic section, this telescopic section cannot be locked or unlocked manually.

Prerequisites



WARNING

Crushing Hazard!

Failure to follow these prerequisites could allow a boom section to retract uncontrolled resulting in injury or equipment damage.

The following prerequisites must be fulfilled before unlocking a telescopic section manually:

- The telescopic section to be unlocked is attached to an auxiliary crane with sufficient load bearing capacity and, in this way, is secured against independent retraction.

OR

- The main boom is lowered into a horizontal position so that the telescopic section is unable to retract independently.

Maintenance

For manual unlocking, two screws are supplied for each telescopic section (Figure 4-30):

- 125 mm (4.92 in) length for telescopic section 5.
- 140 mm (5.51 in) length for telescopic section 4.
- 170 mm (6.69 in) length for telescopic section 3.
- 200 mm (7.87 in) length for telescopic section 2.
- 270 mm (10.63 in) length for telescopic section 1.

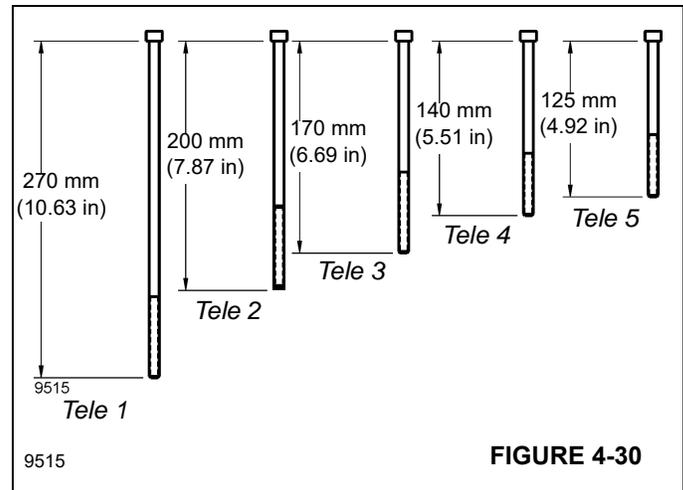


FIGURE 4-30

You can only lock or unlock a telescopic section manually if the recess (2), (Figure 4-31) in the locking pin (1), (Figure 4-31) no longer engages in the telescopic section (3), (Figure 4-31) above it.

Extend the Telescopic Section approximately 20 mm (0.79 in) (with an auxiliary crane, forklift or other means of external force). The locking pin (1), (Figure 4-31) must be centered in the opening and the recess (2), (Figure 4-31) may no longer engage in the telescopic section (3), (Figure 4-31) above it.

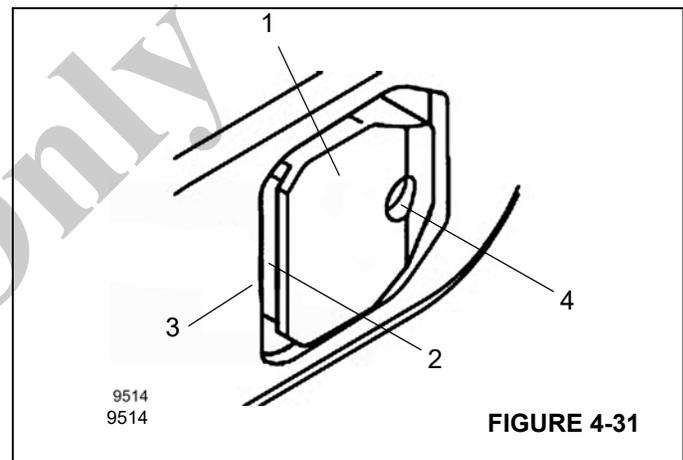


FIGURE 4-31

Unlocking Telescopic Sections

When unlocking Telescopic Sections, start with Tele 5 (fly) and work your way in towards Tele 1 (Figure 4-30) as far as possible. Unlock and lock only one section at a time.

- Remove the grease fitting from the bore hole (4), (Figure 4-31).
- Insert a screw into the hole (4), (Figure 4-31). The locking pin (1), (Figure 4-31) is retracted in the process. You can assist this process by lightly hammering on the locking pins.

3. Tighten the screw against the spring load until the locking pin (1), (Figure 4-31) is pulled in as far as it will go and is situated behind the side wall of the telescopic section.
4. Unlock the other side of the telescopic section using the same procedure.

CAUTION

Released Lock Hazard!

Under no circumstances may you operate the telescoping cylinder as long as the lock is mechanically released. Therefore unscrew all screws out of the bore holes immediately after finishing the repair work.

In this way, you prevent the telescoping cylinder from hitting the locking system and consequently damaging it.

Do not unlock a section and then boom up until it slides in. Damage to equipment will result.

Once the pins are retracted, use your external means (second crane, forklift, etc.) to retract that section and then remove the bolts to pin that section in a retracted state. Move to the next section to be retracted (as necessary).

Locking Telescopic Sections

1. Retract the telescopic section until the locking pin (1), (Figure 4-31) is in the middle of the opening.
2. Remove the screw from the bore hole (4), (Figure 4-31).

The locking pin (1), (Figure 4-31) is then pushed out of the opening due to spring tension.

3. Install the grease fitting into the bore hole.
4. Retract the telescopic section until the recesses (2), (Figure 4-31) have been set down on the telescopic section (3), (Figure 4-31) above it.

NEW YORK HOUSE LOCK



CAUTION

Free Swing Hazard!

The New York House Lock is strictly an additional backup device. The swing brake must always be installed. Equipment damage or injury possible.

The New York House Lock is designed to meet the New York regulations for a mechanical locking of the superstructure. It is not intended for other applications, such as traveling with a load, etc.

It operates with an electrical actuator Up = disengaged (unlocked) and down = engaged (locked). It can be operated by either the super cab display or by the hand held remote. There are 2 proxy switches, one for fully disengaged

(unlocked) and one for fully engaged (locked). This can be seen on the screen of ODM display or remote.

BLEEDING THE TELESCOPING CYLINDERS

There are two vent screws on the telescoping cylinder for bleeding the cylinder chambers. The vent screws are accessible through hand holes in the telescopic sections.

Prerequisites

With the following requirements it is assumed that no lattice extension is rigged.

- Park the truck crane on a level surface.
- Support the truck crane with at least the outrigger span : 7.00 m X 5.61 m (22.97 x 18.4 ft).
- Remove the counterweight.
- Enter the RCL rigging code for the current rigging mode of the truck crane.
- Completely retract all telescopic sections.
- Unreeve the hook block.
- Swing the superstructure to the rear or to the side.
- Lower the boom into a horizontal position.

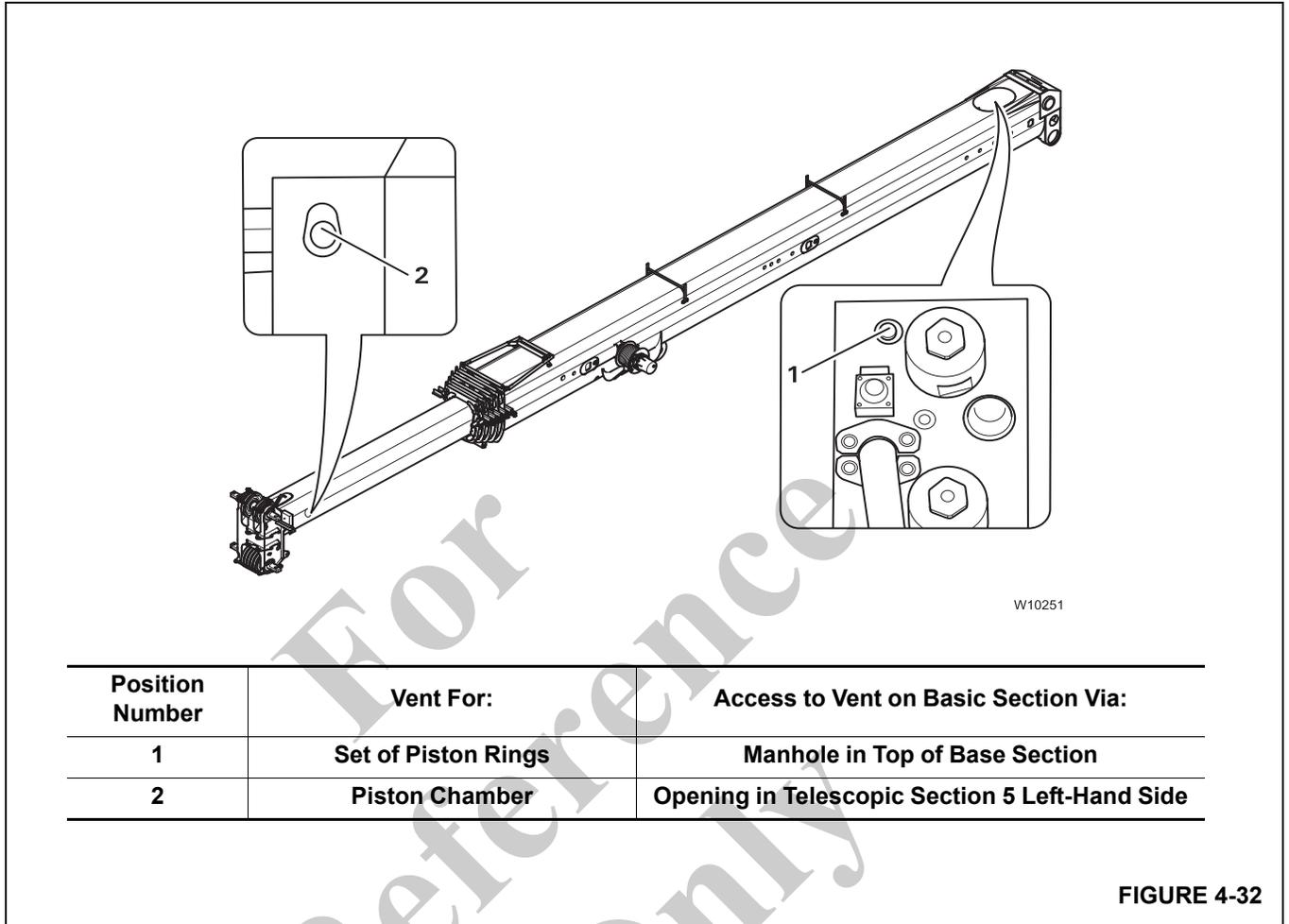
Bleeding Procedure

Carry out the bleeding procedure on all vent screws in turn.

- Remove the cap from the relevant vent screw.
- Place a transparent hose onto the vent screw. Hold the other end of the hose in a container filled with oil.
- Loosen the vent screw by 1 – 2 turns.
- Carefully drain the telescoping cylinder of hydraulic oil until the oil flowing through the hose no longer contains any bubbles. Carefully extend the relevant telescopic section in the direction specified.

The oil collected in the container must not be used again as it contains air.

Location of Vent Screws



4

Telescoping Status

The position numbers indicated below relate to the illustrations in the Location of Vent Screws (Figure 4-32) in this section.

Vent Screw Position No. 1

! WARNING
Crushing Hazard!

Do not reach into the manhole until the boom has been secured so that it cannot retract inadvertently. If you are carrying out this operation with the help of someone else, communicate with the person in the crane cab by means of clear hand signals.

- Screw off the manhole cover plate.
- Extend telescopic section I approximately 2.0 m (6.5 ft) so that the access to the manhole is free.
- Fit the bleeder key through the manhole onto the vent screw (1), (Figure 4-32) on the telescoping cylinder and open with one or two turns.
- Make sure nobody is in the manhole or is reaching into the manhole.
- Carefully move the control lever for telescoping in the retract direction so that the pressure in the set of piston rings increases and the air is pushed out through the plastic hose.
- Tighten the vent screw (1), (Figure 4-32).
- Close the manhole again with the cover plate.

Vent Screw Position No. 2

- Extend the telescopic section V approximately 0.5 m (1.7 ft).
- Insert bleeder key through the opening on the left side of telescopic Section 5 onto the vent screw and open 1 or 2 turns.
- Carefully move the control lever for telescoping in the extend direction so that the pressure in the piston chamber increases and the air is pushed out through the plastic hose.
- Tighten the vent screw (2), (Figure 4-32).

TELESCOPE SLIDE PAD ADJUSTMENT**WARNING****Overturning Hazard!**

Make sure that all the *Prerequisites*, page 4-44 are met. If you do not keep to the rigging mode specified there, the truck crane could overturn.

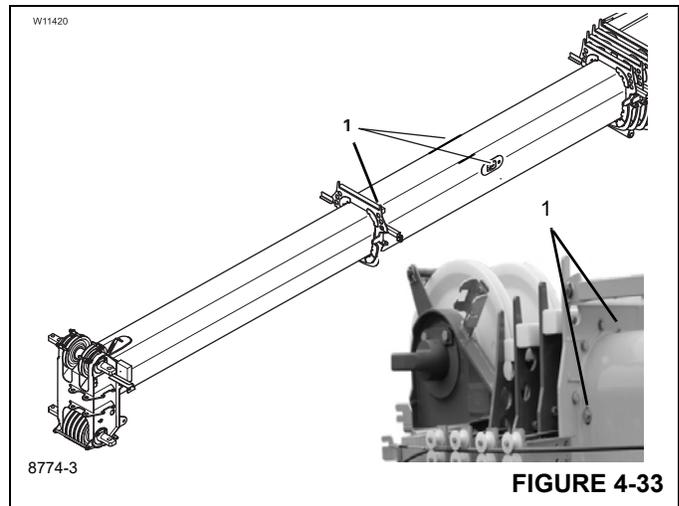
- Extend telescope sections at 15% and shim and torque all bolts securing slide pads to boom. Make sure retaining plates are tight against the slide pads.

NOTE: Length of bolt varies at front top radius pad bolts depending on the pad shims required. Use a 20mm bolt for 5mm shims; 25mm bolt for 6mm-10mm shims and 30mm bolt for 11mm-15mm shims.

- Apply Loctite 243 and tighten the bolts (1), (Figure 4-33) by hand until the washer is within 0.5mm of the boom. Check periodically to ensure bolts remain snug and washer turns freely.

CAUTION**Damage to Equipment Hazard!**

Bolts in telescope slide pad are intentionally left loose. Do not over tighten or possible damage may occur to equipment.

**FIGURE 4-33****WARNING****Overturning Hazard!**

Make sure that all the *Prerequisites*, page 4-44 are met. If you do not keep to the rigging mode specified there, the truck crane could overturn.

Falling Hazard!

There is grease residue on the telescopic sections. For this reason, you must not walk on the main boom.

Use the extendable ladder provided with your crane.

CHECK THE LOCKING SYSTEM**WARNING****Lack of Maintenance Work Hazard!**

Have the additional maintenance work on the main boom locking system performed by your authorized Grove Crane distributor or Manitowoc Crane Care regularly.

This prevents the complete unlocking of a telescoping section in Emergency operation/Emergency program mode, which could cause serious accidents and damage to the truck crane.

- Have the main boom locking system checked by your authorized Grove Crane distributor or Manitowoc Crane Care.

HOIST ROPES

Checking the Position of Sheaves and Rope Drums



WARNING

Entanglement Hazard!

Keep yourself and other people away from the turning rope drum. Death or serious injury may result if entanglement occurs during hoist operation. Keep all body parts and loose clothing clear while hoist is running.

- Check the position of the hoist ropes on the rope drums of the main hoist and the auxiliary hoist.
- Slowly turn the rope drum at least one turn in the lowering direction. Watch the rope on the drum as you do this.
 - The rope must be wound evenly on the drum.
 - The rope turns on the drum must be evenly spaced at a distance of 0 to 2 mm (0 to 0.07 in).
 - The cross-over points must be at an angle of approximately 180°.

NOTE: The upper rope lines lie over the lower rope lines at the cross-over points.

- Check the position of the hoist ropes on the sheaves at the boom head and in the hook block.
- Check the sheaves for damage and wear, and check that they run freely.

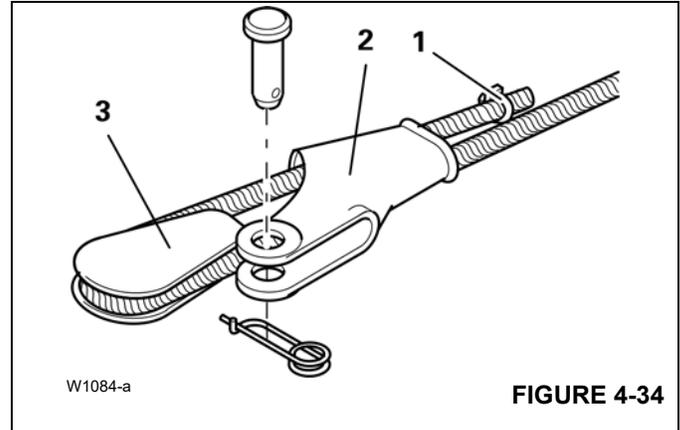


WARNING

Incorrectly Set Lowering Limit Switch Hazard!

Never turn the free rope end under the drum. Turns on the drum which are unwound when the rope drum is stationary cannot be detected by the lowering limit switch. This causes the lowering limit switch to become set incorrectly and to switch off too late or not at all. Consequently the load may fall causing equipment damage or injury.

- Check the securing of the rope end in the rope end clamp (2), (Figure 4-34) for proper seating and correct positioning of rope.
- The rope end clamp (1), (Figure 4-34) must be attached to the free end of the rope and the rope must be secured around the rope wedge (3), (Figure 4-34).



W1084-a

FIGURE 4-34

NOTE: The recommended hook-blocks are designed to be of sufficient weight to overhaul the rope properly when using the parts of line required for the allowed load at the chosen boom length. Operating with a higher number of parts of line than is necessary for a particular boom length may result in poor rope spooling behavior and loosely stored rope, which can result in future rope damage. If operation in these extended ranges is desired, extra weight should be carried by the hookblock or a heavier hookblock should be used.

WIRE ROPE INSPECTION/REPLACEMENT (ALL WIRE ROPE)

NOTE: For cranes equipped with synthetic rope refer to the synthetic rope manual.

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 judgment of an appointed and qualified person who evaluates the remaining strength in a used rope after allowance for any deterioration disclosed by inspection.

Wire rope replacement should be determined by the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies and as recommended by Manitowoc. All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall be taken out of service when any of the following conditions exist:

- Kinking, crushing, birdcaging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than 5%.
- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay

- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- Severe corrosion as evidenced by pitting.
- Manitowoc recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Manitowoc recommends for cable extended booms, that boom extension cables be replaced every seven (7) years.

The following tables show the number of wire breaks in a length 6 times and 30 times the rope diameter which would require rope replacement, for the most common rope diameters.

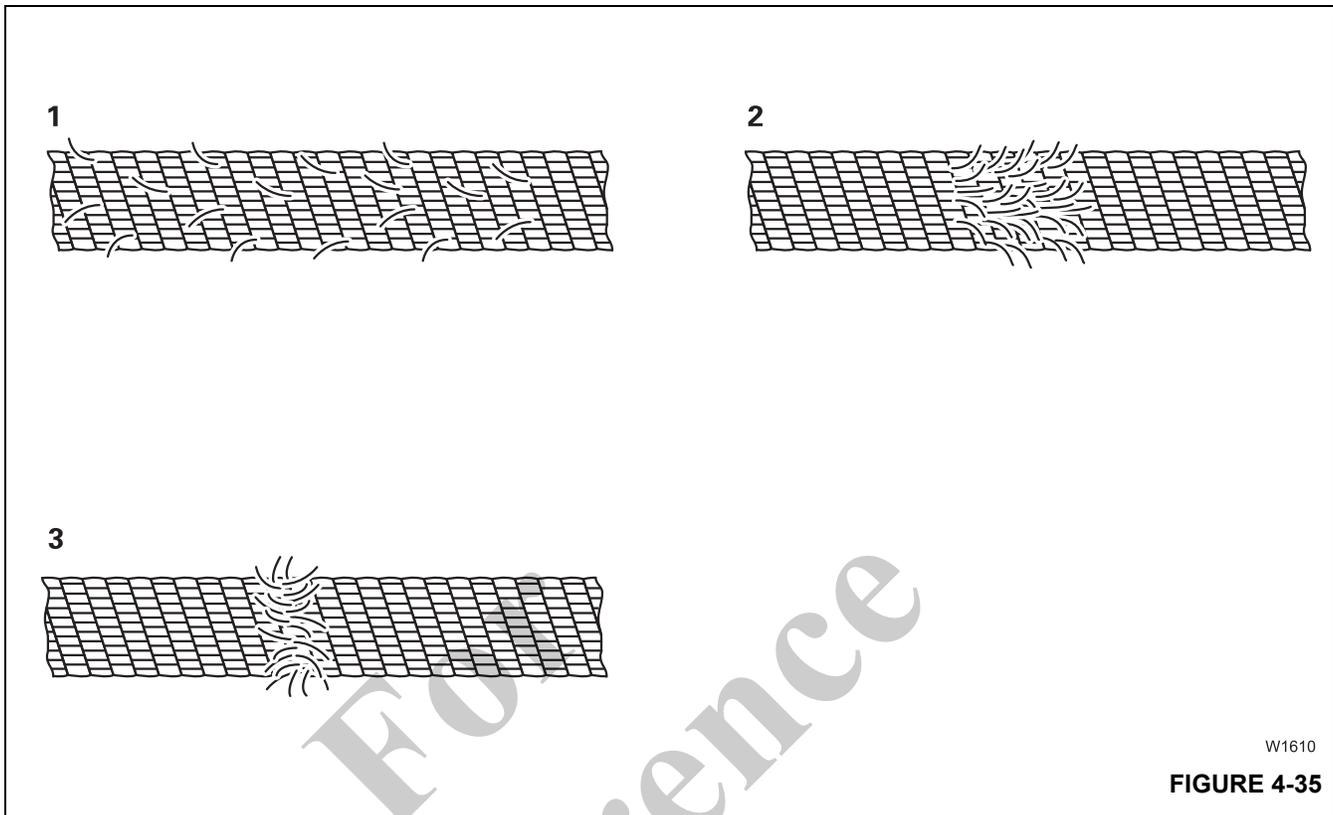
Number of Load-Bearing Outer Wires	Number of Visible Wire Breaks									
	Regular Lay Rope									
	Ø 13 mm		Ø 16 mm		Ø 19 mm		Ø 22 mm		Ø 24 mm	
	to 78 mm	to 390 mm	to 96 mm	to 480 mm	to 114 mm	to 570 mm	to 132 mm	to 660 mm	to 144 mm	to 720 mm
101–120	5	10	5	10	5	10	5	10	5	10
121–140	6	11	6	11	6	11	6	11	6	11

Load-Bearing Outer Wires (Quantity)	Number of Visible Wire Breaks									
	Lang Lay Rope									
	Ø 13 mm		Ø 16 mm		Ø 19 mm		Ø 22 mm		Ø 24 mm	
	to 78 mm	to 390 mm	to 96 mm	to 480 mm	to 114 mm	to 570 mm	to 132 mm	to 660 mm	to 144 mm	to 720 mm
101–120	2	5	2	5	2	5	2	5	2	5
121–140	3	6	3	6	3	6	3	6	3	6

NOTE: The number of visible wire breaks indicated here only applies to the hoist ropes! This information only applies to the initial equipment and original spare parts!

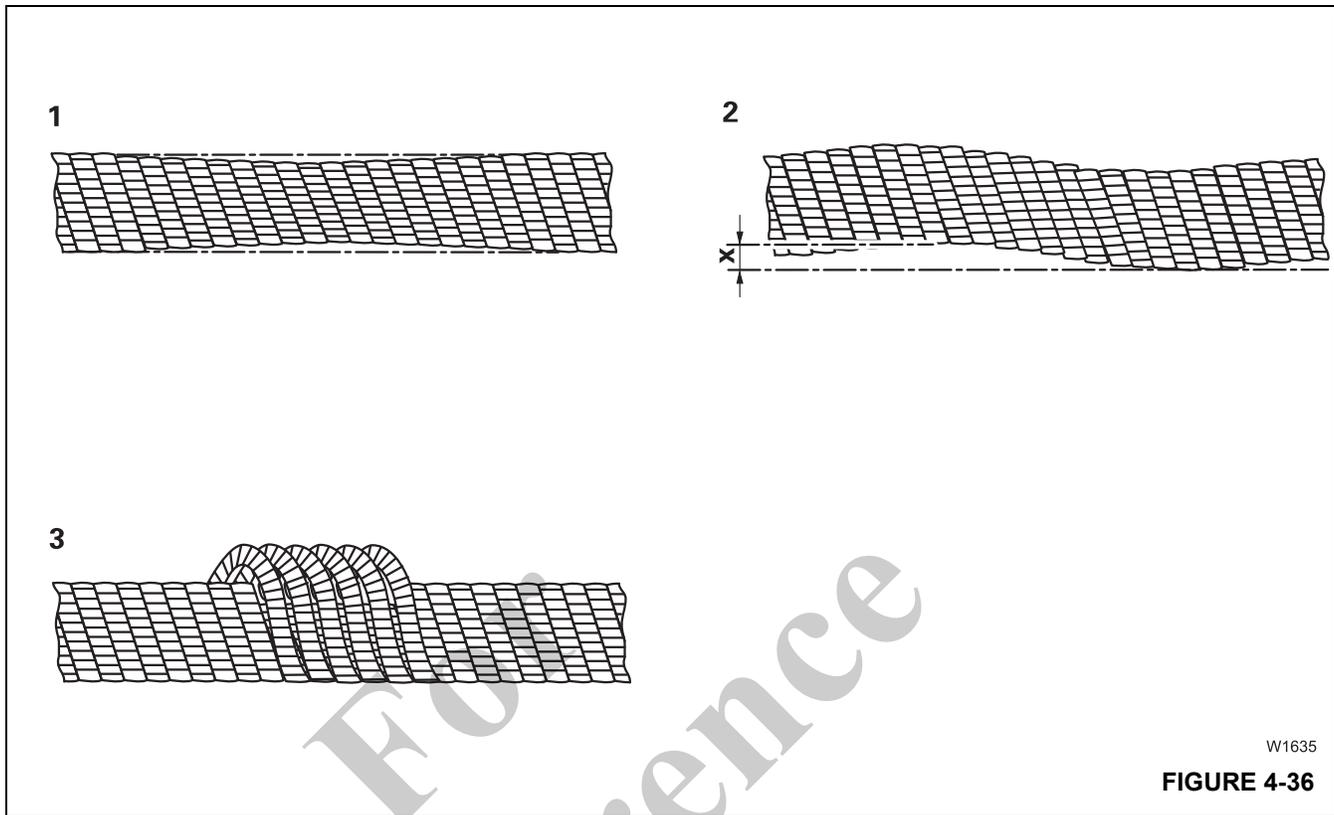
CAUTION

Remember that other factors may also make it necessary to replace the hoist rope before the number of wire breaks requiring rope replacement has been reached (age of rope, frequency of use or exceptional loading).



4

Damage	Description	Cause	Replacement
Wire Breakage (1), (Figure 4-35) Wire Breakage Clusters (2), (Figure 4-35) Strand Breakage (3), (Figure 4-35)	Individual wires are broken; the broken ends of the wires are protruding from the rope.	General wear caused by aging of the rope or subsequent damage resulting from damage to the rope.	Replace hoist rope at the latest when the maximum permissible number of wire strand fractures according to the table are visible externally. Replace hoist rope immediately if wire breakage clusters or strand breakage occur. The frequency of wire breakage increases with rope age. For reasons of safety, it is advisable to replace the hoist rope while the number of broken wires is still low.
Effect of Heat	Tarnishing color is visible externally on the rope.	Rope has been subjected to strong heat.	Replace hoist rope immediately .



W1635

FIGURE 4-36

Damage	Description	Cause	Replacement
Diameter Reduction (1), (Figure 4-36)	The diameter of the rope has become smaller along large sections.	Structural changes.	Immediately replace hoist rope if the diameter has decreased by 15% or more with respect to the nominal diameter.
		Corrosion or abrasion.	Immediately replace the hoist rope if the diameter has decreased by 10% or more with respect to the nominal diameter.
Corkscrew Deformation of Rope (2), (Figure 4-36)	The rope winds its way along its longitudinal axis in a way which is similar to a corkscrew. The deformation is measured with the attached hook block.	Damage resulting from overloading.	Even a small amount of deformation leads to increased abrasion, wire breakage and rough operation of the cable drive. If deformation 'x' at a position on the hoist rope is greater than a third of the rope diameter, the hoist rope must be replaced immediately .
Basket-Type Deformation (3), (Figure 4-36)	Wires from the outer layer are protruding from the rope. In various areas of the rope, the ply has buckled or is protruding from the rope.	Outer and inner layers have dislocated from one another.	Replace the hoist rope immediately .

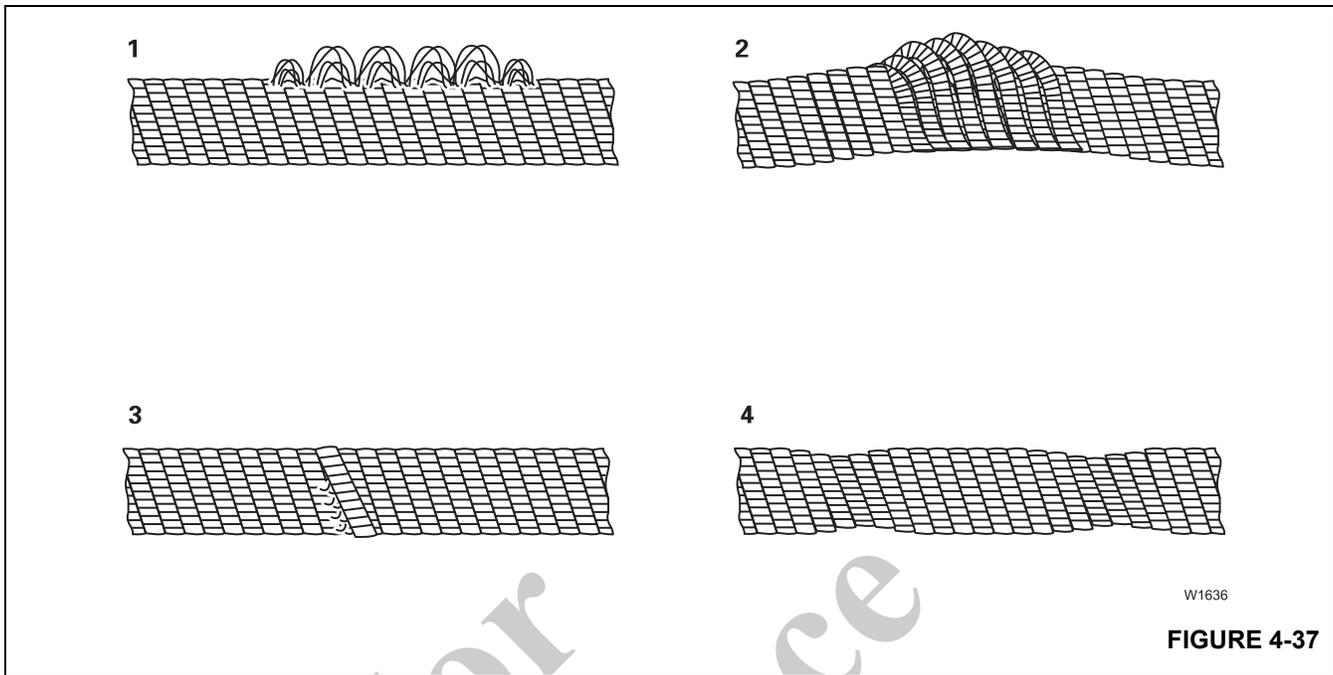
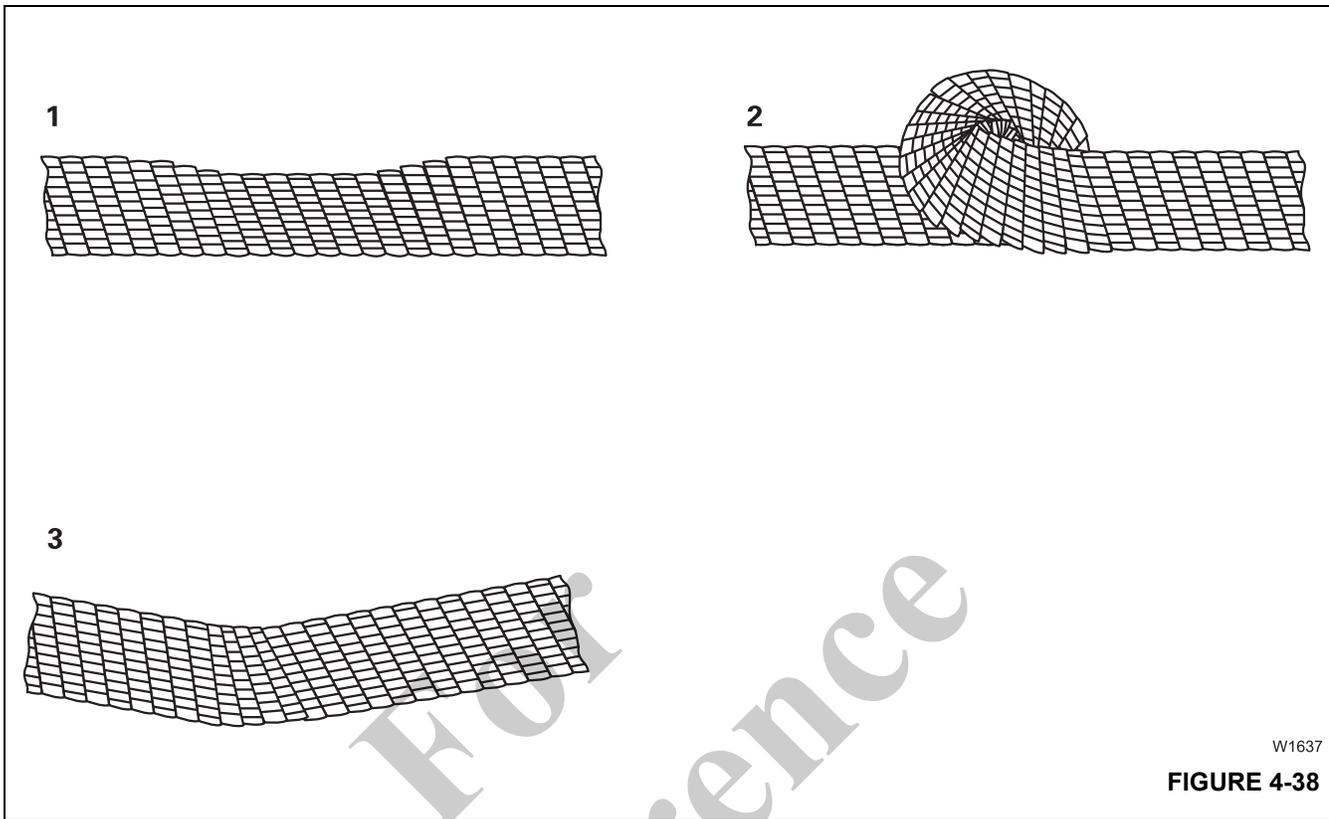


FIGURE 4-37

Damage	Description	Cause	Replacement
Loop Formation (1), (Figure 4-37)	Outer layer wires in the form of hair pins are protruding from the rope on the side opposite the sheave.	General wear due to aging of the rope or subsequent damage resulting from damage to the rope.	Immediately replace hoist rope if the rope structure has been substantially altered by the loop formations.
Loosening of Wires or Strands (2), (Figure 4-37)	Outer wires or strands have become loose. Only the inner strands continue to bear the load.	Corrosion or abrasion.	Replace hoist rope immediately .
		Other causes.	The number of broken wires determines when the rope must be replaced.
Knot Formation (3), (Figure 4-37)	Repeatedly occurring knot-like thickening of rope; core often protrudes. The strands bear on each other at thin points resulting in increased occurrence of wire breakage.	General wear due to aging of the rope or subsequent damage resulting from damage to the rope.	Determine number of broken wires; if serious knot formation occurs, replace rope immediately .
Constriction (4), (Figure 4-37)	Diameter reduction over short sections.	General wear caused by aging of the rope.	Replace hoist rope immediately if serious constriction.



W1637
FIGURE 4-38

Damage	Description	Cause	Replacement
Flattening (1), (Figure 4-38)	Crushed areas, mostly with wire breakage.	Mechanical damage, e.g. due to driving over the rope.	Determine number of broken wires; replace hoist rope immediately if serious crushing occurs.
Crinkle Formation	Crinkle type rope deformation.	Loaded hoist rope was pulled over an edge.	Replace hoist rope immediately .
Kink (2), (Figure 4-38)	Rope deformation with twisting and broken wires.	Rope was pulled straight while twisted and located in eyes.	Replace hoist rope immediately .
Buckle (3), (Figure 4-38)	Buckled section in rope.	Mechanical damage.	Replace hoist rope immediately .

RATED CAPACITY LIMITER

Maintenance of the Slip Ring Assembly of the Cable Drum

Maintenance of the slip ring assembly is carried out in order to prevent contamination and corrosion and to prevent malfunctions on the RCL.

The truck crane has two cable drums whose slip ring assembly needs to be maintained.

There is a cable drum (1), (Figure 4-39) on the left side of the main boom.



FIGURE 4-39

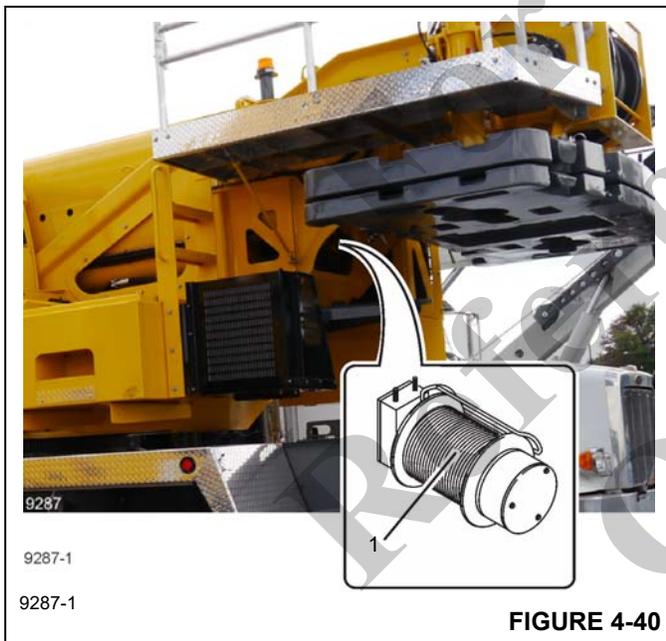


FIGURE 4-40

The second cable drum (1), (Figure 4-40) is located in the main boom underneath the telescoping cylinder.

You can reach the cable drum through the manhole if you first extend Telescopic Section I by approximately 2.0 m (6.6 ft).

WARNING
Crushing Hazard!

Secure the boom against unintentional movement, so that your fingers will not be crushed by the turning slip ring assembly. If you are carrying out this operation with the help of someone else, communicate with the person in the crane cab by means of clear hand signals.

NOTE: The following sections describe the maintenance procedure for the outer cable drum. Maintenance on the cable drum in the boom is carried out in the same way.

Prerequisites

Before maintenance, the following requirements must be met:

- The main boom must be resting in the boom rest.
- The battery master switch is switched off.

CAUTION

Damage to the Rated Capacity Limiter Hazard!

Before maintenance work on the slip ring assembly, always switch off the battery master switch so that the cable drum is current-free.

This prevents short circuits which may lead to damage to the central unit.

Maintenance of the Slip Ring Assembly

To remove abrasion particles from the contact brushes, use only dry, oil-free air or a clean, lint-free cloth.

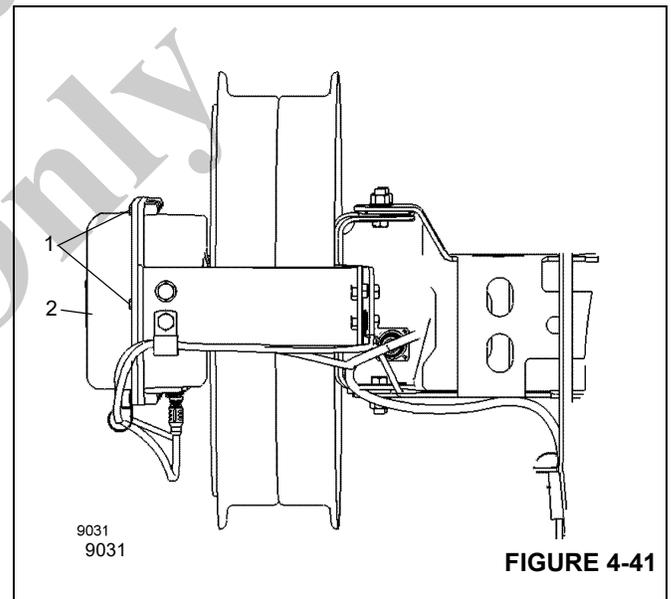


FIGURE 4-41

- Make sure that the cable drum is current-free.
- Unscrew all screws (1), (Figure 4-41) and remove the casing (2), (Figure 4-41).
- Check the seal on the casing for damage and replace it if necessary.
- Remove any moisture in the casing with a clean, lint-free cloth.

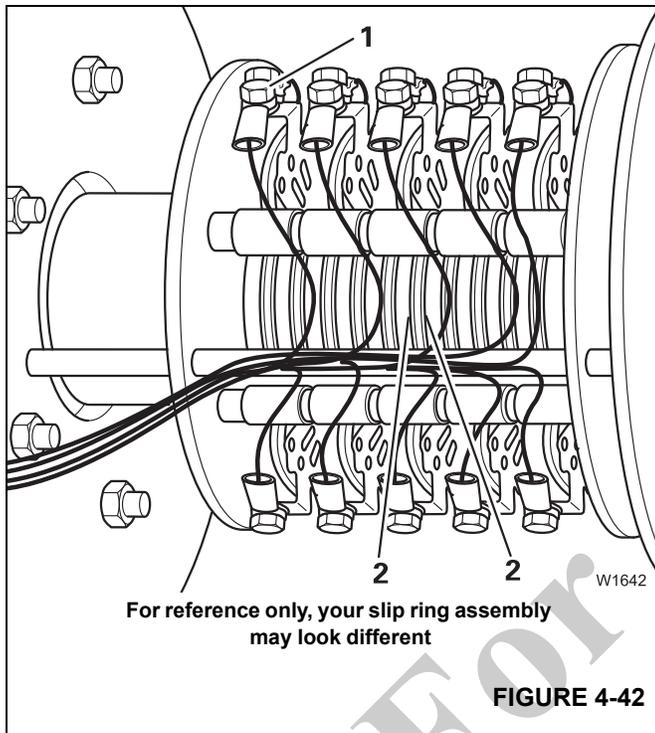


FIGURE 4-42

- Remove visible dirt on the slip rings (2), (Figure 4-42) with a clean, lint-free cloth.

You can turn the drum by pulling the RCL Cable in the direction of the main boom head. If you let go of the cable, the drum turns back because of the initial tension.

- Check to make sure all screws (1), (Figure 4-43) are tight.

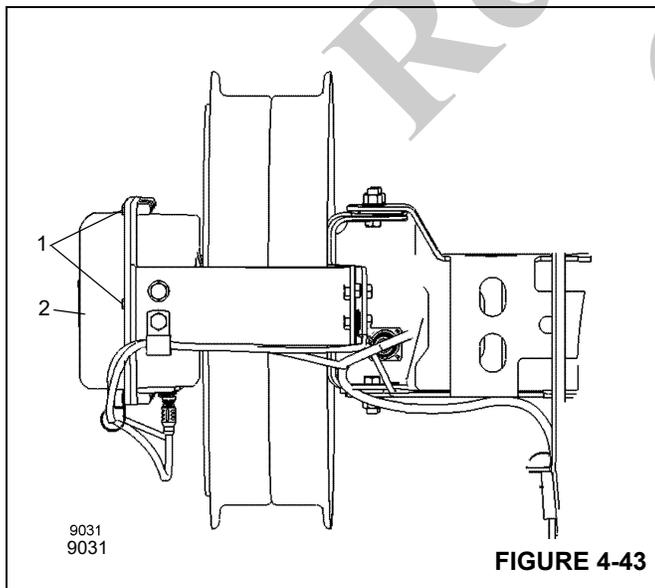


FIGURE 4-43

- Put the casing (2), (Figure 4-43) back in place. Make sure that the seal is in the right place.
- Fasten the casing with all the screws (1), (Figure 4-43).

When all the cable has been wound on the drum it needs to stay on the drum while you are doing the 8 ± 1 revolutions of pre-tension on the entire reel, then start pulling the cable off to route out alongside the boom section.

Lubricating the Swing Angle Sensor

CAUTION

Damage to the Swing Angle Sensor Hazard!

Before lubricating, always unscrew the seal from the swing angle sensor.

In this way you prevent grease penetrating the electrical components, leading to malfunctions in the swing angle sensor.

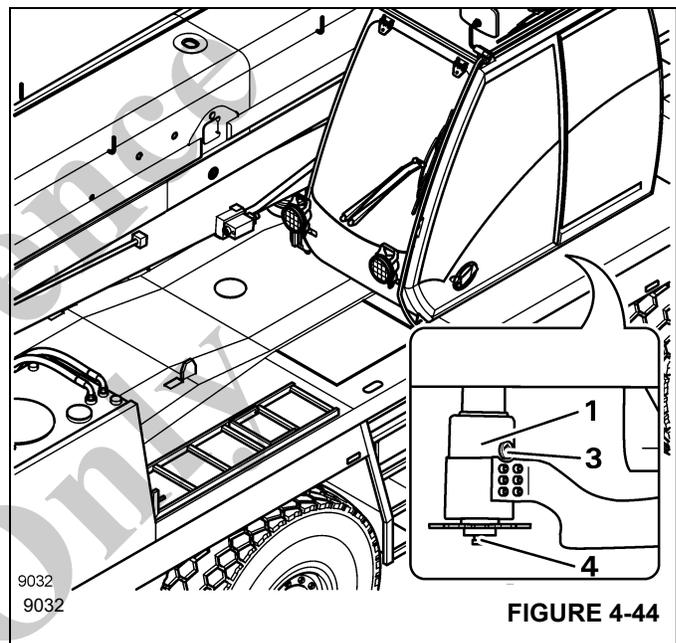


FIGURE 4-44

Depending on the equipment on your crane, there is a swing angle sensor (1), (Figure 4-44) under the crane cab.

- Remove the cover of the swing angle sensor.
- Remove the seal (3), (Figure 4-44) from the opening.
- Remove the protective cap from the lubricating nipple (4), (Figure 4-44).
- Clean any old grease from the lubricating nipple.
- Use a grease gun to press 5 cm³ (0.03 in³) of grease into the lubricating nipple.
- Only use grease specified in *Lubrication*, page 9-1.
- Remove excess grease from the lubricating nipple and from the opening.
- Place the protective cap onto the lubricating nipple (4), (Figure 4-44).

- Screw the seal (3), (Figure 4-44) back on with a new sealing ring and new sealing agent. Tightening torque; see *Torque Values*, page 1-9.
- Replace the cover of the swing angle sensor.

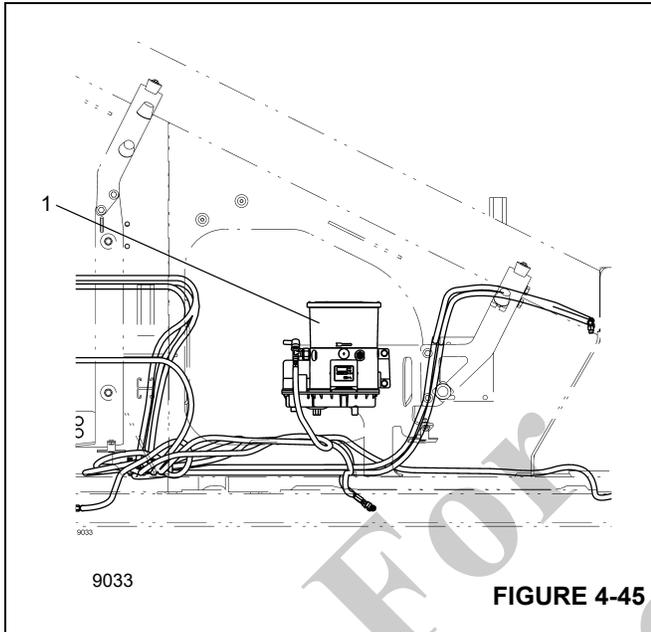


FIGURE 4-45

The grease container (1), (Figure 4-45) is located on the right side of the turntable above the storage compartment.

Only fill with grease as specified in *Lubrication*, page 9-1.

The maintenance of the central lubrication system on the superstructure is the same as the maintenance of the central lubrication system on the carrier.

SUPERSTRUCTURE AIR CONDITIONING SYSTEM (ADDITIONAL EQUIPMENT)

The crane is equipped with only one refrigerant circuit for the air-conditioning system on the carrier and superstructure.

Checking Hoses

- Check all refrigerant hoses for damage and worn areas.
- Only allow damaged hoses to be replaced by Manitowoc Crane Care.

When servicing the air conditioning system, observe the following specifications:

- Minimum Evacuation Time — 60 minutes
- Refrigerant Charge Levels — 2.5 pounds (± 0.5 oz)
- Additional Pag Oil Required Above the 6 ounces in Compressor — 5.0 ounces

OTHER MAINTENANCE WORK

Checking for Correct Operation of the Auxiliary Heater (Additional Equipment)

For additional information, see the section Heating and Ventilating the Superstructure Cab in the Operator Manual.

Lubricating the Piston Rod of the Lifting Cylinder

CAUTION

Damage to the Lifting Cylinder's Gasket Due to Surface Rust Hazard!

Be sure that the uncovered end of the piston rod on the lifting cylinder is always kept lubricated. In this way, you can avoid surface rust, which damages the gasket in the lifting cylinder head when lowering completely.

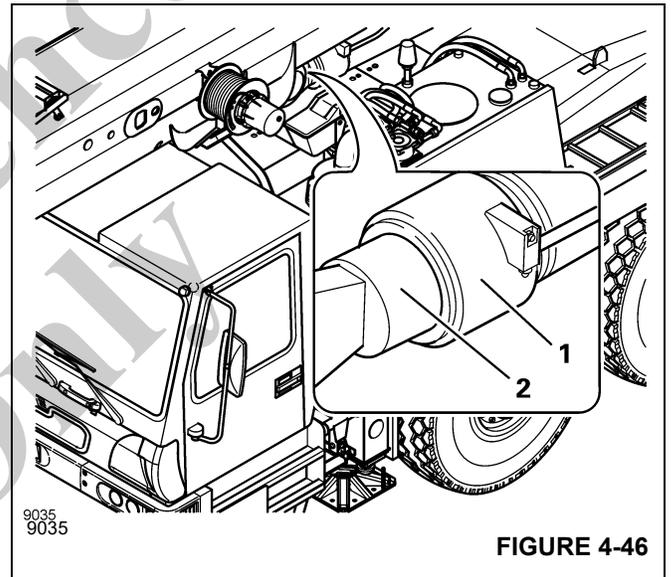


FIGURE 4-46

- Clean the open end (2), (Figure 4-46) of the piston rod of old grease, dirt particles and rust.
- Lubricate the open end (2), (Figure 4-46) of the piston rod on the lifting cylinder head (1), (Figure 4-46) so that it is evenly covered with grease.

NOTE: You can also prevent surface rust if you turn the main boom to the side between maintenance intervals and completely lower it.

For
Reference
Only

This Page Blank

SECTION 5 SUPERSTRUCTURE MAINTENANCE

SECTION CONTENTS

Superstructure Maintenance Overview	5-1
Maintenance Intervals	5-1
Maintenance Plans	5-3
Maintenance Plan W: Weekly	5-5
Maintenance Plan M 1: Monthly/After 100 Operating Hours/Approximately 2,000 km (1240 mi)	5-6
Maintenance Plan M 3: Every 3 Months/After 300 Operating Hours/5 000 - 6 000 km (3,100 - 3,730 mi)	5-6
Maintenance Plan M 6: Every 6 Months/After 500 Operating Hours/10 000 - 12 500 km (6,210 - 7,770 mi)	5-6
Maintenance Plan M 12: Every 12 Months/After 1,000 Operating Hours/20 000 - 25 000 km (12,430 - 15,530 mi)	5-7
Maintenance and Inspection Plan Y 2: Every 24 Months/After 100 000 - 125 000 km (62,150 - 77,800 mi)	5-7
Maintenance and Inspection Plan Y 3: Every 36 Months/After 3,000 Operating Hours	5-7
Maintenance and Inspection Plan Y 5: Every 60 Months/After 5,000 Operating Hours	5-8
Maintenance and Inspection Plan Y 6: Every 72 Months/After 6,000 Operating Hours	5-8
Periodic Inspections	5-9
Load Hook Inspection	5-9
Measures Required for Hoist Monitoring	5-10
Theoretical Service Life	5-10
Proportion of the Theoretical Service Life Used	5-10
Table Example to Determine the Remaining Theoretical Service Life on Hoist No. 1 (Main Hoist)	5-12

SUPERSTRUCTURE MAINTENANCE OVERVIEW

In this chapter, all superstructure periodic maintenance work is described in maintenance plans as:

- Maintenance plans **D** (= daily)
- Maintenance plans **W** (= weekly) and,
- Maintenance plans **M 1** (= once monthly) to **M 12** (= every 12 months) and,
- Maintenance plans **Y 2** (= every 24 months) to **Y 6** (= every 72 months).

The maintenance plans are given in table form in this section for the superstructure. See *Lubrication*, page 9-1 for carrier lubrication.

MAINTENANCE INTERVALS

The length of the interval depends on the operating conditions of the truck crane:

The next maintenance check must be carried out after:

- a specified **time (maintenance deadline)** or
- a specified number of **operating hours**.

The **maintenance interval which occurs first** shall determine when maintenance work is next due.

The following table sets out the maintenance intervals for the maintenance plans:

You can call up the **working hours (operating hours)** of the superstructure's power units individually on the crane control display in the crane operator's cab (front instrument panel). The operating hours of the diesel engine are simultaneously the total operating hours of the superstructure.

Maintenance Plans	Maintenance Interval	Operating Hours of Diesel Engine (Superstructure)
D	daily/before putting into operation	—
W	weekly	—
M 1	monthly	100
M 3	every three months	300
M 6	every six months	500
M 12	every twelve months	1 000
Y 2	every 24 months	—
Y 3	every 36 months	3 000
Y 5	every 60 months	5 000
Y 6	every 72 months	6 000

NOTE: Please note that the long-term maintenance plans always include the short-term ones!

MAINTENANCE PLANS

The descriptions for certain maintenance work for the maintenance plans **D**, **W**, **M 1** to **M 12** and **Y 2** to **Y 6** are provided for in Section 8.

References (chapter and page number) to the description of this maintenance work can be found after the respective maintenance work.

The Section titled - *Description of Maintenance Work on the Superstructure*, page 4-1, contains the symbol (**D** to **Y 6**) of the relevant maintenance plan for better comprehension.

NOTE: The description of the daily (**D**) and weekly (**W**) checks (preventive maintenance) can also be found in part in the operating instructions.

In addition to the **maintenance work on the superstructure**, the maintenance plans also contain the following:

- The **amounts** as approximate values for oil amounts (the exact oil amounts are always determined by the oil level openings, the dipstick or the oil level indicators) or the **number** of existing lubricating points.

Maintenance Plan D: Daily/Before Commissioning

1	Air Cleaner: Check for proper service/level. Check for cracks or leaks.
2	Anti-Two-Block (A2B): Check for proper operation while operating machine. Check connectors and wiring for proper alignment and insulation.
3	Back-up Alarm: Check for proper operation while operating machine.
4	Boom and Attachments: Is item properly installed on machine. Check for excess dirt, grease, or foreign matter. Check for proper operation while operating machine.
5	Boom Angle Indicator: Check for proper operation while operating machine.
6	Brakes (Swing, Foot & Parking): Check for proper working order. Check for proper operation while operating machine.
7	Brakes and Air System (if equipped): Check for proper working order. Check for proper operation while operating machine. Drain moisture.
8	Cooling System: Check for proper service/level. Check for cracks or leaks.
9	Crankcase: Check for proper service/level. Check for excess dirt, grease, or foreign matter.
10	Fuel Tank: Check for proper Level and fill if needed
11	Fuel/Water Separator: Drain moisture.
12	Gauges and Instruments: Check for proper working order. Check for proper reading while operating engine. Check for proper operation while operating machine.
13	Hoists: Is item properly installed on machine. Check for excess dirt, grease, or foreign matter. Check for proper operation while operating machine.
14	Hook Block & Overhaul Ball Safety Latch: Check for proper working order. Check for cracks and leaks. Check for excessive wear.
15	Hourmeter: Check for proper working order. Check for proper reading while operating engine.
16	Hydraulic Oil Filter: Check for proper service/level.
17	Hydraulic Tank: Check for proper service/level. Check for excess dirt, grease, or foreign matter.
18	Rated Capacity Limiter: Check for proper operation while operating machine. Check connectors and wiring for proper alignment and insulation.

19	Lock-out Cylinder & Slew Potentiometer: Check for proper operation while operating machine. Check for proper adjustment.
20	Operator's Manual: Is item properly installed on machine?
21	Signal and Running Lights & Horn: Check for cracked or broken glass. Check for proper working order.
22	Steps and Ladders: Check for excess dirt, grease, or foreign matter. Check for deterioration, damage or excessive wear. check for cracked or broken structures and welds.
23	Tires: Check for proper inflation/pressure. Check for excessive wear. Check for excess dirt, grease or foreign matter.
24	Transmission/Torque Converter: Check for proper service/level.
25	Wire Rope: Check for damaged, frayed, or broken strands.

For
Reference
Only

Maintenance Plan W: Weekly

Maintenance Work on the Superstructure
<p>Main Hoist/Auxiliary Hoist</p> <ul style="list-style-type: none"> • Check the oil level. <i>Hoist Lubrication</i>, page 9-21 • Check for leaks • Check the hoist brake. <i>Hoist</i>, page 4-1 • Lubricate auxiliary hoist drives (only when auxiliary hoist is fitted as additional equipment). <i>Hoist Lubrication</i>, page 9-21
<p>Swing Gear</p> <ul style="list-style-type: none"> • Check the swing gear transmission oil level, page 9-18 • Check the swing gear brake oil level, page 9-18 • Check for leaks
<p>Hydraulic System of the Superstructure</p> <ul style="list-style-type: none"> • Check hydraulic hoses • Check for leaks with the diesel engine running
<p>Central Lubrication System on Superstructure</p> <ul style="list-style-type: none"> • Check the level of the grease container, page 9-22
<p>Hoist Ropes</p> <ul style="list-style-type: none"> • Check condition; <i>Hoist Ropes</i>, page 4-47
<p>Other Maintenance Checks</p> <ul style="list-style-type: none"> • Check the function of the windscreen washing system of the crane operator's cab and the level of fluid in the supply reservoir.

Reference Only

**Maintenance Plan M 1: Monthly/After 100
Operating Hours/Approximately 2,000 km
(1240 mi)**

Maintenance Work on the SUPERSTRUCTURE: Monthly/After 100 Operating Hours
Hook Blocks <ul style="list-style-type: none"> • Lubrication, page 9-1
Hydraulic System of the Superstructure <ul style="list-style-type: none"> • Bleed the telescoping cylinders, page 4-44 • Bleed the lift cylinder
Other Maintenance Work <ul style="list-style-type: none"> • Check for correct operation of the auxiliary heater (additional equipment) • Lubricate cabin door track rollers. • Lubricate the connecting and socket pins. • Lubricate the spring latch.

**Maintenance Plan M 3: Every 3 Months/After
300 Operating Hours/
5 000 - 6 000 km (3,100 - 3,730 mi)**

Maintenance Work on the SUPERSTRUCTURE: Every 3 Months/After 300 Operating Hours
Ball Swing Connection <ul style="list-style-type: none"> • Check tightness of retaining bolts; <i>Torque Values</i>, page 1-9.
Main Boom <ul style="list-style-type: none"> • Lubricate locking pins • Lubricate telescopic slide faces, page 9-23

**Maintenance Plan M 6: Every 6 Months/After
500 Operating Hours/10 000 - 12 500 km
(6,210 - 7,770 mi)**

Maintenance Work on the SUPERSTRUCTURE: Every 6 Months/After 500 Operating Hours
Swing Gears <ul style="list-style-type: none"> • Lubricate the swing gear pinions, page 9-18
Superstructure Air Conditioning System (Additional Equipment) <ul style="list-style-type: none"> • Check hoses
RCL <ul style="list-style-type: none"> • Maintain the slip ring assembly in the cable drums; page 4-53

**Maintenance Plan M 12: Every 12 Months/
After 1,000 Operating Hours/20 000 - 25 000
km (12,430 - 15,530 mi)**

Maintenance Work on the SUPERSTRUCTURE: Every 12 Months/After 1 000 Operating Hours
<p>Main Hoist/Auxiliary Hoist</p> <ul style="list-style-type: none"> • Oil change¹⁾, page 9-21 Check the old oil
<p>Swing Gears</p> <ul style="list-style-type: none"> • Oil change, swing gear transmission • Change the swing gear brake oil
<p>Main Boom</p> <ul style="list-style-type: none"> • Check the locking system
<p>Superstructure Air Conditioning System (Additional Equipment)</p> <ul style="list-style-type: none"> • Check the entire air conditioning system

¹⁾at least once per year

**Maintenance and Inspection Plan Y 2:
Every 24 Months/After 100 000 - 125 000 km
(62,150 - 77,800 mi)**

Maintenance Work on the SUPERSTRUCTURE: Every 24 Months
<p>No maintenance work in this period. The long-term intervals always include the short-term intervals!</p>

**Maintenance and Inspection Plan Y 3:
Every 36 Months/After 3,000 Operating
Hours.**

Maintenance Work on the SUPERSTRUCTURE: Every 36 Months/After 3 000 Operating Hours
<p>Main Hoist/Auxiliary Hoist</p> <ul style="list-style-type: none"> • Carry out partial inspection; page 4-2

**Maintenance and Inspection Plan Y 5:
Every 60 Months/After 5,000 Operating
Hours****Maintenance Work on the SUPERSTRUCTURE:
Every 60 Months / After 5 000 Operating Hours****RCL**

- Lubricate the swing angle sensor, page 4-52

**Maintenance and Inspection Plan Y 6:
Every 72 Months/After 6,000 Operating
Hours****Maintenance Work on the Superstructure:
Every 72 Months/After 6 000 Operating Hours****Main Hoist/Auxiliary Hoist**

- *Carrying Out General Inspection of Hoists*, page 4-2

For
Reference
Only

PERIODIC INSPECTIONS

Your truck crane was inspected before delivery. Regulations in your area may prescribe specific inspection intervals and should be reviewed and adhered to. If such regulations do not exist, an inspection should be carried out by an *expert* at least once a year.

These periodic inspections are generally visual inspections intended to assess the condition of the truck crane and its components. Their purpose is to detect defects at an early stage and thus prevent accidents.

Inspections are to be carried out on the following components, where these are not already contained in the list of routine maintenance tasks:

- the hydraulic and electrical control and safety devices,
- the rated capacity limiter (RCL),
- the mounting and safety devices of all screwed-on parts,
- the hoist ropes,
- load hooks (*Load Hook Inspection*, page 5-9 Section below),
- the load-bearing structural steelwork (for tears, deformation, etc.), including a special check of all welds.

If damage is found in the structural steelwork, have qualified specialists determine the extent of the damage using the required material examination methods. They should then determine what sort of repair action could be done.

The inspector is to write a record containing the result of the inspection and the measures taken to repair any damages.

Load Hook Inspection

The mouth of the load hook must be checked regularly for deformation.

The mouth of the hook may not be expanded by more than 10% of the original dimension y , $y1$, $y2$.

The original dimensions y , $y1$, $y2$ are printed in field (2), (Figure 5-1) on the load hooks.

- To check, measure the distance between the marked measuring points on the load hook shaft (1), (Figure 5-1) and the tip of the hook (3), (Figure 5-1).

The hook block may no longer be used if the mouth has expanded by over 10% of the initial dimension.

The load hook must consequently be replaced.

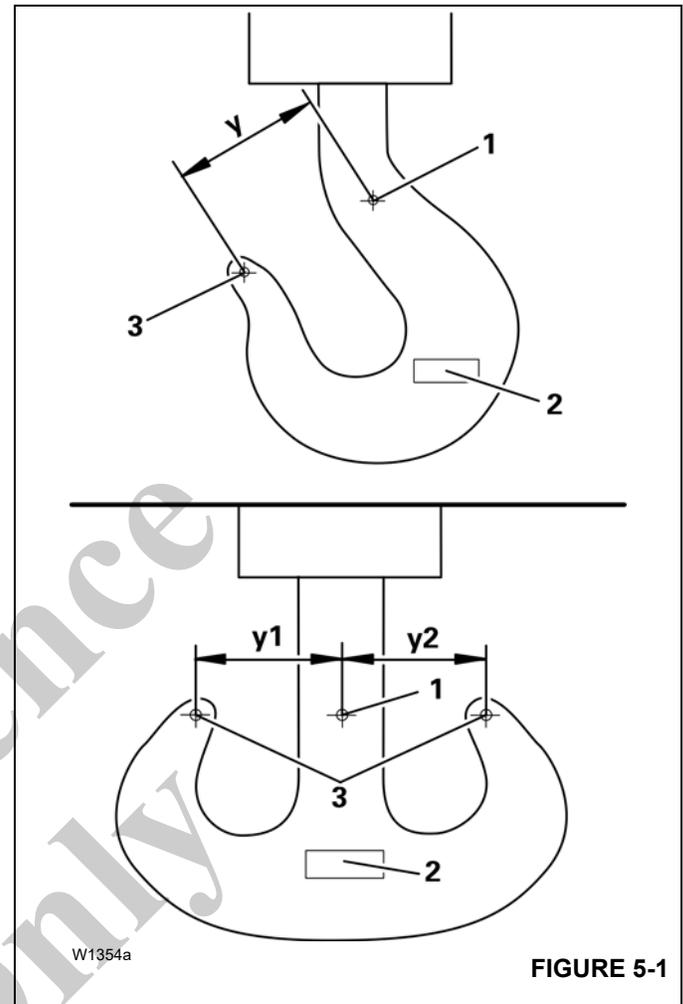


FIGURE 5-1



WARNING

Accidents May Occur if the Load is Allowed to Drop!

Hook blocks with deformed load hooks are no longer operationally safe! The load hooks could break and drop the load. Deformed load hooks must always be replaced!

MEASURES REQUIRED FOR HOIST MONITORING

NOTE: Also observe the information on the general inspection of the hoists.

These measures for monitoring the hoists (hoisting gear) were compiled by VDMA and are to be used for all vehicle cranes according to the *Accident Prevention regulations Winches, Hoisting and Tractor Machines BGV D 6 (VGB 9) and BGV D 8 (VGB 8)*.

Theoretical Service Life

The theoretical service life is the result of certain operating conditions and a theoretical operating time assumed by the design engineer when calculating and dimensioning the winches of your crane.

The winches of your crane are classified as follows (ISO 4301/1, FEM 1.001, DIN calculation rules for power units):

Power unit group:	M
Load spectrum:	Q; (L.....)
Load spectrum factor:	Km	=
Theoretical service life:	D	=

The power unit group M 3 and the collective load L1 (Km = 0.125) are generally given for truck cranes in erection mode, resulting in a theoretical service life of 3200 h.



CAUTION

The theoretical service life is not the same as the real (actual) service life of a hoist.

The real service life of a hoist is affected by a number of additional external factors, such as:

- Overloading caused by improper use of the crane.
- Insufficient maintenance: oil is not changed in the specified intervals.
- Incorrect operation: extreme acceleration or retardation of the load, load drops and stops suddenly while suspended.
- Improper maintenance: using wrong oil, incorrect quantity, contamination during oil change.
- Improper assembly during maintenance and repair work.
- Leaks which were ignored.
- Improper adjustment of safety devices.
- Concealed damage caused by accidents.
- Extreme environmental low or high temperatures, conditions: aggressive atmosphere, dust and dirt.

Proportion of the Theoretical Service Life Used

The crane operator must perform a crane inspection at least once a year (ISO 9927-1 and BGV D 6 (VGB 9) / BGV D 8 (VGB 8)).

This includes establishing the proportion of the theoretical service life that has been used. If required, the crane operator is to appoint an expert for this assessment.

The actual operating conditions (load spectrum) and the operating hours of the hoists are to be determined for each inspection interval when establishing the proportion of the theoretical service life that has been used. The operator is responsible for proper documentation in the crane logbook.

Determining the Operating Conditions (Collective Load)

The collective load of the crane is divided into groups: (also refer to ISO 4301/1, FEM 1.001)

NOTE: When establishing the load spectrum, the existing wire cable is used as a standard, i.e. under certain

circumstances, the crane can be supporting a small load, whereby the hoist is actually supporting a heavy load, e.g. due to insufficient reeving. Therefore, the following graphic representation of the load spectrum refers to the hoist's wire cables.

Collective load Class	Term designation	Working time proportion	Collective load factor Km =	Graphic representation
light Q 1 L 1	Power units or their parts, which are subjected to highest load as an exception, continuously however only very less load	10 % of the operating time with highest load (dead load + 1/1 payload) 40 % of the operating time with dead load + 1/3 payload 50 % of the operating time only with dead load	0.125	W1355
medium Q 2 L 2	Power units or their parts, which are very often subjected to highest load, however continuously less load subjected to load	1/6 of the operating time with highest load (dead load + 1/1 payload) 1/6 of the operating time with dead load + 2/3 payload) 1/6 of the operating time with dead load + 1/3 payload) 50 % of the operating time only with dead load	0.25	W1356
heavy Q 3 L 3	Power units or their parts, which are frequently subjected to highest load and continuously to medium load	50 % of the operating time with highest load (dead load + 1/1 payload) 50 % of the operating time only with dead load	0.5	W1357
very heavy Q 4 L 4	Power units or their parts, which are regularly subjected to loads close to maximum loads.	90 % of the operating time with highest load (dead load + 1/1 payload) 10 % of the operating time only with dead load	1	W1358

One of the load spectrums listed above is to be selected on the basis of the actual operating conditions and entered in the crane logbook for the respective testing interval.

Note for truck cranes: In case of truck cranes in erection mode, as a rule, the collective load L 1 is to be given with the collective load factor Km = 0.125.

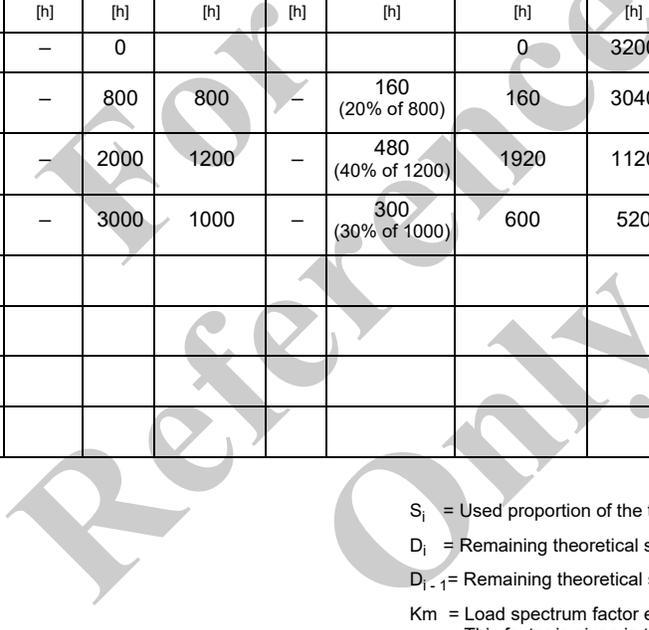


Table Example to Determine the Remaining Theoretical Service Life on Hoist No. 1 (Main Hoist)

Crane model: TMS9000E
 Work number: 3045 42 06
 Commissioned on: 10. 06. 1990
 Serial number of the hoist in accordance with the model plate: 13 301
 Last general overhaul performed on:

Hoist design data (see Operating Instructions):
 Drive gear group: M3
 Load spectrum: Q1 (L1)
 Factor of the load spectrum: Km=0.125
 Theoretical service life: D = 3 200 h

Testing interval no. "i" (max. 1 year)	Date of first operation/date of inspection	Operational condition since the last inspection	Collective load factor Km _i	Operating hours of the entire crane [h]	Operating hours of the superstructure [h]	Operating hours of the superstructure since the last inspection [h]	Operating hours of the winch [h]	Operating hours of the winch since the last inspection [h]	Used proportion of the theoretical service life: $S_i = \frac{K_{m_i}}{K_m} \times T_i$	Remaining theoretical service life $D_i = D_{i-1} - S_i$	Name of the expert	Signature	Note	Name of the approved inspector	Signature
0(*)	10. 6. 90	-	-	-	0				0	3200					
1	5. 6. 91	L 1	0,125	-	800	800	-	160 (20% of 800)	160	3040	Müller				
2	20. 5. 92	L 2	0,5	-	2000	1200	-	480 (40% of 1200)	1920	1120	Huber				
3	18. 5. 93	L 3	0,25	-	3000	1000	-	300 (30% of 1000)	600	520	Schmitz				



S_i = Used proportion of the theoretical service life since the last inspection
 D_i = Remaining theoretical service life
 D_{i-1} = Remaining theoretical service life after the previous inspection
 K_m = Load spectrum factor established during winch calculation. This factor is given in the Operating Instructions.
 K_{m_i} = Load spectrum factor in the inspection interval "i" according to section 2.1
 T_i = Effective working hours in the inspection interval "i" according to section 2.2

NOTE: A general overhaul is to be performed every 10 years!

Alternative provision, refer to Section 5.

Last general overhaul performed on:.....

SECTION 6 SWING SYSTEM

SECTION CONTENTS

Description	6-1	Description	6-10
Theory of Operation	6-1	Maintenance	6-10
Swing Drive	6-1	Swivels	6-15
Swing Brake	6-1	Description	6-15
Maintenance	6-3	Hydraulic Swivel	6-17
Troubleshooting	6-3	Electrical Swivel	6-18
Swing Box Assemblies	6-7	Swing Lock Pin	6-20
Description	6-7	Description	6-20
Swing Motor Maintenance	6-7	Rotating the Turntable Swing Lock Handle	6-20
Swing Gear Brake Function Check	6-8	Maintenance	6-20
Swing Brake Assembly Maintenance	6-8	360° Swing Lock Control (Positive Lock Type)	6-20
Swing Gearbox Maintenance	6-8	Description	6-20
Swing Bearing	6-10	Maintenance	6-20

DESCRIPTION

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term free swing means that, with the swing brake switch in the off position, the superstructure will swing freely after the swing controller is released until it coasts to a stop or the swing brake pedal is depressed.

Swing is activated using the control lever in the cab. When the swing lever is actuated, hydraulic pressure is routed to the swing motors to drive the swing gearboxes in the appropriate direction. As the gearboxes rotate, their pinion gears mesh with the teeth on the swing bearing and rotate the superstructure. Swing speed can be controlled by the control lever and a HIGH/LOW swing speed switch on the front console. The maximum rotation speed is 2.5 rpm in HIGH speed and 1.25 rpm in LOW speed. Braking is accomplished by depressing a glide swing brake pedal which is a proportionate control valve that provides a controlled braking of the swing motion.

The swing system consists of a hydraulic remote controller, swing speed switch, series/parallel selector valve, a directional control valve, the swing drives, the swing brake assemblies, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The crane is equipped with a pin type swing lock as standard and a standard 360 degree positive swing lock. The 360

degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type swing lock will only lock the turntable in a straight ahead position over the front or rear of machine. Both swing locks are operated from the cab.

THEORY OF OPERATION

Swing Drive

The hydraulic power for the swing drive is supplied by hydraulic Pump No. 1. Oil flows from the pump to the hydraulic Port 3 swivel. Flow from the swivel is routed to the swing control valve and then to the swing motors.

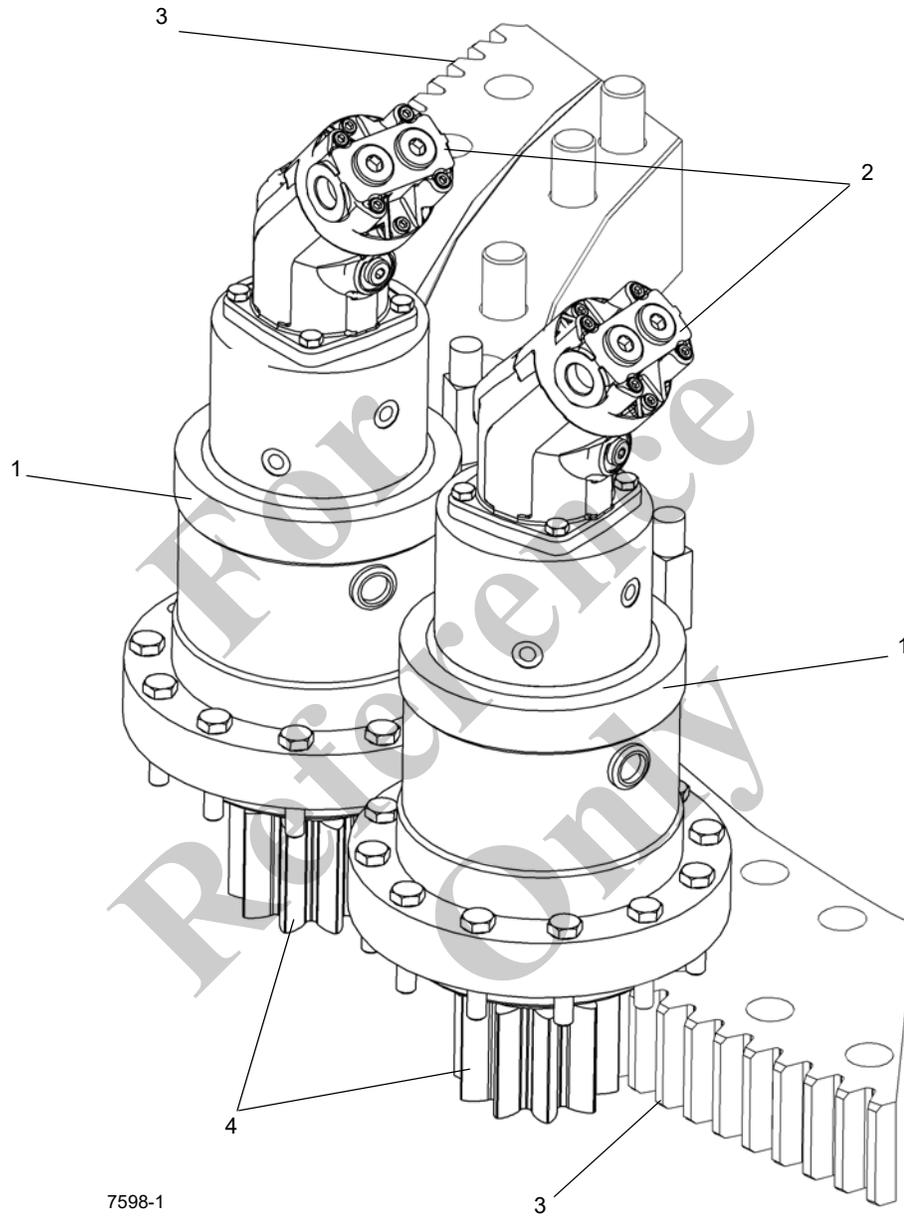
When the hydraulic remote control is positioned to select right or left swing, the flow through the control valve is directed to the series/parallel valve, and then routed to the swing motors. If the Swing Brake Selector Switch is in the OFF position, the superstructure will rotate in the desired direction. Shifting the control to neutral and depressing the brake pedal will stop the swing.

Swing Brake

The hydraulic power for the swing brake is supplied by the pressure reducing/sequence valve in the swing brake and armrest lockout manifold. With the Swing Brake Selector Switch positioned to ON, the swing brake release valve blocks the regulated flow to the brake release ports and spring pressure in the swing brakes applies the brakes. When the Swing Brake Selector Switch is positioned to OFF,

the regulated flow is directed from the pressure reducing/sequence valve to the brake release ports, overcoming the brake spring pressures and releasing the swing brakes. Regulated flow from the pressure reducing/sequence valve

is also provided to the power brake valve where it is available for the activation of the swing brake when the pedal is depressed.



7598-1

Item	Description
1	Swing Drive
2	Axial Piston Motor
3	Turntable Bearing
4	Pinion Gear

Picture May Not be Same Model as Your Machine. It is for REFERENCE ONLY.

FIGURE 6-1

MAINTENANCE

Troubleshooting

Table 6-1

Symptom	Probable Cause	Solution
1. Boom swing operation erratic in either direction.	a. Damaged relief valve.	a. Replace relief valve.
	b. Swing brake dragging (not releasing properly).	b. Readjust and/or replace necessary parts.
	c. Low engine rpm.	c. Increase engine rpm to obtain smooth swing operation.
	d. Low hydraulic fluid.	d. Check system for leaks. Make repairs as needed. Fill reservoir. Refer to <i>Lubrication, page 9-1</i> .
	e. Improper movement of control to neutral.	e. Feather controls to neutral to maintain smooth stopping action.
	f. Insufficient lubricant on swing bearing.	f. Lubricate bearing properly. Refer to <i>Lubrication, page 9-1</i> .
	g. Crane not level.	g. Level crane using outriggers.
	h. Damaged swing motor.	h. Repair or replace swing motor.
	i. Excessive overload.	i. Reduce load. Refer to load capacity chart.
	j. Restricted or partly clogged hydraulic hose or fittings.	j. Replace hose or fittings. Refer to the Manitowoc Crane Care Parts Manual.
	k. Pump cavitation in swing section.	k. Tighten suction hose or replace any damaged fitting. Check hydraulic tank level.
	l. Improperly torqued turntable bolts.	l. Torque turntable bolts evenly.
	m. Excessive preload on upper and lower pinion shaft bearing.	m. Adjust as necessary.
	n. Improperly torqued swing motor attachment bolts.	n. Torque swing motor attachment bolts.
	o. Malfunction of the swing box.	o. Remove swing box and make necessary repairs.
	p. Worn or damaged pump.	p. Repair or replace damaged pump.
	q. Damaged swing directional control valve.	q. Repair or replace swing directional control valve.
r. Damaged swing pinion.	r. Replace pinion.	
s. Damaged turntable bearing.	s. Replace turntable bearing.	
t. Controller settings.	t. Check settings.	
u. Electrical connection.	u. Inspect wiring and connections.	

Symptom	Probable Cause	Solution
2. Boom swing operation erratic in one direction only.	a. Crane not level.	a. Level crane using outriggers.
	b. Turntable bearing binding due to continuous limited swing. (Example: concrete pourer.)	b. Rotate machine 360 degrees in both directions several times and lubricate bearing.
	c. Restricted hose or fitting.	c. Replace hose or fitting.
Boom swing operation erratic in one direction only.	d. Damaged swing directional control valve.	d. Replace swing directional control valve.
	e. Damaged swing pinion.	e. Replace pinion.
	f. Damaged turntable bearing.	f. Replace turntable bearing.
3. Boom will not swing in either direction.	a. Damaged relief valve.	a. Remove, clean, and repair or replace relief valve.
	b. Damaged swing motor.	b. Repair or replace swing motor.
	c. Swing brake not releasing properly.	c. Repair as necessary.
	d. Damaged hydraulic remote control valve.	d. Replace hydraulic remote control valve.
	e. Internal damage to swing box.	e. Remove swing box and repair.
	f. Worn or damaged hydraulic pump.	f. Replace pump section.
	g. Damaged swing directional control valve.	g. Replace swing directional control valve.
	h. Damaged swing pinion.	h. Replace pinion.
	i. Damaged turntable bearing.	i. Replace turntable bearing.
	j. Excessive overload.	j. Reduce load. Refer to load capacity chart.
4. Swing operation slow in either direction.	a. Damaged relief valve.	a. Adjust, repair or replace valve.
	b. Improperly adjusted swing brake.	b. Readjust.
	c. Damaged hydraulic remote control valve.	c. Replace hydraulic remote control valve.
	d. Improperly lubricated swing bearing.	d. Lubricate bearing per <i>Lubrication, page 9-1</i> .
	e. Improper size hose and/or fittings installed.	e. Replace hose or fittings. Refer to your Manitowoc Crane Care Parts Manual.
	f. Clogged or restricted hydraulic hoses or fittings.	f. Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	g. Replace bearings.
	h. Worn or damaged swing motor.	h. Repair or replace motor.
	i. Worn or damaged hydraulic pump.	i. Repair or replace pump.
	j. Crane not level.	j. Level crane.
k. Damaged swing directional control valve.	k. Replace swing directional control valve.	

Symptom	Probable Cause	Solution
5. Swing operation slow in one direction only.	a. Crane not level.	a. Level crane.
	b. Damaged hydraulic remote control valve.	b. Replace hydraulic remote control valve.
	c. Damaged swing directional control valve.	c. Replace the swing directional control valve.
	d. Clogged or restricted hose.	d. Replace hose or fitting.
	e. Improperly torqued turntable bearing.	e. Torque turntable bearing.
6. Swing brake operation erratic.	a. Improper brake adjustment.	a. Adjust brake.
	b. Air in swing brake system.	b. Bleed brake system.
	c. Brake pedal not fully retracted.	c. Check brake pedal return spring; repair or replace spring.
	d. Dirty or glazed brake disc.	d. Clean or replace disc.
	e. Malfunction of the glide swing power brake valve.	e. Repair or replace glide swing power brake valve.
	f. Kinked or bent lines and/or hoses and fittings.	f. Straighten or replace as required.
7. Swing brake system will not operate.	a. Damaged swing brake release valve.	a. Replace release valve.
	b. Damaged glide swing power brake valve.	b. Repair or replace glide swing power brake valve.
	c. Internal damage to the swing brake assembly.	c. Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	d. Tighten or replace lines and fittings.
8. Swing brake pedal is spongy.	a. Damaged glide swing power brake valve.	a. Repair or replace the glide swing power brake valve.
	b. Loose or restricted brake lines or fittings.	b. Tighten or replace brake lines and fittings.
9. Swing brake drags.	a. Damaged glide swing power brake valve.	a. Repair or replace the glide swing power brake valve.
	b. Damaged swing brake release valve.	b. Replace release valve.
	c. Internal damage to the swing brake assembly.	c. Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	d. Tighten or replace brake lines and fittings.
10. Boom swings slowly.	a. Insufficient hydraulic volume.	a. Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	b. Damaged relief valve.	b. Adjust, repair, or replace valve.
	c. Damaged swing motor.	c. Repair or replace motor.
11. Swing motor continues to operate when swing control is in neutral.	a. Hydraulic remote control valve sticking or valve otherwise damaged.	a. Repair or replace valve.
	b. Control valve sticking or valve otherwise damaged.	b. Repair or replace valve.

Symptom	Probable Cause	Solution
12. Swing motor turning in wrong direction.	a. Improper port connections.	a. Reverse port connection.
	b. Improper wiring connection	b. Inspect wiring and connections. Make repairs as needed.
13. Swing motor noisy.	a. Air in system.	a. Refer to <i>Hydraulic System, page 2-1</i> , for removal of air from the system.
	b. Motor binding.	b. Repair or replace motor.

For
Reference
Only

SWING BOX ASSEMBLIES

Description

There are two swing box assemblies (Figure 6-1) for turning and stopping the turntable and superstructure. Each swing box assembly consists of a hydraulic motor on top, a brake assembly, and a swing gearbox on the bottom. Each swing motor on the swing gearbox gear pinion output shaft applies turning force to the turntable bearing's gear teeth to turn the turntable. Operator-applied hydraulic power applies the brake assemblies to stop their swing box assemblies.

Each swing motor runs on hydraulic power to drive its gearbox. Each swing motor has three Ports (A, B and Tank) for connection to the hydraulic system.

Each swing brake assembly is between the swing motor and the swing gearbox. Each brake assembly's mechanism is a disc pack that is hydraulically released and spring applied. The operator steps on a pedal on the cab floor to trigger the swing brake assemblies to stop the swing boxes from turning. The Swing Brake Switch prevents the swing brake assemblies from releasing when ON; this prevents inadvertent swing during travel or other situations when the superstructure should not turn.

Each gearbox bolts to the superstructure base plate. Each gearbox uses double reduction planetary gearing. Each gearbox's pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

A filling plug in the side of the swing brake system assembly housing allows the operator to add gear oil to the swing gearbox and swing brake assembly. There is one drain plug for draining gear oil from the gearbox housing.

There are hydraulic lines to each swing brake assembly; these lines are in a system sealed from gear oil. The hydraulic lines are only for applying or releasing the brake, not providing brake or gearbox lubrication.

There are hydraulic lines to the swing motor; these lines are also in a system sealed from gear oil. The hydraulic lines are for driving the motor in the chosen rotation. There is one drain plug for draining hydraulic fluid from the swing motor.

Swing Motor Maintenance

NOTE: Each swing motor can be removed and disassembled independently of the swing brake assembly.

Removal

1. Engage the swing brake and the swing lock pin.



CAUTION

Personal Injury Hazard!

Hydraulic fluid can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

2. Clean the port area around the swing motor. Tag and disconnect the hydraulic hoses from the swing motor. Cap or plug all openings.
3. Unscrew the drain plug, and drain the oil. After oil is drained, reinstall the drain plug

CAUTION

Machine Damage Hazard!

Pull straight up on the motor assembly to avoid damaging the splined shaft.

4. Remove the fasteners securing the swing motor to the swing brake assembly housing flange. Remove and discard the O-ring from the groove in the swing brake assembly housing.

Installation

CAUTION

Machine Damage Hazard!

Use care when engaging the swing motor drive gear; do not force the shaft to engage. Damage to the gears may result

1. Install a new O-ring in the groove of the swing brake assembly's housing. Position the swing motor on the swing brake.
2. Secure the swing motor to the swing brake assembly housing with the capscrews. Torque the bolts according to the specifications in *Torque Values, page 1-10*.
3. If needed, fill the swing gear box with gear oil. Refer to *Lubrication, page 9-1*.
4. Connect the hydraulic lines to the swing motor as tagged during removal.

Testing

1. Test swing of superstructure in each direction. Stop and start swing boxes several times.
2. Inspect for hydraulic leaks and repair as necessary.

Swing Gear Brake Function Check

A function test must be carried out on the swing gear service brake to check the wear on the swing gear brake plates. This involves swing movement against the swing gear service brake.



WARNING

Overturning when Rotating the Superstructure Hazard!

The truck crane must be on outriggers before rotating the superstructure. Read the notes in the chapter *Crane work with the main boom – slewing* in the *Operating instructions* before checking for proper function.

- Release the slewing gear holding brake by pressing the slewing gear holding brake rocker switch upwards.
- The slewing gear holding brake indicator lamp goes out.
- Push the slewing gear service brake pedal down and hold it.
- Activate the slewing gear. Slowly steer the left control lever to the left or to the right.
If the superstructure turns, the swing gear service brake plates are worn and must be replaced immediately.
- The plates must only be replaced by Manitowoc Crane Care.

Swing Brake Assembly Maintenance

NOTE: Each swing brake assembly can be removed and disassembled independently of the swing gearbox.

Removal

1. Engage the swing lock pin.



CAUTION

Personal Injury Hazard!

Hydraulic fluid can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

2. Tag and disconnect the hydraulic lines connected to the swing motor and the swing brake assembly. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake assembly per the procedure in this section.
4. While observing tension on the bolts due to internal brake springs, unscrew socket head capscrews securing the swing brake assembly to the gearbox. Remove the brake assembly.

5. Remove and discard the O-ring from the swing brake assembly housing.
6. Cover the opening of the swing gearbox to ensure no dirt, dust or other foreign material get into the gearbox.

Installation

1. Install a new O-ring onto the brake assembly's housing and insert the brake assembly into the gearbox.
2. Secure the brake assembly with the socket head capscrews.
3. Install the swing motor on the swing brake assembly per the procedure in this section.
4. Connect the hydraulic lines to the swing motor and swing brake assembly.
5. Bleed all air from the swing brake assembly.

Testing

1. With the Swing Brake Switch in the ON position, move the swing control lever in both directions. Superstructure rotation should not occur.
2. Put the Swing Brake Switch to OFF and swing the superstructure in both directions. Use the swing brake pedal to stop rotation.
3. Check for hydraulic leaks and repair as necessary.

Swing Gearbox Maintenance

Removal

1. Engage the swing lock pin.



CAUTION

Personal Injury Hazard!

Hydraulic fluid can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

2. Tag and disconnect the hydraulic lines from the swing motor and the swing brake assembly. Cap and/or plug all openings.
3. If necessary, remove the swing motor per instructions in this section. Or, do so after removing entire swing box assembly from superstructure.
4. If necessary, remove the swing brake assembly per instructions in this section. Or, do so after removing entire swing box assembly from superstructure.

NOTE: The swing gearbox with swing brake assembly and swing motor attached weighs about 335 lbs (about 150 kg).

5. Attach a suitable lifting device to the swing gearbox.

6. Remove the capscrews and flatwashers securing the swing gearbox to the superstructure base plate. Remove the swing gearbox.
7. Remove the bolts and bottom plate attaching the pinion gear to the swing gearbox shaft. Remove the pinion gear.
8. Cover the opening of the swing gearbox to ensure no dirt, dust, or foreign material gets into the gearbox.

Installation

1. Install the pinion gear and bottom plate on the swing gearbox splined shaft. Secure pinion gear with the bolts.
2. Install the swing brake assembly on the swing gearbox per instructions in this section.
3. Install the swing motor on the swing brake assembly per instructions in this section.
4. Attach a suitable lifting device to the swing gearbox and position the swing gearbox on the superstructure base plate.
5. Install the capscrews and washers removed earlier to secure the swing gearbox to the superstructure base plate.
6. Connect the hydraulic lines to the swing brake.
7. Connect the hydraulic lines to the swing motor.
8. Service the gearbox per the following instructions.

Servicing

Normal maintenance should only consist of proper lubrication and a periodic check of mounting bolt torque values. Lubrication consists of maintaining the gearbox oil level. Oil in a new gearbox should be drained and flushed out after approximately 250 hours of operation, and replaced with premium quality SGL-5 after about 500 hours of operation or each year, whichever occurs first. Operation in high humidity or polluted air areas will require more frequent changes to minimize moisture or contaminate accumulation.

Oil Changing

Change the oil as follows:

1. Unscrew drain plug; remove breather and dipstick. Ensure all oil has been removed.
2. Flush the case with a light flushing oil. Flushing of the gearbox with a solvent helps prevent an accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the vent of the swing bearing.
3. After oil is drained, reinstall the drain plug and any other plugs that were removed to drain the oil.
4. To refill with oil, make sure the breather is open. Fill until proper location on dipstick.
5. Tighten breather and dipstick.

Checking Oil Level

1. Check level on dipstick
2. If no lubricant is visible on dipstick, add SGL-5 until between minimum and maximum on dipstick. Refer to *Lubrication, page 9-1*.
3. Reinstall the dipstick in the brake housing.

Testing

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for leaks. Make repairs as necessary.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the superstructure to the carrier. The bearing inner race is bolted to the superstructure and the outer race is bolted to the carrier. The inner race contains grease fittings for lubrication of the bearing which are hoses to fittings at the front of the turntable center section. The outer race has gear teeth that mesh with the pinion gear of the swing gearbox to provide rotation.

Maintenance

General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the superstructure and carrier. Therefore, proper care of the bearing and periodic maintenance of the turntable-to-bearing attach bolts IS A MUST to ensure safe and efficient operation.

Torquing Turntable Bolts

General



WARNING

Machine Damage and Personal Injury Hazard!

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

Possible Machine Damage Hazard!

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 10.9), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When

a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.



DANGER

Machine Damage and Personal Injury Hazard!

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. Severe injury or death may result if swing bearing is not secure.

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

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

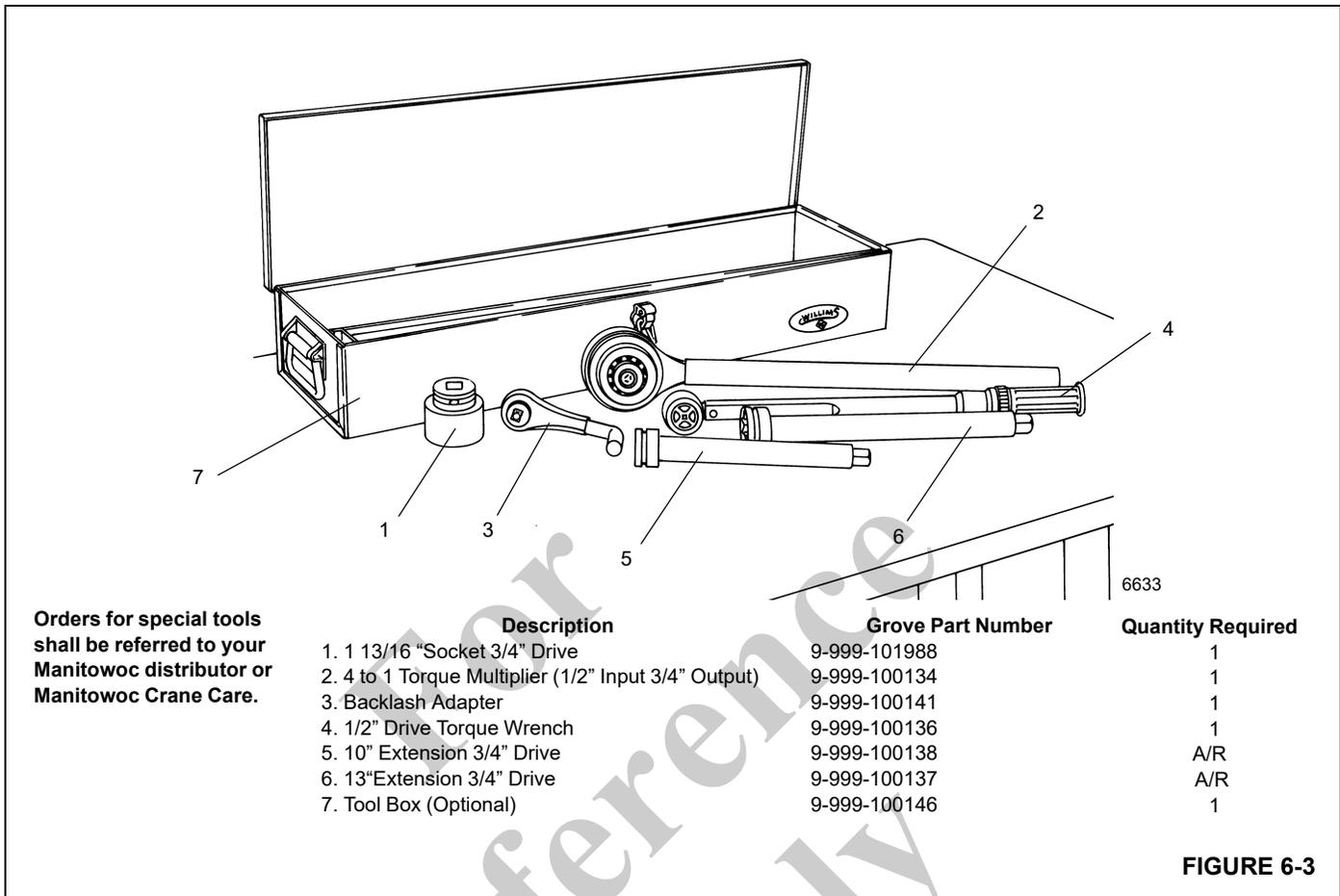
Torque wrenches are precision instruments and must be handled with care. To ensure accuracy, calibrations must be made on a scheduled basis. Whenever there is a possibility that a torque wrench may have been either overstressed or damaged, it should immediately be removed from service until recalibrated.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

If it is reported by the crane operator or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the cranes' capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

Turntable bolts should be torqued according to the procedures outlined in this section.

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

1. Torque wrenches must be those specified and forces must be applied at the handle grip. The use of handle extensions will change applied torque to the bolt.
2. All handles must be parallel to the step wrench during final tightening. Multiplier reaction bars may be misaligned no more than 30 degrees without causing serious error in torque.



Removal

1. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

2. Ensure the boom is in the travel position and the turntable lock pin is engaged.
3. Elevate the boom slightly and shut down the engine.
4. Tag and disconnect the battery cables from the batteries.

NOTE: The boom assembly weighs approximately 32,758 lb (14,859 kg) without stowed boom extension. Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached. The lift cylinder weighs approximately 2765 lb (1254 kg).

5. Remove the boom and lift cylinder following the procedures outlined in *Boom Removal, page 4-9*.

NOTE: The counterweight weighs approximately 63,000 lb (28,576 kg).

6. Remove the counterweight following procedures outlined in the Operator Manual.
7. Tag and disconnect all oil lines from the bottom of the swivel. Cap or plug all lines and openings.
8. Locate the connectors and ground wire that joins the swivel wiring harness to the receptacles and ground stud on the carrier.
9. Disconnect the swivel wiring harness connectors from the carrier wiring receptacles. Remove the ground wire from the ground stud.
10. Remove the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.
11. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turntable removal.
12. On the bottom of the hydraulic swivel, bend the retainer tabs away from the bolt heads. Remove the eight bolts and four bolt retainers securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: The swivel assembly will be removed with the turntable.



DANGER

Machine Damage and Personal Injury Hazard!

Make sure that 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).

- Attach a suitable lifting device to the four superstructure lifting lugs (two near the boom pivot shaft bushings and two near the lower lift cylinder pivot shaft bushings). Take in cable or chain to remove slack. Do not pull up on the superstructure.



DANGER

Crushing Hazard!

Make sure that the superstructure is fully supported before proceeding. Severe injury or death may result if superstructure falls.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be removed from the swing drive side of the turntable.

- Remove the bolts and washers securing the turntable bearing outer race to the carrier.



DANGER

Crushing Hazard!

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.

- Carefully lift the superstructure, using care not to damage the swivel assembly, and set it on blocking that will not allow the superstructure to tilt or shift, or rest on the swivel. Leave the lifting device attached.

NOTE: If the same bearing is to be used again, mark the position of the bearing on the superstructure so it

can be installed in the exact position it was before removal.

NOTE: The bearing weighs approximately 2030 lb (921 kg). Ensure the bearing lifting device is capable of supporting the weight.

- Place an adequate lifting device under the bearing and remove the 68 bolts and washers securing the turntable bearing to the superstructure.
- Using the lifting device, remove the turntable bearing from under the superstructure.

Inspection

Check the bearing teeth for chipping or cracking. If any evidence of these are found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

Installation



DANGER

Possible Machine Damage Hazard!

Anytime a grade 10.9 turntable bolt has been removed, it must be replaced with a new grade 10.9 bolt. Lower grade bolts may cause severe injury or death.

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.

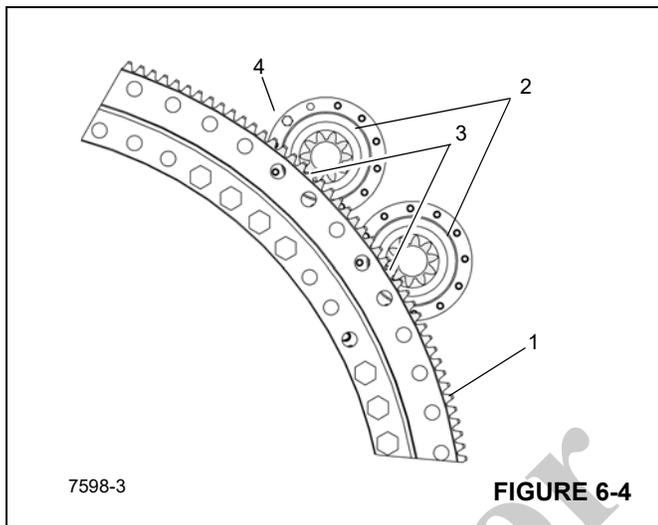
Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

- 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.
- Install new bolts and washers to secure the bearing to the superstructure. Refer to *Inner Race Torquing*, page 6-11 in this Sub-Section.
- Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the swing drive side of the turntable.

- Install 68 new bolts and washers to secure the bearing to the carrier. Refer to *Outer Race Torquing*, page 6-11 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.



Item	Description
1	Bearing
2	Swing Gearbox
3	Backlash Check Point
4	Turntable

5. Orient ring gear such that its point of max eccentricity (“high point”) is located between the swing drives. Position swing drives so that pinion is centered within cutout in base plate and motor ports face towards the outboard side (Figure 6-4).

CAUTION

Possible Machine Damage!

Do not clamp over pinion. Damage to the gear teeth may result.

- a. Using shims, set backlash by moving the swing drive assemblies toward the bearing in order to mesh the pinion with the ring gear teeth.
- b. Check tooth engagement squareness and vertical tooth engagement.
- c. Remove backlash shims and recheck backlash.

NOTE: Adjust the tooth engagement (3), (Figure 6-4) for a backlash of 0.010 in (0.25 mm). Rotate the bearing (1) one revolution while checking the backlash at 90° increments.

- 6. Position the retainer plate on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure them to the spool with four bolt retainers and four bolts. Torque the bolts according to the specifications in *Fasteners and Torque Values, page 1-9*. Bend all the retainer tabs to make contact with the bolt heads.
- 7. Plug the swivel wiring harness connectors into the carrier receptacles. Secure the ground wire to the ground stud using a washer, lockwasher, and nut.
- 8. Install the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel.
- 9. Connect all 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 Installation, page 4-11*.
- 11. Install the counterweight following procedures outlined in following procedures outlined in the Operator Manual.
- 12. Reconnect the batteries.
- 13. Check the slew potentiometer mounted outside of the bearing under the cab.

Testing

Activate the crane and check for proper function.

NOTE: If the superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

SWIVELS

Description

The swivel assembly consists of a 6 port hydraulic, 2 port air conditioning swivel and 20 conductor slip ring assembly (2) (Figure 6-5). Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts (3), (Figure 6-5) washers (4), (Figure 6-5) and bushings (6), (Figure 6-5), which connect to mounting lugs (7) on the case. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier by bolts, and bolt retainer plates attached to the swivel retainer plate (9) which engages the carrier frame lugs with bolts and

jam nuts (10). This allows the spool to remain stationary with the carrier as the case rotates with the superstructure.

The spool portion of the water swivel is attached to the spool of the hydraulic swivel by four bolts. The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case contains a lug which is keyed to a corresponding lug on the hydraulic swivel case, causing the water swivel to rotate with the superstructure.

The electrical swivel center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.

For
Reference
Only

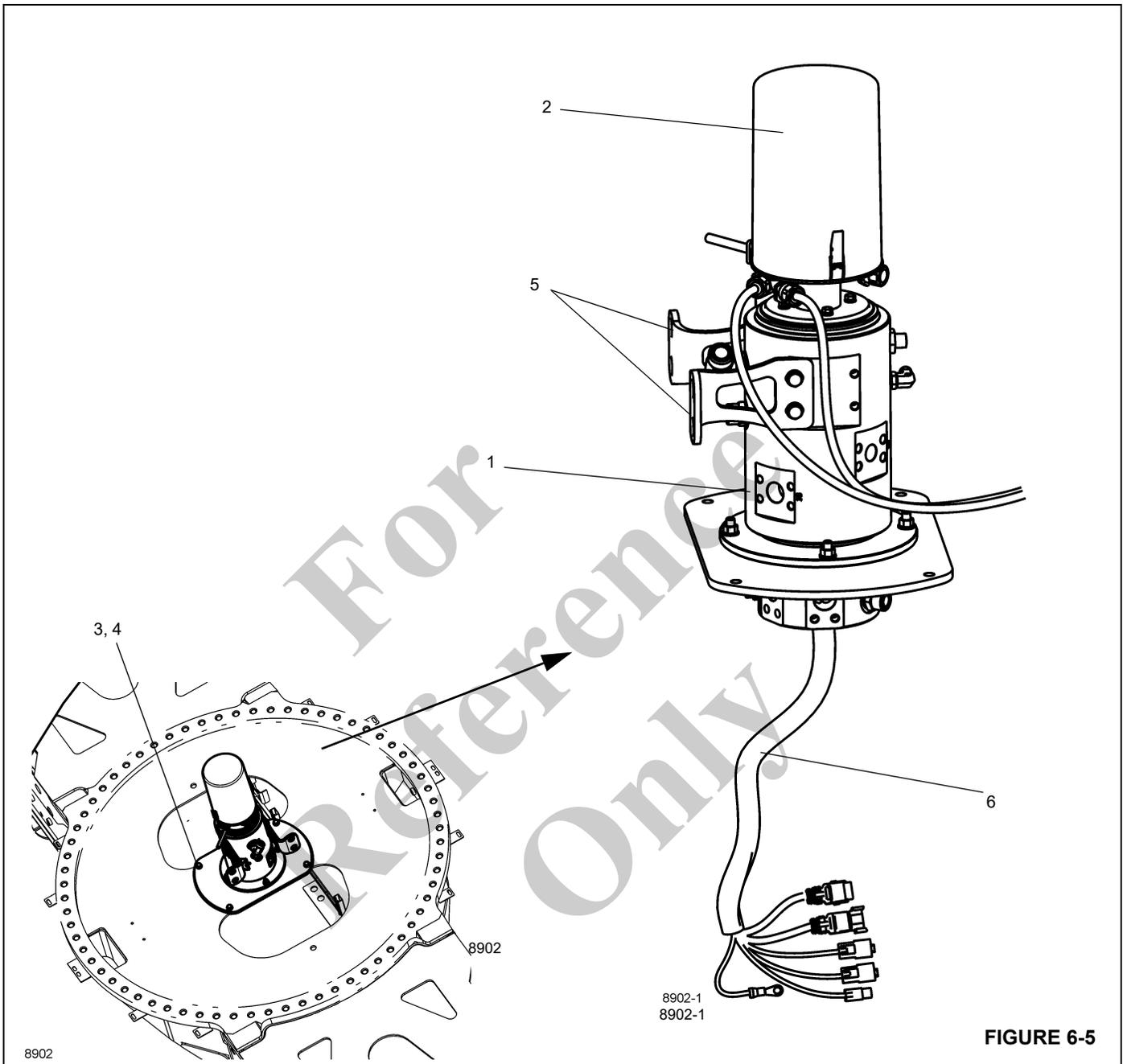


FIGURE 6-5

Item	Description
1	8 Port Hydraulic, AC Swivel
2	20 Conductor Slip Ring Assy
3	Bolt
4	Washer
5	Mounting Bracket
6	Harness

Hydraulic Swivel

Description

Each of the ports on the spool and case of the swivel is stamped with the port number. Theory of Operation

The hydraulic swivel allows oil to flow from the pumps to various crane functions on the superstructure. All oil is routed into the spool portion of the swivel where, through a series of internally drilled passages, oil is transferred to circumferential channels on the spool exterior. These channels correspond with a mating port on the outer case of the swivel. Each channel is separated by a series of nylon and O-ring seals that prevent transfer of oil and pressure. Return flow from the crane superstructure is accomplished in the same manner through another set of ports.

Maintenance

Removal

1. Extend and set the outriggers. Ensure the crane is level and the boom is over the front.
2. Elevate the boom and note at what boom angle, you have the most clearance between the lift cylinder and the turntable side plate. Shut down the engine.
3. Measure the distance from the top of the lift cylinder to the base of the boom section where the lift cylinder attaches. Cut two pieces of 10 x 10 cm (4 x 4 in) hardwood timbers.

NOTE: It might be necessary to raise the boom slightly to allow installation of the blocking.

This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use the blocking to block between the barrel of the lift cylinder and the boom base section.
5. Tag and disconnect the hydraulic lines from the case of the hydraulic swivel. Cap or plug all lines and openings.
6. Tag and disconnect the hydraulic lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
7. Disconnect the swivel wiring harness connectors from the carrier receptacles and the ground wire from the connector mounting bracket on the carrier frame. If necessary, remove the electrical swivel. Refer to *Electrical Swivel*, page 6-18.

NOTE: The hydraulic swivel weighs approximately 93.8 kg (207 lb). The hydraulic and electrical swivel combined weigh approximately 236 kg (520 lb).

8. On the bottom of the swivel, bend the retainer tabs away from the capscrew heads. Remove the eight capscrews and four capscrew retainers securing the two retainer

plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: It may be necessary to remove some drive line components to remove the swivel.

9. Position an adequate supporting device beneath the swivel.
10. Remove the four capscrews and washers securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

Installation

NOTE: The hydraulic swivel weighs approximately 93.8 kg (207 lb). The hydraulic and electrical swivel combined weigh approximately 236 kg (520 lb).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the capscrews and washers. Torque the bolts according to the specifications in *Fasteners and Torque Values*, page 1-9.
3. Position the two retainer plates on the hydraulic swivel spool ensuring they engage the lugs on the carrier frame. Secure the retainer plates with eight capscrews and four capscrew retainers.

Apply Loctite 271 to the capscrew threads. Torque the bolts according to the specifications in *Fasteners and Torque Values*, page 1-9. Bend all the retainer tabs to make contact with the capscrew heads. Tighten the four retainer plate capscrews against the lugs on the carrier frame and tighten the locking nuts.

4. If removed, install the electrical swivel. Refer to *Electrical Swivel*, page 6-18. Connect the swivel wiring harness connectors to the carrier receptacles and the ground wire to the mounting bracket on the carrier frame. Use the bolt and star washers taken off at removal and refer to Grove Engineering Specification A-829-100386 for proper electrical termination of grounds.
5. Install the clamp, lockwasher, flat washer and capscrew to the bottom of the swivel retainer plate securing the wiring harness.

NOTE: Allow a 1/32" max gap between bolt and the retaining lug on the frame. Do not tighten bolt against lug.

6. Connect the hydraulic lines to the spool of the hydraulic swivel as tagged during removal.
7. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.
8. Remove the blocking material from the lift cylinder.
9. Activate all systems; cycle all functions and observe for proper operation and any leakage.

Electrical Swivel

Description

The swivel assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes, leads, and clips which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the swivel. The collector ring leads are formed into one harness which is routed downward through the center of the hydraulic swivel. Extending from the base of the hydraulic swivel, the collector ring leads are also formed into connectors which plug into receptacles from the chassis power supply.

The swivel cover is secured with a seal and bolts.

Theory of Operation

The electrical swivel is located on top of the hydraulic swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity between the carrier and superstructure.

Maintenance

Removal

1. Perform Steps 1 through 4 of *Hydraulic Swivel, page 6-17, Removal, this Section*.



CAUTION

Disconnect the batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

2. Disconnect the batteries. Refer to *Batteries, page 3-1*.
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.

NOTE: If the connectors are too large to go through the center of the hydraulic swivel, they must be removed. Conditional instructions will follow.

5. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.

NOTE: If connectors are too large to go through the center of the hydraulic swivel, tag each wire on each of the connectors. Using the appropriate pin removal tools, remove the pins, with wires still attached, and mark each wire with the pin socket number in the connector. Collect the wires and secure into one bundle. Mark the bundle with the connector number. For a list of the appropriate pin removal tools, refer to *Connector Troubleshooting, page 3-11*.

6. Secure the connectors and wires from each of the numbered connectors so the harness can be withdrawn through the center of the hydraulic swivel.
7. Tag and disconnect the connectors from the junction box on the turntable.
8. Remove the nuts and washers, and remove the cover from the electrical swivel.
9. Loosen the setscrews securing the electrical swivel mounting tube to the center post on the hydraulic swivel.
10. Remove the bolt and nut securing the electrical swivel case to the bracket on the case of the hydraulic swivel.

CAUTION

When withdrawing the wiring harness through the center of the hydraulic swivel, ensure the wires do not get caught and damaged.

11. Remove the swivel and wiring harness from the crane. If necessary, remove the spacer bushing from the center post.

Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic swivel.
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 hydraulic swivel case. Install the bolt through the hole in the bracket and install the nut. Screw the bolt into the hole in the electrical swivel base until the bolt head is approximately 0.25 in (6.4 mm) from the bracket. Tighten the nut against the electrical swivel (Figure 6-6).

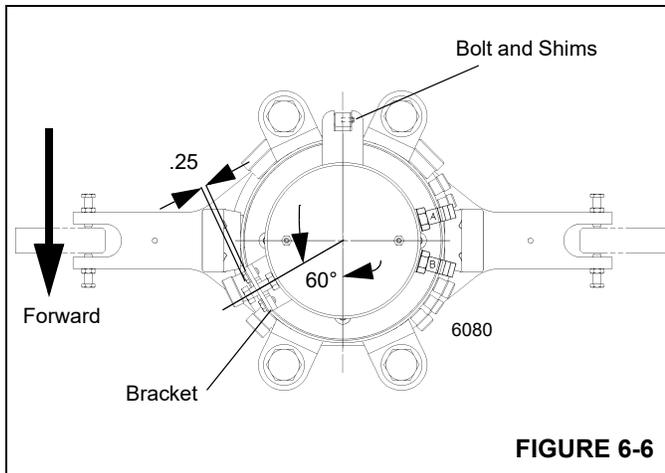


FIGURE 6-6

4. Apply Loctite to the set screws securing the electrical swivel to the center post and tighten them to 45 to 55 in-lb (5 to 6 Nm)
5. Install the swivel cover and two over-center latches.
6. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal.
7. Plug the connector into the carrier wiring receptacle, connect the wires as tagged during removal. Install the

ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken off at removal and refer to Grove Engineering Specification A-829-100386 for proper electrical termination of grounds.

8. Install the clamp securing the harness to the retainer plate on the bottom of the hydraulic swivel assembly.
9. Connect the batteries.
10. Activate all systems, cycle all functions, and observe for proper operation.

Preventive Maintenance

It is recommended that a normal inspection of the electrical swivel collector ring and brush assembly be established. An example of this could be at approximately 100 to 150 engine operating hours. When this time limit is reached, perform the following.

1. Check the collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check the collector ring setscrews and ensure they are tight.
3. Check the brush and arm assembly springs. Ensure they are holding the brushes firmly against the collector rings.

Reference Only

SWING LOCK PIN

Description

The purpose of the swing lock pin is to lock the superstructure in position directly over the front or the rear of the carrier. The swing lock pin installation consists of a large pin, a control handle in the right side of the cab, and a control cable and control linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front or rear, pushing the control handle in inserts the swing lock pin into a socket on the carrier frame, locking the superstructure in place. Pulling the control handle out pulls the pin out of the socket, unlocking the superstructure.

Rotating the Turntable Swing Lock Handle

By rotating the handle (Clockwise/Counter Clockwise), you can lock the handle to prevent movement of the handle.

Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify pin, the turntable bushing the pin passes through, and the sockets on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage and cable are adjusted properly. If they are, the pin bottom will stick out about 4.00 inches (10.16 cm) from the bottom of its bushing in the turntable. (If it is too far in, it might not lock properly. If it is too far out, it might hang up). Using the jam nuts on the linkage parts and cable, adjust the linkage and cable so the pin bottom will be flush with the bottom of its bushing in the turntable when not applied, and the pin will stick out about 4.00 inches (10.16 cm) from the bottom of its bushing in the turntable when applied. Verify the superstructure can lock properly when the pin is applied and the superstructure can rotate without pin hangup when the pin is not applied.

360° SWING LOCK CONTROL (POSITIVE LOCK TYPE)

Description

The purpose of the swing lock is to secure the superstructure in position at one of the positions in its rotation. There are roughly 247 spots about 1.45 degrees apart for the superstructure to lock to in its 360 degree of rotation. The 360 degree swing lock control pedal is on the left side of cab. Pushing the swing lock foot pedal engages the lock between the teeth of the swing gear. Pulling the swing lock control lever up disengages the lock.

Maintenance

Verify cable is routed to avoid damage from superstructure rotation and is undamaged. Verify swing lock assembly is undamaged and working properly. Verify springs are undamaged and have enough strength to pull blade of swing lock assembly completely out of the gear teeth when the control pedal is up. Verify the linkage can put the blade of the swing lock assembly as far as possible between the gear teeth when the control pedal is down.

Verify all attaching hardware is secure and undamaged. Make adjustments as needed.

If the swing lock assembly is damaged, install a replacement. Align the blade of the swing lock assembly so it will fall between gear teeth. Use the shim and the related attaching hardware (two M8x16 screws and M8 lockwashers) to ensure the swing lock assembly cannot move side to side, and can lock up the superstructure. Torque the four M24x100 mounting bolts according to the specifications in *Fasteners and Torque Values, page 1-9*.

As needed, adjust the swing lock control and cable per above instructions. Then operate the control lever several times to verify the swing lock blade assembly engages and disengages properly. Adjust cable as required.

SECTION 7 POWER TRAIN

SECTION CONTENTS

Engine	7-1	Maintenance	7-16
Description	7-1	Cleaning.	7-18
Maintenance	7-2	Component Inspection.	7-19
Removal	7-2	Radiator Assembly Removal and Installation ...	7-20
Installation.	7-4	Drive Train	7-22
Engine Drive Belts	7-4	Description.	7-22
Engine Control System	7-5	Maintenance	7-22
Description	7-5	Drive Lines.	7-22
Functional Operation	7-5	Clutch	7-24
Engine Control System Switches and Indicator Lights	7-6	Description.	7-24
Fuel System	7-6	Theory Of Operation	7-24
Description	7-6	Maintenance	7-26
Maintenance	7-7	Clutch Adjustment Procedure	7-33
Air Intake System	7-8	General Maintenance	7-33
Description	7-8	Gearshift	7-33
Maintenance	7-9	Description.	7-33
Exhaust System	7-11	Maintenance	7-34
Description	7-11	Manual Transmission	7-34
Exhaust System Removal.	7-11	Description.	7-34
System Installation	7-11	Theory of Operation.	7-34
Slip Joint Exhaust Connectors	7-12	Maintenance	7-35
Exhaust System	7-12	Lubrication	7-38
After-Treatment Diesel Exhaust Fluid (DEF) ...	7-13	Preventive Maintenance	7-39
DEF Tank	7-13	Transmission Shift Air System	7-39
DEF Dosing Unit Filter	7-14	Description.	7-39
Water Cooling System	7-16	Theory of Operation.	7-39
Description	7-16	Pump / PTO Assembly	7-40
		Pump / PTO Replacement.	7-40

ENGINE

Description

The engine is a Cummins X12 on-highway engine.

This Service Manual does not include detailed information on this individual engine. A separate manual, as prepared in detail by the engine manufacturer, is supplied with this *Service Manual*. However, a short description and maintenance of certain components of the fuel system, air intake system, and water cooling system are provided in this section.

Engine speed is controlled from the carrier cab by a foot throttle pedal connected electronically to the engine ECM. Speed is electronically controlled in the same manner from the superstructure cab by either a foot throttle pedal or hand throttle. The control module is the control center of the system. It processes all of the inputs and sends commands to the vehicle and engine control devices.

The engine and its components are enclosed within a hood assembly. The hood has openings in the front and rear to allow for adequate air flow over the engine. A door on the top left and right side of the hood may be opened to provide easier access to the engine.

The air intake filter is located on the right side of the engine on the fender. The muffler is located on the left side behind the cab.

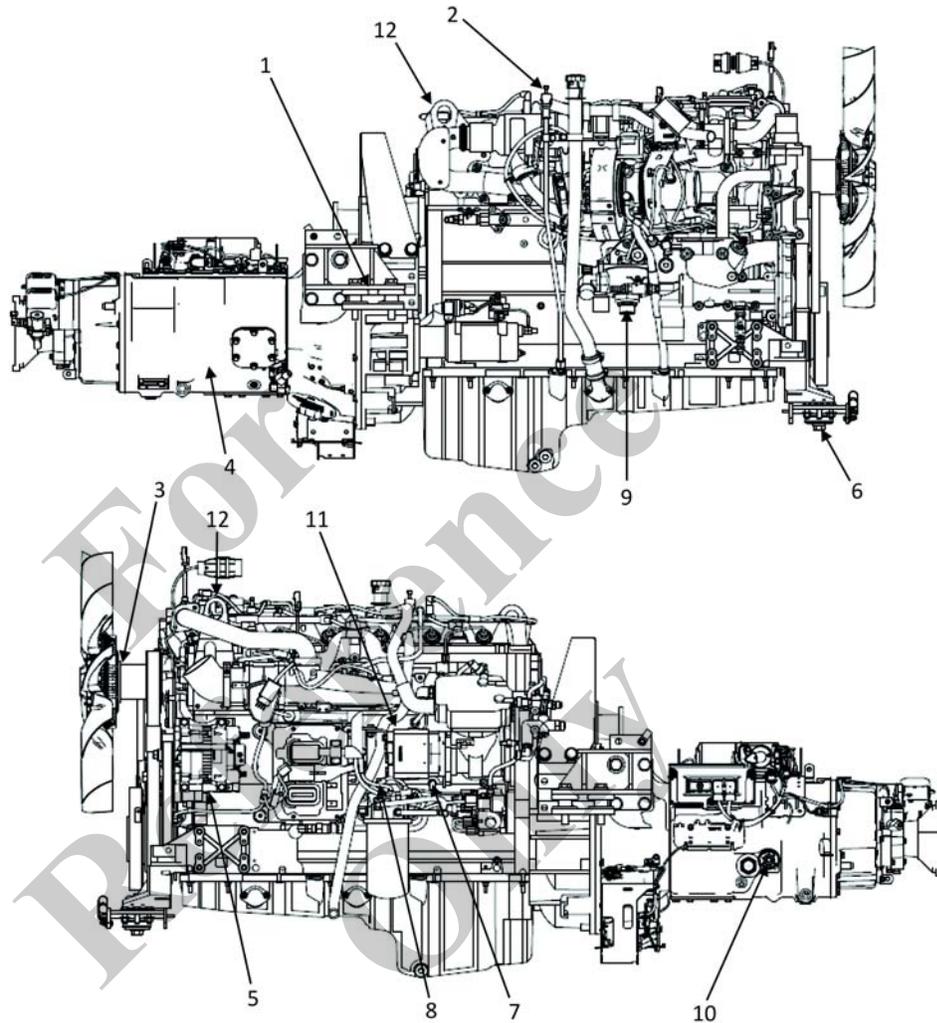
To aid in starting the engine in cold weather, an automatic cold weather starting aid injection system is provided. When engine temperature is below 13°C (55°F) the automatic cold start solenoid is activated when the engine is started, providing an injection of starting fluid to the engine. The system 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.
 3. Open the left and right hood access doors.
 4. Disconnect the air filter tubing at the engine and air cleaner. Remove and lay aside.
 5. Drain the engine lubricating systems.
 6. Drain the transmission lubricating systems.
 7. Drain the engine coolant system.
 8. Disconnect the starting aid tubing from the engine intake manifold. Cap or plug the openings.
 9. Remove the bolts, washers, lockwashers, and nuts securing the start relay and max speed relay to the hood. Lay the relay with the harness on the engine.
 10. Disconnect the muffler exhaust tubing at the engine and aftertreatment assembly (muffler). Remove the tubing clamp bracket and exhaust bracket from the rear of the engine and remove the tubing from the engine.
 11. Unplug the aftertreatment assembly wiring harness from the engine harness and aftertreatment assembly, and unstrap from the engine hood.
 12. Remove the engine hood assembly, counterweight stowage frame work, and decking over transmission.
- NOTE:** 90 kg (200 lb). Make sure that the lifting device is sufficient to lift the aftertreatment assembly.
13. Loosen all mounting bolts to frame.
 14. Attach an adequate lifting device and remove the aftertreatment assembly
 15. Disconnect hoses from main piston pump and cap all openings.
 16. Unbolt driveline from piston pump coupler and lay on transmission.
 17. Remove piston pump assembly.
 18. Attach adequate lifting device to the engine and transmission sufficient to lift and support both the engine and transmission.
 19. Tag and disconnect the engine electrical harness connector from the carrier harness connector, the starting aid valve connector, the fan clutch controller connector, and the battery cables.
 20. Tag and disconnect the transmission oil lines to the filter and oil cooler.
 21. Disconnect and remove the drive line from the transmission. Refer to *Drive Lines*, page 7-22.
 22. Tag and disconnect all lines to the radiator and air cooler. Remove the radiator assembly and fan. Cap or plug all openings.
 23. Tag and disconnect the heater hoses.
 24. Tag and disconnect the fuel lines to the engine. Cap or plug all openings.
 25. Tag and disconnect all air lines to the engine components and transmission. Cap or plug all openings. Move the tubing out of the way so it is not damaged during the removal of the engine and transmission assembly.
 26. Tag and disconnect the hydraulic lines to both the engine and main pumps. Cap or plug all lines and openings.
 27. Remove the main pump assembly.
 28. Tag and disconnect all linkages and cables to the engine, engine components, and transmission.
- NOTE:** The engine and transmission weighs approximately 1533 kg (3379 lb).
29. With the lifting device supporting the weight of the engine and transmission, remove the bolts, washers, lockwashers, nuts and shock mounts from the front engine mounting support and the transmission mounting brackets.
 30. Carefully lift the engine assembly from the crane and move it to a clean work area.
 31. If a new engine is to be installed, remove the transmission, and all engine installed components, fittings, etc. from the old engine and install them on the new engine in the same locations. Refer to *Drive Train*, page 7-22 for transmission removal and installation.
 32. Ensure that the same grade hardware, torque values, and Loctite as were installed by the factory are used.

X12 Engine Installation



8326-8

- | | |
|----------------------------------|-------------------------------------|
| 1. Rear Engine Mounts | 7. Oil Temperature Sensor |
| 2. Engine Oil Dipstick | 8. Oil Pressure Sensor |
| 3. Fan Clutch | 9. Engine Oil Filter (Remote Mount) |
| 4. Transmission | 10. Transmission Oil Fill Plug |
| 5. Alternator | 11. Gear Pump (Power Steering) |
| 6. Front Cross Member and Mounts | 12. Lifting Brackets |

FIGURE 7-1

Installation

1. With all components and fittings installed on the engine, lift the engine assembly into the crane.
2. With the engine assembly in position, install the bolts, washers, lockwashers, nuts, and shock mounts on the front engine mounting support and on the transmission mounting brackets. Torque the bolts to factory specifications as defined in *Torque Values*, page 1-9.
3. Remove the lifting device from engine and transmission.
4. Install the main pump assembly.
5. Connect all linkages and cables to the engine, engine components, and transmission as tagged during removal.
6. Connect all hydraulic lines to both the engine and main pumps as tagged during removal.
7. Connect all air lines to the engine components, transmission, and pump drives as tagged during removal.
8. Connect the fuel lines to the engine as tagged during removal.
9. Connect the heater hoses as tagged during removal.
10. Install the radiator assembly and fan. Connect all lines to the radiator and air cooler as tagged during removal.
11. Connect the drive line to the transmission. Refer to *Drive Lines*, page 7-22.
12. Connect the filter and oil cooler oil lines to the transmission as tagged during removal.
13. Connect the battery cables, starting aid valve connector, and engine electrical harness connector as marked during removal.
14. Install piston pump.

15. Bolt drive line to piston pump coupler.

16. Connect hoses to main piston pump

NOTE: Aftertreatment assembly weighs approximately 90 kg (200 pounds). Ensure lifting device is sufficient to lift the aftertreatment assembly.

17. Attach lifting device to and install the aftertreatment assembly.
18. Install the engine hood assembly, counterweight stowage frame work, and the removed decking.
19. Plug aftertreatment wiring harness to engine harness and aftertreatment assembly.
20. Install the exhaust tubing and connect it to the engine.
21. Position the start relay and max speed relay on the inside of the hood and secure with the bolts, washers, lockwashers, and nuts.
22. Connect the starting aid tubing to the intake manifold.

Engine Drive Belts

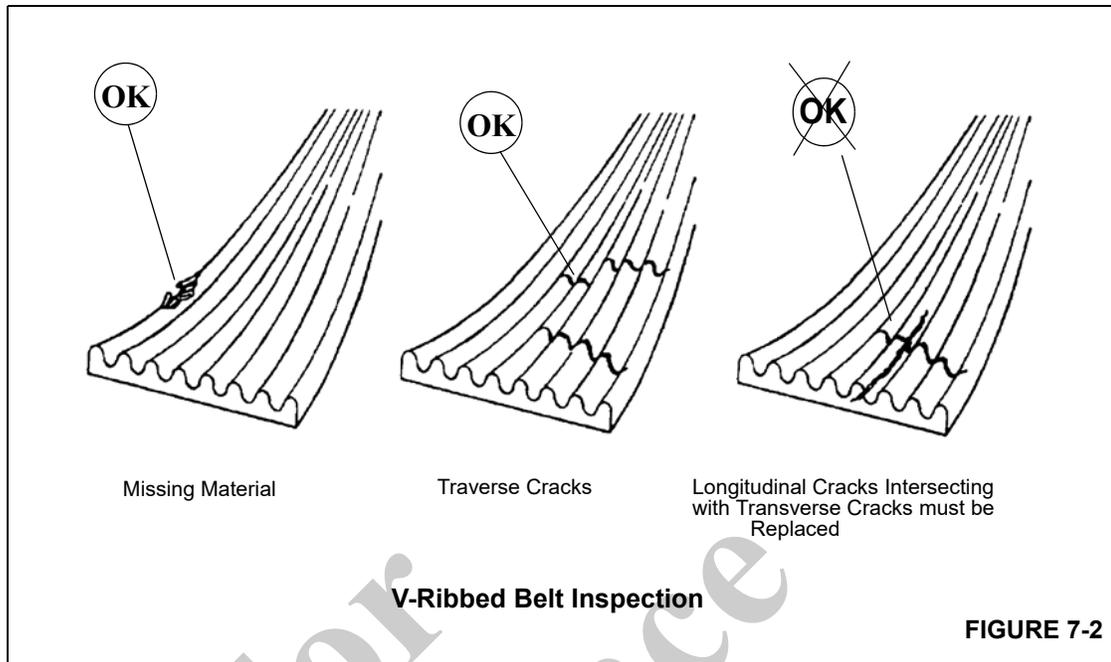
The proper operation of engine belt-driven components such as the alternator, fan clutch, and water pump depend on the proper condition and tension of the engine drive belts.

Belt tension is maintained with an automatic belt tension device.

The engine drive belt should be inspected visually on a daily basis. The drive belt should be inspected for cracks, frayed areas, and glazed or shiny surfaces. 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.



ENGINE CONTROL SYSTEM

Description

The engine control system is an electronically controlled 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 blink or flash when out-of-range conditions continue to get worse.

Functional Operation

Four key switch phases govern the operation of the engine control system:

1. Ignition switch in the on position, idle/diagnostic switch off, engine not cranking or running.
2. Ignition switch in the on position, idle/diagnostic switch on, engine not cranking or running.
3. Ignition switch in the on position, engine cranking.
4. Ignition switch in the on position, engine running.

With the ignition switch on, the diagnostic test switch off and the engine not cranking or running, the electronic control module (ECM) performs diagnostic and status operations. It

reads the logic inputs from the brake, clutch, and cab switches and analog inputs from sensors such as the engine coolant temperature sensor and the manifold boost pressure sensor. During this phase the data link is active and can be accessed by the applicable service tools. The ECM opens the fuel shutoff valve so the engine is ready to be started.

Additionally if the key switch is turned on but the diagnostic switch remains off, the indicator lights illuminate for approximately two seconds to verify they are working and then go out. This is part of the normal operation of the power-up sequence. However, if an active fault is present, one of the lights remains illuminated, determined by the type of fault being sensed.

When the diagnostic test switch is turned on, the red and amber indicator lights illuminate and remain illuminated if there is no active fault. If there is an active fault, the red lamp flashes in a sequence of pulses to indicate that specific fault code.

The electronic subsystem and the starter motor are independent of each other. During the cranking phase, with the ignition switch in the start position, the ECM commands all of the fuel needed to start the engine. There is no need to use the throttle pedal while cranking the engine.

While the engine is cranking the ECM is performing additional diagnostic and status operations. An active fault causes one of the two indicator lamps to illuminate and remain lit. Which lamp is illuminated depends on the severity of the fault.

Engine Control System Switches and Indicator Lights

Engine Stop Indicator

Engine Stop lamp is located in the top right of the speedometer, which is on the right side of the front console in the carrier cab. The indicator illuminates red when energized by a signal from the engine ECM that signifies a serious engine problem that requires the vehicle and the engine to be stopped as soon as safely possible. In addition, a warning buzzer will also sound.

In addition to alerting the operator of system faults, the stop light, in conjunction with the warning 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-digit or four-digit code for the active fault and the amber light flashes again to separate the previous red light sequence from the next one. Each code will be flashed 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.

Engine Warning Indicator

The engine warning/electrical system diagnostic indicator is located in bottom right of speedometer. The top portion is the warning indicator. It illuminates amber when energized by a signal from the engine ECM that signals the operator of an engine problem which must be corrected.

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-digit or four-digit code for the active fault and the amber light flashes again to separate the previous red light sequence from the next one. Each code will be flashed 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.

Filter Exhaust System Cleaning/High Exhaust Indicator

The amber filter exhaust system cleaning indicator, located in the tachometer, will illuminate when the exhaust system has not been able to clean under normal operating conditions and is in need of assistance in order to perform an active cleaning. There are three progressive stages of need for cleaning indicated by this light:

- **A) On Solid:** Cleaning should be done within one shift of operation.
- **B) Flashing:** Cleaning needs to be done soon.
- **C) Flashing with Check Engine Light Illuminated:** Start cleaning immediately.

The high exhaust temperature indicator is located in the tachometer. The indicator illuminates red when an active exhaust cleaning has been initiated and the exhaust temperatures will be elevated above normal levels for operating conditions.

Engine Idle/Diagnostic Switch

The engine idle/diagnostic switch located on the left side of the front console is used when servicing the engines electronic control system.

It is a two position on/off switch used to activate the testing mode (fault codes). When the switch is in the diagnostic position and is used in conjunction with the engine increment/decrement (+/-) switch, access will be gained to toggle up and down through the fault codes.

Engine Increment/Decrement Switch

The engine increment/decrement switch located on the left side of the front console is used when servicing the engine electronic control system.

It is a two-position (+/-) momentary switch that provides idle-control inputs that increases and decreases the engine idle when the idle/diagnostic switch is in the idle position.

Pushing the top of the switch increases (+) engine RPM or pushing the bottom of the switch decreases (-) engine RPM.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, fuel filter-water separator, injection fuel pump, and the fuel injectors. All components except the fuel tank and fuel filter-water separator are installed on the engine or supplied with the engine for remote mounting.

Fuel Tank

The fuel tank is an aluminum round tank located on the left side of the crane. The tank has a draw capacity of 367 l (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 fuel quantity sender units which provide signals to quantity indicators on the instrument panels in both cabs.

Injection Fuel Pump

The fuel is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is metered also, before injection, to meet the load requirements imposed upon the engine.

Surplus fuel, returning from the injectors, is bypassed back to the fuel tank. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

Fuel Filter-Water Separator

The fuel filter-water separator removes impurities from the fuel and also removes water from the fuel before it reaches the engine. It is mounted under the decking forward of the fuel tank.

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 quantity 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 lead 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

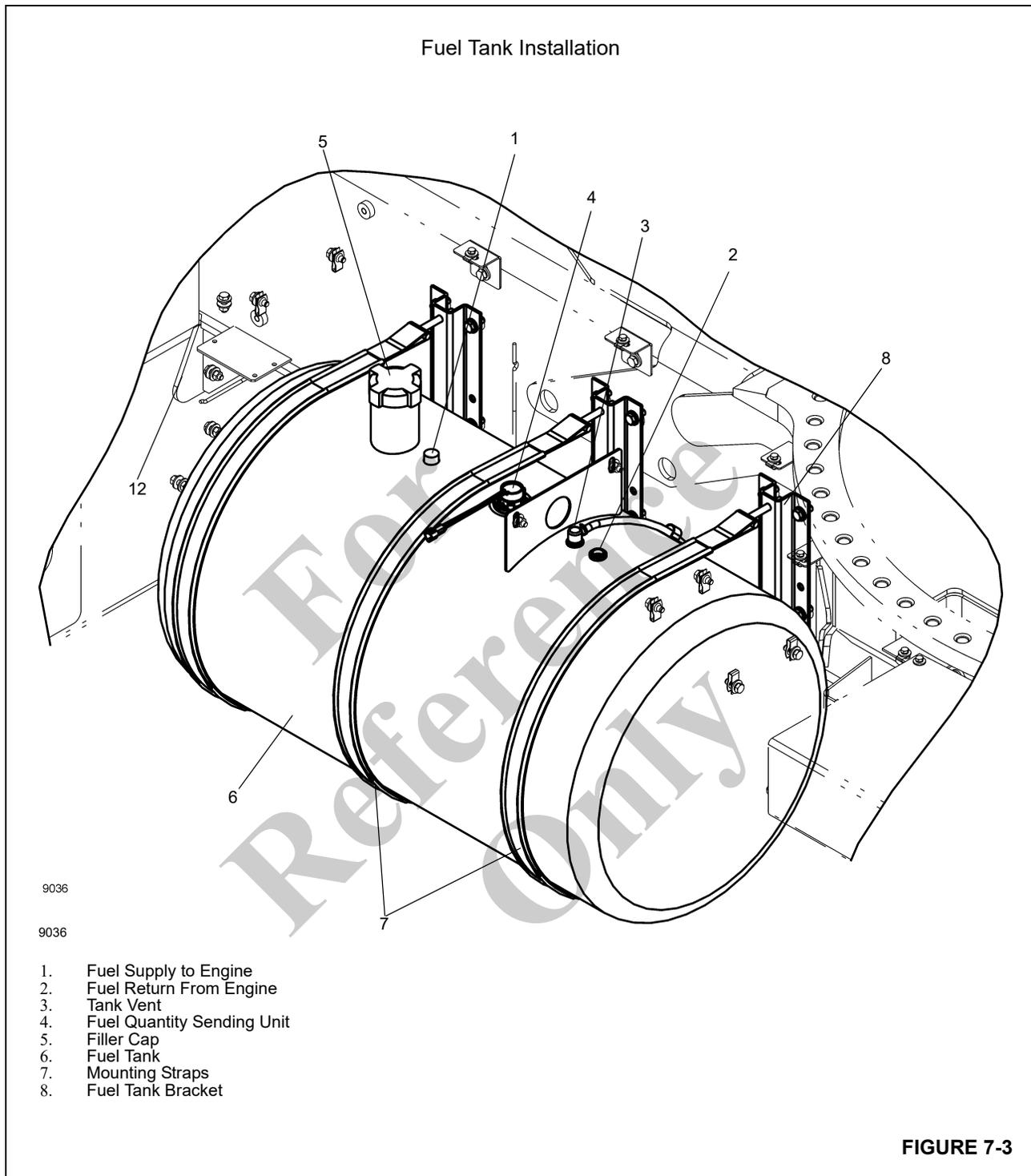
The sump of the fuel filter-water separator should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure.

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.



AIR INTAKE SYSTEM

Description

The engine air intake system 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 optional automatic cold weather starting system consists of a temperature sensor, atomizer, valve assembly, and starting fluid bottle. The quick start system is activated when

the engine temperature is 13°C (55°F) or below to facilitate engine starting. 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. Make sure that 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. Make sure that the element gasket washer is not damaged and the washer's rubber face seals against the element.
3. Inspect the element gasket for damage.
4. Check for structural failures. Any damaged parts must be replaced.
5. Inspect the restriction indicator tap for leaks.

Check For Filter Restriction

As a dry cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (at the air cleaner outlet) increases.

The vacuum is generally measured as restriction in inches of water. The engine manufacturer places a recommended limit on the amount of restriction the engine will stand without loss in performance before the element must be cleaned or replaced. Cummins allows a vacuum of 6.2 kPa (25 inches of water) maximum with a dirty air cleaner at maximum governed RPM.

A service indicator on the air cleaner housing will indicate when the filter needs to be cleaned or replaced. Reset the indicator each time the air cleaner is serviced. If the indicator's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring vacuum.

To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Make sure that 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. Make sure that the correct size connections are used between the air cleaner and the engine.
4. Make sure that all inlet accessories are the correct size and are not plugged by any foreign object.

CAUTION

Engine Damage Hazard!

Never service the air cleaner while the engine is running.

Filter Element Replacement

1. Unlatch the latches, open the air cleaner body, and withdraw the element as follows:
 - a. **RELEASE THE SEAL GENTLY.** The filter element (Figure 7-4) 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.

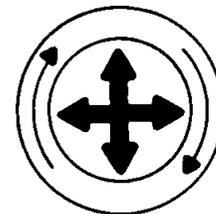


FIGURE 7-4

- b. **AVOID DISLODGING DUST FROM THE FILTER.** Gently pull the filter (Figure 7-5) off the outlet tube and out of the housing. Avoid knocking the filter against the housing.

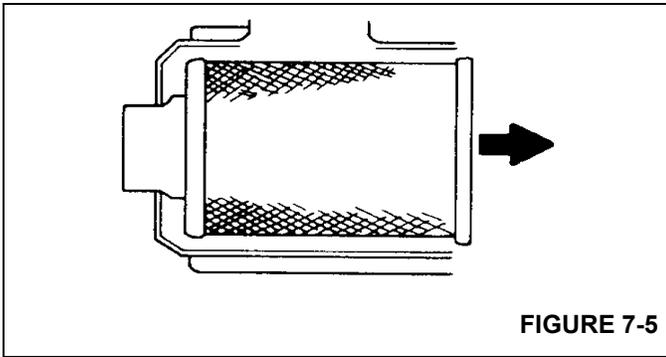


FIGURE 7-5

2. Inspect all parts of the intake system and air cleaner. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube.
3. Install the 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.** Refer to (Figure 7-6). 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.

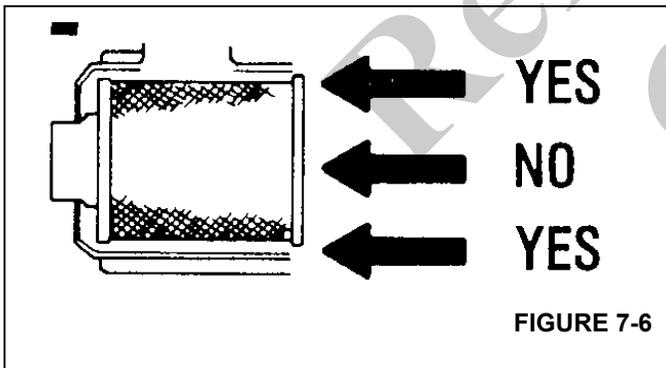


FIGURE 7-6

4. Install the cover on the air cleaner body with the two arrows pointing up. Secure the cover with the latches.
5. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.

Element Cleaning

It is not recommended that filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.

Air Cleaner Body

Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for dents or other damage that would interfere with air flow or with the fins on the element or inside the body. Repair any body dents, being careful not to damage the sealing surfaces. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

Vacuator Valve

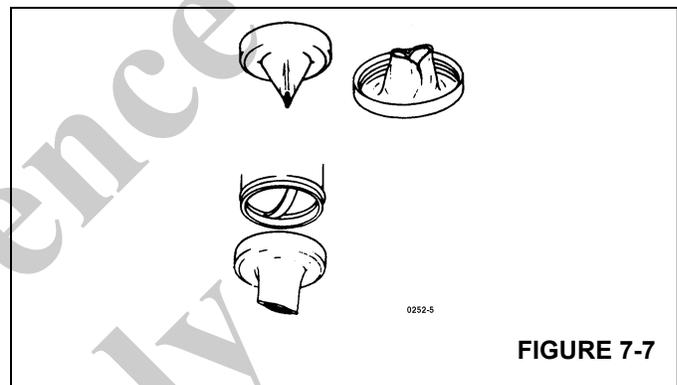


FIGURE 7-7

Vacuator valves (Figure 7-7) 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 un-filtered air into the engine air intake.

3. Check hoses for cracks, chafing, or deterioration, and replace at the first sign of probable failure.

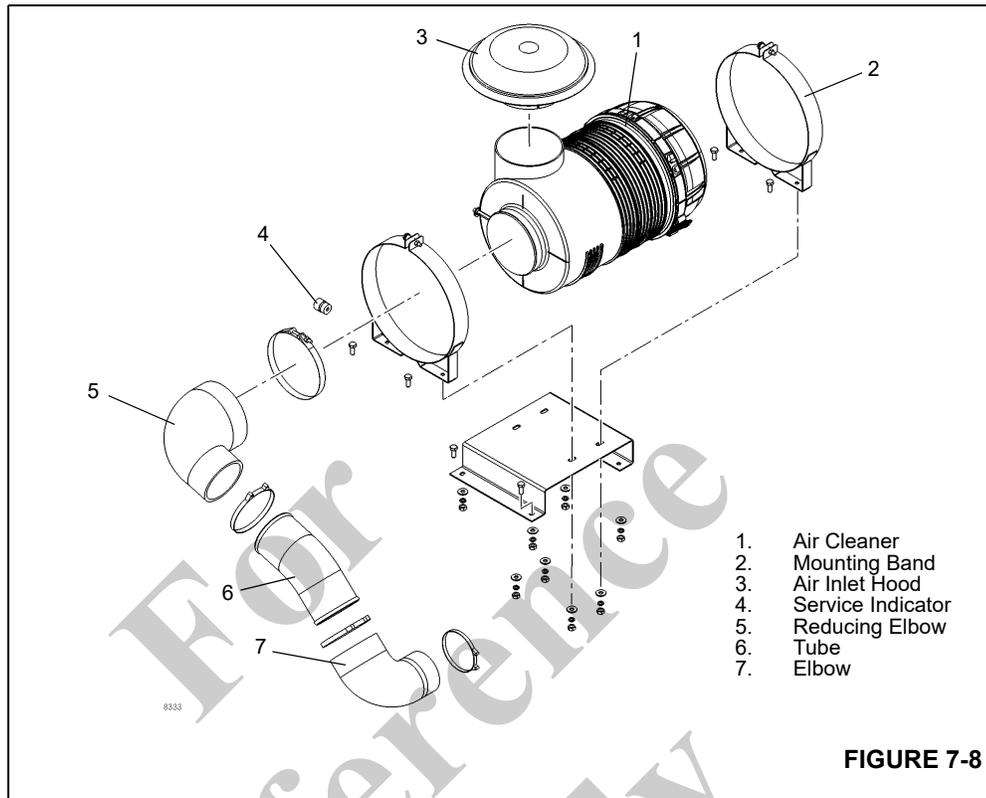


FIGURE 7-8

EXHAUST SYSTEM

Description

The X12 exhaust system consists of a single-module canister that incorporates a diesel particulate filter (DPF) to remove soot, a diesel exhaust fluid (DEF) dosing section (decomposition pipe) to inject the DEF and a selective catalytic reduction (SCR) assembly.

Exhaust System Removal



DANGER

Burn Hazard!

Do not touch exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove capscrews, lockwashers, flat washers, and nuts to free exhaust system guards. Remove guards.
2. Tag and disconnect all wires and hoses.
3. Remove clamp from inlet of aftertreatment.

4. Remove capscrews, lock washers, flat washers, and nuts to free aftertreatment mounting bands.
5. Using a suitable lifting device remove the aftertreatment system.
6. Inspect exhaust tubing, exhaust wrap, outlet sensors and wire leads, and attaching hardware.
7. Inspect the crane's sensor harness wiring that connects to sensor wiring of the exhaust system. Repair or replace any of these components if damaged or missing.

System Installation

1. Install mounting bands on aftertreatment module.
2. Install the aftertreatment module leaving the mounting hardware slightly loose to allow for proper alignment.
3. As needed, loosen the clamps on the aftertreatment so it can rotate. Rotate the aftertreatment module so that the inlet is positioned horizontally to align with the exhaust down-pipe tubing.
4. Secure all exhaust tubing with appropriate clamps and install new gaskets as required.
5. Tighten the mounting hardware for all the components.

6. Attach the crane's sensor harness wires, as tagged during removal, to the sensor wire leads of the system.
7. Attach the tubing as tagged during removal.
8. Secure all wiring and tubing to prevent damage from heat and abrasion.
9. As needed, install a replacement exhaust wrap around the exhaust tube.
10. Install exhaust system guards and secure with capscrews, lock washers, flat washers, and nuts.

Slip Joint Exhaust Connectors

Slip joint exhaust couplers require tightening to avoid exhaust leaks. Perform the following procedures at the appropriate intervals.

After 1000 Hours or One Year

Visually inspect the exhaust connector. If necessary, tighten the v-clamps by one full turn of the nuts.

2000 Hours or 2 Years

Tighten the v-clamps by 1 ½ turns of the nuts.

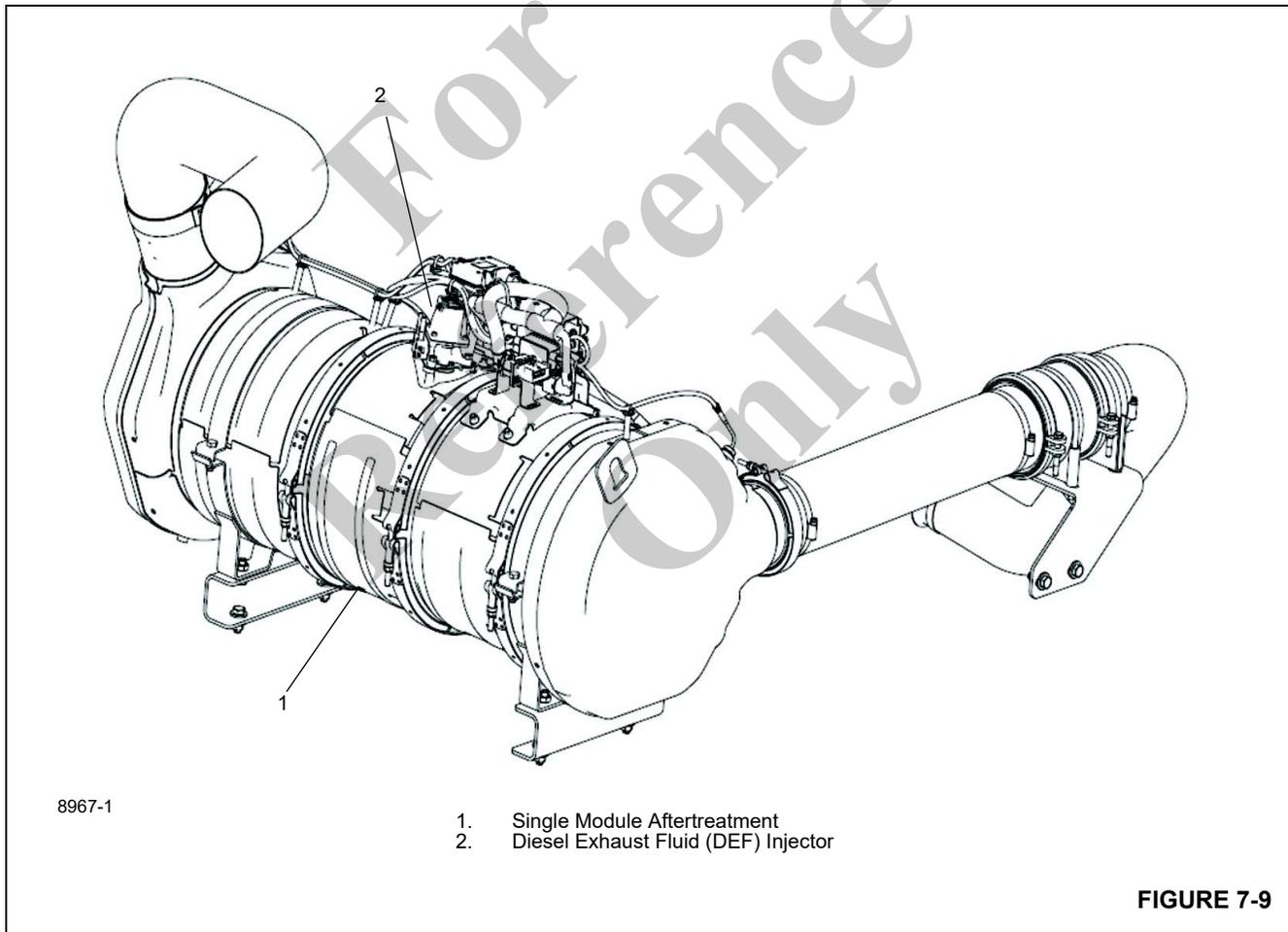
4000 Hours or 4 Years

Tighten the v-clamp by 1 ½ turns of the nuts.

5000 Hours or 5 Years

Remove the v-clamps and gaskets, and replace them with new gaskets and clamps. Tighten the v-clamps to 9.6 to 11.3 Nm (85 to 100 lb-in) of torque.

Exhaust System



AFTER-TREATMENT DIESEL EXHAUST FLUID (DEF)

DEF Tank

Description

This engine uses a Selective Catalytic Reduction (SCR) system. SCR is a technology that uses a urea based DEF and a catalytic converter to significantly reduce oxides of nitrogen (NOx) emissions.

The DEF tank incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

Removal

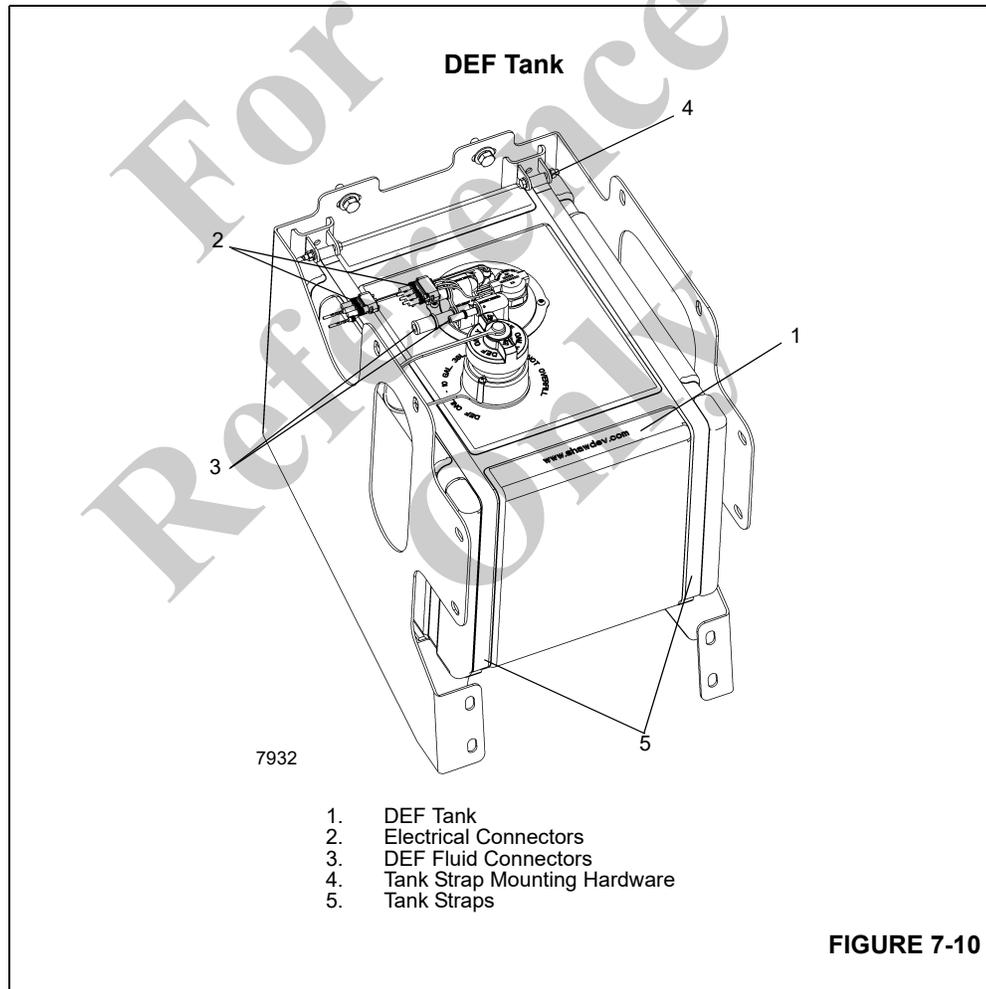
Refer to (Figure 7-10).

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

Refer to (Figure 7-10).

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.



DEF Dosing Unit Filter

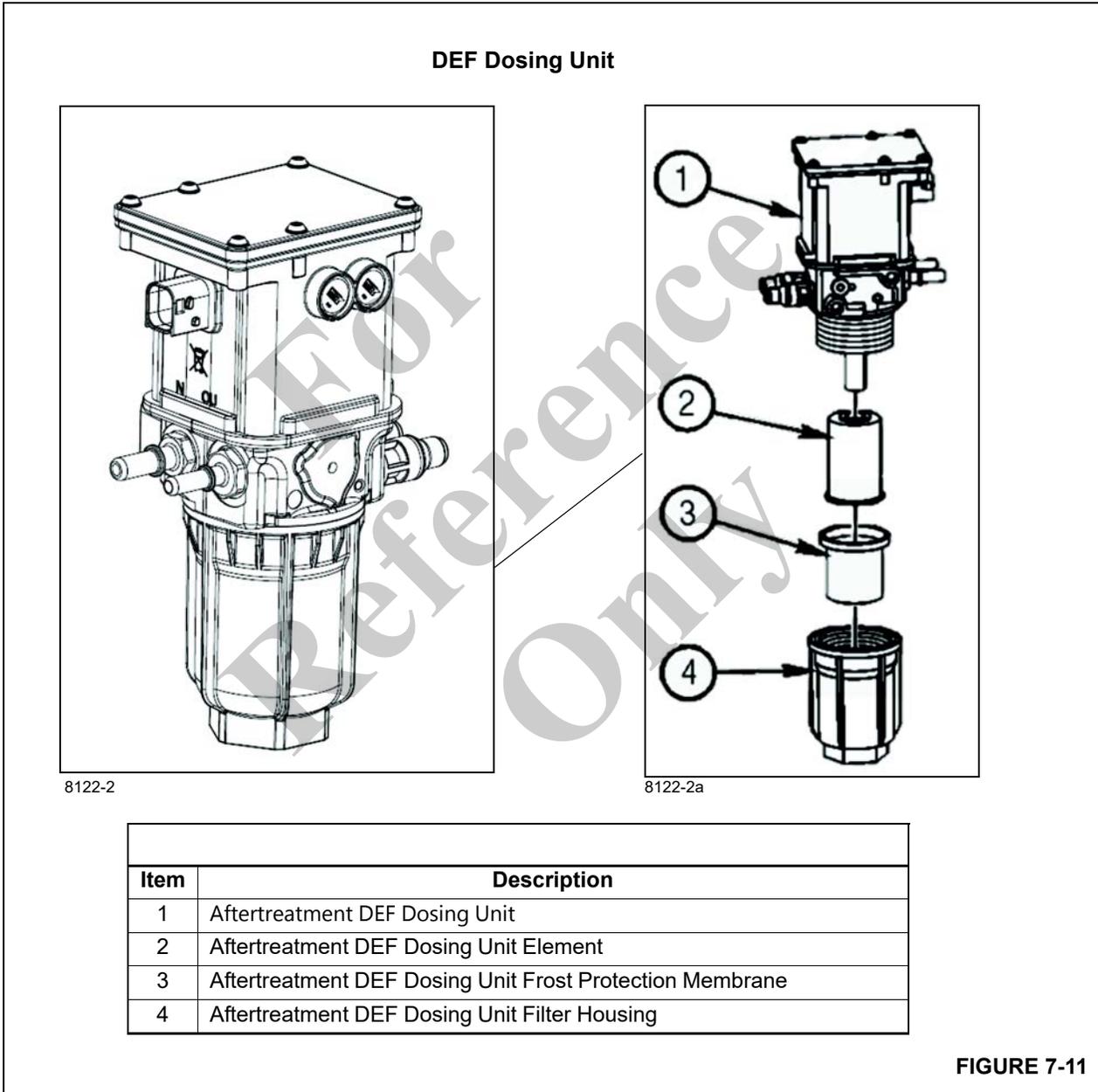
The DEF dosing unit filter (Figure 7-11) is a 10-micron filter designed to prevent foreign objects, that may be suspended in the DEF, from entering the dosing system.

Debris can cause permanent damage and premature failure to either the aftertreatment DEF dosing unit or the aftertreatment DEF dosing valve.

The filter should be replaced every 480,000 km (300,000 miles) or 6750 hours of crane operation.

The aftertreatment DEF dosing unit filter consists of the following components:

- (1) Aftertreatment DEF Dosing Unit Filter Cap
- (2) Aftertreatment DEF Dosing Unit Filter Equalizing Element
- (3) Aftertreatment DEF Dosing Unit Filter Element
- (4) Aftertreatment DEF Dosing Unit Filter Housing



Initial Check

Inspect the area around the seal and vent of the aftertreatment DEF dosing unit filter cap for signs of leakage.

DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section in this procedure.

Preparatory Steps



WARNING

Personal Injury Hazard!

DEF contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow. In the event the DEF is ingested, contact a physician immediately. Reference the Materials Safety Data Sheet (MSDS) for additional information.

NOTE: Do not disconnect the vehicle batteries until the DEF dosing system has completed the purge cycle. Before beginning to remove and/or disconnect any components, wait at least five minutes after the key switch is turned OFF for the aftertreatment DEF dosing system to purge the DEF from the system. The purge cycle is an automatic process and does not require intervention to occur. The aftertreatment DEF dosing unit will create an audible pumping noise during the purging process.

NOTE: Do not power wash or steam clean this unit. Use compressed air to remove any loose debris.

Turn the battery disconnect switch to OFF to disconnect the batteries.

Remove

NOTE: There may be residual DEF in the filter housing (4), (Figure 7-11). A collection container placed below the DEF filter cap is recommended.

Refer to (Figure 7-11).

1. Unscrew the DEF filter cap (1).
2. Remove the aftertreatment DEF filter equalizing element (2).
3. Remove the old aftertreatment DEF dosing unit filter element (3).

NOTE: If removing the aftertreatment DEF dosing unit filter as part of a maintenance interval, discard the equalizer element and filter.

Clean and Inspect for Reuse

If there is the possibility that contaminated DEF has gone through the DEF dosing system, check the DEF filter prior to discarding the filter.

1. Check the DEF for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.
 2. Inspect the DEF filter for debris. If debris is evident, also check:
 - DEF tank pick up screen.
 - The aftertreatment DEF dosing unit inlet connector.
 3. Discard the filter element and equalizing element.
 4. Inspect the aftertreatment DEF dosing unit filter cap for cracks or holes that could create a DEF leak path.
 5. Check the condition of the threads on the aftertreatment DEF dosing unit cap. If the threads are damaged, replace the aftertreatment DEF dosing unit filter cap.
 6. Inspect the aftertreatment DEF dosing unit threads. This is especially important if the aftertreatment DEF dosing unit cap was damaged. If the aftertreatment DEF dosing unit threads are damaged, replace the entire aftertreatment DEF dosing unit.
- NOTE:** Never operate the vehicle with the DEF cap removed.
7. Clean the aftertreatment DEF dosing unit cap with warm water and a clean cloth.

Install

Refer to (Figure 7-11).

NOTE: Lubrication of the DEF filter O-rings is not required.

1. Slide the DEF filter equalizing element (2) into the DEF filter cartridge (3).
2. Insert the assembly into the aftertreatment DEF dosing unit.
3. Install and tighten the cap (1). Torque Value: 80 +/-5 Nm (59 lb-ft).

Finishing Steps

CAUTION

Machine Damage Hazard!

DEF is corrosive to certain metals and paint and should be washed off with mild soap and water if spilled.

CAUTION

Machine Damage Hazard!

Do not use the flow test portion of the INSITE™ electronic service tool Diesel Exhaust Fluid Doser Pump Override Test to check the system for leaks. This will spray diesel exhaust fluid into the exhaust system at too low of temperatures to evaporate, resulting in deposit formations in the exhaust system.

NOTE: The aftertreatment DEF dosing system will not prime until the correct SCR temperatures are reached. To verify that there are no DEF leaks, initiate a manual regeneration to get the SCR system up to temperature.

1. Connect the batteries by turning the battery switch to ON.
2. Operate the engine and check for leaks.

WATER COOLING SYSTEM

Description

The cooling system consists of the radiators, coolant recovery tank, engine cooling circuit, and the connecting hoses. Cooling system capacity is approximately 18.5L (70 quarts). The temperature is controlled by two separate thermostats with staged opening temperatures. The first thermostat opens at 88°C (190°F) located between the top of the engine and the top of the radiator. At all times, the antifreeze/coolant should be properly inhibited against corrosion. It is recommended that a 50/50 fully formulated antifreeze coolant be used at all times.

The radiator assembly consists of the engine water cooler, charge air cooler, and the shroud.

A radiator coolant level switch is installed in the top portion of the radiator surge tank. Coolant level high/low signals are supplied to the engine ECM.

The crane is equipped with a carrier cab hot water heater. Hot water is supplied by the engine coolant system through a cable operated shutoff valve to the heater.

Maintenance

General

The cooling system includes the radiator, coolant recovery tank, thermostat, the fan, and water pump. Radiator hoses are also included in this group.

The cooling system is often neglected because the effects or damage that result from an improperly maintained system

usually occur gradually. The cooling system needs to be maintained with the same attention as other systems.

The circulation of water through the cooling system relies entirely upon the water pump. The water pump draws water from the radiator and forces it through the water jacket and cylinder head. There it accumulates heat and flows to the top radiator tank. Then the water flows down through the radiator core and is cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

Effects Of Cooling System Neglect

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the part directly responsible is not a part of the cooling system. Most of these problems can be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating

An engine that is overheating may lead to troubles such as the following:

- Burned valves.
- Pinging or knocking.
- Excessive fuel consumption.
- Poor lubrication - increased engine wear.
- Sticking valves.
- Short injector life.
- Engine hot spots.
- Need for higher grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

- Excessive fuel consumption.
- Sludge formation in crankcase.
- Corrosive acids formed in crankcase.
- Excessive fuel deposits in the exhaust system.

Rust Prevention

To keep engines operating at newness efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron,

and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times.

For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times. Failure to use and maintain the fully formulated coolant will increase maintenance needs.

Engine Antifreeze/Coolant Fill Procedure (When Level is Low)

1. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant. Fill to the bottom of the surge tank filler neck. Fill slowly. Flow exceeding 19 l/min (5 gpm) can give a false reading.

NOTE: If the engine coolant is changed, the coolant filter must also be changed.

2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating Step 1.
3. Run the engine for 5 minutes and recheck the antifreeze/coolant level. Refill as necessary repeating Step 1.

Engine Antifreeze/Coolant Fill Procedure (After a Complete Draining of the System)

NOTE: If the engine coolant is changed, the coolant filter must also be changed.

1. Open cab heater line valve and SCR cooling line valves.
2. Open petcocks at the Diesel Exhaust Fluid (DEF) Tank (1,2), (Figure 7-12) to allow trapped air to bleed.
3. Slowly fill the system at 11 l/min (3.0 gpm) to the bottom of the surge tank fill neck.

NOTE: A fill rate faster than 11 l/min (3.0 gpm) can give a false reading.

4. Verify a steady stream of fluid (no more than 1 (1 qt) at DEF tank petcocks (1,2), (Figure 7-12), then close.
5. Start the engine and run at idle for 10 seconds. Accelerate to high idle for 1 minute and return to idle.
6. Top off the surge tank.
7. Operate the engine through two (2) thermal cycles and re-check the fluid level. Re-fill as necessary repeating Step 3.

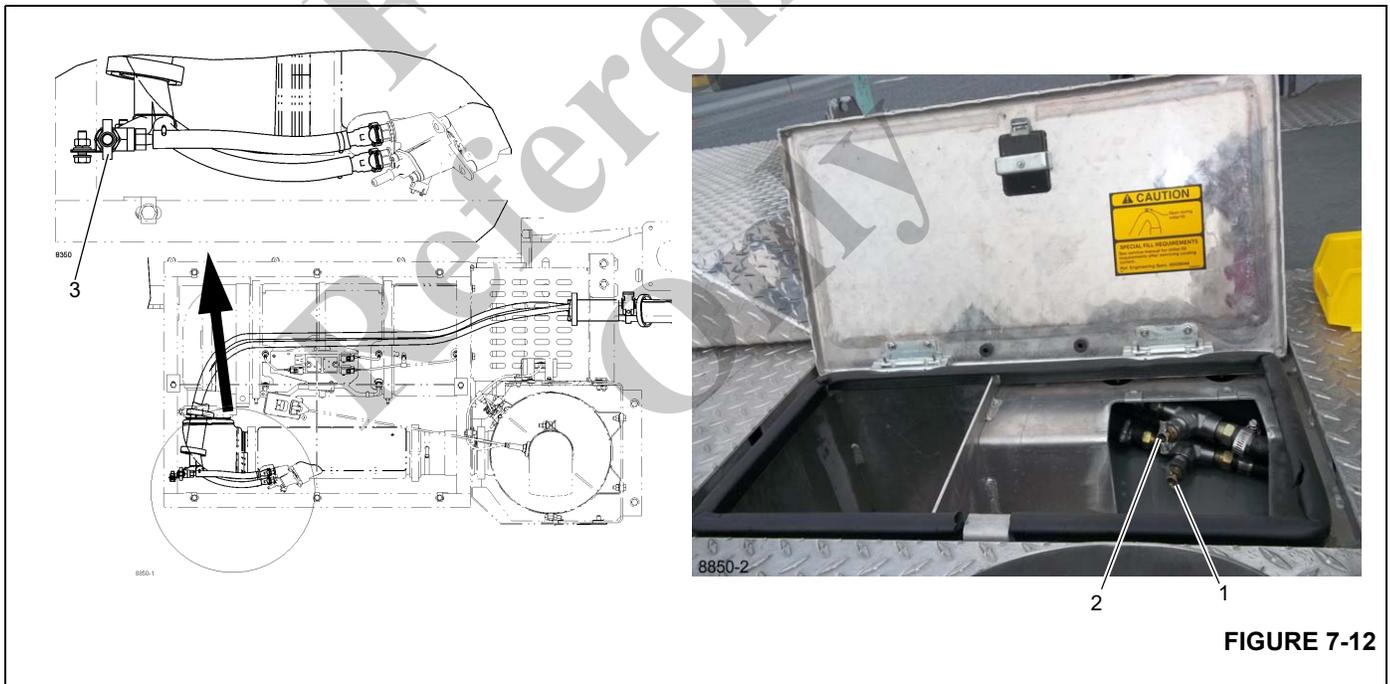


FIGURE 7-12

Antifreeze/Supplemental Coolant Additives Maintenance Summary

Cooling System Level Check Interval

Daily or 10 Hours

The cooling system level should be checked every 10 hours of operation or daily, whichever comes first. Refer to *Lubrication*, page 9-1.

SCA Level Check/Coolant Filter Change Interval

6 Months or 500 Hours

- Check SCA Levels (use only Coolant Test Kit, Grove P/ N 9414101675, to check the coolant additive concentration in the cooling system).

The Coolant Filter contains molybdate. Therefore, it is important to use the Grove Coolant Test Kit, which

checks the molybdate level, regardless of whether the SCA used to replenish the coolant system contains molybdate or not.

Only add coolant additive if levels are less than 1.2 units/gal (see *Lubrication*, page 9-1 for specification and recommended additives).

NOTE: An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Over concentration can cause formation of a "gel" that can cause restriction or plugging of coolant passages, and overheating.

- Change coolant filter.

Install charged filter if SCA levels are normal or below normal; install non-charged filter if SCA levels are above normal (contact Manitowoc Crane Care for filter part number).

1 Year or 1000 Hours

- Test antifreeze/coolant for contamination.

Condemning limits are:

- Sulfate level greater than or equal to 1500 ppm.
- Chloride level greater than or equal to 200 ppm.
- The pH level is less than 6.5
- Oil or fuel contamination can be identified by odor or color.

If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Water Cooling System*, page 7-16.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Cleaning



CAUTION

Burn hazard!

The cooling system is pressurized and injury can result when removing the radiator cap at operating temperature. Use proper protection to remove the radiator cap.

1. Coolant shut-off valves to heaters and other accessories should be open to allow complete circulation during cleaning, flushing, and draining. Run the engine with radiator covered if necessary until temperature is up to operating range 71 to 82°C (160 to 180°F). Stop the engine, remove the radiator cap, and drain the system

by opening the drain cocks on the radiator and engine block.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 82°C (180°F) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 82°C (180°F) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*, page 7-18) and repeat the cleaning operation.
8. If clogging of the core, indicated by low temperature spots on core, is not relieved, the radiator core must be removed for mechanical cleaning. Mechanical cleaning requires removal of the upper and lower tanks, and rodding out the accumulated rust and scale from the water passages of the core.

Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.
3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill the core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the

engine block with water, partly covering the water inlet opening to permit complete filling.

7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. For badly clogged water jackets that do not respond to regular pressure flushing, remove the engine cylinder head and core hole plugs, and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through the openings.
9. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
10. After completing the flushing operation, clean out the overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
11. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

Component Inspection

Radiator/Recovery Tank

1. Top and Bottom Tanks - Look for leaks, particularly where the tank is soldered to the core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler Neck - The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Ensure the overflow tube is not plugged.
3. Radiator Cap - This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

When removing the pressure type cap, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 3 mm (0.13 in). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.



CAUTION

Burn hazard!

Loosen cap slowly and pause a moment to avoid possible burning by hot water or steam.

Continue to turn the cap to the left until it can be removed

4. Tubes are very small and can become easily clogged by rust and scale. The general condition of the cooling system and operating temperature are indications as to whether or not tubes are clean. Another good test is to feel the core for cold spots.
5. Fins are thin metal sheets that dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw etc., so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged, if the cooling system does not receive the proper maintenance.

- Core Plugs - These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.
- Drain Plugs - The water jacket of each engine has one or more drain plugs. These should receive seasonal care and be kept free of rust and scale.
- Gaskets - Must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

Water Pump

The pump should be checked carefully for leaks and proper lubrication. Replace or rebuild if leaking, cracked, or worn.

Fans and Belts

The fan should be checked for cracked or broken blades.

Refer to *Engine Drive Belts*, page 7-4 in this Section.

Thermostat

The thermostat is of the nonadjustable type and is incorporated in the cooling system for the purpose of

retarding or restricting the circulation of coolant during engine warm up. Engine overheating and loss of coolant is sometimes due to an inoperative thermostat. To check for this condition, remove the thermostat and test by submerging it in hot water and noting the temperature at which the thermostat opens and closes. Use an accurate high temperature thermometer for making this test.

Hoses and Clamps

Hoses and their connections must be checked regularly because they are often the source of hidden trouble. Hoses may often times appear in good condition on the outside while the inside will be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. The clamps should be inspected to make sure they are strong enough to hold a tight connection.

Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. "Floating ball" type density testers or hydrometers are not accurate enough for use with heavy duty diesel cooling systems.

Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant at all times. Refer to Lubrication section. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

Radiator Assembly Removal and Installation

Removal

Refer to (Figure 7-13).

1. Set the outriggers and position the boom to over the side.
2. Disconnect the battery.
3. Open the drain cocks (3) at the bottom of the radiator and drain the coolant into a suitable container. Dispose of the coolant in accordance with local and EPA regulations.
4. Open the left and right hood access doors.

5. Disconnect the hoses (12) from the coolant recovery tank (2) and remove the tank.
 6. Remove the hardware securing the top center hood panel to the front and rear cowls and remove the panel with doors from the crane.
 7. Remove the hardware securing the left and right lower side panels to the front cowl.
 8. Remove the hardware securing the front grill panel to the front cowl and remove the grill.
 9. Remove the hardware securing the front cowl and remove the front cowl.
 10. Disconnect the CAC hoses from the air cooler assembly.
 11. Disconnect the hoses from the top and bottom of the radiator assembly.
 12. Remove the bolts, washers, and lockwashers attaching the fan guard to the shroud. Remove the fan guard.
- NOTE:** The radiator assembly weighs approximately 116 kg (256 lb).
13. Attach an adequate lifting device to the radiator/air cooler assembly.
 14. Remove the nuts, hardened washers and mounts securing the radiator/air cooler assembly to the mounting brackets and remove the assembly from the carrier.

Installation

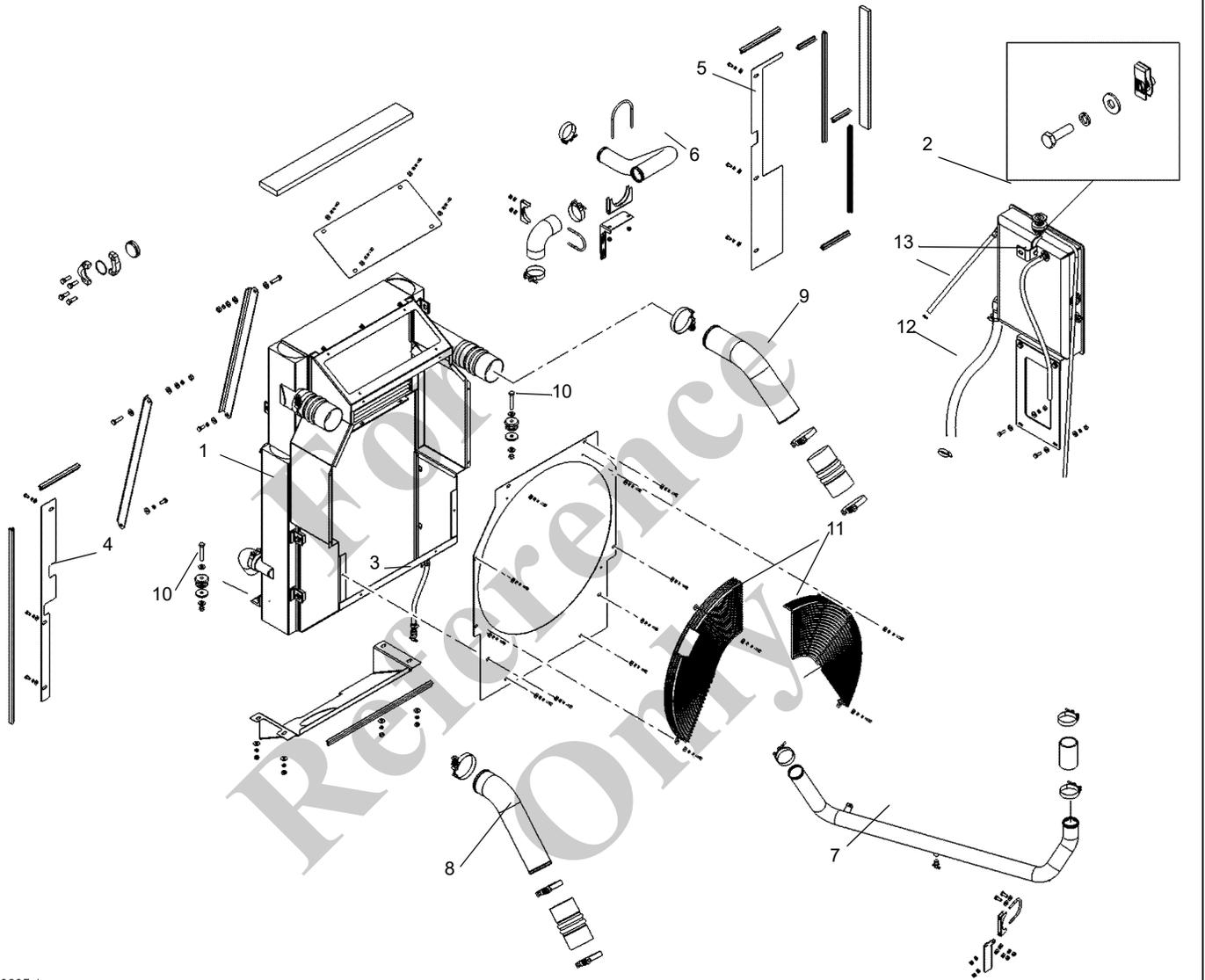
Refer to (Figure 7-13).

1. Position the radiator/air cooler assembly in the carrier using a lifting device and secure to the mounting brackets using the mounts, hardened washers, and nuts.
2. Position the fan guard on the shroud and secure with bolts, washers, and lockwashers.
3. Connect the air cooler tubes to the air cooler using the bellows and clamps. Tighten the clamps to 4 to 5 Nm (35 to 45 in-lb).
4. Connect the hoses to the top and bottom of the radiator.
5. Make sure that the drain cock is closed.
6. Position the front cowl on the frame and secure with the attaching hardware.
7. Position the front grill panel on the front cowl and secure with the attaching hardware.
8. Attach the left and right side lower panels to the front cowl with the attaching hardware.
9. Position the top center panel, with doors attached, on the front and rear cowl and secure with the attaching hardware.

10. Install the coolant recovery tank. Connect the hoses to the tank.

11. Service the engine coolant system as necessary. Start the engine, operate all systems and check for leaks.

Engine Radiator/Charge Air Cooler Assembly



8285-1

Item	Description		
1	Radiator/Charge Air Cooler	8	Cold CAC Tube
2	Recovery Tank	9	Hot CAC Tube
3	Drain Cock	10	Radiator Mount
4	Left Hand Baffle	11	Fan Guards
5	Right Hand Baffle	12	Coolant Recovery Hose
6	Top Radiator Tube	13	Vent Hoses
7	Bottom Radiator Tube		

FIGURE 7-13

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

Refer to (Figure 7-14).

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.

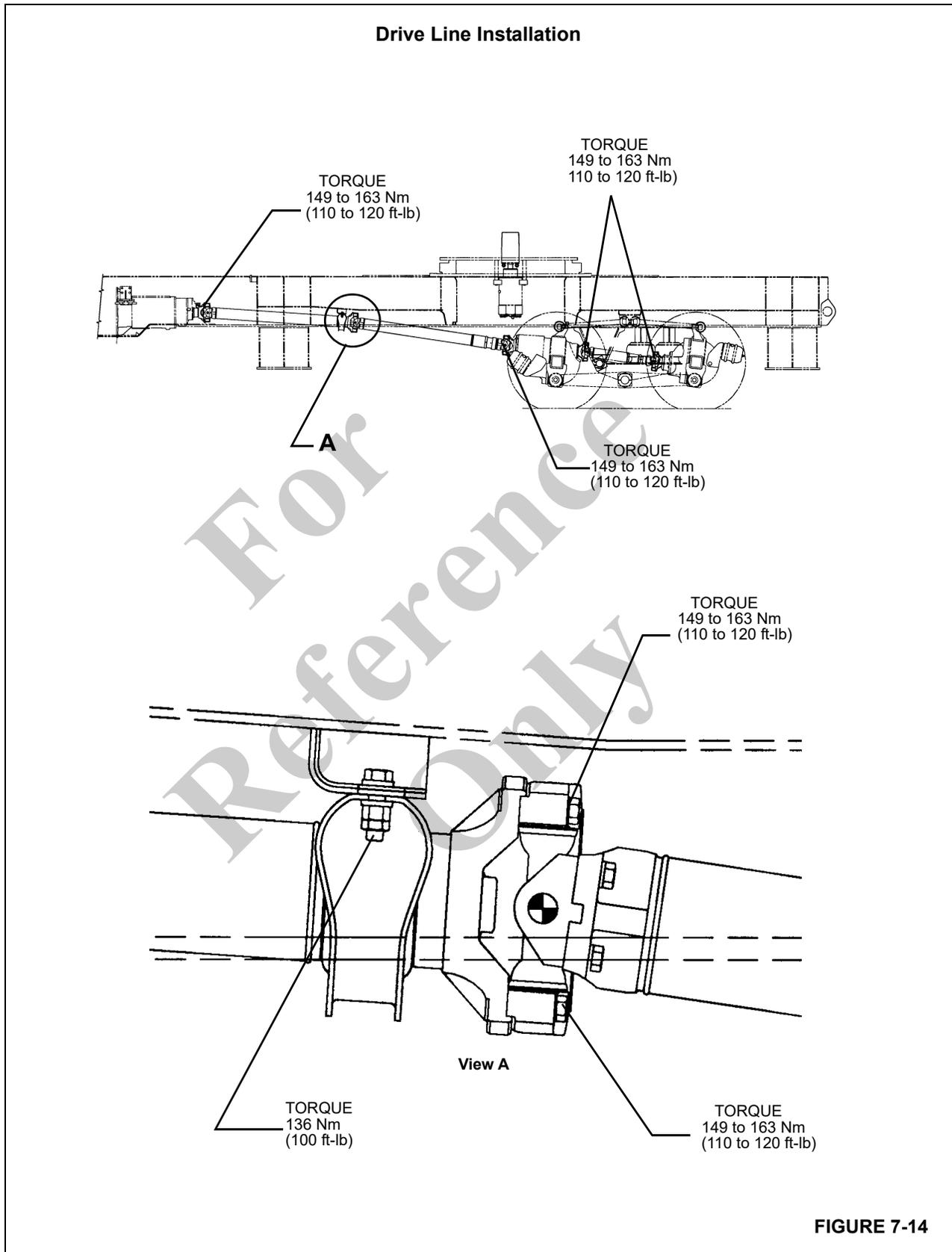
Installation

Refer to (Figure 7-14).

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.



7

CLUTCH

Description

For Clutch Installation, refer to (Figure 7-15).

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

Machine Damage Hazard!

Never fully depress the clutch pedal before the transmission is put in neutral.

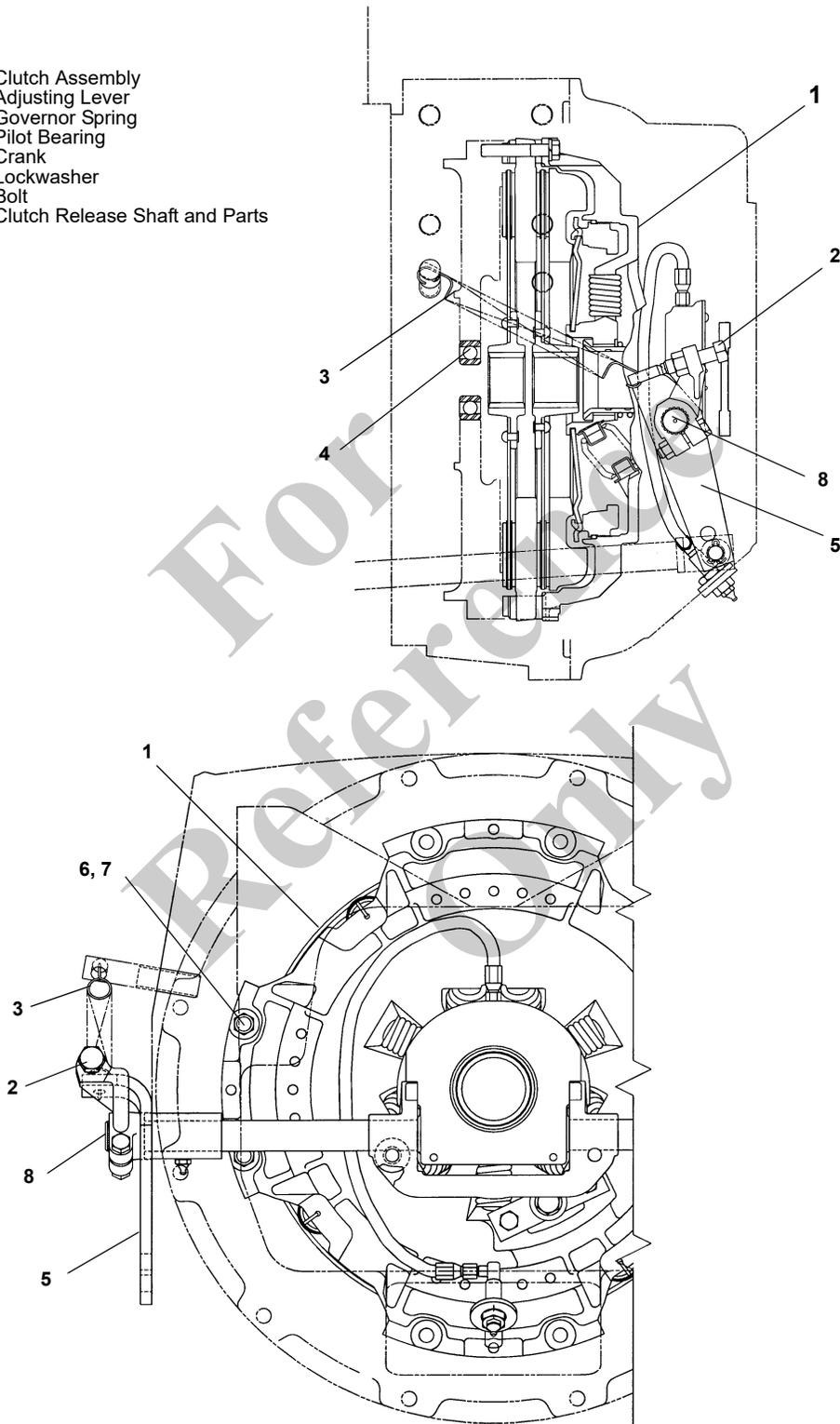
If the clutch brake is applied with the transmission still in gear, a reverse load will be put on the gears making it difficult to get the transmission out of gear. At the same time, it will have the effect of trying to stop or decelerate the vehicle with the clutch brake, with resultant rapid wear and 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.

Clutch Installation

- 1. Clutch Assembly
- 2. Adjusting Lever
- 3. Governor Spring
- 4. Pilot Bearing
- 5. Crank
- 6. Lockwasher
- 7. Bolt
- 8. Clutch Release Shaft and Parts



4749

FIGURE 7-15

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.
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).

SYMPTON	PROBABLE CAUSE	SOLUTION
Insufficient release (continued).	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.	
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
	<p>Broken intermediate plate.</p> <p>Intermediate plate sticking on cover.</p> <p>Warped or bent driven disc assembly.</p> <p>Lever settings wrong.</p> <p>Worn splines.</p> <p>Worn or rusty splines on the splined shaft.</p> <p>Worn pilot bearing.</p>	<p>Replace damaged intermediate plate driven disc assembly.</p> <p>Intermediate plate lugs should have 0.1524 mm (0.006 in) clearance in driving slots of flywheel ring (cover).</p> <p>Replace.</p> <p>Recheck installation.</p> <p>Replace driven disc assembly.</p> <p>Repair or replace.</p> <p>Replace.</p>
Hard pedal.	<p>Excessive spring pressure in the cover assembly.</p> <p>Contact pad of the release bearing carrier worn by the shifter shaft.</p>	<p>Install the proper cover assembly.</p> <p>Replace the carrier and shifter yoke. Also check for proper installation to provide the best linkage operating positions.</p>
Slippage.	<p>Oil or grease on the facing.</p> <p>Loose or worn facings.</p> <p>Weak pressure springs.</p> <p>No free pedal.</p> <p>Release mechanism binding.</p>	<p>Replace facing or install a new driven disc assembly.</p> <p>Replace facings or install a new driven disc assembly.</p> <p>Replace springs.</p> <p>Readjust clutch.</p> <p>Free up mechanism and linkage, check clutch adjustment.</p>
Noisy clutch.	<p>Clutch release bearings dry or damaged.</p> <p>Flywheel pilot bearing dry or damaged.</p> <p>Clutch release bearing housing striking flywheel ring.</p>	<p>Lubricate bearing. Replace if damaged.</p> <p>Lubricate bearing. Replace if damaged.</p> <p>Adjust clutch. Also check wear on cross shafts, bell housing bushings, and release yoke fingers. If badly worn, replace parts.</p>

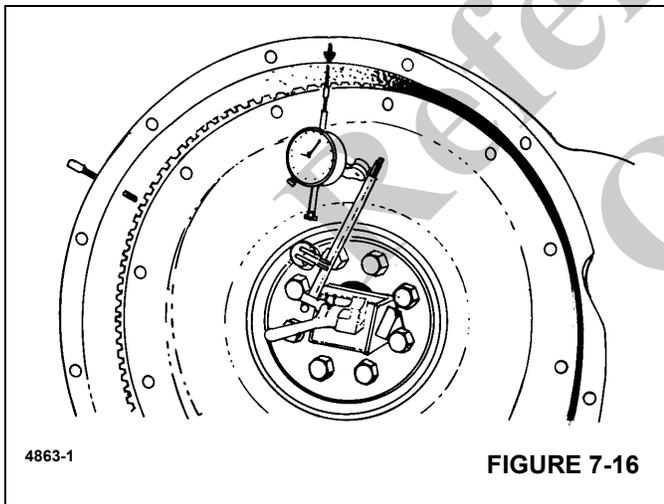
Removal

1. Remove the transmission following the procedures under *Removal of the Transmission*, page 7-37.
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

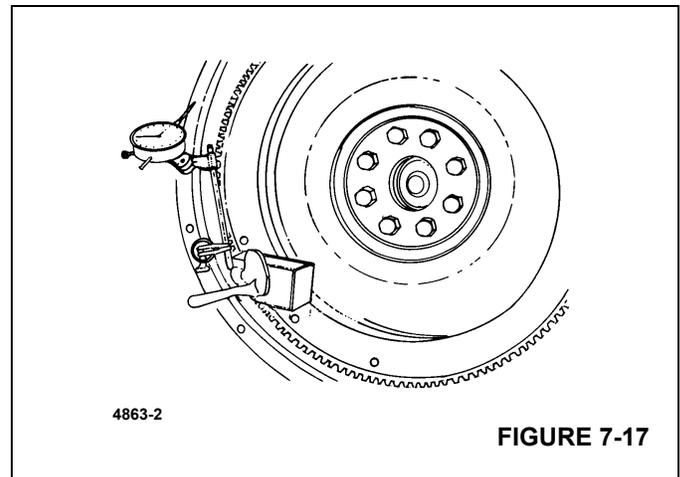
NOTE: Failure to perform inspection may result in low mileage disc/damper failure.

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.



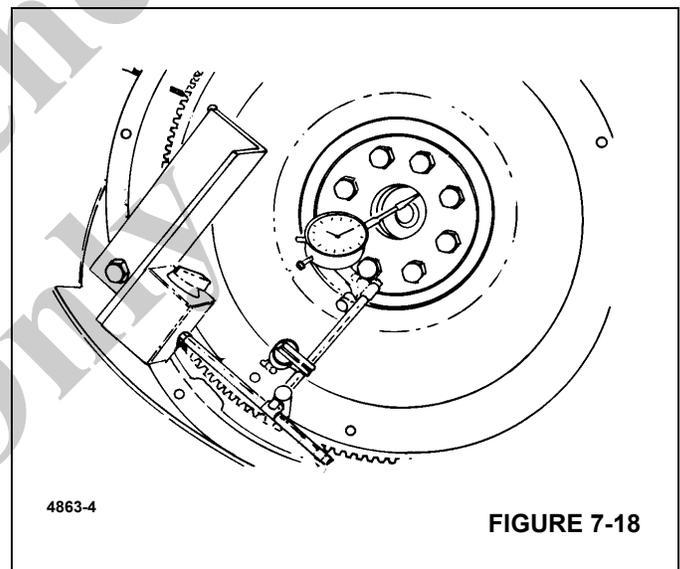
4. Secure a dial indicator to the crankshaft. With the gauge finger against the housing pilot, rotate the crankshaft. Use a marker or soapstone to mark the high and low points.

Total difference between high and low points should not exceed 0.203 mm (0.008 in).



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).

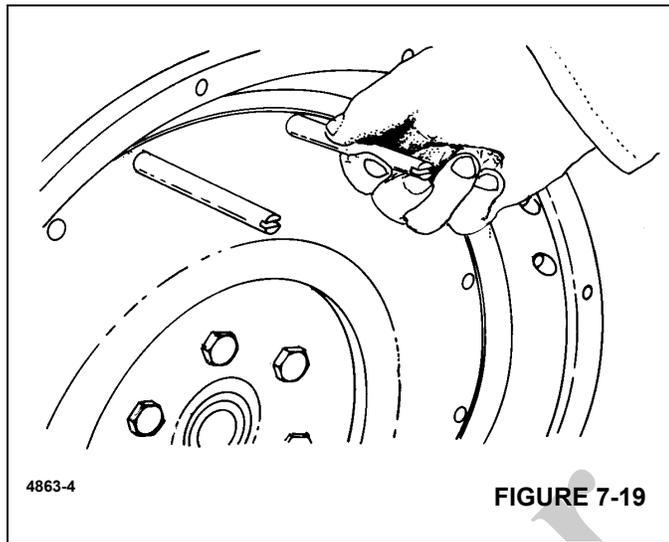


6. Move the gauge finger to contact the pilot bearing bore surface. Again, rotate the flywheel.

The maximum total allowable run-out 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.

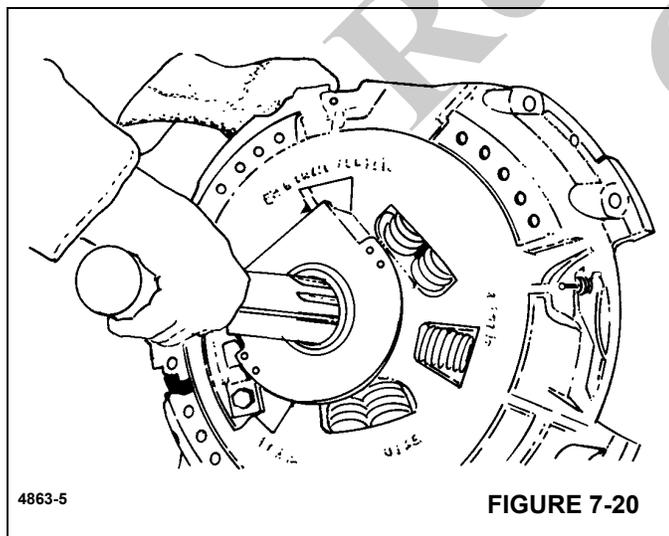
Installation

Refer to the following Figures for Installation.

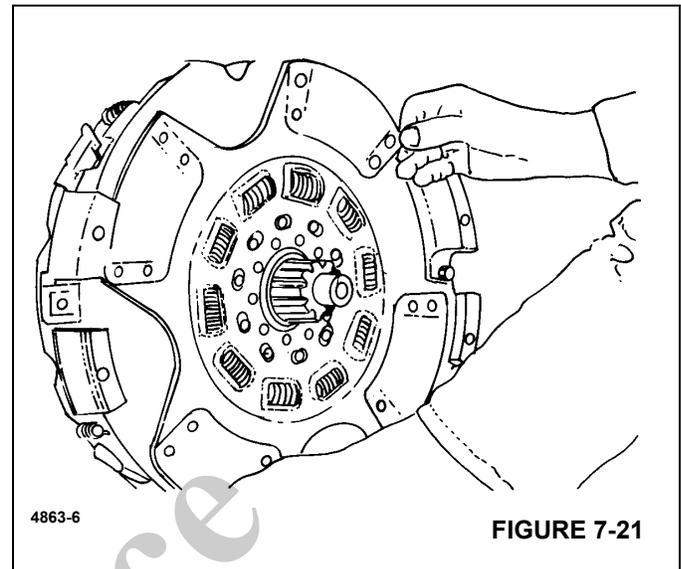


1. Insert two 12.7 cm (5 in) long 7/16 inch - 14 UNC guide studs into the two upper mounting holes of the flywheel.
2. Verify flywheel cavity.
 - - 8 Springs need 18.4 cm (7.25 in) bore.
 - - 10 Springs need 21.7 cm (8.56 in) bore.
 - - 7 Springs need 24.8 cm (9.75 in) bore.
 - - 9 Springs need 24.8 cm (9.75 in) bore.

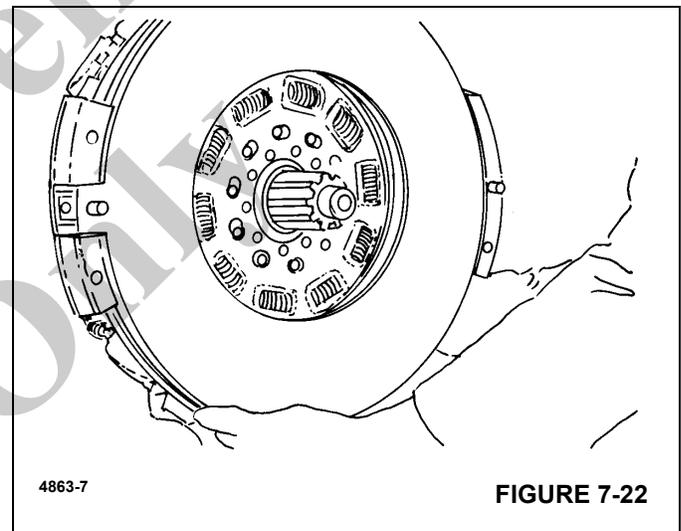
Insert the aligning tool through the release bearing sleeve in the new clutch.



3. Put the rear driven disc on the aligning tool with the side stamped "pressure plate" facing the pressure plate.



4. Place the intermediate plate in the clutch cover and align the driving lugs of the plate with the slots provided.



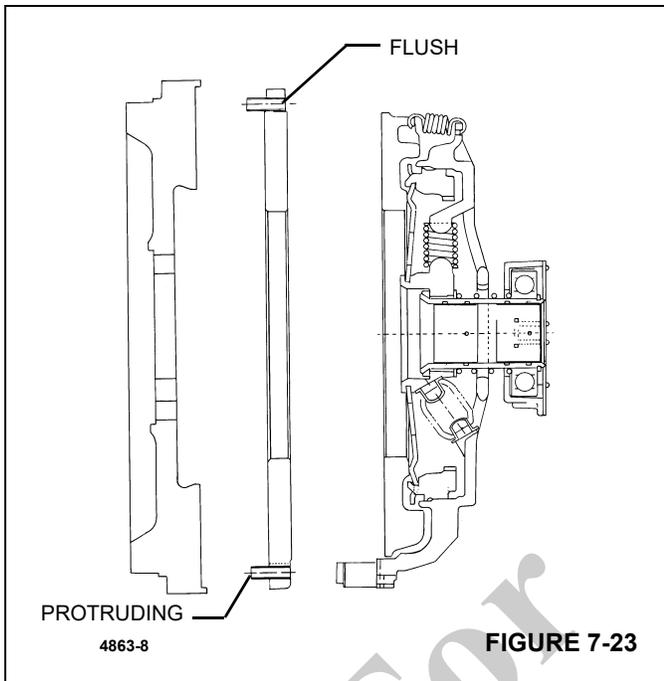


FIGURE 7-23

5. Positive Separator (Roll) pins should be flush on the clutch side, protruding on flywheel side.

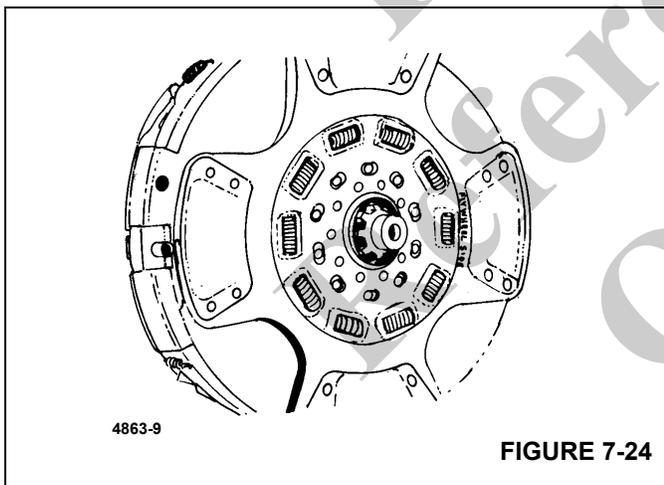


FIGURE 7-24

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: Make sure that the adjustment mechanism will be aligned with the opening in the bell housing of the transmission.

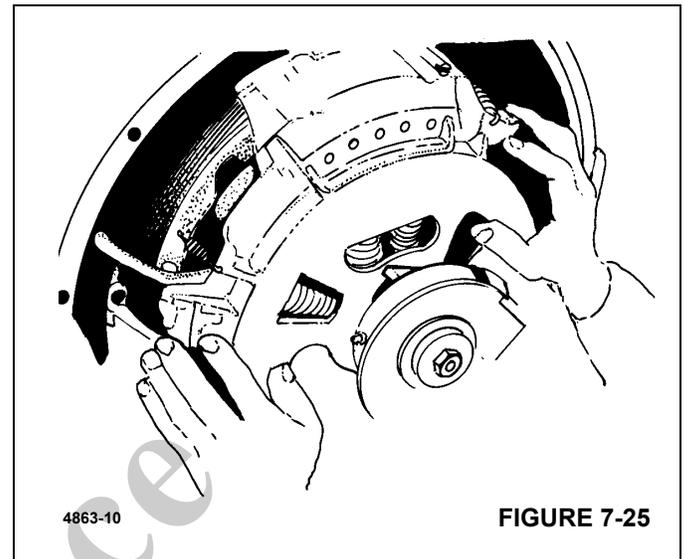


FIGURE 7-25

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

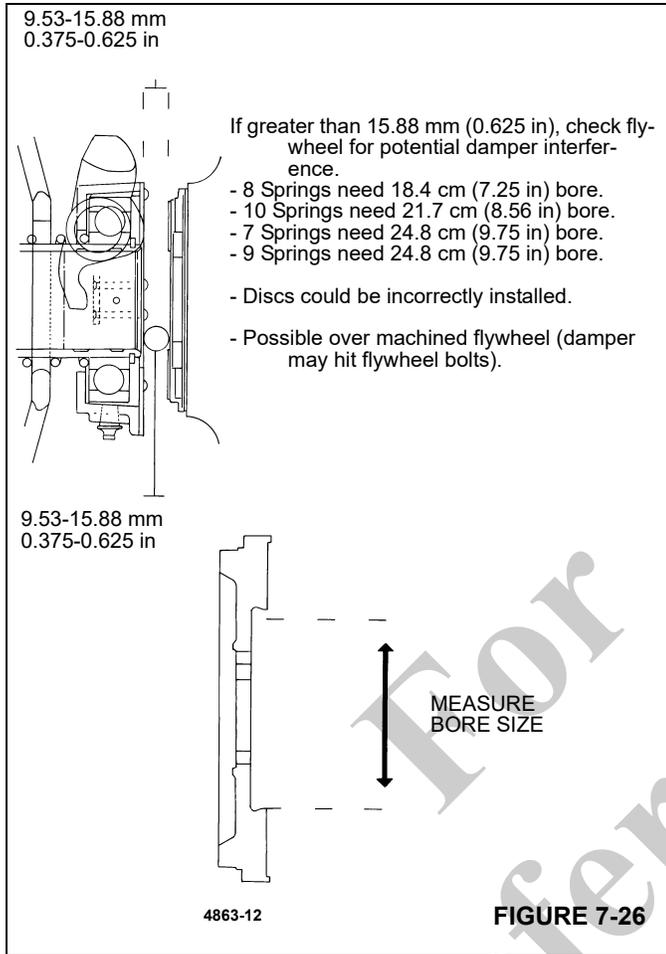
Risk of Damage!

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.

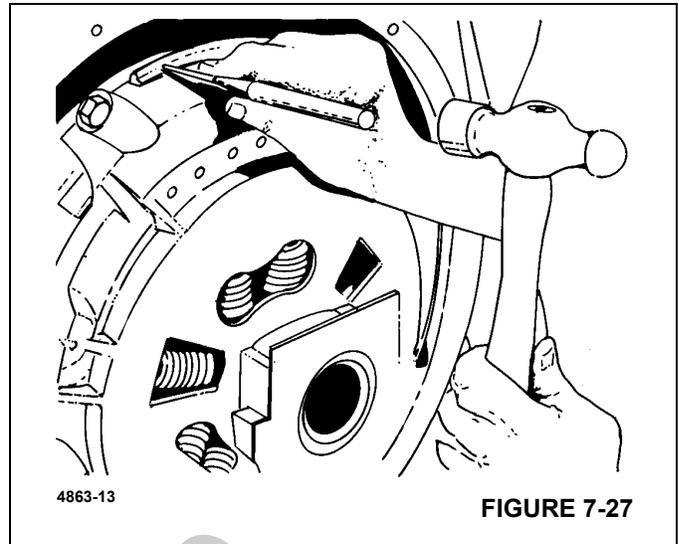
Bearing position should be approximately 9.53 to 15.88 mm (0.375 to 0.625 in) from the clutch cover.



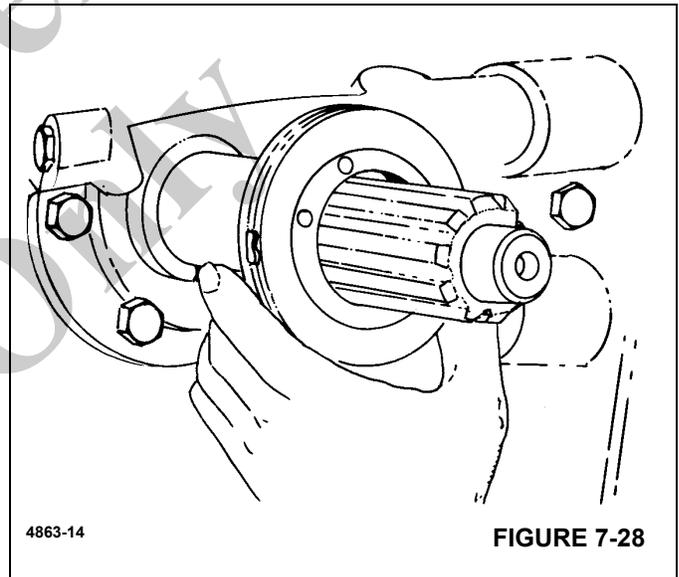
If greater than 15.88 mm (0.625 in) check possible disc to flywheel bore interference.

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.



- 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.



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 7-38, 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.
 - 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 0.060 inch (1.5 mm) 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

- 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.

- 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.
- Remove the capscrews securing the master control unit to the bracket.
- 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

- 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.
- 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.
- 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.

- 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.

- Lubricate the U-joints with chassis grease.
- Connect the nylon tubing to the range shift valve if disconnected.
- 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. Damaged vibration damper. Flywheel out of balance. Unbalanced clutch assembly. Loose engine mountings. Worn U-joints.	Replace fan. Replace damper. Check balance. Replace flywheel if necessary. Check clutch and clutch housing for proper alignment. Tighten mountings. Replace U-joints.
Noisy transmission (in neutral).	Transmission misaligned. Worn transmission pinion bearing. Worn or scored countershaft bearing. Damaged second speed mainshaft gear bushing. Unmatched gears. Worn or rough reverse-idler gear. Eccentric countershaft gear assembly. Sprung or worn countershaft. Excessive backlash in gears. Excessive end play in countershaft. Worn main shaft pilot bearing. Scuffed gear tooth contact surface. Insufficient lubrication.	Align engine and transmission (assembled) with rear axle so as to correct angles of U-joints. Replace bearing. Replace bearings. Replace bushing. Replace unmatched gears. Replace gear. Replace gear. Replace countershaft. Replace worn gears. Adjust to reduce end play. Replace pilot bearing. Replace gear. Check for leaks; fill to proper level.
Sticking in gear.	Clutch operating improperly. Sliding gear tight on main shaft splines. Improper adjustment of linkage	Adjust clutch. Check alignment. Check for galling. Replace as necessary. Adjust linkage.



SYMPTON	PROBABLE CAUSE	SOLUTION
Jumping out of gear.	<p>Misaligned transmission.</p> <p>Shift rail poppet springs broken.</p> <p>Shift rail poppet notch worn.</p> <p>Shift forks sprung or loose on shift rail.</p> <p>Linkage and rods between shift lever and auxiliary transmission not properly adjusted.</p> <p>Clutch gear teeth worn tapered.</p> <p>Bearings worn.</p> <p>Transmission mounting in carrier puts strain on case.</p>	<p>Check alignment.</p> <p>Replace poppet springs.</p> <p>Replace shift rail.</p> <p>Replace sprung fork or tighten setscrew in shift fork.</p> <p>Check and adjust linkage and rods to make sure transmission is shifting full into gear.</p> <p>Replace worn parts.</p> <p>Replace bearings.</p> <p>Line up front mounting bracket so it does not cause strain on front main shaft bearing retainer.</p>
Oil leakage.	<p>Transmission over filled.</p> <p>Breather stopped up.</p> <p>Use of transmission oil that foams and expands when hot.</p> <p>Drain back holes between bearing retainers and main case stopped up.</p> <p>Broken gaskets.</p> <p>Loose drain plug in transmission.</p> <p>Cracked transmission housing.</p> <p>Cover not properly tightened.</p>	<p>Drain to proper level.</p> <p>Clean breather assembly.</p> <p>Drain and refill with proper grade and type of lubricant.</p> <p>Check drain holes and gaskets to ensure openings are clean.</p> <p>Replace gaskets and use gasket cement.</p> <p>Tighten drain plug.</p> <p>Replace transmission.</p> <p>Tighten cover.</p>
Noisy transmission (in gear).	<p>Gears worn and pitted due to lugging engine with transmission in too high a gear range.</p> <p>Bearings worn due to lugging engine with transmission in too high a gear range, or to chips and dirt in oil.</p> <p>Worn, chipped, or tapered sliding gear teeth.</p> <p>Noisy speedometer gears.</p> <p>Transmission not lined up properly with carrier.</p>	<p>Replace gears.</p> <p>Replace worn or rough bearings.</p> <p>Replace gears.</p> <p>Replace gears.</p> <p>Line up transmission with rear axle so as to correct angles of U-joints.</p>
Difficult shifting.	<p>Improperly operating clutch.</p> <p>Sliding gear tight on shaft splines.</p> <p>Burred main shaft splines.</p>	<p>Adjust clutch. Check alignment.</p> <p>Check for galling. Replace as necessary.</p> <p>Replace main shaft.</p>

SYMPTON	PROBABLE CAUSE	SOLUTION
	Improper adjustment of shifting linkage. Worn or bent shifter rails. Insufficient lubricant.	Check and adjust linkage and rods to ensure that transmission is shifting fully into gear. Fill to proper level.
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). Lines crossed between air valve on transmission and the shift cylinder. Low range (down position) on button results in high range gear engagement, and vice versa. 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.	Disconnect crossed air lines and connect properly. Disconnect crossed air lines and connect properly. Disassemble control valve and replace o-ring seals. Disassemble, clean, and repair regulator.
Bearing failure.	Use of wrong lubricant or grade of lubricant. Bearings adjusted to tight or too loose. Lack of cleanliness in overhaul of transmission resulting in damaged gearing due to foreign matter in oil.	Drain transmission; flush and refill with proper grade and type of lubricant. Obtain correct adjustment. Properly clean transmission.

Removal of the Transmission

1. Refer to *Engine*, page 7-1; and *Removal*, page 7-2, and remove the engine and transmission as an assembly from the crane.

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.

CAUTION

Risk of Damage!

Make sure 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.

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 ID 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 ID of the drive gear.
2. Install the snap ring in the ID of the drive gear.
3. Install the washer on the shaft.
4. Move the 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 7-24 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!

Make sure 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 *Torque Values*, page 1-9.
6. Install the bolts and washers securing the engine flywheel to the flywheel ring cover.
7. Refer to *Power Train*, page 7-1 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 distributor.

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.

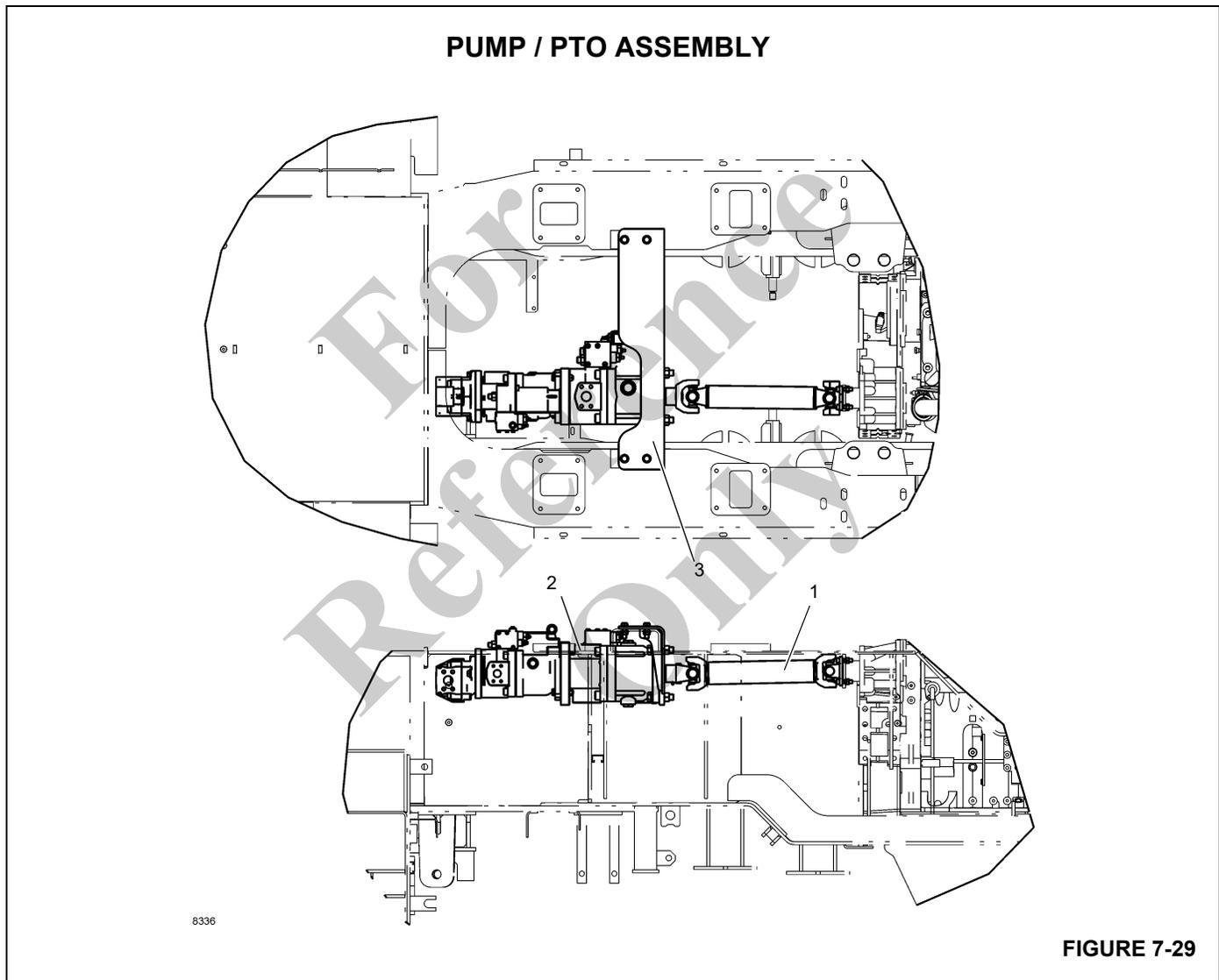
In addition to the range control button, a LO-LO button is incorporated to select two extra low gears.

PUMP / PTO ASSEMBLY

The PTO driveline (1), (Figure 7-29) powers the No. 1 Pump (2), (Figure 7-29) in the QSM engine installation.

Pump / PTO 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.

**Removal**

Refer to (Figure 7-29).

1. Depressurize the hydraulic system.
2. Remove the cap screws, nuts and washers connecting the PTO driveline to the engine. Remove the driveline.
3. Tag, disconnect and plug or cap the hydraulic hoses and ports on the pumps.
4. Tag and disconnect the electrical connectors to the pumps.

5. Remove the four cap screws, nuts and washers securing the clutch mounting bracket (3), (Figure 7-29) to the frame.
6. Attach a suitable lifting device to the mounting bracket/pump assembly—the assembly weighs approximately 167 kg (368 lb).
7. Remove the assembly and place on a suitable workbench.
3. Connect the electrical connectors and hoses to the pumps as tagged during removal.
4. Tighten the hardware connecting the mounting bracket/pump to the frame. Torque the hardware, refer to *Fasteners and Torque Values*, page 1-8.
5. Install the driveline onto the pump 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 1-8.

Installation

1. Using the lifting device place the mounting bracket/pump assembly onto the crane and loosely assemble with the cap screws, nuts and washers.
2. To prime the pumps, add hydraulic oil to the pumps and hoses before installation.
6. Start the engine and check for leaks.

For
Reference
Only

For
Reference
Only

This Page Blank

**SECTION 8
CARRIER**

SECTION CONTENTS

Front Axle	8-2	Normal Braking	8-36
Suspension	8-2	Vehicle Parking	8-36
Maintenance	8-2	Anti-lock Braking Systems (ABS)	8-36
General	8-2	Automatic Traction Control	8-37
Removal	8-5	Emergency Braking	8-37
Disassembly	8-5	Non-Asbestos Warning	8-37
Assembly	8-5	Front Brakes	8-37
Installation	8-6	Description	8-37
Axle Alignment Procedure	8-6	Maintenance	8-38
Steering System	8-12	Automatic Slack Adjuster	8-44
Description	8-12	Description	8-44
Maintenance	8-13	Maintenance	8-44
Steering Pump	8-15	Rear Brakes	8-52
Description	8-15	Description	8-52
Steering Gearbox	8-15	Maintenance	8-52
Maintenance	8-15	Rear Brake Assembly	8-55
Steer Cylinder	8-16	Anti-Lock Brake System (ABS)/Automatic	
Description	8-16	Traction Control (ATC)	8-57
Maintenance	8-16	ABS System Description	8-57
Wheels and Tires	8-17	ATC System Description	8-59
Description	8-17	ABS Troubleshooting	8-61
Maintenance	8-17	Troubleshooting Diagnostic Trouble Codes:	
Rear Axle and Suspension	8-17	Traction Control Valves	8-69
Rear Axle	8-17	Power Supply Tests	8-71
Suspension	8-18	Troubleshooting Diagnostic Trouble Codes:	
Maintenance	8-18	J1939 Serial Communications	8-72
Removal	8-20	Miscellaneous Troubleshooting	8-73
Disassembly	8-20	Troubleshooting Wiring	8-74
Assembly	8-20	Special Tools	8-78
Installation	8-21	Tests, Repair and Adjustment	8-78
Wheels and Tires	8-21	Component Removal and Installation	8-80
Description	8-21	Outriggers	8-83
Maintenance	8-21	Description	8-83
Mounting the Wheels on the Axle	8-21	Theory Of Operation	8-84
Air System	8-22	Maintenance	8-84
Description	8-22	Extension Cylinder	8-92
Theory of Operation	8-22	Outrigger Jack Cylinders	8-92
Braking	8-24	Description	8-92
Maintenance	8-25	Maintenance	8-92
Air System Components	8-27	Center Front Jack Cylinder	8-93
Brakes	8-36	Description	8-93
Description	8-36	Maintenance	8-93
Air Supply	8-36	Functional Check	8-94



**Outrigger Monitoring System (Optional—
Standard in North America) 8-96**

Description 8-96
OMS String Potentiometers 8-96

FRONT AXLE

The carrier has two non-driving front steer axles. The front axle centers are built of tempered seamless steel tube center sections with heat treated steel forged knuckle pin ends.

The two front axles are bolted together with two walking beams making a tandem axle assembly. Each axle is mounted to brackets on the carrier frame and anchored against forward, rearward, and side ways movement by adjustable torque rods attached to the axles.

Suspension

The front axle suspension uses air bags and shock absorbers to provide road shock cushioning. The air bags are mounted on the saddle assemblies, with the shock absorber connected to both the saddle assemblies and the carrier. The two saddle assemblies are connected at the front by pivot blocks to carrier mounting brackets and at the center of both walking beam assemblies.

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 axle 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 carrier frame next to the air bags. Each height control valve is mechanically actuated by a control lever attached to its respective saddle assembly. The valve controls the amount of air in each set of air bags thus controlling the height of the frame. To deflate the entire air suspension system (front and rear), position the SUSPENSION control valve on the carrier cab side panel to DEFLATE. This causes the four height control valves to shift and dump all air from the suspension air bags. Four pressure switches sense the air pressure in each set of air bags. Low air pressure in any of the four sets of air bags will trip the respective pressure switch to illuminate the DEFLATED indicator on the side console.

MAINTENANCE

General

Proper preventive maintenance will help control repair costs and downtime. If a major overhaul is required, remove the saddle assemblies and the tandem axle assembly 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 walking beam center bushing into the saddle assembly. Check bolt torque. Torque should be 310 to 375 Nm (228 to 276 lb-ft).

Beam End Connections and Bushings

Every 16,090 km (10,000 mi) check the torque of the beam end bolts. Torque 615 to 815 Nm (453 to 601 lb-ft). Jack up under each beam end and check for movement of the rubber end bushing. Worn bushings will allow movement and the bushings should be replaced. Periodically inspect the beam for a lowering in the hanger and distorted or frayed rubber. A gap on each side of the visible rubber at the lower end of the end bushing is normal because the end bushings are in compression.

Saddle Assembly End Cap Fasteners

Periodically check the bolt torque on the saddle assembly end caps. Torque should be 310 to 375 Nm (228 to 276 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).

Height Control Valves

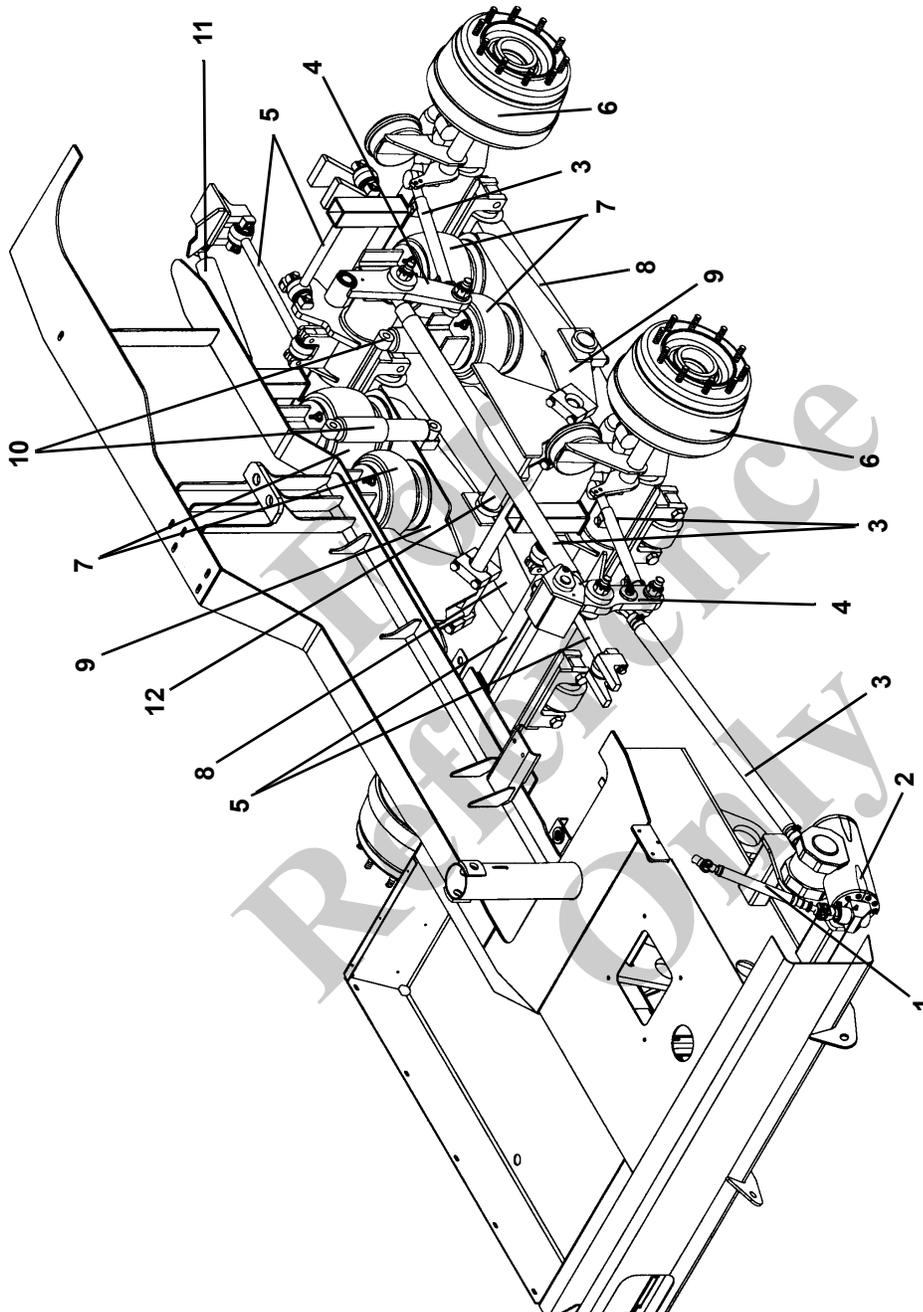
Check valve, fittings, and air lines for leaks. Check actuating linkage for bent or damaged condition.

Shock Absorbers

Check the shock absorbers for leakage and wear.

For
Reference
Only

Axle and Suspension Assembly



- 7. Suspension Air Bag
- 8. Walking Beam
- 9. Suspension Saddle Assembly
- 10. Shock Absorber
- 11. Steer Cylinder
- 12. Trunnion Tube

- 1. Steering Column
- 2. Steering Gearbox
- 3. Vertical Socket Drag Link
- 4. Relay Arm
- 5. Torque Rod
- 6. Steer Axle

FIGURE 8-1

Removal

Refer to (Figure 8-1).

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 and remove the speed sensor harness.
4. Place an adequate lifting/supporting device under the axles and suspension system.

NOTE: The axle and suspension system weighs approximately 1700 kg (3750 lb).

5. Tag and disconnect the air lines to the four brake chambers and the four air bags. Remove the fittings from the air bag connections. Cap all hoses and openings.

NOTE: Do not change the torque rod or vertical socket drag links dimensions. This will make wheel alignment easier when the axle is reinstalled.

6. Remove the bolts, hardened washers, and nuts securing four torque rods to the carrier frame.
7. Remove the cotter pin and nut securing two vertical socket drag links to the axle.
8. Remove the cotter pin and nut securing two steer cylinders to the axles.
9. Remove the hardware securing the linkage rod of each height control valve to its respective saddle assembly.
10. Remove the nut, lockwasher, and hardened washer securing two shock absorbers to the carrier frame.
11. With the axles and suspension fully supported, remove the two nuts and washers securing each of the four air bags to the carrier frame brackets.
12. Remove the two bolts and washers securing each saddle assembly cap blocks to the carrier frame brackets.
13. Remove the axles and suspension assembly from under the carrier

Disassembly

Refer to (Figure 8-1).

Disassemble the axle and suspension assembly as necessary using the following procedures.

NOTE: Check and record the distance for each torque rod from center to center of the rod clevis. Do not change this dimension when installing torque rods. This will make wheel alignment easier when the axle is reinstalled.

1. Remove the bolts, hardened washers, and nuts securing four torque rods to the axle brackets.
2. Remove two shock absorbers from the suspension saddle assembly by removing the nut and two washers securing each. Remove the shock absorber(s).
3. Remove each axle from the walking beams by removing the two bolts, washers, and nuts securing each end of the axle to the walking beam end bushings. Remove the axle(s).
4. Remove the saddle assemblies from the walking beams by removing two bolts and washers from each pivot block cap. Remove the caps. Remove the saddle assemblies and the trunnion tube from the walking beams.
5. Remove each air bag from the saddle assembly by removing the bolt and lockwasher. Remove the air bag(s).

Assembly

Refer to (Figure 8-1).

As necessary, assemble the axle and suspension assembly using the following procedures.

1. Position the air bag(s) on the saddle assembly and secure each with a bolt and lockwasher.
2. Position the trunnion tube through the center bushing on each walking beam. Position each saddle assembly over the center bushing and secure with the pivot block cap and two bolts and lockwashers, apply Loctite to bolt threads. Torque the bolts 310 to 375 Nm (229 to 277 lb-ft).
3. Position the axle(s) under the walking beams aligning the axle brackets with the bar end bushings on the walking beams. Apply Loctite 243 to bolt threads and secure each end with two bolts, washers, and nuts. Torque the bolts 615 to 815 Nm (453 to 601 lb-ft).
4. Position the shock absorber(s) on the saddle assembly and secure each with a nut and two washers, apply Loctite 243 to threads. Torque the nuts 615 Nm (453 lb-ft).
5. Position the torque rods in the axle brackets and secure each with two bolts, hardened washers, and nuts, apply Loctite 243 to the bolt threads. Torque nuts to 295-322 Nm (217-236 lb-ft).

Installation

Refer to (Figure 8-1).

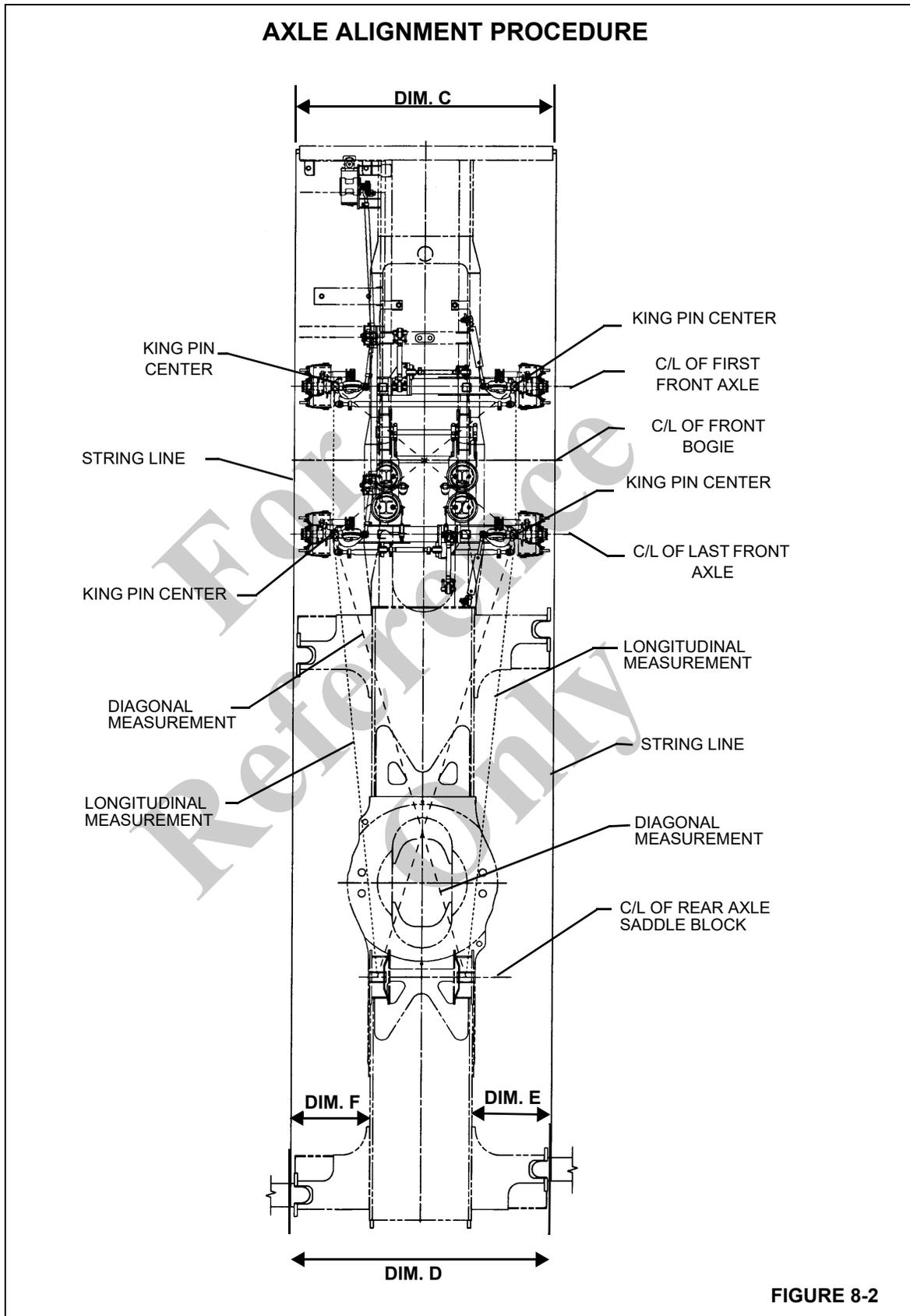
1. Position the axle and suspension assembly under the carrier.
2. Raise the assembly into position under the carrier aligning the saddle assemblies pivot blocks and air bags with the mounting brackets on the carrier.
3. Install saddle assembly cap blocks and secure each with the two bolts and washers, apply Loctite 243 to threads. Torque the bolts to 310 to 375 Nm (228 to 276 lb-ft).
4. Secure the four air bags to the carrier brackets with two nuts and washers. Torque the nuts to 41 Nm (30 lb-ft).
5. Secure two shock absorbers to the carrier frame with a nut, lockwasher, and hardened washer, apply Loctite 243 to threads. Torque nut to 120-130 Nm (88-95 lb-ft).
6. Secure linkage rod of each height control valve to its respective saddle assembly.
7. Attach the steer cylinder to the axle with cotter pin, washer and slotted nut, torque nut 140 to 170 Nm (103 to 125 lb-ft). Tighten to nearest cotter pin hole and insert cotter pin.
8. Attach the vertical socket drag links to each axle using the slotted nut and cotter pin. Torque nut 136 to 170 Nm (100 to 125 lb-ft). Tighten to nearest cotter pin hole and insert cotter pin.
9. Attach the four torque rods to the carrier frame using two bolts, hardened washers, and nuts each, apply Loctite 243 to bolt threads and torque to 295-320 Nm (217-236 lb-ft).

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 and reinstall the wheel speed sensor harness, tie wrap harness every 150 mm. Refer to *Wheels and Tires*, page 8-17 in this Section.
14. Retract the outriggers and check the axles for proper operation.

Axle Alignment Procedure

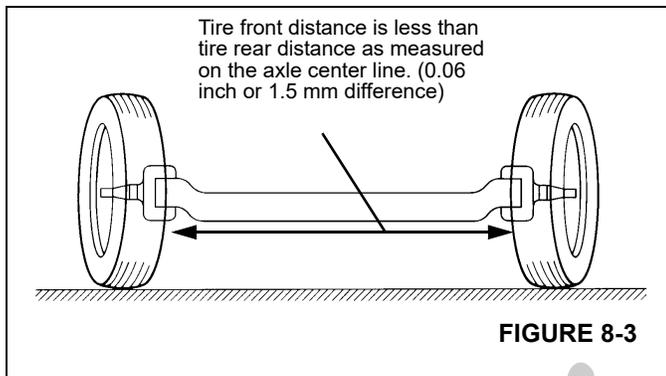
Refer to (Figure 8-2).

1. Place wood blocks between the saddle assemblies and the frame so that the top surfaces of the saddle assemblies is 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 as shown in the figure. 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 as shown in the figure. 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.



Toe-In Adjustment

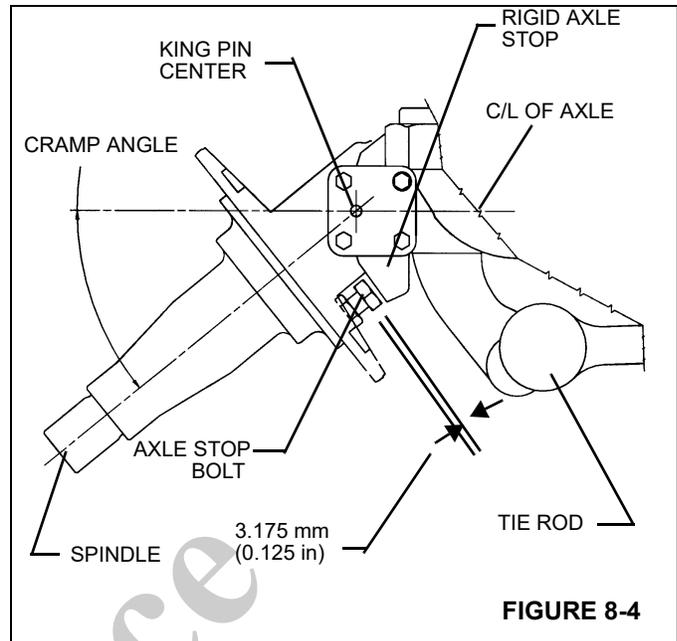
Toe-in is having the wheels of a steerable axle closer together in the front than in the rear. Toe-in is necessary for both tire wear and to keep the wheels from weaving side to side.



1. Position the wheels straight ahead.
2. Loosen the clamps on the tie rods.
3. Adjust the tie rod as needed to provide between 0.0 to 1.5 mm (0 to 0.06 in) of toe-in for each wheel. Double check to ensure both wheels have the correct toe-in.
4. Position the clamps on the tie rod beams so that they clear the axle when the wheels are turned. Tighten the clamps and recheck toe-in measurement.

Axle Stop Settings

1. Remove and discard the axle stop bolts on the last front axle.
2. Adjust the axle stop bolts on the first front axle, the bolts should be adjusted in or out as needed to obtain a measurement of 3.175 mm (0.125 in) minimum from the rigid axle stop to the top of the bolt head.



Drag Link Installation and Axle Synchronization

NOTE: All the following detail numbers are in reference to Drag Link Installation, (Figure 8-8).

1. Secure the drag link (Detail 7), (Figure 8-8) to the front relay arm (Detail 9), (Figure 8-8) with cotter pin. Be sure to keep drag link clamp rotated away from carrier frame to prevent interference. Secure the drag link and relay arm assembly to the carrier frame with pin weldment. Shim as required to obtain a max gap of 1.5 mm (0.059 in) on the inside of the arm assembly and no gap on the outside. Secure screw, flatwasher and lockwasher to pin weldment.
2. Secure the drag link (Detail 7), (Figure 8-8) to the rear relay arm (Detail 8), (Figure 8-8) with cotter pin. Be sure to keep drag link clamp rotated away from carrier frame to prevent interference. Secure the drag link and relay arm assembly to the carrier frame with pin weldment. Shim as required to obtain a max gap of 1.5 mm (0.059 in) on the inside of the arm assembly and no gap on the outside. Secure screw, flatwasher and lockwasher to pin weldment.

NOTE: It is acceptable to use a 21/64 drill as the rig pin(s) in step 3.

3. Install a 8.33 mm (0.328 in) diameter rig pin through the front relay arm mounting bracket and the front relay arm. Adjust drag link (Detail 7), (Figure 8-8) so that a 8.33 mm (0.328 in) rig pin can be installed through the rear relay arm mounting bracket and the rear relay arm.
4. Check that the front wheels are aligned to the straight ahead position by using a straight edge long enough to lay across the wheel mounting surfaces of both front

axles. Position drag links (Detail 5) into relay arms (Details 8 and 9), (Figure 8-8) thread nut onto drag links and torque 135-170 Nm (99.5-125 ft-lb) and install cotter pin thru nut.

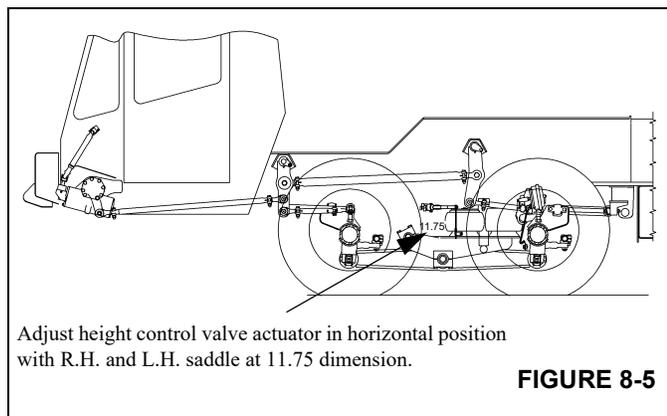
Keep clamps on drag links rotated away from frame to assure no interference. Adjust drag links (Detail 5), (Figure 8-8) to fit between the relay arms (Details 8 and 9), (Figure 8-8) and the axle steer arms.

5. Check the position of the pitman arm on the steering gearbox and adjust if necessary; the timing marks (arrows) on the gearbox shaft and the letter 'B' on the pitman arm should align, if not make adjustment per *Steering System*, page 8-12. Torque pitman nut to 613 Nm (450 ft-lb) after making adjustment.
6. Attach drag link (Detail 6), (Figure 8-8) to the pitman and secure with cotter pin. Adjust drag link length as needed to fit between the pitman arm and the front relay arm (Detail 9), (Figure 8-8) while keeping the pitman arm position fixed. Be sure the drag link clamp is turned in toward the carrier frame with bolt facing down. Secure drag link to front relay arm (Detail 9), (Figure 8-8) with cotter pin.
7. Remove the relay arm rig pins and secure all drag links.
8. Check that the rod ends on all drag links are within the limits shown in the figure.

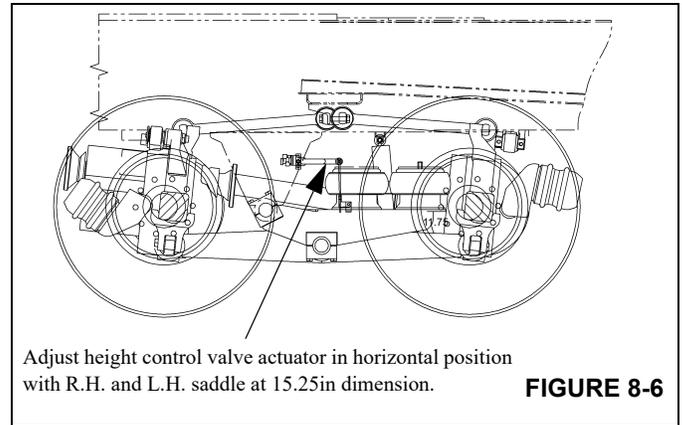
Air Ride Adjustment

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 - 11.75 In (Figure 8-5).

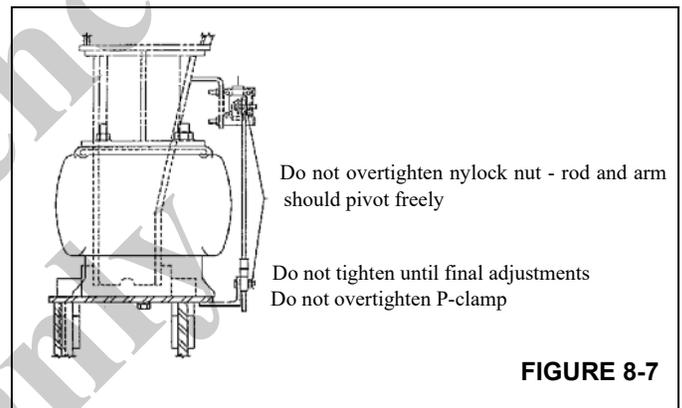


2. Rear Axle Ride Height - 15.25 In (Figure 8-6).



3. Adjust rod to achieve proper ride height setting (Figure 8-7) and torque P-clamp on P-boot to 10 - 15 in lbs.

NOTE: Over-tightening of the P-clamp will cut through the P-boot.



Final Adjustments

1. Inflate tires to the pressure specified on the tire inflation chart located on the carrier cab door.
2. Start the engine and allow both air systems to reach full system pressure. Make sure that the crane is on a flat level surface. Make sure 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.
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.

CAUTION

Vehicle Damage Hazard!

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.

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 paragraph, titled *Drag Link Installation and Axle Synchronization*, page 8-8.

7. Partially extend the outrigger beams. Attach a string line to front and rear outrigger beams as shown in (Figure 8-2), Axle Alignment. Ensure the string line is taut and level.
8. Referring to (Figure 8-2), Axle Alignment, ensure that Dimension C equals Dimension D and that Dimension E equals Dimension F (Figure 8-2).
9. Referring to (Figure 8-8), Drag Link Installation, adjust the drag links (Detail 5), (Figure 8-8) as required so that the distance from the string line to the front of each wheel is the same as the distance from the string line to the rear of the same wheel within 1.5 mm (0.06 in). Check that the rod ends of the drag links are within limits specified in (Figure 8-8).
10. Remove the rig pins.

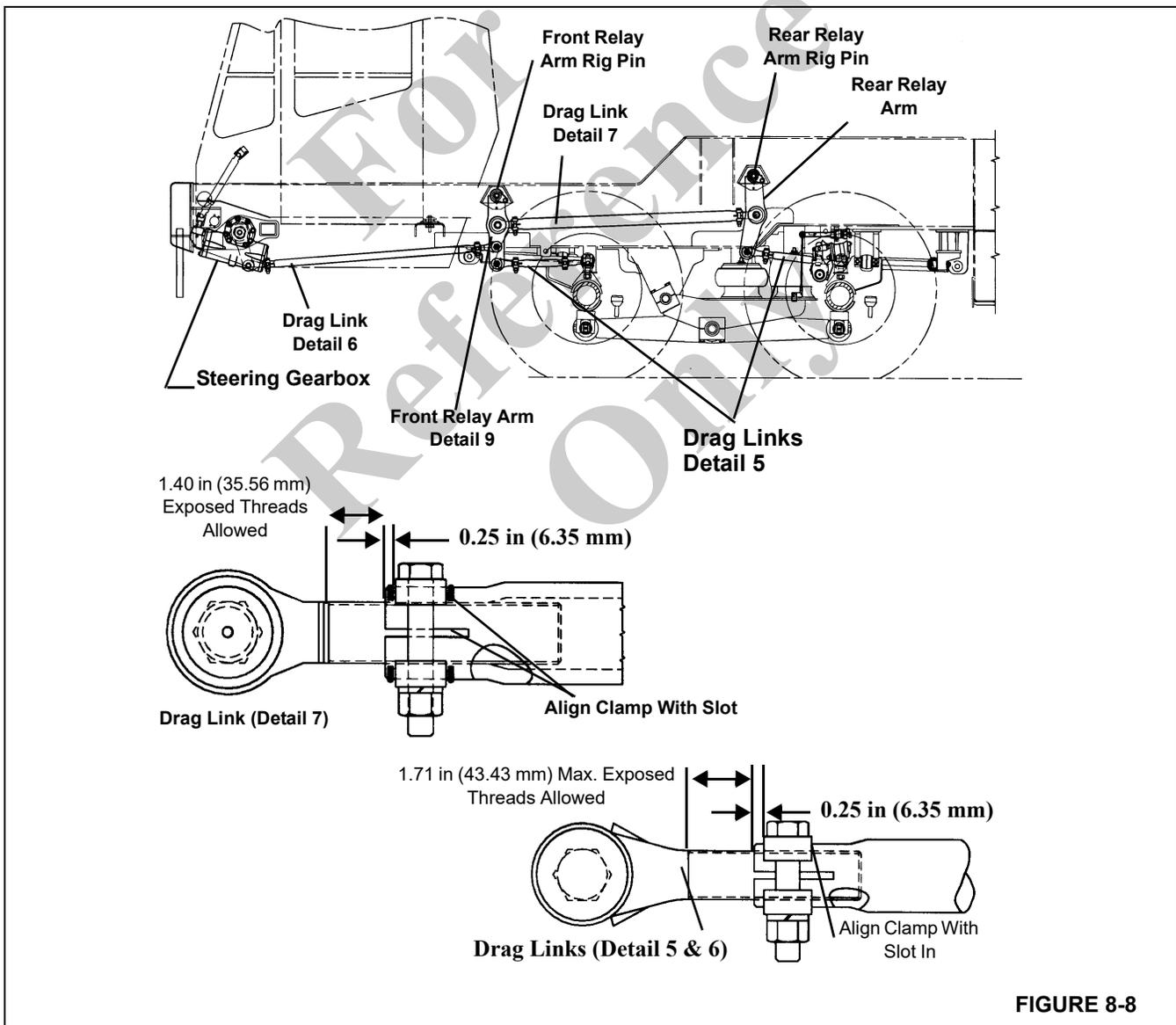


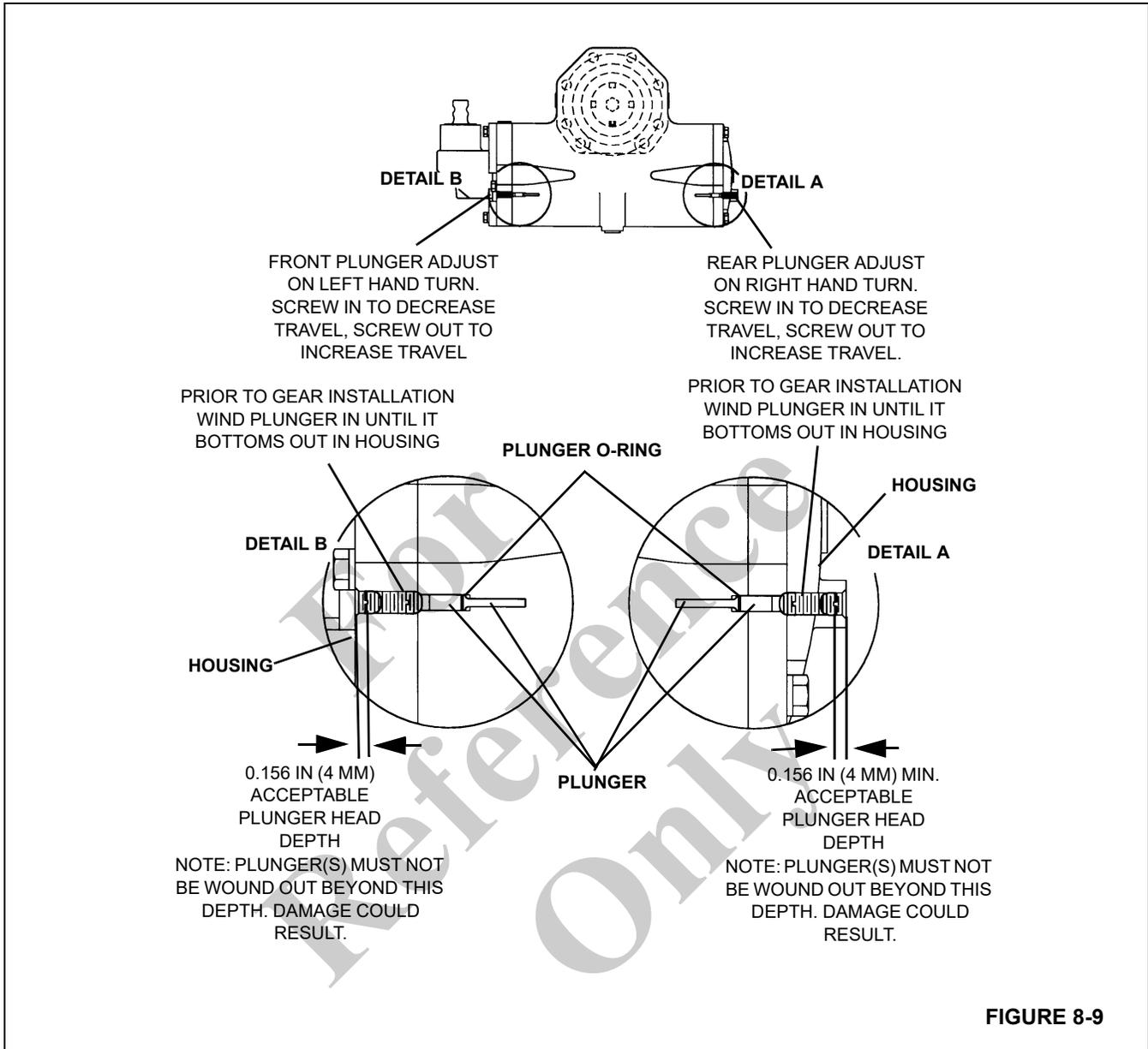
FIGURE 8-8

Setting Axle Stops and Steering Gear Relief Plungers

1. Start the engine and run at idle.
2. Determine straight ahead axle position/wheel position. Adjust drag links accordingly.
3. With the wheels on greased plates, adjust the left and right turn axle stops in or out to meet the maximum cramp angle on #1 axle. Check to be sure there is a minimum of 25.4 mm (1.00 inch) clearance between tires and any components. Remove greased plates.
4. With the full weight of the machine on properly inflated tires, turn steering wheel to full left. If axle stop is contacted, turn front plunger in to limit wheel cut. If gap to axle stop is more than 3.1 mm (0.125 inch) at full turn, adjust plunger to increase wheel cut. Repeat for right turn (rear plunger).

- NOTE:** Do not attempt to set the relief pressure with the tires off the ground. Plungers are fine thread and accept a small flathead screwdriver. After approximately 4 wheel turns, steering effort may be considerably higher. Move machine a foot forward to provide a clean contact patch between the tires and ground.
5. Recheck stops and pressure by driving crane slowly forward while turning wheels to full lock. Plunger relief should be reached before axle stops.
 6. Check to be sure that the plungers are wound into a depth of at least 3.8 mm (0.15 in) as shown in (Figure 8-9).

For
Reference
Only



STEERING SYSTEM

Description

The steering system is comprised of the steering gearbox, steer pump, and two steer cylinders. The steering gearbox provides for full time hydraulic steering, but still allows for manual steering in the event of a system malfunction.

Maintenance

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
Oil leaking at output shaft of steering gear.	Damaged sector shaft seal.	Replace sector shaft.
Oil leaking at actuating shaft of steering gear.	Worn or damaged oil seal. Damaged actuating shaft seal surface.	Replace actuating shaft seal. Replace bearing cap, actuating shafts assembly.
Oil leaking at supply pump drive shaft.	Damaged oil seal. Oil seal-heat damaged. Loose or damaged bushing on pump drive shaft.	Replace oil seal. Check operating temperature. Repair pump per pump service instruction.
Lubricant milky or white in appearance.	Water entry through reservoir venting system.	Clean vent system or replace cap assembly.
Oil forced out of reservoir or foaming.	Clogged oil filter. Air in system. Relief plungers of steering gear not adjusted properly creating high operating temperatures. Air leak in suction side of supply pump.	Change oil and oil filter. Bleed air from the system. Check for air leak on suction side of supply pumps. Adjust relief plungers. Reference pump servicing instruction.
	Pump cavitation. Oil overheating.	Check for restriction in pump supply. Check for restriction in steering gear return.
Engine oil in power steering reservoir (gear driven pump).	Faulty seal at pump drive shaft. Faulty seal at accessory shaft driving supply pump.	Repair pump. Repair accessory drive.
Lubricating oil discolored or smells bad.	Operating temperatures too high. Change intervals too long. Incorrect lubricant used.	Check and correct cause of overheating. Change oil more often. Drain, flush, and refill with recommended lubricant.
High operating temperatures.	Oil flow restriction. Oil flow too high.	Check back pressure. Check maximum oil flow.
Excessive pump pressure with steering gear in neutral.	Pinched oil return line, high back pressure. Binding steering column.	Relocate line. Repair steering column.
Wheel cuts restricted.	Relief plungers not adjusted properly.	Adjust relief plungers.
Erratic steering or mechanical steering only.	Insufficient volume of oil. Sticking pressure relief valve in steering gear.	Refer to pump servicing instructions. Repair or replace relief valve as required.
Hard steering.	Faulty supply pump.	Check pump flow.

SYMPTOM	PROBABLE CAUSE	SOLUTION
	Steering out of alignment.	Align front end.
	High operating temperature.	Locate and correct cause of overheating.
Wheel turns hard in one or both directions.	Dirt or foreign matter trapped in piston relief.	Check pressure relief.
	Bent or damaged king pins and tie rods.	Repair or replace king pins and tie rods.
	Front end load too great.	Lighten load.
	Low oil level in steering system.	Fill oil reserve as required.
	Air in system.	Bleed system and check for cause of air.
	Caster degree incorrect.	Correct to specified degree.
Wheel turns hard in one direction.	Metal or foreign material in relief ball seat in piston of steering gear.	Remove and clean relief valve seats or replace damaged parts.
No attempt to return straight ahead from turns/should also be hard steering complaint.	No positive caster.	Set caster to specified degree.
	Steering column bind.	Check and repair U-joints and support bearings.
	Steering gear mounting distorted.	Shim mounting pads to correct piston to bore interference. Make sure correct bolt length is used on the base mount gears.
	Linkage ball sockets seized or binding.	Check and repair or replace.
	King pins seized or binding.	Repair or replace.
	Oil flow rate incorrect.	Check and correct supply pump.
Darting, wandering, oversteering.	Oil flow too high.	Supply pump not to specifications.
	Air trapped in steering gear.	Bleed system.
	Looseness, worn front end parts.	Check and repair as required.
	Front end alignment not correct.	Align front end - Caster.
	Overloading.	Reduce loads.
	Rear axle not parallel.	Check and repair as required.
	Tight tie rod ends and drag link sockets.	Check rotational torque and replace if necessary.
Excessive backlash, free play.	Worn universal joint.	Replace universal joint.
	Rack on piston damaged.	Replace steering gear.
	Damaged sector shaft/splines.	Replace steering gear.
	Worn or damaged pitman arm splines.	Replace pitman arm and/or sector shaft.
	Universal joint yoke loose on actuating shaft.	Repair or replace damaged parts.
Steering input not smooth.	Worn universal joint.	Check and replace as required.
	Lack of lubrication.	Lubricate per lube chart.
	Universal joints not phased properly.	Re-phase ¹ columns.
	Low oil flow.	Idle speed to slow or supply pump not to specifications.
	Pump cavitation.	Correct pump supply.
	Overheating.	Correct cause of overheating.

¹With the vehicle stationary and engine at idle, place the torque wrench on the steering wheel retaining nut and steer from lock to lock. A reading of more than 1.7 Nm (15 pounds-inch) means improper phasing. To correct, rotate the intermediate steering shaft one spline at a time until the torque reads the same throughout the 360 degree rotation.

Functional Check

A periodic functional check of the power steering system will generally be adequate to ensure satisfactory service.

1. Check all fittings for leakage. Accumulation of moist, black dirt is a good indication of leakage.
2. Turn the steering wheel through the full range with the engine running at both idle and full throttle. Do this with the machine stationary and moving. Note any speed irregularities and sticky sensation. This may indicate dirt in the fluid. If the steering wheel continues to rotate when started and released, a condition known as motoring exists. This may also indicate dirt in the fluid.
3. Ensure the system has adequate power. If there is an indication of hard steering, this can be caused by either a reduced oil flow to the control valve or a reduced system relief pressure. Adequate oil pressure can only be determined by connecting a pressure gauge at the pump outlet port or at the steering gear inlet port. With the engine running at a medium speed, turn the steering wheel to one end of travel and hold at the travel limit just long enough to get a pressure reading. Never hold the system relief pressure for more than a few seconds at a time. The pressure gauge should indicate 13800 kPa (2000 psi) at the pump outlet.

STEERING PUMP

Description

The steering pump is mounted on and driven by the engine. The pump is located on the left side of the engine and provides the hydraulic flow necessary to power the steering gearbox. The pump is a gear type pump and provides a priority flow of approximately 38 lpm (10 gpm) at 13,790 kPa (2000 psi). For additional information on the pump, refer to *Hydraulic Pumps*, page 2-12.

Steering Gearbox

Description

The steering gear box is attached to the frame and is located on the left side beneath the cab. The gearbox provides full-time hydraulic steering and only enough manual effort to overcome the torsion bar and turn the rotate valve is required. With the engine running, there is a constant oil flow through the steering gear which provides an instant response and absorbs road shock. There is mechanical back-up steering so that the vehicle can be steered to the side of the road in the event of hydraulic pressure loss.

Maintenance

Removal

1. Tag and disconnect the hydraulic lines from the steering gearbox. Cap or plug all openings.
2. Remove the steering shaft from the steering gearbox input shaft.
3. Remove the cotter pin and slotted nut securing the drag link vertical socket to the pitman arm.
4. Remove the pitman arm as follows.
 - a. Using a punch and hammer, bend the retainer tab(s) out of the pitman arm retainer nut.
 - b. Using an allen head socket, remove the retainer nut, friction washer, and retainer tab washer.
 - c. Using a 3-jaw puller, remove the pitman arm from the gearbox shaft.

NOTE: The steering gearbox weighs approximately 79 kg (176 lb).

5. Support the weight of the gearbox. Remove the six bolts and hardened washers which secure the gearbox to the frame and remove the gearbox.

Installation

CAUTION

Equipment Damage Hazard!

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). Reference Figure 8-9.
2. Position the gear box on the mounting and secure with six bolts and hardened 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 pitman arm must be at the angle shown in Pitman Arm Location. If the position varies more than 2 degrees, double check the center of travel and timing mark alignment.

7. Install the retainer nut, friction washer and tab washer onto the gear box shaft and secure the pitman arm. Torque the nut to 615 Nm (453 lb-ft).
8. After specified torque is reached, continue to torque until the notches in the retainer nut are aligned with the next

bend tab of the tab washer. Bend two opposing tabs of the washer into the notches of the retainer nut.

9. Attach the steering column to the steering gearbox input shaft.
10. Connect the drag link vertical socket to the pitman arm using a slotted nut. Torque the nut to 135 to 170 Nm (99 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.
12. Apply never-seez compound to steering gear output shaft.

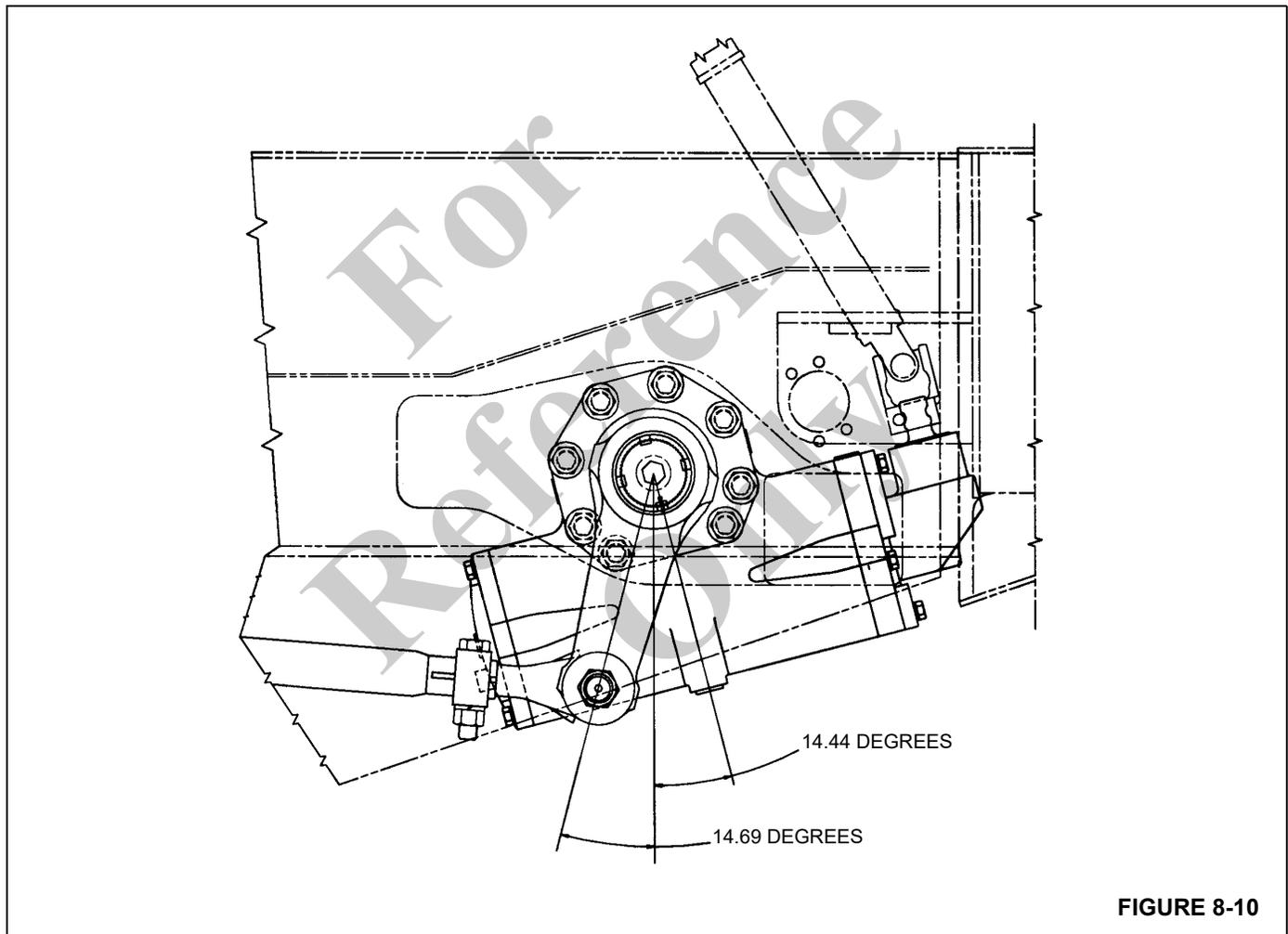


FIGURE 8-10

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 2-31.

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 140 to 170 Nm (103 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.

WHEELS AND TIRES**Description**

One size of tires is available for the front axle: 445/65R22.5.

CAUTION**Equipment Damage Hazard!**

Do not mix tires or rims from different manufacturers.

NOTE: The tire diameters, widths, and weights may vary slightly depending on the tire manufacturer.

Tires are designed to operate with a certain sidewall deflection or bulge. Correct air pressure ensures proper deflection which ensure proper traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lower rim life.

Refer to and adhere to the inflation pressures on the Tire inflation decal on the crane.

Maintenance**WARNING****Do Not Dismount or Mount Tires Without Proper Training!**

The high pressures involved can cause tire, rim parts, and tools to fly apart with enough explosive force to cause severe injury or death to personnel and damage to crane and surrounding area.

Assemblies

NOTE: Do not lubricate the wheel studs or lug nuts. With aluminum wheels, lubricate the wheel pilot or hub pads only with a synthetic lubricant containing Teflon. Do not lubricate wheel or axle faces.

1. Position the wheel assembly on the mounting studs. Install the lug nuts and tighten them until they are just snug, rotating the wheel so the nut being tightened is in the top position.
2. Ensure the wheel assembly is positioned properly on the hub. Tighten the lug nuts in the sequence shown to a preliminary torque of 37 Nm (50 lb-ft).
3. Torque the lug nuts 610 to 678 Nm (450 to 500 lb-ft) in the sequence shown in (Figure 8-11).
4. 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 reseal the lug nuts. Check the torque every 800 km (500 mi) thereafter. An alternative to re-torquing after 80 km (50 mi) is to run the machine in large figure 8's six or seven times and then re-torque the lug nuts.

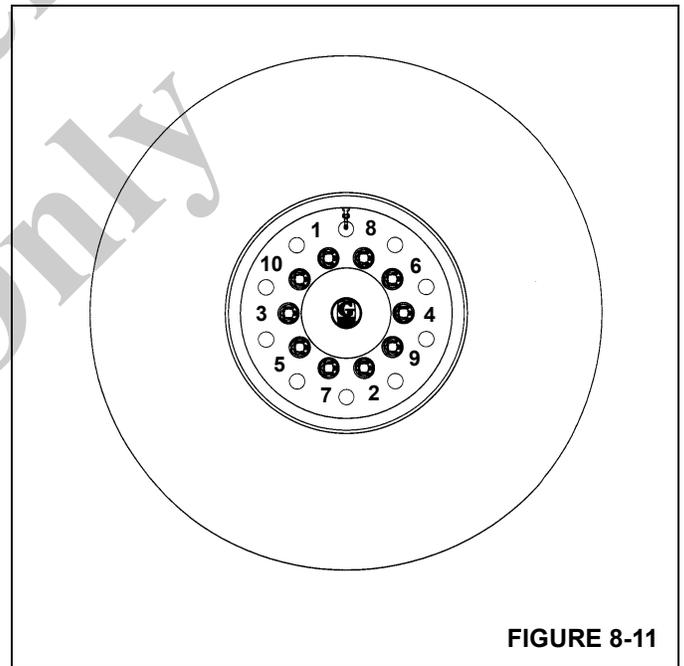


FIGURE 8-11

REAR AXLE AND SUSPENSION**Rear Axle**

The rear axles 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 uses air bags with walking beams. The air bags along with shock absorbers are mounted on saddle assemblies above the walking beams. They provide for cushioning of road shock. The saddle assemblies are connected at the front by pivot blocks to carrier mounted brackets. The air bags and shock absorbers are bolted to the rear of the saddle assemblies and to carrier mounted brackets. A walking beam center is attached to each saddle assembly with the ends attached to each rear axle.

Rubber bushings in the walking beam centers and ends, and torque rod ends, restrict excessive movement but allows enough movement to relieve stresses on metal parts. The rubber joints allow a certain amount of in and out axle movement which permits each axle to follow its own natural course more closely through turns. Once a straight line is resumed, the bushings square off the tandem so that the leading tires set the tracking pattern. Torque rods along with the walking beam creates a parallelogram style linkage that assure positive axle alignment.

Air for the suspension system is controlled by a control valve on the side console in the carrier cab and by two height control valves mounted on each side of the frame by the air bags. Each height control valve is mechanically actuated by a control lever attached to its respective saddle assembly. The valve controls the amount of air in each set of air bags thus controlling the height of the frame. To deflate the entire air suspension system (front and rear), position the SUSPENSION control valve on the carrier cab side panel to DEFLATE. This causes the 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 the *Lubrication*, page 9-1 section 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 walking beam center bushing into the saddle assembly. Check bolt torque. Torque should be 305 to 370 Nm (225 to 273 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 810 Nm (450 to 600 lb-ft). Jack up under each beam end and check for movement of the rubber end bushing. Worn bushings will allow movement and the bushings should be replaced. Periodically inspect the beam for a lowering in the hanger and distorted or frayed rubber. A gap on each side of the visible rubber at the lower end of the end bushing is normal because the end bushings are in compression.

Saddle Assembly End Cap Fasteners

Periodically check the bolt torque on the saddle assembly end caps. Torque should be 305 to 370 Nm (225 to 273 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).

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 additional axle information, refer to the applicable SM Package.

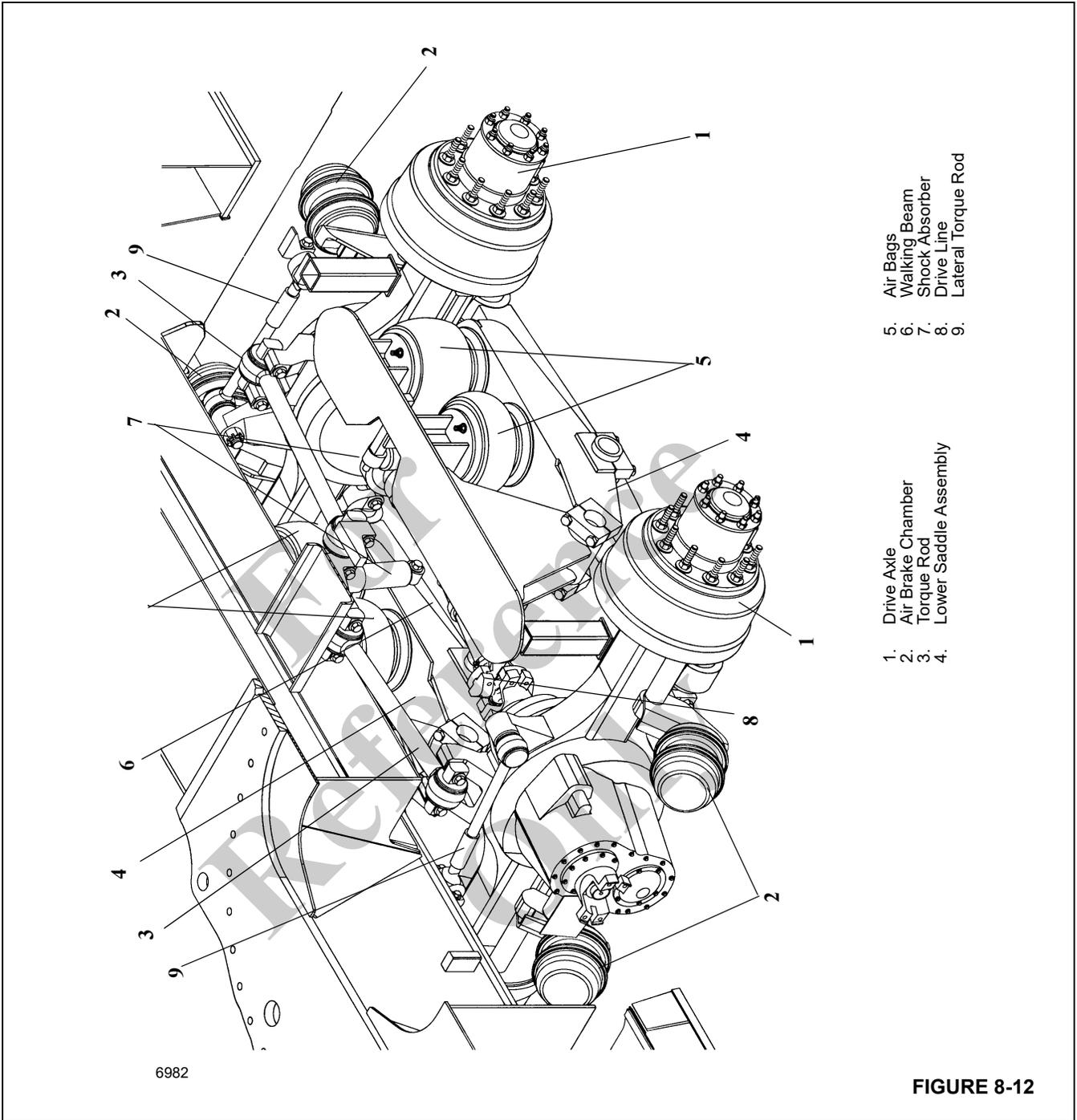


FIGURE 8-12

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 and remove wheel speed sensor harness.
4. Place an adequate lifting/supporting device under the axles and suspension system.

NOTE: The axle and suspension system weighs approximately 2232 kg (4921 lb).

5. Tag and disconnect the air lines to the four brake chambers and the four air bags. Remove the fittings from the air bag connections. Cap all hoses and openings.
6. Disconnect the drive shaft from the front rear axle.
7. Remove the bolts, hardened washers, and nuts (lateral torque rod only) securing two torque rods to the carrier frame.
8. Remove the hardware securing the linkage rod of each height control valve to its respective saddle assembly.
9. Remove the nut, lockwasher, and two washers securing two shock absorbers to the carrier frame.
10. With the axles and suspension fully supported, remove the two nuts and washers securing each of the four air bags to the carrier frame brackets.
11. Remove the two bolts and washers securing each of the four saddle assemblies cap blocks to the carrier frame brackets.
12. Remove the axles and suspension assembly from under the carrier.

Disassembly

Disassemble the axle and suspension assembly as necessary using the following procedures.

1. Remove the drive line between the two rear axles.
2. Remove the bolts, hardened washers, and nuts securing each fore and aft torque rod to the axle brackets. Remove the torque rod(s).
3. Remove the nut securing each lateral torque rod to the axle brackets. Remove the torque rod(s).

4. Remove two shock absorbers from the suspension saddle assembly by removing the bolt and two washers securing each. Remove the shock absorber(s).
5. Remove each axle from the walking beams by removing the two bolts, washers, and nuts securing each end of the axles to the walking beam end bushings. Remove the axle(s).
6. Remove the saddle assemblies from the walking beams by removing two bolts and washers from each pivot block cap. Remove the caps. Remove the saddle assemblies and the trunnion tube from the walking beams.
7. Remove each air bag from the saddle assembly by removing bolt and lockwasher. Remove the air bag(s).

Assembly

As necessary, assemble the axle and suspension assembly using the following procedures.

1. Position four air bag(s) on the saddle assembly and secure each with a bolt and washer.
2. Position the trunnion tube through the center bushing on each walking beam. Position each saddle assembly over the center bushing and secure with the pivot block cap and two bolts and washers, apply Loctite 243 to threads. Torque the bolts 305 to 370 Nm (225 to 273 lb-ft).
3. Position the axle(s) under the walking beams aligning the axle brackets with the bar end bushings on the walking beams. Secure each end with two bolts, washers, and nuts. Torque the bolts 610 to 810 Nm (450 to 600 lb-ft).
4. Position two shock absorber(s) on the saddle assembly and secure each with a bolt and two washers, apply Loctite 243 to threads. Torque the bolts to 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, apply Loctite 243 to threads. Place one additional hardened washer on each side between torque rod and bracket. Torque the nuts. Refer to *Torque Values*, page 1-9.
6. Position two lateral torque rods in the axle brackets and secure each with a nut and pin. Torque the nuts 300 to 315 Nm (177 to 225 lb-ft).
7. Connect the drive shaft between the two rear axles. The drive line assembly must have mating marks (arrows) aligned for phasing of the yokes.

Installation

1. Position the axle and suspension assembly under the carrier.
2. Raise the assembly into position under the carrier aligning the saddle assemblies pivot blocks and air bags with the mounting brackets on the carrier.
3. Install the four saddle assemblies cap blocks and secure each with the two bolts and washers, apply Loctite to threads. Torque the bolts to 305 to 373 Nm (225 to 275 lb-ft).
4. Secure the four air bags to the carrier brackets with two nuts and washers. Torque the nuts to 41 Nm (30 lb-ft).
5. Secure two shock absorbers to the carrier frame with a nut, lockwasher, and hardened washers, place the 1" washer on the same side as the nut, apply Loctite 243 to threads. Torque to 120-130 Nm (89-96 lb-ft).
6. Secure the linkage rod of each height control valve to its respective saddle assembly with the attaching hardware. Install height control to agree with horizontal position of saddle assembly (385 mm/15.16 in).
7. Attach the fore and aft torque rods to the carrier frame using two bolts and hardened washers each, apply Loctite 243 to threads. Torque the bolts. Refer to *Torque Values*, page 1-9.
8. Attach the lateral torque rods to the carrier frame using two bolts, hardened washers, apply Loctite 243 to threads. Torque the nuts 300 to 315 Nm (221-232 lb-ft). Use additional 5/8" 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. Build up air pressure in the systems and check for leaks. Check operation of brakes and air suspension system.
12. Install the tire and wheel assemblies and reinstall the wheel speed sensor harness, tie strap harness every 150 mm. Refer to WHEELS AND TIRES in this Section.
13. Retract the outriggers and check the axles for proper operation.

WHEELS AND TIRES

Description

One size of tire is available on the rear axle: 315/80R22.5.

NOTE: Always replace tires with the same size that were factory installed, this crane has ABS brakes that are calibrated to the original tire size.

Tire diameter, width, and weight may vary slightly depending upon the manufacturer.

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. Over inflation 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 3.175 mm (0.13 in) of the same rolling radius and 19.0 mm (0.75 in) of the same rolling circumference.

CAUTION

Equipment Damage Hazard!

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



WARNING

Explosive Force Hazard!

High pressures can cause tire and rim parts to fly apart with explosive force and cause injury or death. Do not dismount or mount tires on rims without proper training.

Mounting the Wheels on the Axle

NOTE: Do not lubricate the wheel studs or lug nuts. On aluminum wheels, lubricate only the pilot or hub

pads with synthetic lubricant containing Teflon. Do not lube the face of the wheel or rim.

1. Install the wheel assemblies on the mounting studs.
2. Place the mounting ring and hub cover over the hub and studs.
3. Install the lug nuts and tighten until the nuts are just snug. Position the nut that is to be tightened on top.

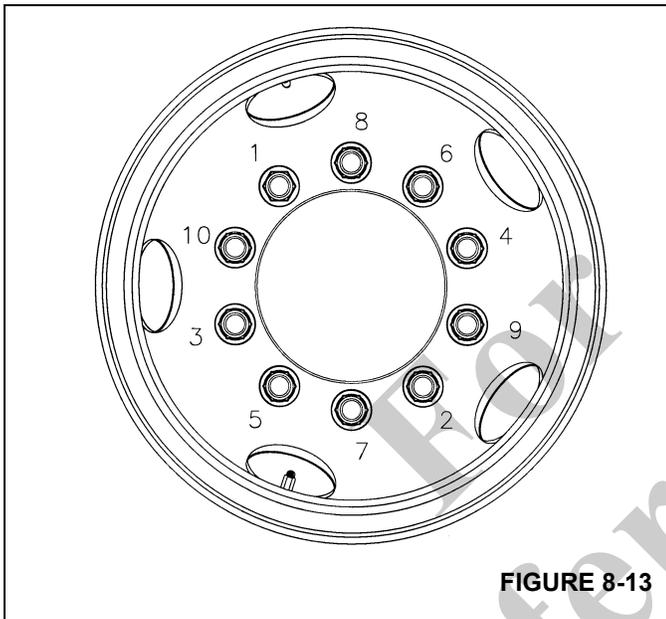


FIGURE 8-13

4. Tighten the lug nuts to a preliminary torque of 68 Nm (50 lb-ft) in the sequence as shown in (Figure 8-13).

Torque the lug nuts 610 to 679 Nm (450 to 500 lb-ft) in the sequence as shown, (Figure 8-13). Retorque lug nuts 80 to 160 km (50 to 100 mi) after the wheels are removed and reinstalled. Check the torque every 804 km (500 mi) thereafter.

AIR SYSTEM

Description

The air system (Figure 8-14) provides the air supply and control to operate the service brakes, parking brakes, air suspension system, inter-axle and optional cross axle differential locks, and tire inflation.

The engine-mounted air compressor provides air system flow. The air system components are operated by the air that is stored in four reservoirs underneath the frame.

An air dryer with integral governor is mounted under the center front decking behind the front bumper. It is connected between the outlet of the supply dump valve and the supply reservoirs. Oil, water, and contaminants are removed from the air during the compression cycle and when the governor is unloading, the contaminants 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 in one system air is retained in the other system. By means of pressure protection valves, spring brake valves, a reserve of air pressure remains to operate the 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 (Tank A). A 1030 kPa (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 731 kPa (106 psi) and are basically check valves. They open at 69 to 103 kPa (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 586 kPa (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 896 kPa (130 psi) is sensed in the air system. When pressure drops to 758 kPa (110 psi), the governor will allow the compressor to supply the air system to maintain proper system pressure.

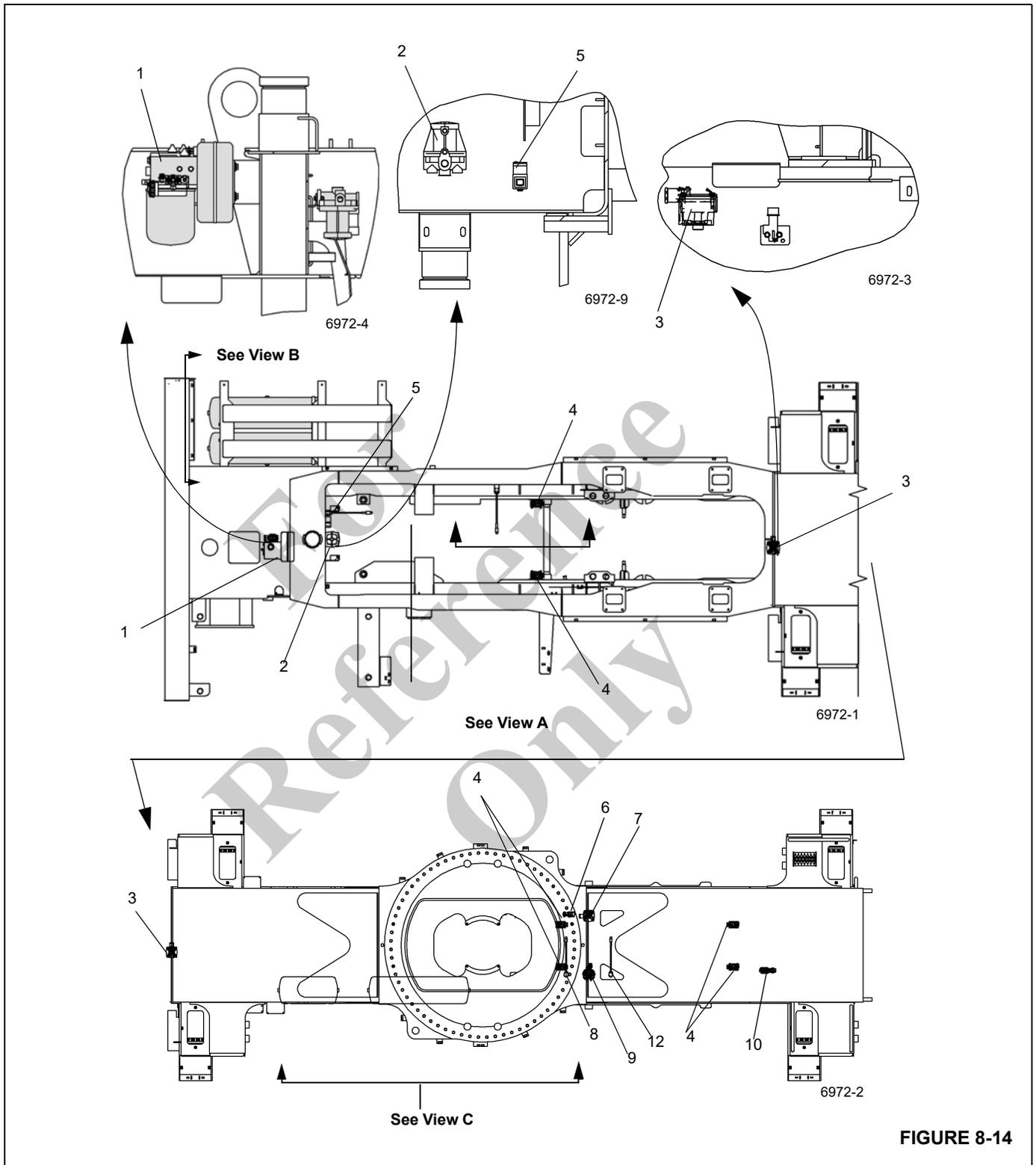


FIGURE 8-14

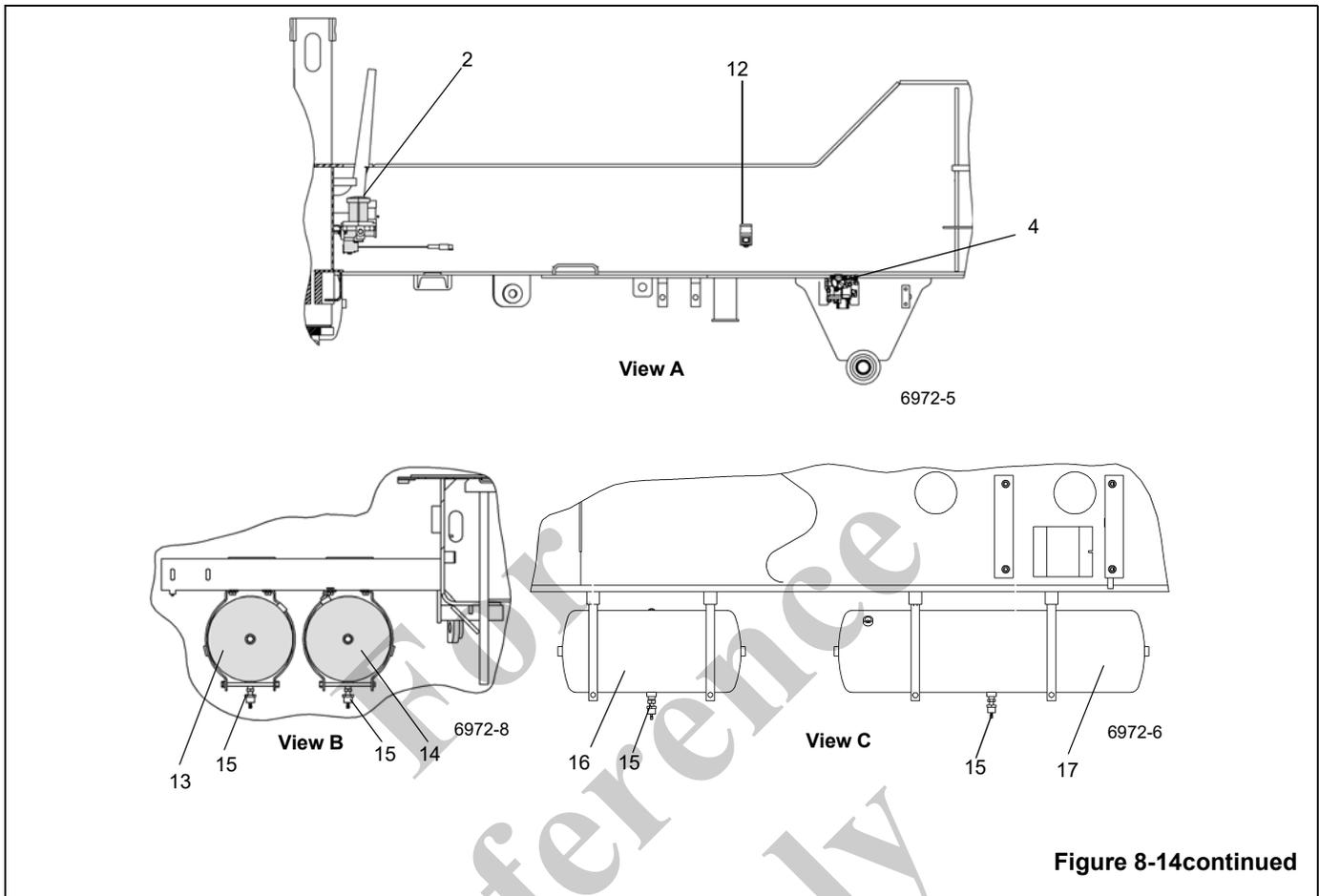


Figure 8-14continued

Item	Description	Item	Description
1	Air Dryer Module	10	Tractor Protection Valve
2	Supply Dump Valve	11	Cross-Axle Diff Lock Solenoid Valve (Opt)
3	Front Service Brake Relay Valve	12	Air Suspension Valve
4	ABS Modulator Valve	13	Secondary Air Reservoir B
5	Tire Suspension Solenoid	14	Secondary Air Reservoir A
6	Traction Control Valve	15	Drain Valve Assembly
7	Rear Service Brake Relay Valve	16	Primary Air Reservoir A
8	Inter-Axle Diff Lock Solenoid Valve	17	Primary Air Reservoir B
9	Spring Brake Relay Valve		

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 side of the front 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 280 kPa (40 psi) is required to keep the parking brake valve engaged. If supply

pressure to the valve drops below 280 kPa (40 psi), the valve will release, applying the brakes.

The service brakes are applied by air pressure. Depressing the foot brake pedal on the cab floor causes pressurized air to enter the service brake chamber on each wheel and apply the brakes. In the event of a loss of supply pressure to the service brakes, the spring brake valve will allow the operator to release or bleed off the air pressure in the spring brake chamber by depressing the foot brake pedal to apply the brakes.

Maintenance



WARNING

Death or Injury Could Occur!

Depressurize both air systems completely before disconnecting air lines or components.

CAUTION

Damage Could Occur!

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 40 kPa (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.

Air System Operational Test



WARNING

Death or Injury Could Occur!

Air pressure must not exceed 900 kPa (130 psi).

NOTE: Refer to (Figure 8-14) for air tank and valve installation.

1. Park the crane on a firm level surface and apply the parking brakes.
2. Push air suspension switch (Figure 8-15) 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 28 ± 14 kPa (4 ± 2 psi).
3. Raise the crane on outriggers.
4. Shutdown the engine.

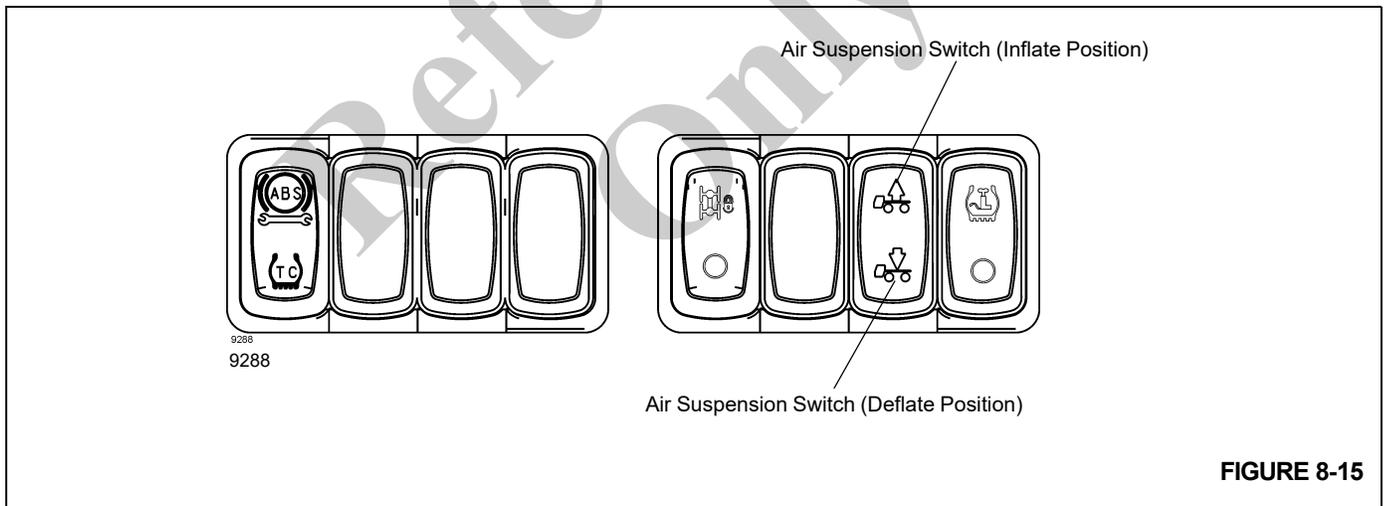


FIGURE 8-15

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. An audio warning should be on until both pressure gauges indicate 414 to 483 kPa (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 $731 \text{ kPa} \pm 41 \text{ kPa}$ (106 ± 6 psi).

At 731 kPa \pm 41 kPa (106 \pm 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 731 kPa \pm 41 kPa (106 \pm 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

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.

- c. Record the amount of time to build air pressure from 586 to 689 kPa (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 896 kPa (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 172 kPa (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 13.8 kPa (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. 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 517 \pm 35 kPa (75 \pm 5 psi). Air pressure in the secondary system should not drop below 689 kPa (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 517 \pm 35 kPa (75 \pm 5 psi). Air pressure in the primary system should not drop below 689 kPa (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 138 to 207 kPa (20 to 30 psi).

8. On units equipped with trailing boom, the trailer emergency supply line should be exhausted between 138 to 310 kPa (20 to 45 psi).

Air System Components

Air Compressor

The air compressor (Figure 8-16) 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 896 kPa (130 psi) the governor vents the compressor. When pressure drops to 758 kPa (110 psi), the governor signals the compressor to start charging again.

Air Dryer

The purpose of the air dryer (Figure 8-16) is to collect and remove solid, liquid, and vapor contaminants from the air system. Clean dry air increases the life of the air system and reduces cost.

For Reference Only

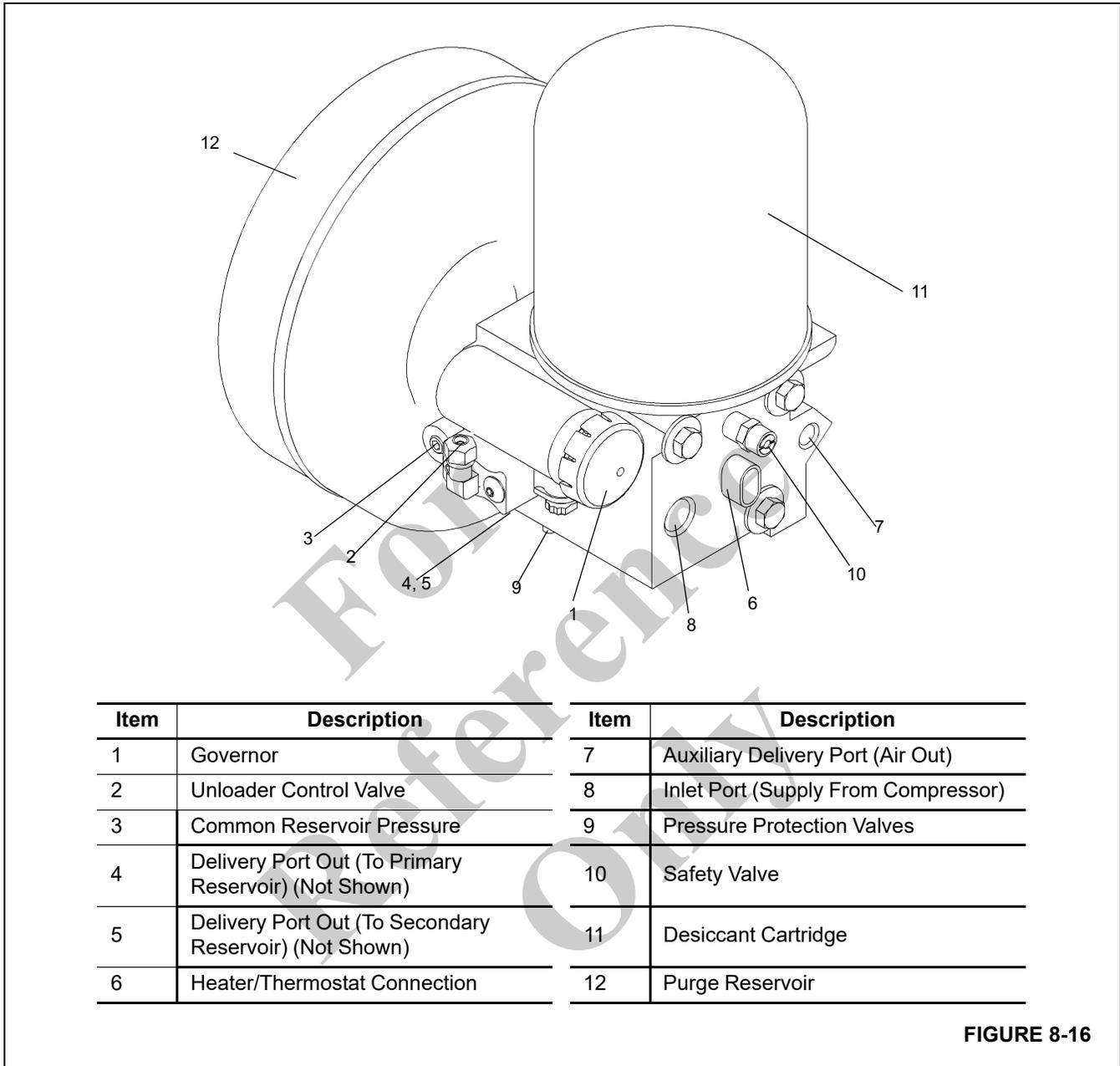


FIGURE 8-16

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 8-16) 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 8-17) 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 517 kPa (75 psi).

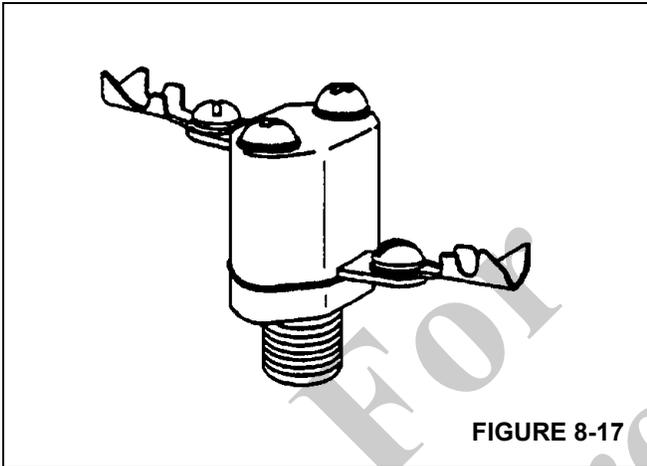


FIGURE 8-17

Stop Light Switch

The stop light switches (Figure 8-18) are installed in the ports of the dual brake valve and are used to illuminate the stoplights 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.

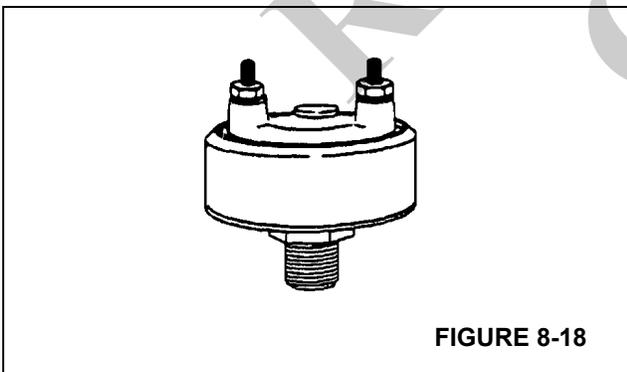


FIGURE 8-18

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 8-19) 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 1030 kPa (150 psi). A second safety valve is installed in the tire inflation circuit and is set at 1207 kPa (175 psi).

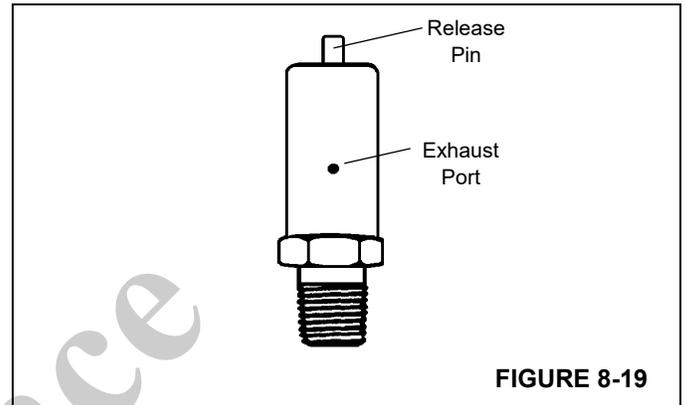


FIGURE 8-19

Pressure Protection Valve

The purpose of the pressure protection valve (Figure 8-20) 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 586 kPa (85 psi) and opening pressure is about 103 to 138 kPa (15 to 20 psi) higher than the closing pressure. The valve is preset to the specified opening and closing pressures.

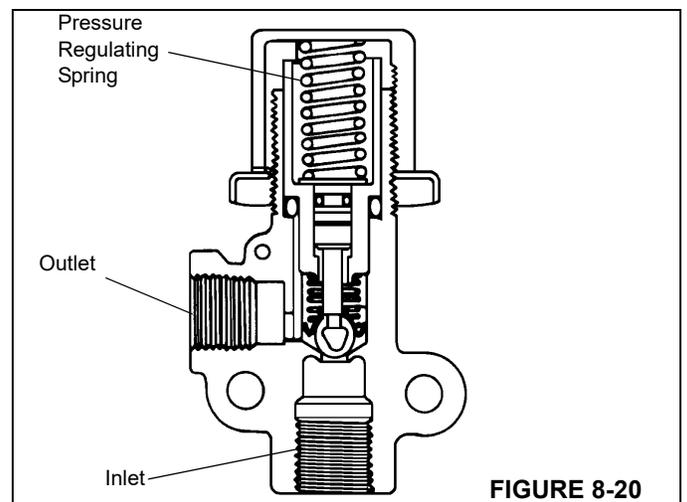
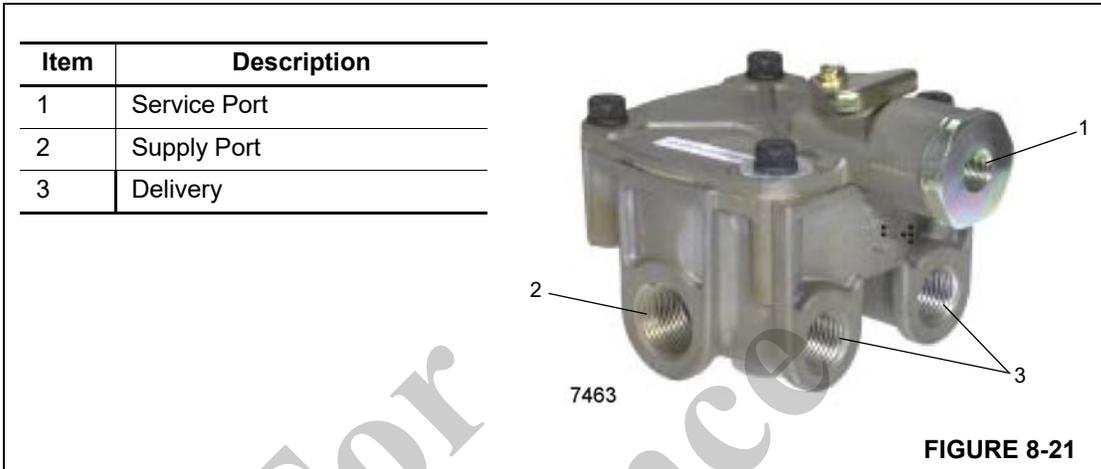


FIGURE 8-20

Relay Valve

The purpose of the two piston operated relay valves (Figure 8-21) 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.

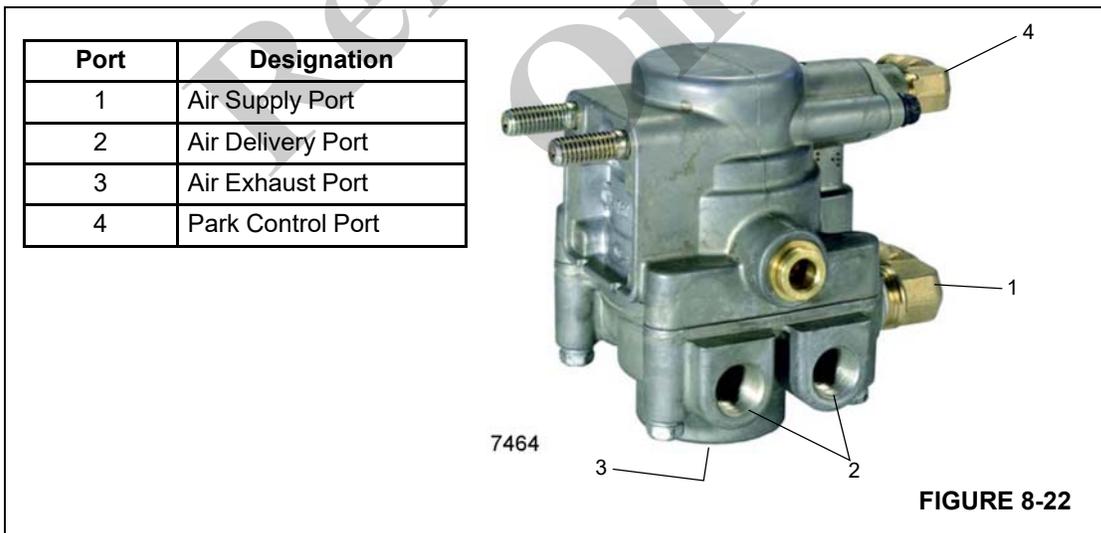


Dual Brake Valve

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 8-22) 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.



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 340 kPa (50 psi) and the button is pushed in, the park brakes are disengaged. The button will pop out when

the air pressure falls below 280 kPa (40 psi) exhausting the delivery line and engaging the brakes.

Anti-lock Modulator

The quick release anti-lock 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 anti-lock controller electronics and the air brake system. The modulator is used to control the braking function on actuators during anti-lock 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.



WARNING

Death or Injury Could Occur!

Depressurize both air systems completely before disconnecting air lines or components.

For more in depth information on Bendix system components go to the Bendix website and download the appropriate document.

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 896 kPa (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 *Torque Values*, page 1-9.
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 *Torque Values*, page 1-9.
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 520 kPa (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 760 kPa (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 *Torque Values*, page 1-9.
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.

- 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 590 ± 35 kPa (85 ± 5 psi).

Leakage Test

- 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.
- 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.

- Remove the snap ring/exhaust cover assembly.
- Pull the insert out and replace.
- Reinstall the exhaust cover and snap ring.

Removal

- Chock the wheel and completely depressurize both air systems.
- Tag and disconnect all air lines connected to the relay valve.
- 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

- Position the valve on the frame and secure with the bolts and washers.
- Connect the air lines as per removal tags.
- Check operation as described under Operating and Leakage Tests.

Operating Test

- Chock the wheels and pressurize both systems. Adjust the brakes.
- Apply and release the brakes several times and check for prompt response of the brakes at all wheels.

Leakage Test

- 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.
- With the dual brake valve applied, check the relay valve exhaust port for leakage of the exhaust valve.
- 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

- Chock the wheel and completely depressurize both air systems.
- Tag and disconnect all air lines connected to the relay valve.
- 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

- Secure the valve with attaching hardware.
- Connect the air lines as per removal tags.
- 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.

- 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 738 kPa (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 30 kPa (4 psi) greater than #2 circuit with both supply reservoirs at the same pressure.

Leakage Test

1. Make and hold a high pressure application 550 kPa (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 heel 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 280 kPa (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.

BRAKES

Description

NOTE: For more in depth information on Bendix system components go to the Bendix website and download the appropriate document.

Air Supply

The vehicle's compressor, see Air Compressor, page 8-27, takes in filtered air at an increased pressure from the intake manifold and compresses it. The compressed air is delivered to the air dryer where water and a small amount of oil is removed. The air then travels into the rear brake system reservoir and a front brake system reservoir as well as any attached trailer reservoirs. For each system, the air pressurizes the reservoir and the air hoses all the way to the next control valve, where the air pressure remains, ready to be used.

A vehicle may use compressed air for many tasks. Some examples are: to provide force for braking, to deliver air to the air suspension system, etc.

Normal Braking

When the driver applies the foot brake, the air pressure is delivered to the rear and front brake systems. This air travels through the delivery (in this case signal) line to the relay valve. This closes the exhaust and opens the delivery of air to the brakes.

The pressure quickly increases in the brake chambers and applies force to the push rod, transferring the force to the S-Cam. When the brakes are released, the air in the brake chambers is able to be quickly released.

Vehicle Parking

Vehicles are parked using powerful springs, which are part of the spring brake assembly, to engage the brakes and hold the vehicle in position. When the driver prepares to move away and releases the parking brake, the spring force is countered by the introduction of air pressure. An anti-compounding valve in the system design helps prevent the application of both the spring and service brakes together.

Anti-lock Braking Systems (ABS)

This Grove crane uses an electronic Anti-lock Braking System (ABS) to help improve braking when excessive wheel slip, or wheel lock-up, is detected. Electronic Control Units (ECUs) monitor wheel speeds (on all wheels equipped with speed sensors) and use ABS modulator valves to adjust or pulse the braking force being applied. These valves operate many times per second during an ABS event. ABS typically improves stability and steerability, and also reduces stopping distances on most surfaces.

In addition to the ABS features above, some advanced ECUs have a drag torque control feature which reduces driven-axle wheel slip (due to driveline inertia) by communicating with the engine's controller and increasing the engine torque.

Automatic Traction Control

In addition to the ABS function, this crane provides an Automatic Traction Control (ATC) feature which can help improve vehicle stability and traction during vehicle acceleration at low speeds.

Emergency Braking

In emergency situations where system air pressure is reduced or lost, the modulating valve actuates the parking-brakes to bring the vehicle to a stop.

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.

- Whenever possible, work on brakes in a separate area away from other operations.
- Always wear a respirator approved by NIOSH or MSHA during all brake service procedures. Wear the respirator from removal of the wheels through assembly.
- 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. If such equipment is not available, carefully clean parts and assemblies in the open air.

- 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.
- 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.
- 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.
- Worker clean-up. Workers should wash their hands before eating or drinking. Working clothes should not be worn home. They should be vacuumed after use and then should be laundered separately, without shaking, to prevent fiber dust from getting into the air.

FRONT BRAKES

Description

The front brakes are air actuated and cam operated. The brake shoes employ 19 mm (0.75 in) tapered block liners. The shoes are fabricated of steel and mounted on individual anchor pins which are supported by cast spiders. Automatic slack adjusters maintain proper pushrod stroke and lining-to-drum clearance during normal service.

NOTE: For information on the ABS speed sensors refer to Wheel Speed Sensor Replacement (Front), page 8-81.

Maintenance

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
Brakes are poor or do not apply.	Insufficient air pressure.	Check for the correct pressure at the compressor and brake air chambers.
	Restriction or leak in lines, valves, etc.	Check all lines, valves, etc., for leaks or restrictions.
	Brakes out of adjustment.	Adjust the brakes.
	Leaking diaphragm.	Replace the diaphragm.
Uneven braking or uneven lining wear.	Ruptured diaphragm.	Replace the Diaphragm.
	Brakes out of adjustment.	Adjust the brakes.
	Grease on the lining.	Replace the lining.
	Glazed lining.	Replace the lining.
	Shoes installed backwards.	Reverse the shoes.
	Combination linings.	Remove the linings and replace with the correct style.

Disassembly



WARNING

Death or Injury Could Occur!

Do not work under a crane supported by only outrigger jacks. Use jack stands to support the carrier.

1. Set the parking brakes and block the wheels.
2. Raise the carrier so that the front wheels are off the ground.
3. Back off the automatic slack adjuster until the brake shoes are clear of the drum.
4. Remove the hub cap, axle spindle nut, and washer.

CAUTION

Damage Could Occur!

Do not strike the axle shaft flange with a hammer. Do not use chisels or wedges to loosen shaft or dowels.

5. Rock the drum and pull outward until the outer wheel bearing can be removed.

CAUTION

Damage Could Occur!

Do not force the drum. Excessive force may damage brake components.

6. To remove the drum, pull outboard while rocking from side to side.
7. Pry the roller retainer loops out of the shoe web holes. Pivot the roller retainer to swing the loops clear of shoe webs.

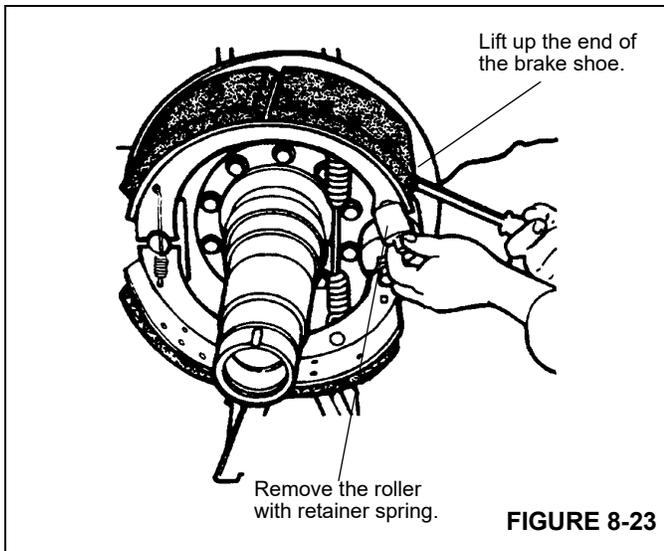


FIGURE 8-23

8. With a large screwdriver or lever (Figure 8-23), lift the upper shoe and remove the roller and retainer as a unit.
9. Repeat Step 8 for the lower shoe roller and retainer.

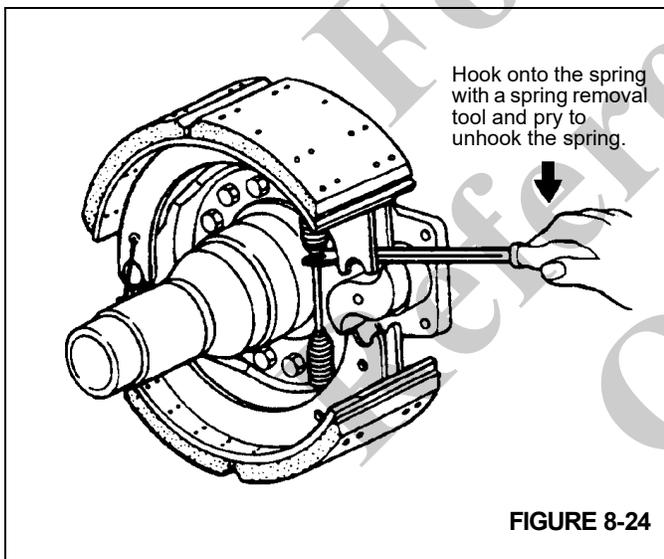


FIGURE 8-24

10. If springs are connected by spring post (horse collar), push cam end of upper shoe toward the cam. Otherwise push cam end of both shoes toward cam. With a spring removal tool, hook onto the spring and pry to unhook the upper shoe return spring. Remove the spring and discard (Figure 8-24).

11. Do the same for the lower return spring
12. Remove the shoes from the axle (Figure 8-25).
13. Remove the slack adjuster; reference Slack Adjuster Removal this Section.
14. Remove the camshaft by grasping the camshaft head and pulling outboard.
15. Remove the bolts attaching the air chamber bracket to the spider and pull it away from the spider.
16. Remove spider-to-axle attaching nuts and bolts and remove the spider (Figure 8-26).

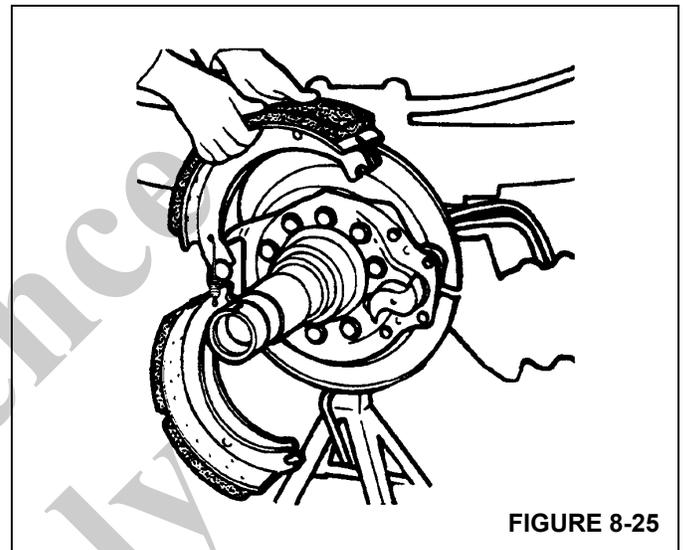


FIGURE 8-25

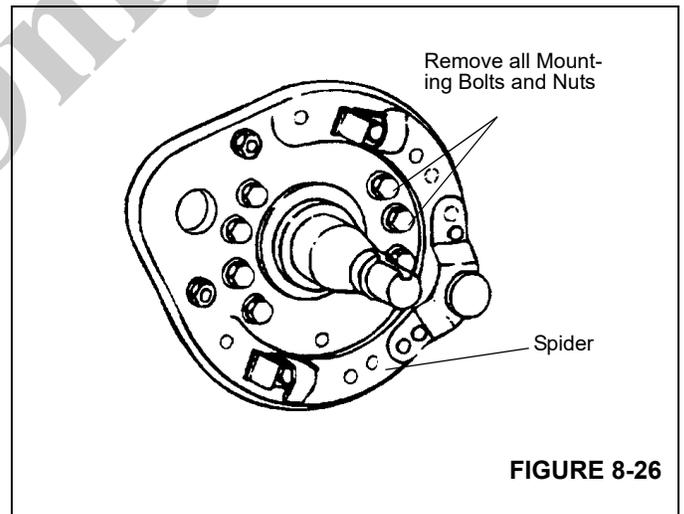
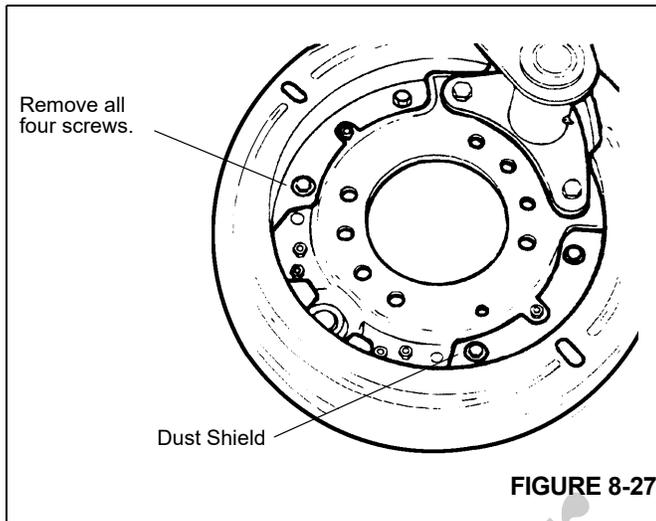


FIGURE 8-26

17. Remove screws and retaining clip securing dust shield to spider and remove dust shield (Figure 8-27).



Cleaning

CAUTION

Damage Could Occur!

Oxidation and dirt on the outside of brake drums 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

NOTE: Refer to (Figure 8-28) for components referenced in 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 manufacturer's specifications.

CAUTION

Damage Could Occur!

Do not use drum if it exceeds maximum diameter or run-out specifications.

2. Inspect the shoes for bent or cracked webs or table, broken welds, loose rivets, or elongated rivet holes. Replace shoes if any are found.
3. Check the anchor pin and cam roller contact areas in the shoe webs for elongation or wear. Replace the shoe if the diameter of the roller end exceeds 21.33 mm (0.835 in) or the diameter of the anchor pin end exceeds 35.56 mm (1.4 in).
4. Check the linings and replace the shoes if contaminated, cracked, or worn to less than 6.35 mm (0.25 in) thickness at any point.
5. Inspect the spider for cracks around mounting bolt holes, cam area, or anchor pin and replace if cracked.
6. Check the anchor pin and replace if loose or grooved more than 0.787 mm (0.031 in) below original surface.

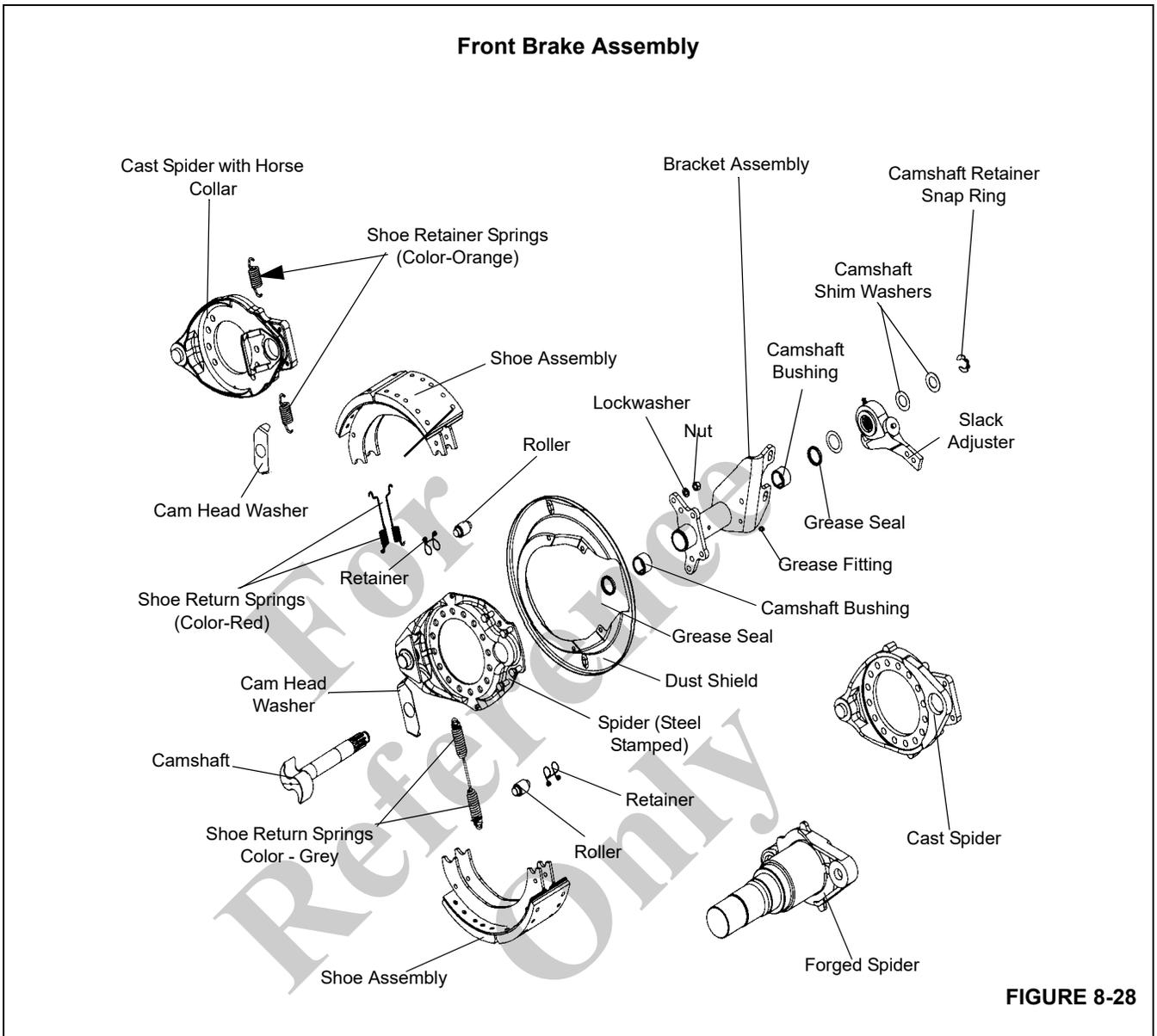
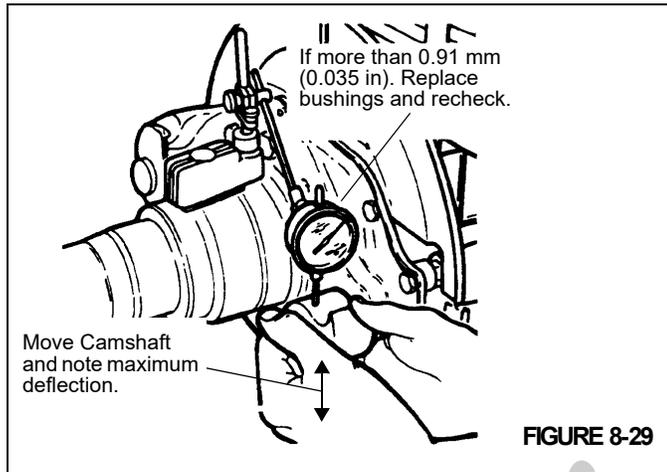


FIGURE 8-28

7. Each time the brake shoes are removed, check camshaft radial play as outlined in Steps 7a thru 7e below and (Figure 8-29).



- 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 0.035 in (0.9 mm), re-bush the air chamber bracket. Refer to Repair/Replacement, page 8-42, this Section.
 - e. After re-bushing, recheck radial play. Replace the camshaft if play is still excessive.
8. Check spline end of the camshaft for cracks and worn or deformed splines. Replace as necessary.
9. Check the camshaft bushing journals for wear or corrosion. If the camshaft shows visible wear or if roughness is felt in the journal, replace the camshaft.
10. Check the camshaft head for brineling, cracking or flat spots. Replace the camshaft if a ridge can be felt between the worn areas and surface of the cam head.

NOTE: The camshaft bushings and seals are mounted in the air chamber bracket assembly.

11. Check the camshaft bushings for deterioration or wear. The inner surface must be smooth. Replace the bushing if surface is rough or abrasive.

12. Check the grease seals and replace if nicked, cut, or distorted.
13. Check the air chamber bracket for a bent, broken, or cracked arm and welds. Replace as necessary.
14. Check the air chamber bracket mounting studs for looseness, damaged threads, or bent studs. Replace as necessary.
15. Check the air chamber for leaks, cracked housing, bent pushrod, loose clamp ring, clogged vent holes, or loose air fittings. Repair or replace as necessary.
16. If the air chamber is replaced or repaired, check the distance from the clevis pin hole centerline to the air chamber face. Reference *Automatic Slack Adjuster*, page 8-44 for adjustment.
17. If a new air chamber is installed, ensure that the cutoff pushrod does not project too far into the clevis. Minimum clearance from the clevis centerline to pushrod end is 22.2 mm (0.875 in).
18. Check air chamber clevis pin for cracks and wear.
19. Check the automatic slack adjuster. Reference *Automatic Slack Adjuster*, page 8-44.

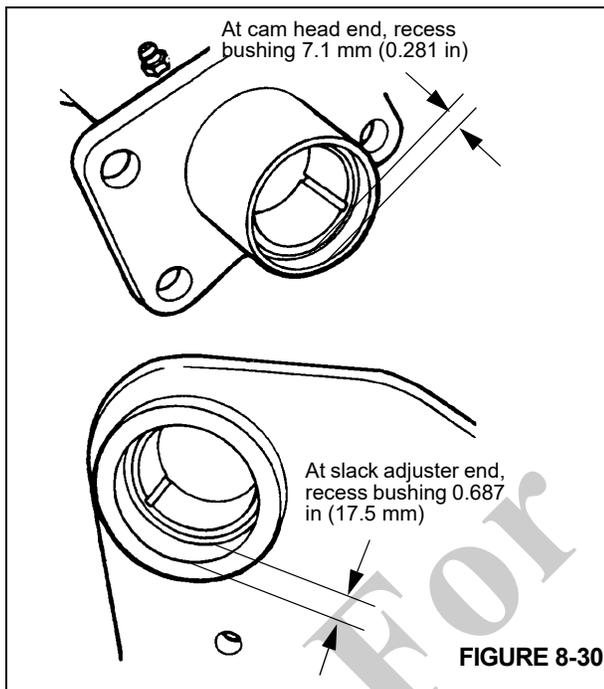
Repair/Replacement

Routinely replace lower cost items such as springs, seals, bushings, and heavily worn parts. Damage caused by failure of worn parts is much more expensive than the cost of the parts.

Camshaft bushing and/or grease seal replacement is as follows:

1. Remove the air chamber bracket.
2. Drive out the old bushing and grease seal with a suitable driver.
3. Clean and inspect the air chamber bracket. Reference *Inspection*, page 8-40 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

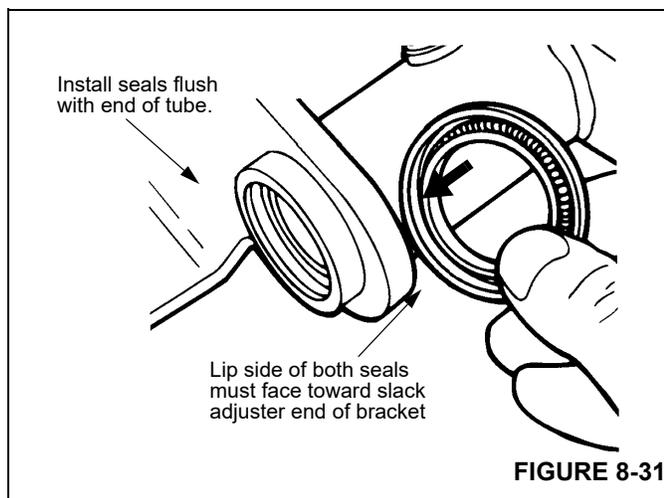
17.5 mm (0.688 in) from the ends of the tube (Figure 8-30).



CAUTION
Damage Could Occur!

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.

5. Install new grease seals with a piloted driver so the seals are flush with the end of the air chamber bracket tube (Figure 8-31).



Assembly

1. Position the spider on the axle flange and install attaching bolts and nuts. Place hardened washers under the bolt head.
2. Position the dust shield against the spider. Install all attaching screws finger tight. Torque screws 16.9 to 20.3 Nm (150 to 180 lb-in).
3. Align the air chamber bracket with the holes on the spider and secure with the bolts and lock washers. Torque 88 to 115 Nm (65 to 85 lb-ft).
4. Installation of camshaft is as follows:
 - a. Check for correct camshaft by rotating the camshaft in the direction of the air chamber push rod extension. The roller should start to ride up on the convex side of the cam head.

CAUTION

Damage Could Occur!

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 *Automatic Slack Adjuster*, page 8-44.
6. Installation of brake shoes is as follows:
 - a. Lubricate the shoe roller recess with chassis grease. Do not get grease on the cam head surface.
 - b. Hook the ends of the new retainer springs into the holes on both shoe webs with the hooks pointing out.
 - c. Position the upper and lower shoes around the anchor pin. Install a new shoe return spring.
 - d. Assemble the roller retainer on both ends of the roller.
 - e. Stretch the return spring and insert the roller and retainer on the lower shoe web.
 - f. Position the roller assembly in the recess. Squeeze the loops of the retainer and rotate to snap loops into the web holes. Make sure that both loops are engaged in the web holes.

- g. Repeat Steps (d) thru (f) on the upper shoe.
7. Install the drum and axle spindle nut(s) and washers.

AUTOMATIC SLACK ADJUSTER

Description

The automatic slack adjuster compensates for normal wear in the brake shoe linings by maintaining a nominal clearance between the lining and drum.

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

NOTE: If your slack adjuster is as pictured in (Figure 8-32), perform the removal, installation and adjustment procedures that follow. If your slack adjuster is as pictured in (Figure 8-42), follow the removal, installation and adjustment procedures on page 8-48.

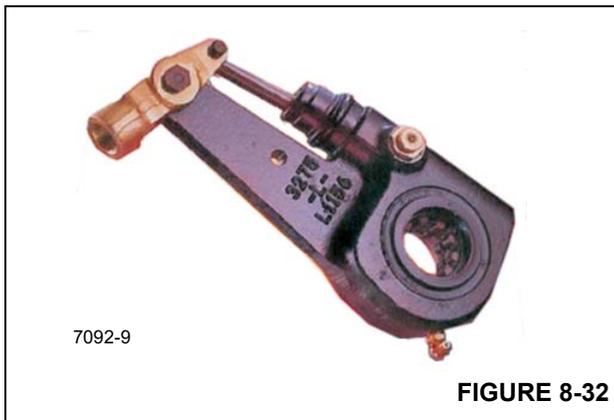


FIGURE 8-32

Removal

CAUTION

Damage Could Occur!

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.



WARNING

Death or Injury Could Occur!

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

Damage Could Occur!

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

Damage Could Occur!

Do not use a hammer to remove the slack adjuster. Damage to the slack adjuster and/or camshaft splines may result.

NOTE: Note the orientation of the slack adjuster with reference to the push rod before removal to ensure proper orientation at installation.

6. Remove the slack adjuster with a suitable puller.

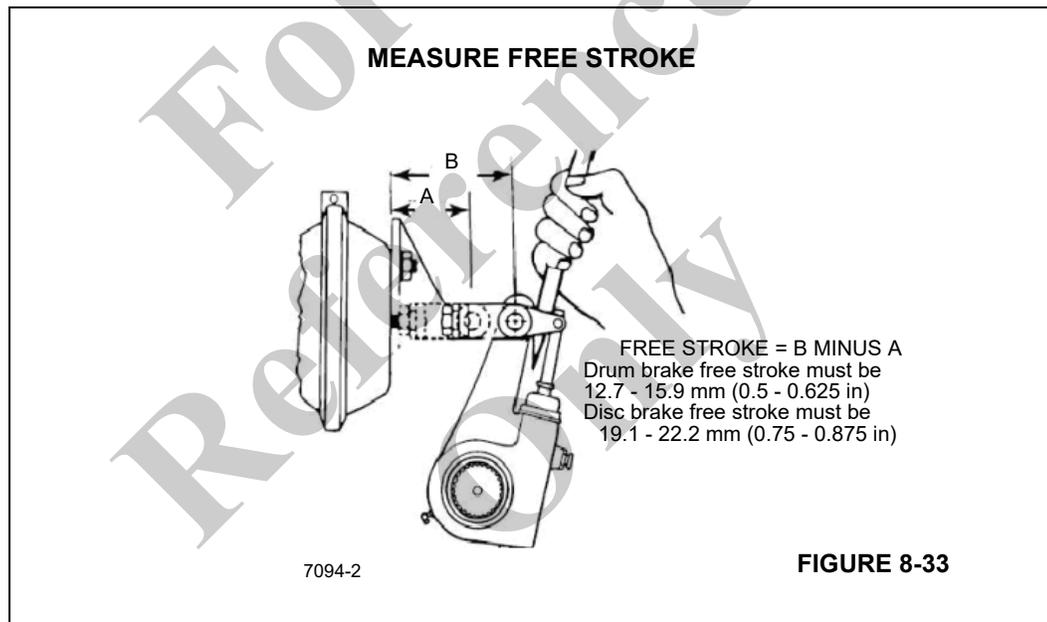
Installation

1. Verify that the pushrod is fully retracted.
2. Install the inner washer on the camshaft. The inner washer has a larger hole.
3. Apply Anti-Seize type lubricant to the camshaft splines. Install the slack adjuster onto the camshaft with the adjusting shaft hex pointing away from the air brake chamber. Secure with outer shim washer(s) and snap ring.
4. Rotate the adjusting shaft hex nut clockwise until the slack adjuster arm and actuator rod holes line up with the clevis holes.
5. Install the clevis pins and the cotter pins.
6. Adjust the brakes by turning the adjusting shaft hex clockwise until the lining contacts the drum. Then rotate the adjusting shaft hex counterclockwise 1/2 turn.

Adjustment Procedures**Brake Applied Stroke Measurement**

Ensure that the brake applied stroke is within required values as outlined below.

1. Chock the wheels.
2. Charge air tanks. Refer to *Air System*, page 8-22.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures 621 to 689 kPa (90 to 100 psi). Refer to *Air System*, page 8-22.
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 8-33).



6. Starting with 621 to 689 kPa (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 8-33).
7. Subtract Dimension "A" from Dimension "B" for each brake position (Figure 8-33). 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 Cranes 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 8-34).



NOTE: If the items referred to in Steps 3 and 4 are not stored in/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. (Figure 8-35) shows the bolt external storage area.

- 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 8-35).



- Insert the release-bolt into the center hole of the head. Make sure that 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 8-36).

NOTE: If not absolutely sure of correct bolt-to-piston engagement, repeat step 4 until sure.

- 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 in) outward movement, repeat Steps 4 and 5 until it locks.
- 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 8-37).

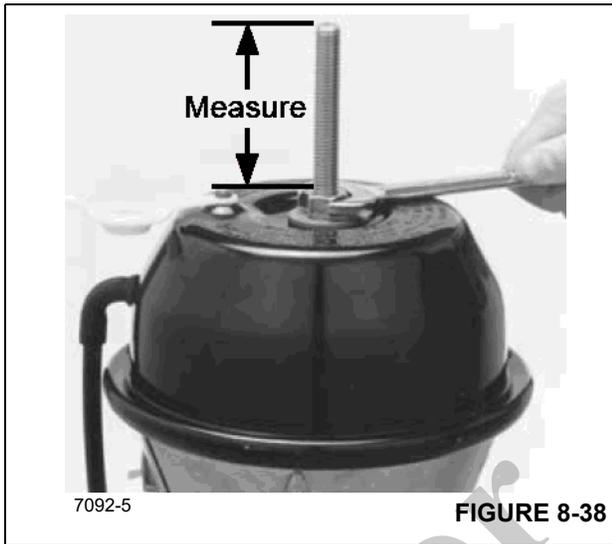


CAUTION

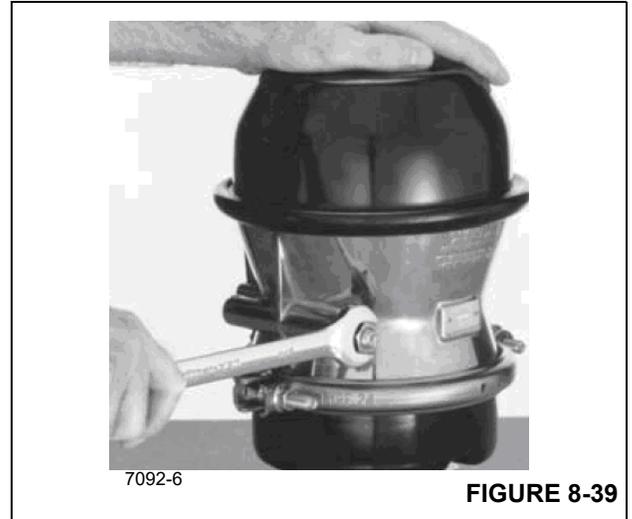
Damage Could Occur!

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 wrench turn the release-nut clockwise until 8.2 cm (3.25 in) length of bolt extends above the nut (Figure 8-38). Do not use an impact wrench.



8. For easier manual-releasing, apply 620 - 861.8 kPa (90 - 125 psi) air pressure to inlet port marked "SPRING BRAKE" before Step 4, but make sure to exhaust all air pressure after Steps 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 8-39).

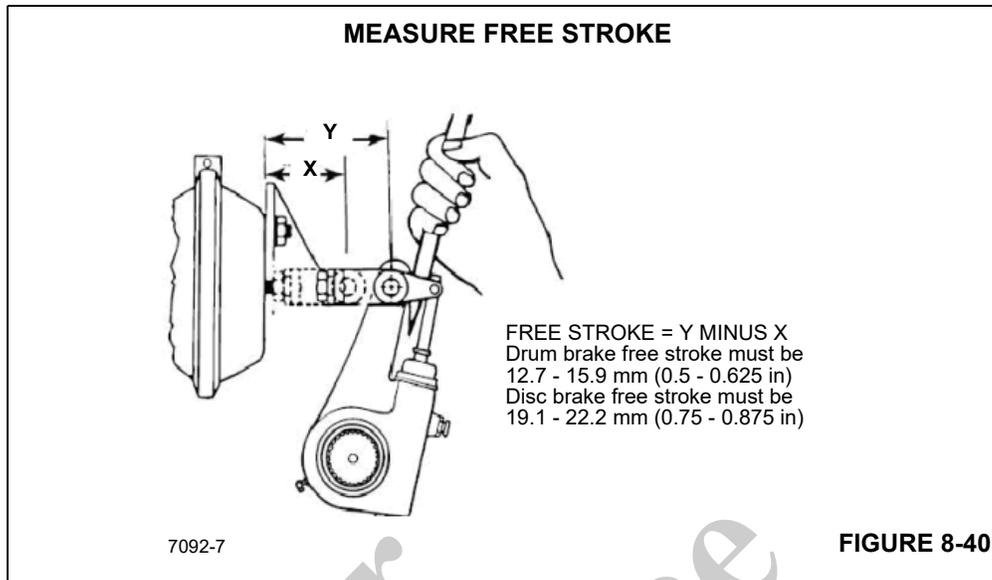


WARNING

Death or Injury Could Occur!

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 8-40).
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 8-40).



CAUTION

Damage Could Occur!

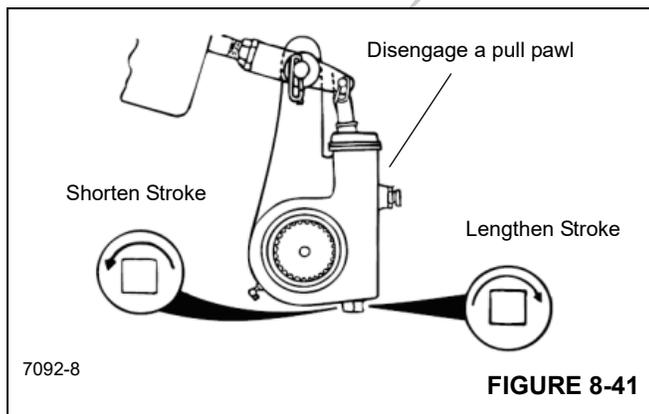
See Figure 8-40 and Figure 8-41, Free Stroke Measurement. Pull pawl must be disengaged before rotating adjusting nut. Pawl teeth will be damaged if not disengaged. Pry on the pull pawl at least 0.8 mm (0.0313 in) to disengage the teeth. When the pry bar is removed, the pull pawl will re-engage immediately.

Continue this process until the stroke is within limits (Figure 8-41).

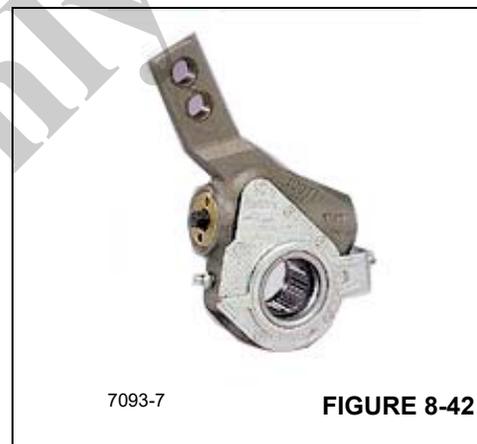
16. Release the pawl and uncage the spring brake, if required.

NOTE: If your slack adjuster is as pictured in (Figure 8-42), follow the removal, installation and adjustment procedures that follow.

13. Subtract dimension "X" from dimension "Y" (Figure 8-40). 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.



14. Disengage the pull pawl (Figure 8-41).
15. Turn the adjusting nut approximately 3.1 mm (0.125 in) turn in the direction required and re-measure the stroke.



CAUTION

Damage Could Occur!

Do not use an impact wrench or permanent internal damage will occur

Removal

1. Block wheels to prevent crane from moving. Ensure system tank pressure is above 689 kPa/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 689 kPa (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**Damage Could Occur!**

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**

Make sure that the brake applied stroke is within required values as outlined below.

1. Chock the wheels.
2. Charge air tanks. Refer to *Air System*, page 8-22.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures 621 to 689 kPa (90 to 100 psi). Refer to *Air System*, page 8-22.
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 8-43).
6. Starting with 621 to 689 kPa (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 8-43).
7. Subtract Dimension "A" from Dimension "B" for each brake position (Figure 8-43). 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 Grove Crane distributor. The crane can not be driven on public roads until repaired.

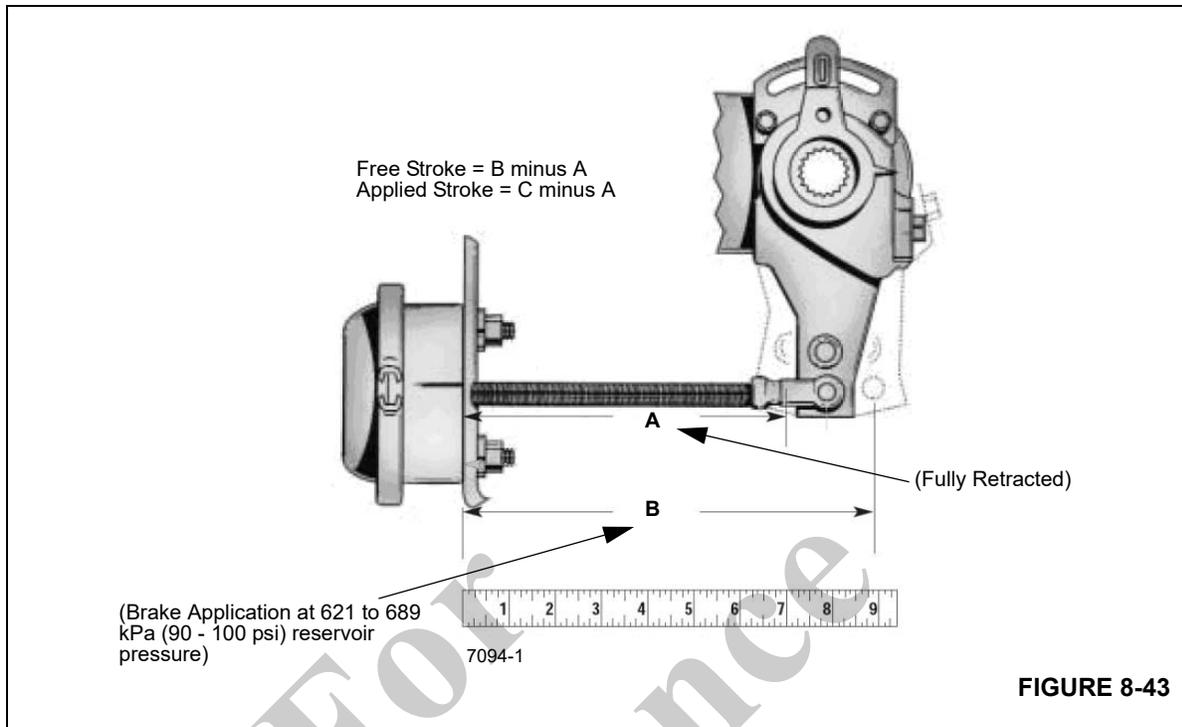


FIGURE 8-43

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.

NOTE: Do not use an impact wrench on bolt.

For easier turning of the release bolt, apply 655 to 862 kPa (95 to 125 psi) air pressure to the air inlet port marked "Spring". After caging, completely exhaust air from the spring chamber.

2. Turn the integral release bolt counterclockwise using a 3/4 inch socket wrench (Figure 8-44), until the power spring is fully caged or compressed. Full cage position requires approximately 22 to 23 turns for 76 mm (3.00 in) stroke units.

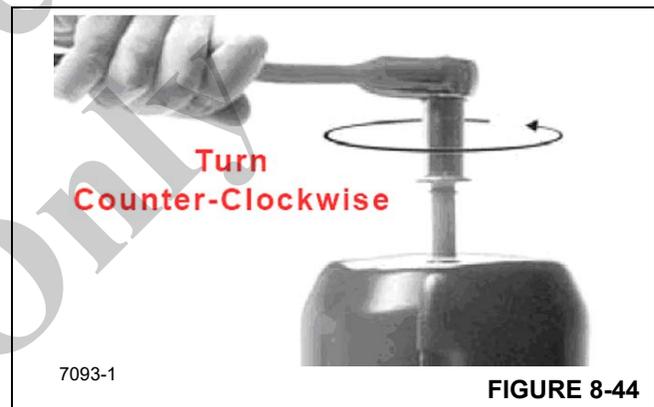


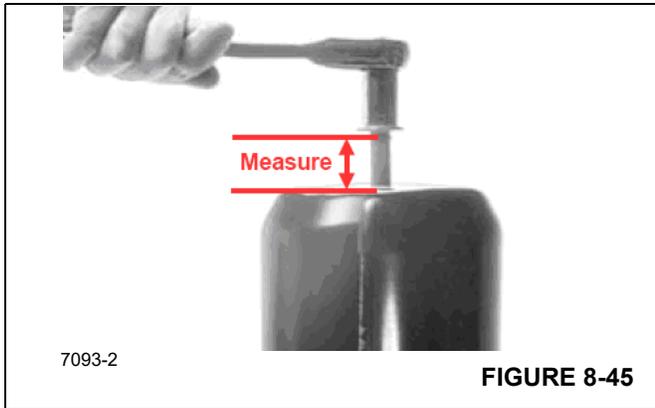
FIGURE 8-44

CAUTION

Damage Could Occur!

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 8-45). After caging, completely exhaust air from the spring chamber.

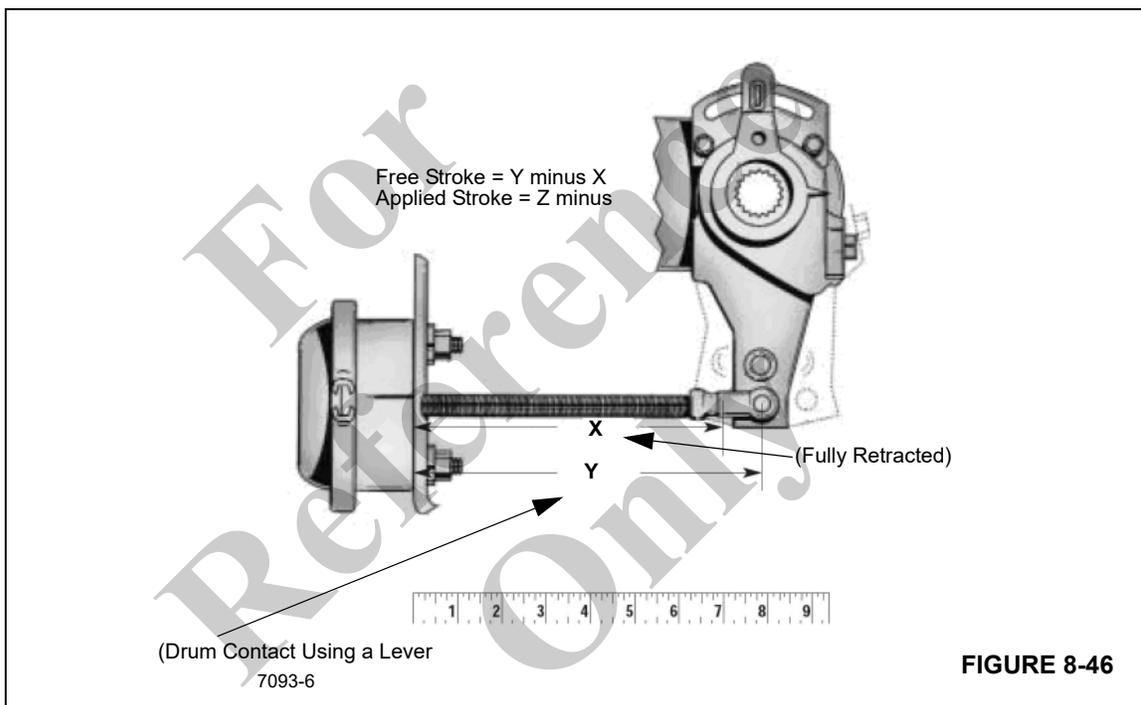


WARNING

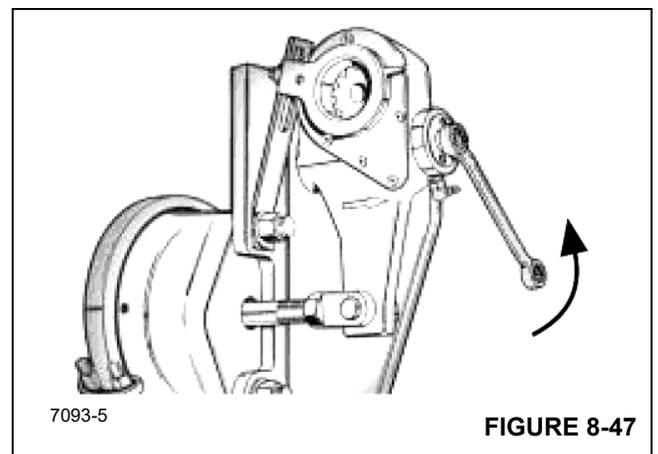
Death or Injury Could Occur!

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 8-46).



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 8-46).
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 8-47).



8. With brakes released, check installation indicator (Figure 8-46) and (Figure 8-47) to determine proper adjustment.
9. If installation indicator is not positioned properly, refer to (Figure 8-47). Loosen fastener holding indicator to anchor bracket, rotate indicator as required and re-tighten fastener.
10. Uncage spring brake if so equipped.

REAR BRAKES

Description

Brakes

The rear brakes are air actuated and cam operated. Each shoe, which is steel fabricated, employs two 19 mm (0.75 in) tapered block liners. The shoes are mounted on individual anchor pins and supported by open type spiders. Automatic slack adjusters maintain proper adjustment of the push rod stroke and lining the drum clearance.

The brake actuator is a conventional brake air chamber with an emergency (parking) brake spring mechanism

incorporated into the air brake chamber. The brake chamber has an aluminum body and pressure plate with a steel nonpressure plate that houses a service/emergency diaphragm, piston, and two springs.

Spring Brake Actuator

The spring brake actuator, which is the upper part of the air brake chamber, is spring applied and air released. When an air pressure of 482 kPa (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

For Maintenance and Troubleshooting Brakes, refer to next Section and Table or *Troubleshooting Brakes*, page 8-53.

Troubleshooting Brakes

SYMPTOM	PROBABLE CAUSE	SOLUTION
Brakes are poor or do not apply.	Insufficient air pressure. Restriction or leak in lines, valves, etc. Brakes are out of adjustment. Leaking diaphragm.	Check for correct pressure at compressor and brake chambers. Check all lines, valves, etc., for leaks or restrictions. Adjust the brakes. Replace diaphragm.
Uneven braking or lining wear.	Ruptured diaphragm. Brakes are out of adjustment. Grease on the lining. Glazed lining. Shoes are installed backwards. Combination linings.	Replace diaphragm. Adjust brakes. Replace lining. Replace lining. Reverse shoes. Replace with correct style.
Automatic adjusters are not working.	Adjusting pawl installed backwards. Pawl is collapsed or missing. Bolt is frozen in adjusting sleeve. Detent is damaged allowing the bolt to rotate with sleeve. Double lip seals are not installed correctly.	Remove and properly install pawl. Replace spring. Free-up or replace the bolt. Replace damaged detent. Remove and correctly install seals.
Spring brake is not holding.	Power spring is not fully released.(uncaged). Brakes are out of adjustment. Hold-off air is not releasing fully. Power spring is broken.	Turn caging bolt fully counterclockwise until stop is reached. Readjust the brakes. Check for faulty air system components. Replace spring brake actuator.
Brake is dragging.	Low spring brake hold-off air pressure 482 kPa (70 psi). Improper connection of the service line at spring brake. Leaking lines or spring brake seals.	Check for minimum spring brake pressure 482 kPa (70 psi). Check for proper functioning of air system components. Check and connect line to proper port. Tighten connections on air lines or replace spring brake unit seals.

Spring Brake Actuator

The upper part of the brake air chamber containing the large spring is not serviceable; however, the lower part of the assembly is serviceable.



WARNING

Death or Injury Could Occur!

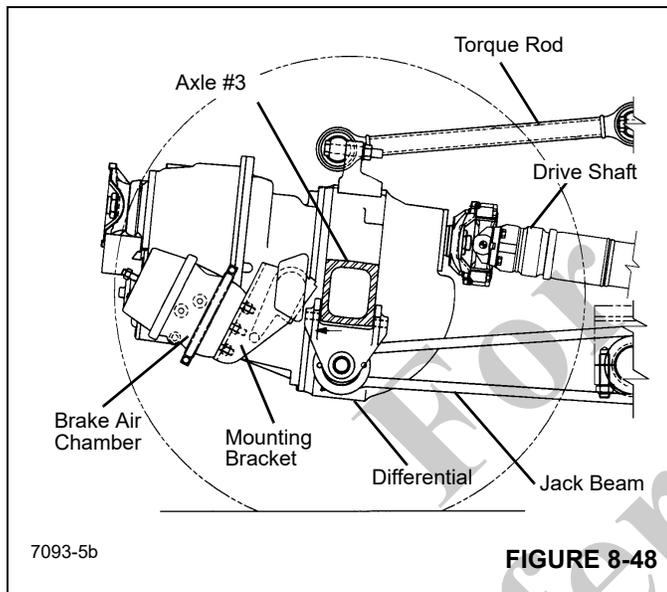
Spring brake unit is powerful enough to cause parts to fly apart with enough force to cause personal injury. The spring brake must be caged before removing or servicing brakes. Uncage the spring brake before returning the crane to service.

Manually Caging the Spring Brake

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**WARNING****Death or Injury Could Occur!**

Cage the spring brake before removal of air brake chamber.

**FIGURE 8-48**

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.

Installation

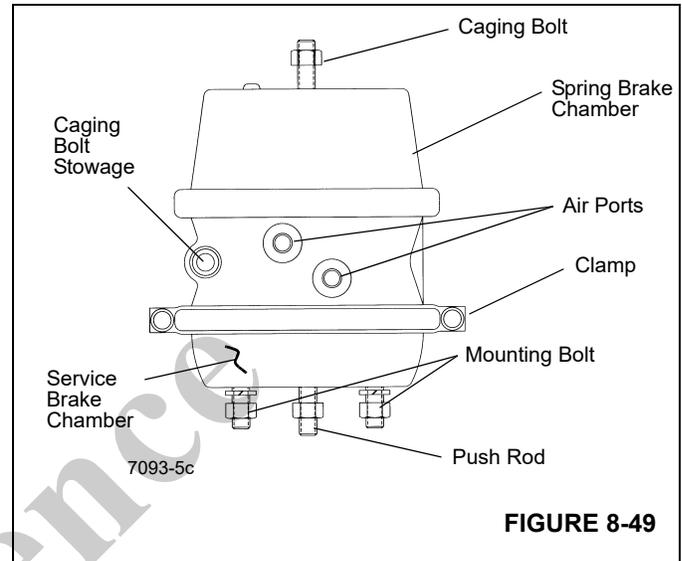
Refer to (Figure 8-48).

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

Refer to (Figure 8-49).

**FIGURE 8-49**

1. Remove the clamp securing the service brake chamber to the spring brake chamber.
2. Separate the lower cover from the spring brake chamber.
3. If the push rod or spring needs to be removed, mark the position of the clevis on the push rod. Remove the clevis and jam nut.
4. Remove the push rod.

Assembly

Refer to (Figure 8-50).

1. Insert the push rod through the spring and cover.
2. Screw on the jam nut and clevis as per removal marks.
3. Position the diaphragm over the push rod.
4. Push the lower cover assembly into the spring brake chamber and secure with the clamp.

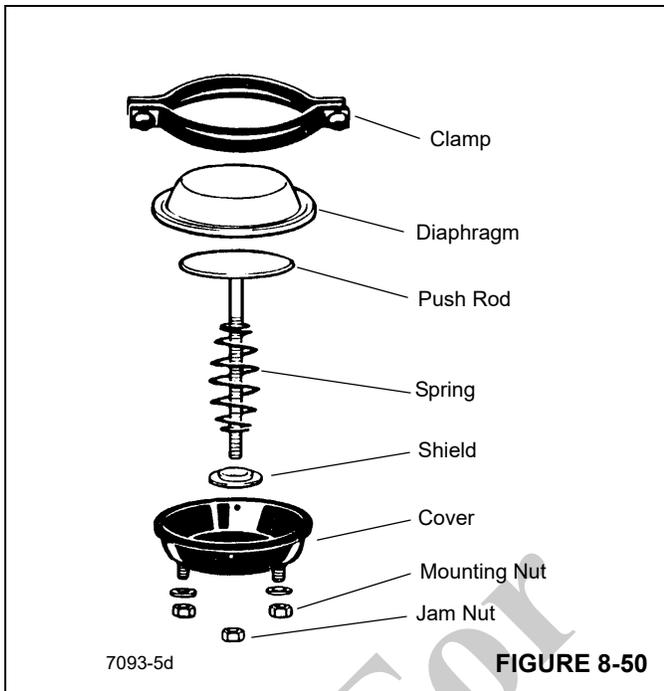


FIGURE 8-50

Rear Brake Assembly

The rear brakes are air actuated and cam operated with two shoes. Each shoe is mounted on separate anchor pins and has open anchor pin ends for easy removal. There are two shoe retainer springs in addition to the shoe return springs.

NOTE: For information on the ABS speed sensors refer to Wheel Speed Sensor, Replacement (Rear), page 8-82.

Disassemble Brakes

1. Raise the crane on outriggers so that the rear wheels are off the ground.



WARNING

Death or Injury Could Occur!

Do not attempt to do any type of work under a crane that is supported by only the outriggers or jacks.

2. Place jack stands under the frame where the wheels are to be removed.
3. Cage the spring brake with the caging bolt provided.
4. Fully release the slack adjuster so that the shoes retract allowing the drums to clear the linings. To retract the slack adjuster, do the following:

- a. Remove the pawl assembly to keep the pawl teeth from being damaged.
- b. Turn the manual adjusting nut until the brake shoe is fully retracted.
- c. Install the pawl assembly into the slack adjuster.

5. Remove the brake drum.

Brake Shoe Removal

1. Push down on the bottom brake shoe and pull on the roller retaining clip to remove the bottom cam roller (Figure 8-51).

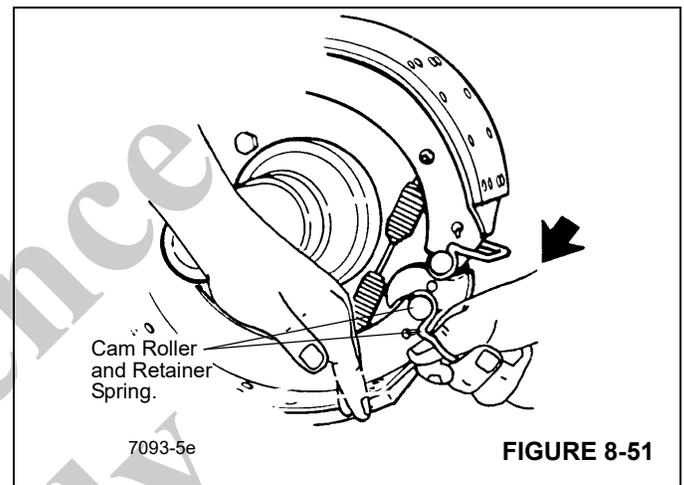


FIGURE 8-51

2. Lift the top shoe and pull on the roller retaining clip and remove the upper cam roller (Figure 8-51).
3. Lift the bottom shoe to release the tension on the brake return spring and remove the spring (Figure 8-52).

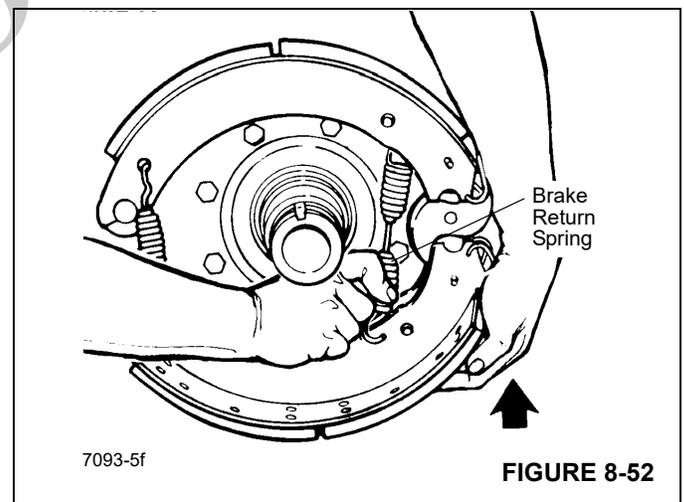


FIGURE 8-52

4. Rotate the bottom shoe to relieve tension on the retaining springs (Figure 8-53). Remove the springs and brake shoes.

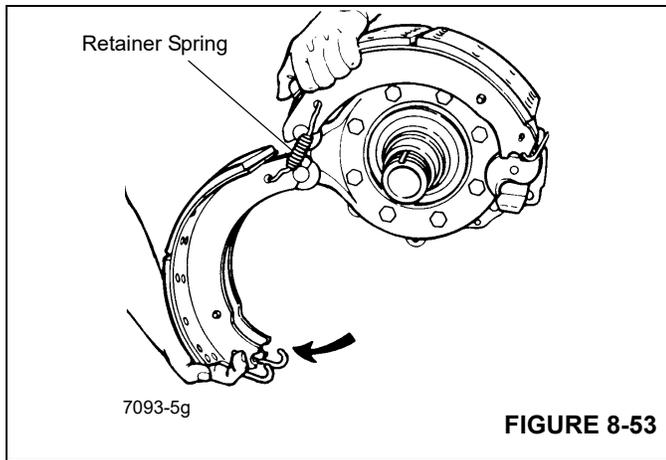


FIGURE 8-53

Clean and Inspect Parts

1. Clean all polished metal parts such as inner bore, gear, and worm with solvent cleaners.



WARNING

Death or Injury Could Occur!

Solvent cleaners can be flammable, poisonous, and cause burns.

2. Use soap and water to clean all nonmetallic parts. Dry all parts with soft clean paper or cloth.

CAUTION

Damage Could Occur!

Do not use solvent cleaners on nonmetallic parts.

3. Apply brake lubricant to all parts except the linings and drums to prevent rust.

Inspect Parts

1. Check the spider for expanded anchor pin holes and cracks. Replace damaged spiders and anchor pin bushings.
2. Check the camshaft bracket for broken welds, cracks, and correct alignment.
3. Check anchor pins for corrosion and wear. Replace damaged anchor pins.
4. Check brake shoes for rust expanded rivet holes, broken welds, and correct alignment. Anchor pin holes must not exceed 26 mm (1.03 in) in diameter. The distance from the center of the anchor pin hole to the center of the roller hole must not exceed 327 mm (12.875 in).

5. Check the camshaft for cracks, wear, and corrosion. Check the cam head, bearing journals, and splines.
6. Check the slack adjuster for the gap between the clevis and collar. If the gap exceeds 1.5 mm (0.060 in), replace the clevis. Check the clevis pins and bushing in the slack adjuster arm. Replace bushing if diameter exceeds 16.6 mm (0.65 in).
7. Rotate the slack adjuster adjusting nut through a 360 degree rotation (about 22 turns of the adjusting nut) with a torque wrench. Torque must be less than 2.8 Nm (25 lb-in) for a new or rebuilt slack adjuster.
8. Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting, and distortion.
9. Measure the inside diameter of the drum in several locations and replace if diameter exceeds manufacturers specifications.
10. Check dust shields for rust and distortion. Replace as necessary.

Assemble Brakes

Each time the brakes are relined, the following parts should also be replaced.

- Springs
- Rollers
- Anchor Pins
- Clevis Pins
- Camshaft Seals

Camshaft Installation

1. Check all spider bolts for the correct torque as shown below (Figure 8-54).

Bolt Size	Nm	Pounds-Foot
7/16" -20	85 -102	60 -75
1/2" -20	115 -156	85 -115
9/16" -18	176 -224	130 -165
7/8" -18	244 -312	180 -230

FIGURE 8-54

2. Install new camshaft seals and, if required, bushings in both the spider and camshaft bracket (Figure 8-55). Use a seal driver to install the bushings.

3. If the camshaft bracket was removed, install the gasket and bracket to the spider. Torque to:

- 1/2"-13 Grade 8 - 122 to 163 Nm (90 to 120 lb-ft)
- 1/2"-13 Grade 5 - 88 to 136 Nm (65 to 100 lb-ft)
- 5/8"-18 Plain Nut - 203 to 258 Nm (150 to 190 lb-ft)
- 5/8"-18 Lock Nut - 176 to 224 Nm (130 to 165 lb-ft)

NOTE: Install both seals with lips toward slack adjuster.

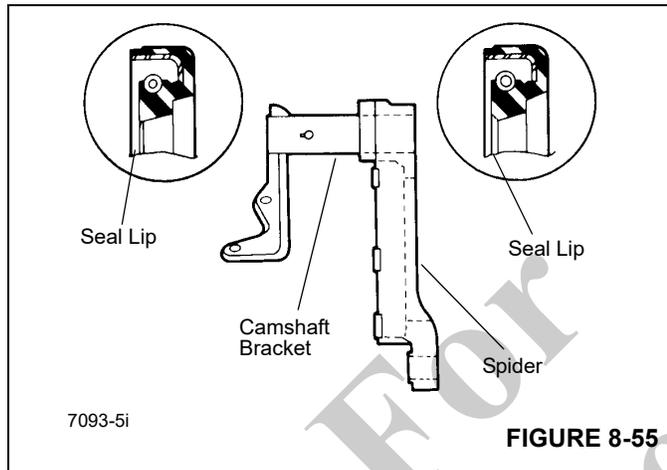


FIGURE 8-55

4. Put the cam head thrust washer on the camshaft. Apply O-617-A or B chassis grease to the camshaft bushings or needle bearings and to the camshaft journals. Install the camshaft through the spider and bracket so that the camshaft turns freely.

Brake Shoe Installation

1. Put the upper brake shoe in position on the top anchor pin. Hold the lower shoe on the bottom anchor pin and install the two new retainer springs.
2. Rotate the lower brake shoe forward and install a new brake shoe return spring (Figure 8-56).

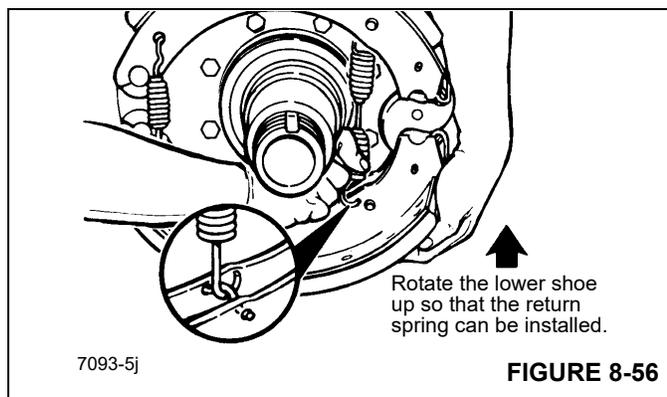


FIGURE 8-56

3. Pull each shoe away from the cam to permit enough space to install the cam rollers and retainers. Press the ears of the retainer together to permit the retainer to fit between the brake shoe webs (Figure 8-57).

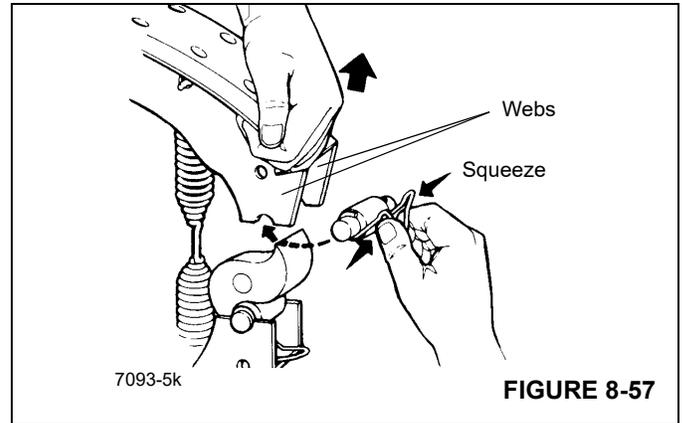


FIGURE 8-57

4. Push the retainer into the brake shoe until its ears lock into the holes in the shoe webs (Figure 8-57).

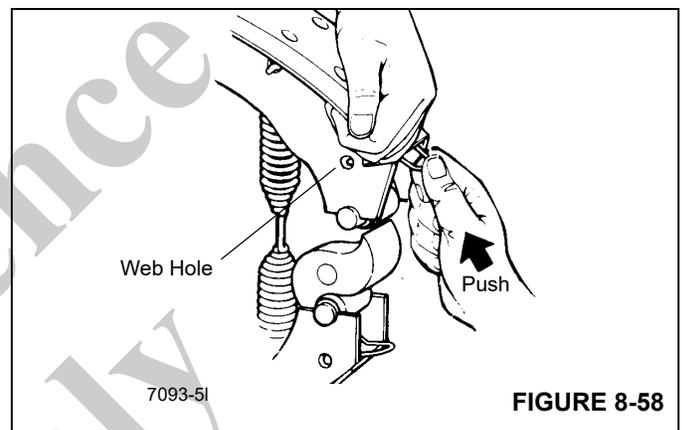


FIGURE 8-58

5. Install the slack adjuster and adjust brakes (Figure 8-58). Refer to the following Sub-Section, *Automatic Slack Adjuster*, page 8-44.

**ANTI-LOCK BRAKE SYSTEM (ABS)/
AUTOMATIC TRACTION CONTROL (ATC)**

ABS System Description

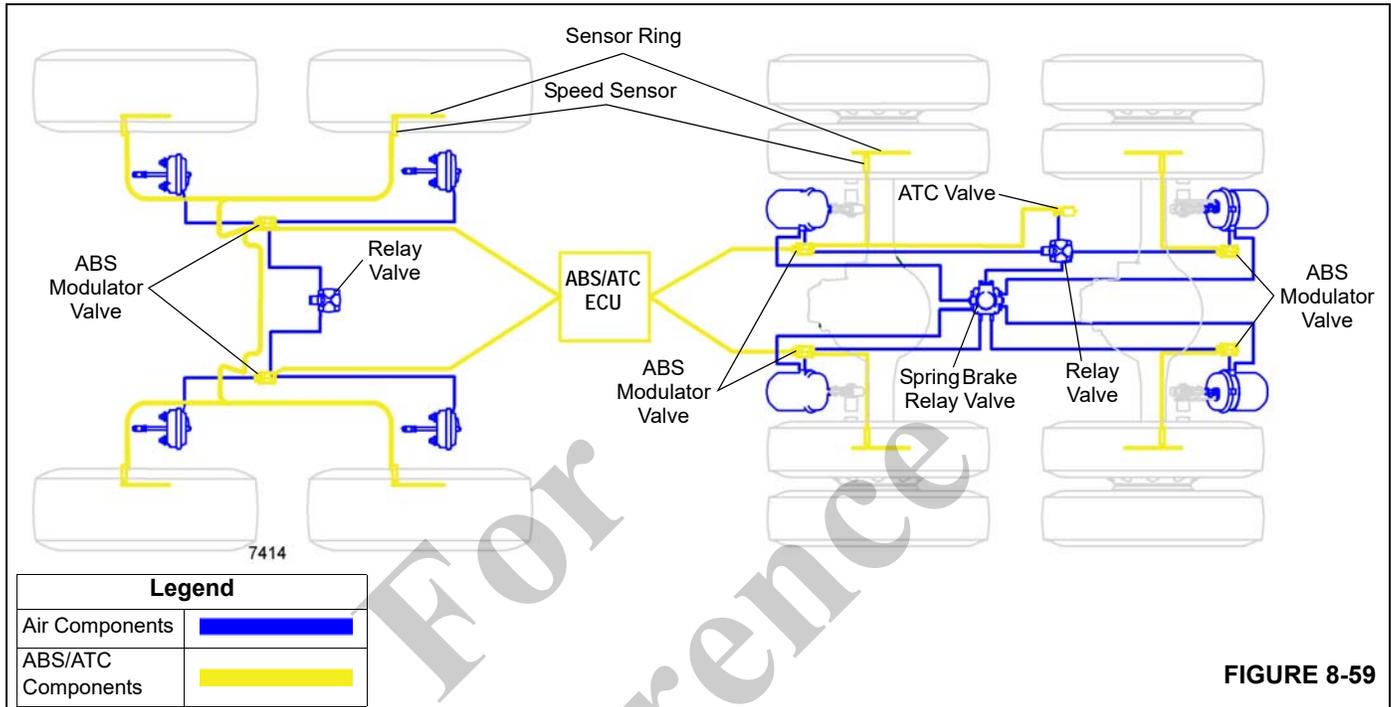
The Bendix Anti-Lock Braking System (ABS) (Figure 8-59) is an electronically controlled system that continually monitors wheel speed and controls wheel braking during extreme braking situations. The ABS is an important component of the foundation brake system. Its purpose is to prevent wheels from locking up when the brakes are applied with great intensity under normal road conditions or when applied normally on slippery road surfaces.

The ABS works in conjunction with the standard vehicle braking system. The ABS monitors the vehicle wheel speed at all times and helps control braking during hard braking or slippery road conditions. The ABS improves the vehicle's stability and control by reducing wheel lock during braking.

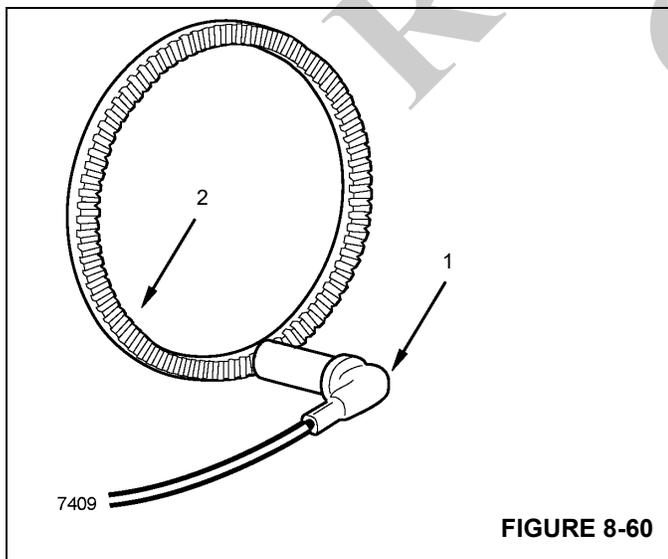
The ABS electronically monitors the rotational speed of both front wheels and the wheels on the rear axle. The wheel

rotation signals are sent to an Electronic Control Unit (ECU) which sends signals to the ABS modulator valves if it detects that a wheel has locked up or is about to lock up. The

modulator valves control the pressure in the brake assembly air chambers.



Wheel rotation is determined by an electronic sensor (1), (Figure 8-60) mounted in the brake spider. A signal is generated by the sensor as high spots on a tooth wheel (2), (Figure 8-60) pass by the sensor. The tooth wheel is either mounted on or is part of the wheel hub.

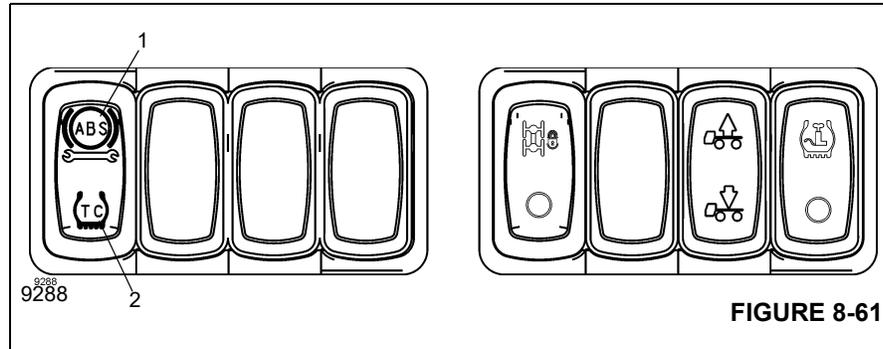


ABS Indicator

The ABS control unit contains a self-testing program that is engaged each time the ignition is turned on. The operator can verify the testing by listening for the ABS modulator valves actuating twice in series. To increase the sound, hold down the foot brake pedal when the ignition is turned on.

NOTE: The ECU will not perform the configuration test when the speed sensors detect that the vehicle is in motion.

If the indicator (1), (Figure 8-61) stays on, there is a problem with the ABS. If the ABS indicator lights during driving, the ABS self test has detected a fault in the system. The vehicle can still be driven with a problem in the ABS. However, the ABS will not be operating and standard air braking is in effect.



ATC System Description

Just as ABS improves vehicle stability during braking, ATC improves vehicle stability and traction during vehicle acceleration. The Electronic Control Unit (ECU) ATC function uses the same wheel speed information and modulator control as the ABS function. The ECU detects excessive drive wheel speed, compares the speed of the front, non-driven wheels, and reacts to help bring the wheel spin under control. The ECU is configured to use engine torque limiting and differential braking to control wheel spin. The ATC system is controlled by the ABS ECU. It helps improve traction on slippery or unstable driving surfaces by preventing excessive wheel spin. ATC also enhances vehicle stability by prevention of initial loss of traction.

ATC Operation

During periods of wheel slip, the Electronic Control Unit enters an Automatic Traction Control mode. There are various modes of Automatic Traction Control.

System Operation

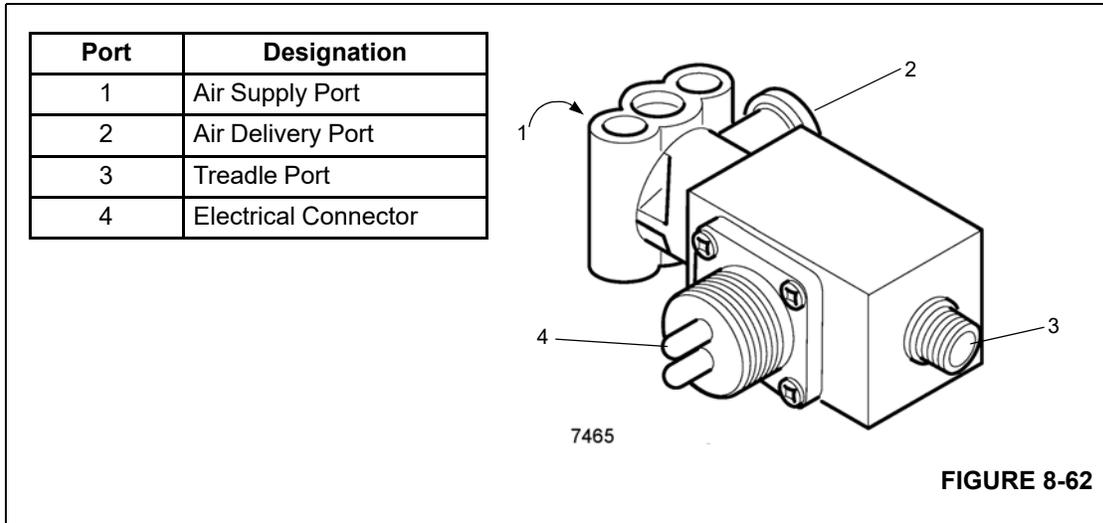
- At speeds above 40 km/h (25 mph), the engine is throttled back via the data link to control spin out.

- At speeds below 40 km/h (25 mph), both engine control and differential brake control are activated as required to control wheel slip. Once triggered, differential braking mode remains active regardless of vehicle speed.
- The off-road switch allows greater wheel spin (more torque) when activated. It is intended for adverse conditions, usually off-highway. The switch is programmed for momentary operation. ATC reverts to normal operation when the switch is cycled a second time and whenever the system goes through a power-up cycle.

ATC Valve

During normal operation, air is delivered to the ATC valve treadle port (3), (Figure 8-62) from the Brake Pedal Control Valve, which in turn supplies the air from the air delivery port (2), (Figure 8-62) to the Rear Service Brake Relay Valve.

When traction control is utilized, the ATC valve is activated, diverting supply tank air from the air supply port (1), (Figure 8-62) to the Modulator Valves on the drive axle(s) by way of the air delivery port (2), (Figure 8-62). The Electronic Control Unit then activates the appropriate solenoids in order to apply a brake force to the spinning wheel. The Automatic Traction Control System cannot increase traction to a particular wheel; it can only utilize the available traction.



ATC Indicator

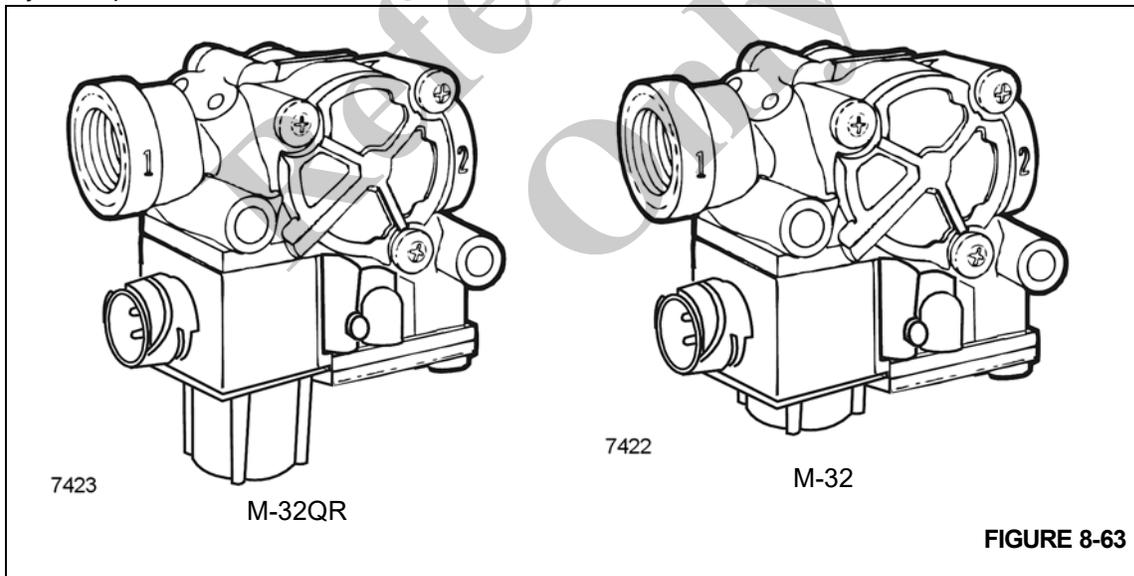
The ATC indicator (2), (Figure 8-61) is the primary indicator of the ATC status. The ATC indicator:

- Lights at key-ON and turns off after a two second lamp check. ATC is active after the lamp check.
- Flashes rapidly when ATC is operating.
- Flashes slowly when the off-road mode is selected and then flashes more rapidly when the automatic traction control system operates.

- Remains ON if an engine data link failure occurs.

Pressure Modulator Valves

Two types of ABS brake modulator valves are used with the Bendix Anti-Lock Brake System: the M-32 and the M-32QR (quick release) (Figure 8-63) anti-lock system modulators. This section includes general information on both valves.



The M-32 and M-32QR (quick release) anti-lock system modulators are high capacity, on/off air valves that use a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface between the anti-lock controller electronics and the air brake system. The modulator is used to control the braking function during anti-lock activity.

The modulator consists of a die cast aluminum body and a solenoid assembly which contains one normally open solenoid, one normally closed solenoid, and an inlet and exhaust diaphragm valve. A three-pin, weather resistant electrical connector is an integral part of the modulator solenoid assembly and serves to carry control commands from the anti-lock controller to the modulator. The supply,

delivery and exhaust ports on both modulators are identified with a cast, embossed numeral for positive identification.

Acceptable Tire Sizes

The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 revolutions per mile. This figure is based on the actual rolling circumference of the tires, which varies with tire size, tire wear, tire pressure, vehicle loading, etc. The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all wheels. For a 100 tooth exciter ring, the minimum number of tire revolutions per mile is 426, and the maximum is 567.

The ECU will set diagnostic trouble codes if the number of revolutions is out of this range. In addition, the size of the steer axle tires compared to the drive axle tires also has to be within the ABS system design. To avoid diagnostic trouble codes, the ratio of the effective rolling circumference of the steer axle, divided by the effective rolling circumference of the drive axle, must be between 0.85 to 1.15.

ABS Troubleshooting

Diagnostic Connector and ABS Diagnostic Switch Location

The 9-pin on board diagnostic connector (1), (Figure 8-64) is located under the dashboard to the left of the steering column. The ABS diagnostic switch (1), (Figure 8-64) is located near the lower left of the control panel as shown in (Figure 8-65).

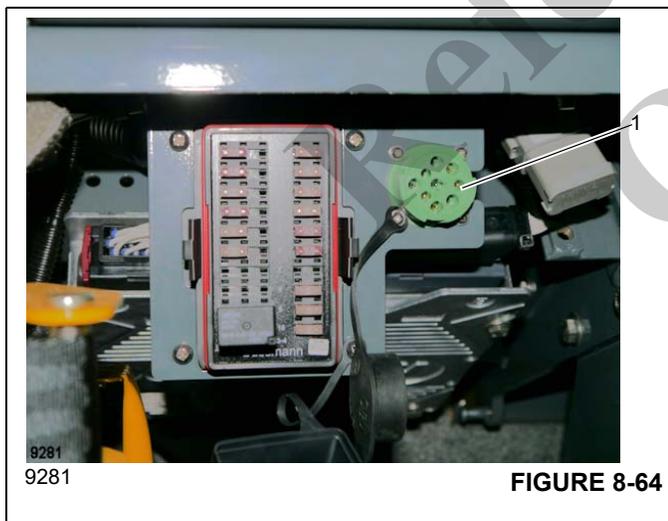


FIGURE 8-64

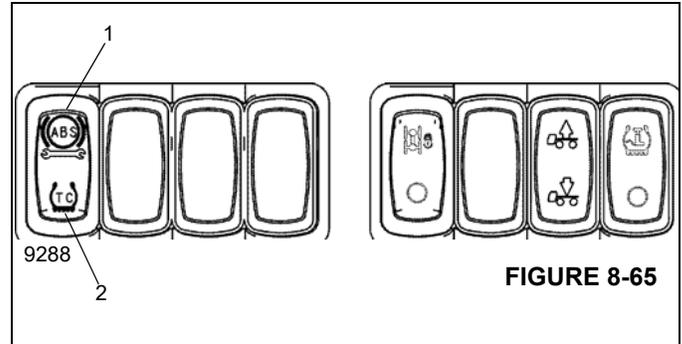


FIGURE 8-65

The ABS ECU is located at the rear of the cab behind the driver's seat. The ABS wiring harness is combined with the main cab and engine harness.

Troubleshooting: Blink Codes and Diagnostic Modes

The EC-60 controller (ECU) contains self-testing diagnostic circuitry that continuously checks for the normal operation of internal components and circuitry, as well as external ABS components and wiring.

ECU Diagnostics

Active Diagnostic Trouble Codes

When an erroneous system condition is detected, the EC-60 controller:

1. Illuminates the appropriate indicator lamp(s) and disengages part or all of the ABS and ATC functions.
2. Places the appropriate trouble code information in the ECU memory.
3. Communicates the appropriate trouble code information over the serial communications diagnostic link as required. Hand-held or PC-based diagnostic tools attach to the vehicle on board diagnostic connector, located under the left-side dash.

NOTE: When using a hand-held device such as the Bendix RDU or Pro-Link refer to the manual that came with the device.

Blink Codes

Blink codes allow a technician to troubleshoot ABS problems without using a hand-held or PC-based diagnostic tool. Instead, information about the ABS system is communicated by the ECU using the ABS indicator lamp to display sequences of blinks.

NOTE: The ECU will not enter the diagnostic blink code mode if the wheel speed sensors show that the vehicle is in motion. If the ECU is in the diagnostic blink code mode and then detects vehicle motion, it will exit the blink code mode.

In addition, by operating the blink code switch as described below, one of several diagnostic modes can be entered. Refer to Diagnostic Mode Selection.

Blink Code Switch Activation

When activating the blink code switch:

1. Wait at least two seconds after “ignition on.” (When entering Reconfiguration Mode, refer to Reconfigure ECU Mode.)
2. For the ECU to recognize that the switch is activated “on,” the technician must press for at least 0.1 second, but less than five seconds. (If the switch is held for more than five seconds, the ECU will register a malfunctioning switch.)
3. Pauses between pressing the switch when a sequence is required, (e.g. when changing mode) must not be longer than two seconds.
4. After a pause of 3.5 seconds, the ECU will begin responding with output information blinks.

Blink Code Timing

The ECU responds with a sequence of blink codes. The overall blink code response from the ECU is called a “message.” Each message includes, depending on the mode selected by the technician, a sequence of one or more groups of blinks. Simply record the number of blinks for each sequence and then use the Active or Inactive Diagnostic Trouble Codes Index for active or inactive trouble codes and you will be directed to the page that provides troubleshooting information.

Be aware of the following:

1. Sequences of blinks illuminate the ABS indicator lamp for half a second, with half-second pauses between them.
2. Pauses between blink code digits are 1.5 seconds.
3. Pauses between blink code messages are 2.5 seconds.
4. The lamp remains on for five seconds at the end of messages.

Once the ABS indicator lamp begins displaying a sequence of codes, it continues until all blink code messages have been displayed and then returns to the normal operating mode. During this time, the ECU will ignore any additional blink code switch activation.

All trouble codes, with the exception of voltage and J1939 trouble codes, will remain in an active state for the remainder of the power cycle.

Voltage trouble codes will clear automatically when the voltage returns within the required limits. All ABS functions will be re-engaged.

J1939 trouble codes will clear automatically when communications are re-established.

Diagnostic Modes

In order to communicate with the ECU, the controller has several modes that the technician can select, allowing information to be retrieved, or other ECU functions to be accessed.

Diagnostic Mode Selection

To enter the various diagnostic modes:

No. of Times to Press the Blink Code Switch	System Mode Entered
1	Active diagnostic trouble code retrieval
2	Inactive diagnostic trouble code retrieval
3	Clear active diagnostic trouble codes
4	System configuration check
5	Dynamometer Test Mode
7 ¹	Reconfigure ECU

- ¹ To enter the Reconfiguration Mode, the switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

Active Diagnostic Trouble Code Mode

For troubleshooting, typically the Active and Inactive Diagnostic Trouble Retrieval Modes are used. The technician presses the blink code switch once and the ABS indicator lamp flashes a first group of two codes, and if there are more trouble codes recorded, this is followed by a second set of codes, etc. (See Reconfigure ECU Mode for a directory of these codes.) All active trouble codes may also be retrieved using a handheld or PC-based diagnostic tool.

To clear active diagnostic trouble codes (as problems are fixed), simply clear (or “self-heal”) by removing and re-applying ignition power. The only exception is for wheel speed sensor trouble codes, which clear when power is removed, re-applied, and the ECU detects valid wheel speed from all wheel speed sensors. Alternately, codes may be cleared by pressing the diagnostic blink code switch three times (to enter the Clear Active Diagnostic Trouble Code Mode) or by using a hand-held or PC-based diagnostic tool. Hand-held or PC-based diagnostic tools are able to clear wheel speed sensor trouble codes without the vehicle being driven.

Inactive Diagnostic Trouble Code Mode

The ECU stores past trouble codes and comments (such as configuration changes) in its memory. This record is

commonly referred to as “event history.” When an active trouble code is cleared, the ECU stores it in the event history memory as an inactive trouble code.

Using blink codes, the technician may review all inactive trouble codes stored on the ECU. The ABS indicator lamp will display inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released two times. See Active or Inactive Diagnostic Trouble Codes for the index showing trouble codes and the troubleshooting guide page to read for help. Inactive trouble codes, and event history, may be retrieved and cleared by using a hand-held or PC-based diagnostic tool.

Clearing Active Diagnostic Trouble Codes

The ECU will clear active trouble codes when the diagnostic blink code switch is depressed and released three times.

Dynamometer Test Mode

The Dynamometer Test Mode is used to disable ATC when needed (e.g. when performing any vehicle maintenance where the wheels are lifted off the ground and moving, including dyno testing). This mode is not reset by power off, power on, cycling. Instead a hand-held or PC-based diagnostic tool must be used to change the setting. Alternatively, depressing and releasing the blink code switch three times will cause the ECU to exit the blink code mode.

Reconfigure ECU Mode

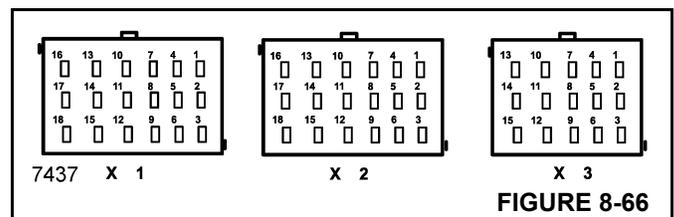
NOTE: To enter the Reconfiguration Mode, the blink code switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

System Configuration Check Mode

The ABS indicator lamp will display system configuration information when the diagnostic blink code switch is depressed and released four times. The lamp will blink out configuration information codes using the patterns listed in the System Configuration Check table, shaded rows indicate proper code: “2-6-6-1-5-1”. In this mode the ECU tells the technician, by means of a series of six blink codes, the type of ABS system that the ECU has been set up to expect.

System Configuration Check	
1st Number	System Power
1	12 Volts
2	24 Volts
2nd Number	Wheel Speed Sensors
4	4 Sensors
6	6 Sensors
3rd Number	Pressure Modulator Valves
4	4 Modulators
5	5 Modulators
6	6 Modulators
4th Number	ABS Configuration
1	4S/4M or 6S/6M
2	6S/4M
3	6S/5M
5th Number	Traction Control Configuration
2	No ATC
3	ATC Engine Control Only
4	ATC Brake Control Only
5	Full ATC (Engine Control and Brake Control)
6th Number	Retarder Configuration
1	No Retarder
2	J1939 Retarder
3	Retarder Relay
4	J1939 Retarder, Retarder Relay

EC-60 Controller Wire Harness Connector Pin Assignments



Conn. Designation	Number of Contacts	Deutsch Part Number
X1	15	DT16-15SA-K003
X2	18	DT16-18SB-K004
X3	18	DT16-18SC-K004

X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	J1587 (B)
2	Trailer ABS WL	8	J1939 High	14	J1587 (A)
3	Ignition	9	SLS	15	ABS WL Interlock
4	TCV CMN	10	WSS DA Right (+)	16	Battery
5	TCV	11	WSS DA Right (-)	17	Not Used
6	ATC Lamp/Switch	12	ABS WL Ground	18	ABS WL

X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	PMV SA Left HLD	7	PMV SA Right REL	13	PMV DA Right REL
2	PMV SA Left REL	8	WSS SA Left (-)	14	WSS SA Right (-)
3	PMV SA Left CMN	9	PMV DA Right CMN	15	WSS DA Left (+)
4	PMV SA Right HLD	10	PMV DA Right HLD	16	PMV DA Left HLD
5	WSS SA Left (+)	11	WSS SA Right (+)	17	PMV DA Left REL
6	PMV SA Right CMN	12	PMV DA Left CMN	18	WSS DA Left (-)

X3 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	ABS ORS	6	PMV AA Left CMN	11	WSS AA Left (+)
2	Not used	7	PMV AA Left REL	12	WSS AA Right (+)
3	Not Used	8	Input/Output 3	13	PMV AA Right REL
4	PMV AA Left HLD	9	PMV AA Right CMN	14	WSS AA Left (-)
5	Input/Output 2	10	PMV AA Right HLD	15	WSS AA Right (-)

Active or Inactive Diagnostic Trouble Codes: Index

How to interpret the first digit of messages received when Active or Inactive Diagnostic Trouble Code Mode is entered:

1st Blink Code Number	Troubleshooting Test Location	Refer to
1	No faults (Code 1, 1)	
2	Wheel Speed Sensors	page 8-65
3	Wheel Speed Sensors	page 8-65
4	Wheel Speed Sensors	page 8-65
5	Wheel Speed Sensors	page 8-65
6	Power Supply	page 8-70
7	Pressure Modulator Valves	page 8-67
8	Pressure Modulator Valves	page 8-67
9	Pressure Modulator Valves	page 8-67
10	Pressure Modulator Valves	page 8-67
11	J1939	page 8-71

1st Blink Code Number	Troubleshooting Test Location	Refer to
12	Miscellaneous	page 8-72
14	Wheel Speed Sensors	page 8-65
15	Wheel Speed Sensors	page 8-65
16	Pressure Modulator Valves	page 8-67
17	Pressure Modulator Valves	page 8-67
18	Traction Control Valves	page 8-69

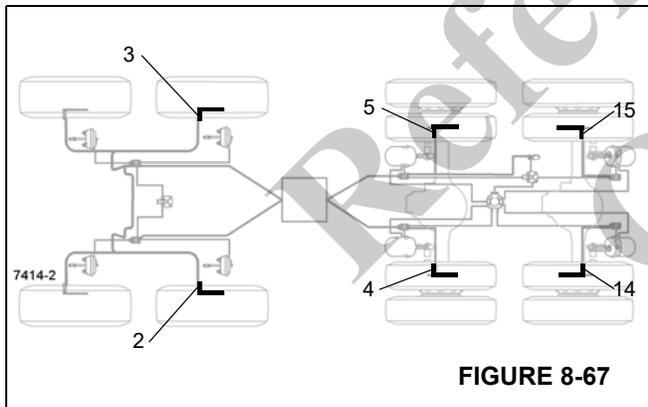
Example: For a message sequence of 3, 2 and 12, 4. For the first sequence (3, 2), go to Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors, page 8-65; the first code (3) indicates Right Steer Axle Sensor the second code (2) indicates Output Low at Drive-off. The second sequence (12, 6), go to Troubleshooting Diagnostic Trouble Codes: Miscellaneous, page 8-72; the first code (12) indicates Miscellaneous and the second code (6) indicates ABS Indicator Lamp Circuit Fault.

¹ The front steer axles have sensors installed but are not electrically connected.

Troubleshooting Diagnostic Trouble Codes: ECU

The 1st. Blink Code is 13, the 2nd. Blink Codes are 2-13. For all codes, check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If diagnostic trouble codes return, replace the ECU.

Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors



1st Blink Code	Location
2	Left Steer Axle Sensor ¹
3	Right Steer Axle Sensor ¹
4	Left Drive Axle Sensor
5	Right Drive Axle Sensor
14	Left Additional Axle Sensor
15	Right Additional Axle Sensor

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
2	Output Low at Drive-off	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
3	Open or Shorted	Verify 1500-2500 ohms across sensor leads. Verify no continuity between sensor leads and ground or voltage. Verify no continuity between sensor leads and other sensors. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
4	Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
5	Wheel End	Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check mechanical function of brake. Check for kinked or restricted air lines.
6	Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
7	Tire Size Calibration	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth.
8	Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.

Speed Sensor Repair Tests

1. Take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.
2. Wheel speed sensor measurements should read:

Location	Measurement
Sensor	1500 - 2500 Ohms
Sensor to voltage or ground	Open Circuit (no continuity)
Sensor output voltage	0.25 of VAC sensor output at ~ 0.5 revs/ sec.

3. Clear DTC after issue is corrected. The sensor DTC will remain until the power is cycled to the ABS ECU and vehicle is driven above 15 MPH or DTC was cleared using either the diagnostic blink code switch or diagnostic tool.

ECU Wire Harness Connector: Speed Sensor Pins

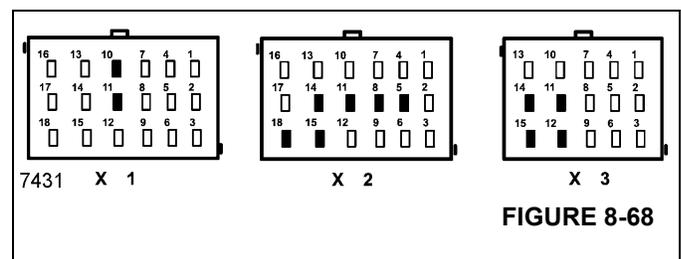
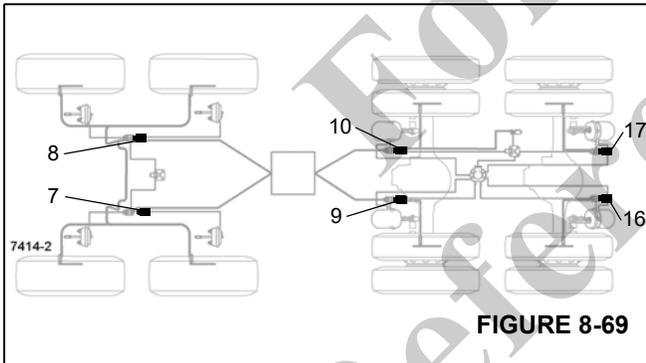


FIGURE 8-68

Connector	Pin	Wheel Speed Sensor Location
X1 18 Way	10	Right Drive Axle (+)
	11	Right Drive Axle (-)
X2 18 Way	5	Left Steer Axle (+)
	8	Left Steer Axle (-)
	11	Right Steer Axle (+)
	14	Right Steer Axle (-)
	15	Left Drive Axle (+)
X3 15 Way	11	Left Additional Axle (+)
	14	Left Additional Axle (-)
	12	Right Additional Axle (+)
	15	Right Additional Axle (-)

**Troubleshooting Diagnostic Trouble Codes:
Pressure Modulator Valves**



1st Blink Code	Location
7	Left Steer Axle
8	Right Steer Axle
9	Left Drive Axle
10	Right Drive Axle
16	Left Additional Axle
17	Right Additional Axle

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Release Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
2	Release Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
3	Release Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
4	Hold Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
5	Hold Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
6	Hold Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
7	CMN Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
8	Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration.

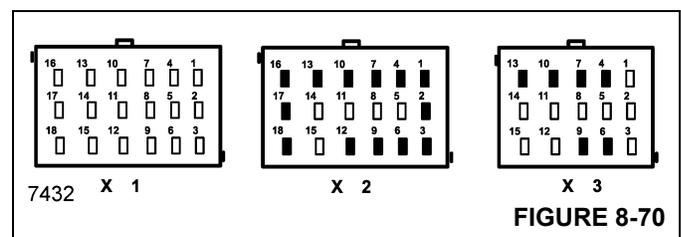
Pressure Modulator Valve Repair Test

1. Take all measurements at ECU harness connector pins in order to check wire harness and PMV. Probe the connector carefully so that the terminals are not damaged.
2. Pressure modulator resistance should read:

Location	Measurement
Release to Common	4.9 to 5.5 Ohms
Hold to Common	4.9 to 5.5 Ohms
Release to Hold	9.8 to 11.0 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

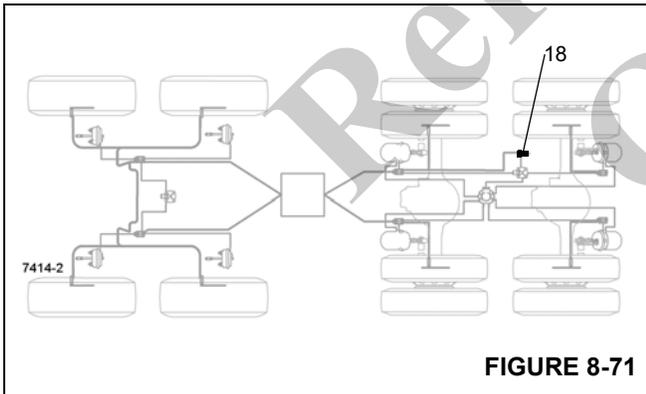
NOTE: When troubleshooting modulator trouble codes, check inactive trouble codes and event history for over-voltage or excessive noise trouble codes. If one of these is found, troubleshoot these trouble codes first before the PMV.

ECU Wire Harness Connector: Pressure Modulator Valves Pins



Connector	Pin	PMV Location
X2 18 Way	1	Left Steer Axle Hold
	2	Left Steer Axle Release
	3	Left Steer Axle Common
	4	Right Steer Axle Hold
	6	Right Steer Axle Common
	7	Right Steer Axle Release
	9	Right Drive Axle Common
	10	Right Drive Axle Hold
	13	Right Drive Axle Release
	12	Left Drive Axle Common
	16	Left Drive Axle Hold
	17	Left Drive Axle Release
X3 15 Way	4	Left Additional Axle Hold
	6	Left Additional Axle Common
	7	Left Additional Axle Release
	9	Right Additional Axle Common
	10	Right Additional Axle Hold
	13	Right Additional Axle Release

**Troubleshooting Diagnostic Trouble Codes:
Traction Control Valves**

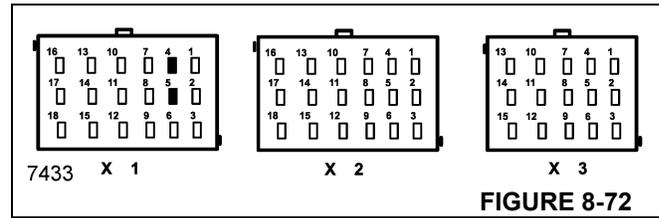


1st Blink Code	Location
18	Traction Control Valve

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	TCV Solenoid Shorted to Ground	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded / damaged wiring or connectors between ECU and TCV.
2	TCV Solenoid Shorted to Voltage	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded / damaged wiring or connectors between ECU and TCV.
3	TCV Solenoid Open Circuit	Verify 7 to 19 ohms between TCV and TCV common. Check for corroded / damaged wiring or connectors between ECU and TCV.

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
4	TCV Configuration Error	The ECU is not configured for TCV, but has detected the presence of a TCV. Verify TCV wiring. Inspect for the presence of a TCV. Verify ECU configuration.

ECU Wire Harness Connector: Traction Control Valve Pins



Traction Control Valve Repair Tests

1. Take all measurements at ECU harness connector pins in order to check wire harness and traction control valve. Probe the connector carefully so that the terminals are not damaged.
2. Tractor Control Valve resistance measurements should read:

Location	Measurement
TCV to TCV Common	7 to 19 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

Connector	Pin	Traction Control Test
X1 18 Way	4	Traction Control Valve Common
	5	Traction Control Valve

Troubleshooting Diagnostic Trouble Codes: Power Supply

1st Blink Code	Location
6	Power Supply

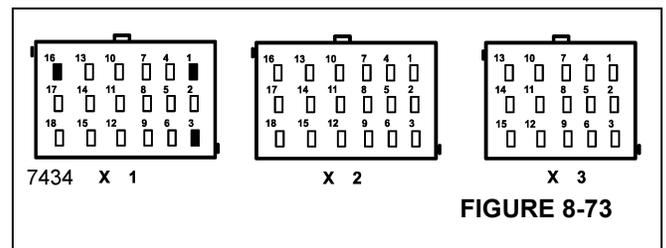
Reference Only

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Battery Voltage Too Low	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
2	Battery Voltage Too High	Measure battery voltage under load. Ensure that battery voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
3	Battery Voltage Too Low During ABS	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
4	Battery Voltage Open Circuit	Measure battery voltage under load. Check condition of fuse. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
5	Ignition Voltage Too Low	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections. Check condition of fuse.
6	Ignition Voltage Too High	Measure ignition voltage under load. Ensure that ignition voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
7	Ignition Voltage Too Low During ABS	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
8	Input Voltage has Excessive Noise (Temporary)	Check alternator output for excessive noise. Check for other devices causing excessive noise.
9	Input Voltage has Excessive Noise	Check alternator output for excessive noise. Check for other devices causing excessive noise.

Power Supply Tests

1. Take all measurements at ECU harness connector.
2. Place a load (e.g. an 1157 stop lamp) across battery or ignition and ground connection, measure ignition and battery voltage with the load. Ignition to Ground should measure between 9 to 17 VDC. Battery to Ground should also measure between 9 to 17 VDC.
3. Check for damaged wiring, damaged or corroded connectors and connections.
4. Check condition of vehicle battery and associated components. Verify ground connection is good and tight.
5. Check alternator output for excessive noise.

ECU Wire Harness Connector: Power Supply Pins



Connector	Pin	Traction Control Test
X1 18 Way	1	Ground
	3	Ignition
	16	Battery

Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications

J1939 Troubleshooting Tests

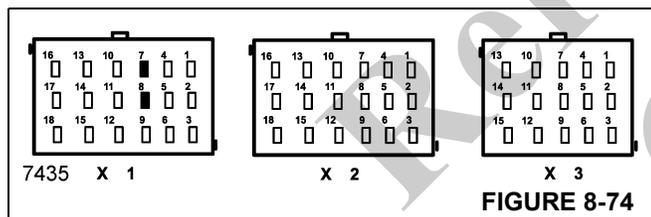
1. Take all measurements at ECU harness connector.
2. Check for damaged or reversed J1939 wiring.

3. Check for corroded or damaged wiring connector problems such as opens or shorts to voltage or ground.
4. Check for other J1939 devices which may be loading down (inhibiting) J1939 communication.

1st Blink Code	Location
11	J1939

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	J1939 Serial link	Loss of communications between the E-60 controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
2	J1939 Retarder	Loss of communications between the E-60 controller and other devices connected the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of retarder on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
3	J1939 Engine Communications	Loss of communications between the E-60 controller and the engine ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.

ECU Wire Harness Connector: J1939 Serial Communications Pins



Connector	Pin	J1939
X1	7	J1939 Low
18 Way	8	J1939 High

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st Blink Code	Location
12	Miscellaneous

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Stop Lamp Switch Not Detected	ECU has not detected the presence of the stop lamp switch since ignition power was applied (note that stop lamp switch input may be applied to the E-60 controller using either hardwire input or J1939). Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
2	Stop Lamp Switch Defective	Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
3	Dynamometer Test Mode	ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or a hand-held or PC-based diagnostic tool. ATC is disabled.
4	Retarder Relay Open Circuit or Shorted to Ground	Verify vehicle contains a retarder relay. Verify ECU configuration. Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of E-60 controller and ground. Verify condition and wiring of the retarder relay.
5	Retarder Relay Circuit Shorted to Voltage	Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of E-60 controller and voltage. Verify condition and wiring of the retarder relay.
6	ABS Indicator Lamp Circuit Fault	Check operation of diagnostic blink code switch. Check wiring of diagnostic blink code switch, ABS WL and ABS WL relay (frame ECUs only). Verify ABS WL ground input (cab ECUs only).
7	PMV Common Shorted to Ground	Verify no continuity between the CMN of all PMVs, TCV, and Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and CMN of all PMVs, TCV and Diff. Lock Solenoid.
8	PMV Common Shorted to Voltage	Verify no continuity between the CMN of all PMVs, TCV, and Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and CMN of all PMVs, TCV and Diff. Lock Solenoid.
9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes.
10	Tire Size Out of Range (Front to Rear)	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth. Verify that the ECU has the proper tire size settings.
11	Wheel Speed Sensors Reversed on an Axle	Sensors are reversed (left to right) on one of the axles. Verify proper installation, connection and wiring of the sensors.
12	Diff. Lock Solenoid Shorted to Ground or Open Circuit	Verify no continuity between the Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and Diff. Lock Solenoid.
13	Diff. Lock Solenoid Shorted to Voltage	Verify no continuity between the Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and Diff. Lock Solenoid.
23	I/O 2 or I/O 3 Shorted High	Check for short circuit condition between voltage and the I/O 2 and I/O 3 circuits.

Miscellaneous Troubleshooting

For all tests below, take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.

Stop Lamp Switch Test

1. With the service brake applied, measure the system voltage (9 to 17 VDC) stop lamp switch input to ECU.
2. Apply and release service brake. Does lamp extinguish?

3. Verify brake lamp switch is connected to ECU via hard wire or J1939.
4. With service brake released, check for presence of stop lamp bulb.

Dynamometer Test Mode (ATC Indicator Lamp Continuously Illuminated)

Clear the dynamometer test mode by depressing and releasing the blink code switch three times (or use an off-board diagnostic tool).

ABS Indicator Lamp

Verify diagnostic blink code switch is open when not activated.

PMV Commons

Measure resistance between any common (PMV, TCV and Diff.) and voltage or ground.

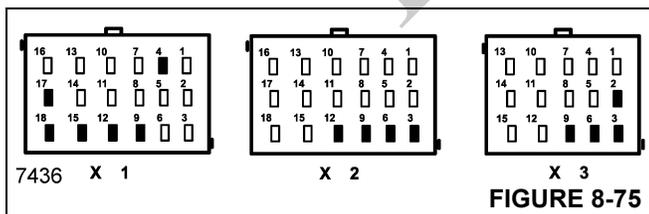
Test	Measurement
Any PMV, TCV or Diff. Common to Voltage or Ground	Open Circuit (no continuity)

Differential Lock Solenoid

Measure resistance between Diff lock solenoid and voltage or ground.

Test	Measurement
Diff. Lock Solenoid to Voltage or Ground	Open Circuit (no continuity)

ECU Wire Harness Connector: Miscellaneous Pins



Connector	Pin	PMV Location
X1 18 Way	4	TCV Common
	9	Stop Lamp Switch
	12	ABS WL Ground
	15	ABS WL Interlock
	17	Not Used
	18	ABS WL

Connector	Pin	PMV Location
X2 18 Way	3	PMV Left Steer Axle Common
	6	PMV Right Steer Axle Common
	9	PMV Right Drive Axle Common
	12	PMV Left Drive Axle Common
X3 15 Way	2	Diff. Lock Solenoid
	3	Diff. Lock Solenoid Common
	6	PMV Left Additional Axle Common
	9	PMV Right Additional Axle Common

Troubleshooting Wiring

CAUTION

Possible Equipment Damage!

All unused ECU connectors **MUST** be covered and receive proper environmental protection.

ABS/ATC Wiring

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.

CAB ECU Wiring Harness Connectors

The in-cab EC-60™ controllers are designed to interface with AMP MCP 2.8 connectors. Follow all AMP requirements for the repair of wire harnesses.

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.

ABS Wiring Requirements

As a matter of good practice and to ensure maximum system robustness, always use the maximum size wire supported by the wire harness connectors for battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and indicator lamp circuits.

All sensor and serial communications circuits (J1587 and J1939) must use twisted pair wiring (one to two twists per inch). See the appropriate SAE document for additional details.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend. Battery and ground wires should be kept to a minimum length.

If convoluted tubing is used, its I.D. must match the size of the wire bundle as closely as possible.

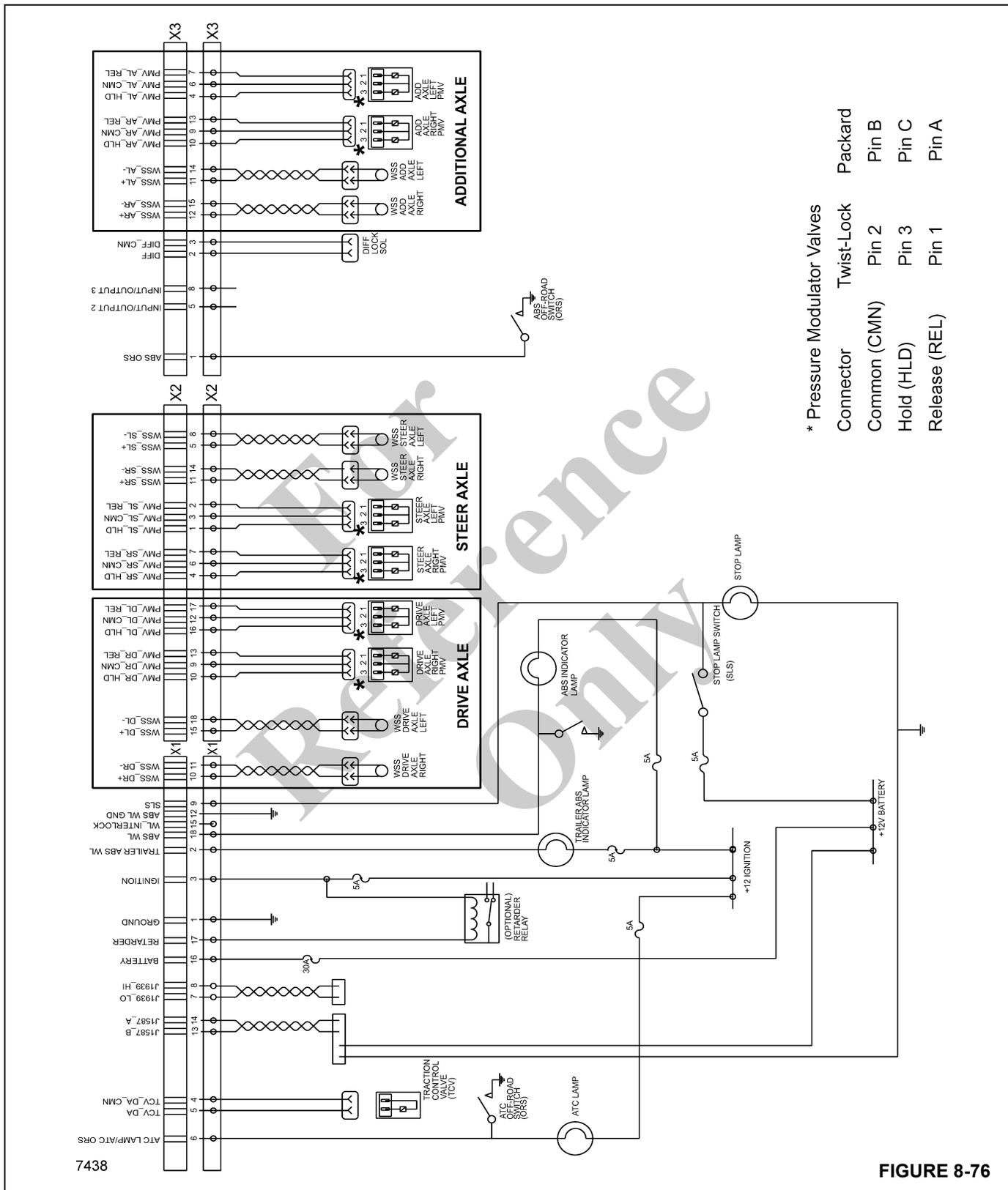
CAUTION**Possible Equipment Damage!**

All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured approximately every 6 to 12 inches using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

Wire harness lengths **MUST** be carefully selected for the vehicle. Harnesses that are too long increase the possibility of electrical interference and wire damage. Excess lengths of wire are not to be wound to form coils, instead re-route, repair or replace wire harness. **DO NOT** attempt to stretch harnesses that are too short, since mechanical strain can result in wire breakage.

For
Reference
Only

ABS/ATC Cab Wiring Schematic



* Pressure Modulator Valves

Connector	Twist-Lock	Packard
Common (CMN)	Pin 2	Pin B
Hold (HLD)	Pin 3	Pin C
Release (REL)	Pin 1	Pin A

FIGURE 8-76

ABS/ATC Frame Wiring Schematic

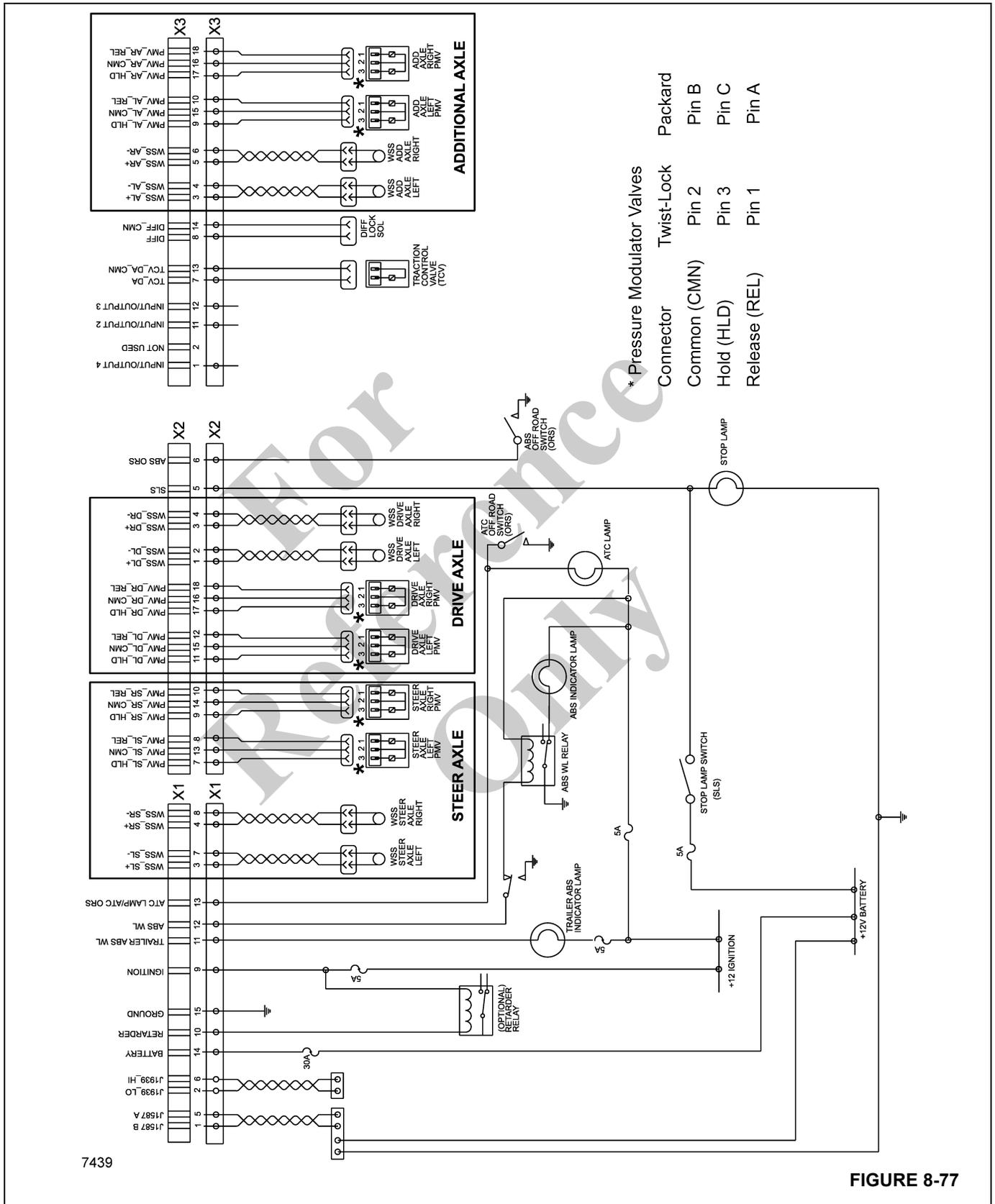
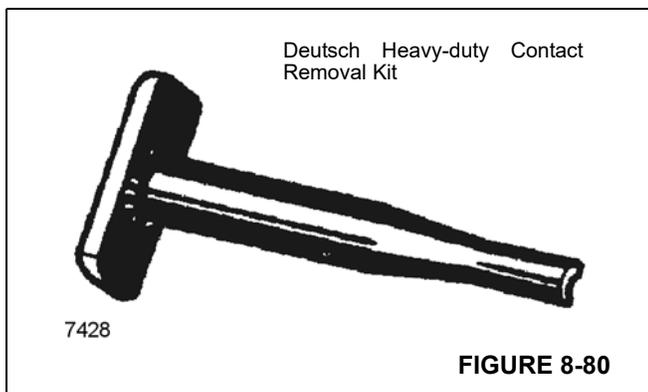
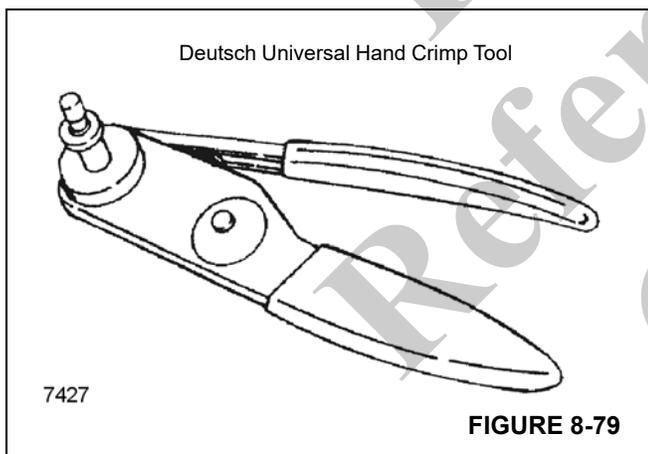
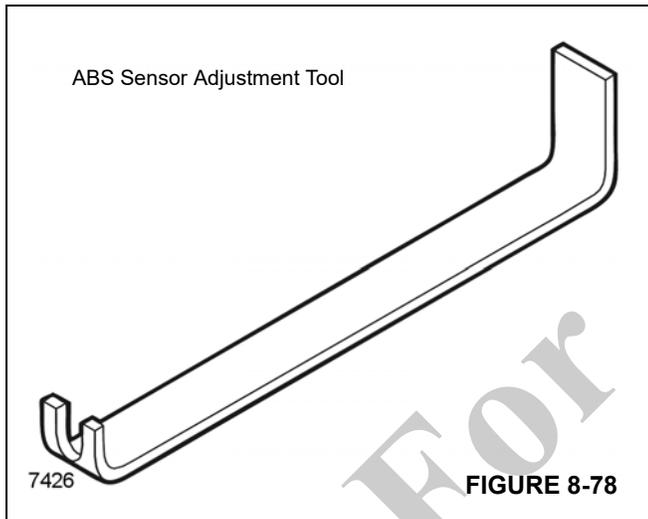


FIGURE 8-77

SPECIAL TOOLS

The following tools are recommended for use in the procedures described in this manual. In some cases, use of the tool is necessary to carry out the troubleshooting / repair procedure. The following tools (Figure 8-78), (Figure 8-79) and (Figure 8-80) are recommended for use in the procedures described in this manual.



Tests, Repair and Adjustment

ABS EC-60 Controller

Installing a New ABS EC-60 Controller

NOTE: When replacing the EC-60 controller, verify the unit you are installing has the correct default settings. Failure to do so could result in a loss of features, such as ATC and PLC, or noncompliance with U.S. regulations such as FMVSS 121. It is recommended to use only the correct replacement part number. Verify correct operation of the EC-60 controller system and indicator lamps prior to putting the vehicle back into service. Towing vehicles manufactured after March 1, 2001 must support the trailer ABS indicator lamp located on the dash. For further information, contact either your authorized Manitowoc Cranes distributor or Manitowoc Crane Care.

1. Position and secure the EC-60 controller in the original mounting orientation using the mounting bolts retained during removal.
2. Torque the mounting bolts for frame-mounted units to 7.5 to 9 Nm (66-80 in-lb). Over tightening the mounting hardware can cause damage to the EC-60 controller.
3. Reconnect the electrical connectors to the EC-60 controller.
4. Apply power and monitor the EC-60 controller power-up sequence to verify proper system operation.

Reconfiguring EC-60 Controllers

The EC-60 controller is programmed for features specific to this Grove crane. Contact your Manitowoc Cranes distributor or Manitowoc Crane Care if reconfiguring the controller is necessary.

ATC Valve

Follow the steps listed below to locate and correct ATC problems.

1. Access active diagnostic trouble code(s) using either the Blink Code procedure or the hand-held tester procedure.
2. Lookup the code description, the possible causes and the repair procedures provided in this section.
3. Perform the recommended repair procedures.
4. After the repairs are completed, clear all codes and check for any additional codes.

ABS Modulator Valves

NOTE: For more in depth information on modulator valves go to the Bendix website and download the appropriate document.

1. Remove any accumulated contaminants and visually inspect the exterior for excessive corrosion and physical damage.
2. Inspect all air lines and wire harnesses connected to the modulator for signs of wear or physical damage. Replace as necessary.
3. Test air line fittings for leakage and tighten or replace as necessary.
4. Perform the Operational Valve and Leakage Test described in this manual.

Electrical Connector	Pin Values
41	Exhaust
42	Source
43	Hold

Leakage Test: M-32 and M-32QR Modulator Valves

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to full pressure.
2. Turn the engine OFF and make four or five brake applications and note that the service brakes apply and release promptly.
3. Build system pressure to governor cut-out and turn the engine OFF.
4. After determining the pressure loss with the brakes released (2 psi/minute allowed), make and hold a full service brake application. Allow the pressure to stabilize for one minute.
5. Begin timing pressure loss for two minutes while watching the dash gauges for a pressure drop. The leakage rate for the service reservoirs should not exceed 3 psi/ minute.
6. If either circuit exceeds the recommended 2 psi / minute, apply soap solution to the exhaust port of the modulator and any other components in the respective circuit.
7. The leakage at the exhaust port of most Bendix components, including M-32 modulators, should not exceed a 25 mm (one-inch) bubble in three seconds. If leakage at the modulator is determined to exceed the maximum limits, replace the modulator.

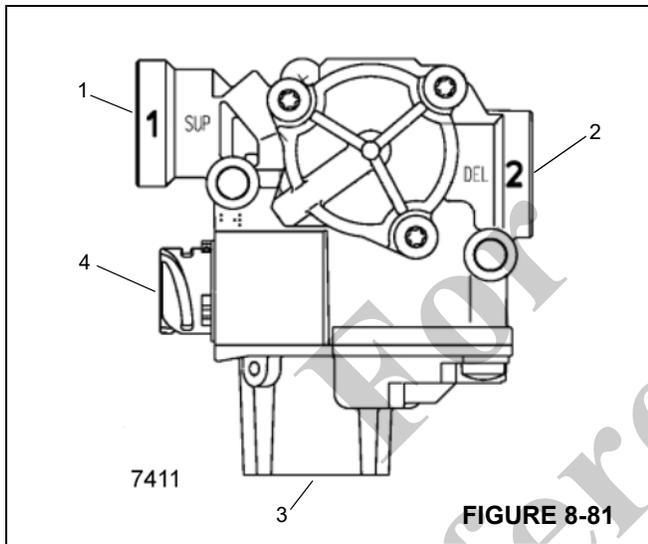


FIGURE 8-81

Port	Designation
1	Air Supply Port
2	Air Delivery Port
3	Air Exhaust Port
4	Elec. Connector-Twist Lock

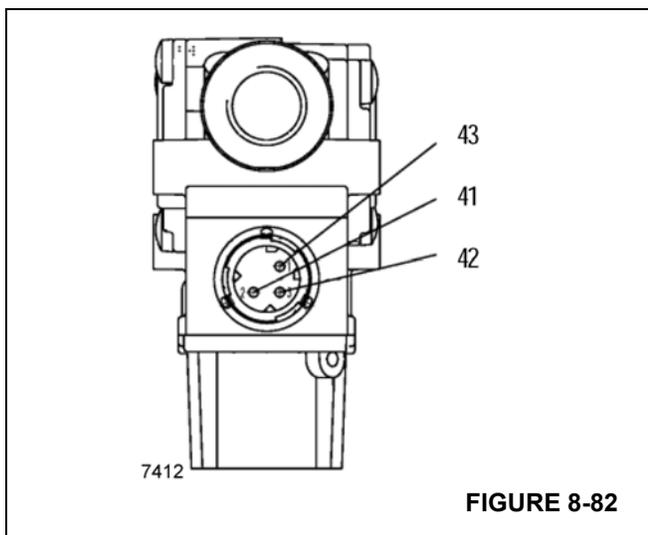


FIGURE 8-82

Operation Test: M-32 and M-32QR Modulator Valves

To properly test the function of the modulator will require two service technicians.

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to governor cut out.
2. Turn the engine ignition key to the "OFF" position then make and hold a full brake application.
3. With the brake application held, and one (1) service technician posted at one (1) of the modulators, turn the vehicle ignition key to the "ON" position. One or two short bursts of air pressure should be noted at the modulator exhaust. Repeat the test for each modulator on the vehicle. If at least a single burst of exhaust is not noted or the exhaust of air is prolonged and not short, sharp and well defined, perform the Electrical Tests.

Electrical Tests: Modulator Valves

NOTE: Before testing the solenoid assembly of a suspect modulator, its location on the vehicle should be confirmed using the Troubleshooting or Start Up procedure for the specific anti-lock controller in use. (See the Service Data Sheet for the anti-lock controller for this procedure at the Bendix website: [Bendix Service Literature.](#))

Proceed to the modulator in question and inspect its wiring connector. Disconnect the connector and test the resistance between the pins on the modulator. Refer to (Figure 8-82);

- Hold to Source (41-42): Read 4.9 to 5.5 ohms.
- Exhaust to Source (43-41): Read 4.9 to 5.5 ohms.
- Exhaust to Hold (43-42): Read 9.8 to 11.0 ohms.

Individually test the resistance of each pin to vehicle ground and note there is no continuity. If the resistance readings are as shown, the wire harness leading to the modulator may require repair or replacement. Before attempting repair or replacement of the wire harness, refer to the test procedures specified for the anti-lock controller in use for possible further testing that may be required to substantiate the wire harness problem. If the resistance values are not as stated, replace the modulator.

ABS Sensor Adjustment

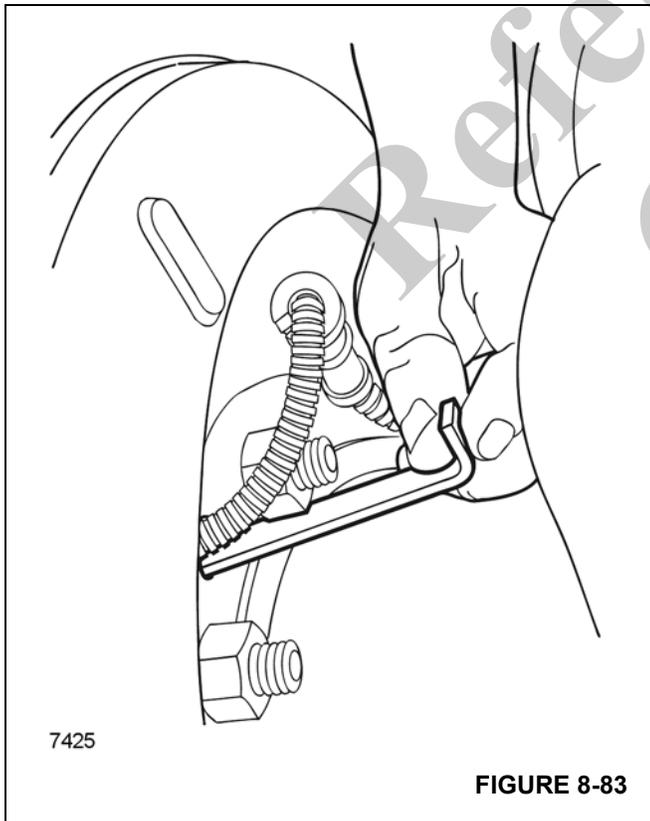


FIGURE 8-83

1. Slide the notched end of an ABS sensor adjustment tool (Figure 8-83) through the opening in the brake spider until it rests against the sensor (the tool will go in the hole at a slight angle).

NOTE: It is not necessary to remove the wheel or drum to adjust sensors using the adjustment tool.

CAUTION

Possible equipment damage!

DO NOT use a screwdriver or sharp instrument to adjust the sensor. Use of a sharp instrument could permanently damage the sensor.

DO NOT use a hammer to drive the sensor into position. Hammering the sensor could permanently damage it.

2. Press the sensor toward the wheel hub until the sensor contacts the tooth wheel.
3. Remove the sensor adjustment tool.
4. Verify proper sensor adjustment by driving the vehicle. This allows the ABS to perform an additional self test. Once the vehicle reaches approximately 11 km/h (7 mph), the ABS warning lamp will go out if the sensor is properly adjusted.
5. To check wheel speed sensor resistance, refer to Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors.

Component Removal and Installation



WARNING

Personal Injury Hazard!

Before working on a vehicle, set the parking brakes, place the transmission in neutral and block the wheels.

DO NOT work under a vehicle supported only by jacks. Always use jack stands under the vehicle.

Stop the engine and remove ignition key when working under or around the vehicle.

If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle.

Failure to follow these warnings can cause serious personal injury or death.

Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.

For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON, see Dynamometer Test Mode, page 8-63) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.

ATC Valve

Removal

1. Disconnect the wiring electrical connector (4), (Figure 8-62) from the ATC valve.
2. Disconnect the air lines from the supply (1), (Figure 8-62) and delivery port (2), (Figure 8-62) and treadle port (3), (Figure 8-73) of the ATC valve.
3. Disconnect the valve mounting fasteners, and remove the valve.

Installation

1. Install the ATC valve. Torque fasteners to manufacturers specification.
2. Connect air lines to the supply port (1), (Figure 8-62) delivery port (2), (Figure 8-62) and treadle port (3), (Figure 8-62) of the ATC valve.
3. Install the wiring connector to the ATC valve.
4. Test the installation.

Leak Test: Traction Control Valve

Make and hold brake application. No audible air leaks are permitted.

Traction Control Valve Component Test with Hand-Held Diagnostic Tool

1. Select Traction Control Valve.
2. Verify traction control light operation.
3. Drive the vehicle and verify ABS indicator lamp operates properly.



WARNING

Personal Injury and Machine Damage Hazard!

Do not start and engage the transmission with one wheel raised from the floor. With ATC, power will go to the wheel on the floor and cause the vehicle to move which can injure personnel or damage the machine.

See Dynamometer Test Mode, page 8-63 to disable ATC for dyno testing.

Modulator Valves M-32, M-32QR

Removal

1. Locate the modulator that will be replaced and clean the exterior.
2. Identify and mark or label all air lines and their respective connections on the valve to facilitate ease of installation.
3. Disconnect all air lines and the electrical connector.
4. Remove all air line fittings and plugs. These fittings will be re-used in the replacement modulator.

Installation

1. Install all air line fittings and plugs, making certain thread sealing material does not enter the valve.
2. Install the assembled valve on the vehicle.
3. Reconnect all air lines to the valve using the identification made during removal.
4. Reconnect the electrical connector to the modulator.
5. After installing the valve, test all air fittings for excessive leakage and tighten as needed.

Wheel Speed Sensor Replacement (Front)

Removal

Refer to (Figure 8-84).

1. Park the vehicle on a level surface. Apply the parking brake, place the transmission in neutral and block the rear wheels. Make sure vehicle ignition is in the "OFF" position.
2. Raise the wheel where the faulty sensor is located. Place jack stands of adequate rating under the axle.
3. Remove the wheel from the axle.
4. If equipped with spring brakes, release the brakes. Back off the slack adjuster.
5. Remove the brake drum, cam rollers, return spring and brake shoes.

NOTE: DO NOT pull on the sensor cable to remove it, as this may permanently damage the sensor. DO NOT use any device to pry the sensor from its mounting block, as this may damage the steel casing on the sensor and can void any existing warranty.

6. Remove the mounting bolts for the sensor bracket (2), (Figure 8-84). Cut the tie straps along the sensor cable. Remove the P-clips at the S-cam tube, bracket and frame rail. Using a slight twisting motion, remove the sensor from its mounting block. Use extreme care not to damage the tooth wheel or the sensor.

7. Remove the sensor spring clip (4), (Figure 8-84) from the mounting block.
8. Disconnect any fasteners that hold the sensor cable and the hose clamp to other components.
9. Disconnect the sensor from the vehicle wiring at the connector closest to the sensor.
10. Pull the sensor cable through the hole in the frame rail.

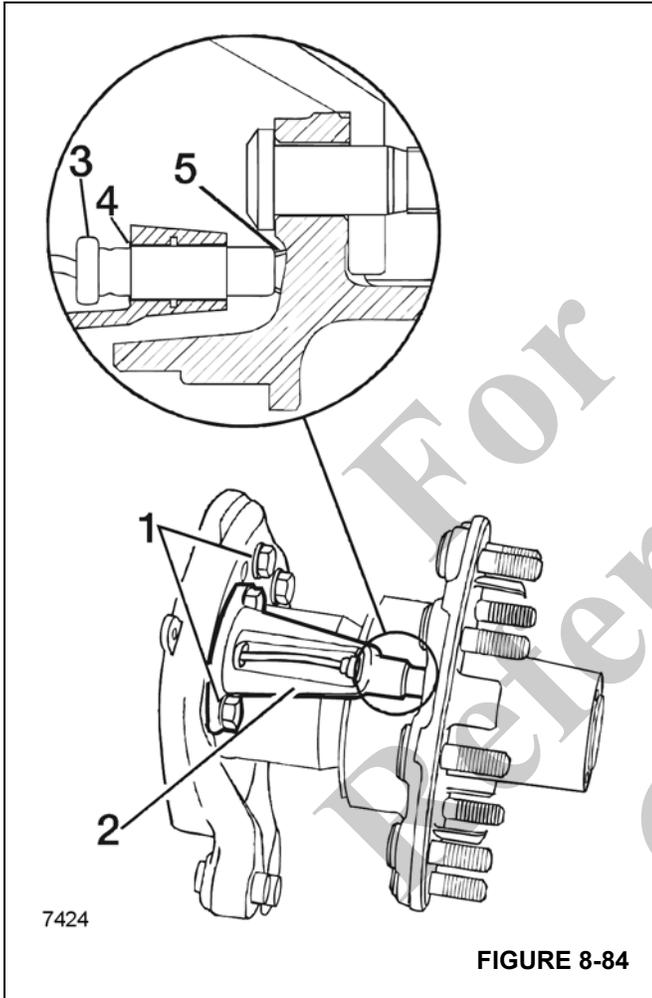


FIGURE 8-84

Item No.	Specification
1	Spider Mounting Bolts
2	Sensor Bracket
3	Sensor
4	Spring Clip
5	Tooth Wheel

Installation

Refer to (Figure 8-84).

NOTE: The sensor spring clip must be installed with the flange stops facing the inboard side of the vehicle.

1. Push the sensor spring clip (4), (Figure 8-84) all the way into the mounting block.
2. Insert the sensor cable through the brake spider housing, around the S-cam tube and bracket, up the brake chamber airline, and route the cable along the frame rail.
3. Connect the sensor cable connector.
4. Install the sensor into the bracket and spring clip. Install the bracket and sensor onto the spider assembly. Tighten the bracket to a torque of $175 \pm 15 \text{ Nm}$ ($130 \pm 10 \text{ ft-lb}$).
5. Install the P-clip on the S-cam tube and bracket. Fasten the sensor cable to the brake air line using a tie strap. Install P-clip inside the frame rail.

NOTE: DO NOT use a screwdriver or sharp instrument to adjust the sensor. Use of a sharp instrument could permanently damage the sensor.

DO NOT use a hammer to drive the sensor into position. Hammering the sensor could permanently damage it.

6. Using an ABS sensor adjustment tool, adjust the sensor against the tooth wheel and install the rubber grommet.
7. Install the brake lining onto the spider housing. Install the return spring, S-cam rollers and brake drum.
8. Install the wheel and tighten wheel nuts to a torque of $645 \pm 35 \text{ N}\cdot\text{m}$ ($475 \pm 25 \text{ ft-lb}$).
9. Adjust the front axle brakes.
10. Remove the jack stand(s) from under the vehicle.
11. Lower the vehicle and remove the wheel blocks.
12. Readjust the brakes.
13. Verify proper sensor adjustment by driving the vehicle. This allows the ABS to perform an additional self test. Once the vehicle reaches approximately 11 km/h (7 mph), the ABS warning lamp will go out if the sensor is properly adjusted.

Wheel Speed Sensor, Replacement (Rear)

Removal

Refer to (Figure 8-84).

1. Park the vehicle on a level surface. Apply the parking brake, place the transmission in neutral, and block the rear wheels. Make sure vehicle ignition is in the "OFF" position.
2. Using an adequate lift, raise the wheel where the faulty sensor is located. Place jack stands of adequate rating under the axle.
3. Using a wheel lift, remove the wheel from the axle.

4. If equipped with spring brakes, release the brakes. Back off the slack adjuster.
5. Remove the brake drum, cam rollers, return spring, and brake shoes.

NOTE: DO NOT pull on the sensor cable to remove it, as this may permanently damage the sensor. DO NOT use any device to pry the sensor from its mounting block, as this may damage the steel casing on the sensor and can void any existing warranty.

6. Remove the mounting bolts for the sensor bracket. Cut the tie straps along the sensor cable. Remove the P-clips at the S-cam tube, bracket and frame rail. Using a slight twisting motion, remove the sensor from its mounting block. Use extreme care not to damage the tooth wheel or the sensor.
7. Remove the sensor spring clip from the mounting block.
8. Disconnect any fasteners that hold the sensor cable and the hose clamp to other components.
9. Disconnect the sensor from the vehicle wiring at the connector closest to the sensor.
10. Pull the sensor cable through the hole in the frame rail.

Installation

Refer to (Figure 8-84).

NOTE: The sensor spring clip must be installed with the flange stops facing the inboard side of the vehicle.

1. Push the sensor spring clip all the way into the mounting block.
2. Insert the sensor cable through the brake spider housing, around the S-cam tube and bracket, up the brake chamber airline, and route the cable along the frame rail.
3. Connect the sensor cable connector.
4. Install the sensor into the bracket and spring clip. Install the bracket and sensor onto the spider assembly. Tighten the bracket to a torque of $225 \pm 25 \text{ N}\cdot\text{m}$ ($165 \pm 18 \text{ ft}\cdot\text{lb}$).
5. Install the P-clip on the S-cam tube and bracket. Fasten the sensor cable to the brake air line using a tie strap. Install P-clip inside the frame rail.

NOTE: DO NOT use a screwdriver or sharp instrument to adjust the sensor. Use of a sharp instrument could permanently damage the sensor.

DO NOT use a hammer to drive the sensor into position. Hammering the sensor could permanently damage it.

6. Using a J-42942 ABS sensor adjustment tool, adjust the sensor against the tooth wheel, and install the rubber grommet.
7. Install the brake lining onto the spider housing. Install the return spring, S-cam rollers and brake drum.
8. Install the wheel and tighten nuts to a torque of $645 \pm 35 \text{ Nm}$ ($475 \pm 25 \text{ ft}\cdot\text{lb}$).
9. Adjust the rear axle brakes.
10. Remove the jack stands from under the vehicle.
11. Lower the vehicle and remove the wheel blocks.
12. Readjust the brakes.
13. Verify proper sensor adjustment by driving the vehicle. This allows the ABS to perform an additional self test. Once the vehicle reaches approximately 11 km/h (7 mph), the ABS warning lamp will go out if the sensor is properly adjusted.

OUTRIGGERS

Description

The outriggers, when properly extended and set, provide a rigid four point platform which is capable of supporting the crane and its maximum load capacity. The outriggers consist of inverted jack cylinders with two stage outrigger beams to allow for fully retracted, partial extension and fully extended operation. A center front jack is provided for stabilization during over the front lifting. The front outrigger box is mounted behind the front axles while the rear outrigger box is mounted behind the rear axles. The center front jack is mounted on the center of a cross member at the front of the crane.

The outrigger beam assembly consists of two separate beams; the jack beam and mid beam. Both beams retract into the outrigger box. The beam assembly contains the extension cylinder and the jack cylinder, which is mounted in a tube at the end of the jack beam. Two Outrigger Monitoring System (OMS) (Optional—Standard in North America) string potentiometers are mounted inside each outrigger box. The potentiometers are connected by cables to the outrigger beams to monitor the beams' position—fully retracted, mid-extend, or fully extended

The outrigger circuit consists of an outrigger selector valve, four extension cylinders, eight OMS string potentiometers (if equipped), five jack cylinders, a relief valve, a pressure switch, and check valves. Each jack cylinder has a port block mounted on its side with the pilot-operated check valve threaded into the port block. The pressure switch is mounted in a port on the center front jack cylinder.

There are three outrigger control panels on the crane. One outrigger control panel is located in the superstructure cab

on the right hand side console. There is also a control panel on either side of the crane behind the front outriggers.

A sight bubble level is mounted on the right side console in the cab and on each of the side control panels. The sight bubble level provides the operator with a visual indication of crane level attitude.

Theory Of Operation

When the outrigger extension cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

The appropriate Extension/Jack Switch must be depressed before the Outrigger Extend/Retract Switch is pressed. Depressing one of the outrigger selector switches causes that solenoid valve (located on the integrated outrigger valve) to open. As the selector switch is moved, the selector valve shifts, allowing flow to either the extend or retract line, as applicable. If the selector switch is in the EXTEND position, the flow continues through the open solenoid valve to the barrel side of the cylinder. If a jack is to be extended,

the flow first unseats the check valve then extends the cylinder. The oil from the rod end flows to the selector valve and through the swing bank on the way to the reservoir.

When the selector switch is in the RETRACT position, the flow through the selector valve is to the rod side of the cylinder. The oil in the barrel side flows through the open solenoid back to the selector valve and through the swing bank on the way to the reservoir.

The front jack functions similar to any of the other outrigger cylinders. A pressure switch is used to sense pressure in the barrel end of the cylinder after extension. When the pressure reaches 31,028 kPa (4500 psi), the switch causes a red light to be illuminated on the superstructure front console. This alerts the operator that the center jack is approaching an overloaded condition.

The in line relief valve prevents over pressurization of the center front jack cylinder. The valve is installed in line between the solenoid valve and the cylinder, and is set at 1379 kPa (200 psi).

Maintenance

For troubleshooting and maintenance, please refer to the symptoms, causes and solutions on the next few pages.

Reference Only

Troubleshooting

SYMPTOM	PROBABLE CAUSE	SOLUTION
Slow or erratic operation of outrigger extension cylinders.	Damaged relief valves. Low hydraulic oil. Sticking solenoid valve spool. Improper ground to base of solenoid. Damaged O-rings and swivel. Directional selector switch sticking. Collector ring dirty or glazed. Damaged wiring to solenoid switch. Weak brush springs on collector switch. Damaged extension cylinder (internal parts). Bent cylinder rod. Excessive material on outrigger beams. Binding outrigger beam. Damaged outrigger valve. Damaged valve coil. Main hydraulic pump cavitation. Partially shifted hydraulic selector spool. Insufficient voltage for operation of solenoid valve. Damaged piston seals.	Remove relief valve, clean or replace. Replenish oil to proper level. Repair or replace valve spool. Ground properly. Remove swivel and replace O-rings. Clean or replace switch. Clean and deglaze collector ring. Replace wiring. Replace brush springs. Remove extension cylinder and repair as necessary. Replace piston rod and seals. Clean outrigger beams. Repair or replace outrigger beam. Repair or replace valve. Replace coil. Replace or tighten hose or fittings. Disassemble, clean, and polish spool and valve housing with very fine emery cloth. Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical swivel coupling collector rings.
Slow or erratic operation of outrigger extension cylinders. (Continued)	Worn or damaged hydraulic pump section. Scored cylinder barrel. Cracked or damaged piston. Piston loose on piston rod.	Replace all cylinder seals. Repair or replace pump section. Repair or replace barrel. Replace piston and all cylinder seals. Replace all cylinder seals and torque piston locknut.
Sticking spool.	Dirt in system. Distortion caused by tie bolts being over torqued.	Change oil and flush system. Retorque tie bolts.

Reference Only

SYMPTOM	PROBABLE CAUSE	SOLUTION
	<p>Flow in excess of valve rating.</p> <p>Pressure in excess of valve rating.</p> <p>Electrical failure.</p>	<p>Limit flow through valve to that recommended. Check pump output and cylinder rating.</p> <p>Check relief valve setting or pump compensation and adjust or replace as necessary.</p> <p>Check wiring and solenoids.</p>
External leakage.	<p>Damaged O-rings or quad rings.</p> <p>Loose tie bolts.</p> <p>Damaged solenoid.</p>	<p>Check for chipped packings and replace.</p> <p>Retorque tie bolts.</p> <p>Replace damaged parts.</p>
Solenoid failure.	<p>No current.</p> <p>Damaged solenoid assembly.</p> <p>Short in solenoid.</p> <p>Loss of solenoid force.</p>	<p>Check power source of at least 85% of coil rating.</p> <p>Replace solenoid.</p> <p>Replace coil.</p> <p>Decrease time of solenoid energization.</p>
Outrigger vertical jack cylinder slow or erratic.	<p>Low in hydraulic oil.</p> <p>Damaged main relief valve.</p> <p>Damaged holding valve seals.</p> <p>Bent cylinder rod.</p> <p>Bent outrigger housing.</p> <p>Damaged O-rings in swivel.</p> <p>Excessive material on beams.</p> <p>Sticking solenoid valve spool.</p> <p>Damaged wiring to solenoid.</p> <p>Weak brush springs.</p> <p>Collector ring dirty or glazed.</p> <p>Directional selector switch sticking.</p> <p>Main hydraulic pump cavitation.</p> <p>Worn or damaged hydraulic pump section.</p>	<p>Replenish oil to proper level.</p> <p>Repair or replace valve.</p> <p>Replace holding valve seals.</p> <p>Replace cylinder rod and seals.</p> <p>Repair or replace outrigger housing.</p> <p>Replace O-rings.</p> <p>Clean outrigger beams.</p> <p>Repair or replace valve spool.</p> <p>Repair or replace wiring.</p> <p>Replace brush springs.</p> <p>Clean or deglaze collector ring.</p> <p>Clean or replace switch.</p> <p>Replace or tighten hose and fittings.</p> <p>Repair or replace pump section.</p>
Jack cylinder retracts under load.	<p>Damaged piston seals.</p> <p>Damaged holding valve seals.</p> <p>Damaged holding valve.</p> <p>Scored cylinder barrel.</p>	<p>Replace all cylinder seals.</p> <p>Replace seals.</p> <p>Replace valve assembly.</p> <p>Repair or replace cylinder.</p>

SYMPTOM	PROBABLE CAUSE	SOLUTION
	Cracked or damaged piston.	Replace piston and all cylinder seals.
Jack cylinder extends while machine is traveling.	Damaged piston seals. Scored cylinder barrel. Cracked or damaged piston. Piston loose on cylinder rod.	Replace all cylinder seals. Replace jack cylinder. Replace piston and seals. Replace seal and retorque.
Outrigger system will not activate (from stowed or extended and down position).	Hydraulic oil low. Loose or broken wire on switch. Clogged, broken, or loose lines or fittings. Damaged relief valve or damaged control valve.	Replenish oil to proper level. Repair or replace wiring. Clean, tighten, or replace lines or fittings. Repair or replace valve.
Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	Clogged, broken, or loose hydraulic lines or fittings. Loose or broken wire on control switch or solenoid valve. Damaged solenoid valve. Damaged control switch. Damaged hydraulic cylinder.	Clean, tighten, or replace lines or fittings. Repair or replace wiring. Repair or replace valve. Replace switch. Repair or replace cylinder.
Outrigger will not set.	Improper sequence of activation.	Activate individual control switch; then activate system control switch.
Two outriggers activate from single control switch.	Damaged solenoid valves.	Repair or replace damaged parts.
One/two outriggers will not stow.	Hydraulic lock.	Recycle individual outrigger(s).
Individual outrigger will not set or stow.	Damaged piston seals. Damaged check valve.	Replace seals. Repair or replace valve.
Jack cylinder retracts under load.	Loose or broken wire on control switch or solenoid valve. Damaged solenoid valve.	Repair or replace wiring. Repair or replace valve.

Outrigger Beam (with Adjustable Wear Pads)

Removal

1. Remove the rear cover of the outrigger box.
2. Disconnect both string potentiometer spring clips.
3. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
4. From the opposite side of the outrigger housing, remove the end cover.

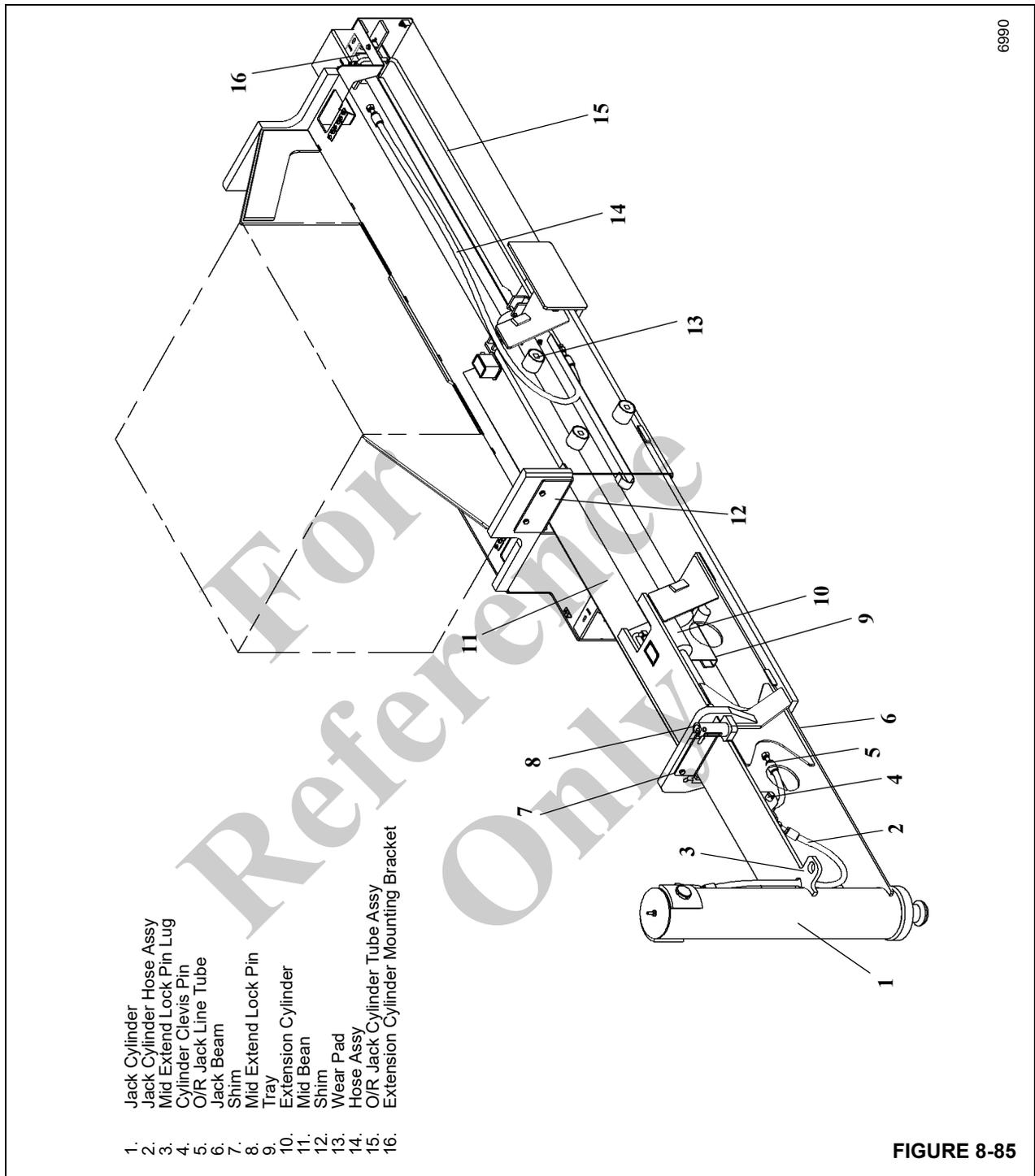
5. Tag and disconnect the hydraulic lines to the cylinder end of the extension cylinder. Cap all lines and fittings.
6. On the side of the outrigger housing, remove the two setscrews from the side adjustable wear pads and back off the wear pads from the housing (Figure 8-86).
7. Remove the bolt, washer, lockwasher and nut securing each hydraulic tube to the outrigger housing.
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 damage to 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.

**WARNING****Death or Injury Could Occur!**

Make sure that any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

For
Reference
Only



NOTE: The outrigger beam assembly weighs approximately 776 kg (1710 lb).

- 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.

2. After attaching a suitable lifting device of straps or belts, instead of chains to prevent damage to 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.



WARNING

Death or Injury Could Occur!

Make sure that any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

NOTE: The outrigger jack beam assembly weighs approximately 544 kg (1200 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 66 kg (146 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 jack 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.
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 jack cylinder. Cap or plug all openings.

15. Remove the jack cylinder from the jack beam. Refer to **OUTRIGGER JACK 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 jack cylinder in the jack beam. Refer to paragraph *Outrigger Beam (with Adjustable Wear Pads)*, page 8-87.
2. Connect the hoses, as tagged during disassembly, to the jack cylinder and route them into the jack beam.
3. Coat the inside of the tube trays with Never-Seize. 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 lock washers.
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 damage to 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 (EPMPG) 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 damage to 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. Connect the hydraulic lines as tagged prior to removal.
8. Install the side adjustable wear pads in the outrigger box.
9. Adjust the wear pads, refer to Wear Pad Adjustment in this section.
10. Connect both string potentiometer spring clips.
11. Install the rear cover of the outrigger box.

NOTE: At installation, be sure that the outrigger jack cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

Wear Pad Adjustment

NOTE: When adjusting wear pads, refer to (Figure 8-86)

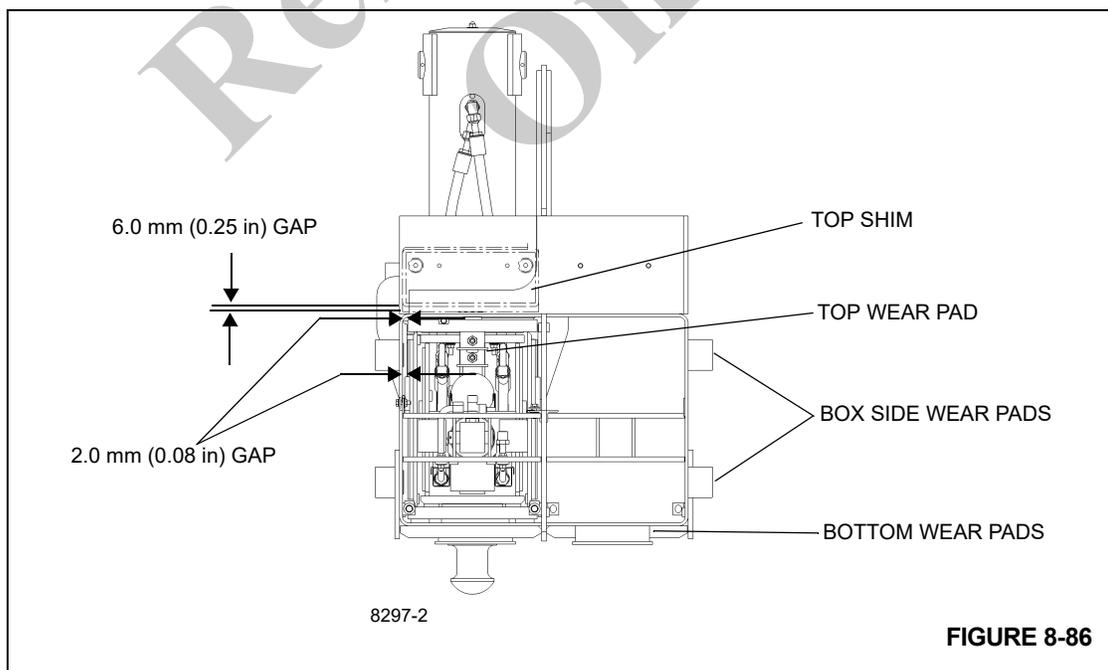
1. Adjust outrigger box side wear pads until a gap of 2.0 mm (0.08 in) is obtained at the tightest point during full extension.
2. Adjust the wedge type wear pad at the upper end of the outrigger until a gap of 2.0 mm (0.08 in) is obtained at the tightest point during full extension (not shown in Figure 8-86).
3. Insert shims between the top of the outrigger mid beam and the outrigger jack beam until a gap of 6.0 mm (0.25 in) is obtained at the tightest point during full extension.

CAUTION

Damage Could Occur!

Ensure the piston side of all outrigger cylinders is connected to the solenoid valve bank. Reversal of port connections could result in damage to the cylinders as very high pressure intensification will occur.

During initial start-up and checking of the outrigger operation, each control switch must be operated before operating the selector valve. If hydraulic lines are reversed to one or more cylinders, this will prevent damage to the cylinders.



Extension Cylinder

Description

The outrigger extension cylinder is a combination unit with two rods, one for extending each direction. 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 (fly) beam.

Each barrel has a 6.4 cm (2.50 in) diameter bore. Internal seals are used to prevent internal and external leakage. A wiper ring is mounted to the front of the barrel to wipe dirt from the rod as it is retracted.

The overall retracted length of the cylinder assembly is 183.4 cm (71.93 in) from the center of the rod mounting hole to the center of the other rod mounting hole. The lower barrel has a stroke of 119.4 cm (47.00 in) and the upper barrel has a stroke of 130.8 cm (51.50 in). The fully extended length is 433 cm (169.33 in).

Each cylinder weighs approximately 86 kg (190 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-29 for Disassembly and Assembly of the cylinders.

Removal

1. Remove the outrigger beam.
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.

CAUTION

Damage Could Occur!

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

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 paragraph *Outrigger Beam (with Adjustable Wear Pads)*, page 8-87.

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 JACK CYLINDERS

Description

The jack 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.

The cylinders have a retracted length of 109.5 cm (43.12 in) from the center of the mounting fixture on the barrel to the end of the rod. The fully extended length is 160.3 cm (63.12 in). The stroke is 50.8 cm (20.00 in).

Each cylinder weighs approximately 89 kg (196 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-29 for Disassembly and Assembly of the cylinders.

Removal

1. Extend the outrigger beam slightly for improved access to the jack cylinder. Shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.

5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin.
6. Jack the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

CAUTION

Damage Could Occur!

Use a nylon strap to remove the cylinder. this will ensure the retaining pin is not damaged.

7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

Installation

1. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under REMOVAL, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
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

Damage Could Occur!

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

5. Connect the hydraulic hoses to the jack cylinder as marked during disassembly.

Functional Check

1. Activate the hydraulic system.
2. Extend and retract the jack cylinder.
3. Check for smooth operation of the cylinder.
4. Check all hydraulic connections and hoses for evidence of leakage.

CENTER FRONT JACK CYLINDER

Description

The center front jack cylinder (Figure 8-87) 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 cross member 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 (113.8 lb).

Maintenance

NOTE: Refer to *Cylinders*, page 2-29 for Disassembly and Assembly of the cylinder.

Removal

1. Remove the screws, washers, flatwashers, and hex nuts securing the plate. Remove plate.
2. Remove the bolts, lockwashers, bushing, and nuts securing the float pad to the cylinder ball and remove the float pad.
3. Remove the washers and nuts securing the cylinder cap.
4. Tag, disconnect, and cap the hydraulic lines to the cylinder.
5. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
6. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
7. Jack the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

CAUTION

Damage Could Occur!

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

8. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube.

9. Remove the wear ring from the groove of the cylinder. Remove the wear ring from the groove in the bottom of the tube.

Installation

1. Apply grease (EPMPG) to the ID of the jack cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube. Using the same method as described under Removal, lower the jack cylinder into the cylinder tube until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.

CAUTION

Damage Could Occur!

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 anti-seize to the retaining pin. Secure the cylinder and cylinder cap

retaining bracket in place with the retaining pin and cotter pins.

6. Install the hydraulic lines as tagged prior to removal.
7. Install the cylinder cap and secure with the washers and nuts.
8. Position the float pad on the cylinder ball and secure with bolts, lockwashers, bushing and nuts. Torque the bolts 97.6 to 105.7 Nm (72 to 78 lb-ft)
9. Position the plate on the mounting bracket and secure with the screws, washers, flatwashers, and nuts. Thread nut on bolt until washer contacts pad. Do not tighten bolt any further.

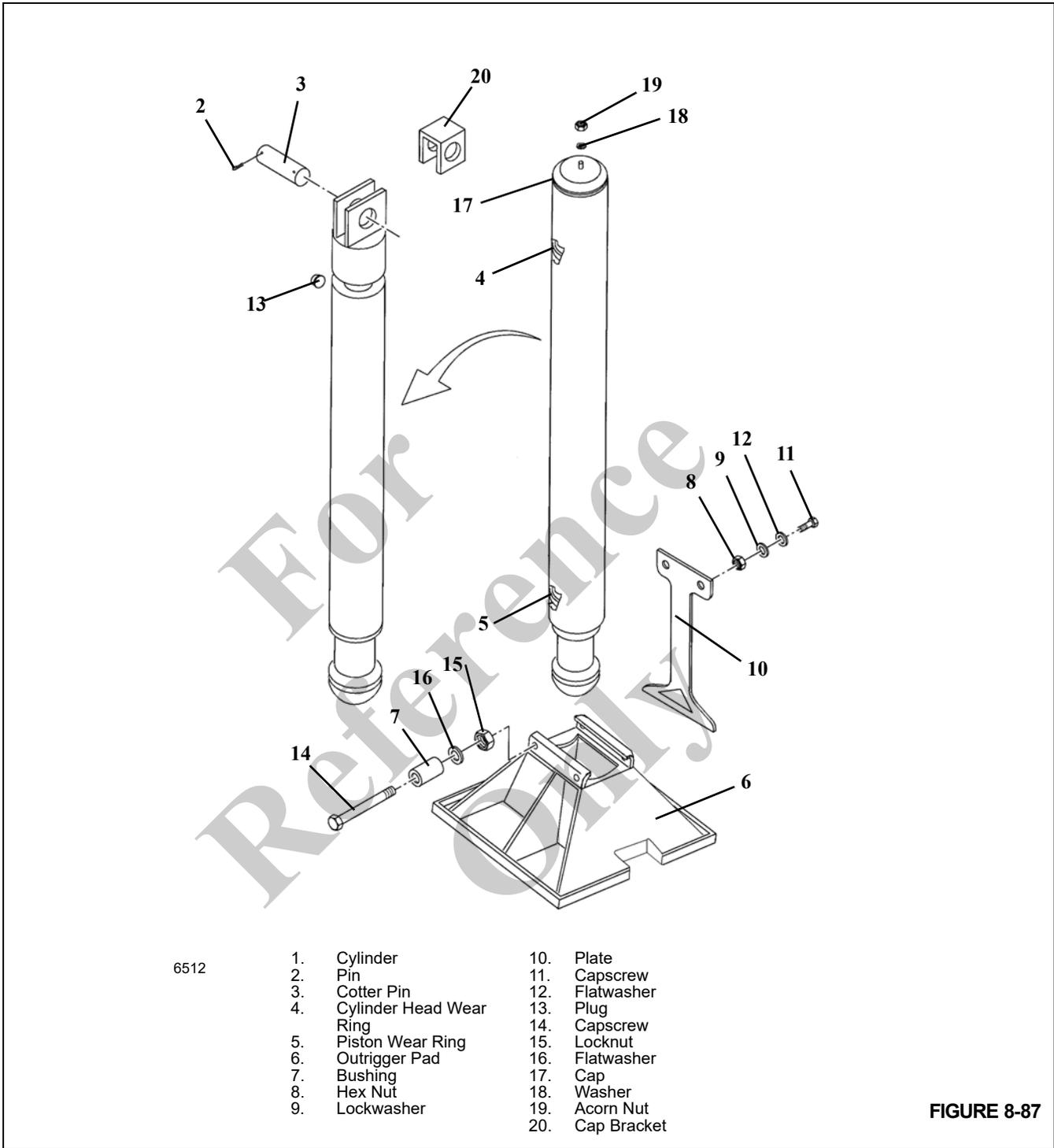
Functional Check

CAUTION

Damage Could Occur!

Extend and set the four main outriggers before extending the center front jack.

1. Extend and set the outriggers.
2. Activate the hydraulic system; extend and retract the outrigger.
3. Observe for proper operation of the cylinder.
4. Check the hydraulic connections for 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)(EKS.5) by automatically identifying the position of each outrigger beam. The OMS uses eight sensors, two per outrigger beam—one for each outrigger stage—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 position of each of the four outrigger beams. The operator must confirm the outrigger positions and rigging code. Refer to the *Operator Manual* for more information.

OMS String Potentiometers

Removal

1. Remove the rear access cover plate from outrigger box.
2. Remove the OMS string potentiometer spring clip (1), (Figure 8-88) from the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to OMS string potentiometer.

3. Tag and disconnect the electrical connector and secure to avoid damage.
4. Remove the mounting hardware.
5. Remove the OMS string potentiometer (2), (Figure 8-88).

Repeat Steps 2 through 5 for the other potentiometer, if necessary.

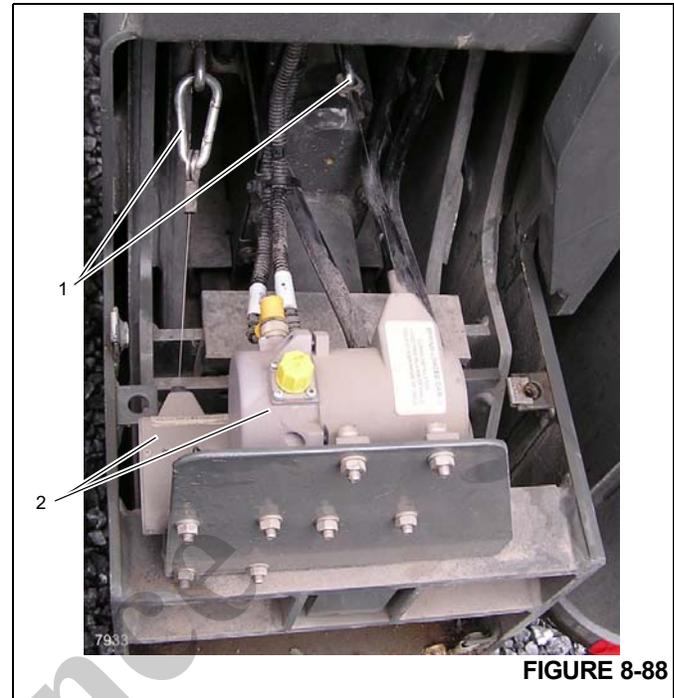


FIGURE 8-88

Installation

1. Install string potentiometer inside outrigger beam (Figure 8-88).
2. Install the mounting hardware.
3. Attach the OMS string potentiometer spring clip (1), (Figure 8-88) to the attaching point on the outrigger beam.

NOTE: Avoid free-release of cable to prevent damage to the OMS string potentiometer.

4. Connect electrical connector, as tagged during removal, to string potentiometer.
5. Install access cover plate to outrigger box.

SECTION 9 LUBRICATION

SECTION CONTENTS

<p>General 9-1</p> <p style="padding-left: 20px;">Environmental Protection 9-1</p> <p style="padding-left: 20px;">Cummins Oil Registration List 9-1</p> <p style="padding-left: 20px;">Arctic Conditions Below -18° C (0° F) 9-2</p> <p>Cylinder Rod Surface Protection 9-2</p> <p>Lubrication Points 9-2</p> <p style="padding-left: 20px;">Standard Lubricants 9-3</p> <p style="padding-left: 20px;">Cold Weather Lubricants 9-5</p> <p style="padding-left: 20px;">Arctic Lubricants and Conditions 9-7</p> <p style="padding-left: 20px;">Drivetrain Lubrication 9-8</p> <p style="padding-left: 20px;">Clutch Release Bearing Grease Interval 9-11</p> <p style="padding-left: 20px;">Steering Lubrication 9-13</p> <p style="padding-left: 20px;">Axle Lubrication 9-13</p>	<p style="padding-left: 20px;">Outrigger Lubrication 9-17</p> <p style="padding-left: 20px;">Miscellaneous Lubrication 9-18</p> <p style="padding-left: 20px;">Turntable & Cab Tilt Lubrication 9-18</p> <p style="padding-left: 20px;">Hoist Lubrication 9-21</p> <p style="padding-left: 20px;">Turntable Central Lubrication 9-22</p> <p style="padding-left: 20px;">Boom Lubrication 9-23</p> <p style="padding-left: 20px;">Monthly Lubrication Work 9-28</p> <p>Carwell® Rust Inhibitor 9-29</p> <p style="padding-left: 20px;">Protecting Cranes From Corrosion 9-29</p> <p style="padding-left: 20px;">Cleaning Procedures 9-29</p> <p style="padding-left: 20px;">Inspection and Repair 9-30</p> <p style="padding-left: 20px;">Application 9-30</p> <p style="padding-left: 20px;">Areas of Application 9-30</p>
---	---

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 Cranes distributor or Manitowoc Crane Care.

CAUTION

Possible Equipment Damage!

Chassis grease lubricants must not be applied with air pressure devices as this lubricant is used on sealed fittings.

The multipurpose grease installed during manufacture is of a lithium base. Use of a non-compatible grease could result in damage to equipment.

Environmental Protection

Dispose of Waste Properly! Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Grove 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.

Cummins Oil Registration List

Cummins has a program that lists engine oils that it has tested to meet its engineering specifications. Listing of recommended oils is on QuickServe® Online. Log on to quickservice.cummins.com and login with a current username and password or create a new account by selecting “Create an Account” under information, choose Limited Owners Plan

and register. Once logged in, click on the “Service” Tab in the top red bar, “Service Tools” mini-tab and “Oil Registration Lists” link within the Service Tools list. This will load a list of the different Cummins Engineering Specification numbers. Select the one that applies to your engine to view the registered oils.

Arctic Conditions Below -18° C (0° 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 Cranes distributor or Manitowoc Crane Care.

Regardless of temperature and oil viscosity, always use suitable start-up procedures to ensure adequate lubrication during system warm-up.

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

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

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. 1 oz (0.28 kg) of EP-MPG equals one pump on a standard 1 lb (0.45 kg) grease gun.

Over lubrication on non-sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.

On sealed U-joints, care must be exercised to prevent rupturing seals. Fill only until expansion of the seals first becomes visible.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, levers etc., should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to ensure complete lubrication of the entire wear area.

Standard Lubricants

Standard lubricants are used on all Grove cranes unless the crane is ordered with a cold weather package. These

standard lubricants are effective in ambient temperatures down to -9°C (15°F). Refer to (TABLE 9-1:) for a list of the recommended standard lubricants.

TABLE 9-1: Standard Lubricants/Fluids [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Extreme Pressure 3% Moly Grease	6829015304	Citgo: Lithoplex CM2 Mobil: Mobilgrease CM-P Ipiranga: IPIFLEX LI-COMP Moly 2	NLGI Grade 2	
Synthetic Gear Lube SAE 40	80078954	Emgard MTF 7000 (BASF) Phillips 66 Triton Synthetic MTF Kendall SHP Synthetic MTF		
Gear Lube (GL-5)	6829014058	CITGO, Synthetic Gear Lube 75W-90 Eaton, Roadranger EP75W-90 Mobil, Mobilube SHC 75W-90 Shell, Spirax® S 75W-90 Sunoco®, Duragear EP75W-90 Petro-Canada, Traxon E Synthetic 75W-90	75W-90	
Extended Service Interval Gear Lubricant	6829012964	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO	80W-90	
Engine Oil	6829104182	Conoco Fleet Supreme EC (non-current, replaced by Phillips 66 Product) Mobil Delvac 1300 Super Mobil Delvac MX ESP Mobil HDEO Phillips 66 Fleet Supreme EC 15W-40 Other Products listed on Cummins' "Oil Recommendation List" for CES-20086	15W-40	CJ-4
Engine Oil	6829003483	Exxon XD-3 Conoco Fleet Supreme Phillips 66 Super HD II Phillips 66 Power-D Engine Oil	15W-40	CI-4

TABLE 9-1: Standard Lubricants/Fluids [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Hydraulic/Transmission Oil	6829006444	Kendall Hyken 052 Exxon Torque Fluid 56 Esso Torque Fluid 56 BP-Eldoran UTH & Trak-Tran 9 BP- Blend- 7367 Phillip 66 PowerTran XP	10W-20	Must Meet John Deere Std. JDM J20c
		Exxon Mobil 424	10W-30	
Hoist Gear/Swing Drive Oil	6829014058	CITGO, Synthetic Gear Lube 75W-90 Eaton, Roadranger EP75W-90 Mobil, Mobilube SHC 75W-90 Shell, Spirax® S 75W-90 Sunoco®, Duragear EP75W-90 Petro-Canada, Traxon E Synthetic 75W-90	75W-90	GL-5
Grease, Multipurpose	6829003477	Citgo: Lithoplex Red MP Grease Chevron: Starplex EP 2 Phillips 66: Multiplex Red Mobil: Mobilgrease XHP 222 Ipiranga: IPIFLEX LI-COMP EP 2	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Anti-Seize Compound (ASC)	6829003689	Jet Lube Kopr Kote Loctite C5-A Compound		
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Fuel		Ultra Low Sulfur Diesel Fuel	#2-D	
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Bechem High--Lub LM2 EP (400g)	03313195	Bechem High-Lub LM2 EP (400g)		
Multi-purpose Grease	01373458	Berulub PAL 1		
Hydraulic Oil - ATF 66M Avia Fluid	01930670	Avia 66M		

Cold Weather Lubricants

Cold weather lubricants are used on all Grove cranes when the crane is ordered with a cold weather package. These

optional lubricants are effective in ambient temperatures down to -29°C (-20°F). Refer to (TABLE 9-2:) for a list of the recommended optional lubricants.

TABLE 9-2: Optional Lubricants/Fluids [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Extreme Pressure 3% Moly Grease	6829104275	Mobil: Mobilith SHC 220 (Red) Petro-Canada: Precision Synthetic EP1 () Phillips 66: Triton 220 (replaced by Multiplex FS220) (Purple) Phillips 66: Multiplex FS 220 (Purple)	NLGI Grade 2	
Synthetic Gear Lube SAE 40	80078954	Emgard MTF 7000 (BASF) Phillips 66 Triton Synthetic MTF Kendall SHP Synthetic MTF		
Gear Lube (GL-5)	6829014058	CITGO, Synthetic Gear Lube 75W-90 Eaton, Roadranger EP75W-90 Mobil, Mobilube SHC 75W-90 Shell, Spirax® S 75W-90 Sunoco®, Duragear EP75W-90 Petro-Canada, Traxon E Synthetic 75W-90	75W-90	
Extended Service Interval Gear Lubricant	6829014058	CITGO, Synthetic Gear Lube Eaton, Roadranger EP75W-90 Mobil, Mobilube SHC 75W-90 Shell, Spirax® S 75W-90 Sunoco®, Duragear EP75W-90 Petro-Canada, Traxon E Synthetic 75W-90	75W-90	
Engine Oil	80056036	Shell Rotella® T6 0W-40 Mobil Delvac 1 ESP 0W-40 Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Hydraulic Fluid	6829006993	Exxon Mobil Univis HVI 26		
Extreme Pressure Gear Lube	6829103636	Mobil SHC629 Petro-Canada; Enduratex Synthetic EP 150		AGMA No. 4 EP
Extreme Pressure Multipurpose Grease	6829104275	Mobil: Mobilith SHC 220 Petro-Canada; Precision Synthetic EP1	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	

TABLE 9-2: Optional Lubricants/Fluids [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Multipurpose Grease	01373458			
Extreme Pressure Gear Lube	02313611	Aral Getriebeöl EP Synth. SAE 75W-90		
Hydraulic Oil - ATF 66M Avia Fluid	01930670	Avia Fluid ATF 66 M		
Bechem High-Lub LM2 EP (400g)	03313195			
Anti-Seize Compound (ASC)	6829003689	Jet Lube Kopr Kote Loctite C5-A Compound		
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
Supplemental Coolant Additive (SCA)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Fuel	80069407	Ultra Low Sulfur Diesel Fuel	#1-D	
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		

Arctic Lubricants and Conditions

Temperatures Below -9°C (15°F)

Regions with ambient temperatures below -9°C (15°F) are considered arctic. In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results in these temperatures. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, may not be compatible with hydraulic system seals and wear bands. Therefore, always check with an authorized Grove distributor or Manitowoc Crane Care if in doubt of the suitability of a specific fluid or lubricant.

When operating in cold weather and regardless of the oil viscosity of the crane's lubricants, always follow the cold weather start-up and operating procedures described in the *Operator Manual* to ensure adequate lubrication during system warm-up and proper operation of all crane functions.

Cold Weather Package and Lubricants

Grove recommends cold weather lubricants for use with ambient temperatures down to -29°C (-20°F) (TABLE 9-2:). The following lube intervals are to be used as a guideline only. Actual lube intervals should be formulated by the operator to correspond according to conditions such as continuous duty cycles and/or hazardous environments.

Notes Listed in the Following Tables

1. All points requiring periodic lubrication shall be lubricated as required at assembly.
2. Final fluid levels shall be adjusted to indicating arrows, dipstick markings, or to filler plugs.
 - a. **Caution:** axle fluid levels shall be adjusted to "bottom of fill plug threads". Check with crane on level ground, at normal ride height, cold or room temperature oil only!
3. Change filter when changing gear oil.
4. Capacities indicated are for a fully formulated mixture of 50% AFC and 50% water.
5. Brush lubricant on top and bottom of outrigger beams contact area.
6. The hydraulic oil shall meet or exceed ISO 4406 class 17/14 cleanliness level (ref J-SAE J1165).
7. Brush lubrication on I.D. of center front jack cylinder support tube and wear bands before installing jack cylinder.
8. Use grease fittings provided.
9. Fill radiator to bottom of filler neck per Engineering Specification 80029046. Run engine through (2) thermal cycles. check level and refill as required.
10. Fill through dipstick opening.

11. Check fluid level using sight gauge on the side of the tank with boom retracted and in boom rest and all outrigger cylinders retracted.

12. Engine shall be running during lubrication to ensure equal distribution of grease.

13. Clean magnetic drain plug when changing lubricant.

14. Service by whichever interval occurs first.

15. Air conditioner - refer to applicable air conditioner manual.

16. See operator's manual when ambient temperatures are expected between +4°C (+40°F) and -62°C (-80°F).

17. Generously coat the wheel pilot or hub pads with lubricant. Do not lubricate the face of the wheel or the hub.

18. Apply lubricant during assembly and reapply lubricant whenever wheels are removed for service.

19. Clean coolant strainer after first 100 hours of use and at 2000 hrs/1 yr intervals thereafter.

20. Replace air cleaner element when indicator shows red (25" H₂O).

21. Change filter at first 200 hours. thereafter, at normal intervals. Drain with oil temperature at 65°C - 95°C (150°F - 200°F).

22. Change filter when changing gear oil.

23. Drain water trap every ten hours or daily.

24. QSM T3 engine can also use CJ-4 oil when fueled with ultra low sulfur diesel (less than 15ppm).

25. Only use on X12 engine machines.

26. When using CJ-4 engine oil, service hours must be reduced as follows:

- a. 500 (0-55 ppm sulfur fuel)
- b. 400 (500-5000 ppm sulfur fuel)
- c. 250 (>5000 ppm sulfur fuel. Not recommended.)

27. Extend boom for access.

28. Lubricate more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.

29. Access through hole in base section.

30. Access through hole in tele 1 section.

31. Access through hole in tele 2 section.

32. Access through hole in tele 3 section.

33. Access through hole in tele 4 section.

34. **CAUTION:** DEF is corrosive to certain metals and paint and should be washed off with mild soap and water if spilled.

35. Fill turntable gearbox until oil level is at middle to top of sight gauge.

36. Fill turntable gear brake until oil level is at top of sight gauge.

37. Fill grease container until grease level is at the "max" mark.

38. Brush lubricant on top and bottom wear pads of outrigger beams.

39. Replace the hydraulic filter element when the restriction indicator gauge on the filter head is in the red with the oil at a

minimum of 100°F. When replacing the filter, also replace the breather.

40. Access through hole in the boom nose with the boom fully retracted.

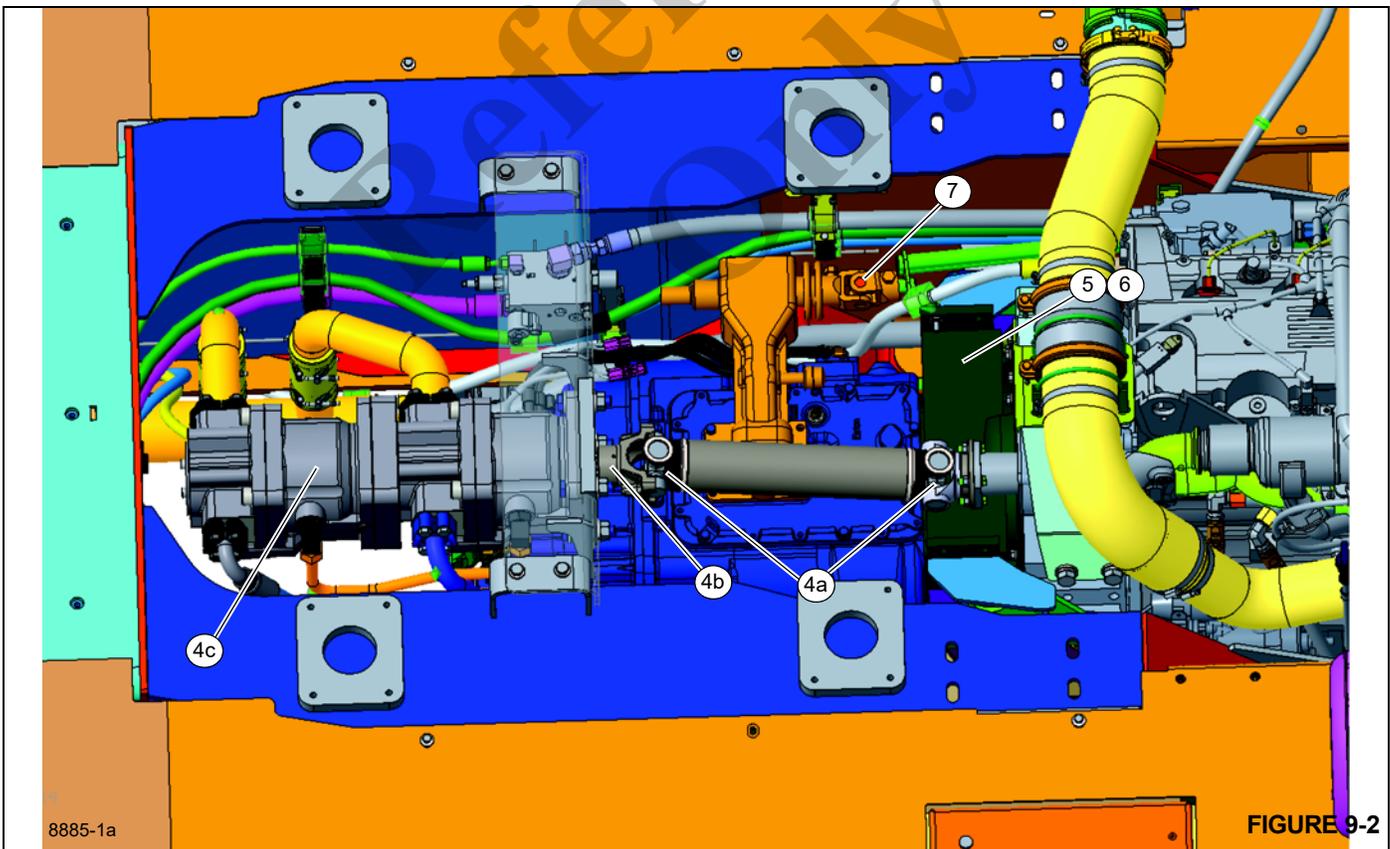
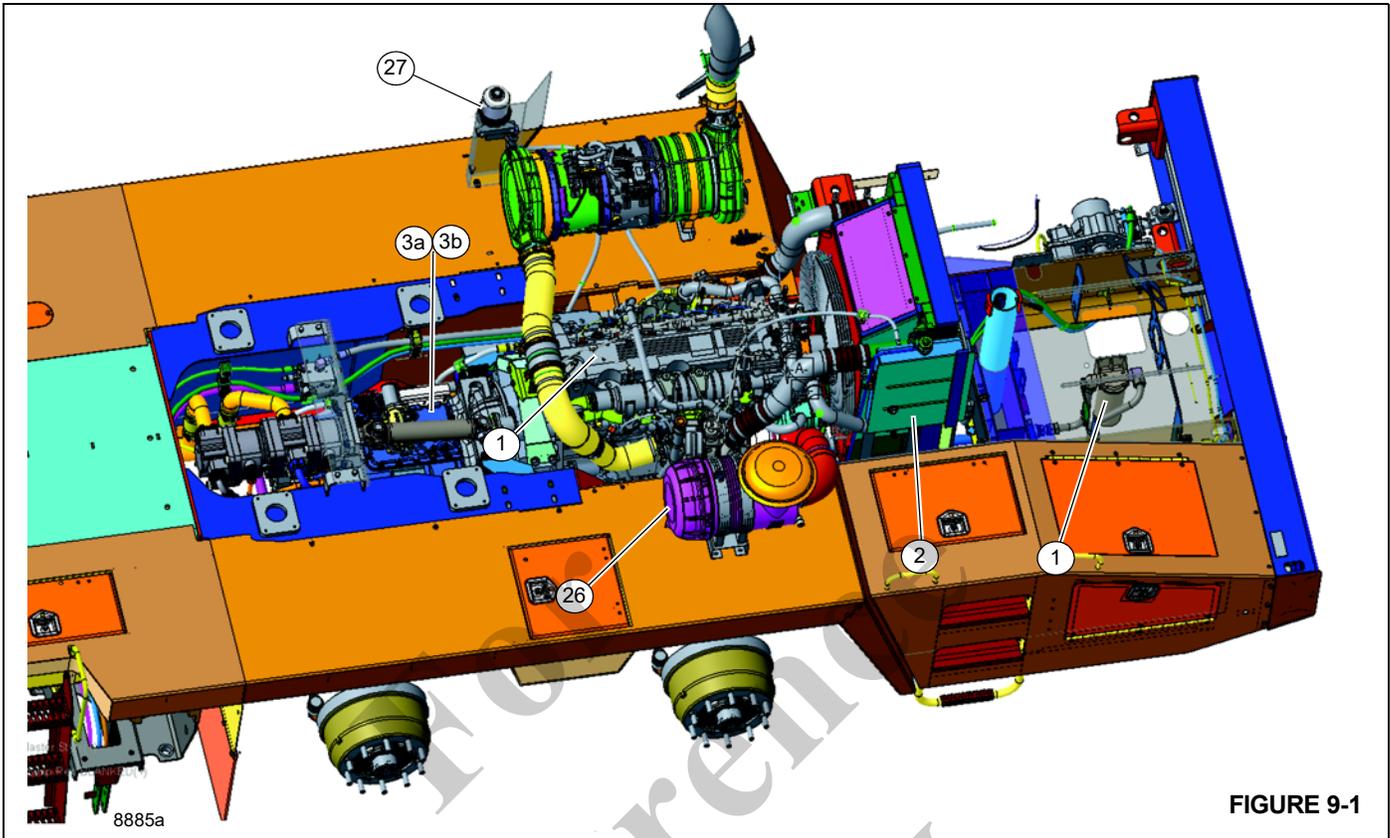
The following describes the lubrication points and gives the lube type, lube interval, lube amount and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown in the following figures.

Drivetrain Lubrication

ITEM NUMBER	LOCATION NAME	APPROXIMATE CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
DRIVETRAIN							
1	ENGINE CRANKCASE X12	-----	6829104182	2, 14	1	CHECK & FILL	10 HRS/DAILY
	WITH FILTER	47.3 L (12.5 GAL)	6829104182	2	1	DRAIN & FILL	750 HRS
2a	ENGINE COOLING SYSTEM	-----	6829101130	4, 9, 14	1	CHECK & FILL	10 HRS/DAILY
	ENGINE COOLING SYSTEM - X12	70.0 L (18.5 GAL)	6829101130		1	DRAIN & FILL	SEE SERVICE MANUAL
2b	ENGINE COOLING SYSTEM - X12	AS REQUIRED	6829012858		1	TEST AND ADD	750 HRS
2c	COOLANT STRAINER	-----	-----	14, 19	1	CHANGE FILTER	2000 HRS/ 1 YR
3a	TRANSMISSION - MANUAL	-----	80078954	2, 14	1	CHECK & FILL	500 HRS/6 MONTHS/ 9000 MI
		16.1 L (17.0 QT)	80078954	2, 14	1	DRAIN & FILL	2 YRS/50000 MI
3b	TRANSMISSION - AUTOMATED MANUAL	-----	80078954	2, 14	1	CHECK & FILL	500 HRS/6 MONTHS/ 9000 MI
		16.1 L (17.0 QT)	80078954	2, 14	1	DRAIN & FILL	2 YRS/50000 MI
3c	TRANSMISSION FILTER	-----	-----	2, 21	1	CHANGE FILTER	3000 HRS
4a	PUMP DRIVE SHAFT U-JOINTS	-----	6829003477	8	2	LUBE	250 HRS
4b	PUMP DRIVE SHAFT SPLINE	-----	6829003477	8	1	LUBE	500 HRS

ITEM NUMBER	LOCATION NAME	APPROXIMATE CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
5	CLUTCH RELEASE BEARING	-----	6829003477	8, 12	1	LUBE	250 HRS See "Clutch Release Bearing Grease Interval" on page 11.
6	CLUTCH LINKAGE (MANUAL TRANSMISSION ONLY)	-----	6829003477	8	3	LUBE	500 HRS
7	TRANSMISSION SHIFT U-JOINTS/ CONTROL UNIT	-----	6829003477	8	3	LUBE	500 HRS
26	AIR CLEANER FILTER	-----	-----	20	1	CHANGE FILTER	SEE NOTE 20
27	FUEL FILTER - PRIMARY	-----	-----	23	1	CHANGE FILTER	1000 HRS/6 MONTHS
8	DRIVELINE SLIP	-----	6829003477	8, 14	2	LUBE	500HRS/10000 MI

For Reference Only



Clutch Release Bearing Grease Interval

The transmission has an optional prognostic feature that notifies the operator when the clutch release bearing needs greasing. At the appropriate grease interval and after each engine start, "GI" will momentarily appear in the gear display, along with an audible tone. This will continue to occur at each engine start until clutch service has been completed.

NOTE: "GI" stands for GREASE INTERVAL and may be mis-read as "G1" on the gear display.

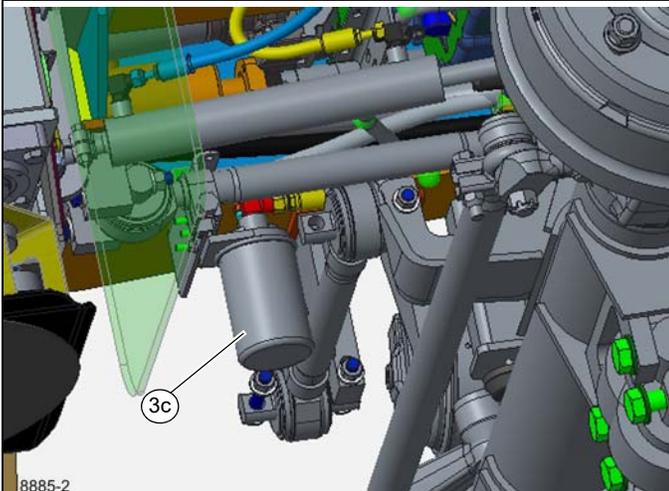
The operator can choose to follow this automated lube schedule or lubricate every 250 hours. See "CLUTCH RELEASE BEARING" on page 9. It is important to reset the grease interval count every time the release bearing is greased.

Clutch Release Grease Interval Reset

1. From the **OFF** position, turn ignition **ON** without cranking engine.
2. Move the transmission shift lever to **LOW**. Do not apply the brake pedal.
3. Press the manual up-shift button (1) until the gear display shows "3" (2, Figure 9-3).
4. Press Accelerator to the floor. Gear display will show a "Down" arrow.
5. Release the Accelerator. Gear display will show a "0".
6. Select **NEUTRAL**.
7. Turn ignition to **OFF** in order to save the reset.

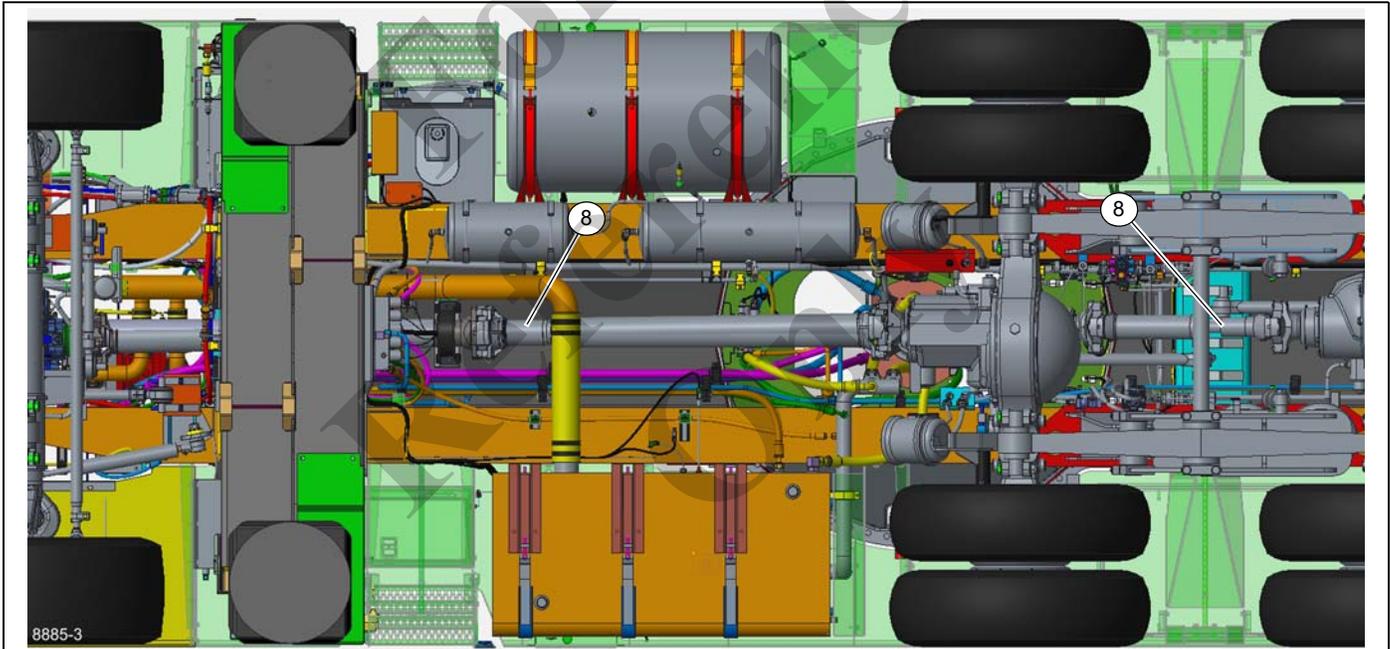


FIGURE 9-3



8885-2
8885-2

FIGURE 9-4



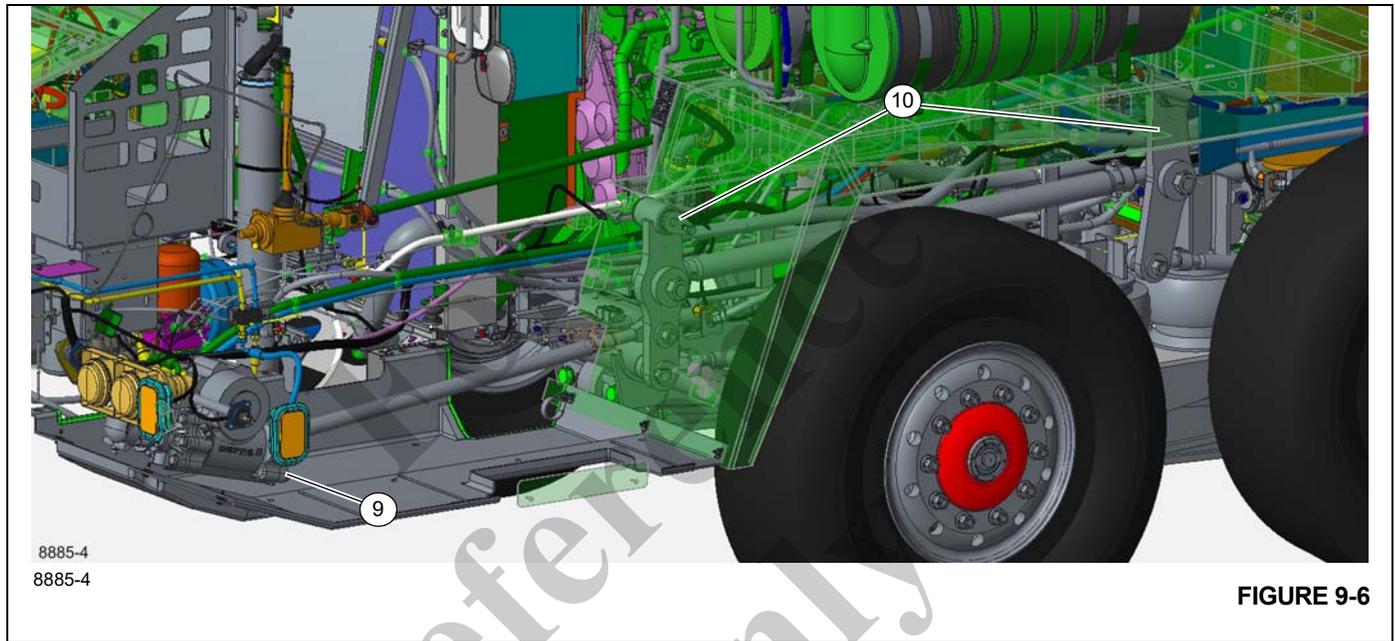
8885-3

8885-3

FIGURE 9-5

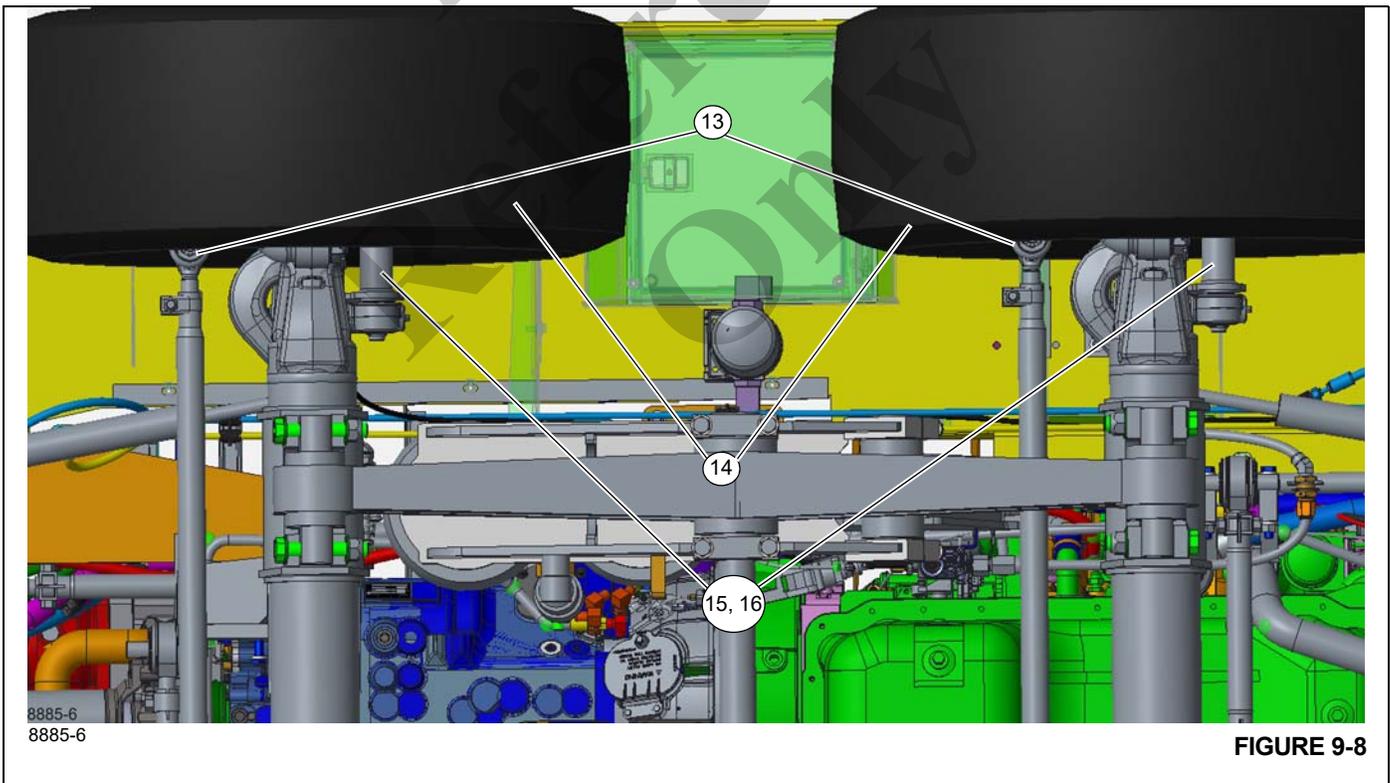
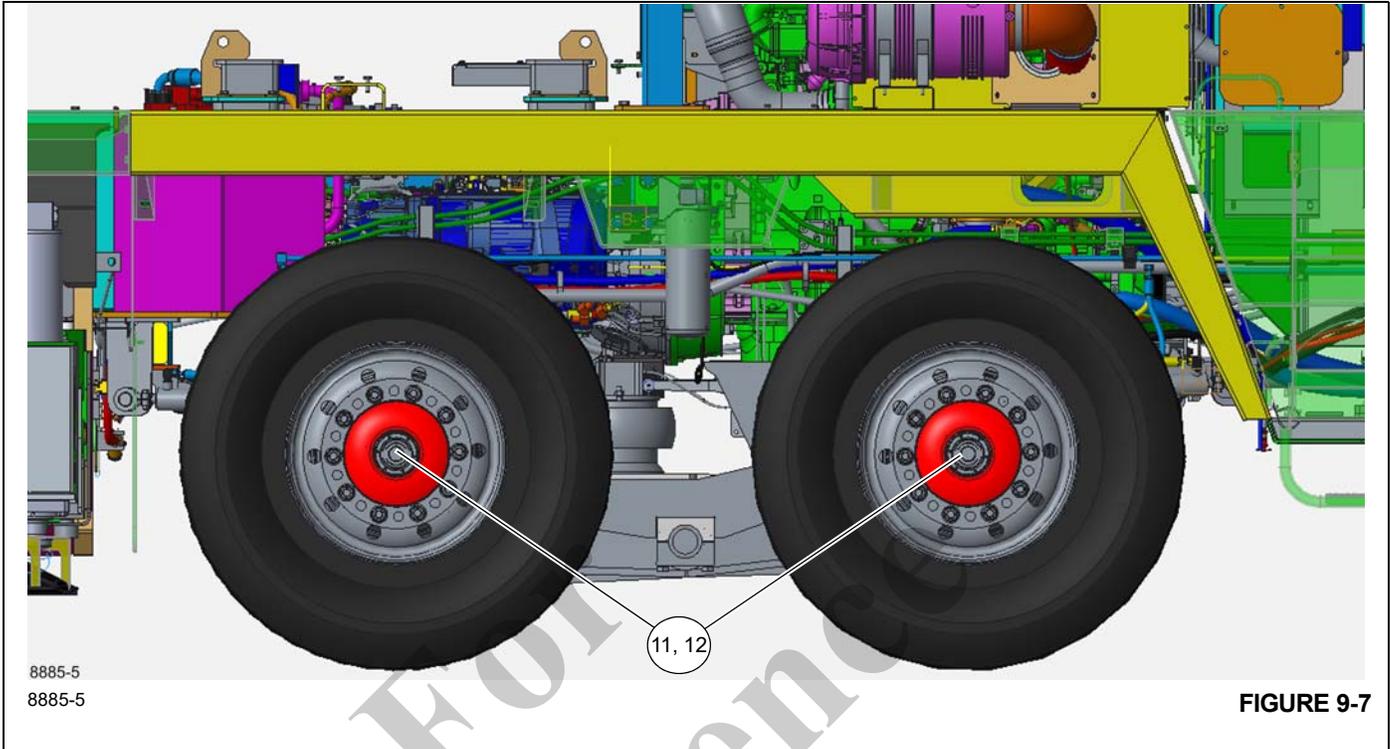
Steering Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
STEERING							
9	POWER STEERING GEARBOX	-----	6829003477	8	1	LUBE	1000 HRS
10	STEERING RELAY ARMS	-----	6829003477	8	2	LUBE	250 HRS

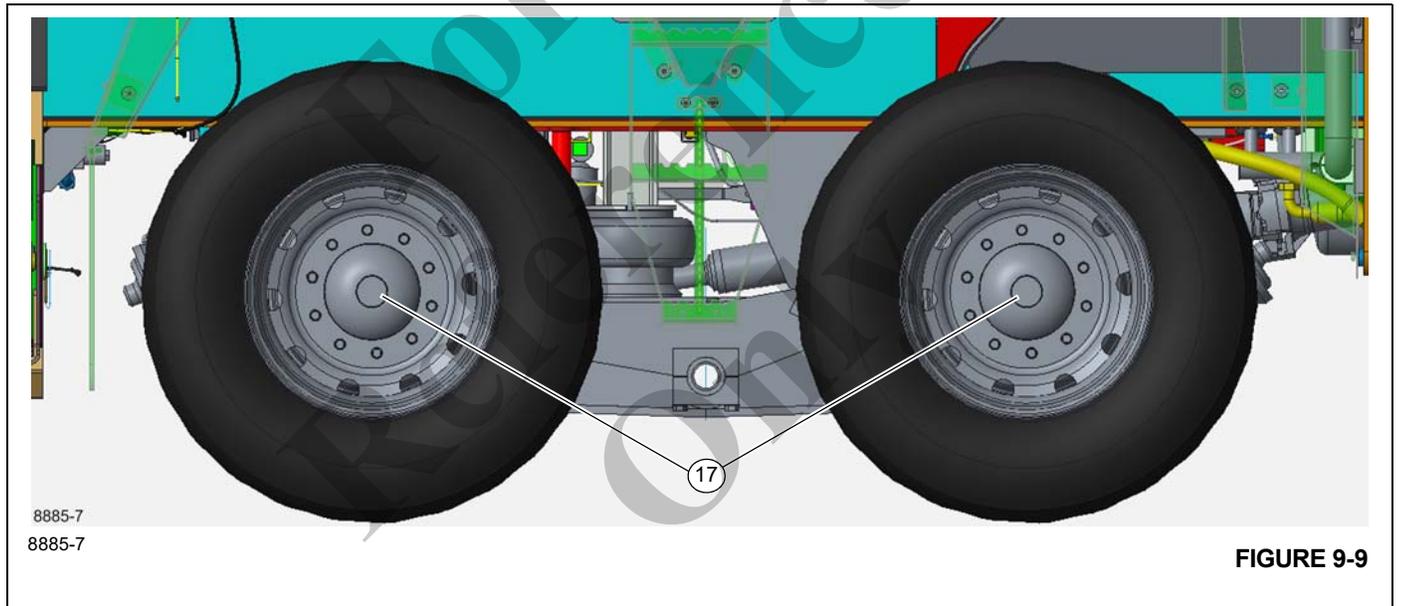


Axle Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
FRONT AXLES							
11	FRONT WHEEL PILOTS	-----	6829003689	17	4	BRUSH ON	SEE NOTE 18
12	FRONT AXLE HUBS	.47 L (1 PT) EACH	6829012964	2	4	CHECK & FILL	250 HRS
13	FRONT AXLE TIE ROD ENDS	-----	6829003477	8	4	LUBE	1000 HRS
14	FRONT AXLE KING PINS	-----	6829003477	8	8	LUBE	1000 HRS
15	FRONT AXLE BRAKE SLACK ADJUSTERS	-----	6829003477	8	4	LUBE	1000 HRS
16	FRONT AXLE BRAKE CAMSHAFTS	-----	6829003477	8	4	LUBE	1000 HRS



ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
REAR AXLES							
17	REAR WHEEL PILOTS	-----	6829003689	17	8	BRUSH ON	SEE NOTE 18
18	FRONT REAR AXLE BOWL	-----	6829012964	2	1	CHECK & FILL	250 HRS
		20.5 QTS	6829012964	2, 3, 13, 14	1	DRAIN & FILL	2 YRS/50000 MI
18b	DIFFERENTIAL FILTER	-----	-----	22	1	CHANGE FILTER	2 YRS/50000 MI
19	REAR REAR AXLE BOWL	-----	6829012964	2	1	CHECK & FILL	250 HRS
		19.5 QTS	6829012964	2, 13, 14	1	DRAIN & FILL	2YRS/50000 MI
20	REAR AXLE BRAKE SLACK ADJUSTERS	-----	6829003477	8	4	LUBE	1000 HRS



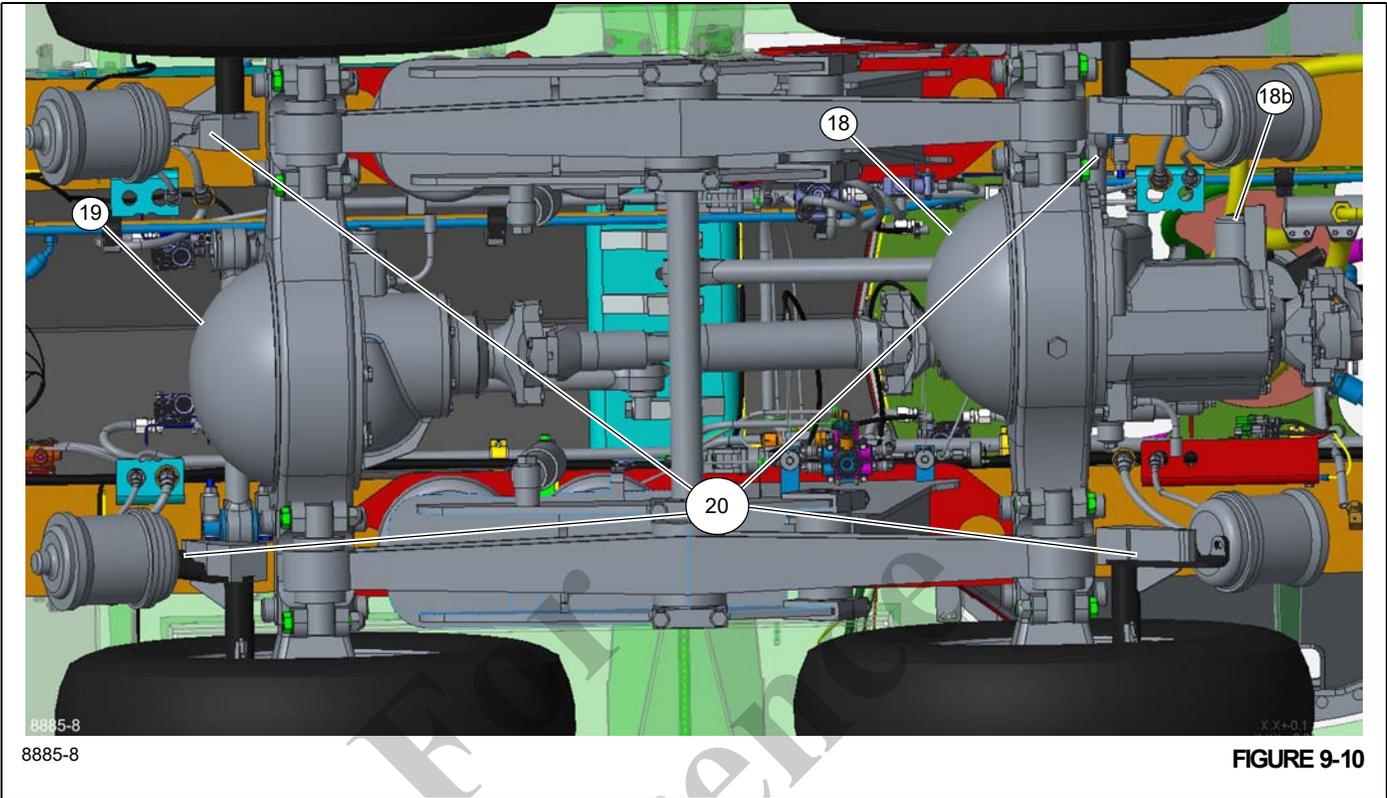
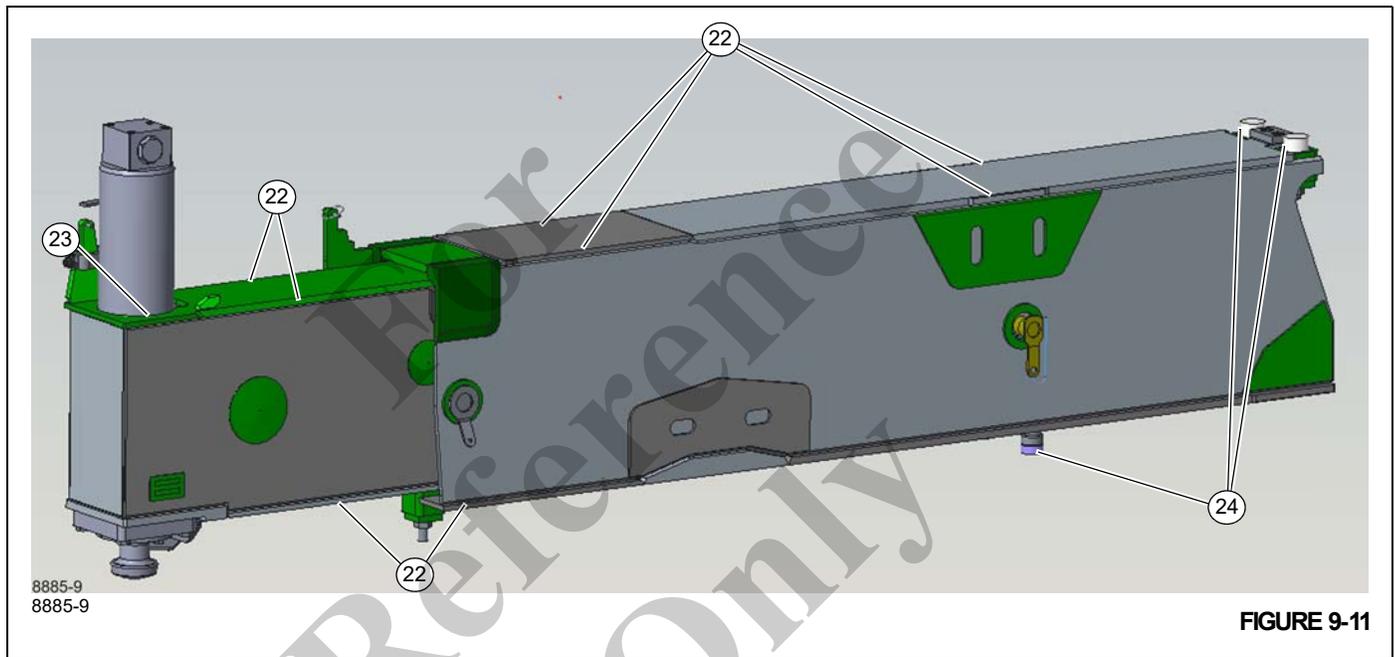


FIGURE 9-10

Reference Only

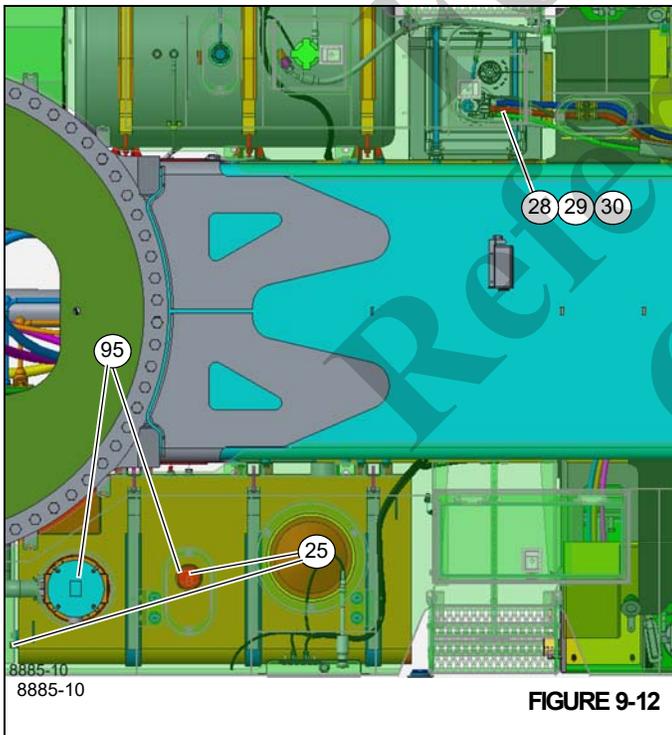
Outrigger Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
OUTRIGGERS							
22	O/R BEAMS	-----	6829015304	5, 14	8	BRUSH ON	50/1 WEEK
23	CENTER FRONT JACK CYLINDER SUPPORT TUBE (Not Shown)	-----	6829015304	7	5	BRUSH ON	SEE NOTE 7
24	WEAR PADS	-----	6829015304	38, 14	24	BRUSH ON	50/1 WEEK



Miscellaneous Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
MISCELLANEOUS							
25	HYDRAULIC RESERVOIR	507 L (134 GAL) (TANK ONLY)	6829006444	6, 11, 14	1	CHECK & FILL	10 HRS/DAILY
95	HYDRAULIC FILTER & BREATHER	-----	-----	39	1	CHANGE FILTER & BREATHER	SEE NOTE 39
28	DEF SUPPLY MODULE FILTER	-----	-----	-----	1	CHANGE FILTER	4500 HRS/ 200000 MI
29	DIESEL EXHAUST FLUID TANK	37.9 L (10 GAL) (TANK ONLY)	80019225	34	1	CHECK & FILL	-----
30	DEF TANK FILTER	-----	-----	-----	1	CHECK FILTER	1 YEAR

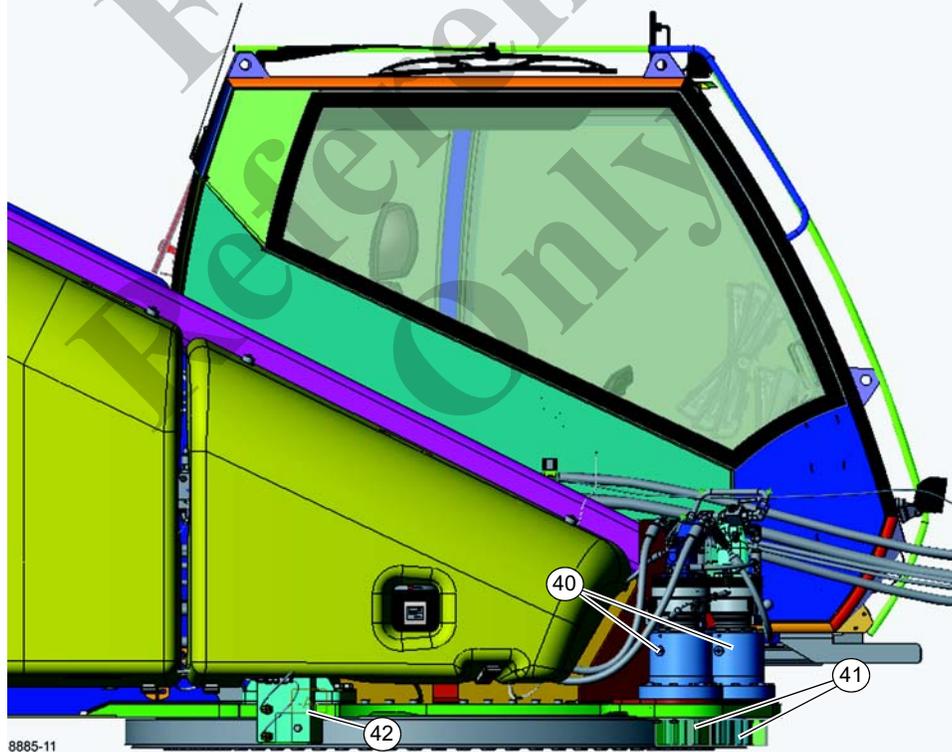


8885-10
8885-10

FIGURE 9-12

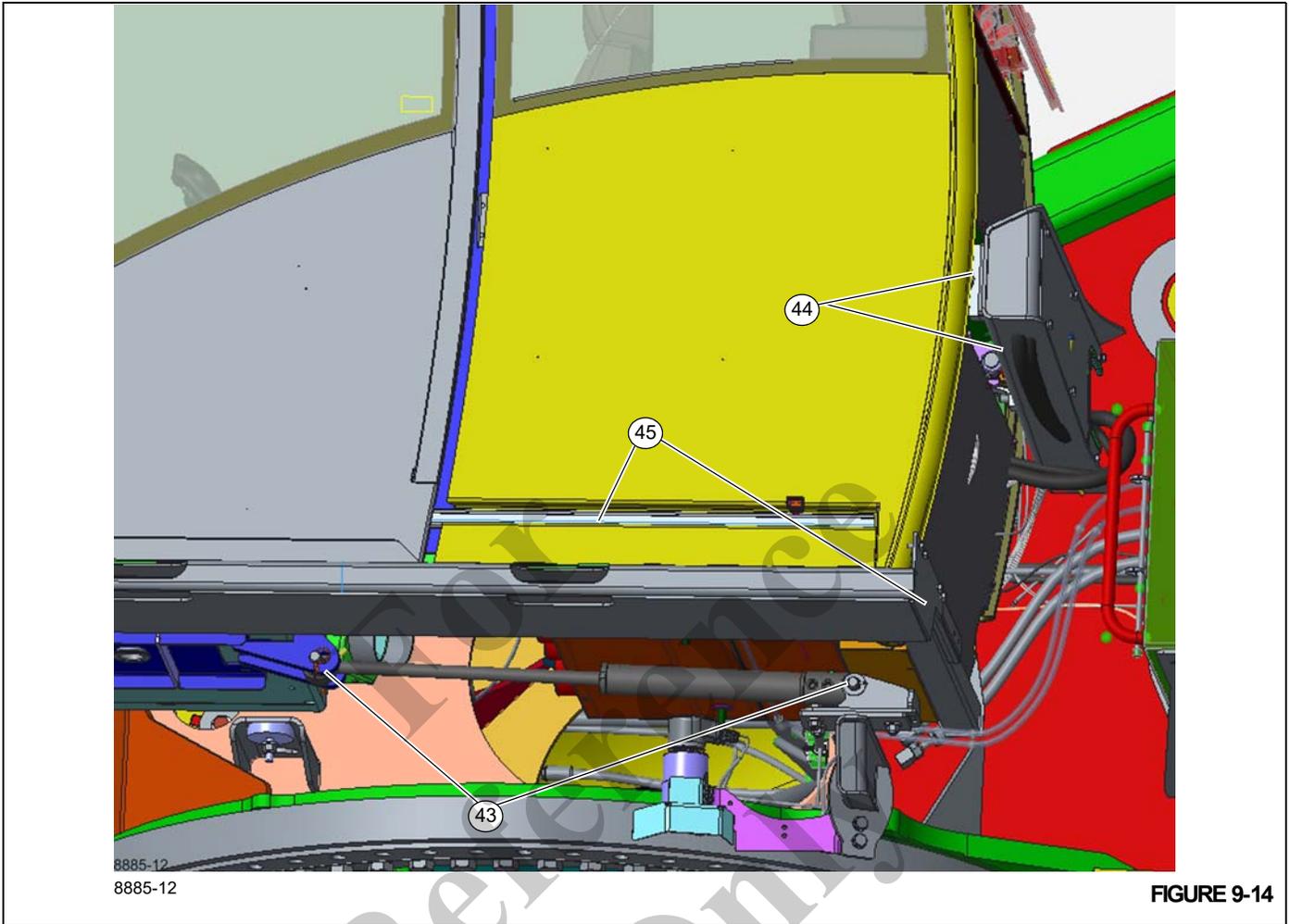
Turntable & Cab Tilt Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
TURNTABLE & CAB TILT							
40	TURNTABLE GEAR BOX	0.9 L (.95 QT)	6829014058	35	2	CHECK & FILL	50 HRS/1 WEEK
		0.9 L (.95 QT)	6829014058	14, 35	2	DRAIN & FILL	1000 HRS/12 MONTHS
41	TURNTABLE GEAR & DRIVE PINION	-----	6829102971	1, 14	2	SPRAY ON	500 HRS/6 MONTHS
42	TURNTABLE 360° SWIVEL LOCK	-----	6829003477	1, 14	1	LUBE	500 HRS/6 MONTHS
43	TILT CYLINDER PIVOT PINS	-----	6829003477	1, 14	2	LUBE	500 HRS/3 MONTHS
44	PILLOW BEARING	-----	6829003477	1, 14	2	LUBE	500 HRS/3 MONTHS
45	CAB TRACK & ROLLERS	-----	LIGHT OIL				



8885-11
8885-11

FIGURE 9-13

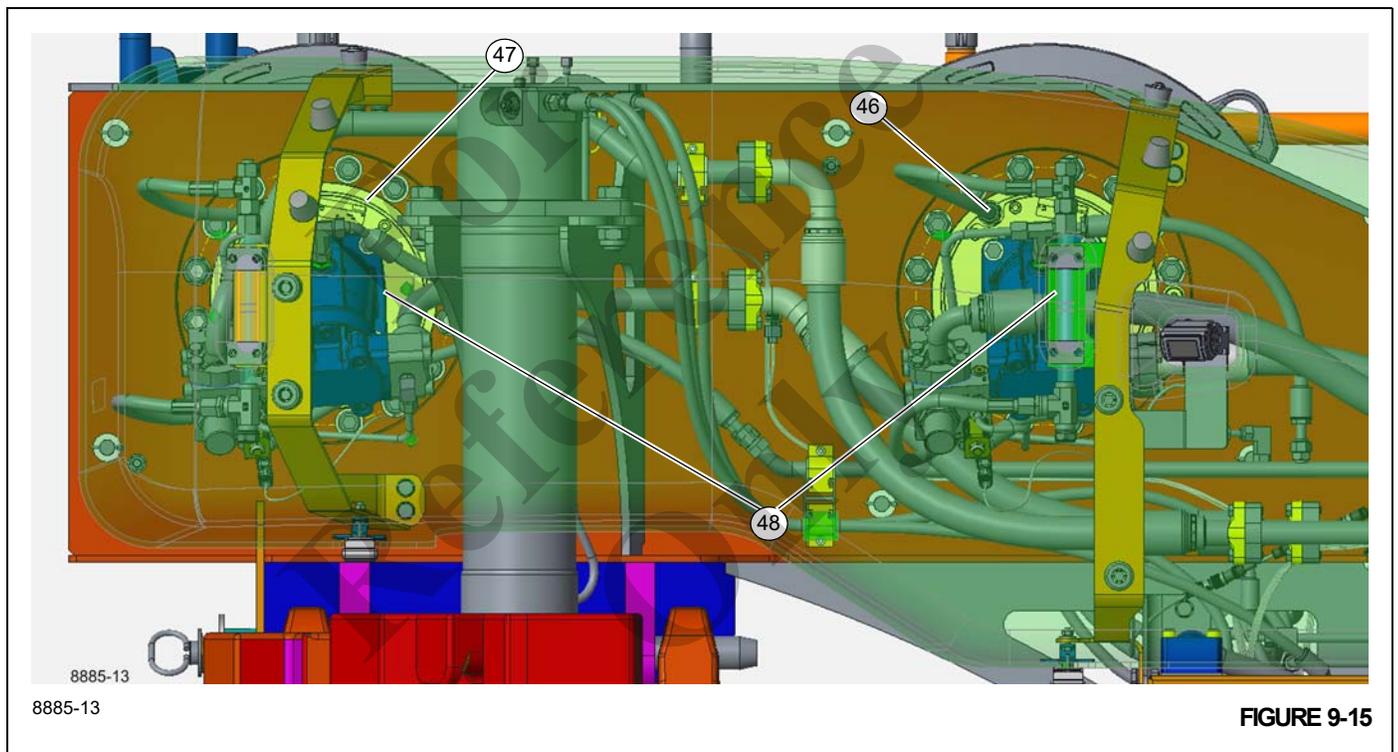


8885-12
8885-12

FIGURE 9-14

Hoist Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
HOIST							
46	MAIN HOIST - TRANSMISSION	-----	6829014058	2, 14	1	CHECK & FILL	50 HRS / WEEKLY
		4.0 L (1 GAL)	6829014058	2, 14	1	DRAIN & FILL	1000 HRS/12 MONTHS
47	AUX HOIST - - TRANSMISSION	-----	6829014058	2, 14	1	CHECK & FILL	50 HRS / WEEKLY
		4.0 L (1 GAL)	6829014058	2, 14	1	DRAIN & FILL	1000 HRS/12 MONTHS
48	HOIST BRAKE (MAIN & AUX)	-----	01930670	2, 14	1	CHECK & FILL	1000 HRS/12 MONTHS

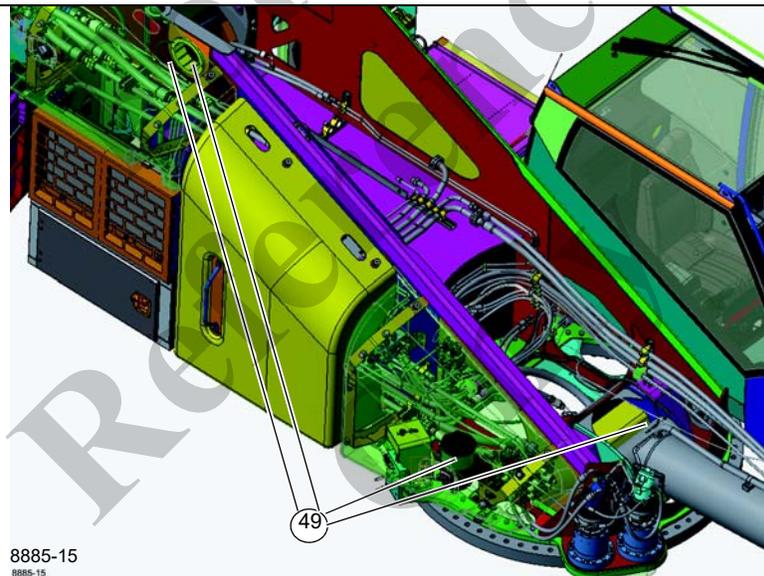


8885-13

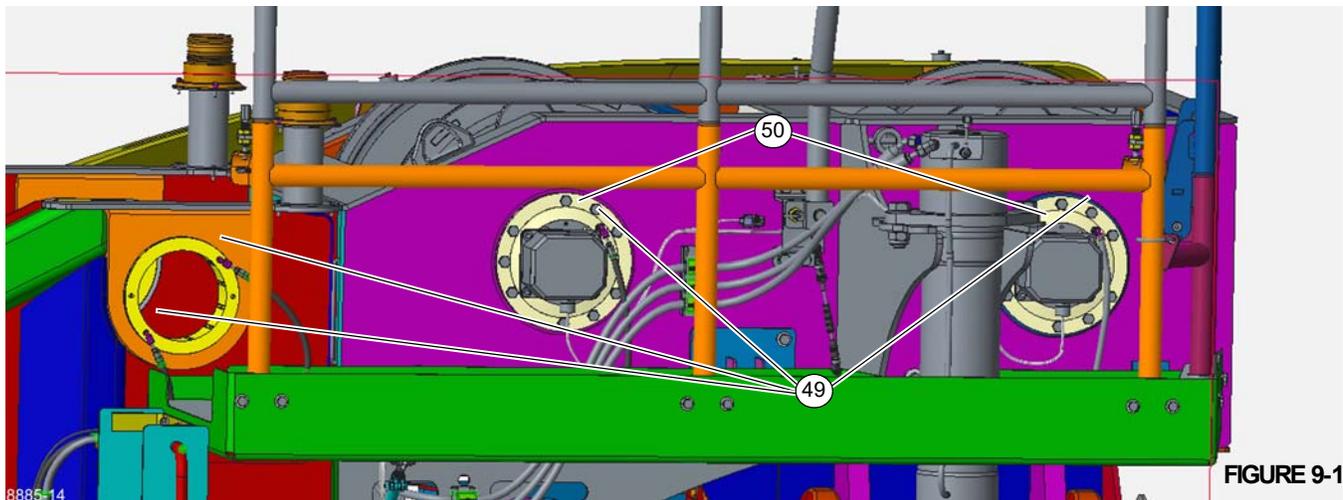
FIGURE 9-15

Turntable Central Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
HOIST							
49	TURNTABLE (SLEW) BEARING - INNER RACE	-----	6829003477	37	4	LUBE (AUTO)	50 HRS/1 WEEK
	LIFT CYLINDER PINS	-----	6829003477	37	1	LUBE (AUTO)	50 HRS/1 WEEK
	BOOM PIVOT PIN	-----	6829003477	37	4	LUBE (AUTO)	50 HRS/1 WEEK
	MAIN HOIST - GEARS	-----	6829003477	37	1	LUBE (AUTO)	50 HRS/1 WEEK
	AUX HOIST - GEARS	-----	6829003477	37	1	LUBE (AUTO)	50 HRS/1 WEEK
50	HOIST LOWER LIMIT SWITCH	-----	01373458		2	LUBE	250 HRS/ 3 MONTHS



8885-15
8885-15



8885-14

FIGURE 9-16

Boom Lubrication

Crane Setup

- Machine to be set up on firm level surface with fully extended outriggers and a minimum of 6000 lbs counterweight installed. Make sure that the crane is level.
- Boom must be directly over the rear.

- Set boom angle at zero degrees (horizontal).
- Disable the swing function to engage the swing brakes, and engage the 360-swing lock, if applicable.
- To grease each of the rear upper wear pads (Items 71-75), extend the boom to the Tele sequence in the Table below to expose the grease fittings.

LUBRICATION OF TELE SECTION	TO GREASE TELE 5	TO GREASE TELE 4	TO GREASE TELE 3	TO GREASE TELE 2	TO GREASE TELE 1
TELE 1	0	0	0	50	100
TELE 2	0	0	50	100	0
TELE 3	0	50	100	0	0
TELE 4	50	100	0	0	0
TELE 5	100	0	0	0	0

Greaseless Boom

The operator should ensure that each of the telescoping boom sections are clean during operation. Any dirt that is on the painted boom sections can get stuck in the wear pads, and this will lead to scoring of the paint. Eventually, the telescoping of a section with damaged paint will become more difficult to complete as the paint damage becomes more severe. Each of the telescoping boom sections should

be cleaned and wiped down with a non-solvent cleaning agent at least once a month or as required.

The operator has the option to grease the boom if they so choose. All of the grease fittings still exist in the boom. However, from that point forward, the boom will always need to be greased on a typical interval.

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
BOOM							
70	TELESCOPIC SLIDE FACES	-----	01373458	1, 14, 27, 28	5	BRUSH ON	500 HRS/6 MONTHS
71	TELE 1 REAR UPPER WEAR PAD	-----	01373458	1, 14, 27, 28, 29, 34	2	LUBE	500 HRS/6 MONTHS
72	TELE 2 REAR UPPER WEAR PAD		01373458	1, 14, 27, 28, 30, 34	2	LUBE	500 HRS/6 MONTHS
73	TELE 3 REAR UPPER WEAR PAD		01373458	1, 14, 27, 28, 31, 34	2	LUBE	500 HRS/6 MONTHS
74	TELE 4 REAR UPPER WEAR PAD		01373458	1, 14, 27, 28, 32, 34	2	LUBE	500 HRS/6 MONTHS
75	TELE 5 REAR UPPER WEAR PAD		01373458	1, 14, 27, 28, 33, 34	2	LUBE	500 HRS/6 MONTHS
76	TELE 5 LOCK PIN	-----	03313195	1, 14, 28, 34	2	LUBE	250 HRS/3 MONTHS
77	TELE 4 LOCK PIN	-----	03313195	1, 14, 28, 34	2	LUBE	250 HRS/3 MONTHS
78	TELE 3 LOCK PIN	-----	03313195	1, 14, 28, 34	2	LUBE	250 HRS/3 MONTHS
79	TELE 2 LOCK PIN	-----	03313195	1, 14, 28, 34	2	LUBE	250 HRS/3 MONTHS

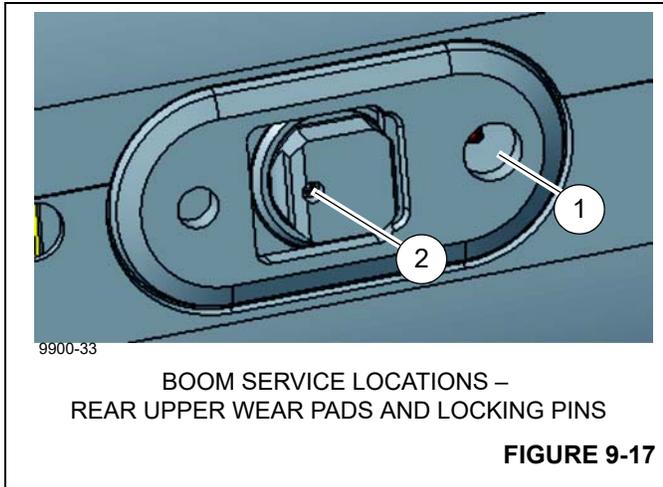
ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
BOOM							
80	TELE 1 LOCK PIN	-----	03313195	1, 14, 28, 34	2	LUBE	250 HRS/3 MONTHS
81	TELE-CYLINDER SLED	-----	01373458	14, 27, 28, 34, 40	1	BRUSH ON	500 HRS/6 MONTHS
82	DERRICKINGCYL PIVOT PIN	-----	6829003477	1, 8, 14	2	LUBE	100 HRS/ MONTHLY
83	ADAPTER SECTION PIVOT PIN	-----	6829003477	1, 8, 14	2	LUBE	100 HRS/ MONTHLY
84	BOOM EXTENSION SHEAVE	-----	6829003477	1	2	LUBE	DURING REPAIR
85	MAST SHEAVE	-----	6829003477	1	2	LUBE	DURING REPAIR
86	BOOM NOSE SHEAVES	-----	6829003477	1	7	LUBE	DURING REPAIR
87	AUX BOOM NOSE SHEAVE	-----	6829003477	1	1	LUBE	DURING REPAIR
88	HEAVYJIB SHEAVES	-----	6829003477	1	2	LUBE	DURING REPAIR
89	JIB SCREW	-----	6829003477	1, 14, 28	1	BRUSH ON	250 HRS/3 MONTHS
90	HOOK BLOCK - 102 TON (6 SHEAVES) SWIVEL BEARING	-----	6829003477	8, 14	3	LUBE	250 HRS/3 MONTHS
91	HOOK BLOCK - 66 TON (5 SHEAVE) SWIVEL BEARING	-----	6829003477	8, 14	3	LUBE	250 HRS/3 MONTHS
92	HOOK BLOCK - 50 TON (3 SHEAVE) SWIVEL BEARING	-----	6829003477	8, 14	3	LUBE	250 HRS/3 MONTHS
93	HOOK BLOCK - 29 TON (1 SHEAVE) SWIVEL BEARING	-----	6829003477	8, 14	3	LUBE	250 HRS/3 MONTHS
94	OVERHAUL BALL - SWIVEL	-----	6829003477	8, 14	1	LUBE	250 HRS/3 MONTHS

Telescope Section 5 (Tele 5)

1. Make sure that the Tele cylinder is locked to Tele 5.
2. Extend and lock Tele 5 to the 100% pinning location.
3. Extend and lock Tele 4 to the 50% pinning location.
4. Lower the boom to 0° and perform the following greasing in this position:

- a. Grease outer sides of Tele 5 in the areas that touch the front wear pads of Tele 4.
- b. Grease the rear upper wear pads of Tele 5 on both sides, at the grease fittings (1), ((Figure 9-17), through the openings in Tele 4.
- c. Grease locking pins on both sides (2), (Figure 9-17).

NOTE: To grease the rear upper wear pads of Tele 5 at the 50% or 92% pinning locations, extend and lock Tele 5 to these pinning locations and repeat **Step 4b** greasing.



5. While in the horizontal position, first retract Tele 4, and then retract and extend Tele 5 several times to make sure that grease is properly distributed.
6. When Tele 5 greasing is complete, retract and lock Tele 5 to the 0% pinning location.
7. Raise boom to 70°.

Telescope Section 4 (Tele 4)

1. Make sure that the Tele cylinder is locked to Tele 4.
2. Extend and lock Tele 4 to the 100% pinning location.
3. Extend and lock Tele 3 to the 50% pinning location.
4. Lower the boom to 0° and perform the following greasing in this position:
 - a. Grease outer sides of Tele 4 in the areas that touch the front wear pads of Tele 3.
 - b. Grease the rear upper wear pads of Tele 4 on both sides, at the grease fittings (1), (Figure 9-17), through the openings in Tele 3.
 - c. Grease locking pins on both sides (2), (Figure 9-17).

NOTE: To grease the rear upper wear pads of Tele 4 at the 50% or 92% pinning locations, extend and lock Tele 4 to these pinning locations and repeat **Step 4b** greasing.

5. While in the horizontal position, first retract Tele 3, and then retract and extend Tele 4 several times to make sure that grease is properly distributed.
6. When Tele 4 greasing is complete, retract and lock Tele 4 to the 0% pinning location.
7. Raise boom to 70°.

Telescope Section 3 (Tele 3)

1. Make sure that the Tele cylinder is locked to Tele 3.
2. Extend and lock Tele 3 to the 100% pinning location.

3. Extend and lock Tele 2 to the 50% pinning location.
4. Lower the boom to 0° and perform the following greasing in this position:
 - a. Grease outer sides of Tele 3 in the areas that touch the front wear pads of Tele 2.
 - b. Grease the rear upper wear pads of Tele 3 on both sides, at the grease fittings (1), (Figure 9-17), through the openings in Tele 2.
 - c. Grease locking pins on both sides (2), (Figure 9-17).

NOTE: To grease the rear upper wear pads of Tele 3 at the 50% or 92% pinning locations, extend and lock Tele 3 to these pinning locations and repeat **Step 4b** greasing.

5. While in the horizontal position, first retract Tele 2, and then retract and extend Tele 3 several times to make sure that grease is properly distributed.
6. When Tele 3 greasing is complete, retract and lock Tele 3 to the 0% pinning locations.
7. Raise boom to 70°.

Telescope Section 2 (Tele 2)

1. Make sure that the Tele cylinder is locked to Tele 2.
2. Extend and lock Tele 2 to the 100% pinning location.
3. Extend and lock Tele 1 to the 50% pinning location.
4. Lower the boom to 0° and perform the following greasing in this position:
 - a. Grease outer sides of Tele 2 in the areas that touch the front wear pads of Tele 1.
 - b. Grease the rear upper wear pads of Tele 2 on both sides, at the grease fittings (1), (Figure 9-17), through the openings in Tele 1.
 - c. Grease locking pins on both sides (2), (Figure 9-17).

NOTE: To grease the rear upper wear pads of Tele 2 at the 50% or 92% pinning locations, extend and lock Tele 2 to these pinning locations and repeat **Step 4b** greasing.

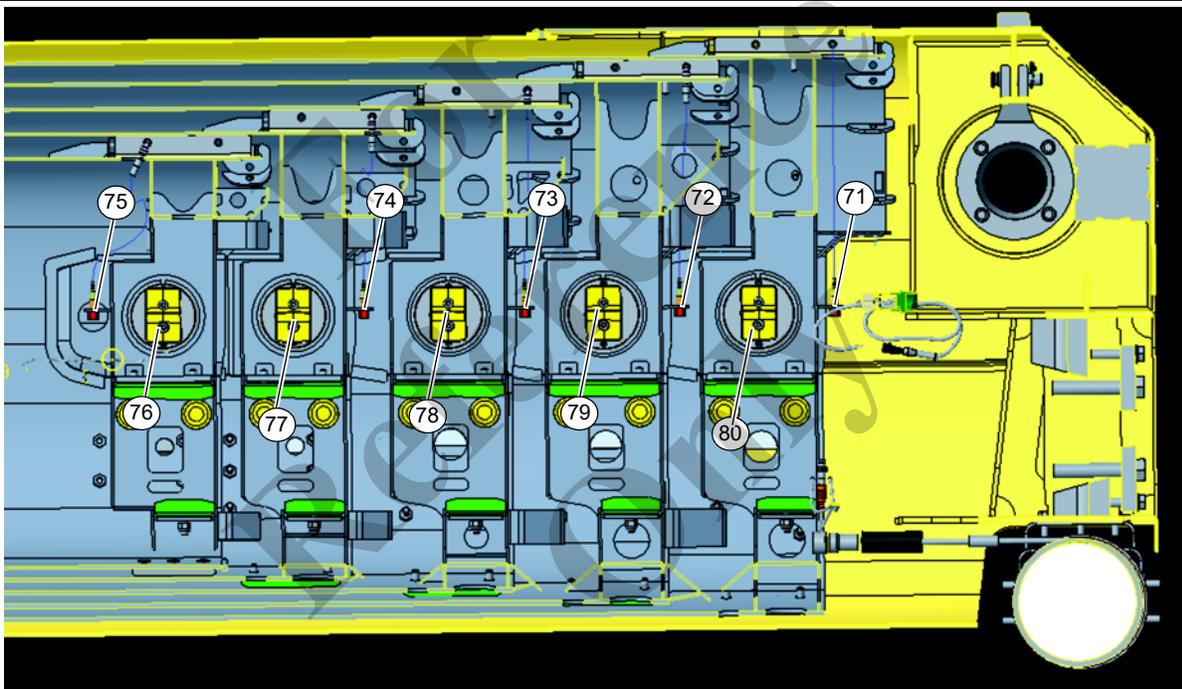
5. While in the horizontal position, first retract Tele 1, and then retract and extend Tele 2 several times to make sure that grease is properly distributed.
6. When Tele 2 greasing is complete, retract and lock Tele 2 to the 0% pinning location.
7. Raise boom to 70°.

Telescope Section 1 (Tele 1)

1. Make sure that the Tele cylinder is locked to Tele 1.
2. Extend and lock Tele 1 to the 100% pinning location.

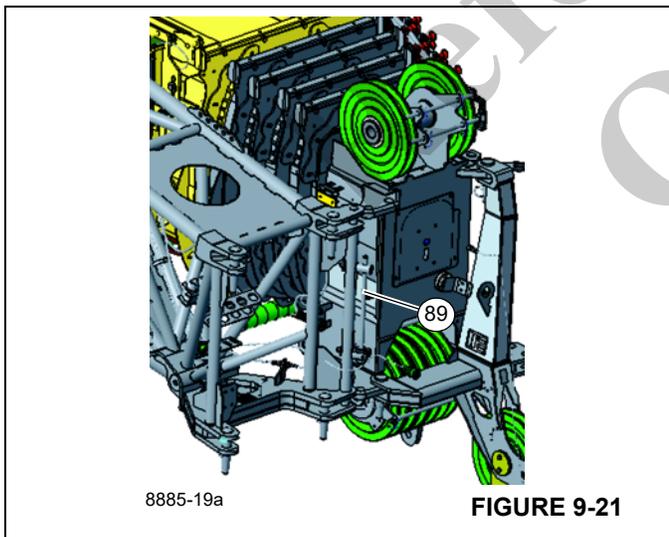
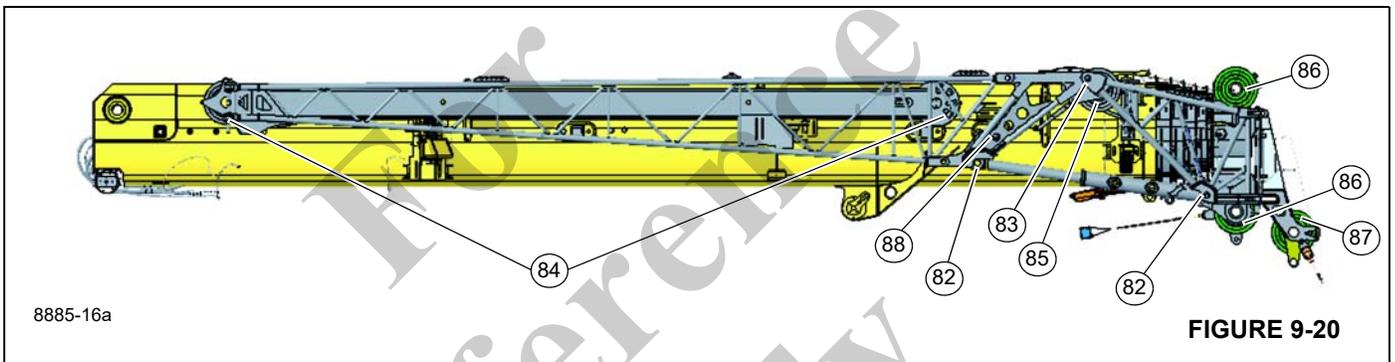
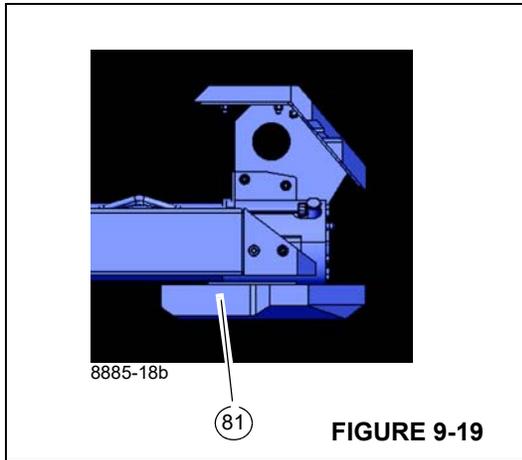
3. Lower the boom to 0° and perform the following greasing in this position:
 - a. Grease outer sides of Tele 1 in the areas that touch the front wear pads of the base section.
 - b. Grease the rear upper wear pads of Tele 1 on both sides, at the grease fittings (1), (Figure 9-17), through the openings in the base section.
 - c. Grease locking pins on both sides (2), (Figure 9-17).
- NOTE:** To grease the rear upper wear pads of Tele 1 at the 50% or 92% pinning locations, extend and lock Tele 1 to these pinning locations and repeat **Step 3b** greasing.
4. While in the horizontal position, extend and retract Tele 1 several times to make sure that grease is properly distributed.
5. When Tele 1 greasing is complete, retract and lock Tele 1 to the 0% pinning location.

Boom Tele Section Lubrication procedures are complete.



8885-17a

FIGURE 9-18



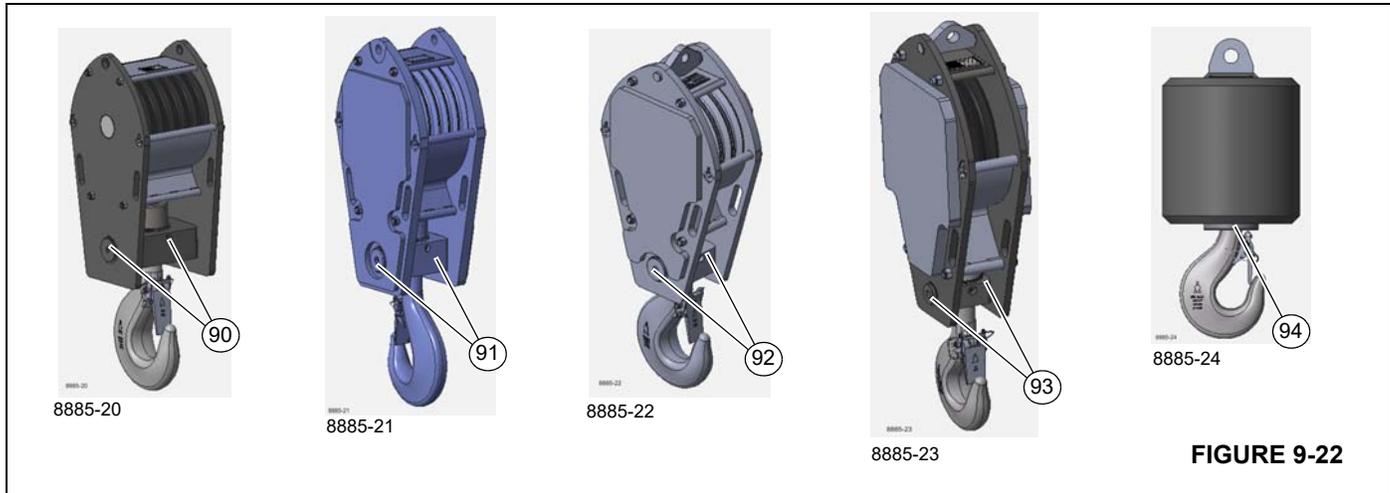


FIGURE 9-22

Monthly Lubrication Work

Pins

Lubricate the following:

- 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 lubrication interval applies to average operation. Also, lubricate the pins after high-pressure cleaning and generally at an interval that will prevent them getting dry.

For Reference Only

CARWELL® RUST INHIBITOR

Protecting Cranes From Corrosion

Grove 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 29CFR1910.1200. 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

Possible Machine Damage!

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.

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:

Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

NOTE: 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 primed and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

Reference (Figure 9-23).

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; valves, hose ends and fittings, swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoists, roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.

- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, overhaul ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.

For
Reference
Only



FIGURE 9-23

Item	Description	Item	Description
1	Hoist Hose Connections	11	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
2	Boom Extension Pins, Clips	12	Powertrain Hardware Inside Compartment
3	Valve Bank	13	O/R Pins, Clips
4	Hose Connections Inside Turntable	14	Entire Underside of Unit
5	Boom Extension Hanger Hardware	15	Turntable Bearing Fasteners
6	Boom Nose Pins, Clips	16	Counterweight Pins
7	Hook Block Tie-down Cable	17	Wire Rope
8	Overhaul Ball/Hook Block	18	Tension Spring
9	Mirror Mounting Hardware	19	Outrigger Beam Wear Pad Adjustment Hardware
10	O/R Hose Connections		

For
Reference
Only

For
Reference
Only

This Page Blank

Alphabetical Index

360° Swing Lock Control (Positive Lock Type)	6-20
After-Treatment Diesel Exhaust Fluid (DEF)	7-13
Air Intake System.	7-8
Air System	8-22
Anti-Lock Brake System (ABS)/Automatic Traction Control (ATC)	8-57
Automatic Slack Adjuster.	8-44
Bleeding the Telescoping Cylinders	4-44
Boom Assembly	4-18
Boom Disassembly	4-17
Boom Installation	4-11
Boom Nose Sheaves.	4-13
Boom Removal	4-9
Brakes	8-36
Breaking in a New Crane.	1-2
Carrier Valves	2-17
Carwell® Rust Inhibitor	9-29
Center Front Jack Cylinder	8-93
Center Front Stabilizer Cylinder.	2-41
Check the Locking System	4-46
Cleaning.	1-7
Clutch.	7-24
Counterweight Cylinder	2-47
Cylinder Rod Surface Protection	9-2
Cylinders	2-29
Definitions of Stated Directions	1-2
Description of Maintenance Work on the Superstructure	4-1
Drive Train	7-22
Engine Control System	7-5
Engine	7-1
Exhaust System.	7-11
Fasteners and Torque Values	1-8
Front Axle	8-2
Front Brakes	8-37
Fuel System.	7-6
Gearshift	7-33
General	9-1
Handling Substances which are Harmful to the Environment	1-4
Hoist Ropes	4-47
Hydraulic Pumps	2-12
Hydraulic System of the Superstructure	2-29
Jump Starting the Crane	3-23
Lift Cylinder	2-44
Lubrication Points	9-2
Maintenance Intervals	5-1
Maintenance Plans	5-3
Manitowoc CraneCare Service instructions.	1-2
Manual Transmission.	7-34
Measures Required for Hoist Monitoring	5-10
Mechanical Emergency Unlocking and Locking of the Telescopic Sections	4-43
New York House Lock	4-44
Non-Asbestos Warning	8-37
Other Maintenance Work.	4-55
Outrigger Control Manifold.	2-21
Outrigger Extension Cylinder.	2-34

Outrigger Jack Cylinder	2-37
Outrigger Jack Cylinders	8-92
Outrigger Monitoring System (Optional—Standard in North America)	8-96
Outrigger Selector-A/C Manifold Valve	2-19
Outriggers	8-83
Overview of the Components that are Easily Damaged when Cleaning	1-8
Overview of the Operating and Display Elements	1-4
Periodic Inspections	5-9
Pilot Operated Check Valve	2-24
Pinning Boom Components	4-38
Pressure Setting Procedures	2-49
Pump / PTO Assembly	7-40
Rated Capacity Limiter	4-52
Rear Axle and Suspension	8-17
Rear Brakes	8-52
Remote Controller (Optional)	3-22
Return Hydraulic Filter Assembly	2-10
Safety Messages	1-1
Safety Rules	1-3
Special Tools	8-78
Steer Cylinder	2-31
Steer Cylinder	8-16
Steering Pump	8-15
Steering System	8-12
Superstructure Air Conditioning System (Additional Equipment)	4-55
Superstructure Maintenance Overview	5-1
Superstructure Valves	2-26
Supply Pressure and Return Circuit	2-6
Swing Bearing	6-10
Swing Box Assemblies	6-7
Swing Lock Pin	6-20
Switch Replacement	3-18
Swivels	6-15
Telescope Cylinder	2-48
Telescope Slide Pad Adjustment	4-46
Theory of Operation	6-1
Torque Values	1-9
Torque Wrenches	1-9
Transmission Shift Air System	7-39
Using the Service Manual	1-1
Water Cooling System	7-16
Wheels and Tires	8-17
Wheels and Tires	8-21
Windshield Washer Assembly Replacement	3-21
Windshield Wiper Assembly Replacement	3-19
Wire Rope Inspection/Replacement (All Wire Rope)	4-47

For
Reference
Only

For
Reference
Only