Grove GRT9165

Service Manual

9897

Grove Manitowoc National Crane Potain

WARNING

California Proposition 65

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

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

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

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

California Spark Arrestor

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

The original language of this publication is English.

SERVICE MANUAL

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

GRT9165

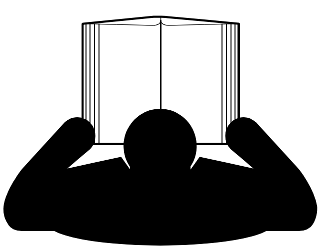
Crane Model Number

This manual is divided into the following Sections:

NOTICE

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

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



DANGER

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

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

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SECTION 1
INTRODUCTION

SECTION CONTENTS

GENERAL

This manual provides important information about your Grove Crane.

Overview of Manuals

Before placing the crane in service, take time to thoroughly familiarize yourself with the contents of this manual. After all sections have been read and understood, retain the manual for future reference in a readily accessible location.

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

Engine operating procedures and routine maintenance procedures are supplied in separate manuals with each crane, and should be referred to for detailed information. A separate safety manual is also provided with each crane. See the *Operator Manual*, Section 2 for other Safety related issues.

Customer Support

Grove Crane and our Distributor Network want to ensure your satisfaction with our products and customer support. Your local distributor is the best equipped and most knowledgeable to assist you for parts, service and warranty issues. They have the facilities, parts, factory trained personnel, and the information to assist you in a timely manner. We request that you first contact them for assistance. If you feel you need factory assistance, please ask the distributor's service management to coordinate the contact on your behalf.

A compact disc or USB flash drive, which includes sections on Operation, Safety and Maintenance for crane operators and owners, is supplied when the crane is purchased new. Additional copies are available from your Grove distributor.

New Owners

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

Go to https://www.manitowoccranes.com/en/Parts_Services/ServiceAndSupport/ChangeOfOwnershipForm and complete the form.

General Crane Design

The Grove crane has been designed for maximum performance with minimum maintenance. With proper care, years of trouble-free service can be expected.

Constant improvement and engineering progress makes it necessary that we reserve the right to make specification and equipment changes without notice.

Specific Crane Description

The crane incorporates an all welded parallel box construction steel frame, utilizing two drive steer axles and one non-drive steer axle. Axle steering is accomplished utilizing hydraulic steer cylinders. The engine is mounted at the rear of the crane carrier and provides motive power through a six speed forward and reverse transmission. The outriggers are single stage, double box, telescopic beam type outriggers.

The superstructure is capable of 360 degree rotation in either direction. All crane functions are controlled from the fully - enclosed cab mounted on the superstructure. One boom is available on the crane: a six section pinning boom, 13.7 m to 62.5 m (44.9 ft to 205 ft) boom. Additional reach is obtained by utilizing one of two optional boom extensions; a manually or hydraulically offsettable 10.9 m to 17.8 m (35.7 ft to 58.4 ft) folding swingaway boom extension.

Lifting Capacities (Load Chart)

Lift Capacities are listed on the Load Chart in the cab.

Basic Components

For basic Crane Component locations see Figure 1-2.

Axle Weight Distribution

For Axle Weight Distribution see Table 1-2.

Serial Number Location

Crane Serial Numbers are stamped on the left side of front frame and on manual holder in cab.

Transportation and Lifting Data

Transportation and Lifting data Figure 1-1 are located on the hydraulic tank on the right side of the crane.

LIST OF SPECIFICATIONS

General

Model GRT9165
Full Vision Cab . . . . 20° cab tilt
Rated Capacity. . . . See *Load Chart Manual* in cab
Drive. . . . . .6 x 4 x 6
Gross Weight . . See Axle Weight Distribution Table

Dimensions

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

Wheelbase . . . . 5000 mm (197 in)
Overall Crane Length . . . . . . 16021 mm (630.75 in)
Compact Transport Length. . . . . . . (8.5 m) (27.9 ft)
Overall Crane Width
with Counterweight . . . . 3996 mm (157 in)
without Counterweight. . . . 3800 mm (149.6 in)
Overall Crane Height
Ride Height . . . . 3792 mm (149.29 in)
Fully Lowered . . . . 3741 mm (147.29 in)
Outside Turning Radius
(with Jib Installed)
2 Wheel Steer (in meters) . . 19.7 m (64 ft 8 in)
6 Wheel Steer (in meters) . . 15.0 m (49 ft 3 in)
Outside Turning Radius
(without Jib Installed)
2 Wheel Steer (in meters) . . 19.0 m (62 ft 4 in)
6 Wheel Steer (in meters) . . 14.4 m (47 ft 3 in)
Outside Curb Clearance
2 Wheel Steer (in meters) . . 15.6 m (51 ft 2 in)
6 Wheel Steer (in meters) . . 10.6 m (34 ft 9 in)

Capacities

Fuel Tank (Usable). . . . . .271 L (72 gal)
Engine Cooling System . . . . 42 L (11.1 gal)
Engine Cooling System (Liquid Coolant
Conditioner . . . .(test and add, as necessary)
Engine Crankcase with filter (Tier 4) . . .15 L (4 gal)
Hydraulic Tank (Reservoir Capacity)
Total. . . . . .838.58 L (221.5 gal)
Full Level. . . . . 729 L (192.6 gal)
Hoist Drums (each) . . . . .4 L (1 gal)
Swing Drive Gearboxes (each) . . . . 4 L (4.2 qt)
Swing Drive Gearbox Brake
Assemblies (each) . . . . 0.3 L (0.6 pt)
Axle Planetary Hubs and Wheel
Bearings (each wheel end). . . . . . 9.8 L (10.4 qt)
Axle Differentials (each) . . . . .44.8 L (11.8 gal)
Transmission (includes Torque
Converter . . . . .44.5 L (11.75 gal)
Diesel Exhaust Fluid (DEF) Tank . . . 37.9 L (10 gal)

Transmission

Gear Ratios — Forward and Reverse
Low Range
1st 12.64:1
2nd 6.11:1
3rd. 2.25:1
High Range
4th. 4.30:1
5th. 2.08:1
6th. 0.76:1

Torque Converter

Stall Ratio 1.784:1
Charge Pump
Capacity . . . . 80 L/min (21 gal/min) @ 2000 rpm

Engine

Cummins QSB 6.7L - Stage V/Tier 4F

Type . . . . 4-cycle, Diesel
with After-Treatment System
6-cylinder Turbocharged . . . .After-Cooled Engine
Horse Power Rating. .224kW (300 hp) @ 2500 rpm
Maximum Speed, No Load . . . . 2700 rpm
Max. Torque . . . . .1288 N·m (950 lb-ft) at 1500 rpm
24 Volt Electrical System . . . . two 12 Volt Batteries
Fuel . . . . Maximum 15 ppm sulfur content (ULSD)
plus Diesel Exhaust Fluid (DEF)

Cummins QSB 6.7L - Non-Certified

Type . . . . 4-cycle, Diesel
6-cylinder Turbocharged . . . . After-Cooled Engine
Horse Power Rating. .224kW (300 hp) @ 2500 rpm
Maximum Speed, No Load . . . . 2700 rpm
Max. Torque . . . . .1288 N·m (950 lb-ft) at 1500 rpm
24 Volt Electrical System . . . . two 12 Volt Batteries
Fuel . . . . Maximum 5000 ppm Sulfur Diesel

Axles

Total Ratio 36.84:1
Carrier Ratio 6.14:1
Planetary Ratio 6:1

Steering

Type . . . . . . Independent Hydraulic Power Steering
Front axle . . . . controlled via steering wheel
Rear axles . . . . .mechanically linked and
controlled via separate switch in cab
Rear steer . . . . alignment indicator included
Coordinated Turning Radius
Outside 6 Wheel Steer . . . . . . .10.2 m (22.5 ft)
Inside 6 Wheel Steer . . . . .7.4 m (24.2 ft)

Brakes

Type . . . . 6 Wheel Hydraulic Dry Disc
Acting on all Wheels w/ Dual Calipers
Parking. . . . . . .Front Axle Mounted, Spring Applied
Hydraulic Released

Wheels and Tires

Lugs per Wheel 24
Torque . . . . .610 to 678 N·m (450 to 500 lb-ft)
Tire Size. . . . . .26.5 x 25, 44 bias ply rating

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

Swing Gearbox

Reduction Ratio 37.5:1
Continuous Torque. . . . . .381 N·m (281 lb-ft)
Maximum Torque . . . . .762 N·m (562 lb-ft)

Boom

Length . . . . 13.7 m to 62.5 m (44.9 ft to 205 ft)
Sections . . . . 6 Section, MEGAFORM™
Pinning . . . . .TWIN-LOCK™ Boom Pinning
Max Tip Height without
Extension . . . . 65.2 m (214 ft)
Elevation . . . .-2° to +80°
Extensions (Optional)
Manual Bi-Fold Lattice Swingaway
Jib. . . . . 10.9 m to 17.8 m (35.7 ft to 58.4 ft)
Hydraulic Offsets at . . . 0°, 15°, 30°, and 50°
Maximum Tip Height. . . . . . . 83.2 m (273 ft)
Hydraulic Bi-Fold Lattice Swingaway
Jib. . . . . 10.9 m to 17.8 m (35.7 ft to 58.4 ft)
Hydraulic Offsets from . . . . 0° to 50°
Maximum Tip Height. . . . . . . 83.2 m (273 ft)

Outriggers

Outrigger Spread
Retracted . . . . 3558 mm (140 in)
Mid Extend. . . . . 6022 mm (237 in)
Fully Extended . . . . 8486 mm (334 in)
Outrigger Pad Diameters
Polymer . . . . .500 mm (19.68 in)
Aluminum. . . . . .610 mm (24.06 in)
Max Individual Outrigger
Pad Load . . . . . 738.4 kN (166,000 lb or 166 kip)

Swivel Assembly

Electrical . . . . .20 Slip Rings
Hydraulic. . . . . .10 ports
Water. . . . . .2 ports
Air Conditioning. . . . . .2 ports

Hydraulic Pumps

NOTE: Pump flow rate (output) figures are theoretical.

Pump #1

Type . . . . Piston
Sections 1
Output - @ loaded engine speed
Section 1 flow rate . . . 253 L/min (66.8 gal/min)

Pump #2

Type . . . . Piston
Sections 1
Output - @ loaded engine speed
Section 1 flow rate . . . 184 L/min (48.6 gal/min)

Pump #3

Type . . . . Gear
Sections 1
Output - @ loaded engine speed
Section 1 flow rate . . . 119 L/min (31.4 gal/min)

Pump #4

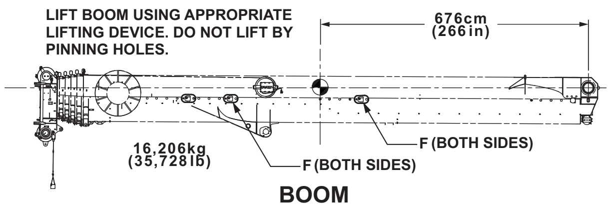
Type . . . . Gear
Sections 1
Output - @ loaded engine speed
Section 1 flow rate . . . . 58 L/min (15.3 gal/min)

Hoists

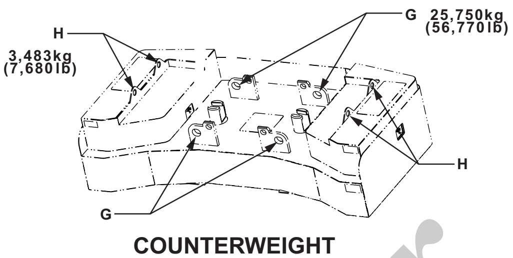
Drum Dimensions
Diameter . . . . .371 mm (14.61 in)
Length . . . . .550 mm (21.63 in)
Cable, Main, 35x7 Steel
Diameter . . . . .19 mm (0.75 in)
Length . . . . .294 m (964.5 ft)
Max Permissible
Line Pull . . . . .7784 kg (17,160 lb)
Cable, Aux., 35x7 Steel
Diameter . . . . .19 mm (0.75 in)
Length . . . . .233 m (764.4 ft)
Max. Permissible
Line Pull . . . . .7784 kg (17,160 lb)
Max. Single Line Speed at:. 140 m/min (459 ft/min)
Motor Displacement . . . . 80 cc (4.88 in³)

TRANSPORTATION AND LIFTING DATA GRT9165

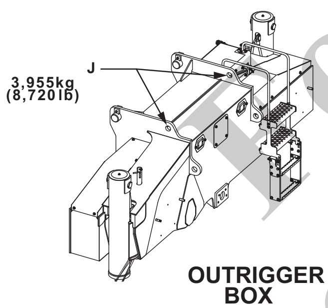
LIFT BOOM USING APPROPRIATE LIFTING DEVICE. DO NOT LIFT BY PINNING HOLES.



FITTINGS	NO./UNIT	TOTAL UNIT LIFT	TOTAL UNIT TOW	TOTAL UNIT TIE DOWN	CARRIER LIFT	CARRIER TOW	CARRIER TIE DOWN	BOOM LIFT	CWT LIFT	CWT LIFT	O/R BOX LIFT	FITTING CAPACITY (TONS) LIFT	FITTING CAPACITY (TONS) TOW	FITTING CAPACITY (TONS) TIE DOWN
A	12			X			X							11
B	2			X			X							44
C	4			X			X							44
D	4		X			X							50	
E	4	X			X							33	SEE NOTE #5	
F	4							X						
G	4								X					
H	2									X				
J	2										X			



1. LIFTING OF ENTIRE CRANE OR MAJOR CRANE ASSEMBLIES MUST BE ACCOMPLISHED BY UTILIZING SPECIFIC FITTINGS INDICATED ON THE ABOVE CHART. USE OF FITTINGS FOR PURPOSES OTHER THAN THOSE DESIGNATED ON THIS CHART IS PROHIBITED. FITTING CAPACITIES ARE MAXIMUM ALLOWABLE LOADS PER INDIVIDUAL FITTING.
2. RIGGING PERSONNEL SHALL BE RESPONSIBLE FOR PROPER SELECTION AND PLACEMENT OF ALL SLINGS AND LOAD HANDLING DEVICES.
3. DIMENSIONS AND WEIGHTS SHOWN ARE THE LARGEST CONFIGURATION AVAILABLE.
4. RIGGING PERSONNEL SHALL VERIFY DIMENSIONS AS REQUIRED FOR CLEARANCE.
5. EXTEND OUTRIGGER BEAMS 48 CM (18 IN) AND SLING AROUND BEAMS TO LIFT.
6. DO NOT USE PINTLE HOOKS OR CWT LUGS FOR LIFTING OR TYING DOWN THE ENTIRE CRANE.
7. REMOVE OUTRIGGERS AND COUNTERWEIGHT FOR TRANSPORT AS REQUIRED.



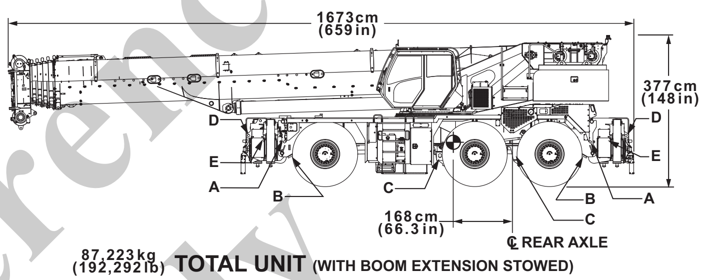


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FIGURE 1-1

Table 1-1 Axle Weight Distribution Table

Description	CG To CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
Basic Unit				
Maximum Axle Allowable at 16 km/h (10 mph)			33113 (73000)	66225 (146000)
Maximum Axle Allowable at 4 km/h (2.5 mph)			43727 (96400)	87454 (192800)
Standard Carrier Assembly + All Fluids + Outrigger Boxes and Beams	177.29 (69.80)	32235 (71065)	11430 (25199)	20805 (45866)
Superstructure Assembly w/both hoists + 294 m (965 ft) main hoist cable + 233 m (764 ft) aux hoist cable	31.52 (12.41)	8411 (18543)	530 (1169)	7881(17374)
Removable Counterweight	-164.64 (-64.82)	25760 (56790)	-8482 (-18700)	34242 (75490)
Boom Assembly with Lift Cylinder Upper Pin & Pivot Pin	610.41 (240.32)	15662 (34528)	19120 (42153)	-3459 (-7625)
Lift Cylinder & Lower Shaft	485.55 (191.16)	1402 (3091)	1362 (3002)	40 (89)
Complete Basic Machine: 13.7 m - 62.5 m (44.9 ft - 205 ft) 6-Section Boom, Cummins QSB6.7L Tier 4F Final Engine, 26. 5x 25 (44 ply) Titan Tires, Main Hoist with 294 m (965 ft) of 19 mm (3/4 in) 35 x 7 cable, Aux Hoist with 233 m (764 ft) of 19 mm (3/4 in) 35x7 cable, Full Fuel and Hydraulic Oil	148.62 (58.51)	83470 (184017)	23960 (52822)	59510 (131195)
Add To Basic Unit Weight - Boom Extensions				
10.9 to 17.8 m (35.7 to 58.4 ft) Manually Offsetable Boom Extension	840.21 (330.79)	1658 (3655)	2786 (6142)	-1128 (-2487)
10.9 to 17.8 m (35.7 to 58.4 ft) Hydraulic Offsetable Boom Extension	851.10 (335.08)	1759 (3878)	2994 (6601)	-1235 (-2723)
Extension Carrier Brackets - Manual Extension	712.01 (280.32)	154 (340)	220 (484)	-65 (-144)
Extension Carrier Brackets - Hydraulic Extension	750.11 (295.32)	133 (294)	200 (441)	-67 (-147)
Hose Reel for Hydraulic Extension	986.33 (388.32)	216 (476)	426 (939)	-210 (-463)
Aux Boom Nose - Installed	1369.06 (539.00)	195 (430)	534 (1177)	-339(-747)
8 m (26.2 ft) Insert - Manual Boom Extension (not included in weight)		620 (1367)		
8 m (26.2 ft) Insert - Hydraulic Boom Extension (not included in weight)		631 (1391)		
Add to Basic Unit Weight - Rigging Equipment				
11 t (12 USt) Overhaul Weight - tied to O/R Box	787.40 (310.00)	380 (838)	599 (1320)	-219 (-482)
11 t (12 USt) Overhaul Ball - tied to O/R Box	787.40 (310.00)	378 (833)	595 (1312)	-217 (-479)

Description	CG To CL Rear Bogie cm (in)	Weight kg (lb)	Front Axle kg (lb)	Rear Axle kg (lb)
120 t (134 USt) Hookblock (8 sheave) - in stowage tray	469.90 (185.00)	1180 (2601)	1109 (2444)	71 (157)
100 t (112 USt) Hookblock (7 sheave) - in stowage tray	469.90 (185.00)	1140 (2513)	1071 (2362)	68 (151)
75 t (83 USt) Hookblock (5 sheave) - in stowage tray	469.90 (185.00)	1070 (2359)	1006 (2217)	64 (142)
45 t (50 USt) Hookblock (3 sheave) - in stowage tray	469.90 (185.00)	770 (1698)	724 (1596)	46 (102)
26 t (29 USt) Hookblock (1 sheave) - in stowage tray	469.90 (185.00)	323 (712)	303 (669)	20 (43)
Add to Basic Unit Weight - Optional Equipment				
360° Swing Lock	174.45 (68.68)	34 (75)	12 (26)	0 (49)
Rubber Mat in Front Storage Tray	466.09 (183.50)	26 (58)	24 (54)	2 (4)
Cold Weather Package - Carrier (-29°)	116.84 (46.00)	67 (147)	15 (34)	51 (113)
Cold Weather Package - Carrier (-40°)	182.88 (72.00)	113 (250)	41 (91)	72 (159)
Cold Weather Package - S/S	149.05 (58.68)	38 (84)	11 (25)	27 (59)
Driver	218.44 (86.00)	113 (250)	49 (109)	64 (141)
Substitutions and Removals from Basic Unit Weight				
REM: Front Outrigger Box and Beam Assembly	662.99 (261.02)	3955 (-8720)	-5245 (-11563)	1290 (2843)
REM: Rear Outrigger Box and Beam Assembly	-262.99 (-103.54)	-3955 (-8720)	2081 (4587)	-6036 (-13307)
REM: Titan 26.5 x 25 (44) tires (for travel)	167.64 (66.00)	-4267 (-9408)	-1431 (-3154)	-2837 (-6254)
SUB: Export Engine (Non Certified)	93.98 (37.00)	-107 (-236)	-20 (-44)	-87 (-192)
REM: Main Hoist cable (294 m (965 ft) of 19 mm (3/4 in) 35x7)	-127.30 (-50.12)	-567 (-1250)	144 (318)	-711 (-1568)
REM: Aux Hoist cable (233 m (764 ft) of 19 mm (3/4 in) 35x7)	-213.51 (-84.06)	-450 (-992)	192 (424)	-642 (-1416)
Add: Lift Cylinder Travel Support	505.46 (199.00)	59 (129)	59 (130)	0 (-1)

GRT9165 CRANE COMPONENTS

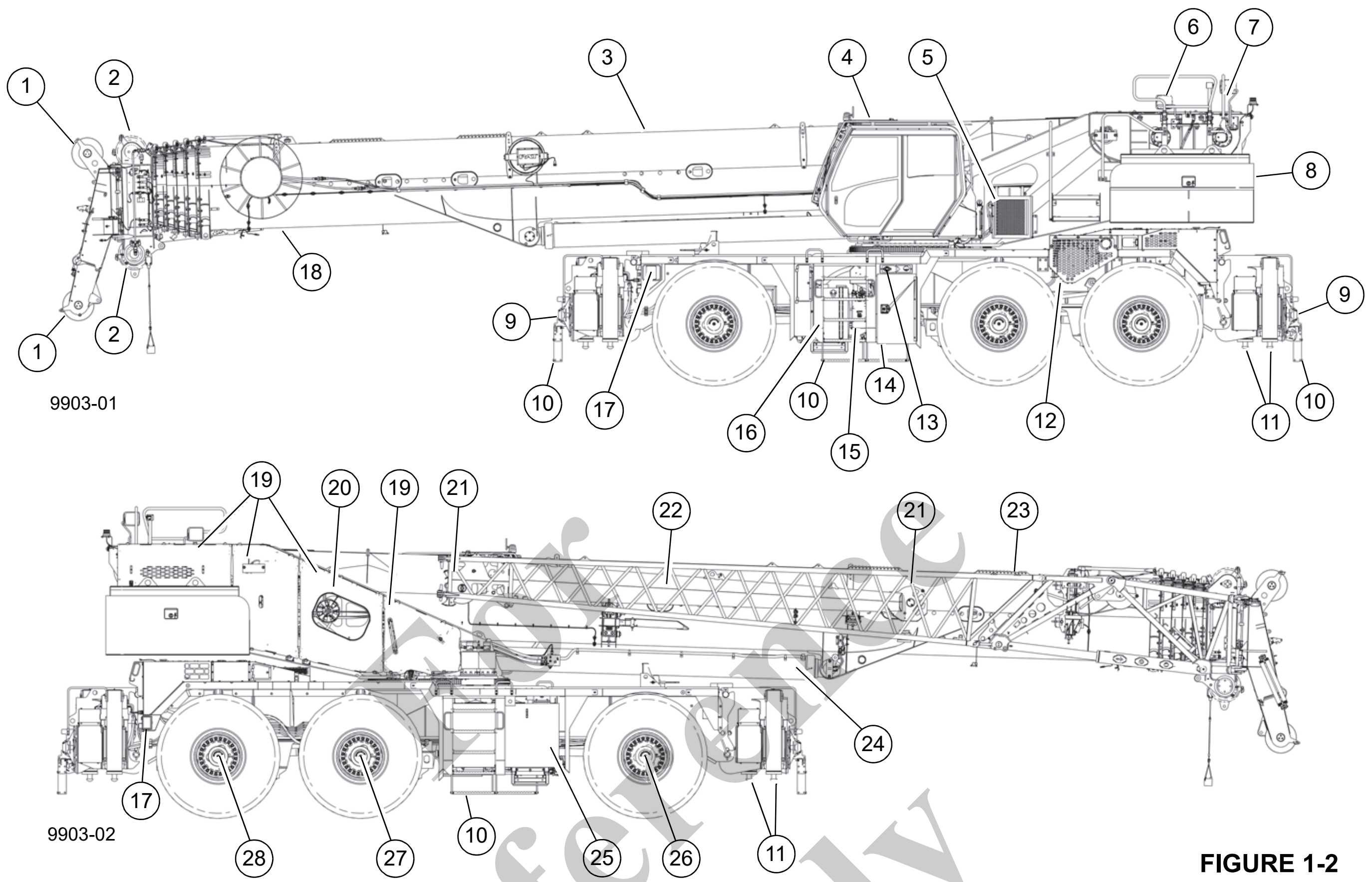


FIGURE 1-2

Item	Description	Item	Description
1	Auxiliary Boom Nose Sheaves	15	Diesel Exhaust Fluid (DEF) Tank*
2	Boom Nose Sheaves	16	Fuel Tank*
3	Boom	17	Outrigger Box Pinning Control
4	Cab	18	Boom Work Lights
5	Air Conditioning Condenser	19	Superstructure Valve Covers
6	Main Hoist	20	Hydraulic Oil Cooler
7	Auxiliary Hoist	21	Boom Extension Sheaves
8	Counterweight	22	Boom Extension Fly Section
9	Outrigger Pads	23	Boom Extension Base Section
10	Crane Steps and Grab Handles	24	Lift Cylinder
11	Outrigger Jack Cylinders	25	Hydraulic Tank
12	Exhaust Aftertreatment	26	Axle #1 (Front Drive and Steer)
13	Battery Disconnect Switch	27	Axle #2 (Steer only)
14	Battery and Control Module Compartment	28	Axle #3 (Rear Drive and Steer)
*Stage V/Tier 4F engines use Ultra Low Sulfur Fuel (Max 15 ppm) and Diesel Exhaust Fluid (DEF)			

GENERAL MAINTENANCE

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

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

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

Cleanliness

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

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

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

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

After Cleaning

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

> **CAUTION**
>
> **Eye Injury Hazard!**
>
> When using compressed air use only low air pressure and keep air stream from direction of face.
>
> Always wear eye and face protection when using compressed air. Injury to eyes could occur.

Removal and Installation

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

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

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

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

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

Disassembly and Assembly

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

Pressing Parts

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

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

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

Locking Devices

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

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

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

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

Wires and Cables

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

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

Shims

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

Hoses and Tubes

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Inspection

Check hoses carefully. Do not use your bare hands to check for leaks.

Tighten all connections to recommended torque.

If the hose end connections are damaged, always replace the hose or tube. Damaged, dented, crushed, or leaking hose fittings restrict oil flow and the operation of the parts being served. Fittings showing signs of movement from their original position have failed and must be replaced.

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

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

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

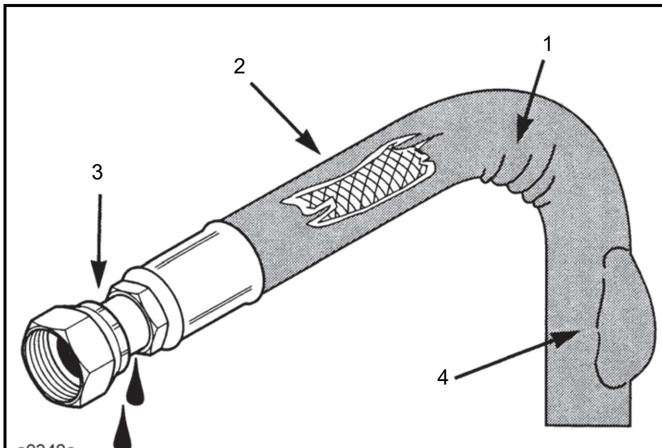


FIGURE 1-3

Installation

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

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

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

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

Sleeve Bearings

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

Gaskets

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

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

Batteries

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

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

Hydraulic Systems

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

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

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

Visual Inspection of Hoses and Fittings

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

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

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

    If any of these conditions exist, address them appropriately.

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

Table 1-2: Climate Zones

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

Hydraulic Fittings

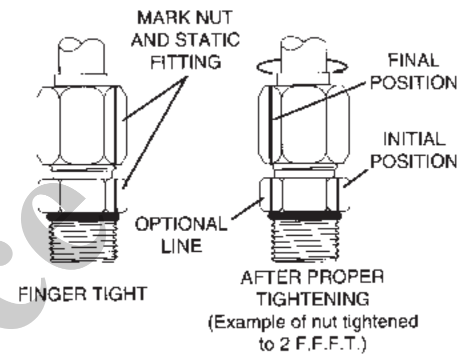
Flats from Finger Tight (F.F.F.T.) Method

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

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

Follow these steps when tightening all fitting connections:

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



a0027 **FIGURE 1-4**

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

37° Flared Steel Fitting: Tube or Hose to Fitting

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

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

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

T-2-5

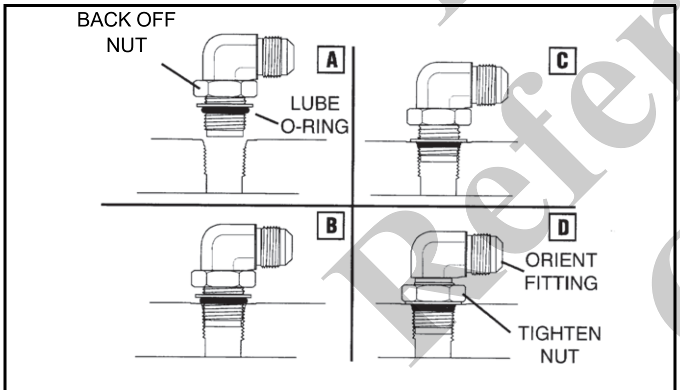
Adjustable Straight Thread O-ring Fittings

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

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

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

T-2-6



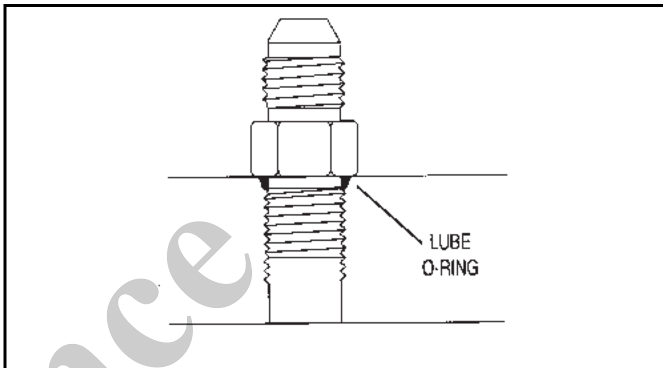
a0030 Adjustable Fitting to Port **FIGURE 1-5**

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

Nonadjustable Straight Thread O-ring Fitting: Fitting to Port

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

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-6).



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

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

Table 1-5: Straight Thread Fittings

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

T-2-7

Electrical System

Harnesses, Wires, and Connectors

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

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

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

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

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

Fatigue of Welded Structures

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

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

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

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

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

Loctite®

> **⚠ CAUTION**
>
> **Skin and/or Eye Hazard!**
>
> Loctite® type adhesives contain chemicals that may be harmful if misused. Read and follow the instructions on the container.

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

Application of Medium Strength Loctite®

NOTE: Fastener may be re-used. Adhesive may be re-applied over cured adhesive residue.

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

NOTE: Ensure male and female threaded surfaces are clean of contaminants, dirt, and oil.

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (Figure 1-7).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.

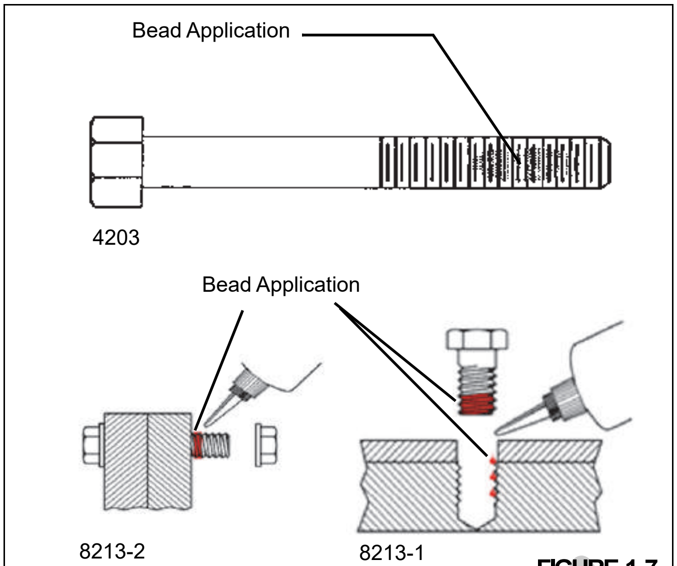


FIGURE 1-7

3. After application and engagement of mated threads, fixturing will occur within five (5) minutes. Time required to achieve full strength is 24 hours.

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 of 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 (N-m), multiply the pounds-foot quantity by 1.3558.

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

Torque Values

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

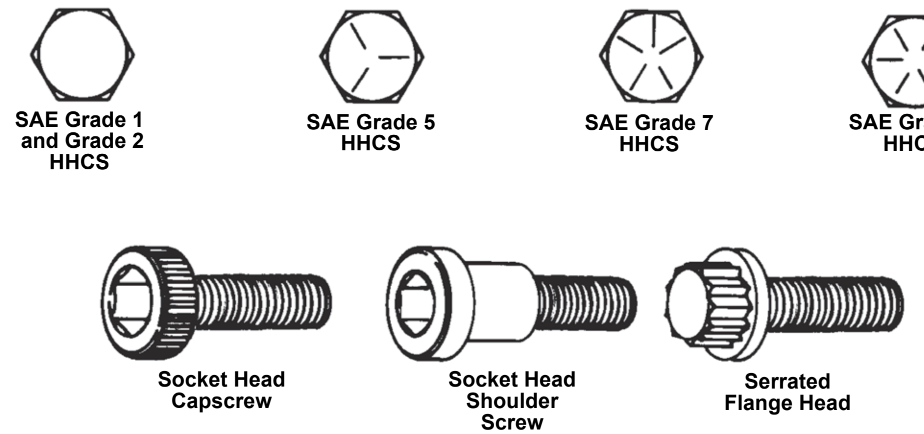


FIGURE 1-8

Table 1-6Inch 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

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
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 1-7 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

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
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 1-8 Metric Series with Coarse Threads – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (N-m)		
		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
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

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (N-m)		
		Maximum	Nominal	Minimum
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
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 1-9 Metric Series with Fine Threads – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (N-m)		
		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

Nominal Size, Threads per Inch, and Series Designation	Property Class	Torque (N-m)		
		Maximum	Nominal	Minimum
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
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 1-10 Metric Series Screws of STAINLESS STEEL A2-70/A4-70 with Coarse Threads

Size	Torque (N-m)
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 1-11 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 1-12 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 1-13 Metric Series Bearing Bolts– Untreated (black finish)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (N-m)		
		Maximum	Nominal	Minimum
M20X2.5	12.9	756	727	698
M24X3	10.9	1089	1047	1005
M24X3	12.9	1306	1256	1206
M27X3	10.9	1591	1530	1469

Table 1-14 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 1-15 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 1-16 Metric Series with Coarse Threads – Untreated (black finish)

Size	Property Class	Torque (N-m)		
		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 (N-m)		
		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

Table 1-17 Metric Series with Fine Threads – Untreated (black finish)

Size	Property Class	Torque (N-m)		
		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

Size	Property Class	Torque (N-m)		
		Maximum	Nominal	Minimum
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
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

Weld Studs

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

Table 1-18: Weld Stud Torque Values

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

T-2-4

WIRE ROPE

General

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

Environmental Conditions

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

Dynamic Shock Loads

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

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

Lubrication

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

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

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

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

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

Precautions and Recommendations During Inspection or Replacement

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

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

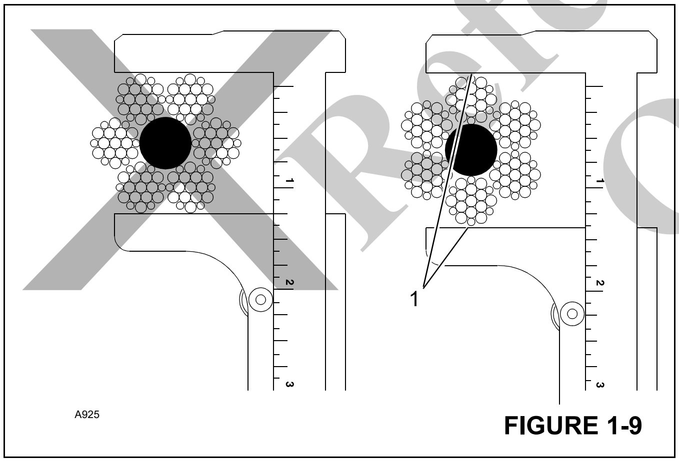


FIGURE 1-9

13. When checking for broken wires (5) (Figure 1-10) relax the rope, move it off "pick-up points", and flex it as much as possible. Defect in the rope is in relation to "Lay Length" (2) which is the distance measured along rope in which one strand (3) makes one complete revolution around the core (4).

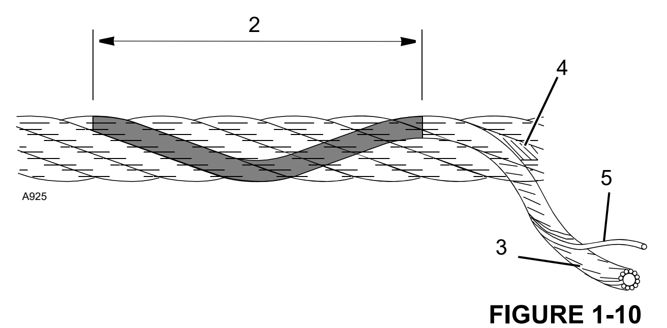


FIGURE 1-10

Wire Rope Inspection (Running Ropes and Pendant Cables)

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

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

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

Keeping Records

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

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

Frequent Inspection

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

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

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

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

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

Periodic Inspection

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

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

Wire Rope Inspection (Boom Extension and Retraction Cables)

Periodic Inspection

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

- Inspect for reduction of rope diameter below nominal diameter.
- Inspect for severely corroded or broken wires at end connections.
- Inspect for severely corroded, cracked, bent, worn, or improperly applied end connections.
- Inspect wire rope in areas subjected to rapid deterioration such as:
  - Sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.
  - Sections of wire rope at or near terminal ends where corroded or broken wires may protrude.
  - Sections of wire rope in contact with stationary surfaces where abrasion or chafing may take place as a result of equipment vibration.
- Inspect for damaged or wobbly boom extension and retraction sheaves that may cause rapid deterioration of the wire rope.
- Inspect for unusual cable sag/stretch and be sure cables used in sets all have an equal tension applied. Repeated need for adjustment of an individual cable is evidence of cable stretch and indicates the need for additional and more thorough inspection in order to determine and correct the cause.
- Manitowoc recommends that boom extension cables be replaced every seven (7) years.

Wire Rope Inspection/Replacement (All Wire Rope)

No precise rules can be given for determination of the exact time for replacement of wire rope since many variable factors are involved. Determination regarding continued use or replacement of wire rope depends largely upon the good 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.

Seizing Wire Rope

It is important to seize the ends of rotation resistant wire ropes to prevent the displacement and unraveling of the individual wires and strands at the ends. All preformed and non-preformed styles of wire rope should be seized prior to cutting. Seizings must be placed on both sides of the point where the wire rope is to be cut.

The two preferred methods for seizing wire ropes are:

Method 1

Using a length of soft annealed wire (Figure 1-11), place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

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

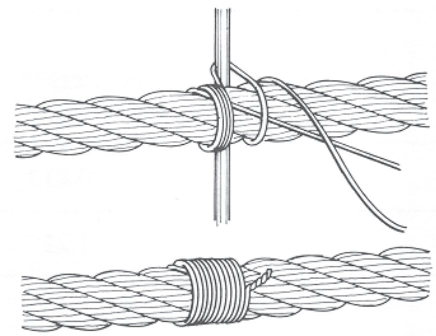


FIGURE 1-11

Method 2

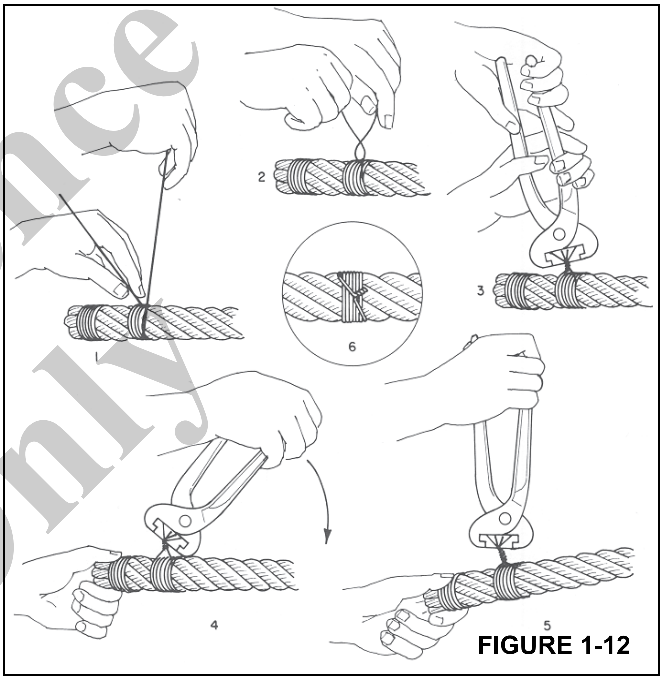


FIGURE 1-12

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

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

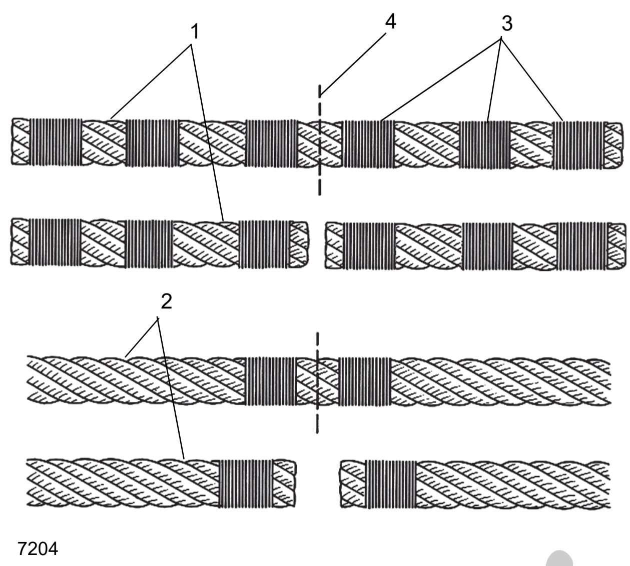


FIGURE 1-13

Installing 35x7 Class Wire Rope

CAUTION

Any cutting of this specific wire rope is not recommended. If 35x7class wire rope must be cut for any reason, it is necessary to follow the following instructions. Also, unlike other types of wire rope, the ends on this wire rope must be welded to retain the rotation resistant characteristics.

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

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

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

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

Procedures for Cutting and Preparing 35x7 Class Wire Rope

35x7 class rope is a special wire rope that must be handled differently than any other rope manufactured. One characteristic that makes this rope special is that the outer strands are not preformed. It is because of this that the following procedures for cutting and preparing 35x7class rope must be followed:

1. The welded ends prepared by the manufacturer are not to be removed.
2. Before cutting the rope, make three separate bands with seizing strand on each side of where the cut is to be made (total of six bands for each cut). Each band is to have a minimum length of one and one half times the rope diameter. The two bands closest to the cut should be located at a distance equal to one rope diameter away from the cut. The four remaining bands should be evenly spaced at a distance equal to three rope diameters.
   a. If a welder is available, the cut should be made with an abrasive saw. Immediately after the cut, both ends of the rope are to be cap welded so that all inner and outer strands are welded together, preventing any movement between them.

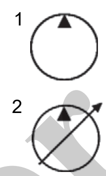
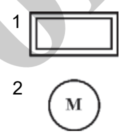
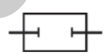
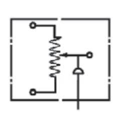
SECTION 2
HYDRAULIC SYSTEM

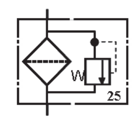
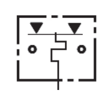
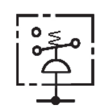
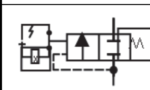
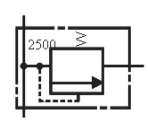
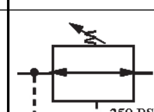
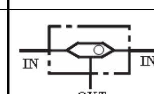
SECTION CONTENTS

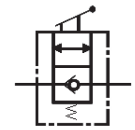
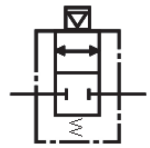
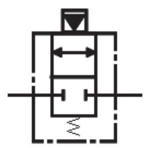
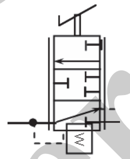
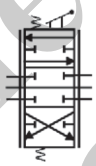
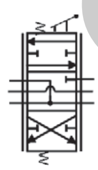
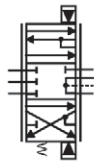
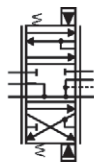
DESCRIPTION

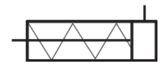
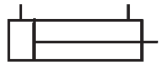
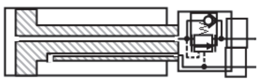
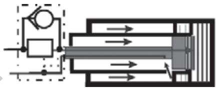
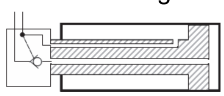
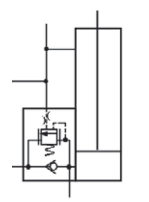
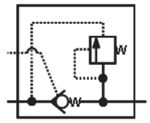
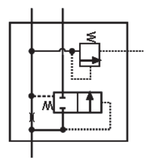
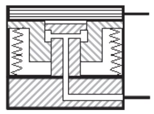
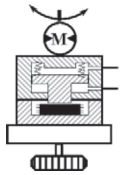
This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return hydraulic circuit, hydraulic pumps, all hydraulic valves, and all hydraulic cylinders. Detailed descriptions and operation of individual hydraulic circuits are discussed within their individual sections as applicable. A complete hydraulic system schematic showing all options is at the back of this manual.

HYDRAULIC SYMBOLS

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

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

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

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

MAINTENANCE

Preparation

The following precautions shall be taken before maintenance, adjustments, and repairs are started on a crane:

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

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

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

Hydraulic System Maintenance Precautions

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

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

Disassemble and reassemble hydraulic components on a clean surface.

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

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

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

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

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

Label Parts when Disassembling

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

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

Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to *Hydraulics Lubrication*, page 9-46.

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.

CAUTION

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

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

CAUTION

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

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Working reservoir capacity (Capacity to full mark) is 838.6 L (221.53 gal). Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge. After the reservoir is filled, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

Removing Air From the Hydraulic System

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

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 0.138 to 0.276 bar (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service.

Operate all hydraulic circuits several times in both directions.

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

CAUTION

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

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

CAUTION

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

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

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

Parts Replacement

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

Directional Control Valves

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

Inspection

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

Valve Leakage

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

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

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

Binding Spools

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

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

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

Visual Inspection of Hoses and Fittings

CAUTION

Ensure hydraulic hose is depressurized before loosening the connections.

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

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

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

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

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

If any of these conditions exist, address them appropriately.

All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life. Working conditions, ambient temperatures and high duty circuits can affect service life of hose assemblies and must be taken into account when inspecting and replacing hoses. High duty circuits can include, but are not limited to, outriggers, hoist(s), boom lift, swing, pump suction and discharge to directional valves and directional valve return to the reservoir.

Hydraulic hose assemblies operating in a temperature climate zone “C” Table 2-1 are recommended to be replaced after 8000 hours of service life.

Hydraulic hose assemblies operating in climate zones “A” and “B” Table 2-1 with high ambient temperatures, could see hose service life reduced by 40 to 50%, therefore, it is recommended to replace these hoses after 4000 to 5000 hours of service life.

Hydraulic hose assemblies operating in climate zones “D” and “E” Table 2-1, cold climates, should expect a degrade of mechanical properties, long term exposure to these cold temperatures will negatively impact service life. Therefore it is recommended for these hoses to be inspected thoroughly as service life may be less than 8000 hours.

Table 2-1 Climate Zones

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

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

The supply pressure and return circuit routes hydraulic oil from the three hydraulic pumps to the directional control valves for individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, three hydraulic pumps, a hydraulic oil cooler, and a 12-port hydraulic swivel. Refer to Hydraulic Pumps in this section for descriptions and maintenance instructions for each hydraulic pump. Refer to *Swing System*, page 6-1 for description and maintenance instructions for the hydraulic swivel. Each circuit description and components begin with the circuit directional control valve.

Hydraulic Reservoir, Filter, and Temperature Switches

The reservoir (Figure 2-1), attached to the right side of the carrier frame has a total capacity of 838.58 L (221.5 gal), with a full level of 729.5 L (192.6 gal).

The all-steel reservoir has an internally mounted full-flow filter (Figure 2-2) and integral baffles that help cool the hydraulic oil and prevent hydraulic oil foaming.

A tube located at the lower rear of the reservoir supplies oil to the three hydraulic pumps. Return oil from the carrier combination manifold bypasses the hydraulic cooler and returns directly to the hydraulic oil filter in the top of the reservoir. Return oil from all other functions is directed through the hydraulic oil cooler and then to the hydraulic oil filter. All return oil to the reservoir comes from the No. 1 dual-port on the hydraulic swivel.

A temperature switch and thermistor are installed in the lower rear of the hydraulic reservoir. The temperature switch (190°F rising) (7, Figure 2-1) turns the hydraulic oil cooler fan on and off as needed (see *Hydraulic Oil Cooler*, page 2-12). The thermistor (200°F rising) (6, Figure 2-1) will cause a warning light in the cab to illuminate if the hydraulic oil temperature is too high. The thermistor will also turn on the oil cooling fan if the temperature switch fails.

NOTE: NOTE: Tightening torque for the thermistor is 44.7 ±4.7 N-m (33 ±3.5 ft-lbs)

Tightening torque for the temperature switch is 10.9 ±2.7 N-m (8 ±2 ft-lbs)

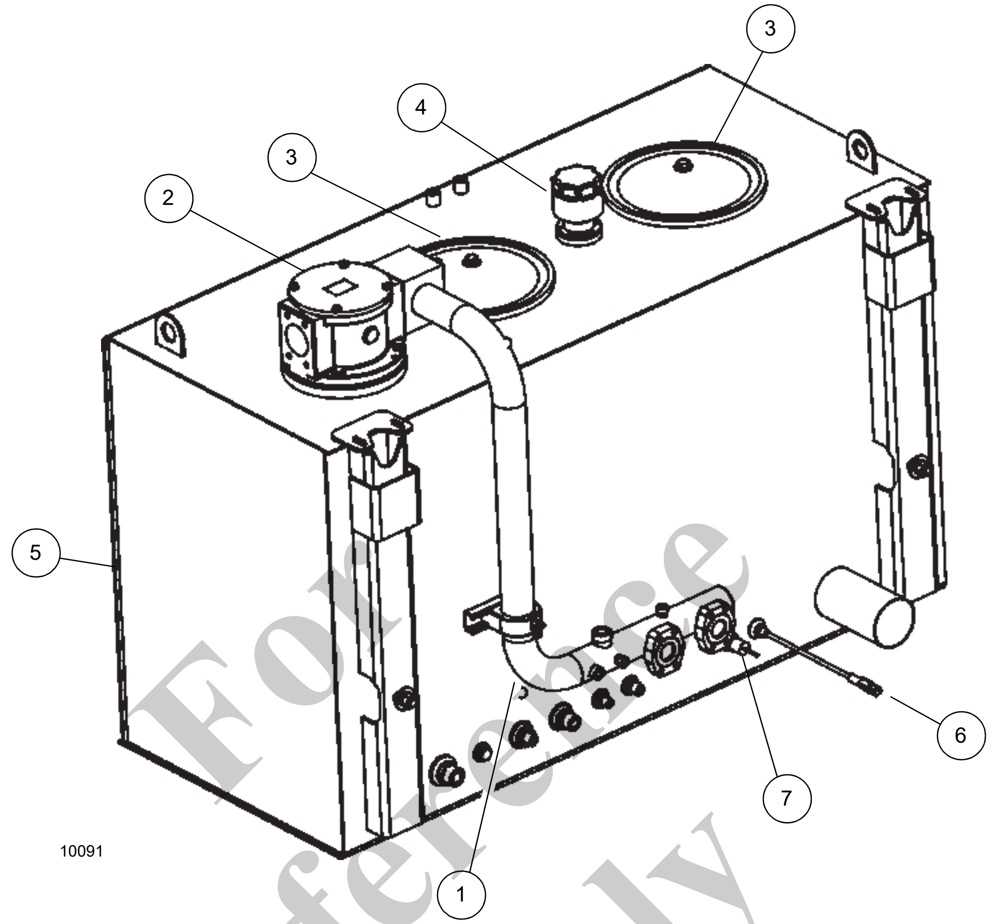
A sight gauge is located on the front end of the reservoir to indicate hydraulic oil level.

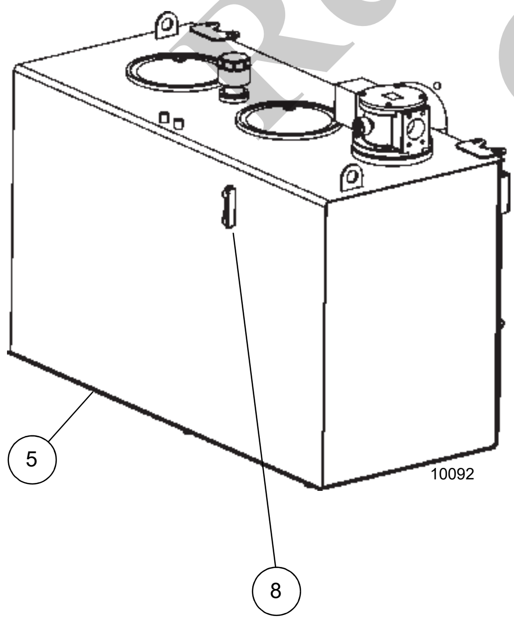
A filler neck and breather on top of the reservoir are for filling and venting the reservoir. The filler neck includes a strainer for catching contaminants and gaskets to prevent leaking. The breather allows air to enter or exhaust from the reservoir.The breather must be kept clean to prevent damage to the reservoir. A breather guard protects the breather and filler neck.

Two large round access covers on the top of the reservoir provide access for cleaning. The covers are bolted to the top of the reservoir and have gaskets to prevent leaking.

The hydraulic oil filter bolts to the top of the reservoir. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, filter element, and into the reservoir (see *Hydraulic Oil Return Filter Assembly*, page 2-10).

A gauge on the filter head indicates filter element restriction. When back pressure caused by a dirty filter element exceeds 1.7 bar (25 psi), the bypass feature of the filter head allows hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet.





1	Return Hose
2	Return Filter
3	Cover
4	Fill Cap/Breather
5	Hydraulic Tank
6	Thermistor (200°F) - High Oil Temp. Indicator Light
7	Temperature Switch (190°F) - Oil Cooler Fan On/Off
8	Oil Level Gauge

FIGURE 2-1

Hydraulic Oil Return Filter Assembly

The hydraulic oil return filter assembly (see Figure 2-1 and Figure 2-2) is located in the reservoir. It bolts to the top of the reservoir and its bypass outlet fits into a tube welded in the reservoir. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element, and into the reservoir.

An element condition indicator on the filter head indicates when to change the filter element. When back pressure caused by a dirty filter element exceeds 1.72 bar (25 psi), the filter head's bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead. A bypass filter screen prevents gross contamination from passing through the filter even during bypass.

Refer to the following procedures and Figure 2-2 when removing or installing the hydraulic oil return filter element.

CAUTION

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

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

Element Removal

1. Shut down all hydraulic systems.
2. Wipe any dirt from the cap on top of the return filter head.
3. Remove the four bolts securing the cap to the return filter head. Remove cap.
4. Inspect the bypass valve (attached to the cap) for any damage. Replace if necessary.
5. Remove and discard the O-ring between the cap and the return filter head.
6. Remove the element from the return filter head.

Element Installation

1. Replace the filter with one having the same part number as the one removed. Lube the O-rings on both ends of the element and insert the element into the return filter head.
2. Install the cap on top of the return filter head making sure that the bypass valve is inserted into the element and that the new O-ring between the cap and filter head is installed correctly.
3. Secure the cap to the filter head using the bolts and lock washers; torque bolts to their specified value.
4. Activate the hydraulic system and check for leaks. Make repairs as needed.

Fill Cap/Breather

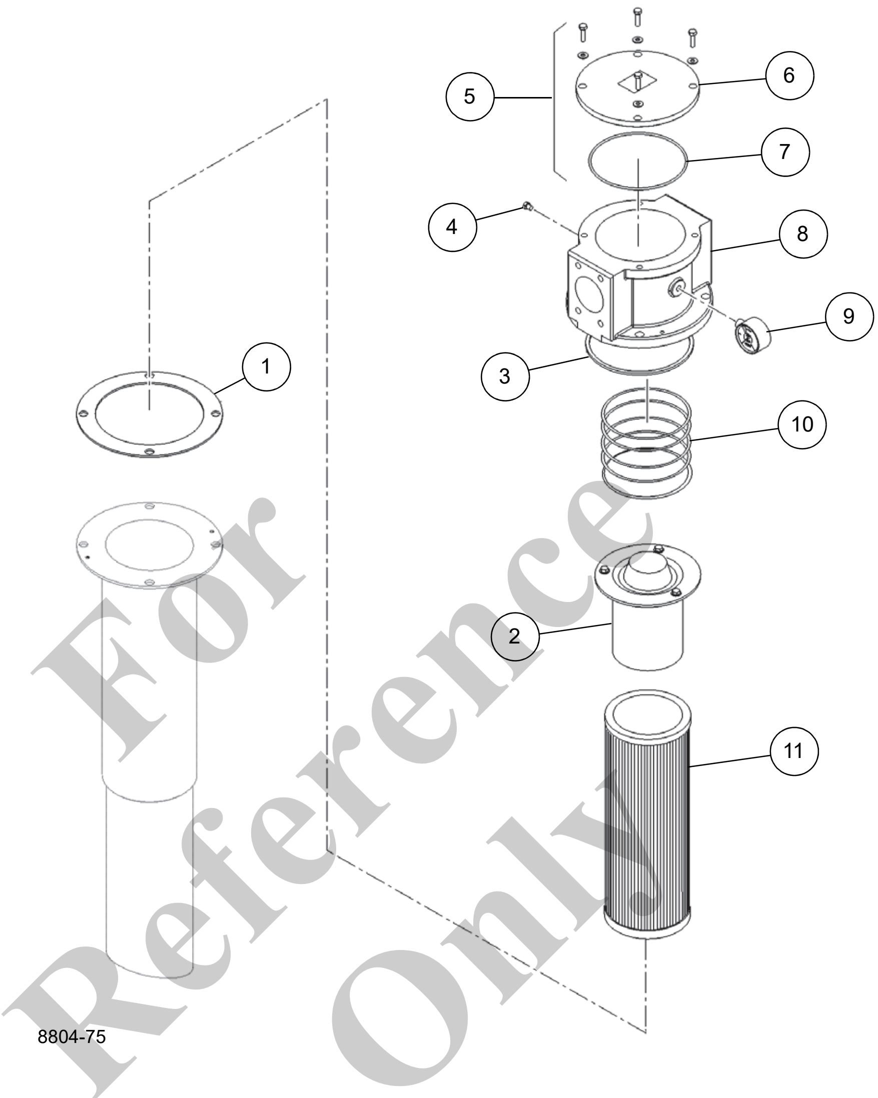
Removal and Replacement

CAUTION

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

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

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



1	Gasket
2	By-pass Assembly
3	O-ring
4	Plug
5	Cap Assembly
6	Cap

7	O-ring
8	Filter Head
9	Gauge Assembly
10	Spring
11	Element

FIGURE 2-2

HYDRAULIC OIL COOLER

Description

An air cooled hydraulic oil cooler (Figure 2-3) is located on the right side of the superstructure.

The hydraulic oil filter is connected to the T1 port on the Main Directional Control Valve and swivel port 1.The return oil circuit for all other functions is directed through the hydraulic oil cooler and on to the hydraulic oil filter. A 30 psi check valve in this return oil circuit diverts oil to the return circuit which bypasses the hydraulic oil cooler if the return oil pressure ever increases due to several functions being operated simultaneously.

A hydraulically driven fan pulls cool air through the cooling fins on the two coolers. The fan is turned on and off as needed by a temperature switch (190°F rising) that is installed in the hydraulic oil tank. A thermistor (200°F rising) is installed in the hydraulic oil tank which will cause a warning light in the cab to illuminate if the hydraulic oil temperature is too high. The thermistor will also turn on the oil cooling fan if the temperature switch fails.

Maintenance

The oil cooler should be checked daily for dirt buildup, as a dirty cooler will result in high oil temperatures. High oil temperatures will reduce the performance and useful life of the oil, which can ultimately result in component failure.

If the cooler is contaminated with dust, it can be cleaned using compressed air. If the cooler is contaminated with a mixture of oil and dust, it should be disassembled and treated with a liquid cleaner, then cleaned of debris using compressed air. Take care when using compressed air, a high pressure washer, or a steam cleaner, as the fins of the cooler may be damaged. To ensure effective cleaning, the direction of air, water, or steam must be opposite to the direction of normal airflow through the cooler. On cranes that operate in corrosive environments (salt), frequently clean the cooler with water to help prevent corrosion.

Removal

1. Tag and disconnect electrical connectors (2, Figure 2-3) from the fans (1).
2. Tag and disconnect hydraulic lines.

NOTE: The hydraulic oil cooler fan assembly weighs approximately 90.9 kg (198.4 lb).

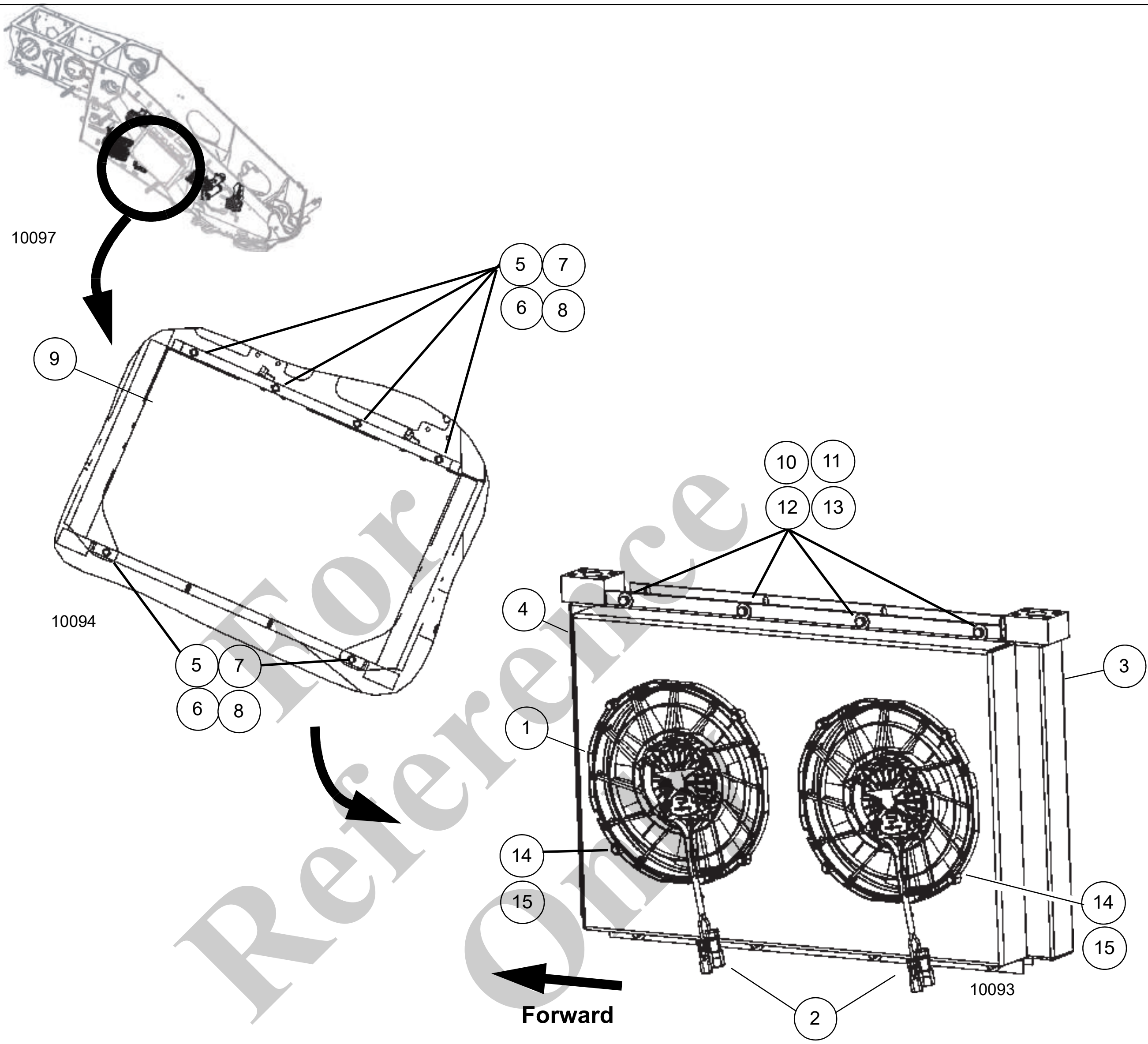
3. Remove nuts (5), washers (6), lockwashers (7), and capscrews (8). Remove hydraulic oil cooler assembly from superstructure frame (9).
4. Remove nuts (13), capscrews (10), lockwashers (11), washers (12), and core assembly (3) from the fan shroud assembly (4).
5. Remove capscrews (14), washers (15), and fans (1) from core assembly (3).

Installation

1. Install the fans (1) on the core assembly (3) with washers (15) and capscrews (14). Torque the nuts according torque specifications cited in *Fasteners and Torque Values*, page 1-16.
2. Install the core assembly (3) in the shroud assembly (4) with capscrews (10), lockwashers (11), washers (12), and nuts (13). Torque the nuts according torque specifications cited in *Fasteners and Torque Values*, page 1-16.

NOTE: The hydraulic oil cooler fan assembly weighs approximately 90.9 kg (198.4 lb).

3. Install the oil cooler assembly on the superstructure frame (9) with capscrews (8), lockwashers (7), washers (6), and nuts (5). Torque the nuts according torque specifications cited in *Fasteners and Torque Values*, page 1-16.
4. Connect the hydraulic lines as tagged.
5. Install electrical connectors (2) as tagged.



Hydraulic Oil Fan Assembly	
1	Fan Assembly (Two places)
2	Fan Electrical Connector (Two places)
3	Core Assembly
4	Fan Shroud Assembly
5	Nut
6	Washer
7	Lockwasher
8	Capscrew
9	Superstructure Frame
10	Capscrew
11	Lockwasher (x2)
12	Washer
13	Nut
14	Capscrew
15	Washer

FIGURE 2-3

HYDRAULIC PUMPS

NOTE: Refer to Figure 2-4 for pump locations.

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

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

For specifications of each pump, see *List Of Specifications*, page 1-3.

Maintenance

Pump No. 1 Removal

CAUTION

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

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

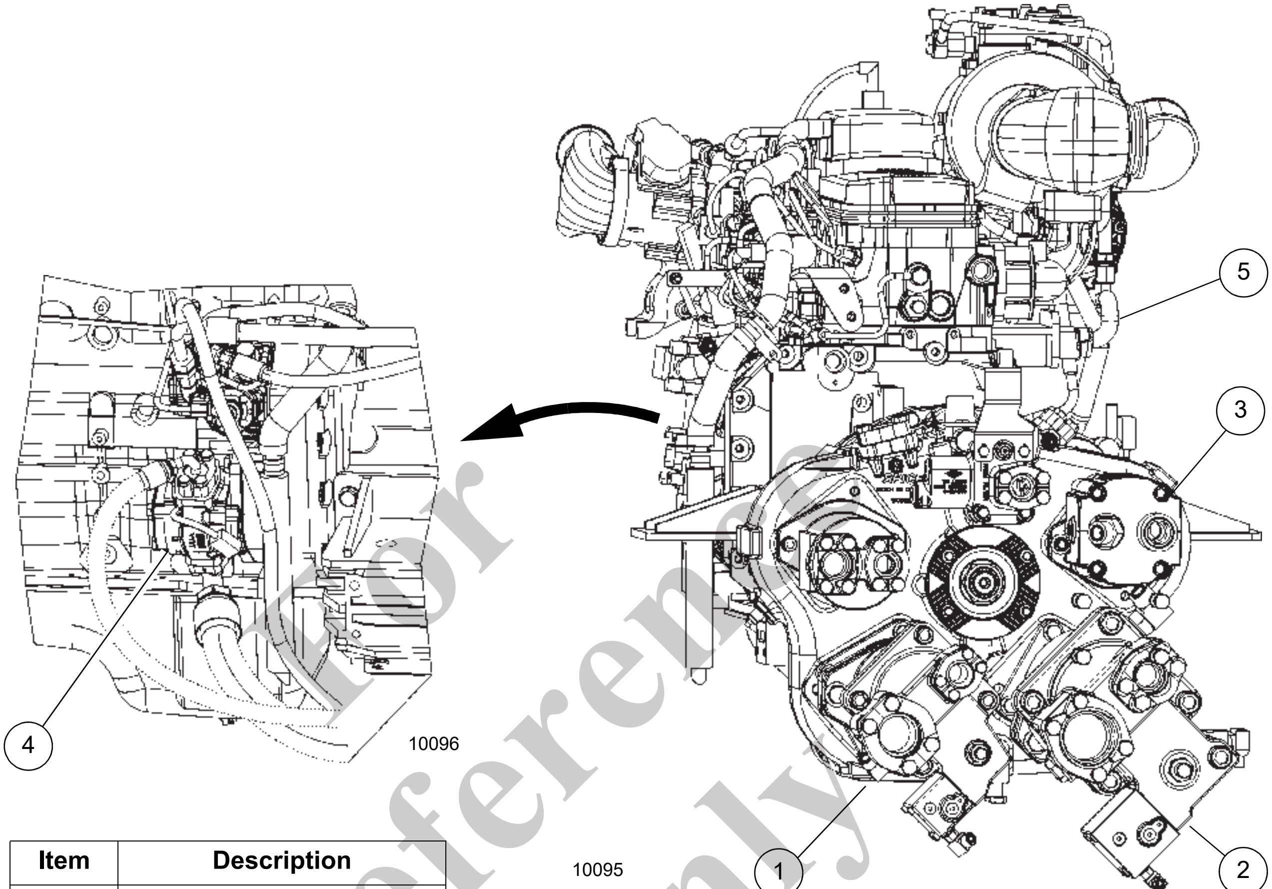
CAUTION

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

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

Pump No. 1 Installation

1. Clean the pump and the torque converter drive pad with Loctite® cleaning solvent 7070 or similar non-chlorinated solvent.
2. Apply gasket material Loctite® Master Gasket 518 to pump and drive pad mounting surfaces. (This material partially cures in 4 hours and fully cures in 48 hours.)
3. Apply Loctite® 243 to the threads of the capscrews. Install pump, spacer, and gaskets on drive pad with capscrews and washers. Make sure the splines mesh properly.
4. Torque capscrews to recommended torque.
5. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.



Item	Description
1	Hydraulic Pump No. 1
2	Hydraulic Pump No. 2
3	Hydraulic Pump No. 3
4	Hydraulic Pump No. 4
5	Engine

FIGURE 2-4

Pump No. 2 Removal

CAUTION

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

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

CAUTION

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

4. Remove the capscrews, spacer, washers, and gaskets attaching the pump to the drive pad on the torque converter. Remove the pump.
5. Clean the gasket material from the drive pad of the drive-through charge pump and from the pump.

6. Cover the drive pad’s opening to prevent dirt from entering.

Pump No. 2 Installation

1. Clean the pump and the drive pad of the drive-through charge pump with Loctite® cleaning solvent 7070 or similar non-chlorinated solvent.
2. Apply gasket material Loctite® Master Gasket 518 to pump and drive pad mounting surfaces. (This material partially cures in 4 hours and fully cures in 48 hours.)
3. Apply Loctite® 243 on the threads of the capscrews. Install pump and gasket on drive pad with capscrews and washers. Make sure the splines mesh properly.
4. Torque capscrews to recommended torque.
5. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.

No. 3 Pump Removal

CAUTION

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

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

CAUTION

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

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

No. 3 Pump Installation

1. Clean the pump and the torque converter drive pad with Loctite® cleaning solvent 7070 or similar non-chlorinated solvent.
2. Apply gasket material Loctite® Master Gasket 518 to pump and drive pad mounting surfaces. (This material partially cures in 4 hours and fully cures in 48 hours.)
3. Apply Loctite® 243 to the threads of the capscrews. Install pump and gasket on drive pad with capscrews and washers. Make sure the splines mesh properly.
4. Torque capscrews to recommended torque.
5. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.

No. 4 Pump Removal

CAUTION

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

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

CAUTION

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

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

No. 4 Pump Installation

1. Clean the pump and the engine drive pad with Loctite® cleaning solvent 7070 or similar non-chlorinated solvent. Likewise clean both surfaces of the new rubber/steel gasket, the spacer, and the new gasket.
2. Apply a light coating of Loctite® Master Gasket 518 to both surfaces of the gasket. Do not coat either side of the rubber/steel gasket or the facing sides of the parts that will touch it. (This material partially cures in 4 hours and fully cures in 48 hours.)

3. Apply Loctite® 243 or equivalent to the threads of the capscrews. Install pump and gasket on drive pad with capscrews and washers. Make sure the splines mesh properly.
4. Torque capscrews to recommended torque.
5. Connect the distribution and supply lines to the pump as tagged during removal. On lines that use them, discard any old O-ring and install a new O-ring in its place.

CAUTION

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

Piston Pump Start-up Procedure

CAUTION

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

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1. Ensure the reservoir is filled with the proper hydraulic fluid to the high level mark on the reservoir sight gauge.
2. Ensure no air is entering the pump inlet, and that the pump suction or inlet fluid is not bleeding back to the reservoir when the engine is stopped, by making sure all suction or inlet lines are air tight.
3. Remove the case drain hose and adapter from the “DR” port Figure 2-5 on both pumps and fill the housing with the same hydraulic fluid that was used to fill the hydraulic reservoir to the bottom of the o-ring case drain port. Re-install the case drain adapter and hose running to the hydraulic reservoir.

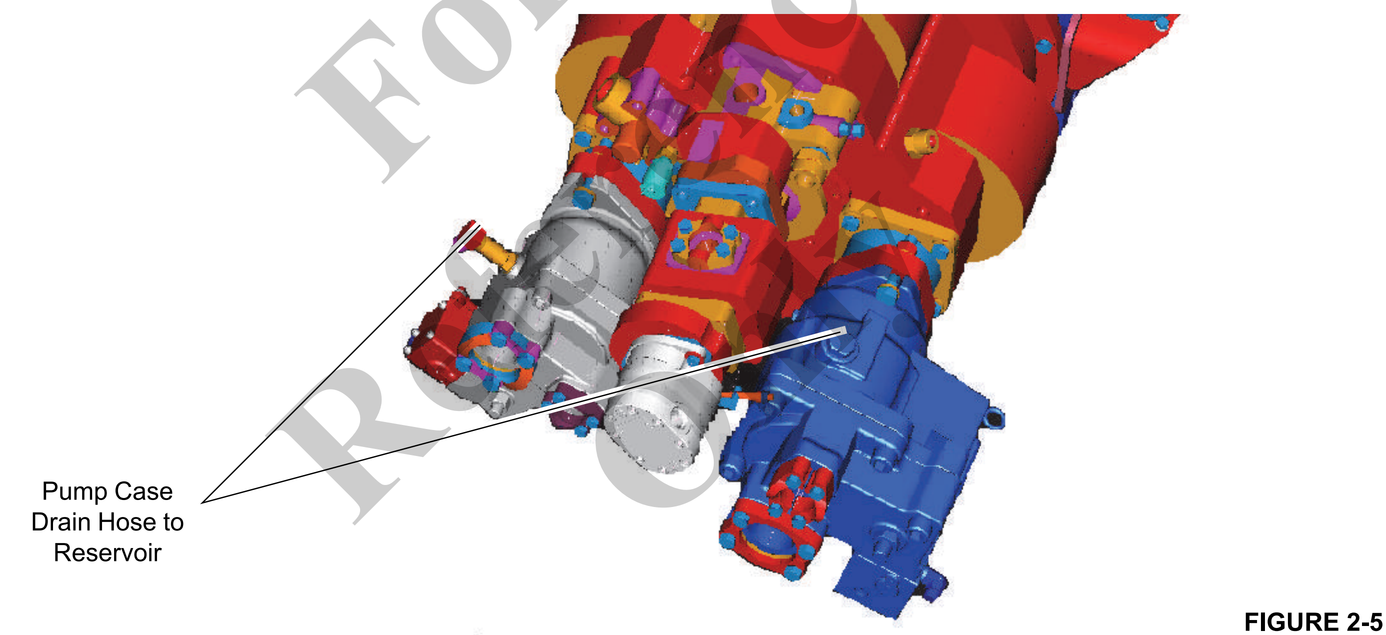


FIGURE 2-5

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

10. Check pressure settings. Refer to Pressure Setting Procedures in this section.

Hydraulic Pump Distribution

No. 1 Pump

The torque converter drives the No. 1 variable displacement piston pump, which supplies oil to the following manifolds and valves:

- Combination manifold on the carrier, which includes valves for controlling the rear steer, axle lockout, outriggers, and hydraulic oil cooler fan.
- Main directional control valve on the superstructure, which includes valves for controlling the auxiliary hoist, main hoist, boom telescope, and boom lift.

No. 2 Pump

The torque converter drives the No. 2 variable displacement piston pump, which supplies oil to the following manifolds and valves:

- Steer/brake/pilot supply valve on the superstructure, which includes valves for controlling the front steering, disc brakes, and swing brake.
- Main directional control valve on the superstructure, which includes valves for controlling the auxiliary hoist, main hoist, boom telescope, and boom lift.
- Telescope and telescope fill stage select/thermal contraction valve on the superstructure.
- Compact valve on the superstructure, which includes valves for controlling the boom lift, counterweight removal, counterweight pin, and cab tilt.
- Main and auxiliary hoist brake release valves.

No. 3 Pump

The engine drives the No. 3 gear pump, which supplies oil to the swing directional control valve on the superstructure.

Troubleshooting

Symptoms and Solutions

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

Troubleshooting Aids

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

Troubleshooting Procedures

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

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

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

Remember:

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

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

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

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

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

VALVES

This section describes several of the main hydraulic valves used on this crane. For a listing of the valves, the circuit they are used in, and their physical location, refer to Table 2-2. Refer to Figure 2-6 and Figure 2-14 for valve locations.

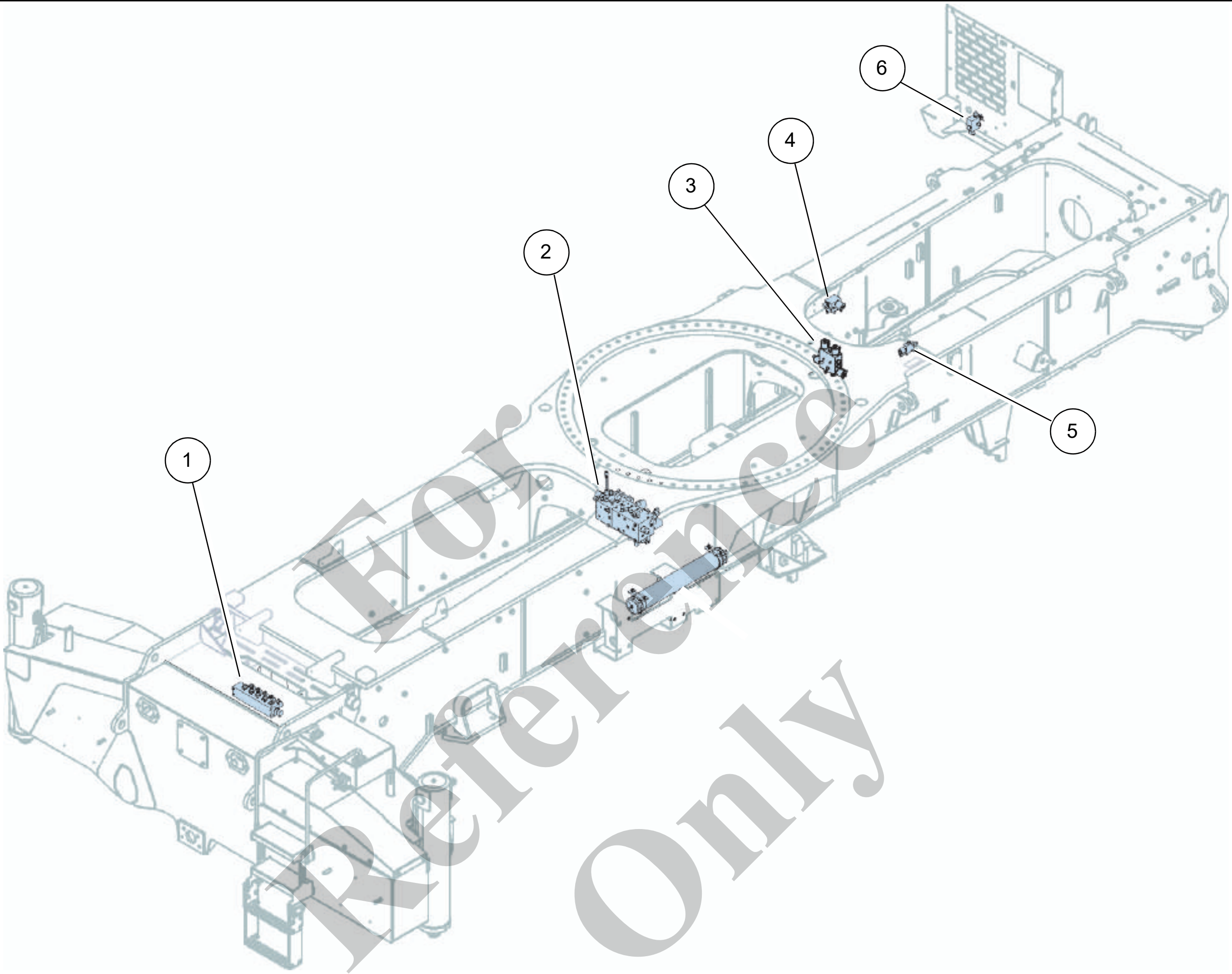
The description of each valve given here is for the valve itself. For information on how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

Table 2-2 Valve Usage Table

Item	Circuit	Location
Carrier		
Carrier Manifold Valve	Load Sense Dump/Rear Steer/ Outriggers/Transmission Fan/Parking Brake/Suspension Fill	Inside turret on carrier
Outrigger Control Manifolds	Outrigger	Front and rear outrigger boxes
Differential Lock Valve	Axle differential lock	Front side rear center frame cross member on carrier
Suspension Valve	Suspension	Center of carrier frame near the turntable bearing.
Fan Control Valve	Radiator Fans	
Superstructure		
Main Directional Control Manifold Valves	Hoist/Lift /Telescope	Right side superstructure
Swing Manifold Valve	Swing	Right side superstructure
Compact Manifold Valve	Counterweight Removal/Cab Tilt/Tele Fill	Right side superstructure
Accessory Manifold Valve	Front Steer/Swing Brake/Pilot Supply/ Fill Tube	Right side superstructure
Telescope and Tele Fill Stage Select Manifold Valve	Telescope	Inside the rear of the boom assembly
Hydraulic Boom Extension Manifold Valve (Optional)	Hydraulic Boom Extension	Upper right side of infrastructure.

CARRIER VALVES

Figure 2-6 and the following sections describe the hydraulic manifold valves on the GRT9165 carrier.



Valve Installation - Carrier		Page
1	Outrigger Control Manifold Valve (2 places)	2-23
2	Carrier Manifold Valve	2-25
3	Suspension Manifold Valve	2-28
4	Fan Control Manifold Valve	2-29
5	Differential Lock Manifold Valve	2-30
6	Bleed Off Valve	2-31

FIGURE 2-6

Outrigger Control Manifold Valves

There are two outrigger control manifold valves (Figure 2-7) used on the crane: one located on the front outrigger box for controlling the front outriggers and one located on the rear outrigger box for controlling the rear outriggers (Figure 2-6). Each manifold valve features four normally-closed, two-position, two-way solenoid valve assemblies, one for each jack and extension cylinder.

Removal

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

Inspection

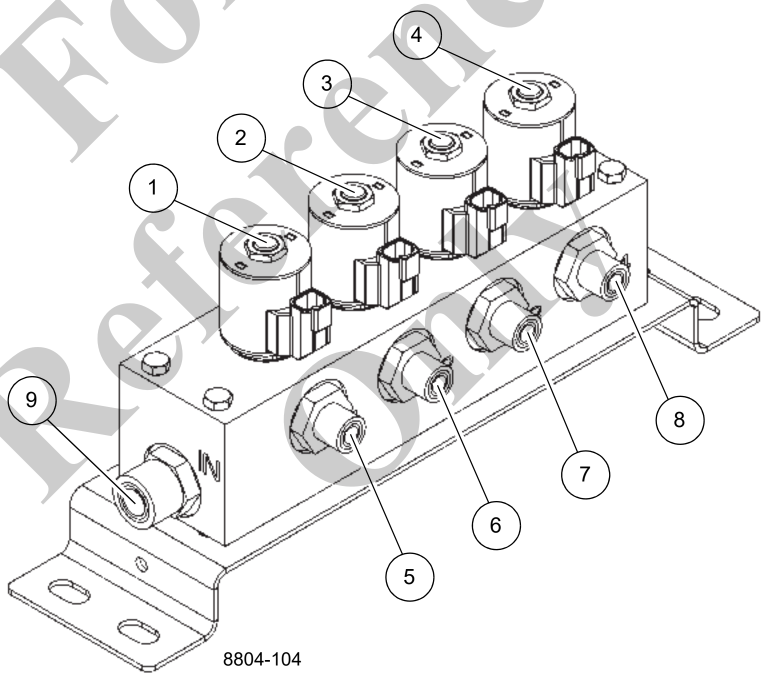
Visually inspect the valves and hydraulic connections for any evidence of leaks or other damage. Check security of the electrical connections. Inspect the wiring for any evidence of cracks or breaks.

Installation

1. Position the manifold on the outrigger box and secure with the washers, hex nuts, and capscrews. Torque capscrews - refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the electrical connectors to the solenoids as marked during removal.
3. Connect the hydraulic lines to the valves as marked during removal.

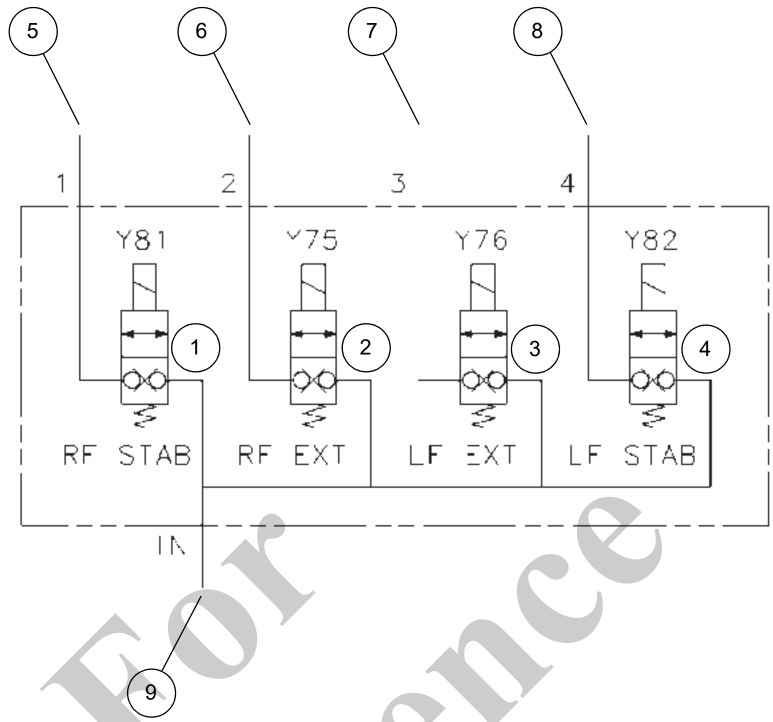
Functional Check

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

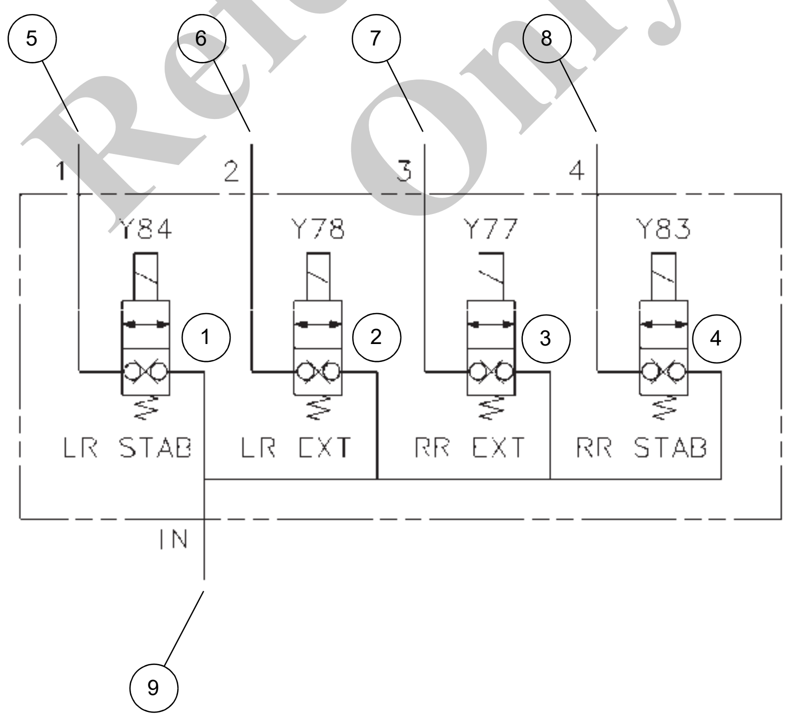


Outrigger Control Manifold	
1	Control Valve - Right Front or Left Rear Jack
2	Control Valve - Right Front or Left Rear Extension
3	Control Valve - Left Front or Right Rear Extension
4	Control Valve - Left Front or Right Rear Jack
5	Work Port - Right Front or Left Rear Jack
6	Work Port - Right Front or Left Rear Extension
7	Work Port - Left Front or Right Rear Extension
8	Work Port - Left Front or Right Rear Jack
9	Inlet Port (IN)

FIGURE 2-7



Front Outrigger Control Manifold Cont.



Rear Outrigger Control Manifold Cont.

FIGURE 2-7 continued

Carrier Manifold Valve

The carrier manifold valve (Figure 2-8) is located on the inside carrier frame rail at the turntable bearing (Figure 2-6). This manifold controls the following functions:

- Load Sense Dump
- Rear Steer
- Axle Lockout
- Outriggers (Extend/Retract)
- Transmission Fan Motor
- Park Brake
- Suspension Fill

Supply oil to all functions on the carrier combination manifold valve is limited by a pressure reducing valve.

Load Sense Dump

The LS dump function consists of a shuttle valve and a control valve which combines the load sense oil received from the carrier and superstructure circuits and diverts it to tank during engine cranking. This action aids in starting the engine by preventing the pumps from building pressure during the engine cranking function, thereby lessening the load on the engine starter.

Rear Steer

The rear steer function is controlled by a control valve with dual cross-port, pilot-operated check valves in the work lines. The dual cross-port, pilot-operated check valves maintain pressure on the rod and piston of both rear steer cylinders when stationary and when turning.

Outriggers

The outrigger extend/retract circuit consists of a solenoid-controlled valve, which is controlled by the control system based on operator inputs. A request to extend or retract an outrigger jack or extension results in the crane control system energizing the respective solenoid, thereby sending system pressure to shift a dual pilot-controlled valve, which controls the flow of oil to extend and retract the four jack cylinders and four extension cylinders. A check valve maintains a maximum pressure of 100 psi in the retract circuit.

Transmission Cooler Fan

The oil cooler fan circuit consists of a proportional flow control valve in sequence with a solenoid-operated, proportional flow control valve, which is controlled by the crane control system, based on inputs from the transmission oil temperature sending unit and the hydraulic oil sending unit. Return oil from the motor goes to tank.

Park Brake

The park brake solenoid valve controls the flow of hydraulic oil to the parking brake. In its de-energized position, the inlet port is blocked and the parking brake actuator is drained to the reservoir. When the solenoid is energized, the reservoir port is blocked and pressurized oil is directed to the parking brake actuator.

Suspension Fill

The suspension fill solenoid valves control the flow of hydraulic oil to the suspension cylinders. The suspension cylinders control the height of the rear suspension. For more information, *Suspension Manifold Valve*, page 2-28.

Removal

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

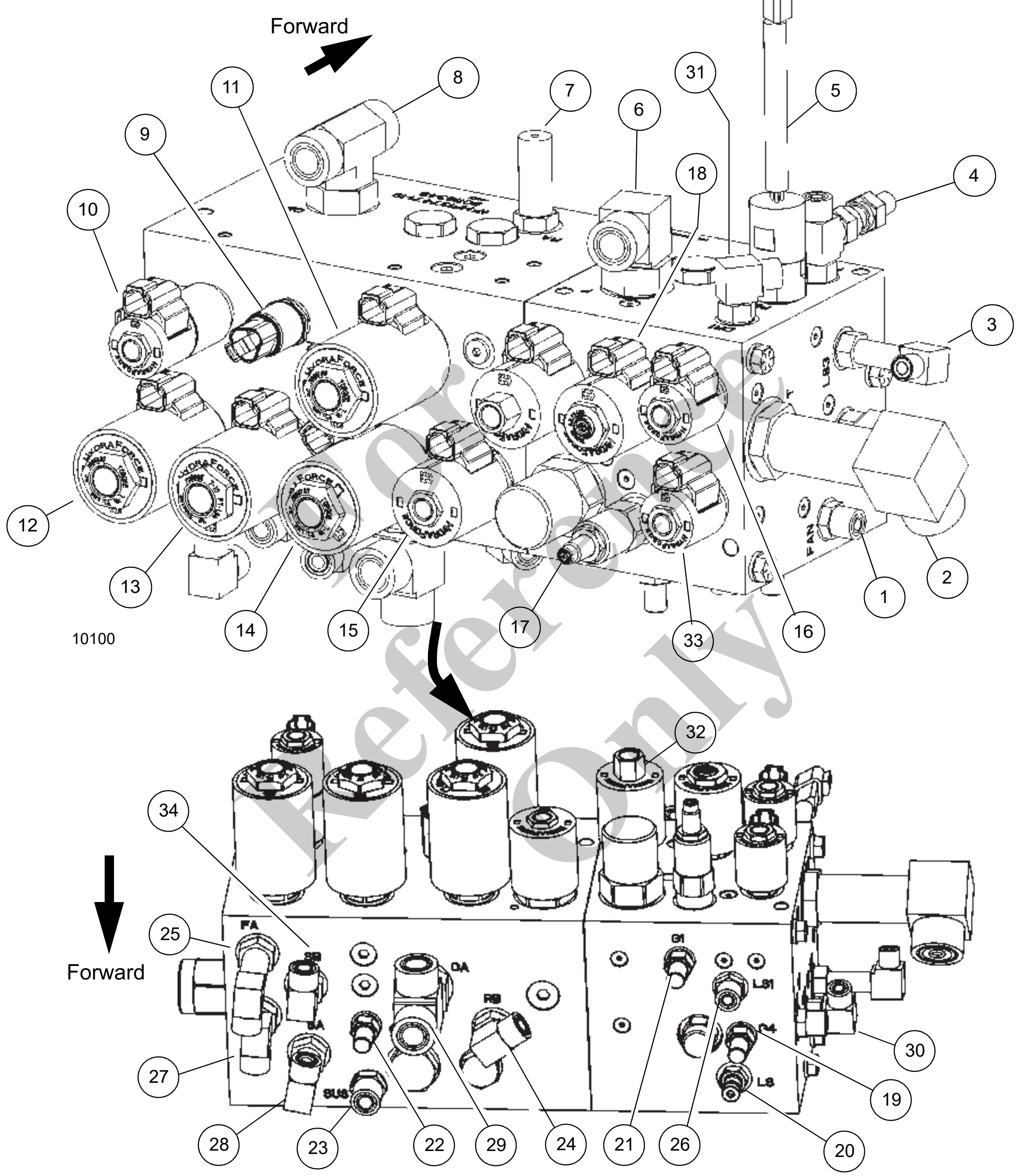
Installation

1. Install the valve assembly to the frame. Secure the valve assembly with the flatwashers, lockwashers, hex nuts and capscrews. Torque capscrews - refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the hydraulic lines to the valve assembly as tagged during removal.
3. Connect the electrical connectors to the valve assembly as tagged during removal.

Functional Check

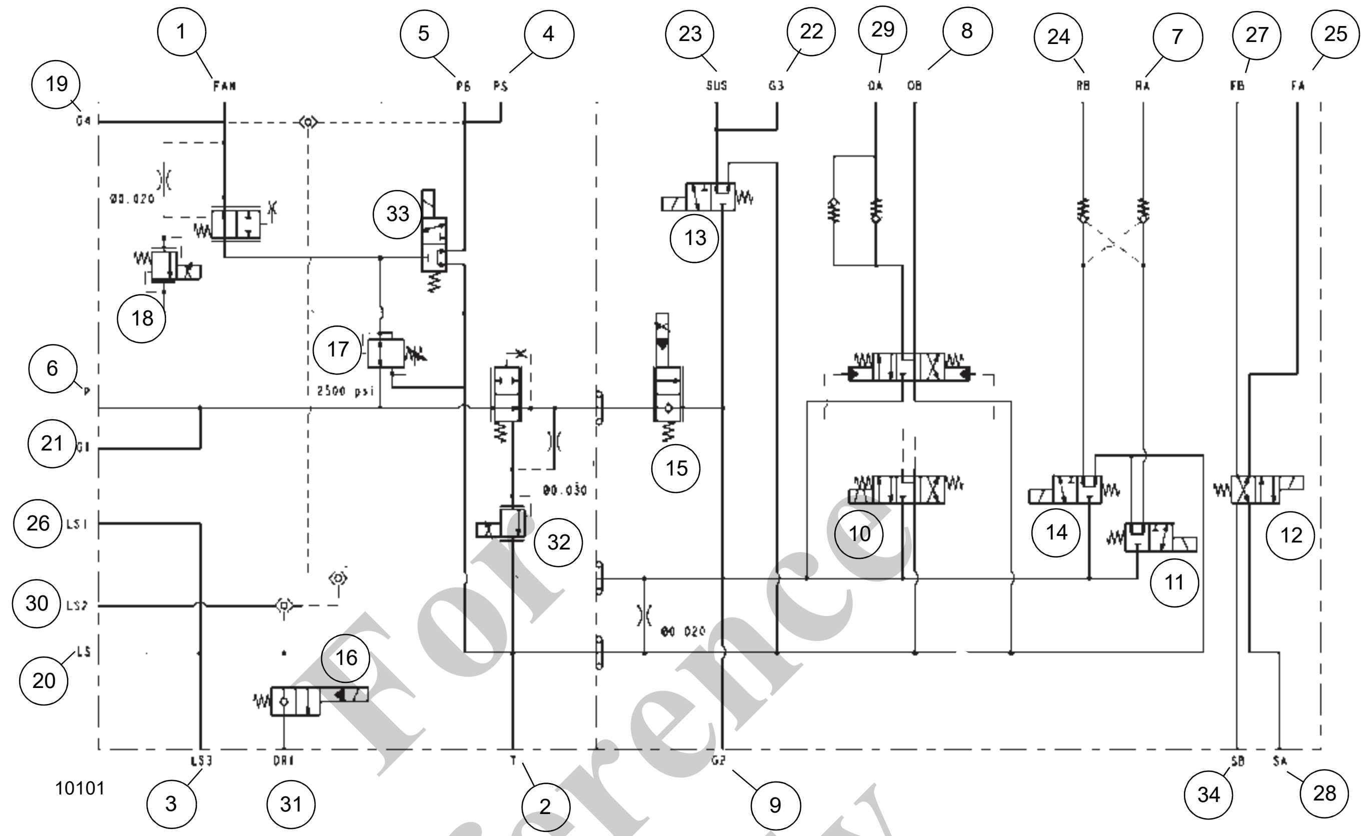
1. Cycle an outrigger cylinder several times. Verify the cylinder extends and retracts properly.
2. Rear steer the crane to the left and to the right several times. Verify the crane steers properly in both directions.
3. Ensure the axle lockout function operates properly by performing the procedures under *Axle Oscillation Lockouts Operation* in section 3 of the Operator Manual.

Carrier Manifold Valve



Carrier Manifold Valve — Bottom

FIGURE 2-8



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Carrier Manifold Valve	
1	Transmission Fan Port
2	T Port — Tank
3	Load Sense Port — LS3
4	PS Port — Park Brake
5	PB Port
6	P Port — Supply
7	RA Port — Rear Steer
8	OB Port — Outrigger Extend
9	Gauge Port — GP2
10	Solenoid Valve — Outriggers
11	Solenoid Valve — Rear Steer
12	Solenoid Valve — Single Axle Reversal
13	Solenoid Valve — Suspension
14	Solenoid Valve — Rear Steer
15	Flow Control
16	Solenoid Valve — Load Sense Dump
17	Pressure Reducing Valve

18	Solenoid — Transmission Fan Coil
19	Gauge Port — G4
20	Load Sense Port — LS
21	Gauge Port — G1
22	Gauge Port — G3
23	SUS Port — Suspension
24	RB Port — Rear Steer
25	FA Port — Single Axle Reversal
26	Load Sense Port — LS1
27	FB Port — Single Axle Reversal
28	SA Port to Swivel Port 7
29	OA Port — Outrigger Retract
30	Load Sense Port — LS2
31	DR1 Port — Load Sense Dump
32	Solenoid Valve — TS1
33	Solenoid Valve — Park Brake
34	Port SB to Swivel Port 6

FIGURE 2-8 continued

Suspension Manifold Valve

The suspension manifold valve controls the flow of oil to the suspension system, locks out the suspension, and connects/disconnects the suspension to a damping/oscillation accumulator (Figure 2-9). The valve is located on the center of the carrier frame near the turntable bearing (Figure 2-6). Pressure is supplied to the valve from the carrier manifold valve.

Removal

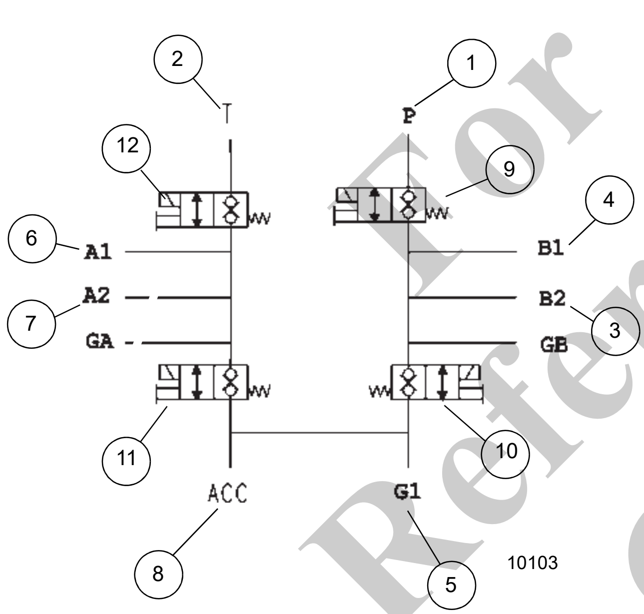
1. Tag and disconnect electrical connectors to the valve.
2. Tag and disconnect hydraulic hoses from the valve. Cap or plug lines and ports.
3. Remove capscrews, lockwashers, flatwashers, and nuts securing valve to the frame. Remove valve.

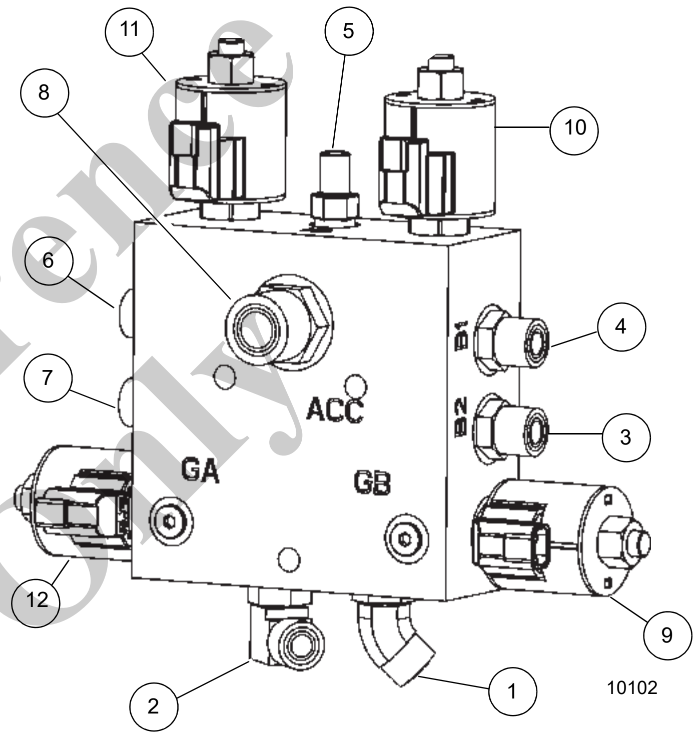
Installation

1. Secure valve to frame with nuts, flatwashers, lockwashers, and capscrews. Torque capscrews - refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect hydraulic hoses to ports on valve as tagged during removal.
3. Connect electrical connectors to valve as tagged during removal.

Functional Tests

1. Start and idle engine.
2. With unit on outriggers, check for proper two/four wheel operation.





Suspension Manifold Valve	
1	Inlet Port — P
2	Tank Port — T
3	B2 Port — Right Center Cylinder
4	B1 Port — Right Rear Cylinder
5	Gauge Port — G1
6	A1 Port
7	A2 Port
8	Accumulator Port

9	Solenoid Valve — Suspension Fill from SUS port on Carrier Manifold valve.
10	Solenoid Valve — Return
11	Solenoid Valve — Solenoid
12	Solenoid Valve — Lower

FIGURE 2-9

Fan Control Manifold Valve

The fan control manifold valve (Figure 2-10) controls the flow of oil to the radiator fan motors. The fan control manifold receives hydraulic oil from hydraulic pump #4.

Removal

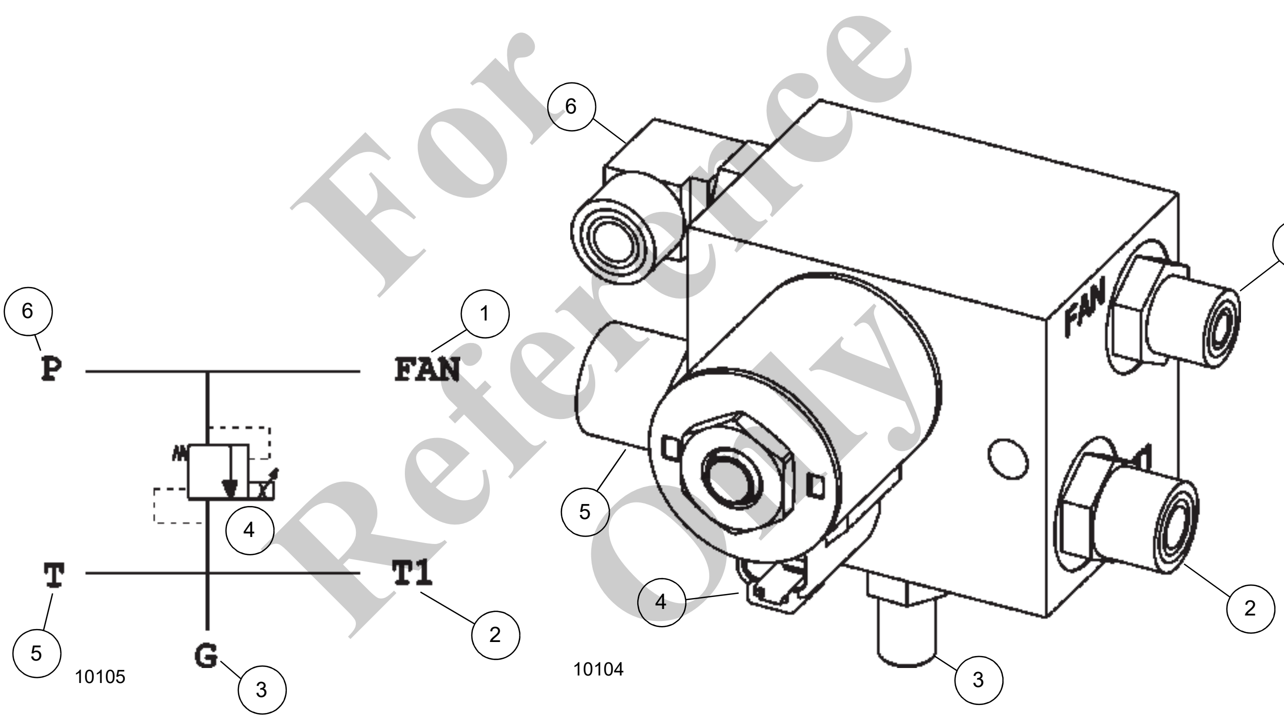
1. Tag and disconnect electrical connectors to the valve.
2. Tag and disconnect hydraulic hoses from the valve. Cap or plug lines and ports.
3. Remove capscrews, lockwashers, flatwashers, and nuts securing valve to the frame. Remove valve.

Installation

1. Secure valve to frame with nuts, flatwashers, lockwashers, and capscrews. Torque capscrews - refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect hydraulic hoses to ports on valve as tagged during removal.
3. Connect electrical connectors to valve as tagged during removal.

Functional Tests

1. Start and idle engine.
2. With unit on outriggers, check for proper operation.



Fan Control Manifold	
1	FAN Port — Output to Fans
2	T1 Port — Return from Fans
3	Gauge Port — G
4	Solenoid Valve — Fan
5	Tank Port — T
6	Inlet Port — P

FIGURE 2-10

Differential Lock Manifold Valve

The differential lock switch in the cab activates the differential locks on the front and rear axles for additional traction. The differential lock manifold (Figure 2-11), located inside the carrier frame near the middle axle, valve controls the flow of the hydraulic oil to the engage port of the differential lock actuators. When the actuators are extended, they engage the splines on the differential case and the axle shafts to lock the differential assemblies together.

Releasing the differential lock switch unlocks the solenoid valve to release hydraulic pressure to retract-the actuators. As the actuators retract, the axles are unlocked.

Removal

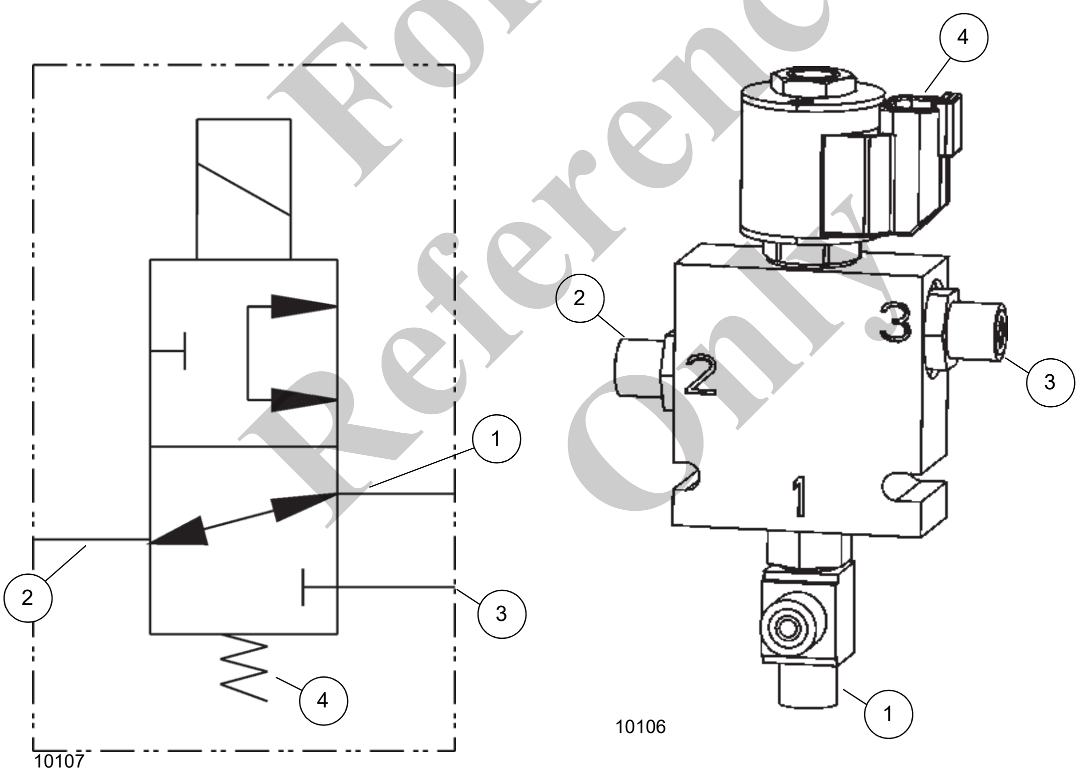
1. Tag and disconnect electrical connectors to the valve.
2. Tag and disconnect hydraulic hoses from the valve. Cap or plug lines and ports.
3. Remove capscrews, lockwashers, flatwashers, and nuts securing valve to the frame. Remove valve.

Installation

1. Secure valve to frame with nuts, flatwashers, lockwashers, and capscrews. Torque capscrews - refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect hydraulic hoses to ports on valve as tagged during removal.
3. Connect electrical connectors to valve as tagged during removal.

Functional Tests

1. Start and idle engine.
2. With unit on outriggers, check for proper two/four wheel operation.



Differential Lock Manifold Valve	
1	Output Port (to front and rear axles)
2	Tank Port (to tank port on transmission)
3	Pressure Port (from transmission port
4	Solenoid Valve — Differential Lock Switch

FIGURE 2-11

Bleed Off Valve

NOTE: Make sure the outrigger box pressure bleed off valve is shut before checking the cut-off and differential settings. For more information, see the *Operator Manual*.

The pressure bleed-off valve (Figure 2-12) is used to manually drain to reservoir any trapped pressure from behind the outrigger box removal quick disconnects or the telescope boom removal quick disconnects.

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

Whenever possible, the bleed adapter should be mounted at the highest point within the hydraulic system. The trapped air can be relieved while the system is running at low pressure. To bleed, loosen the bleed screw 1/2 turn counterclockwise. After the hydraulic fluid begins to run freely from the bleed screw, the bleed screw should be re-tightened.

WARNING

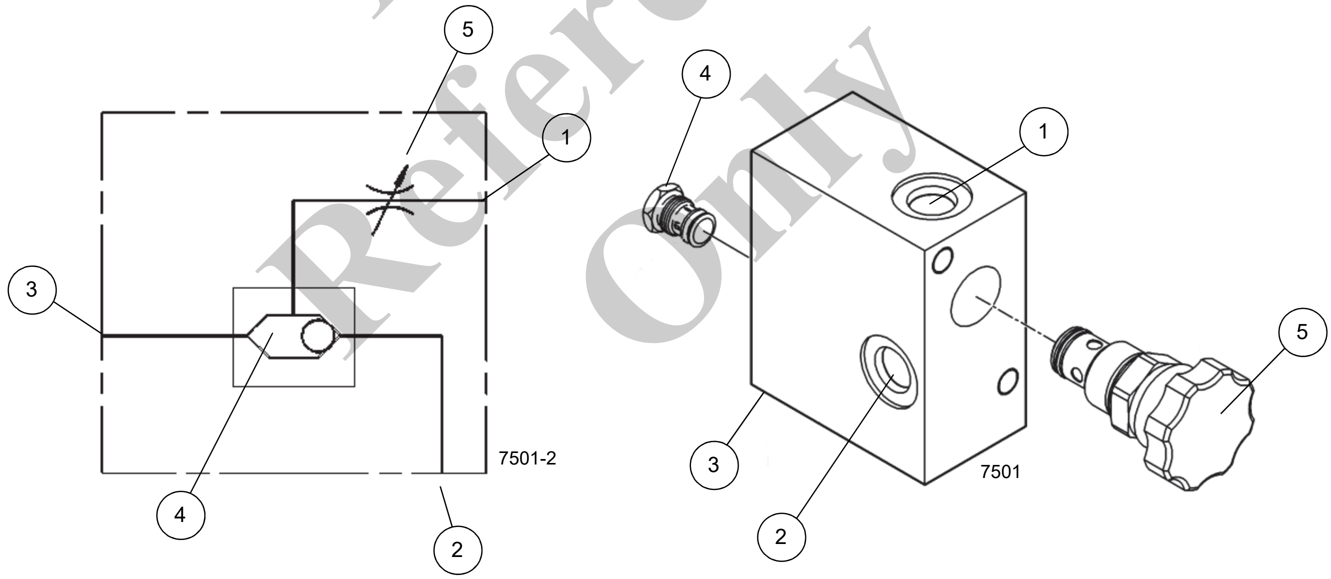
When bleeding hydraulic fluid, operate the system below 500 psi. To avoid injury, ensure that all persons are clear of the path of discharge. Another recommended practice is to attach a section of hose over the bleed screw/ adapter to direct oil away from the area and to reduce oil spillage.

Removal

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

Installation

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

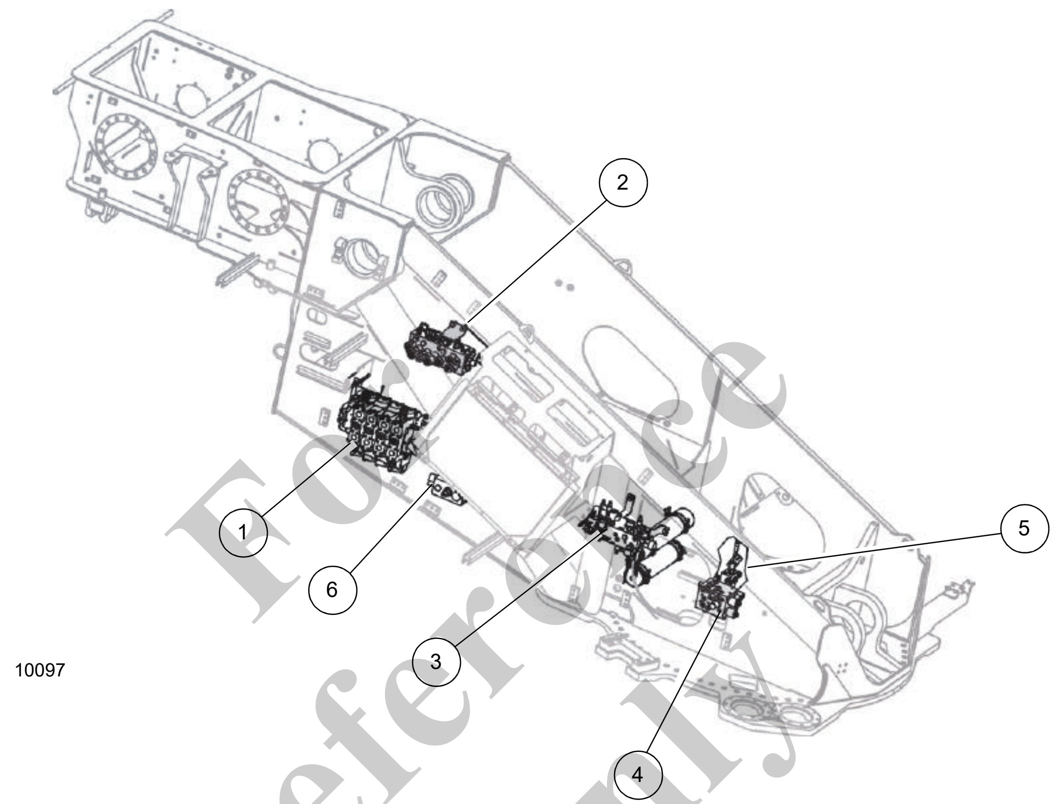


Bleed Off Valve	
1	Tank Port — T
2	To Outrigger Extend Port “B”
3	To Outrigger Retract Port “A”
4	Shuttle Valve
5	Adjustable Flow Control Valve

FIGURE 2-12

SUPERSTRUCTURE VALVES

Figure 2-13 and the following sections describe the hydraulic manifold valves located in the superstructure.



Valve Installation - Superstructure	
1	Main Directional Control Manifold Valve
2	Compact Manifold Valve
3	Accessory Manifold Valve
4	Swing Manifold Valve
5	Dual Accumulator Charge Manifold Valve
6	Check Valve

FIGURE 2-13

Main Directional Control Valve

The main directional control valve (Figure 2-14) is located on the right side of the superstructure (1, Figure 2-13). The main directional valve controls the lift, telescope, and main and auxiliary hoist functions. The valve solenoids are controlled electronically through the crane control system and CANBus system when the controllers in the cab are actuated. The main DCV is installed and removed as an assembly.

Main Directional Control Manifold Valve Removal

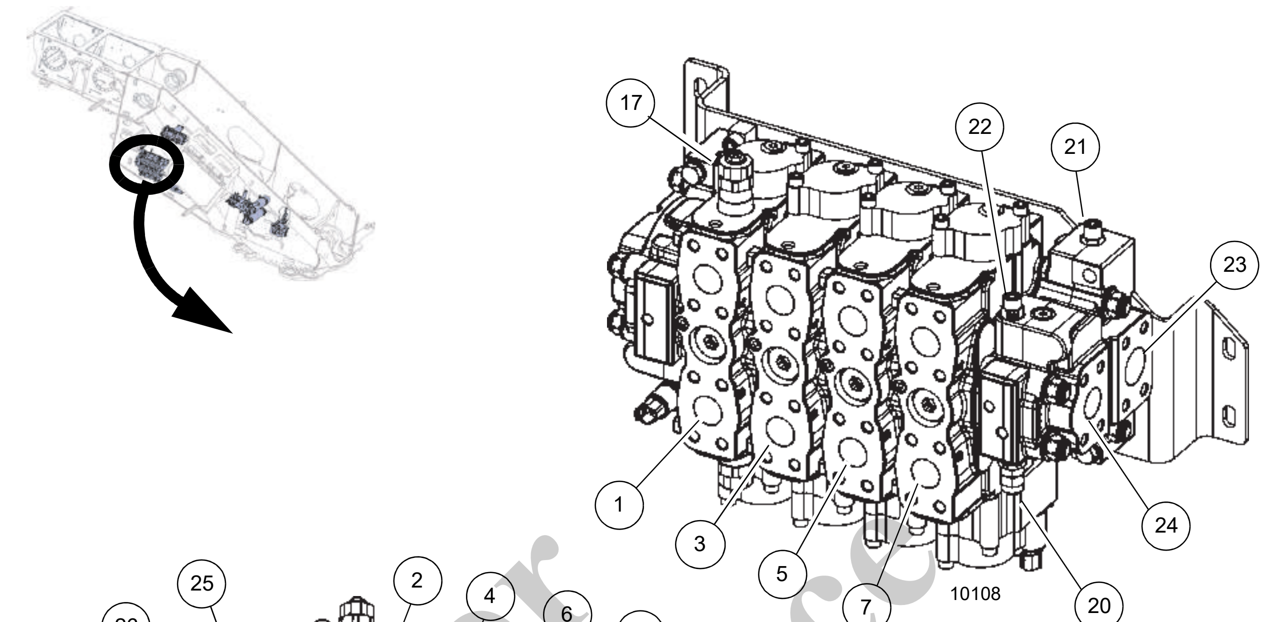
1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Tag and disconnect electrical connectors from the valve.
3. Remove the capscrews, flatwashers, and lockwashers securing the valve. Remove the valve.

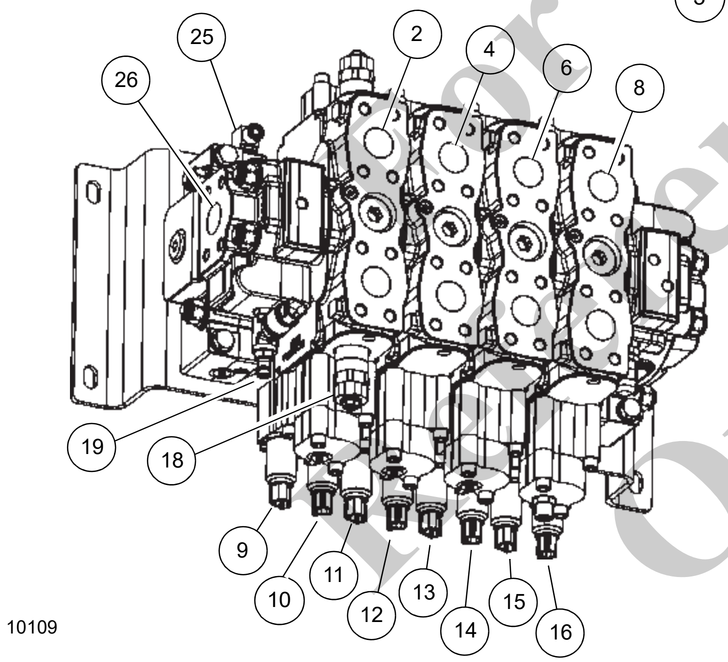
Main Directional Control Manifold Valve Installation

1. Install the valve on the turntable upright and secure with the capscrews, flatwashers, and lockwashers. Torque capscrews. Refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valves as tagged during removal.

Functional Check

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

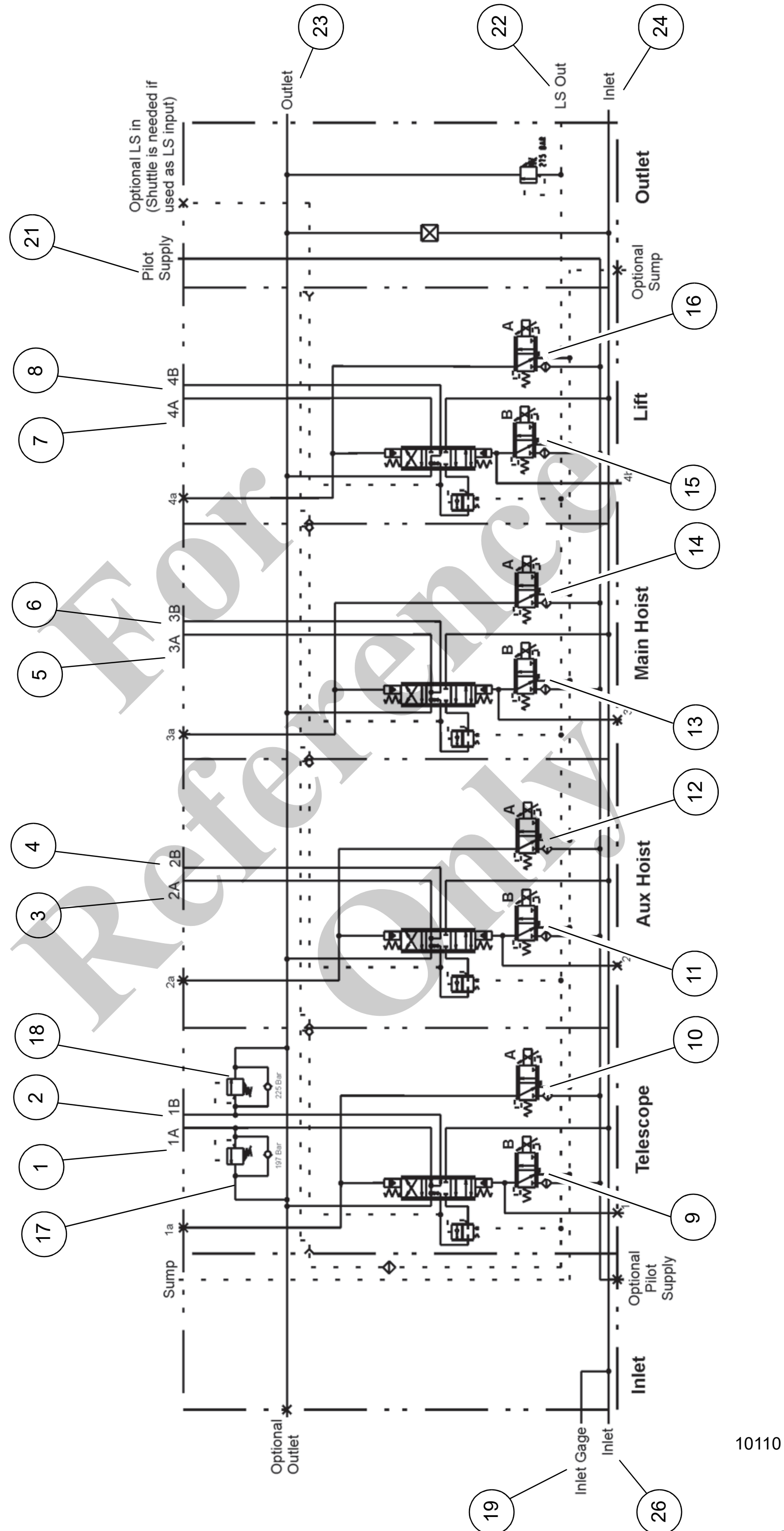




Main Directional Control Manifold Valve

Item	Description
1	Port 1A - Telescope Extend
2	Port 1B - Telescope Retract
3	Port 2A - Auxiliary Hoist Up
4	Port 2B - Auxiliary Hoist Down
5	Port 3A - Main Hoist Up
6	Port 3B - Main Hoist Down
7	Port 4A - Lift Cylinder Up
8	Port 4B - Lift Cylinder Down
9	Solenoid Valve - Telescope
10	Solenoid Valve - Telescope
11	Solenoid Valve - Auxiliary Hoist
12	Solenoid Valve - Auxiliary Hoist
13	Solenoid Valve - Main Hoist
14	Solenoid Valve - Main Hoist
15	Solenoid Valve - Lift Cylinder
16	Solenoid Valve - Lift Cylinder
17	Telescope Extend Relief Valve
18	Telescope Retract Relief Valve
19	Gauge Port - Inlet Diagnostic
20	Load Sense Relief Valve
21	Pilot Supply Port
22	Load Sense Out Port
23	Outlet Port
24	Inlet Port
25	Pilot Drain Port
26	Inlet Port (From Swivel Port 2)

FIGURE 2-14



Main Directional Control Manifold Valve Cont.

FIGURE 2-14 continued

Compact Manifold Valve

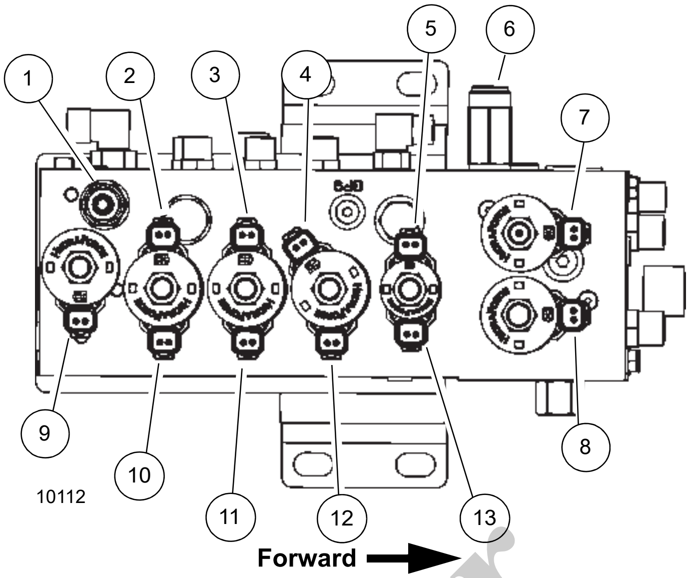
The compact block manifold (Figure 2-15) directs and controls hydraulic fluid flow for the counterweight pin lock, counterweight raise/lower, cab tilt and telescope pinning lock/unlock functions. The valve is located on the left side of the superstructure (2, Figure 2-13). The valve bank is removed and installed as an assembly.

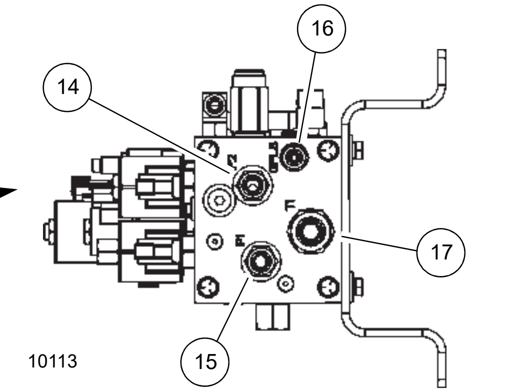
Removal

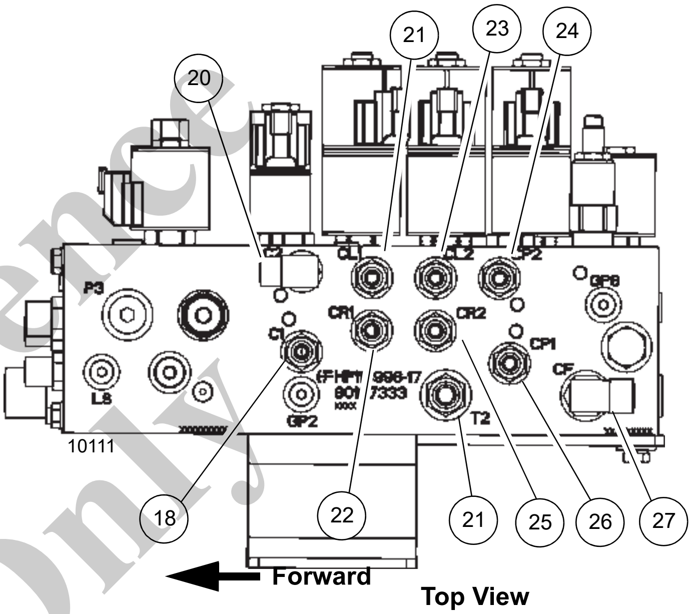
1. Tag and disconnect the hydraulic lines from the valve. Cap or plug the lines and ports.
2. Remove the capscrews and washers securing the valve. Remove the valve bank.

Installation

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

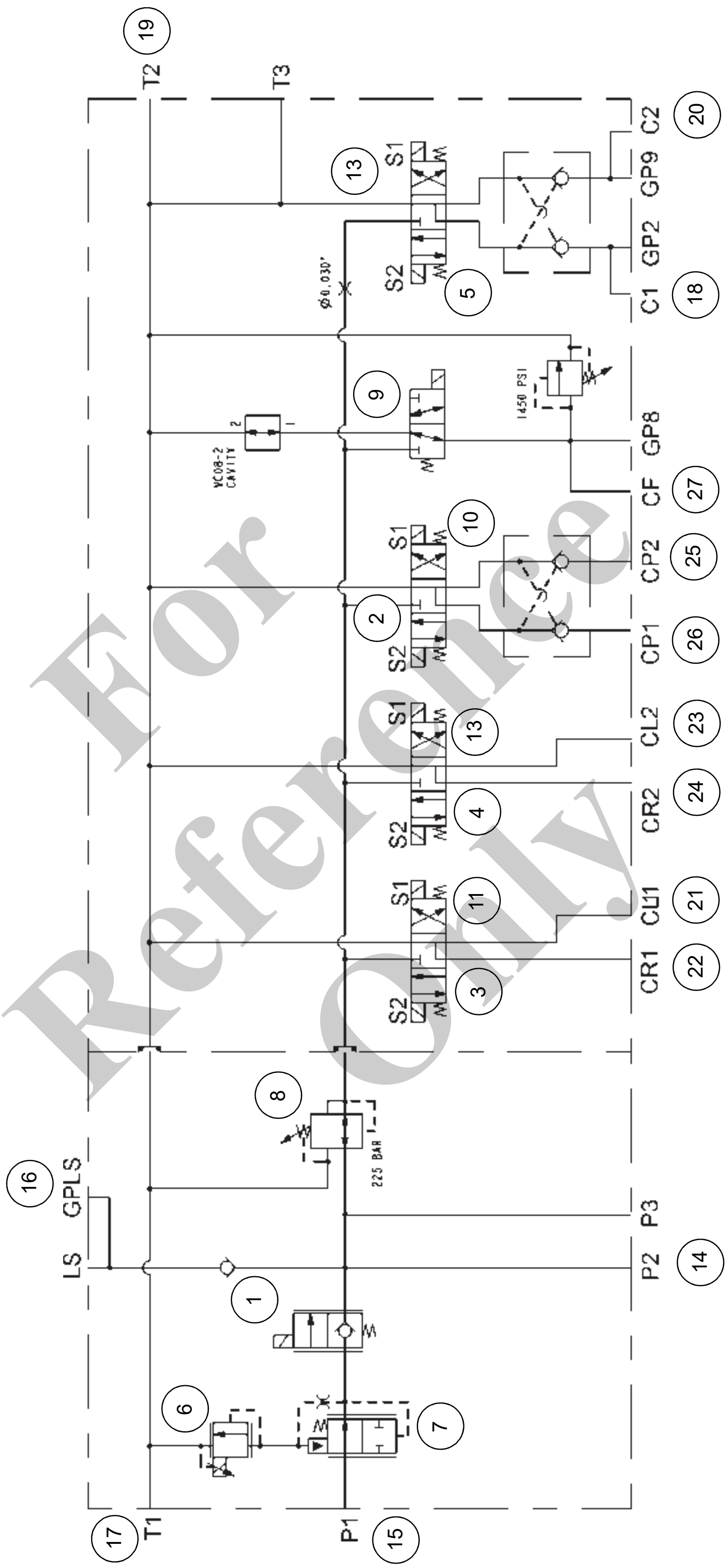






Compact Manifold Valve	
1	Relief Valve
2	Solenoid Valve — Counterweight Pin Retract
3	Solenoid Valve — Right Counterweight Lower
4	Solenoid Valve — Left Counterweight Lower
5	Solenoid Valve — Cab Tilt Lower
6	Pressure Relief Valve
7	Solenoid Valve — Flow Control
8	Solenoid Valve — Pressure Control
9	Solenoid Valve — Tele Fill Drain
10	Solenoid Valve — Counterweight Pin Extend
11	Solenoid Valve — Right Counterweight Raise
12	Solenoid Valve — Left Counterweight Raise
13	Solenoid Valve — Cab Tilt Raise
14	Pressure Port — P2 (for Hydraulic Boom Extension)
15	Pressure Port — P1
16	Gauge Port Load Sense — GPLS
17	Tank Port — T1
18	Cab Tilt Raise — C1
19	Tank Port — T2 (for Hydraulic Boom Extension)
20	Cab Tilt Lower — C2
21	Left Counterweight Lower — CL1
22	Left Counterweight Raise — CR1
23	Right Counterweight Lower — CL2
24	Right Counterweight Raise — CR2
25	Counterweight Pin Extend — CP2
26	Counterweight Pin Retract — CP1
27	Cylinder Fill — CF

FIGURE 2-15



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Compact Manifold Valve

FIGURE 2-15 continued

Accessory Manifold Valve

The accessory manifold valve (Figure 2-16) is located on the superstructure side plate (3, Figure 2-13) and includes valves for controlling the priority steer, swing brake, and pilot supply. This manifold valve receives hydraulic oil through swivel port 3.

Removal

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

Installation

1. Position the manifold and spacer bushings on turntable and secure with the capscrews, flatwashers and lockwashers. Torque capscrews - refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the hydraulic lines to the manifold as tagged during removal.
3. Connect the electrical connectors to the manifold as tagged during removal.

Function Check — Priority Steer

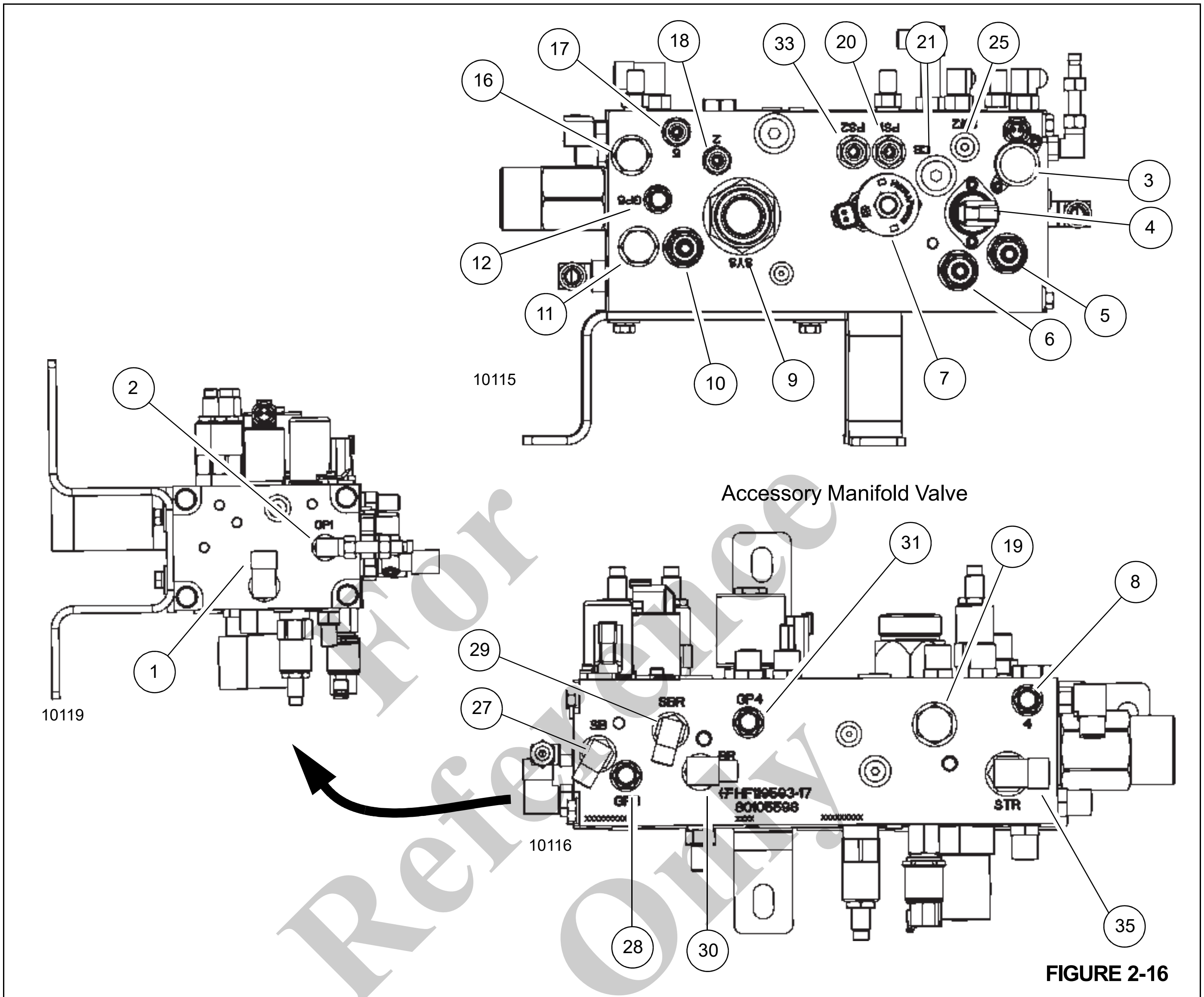
1. Start the engine.
2. Drive the crane at a slow speed and verify the front steering function works properly.

Function Check — Swing Brake Release Valve

1. Start the engine.
2. Enable all crane functions using the crane function switch to ON.
3. Swing the turntable to verify the swing brake releases. Depress the swing brake pedal to stop the turntable.
4. Position the swing enable switch to off and verify the swing brake applied icon appears on the CCS display.
5. Activate the swing function and ensure the turntable does not rotate.
6. Check for leaks. Make repairs as needed.

Function Check — Pilot Supply

1. Start the engine.
2. Enable all crane functions using the crane function switch.
3. Verify the following crane functions operate properly:
   a. Turntable swing left and right
4. Check for leaks. Make repairs as needed.


17
18
33
20
21
25
16
3
4
12
5
6
11
10115
10
9
7
2
Accessory Manifold Valve
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19
8
1
10119
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27
10116
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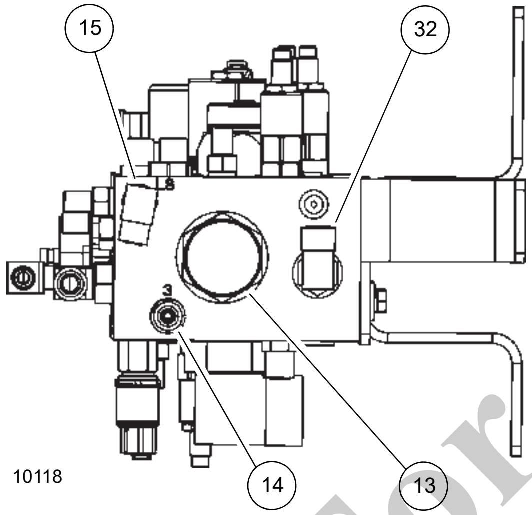
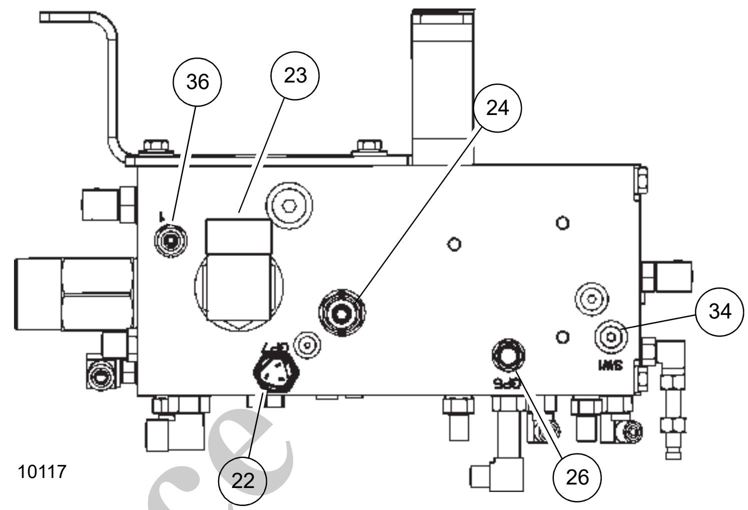
28
30
For Reference Only

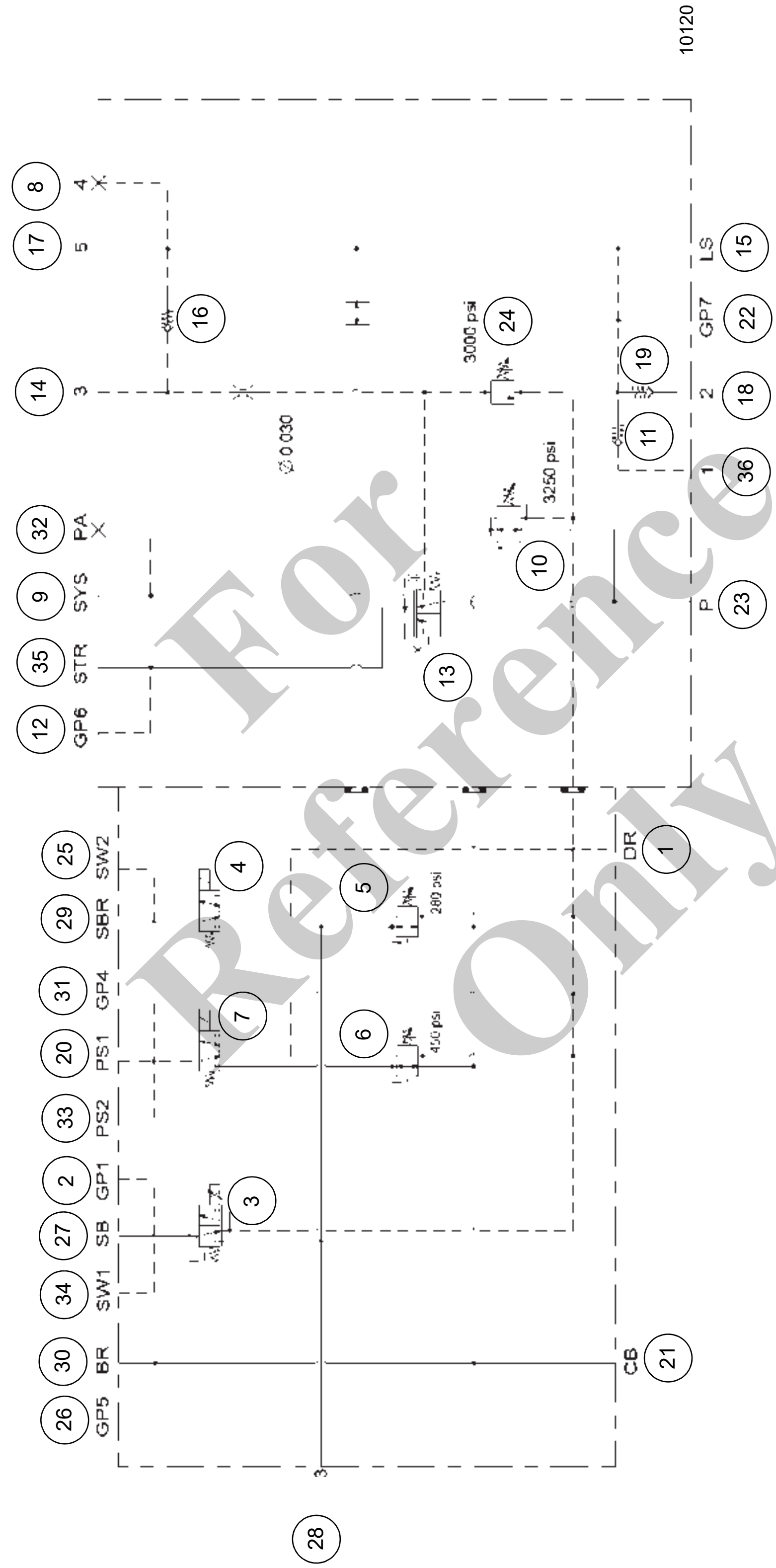
FIGURE 2-16





Accessory Manifold Valve	
1	Drain Port Outlet (DR)
2	Gauge Port (GP1)
3	Solenoid Valve - Swing Brake Apply
4	Solenoid Valve - Swing Brake Release
5	Pressure Reducing Valve - 280 psi
6	Pressure Reducing Valve - 450 psi
7	Solenoid Valve - Pilot Supply
8	Load Sense Port (4)
9	Inlet Port (SYS)
10	Pressure Reducing Valve - 3250 psi
11	Check Valve
12	Gauge Port (GP6)
13	Priority Valve - Steering
14	Load Sense Port (3)
15	Load Sense Port (LS)
16	Check Valve
17	Load Sense (5)
18	Drain Port Inlet (2)
19	Check Valve
20	Pilot Supply Port (PS1)
21	Outlet Port (CB)
22	Gauge Port (GP7)
23	Inlet Port (P)
24	Pressure Relief Valve - 3000 psi
25	Work Port (SW2)
26	Gauge Port (GP5)
27	Work Port - Swing Brake Apply (SB)
28	Gauge Port (GP3)
29	Work Port - Swing Brake Release (SBR)
30	Work Port - Brakes (BR)
31	Gauge Port (GP4)
32	Work Port (PA)
33	Work Port (PS2)
34	Work Port (SW1)
35	Work Port - Steering (STR)
36	Load Sense Port (1)

FIGURE 2-16 continued



Accessory Manifold Valve

FIGURE 2-16 continued

Swing Directional Control Valve

The swing directional control valve (Figure 2-17) is located on the superstructure side plate near the turntable bearing (4, Figure 2-13). A dual pilot-operated, proportional control valve controls the oil flow from the No. 3 hydraulic pump through swivel port 5 to maintain pressure in the left and right swing circuits. Excess oil from the valve flows back to tank. The left and right swing functions are controlled by two pilot-operated, solenoid-controlled proportional valves. An additional solenoid-controlled valve acts as a “swing enable” valve, which is only energized when the left or right swing function is actuated. When energized, this valve sends oil through a pilot line to shift the dual pilot-operated, proportional control valve to send full flow from the No. 3 gear pump to the swing circuit.

Swing Directional Control Valve Removal

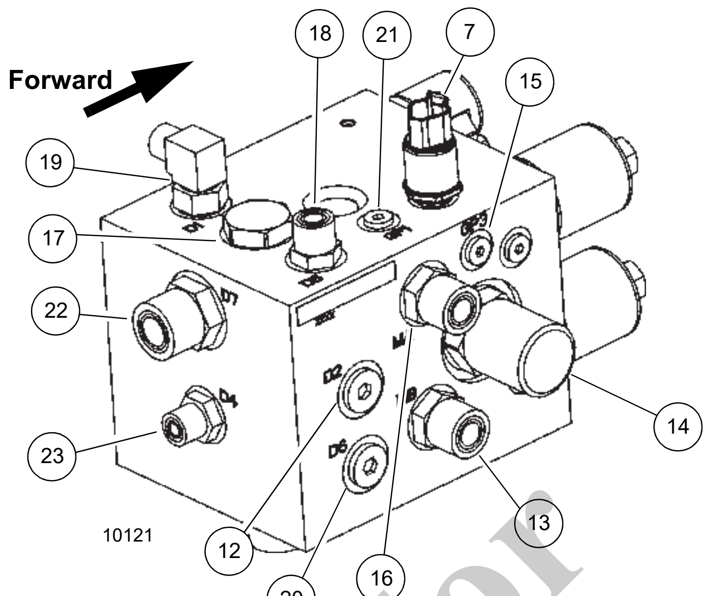
1. Tag and disconnect the hydraulic lines from the valves. Cap or plug the lines and ports.
2. Tag and disconnect electrical connectors from the valve.
3. Remove the capscrews, flatwashers, and lockwashers securing the valve. Remove the valve.

Swing Directional Control Valve Installation

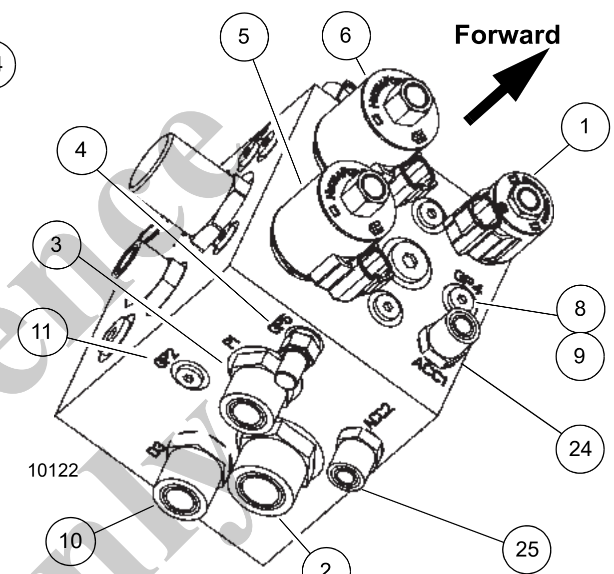
1. Install the valve on the turntable upright and secure with the capscrews, flatwashers, and lockwashers. Torque capscrews. Refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the electrical connectors to the valve as tagged during removal.
3. Connect the hydraulic lines to the valves as tagged during removal.
4. Remove the capscrews and nuts securing the valve. Remove the valve.

Functional Check

1. Start the engine and run it at normal speed.
2. Operate the joystick right and left. Check for proper operation.
3. Check the valve bank(s) and lines for leakage. Make repairs as needed.



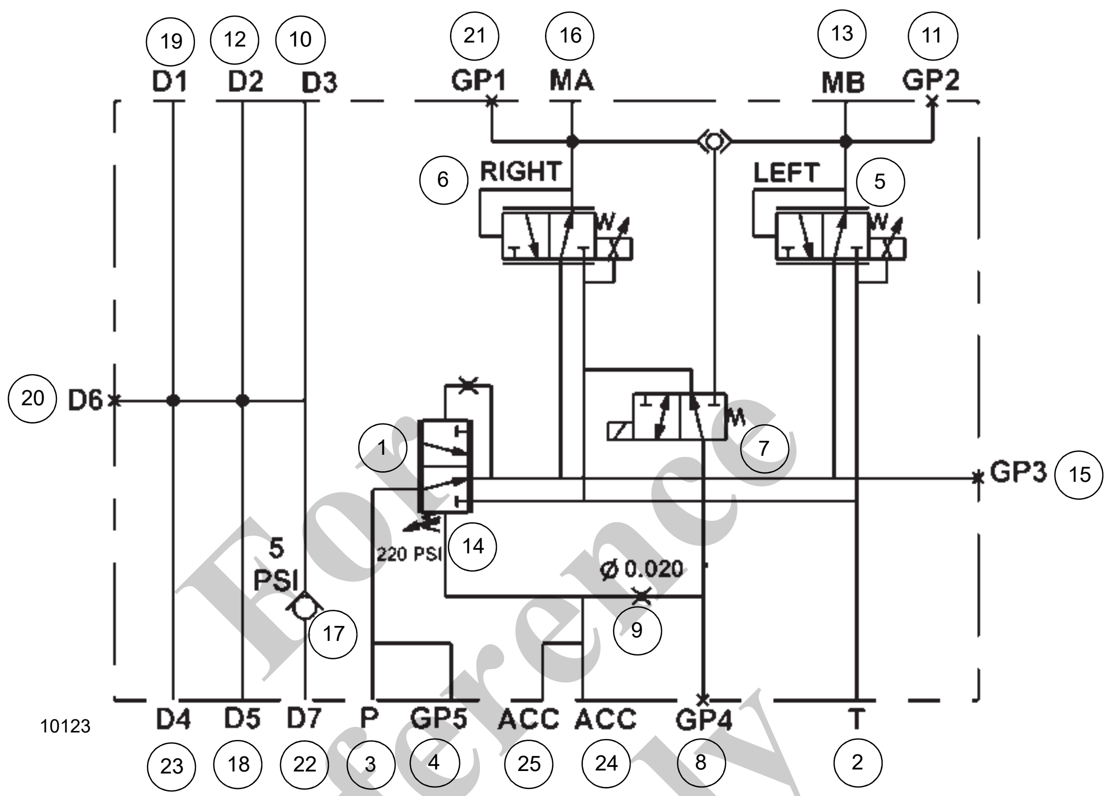
Front View



Bottom View

Swing Directional Control Manifold Valve	
1	Solenoid Valve - Swing Enable
2	Tank Port — T
3	Inlet Port — P1
4	Gauge Port — GP5
5	Solenoid Valve - Left Swing
6	Solenoid Valve - Right Swing
7	Pressure Transducer
8	Gauge Port — GP4
9	Orifice - 0.020 in
10	Drain Port — D3
11	Gauge Port — GP2
12	Drain Port — D2
13	Work Port — MB — Left Swing
14	Pressure Compensating Valve
15	Gauge Port — GP3
16	Work Port — MA — Right Swing
17	Shuttle Valve
18	Drain Port — D5
19	Drain Port — D1
20	Drain Port — D6
21	Gauge Port — GP1
22	Drain Port — D7
23	Drain Port — D4
24	Accumulator Port — ACC1
25	Accumulator Port — ACC2

FIGURE 2-17



Swing Directional Control Manifold Valve

FIGURE 2-17 continued

Dual Accumulator Charger Manifold Valve

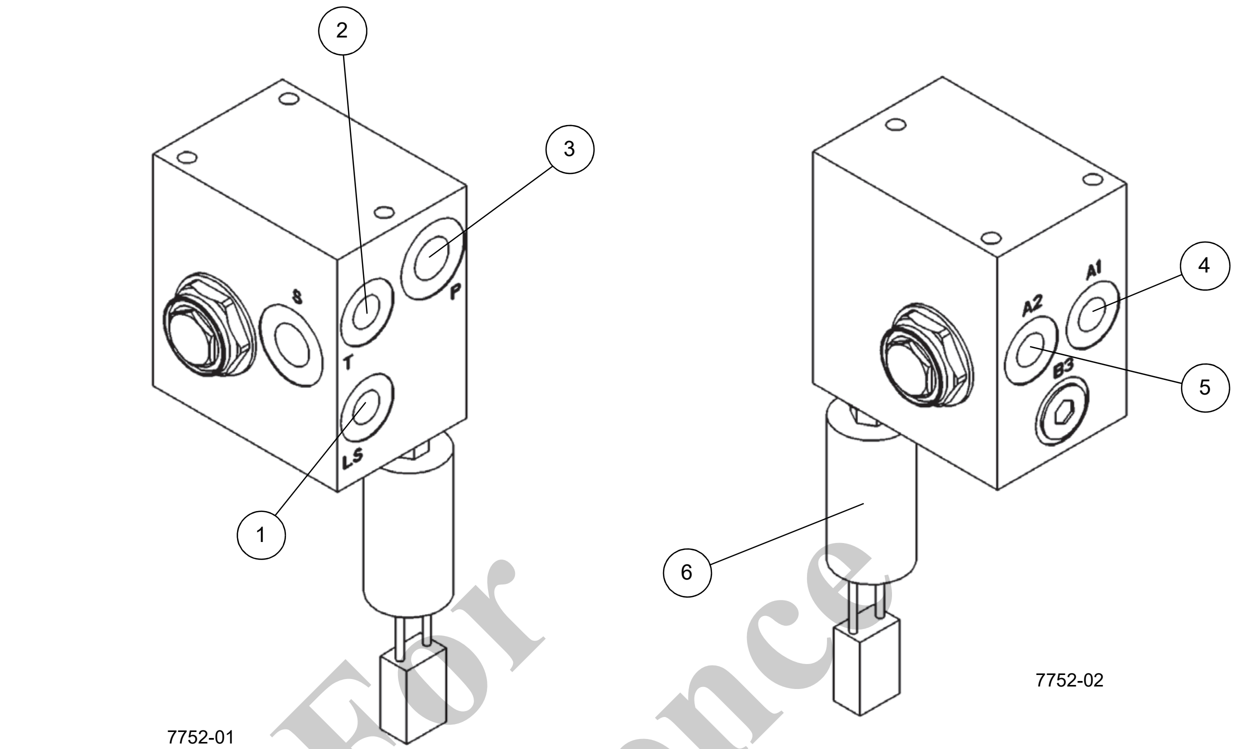
The dual accumulator charge manifold valve (Figure 2-18) is located on the inside of the left superstructure side plate (Figure 2-13). The valve provides pressure regulation to the service brake circuit.

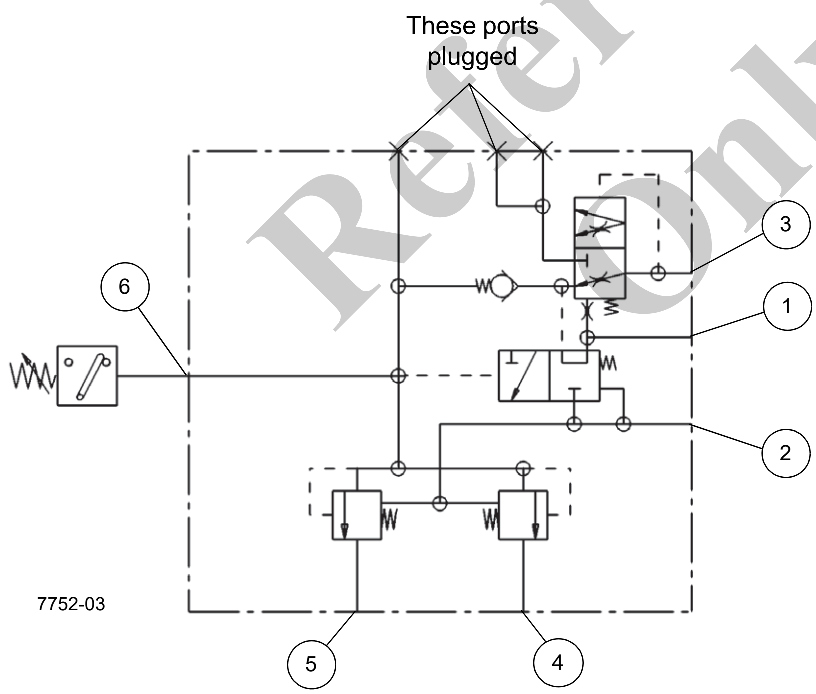
Removal

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

Installation

1. Position the valve on the superstructure with ports A1, A2, and B3 facing up and secure with three bolts, washers, and lockwashers. Torque bolts.
2. Connect the hydraulic hoses to the valve ports as tagged during removal.
3. Start the engine and check for leaks. Make repairs as needed.
4. Depress the brake pedal several times to cause the brake valve to charge. Make several turns with the steering wheel, and swing the superstructure left and right. Verify the brakes, swing, and front steering work properly.





Dual Accumulator Charge Valve	
1	Load Sense Port (LS)
2	Tank Port (T)
3	Pressure Port (P)
4	Accumulator Port (A1)
5	Accumulator Port (A2)
6	Pressure Switch

FIGURE 2-18

Check Valve Assembly

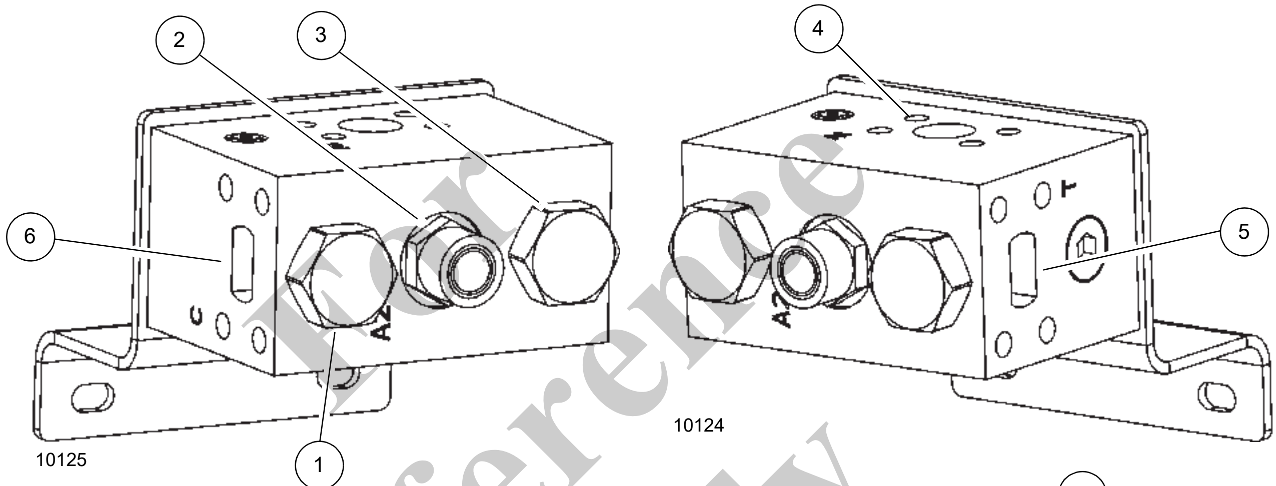
The check valve assembly (Figure 2-19) is located on the right side of the superstructure (Figure 2-13).

Removal

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

Installation

1. Install the valve on the turntable upright and secure with the capscrews, flatwashers, and lockwashers. Torque capscrews. Refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
2. Connect the hydraulic lines to the valves as tagged during removal.
3. Secure the valve using capscrews and nuts.



Check Valve Assembly	
1	Check Valve - 30 PSI
2	Work Port - A2 to Compact Valve T1
3	Check Valve - 45 PSI
4	Work Port - A1 from Main Directional Control Valve
5	Tank Port - Tank/return leg to swivel
6	Work Port - Tank/return leg to cooler

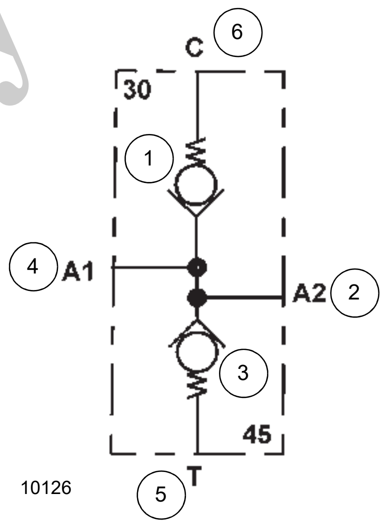
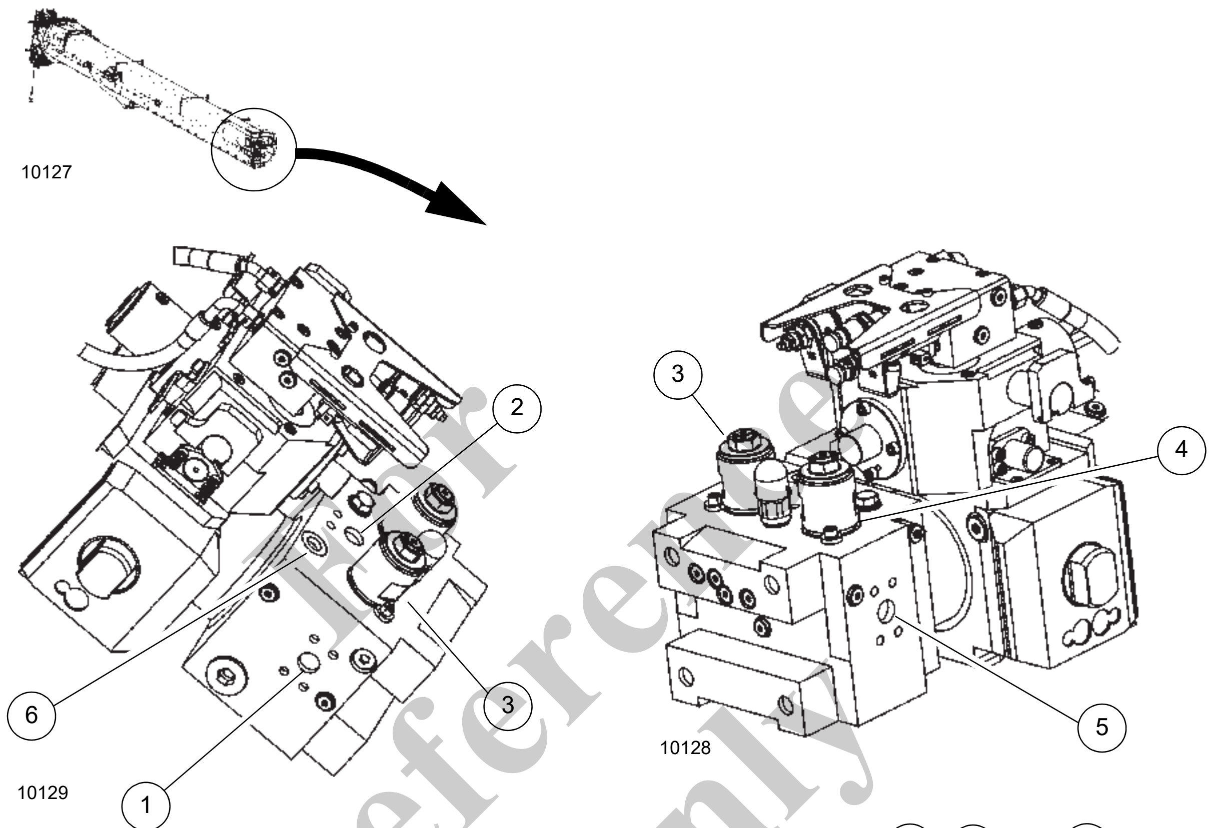
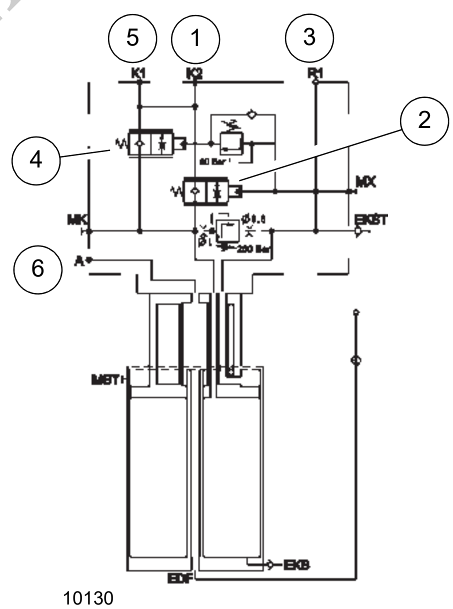


FIGURE 2-19

Telescope Cylinder Control Valve

The telescope cylinder valve (Figure 2-20) is a cartridge style holding valve located on the rear of the boom telescope cylinder.





Telescope Cylinder Valve	
1	Work Port — K2 Extend (6000 PSI)
2	Lock Valve — V2
3	Work Port — R1 Retract (6000 PSI)
4	Lock Valve — V1
5	Work Port — K1 Extend (6000 PSI)
6	Work Port — Tele Fill A (From Compact Manifold)

FIGURE 2-20

Removal

WARNING

Falling Boom

Never remove a telescope cylinder valve from the lift or telescope cylinder circuits without first fully retracting the cylinders. Death or serious injury can occur.

WARNING

High Hydraulic Pressure

Never remove a telescope cylinder from the lift or telescope cylinder circuits without first fully retracting the cylinders to remove the high hydraulic pressure in the circuits. Fluid in these hydraulic systems can be under enough pressure that it will penetrate the skin, causing serious injury or death.

1. Start the engine and fully retract the telescope the lift cylinders using the joysticks. Use the RCL override function to fully retract the lift cylinder.
2. Shut off engine.
3. Tag and remove hoses.

Installation

1. Check inside of port block or manifold for sharp edges or burrs. Remove as necessary with emery cloth.
2. Install new O-rings on telescope cylinder valve.
3. Lubricate telescope cylinder valve O-rings with clean hydraulic oil.

CAUTION

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

NOTE: Telescope cylinder valve should turn by hand until O-rings compress.

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

Lift Cylinder Manifold

The lift cylinder manifold valve (Figure 2-21) is located on the lift cylinder. This valve features two pressure transducers that report system pressure to the RCL for lift up and down functions. If the transducers are replaced, the RCL must be recalibrated.

DANGER

Make sure the lift cylinder is full retracted before removing the hoses and transducers. Failure to fully retract the lift cylinder before removing hoses and transducers may result in injury or death.

The lift cylinder manifold valve hoses and transducers can be disconnected, but valve manifold cannot be removed from the lift cylinder. Contact your Grove Crane distributor or Manitowoc Crane Care if the lift cylinder needs repair.

Removal

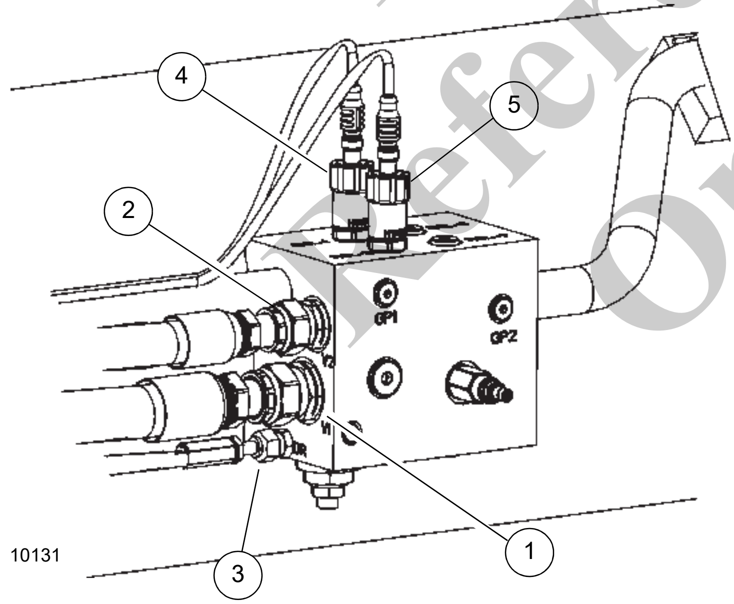
1. Start the engine and fully retract the telescope the lift cylinders using the joysticks. Use the RCL override function to fully retract the lift cylinder.
2. Raise the hydraulic boom extension to 0° offset.
3. Shut off engine.
4. Tag and remove hydraulic hoses from the hydraulic boom extension manifold valve.
5. Tag and disconnect electrical connections.

Installation

1. Connect hydraulic hoses as tagged.
2. Connect electrical connectors as tagged.
3. Re-calibrate the transducers.

Functional Test

1. Start the engine and run it at normal speed.
2. Raise and lower the boom extension. Check for smooth operation of cylinders and motors.
3. Check the valve and lines for leakage. Make repairs as needed.



Telescope Cylinder Valve	
1	Work Port — V1 (80 GPM)
2	Work Port — V2 (20 GPM)
3	Drain Port — DR
4	Pressure Transducer — RCL-1 — Lift Down
5	Pressure Transducer — RCL-2 — Lift Up

FIGURE 2-21

HYDRAULIC BOOM EXTENSION VALVE (OPTIONAL)

When installed, the hydraulic boom extension valve (Figure 2-22) is located on the upper right side of the superstructure. This valve controls the flow of hydraulic fluid to the hydraulic boom extension, if installed.

Removal

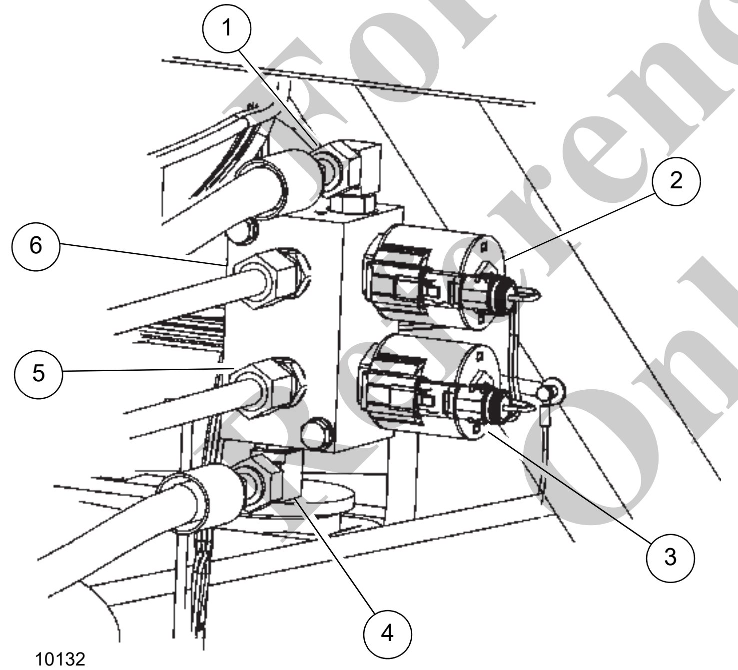
1. Start the engine and fully retract the telescope the lift cylinders using the joysticks. Use the RCL override function to fully retract the lift cylinder.
2. Raise the hydraulic boom extension to 0° offset.
3. Shut off engine.
4. Tag and remove hydraulic hoses from the hydraulic boom extension manifold valve.
5. Tag and disconnect electrical connects.
6. Remove capscrews, lockwashers, washers, and hydraulic boom extension manifold from bracket.

Installation

1. Install hydraulic boom extension manifold valve on bracket with capscrews, washers, lockwashers, and nuts.
2. Connect hydraulic hoses as tagged.
3. Connect electrical connectors as tagged.

Functional Test

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



Hydraulic Boom Extension Valve	
1	Pressure Port — P (from P2 Port on Compact Manifold Valve)
2	Solenoid Valve — Move Raise
3	Solenoid Valve — Move Lower
4	Tank Port — T (fromT2 Port on Compact Manifold Valve)
5	Work Port — B — Lower
6	Work Port — A — Raise

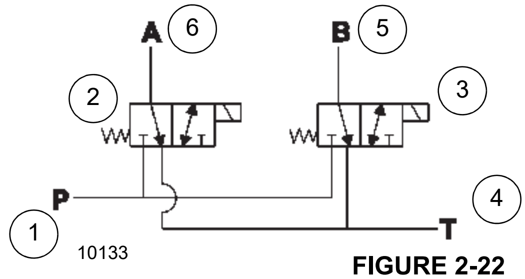


FIGURE 2-22

PRESSURE SETTING PROCEDURES

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

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

- Pressure Gauge (1) three dial gauge 0 to 34.5 MPa (0 to 5000 psi)
- Accumulator charging and gauging assembly for 20.7 MPa (3000 psi)
- ORFS reducers as required to attach work port hoses to the gauge.

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

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

Table 2-3 Hydraulic Valve Pressure Settings

VALVE TO BE SET	GAUGE PRESSURE PSI (bar)	TOLERANCE PSI (bar)	PROCEDURE
Pump No. 1 differential pressure	550 (38)	±25 (2)	*Checking/Setting the Piston Pumps Cut-off and Differential Pressures*, page 2-54.
Pump No. 2 differential pressure	500 (34.5)	±25 (2)	*Checking/Setting the Piston Pumps Cut-off and Differential Pressures*, page 2-54.
Pilot supply pressure	450 (31)	±50 (4)	*Checking/Setting the Pilot Supply Pressure*, page 2-56.
Load Sense (max system) pressure	4350 (300)	±50 (4)	*Load Sense Relief (Max System Pressure)*, page 2-59.
Telescope Retract Pressure	3250 (224)	±100 (7)	*Telescope Extend and Retract Relief Pressures*, page 2-59.
Telescope Extend Pressure	2900 (200)	±100 (7)	*Telescope Extend and Retract Relief Pressures*, page 2-59.
Swing left and right pressures	2900 (200)	±100 (7)	*Checking / Setting the Swing Brake Release Pressure*, page 2-60.
Swing brake release pressure	260-300 (18-21)	See range	*Checking the Swing Work Pressure*, page 2-61.
Cab Tilt Pressure	3100 (214)	±100 (7)	*Checking/Setting Cab Tilt Raise and Lower Pressures*, page 2-63.
Counterweight Lower Pressure	1450 (100)	±100 (7)	*Checking/Setting Counterweight and Hydraulic Boom Extension Pressures*, page 2-63.
Counterweight Raise Pressure	3200 (221)	±100 (7)	*Checking/Setting Counterweight and Hydraulic Boom Extension Pressures*, page 2-63.
Counterweight Pin Pressure	2600 (179)	±50 (4)	*Checking/Setting Counterweight and Hydraulic Boom Extension Pressures*, page 2-63.
Outrigger Beam Extend Pressure	1200 (83)	±50 (4)	*Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise*, page 2-65.

Table 2-3 Hydraulic Valve Pressure Settings (Continued)

VALVE TO BE SET	GAUGE PRESSURE PSI (bar)	TOLERANCE PSI (bar)	PROCEDURE
Outrigger Beam/Jack Retract Pressure	2500 (172)	±100 (7)	*Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise*, page 2-65.
Outrigger Jack Extend Pressure	3000 (207)	±100 (7)	*Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise*, page 2-65.
Rear Steer Pressure	2750 (190)	±50 (4)	*Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise*, page 2-65.
Front steer pressure	2750 (190)	±50 (4)	*Checking/Setting the Front Steer Pressure*, page 2-61.
Service brake high charge limit	2900 (200)	±145 (10)	*Check the Service Brake Accumulator Charging Valve Pressure*, page 2-61.
Service brake low charge limit	2465 (170)	±145 (10)	*Check the Service Brake Accumulator Charging Valve Pressure*, page 2-61.
Service brake accumulator pre-charge	Front: 1500 to 1550 (103 to 107) Rear: 1400 to 1450 (97-100)	See range	*Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise*, page 2-65.
Suspension Fill Pressure	2500 (172)	±50 (4)	*Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise*, page 2-65.
Suspension Accumulator Pre-Charge	1300-1350 (90-93)	See Range	*Service Brake Accumulators Pre-charge*, page 2-62.
Outrigger Box Pinning Extend	3000 (207)	±50 (4)	*Checking/Setting Counterweight and Hydraulic Boom Extension Pressures*, page 2-63.
Outrigger Box Pinning Retract	1000 (69)	±50 (4)	*Checking/Setting Counterweight and Hydraulic Boom Extension Pressures*, page 2-63.
Hydraulic Boom Extension Raise/Lower Pressure (Optional)	4060 (280)	±50 (4)	*Checking/Setting Counterweight and Hydraulic Boom Extension Pressures*, page 2-63.
Transmission Fan Pressure/Park Brake	3000 (207)	±45 (3)	*Checking/Setting Park Brake Pressure and Transmission Fan Max Pressure*, page 2-67.

Accessing the Diagnostic Connector

The diagnostic connector (1, Figure 2-23) is located behind the operator seat. The rear electrical upper cover (2) must be removed to access the diagnostic connector.

Removing the Upper Electrical Cover

1. Move the operator seat as necessary to access the upper cover (2, Figure 2-23).
2. Turn the thumb screws (3).
3. Remove the upper electrical cover (2).

Installing the Upper Electrical Cover

1. Move the operator seat as necessary to access the upper cover (2, Figure 2-23).
2. Install the cover (2) over thumbscrews (3). Make sure the edges of the cover fits securely.
3. Turn the thumbscrews (3) to secure the cover (2).

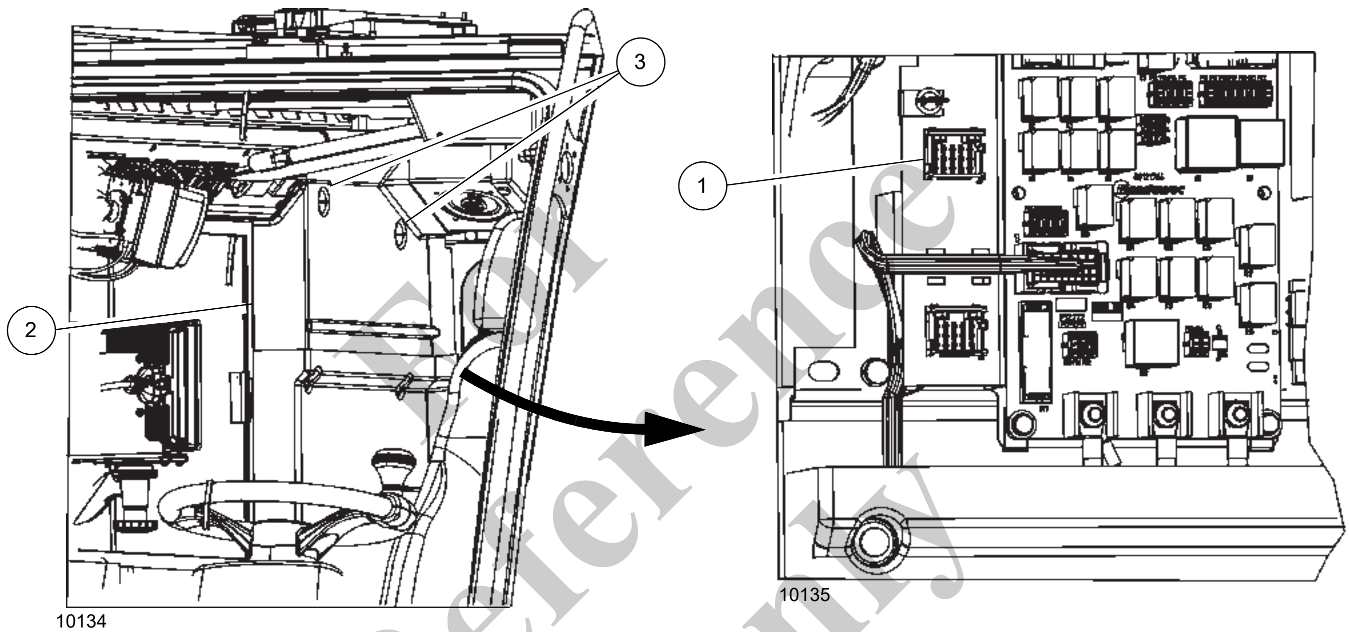


FIGURE 2-23

Connecting the Manitowoc Crane Service Tool

Use the following procedure to connect the diagnostic cable and Manitowoc Crane Service Tool to the crane diagnostic port.

Required Equipment
PC with Manitowoc Crane Service tool installed.
Diagnostic Cable.

1. Remove the upper electrical cover. For more information, see *Removing the Upper Electrical Cover*, page 2-54.
2. Connect the USB end of the diagnostic cable to the PC.
3. Connect cOSI connector to the diagnostic port (1, Figure 2-23).
4. Launch the Manitowoc Crane Service Tool.

Checking/Setting the Piston Pumps Cut-off and Differential Pressures

Use the following procedure to check and set the cut-off and differential pressures for both piston pumps (1 and 2, Figure 2-25).

NOTE: Make sure the outrigger box pressure bleed off valve is shut before checking the cut-off and differential settings. For more information, see the *Operator Manual*.

1. Install a pressure check diagnostic quick disconnect (Parker PD240 or equivalent) with gauge onto test nipple in the GP port of the main directional control valve (1, Figure 2-26).
2. Adjust the piston pump cutoff maximum on both piston pumps (1 and 2, Figure 2-25) as follows:
    a. Make sure the piston pump cut-off maximum (3, Figure 2-25) factory setting is correct. Loosen the jam nut on the cut-off maximum adjusting screw.

b. Back the adjusting screw out until there is 8.0 ± 0.5 mm (0.32 in ±0.02 in) from the end of the adjusting screw to the top of the jam nut seated against the valve body (see Cut-Off Screw Adjustments in Figure 2-25). This adjustment makes sure the full system pressure cited in Table 2-3 can be obtained but limit the maximum cutoff pressure of the pumps.

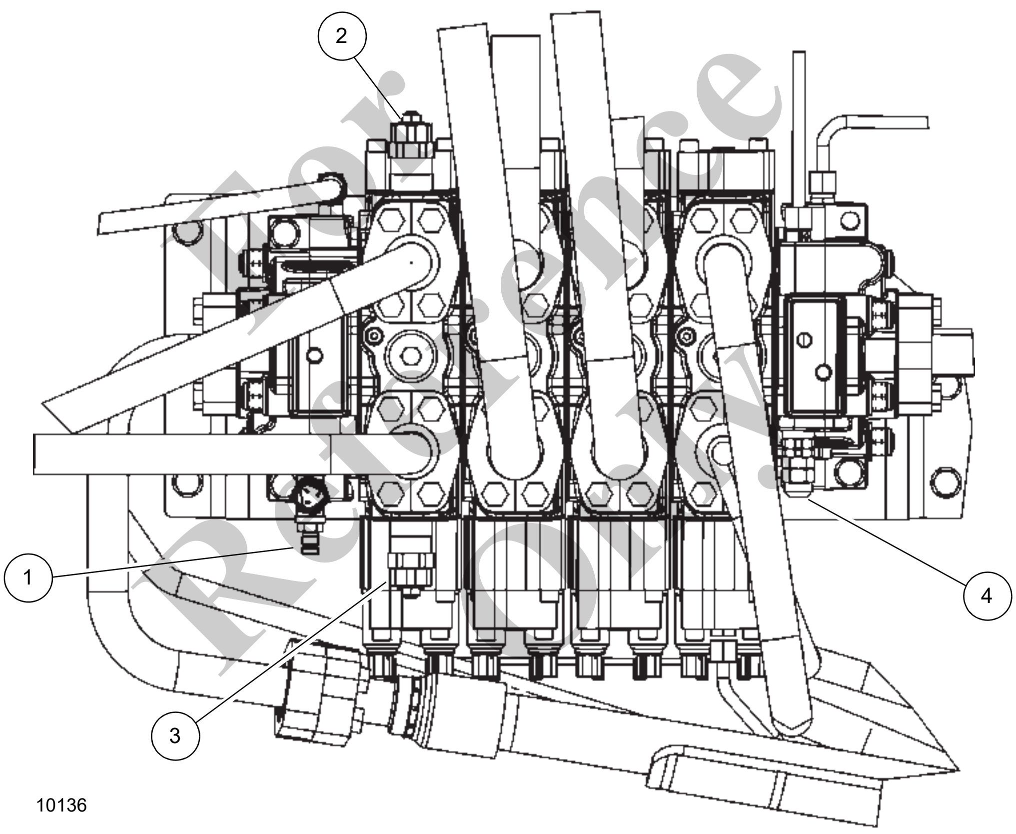
3. Do the following to make sure the piston pump differential pressure (stand-by) is correct:

   a. With diagnostic quick disconnect (Parker PD240 or equivalent) still installed in the GP port of the main directional control valve (1, Figure 2-26), start the engine.

   b. At idle RPM, adjust the piston pump 2 (4, Figure 2-26) differential setting screw in to increase or out to decrease so that a gauge reading cited in Table 2-3 is achieved. It may be necessary to back out the stand-by adjustment screw for pump 1 if the pressure cannot be achieved.

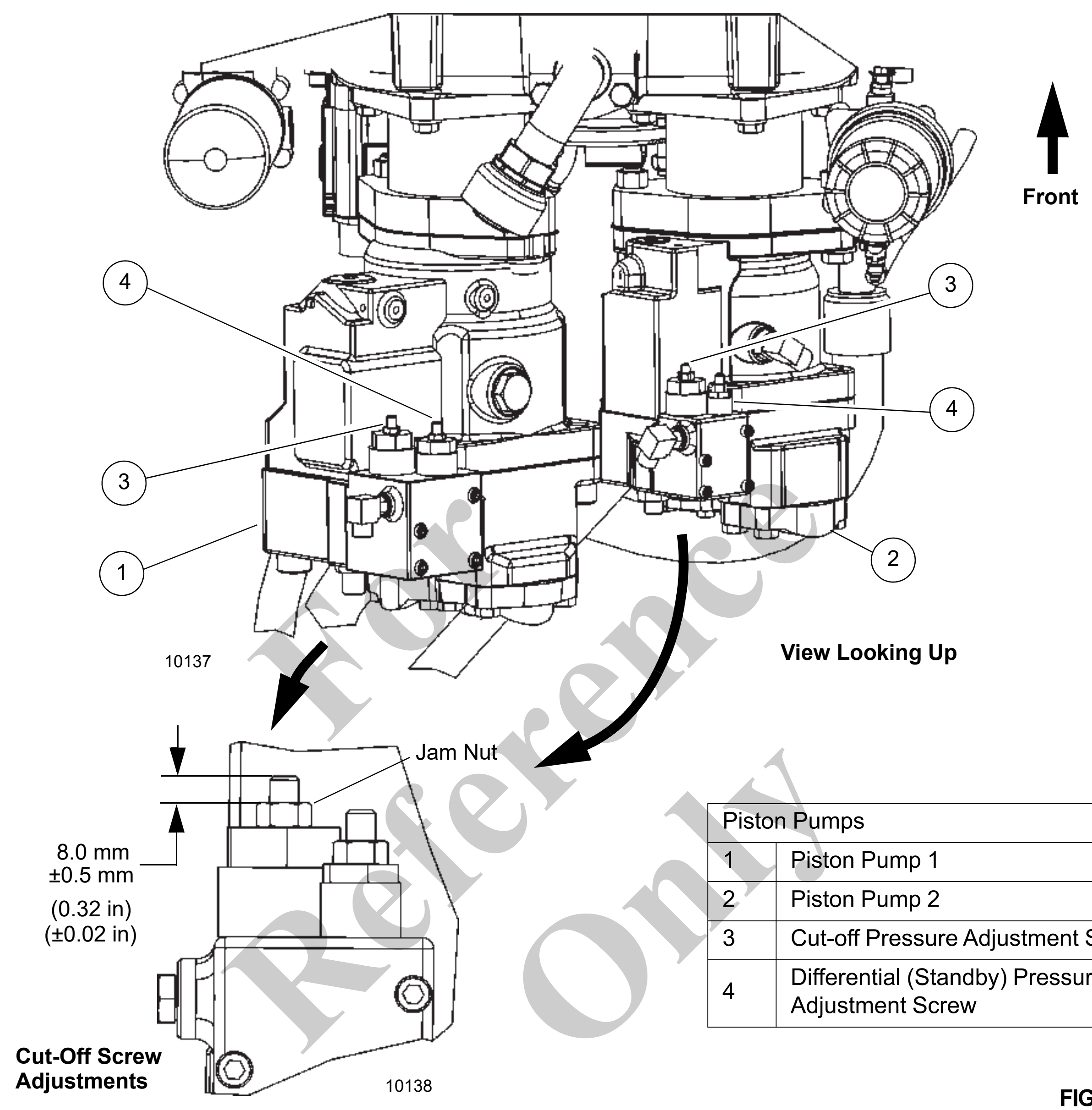
   c. With the engine still at idle RPM adjust the piston pump 1 differential setting screw "in" to increase or "out" to decrease so that a gauge reading cited in is achieved.

4. Stop the engine. Remove the diagnostic coupler.



Main Directional Valve	
1	Main Directional Valve GP Diagnostic Port
2	Telescope Extend Relief
3	Telescope Retract Relief
4	LS Relief

FIGURE 2-24



Piston Pumps	
1	Piston Pump 1
2	Piston Pump 2
3	Cut-off Pressure Adjustment Screw
4	Differential (Standby) Pressure Adjustment Screw

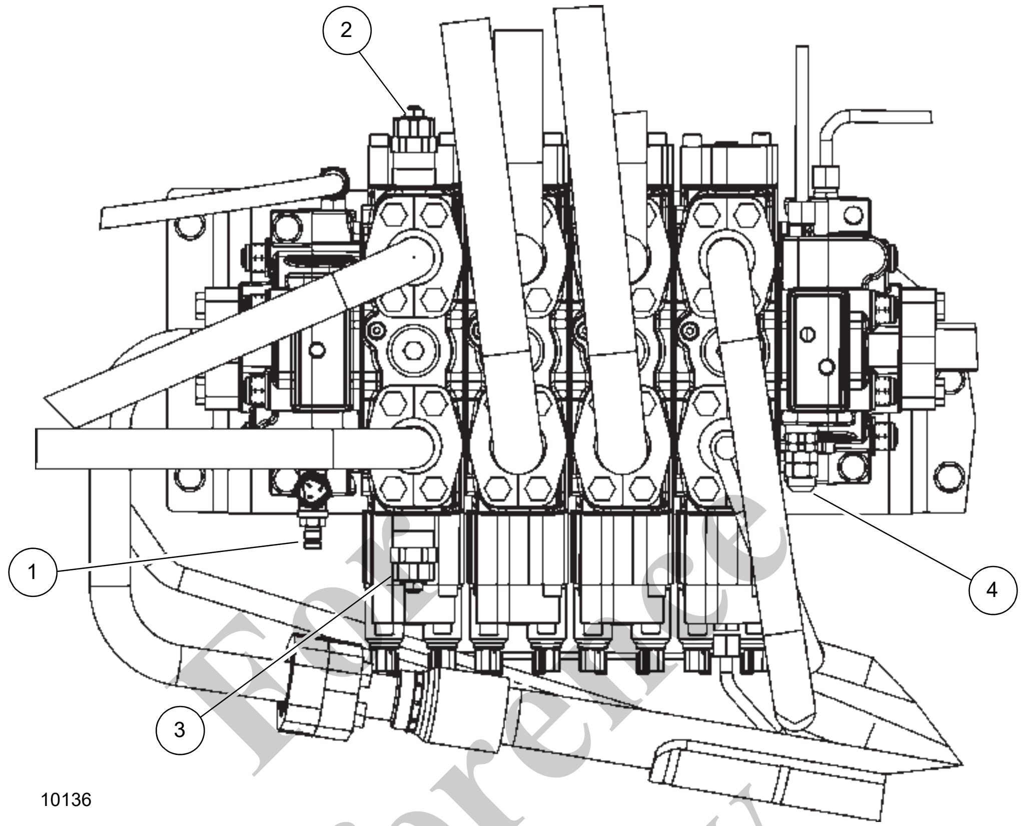
FIGURE 2-25

Checking/Setting the Pilot Supply Pressure

Use the following procedure to check and set the pressure for the pilot supply pressure.

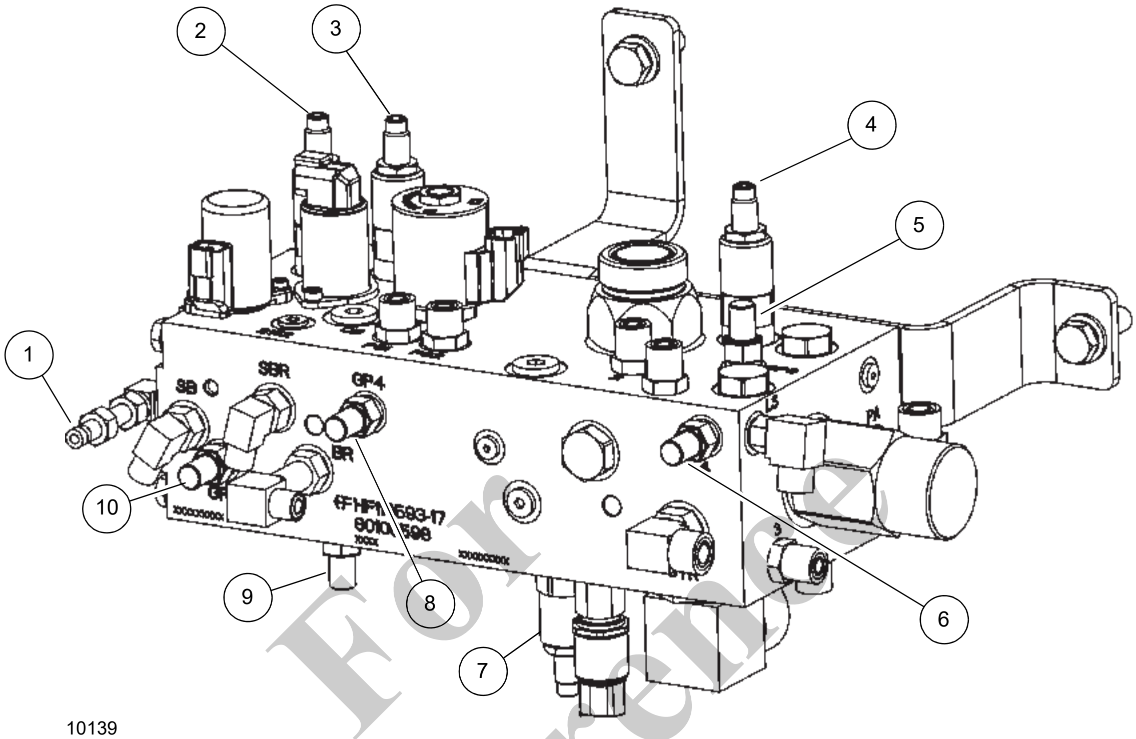
NOTE: Make sure the outrigger box pressure bleed off valve is shut before checking the cut-off and differential settings. For more information, see the *Operator Manual*.

1. With the engine off, install pressure check diagnostic quick disconnect (Parker PD240 or equivalent) with gauge onto test the nipple at GP4 port of the Accessory manifold (Figure 2-26).
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. Gradually increase to raise or lower and hold. (If the cylinder is fully stroked in either direction the RCL override switch will need to be active to assure that the pilot supply will not be cut off before the cylinder can be fully extended) The reading at GP4 should be the value cited in Table 2-3. If it is not, adjust the pilot supply pressure reducing valve (see Figure 2-27) “in” to increase or “out” to decrease until the reading is achieved.
5. Stop the engine. Remove the diagnostic couplers.



Main Directional Control Valve	
1	Main Directional Valve GP Diagnostic Port
2	Telescope Extend Relief
3	Telescope Retract Relief
4	Load Sense (LS) Relief

FIGURE 2-26



Accessory Manifold	
1	GP1 Port
2	Swing Brake Pressure Reducing Valve
3	Pilot Supply Pressure Reducing Valve
4	Accessory Pressure Reducing Valve
5	GP6 Port
6	Port 4 Load Sense
7	Steer Priority Relief Valve
8	GP4 Port
9	GP5 Port
10	GP3 Port

FIGURE 2-27

Load Sense Relief (Max System Pressure)

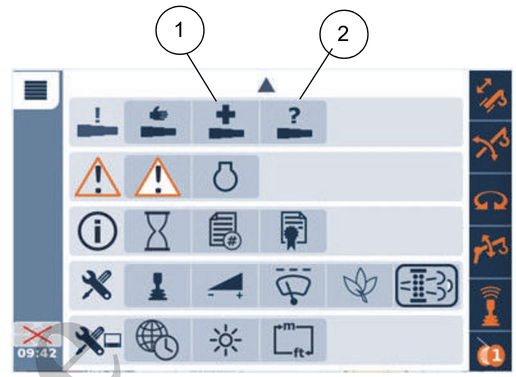
Use the following procedure to check and set the load sense relief pressure.

1. With the engine off, install pressure check diagnostic quick disconnect, such as the Parker PD240 or equivalent, with gauge onto the GP gauge port on the Main Directional Control Valve (Figure 2-26).
2. If the lift cylinder is not attached, make sure the hoses are capped.
3. The ODM/RDM override switch needs to be activated to do lift up and lift down functions if the hoses are attached to the cylinder to make sure 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 the value cited in Table 2-3. If it is not, adjust the LS relief (Figure 2-26) “in” to increase or “out” to decrease until the reading is achieved.
5. If the pressure cannot be achieved, ensure each piston pump’s “cut-off” max setting is correct with the following procedure:
    a. Loosen both pump’s jam nuts on the cut-off pressure adjusting screws (Figure 2-25).
    b. Turn both pumps “in” one quarter-turn at a time - one pump a quarter turn, then the other pump a quarter turn, repeat, etc. - until the specified LS pressure is achieved.
    c. Turn each pump “in” 1/8 of a turn and tighten the jam nuts to lock in the screw positions.
    d. Repeat step 4, taking care to turn the LS relief back into where you started.

Telescope Extend and Retract Relief Pressures

Use the following procedure to set the boom telescope extend and retract relief pressures.

1. With the engine off, install pressure check diagnostic quick disconnect (such as Parker PD240) with gauge onto test the nipple at Port 4 of the Accessory manifold (Figure 2-27).
2. Start the engine and navigate to the lower display menu screen.



Lower Display Menu	
1	Emergency Mode Icon
2	Boom Lost Icon

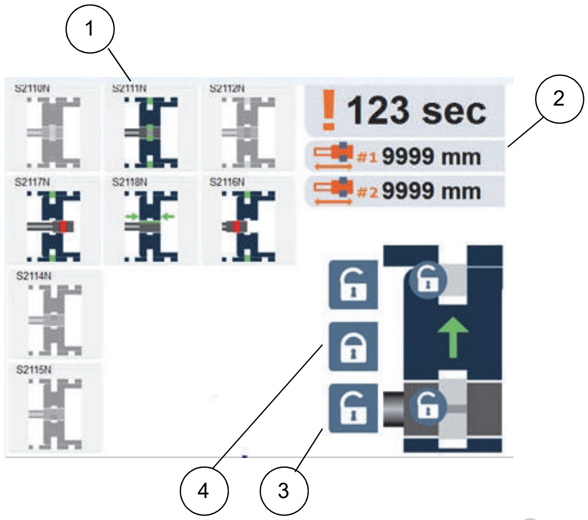
FIGURE 2-28

3. Navigate to the Lower display menu screen and select the Emergency Mode icon (1, Figure 2-28).

    The Emergency Mode Setup screen appears.

4. Use the jog dial or keypad to highlight and change the word GELP to HELP, then select the check box. Press OK on the keypad or press down on the jog dial.

The Boom Recovery screen appears.



Boom Recovery Screen	
1	Cylinder 1 (S2111N)
2	Cylinder 1 Length Indicator
3	Cylinder Unlock Button
4	Lock Button

FIGURE 2-29

5. Make sure cylinder 1 (1, Figure 2-29) is at 0 mm (2).

   a. If cylinder 1 is not at 0 mm, unlock the cylinder using the cylinder unlock button (3) and the jog dial selector.

   b. Use the joystick and retract cylinder 1 (1) until the length reads 0 mm (2).

   c. Make sure that cylinder 1 (S2111N) (1) is green.

   d. If it is not green, use the lock button (4) and the jog dial to lock the boom and verify that cylinder 1 (S2111N) (1) is green.

Tele Extend

1. Gradually extend the cylinder until the cylinder is fully extended and hold.

2. Slowly accelerate the engine to full RPM. The reading at Port 4 should be 2900 ±100 PSI (200 ±7 bar). If it is not, adjust the Tele extend relief (2, Figure 2-26) "in" to increase or "out" to decrease until the reading is achieved.

Tele Retract

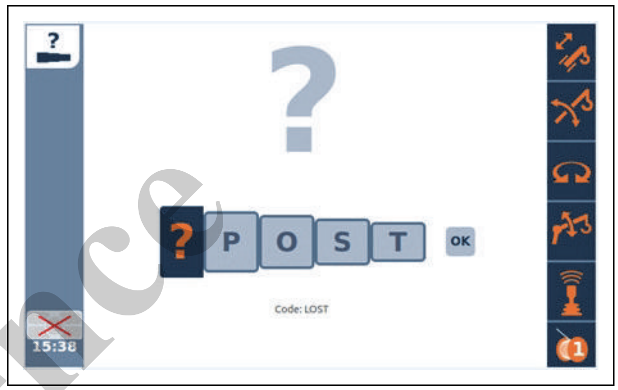
1. Gradually extend the cylinder until the cylinder is fully extended and hold. Slowly accelerate the engine to full RPM. The reading at port 4 should be the value cited in Table 2-3. If it is not, adjust the Tele retract relief (2, Figure 2-26) "in" to increase or "out" to decrease until the reading is achieved

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

3. Return the boom pinning to its normal state.

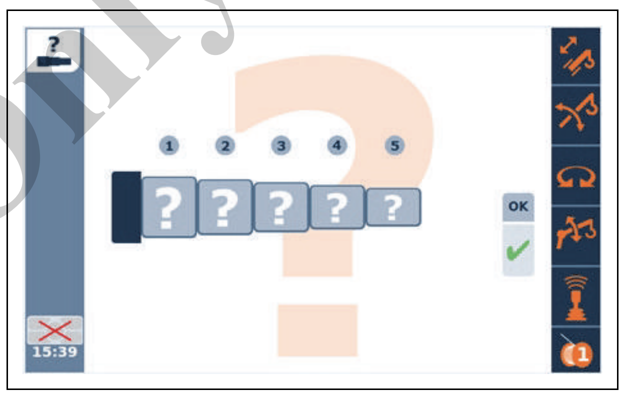
4. Navigate to the Lower display menu screen and select the Boom lost icon. (2, Figure 2-28).

   The Boom Lost setup screen appears.



5. Use the jog dial or keypad to navigate to and change the word "POST" to "LOST", then select the "OK" box and press down on the jog dial or OK button on the keypad.

   The Boom Lost screen appears.



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

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

7. Select the "OK" button.

8. Stop engine. Remove diagnostic couplers.

Checking / Setting the Swing Brake Release Pressure

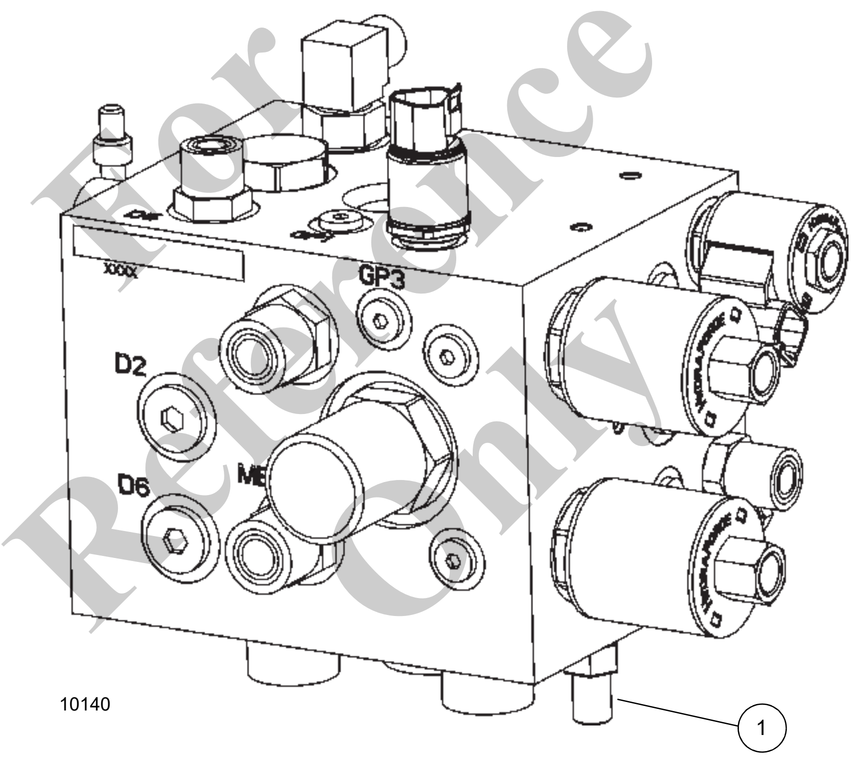
1. With the engine off, install a pressure check diagnostic quick disconnect (such as Parker PD240) with gauge

onto test nipple at GP3 port (10, Figure 2-27) of the Accessory manifold.

2. Start engine and idle, adjust the swing brake release pressure reducing valve (2, Figure 2-27) “in” to increase or “out” to decrease so that the gauge pressure reads the value cited in Table 2-3.
3. Stop engine. Remove the diagnostic coupler.

Checking the Swing Work Pressure

1. With the engine off, install a pressure check diagnostic coupler (such as Parker PD240) with gauge onto the diagnostic nipple at GP5 port (1, Figure 2-30) of the superstructure swing directional valve.
2. Start the engine and throttle to full RPM. Engage the swing house lock. Gradually engage the swing right function until full controller stroke is reached and hold. The pressure gauge should read the value cited in Table 2-3. If the reading does not match the values in Table 2-3, adjust the maximum software current output (*Imax)* value in the joystick EEPROMs can be adjusted. Raise the *Imax* to raise the pressure or reducing the Imax to decrease pressure to adjust the *Imax* value in the joystick EEPROM. If adjusting the *Imax* does not work, contact Manitowoc Crane Care.
3. Repeat step 2 for swing left function.
4. Stop engine. Remove the diagnostic coupler.



Swing Valve	
1	GP5 Port

FIGURE 2-30

Checking/Setting the Front Steer Pressure

1. With the engine off, install pressure check diagnostic quick disconnect (such as Parker PD240) with gauge onto test nipple at GP6 port (5, Figure 2-27) of the accessory manifold.
2. Start engine and throttle up to full RPM. Fully turn the steering wheel left or right against the axle stop and hold. Adjust the steering load sense relief valve (Figure 2-27) “in” to increase or “out” to decrease so that the gauge pressure reads the value cited in Table 2-3.
3. Stop the engine. Remove diagnostic couplers.

Check the Service Brake Accumulator Charging Valve Pressure

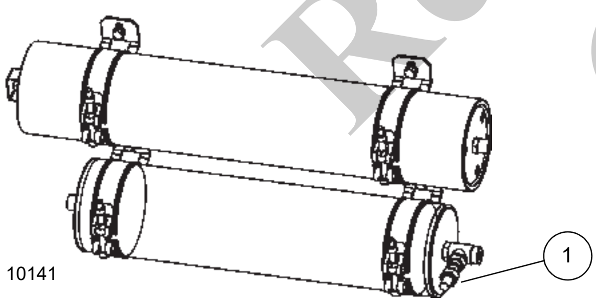
Use the following procedure to check the service break accumulator charging valve pressure.

NOTE: This accumulator charge valve is non-adjustable.

1. With engine off, depress the service break pedal 12 to 15 times to discharge all the pressurized fluid stored in the accumulators.
2. Install pressure check diagnostic quick disconnect (such as Parker PD240) with gauge onto test nipple at the brake accumulators (1, Figure 2-31).
3. Start the engine and idle. The charging valve will immediately start to charge the accumulators. Watch the pressure gauge, the high charge limit should read the value cited in Table 2-3 (when the pressure will stop rising).

NOTE: This accumulator charge valve is non-adjustable. If the pressure is less than specified value and the valve does not stop charging, turn the accessory manifold pressure reducing valve in a half turn at a time (4, Figure 2-27) and repeat step 3. It may require adjusting the accessory manifold pressure reducing valve by a half turn several times before the pressure is set high enough to allow the brake valve to fully charge.

4. With the engine still at idle, repeatedly depress the service brake pedal on the cab floor until the gauge pressure reads approximately 2600 PSI (179 bar). After the pressure is reached, push the brake pedal again to start the recharge cycle (this could take two pedal applications). Watch the gauge and verify the low charging limit is the value cited in Table 2-3 (when it starts to recharge).
5. Stop the engine. Remove the pressure gauge.



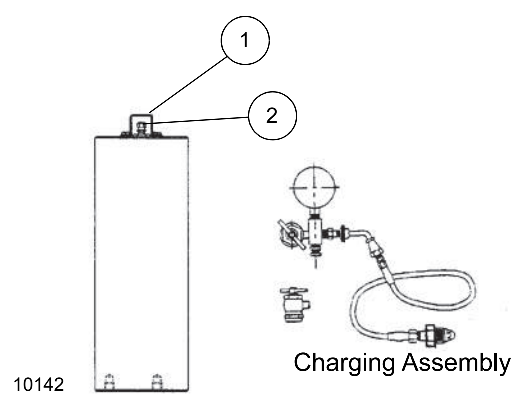
Brake Pressure Port Location	
1	Brake Pressure Port

FIGURE 2-31

Service Brake Accumulators Pre-charge

Use the following procedure to pre-charge the service brake accumulators.

1. With the engine off, depress the service brake pedal four to six times to discharge all of the pressurized oil stored in the accumulators. Remove the gas valve guard and cap on the accumulator (Figure 2-31).
2. Before attaching the gas charging assembly (Figure 2-31) onto the gas valve, back the gas chuck “T” handle counterclockwise.
3. Close the charging assembly bleed valve. Attach the swivel nut onto the gas valve and tighten (10-15 lbs/ inch).
4. Turn the gas chuck “T” handle clockwise, which will depress the core in the gas valve.
5. Check the pre-charge pressure. The readings of the following gauges should read the value of cited in Table 2-3:
   - **a.** Service brake accumulator pre-charge, rear
   - **b.** Service brake accumulator pre-charge, front
   - **c.** Suspension accumulator pre-charge
6. If the pressure meets the above pressures, remove the charging valve assembly by turning the “T” handle all the way out on the gas chuck, and then open the bleed valve and proceed to step 7 (Figure 2-32). If the pressure is low see pre-charging procedure below.
7. Secure the gas valve, loosen the swivel nut and remove the charging assembly (Figure 2-32). Replace the gas valve cap (2) and guard (1).



Accumulator Charging	
1	Gas Valve Guard
2	Gas Valve

FIGURE 2-32

Checking the Service Brake Accumulator Pre-charge

Use the following procedure to check the service brake accumulator pre-charge.

1. With the engine off, depress the service brake pedal on the cab floor 10 to12 times to discharge all of the pressurized oil stored in the accumulators. Remove the gas valve guard and cap on the accumulator (Figure 2-32).
2. Ensure that the nitrogen supply bottle is shut off, then attach the charging valve assembly to it.
3. Before attaching the charging assembly to the accumulator gas valve, fully back out the gas chuck "T" handle (counterclockwise).
4. Close the charging assembly bleed valve. Without looping or twisting the hose, attach the swivel nut to the accumulator gas valve and tighten (10 – 15 lbs/inch).
5. Turn the gas chuck "T" handle all the way down (clockwise), which will depress the core in the gas valve.
6. Slowly open the nitrogen bottle valve and fill the accumulator. Close the valve when the readings of the following gauges read the value of cited in Table 2-3:
   - **a.** Service brake accumulator pre-charge, rear
   - **b.** Service brake accumulator pre-charge, front
   - **c.** Suspension accumulator pre-charge
7. If the pre-charge is higher than specified in Table 2-3, close the nitrogen bottle and slowly open the bleed valve on the charging assembly (Figure 2-32) until the pressure is to specification.
8. Remove the charging valve assembly (turn counterclockwise), and then open the bleed valve.
9. Secure the gas valve, loosen the swivel nut and remove the charging assembly. Replace the gas valve cap and guard.

Checking/Setting Cab Tilt Raise and Lower Pressures

Use the following procedure to check and set the raise and lower pressures for the cab tilt cylinder.

NOTE: This procedure assumes use of Manitowoc Crane Service Tool.

1. With the engine off, install pressure check diagnostic quick disconnect (such as Parker PD240) with gauge onto test the nipple at port 4 of the Accessory manifold (6, Figure 2-27).

Cab Tilt Lower

2. 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 port 4 should read the value cited in Table 2-3. If it is not in the value range, use the service tool to adjust.
   - **a.** Remove the upper electrical panel to access the diagnostic connector.
   - **b.** Connect the Manitowoc Crane Tool to the diagnostic connector.
   - **c.** In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Super > Cab Tilt > Tilt Down Pressure. In the *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.
   - **d.** After the pressure is achieved make sure to "Save active to customer" and "Save active to factory".

Cab Tilt Raise

1. 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 port 4 should read the value cited in Table 2-3. If it is not within the range, use the service tool as follows to adjust:
   - **a.** Remove the upper electrical panel to access the diagnostic connector.
   - **b.** Connect the Manitowoc Crane Tool to the diagnostic connector.
   - **c.** In the In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Super > Cab Tilt > Tilt Up Pressure. In the *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.
   - **d.** After the pressure is achieved, make sure to "Save active to customer" and "Save active to factory."
2. Stop the engine. Remove diagnostic couplers.

Checking/Setting Counterweight and Hydraulic Boom Extension Pressures

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

onto test the nipple at port 4 of the Accessory manifold (Figure 2-27).

2. Make sure that the counterweight is not attached to the cylinders and the superstructure is in a position that the cylinders can be fully actuated in both directions.

Counterweight Lower

1. Start engine and idle. Activate the counterweight lower function (see *Operator Manual*) until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at port 4 should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust.
   a. Remove the upper electrical panel to access the diagnostic connector.
   b. Connect the Manitowoc Crane Tool to the diagnostic connector.
   c. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Super > Counterweight > Lower Pressure. In the *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, contact your Grove Crane distributor or Manitowoc Crane Care.
   d. After the pressure is achieved, make sure to “Save active to customer” and “Save active to factory.”

Counterweight Raise

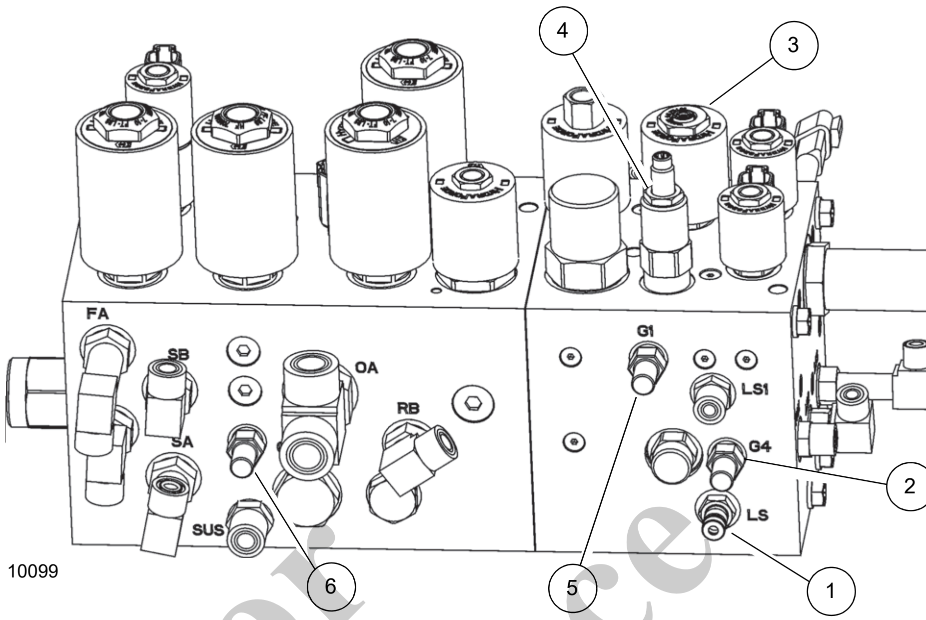
1. Start engine and idle. Activate the counterweight raise function (see *Operator Manual*) until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at port 4 should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust:
   a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Super > Counterweight > Raise Pressure. In the *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. After the pressure is achieved make sure to “Save active to customer” and “Save active to factory.”
2. Stop the engine.

Counterweight Pin

1. Start engine and idle. Active the counterweight pin function until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at port 4 should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust:
2. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Super > Counterweight > Pin Pressure. In the *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 to be adjusted by more than 100 mA, contact your Grove Crane distributor or Manitowoc Crane Care.
3. After the pressure is achieved make sure to “Save active to customer” and “Save active to factory.”
4. Stop the engine.

Hydraulic Boom Extension

1. Start the engine and idle. Activate the hydraulic boom extension function until end stroke of the cylinder is achieved in either direction and hold. If the boom extension cylinder is not installed, plug the hoses instead. Slowly accelerate the engine to full RPM. The reading at port 4 should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust:
   a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Super > Counterweight > Jib Pressure. In the 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. After the pressure is achieved make sure to “Save active to customer” and “Save active to factory.”
2. Stop the engine.
3. Remove the diagnostic cable.
4. Install the upper electrical cover. For more information, see *Installing the Upper Electrical Cover*, page 2-54.



Main Carrier Manifold	
1	LS Port
2	G4 Port
3	Transmission Fan Coil
4	Pressure Reducing Valve
5	G1 Port
6	G3 Port

FIGURE 2-33

Checking/Setting Outrigger Pressure, Rear Steer, and Suspension Raise

Use the following procedures to check and set outrigger pressure, rear steer, and suspension raise settings.

1. With the engine off, install a pressure check diagnostic coupler (such as Parker PD240) with gauge onto the diagnostic nipple at the LS port (1, Figure 2-33) on the main carrier manifold.

Outrigger Beam Extend

1. Start engine and idle. Make sure 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 LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust:

   a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Outrigger Beams Extend Target. In the *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 the column to “active settings”. Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA, contact your Grove Crane distributor or Manitowoc Crane Care.

   b. After the pressure is achieved, make sure to “Save active to customer” and “Save active to factory.”

Outrigger Beam Retract

1. 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 LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust:

   a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Outrigger Beams

Retract Target. In the *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 the column to "active settings." Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA, contact your Grove Crane distributor or Manitowoc Crane Care.

b. After the pressure is achieved, make sure to "Save active to customer" and "Save active to factory."

Outrigger Jack Extend Pressure

1. 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 LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust.

a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Outrigger Jacks Extend Target. In the *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, contact your Grove Crane distributor or Manitowoc Crane Care.

b. After the pressure is achieved, make sure to "Save active to customer" and "Save active to factory."

Outrigger Jack Retract Pressure

1. 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 LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust.

a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Outrigger Jacks Extend Target In the *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."

b. Repeat this step until the pressure is achieved. If the value needs adjusted by more than 100 mA, contact your Grove Crane distributor or Manitowoc Crane Care.

c. After the pressure is achieved, make sure to "Save active to customer" and "Save active to factory."

Rear Steer Pressure

1. Start engine and idle. Slowly accelerate the engine to full RPM, operate rear steer switch until reaching an axle stop, and hold. The reading at LS should port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust.

a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Rear Steer Target. In the *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, contact your Grove Crane distributor or Manitowoc Crane Care.

b. After the pressure is achieved, make sure to "Save active to customer" and "Save active to factory." Stop the engine.

Outrigger pinning pressure

1. Start engine and idle. Slowly accelerate the engine to full RPM, operate pinning extend until end of stroke, and hold. The reading at LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust.

a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Outrigger Pinning Extend Target. In the *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, contact your Grove Crane distributor or Manitowoc Crane Care.

2. Repeat procedure for outrigger pinning retract. The reading at the LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust.

a. In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Outrigger Pinning Retract Target. In the *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.” Stop the engine.

Suspension Raise Pressure

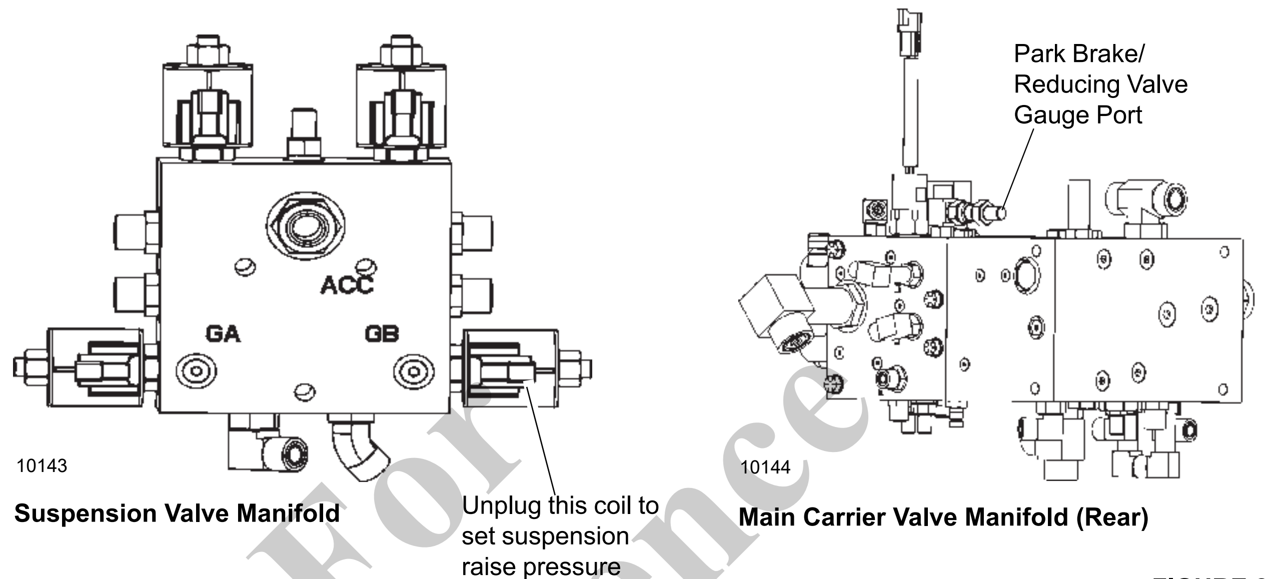


FIGURE 2-34

1. On suspension valve manifold (Figure 2-34), unplug the coil on valve inlet port P. Start the engine and idle. Operate the suspension fill function and hold. The reading at LS port (1, Figure 2-33) should read the value cited in Table 2-3. If it is not, use the service tool as follows to adjust:
   - **a.** In the Manitowoc Crane Tool, open Tools > EEprom > View Parameters > Cabin > Solenoid PWM Control (carrier) > Pressure Sol – Suspension Raise Target. In the *params* row, increase the valve to increase the pressure or decrease the valve 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.** After the pressure is achieved make sure to “Save active to customer” and “Save active to factory.”
2. Stop the engine. Plug the inlet coil in on the suspension valve manifold.

Checking/Setting Park Brake Pressure and Transmission Fan Max Pressure

1. With the engine off, install a pressure check diagnostic coupler (such as a Parker PD240) with gauge onto the diagnostic nipple at the PS port of the main carrier valve (Figure 2-34).
2. Unplug transmission fan coil from harness (Figure 2-34).
3. Start engine and idle. Release (pressurize) the parking brake. Read gauge and adjust the pressure reducing valve (Figure 2-34) “in” to increase or “out” to decrease to the value cited in Table 2-3.
4. With coil unplugged, and parking brake released, check fan speed with photo tachometer. Fan speed should the value cited in Table 2-3. Be sure to have the oil temperature between 49 to 60°C (120 to 140°F) when reading and adjusting.
5. Stop the engine. Remove the diagnostic couplers. Plug fan coil back in to harness.

Adjusting Controller Functions

All controller defaults are set at the factory. If there is an issue with the crane controller functions, try the following:

- Set all function pressure correctly per the above procedures
- Adjust the function speed through the CCS control screens
- Adjust the function control through the CCS control screen selectable curves

If an issue persists after performing the above procedures, contact your local Grove distributor or Manitowoc Crane Care.

CYLINDERS

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 hydraulic 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.

CAUTION

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

Leak 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 rod to its maximum stroke. Remove retract hose from cylinder. Cap retract hose.

DANGER

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

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

DANGER

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

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

   If leaks are observed, cylinder seals must be replaced.
5. Reconnect all cylinder ports.

Temperature Effects On Hydraulic Cylinders

Hydraulic oil expands when heated and contracts when cooled. This is a natural phenomena that happens to all liquids. The coefficient of expansion for API Group 1 hydraulic oil is approximately 0.00043 cubic inches per cubic inch of volume for 1°F of temperature change. **Thermal contraction will allow a cylinder to retract as the hydraulic fluid which is trapped in the cylinder cools.**

The change in length of a cylinder is proportional to the extended length of the cylinder and to change in temperature of the oil in the cylinder.

For example, a cylinder extended 25 feet in which the oil cools 60°F would retract approximately 7 3/4 inches (see chart below).

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

Thermal contraction coupled with improper or inadequate lubrication or improper wear pad adjustments, and operation at low boom angles may, under certain conditions, cause a “stick-slip” condition in the boom.

This “stick-slip” condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement, of the boom may be undetected by the operator unless a load is suspended for a long period of time.

To minimize the effects of thermal contraction or “Stick-slip” it is recommended that the telescope joystick is activated periodically in the extend position to mitigate the effects of cooling oil. If a load and the boom is allowed to remain stationary for a period of time and the ambient temperature is cooler than the trapped oil temperature, 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 2-4 Boom Drift Chart (Cylinder length change in inches)

Coeff. = 0.00043 ($in^3/in^3/ °F$)

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

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

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

Coeff. = 0.000774 (1/ °C)

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

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

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SECTION 3
ELECTRICAL SYSTEM

SECTION CONTENTS

DESCRIPTION

General

The electrical system is 24-volt operation with 24-volt starting, consisting of an alternator and two lead-acid batteries wired in series. Electrical power is transferred to and from the carrier and superstructure through the electrical swivel. The CAN bus system consists of many control modules which are located on the carrier, superstructure, boom, and operator's cab. For more detailed information on the electrical swivel, refer to *Swing System*, page 6-1.

Alternator

A belt-driven (2, Figure 3-1) 24 volt, 110 ampere alternator with an integral transformer - rectifier unit (1) is mounted on the engine. It provides power to the crane electrical circuits and voltage to recharge batteries and maintain them at a full state of charge.

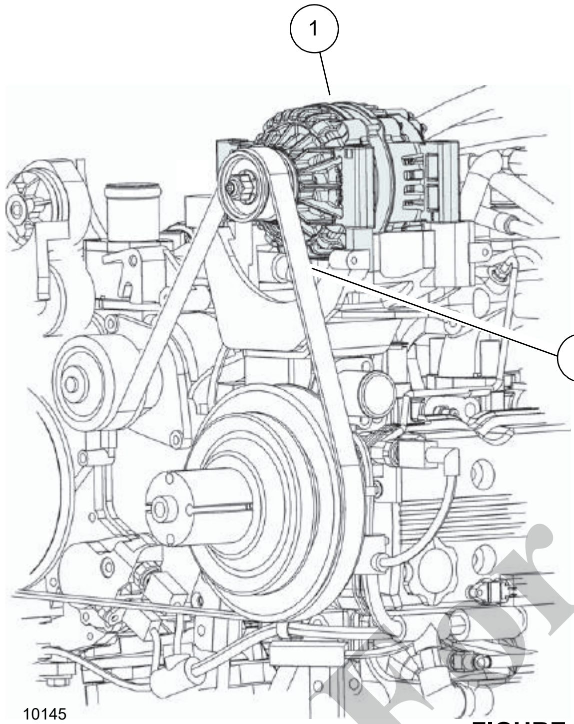


FIGURE 3-1

Batteries and Battery Disconnect Switch

Batteries are located in a compartment on the left side of the crane. Batteries are the maintenance free type and completely sealed except for a small vent hole in the side. The vent hole allows a small amount of gases produced in the battery to escape.

A Battery Disconnect Switch (1, Figure 3-2) is located above the battery compartment. To disconnect batteries, turn Battery Disconnect Switch OFF. Turn switch ON to connect the batteries.

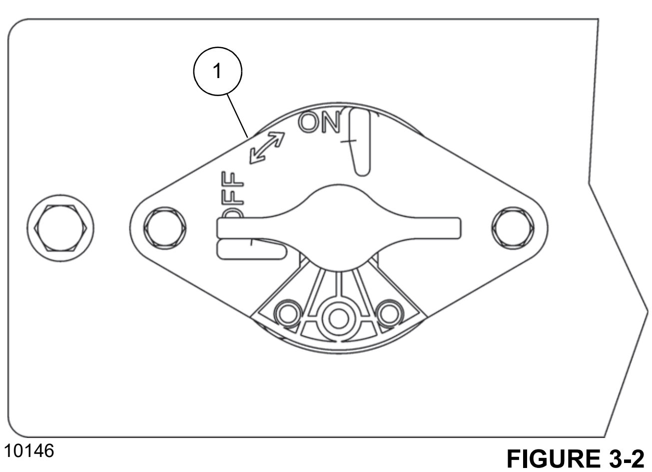


FIGURE 3-2

Jump Starting Hazard

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.

This crane has multiple computer systems (crane control, RCL, engine and 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. Refer to *Charging the Batteries*, page 3-2.

Charging the Batteries

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.

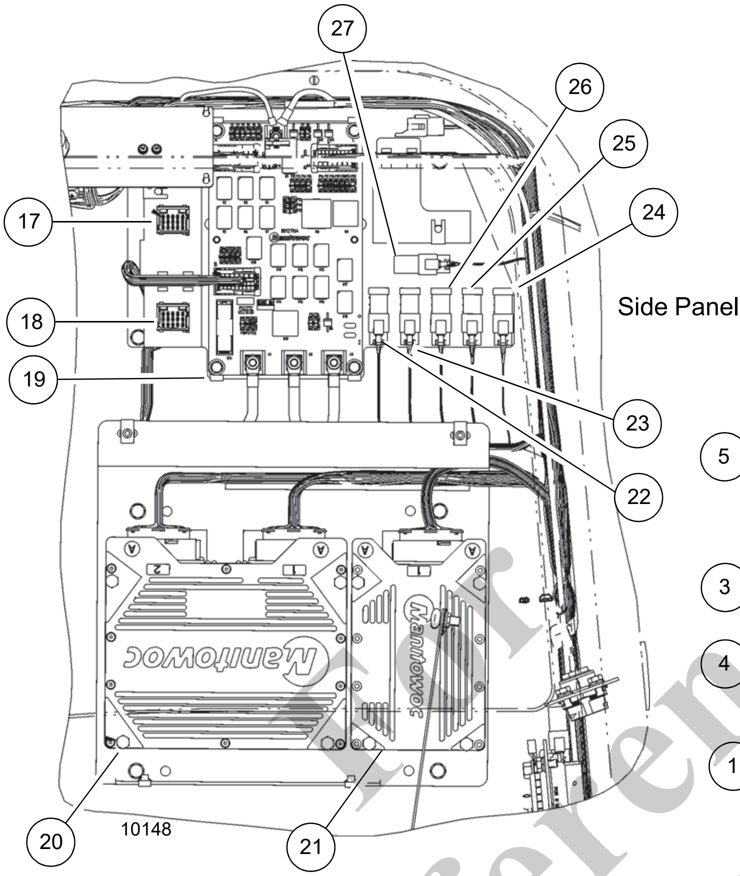
"Slow charging" is preferred to "fast charging". Fast charging saves time but risks overheating the battery(s). Slow charging at six (6) amps or less develops less heat inside the battery and breaks up the sulfate on the battery plates more efficiently to bring the battery up to full charge. The use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

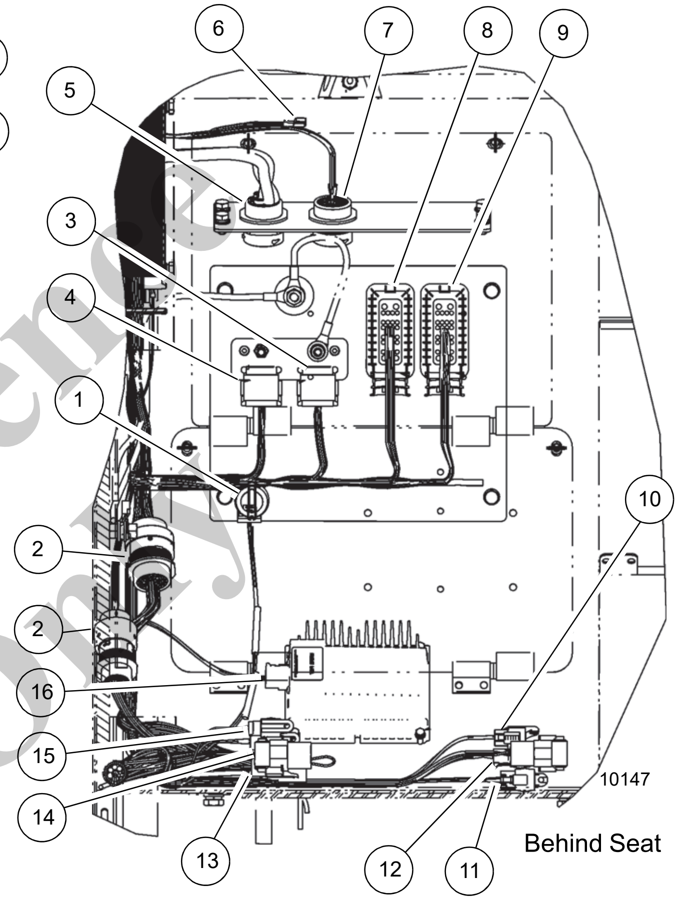
Cab Electrical Panels

NOTE: Refer to the electrical schematic in the back of this manual for a diagram of the electrical system.

The cab electrical panels (Figure 3-3 and Figure 3-4) are located inside the crane cab, behind the operator's seat and the right side panel. They feature cab and superstructure relay and fuse boxes, wiring harness connector bulkhead, and RCL module.

NOTE: Cab control modules and RCL module are not serviceable. Contact Crane Care Customer Service with module service or repair questions.



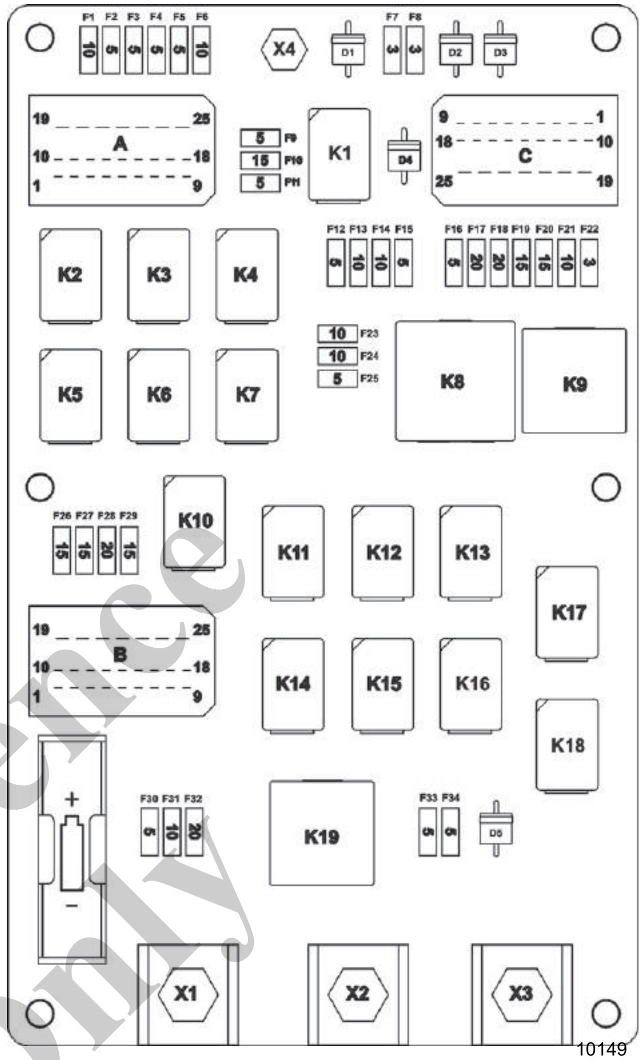


Cab Electrical Panel	
1	RCL Override Switch
2	Cab Rear
3	Ground SPL-B
4	Ground SPL-A
5	Cab-to-Swivel Connector
6	Circulation Fan Connector
7	Swivel Connector
8	Superstructure A
9	Superstructure B
10	Cold Weather Module
11	Crane Star Module
12	Camera Option
13	Options
14	Wireless Remote
15	Remote Charger
16	Converter
17	D1 Connector
18	D2 Connector

19	Cab Fuse Panel
20	Electronic Control Unit (MWIOL)
21	Electronic Control Unit (MWSCM)
22	CAN-A
23	CAN-B
24	CAN-C
25	CAN-D
26	CAN-E
27	Diagnostic Connector

FIGURE 3-3

Fuse	Amp	Description
F1	10	Cab Work Lights
F2	5	E-Stop Switch Signal
F3	5	Boom Motorized Work Lights
F4	5	Accessory Lights
F5	5	Map Light and USB Power
F6	10	Radio Ignition Power
F7	3	System Wake-up
F8	3	Key Switch Signal
F9	5	Circulation Fan
F10	15	Heater / AC Switch Power
F11	5	Dome Light
F12	5	Windshield Washer Relay Fuse Power
F13	10	Heated Seat Power
F14	10	UE+ T/T CCM10/IOL45/IOS20 Module Battery Power
F15	5	Radio/Cranestar Battery Power
F16	5	UE+ Cab SCM0/IOL32 Module Battery Power
F17	20	Oil Cooler Power Fan 1
F18	20	Oil Cooler Power Fan 2
F19	15	UB+ T/T IOL45 Power
F20	15	UB+ T/T IOL45 Power
F21	10	UB+ IOL32
F22	3	B+ To Key Switch
F23	10	Sky Light Wiper
F24	10	Windshield Wiper Power
F25	5	Sky Light Washer Relay Fuse Power
F26	15	UB+ T/T CCM10
F27	15	UB+ T/T CCM10
F28	20	24V Supply 12V-DC Converter
F29	15	UB+ IOS20 / UE/UB+ IOS21
F30	5	Diagnostic Conn Power
F31	10	UB+ IOL32
F32	20	Actuator 1, 2, & 3 Relay Fuse Power
F33	5	Display / Jog Dial Relay Fuse Power
F34	5	Fused B+
K1		Windshield Washer Relay
K2		Sky Light Wiper Relay
K3		Sky Light Wiper Low
K4		Windshield Wiper High
K5		Windshield Wiper Relay
K6		Sky Light Wiper High
K7		Windshield Wiper Low
K8		Accessory Relay
K9		Oil Cooler Relay

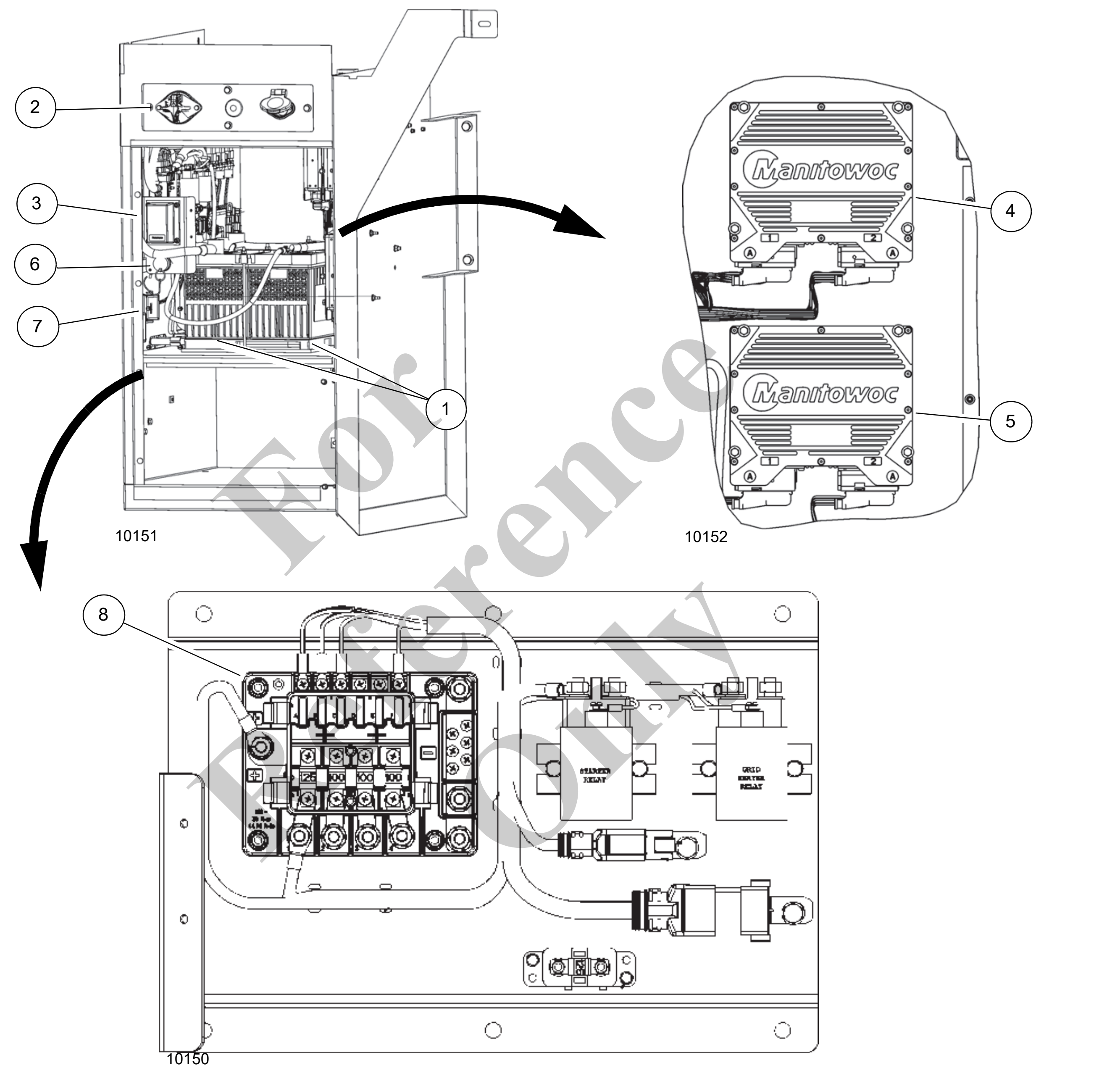


Fuse	Amp	Description
K10		Sky Light Washer Relay
K11		Actuator 2 (IN) Relay
K12		Actuator 1 (Out) Relay
K13		Actuator 3 (In) Relay
K14		Actuator 2 (Out) Relay
K15		Actuator 1 (In) Relay
K16		Actuator 3 (Out) Relay
K17		Display / Jog dial Relay
K18		Horn Relay
K19		Actuator Enable Relay
X1		Battery Disconnect Switch Power Wire 1274
X2		Battery Disconnect SW Power Wire 6
X3		Battery Disconnect SW Power Wire 5
X4		Ground

FIGURE 3-4

Carrier Electrical Panel

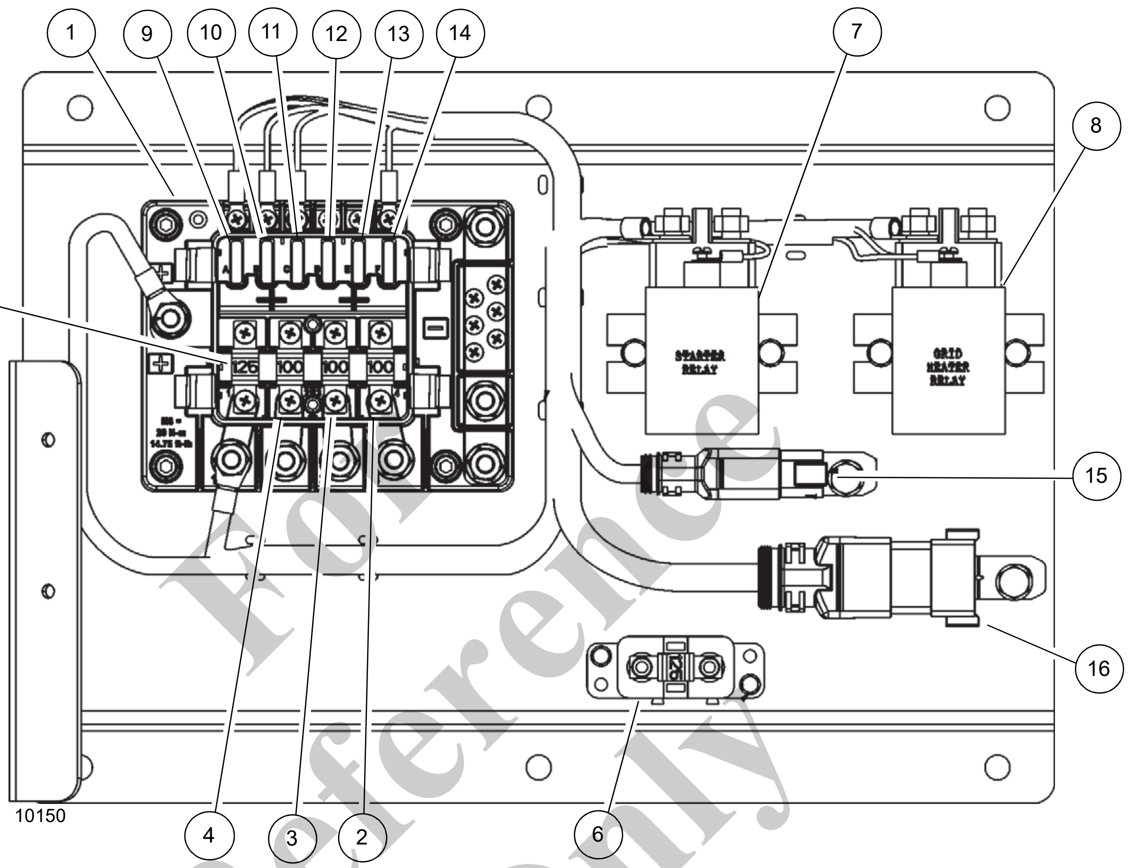
The carrier electrical panel (Figure 3-5) is located on the fuel tank side of the crane, inside the electrical compartment. It consists of the two batteries, battery disconnect switch, fuse and relay boxes, starter and grid heater relays, and electronic control units.



Carrier Electrical Panel

1	Batteries - 12V	5	Electronic Control Unit - MWCCM
2	Battery Disconnect Switch	6	J1939 Diagnostic Connector
3	Fuse and Relay Box 2 (see Figure 3-8)	7	Fuse and Relay Box 1 (see Figure 3-7)
4	Electronic Control Unit - CCM and IOL	8	Fuse Panel (see Figure 3-6)

FIGURE 3-5

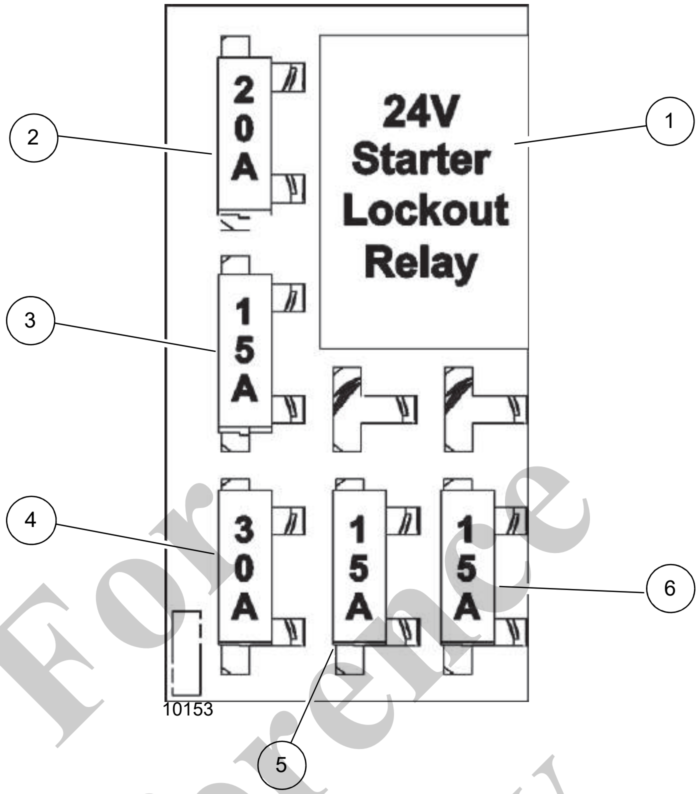


Carrier Electrical Panel	
1	Carrier Electrical Panel
2	F4 - 100 Amp Power
3	F3 - 100 Amp Power
4	F2 - 100 Amp Power
5	F1 - 125 Amp Intake Air Heater Relay Power
6	F51 - 125 Amp Alternator Power
7	Grid Heater Relay
8	Starter Relay

9	FA - 15 Amp Module Battery Power
10	FB - 15 Amp UB+ Carrier CCM11/IOL31 Module Battery Power
11	FC - 5 Amp Starter Lockout Fused Relay Power
12	FD - 15 Amp Cold Weather Power
13	FE - 15 Amp Cold Weather Power
14	FF - 5 Amp Diagnostic Tool Power
15	Connector - Relay Panel
16	Connector - Relay Panel 2

FIGURE 3-6

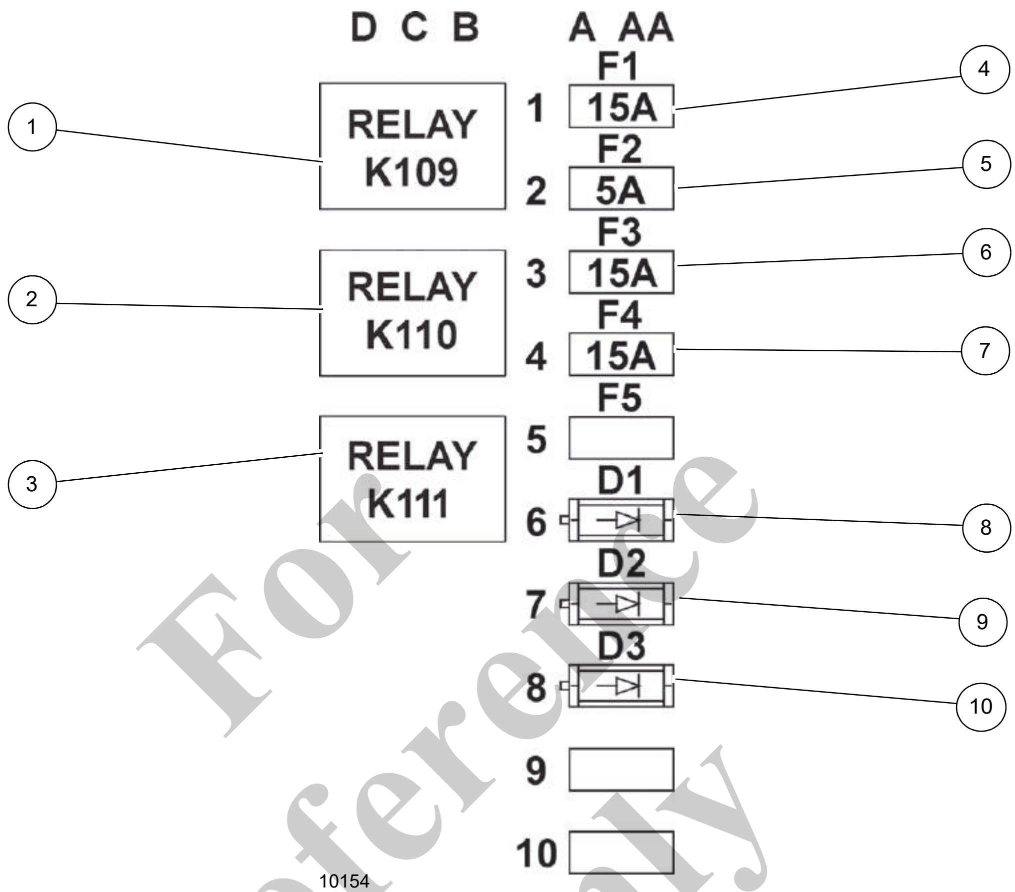
Published 09-01-2021 Control # 699-01



Carrier Fuse and Relay Box 1	
1	K108 - 24V Starter Lockout Relay
2	20 Amp - Fused Battery Power
3	15 Amp - UE+ Carrier CCM3/IOL31 Module Battery Power

4	30 Amp - Engine ECM Power
5	15 Amp - UB+ Carrier CCM12 Module Battery Power
6	15 Amp - UB+ Carrier CCM12 Module Battery Power

FIGURE 3-7



Carrier Fuse and Relay Box 2	
1	K109 - DEF Lines Heater Relay
2	K110 - DEF Supply Module
3	K111 - After-treatment Sensors Power Relay
4	F1 - 15 Amp - DEF Lines Heater Fused Relay Power
5	F2 - 5 Amp - DEF Lines Heater Fused Relay Coil Power
6	F3 - 15 Amp - DEF Supply Module Fused Relay Power
7	F4 - 15 Amp - After-treatment Sensors Fused Relay Power
8	D1 - Pressure Line Heater
9	D2 - Return Line Heater
10	D3 - Suction Line Heater

FIGURE 3-8

MAINTENANCE

General

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

DANGER

Serious burns may result from accidental grounding or shorting circuits

Ensure battery is disconnected before performing any maintenance on an electrical circuit.

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

CAUTION

Never replace original wiring with wiring of a smaller size (gauge). Fire or other damage to machine may result.

Dielectric Grease

Dielectric grease was applied to the following connections at the factory when the crane was assembled. When servicing electrical connections, dielectric grease must be re-applied to these connections.

- All Deutsch Connectors
- All Valve Solenoid connections on Hydraulic valves and Transmissions
- All Harness Connections
- RCL Module Connections (except M12 and M8 connectors)

Excluded Connections

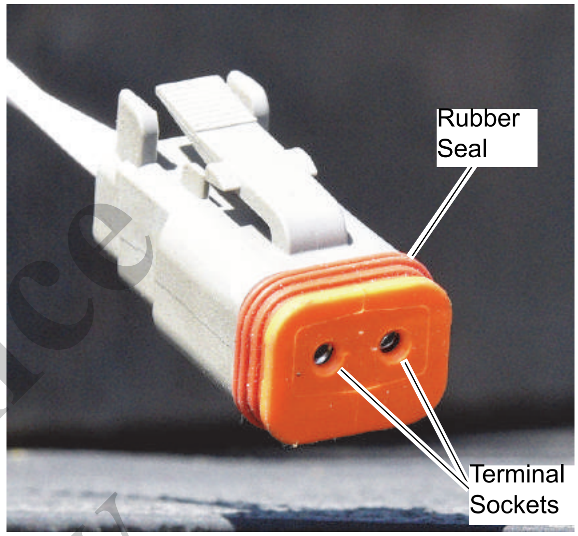
Do not apply dielectric grease to the following connections:

- All Connections Inside the Cab
- M12 and M8 Connectors
- Pin-type Contacts

Applying Dielectric Grease to an Electrical Connector

Use the following procedure to apply dielectric grease to an electrical connection. Grease should be applied immediately prior to securing the connector. Ensure that grease is applied to all terminal sockets (Figure 3-9).

1. Check the connection for moisture before application of the grease. If moisture is found, clean or replace the connector as necessary.
2. Screw a tip or trigger assembly on to the can of dielectric grease if necessary.
3. Apply the grease onto socket (female) contacts.



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Example. For illustration purposes only. Your connector may differ. **FIGURE 3-9**

4. Use a clean towel to remove excess grease from the surface of the connector, and wipe grease into the terminal sockets (Figure 3-9).
5. Ensure grease is applied to each terminal socket. The towel with excess grease can be used to fill empty terminal sockets (Figure 3-9).
6. Ensure grease is applied to the entire surface of the connector's rubber seal (Figure 3-9).

NOTE: Do not allow grease to come in contact with any painted surface, or any other components.

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

Visual Inspection and Replacement of Electrical Harnesses and Cables

CAUTION

Ensure battery cables are disconnected from batteries before loosening any electrical connections.

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

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

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

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

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

If any of these conditions exist, address them appropriately.

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

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

Table 3-1

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

General Troubleshooting

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

1. Use reported symptoms to identify a problem or a suspect component.
2. Test suspect component per instructions in this section. Instructions identify 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 circuit for continuity if you suspect a broken circuit, or for voltage if you suspect a power problem. Check electrical schematic and wiring diagram for most accurate wiring information.

4. If component proves faulty, replace it with a known working component. If wiring proves faulty, replace it with wiring of equal gauge.
5. After troubleshooting, test the repaired circuit. Verify circuit works properly.

Tools for Troubleshooting

The GRT9165 uses a CAN bus Multiplex system. To effectively troubleshoot the electrical system, use the diagnostics functions on the RDM. Descriptions for the diagnostics codes can be found on the Manitowoc Diagnostic Code smart phone application. You can also use a Windows-based PC, CAN-link service software, and a connection cable. The information about the diagnostics functions, the CAN-link service software, and connection cable are available through Crane Care to service technicians who have attended the Grove New Technology training course.

Swivel Electrical Troubleshooting

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

Connector Troubleshooting

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

Refer to the following tables listing required tools for connector maintenance.

Pins and sockets are crimped to the wires and cannot be removed. Remove pins or sockets from plugs or receptacles using an extraction tool. Cut wire as close to pin or socket as possible. After cutting off pin or socket, the wire may be too short.

Using a wire that is too short will apply tension to the pin, socket, or wire where they are crimped when pin or socket is inserted in a plug or receptacle. Add a short length of the same size wire to the short wire by crimp splice or solder. Use heat shrinkable tubing or other suitable material to insulate the splice.

Table 3-2. AMP Extraction Tool Table

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

Table 3-3. AMP Crimping Tool Table

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

Table 3-4. Deutsch Extraction Tool Table

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

Table 3-5. Deutsch Crimping Tool Table

Description	Deutsch Part Number	Manitowoc Part Number
12, 14, 16, 18, 20 gauge wire	HDT-48-00	9999100808
4, 6, 8, 10 gauge wire	HDT04-08	9999100842

Alternator/Charging System Troubleshooting

Test batteries, alternator, and cables any time there is a problem with the charging system.

Required Tools

The following tools are required to diagnose the charging system:

Equipment	Example	Manitowoc Part No.
Digital Multimeter	Fluke® 177	9999101763
Carbon Pile Load Tester	Autometer® SB5	9999101765
Current Clamp Meter	Fluke® 336	9999101764

Visual Check

- Belts: tight, in good condition, not frayed, cracked or glazed.
- Pulley: tight, aligned with other pulleys, not glazed.
- Alternator mounting bolts and wiring connections: clean and tight, no signs of heat damage.
- Batteries: terminals and cables, clean and tight, no corrosion or signs of heat damage.
- Check alternator fuse if Alternator Charge Lamp is illuminated on the steering column display while engine is running.

Engine Off Tests

Batteries

DANGER

Do not smoke or allow sparks or open flame near batteries, they can explode.

When working with batteries always wear protective clothing, gloves and eye protection. Batteries contain corrosive liquids that can burn skin and eyes and destroy clothing.

Remove rings, watches or other jewelry before working with batteries. A battery can produce a short-circuit current high enough to weld a ring or similar to metal causing severe burns

1. Disconnect batteries and test each battery individually.
2. Check electrolyte level if possible.
3. Using a multimeter, measure voltage across terminals. If should read 130 A to 135 A.

NOTE: If correct readings were not obtained in the Engine On Tests, perform the following two tests.

Voltage Drop Test

Positive Side

1. Set multimeter to the 2 volt range.
2. Connect positive (+) lead to alternator output terminal and negative (–) lead to battery positive terminal or post. Do not connect meter to battery cable.
3. Run engine at 2000 rpm.
4. Load system with carbon pile load or lights and heater blower. Allowable drop is 0.2 to 0.5 volts. Higher voltage drop indicates loose, corroded, or broken connections.

Negative Side

1. Set multimeter to 2 volt range.
2. Connect negative (–) lead to alternator case and positive (+) lead to battery negative terminal or post. Do not connect meter to battery cable.
3. Run engine at 2000 RPM.
4. Load system with carbon pile load, or lights and heater blower.

Allowable drop is 0.1 to 0.3 volts. Higher voltage drop indicates loose, corroded, or broken connections. If any voltage drop is greater than the normal range, troubleshoot system and repair any problems.

After correcting any problems, perform Engine On Tests again. If satisfactory results are not obtained, remove alternator and bench test.

Alternator Replacement

Removal

1. Ensure key switch has been in the OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.
3. Remove ECM power fuse.
4. Remove negative battery cables.
5. Open engine compartment.
6. Tag and disconnect electrical leads from alternator terminals.
7. Using a 1/2 in drive bar/ratchet, turn tensioner below the alternator clockwise to remove belt tension. Slip belt off alternator pulley. Let tensioner return to its normal position.
8. Remove alternator mounting capscrews and alternator.

Installation

1. Inspect belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. Install alternator using mounting bolts and washers. Torque bolts. Refer to *Fasteners and Torque Values*, page 1-16 for the proper torque value.
3. Install belt on all engine pulleys except alternator pulley.
4. Turn tensioner clockwise. Slip belt on alternator pulley, then carefully return t tensioner to its normal position. Make sure belt is centered on tensioner.
5. Check belt tension at center of longest distance between pulleys. Push in on belt with your thumb. Belt should deflect no more than 3/8 in - 1/2 in (10 mm - 13 mm). Or, using a belt tension gauge, verify 60 lb - 130 lb (267 N - 578 N) tension. Replace belt if it is too loose (overstretched).
6. Verify tensioner bolt is torqued to 32 lb-ft (43 N-m).
7. Connect electrical leads to terminals as tagged during removal.
8. Close engine compartment.
9. Reconnect ground cables to the battery.
10. Install ECM power fuse.
11. Turn battery disconnect switch to 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 key switch has been in the OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.
3. Remove ECM power fuse.
4. Remove negative battery cables.
5. Open engine compartment.
6. Tag and disconnect electrical leads from starter terminals.
7. Remove bolts holding starter to mounting pad. Remove starter.

Installation

1. Place starter on mounting pad. Secure starter with bolts. Torque to 32 lb-ft (43 N-m).
2. Connect electrical leads to terminals as tagged during removal.
3. Reconnect the ground cables to battery.
4. Install ECM power fuse.
5. Turn the battery disconnect switch to the ON position.

Check

1. Try to start engine. Verify starter engages engine.
2. Start engine again and listen for starter noises. Verify there is no abnormal noise indicating starter gear is meshing properly with flywheel, gear hasn't remained engaged to the flywheel after the ignition switch is in the

ignition (run) position, or some other problem. Install starter properly as needed.

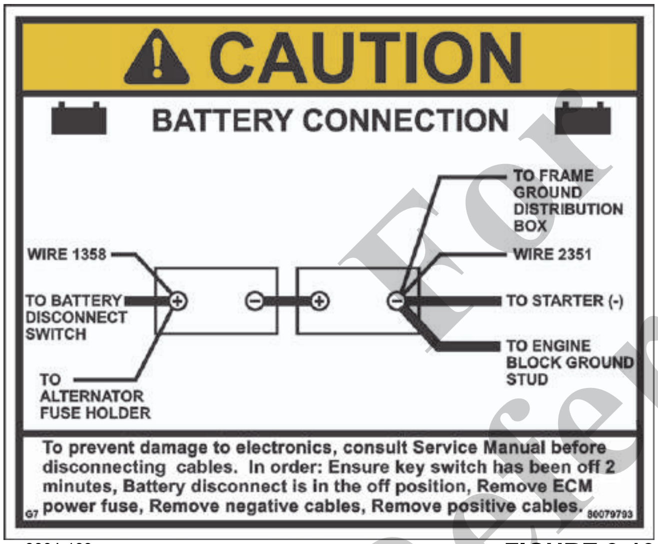
Battery Replacement

Removal

CAUTION

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

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



8804-133

FIGURE 3-10

1. Open battery compartment door.
1. Ensure key switch has been in the OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.
3. Remove ECM power fuse.
4. Remove negative battery cables.
5. Remove positive battery cables.
6. Remove nuts and washers from bracket hold down rods. Remove hold down bracket.
7. Remove batteries.

Installation

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

Steering Column and Dashboard

Rocker Switch

Refer to Figure 3-11.

Removal

1. Ensure key switch has been in OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.

NOTE: Only remove as much as needed to access switch being replaced.

3. Remove four screws (11) from dashboard cover (1).
4. Remove locking lever (15).
5. Remove four screws (14) from left side cover (16).
6. Remove left side cover (16) from steering column.
7. Disconnect wire harness from back of ignition switch (12).
8. Remove right side cover (10) from steering column assembly (9).
9. Disconnect wire harness (not shown) from bottom of switch to be replaced (21 – 24). Remove switch by squeezing retaining clips on each side of switch and pushing upwards until switch is free of cover.

Inspection

1. Visually check switch for evidence of cracks, damaged connections, or other damage. Replace switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Check all connectors for corrosion. Replace corroded components as needed.
4. Use a multimeter to check for continuity between switch terminals with switch ON. Meter should register zero ohms. Place switch OFF. Meter should register infinity (no continuity). Replace switch if it fails either part of the check.

Installation

1. Note orientation of rocker markings to switch. Remove rocker from old switch (21 – 24). Hold switch by its sides in one hand. Squeeze left and right sides of rocker with other hand and pull up.
2. Orient rocker markings correctly to switch. Install rocker in switch.
3. Push switch down through top of dashboard cover (1) until retaining clips click in place.
4. Connect wire harness to bottom of switch.
5. Install right side cover (10) on steering column (9).
6. Connect wire harness to ignition switch (12).
7. Install left side cover (16) on steering column overlapping right side cover.
8. Install four button head screws (14) through side covers.
9. Install dashboard cover (1) on side covers with four button head screws (11).
10. Install lever (15) on column assembly (9).
11. Pull column assembly rubber boot up and over bottom of side covers.

Check

1. Turn battery disconnect switch to ON position.
2. Operate switch and verify each function works.
3. Troubleshoot any system or circuit malfunction not corrected by repair or replacement of switch or associated wiring.

Ignition Switch

Refer to Figure 3-11.

Removal

1. Ensure key switch has been in OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.
3. Pull rubber boot off bottom of side covers (10,16).
4. Remove four screws (11) from dashboard cover (1) and pull up cover.
5. Remove four screws (14) from side covers and column assembly (9). Pull right side cover (10) away from column.
6. Disconnect wire harness (not shown) from back of ignition switch (12).
7. Remove lock nut (not shown) from ignition switch and remove switch.

Inspection

1. Visually check ignition switch for evidence of cracks, damaged connectors, or other damage. Replace switch as needed.
2. Check wiring for damaged insulation or damaged connectors. Repair as needed.
3. Use a multimeter to check for continuity between switch terminals with switch ON. Meter should register zero ohms. Place switch OFF. Meter should register infinity (no continuity). Replace switch if it fails either part of the check.

Installation

1. Install ignition switch (12) in right side cover (11). Secure with lock nut (not shown).
2. Install right side cover on steering column (9).
3. Connect wire harness (not shown) to ignition switch.
4. Install left side cover (16) on steering column overlapping right side cover.
5. Install four button head screws (14) through side covers.
6. Install dashboard cover (1) on side covers with four button head screws (11).
7. Install lever (15) on column assembly (9).
8. Pull column assembly rubber boot up and over bottom of side covers

Check

1. Turn battery disconnect switch to ON position.
2. Operate switch and verify each function works.
3. Troubleshoot any system or circuit malfunction not corrected by repair or replacement of switch.

Turn Signal and Transmission Shift Levers

Refer to Figure 3-11.

Removal

1. Ensure key switch has been in OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.
3. Remove steering wheel cover (3). Use a twisting motion by pushing on side of cap closest to you with your thumbs while pulling on side of cap farthest from you with your fingers.
4. Remove nut (4) from column assembly shaft (9). Remove steering wheel (5).
5. Remove screws and knob (19) from steering wheel (5) as necessary.

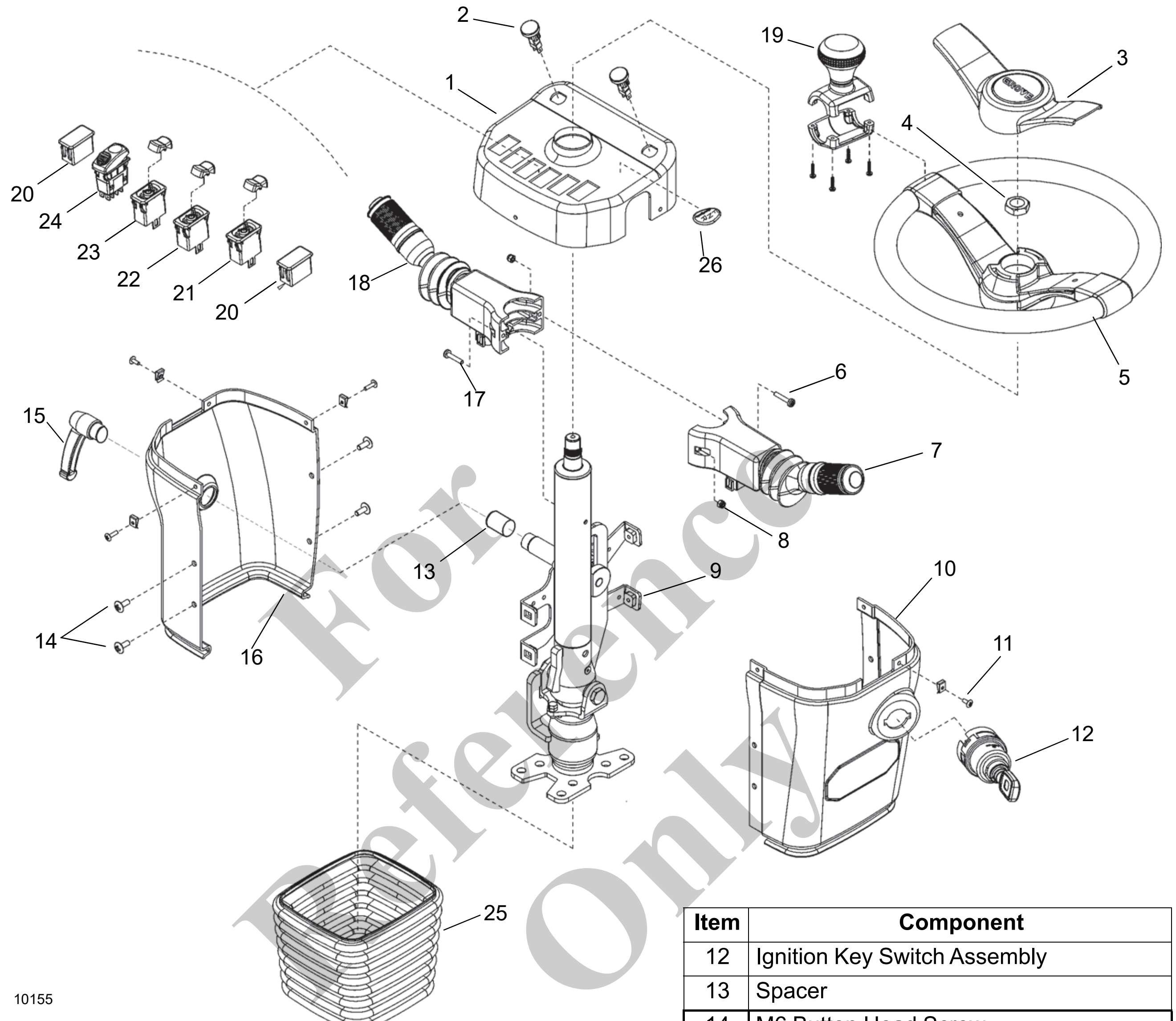
6. Remove four screws (11) from dashboard cover (1).
7. Remove locking lever (15).
8. Remove four screws (14) from left side cover (16).
9. Remove left side cover (16) from steering column.
10. Disconnect wire harness from back of ignition switch (12).
11. Remove right side cover (10) from steering column assembly (9).
12. Tag and disconnect wire harness (not shown) from switches (21 – 24) and turn signal indicators (2).
13. Remove dashboard cover (1) from steering column.
14. Tag and disconnect wire harnesses from turn signal lever (18) and transmission shift lever (7).
15. Remove two screws (6) and locknuts (8). Remove turn signal and shift lever assemblies.

Installation

1. Ensure locking pin (17) is installed in turn signal lever assembly (18).
2. Align turn signal lever assembly (18) and transmission shift levers assembly (7) with holes in steering column (9). Secure levers with two screws (6) and locknuts (8).
3. Connect wire harnesses to levers (7).
4. Install switch cover (6) on steering column.
5. Install wire harnesses on switches (21 – 24) and turn signal indicators (2) as tagged during removal.
6. Install right side cover (10) on steering column (9).
7. Connect wire harness to ignition switch (12).
8. Install left side cover (16) on steering column overlapping right side cover.
9. Install four button head screws (14) through side covers.
10. Install dashboard cover (1) on side covers with four button head screws (11).
11. Install lever (15) on column assembly (9).
12. Pull column assembly rubber boot up and over bottom of side covers.
13. If necessary, install knob (19) on steering wheel (5) with screws.
14. Install steering wheel (5). Install steering wheel nut (4). Torque to 30 lb-ft ±4 (40 N-m ±5).
15. Install steering wheel cap (3).
16. Turn battery disconnect switch to ON position.

Check

1. Operate turn signal lever or transmission shift lever per Operator Manual. Verify each function.
2. Troubleshoot any system or circuit malfunction not corrected by repair or replacement of lever or related wiring.



Item	Component
1	Dashboard Cover
2	Turn Signal Indicator
3	Steering Wheel Cap
4	Steering Wheel Nut
5	Steering Wheel
6	Screw
7	Three-Speed Transmission Shift Switch
8	Locknut
9	Column Assembly
10	Right Side Cover
11	M4 Button Head Screw

Item	Component
12	Ignition Key Switch Assembly
13	Spacer
14	M6 Button Head Screw
15	Lock Handle
16	Left Side Cover
17	Steering Column Tilt and Telescope
18	Turn Signal, Lights, Wiper Switch
19	Knob
20	Switch Blank
21	Hazard On/Off Switch
22	2WD/4WD Switch
23	Headlight Switch
24	Parking Brake Switch Assembly
25	Billows
26	F-N-R Label

FIGURE 3-11

Windshield Wiper Assembly Replacement

Removal

1. Ensure key switch has been in OFF position for two minutes.
2. Turn battery disconnect switch to OFF position.
3. Tag and disconnect electrical leads from motor.
4. Disconnect washer hose on wiper arm from washer nozzle fitting assembly.
5. Remove two cap nuts and washers securing wiper arm to adapter.
6. Remove wiper arm from adapter and pivot shaft.
7. Remove attaching hardware and motor to wiper link.
8. Remove flanged sleeve, nut, and two flat washers from pivot shaft kit.
9. Remove two capscrews and lockwashers securing adapter to cab exterior. Remove adapter and gasket.
10. Remove windshield wiper motor bracket from cab interior. Remove bracket with motor and pivot shaft from cab.

NOTE: Remove other parts as needed to access motor and bracket. Do not damage parts.

11. Remove nut from wiper motor kit crank.
12. Remove three screws, washers, and wiper motor from bracket. Leave other parts attached to bracket.

Inspection

1. Visually check 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 wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect wiper arm and parts of linking component kits (pantograph adapter kit, pivot shaft kit, wiper motor kit link and crank, wiper motor bracket) for damage. Replace as needed.

Installation

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

NOTE: Do not damage parts while moving bracket assembly around steering column.

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

Check

1. Squirt some cleaning fluid onto the windshield with windshield washer.
2. Test windshield wiper. Replace wiper blade if it streaks or wipes poorly.

Windshield Washer Assembly Replacement

Removal

1. Ensure key switch has been in OFF position for 2 minutes.
2. Turn battery disconnect switch to OFF position.
3. Locate windshield washer container and pump on left rear side of cab.
4. Tag and disconnect pump electrical lead and ground wire.
5. Disconnect hose from windshield washer pump. Point it so it will not spill cleaning fluid. Catch cleaning fluid from windshield washer container with a suitable container.
6. Remove four self tapping screws securing the windshield washer container to the cab. Remove the windshield washer container and pump.
7. Remove pump and pump seal from container.

Inspection

1. Visually check pump for evidence of cracks, leaks, or other damage. Replace pump if damaged.
2. Inspect 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 nozzle with a fine piece of wire and compressed air.

Installation

1. Install pump and pump seal on container.
2. Install windshield washer container on the cab. Secure the container with four self tapping screws.
3. Attach hose to windshield washer pump.
4. Connect pump's electrical lead and ground wire as tagged during removal.
5. Turn battery disconnect switch to ON position.
6. Fill container with cleaning fluid.

Check

1. Test windshield washer operation.
2. Perform additional troubleshooting and repair as needed.

Skylight Wiper Assembly Replacement

Removal

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

Inspection

1. Visually check 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 wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect wiper arm and parts for damage. Replace as needed.

Installation

1. Install sealant material around both holes in cab roof, both inside and outside.
2. Install screw with nylon flat washer (from outside) through mounting hole in cab roof.
3. Install flat nylon washer on motor shaft and insert motor shaft through hole in cab roof. Position small nylon washer and flat washer on screw between mounting bracket and cab roof. Secure with lockwasher and nut.
4. Install nylon flat washer, leather washer, spacer, and nut on motor shaft. Tighten nut.
5. Install wiper arm and blade on motor shaft.
6. Connect electrical leads to wiper motor as marked before removal.
7. Turn battery disconnect switch to ON position.

Check

1. Operate skylight wiper for correct operation. Replace wiper blade if it streaks or wipes poorly.

3

Adjusting Electronic Joysticks

If the meter-in dead band of a joystick function is too fast or too slow or its maximum function speed is slower or faster than design specifications, adjustments can be made using the Grove CAN-link service software providing the following have been performed:

- All function pressures have been set correctly following the procedures in the *Hydraulic System*, page 2-1.
- Correct function speeds cannot be attained by adjustments made through the Operator Display Module (ODM) control screens.
- Correct function control cannot be attained by adjustments made through the ODM control screen selectable curves.

To adjust the meter-in dead band and maximum function speed of a joystick, a Windows-based PC, CAN-link service software (9999102409), and a connection cable (80059224) are required. The CAN-Link service software and connection cable are available through Manitowoc Crane Care to those service technicians who have attended the Grove New Technology training course.

CALIBRATING ODM SENSORS

ODM sensors are located throughout the crane. When a sensor requires calibration, its icon appears in the ODM. The sensors are calibrated at the factory before the crane is delivered, but must to be calibrated through the ODM in the following circumstances:

- The sensor readings are inaccurate (individual sensor only must be calibrated)
- The sensor or component being measured is replaced, adjusted, removed, or reinstalled (individual sensor only must be calibrated)
- The software has been updated (all sensors must be calibrated)
- The ODM display is replaced (all sensors must be calibrated)

Detailed information about the calibration process is available to technicians who have attended the Grove New Technology training course.

DIAGNOSTICS

The following sections describe the GRT9165 diagnostic functions.

Viewing Diagnostic Fault Codes

The Operator Display Module (ODM) 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 ODM display.

For more information about accessing the faults, see “Faults Menu Group” in the *Operator Manual*.

A list of all fault codes and their definitions are available through Manitowoc Diagnostic Code application. For more information, see *About the Manitowoc Diagnostic Code Mobile Application*, page 3-20.

About the Manitowoc Diagnostic Code Mobile Application

The Manitowoc Diagnostic Code Mobile Application is a free mobile application that enables the user to enter and retrieve information about specific crane fault codes on a mobile device. The application is available from the Google and Apple stores and compatible with most Android and Apple mobile devices.

To look up a fault code with the Manitowoc Diagnostic Code mobile application:

1. Find the fault code you want to research in the Fault Code function screen of the Operator Display Module (ODM). For more information, see *Viewing Diagnostic Fault Codes*, page 3-20.

2. Open the Manitowoc Diagnostics Code Application on your mobile device.

   The Diagnostic Code Application splash screen appears.

10156

3. Click CCS.

   The CCS screen appears.

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4. Complete the following using information from the error code displayed on the ODM:

   - Select Crane Type—Select the crane model from the dropdown list.
   - Component—Enter the component information from the fault code.
   - Condition—Enter the condition information from the fault code.
   - Device—Enter the device number from the fault code.
   - Index—Enter the index number information from the fault code.

5. Click Continue.

   The Fault code information is displayed.

6. Click OK to return to the main screen.

OPTIONAL EQUIPMENT

This section is provided to give a brief description of optional equipment for the crane which is not discussed elsewhere in this service manual.

Beacon Light

The beacon lights are installed on the left side of the turntable in front of the main hoist.

Boom Mounted Floodlights

The boom light switch is located in the cab overhead panel. The switch is an On/Off rocker switch that will turn the lamps located on the underside of the boom On and Off.

Rear View Mirror

The rear view mirror installation consists of a rear view mirror mounted on the top left corner of the cab. Mirror can be adjusted for optimum view from cab while boom is over front of crane.

Air Conditioner

An electrically driven air conditioner is installed on the left side of the turntable. It consists of an engine-mounted compressor motor, condenser unit, and a cab unit mounted under the operators seat. It is turned on and off by a rotary switch mounted on the overhead console. Refer to Air Conditioner Control Switch (Optional) in the Operator Manual (Section 3 -Operating Controls and Procedures).

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

Cold Weather Operation

Regions with ambient temperatures below -9°C (15°F) are considered arctic. The following recommendations are for operating Grove cranes in very low temperatures.

Use particular care to ensure that cranes being operated in very cold temperatures are operated and maintained in accordance with the procedures as provided by Manitowoc. Always ensure adequate lubrication during system warm-up and proper operation of all crane functions when operating in cold weather. Regardless of oil viscosity, always follow cold weather start-up and operating procedures described in the *Operator Manual.* To ensure adequate lubrication during system warm-up and proper operation of all crane functions, Refer to *Warm-up Procedure*, page 5-2.

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

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

Component Coolant Heater

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

WARNING

Explosion Hazard!

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

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

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

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

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

Troubleshooting

In case of faults, check the following points:

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

Maintenance Instructions

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

Wind Speed Indicator and Boom Position Indicator Light

The wind speed indicator and boom position indicator light are installed at the end of the boom or boom extension. For information and removing and installing, see the *Operator Manual*.

Cameras

The GRT9165 features an optional 3-camera package. The cameras are located in the following locations:

- Hoist camera
- Right rear camera
- Back-up camera

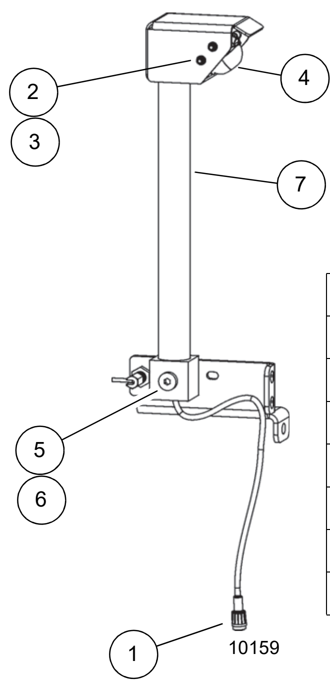
The following sections describe removal and installation instructions for the cameras.

Hoist Camera

The following sections describe removing and installing the hoist camera.

Removing Hoist Camera

1. Disconnect the data cable (1, Figure 3-12).



Hoist Camera	
1	Data Cable
2	Capscrew
3	Washer
4	Camera
5	Setscrew
6	Bushing
7	Hoist Camera Arm

FIGURE 3-12

2. Remove capscrews (2), washers (3), and camera (4) from hoist camera arm (7).
3. Remove setscrew (5), bushings (6), and hoist camera arm (7) from bracket.

Installing Hoist Camera

1. Install bushings (6), setscrew (5) and hoist camera arm (7) on bracket.
2. Install camera (4) on hoist arm (7) using washers (3) and capscrews (2).
3. Connect data cable (1).

Right Rear Camera

The following sections describe removing and installing the right rear camera (1, Figure 3-13). The right rear camera is located on the right side of the superstructure.

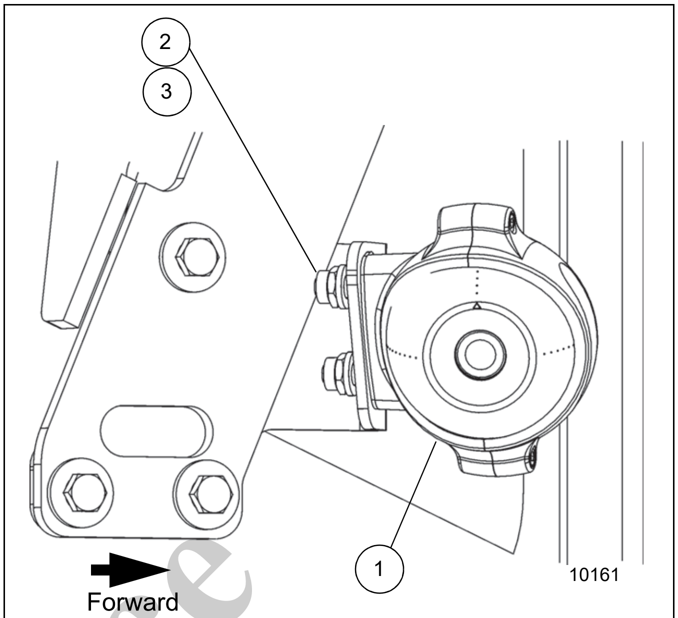


FIGURE 3-13

Removing Right Rear Camera

1. Remove the maintenance cover on the right side of the superstructure.
2. Disconnect the data cable.
3. Remove capscrews (2), washers (3), and camera (1) from bracket.

Installing Right Rear Camera

1. Install camera (1) on bracket using washers (3) and capscrews (2).
2. Connect the data cable.
3. Install the maintenance cover on the right side of the superstructure.

Back-up Camera

The following sections describe removing and installing the back-up camera (1, Figure 3-14). The back-up camera is located on the rear of the superstructure near the hoists.

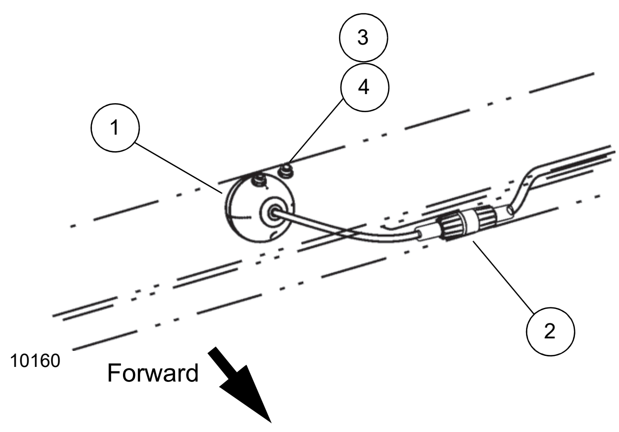


FIGURE 3-14

Removing the Back-up Camera

1. Disconnect the data cable (2).
2. Remove capscrews (3), washers (4), and camera (1) from the bracket.

Installing the Back-up Camera

1. Install the camera (1) on the bracket with washers (4) and capscrews (3).
2. Connect the data cable (2).

RCL Light Tower

When installed, the RCL light tower is located on the right side of the operator cab. Disconnect the data cable and remove the tower from the bracket. For more information, see *Operator Manual*.

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SECTION 4
BOOM

SECTION CONTENTS

The following sections describe maintenance procedures for the GRT9165 boom. For lubrication information, see *Maintenance and Lubrication*, page 9-1. Additional information can be found in the *Operator Manual* and Parts Book.

BOOM REMOVAL

NOTE: The boom with no boom extension weighs approximately 16206 kg (35728 lbs).

1. Extend and set the outriggers to level the crane and ensure the boom is fully retracted, locked, and in a horizontal position over the front of the crane.
2. Remove the counterweight. For more information, see the *Operator Manual*.
3. Rotate turntable so boom is over the front of the crane and engage the turntable lock pin.
4. If installed, remove the boom extension and auxiliary nose. For more information, see the *Operator Manual*.

CAUTION

Injury Hazard!

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

5. Remove the hook block or overhaul ball and wind all the wire rope onto the hoist drum.

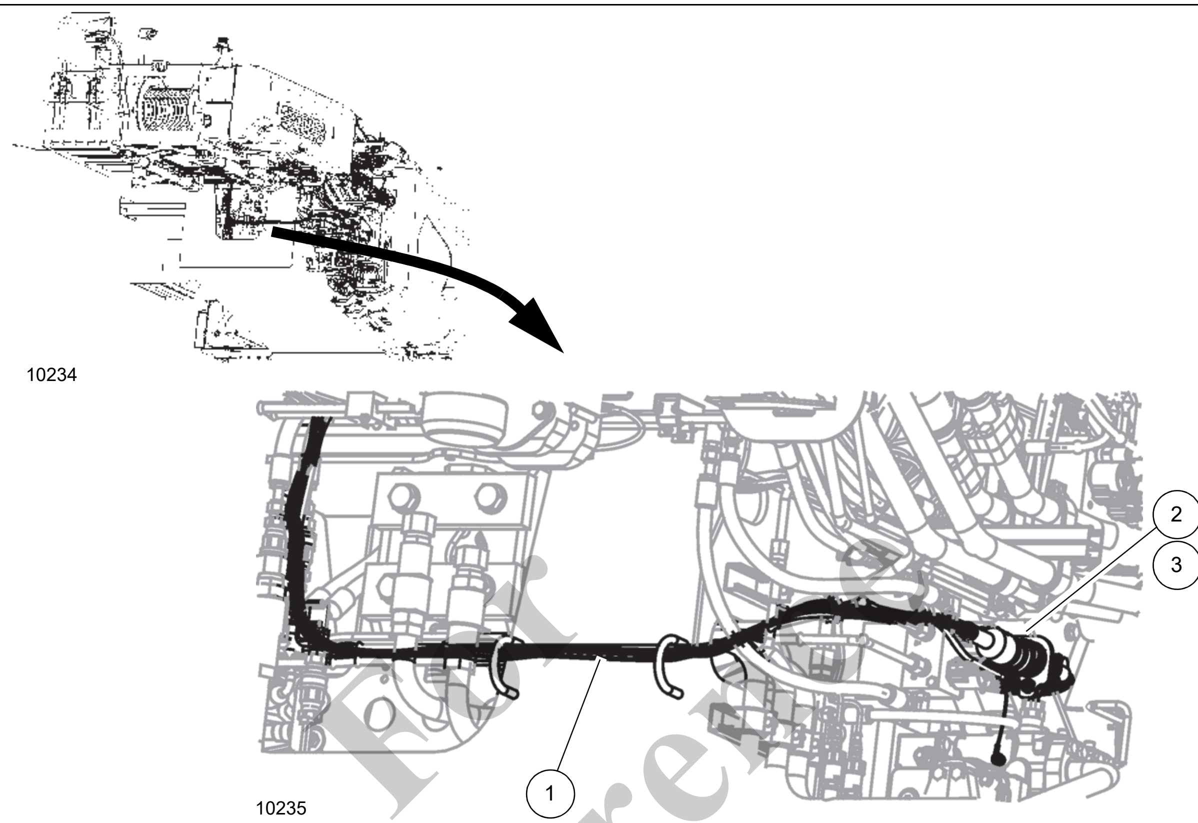


FIGURE 4-1

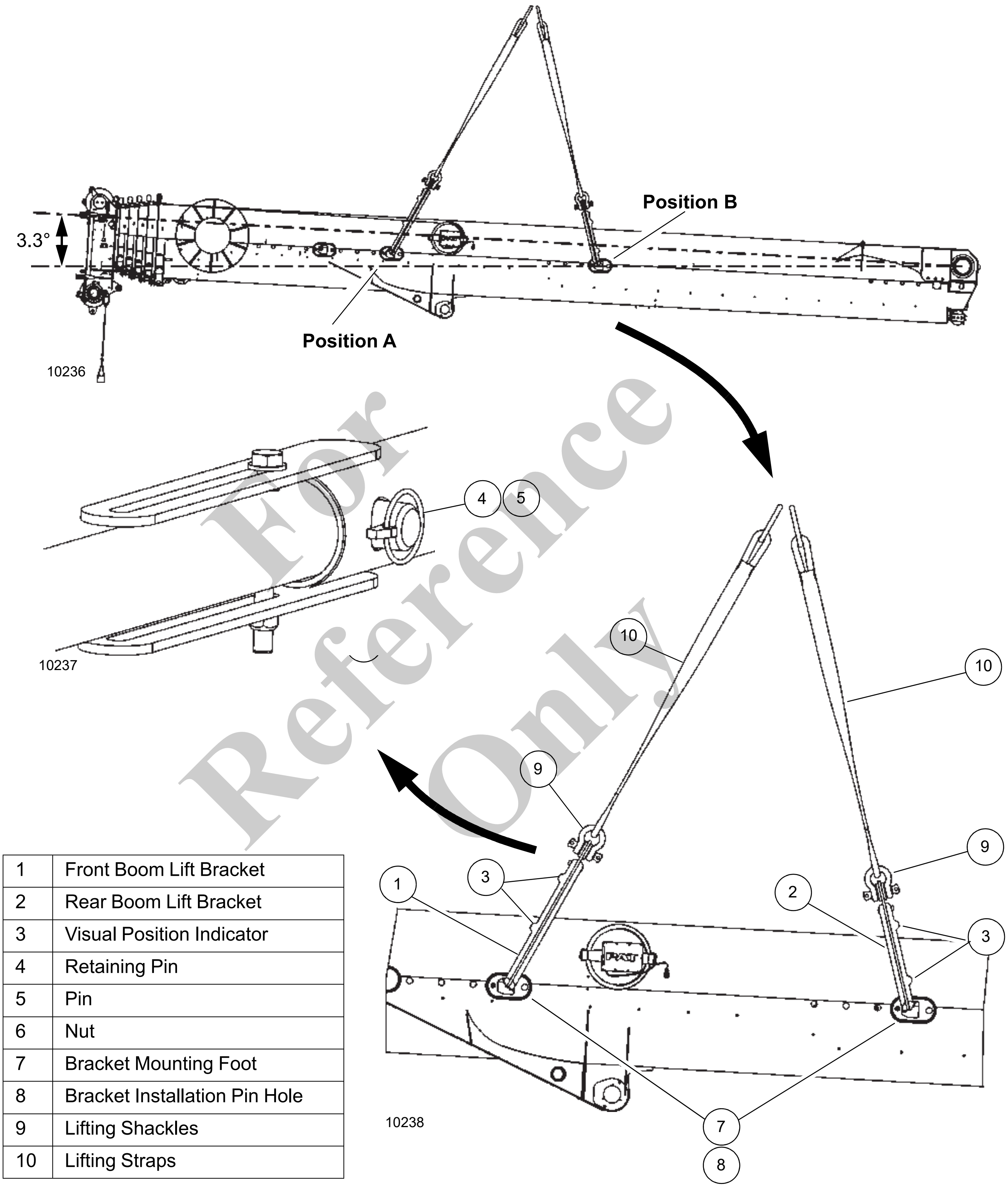
6. Remove the rear maintenance cover from the right side of the superstructure. Disconnect the boom electrical connectors (2 and 3, Figure 4-1). Route the electrical cable (1) through the superstructure and secure the cable.
7. Elevate boom to allow access to the telescope hose disconnects.
8. Disconnect hydraulic lines from the boom telescope cylinder. Tag and disconnect the telescopic hydraulic lines. If equipped, also disconnect the hydraulic boom extension hydraulic hoses.
9. Attach tag lines to the boom as necessary.

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

10. Install the front (1, Figure 4-2) and rear (2) boom lift brackets as follows:
    - **a.** Remove retaining pin (4) and pin (5). Loosen nut (6). Expand the front boom lift bracket (1) to fit over the boom.

NOTE: Make sure the visual position indicators (3) are pointed forward for the front bracket.

   - **b.** Insert bracket mounting feet (7) in the boom at the pin hole (Position A) in the boom.
   - **c.** Install pin (5) and retaining pin (4). Tighten nut (6) to secure the mounting bracket.
   - **d.** Remove retaining pin (4) and pin (5). Loosen nut (6). Expand the rear boom lift bracket (2) to fit over the boom.
   - **e.** Make sure the visual position indicators (3) are pointed to the rear for the rear bracket.
   - **f.** Insert bracket mounting feet (7) in the boom at the pin hole (Position B) in the boom.
   - **g.** Install pin (5) and retaining pin (4). Tighten nut (6) to secure the mounting bracket.
   - **h.** Install lifting shackles (9) and straps (10) to the boom lifting brackets (1 and 2).
   - **i.** Connect the lifting straps (10) to a suitable lifting device.



1	Front Boom Lift Bracket
2	Rear Boom Lift Bracket
3	Visual Position Indicator
4	Retaining Pin
5	Pin
6	Nut
7	Bracket Mounting Foot
8	Bracket Installation Pin Hole
9	Lifting Shackles
10	Lifting Straps

FIGURE 4-2

11. If necessary, install the lift cylinder support (1, Figure 4-3) on the carrier as follows:

NOTE: The lift cylinder support weighs approximately 59 kg (129 lb).

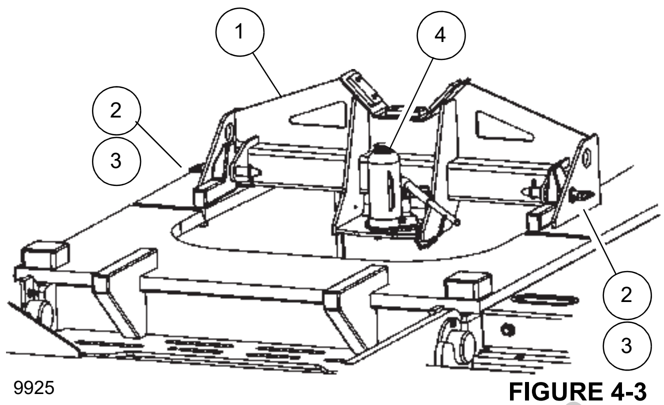


FIGURE 4-3

- **a.** Remove retaining clips (2) and pins (3).
- **b.** Position the lift cylinder support (1) on the carrier. Align support holes with the holes in the counterweight stops.
- **c.** Secure the support (1) to the carrier with pins (3) and retaining clips (2).
- **d.** Make sure the bottle jack (4) is fully retracted.

12. Slowly lower the boom so the lift cylinder is near the support (1).

13. Install a piece of wood between the lift cylinder and the bottle jack on the lift cylinder support. Raise the bottle jack (4) and wood cribbing up to the lift cylinder. The bottle jack and wood cribbing should be in firm contact with the lift cylinder.

14. Remove capscrew (1, Figure 4-4) and washer (2) that secures pin.

15. Turn the direction lever (3) to the correct position. Use the hand pump (4) to remove the lift cylinder pivot pin. Tag and identify the locations of shims.

16. Use bottle jack (4, Figure 4-3) on the lift cylinder support (1) as necessary to adjust the position of the lift cylinder pivot pin.

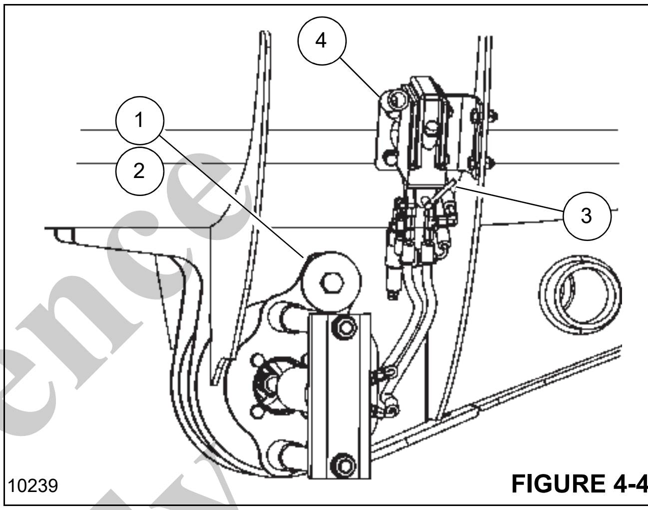
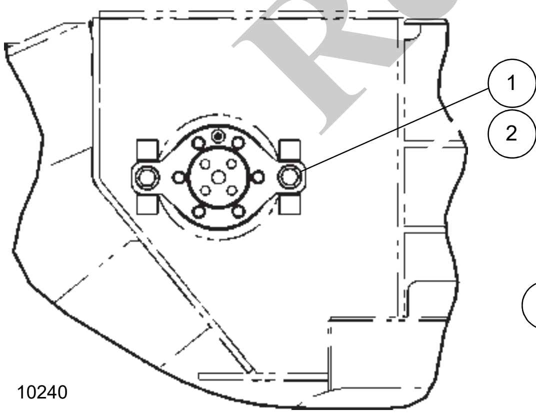


FIGURE 4-4

17. Install the boom pivot pin removal tool (3, Figure 4-5) on the right side of the superstructure as follows:



1	Capscrew M20 x 55 LG
2	Bushing
3	Boom Pivot Pin Removal Tool
4	Hydraulic Connection
5	Hydraulic Connection

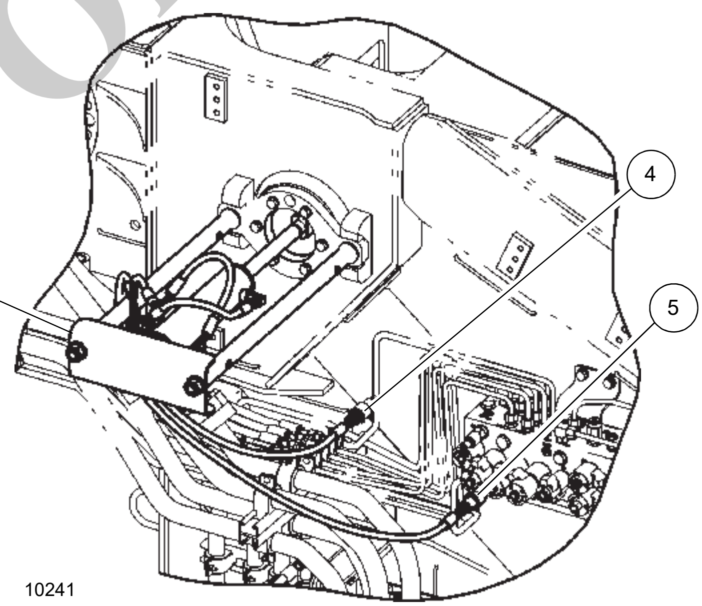


FIGURE 4-5

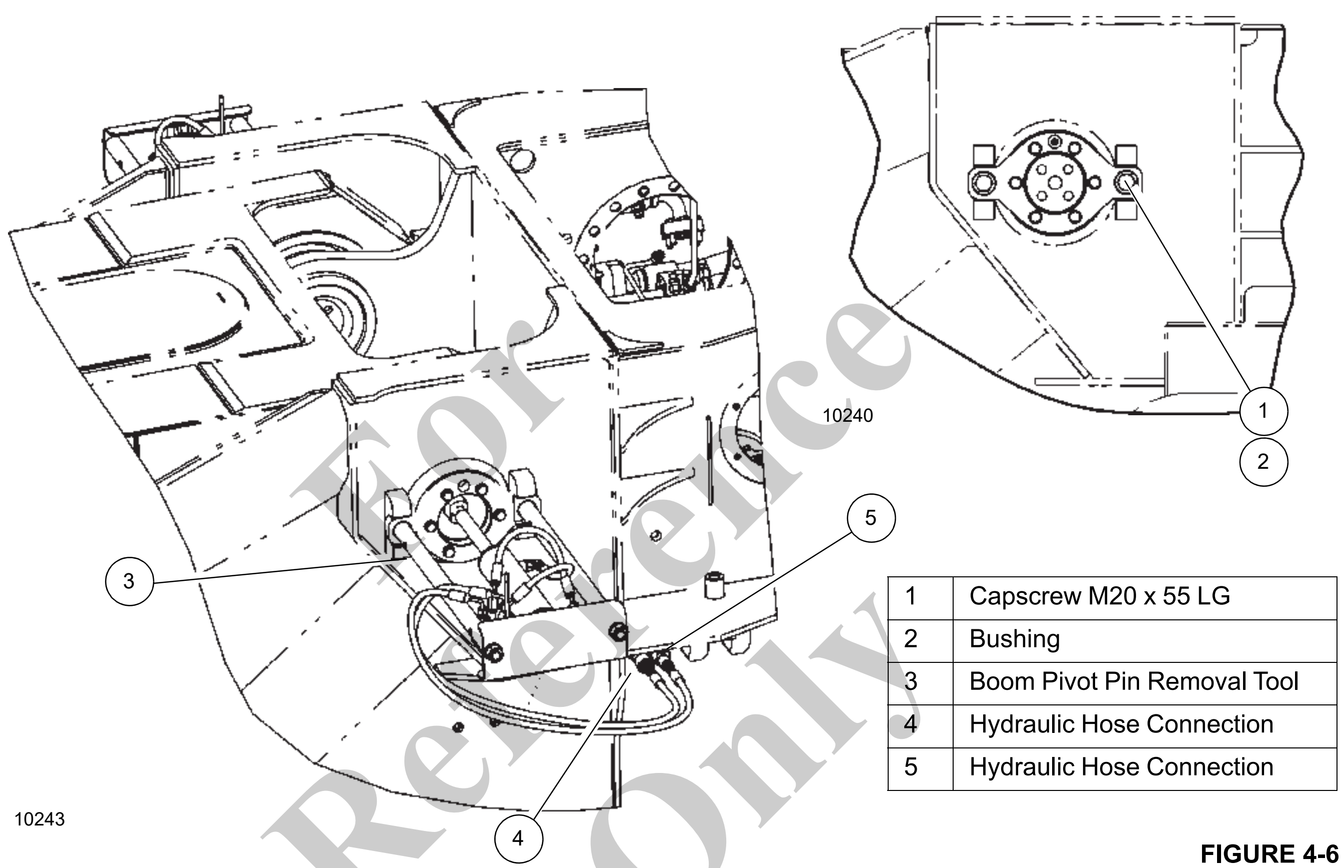
a. Remove the right rear valve maintenance cover.

b. Remove capscrews (1, Figure 4-5) and bushings (2) from the pivot pin.

c. Remove the nuts from the end of the push rods. Install the pin removal tool (3) in the capscrew holes. Thread the rods into the capscrew holes.

d. Connect hydraulic hoses (4 and 5).

18. Install the boom pin removal tool (3, Figure 4-6) to the left (cab) side of the superstructure as follows:



1	Capscrew M20 x 55 LG
2	Bushing
3	Boom Pivot Pin Removal Tool
4	Hydraulic Hose Connection
5	Hydraulic Hose Connection

FIGURE 4-6

a. Deploy the maintenance platform as necessary. For more information, see the *Operator Manual*.

b. Remove capscrews (1) and bushings (2) from the pin.

c. Remove the nuts from the ends of the push rods. Install the boom pin removal tool (3) in the capscrew holes. Thread the rods into the capscrew holes.

NOTE: The hydraulic ports for the pin removal tool have red caps.

d. Connect the hydraulic hoses (4 and 5).

19. Start the engine.

20. If necessary, verify that the hydraulic pin removal tools are operational In the ODM. For more information, see the “Boom Removal/Installation Function” section in the *Operator Manual*.

WARNING

Crushing Hazard!

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

Severe injury or death may result.

21. For the right side pin, move the control handle (1, Figure 4-7) on the removal tool to retract the pin.

22. For the left (cab) side pin, move the control hand (1) on the removal tool to retract the pin.

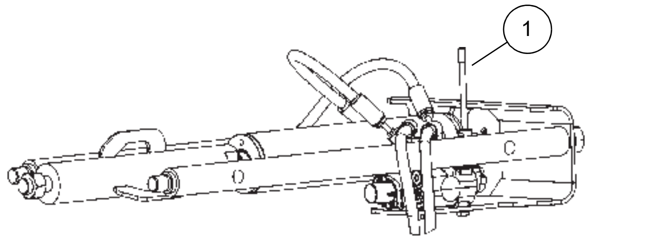


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FIGURE 4-7

23. The support crane now holds the weight of the boom.
24. Raise the boom clear of the crane and lower it to the ground or trailer. Set cribbing to support the boom and prevent tipping.
25. Remove straps and lift brackets from the boom.
26. Re-install the pivot pins for later use and remove the boom pivot pin removal tools from the superstructure.

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 approximately 15662 kg (34528 lbs).

DANGER

Crushing Hazard!

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

Block the boom before doing any work under the boom.

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

---

1. Set up the machine properly on outriggers.
2. Attach the front (1, Figure 4-2) and rear (2) lifting brackets to the boom. For more information, see step 10 on page 4-2.
3. Install the rear boom pivot pins as follows:
    - **a.** Install the boom pivot pin removal tool on the right side of the superstructure (Figure 4-5). For more information, see step 17 on page 4-4.
    - **b.** Install the boom pivot pin removal tool on the right side of the superstructure (Figure 4-6). For more information, see step 18 on page 4-5.
    - **c.** For the right side pin, move the control handle (1, Figure 4-7) on the removal tool to extend the pivot pin.
    - **d.** For the left (cab) side pin, move the control hand (1) on the removal tool to extend the pivot pin.
    - **e.** For the right side pin, disconnect the removal tool hydraulic connections (4 and 5, Figure 4-4) and remove the hydraulic tools.
    - **f.** For the left (cab) side pin, disconnect the removal tool hydraulic connections (4 and 5, Figure 4-5) and remove the hydraulic tools.
    - **g.** For the right side pin, secure the pivot pin to the superstructure with busings (2, Figure 4-4) and capscrews (1). Torque the capscrews. For more information, see *Fasteners and Torque Values*, page 1-16.
    - **h.** For the left (cab) side pin, secure the pivot pin to the superstructure with busings (2, Figure 4-5) and capscrews (1). Torque the capscrews. For more information, see *Fasteners and Torque Values*, page 1-16.
4. Remove the rear boom pivot pins.
5. Attach tag lines to the boom as necessary.
6. Lift the boom. Lower the rear of the boom into position. Align the boom pivot mounting holes with mounting holes in the turntable. Make sure all hydraulic and electrical cables are out of the way so they will not be damaged.
7. 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.

8. Apply anti-seize compound to the boom pivot shafts.
9. Prior to starting the lift cylinder to boom installation, make sure the lift cylinder is securely resting on the lift cylinder support.
10. Lower the boom so the boom is near the lift cylinder.

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.

CAUTION

Pinch Hazard!

Use caution when installing pin, high pinch point risk.

NOTE: Install a piece of wood between the lift cylinder and the bottle jack on the lift cylinder support.

11. Turn the direction lever (3, Figure 4-4) to the correct position. Use the hand pump (4) to install the lift cylinder pivot pin. Use the hand pump (4) and bottle jack (4, Figure 4-3) on the lift cylinder support (1) as necessary to adjust the position of the lift cylinder rod end is centered on the pivot pin.
12. Install shims as tagged during removal.
13. Install washer (2) and capscrew (1) to secure the lift cylinder pin. Torque the capscrew (1). For more information, see *Fasteners and Torque Values*, page 1-16.
14. Disconnect the straps (10, Figure 4-2) from the lifting device. Remove the straps (10) and front and rear boom lift brackets (1 and 2).
15. Remove tag lines as necessary.
16. Connect the hydraulic lines as tagged to the boom telescope cylinder. If equipped, connect the hydraulic boom extension hydraulic hoses.
17. Route the electrical cables (2 and 3, Figure 4-1) through the superstructure. 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. Ensure 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 (1, Figure 4-8) from the cable retainer pins (2 and 3) and remove the cable retainer pins from the upper and lower part of the boom nose.
2. Pull the lever to retract the lower inside cable retainer pin (4).
3. Remove the hex head screws (5) securing the cover plate (6) to the upper boom nose sheave (7). Remove the cover plate.

NOTE: The upper boom nose sheave shafts weigh approximately 11 kg (24 lb) and 7 kg (15 lbs). The lower boom nose sheave shaft weighs 49 kg (108 lbs). The boom nose sheaves weigh approximately 10 kg (22 lb) each.

4. Carefully pull the upper boom nose sheave shaft (8) from the boom nose, removing the spacers, bushings, capscrews, plate, rope fixed point assembly, and boom nose sheaves (9). Note the quantity of the spacers for installation.
5. Remove the hex head screws (10) securing the cover plate (11) to the lower boom nose sheave (12). Remove the cover plate.

NOTE: The upper boom nose sheave shafts weigh approximately 11 kg (24 lb) and 7 kg (15 lbs). The lower boom nose sheave shaft weighs 49 kg (108 lbs). The boom nose sheaves weigh approximately 10 kg (22 lb) each.

6. Carefully pull the lower boom nose sheave shaft (12) from the boom nose, removing the spacers, rope fixed point assembly, and boom nose sheaves (9, Figure 4-8). Note the quantity of the spacers for installation.

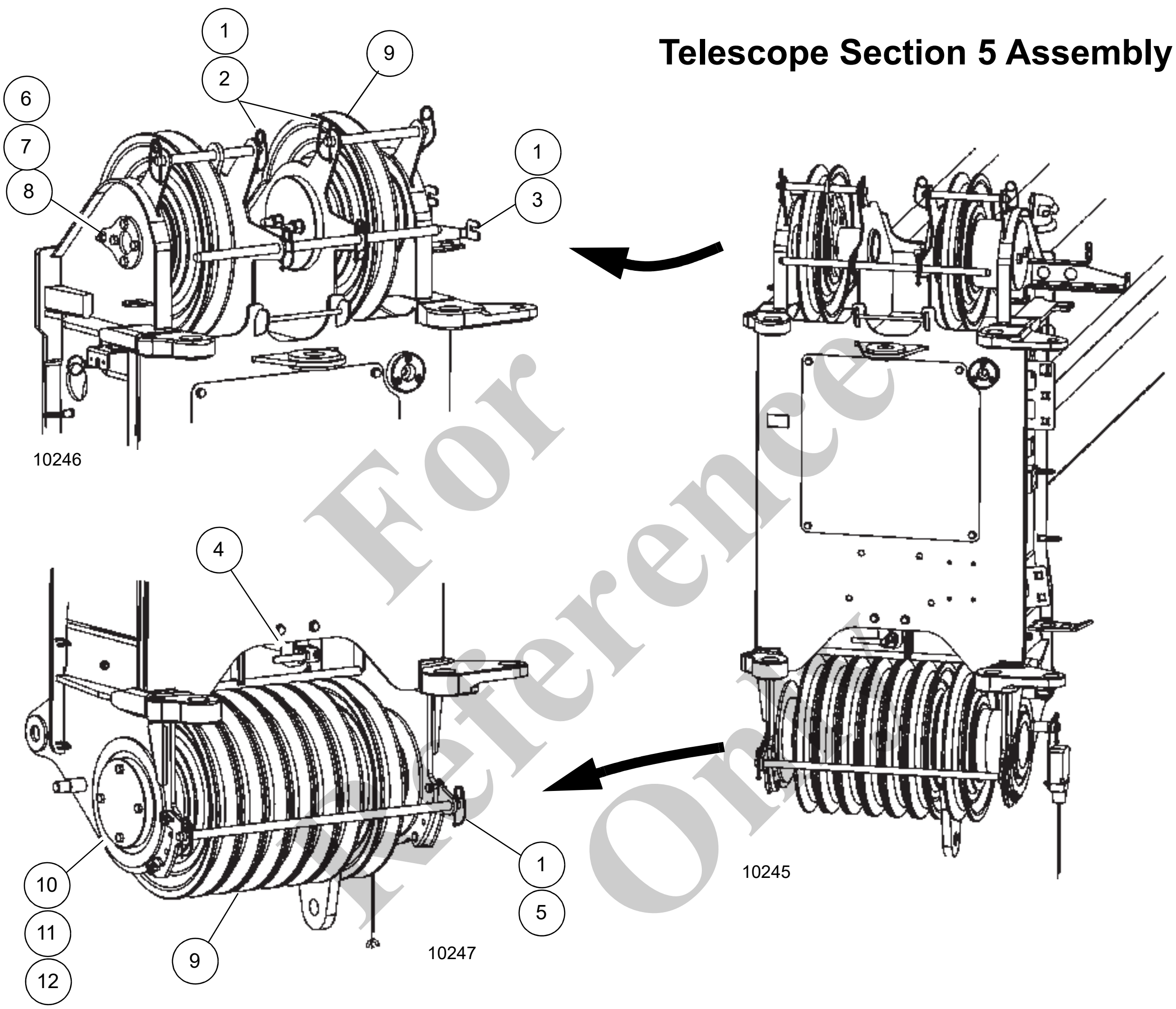
Boom Nose Sheaves Installation

Refer to Figure 4-8 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 spacers, rope fixed point assembly, and sheaves (9) onto the lower sheave shaft (12) while installing the sheave shaft into the lower boom nose.
2. Secure the shaft (12) with the cover (11) and screws (10).
3. Repeat steps 1 and 2 for the upper boom nose sheaves and shaft.
4. Install the cable retainer pins (2, 3, 4, and 5) into the upper and lower part of the boom nose and secure in place with the retaining pins (1).

Telescope Section 5 Assembly



1	Retaining Pin
2	Cable Retaining Pin
3	Cable Retaining Pin
4	Cable Retaining Pin
5	Cable Retaining Pin
6	Screw

7	Cover Plate, Upper Sheave
8	Upper Sheave Shaft
9	Sheave
10	Screw
11	Cover Plate, Lower Sheave
12	Lower Sheave Shaft

FIGURE 4-8

Telescope Section 5 Assembly (Continued)

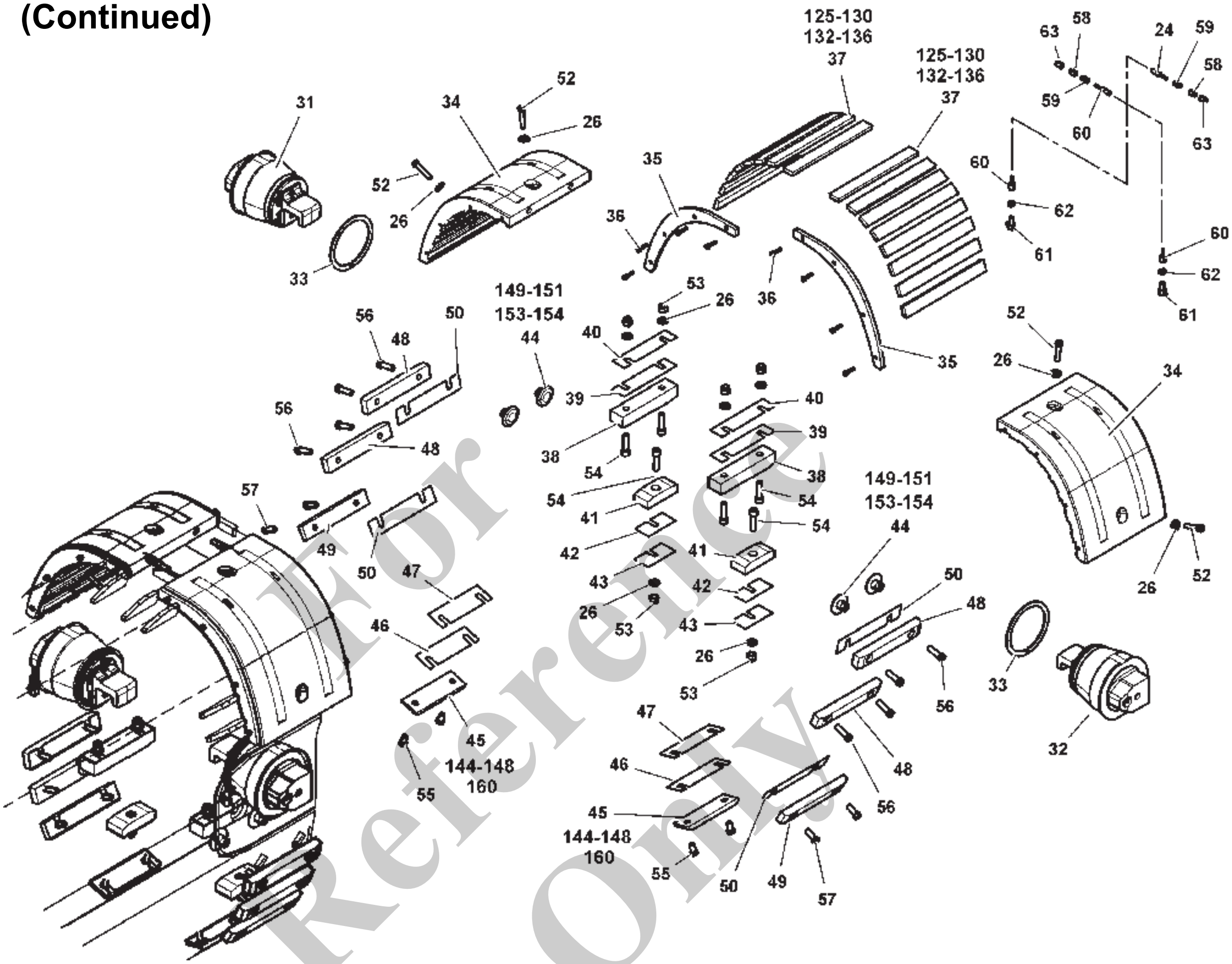


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FIGURE 4-8 continued

Table 4-1Telescope Section 5 (Figure 4-8)

Item	Description
1	TELE 5 WELDMENT
2	AXLE
3	COVER PLATE
4	HEX HEAD SCREW
5	ROPE PULLEY CPL.
8	ROPE FIXED POINT ASSEMBLY
11	SPACER RING
12	SPACER RING
14	SPACER RING
15	AXLE
16	BUSHING
17	BUSH
18	PLATE
19	NUT M12 8-A3C ISO 4032
20	CAPSCREW M12X30
21	PLATE
22	WASHER
23	CAPSCREW M10X16 8.8-A3C ISO 4017
24	LUBRICANT HOSE
26	WASHER
27	SPACER
28	SOCKET-HEAD SCREW
29	SCREW
30	NUT
31	LOCKING UNIT TELE 5
32	LOCKING UNIT TELE 5
33	RETAINING RING 125X4 SPRING ST
34	WEAR PAD
35	PLATE
36	CAPSCREW
37	SHIM
38	WEAR PAD
39	PLATE
40	PLATE
41	WEAR PAD
42	PLATE
43	PLATE

Table 4-1Telescope Section 5 (Figure 4-8) (Continued)

Item	Description
44	GUIDE PILOT
45	SLIDER
46	FILL PLATE-1MM
47	FILL PLATE-2MM
48	WEAR PAD
49	WEAR PAD
50	PLATE
52	CAPSCREW M10X50
53	NUT M12 8-A3C ISO 7040
54	CAPSCREW
55	SOCKET-HEAD SCREW
56	SOCKET-HEAD SCREW
57	SOCKET-HEAD SCREW
58	ADAPTER
59	FITTING
60	LUBRICANT HOSE
61	PIPE UNION M12X1
62	NUT
63	INSERT
65	PLATE
66	PIN
67	PIN
68	CAPSCREW, HEX HEAD M10X35MM
69	NUT M10
70	SECURING PIN 4 SPRING STEEL GA
77	SHACKLE
78	LIMIT SWITCH-WEIGHT ASSEMBLY
79	CAPSCREW M8x50 8.8-A2C ISO 4762
80	NUT M8 8-A2C ISO 4032
81	OUTER STOCK SUPPORT
82	HEX HEAD SCREW
83	PIN
86	SPACER RING OUTSIDE
87	SPACER RING INSIDE
88	SPACER RING
89	CABLE CLIP
90	WEAR PAD

Table 4-1Telescope Section 5 (Figure 4-8) (Continued)

Item	Description
91	WASHER 8 200HV-A2 ISO 7089
92	NUT M8 A2-70 ISO 7040
93	CAPSCREW M8X30
94	WELDMENT
95	PLATE
96	ROPE PROTECTION
97	NUT
98	PIN
99	PIN, LINCH 5 X 32
100	HEX HEAD SCREW
102	PLATE
103	PIN
125	SHIM
126	SHIM
127	SHIM
128	SHIM
129	SHIM
130	SHIM
132	SHIM
133	SHIM
134	SHIM
135	SHIM
136	SHIM
137	SPACER
138	SPACER
140	PLATE
141	PLATE
142	PLATE
144	WEAR PAD
145	WEAR PAD

Table 4-1Telescope Section 5 (Figure 4-8) (Continued)

Item	Description
146	WEAR PAD
147	PLATE
148	PLATE
149	GUIDE PILOT
150	GUIDE PILOT
151	GUIDE PILOT
153	GUIDE PILOT
154	GUIDE PILOT
155	SOCKET-HEAD SCREW
156	SPACER RING
157	SPACER RING
158	PLATE
159	CAPSCREW
160	SLIDER
161	SHEAVE INSTALLATION
500	WEAR PADS TELESCOPE 5

BOOM DISASSEMBLY

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.

1. Pin the cylinder to tele 1.
2. Remove the cylinder retaining bolts (1, Figure 4-9), washers (2), and two retaining plates (3).

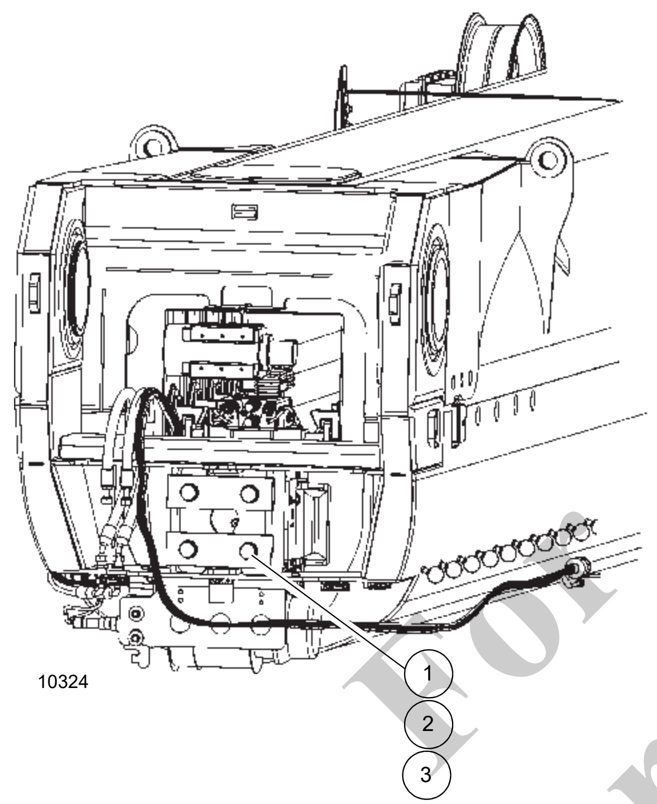


FIGURE 4-9

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 wear pads, strips, shims, and plates (3, 4, 5, 6, 7, 8, 9, 11, 12, and 13, Figure 4-16).
5. Remove the holders and plates (10, 14, 15, 16,17).
6. Remove tele section 1 from the base section.
7. Remove the tele power plug (1, Figure 4-10).
8. Remove the tele power cable strain relief (2).

9551 FIGURE 4-10

9. Remove the tele cylinder.
10. Remove the wear pads, plates, and strips (34, 35, 37, Figure 4-15), as necessary.
11. Remove the wear pads, fill plates, plates, and guide pilots (38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 148), as necessary. Tag the plates and wear pads 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, 15, 16, 17).
13. Remove the rope protection bar (2).
14. Remove the guide (64).
15. Remove tele section 2.
16. Remove the wear pads, holders, shims, and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17, Figure 4-14).
17. Remove the wear pads, fill plates, plates, and guide pilots (38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51), as necessary. Tag the plates and wear pads as to their location for reassembly.
18. Remove the wear pads, plates, and strips (34, 35, 37), as necessary.
19. Remove the rope protection bar (2).
20. Remove the guide (64).
21. Remove tele section 3.
22. Remove the wear pads, holders, strips, and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, and 17, Figure 4-13).
23. Remove the sliders, wear pads, fill plates, plates, and guide pilots (38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50), as necessary. Tag the plates, wear pads, and sliders as to their location for reassembly.

24. Remove the wear pads, plates, and shims (34, 35, and 37), as necessary.
25. Remove the rope protection bar (2).
26. Remove the guide (64).
27. Remove tele section 4.
28. Remove the wear pads, holders, shims, and plates (3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,and 15, Figure 4-12).
29. Remove the wear pads, fill plates, plates, and guide pilots (38, 39, 40, 41, 42, 44, 45, 46, 47, 48, and 49), as necessary. Tag the plates and wear pads as to their location for reassembly.
30. Remove the wear pads, plates, and shims (34, 35, 37), as necessary.
31. Remove the rope protection bar (2).
32. Remove the guide (24).
33. Remove tele section 5.
34. Remove the wear pads, shims, and plates (34, 35, 37, Figure 4-8).
35. Remove the sliders, plates, guide pilots, fill plates and wear pads (38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, and 50). 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.

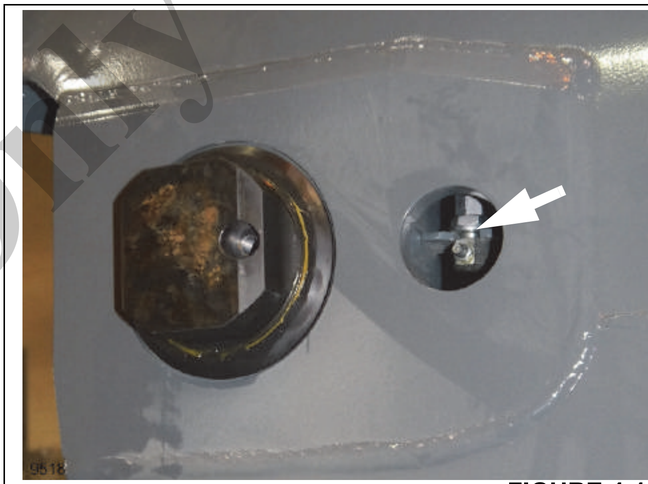
NOTE: **Wear Pads**. When installing upper and lower side wear pad, use shims as necessary so wear pad is within 1.52 mm (0.06 inch) from side plate of next inner section. Use equal number of shims on each side.

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

Telescope Section 5 Assembly

Refer to Figure 4-8 when assembling this section.

1. Install the plates (46, 47, 50) and sliders and wear pads (45, 49).
2. Install the wear pads (48).
3. Install the plates (42, 43) and wear pads (41).
4. Install the guide pilots (44).
5. Install the plates (39, 40) and wear pads (38).
6. Place the wear pad (34) on the section and insert strips (37) inside.
7. Secure the wear pad (34) with the plate (35).
8. Install the opposite wear pad (34), shims (37), and plate (35).
9. Assemble the lubrication hoses (60) and connect to the wear pads (34).
10. Attach the thin nuts (62) and pipe unions (59, 61) to the lubrication hoses and secure the hoses to the tabs (Figure 4-11) inside the section.



9518 **FIGURE 4-11**

11. Install the locking unit assemblies (31, 32).
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.

Telescope Section 4 Assembly

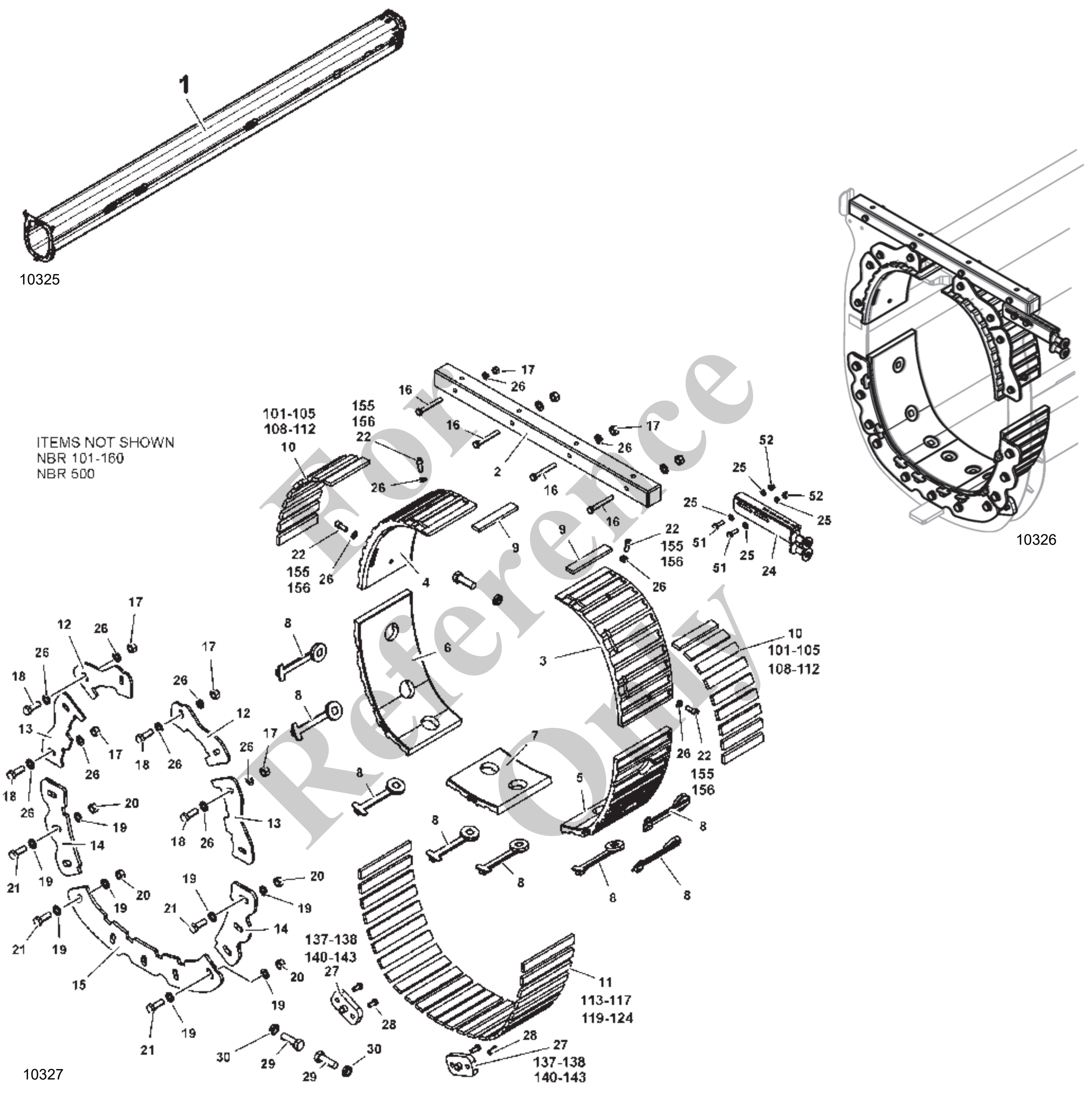


FIGURE 4-12

Telescope Section 4 Assembly (Continued)

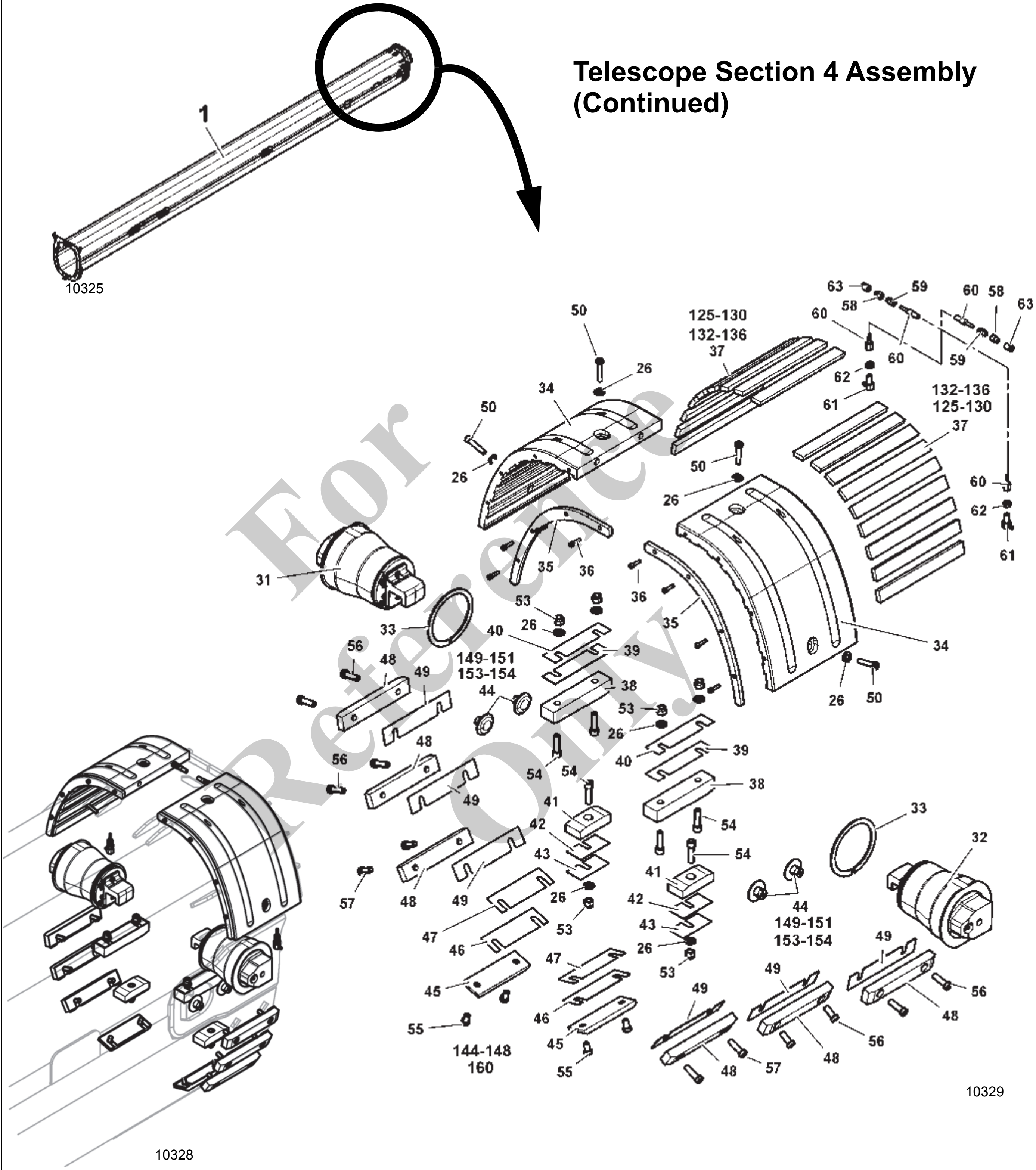


FIGURE 4-12 continued

Table 4-2 Telescope Section 4 (Figure 4-12)

Item	Description
1	TELE4 - WELDMENT
2	ROPE PROTECTION
3	WEAR PAD
4	WEAR PAD
5	WEAR PAD
6	WEAR PAD
7	WEAR PAD
8	HOLDER
9	SHIM
10	SHIM
11	SHIM
12	PLATE
13	PLATE
14	PLATE
15	PLATE
16	CAPSCREW M12x90 -8.8 ISO 4014
17	NUT M12 8-A3C ISO 4032
18	CAPSCREW M12X40 8.8-A3C ISO 4017
19	WASHER 16 140HV-A3C ISO 7090
20	NUT M16 8-A3C ISO 4032
21	CAPSCREW M16X45 8.8-A3C ISO 4017
22	CAPSCREW M12x30 8.8-A3C ISO 4762
24	GUIDE
25	WASHER 10 300HV-A3C ISO 7090
26	WASHER 12 140HV-A3C ISO 7090
27	SPACER
28	CAPSCREW M12x25 8.8-A3C DIN 79
29	HEX HEAD SCREW M20X60 8.8
30	NUT M20 04-A3C IS
31	LOCKING UNIT TELE 4
32	LOCKING UNIT TELE 4
33	RETAINING RING 125X4 SPRING ST
34	WEAR PAD
35	PLATE
36	CAPSCREW M6x25 8.8-A2C ISO 4762
37	SHIM
38	WEAR PAD

Table 4-2 Telescope Section 4 (Figure 4-12) (Continued)

Item	Description
39	PLATE
40	PLATE
41	WEAR PAD
42	PLATE
43	PLATE
44	GUIDE PILOT
45	SLIDER
46	FILL PLATE
47	FILL PLATE
48	WEAR PAD
49	PLATE
50	CAPSCREW M10x50 SS DIN 7984
51	CAPSCREW M10x30 8.8-A3C ISO 4017
52	NUT M10 8-A3C ISO 7040
53	NUT M12 8-A3C ISO 7040
54	CAPSCREW M12X45 8.8-A3C ISO 4762
55	CAPSCREW M12x20 8.8-A3C DIN 79
56	CAPSCREW M12x40 8.8-A3C DIN 79
57	CAPSCREW M12x30 8.8-A3C ISO 7984
58	ADAPTER M10x1M10x
59	STRAIGHT PIPE UNION
60	LUBRICANT HOSE
61	PIPE UNION M12x1
62	NUT M12x1.5 5 DIN 80705
63	INSERT
101	SHIM
102	SHIM
103	SHIM
104	SHIM
105	SHIM
108	SHIM
109	SHIM
110	SHIM
111	SHIM
112	SHIM
113	SHIM
114	SHIM

Table 4-2 Telescope Section 4 (Figure 4-12) (Continued)

Item	Description
115	SHIM
116	SHIM
117	SHIM
119	SHIM
120	SHIM
121	SHIM
122	SHIM
123	SHIM
124	SHIM
125	SHIM
126	SHIM
127	SHIM
128	SHIM
129	SHIM
130	SHIM
132	SHIM
133	SHIM
134	SHIM
135	SHIM
136	SHIM
137	SPACER
138	SPACER
140	PLATE
141	PLATE
142	PLATE
143	CAPSCREW M12x25 8.8-A3C DIN 79
144	WEAR PAD
145	WEAR PAD
146	WEAR PAD
147	PLATE
148	PLATE
149	GUIDE PILOT
150	GUIDE PILOT
151	GUIDE PILOT
153	GUIDE PILOT
154	GUIDE PILOT
155	CAPSCREW M12x20 -8.8 ISO 4762
156	CAPSCREW M12x35 8.8-A3C ISO 4762
160	SLIDER
500	WEAR PADS TELESCOPE 4

Telescope Section 4 Assembly

Refer to Figure 4-12 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 shims (11), holders (8) and wear pads (5, 6, 7) can be installed.
2. Install the hexagon head screws (29) and hexagon thin nuts (30).
3. Install the spacers (27).
4. Secure the shims and wear pads in place with the plates (14, 15).
5. Lower tele 5.
6. Install the wear pads (3, 4).
7. Install the shims (10).
8. Secure the shims and wear pads with the plates (12, 13).
9. Install the rope protection bar (2).
10. Install the guide (24).
11. On the opposite end of tele 4, install sliders (45) and fill plates (46, 47).
12. Install wear pads (48) and plates (49).
13. Install wear pads (41) and plates (39, 40).
14. Install the guide pilots (44).
15. Install the wear pads (38) and plates (39, 40).
16. Place the wear pad (34) on the section and insert shims (37) inside.
17. Secure the wear pad (34) with the plate (35).
18. Install the opposite wear pad (34), shims (37) and plate (35).
19. Assemble the lubrication hoses (60) and connect to the wear pads (34).
20. Attach the thin nuts (62) and pipe unions (59, 61) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (31, 32).
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 thiner sliders and wear pads.

24. Insert section 4 into section 3 half way.

Telescope Section 3 Assembly

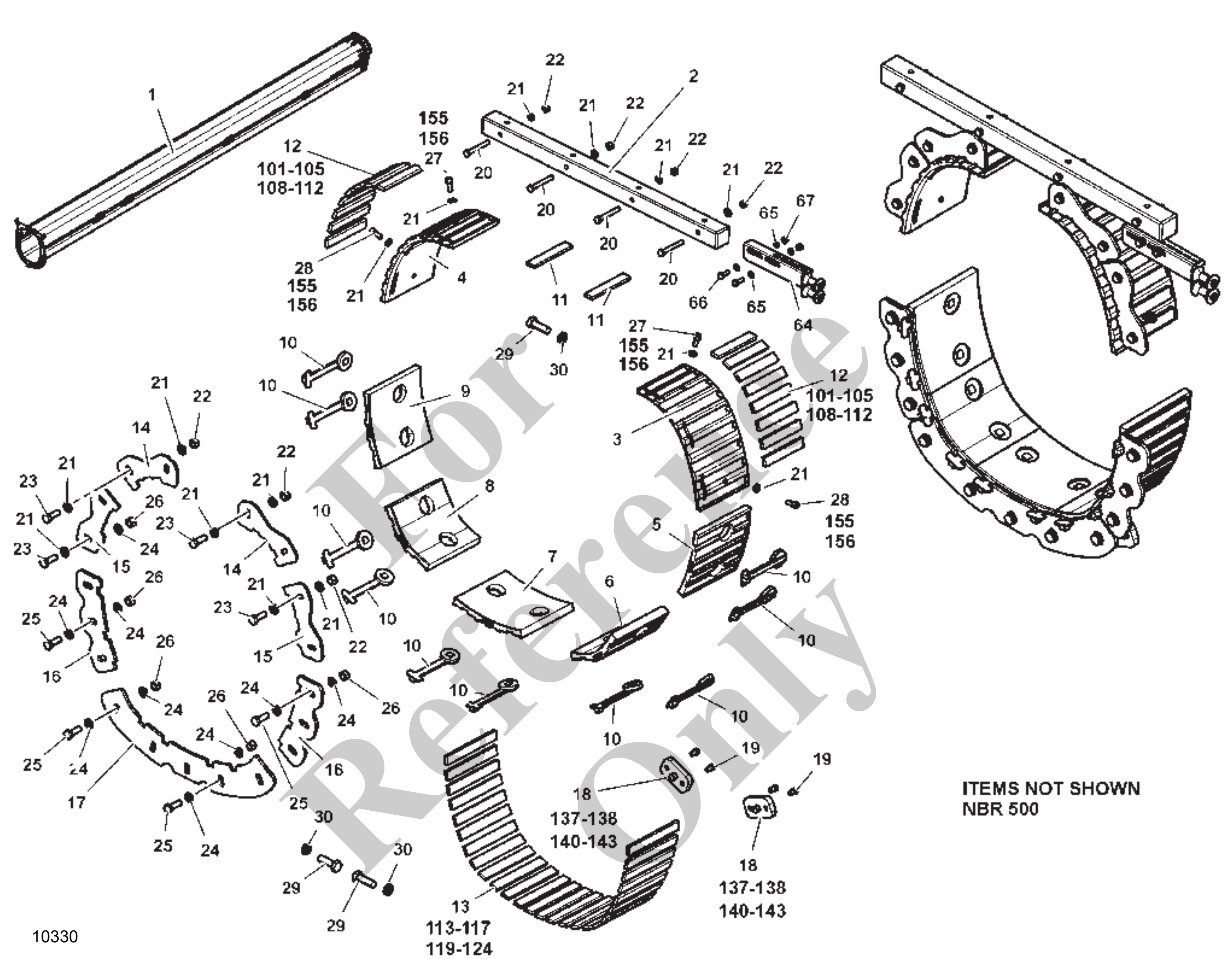


FIGURE 4-13

Telescope Section 3 Assembly (Continued)

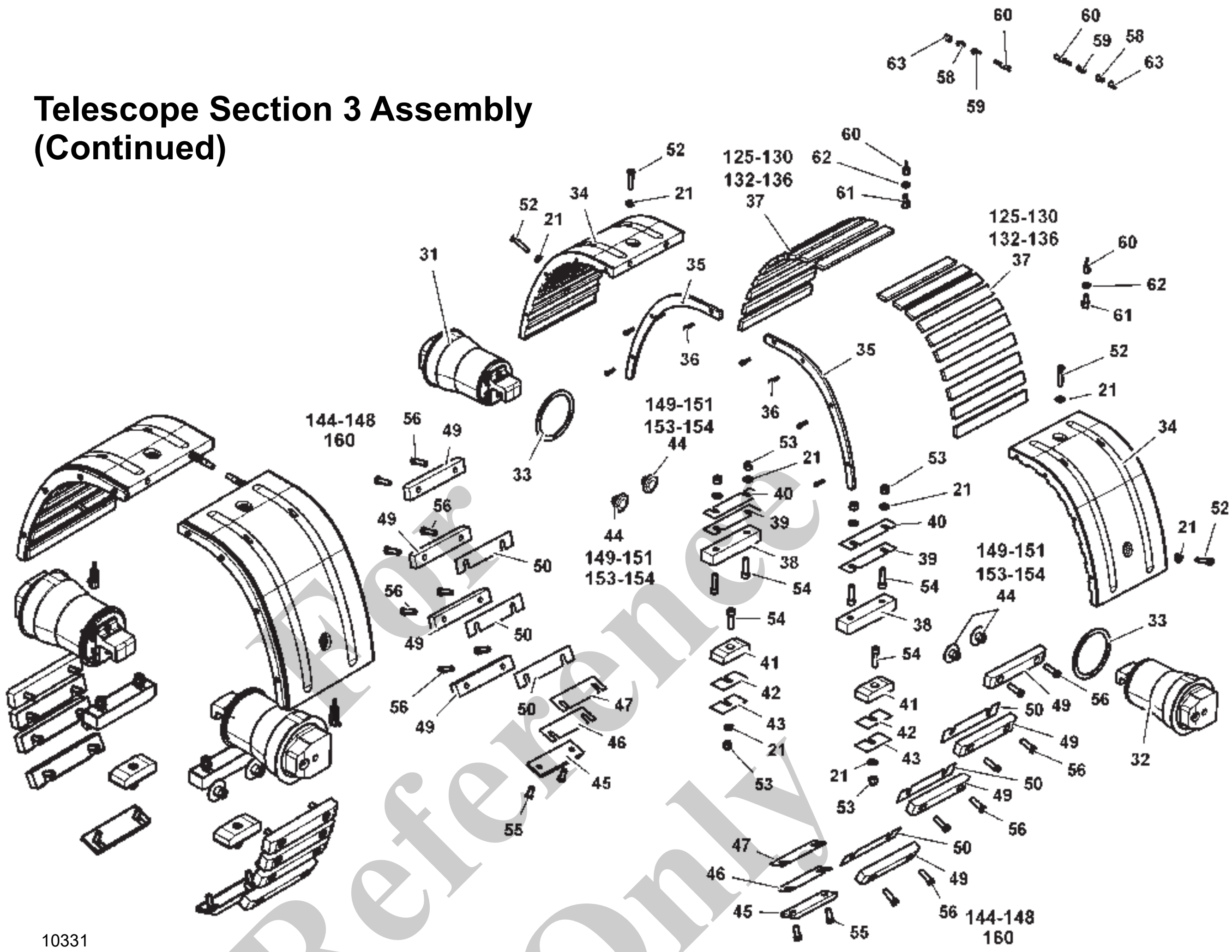


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FIGURE 4-13 continued

Table 4-3 Telescope Section 3 (Figure 4-13)

Item	Description
1	TELE 3 - WELDMENT
2	ROPE GUARD
3	WEAR PAD
4	WEAR PAD
5	WEAR PAD
6	WEAR PAD
7	WEAR PAD
8	WEAR PAD
9	WEAR PAD
10	HOLDER

Table 4-3 Telescope Section 3 (Figure 4-13) (Continued)

Item	Description
11	SHIM
12	SHIM
13	SHIM
14	PLATE
15	PLATE
16	PLATE
17	PLATE
18	SPACER
19	CAPSCREW M12x20 8.8-A3C DIN 79
20	CAPSCREW M12x90 -8.8 ISO 4014
21	WASHER 12 140HV-A3C ISO 7090

Table 4-3 Telescope Section 3 (Figure 4-13) (Continued)

Item	Description
22	NUT M12 8-A3C ISO 4032
23	CAPSCREW M12X40 8.8-A3C ISO 4017
24	WASHER 16 140HV-A3C ISO 7090
25	CAPSCREW M16X45 8.8-A3C ISO 4017
26	NUT M16 8-A3C ISO 4032
27	CAPSCREW M12x25 -8.8 ISO 4762
28	CAPSCREW M12x30 8.8-A3C ISO 4762
29	HEX HEAD SCREW M20X60 8.8-
30	NUT M20 04-A3C IS
31	LOCKING UNIT TELE 3
32	LOCKING UNIT TELE 3
33	RETAINING RING 125X4 SPRING ST
34	WEAR PAD
35	PLATE
36	CAPSCREW M6x25 8.8-A2C ISO 4762
37	SHIM
38	WEAR PAD
39	PLATE
40	PLATE
41	WEAR PAD
42	PLATE
43	PLATE
44	GUIDE PILOT
45	SLIDER
46	FILL PLATE
47	FILL PLATE
49	WEAR PAD
50	PLATE
52	CAPSCREW M10x50 SS DIN 7984
53	NUT M12 8-A3C ISO 7040
54	CAPSCREW M12X45 8.8-A3C ISO 4762
55	CAPSCREW M12x30 8.8-A3C ISO 7984
56	CAPSCREW M12x40 8.8-A3C DIN 79
58	ADAPTER 304-19509-1 M10x1/M10x
59	STRAIGHT PIPE UNION
60	LUBRICANT HOSE
61	PIPE UNION SV-06L/SW17 M12x1

Table 4-3 Telescope Section 3 (Figure 4-13) (Continued)

Item	Description
62	NUT M12x1.5 5 DIN 80705
63	INSERT
64	GUIDE
65	WASHER 10 300HV-A3C ISO 7090
66	CAPSCREW M10x30 8.8-A3C ISO 4017
67	NUT M10 8-A3C ISO 7040
101	SHIM
102	SHIM
103	SHIM
104	SHIM
105	SHIM
108	SHIM
109	SHIM
110	SHIM
111	SHIM
112	SHIM
113	SHIM
114	SHIM
115	SHIM
116	SHIM
117	SHIM
119	SHIM
120	SHIM
121	SHIM
122	SHIM
123	SHIM
124	SHIM
125	SHIM
126	SHIM
127	SHIM
128	SHIM
129	SHIM
130	SHIM
132	SHIM
133	SHIM
134	SHIM
135	SHIM

Table 4-3 Telescope Section 3 (Figure 4-13) (Continued)

Item	Description
136	SHIM
137	SPACER
138	SPACER
140	PLATE
141	PLATE
142	PLATE
143	CAPSCREW M12x25 8.8-A3C DIN 79
144	WEAR PAD
145	WEAR PAD
146	WEAR PAD
147	PLATE
148	PLATE
149	GUIDE PILOT
150	GUIDE PILOT
151	GUIDE PILOT
153	GUIDE PILOT
154	GUIDE PILOT
155	CAPSCREW M12x20 -8.8 ISO 4762
156	CAPSCREW M12x35 8.8-A3C ISO 4762
160	SLIDER
500	WEAR PADS TELESCOPE 3

Telescope Section 3 Assembly

Refer to Figure 4-13 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 shims (13), holders (10), and wear pads (5, 6, 7, 8, 9) can be installed.
2. Install the hexagon head screws (29) and hexagon thin nuts (30).
3. Install the spacers (18).
4. Secure the shims and wear pads in place with the plates (16, 17).
5. Lower tele 4.
6. Install the wear pads (3, 4).
7. Install the shims (11, 12).
8. Secure the shims and wear pads with the plates (14, 15).
9. Install the rope protection bar (2).
10. Install the guide (64).
11. On the opposite end of tele 3, install sliders (45) and fill plates (46, 47).
12. Install wear pads (49) and plates (50).
13. Install sliders (41) and plates (39, 40).
14. Install the guide pilots (44).
15. Install the wear pads (38) and plates (39, 40).
16. Place the wear pad (34) on the section and insert nine shims (37) inside.
17. Secure the wear pad (34) with the plate (35).
18. Install the opposite wear pad (34), shims (37) and plate (35).
19. Assemble the lubrication hoses (60) and connect to the wear pads (34).
20. Attach the thin nuts (62) and pipe unions (59, 61) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (31, 32).
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 thiner sliders and wear pads.
23. Insert section 3 into section 2 half way.

Telescope Section 2 Assembly

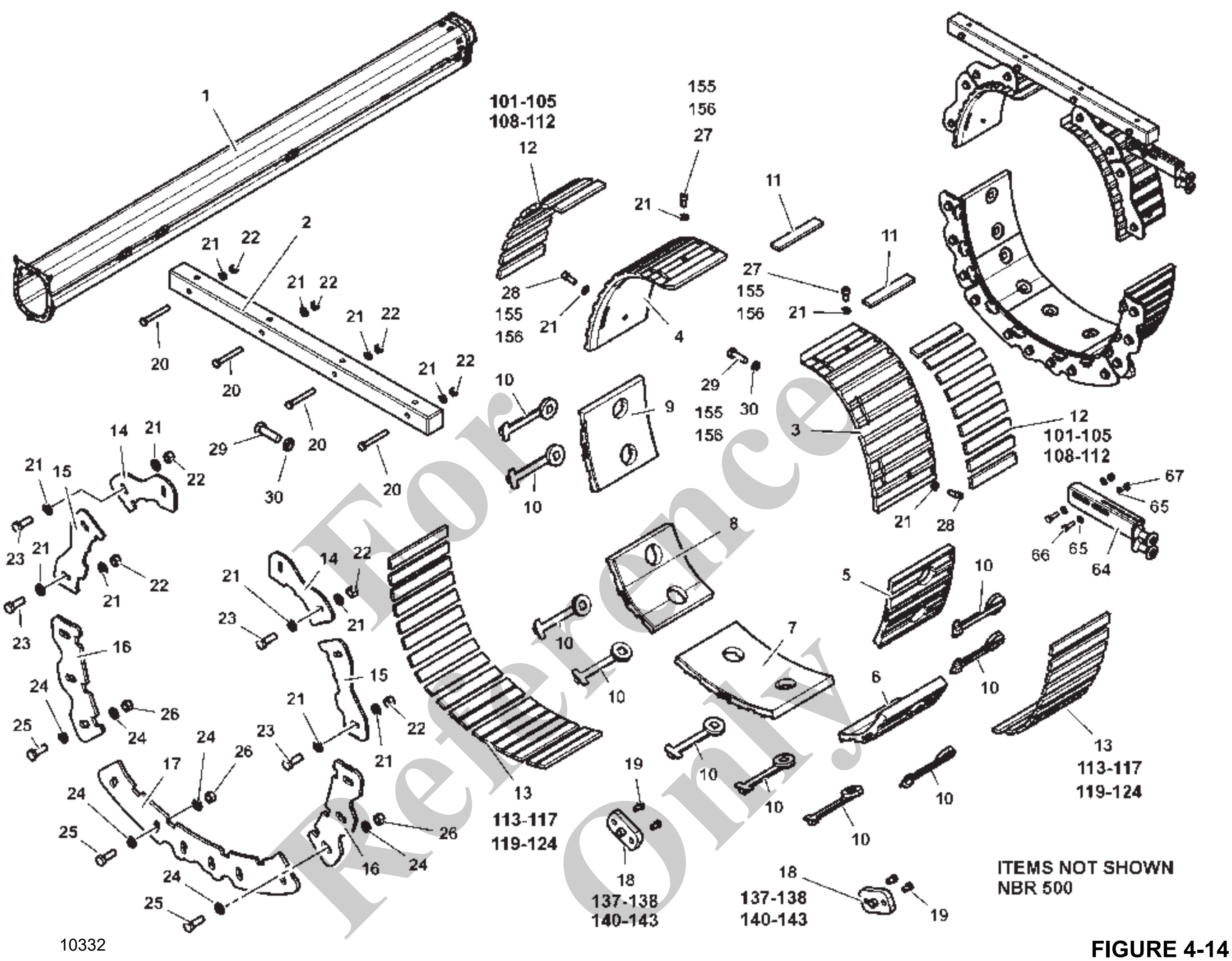

FIGURE 4-14

Telescope Section 2 Assembly (Continued)

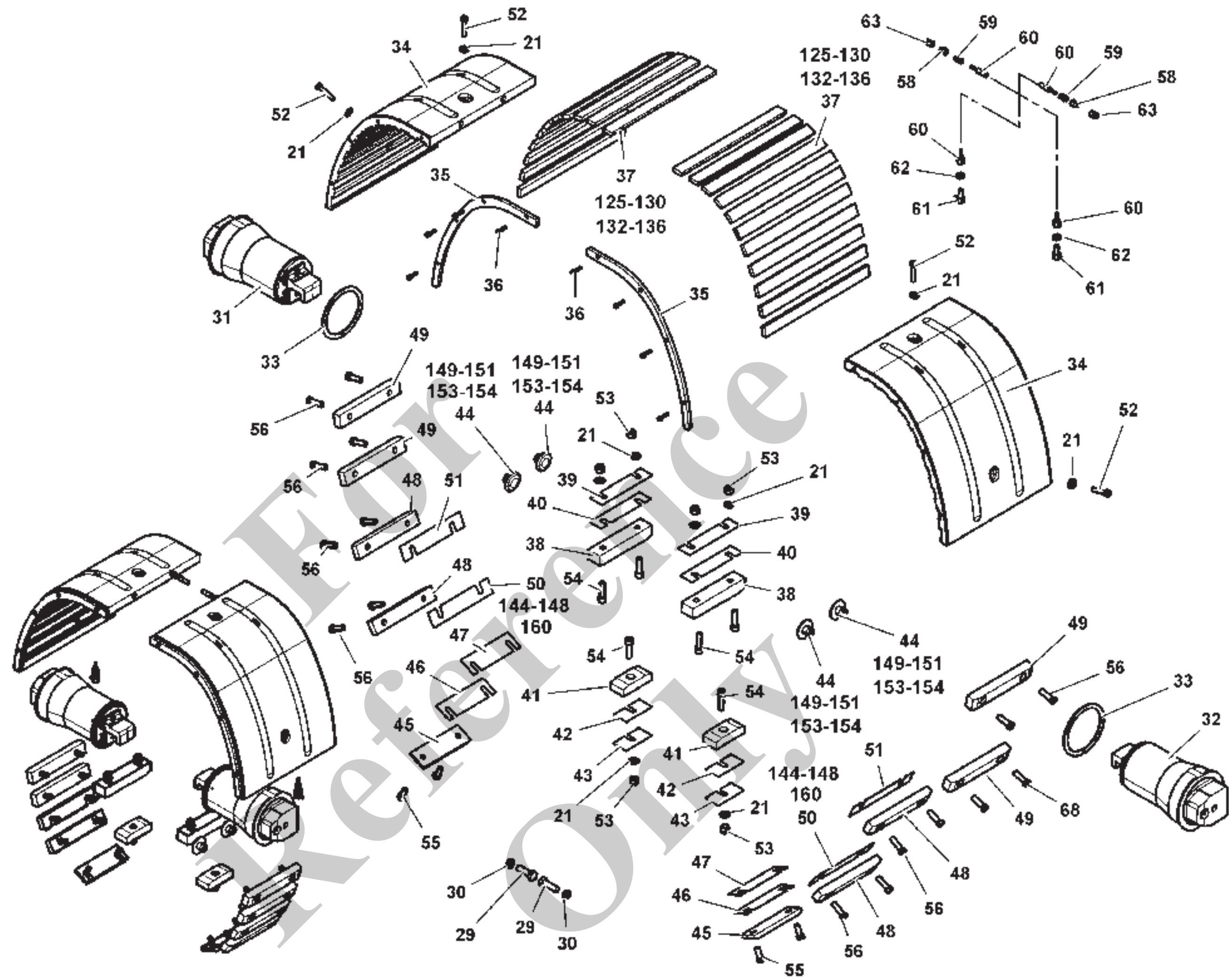

FIGURE 4-14 continued

Table 4-4 Telescope Section 2 (Figure 4-14)

Item	Description
1	TELE-2 WELDMENT
2	ROPE GUARD
3	WEAR PAD
4	WEAR PAD
5	WEAR PAD
6	WEAR PAD

Table 4-4 Telescope Section 2 (Figure 4-14) (Continued)

Item	Description
7	WEAR PAD
8	WEAR PAD
9	WEAR PAD
10	HOLDER
11	SHIM
12	SHIM
13	SHIM

Table 4-4 Telescope Section 2 (Figure 4-14) (Continued)

Item	Description
14	PLATE
15	PLATE
16	PLATE
17	PLATE
18	SPACER
19	CAPSCREW M12x20 8.8-A3C DIN 79
20	CAPSCREW M12x90 -8.8 ISO 4014
21	WASHER 12 140HV-A3C ISO 7090
22	NUT M12 8-A3C ISO 4032
23	CAPSCREW M12X40 8.8-A3C ISO 4017
24	WASHER 16 140HV-A3C ISO 7090
25	CAPSCREW M16X45 8.8-A3C ISO 4017
26	NUT M16 8-A3C ISO 4032
27	CAPSCREW M12x25 -8.8 ISO 4762
28	CAPSCREW M12x30 8.8-A3C ISO 4762
29	SCREW M20X60 8.8-
30	NUT M20 04-A3C IS
31	LOCKING UNIT TELE 2
32	LOCKING UNIT TELE 2
33	RETAINING RING 125X4 SPRING ST
34	WEAR PAD
35	PLATE
36	CAPSCREW M6x25 8.8-A2C ISO 4762
37	STRIP
38	WEAR PAD
39	PLATE
40	PLATE
41	WEAR PAD
42	PLATE
43	PLATE
44	GUIDE PILOT
45	SLIDER
46	FILL PLATE
47	FILL PLATE
48	WEAR PAD
49	WEAR PAD
50	PLATE

Table 4-4 Telescope Section 2 (Figure 4-14) (Continued)

Item	Description
51	PLATE
52	CAPSCREW M10x50 SS DIN 7984
53	NUT M12 8-A3C ISO 7040
54	CAPSCREW M12X45 8.8-A3C ISO 4762
55	CAPSCREW M12x30 8.8-A3C ISO 7984
56	CAPSCREW M12x40 8.8-A3C DIN 79
58	ADAPTER M10x1/M10x
59	STRAIGHT PIPE UNION
60	LUBRICANT HOSE
61	PIPE UNION SV-06L/SW17 M12x1
62	NUT M12x1.5 5 DIN 80705
63	INSERT
64	GUIDE
65	WASHER 10 300HV-A3C ISO 7090
66	CAPSCREW M10x30 8.8-A3C ISO 4017
67	NUT M10 8-A3C ISO 7040
101	SHIM
102	SHIM
103	SHIM
104	SHIM
105	SHIM
108	SHIM
109	SHIM
110	SHIM
111	SHIM
112	SHIM
113	SHIM
114	SHIM
115	SHIM
116	SHIM
117	SHIM
119	SHIM
122	SHIM
125	SHIM
128	SHIM
132	SHIM
135	SHIM

Table 4-4 Telescope Section 2 (Figure 4-14) (Continued)

Item	Description
138	SPACER
142	PLATE
145	WEAR PAD
148	PLATE
151	GUIDE PILOT
155	CAPSCREW M12x20 -8.8 ISO 4762
500	WEAR PADS TELESCOPE 2

Telescope Section 2 Assembly

Refer to Figure 4-14 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 shims (13), holders (10), and wear pads (5, 6, 7, 8, 9) can be installed.
2. Install the hexagon head screws (29) and hexagon thin nuts (30).
3. Install the spacers (18).
4. Secure the shims and wear pads in place with the plates (16, 17).
5. Lower tele 3.
6. Install the wear pads (3, 4).
7. Install the shims (11, 12).
8. Secure the shims and wear pads with the plates (14, 15).
9. Install the rope protection bar (2).
10. Install the guide (64).
11. On the opposite end of tele 2, install sliders (45) and fill plates (46, 47).
12. Install wear pads (48, 49) and plates (50, 51).
13. Install sliders (41) and plates (42, 43).
14. Install the guide pilots (44).
15. Install the wear pads (38) and plates (39, 40).
16. Place the wear pad (34) on the section and insert strips (37) inside.
17. Secure the wear pad (34) with the plate (35).
18. Install the opposite wear pad (34), strips (37) and plate (35).
19. Assemble the lubrication hoses (60) and connect to the wear pads (34).
20. Attach the thin nuts (62) and pipe unions (59, 61) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (31, 32).
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 thiner sliders and wear pads.
23. Insert section 2 into section 1 half way.

Telescope Section 1 Assembly

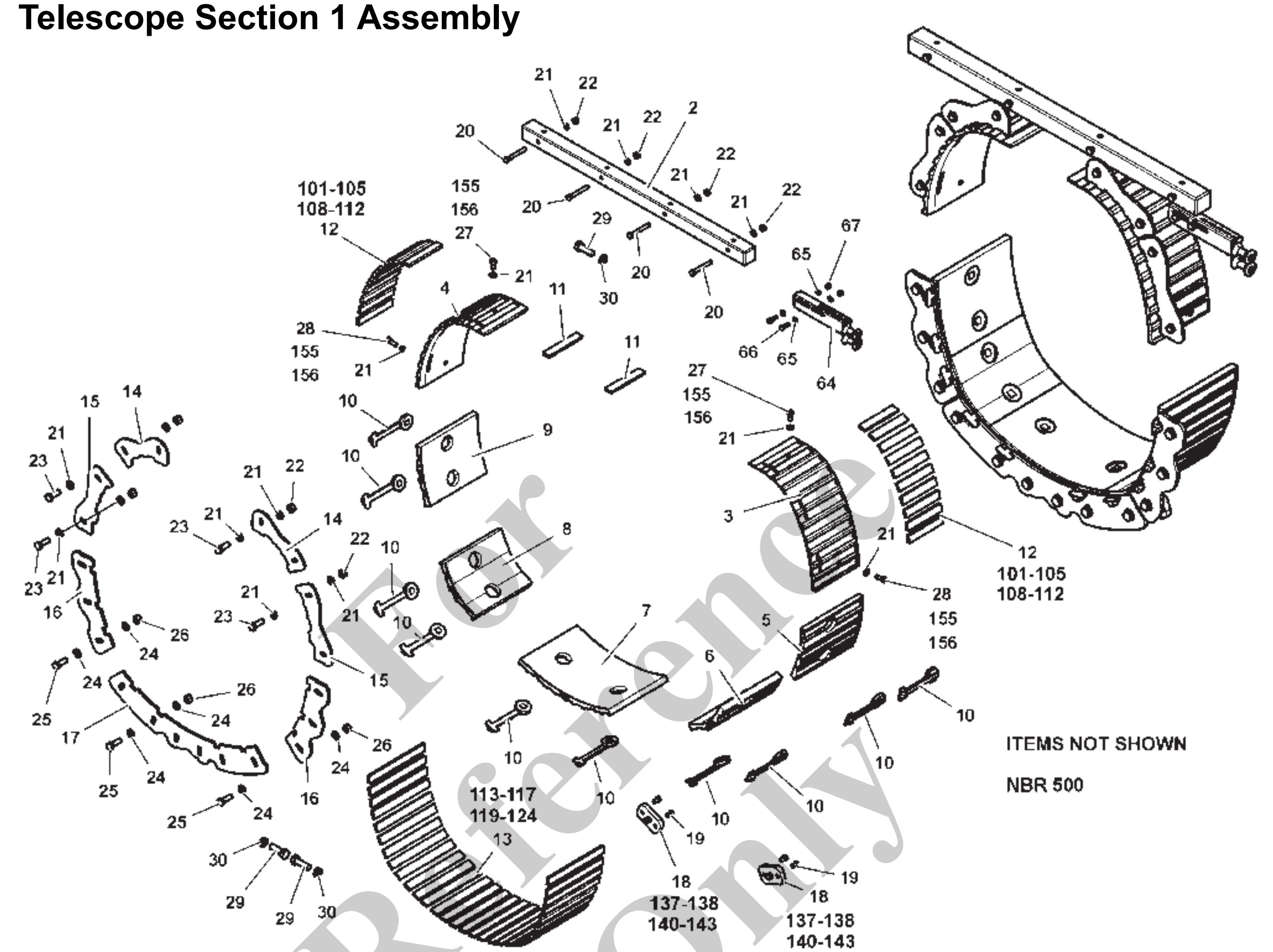

FIGURE 4-15

Telescope Section 1 Assembly (Continued)

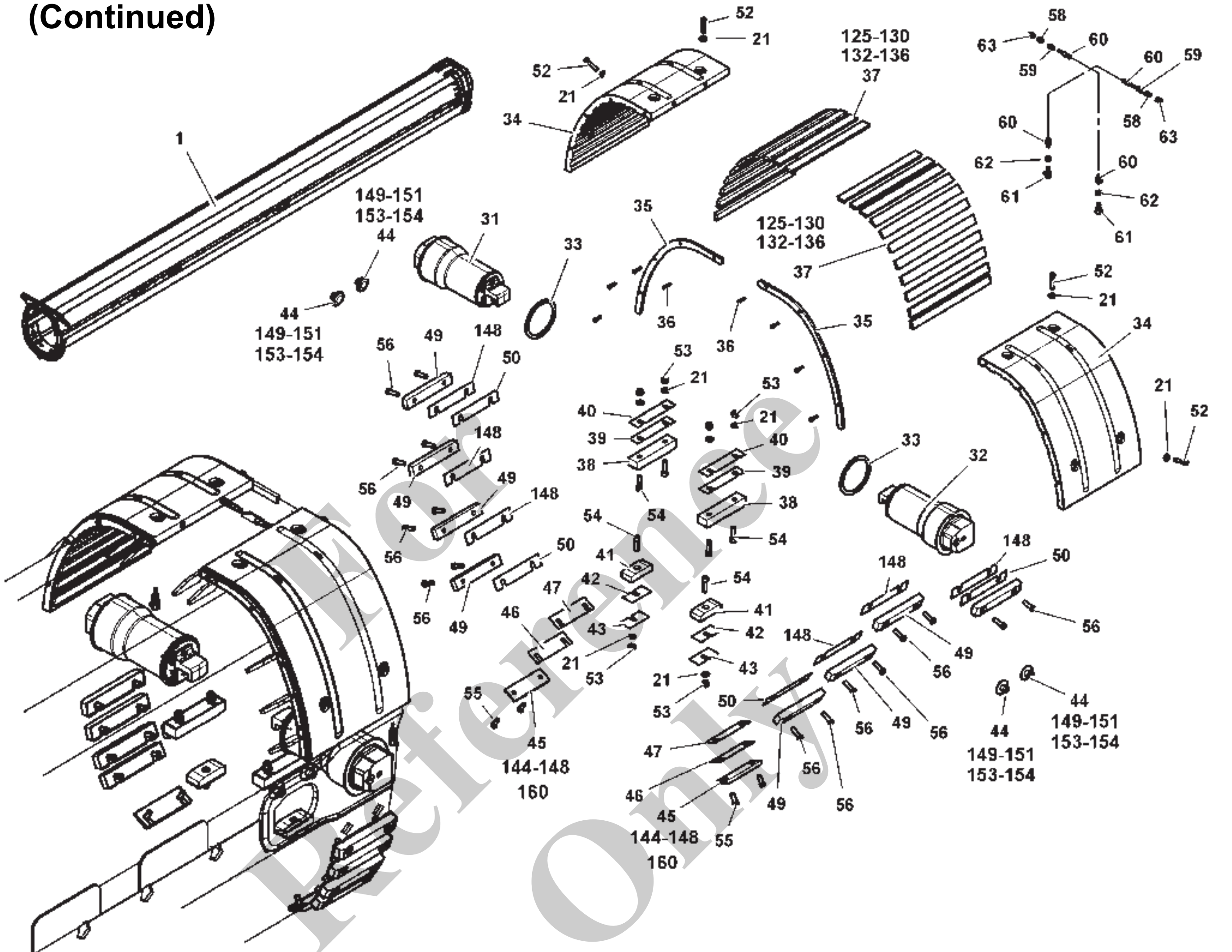

FIGURE 4-15 continued

Table 4-5 Telescope Section 1 (Figure 4-15)

Item	Description
1	TELE-1 WELDMENT
2	ROPE GUARD
3	WEAR PAD
4	WEAR PAD
5	WEAR PAD
6	WEAR PAD
7	WEAR PAD
8	WEAR PAD
9	WEAR PAD

Table 4-5 Telescope Section 1 (Figure 4-15) (Continued)

Item	Description
10	HOLDERS
11	SHIM
12	SHIM
13	STRIP
14	PLATE
15	PLATE
16	PLATE
17	PLATE
18	SPACER
19	CAPSCREW M12x20 8.8-A3C DIN 79

Table 4-5 Telescope Section 1 (Figure 4-15) (Continued)

Item	Description
20	CAPSCREW M12x90 -8.8 ISO 4014
21	WASHER 12 140HV-A3C ISO 7090
22	NUT M12 8-A3C ISO 4032
23	CAPSCREW M12X40 8.8-A3C ISO 4017
24	WASHER 16 140HV-A3C ISO 7090
25	CAPSCREW M16X45 8.8-A3C ISO 4017
26	NUT M16 8-A3C ISO 4032
27	CAPSCREW M12x25 -8.8 ISO 4762
28	CAPSCREW M12x30 8.8-A3C ISO 4762
29	SCREW M20X60 8.8-
30	NUT M20 04-A3C IS
31	LOCKING UNIT TELE 1
32	LOCKING UNIT TELE 1
33	RETAINING RING 125X4 SPRING ST
34	WEAR PAD
35	PLATE
36	CAPSCREW M6x25 8.8-A2C ISO 4762
37	STRIP
38	WEAR PAD
39	PLATE
40	PLATE
41	WEAR PAD
42	PLATE
43	PLATE
44	GUIDE PILOT
45	SLIDER
46	FILL PLATE
47	FILL PLATE
49	WEAR PAD
50	PLATE
51	PLATE
52	CAPSCREW M10x50 SS DIN 7984
53	NUT M12 8-A3C ISO 7040
54	CAPSCREW M12X45 8.8-A3C ISO 4762
55	CAPSCREW M12x30 8.8-A3C ISO 7984
56	CAPSCREW M12x40 8.8-A3C DIN 79
58	ADAPTER M10x1M10x

Table 4-5 Telescope Section 1 (Figure 4-15) (Continued)

Item	Description
59	STRAIGHT PIPE UNION
60	LUBRICANT HOSE
61	PIPE UNION SV-06LSW17 M12x1
62	NUT M12x1.5 5 DIN 80705
63	INSERT
64	GUIDE
65	WASHER 10 300HV-A3C ISO 7090
66	CAPSCREW M10x30 8.8-A3C ISO 4017
67	NUT M10 8-A3C ISO 7040
101	SHIM
102	SHIM
103	SHIM
104	SHIM
105	SHIM
108	SHIM
109	SHIM
110	SHIM
111	SHIM
112	SHIM
113	SHIM
114	SHIM
115	SHIM
116	SHIM
117	SHIM
119	SHIM
120	SHIM
121	SHIM
122	SHIM
123	SHIM
124	SHIM
125	SHIM
126	SHIM
127	SHIM
128	SHIM
129	SHIM
130	SHIM
132	SHIM

Table 4-5 Telescope Section 1 (Figure 4-15) (Continued)

Item	Description
133	SHIM
134	SHIM
135	SHIM
136	SHIM
137	SPACER
138	SPACER
140	PLATE
141	PLATE
142	PLATE
143	CAPSCREW M12x25 8.8-A3C DIN 79
144	WEAR PAD
145	WEAR PAD
146	WEAR PAD
147	PLATE
148	PLATE
149	GUIDE PILOT
150	GUIDE PILOT
151	GUIDE PILOT
153	GUIDE PILOT
154	GUIDE PILOT
155	CAPSCREW M12x20 -8.8 ISO 4762
156	CAPSCREW M12x35 8.8-A3C ISO 4762
160	SLIDER
500	WEAR PADS TELESCOPE 1

Telescope Section 1 Assembly

Refer to Figure 4-15 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 (13), holders (8, 9), and wear pads (5, 6, 7, 8, 9) can be installed.
2. Install the hexagon head screws (29) and hexagon thin nuts (30).
3. Install the spacers (18).
4. Secure the strips and wear pads in place with the plates (16, 17).
5. Lower tele 2.
6. Install the wear pads (3, 4).
7. Install the shims (11, 12).
8. Secure the strips and wear pads with the plates (14, 15).
9. Install the rope protection bar (2).
10. Install the guide (64).
11. On the opposite end of tele 1, install sliders (45) and fill plates (46, 47).
12. Install wear pads (49) and plates (50, 148).
13. Install wear pads (41) and plates (42, 43).
14. Install the guide pilots (44).
15. Install the wear pads (38) and plates (39, 40).
16. Place the wear pad (34) on the section and insert strips (37) inside.
17. Secure the wear pad (34) with the plate (35).
18. Install the opposite wear pad (34), strips (37) and plate (35).
19. Assemble the lubrication hoses (60) and connect to the wear pads (34).
20. Attach the nuts (62) and pipe unions (59, 61) to the lubrication hoses and secure the hoses to the tabs inside the section.
21. Install the locking unit assemblies (31, 32).
22. Insert the telescope cylinder assembly into section 1.
23. Install the tele power cable strain relief (2, Figure 4-10).
24. Install the tele power plug (1).
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 thiner sliders and wear pads.
26. Insert section 1 into the base section half way.

Base Telescope Section Assembly

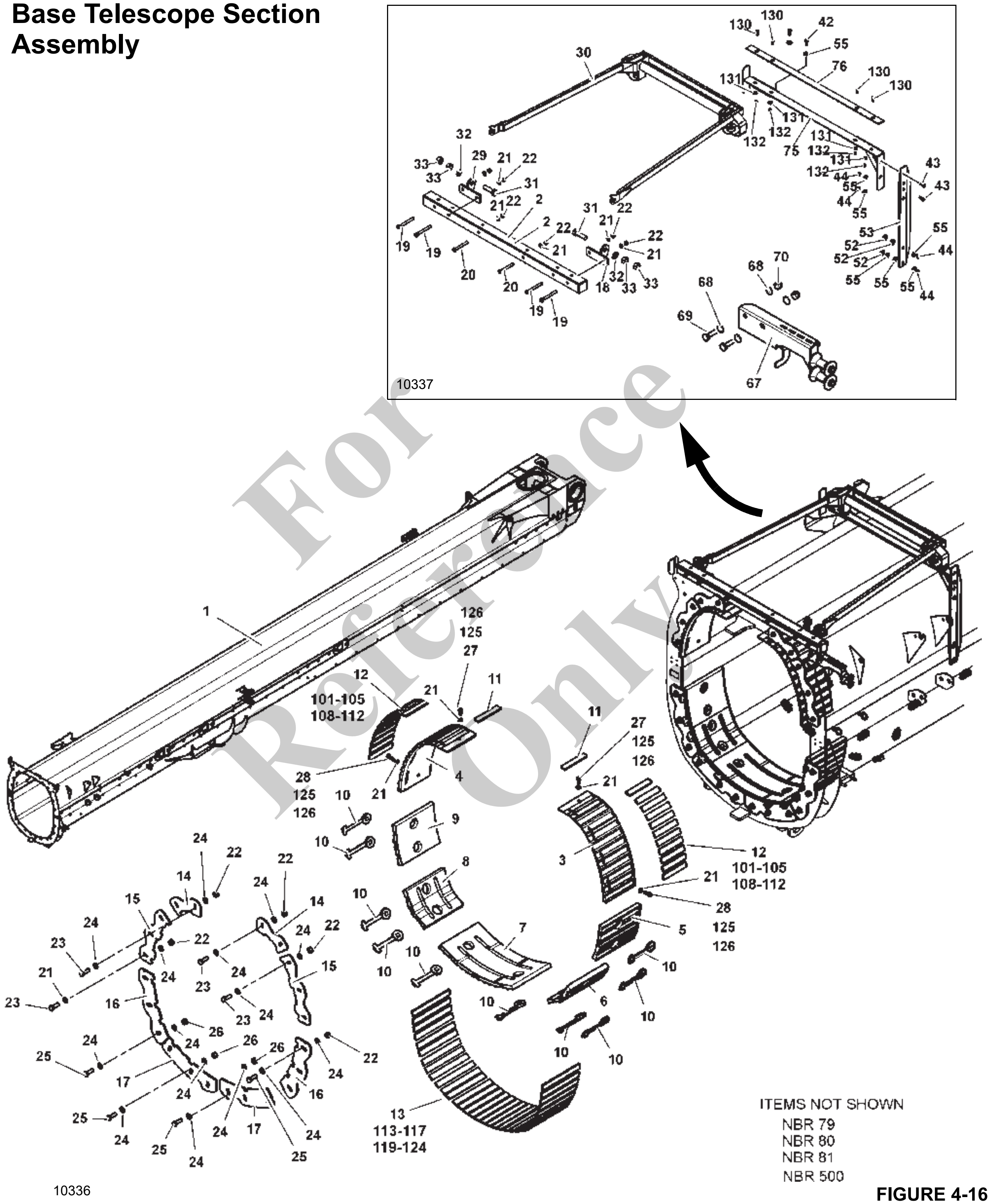

FIGURE 4-16

Base Telescope Section Assembly (Continued)

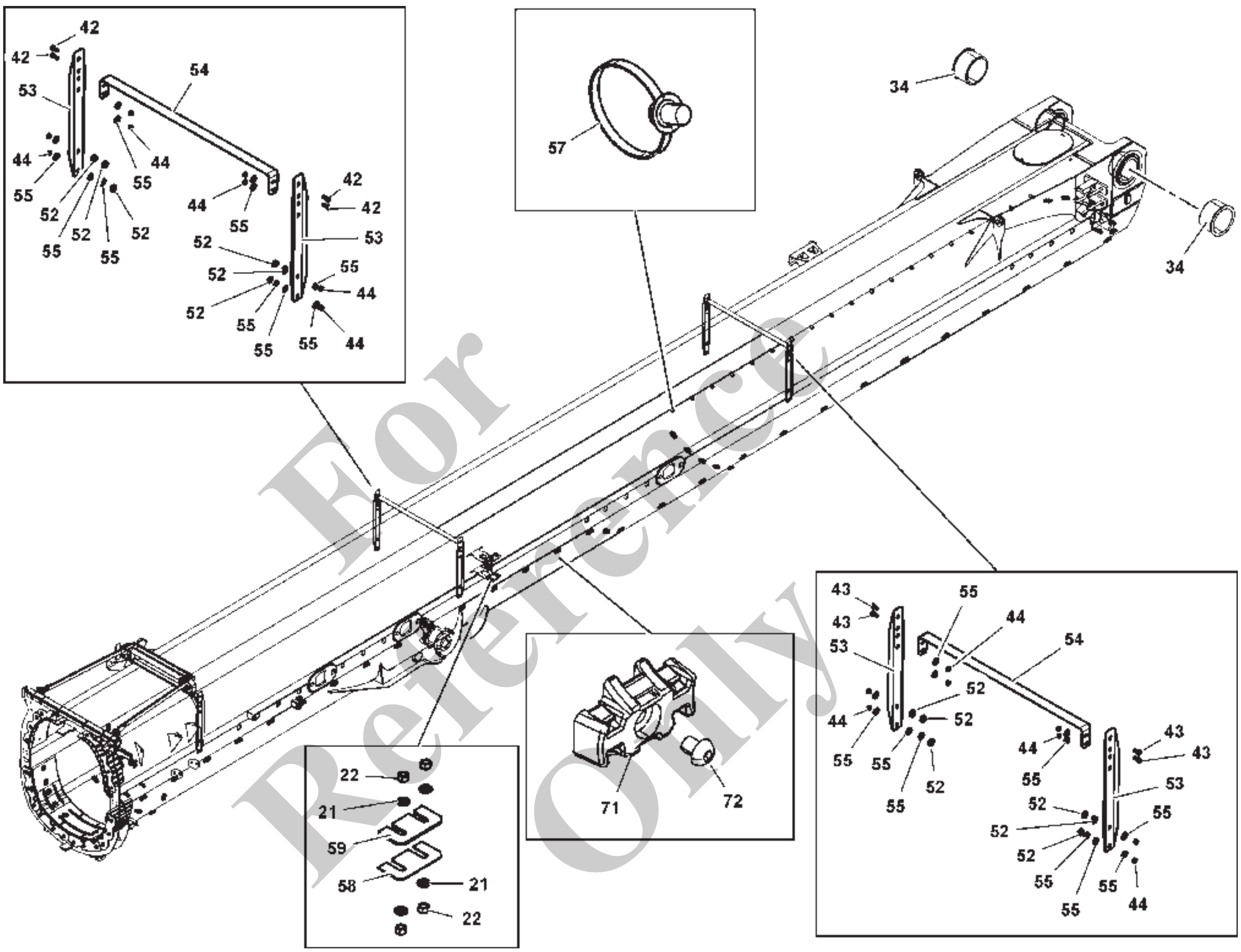

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FIGURE 4-16 continued

Base Telescope Section Assembly (Continued)

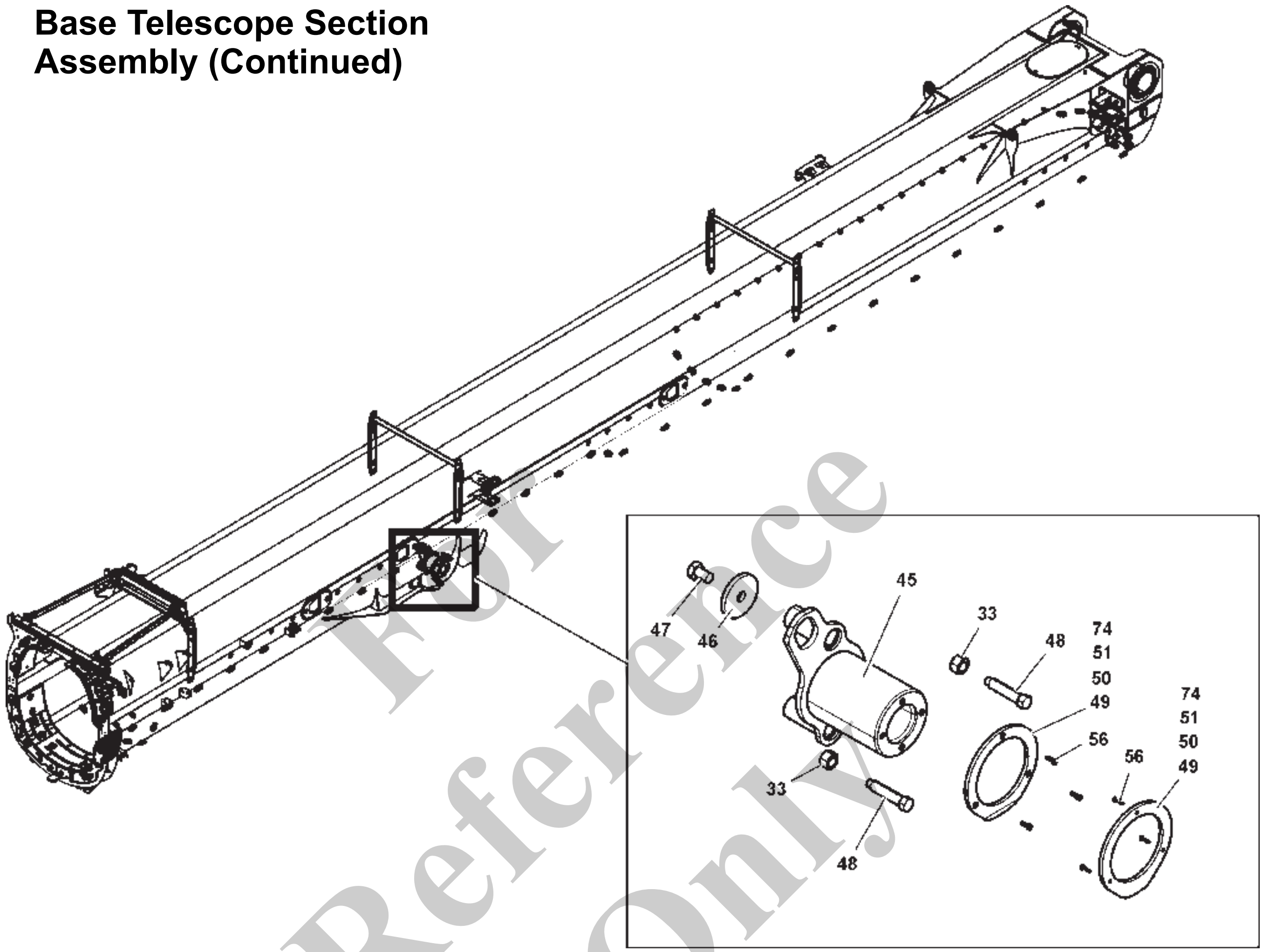

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FIGURE 4-16 continued

Base Telescope Section Assembly (Continued)

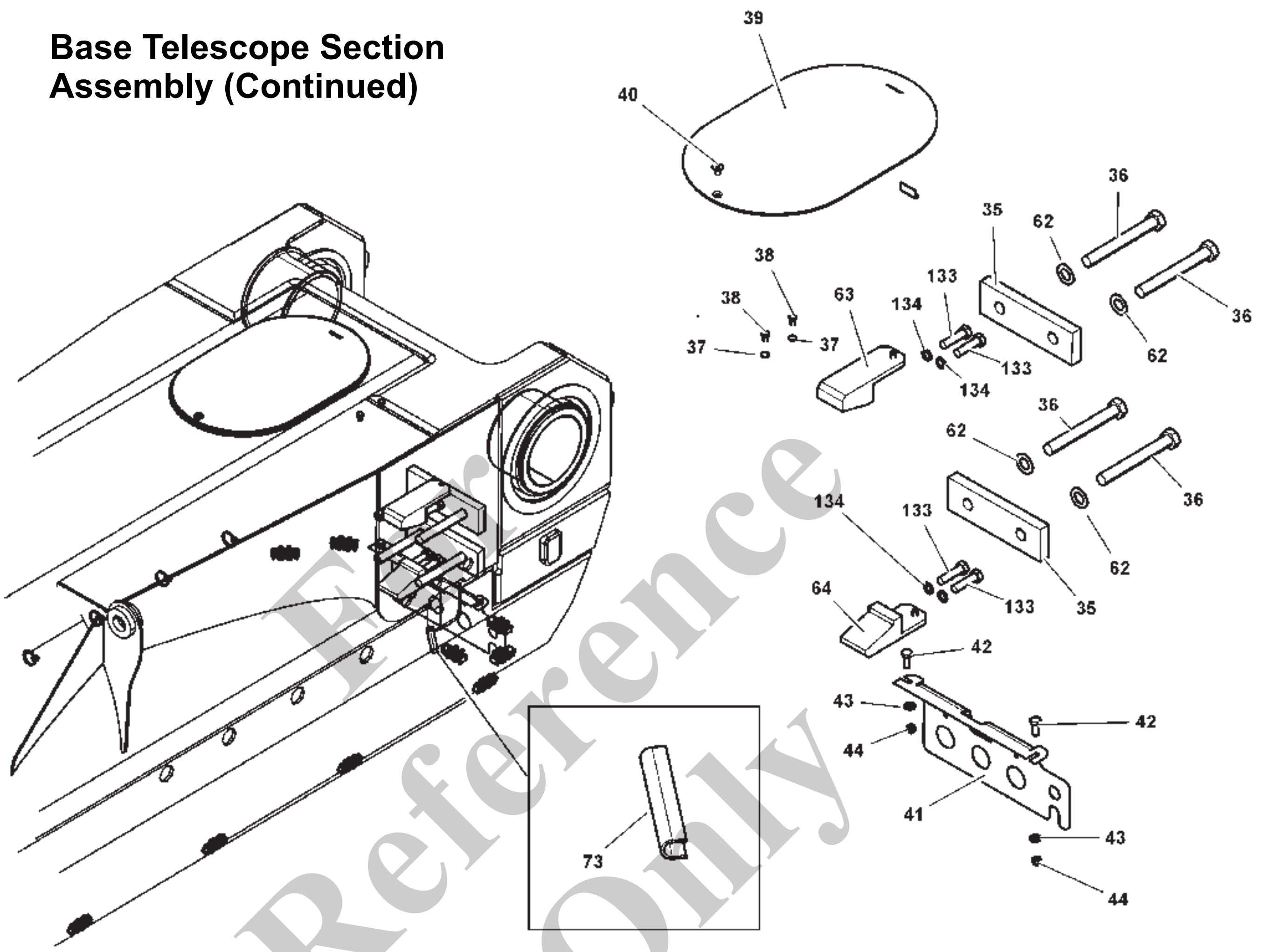


FIGURE 4-16 continued

Table 4-6 Base Section (Figure 4-16)

Item	Description
1	BASE SECTION - WELDMENT
2	ROPE PROTECTION
3	WEAR PAD
4	WEAR PAD
5	WEAR PAD
6	WEAR PAD
7	WEAR PAD
8	WEAR PAD
9	WEAR PAD
10	HOLDERS

Table 4-6 Base Section (Figure 4-16) (Continued)

Item	Description
11	SHIM
12	SHIM
13	STRIP
14	PLATES
15	PLATES
16	PLATES
17	PLATES
18	BRACKET
19	BOLT M12X100 8.8-
20	CAPSCREW M12x90 -8.8 ISO 4014
21	WASHER 12 140HV-A3C ISO 7090

Table 4-6 Base Section (Figure 4-16) (Continued)

Item	Description
22	NUT M12 8-A3C ISO 4032
23	CAPSCREW M12X40 8.8-A3C ISO 4017
24	WASHER 16 140HV-A3C ISO 7090
25	CAPSCREW M16X45 8.8-A3C ISO 4017
26	NUT M16 8-A3C ISO 4032
27	CAPSCREW M12x25 -8.8 ISO 4762
28	CAPSCREW M12x35 8.8-A3C ISO 4762
29	BRACKET
30	STIRRUP ASSY
31	SCREW M20X65 8.8-
32	WASHER 20 140HV-A3C ISO 7090
33	NUT M20 8-A3C ISO 4032
34	BUSHING
35	BAR
36	BOLT M24X195 10.9
37	WASHER 8 200HV-A2 ISO 7089
38	CAPSCREW M8x16 8.8-A2C ISO 4017
39	COVER
40	CAPSCREW M10x16 SS ISO 10642
41	PLATE
42	CAPSCREW M10X25 8.8-A3C ISO 4017
43	WASHER 10 200HV-A3C ISO 7092
44	NUT M10 8-A3C ISO 4032
45	AXLE
46	WASHER
47	CAPSCREW M20X30 10.9-FLZ ISO 4017
48	SET SCREW BM20X90 5.6
49	PLATE
50	PLATE
51	PLATE
52	WASHER 13 St-A3C DIN 7349
53	PLATE
54	PLATE
55	WASHER
56	CAPSCREW M6x20 -8.8 DIN 7984
57	CABLE CLIP
58	FILL PLATE

Table 4-6 Base Section (Figure 4-16) (Continued)

Item	Description
59	FILL PLATE
62	WASHER 24 ST-TZN EN 14399-6
63	WEDGE
64	WEDGE
67	GUIDE
68	WASHER 10 300HV-A3C ISO 7090
69	CAPSCREW M10x30 8.8-A3C ISO 4017
70	NUT M10 8-A3C ISO 7040
71	CABLE CLIP FOR HEAVY DUTY APPL
72	CAPSCREW M8x10 10.9 ISO7380
73	FLEXIBLE EDGE GUARD
74	PLATE
75	PLATE CABLE GUIDE
76	PLATE
79	SHIM RING
80	SHIM RING
81	SHIM RING
101	SHIM
102	SHIM
103	SHIM
104	SHIM
105	SHIM
108	SHIM
109	SHIM
110	SHIM
111	SHIM
112	SHIM
113	SHIM
114	SHIM
115	SHIM
116	SHIM
117	SHIM
119	SHIM
120	SHIM
121	SHIM
122	SHIM
123	SHIM

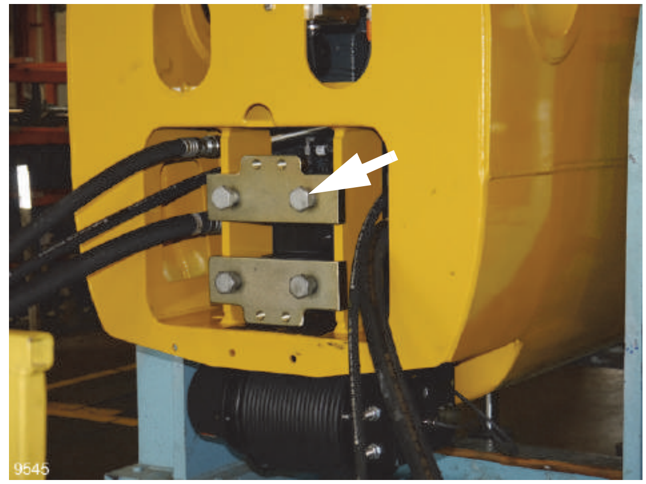
Table 4-6 Base Section (Figure 4-16) (Continued)

Item	Description
124	SHIM
125	CAPSCREW M12x20 -8.8 ISO 4762
126	CAPSCREW M12x30 8.8-A3C ISO 4762
130	CAPSCREW M8x25 8.8-A2C ISO 10642
131	WASHER 8 ST-A2C ISO 7093-1
132	NUT M8 8-A2C ISO 7040
133	CAPSCREW M16x60 -8.8 ISO 4017
134	SHIM RING 17X24X2 DIN 988
500	WEAR PADS BASIC MEMBER

Telescope Base Section Assembly

Refer to Figure 4-16 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 (13), holders (10), and wear pads (5, 6, 7, 8, 9) can be installed.
2. Secure the strips and wear pads in place with the plates (16, 17).
3. Lower tele 1.
4. Install the wear pads (3, 4).
5. Install the shims (11, 12).
6. Secure the strips, shims, and wear pads with the plates (14, 15).
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 4-17.
8. Secure the tele cylinder with the four cylinder retaining bolts (Figure 4-17) and two retaining plates.



9545 **FIGURE 4-17**

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 unscrewed 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.

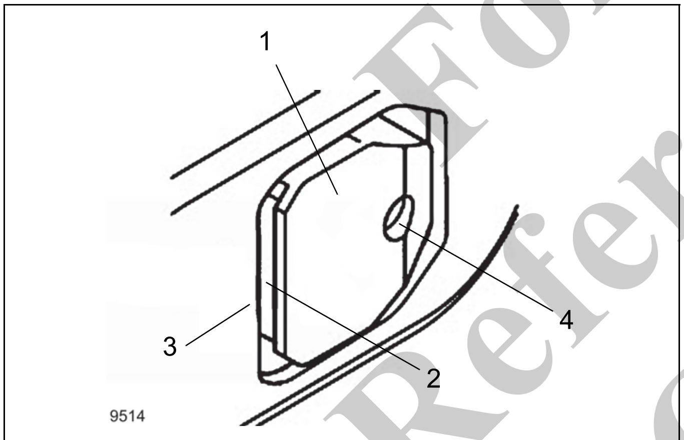
Or

- The main boom is lowered into a horizontal position so that the telescopic section is unable to retract independently.

Maintenance

For manual unlocking, two capscrews (M8x110 Grade 8.8) are supplied for all pins and sections You can only lock or unlock a telescopic section manually if the recess (2, Figure 4-18) in the locking pin (1) no longer engages in the telescopic section (3) 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) must be centered in the opening and the recess (2) may no longer engage in the telescopic section (3) above it.



9514 **FIGURE 4-18**

Unlocking Telescopic Sections

When unlocking sections start with Tele 5 (fly) and work your way in towards Tele 1 as far as possible. Unlock and lock only one section at a time.

1. Remove the grease fitting from the bore hole (4, Figure 4-18).
2. Insert a screw into the hole (4). The locking pin (1) 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) 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.

After 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 4-18) is in the middle of the opening.
2. Remove the screw from the bore hole (4). The locking pin (1) 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) have been set down on the telescopic section (3) above it.

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.

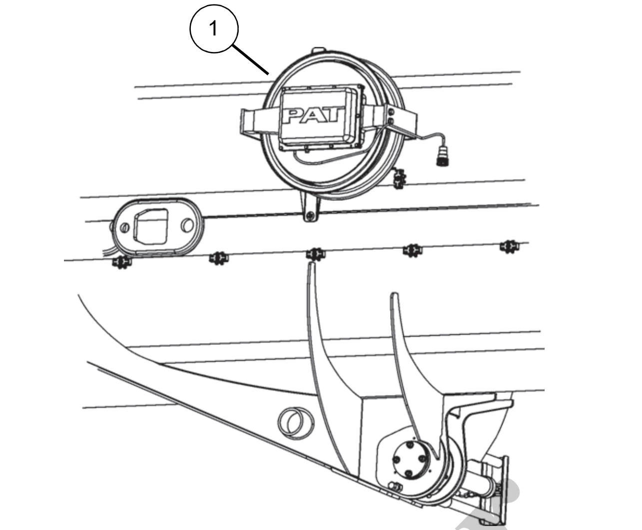
Your authorized Grove Crane distributor or Manitowoc Crane Care should check the main boom locking system.

ODM COMPONENTS

Maintenance of the Slip Ring Assembly of the Cable Drum

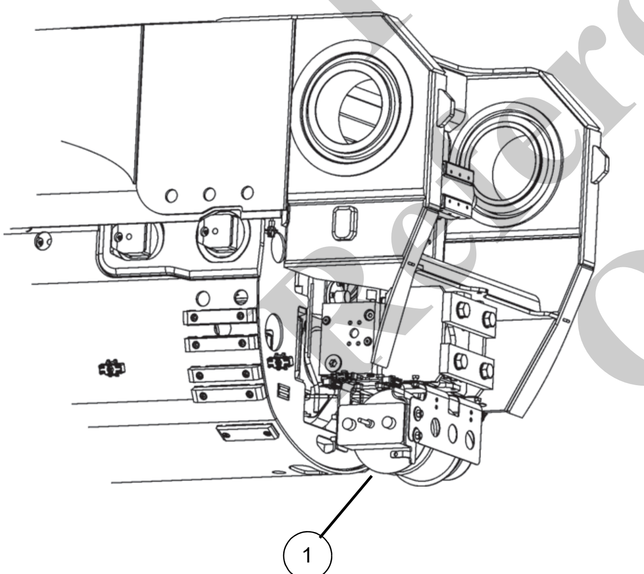
Maintenance of the slip ring assembly is carried out to prevent contamination and corrosion and to prevent malfunctions on the RCL. Two cable drums feature slip ring assemblies that require maintenance:

- The cable drum (1, Figure 4-19) on the left side of the main boom.



10248 FIGURE 4-19

- The second cable drum (1, Figure 4-20) is located in the main boom underneath the telescoping cylinder.



10249 FIGURE 4-20

WARNING

Risk of accidents due to rope end fitting being overloaded!

After installing a new hoist rope, the lowering limit switch must always be reset.

You can reach the cable drum through the manhole if you first extend telescopic section 1 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.

Prerequisite

Before maintenance, the following requirement must be met:

- The battery disconnect switch is switched off.

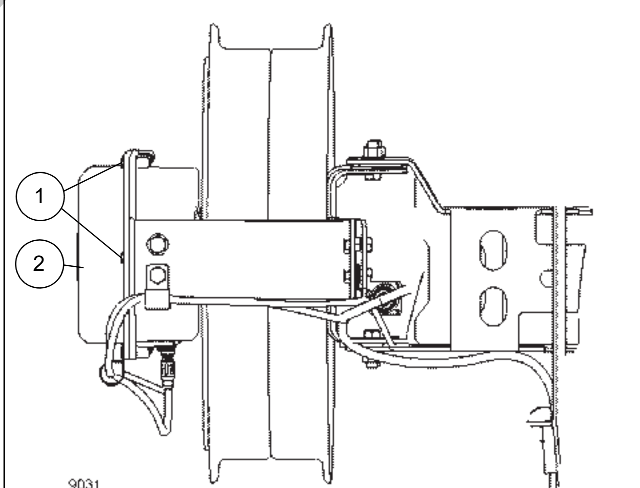
CAUTION

Damage to the Rated Capacity Limiter Hazard!

Before maintenance work on the slip ring assembly, always switch off the battery disconnect switch so that the cable drum is current-free.
This prevents short circuits which may lead to damage to the central unit.

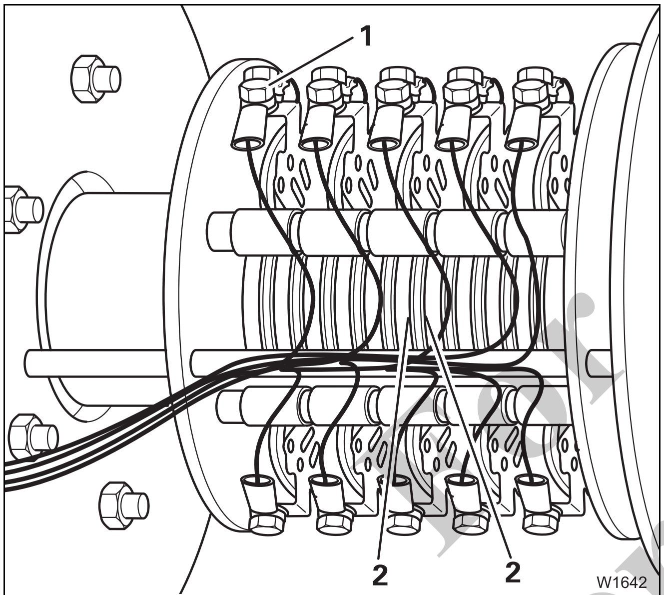
Maintenance of the Slip Ring Assembly

To remove abrasion particles from the contact brushes, use only dry, oil-free air or a clean, lint-free cloth.



9031 FIGURE 4-21

1. Make sure that the cable drum is current-free.
2. Unscrew all screws (1, Figure 4-21) and remove the casing (2).
3. Check the seal on the casing for damage and replace it if necessary.
4. Remove any moisture in the casing with a clean, lint-free cloth.



For reference only, your slip ring assembly may look different

FIGURE 4-22

5. Remove visible dirt on the slip rings (2, Figure 4-22) 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.

6. Check to make sure all screws (1) are tight.
7. Put the casing (2, Figure 4-21) back in place. Make sure that the seal is in the right place.
8. Fasten the casing with all the screws (1).

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.

BOOM EXTENSION

DANGER

Crushing Hazard!

Before attempting to erect or stow the boom extension, read and strictly adhere to all warning decals installed on the swingaway and stowage brackets.

To prevent uncontrolled swinging of boom extension, always secure the extension with a guide rope on the main boom before removing any connections.

For instructions on installing, removing or deployment of the boom extension(s) refer to the *Operator Manual*. For lubrication information, see *Maintenance and Lubrication*, page 9-1.

HOOK BLOCK/OVERHAUL BALL

For information about removing and installing the hook blocks, see the *Operator Manual*. For lubrication information, see *Maintenance and Lubrication*, page 9-1.

SECTION 5
HOIST AND COUNTERWEIGHT

SECTION CONTENTS

HOIST DESCRIPTION

One standard hoist is available for both the main and auxiliary (Figure 5-1). The hoist incorporates one single 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.

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.

HOIST MAINTENANCE

Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below 4°C (40°F).

The prime mover should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

DANGER

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

Hoist Area Access

DANGER

Do not use platform for hauling passengers. Death or serious injury could occur.

No storage of components is allowed on the platform.

Only one person at a time is allowed on the platform.

The hoist area access platform must be deployed when working on the hoists. The hoist area access platform must be retracted when traveling. For more information about hoist area access, see the *Operator Manual*.

INSTALLING CABLE ON HOIST

xxxx

For information about install the cable on the hoist, see the *Operator Manual*.

REMOVING/INSTALLING THE HOIST

Refer to Figure 5-1, on page 5-4.

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 plug from the tee in the 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 (29) 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 upper shaft (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 (15 and 31). Install three long capscrews into the three short capscrew holes. Use capscrews as jack screws to pull the bearing support (8) off of the drum shaft (1).
15. Remove the hoist mounting capscrews (16) and washers (20), 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 (16) and washers (20). Torque the capscrews following specifications in *Fasteners and Torque Values*, page 1-16.
4. Install the bearing support assembly (8) to the drum shaft with grease fittings at the 9-o'clock position. Align and install the capscrews (15) into the threaded turntable holes. Install the capscrews(31) into the blind

holes. Torque capscrews following specification under *Fasteners and Torque Values*, page 1-16.

5. Install the hoist roller (11).
6. Install the upper shaft (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 (29). Torque standoff fitting to 35 N-m (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 N-m (31 ft-lb).
11. Install new O-ring (22). Lube O-ring, then install hydraulic motor. Torque capscrews following specification in *Fasteners and Torque Values*, page 1-16.
12. Connect the hoist control valve electrical connectors as tagged during removal.
13. Reattach gearbox sight glass hoses and fittings.
14. Reinstall plug into the tee in the lower hose of the 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. Refer to section titled *Hoist Lubrication*, page 9-44.
18. Install cable onto hoist assembly. Refer to *Installing Cable On Hoist*, page 5-2.
19. Adjust the minimum wrap switch, refer to *Adjusting 3rd Wrap Switch*, page 5-9.

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

Refer to the sub-section titled *Hoist Lubrication*, page 9-44 of the Lubrication section for information on properly checking the hoist oil level.

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.

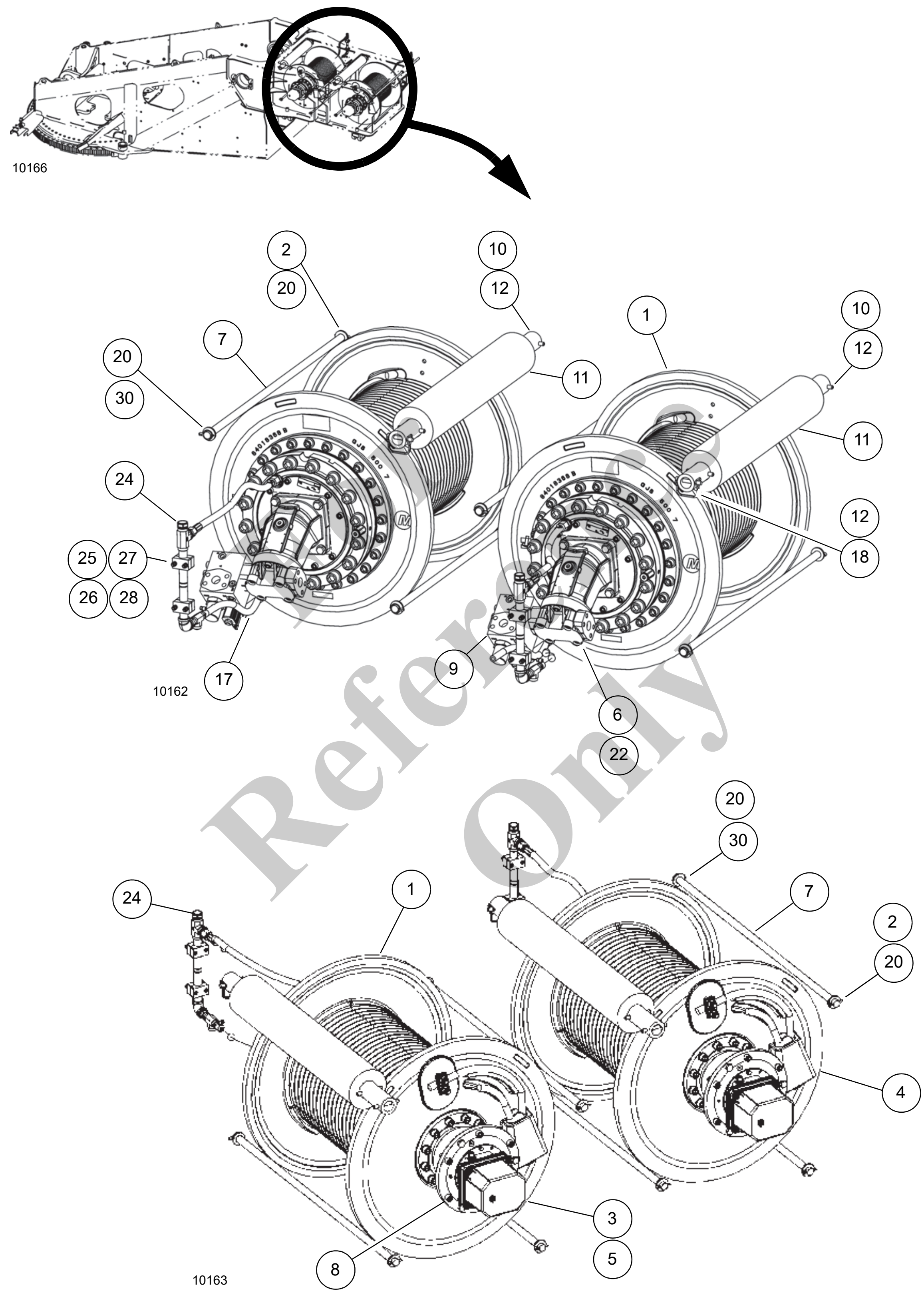
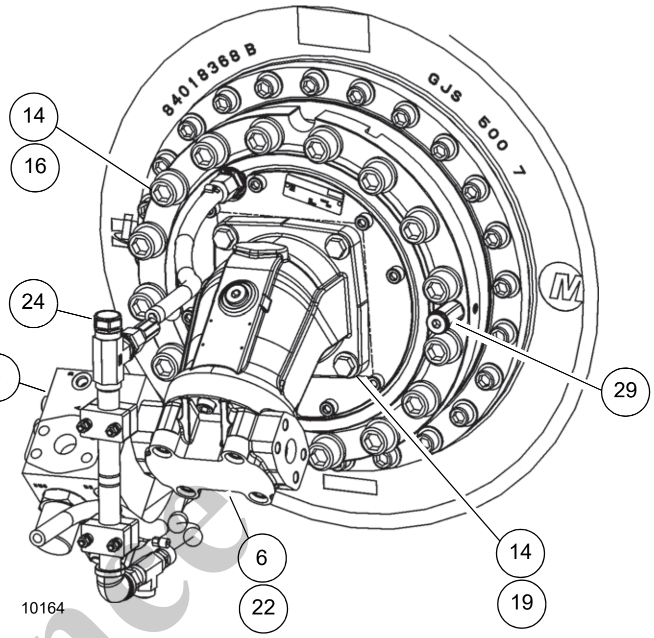
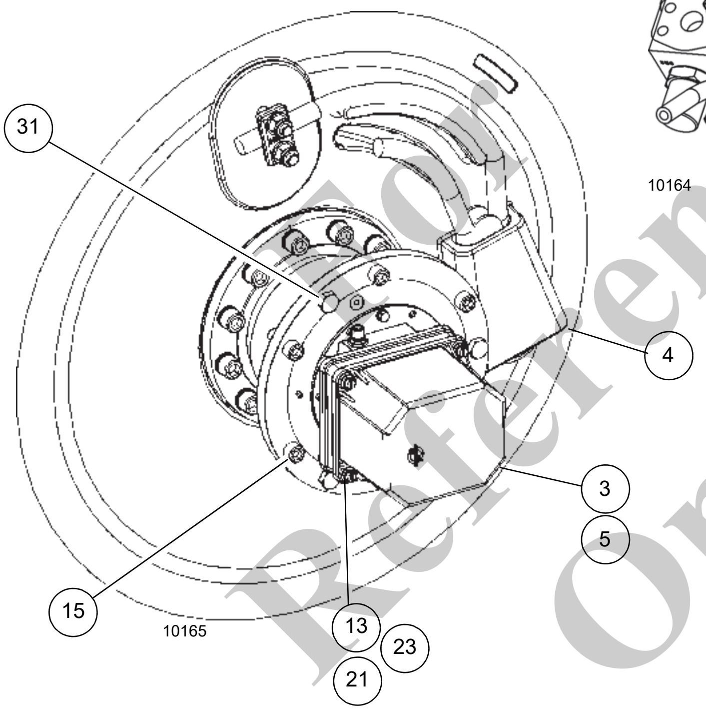

10166
2
20
10
12
1
10
12
7
20
30
11
11
24
12
18
25
27
26
28
9
17
10162
6
22
20
30
24
1
7
2
20
4
3
5
8
10163

FIGURE 5-1





1	Hoist
2	Cotter Pin
3	O-Ring
4	Cable Wedge
5	Limit Switch Assembly
6	Motor
7	Shaft
8	Bearing Support
9	Motor Control Valve
10	Shaft

11	Hoist Roller
12	Spring Pin
13	Capscrew M6x16 SS
14	Capscrew M12x45 8.8
15	Capscrew M12x35 10.9
16	Capscrew M20x40 10.9
17	Straight Thread Adapter
18	Lock Pin
19	Flat Washer
20	Flat Washer
21	Narrow Flat Washer
22	O-Ring
23	Lockwasher
24	Sight Glass
25	SHCS M6x45 8.8
26	Washer
27	Lockwasher
28	Nut
29	Standoff Fitting
30	Cotter Pin
31	Capscrew M12x12 SS

FIGURE 5-1 continued

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.

DANGER

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

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

1. Pre-Use or Daily Inspection.

Must include but is not limited to the following inspections that will be performed prior to placing the crane into service and then as necessary during extended operation. This inspection must be performed by a qualified crane operator or qualified crane technician.

- Check for external oil leaks and repair as necessary. This is extremely important due to accelerated wear from insufficient lubricating oil in the hoist. Hoists with a sight glass: check oil level daily. Hoists without a sight glass: check oil level monthly if no external oil leaks are detected. Lubricant level must be maintained between the minimum and maximum levels; midway up sight glass or at bottom of level plug port as equipped. Use ONLY the recommended type of lubricant. Refer to *Maintenance and Lubrication*, page 9-1.
- Check hydraulic fittings and hoses for chaffing, deterioration or corrosion and repair as necessary.
- Visually inspect for corroded, loose or missing bolts, pins or other fasteners and replace or tighten as necessary.
- Visually inspect rotation indicator transmitters, anti-two-blocking switches and other safety equipment and repair as necessary.

2. Quarterly Inspection (every three months).

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

- Perform 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 5-7 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 5-7. Refill hoist to proper level with recommended lubricant. Refer to *Maintenance and 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.

Hoist 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 *Maintenance and 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 and 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.

5

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.

HOIST 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 assembly.

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. Refer to the hoist draining procedures in *Hoist Lubrication*, page 9-44. After 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 motor adapter plate. Remove the motor and motor control valve as a unit. Discard the O-ring. Remove the motor adapter plate and o-ring from the gearbox. Discard the o-ring.
5. Cover the gearbox opening in the brake cylinder to protect drive components inside the hoist drum.
6. If disassembling the brake, remove the hoist assembly from the crane. Brake disassembly requires special tools and is more easily done when the hoist assembly removed from the crane.

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 N-m (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 in *Hoist Lubrication*, page 9-44.

HOIST ROTATION AND 3RD WRAP INDICATOR SYSTEM

Description

The main and auxiliary hoists are each equipped with an encoder (Figure 5-2) that is part of the hoist rotation and 3rd 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 operation (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 thumb thumper solenoid to provide a physical indication to the operator of hoist operation. Actuation of the thumb thumper is controlled by the CAN bus modules from input supplied by the hoist drum encoder. The pulsing thumb thumper solenoid is located in the main and auxiliary hoist joystick handles and provides feedback proportional to the hoist line speed by pulsing the rubber button on top of the hoist joystick. The thumb thumper solenoid will cease operation at high line speeds to prevent damage to the solenoid.

3rd Wrap Indicator

The 3rd wrap indicator system uses the main and auxiliary hoist encoders to indicate when there are three wraps of cable remaining on the respective hoist. When three 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 3rd wrap symbol on the ODM display to indicate that three wraps of cable remain on the respective hoist. The encoder must be properly adjusted for this system to function properly. Refer to *Adjusting 3rd Wrap Switch*, page 5-9.

Maintenance

General

DANGER

Disconnect the batteries before performing any maintenance on this system. Serious burns may result from accidental shorting or grounding of live circuits.

Proper circuit operation can be checked for each individual electrical component. If a malfunction occurs within the system, repairs should be limited to finding and replacing the faulty component(s). To determine which component is at fault, refer to the troubleshooting section of your CAN bus CD.

Adjusting 3rd Wrap Switch

1. Install hoist rope on the hoist.
2. Reeve hook block with six or more parts of line from hoist to be adjusted.
3. Raise and extend boom as necessary.
4. Lower hook block until three wraps of rope remain on hoist drum.

NOTE: If using synthetic rope, lower hook block until three wraps of line remain on hoist drum.

5. Remove four screws and cover from switch (1, Figure 5-2).
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 three rope wraps on hoist drum.

NOTE: If using synthetic rope, lower hook block to verify lower limit switch actuates with three 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.

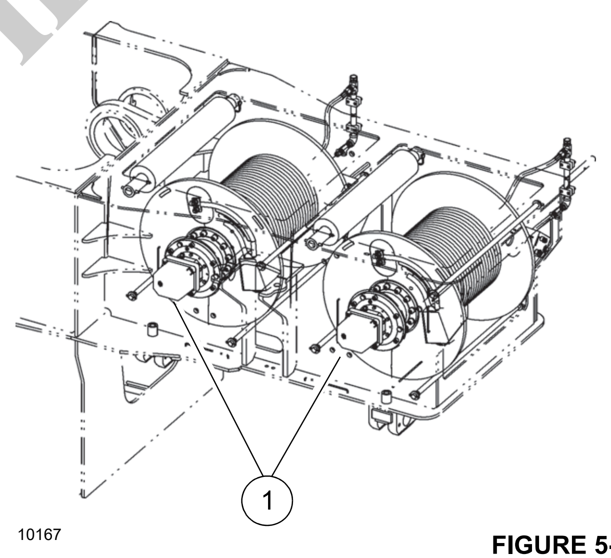


FIGURE 5-2

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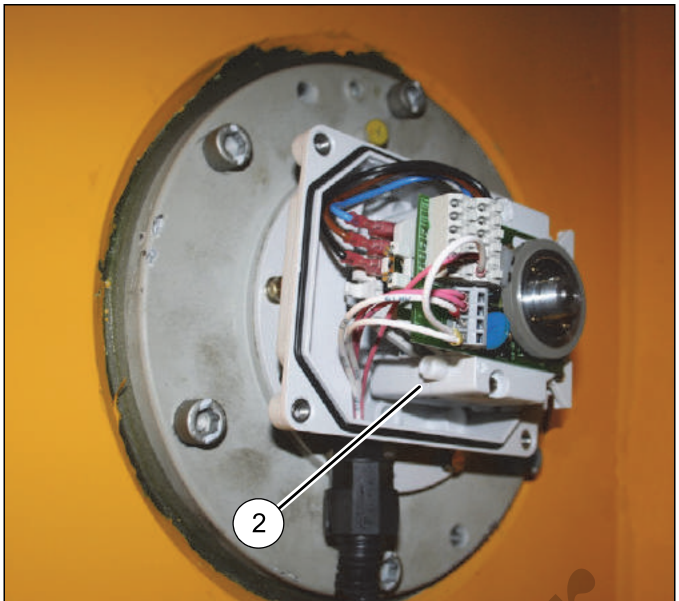

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FIGURE 5-2 continued

HOIST CONTROL VALVES

Description

NOTE: For more detailed information, refer to *Valves*, page 2-21.

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.

REMOVABLE COUNTERWEIGHT

DANGER

Falling counterweight can crush and cause death or serious injury.

Ensure all mounting pins are properly installed and locked, during and after operating the counterweight removal system.

Counterweight is installed and removed using hydraulic cylinders controlled by a counterweight controls in the ODM or remote control. Hydraulic cylinders and locking pins hold the counterweight assembly in place.

For more information about assembling, removing and installing the counterweight, see the *Operator Manual*.

SECTION 6
SWING SYSTEM

SECTION CONTENTS

DESCRIPTION

The purpose of the swing system is to allow the crane superstructure to rotate atop the carrier frame. The superstructure swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. The term *free swing* means that the superstructure will swing freely after the Swing joystick is released for 6 seconds or the Swing Brake Pedal is depressed.

Swing is activated when the Swing Enable/Disable switch on the left armrest is pressed once. When enabled, the Swing Enable/Disable Indicator appears on the ODM. Use the swing controller joystick in the cab to rotate the superstructure. When the Swing joystick is actuated, hydraulic pressure is routed to the Swing Motors to drive the gearboxes in the appropriate direction. As the gearbox rotates, the pinion gears mesh with the teeth on the swing bearing and rotates the superstructure. The rotation speed is variable up to the maximum rotation speed of 1.1 rpm. Braking is accomplished by depressing a Swing Brake Pedal which is a proportionate control valve that provides a controlled braking of the swing motion. When active, press the Swing Enable/Disable switch to disable rotating the superstructure.

The swing system consists of a electric remote controller, a directional control valve, two swing drives, the swing brake assemblies, the brake pedal and power brake valve, and a swing brake release solenoid valve.

The crane features a pin type swing lock as standard equipment, and can feature an optional 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type swing lock can only be engaged when the boom is centered over the front or rear of the carrier. Both swing locks are operated from the cab.

THEORY OF OPERATION

The GRT9165 features two combination swing drives and brakes located on the right side of the superstructure.

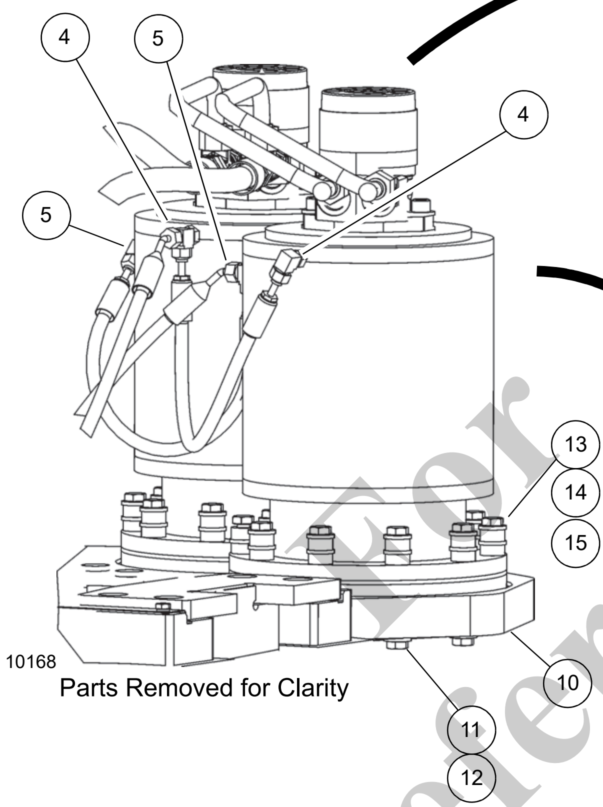
Swing Drive

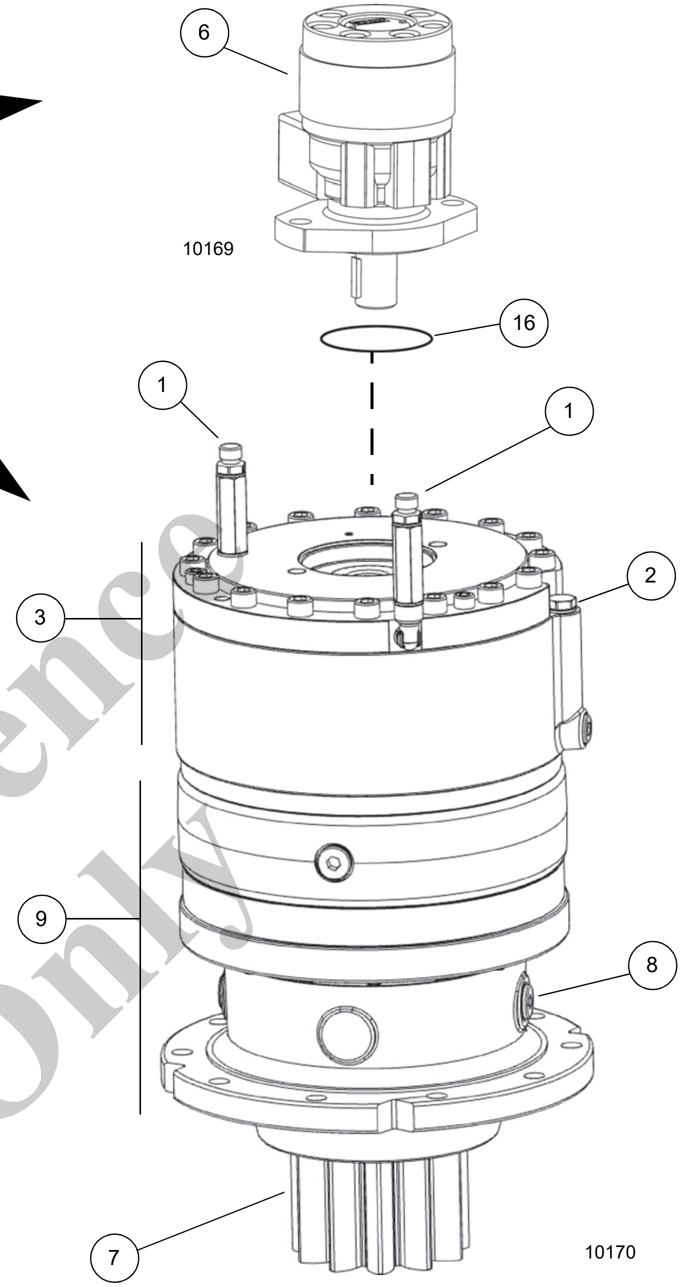
The hydraulic power for the swing drives Figure 6-1 is supplied by the engine driven hydraulic pump. Oil flows from the pump to the hydraulic swivel. Flow from the swivel is routed to the Swing Directional Control Valve.

When the hydraulic remote control is positioned to select right or left swing, the flow through the control valve is directed to the Swing Motor. If the Swing Enable Switch is in the ON 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 (static) swing brake is spring-applied, hydraulic released while the service (dynamic) brake is pressure applied. A two position solenoid valve controls the pressure to release the swing brake. A pressure reducing valve maintains a pressure of 260 to 300 psi to the inlet of both the brake releases and brake apply valves. The circuit is designed such that when the engine is running and the swing enable switch is activated pressure is supplied to the swing brake release to release the brake while at the same time pressure is increased on the swing service brake proportionally to the maximum pressure. When the swing control joystick is actuated to swing left or right, the proportional valve is de-energized there by releasing the pressure from the swing service brake and allowing motion. When the swing joystick is returned to the center (neutral) position, the control system gradually re-energizes the proportional valve (apply valve), thereby slowly increasing oil pressure to apply the brake. Actuating the swing brake foot pedal results in the same action.





1	Breather Plug
2	Level and Fill Plug and Dipstick
3	Swing Brake
4	Hydraulic Apply Brake Port
5	Hydraulic Release Brake Port
6	Motor
7	Pinion
8	Drain Plug
9	Swing Gearbox
10	Pinion Guard
11	Capscrew
12	Washer

13	Capscrew
14	Washer
15	Bushing
16	O-ring

FIGURE 6-1

SWING MOTOR

Description

The Swing Motors are mounted on the swing brake housings and drives the swing gearboxes through the brake assemblies (6, Figure 6-1). The motors have two ports for connections to the hydraulic system.

Maintenance

Use the following procedures to remove, install, and test each swing motor.

Removal

1. Ensure swing brakes and swing lock are engaged.
2. Clean port area around motor. Tag and disconnect hydraulic hoses from motor assembly. Cap or plug all openings.

CAUTION
Hydraulic oil can be hot and cause burns. Always wear gloves and allow the hydraulic system to cool.

3. Unscrew drain plug, filler and level plugs, and drain oil. After oil is drained, replace drain plug.

CAUTION
Pull straight up on motor assembly to avoid damaging splined shaft.

4. Remove two screws and separate motor from brake flange. Remove and discard O-ring from groove in the swing brake.

Installation

CAUTION
Use care when engaging swing motor drive gear. Do not force shaft to engage. Damage to gears may result

1. Install new O-ring in swing brake groove. Position swing motor on swing brake.
2. Apply Loctite 243 on two screws. Install screws and secure motor to brake housing. Torque screws 97.2 N-m to 102.4 N-m (71.7 lb-ft to 75.5 lb-ft) in accordance with torque specifications. For more information, see *Fasteners and Torque Values*, page 1-16.
3. Replace plugs and extensions. Fill assembly with oil. Refer to *Maintenance and Lubrication*, page 9-1.
4. Connect hydraulic lines to swing motor as tagged during removal.

Test

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING GEARBOX AND BRAKE

Description

The Swing Gearbox and Brake (Figure 6-1), used with the Swing Motor, rotates and stops the superstructure. A pedal on the cab floor activates the Swing Brake (1). The Swing Gearbox (2) is bolted to the superstructure base plate. Its pinion gear meshes with the turntable bearing ring gear to rotate the turntable.

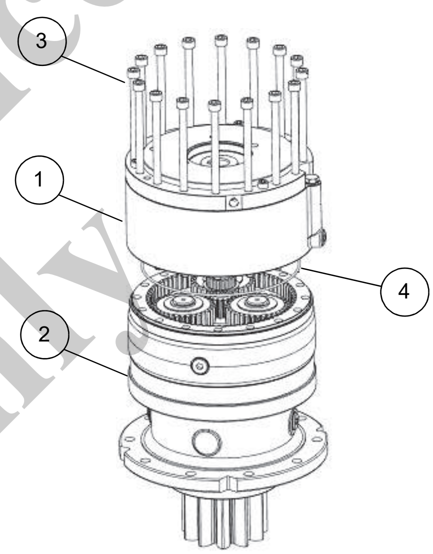


FIGURE 6-2

Maintenance

NOTE: Swing Brake can be removed and disassembled independently of Swing Gearbox.

Swing Brake

Removal

1. Engage turntable lock pin.
2. Tag and disconnect hydraulic lines connected to swing motor and brake. Cap and/or plug all openings.
3. Remove swing motor from swing brake. For more information, see *Swing Motor*, page 6-4.

4. Remove bolts (3) securing the brake (1) to gearbox (2). Remove brake assembly (1).
5. Remove and discard the O-ring (4) from the brake housing.
6. Cover swing gearbox opening to ensure no debris, such as dirt and dust, gets into the gearbox.

Installation

1. Install a new O-ring (4) onto the brake (1) housing and insert the brake assembly into the gearbox (2). Secure with the capscrews (3).
2. Install swing motor into the swing brake. For more information, see *Swing Motor*, page 6-4.
3. Connect hydraulic lines to the motor and brake.
4. Bleed air from brake assembly.

Testing

1. With Swing Brake switch in the ON position, position the swing joystick in both directions. Superstructure rotation should not occur.
2. Position Swing Brake switch to OFF and swing superstructure in both directions. Use the swing brake pedal to stop rotation.
3. Check for hydraulic leaks and repair as necessary.

Gearbox

Removal

1. Engage turntable lock pin.
2. Tag and disconnect hydraulic lines from swing motor and swing brake. Cap and/or plug all openings.
3. Remove capscrews (11), washers (12), and pinion guard (10) as necessary.

NOTE: Gearbox assembly with motor weighs approximately 126 kg (277.8 lb).

4. Attach a suitable lifting device to the swing gearbox. Remove capscrews (13), washers (14), and bushings (15) securing gearbox to the superstructure.
5. Remove the swing gearbox.
6. If necessary, remove the swing motor. For more information, see *Swing Motor*, page 6-4.
7. If necessary, remove the swing brake. For more information, see *Swing Brake*, page 6-4.
8. Cover the swing gearbox opening to ensure no debris, such as dirt and dust, gets into the gearbox.

Installation

1. If removed, install the swing brake. For more information, see *Swing Brake*, page 6-4.
2. If removed, install the swing motor. For more information, see *Swing Motor*, page 6-4.
3. Attach a suitable lifting device to the swing gearboxes and lift and position the swing gearboxes in place on the mounting plate. Adjust the pinions as necessary so the pinions mesh with the turntable bearing.
4. Install capscrews (13), washers (14), and bushings (15). Torque capscrews 97.2 N-m to 102.4 N-m (71.7 lb-ft to 75.5 lb-ft). Refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
5. Install pinion guard (10) with washers (12) and capscrews (11).
6. Connect hydraulic lines to the swing brake.
7. Connect hydraulic lines to the swing motor.
8. Service gearbox as indicated under *Servicing*.

Servicing

As with all highly stressed mechanisms, reasonable operating procedures are always required. Normal maintenance should only consist of proper lubrication and a periodic check of mounting bolt torque values. For more information about oil specifications, see *Lubricants and Lubrication Intervals*, page 9-1.

Change the oil as follows.

1. Unscrew drain plug (8, Figure 6-1). Remove fill plug and dipstick(2) to ensure all oil has been removed.
2. Flush case with a light flushing oil.

NOTE: Cleaning gearbox with a solvent is recommended to prevent accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the swing bearing.

3. After oil is drained, replace drain plug (8) and fill plug and dipstick (1) any other plugs removed to drain oil.
4. To refill with oil, make sure breather is open. Fill to proper location on dipstick (2).
5. Tighten dipstick (2).

Checking the Oil Level

1. Check level on dipstick (2).
2. If no lubricant is visible on dipstick, add oil until between minimum and maximum on dipstick.
3. Replace dipstick(2) in brake housing.

Testing

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

MAINTENANCE

Table 6-1: Troubleshooting

Symptom	Probable Cause	Solution
1. Boom swing operation erratic in either direction.	**a.** Damaged relief valve.	**a.** Replace relief valve.
	b. Swing brake dragging (not releasing properly).	**b.** Readjust and/or replace parts.
	c. Low engine rpm.	**c.** Increase engine rpm to obtain smooth swing operation.
	d. Low hydraulic oil.	**d.** Check system for leaks. Make repairs as needed. Fill reservoir.
	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 *Maintenance and Lubrication*, page 9-1.
	g. Crane not level.	**g.** Level crane using outriggers.
	h. Damaged swing motor.	**h.** Repair or replace swing motor.
	i. Excessive overload.	**i.** Reduce load. Refer to load capacity chart.
	j. Restricted or partly clogged hydraulic hose or fittings.	**j.** Replace hose or fittings. Refer to the Manitowoc Crane Care Parts Manual.
	k. Pump cavitation in swing section.	**k.** Tighten suction hose or replace damaged fittings. 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.
	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 recommendations. Refer to *Maintenance and Lubrication*, page 9-1.
	e. Improper size hose and/or fittings installed.	**e.** Replace hose or fittings. Refer to the Manitowoc Crane Care Parts Manual.
	f. Clogged or restricted hydraulic hoses or fittings.	**f.** Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	**g.** Replace bearings.
	h. Worn or damaged swing motor.	**h.** Repair or replace motor.
	i. Worn or damaged hydraulic pump.	**i.** Repair or replace pump.
	j. Crane not level.	**j.** Level crane.
	k. Damaged swing directional control valve.	**k.** Replace swing directional control valve.
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

Symptom	Probable Cause	Solution
6. Swing brake operation erratic.	**a.** Improper brake adjustment.	**a.** Adjust brake.
	b. Air in swing brake system.	**b.** Bleed brake system.
	c. Brake pedal not fully retracted.	**c.** Check brake pedal return spring; repair or replace spring.
	d. Dirty or glazed brake disc.	**d.** Clean or replace disc.
	e. Malfunction of the glide swing power brake valve.	**e.** Repair or replace glide swing power brake valve.
	f. Kinked or bent lines and/or hoses and fittings.	**f.** Straighten or replace as required.
7. Swing brake system will not operate.	**a.** Damaged swing brake release valve.	**a.** Replace release valve.
	b. Damaged glide swing power brake valve.	**b.** Repair or replace glide swing power brake valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace lines and fittings.
8. Swing brake pedal is spongy.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Loose or restricted brake lines or fittings.	**b.** Tighten or replace brake lines and fittings.
9. Swing brake drags.	**a.** Damaged glide swing power brake valve.	**a.** Repair or replace the glide swing power brake valve.
	b. Damaged swing brake release valve.	**b.** Replace release valve.
	c. Internal damage to the swing brake assembly.	**c.** Repair or replace affected parts.
	d. Loose or restricted brake lines or fittings.	**d.** Tighten or replace brake lines and fittings.
10. Boom swings slowly.	**a.** Insufficient hydraulic volume.	**a.** Check delivery of hydraulic pump. Ensure sufficient fluid is available to pump. Check pump drive speed.
	b. Damaged relief valve.	**b.** Adjust, repair, or replace valve.
	c. Damaged swing motor.	**c.** Repair or replace motor.
11. Swing motor continues to operate when swing control is in neutral.	**a.** Hydraulic remote control valve sticking or valve otherwise damaged.	**a.** Repair or replace valve.
	b. Control valve sticking or valve otherwise damaged.	**b.** Repair or replace valve.
12. Swing motor turning in wrong direction.	**a.** Improper port connections.	**a.** Reverse port connection.
	b. Improper wiring connection	**b.** Inspect wiring and connections
13. Swing motor noisy.	**a.** Air in system.	**a.** Refer to *Hydraulic System*, page 2-1, for removal of air from the system.
	b. Motor binding.	**b.** Repair or replace motor.
14. Calibration alert appears in the ODM	**a.** Slew sensor is malfunctioning, has been replaced, or software has been updated.	**a.** Calibrate the slew sensor in the ODM.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the superstructure to the carrier. The bearing inner race is bolted to the superstructure and the outer race is bolted to the carrier. The inner race contains two grease fittings for lubrication of the bearing which are hosed to two fittings at the front of the turntable center section. The outer race also contains two grease fittings and incorporates gear teeth that mesh with the pinion gears of the swing gearboxes to provide rotation.

Maintenance

General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the superstructure and carrier. Therefore, proper care of the bearing and periodic maintenance of the turntable-to-bearing attach bolts IS A MUST to ensure safe and efficient operation.

Torquing Turntable Bolts

General

DANGER

Failure to maintain proper torque of turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the superstructure from the carrier.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification. Torque the capscrews to recommended values, refer to *Fasteners and Torque Values*, page 1-16.

NOTE: Zinc flake coated bearing bolt heads are stamped with the suffix “ZF” as a visual identifier.

DANGER

It is mandatory that bearing attaching bolts be inspected for lack of torque and retorqued, as required, after the first 300 hours of crane operation. The bolts may loosen in service due to vibration, shock-loads, and temperature changes, therefore, periodic inspection should be accomplished every 500 hours thereafter, ensuring the bolts are properly torqued.

When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.

Before performing the following procedure refer to *Torque Wrenches*, page 1-16 on the proper use of a torque wrench.

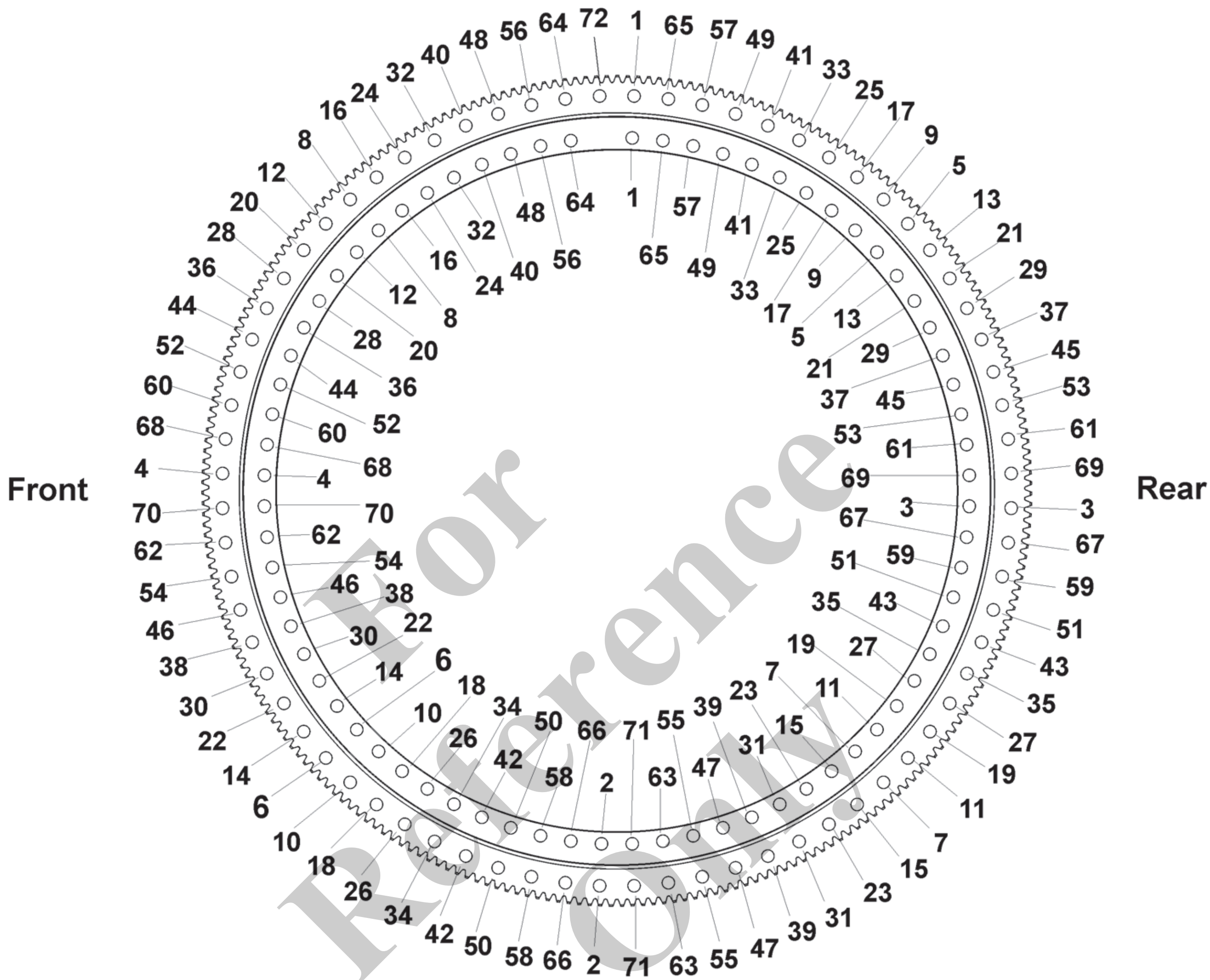


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FIGURE 6-3

Swing Bearing Bolts

The inner race of the bearing is secured to the turntable by a quantity of 71, M12x75mm, 8.8 grade bolts. The outer race of the bearing is secured to the carrier frame by a quantity of 72, M12x75 mm, 8.8 grade bolts.

Tools Required

The Figure 6-4 illustrates and lists the complete set of special tools required to torque the turntable bolts.

Inner Race Torquing

The inner race bearing bolts are located on top of the inner race (Figure 6-3).

1. Extend and set the outriggers.
2. Fully elevate the boom.
3. Torque all bolts to 80% of the full torque value following a star pattern sequence as shown in (Figure 6-3) starting with bolt number 1. For more information about torque values, see *Fasteners and Torque Values*, page 1-16.

Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.

4. Return to bolt 1 and torque all bolts using the same star pattern sequence to the final torque of cited in *Fasteners and Torque Values*, page 1-16. The same tools are used as in step 3.

Outer Race Torquing

The outer race bearing bolts are located on top of the outer race (Figure 6-3).

1. Extend and set the outriggers.
2. Fully elevate the boom.
3. Torque all bolts to 80% of the full torque value following star pattern sequence as shown in (Figure 6-3) starting with bolt number 1. For more information about torque values, see *Fasteners and Torque Values*, page 1-16.

Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.

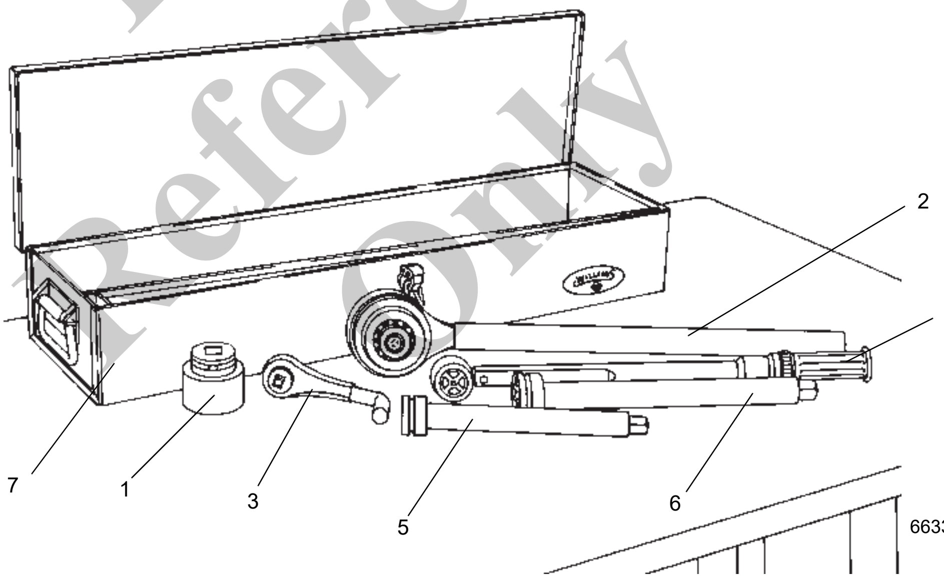
4. Return to bolt 1 and torque all bolts using the same star pattern sequence to the final torque cited in For more information about torque values, see *Fasteners and Torque Values*, page 1-16. The same tools are used as in step 3.

Removal

1. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

2. Ensure the boom is in the travel position and the turntable lock pin is engaged.
3. Elevate the boom slightly and shut down the engine.
4. Tag and disconnect the battery cables from the batteries.
5. Remove the boom and lift cylinder following the procedures outlined in Section 4 - *Boom*, page 4-1.
6. Remove the counterweight. Refer to the *Operator Manual*.
7. Tag and disconnect all water and oil lines from the bottom of the swivel. Cap or plug all lines and openings.
8. Locate the connectors and ground wire that joins the swivel wiring harness to the receptacles and ground stud on the carrier.



Orders for special tools shall be referred to:

The Manitowoc Company, Inc
1565 Buchanan Trail East
Shady Grove, PA 17256
Phone: (717) 597-8121
Fax: (717) 593-5929

Description	Grove Part Number	Quantity Required
1. 1½” Socket 3/4” Drive	9999100143	1
2. 4 to 1 Torque Multiplier (1/2” Input 3/4” Output)	9999100134	1
3. Backlash Adapter	9999100141	1
4. 1/2” Drive Torque Wrench	9999100136	1
5. 10” Extension 3/4” Drive	9999100138	A/R
6. 13” Extension 3/4” Drive	9999100137	A/R
7. Tool Box (Optional)	9999100146	1

FIGURE 6-4

9. Disconnect swivel wiring harness connectors from carrier wiring receptacles. Remove ground wire from ground stud.
10. Remove clamp securing swivel wiring harness to retainer plate on bottom of hydraulic swivel assembly.
11. Coil wiring harness and secure it to the swivel to prevent damage to harness during turntable removal.
12. On bottom of the hydraulic swivel, bend retainer tabs away from bolt heads. Remove four bolts and two bolt retainers securing retainer plate to the spool. Remove retainer plate from spool and lugs on carrier frame.

NOTE: Swivel assembly will be removed with turntable.

DANGER

Ensure lifting device is capable of fully supporting weight of the superstructure and superstructure will not tilt or slide during lifting and moving. Failure to do so may result in death or serious injury and damage to equipment.

NOTE: If a lifting device capable of lifting entire superstructure is not available, superstructure weight may be reduced by removing various components such as hoist(s).

13. Attach a suitable lifting device to four superstructure lifting lugs (two at boom pivot shaft bushings and two at lower lift cylinder pivot shaft bushings). Take in cable or chain to remove slack. Do not pull up on superstructure.

DANGER

Ensure superstructure is fully supported before proceeding. Death or serious injury may result.

NOTE: It is necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be removed from the front or from under cab.

14. Remove 72 bolts and washers securing turntable bearing outer race to carrier.

DANGER

Ensure any blocking material used is capable of fully supporting weight of superstructure and will not allow it to tilt or shift. Failure to do so may result in death or serious injury.

15. Carefully lift superstructure, using care not to damage swivel assembly, and set it on blocking that will not allow superstructure to tilt or shift, or rest on the swivel. Leave lifting device attached.

NOTE: If same bearing is to be used again, mark position of bearing on superstructure so it can be installed in the exact position before removal.

NOTE: Bearing weighs 628.8 kg (1552 lb). Ensure bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under bearing and remove 71 bolts and washers securing turntable bearing to superstructure.
17. Using lifting device, remove turntable bearing from under superstructure.

Inspection

Check bearing teeth for chipping or cracking. If any evidence of these is found, replace bearing. Ensure bolt holes are free of dirt, oil, or foreign material.

Installation

DANGER

Anytime a turntable bolt has been removed, it must be replaced with a new grade 8 bolt. Death or serious injury may result.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

Installation is in the travel position. Ensure the swing lock is disengaged before attempting to mate the bearing to the superstructure.

1. Using an appropriate lifting device, position the turntable bearing under the superstructure. If the same bearing is being used, position it as marked prior to removal.
2. Install 71 new bolts and washers securing the bearing to the superstructure. Refer to Inner Race Torquing in this Sub-Section.
3. Using an appropriate lifting device, align the superstructure over the carrier in the travel position and carefully lower the superstructure, being careful not to damage the swivel assembly, into position on the carrier bearing plate.

NOTE: It will be necessary to rotate the superstructure while attached to the lifting device. Outer race bolts can only be installed from the front or from under the cab.

4. Install 72 new bolts and washers. Refer to *Outer Race Torquing*, page 6-11.

NOTE: If a new bearing is being installed, a new pinion gear must also be used. Align the high point (maximum eccentricity) on the bearing with the new pinion gear high point.

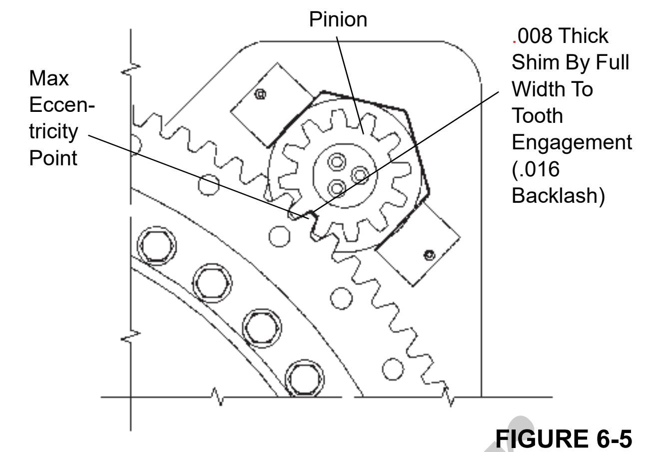


FIGURE 6-5

5. Install a swing gearbox and brake assembly. Align the gearbox pinions with the swing bearing. Align the swing gearbox pinion with the high point (maximum eccentricity) on the turntable bearing. Using a 0.203 mm (0.008 in) thick shim, check backlash (Figure 6-5). If the pinion must be moved to achieve proper backlash, contact your local distributor. For more information about installing swing gearbox and brake assembly, see *Swing Gearbox And Brake*, page 6-4.
6. Repeat step 5. to install and measure the second swing gearbox and brake assembly.
7. Position retainer plate on bottom of hydraulic swivel spool. Engage lugs on carrier frame and secure to spool with two bolt retainers and four bolts after applying Loctite® #271 to bolt threads. Torque bolts to 270 N-m (199 lb-ft). Bend all retainer tabs to make contact with bolt heads.
8. Plug swivel wiring harness connectors in carrier receptacles. Secure ground wire to ground stud using a washer, lockwasher, and nut.
9. Install clamp securing swivel wiring harness to retainer plate on bottom of hydraulic swivel.
10. Connect all water and hydraulic lines to ports on bottom of swivel as tagged during removal.
11. Install boom and lift cylinder following procedures outlined in Section 4 - *Boom*, page 4-1.
12. Reconnect batteries.
13. Check slew potentiometer in the for proper orientation. Refer to *Swivels*, page 6-13.

Testing

Activate crane and check for proper function.

NOTE: If superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

SWIVELS

Description

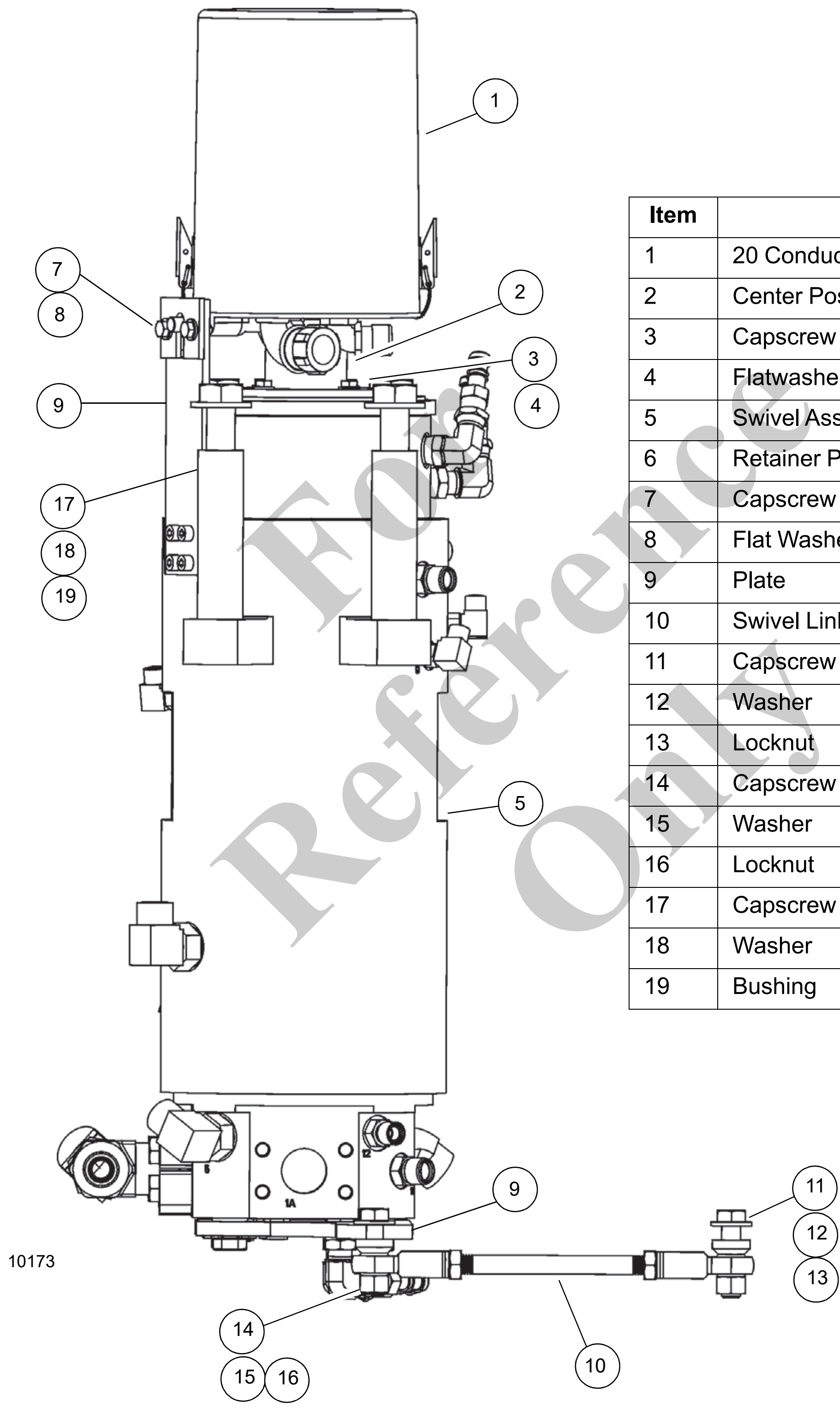
The swivel assembly consists of a 12 port hydraulic swivel (Figure 6-6), a 2 port water swivel, and a 20 conductor slip ring electrical swivel. Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. Use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four bolts, washers, and bushings which connect to mounting lugs on the case.

The spool portion of the swivel rides on a thrust ring at the top of the swivel case. The spool portion is held stationary to the carrier by bolts and bolt retainer plates attached to the swivel retainer plate. This engages the carrier frame lugs with bolts and jam nuts and 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 retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.



Item	Description
1	20 Conductor Slip Ring Assembly
2	Center Post
3	Capscrew
4	Flatwasher
5	Swivel Assembly
6	Retainer Plate
7	Capscrew
8	Flat Washer
9	Plate
10	Swivel Linkage Assembly
11	Capscrew
12	Washer
13	Locknut
14	Capscrew
15	Washer
16	Locknut
17	Capscrew
18	Washer
19	Bushing

FIGURE 6-6

HYDRAULIC SWIVEL

Description

Each port on the spool and case of the swivel is stamped with the port number. The function of each port is described below.

Port #	Test Pressure Bar (psi)	Function
1	35 (100)	Return
1	35 (100)	Return
2	330 (4790)	Supply
3	330 (4790)	Supply
4	4 (50)	Drain
5	270 (3920)	Swing
6	170 (2500)	Steer Left
7	170 (2500)	Steer Right
8	306 (4436)	Load Sense
9	145 (2100)	Brakes Front
10	145 (2100)	Brakes Rear
11	2 (30)	A/C Supply
12	2 (30)	A/C Return
A	2 (30)	Heater
B	2 (30)	Heater

Theory of Operation

The hydraulic swivel allows oil to flow from the pumps to various crane functions on the superstructure. All oil is routed into the spool portion of the swivel where, through a series of internally drilled passages, oil is transferred to circumferential channels on the spool exterior. These channels correspond with a mating port on the outer case of the swivel. Each channel is separated by a series of nylon and O-ring seals that prevent transfer of oil and pressure. Return flow from the crane superstructure is accomplished in the same manner through another set of ports.

Maintenance

Removal

1. Extend and set outriggers. Ensure crane is level and boom is over the front.
2. Elevate boom and note at what boom angle, you have the most clearance between the lift cylinder and the turntable side plate. Shut down engine.
3. Measure distance from top of lift cylinder to base of boom section where lift cylinder attaches. Cut two pieces of 10 x 10 cm (4 x 4 in) oak to fit.

NOTE: It may be necessary to raise boom slightly to allow installation of blocking.

NOTE: This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use oak blocking to block between barrel of lift cylinder and boom base section.
5. Tag and disconnect hydraulic lines from case of hydraulic swivel. Cap or plug all lines and openings.
6. Tag and disconnect the hydraulic lines and water lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
7. Tag and disconnect water lines from case of water swivel. Cap or plug all lines and openings.
8. Disconnect swivel wiring harness connectors from carrier receptacles and yellow ground wire from connector mounting bracket on carrier frame. If necessary, remove electrical swivel. Refer to Electrical Swivel in this Section.

NOTE: Combined hydraulic, water, and electrical swivels weigh approximately 200 kg (441 lb).

9. Remove the capscrew (14), washer (15),and locknut (16). Loosen capscrew (11), washer (12), and locknut (13), and turn the swivel linkage arm (11) out of the way.
10. If necessary, on the bottom of the swivel, bend the retainer tabs away from the bolt heads. Remove the capscrews and retainers securing the retainer plate to the spool. Remove the retainer plate from the swivel.

NOTE: It may be necessary to remove some drive line components to remove the swivel.

11. Position adequate supporting device beneath swivel.

NOTE: Make sure the swivel linkage arm is retracted when lowering the swivel assembly.

12. Remove four bolts (17), washers (18), and bushings(19) securing swivel barrel to turntable base plate. Lower swivel(5) to the ground.

Installation

NOTE: Combined hydraulic, water, and electrical swivels weigh approximately 200 kg (441 lb).

1. Lift swivel into position.
2. Secure hydraulic swivel to turntable base plate with bushings (19), capscrews (18), and washers (17). Torque capscrews to 571.3 N-m to 601.3 N-m (421.4 ft-

6

lb to 443.5 ft-lb). Refer to *Fasteners and Torque Values*, page 1-16 for proper torque.

3. Position retainer plate on hydraulic swivel spool ensuring they engage the lugs on the carrier frame.

NOTE: Allow a 1/32” max gap between bolt and retaining lug on frame. Do not tighten bolt against lug.

4. If removed, apply Loctite® 271 to bolt threads. Secure retainer plate with four capscrews and two bolt retainers. Torque bolts to 270 N-m (199 lb-ft). Bend retainer tabs to make contact with bolt heads. Snug four retainer plate bolts against lugs on carrier frame. Tighten locknuts.
5. Connect swivel linkage assembly (10) to plate (9) with capscrew (14), washer (15), locknut (16). Torque the locknut to 150.2 N-m to 158.1 N-m (110.8 ft-lb to 116.6 ft-lb).
6. Install electrical swivel if removed. Refer to Electrical Swivel in this Section. Connect swivel wiring harness connectors to carrier receptacles and yellow ground wire to mounting bracket on carrier frame. Reuse previously removed bolt and star washers. Refer to Grove Engineering Specification 6829100386 for proper electrical termination of grounds.
7. Install clamp, washer, flatwasher, and capscrew to bottom of swivel retainer plate securing wiring harness.
8. Connect hydraulic lines to spool of hydraulic swivel as tagged during removal.
9. Connect hydraulic lines to hydraulic swivel case as tagged during removal.
10. Connect water lines to water swivel case as tagged during removal.
11. Remove blocking material from lift cylinder.
12. Activate all systems. Cycle all functions and observe for proper operation and any leakage.

TWO PORT WATER SWIVEL

Description

The two port water swivel allows engine coolant to flow from the carrier-mounted engine to the hot water heater in the operator’s cab. Coolant is transferred to a circumferential groove on the water spool exterior through an internally drilled passage in the 12 port hydraulic swivel spool. This groove corresponds with a mating port on the outer case of the water swivel. Spool grooves are separated by a quad ring/Teflon bronze ring seal. The lip seal prevents coolant from leaking externally. Return engine coolant flow from the hot water heater is accomplished in the same manner through the opposite port of the water swivel.

Maintenance

Removal

1. Perform steps 1 thru 4 of *Hydraulic Swivel*, page 6-15 -.
2. Remove electrical swivel. Refer to *Electrical Swivel*, page 6-17.
3. Tag and disconnect lines from the case of the water swivel. Cap or plug all lines and openings.
4. Remove screw and shim(s) from water/hydraulic swivel keying lugs.
5. Remove four capscrews and washers securing water swivel and electrical swivel center post to hydraulic swivel. Remove water swivel and center post.

Disassembly

NOTE: Any maintenance requiring disassembly of the water swivel should include replacement of all seals and rings.

1. Withdraw the spool from the case.
2. Place spool on a clean work surface in a dust-free area. Block spool to prevent movement during disassembly.

CAUTION

When removing seals and rings, avoid scratching grooved and gland surfaces. Damage to spool may result in unexpected operation.

NOTE: Aligning discarded seals and rings in order of disassembly will assist with installation of new seals and rings.

3. Remove seals and rings from spool.

Cleaning and Inspection

WARNING

Cleaning solvents can be toxic, flammable, an irritant to the skin, or give off harmful fumes. Avoid prolonged skin contact, inhalation of vapors, or smoking. Always use approved safety equipment; gloves, face masks, and eye wear. Failure to comply can result in injury or death to personnel.

1. Clean spool and case with a suitable solution and dry with compressed air. Plug all ports with plastic caps.
2. Check spool and inside of case for scratches, grooves, scoring, etc. If any grooves have developed with a depth of 0.127 mm (0.005 in) the unit should be replaced.

Assembly

NOTE: Lubricate interior of swivel to prevent rusting from condensation.

1. Lubricate spool, seals, and rings.

CAUTION

When installing seals and rings, avoid stretching seals or scratching grooved and gland surfaces. Damage to the spool assembly may result in unexpected operation.

Proper alignment when installing the case is required. Do not force the spool into the case. Damage to the seals may result.

2. Install new seals and rings on spool.
3. Insert spool in barrel.

Installation

1. Install water swivel on top of hydraulic swivel. Align keyed lug on water swivel with lug on hydraulic swivel. Secure water swivel and electrical swivel center post with four capscrews and washers.
2. Install shim(s) on keying lug to provide a snug fit. Secure with screw.
3. Connect lines to swivel case as tagged during removal.
4. Install electrical swivel. Refer to *Electrical Swivel*, page 6-17.
5. Perform steps 8 and 9 of *Hydraulic Swivel*, page 6-15.
6. Activate all systems and cycle all functions. Check for proper operation and leaks.

ELECTRICAL SWIVEL

Description

The swivel assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes and leads which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the swivel. The collector ring leads are formed into one harness which is routed downward through the center of the hydraulic swivel. Extending from the base of the hydraulic swivel, the collector ring leads are also formed into connectors which plug into receptacles from the chassis power supply.

The swivel cover is secured with a seal and bolts

The slip ring assembly contains an angle encoder. The encoder sends data via CAN bus to the RCL. The RCL converts this data into a slew angle which is used to determine the working area definition and also for controlling the rear axle oscillation.

Theory of Operation

The electrical swivel is located on top of the water swivel and transfers electricity between the carrier and superstructure. Wiring harnesses transmit the electricity between the carrier and superstructure.

Maintenance

Removal

1. Perform steps 1 through 4 of *Hydraulic Swivel*, page 6-15.

CAUTION

Disconnect batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

2. Disconnect batteries. Refer to *Electrical System*, page 3-1.
3. Locate connectors which join the collector ring harness to carrier receptacles.
4. Tag connectors and their receptacles with numbers. Disconnect connectors from chassis wiring receptacles.

NOTE: Connectors are too large pass through center of hydraulic swivel. They must be removed.

5. Remove clamp securing wiring harness to retainer plate on bottom of hydraulic swivel assembly.
6. Tag each wire on each connector. Using the appropriate pin removal tools, remove pins with wires still attached. Mark each wire with the connector pin socket number. Secure wires into one bundle. Mark bundle with connector number. For a list of pin removal tools, refer to *Connector Troubleshooting*, page 3-11.
7. Secure connectors and wires from each of the numbered connectors so harness can be pulled through center of hydraulic swivel.
8. Tag and disconnect connectors from receptacles on the cab bulkhead mounting plate.
9. Loosen jam nuts and setscrews securing electrical swivel mounting tube to water swivel center post.
10. Remove bolt and nut securing electrical swivel anti-rotation pin to bracket on case of the water swivel.

CAUTION

When pulling wiring harness through center of hydraulic and water swivels, ensure wires are not damaged.

11. Remove swivel and wiring harness from crane. If necessary, remove spacer bushing from center post.

Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic and water swivels.

NOTE: The boom should be centered directly over the front of the crane before adjustment is made to the slew encoder.

2. Slide electrical swivel mounting shaft on center post.
3. Ensure the anti-rotation pin in the bottom of the electrical swivel base is aligned with the mounting hole in the bracket on the water swivel case.

NOTE: Allow a 1/32” max gap between bolt and retaining lug on frame. Do not tighten bolt against lug.

4. Apply medium strength Loctite® to set screws securing electrical swivel to center post. Torque 45 to 55 lb-in (5 to 6 N-m). Tighten jam nuts.
5. Connect wiring harness connectors to receptacles on cab bulkhead mounting plate as tagged during removal.
6. Unbundle wires of collector core wiring harness. Install pins, with wire attached, to connector as tagged during removal.
7. Plug connector into carrier wiring receptacle, connect wires as tagged during removal. Install yellow ground wire to connector mounting bracket on carrier frame using the bolt and star washers taken of at removal and refer to Grove Engineering Specification 6829100386 for proper electrical termination of grounds.
8. Install clamp securing harness to retainer plate on bottom of hydraulic swivel assembly.
9. Connect batteries.

CAUTION

The slew potentiometer must be adjusted any time work is done to the electrical swivel. Personnel injury or damage to the machine may result.

10. Activate all systems, cycle all functions, and observe for proper operation. Adjust slew angle in accordance with *Slew Angle Verification*, page 6-18.

Preventive Maintenance

It is recommended 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 collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check collector ring setscrews are tight.
3. Check brush and arm assembly springs. Ensure they are holding brushes firmly against the collector rings.

Slew Angle Verification

1. Rotate superstructure over front and engage house lock pin.
2. Set RCL console to read slewing angle as follows:

NOTE: Refer to *Operator Manual* for detailed instructions.

   a. Complete the RCL console setup according to the crane’s current operating configuration.
   b. Select Info icon.
   c. Select Info icon.

3. Verify angle indicated on console does not exceed ± 1.0 degree.

SWING LOCK PIN

Description

The purpose of the swing lock pin is to lock the superstructure in position directly over the front for pick and carry loads. The pin swing lock installation consists of a large pin, a control handle in the right side of the cab, and control linkage that allows the crane operator to set and free the pin.

When the superstructure is directly over the front, pushing the control handle down drops the swing lock pin into a socket on the carrier frame, locking the superstructure in place. Pulling the control handle up pulls the pin out of the socket, unlocking the superstructure.

Maintenance

Verify linkage is installed to avoid damage from superstructure rotation and is undamaged. Verify pin, turntable bushing pin passes through, and socket on the frame are undamaged. Verify all attaching hardware is secure and undamaged.

Ensure linkage is adjusted properly. If it is, the pin bottom will stick out about 5.89 cm (2.32 in) from the bottom of its bushing in the turntable. (If it is too far in, it might not lock properly. If it is too far out, it might hang up). Using the jam nuts on the linkage parts, adjust the linkage so the pin bottom will stick out about 5.89 cm (2.32 in) from the bottom of its bushing in the turntable; verify the superstructure can lock properly and the superstructure can rotate without lock pin hangup.

360° SWING LOCK CONTROL (POSITIVE LOCK TYPE) (OPTIONAL)

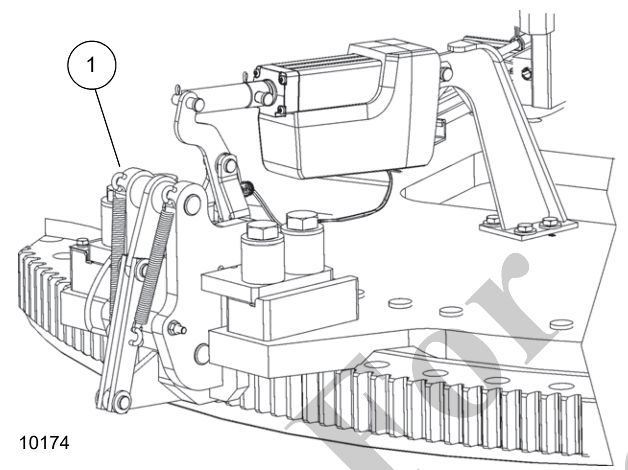


FIGURE 6-7

Description

The purpose of the swing lock (1, Figure 6-7) is to secure the superstructure in position at one of the positions in its rotation. There are roughly 120 spots approximately3.0 degrees apart for the superstructure to lock to in its 360 degree of rotation. The 360 degree swing lock control lever is on the right side of cab. Pushing the swing lock control lever down 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 spring is undamaged and has enough strength to pull blade of swing lock assembly completely out of the gear teeth when the control lever 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 lever is down. Verify all attaching hardware is secure and undamaged. Make adjustments as needed. When the lever is fully up, the top diagonal surface of the blade of the swing lock assembly (the beveled surface from the blade's top horizontal surface to its "ax blade" vertical surface should be 1.45 cm (0.57 in) from the tips of the gear teeth.

If the swing lock assembly is damaged, install a replacement. Align the blade of the swing lock assembly so it will fall between gear teeth. Use the shim and the related attaching hardware (two 5/16-18 screws and 5/16 ID lockwashers) to ensure the swing lock assembly cannot move side to side, and can lock up the superstructure. Torque the four 3/4-10 mounting bolts to their specified torque found in *Fasteners and Torque Values*, page 1-16.

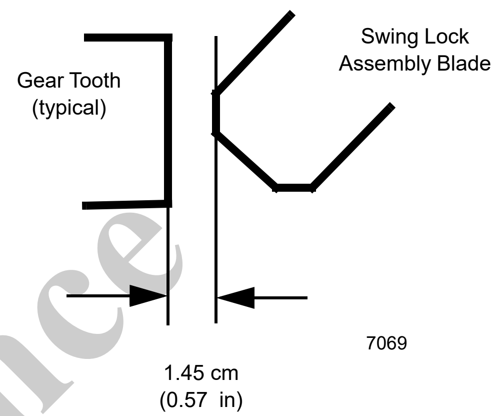


FIGURE 6-8

SLEW SENSOR

The slew sensor assembly (1, Figure 6-9), located under the operator cab, calculates the angle of the crane superstructure. Sensor readings are transferred over the CANbus network and appear in the ODM.

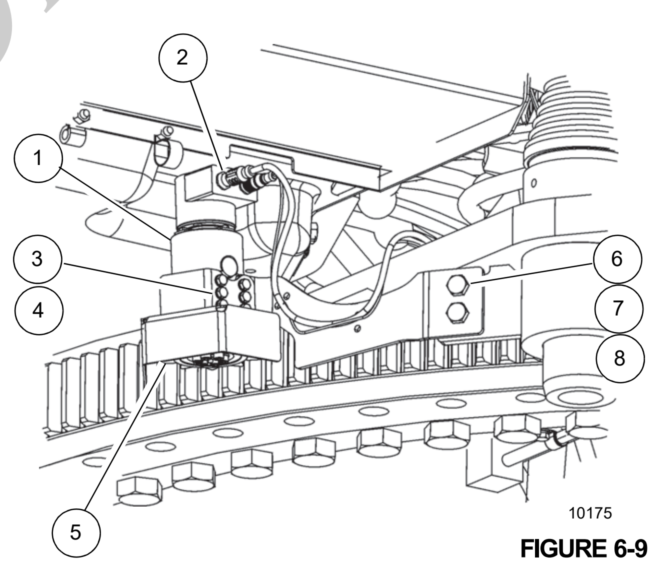


FIGURE 6-9

6

Removing the Slew Sensor

1. Disconnect transducer connectors (2) from slew sensor (1).
2. Remove capscrews (3), washers (4), left pinion protection shield (5), and slew sensor (1).
3. Remove capscrews (6), washers (7), and plate (8) as necessary.

Installing the Slew Sensor

1. Install plate (8) on superstructure with washers (7) and capscrews (6).
2. Install slew sensor assembly (1) and left pinion protection shield (5) with washers (4) and capscrews (3).
3. Connect transducer connectors to slew sensor assembly.
4. If install new transducers, you must re-calibrate the sensors. For more information, see *Calibrating ODM Sensors*, page 3-20.

SECTION 7
POWER TRAIN

SECTION CONTENTS

ENGINE

Description

The engine (1, Figure 7-1) is a Cummins B 6.7L diesel engine. The engine (1) is equipped with a torque converter (2). A drive shaft (4) connects the torque converter (2) and transmission (3). The engine and torque converter are considered one assembly. Four combinations of the engine and torque converters are available:

- Stage V/Tier 4 Final Cummins B 6.7L with torque converter with lockup.
- Stage V/Tier 4 Final Cummins B 6.7L with torque converter without lockup.
- Non-certified Cummins B 6.7L with torque converter with lockup.
- Non-certified Cummins B 6.7L with torque converter without lockup.

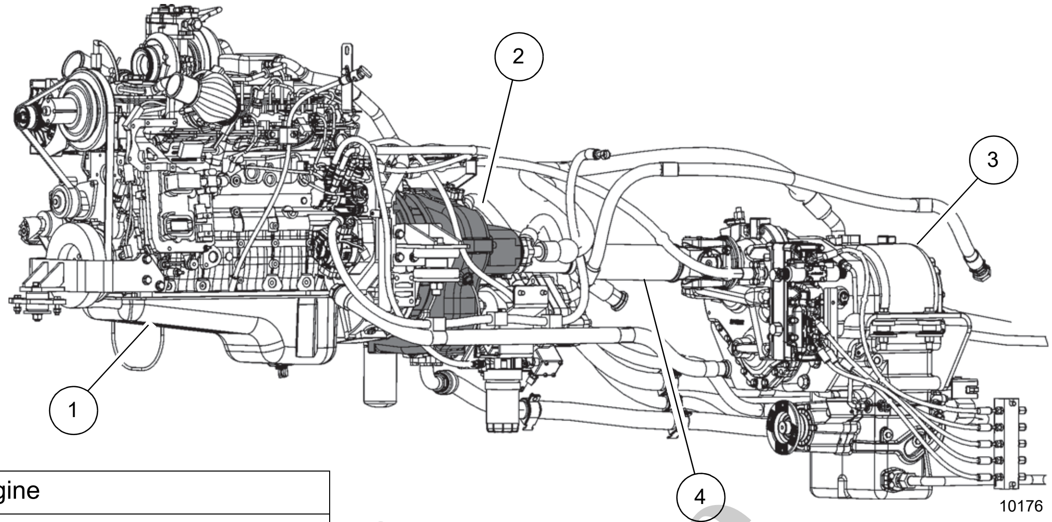
For more details about the engine, torque converter, and transmission, see *List Of Specifications*, page 1-3.

This *Service Manual* does not include detailed information on the engine itself. A separate manual as prepared in detail by the engine manufacturer, is supplied with this *Service Manual*. However, a short description and maintenance of certain components of the fuel system, air intake system, and water cooling system is provided in this section.

The engine is electronically controlled by the Electronic Control Module (ECM); it is the control center of the system. It processes all of the inputs and sends commands to the fuel systems as well as vehicle and engine control devices. On Stage V/Tier 4 Final engines, the ECM also controls the Diesel Exhaust Fluid (DEF) system.

The foot throttle pedal in the cab controls the engine speed. It controls engine RPM which increases or decreases proportionately with the amount of foot pressure applied to the pedal. Engine speed is also controlled by the idle switch, which is a three position rocker switch located on the upper right control panel. The idle switch allows the operator to infinitely vary and hold the engine speed between the engine's minimum and maximum idle settings (refer to Section 3, Operating Controls and Procedures in the *Operator Manual* for details on the operation of the idle switch). The foot throttle pedal is electrically connected to the superstructure control module which sends the signal to the engine ECM via the J1939 data link.

The engine and its components are enclosed in a hood assembly with a grill in the rear of the hood for adequate air circulation. Access to the engine is gained through a door assembly in the top of the hood that opens from both sides.



1	Engine
2	Torque Converter
3	Transmission
4	Driveshaft

FIGURE 7-1

The air intake filter is mounted on the right rear fender. The muffler is mounted on the left side of the carrier between the rear axles.

WARNING

Do not spray starting fluid into the air inlet. The spray will contact the heater elements and could explode causing personal injury.

The engine is equipped with electric air heating elements located in the engine intake air stream to aid in cold starting and reduce white smoke at start-up. In preheat mode, the engine should not be cranked until Wait-to-Start Lamp turns off. The Wait-to-Start Lamp is illuminated during the preheat time that takes place when the ignition switch is in the ON position during cold weather starting. The ECM checks information it receives from various sensors on the engine to determine how long to energize the air heater before extinguishing the Wait-to-Start Lamp. Once the engine is started, the electric air heating element will be energized again for a time period determined by intake air temperature.

Maintenance

Engine Removal

1. Set outriggers and position boom over the side.
2. Rotate the superstructure so it is over the side of the crane.
3. Open and remove hood top door assembly.
4. Disconnect air filter tubing at engine and air cleaner. Remove and lay aside.
5. On Non-certified engines, disconnect exhaust tubing at engine and muffler.
6. On Stage V/Tier 4 Final engines, disconnect the muffler exhaust tubing at the engine and aftertreatment assembly (muffler) remove the tubing from the engine. Lay to the side.
7. Tag and disconnect engine electrical harness connector from carrier harness connector and battery cables.
8. Unbolt fuel filter and engine lubrication filter from frame and lay on the engine.
9. Drain engine coolant system.
10. Drain engine lubrication system.
11. Remove engine hood assembly and pump cover from machine.
12. Remove capscrews, locknuts, and disconnect driveshaft (4, Figure 7-1) from the transmission (3) flywheel.
13. Tag and disconnect all lines from the radiator. Disconnect coolant level sensor harness from engine harness. Tie up excess harness so it is out of the way. Remove radiator. Refer to *Radiator Removal and Installation*, page 7-23 in this Section.
14. Tag and disconnect all lines and tubing from engine/torque converter, and all other components. On Tier 4 Final / Stage V engines, tag and disconnect the DEF coolant hoses.

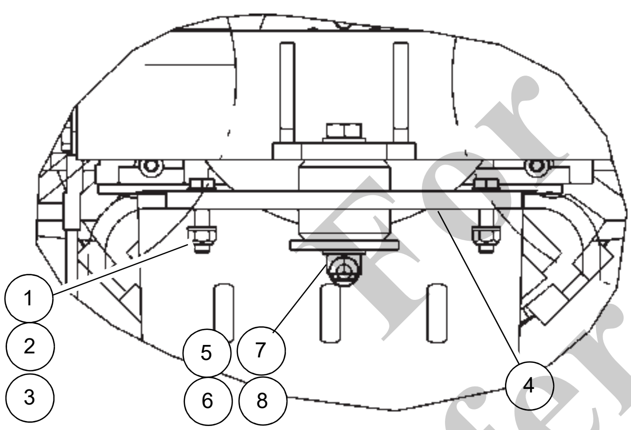
⚠ DANGER

Lifting device must be able to support combined weight of engine and transmission.

NOTE: Engine and torque converter assembly weighs approximately 1320 kg (2910 lb).

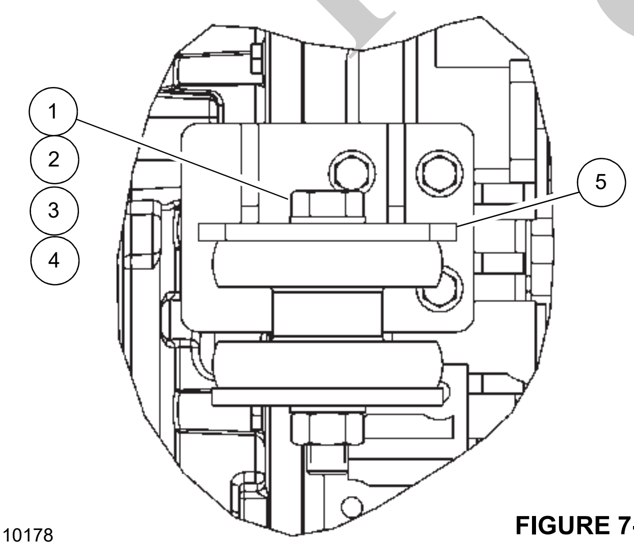
15. Attach a lifting device to engine capable of supporting weight of engine/torque converter.

16. With lifting device supporting weight of engine, remove capscrews (1, Figure 7-2), washers (2), and nuts (3) the securing plate (4).



10177 **FIGURE 7-2**

17. Remove locknut (1), washers (2), shock mount (3), and capscrew (4) securing right side engine mount to carrier (Figure 7-3).



10178 **FIGURE 7-3**

18. Repeat step 17 to remove attaching hardware from the left side engine mount.

19. Using lifting device, lift engine/torque converter as an assembly from the crane.

20. If a new engine is installed, remove all components, fittings, etc., from old engine and install them on new engine in same locations.

Engine Installation

⚠ DANGER

Lifting device must be able to support combined weight of engine and torque converter.

1. With all components and fittings installed on the new engine, lift the engine into the crane.

2. With engine in position, secure each side of the engine with capscrews (4, Figure 7-3), washers (3), shock mounts (2), locknuts (1).

3. Secure each side of the engine to the carrier with capscrews (4, Figure 7-2), shock mounts (3), washers (2), and locknuts (1).

4. At front of the engine, secure engine mount to frame with nuts. Secure the securing plate (4) with capscrew (1), washers (2), and locknuts (3).

5. Remove lifting device.

6. Connect all lines and tubing to the engine, torque converter, and all other components in accordance with identification marks made during removal.

CAUTION

Do not apply sealant to inside of hydraulic suction hoses.

7. Apply a moderate coat of to the male hose adapter and install the hydraulic hoses. Do not apply sealant to the inside of the hydraulic hose, and push it onto the male adapter. This can result in excess sealant being pushed ahead of the male adapter and being exposed to the hydraulic oil.

8. Install radiator. Refer to *Radiator Removal and Installation*, page 7-23. Connect all hoses and electrical harnesses to the radiator as tagged during removal.

9. Connect the drive shaft (4, Figure 7-1) to the transmission with capscrews and locknuts.

10. Install hood assembly. Install pump cover.

11. Attach fuel filter and engine lubrication filter to the frame. Connect battery cables and engine electrical harness connector in accordance with identification marks made during removal.

12. Connect electrical wiring to the hourmeter as tagged during removal.
13. Connect air filter tubing at engine and air filter. Connect exhaust tubing to engine and muffler. On Stage V/Tier 4 engines, replace exhaust tube gaskets with new ones.
14. Install hood top door assembly.
15. Service engine lubrication system, and engine cooling system.
16. Start engine. Check all hoses and fittings for leaks. Recheck all fluid levels.

Engine Drive Belts

Proper operation of engine belt-driven components such as alternator, fan, and water pump depend on proper condition and tension of the engine drive belt.

NOTE: Belt tension is maintained with an automatic belt tension device.

The engine drive belt should be inspected visually on a daily basis. Inspect drive belt for cracks, frayed areas, and glazed or shiny surfaces (see Figure 7-4). A drive belt that is glazed or shiny indicates belt slippage.

Engine drive belt damage can be caused by various factors such as incorrect tension, incorrect belt size, misaligned engine pulleys, incorrectly installed belt, or by oil, grease, or hydraulic fluid on the belt.

Refer to engine manufacturer's manual for special tools or belt tension specifications.

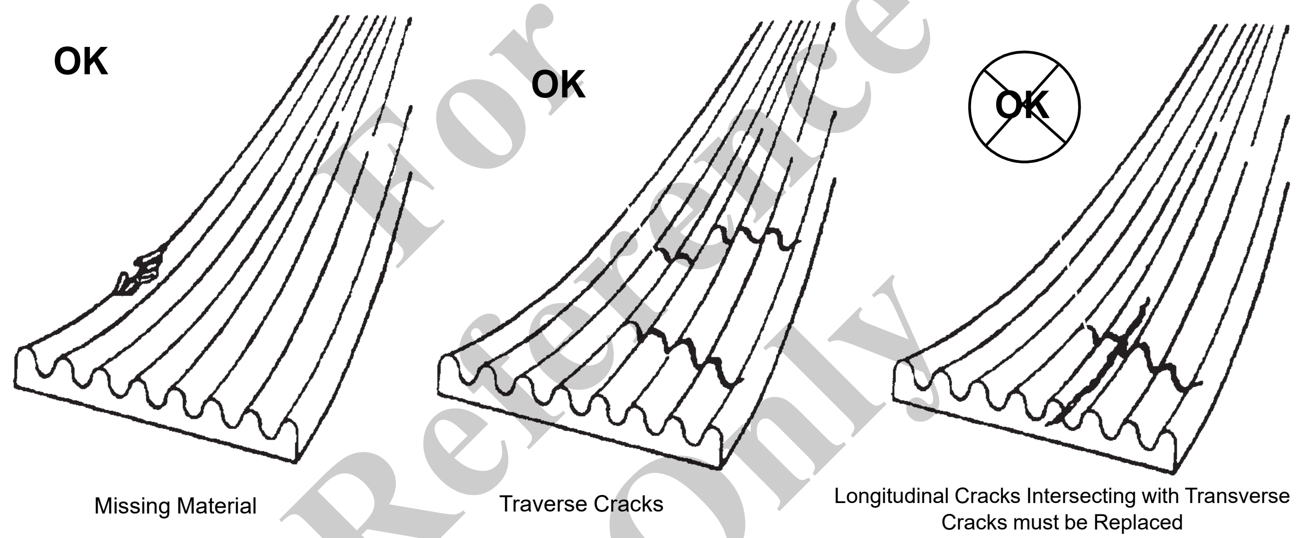


FIGURE 7-4

ELECTRONIC CONTROL SYSTEM

Description

The engine control system is an electronically operated fuel control system that also provides many operator and vehicle features as well as reducing exhaust emissions while optimizing engine performance.

The ECM performs diagnostic tests on most of its circuits and will activate a fault code if a problem is detected in one of these circuits. Along with the fault code identifying the problem, a snapshot of engine operating parameters at the time of fault activation is also stored in memory. Some fault codes will cause a diagnostic lamp to activate to signal the driver. The fault codes can be viewed on the crane control system display in the operator's cab.The ECM communicates with service tools supplied by Cummins through a SAE J1939 datalink.

The ECM also monitors the condition of the diesel particulate filter (Stage V/Tier 4 engines only) and alerts the operator by way of an indicator on the ODM display if the filter becomes clogged with carbon. When the filter becomes clogged, the ECM will control the exhaust system cleaning process to clean the filter of particulate matter.

Engine Control System Indicator Lights

Engine Stop Light

The Engine Stop Light is located in the ODM display. It is a red indicator light that illuminates to signify a serious engine problem that requires the vehicle and the engine to be stopped as soon as safely possible. The engine should

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remain shut down until the fault can be repaired. For more information, see the *Operator Manual*.

Engine Warning Light

The Engine Warning Light is located in the ODM display. It is an amber indicator light that is a part of the engine's electronic control system and when illuminated, gives the operator a signal that there is a engine or transmission problem which must be corrected. For more information, see the *Operator Manual*.

Exhaust System Cleaning Required Indicator

The Exhaust System Cleaning Required indicator is located in the ODM display. This indicator illuminates amber when the diesel particulate filter is getting filled with soot and needs to be cleaned out. For more information, see the *Operator Manual*.

CAUTION

Engine Shut-down Condition!

When the DPF indicator illuminates or flashes, start the exhaust system cleaning process.

Should the engine light come on with the DPF indicator, the engine will shut down and an authorized engine manufacturer service person must be contacted to re-start the engine.

WARNING

Fire or Burn Hazard!

During the exhaust system cleaning process the exhaust becomes very hot. Do not park the vehicle near flammable objects.

Use caution near the exhaust tailpipe during exhaust system cleaning as it will become very hot.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, fuel-water separator, secondary filter, lift pump, high-pressure pump, high-pressure common fuel rail (Tier 4 only) and the fuel injectors. All components except the fuel tank are installed on the engine or supplied with the engine for remote mounting.

Fuel Tank

The fuel tank (Figure 7-5) is a steel cylinder-type tank located on the left side of the machine. The fuel tank has a draw capacity of 271 L (72 gal). A connection on the bottom of the tank provides for fuel supply to the engine. Surplus fuel from the engine is provided to the bottom of the fuel tank below the fuel level. The tank is equipped with a non-vented filler cap, chain-attached to the tank, and a fuel quantity sender unit which provides a signal to a fuel quantity gauge on the instrument panel in the cab.

Injection Fuel Pump

The fuel oil is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is metered also, before injection, to meet the load requirements imposed upon the engine. Surplus fuel, returning from the injectors, is bypassed back to the fuel tank or to the inlet side of the pump. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

Fuel Filter-Water Separator

The fuel filter-water separator removes impurities from the fuel and also removes water from the fuel before it reaches the engine. The filter is mounted near the fuel tank on the left side of the crane.

The fuel mixture passes through the outer wrap of the first stage of the filter paper, where large droplets of water are formed as it is stripped from the fuel. The water falls out into the void between the two paper elements and goes to a reservoir in the bottom of the housing, where it can be drained through a drain plug at the bottom of the housing.

The water in fuel sensor is located in the fuel filter housing. After the storage space in the bottom of the filter housing fills with a certain amount of water, the sensor will signal the ECM.

Maintenance

NOTE: The entire fuel system must be maintained air tight to prevent loss of prime.

Fuel Tank

The fuel tank (1, Figure 7-5) should be kept filled, especially overnight, to minimize condensation. Refer to the applicable engine manual for the recommended schedule for draining any water or sediment from the tank.

Removal

1. Position a suitable container under the fuel tank and drain all fuel from the tank (1).
2. Tag and disconnect the lines from supply (11) and return (12) ports on the bottom of the tank.
3. Disconnect the electrical lead from the fuel quantity sending unit (3).
4. Support the weight of the tank, loosen and remove the nuts (7) and washers (8) securing the straps (9) to the mounting brackets. Remove the tank (1).

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5. If a new tank is to be installed, remove the two fittings, the fuel quantity sender (3), and steps from the tank and install them in the new tank.

Installation

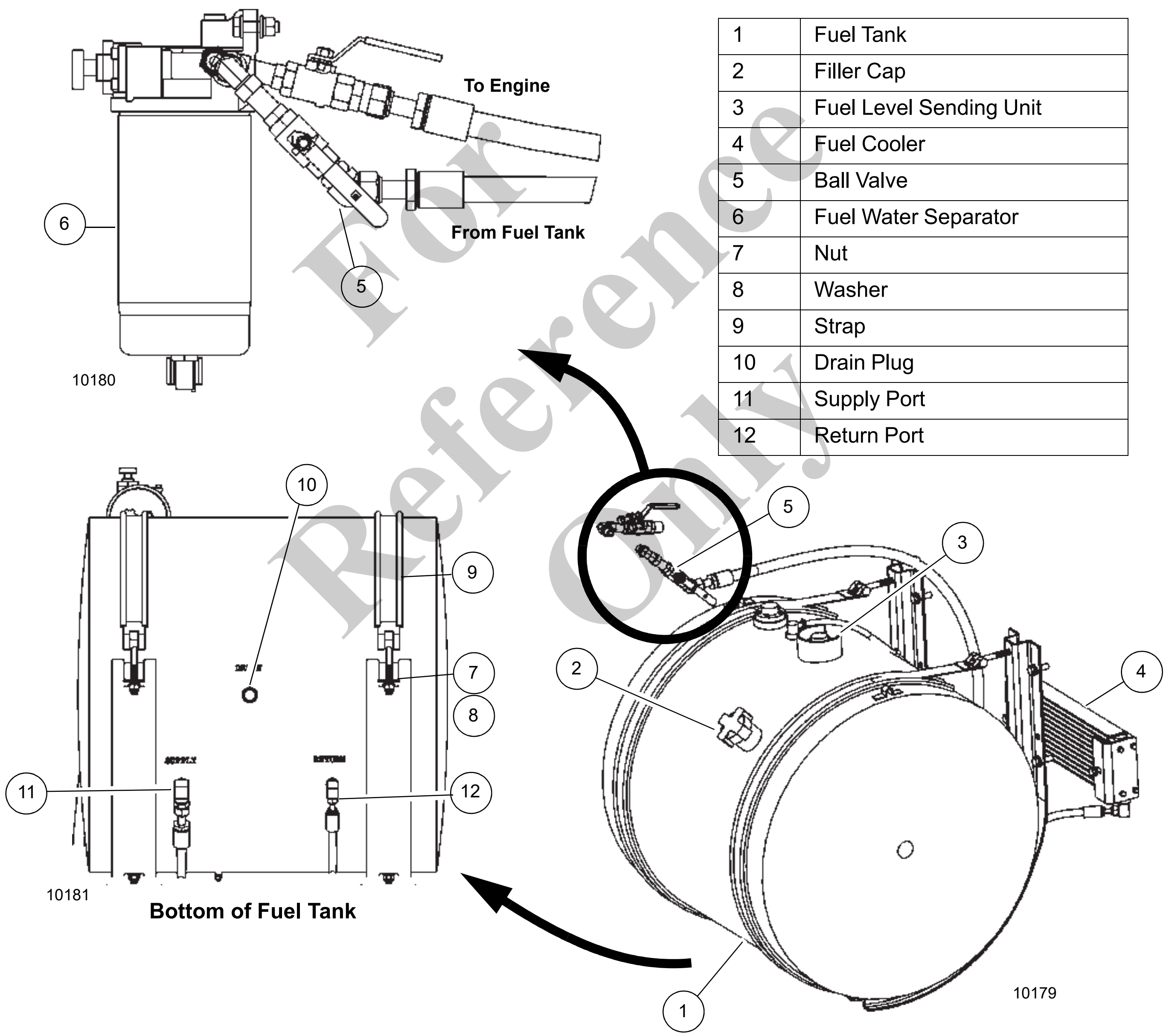
1. Position the new tank on the mounting brackets and install the nuts (7) and washers (8) on the two straps (9).
2. Connect the electrical lead to the fuel quantity sender unit (3).
3. Connect the two lines to the supply (11) and return (12) fittings on the bottom of the tank (1) in accordance with the identification marks made during removal.
4. Service the tank (1).

Fuel Filter-Water Separator

Draining

The sump of the fuel filter-water separator (6, Figure 7-5) should be drained daily, 30 minutes after the engine is shut down to remove any water and sediment. Adhere to the following procedure.

1. Open the drain plug.
2. Drain until fuel appears.
3. Close the drain plug.



1	Fuel Tank
2	Filler Cap
3	Fuel Level Sending Unit
4	Fuel Cooler
5	Ball Valve
6	Fuel Water Separator
7	Nut
8	Washer
9	Strap
10	Drain Plug
11	Supply Port
12	Return Port

FIGURE 7-5

AIR INTAKE AND EXHAUST SYSTEM

Description

The air intake system (Figure 7-6) controls the quality and amount of air available for combustion. System components are the Air Cleaner, Turbocharger, Charge Air Cooler, Cylinder Head, and Exhaust Manifold. Inlet air is pulled through the Air Cleaner, compressed and heated in the compressor side of the Turbocharger. The air is pushed through the Charge Air Cooler to the Air Inlet Manifold. Cooling the inlet air increases combustion efficiency, lowers fuel consumption, and increases the horsepower. The air is forced into the cylinder head to fill the inlet ports. Air flow from the inlet port into the cylinder is controlled by the intake valves.

Each cylinder has two intake valves and two exhaust valves. When the intake valves open, cooled compressed air from the inlet port is pulled into the cylinder. The intake valves close and the piston begins to move up on the compression stroke. Fuel is injected into the cylinder and combustion starts. The piston is forced down and is on the exhaust stroke when it moves up again. The exhaust valves open and exhaust is expelled through the exhaust port into the exhaust manifold.

The exhaust gas from the exhaust manifold enters the turbine side of the turbocharger and causes the turbine to turn driving the compressor. Exhaust from the turbocharger passes through the exhaust pipe and diesel particulate filter into the atmosphere.

The Air Cleaner (Figure 7-6) is the dry-type with a replaceable element and is located on the right rear fender. An Air Intake Restriction Monitor (AIRM) system is designed to calculate real-time air filter restriction at operational flow rate using the temperature and pressure input from the TBAP sensor (3, Figure 7-6) installed on the air cleaner housing.

On the Cummins B Engine there are electric air heating elements that are located in the engine's intake air stream. These elements heat the intake air when starting the engine in cold ambient conditions. Startability and white smoke control are enhanced by the use of the intake air heater. A Wait-to-Start Lamp is located on the crane control system display to indicate when to crank the engine.

Air Intake

Air Cleaner Checks

Dust passing the air cleaner, even through small holes, can cause rapid engine wear. Ensure all connections between the air cleaner and the engine are tight and sealed. If these connections are all well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Ensure the element sealing surface is not damaged and seals well against the element.
3. Inspect the element sealing surface for damage.
4. Check for structural failures. Any damaged parts must be replaced.

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.

On Stage V/Tier 4 engines, a TBAP sensor attached to the air cleaner housing provides input to the Air Intake Restriction Monitor (AIRM) system to activate a fault code when the filter needs to be replaced. The Engine Warning Indicator will blink at engine start for fault code 5576 indicating the air cleaner is becoming clogged. The indicator will be on solid for fault code 3341 indicating the filter is clogged and must be changed.

If the accuracy of either the mechanical service indicator or TBAP sensor 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 pressure 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.

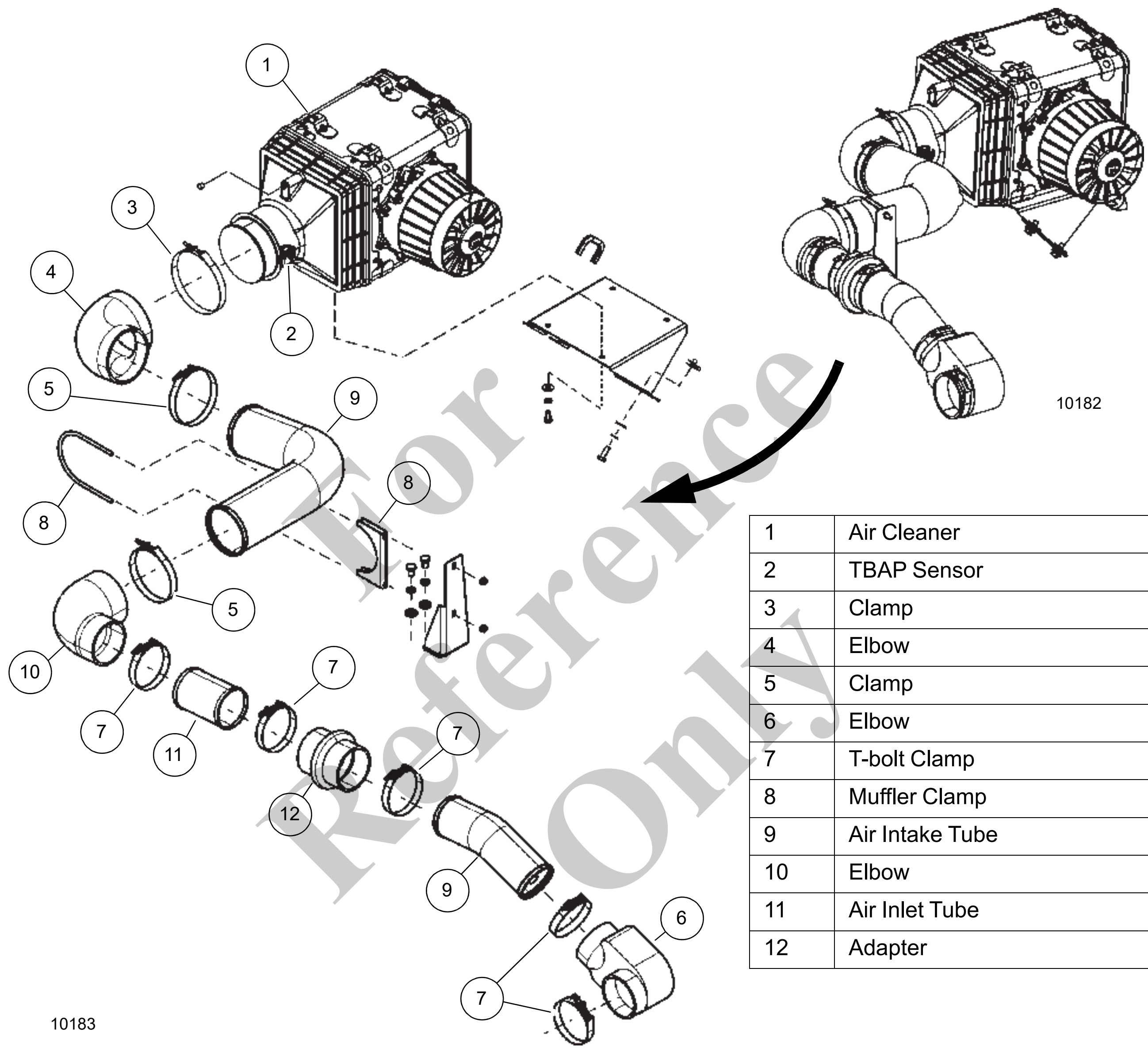
With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters is the air cleaner restriction. The maximum restriction for this engine is 25 inches of water.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Ensure the air cleaner inlet is not plugged.
2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.

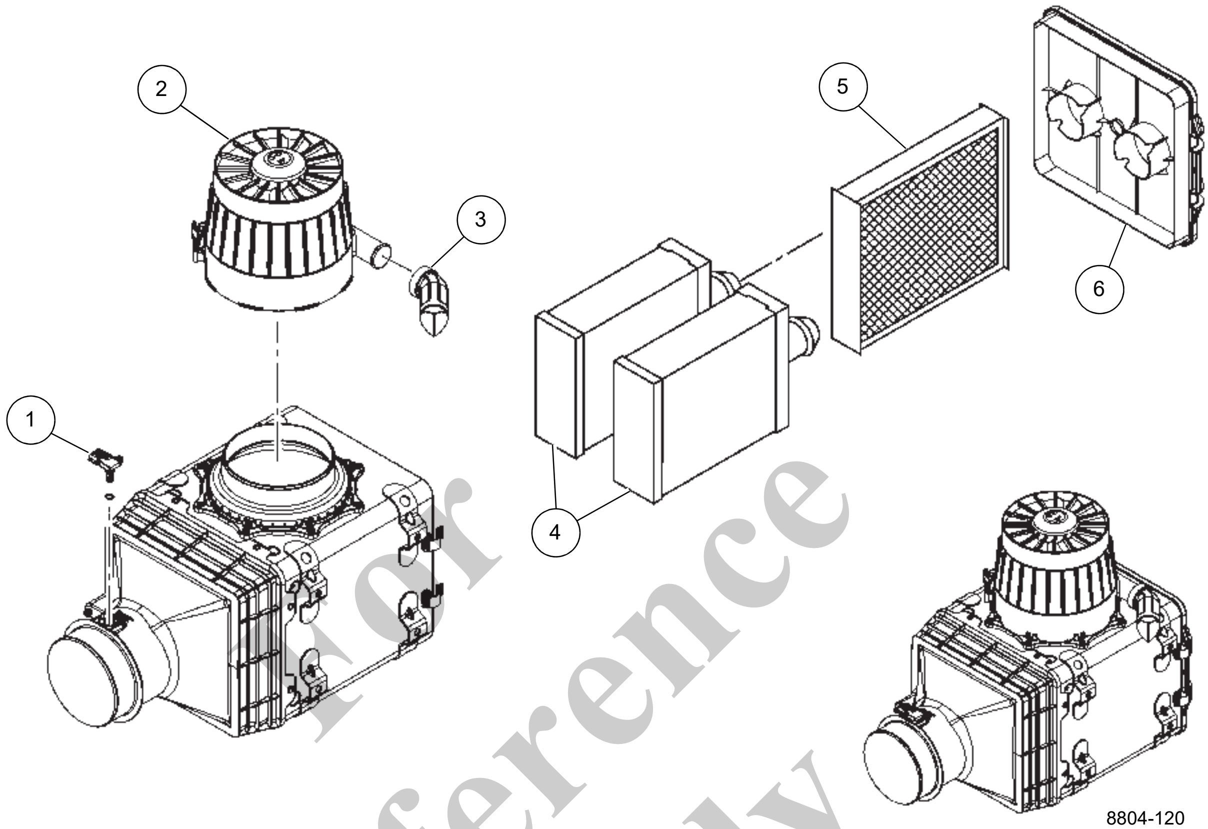
3. Ensure the correct size connections are used between the air cleaner and the engine.

4. Ensure all inlet accessories are the correct size and are not plugged by any foreign object.



1	Air Cleaner
2	TBAP Sensor
3	Clamp
4	Elbow
5	Clamp
6	Elbow
7	T-bolt Clamp
8	Muffler Clamp
9	Air Intake Tube
10	Elbow
11	Air Inlet Tube
12	Adapter

FIGURE 7-6



Air Filter Assembly

1	Temp/Air Pressure Sensor
2	Pre-cleaner
3	Evacuator Valve
4	Primary Air Filter
5	Secondary Air Filter
6	Service Door

FIGURE 7-7

Filter Element Replacement

CAUTION

Never service the air cleaner while the engine is running.

1. Loosen bolts and remove the access ladder.
2. Lift the clips (1, Figure 7-8) securing the cover to the air cleaner body and remove the cover.

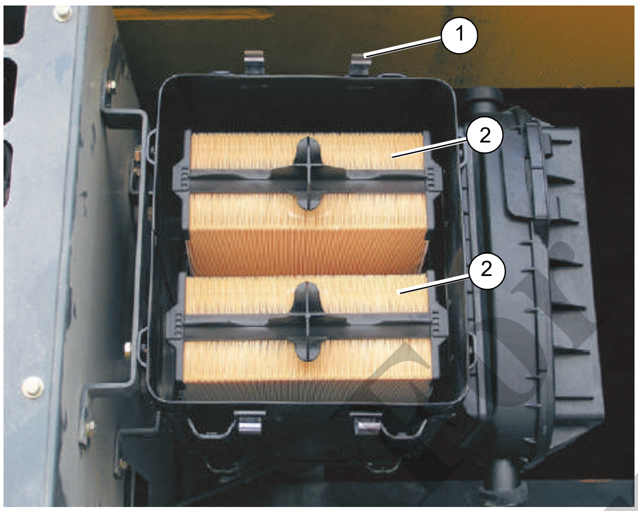


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FIGURE 7-8

3. Remove Primary Filter from the Air Cleaner and inspect for foreign material and marks of dust. Replace as necessary
4. Remove Secondary Filter (not shown) from behind the Primary Filter. Replace Secondary Filter every third time the Primary Filter is changed.
5. Thoroughly clean the sealing surface and inside of the air filter housing. Inspect all parts of the intake system and air cleaner.
6. Place the cover back on the air cleaner housing and secure with clips (1).
7. 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.

Pre-cleaner

The pre-cleaner (1, Figure 7-9) prevents large debris from entering the air cleaner and should be cleaned periodically, especially when working in severe dust conditions. Remove the top half of the pre-cleaner by releasing the two latches on the sides of the pre-cleaner. Remove all debris from inside pre-cleaner and reassemble.

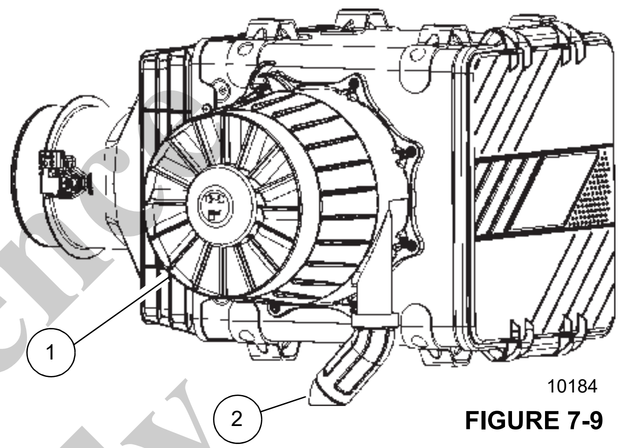

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FIGURE 7-9

Evacuator Valve

Evacuator valve (2, Figure 7-9 and Figure 7-10) is designed to automatically expel loose dust and dirt from the air cleaner body, thus lengthening the element service life. The valve lips must point straight down and be kept free of debris to operate effectively. Mud and chaff can lodge in these lips periodically and hold them open during engine operation.

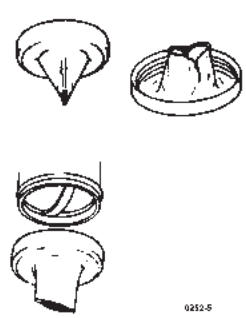

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FIGURE 7-10

Check the condition of the valve and lips frequently and keep them clean. The valve lips should be open only when the engine is shut down, or running at low idle speed. If the valve is turned outside in, check for a clogged air cleaner inlet. Malfunction of this valve does not reduce the air cleaner effectiveness, but does allow the element to get dirty faster and reduces serviceable life. If a valve is lost or damaged, replace it with a new valve of the same part number.

Duct Work

1. Check the intake pipe cap and screen for accumulation of leaves, trash, and other debris that could restrict air flow. Repair the screen or replace the cap if any large holes are found in the screen.

2. Check all mounting hardware for security to eliminate possible vibration of intake piping. Such vibration leads to early failure of hoses, clamps, and mounting parts, and can cause hoses to slip off the connecting pipes, allowing un-filtered air into the engine air intake.

3. Check hoses for cracks, chafing, or deterioration, and replace at the first sign of probable failure.

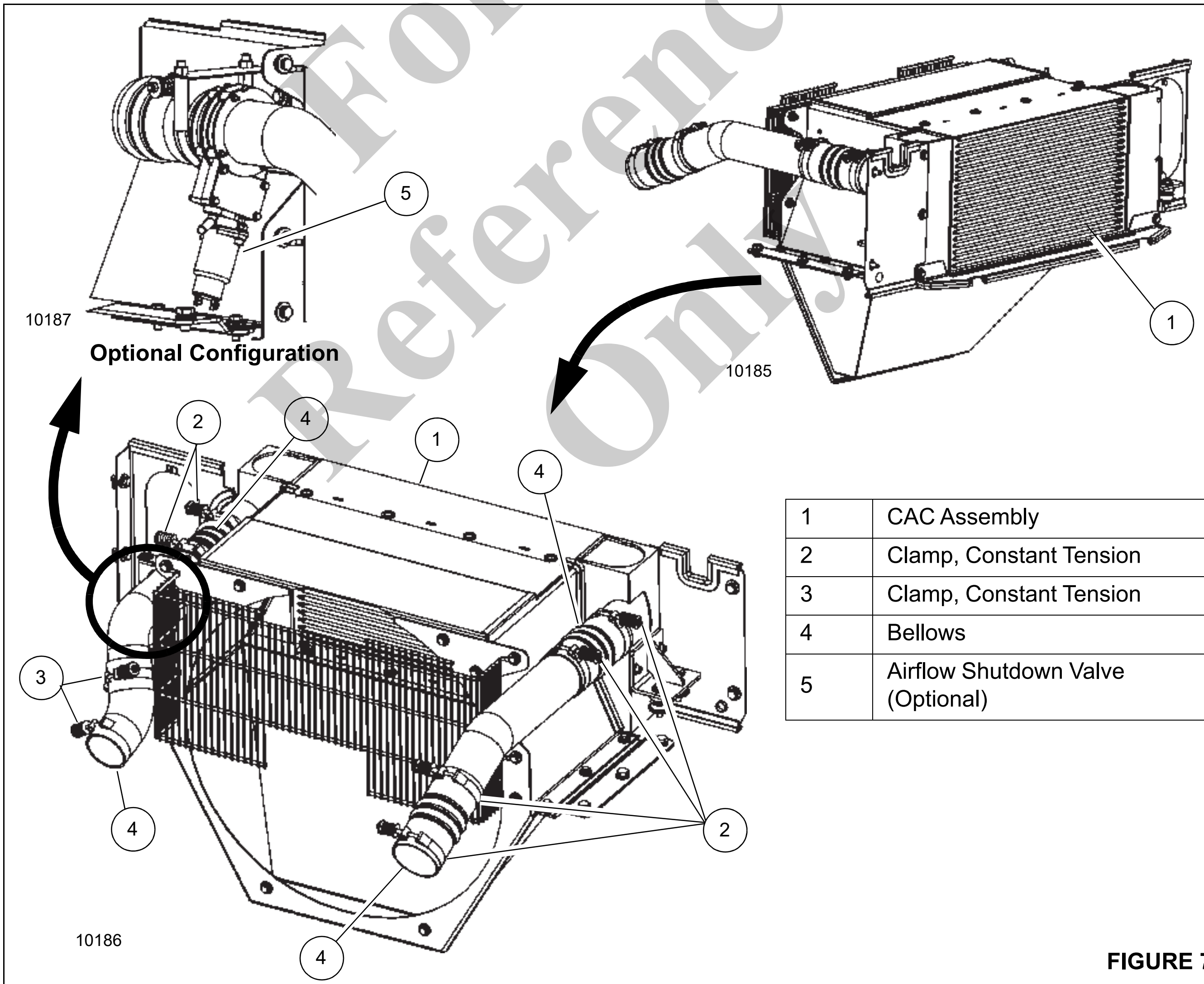
Charge-Air Cooler System

The charge-air cooler (CAC) (1, Figure 7-11) is used to cool engine air after it has passed through a turbocharger, but before it enters the engine. The charge-air cooler provides better horsepower, increased fuel efficiency, and reduces engine emissions.

The CAC system consists of the ducting to and from the charge-air cooler and a hydraulically driven fan. The charge-air cooler system must be air-tight to work efficiently.

The ducting consists of metal tubing, hose clamps (2 and 3) and bellows (4). The recommended installation torque for the large constant tension clamps (2) is 4.5 N-m (40 lb-in) and the small constant tension clamps is 6.8 N-m (60 in-lb). Do not compress the spring completely, the bellows and/or clamp may be damaged from thermal expansion of the CAC tube.

On cranes equipped with an optional refinery package, the CAC features an airflow shutdown valve (5).



1	CAC Assembly
2	Clamp, Constant Tension
3	Clamp, Constant Tension
4	Bellows
5	Airflow Shutdown Valve (Optional)

FIGURE 7-11

Maintenance

1. Check hose clamps for proper torque.
2. Inspect bellows for cracks or holes.
3. Clean charge-air cooler. Remove any dirt or debris.
4. Verify fan is operating correctly and there are no hydraulic leaks.

Exhaust System

Non-Certified Engine Exhaust System

The exhaust system on non-certified engines (Figure 7-13) is made of a muffler and various tubes, elbows, and clamps.

When removing and installing a muffler, tighten all hardware to specifications found under *Fasteners and Torque Values*, page 1-16, unless specified otherwise:

- Tighten V-band clamps to 13.5±1.5 N-m (9.96±1.10 ft-lb).
- Tighten slip joint to 9 to 11.3 N-m (85 to 100 ft-lb).
- Tighten mounting bands to 5.4 N-m (4.0 ft-lb).

Stage 5/Tier 4 Engine Exhaust System

The Stage V/Tier 4 exhaust system (Figure 7-14) features a aftertreatment unit (1) and various tubes, elbows, and clamps.

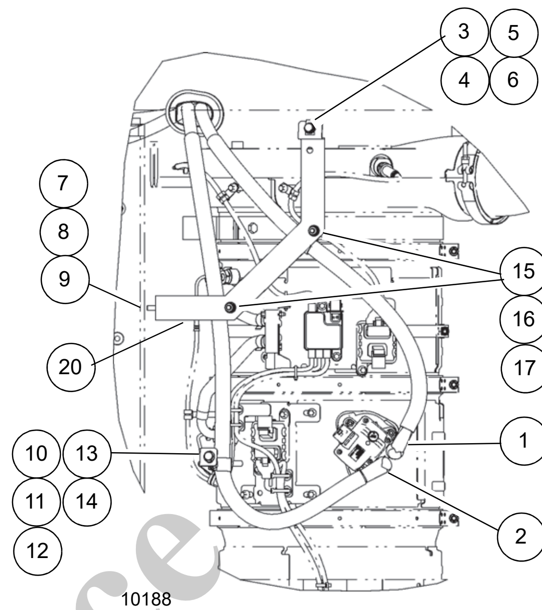
Removal

CAUTION

Burn Hazard!

Do not touch exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove the sheet metal guard to gain access to the exhaust system.
2. Remove clamps (2) to free the exhaust tailpipe (3).
3. Tag and disconnect electrical connections.



1	DEF Fluid Out	11	Lockwasher
2	DEF Fluid In	12	Washer
3	Nut	13	Capscrew
4	Lockwasher	14	Clamp
5	Washer	15	Nut
6	Capscrew	16	Lockwasher
7	Capscrew	17	Washer
8	Lockwasher	18	Capscrew
9	Washer	19	Clamp
10	Nut	20	Support Bracket

FIGURE 7-12

4. Disconnect the DEF hoses (1 and 2, Figure 7-12).
5. Remove nut (3), lockwasher (4), washer (5), and capscrew (6).
6. Remove capscrew (7), lockwasher (8), and washer (9).
7. Remove nut (10), lockwasher (11), washer (12), capscrew (13), and clamp (14) from hose (2).
8. Remove nuts (15), lockwashers (16), washers (17), capscrews (18), clamps (19), and support bracket (20).
9. Remove clamp (4, Figure 7-14) and tailpipe.
10. Remove attaching hardware and mounting band clamps (5).
11. Disconnect clamp (11), gasket (12), and tube (10) from the engine exhaust.
12. Remove (9) coupler from tubes (8 and 10).

13. Remove clamp (6), gasket (7), and tube (8) from the aftertreatment unit (1).

14.

NOTE: The aftertreatment unit weighs approximately 92.26 kg (203.4 lb).

15. Using an appropriate lifting device, remove the aftertreatment unit (1).

16. Inspect the aftertreatment unit, exhaust tailpipe, exhaust tubes, bracket, and attaching hardware. Repair or replace any of these parts if damaged or missing.

Installation

NOTE: Tighten all hardware to specifications found under *Fasteners and Torque Values*, page 1-16, unless specified otherwise:

- Tighten V-band clamps to 13.5±1.5 N-m (9.96±1.10 ft-lb).
- Tighten slip joint to 9 to 11.3 N-m (85 to 100 ft-lb).
- Tighten mounting bands to 5.4 N-m (4.0 ft-lb).

NOTE: Make sure the aftertreatment unit pressure sensor is within 10° of vertical.

1. Using an appropriate lifting device, lower the aftertreatment unit (1) on the aftertreatment weldment on the carrier.
2. Install tube (8) to aftertreatment unit (1) with gasket (7) and clamp (6).
3. Install coupler (9) on tube (8). Install tube (10) on coupler (9).
4. Install tailpipe (2) on aftertreatment unit (1) with clamp (4).
5. Connect the tube (10) and gasket (12) to engine exhaust with clamp (11).
6. Secure the aftertreatment unit (1) with mounting band clamps (5).
7. Secure tail pipe (2) with tail pipe clamps (3).
8. Install the support bracket (20, Figure 7-12) in place. Secure DEF fluid hoses (1 and 2) with nuts (15), lockwashers (16), washers (17), capscrews (18), clamps (19), and support bracket (20).
9. Secure one end of the mounting bracket (2) with nut (3), lockwasher (4), washer (5), and capscrew (6).
10. Secure the other end of the mounting bracket (2) with capscrew (7), lockwasher (8), and washer (9).
11. Secure hose (2) with clamp (14), capscrew (13), lockwasher (11), washer (12), and nut (10).
12. Connect electrical connections as tagged during disassembly.
13. Connect DEF hoses (1 and 2).
14. Install sheet metal guard.

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-band clamps by one full turn of the nuts.

2000 Hours or 2 Years

Tighten the V-band clamps by 1 ½ turns of the nuts.

4000 Hours or 4 Years

Tighten the V-band clamps by 1 ½ turns of the nuts.

5000 Hours or 5 Years

Remove the V-band clamps and gaskets, and replace them with new gaskets and clamps. Tighten the V-band clamps to 13.5±1.5 N-m (9.96±1.10 ft-lb) of torque.

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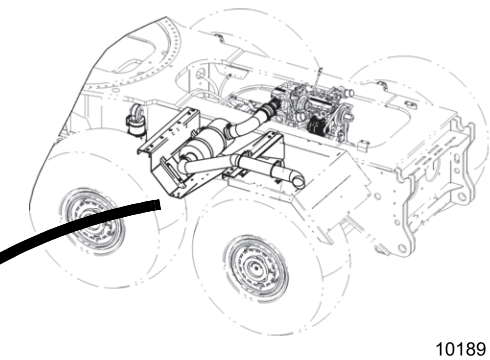

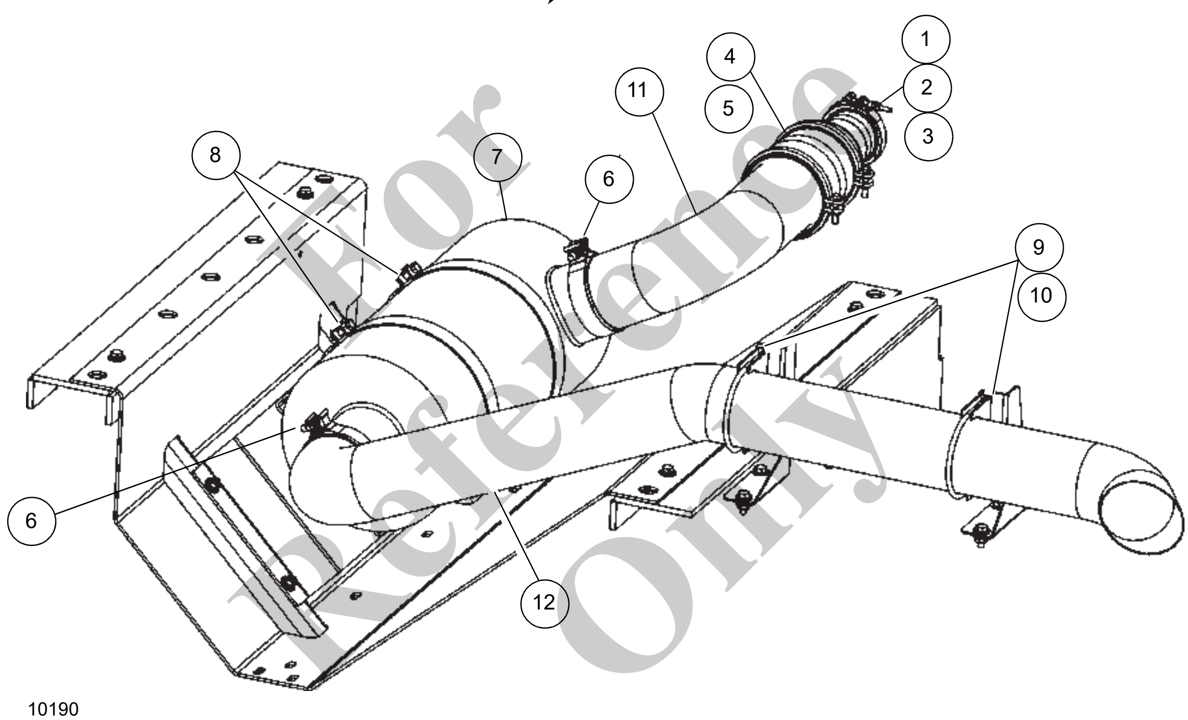

Exhaust System - Non-Certified Engine

1	Jam Nut
2	Clamp, V-Band
3	Gasket
4	Flex Coupler
5	Clamp, V-Band
6	Clamp, Slip Joint

7	Muffler
8	Clamp, Mounting Band
9	Muffler Clamp
10	Nut
11	Tail Pipe Tube
12	Tail Pipe

FIGURE 7-13

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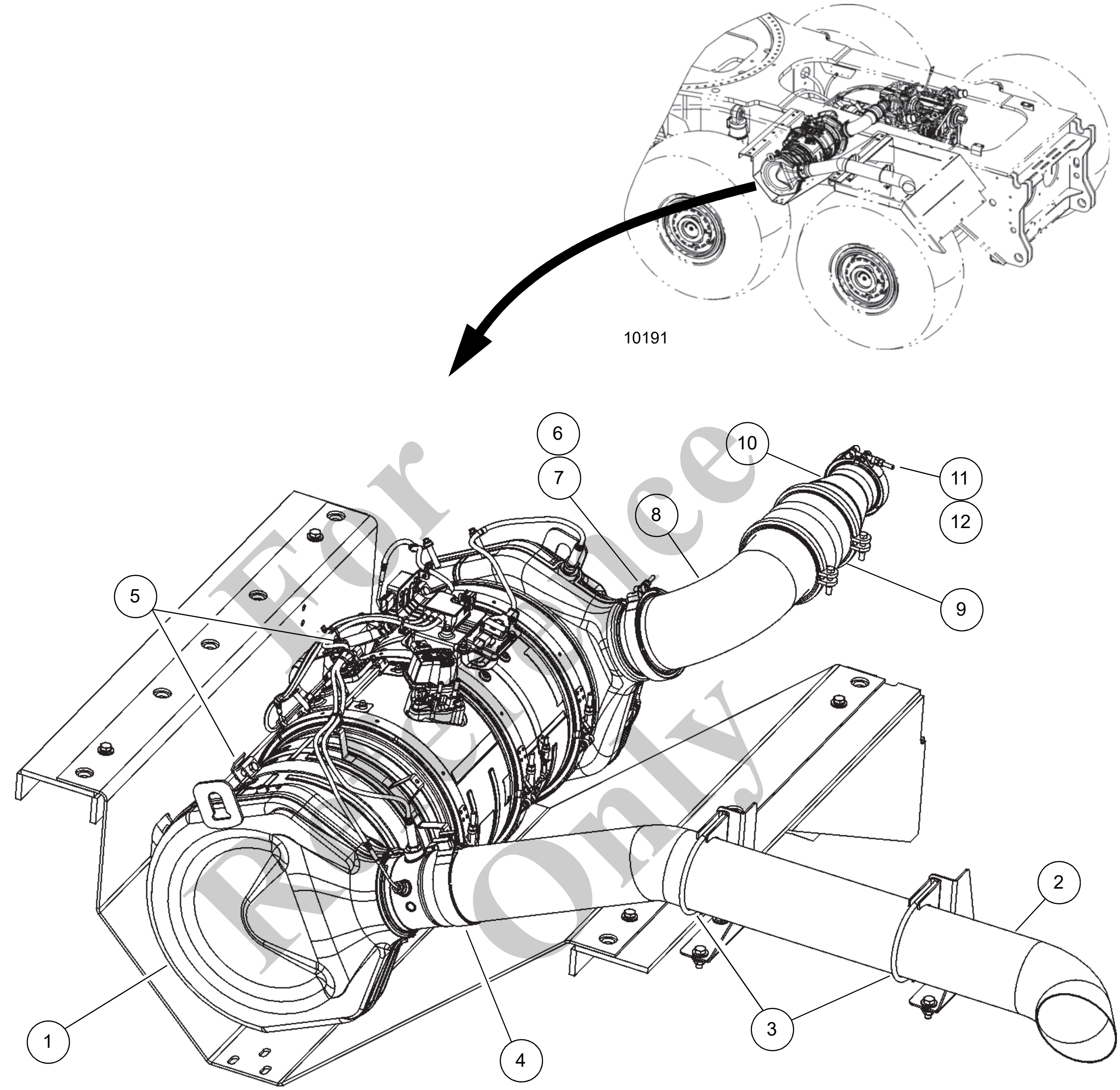


Exhaust System - Stage 5/Tier 4

1	Aftertreatment Unit
2	Tailpipe
3	Tailpipe Clamp
4	Clamp, Slip Joint
5	Clamp, Mounting Band
6	Clamp, V-Band

7	Gasket
8	Tube
9	Coupler
10	Mounting Bands
11	Clamp, V-band
12	Gasket

FIGURE 7-14

AFTERTREATMENT DIESEL EXHAUST FLUID (DEF)

DEF Tank

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.

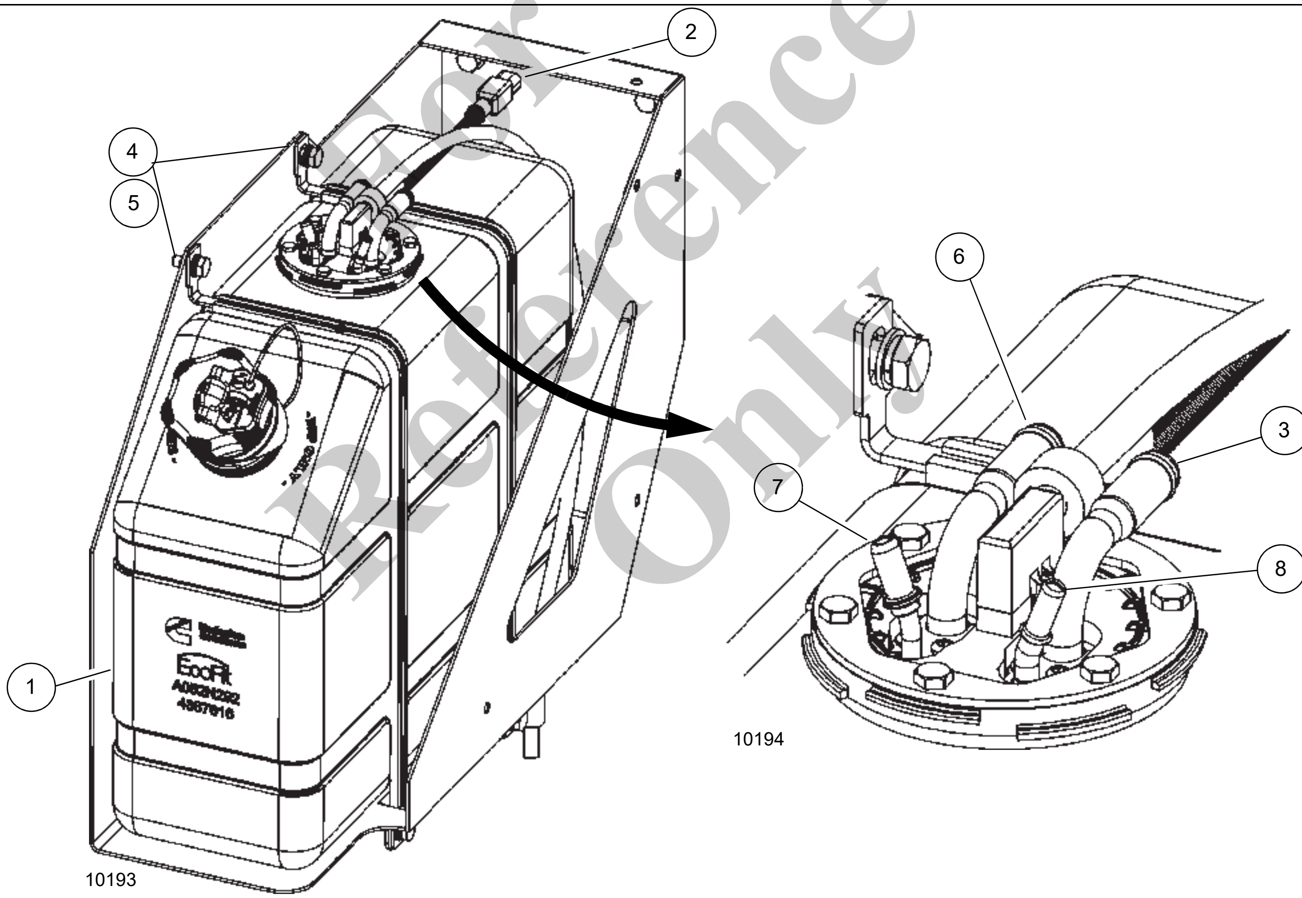
The DEF tank (1, Figure 7-15) incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

Removal

1. Tag and disconnect the electrical connector (2) on the DEF tank (1).
2. Tag and disconnect the fluid lines (3, 6, 7, 8) on the tank.
3. Remove the hardware (4) holding the tank straps (5) in place.
4. Remove the tank (1).

Installation

1. Place the DEF tank (1) onto the location on the frame.
2. Place the tank straps (5) around the tank and secure with the hardware (4).
3. Connect the fluid lines (3, 6, 7, 8) as tagged during removal.
4. Connect the electrical connector (2) as tagged during removal.



1	DEF Tank		5	Tank Straps
2	Electrical Connector		6	Coolant Outlet
3	Coolant Inlet		7	Suction Port
4	Tank Strap Mounting Hardware		8	Return Port

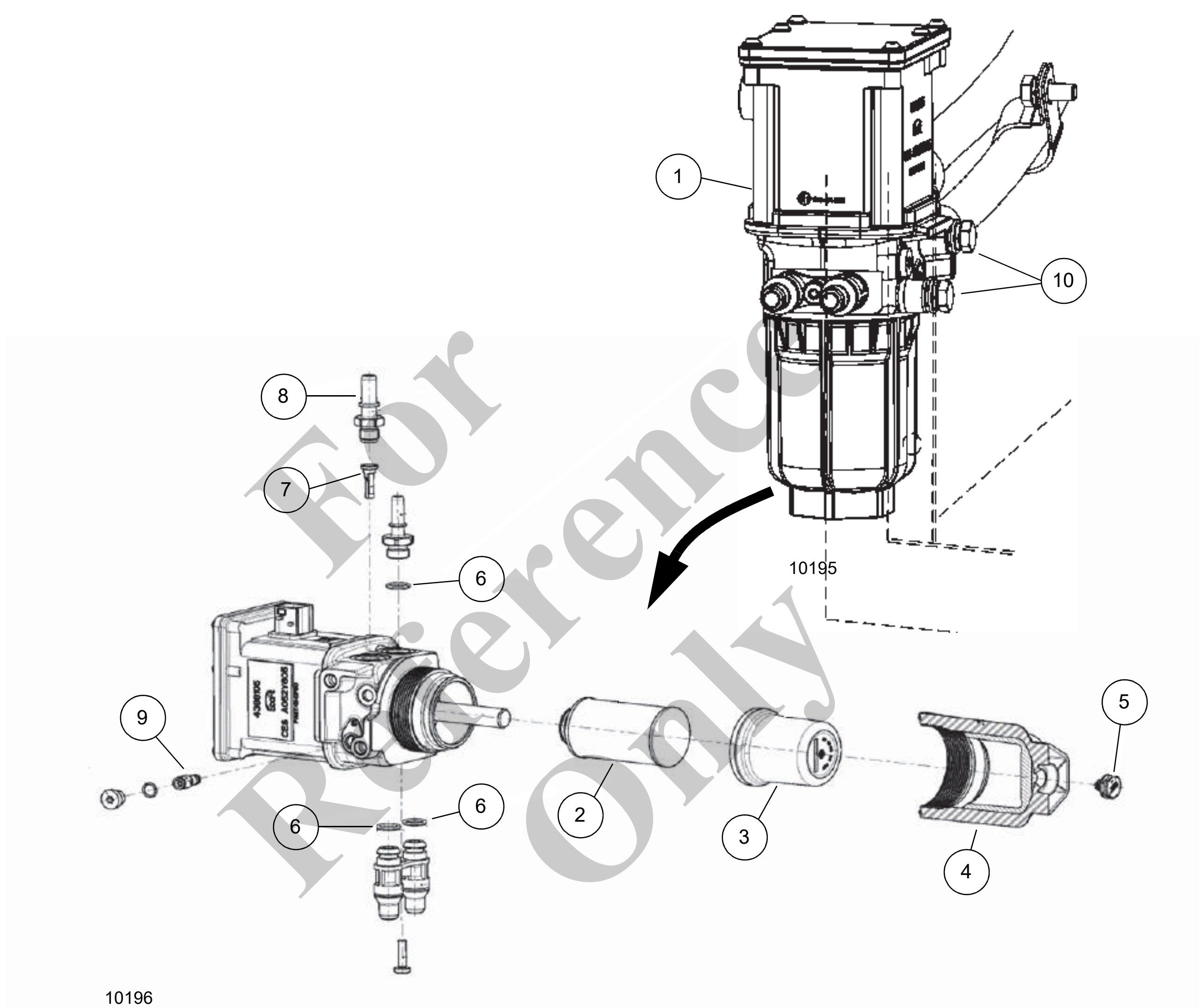
FIGURE 7-15

DEF Supply Pump Filter

The DEF supply pump filter (2, Figure 7-16) 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 DEF supply pump or the aftertreatment DEF dosing valve.

The filter should be replaced every 480,000 km (300,000 miles) or 6750 hours of crane operation.



1	DEF Supply Pump, 24V
2	DEF Filter
3	Protective Cover
4	Filter Housing
5	Ventilation Cap

6	O-Ring
7	Filter Screen
8	Quick Disconnect Connector
9	Press Relief Valve
10	Attaching Hardware

FIGURE 7-16

Initial Check

Inspect the area around the seal and vent of the DEF supply pump filter housing 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 supply pump has completed the purge cycle. Before removing and/or disconnecting any components, wait at least five minutes after the key switch is turned OFF for the DEF supply pump to purge the DEF from the system. The purge cycle is an automatic process and does not require intervention to occur. The DEF supply pump 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.

1. Turn the battery disconnect switch to OFF to disconnect the batteries.
2. (optional) Tag and disconnect hoses. Remove attaching hardware (10) and DEF supply pump assembly (1) from the side tool box.

Filter Remove

NOTE: There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

1. Unscrew and remove the DEF filter housing (4).
2. Loosen the ventilation cap (5) and drain excess DEF.
3. Remove the protective cap (3) and DEF filter (2).

NOTE: If removing the DEF filter as part of a maintenance interval, discard the 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 filter screen (7).
   - The DEF dosing unit inlet quick disconnect connector (8).
3. Discard the DEF filter.
4. Inspect the DEF filter protective cover (3) for cracks or holes that could create a DEF leak path.
5. Check the condition of the threads on the DEF filter protective cover (3). If the threads are damaged, replace the DEF filter protective cap.
6. Inspect the DEF filter housing (4) threads. This is especially important if the DEF filter housing (4) was damaged. If the DEF filter housing threads are damaged, replace the entire DEF supply pump.

NOTE: Never operate the vehicle with the DEF housing removed.

7. Clean the DEF housing (4) with warm water and a clean cloth.

Filter Installation

NOTE: Lubrication of the DEF filter O-rings is not required.

1. Slide the DEF filter (2) into the DEF protective cap (3).
2. Insert the assembly into the DEF housing unit.
3. Install the DEF filter housing(4) on the DEF supply pump (1). Torque Value: 80 +/-5 Nm (59 lb-ft).
4. tighten the ventilation cap (5) as necessary.

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 DEF supply pump 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. If necessary, install the DEF supply pump assembly on the side of the battery box with attaching hardware (10). Reconnect hoses as tagged.
2. Connect the batteries by turning the battery switch to ON.
3. Operate the engine and check for leaks.

WATER COOLING SYSTEM

Description

The cooling system (Figure 7-17) consists of a radiator, surge tank, engine cooling circuit, and the connecting hoses and connecting tubes. At all times, the antifreeze/coolant should be properly inhibited against corrosion. It is recommended that a mixture of AFC-50/50 blended ethylene-glycol, low silicate, fully formulated, engine antifreeze/coolant concentrate and water which does not require a pre-charge of supplemental coolant additives (SCA) for use in initial fill of heavy duty liquid cooled internal combustion engines be used at all times.

The crane is equipped with a cab hot water heater. Hot water is supplied by the engine coolant system through a strainer and two port water swivel to the cab heater. The strainer is a cleanable type and is located on the left side of the transmission by the rear engine/transmission mount. Refer to *Maintenance and Lubrication*, page 9-1 for service of the strainer.

Maintenance

General

The cooling system includes the Radiator, Surge Tank, Thermostat, the Fans, 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 radiator tank. Then the water flows across through the radiator core and is cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

Effects of Cooling System Neglect

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the part directly responsible is not a part of the cooling system. Most of these problems can be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating

An engine that is overheating may lead to troubles such as the following:

1. Burned valves.
2. Pinging or knocking.
3. Excessive fuel consumption.
4. Poor lubrication - increased engine wear.
5. Sticking valves.
6. Short injector life.
7. Engine hot spots.
8. Need for higher grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids formed in crankcase.
4. Excessive fuel deposits in the exhaust system.

Antifreeze/Coolant

Heavy duty diesel engines require a balanced mixture of water and antifreeze/coolant. For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times. Refer to *Maintenance and Lubrication*, page 9-1. Do

7

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.

Rust Prevention

To keep engines operating at like new efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times. Supplemental coolant additives (SCA) are recommended for this cooling system. Antifreeze/coolant alone does not provide sufficient protection for heavy-duty diesel engines. Refer to *Section 9* for SCA specification and compatible brands.

Antifreeze/Supplemental Coolant Additives Maintenance Summary

Cooling System Level Check Interval

Daily or 10 hours

Check cooling system level every 10 hours of operation or daily, whichever comes first. Refer to *Maintenance and Lubrication*, page 9-1.

SCA Level Check Interval

6 months or 500 hours

- Check SCA Levels (use only Coolant Test Kit, Grove part number 9414101675, to check the coolant additive concentration in the cooling system).

  Only add coolant additive if levels are less than 1.2 units/gal (see *Maintenance and 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.

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.
  - 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 *Radiator Fill and Servicing*, page 7-25.

NOTE: Remove radiator caps when draining system to ensure proper draining.

Cleaning

CAUTION

Burn Hazard!

The cooling system contains very hot pressurized liquid 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, drain the system. For more information, see *Radiator Fill and Servicing*, page 7-25.

NOTE: Use a cleaning compound that is not corrosive to aluminum to prevent damage to the radiator.

2. Allow engine to cool, close radiator caps, and pour the cleaning compound into the surge tank according to the directions. Fill 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 caps 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 engine as often as necessary to prevent boiling.
6. With engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*) and repeat the cleaning operation.
8. If problem persists, replace the radiator.

Pressure Flushing

1. Disconnect both radiator hoses that connect the radiator to the engine.
2. Clamp a convenient length of hose to the radiator core outlet opening, and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.
3. Connect the flushing gun to compressed air and water pressure, and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. Fill core with water. Turn on air pressure in short blasts to prevent core damage.
5. Continue filling the radiator with water and applying air pressure as above until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill the engine block with water, partly covering the water inlet opening to permit complete filling.
7. Turn on compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
9. After completing the flushing operation, clean out the surge tank overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
10. Blow insects and dirt from the radiator core air passages. Use water to soften obstructions if necessary.

Component Inspection

Radiator/Surge Tank

1. Side Tanks — Look for leaks, particularly where the tank is attached 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). 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 easily become clogged by rust and scale. The general condition of the cooling system and operating temperature are indications as to whether or not tubes are clean. Another good test is to feel the core for cold spots.
5. Fins are thin metal sheets that dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw etc., so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket

The water jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged, if the cooling system does not receive the proper maintenance.

1. Core Plugs — These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.
2. Drain Plugs — The water jacket of each engine could have one or more drain plugs. These should receive seasonal care and be kept free of rust and scale.
3. Gaskets — All gaskets must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

Water Pump

The pump should be checked carefully for leaks and proper lubrication. Replace or rebuild if leaking, cracked, or worn.

Fans and Belts

The fan should be checked for cracked or broken blades.

Refer to *Engine Drive Belts*, page 7-4.

Thermostat

The thermostat is nonadjustable 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.

Radiator Removal and Installation

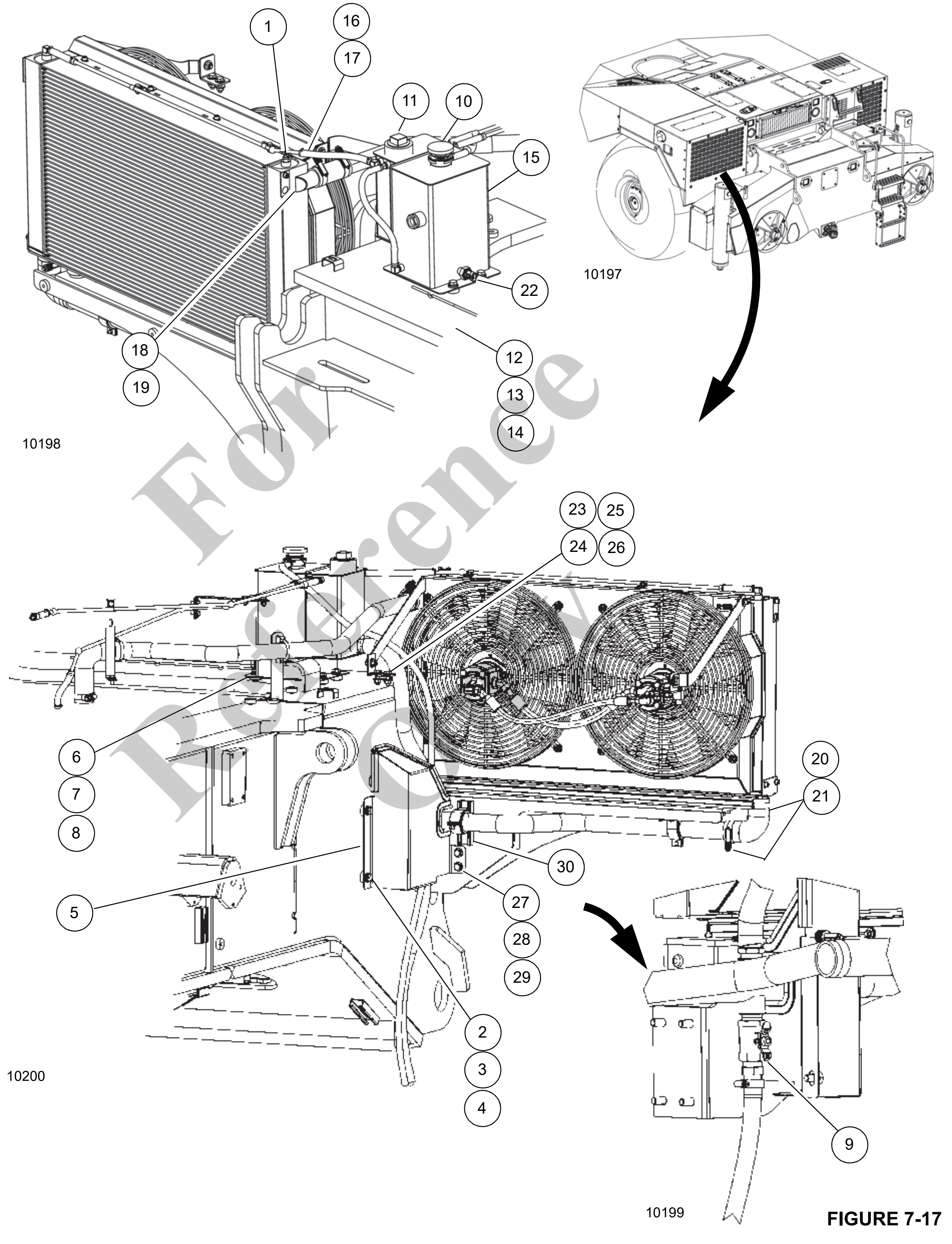


FIGURE 7-17

Table 7-1 Legend for Figure 7-17

1	Bleeder Valve
2	Capscrew
3	Washer
4	Lockwasher
5	Drain Valve Cover
6	Capscrew
7	Washer
8	Lockwasher
9	Drain Valve
10	Surge Tank Cap
11	Radiator Cap
12	Capscrew
13	Washer
14	Lockwasher
15	Surge Tank Assembly
16	Clamp
17	Hose
18	Clamp
19	Hose
20	Clamp
21	Hose
22	Coolant Level Sensor
23	Capscrew
24	Washer
25	Lock Nut
26	Angle Mount
27	Capscrew
28	Lockwasher
29	Washer
30	Clamp

Removal

1. Set the outriggers and position the boom to over the side.
2. Open and remove the hood top door assembly.
3. Remove the capscrews and nuts holding the rear engine hood panel to the engine hood. This will gain access to the rear of the radiator (1, Figure 7-17) and the surge tank mounting hardware.
4. If necessary, remove capscrews (2), washers (3), lockwashers (4), and drain valve cover (5).
5. Loosen the radiator cap (11) and surge tank cap (10).
6. Open the drain valve (9) and drain the coolant into a suitable container. Dispose of the coolant in accordance with local and EPA regulations.
7. Tag and disconnect the hoses from the surge tank to the engine and from the surge tank to the radiator.
8. Remove the capscrews (12), washers (13), and lockwashers (14) holding the surge tank assembly (15) to the frame. Remove the surge tank assembly (15).
9. Remove the clamps (16) securing the hose (17) to the radiator.
10. Remove clamps (18) and hose (19) from radiator.
11. Remove the hose clamps(20) and hose (21) from radiator.
12. Remove capscrews (23), washers (24), lock nuts (25), and angle mounts (26).
13. If not already removed, remove capscrews (27), lockwashers (28), and washers from drain valve cover and radiator flange.
14. Remove clamp (30) from bracket.
15. Disconnect the electrical harness from the coolant level sensor (22).

NOTE: The radiator weighs approximately 121.5 kg (267.9 lb).

16. Attach an adequate lifting device to the radiator assembly.

1	Radiator
2	Capscrew M12X35 8.8
3	Washer
4	Radiator Flange
5	Clamp

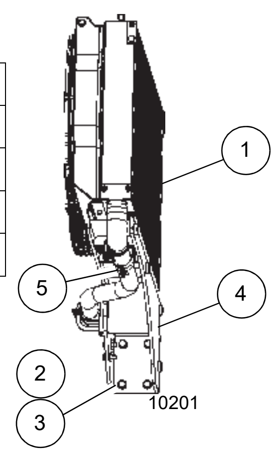


FIGURE 7-18

17. Remove clamp (5, Figure 7-18).
18. Remove the capscrews (2) and washers (3) securing the radiator flange (4) to the frame. Remove the radiator (1) from the carrier.

19. If a new radiator is to be installed, remove all fittings and hoses from the old one and install them in the same locations on the new one.

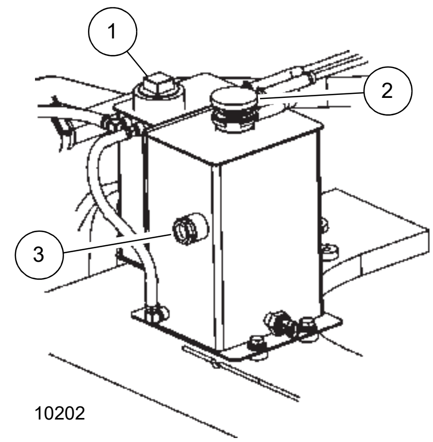
Installation

1. Ensure all fittings and hoses are installed on the radiator.
2. Apply Loctite® 243™ or equivalent to capscrew threads. Position the radiator (1, Figure 7-18) on the carrier using a lifting device. Secure the radiator flange (4) to the frame using capscrews (2) and washers (3). Torque capscrews to 99.8 Nm (73.6 ft lbs).
3. Attach hose to radiator flange (4) with clamp (5).
4. Connect the electrical harness to the coolant level sensor (22).
5. If necessary, attach drain valve cover to radiator flange with capscrews (27, Figure 7-17), lockwashers (28), and washers (29).
6. Install clamp (30) in bracket.
7. Secure the angle mounts (26, Figure 7-17) to the decking with capscrews (23), washers (24), and lock nuts (25).
8. Attach hose (21) to radiator with clamps (20). Torque clamps to 11.3 Nm (100 in-lb).
9. Attach hose (19) with clamps (18). Torque clamps to 11.3 Nm (100 in-lb).
10. Attach hose (17) to radiator with clamps (16).
11. Install surge tank assembly (15) with lockwashers (14), washers (13), and capscrews (12).
12. Make sure the drain valve (10) is closed.
13. Fill the engine coolant system, refer to *Radiator Fill and Servicing*, page 7-25. Start the engine, operate all systems and check for leaks.
14. Install the hood assembly.
15. Install the bolts and nuts holding the rear engine hood panel to the engine hood.
16. Install the hood top door assembly.

Radiator Fill and Servicing

Use the following to drain and fill the radiator. Refer to *Maintenance and Lubrication*, page 9-1 for complete fill and service procedures.

Antifreeze/Coolant Drain Procedure



1	Radiator Reservoir
2	Overflow Tank
3	Sight Glass

FIGURE 7-19

1. Loosen the radiator reservoir cap (1, Figure 7-19) and overflow tank cap (2).
2. Open the drain valve (9, Figure 7-17) and drain the coolant into a suitable container. Dispose of the coolant in accordance with local and EPA regulations.

Antifreeze/Coolant Fill Procedure

1. Open the bleeder valve (1, Figure 7-17).
2. Remove the radiator reservoir cap (1, Figure 7-19) and overflow cap (2).
3. Fill the radiator through the threaded opening for the radiator reservoir cap (1). Fill system with a 50/50 blended, fully formulated extended life antifreeze/ coolant. Fill slowly. Flow exceeding 3 gpm (11.2 L/min) can give a false reading.
4. Fill the overflow tank (2) until the fluid level is above the sight glass (3).
5. Apply Loctite® 243™ or equivalent to the threads of the radiator cap (1). Install and tighten the radiator reservoir cap (1).
6. Install and tighten the overflow tank cap (2).
7. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating step 4.
8. Run engine for 5 minutes and recheck the antifreeze/ coolant level. Refill as necessary repeating step 4. Refer to *Maintenance and Lubrication*, page 9-1.

DRIVE TRAIN

Description

The drive train consists of the transmission/torque converter assembly and two drive lines.

The transmission/torque converter is mounted on and driven by the engine. The torque converter assembly provides for mounting and driving the two variable displacement pumps and one gear pump. The transmission is a Range Shift with six forward speeds and six reverse speeds. The transmission is controlled electrically by a shift lever/knob located on the right side of the steering column and an axle drive mode selector rocker switch located on the steering wheel console.

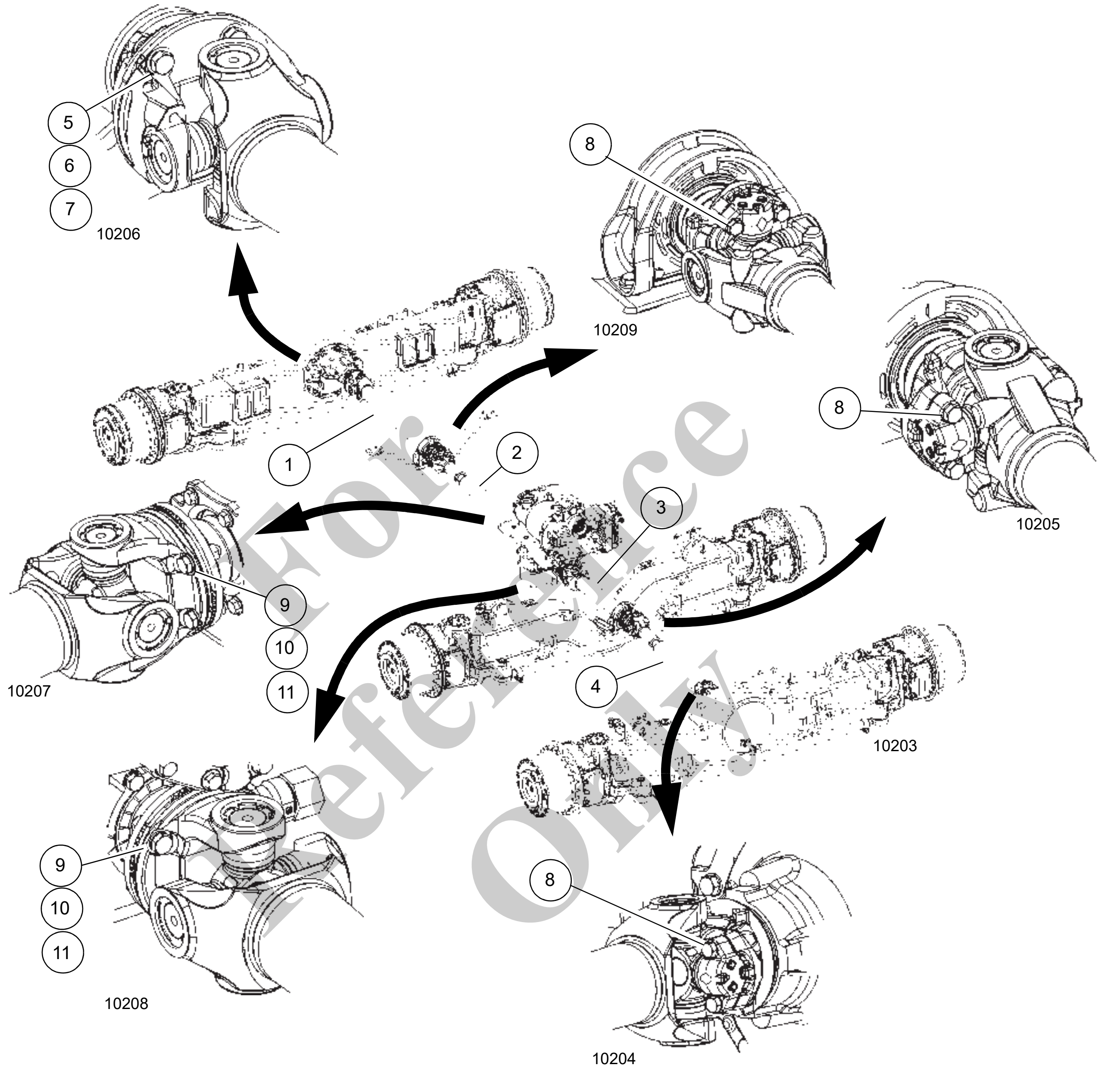
The transmission/torque converter oil is cooled by passing the oil through an externally mounted transmission cooler that is located on the left side of the crane. An oil filter is mounted on the left frame rail near the fuel tank.

Four drive lines are used. Two drive lines are connected between the transmission/torque converter and the front axle and the other drive line is connected between the transmission/torque converter and the rear axle.

Maintenance

Transmission

Refer to the engine and transmission manuals and other portions of this section for removal, scheduled maintenance and corrective maintenance, and installation.



1	Driveshaft
2	Driveshaft, Slip
3	Driveshaft
4	Driveshaft, Slip
5	Capscrew M14x50
6	Lockwasher

7	Nut
8	Capscrew 1/2-20UNFx2 G8
9	Capscrew M12x45 10.9
10	Lockwasher
11	Nut

FIGURE 7-20

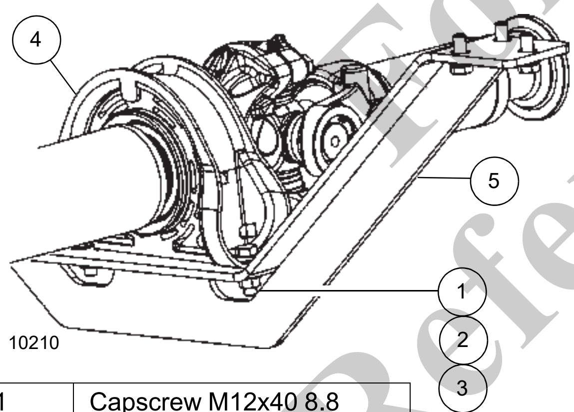
Drive Shafts

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

Removal

1. Support the drive shaft being removed so it does not fall when disconnected. If removing the coupling shaft or the forward slip shaft, support the other shaft also.
2. Remove capscrews (5, Figure 7-20), lockwashers (6), nuts (7), and driveshaft (1) from the front axle.
3. Remove capscrews (8) and slip driveshaft (2) from bearings assembly.



1	Capscrew M12x40 8.8
2	Washer
3	Nut
4	Driveshaft and Bearing Assembly
5	Carrier Bearing Weldment

FIGURE 7-21

4. Remove capscrews (1, Figure 7-21), washers (2), nuts (3), and driveshaft and bearing assembly (4) from the carrier bearing weldment.
5. Remove capscrews (9, Figure 7-20), lockwashers (10), nuts (11), and slip driveshaft (2) from the transmission.
6. Remove capscrews (9), lockwashers (10), nuts (11), and driveshaft (3) from the transmission.
7. Remove capscrews (8) and slip driveshaft (4) from driveshaft and bearing assembly.
8. Remove capscrews (1, Figure 7-21), washers (2), nuts (3), and driveshaft and bearing assembly (4) from the carrier bearing weldment.
9. Remove capscrews (8, Figure 7-20) and slip driveshaft (4) from rear axle.

Installation

1. Install slip driveshaft (4, Figure 7-20) on rear axle with capscrews (8). Torque capscrews (8) to 155.9 Nm to183.0 Nm (115 ft-lb to 135 ft-lb).
2. Install driveshaft (3) on transmission with lockwashers (10), capscrews (9), and nuts (11). Torque nuts (11) to 101.7 Nm to 128.8 Nm (75 to 95 ft-lb).
3. Install driveshaft (3) and bearing assembly (4, Figure 7-21) on rear carrier bearing weldment (5) with washers (2), capscrews (1), and nuts (3). Torque nuts to 66.2 Nm to 69.7 Nm (48.8 ft-lbs to 51.4 ft-lbs).
4. Install slip driveshaft (4, Figure 7-20) on the rear driveshaft and bearing assembly with capscrews (8). Torque capscrews (8) to 155.9 Nm to 183.0 Nm (115 ft-lb to 135 ft-lb).
5. Install slip driveshaft (2) to transmission with capscrews (9). washers (10), and nuts (11). Torque nuts to 101.7 Nm to 128.8 Nm (75 to 95 ft-lb).
6. Install driveshaft (1) on front axle with lockwashers (6), capscrews (5), and nuts (7). Torque nuts (7) to 180.3 Nm to 219.6 Nm (133 to 162 ft-lbs).
7. Install driveshaft (1) and bearing assembly (4, Figure 7-21) on carrier bearing weldment (5) with washers (2), capscrews (1), and nuts (3). Torque nuts to 66.2 Nm to 69.7 Nm (48.8 ft-lbs to 51.4 ft-lbs).
8. Install slip driveshaft (2, Figure 7-20) on the front driveshaft and bearing assembly with capscrews (8). Torque capscrews (8) to 155.9 Nm to 183.0 Nm (115 ft-lb to 135 ft-lb).

Lubrication

The drive line slip joints require lubrication. Refer to *Maintenance and Lubrication*, page 9-1.

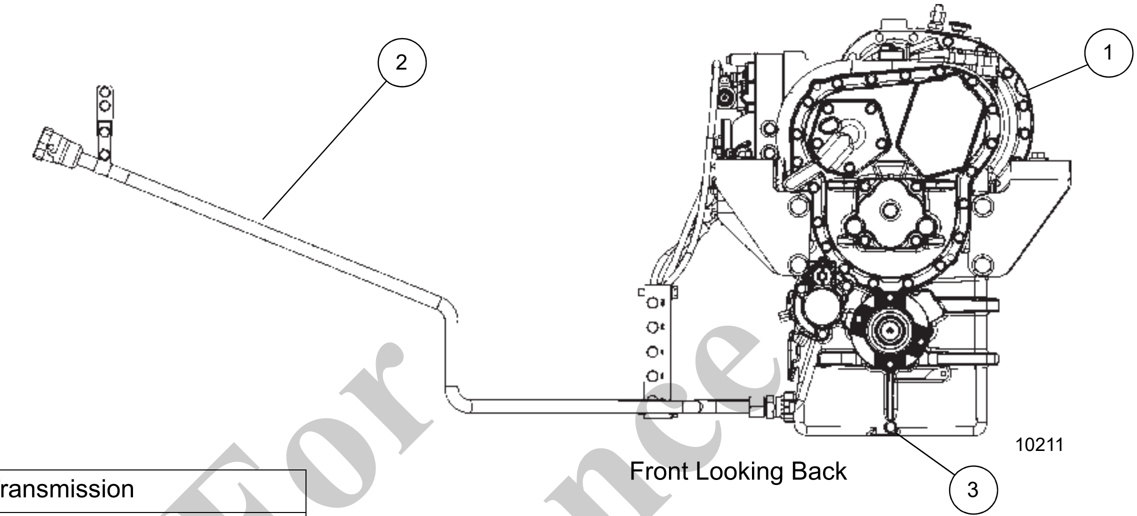
TRANSMISSION

Description

The transmission assembly (1, Figure 7-23) is connected to the engine torque converter with a driveshaft. The transmission is connected to the front and rear axles by four drive shafts.

Troubleshooting and Maintenance

For transmission maintenance information, see *Maintenance and Lubrication*, page 9-1. For troubleshooting steps, see Table 7-2.



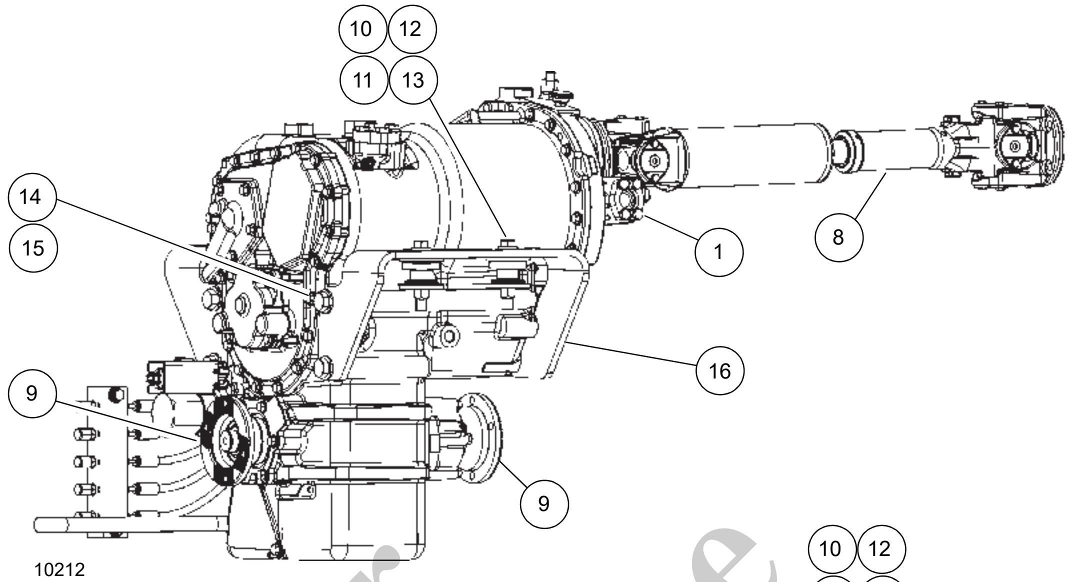
1	Transmission
2	Transmission Fluid Dipstick
3	Transmission Drain Plug

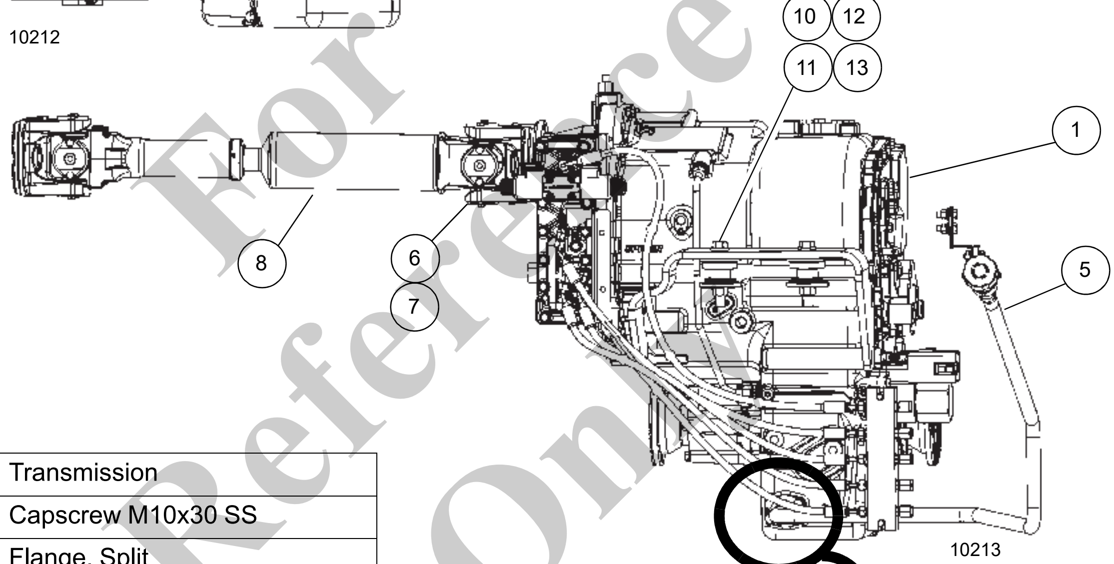
FIGURE 7-22

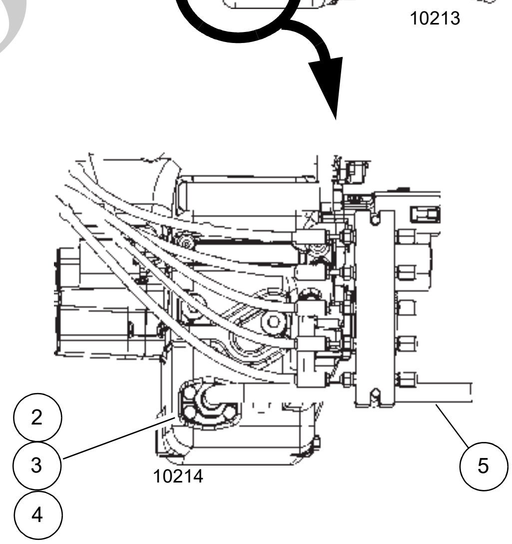
7

Table 7-2Troubleshooting

SYMPTOM	PROBABLE CAUSE	REMEDY
1. Low clutch pressure.	**a.** Low oil level.	**a.** Fill to proper level.
	b. Clutch pressure regulating valve spool stuck open.	**b.** Clean valve spool and housing.
	c. Faulty charging pump.	**c.** Replace pump.
	d. Broken or worn clutch shaft or piston sealing rings.	**d.** Replace clutch shaft or sealing rings, as applicable.
	e. Clutch piston bleed valve stuck open.	**e.** Clean bleed valves thoroughly.
2. Low converter charging pump pressure.	**a.** Low oil level.	**a.** Fill to proper level. Refer to *Maintenance and Lubrication*, page 9-1
	b. Suction screen plugged.	**b.** Clean suction screen.
	c. Defective oil pump.	**c.** Replace pump.
3. Overheating.	**a.** Worn oil sealing rings.	**a.** Remove, disassemble, and rebuild converter assembly.
	b. Worn oil pump.	**b.** Replace pump.
	c. Low oil level.	**c.** Fill to proper level.
4. Noisy converter.	**a.** Worn oil pump.	**a.** Replace pump.
	b. Worn or damaged bearings.	**b.** A complete disassembly will be necessary to determine what bearing is faulty.
5. Lack of power.	**a.** Low engine RPM at converter stall.	**a.** Tune engine and check governor.
	b. See “Overheating” and make same checks.	**b.** Make corrections as explained in “Overheating.”





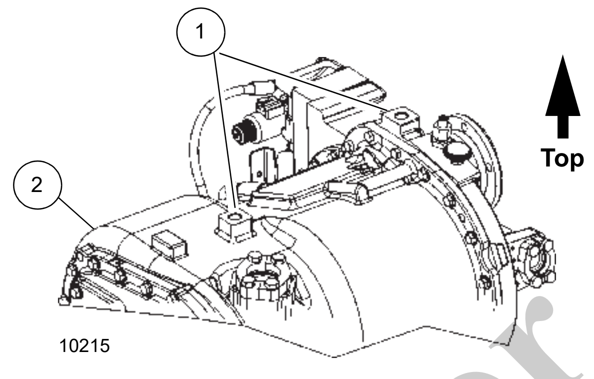


1	Transmission
2	Capscrew M10x30 SS
3	Flange, Split
4	O-Ring
5	Dipstick Tube
6	Capscrew M12x45 10.9
7	Locknut
8	Driveshaft
9	Driveshaft Coupler
10	Locknut
11	Washer
12	Shock Mount
13	Capscrew 5/8-11UNC G8
14	Capscrew M20x45 10.9
15	Washer
16	Installation Bracket

FIGURE 7-23

Transmission Removal

1. Extend and set outriggers just enough to take up the slack in the outrigger pads. Chock the wheels.
2. Remove the superstructure.
3. Remove the engine/torque converter from the crane as an assembly. Refer to *Engine Removal*, page 7-2.



1	Lifting Eyes M25x2.5
2	Transmission

FIGURE 7-24

NOTE: The transmission weighs approximately 624.64 kg (1377.1 lb) dry.

4. Attach an suitable lifting device to the lifting eyes (1, Figure 7-24) on the top of the transmission (2) and take up any slack.
5. Tag and disconnect hydraulic hoses.
6. Tag and disconnect electrical connectors.
7. Remove capscrews (2, Figure 7-23), split flanges (3), o-ring (4), and dipstick tube (5) from the transmission (1). Inspect the o-ring (4) and replace as necessary.
8. If not already done, remove capscrews (6), locknuts (7), and driveshaft (8).
9. Disconnect front and rear drive shafts from transmission drive shaft couplers (9). For more information, see *Drive Train*, page 7-26.
10. Remove the locknuts (10), washers (11), shock mounts (12), and capscrews (13) from both sides of the transmission (1).
11. Using a suitable lifting device, remove the transmission from the carrier frame. Place the transmission on a suitable platform.
12. If necessary, remove capscrews (14), washers (15), and installation brackets (16) from both sides of the transmission (1).

Transmission Installation

NOTE: The transmission weighs approximately 624.64 kg (1377.1 lb) dry.

1. If a new transmission (1, Figure 7-23) is to be installed, remove all fittings and brackets from the old one and install them in the same locations on the new transmission.
2. Install the engine/torque converter to the carrier frame as an assembly. Refer to *Engine Removal*, page 7-2.
3. If necessary, apply Loctite® 243 or equivalent to capscrew (14) threads. Install installation brackets (16) with capscrews (14) and washers (15). Torque capscrews (14). For more information, see *Fasteners and Torque Values*, page 1-16.
4. Attach an suitable lifting device to the lifting eyes on the top of the transmission (1) and take up any slack. Lower the transmission in to the carrier frame. Secure the transmission (1) to the carrier frame with shock mounts (12), washers (11), capscrews (13), and locknuts (10). Torque locknuts (10). For more information, see *Fasteners and Torque Values*, page 1-16. Connect to the front and rear drive shafts to the drive shaft couplers (9) on the transmission (1). For more information, see *Drive Train*, page 7-26.
5. If necessary, install driveshaft (8) on transmission with capscrews (6) and locknuts (7). Torque the capscrews (6). For more information, see *Fasteners and Torque Values*, page 1-16.
6. Install dipstick tube (5) to transmission (1) with new o-ring (4), split flanges (3), and capscrews (2).
7. Install electrical connectors as tagged.
8. Install hydraulic hoses as tagged.
9. Service the crane as outlined under *Servicing the Crane after Transmission Overhaul*, page 7-34.
10. Cycle all functions and observe for proper operation.

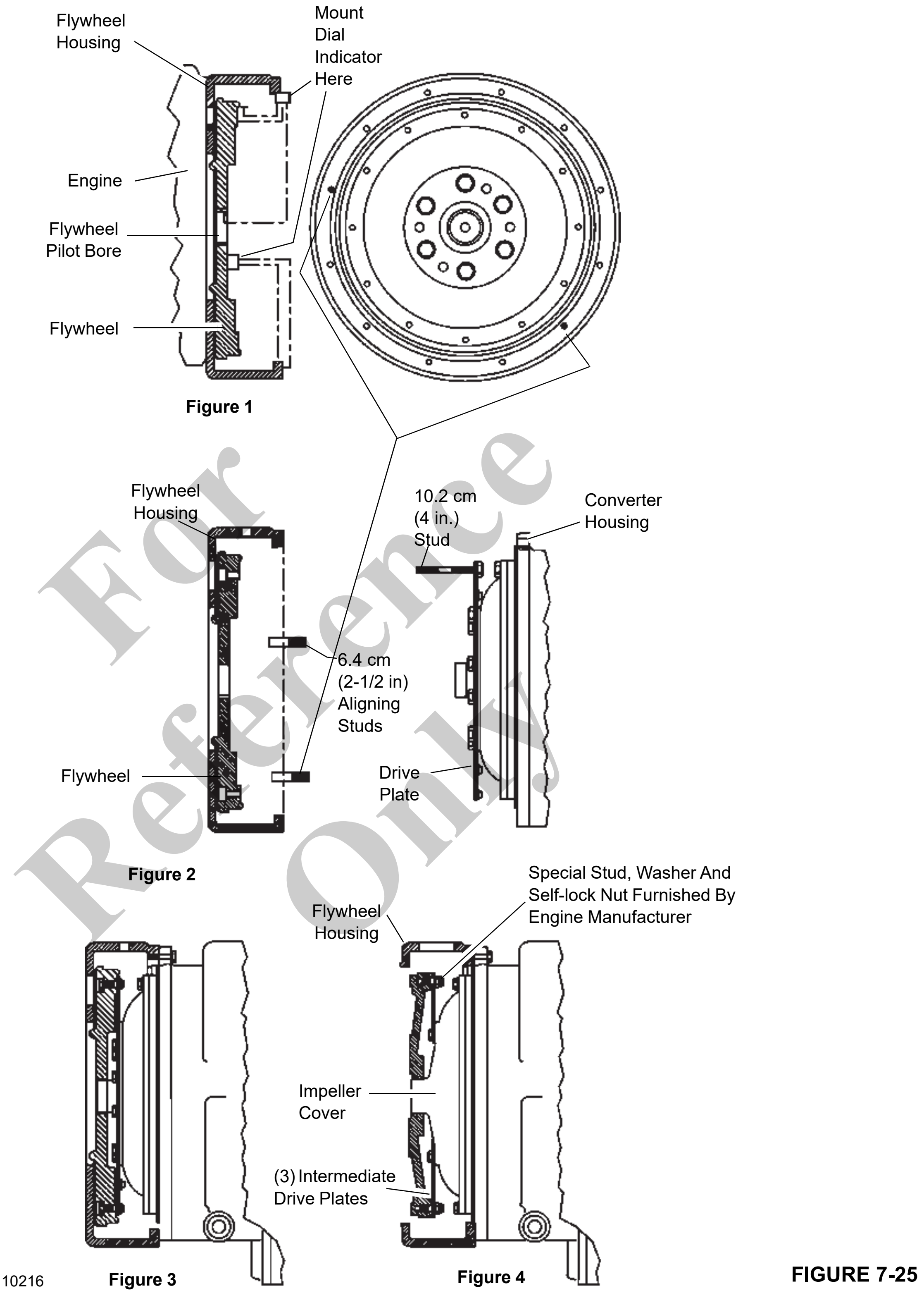

Flywheel Housing
Mount Dial Indicator Here
Engine
Flywheel Pilot Bore
Flywheel
Figure 1
Flywheel Housing
10.2 cm (4 in.) Stud
Converter Housing
6.4 cm (2-1/2 in) Aligning Studs
Flywheel
Drive Plate
Figure 2
Special Stud, Washer And Self-lock Nut Furnished By Engine Manufacturer
Flywheel Housing
Impeller Cover
(3) Intermediate Drive Plates
10216
Figure 3
Figure 4

FIGURE 7-25

Servicing the Crane after Transmission Overhaul

The transmission and its allied hydraulic system are important links in the drive line between the engine and the wheels. The proper operation of either the unit or the system depends greatly on the condition and operation of the other; therefore, whenever repair or overhaul of the transmission is performed, the balance of the system must be considered before the job can be considered completed.

After the overhauled or repaired transmission has been installed in the crane, the oil cooler and connecting hydraulic system must be thoroughly cleaned. This can be accomplished in several ways, and a degree of good judgment must be exercised as to the method employed.

The following are considered the minimum steps to be taken:

1. Drain the entire system thoroughly.
2. Disconnect and clean all hydraulic lines. Where feasible, hydraulic lines should be removed from the machine for cleaning.
3. Replace oil filter elements, cleaning out the filter cases thoroughly.
4. The oil cooler must be thoroughly cleaned. The cooler should be back flushed with oil and compressed air until all foreign material has been removed. Flushing in the direction of normal oil flow will not adequately clean the cooler. If necessary, the cooler assembly should be removed for cleaning, using oil, compressed air and a steam cleaner for that purpose.

CAUTION

Do not use flushing compounds for cleaning purposes.

5. Remove the drain plug from the transmission and inspect the interior of the unit housing, gears, etc. If the presence of considerable foreign material is noted, it will be necessary for the unit to be removed, disassembled, and cleaned thoroughly. It is realized this entails extra labor, however, such labor is a minor cost compared to the cost of difficulties which can result from the presence of such foreign material in the system.
6. Assemble all components and use only the type oil recommended. Fill the transmission through the fill pipe until fluid is at the top of the fill range on the dipstick. Run the engine for two minutes at 600 rpm to 800 rpm to prime the torque converter and hydraulic lines. Recheck the level of oil in the transmission with the engine running at idle (600 rpm to 800 rpm). Add oil as necessary to bring the level to the LOW mark on the dipstick. After the oil temperature reaches 82°C to 93°C (180°F to 200°F), add oil to bring the level to the FULL mark on the dipstick.
7. Recheck all drain plugs, lines, connections, etc., for leaks and tighten where necessary.

Lubrication

Type of Oil and Capacities

Refer to *Maintenance and Lubrication*, page 9-1 for types of oil, capacities, and change intervals.

Normal Transmission Fluid Period

NOTE: Normal drain periods and filter change intervals are for average environmental and duty-cycle conditions. Severe or sustained high operating temperatures or very dusty atmospheric conditions will cause accelerated deterioration and contamination. For extreme conditions, judgment must be used to determine the required change intervals.

1. Drain transmission and remove pump screen. Clean screen thoroughly and replace, using a new gasket.
2. Remove and discard oil filter. Clean filter housing and install new filter.
3. Refill transmission to FULL mark.
4. Run engine at 500 rpm to 600 rpm to prime converter and lines.
5. Recheck level with engine running at 600 rpm to 800 rpm and add oil to bring level to FULL mark. When oil temperature is hot [82°C to 93°C (180°F to 200°F)], make final oil level check. Bring oil level to full mark.

Towing or Pushing

Before towing crane, lift the driven axle wheels off the ground or disconnect both front and rear drive lines. Engine cannot be started by pushing or towing because of hydraulic system design.

SECTION 8
UNDERCARRIAGE

SECTION CONTENTS

AXLES

The GRT9165 features three axles and six wheels. The axles incorporate an all welded steel frame using planetary drive axles. The front axle and rear axle are powered to provide four-wheel drive. The middle axle is not powered.

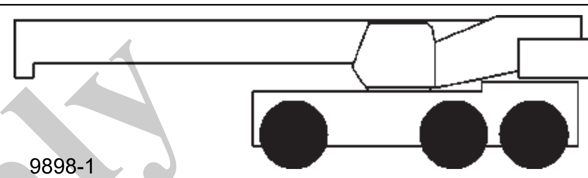
Axle steering is accomplished utilizing hydraulic steer cylinders to provide six-wheel steering:

- 2-wheel front
- 4-wheel rear
- 6-wheel coordinated
- 6 wheel crab

Drag links connect the middle and rear axles to enable synchronized steering.

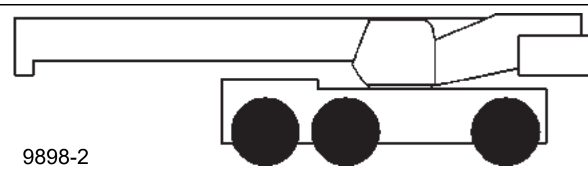
The GRT9165 crane can be driven in the Standard Driving Configuration—with the boom centered over the front single axle (Figure 8-1) or, in the Alternate Driving Configuration—with the boom centered over the rear tandem axles (Figure 8-2).

These two driving configurations, along with Rear Steering and Steering Reversal features, enable crane positioning, and precise maneuvering on the jobsite. These features assist the operator, and provide smooth control of the crane when reversing the driving controls and changing crane direction of travel.



Standard Driving Configuration

FIGURE 8-1



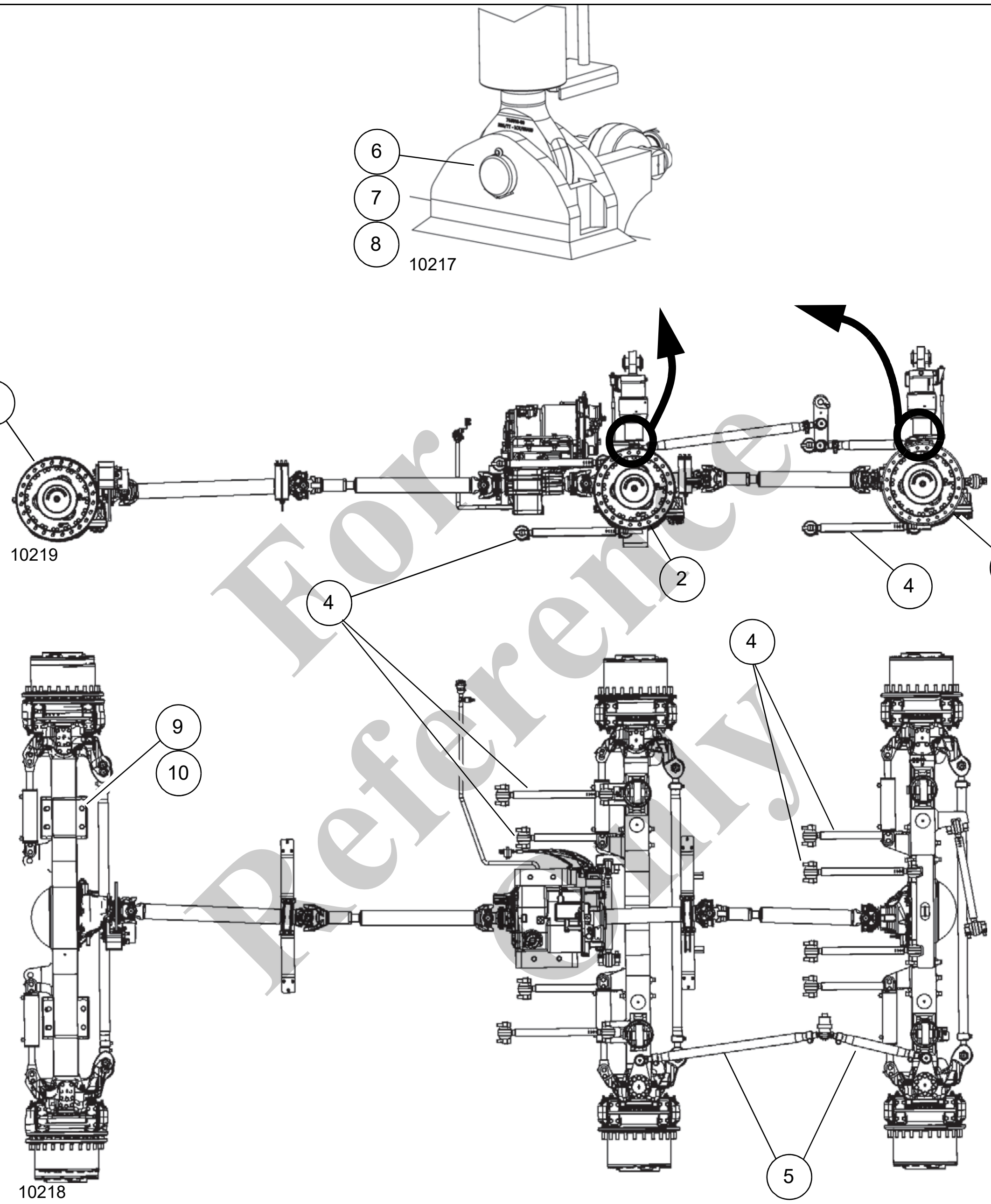
Alternate Driving Configuration

FIGURE 8-2

The carrier frame features provides axle oscillation. Axle oscillation lockout is automatic when the superstructure rotates from the travel position.

The front axle is rigid mounted. Rear axles oscillate up to 152 mm (6 in) with automatic lockout. Rear axles have a hydro-gas design that allows for compact height reduction when transporting without a counterweight.

The front and rear wheels feature a disc type hydraulic braking system. A disc-type parking brake is mounted on the front axle input shaft.



1	Front Axle Assembly
2	Middle Axle Assembly
3	Rear Axle Assembly
4	Torque Rod
5	Drag Link Assembly

6	Cotter Pin
7	Spacer
8	Suspension Pin
9	Washer
10	Capscrew 1-1/4-7 UNC x 13 G8

FIGURE 8-3

Each axle incorporates a single reduction carrier with hypoid gearing mounted in the axle center. The final reduction is of planetary design spur gearing built into the wheel hubs.

The hypoid pinion and differential assembly of the first reduction are supported by tapered roller bearings. The pinion bearing preload is adjusted and maintained by a hardened precision spacer between the inner and outer bearing. The differential tapered bearing preload is adjusted and maintained by the positioning of the threaded adjusting rings in the carrier leg and cap bores.

In the planetary wheel ends, the spur teeth of the sun gear mesh with teeth of the planet spur gears. The planet spur gears rotate on planet pins which are mounted in a spider. The planet spur gear teeth in turn mesh with teeth of the floating ring gear.

Power is transmitted by the hypoid gear set in the differential carrier to the axle shafts and the sun gear of the final reduction, through the revolving planet gears, and into the planetary spider which drives the wheel hub.

As an option, the front axle and rear axle may be provided with a differential lock. When in the locked mode, the axle shafts and the differential are locked together and there is no differential action between the wheels.

Maintenance

NOTE: The axles do not have to be removed from the crane to remove the planetary wheel ends or the drive units.

Axle Removal

1. Using the outriggers, raise the wheels off of the ground.
2. Install supports under the frame at the outboard ends of the outrigger boxes.

CAUTION

Do not disassemble drive lines when removing them from the crane. Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

3. Disconnect and remove the drive line from the applicable axle. Do not disassemble the drive lines. Refer to *Drive Shafts*, page 7-28.
4. Tag, disconnect, and cap the hydraulic brake line at each wheel.
5. Tag, disconnect, and cap the hydraulic lines to the steer cylinders.
6. On the front axle only, tag and disconnect the hydraulic line from the park brake actuator.
7. On the left side of the rear axle only, tag and disconnect the electrical wires from the rear wheels not centered switch.

NOTE: Each tire and wheel assembly weighs approximately 749 kg (1651 lb).

8. Remove the wheels from the axle.

NOTE: The front axle weighs approximately 2036 kg (4489 lb). The middle axle weighs approximately 1754 kg (3867 lb). The rear axle weighs approximately 2000 kg (4409 lb).

9. Position jacks, which are capable of handling the weight of the axle, under the axle for support.
10. Remove the rear axles as follows:
    a. Disconnect torque rods (4, Figure 8-3) from axle (middle or rear).
    b. Disconnect the drag link assembly (5) from the axle (middle or rear).
    c. Remove cotter pins (6), spacers (7), and lower suspension pins (8) from the axle. Lower the rear axle slowly.
11. Remove the front axle as follows:
    a. Remove the washers (9) and capscrews (10) securing the axle to the frame/cradle.
    b. Lower the axle to the ground and move it to a clean working area.
12. If a new axle is to be installed, remove the following from the old axle and install them on the new one.
    a. The steer cylinders. For more information, see *Steer Cylinders*, page 8-11.
    b. The rear wheels not centered switch actuator brackets (rear axles only). For more information, see *Rear Steer Sensor Adjustment Procedure*, page 8-7.
    c. The parking brake actuator (front axle only). Refer to *Brake System*, page 8-13 in this section.

Cleaning

Completely assembled axles may be steam cleaned on the outside only, to facilitate initial removal and disassembly, providing all openings are closed. Breathers, vented shift units, and all other openings should be tightly covered or closed to prevent the possibility of water entering the assembly.

Axle Installation

1. If a new axle is to be installed, remove the following from the old axle and install them on the new one.
   a. The steer cylinders. For more information, see *Steer Cylinders*, page 8-11.
   b. The rear wheels not centered switch actuator brackets (rear axles only). For more information, see *Rear Steer Sensor Adjustment Procedure*, page 8-7.
   c. The parking brake actuator (front axle only). Refer to *Brake System*, page 8-13 in this section.

NOTE: The front axle weighs approximately 2036 kg (4489 lb). The middle axle weighs approximately 1754 kg (3867 lb). The rear axle weighs approximately 2000 kg (4409 lb).

2. Install the front axle (1, Figure 8-3) as follows:
   a. Position the axle under the crane on jacks which are capable of handling the weight of the axle.
   b. Raise the axle into place and secure with the eight attaching capscrews (10) and washers (9). Torque capscrews. For more information, see *Fasteners and Torque Values*, page 1-16 for proper torque value.
3. Install the middle (2) and rear (3) axles as follows:
   a. Install the strut cylinder to the frame with spacers (7), suspension pins (8), and cotter pins (6).
   b. Connect the drag link assembly (5) to the middle (2) or rear (3) axle. Apply Loctite® 243 or equivalent to drag link clamp capscrews. Torque ball joints from 332 N-m to 366 N-m (240 ft-lbs to 270 ft-lbs).
   c. Apply Loctite® 243 or equivalent to capscrews and connect torque rods (4) to middle (2) or rear (3) axle. Torque the capscrews. For more information, see *Fasteners and Torque Values*, page 1-16.
   d. Synchronize the rear axle drag links. For more information about synchronizing the rear axle drag links, see *Rear Axle Drag Link Synchronization*, page 8-4.
4. Install the wheels onto the axle. Refer to *Wheels And Tires*, page 8-7 in this section.
5. Connect the hydraulic lines to the steer cylinder as tagged during removal.
6. Connect the hydraulic brake line to each wheel as marked during removal.
7. On the front axle only, connect the hydraulic line to the parking brake actuator.
8. On the left side of the rear axle only, connect the electrical wires to the rear wheels not centered switch. Adjust the switch as outlined under, *Rear Steer Sensor Adjustment Procedure*, page 8-7.
9. Connect the drive line to the applicable axle. Refer to *Drive Shafts*, page 7-28.
10. Refer to *Brake System*, page 8-13 and bleed the hydraulic brake system.
11. Remove the blocking under the frame and retract the outriggers to lower the crane to the ground.

Front Wheel Alignment Check Procedure

1. Check the axle for wheel alignment. The wheels are to be straight ahead with no toe-in or toe-out. Adjust if necessary by turning the tie rod ends in the direction necessary.
2. Check pre-set axle stop as follows:
   a. Turn the wheels to the extreme left.
   b. Check the clearance between the inside of the tire and the nearest object.
   c. Clearance should be 25.4 mm (1.00 in) minimum, If necessary, adjust the axle stop to provide clearance.
3. Turn axle to extreme right and repeat step 2.

Rear Axle Drag Link Synchronization

NOTE: For best results, synchronize the rear axle links when the tires are removed.

1. Extend the rear outrigger jack cylinders to raise the rear axles off of the ground. The front tires should remain on the road. Raising the rear outriggers this way enables the adjustment of the drag links without damage.
2. Place jacks under the rear axles as necessary.
3. If the axle was replaced, loosen the fittings on each steer cylinder. Turn the steering wheel lock to lock. Bleed cylinders until no air appears. Tighten fittings.

CAUTION

Do not attempt to adjust the axle drag links or the tie rod ends while the full weight of the crane is on the axles. Failure to do so may result in component damage.

4. Raise the rear of unit 38 mm (1.50 inches) from the ride height as follows:

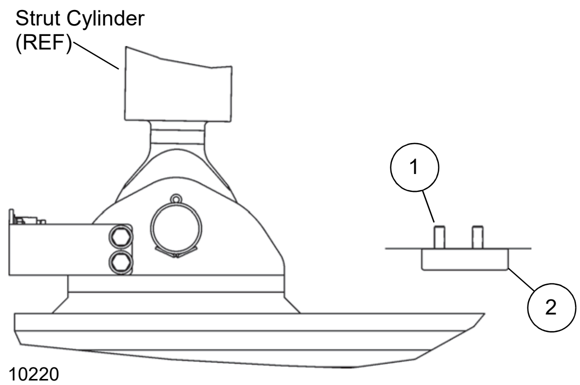


FIGURE 8-4

- **a.** Reference a point on the frame to center the rear axle.
- **b.** Use a straight edge to align the middle axle with rear axle, making sure the front of the wheel hubs are aligned.
- **c.** Remove capscrews (1, Figure 8-4) and bump stop (2) from the frame.
- **d.** Position the tooling jig (108 mm (4.25 inch) diameter and 30 mm (1.181 in) disk) on the axle under the bump stop on the frame.
- **e.** Use a floor jack to raise the axle up to the tooling jig. Raising the axle ensures the axles are at the correct height for synchronizing the rear axle drag links.

5. Install relay arm (5, Figure 8-5) and pin (6) with capscrew and washer. Add shims (9) as necessary to create a maximum gap of 1.5 mm (0.06 in) closest to the frame and no gap on the outside.

NOTE: The rig pin should be 8.33 mm (0.33 in) diameter x 136.7 mm (5.38 inch).

6. Install rig pin (11) through the hole (10) in the relay arm mounting bracket and relay arm (5).

7. Install drag links (3 and 4) on relay arm (5).

8. With the rig pin (11) inserted, verify the left rear wheels are aligned and in the straight ahead position by using a straight edge long enough to lay across the wheel mounting surfaces of both rear axles. Adjust drag links to fit between the relay arm and axle steer arms.

9. Remove rig pin (11) and tighten tube clamps on drag links (3 and 4). Torque ball joints from 332 N-m to 366 N-m (240 ft-lbs to 270 ft-lbs).

10. Remove tooling jig (108 mm (4.25 inch) diameter and 30 mm (1.181 in) disk) from axle.

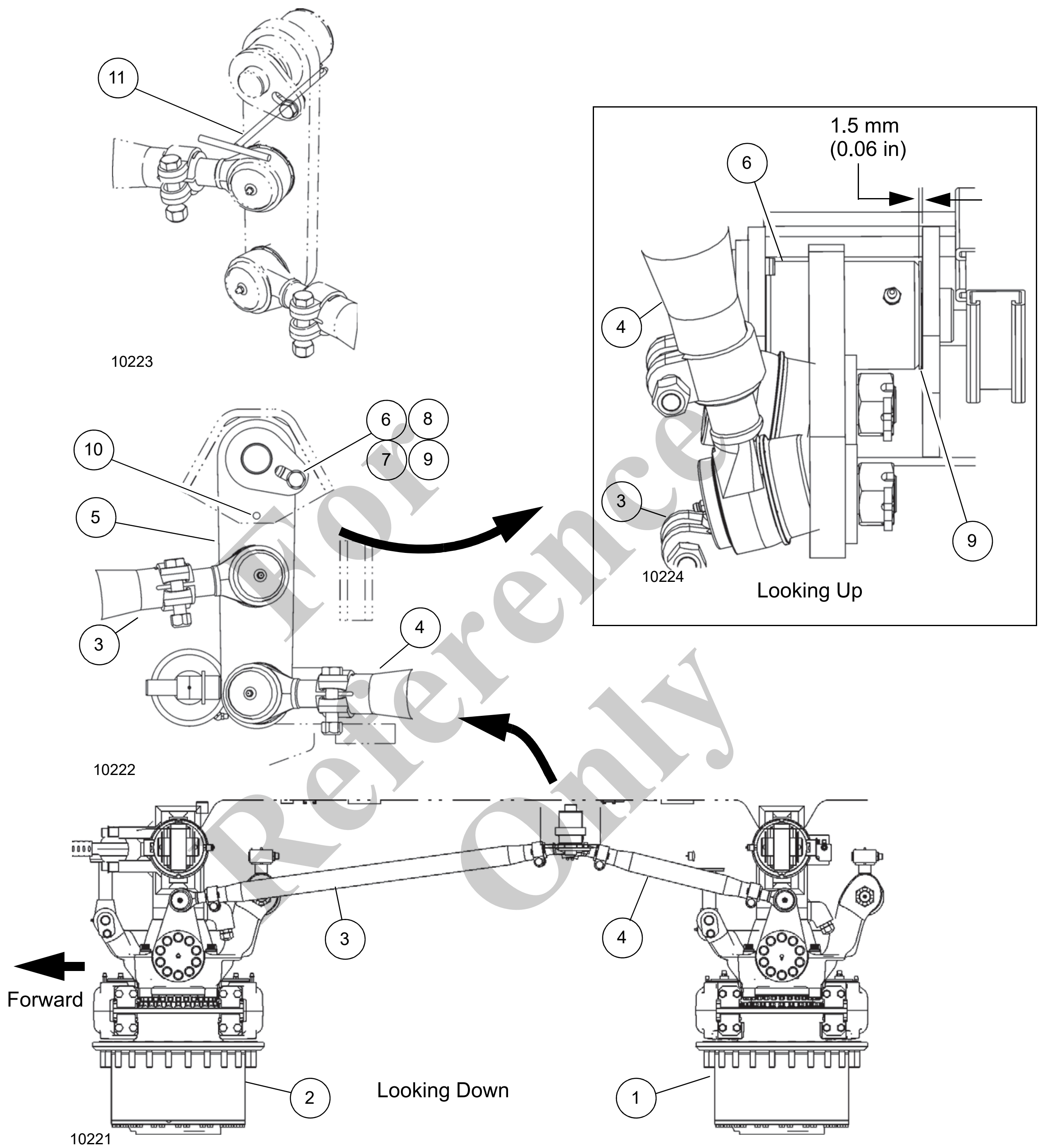
11. Apply Loctite® 243™ or equivalent to threads of capscrews (1, Figure 8-4). Install bump stop (2).

12. Lower the axles. Remove floor jack.

13. Install the tires on the axles. For more information, see *Wheels And Tires*, page 8-7.

14. Retract the outriggers.

15. With full weight on the rear axles, verify the alignment. Adjust alignment as necessary.



1	Rear Axle Assembly
2	Middle Axle Assembly
3	Drag Link, 1311 mm (51.6 in)
4	Drag Link, 731 mm (28.8 in)
5	Relay Arm

6	Pin
7	Capscrew
8	Washer
9	Shim
10	Rig Tool Hole
11	Rig Tool

FIGURE 8-5

Rear Steer Sensor Adjustment Procedure

Use the following procedure the adjust the rear steer sensor. A proximity switch on the rear axle senses the position of the rear wheels. If the wheels are not centered, a signal is sent to the ODM, which displays the Rear Wheels Not Centered Indicator in the Alerts area of the ODM. For more information about steering configurations and the ODM, see the *Operator Manual*.

1. Ensure the wheels are straight ahead.

NOTE: When performing rear steer indicator adjustment using the following steps, refer to Figure 8-6.

2. Slide the proximity switch through hole in the mounting bracket and secure with nuts and washers.
3. Set face of proximity switch from 4 mm (0.16 in) to 6 mm (0.24 in) from opening in rear steer sensor plate. Tighten the fasteners.
4. Turn the rear wheels to verify proper operation. Rear Wheels Not Centered Light in cab should be out when rear wheels are centered and the sensor switch is centered in the slot of the sensor plate. Adjust proximity switch in or out as needed.

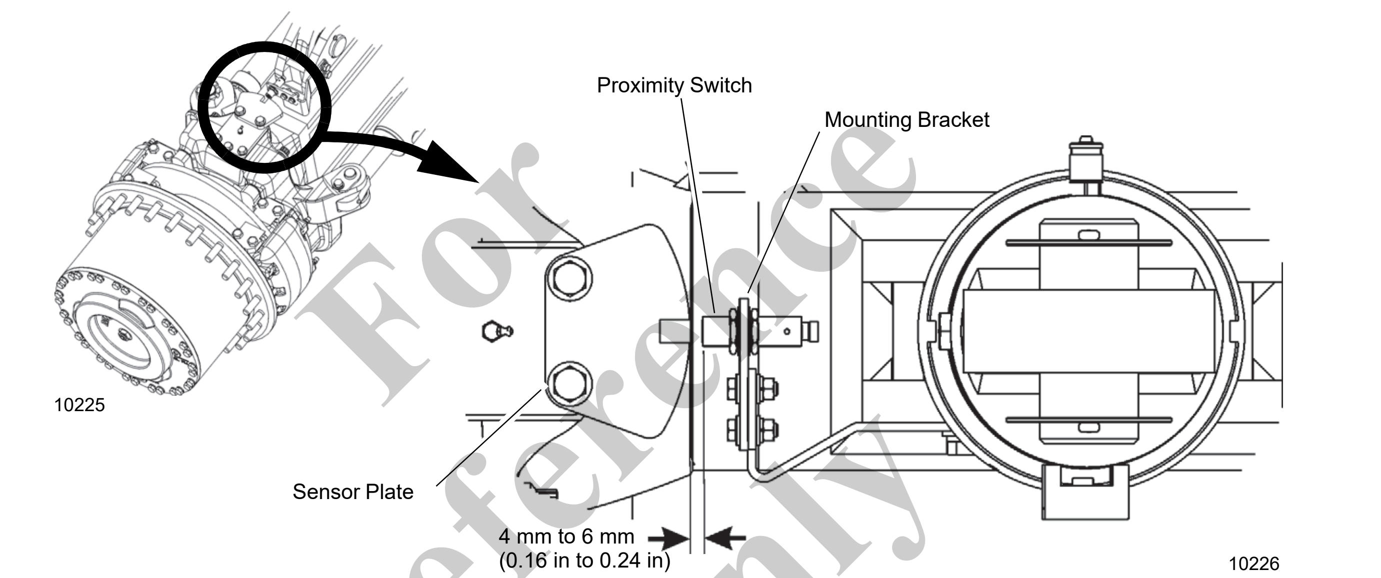


FIGURE 8-6

Wheels And Tires

Description

The standard tire size for this unit is 26.5x25-44 ply.

WARNING

Possible equipment damage and/or personal injury!

Driving the crane with a tire under inflated at 80% or less of its recommended pressure can cause the wheel and/or tire to fail. Per OSHA Standard 1910.177(f)(2)(i), when a tire has been driven under inflated at 80% or less of its recommended pressure, it must first be completely deflated, removed from the axle, disassembled, and inspected before re-inflation.

CAUTION

Do not mix tires or rims from different manufacturers. Vehicle stability can be affected.

Each wheel assembly (tire and rim) is mounted on the planetary hub with 24 3/4-16UNF lug nuts.

NOTE: The tire diameters, widths, and weights may vary slightly depending on the tire manufacturer.

Off-highway tires are designed to operate with a certain sidewall deflection or bulge. Correct air pressure ensures prior deflection which, in turn, ensures proper traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lowered rim life.

Refer to and adhere to the inflation pressures in the Load Chart Book in the crane cab.

Maintenance

DANGER

Do not attempt to demount or mount tires without proper training. The high pressures involved can cause tire and rim parts and tools to fly with explosive force, if proper procedures are not used, causing severe injury or death to personnel and damage to the crane and surrounding area.

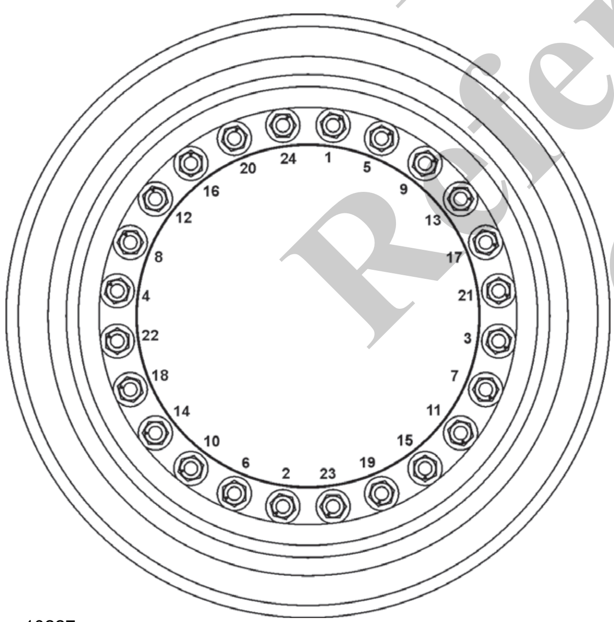
Mounting Wheel Assemblies

NOTE: Do not lubricate the wheel studs or lug nuts.

1. Raise the crane on outriggers so the wheels are off the ground.

NOTE: Prior to wheel installation remove any dirt or grease from wheel mounting surfaces.

2. Position the wheel assembly on the wheel end pilot. Install the lug nuts and tighten them to 70 N-m (50 lb-ft) in the sequence shown in Figure 8-7.
3. Ensure the wheel assembly is positioned properly on the hub.



10227 **FIGURE 8-7**

4. Continue to torque the lug nuts 610 N-m to 680 N-m (450 lb-ft to 500 lb-ft) in the sequence shown in Figure 8-7.
5. Lower the crane onto its tires. Retract and stow the outrigger assemblies and the floats.
6. Retorque lug nuts after approximately one hour of travel.

STEERING SYSTEMS

Description

To maximize maneuverability, the crane can be steered by the front axle, the rear axles, or by the front and rear axles simultaneously. The crane features two separate steering systems: one to control front axle steering and one for rear axle steering. The front steer reversal feature enables the front axle steering in standard or alternate driving modes. For more information about front axle driving modes, see the *Operator Manual*. Standard and alternate driving modes are also supported when rear steering is used. For more information about rear steering, see the *Operator Manual*.

Front Steering System

The front steering system consists of a load sense steer priority flow valve (part of the accessory manifold valve), load sense steering control valve, single axle reversal valve (part of the Main Carrier Manifold), and two steer cylinders. Refer to *Front Steering Control Valve*, page 8-9 and *Accessory Manifold Valve*, page 2-39 for a description of the front steer hydraulic components, their functions, and maintenance information.

Rear Steering System

Refer to *Carrier Manifold Valve*, page 2-25 for a description of the rear steer hydraulic components, their functions, and maintenance information. A rear steer indicator system is provided to indicate when the rear wheels are not centered. This system consists of an indicator light located on the ODM in the cab and a proximity switch located on the right side of the rear axle. When the rear wheels are turned to the left or right, the amber indicator will illuminate. For more information, see *Rear Steer Sensor Adjustment Procedure*, page 8-7.

Maintenance

Front Steering System

Troubleshooting

Table 8-1

Symptom	Probable Cause	Solution
1. Hard to steer left and right.	**a.** Hydraulic oil low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective flow divider valve(s).	**c.** Repair or replace valve(s).
	d. Defective steering control valve.	**d.** Repair or replace valve.
	e. Defective hydraulic pump.	**e.** Repair or replace pump.
	f. Lack of Lubrication.	**f.** Grease axle kingpins and relay arm.
2. Hard to steer either left or right.	**a.** Clogged or loose hydraulic lines or fittings.	**a.** Clean or tighten lines or fittings.
	b. Defective steer cylinder.	**b.** Repair or replace cylinder.
3. Steering is erratic left and right.	**a.** Hydraulic oil low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.

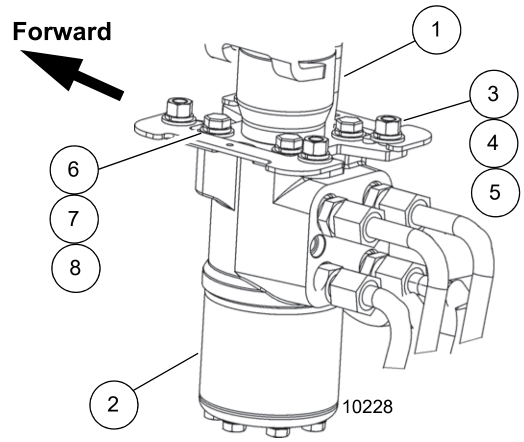
Functional Check

A normal periodic functional check of the entire steering system will generally be adequate to ensure satisfactory service.

1. Check all fittings for leakage. An accumulation of moist, black dirt is a good indication of leakage.
2. With the engine running at idle and at full throttle, and with the machine standing still and moving, turn the steering wheel through the full range of travel. Note any speed irregularities and sticky sensation. This may indicate dirt in the fluid. If the steering wheel continues to rotate when started and released, a condition known as Motoring exists. This may also indicate dirty fluid in the system.
3. Ensure the system has adequate power. If there is an indication of hard steering, this can be caused by either a reduced oil flow to the control valve or a reduced system relief pressure. Adequate oil flow under all conditions can best be checked by timing the full travel of the cylinder with the steered axle unloaded and loaded. If there is a great difference at low engine speed and slight difference at high engine speeds this may indicate a defective pump drive. Refer to *Checking/ Setting the Front Steer Pressure*, page 2-61.

Front Steering Control Valve

The steering control valve is located under the dash and is actuated by a conventional steering wheel and steering column, providing precise, full hydraulic steering. Precise steering is accomplished by a metering system within the valve that is directly connected to the steering column and wheel.



1	Steering Column
2	Steering Control Valve
3	Hex Nut 3/8-16 UNC SAE-2
4	Lockwasher
5	Flat Washer
6	Capscrew 3/8-16 UNC G5
7	Lockwasher
8	Flat Washer

FIGURE 8-8

Removal

1. Thoroughly clean the steering control valve and the surrounding area before removing the hydraulic hoses from the valve.
2. Tag and disconnect the hydraulic hoses from the steering control valve (2, Figure 8-8). Cap or plug each hose and the ports of the valve.
3. Remove hex nuts (3), lockwashers (4), and washers (5).
4. Remove the capscrews (6), lockwashers (7), and washers (8) securing the valve (2) to the bracket and the steering column (1). Remove the control valve, leaving the steering column in the cab.

Installation

1. Position the control valve to the bracket and steering column(1) and install the flatwashers (8), lockwashers (7), and capscrews (6). Torque capscrews; refer to *Fasteners and Torque Values*, page 1-16 for proper torque.
2. Install washers (5), lockwashers (4), and hex nuts (3).
3. Connect the hydraulic hoses to the control valve (2) as tagged during removal.
4. Start the engine and check for proper operation and any leakage.

Rear Steering System

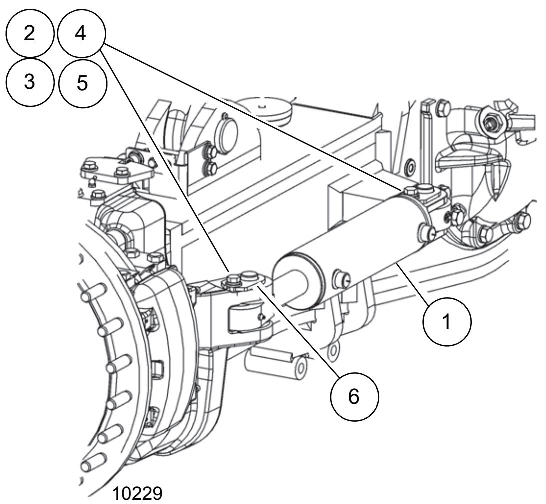
Troubleshooting

Table 8-2

Symptom	Probable Cause	Solution
1. Rear steering inoperative.	**a.** Hydraulic oil low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged, broken, or loose hydraulic lines or fittings.	**b.** Clean, tighten, or replace lines or fittings.
	c. Steer cylinder locked.	**c.** Repair or replace cylinders.
	d. Defective control valve.	**d.** Repair or replace valve.
	e. Defective steer cylinder(s).	**e.** Repair or replace cylinder(s).
	f. Lack of electrical signal	**f.** Check electrical connections/wiring
2. Difficult to steer left and right.	**a.** Hydraulic oil low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.
	e. Clogged or loose hydraulic lines or fittings.	**e.** Clean or tighten lines or fittings.
	f. Defective steer cylinder.	**f.** Repair or replace cylinder.
	g. Damaged relief.	**g.** Replace relief valve.
3. Steering is erratic left and right.	**a.** Hydraulic oil low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Clogged or loose hydraulic lines or fittings.	**b.** Clean or tighten lines or fittings.
	c. Defective steering control valve.	**c.** Repair or replace valve.
	d. Defective hydraulic pump.	**d.** Repair or replace pump.

Steer Cylinders

The steer cylinders are mounted on the axles, two cylinders on each axle. The barrel end of each cylinder is attached to a bracket on the axle housing and the rod end is attached to the steering lug on the wheel end. The Carrier Manifold Valve controls the rear axle steer cylinders. For more information, see *Carrier Manifold Valve*, page 2-25. The steer control valve in the steering column controls the front axle steer cylinders. For more information, see *Front Steering Control Valve*, page 8-9.



1	Steer Cylinder
2	Capscrew 1/2-20UNF G5
3	Washer
4	Lockwasher
5	Pin Weld
6	Thrust Washer

FIGURE 8-9

Removal

1. Tag and disconnect the hydraulic lines from the steer cylinder (1, Figure 8-9). Cap or plug all openings.
2. Remove the capscrew (2), flatwasher (3), and lockwasher (4) securing each pin weld (5) in the rod end and barrel end of the cylinder.

NOTE: Steer cylinder weighs approximately 20 kg (44 lb).

3. Remove both pin welds and two thrust washers (6), and remove the cylinder from the axle.

Installation

1. Position the cylinder onto the attachment fittings on the axle and install both pin welds (5). On the rod end, install a thrust washers (6) top and bottom of lug.
2. Secure each pin weld with the capscrew (2), flatwasher (3), and lockwasher (4). Torque capscrews (2) refer to *Fasteners and Torque Values*, page 1-16 for proper torque value.
3. Connect the hydraulic lines to the cylinder as tagged during removal.
4. Operate the steering system and check the cylinder for proper operation and any leakage.

REAR AXLE OSCILLATION LOCKOUT AND SUSPENSION RAISE/LOWER SYSTEM

The rear axle oscillation and height adjustment system Figure 8-10 and consists of four hydraulic struts (two per axle), suspension valve, and on two of the struts, length sensors. The main carrier manifold controls the flow of the hydraulic oil to the suspension valve. The suspension manifold features oscillation lockout solenoids. For more information about the suspension valve, see *Suspension Manifold Valve*, page 2-28.

The right middle axle strut and left rear axle strut feature length sensors. The length sensors measure the height of the rear axles and reports the data over the CANbus network from the ODM. The rear axle oscillation lockout feature can be enabled and disabled from the operator cab. For more information, see the *Operator Manual*.

The suspension manifold also controls the suspension raise/lower feature. The struts can lower the suspension 76.2 mm (3 inches) from the ride height for reduced transportation height. The suspension raise/lower feature is controlled from the ODM in the operator cab. For more information, see the *Operator Manual*.

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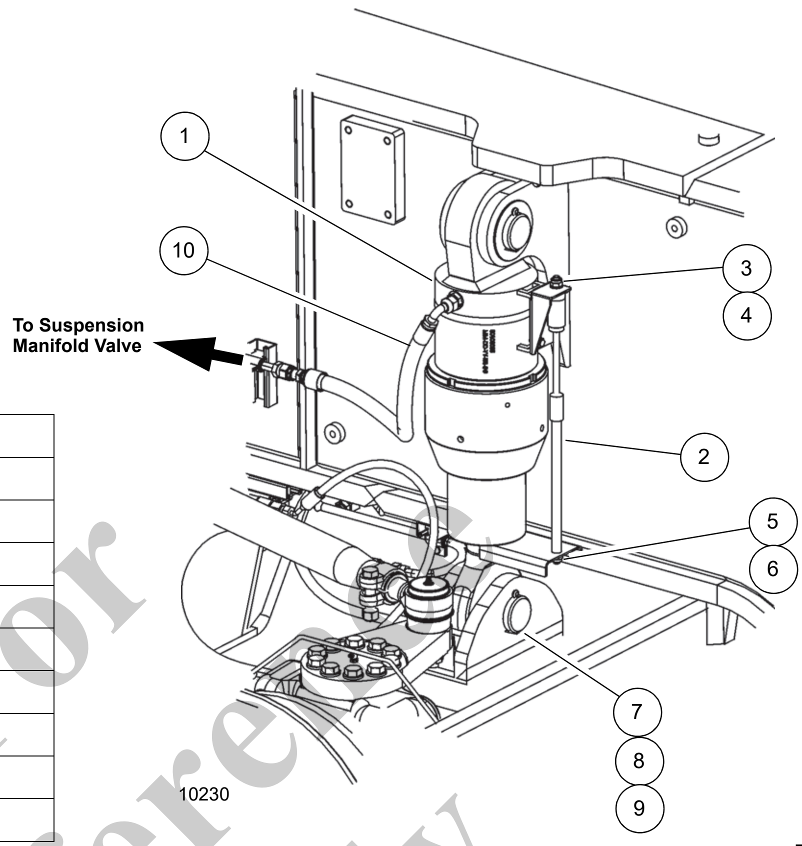


1	Hydraulic Strut
2	Length Sensor
3	Nut
4	Washer
5	Nut
6	Washer
7	Cotter Pin
8	Spacer
9	Suspension Pin
10	Hydraulic Hose

FIGURE 8-10

Removing the Hydraulic Strut

1. Remove the wheels. For more information, see *Wheels And Tires*, page 8-7.
2. Add a block or rigging under the axle to support the axle's weight.
3. Remove the hydraulic hose (10, Figure 8-10). Cap the hydraulic hose (10).
4. Remove nut (3) and washer (4) from the top length sensor bracket.
5. Remove nut (5), washer (6), and length sensor (2) from bottom length sensor bracket.

NOTE: The hydraulic strut weighs approximately 72.6 kg (160 lb).

6. Remove cotter pins (7), spacers (8), suspension pin (9), and strut (1) from the axle.

Installing the Hydraulic Strut

NOTE: The hydraulic strut weighs approximately 72.6 kg (160 lb).

1. Install the bottom of the strut (1) on the axle with spacers (8), suspension pin (9), and cotter pins (7).
2. Install the length sensor (2) on to the bottom of the strut (1) bracket with washer (6) and nut (5).
3. Install the length sensor (2) on to the top strut (1) bracket with washer (4) and nut (3).
4. Uncap and install hydraulic hose (10).
5. Remove blocks or rigging from under the axle.
6. Install wheels. For more information, see *Wheels And Tires*, page 8-7.

BRAKE SYSTEM

Description

The brake system includes all the components necessary for the application of the service brakes and the parking brake.

Service Brakes

The service brakes are full power hydraulic brakes which are hydraulically controlled and are used to apply the brake assemblies on all six wheels. The system consists of the tandem brake valve with treadle pedal, the dual accumulator charge valve, two hydraulic accumulators, the brake assemblies, and all the associated hoses and tubing. The operator depresses the pedal on the tandem brake valve, located on the cab floor, and the valve modulates the brake line pressure to the brake assemblies at each wheel. The full powered brake system supplies a high brake system pressure with relatively low reactive pedal forces, while controlling the maximum brake line pressure. The service brake dual accumulator charge valve regulates flow to the hydraulic accumulators to provide fully powered independently separate, primary (front) and secondary (rear), service brake circuits. Hydraulic pressure is constantly maintained in the brake circuits by the accumulators and the charging valve. The brake assemblies are disc type brakes.

Parking Brake

The parking brake is a hydraulically-controlled, disc-type brake, located on the front axle. It is spring applied and hydraulically released. The system consists of a two-position switch, a three-way solenoid valve, actuator, brake assembly, and all the associated hardware and tubing. The selector switch, located on the steering column in the cab, is used to activate the solenoid valve which controls the park brake actuator, which applies and releases the park brake.

NOTE: For Description and Maintenance of the tandem brake valve with treadle pedal, the accumulators, and the dual accumulator charge valve, refer to *Valves*, page 2-21.

Maintenance

Troubleshooting

Table 8-3

Symptom	Probable Cause	Solution
1. Brakes are insufficient.	**a.** Lining thickness less than 0.125 in (3 mm).	**a.** Replace lining.
	b. Restriction or leaks in lines.	**b.** Check all lines for leaks and restrictions.
	c. Low hydraulic oil flow.	**c.** Check the hydraulic oil level in reservoir and check flow from the tandem brake valve.
	d. Air in brake lines.	**d.** Bleed the brakes.
	e. Brake pads/linings are grease-soaked.	**e.** Replace pads/linings.
	f. Engine not running.	**f.** Start engine. Due to the operation, the engine must be running to provide full brake power.
	g. Brake relief valve stuck open.	**g.** Replace the relief valve.
	h. Dual accumulator charge valve not charging	**h.** Check valve operation and repair or replace valve.
	i. Accumulators not pre-charged.	**i.** Check accumulator pre-charge.
2. Hard brake pedal with engine running.	**a.** Pedal travel obstructed.	**a.** Check pedal and ensure it is unobstructed and moves properly.
3. Brakes lock up.	**a.** Too much hydraulic pressure.	**a.** Check the flow from the flow divider.
	b. Brake pedal push rod improperly adjusted, causing brakes to be always applied.	**b.** Adjust the push rod linkage so the brake pedal and push rod fully return.

Symptom	Probable Cause	Solution
4. Uneven braking or pad wear.	**a.** Lining thickness less than 0.125 in (3 mm).	**a.** Replace the lining.
	b. Grease on the pads/linings.	**b.** Replace the pads/linings.

General

A schedule for the periodic adjustment, cleaning, inspection, and lubrication of brake equipment should be established by the operator on the basis of past experience and severity of operation.

The disc brakes are not adjustable. Brakes should be cleaned, inspected, and linkage lubricated periodically to assure maximum performance.

Bleeding the Brake System

The brake system should be bled whenever air becomes entrapped within the brake system (usually characterized by a spongy feeling during brake pedal application), whenever any brake system line has been opened, or whenever any brake component has been replaced.

Always start at the point in the system that is furthest from the tandem brake valve and work back toward the tandem brake valve. Bleed every bleeder screw on every caliper/actuator on every wheel. When you complete a bleeder screw, go to the next closest bleeder screw on the same caliper/actuator. When you complete a wheel, go to the furthest bleeder screw on the next closest wheel.

Manually Bleeding the Brake System

NOTE: Before bleeding the brake system, ensure the hydraulic accumulators are fully charged.

1. Connect the end of the bleeder hose to the bleed screw on the caliper. Submerge the other end in a jar partially filled with clean hydraulic oil.
2. Open the bleed screw on the caliper/actuator and allow fluid to flow into the jar, while depressing the brake pedal. Depress the brake pedal and close the bleeder screw, then release the brake pedal. Torque the bleeder screw 11.3 N-m to 13.6 N-m (100 lb-in to 120 lb-in).
3. Repeat step 2 until a solid stream free of air bubbles is obtained.
4. Repeat steps 1 thru 3 for the remaining wheel calipers/actuators.

SERVICE BRAKES

Description

The brakes utilized on the axles are hydraulic disc-type brakes. Two brake assemblies are used at the end of each axle. The action of the brake pads pressing against the brake discs acts to slow the rotation of the wheels.

Maintenance

NOTE: To perform maintenance on the brake caliper, remove the tire and wheel assembly. Refer to *Axles*, page 8-1 in this section.

CAUTION

To prevent serious eye injury, always wear eye protection when doing maintenance or service.

Removal

Linings

1. Block the wheels.
2. Remove the bolts securing the end plates to one side of the caliper housing. Remove the end plates.
3. Loosen the bleeder screws to release hydraulic pressure in the caliper.

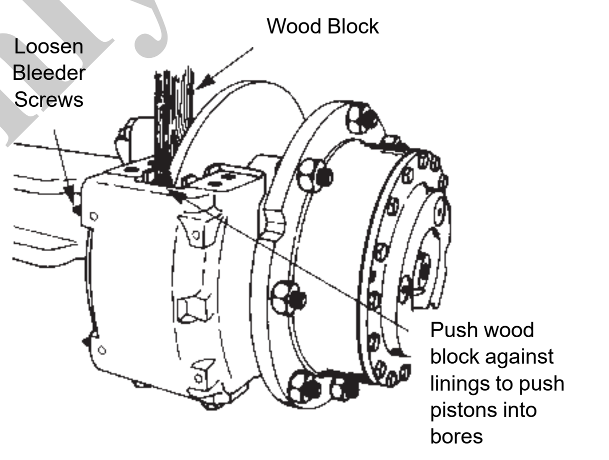


FIGURE 8-11

4. Use a piece of wood against the linings as a pry bar to push the pistons completely into the housing. Tighten the bleeder screws Figure 8-11. Torque the bleeder screw 11.3 N-m to 13.6 N-m (100 lb-in to 120 lb-in).
5. Remove the linings from the caliper housing. If necessary, discard the linings.

Caliper

1. Block the wheels
2. Disconnect the hydraulic brake line from the inlet fitting on the caliper. Cap or plug all openings.
3. Remove the linings as described under linings.
4. Remove the bolts securing the caliper housing to the mounting bracket. Remove the caliper housing from the mounting bracket. If shims are used mark the position of the shims.

Disassembly

Caliper

1. Remove the inlet fitting and o-ring from the cylinder cap.
2. Drain and discard the brake fluid.
3. Clean the outside of the housing with isopropyl alcohol. Dry the housing with a clean cloth.
4. If installed, remove the bolts that secure the end plates to the housing. Remove the end plates and linings.
5. Remove the pistons from the side of the housing opposite the mounting plate according to the following procedure.
   a. Use a C-clamp to hold a 12.7 mm (0.5 in) block of wood against two pistons on the mounting side of the housing. Ensure the C-clamp is not in the area in front of the piston bore. Refer to Figure 8-12.

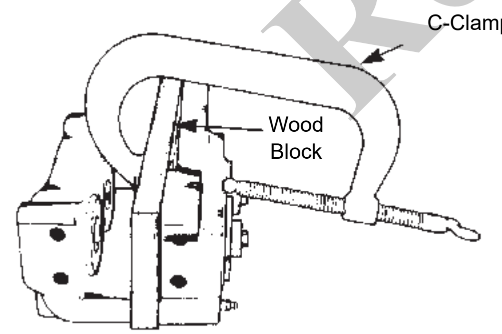


FIGURE 8-12

DANGER

Do not place hand in front of pistons when forcing them out. Serious personal injury may occur.

   b. Apply compressed air to the inlet fitting to force the pistons out of the other housing. If one piston comes out before the other piston, put a piece of wood in front of the piston that comes out first. Apply compressed air to force the other piston out of the housing. Refer to Figure 8-13.

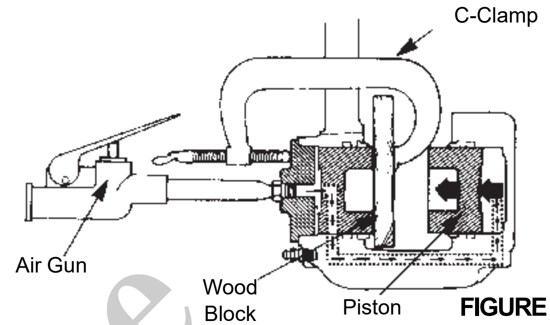


FIGURE 8-13

   c. Remove the wood block and the C-clamp from the housing.
   d. Remove the pistons from the bores that are opposite from the mounting plate.
6. Remove the two bleeder screws from the housing.
7. Remove the cylinder caps from the housing using an open end wrench. Remove and discard the O-rings Figure 8-14.

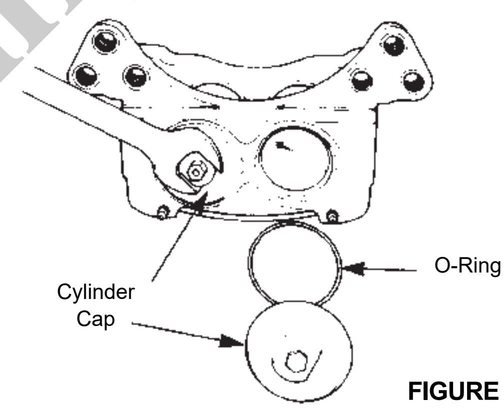


FIGURE 8-14

8. Remove the pistons from the mounting plate side of the housing. Push on the ends of the pistons to force them out of the disc side of the housing. Refer to Figure 8-15.

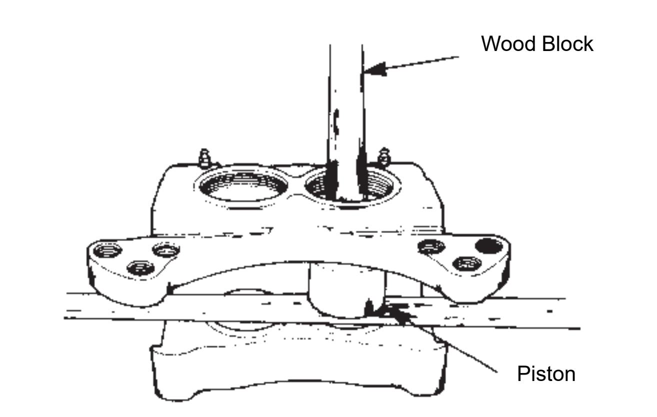


FIGURE 8-15

9. Remove the dust seals from the housing.

10. Remove and discard the O-ring and the backup rings. Refer to Figure 8-16.

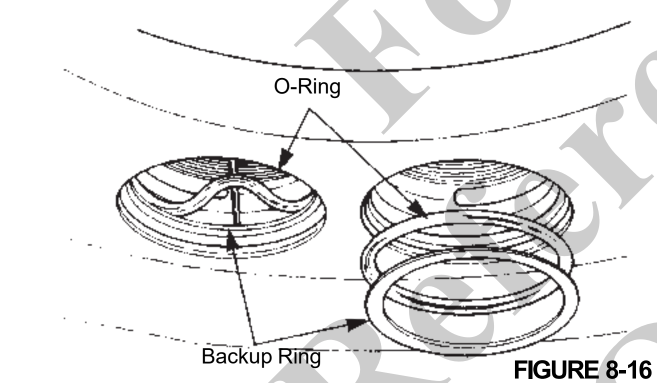


FIGURE 8-16

11. Inspect the ring grooves in the housing for scratches and rust. Remove small scratches and rust with emery cloth. Replace the housing if there are large scratches or large amounts of rust. Refer to *Caliper Parts*, page 8-18 in this section.

12. Inspect the pistons and the bores for scratches and rust. Remove small scratches and rust with emery cloth. Replace the components if they are worn or if there are large scratches or large amounts of rust. Refer to *Caliper Parts*, page 8-18 in this section.

Inspection

Periodic On-Vehicle

Inspect the caliper, linings, and disc for any damage.

Shoes, Linings, and End Plates

Remove the shoes and linings. To help prevent abnormal lining wear, replace worn, bent, or cracked end plates and distorted backing plates. Inspect end plate bolts for wear. Replace the bolts if worn. Inspect the linings for:

- Lining Wear: Replace the linings when the thickness of the lining is less than 3.2 mm (0.125 in) from the back plate. Refer to Figure 8-17.
- Lining Wear Not Even: Replace the linings if the thickness of the two linings is significantly different. Check the pistons for correct operation. Replace the piston and/or housing if a piston is cocked in the bore. Check that the disc surface is flat and parallel to the linings. Refer to Figure 8-17.

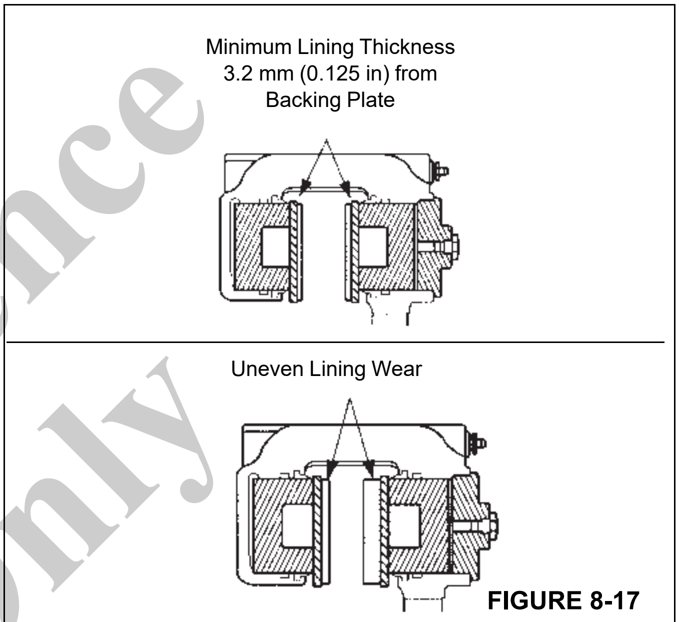


FIGURE 8-17

- Oil or Grease on Linings. Replace the linings.
- Cracks on Linings. Replace linings that have large or deep cracks.

NOTE: Small, tight cracks on the surface of the lining are normal when the caliper is used under high temperature conditions.

Caliper for Leaks

Inspect the following areas for fluid leaks. Refer to Figure 8-18.

8

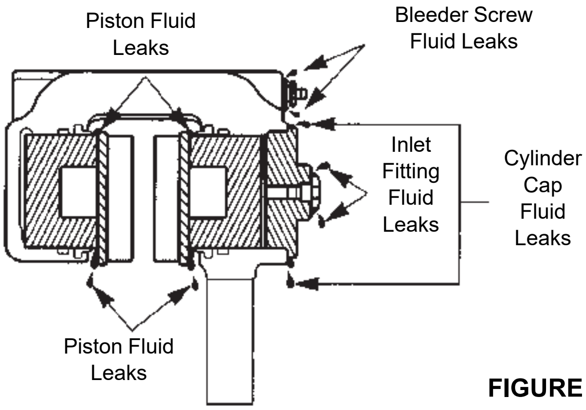


FIGURE 8-18

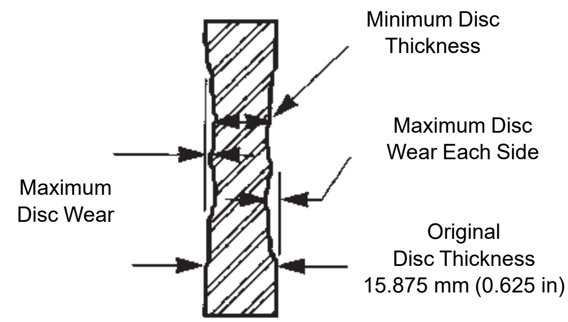
- **Pistons:** If fluid leaks at a piston, disassemble the caliper. Inspect the piston, the bore, the o-rings, and back-up rings. Service as necessary.
- **Cylinder Cap:** If fluid leaks at a cylinder cap, tighten the cylinder cap, the inlet fitting, and the plug. If the leak continues, disassemble the caliper. Inspect the cylinder cap threads, the housing threads, and the o-ring. Service as necessary.
- **Bleeder Screw:** If fluid leaks at the bleeder screw, tighten the bleeder screw. If the leak continued, replace the bleeder screw.
- **Inlet Fitting:** If fluid leaks at the inlet fitting, tighten the fitting. If the leak continues, replace the O-ring.

Dust Seals

Ensure the dust seals are soft and flexible. Disassemble the caliper and replace dust seals that are hard or damaged.

Disc

If the disc is worn beyond the wear limits, replace the disc. Refer to Figure 8-19.



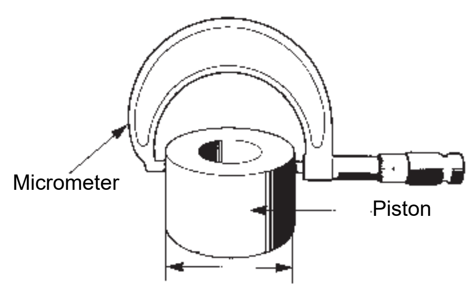
Typical Section Through Disc Showing Recommended Maximum Wear Limits

FIGURE 8-19

Lining Backing Plate Thickness	Maximum Disc Wear Each Side	Minimum Disc Thickness
7.1 mm (0.28 in)	1.5 mm (0.06 in)	12.7 mm (0.50 in)
8.6 mm (0.34 in)	2.3 mm (0.09 in)	11.2 mm (0.44 in)

Caliper Parts

1. Inspect the pistons, housing bores, and o-ring grooves for scratches or corrosion. Remove small scratches or corrosion with fine emery cloth. Replace the components if they are worn beyond wear limits or if there are large scratches or large amount of corrosion.
2. Measure the diameter of the piston. Replace the piston if the outer diameter is worn less than 76.073 mm (2.995 in). Refer to Figure 8-20.



Replace Piston if Outer Diameter is Worn to Less than 76.073 mm (2.995 in)

FIGURE 8-20

Manitowoc Crane Care

3. Measure the diameter of the housing bore. Replace the housing if the diameter is worn to more than 3.003 in (76.276 mm). Refer to Figure 8-21.

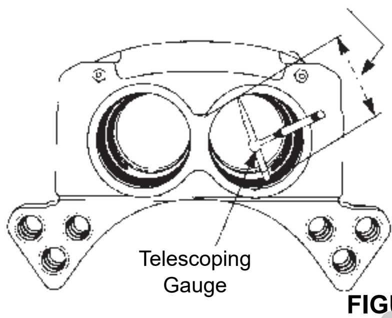


FIGURE 8-21

4. Inspect the linings as described previously.

5. Inspect the threads of the caliper, cylinder caps, and all fittings. Replace any component that has thread damage that cannot be repaired.

6. Discard all back-up rings, O-rings, and dust seals. Use new ones when assembling the caliper.

Cleaning

DANGER

Use of cleaning solvents, hot solution tanks, or alkaline solutions incorrectly, can cause serious personal injury. To prevent serious personal injury, follow the instructions supplied by the manufacturer of these products. Do not use gasoline to clean parts. Gasoline can explode and cause serious personal injury.

- Use solvent cleaners to clean all metal parts that have ground or polished surfaces. Examples of ground or polished parts are the piston and the piston bore in the caliper.
- Metal parts with rough surfaces can be cleaned with solvent cleaners or with alkaline solutions.
- Use a wire brush to clean the threads of fasteners and fittings.
- Use soap and water to clean parts that are not made of metal.
- Scrape away build-ups of mud and dirt on the linings. Replace all linings contaminated with oil or grease.
- Immediately after cleaning, dry all parts with clean paper or rags.

Corrosion Protection

Apply brake system hydraulic fluid to the cleaned and dried parts that are not damaged and are to be immediately assembled. **Do Not** apply fluid to the brake linings or the disc.

If parts are to be stored, apply a special material that prevents corrosion to all surfaces. **Do Not** apply the material to the brake linings or the disc. Store the parts inside special paper or other material that prevents corrosion.

Assembly

Caliper

CAUTION

Use only specified components when assembling the calipers. Do not mix components from other calipers. Installing the wrong components may cause the caliper not to operate correctly and may cause damage to equipment. Use of non manufacturer's parts can cause damage, loss of braking, and serious personal injury.

NOTE: The O-rings, back-up rings, pistons, and bores must be lubricated before installing the pistons.

1. Lubricate all pistons, bores, O-rings, and back-up rings with silicone grease. If silicone grease is not available, use the same type of fluid that is used in the brake system.

2. Install new O-ring and a new back-up ring in the groove in the middle of the bore. The O-ring is installed toward the outboard end of the bore. The back-up ring is installed toward the lining side of the bore. Refer to Figure 8-22.

CAUTION

Do not use silicone grease on the dust seal. Damage to the seal could occur

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3. Install a new dust seal in the top groove of the bore. Refer to Figure 8-22.

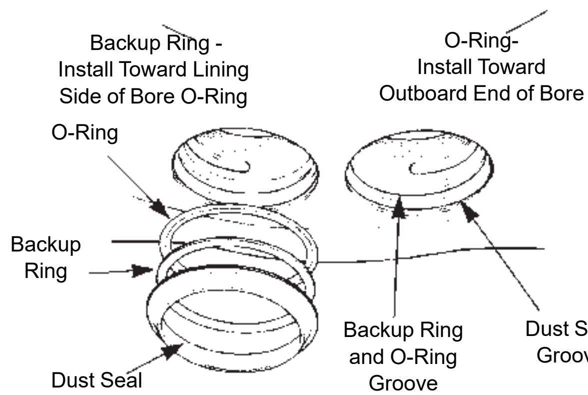

FIGURE 8-22

4. Install the pistons in the housing. Push the pistons in from the lining side of the housing. Ensure the pistons are straight in the bores. Push each piston into the bore until the top of the piston is even with the top of the dust seal. Refer to Figure 8-23.

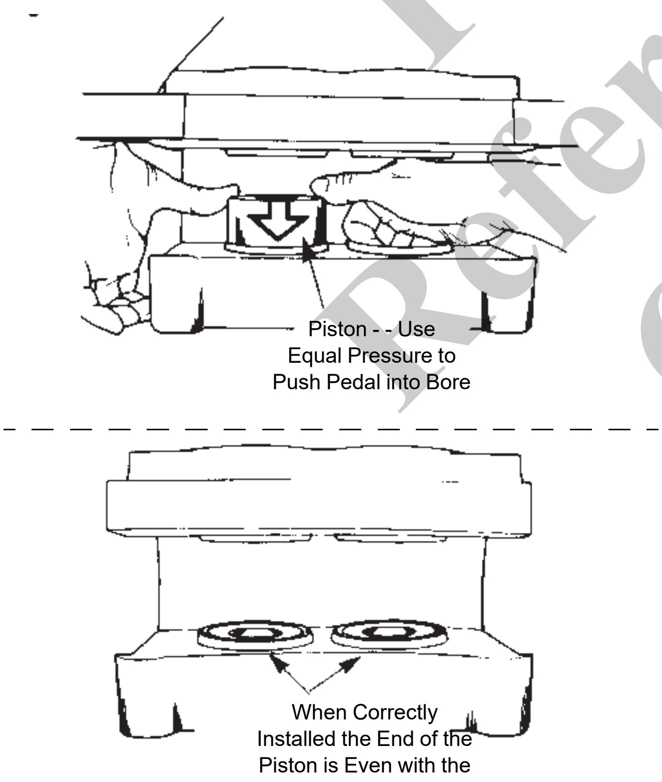

FIGURE 8-23

5. Install a new O-ring in the groove of the cylinder cap. Ensure the O-ring is not cut by the threads on the cylinder cap.

NOTE: Apply extra grease on O-ring before installing cylinder caps. this will keep O-ring from catching on threads as cylinder cap is threaded into housing.

6. Install the cylinder caps in the caliper housing. Tighten the cylinder caps to 100 N-m (75 lb-ft) minimum as shown in Figure 8-24.

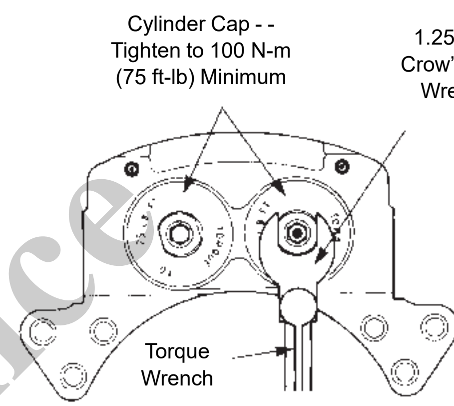

FIGURE 8-24

7. Install the bleeder screws in the housing. Tighten to 11.3 N-m to 13.6 N-m (100 lb-in to 120 lb-in).

8. Install the O-ring and the inlet fitting in the cylinder cap.

Installation

Linings

CAUTION

Always replace both linings. If only one lining is replaced, possible disc damage can occur.

1. Block the wheels.
2. Install the linings in the caliper housing.
3. Apply Loctite® 271 or equivalent to the bolt threads. Position the end plates on the housing and secure with bolts. Tighten the bolts to 224 N-m to 285 N-m (165 lb-ft to 210 lb-ft).
4. Ensure the linings move freely in the housing.
5. Bleed the brake system.
6. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

Caliper

1. Position the caliper housing on the mounting bracket. If shims where used, place them as marker during removal.
2. Secure the caliper housing with the bolts and tighten them to 678 N-m to 813 N-m (500 lb-ft to 600 lb-ft).
3. Install the linings. Refer to *Linings*, page 8-15.
4. Ensure the housing is installed correctly on the mounting bracket. The disc must be within ±1.5 mm (±0.06 in) of being centered between the lining end plates.
   a. To increase outboard clearance and decrease inboard clearance, install a shim either between the housing and mounting bracket or between the hub and disc.
   b. The shims must be steel, ground flat, and parallel and must cover the entire mounting surface of the hub or housing. The linings must move freely in the housing and between the end plates. Refer to Figure 8-25.

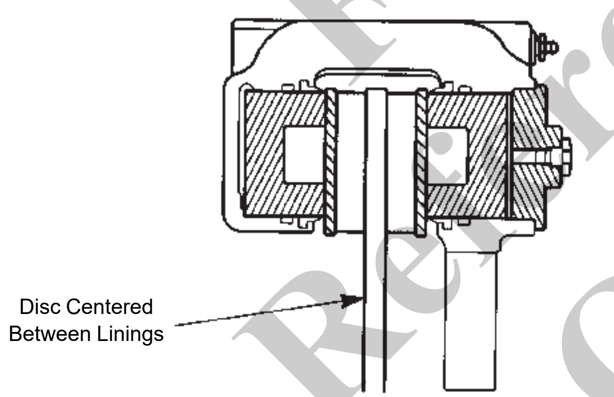

FIGURE 8-25

5. Connect the hydraulic brake line to the inlet fitting.
6. Bleed the brake system.
7. Apply and release the brakes three times to ensure the caliper operates correctly. Check for fluid leaks. Ensure the linings move freely.

PARKING BRAKE

The parking brake is mounted on the front axle input shaft in line between the front axle and the driveline from the transmission. The brake is a disc-type brake that is controlled by a switch on the steer column in the cab.

PARK BRAKE SOLENOID VALVE

The park brake solenoid valve is part of the Carrier Manifold Valve. Refer to *Carrier Manifold Valve*, page 2-25 for a description of the park brake solenoid valve, its function, and maintenance information.

OUTRIGGER

Outrigger Circuit

The outrigger circuit consists of four extension cylinders, four jack cylinders, an extend/retract directional control valve, front and rear outrigger control manifolds, and an Outrigger Monitoring System (OMS). The front two extension cylinders are mounted in the front outrigger beams and the rear two extension cylinders are mounted in the rear outrigger beams. The front and rear outrigger beams are mounted on their respective outrigger boxes; in turn the jack cylinders are mounted on the end of each outrigger beam. The extend/retract directional control valve is part of the carrier manifold valve, which is mounted to the inside carrier frame rail at the turntable bearing. The front and rear outrigger control manifolds are mounted on the inside center of their respective outrigger box. The OMS consists of a sensor inside each outrigger extension cylinder. The sensor detects the position of the outrigger extension cylinder piston and reports data to the RDM in the operator cab.

The Carrier Manifold Valve controls the supply of hydraulic oil to the outrigger manifold valves that control outrigger extension cylinder and jacks. The outrigger manifold valves are electrically actuated through operator inputs made at the ODM display or jog dial in the operator cab.

Maintenance

Troubleshooting

Table 8-4

Symptom	Probable Cause	Solution
1. Slow or erratic operation of outrigger extension cylinders.	**a.** Damaged relief valve.	**a.** Remove relief valve; clean or replace.
	b. Low hydraulic oil.	**b.** Check system for leaks. Make repairs as needed. Fill reservoir.
	c. Sticking solenoid valve spool.	**c.** Repair or replace valve spool.
	d. Improper ground to base of solenoid.	**d.** Ground properly.
	e. Directional selector switch sticking.	**e.** Clean or replace switch.
	f. Damaged wiring to solenoid.	**f.** Replace wiring.
	g. Damaged extension cylinder (internal parts).	**g.** Remove extension cylinder and repair or replace as necessary.
	h. Bent cylinder rods.	**h.** Replace piston rods and seals.
	i. Excessive material on outrigger beams.	**i.** Clean outrigger beams.
	j. Binding outrigger beam.	**j.** Do one of the following: Adjust wear pads. Repair or replace outrigger beam.
	k. Damaged outrigger valve.	**k.** Repair or replace valve.
	l. Damaged valve coil.	**l.** Replace coil.
	m. Main hydraulic pump cavitation.	**m.** Replace or tighten hose or fitting. Refer to your Manitowoc Crane Care Parts Manual.
	n. Partially shifted hydraulic spool in selector valve or manifolds.	**n.** Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	o. Insufficient voltage for operation of solenoid valve.	**o.** Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring.
	p. Damaged piston seals.	**p.** Replace all cylinder seals.
	q. Worn or damaged hydraulic pump section.	**q.** Repair or replace pump section.
	r. Scored cylinder barrel.	**r.** Repair or replace extension cylinder.
	s. Cracked or damaged piston.	**s.** Replace piston and all cylinder seals.
	t. Incorrect EEPROM settings.	**t.** Update EEPROM settings. Contact your Grove distributor or Manitowoc Crane Care.

Symptom	Probable Cause	Solution
2. Sticking spool.	**a.** Dirt in the system.	**a.** Change oil and flush system.
	b. Flow in excess of valve rating.	**b.** Limit flow through valve to that recommended. Check pump output and cylinder ratio.
	c. Pressure in excess of valve rating.	**c.** Check relief valve setting or pump compensation with that recommended.
	d. Electrical failure.	**d.** Check wiring and solenoids.
3. External leakage.	**a.** Damaged O-ring or quad rings.	**a.** Check for chipped packings and replace.
	b. Damaged solenoid.	**b.** Replace damaged parts.
4. Solenoid failure.	**a.** No current.	**a.** Check power source of at least 85% of coil rating.
	b. Damaged solenoid assembly.	**b.** Replace solenoid.
	c. Short in solenoid.	**c.** Replace coil.
	d. Loss of solenoid force.	**d.** Decrease time of solenoid energization, decrease cycle rate.
5. Outrigger jack cylinder slow or erratic.	**a.** Low in hydraulic oil.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Damaged main relief valve.	**b.** Repair or replace valve.
	c. Damaged holding valve seals.	**c.** Replace holding valve seals.
	d. Bent cylinder rod.	**d.** Replace cylinder rod and seals.
	e. Bent outrigger housing.	**e.** Repair or replace outrigger housing.
	f. Excessive material on beams.	**f.** Clean outrigger beams.
	g. Sticking solenoid valve spool.	**g.** Repair or replace valve spool.
	h. Damaged wiring to solenoid.	**h.** Repair or replace wiring.
	i. Directional selector switch sticking.	**i.** Clean or replace switch.
	j. Main hydraulic pump cavitation.	**j.** Replace or tighten hose and fittings.
	k. Worn or damaged hydraulic pump section.	**k.** Repair or replace pump section.
6. Outrigger jack cylinder retracts under load.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Damaged holding valve seals.	**b.** Replace seals.
	c. Damaged holding valve.	**c.** Replace valve assembly.
	d. Scored cylinder barrel.	**d.** Repair or replace cylinder.
	e. Cracked or damaged piston.	**e.** Replace piston and all cylinder seals.
7. Outrigger jack cylinder extends while machine is traveling.	**a.** Damaged piston seals.	**a.** Replace all cylinder seals.
	b. Scored cylinder barrel.	**b.** Replace jack cylinder.
	c. Cracked or damaged piston.	**c.** Replace piston and seals.
	d. Piston loose on cylinder rod.	**d.** Replace seal and retorque.

Symptom	Probable Cause	Solution
8. Outrigger system will not activate (from stowed or extended and down position).	**a.** Hydraulic oil low.	**a.** Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Loose or broken wire on switch.	**b.** Repair or replace wiring.
	c. Clogged, broken, or loose lines or fittings.	**c.** Clean, tighten, or replace lines or fittings.
	d. Damaged relief valve or damaged control valve.	**d.** Repair or replace valve.
9. Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	**a.** Clogged, broken, or loose hydraulic lines or fittings.	**a.** Clean, tighten, or replace lines or fittings.
	b. Loose or broken wire on control switch or solenoid valve.	**b.** Repair or replace wiring.
	c. Damaged solenoid valve.	**c.** Repair or replace valve.
	d. Damaged control switch.	**d.** Replace switch.
	e. Damaged hydraulic cylinder.	**e.** Repair or replace cylinder.
10. Outriggers will not set.	**a.** Improper sequence of activation.	**a.** Activate individual control switch; then activate system control switch.
11. Two outriggers activate from single control switch	**a.** Damaged solenoid valves.	**a.** Repair or replace.
12. The two outriggers will not stow.	**a.** Hydraulic lock.	**a.** Recycle individual outrigger(s).
13. Individual outrigger will not set or stow.	**a.** Damaged piston seals.	**a.** Replace seals.
	b. Damaged check valve.	**b.** Repair or replace valve.
	c. Loosen or broken wire on control switch or solenoid valve.	**c.** Repair or replace wiring.
	d. Damaged solenoid valve.	**d.** Repair or replace valve.

Outrigger Beam

Description

The outrigger box assembly(1, Figure 8-26) consists of an outrigger beam, a jack cylinder (2), an extension cylinder (23) (including the Outrigger Monitoring System (OMS) sensor), and the required hoses and mounting hardware.

Theory Of Operation

When the outrigger extension is activated, it extends or retracts the outrigger beam within the outrigger box. The outrigger beam can be extended to the mid-extend position by allowing the lock pin to ride on the top of the beam while it's extending. The lock pin will automatically drop into the hole when the beam reaches the mid-extend position.

The Outrigger Monitoring System (OMS) features a sensor mounted inside each extension cylinder. The sensor monitors the position of the outrigger beam—full, half or retracted.

The jack cylinder (2) is mounted to the end of the beam and applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

Maintenance

NOTE: Outrigger beam removal and installation is similar for both the front and rear outriggers beams (Figure 8-26).

Removal

1. Remove the outrigger boxes from the crane as necessary. For more information, see the *Operator Manual*.
2. If necessary, remove capscrews (3), lockwashers (4), washers (5) from the grab handles (6).
3. If necessary, remove capscrews (7), washers (8), spacers (9), and grab handles (6) from ladder (10).
4. Remove capscrews (3), lockwashers (4), washers (5), and the outrigger beam end cover (12).
5. On the jack cylinder end of the beam, loosen the two jam nuts (14), plates, and wear pads (16).
6. On the opposite end of the beam, remove capscrews (17), plates (18), and wear pads (19) from the top of outrigger beam.
7. Extend the outrigger slightly and attach an adequate lifting device to the outrigger beam (see Figure 8-27).

NOTE: Lifting belts or straps should be used for lifting purposes so as to avoid nicking or scratching the bottom edges of the outrigger beam (Figure 8-27).

Outrigger beam assembly, with jack cylinder, weighs approximately 984 kg (2169 lb).

DANGER

Be sure any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

8. Place adequate blocking material under outrigger beam.
9. Tag and disconnect the hydraulic lines (20) at the cylinder barrel end of the extension cylinder. Cap all lines and fittings. Disconnect OMS electrical cable connection at the outrigger extension cylinder.

NOTE: Do not allow the end of the outrigger beam extension cylinder to fall when the clevis pin is removed. Use blocking to limit the drop or an adequate soft support to cushion any distance the rod will drop.

10. Remove the cotter pin (21) and clevis pin (22) securing the cylinder barrel end of the extension cylinder (23) to the outrigger box. Carefully pull the outrigger beam out of the outrigger box until the extension cylinder is free of the box and carefully lay the end of the cylinder on the bottom of the outrigger beam or leave on blocking.

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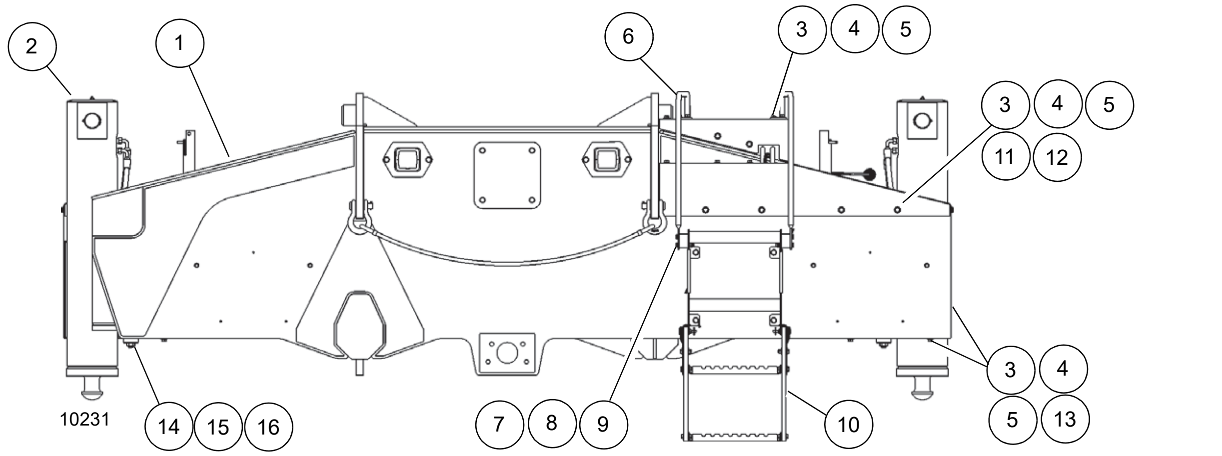
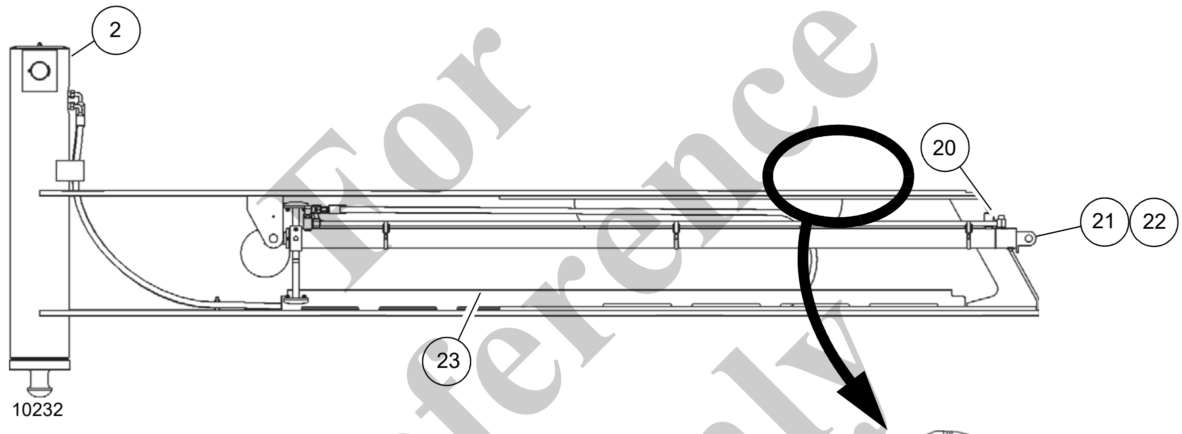
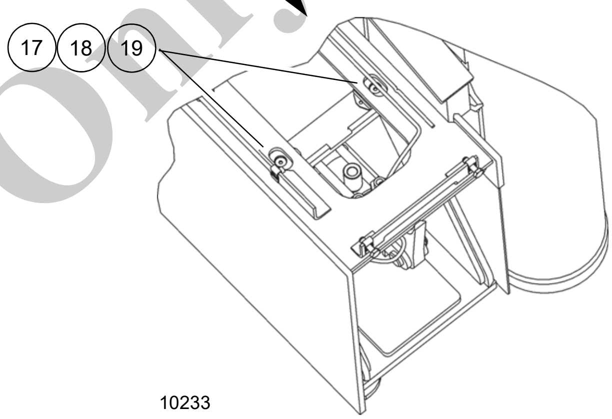






1	Outrigger Box
2	Outrigger Jack Cylinder
3	Capscrew 10 x 30 8.8
4	Lockwasher
5	Washer
6	Grab Handle
7	Capscrew M10x70 SS
8	Washer
9	Spacer
10	Ladder
11	Retaining Nut
12	Lower Outrigger Cover
13	Outrigger End Cover
14	Jam Nut
15	Plate
16	Wear Pad

17	Capscrew M10x25 10.9
18	Plate
19	Wear Pad
20	Hydraulic Hose
21	Cotter Pin
22	Clevis Pin
23	Outrigger Extension Cylinder

FIGURE 8-26

11. Pull the outrigger beam out of the outrigger box, re-adjusting the lifting attachment to prevent the extension cylinder from sliding out of the outrigger beam when the beam clears the outrigger box.

DANGER

Be sure any blocking material used is capable of supporting outrigger beam weight. Do not allow it to tilt or slide.

12. Position outrigger beam on blocking material.

Inspection

Inspect outrigger beams for bends, evidence of cracks, or other damage. Check outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder, loose connection, or damaged hydraulic line.

Installation

1. If removed, install wear pads (16) into bottom inside of outrigger box using plates (15) and jam nuts (14). Apply anti-seize compound to the wear pads (16).
2. If removed, install wear pads (19) and plates (18) to the top of the outrigger beam using capscrews (17). Apply anti-seize to the wear pads (19).
3. Attach an adequate lifting device of straps or belts to the beam. Do not use chains, as they may nick the bottom edges of the outrigger beam (see Figure 8-27).

NOTE: Outrigger beam assembly, with jack cylinder, weighs approximately 984 kg (2169 lb).

4. Slide the beam into the outrigger housing and align the cylinder bushing with the mounting hole. Be sure jack cylinder hydraulic hoses do not get trapped against the outrigger box during insertion.
5. Apply anti-seeze compound to the clevis pin (22, Figure 8-26). Secure the cylinder barrel to the housing with the clevis pin (22) and cotter pins (21).

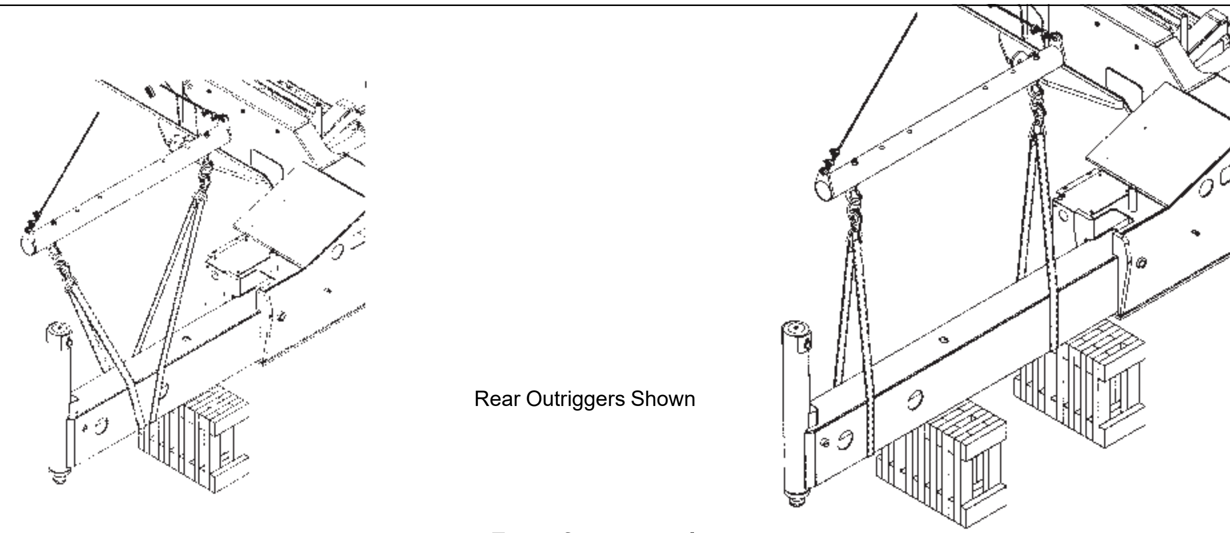
CAUTION

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

6. Connect the hydraulic lines (20) as tagged during removal. Connect the OMS electrical cable as tagged during removal.

NOTE: If extension cylinder was replaced with a new cylinder, recalibrate the outriggers.

7. Fully extend and retract the outrigger beam, ensuring the beam assembly rides on the top and bottom wear pads.
8. Install outrigger end cover (13) with remove capscrews (3), lockwashers (4), and washers (5).
9. Install lower outrigger cover (12) with washers (5), lockwashers (4), capscrews (3), and retaining nuts (11).
10. If necessary, install grab handles (6) on ladder (10) with capscrews (7), washers (8), and spacers (9).
11. If necessary, install grab handles (6) to upper cover (13) with capscrews (3), lockwashers (4), and washers (5).
12. Install the outrigger boxes. For more information, see the *Operator Manual*.
13. If extension cylinder was replaced, recalibrate the outriggers.



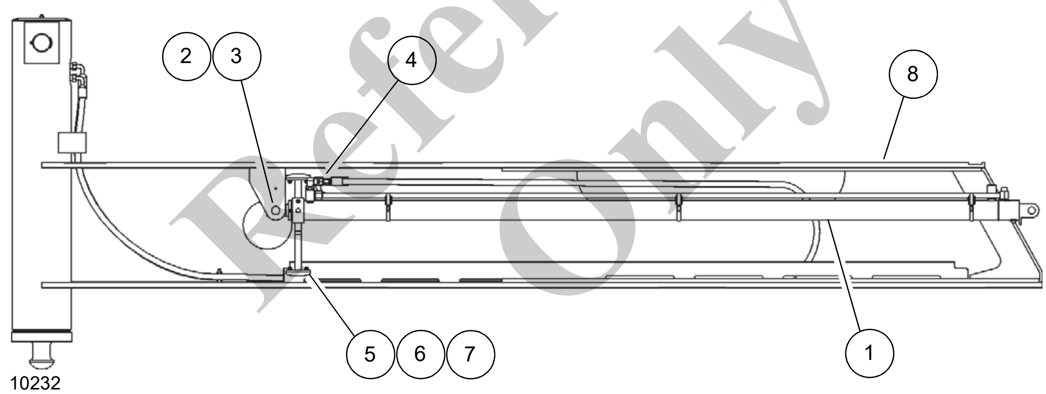
For reference only

FIGURE 8-27

Outrigger Extension Cylinder

Description

Two outrigger extension cylinders(1, Figure 8-28) are utilized within each outrigger box assembly. The extension cylinders provide the force for the outrigger beam's horizontal movement. The cylinder weighs approximately 54 kg (119 lb).



1	Outrigger Extension Cylinder
2	Clevis Pin
3	Cotter Pin
4	Hydraulic Hose

5	Capscrew M8x25 8.8
6	Locknut
7	Wear Pad
8	Outrigger Beam Assembly

FIGURE 8-28

Removal

1. Remove the outrigger extension beam (1, Figure 8-28) from the outrigger box. For more information, see *Outrigger Beam*, page 8-25.
2. Remove the cotter pin (2) and clevis pin (3) securing the rod end of the extension cylinder (1) to the outrigger beam (8).
3. Pull the extension cylinder (1) from the outrigger beam until the hydraulic hoses (4) on the rod end of the cylinder can be accessed. Tag and disconnect the

hydraulic hoses (4) from the rod end of the cylinder. Cap or plug all openings.

4. Remove the extension cylinder (1).
5. If necessary, remove capscrews (5), locknuts (6), and wear pads (7) from the extension cylinder (1).

Installation

1. If necessary, install the wear pads (7) on the extension cylinder (1) with capscrews (5) and locknuts (6).
2. Place the extension cylinder (1) in the beam.
3. Position the extension cylinder (1) so the hydraulic ports on the rod end of the cylinder can be accessed. Connect the hydraulic hoses (4) to the ports as tagged during removal.
4. Push the extension cylinder (1) into the outrigger beam. Align the cylinder rod with the clevis in the beam. Apply anti-seeze to the clevis pin (2) and secure in place with the clevis pin (2) and cotter pin (3).
5. Install the outrigger beam (8) in the outrigger box. For more information, see *Outrigger Beam*, page 8-25.

Functional Check

1. Activate the hydraulic system. Fully extend and retract the outrigger.
2. Observe the operation of the outrigger beam. If hydraulic lines are reversed, stop immediately and connect lines properly per instructions. Verify jack cylinder hoses are not trapped or twisted by full outrigger beam retraction. If any hose is trapped, stop immediately and install lines properly to avoid trapping.
3. Check the hydraulic connections and hoses for any evidence of leakage. Make repairs as needed.
4. Recalibrate the Outrigger Monitoring System in the ODM as needed.

Outrigger Jack Cylinder

Description

Four jack cylinders are used on the crane, one at the end of each outrigger beam. The jack cylinders provide the force for the outrigger beam's vertical movement. The cylinder weighs approximately 108.6 kg (239.4 lb).

Removal

1. Slightly extend outrigger beam for improved access to the jack cylinder. Shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder (see Figure 8-29). Remove the fittings from the ports. Cap or plug all openings.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.

NOTE: Jack cylinder weighs approximately 108.6 kg (239.4 lb).

5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
6. Using jack, raise cylinder up just enough to insert retaining pin into cylinder. Insert retaining pin in lugs on cylinder. Secure pin in place with cotter pins.

CAUTION

Use a nylon strap to remove cylinder. This will ensure retaining pin is not damaged.

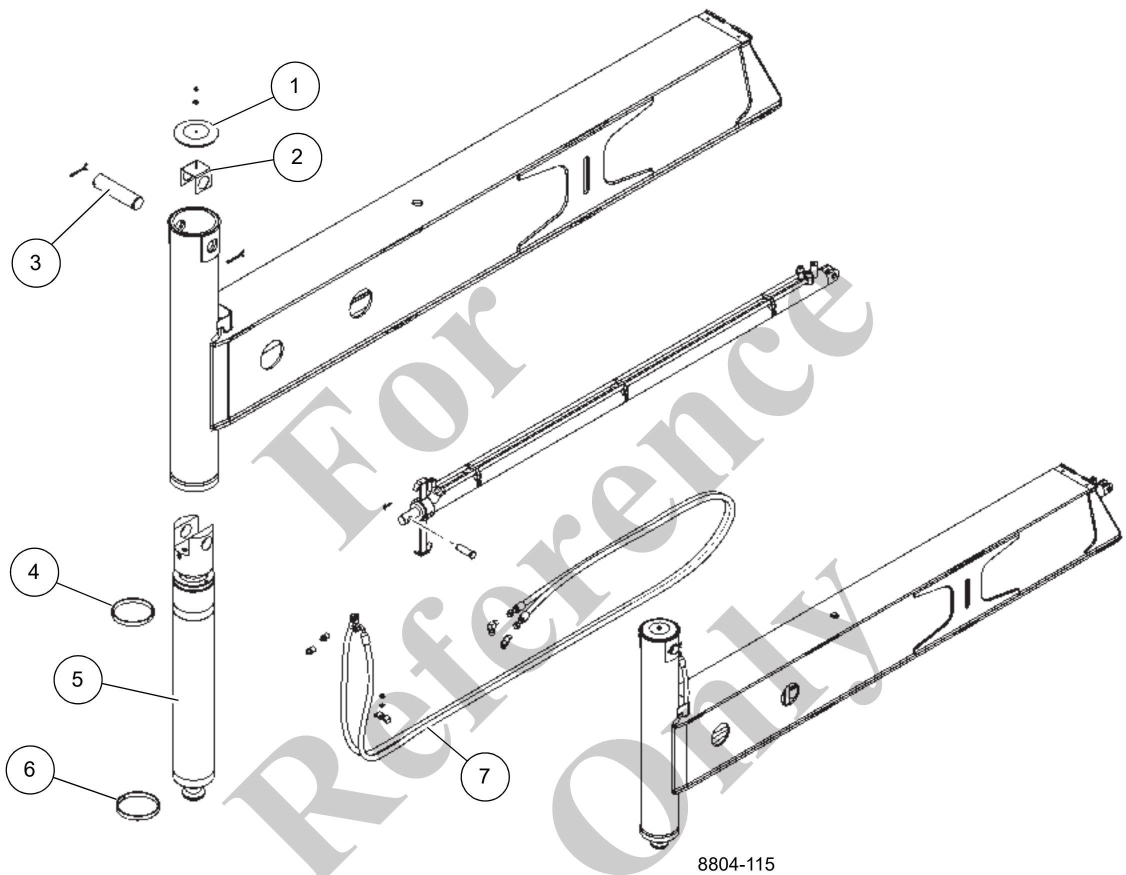
7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of tube of the beam assembly.

Installation

1. Apply grease (EP-MPG) to ID of jack cylinder support tube.
2. If removed, install wear ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under Removal, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove lifting device from cylinder.
4. Remove retaining pin and cotter pins from cylinder.
5. Using the jack, lower the cylinder until holes in cylinder rod align with holes in outrigger beam.
6. Apply anti-seeze compound to retaining pin. Secure cylinder and cylinder cap retaining bracket to support tube with retaining pin and cotter pins.
7. Install cylinder cap.
8. Install the fittings in the cylinder ports and connect the hoses as tagged during removal. Verify the piston side of the jack cylinder is connected to the solenoid valve bank to prevent damage. Verify jack cylinder hoses are not trapped or twisted by full outrigger beam retraction.

Functional Check

1. Activate the hydraulic system. Fully extend and retract the jack cylinder.
2. Observe the operation of the jack cylinder. If hydraulic lines are reversed, stop immediately and connect lines properly per instructions. Verify jack cylinders are not trapped or twisted by full outrigger beam retraction. If any is, stop immediately and install lines properly to avoid trapping.
3. Check the hydraulic connections and hoses for evidence of leakage. Make repairs as needed.



Item	Description
1	Jack Cylinder Cap
2	Cap Bracket
3	Pin
4	Head Wear Ring
5	Jack Cylinder
6	Bearing
7	Jack Cylinder Hydraulic Hoses

FIGURE 8-29

SECTION 9
MAINTENANCE AND LUBRICATION

SECTION CONTENTS

GENERAL

Following the designated lubrication procedures is important to ensure maximum crane lifetime and utilization. Procedures and lubrication charts in this section include information on types of lubricants used, location of the lubrication points, frequency of lubrication, and other information.

Refer to your *Inspection and Lubrication Service Log* for routine checks which will help maintain the safety, dependability, and productivity designed into your crane.

One copy of the *Inspection and Lubrication Service Log* is provided in the original package of manuals shipped with the crane. Additional copies are available through the Grove distributor network or Manitowoc Crane Care.

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, filters, air conditioning refrigerant, 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 filling pump.
- Immediately clean up any spills.

LUBRICANTS AND LUBRICATION INTERVALS

Use lubricants as listed in this section. See also the appropriate section for maintenance and lubrication instructions.

CAUTION

Possible Equipment Damage!

The multipurpose grease installed during manufacture of this crane contains a lithium base.

Do not apply chassis grease lubricants with air pressure devices, as chassis contains sealed fittings.

Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.

Failure to follow this instruction may cause damage to equipment.

Grove recommends the use of Standard lubricants for Grove cranes operating in regions where moderate ambient temperature, humidity, and atmospheric conditions prevail. These Standard lubricants are effective in ambient temperatures down to -9°C (+15°F).

Cold weather temperatures below -9°C (+15°F) are considered arctic. Grove recommends the use of Cold Weather lubricants for Grove cranes operating in arctic conditions.

In regions where Grove cranes are operating with arctic conditions down to -29°C (-20°F), Grove recommends the use of the Cold Weather lubricants found in Table 9-2.

In regions where Grove cranes are operating with arctic conditions down to -40°C (-40°F), Grove recommends the use of the Cold Weather lubricants found in Table 9-3.

NOTE: All fluids and lubricants may be purchased by contacting an authorized Grove distributor or Manitowoc Crane Care Parts Department.

Standard Lubricants

Standard lubricants are used on all Grove cranes. Cranes can also be ordered with Cold Weather lubricants. The Standard lubricants listed in Table 9-1 are effective in ambient temperatures down to -9°C (+15°F).

Table 9-1 : **Standard Lubricants [Down to -9°C (+15°F)]**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Extended Service Interval Axle Gear Oil	6829012964	Century Unigear Semi-synthetic Texaco Multigear SS Chevron DELO Gear Lubricant	80W-90	GL-5
Engine Oil (SAE) (EO 15W-40)	6829104182	Conoco Fleet Supreme EC Mobil Delvac 1300 Super Mobil Delvac MX ESP	15W-40	CJ-4
Hydraulic/Transmission Oil	6829006444	Phillip 66 PowerTran XP Exxon Mobil 424	ISO 46/68	Must meet John Deere Standard JDM J20C
Extreme Pressure Hoist Gear Oil Swing Drive Oil	6829100213	Mobil Mobilgear 600XP 150 Gear Oil Texaco Meropa 150 Phillips 66 Extra Duty Gear Oil	AGMA EP-4	AGMA No. 4 EP
Extreme Pressure Multipurpose Grease (EP-MPG)	6829003477	Citgo Lithoplex MP# 2 (red) Chevron Starplex EP-2 (red) Phillips 66 Multiplex Red (red) Mobil Mobilgrease XHP 222 (dark blue) IPIFLEX LI-COMP EP2 (red) Renolit Hi-Temp 220 (Ivory)	NLGI 2	GC-LB Certified
Open Gear Lube (EP-OGL)	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	

Table 9-1 : Standard Lubricants [Down to -9°C (+15°F)] (Continued)

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA (red) Caterpillar DEAC (magenta) Fleetguard ES Compleat EG (blue)	AFC - 50/50 Mix 50/50	
Liquid Coolant Conditioner (LCC)	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000	LCC	
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF	DEF	
Extreme Pressure 3% Moly Grease (EM-3MG)	6829015304	Citgo Lithoplex CM2 Mobil Mobilgrease CM-P Phillips 66 Megaplex XD3 Ipiranga IPIFLEX LI-COMP MOLY 2 (Gray)	NLGI 2 NLGI 2 NLGI 1 NLGI 2	 GC-LB Certified GC-LB Certified
BECHEM PAL1	01373458			
BECHEM High-Lub LM 2 EP (400g)	03313195		NLGI 2	

ARCTIC LUBRICANTS AND CONDITIONS

Arctic Conditions 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. 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 or lubricant, check with an authorized Grove distributor or Manitowoc Crane Care.

NOTE: All fluids and lubricants may be purchased by contacting your local Grove distributor or Manitowoc Crane Care.

Regardless of temperature and oil viscosity, always follow the cold weather start-up and operating procedures, as described in *Section 4 - Operating Procedures* 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 specific Cold Weather lubricants for use in ambient temperatures down to -29°C (-20°F). Refer to Table 9-2 for a list of these recommended Cold Weather lubricants.

Additionally, Grove recommends specific Cold Weather lubricants for use in ambient temperatures down to -40°C (-40°F). Refer to Table 9-3 for a list of these recommended Cold Weather lubricants.

These recommended Cold Weather lubricants alone are not sufficient to operate the crane in extreme low temperatures (arctic conditions). Therefore, Grove recommends that the crane be equipped with specific cold weather accessories, as listed under the section *Crane Warm-up Procedures*, in the *Operator Manual*.

Table 9-2 : **Cold Weather Lubricants in Arctic Conditions [Down to -29°C (-20°F)]**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	**Grade**	**Classification**
Synthetic Axle Gear Oil	6829014058	CITGO Synthetic Gear Lube Eaton Roadranger EP Mobil Mobilube SHC Mobil Delvac Synthetic Gear Shell Spirax S6 Sunoco Duragear EP Petro-Canada Traxon E Synthetic Phillips 66 Triton Syngear FE	75W-90	OEM Meritor 076N (GL-5)
Engine Oil (SAE)	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Hydraulic/Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20C & J20D
Hoist Gear Oil Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629 Phillips 66 Syncon EP Plus	ISO 150	AGMA No. 4 EP

Table 9-2 : **Cold Weather Lubricants in Arctic Conditions [Down to -29°C (-20°F)] (Continued)**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
Extreme Pressure Multipurpose Grease (Cold Weather) (EP-MPG)	6829104275	Mobil Mobilith SHC 220 (red) Petro-Canada Precision Synthetic EP1 Phillips 66: Triton 220 (replaced by Multiplex FS 220 (purple) Phillips 66: Multiples FS220 (purple)	NLGI 2	GC-LB Certified
Open Gear Lube	6829102971	Fuchs: Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829101130	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Compleat EG	Mix 50/50	
Liquid Coolant Conditioner	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Extreme Pressure 3% Moly Grease	6829104275	Mobil Mobilith SHC 220 Petro-Canada Precision Synthetic EP1	NLGI 2	
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III Product #1	#1	NLOCK08
BECHEM PAL1	01373458			
BECHEM High-Lub LM 2 EP (400g)	03313195		NLGI 2	

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Table 9-3 : **Cold Weather Lubricants in Arctic Conditions [Down to -40°C (-40°F)]**

Lubricant/Fluid	Grove Spec.	Recommended Lubricant Type	Grade	Classification
Axle Gear Oil Hoist Gear Oil	6829014058	Petro-Canada Traxon E Synthetic CITGO Synthetic Gear Lube Eaton Roadranger EP Mobil Mobilube SCH Shell Spirax S Sunoco Duragear EP	75W-90	GL-5
Engine Oil (SAE)	80056036	Shell Rotella® T6 Mobil Delvac 1 ESP Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Hydraulic/Transmission Oil	6829101559	Petro-Canada Duratran Synthetic THF Chevron All Weather THF Texaco TDH Oil SS		Must Meet John Deere Std. JDM J20C & J20D
Swing Drive Oil	6829103636	Petro-Canada ENDURATEX Synthetic EP 150 Mobil SHC629		AGMA No. 4 EP
Grease, Extreme Pressure Multipurpose	6829104275	Petro-Canada Precision Synthetic EP1 Mobil, Mobilith SHC 220	NLGI 2	
Open Gear Lube	6829102971	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Antifreeze Coolant	6829104212	Old World Industries, Inc. Fleet Charge SCA Pre-charged Fleetguard Compleat EG Petro-Canada	Mix 60/40	
Liquid Coolant Conditioner	6829012858	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Exhaust Fluid (DEF)	80019225	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		
Extreme Pressure 3% Moly Grease	6829104275	Mobil Mobilith SHC 220 Petro-Canada Precision Synthetic EP1	NLGI 2	
Windshield Washer fluid	90037773	Splash De-icer		
Diesel Fuel	80069407	NOCO Kerosene, 3, UN1223, III	#1	NLOCK08

Table 9-3 : Cold Weather Lubricants in Arctic Conditions [Down to -40°C (-40°F)] (Continued)

Lubricant/Fluid	Grove Spec.	Recommended Lubricant		
		Type	Grade	Classification
BECHEM PAL1	01373458			
BECHEM High-Lub LM 2 EP (400g)	03313195		NLGI 2	

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 crane operating temperatures will allow hydraulic oil to warm sufficiently to penetrate these cracks and if cranes are operated daily, protect the rods. Cranes 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 crane 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 cranes once a week and reapply Boeshield® to unprotected rods.

WIRE ROPE LUBRICATION

Wire rope is lubricated during manufacturing so that the strands, and individual wires in strands, may move as the rope moves and bends. A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added periodically throughout the life of a rope to replace factory lubricant which is used or lost. For more detailed information concerning the lubrication and inspection of wire rope, refer to *Wire Rope*, page 1-28.

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, for example, weekly, monthly, etc.

Check all oil levels with crane parked on a level surface in transport position, while oil is cold, unless otherwise specified.

On plug type check points, oil levels are to be at the bottom edge of the check port.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. One pump on a standard 0.45 kg (1 lb) grease gun equals 28 grams (1 oz) of EP-MPG.

Over-lubrication on non-sealed fittings will not harm fittings or components, but under-lubrication will definitely lead to a shorter lifetime.

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 lubricate again to make sure that the entire wear area is fully lubricated.

CraneLUBE

Grove highly recommends use of Manitowoc CraneLUBE lubricants to increase crane reliability and performance. Contact your Grove distributor for information about the Manitowoc CraneLUBE lubrication program.

Cummins Oil Registration List

Cummins has a program that lists engine oils that have been tested and meet the requirements of Cummins Engineering Specifications. A listing of recommended oils is on QuickServe® Online. Log on to quickserve.cummins.com and login with a current username and password. Or create a new account by selecting “Create an Account” under information, then 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, and view the registered oils.

Safety

WARNING

Crushing Hazard!

Movement of the superstructure the boom, and outriggers may create a crushing and/or pinching hazard.

Make sure that personnel maintain an adequate clearance from moving parts when these parts are operated during lubrication of the crane.

Failure to follow this instruction may cause serious injury or death to personnel.

To lubricate many of the locations on the crane, the engine must be started. Parts of the crane, to include the boom, superstructure, outriggers, and the like, must be retracted or extended, or swung left or right, which movement may cause pinching and crushing hazards.

After positioning areas of the crane for lubrication, turn off the engine and make sure that the moving parts of the crane are stopped before approaching.

Table 9-4 : **Approved Lubricant Reference Table**

Ref.	Approved Lubricant	Lube Specification Down To -9˚C (+15˚F)	Lube Specification Down To -29˚C (-20˚F)	Lube Specification Down To -40˚C (-40˚F)
A	Extreme Pressure Multipurpose Grease	6829003477	6829104275	6829104275
B	Gear Lube (GL-5)	6829012964	6829014058	6829014058
C	Fully Formulated Anti-Freeze Coolant	6829101130	6829101130	6829104212
D	Liquid Coolant Conditioner (LCC)	6829012858	6829012858	6829012858
E	Tractor Hydraulic Fluid	6829006444	6829101559	6829101559
F	Engine Oil (SAE)	6829104182 (15W-40)	80056036 (0W-40)	80056036 (0W-40)
G	Open Gear Lube	6829102971	6829102971	6829102971
H	Extreme Pressure Gear Lube	6829100213	6829103636	6829103636
J	Hydraulic Oil	6829006444	6829101559	6829101559
K	Diesel Exhaust Fluid (DEF)	80019225	80019225	80019225
L	Extreme Pressure 3% MOLY Grease	6829015304	6829104275	6829104275
M	BECHEM PAL1	01373458	01373458	01373458
N	BECHEM High-Lub LM 2 EP (400g)	03313195	03313195	03313195

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Drive Train						
1	Engine Air Cleaner Filter Element	Figure 9-1	—	—	When indicator shows red (25″ H_2O)	REPLACE engine air cleaner filter **See NOTE 1.**
2	Engine Cooling System	Figure 9-1	C	42 L (11.1 gal) **See NOTE 2.**	Every 10 hours/daily	CHECK coolant level in sight glass (rear of crane) **See NOTE 3.**
					LIFETIME	DRAIN and FILL **See NOTE 4.**
	Liquid Cooling Conditioner (LCC)	Figure 9-1	D	As necessary	See Service Manual	TEST and ADD **See NOTE 5.**
3	Coolant Strainer (Cab Heater)	Figure 9-1	—	—	After first 100 hours of service	CLEAN strainer **See NOTE 6.**
					Then, every 2000 hr, or 1 year, whichever interval comes first	REPLACE strainer **See NOTE 6.**
4	Engine Crankcase Cummins B6.7L Stage V, with Engine Oil Filter	Figure 9-1	F	—	Every 10 hours/daily	CHECK oil level ADD oil through crankcase fill cap to FULL on DIPSTICK
			F	15 L (4 gal)	Every 500 hours	DRAIN engine crankcase
						REPLACE oil filter **See NOTE 7.**
						FILL engine crank-case through fill cap to FULL on DIPSTICK **See NOTE 7.**

NOTE 1: If installed, ladder must be removed to access the Engine Air Cleaner Filter element.

NOTE 2: Engine Anti-Freeze Coolant capacities indicated are for a fully formulated mixture of 50% AFC and 50% water.

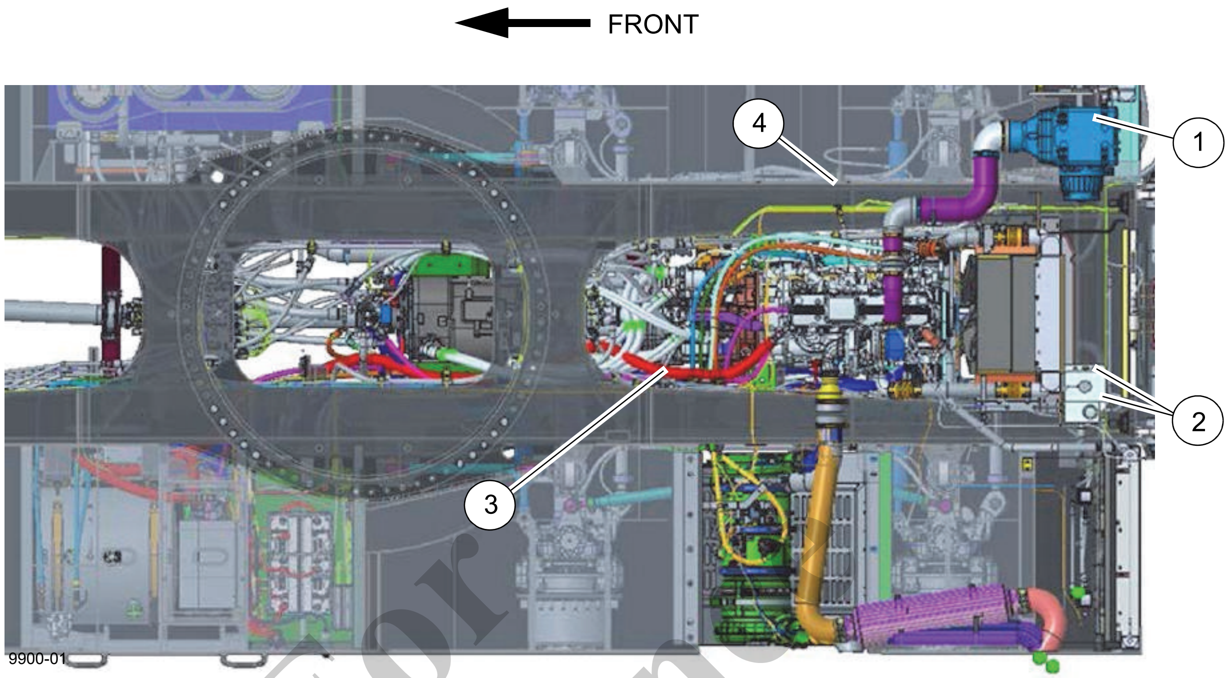
NOTE 3: If coolant LEVEL in the large surge tank, with 15 PSI cap, is LOW, then FILL the large surge tank to COLD on sight glass (MAX FILL RATE 11.2 L/min (3 gal/min), and ADD 0.95 L (1 qt) above it. Resume normal operation.

NOTE 4: See your GRT9165 *Service Manual* for specified coolant fill instructions.

NOTE 5: See your GRT9165 *Service Manual* for information about Liquid Cooling Conditioner (LCC) levels.

NOTE 6: The Coolant Strainer should be CLEANED after the first 100 hours of service, and then REPLACED at 2000 hours or 1 year of service thereafter, whichever interval comes first.

NOTE 7: Engine Oil Fill is located on top of the Engine Crankcase. Engine Oil Dipstick is located on the right side nearby the Engine Oil Fill. Engine Oil Filter is located on lower inside left side of the frame adjacent to the torque converter.



TOP VIEW OF CARRIER

FIGURE 9-1

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Drive Train (Continued)						
5a	Transmission and Torque Converter Locations	Figure 9-2	J	44.5 L (11.75 gal)	Every 10 hours/daily	CHECK fluid level **See NOTE 8.** **See NOTE 9.** **See NOTE 10.** FILL transmission sump to FULL on DIPSTICK **See NOTE 12.**
					PERFORM after first 50 hours of service, and **REPEAT** after another 50 hours for a total of 100 hours of service	DRAIN transmission sump **See NOTE 11.** REPLACE transmission and torque converter filter **See NOTE 11.** CLEAN magnetic drain plug INSTALL magnetic plug in drain port FILL transmission sump to FULL on DIPSTICK
					Then every 1000 hours, or 6 months, thereafter, whichever interval comes first	DRAIN transmission sump **See NOTE 11.** REPLACE transmission and torque converter filter **See NOTE 11.** FILL transmission sump to FULL on DIPSTICK **See NOTE 12.**

NOTE 8: Check Transmission Fluid level using the transmission oil dipstick located on the side of carrier adjacent to the hydraulic tank. Check fluid level with boom fully retracted and lowered, and all outrigger cylinders retracted.

NOTE 9: Only check the fluid level when transmission is at operating temperature.

NOTE 10: Level should be checked with engine running at 850 rpm idle and torque converter fluid temp at 65°C to 90°C (150°F to 200°F). To bring fluid temperature to this range, it is necessary to work the crane or stall the converter.

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application

CAUTION

Possible Equipment Damage!

Do not operate torque converter at stall condition for longer than 30 seconds at one time.

Shift to neutral for 15 seconds, and repeat procedure until desired fluid temperature is reached.

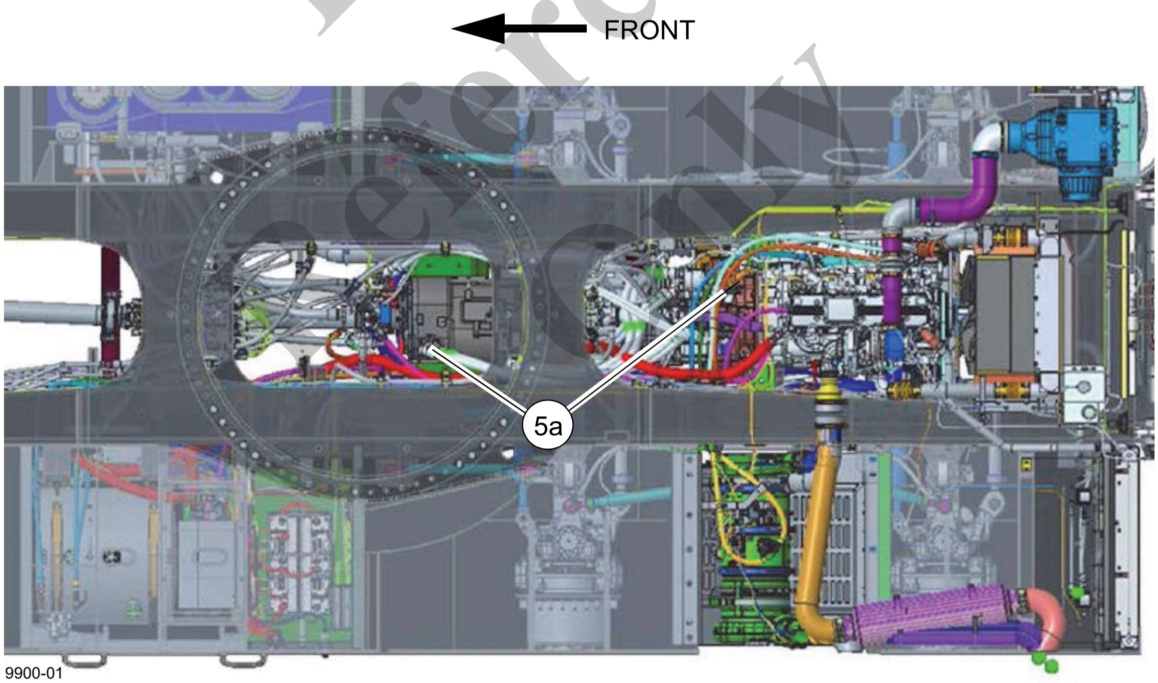
Excessive fluid temperature [120°C (250°F) maximum] will damage transmission clutches, transmission fluid, torque converter, and seals.

Failure to follow this instruction may cause damage to equipment.

NOTE 11: Drain Transmission Fluid at a temperature of 65°C to 90°C (150°F to 200°F). Clean magnetic drain plug when changing lubricant. Transmission and Torque Converter filter is located on the inside left side of the frame behind the battery box.

NOTE 12: Follow these specified transmission fluid fill instructions:

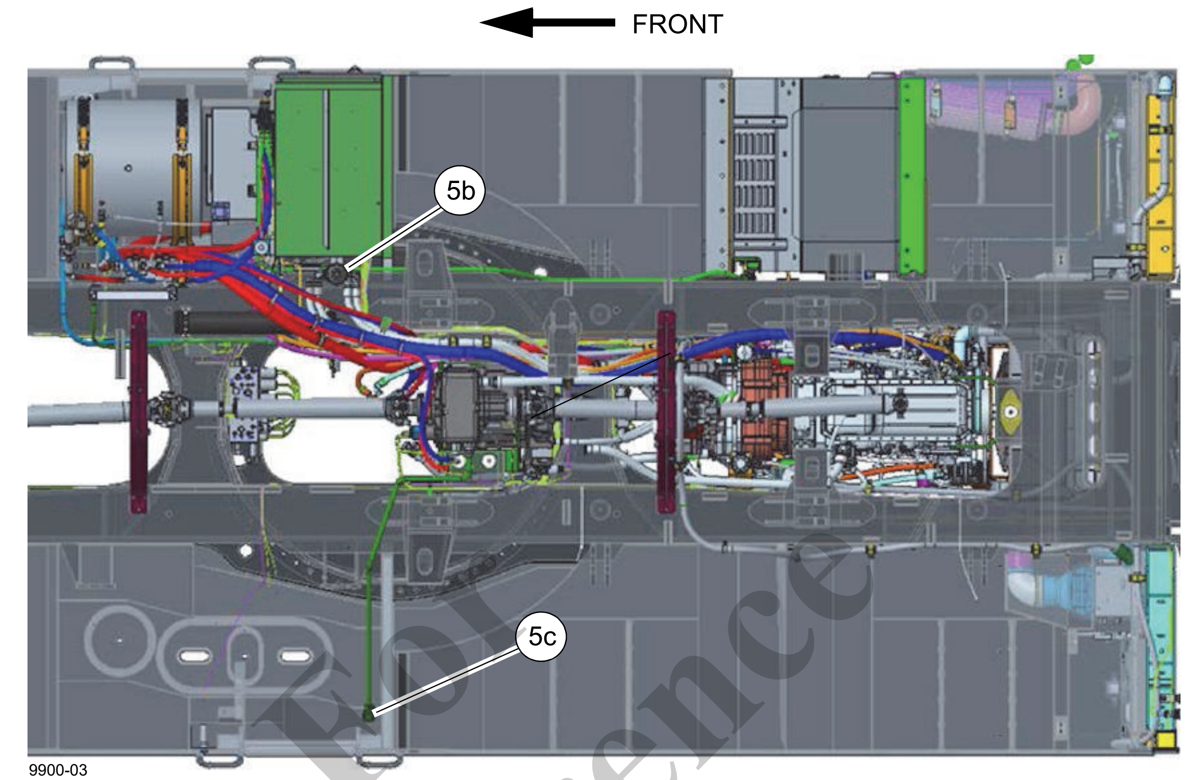
- **a.** Fill to FULL on DIPSTICK. Dipstick is located on the side of the carrier, adjacent to the hydraulic tank.
- **b.** Run engine at 850 rpm to prime torque converter and lines.
- **c.** Check fluid level with engine running at 850 rpm and torque converter fluid at 65°C to 90°C (150°F to 200°F).
- **d.** Add transmission fluid, as necessary. FILL to FULL on DIPSTICK.



TOP VIEW OF CARRIER

FIGURE 9-2

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Drive Train (Continued)						
5b	Transmission and Torque Converter Filter	Figure 9-3	—	—	**PERFORM** after first 50 hours of service, and	REPLACE transmission and torque converter filter **See NOTE 11.**
					REPEAT after another 50 hours for a total of 100 hours of service	REPLACE transmission and torque converter filter
					THEN every 1000 hours, or 6 months, thereafter whichever interval comes first	REPLACE transmission and torque converter filter
5c	Transmission Fluid FILL and DIPSTICK	Figure 9-3	J	44.5 L (11.75 gal)	As necessary, in DRAIN and FILL routines	FILL transmission sump to FULL on DIPSTICK **See NOTE 13.**
NOTE 13: The Transmission Fluid FILL and DIPSTICK is in a remote location for ease of servicing the transmission.						



BOTTOM VIEW OF CARRIER

FIGURE 9-3

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Drive Train (Continued)						
6	Fuel Filter/ Water Separator (showing Side View)	Figure 9-4	—	—	Every 10 hours/daily	DRAIN water trap
7	Diesel Exhaust Fluid (DEF) Tank	Figure 9-4	K	37.9 L (10 gal)	Every 10 hours/daily	CHECK DEF level and FILL Indicator in cab comes on when DEF level is low **See NOTE 14.**
	DEF Tank Filter	Figure 9-4	—	—	Every 2000 hours, or 1 year, whichever interval comes first	CHECK DEF tank filter
NOTE 14: The Diesel Exhaust Fluid (DEF) Level Indicator in the Crane Vitals Area of the Operator Display Module (ODM) comes on YELLOW when the DEF tank is 5%–10% FULL, and RED when the tank is <5% FULL.						

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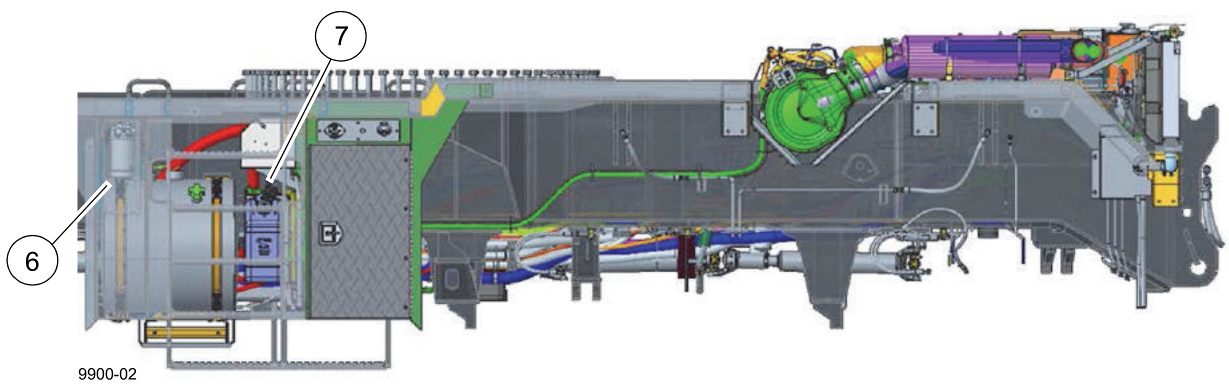
FRONT



SIDE VIEW OF CARRIER

FIGURE 9-4

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Drive Train (Continued)						
8	DEF Supply Module Filter	Figure 9-5	—	—	Every 4500 hours of service, or 3 years, whichever interval comes first	CHECK DEF Supply Module filter
9	Engine Oil Filter	Figure 9-5	—	—	Every 500 hours	REPLACE engine oil filter **See NOTE 15.**
10	Driveline – Slip Joints	Figure 9-5	A	Until grease extrudes	Every 500 hours of service, or 3 months, whichever interval comes first	LUBRICATE 3 grease fittings **See NOTE 17.**
11	Fuel Filter	Figure 9-5	—	—	Every 500 hours of service, or 6 months, whichever interval comes first	REPLACE fuel filter **See NOTE 16.**

NOTE 15: The Engine Oil Filter is located on the lower inside left side of the frame adjacent to the torque converter.

NOTE 16: The Fuel Filter is located on the lower inside right side of the frame adjacent to the torque converter.

CAUTION

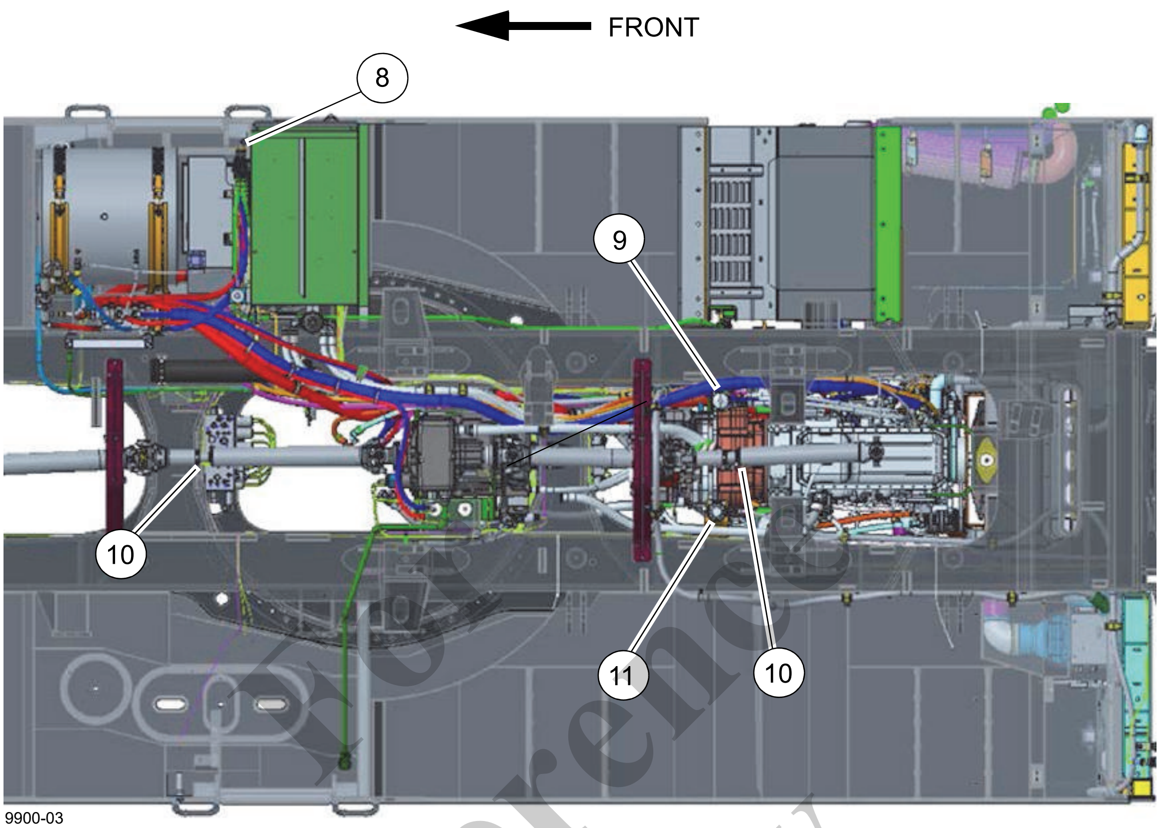
Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of this *Operator Manual*. See also *Aftertreatment Diesel Exhaust Fluid (DEF)*, page 7-16 for maintenance and lubrication instructions.

Use of non-approved lubricant may damage components and/or invalidate published lubricant intervals.

Failure to follow this instruction may cause damage to equipment.

NOTE 17: **DO NOT USE non semi-synthetic lubricant.** Use of non-approved lubricant may damage components.

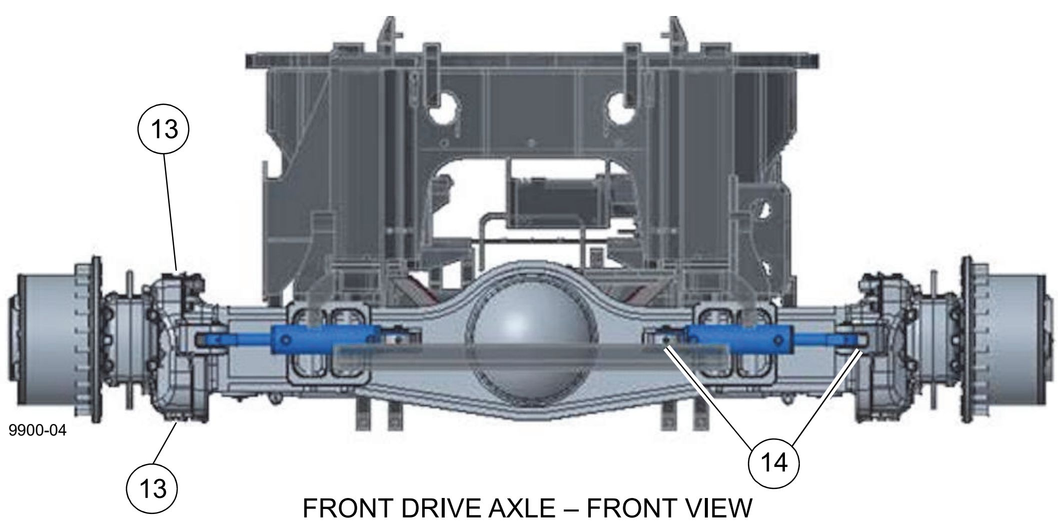


BOTTOM VIEW OF CARRIER

FIGURE 9-5

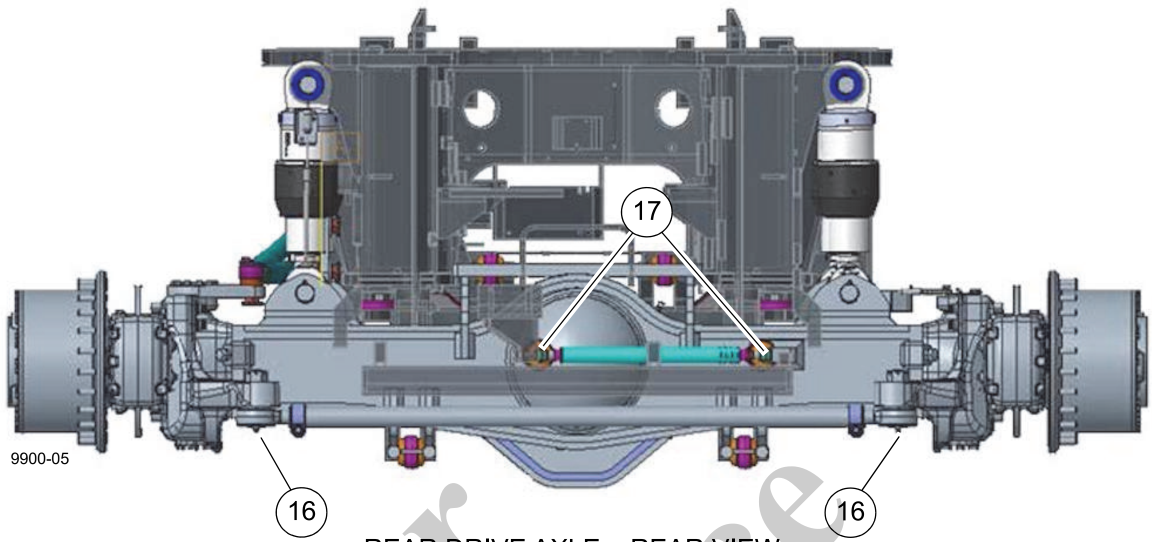
Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Steering and Suspension						
13	Upper and Lower King Pins **See NOTE 18.**	Figure 9-6	A	Until grease extrudes	Every 500 hours, or 3 months, whichever interval comes first	LUBRICATE 4 grease fittings per axle, 3 axles 12 service points
14	Steering Cylinder Pivot Pins **See NOTE 18.**	Figure 9-6	A	Until grease extrudes	Every 500 hours, or 3 months, whichever interval comes first	LUBRICATE 4 grease fittings per axle, 3 axles 12 service points
16	Tie Rod Pivots **See NOTE 18.**	Figure 9-7	A	Until grease extrudes	Every 500 hours, or 3 months, whichever interval comes first	LUBRICATE 2 grease fittings per axle, 3 axles 6 service points
17	Panhard Rod Pivots **See NOTE 18.**	Figure 9-7	A	Until grease extrudes	Every 500 hours, or 3 months, whichever interval comes first	LUBRICATE 2 grease fittings per rod pivot, 2 axles 1 rod pivot Axle 2, 1 rod pivot Axle 3 4 service points
18	Drag Link Pivots **See NOTE 18.**	Figure 9-8	A	Until grease extrudes	Every 500 hours, or 3 months, whichever interval comes first	LUBRICATE 2 grease fittings per drag link, 2 drag links 4 service points
19	Trailing Rod Pivots **See NOTE 18.**	Figure 9-8	A	Until grease extrudes	Every 500 hours, or 3 months, whichever interval comes first	LUBRICATE 2 grease fittings per rod pivot, 2 axles 4 rod pivots Axle 2, 4 rod pivots Axle 3 16 service points

NOTE 18: Use grease fittings provided.



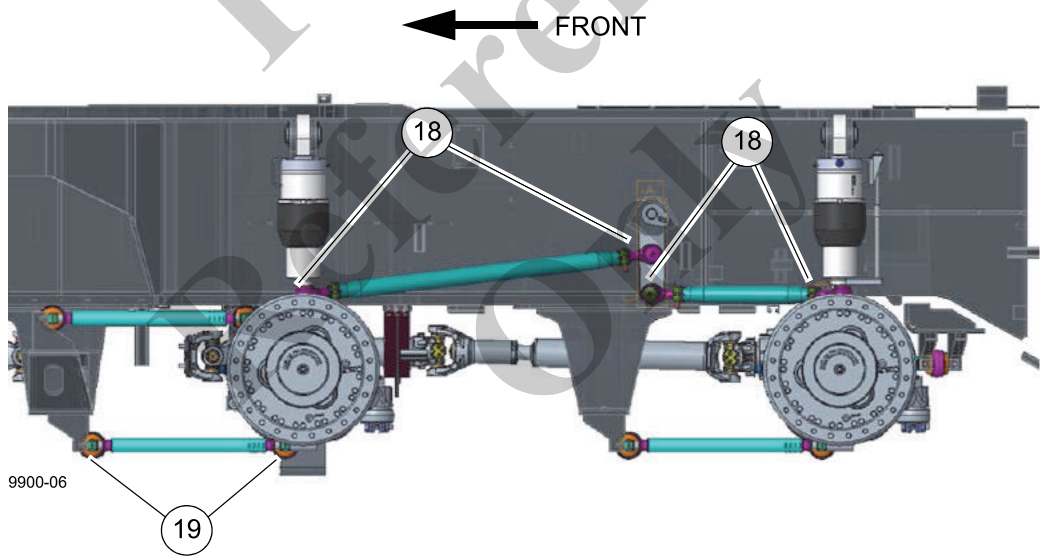
FRONT DRIVE AXLE – FRONT VIEW

FIGURE 9-6



REAR DRIVE AXLE – REAR VIEW

FIGURE 9-7



REAR DRIVE AXLE – SIDE VIEW

FIGURE 9-8

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Axle Lubrication						
20	Differentials	Figure 9-9	B	44.8 L (11.8 gal) ea **NOTE 21.** **NOTE 22.**	Every 250 hours, or 1 month, whichever interval comes first	CHECK and FILL 2 service points
					Every 3000 hours, or 2 years, whichever interval comes first	DRAIN and FILL 2 service points CLEAN magnetic drain plug INSTALL magnetic plug in drain port
21	Planetary Hubs & Wheel Bearings	Figure 9-10	B	9.8 L (10.4 qt) ea Wheel End **NOTE 21.** **NOTE 22.**	Every 250 hours, or 1 month, whichever interval comes first	CHECK and FILL 6 service points **See NOTE 19.**
	Side View, Planetary DRAIN and FILL ports	Figure 9-11			Every 3000 hours, or 2 years, whichever interval comes first	DRAIN and FILL 6 service points **See NOTE 19.** **See NOTE 20.**

NOTE 19: Planetary Hubs and Wheel Bearings must be filled to oil fill level indicated on axle hub. To provide sufficient lubrication, final fluid level MUST BE LEVEL with the filler plug hole at the Wheel End, with fluid even slightly dripping from the hole. CLEAN magnetic plug, then INSTALL magnetic plug in drain port.

NOTE 20: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard bearing lubricant must be fully purged and replaced with Cold Weather lubricant meeting Grove U.S. L.L.C. specifications as shown in Table 9-1*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your GRT9165 *Service Manual* for maintenance and lubrication instructions.

NOTE 21: **If the makeup amount of fluid is substantially more than 0.23 L (0.5 pt)**, CHECK for leaks.

CAUTION

Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of this *Operator Manual*. See also *Undercarriage*, page 8-1 for maintenance and lubrication instructions.

Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals.

Failure to follow this instruction may cause damage to equipment.

NOTE 22: **DO NOT USE non semi-synthetic lubricant.** Use of non-approved lubricant may damage components.

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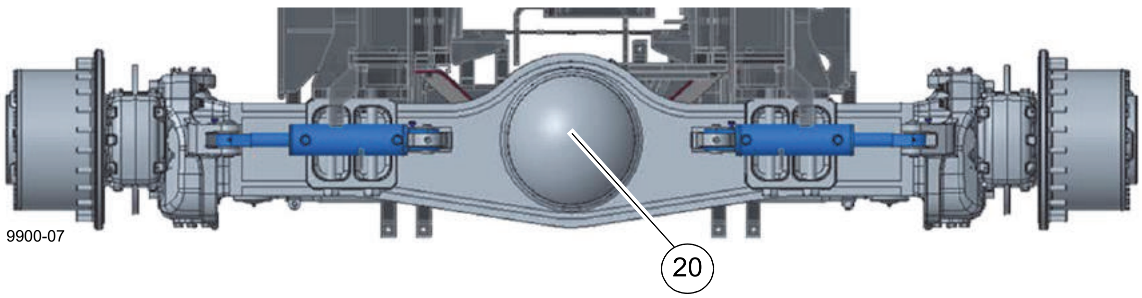
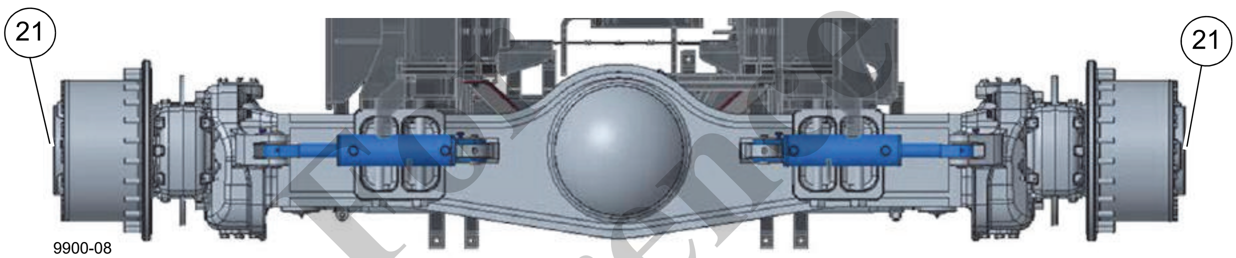


FRONT DRIVE AXLE – FRONT VIEW – DIFFERENTIAL

FIGURE 9-9

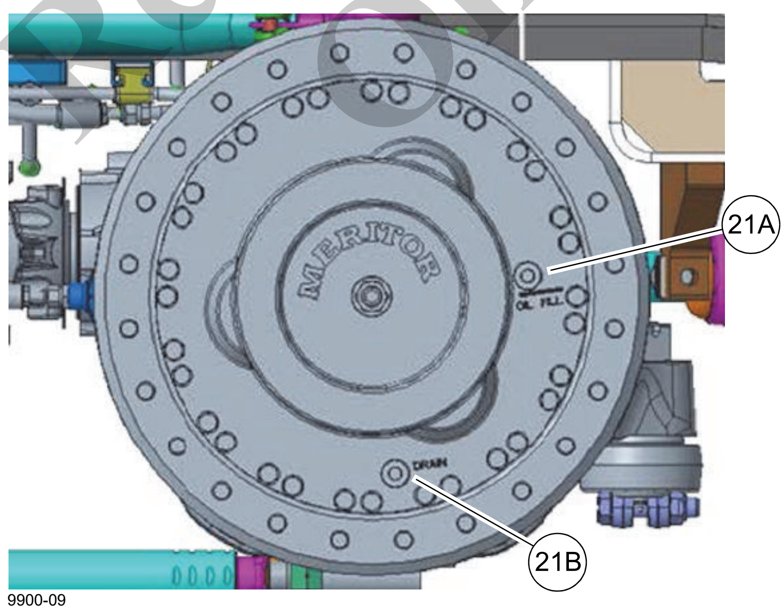


FRONT DRIVE AXLE – FRONT VIEW – PLANETARY HUBS & WHEEL BEARINGS

FIGURE 9-10

LEGEND

21A - OIL FILL
21B - OIL DRAIN



SIDE VIEW – AXLE HUB – PLANETARY DRAIN AND FILL PORTS

FIGURE 9-11

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Superstructure Lubrication						
22	Swing Drive Bearing	Figure 9-12	A	ROTATE the S/S 90° then grease again REPEAT until the S/S has made one full rotation	Every 500 hours, or 6 months, whichever interval comes first	LUBRICATE 4 grease fittings at front of superstructure (S/S) 4 service points **See NOTE 23.** **See NOTE 24.** **See NOTE 25.**

NOTE 23: Apply grease to four (4) fittings at front of superstructure. Then rotate superstructure 90° and apply grease to fittings once more. Repeat rotating the superstructure in 90° increments and applying grease to the fittings until the entire superstructure has made a full rotation.

NOTE 24: The swing drive bearing in this crane is supplied with *Cold Weather* (arctic) bearing grease capable of ambient temperatures between -40°C and +49°C (-40°F to +120°F), If operating the crane in regions expecting sustained winter/cold season temperatures below 15°F, top off bearing grease using **Table 9-2**, *Cold Weather Lubricants in Arctic Conditions [Down to -29°C (-20°F)]*. If temperatures below -9°C (15°F) are rare and intermittent, then greases from **Table 9-1**, *Standard Lubricants [Down to -9°C (+15°F)],* are acceptable.

CAUTION

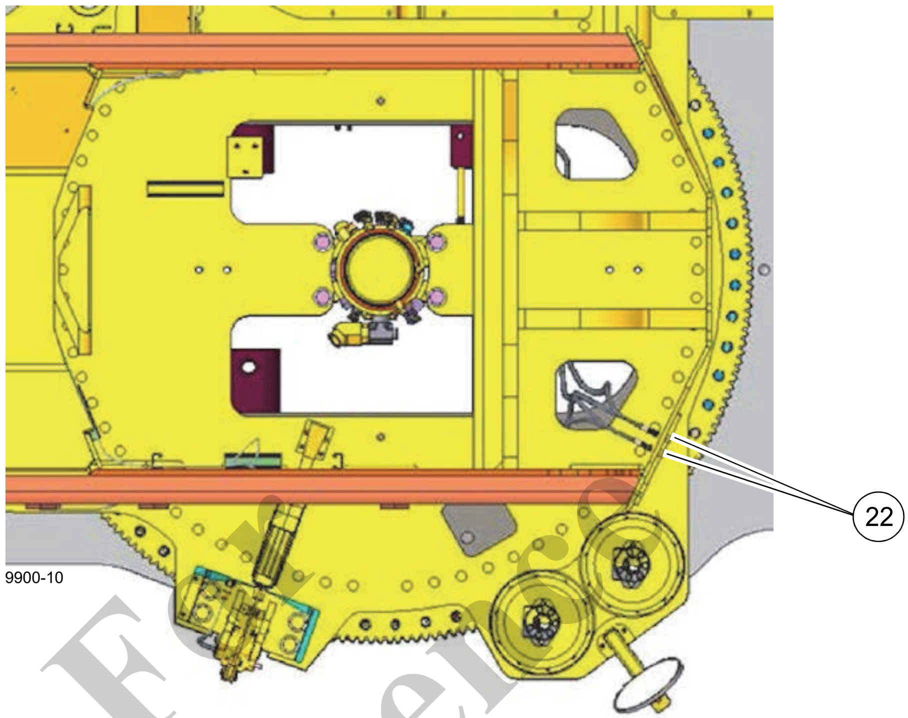
Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of this *Operator Manual*. See also *Swing System*, page 6-1 for maintenance and lubrication instructions.

Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals.

Failure to follow this instruction may cause damage to equipment.

NOTE 25: **DO NOT USE non semi-synthetic lubricant**. Use of non-approved lubricant may damage components.



TOP VIEW – SUPERSTRUCTURE

FIGURE 9-12

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Superstructure Lubrication						
23	Swing Drive Gearbox **See NOTE 29.** **See NOTE 30.**	Figure 9-13	B	4 L (4.23 qt) each gearbox	Every 50 hours of service	CHECK oil level FILL swing drive gearbox to LEVEL on DIPSTICK (23a) 2 service points **See NOTE 26.**
					Every 1000 hours, or 12 months of service, whichever interval comes first	DRAIN swing drive gearbox at (23b) FILL swing drive gearbox to LEVEL on DIPSTICK (23a) 2 service points **See NOTE 26.**
24	Swing Drive Gearbox – Brake Assembly **See NOTE 29.** **See NOTE 30.**	Figure 9-13	H	0.3 L (0.63 pt) each gearbox	After first 50 hours of service	REMOVE Breather at (24) and DRAIN swing drive brake assembly FILL swing drive brake assembly at (24) to top of elbow **See NOTE 27.**
					Then, every 50 hours of service, thereafter	CHECK oil level FILL swing drive brake assembly at (24) to top of elbow **See NOTE 27.**
					Every 1000 hours, or 6 months of service, whichever interval comes first	REMOVE Breather at (24) and DRAIN swing drive brake assembly FILL swing drive brake assembly at (24) to top of elbow **See NOTE 27.**
25	Swing Drive Gearbox – Drive Pinion **See NOTE 29.** **See NOTE 30.**	Figure 9-13	G	SPRAY ON	Every 500 hours, or 6 months of service, whichever interval comes first	SPRAY ON swing drive pinions COAT ALL TEETH
26	Boom Pivot Pins **See NOTE 29.** **See NOTE 30.**	Figure 9-13	L	Until grease extrudes	Every 300 hours, or 3 months of service, whichever interval comes first	LUBRICATE 2 grease fittings **See NOTE 28.**

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application

NOTE 26: CHECK fluid level in each of two (2) Swing Drive Gearboxes, and FILL to MAX LEVEL on DIPSTICK.

NOTE 27: CHECK level in each of two (2) Swing Drive Gearbox Brake Assemblies, and FILL to TOP of ELBOW.

NOTE 28: Perform same service for each of two (2) Boom Pivot Pins.

CAUTION

Possible Equipment Damage!

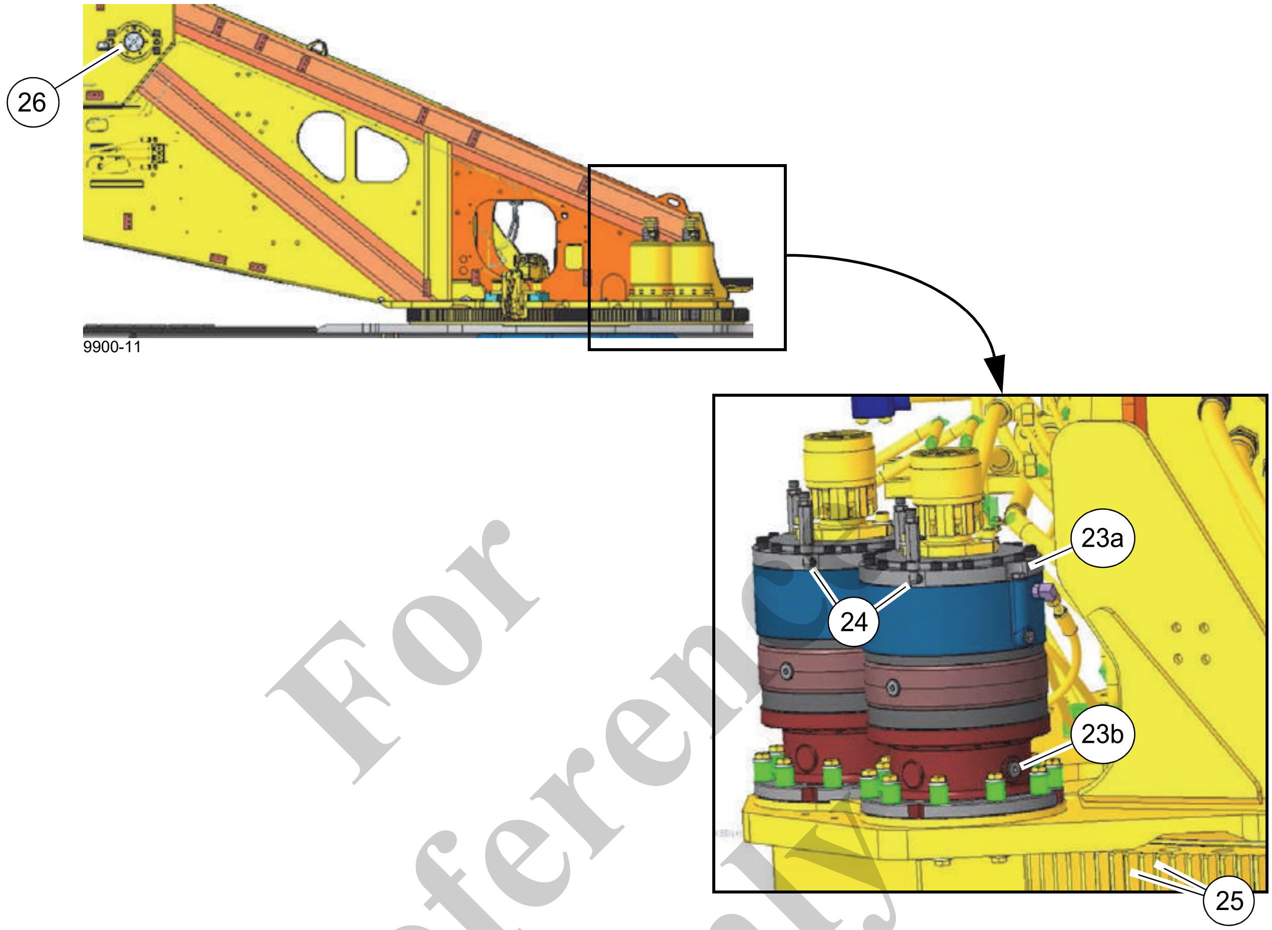
Use semi-synthetic or synthetic lubricants as listed in Section 6 of this *Operator Manual*. See the appropriate section in this *Service Manual* for maintenance and lubrication instructions.

Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals.

Failure to follow this instruction may cause damage to equipment.

NOTE 29: **DO NOT USE non semi-synthetic lubricant**. Use of non-approved lubricant may damage components.

NOTE 30: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard lubricant must be fully purged and replaced with Cold Weather lubricant meeting Grove U.S. L.L.C. specifications as shown in Table 9-4*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your *Service Manual* for maintenance and lubrication instructions.



RIGHT SIDE VIEW – SUPERSTRUCTURE

FIGURE 9-13

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Superstructure and Cab Tilt Lubrication						
27	Pillow Block Bearings **See NOTE 34.**	Figure 9-14	A	Until grease extrudes from entire bearing circumference	Every 500 hours, or 3 months of service, whichever interval comes first	LUBRICATE 2 grease fittings per pillow block bearing, 2 bearings 4 service points **See NOTE 31.** **See NOTE 33.**
28	Turntable Swivel Lock Pin	Figure 9-14	G	Spray on	Every 500 hours, or 6 months of service, whichever interval comes first	SPRAY ON 1 service point
29	Swing Angle Sensor	Figure 9-14	A	Apply grease to fitting **See NOTE 32**	Every 5000 hours, or 60 months of service, whichever interval comes first	REMOVE M16x1.5 plug from housing LUBRICATE fitting on bottom of swing angle sensor **See NOTE 32.** **See NOTE 33.** INSTALL M16x1.5 plug TORQUE plug to 25 N·m (18.45 lbf-ft)
30	Cab Tilt Cylinder Pivot Pins	Figure 9-14	A	Until grease extrudes	Every 500 hours, or 3 months of service, whichever interval comes first	LUBRICATE 2 service points **See NOTE 31.** **See NOTE 33.** **See NOTE 35.**
31	Cab Door Tracks and Rollers	Figure 9-15	Light Oil	—	Every 6 months	LUBRICATE 2 service points **See NOTE 36.**
32	Air Conditioner Condenser Filter	Figure 9-15	—	—	Every 1000 hours, or 6 months of service, whichever interval comes first	CHECK/CLEAN air conditioner condenser filter 1 service point

NOTE 31: Use grease fittings provided.

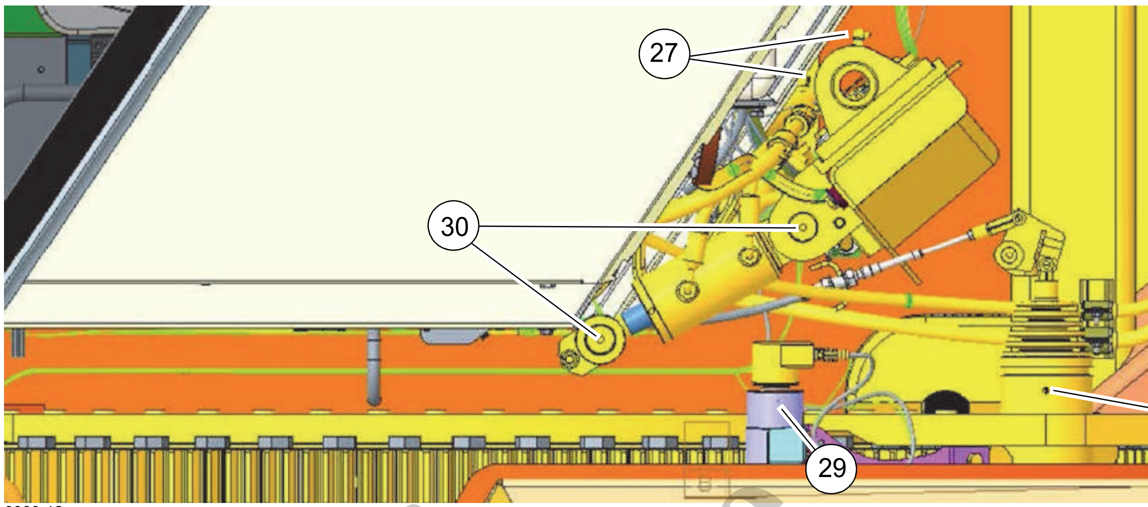
NOTE 32: Remove plug (M16x1.5) from housing. Apply grease to fitting on bottom of sensor. Install plug again and torque plug to 25 N·m (18.45 lb-ft).

NOTE 33: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard bearing grease must be fully purged and replaced with Cold Weather grease meeting Grove U.S. L.L.C. specifications as shown in Table 9-4*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your GRT9165 *Service Manual* for maintenance and lubrication instructions.

NOTE 34: Perform same service for each of two (2) Pillow Block Bearings.

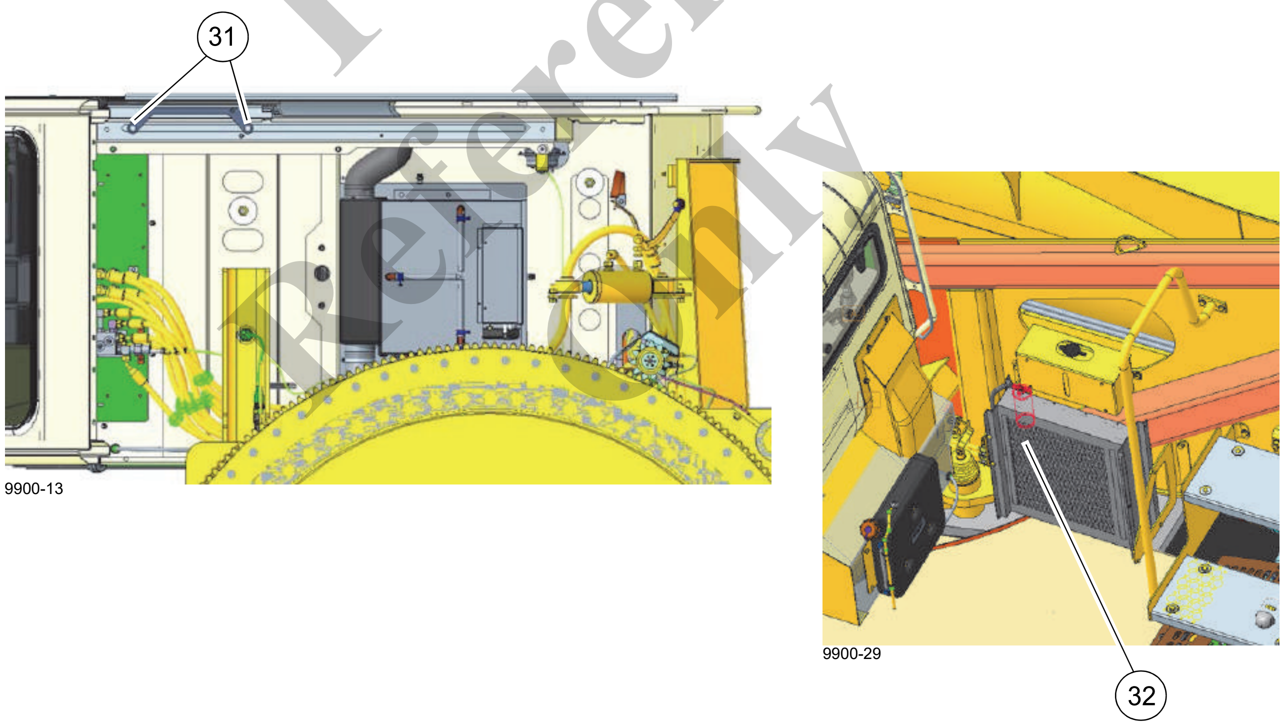
NOTE 35: Perform lubrication service for each grease fitting on two (2) Cab Tilt Cylinder Pivot Pins.

NOTE 36: Perform lubrication service for each of two (2) Cab Door Tracks and Rollers.



LEFT SIDE – SUPERSTRUCTURE

FIGURE 9-14



UNDERSIDE OPERATOR CAB – SUPERSTRUCTURE

FIGURE 9-15

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Outrigger Lubrication						
33	Jack Cylinder Support Tubes	Figure 9-16	L	Brush on I.D. of each cylinder support tube and wear bands	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON I.D. of 4 service points **See NOTE 37.** **See NOTE 38.** **See NOTE 42.**
34	Outrigger Box Pins **See NOTE 42.**	Figure 9-16	L	Brush on	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON 8 service points at assembly and/or tear down. **See NOTE 37.**
35	Outrigger Beams –Top Plates	Figure 9-16	L	Brush on	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON beam top plate as beam is fully extended. **See NOTE 37.** **See NOTE 39.** **See NOTE 40.** **See NOTE 41.** **See NOTE 42.**
	Outrigger Beams –Bump-outs	Figure 9-16	L	Brush on	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON 3 TOP, and 3 BOTTOM bump-outs on each side of outrigger beam 12 service points each beam. **See NOTE 37.** **See NOTE 39.** **See NOTE 40.** **See NOTE 41.** **See NOTE 42.**
36	Wear Pads	Figure 9-16	L	Brush on	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON 2 TOP wear pads (rectangular–rear), and 2 BOTTOM wear pads (circular–front) of ea outrigger beam 4 service points each beam **See NOTE 37.** **See NOTE 39.** **See NOTE 42.**
37	Jack Cylinder Barrels **See NOTE 42.**	Figure 9-16	L	Brush on	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON 4 service points **See NOTE 37.** **See NOTE 38.**

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
38	Extend Cylinder Supports **See NOTE 40. See NOTE 42.**	Figure 9-16	L	BRUSH ON	Every 50 hours, or 1 week of service, whichever interval comes first	BRUSH ON 8 service points **See NOTE 37. See NOTE 39.**

CAUTION
Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of this *Operator Manual.* See also *Boom*, page 4-1for maintenance and lubrication instructions. Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals. Failure to follow this instruction may cause damage to equipment.

NOTE 37: **DO NOT USE non semi-synthetic lubricant.** Use of non-approved lubricant may damage components.

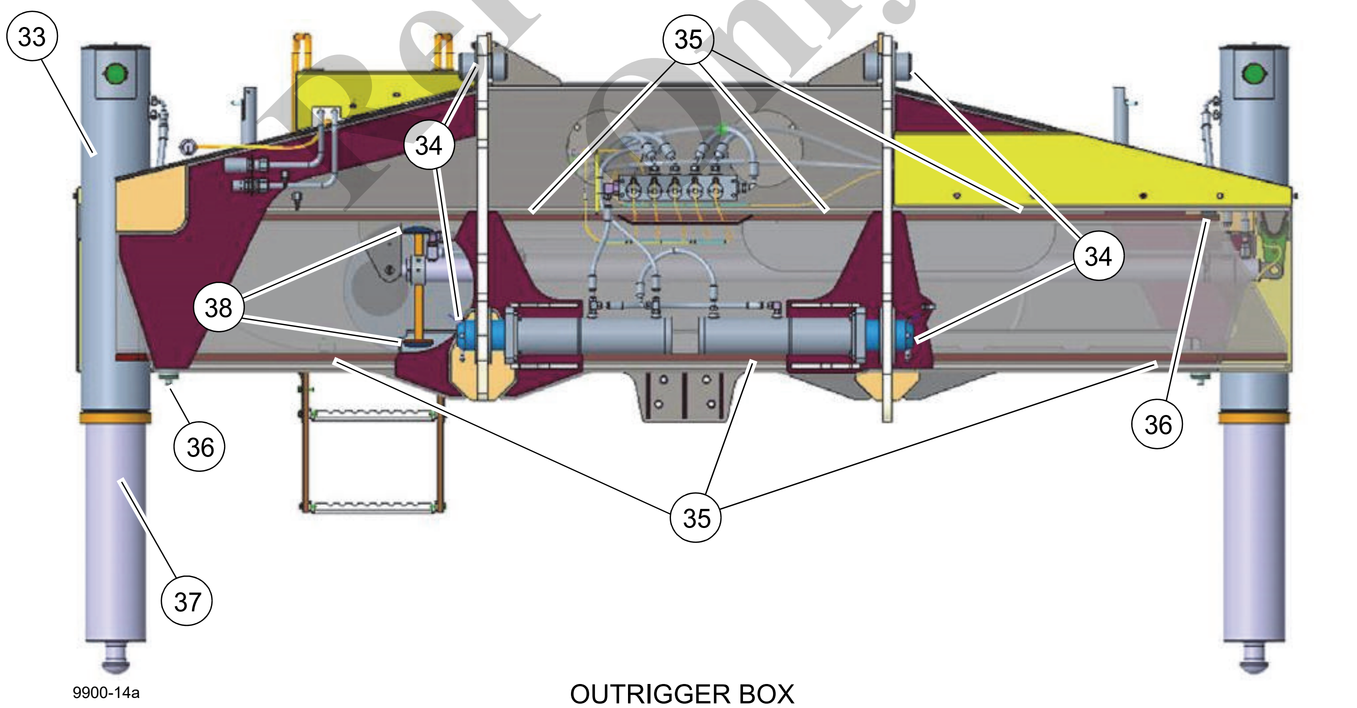
NOTE 38: Brush lubricant in I.D. of Jack Cylinder Support Tubes and Wear Bands before installing Jack Cylinders.

NOTE 39: Brush lubricant on TOP wear pads (rectangular–rear), and BOTTOM wear pads (circular–front) of Outrigger Beams and Extend Cylinder Supports.

NOTE 40: Brush lubricant on three (3) TOP and three (3) BOTTOM bump-outs found on each side of the outrigger beam where top and bottom plates contact the sides of the outrigger box. Lubricate 6 points each side, per outrigger, when the beam is fully extended.

NOTE 41: Perform same service for each of four (4) Outrigger Beams, for a total of 48 service points.

NOTE 42: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard grease must be fully purged and replaced with Cold Weather grease meeting Grove U.S. L.L.C. specifications as shown in Table 9-4*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your GRT9165 *Service Manual* for maintenance and lubrication instructions.



OUTRIGGER BOX

FIGURE 9-16

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Lift Cylinder Lubrication						
39a	Lower Lift Cylinder Pivot Pin	Figure 9-17	L	Until grease extrudes	Every 100 hours, or 1 month, whichever interval comes first	LUBRICATE 1 grease fitting, 1 service point **See NOTE 43. See NOTE 44.**
39b	Lower Lift Cylinder Pivot Pin	Figure 9-17	L	Until grease extrudes	Every 100 hours, or 1 month, whichever interval comes first	LUBRICATE 1 grease fitting, 1 service point **See NOTE 43. See NOTE 44.**

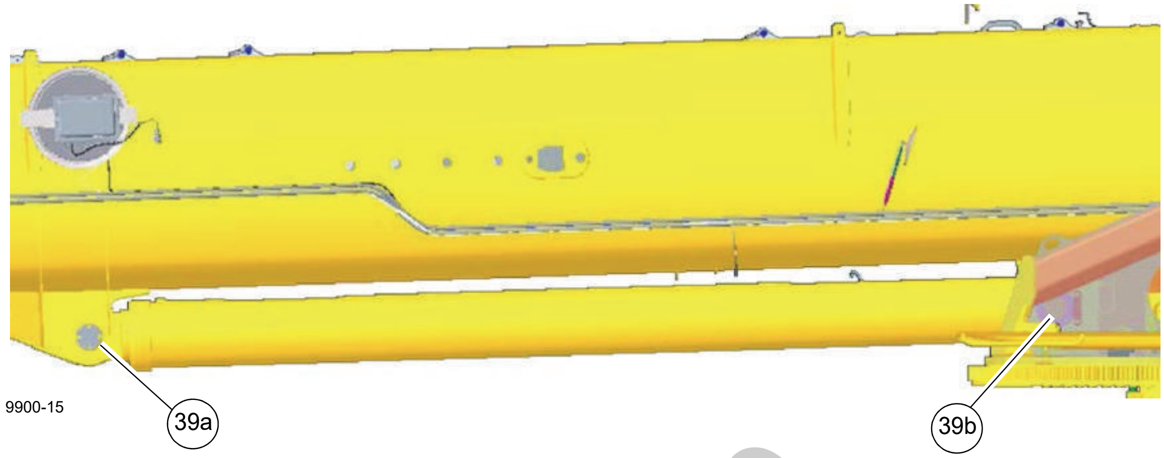
CAUTION

Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of the *Operator Manual*. See also *Undercarriage*, page 8-1 for maintenance and lubrication instructions. Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals. Failure to follow this instruction may cause damage to equipment.

NOTE 43: **DO NOT USE non semi-synthetic lubricant**. Use of non-approved lubricant may damage components.

NOTE 44: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard grease must be fully purged and replaced with Cold Weather grease meeting Grove U.S. L.L.C. specifications as shown in Table 9-4*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your GRT9165 *Service Manual* for specified maintenance and lubrication instructions.



LIFT CYLINDER

FIGURE 9-17

Boom Lubrication

READ FIRST! IMPORTANT CRANE SET-UP INFORMATION!

1. With crane set on a firm level surface and counterweight installed, fully extend the outriggers, and level the crane.
2. Center the boom over the front of the crane, engage the turntable swing lock pin, and disable the swing function.
3. Fully retract the boom and set boom angle to 70°.
4. Limit rigging to an overhaul ball or a hook block of no more than 2000 lb.
5. Program the RCL to Rigging Code 0001. Do Not Override the RCL with the Limit Bypass Switch to service the boom.
6. Use the Manual Telescope Mode in the ODM to extend and retract the Tele Sections in the sequences given.
7. To grease rear upper wear pads, front wear pads, and locking pins **on each Tele Section**, extend boom to the sequence given in the following chart.
8. Start with Tele Section 5 (Tele 5).

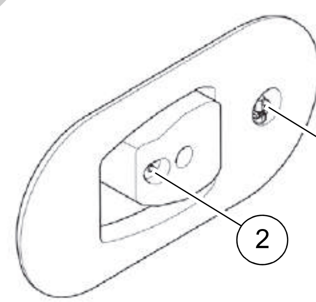
	To Grease Tele 5	To Grease Tele 4	To Grease Tele 3	To Grease Tele 2	To Grease Tele 1
Position Tele 1	0	0	0	55	100
Position Tele 2	0	0	55	100	0
Position Tele 3	0	50	100	0	0
Position Tele 4	50	100	0	0	0
Position Tele 5	100	0	0	0	0

If necessary, refer to the following detailed procedures to lubricate the boom in Manual Telescope Mode.

Telescope Section 5 (Tele 5)

1. Select the Manual Telescope Mode function icon in the Operator Display Module (ODM) to enter Manual Telescope Mode.
2. Make sure that the tele cylinder is locked to Tele 5.
3. Extend and lock Tele 5 to the 100% pinning location.
4. Extend and lock Tele 4 to the 50% pinning location.
5. 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 9-18), through the openings in Tele 4.
   c. Grease locking pins on both sides (2, Figure 9-18).

NOTE: To grease the rear upper wear pads of Tele 5 at the 50% or 89% pinning locations, extend and lock Tele 5 to these pinning locations and repeat **Step 5b** greasing.



9900-32

BOOM SERVICE LOCATIONS –
REAR UPPER WEAR PADS AND LOCKING PINS

FIGURE 9-18

6. 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.
7. When Tele 5 greasing is complete, retract and lock Tele 5 to the 0% pinning location.
8. 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 9-18), through the openings in Tele 3.
   c. Grease locking pins on both sides (2, Figure 9-18).

NOTE: To grease the rear upper wear pads of Tele 4 at the 50% or 89% 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 55% 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 9-18), through the openings in Tele 2.
   c. Grease locking pins on both sides (2, Figure 9-18).

NOTE: To grease the rear upper wear pads of Tele 3 at the 50% or 89% 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 55% 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 9-18), through the openings in Tele 1.
   c. Grease locking pins on both sides (2, Figure 9-18).

NOTE: To grease the rear upper wear pads of Tele 2 at the 55% or 89% 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 9-18), through the openings in the base section.
   c. Grease locking pins on both sides (2, Figure 9-18).

NOTE: To grease the rear upper wear pads of Tele 1 at the 55% or 89% 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.

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Boom Lubrication (Continued)						
41	Telescopic Slide Faces **See NOTE 45.**	Figure 9-19	N	BRUSH ON	Every 500 hours, or 6 months, whichever interval comes first	BRUSH ON front faces in a thin line **See NOTE 46.**

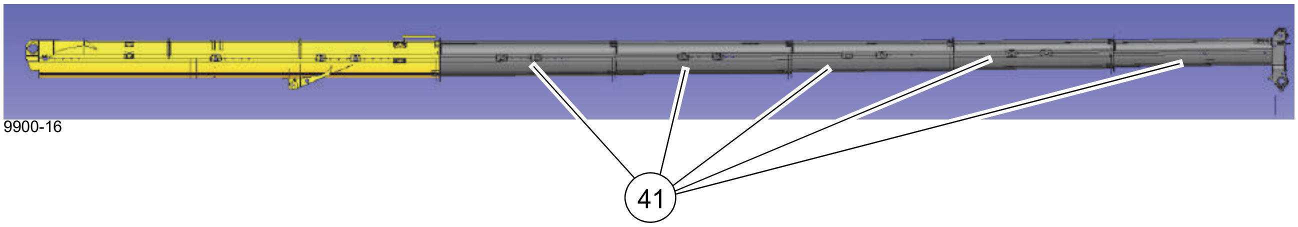
CAUTION

Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of the *Operator Manual.* See also *Boom*, page 4-1 for maintenance and lubrication instructions. Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals. Failure to follow this instruction may cause damage to equipment.

NOTE 45: **DO NOT USE non semi-synthetic lubricant**. Use of non-approved lubricant may damage components.

NOTE 46: Extend boom for **access to telescopic slide front faces** that contact wear pads inside the boom. Follow the boom Tele Section positioning and lubrication instruction given in the section titled *READ FIRST! IMPORTANT CRANE SET-UP INFORMATION!*, page 9-34. If the weather is very bad or operating conditions are poor, then more frequent intervals are necessary. Monitor the service points and adjust lubrication intervals, as necessary.



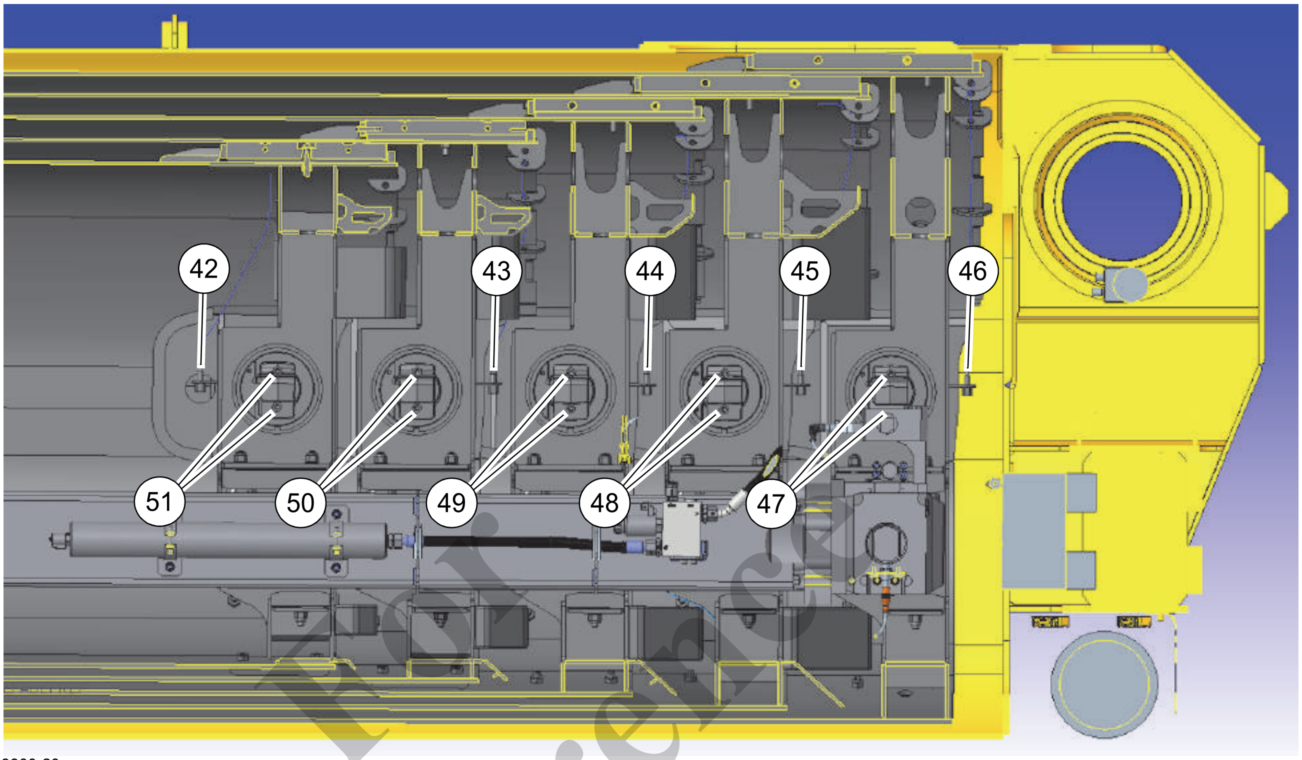
TELESCOPIC SECTION SLIDE FRONT FACES

FIGURE 9-19

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Boom Lubrication (Continued)						
42	Tele 5 Rear Upper Wear Pad	Figure 9-20	N	Only until resistance is felt	Every 500 hours, or 6 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 47.**
43	Tele 4 Rear Upper Wear Pad	Figure 9-20	N	Only until resistance is felt	Every 500 hours, or 6 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 47.**
44	Tele 3 Rear Upper Wear Pad	Figure 9-20	N	Only until resistance is felt	Every 500 hours, or 6 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 47.**
45	Tele 2 Rear Upper Wear Pad	Figure 9-20	N	Only until resistance is felt	Every 500 hours, or 6 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 47.**
46	Tele 1 Rear Upper Wear Pad	Figure 9-20	N	Only until resistance is felt	Every 500 hours, or 6 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 47.**
47	Tele 1 Lock Pin	Figure 9-20	P	1 or 2 pumps each fitting	Every 250 hours, or 3 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 48.**
48	Tele 2 Lock Pin	Figure 9-20	P	1 or 2 pumps each fitting	Every 250 hours, or 3 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 48.**
49	Tele 3 Lock Pin	Figure 9-20	P	1 or 2 pumps each fitting	Every 250 hours, or 3 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 48.**
50	Tele 4 Lock Pin	Figure 9-20	P	1 or 2 pumps each fitting	Every 250 hours, or 3 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 48.**
51	Tele 5 Lock Pin	Figure 9-20	P	1 or 2 pumps each fitting	Every 250 hours, or 3 months, whichever interval comes first	LUBRICATE 2 service points **See NOTE 48.**

NOTE 47: **DO NOT apply excessive pressure or force** when greasing wear pads. Applying excessive pressure or force can cause grease fitting to separate from wear pad. **Apply grease only until resistance is felt**.

NOTE 48: To grease rear upper-wear pads, front wear pads, and locking pins on each Tele Section, follow the boom Tele Section positioning and lubrication instruction given in the section titled *READ FIRST! IMPORTANT CRANE SET-UP INFORMATION!*, page 9-34. Start with Tele Section 5 (Tele 5). See also your GRT9165 *Service Manual* for detailed service interval and specified boom lubrication instructions.



LEFT SIDE BOOM – REAR UPPER WEAR PADS AND LOCK PINS

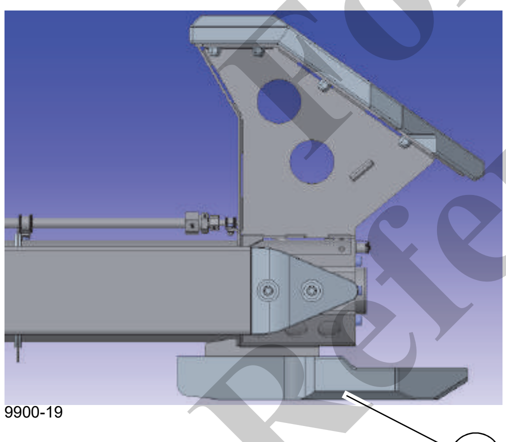
FIGURE 9-20

9

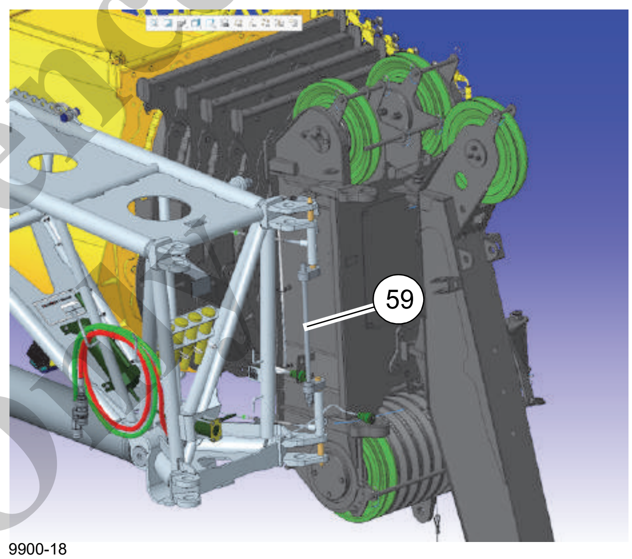
Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Boom Lubrication (Continued)						
52	Tele Cylinder Wear Pad	Figure 9-21	N	Coat areas that the wear pads move on	Every 500 hours, or 6 months of service, whichever interval comes first	BRUSH ON 5 service points
53	Boom Extension Pivot Pin	Figure 9-21	A	Until grease extrudes	Every 100 hours, or 1 month of service, whichever interval comes first	LUBRICATE 2 service points
54	Mast Sheave	Figure 9-21	—	—	Every 250 hours, or 3 months of service, whichever interval comes first	CHECK 1 service point CHECK sheave for dry points of operation CHECK sheave for grease leaks **See NOTE 49.**
55	Boom Nose Sheave	Figure 9-21	—	—	Every 250 hours, or 3 months of service, whichever interval comes first	CHECK 7 service points CHECK sheave for dry points of operation CHECK sheave for grease leaks **See NOTE 49.**
56	Auxiliary Boom Nose Sheave	Figure 9-21	—	—	Every 250 hours, or 3 months of service, whichever interval comes first	CHECK 1 service point CHECK sheave for dry points of operation CHECK sheave for grease leaks **See NOTE 49.**
57	Boom Extension Offset Cylinder Pivot Pin	Figure 9-21	A	Until grease extrudes	Every 100 hours, or 1 month of service, whichever interval comes first	LUBRICATE 2 service points

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Boom Lubrication (Continued)						
58	Boom Extension Sheaves	Figure 9-21	—	—	Every 250 hours, or 3 months of service, whichever interval comes first	CHECK 3 service points CHECK sheaves for dry points of operation CHECK sheaves for grease leaks **See NOTE 49.**
59	Boom Extension Screw	Figure 9-21	A	Brush on entire screw	BRUSH ON, as necessary	BRUSH ON 1 service point

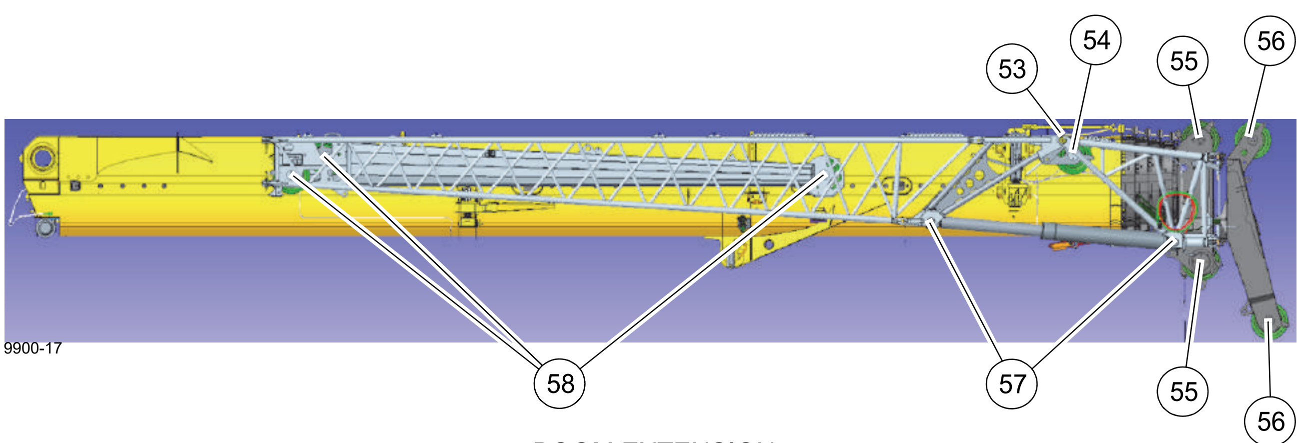
NOTE 49: Slowly turn the sheave, and **examine it for rough or dry points** of operation and **grease leaks.** If rough or dry points of operation are found, then **replace the sheave.** If grease leaks are found, then **replace the sheave.**



TELE CYLINDER WEAR PAD



BOOM EXTENSION SCREW



BOOM EXTENSION

FIGURE 9-21

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
Boom Lubrication (Continued)						
60	Hook Block Swivel Bearing	Figure 9-22	A	Until grease extrudes	Every 250 hours, or 3 months of service, whichever interval comes first	LUBRICATE 1 to 2 service points **See NOTE 50.** **See NOTE 51.** **See NOTE 53.**
61A	Hook Block Sheaves – 100MT	Figure 9-22	—	—	Every 250 hours, or 3 months of service, whichever interval comes first	CHECK sheaves on each of five (5) hook blocks listed. 1 service point ea as defined below: CHECK sheaves for dry points of operation CHECK sheaves for grease leaks **See NOTE 52.**
61B	Hook Block Sheaves – 120MT					
61C	Hook Block Sheaves – 26MT					
61D	Hook Block Sheaves – 45MT					
61E	Hook Block Sheaves – 75MT					
62	Swivel Rope	Figure 9-22	A	Until grease extrudes	Every 250 hours, or 3 months of service, whichever interval comes first	LUBRICATE 1 service point on each of three (3) items listed **See NOTE 50.** **See NOTE 51.** **See NOTE 53.**
63	Overhaul Weight					
64	Overhaul Ball					

CAUTION

Possible Equipment Damage!

Use semi-synthetic or synthetic lubricants as listed in Section 6 of the *Operator Manual.* See also *Boom*, page 4-1 for maintenance and lubrication instructions.

Use of non-approved, non semi-synthetic lubricant may damage components and/or invalidate published lubricant intervals.

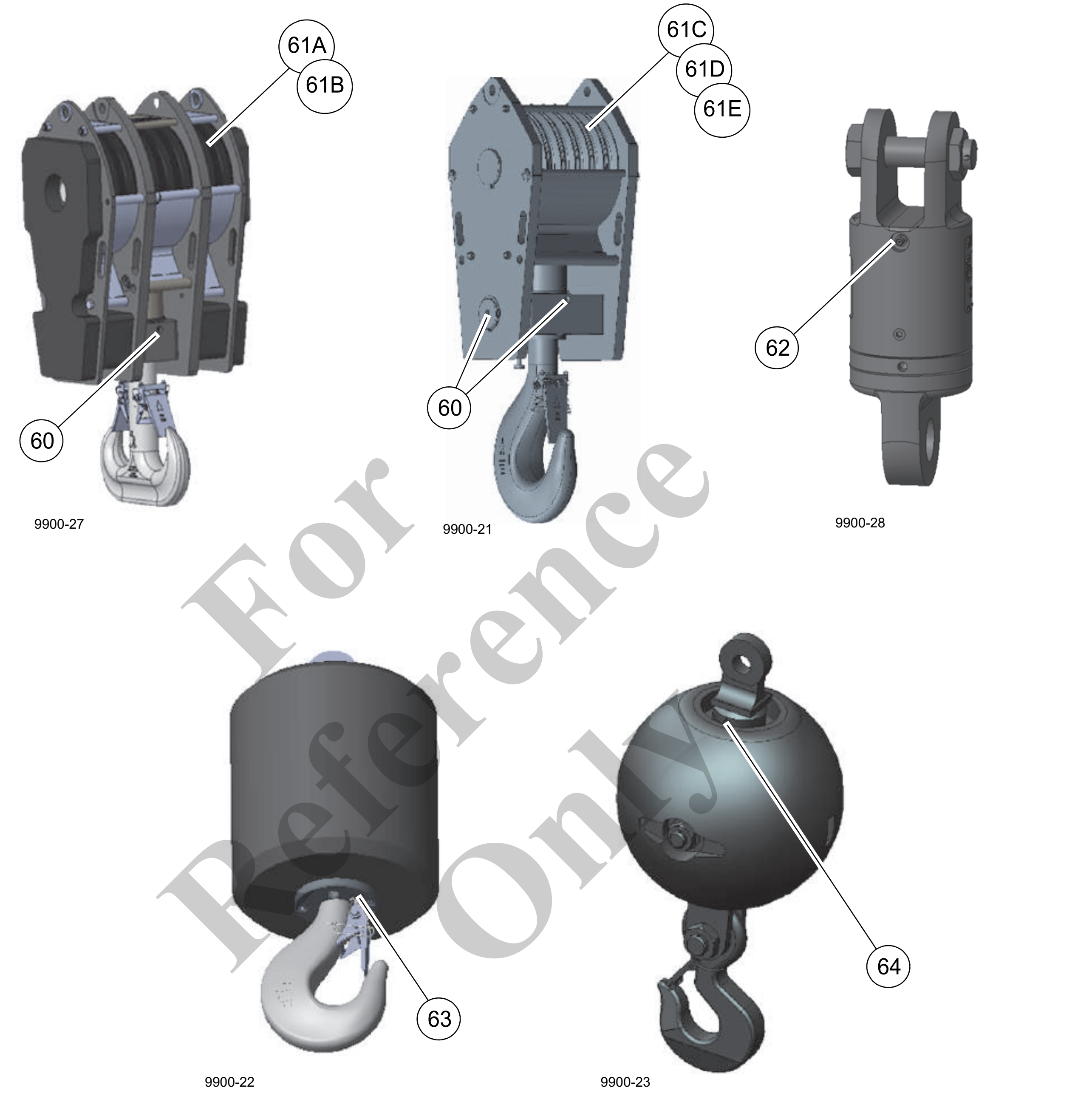
Failure to follow this instruction may cause damage to equipment.

NOTE 50: **DO NOT USE non semi-synthetic lubricant**. Use of non-approved lubricant may damage components.

NOTE 51: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard grease must be fully purged and replaced with Cold Weather grease meeting Grove U.S. L.L.C. specifications as shown in Table 9-4*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your GRT9165 *Service Manual* for maintenance and lubrication instructions.

NOTE 52: Slowly turn the sheave, and **examine it for rough or dry points** of operation and **grease leaks**. If rough or dry points of operation are found, then replace the sheave. If grease leaks are found, then replace the sheave.

NOTE 53: If the weather is very bad or operating conditions are poor, then more frequent intervals are necessary. Monitor the service points and adjust lubrication intervals, as necessary.



HOOK BLOCK and OVERHAUL BALLS

FIGURE 9-22

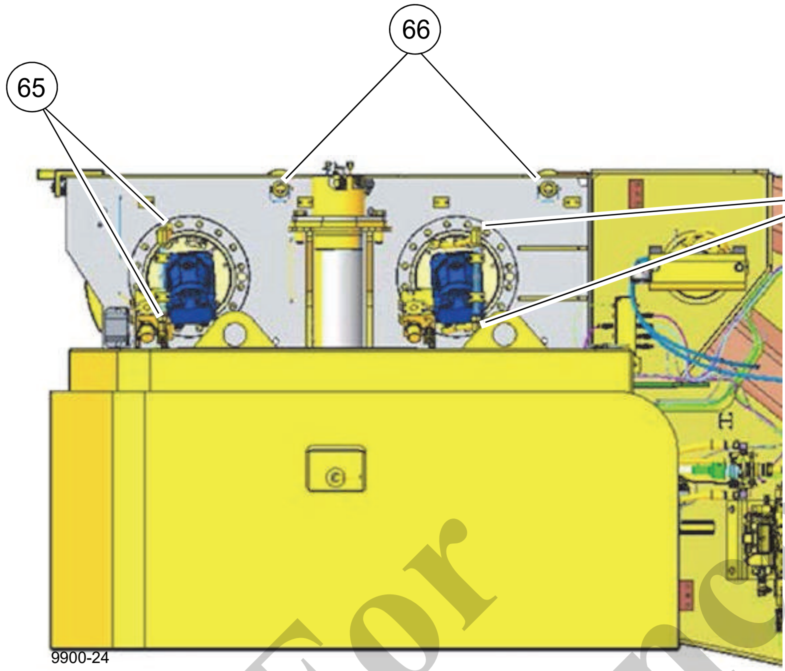
<table>
<tr><th>Item</th><th>Lube Point Description</th><th>Figure No.</th><th>Approved Lubricant</th><th>Approximate Capacity</th><th>Service Interval</th><th>Service Application</th></tr>
<tr><td colspan="7">Hoist Lubrication</td></tr>
<tr><td rowspan="5">65</td><td rowspan="5">Hoist Drums
(Main & Auxiliary)</td><td rowspan="5">Figure 9-23</td><td rowspan="5">H</td><td rowspan="5">4 L (1.05 gal)</td><td rowspan="2">Every 50 hours of service, or weekly, whichever interval comes first</td><td>CHECK oil level
2 service points
REMOVE vent or hose from top of the sight glass to FILL
FILL hoist drums to LEVEL visible in sight glass
2 service points
See NOTE 54.
See NOTE 55.
See NOTE 57.</td></tr>
<tr><td>CHECK and CLEAN breather as needed</td></tr>
<tr><td rowspan="3">Every 1000 hours, or 12 months of service, whichever interval comes first</td><td>REMOVE plug or hose from bottom of sight glass to DRAIN oil
DRAIN hoist drums
2 service points</td></tr>
<tr><td>FILL hoist drums to LEVEL visible in sight glass
See NOTE 54.
See NOTE 55.
See NOTE 57.</td></tr>
<tr><td>CHECK and CLEAN breather as needed</td></tr>
<tr><td>66</td><td>Hoist Rope Rollers</td><td>Figure 9-23</td><td>A</td><td>Brush on outer surface of roller</td><td>Every 250 hours, or 3 months of service, whichever interval comes first</td><td>BRUSH ON
2 service points
See NOTE 54.
See NOTE 56.</td></tr>
<tr><td>67</td><td>Hoist Bearings</td><td>Figure 9-23</td><td>A</td><td>Until grease extrudes from entire bearing circumference</td><td>Every 250 hours, or 3 months of service, whichever interval comes first</td><td>LUBRICATE
2 service points
See NOTE 54.
See NOTE 57.</td></tr>
</table>

NOTE 54: **DO NOT USE non semi-synthetic lubricant**. Use of non-approved lubricant may damage components.

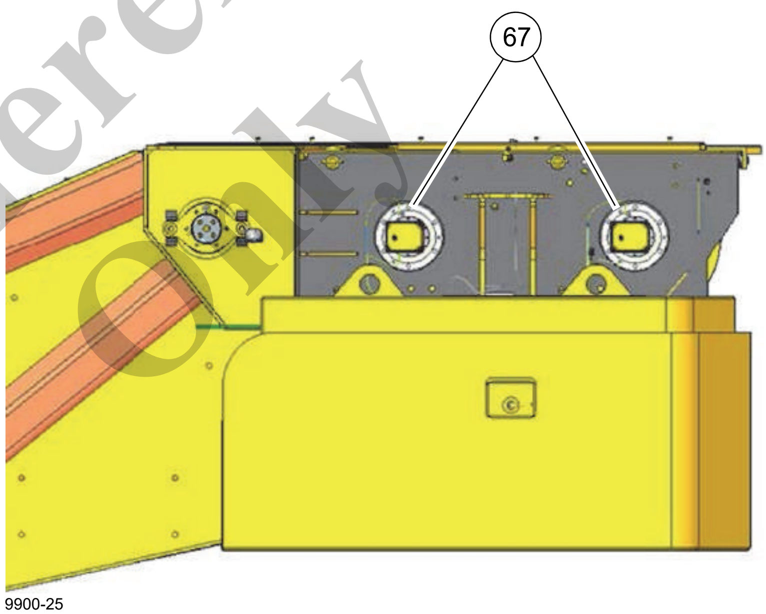
NOTE 55: Check oil level in hoist drum sight glass. Hoist oil level MUST be between the high and low marks on sight glass. If oil is not visible, hoist may be underfilled. If oil is escaping from the vent plug, hoist may be overfilled.

NOTE 56: If the weather is very bad or operating conditions are poor, then more frequent intervals are necessary. Monitor the service points and adjust lubrication intervals, as necessary.

NOTE 57: Before operating crane in cold weather (arctic) ambient temperatures below -9°C (+15°F), Standard bearing grease must be fully purged and replaced with Cold Weather bearing grease meeting Grove U.S. L.L.C. specifications as shown in Table 9-4*: Approved Lubricant Reference Table*, page 9-8 in this *Operator Manual*. See also your GRT9165 *Service Manual* for maintenance and lubrication instructions.



HOIST DRUM – RIGHT SIDE



HOIST DRUM – LEFT SIDE

HOIST DRUMS – (MAIN and AUXILIARY)

FIGURE 9-23

Item	Lube Point Description	Figure No.	Approved Lubricant	Lube Capacity	Lube Interval	Application
Hydraulics Lubrication						
68	Hydraulic Tank SIGHT GLASS	Figure 9-24	J	729 L (192.6 gal)	Every 10 hours of service, or daily, whichever interval comes first	CHECK oil level FILL hydraulic tank to LEVEL in SIGHT GLASS **See NOTE 58.** **See NOTE 61.**
69	Hydraulic Tank BREATHER				PERFORM SERVICE INSPECTION every 3 to 6 months	PERFORM SERVICE INSPECTION of oil, filters, and breathers **See NOTE 59.** **See NOTE 60.** **See NOTE 61.**
					SAMPLE hydraulic oil every 3 to 6 months	SAMPLE hydraulic oil
70	Hydraulic Filter	Figure 9-24	—	—	REPLACE hydraulic filter when restriction indicator gauge on the filter head shows red	REPLACE hydraulic filter element **See NOTE 59.** **See NOTE 61.**

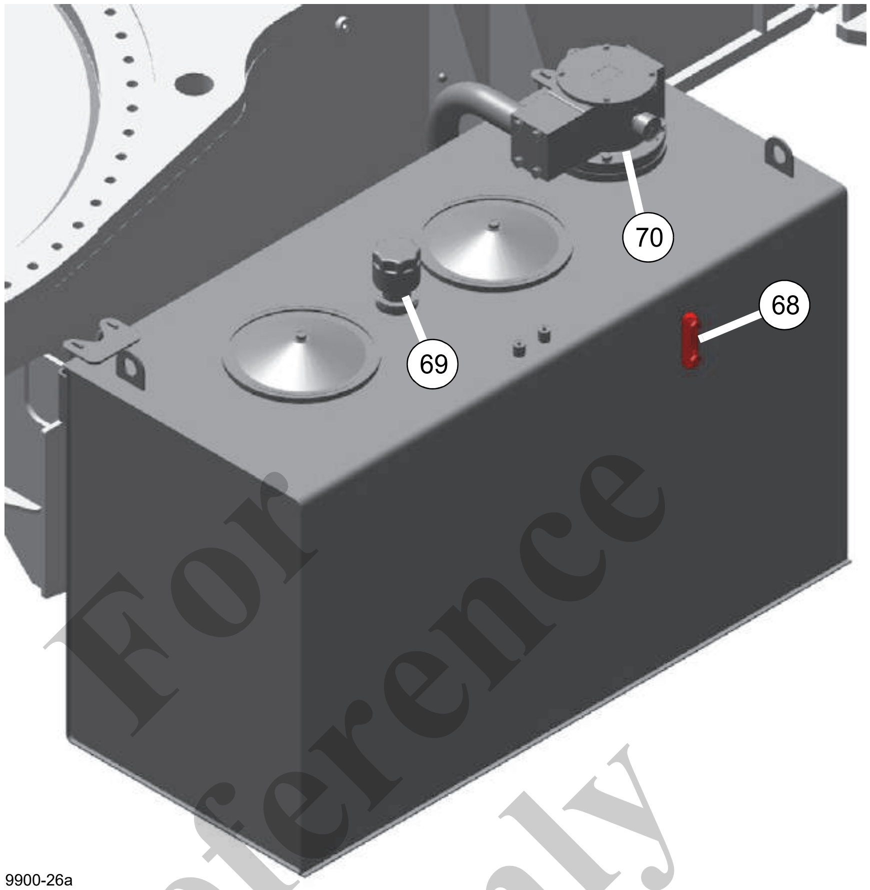
NOTE 58: Check Hydraulic oil level using sight glass on tank with boom fully retracted and lowered, and all outrigger cylinders retracted.

NOTE 59: REPLACE hydraulic filters at **first 50-hours of service** and **repeat after another 50-hours**, for a total of **100 hours of service**, thereafter, at normal intervals. **Hydraulic oil MUST BE at operating temperature** at hydraulic filter and tank inspection and service.

NOTE 60: Hydraulic oil should be drained at a temperature of 65°C to 90°C (150°F to 200°F).

NOTE 61: **Hydraulic oil SHALL MEET or EXCEED ISO 4406 class 17/14 cleanliness level** (reference SAE J1165).

- Working in harsh environmental conditions can dramatically affect the performance and condition of hydraulic oil, filters, and breathers. Therefore, specific intervals for servicing/changing hydraulic oil, filters, and hydraulic tank breathers cannot be set. Thus, it is imperative for the continued satisfactory performance of Grove cranes, that service inspections be performed on the basis of how and where each crane is used. Airborne and ingested contaminants can significantly reduce the life of oil, and condition of hydraulic oil filters and tank breathers.
- Under normal operating conditions, Grove recommends that **hydraulic oil**, **filters**, and **breathers** be serviced, and **hydraulic oil sampled** at least every 3 to 6 months. Service inspections should be for airborne or ingested particles and water that deteriorates and contaminates the hydraulic oil. Contaminated hydraulic oil appears “milky” or no longer has a transparent clear to amber color. The return filter by-pass indicator should be observed daily to determine if the contaminant content is high. If the filter by-pass indicator reaches the red zone or indicates a by-pass condition, the hydraulic oil must be sampled. Perform service to **make sure that the hydraulic oil tank breather does not restrict air flow IN, or air flow OUT of the reservoir**.
- FILL procedure for Hydraulic Tank operation below -9°C (+15°F):
  - **a.** DRAIN existing oil.
  - **b.** FILL tank with oil per 6829101559 and cycle all cylinders.
  - **c.** DRAIN oil.
  - **d.** FILL tank with oil per 6829101559.
- See also your GRT9165 *Service Manual* for further details on Hydraulic Oil Sampling Test. Should you have any questions, please contact your local authorized Grove distributor.



HYDRAULIC TANK

FIGURE 9-24

Item	Lube Point Description	Figure No.	Approved Lubricant	Approximate Capacity	Service Interval	Service Application
HVAC System						
80	HVAC Filter	—	—	—	Replace HVAC filter yearly. If used in dirty conditions, check filter monthly or as needed and replace if necessary.	HVAC filter is located behind access panel on bottom side of cab.

RUST PROTECTION

Protecting Cranes From Rusting

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 are treated with Carwell® T32 (CP-90) rust inhibitor. While a rust inhibitor cannot guarantee that a crane will never rust, this product helps protect against corrosion on Grove cranes.

Carwell® is a treatment, not a coating. It contains no silicones, solvents, chlorofluorocarbons (CFC), or anything that would be classified as hazardous under OSHA Regulation 29CRF 1910.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, and water-repelling/ water-displacing agents.

Special equipment is used to spray a light film on the entire undercarriage and various other areas of each new crane before shipment. When applied, the product has a red tint to allow applicators to view coverage. This red tint turns clear 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 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, owners of Grove cranes 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 crane surfaces that are easily seen have the biggest impact on appearance, particular attention should be given to the undercarriage to minimize harmful effects of corrosion.

Exercise special care and increase frequency of cleaning if 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 (for example, 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 undercarriage and wheel housings. Keeping these areas clean will decrease the rate of corrosion, and improve the ability to identify possible issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing near electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse 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 before washing. Do not use solvents or gasoline.
- Wash the crane only with soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow crane to dry thoroughly. You can increase the speed of evaporation by using compressed air to remove excess water.

NOTE: Polishing and waxing (using automotive-type wax) is recommended to maintain original paint finish.

Inspection and Repair

- Immediately following cleaning of the Grove crane, 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.
- Any area scratched through to bare metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends a qualified body repair technician prepare, prime, and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Grove crane must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

1. Sand to remove scratch. Feather outward from the mark to blend repair into the original surface. Apply body putty as necessary to hide the defect, then sand smooth.
2. Cover all bare metal with a primer compatible with the original paint finish, and allow to dry thoroughly.
3. Prepare surface before applying finish coat of paint.
4. Apply a finish coat using accepted blending techniques. Use of original paint colors is recommended to ensure 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 decrease the rate of corrosion, and enable you to do the repair later during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous. Only using a single coat of primer will allow air and water to penetrate the repair over time.

Application

Depending on the environment in which a crane is used and/or stored, initial factory application of Carwell® T32 (CP-90) should help inhibit corrosion for approximately 12 months.

It is recommended the treatment be periodically reapplied by the crane owner, after that time, to help continue protection 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, for example, repeat treatment in 6 to 9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24-hour period is needed for cure time before applying treatment.

NOTE: The crane must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. The crane should not have puddles or runs evident anywhere.
- To ensure proper coverage, product needs to be fogged on the crane.
- Use of pressure pots to apply treatment is recommended.
- Carwell® treatment is available in 16-ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After treatment application is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all crane access areas, as necessary.

Contact your local Grove distributor or Manitowoc Crane Care should you have any questions.

Areas of Application

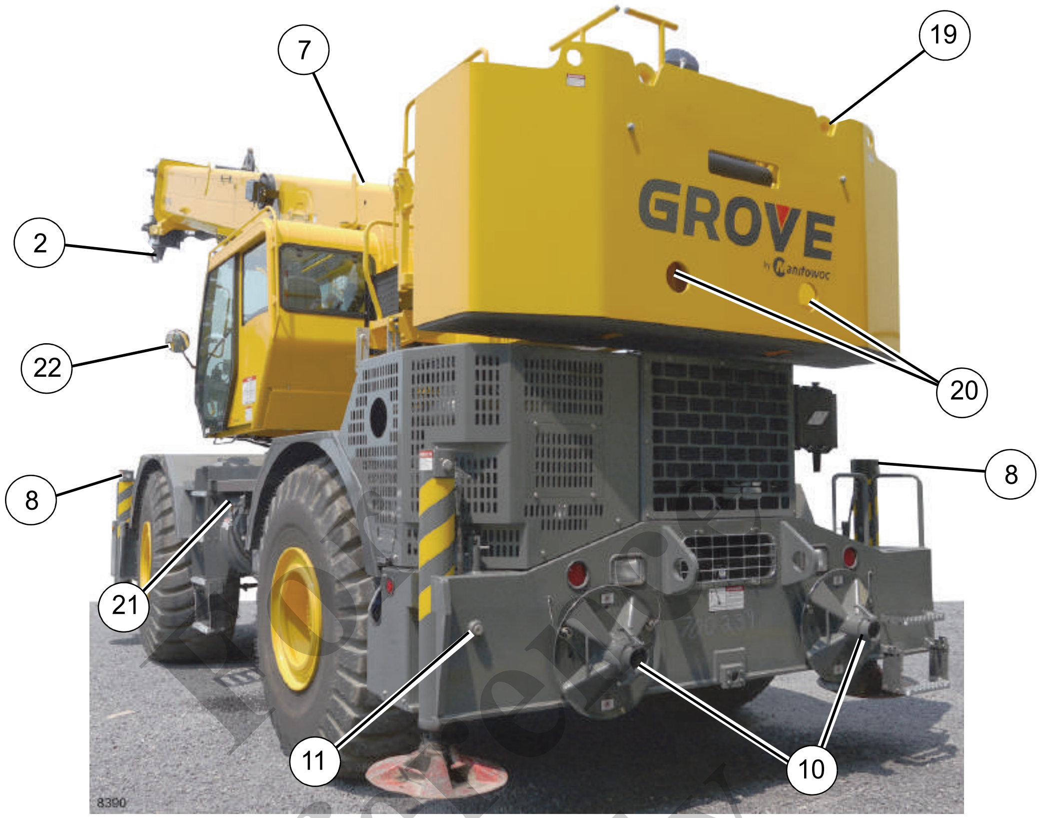
Refer to Figure 9-25 and Figure 9-26 for location of crane components that need periodic application of Carwell® T32 (CP-90) for continued protection against corrosion.

- Underside of crane will have full coverage of the rust inhibitor. These are the only areas that a full coat of rust inhibitor is acceptable on painted surfaces. These areas include; valves, hose end and fittings, swivel, pumps, axles, drive lines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose end and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners, and all bare metal surfaces.
- Boom applications areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, overhaul ball pins, hook block pins, and fasteners.
- All hardware, clips, pins, and hose connections that are not painted will have treatment applied.

7650-75

Picture may not be same model as your crane, it is for reference only.

Figure 9-25



Picture may not be same model as your crane, it is for reference only.

Figure 9-26

Table 9-1 Rust Inhibitor Application Locations

1	Boom Extension Pins, Clips	12	Entire underside of crane
2	Boom Nose Pins, Clips	13	Turntable Bearing Fasteners
3	Hook Block/Overhaul Ball	14	Powertrain Hardware Inside Compartment
4	Boom Extension Hanger Hardware	15	Valve Bank
5	Pivot Shaft	16	Hoist Hose Connections
6	Hose Connections Inside Turntable	17	Tension Spring
7	All Hardware, Clips, Pins, Hose Connections not painted Outrigger Pins, Clips	18	Wire Rope
8	Outrigger Hose Connections	19	Counterweight Mounting Hardware
9	Hook Block Tiedown Cable	20	Counterweight Pins
10	Outrigger Pins, Clips	21	Hose Connections
11	O/R Beam Wear Pad Adjustment Hardware	22	Mirror Mounting Hardware

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WORD INDEX

Numerics