Grove TMS500-2

Service Manual

9826

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

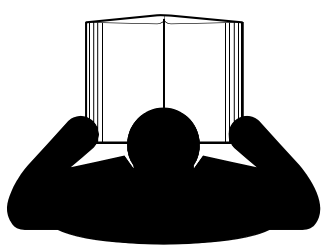
Operation of this equipment may create sparks that can start fires around dry vegetation. A spark arrestor may be required. The owner/operator should contact local fire agencies for laws or regulations relating to fire prevention requirements.

The original language of this publication is English.

GROVE
by Manitowoc

SERVICE MANUAL

TMS500-2



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

Published 07-21-2020, Control # 673-02

THIS PAGE BLANK

TABLE OF CONTENTS

SECTION 1 . . . . Introduction 1
Using The Service Manual 1-1
Safety Messages 1-2
List Of Specifications 1-3
General 1-3
Dimensions 1-3
Capacities 1-3
Transmission 1-3
Engine 1-3
Suspension 1-3
Axles 1-3
Brakes 1-3
Wheels and Tires 1-3
Swing Gearbox 1-3
Boom 95’ 1-3
Boom 102’ 1-4
Swivel Assembly 1-4
Hydraulic Pumps 1-4
Hoists 1-4
Cable 1-4
General Maintenance 1-11
Cleanliness 1-11
Removal and Installation 1-11
Disassembly and Assembly 1-11
Pressing Parts 1-11
Locks 1-11
Wires and Cables 1-12
Bearings 1-12
Gaskets 1-12
Batteries 1-12
Hydraulic Systems 1-13
Fatigue of Welded Structures 1-13
Loctite® Thread Locking Compound 1-13
Fasteners and Torque Values 1-14
Weld Studs 1-21
Hoist Cable Inspection and Maintenance 1-21
Wire Rope 1-22
Wire Rope Inspection (Running Ropes and Pendant Cables) 1-23
Wire Rope Inspection (Boom Extension and Retraction Cables) 1-24
Wire Rope Replacement (All Wire Rope) 1-24
Seizing Wire Rope 1-24
Installing 35x7Class Wire Rope 1-25
Procedures for Cutting and Preparing 35x7 Class Wire Rope 1-26

SECTION 2 . . . . Hydraulic System 1
Description 2-1
Maintenance 2-3
Draining and Flushing 2-3
Removing Air from the Hydraulic System 2-4
Parts Replacement 2-5
Supply Pressure and Return Circuit 2-5
Description 2-5
Hydraulic Reservoir and Filter 2-5

Pump Distribution 2-6
Maintenance 2-8
Troubleshooting 2-8
Return Hydraulic Filter Assembly 2-9
Environmental Protection 2-9
Element Removal 2-9
Element Installation 2-9
Hydraulic Pumps 2-11
Description 2-11
Maintenance 2-11
Carrier Valves 2-17
General 2-17
Outrigger Selector Manifold Valve 2-19
Description 2-19
Maintenance 2-19
Outrigger Control Manifold 2-21
Description 2-21
Maintenance 2-21
Pilot Operated Check Valve 2-26
Description 2-26
Internal Leak Testing 2-26
Maintenance 2-27
Superstructure Hydraulic Valves 2-28
Main Directional Valve Assembly 2-29
Accessory Manifold Assembly 2-30
Superstructure Hydraulic system 2-31
Checking for Leaks 2-31
Cylinders 2-31
General 2-31
Maintenance 2-31
Pressure Setting Procedures 2-33
Objective 2-33
Equipment 2-33
Valve Pressure Setting Table 2-33
Service Tool Notes 2-34
A. Procedure for Checking/Setting the Piston Pump Cut-off and Differential Pressures 2-36
B. Procedure for Checking/Setting the Pilot Supply Pressure 2-37
C. Procedure for Checking/Setting the Main Directional Control Valve, Load Sense, Lift and Telescope Pressures 2-38
D. Procedure for Checking/Setting Swing Pressure 2-40
E. Procedure for Checking/Setting the Swing Brake Release Pressure 2-40
F. Procedure for Checking/Setting Outrigger Pressure 2-41
G. Procedure for Checking Air Conditioning Operation 2-43
H. Procedure for Checking/Setting the Center Front Stabilizer Pressure 2-44
I. Procedure for Checking/Setting the Front Steer Pressure 2-44
J. Procedure for Adjusting Electronic Controllers (Meter-in Dead Band and/or Max Function Speeds) 2-46

SECTION 3. . . . . . Electrical System 1

Description 3-1
Carrier Cab 3-1
Batteries 3-1
Carrier Power Panel and Fuse Panels 3-2
Carrier Cab Fuse and Relay Panels 3-4
Anti-Lock Brake System (ABS) 3-5

Superstructure Cab Fuse and Relay Panels 3-7
Camera System (Optional) 3-9
Radios (Optional). 3-9
Maintenance 3-9
General 3-9
General Troubleshooting 3-10
Tools for Troubleshooting 3-10
Troubleshooting Engine Starting Problems 3-10
Jump Starting Hazard 3-11
Charging the Batteries 3-11
Troubleshooting 3-11
Troubleshooting Battery Charging Problems 3-11
Troubleshooting Slip Ring-Caused Electrical Problems 3-11
Connector Troubleshooting. 3-11
Di-electrical Grease Application 3-12
Troubleshooting Lights 3-13
Troubleshooting Gauges and Meters 3-14
Troubleshooting Alarms, Indicators, and Emergency Components 3-14
Troubleshooting Accessories. 3-14
Alternator Replacement 3-14
Starter Replacement. 3-15
Battery Replacement 3-17
Relay Panel Component Replacement. 3-18
Instrument Replacement. 3-18
Switch Replacement 3-19
Rocker Switch. 3-19
All Other Switches. 3-19
Windshield Wiper Assembly Replacement - Carrier Cab 3-20
Windshield Washer Assembly Replacement. 3-23
Superstructure Wiper Assembly 3-23
Skylight Wiper Assembly Replacement 3-23
Windshield Wiper Assembly Replacement - Superstructure Cab 3-24
Windshield Washer Assembly Replacement. 3-27
Computer Modules 3-28
Troubleshooting the Crane Control System (CCS). 3-28
Using the Operator Display Module (ODM). 3-28
Fault Codes. 3-28
Remote Controller (Optional). 3-28
Receiver 3-31
Battery Charger. 3-31
Remote Controller Battery 3-31

SECTION 4 . . . . Boom 1
Description. 4-1
Safety 4-1
Boom System Components 4-2
Telescope Cylinder 4-2
Fly Section Extension Cables 4-2
Extend Synchronizing Cable. 4-2
Fly Retraction Cables 4-2
Outer Mid Retract Cables 4-2
Boom Extension Sequence 4-2
Boom Retract Sequence 4-4
Telescope Circuit. 4-4
Description 4-4
Theory of Operation 4-4

Telescope Circuit Troubleshooting . . . 4-5
Lift Circuit . . . 4-6
Description . . . 4-6
Theory of Operation . . . 4-7
Lift Circuit Troubleshooting . . . 4-7
General Maintenance Notes . . . 4-8
Boom Extension Removal (Optional) . . . 4-9
Boom Removal . . . 4-10
Disconnect the Base Section . . . 4-12
Remove the Base Section . . . 4-13
Disconnect the Inner Mid Section . . . 4-14
Remove the Inner Mid Section . . . 4-15
Remove the Outer Mid Section . . . 4-17
Remove the Telescope Cylinder . . . 4-19
Boom Nose Sheaves . . . 4-20
Boom Nose Sheave Removal . . . 4-21
Boom Nose Sheave Installation . . . 4-22
Boom Assembly Procedure . . . 4-23
Install Telescope Cylinder . . . 4-23
Install the Outer Mid Section . . . 4-26
Install the Inner Mid Section . . . 4-30
Tensioning the Boom Extend and Retract Cables . . . 4-35
Install the Base Section . . . 4-38
Final Boom installation . . . 4-40
Swingaway Extension Installation (Optional) . . . 4-41
Boom Maintenance . . . 4-43
Functional Test of the Boom . . . 4-43
Boom Inspection . . . 4-43
Boom Alignment and Servicing . . . 4-44
Extension and Retraction Cable Maintenance . . . 4-44
Inspection . . . 4-45
Lift Cylinder Maintenance . . . 4-46
Lift Cylinder Removal . . . 4-46
Lift Cylinder Installation . . . 4-46

SECTION 5. . . . Hoist and Counterweight 1
Description . . . 5-1
Theory of Operation . . . 5-1
Maintenance . . . 5-2
Warm-up Procedure . . . 5-2
Removal . . . 5-2
Installation . . . 5-3
Functional Check . . . 5-3
Servicing . . . 5-3
Hoist Maintenance and Inspection . . . 5-4
Usage and Inspection . . . 5-4
Pre-Use or Daily Inspection . . . 5-5
Quarterly Inspection (Every Three Months) . . . 5-5
Semi-Annual Inspections (Every Six Months) . . . 5-5
Annual Inspection . . . 5-5
Preventive Maintenance and Oil Sampling . . . 5-5
Oil Change . . . 5-5
Gear Oil Sampling and Analysis . . . 5-5
Brake Test Procedure . . . 5-6
Hoist to Boom Alignment . . . 5-7
Preparation . . . 5-7

Tools Required 5-7
Procedure 5-7
Piston Motor and Control Valve 5-8
Description 5-8
Maintenance 5-8
Idler Drum and Cable Follower 5-9
Description 5-9
Maintenance 5-9
Hoist Drum Rotation Indicator System 5-11
Description 5-11
Maintenance 5-11
Troubleshooting 5-11
Counterweights 5-13
Counterweight Removal 5-13

SECTION 6 . . . . . . Swing Section 1
Introduction 6-1
Description 6-1
Theory of Operation 6-1
Maintenance 6-3
Troubleshooting 6-3
Swing Motor 6-6
Description 6-6
Maintenance 6-6
Swing Gearbox and Brake 6-7
Description 6-7
Maintenance 6-7
Maintenance of Gearbox 6-8
Swing Bearing 6-8
Description 6-8
Maintenance 6-8
Swivels 6-14
Description 6-14
Hydraulic Swivel 6-16
Electrical Slip Ring Assembly 6-18

SECTION 7 . . . . . . Power Train 1
Engine 7-1
Description 7-1
Maintenance 7-2
Engine Removal 7-2
Engine Installation 7-5
Engine Drive Belts 7-6
Engine Control System 7-6
Description 7-6
Functional Operation 7-6
Engine Control System Switches and Indicator Lights 7-7
Fuel System 7-9
Description 7-9
Maintenance 7-10
Air Intake System 7-11
Description 7-11
Maintenance 7-11
Exhaust System 7-15
Description 7-15
Exhaust System Removal 7-15

System Installation. 7-15
Slip Joint Exhaust Connectors. 7-15
Exhaust System. 7-16
After-treatment Diesel Exhaust Fluid (DEF) 7-17
DEF Tank. 7-17
DEF Dosing Unit Filter 7-18
Water Cooling System 7-20
Description. 7-20
Maintenance 7-20
Cleaning. 7-22
Component Inspection. 7-23
Radiator Assembly Removal and Installation 7-24
Drive Train 7-26
Description. 7-26
Maintenance 7-26
Drive Lines. 7-26
Electronic Clutch Actuator (ECA) 7-28
Installation Instructions 7-28
ECA Removal and Assembly Instructions 7-28
Transmission 7-28
Removing Transmission from Engine 7-28
Mounting Transmission to Engine 7-29
Pump/PTO Assembly 7-30
Pump/PTO Replacement. 7-30

SECTION 8. . . . . Undercarriage 1

Axles. 8-1
Description. 8-1
Maintenance 8-2
Front Axle 8-2
Rear Axles 8-7
Wheels and Tires 8-12
Description. 8-12
Vehicle Maintenance Schedule 8-12
Steering System 8-13
Description. 8-13
Maintenance 8-13
Steering Gearbox 8-16
Description. 8-16
Maintenance 8-16
Air System 8-17
Description. 8-17
Theory of Operation. 8-17
Braking. 8-20
Maintenance 8-20
Air System Components 8-22
Brakes 8-32
Description. 8-32
Air Supply 8-33
Normal Braking 8-33
Vehicle Parking 8-33
Anti-lock Braking Systems (ABS) 8-33
Automatic Traction Control 8-33
Emergency Braking 8-33
Non-Asbestos Warning. 8-33
Front Brakes 8-34

Description 8-34
Maintenance 8-34
Automatic Slack Adjuster 8-40
Description 8-40
Maintenance of Slack Adjuster 8-40
Rear Brakes 8-43
Description 8-43
Maintenance 8-44
Rear Brake Assembly 8-48
Anti-Lock Brake System (ABS)/Automatic Traction Control (ATC) 8-51
ABS System Description 8-51
ATC System Description 8-53
ABS Troubleshooting 8-55
Troubleshooting Diagnostic Trouble Codes: Traction Control Valves 8-63
Power Supply Tests 8-65
Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications 8-65
Miscellaneous Troubleshooting 8-67
Troubleshooting Wiring 8-68
Special Tools 8-71
Tests, Repair and Adjustment. 8-71
Component Removal and Installation 8-73
Outriggers 8-75
Description 8-75
Theory of Operation 8-75
Maintenance 8-76
Extension Cylinder 8-83
Maintenance for Extension Cylinder 8-83
Outrigger Jack Cylinders 8-83
Description 8-83
Maintenance for Jack Cylinders 8-83
Center Front Jack Cylinder 8-84
Description 8-84
Maintenance for Center Front Jack Cylinder 8-84
Functional Check of Center Front Jack Cylinder 8-85
Outrigger Monitoring System 8-87
Description 8-87
OMS Linear Position Sensors. 8-87

SECTION 9 . . . . Lubrication 1
GENERAL 9-1
Environmental Protection 9-1
Cummins Oil Registration List. 9-1
Standard Lubricants 9-2
Arctic Lubricants and Conditions 9-4
Cylinder Rod Surface Protection 9-6
Wire Rope Lubrication 9-6
Lubrication Points 9-6
Drivetrain Lubrication 9-8
Steering Lubrication 9-12
Axle Lubrication 9-13
Outrigger Lubrication 9-17
Miscellaneous Lubrication. 9-18
Turntable & Cab Platform Lubrication. 9-19
Hoist Lubrication 9-21
Turntable Central Lubrication 9-22
Boom Lubrication 9-24

Monthly Lubrication Work 9-29
Carwell® Rust Inhibitor. 9-30
Protecting Cranes From Corrosion 9-30
Cleaning Procedures 9-30
Inspection and Repair 9-31
Application 9-31
Areas of Application. 9-31

SECTION 1
INTRODUCTION

SECTION CONTENTS

Using The Service Manual 1-1
Safety Messages 1-2
List Of Specifications 1-3
General 1-3
Dimensions 1-3
Capacities 1-3
Transmission 1-3
Engine 1-3
Suspension 1-3
Axles 1-3
Brakes 1-3
Wheels and Tires 1-3
Swing Gearbox 1-3
Boom 95’ 1-3
Boom 102’ 1-4
Swivel Assembly 1-4
Hydraulic Pumps 1-4
Hoists 1-4
Cable 1-4
General Maintenance 1-11
Cleanliness 1-11
Removal and Installation 1-11
Disassembly and Assembly 1-11
Pressing Parts 1-11
Locks 1-11
Wires and Cables 1-12
Bearings 1-12
Gaskets 1-12
Batteries 1-12
Hydraulic Systems 1-13
Fatigue of Welded Structures 1-13
Loctite® Thread Locking Compound 1-13
Fasteners and Torque Values 1-14
Weld Studs 1-21
Hoist Cable Inspection and Maintenance 1-21
Wire Rope 1-22
Wire Rope Inspection (Running Ropes and Pendant Cables) 1-23
Wire Rope Inspection (Boom Extension and Retraction Cables) 1-24
Wire Rope Replacement (All Wire Rope) 1-24
Seizing Wire Rope 1-24
Installing 35x7Class Wire Rope 1-25
Procedures for Cutting and Preparing 35x7 Class Wire Rope 1-26

USING THE SERVICE MANUAL

This Manual provides information for the maintenance of the Model TMS500-2 Series Grove Crane (Figure 1-3).This manual is not designed to replace proper training and instruction.

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

The carrier incorporates a high strength, low alloy steel, all welded triple box section steel frame. The 6x4x2 carrier utilizes two drive axles and one steer axle. Axle steering is power assist controlled and controlled by the steering wheel. The engine is mounted at the front of the crane carrier and provides motive power through an automatic transmission.

The outriggers are single stage, double box, telescopic beam type outriggers. The outriggers have three positions; fully extended, intermediate (50%) extended, and fully retracted. The carrier is also equipped with a center front stabilizer that has a permanently mounted float pad.

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.

Two booms are available on the crane; an 8.8 m to 29 m (29-95 ft) four section boom or a 9.8 m to 31.0 m (32-102 ft) four section boom. Additional reach is obtained by utilizing a 7.9 to 13.7 meter (26 to 45 foot) telescoping offsettable swingaway extension.

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

SAFETY MESSAGES

When carrying out maintenance work, it is imperative that you observe the applicable accident prevention regulations.

The following instructions are general safety rules for maintenance personnel:

- Use personal protective equipment when performing maintenance (e.g., safety shoes, gloves, safety glasses, hard hats, fall protection, etc.).
- Familiarize yourself with the crane and its operation.
- Read the operating instructions carefully and request guidance from the crane operator.
- Do not carry out maintenance work unless you are authorized to do so.
- Observe all safety and warning signs on the crane.
- Observe all safety instructions contained in this maintenance manual.
- Familiarize yourself with the conditions under which the superstructure may be slewed and the boom may be extended into horizontal position.
- Do not carry out maintenance work unless the crane is standing on flat, stable ground and is prevented from rolling.
- Keep all handles, steps, landings and ladders free of dirt, grease, snow, and ice.
- Use the proper access aids and working platforms when carrying out maintenance work high overhead.
- Wear a harness when carrying out maintenance work high overhead.
- Walk only on those machine parts which are equipped with appropriate steps and railings. During rigging and maintenance work, use ladders and/or other equipment to assist in reaching locations at height where other means of access are not provided (e.g., when lubricating telescopic slide faces).
- Perform maintenance work only after the crane has been shut down. Always make sure that the crane is protected from unauthorized operation before beginning maintenance work. Remove the key and put up warning signs.
- If, as an exception, the crane needs to be put into operation for certain types of maintenance work, great care must be taken where there are moving parts (superstructure, outrigger, drive shafts, swiveling connections, motors, tilt-able crane cabs, superstructure lock). There is a risk of injury!
- Make sure that all hydraulic components are returned to their initial positions (e.g., the boom) or locked (e.g., the outrigger).
- Escaping hydraulic fluid or compressed air can cause severe injury. Remember that hydraulic and compressed air systems of the crane are pressurized even when the crane is not in operation. Only tighten loose screw connections when the system is in depressurized condition. Always depressurize the hydraulic and compressed air systems before opening them.
- Do not allow hot materials to escape unchecked. Risk of scalding!
- Observe the applicable safety regulations when working with inflammable fluids.
- Observe the applicable safety regulations when working with process materials.
- Disconnect the earthing terminal and switch off all electrical consumers before removing any batteries.
- Keep the corroding effect of battery acid in mind.
- Note the fire alarm and firefighting facilities on the site.
- Return the crane to proper working order once maintenance work is completed. Inform the crane operator accordingly.

LIST OF SPECIFICATIONS

General

Model . . . . .TMS500-2 Series
Rated Capacity. . . . . .See *Load Chart* in cab
Drive. . . . . .6 x 4 x 2
Gross Vehicle Weight 95' Boom (See Table 1-1
  No CWT . . . . .24741 kg (54545 lb)
  Light CWT . . . . .26989 kg (59499 lb)
  Full CWT . . . . .28576 kg (62999 lb)
Gross Vehicle Weight 102' Boom (See Table 1-2
  Full CWT . . . . .29457 kg (64940 lb)

Dimensions

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

Wheelbase . . . . 5385 mm (212 in)
Overall Crane Length. . . . . 11,684 mm (461 in)
Overall Crane Width (Over Fenders)
. . . . 2540 mm (100 in)
Overall Crane Height . . . . 3429 mm (135 in)
Tail-Swing. . . . . 3658 mm (144 in)
Outrigger Spread
  Retracted. . . . . 2390 mm (94 in)
  Mid Extend . . . . 4270 mm (168 in)
  Fully Extended . . . . 6098 mm (240 in)

Capacities

Fuel Tank . . . . .220 liters (58 gal)
Coolant System . . . . 67 liters (17.7 gal)
Engine Lubrication System . . . . See Engine Specifications
Hydraulic Tank (Reservoir Capacity)
  Total. . . . . .458 liters (121 gal)
  at Full Level. . . . . .405 liters (107 gal)
  at Add Level . . . . .375 liters (99 gal)
  Expansion Space . . . . 54 liters (14.2 gal)
Hoists . . . . .5.2 liters (5.5 qt)
Swing Gearbox. . . . . .4.0 liters (4.25 qt)
Front Axle Hubs . . . . .0.56 liters (.6 qt)
Front Rear Axle Differentials . . .18.5 liters (39.1 pt)
Rear Rear Axle Differentials. . . .16.3 liters (34.4 pt)
Transmission . . . . .13.2 liters (28.0 pt)

Transmission

Speeds . . . . 11 forward - 3 reverse
Gear Ratios
  First 26.08
  Second. 16.30
  Third 11.85
  Fourth. 7.41
  Fifth 5.23
  Sixth 3.79
  Seventh 2.77
  Eighth. 1.95
  Ninth. 1.38
  Tenth 1.00
  Eleventh 0.73
  Reverse High 3.43
  Reverse Low 13.03
  Deep Reduction 20.85

Engine

Cummins L9

Bore . . . . 114 mm (4.5 in)
Stroke. . . . . 145 mm (5.69 in)
Displacement . . . . 8.9 liters (543 cu in)
Firing Order 1-5-3-6-2-4
Lube Amount . . . . .18.9 liters (20 quart)

Suspension

Front . . . . .Springs
Rear . . . . .Air
Ride Height = 1.62" +/- 0.19" between trailing arm and suspension stop.

Axles

Front

Type . . . . Non-drive steer
Steer Axle Toe = 0.030" +/- 0.030"
Steer Axle Caster = 2.50 degrees +/- 0.50 degrees
Steer Axle Camber = 0.12 degrees +/- 0.25 degrees

Rear

Type . . . . Single reduction tandem
Ratio 4.89:1
Drive Axle Thrust = 0.75" max.

Brakes

Front

Type . . . . Air operated S-Cam
Size . . . . .419 x 152 mm (16.5 x 6.0 in)

Rear

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

Wheels and Tires

Lugs 10
Torque . . . . .610 to 678 N-m (450 - 500 ft lb)
Tire Size
  Front 425/65R22.5
  Rear 11R22.5
Tire/wheel lateral and radial run-out = 0.060" max.
For roading and lifting pressures, refer to the tire inflation decal.

Swing Gearbox

Reduction Ratio 36:1
Output Torque . . . . .3340 N-m (29,562 in-lb)

Boom 95'

Length . . . . .8.8 to 29.0 meters (29.0 to 95.0 ft)
Power. . . . . . . 4 Section, Synchronized Full Power
Elevation . . . .-3 to +76 degrees
Extensions
  Telescoping* 7.92 or 13.70 meters (26 or 45 ft) offsettable at 0,15 or 30 degrees . . . .

Boom 102’

Length . . . . 9.8 to 31.0 meters (32.0 to 102.0 ft)
Power . . . . 4 Section, Synchronized Full Power
Elevation . . . . -3 to +76 degrees
Extensions
Telescoping* 7.92 or 13.70 meters (26 or 45 ft) offsettable at 0,15 or 30 degrees

Swivel Assembly

Electrical . . . . 20 Slip Rings
Hydraulic . . . . 5 ports
Water. . . . . 2 ports

Hydraulic Pumps

NOTE: Pump output figures are theoretical.

Pump No. 1

Type . . . . Gear
Sections 1
Output - @ 2090 rpm w/no load
Section 1 . . . . 78.7 L/min (20.8 gpm)

Pump No. 2

Type . . . . Variable Displacement Piston
Sections 1
Output - @ 2185 rpm w/no load
Section 1 . . . . 293 L/min (77.5 gpm)

Hoists

Drum Dimensions
Diameter . . . . 270 mm (10.625 in)
Length . . . . 437 mm (17.2 in)
Max. Single Line Speed . . . . . . 69 m/min (225 fpm)
Hoist Motor Displacement
. . . . . . 56/40 cm³ (3.42/2.44 in³) per revolution

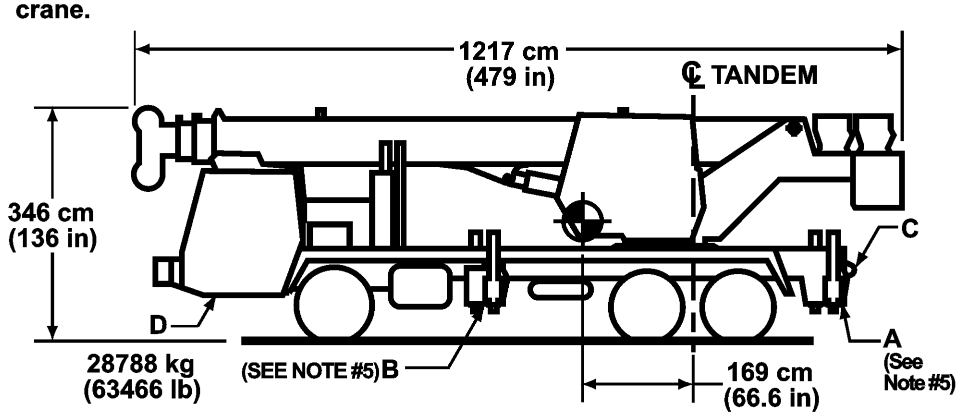
Cable

Diameter . . . . 16 mm (5/8 in)
Length . . . . 138 m (452 ft)
Max. Permissible Line Pull (35x7)
. . . . 5,280 kg (11,640 lb)

TRANSPORTATION AND LIFTING DATA TMS500-2 (95' BOOM)

FITTINGS	NO./UNIT	TOTAL UNIT			CARRIER			FITTING CAPACITY (TONS)				
		LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN FORE & AFT	TIE DOWN SIDE	TIE DOWN DOWN
A	2	X			X			SEE NOTE #5				
B	2	X			X			SEE NOTE #5				
C	2		X	X		X	X		27.2	12.2	16.4	16.4
D	2		X	X		X	X		27.2	12.2	6.5	11.9

1. Lifting of entire crane or major crane assemblies must be accomplished by utilizing specific fittings indicated on above chart. Use of fittings for purposes other than those designated on chart is prohibited. Fitting capacities are maximum allowable loads per individual fitting.
2. Rigging personnel shall be responsible for proper selection and placement of all slings and load handling devices.
3. Dimensions and weights shown are for largest configuration available. Weights do not include boom extension and /or jib, unless noted otherwise.
4. Rigging personnel shall verify dimensions as required for clearance.
5. Extend outrigger beams 46 cm (18.0 in) and sling around beams.
6. Do not use pintle hook or counterweight lugs for lifting or tiedown of entire crane.



TOTAL UNIT WITH BOOM EXTENSION

G7 80116384

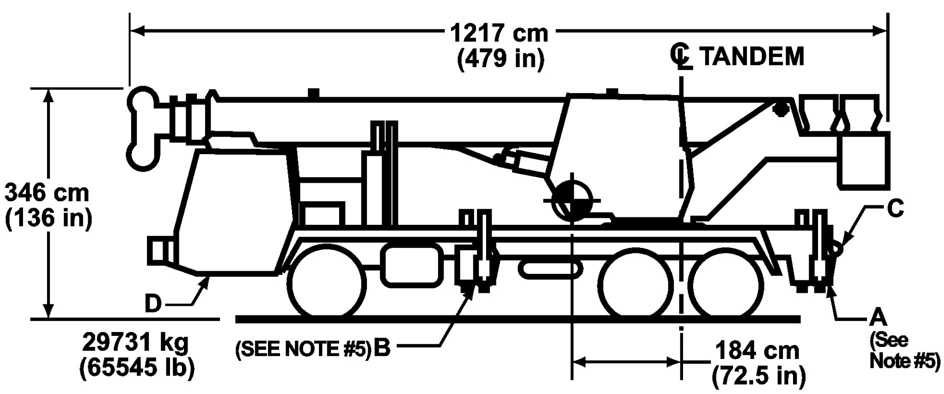
9739

FIGURE 1-1

TRANSPORTATION AND LIFTING DATA TMS500-2 (102' BOOM)

FITTINGS	NO./UNIT	TOTAL UNIT			CARRIER			FITTING CAPACITY (TONS)				
										TIE DOWN		
		LIFT	TOW	TIE DOWN	LIFT	TOW	TIE DOWN	LIFT	TOW	FORE & AFT	SIDE	DOWN
A	2	X			X			SEE NOTE #5				
B	2	X			X			SEE NOTE #5				
C	2		X	X		X	X		27.2	12.2	16.4	16.4
D	2		X	X		X	X		27.2	12.2	6.5	11.9

1. Lifting of entire crane or major crane assemblies must be accomplished by utilizing specific fittings indicated on above chart. Use of fittings for purposes other than those designated on chart is prohibited. Fitting capacities are maximum allowable loads per individual fitting.
2. Rigging personnel shall be responsible for proper selection and placement of all slings and load handling devices.
3. Dimensions and weights shown are for largest configuration available. Weights do not include boom extension and /or jib, unless noted otherwise.
4. Rigging personnel shall verify dimensions as required for clearance.
5. Extend outrigger beams 46 cm (18.0 in) and sling around beams.
6. Do not use pintle hook or counterweight lugs for lifting or tiedown of entire crane.

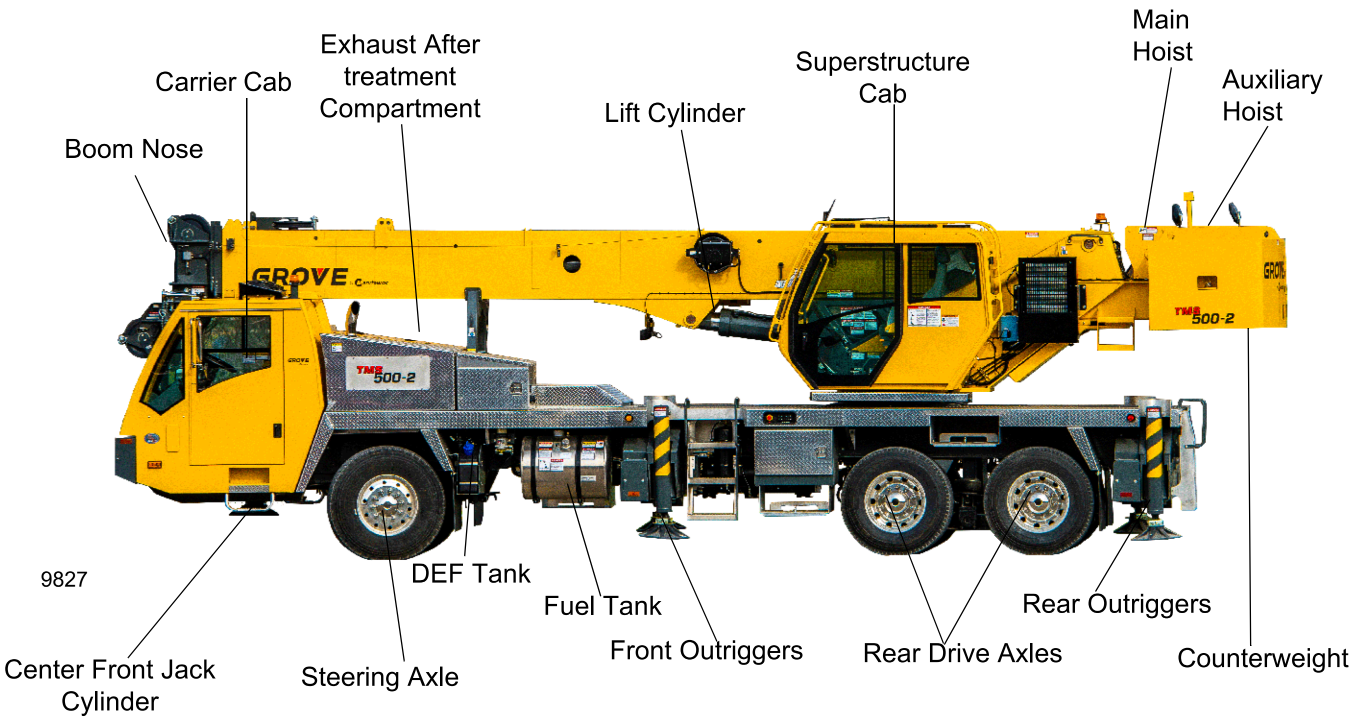


TOTAL UNIT WITH BOOM EXTENSION

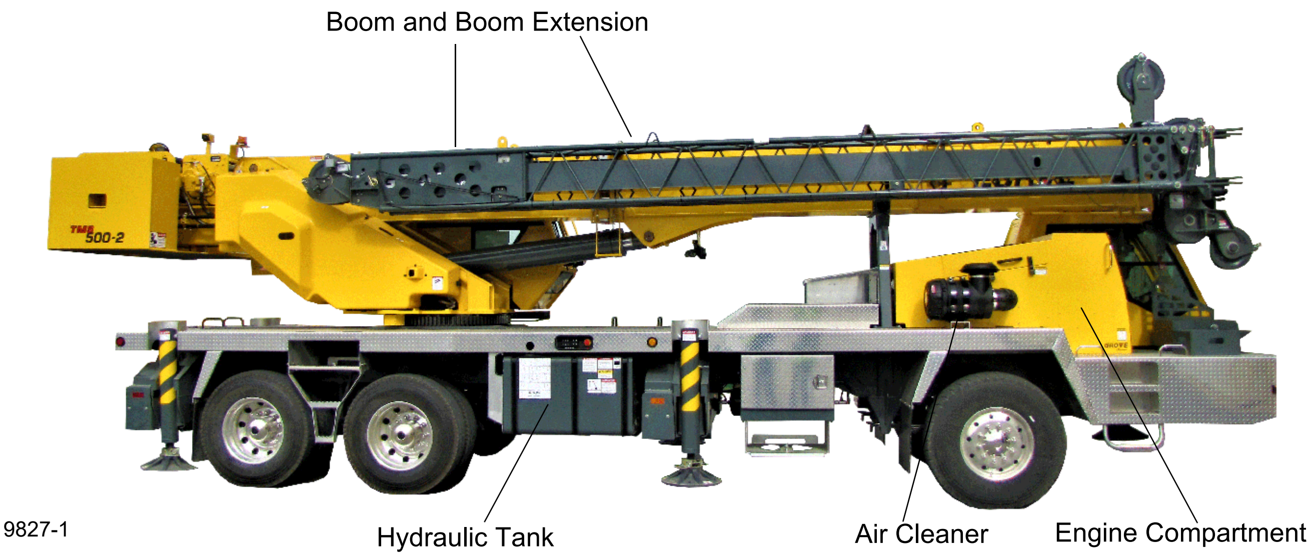
G7 80116385

9740

FIGURE 1-2



9827



9827-1

Basic Nomenclature

FIGURE 1-3

Table 1-1: Axle Weight Distribution Table - 95' Boom

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
Maximum Tire & Wheel Loads Allowed					10342	(22800)	21791	(48040)
Maximum Axle Loads Allowed					9752	(21500)	20865	(46000)
Standard Carrier Ass'y (6x4x2)	260.93	(102.73)	13152	(28996)	6046	(13328)	7107	(15668)
Fuel Tank Full (60 gal)	383.54	(151.00)	195	(430)	132	(291)	63	(139)
Superstructure Ass'y - main hoist w/cable, IPO cwt	-51.82	(-20.40)	3901	(8600)	-356	(-785)	4257	(9385)
29'-95' Boom Ass'y w/(2/4) sheaves, pivot pins - retracted	318.26	(125.30)	5144	(11340)	2884	(6358)	2260	(4982)
Lift Cylinder and lower shaft	104.22	(41.03)	598	(1318)	110	(242)	488	(1076)
Complete Basic Machine: Carrier Ass'y, S/S Ass'y, 29'-95' 4-Section Boom, Cummins L9-2017 Engine, 425/65R22.5 Michelin Front Tires, 11R22.5 Michelin Rear Tires, Full Fuel and Hydraulic Oil	217.65	(85.69)	22990	(50684)	8815	(19433)	14175	(31251)
Boom Extensions								
7.9 - 13.7 m (26 - 45 ft) Tele Boom Extension	400.15	(157.54)	745	(1642)	525	(1157)	220	(485)
Boom Extension Carrier Brackets	327.66	(129.00)	116	(256)	67	(148)	49	(108)
Aux Boom Nose	802.74	(316.04)	48	(105)	67	(148)	-20	(-43)
Counterweights								
Full Counterweight	-232.41	(-91.50)	3860	(8510)	-1580	(-3484)	5440	(11994)
Light Counterweight	-233.68	(-92.00)	2273	(5010)	-935	(-2062)	3208	(7072)
No Counterweight (Hoist Access Platform)	-223.52	(-88.00)	25	(56)	-10	(-22)	35	(78)
Rigging Equipment								
(7 t) 7.5 ton Overhaul Ball - in stowage tray	777.24	(306.00)	167	(369)	229	(505)	-62	(-136)
(7 t) 7.5 ton Overhaul Ball - tied to front bumper	868.68	(342.00)	167	(369)	256	(565)	-89	(-196)
(17 t) 18.7 ton Hookblock (1 sheave) - in stowage tray	795.02	(313.00)	261	(575)	365	(805)	-104	(-230)
(17 t) 18.7 ton Hookblock (1 sheave) - tied to front bumper	868.68	(342.00)	261	(575)	399	(880)	-138	(-305)
(17 t) 18.7 ton Hookblock (1 sheave) - behind boom rest	279.40	(110.00)	261	(575)	128	(283)	132	(292)
(30 t) 33 ton Hookblock (3 sheave) - in stowage tray	795.02	(313.00)	292	(644)	409	(902)	-117	(-258)
(30 t) 33 ton Hookblock (3 sheave) - tied to front bumper	868.68	(342.00)	292	(644)	447	(985)	-155	(-341)
(30 t) 33 ton Hookblock (3 sheave) - behind boom rest	279.40	(110.00)	292	(644)	144	(317)	148	(327)
(36 t) 40 ton Hookblock (4 sheave) - in stowage tray	795.02	(313.00)	351	(774)	492	(1084)	-141	(-310)

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
(36 t) 40 ton Hookblock (4 sheave) - tied to front bumper	868.68	(342.00)	351	(774)	537	(1184)	-186	(-410)
(36 t) 40 ton Hookblock (4 sheave) - behind boom rest	279.40	(110.00)	351	(774)	173	(381)	178	(393)
Rigging & Cribbing	210.82	(83.00)	136	(300)	50	(111)	86	(189)
Rigging & Cribbing	210.82	(83.00)	363	(800)	135	(297)	228	(503)
Optional Equipment								
360 Swing Lock	83.82	(33.00)	27	(59)	4	(9)	23	(50)
Carrier Camera	220.98	(87.00)	15	(34)	6	(13)	10	(21)
Aluminum Toolbox	396.24	(156.00)	21	(46)	15	(32)	6	(14)
S/S Cab Heater	15.24	(6.00)	32	(71)	1	(2)	31	(69)
Driver	746.76	(294.00)	113	(250)	149	(329)	-36	(-79)
Substitutions and Removals								
SUB: Aux Hoist (replace IPO cwt with aux hoist & cable)	-228.60	(-90.00)	186	(409)	-75	(-165)	260	(574)
REM: Main Hoist Cable (453’ of 5/8” 35x7)	-175.26	(-69.00)	-185	(-408)	57	(126)	-242	(-534)
REM: Aux Hoist Cable (453’ of 5/8” 35x7)	-236.22	(-93.00)	-185	(-408)	77	(170)	-262	(-578)
SUB: 29’-95’ Boom Ass’y - extended to 34.25 ft			11	(24)	615	(1355)	-604	(-1331)
SUB: Aluminum Outrigger Floats	73.66	(29.00)	15	(32)	2	(4)	13	(28)
REM: 1/2 Fuel Tank (30 gal)	383.54	(151.00)	-98	(-215)	-66	(-145)	-32	(-70)

Table 1-2Axle Weight Distribution Table - 102’ Boom

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
Maximum Tire & Wheel Loads Allowed					10342	(22800)	21791	(48040)
Maximum Axle Loads Allowed					9752	(21500)	20865	(46000)
Standard Carrier Ass’y (6x4x2)	260.93	(102.73)	13152	(28996)	6046	(13328)	7107	(15668)
Fuel Tank Full (60 gal)	383.54	(151.00)	195	(430)	132	(291)	63	(139)
Superstructure Ass’y - main hoist w/cable, IPO cwt	-51.82	(-20.40)	3901	(8600)	-356	(-785)	4257	(9385)
32’-102’ Boom Ass’y w/(2/4) sheaves, pivot pins	350.52	(138.00)	5954	(13126)	3676	(8105)	2278	(5021)
Lift Cylinder and lower shaft	108.46	(42.70)	668	(1473)	127	(281)	541	(1192)
Complete Basic Machine: Carrier Ass’y, S/S Ass’y, 32’-102’ 4-Section Boom, Cummins L9-300 Engine, 425/65R22.5 Michelin Front Tires, 11R22.5 Michelin Rear Tires, Full Fuel and Hydraulic Oil	228.90	(90.12)	23871	(52625)	9625	(21219)	14246	(31406)
Boom Extensions								
7.9 - 13.7 m (26 - 45 ft) Tele Boom Extension	501.95	(197.62)	745	(1642)	659	(1452)	86	(190)

Description	CG To CL Rear Bogie cm (in)		Weight kg (lb)		Front Axle kg (lb)		Rear Axle kg (lb)	
Boom Extension Carrier Brackets	429.26	(169.00)	116	(256)	88	(194)	28	(62)
Aux Boom Nose	904.54	(356.12)	48	(105)	76	(167)	-28	(-62)
Counterweight								
Full Counterweight	-232.41	(-91.50)	3860	(8510)	-1580	(-3484)	5440	(11994)
Rigging Equipment								
(7 t) 7.5 ton Overhaul Ball - in stowage tray	777.24	(306.00)	167	(369)	229	(505)	-62	(-136)
(7 t) 7.5 ton Overhaul Ball - tied to front bumper	868.68	(342.00)	167	(369)	256	(565)	-89	(-196)
(17 t) 18.7 ton Hookblock (1 sheave) - in stowage tray	795.02	(313.00)	261	(575)	365	(805)	-104	(-230)
(17 t) 18.7 ton Hookblock (1 sheave) - tied to front bumper	868.68	(342.00)	261	(575)	399	(880)	-138	(-305)
(17 t) 18.7 ton Hookblock (1 sheave) - behind boom rest	279.40	(110.00)	261	(575)	128	(283)	132	(292)
(30 t) 33 ton Hookblock (3 sheave) - in stowage tray	795.02	(313.00)	292	(644)	409	(902)	-117	(-258)
(30 t) 33 ton Hookblock (3 sheave) - tied to front bumper	868.68	(342.00)	292	(644)	447	(985)	-155	(-341)
(30 t) 33 ton Hookblock (3 sheave) - behind boom rest	279.40	(110.00)	292	(644)	144	(317)	148	(327)
(36 t) 40 ton Hookblock (4 sheave) - in stowage tray	795.02	(313.00)	351	(774)	492	(1084)	-141	(-310)
(36 t) 40 ton Hookblock (4 sheave) - tied to front bumper	868.68	(342.00)	351	(774)	537	(1184)	-186	(-410)
(36 t) 40 ton Hookblock (4 sheave) - behind boom rest	279.40	(110.00)	351	(774)	173	(381)	178	(393)
Rigging & Cribbing	210.82	(83.00)	136	(300)	50	(111)	86	(189)
Rigging & Cribbing	210.82	(83.00)	363	(800)	135	(297)	228	(503)
Optional Equipment								
360 Swing Lock	83.82	(33.00)	27	(59)	4	(9)	23	(50)
Carrier Camera	220.98	(87.00)	15	(34)	6	(13)	10	(21)
Aluminum Toolbox	396.24	(156.00)	21	(46)	15	(32)	6	(14)
S/S Cab Heater	15.24	(6.00)	32	(71)	1	(2)	31	(69)
Driver	746.76	(294.00)	113	(250)	149	(329)	-36	(-79)
Substitutions and Removals								
SUB: Aux Hoist (replace IPO cwt with aux hoist & cable)	-228.60	(-90.00)	186	(409)	-75	(-165)	260	(574)
REM: Main Hoist Cable (453’ of 5/8” 35x7)	-175.26	(-69.00)	-185	(-408)	57	(126)	-242	(-534)
REM: Aux Hoist Cable (453’ of 5/8” 35x7)	-236.22	(-93.00)	-185	(-408)	77	(170)	-262	(-578)
SUB: Aluminum Outrigger Floats	73.66	(29.00)	15	(32)	2	(4)	13	(28)
REM: 1/2 Fuel Tank (30 gal)	383.54	(151.00)	-98	(-215)	-66	(-145)	-32	(-70)

GENERAL MAINTENANCE

The suggestions and instructions throughout this manual should be helpful in operating the crane. In analyzing a system malfunction, use a systematic procedure to locate and correct the problem, such as follows:.

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

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

Cleanliness

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

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

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

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

Removal and Installation

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

When using hoisting equipment, follow the hoist manufacturers recommendations. Use proper lifting devices that allow the proper balance of the assemblies being lifted and to make sure of safe handling. Unless otherwise specified, anything that needs to be removed that requires hoisting equipment should be accomplished using an adjustable lifting attachment. All supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.

CAUTION

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

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

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

Disassembly and Assembly

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

Pressing Parts

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

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

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

Locks

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

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

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

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

Wires and Cables

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

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

Shims

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

Bearings

Antifriction Bearings

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

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

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

Sleeve Bearings

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

Gaskets

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

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

Batteries

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

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

Hydraulic Systems

DANGER

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

When installing metal tubes, tighten all fittings finger-tight. Then, in order, tighten the fittings 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 fittings finger-tight. Position the hose so it does not rub the machine or another hose and has a minimum of bending and twisting. Tighten fittings in both couplings.

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

Fatigue of Welded Structures

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

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

1. Power Telescope Boom - wear pad retaining structures, hydraulic cylinder attaching points, boom pivot shaft retaining structures.
2. Outrigger pads, beams, boxes and attachment structures.
3. Main frames - generally in the area of doubler plates and crossmembers; at the junction of front and rear frame members on cranes.
4. Turntable bearing connection (where the bearing is welded to the crane superstructure or chassis).
5. Counterweight support structures.
6. Chassis axle and suspension mounting structures.
7. Hydraulic cylinder end connections.

The above known high-stress list 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 the same by contacting your local Grove distributor.

Loctite® Thread Locking Compound

DANGER

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

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

Application of Medium Strength Loctite®

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

The following procedure covers the proper application and curing method for medium-strength Loctite® adhesive/ sealant (Loctite® #243) and primer (Locquic Primer T7471).

Primer Application

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

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

Adhesive/Sealant Application

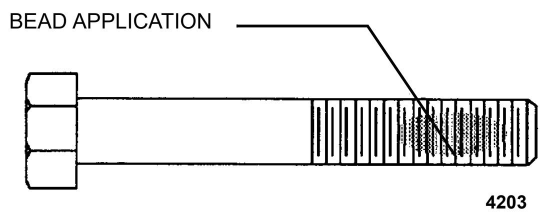


FIGURE 1-4

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

Fasteners and Torque Values

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

Torque values should correspond to the type of bolts, studs, and nuts being used (Figure 1-5) and (Figure 1-6).

The torque tables Table 1-3, Table 1-4, Table 1-5,Table 1-6, Table 1-7, Table 1-8, and Table 1-9 are provided by Grove 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 3, 5, etc.), the mechanic must be aware that he 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.

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

When referring to the applicable torque charts, use values as close as possible to the torque values shown to allow for wrench calibration tolerance. An erratic or jerking motion of the wrench can easily result in excessive torque. ALWAYS use a slow wrench movement and STOP when the predetermined value has been reached.

Torque wrenches are precision instruments and are to be handled with care to ensure calibrated accuracy. Calibration checks should be made on a scheduled basis. Whenever the wrench might be either over stressed or damaged, it should immediately be removed from service until recalibrated.

KNOW YOUR TORQUE WRENCH! Flexible beam type wrenches, even though they might have a preset feature, must be pulled at right angles and the force must be applied at the exact center of the handle. Force value readings must be made while the tool is in motion.

Rigid handle type torque wrenches are available with torque limiting devices that can be preset to required values and which eliminate dial readings.

NOTE: To convert pounds-foot of torque to newton meters (N-m), multiply the pounds-foot quantity by 1.3558.

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

NOTE: When multipliers and/or special tools are used to reach hard to get at spots, ensure torque readings are precisely calculated.

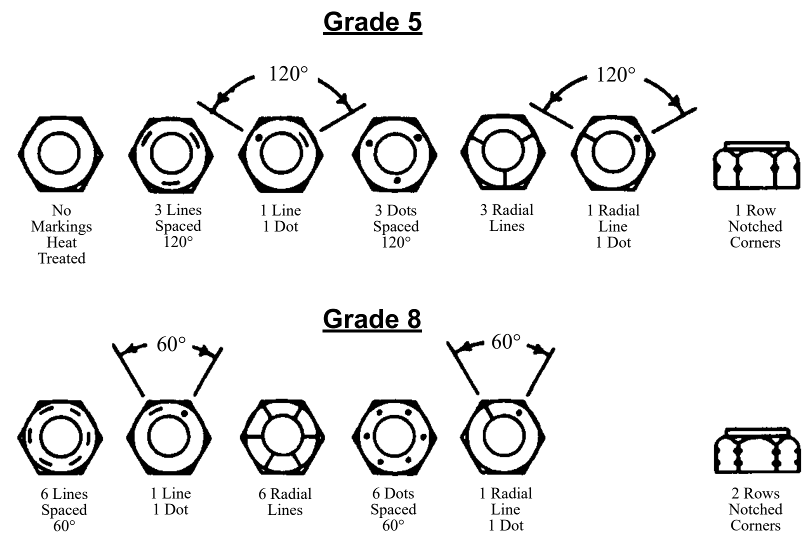


FIGURE 1-5

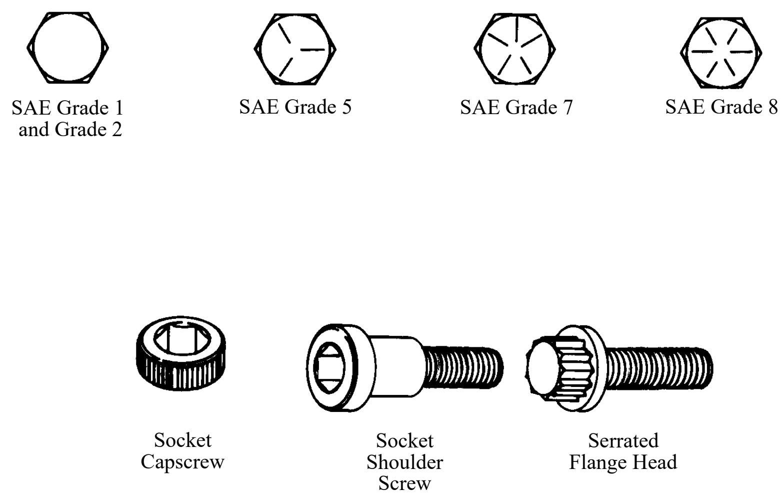


FIGURE 1-6

Table 1-3Inch Series with Coarse Threads (UNC) – Zinc Flake Coated

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

Table 1-4 Inch Series with Fine Threads (UNF) – Zinc Flake Coated

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

Table 1-5 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

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

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

Table 1-6 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
M14x1.5	8.8	120.2	117.2	114.2
	10.9	176.5	172.1	167.7
	12.9	206.6	201.4	196.2
M16x1.5	8.8	184.4	179.8	175.2
	10.9	270.9	264.1	257.3
	12.9	317.0	309.1	301.2
M18x1.5	8.8	276.6	269.7	262.8
	10.9	394.0	384.2	374.3
	12.9	461.1	449.6	438.0
M20x1	8.8	405.7	395.5	385.4
	10.9	577.8	563.3	548.9
	12.9	676.1	659.2	642.3

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

Table 1-7: UNC (Coarse) Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

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

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

Table 1-8: Metric Coarse Thread: Torque Values for Stainless Steel Fasteners with Oil Lubrication

Size	Torque Value
	Nm
M2.5	0.4
M3	0.9
M4	1.5
M5	3.1
M6	5.3
M8	13.0
M10	27.0
M12	45.0
M14	71.1
M16	109
M18	157
M20	220

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

Weld Studs

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

Table 1-9: 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

Hoist Cable Inspection and Maintenance

Hoist Rope

The Crane may be equipped with synthetic hoist rope or wire rope. Hoist rope may be purchased through Manitowoc Crane Care.

For detailed information concerning synthetic hoist rope, refer to *K100™ Synthetic Crane Hoist Line Manual* P/N 9828100734 available by contacting Manitowoc Crane Care.

During installation and setup, care must be taken to avoid overlap and crossing of wire rope and synthetic hoist ropes.

Make sure that the crane surfaces such as wear pads, sheaves, etc., have not been damaged in a manner that can then damage the synthetic hoist rope.

⚠ WARNING

Worn or Damaged Equipment Hazard!

Never use a worn or damaged hoist rope. Death or serious injury could result from using worn or damaged hoist rope.

Hoist 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.

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

Keeping Records

A signed and dated report of the hoist rope 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 hoist rope should be replaced.

It is recommended that the hoist 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.

Wire Rope

General

The following information is a compendium of information from various wire rope manufacturers and includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and Grove Cranes. 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.

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

Lubrication

A wire rope cannot be lubricated sufficiently during manufacture to last its entire life. Therefore, new lubricant must be added throughout the life of a rope to replace factory lubricant which is used or lost. It is important that lubricant applied as part of a maintenance program shall be compatible with the original lubricant, and to this end, the rope manufacturer should be consulted. Any lubricant applied shall be of the type which does not hinder visual inspection. 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 what is needed for the full useful life of the rope. Because of this possibility, periodic applications of a suitable rope lubricant are necessary.

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

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

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

Precautions and Recommendations During Inspection or Replacement

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

Wire Rope Inspection (Running Ropes and Pendant Cables)

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

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

Frequent Inspection

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

- Distortion, kinking, crushing, un-stranding, bird caging, reduction of diameter, etc.
- General corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- End fitting wear/abrasion.

Periodic Inspection

Wire rope should be inspected periodically/annually or at a shorter time interval if necessitated by environmental or other adverse conditions, and shall cover the entire length of the wire rope. Only the outer surface of the wire rope needs to be inspected, and no attempt should be made to open the rope. Periodic inspection should include all items listed under Frequent Inspection (refer to *Frequent Inspection*, page 1-23) plus the following:

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

Wire Rope Inspection (Boom Extension and Retraction Cables)

Periodic Inspection

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

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

Wire Rope Replacement (All Wire Rope)

No precise rules can be given for determination of the exact time for replacement of wire rope since many variable factors are involved. Determination regarding continued use or replacement of wire rope depends largely upon the good 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 Grove Cranes. All wire rope will eventually deteriorate to a point where it is no longer usable. Wire rope shall be taken out of service when any of the following conditions exist:

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- Wear of one-third the original diameter of outside individual wires. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than:
  - 1/64 inch for diameters up to and including 5/16 inch.
  - 1/32 inch for diameters 3/8 and 1/2 inch inclusive.
  - 3/64 inch for diameters 9/16 to 3/4 inch inclusive.
  - 1/16 inch for diameters 7/8 to 1 1/8 inches inclusive.
  - 3/32 inch for diameters 1/14 to 1 1/2 inches inclusive.
- In 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.
- Grove Cranes recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the entire set of extension cables.
- Grove Cranes recommends for cable extended booms, that boom extension cables be replaced every seven (7) years.

Seizing Wire Rope

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

The two preferred methods for seizing wire ropes are:

Method 1

Using a length of soft annealed wire, place one end in the groove between two strands of the wire rope (Figure 1-7). 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.

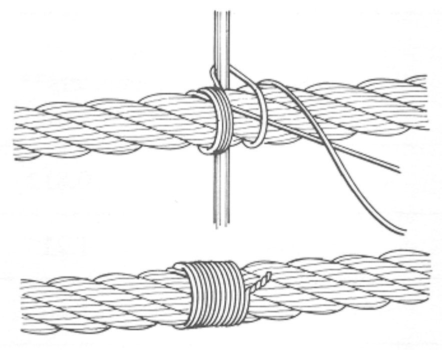


FIGURE 1-7

Method 2

Wind a length of soft annealed wire around the wire rope at least seven times (Figure 1-8). The two ends should be twisted together in the center of the seizing. Tighten the seizing by alternately prying and twisting. Cut off both ends of the wire and pound the twist flat against the rope.

NOTE: Non-preformed wire rope should have two seizings located on each side of the cut (Figure 1-9).

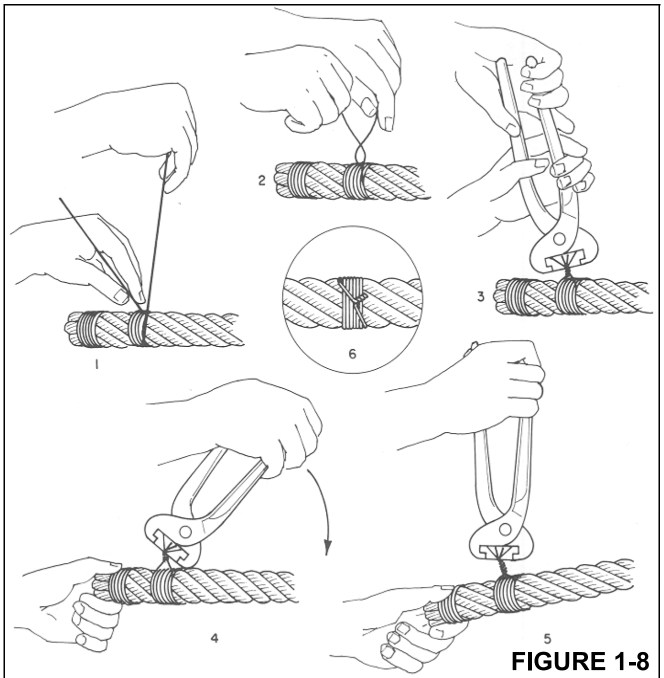


FIGURE 1-8

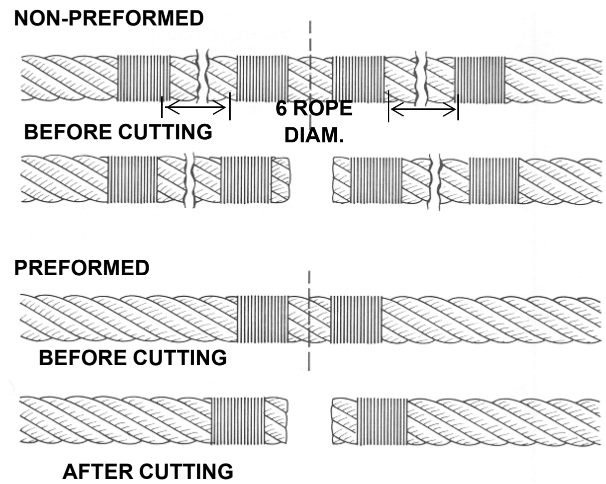


FIGURE 1-9

Installing 35x7Class 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 attached instructions. Also, unlike other types of wire rope, the ends on this wire rope must be welded.

1. Unload properly and relieve any twists. Pull the rope off the shipping reel or unroll it from a shipping coil. (If done improperly, you may kink the rope, which will result in permanent damage to the rope.) Then lay the rope on the ground in direct line with the boom. This helps release any twist in the rope.
2. Attach rope's end to drum. Pull the rope over the point sheave and attach the end to the drum. Be sure not to remove the welded end.
3. Wind rope onto drum slowly and carefully. At this point, it isn't necessary to provide additional load other than the weight of the rope being pulled across the ground.
4. Spool first layer tightly. It is essential that the first layer is spooler with wraps tight and close together since the first layer forms the foundation for succeeding layers. If need be, use a rubber, lead or brass mallet (but never a steel hammer) to tap the rope in place.
5. Spool multiple layers with sufficient tension. It's very important to apply a tensioning load to the ropes during the rope breaking-in process. (If not, the lower layers may be loose enough that the upper layers become wedged into the lower layers under load, which can seriously damage the rope.) The tensioning load should

range from 1 to 2% of the rope's minimum breaking force.

6. For ropes in multi-part systems: Reeve the traveling block and boom tip sheaves so the rope spacing is maximized and the traveling (hook) block hangs straight and level to help assure block stability.

7. Breaking in your new 35x7 class wire rope: After installation, you should properly break in your rope, which allows the rope's component parts to adjust themselves to your operating conditions.

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

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

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

Procedures for Cutting and Preparing 35x7 Class Wire Rope

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

1. The welded ends prepared by the manufacturer are not to be removed.

2. Before cutting the rope, make three separate bands with seizing strand on each side of where the cut is to be made (total of six bands for each cut as shown in Figure 1-10). Each band is to have a minimum length of one and one half times the rope diameter. The two bands closest to the cut should be located at a distance equal to one rope diameter away from the cut. The four remaining bands should be evenly spaced at a distance equal to three rope diameters.

3. Cut the rope:

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

NOTE: The outer strands must not be able to move with respect to the inner strands. The weld must not exceed the diameter of the rope.

   b. If a welder is not available, the cut is to be made with an acetylene torch. The cut is to be made in such a way that both ends of the rope are completely fused so that all inner and outer strands are bonded together, preventing any movement between strands.

NOTE: The outer strands must not be allowed to move with respect to the inner strands. The fused end must not exceed the diameter of the rope.

4. Once the cuts have been completed, the seizing bands are to be left in place for shipment of the rope.

5. Attach a "Do not remove welded ends" tag on each reel flange.

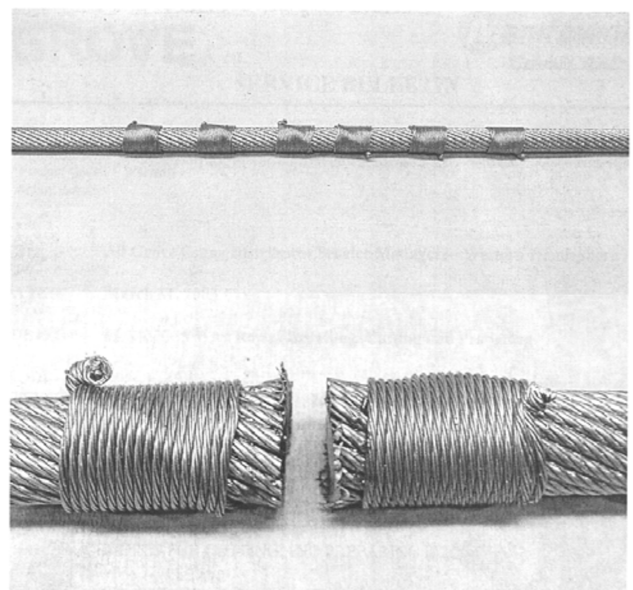


FIGURE 1-10

SECTION 2
HYDRAULIC SYSTEM

SECTION CONTENTS

Description 2-1
Maintenance 2-3
Draining and Flushing 2-3
Removing Air from the Hydraulic System 2-4
Parts Replacement 2-5
Supply Pressure and Return Circuit 2-5
Description 2-5
Hydraulic Reservoir and Filter. 2-5
Pump Distribution 2-6
Maintenance 2-8
Troubleshooting 2-8
Return Hydraulic Filter Assembly 2-9
Environmental Protection 2-9
Element Removal 2-9
Element Installation 2-9
Hydraulic Pumps 2-11
Description 2-11
Maintenance 2-11
Carrier Valves 2-17
General 2-17
Outrigger Selector Manifold Valve 2-19
Description 2-19
Maintenance 2-19
Outrigger Control Manifold 2-21
Description 2-21
Maintenance 2-21
Pilot Operated Check Valve 2-26
Description 2-26
Internal Leak Testing 2-26
Maintenance 2-27
Superstructure Hydraulic Valves. 2-28
Main Directional Valve Assembly 2-29
Accessory Manifold Assembly 2-30
Superstructure Hydraulic system 2-31
Checking for Leaks 2-31
Cylinders 2-31
General 2-31
Maintenance 2-31
Pressure Setting Procedures 2-33
Objective 2-33
Equipment 2-33
Valve Pressure Setting Table 2-33
Service Tool Notes 2-34
A. Procedure for Checking/Setting the Piston Pump Cut-off and Differential Pressures 2-36
B. Procedure for Checking/Setting the Pilot Supply Pressure 2-37
C. Procedure for Checking/Setting the Main Directional Control Valve, Load Sense, Lift and Telescope Pressures 2-38
D. Procedure for Checking/Setting Swing Pressure 2-40
E. Procedure for Checking/Setting the Swing Brake Release Pressure 2-41
F. Procedure for Checking/Setting Outrigger Pressure 2-41
G. Procedure for Checking Air Conditioning Operation. 2-43
H. Procedure for Checking/Setting the Center Front Stabilizer Pressure 2-44
I. Procedure for Checking/Setting the Front Steer Pressure. 2-44
J. Procedure for Adjusting Electronic Controllers (Meter-in Dead Band and/or Max Function Speeds). 2-46

DESCRIPTION

This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return hydraulic circuit, hydraulic pumps, all hydraulic valves, and all hydraulic cylinders. Detailed descriptions and operation of individual hydraulic circuits are discussed within their individual sections as applicable.

A complete hydraulic system schematic showing all options is at the back of this manual. Figure 2-1 provides A.N.S.I graphical symbols and Figure 2-2 provides hydraulic symbol information for this section.

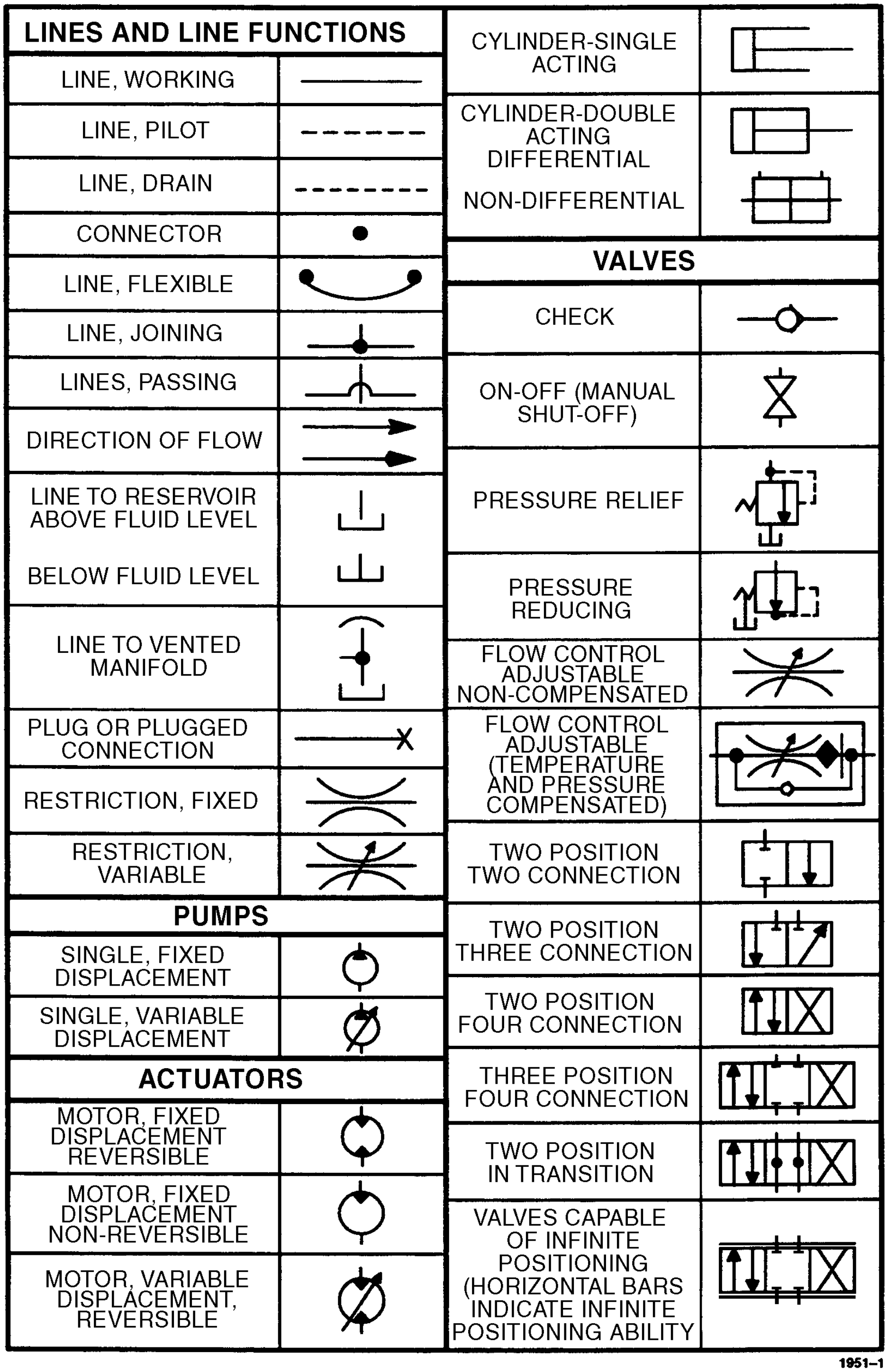

LINES AND LINE FUNCTIONS
LINE, WORKING
LINE, PILOT
LINE, DRAIN
CONNECTOR
LINE, FLEXIBLE
LINE, JOINING
LINES, PASSING
DIRECTION OF FLOW
LINE TO RESERVOIR ABOVE FLUID LEVEL
BELOW FLUID LEVEL
LINE TO VENTED MANIFOLD
PLUG OR PLUGGED CONNECTION
RESTRICTION, FIXED
RESTRICTION, VARIABLE
PUMPS
SINGLE, FIXED DISPLACEMENT
SINGLE, VARIABLE DISPLACEMENT
ACTUATORS
MOTOR, FIXED DISPLACEMENT REVERSIBLE
MOTOR, FIXED DISPLACEMENT NON-REVERSIBLE
MOTOR, VARIABLE DISPLACEMENT, REVERSIBLE
CYLINDER-SINGLE ACTING
CYLINDER-DOUBLE ACTING DIFFERENTIAL
NON-DIFFERENTIAL
VALVES
CHECK
ON-OFF (MANUAL SHUT-OFF)
PRESSURE RELIEF
PRESSURE REDUCING
FLOW CONTROL ADJUSTABLE NON-COMPENSATED
FLOW CONTROL ADJUSTABLE (TEMPERATURE AND PRESSURE COMPENSATED)
TWO POSITION TWO CONNECTION
TWO POSITION THREE CONNECTION
TWO POSITION FOUR CONNECTION
THREE POSITION FOUR CONNECTION
TWO POSITION IN TRANSITION
VALVES CAPABLE OF INFINITE POSITIONING (HORIZONTAL BARS INDICATE INFINITE POSITIONING ABILITY
1951–1

FIGURE 2-1

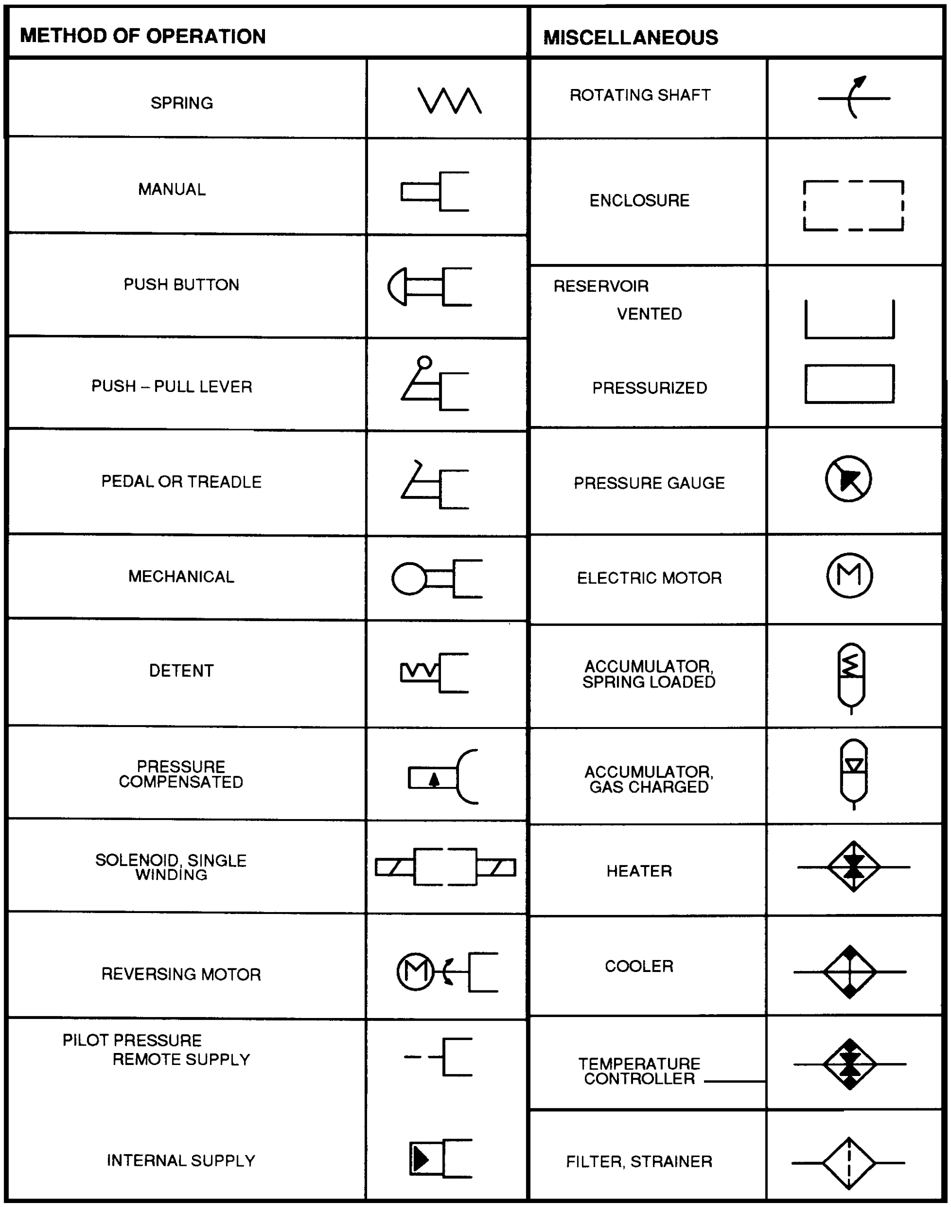


FIGURE 2-2

Maintenance

Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to *Standard Lubricants*, page 9-2.

Draining and Flushing

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

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

.

CAUTION

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

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

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

CAUTION

Machine Damage Hazard!

When draining the outrigger jack 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. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
18. Connect the return line to the main hoist motor and fully hoist down, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
19. Repeat Steps 17 and 18 for the auxiliary hoist as necessary.
20. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
21. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

Machine Damage!

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

Incompatible hydraulic oils can damage the components or system.

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

Removing Air from the Hydraulic System

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

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

> Seal all normal openings in the hydraulic system and the reservoir. Using a positive means to control the pressure (like a regulator), pressurize the hydraulic system to 13.8 to 27.6 kPa (2 to 4 psi) and inspect all joints and fittings for evidence of leaks. A soap solution applied to the fittings and joints may also prove helpful in detecting

minute leaks while the system is pressurized. Remove the pressure, repair any leaks found, and reopen any openings (such as a vent) closed for inspection. Refill the reservoir after completing any repairs or service. Operate all hydraulic circuits several times in both directions.

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

WARNING

Projectile Hazard!

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

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

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

WARNING

Skin Injection Hazard!

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

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

In the event that air entrapment should persist, bleeding of air by loosening various clamp and screw-type fittings may become necessary.

If the above procedures fail to eliminate air entrapment, contact your authorized Grove Distributor.

Parts Replacement

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

SUPPLY PRESSURE AND RETURN CIRCUIT

Description

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the hydraulic pumps to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, two hydraulic pumps, a hydraulic oil cooler, and a 5-port hydraulic swivel. Refer to *Hydraulic Pumps*, page 2-11 in this section for descriptions and maintenance instructions for each hydraulic pump. Refer to *Hydraulic Swivel*, page 6-16 for description and maintenance instructions for the 5-port hydraulic swivel.

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

Hydraulic Reservoir and Filter

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

Hydraulic Reservoir Capacities

Level	Capacity
Total Reservoir	458 L (121 gallons)
Full Level	405 L (107 gallons)
Low Level	374.8 L (99 gallons)
Expansion Volume	53.8 L (14.2 gallons)

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

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

Multiple magnetized drain plugs in the bottom of the reservoir collect metal particles from the hydraulic oil if it becomes contaminated.

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

A filler cap (2), (Figure 2-3) on the top of the reservoir is for filling the reservoir. The filler cap includes a strainer for catching contaminants and gaskets to prevent leaking. A breather cap (vent) is located on top of the reservoir to allow air to enter or exhaust to escape from the reservoir. It is most important that the breather be kept clean to prevent damage to the reservoir.

A large access cover on the top of the reservoir provides access for cleaning. The cover is secured to the top of the reservoir with a bolt clamp. The access cover can also be used to fill the reservoir after it has been completely drained.

The hydraulic oil filter (Figure 2-3) and (Figure 2-4) is located in the reservoir. It is installed to the top of the reservoir, and its bypass outlet is integral to the filter housing. The filter housing contains a replaceable filter element. Returning hydraulic oil flows through the filter head, through the filter element, and into the reservoir.

A restriction indicator connected to the filter head indicates the amount of filter restriction. When back pressure caused by a dirty filter element exceeds 170 kPa (25 psi), the filter head’s bypass feature functions to allow the hydraulic oil to bypass the filter element and flow into the reservoir through the bypass outlet instead.

Hydraulic Reservoir Filling Breather Filter

The Hydraulic Reservoir Filling Breather Filter element filters the air in and out of the oil reservoir as the level changes. The breather incorporates a filter to strain the oil when adding to the tank. The breather should be replaced when the hydraulic oil filter is changed, 6 months or 500 hours.

Hydraulic Reservoir Temperature Sending Unit

The Temperature Sender can be damaged by over-torquing. Use the following torques when installing this device:

- Temperature Sender - 10.8 ± 20 N-m (8 ± 2 lb-ft).

Pump Distribution

No. 1 and 2 Pump

Pump No. 1 is a gear pump mounted to the front gear accessory drive and has a displacement of 39.3 cu cm (2.4 cu in). Pump No. 2 is a variable displacement piston pump driven by the engine PTO and is mounted to the carrier frame. The pump has a displacement of 140 cu cm (8.54 cu in).

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

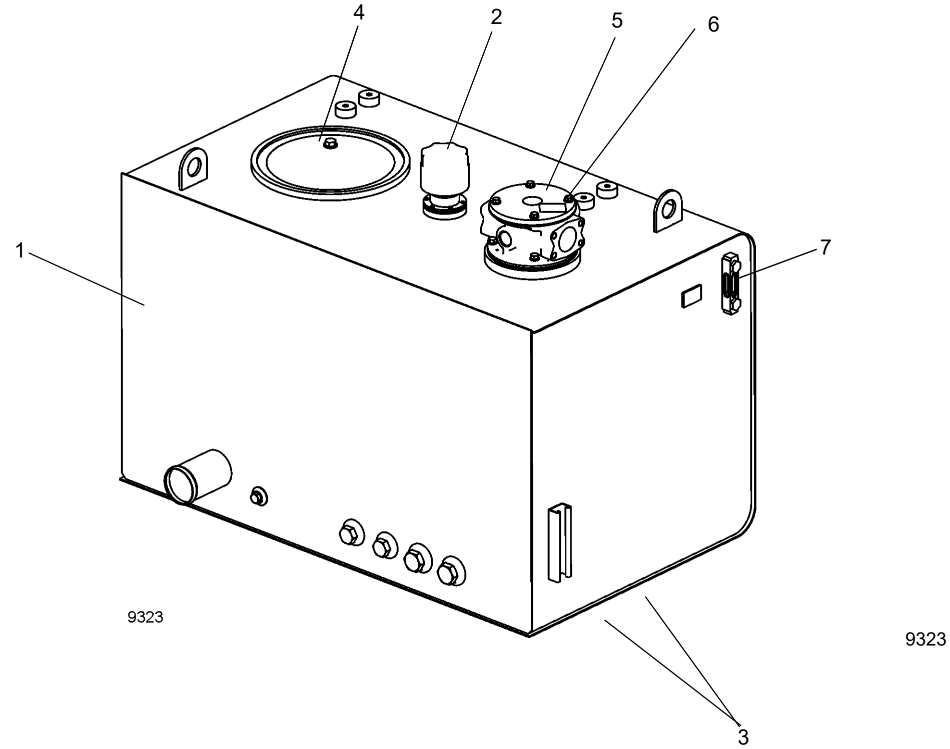


FIGURE 2-3

Item	Description
1	Reservoir
2	Filler Cap with Breather
3	Magnetic Drain Plugs (Under tank)
4	Access Cover

Item	Description
5	Return Filter
6	Lock Washers
7	Sight Glass

MAINTENANCE

Troubleshooting

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

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

RETURN HYDRAULIC FILTER ASSEMBLY

Environmental Protection

Dispose of waste properly! Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Grove cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

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

When filling and draining crane components:

- Do not pour waste fluids onto the ground, down any drain, or into any source of water.
- Always drain waste fluids into leak proof container clearly marked with what they contain.
- Always fill or add fluids with a funnel or filling pump.
- Immediately clean up spills.

Element Removal

WARNING

Skin Injection Hazard!

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

Wear gloves when working with hydraulic system components.

Refer to Figure 2-4 to Remove Element.

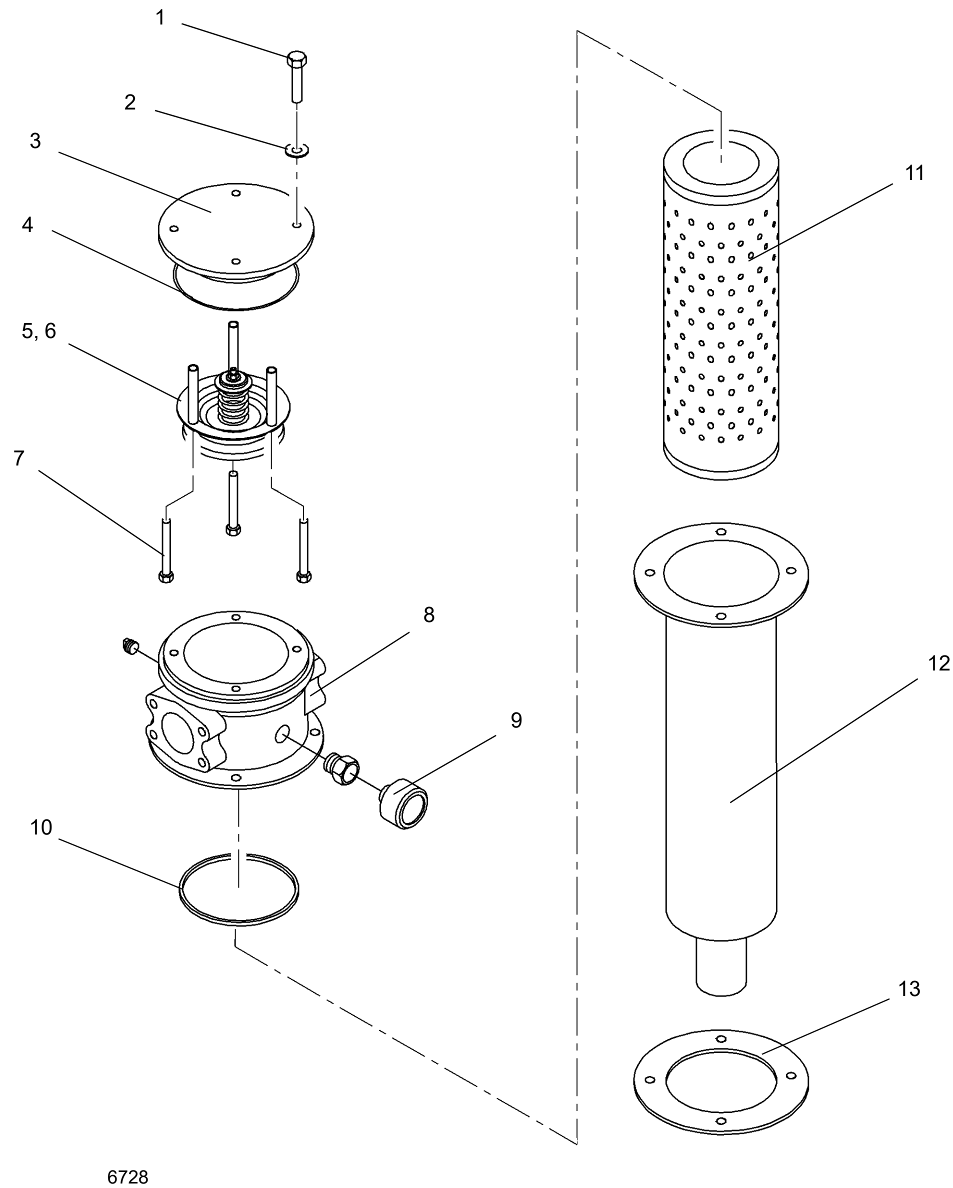
1. Shut down all hydraulic systems.
2. Wipe any dirt from the filter head and cap assembly.

NOTE: The bypass valve (5), (Figure 2-4) assembly is installed to the cap and is removed with the cap.

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

Element Installation

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



Item	Description
1	Capscrew
2	Washer
3	Cap
4	O-ring
5	Bypass Valve
6	Spacer
7	Capscrew

Item	Description
8	Filter Head
9	Gauge
10	O-ring
11	Element
12	Bowl
13	Gasket

FIGURE 2-4

HYDRAULIC PUMPS

Description

The engine drives the No. 1 gear pump (Figure 2-5) mounted to the air compressor. The No. 1 gear pump supplies the front axle power steering gear and the swing function.

The No. 2 variable displacement piston pump (Figure 2-7) is frame mounted above the transmission and is driven by a drive shaft attached to the engine PTO. The pump supplies the main hoist, lift, telescope and aux hoist functions which are in the same directional control valve.

Maintenance

CAUTION

Machine Damage!

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

No. 1 Pump Removal

Removal of No. 1 Pump (Refer to Figure 2-5).

1. Remove the engine cover to gain access to the pump.
2. Remove the capscrews, flatwashers and O-Ring (Figure 2-4) securing the hydraulic tank hose assembly to the pump.
3. Tag and disconnect all other lines from the pump. Cap all lines and ports.

CAUTION

Machine Damage!

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

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

No. 1 Pump Installation

1. Install a new gasket to the pump mounting flange.
2. Install No. 1 pump on the front cover accessory drive with capscrews and flatwashers. Make sure that the spline teeth mesh properly. Torque capscrews according to *Fasteners and Torque Values*, page 1-14.
3. Connect the distribution and supply lines as tagged during removal.
4. Install the hydraulic tank hose to the pump and secure with the capscrews, flatwashers and O-Ring (Figure 2-4). Torque capscrews according to *Fasteners and Torque Values*, page 1-14.
5. Before start-up, the pump needs to be primed, refer to *Gear Pump Inlet Port Air Purge/Bleed*, page 2-12.

No. 2 Pump Removal

Removal of No. 2 Pump, (refer to Figure 2-5)

1. Remove the pump cover to gain access to the pump.
2. Remove the PTO driverline, capscrews, flatwashers and O-Ring (Figure 2-4) securing the hydraulic hose assembles to the pump. Tag all hoses for reassembly. Cap all lines and ports.
3. Remove the capscrews and lockwashers (Figure 2-5) attaching the pump mounting bracket to the frame. Remove the pump assembly.

CAUTION

Crushing Hazard!

The pump assembly weighs approximately100 kg (220 lbs). Use an appropriate lifting device to lift the pump.

CAUTION

Machine Damage!

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

4. Remove the capscrews and flatwashers (Figure 2-5) securing the pump to the pump mounting bracket. Remove the pump.

No. 2 Pump Installation

Refer to Figure 2-4.

CAUTION

Crushing Hazard!

The pump assembly weighs approximately100 kg (220 lbs). Use an appropriate lifting device to lift the pump.

1. Install the pump to the mounting bracket. Torque capscrews according to *Fasteners and Torque Values*, page 1-14.
2. Install the pump assembly onto the frame. Align the splines to the PTO driveline.Torque capscrews according to *Fasteners and Torque Values*, page 1-14.
3. Install the hydraulic hoses to the pump and secure with the capscrews, flatwashers and O-Ring (Figure 2-4). Torque capscrews according to *Fasteners and Torque Values*, page 1-14.

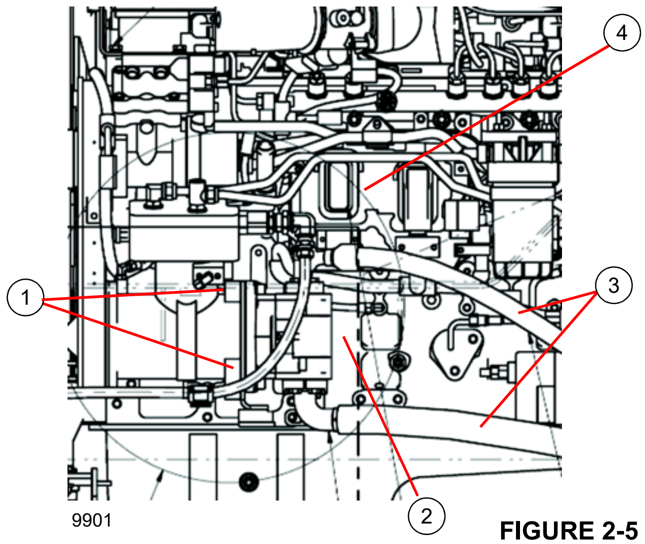


FIGURE 2-5

Item	Description
1	Capscrews and Lock Washers
2	Pump No. 1
3	Hydraulic Tank Hoses
4	Engine

Pump Priming Tool

The Pump Priming Tool (Figure 2-6), P/N 80030367, available from Manitowoc Crane Care, is used to prime the pumps after they have been removed from the crane.

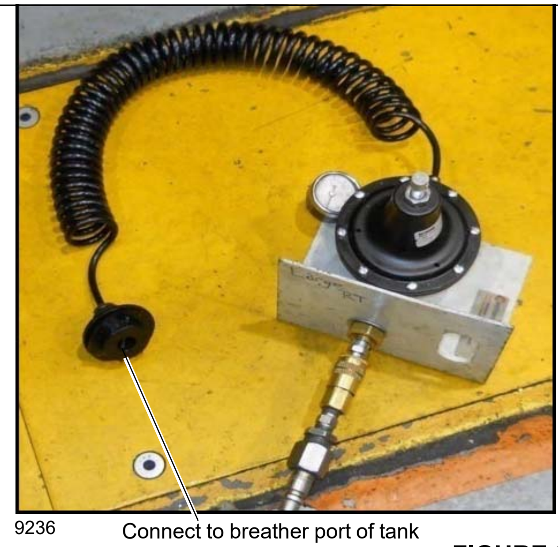


FIGURE 2-6

Gear Pump Inlet Port Air Purge/Bleed

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

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

1. Crack open the inlet port hose from the pumping section.
2. Remove the hydraulic reservoir mounted breather, install the Pump Priming Tool and connect it to a shop air source.
3. When a solid stream of fluid, free of air bubbles exits the hose, reinstall the hose to the pump while the fluid is still coming out.
4. Remove the shop air supply from the Pump Priming Tool.
5. Torque hose connections to the specified Manitowoc torque setting. (Refer to *Fasteners and Torque Values*, page 1-14.)

Gear Pump Outlet Port Air Bleeding:

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

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

1. Install the pump priming tool and connect to a shop air source.
2. Bleeding to be done after fluid and inlet checks are made.
3. Remove the outlet hose from the pump.
4. Jog the engine starter until a solid stream of air free fluid exits the pump.
5. Remove the shop air supply from the pump priming tool and re-tighten the hose to the pump following the proper Manitowoc torque specifications. Refer to *Fasteners and Torque Values*, page 1-14.).

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

1. Make sure the hydraulic reservoir is filled to the proper level and the fluid is not aerated. If so, let unit sit until air has escaped and the fluid is a dark solid color.
2. If the circuit includes an air conditioning compressor drive motor, make sure it is in the OFF position before initial start up.
3. Start the engine and let idle for 2-3 minutes with NO crane functions actuated. If the pump outlet becomes too warm to keep your hand on comfortably, stop the engine immediately.
4. Slowly increase the engine speed to approximately 1500 RPM and hold for no longer than 1 minute and make the same checks as outlined previously.
5. Slowly increase engine speed to full RPM and hold for no longer than one minute while making the same checks as outlined previously.
6. At full engine RPM, cycle all functions fully extending and retracting the cylinders to their stop position to verify operation and that the pump stays quiet and does not become excessively hot.

Testing After Rebuild or Replacement

CAUTION

Pump Damage!

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

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

CAUTION

Pump Damage!

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

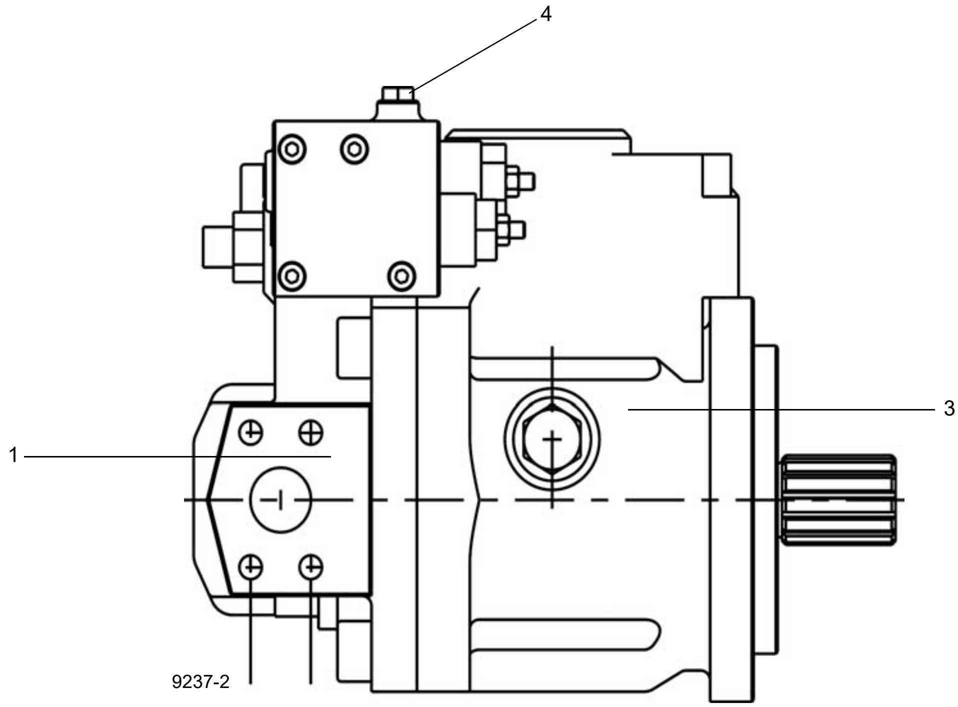
2. Touch pump to verify it has not become hot from binding. Listen for abnormal noises indicating low hydraulic oil level or internal pump problems. If the pump appears to be operating satisfactorily, increase the RPM by steps, until reaching governed RPM. Operate pump about five minutes while checking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

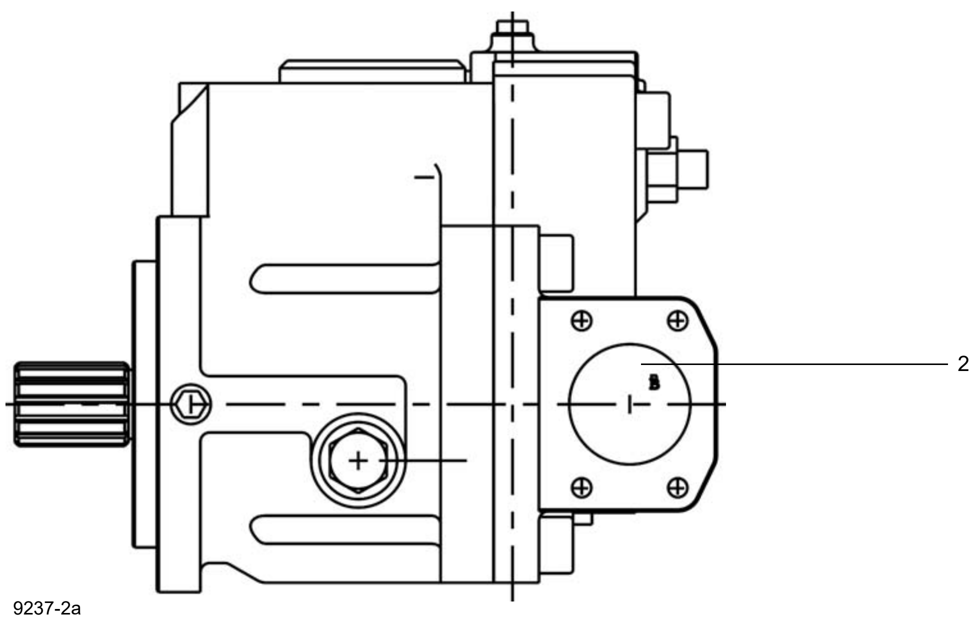
Piston Pump Air Purge/Bleed and Case Filling

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

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

2. Remove the adapter and hose from the Dr Port. Fill the pump casing with the same hydraulic fluid that was used to fill the reservoir. When full, re-install the adapter and hose using the specified Manitowoc torque setting.
3. Remove the plug from pump port T air (Figure 2-7).
4. Remove the hydraulic reservoir mounted breather, install the Pump Priming Tool and connect it to a shop air source.
5. When a solid stream of fluid, free of air bubbles exits the T air port, reinstall the plug to port T air at 12 N-m (9ft lbs) while fluid is still coming out.
6. Remove the shop air supply from the pump priming tool.
7. Remove the pump priming tool and reinstall the breather.





Item	Description	Port Sizes
1	A	SAE J518C Code 62 1 1/4”
2	B	SAE J518C Code 61 2 1/2”
3	Dr	SAE J1926/1 ORB-12 1 1/16-12 UN-2B THD
4	PL	SAE J1926/1 ORB-04 7/16-20 UNF-2B THD

FIGURE 2-7

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

1. Make sure the hydraulic reservoir is filled to the proper level and that the fluid is not aerated. If it is aerated, let the unit sit until the air has escaped and fluid is a dark solid color.
2. If the circuit includes an air conditioning compressor drive motor, make sure it is in the OFF position before initial start up.
3. Start the engine and let idle for 2-3 minutes with NO crane functions actuated. If the pump outlet becomes too warm to keep your hand on comfortably, stop the engine immediately.
4. Slowly increase the engine speed to approximately 1500 RPM and hold for no longer than one minute and make the same checks as outlined previously.
5. Slowly increase engine speed to full RPM and hold for no longer than one minute while making the same checks as outlined previously.
6. At full engine RPM, cycle all functions fully extending and retracting the cylinders to their stop position to verify operation and that the pump stays quiet and does not become excessively hot.
7. Proceed to the pressure setting procedure.

CAUTION

Pump or Reservoir Damage!

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

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

The Pump Priming Tool is factory set at 7-14 kPa (1-2 psi) to lift the fluid to the inlet of the pumps and to prevent the reservoir from being over-pressurized and damaged. DO NOT ATTEMPT TO ADJUST IT. It is necessary to monitor the pressure gauge to ensure that 14 kPa (2 psi) is not exceeded during air bleeding and pump start-up to prevent possible reservoir damage. **Again, irreparable damage to the reservoir may occur.**

Pump No. 2 Assembly

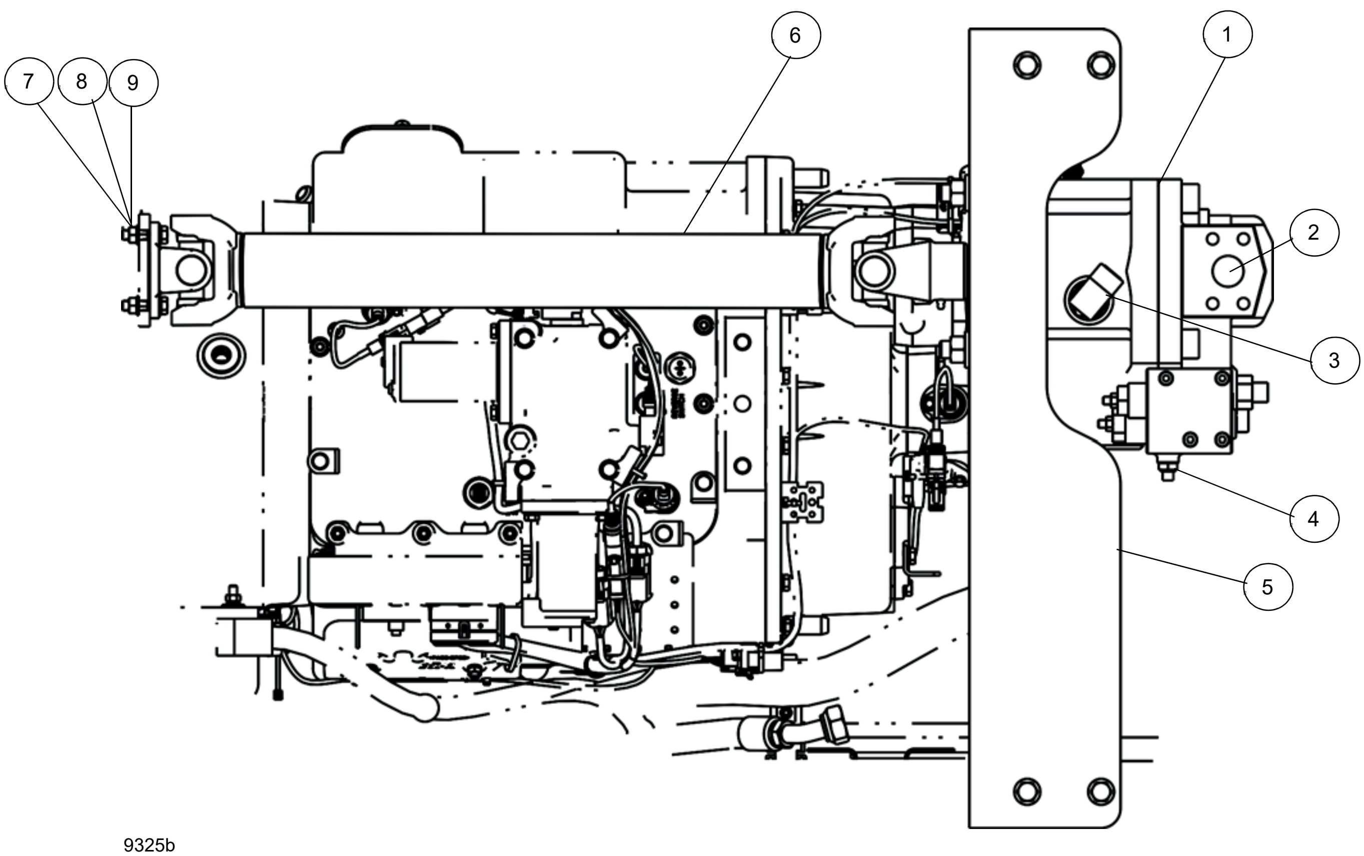


FIGURE 2-8

Item	Description
1	Pump, Variable Displacement
2	Outlet Port
3	90 Deg Elbow
4	Straight Thread Adapter
5	Assy Pump Support
6	Driveshaft Hydraulic Pump
7	Washer
8	HHCS
9	Hex Nut

CARRIER VALVES

General

This subsection provides descriptive information for the hydraulic valves used on this crane. For a listing of the valves, the carrier circuit they are used in, and their physical location, refer to VALVE USAGE TABLE - CARRIER. Refer to Figure 2-9 for valve locations. The description of each valve given here is for the valve itself. For information on how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

For information on the superstructure hydraulic components, refer to Figure 2-17.

.

VALVE USAGE TABLE - CARRIER

Valve Name	Circuit Used In	Physical Location
Outrigger Selector Manifold Valve	Outrigger	On front face of carrier frame front cross member forward of hydraulic swivel
Outrigger Control Manifold (2)	Outriggers	4 stack on rear outrigger box; 5 stack on front outrigger box
Pilot Operated Check Valve	Outrigger	
Swing/Steer Selector Valve	Swing/Steer	Front frame of the carrier.

.

VALVE USAGE TABLE - SUPERSTRUCTURE

Valve Name	Circuit Used In	Physical Location
Directional Control Valves	Boom Lift/Telescope(s)/Hoist(s) Swing	Superstructure Right Side Plate Superstructure Right Side Plate
Swing/Accessory Manifold	Swing Directional Control Swing Brake Release Pilot Supply	Superstructure Right Side Plate
Holding Valves	Boom Lift Telescope	Lift Cylinder (Bolt on Manifold) Cylinder Port Blocks (Cartridge Style)
Hoist Motor Control Valve	Hoist(s)	Both Hoists (See Hoist Section)
Check Valves	Return Circuit	One in Parallel with Oil Cooler

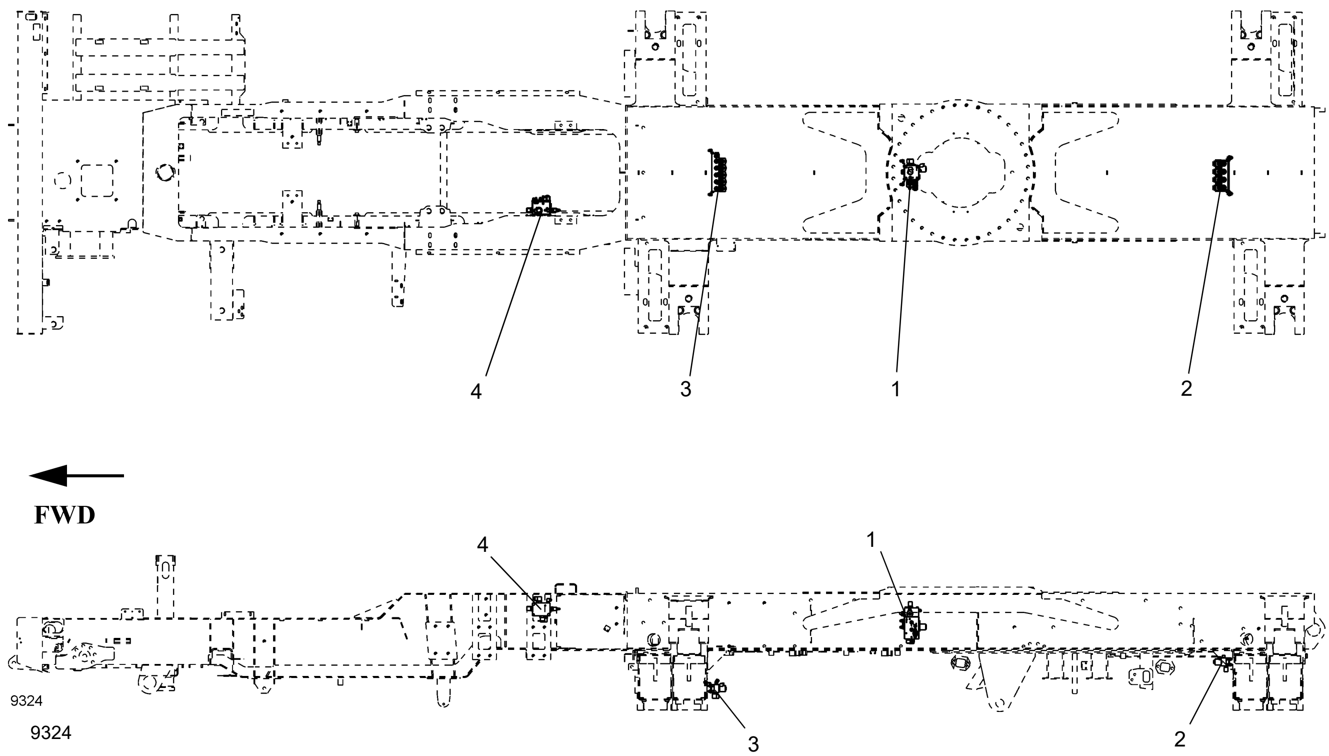


FIGURE 2-9

Item	Description
1	Outrigger Selector Manifold Valve
2	Rear Outrigger Manifold Valve

Item	Description
3	Front Outrigger Manifold Valve
4	Swing/Steer Selector Valve

OUTRIGGER SELECTOR MANIFOLD VALVE

Description

The outrigger selector manifold (Figure 2-10) directionally controls the outrigger circuit. The valve is mounted on the rear face of the carrier frame member forward of the swivel.

The valve inlet contains a pilot operated pressure reducing valve with the pressure in the neutral position limited to approximately 827 kPa (120 psi) via the bias spring. The manifold also has a proportional flow control. As current in increased, the flow is increased. The pilot pressure supplied to this reducing valve is controlled by a solenoid operated proportional pressure relief valve. As current is increased to this relief valve, the pressure allowed downstream of the reducing valve is increased.

The outrigger circuit contains two three-position closed center four-way valves. One is solenoid operated and controls the pilot supply to the other which is pilot operated. Activation of the outriggers will energize the solenoid operated flow control relief valve and the solenoid operated four-way sending a load sense pressure to the pump allowing it to supply flow to the circuit. This allows movement of the desired outrigger function while limiting the pressure and flow based on the function selected. See the *Pressure Setting Procedures*, page 2-33 for specific pressures.

Maintenance

Removal of Manifold Valve

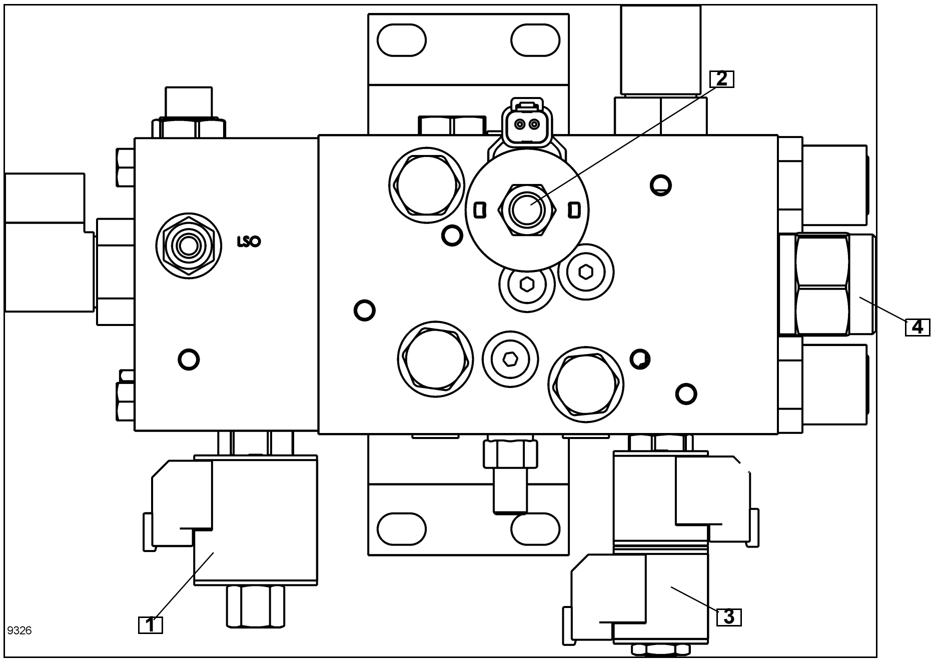
1. Tag and disconnect the electrical connectors to the outrigger selector valve.
2. Tag and disconnect the hydraulic lines to the integrated outrigger valve. Cap or plug the lines and ports.
3. Remove the capscrews, washers and nuts securing the outrigger selector valve to the frame. Remove the valve.

Installation of Manifold Valve

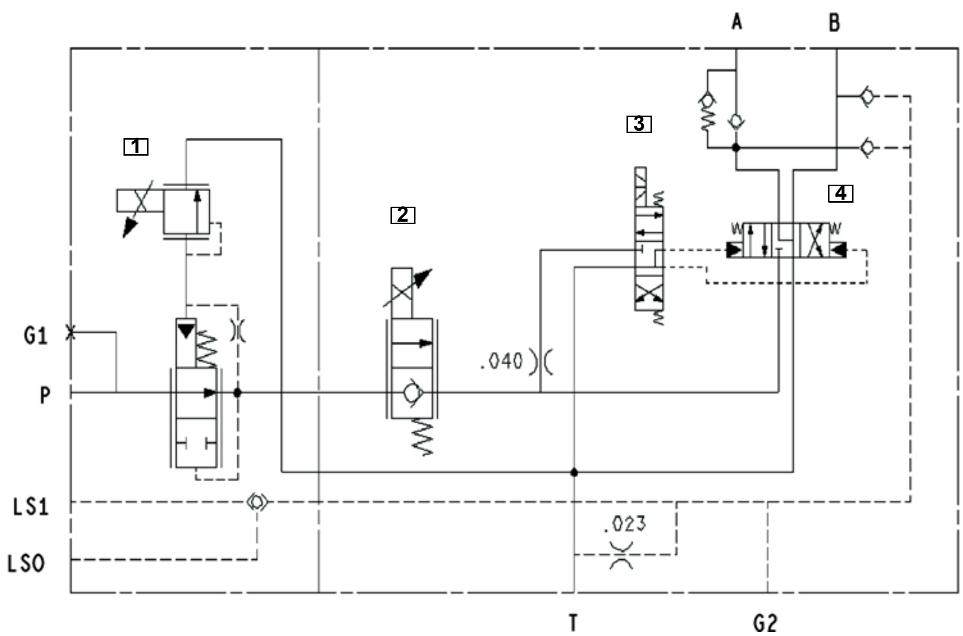
1. Install the fittings into the outrigger selector valve.
2. Install the outrigger selector valve to the frame. Secure the valve with the washers, nuts and capscrews. Torque the capscrews. Refer to *Fasteners and Torque Values*, page 1-14.
3. Connect the hydraulic lines to the outrigger valve as tagged during removal.
4. Connect the electrical connectors to the outrigger selector valve as tagged during removal.

Functional Check of Manifold Valve

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



9326



9239b

FIGURE 2-10

Item	Description
1	Solenoid Relief Valve
2	Proportional Flow Control Valve
3	4-way Solenoid Pilot Valve
4	4-way Outrigger Directional Valve

OUTRIGGER CONTROL MANIFOLD

Description

There are two outrigger control manifolds used on the crane, one for the front outriggers and center front stabilizer, and one for the rear outriggers. The front manifold (Figure 2-13) consists of five normally closed two-position two-way solenoid valves and a 200 psi (14 bar) check valve.The rear manifold (Figure 2-14) consists of four normally closed two-position two-way solenoid valves. They are mounted inside the frame of their respective outrigger box.

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

Maintenance

Removal of Outrigger Control Manifold

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

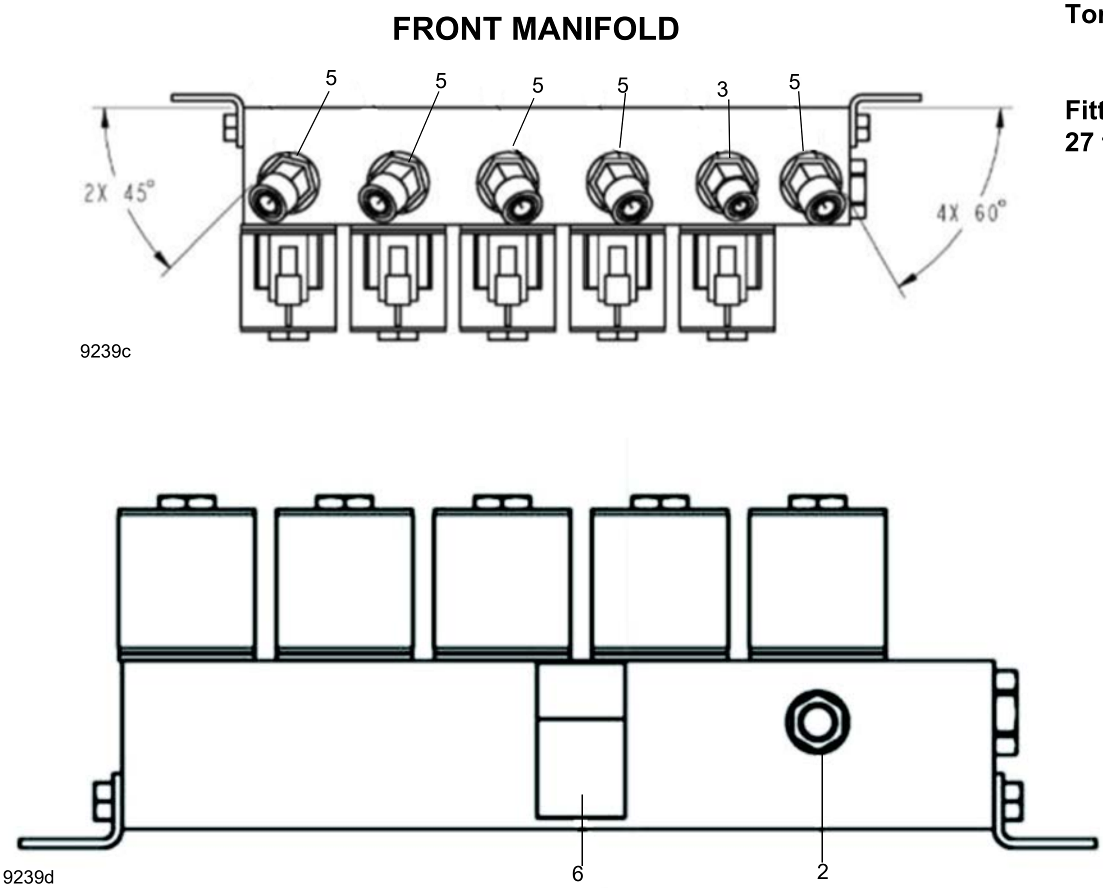
Inspection of Outrigger Control Manifold

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 of Outrigger Control Manifold

1. Install fittings and orient as shown in Figure 2-12 and Figure 2-12.
2. Position the manifold on the mounting; secure with the washers, nuts and bolts. Torque the cap screws. Refer to *Fasteners and Torque Values*, page 1-14.
3. Connect the electrical connectors to the solenoids as marked during removal.
4. Connect the hydraulic lines to the valves as marked during removal.

.



Fittings 5, 3, 6 Same Torque Value = 42 ft-lbs.

Fitting 2 Torque Value = 27 ft-lbs.

FIGURE 2-11

.

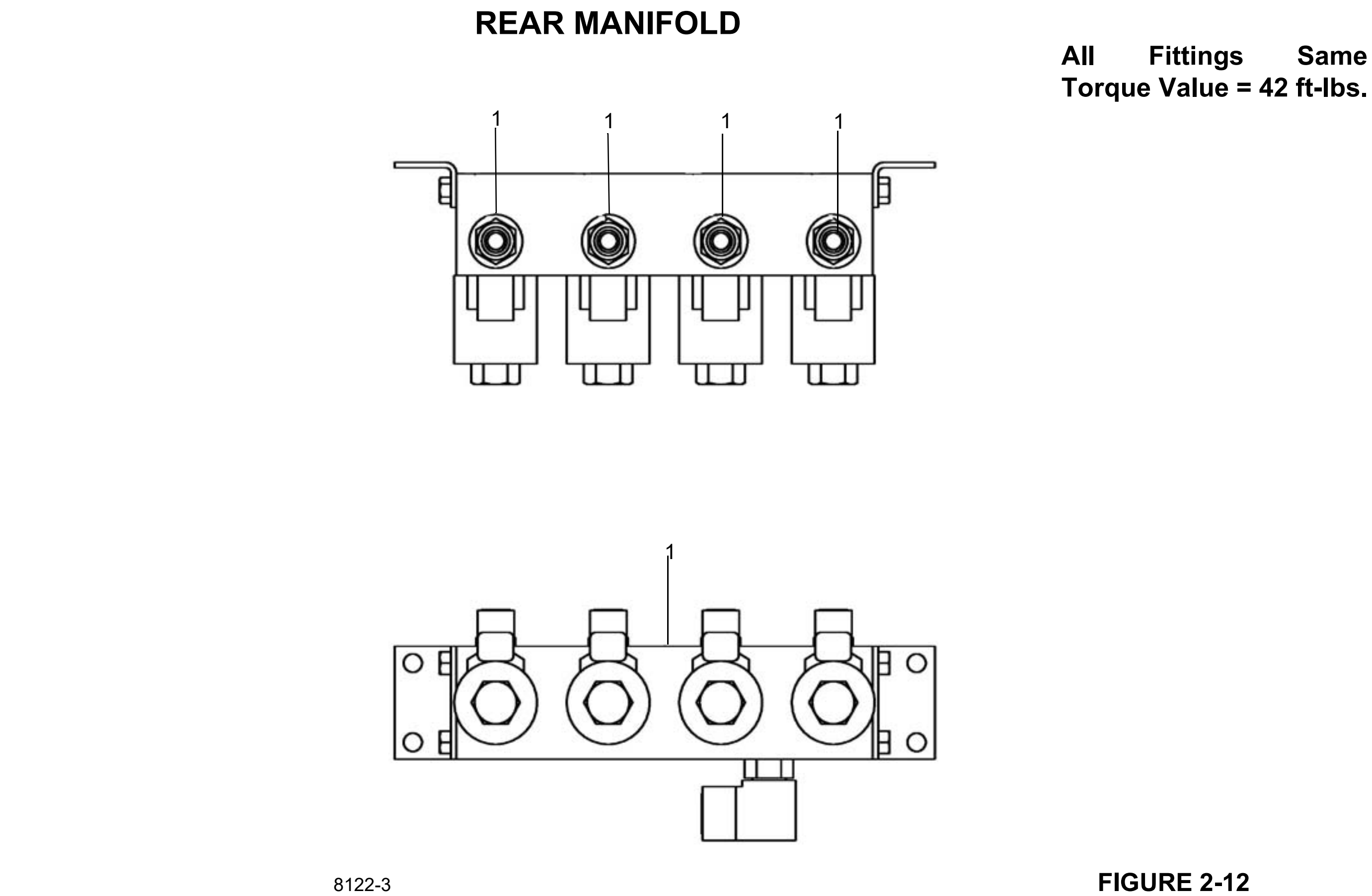


FIGURE 2-12

Changing Solenoid Valves

To change the solenoid valve,

1. Unscrew and remove the old solenoid value.
2. Screw the new valve into the manifold. Torque solenoid valves to 24-26 ft-lbs.

Functional Check

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

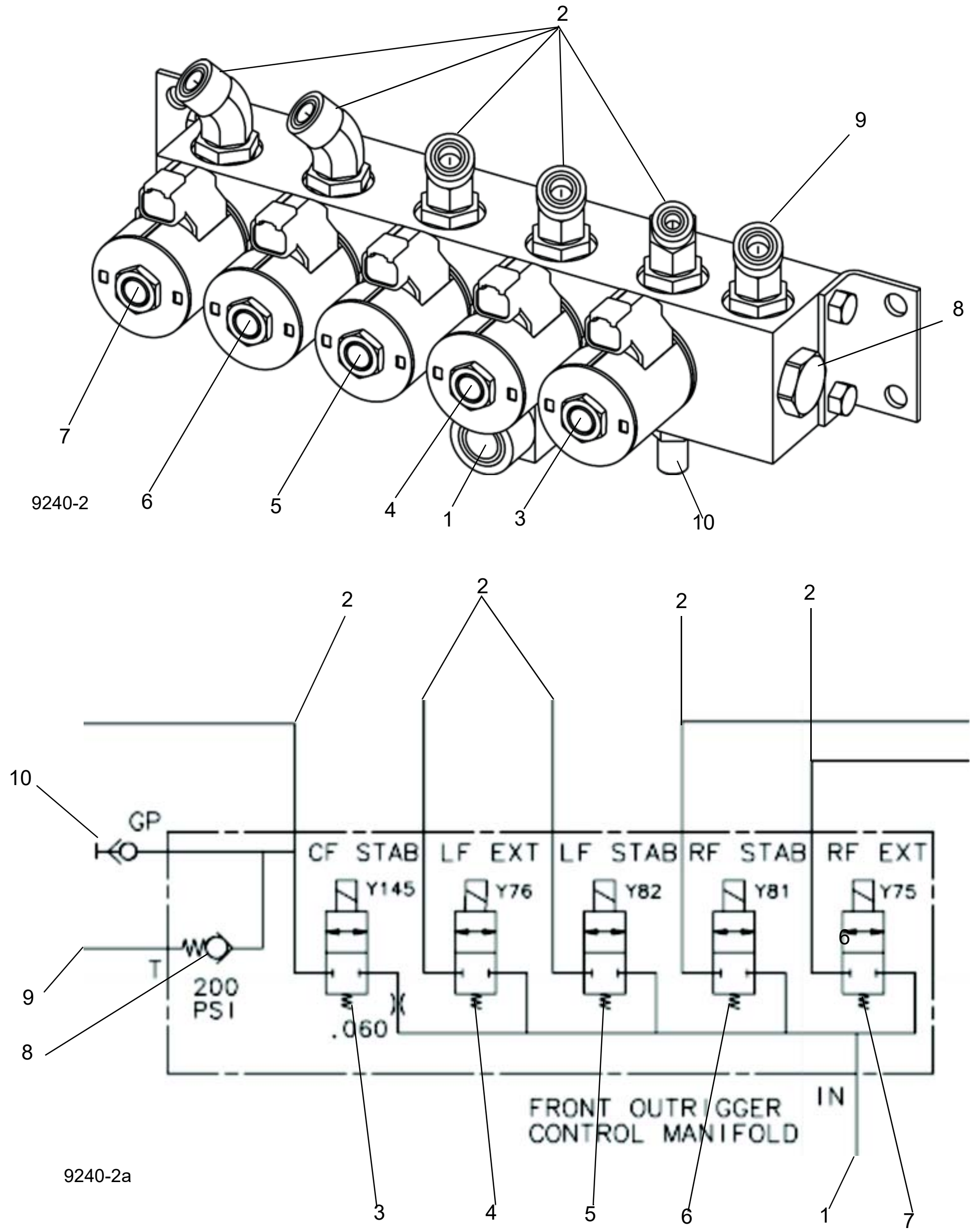


FIGURE 2-13

Item	Description
1	In Port
2	Out Ports
3	Center Front Stabilizer
4	Left Front Extension Cylinder
5	Left Front Jack Cylinder
6	Right Front Jack Cylinder
7	Right Front Extension Cylinder
8	Check Valve
9	Tank
10	Gauge Port

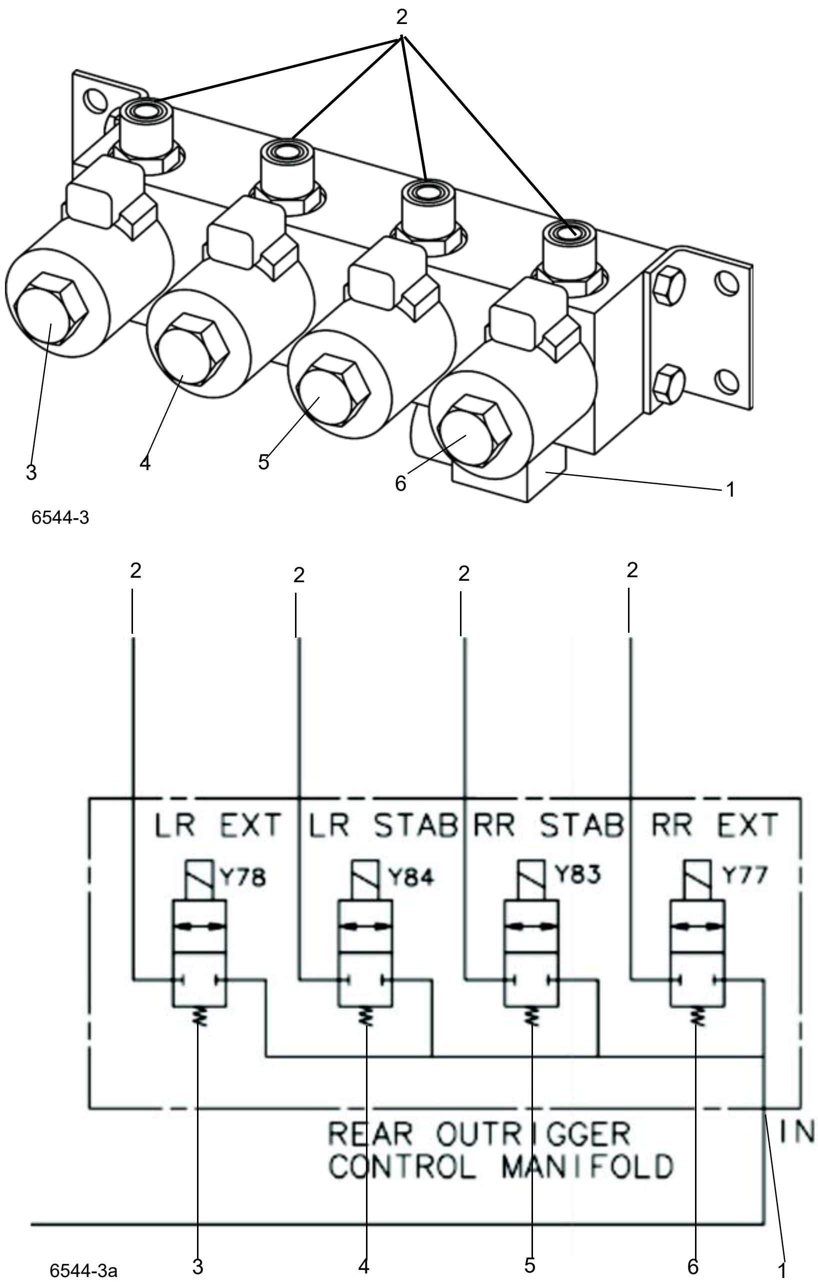


FIGURE 2-14

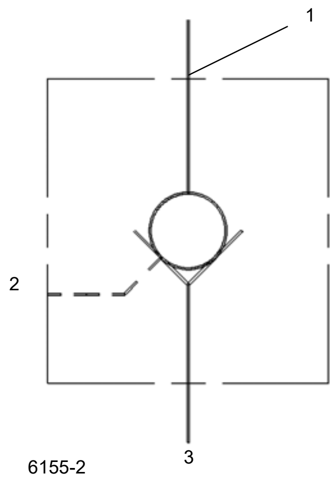
Item	Description	Item	Description
1	In Port	4	Left Rear Jack Cylinder
2	Out Ports	5	Right Rear Jack Cylinder
3	Left Rear Extension Cylinder	6	Right Rear Extension Cylinder

PILOT OPERATED CHECK VALVE

Description

A pilot operated (PO) check valve is located in each outrigger jack cylinder port block. The check valve functions as a holding valve for the jack cylinder. Oil flow is directed from the “V” port to the “C” ports, while blocking flow in the opposite direction. Flow is reversed from “C” to “V” when pressure pilot oil is applied to the opposite side “V” port (Figure 2-15).

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



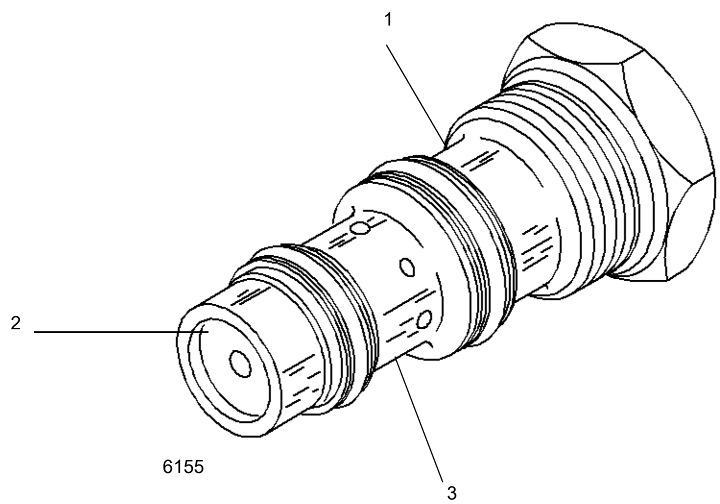


FIGURE 2-15

Internal Leak Testing

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

CAUTION

Machine Damage!

Perform the following procedure with the crane set up on outriggers and the crane in the travel position. Only remove the hoses from one cylinder at a time.

Check Cylinder for Internal Piston Seal Leak

With machine set up on outriggers remove the rod side cylinder hose from the suspected leaking stabilizer cylinder. (See Figure 2-16).

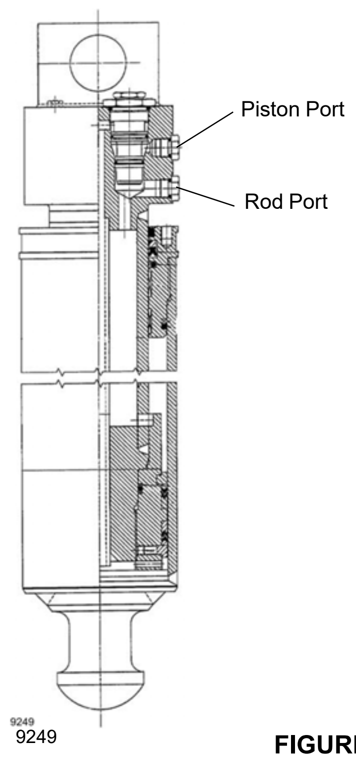


FIGURE 2-16

CAUTION

Personal Injury Hazard!

Release hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port PO check valves in the outrigger selector valve.

Hydraulic oil is under pressure that can cut and inject into the skin.

Always wear gloves when working with hydraulic system components.

Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the rod side port (Figure 2-16).

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

If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking (Figure 2-16).

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

Test PO Check Valve For Leakage

Remove the piston side hose from the port block of the cylinder see Figure 2-16.

CAUTION

Personal Injury Hazard!

Release hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port PO check valves in the outrigger selector valve.

Hydraulic oil is under pressure that can cut and inject into the skin.

Always wear gloves when working with hydraulic system components.

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

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

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

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

Maintenance

Removal of PO Check Valve

NOTE: If the cylinder has not been removed, the cylinder pin must be removed before the PO check valve can be removed.

WARNING

Projectile Hazard!

There must not be any load on the jack cylinder when removing check valve to prevent the valve from becoming a projectile. Make sure there is no load on the outrigger jack before removing the outrigger jack cylinder holding valve.

1. With no load on the cylinder, unscrew the check valve from the jack cylinder port block.

Installation of PO Check Valve

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

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

CAUTION

Damage Could Occur!

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

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

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

Superstructure Hydraulic Valves

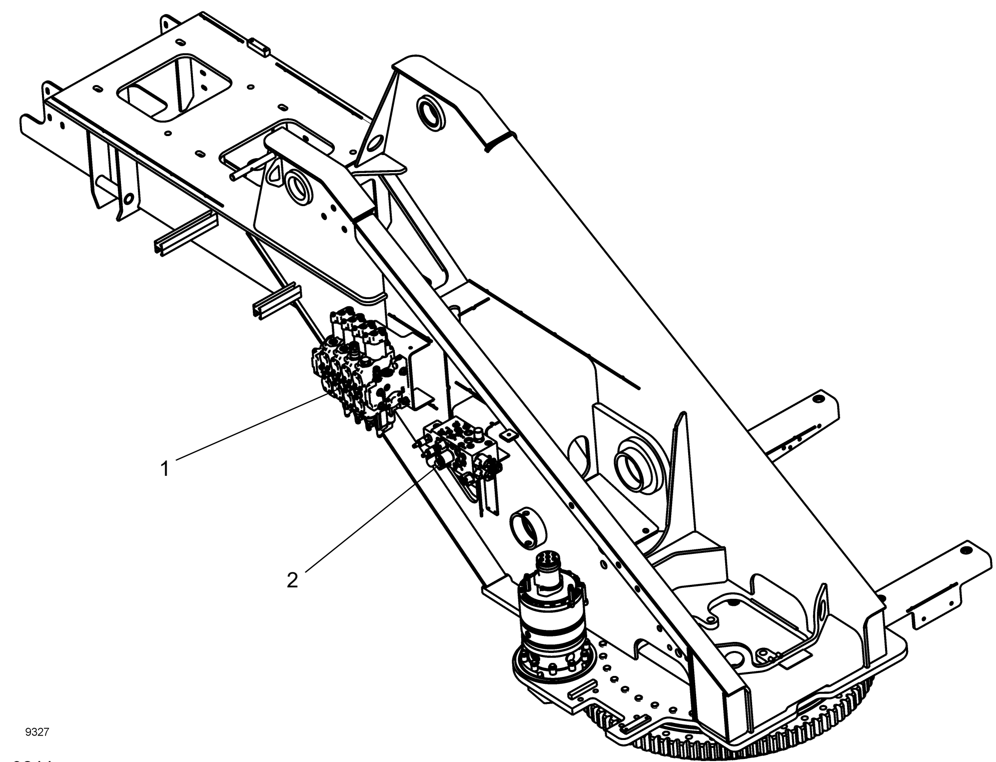


FIGURE 2-17

Item	Description
1	Main Directional Valve Assembly
2	Accessory Manifold

Main Directional Valve Assembly

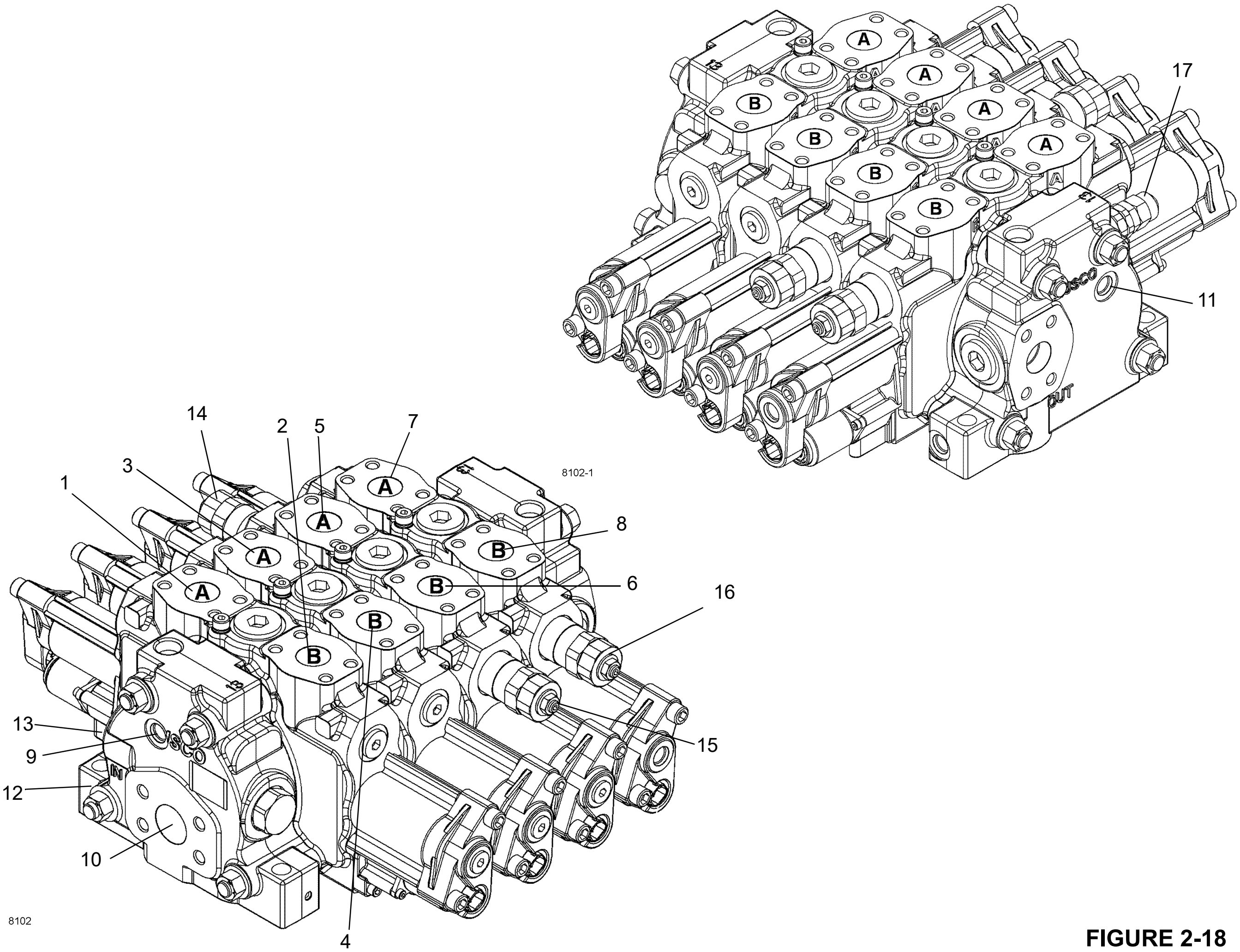
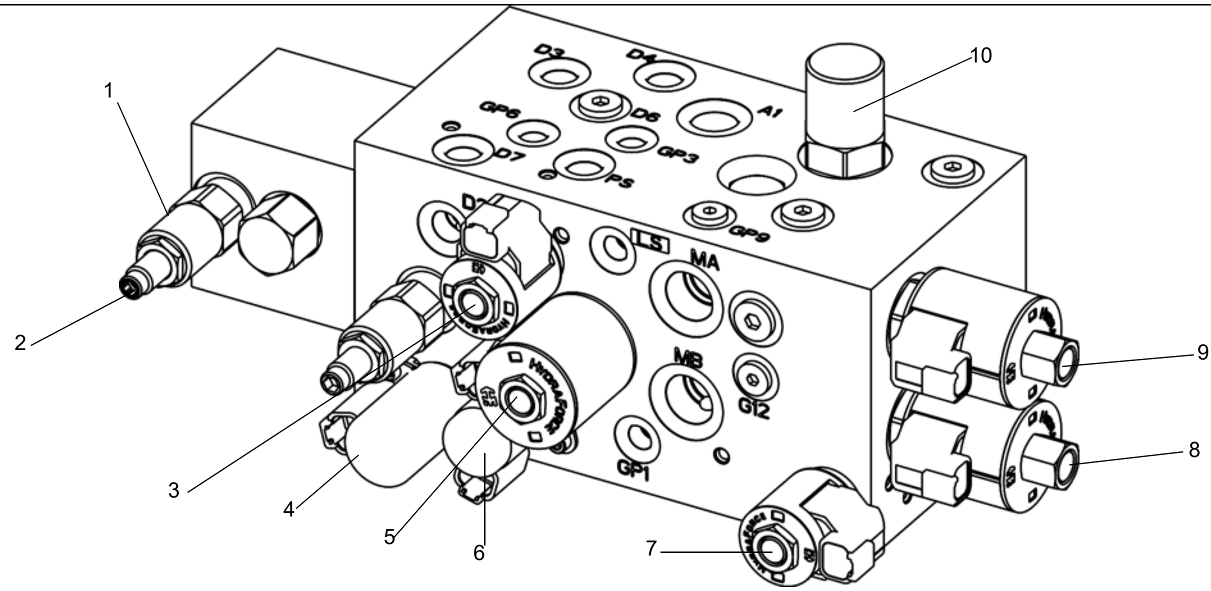


FIGURE 2-18

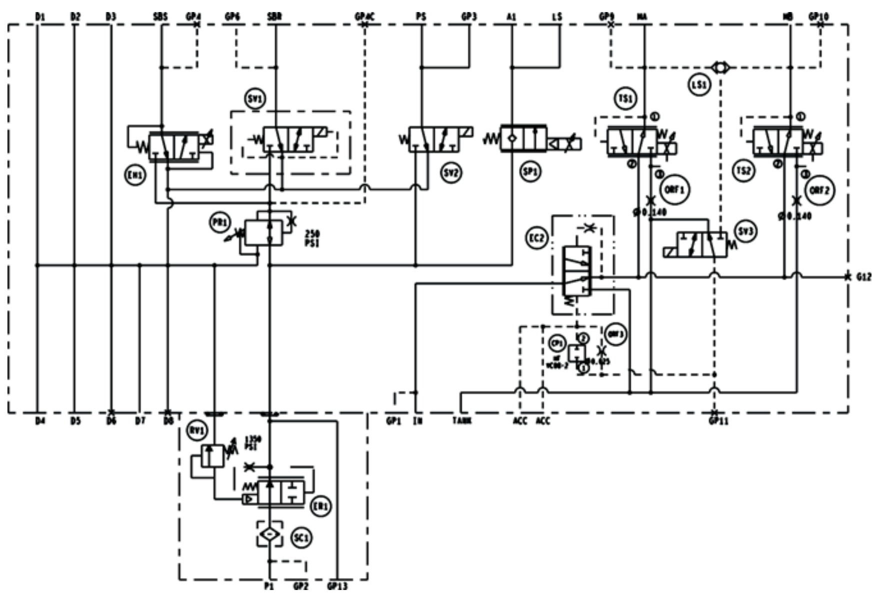
Item	Description
1	Port 1A -Main Hoist Down
2	Port 1B - Main Hoist Up
3	Port 2A - Aux Hoist Down
4	Port 2B - Aux Hoist Up
5	Port 3A - Telescope Extend
6	Port 3B - Telescope Retract
7	Port 4A - Lift Up
8	Port 4B - Lift Down
9	Load Sense - Outlet Port
10	Port P1 - From Swivel Port 6

Item	Description
11	Load Sense - Inlet Port
12	Port PS - Pilot Supply
13	Gauge Port
14	Relief Valve - Telescope Extend
15	Relief Valve - Telescope Retract
16	Relief Valve - Lift
17	Relief Valve - Load Sense

Accessory Manifold Assembly



9328-1



9328-4

FIGURE 2-19

Item	Description
1	Air Conditioning Relief Adjustment
2	Swing Brake Release Relief Adjustment
3	Joystick Pilot Supply Solenoid and Valve - SV2
4	Swing Brake Solenoid Valve - EH1
5	Air Conditioning Solenoid and Valve - SP1

Item	Description
6	Swing Brake Release Solenoid Valve - SV1
7	Load Sense Dump Solenoid Valve - SV3
8	Swing Left Solenoid Valve - TS1
9	Swing Right Solenoid Valve - TS2
10	Pressure Compensating Value-Swing

SUPERSTRUCTURE HYDRAULIC SYSTEM

WARNING

Skin Injection Hazard!

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

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

Checking for Leaks

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

WARNING

Danger of Accidents!

Never tighten leaking connections when the system is under pressure. Only change seals, pipes, and hoses when the system is depressurized.

If damage cannot be rectified immediately, further damage is likely:

- Inform Manitowoc Crane Care or your repair personnel.

CAUTION

Risk of Environmental Damage Due to Leaking Consumables!

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

CYLINDERS

General

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

Any items related to Cylinders, please contact Crane Care for service and/or repair information.

Maintenance

General

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

The approximate Wear Ring Gaps are indicated in the following table:

WEAR RING GAP

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

Leakage Check

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

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

WARNING

Injury Could Occur!

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

2. Apply hydraulic pressure to the piston side of the cylinder and observe the open cylinder port for leakage. If leakage is observed, the seals in the cylinder must be replaced.

3. Fully retract the cylinder rod. Remove the extend hose from the cylinder. Cap the extend hose.

WARNING

Injury Could Occur!

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

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

5. Reconnect all cylinder ports.

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

Temperature Effects On Hydraulic Cylinders

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

Thermal contraction coupled with improper lubrication or improper wear pad adjustments may, under certain conditions, cause a “stick-slip” condition in the boom. This “stick-slip” condition could result in the load not moving smoothly. Proper boom lubrication and wear pad adjustment is important to permit the boom sections to slide freely. Slow movement, of the boom may be undetected by the operator unless a load is suspended for a long period of time. To minimize the effects of thermal contraction or “stick-slip”, it is recommended that the telescope control lever 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, the trapped oil in the cylinders will cool. The load will lower as the telescope cylinder(s) retracts allowing the boom to come in. Also, the boom angle will decrease as the lift cylinder(s) retracts causing an increase in radius and a decrease in load height.

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

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

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

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

Coeff. =	0.00043	(in^3/in^3/ °F)								
STROKE	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 2-2 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

PRESSURE SETTING PROCEDURES

Objective

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

Equipment

Required pressure gauge analog or digital capable of reading 0-34.5 MPa (0-5000 psi). Diagnostic Quick Disconnect (Manitowoc 9999101806).

Valve Pressure Setting Table

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

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

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

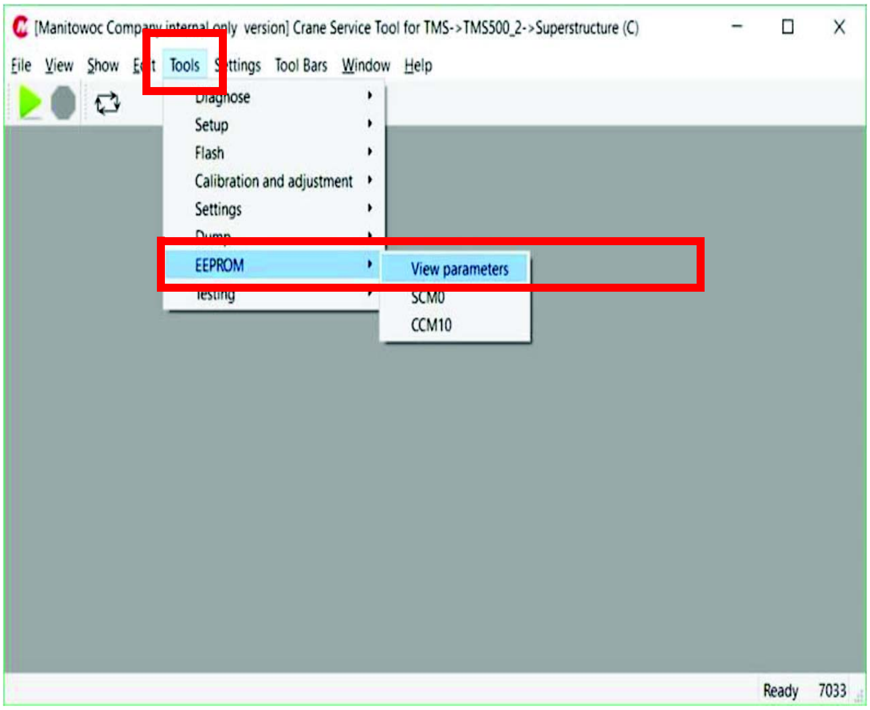
.

PRESSURE TO BE CHECKED	GAUGE PRESSURE PSI (bar)	TOLERANCE PSI (bar)	PROCEDURE
Pump differential pressure	325-400 (-23-28)	See Range	A
Pilot supply pressure	1350 (93)	± 50 (4)	B
Load sense (max system) pressure	4000 (275)	± 50 (4)	C
Tele extend pressure (102’ Boom Option)	3500 (241)	± 50 (4)	C
Tele retract pressure (102’ Boom Option)	3250 (224)	± 50 (4)	C
Tele extend pressure (95’ Boom Option)	2700 (186)	± 50 (4)	C
Tele retract pressure (95’ Boom Option)	3000 (207)	± 50 (4)	C
Swing pressure	2100-2450 (145-169)	See Range	D
Swing Brake Release pressure	250-275 (17-19)	See Range	E
Outrigger beam extend pressure	1000 (69)	± 50 (4)	F
Outrigger beam retract pressure	1500 (103)	± 100 (7)	F
Outrigger jack extend pressure	3000 (207)	± 50 (4)	F
Outrigger jack retract pressure	2500 (172)	± 150 (10)	F
Air Conditioning Operation	1350 (93)	± 50 (4)	G
Center front stabilizer pressure	150-300 (10-21)	See Range	H
Front steer pressure	2175 (150)	± 50 (4)	I

Service Tool Notes

1. Attach laptop to DIAG_1 connector in cab and make sure CAN C is selected (position 3 on CAN selector knob.)
2. Open the CCS Crane Service Tool. From the Menu bar, select Settings->Crane Model->Auto Detect. The auto detection procedure should detect TMS->TMS500-2->Superstructure (C).
3. The current settings for each function can be found in the Crane Service Tool in the Menu bar under Tools->EEprom->View Parameters as shown in Figure 2-20.

Finding Menu Bar Functions

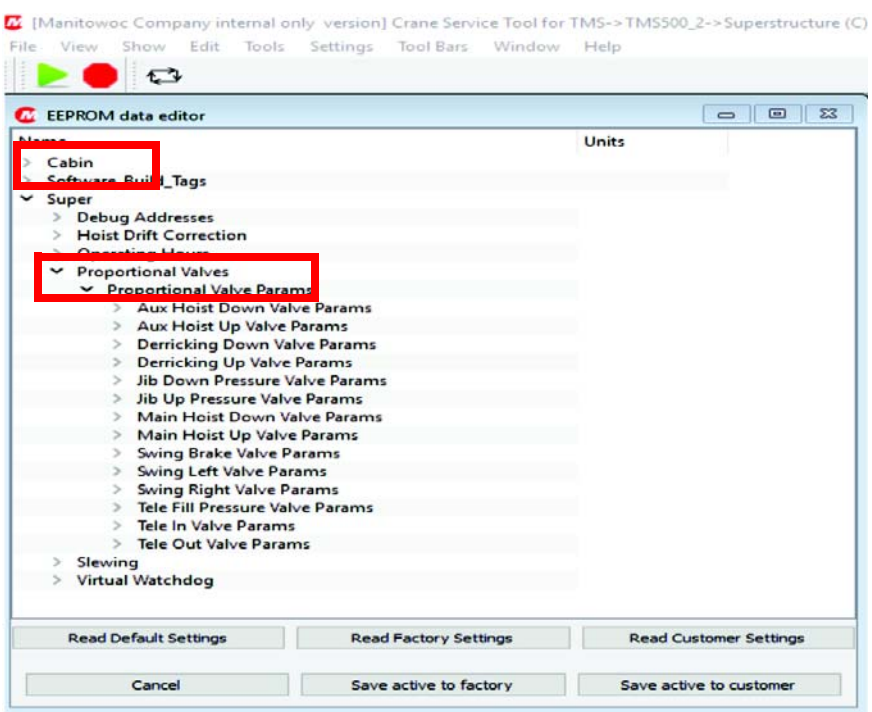


9265-2a

FIGURE 2-20

4. Next, select the function that needs adjusted. The Main crane functions can be found under Proportional Valves (Figure 2-21). The Carrier functions can be found under Cabin also shown in Figure 2-21.

Finding Main Crane Functions



9265-1a

FIGURE 2-21

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

1. Refer to Figure 2-22.
2. With engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at GP2 gauge port on the accessory manifold with swing (see Figure 2-23).
3. Start engine and idle. Gauge port GP2 should read 325-400 psi (23-28 bar). If it does not, adjust the Differential Pressure Adjustment Screw (Figure 2-22) **IN** to increase or **OUT** to decrease so that a gauge reading is achieved.

PISTON PUMP

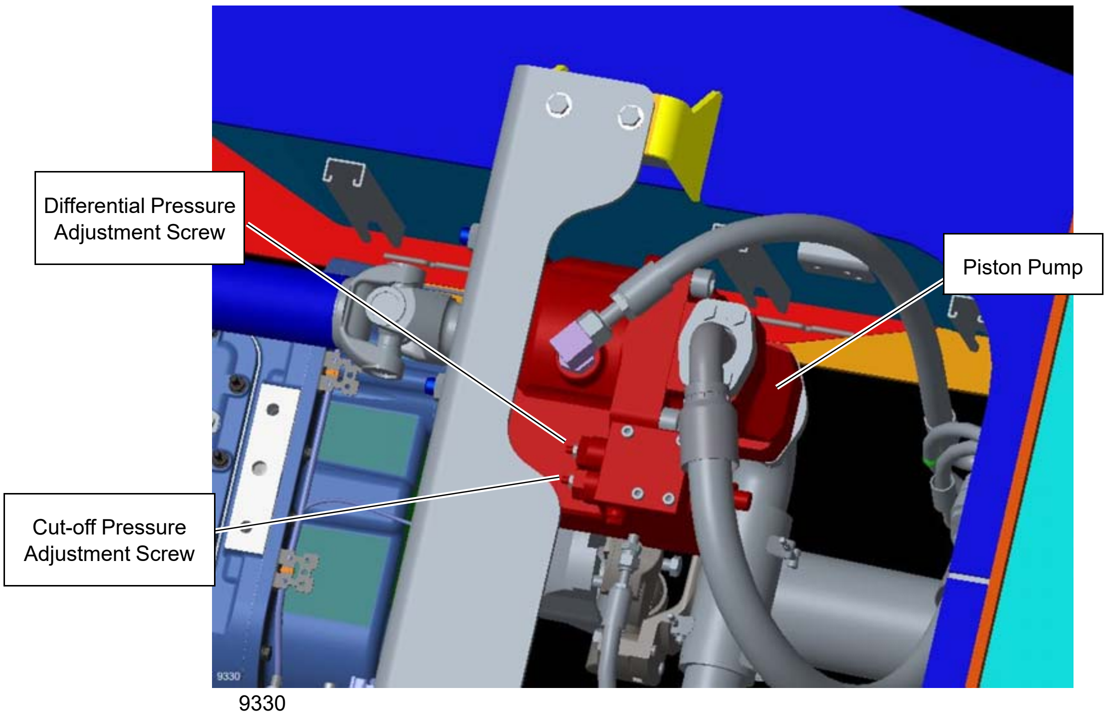


FIGURE 2-22

4. Stop the engine and remove the diagnostic coupler.
5. Assure the piston pump "cut-off" max setting is correct. Loosen the jam nut on the Cut-off Pressure Adjusting Screw (Figure 2-22) and turn it "**IN**" until it softly seats or bottoms out. Then, back the Adjusting Screw "**OUT**" a ½ turn and lock it in place with the jam nut.

B. Procedure for Checking/Setting the Pilot Supply Pressure

1. Refer to Figure 2-23.
2. With the engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at the GP3 port of the accessory manifold with swing (see Figure 2-23).
3. If the lift cylinder is not installed, plug the lift hoses. If the cylinder is installed, omit this step.
4. Start engine and idle.
5. Feather into lift up or down and hold. (If the cylinder is fully stroked in either direction, the Limits Bypass Switch (also refer to the Operations Manual, page 95) may need to be active to assure that the Pilot Supply will not be cut off before the cylinder can be dead headed). The reading at GP3 should be 1350 ± 50 psi (93± 4 bar). If it is not, adjust the Pilot Supply Pressure Reducing Valve (see Figure 2-23) "**IN**" to increase or "**OUT**" to decrease until the reading is achieved.
6. Stop engine. Remove diagnostic couplers.

ACCESSORY MANIFOLD

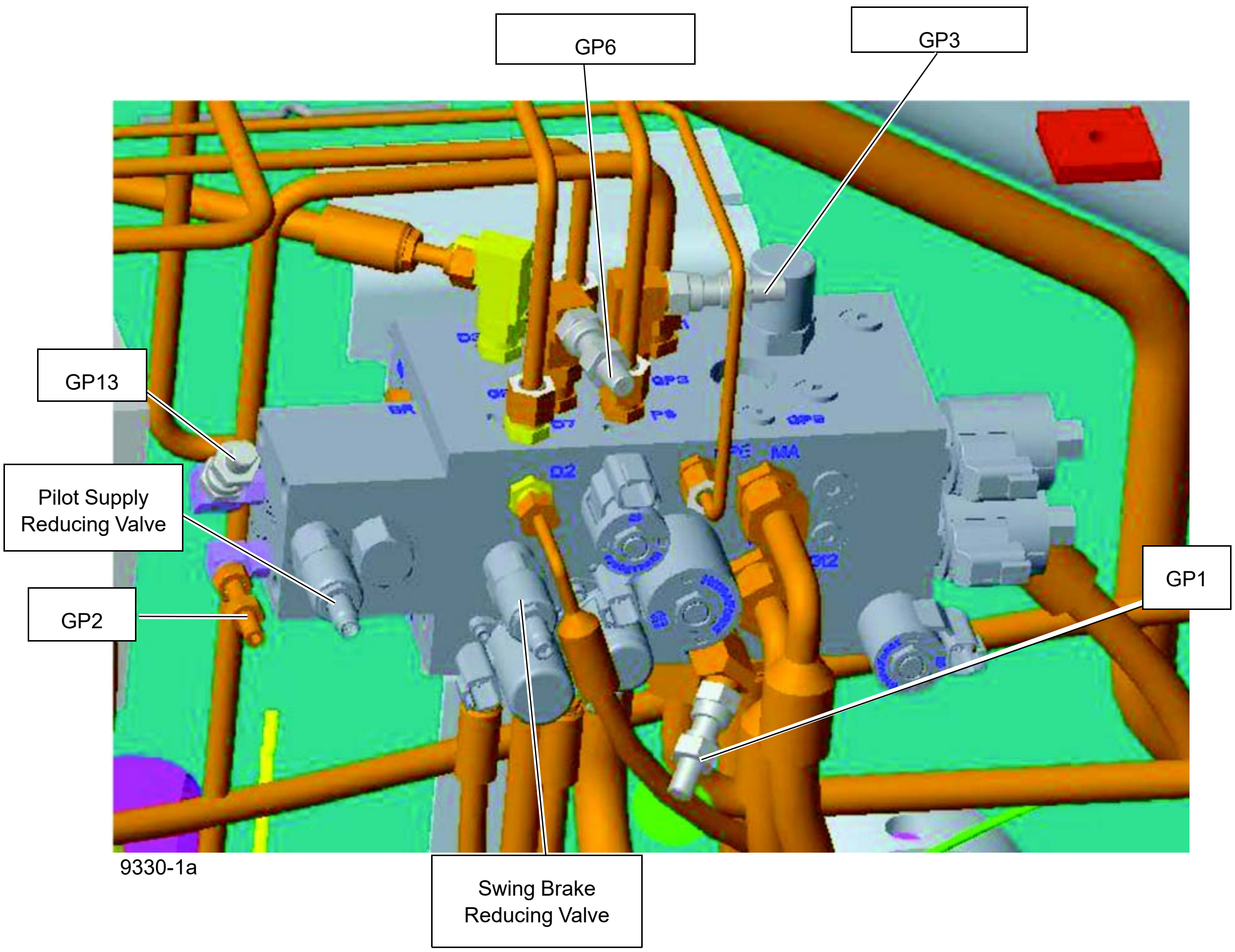


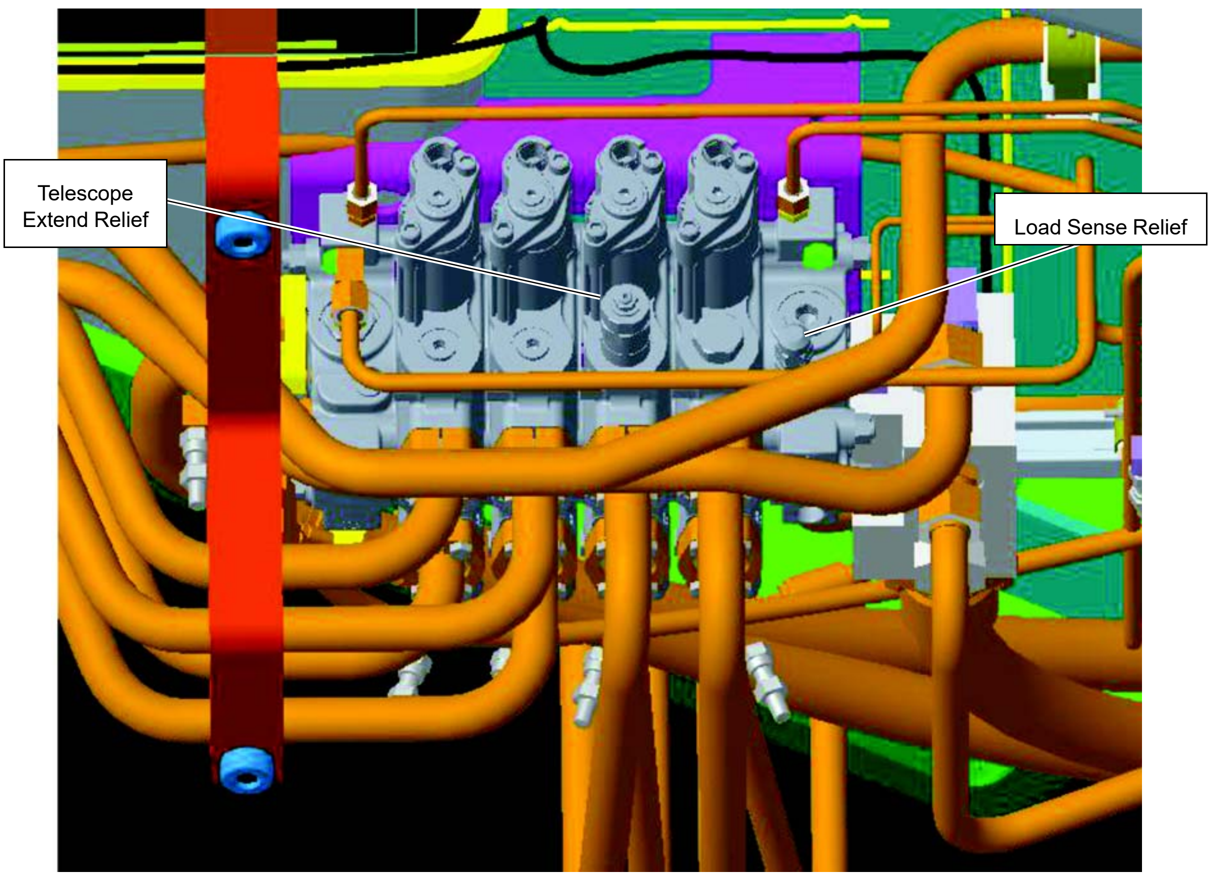
FIGURE 2-23

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

To Set Hoist(s) and Boom Lift

1. Refer to Figure 2-23.
2. With the engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at the GP2 port of the accessory manifold (see Figure 2-23).
3. If the lift cylinder is not installed, plug the extend hose (the larger of the two). If lift cylinder is installed, omit this step and continue to step #4.
4. Start the engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 in this Section). Feather into the boom lift controller to full controller stroke in the up direction and hold. If the boom is installed, boom up to max elevation and hold **OR** boom down to minimum elevation and hold. Adjust the load sense relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 4000 ±50 psi (275 ± 4 bar) is achieved (see Figure 2-24).
5. Stop the engine and remove the diagnostic couplers from the test nipples.

MAIN DIRECTIONAL VALVE TOP



9330-2a

FIGURE 2-24

To Set the Telescope Extend and Retract

102' Boom Option

Extend 102' Boom

1. With the engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at the GP7 port of the main directional control valve (see Figure 2-25).

2. If the boom is not installed, cap the hose (the larger of the two) running from port A, Telescope Section of the main directional control valve to the cylinder port block at the back of the base section.

MAIN DIRECTIONAL VALVE BOTTOM

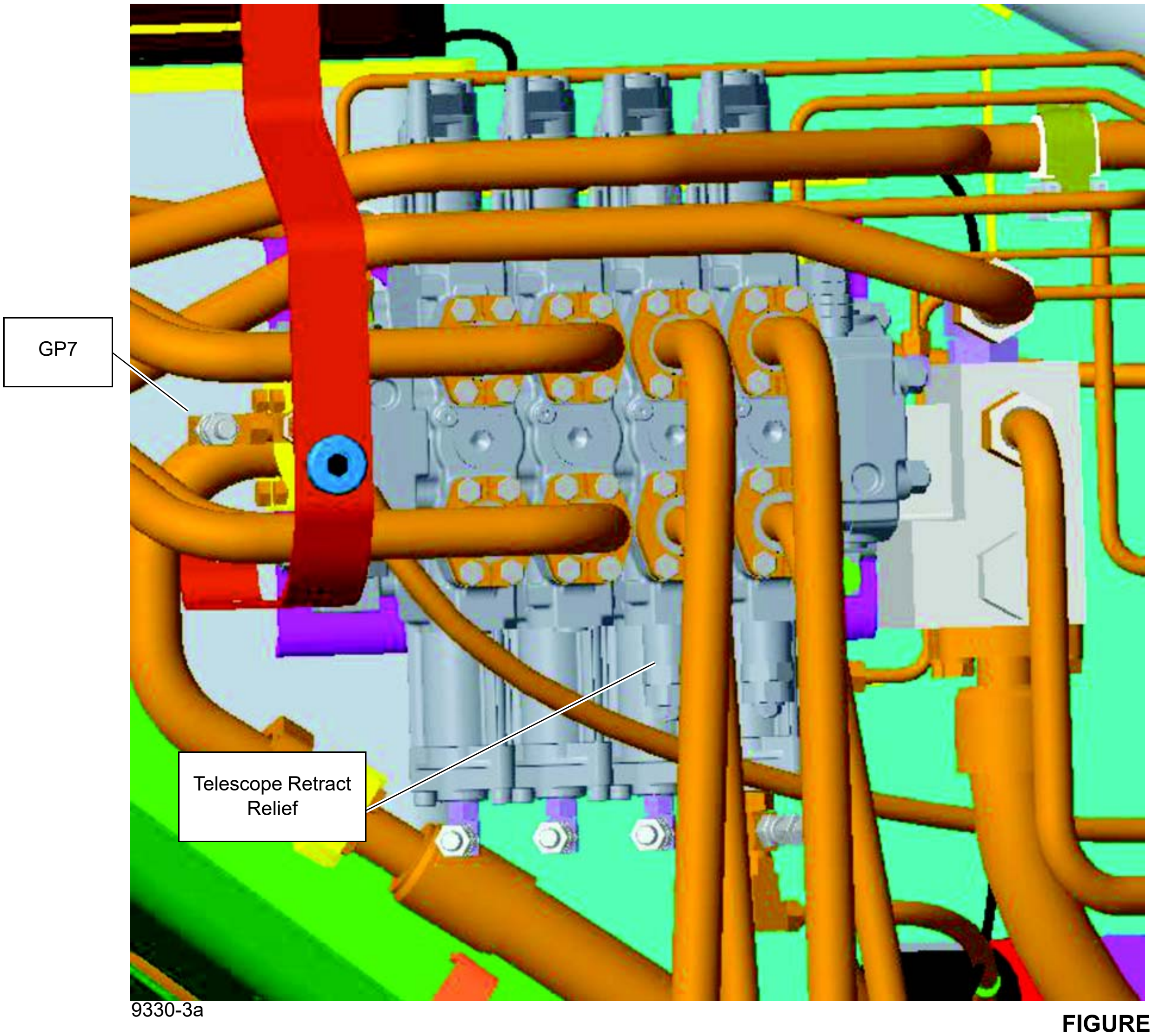


FIGURE 2-25

3. Start engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 of this Section). Attempt to telescope OUT by feathering into the controller to full controller stroke. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 3500 ±50 psi (241 ± 4 bar) is achieved (see Figure 2-24).

4. If the boom is installed, start the engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 in this Section). Attempt to telescope OUT by feathering into the controller to full controller stroke. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 3500 ±50 psi (241 ± 4 bar) is achieved (see Figure 2-24).

5. Stop the engine and remove pressure gauge and re-connect plumbing.

Retract 102' Boom

1. With the engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at the GP7 port of the main directional control valve (see Figure 2-25).
2. If the boom is not installed, cap the hose (the smaller of the two) running from port B, Telescope Section of the main directional control valve to the cylinder port block at the back of the base section.
3. Start the engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 in this Section). Attempt to telescope IN by feathering into the controller to full controller stroke. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 3250 ±50 psi (224 ± 4 bar) is achieved (see Figure 2-25).
4. If the boom is installed, start the engine and throttle up to full RPM. Telescope IN to fully retract the boom and hold. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 3250 ±50 psi (224 ± 4 bar) is achieved (see Figure 2-25).
5. Stop engine and remove pressure gauge and re-connect plumbing.

95' Boom Option

Extend 95' Boom

1. With the engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at the GP7 port of the main directional control valve (see the Figure 2-25).
2. If the boom is not installed, cap the hose (the larger of the two) running from port A, Telescope Section of the main directional control valve to the cylinder port block at the back of the base section.
3. Start the engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 of this Section). Attempt to telescope OUT by feathering into the controller to full controller stroke. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 2700 ±50 psi (186 ± 4 bar) is achieved (see Figure 2-24).
4. If the boom is installed, start the engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 in this Section). Telescope OUT to fully extend the boom and hold. Adjust the work port relief valve '"**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 2700 ±50 psi (186 ± 4 bar) is achieved (see Figure 2-24).
5. Stop the engine and remove pressure gauge and re-connect plumbing.

Retract 95' Boom

1. With the engine off, install a pressure check diagnostic quick disconnect (Parker PD240) with gauge onto the test nipple at the GP7 port of the main directional control valve (see Figure 2-25).
2. If the boom is not installed, cap the hose (the smaller of the two) running from port B, Telescope Section of the main directional control valve to the cylinder port block at the back of the base section.
3. Start engine and throttle up to full RPM (see *Service Tool Notes*, page 2-34 in this Section). Attempt to telescope IN by feathering into the controller to full controller stroke. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 3000 ±50 psi (207 ± 4 bar) is achieved (see Figure 2-25).
4. If the boom is installed, start engine and throttle up to full RPM. Telescope IN to fully retract the boom and hold. Adjust the work port relief valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure reading of 3000 ±50 psi (207 ± 4 bar) is achieved (see Figure 2-25).
5. Stop the engine and remove pressure gauge and re-connect plumbing.

D. Procedure for Checking/Setting Swing Pressure

1. With the engine off, install a diagnostic quick disconnect coupler (Manitowoc 9999101806) with gauge onto the test nipple at GP1 port of the accessory manifold with swing directional control valve (see Figure 2-23).
2. Start the engine and throttle up to full RPM. With the swing house lock engaged, and the boom out of the boom rest and elevated enough to clear the carrier cabin, swing full right and hold controller. Pressure gauge should read 2100 - 2450 psi (145 - 170 bar). If the reading is not within this range, the Imax needs to be adjusted via the service software. Lowering the Imax will lower the pressure, raising the Imax will raise the pressure. Adjust as necessary to obtain a reading within the acceptable range.
3. Repeat Step #2 for swing left.
4. Stop the engine. Remove the diagnostic coupler.

E. Procedure for Checking/Setting the Swing Brake Release Pressure

1. With the engine off, install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at GP6 port of the accessory

manifold with swing directional control valve (see Figure 2-23).

2. Start the engine and idle, enable swing and adjust the swing brake pressure reducing valve "**IN**" to increase or "**OUT**" to decrease so that a gauge pressure of 250-275 psi (17 - 19 bar) is achieved (see Figure 2-23).

3. If adjustment cannot obtain the setting in Step #2, stop the engine and install a pressure check diagnostic quick disconnect (Manitowoc 9999101806) with gauge onto the test nipple at GP2 at the accessory manifold valve (see Figure 2-23). Follow Procedure A to set pump stand-by. Repeat Steps 1-2 to set the swing brake release pressure.

4. Stop the engine. Remove the diagnostic coupler.

F. Procedure for Checking/Setting Outrigger Pressure

1. With the engine off, install a pressure check diagnostic coupler (Manitowoc 9999101806) with gauge onto the diagnostic nipple at the G2 port of the outrigger selector manifold (see Figure 2-26).

2. **Outrigger Beam Extend:** Start the 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 G2 should be 1000 ±50 psi (69 ±4 bar). If it is not, use the service tool as follows to adjust:

- In the Tools->EEPROM->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Beams Extend Target params Row, increase the value to increase the pressure or decrease the value to decrease the pressure (**adjustment by 10 mA increments is suggested**). Make sure to write column to "active settings". Repeat this Step until the pressure is achieved. If the value needs adjusted by more than 100 mA, there may be other problems within the circuit.

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

OUTRIGGER SELECTOR MANIFOLD

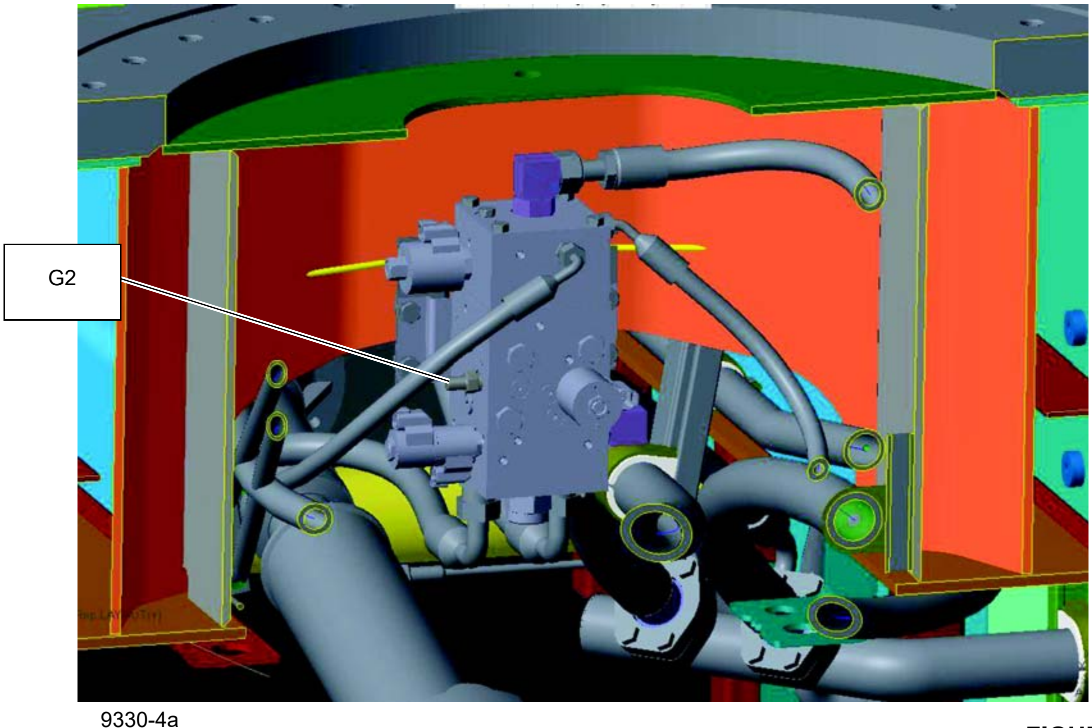


FIGURE 2-26

3. **Outrigger Beam Retract**: Start the engine and idle. Retract any outrigger beam until the outrigger beam is fully retracted and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 1500 ±100 psi (103 ±7 bar).If it is not, use the service tool as follows to adjust:

- In the Tools->EEPROM->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol -

Outrigger Beams Retract Target params Row, increase the value to increase the pressure or decrease the value to decrease the pressure (**adjustment by 10 mA increments is suggested**). Make sure to write column to "active settings". Repeat this Step until the pressure is achieved. If the value needs adjusted by more than 100 mA, there may be other problems within the circuit.

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

4. **Outrigger Jack Extend Pressure:** Start the engine and idle. Extend any outrigger jack until the outrigger jack is fully retracted and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 3000 ±50 psi (207 ±4 bar).If it is not, use the service tool as follows to adjust:

- In the Tools->EEPROM->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Jacks Extend Target params Row, increase the value to increase the pressure or decrease the value to decrease the pressure (**adjustment by 10 mA increments is suggested**). Make sure to write column to "active settings". Repeat this Step until the pressure is achieved. If the value needs adjusted by more than 100 mA, there may be other problems within the circuit.
- Once the pressure is achieved, make sure to "Save active to customer" and "Save active to factory".

5. **Outrigger Jack Retract Pressure**: Start the engine and idle. Retract any outrigger jack until full stroke of the cylinder is achieved and hold. Slowly accelerate the engine to full RPM. The reading at G2 should be 2500 ±150 psi (172 ±10 bar).If it is not, use the service tool as follows to adjust:

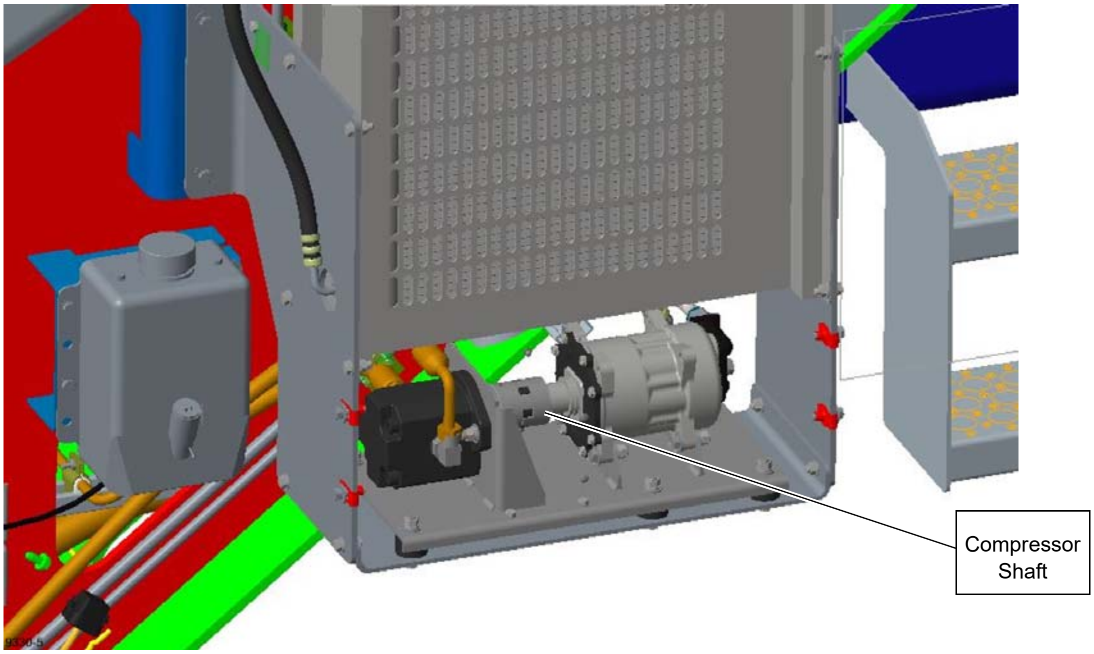
- In the Tools->EEPROM->View Parameters->Cabin->Solenoid PWM Control (carrier)->Pressure Sol - Outrigger Jacks Extend Target params Row, increase the value to increase the pressure or decrease the value to decrease the pressure (**adjustment by 10 mA increments is suggested**). Make sure to write column to "active settings". Repeat this Step until the pressure is achieved. If the value needs adjusted by more than 100 mA, there may be other problems within the circuit.
- Once the pressure is achieved, make sure to "Save active to customer" and "Save active to factory".

6. Stop the engine. Remove the diagnostic couplers.

G. Procedure for Checking Air Conditioning Operation

1. With the engine off, install a pressure check diagnostic coupler (Manitowoc 9999101806) with gauge onto the diagnostic nipple at the GP13 port of the accessory manifold (see Figure 2-23).
2. Start the engine and idle. Turn on the Air Conditioning (A/C). Listen to make sure that the compressor motor is running or verify by removing the cover (see Figure 2-27) and looking at the shaft. The reading at GP13 should be 1350 ±50 psi (93 ±4 bar). If the pressure is incorrect, refer to Procedure B for adjustment.

A/C COMPRESSOR & HYDRAULIC MOTOR WITH COVER REMOVED



9330-5

FIGURE 2-27

3. If the pressure is correct and the A/C is still not working correctly, remove the cover and check the shaft speed (see Figure 2-27) with a photo tach. The shaft speed should be 1800 to 2000 RPM when the unit is running. If the shaft speed is not in this range, use the service tool as follows to adjust:

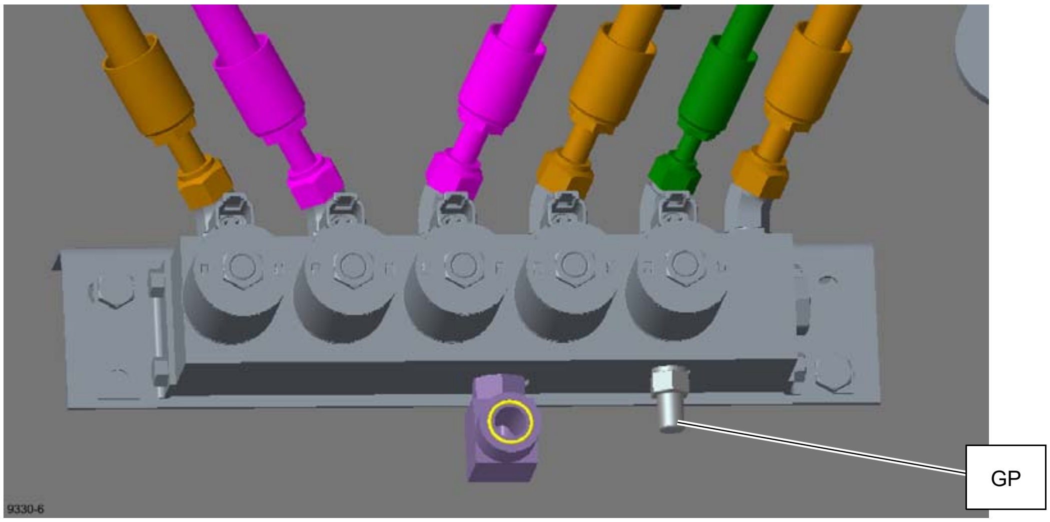
- In the Tools->EEPROM->View Parameters->Cabin->Solenoid PWM Control (carrier)->Flow Sol AC Target params Row, increase the value to increase the flow or decrease the value to decrease the flow (**adjustment by 10 mA increments is suggested**). Make sure to write column to "active settings". Repeat this Step until the pressure is achieved. If the value needs adjusted by more than 100 mA, there may be other problems within the circuit.
- Once the correct speed is achieved, make sure to "Save active to customer" and "Save active to factory".

4. Stop the engine. Remove the diagnostic couplers.

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

1. With the engine off, install a pressure check diagnostic coupler (Manitowoc 9999101806) with gauge onto the diagnostic nipple at the GP port of the outrigger 5-stack valve (see Figure 2-28).

OUTRIGGER 5-STACK VALVE



9330-6

FIGURE 2-28

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

I. Procedure for Checking/Setting the Front Steer Pressure

1. With the engine off, install a pressure check diagnostic coupler (Manitowoc 9999101806) with gauge onto the diagnostic nipple at the GP port of the power steering gear box (see Figure 2-29).
2. Using a flat screwdriver, turn the right turn steer plunger in (clockwise) fully until it seats SOFTLY. Then back the

plunger out (counterclockwise) 10 full turns (see Figure 2-29).

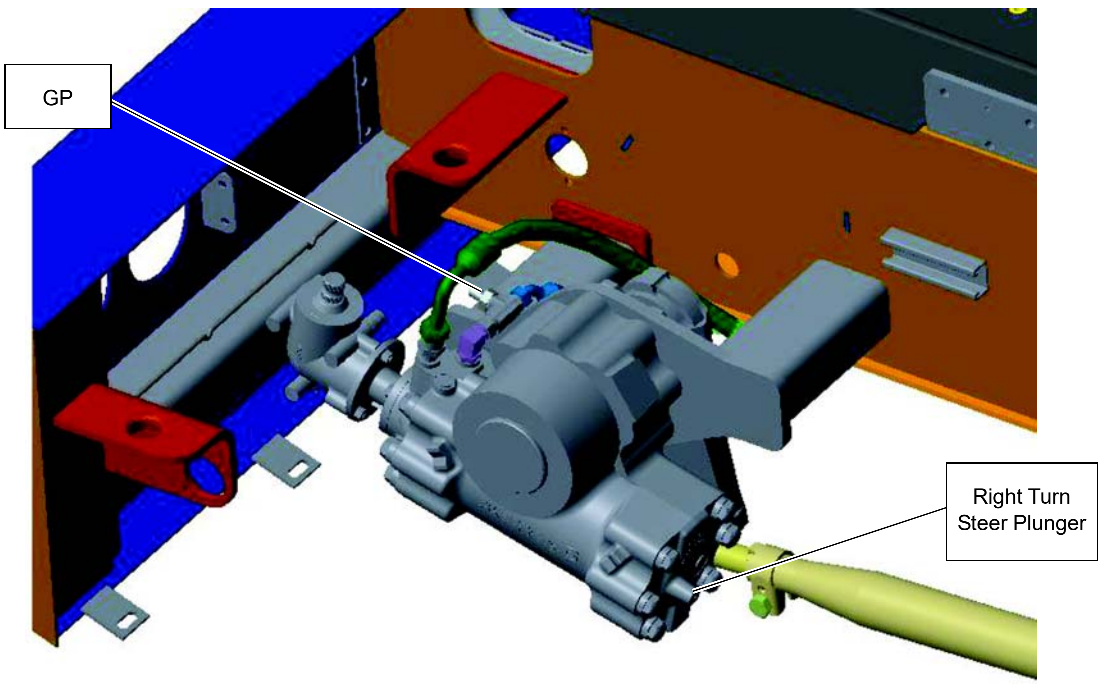
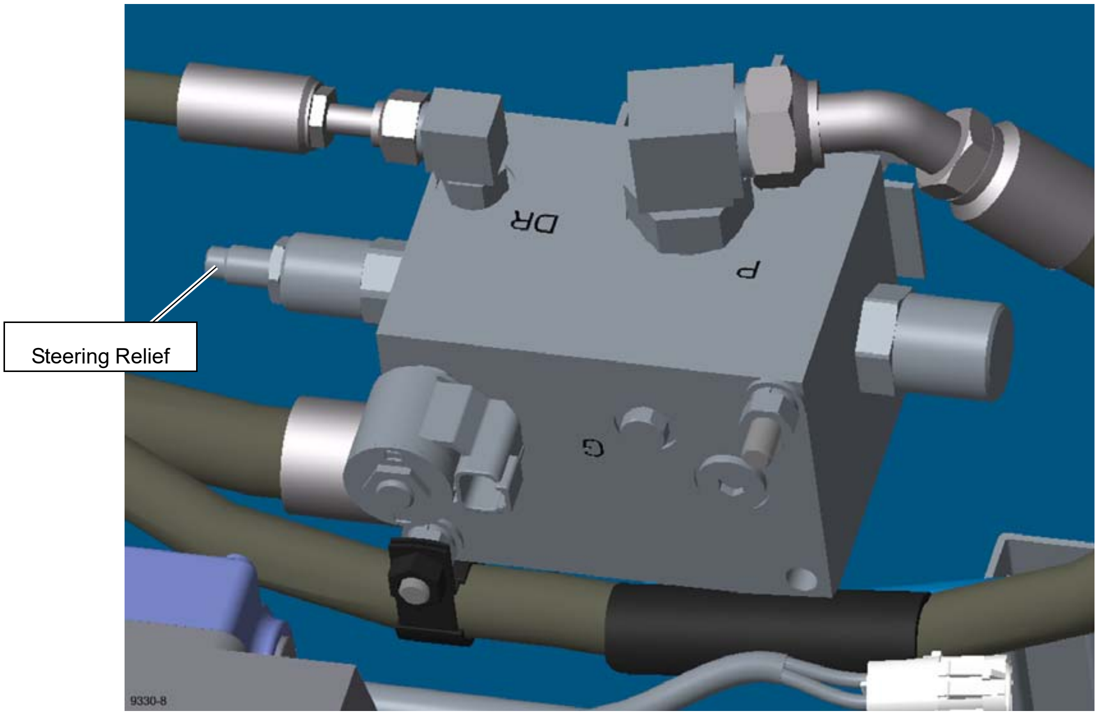


FIGURE 2-29

3. Start the engine and throttle up to full RPM. Fully turn the steering wheel to the right and hold. The reading at GP should be 2175 ±50 psi (150 ±4 bar). If it is not, adjust the steering relief (see Figure 2-30) "**IN**" to increase or "**OUT**" to decrease until the reading is achieved. **NOTE**: Steering stops must be in place on the axle to obtain the correct steer pressure.
4. Stop the engine. Remove the diagnostic couplers.
5. Re-adjust the right turn plunger per the TMS500-2 axle and steering specification documents (refer to *Section Contents*, page 8-1 and *Steering System*, page 8-13).

STEER / SWING VALVE



9330-8

FIGURE 2-30

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

All controller, Electrically Erasable Programmable Read-Only Memory (EEPROM), settings should be set to factory defaults specific to the crane model. This procedure should **ONLY** be used if there is an issue with the crane controller functions and the following items have been tried first:

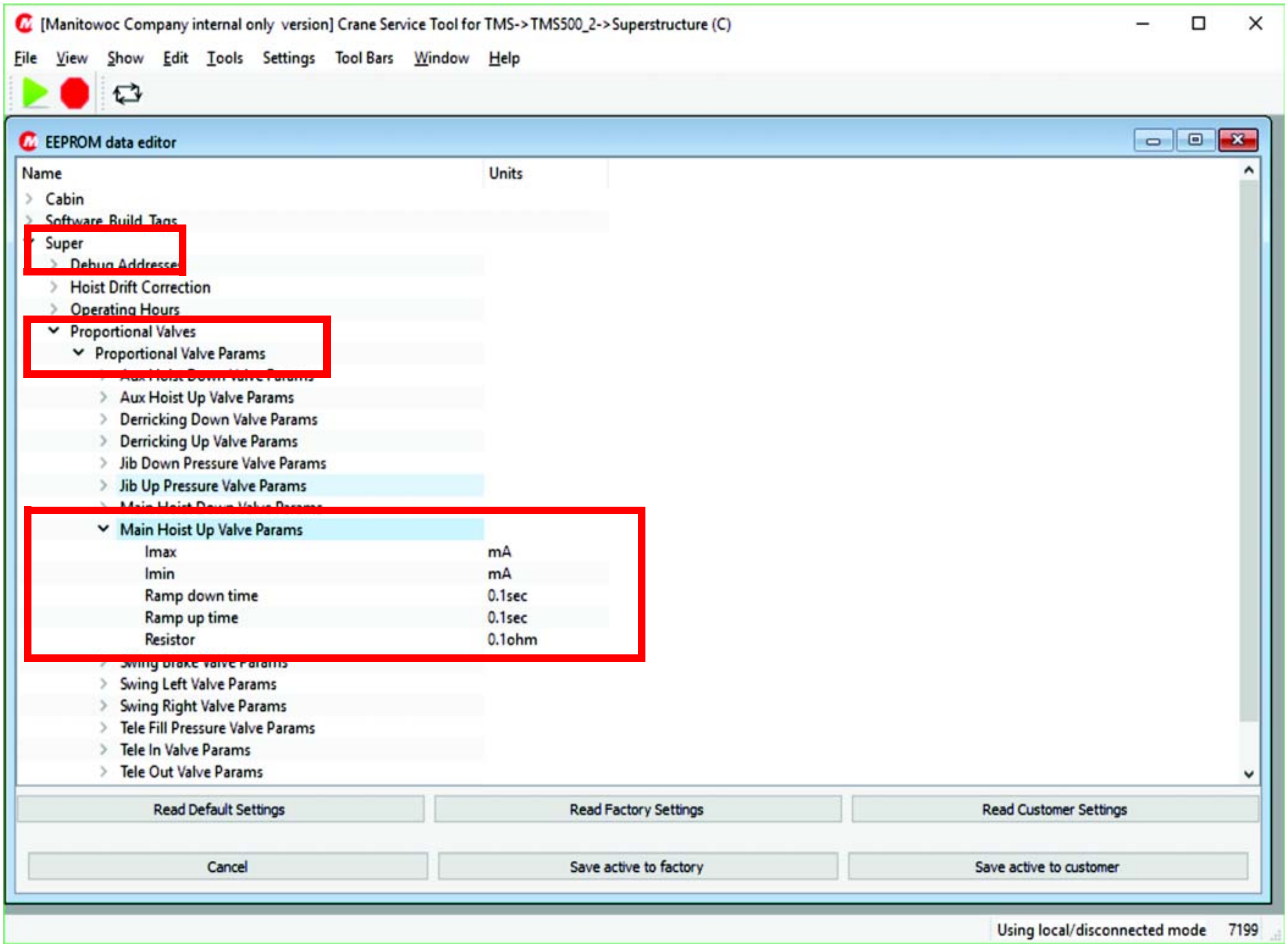
- All function pressures are set correctly per this procedure.
- Operator has tried adjusting the function speed thru the Crane Control System (CCS) control screens.
- Operator has tried adjusting the function control thru the Crane Control System (CCS) control screen selectable curves.

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

- For meter-in too fast - lower Imin setting.
- For meter-in too slow - raise Imin setting.
- For low function flow - raise Imax setting. (**DO NOT EXCEED 1500 mA.)**
- For high function flow - lower Imax setting.

1. Follow the *Service Tool Notes*, page 2-34, then do the following:
2. Current range settings for each function can be found in the Crane Service Tool in the Menu bar under Tools->EEPROM>View Parameters->Super->Proportional Valves->Proportional Valve Params->Main Hoist Up Valve Params. An Example is shown for Main Hoist Up in Figure 2-31.

EXAMPLE ONLY - for MAIN HOIST UP



9330-9b

FIGURE 2-31

3. Adjust the Imin or Imax per the information above (**adjustment by 10 mA increments is suggested**). Make sure to write column to "active settings".

4. Try function again. If it is now satisfactory, continue to Step 5. If not, repeat Step 3 until the results are satisfactory, or until you have adjusted by 100 mA. Adjustment of 100 mA in either direction is considered excessive and may indicate checks and/or trouble-shooting may be needed in other components.

5. After setting all of the functions, save the EE Configuration to the controller's Factory and Customer settings area. This is done by selecting Tools->Calibration and Adjustment->EEPROM and pressing the “Save active” to Customer and “Save active” to Factory buttons.

6. Next save the configuration to a file by right clicking on the 'Active' column and Write->Write column to file from the Context Menu. Save the file in a folder under the Model Designation (TMS500-2). Name the file as follows: (Sales order number_Date). Sample: (700287_2015june25).

Contact Crane Care concerning any calibration requests that may involve the following, but are not limited to:

- Pedals
- OMS
- Level Sensors
- RCL
- Transducers
- Real Time Clock (RTC)
- Counterweight Cylinder Length
- Ride Height

THIS PAGE BLANK

SECTION 3
ELECTRICAL SYSTEM

SECTION CONTENTS

Description 3-1
Carrier Cab 3-1
Batteries 3-1
Carrier Power Panel and Fuse Panels 3-2
Carrier Cab Fuse and Relay Panels 3-4
Anti-Lock Brake System (ABS) 3-5
Superstructure Cab Fuse and Relay Panels 3-7
Camera System (Optional) 3-9
Radios (Optional) 3-9
Maintenance 3-9
General 3-9
General Troubleshooting 3-10
Tools for Troubleshooting 3-10
Troubleshooting Engine Starting Problems 3-10
Jump Starting Hazard 3-11
Charging the Batteries 3-11
Troubleshooting 3-11
Troubleshooting Battery Charging Problems . . . 3-11
Troubleshooting Slip Ring-Caused Electrical Problems 3-11
Connector Troubleshooting 3-11
Di-electrical Grease Application 3-12
Troubleshooting Lights 3-13
Troubleshooting Gauges and Meters 3-14
Troubleshooting Alarms, Indicators, and Emergency Components 3-14
Troubleshooting Accessories 3-14
Alternator Replacement 3-14
Starter Replacement 3-15
Battery Replacement 3-16
Relay Panel Component Replacement 3-18
Instrument Replacement 3-18
Switch Replacement 3-19
Rocker Switch 3-19
All Other Switches 3-19
Windshield Wiper Assembly Replacement - Carrier Cab 3-20
Windshield Washer Assembly Replacement . . . 3-23
Superstructure Wiper Assembly 3-23
Skylight Wiper Assembly Replacement 3-23
Windshield Wiper Assembly Replacement - Superstructure Cab 3-24
Windshield Washer Assembly Replacement . . . 3-27
Computer Modules 3-28
Troubleshooting the Crane Control System (CCS) 3-28
Using the Operator Display Module (ODM) 3-28
Fault Codes 3-28
Remote Controller (Optional) 3-28
Receiver 3-31
Battery Charger 3-31
Remote Controller Battery 3-31

DESCRIPTION

Carrier Cab

Crane Control System

For information on the Crane Control System, refer to *Troubleshooting Accessories*, page 3-14 of this manual.

General

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

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

Alternator

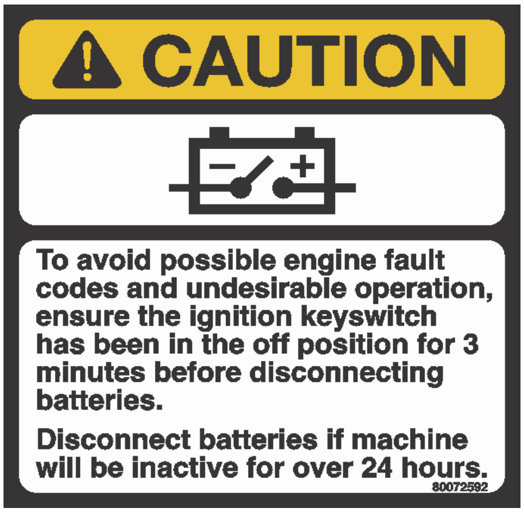
The alternator is mounted on the engine and is belt driven. It is a 140-ampere alternator. When the engine is running, and the alternator is turning, the alternator's output terminal supplies the cranes electrical circuits. The output terminal also supplies the current to recharge the batteries.

BATTERIES

The batteries are located in a box on the driver's side of the carrier directly behind the exhaust system compartment (Figure 3-1). The batteries are the maintenance-free type and are completely sealed except for a small vent hole in the side. The vent hole allows what small amount of gases that are produced in the battery to escape. On some batteries, a test indicator located on the top of the battery is used to determine if the battery can be tested in case of a starting problem.

In addition to the batteries, the battery box also contains five 100 amp fuses, one 125 amp fuse, and one 200 amp fuse as shown in (Figure 3-5). The fuses protect all electrical circuits except the starter circuit.

Battery Disconnect



A battery disconnect switch is located on the rear of the battery box on the left side of the crane, behind the exhaust system compartment (1), (Figure 3-1). To disconnect batteries, turn the battery disconnect switch to the OFF position. Turn the switch to the ON position to connect the batteries.

1

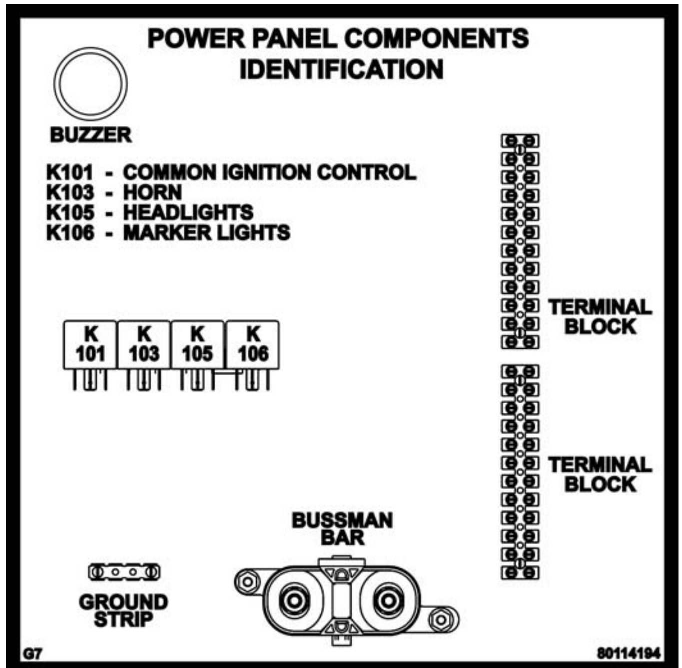
9824 **FIGURE 3-1**

CARRIER POWER PANEL AND FUSE PANELS

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

Carrier Cab Power Panel

The carrier power panel contains 1 relay, a flasher and a buzzer. Refer to the Power Panel and Power Panel Decal illustrations (Figure 3-2).



9279-2 **FIGURE 3-2**

Carrier Cab Relays

The carrier has 4 relays (Figure 3-3) which control many of its functions. The relays are located on the power panel in the carrier cab. When any relay coil is energized, its contacts either open or close. This allows power to go to or be removed from the related circuits. For any relay coil to energize, the battery must be connected.

Carrier Cab Relays

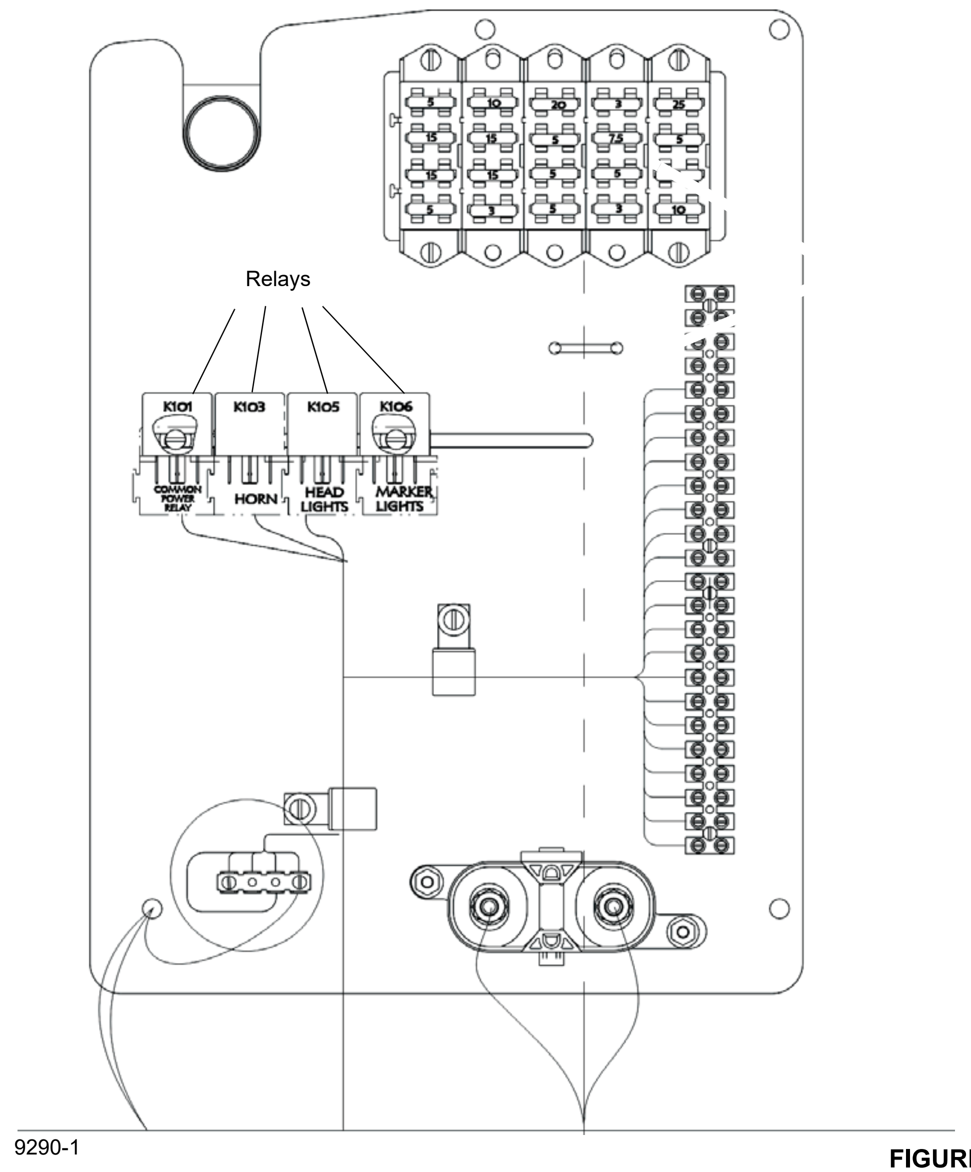


FIGURE 3-3

The coils of the accessory relay (Figure 3-3), (K101) is energized when the ignition switch is at the RUN (1) position. The coil of Horn relay (K103) is energized when the Horn button is depressed.The coils of the Headlights on relay (K105) and Marker Lights on relay (K106) are energized when the Marker Lights and Headlights ON switch contacts are closed.

Carrier Cab Fuse and Relay Panels

Refer to (Figure 3-4) for carrier fuse assignments and relay box identification.

Carrier Cab Fuse & Relay Identification

CARRIER FUSE IDENTIFICATION

F1 5A	F5 10A	F9 20A	F13 3A	F17 25A
F2 15A	F6 15A	F10 5A	F14 7.5A	F18 5A
F3 15A	F7 15A	F11 5A	F15 5A	F19 5A
F4 5A	F8 3A	F12 5A	F16 3A	F20 10A

F1 - 5A - SPARE
F2 - 15A - IOL 30
F3 - 15A - IOL 30
F4 - 5A - WIPER PARK
F5 - 10A - TURN SIGNAL
F6 - 15A - CONVERTER
F7 - 15A - OUTLET/ USB/ CHARGER STATION
F8 - 3A - STEERING WHEEL
F9 - 20A - BLOWER FAN
F10 - 5A - HEATER VALVE MOTOR
F11 - 5A - POWER IGNITION
F12 - 5A - ABS IGNITION
F13 - 3A - BEACON LAMP/ SWITCH LEDS
F14 - 7.5A - CIRCULATING FAN
F15 - 5A - REMOTE POWER RECEIVER
F16 - 3A - CAMERA DISPLAY
F17 - 25A - ABS POWER
F18 - 5A - GAUGE CLUSTER
F19 - 5A - RADIO
F20 - 10A - RADIO IGN

G7 80114193

9280-3a

RELAY BOX IDENTIFICATION

A B	C D	E F
K51	K56	1 / 2
K52	K57	3 / 4
K53	K58	5 / 6
K54	K59	7 / 8
K55		9 / 10

K51 - AFT POWER RELAY
K52 - ECM IGN RELAY
K53 - DEF LINE HEATER RELAY
K54 - CONDENSOR FANS RELAY
K55 - DEF PUMP MTR RELAY
K56 - IGN COMMON RELAY
K57 - START RELAY
K58 - SS MAX RPM LIMIT RELAY
K59 - STARTER LOCKOUT RELAY

G7 80114198

9280a

FUSE IDENTIFICATION

D C B		A AA	
1	5A	11	5A
2	3A	12	7.5A
3	15A	13	10A
4	10A	14	10A
5	30A	15	10A
6	15A	16	
7	5A	17	
8	20A	18	→⊢
9	20A	19	→⊢
10	10A	20	→⊢

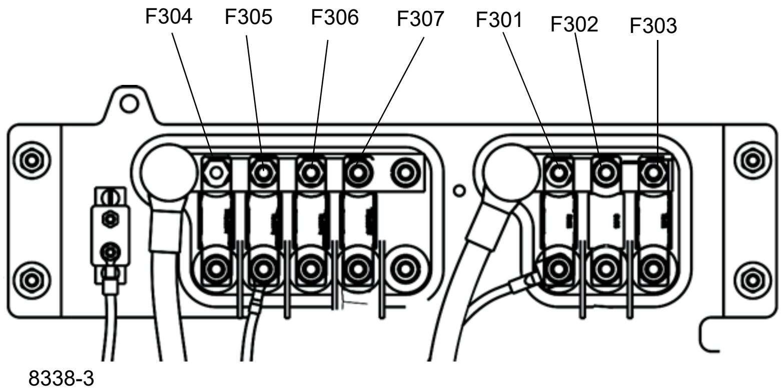
1 F51 - 5A-POWER TO RELAY 53 DEF LINE HEATER (COIL+)
2 F52 - 3A-POWER TO RELAY 57 STR (COIL +)
3 F53 - 15A-POWER TO RELAY 53, DEF LINE HEATER (COMMON)
4 F54 - 10A-POWER TO RELAY 55, DEF MODULE SUPPLY (COMMON)
5 F55 - 30A-POWER TO ENGINE ECM
6 F56 - 15A-POWER TO RELAY 51, AFT POWER (COMMON)
7 F57 - 5A-POWER TO RELAY 52, ECM RELAY (COMMON)
8 F58 - 20A-POWER TO RELAY 54, CONDENSOR FANS (COMMON)
9 F59 - 20A-POWER TO RELAY 56, IGN COMMON RELAY (COMMON)
10 F60 - 10A-POWER TO +UE I0L32 & CCM10
11 F61 - 5A-POWER TO +UE CCM11 & I0L31
12 F62 - 7.5A-POWER TO AIR DRYER
13 F63 - 10A-POWER TO +UB CCM11
14 F64 - 10A-POWER TO TRANSMISION
15 F65 - 10A-POWER TO +UB CCM11
16 SPARE
17 SPARE
18 D51 - PRESSURE LINE HEATER DIODE
19 D52 - BACKFLOW HEATER DIODE
20 D53 - SUCTION LINE HEATER DIODE

G7 80114195

9280-1a

FIGURE 3-4

Battery Box Main Power Distribution



Fuse Number	Rating	Circuit
F304	100A	Disconnect Battery + Main Carrier Cab Power
F305	100A	Disconnect Battery + Carrier Ignition Relay Power, Carrier ECM Relay Power and Carrier Head Lights Circuit Breaker
F306	100A	Disconnect Battery + Main Super Cab Power
F307	125A	Disconnect Battery + Air Intake Heater Power
F301	100A	Battery + Transmission ECA and ECU Power
F302	200A	Battery + Alternator Charge Line
F303	100A	Battery + Super Cab Power

FIGURE 3-5

Anti-Lock Brake System (ABS)

Electronic Control Unit (ECU)

The ABS ECU (1), (Figure 3-6) is located inside the carrier cab behind the seat. ABS wiring is combined with the main cab and engine harnesses. For additional information on the ABS ECU, refer to the Operators Manual, page 4-20 ABS.

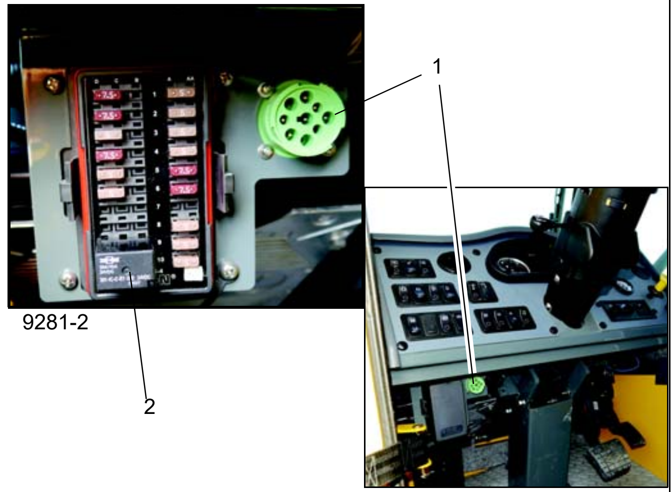
10026 FIGURE 3-6

Diagnostic Connector

The 9-pin on-board diagnostic connector (1), (Figure 3-7) is located below the carrier cab control panel on the left side of the dash board.

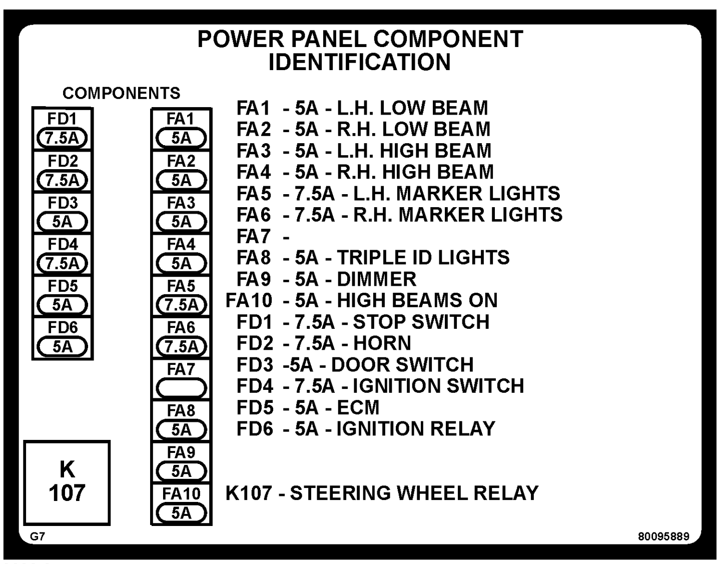
Console Power Panel Identification

The Carrier Cab Console Power Panel (Figure 3-8) contains 1 relay (2), (Figure 3-7) and the fuse box (Figure 3-7)



9281-3 FIGURE 3-7

Carrier Cab Power Panel



9280-2

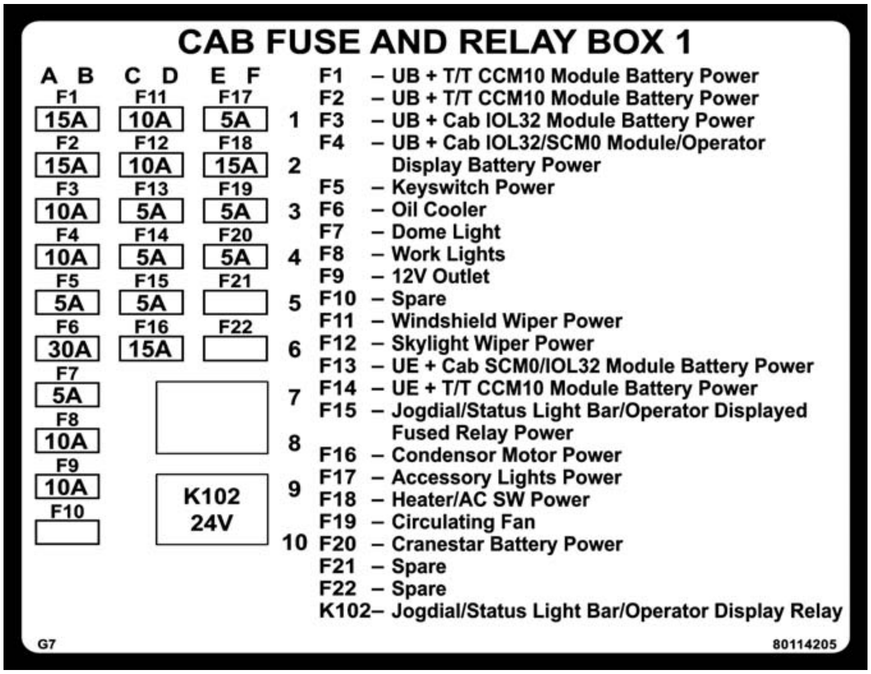
9780-2 FIGURE 3-8

SUPERSTRUCTURE CAB FUSE AND RELAY PANELS

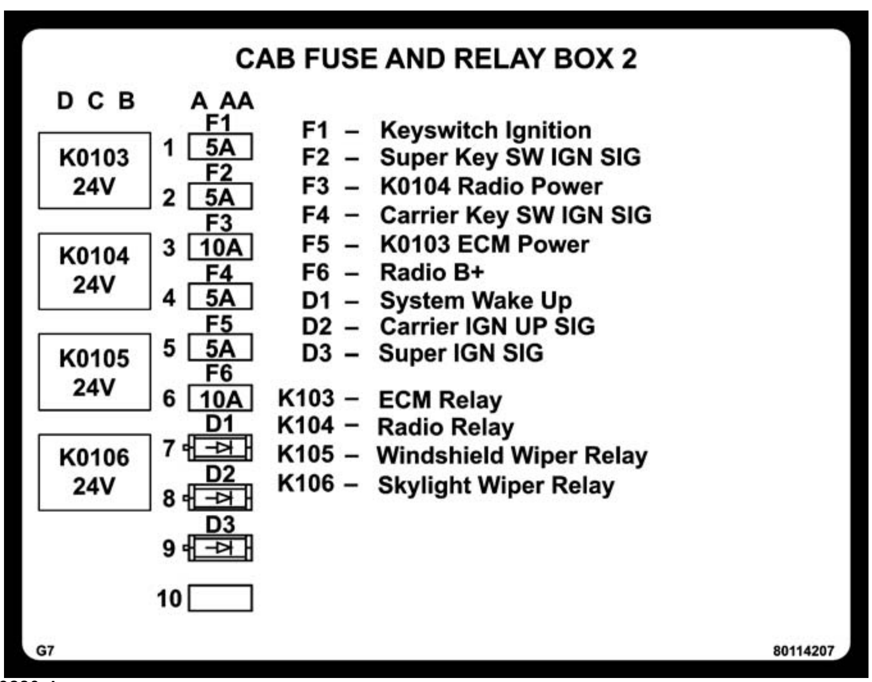
Refer to for the Superstructure fuse assignments and relay panels as shown in (Figure 3-9) and the location on the Superstructure Cab in (Figure 3-10).

Most superstructure electrical circuits are protected by the

Superstructure Cab Fuse & Relay Panel



9280-4

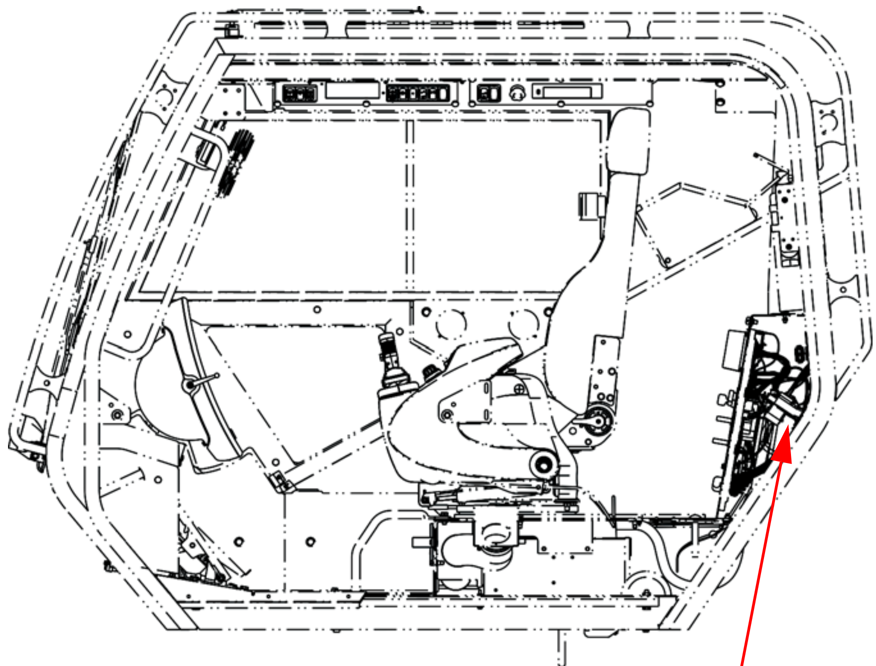


9280-4a

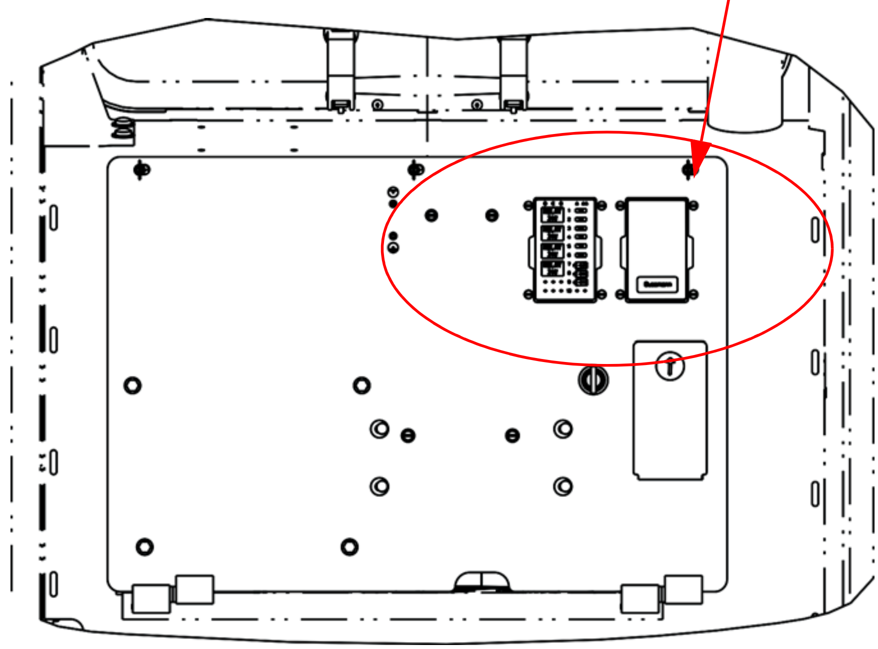
FIGURE 3-9

components of the fuse and relay panel (Figure 3-10) located at the rear of the superstructure cab. Access to all the fuses may be gained by removing the small plastic cover on the front of the panel. Inside the small plastic fuse cover, a fuse decal as shown in (Figure 3-9) can be found.

Superstructure Cab Fuse & Relay Panel



9280-4b



9280-4c

FIGURE 3-10

CAMERA SYSTEM (OPTIONAL)

There is an optional group camera package which consists of four cameras as shown in (Figure 3-11). Further information on optional cameras can be found in the Operators Manual, Section 6, page 6-13.

Additionally, a supplemental manual is provided from the suppliers when this option is used. Please refer to the supplemental manual or contact Crane Care for service and repair instructions.

NOTE: The camera package contains cameras and displays on the carrier that are separate and do not interconnect with the superstructure camera system.

Carrier Cab Cameras (Optional)

The Carrier Cab camera display is located in the center top of the cab above the steering wheel. A camera is located in the center rear panel (4), (Figure 3-11) at the rear of the crane and one is on the right side mirror bracket (1), (Figure 3-11). The power for the display/cameras is supplied by a 3A fuse, F16 in the carrier cab power panel as shown in (Figure 3-4) on the Carrier Fuse Identification Panel.

The carrier cameras switch box controller for the switching of the display from the rear camera view or the right side camera view is mounted on the rear carrier left side under the O/R cover.

Superstructure Cameras (Optional)

The Superstructure Cameras are located (one) in the center between the 2 hoists (3), (Figure 3-11) and one on the right side of the superstructure (2), (Figure 3-11) thru a hole in the plastic valve cover. They are both powered by a 5A fuse, F15 in the Superstructure Cab Power Panel as shown in (Figure 3-9) Cab Fuse and Relay Box 1. The camera views are projected in the Crane Control System (CCS) displays in the superstructure cab.

FIGURE 3-11

RADIOS (OPTIONAL)

There are two radios (optional) independent of each other: one in the carrier cab and a second in the superstructure cab. In the carrier cab, the radio is located overhead on the right side of the carrier cab next to the air horn. The carrier cab radio is powered by a 5A fuse, F19 as shown in (Figure 3-4) under the Carrier Fuse Identification. The superstructure cab radio is powered by a 5A fuse, F3 as shown in (Figure 3-9) of the Cab Fuse and Relay Box 2.

A supplemental manual is provided from the supplier when the radio options are chosen. Refer to the supplemental manual or contact Crane Care for service and repair instructions.

MAINTENANCE

General

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

WARNING

Serious Injury Could Occur!

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

CAUTION

Damage Could Occur!

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

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

General Troubleshooting

WARNING

Serious Injury Could Occur!

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

Tools for Troubleshooting

This machine Incorporates a CAN bus Multiplex system. In order to effectively troubleshoot the electrical system, you need a Windows-based PC. The Crane Service Tool (CST) is the Crane Control System (CCS) troubleshooting tool available thru Crane Care to those who have attended their technical training courses.

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

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

Troubleshooting Engine Starting Problems

1. Verify the battery terminals are connected and clean, the transmission is in neutral, and the machine is fueled.
2. Check Fuse F61. Fuse F61 can be found in the carrier's battery box. Replace, if necessary.
3. Try to turn on the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights to verify the batteries have at least some charge. If none of these lights comes on, suspect the batteries. Charge batteries as needed, or jump-start the crane from another crane. If the batteries will not take a charge replace them.
4. If you hear the starter relay clicking repeatedly, power is reaching the starter, but not enough. Suspect the batteries. Charge batteries as needed, or jump-start the crane from another crane. Refer to *Jump Starting Hazard*, page 3-11. If the batteries will not take a charge, replace them.
5. Turn the ignition switch on **Ignition Switch Cavity 1 of connector to check for 24V,** using a multimeter. If there is not 24 volts (but the head lights, tail lights, marker lights, dome light, work light, or gauge lights and panel lights will come on), suspect the ignition switch and the power circuit to it starting at the ignition switch(es) fuse FD4. Fuse FD4 is located in the carrier cab front console. Repair or replace circuit, switch, or fuse as needed.
6. If the batteries, fuses, ignition switch(es), and power circuit to the ignition switch check out, do one of the following:
   a. If you hear no noise when you try to turn the starter, troubleshoot the start circuit (ignition switch, electric shifter, neutral start switch and wiring from ignition switch to starter relay). Make repairs as needed.
   b. If the engine still will not start, and you hear no noise or just a single click, suspect the starter. Troubleshoot the start circuit from the starter relay through the starter solenoid to the starter motor and ground. Make repairs as needed. If the starter solenoid or the starter motor is faulty, replace the starter.

c. If the starter engages but you cannot turn the engine (and the lights dim, signaling power drain during start attempt), check the starter's feed circuit from the batteries for resistance. If the resistance is high, make repairs. If the circuit checks out, replace the starter. If the engine still won't start, suspect a seized engine.

d. If the starter turns the engine, but it still will not start, suspect a faulty engine control system. Refer to the engine manual for further instructions.

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

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

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.

All crane models have multiple computer systems (crane control, RCL, engine & transmission control) that are highly susceptible to voltage/amperage surges in the electrical system.

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

Charging 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.

TROUBLESHOOTING

Troubleshooting Battery Charging Problems

1. Verify that the battery terminals are connected and clean and all wires in the charging system are in good repair and are connected properly.
2. Verify that the alternator belt is properly installed and is under proper tension.
3. Verify that the batteries put out 24 volts minimum. Charge battery as needed so that the battery can supply a minimum excitation voltage to the engine's charging system.
4. Verify that there is a minimum of 24 volts at the alternator from the batteries, and that the alternator is properly grounded.
5. Replace the alternator if the other conditions check out.
6. Refer to the engine manual for further instructions.

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

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

Troubleshooting Slip Ring-Caused Electrical Problems

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

Connector Troubleshooting

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

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

Table 3-1
Deutsch Extraction Tool Table

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

Table 3-2
Deutsch Crimping Tool Table

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

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

Di-electrical Grease Application

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

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

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

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

Procedure

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

1. Screw the tip/trigger assembly onto the can, if necessary.
2. Squeeze the trigger to dispense the material onto the female (socket) contact.as shown in (Figure 3-12).

Grease Application

6862-41

FIGURE 3-12

3. Use a clean towel (or clean glove) to remove any excess material from the surface of the connector, and wipe material into the terminal sockets as shown in (Figure 3-13)

Clean off Excess Material

6862-42 **FIGURE 3-13**

4. Make sure that each socket has material. The towel with excess material can be used to fill empty terminal sockets as shown in (Figure 3-14).

Make sure Coverage in each Socket

6862-43 **FIGURE 3-14**

5. Make sure that grease is also applied to the entire surface of the rubber seal as shown in (Figure 3-15).

Make sure Coverage of Rubber Seal

6862-44 **FIGURE 3-15**

6. Do not allow material to come in contact with any painted surface, or any other components as shown in (Figure 3-16).

Excessive Paste Must be Wiped Off

6862-45 **FIGURE 3-16**

7. If clean-up is necessary, contact cleaner or petroleum distillates can be used.

8. Secure the connectors when complete.

NOTE: EXCLUSIONS: The following items are excluded from the application of Di-Electric Grease:

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

Pin Connectors M8/M12

6862-40 **FIGURE 3-17**

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

Troubleshooting Lights

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

The following carrier circuit designs apply:

- Headlights: Main Power CB01, (Circuit Breaker). Location: Battery Box.
- CBO1: Power to Headlight Relay, Marker Light Relay, and Dimmer Switch. Location: Carrier Cab.
- Headlight and Marker Light Fuses: FA01 LH Low Beam, FA02 RH Low Beam, FA03 LH High Beam,

FA04 RH High Beam, FA05 LH Marker Lights, FA06 RH Marker Lights. Location: Carrier Cab.

- Triple ID Lights: FA08. Location: Carrier Cab.
- Gauge Lights: FA09. Location: Carrier Cab.
- Turn Signal Lights: Controlled by CCS.
- Hazard Lights: Controlled by CCS.
- Stop Lights: Controlled by CCS.
- Beacon Light (Carrier Cab Optional): F13, Beacon Light Switch Power. Location: Carrier Cab.
- Beacon Light (Superstructure): No fuse or switch. Automatically controlled by CCS with ignition switch.
- Cab Dome Light: FD03, switch on dome light, parallel circuit through door switch, lamp, ground. Location: Carrier Cab.

Troubleshooting Gauges and Meters

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

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

Troubleshooting Alarms, Indicators, and Emergency Components

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

The following carrier circuit designs apply:

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

TROUBLESHOOTING ACCESSORIES

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

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

The following carrier circuit designs apply:

- Windshield wiper motor and windshield washer pump motor. F04, wiper/washer switch, motors in parallel, grounds.
- Heater/defroster fan. F09, heater switch, fan motor, ground.
- Cab circulating fan. F14, switch, motor, ground.
- Air dryer heater. F62 contacts to air dryer temperature switch, to heating element to ground.

Alternator Replacement

Alternator Removal

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse. The ECM Power Fuse is F57 in the Battery Box.
4. Remove the negative battery cables (3), (Figure 3-20).
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the alternator.
7. Relieve tension on belt by rotating automatic tensioner. Once tension is relieved, slip the belt off the alternator pulley.

8. Remove the four bolts attaching the alternator to the mounting bracket. Remove the alternator.

Alternator Installation

1. Inspect the belt. Verify it has no cracks or other damage. Replace damaged belt as needed.
2. Place the alternator on the mounting bracket. Secure the alternator with the bolts. Torque mounting bolts. Refer to *Fasteners and Torque Values*, page 1-14.
3. Install the belt on all engine pulleys except the alternator pulley, for now.
4. Rotate the tensioner to create slack in the belt. Slip the belt onto the alternator pulley, then carefully return the tensioner to its normal position so it puts tension on the belt. Make sure the belt is centered on the tensioner.
5. Connect the electrical leads to the terminals as tagged during removal.
6. Connect the batteries. Close the engine compartment.
7. Install the ECM power fuse. The ECM Power Fuse is F57 in the Battery Box.
8. Turn the battery disconnect switch to the ON position.

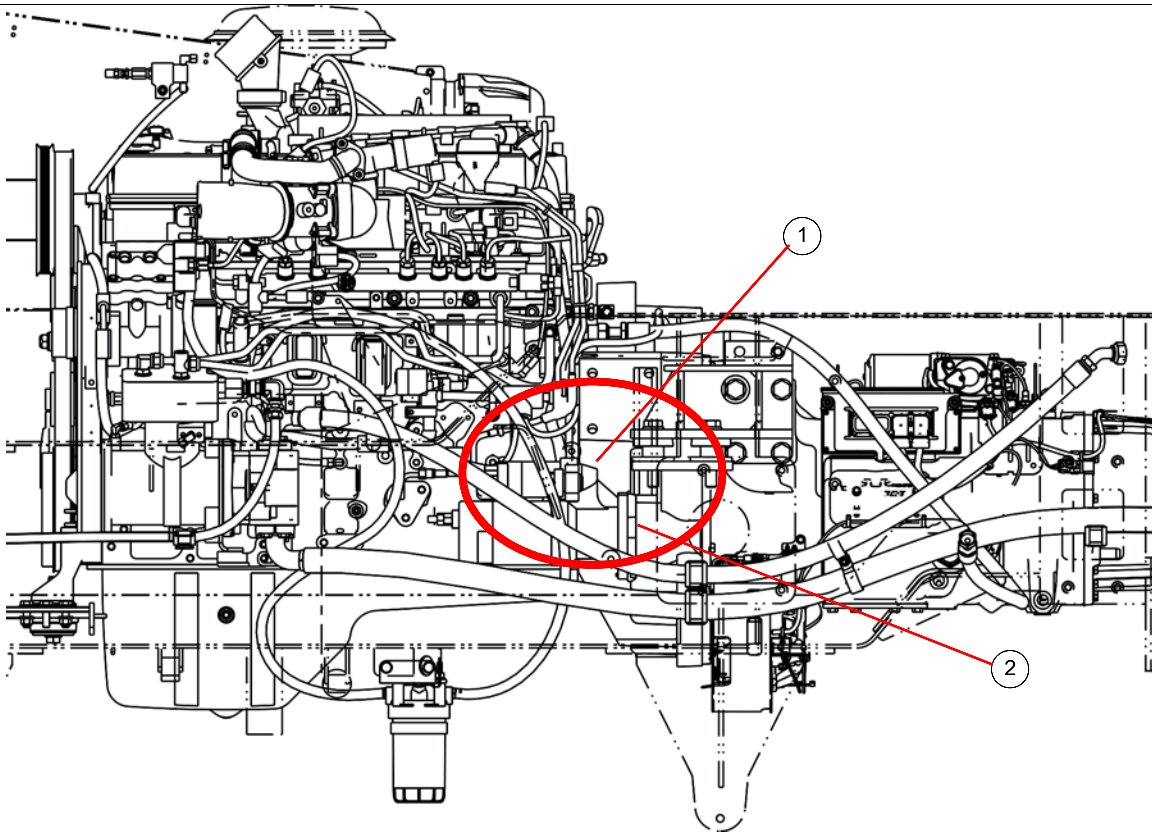
Alternator Check

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 the alternator did not correct the problem in charging system.

Starter Replacement

Starter Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse. The ECM Power Fuse is F57 in the Battery Box.
4. Remove the negative battery cables (3), (Figure 3-20).
5. Open the engine compartment.
6. Tag and disconnect the electrical leads from the terminals on the starter. Refer to (Figure 3-18).
7. Remove the bolts holding the starter to the mounting pad. Remove the starter. The weight of the starter motor is 14 kg (31 lbs).



Item	Description
1	Starter
2	Mounting to Bell Housing

FIGURE 3-18

Starter Installation

1. Place the starter on its mounting pad. Secure the starter with the bolts. Refer to Cummins Manual for torque instructions.
2. Connect the electrical leads to the terminals as tagged during removal.
3. Connect the batteries.
4. Install the ECM power fuse.The ECM Power Fuse is F57 in the Battery Box.
5. Turn the battery disconnect switch to the ON position.
6. Close the engine compartment.

Starter Check

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

Battery Replacement

Battery Removal

CAUTION

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

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

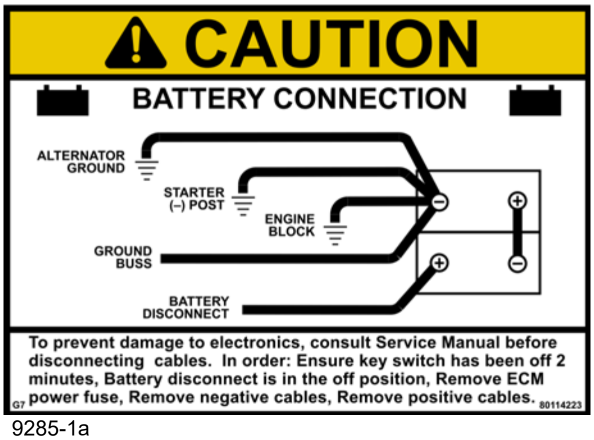


FIGURE 3-19

1. Ensure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the ECM power fuse.The ECM Power Fuse is F57 in the Battery Box.
4. Remove the negative battery cables (3), (Figure 3-20).
5. Remove the positive battery cables (2), (Figure 3-20).
6. Remove the nuts and washers from the battery bracket hold down rod (1), (Figure 3-20). Remove the battery bracket hold down rod (1), (Figure 3-20).
7. Remove the batteries (4), (Figure 3-20). The weight of the starter motor is 14 kg (31 lbs).

Battery Installation

1. Place the batteries in the battery compartment, refer to (Figure 3-20).

.

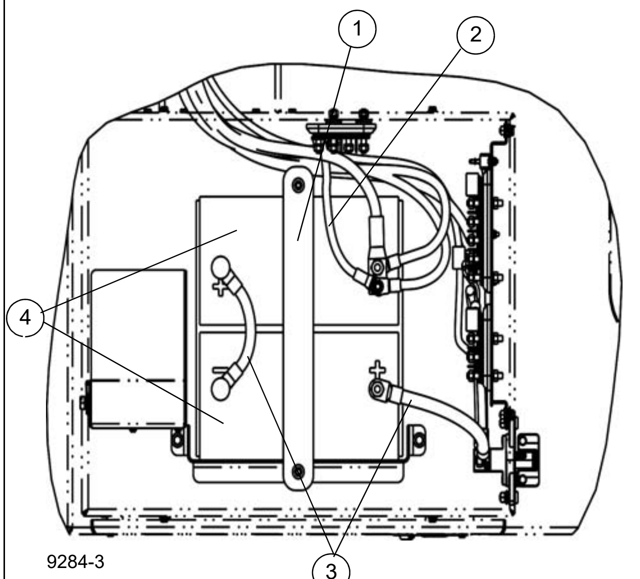


FIGURE 3-20

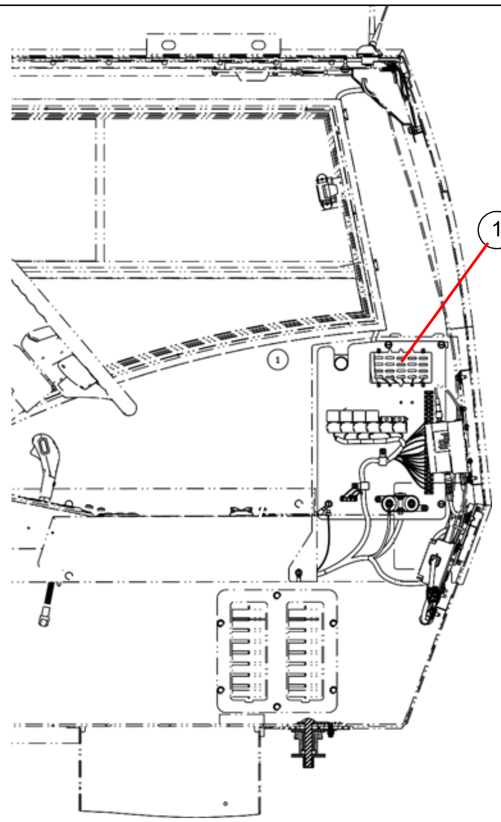
Item	Description
1	Battery Bracket Hold Down Rod
2	Negative Battery Cables
3	Positive Battery Cables
4	Batteries (2)

2. Install the battery bracket hold down rod. Secure the bracket to the bracket hold down rod with nuts and washers.
3. Make sure the battery disconnect switch is in the disconnect position and all key switches are in the “OFF” position.
4. Connect cables to the battery terminals starting with the positive terminals.
5. Close the battery box cover.
6. Install the ECM power fuse.The ECM Power Fuse is F57 in the Battery Box.
7. Turn the battery disconnect switch to ON.
8. Verify replacement batteries work by starting crane’s engine and operating various crane components.

Relay Panel Component Replacement

Accessory Relay Replacement

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the cover from the relay panel (1), (Figure 3-21).
4. Tag and disconnect the electrical leads from the suspect relay.
5. Remove the hardware securing the suspect relay to the relay panel assembly. Remove suspect relay.
6. Install replacement relay on relay panel and secure it with attaching hardware.
7. Connect the electrical leads to the relay as tagged during removal.
8. Install the cover.
9. Turn the battery disconnect switch to the ON position.
10. Verify proper installation by operating all components involved with the replacement relay and verifying they all work.



9284-6 **FIGURE 3-21**

Buzzer Replacement

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

Plug-in Relays Replacement

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

Instrument Replacement

Instrument Removal

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

Instrument Inspection

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

Instrument Installation

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

Instrument Check

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

SWITCH REPLACEMENT

Rocker Switch

Rocker Switch Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the hardware securing the console cover and remove the cover.
4. Disconnect the electrical connector from the switch.
5. Depress the plastic tabs on top and bottom of switch and push the switch through the front of the console panel to remove it.

Rocker Switch Inspection

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

Rocker Switch Installation

1. Place the switch on the console panel and secure it by pushing the switch into the panel, until it snaps into place.
2. Connect the electrical connector to the switch.
3. Position the console cover on the console and secure with the attaching hardware.
4. Turn the battery disconnect switch to the ON position.

Rocker Switch Check

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

All Other Switches

Other Switch Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove the hardware securing the console cover and remove the cover.
4. Tag and disconnect the electrical leads from the switch.
5. On the front of the console panel, remove the nut securing the switch to the panel. As necessary, remove the knob from the switch first.
6. Remove the switch from the hole in the panel.

Other Switch Inspection

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

Other Switch Installation

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

Other Switch Check

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

WINDSHIELD WIPER ASSEMBLY REPLACEMENT - CARRIER CAB

Windshield Wiper Assembly Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove hardware for the front console cover and remove the cover. Tag and disconnect the electrical leads from the motor (1), (Figure 3-22).
4. Disconnect the washer hose on the wiper arm (4), (Figure 3-22) (also called the pantograph arm assembly) from the washer nozzle fitting assembly.
5. Remove the cap nut, washer, and tapered sleeve securing the wiper arm (4), (Figure 3-22) to the pivot shaft (3), (Figure 3-22) assembly.
6. Remove the acorn nuts from the pivot shaft (3) and adapter (6), (Figure 3-22).
7. Remove the wiper arm (4),(Figure 3-22) from the pantograph arm assembly
8. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft (3), (Figure 3-22).
9. Remove the two capscrews and lock washers securing the pantograph arm assembly's adapter to the cab exterior. Remove the pantograph arm assembly's adapter (6), (Figure 3-22) and gasket.
10. Remove attaching hardware to free the windshield wiper motor (1), (Figure 3-22) bracket from the cab interior. Remove the bracket, with motor and pivot shaft connected, from the cab.

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

11. Remove the nut to free the wiper motor's shaft from the wiper motor crank. Remove the three screws and washers to free the wiper motor from its bracket. Remove the wiper motor (1), (Figure 3-22) from its bracket. Leave the other parts attached to the bracket for now.

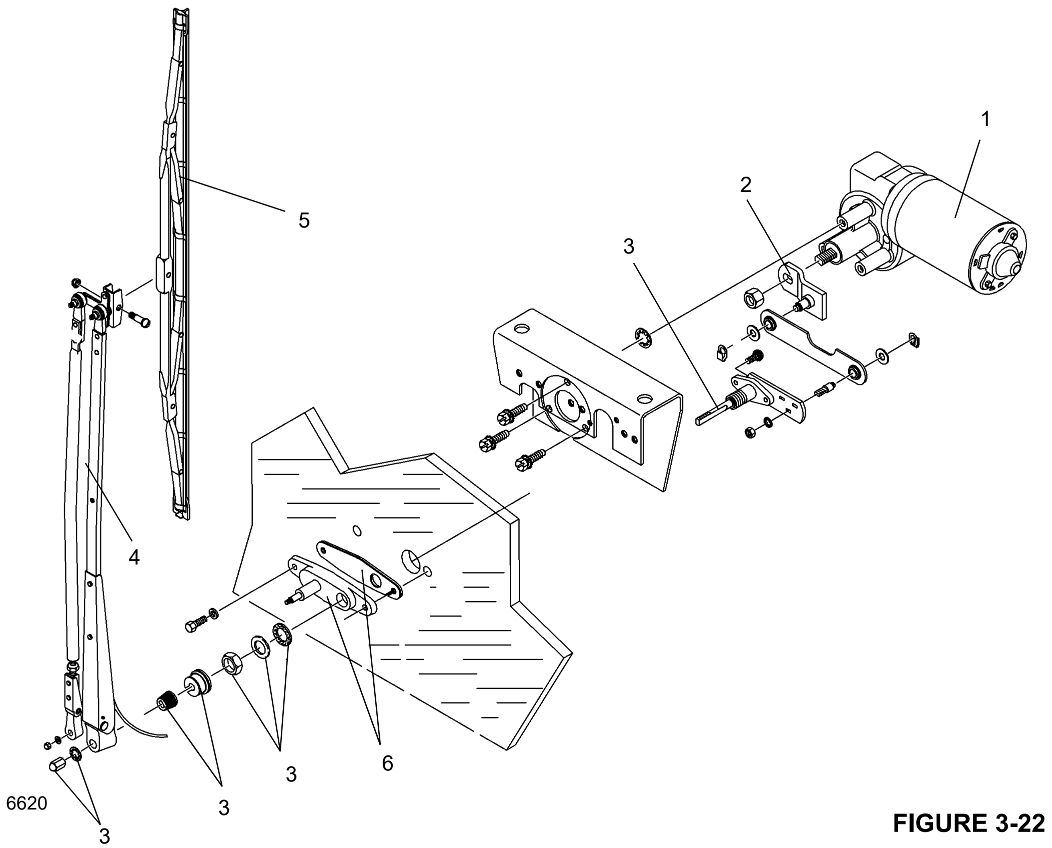


FIGURE 3-22

Item	Description	Item	Description
1	Motor	4	Wiper Arm or Pantograph Arm Assembly
2	Arm Drive	5	Wiper Blade
3	Pivot Shaft and Hardware	6	Pantograph Adapter and Gasket

Windshield Wiper Assembly Inspection

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

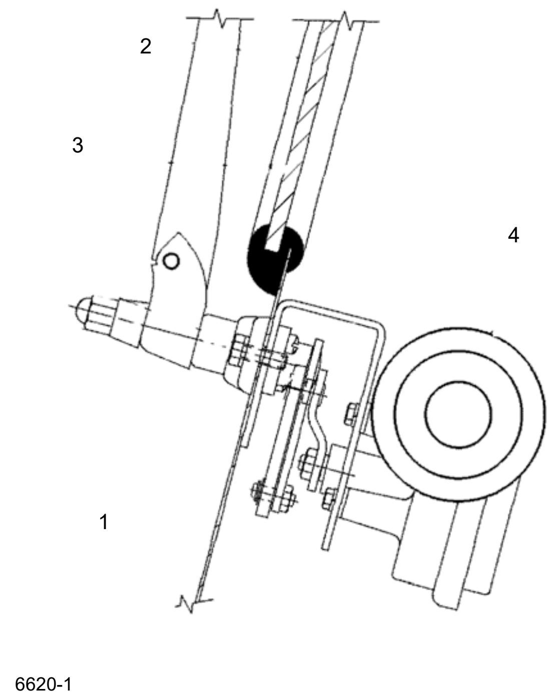
Windshield Wiper Assembly Installation

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

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

5. Secure the pivot shaft to the pantograph adapter with the pivot shaft assembly's nut and washers. Install the flanged sleeve on the pivot shaft.
6. Install the wiper arm on the shafts of the pantograph adapter and the pivot shaft assembly. Secure the wiper arm to the pantograph adapter shaft with its own washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft's own tapered sleeve, washer, and cap nut.For the adjustment of wiper arm when in park position, see Note below and (Figure 3-23).

NOTE: The wiper arm in park position is to be at the side of the glass. The wiper blade is never to leave the glass in "ON" mode during full stroke.



Item	Description
1	Carrier Cab Assembly
2	Molding
3	Glass Windshield
4	24 Volt Front Wiper Kit

FIGURE 3-23

7. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
8. Connect the electrical leads to the wiper motor as marked before removal.
9. Turn the battery disconnect switch to the ON position.

Windshield Wiper Assembly Check

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

WINDSHIELD WASHER ASSEMBLY REPLACEMENT

Windshield Washer Assembly Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Locate the windshield washer container and pump. This should be located at the right front of the carrier, behind the front bumper.
4. Tag and disconnect the pump's electrical lead and ground wire.
5. Disconnect the hose from the windshield washer pump. Point it so that it will not spill windshield washer fluid. Catch excess windshield washer fluid from the windshield washer container with a suitable container.
6. Remove four hex head cap screws securing the windshield washer container. Remove the windshield washer container and pump.
7. Remove pump and pump seal from container.

Windshield Washer Assembly Inspection

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

Windshield Washer Assembly Installation

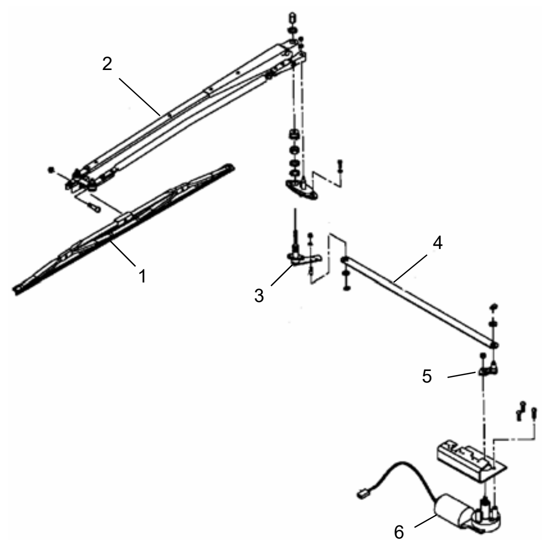
1. Install pump and pump seal on container.
2. Install windshield washer container. Secure the container with four hex head cap screws.
3. Attach the hose to the windshield washer pump.
4. Connect the pump's electrical lead and ground wire as tagged during removal.
5. Turn the battery disconnect switch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

Windshield Washer Assembly Check

1. Squirt some windshield washer fluid onto the windshield with the windshield washer.
2. Make repairs if windshield washer does not work.

SUPERSTRUCTURE WIPER ASSEMBLY

Skylight Wiper Assembly Replacement



9525

Item	Description
1	Wiper Blade
2	Wiper Arm
3	Pivot Shaft
4	Link
5	Drive Arm Link
6	24V Motor Assembly

FIGURE 3-24

Skylight Wiper Assembly Removal

Refer to (Figure 3-24).

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Tag and disconnect the electrical leads from the motor.
4. Remove the wiper arm from the motor shaft.
5. Remove the nut, spacer, leather washer, and nylon flat washer from the motor shaft outside the cab roof.
6. Remove the nut and lockwasher securing the motor bracket to the cab roof and remove the motor from the cab roof. Remove large nylon flat washer from motor

shaft and flat washer and smaller nylon flat washer from mounting screw.

7. Remove mounting screw and nylon flat washer from outside cab roof.
8. Clean any sealing material from around holes in cab roof.

Skylight Wiper Assembly Inspection

1. Visually check the motor housing for evidence of cracks or other damage. Check for excessive shaft end play indicating worn or damaged bearings. Replace motor if damaged.
2. Inspect the wiper blade for serviceability. Replace wiper blade when worn.
3. Inspect the wiper arm and parts for damage. Replace as needed.

Skylight Wiper Assembly Installation

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

Skylight Wiper Assembly Check

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

WINDSHIELD WIPER ASSEMBLY REPLACEMENT - SUPERSTRUCTURE CAB

Windshield Wiper Assembly Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Remove hardware for the front console cover and remove the cover. Tag and disconnect the electrical leads from the motor (1), (Figure 3-25).
4. Disconnect the washer hose on the wiper arm (4), (Figure 3-25) (also called the pantograph arm assembly) from the washer nozzle fitting assembly.
5. Remove the cap nut, washer, and tapered sleeve securing the wiper arm (4), (Figure 3-25) to the pivot shaft (3), (Figure 3-25) assembly.
6. Remove the acorn nuts from the pivot shaft (3) and adapter (6), (Figure 3-25).
7. Remove the wiper arm (4), (Figure 3-25) from the pantograph arm assembly
8. Remove the flanged sleeve, nut, and two flat washers from the pivot shaft (3), (Figure 3-25).
9. Remove the two capscrews and lock washers securing the pantograph arm assembly’s adapter to the cab exterior. Remove the pantograph arm assembly’s adapter (6), (Figure 3-25) and gasket.
10. Remove attaching hardware to free the windshield wiper motor (1), (Figure 3-25) bracket from the cab interior. Remove the bracket, with motor and pivot shaft connected, from the cab.

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

11. Remove the nut to free the wiper motor’s shaft from the wiper motor crank. Remove the three screws and washers to free the wiper motor from its bracket. Remove the wiper motor (1), (Figure 3-25) from its bracket. Leave the other parts attached to the bracket for now.

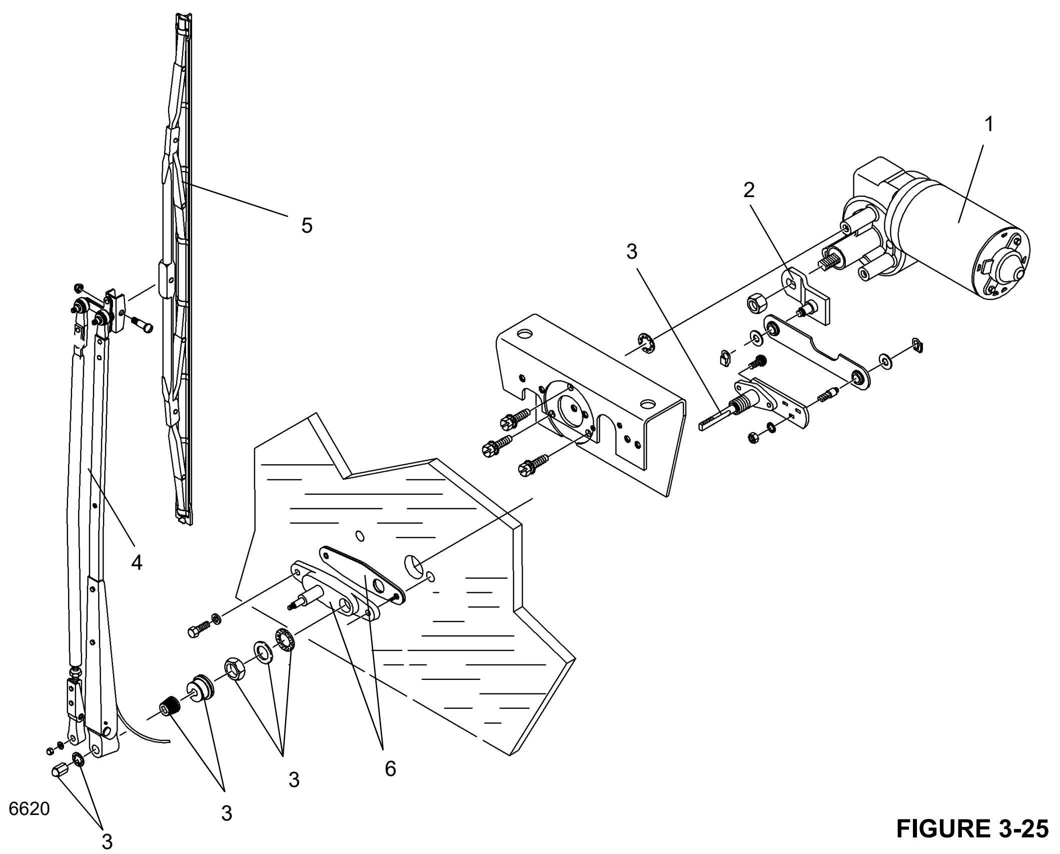


FIGURE 3-25

Item	Description	Item	Description
1	Motor	4	Wiper Arm or Pantograph Arm Assembly
2	Arm Drive	5	Wiper Blade
3	Pivot Shaft and Hardware	6	Pantograph Adapter and Gasket

Windshield Wiper Assembly Inspection

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

Windshield Wiper Assembly Installation

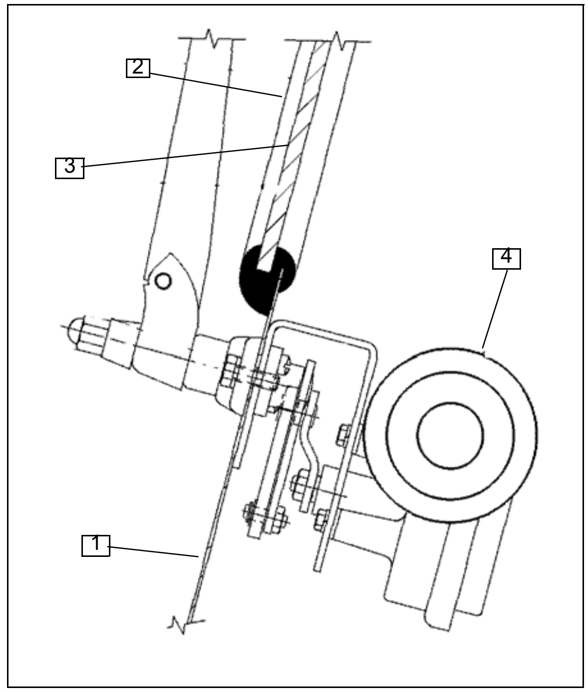
1. Verify the pivot shaft and the wiper motor link and crank are in place on the motor bracket. (Washers and clip springs fasten the link to the pivot pins on the crank and the pivot shaft. The pivot shaft's pivot pin mounts in the hole nearest the end of the pivot shaft's lever.)
2. Connect the wiper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

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

5. Secure the pivot shaft to the pantograph adapter with the pivot shaft assembly's nut and washers. Install the flanged sleeve on the pivot shaft.
6. Install the wiper arm on the shafts of the pantograph adapter and the pivot shaft assembly. Secure the wiper arm to the pantograph adapter shaft with its own washer and cap nut. Secure the wiper arm to the pivot shaft with the pivot shaft's own tapered sleeve, washer, and cap nut. For the adjustment of wiper arm when in park position, see Note below and (Figure 3-26).

NOTE: The wiper arm in park position is to be at the side of the glass. The wiper blade is never to leave the glass in "ON" mode during full stroke.

.



6620-1

Item	Description
1	Cab Assembly
2	Moulding
3	Glass Windshield
4	24 Volt Front Wiper Kit

FIGURE 3-26

7. Connect the wiper arm's washer hose to the washer nozzle fitting assembly.
8. Connect the electrical leads to the wiper motor as marked before removal.
9. Turn the battery disconnect switch to the ON position.

Windshield Wiper Assembly Check

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

WINDSHIELD WASHER ASSEMBLY REPLACEMENT

Windshield Washer Assembly Removal

1. Make sure that the key switch has been in the OFF position for 2 minutes.
2. Turn the battery disconnect switch to the OFF position.
3. Locate the windshield washer container and pump. This should be located at the right front of the carrier, behind the front bumper.
4. Tag and disconnect the pump's electrical lead and ground wire.
5. Disconnect the hose from the windshield washer pump. Point it so that it will not spill windshield washer fluid. Catch excess windshield washer fluid from the windshield washer container with a suitable container.
6. Remove four hex head cap screws securing the windshield washer container. Remove the windshield washer container and pump.
7. Remove pump and pump seal from container.

Windshield Washer Assembly Inspection

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

Windshield Washer Assembly Installation

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

Windshield Washer Assembly Check

1. Squirt some windshield washer fluid onto the windshield with the windshield washer.
2. Make repairs if windshield washer does not work.

COMPUTER MODULES

This crane is equipped with 5 computer modules. The modules and locations are listed in the table below. The modules are susceptible to voltage / amperage surges in the electrical system. (Refer to *Jump Starting Hazard*, page 3-11 of this Section.)

)

Modules	Location
MWIOL32	Superstructure Cab
MWSCM0	Superstructure Cab
MWCCM10	Superstructure Turntable--Right-hand Side
CCM11	Carrier Frame - Left Side by Ladder
I0L31	Carrier Cab Front Console

Troubleshooting the Crane Control System (CCS)

The Crane Control System (CCS) monitors the engine, transmission, and crane functions to make sure they are functioning properly. If a malfunction is detected within any of these areas, the Crane Control System Display, (Figure 7-4), (also refer to *Engine Control System Switches and Indicator Lights*, page 7-7) will illuminate the engine system warning icon for engine and transmission faults, or the crane error icon for any crane function faults. These icons are also located on the main menu screen of the CCS display located on the Operator Display Module (ODM) located in the Superstructure Cab. For more information on the ODM, refer to the Operator Display Module and Rated Capacity Limiter Display Module in the Operator Manual, page 3-33.

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

USING THE OPERATOR DISPLAY MODULE (ODM)

NOTE: Refer to the Operators Manual, *Operator Display Module and Rated Capacity Limiter Display Module*, page 3-33 for additional information.

Fault Codes

The Crane Control System (CCS) monitors the engine, transmission, and crane functions to make sure that they are functioning properly. If a malfunction is detected within any of these areas, the crane control system display will illuminate the Engine Warning Indicator (Figure 7-4) for engine and transmission faults, or the Crane Fault Indicator for any crane function faults. Both of these icons are located on the Main Menu Screen of the Operator Display Module (ODM) located inside the Superstructure Cab.

Refer to the Operators Manual, *Operator Display Module and Rated Capacity Limiter Display Module,* page 3-33 for additional information.

REMOTE CONTROLLER (OPTIONAL)

The remote controller consists of the following:

- A hand held remote transmitter (1), (Figure 3-27).
- A receiver (2), (Figure 3-27) mounted behind the seat in the carrier cab.
- A battery charger (3), (Figure 3-27).
- A second battery (4), (Figure 3-27). The other battery is in the remote.
- The battery charger clip (5), (Figure 3-27) that holds the charger in place.

FIGURE 3-27

Remote Control Components

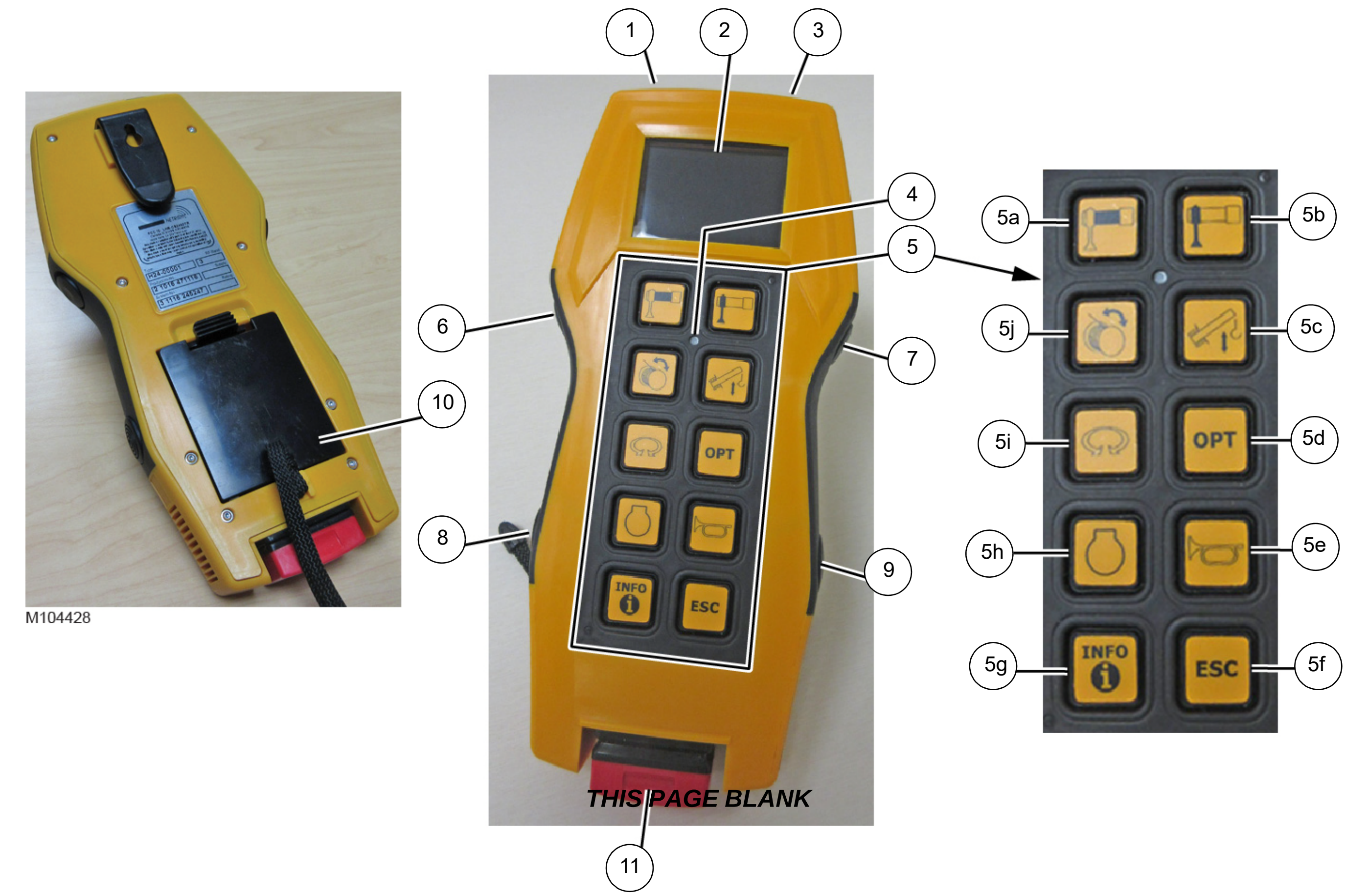


FIGURE 3-28

Table 3-3 Remote Control Components

Item	Component (Figure 3-28)	Description
1	Programming Port	For Grove factory authorized use only
2	Color Display	Displays information for the selected function
3	Power Button	ON/OFF switch which activates and deactivates the remote control
4	Indicator LED	Amber, solid = remote control in boot loader mode (ready to be programmed) Green, slow blink = wireless communication OK Red, slow blink = E-stop relay open or wireless communication stopped Red, fast blink = battery low Red, solid = remote controlling error

5	Function Selector Buttons (qty 10)	Momentary buttons that activate the selected function in the display: 5a - Outrigger beams 5b - Outrigger jacks 5c - Boom lift 5d - Option: 5e - Horn (activates the superstructure horn) 5f - Escape: exits the selected function screen 5g - Information (software version/revision and crane serial number) 5h - Engine 5i - Swing 5j - Main/aux hoist
6 7	Left Motion Button Right Motion Button	Holding down either button operates the selected function in the desired direction (for example: turn a hoist up or down, extend or retract a jack or beam, swing right or left). Speed depends on how far either button is depressed.
8	Left Enable Button	Holding down either button allows (enables) a selected function to be operated in the desired direction by the corresponding motion button.
9	Right Enable Button	
10	Battery	3.2Ah Lithium-Po rechargeable battery
11	E-Stop Knob	Pull out = allow operation of the crane functions from the remote control Push in = STOP engine and current function

Receiver

Receiver Removal

1. Refer to (Figure 3-27).
2. Tag and remove the cables from the receiver.
3. Remove the four screws holding the receiver to the panel.
4. Remove the receiver.

Receiver Installation

1. Refer to (Figure 3-27).
2. Align the receiver’s four mounting holes with the holes in the panel.
3. Install the four screws and tighten.
4. Connect the cables as tagged during removal.

Battery Charger

Battery Charger Removal

1. Refer to (Figure 3-27).
2. Unplug the wire from the battery charger.
3. Loosen the screw securing the battery charger clip (5).
4. Loosen the nuts securing the battery charger to the panel.
5. Slide the battery charger up and remove it.

Battery Charger Installation

1. Refer to (Figure 3-27).
2. Hold head of screws, that secure the battery charger, approximately 3 mm (0.13 in) off the panel and slide the battery charger over the screw heads.
3. Secure the screws with the nuts.
4. Slide the battery charger clip down onto the battery charger and secure with the screw.
5. Plug in the wire to the battery charger.

Remote Controller Battery

Remove/install the battery (a 3.2Ah Lithium-Po rechargeable battery) into the remote transmitter or charger by squeezing the tab on the base of the battery and pulling/pushing the battery out/in. For additional information on the Remote Controller, refer to the Operations Manual, Section 3 Remote Control (Optional) and Table 3-3 Remote Control System Components (noted above).

THIS PAGE BLANK

SECTION 4
BOOM

SECTION CONTENTS

Description . . . 4-1
Safety . . . 4-1
Boom System Components . . . 4-2
Telescope Cylinder . . . 4-2
Fly Section Extension Cables . . . 4-2
Extend Synchronizing Cable . . . 4-2
Fly Retraction Cables . . . 4-2
Outer Mid Retract Cables . . . 4-2
Boom Extension Sequence . . . 4-2
Boom Retract Sequence . . . 4-4
Telescope Circuit . . . 4-4
Description . . . 4-4
Theory of Operation . . . 4-4
Telescope Circuit Troubleshooting . . . 4-5
Lift Circuit . . . 4-6
Description . . . 4-6
Theory of Operation . . . 4-7
Lift Circuit Troubleshooting . . . 4-7
General Maintenance Notes . . . 4-8
Boom Extension Removal (Optional) . . . 4-9
Boom Removal . . . 4-10
Disconnect the Base Section . . . 4-12
Remove the Base Section . . . 4-13
Disconnect the Inner Mid Section . . . 4-14
Remove the Inner Mid Section . . . 4-15
Remove the Outer Mid Section . . . 4-17
Remove the Telescope Cylinder . . . 4-19
Boom Nose Sheaves . . . 4-20
Boom Nose Sheave Removal . . . 4-21
Boom Nose Sheave Installation . . . 4-22
Boom Assembly Procedure . . . 4-23
Install Telescope Cylinder . . . 4-23
Install the Outer Mid Section . . . 4-26
Install the Inner Mid Section . . . 4-30
Tensioning the Boom Extend and Retract Cables . . . 4-35
Install the Base Section . . . 4-38
Final Boom installation . . . 4-40
Swingaway Extension Installation (Optional) . . . 4-41
Boom Maintenance . . . 4-43
Functional Test of the Boom . . . 4-43
Boom Inspection . . . 4-43
Boom Alignment and Servicing . . . 4-44
Extension and Retraction Cable Maintenance . . 4-44
Inspection . . . 4-45
Lift Cylinder Maintenance . . . 4-46
Lift Cylinder Removal . . . 4-46
Lift Cylinder Installation . . . 4-46

4

DESCRIPTION

The crane is equipped with one of two booms: a 29 m (95 ft) or a 31 m (102 ft.) boom. (Refer to Figure 1-1 and Figure 1-2 for additional information.)

The boom is rectangular in design and utilizes one two-stage double-acting, rod ported telescope cylinder. The telescoping sections are supported on graphite impregnated nylatron wear pads. Adjustable side wear pads prevent metal to metal contact between the sections.

Boom assembly lift is provided by a single lift cylinder. Boom elevation range is from -3 to 76 degrees.

An optional auxiliary boom nose (rooster sheave) is available for the boom to simplify single part cable usage. The rooster sheave is installed on the main boom nose and is secured by pins that pass through the rooster sheave.

The boom has a 7.92 to 13.7 m (26 to 45 ft) telescoping offsetable swingaway boom extension provided to obtain additional boom reach. The boom extension mounts directly to the boom nose utilizing a four point attachment. The boom extensions may be offset at 0,15, and 30 degrees. In addition, the swingaway can be stowed on the right side of the boom base section.

Safety

Do not attempt to work on the boom without experienced supervision. (Also, refer to the Safety Messages (pg 1-2) Section of this manual.

DANGER

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

BOOM SYSTEM COMPONENTS

Telescope Cylinder

The telescope cylinder is attached to the boom in three places: (refer to Figure 4-1 for item location).

- The outer rod end (1) of the telescope cylinder is secured to the boom base section (2).
- The inner rod end (3) is secured to the inner mid-section (4).
- The cylinder barrel (5) is secured to the outer mid-section (6).

Fly Section Extension Cables

The fly section has five extension cables (7) attached to it. Refer to Figure 4-1 for item location.

The extension cables (7) are secured to the inner mid-section (8) and are routed around a five groove sheave assembly (9) at the barrel end (boom nose) of the telescope cylinder (10). These cables are secured at the base end of the fly section (11).

Extend Synchronizing Cable

Refer to Figure 4-1 for item location. The long extend synchronizing cables (12) are connected to the rear of the outer mid-section (6) and is routed around two sheaves (21) on the top front of the inner mid-section (4), and secured to the rear of the base section (13).

Fly Retraction Cables

Refer to Figure 4-1 for item location. The two retraction cables (14) are secured at the outside front of the inner mid-section (4), are routed around sheaves (15) mounted on the end of the outer mid-section (6) and are secured at the opposite end (16) to the fly section (17).

Outer Mid Retract Cables

Refer to Figure 4-1 for item location. The four retraction cables (18) are secured at the outside front of the base section (2), are routed around sheaves (19) mounted on the end of the inner mid-section (4) and are secured (20) at the opposite end to the outer mid-section (6).

BOOM EXTENSION SEQUENCE

Refer to Figure 4-1 for item location. As the telescope cylinder extends, the cylinder barrel (5), which is attached to the outer mid-section (6), and the inner cylinder rod (3) which is attached to the inner mid-section (4), pulls the mid sections out along with it.

At the same time, the five groove sheave assembly (9) at the nose end of the telescope cylinder pulls on the five fly extension cables around it. This causes the fly section (17) and mid sections (6, 4) to deploy at the same time and rate.

The long extend synchronizing cables (12) ensures the mid sections and the telescope cylinder remain in synchronization.

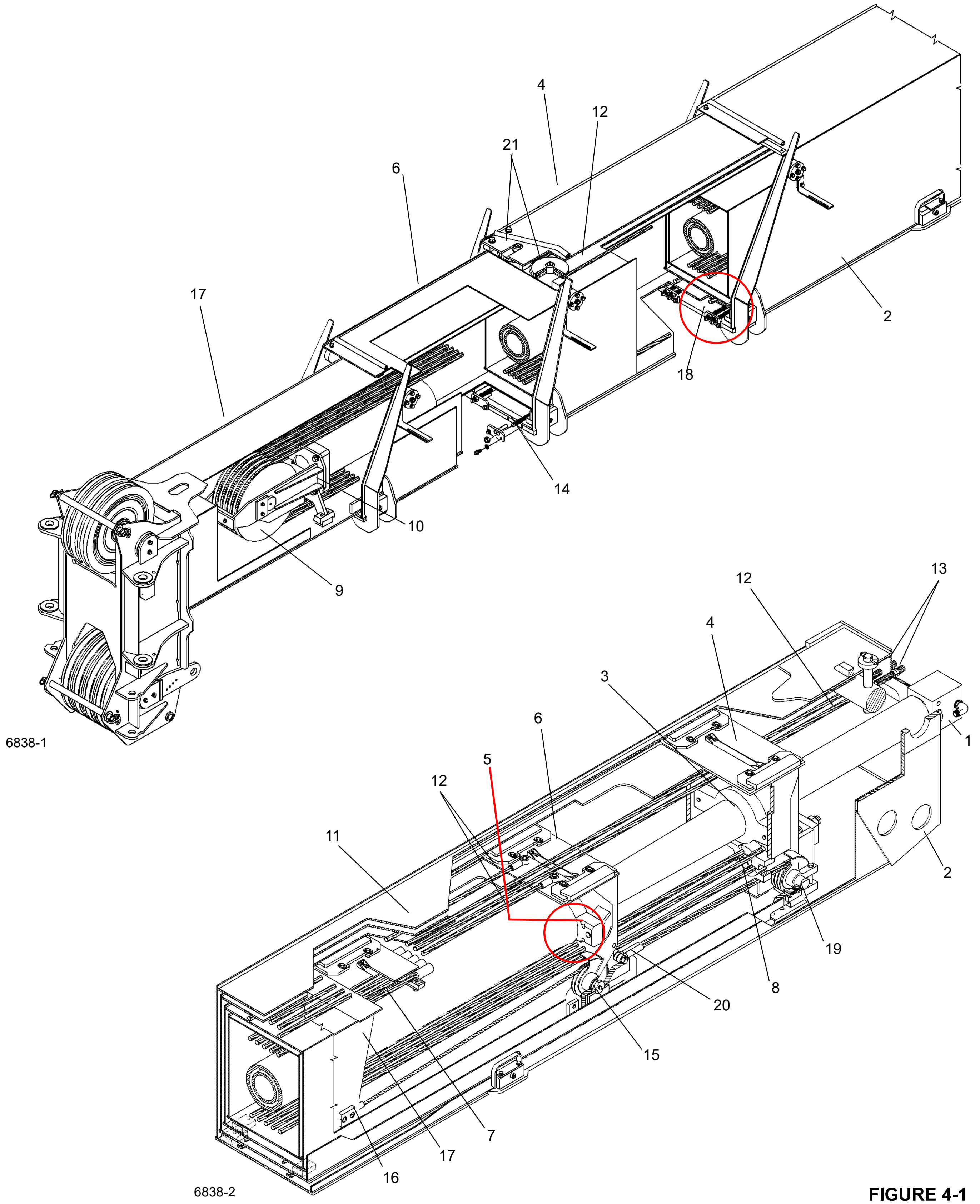

4
12
21
6
17
2
18
14
10
9
6838-1
13
12
4
3
1
6
5
12
2
11
19
8
20
15
7
17
16
6838-2

FIGURE 4-1

Item	Description	Item	Description
1	Outer Rod End of Telescope Cylinder	12	Extend Synchronizing Cables
2	Boom Base Section	13	Base Section Synchronizing Cable Termination
3	Inner Rod End Section of Telescope Cylinder	14	Fly Retraction Cables
4	Inner Mid Section	15	Fly Section Retract Cable Sheaves
5	Cylinder Barrel of Telescope Cylinder	16	Retract Cable Termination Fly Section
6	Outer Mid-Section	17	Fly Section
7	Extension Cables	18	Outer Mid Retract Cable Termination
8	Inner Mid-Section Extend Cable Termination	19	Outer Mid Retract Cable Sheaves
9	Five Groove Sheave Assembly	20	Outer Mid Section Retract Cable Termination
10	Barrel End of Telescope Cylinder	21	Synchronizing Sheaves
11	Fly Section Extend Cable Termination		

BOOM RETRACT SEQUENCE

Refer to Figure 4-1 for item location. As the telescope cylinder is retracted, the outer mid-section (6) (attached to the cylinder barrel) and the inner mid-section (4) (attached to the inner cylinder rod) are pulled in.

During retraction, the two fly and four outer mid-retraction cables are forced around sheaves (15, 19) at the rear of the mid section. This cable arrangement keeps the fly section, outer mid-section, and the telescope cylinder in the proper sequence and timing.

TELESCOPE CIRCUIT

Description

The boom telescope circuit consists of the telescope function remote control, telescope directional control valve, holding valve, and the telescope cylinder.

NOTE: If the crane is equipped with an auxiliary hoist, the telescope function is controlled by a foot pedal instead of a controller.

The telescope control valve is part of the main directional control valve assembly and is described under the Main Directional Valve Assembly (pg 2-29).

The boom telescope cylinder is a two-stage double acting, rod ported cylinder. Foreign material is prevented from entering the cylinder by a wiper seal during rod retraction. O-Ring seals prevent internal and external leakage.

The holding valve is threaded into a port block on the inner rod end of the telescope cylinder. The holding valve functions during the retraction, extension, or holding operation. When holding the boom section at a given length, oil is trapped in the cylinder by the holding valve. Refer to Valve Pressure Setting Table (pg 2-33).

Theory of Operation

Flow from the pump travels to the telescope directional control valve. Movement of the control lever for telescope functions from neutral sends an electrical signal to the directional control valve to shift the spool in the directional control valve. This aligns the appropriate passages in the control valve to route oil to the telescope cylinder holding valve. The holding valve, with its internal make-up of valves and springs, passes oil to and from the telescope cylinder. During extension, oil unseats the poppet (check) valve in the holding valve. This oil is routed to the piston sides of the cylinder which extends the cylinder, causing the boom section to extend.

During retraction, oil enters the retract port and flows to the rod sides of the cylinder. When pilot pressure reaches a pre-determined value, the main poppet unseats, and oil flows from the piston sides of the cylinder to the reservoir causing the boom section to retract. All return flow from the directional control valve goes to the reservoir.

TELESCOPE CIRCUIT TROUBLESHOOTING

Table 4-1

SYMPTOM	PROBABLE CAUSE	SOLUTION
1. Erratic operation of extending telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Damaged relief valves.	**b.** Repair or replace relief valves.
	c. Air in telescope cylinder.	**c.** Bleed by lowering telescope cylinder below horizontal.
	d. Low engine RPM.	**d.** Increase engine RPM to recommended setting.
	e. Lack of lubrication on boom sections.	**e.** Properly lubricate all boom sections.
	f. Extremely tight boom extension sheaves.	**f.** Inspect and properly lubricate boom extension sheaves.
	g. Improper boom alignment caused from side loading.	**g.** Reduce and properly hoist load.
	h. Worn boom wear pads.	**h.** Replace wear pads and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Damaged telescope cylinder.	**j.** Repair or replace cylinder.
	k. Clogged, broken, or loose hydraulic lines or fittings.	**k.** Clean, tighten, or replace lines or fittings.
	l. Damaged control valve.	**l.** Repair or replace control valve.
2. Erratic operation of retracting telescoping cylinder.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Damaged relief valve.	**b.** Repair or replace relief valve.
	c. Air in cylinder.	**c.** Bleed by lowering telescoping cylinder below horizontal and cycle telescope cylinder.
	d. Low engine RPM.	**d.** Increase engine RPM to recommended setting.
	e. Lack of lubrication.	**e.** Properly lubricate all boom sections.
	f. Check valve malfunctioning.	**f.** Repair or replace check valve.
	g. Improper boom alignment caused from side loading.	**g.** Reduce and properly hoist load.
	h. Extremely tight boom retraction sheave.	**h.** Inspect and properly lubricate.
	i. Distorted boom section.	**i.** Replace distorted section.
	j. Worn boom wear pads.	**j.** Replace wear pads and properly lubricate.
	k. Bent cylinder rod(s).	**k.** Replace cylinder rod(s) and all cylinder seals.
	l. Scored cylinder barrel.	**l.** Repair or replace cylinder barrel.
	m. Damaged piston seals.	**m.** Replace all cylinder seals.
	n. Loose or damaged piston(s).	**n.** Replace all seals and re-torque or replace piston(s).

SYMPTOM	PROBABLE CAUSE	SOLUTION
3. Telescope cylinder will not extend.	**a.** Low hydraulic oil level.	**a.** Replenish oil to proper level.
	b. Relief valve malfunctioning.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load.
	d. Clogged hose and fittings.	**d.** Replace hose or fittings. (Refer to Manitowoc Crane Care *Parts Manual*).
	e. Broken valve spool.	**e.** Replace valve.
	f. Damaged piston seals.	**f.** Replace all cylinder seals.
	g. Damaged piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Bent boom section(s).	**h.** Replace damaged boom section(s).
	i. Broken hydraulic pump coupling.	**i.** Replace broken hydraulic pump coupling.
	j. Worn or damaged hydraulic pump section.	**j.** Repair or replace pump section.
4. Telescope cylinder will not retract.	**a.** Low hydraulic oil level.	**a.** Replenish oil to proper level.
	b. Relief valve damaged.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load. (Refer to *Load Chart*).
	d. Inoperative check valve.	**d.** Replace check valve.
	e. Clogged hose and fittings.	**e.** Replace hose or fittings. (Refer to Manitowoc Crane Care *Parts Manual*).
	f. Broken valve spool.	**f.** Replace valve section.
	g. Broken piston(s).	**g.** Replace piston(s) and all cylinder seals.
	h. Damaged piston seals.	**h.** Replace all cylinder seals.
	i. Bent boom section(s).	**i.** Replace damaged boom section(s).
	j. Broken hydraulic pump coupling.	**j.** Replace broken hydraulic pump coupling.
	k. Worn or damaged hydraulic pump.	**k.** Repair or replace pump.
	l. Broken hydraulic pump shaft.	**l.** Replace pump shaft.

LIFT CIRCUIT

Description

The boom lift circuit consists of the lift function remote control, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -3 to +76 degrees from horizontal.

The lift directional control valve is part of the main directional control valve assembly and is described under the Main Directional Valve Assembly (pg 2-29)

The lift cylinder is the double acting type. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage by a wiper seal during rod retraction. Oil seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage.

The holding valve is a balanced poppet type hydraulic valve. It is threaded into the port block which is an integral portion of the lift cylinder barrel. The holding valve functions when booming up (cylinder rod extending), booming down (cylinder rod retracting), or holding (cylinder rod stationary).

An orifice fuse is installed in the RCL piston transducer port of the lift cylinder port block. The orifice is used to slow inadvertent retraction (lowering) of the lift cylinder should the line to the transducer develop a leak.

Theory of Operation

The boom lift circuit consists of the lift electric controller, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -3 to +78 degrees from horizontal.

When booming up, oil unseats the poppet (check) valve in the holding valve, letting oil flow to the piston side of the cylinder. Pressure is applied to the piston, forcing the cylinder to extend, raising the boom.

When booming down, oil enters the retract port of the port block and flows to the cylinder rod side. When pilot pressure reaches a pre-determined value, the main poppet unseats and oil flows from the piston side of the cylinder to the reservoir.

All return flow from the control valve goes to the reservoir.

LIFT CIRCUIT TROUBLESHOOTING

Table 4-2

Symptom	Probable Cause	Solution
1. Boom raises erratically.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper level.
	b. Low engine RPM.	**b.** Increase engine RPM to recommended setting.
	c. Main relief valve damaged.	**c.** Replace relief valve.
	d. Air in cylinder rod.	**d.** Bleed cylinder rod.
	e. Bent boom pivot shaft.	**e.** Replace pivot shaft.
2. Boom lowers erratically.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper oil level.
	b. Low engine RPM.	**b.** Increase engine RPM to recommended level.
	c. Circuit and/or relief valve inoperative.	**c.** Repair or replace relief valve.
	d. Air in hydraulic cylinder.	**d.** Bleed air from cylinder.
	e. Damaged hydraulic pump section.	**e.** Repair or replace pump section.
3. Boom raises slowly.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Low engine RPM.	**b.** Increase and maintain engine RPM.
	c. Damaged relief valve.	**c.** Repair or replace relief valve.
	d. Extremely cold hydraulic oil.	**d.** Operate unit to bring oil to operating temperature.
	e. Improper hose or fittings installed.	**e.** Replace hose or fittings. (Refer to Manitowoc Crane Care *Parts Manual*).
	f. Operating two functions within the same control valve bank assembly.	**f.** Feather controls to obtain desired speed of both functions.
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals leaking.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. Worn hydraulic pump section.	**j.** Repair or replace pump section.
	k. EEPROM settings not working.	**k.** Repair EEPROM settings.

Symptom	Probable Cause	Solution
4. Boom lowers slowly.	**a.** Low hydraulic oil level.	**a.** Replenish hydraulic oil to proper level.
	b. Low engine RPM.	**b.** Increase RPM to recommended level.
	c. Damaged relief valve.	**c.** Repair or replace relief valve.
	d. Operating two functions within the same control valve bank assembly.	**d.** Feather controls to obtain desired speed of both functions.
	e. Extremely cold hydraulic oil.	**e.** Operate unit to bring oil to operating temperature.
	f. Improper hose or fittings installed.	**f.** Replace hose or fittings. (Refer to Manitowoc Crane Care *Parts Manual*).
	g. Restriction in return hose.	**g.** Replace return hose.
	h. Cylinder piston seals worn.	**h.** Replace all cylinder seals.
	i. Scored cylinder barrel.	**i.** Hone or replace barrel.
	j. EEPROM settings not working.	**j.** Repair EEPROM settings.
	k. Worn hydraulic pump section.	**k.** Repair or replace pump section.
	l. Piston rod broken (loose from piston).	**l.** Replace piston rod and all cylinder seals.
5. Boom will not raise.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper level.
	b. Main relief valve or circuit relief valve damaged.	**b.** Repair or replace relief valve.
	c. Excessive load.	**c.** Reduce load as required.
	d. Worn or damaged hydraulic pump section.	**d.** Repair or replace pump section.
	e. Broken pump shaft.	**e.** Replace pump shaft and seals.
	f. Broken pump drive coupling.	**f.** Replace drive coupling.
	g. Broken control valve spool.	**g.** Replace control valve.
6. Boom will not lower.	**a.** Low hydraulic oil.	**a.** Replenish hydraulic oil to proper level.
	b. Main relief valve or circuit relief valve damaged.	**b.** Repair or replace relief valve.
	c. Worn or damaged hydraulic pump section.	**c.** Repair or replace pump section.
	d. Broken pump shaft.	**d.** Replace pump shaft and seals.
	e. Broken pump drive coupling.	**e.** Replace drive coupling.
	f. Broken control valve spool.	**f.** Replace control valve.

GENERAL MAINTENANCE NOTES

- Apply medium strength thread locking adhesive/sealant and primer to all hardware except items Mid Syncro Cable threads, Fly Retract Cable threads, and Outer Mid Retract Cable threads.
- Unless otherwise specified, torque values for all metric class 8.8 and/or 10.9 and grade 5 and/or grade 8 fasteners shall be as specified under Fasteners and Torque Values (pg 1-14).
- Apply multipurpose grease to all wear surfaces.
- Adjust bottom front adjustable wear pads such that wear pad is within 1 mm from side plate or bottom plate of next inner section. Use shims only if section needs to be adjusted for twist.
- Adjust top rear adjustable wear pads such that the wear pad is just in contact with side plate of next outer section.

- To adjust the lower side wear pads, use shims so that wear pads are just in contact with the side plate of the next outer section.
- To adjust the rear bottom wear pads, use shims so that wear pads are within 2 mm of the bottom plate of the next outer section.

BOOM EXTENSION REMOVAL (OPTIONAL)

NOTE: Do not attempt to remove the boom extension unless you have read and understand the instructions. The boom extension must be supported and secured throughout the process to prevent the boom extension from falling.

DANGER

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

DANGER

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

NOTE: A Tag line (Figure 4-2) used in these procedures is to control the movement of the boom extension.

FIGURE 4-2

DANGER

Before attempting to remove the boom extension; read and strictly adhere to all danger decals installed on the boom/boom nose, boom extension, and stowage brackets to prevent serious injury or death.

1. Attach a length of rope (tag line) to the boom extension tip, as shown in Figure 4-2, to aid in swinging the boom extension into place ahead of the boom nose.
2. Visually check to ensure all pins are installed.
3. Crane should be set up on fully extended outriggers using normal setup procedures as found in the *Operator Manual, Using the Outriggers, page 4-26.*
   a. Fully retract the boom.
   b. Swing the boom over the rear of the crane and lower the boom to a horizontal position for removal.
4. Remove the pin (5) securing the sliding portion of the rear stowage bracket in the “IN” position. Pull the handle (6), (Figure 4-4) to move the sliding portion of the rear stowage bracket to the “OUT” position. Secure in place with pin (5), (Figure 4-4).
5. Remove the retainer clips from the right side attachment pins stowed in the base of the boom extension and remove the attachment pins from the boom extension. Insert the right side attachment pins (1), (Figure 4-3), through the boom attachment and boom extension anchor fittings (2), (Figure 4-3). Install the retainer clips in the attachment pins.

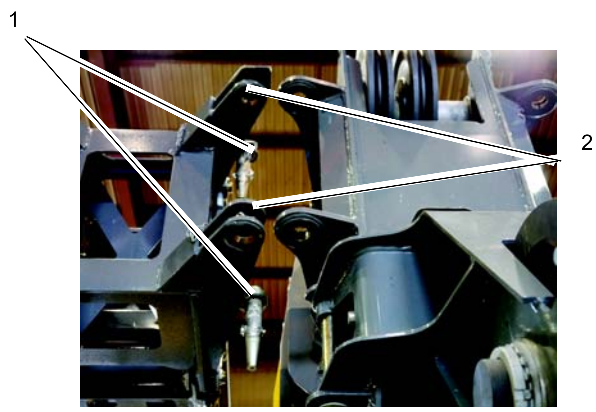
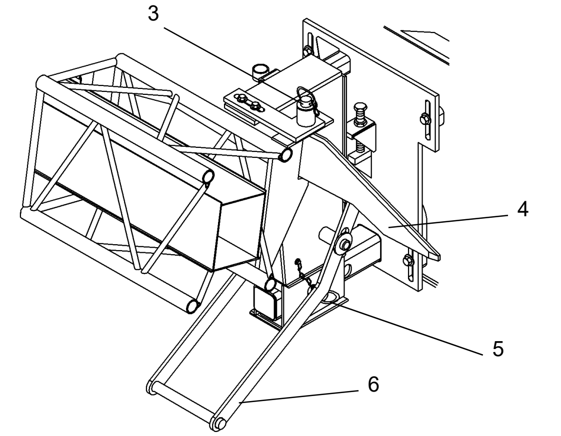


FIGURE 4-3

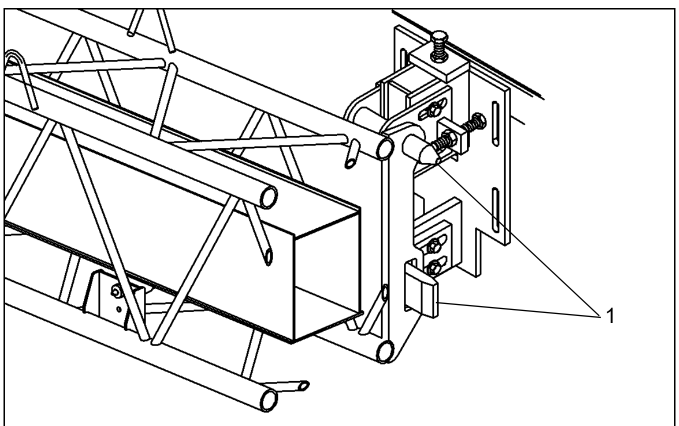
NOTE: Prior to Step 6, before removing the hitch pin (3), ((Figure 4-4)), make sure that the boom extension is attached to the right side boom nose attachment lugs with the pins and that the pins are secured.

6. Remove the retaining pin from the hitch pin (3), (Figure 4-4) that secures the boom extension to the rear stowage bracket. Remove the hitch pin, unlocking the boom extension from the boom.



6821-1 **FIGURE 4-4**

7. Extend the boom approximately 51 to 64 cm (20 to 25”). Make certain that the boom extension stowage lugs clear the guide pins (1), (Figure 4-5) and ramp (4), (Figure 4-4) on the front and rear stowage brackets.



6821-3 **FIGURE 4-5**

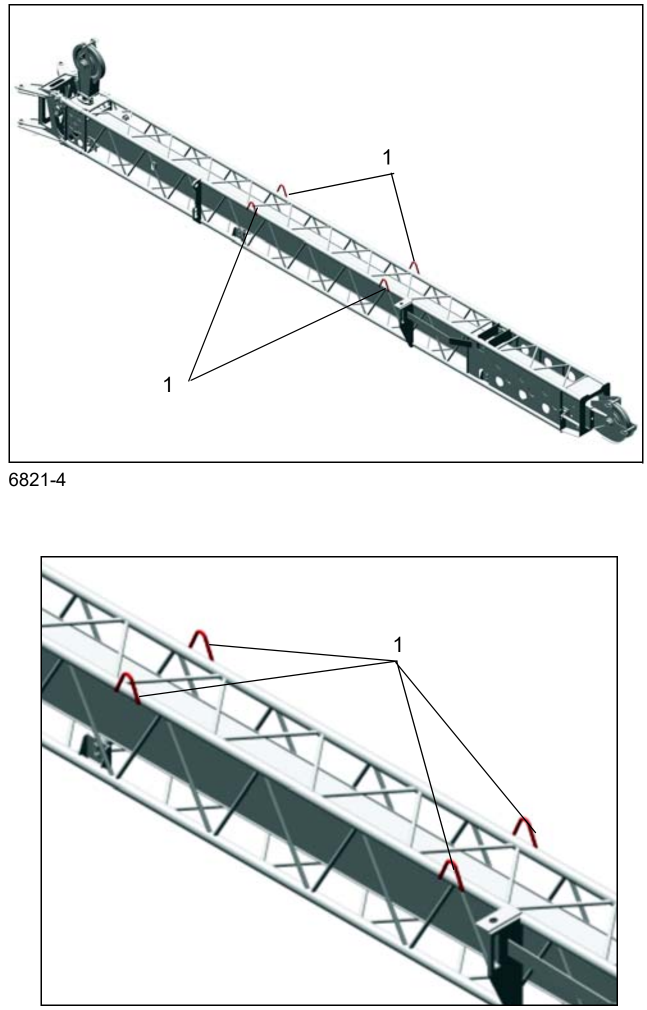
DANGER

When removing the boom extension, make sure that all personnel and equipment are kept clear of the swing path.

8. Slightly raise and/or lower the boom to help control the boom extension. Using the tag line (Figure 4-2) attached to the tip of the boom extension, manually swing the extension into place ahead of the boom nose.

NOTE: The jib weighs 748 kg (1650 lbs).

9. Attach a lifting device to the lifting lugs (1), (Figure 4-6) on the swingaway extension taking pressure off the attaching pins. Remove the pins.



6821-4a **FIGURE 4-6**

10. Make sure that the swingaway extension is placed in a safe secure location.

BOOM REMOVAL

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

DANGER

Before attempting to remove the boom, read and strictly adhere to all DANGER decals installed on the boom/ boom nose, boom extension, and stowage brackets.

DANGER

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

NOTE: The complete boom assembly weighs are: 95' approximately 5144 kg (11,341 lb) and 102' approximately 5954 kg (13,126 lb) without the swingaway boom extension attached. Removal of the boom extension prior to the removal of the base should be mandatory.

1. Fully extend and set the outriggers to level the crane and make sure that the boom is fully retracted and in a horizontal position over the front of the crane.

NOTE: If the boom extension is stowed on the side of the base section, it must be removed before continuing. Refer to Boom Extension Removal (Optional) (pg 4-9).

CAUTION

Wear gloves when handling wire rope. Moderate to minor injury may result if using bare hands.

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

DANGER

Make sure all blocking and lifting devices are capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

3. Shut down hydraulic power to crane.
4. With hydraulic power removed, move the Boom Extend control from “EXTEND” to “RETRACT” several times. This will relieve most residual pressure in Tele Circuit and make Tele Cylinder removal easier.
5. Attach a lifting device to the four lifting lugs (1), (Figure 4-6) at the top of the boom that provides for equal weight distribution.

DANGER

Make sure the boom lift cylinder is properly supported before disconnecting it from the boom. Death or serious injury may result if lift cylinder is not supported.

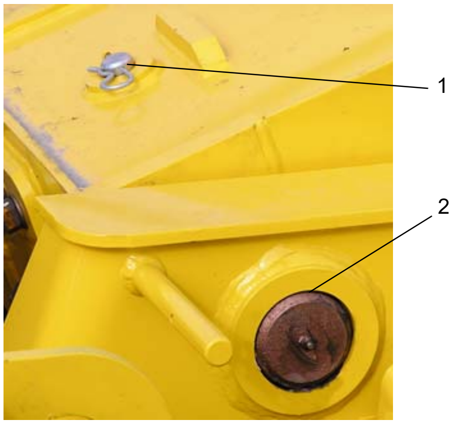
6. Turn off key and remove power using the battery disconnect.
7. Disconnect any electrical wiring from the boom.
8. Tag and disconnect the hydraulic lines to the telescope cylinder. Hard cap or plug the lines and openings.
9. Remove the bolt (1), (Figure 4-7) and washer securing the upper lift cylinder shaft (2), (Figure 4-7) to the side of the lift box (3), (Figure 4-7) on the boom.

FIGURE 4-7

DANGER

Make sure the boom lift cylinder is properly supported before disconnecting it from the boom. Death or serious injury may result if lift cylinder is not supported.

10. Make sure that the boom lift cylinder is properly supported before disconnecting it from the boom. Remove the upper lift cylinder shaft (2), (Figure 4-7).
11. Start the engine from the superstructure cab. Enable the lift function (toggle switch on arm rest) and retract the lift cylinder rod enough to clear the lift box (3), (Figure 4-7).
12. Take up the slack on the boom lifting device
13. .Remove the clip pin and retaining pin (1), (Figure 4-8) securing the boom pivot shaft (2), (Figure 4-8) on the boom to the superstructure assembly.
14. Remove the grease fittings from the pivot shaft to prevent damage. Remove the boom pivot shaft.



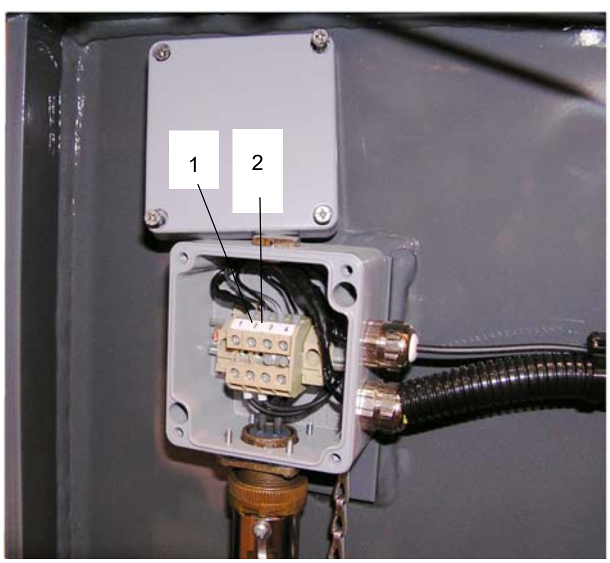
6835 FIGURE 4-8

15. Raise the boom clear of the crane and lower to blocking or cribbing for service.

Disconnect the Base Section

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

1. Remove the boom from the crane superstructure in accordance with Boom Removal (pg 4-10) procedure.
2. Remove the RCL/A2B cable from the boom nose.
   a. Remove the cover from the junction box (Figure 4-9).
   b. Disconnect the “SHD” wire(1), (Figure 4-9) from Terminal 1 and “CORE” wire (2), (Figure 4-9) from Terminal 3.
   c. Disconnect the cable connector from the side of the junction box (Figure 4-9).

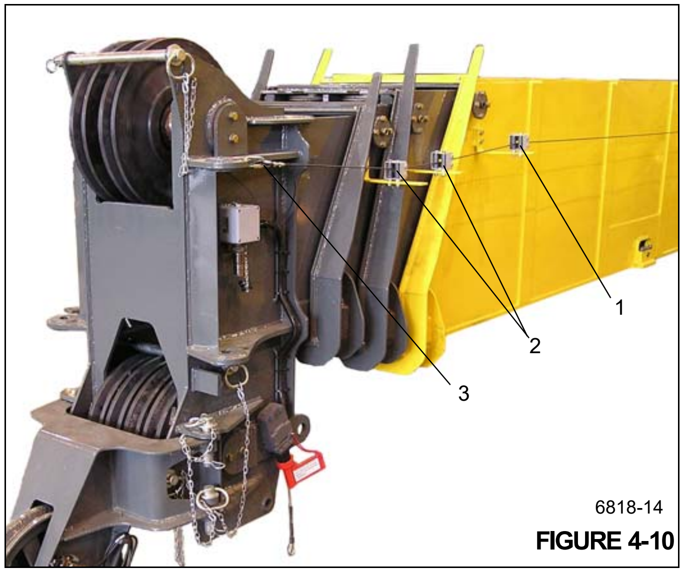


6837 FIGURE 4-9

CAUTION

Use extreme caution as cable reel is spring tensioned.

3. Disconnect the cable from the Fly section (3), (Figure 4-10) and feed the cable through the cable guides (1), (Figure 4-10), and attach the cable to the Base section cable guide (2), (Figure 4-10). Disconnect the A2B Connector cable, if needed.



6818-14
FIGURE 4-10

4. Chain the Fly, Outer Mid and Inner Mid sections together as shown in Figure 4-11. This will prevent the inadvertent or unexpected extension of these sections during the boom disassembly.
5. Remove the tube assemblies (3), (Figure 4-12) from the telescopic cylinder and cap the ports.

6862-8 FIGURE 4-11

6. Remove the bolts and washers securing the telescope cylinder outer rod (1), (Figure 4-12) to the rear of the base section.

CAUTION

Use extreme caution during piston and rod tube assembly removal. The telescopic cylinder will still be under hydraulic pressure due to the holding valve.

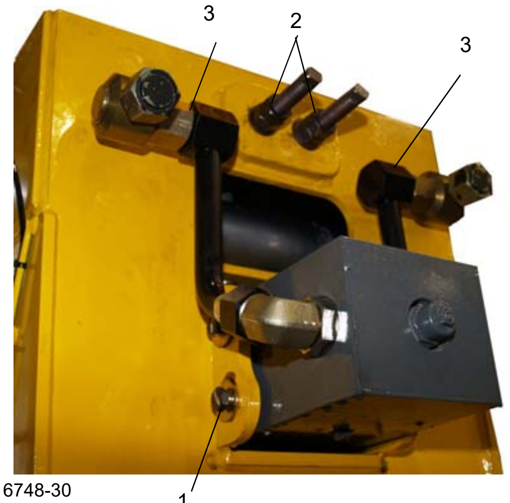


FIGURE 4-12

7. Remove the nuts and washers securing the synchronizing cable ends (2), (Figure 4-12) to the base section.

Remove the Base Section

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

.

DANGER

The combined weight of the boom inner mid, outer mid, and fly sections, including the telescope cylinder, is approximately 3680 kg (8110 lb). Make sure that adequate and properly tested lifting devices are used to remove these sections.

DANGER

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

1. Remove the access cover (1), (Figure 4-13) on the top rear of the base section. Slide the assembly out of the base section (1), (Figure 4-14) enough to gain access to the top rear adjustable wear pads on the inner midsection (2), (Figure 4-14).

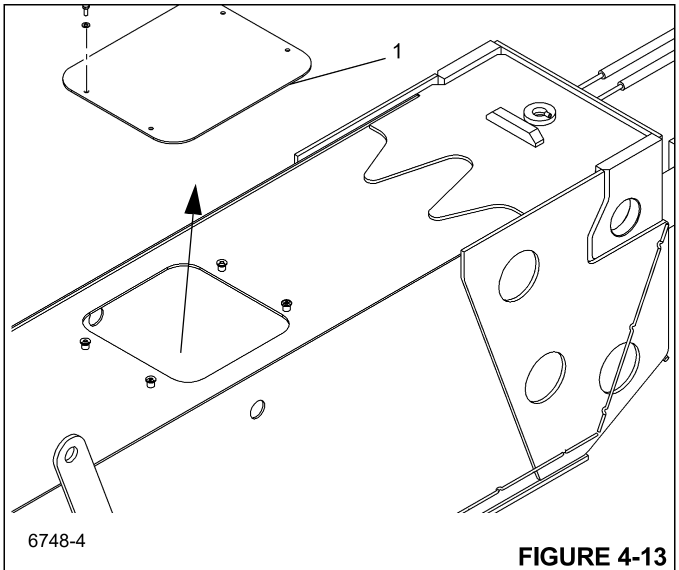
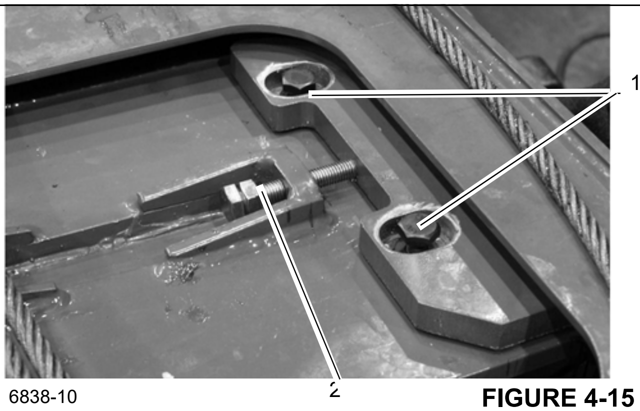


FIGURE 4-13

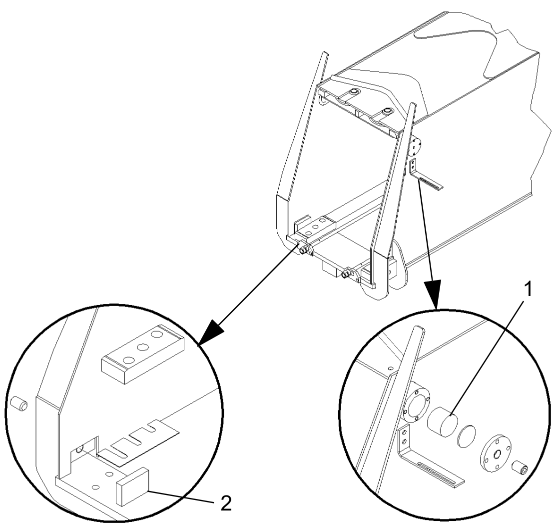
FIGURE 4-14

2. Remove the bolt, washer, and offset washer (1), (Figure 4-15) securing each top rear adjustable wear pad and remove the wear pads, keeper plates and bolts (2), (Figure 4-15) from the top of the inner mid section. **Note the location of wear pads and shims for installation.**



6838-10 **FIGURE 4-15**

3. On the top front of the base section (Figure 4-15), remove the two bolts (1), (Figure 4-15) securing the kick back plate and remove the plates.
4. Remove the bolts securing the outer mid retract cable anchor plates to the lower front of the base section. Remove the cable locknuts and the anchor plates from the cables.
5. Remove the two screws securing each top (1), (Figure 4-16) and bottom (2), (Figure 4-16) side wear pads at the front of the base section. Remove wear pads, shims, and mounting angle (top left side only).



6748-25 **FIGURE 4-16**

6. Raise the front of the assembly slightly and remove the wear pad mounting bolts and the wear pads from the bottom of the base section.
7. Continue to pull the assembly until it is clear of the base section.

NOTE: Pull the outer mid retract cables out with the assembly to prevent them from becoming damaged.

8. Place base section in a secure location

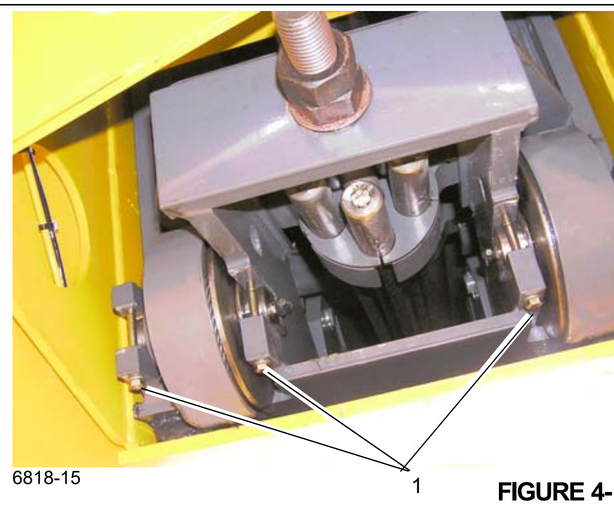
Disconnect the Inner Mid Section

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

DANGER

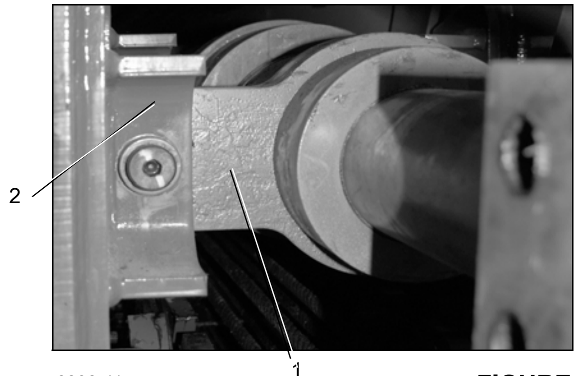
To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

1. On both sides, remove the bolts (1), (Figure 4-17) securing each retract sheave assembly shaft weldment. Remove the shaft, spacer bushing, sheave assembly, and thrust washers. If necessary, remove the grease fitting from the shaft weldments.



6818-15 **FIGURE 4-17**

2. Remove the two bolts and bushings securing the cylinder inner rod (1), (Figure 4-18) to the rear of the inner mid section (2), (Figure 4-18).



6838-11 **FIGURE 4-18**

3. Remove the two nuts from the extend cable anchor plate adjusting bolts.

4. Pull the four retract cables up through the holes in the bottom of the inner mid section and lay them out to the rear.

Remove the Inner Mid Section

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

DANGER

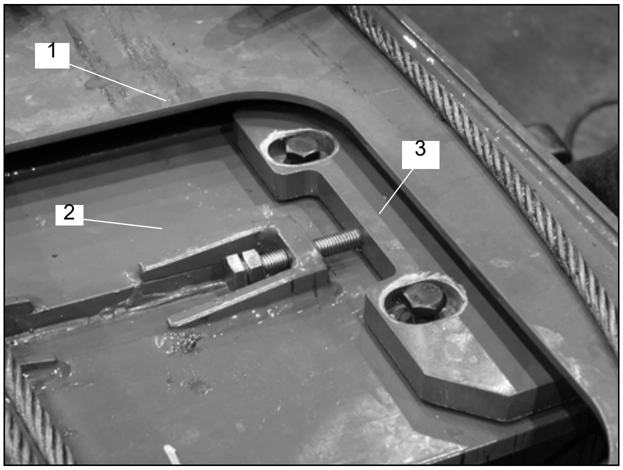
To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

DANGER

The combined weight of the boom outer mid, and fly sections, including the telescope cylinder, is approximately 2550 kg (5610 lb). Make sure that adequate and properly tested lifting devices are used to remove these sections.

1. Slide the assembly out of the inner mid section (1), (Figure 4-19) enough to gain access to the top rear adjustable wear pads on the outer midsection (2), (Figure 4-19) through the hole in the top of the inner mid section.

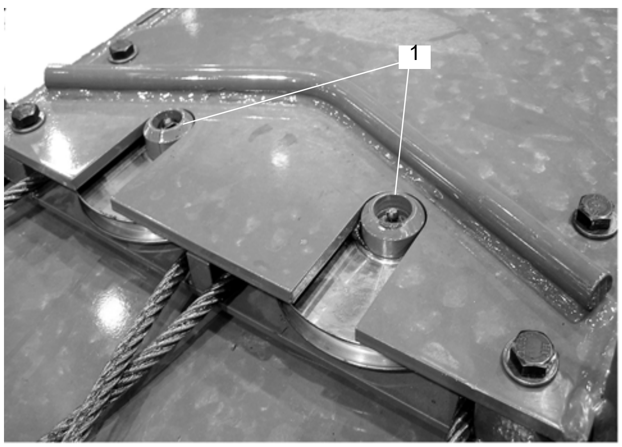
2. Remove the bolt, washer, and offset washer securing each top rear adjustable wear pad and remove the wear pads, keeper plates (3), (Figure 4-19) and bolts from the top of the outer mid section.



6838-10 **FIGURE 4-19**

4

3. At the top front of the inner mid section, remove the four bolts and washers securing the synchronizing cable sheave assembly (1), (Figure 4-20). Lay the assembly with cables on top of the outer mid section.



6838-13 **FIGURE 4-20**

4. At the lower front of the inner mid section, remove the bolts securing the fly retract cable anchor plates (1), (Figure 4-21). Remove the cable locknuts and the anchor plates from the cables.

5. Install thread protectors on cable ends.

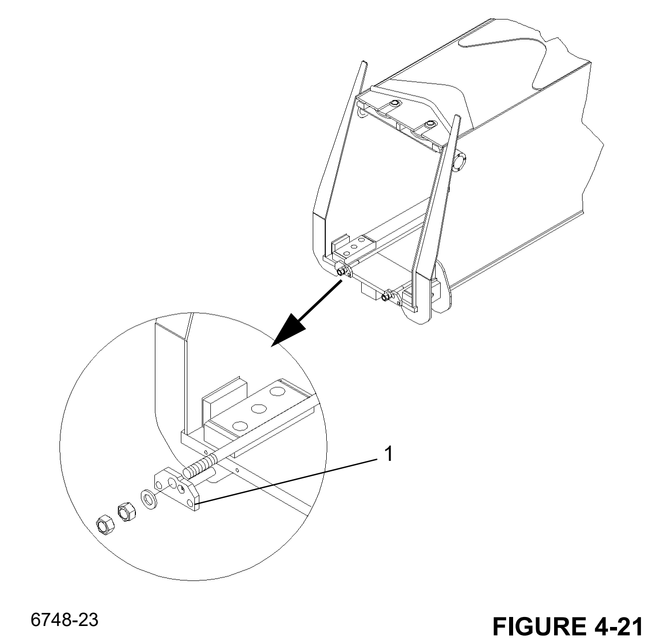


FIGURE 4-21

6. Remove the screws securing each top (1), (Figure 4-22) and bottom side wear pads (2), (Figure 4-22) at the front of the inner mid section. Remove wear pads and shims. Keep the shims with each individual wear pad for re-installation.
7. Remove the RCL cable guide mounting angle (3), (Figure 4-22) (top left side only).

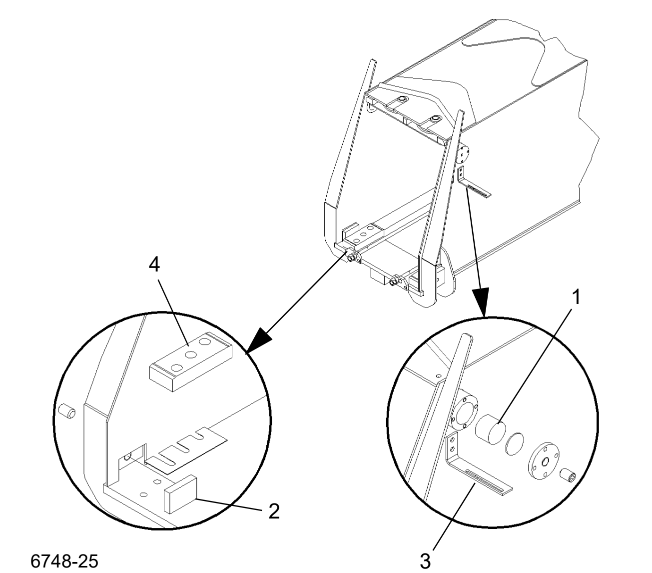


FIGURE 4-22

8. Lift up on the front of the assembly and remove the wear pad bolts and wear pads (4), (Figure 4-22) from the bottom of the inner mid section (Figure 4-22).
9. Remove the lock nut and adjustment nut (1), (Figure 4-23) from the extend cable adjustment bolt. This will free the extend cable from the inner mid weldment.

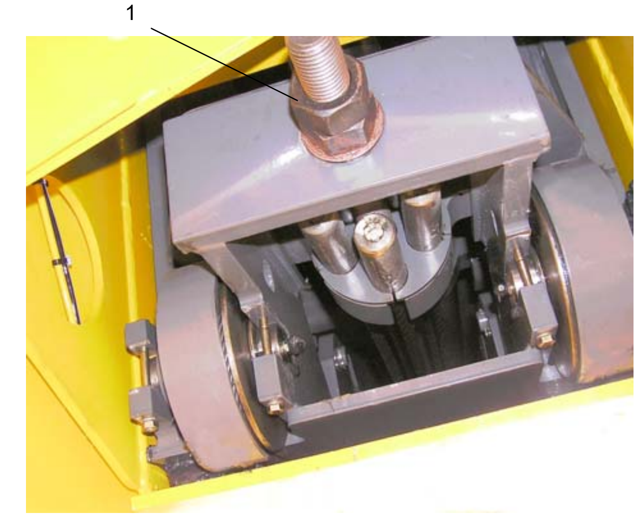


FIGURE 4-23

10. Secure the extend cable keeper plate and adjustment bolt to the tele cylinder with cable ties (1), (Figure 4-24) or tape. Failure to do so may allow the cables and keeper to become jammed during disassembly.

NOTE: It is not necessary to remove the extend cable keeper plates at this time. If it is necessary to remove the cable keeper plates, be sure to mark the extend cable in the proper sequence for re-assembly.

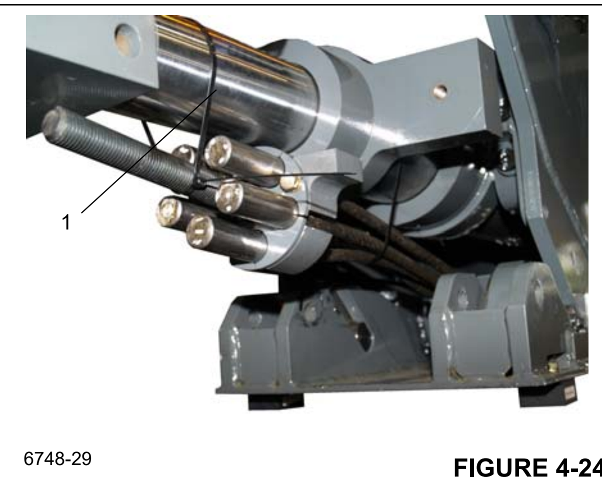


FIGURE 4-24

11. Continue to pull the assembly from the inner mid section until access to the rear of the outer mid section is gained in order to disconnect the four **retract** cables (1), (Figure 4-25).

12. Remove the cotter pins and pins (2), (Figure 4-25) securing the four retract cables to the rear of the outer mid section.

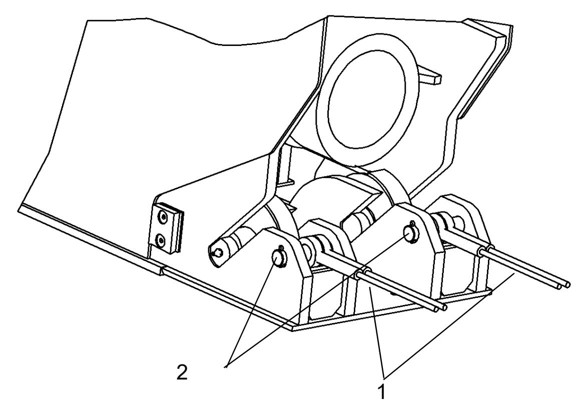


FIGURE 4-25

13. If necessary, remove the two bolts securing the bottom wear pad to the inner mid section. Remove the wear pad.
14. If necessary, remove the two bolts securing each lower rear side wear pad to the inner mid section. Remove wear pads and shims. **Note** the location of shims for installation.
15. Remove the inner mid section from the outer/fly/telecylinder assembly.

Remove the Outer Mid Section

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

DANGER

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

DANGER

The combined weight of the boom fly section including the telescope cylinder, is approximately 1960 kg (3720 lb). Make sure that adequate and properly tested lifting devices are used to remove these sections

1. At the rear of the outer mid section, on both sides, remove the bolt and cable retainer bushing from above each retract cable sheave assembly (1), (Figure 4-26).
2. Remove the shaft, spacer bushing, sheave assembly, and thrust washer. If necessary, remove the grease fitting from the shaft weldments.

.

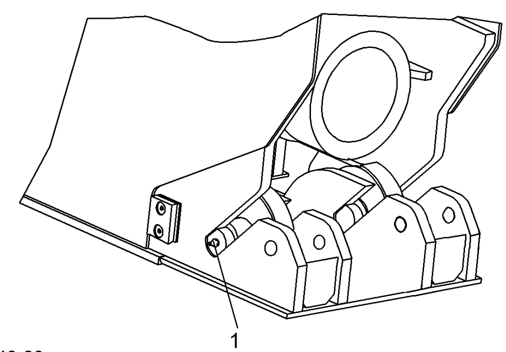


FIGURE 4-26

3. Place wood block (1), (Figure 4-27) under cylinder and remove the four bolts and bushings securing the cylinder

4

barrel (2), (Figure 4-27) to the rear of the outer mid section.

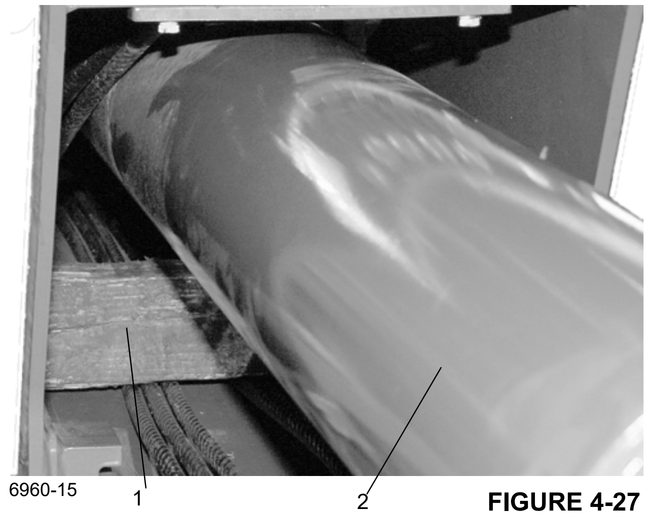


FIGURE 4-27

4. Pull the two retract cables up through the holes in the bottom of the outer midsection and lay them out to the rear.

5. Turn the cylinder rod inner mounting lugs (1), (Figure 4-28) so that they are vertical to clear the mounting bracket (2), (Figure 4-28) in the outer mid section.

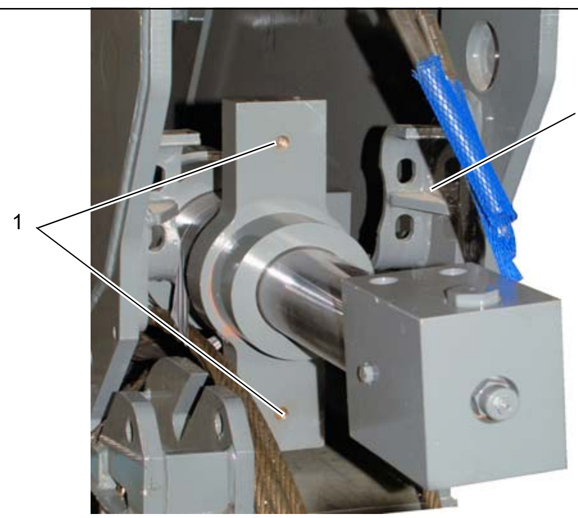


FIGURE 4-28

6. Slide the fly assembly out of the outer mid section enough to gain access to the top rear adjustable wear pads on the fly assembly through the hole in the top of the outer mid section.

7. Remove the bolt, washer, and offset washer (Figure 4-29) securing each top rear adjustable wear pad and remove the wear pads, keeper plates, and bolts from the top of the fly assembly.

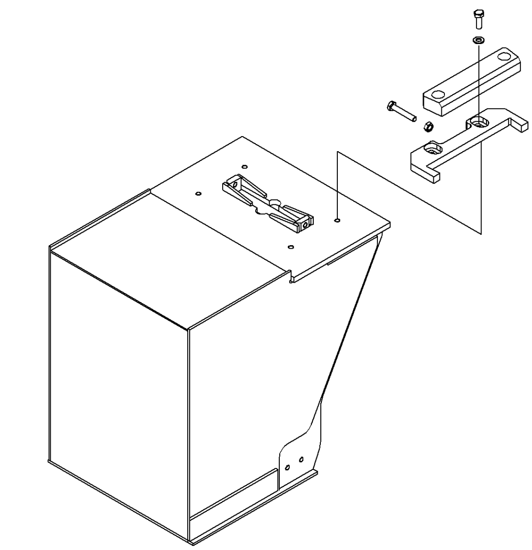


FIGURE 4-29

8. At the top front of the outer mid section, remove the two bolts (1), (Figure 4-30) securing the kickback plate. Remove the kickback plate.

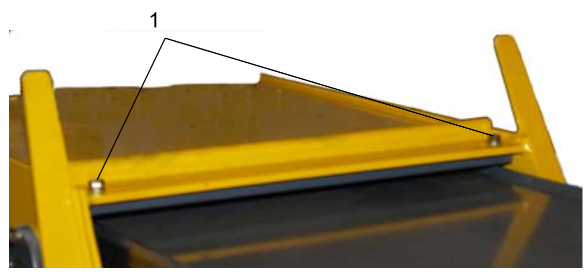


FIGURE 4-30

9. Remove the two screws securing each top (1), (Figure 4-31) and bottom (2), (Figure 4-31) side wear pads at the front of the outer mid section. Remove the

wear pads, shims, and mounting angle (3), (Figure 4-31) (top left side only).

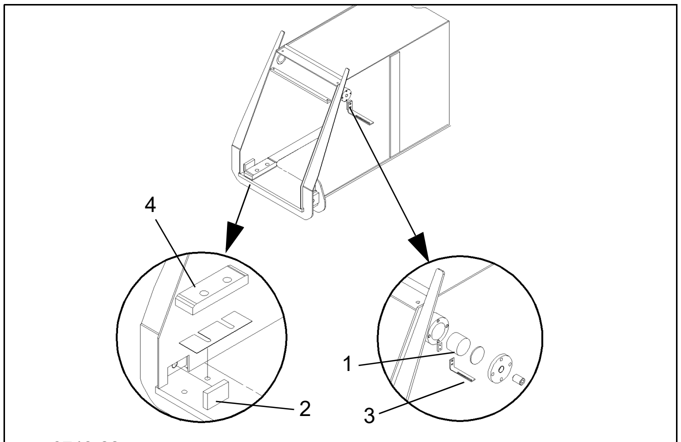


FIGURE 4-31

DANGER

Be extremely careful when removing bottom wear pads. Do not place your hands or fingers in an area that could cause injury. Use approved tools to remove wear pads.

10. Lift up on the front of the fly assembly and remove the wear pads (4), (Figure 4-31) from the pockets in the bottom of the outer mid section.
11. Continue to pull the fly assembly from the outer mid section until access to the rear of the fly assembly is gained to disconnect the two retract cables.
12. Remove the retaining plate securing the two fly retract cables (1), (Figure 4-32) to the rear of the fly assembly.

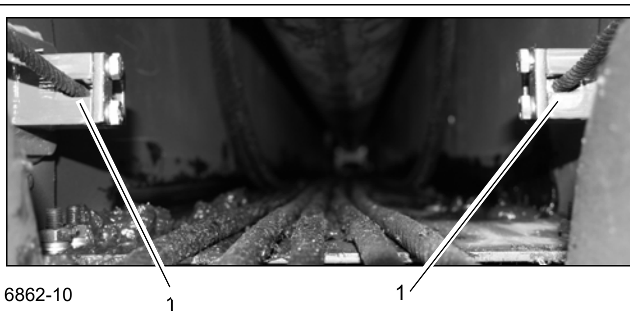


FIGURE 4-32

13. Remove the synchronizing cable and sheave assembly from the top of the outer mid section.
14. Remove the two fly retract cables from the inside of the outer mid section.
15. Remove the two bolts securing each lower rear side wear pad to the outer mid section. Remove the wear pads and shims. **Note** the location of the shims for installation.

Remove the Telescope Cylinder

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

DANGER

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

DANGER

The weight of the telescope cylinder is approximately 889 kg (1960 lb) for the 95' boom and the weight of the telescope cylinder for the 102' boom is 1115 kg (2458 lb).

Make sure that adequate and properly tested lifting devices are used to remove the telescope cylinder.

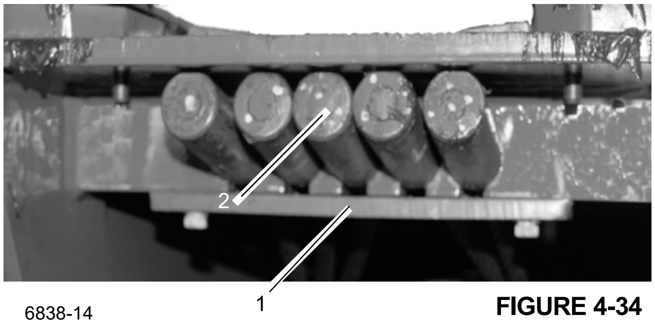
1. Attach a suitable lifting device to the telescope cylinder. Raise the telescope cylinder (2), (Figure 4-27) and remove the blocking device (1), (Figure 4-27) from under the cylinder.
2. Slide the telescope cylinder out of the fly section until it is just ready to "drop out" of the section. Do not pull the telescope cylinder completely out of the fly section yet.

NOTE: Pull the extend cable along with the telescope cylinder (Figure 4-33). Failure to do so will cause binding and jamming of the cables in the fly section.

FIGURE 4-33

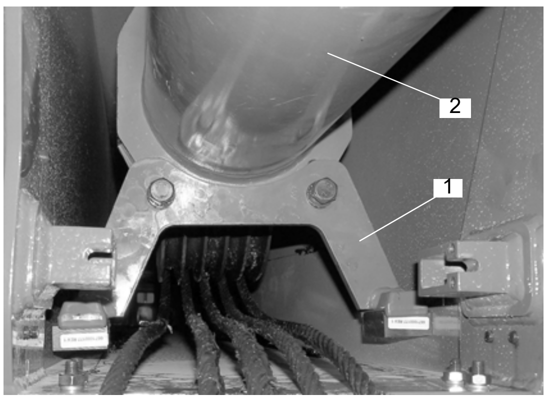
3. Remove the two bolts securing the extend cable keeper plate (1), (Figure 4-34) to the rear of the fly. Remove the keeper plate and remove the five extend cable ends (2), (Figure 4-34) from the slots in the fly.

4



6838-14 **FIGURE 4-34**

4. After supporting the weight of the telescope cylinder, remove the two bolts securing the cylinder foot weldment (1), (Figure 4-35) to the telescope cylinder (2), (Figure 4-35). Remove the foot weldment.



6838-15 **FIGURE 4-35**

5. Completely remove the telescope cylinder from the fly section.
6. Remove the bottom and lower rear side wear pads and shims if they are to be replaced. **Note** the location of the shims for installation.

Extend Cable Sheave Removal

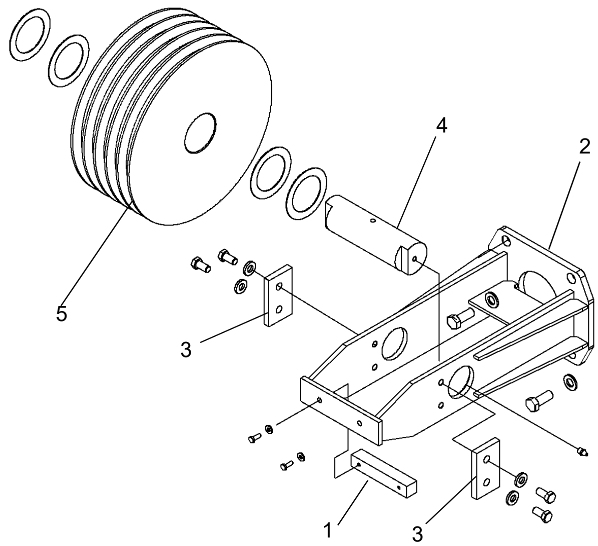
1. Remove the bolts holding the Cable Retainer (1), (Figure 4-36) to the Sheave Mount (2), (Figure 4-36). Remove the Retainer.

NOTE: If the extend cables are to be reused, be sure that they are marked before removal to aid in reassembly.

2. Remove the five extend cables.

NOTE: The extend cable sheave weighs approximately 17.3 kg (38 lb).

3. Remove the sheave shaft retainer plates (3), (Figure 4-36) from the left and right sides of the sheave mount.
4. Carefully pull the sheave shaft (4), (Figure 4-36) from the assembly, removing the spacers, and sheave (5), (Figure 4-36). **Note** the exact number of spacers you have for installation.



6748-35

Item	Description
1	Cable Retainer
2	Sheave Mount
3	Sheave Shaft Retainer Plates
4	Sheave Shaft
5	Sheave and Spacers

FIGURE 4-36

BOOM NOSE SHEAVES

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

DANGER

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

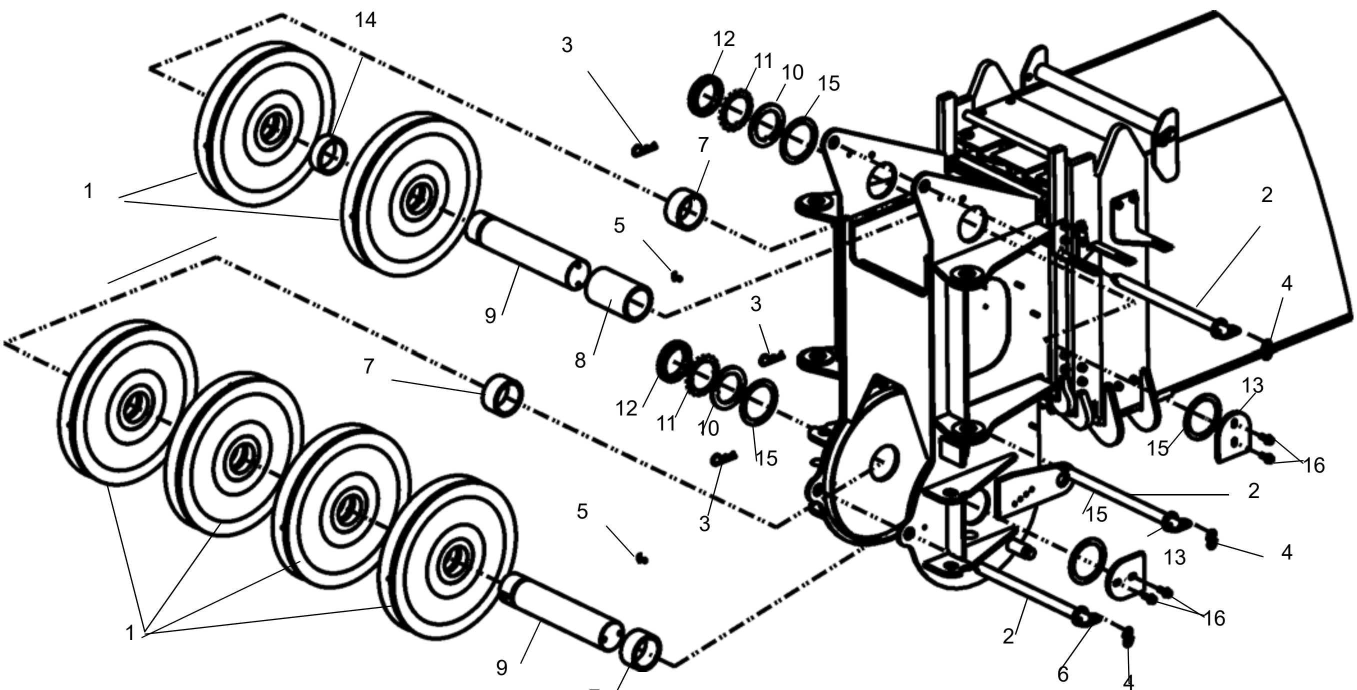
Boom Nose Sheave Removal

1. Refer to Figure 4-37. Remove the hitch pin clip (3) from the pin and remove the pin lock hair (2) from the upper and lower part of the boom nose (9).
2. Remove the two bolts (16) securing the end cap (13) to the upper boom nose sheave shaft (9). Remove the end cap (13).

NOTE: The boom nose sheave shafts weigh approximately 12.5 kg (27.5 lb) each. The boom nose sheaves weigh approximately 9.4 kg (21 lb) each.

3. Carefully pull the upper boom nose sheave shaft (9) from the boom nose, removing the spacers (7, 8, 14) and boom nose sheaves (1). **Note** the exact number and location of the spacers for installation.
4. Repeat steps 2 and 3 and remove the lower boom nose sheave shaft (Figure 4-37).
5. Remove the shim (15), washer (10), keyed washer (11) and locknuts (12) from both sheave shafts (9).

95' Boom Nose Assembly



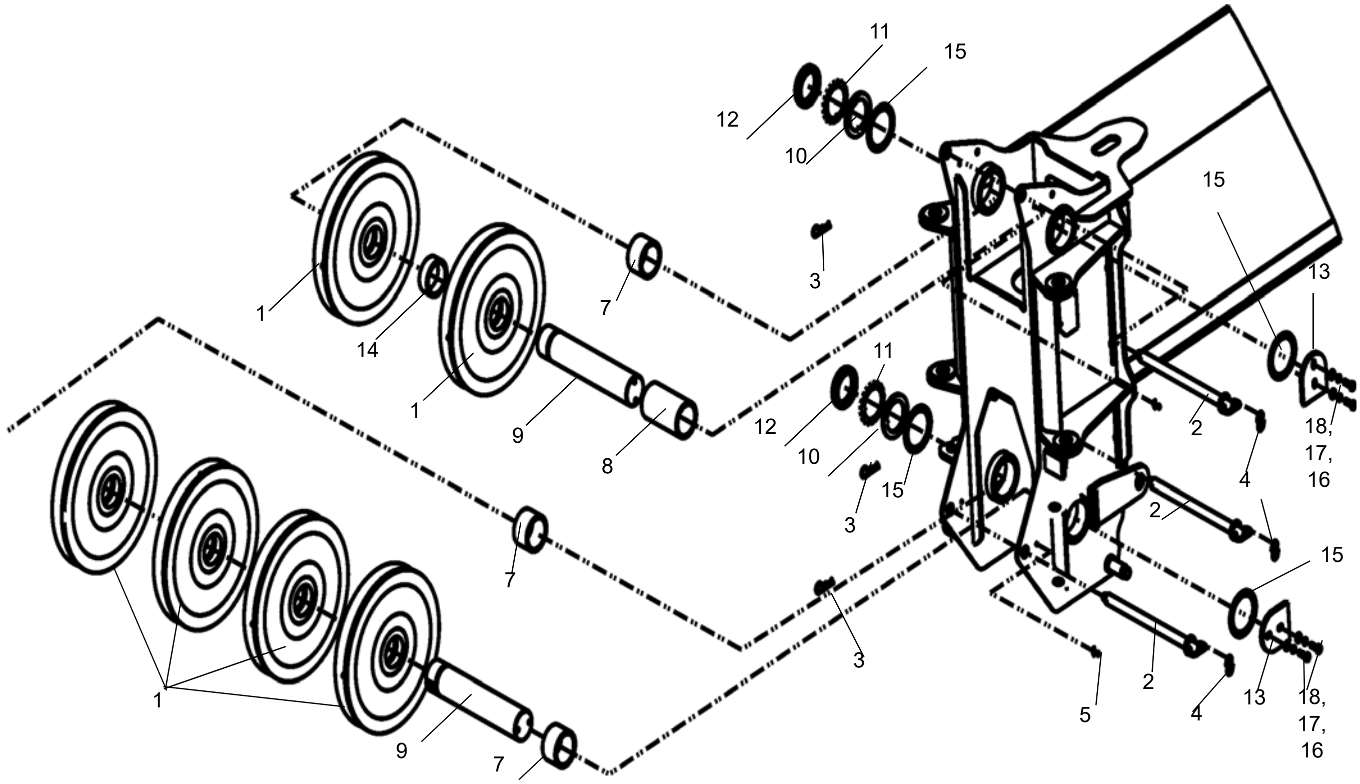
6748-13a

Item	Description
1	Sheave Assembly
2	Pin Lock Hair
3	Hitch Pin Clip
4	Standard S-Hook
5	Cotter Pin
6	Chain (Not Shown)
7	Spacer
8	Spacer

Item	Description
9	Shaft, Boom Nose
10	F Washer
11	L Washer
12	Lock Nut
13	End Cap
14	Spacer
15	Shim
16	Flange

FIGURE 4-37

102' Boom Nose Assembly



Item	Description
1	Sheave Assembly
2	Pin Lock Hair
3	Hitch Pin Clip
4	Standard S-Hook
5	Cotter Pin
6	Chain (Not Shown)
7	Spacer
8	Spacer Tube
9	Shaft, Boom Nose

Item	Description
10	F Washer
11	L Washer
12	Lock Nut
13	End Cap
14	Spacer
15	Shim
16	HHCS
17	L Washer
18	F Washer

FIGURE 4-38

Boom Nose Sheave Installation

NOTE: The boom nose sheave weighs approximately 9.4 kg (21 lb).

1. Refer to Figure 4-37. Install the spacers (7, 8, 14) and sheaves (1) onto the sheave shaft (9) while installing the sheave shafts into the lower boom nose (9).
2. Install the lockwasher (11) onto the sheave shaft (9) with the tabs facing out.

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

3. Install the locknut (12), washer (10), keyed washer (11), and shims (15) (if necessary) onto the boom nose sheave shaft (9) with the chamfer side out. Install the end cap (13) onto the opposite end of the sheave shafts (9) and secure in place with the two bolts (16).
4. Tighten the locknut (12) until the play in the bearings is eliminated. Bend the lockwasher (11) tabs to secure the locknut (12) in place.
5. Repeat steps 1 through 4 for the upper boom nose sheaves (9) and sheave shaft (9).
6. Install the pin lock hair (2) into the upper and lower part of the boom nose (9) and secure in place with the hitch pin clip (3).

BOOM ASSEMBLY PROCEDURE

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

DANGER

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

Extend Cable Sheave Installation

CAUTION

The extend cable sheave weighs approximately 17.3 kg (38 lb).

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 sheave shaft.

1. Refer to Figure 4-36. Clean and inspect the sheave assembly shaft bushing. Replace the bushing if damage is found.
2. Lubricate the shaft bushing.
3. Determine the number of spacers (5) required for the sheave shaft (4).

   As many as six spacers (3 on each side) may be required. If you have placed 3 spacers on the first side, and find that only two spacers will fit on the second side, that will be acceptable. It will not be necessary or desirable to remove one spacer from the first side.
4. Apply a light coat of lubricant to the sheave shaft (4), (Figure 4-36).
5. Install the sheave assembly and spacers. Install the shaft with the lubrication fitting to the LEFT and the notches to the Front of the boom.
6. Install the sheave shaft retainer plates (3) on the left and right sides with 2 capscrews and 2 washers in each plate.

Install Telescope Cylinder

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

DANGER

Make sure that adequate and properly tested lifting devices are used to remove the telescope cylinder.

DANGER

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.

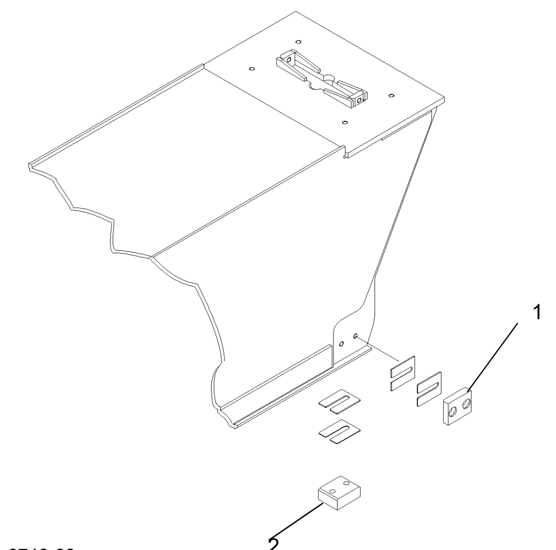
Apply multipurpose grease (MPG) to all wear surfaces.

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

NOTE: **Wear Pads**. When installing upper and lower side wear pads, 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.

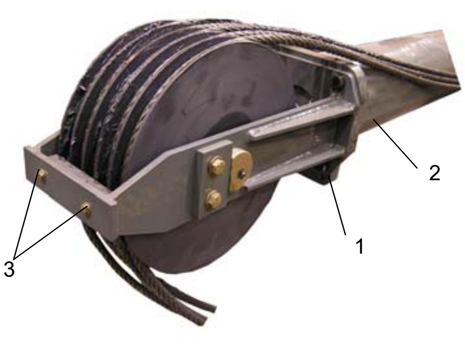
If wear pad shims were previously removed, place shims in same locations that was noted during removal.

1. Measure and mark the center line of the Fly Section. This mark will be used to set the adjustable wear pads(1), (Figure 4-39) after the section is installed in the Outer Mid Section.
2. Install the lower rear side wear pads (1), (Figure 4-39) and shims on the Fly Section with two screws each.



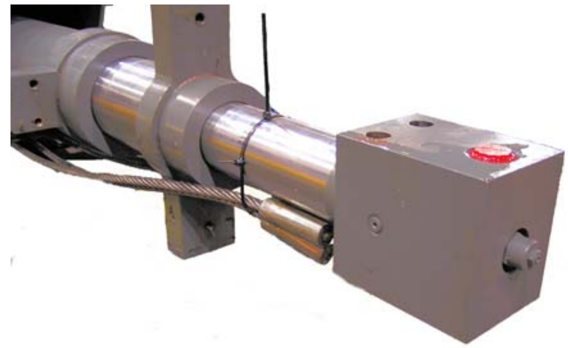
6748-33 FIGURE 4-39

3. Install the bottom rear wear pad (2), (Figure 4-39) on the Fly Section with two screws.
4. Install the Telescope Cylinder Sheave Mount and sheave assembly (1), (Figure 4-40) to the Telescope Cylinder (2), (Figure 4-40).
   a. Install the sheave shaft with the grease fitting to the left side.
   b. Do not install the cable retainer with the hardware (3), (Figure 4-40) until the Extend Cables are reeved around the sheave.
   c. Lubricate the sheave bearing utilizing the grease fitting located on the sheave shaft.



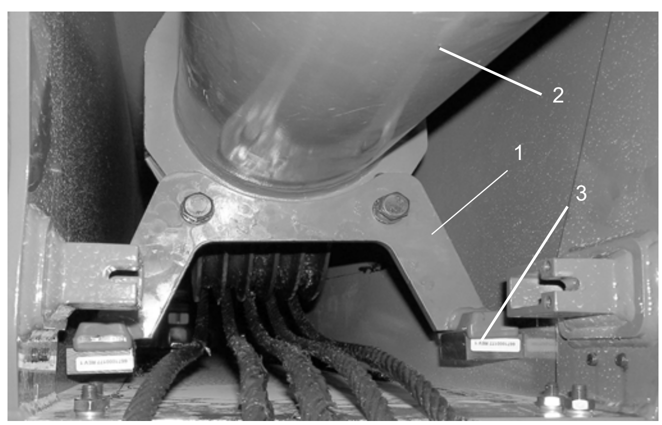
6748-32 FIGURE 4-40

5. Mark **BOTH ENDS** of the five extend cables (Figure 4-43).
6. Reeve the five extend cables around the Telescope Cylinder sheave (Figure 4-40).



6862-11 FIGURE 4-41

7. Install cable retainer (3), (Figure 4-40) as referenced in Step 4b above.
8. Attach a suitable lifting device to the Telescope Cylinder. Raise the Telescope Cylinder.
9. Position the sheave end of the Telescope Cylinder at the rear of the Fly Section, with the port block turned as shown (Figure 4-41).
10. Carefully insert the Telescope Cylinder into the Fly Section until the sheave weldment clears the retract cable weldment.



6838-15 FIGURE 4-42

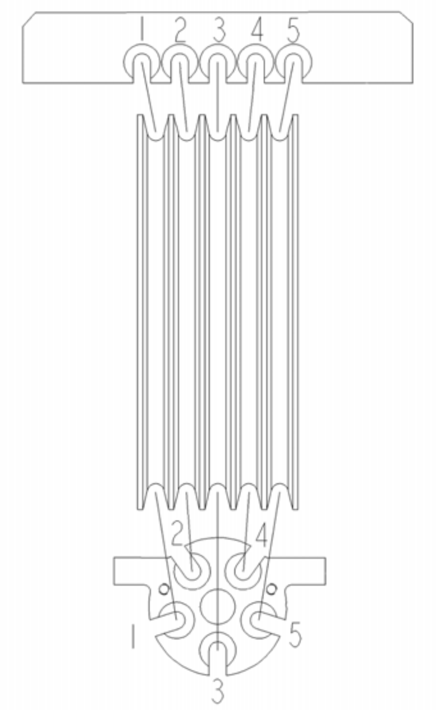
CAUTION

The five Extend Cables must be marked at both ends prior to installation. If the cables are not marked, they will be difficult to install in the correct order.

Do not allow the cables to become entangled or overlap the cable as boom failure could result.

11. Install the two wear pads on the support foot weldment with two bolts each. Torque the bolts.

.



6838-5

FIGURE 4-43

CAUTION

When adjusting the cables, hold the cable end and turn the nut. Do not turn the cable.

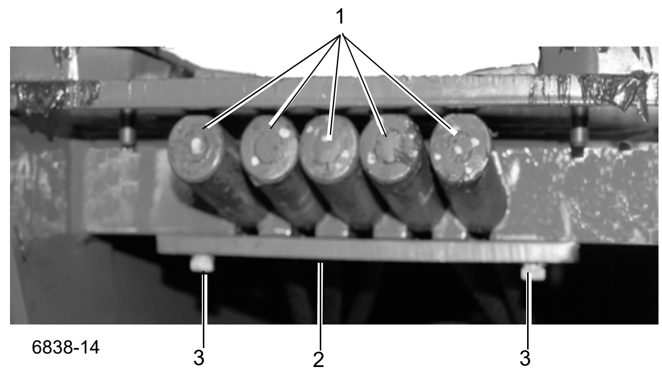
Turning or twisting of the cable while adjusting will result in damage or failure of the cable.

Install cables in their natural untwisted condition.

12. Install the cylinder foot weldment (1), (Figure 4-42) to the Telescope Cylinder (2), (Figure 4-42) using two bolts.

13. Lower the cylinder so that the cylinder foot weldment rests on the support foot weldment (3), (Figure 4-42) wear pads.

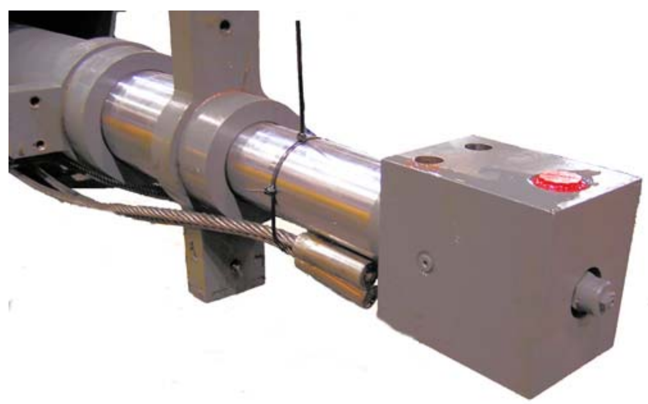
14. Place the five extend cable dead ends (1), (Figure 4-44) in the slots at the top of the Fly Section and secure them with the extend cable keeper plate (2), (Figure 4-44) and two bolts (3), Figure 4-44).



6838-14

FIGURE 4-44

15. Turn the cylinder rod mounting lug ends (Figure 4-45) so that they are aligned vertically to clear the mounting brackets in the outer mid section.



6862-12

FIGURE 4-45

16. Slide the Telescope Cylinder assembly completely into the Fly Section.

17. Inspect the extend cables to make sure that they are not crossed or out of sequence.

18. Place blocking (1), (Figure 4-46) under the rear of the Telescope Cylinder to aid in assembly (Figure 4-46).

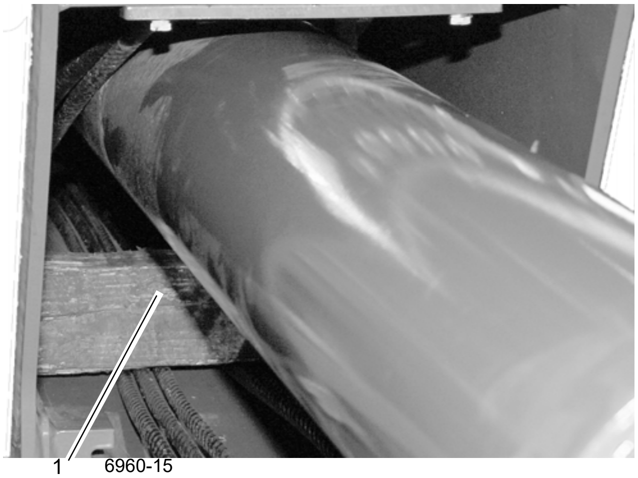


FIGURE 4-46

19. Temporarily tie extend cables to the Telescope Cylinder to maintain proper cable alignment during assembly (Figure 4-45).

Install the Outer Mid Section

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

DANGER

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

NOTE: Before the fly section is installed, the center point of the fly section must be determined. Measurement from this center point will be used to properly set the adjustable wear pads.

1. Align two straight edge tools with the **outer edge of the Fly Section** at the rear of the section (not the wear pad adjustment weldment). The tools should extend past the wear pad adjustments as shown in (Figure 4-47).

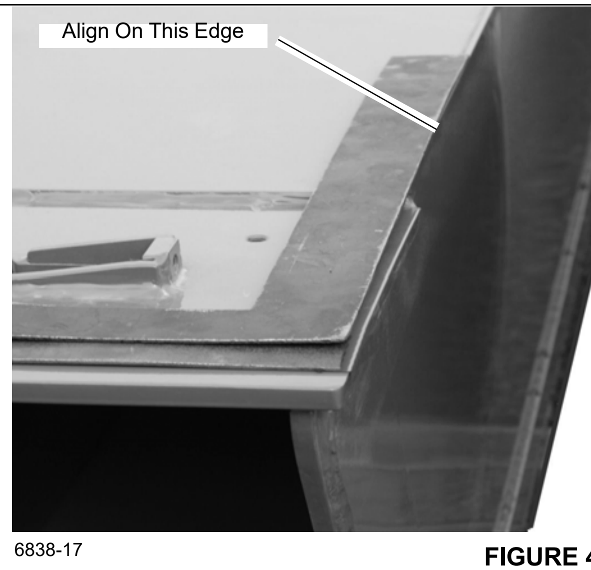


FIGURE 4-47

a. Measure and note the total width of the boom section.

b. Using the measurement obtained, determine the center point of the boom section and clearly mark it (Figure 4-48).

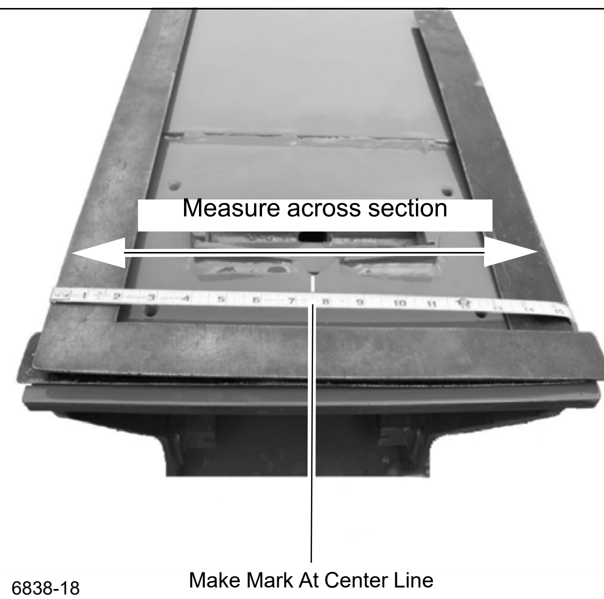


FIGURE 4-48

2. Install the lower (brass) wear pads (1), (Figure 4-49) to the outer mid section. Back out the adjustment set screw so that the pad seats fully into the pocket (2), (Figure 4-49). The pad should extend no more than 3.2 mm (0.12 inch) into the outer mid section for the initial installation.

NOTE: Use grease to aid in holding the wear pad in place.

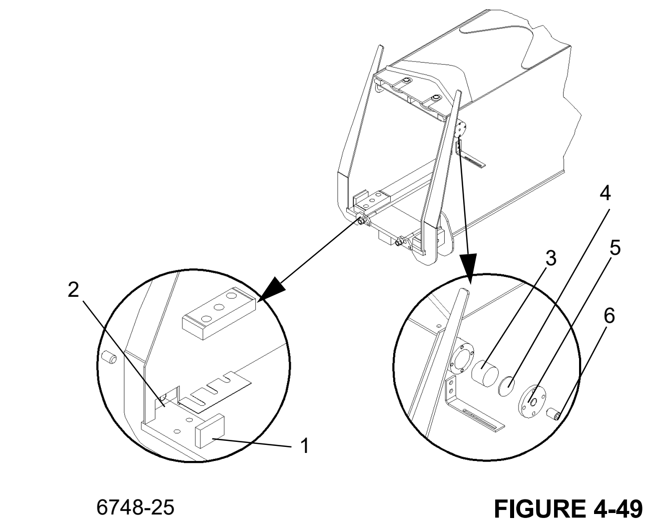


FIGURE 4-49

3. Insert the upper wear pad (3), (Figure 4-49), backing plate (4), (Figure 4-49) and adjusting plate (5), (Figure 4-49).
   a. Attach each wear pad assembly with four washers, four lock washers and four capscrews.
   b. Insert the hex socket head adjusting screws (6), (Figure 4-49). Do not tighten at this time.
4. Apply lubricant to the wear pad contact areas of the fly section.
5. To aid in the installation of the fly section into the outer mid section, apply lubricant to the wear pad contact areas of the fly section and secure the extend cables to the Telescope Cylinder (Figure 4-50).
   a. Rotate the Port Block as shown in Figure 4-50.

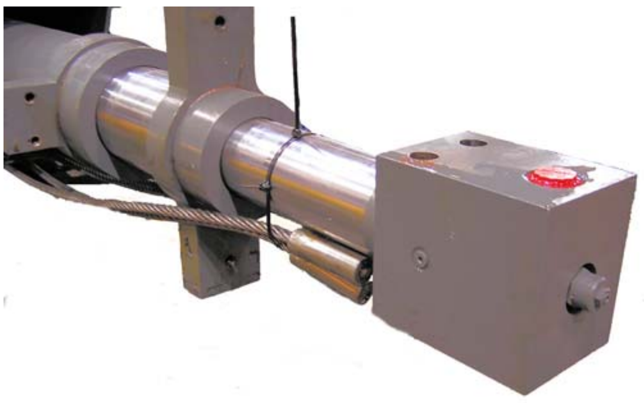


FIGURE 4-50

CAUTION

Do not allow the cables to become entangled or overlap. Cable or boom failure could result.

6. Attach the fly retract cables to the cable anchors (1), (Figure 4-51) on the base end of the fly section on both sides. Install the two cable keepers with two lock washers and two bolts on each keeper.
7. Feed the threaded end through the outer mid section and lay it out towards the front of the outer mid section.

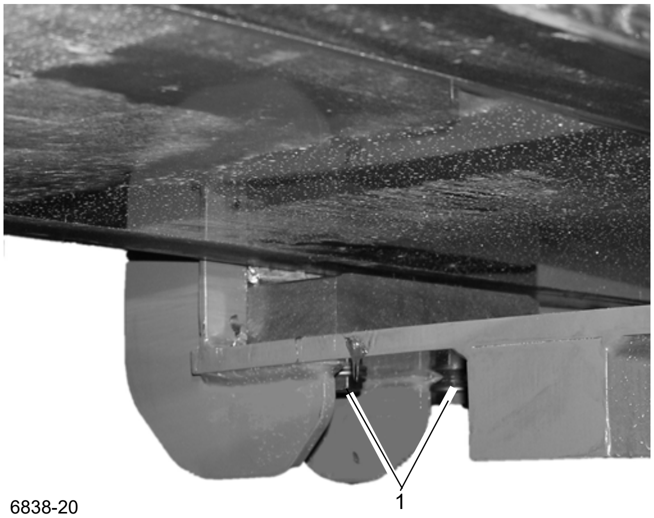
FIGURE 4-51

8. Slide the fly section into the outer mid section until the wear pad adjustment is accessible though the access plate (2), (Figure 4-51) on top of the outer mid section.

CAUTION

Pull the two fly retract cables through the outer midsection as the fly section is being installed. Do not allow the cables to become entangled or overlap. Cable or boom failure could result.

9. Raise the fly section slightly and insert the bottom wear pad into place and secure with retaining bolts. Insert the bolts (1), (Figure 4-52) from the bottom of the outer mid section.



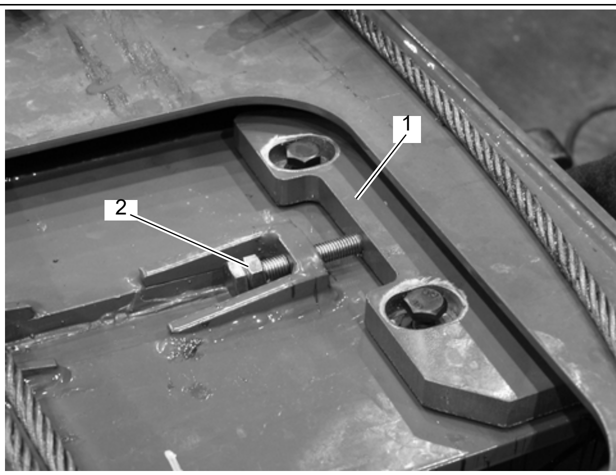
6838-20

FIGURE 4-52

10. Insert the wear pads and pad holders (1), (Figure 4-53) on the left and right side of the fly section.

NOTE: The “buttons” on the wear pads may be “shaved down” if needed. Do not cut into the wear pad(s).

11. Measure and adjust the wear pads until the fly section is centered ± 1mm (± 0.04 inch) in the outer mid section. Apply Loctite® and tighten jam nut (2), (Figure 4-53).



6838-21

FIGURE 4-53

CAUTION

Do not allow the cables to become entangled or overlap. Cable or boom failure could result.

12. Slide the fly section the rest of the way into the outer mid section.

13. Align the cylinder mounting holes with the mounting bracket holes in the rear of outer mid section and secure with two bolts and bushings on each side. See (Figure 4-54).

NOTE: It is important that the cylinder mount bolts be properly torqued. The correct torque will allow the cylinder to “float” in the mount.

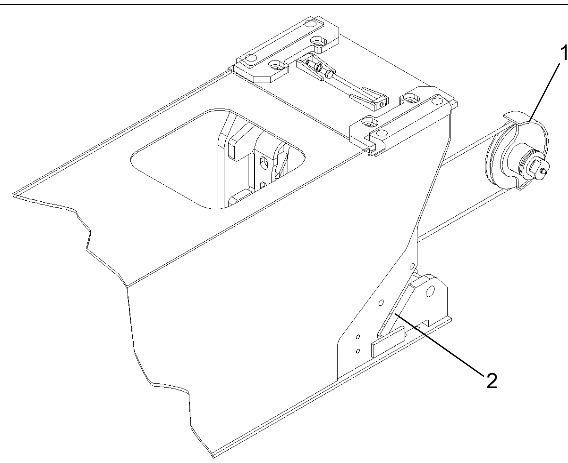
6862-14

FIGURE 4-54

14. Remove the block of wood holding the Telescope Cylinder.

15. Route the fly retract cables down through the bottom of the outer mid section. Lay the cables out toward the nose end of the outer mid section.

16. Reeve the fly retract cable around the fly retract cable sheave (1), (Figure 4-55) and install in the angled slots (2), (Figure 4-55) on each side of the outer mid section.

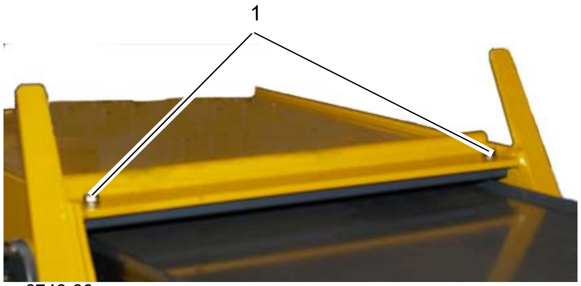


6748-34

FIGURE 4-55

17. Lubricate the retract cable shaft.

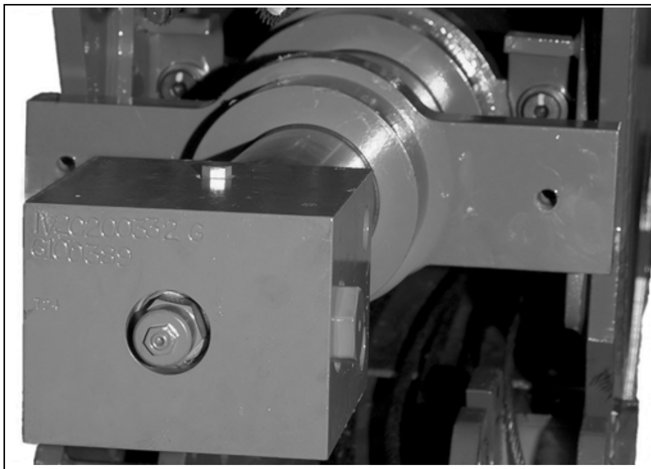
18. Install the kickback plate and hardware (1), (Figure 4-56) on the inside top of outer mid section.



6748-30a

FIGURE 4-56

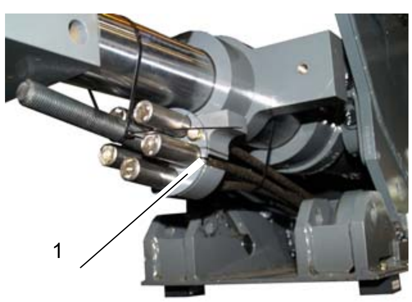
19. Rotate the cylinder mounting to make mounting easier into the inner mid section. (Figure 4-57)



6748-31

FIGURE 4-57

20. Install the extend cables in to the round keeper plate (1), (Figure 4-58) and (Figure 4-59).

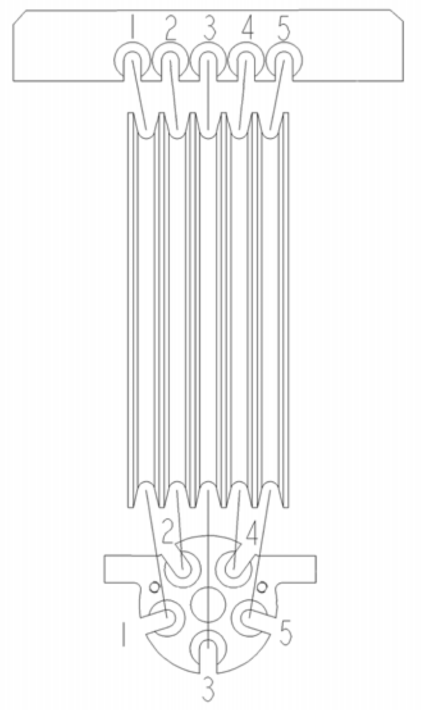


6748-29

FIGURE 4-58

CAUTION

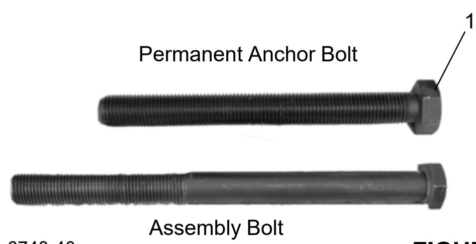
Install the extend cables in proper sequence. Do not allow the cables to become entangled or overlap. Cable or boom failure could result.



6838-5

FIGURE 4-59

21. Install the adjusting bolt (1), (Figure 4-60) to the anchor assembly.



6748-40

FIGURE 4-60

22. Temporarily secure anchor assembly to the extend cylinder rod.

23. Attach the mid retract cables to the anchor point at the base end of the outer mid section.

a. Lubricate and install the pin through the cable ends. Secure the pin (1), (Figure 4-61) with the cotter pins.

24. Lay out the threaded end of the mid retract cables through the inner mid section toward the base end.

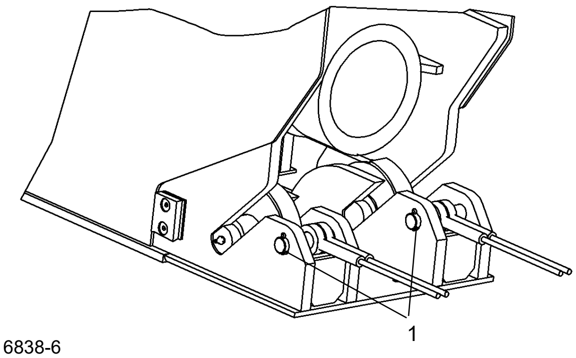


FIGURE 4-61

Install the Inner Mid Section

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

.

DANGER

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

1. Insert the adjustable brass wear pads (1), (Figure 4-62) and the upper wear pads (2), (Figure 4-62). Do not install the bottom wear pads at this time.

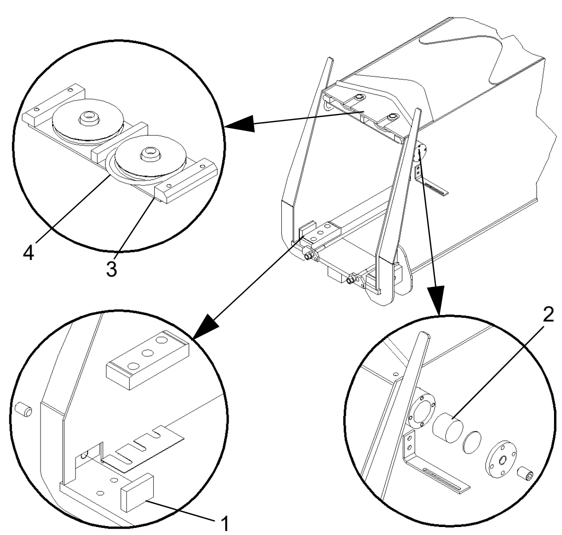


FIGURE 4-62

2. Attach both the mid-syncro cable anchor ends (1), (Figure 4-63) with the capscrews and bushings to the base end (2), (Figure 4-63) of the outer mid section.

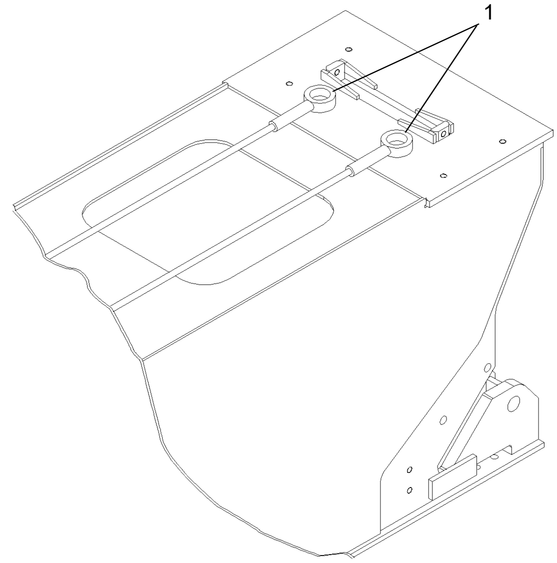
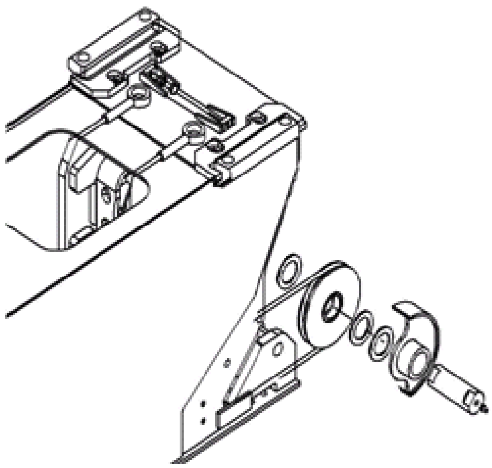


FIGURE 4-63

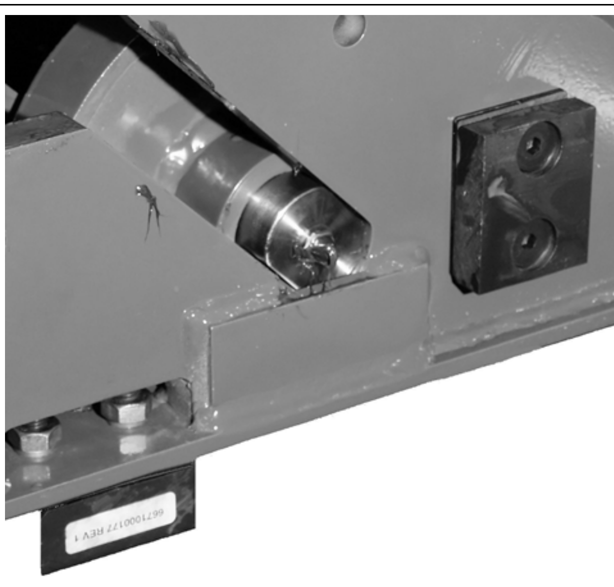
3. Assemble the mid-syncro cable sheave assembly (3), (Figure 4-62) and lay it on top of the outer mid section about where it will go.
   a. Reeve the mid-syncro cables (4), (Figure 4-62) around the sheaves.
   b. **NOTE:** The cables should be reeved from the cable anchor around the outside of the sheave wheels to the inside of the sheave wheels. The threaded end of the cable should be laid out down the center of the inner mid section toward the base end.
4. Attach the fly retract cables button ends to the cable anchor points (1), (Figure 4-64) in the fly section. Use one keeper plate (2), (Figure 4-64), two cap screws, and two washers on each anchor to secure the cables.

FIGURE 4-64

5. Pass the threaded end of the fly retract cables down though the bottom of the fly section. Lay the cables out toward the nose end of the fly section.
6. Reeve each fly retract cable around the retract sheaves at the base of the outer mid section.
7. Assemble the fly retract sheave assembly as shown in Figure 4-65 and Figure 4-66. **Note** that the pin has one thrust washer to the inside of the boom and two thrust washers to the outside of the boom.
8. Lubricate both sheave assemblies.

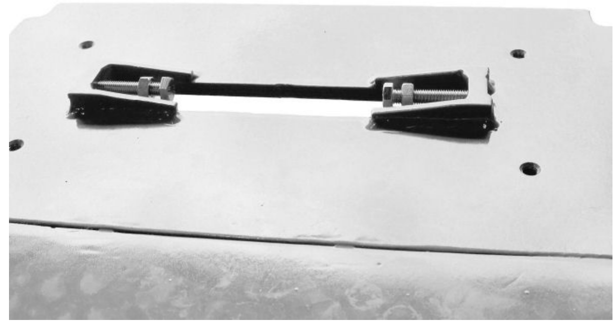


6748-17 **FIGURE 4-65**



6838-22 **FIGURE 4-66**

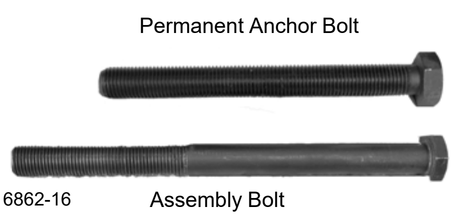
9. Install the rear bottom and side and brass wear pads. Install shims with the open end facing the base end of the boom section.
10. Install adjustment bolts and lock nuts to the upper adjustable wear pad weldment. Do not install wear pads at this time (Figure 4-67).



6862-15 **FIGURE 4-67**

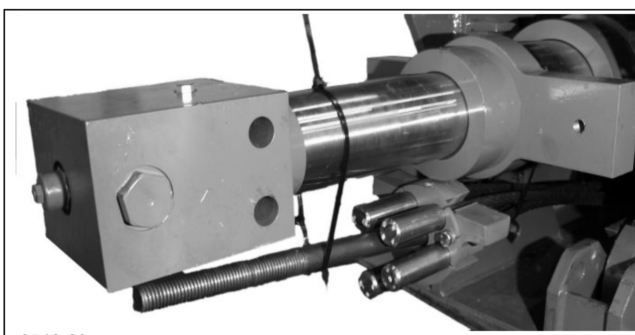
NOTE: Installation of the extend cable anchor assembly will require the use of a bolt longer than the permanent bolt. The weight of the five extend cables and anchor assembly will make the installation of the anchor assembly extremely difficult without use of a longer bolt. (Refer to Figure 4-68).

Use bolt Part Number 7099000555 (or equivalent) for installation only (Figure 4-68).



6862-16 **FIGURE 4-68**

11. Insert assembly bolt into extend cable anchor (Figure 4-68).
12. Tie the extend cable anchor assembly to the Telescope Cylinder (Figure 4-69).



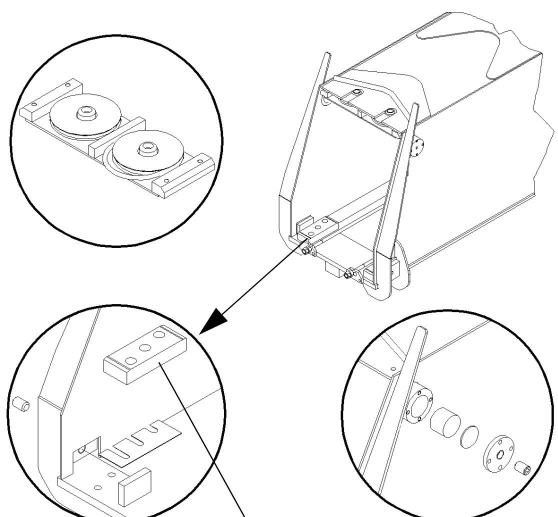
6748-29 **FIGURE 4-69**

13. Assemble the fly retract cable anchor weldments to the retract cables. Thread the single nut on the cable end until there is 38 mm (1 1/2 inch) of thread showing, then install the locknut (Figure 4-70).

NOTE: There are left and right anchors. Check to make sure the anchors are in the correct position.

6862-17 **FIGURE 4-70**

14. Install the brass wear pad (1), (Figure 4-71) at the nose end of the inner mid section.



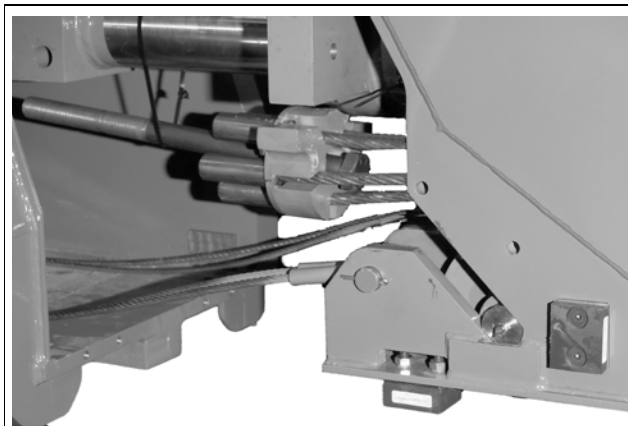
6748-24 **FIGURE 4-71**

15. Pull the outer mid retract cables through the inner mid section with the threaded end towards the base end of the section.

NOTE: Always lay out and inspect the cables before installation. Laying out cables will help eliminate twists, kinks and make inspection easier.

16. Apply grease to those parts of the inner mid and outer mid sections where the wear pads will contact.

17. Attach the mid retract cables to the outer mid section as shown in (Figure 4-72).



6862-18 **FIGURE 4-72**

18. Align the outer mid section with the inner mid section as shown in (Figure 4-73). Slide sections together until the side wear pads on the outer mid section engage with the inner mid section. Measure clearance at pads and shim as required.

6862-19 **FIGURE 4-73**

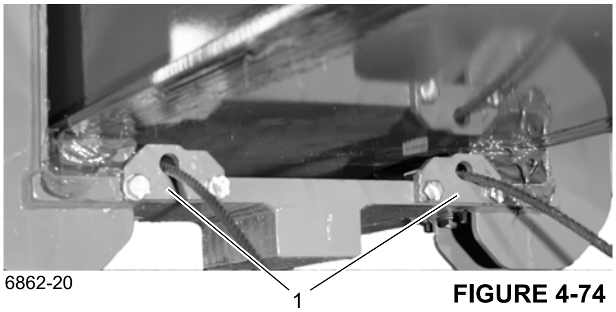
NOTE: Pull the mid retract cables through the base section as the sections are joined.

CAUTION

Do not allow the cables to become entangled or overlap. Cable or boom failure could result.

19. Insert bottom wear pads on the inner mid section.

20. Attach the fly retract cable anchors to the nose of the inner mid section (1), (Figure 4-74).

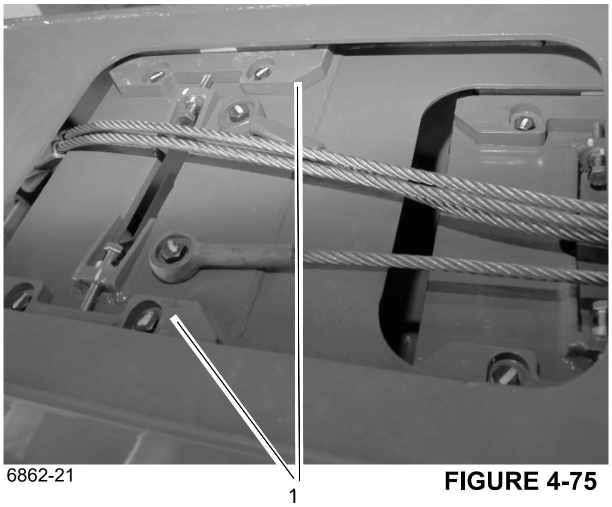


6862-20

FIGURE 4-74

21. Continue inserting the outer mid section into the inner mid section. Stop when the upper rear adjustable wear pads on the inner mid section are accessible.

22. Install the adjustable wear pads (1), (Figure 4-75) to the top of the base end of the inner mid section.



6862-21

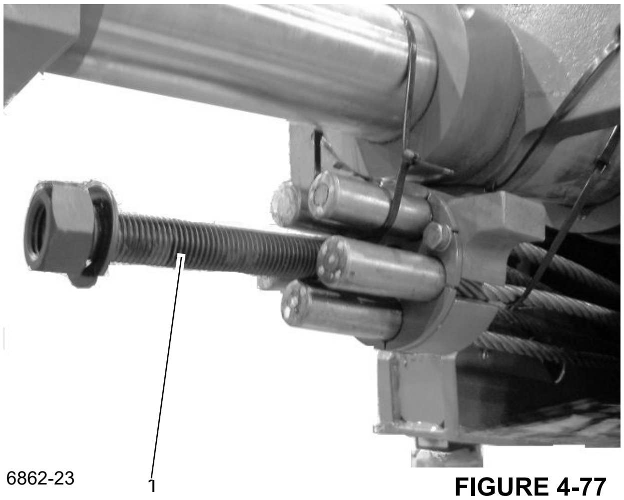
FIGURE 4-75

23. Install the kickback plate on the inside top of the inner mid section (1), (Figure 4-76).Install the mid syncro cable sheave assembly (2), (Figure 4-76) to the top inside of the inner mid section.

6862-22

FIGURE 4-76

24. Check to make sure that the long cable installation bolt (1), (Figure 4-77) is installed into the extend cable anchor assembly.



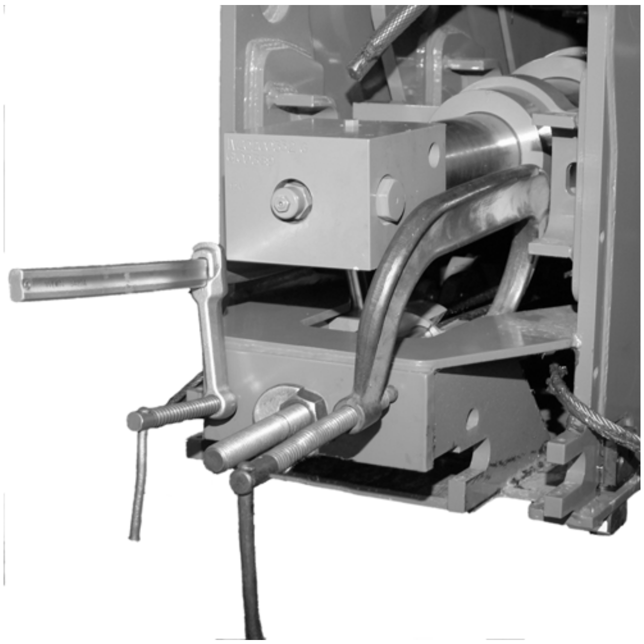
6862-23

FIGURE 4-77

25. Insert the installation bolt into the inner mid anchor weldment and take up as much slack as possible.

NOTE: Make certain that the extend cable anchor is seating properly into the boom section weldment. The “ears” on the anchor must fit into the grooves machined into the sides of the inner mid anchor plate.

26. Carefully clamp the anchor assembly to the inner mid anchor weldment (Figure 4-78).
    a. Remove the installation bolt and replace with the standard adjustment bolt.
    b. Take up the slack on the anchor adjustment bolt and remove the clamps.

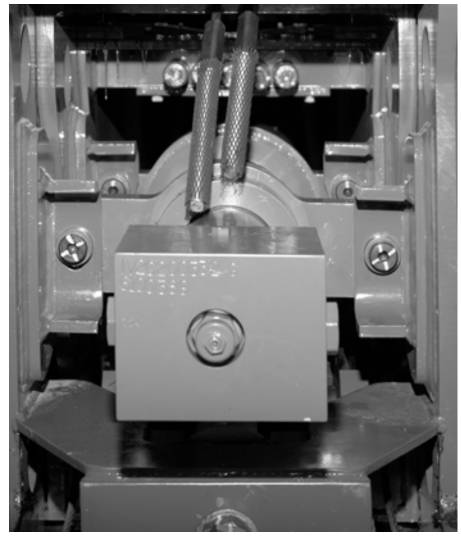


6862-24

FIGURE 4-78

27. Adjust the adjustment nut until there is 2.75 inches of thread showing. Install the jam nut.
28. Attach the Telescope Cylinder to the inner mid mounting flanges. Check to ensure bushings are free to rotate after the bolts are tightened (Figure 4-79).
29. Assemble the mid retract sheave assembly as shown in Figure 4-80 and Figure 4-81. **Note** that the pin has one thrust washer (1), (Figure 4-80) to the inside of the boom and two thrust washers (2), (Figure 4-80) to the outside of the boom.

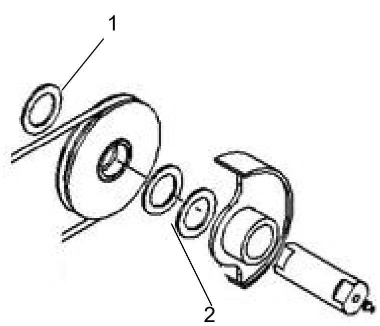
NOTE: Insert ONE thrust washer to the INSIDE and TWO thrust washers to the OUTSIDE of each assembly as shown in Figure 4-80.



6862-25

FIGURE 4-79

30. Reeve the mid retract cables on the left and right mid retract cable sheave assemblies and install as shown in Figure 4-80.



6862-26

FIGURE 4-80

31. Install the retainer capscrew, washer, and the nut to lock the sheave assembly pins in place (1), (Figure 4-81).

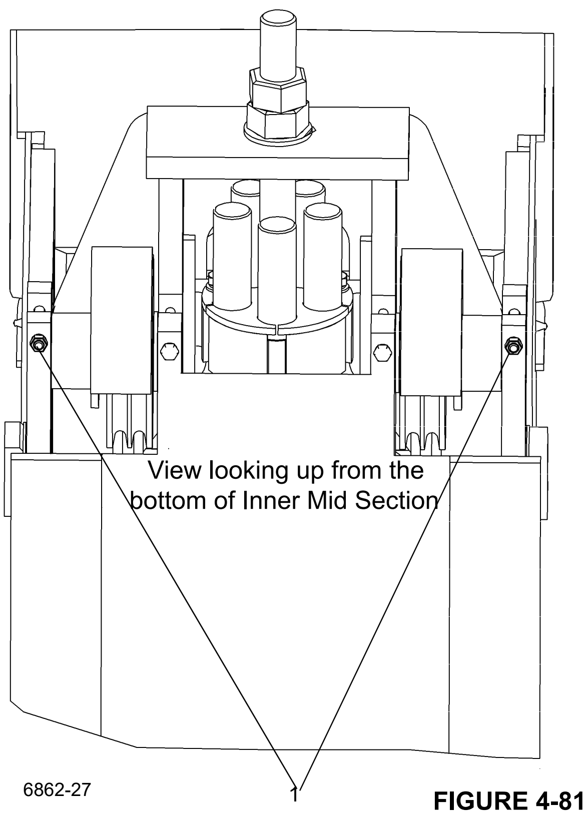


FIGURE 4-81

32. Lay out the mid retract cables toward the nose end of the inner mid section.
33. Attach two cables to each anchor, adjust each cable to 1.75 inches and install the locknuts (Figure 4-82).

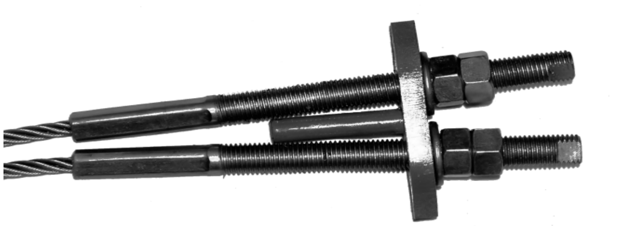


FIGURE 4-82

34. Turn the Telescope Cylinder port block so that the test port is down (Figure 4-83).

CAUTION

Failure to properly position the port block will cause problems when mounting the boom on the crane. The crane hydraulic system will not function properly if the port block in installed incorrectly.

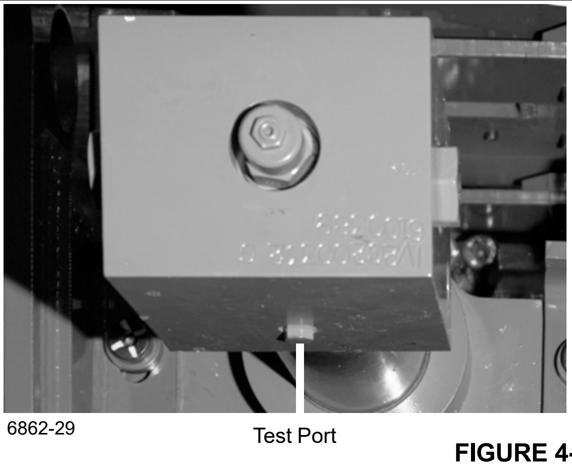


FIGURE 4-83

TENSIONING THE BOOM EXTEND AND RETRACT CABLES

The boom extend and retract cables must be tensioned after the boom has been rebuilt and installed on the crane and any time the cables appear to be loose.

Perform the following procedure to tension the extend and retract cables:

Tools required:

- 15/16 in, 1-1/4 in, and 1-13/16 in crow's feet
- Torque wrench with torque capabilities of 72 in-lb to 360 in-lb

CAUTION

When adjusting cables, use two wrenches. Hold the "flat" on the cable and turn the adjusting nut.

Do not allow the cables to twist. Cable failure could result.

- When tightening or loosening the cables, secure the cables using the flats at the front of the cable ends to prevent the cables from twisting.
- Make sure that all tensioning nuts thread ON and OFF of the threaded studs by hand; weld spalls or thread damage will adversely affect torque values.

- To assure cables are adequately tensioned, torque cables to at least the minimum torque values found in Table 4-3.

WARNING

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

CAUTION

Possible Cable Damage!

Use of an impact wrench to tighten the cable tensioning nuts can cause the extend and retract cables to twist, resulting in cable failure.

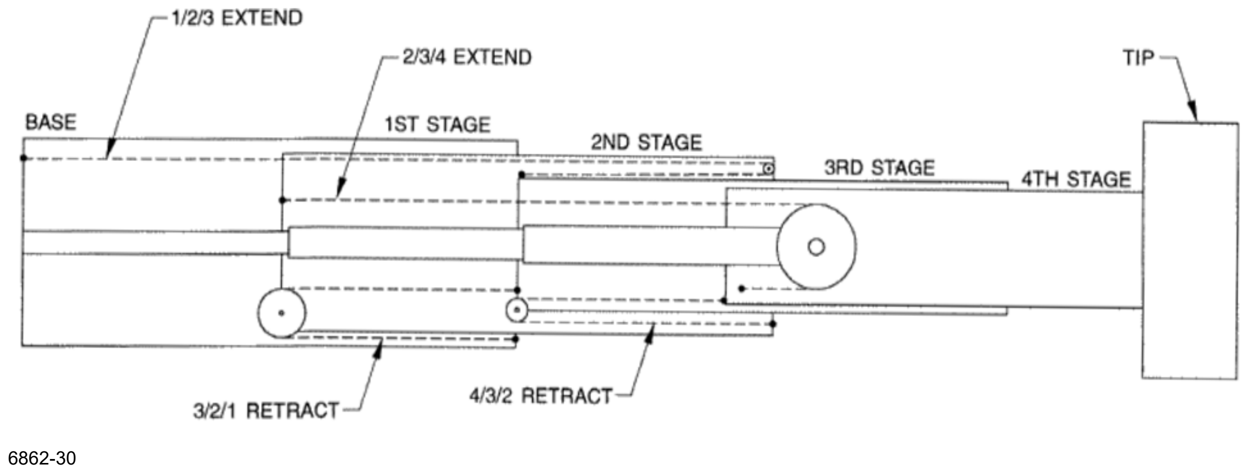
Do not use an impact wrench when tensioning the extend and retract cable.

Refer to the following procedures, Figure 4-84, and Table 4-3 when tensioning the extend and retract boom cables:

1. Position the boom to horizontal position before making adjustments.
2. Slightly tighten all cables.
3. Fully retract the boom.
4. In the order listed here, tighten the 4/3/2 retract, the 2/3/4 extend, the 3/2/1 retract, and the 1/2/3 extend cables to remove the excess slack from the cables.
5. In the order listed, torque the 4/3/2 retract, the 2/3/4 extend, the 3/2/1 retract, and the 1/2/3 extend cables to the minimum torque values specified in Table 4-3.

   To provide better access to adjust the 3/2/1 retract cables, extend the boom approximately 300 mm (12 in), then retract the boom approximately 150 mm (6 in) to tension the cables correctly prior to torques being set.

   Fully retract the boom before setting the torque on the 1/2/3 extend cables.
6. Fully cycle the boom.
7. Tighten the extend and retract cables as follows to ensure that all boom sections fully extend and fully retract simultaneously and that they do not drift out when the hydraulic valve is in neutral.
   a. If the 2nd stage is fully retracting late, loosen the 3/2/1 retract cables and tighten the 1/2/3 extend cables. Extend and retract the boom a few feet. Re-torque the 3/2/1 retract cables and the 1/2/3 extend cables to verify that the **minimum torque value** is achieved as specified in Table 4-3.
   b. If the 3rd stage is fully retracting late, loosen the 4/3/2 retract cables, tighten the 2/3/4 extend cables, then extend and retract the boom a few feet. Re-torque the 4/3/2 retract cables and the 2/3/4 extend cables to verify that the **minimum torque value** is achieved as specified in Table 4-3.
8. Make sure that all extend and retract cables achieve the **minimum torque value** as specified in Table 4-3.
9. Add jam nuts and tighten as specified in Table 4-3.
10. Coat all stud threads with Never Seize and install cable protectors. All threaded cable ends must be equipped with **retainer nuts** and jam nuts.



4-Section Boom Cable Positioning and Adjustment Locations

FIGURE 4-84

Table 4-3: Minimum Torque Values for Boom Cable Tensioning

Cables (Extend/Retract)	Minimum Torque Values
4/3/2 retract	10.5 N-m (96 in-lb)
2/3/4 extend	40.5 N-m (360 in-lb)
3/2/1 retract	8 N-m (72 in-lb)
1/2/3 extend	16 N-m (144 in-lb)

Note: All above torque values shown are minimums and are calculated with the use of a standard crow's foot attached to the torque wrench in a straight-ahead position.

Install the Base Section

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

DANGER

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

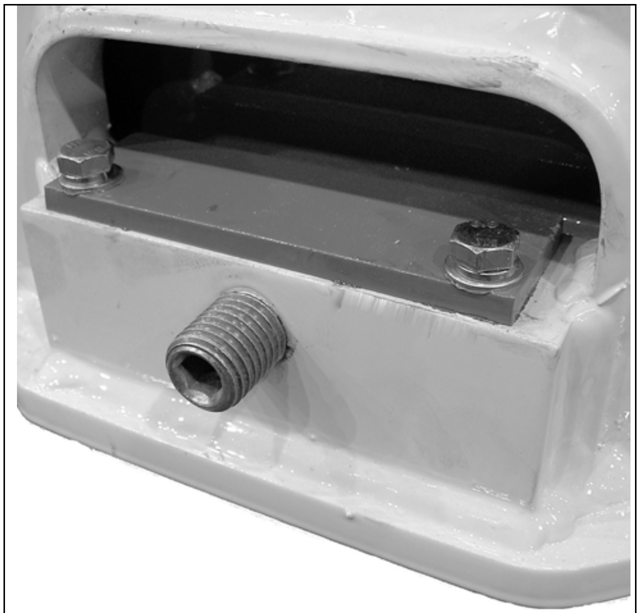
DANGER

Make sure that the lifting device is capable of supporting the boom assembly. Death or serious injury may result if the lifting device cannot support the load.

1. Insert the inner mid section into the base section until the inner mid section is past the side wear pad access and stop.
2. Install the lower front wear pads between sections.

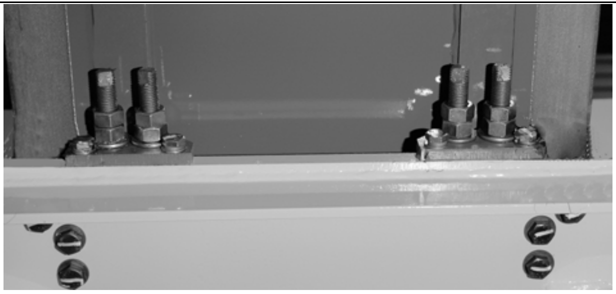
NOTE: Use grease to hold the wear pads in place during assembly.

3. Install the brass wear pad thru the base access hole in the side of the base section and slide the inner mid section past the wear pad and install the lock plate (Figure 4-85).



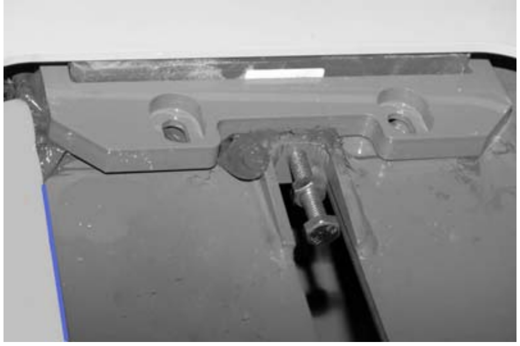
6838-25 **FIGURE 4-85**

4. Connect the mid retract cables to the front end of the base section (Figure 4-86).



6862-31 **FIGURE 4-86**

5. Install the kickback bar between the inner mid section and the base section (top front of base).
6. Install the top wear pad adjusting assembly inside the base section at the top rear access opening (Figure 4-87).



6862-32 **FIGURE 4-87**

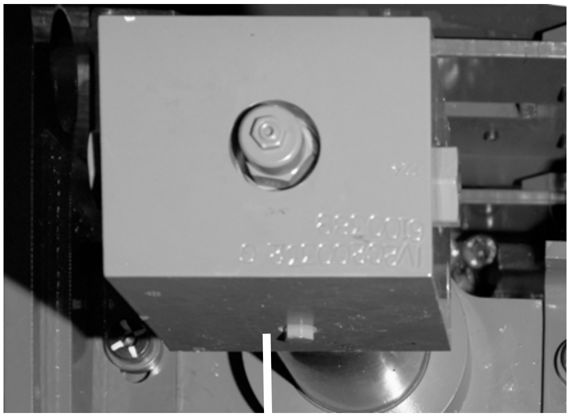
CAUTION

Make sure that the Telescope Cylinder Port Block is correctly positioned before proceeding. The boom will not function properly if the Port Block is not installed as shown in Figure 4-88.

CAUTION

There is less than 3mm of clearance between the sides of the weldment and the port block during installation.

Remove any plugs/caps that may interfere with installation.

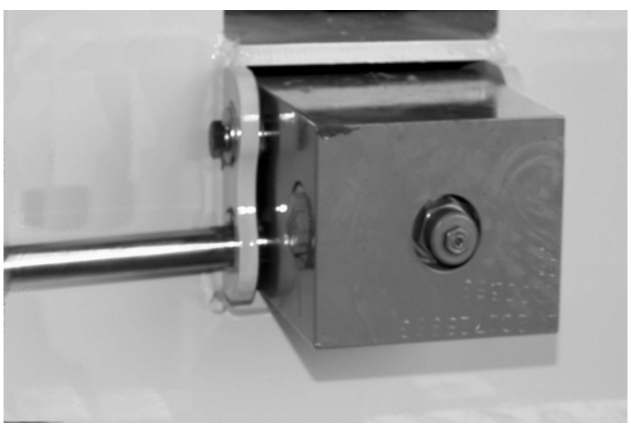


6862-33 Test Port

FIGURE 4-88

7. Carefully guide the port block into the anchor weldment.
8. Insert two telescope rod end pins. Secure both ends of each pin with a flat washer, lock washer, and capscrew (Figure 4-89).

NOTE: It may be necessary to gently pry the port block to align the pin holes.



6862-34

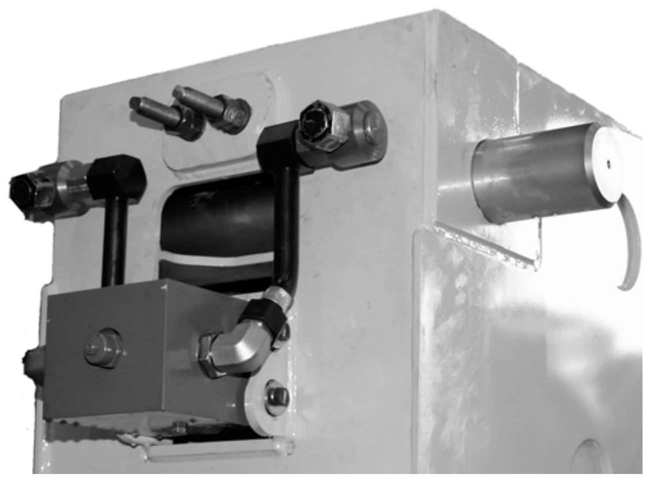
FIGURE 4-89

9. Connect the mid syncro-cables to the rear of the base section.
10. Adjust the cable until there is 76mm (3 inch) of threads showing past the adjustment nut (Figure 4-90).

6862-35

FIGURE 4-90

11. Plumb the port block with tubing (Figure 4-91).



6862-36

FIGURE 4-91

12. Disconnect the RCL/A2B cable that was attached to the base section cable guide (1), (Figure 4-92) in the removal of the boom and feed the cable through the inner and outer mid section cable guides (2), (Figure 4-92) and then through the fly section cable guide (3), (Figure 4-92).

6818-14

FIGURE 4-92

13. Remove the RCL/ A2B cable from boom nose.

  a. Connect the cable connector to the side of the junction box.

  b. Connect the “SHD” wire (1), (Figure 4-93) to Terminal 1 and the “CORE” wire (2), (Figure 4-93) to Terminal 2.

  c. Replace the cover to the junction box.

6837

FIGURE 4-93

FINAL BOOM INSTALLATION

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

DANGER

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

NOTE: The complete boom assembly weighs are: 95’ approximately 5144 kg (11,341 lb) and 102’ approximately 5954 kg (13,126 lb) without the swingaway boom extension attached.

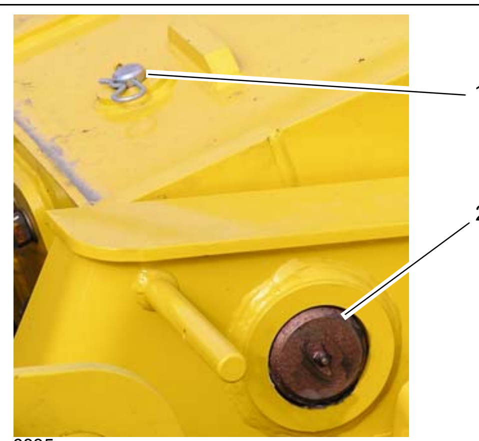
1. Attach a lifting device to the boom to provide for equal weight distribution.

2. Raise the boom off of the blocking or cribbing high enough to clear the crane and then lower the boom to the crane superstructure assembly.

3. Align the boom with the superstructure assembly.

4. Insert the boom pivot shaft and thrust washers through the superstructure assembly and boom.

5. Insert the clip pin and the retaining pin (1), (Figure 4-94) securing the boom pivot shaft (2), (Figure 4-94) on the boom to the superstructure assembly.



6835

FIGURE 4-94

6. Install the grease fittings on the pivot shaft and add grease per the requirements listed in the (pg 9-1) Section.

7. Remove the hard cap or plugs in the hydraulic lines and openings and connect the hydraulic lines to the telescope cylinder.

8. Connect all electrical wiring to the boom.

9. Make sure that the lift cylinder is properly supported with a structure capable of supporting the weight of the lift cylinder.
10. Elevate the boom slightly with the lifting device so that the lift cylinder can be extended approximately 30 cm (12 in) to allow for insertion of the lift cylinder rod end to the lift cylinder lift box on the bottom of the boom.
11. Activate the hydraulic system and extend the lift cylinder rod enough to slide in the lift box (1), (Figure 4-95).

DANGER

Make sure that the boom lift cylinder is properly supported. Death or serious injury may result if the lift cylinder is not supported.

6818-12 **FIGURE 4-95**

12. Insert the upper lift cylinder shaft (2), (Figure 4-95).
13. Install the upper shaft weldment (3), (Figure 4-95), and bolt (4), (Figure 4-95) and washer to the side of the lift box securing the upper lift cylinder shaft on the boom.
14. Remove the boom lifting device.
15. Make sure that the boom is fully retracted.

CAUTION

Wear gloves when handling wire rope. Moderate to minor injury may result if using bare hands.

SWINGAWAY EXTENSION INSTALLATION (OPTIONAL)

DANGER

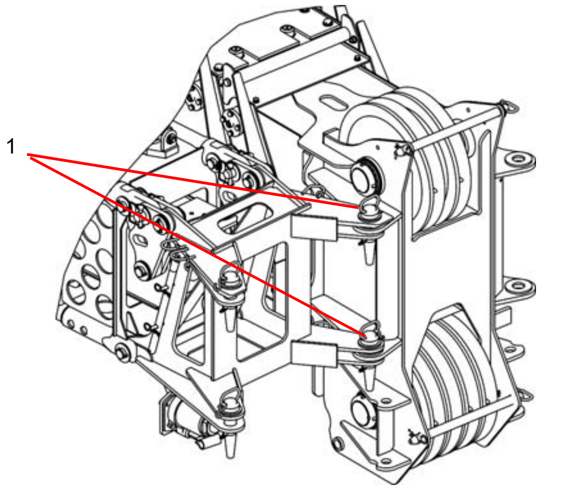
To prevent serious injury or death, always wear personal protective equipment; i.e., a hard hat, eye protection, gloves and metatarsal boots.

1. The Crane should be set up on outriggers using normal setup procedures as found in the *Operator Manual*.
   a. Fully retract the boom.
   b. Lower the boom to horizontal position extending the boom over the front of the crane.
2. Attach a lifting device to the lifting lugs (1), (Figure 4-6) on the swingaway extension.
3. Attach a length of rope to the boom extension tip (Figure 4-2), also called a Tag line, to aid in swinging the boom extension into place ahead of the boom nose.

DANGER

When installing and/or removing the boom extension, make sure that all personnel and equipment are kept clear of the swing path.

4. Raise the swingaway extension to a safe height to move to the boom and to move the extension into place ahead of the boom nose.
5. Using the Tag line attached to the tip of the boom extension, manually align the boom attachment to the boom extension anchor fittings (1), (Figure 4-96).
6. Move the boom slightly up or down, as necessary, to help align the boom attachment and boom extension anchor fittings (1), (Figure 4-96).
7. Insert the right side attachment pins (1), (Figure 4-96) through the boom attachment and boom extension anchor fittings. Install the retainer clips in the attachment pins.

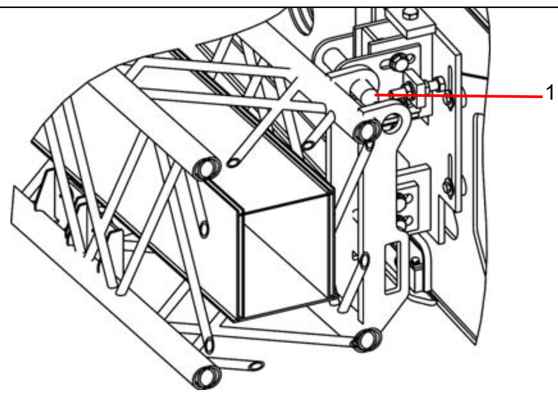


6814-4a

FIGURE 4-96

8. Be sure that the sliding portion (4), (Figure 4-98) of the rear stowage bracket is in the “OUT” position and secured in place with retaining pin(s) (5), (Figure 4-98) before Step 9.

9. Extend the boom approximately 51 to 64 cm (20 to 25”).

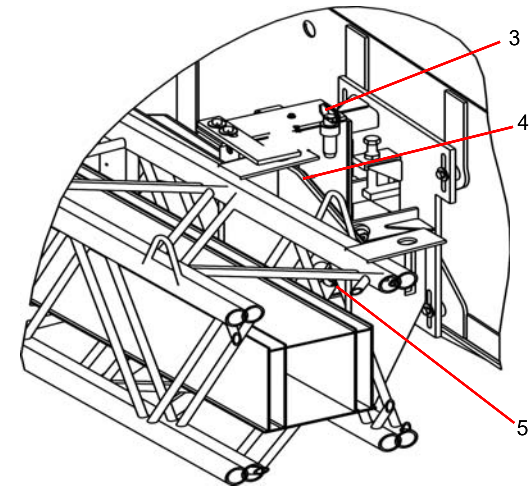


6821-3a

FIGURE 4-97

10. Make sure that the hitch pin and clip pin (3), (Figure 4-98) are removed from the rear stowage bracket (4), (Figure 4-98).

11. Make sure that the sliding portion of the rear stowage bracket is in the “OUT” position and secured in place with the retaining pin (5), (Figure 4-98).



6821-3b

FIGURE 4-98

DANGER

When stowing the boom extension, make sure that all personnel and equipment are kept clear of the swing path.

CAUTION

Do not allow the boom extension to slam into the stowage bracket when swinging into the stowed position.

12. Using the Tag line (Figure 4-2) attached to the tip of the boom extension, manually swing the extension to the side of the boom.

13. Slightly raise and/or lower the boom to help control the boom extension.

14. Align the stowage lugs on the boom extension with the guide pins (1), (Figure 4-97) and ramp (4), (Figure 4-98) on the stowage brackets and fully retract the boom.

15. Fully retract the boom. Make sure that the stowage lugs of the boom extension engage the guide pins (1), (Figure 4-97) and ramp (4), (Figure 4-98) of the stowage brackets.

16. Install the hitch pin and clip pin (3), (Figure 4-98) securing the boom extension to the rear stowage bracket.

NOTE: Make sure that the boom extension is on the guide pins(1), (Figure 4-97) and ramp (4), (Figure 4-98) and that it is secured with the hitch pin (3) (Figure 4-98),before moving to Step 16.

DANGER

Before performing Step 16, confirm that the extension is fully supported and secured prior to removing the attachment pins or the jib could fall.

17. Remove the attachment pins and clip pins (1), (Figure 4-96) from the anchor and attachment fittings (2), (Figure 4-96) on the right side of the boom nose and stow them in the base of the boom extension. Stow the left side attachment pins and clips in the outside attachment fitting on the swingaway.

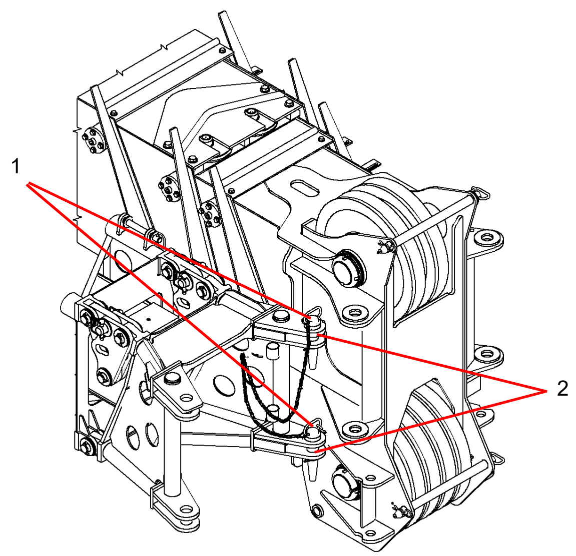


FIGURE 4-99

18. On the rear stowage bracket, remove the retainer pin (5), (Figure 4-100) securing the sliding support in the “OUT” position. Push in on the handle (6), (Figure 4-100) to push the swingaway against the rear of the boom, disengaging the swingaway anchor fittings from the boom nose attachment lugs.

19. Install the retainer pin (5), (Figure 4-100) securing the sliding support in the “IN” position.

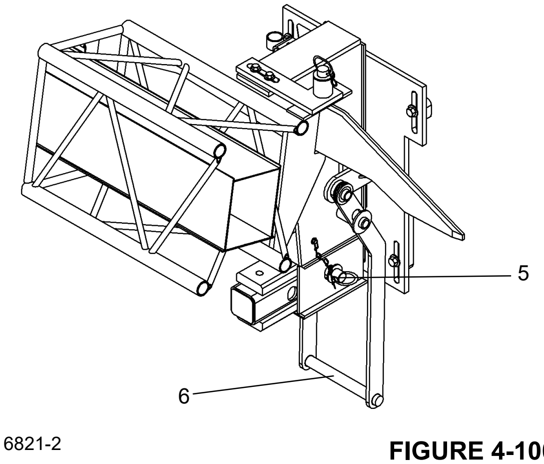


FIGURE 4-100

20. Rig the boom nose and hoist cable as desired per Section 4 of the *Operator Manual*.

21. Align the main and auxiliary hoists to the boom as per the Hoist to Boom Alignment (pg 5-7).

22. Install the hook block or overhaul ball.

23. Perform all adjustments and maintenance for the boom.

BOOM MAINTENANCE

Functional Test of the Boom

1. Activate the hydraulic system and check for proper operation and any leaks.
2. Make sure that the boom will extend and retract properly.
3. Make sure that the lift cylinder will not allow the boom to drift down until the operator lowers it.
4. Make sure that all electrical components that were disconnected during removal are operating properly.

Boom Inspection

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

DANGER

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

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

Boom Alignment and Servicing

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

DANGER

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

Boom alignment is achieved by the adjustment of the wear pads located at various points in the boom assembly. Adjustment of the wear pads is as follows:

1. Fully extend the boom horizontally.
2. Lubricate the boom bottom plates (sides and bottom).
3. Shim the front lower side wear pads to within 1.52 mm (0.06 in) from the side plate of the next inner boom section, then shim the front upper wear pads in the same manner. Use an equal number of shims on each side.

CAUTION

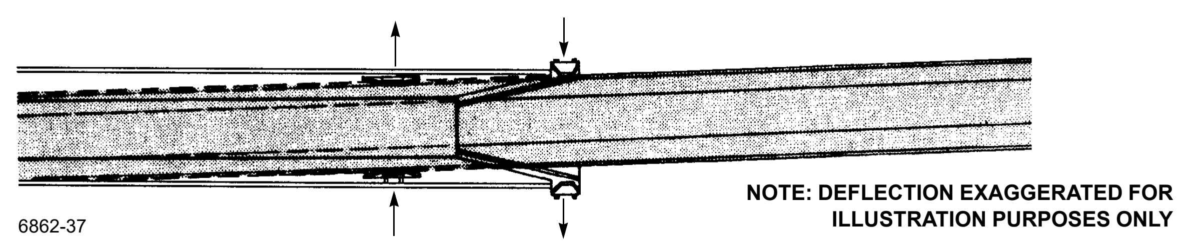
When extending and retracting the boom during alignment, movement should be stopped if a restriction is encountered. Re-shim the wear pads as necessary to provide for free travel of the affected boom section(s).

4. Retract and extend the boom; check for the high point where the boom has brushed the wear pads at the widest point.
5. Retract the boom sections to align the high point on the boom section with the adjacent wear pads.
6. Add or subtract shims as necessary.

Table 4-4

Example	
If the boom deflects to the left:	
1	The forward left wear pad would be shimmed in.
2	The rear left adjustable wear pad would be adjusted out, away from the internal boom section.
3	The forward right wear pad will be shimmed out.
4	The right rear adjustable pad adjusted in.

7. Attach a weight and extend the boom full length. Check for side deflection.



Boom Alignment

FIGURE 4-101

EXTENSION AND RETRACTION CABLE MAINTENANCE

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

DANGER

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

NOTE: For more detailed information concerning maintenance of the extension and retraction cables, refer to Wire Rope (pg 1-22).

Inspection

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

CAUTION

Never handle wire rope with bare hands. Injury to hands could result.

DANGER

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

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

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

- In running ropes, six randomly distributed broken wires in one lay or three broken wires in one strand in one lay.
- Wear of one-third the original diameter of outside individual wires. Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of any heat damage from any cause.
- Reductions from nominal diameter of more than:
  - 0.4 mm (0.016 in) for diameters up to and including 8 mm (0.3125 in).
  - 0.79 mm (0.031 in) for diameters 10 and 13 mm (0.375 and 0.5 in) inclusive.
  - 1.19 mm (0.047 in) for diameters 14 to 19 mm (0.5625 to 0.75 in) inclusive.
  - 1.59 mm (0.063 in) for diameters 22 to 29 mm (0.875 to 1.125 in) inclusive.
  - 2.38 mm (0.094 in) for diameters 32 to 38 mm (1.25 to 1.5 in) inclusive.
- 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.

LIFT CYLINDER MAINTENANCE

Lift Cylinder Removal

1. Extend and set the outriggers and level the crane.
2. Elevate the boom slightly so that the lift cylinder is extended approximately 0.3 m (1 ft).

NOTE: The weight of the Lift Cylinders are as follows:

For the 95’ Boom: The cylinder weighs (dry) approximately 487.3 kg (1074 lb).

For the 102’ Boom: The cylinder weighs (dry) approximately 569.7 kg (1256 lb).

DANGER

Make sure that adequate and properly tested lifting devices are used to remove the Lift Cylinder. Death or serious injury may result if the lifting device cannot support the load.

3. Make sure that the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.
4. Remove the bolt and washer securing the lift cylinder upper pivot shaft to the boom (see Figure 4-102).
5. Remove the bolt and locknut securing the lift cylinder lower pivot shaft to the turntable.
6. Attach an adequate lifting/supporting device to the lift cylinder being removed.
7. Remove the upper pivot shaft. Activate the hydraulic system and retract the lift cylinder enough to clear the upper attach point.
8. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.
9. Pull the lower lift cylinder pivot shaft out far enough to remove the cylinder.
10. Move the lift cylinder to a clean work area.

DANGER

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

Lift Cylinder Installation

1. Attach an adequate lifting device to the lift cylinder and position the cylinder over the attach fitting on the turntable.
2. Lower the lift cylinder into the attach fittings on the turntable and align the lift cylinder bushing with the attach fitting holes.
3. Install the lower pivot shaft (Detail B), (Figure 4-102) with tapped hole on the right side, side opposite the cab.
4. Install the lift cylinder lower pivot shaft and secure with the bolt and locknut.
5. Connect the extend and retract hoses to the lift cylinder.
6. Activate the crane’s hydraulic system and align the lift cylinder rod end with the attach point on the boom. Install the upper pivot shaft through the cylinder and boom attach points. Shut down the engine.
7. Secure the upper pivot shaft with the bolt and washer.
8. Remove the lifting and supporting devices from the boom and lift cylinders. Activate the hydraulic system and check the lift cylinders for proper operation and any leaks.
9. Lubricate the pivot shafts using grease fittings.

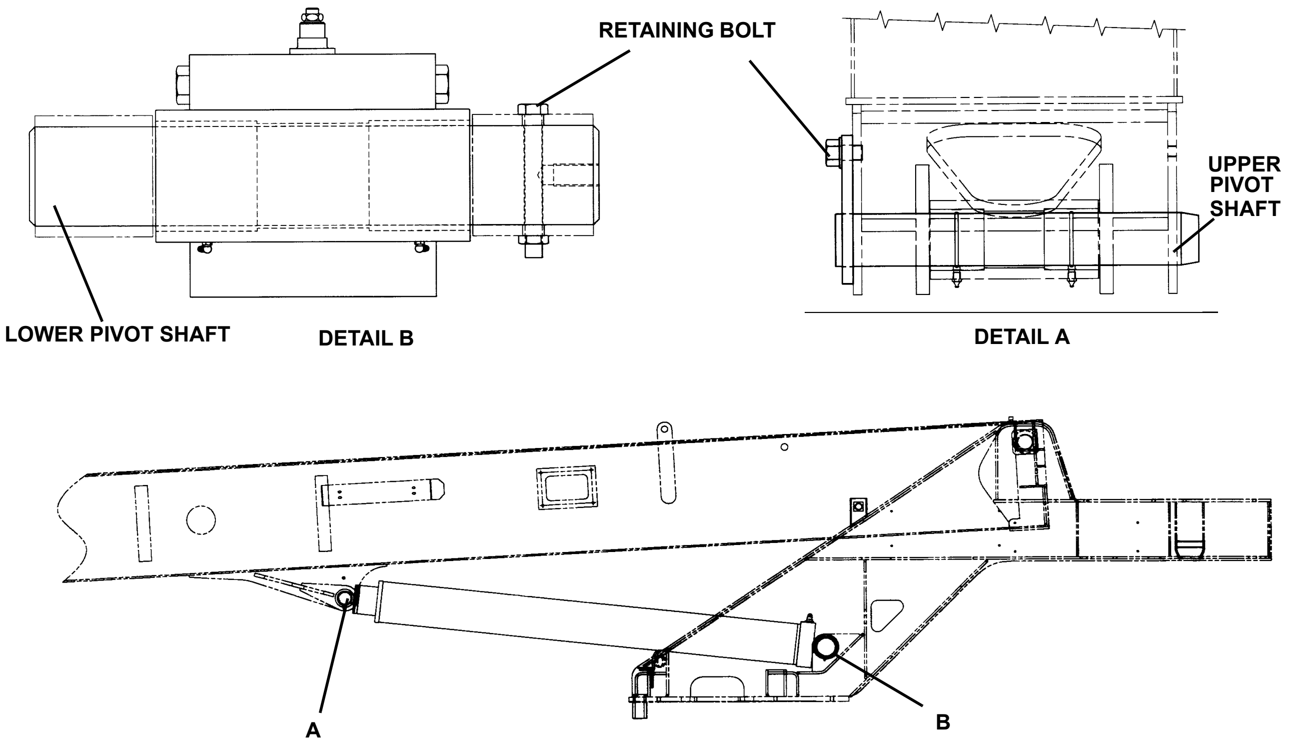

RETAINING BOLT
UPPER PIVOT SHAFT
LOWER PIVOT SHAFT
DETAIL B
DETAIL A
A
B
6862-38

FIGURE 4-102

THIS PAGE BLANK

SECTION 5
HOIST AND COUNTERWEIGHT

SECTION CONTENTS

Description 5-1
Theory of Operation 5-1
Maintenance 5-2
Warm-up Procedure 5-2
Removal 5-2
Installation. 5-3
Functional Check 5-3
Servicing 5-3
Hoist Maintenance and Inspection 5-4
Usage and Inspection 5-4
Pre-Use or Daily Inspection 5-5
Quarterly Inspection (Every Three Months) 5-5
Semi-Annual Inspections (Every Six Months). . . . 5-5
Annual Inspection 5-5
Preventive Maintenance and Oil Sampling 5-5
Oil Change 5-5
Gear Oil Sampling and Analysis 5-5
Brake Test Procedure 5-6
Hoist to Boom Alignment 5-7
Preparation 5-7
Tools Required 5-7
Procedure 5-7
Piston Motor and Control Valve 5-8
Description. 5-8
Maintenance 5-8
Idler Drum and Cable Follower. 5-9
Description. 5-9
Maintenance 5-9
Hoist Drum Rotation Indicator System 5-11
Description. 5-11
Maintenance 5-11
Troubleshooting 5-11
Counterweights 5-13
Counterweight Removal 5-13

5

DESCRIPTION

Two hoists are available: the Main and Auxiliary with one model hoist available.

The hoist incorporates one dual displacement piston motor which drives a reduction unit within the hoist. The hoist utilizes planetary reduction with a multi-disc automatic brake that is spring applied and hydraulically released. An overrunning clutch allows the hoist to be raised without releasing the brake, while at the same time, holding the load until there is sufficient pressure to release the brake when hoisting down. The hoist motor controls both speed and torque of the hoist.

There are two modes in which the hoist operates: high and low. In high speed, the pilot solenoid valve shifts the selector spool on the motor to provide minimum motor displacement. This gives high line speed and low torque.

The second mode is low speed. The pilot solenoid valve shifts the selector spool on the motor to provide maximum motor displacement. This gives low line speeds and high torque.

THEORY OF OPERATION

The hoist assembly is controlled by electronic remote controllers located in the cab. When the control lever in the cab is moved from neutral, it causes the hoist section of the directional control valve to shift the valve spool to route hydraulic flow to the hoist motor control valve. The hoist motor control valve is used to stop or slow the hoist when the load is trying to drive the hoist down too quickly. The motor control valve is piloted open by the hoist down pressure. If the load lowers faster than the flow of oil in the hoist down line, the pilot pressure decreases and the motor control valve partially closes to restrict the oil leaving the motor until a balance occurs. This results in the load lowering at a uniform speed based on the position of the hoist control lever.

During stopping, when the hoist down flow ceases, the pilot pressure holding the motor control valve open decreases to zero and the motor control valve spool closes, thus blocking all flow of oil out of the hoist motor. This decrease in pressure allows the spring applied pressure released hoist brake to apply when the load is fully stopped. This brake acts as a “parking brake” and holds the load in the stopped position.

MAINTENANCE

Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential at ambient temperatures below 4°C (+40°F).

The prime mover should be run at its lowest recommended RPM with the hydraulic hoist control valve in neutral allowing sufficient time to warm up the system. The hoist should then be operated at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil, and to circulate gear lubricant through the planetary gear sets.

DANGER

Failure to properly warm up the hoist, particularly under low ambient temperature conditions, may result in temporary brake slippage due to high back pressures attempting to release the brake, which could result in property damage, severe personal injury or death.

Removal

1. Remove all cable from the hoist drum.
2. Tag and disconnect the hydraulic lines to the hoist. Cap or plug all lines and openings.
3. Tag and disconnect the electrical wires to the hoist rotation indicator sensor.
4. Tag and disconnect the electrical wires to the hoist high-speed solenoid valve.
5. Remove the hoist mounting nuts, capscrews, washers, and shims (if shims are used, mark their location).

NOTE: The hoist assembly, less the cable, weighs approximately 336 kg (741 lb).

6. Using an adequate lifting device, remove the hoist from the crane.

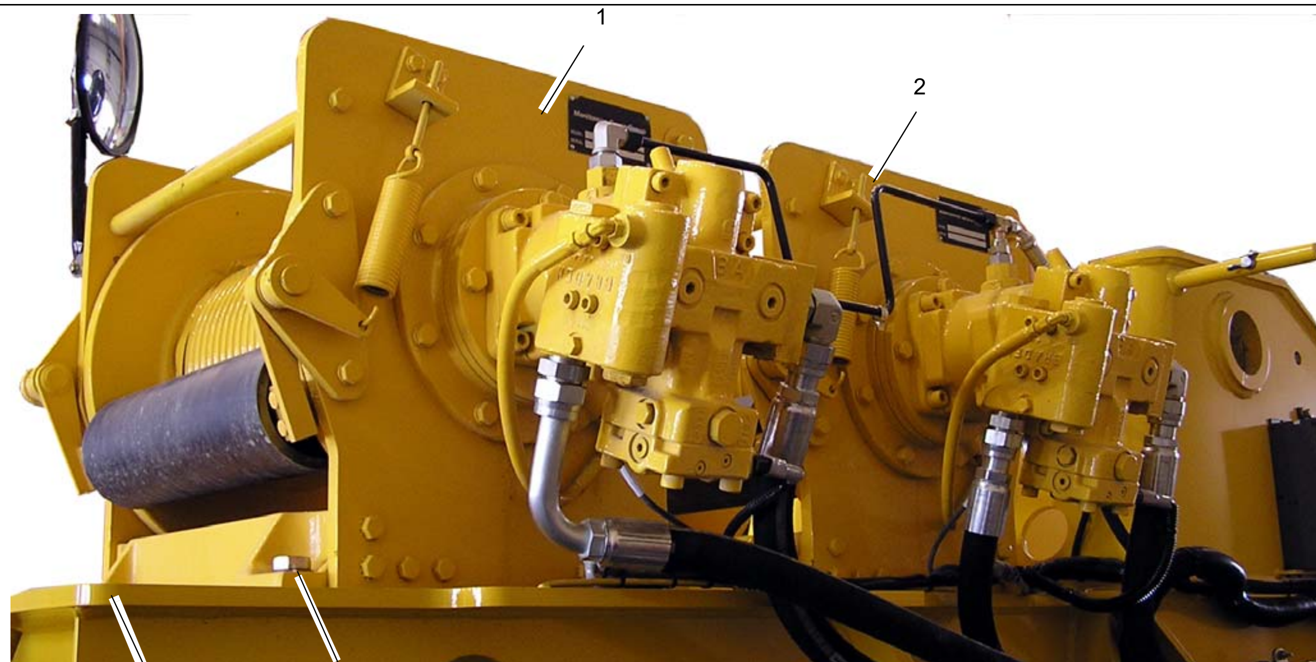


FIGURE 5-1

Item	Description
1	Auxiliary Hoist (Optional)
2	Main Hoist
3	Turntable
4	Capscrew

Item	Description
5	Washer
6	Hex Nut
7	Shims

Installation

1. Make sure that the mounting plate and hoist pads are clean and free from debris and that the hoist has not been damaged during handling.
2. With the hoist supported by a suitable lifting device, position the hoist on the mount.
3. Check the hoist to boom alignment according to the Hoist to Boom Alignment (pg 5-7) Procedure in this section.
4. Place a level between the boom pivot shaft bushings to be sure of levelness.
5. Place a level across the top of the hoist drum and determine if the hoist is sitting in the same plane in relation to the level positioned between the boom pivot shaft bushings.
6. With the hoist level, check to determine if all the hoist mounting pads are in contact with the mounting plate by rocking the hoist.
7. Keeping the hoist level, use a feeler gauge to determine the amount of gap existing between the pads and the mounting plate.
8. Add shims to satisfy any existing gaps. Altering the shim thickness to fit a tapering gap is acceptable. Install the capscrews, washers and nuts (Figure 5-1) and torque. Refer to Fasteners and Torque Values (pg 1-14).
9. Remove the lifting device from the hoist.
10. Connect the hydraulic lines to the hoist making sure that the proper lines are connected to the correct ports as marked during removal.
11. Connect the electrical wires to the hoist high- speed solenoid valve as marked during removal.
12. Connect the electrical wires to the hoist rotation indicator sensor as tagged during removal.
13. Install the cable following the procedures outlined under Installing Cable on the Hoist, Section 6, page 6-2 in the *Operator Manual*.

Functional Check

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

Servicing

Remove the large plug from the center of the drum support and refer to the Lubrication (pg 9-1) Section of this manual. Also refer to Hoist Lubrication (pg 9-21).

HOIST MAINTENANCE AND INSPECTION

It is extremely important that the maintenance staff involved with crane inspections be made aware of the possibility that deterioration of internal critical components within the hoist can occur. Hoists incorporate planetary gears, multi-disc brake assemblies and sprag clutches which do not have an infinite service life span. Although these components have been designed to achieve long service life, reliability can be substantially reduced by a variety of influencing factors such as:

- High-cycle operation
- Operating in high ambient temperatures
- High external contamination, such as dusty or sandy conditions
- Type of lubricant used
- Level of maintenance

The following routine servicing points must be carried out in accordance with the manufacturer's instructions:

Usage and Inspection

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

- **Idled** - The crane/hoist has not been used for three months.
- **Infrequent Usage** - The crane/hoist is used less than ten hours per month based on a three-month average.
- **Moderate Usage** - Crane/hoist used 10 - 50 hours per month based on a three-month average.
- **Heavy Usage** - Crane/hoist used 50 - 200 hours per month.
- **Severe Duty -** 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.

NOTE: For idled units with unknown maintenance and repair history, it is highly recommended that the hoist undergo a tear-down inspection prior to being placed into service.

The following chart lists the inspections that are required for each type of usage category:

INSPECTION / 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	—
INFREQUENT USAGE less than ten hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
MODERATE USAGE 10-50 hours per month	REQUIRED	REQUIRED	REQUIRED	REQUIRED
HEAVY USAGE 50-200 hours per month	REQUIRED	REQUIRED MONTHLY	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)
SEVERE USAGE 200+ hours per month or 50% of lifts exceed 75% rated capacity	REQUIRED	REQUIRED	REQUIRED QUARTERLY (3 months)	REQUIRED SEMI-ANNUALLY (6 months)

Pre-Use or Daily Inspection

The 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.

1. Check for external oil leaks and repair as necessary. This is extremely important due to the accelerated wear that will result from insufficient lubricating oil in the hoist. If the hoist has a sight glass, check the oil level daily. If the hoist does not have a sight glass, check the oil level monthly as long as there are no external oil leaks detected. The lubricant level must be maintained between the minimum and the maximum levels; midway up sight glass or at the bottom of level plug port as equipped. Use **ONLY** the recommended type of lubricant. Refer to the machine's lubrication chart.
2. Check the hydraulic fittings and hoses for chaffing, deterioration, or corrosion and repair as necessary.
3. Visually inspect for corroded, loose or missing bolts, pins or other fasteners and replace or tighten as necessary.
4. Visually inspect rotation indicator transmitters, anti-two-blocking switches and other safety equipment and repair as necessary.

Quarterly Inspection (Every Three Months)

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

1. Perform the pre-use inspection.
2. Inspect for corrosion of fasteners, hoist base, drum, and so on and repair or replace as required to maintain the structural integrity of the hoist.

Semi-Annual Inspections (Every Six Months)

1. Perform the pre-use and quarterly inspections.
2. Take a sample of the lubricant from the hoist gear cavity as described on this page and analyze it for wear metals content, correct viscosity, lubricant deterioration, moisture and other contaminants. If the oil sample contains a high amount of metallic particles, the hoist must be taken out of service to undergo a tear down inspection.

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

Annual Inspection

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

1. Perform the pre-use/daily, quarterly and semi-annual inspections.
2. Change the lubricating oil in the hoist gear cavity after an oil sample has been taken as described on this page. Refill the hoist to the proper level with recommended lubricant. Refer to the machine's lubrication chart.

WARNING

Possible Equipment Damage and/or Personal Injury!

Failure to use the proper type and viscosity of planetary gear oil may contribute to intermittent brake clutch slippage which could result in property damage, severe personal injury, or death. Some gear lubricants contain large amounts of 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 that excessively heavy or thick gear oil may contribute to intermittent brake clutch slippage. Make certain that the gear oil viscosity used in your hoist is correct for your prevailing ambient temperature.

PREVENTIVE MAINTENANCE AND OIL SAMPLING

WARNING

Risk of Personal Injury!

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 43°C or 110°F) before taking an oil sample, changing oil, or servicing the hoist.

Oil Change

The hoist gear oil must be changed after the first 100 operating hours then on an annual basis, at a minimum thereafter. In severe duty applications, the gear oil should be changed every six months. Use the recommended lubricants. Refer to the machine's lubrication chart and the Lubrication (pg 9-1) Section of this manual.

Gear Oil Sampling and Analysis

The 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 an accelerated component wear allows the scheduling of corrective maintenance.

Prepare the hoist by cleaning the drain plug area and drain the extension tube in order to obtain an uncontaminated sample. Operate the hoist in both directions for one or two minutes to thoroughly mix the gear oil, then take the sample from the midstream flow of the oil to obtain an accurate representation of the oil condition. After taking the oil sample, continue with the oil change or refill the hoist gear cavity to the proper level with the recommended lubricant. Iron-contaminant levels will be on the high side of “normal” during the initial break-in.

General Guidelines for Iron-Contaminant Level

PPM	Condition of Oil
100-500	**Normal -** Acceptable level; little significant contamination.
500-800	**Caution -** Abnormal sample. Change oil and retake sample after 50 hours of operation. If second sample is above 500 PPM, remove the hoist from service and perform a tear-down inspection to determine the source of contamination.
Over 800	**Unacceptable -** Remove the hoist from service and perform a tear-down inspection to determine the source of contamination.

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

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

BRAKE TEST PROCEDURE

The hoists have a spring applied, hydraulically released, multiple disc brake inside the hoist housing. This brake holds a suspended load when the directional control valve is in neutral, or when hydraulic power is lost. An over-running brake clutch assembly permits the power train and drum to rotate in the direction to lift a load, while the brake remains fully applied. A load cannot be lowered, however, without applying hydraulic pressure to the release port and releasing the brake.

The following steps are the Brake Test Procedure (To be Performed With no Load on the Hoist):

1. Remove and cap or plug the brake release line from fitting in the hoist brake release port.
2. With the hydraulic power unit running, move the directional control valve handle slowly to the full open, lowering position.
3. Increase the engine speed, if necessary, to bring system pressure up to the relief valve setting. The hoist drum should remain stationary.
4. If the hoist drum rotates, the hoist should be disassembled and the brake components should be examined for wear. Additionally, the brake springs should be measured for the correct free length in those hoists using helical compression springs.
5. Replace any parts showing excessive wear and any spring whose length is shorter than the minimum shown in the applicable hoist Service Manual.
6. Reassemble the brake and hoist, then repeat the above steps.
7. When testing is complete, reattach the brake release line to the brake release port.

Contact Crane Care with any questions.

HOIST TO BOOM ALIGNMENT

Preparation

Boom alignment must be completed before attempting hoist alignment. If the hoist is not properly aligned, the cable can be damaged or fine control could be affected.

The crane must be set on outriggers fully extended and the crane must be leveled. The boom must be over the front.

Tools Required

- Two foot square
- Mason cord
- Chalk
- Protractor

Procedure

The hoist mounting location will determine the alignment procedure used. It may be necessary to shim under one side of the hoist to make it level.

The hoist must be checked in two directions:

- zero degrees, and
- 45 degree boom angle

Check the hoist at 0 degree to see if the hoist is aligned to the boom nose sheave. The main hoist is aligned to the right hand sheave and the auxiliary hoist is aligned to the center sheave (Figure 5-2).

NOTE: The hoist cable will have gaps in it during spooling if the alignment is not correct.

NOTE: The hoist is not level if the cable is piling up on one side of the drum.

1. The boom must be extended one half of full extension on all hoist alignments. This length is used because when the main hoist cable is positioned on the top right hand boom nose sheave, the cable must leave the center of the drum at a 90 degree angle. The boom has the ability to extend, retract, and change the angle of departure from the drum. Extend the boom half way to provide a center point of adjustment to check the fleet angle of the cable.
2. All the cable must be removed from the hoist drum to check the fleet angle. Using mason cord or cat gut fishing line you will be able to pull the line tight to make an accurate measurement of the fleet angle. Find the centerline of the hoist drum by using a square and drawing a line horizontal on the drum. Put a line vertical to the horizontal line in the absolute center of the drum by using a tape measure. With the boom at 0 degree, tie the line tight to the boom nose and have it in the center of the right hand boom nose sheave.

NOTE: If this special equipment is not available, sufficient accuracy in locating a centerline may be obtained by using a steel square against the machined inner surfaces of both flanges. It is advisable to avoid using any cast surfaces in this procedure unless a check from both flanges indicates that the resultant line is straight.

3. Tie the line around the hoist drum so that the line is very tight and the line is crossing the absolute center of the drum at the centerline mark you put on the drum.
4. Using a protractor, lay it on the vertical line on the hoist drum so the string line is in the center of the protractor. The string line will be at the 90 degree mark on the protractor if the hoist is straight with the boom nose sheave. If it is not at the 90 degree mark, the hoist mounting bolts will have to be loosened and the hoist moved so that it is.

NOTE: This test is for cable leaving gaps while spooling.

CAUTION

Do not alter holes or stop blocks on the crane mounting plate, as very small adjustments result in large angular changes. Extreme care should be taken to avoid over-correction.

5. Elevate the boom above a 45-degree boom angle to check if the hoist is level. Reposition the hoist drum and tighten the cord so that you can have the cord in the center of the protractor at the 90-degree mark. If the cord is not at the 90-degree mark, the hoist will have to be shimmed until the cord is at the 90-degree mark.

NOTE: This test is for cable piling up on one side of the hoist drum.

5

.

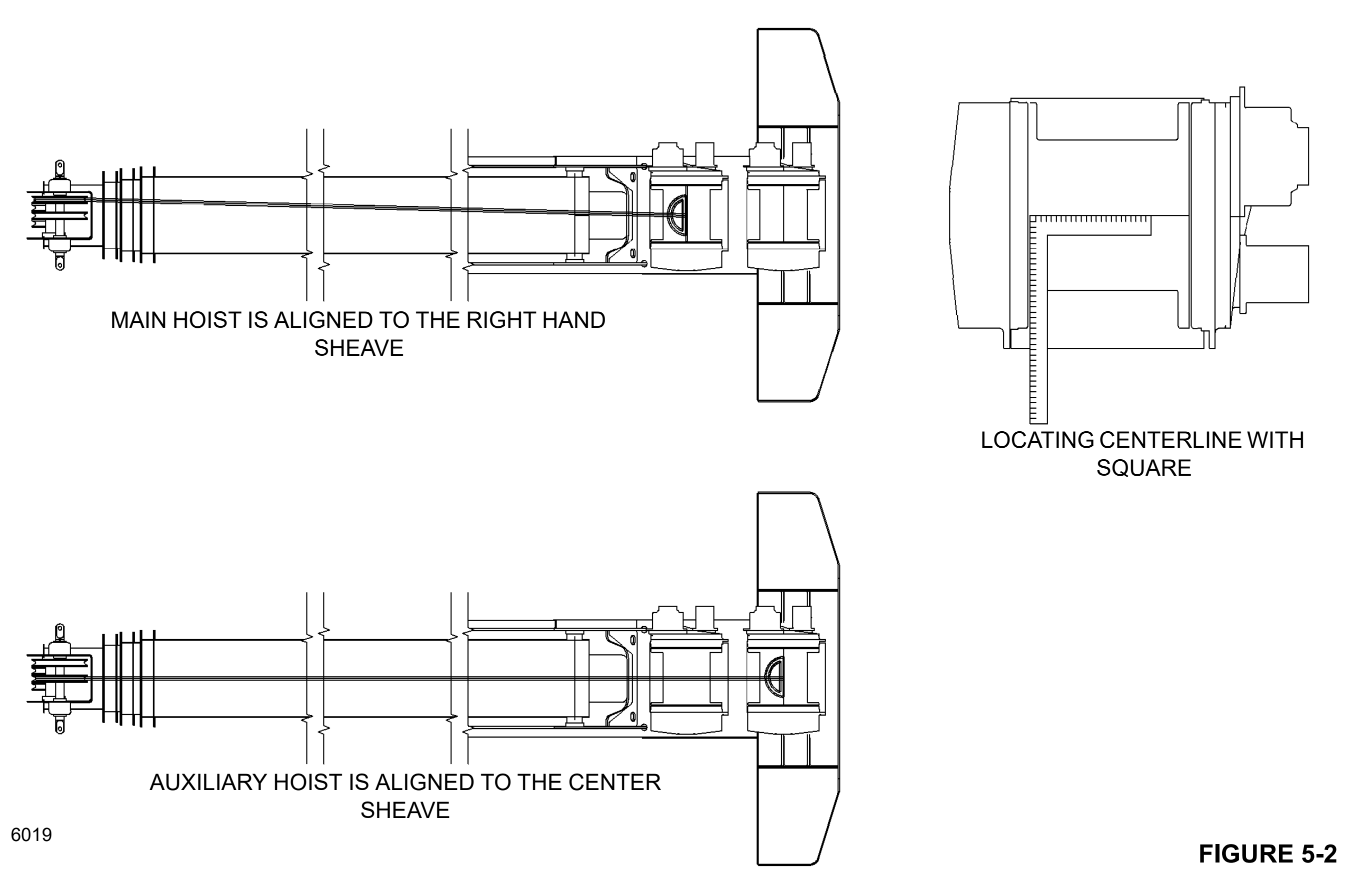


FIGURE 5-2

PISTON MOTOR AND CONTROL VALVE

Description

The piston motor is a bent axis, bi-directional, variable displacement, heavy-duty motor. The motor is bolted to the hoist and is geared directly to the hoist planetary.

The motor control valve is bolted to the motor.

Maintenance

Removal

1. Thoroughly clean the external surfaces of the drum and motor with steam or clean solvent and blow it dry.
2. Tag and disconnect the hydraulic lines connected to the hoist motor and the motor control valve.
3. Remove the capscrews and lockwashers that secures the motor and motor control valve to the hoist.

NOTE: The hoist motor weighs approximately 28 kg (62 lb).

4. Place the motor and motor control valve in a clean, dry, suitable work area.

Installation

NOTE: Care must be taken to assure that the primary thrust plate remains properly located in its counterbore when the motor is re-installed. If the winch is operated with the primary thrust plate wedged between the primary gears and the planet carrier, or with a thrust washer out of position, severe damage to the internal winch components could result.

1. Install a new O-Ring on the motor pilot then lubricate with petroleum jelly or gear oil. Engage the motor shaft with the brake clutch inner race and lower into place.
2. Apply Loctite No. 243 to the mounting bolts, and install the bolts and lockwashers. Torque the bolts to 108 N-m (80 lb-ft).
3. Connect the hydraulic lines as tagged during removal.
4. Fill the drum with oil. Refer to Lubrication (pg 9-1) Section in this manual.

IDLER DRUM AND CABLE FOLLOWER

Description

The main and auxiliary hoists are equipped with an idler drum on the forward side of the hoist. The main hoist idler drum is used to keep the hoist cable from coming in contact with the boom. When the crane is also equipped with an auxiliary hoist, the idler drum on the auxiliary hoist is used to keep the hoist cable from coming in contact with the main hoist. The cable follower is mounted on the rear side of it's respective hoist. The cable follower applies a downward spring pressure against the cable onto the hoist drum, to ensure that the cable will be uniformly wound onto the hoist drum, and also prevent cable from jumping under abnormal line conditions.

Maintenance

Idler Drum

Idler Drum Removal and Disassembly

1. Remove the bolt, washer, and lockwasher from the right side of the idler drum (Figure 5-3).
2. Support the idler drum and withdraw the shaft from the left side. Take care not to lose the dowel pin on the end.
3. Remove the idler drum from between the side plates.

Idler Drum Cleaning and Inspection

1. Clean all rust and dirt from the shaft.
2. Inspect the shaft and idler drum for cracks, scoring, or grooving. Replace if necessary.

Idler Drum Assembly and Installation

1. Position the idler drum between the side plates
2. Install the shaft through the left side plate and the idler drum. Make sure that the flat on the shaft end aligns with the stop welded on the side plate, align the dowel pin.
3. Secure the shaft to the right side plate with a bolt, washer, and lockwasher. Apply Loctite 243 to the bolt threads.

Cable Follower

Cable Follower Removal and Disassembly

1. Loosen the adjusting nuts and remove the tension spring and adjusting rod from both sides of the hoist. See (Figure 5-3).
2. Support the cable follower drum and remove the bolts and washers securing the arms to the angles on each end of the drum. Remove the cable follower drum.
3. Disassemble the cable follower drum as follows.
   - **a.** Remove the two bolts and washers securing the angle to the right side of the shaft.
   - **b.** Remove the shims and drum from the shaft.
   - **c.** If necessary, remove the bearing and bearing housing from both ends of the drum.
4. Remove the bolt and locknut securing the arm to the spring-attaching lever on each side of the hoist. Remove arms and levers from the side plates.

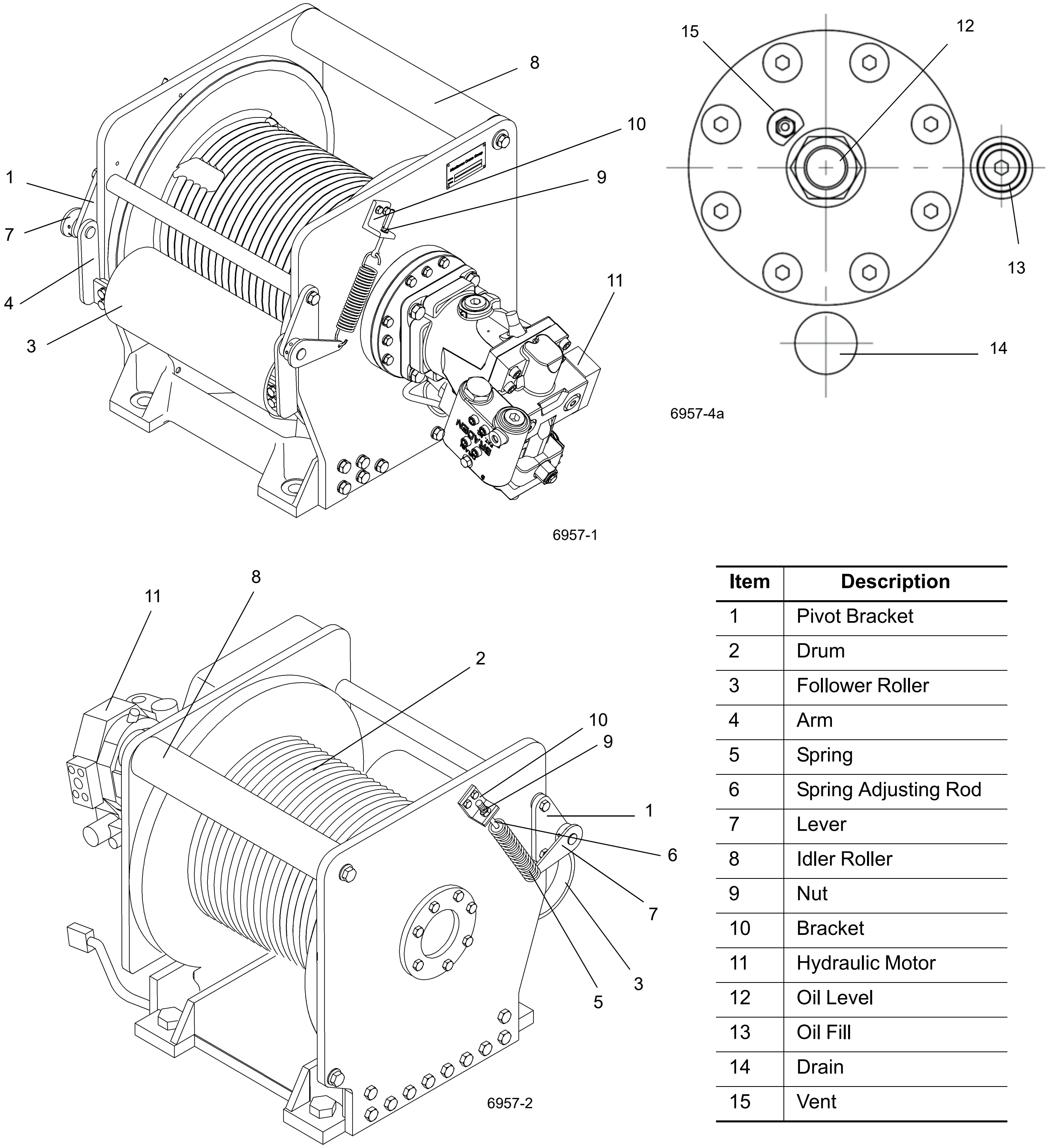
NOTE: Be sure to mark each arm and lever as to what side (left or right) they were removed from. This will be helpful during installation.

Cable Follower Cleaning and Inspection

1. Clean all grease from the shaft, bearing, and drum.
2. Check the shaft, drum, and bearings for cracks, scoring, or grooving. Replace if necessary.
3. Check the spring tension. If the springs will not provide sufficient tension when adjusted, replace them.

Cable Follower Assembly and Installation

1. Install the left arm through the bushing on the left side plate. Install the left spring-attaching lever on the arm and secure with a bolt and locknut. Apply Loctite 243 to the bolt threads.
2. Repeat step 2 on the right side.
3. Assemble the cable follower drum as follows.
   - **a.** Apply high strength retaining compound Loctite 680 to the bearing housings and the bearings. Install them in both ends of the drum.
   - **b.** Install the shaft into the drum with at least one shim on each end.
   - **c.** Position the angle on the right side of the shaft and secure with two bolts and washers. Apply Loctite 243 to the bolt threads.
4. Position the cable follower drum on the arms and secure with four bolts and washers. Center the drum between the hoist drum flanges and tighten the bolts.
5. Attach one end of the tension springs to the levers on each side. Install the adjusting rod through the lug on each side plate and connect to the other end of the spring. Install the adjusting nuts on each rod and tighten enough to take the slack out of the springs.
6. Using a grease gun, apply grease to the fittings on each side plate bushing.
7. Adjust the roller as follows.



Item	Description
1	Pivot Bracket
2	Drum
3	Follower Roller
4	Arm
5	Spring
6	Spring Adjusting Rod
7	Lever
8	Idler Roller
9	Nut
10	Bracket
11	Hydraulic Motor
12	Oil Level
13	Oil Fill
14	Drain
15	Vent

FIGURE 5-3

a. With one layer of cable on the hoist drum, adjust the bolts on the front of each side plate (that push against each arm) so the roller applies pressure on the layer of cable, and does not interfere with filler/ riser protrusions on the hoist drum flanges. Tighten jam nuts to secure setting.

b. With a full drum of cable, the spring adjuster bolt should be set at 36 mm from the nut to the end of the rod. Adjust rods as necessary and tighten jam nuts to secure this setting.

HOIST DRUM ROTATION INDICATOR SYSTEM

Description

The hoist drum rotation indicator system (Figure 5-4) is an electrically operated system that provides the operator with a tactile indication of drum rotation so the operator will know if and at what speed the hoist drum is rotating, even under the most distracting conditions. The RCL Display will also illuminate a hoist up or hoist down indicator light to show the direction of hoist motion.

The rotation indicator system consists of the rotation indicator sensor and joystick thumper solenoid. The rotation sensor is located on the hoist. The pulsing joystick thumper solenoid is located in the applicable hoist control lever handle. Actuation of the joystick thumper and illumination of the direction lights is controlled by the CAN-Bus System from input supplied by the rotation indicator sensor. The rotation indicator will cease operation at high line speeds to prevent damage to the solenoid.

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.

Joystick Thumper Solenoid

The joystick thumper solenoid provides feedback proportional to the hoist line speed by pulsing the rubber button on top of the hoist controller. The joystick thumper will cease operation at high line speeds to prevent damage to the solenoid.

Troubleshooting

NOTE: This machine incorporates a CAN-Bus Multiplex system. In order to effectively troubleshoot the electrical system, you will need a Windows-based PC, the CAN-link service software (9999102409), and a connection cable (9999102296). The CAN-link service software and connection cable may be ordered from Manitowoc Crane Care.

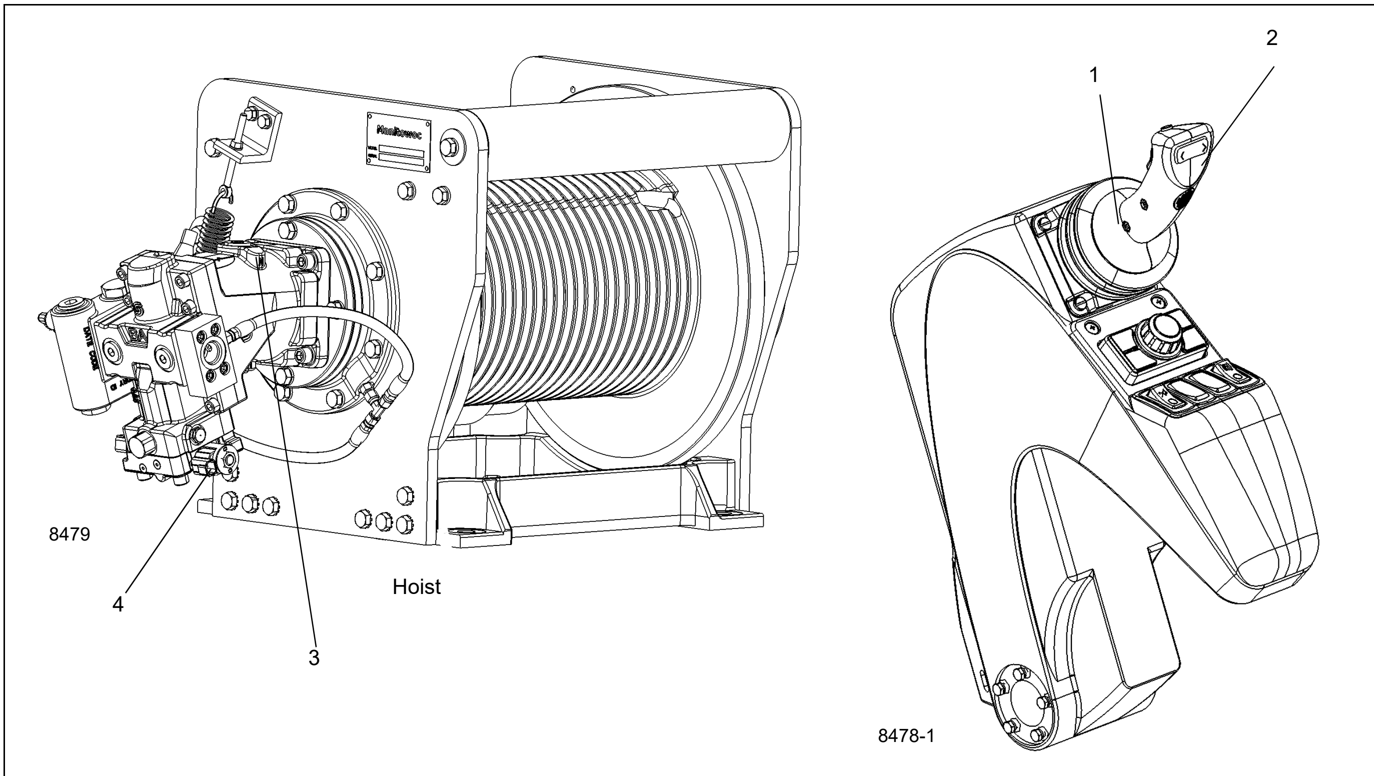


FIGURE 5-4

Item	Description
1	Rotation Indicator
2	Controller
3	Rotation Sensor Connection
4	Two Speed Solenoid Connection

COUNTERWEIGHTS

Configurations for counterweights follows below.

Fixed Counterweight Description

The Standard Counterweight is a 2268 kg (5000 lb) box attached to the Superstructure. An optional Heavy Counterweight package adds two 794 kg (1750 lb) weight blocks to the box for a total of 3856 kg (8500 lb). (Refer to the Fixed Counterweight Description (pg 5-13)) of the Operator Manual.

Both weight blocks must be used together. An optional Zero Counterweights configuration can be utilized by removing the box.

(All three configurations can be used with the 95’ boom length. The 102’ boom length must be used with the Heavy Counterweight option only. For cranes without an auxiliary hoist, a 351 kg (773 lb) counterweight is bolted to the hoist mount in place of the auxiliary hoist.

COUNTERWEIGHT REMOVAL

Fixed Counterweight Removal

DANGER

Death or serious injury could result from being crushed by a falling counterweight.

Ensure the retainer pin is properly installed to secure the counterweight mounting pin.

NOTE: Use of a forklift to remove/install the fixed counterweight is not recommended.

1. Fully extend and set the outriggers.

NOTE: The counterweight weighs approximately 2268 kg (5000 lb) or 3856 kg (8500 lb.) if Heavy Counterweight Package blocks are installed.

2. Lower and fully retract the boom.
3. Shut down the crane.
4. Attach an adequate lifting device to the counterweight.
5. Make sure that the four counterweight leveling capscrews are set for maximum clearance with the turntable.
6. Slowly raise the counterweight until the pin assembly can be removed by pushing and turning the pin.
7. Remove the pin assembly from the opposite side.
8. Lower the counterweight until the attaching lugs are clear of the turntable.
9. Back the counterweight away from the turntable until it is clear of the crane.
10. Replace the pin assembly in the turntable counterweight mounting lugs.
11. Move the counterweight far enough away from the crane to allow the turntable/superstructure to clear during repositioning.

Fixed Counterweight Installation

1. Fully extend and set the outriggers.
2. Lower and fully retract the boom.
3. Shut down the crane.

CAUTION

When lifting/handling the counterweight, keep the chains/ straps vertical to minimize side pull on the lifting lugs.

NOTE: The counterweight weighs approximately 2268 kg (5000 lb) or 3856 kg (8500 lb.) if Heavy Counterweight Package blocks are installed.

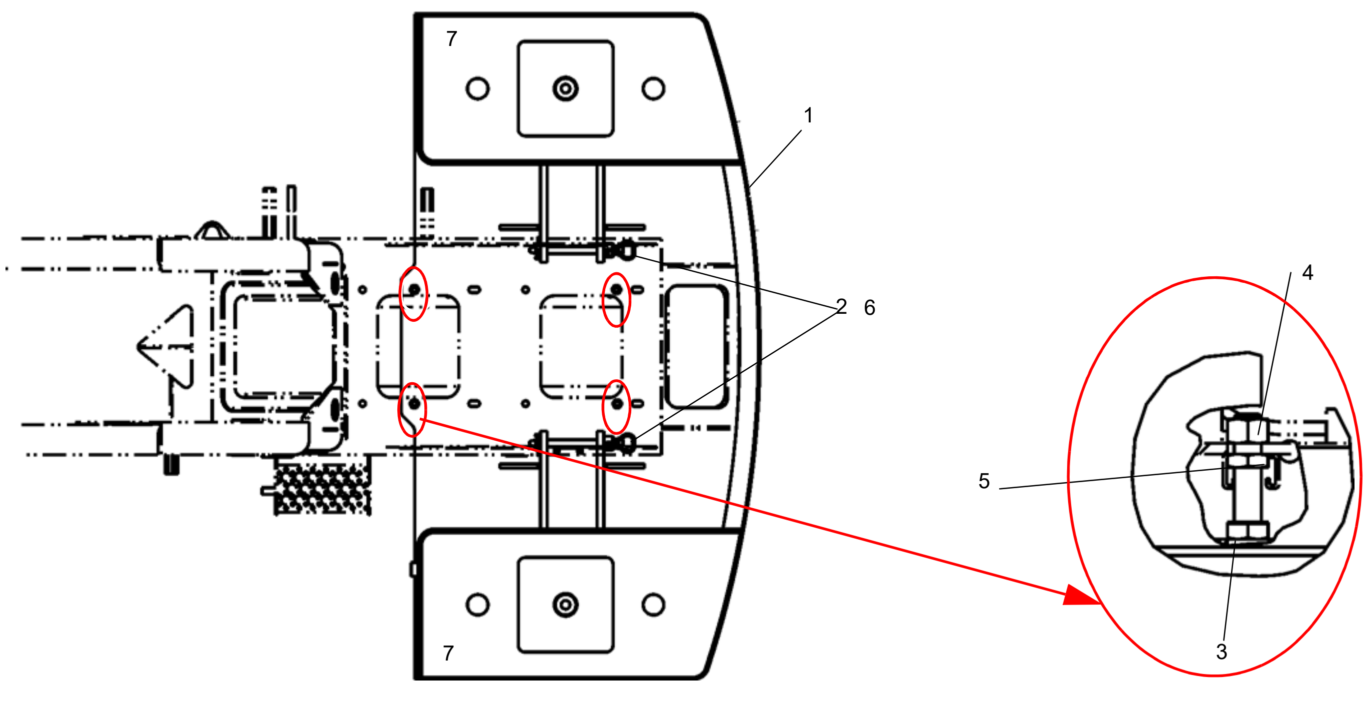
Use of a forklift to remove/install the fixed counterweight is NOT recommended.

4. Attach an adequate lifting device to the counterweight and lift the counterweight into place on the superstructure, aligning the mounting holes on the counterweight to the holes in the superstructure.
5. Install the counterweight mounting pins and secure them in place with hitch pin retainers.
6. Remove the lifting device from the counterweight.
7. Using the four counterweight leveling bolts, level the counterweight and eliminate any relative movement between the counterweight and turntable. Maximum width of counterweight shall not exceed 6.0 mm (0.25 in) out of level with the turntable bearing when measured from either counterweight outer edge.

No Counterweights Option

If the crane does not have any counterweight installed for operation purposes and the hoists, boom pin, oil cooler, and so on, need serviced, a platform that is shipped loose with the machine will need to be installed. See (Figure 5-6).

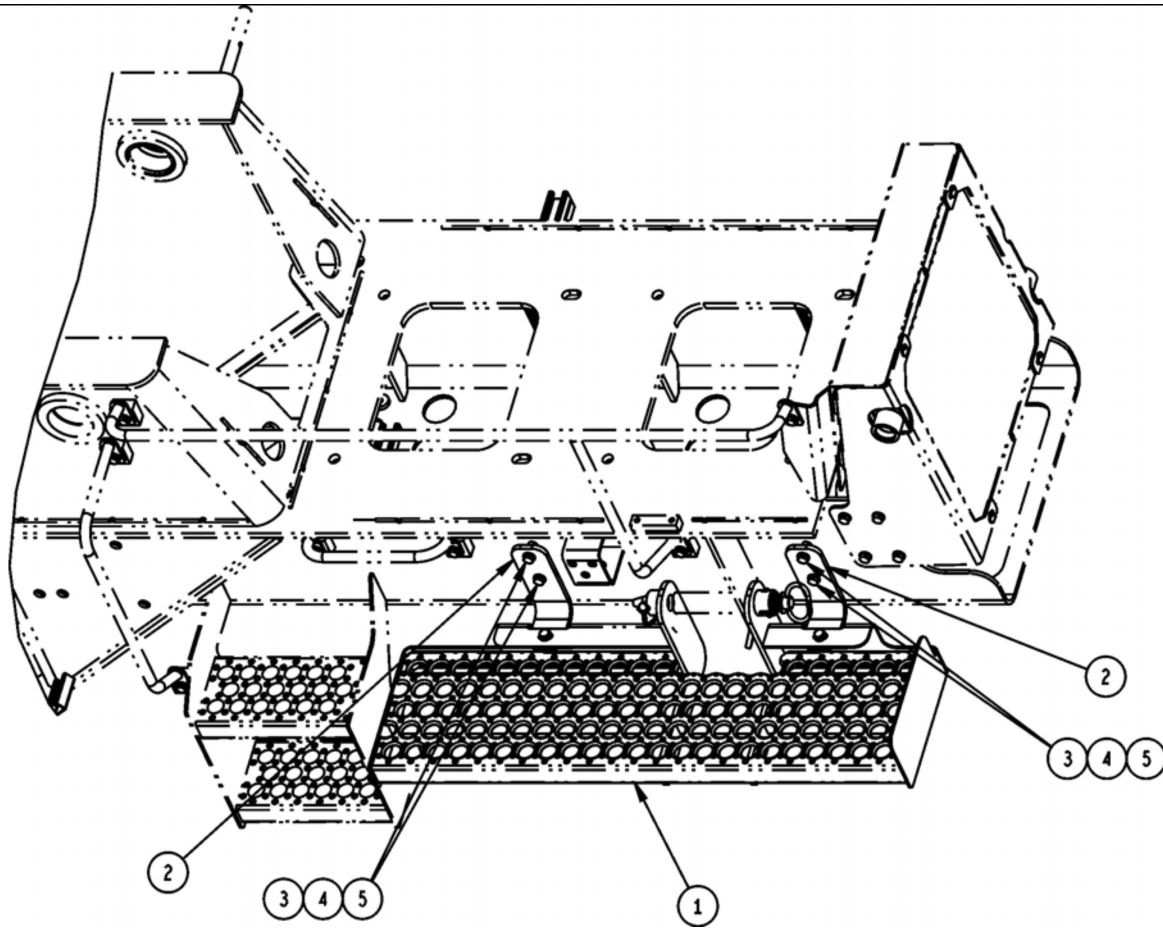
1. Attach brackets (Item 2) with un-tightened hardware. Attach the platform (Item 1) with pin from the counterweight installation. With the platform supported by the pin, level the platform and torque the hardware.
2. Apply medium strength thread locking adhesive/sealant and primer to all hardware.



Item	Description
1	Counterweight
2	Pin Assembly
3	Capscrew
4	Hex Nut

Item	Description
5	Jam Nut
6	Lock Pin
7	Counterweight Inserts

FIGURE 5-5



Item	Description
1	Weldment, Platform
2	Bracket, Platform MTG.
3	HHCS

Item	Description
4	Hex Nut
5	F Washer

FIGURE 5-6

THIS PAGE BLANK

SECTION 6
SWING SECTION

SECTION CONTENTS

Introduction . . . 6-1
Description . . . 6-1
Theory of Operation . . . 6-1
Maintenance . . . 6-3
Troubleshooting . . . 6-3
Swing Motor . . . 6-6
Description . . . 6-6
Maintenance . . . 6-6
Swing Gearbox and Brake . . . 6-7
Description . . . 6-7
Maintenance . . . 6-7
Maintenance of Gearbox . . . 6-8
Swing Bearing . . . 6-8
Description . . . 6-8
Maintenance . . . 6-8
Swivels . . . 6-14
Description . . . 6-14
Hydraulic Swivel . . . 6-16
Electrical Slip Ring Assembly . . . 6-18

INTRODUCTION

Description

The swing system consists of an electric remote controller, a swing enable/disable switch, a directional control valve, the swing drive, the swing brake assembly, the brake pedal and the power brake valve, and a swing brake release solenoid valve.

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 swing brake is applied when the Swing Controller is in the center position and is automatically released when the Swing Controller is actuated. Swing is activated using the Swing Enable/Disable Switch and the control lever in the cab. When the swing controller is actuated, hydraulic pressure is routed to the swing motor to drive the gearbox in the appropriate direction. As the gearbox rotates, the pinion gear meshes with the teeth on the swing bearing and rotates the superstructure. Swing speed is controlled by the controller. The maximum rotation speed is 1.5 RPM with no load. Positioning the lever to the left or right actuates a control valve through electric signal to provide 360 degree continuous rotation in the desired direction. Upon moving the controller to the center position, the crane control system will gradually reapply the swing brake until it is fully applied. The operator can apply the swing brake manually by pressing the Swing Brake Foot Pedal. The Swing Enable/Disable Switch is located on the left arm rest. Pressing the switch one time enables the swing function and pressing the switch again disables the swing function.

The crane is equipped with a pin type turntable lock as standard and an optional 360 degree positive swing lock. The 360 degree positive swing lock meshes with the swing gear teeth at any point of rotation. The pin type turntable lock can be engaged over the front and the rear positions of the machine. Both swing locks are operated from the cab.

6

Theory of Operation

Swing Drive

The hydraulic power for the swing drive (Figure 6-1) is supplied by the engine PTO driven hydraulic pump. Oil flows from the pump to the hydraulic Port 4 swivel. Flow from the swivel is routed to the accessory manifold.

When the electric remote control is positioned to select right or left swing, the flow through the control valve is directed to the swing motor. If the SWINGENABLE selector switch is in the ON position, the superstructure will rotate in the desired direction. The Swing Brake will apply as the controller is returned to neutral.

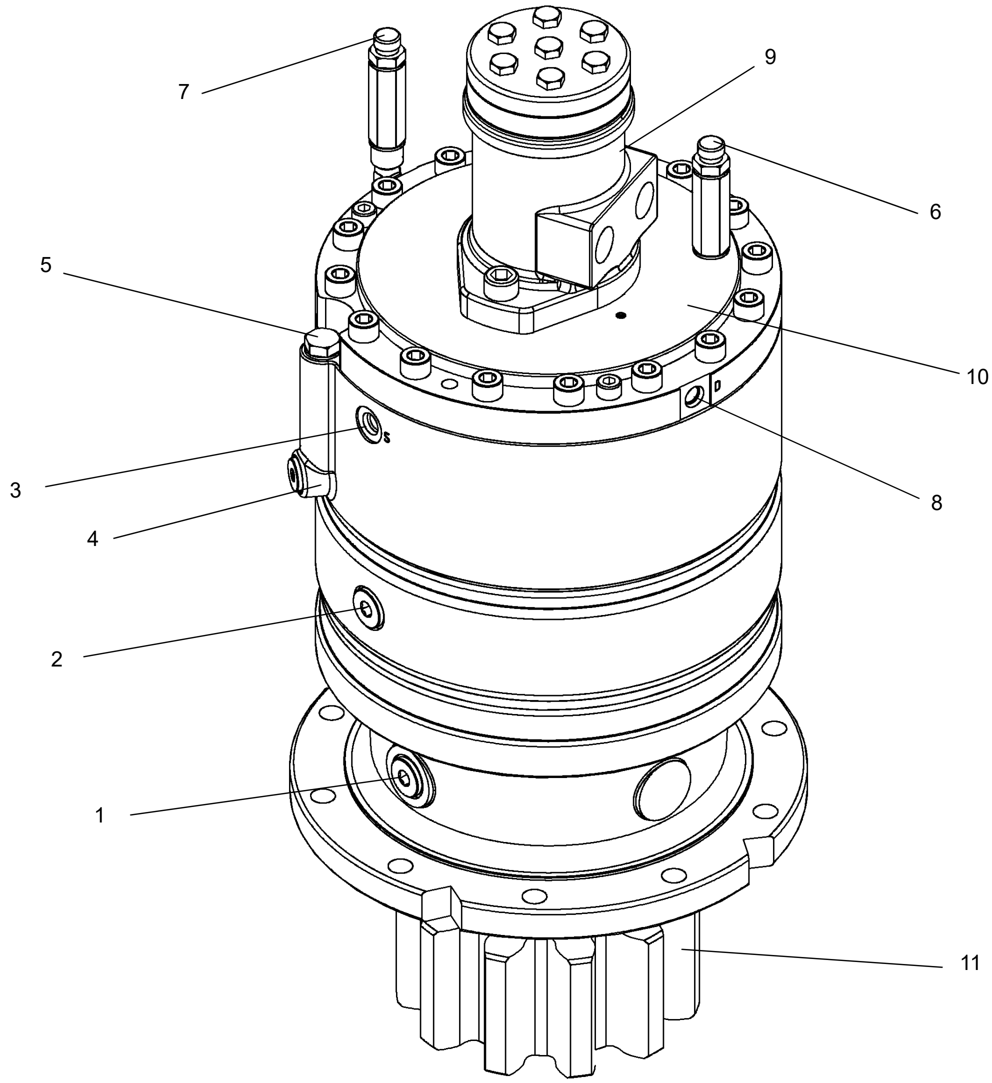


FIGURE 6-1

Item	Description
1	Plug
2	Plug
3	Brake Release Port
4	Drain Plug for Brake Housing
5	Fill Plug and Oil Level Indicator
6	Breather

Item	Description
7	Breather
8	Brake Apply Port
9	Motor
10	Gearbox and Brake
11	Pinion

Maintenance

Troubleshooting

Symptom	Probable Cause	Solution
1. Superstructure swing operation erratic in either direction.	**a.** Damaged relief valve.	**a.** Replace relief valve.
	b. Swing brake dragging (not releasing properly).	**b.** Readjust and/or replace necessary parts.
	c. Low engine RPM.	**c.** Increase engine RPM to obtain smooth swing operation.
	d. Low hydraulic oil.	**d.** Replenish hydraulic oil to proper level.
	e. Improper movement of control to neutral.	**e.** Feather controls to neutral to maintain smooth stopping action.
	f. Insufficient lubricant on swing bearing.	**f.** Lubricate bearing properly. Refer to Section 9 - LUBRICATION.
	g. Crane not level.	**g.** Level crane using outriggers.
	h. Damaged swing motor.	**h.** Repair or replace swing motor.
	i. Excessive overload.	**i.** Reduce load. Refer to load capacity chart.
	j. Restricted or partly clogged hydraulic hose or fittings.	**j.** Replace hose or fittings.
	k. Pump cavitation.	**k.** Tighten suction hose or replace any damaged fitting. Check hydraulic tank level.
	l. Improperly torqued turntable bolts.	**l.** Torque turntable bolts evenly.
	m. Excessive preload on upper and lower pinion shaft bearing.	**m.** Adjust as necessary.
	n. Improperly torqued swing motor attachment bolts.	**n.** Torque swing motor attachment bolts.
	o. Malfunction of the swing box.	**o.** Remove swing box and make necessary repairs.
	p. Worn or damaged pump.	**p.** Repair or replace damaged pump.
	q. Damaged swing directional control valve.	**q.** Repair or replace swing directional control valve.
	r. Damaged swing pinion.	**r.** Replace pinion.
	s. Damaged turntable bearing.	**s.** Replace turntable bearing.
	t. EEPROM Settings.	**t.** Adjust EEPROM Settings as necessary.

Symptom	Probable Cause	Solution
2. Superstructure swing operation erratic in one direction only.	**a.** Crane not level.	**a.** Level crane using outriggers.
	b. Turntable bearing binding due to continuous limited swing. (Example: concrete pour.)	**b.** Rotate machine 360 degrees in both directions several times and lubricate bearing.
	c. Restricted hose or fitting.	**c.** Replace hose or fitting.
	d. Damaged swing directional control valve.	**d.** Replace swing directional control valve.
	e. Damaged swing pinion.	**e.** Replace pinion.
	f. Damaged turntable bearing.	**f.** Replace turntable bearing.
	g. EEPROM Settings.	**g.** Adjust EEPROM Settings as necessary.
3. Superstructure 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. Electric remote control valve.	**d.** Replace electric 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.
	k. EEPROM Settings.	**k.** Adjust EEPROM Settings as necessary.
	l. Cold ambient temperatures.	**l.** Refer to the Crane Warm-Up Procedures in the Operators Manual under Section 4, p4-12.

Symptom	Probable Cause	Solution
4. Superstructure swing operation slow in either direction.	**a.** Damaged relief valve.	**a.** Remove, clean, and repair or replace valve.
	b. Improperly adjusted swing brake.	**b.** Readjust.
	c. Damaged electric remote control valve.	**c.** Replace electric remote control valve.
	d. Improperly lubricated swing bearing.	**d.** Lubricate bearing per recommendations.
	e. Improper size hose and/or fittings installed.	**e.** Refer to the *Parts Manual*.
	f. Clogged or restricted hydraulic hoses or fittings.	**f.** Clean or replace damaged parts.
	g. Worn or damaged output shaft bearings	**g.** Replace bearings.
	h. Worn or damaged swing motor.	**h.** Repair or replace motor.
	i. Worn or damaged hydraulic pump.	**i.** Repair or replace pump.
	j. Crane not level.	**j.** Level crane.
	k. Damaged swing directional control valve.	**k.** Replace swing directional control valve.
	l. EEPROM Settings.	**l.** Adjust EEPROM Settings as necessary.
5. Superstructure swing operation slow in one direction only.	**a.** Crane not level.	**a.** Level crane.
	b. Damaged electric remote control valve.	**b.** Replace electric 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.
	f. EEPROM Settings.	**f.** Adjust EEPROM Settings as necessary.
6. Swing brake operation erratic.	**a.** Damaged brake.	**a.** Repair brake.
	b. Air in swing brake system.	**b.** Bleed brake system.
	c. Brake pedal not fully retracted.	**c.** Replace swing brake pedal.
	d. Dirty or glazed brake disc.	**d.** Clean or replace disc.
	e. Electric pedal.	**e.** Repair or replace electric pedal.
	f. Kinked or bent lines and/or hoses and fittings.	**f.** Straighten or replace as required.
	g. EEPROM Settings.	**g.** Adjust EEPROM Settings as necessary.

Symptom	Probable Cause	Solution
7. Swing brake system will not operate.	**a.** Damaged swing brake release valve.	**a.** Replace release valve.
	b.	**b.**
	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.
	e. EEPROM Settings.	**e.** Adjust EEPROM Settings as necessary.
8. Swing brake drags.	**a.** Damaged swing brake release valve.	**a.** Replace release valve.
	b. Internal damage to the swing brake assembly.	**b.** Repair or replace affected parts.
	c. Loose or restricted brake lines or fittings.	**c.** Tighten or replace brake lines and fittings.
	d. EEPROM Settings.	**d.** Adjust EEPROM Settings as necessary.
9. Swing motor continues to operate when swing control is in neutral.	**a.** Control valve sticking or valve otherwise damaged.	**a.** Repair or replace valve.
	b. EEPROM Settings.	**b.** Adjust EEPROM Settings as necessary.
10. Swing motor turning in wrong direction.	**a.** Improper port connections. **b.** EEPROM Settings.	**a.** Reverse port connection. **b.** Adjust EEPROM Settings as necessary.
11. Swing motor noisy.	**a.** Air in system.	**a.** Refer to Hydraulic System (pg 2-1), for removal of air from the system.
	b. Motor binding.	**b.** Repair or replace motor.
	c. EEPROM Settings.	**c.** Adjust EEPROM Settings as necessary.

SWING MOTOR

Description

The swing motor is mounted on the swing brake housing and drives the swing gearbox through the brake assembly. The swing motor is a hydraulic gerotor type with low speed and high torque characteristics. It has only three moving parts, the commutator valve, the drive, and the gerotor star. The motor has two ports for connection to the hydraulic system.

Maintenance

Swing Motor Removal

1. Make sure that the swing brake and swing lock are engaged.
2. Clean the port area around the motor. Tag and disconnect the hydraulic hoses from the motor assembly. Cap or plug all openings.

CAUTION

Oil can be hot and can cause burns.

CAUTION

Pull straight up on the motor assembly to avoid damaging the splined shaft.

3. Remove the two screws securing the motor and lift the swing motor free of the flange. Remove and discard the O-Ring from the groove in the swing brake.

Swing Motor Installation

CAUTION

Use care when engaging the swing motor drive gear, do not force the shaft to engage.

1. Install a new O-Ring in the groove of the swing brake. Position the swing motor on the swing brake, engaging the shaft with the brake input shaft.
2. Apply Loctite 243 to the screw threads. Install the screws and secure the motor to the brake housing. Torque the screws 85 to 103 N-m (44 to 72 lb-ft).
3. Connect the hydraulic lines to the swing motor as tagged during removal.

Test

1. Test swing of superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING GEARBOX AND BRAKE

Description

The swing gearbox and brake, used in conjunction with the swing motor, rotates and stops the superstructure. A pedal on the cab floor is used to activate the swing brake. The swing gearbox is bolted to the superstructure base plate, and its pinion gear meshes with the ring gear of the turntable bearing to rotate the turntable.

The swing gearbox utilizes double reduction planetary gearing. The multi-disc swing brake assembly is an integral part of the swing gearbox and is located between the swing motor and the swing gearbox. The brake mechanism is a disc pack that is hydraulically released and spring applied.

Maintenance

NOTE: The swing brake can be removed and disassembled independently of the swing gearbox.

Swing Brake

Swing Brake Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines connected to the swing motor and the brake. Cap and/or plug all openings.
3. Remove the swing motor from the swing brake according to the procedures found in this Section under Swing Motor (pg 6-6).

CAUTION

Use care when removing the capscrews securing the brake, as there is tension on the bolts due to internal brake springs.

4. Unscrew the screws securing the brake to the gearbox. Lift the brake using the brake flange, then remove the O-Ring.
5. Cover the opening of the swing gearbox to make sure that no dirt, dust, and the like, gets into the gearbox.

Swing Brake Installation

1. Install a new O-Ring onto the brake housing.
2. Apply Loctite 243 to the screws. Install the brake onto the gearbox and secure with the screws. Torque the screws 50 to 60 N-m (36.8 to 44.2 lb-ft).
3. Install the swing motor into the swing brake according to the procedures found in this Section under Swing Motor (pg 6-6).
4. Connect the hydraulic lines to the motor and the brake.
5. Bleed all air from the brake assembly.

Gearbox

Gearbox Removal

1. Engage the turntable lock pin.
2. Tag and disconnect the hydraulic lines from the swing motor and the swing brake. Cap and/or plug all openings.

NOTE: The complete gearbox assembly with motor weighs approximately 126 kg (277 lb).

3. Attach a suitable lifting device to the swing gearbox. Remove the capscrews, flatwashers, and bushings securing the gearbox to the mounting plate.

NOTE: Take note of the swing motor port orientation to make sure of proper installation.

4. Remove the swing gearbox.
5. If necessary, remove the swing motor according to the procedures found under the Swing Motor (pg 6-6) Section in this Manual.
6. If necessary, remove the swing brake according to the procedures found in the Swing Brake Removal (pg 6-7) Section in this Manual.
7. Cover the opening of the swing gearbox to make sure that no dirt, dust, and the like gets into the gearbox.

Gearbox Installation

1. If removed, install the swing brake according to the procedures found in this Section under Swing Brake (pg 6-7).
2. If removed, install the swing motor according to the procedures found in this Section under Swing Motor Installation (pg 6-7).
3. Attach a suitable lifting device to the swing gearbox and lift, and then position the swing gearbox in place on the mounting plate.
4. Install the capscrews, flatwashers and bushings. Torque the capscrews as per Table 1-3. Apply Loctite 243 to screws. Install the pinion gear on the output shaft. Install the cover and secure it with three screws. Torque screws 50 N-m (36.8 lb-ft).
5. Connect the hydraulic lines to the swing brake.
6. Connect the hydraulic lines to the swing motor.

Maintenance of Gearbox

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 the mounting bolt torque values. Lubrication consists of maintaining the gearbox oil level. Oil in a new gearbox should be drained and flushed out after approximately 250 hours of operation, and replaced with premium quality SSGL-5 (spec 6829012964) after approximately 500 hours of operation, or each year, whichever occurs first. Operation in high humidity or polluted air areas will require more frequent changes to minimize the moisture or contaminate accumulation. Change the oil as follows.

1. Unscrew the drain plug. To make sure that all oil has been removed, unscrew the filler and level plugs.
2. After oil is drained, replace the drain plug and any other plugs that were removed to drain the oil.
3. Flush the case with a light flushing oil.

NOTE: Cleaning of the gearbox with a solvent is recommended to prevent an accumulation of grit and grime. Avoid steam cleaning where moisture and dirt might be driven into the vent of the swing bearing.

4. To refill with oil, fill through the filler plug until it begins to flow out of the level plug.
5. Tighten the level and filler plugs.

Checking the Oil Level

1. Check the oil level through the level plug.
2. If no oil is visible on the level plug, add oil until the level is between the min and max on the level plug.
3. Refer to Lubrication (pg 9-1) of this manual.

Testing

1. Test the swing of the Superstructure in each direction. Stop and start swing several times.
2. Inspect for hydraulic leaks and repair as necessary.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the Superstructure to the Carrier. The bearing inner race is bolted to the Superstructure and the outer race is bolted to the Carrier. The inner race contains four grease fitting two of which are hosed to the front right side of the turntable center section for lubrication of the bearing.

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 attachment bolts --IS A MUST--to ensure safe and efficient operation.

Torquing Turntable Bolts

General

DANGER

Failure to maintain proper torque of the turntable bearing attaching bolts will result in damage to the crane and possible injury to personnel.

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the Superstructure from the Carrier.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8 and metric grade 10.9), the serviceman must be aware of bolt classifications and that he is installing a high-strength, heat-treated tempered component and that the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high-strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.

DANGER

It is mandatory that all 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, making sure that the bolts are properly torqued.

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

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

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

If it is reported, by the crane operator, or suspected that the crane has been overloaded beyond the capacities specified above the bold line on the cranes' capacity chart, then all turntable bolts must be inspected for looseness and retorqued to specifications.

Turntable bolts should be torqued according to the procedures outlined in this section. Also, refer to Fasteners and Torque Values (pg 1-14).

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

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

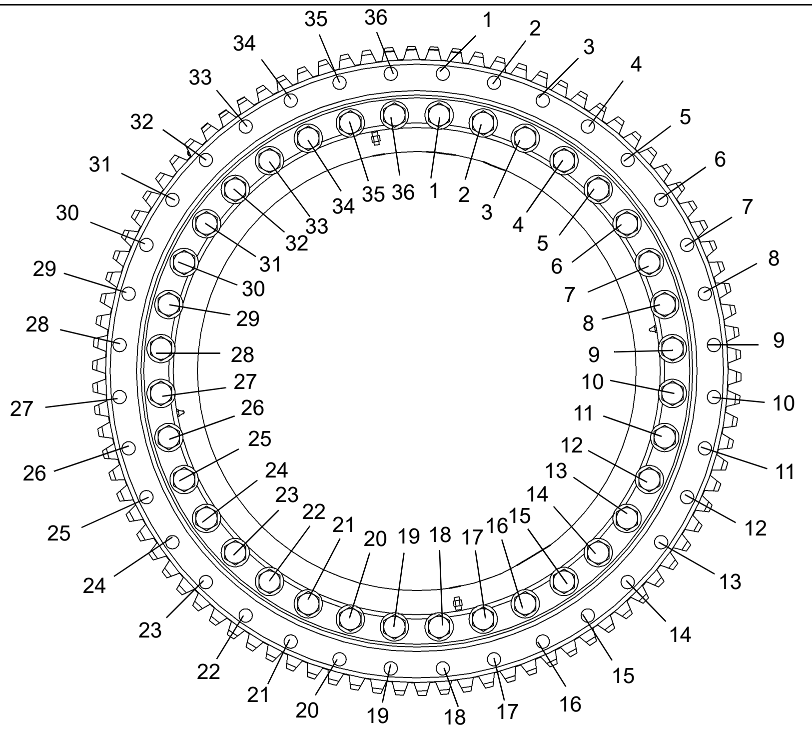


FIGURE 6-2

The inner race of the bearing is secured to the turntable by 36, 1 inch, grade 8 bolts. The outer race of the bearing is secured to the carrier frame by 36, 7/8 inch, grade 8 bolts.

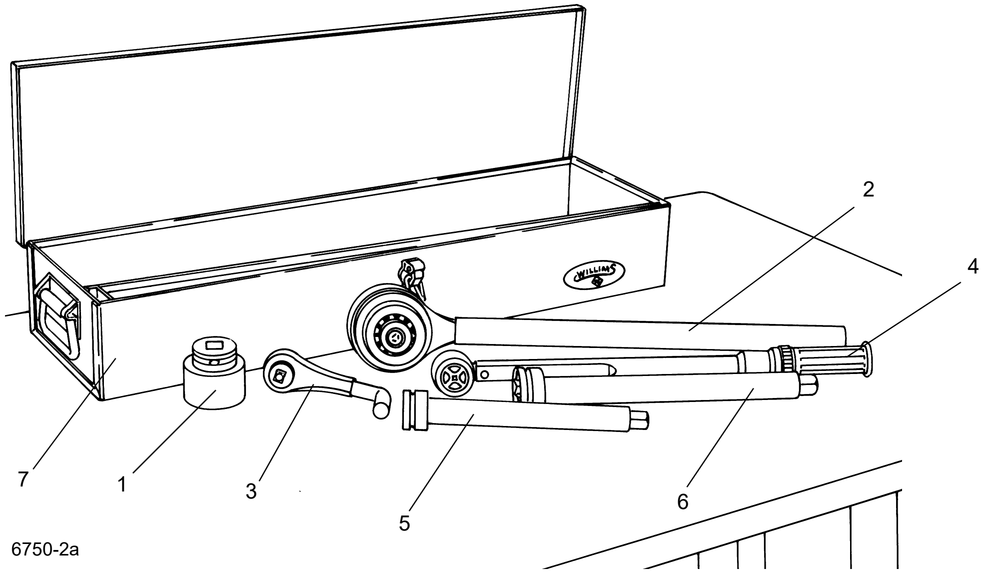
Torque Values

Torque all inner race turntable bolts (Figure 6-2) to a final torque of 911 to 958 N-m (672 to 707 ft-lbs).

Torque all outer race turntable bolts (Figure 6-2) to a final torque of 638 to 607 N-m (471 to 448 ft-lbs).

Tools Required

(Figure 6-3) lists the complete set of special tools required to torque the turntable bolts.



Orders for Special Tools Shall be Referred to:

Manitowoc/Grove Crane Care
1565 Buchanan Trail East
Shady Grove, PA 17256-0021
Phone: (717) 597-8121
Fax: (717) 593-5929

Description	Grove Part Number	Quantity Required
1. 1 1/2” Socket 3/4” Drive	9-999-100143	1
2. 4 to 1 Torque Multiplier (1/2” Input 3/4” Output)	9-999-100134	1
3. Backlash Adapter	9-999-100141	1
4. 1/2” Drive Torque Wrench	9-999-100136	1
5. 10” Extension 3/4” Drive	9-999-100138	A/R
6. 13” Extension 3/4” Drive	9-999-100137	A/R
7. Tool Box (Optional)	9-999-100146	1

Special Turntable Bolt Torquing Tools

FIGURE 6-3

Removal

1. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

2. Make sure that the boom is in the travel position and that the turntable lock pin is engaged.

3. Elevate the boom slightly and shut down the engine.

4. Tag and disconnect the battery cables from the batteries.

NOTE: The boom assembly weights are as follows:

Gross Weight 95’ Boom
No CWT . . . . .24741 kg (54545 lb)
Light CWT . . . . .26989 kg (59499 lb)
Full CWT . . . . .28576 kg (62999 lb)
Gross Weight 102’ Boom
Full CWT . . . . .29457 kg (64940 lb)

Removal of the swingaway boom extension will simplify boom removal, therefore, the above weight is for the boom without the swingaway boom extension attached. The lift cylinder weighs approximately 578 kg (1274 lb).

5. Remove the boom and lift cylinder following the procedures outlined in Boom System Components (pg 4-2).

6. Remove the counterweight following the procedures outlined in Hoist and Counterweight (pg 5-1).

7. Tag and disconnect all water and oil lines from the bottom of the swivel. Cap or plug all lines and openings.

8. Locate the connectors and the ground wire that joins the swivel wiring harness to the receptacles and the ground stud on the carrier.

9. Disconnect the swivel wiring harness connectors from the carrier wiring receptacles. Remove the ground wire from the ground stud.

10. Remove the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.

11. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turntable removal.

12. On the bottom of the hydraulic swivel, bend the retainer tabs away from the capscrew heads. Remove the capscrews securing the two retainer plates to the spool. Remove the retainer plates from the spool and the lugs on the carrier frame.

NOTE: The swivel assembly will be removed with the turntable.

DANGER

Make sure that the lifting device is capable of fully supporting the weight of the Superstructure.
Also, make sure that the Superstructure will not tilt or slide during lifting and moving. Failure to do so may result in death or injury to personnel and damage to equipment.

NOTE: If a lifting device capable of lifting the entire Superstructure is not available, the Superstructure weight may be reduced by removing various components such as the hoist(s).

13. Attach a suitable lifting device to the four Superstructure lifting lugs (two near the boom pivot shaft bushings and two near the lower lift cylinder pivot shaft bushings). Take in the cable or chain to remove the slack. Do not pull up on the Superstructure.

DANGER

Make sure that the Superstructure is fully supported before proceeding.

NOTE: It will be necessary to rotate the Superstructure while attached to the lifting device. The outer race bolts can only be removed from the swing drive side of the turntable.

14. Remove the 36 bolts and washers securing the turntable bearing outer race to the Carrier.

DANGER

Make sure that any blocking material used is capable of fully supporting the weight of the Superstructure and will not allow it to tilt or shift. Failure to do so may result in death or injury to personnel.

15. Carefully lift the Superstructure, using care not to damage the swivel assembly, and set it on blocking that will not allow the Superstructure to tilt or shift, or rest on the swivel. Make sure that blocking is supporting the bearing and tail end of the Superstructure. Leave the lifting device attached.

NOTE: If the same bearing is to be used again, mark the position of the bearing on the Superstructure so that it can be installed in the exact same position it was before removal.

NOTE: The bearing weighs approximately 862 kg (1900 lb). Make sure that the bearing lifting device is capable of supporting the weight.

16. Place an adequate lifting device under the bearing and remove the 36 bolts and washers securing the turntable bearing to the Superstructure.

17. Using the lifting device, remove the Superstructure from over the turntable bearing.

Inspection

Check the bearing teeth for chipping or cracking. If there is any evidence of chipping or cracking, replace the bearing. Make sure that the bolt holes are free of dirt, oil, or any other foreign material.

Installation

DANGER

Anytime a turntable bolt has been removed, it must be replaced with a new bolt.

NOTE: If the same bearing is to be used again, align the marked teeth on the pinion shaft and the marked teeth on the bearing.

NOTE: Installation is in the travel position. Make sure that the swing lock is disengaged before attempting to mate the bearing to the Superstructure.

1. Using an appropriate lifting device, position the Superstructure over the bearing. If the same bearing is being used, position it as marked prior to removal.

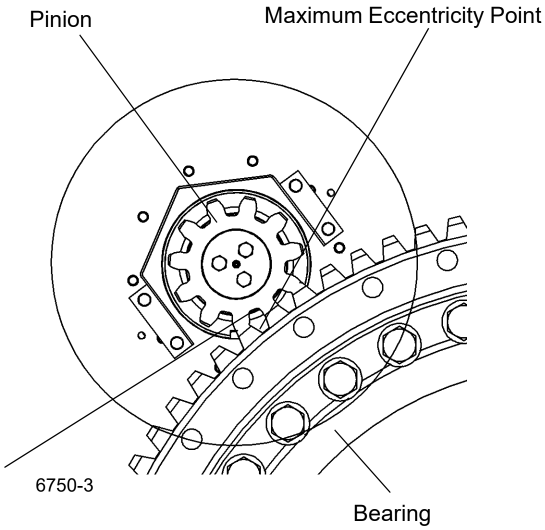
2. Install 36 new bolts and washers securing the bearing to the Superstructure. Refer to I (pg 6-11) in this Sub-Section.

NOTE: If a new bearing is being installed, a new pinion gear must also be used. Align the high point (maximum eccentricity) on the bearing with the new pinion gear high point (Figure 6-4). Also, for a new bearing, the fill plug location must be oriented to the side of the turntable.

3. Using an appropriate lifting device, align the Superstructure over the Carrier in the travel position and carefully lower the Superstructure, being careful not to damage the swivel assembly, into position on the Carrier bearing plate.

NOTE: It will be necessary to rotate the Superstructure while attached to the lifting device. Outer race bolts can only be installed from the swing drive side of the turntable.

4. Install 36 new bolts and washers. Refer to Torquing Turntable Bolts (pg 6-8) in this Sub-Section.



0.2 mm (0.008inch) Thick Shim By Full Width to Tooth Engagement [0.04 mm (0.016 inch) Backlash]

FIGURE 6-4

Orient ring gear to the point of max eccentricity ("high point"). Position swing drive so that pinion is centered within cutout in base plate and the motor ports face towards the outboard side as shown in (Figure 6-4).

CAUTION

Do Not Clamp Over Pinion.

- Using shims, set backlash by moving the swing drive assembly toward the bearing in order to mesh the pinion with the ring gear teeth (see Figure 6-4).
- Check tooth engagement squareness and vertical tooth engagement.
- Remove backlash shims and recheck backlash.

5. Apply Loctite 271 to the capscrews. Position the two retainer plates on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure them to the spool with four capscrew retainers and bolts. Torque the bolts 298 to 322 N-m (220 to 237 lb-ft). Bend all the retainer tabs to make contact with the bolt heads.
6. Plug the swivel wiring harness connectors into the Carrier receptacles. Secure the ground wire to the ground stud using a washer, lockwasher, and nut.
7. Install the clamp securing the swivel wiring harness to the retainer plate on the bottom of the hydraulic swivel. Connect all water and hydraulic lines to the ports on the bottom of the swivel as tagged during removal.
8. Install the boom and lift cylinder following the procedures outlined in Boom (pg 4-1).

NOTE: The counterweight structure weighs approximately 3818 kg (8417 lb).

9. Install the counterweight and auxiliary hoists, if removed, following the procedures outlined in Section 4 of the *Operator Manual and* Fixed Counterweight Installation (pg 5-13) Section of this manual.
10. Reconnect the batteries.
11. Check the slew potentiometer in the electrical swivel for proper orientation. Refer to Swivels (pg 6-14) in this Section.

Testing

Activate the crane and check for proper functioning.

NOTE: If the Superstructure does not turn freely after bearing and pinion replacement, contact your local distributor.

SWIVELS

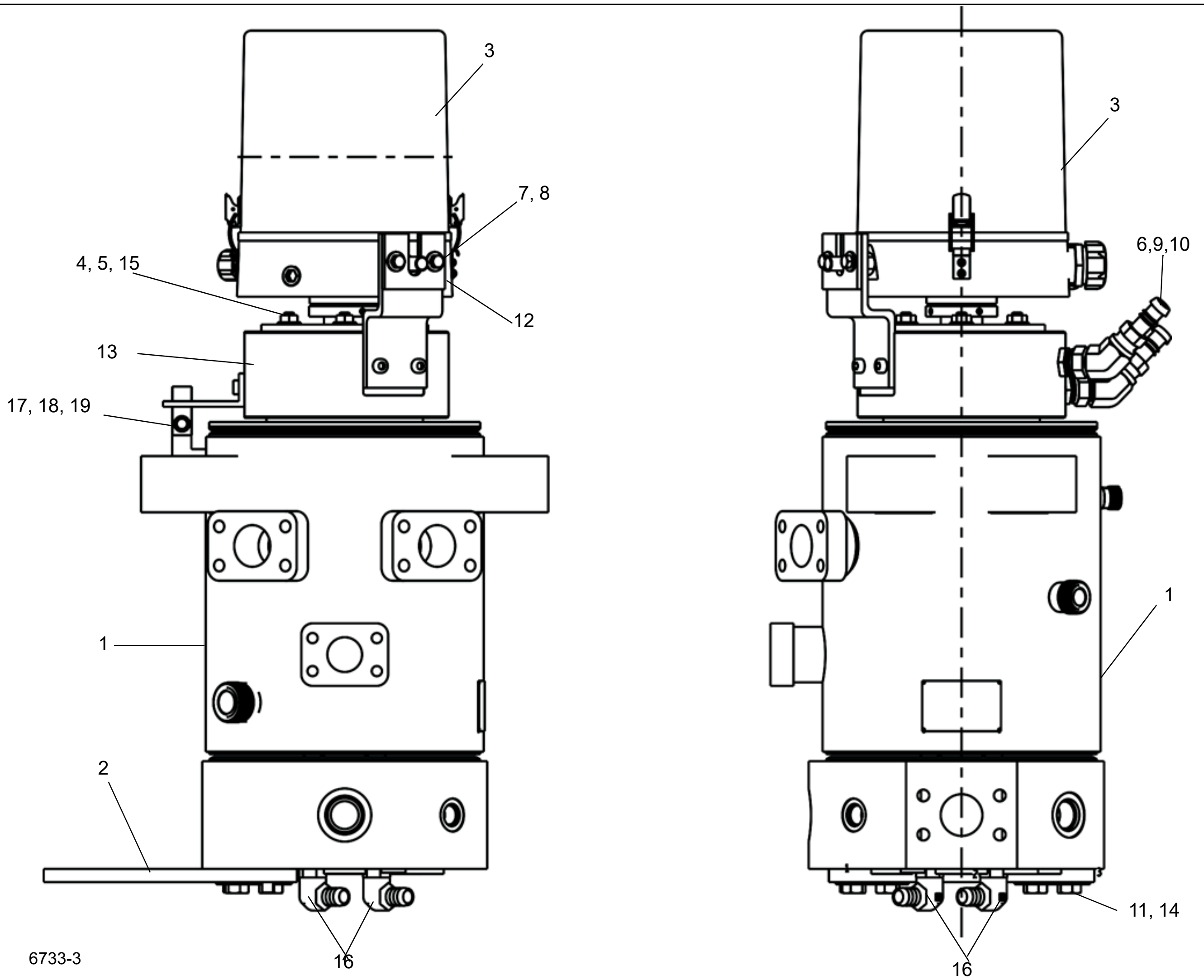
Description

The swivel assembly (Figure 6-5) consists of a 5-port hydraulic swivel, a 2-port water swivel, and a 20-conductor electric slip ring assembly. Solid connections cannot be used to transfer oil, heater hot water and electricity between the carrier and superstructure due to the continuous 360 degree swing. The use of swivels efficiently accomplishes this function.

The barrel portion of the hydraulic swivel is attached to the turntable base plate by four capscrews, washers and bushings. The spool portion of the swivel rides upon a thrust ring at the top of the swivel case. The spool portion is held stationary with the carrier by bolts, and bolt retainer plates attached to the swivel retainer plate which engages the carrier frame lugs with capscrews and hex nuts. This allows the spool to remain stationary with the carrier as the case rotates with the superstructure.

The hydraulic and water swivel spools remain stationary with the carrier as the superstructure rotates. The water swivel case engages to the hydraulic case by four dowel pins.

The electrical slip ring center or collector ring assembly is secured by setscrews to a center post which is bolted to the spool of the hydraulic swivel. This allows the collector ring assembly to remain stationary with the carrier. The outer portion or brush assembly is mounted on two studs which are located on the mounting plate assembly which is retained to the water swivel barrel by a bolt. This allows the brush assembly to rotate with the superstructure around the stationary collector core.



Item	Description
1	Swivel Assembly
2	Plate
3	Slip Ring Assembly
4	HHCS, Stud
5	F Washer
6	Elbow
7	HHCS
8	F Washer
9	Hose Nipple
10	Swivel Adapter

Item	Description
11	HHCS
12	Plate
13	2 Port Water Swivel
14	Retainer Plate
15	Hex Lock Nut
16	Adapter
17	HSerFlgs
18	Shim
19	Shim

FIGURE 6-5

Hydraulic Swivel

Description

Each of the ports on the spool and case of the swivel is stamped with the port number. The hydraulic and water swivels are separate components. The function of each port is described below.

Port #	Max Test Pressure bar (psi)	Function
Hydraulic Swivel		
1	414 (6000)	Load Sense
2	52 (750)	Dual Return
3	259 (3750)	Swing and Superstructure Accessories
4	414 (6000)	Hoist/Lift/Telescope
5	52 (750)	Case Drain
Water Swivel		
A	—	Heater Supply
B	—	Heater Return

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.

Engine coolant flows from the carrier-mounted engine to the hot water heater in the operator cab through ports A and B of the swivel.

Maintenance

Removal

1. Extend and set the outriggers. Make sure that the crane is level and that the boom is over the front.
2. Elevate the boom and note at what boom angle you have the most clearance between the lift cylinder and the turntable side plate. Shut down the engine.
3. Measure the distance from the top of the lift cylinder to the base of the boom section where the lift cylinder attaches. Cut two pieces of 10 x 10 cm (4 x 4 in) oak to fit.

NOTE: It might be necessary to raise the boom slightly to allow installation of the blocking.

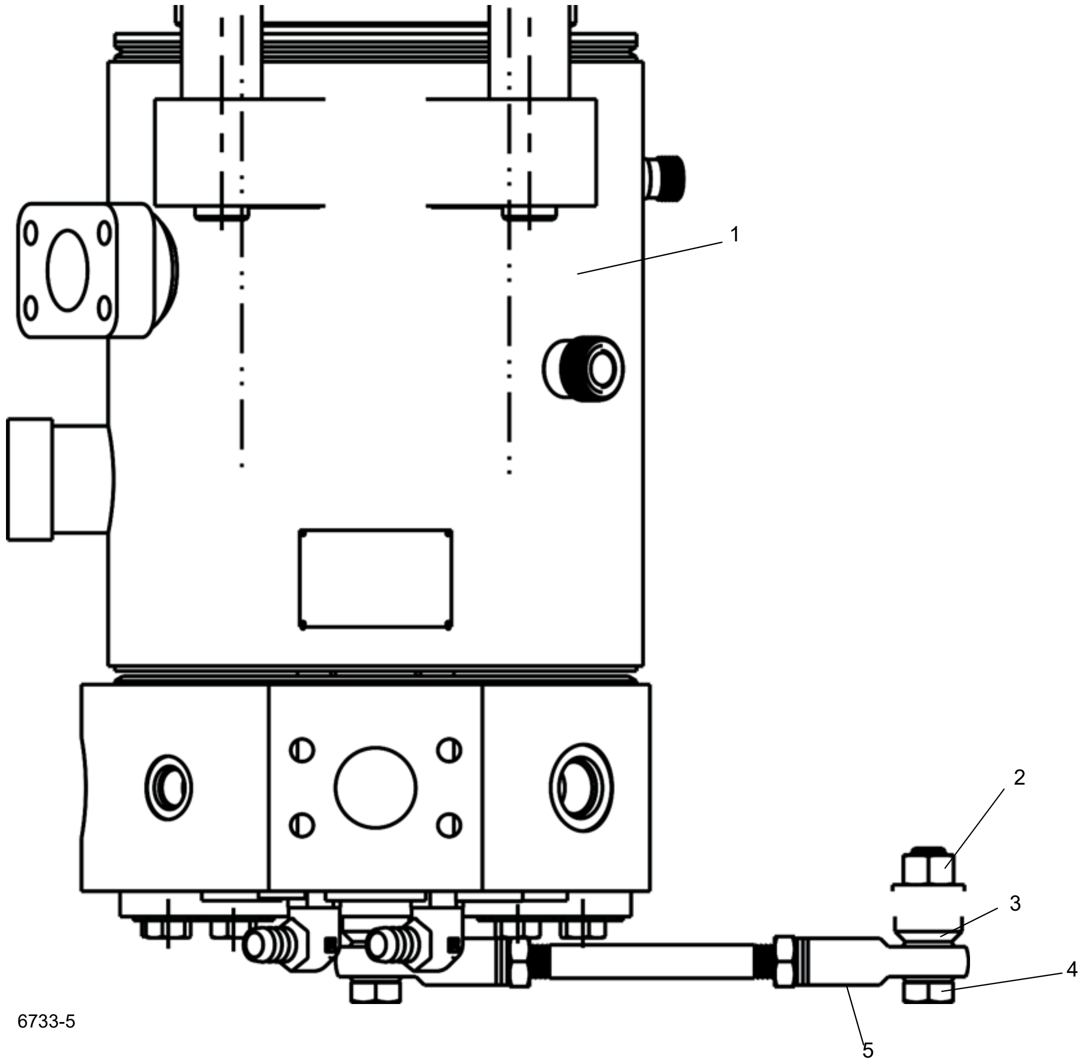
NOTE: This blocking is to add extra support for the boom. Any seepage or leakage in the holding valves or internally in the cylinders will allow the boom to settle over a period of time.

4. Use the oak blocking to block between the barrel of the lift cylinder and the boom base section.
5. Tag and disconnect the hydraulic lines from the case of the hydraulic swivel. Cap or plug all lines and openings.
6. Tag and disconnect the hydraulic lines and water lines from the spool of the hydraulic swivel. Cap or plug all lines and openings.
7. Tag and disconnect the water lines from the case of the water swivel. Cap or plug all lines and openings.
8. Disconnect the swivel wiring harness connectors from the carrier receptacles and the yellow ground wire from the connector mounting bracket on the carrier frame. If necessary, remove the electrical slip ring assembly. Refer to *Electrical Slip Ring Assembly (pg 6-18)* in this Section.

NOTE: The hydraulic swivel weighs approximately 117 kg (258 lb). The hydraulic 117 kg (258 lb), water 10 kg (22 lb), and electrical 39.72 kg (88 lb) swivels combined weigh approximately 167 kg (368 lb).

9. On the bottom of the swivel, bend the retainer tabs away from the capscrews. Install the linkage rod, with the included spacers, towards the spherical rod end as shown in (Figure 6-6). The swivel linkage rod is set from the manufacturer to a pre-set distance.

NOTE: Do not adjust the swivel linkage rod. Rotate swivel to align with the mounting holes, and install the hardware (bolt, lock washer, and nut) on both ends of linkage rod as additionally shown in (Figure 6-6). Torque the bolts (Figure 6-2).



Item	Description
1	Swivel Assembly, Elect, Water & Hydraulic
2	Washer & Hex Lock Nut
3	Spacer
4	Bolt (HHCS)
5	Swivel Linkage Assembly

FIGURE 6-6

10. Remove the forward-rear axle. Refer to Rear Tandem Removal (pg 8-8).
11. Position an adequate supporting device beneath the swivel.
12. Remove the capscrews, washers, and bushings securing the swivel barrel to the turntable base plate and lower the swivel to the ground.

Installation

NOTE: The hydraulic swivel weighs approximately 117 kg (258 lb). The hydraulic 117 kg (258 lb), water 10 kg (22 lb), and electrical 39.72 kg (88 lb) swivels combined weigh approximately 167 kg (368 lb).

1. Raise the swivel into position.
2. Secure the hydraulic swivel to the turntable base plate with the bushings, capscrews and washers. Torque the capscrews to 714 to 774 N-m (526 to 571 lb-ft).
3. Apply Loctite 271 to the capscrews. Position the two retainer plates on the bottom of hydraulic swivel spool, engaging the lugs on the carrier frame, and secure them to the spool with four capscrew retainers and bolts. Torque the bolts 298 to 322 N-m (220 to 237 lb-ft). Bend all the retainer tabs to make contact with the bolt heads.
4. If removed, install the electrical swivel. Refer to Electrical Slip Ring Assembly (pg 6-18) in this Section. Connect the swivel wiring harness connectors to the carrier receptacles and the yellow ground wire to the mounting bracket on the carrier frame. Use the bolt and star washers taken off at removal. Spray ground stud with a terminal protector to help prevent corrosion.
5. Install the clamp, lockwasher, flat washer and capscrew to the bottom of the swivel retainer plate securing the wiring harness.
6. Connect the hydraulic lines and water lines to the spool of the hydraulic swivel as tagged during removal.
7. Connect the hydraulic lines to the hydraulic swivel case as tagged during removal.
8. Connect the water lines to the water swivel case as tagged during removal.
9. Remove the blocking material from the lift cylinder.
10. Activate all systems; cycle all functions, and observe for proper operation and any leakage.

Electrical Slip Ring Assembly

Description

The Electrical Slip Ring Assembly consists of a 20 conductor slip ring and cover assembly.

Each brush set incorporates two brushes, leads, and clips which are attached to a brush holder assembly. The brush set leads are formed into harnesses which are routed through the mounting plate on the assembly. 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 slip ring assembly cover is secured with a seal and bolts

The electrical slip ring assembly also incorporates a slew potentiometer. The potentiometer controls functions in the Rated Capacity Limiter (RCL) and Working Range Limiter (WRL).

Theory of Operation

The electrical slip ring assembly 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 the superstructure.

Maintenance

Removal

1. Perform Steps 1 through 4 of the Hydraulic Swivel (pg 6-16) in this section.

CAUTION

Disconnect the batteries before performing any maintenance on the electrical system. Serious burns may result from accidental shorting or grounding of live circuits.

---

2. Disconnect the batteries. Refer to Section 3 - Batteries (pg 3-1) and Electrical System (pg 3-1).
3. Locate the connectors which join the collector ring harness to the receptacles for the carrier.
4. Tag the connectors and their receptacles with numbers. Disconnect the connectors from the chassis wiring receptacles.
5. Remove the clamp securing the wiring harness to the retainer plate on the bottom of the hydraulic swivel assembly.
6. Secure the connectors and wires from each of the numbered connectors so that the harness can be withdrawn through the center of the hydraulic swivel.
7. Tag and disconnect the connectors from the receptacles on the cab bulkhead mounting plate.
8. Remove the setscrews and remove the cover from the electrical slip ring assembly.
9. Loosen the capscrews securing the electrical slip ring assembly mounting tube to the center post on the water swivel.
10. Remove the capscrew and jam nut securing the electrical slip ring assembly case to the plate on the case of the water swivel.

CAUTION

When withdrawing the wiring harness through the center of the hydraulic and water swivels, make sure that the wires do not get caught and damaged.

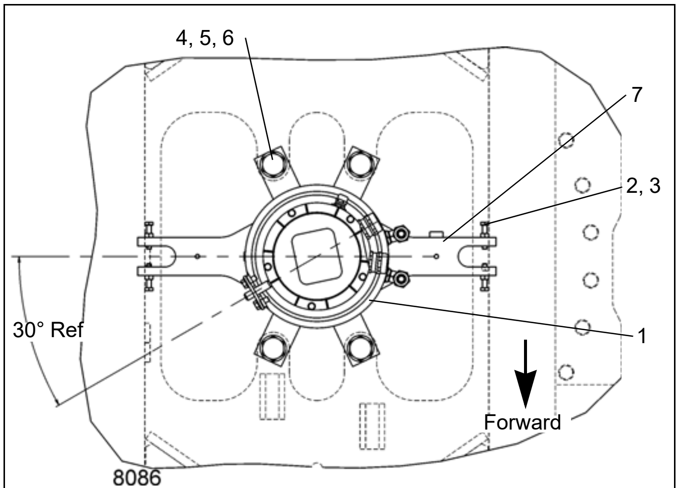
11. Remove the electrical slip ring assembly and wiring harness from the crane. If necessary, remove the spacer bushing from the center post.

Installation

1. If removed, install the spacer bushing on the center post. Route the collector core wiring harness through the center of the hydraulic and water swivels.

NOTE: The boom should be centered directly over the front of the crane before adjustment is made to the slew potentiometer.

2. Slide the electrical slip ring assembly mounting shaft onto the center post.
3. Make sure that the threaded hole on the bottom of the electrical slip ring assembly base is aligned with the mounting hole in the plate on the water swivel case. Install the capscrew through the hole in the plate and install the jam nut. Screw the capscrew into the hole in the electrical slip ring assembly base until the capscrew head is approximately 6.0 mm (0.23 in) from the bracket. Tighten the nut against the electrical slip ring assembly (Figure 6-7).
4. Apply medium strength Loctite to the setscrews securing the electrical slip ring assembly to the center post and tighten them 5 to 6 N-m (44 to 53 lb-in).
5. Install the slip ring assembly cover and secure with capscrews and washers.
6. Connect the wiring harness connectors to the receptacles on the cab bulkhead mounting plate as tagged during removal.



TOP OF ELECTRICAL SLIP RING ASSEMBLY **FIGURE 6-7**

Item	Description
1	Electrical Slip Ring Assembly
2	Capscrew
3	Hex Nut
4	Capscrew
5	Washer
6	Bushing
7	Retaining Plate

7. Plug the connector into the carrier wiring receptacle, connect the wires as tagged during removal. Install the yellow ground wire to the connector mounting bracket on the carrier frame using the bolt and star washers taken off at removal. Spray ground stud with a terminal protector to help prevent corrosion.
8. Install the clamp securing the harness to the retainer plate on the bottom of the hydraulic swivel assembly.
9. Connect the batteries. For more information on batteries, refer to Batteries (pg 3-1).

CAUTION

It is imperative that the slew potentiometer be adjusted anytime work is done to the electrical slip ring assembly.

10. Activate all systems, cycle all functions, and observe for proper operation. Adjust the slew potentiometer in accordance with the Slew Potentiometer Adjustment (pg 6-20) procedures in this Sub-Section.

Preventive Maintenance

It is recommended that a normal inspection of the electrical slip ring assembly collector ring and brush assembly be established. An example of this could be at approximately 100 to 150 engine operating hours. When this time limit is reached, perform the following:

1. Check the collector ring and brush assembly for any corrosion, pitting, arcing, and wear.
2. Check the collector ring setscrews and make sure that they are tight.
3. Check the brush and arm assembly springs. Make sure that they are holding the brushes firmly against the collector rings.

Slew Potentiometer Adjustment

1. Rotate the superstructure over the front and engage the house lock pin.
2. Remove the electrical slip ring assembly cover.

CAUTION

Do not attempt to rotate the slotted shaft in the center of the slew potentiometer.

3. Disengage the house lock pin and swing the superstructure approximately 10 degrees to the right (clockwise). Slowly swing the superstructure back to the left and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, Step 3 must be repeated.

4. Loosen the three screws that secure the slew potentiometer to the mounting plate.
5. Rotate the body of the slew potentiometer until the slew angle indicates 0.0 ± 0.1 degree.

NOTE: The slew angle indication in Step 5 may not be obtainable due to a limited wire length on the potentiometer, or the electrical terminals interference with one of the three mounting screws. If this occurs, reposition the collar set screwed to the potentiometer shaft and repeat Steps 3 through 5.

6. Tighten the three screws that secure the slew potentiometer to the mounting plate. Install the electrical slip ring assembly cover.
7. Disengage the house lock pin and swing the superstructure approximately 10 degrees to the left (counterclockwise). Slowly swing the superstructure back to the right and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, Step 7 must be repeated.

8. If the angle indicated on the console does not exceed ± 1.0 degree, proceed to Step 10. If the indicated angle exceeds ± 1.0 degree, return to Step 3.
9. Disengage the house lock pin and swing the superstructure approximately 10 degrees to the right (clockwise). Slowly swing the superstructure back to the left and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, Step 10 must be repeated.

10. If the angle indicated on the console does not exceed ± 1.0 degree, proceed to Step 12. If the indicated angle exceeds ± 1.0 degree, return to Step 3.
11. Disengage the house lock pin and swing the superstructure approximately 10 degrees to the left (counterclockwise). Slowly swing the superstructure back to the right and engage the house lock pin.

NOTE: If the superstructure swings past the house lock pin engaged position, Step 12 must be repeated.

12. Verify that the angle indicated on the console does not exceed ± 1.0 degree. If the indicated angle exceeds ± 1.0 degree, return to Step 3.

SECTION 7
POWER TRAIN

SECTION CONTENTS

Engine 7-1
Description 7-1
Maintenance 7-2
Engine Removal 7-2
Engine Installation 7-5
Engine Drive Belts 7-6
Engine Control System 7-6
Description 7-6
Functional Operation 7-6
Engine Control System Switches and Indicator Lights 7-7
Fuel System. 7-9
Description 7-9
Maintenance 7-10
Air Intake System 7-11
Description 7-11
Maintenance 7-11
Exhaust System 7-15
Description 7-15
Exhaust System Removal. 7-15
System Installation 7-15
Slip Joint Exhaust Connectors 7-15
Exhaust System 7-16
After-treatment Diesel Exhaust Fluid (DEF) 7-17
DEF Tank. 7-17
DEF Dosing Unit Filter. 7-18
Water Cooling System 7-20
Description. 7-20
Maintenance 7-20
Cleaning. 7-22
Component Inspection. 7-23
Radiator Assembly Removal and Installation . . . 7-24
Drive Train 7-26
Description. 7-26
Maintenance. 7-26
Drive Lines. 7-26
Electronic Clutch Actuator (ECA) 7-28
Installation Instructions 7-28
ECA Removal and Assembly Instructions 7-28
Transmission 7-28
Removing Transmission from Engine 7-28
Mounting Transmission to Engine 7-29
Pump/PTO Assembly 7-30
Pump/PTO Replacement. 7-30

ENGINE

Description

The TMS500-2 has a Cummins L9 on-highway engine.

This *Service Manual* does not include detailed information on this individual engine. A separate manual, as prepared in detail by the engine manufacturer, is supplied with this *Service Manual*. However, a short description and maintenance of certain components of the fuel system, air intake system, and water cooling system are provided in this section.

Engine speed is controlled from the carrier cab by a foot throttle pedal connected electronically to the engine ECM. Speed is electronically controlled in the same manner from the superstructure cab by either a foot throttle pedal or hand throttle. The control module is the control center of the system. It processes all of the inputs and sends commands to the vehicle and engine control devices.

The engine and its components are enclosed within a hood assembly. The hood has openings in the front and rear to allow for adequate air flow over the engine. A door on the top left and right side of the hood may be opened to provide easier access to the engine.

The air intake filter is located on the right side of the engine on the fender. The after treatment system is located on the left side behind the cab. It is mounted to the decking.An immersion type engine block heater with a choice of 120V or 240V is also provided.

MAINTENANCE

Engine Removal

NOTE: If the Transmission needs to be removed from the Engine, refer to Steps 1-3 on *ECA Removal and Assembly Instructions*, page 7-28 in this Manual.

1. Fully extend and set the outriggers and position the boom over the side to provide working clearance.
2. Disconnect the battery.
3. Open the left and right hood access doors.
4. Disconnect the air filter tubing at the engine and air cleaner. Remove and lay aside.
5. Drain the engine lubricating systems.
6. Drain the transmission lubricating systems.
7. Drain the engine coolant system.
8. Remove the bolts, washers, lockwashers, and nuts securing the start relay and max speed relay to the hood. Lay the relay with the harness on the engine.
9. Disconnect the exhaust tubing at the engine and After-treatment Assembly. Remove the tubing clamp bracket and the exhaust bracket from the boom rest and remove the tubing from the engine.
10. Unplug the After-treatment Assembly wiring harness from the carrier harness and the After-treatment Assembly.
11. Remove the engine hood assembly and the decking over the transmission.

DANGER

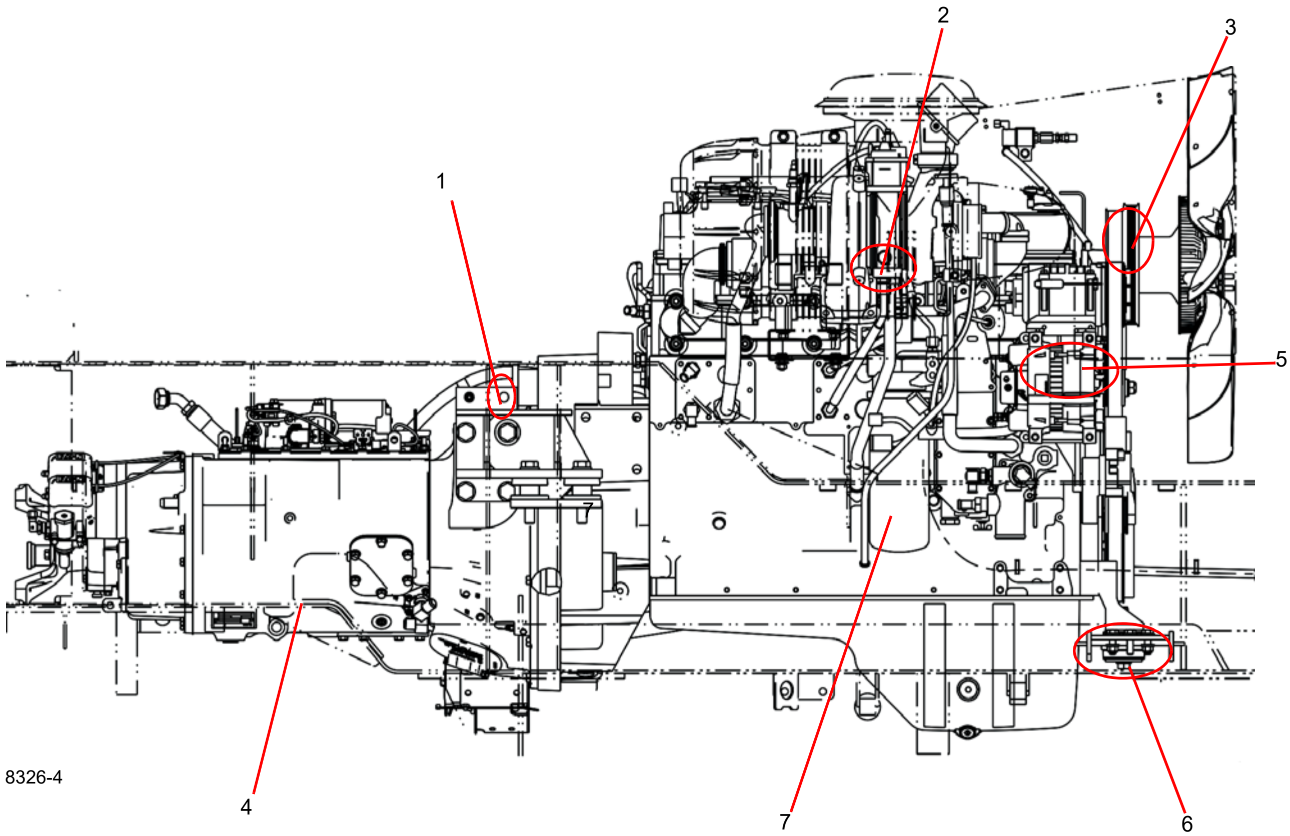
The lifting device must be able to support the combined weight of the engine and the transmission.

12. Loosen all of the mounting bolts to the frame.
13. Disconnect hoses from main piston pump and cap all of the openings.
14. Unbolt the driveline from the piston pump coupler and lay on transmission.
15. Locate the rear engine lifting bracket on the rear of the cylinder head. Attach an adequate lifting device to the engine and transmission sufficient to lift and support both the engine and the transmission.
16. Tag and disconnect the engine electrical harness connector from the carrier harness connector and the battery cables.
17. Tag and disconnect the transmission oil lines to the filter and to the oil cooler.
18. Disconnect and remove the drive line from the transmission.
19. Tag and disconnect all lines to the radiator and charge air cooler. Remove the radiator assembly and fan. Cap or plug all openings.
20. Tag and disconnect the heater hoses.
21. Tag and disconnect the fuel lines to the engine. Cap or plug all openings.
22. Tag and disconnect all air lines to the engine components and to the transmission. Cap or plug all openings. Move the tubing out of the way so it is not damaged during the removal of the engine and the transmission assembly.
23. Tag and disconnect the hydraulic lines to the engine. Cap or plug all lines and openings.
24. Tag and disconnect all linkages and cables to the engine, to the engine components, and to the transmission.

NOTE: The engine and transmission weighs approximately 1350 kg (2976 lb).

25. With the lifting device supporting the weight of the engine and the transmission, remove the bolts, washers, lockwashers, nuts, and isolators from the front engine mounting support and the transmission mounting brackets.
26. Carefully lift the engine assembly from the crane and move it to a clean work area.
27. If a new engine is to be installed, remove the transmission, and all of the engine installed components, fittings, etc,. from the old engine and install them on the new engine in the same locations.
28. Make sure that the same grade hardware, torque values, and Loctite, as were installed by the factory, are used.

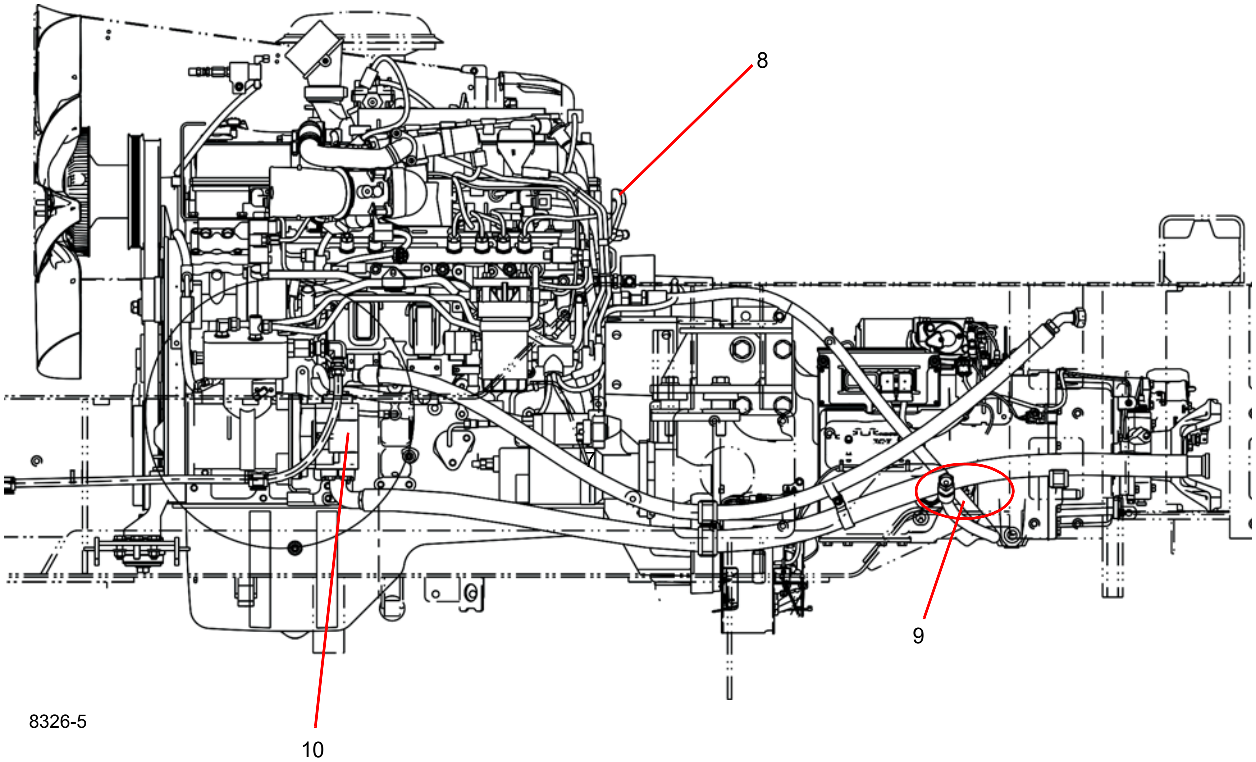
Engine Installation - Right View



Item	Description
1	Transmission Mount
2	Engine Oil Dipstick
3	Fan Clutch
4	Transmission
5	Alternator
6	Front Cross Member and Isolators
7	Engine Oil Filter

FIGURE 7-1

Engine Installation - Left View



Item	Description
8	Lifting Bracket, Rear, Lifting Position
9	Transmission Oil Fill Plug

Item	Description
10	Gear Pump

FIGURE 7-2

Engine Installation

Refer to (Figure 7-1), (Figure 7-2) and (Figure 7-3).

1. With all components and fittings installed on the engine, lift the engine assembly into the crane.
2. With the engine assembly in position, install the bolts, washers, lockwashers, nuts, and isolators on the front engine mounting support and on the transmission mounting brackets. Torque the bolts in the front engine mount to 92 N-m (68 lb-ft). Torque the bolts in the transmission mount until the Isolator has a compressed height of 41 mm (1.63 in) and 264 N-m (195 lb-ft).
3. Remove the lifting device from the engine and transmission.
4. Install the main pump assembly.
5. Connect all linkages and cables to the engine, engine components, and transmission as tagged during removal.
6. Connect all hydraulic lines to the engine as tagged during removal.
7. Connect all air lines to the engine components, transmission, and pump drives as tagged during removal.
8. Connect the fuel lines to the engine as tagged during removal.
9. Connect the heater hoses as tagged during removal.
10. Install the radiator assembly and fan. Connect all lines to the radiator and air cooler as tagged during removal.
11. Connect the drive line to the transmission. Refer to *Drive Lines*, page 7-26.
12. Connect the filter and oil cooler oil lines to the transmission as tagged during removal.
13. Connect the battery cables, and engine electrical harness connector as marked during removal.

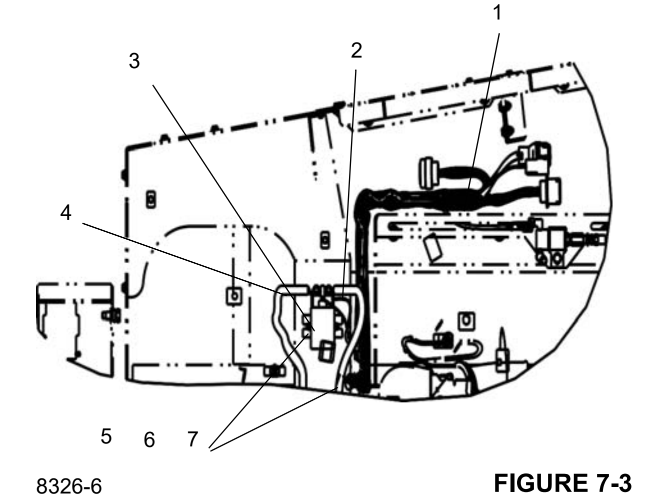


FIGURE 7-3

Item	Description
1	Wiring Engine Harness
2	Cable Assembly
3	Sealed Power Relay
4	Cable Assembly
5	Slot PMS
6	F Washer
7	L Washer

14. Install the piston pump.
15. Bolt the drive line to the piston pump coupler.
16. Connect the hoses to the main piston pump.

DANGER

The lifting device must be able to support the combined weight of the engine and the transmission.

17. Install the engine hood assembly and the removed decking.
18. Plug the After-treatment wiring harness to the carrier harness and After-treatment Assembly.
19. Install the exhaust tubing clamp mounting bracket to the boom rest. Install the exhaust tubing and connect it to the engine.
20. Reinstall the boom rest.

21. Position the start relay and max speed relay on the inside of the hood and secure with the bolts, washers, lockwashers, and nuts. Refer to (Figure 7-3).

Engine Drive Belts

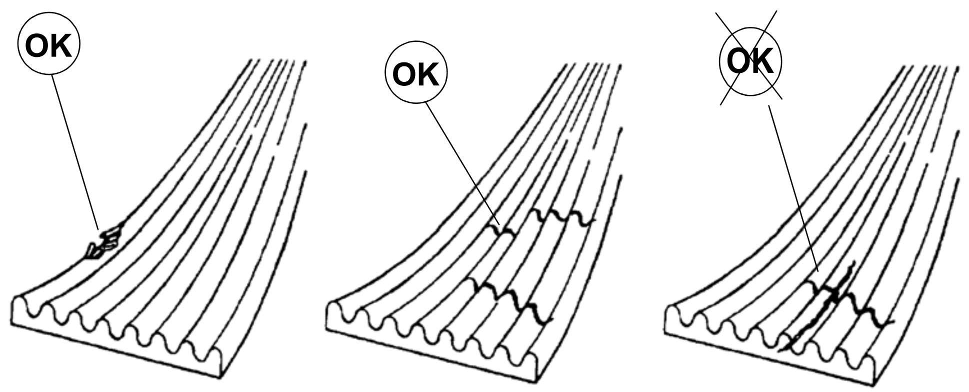
The proper operation of engine belt-driven components such as the alternator, fan clutch, and water pump depend on the proper condition and tension of the engine drive belts.

Belt tension is maintained with an automatic belt tension device.

The engine drive belt should be inspected visually on a daily basis. The drive belt should be inspected for cracks, frayed areas, and glazed or shiny surfaces. A drive belt that is glazed or shiny indicate belt slippage.

Engine drive belt damage can be caused by various factors such as incorrect tension, incorrect belt size, misaligned engine pulleys, incorrectly installed belts, or by oil, grease, or hydraulic fluid on the belt.

Refer to the engine manufacturer's manual for any special tools or belt tension specifications.



V-Ribbed Belt Inspection

ENGINE CONTROL SYSTEM

Description

The Engine Control System is an electronically controlled fuel injection system that optimizes fuel economy and reduces exhaust emissions. It accomplishes this by controlling the torque and horsepower curve, air fuel control function, engine high speed, low idle and road speed. The system monitors critical engine temperatures and pressures, and will log diagnostic faults when an abnormal operating condition occurs. If an out-of-range condition exists, and engine derate action is to be initiated, the operator will be alerted by an in-cab warning light. The warning light will blink or flash when out-of-range conditions continue to get worse.

Functional Operation

Four key switch phases govern the operation of the Engine Control System:

1. Ignition switch in the ON position, idle/diagnostic switch OFF, engine not cranking or running.
2. Ignition switch in the ON position, idle/diagnostic switch ON, engine not cranking or running.
3. Ignition switch in the ON position, engine cranking.
4. Ignition switch in the ON position, engine running.

With the ignition switch ON, the diagnostic test switch OFF and the engine not cranking or running, the Electronic Control Module (ECM) performs diagnostic and status operations. It reads the logic inputs from the brake, clutch, and cab switches and analog inputs from sensors such as the engine coolant temperature sensor and the manifold boost pressure sensor. During this phase, the data link is active and can be accessed by the applicable service tools. The ECM opens the fuel shut-off valve so that the engine is ready to be started.

Additionally, if the key switch is turned ON but the diagnostic switch remains OFF, the indicator lights illuminate for approximately two seconds to verify that they are working and then go out. This is part of the normal operation of the power-up sequence. However, if an active fault is present, one of the lights remains illuminated, determined by the type of fault being sensed.

When the diagnostic test switch is turned ON, the red and amber indicator lights illuminate and remain illuminated if there is no active fault. If there is an active fault, the red lamp flashes in a sequence of pulses to indicate that specific fault code.

The electronic subsystem and the starter motor are independent of each other. During the cranking phase, with the ignition switch in the start position, the ECM commands all of the fuel needed to start the engine. There is no need to use the throttle pedal while cranking the engine.

While the engine is cranking, the ECM is performing additional diagnostic and status operations. An active fault causes one of the two indicator lamps to illuminate and remain lit. Which lamp is illuminated depends on the severity of the fault.

Engine Control System Switches and Indicator Lights

For a list of the Engine Control System Switches and Indicator Lights, refer to (Figure 7-4) and the Table listing below. Also, refer to the Control Panel Indicator and Gauge Display in the Operators Manual, Section 3, page 3-11 for a list of the items included in the display, including descriptions.

Engine Control System Switches & Indicator Lights

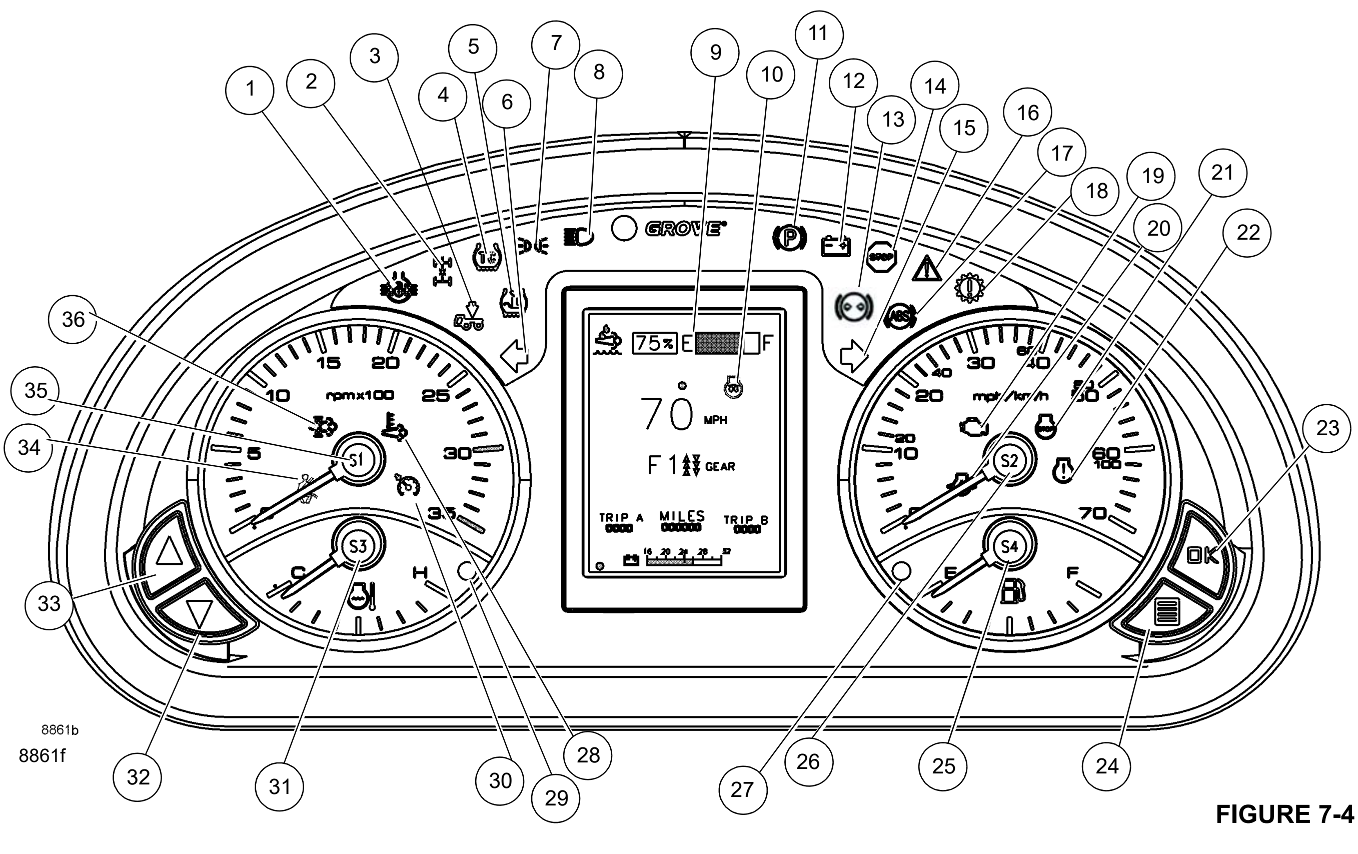


FIGURE 7-4

7

Engine Control System Switches & Indicator Lights

Item	Description	Color
1	Cross-Axle Lock Indicator (Optional)	Amber
2	Inter-axle Locked Indicator	Amber
3	Suspension Deflated Indicator	Amber
4	ABS Traction Control Indicator	Amber
5	Tire Inflation Indicator	Amber
6	Left Turn Signal Indicator	Green
7	Marker Lights/Headlamps ON Indicator	Green
8	High Beam Indicator	Blue
9	LCD	None
10	Wait-to-Start Indicator	None
11	Park Brake Engaged Indicator	Red
12	Battery Charge Indicator	Red
13	Low Air Pressure Indicator	Amber
14	Emergency Stop Indicator	Red
15	Right Turn Signal Indicator	Green
16	Crane Control System (CCS) Fault Indicator	Amber
17	Anti-lock Braking System Indicator	Amber
18	Check Transmission Indicator	Red
19	Malfunction Indicator Lamp	Amber
20	Low Oil Pressure Indicator	Red
21	Engine Stop Indicator	Red
22	Engine Warning Indicator	Amber
23	OK Button	None
24	Menu Button	None
25	Fuel Level Gauge	None
26	Speedometer	None
27	Low Fuel Level Indicator	Amber
28	High Exhaust Temperature Indicator	Amber
29	Engine Coolant High Water Temperature Indicator	Red
30	Cruise Control Indicator	Amber
31	Engine Temperature Gauge	None
32	Down Button	None
33	Up Button	None
34	Seat Belt Unfastened Indicator	None
35	Tachometer	Red at 2600 RPM
36	REGEN Needed (Exhaust System Cleaning Indicator)	Amber

Engine Stop Indicator

Engine Stop lamp is located in the top right of the speedometer (21), (Figure 7-4), which is on the right side of the front console in the carrier cab. The indicator illuminates red when energized by a signal from the engine ECM that signifies a serious engine problem that requires the vehicle and the engine to be stopped as soon as safely possible. In addition, a warning buzzer will also sound.

In addition to alerting the operator of system faults, the Engine Stop light, in conjunction with the Engine Warning light (22), (Figure 7-4), is used in the diagnostic operation of the engine control system. The diagnostic mode begins when the ignition and engine diagnostic switch is on and the engine is not running. The amber light flashes at the beginning of a fault code sequence, the red light flashes the three-digit or four-digit code for the active fault and the amber light flashes again to separate the previous red light sequence from the next one. Each code will be flashed twice before moving to the next code. When all codes have been flashed, the sequence will begin again. If no codes are present, both the engine warning and engine stop lights will remain on.

Engine Warning Indicator

The Engine Warning/electrical system diagnostic indicator (22), (Figure 7-4) is located in bottom right of speedometer. It illuminates amber when energized by a signal from the engine ECM that signals the operator of an engine problem which must be corrected.

In addition to alerting the operator of system faults, the engine warning light, in conjunction with the engine stop light, is used in the diagnostic operation of the engine control system. The diagnostic mode begins when the ignition and engine diagnostic switch is on and the engine is not running. The amber light flashes at the beginning of a fault code sequence, the red light flashes the three-digit or four-digit code for the active fault and the amber light flashes again to separate the previous red light sequence from the next one. Each code will be flashed twice before moving to the next code. When all codes have been flashed, the sequence will begin again. If no codes are present, both the warning and stop lights will remain on.

High Exhaust Temperature Indicator

The amber filter exhaust system cleaning/high exhaust temperature indicator (28), (Figure 7-4), located in the tachometer will illuminate when the exhaust system has not been able to clean under normal operating conditions and is in need of assistance in order to perform an active cleaning. There are three progressive stages of need for cleaning indicated by this light:

- A) On solid: Cleaning should be done within one shift of operation.
- B) Flashing: Cleaning needs to be done soon.
- C) Flashing with Check Engine Light illuminated: Start cleaning immediately.

The high exhaust temperature indicator (28), (Figure 7-4) is located in the tachometer. The indicator illuminates amber when an active exhaust cleaning has been initiated and the exhaust temperatures will be elevated above normal levels for operating conditions.

Engine Increment/Decrement Switch

The engine increment/decrement switch is located on the left side of the front console and is used when servicing the engine electronic control system.

It is a two-position (+/-) momentary switch that provides idle-control inputs that increases and decreases the engine idle.

Pushing the top of the switch increases (+) engine RPM or pushing the bottom of the switch decreases (-) engine RPM.

FUEL SYSTEM

Description

The fuel system consists of the fuel tank, fuel filter-water separator, injection fuel pump, and the fuel injectors. All components except the fuel tank and fuel filter-water separator are installed on the engine or supplied with the engine for remote mounting.

Fuel Tank

The fuel tank is a steel round tank located on the left side of the crane. The tank has a draw capacity of 220 L(58 gal). Two connections on the bottom of the tank provide for fuel supply to the engine and return of surplus fuel from the engine. The tank is equipped with a spin-type filler cap and fuel quantity sender unit which provides signals to quantity indicators on the instrument panels in both cabs.

Injection Fuel Pump

The fuel is finely atomized as it is injected into the cylinder and ignited by the heat of compression. It is metered also, before injection, to meet the load requirements imposed upon the engine.

Surplus fuel, returning from the injectors, is bypassed back to the fuel tank. The continuous flow of fuel through the injectors helps to cool the injectors and to purge air from the system.

Fuel Filter-Water Separator

The fuel filter-water separator removes impurities from the fuel and also removes water from the fuel before it reaches the engine. It is mounted under the decking in front of the fuel tank.

The fuel mixture passes through the outer wrap of the first stage of the filter paper, where large droplets of water,

7

removed from the fuel, are formed. The water droplets drain into a void between the two paper elements and to a reservoir in the bottom of the housing, where it can be drained through a petcock.

As the filter becomes clogged, the level of fuel will increase. When the filter looks full of fuel, the filter should be changed.

Maintenance

Fuel Tank

The fuel tank should be kept filled, especially overnight, to reduce condensation to a minimum. Refer to the applicable engine manual for the recommended schedule for draining any water or sediment from the tank.

Removal

1. Place a suitable container under the fuel tank and drain all fuel from the tank.
2. Tag and disconnect the two lines from the tank.
3. Disconnect the electrical leads from the fuel quantity sender units.
4. Remove the hardware securing the tank in place and using a suitable lifting device, remove the fuel tank.
5. If a new tank is to be installed, remove the two fittings, the fuel quantity sender, and install them on the new tank.

Installation

Refer to (Figure 7-5).

1. Position the tank and install the hardware securing the tank in place.
2. Connect the electrical lead to the fuel quantity sender unit.
3. Connect the two lines to the fittings on the tank in accordance with the identification marks made during removal.
4. Service the tank.

Fuel Filter-Water Separator

Draining

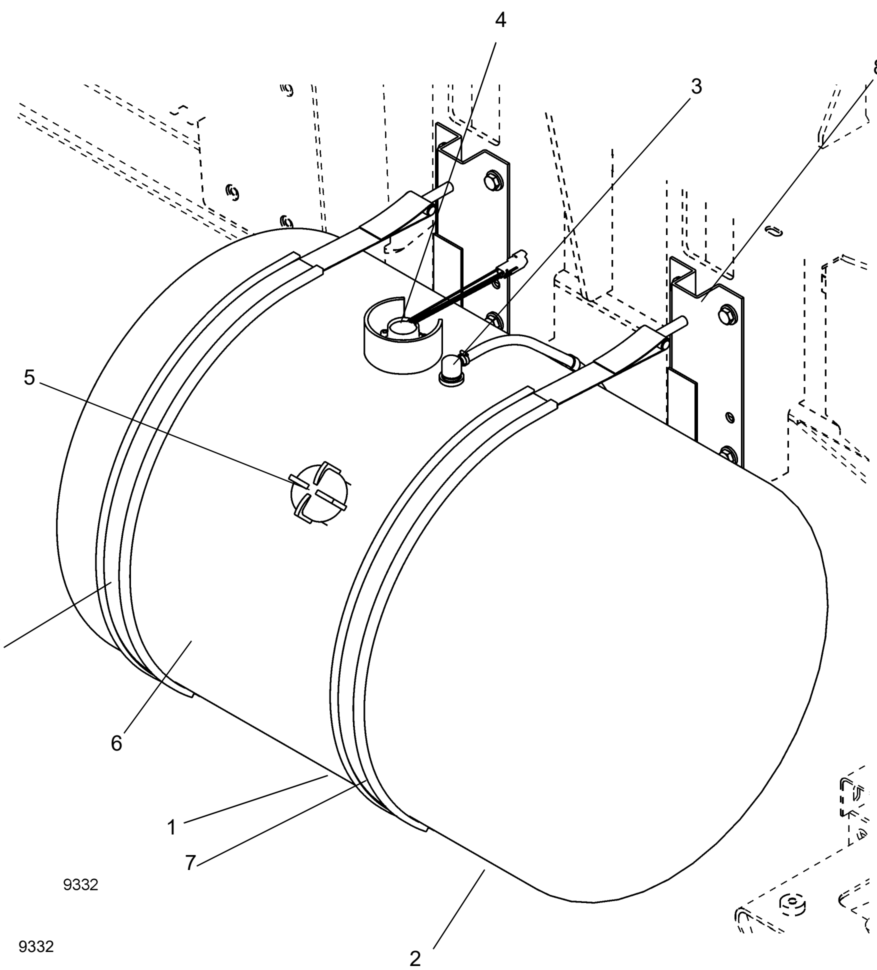
The sump of the fuel filter-water separator should be drained daily, 30 minutes after the engine is shut down, to remove any water and sediment. Adhere to the following procedure.

1. Place a suitable container under the filter and open the drain plug.
2. Drain until fuel appears.
3. Close the drain plug.

Filter Change Procedure

1. Turn off the engine. Loosen the vent cap to break the air lock in the filter.
2. Open the drain valve and drain the fuel level below the collar, then close the drain valve.
3. Using the collar/vent cap wrench (Grove part number 90023151), remove the clear cover from the fuel processor by removing the collar. Discard the O-Ring from the base of the cover. (A new O-Ring seal is supplied with the new filter.) Remove the filter element from the filter body by pulling upward and twisting slightly. Be sure the sealing grommet is removed from the center stud.
4. Install the new filter element (supplied with a sealing grommet already inserted into the element) on the processor center stud by pushing down and twisting slightly. After checking to make sure the new O-Ring seal (supplied with the filter) at the base of the cover is in place, install the cover and collar. Hand tighten the collar until seated. Do not use tools to tighten.
5. Remove the vent cap from the top of the clear cover by turning the vent cap counterclockwise. Fill the clear cover with enough clean fuel to cover the bottom half of the filter element. Make sure the new O-Ring (supplied with the filter) is installed on the vent cap. Reinstall the vent cap and tighten by hand only.
6. Start the engine. When the lubrication system reaches its normal operating pressure, increase engine RPM for one minute.

NOTE: The clear filter cover will not fill completely during engine operation. It will gradually fill over time as the filter becomes clogged. The filter element does not need to be changed until the fuel level has risen to the top of the filter element.



9332

1. Fuel Supply to Engine
2. Fuel Return From Engine
3. Tank Vent
4. Fuel Quantity Sending Unit
5. Filler Cap
6. Fuel Tank
7. Mounting Straps
8. Fuel Tank Bracket

FIGURE 7-5

Fuel Tank Installation

AIR INTAKE SYSTEM

Description

The engine air intake system consists of an air cleaner and associated piping for channeling the air from the atmosphere to the engine intake manifold.

The air cleaner is the dry-type with a replaceable element. It is located on the right front fender. A service indicator, designed to indicate red when servicing is required, is installed at the air cleaner outlet.

Maintenance

Troubleshooting

Dust passing the air cleaner, even through small holes, can cause rapid engine wear. Make sure that all connections between the air cleaner and the engine are tight and sealed. If these connections are all well sealed, and there is still evidence of dust leakage, check the following places for possible trouble.

NOTE: Dust that gets by the air cleaner system can often be detected by looking for dust streaks on the air transfer tubing or just inside the intake manifold inlet.

1. Inspect the air cleaner outlet tube for damage.
2. Make sure that the element gasket washer is not damaged and the washer's rubber face seals against the element.
3. Inspect the element gasket for damage.
4. Check for structural failures. Any damaged parts must be replaced.
5. Inspect the restriction indicator tap for leaks.

Check For Filter Restriction

As a dry cleaner element becomes loaded with dust, the vacuum on the engine side of the air cleaner (at the air cleaner outlet) increases.

The vacuum is generally measured as restriction in inches of water. The engine manufacturer places a recommended limit on the amount of restriction the engine will stand without loss in performance before the element must be cleaned or replaced. Cummins allows a vacuum of 6.2 kPa (25 inches of water) maximum with a dirty air cleaner at maximum governed RPM.

A service indicator on the air cleaner housing will indicate when the filter needs to be cleaned or replaced. Reset the indicator each time the air cleaner is serviced. If the indicator's accuracy is suspect, a water manometer is the most accurate and dependable method of measuring vacuum.

To use the manometer, hold it vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to the atmosphere.

Maximum restriction in the air cleaner occurs at maximum air flow. On this turbocharged diesel engine, the maximum air flow occurs only at maximum engine power.

With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs, measured in inches or centimeters is the air cleaner restriction. Restriction indicators are generally marked with the restriction at which the red signal flag locks up.

If the initial restriction on a new or clean filter reads above the maximum allowed for the engine, check the following items.

1. Make sure that the air cleaner inlet is not plugged.
2. Inspect the air cleaner outlet to be sure it is not plugged by paper, rags, etc.
3. Make sure that the correct size connections are used between the air cleaner and the engine.
4. Make sure that all inlet accessories are the correct size and are not plugged by any foreign object.

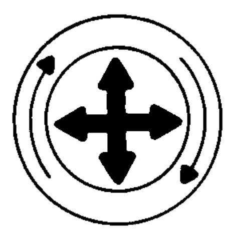
CAUTION

RISK of DAMAGE!

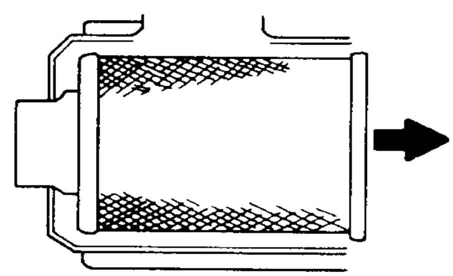
Never service the air cleaner while the engine is running.

Filter Element Replacement

1. Unlatch the latches, open the air cleaner body, and withdraw the element as follows:
   a. RELEASE THE SEAL GENTLY. The filter element fits tightly over the outlet tube, creating the critical seal on the inside diameter of the filter end cap. The filter should be removed gently to reduce the amount of dust dislodged. There will be some initial resistance, similar to breaking the seal on a jar. Gently move the end of the filter up and down and side to side or twist to break the seal.



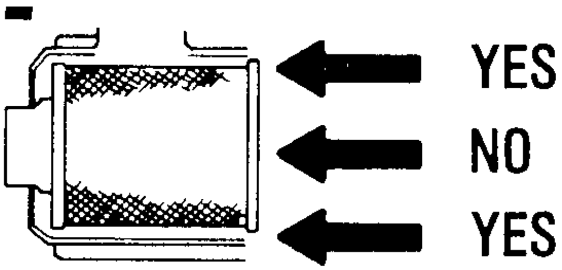
   b. AVOID DISLODGING DUST FROM THE FILTER. Gently pull the filter off the outlet tube and out of the housing. Avoid knocking the filter against the housing.



2. Inspect all parts of the intake system and air cleaner. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube.
3. Install the element into the air cleaner body as follows:

a. INSPECT THE FILTER FOR DAMAGE. Always look for filter damage, even if a new filter element is being installed. Pay special attention to the inside of the open end (sealing area). Do not install a damaged filter.

b. INSERT THE FILTER PROPERLY. The seal area is on the inside of the open end of the primary filter. A new filter has a dry lubricant to aid installation. The critical sealing area will stretch slightly, adjust itself and distribute the sealing pressure evenly. To complete a tight seal, apply pressure at the outer rim of the filter, not the flexible center. No cover pressure is required to hold the seal.



4. Install the cover on the air cleaner body with the two arrows pointing up. Secure the cover with the latches.

5. Check all connections and ducts for an air tight fit. Make sure that all clamps, bolts, and connections are tight. Check for holes in piping. Leaks in the air intake system may send dust directly to the engine.

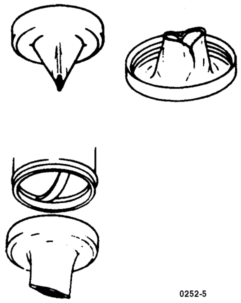
Filter Element Cleaning

It is not recommended that filter elements be cleaned. Cummins and most other manufacturers will not warrant a cleaned air filter.

Air Cleaner Body

Before installing the filter element, remove foreign material (leaves, lint or other foreign matter) that may have collected inside the air cleaner body. Inspect the inside of the body for dents or other damage that would interfere with air flow or with the fins on the element or inside the body. Repair any body dents, being careful not to damage the sealing surfaces. Be sure to clean the sealing surface of the outlet tube and the inside of the outlet tube, taking care not to damage the sealing area on the tube.

Vacuator Valve



Vacuator valves are designed to expel loose dust and dirt from the air cleaner body automatically, thus lengthening the element service life. The valve lips must point straight down and be kept free from debris to operate effectively. Mud and chaff can lodge in these lips periodically and hold them open during engine operation.

Check the condition of the valve and lips frequently and keep them clean. The valve lips should be open only when the engine is shut down, or running at low idle speed. If the valve is turned inside out, check for a clogged air cleaner inlet. Malfunction of this valve does not reduce the air cleaner effectiveness, but does allow the element to get dirty faster and reduces serviceable life. If a valve is lost or damaged, replace it with a new valve of the same part number.

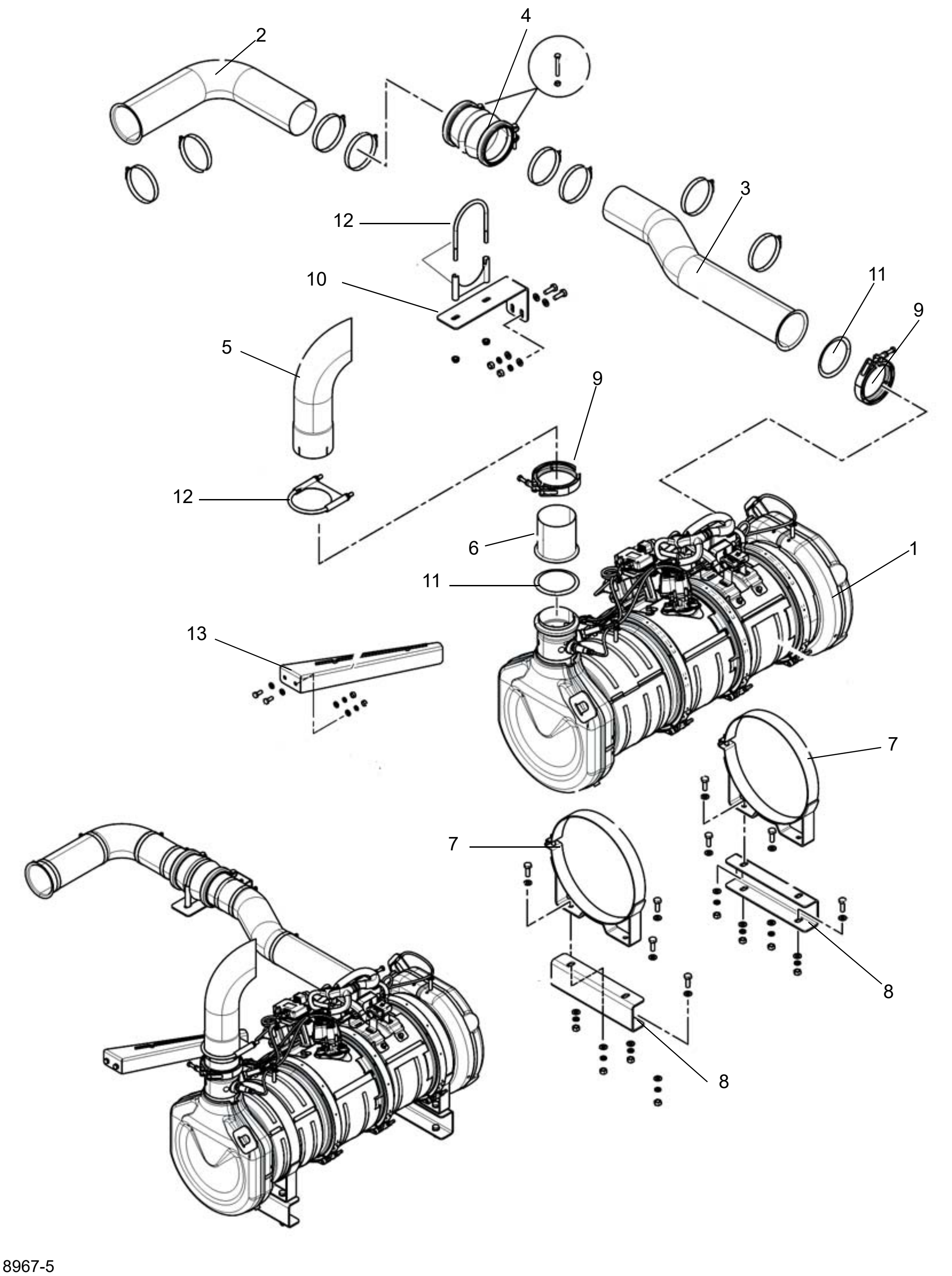
Duct Work

1. Check the intake pipe cap and screen for accumulation of leaves, trash, and other debris that could restrict air flow. Repair the screen or replace the cap if any large holes are found in the screen.

2. Check all mounting hardware for security to eliminate possible vibration of intake piping. Such vibration leads to early failure of hoses, clamps, and mounting parts, and can cause hoses to slip off the connecting pipes, allowing 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.

7



1. After-Treatment Module
2. Exhaust Down Pipe
3. Exhaust Tube
4. Flex Coupler
5. Tailpipe
6. Exhaust Tube - Adapter
7. Mounting Bond
8. Mounting Bracket
9. V-Band Clamp
10 Mounting Bracket - Flex Coupler
11. Gasket
12. U-Bolt Clamp
13. Support Bracket - DEF Lines

FIGURE 7-6

EXHAUST SYSTEM

Description

The exhaust system utilizes a single module after-treatment which is comprised of a diesel oxidation catalyst (DOC), a diesel particulate filter (DPF), a diesel exhaust fluid (DEF) dosing/mixing section, selective catalytic reduction (SCR), and ammonia slip catalyst (ASC) section.

Exhaust System Removal

DANGER

Do not touch exhaust parts until they are at ambient temperature. Severe burning may result.

1. Remove capscrews, lockwashers, flat washers, and nuts to free exhaust system guards. Remove guards.
2. Tag and disconnect all wires and hoses.
3. Remove clamp from inlet of after-treatment module and disconnect the exhaust tube.
4. Remove capscrews, lock washers, flat washers, and nuts to free After-treatment module mounting bands.
5. Using a suitable lifting device remove the After-treatment module.
6. Inspect exhaust tubing, exhaust wrap, outlet sensors and wire leads, and attaching hardware.
7. Inspect the crane's sensor harness wiring that connects to sensor wiring of the exhaust system. Repair or replace any of these components if damaged or missing.

System Installation

1. Install mounting bands on After-treatment Module.
2. Install the After-treatment Module leaving the mounting hardware slightly loose to allow for proper alignment.
3. As needed, loosen the clamps on the After-treatment Module so that it can rotate. Rotate the After-treatment Module so that the tailpipe is vertical and the inlet aligns with the exhaust tube.
4. Install the After-treatment Module and install new gaskets as necessary.
5. Secure all exhaust tubing with appropriate clamps.
6. Tighten the mounting hardware for all the components.
7. Attach the crane's sensor harness wires, as tagged during removal, to the sensor wire leads of the system.
8. Attach the tubing as tagged during removal.
9. Secure all wiring and tubing to prevent damage from heat and abrasion.
10. As needed, install a replacement exhaust wrap around the exhaust tube.
11. Install exhaust system guards and secure with capscrews, lock washers, flat washers, and nuts.

Slip Joint Exhaust Connectors

Slip joint exhaust couplers require tightening to avoid exhaust leaks. Perform the following procedures at the appropriate intervals.

After 1000 Hours, or One Year

Visually inspect the exhaust connector. If necessary, tighten the v-clamps by one full turn of the nuts.

2000 Hours or 2 Years

Tighten the v-clamps by 1 ½ turns of the nuts.

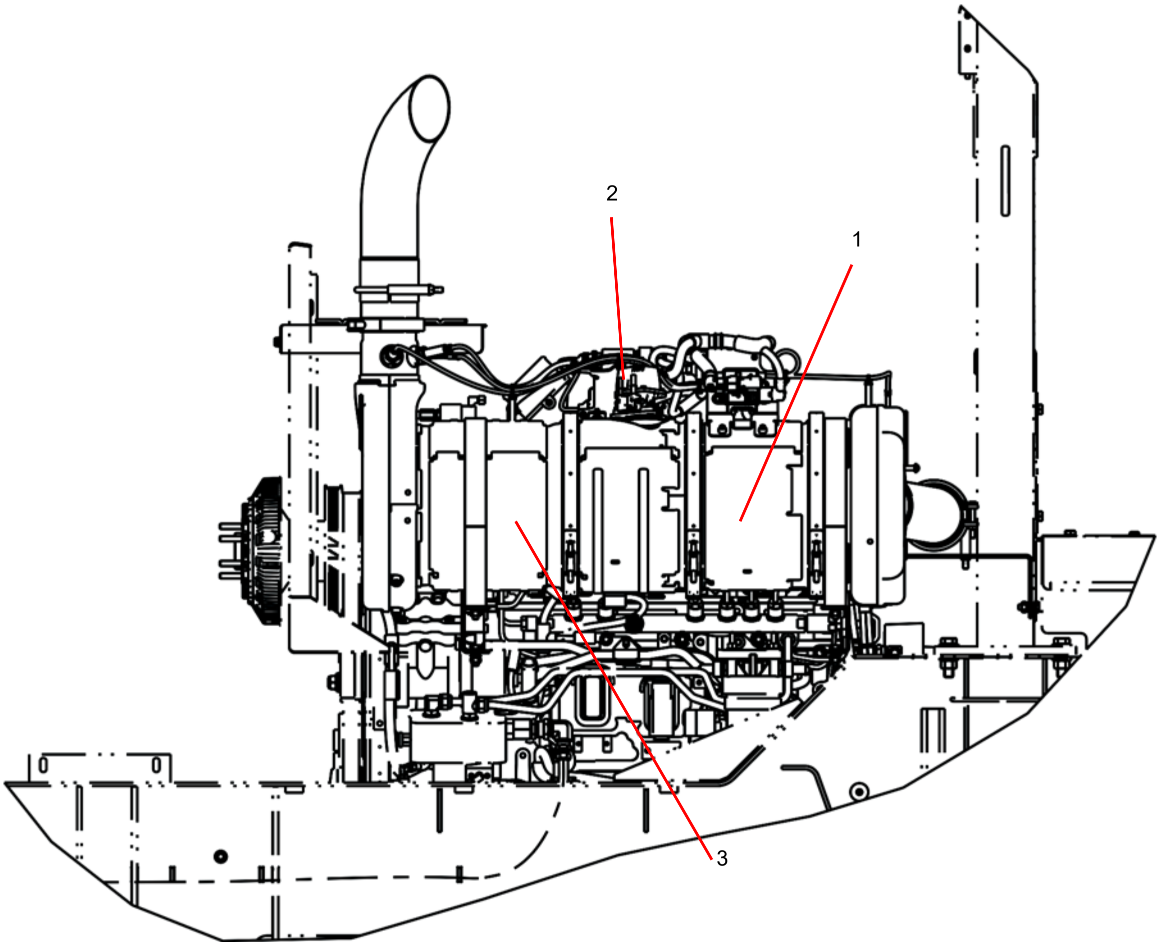
4000 Hours or 4 Years

Tighten the v-clamp by 1 ½ turns of the nuts.

5000 Hours or 5 Years

Remove the v-clamps and gaskets, and replace them with new gaskets and clamps. Tighten the v-clamps to 9.6 to 11.3 N-m (85 to 100 lb-in) of torque.

Exhaust System



1. Diesel Particulate Filter (DPF)
2. Diesel Exhaust Fluid (DEF) Dosing Module
3. Selective Catalytic Reduction (SCR) Stack

FIGURE 7-7

AFTER-TREATMENT DIESEL EXHAUST FLUID (DEF)

DEF Tank

Description

This engine uses a Selective Catalytic Reduction (SCR) system. SCR is a technology that uses a urea based DEF and a catalytic converter to significantly reduce oxides of nitrogen (NOx) emissions.

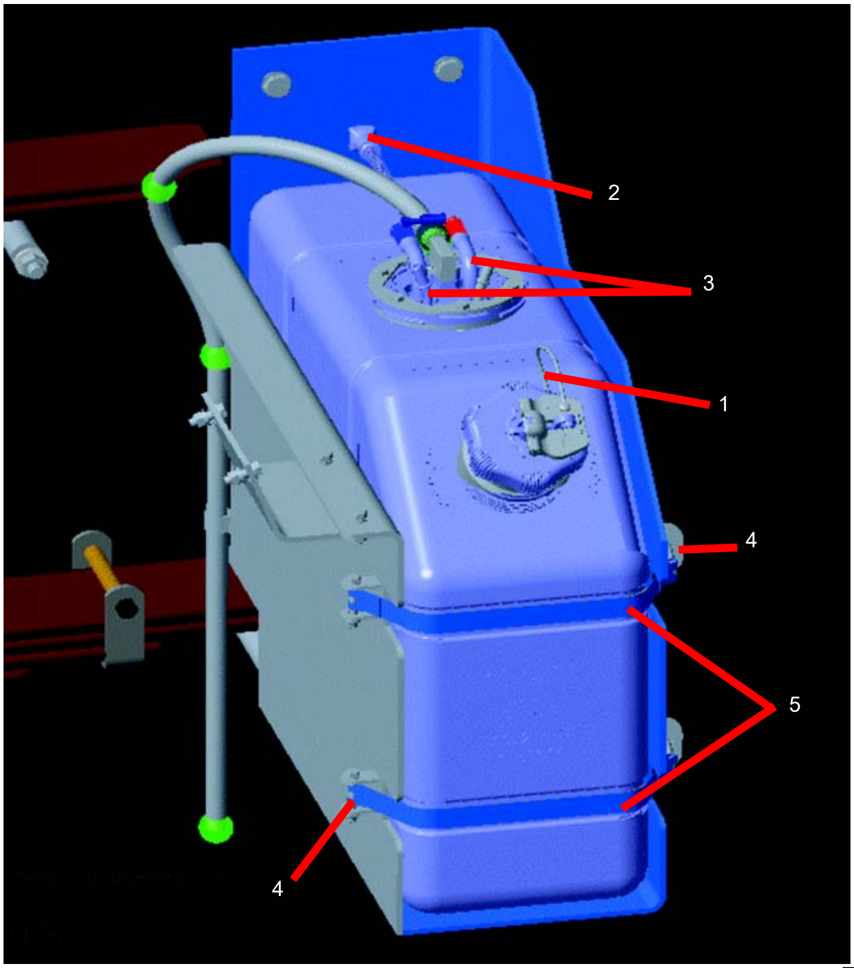
The DEF tank incorporates a fluid level sending unit and a heating element to keep the DEF from freezing.

Removal

1. Tag and disconnect the electrical connectors on the DEF tank.
2. Tag and disconnect the fluid lines on the tank.
3. Remove the hardware holding the tank straps in place.
4. Remove the tank.

Installation

1. Place the DEF tank onto the location on the frame.
2. Place the tank straps around the tank and secure with the hardware.
3. Connect the fluid lines as tagged during removal.
4. Connect the electrical connectors as tagged during removal.



7932a

DEF TANK **FIGURE 7-8**

7

DEF Dosing Unit Filter

The DEF dosing unit filter is a 10-micron filter designed to prevent foreign objects, that may be suspended in the DEF, from entering the dosing system.

Debris can cause permanent damage and premature failure to either the After-treatment DEF dosing unit or the After-treatment DEF dosing valve.

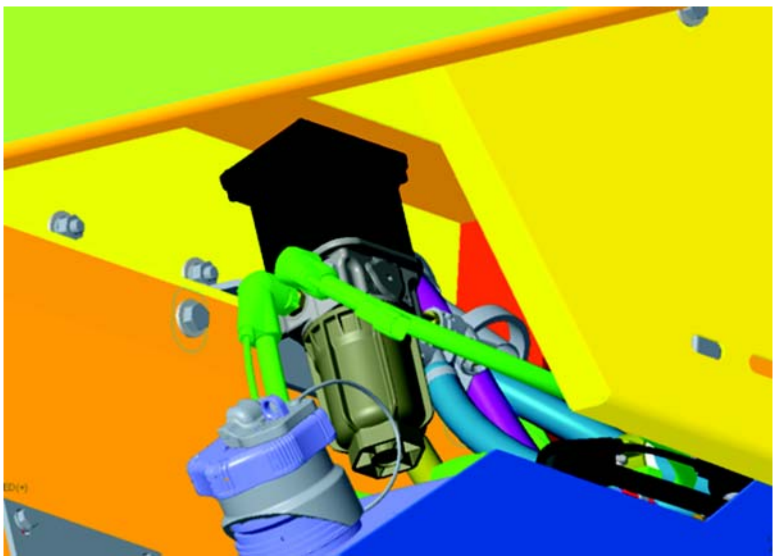
The filter should be replaced every 480,000 km (300,000 miles) or 6500 hours of crane operation.

The After-treatment DEF dosing unit filter consists of the following components:

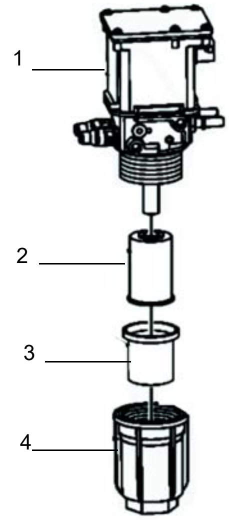
(1) After-treatment DEF Dosing Unit Filter Cap.

(2) After-treatment DEF Dosing Unit Filter Equalizing Element.

(3) After-treatment DEF Dosing Unit Filter Element.



8122-2a



8122-2

DEF Dosing Unit

1. DEF Dosing Unit
2. DEF Dosing Unit Element
3. DEF Dosing Unit Frost Protection Membrane
4 DEF Dosing Unit Filter Housing

FIGURE 7-9

Initial Check

Inspect the area around the seal and vent of the After-treatment DEF dosing unit filter cap for signs of leakage.

DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section in this procedure.

Preparatory Steps

WARNING

DEF contains urea. Do not get the substance in your eyes. In case of contact, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow. In the event the DEF is ingested, contact a physician immediately. Reference the Materials Safety Data Sheet (MSDS) for additional information.

NOTE: Do not disconnect the vehicle batteries until the DEF Dosing System has completed the purge cycle. Before beginning to remove and/or disconnect any components, wait at least five minutes after the key switch is turned OFF for the After-treatment DEF Dosing System to purge the DEF from the system. The purge cycle is an automatic process and does not require intervention to occur. The After-treatment DEF Dosing Unit will create an audible pumping noise during the purging process.

NOTE: Do not power wash or steam clean this unit. Use compressed air to remove any loose debris.

Turn the battery disconnect switch to OFF to disconnect the batteries.

Remove

NOTE: There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

NOTE: In Step 2, the frost protection membrane will be removed. A small amount of DEF could leak.

1. Unscrew the DEF filter housing (4), (Figure 7-9).
2. Remove the frost protection membrane (3), (Figure 7-9). A small amount of DEF could leak out of it.
3. Discard the filter element.
4. Remove the filter element from the unit by twisting, while pulling. Absorb the dripping DEF with a dry, clean lint-free cloth, and dry the unit.
5. Remove the frost protection membrane (3), (Figure 7-9) and inspect. A small amount of DEF could leak out of it.

NOTE: If there is a possibility that contaminated DEF has gone through the DEF Dosing System, check the DEF Filter prior to discarding it.

6. Check the dosing unit filter for evidence of contaminated DEF. Use visual and aroma characteristics of the filer to determine if contaminated fluid has passed through the dosing system.
7. Inspect the DEF filter for debris. If debris is evident, also check the DEF tank filter and the After-treatment DEF dosing unit inlet connector.

Clean and Inspect for Reuse

If there is the possibility that contaminated DEF has gone through the DEF Dosing System, check the DEF filter prior to discarding the filter.

1. Check the DEF for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.
2. Inspect the DEF filter for debris. If debris is evident, also check:

- DEF tank pick up screen.
- The After-treatment DEF dosing unit inlet connector.

3. Discard the filter element and equalizing element.
4. Inspect the After-treatment DEF dosing unit filter cap for cracks or holes that could create a DEF leak path.
5. Check the condition of the threads on the After-treatment DEF dosing unit cap. If the threads are damaged, replace the After-treatment DEF dosing unit filter cap.
6. Inspect the After-treatment DEF dosing unit threads. This is especially important if the After-treatment DEF dosing unit cap was damaged. If the After-treatment DEF dosing unit threads are damaged, replace the entire After-treatment DEF dosing unit.

NOTE: Never operate the vehicle with the DEF filter or filter housing removed.

7. Clean the After-treatment DEF dosing unit filter housing with warm water and a clean cloth.

Install

NOTE: Use only DEF to lubricate the DEF filter O-Ring. The use of any other lubricant can cause damage.

CAUTION

Confirm the filer is correctly seated. DEF system damage will occur if not seated.

1. Lubricate the new filter O-Ring with DEF.
2. Slide the new filter element onto the DEF Dosing Unit.
3. Push up on the filter until a click is heard.
4. Install a new frost protection membrane over the filter element.

NOTE: The sealing bead of the frost protection membrane **must** sit completely in the groove of the pump housing.

NOTE: The provided lubricant **must** be used when installing the filter housing.

5. Spray the supplied lubricant to the threads on the pump housing and sealing bead of the frost protection membrane.
6. Install and tighten the filter housing with a 46 mm socket.

7. Torque Value: 80 n-m (59 ft-lb).

Finishing Steps

WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative battery cable first and attach the negative battery cable last.

CAUTION

DEF is corrosive to certain metals and paint and should be washed off with mild soap and water if spilled.

CAUTION

Do not use the flow test portion of the INSITE™ electronic service tool Diesel Exhaust Fluid Doser Pump Override Test to check the system for leaks. This will spray diesel exhaust fluid into the exhaust system at too low of temperatures to evaporate, resulting in deposit formations in the exhaust system.

NOTE: The After-treatment DEF dosing system will not prime until the correct SCR temperatures are reached. To verify that there are no DEF leaks, initiate a manual regeneration to get the SCR System up to temperature.

1. Connect the batteries by turning the battery switch to ON.

2. Operate the engine and check for leaks.

WATER COOLING SYSTEM

Description

The cooling system consists of the radiators, coolant recovery tank, engine cooling circuit, and the connecting hoses. Cooling system capacity is approximately 37.9 liters (52 quarts). The temperature is controlled by a 83°C (181°F) thermostat located between the top of the engine and the top of the radiator. At all times, the antifreeze/coolant should be properly inhibited against corrosion. It is recommended that a 50/50 fully formulated antifreeze coolant be used at all times.

The radiator assembly consists of the engine water cooler, auxiliary radiator, charge air cooler, and the shroud.

A radiator coolant level switch is in the surge tank. Coolant level high/low signals are supplied to the engine ECM.

The crane is equipped with two hot water heaters: one in the carrier cab and one in the Superstructure cab. Hot water is supplied by the engine coolant system through a cable operated shutoff valve to the heater.

There is also an Optional Superstructure Diesel-fired heater available.

Maintenance

General

The cooling system includes the radiator, coolant recovery tank, thermostat, the fan, and water pump. Radiator hoses are also included in this group.

The cooling system is often neglected because the effects or damage that result from an improperly maintained system usually occur gradually. The cooling system needs to be maintained with the same attention as other systems.

The circulation of water through the cooling system relies entirely upon the water pump. The water pump draws water from the radiator and forces it through the water jacket and cylinder head. There it accumulates heat and flows to the top radiator tank. Then the water flows down through the radiator core and is cooled by air from the fan. This process of removing heat from water as it circulates holds the engine to its efficient operating temperature.

The following paragraphs point out several facts about cooling system components, the effects of cooling system neglect, and procedures to be followed for cooling system maintenance.

Effects Of Cooling System Neglect

Whenever an engine does not perform at top efficiency, a neglected cooling system may be at fault even though the part directly responsible is not a part of the cooling system. Most of these problems can be traced to overheating; however, an engine that is running too cold can be just as troublesome.

Overheating

An engine that is overheating may lead to troubles such as the following:

- Burned valves.
- Pinging or knocking.
- Excessive fuel consumption.
- Poor lubrication - increased engine wear.
- Sticking valves.
- Short injector life.
- Engine hot spots.
- Need for higher-grade fuel.

Overcooling

The following engine troubles result when an engine is overcooled:

- Excessive fuel consumption.
- Sludge formation in crankcase.
- Corrosive acids formed in crankcase.
- Excessive fuel deposits in the exhaust system.

Rust Prevention

To keep engines operating at newness efficiency, all forms of rust formation must be prevented. The formation of rust in the cooling system is a result of the interaction of water, iron, and oxygen, and can only be prevented by maintaining full strength corrosion protection at all times.

For maximum rust, freeze, and boiling point protection, a 50/50 blended, fully formulated extended life antifreeze/coolant should be maintained at all times. Failure to use and maintain the fully formulated coolant will increase maintenance needs.

Engine Antifreeze/Coolant Fill Procedure (When Level is Low)

1. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant. Fill to the bottom of the surge tank filler neck. Fill slowly. Flow exceeding 19 L/min (3 gpm) can give a false reading.

NOTE: If the engine coolant is changed, the coolant filter must also be changed.

2. Wait one minute and recheck the antifreeze/coolant level. Refill as necessary repeating Step 1.
3. Run the engine for 5 minutes and recheck the antifreeze/coolant level. Refill as necessary repeating Step 1.

Engine Antifreeze/Coolant Fill Procedure (After a Complete Draining of the System)

NOTE: If the engine coolant is changed, the coolant filter must also be changed.

1. Open the cab heater valves in both cabs by turning the cab heat on. Make sure that the valves are open at the coolant filter..

NOTE: There are no petcocks in this system that need to be opened during the fill procedure.

2. Slowly fill the system at 11 L/min (3.0 gpm) to the bottom of the surge tank fill neck.

NOTE: A fill rate faster than 11 L/min (3.0 gpm) can give a false reading.

3. Start the engine and run at idle for 10 seconds. Accelerate to high idle for 1 minute and return to idle.
4. Top off the surge tank.
5. Operate the engine through two (2) thermal cycles and re-check the fluid level. Re-fill as necessary repeating Step #2.

Antifreeze/Supplemental Coolant Additives Maintenance Summary

Cooling System Level Check Interval

Daily or 10 hours

The cooling system level should be checked every 10 hours of operation or daily, whichever comes first. Refer to *Lubrication*, page 9-1.

SCA Level Check/Coolant Filter Change Interval

6 months or 500 hours

- Check SCA Levels (use only Coolant Test Kit, Grove P/N 9414101675, to check the coolant additive concentration in the cooling system).

  The Coolant Filter contains molybdate. Therefore, it is important to use the Grove Coolant Test Kit, which checks the molybdate level, regardless of whether the SCA used to replenish the coolant system contains molybdate or not.

  Only add coolant additive if levels are less than 1.2 units/gal. An inadequate concentration of coolant additive can result in major corrosive damage to the cooling system components. Over concentration can cause formation of a “gel” that can cause restriction or plugging of coolant passages, and overheating.

- Change coolant filter.

  Install charged filter if SCA levels are normal or below normal; install non-charged filter if SCA levels are above normal (contact Manitowoc Crane Care for filter part number).

1 year or 1000 hours

- Test antifreeze/coolant for contamination.

  Condemning limits are:

  - Sulfate level greater than or equal to 1500 ppm.
  - Chloride level greater than or equal to 200 ppm.
  - The pH level is less than 6.5.
  - Oil or fuel contamination can be identified by odor or color.

  If condemned, flush the system using a commercially available flushing agent. Refill system with fully formulated extended life coolant. Refer to *Water Cooling System*, page 7-20, and *Lubrication*, page 9-1.

NOTE: Remove the radiator cap when draining the system to ensure proper draining.

Cleaning

CAUTION

The cooling system is pressurized and injury can result when removing the radiator cap at operating temperature.

Use proper protection to remove the radiator cap.

1. Coolant shut-off valves to heaters and other accessories should be open to allow complete circulation during cleaning, flushing, and draining. Run the engine with the radiator covered, if necessary, until the temperature is up to operating range 71 to 82°C (160 to 180°F). Stop the engine, remove the radiator cap, and drain the system by opening the drain cocks on the radiator and engine block.

NOTE: Use a cleaning compound that is not corrosive to aluminum to prevent damage to the radiator.

2. Allow the engine to cool, close the drain cocks, and pour the cleaning compound into the surge tank according to the directions. Fill the system with water.
3. Place a clean drain pan to catch the overflow, and use it to maintain the level in the radiator. Do not spill the solution on the vehicle’s paint.
4. Replace the radiator cap and run the engine at moderate speed, covering the radiator if necessary, so the system reaches a temperature of 82°C (180°F) or above, but does not reach the boiling point. Allow the engine to run at least two hours, or according to recommendations of the manufacturer of the cleaning compound, at 82°C (180°F) so the cleaning solution may take effect. Do not drive the vehicle or allow the liquid level in the radiator to drop low enough to reduce circulation.
5. Stop the engine as often as necessary to prevent boiling.
6. With the engine stopped, feel the radiator core with bare hands to check for cold spots, and then observe the temperature gauge reading. When there is no change in temperature for some time, drain the cleaning solution.
7. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see *Pressure Flushing*, page 7-22) 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 the core with water. Turn on air pressure, in short blasts, to prevent core damage.
5. Continue filling the radiator with water and applying air pressure, as noted 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 the water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. For badly clogged water jackets that do not respond to regular pressure flushing, remove the engine cylinder head and core hole plugs, and with a suitable length of small copper tubing attached to the flushing gun nozzle, and flush the water jackets through the openings.
9. When the vehicle is equipped with a water heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
10. After completing the flushing operation, clean out the overflow pipe; inspect the water pump; clean the thermostat and the radiator cap control valves. Check the thermostat for proper operation before installation.
11. Blow insects and dirt from the radiator core air passages, using water, if necessary, to soften obstructions.

Component Inspection

Radiator/Recovery Tank

1. Top and Bottom Tanks - Look for leaks, particularly where the tank is soldered to the core. Vibration and pulsation from pressure can fatigue soldered seams.
2. Filler Neck - The sealing seat must be smooth and clean. Cams on filler neck must not be bent or worn so as to allow a loose fitting cap. Make sure that the overflow tube is not plugged.
3. Radiator Cap - This is the pressure-setting type. Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of solution due to evaporation and overflow.

   The cap has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure falls below the predetermined point.

   When removing the pressure type cap, perform the operation in two steps. Loosening the cap to its first notch raises the valve from the gasket and releases the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 3 mm (0.13 in). The prongs on the cap can be bent to adjust this condition. Care must be taken that the cap is not too loose as this would prevent proper sealing.

CAUTION

Loosen the cap slowly and pause for a moment to avoid any possible burning by the hot water or the steam.

Continue to turn the cap to the left until it can be removed.

4. Tubes are very small and can become easily clogged by rust and scale. The general condition of the cooling system and operating temperature are indications as to whether or not tubes are clean. Another good test is to feel the core for cold spots.
5. Fins are the thin metal sheets that dissipate heat picked up by the tubes. They should be kept free of bugs, leaves, straw, and so forth so as to allow the free passage of air. Bent fins should be straightened.

Engine Water Jacket

The Engine Water Jacket permits coolant to be circulated around the cylinder walls, combustion chamber, and valve assemblies. Some of these coolant passages are small and can easily become clogged if the cooling system does not receive the proper maintenance.

- Core Plugs - These are sometimes mistakenly called freeze plugs. They do not provide protection against freezing expansion, but are only present because of engine block casting methods. Remove and replace core plugs that show signs of leaking or rusting through. Use an installation tool for core plug replacement.
- Drain Plugs - The water jacket of each engine has one or more drain plugs. These should receive seasonal care and be kept free of rust and scale.
- Gaskets - Must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine. Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

Water Pump

The pump should be checked carefully for leaks and proper lubrication. Replace or rebuild if leaking, cracked, or worn.

Fans and Belts

The fan should be checked for cracked or broken blades. Refer to *Engine Drive Belts*, page 7-6 in this Section.

Thermostat

The thermostat is of the nonadjustable type and is included 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 it 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 also be inspected to make sure they are strong enough to hold a tight connection.

Liquid Density Test Equipment

The antifreeze/coolant concentration must be checked using a refractometer. The “Floating Ball” type density testers or hydrometers are not accurate enough for use with heavy-duty diesel cooling systems.

Antifreeze/Coolant

Heavy-duty diesel engines require a balanced mixture of water and antifreeze/coolant. Fill the system with a 50/50 blended, fully formulated extended life antifreeze/coolant at all times. Refer to the *Lubrication*, page 9-1 Section of this manual. Do not use more than 50 percent antifreeze/coolant in the mixture unless additional freeze protection is required. Never use more than 68 percent antifreeze/coolant under any condition. Antifreeze/coolant at 68 percent provides the maximum freeze protection; antifreeze/coolant protection decreases above 68 percent.

Coolant Filter

The engine has a coolant filter of the canister or spin-on type that requires periodic servicing. It is suggested that this be done when the engine oil and filter are changed. Refer to *Antifreeze/Supplemental Coolant Additives Maintenance Summary*, page 7-21. There is a shut-off valve located on the coolant filter head. Turn it to the OFF position before removing the filter. After changing the filter, be sure the valve is positioned to the ON position.

Radiator Assembly Removal and Installation

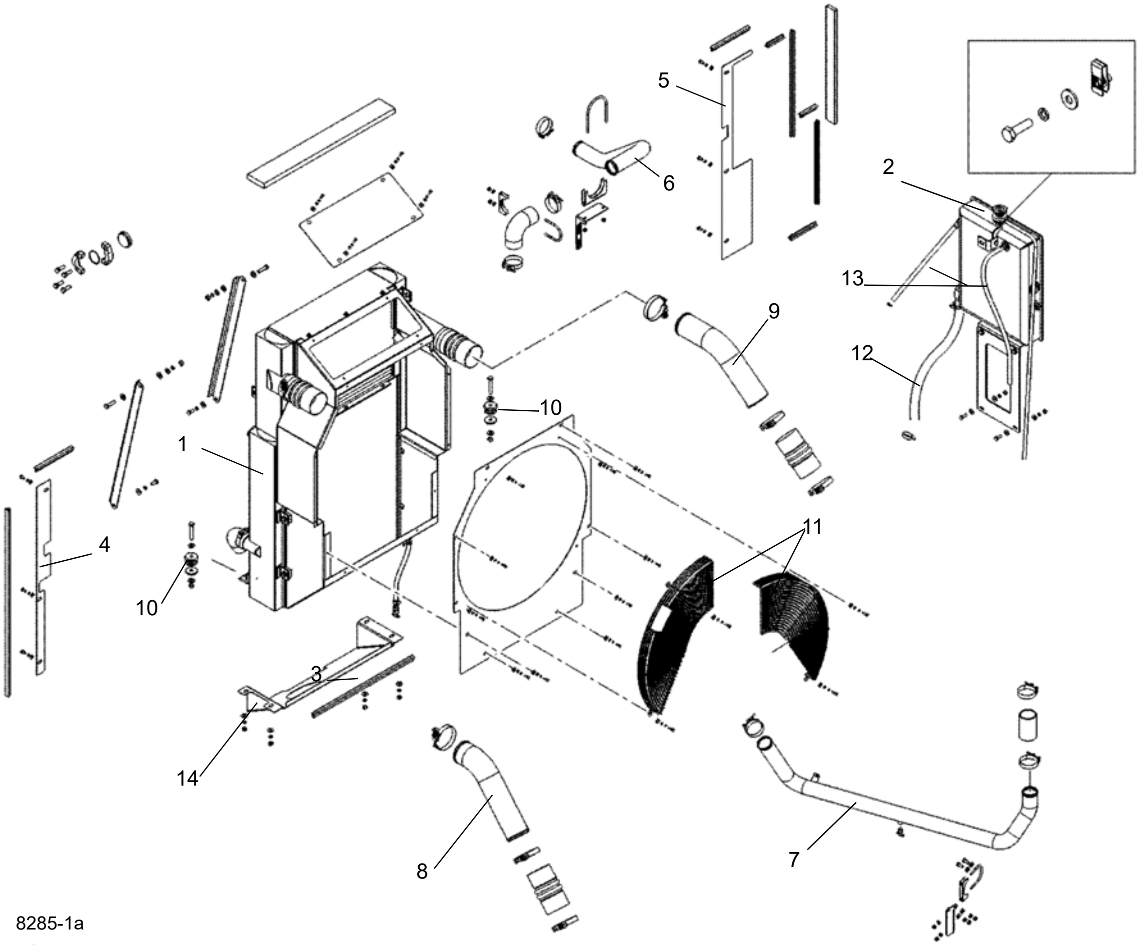
Removal

1. Set the outriggers and position the boom to over the side. **Note:** the Boom could also be positioned over the rear of the machine.
2. Disconnect the battery.
3. Open the drain cocks at the bottom of the radiator and drain the coolant into a suitable container. Dispose of any/all coolants/liquids in accordance with local and EPA regulations. Refer to *Environmental Protection*, page 9-1 of this manual.
4. Open the left and right hood access doors.
5. Disconnect the hoses from the coolant recovery tank and remove the tank.
6. Remove the hardware securing the top center hood panel to the front and rear cowls and remove the panel with doors from the crane.
7. Remove the hardware securing the left and right lower side panels to the front cowl.
8. Remove the hardware securing the front grill panel to the front cowl and remove the grill.
9. Remove the hardware securing the front cowl and remove the front cowl.
10. Disconnect the CAC hoses from the charge air cooler assembly.
11. Disconnect the hoses from the top and bottom of the radiator assembly.
12. Remove the bolts, washers, and lockwashers attaching the fan guard to the shroud. Remove the fan guard.

NOTE: The radiator assembly weighs approximately 137 kg (302 lb).

13. Attach an adequate lifting device to the radiator/charge air cooler assembly.
14. Remove the nuts, hardened washers and mounts securing the radiator/charge air cooler assembly to the mounting brackets and remove the assembly from the carrier.

Engine Radiator/Charge Air Cooler Assembly



Item	Description
1	Radiator/Charge Air Cooler
2	Surge Tank
3	Drain Cock
4	Left Hand Baffle
5	Right Hand Baffle
6	Top Radiator Tube
7	Bottom Radiator Tube

Item	Description
8	Cold CAC Tube
9	Hot CAC Tube
10	Radiator Mount
11	Fan Guards
12	Coolant Recovery Hose
13	Vent Hoses
14	Sheet Metal Piece

FIGURE 7-10

Installation

1. Position the radiator/charge air cooler assembly in the carrier using a lifting device and secure to the mounting brackets using the mounts, hardened washers, and nuts.
2. Position the fan guard on the shroud and secure with bolts, washers, and lockwashers.

3. Connect the air cooler tubes to the air cooler using the bellows and clamps. Tighten the clamps to 4 to 5 N-m (35 to 45 in-lb).
4. Connect the hoses to the top and bottom of the radiator.
5. Ensure the drain cock is closed.
6. Position the front cowl on the frame and secure with the attaching hardware.
7. Position the front grill panel on the front cowl and secure with the attaching hardware.
8. Attach the left and right side lower panels to the front cowl with the attaching hardware.
9. Position the top center panel, with doors attached, on the front and rear cowl and secure with the attaching hardware.
10. Install the coolant recovery tank. Connect the hoses to the tank.
11. Service the engine coolant system as necessary. Start the engine, operate all systems and check for leaks.

DRIVE TRAIN

Description

The drive train consists of the automated transmission and drive lines.

The transmission is 11 speed forward and three speed reverse and is controlled through a remote shifter. Range shift is air controlled. The transmission oil is cooled by an oil cooler mounted in front of the radiator.

There are two driveshafts connected between the transmission and the front rear axle. An inter-axle shaft connects the rear axles.

MAINTENANCE

Drive Lines

CAUTION

Do Not Disassemble Drive Lines When Removing Them From The Crane!

Dirt can enter the spline and cannot be purged. In addition, the drive lines are assembled in a specific orientation when manufactured and can easily be incorrectly reassembled.

Removal

1. Support the drive line being removed so it does not fall when disconnected.
2. Remove the bolts from the bearing cap on each end of the drive line. Remove the drive line.

Installation

1. Position the drive line, install the bearing cap bolts and tighten bolts securely.
2. Torque the bearing cap bolts on the drive line 155 to 183 N-m (115 to 135 ft-lbs).

Lubrication

Drive line U-joints are permanently lubricated and do not have any provisions for servicing. Also refer to *Lubrication*, page 9-1 in this manual.

Drive Line Installation

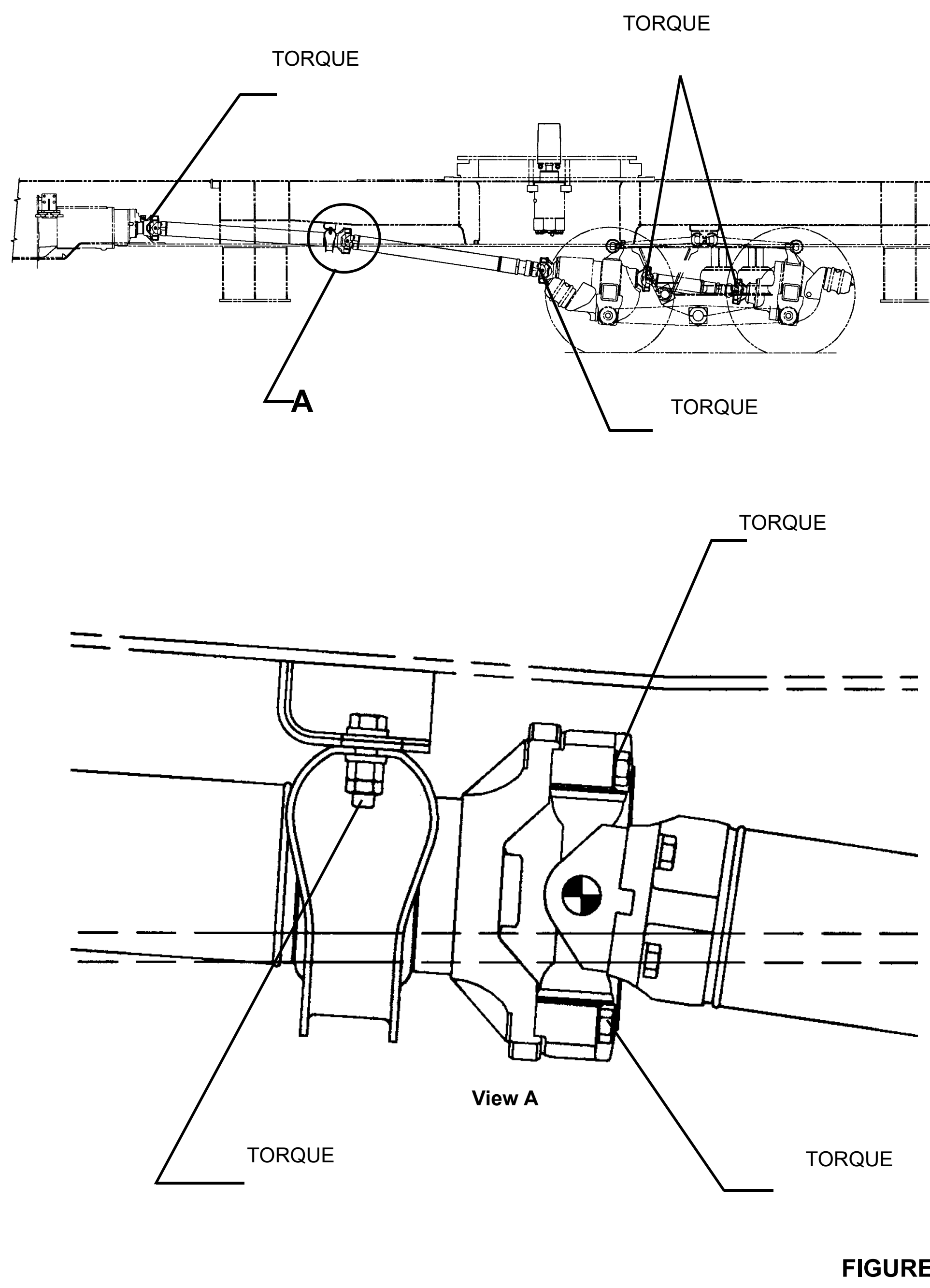


FIGURE 7-11

ELECTRONIC CLUTCH ACTUATOR (ECA)

All Fuller UltraShift PLUS Model transmissions require an adjustment-free Electronic Clutch Actuator (ECA) UltraShift clutch.

Installation Instructions

- Install two guide studs into the upper mounting holes. Be sure to use guide studs to make sure of the proper alignment of the clutch assembly to the flywheel.
- Use a lifting device to pick up the clutch.

NOTE: The intermediate plate is bolted to the cover assembly and the rear disc is in between the pressure plate and the intermediate plate. Do not unbolt the intermediate plate from the cover assembly.

- Insert aligning tool through the bearing and splined strapped driven disc.

NOTE: The alignment tool for the ECA UltraShift clutch is a 14-tooth shaft and is 1-3/4" longer. A modified input shaft (Eaton P/N 4306034 or contact Manitowoc Crane Care) can be used as an alignment tool.

- Install second disc onto aligning tool. Follow the orientation instructions on the disc.
- Slide the clutch assembly over the guide studs and start six of the clutch mounting bolts. Start at the lower left when tightening the clutch mounting bolts. This will make sure that the clutch is properly pulled into the flywheel pilot. Failure to do this could result in improper piloting of the clutch and cause clutch damage. Tighten the clutch mounting bolts in a crossing pattern to 54-68 N-m (40-50 ft lbs) as on any other clutch. Remove the guide studs and install the two remaining bolts.
- Remove the shipping bolts in an even 1/4 turn crossing pattern.
- Remove the alignment shaft.
- The release bearing shall be positioned so that the orientation of the lube fitting/hose is in the 4 o'clock position.

NOTE: No initial clutch adjustment is required.

ECA Removal and Assembly Instructions

If transmission removal is necessary, the ECA must first be released from the clutch by one of two methods.

The first method is to use ServiceRanger. ServiceRanger is the computer diagnostics and service tool designed for support of the automated transmission and powertrain system.

1. Go into the Advanced Product Functions and select ECA clutch service utility. This page will give instructions for a variety of operations.
2. Select “Move to Service Position” and click next.
3. Once in the Electronic Clutch Actuator (ECA) service utility, select the button that says: “Move to Service Position”. This will rotate the clutch fork to the open position so that the transmission can be pulled back from the engine without damaging the clutch.

The other option is to remove the ECA by using the following instructions. Refer to the following procedure in the even that the Electronic Clutch Actuator (ECA) Assembly requires removal and replacement.

ECA Removal

- Cut the tie straps that secure the ECA harness (if applicable).
- Disconnect the harness to the ECA.
- Remove the (4) 3/8"-16 capscrews that secure the ECA bracket. Remove the bracket.
- Remove the (4) 3/8"-16 capscrews that secure the ECA to the housing. Remove the ECA. The ECA will need to be rotated to line up a locating pin with a notch in the housing in order to remove the ECA from the clutch housing.

ECA Installation

- Make sure that the clutch fork is positioned against the stop.
- Apply anti-seize compound to the bore of the ECA.
- The ECA will need to be rotated to line up a locating pin with a notch in the housing in order to install the ECA into the clutch housing.
- Install the ECA onto the housing, while matching the splines of the ECA motor to the shaft.
- Install (4) 3/8"-16 capscrews to secure the ECA to the housing. Torque to 34-47 N-m (25-35 ft lbs).
- Install (4) 3/8"-16 capscrews to secure the ECA support bracket with applying loctite 242 to the threads. Torque capscrews to 34-47 N-m (25-35 ft lbs).
- Reconnect the appropriate wire connectors.
- Replace the tie straps that secure the harnessing.

TRANSMISSION

Removing Transmission from Engine

Follow the procedure to remove the engine and transmission as outlined under the *Engine Removal*, page 7-2 Section of this Manual.

1. Attach a two-point lift chain with a minimum capacity of 680 kg (1500 lbs) to the transmission.
2. Remove the capscrews securing the transmission to the engine.
3. Slide the transmission out of the engine.

Mounting Transmission to Engine

Use the two transmission lifting eyes provided. The lifting eye position shall not be changed on the transmission.

1. Use a two-point lift chain or transmission jack with a minimum capacity of 680 kg (1500 lbs).
2. Inspect the engine to transmission mating surfaces for damage or debris prior to installation. Make sure that the engine flywheel housing face, transmission clutch housing face, input shaft, etc. are free of paint, debris, rust, and any type of damage before installation.
3. Manually index the input shaft to mate up with the clutch splines.
4. Make sure the grease fitting on the release bearing is at approximately the 4 o'clock position to allow installation of the of grease tube.
5. Adjust the lift chain or transmission jack to obtain the same relative angle as the engine. The face of the engine flywheel housing and the face of the transmission clutch housing shall be parallel during installation. Rotate the output shaft/yoke while sliding the input shaft into the clutch to line up the splines. If the transmission is properly aligned and the clutch splines are properly aligned, very little force is required to slide the input shaft through the clutch and into the pilot bearing.

   If interference is encountered, move the transmission away from the engine to investigate the cause. The use of excessive force to overcome misalignment may cause damage to the transmission input shaft and the clutch.

   The clutch/yoke will remain in the released position during the entire transmission installation. A key on the ECA will rotate the clutch/yoke to its proper position.

Once the transmission is seated against the engine flywheel housing, align the clutch housing bolt holes with the engine flywheel housing bolt holes and install all capscrews and tighten (4) capscrews 90 degrees apart starting with the cap screw immediately above the ECA. Then tighten the remaining (8) capscrews.

NOTE: The clutch housing shall be flushed against the engine flywheel housing before tightening any capscrews. Do not use the capscrews to seat the housing.

NOTE: The use of a swivel socket may be required for the (2) bolts entering through the ECA device.

NOTE: Do not tighten any mounting capscrews until all capscrews have been installed and finger tightened. Do not remove the transmission support chain or jack until all mounting bolts have been tightened.

7

PUMP/PTO ASSEMBLY

The PTO driveline (1), (Figure 7-12) powers the no. 2 pump (2), (Figure 7-12) in the L9 engine installation.

Pump/PTO Replacement

CAUTION

Damage Could Occur!

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

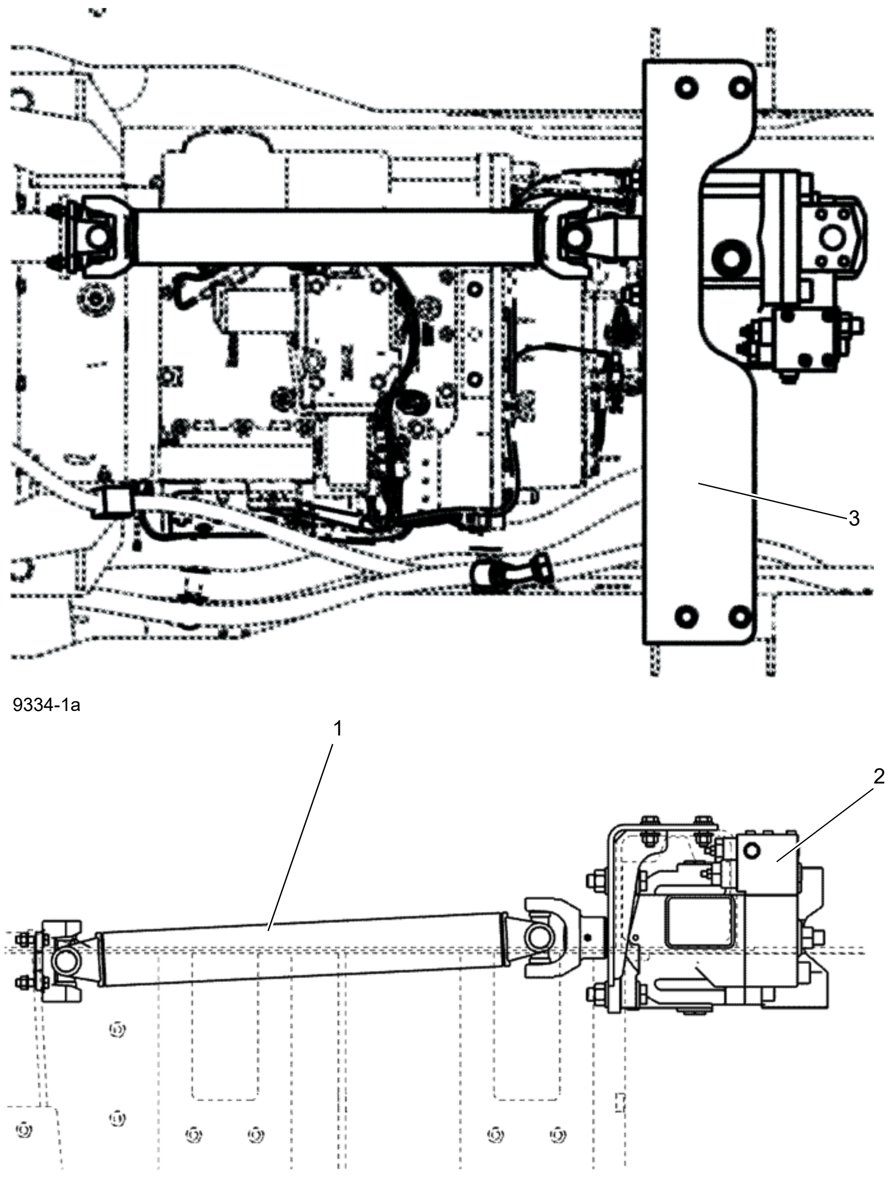


FIGURE 7-12

Removal

1. De-pressurize the hydraulic system.
2. Remove the cap screws, nuts, and washers connecting the PTO Driveline (1), (Figure 7-12) to the engine. Remove the driveline.
3. Tag, disconnect, and plug or cap the hydraulic hoses and ports on the pump (2), (Figure 7-12).
4. Tag and disconnect the electrical connectors to the pump.
5. Remove the four cap screws, nuts, and washers securing the pump mounting bracket (3), (Figure 7-12) to the frame.
6. Attach a suitable lifting device to the mounting bracket/ pump assembly—the assembly weighs approximately167 kg (368 lb).
7. Remove the assembly and place on a suitable workbench.

Installation

1. Using the lifting device, place the mounting bracket/ pump assembly onto the crane and loosely assemble with the cap screws, nuts, and washers.
2. To prime the pump, add hydraulic oil to the pump and hoses before installation.
3. Connect the electrical connectors and hoses to the pump as tagged during removal.
4. Tighten the hardware connecting the mounting bracket/ pump to the frame. Torque the hardware. Refer to *Fasteners and Torque Values*, page 1-14.
5. Install the driveline onto the pump input shaft and transmission output. Secure the driveline to the transmission with the cap screws, nuts, and washers. Torque the hardware. Refer to *Fasteners and Torque Values*, page 1-14.
6. Start the engine and check for leaks. Also, refer to *Piston Pump Start-up Procedure (Pump No. 2)*, page 2-15.

7

THIS PAGE BLANK

SECTION 8
UNDERCARRIAGE

SECTION CONTENTS

Axles **8-1**
Description 8-1
Maintenance **8-2**
Front Axle 8-2
Rear Axles 8-7
Wheels and Tires **8-12**
Description 8-12
Vehicle Maintenance Schedule 8-12
Steering System **8-13**
Description 8-13
Maintenance 8-13
Steering Gearbox **8-16**
Description 8-16
Maintenance 8-16
Air System **8-17**
Description 8-17
Theory of Operation 8-17
Braking 8-20
Maintenance 8-20
Air System Components 8-22
Brakes **8-32**
Description 8-32
Air Supply 8-33
Normal Braking 8-33
Vehicle Parking 8-33
Anti-lock Braking Systems (ABS) 8-33
Automatic Traction Control 8-33
Emergency Braking 8-33
Non-Asbestos Warning **8-33**
Front Brakes **8-34**
Description 8-34
Maintenance 8-34
Automatic Slack Adjuster **8-40**
Description 8-40
Maintenance of Slack Adjuster 8-40
Rear Brakes **8-43**
Description 8-43
Maintenance 8-44
Rear Brake Assembly 8-48
Anti-Lock Brake System (ABS)/Automatic Traction Control (ATC) **8-51**
ABS System Description 8-51
ATC System Description 8-53
ABS Troubleshooting. 8-55
Troubleshooting Diagnostic Trouble Codes: Traction Control Valves 8-63
Power Supply Tests. 8-65
Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications. 8-65
Miscellaneous Troubleshooting 8-67
Troubleshooting Wiring 8-68
Special Tools **8-71**
Tests, Repair and Adjustment 8-71
Component Removal and Installation 8-73
Outriggers **8-75**
Description. 8-75
Theory of Operation. 8-75
Maintenance 8-76
Extension Cylinder. 8-83
Maintenance for Extension Cylinder 8-83
Outrigger Jack Cylinders **8-83**
Description. 8-83
Maintenance for Jack Cylinders. 8-83
Center Front Jack Cylinder. **8-84**
Description. 8-84
Maintenance for Center Front Jack Cylinder 8-84
Functional Check of Center Front Jack Cylinder . 8-85
Outrigger Monitoring System. **8-87**
Description. 8-87
OMS Linear Position Sensors 8-87

AXLES

Description

The carrier has one front steer axle (Figure 8-1). The axle is suspended on both sides by flat leaf spring units that have eyes that locate the axle. To help reduce road shock, shock absorbers are attached to the frame and the bottom spring mounting plates. The axle is built of a forged I-beam center section and heat-treated steel forged knuckle pins.

The rear axles have single reduction differentials. The differentials have hypoid drive pinions, ring gear sets, and bevel gears. A straight roller bearing is mounted on the head of the drive pinion and all other bearings are tapered roller bearings. If equipped with a differential lock, the differential has the same gears and bearings as the standard differential. An air actuated shift collar moves toward the center of the differential and when the splines of the shift collar and axle shafts are meshed, the differential is locked.

Rear Axle Suspension

The rear axle suspension uses air bags with walking beams. The air bags, along with shock absorbers, are mounted on trailing arm assemblies above the walking beams. They provide for cushioning of road shock. The trailing arm assemblies are connected at the front by pivot blocks to carrier mounted brackets. The air bags and shock absorbers are bolted to the rear of the trailing arm assemblies and to carrier mounted brackets. A walking beam center is attached to each trailing arm assembly with the ends attached to each rear axle.

Rubber bushings in the walking beam centers and ends, and torque rod ends, restrict excessive movement but allows enough movement to relieve stresses on metal parts. The rubber joints allow a certain amount of in and out axle movement which permits each axle to follow its own natural course more closely through turns. Once a straight line is resumed, the bushings square off the tandem so that the leading tires set the tracking pattern. Torque rods, along with the walking beam, create a parallelogram-style linkage that assures positive axle alignment.

Air for the suspension system is controlled by a control valve on the left sideof the console in the carrier cab and by two height control valves mounted on each side of the frame by the air bags. Each height control valve is mechanically actuated by a control lever attached to its respective trailing arm assembly. The valve controls the amount of air in each set of air bags thus controlling the height of the frame. To deflate the entire air suspension system, position the SUSPENSION control valve on the carrier cab side panel to DEFLATE. This causes the two height control valves to shift and dump all air from the suspension air bags.

MAINTENANCE

Front Axle

Front Axle Fasteners

Tighten the axle bolts to 481 to 522 N-m (355 to 385 pounds-foot) after the first (1287.4 km) 800 miles and check every six months thereafter.

The axle bolts conform to SAE Grade 8 specifications. Do not replace them with standard bolts.

Springs

The two main causes of leaf spring failure are loose bolts and fatigue. Proper maintenance can eliminate failures resulting from loose bolts; however, spring service life is limited by fatigue.

Fatigue failures are progressive which can start at a scratch, notch, or point of rust. These cracks are apt to start on the tension side of the leaf, usually near the corners, and become progressively larger as the spring flexes.

Some of the factors affecting spring life are vehicle gross weight, type of load, road conditions, speed, and maintenance. Repairs do not restore the fatigue lift of reused leaves and it may be cheaper to use new springs rather than repair the old ones. The problem is to determine when it is better to repair broken springs. Consideration should be given to spring mileage, number of previous repairs, and the cost of repairs as compared to the cost of new springs.

Guidelines for spring repair are as follows:

1. Repair the spring if the spring has been previously repaired less than two times.
2. Repair the spring if the spring mileage is less than half the normal life.
3. Repair the spring if the cost of repairs is less than two-thirds of the cost of a new spring.

Front Axle Removal

NOTE: The Front Axle does not have to be removed from the crane for maintenance.

1. Raise the crane on outriggers until the weight is off the tires and place jack stands under the carrier frame.
2. Completely drain the air pressure from both systems.
3. Remove the tire and wheel assemblies from both sides of the axle.
4. Place an adequate lifting/supporting device under the axle.
5. Tag and disconnect the air lines. Cap all hoses and openings.
6. Remove the cotter pin, nut, and washer(s) securing the drag link to the steer arm on the axle.

NOTE: Do not change the drag link dimensions. This will make wheel alignment easier when the axle is reinstalled. The dimension should be about 1994 mm (78.50 in).

7. With the axle fully supported, remove the eight bolts and hardened washers securing the axle to the bottom spring mounting plates. Remove the axle.

Front Axle Installation

1. Position the axle under the crane.
2. Align the holes in the axle with the spring bottom mounting plate. Install the eight bolts and hardened washers and torque the bolts to 481-522 N-m (355-385 ft-lb).
3. Install the drag link on the axle steer arm. Install the nut and washer(s) and torque the nut to 163-231 N-m (120-170 ft-lbs). Tighten to the nearest cotter pin hole and install the cotter pin.

NOTE: Use washers, as necessary, to allow the cotter pin to engage the nut.

4. Connect the air lines to the air chambers as per the removal tags.
5. Service the axle. Refer to *Lubrication*, page 9-1 Section of this manual.
6. Build up the air pressure in the system and check for leaks.
7. Remove the blocking from under the axle.
8. Install the tire and wheel assemblies. Refer to *Wheels and Tires*, page 8-12 of this Section.
9. Retract the outriggers.
10. Check the axle for proper operation.

Alignment

Have a qualified alignment specialist inspect the machine for compliance with the following machine specifications:

- Tire pressure (front & rear): 120 psi (If experiencing tire wear due to over-inflation, contact Crane Care for alternate tire inflation solutions).
- Tire/Wheel lateral & radial run-out: 0.060” maximum.
  For Run-out Tolerances use the 30/60/90 Rule:
  0.000” - 0.030”: Excellent
  0.031” - 0.060”: Good
  0.061” - 0.090”: Use 3R’s:
  - Rotate tire 180 degrees . . . .
  - Re-lubricate tire and wheel
  - Re-inflate with tire laying flat (5 psi. max). . . .
  0.091” - Higher: Inspect all wheel end components.
- Ride Height: 1.62” +/- 0.19” between trailing arm and suspension stop. 0.19" max difference side to side.
- Steer and Drive axles offset:0.00” +/- 0.19”
- Drive axles parallelism: 0.00” +/- 0.13”
- Drive tandem thrust: 0.75” maximum
- Steer axles toe: +0.030” +/- 0.030”
- Steer axle wheel ends caster: 3.00 degrees +/- 1.00 degrees.
- Steer axle wheel ends camber: +0.25 degrees +/- 0.44 degrees (not adjustable).

8

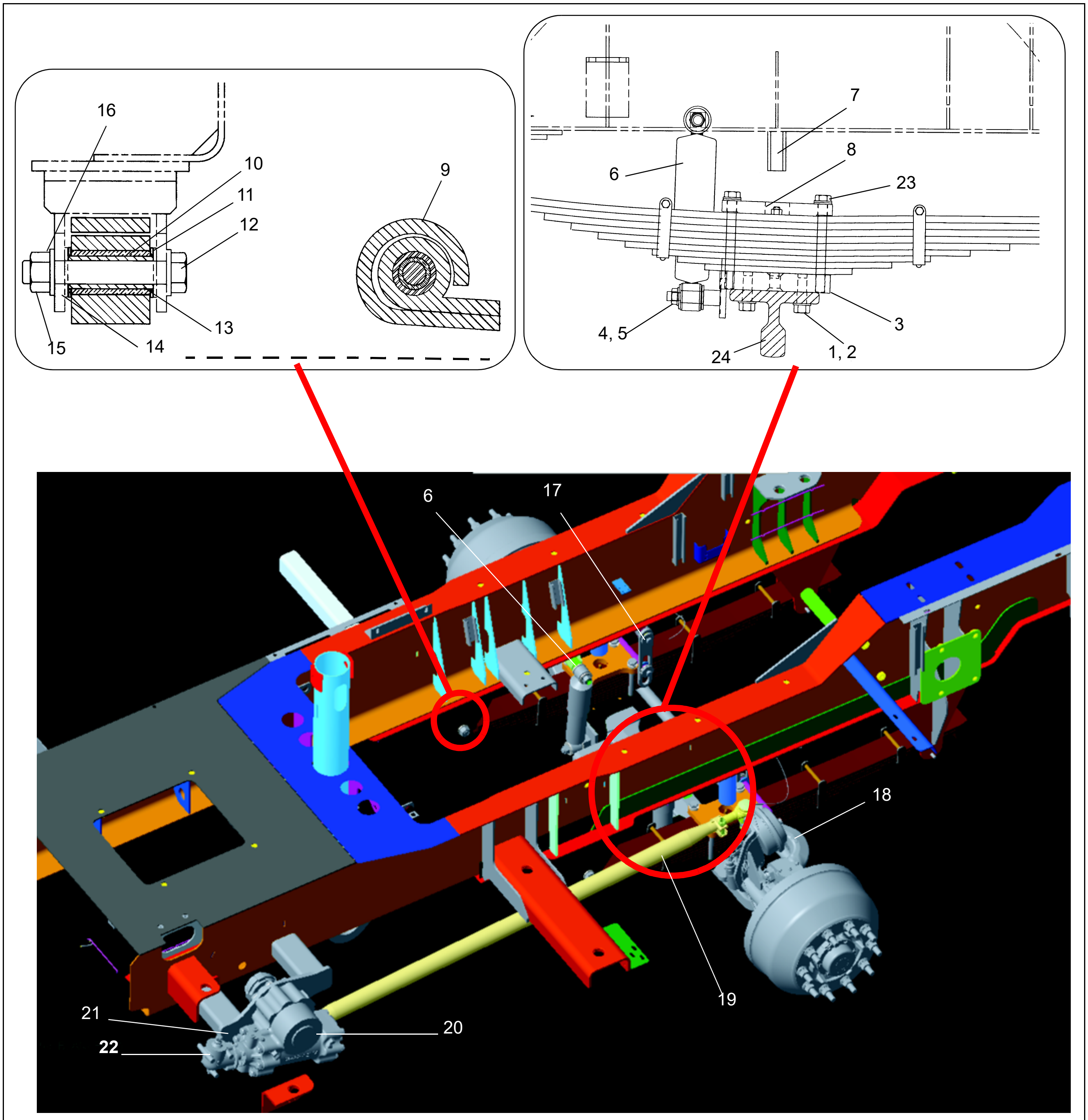


FIGURE 8-1

Item	Description	Item	Description
1	Bolt	13	Inner Bushing
2	Washer	14	Washer
3	Spring Mount	15	Nut
4	Hex Nut	16	Washer
5	Washers	17	Hangar Link
6	Shock Absorber	18	Steer Arm
7	Axle Stop	19	Drag Link
8	Top Plate	20	Steering Gear
9	Spring	21	Steering Column
10	Outer Bushing	22	Miter Gear
11	Washer	23	Bolt
12	Capscrew	24	Axle

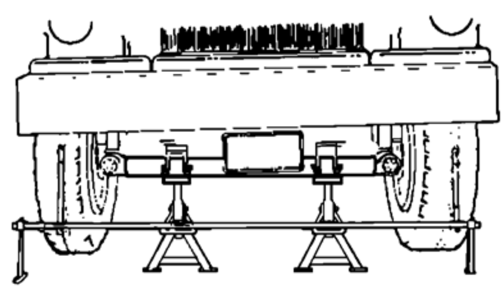
Toe-In Adjustment

Toe-in (Figure 8-3) is having the wheels of a steerable axle closer together in the front than in the rear. Toe-in is necessary for both tire wear and to keep the wheels from weaving side to side.

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Set the parking brake.
2. Use jacks to raise the vehicle so that the front tires are off the ground. Support the front axle with safety stands.
3. Use paint or chalk to mark the center area of both front tires around the complete outer surface of the tire.
4. Place the pointers of a trammel bar on the marks of each tire. Rotate the tires. Verify that a straight line is marked on the outer surface of the tire.
5. Lower the vehicle to the floor. Do not measure toe with the front axle in the raised position. The weight of the vehicle must be on the front axle when toe is measured. Move the vehicle FORWARD and BACKWARD 10 feet (3 meters).
6. Place the trammel bar at the back of the tires. Raise the pointers so that the pointers are level with the spindles. Align the pointers with the marks on the tires. Measure and record the distance between the pointers.
7. Repeat Step 6 for the front of the tires (Figure 8-2).



6958-1

FIGURE 8-2

8. To obtain the toe measurement, subtract the distance reading between the front of the tires from the distance reading between the back of the tires as shown in (Figure 8-3).
9. Use the following procedure if the toe measurement is not within the correct specifications:

   1.587mm (1/16 inch) ± 0.794mm (1/32 inch) for Unloaded vehicle.

8

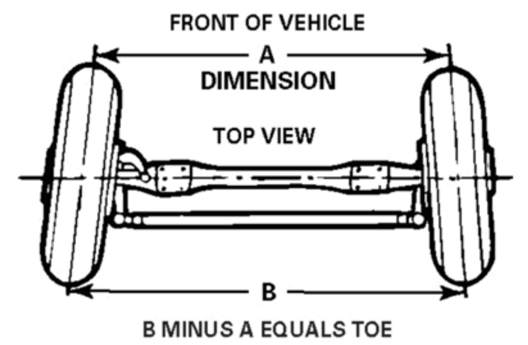


FIGURE 8-3

0.794mm (1/32 inch) ± 0.794mm (1/32 inch) for Loaded vehicle.

a. Loosen the tube clamp nut and bolt on each end of the cross tube.

b. Turn the cross tube until the specified toe distance is obtained.

c. The threaded portion of the tie rod end must be installed into the cross tube beyond the point where the tube slot stops.

d. Tighten the nut and bolt on each end of the cross tube to the specified torque.‘

5/8”-11 torque to 55-81N-m (40-60 ft lbs).

3/4”-10 torque to 211-237 N-m (155-175 ft lbs).

10. Repeat Step 1 through Step 8 to check the toe dimensions as shown in (Figure 8-3).

Drag Link Installation

1. Adjust the drag link to the dimensions shown in (Figure 8-4). Keep the exposed threads at the ends of the vertical socket equal and within specified maximums. Torque the drag link ball joints to 292 N-m (215 ft-lb).

Initial Adjustment of Axle Stop Bolts

1. Set the axle stops to get the proper cramp angle. This should result in the steering wheel turning equalrevolutions from the center for both the left and right turns.

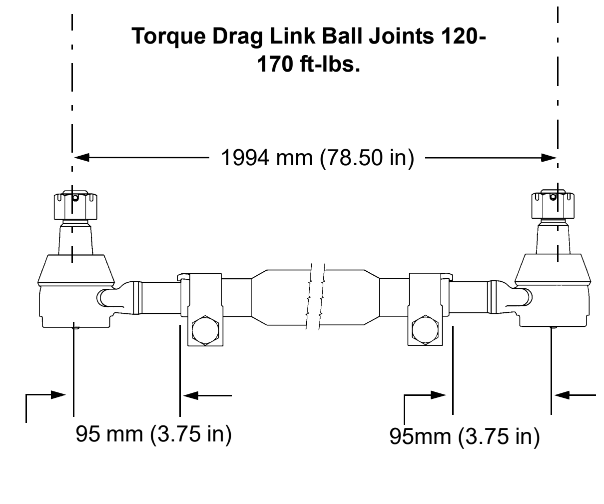


FIGURE 8-4

2. Turn the wheel in one direction until the wheel is stopped by the axle stop bolt.

3. Adjust the axle stop bolt until there is a 1.5 mm (0.06 in) clearance between the axle stop and the axle beam. Refer to (Figure 8-5).

4. Repeat for travel in the opposite direction.

Final Adjustments

1. Inflate tires to the pressure specified on the tire inflation chart, located in the load chart manual in the cab.

2. To make sure of the proper adjustment, drive the front wheels onto greased plates or a suitable turntable so that the friction between the tires and the ground is reduced.

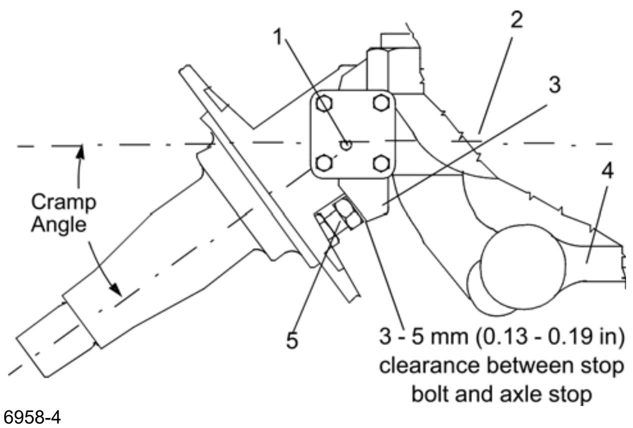
3. Position the wheels straight ahead. If the wheels cannot be positioned straight ahead, adjust the drag link until the straight ahead position is obtained. Do not adjust beyond the maximum dimension on the drag link ends.

Setting Axle Stops

1. Start the engine and let it run at idle.

2. Turn the wheels in both directions and check for clearances. Tire clearances should be no less than 25 mm (1.00 in).

Setting Axle Stops



Item	Description
1	King Pin Center
2	Axle Center Line
3	Axle Stop
4	Tie Rod
5	Axle Stop Bolts

FIGURE 8-5

3. Adjust the axle stop as necessary to get the maximum cramp angle and proper tire clearance. A tire clearance greater than 38 mm (1.50 in) is permissible if the tie-rod/axle bolt clearance is limiting the cramp angle.

Automatic Steering Gear Relief Plungers

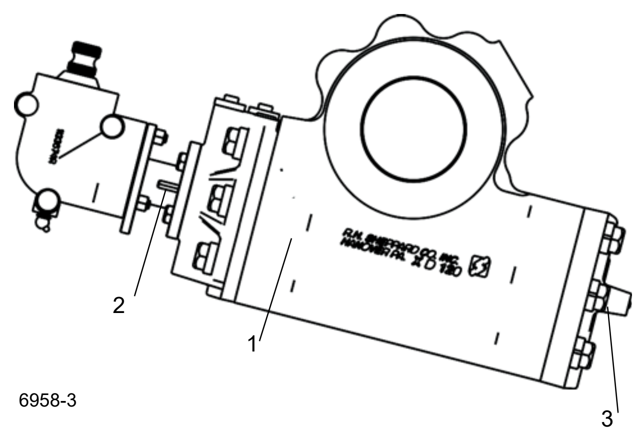
NOTE: Refer to (Figure 8-6).

1. Determine the Straight-Ahead Axle Position/Wheel Position. Then adjust the drag link accordingly. Once it is adjusted, torque the clamp nuts to 50-60 lb-ft.
2. Place greased plates or turntables under both front tires.
3. With the wheels still on the greased plated, adjust the left and right turn axle stops IN or OUT to meet the max cramp angle. Check to make sure that there is a minimum of 1.00” clearance between the tires and any components. Then remove the greased plates.
4. With the full weight of the vehicle on the tires, turn the steering wheel to full left. If axle stop is contacted, turn front plunger (2), (Figure 8-6) IN to limit the wheel cut. If the gap to axle stop is more than 1/8” at full turn, adjust the plunger out to increase the wheel cut. Repeat for the right turn (rear plunger) (3), (Figure 8-6).

NOTE: Do not attempt to set the relief pressure with the tires off the ground. Plungers are fine thread and accept a small flathead screwdriver. After approximately 4 wheel turns, steering may be considerable higher. Move the vehicle a foot forward to provide a clean contact patch between the tires and the ground.

5. Recheck the stops and pressure by driving the crane slowly forward while turning the wheels to full lock. Plunger relief should be reached before axle stops.
6. Check to be sure that the plungers are wound IN to a depth of at least 5/32”.

Automatic Steering Gear Relief Plungers



Item	Description
1	Steering Gearbox
2	Front Plunger Adjustment on Left Hand Turn
3	Rear Plunger Adjustment on Right Hand Turn

FIGURE 8-6

Rear Axles

General

Proper preventive maintenance will help control repair costs and downtime. If a major overhaul is required, remove the trailing arm assemblies and the tandem axle assembly from the carrier. However, torque rods, air bags, shock absorbers, walking beams, and other components can be removed separately as required with the axles remaining on the carrier. Refer to *Lubrication*, page 9-1 for specified lubrication intervals. Check the torque on all bolts at least once a year.

Beam Center Cap Fasteners

Periodically check the bolts on the saddle cap to prevent wear of the walking beam center bushing into the trailing arm assembly. Check bolt torque. Torque should be 310 to 375 N-m (228 to 276 ft-lbs).

Beam End Connections and Bushings

Every 16,090 km (10,000 mi) check the torque of the beam end bolts. Torque 615 to 815 N-m (453 to 601 ft-lbs). Jack up under each beam end and check for movement of the rubber end bushing. Worn bushings will allow movement and the bushings should be replaced. Periodically inspect the beam for a lowering in the hanger and for distorted or frayed rubber. A gap on each side of the visible rubber at the lower end of the end bushing is normal because the end bushing is in compression.

Trailing Arm Assembly Pivot Bushings and Fasteners

Periodically check the bolt torque on the trailing arm assembly end caps. Torque should be 603 to 671 N-m (445 to 495 ft-lbs).

Beam Center Bushings

The beam center bushings control lateral movement of the axles during cornering. Normal wear is evidenced by rubber shredding from each end of the bushing. Worn bushings result in increased lateral movement on turns, causing the inside walls of the tires to rub on the suspension saddle assemblies during turns. Replace the bushings before serious tire damage results.

Beam Center Cross Tube

The center cross tube connects the two walking beams and maintains axle alignment in turns. Inspect the cross tube for damage and, if bent, it must be replaced. A bent tube will result in axle misalignment and will cause abnormal tire wear.

Air Bags

Check for wear or road damage. Check for air leaks. Check tightness of nuts and bolts. Torque should be 27 to 40 N-m (20 to 30 ft-lbs).

Height Control Valves

Check valve, fittings, and air lines for leaks. Check actuating linkage for bent or damaged condition.

Shock Absorbers

Check the shock absorbers for leakage and wear. Replace as necessary.

Rear Tandem Removal

NOTE: The axle does not have to be removed from the crane for maintenance.

1. Remove the hardware securing the axle limiting straps on each side of the axle and remove the straps.
2. Raise the crane on outriggers until the weight is off the tires and place the jack stands under the carrier frame.
3. Completely drain the air pressure from both systems.
4. Remove the tire and wheel assemblies from both sides of the axles.
5. Place an adequate lifting/supporting device under the axles and suspension system.

NOTE: The axle and suspension system weighs approximately 1660 kg (3660 pounds).

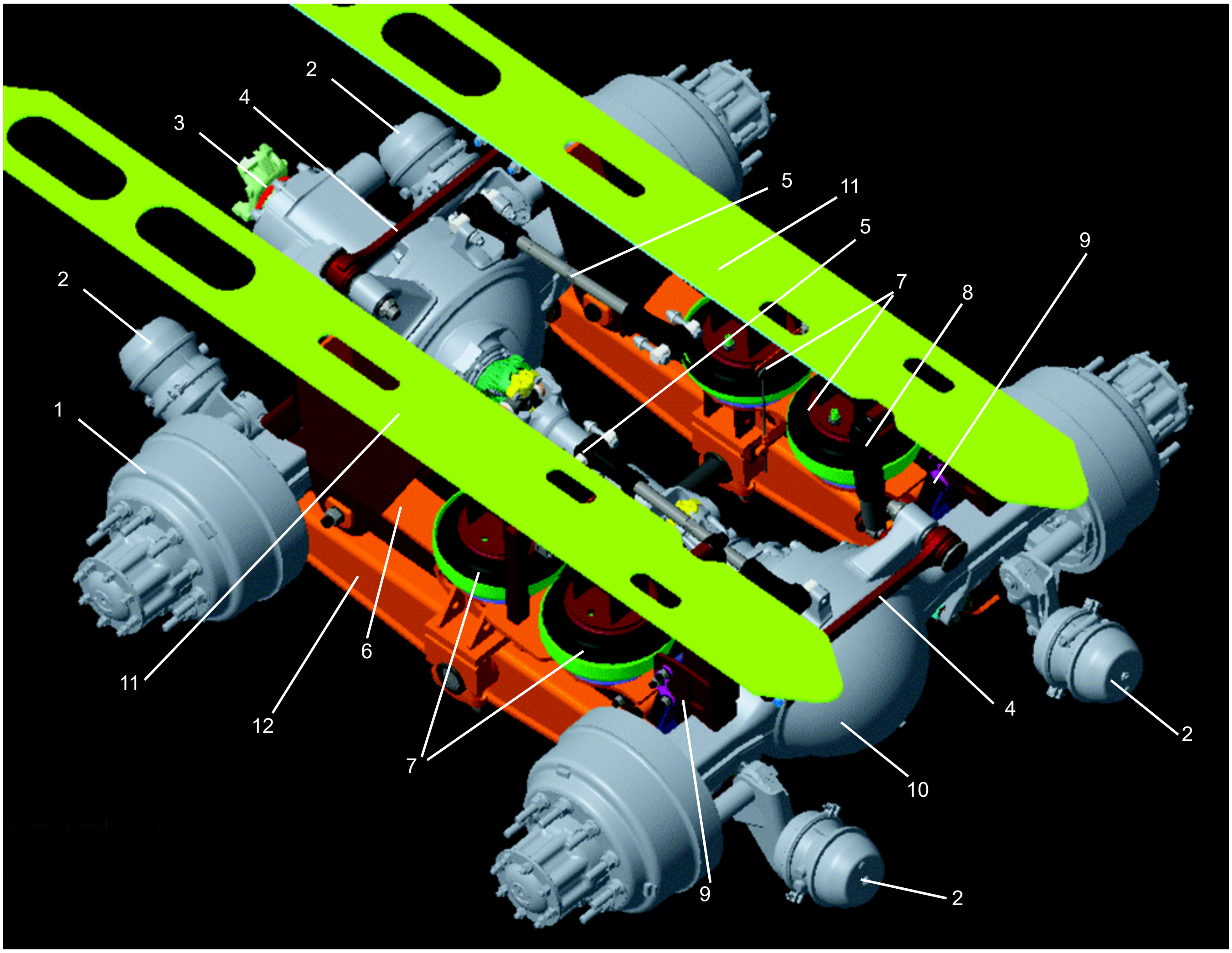
6. Tag and disconnect the air lines to the four brake chambers and the four air bags. Remove the fittings from the air bag connections. Cap all hoses and openings.
7. Disconnect the drive shaft from the front rear axle.
8. Remove the bolts, hardened washers, and nuts securing each of the torque rods to the carrier frame.
9. Remove the hardware securing the linkage rod of each height control valve to its respective trailing arm assembly.
10. Remove the hardware securing the limiting straps to the walking beam assemblies.
11. Remove the nut, lockwasher, and two washers securing each shock absorber to the carrier frame.
12. With the axles and suspension fully supported, remove the two nuts and washers securing each of the four air bags to the carrier frame brackets.
13. Remove the two bolts and washers securing each of the trailing arm pivot bushings to the carrier frame brackets.
14. Remove the axles and suspension assembly from under the carrier.

Rear Tandem Disassembly

Disassemble the axle and suspension assembly as necessary using the following procedures:

1. Remove the drive line between the two rear axles.
2. Remove the bolts, hardened washers, and nuts securing each fore and aft torque rod to the axle brackets. Remove the torque rod(s).
3. Remove the nut securing each lateral torque rod to the axle brackets. Remove the torque rod(s).

4. Remove each shock absorber from the trailing arm assembly by removing the nut and two washers securing each. Remove the shock absorber(s).
5. Remove each axle from the walking beams by removing the two bolts, washers, and nuts securing each end of the axle to the walking beam end bushings. Remove the axle(s).
6. Remove the trailing arm assemblies from the walking beams by removing two bolts and washers from each pivot block cap. Remove the caps. Remove the trailing arm assemblies and the trunnion tube from the walking beams.
7. Remove each air bag from the trailing arm assembly by removing the bolt, washer, and lockwasher. Remove the air bag(s).



6861-1a

Item	Description	Item	Description
1	Front Rear Drive Axle	7	Air Bags
2	Air Brake Chamber	8	Shock Absorber
3	Drive Line Yokes	9	Limiting Strap Bracket
4	Transverse Torque Rod	10	Back Rear Drive Axle
5	Longitudinal Torque Rod	11	Frame
6	Trailing Arm Assembly	12	Walking Beam

FIGURE 8-7

Axle and Suspension Assembly

As necessary, assemble the axle and suspension assembly using the following procedures:

1. Position the air bag(s) on the trailing arm assembly and secure each with a bolt, washer, and lock washer.
2. Position the trunnion tube through the center bushing on each walking beam. Position each trailing arm assembly over the center bushing and secure with the pivot block cap and two bolts and washers. Torque the bolts to 305 to 373 N-m (225 to 275 ft-lb).
3. Position the axle(s) on the walking beams aligning the axle brackets trailing arm the walking beams aligning the axle brackets with the bar end bushings on the walking beams. Secure each end with two bolts, washers, and nuts. Torque the bolts 610 to 814 N-m (450 to 600 ft-lb).
4. Position the shock absorber(s) on the trailing arm assembly and secure each with a nut and two washers. Torque the nuts 68 to 95 N-m (50-70 ft-lb).
5. Position the fore and aft torque rods in the axle brackets and secure each with two bolts, hardened washers, and nuts. Torque the nuts 237 to 305 N-m (175 to 225 ft-lbs).
6. Position the lateral torque rods in the axle brackets and secure each with a nut. Torque the nuts 237 to 305 N-m (175 to 225 pounds-foot).
7. Connect the drive shaft between the two rear axles. Torque the cross cap bolts 155 to 183 N-m (115 to 135 lb-ft).

Axle and Suspension Assembly Installation

1. Position the axle and suspension assembly under the carrier.
2. Raise the assembly into position under the carrier aligning the trailing arm assemblies pivot blocks and air bags with the mounting brackets on the carrier.
3. Install the pivot bushings and fasteners through the carrier frame and trailing arm assembly. Torque the bolts to 603 to 671 N-m (445 to 495 ft-lbs).
4. Secure the four air bags to the carrier brackets with two nuts and washers. Torque the nuts 67 to 95 N-m (50 to 70 ft-lb).
5. Secure each shock absorber to the carrier frame with a nut, lock washer, and hardened washers. Torque 67 to 95 N-m (50 to 70 ft-lb).
6. Secure the linkage rod of each height control valve to its respective trailing arm assembly with the attaching hardware. Torque the top valve linkage rod connection to 13 to 16 N-m (10 to 12 ft-lb).
7. Attach the fore and aft torque rods to the carrier frame using two bolts and hardened washers on each. Torque the bolts per Table 1-3, *Inch Series with Coarse Threads (UNC) – Zinc Flake Coated*, page 1-16 in this Manual.
8. Attach the lateral torque rods to the carrier frame using two bolts, hardened washers, and nuts. Use additional hardened washers between the torque rod and the bracket to aid in properly centering the axle.
9. Connect the drive shaft to the front rear axle. Torque cross cap bolts 155 to 183 N-m (115 to 135 ft-lb).
10. Install the air fittings in the inlet of the air bags. Connect the air lines to the air bags and brake chambers as tagged during removal.
11. Position the limiting straps on each side of the axle and secure with the attaching hardware.
12. Service the axles and suspension system. Refer to *Lubrication*, page 9-1 Section in this manual.
13. Build up air pressure in the systems and check for leaks. Check operation of brakes and air suspension system.
14. Install the tire and wheel assemblies. Refer to *Wheels and Tires*, page 8-12 in this Section.
15. Retract the outriggers.

NOTE: The air ride must be set to the proper height when setting axle angles

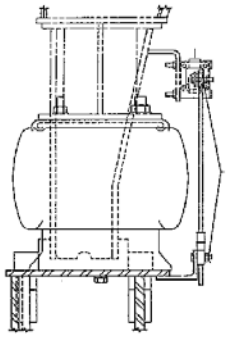
16. Once finished with the axle/suspension installation, check axle angles. Contact Crane Care for the required angles. If axles do not meet the required angle, adjust fore and aft torque rods by loosening the locking clamp hardware and rotating the torque rod center until the axle yokes are at the proper angle. Once the proper axle angles are achieved, tighten the locking clamp hardware and torque to 102-142 N-m (75-105 fl-lb).
17. Check the axles for proper operation.

Air Ride Rear Suspension Adjustment

NOTE: This model is equipped with an air ride rear suspension. It is necessary to periodically inspect the suspension for proper adjustment. Operating this machine with incorrect ride height adjustment could result in poor ride quality or possible damage to suspension and axle components.

1. See Crane Care for Proper Ride Height dimensions and adjust as needed.
2. Adjust the rod to achieve proper ride height setting (Figure 8-8) and torque P-clamp on P-boot to 10-15 in lbs.

NOTE: Over-tightening of the P-clamp will cut through the P-boot.



6861-1b

FIGURE 8-8

WHEELS AND TIRES

Description

Tire size on the front wheels is 425/65 R22.5 and size 11R22.5 on the rear wheels.

CAUTION

Risk of damage!

Do not mix tires or rims from different manufacturers.

NOTE: The tire diameters, widths, and weights may vary slightly depending on the tire manufacturer.

Tires are designed to operate with a certain sidewall deflection or bulge. Having correct air pressure allows for proper deflection that makes sure of proper traction, flotation, support of load, and prevents excessive flexing of the tire. Over inflation increases rim stresses, which results in lower rim life.

Refer to and adhere to the inflation pressures listed in the Load Chart.

Unmatched tires on either of the tandems will cause wear, scuffing, and possible damage to drive units. It is recommended that tires be matched to within 3.175 mm (0.13 in) of the same rolling radius and 19.0 mm (0.75 in) of the same rolling circumference.

CAUTION

Do not install the largest tires on one driving axle and the smallest on the other driving axle. This will cause axle "fight" and high lubricant temperatures resulting in premature lubricant breakdown and costly axle service.

In addition to matching individual tire rolling radii and circumference, match the total tire circumference of one driving axle to the other driving axle.The result will be satisfactory axle lubricant temperatures.

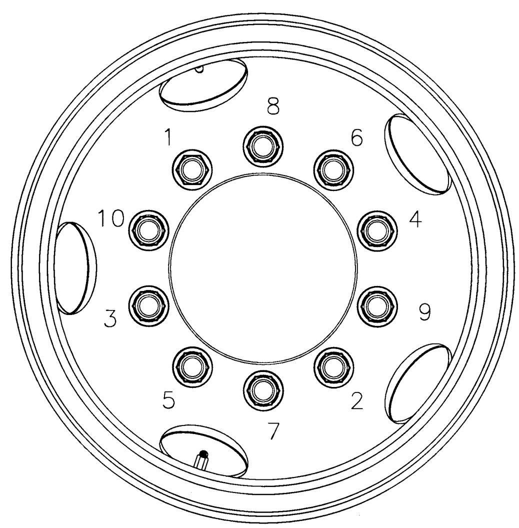
Vehicle Maintenance Schedule

- Correct tire pressure should be maintained at all times.
- Wheel alignments and tire balancing should be performed after every 24,000 miles or 12 months of service, whichever comes first.
- **This vehicle is factory-equipped with tires that have been certified for Greenhouse Gas and Fuel Efficiency regulations. Replacement of these tires must be with an equal or lower rolling resistance level tire (TRRL or Crr) in order to maintain compliance with applicable CO2 emission standards. Consult with your tire supplier(s) for appropriate replacement tires.**

Mounting the Wheels on the Rear Axle

DANGER

Do not dismount or mount tires on rims without proper training. High pressures can cause tire and rim parts to fly apart with explosive force and cause injury or death.



6861-1c

FIGURE 8-9

NOTE: Do not lubricate the wheel studs or lug nuts. On aluminum wheels, lubricate only the pilot or hub pads with synthetic lubricant containing Teflon. Do not lube the face of the wheel or rim.

1. Install the wheel assemblies on the mounting studs.
2. Place the mounting ring and hub cover over the hub and studs.
3. Install the lug nuts and tighten until the nuts are just snug. Position the nut that is to be tightened on top.
4. Tighten the rear wheel lug nuts to a preliminary torque of 68 N-m (50 pounds-foot) in the sequence as shown in (Figure 8-9).
5. Torque the rear wheel lug nuts 610 to 678 N-m (450 to 500 pounds-foot) in the sequence as shown in (Figure 8-9).

   Retorque rear wheel lug nuts 80 to 160 km (50 to 100 miles) after the wheels are removed and reinstalled. Check the torque every 804 km (500 miles) thereafter.

Mounting the Wheels on the Front Axle

NOTE: Do not lubricate the wheel studs or lug nuts. Lubricate the pilot only. Do not lubricate wheel or axle faces.

1. Position the wheel assembly on the mounting studs. Install the lug nuts and washers and tighten them until they are just snug, rotating the wheel so the nut being tightened is in the top position.
2. Make sure that the wheel assembly is positioned properly on the hub. Tighten the lug nuts in the sequence shown (Figure 8-10) to a preliminary torque of 68 N-m (50 pounds-foot).
3. Check the tire/wheels run-out and correct if greater than 0.40.
4. Torque the front lug nuts to 610 to 678 N-m (450 to 500 pounds-foot) in the sequence shown in (Figure 8-10).
5. Maintain proper torque on wheel lugs and check for proper wheel mounting. Retorque the lug nuts 80 to 160 km (50 to 100 mi) after the wheels are removed and reinstalled. This will reseat the lug nuts. Check the torque every 800 km (500 mi) thereafter. An alternative to re-torquing after 80 km (50 mi) is to run the machine in large figure 8’s six or seven times and then re-torque the lug nuts.

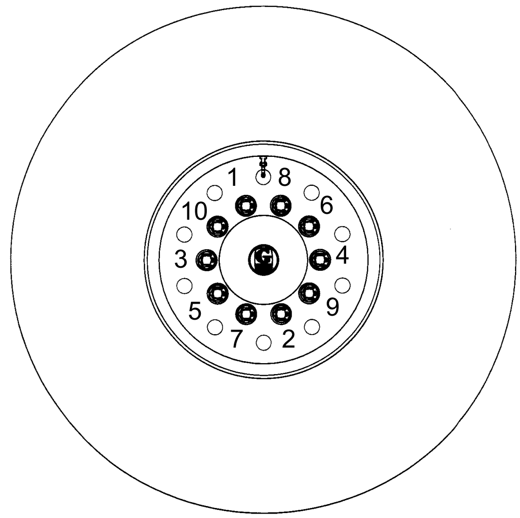


FIGURE 8-10

STEERING SYSTEM

Description

The steering system is comprised of the steering gear which is supplied hydraulic oil from Pump #1 in the hydraulic system. The steering gear provides for full time hydraulic steering, but still allows for manual steering in the event of a system malfunction.

Maintenance

Troubleshooting the Steering System

Symptom	Probable Cause	Solution
1. Oil leaking at output shaft of steering gear.	**a.** Damaged sector shaft seal.	**a.** Replace sector shaft.
2. Oil leaking at actuating shaft of steering gear.	**a.** Worn or damaged oil seal.	**a.** Replace actuating shaft seal.
	b. Damaged actuating shaft seal surface.	**b.** Replace bearing cap, actuating shafts assembly.
3. Oil discolored or smells bad.	**a.** Operating temperatures too high.	**a.** Check and correct cause of overheating.
	b. Change intervals too long.	**b.** Change oil more often.
	c. Incorrect lubricant used.	**c.** Drain, flush, and refill with recommended lubricant.

8

Symptom	Probable Cause	Solution
4. High operating temperatures.	**a.** Oil flow restriction.	**a.** Check back pressure.
	b. Oil flow too high.	**b.** Check maximum oil flow.
5. Excessive pump pressure with steering gear in neutral.	**a.** Pinched oil return line, high back pressure.	**a.** Relocate line.
	b. Binding steering column.	**b.** Repair steering column.
6. Wheel cuts restricted.	**a.** Relief plungers not adjusted properly.	**a.** Adjust relief plungers.
7. Erratic steering or mechanical steering only.	**a.** Insufficient volume of oil.	**a.** Refer to pump servicing instructions.
	b. Sticking pressure relief valve in steering gear.	**b.** Repair or replace relief valve as required.
8. Hard steering.	**a.** Faulty supply pump.	**a.** Check pump flow.
	b. Steering out of alignment.	**b.** Align front end.
	c. High operating temperature.	**c.** Locate and correct cause of overheating.
9. Wheel turns hard in one or both directions.	**a.** Dirt or foreign matter trapped in piston relief.	**a.** Check pressure relief.
	b. Bent or damaged king pins and tie rods.	**b.** Repair or replace king pins and tie rods.
	c. Front end load too great.	**c.** Lighten load.
	d. Low oil level.	**d.** Fill reserve as required.
10. Wheel turns hard in one or both directions.	**a.** Air in system.	**a.** Bleed system and check for cause of air.
	b. Caster degree incorrect.	**b.** Correct to specified degree.
11. Wheel turns hard in one direction.	**a.** Metal or foreign material in relief ball seat in piston of steering gear.	**a.** Remove and clean relief valve seats or replace damaged parts.
12. No attempt to return straight ahead from turns/should also be hard steering complaint.	**a.** No positive caster.	**a.** Set caster to specified degree.
	b. Steering column bind.	**b.** Check and repair U-joints and support bearings.
	c. Steering gear mounting distorted.	**c.** Shim mounting pads to correct piston to bore interference. Make sure correct bolt length is used on the base mount gears.
	d. Linkage ball sockets seized or binding.	**d.** Check and repair or replace.
	e. King pins seized or binding.	**e.** Repair or replace.
	f. Oil flow rate incorrect.	**f.** Check and correct supply pump.

Symptom	Probable Cause	Solution
13. Darting, wandering, oversteering.	**a.** Oil flow too high.	**a.** Supply pump not to specifications.
	b. Air trapped in steering gear.	**b.** Bleed system.
	c. Looseness, worn front end parts.	**c.** Check and repair as required.
	d. Front end alignment not correct.	**d.** Align front end - Caster.
	e. Overloading.	**e.** Reduce loads.
	f. Rear axle not parallel.	**f.** Check and repair as required.
	g. Tight tie rod ends and vertical socket sockets.	**g.** Check rotational torque and replace if necessary.
14. Excessive backlash, freeplay.	**a.** Worn universal joint.	**a.** Replace universal joint.
	b. Rack on piston damaged.	**b.** Replace steering gear.
	c. Damaged sector shaft/ splines.	**c.** Replace steering gear.
	d. Worn or damaged pitman arm splines.	**d.** Replace pitman arm and/or sector shaft.
	e. Universal joint yoke loose on actuating shaft.	**e.** Repair or replace damaged parts.
15. Steering input not smooth.	**a.** Worn universal joint.	**a.** Check and replace as required.
	b. Lack of lubrication.	**b.** Lubricate per lube chart.
	c. Universal joints not phased properly.	**c.** Re-phase columns.
	d. Low oil flow.	**d.** Idle speed to slow or supply pump not to specifications.
	e. Pump cavitation.	**e.** Correct pump supply.
	f. Overheating.	**f.** Correct cause of overheating.

NOTE: *With the vehicle stationary and engine at idle, place the torque wrench on the steering wheel retaining nut and steer from lock to lock. A reading of more than 1.7 N-m (15 pounds-inch) means improper phasing. To correct, rotate the intermediate steering shaft one spline at a time until the torque reads the same throughout the 360 degree rotation.

Steering System Functional Check

A periodic functional check of the steering system will generally be adequate to make sure of satisfactory service.

1. Check all fittings for leakage. Accumulation of moist, black dirt is a good indication of leakage.
2. Turn the steering wheel through the full range with the engine running at both idle and full throttle. Do this with the machine stationary and moving. Note any speed irregularities and sticky sensation. This may indicate dirt in the fluid. If the steering wheel continues to rotate when started and released, a condition known as motoring exists. This may also indicate dirt in the fluid.
3. Make sure that the system has adequate power. If there is an indication of hard steering, this can be caused by either a reduced oil flow to the control valve or a reduced system relief pressure. Adequate oil pressure can only be determined by connecting a pressure gauge at the pump outlet port or at the steering gear inlet port. With the engine running at a medium speed, turn the steering wheel to one end of travel and hold at the travel limit just long enough to get a pressure reading. Never hold the system relief pressure for more than a few seconds at a time. The pressure gauge should indicate a 150 bar (2175 psi) at the pump outlet.

STEERING GEARBOX

Description

The steering gear box (Figure 8-11) is attached to the frame and is located on the left side beneath the carrier cab. The gearbox provides full-time hydraulic steering and only enough manual effort to overcome the torsion bar and turn the rotate valve is required. With the engine running, there is a constant oil flow through the steering gear which provides an instant response and absorbs road shock. There is mechanical back-up steering so that the vehicle can be steered to the side of the road in the event of hydraulic pressure loss in the primary and back-up systems.

Maintenance

Steering Gearbox Removal

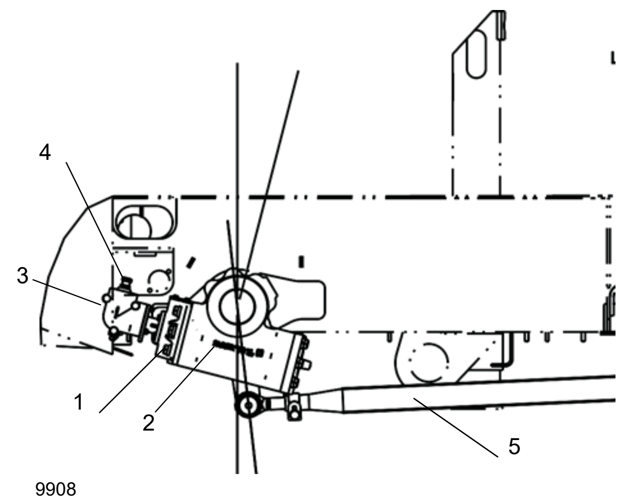
1. Remove the bolt and locknut (Figure 8-11) securing the steering shaft to the steering gearbox, then remove the shaft from the gearbox.
2. Disconnect the hydraulic hoses.
3. Remove the cotter pin, nut, and washer (Figure 8-11) (if installed) securing the steering gearbox pitman arm to the ”drag link”.
4. Using a small punch and ball peen hammer, bend the two restraining tabs out of the pitman arm retainer (Figure 8-12) so that the retainer can be removed. Do not bend the tabs in the pitman arm slot.
5. Remove the pitman arm retainer (Figure 8-12) using an Allen head socket and breaker bar.
6. Attach a 3-jaw puller and remove the pitman arm from the steering gearbox (Figure 8-11) and (Figure 8-12).
7. Remove the capscrews and washers (Figure 8-11) securing the steering gearbox to the frame and remove the gearbox from the frame.

Steering Gearbox Installation

CAUTION

Do not deviate from the following step. Seal damage and/ or leakage could result.

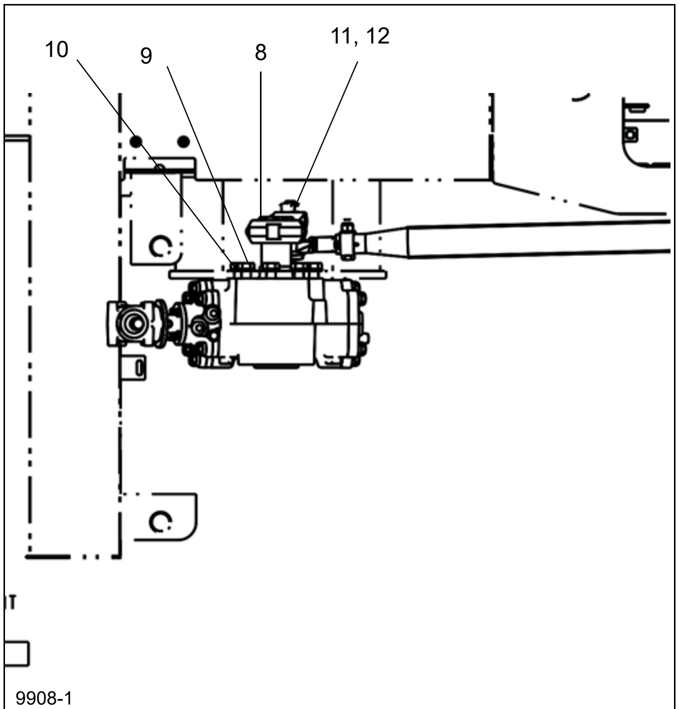
1. Prior to installation, wind the relief plungers, located at both ends of the gearbox, until they bottom out. Do not remove or wind the plungers out past a depth of 4 mm (0.16 in).
2. Apply Loctite #243 to the steering gearbox mounting bolts. Install the gearbox to the frame with the capscrews and washers. Torque the bolts per Table 1-5 Metric Series with Coarse Threads – Zinc Flake Coated, page 1-17
3. Turn the input shaft on the gearbox until it bottoms out.
4. Turn the input shaft in the opposite direction while counting the number of turns until it bottoms out.



Item	Description
1	Power Steering Gear Assembly
2	Steering Gearbox
3	Miter Box
4	Input Shaft
5	Drag Link

FIGURE 8-11

5. Divide the number of turns by two, then turn the input shaft back that number of turns to center the steering gear.
6. After centering the steering gear, locate the pitman arm on the gear by aligning the timing mark on the output shaft of the steering gear with the timing mark on the pitman arm (Figure 8-12).
7. Screw the retainer and tab washer into the output shaft by hand, aligning the tabs of the retainer in the notches of the pitman arm (Figure 8-12).
8. Using an Allen head socket and torque wrench, install the retainer in to the output shaft by torquing the retainer to 615 N-m (453lb-ft).
9. After the specified torque value is reached, continue torquing until the notches in the retainer are aligned with the next bent tab of the washer.



Item	Description
8	Pitman Arm
9	Capscrew
10	Washer
11	Cotter Pin
12	Washer

FIGURE 8-12

10. Complete the installation by bending two opposing tabs of the washer into the notches of the retainer.

11. Attach the steering column to the steering gear.

12. Install the drag link to the pitman arm. Install the attaching nut and torque the nut to 163-231 N-m (120-170lb-ft). Tighten the nut to the next cotter pin hole and install the cotter pin. If the cotter pin holes in the nut fail to align with the cotter pin holes in the stud, remove the nut and install washers as necessary to allow the cotter pin holes to align.

AIR SYSTEM

Description

The air system (Figure 8-14) provides the air supply and control to operate the service brakes, parking brakes, air suspension system, inter-axle and optional cross axle differential locks, tire inflation, and the engine fan clutch solenoid valve.

The engine-mounted air compressor provides air system flow. The air system components are operated by the air that is stored in three reservoirs underneath the frame.

An air dryer, with integral governor, is mounted under the center front decking behind the front bumper. It is connected between the outlet of the supply dump valve and the supply reservoirs. Oil, water, and contaminates are removed from the air during the compression cycle and when the governor is unloading, the contaminates are removed from the dryer.

The air system is split into a primary system and a secondary system. The systems are isolated from each other so that in the event of a failure in one system, air is retained in the other system. By means of pressure protection valves, spring brake valves, a reserve of air pressure remains to operate the brakes through normal use of the brake pedal. Any unusual loss of pressure should be investigated immediately and corrected, so as to restore the full backup capability of the system.

Theory of Operation

Through reciprocating motion, the piston in the compressor compresses air with every cycle. The compressed air passes through the supply dump valve and air dryer and into the supply reservoirs. A 1030 kPa (150 psi) safety valve is installed on the air dryer module for protection from excess pressure. The pressurized air flows to the primary service reservoirs and secondary service reservoirs. Both primary and secondary air reservoirs provide the supply for the dual brake and spring brake control valves. Air to the service brakes is supplied by the primary reservoirs. The secondary reservoirs provide the supply for the service brakes on axle #1.

Pressure protection valves, within the air dryer, are set at 731 kPa (106 psi). They open at 69 to 103 kPa (10 to 15 psi) above the set protection pressure. These valves protect a circuit if a line is ruptured to make sure that a priority is given to the brake circuit. Pressure protection valve for tire inflation is set at 586 kPa (85 psi).

The compressor which is mounted on and driven by the engine, is regulated by an air governor which vents the compressor when a pressure of 896 kPa (130 psi) is sensed in the air system. When pressure drops to 758 kPa (110 psi), the governor will allow the compressor to supply the air system to maintain proper system pressure. Refer to (Figure 8-13).

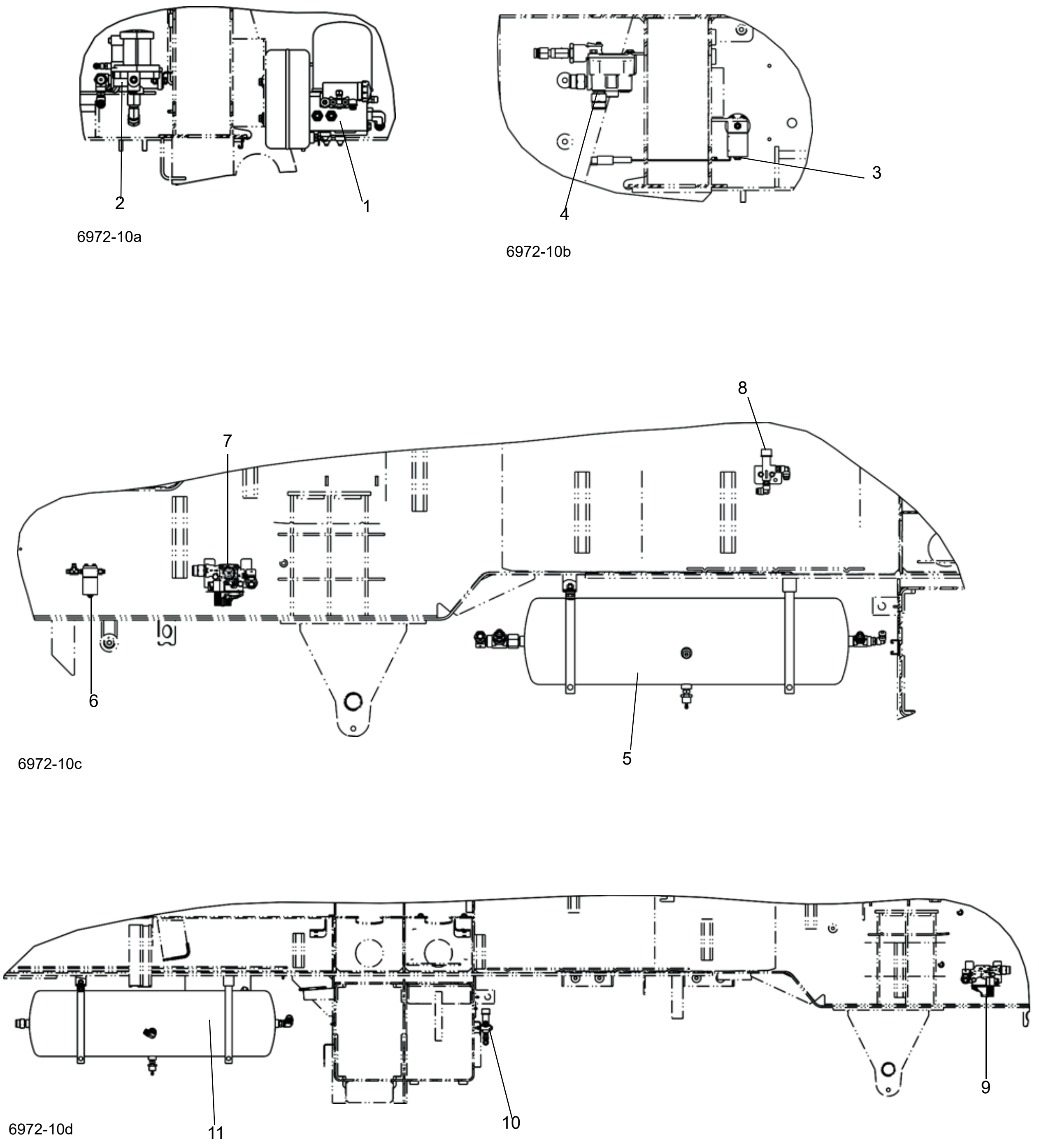


FIGURE 8-13

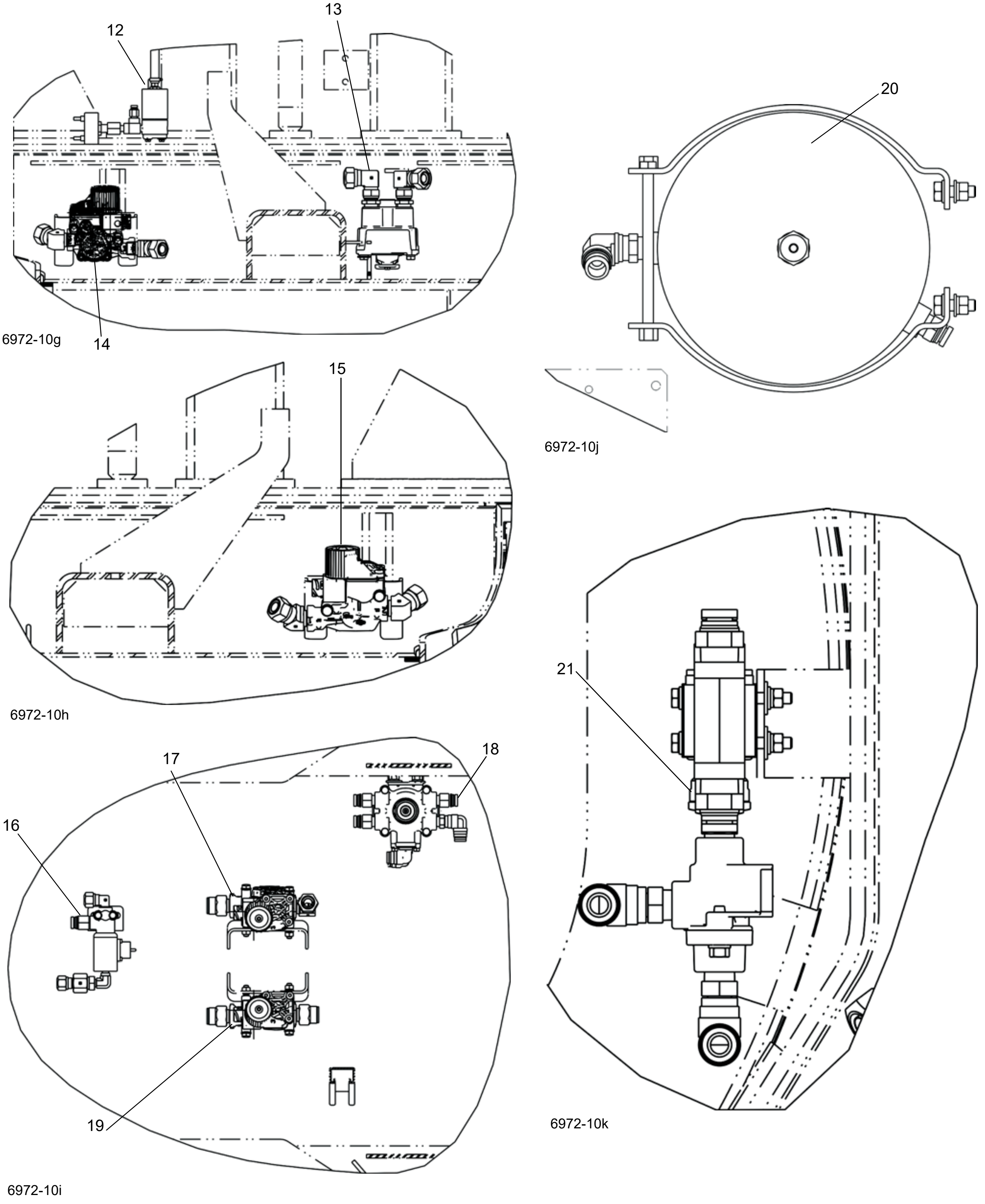


Figure 8-13continued

Item	Description
1	Air Dryer Module
2	Supply Dump Valve
3	Tire Inflation Solenoid Valve
4	Service Brake Relay Valve
5	Secondary Tank A
6	Air Suspension Solenoid Valve
7	ABS Modulator Valve Axle 1, RIGHT
8	Pressure Protection Valve, Transmission
9	ABS Modulator Valve Axle 1, LEFT
10	Pressure Protection Valve, Tire Inflation
11	Primary Tank B
12	Inter-Axle Differential Lock Solenoid Valve
13	Rear Service Brake Relay Valve
14	ABS Modulator Valve Axle 2, LEFT
15	ABS Modulator Valve Axle 2, RIGHT
16	Traction Control Valve
17	ABS Modulator Valve Axle 3, LEFT
18	Spring Brake Relay Valve
19	ABS Modulator Valve Axle 3, RIGHT
20	Primary Tank A
21	Hill Start Assist Valve

Figure 8-13continued

Braking

The top priority of the air system is to provide braking. Each rear wheel has a spring brake chamber and a service brake chamber. The spring brake is applied by a spring and released by pressurized air. The spring brakes on all four rear wheels are released by the parking brake push-pull knob on the right side of the front console in the cab (refer to *Service and Parking Brakes* in the Operators Manual and Figure 4-1 for additional information). Pushing in on the parking brake causes air pressure to enter the spring brake chamber on each wheel and compress the spring, releasing the brakes. At least 280 kPa (40 psi) is required to keep the parking brake valve engaged. If supply pressure to the valve drops below 280 kPa (40 psi), the valve will release, applying the brakes.

The service brakes are applied by air pressure. Depressing the foot brake pedal on the cab floor causes pressurized air to enter the service brake chamber on each wheel and apply the brakes. In the event of a loss of supply pressure to the service brakes, the spring brake valve will allow the operator to release or bleed off the air pressure in the spring brake chamber by depressing the foot brake pedal to apply the brakes.

Air System Operational Test

1. Park the crane on a firm level surface and apply the parking brakes.

Maintenance

WARNING

Death or Injury Could Occur!

Depressurize both air systems completely before disconnecting air lines or components.

CAUTION

Damage Could Occur!

Do not expose nylon tubing to flames or heat. Replace tubing if outside covering shows white. Eliminate cause of chafing or other damage.

Leak Detection

If a leak is suspected, shut off the engine and note the air pressure reading of both circuits. Acceptable air pressure loss is 40 kPa (6 psi) within 30 minutes. A hard to detect leak can be found by wetting the suspected area with a soap solution and observing for bubbles.

2. Push the air suspension switch (Figure 8-14) in the carrier cab to the deflate position to deflate the air suspension bags. The amber suspension deflate indicator light should illuminate when the pressure in all air bags drops below 28 ± 14 kPa (4 ± 2 psi).

3. Raise the crane on the outriggers.
4. Shutdown the engine.

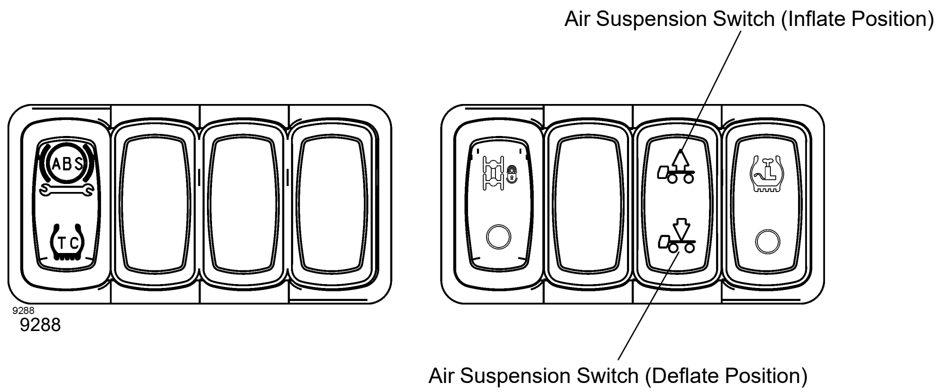


FIGURE 8-14

WARNING

Death or Injury Could Occur!

Air pressure must not exceed 900 kpa (130 psi).

Pressure Warnings and Pressure Build-up

1. Drain all reservoirs to zero (0) psi by opening the drain valves. If not already applied, the parking brake will be applied as the system is drained. Make sure that the parking brakes are applied on all rear wheels.
2. Close the drain valves and start the engine. Set the engine speed to fast idle.
    a. The low air pressure indicator (Figure 8-16) should be on, and an audio warning should be on until both pressure gauges indicate 414 to 483 kPa (60 to 70 psi) air pressure.
    b. Air will fill the primary (rear) first, followed by the secondary (front) reservoirs first. The red needle on the gauge represents the primary air pressure. The green needle on the gauge represents the secondary air pressure. The primary gauge should rise until it reaches 731 kPa ± 41 kPa (106 ± 6 psi). At 731 kPa ±41 kPa (106 ± 6 psi), the pressure protection valve will open and allow air to flow into the reservoirs. The pressure will level off, or momentarily fall as the next pressure protection valve opens for the secondary system. When the secondary system reaches 731 kPa ± 41 kPa (106 ± 6 psi), the pressure will level off, or momentarily fall as the third and fourth pressure protection valves open. Then the primary and secondary gauges should increase together until they reach their full pressure.

CAUTION

Damage Could Occur!

Do not attempt to adjust or service the pressure protection valves.

    c. Record the amount of time to build air pressure from 586 to 689 kPa (85 to 100 psi). This time should be less than 40 seconds.
    d. Continue charging the air system until the air dryer cycles and the compressor shuts off. All system gauges should read 896 kPa (130 psi).
    e. Reduce air pressure by applying the service brakes until governor cut-in pressure is reached. The difference between governor cut-out and cut-in pressure should be 172 kPa (25 psi) or less.
    f. Release the park brakes by pushing the yellow knob (as shown in the *Operators Manual,* Section 4, Figure 4-1) on the front console of the carrier cab.
    g. Check that all wheels turn freely.
    h. Attempt to operate the outriggers. The outriggers should not operate with the park brakes released.
    i. Turn engine off.

Air Leakage Test

1. If necessary, start the engine and charge the air system to governor cut-out pressure.
2. Turn the engine off and allow the air pressure to stabilize for one minute.

3. Observe the air pressure gauge, on the front console, for two additional minutes without the service brakes applied. Any decrease in air pressure shall not exceed one (1) psi per minute.
4. Apply the service brakes to full application and hold. Allow the air pressure to stabilize. Continue holding the service brakes for two minutes. Any decrease in air pressure shall not exceed 13.8 kPa (2 psi) per minute.

Loss of Primary (Rear) Air System

1. If necessary, start the engine and charge the air system to governor cut-out pressure.
2. Turn the engine off and allow the air pressure to stabilize for one minute.
3. Release the parking brakes by pushing the yellow button on the front console (of the carrier cab). (Refer to the *Operators Manual,* Section 4, Figure 4-1 for additional information.)
4. Check that all wheels turn freely.
5. Simulate a full air leak by opening the drain valve in one of the two primary reservoirs.
6. The low air pressure indicator and warning buzzer should come on when the air pressure in the primary system drops below 517 ± 35 kPa (75 ± 5 psi). Air pressure in the secondary system should not drop below 689 kPa (100 psi).
7. Continue draining the primary reservoirs to zero (0) psi.
8. Apply the service brakes.
9. Both front axle brakes and the four rear axle spring brakes should apply. The brake lights on the rear of the crane should illuminate.
10. Release the service brakes.

Loss of Secondary (Front) Air System

1. If necessary, start the engine and charge the air system to governor cut-out pressure.
2. Turn the engine off and allow the air pressure to stabilize for one minute.
3. Release the park brakes by pushing the yellow button on the front console in the carrier cab. (Refer to the *Operators Manual,* Section 4, Figure 4-1 for additional information.)
4. Check that all wheels turn freely.
5. Simulate a full air leak by opening the drain valve in one of the two secondary reservoirs.
6. The low air pressure indicator and warning buzzer should come on when the air pressure in the secondary system drops below 517 ± 35 kPa (75 ± 5 psi). Air pressure in the primary system should not drop below 689 kPa (100 psi).
7. Continue draining the secondary reservoirs to zero (0) psi.
8. Apply the service brakes.
9. All four rear axle brakes should apply. The brake lights on the rear of the crane should illuminate.
10. Release the service brakes.

Emergency Brake Application

1. If necessary, start the engine and charge the air system to governor cut-out pressure.
2. Turn the engine off and allow the air pressure to stabilize for one minute.
3. Release the parking brakes by pushing the yellow knob on the front console in the carrier cab. (Refer to the *Operators Manual,* Section 4, Figure 4-1 for additional information.).
4. Check that all wheels turn freely.
5. Simulate a full air leak by opening the drain valve in one of the two secondary reservoirs.
6. Slowly drain the primary reservoirs.
7. The yellow park brake control knob (on the carrier front console) should automatically “pop” out when the pressure decreases below 138 to 207 kPa (20 to 30 psi).

Air System Components

Description

Air Compressor

The air compressor (Figure 8-15) is mounted on and driven by the engine. It provides the source of compressed air for the operation of the air system components. It is controlled (cycled on and off) by an air governor.

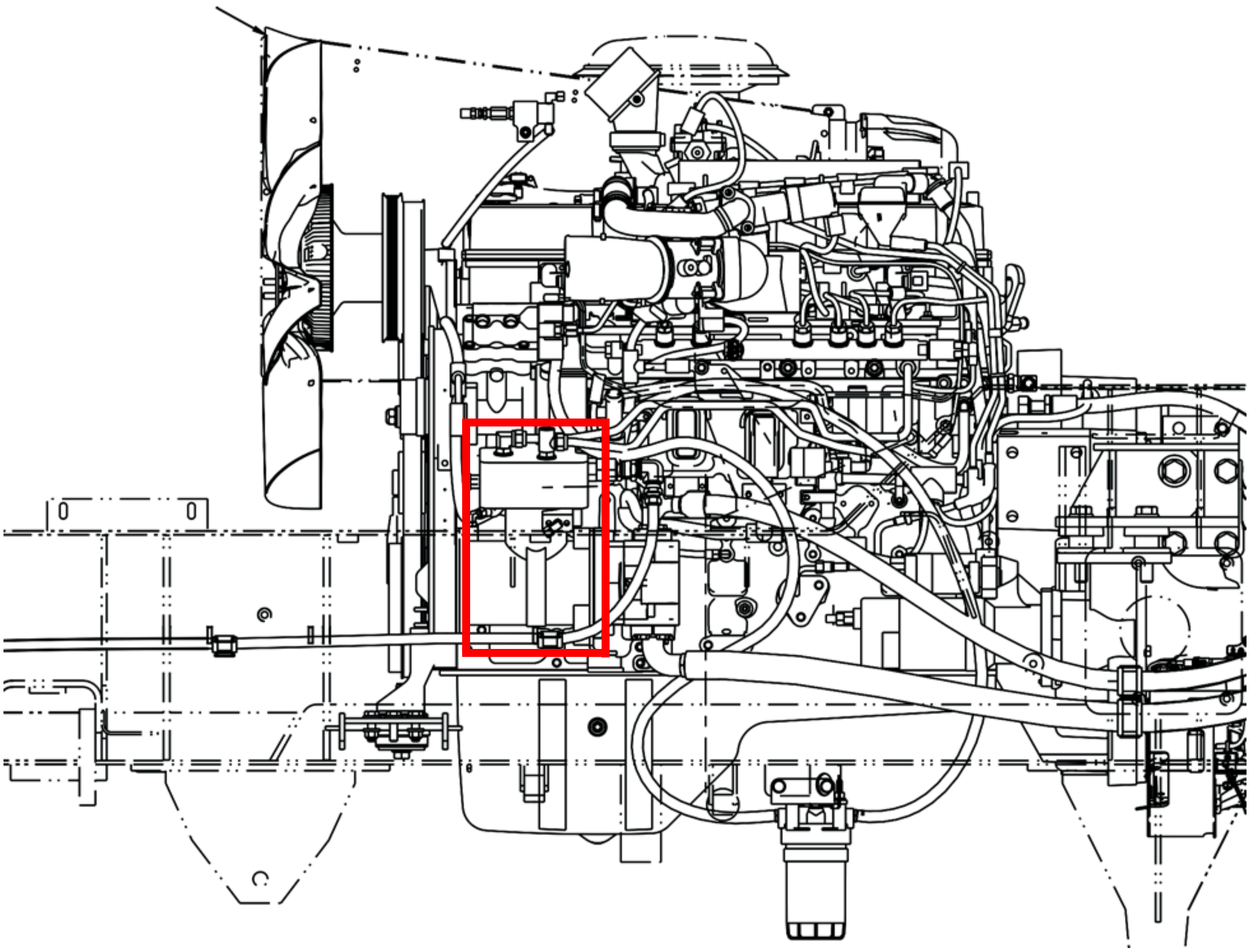
Air Governor

The air governor is mounted on the air dryer behind the front bumper under the center decking. The governor senses the system pressure and when pressure reaches 896 kPa (130 psi) the governor vents the compressor. When pressure drops to 758 kPa (110 psi), the governor signals the compressor to start charging again.

Air Dryer

The purpose of the air dryer (Figure 8-16) is to collect and remove solid, liquid, and vapor contaminates from the air system. Clean dry air increases the life of the air system and reduces cost.

Air Compressor



9907

FIGURE 8-15

Air Dryer

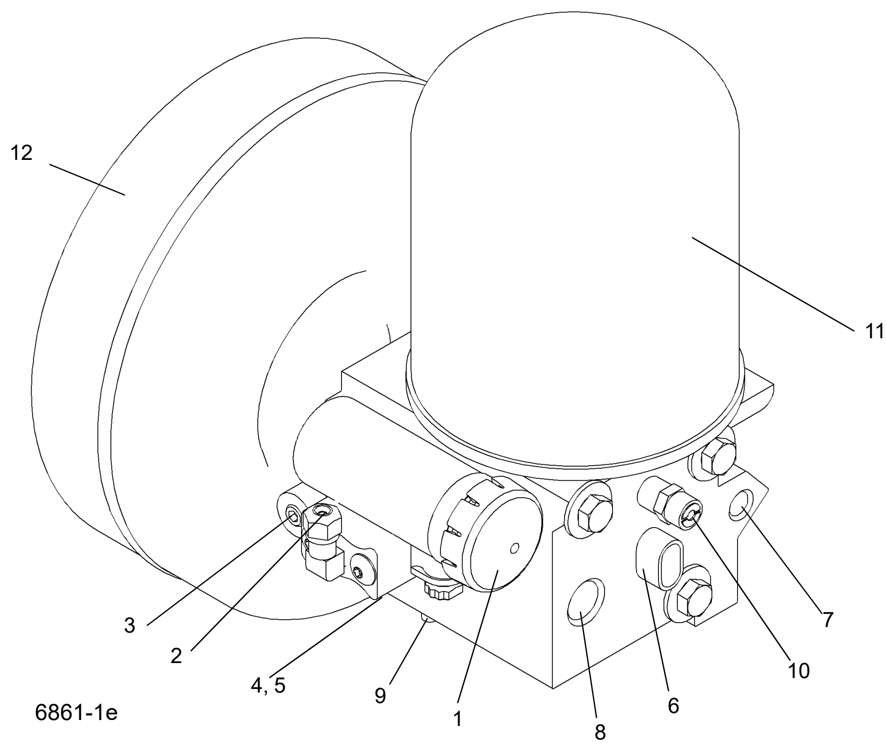


FIGURE 8-16

Item	Description
1	Governor
2	Unloader Control Valve
3	Common Reservoir Pressure
4	Delivery Port Out (To Primary Reservoir) (Not Shown)
5	Delivery Port Out (To Secondary Reservoir) (Not Shown)
6	Heater/Thermostat Connection
7	Auxiliary Delivery Port (Air Out)
8	Inlet Port (Supply From Compressor)
9	Pressure Protection Valves
10	Safety Valve
11	Desiccant Cartridge
12	Purge Reservoir

CAUTION

Do NOT Attempt to Adjust or Service the Pressure Protection Valves!

Incorrect pressure protection valve settings can result in automatic application of vehicle spring brakes without prior warning.

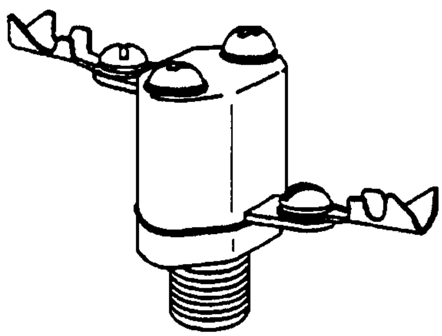
The Air Dryer, with integral governor (Figure 8-16), consists of a spin-on desiccant cartridge to collect and remove air system contaminants before they enter the brake system. The base contains a check valve, safety valve, heater and thermostat assembly, four pressure protection valves, threaded air connections, and the purge valve assembly.

Reservoirs

Four air reservoirs store compressed air for braking and auxiliary air devices. The first reservoir in the system (in air dryer module) also acts as a purge tank to remove additional moisture not removed by the air dryer. The reservoirs have manual drain valves.

Low Pressure Indicator Switches

The low pressure indicator switches (Figure 8-17) are used to warn the operator of low pressure in the air systems. One switch is installed in each system and they are electrically connected in parallel to illuminate the Low Air Pressure indicator on the front console in the cab. Observe the dual air pressure gauge to determine which system is low. The switch contacts close when the pressure in the system decreases to 517 kPa (75 psi).

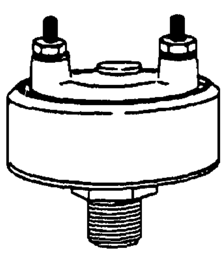


6861-1f

FIGURE 8-17

Stop Light Switch

The stop light switches (Figure 8-18) are installed in the ports of the dual brake valve and are used to illuminate the stop lights on the rear of the carrier when the brakes are applied. There is one switch in each system (primary and secondary) and they are connected electrically in parallel.



6861-1h

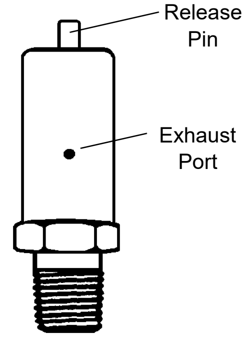
FIGURE 8-18

Air Pressure Gauge

The dual air pressure gauge is located on the right side of the front console. The gauge is a direct reading pressure gauge with two indicating pointers, red for the primary system and green for the secondary system. The gauge has a dual scale calibrated from 0 to 150 psi and 100 to 1000 kPa.

Safety Valve

A safety valve (Figure 8-19) is installed in the air dryer module to protect the air system against excessive air pressure buildup. The valve consists of a spring loaded ball which exhausts the system if the pressure rises above 1030 kPa (150 psi). A second safety valve is installed in the tire inflation circuit and is set at 1207 kPa (175 psi).



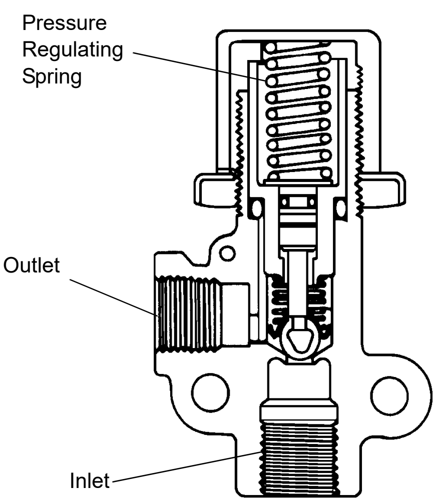
6861-1g

FIGURE 8-19

Pressure Protection Valve

The purpose of the pressure protection valve (Figure 8-20) is to isolate one system from the other by closing at a preset pressure. One valve isolates the primary system from the secondary system, one valve isolates the auxiliary system from the primary system, and the other isolates the tire inflation system from the primary system. The valve is a normally closed valve which can also be referred to as a non-exhausting sequencing valve.

The valve has two ports: a supply port and a delivery port. The closing pressure is 586 kPa (85 psi) and opening pressure is about 103 to 138 kPa (15 to 20 psi) higher than the closing pressure. The valve is preset to the specified opening and closing pressures.



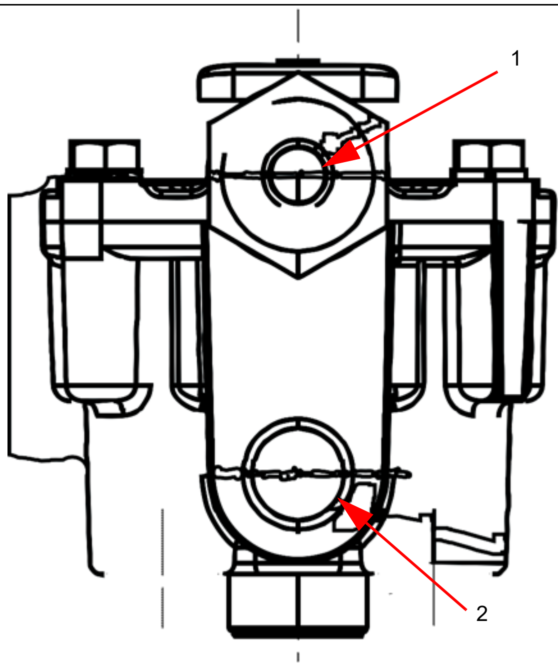
6861-1i

FIGURE 8-20

Relay Valve

The purpose of the two piston operated relay valves (Figure 8-21) and (Figure 8-22) is to speed up application of the service brakes. The valve is remote mounted and delivers air to the brakes in response to signals from the foot brake control valves.

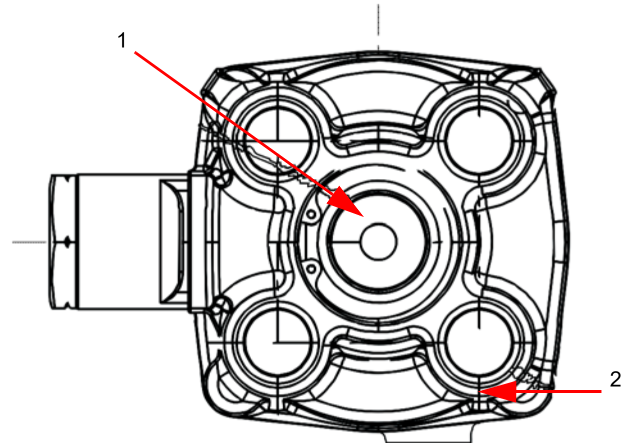
One valve is mounted on the front of the frame for front service brakes and one is mounted on the rear of the frame for the rear service brakes. Air pressure, which controls the valve, enters through the service port to either deliver or exhaust air pressure from the circuits serviced by the relay valve.



7463-1

Item	Description
1	Service Port
2	Supply Port

FIGURE 8-21



7463-2

Item	Description
1	Exhaust Port
2	Delivery Port

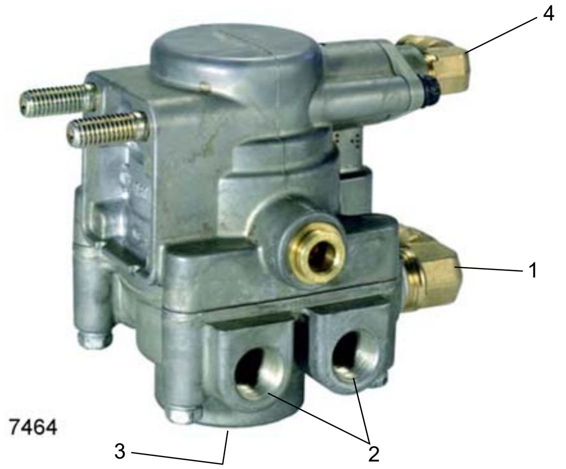
FIGURE 8-22

Dual Brake Valve

The dual brake valve is a suspended, pedal operated brake valve which has two separate supply and delivery circuits. The valve is located under the front console to the right of the steering column. The valve provides the driver with a graduated control for applying the service brakes or the parking brakes through the spring brake control valve.

Spring Brake Control Valve

The spring brake control valve (Figure 8-23) is located on the rear of the carrier frame. The purpose of the valve is to supply a specific, limited hold of pressure to the spring brakes, and in the event of a loss of primary pressure, to modulate the spring brakes through the use of the dual brake valve.



Port	Designation
1	Air Supply Port
2	Air Delivery Port
3	Air Exhaust Port
4	Park Control Port

FIGURE 8-23

Park Brake Control Valve

The park brake control valve is an ON/OFF push/pull control valve located on the front console. When the air pressure reaches 340 kPa (50 psi) and the button is pushed in, the park brakes are disengaged. The button will pop out when the air pressure falls below 280 kPa (40 psi) exhausting the delivery line and engaging the brakes.

Anti-lock Modulator

The quick release anti-lock system modulators are ON/OFF air valves that incorporate a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface between the anti-lock controller electronics and the air brake system. The modulator is used to control the braking function on actuators during anti-lock activity.

Traction Control Valve

The traction control valve is installed on the right rear side of the frame. It is used in the air system to improve stability and traction during acceleration (at low speeds) and lateral stability while driving around curves.

Maintenance

WARNING

Death or Injury Could Occur!

Depressurize both air systems completely before disconnecting air lines or components.

NOTE: For more in-depth information on Bendix system components, go to the Bendix website and download the appropriate document.

Air Compressor

NOTE: Detailed maintenance instructions for the air compressor are contained in the Engine Service Manual.

Removal of Air Compressor

1. Chock the wheels and depressurize both primary and secondary air circuits.
2. Open the engine compartment to gain access to the air compressor.
3. Remove Pump #1 before the air compressor can be removed.
4. Disconnect and tag the air lines connected to the air compressor.
5. Unbolt and remove the compressor from the engine.

Installation of Air Compressor

1. Bolt the air compressor to the engine. Refer to engine manual for appropriate torque.
2. Connect air lines as tagged during removal.
3. Install Pump #1 onto the air compressor. Torque hardware per Table 1-5.

Air Governor

Removal of the Air Governor

1. Chock the wheels and depressurize both primary and secondary air circuits.
2. Disconnect the air line from the governor.
3. Remove the bolts, lockwashers, and nuts securing the air governor to the air dryer module. Remove the air governor.

Installation of the Air Governor

1. Position the air governor on the air dryer module and secure with bolts, lockwashers, and nuts.
2. Connect the air line to the governor.

Operational Test for the Air Governor

Start the engine and pressurize the system. Check the governor cut-out pressure with either the panel gauge or a test gauge 896 kPa (130 psi). At the cut-out pressure, the compressor is unloaded and the air dryer is purged.

Leakage Test for the Air Governor

1. Leakage checks on the governor are made at the exhaust port with a soap solution in both the cut-in and cut-out positions. In the cut-in position, the leakage can be through either the inlet valve or bottom piston grommet. In the cut-out position, leakage can be through the exhaust valve seat or upper piston grommet. The soap solution test on the exhaust port is done to verify a leak and determine its location.
2. If the governor does not function properly or has excessive leakage, repair or replace the air governor. Check the applicable Grove Parts Manual.

Air Dryer

Removal of the Air Dryer

1. Turn the ignition switch OFF.
2. Turn the battery disconnect switch in the battery compartment to the OFF position.
3. Chock the wheels and completely depressurize the air system.
4. Tag and disconnect all air and electrical lines connected to the air dryer.
5. Remove the capscrews and washers securing the dryer to the carrier frame and remove the dryer.
6. If the dryer is to be replaced with a new one, remove the fittings from the old dryer.

Installation of the Air Dryer

1. Install the fittings on the new dryer.
2. Position the air dryer on the carrier frame and secure with the capscrews and washers. Torque the capscrews. Refer to *Fasteners and Torque Values*, page 1-14.
3. Connect the air and electrical lines as tagged during removal. Run the lines downhill so that pockets of water do not collect in the lines and freeze.

Preventive Maintenance for the Air Dryer

The recommended desiccant cartridge change is 3 years but can be shorter or longer depending on conditions.

1. Every 900 hours, or 40,000 km (25,000 mi) check for moisture in the air system by opening the reservoir’s drain cock or automatic drain valve.
2. Replacement of the desiccant cartridge may be necessary if moisture is present; however, the following conditions can also cause water accumulation and should be considered before changing the desiccant.
    a. An outside air source has been used to charge the system that has not been passed through a drying bed.
    b. Excessively high air demands, which is not normal, that do not allow the compressor to unload in a normal fashion. Check for air system leakage.
    c. In areas where the temperature varies 15° C (30° F) or more daily, small amounts of water can accumulate in the air system due to condensation. This is normal and should not be considered as an indication that the dryer is not performing properly.
3. Location of the air dryer is too close — less than 1.8 m (6 ft) — to the air compressor.
4. Check the electrical connections and mounting bolts for tightness.
5. With the ignition switch ON, unplug the electrical connector at the air dryer and check for power. If there is no power, check for a blown fuse and broken wires.
6. Every 10,800 hrs, 500,000 km (300,000 mi), or 36 months, rebuild the air dryer and replace the desiccant cartridge.
7. Check the heater and thermostat as follows:
    a. Turn off the engine and let the air dryer end cover cool to below 4° C (40° F).
    b. Check the resistance across the pins in the female connector on the bottom of the air dryer. The resistance should be 6.0 to 9.0 ohms for a 24 volt system.
    c. Warm the end cover to over 32° C (90° F) and check the resistance again. The resistance should exceed 1000 ohms.
    d. If the resistance is outside the specified limits, replace the purge valve housing assembly which includes the thermostat and heater.

Leak Tests for the Air Dryer

1. Test the outlet port check valve in the dryer by observing the pressure after the governor cuts out. A rapid loss in pressure indicates a possible failed check valve in the outlet port.
2. Test the purge valve by applying a soap solution to the exhaust. Observe for bubbles during the loading cycle.
3. Test the safety valve by pulling the stem while the compressor is loading. Air must exhaust while the stem is held and stop when the stem is released.
4. Test all lines and fittings leading to and from the air dryer with a soap solution for leaking.

Reservoirs

Removal of the Reservoirs

1. Chock the wheels and completely depressurize both systems.
2. Disconnect and tag all air lines connected to the reservoir.
3. Remove the capscrews, washers, and nuts and remove the reservoir from the clamping brackets. If a new reservoir is to be installed, remove the fittings from the old reservoir.

Maintenance for the Reservoir

Maintenance of the reservoir is limited to inspecting the mounting hardware. It is not recommended that tanks be repaired. Damaged tanks need to be replaced.

Cleaning the Reservoir

If the inside of the reservoir has become excessively coated with sludge that cannot be drained off, remove the reservoir and clean with solvent, steam, or water. Aerate the reservoir before reinstalling.

Installation of the Reservoir

1. Install the reservoirs to the brackets and secure with the nuts, washers, and capscrews. Refer to *Fasteners and Torque Values*, page 1-14.
2. Connect all air lines to the reservoir.

Low Pressure Indicator Switches

Maintenance is limited to leakage and pressure checks. Replace faulty switches.

Operating and Leakage Checks

1. Shut down the engine and slowly reduce the pressure.
2. The switch should activate at about 520 kPa (75 psi). The air gauges and indicators in the cab can be used to test the switch.
3. With system pressurized, coat the switch with a soap solution and observe for bubbles. No leaking is permitted.

Removal of Low Pressure Indicator Switches

1. Chock the wheels and completely depressurize both systems.
2. Disconnect the electrical lead and unscrew the switch from the fitting.

Installation of Low Pressure Indicator Switches

Screw the switch into the fitting and connect the electrical leads.

Preventive Maintenance for the Low Pressure Indicator Switches

Every 16,000 km (10,000 mi) or monthly do the procedures as outlined under Operating and Leakage Checks above.

Stop Light Switch

Operational Test for Stop Light Switch

Depress the brake pedal and observe that the stop lights illuminate.

Leakage Test for Stop Light Switch

With pressure applied, coat the switch with a soap solution and observe for bubbles. No leaks are permitted.

Removal of Stop Light Switch

Disconnect the electrical leads and unscrew the switch from the dual brake valve with a wrench.

Installation of Stop Light Switch

Screw the switch into the dual brake valve with a wrench and connect the electrical leads.

Air Pressure Gauge

Removal of Air Pressure Gauge

1. Chock the wheels and completely depressurize both systems.
2. Remove the hardware securing the cover to the front console and remove the cover.
3. Gain access to the rear of the air pressure gauge. Tag and disconnect the nylon tubes from the rear of the gauge. Tag and disconnect the electrical connector.
4. Remove the hardware securing the gauge to the front console and remove the gauge.

Installation of Air Pressure Gauge

1. Install the air pressure gauge in the front console with the attaching hardware.
2. Connect the two nylon tubes to the fittings in the rear of the gauge and connect the electrical connector as per removal tags.
3. Install the front console cover and secure with attaching hardware.

Functional Check of Air Pressure Gauge

Start the engine and observe the air pressure gauge. The red arrow on the gauge (primary) should rise first until a pressure reading of about 590 kPa (85 psi) at which time the green arrow (secondary) should begin to climb. Both arrows should level off at about 760 kPa (110 psi).

Safety Valve

Removal of Safety Valve

1. Chock the wheels and completely depressurize the system.
2. Using a wrench, unscrew the valve from the fitting.

Installation of the Safety Valve

Screw the valve into the fitting.

Operating and Leakage Checks for the Safety Valve

With the system pressurized, pull the valve stem and air should exhaust from the valve exhaust port. Release the stem and air flow should stop. Replace the safety valve if it does not pass the operation test.

Coat the valve and fitting with a soap and water solution and observe for leaks. Replace the valve if excessive leaking is present.

Check the valve every 160,000 km (100,000 mi), 3600 hrs, or yearly.

Tire Inflation Pressure Protection Valve

Removal of the Tire Inflation Pressure Protection Valve

1. Chock the wheels and completely depressurize both air systems.
2. Tag and disconnect the air lines from the pressure protection valve.
3. Remove the capscrews, nuts, and washers securing the valve to the mounting studs.

Installation of the Tire Inflation Pressure Protection Valve

1. Install the valve on the mounting studs and secure with the capscrews, nuts, and washers. Refer to *Fasteners and Torque Values*, page 1-14.
2. Connect the air lines as tagged during removal.

Operational Check of the Tire Inflation Pressure Protection Valve

NOTE: Replace any pressure protection valve that does not operate properly.

1. Install a pressure gauge and drain valve at both the supply and delivery sides of the pressure protection valve.
2. Pressurize the system and shut off the engine.
3. Slowly exhaust the delivery side of the valve. The gauge on the supply side should stop while the gauge on the delivery side should continue to show a pressure loss. The closing pressure should be 590 ±35 kPa (85 ±5 psi).

Leakage Test of the Tire Inflation Pressure Protection Valve

1. Apply a soap solution around the cap of the valve with the system pressurized and observe for bubbles. A 25 mm (1 in) bubble in three seconds or longer is acceptable.
2. Disconnect the air line on the delivery side of the valve and apply a soap solution to the delivery port. A 25 mm (1 in) bubble in five seconds or more is acceptable.

Preventive Maintenance for the Tire Inflation Pressure Protection Valve

Every 900 hrs, 40,000 km (25,000 mi) or 3 months, check for operation and leakage as described above.

Relay Valve

WARNING

Death or Injury Could Occur!

Completely depressurize all reservoirs before removing the insert.

The inlet/exhaust valve assembly can be replaced without removing the valve. Replacement is as follows.

1. Remove the snap ring/exhaust cover assembly.
2. Pull the insert out and replace.
3. Reinstall the exhaust cover and snap ring.

Removal of the Relay Valve

1. Chock the wheel and completely depressurize both air systems.
2. Tag and disconnect all air lines connected to the relay valve.
3. Remove the bolts and washers securing the valve to the frame and remove the valve.

Inspection of the Relay Valve

Inspect all air lines for kinks, cuts, chafing, or deterioration. Replace lines showing these defects.

Installation of the Relay Valve

1. Position the valve on the frame and secure with the bolts and washers.
2. Connect the air lines as per removal tags.
3. Check operation as described under Operating and Leakage Tests.

Operating Test for the Relay Valve

1. Chock the wheels and pressurize both systems. Adjust the brakes.
2. Apply and release the brakes several times and check for prompt response of the brakes at all wheels.

Leakage Test for the Relay Valve

1. With dual brake valve released, coat the relay valve exhaust port with a soap solution to check for inlet valve and O-Ring leakage. A 25 mm (1 in) bubble in five seconds is permissible.
2. With the dual brake valve applied, check the relay valve exhaust port for leakage of the exhaust valve.
3. Apply a soap solution around where the relay valve cover and body meet to check for seal ring leakage. A 25 mm (1 in) bubble in five seconds is permissible.

Preventive Maintenance for the Relay Valve

Every 300 hours, 1600 km (1000 mi), or monthly:

Check the relay valve for leakage and proper operation.

Every 3600 operating hours, 16000 km (10000 mi), or annually:

Disassemble the valve, clean and inspect all parts. Repair and replace as necessary.

Spring Brake Control Valve

Removal of the Spring Brake Control Valve

1. Chock the wheel and completely depressurize both air systems.
2. Tag and disconnect all air lines connected to the relay valve.
3. Remove the attaching hardware to free the valve. Remove the valve.

Inspection of the Spring Brake Control Valve

Inspect all air lines for kinks, cuts, chafing, or deterioration. Replace lines showing these defects.

Installation of the Spring Brake Control Valves

1. Secure the valve with attaching hardware.
2. Connect the air lines as per removal tags.
3. Check operation as described under Operating and Leakage Tests.

Operating Test for the Spring Brake Control Valve

Block vehicle and hold by means other than vehicle brakes.

Charge air brake system to governor cut-out pressure.

1. Place parking control valve in “park” position. Observe that the spring brake actuators apply promptly. Remove one line from the delivery port of the valve and install the test gauge. Place parking control valve in “release” position. Observe that the spring brake actuators release fully.
2. With the parking control valve in “release” position, note the gauge pressure reading. (Correct spring brake actuator hold-off pressure is 738 kPa (107 psi) nominally.)
3. Place parking control valve in “park” position - gauge reading should drop to zero promptly. A lag (more than 3 seconds) in drop of pressure would indicate faulty operation.
4. With the parking control valve in the “park” position, gradually apply the foot brake valve and note a pressure reading increase on the gauge installed in the delivery port.
5. Place parking control valve in the “release” position.
6. Drain the reservoir, which supplies the rear service brake circuit, apply the foot brake valve several times and note that the pressure reading on the gauge decreases each time the foot brake valve is applied (spring brake modulation). After the foot brake valve has been applied several times, pressure on the gauge will drop to the point where release of the spring brake actuators will no longer occur.

Leakage Test for the Spring Brake Control Valve

Place the park control valve in the “release” position; using a soap solution, coat all ports including the exhaust port. A 25 mm (1 in) bubble in 3 seconds is permitted. If the valve does not function as described, or leakage is excessive, the valve should be replaced with a new or re-manufactured unit.

WARNING

Death or Injury Could Occur!

Do not attempt to disassemble the valve. The valve contains high spring forces that could result in personal injury if disassembly is attempted!

Dual Brake Valve

Removal of the Dual Brake Valve

1. Chock the wheels and completely depressurize both air systems.
2. Remove the windshield and front console cover.
3. Tag and disconnect all air lines connected to the brake valve.
4. Remove the nuts, washers, and lockwashers securing the valve to the mounting studs and remove the brake valve and pedal assembly.

Installation of the Dual Brake Valve

1. Position the brake valve and pedal assembly onto the studs under the front console and secure with the nuts, washers, and lockwashers.
2. Connect all the air lines to the brake valve as per the removal tag.

Operating Test for the Dual Brake Valve

CAUTION

Damage Could Occur!

A change in braking characteristics or low air pressure may be an indication of a malfunction in one of the brake circuits. Do not operate the vehicle until repairs have been made and both circuits are operating properly. Always check brakes after servicing.

1. Check the delivery pressure of both #1 and #2 circuits with a test gauge. Depress the treadle to several positions between fully released and applied. Check the pressure on the gauges to see if it varies equally and proportionately with the movement of the brake pedal.
2. After the brakes are released, the reading on the test gauges should fall to zero. The delivery pressure in #1 circuit should be 30 kPa (4 psi) greater than #2 circuit with both supply reservoirs at the same pressure.

Leakage Test for the Dual Brake Valve

1. Make and hold a high pressure application 550 kPa (80 psi).
2. Coat the exhaust port and body of the brake valve with a soap solution. A leakage of a 25 mm (1 in) bubble in three seconds is permitted.

Preventive Maintenance for the Dual Brake Valve

Every 300 operating hours, 16,000 km (10,000 mi), or three months.

1. Clean dirt away from the heal of the treadle, plunger boot, and mounting plate.
2. Lubricate the treadle roller, hinge pin, and roller pin using a barium base lubricant.
3. Check the rubber plunger boot for deterioration and replace as necessary.
4. Lubricate the plunger with a barium base lubricant.

Every 3600 operating hours, 16,000 km (10,000 mi), or yearly.

Replace inlet and exhaust valves, exhaust diaphragm, O-Rings, and rubber graduating spring if worn or deteriorated.

Every 7200 operating hours, 32,000 km (20,000 mi) or two years.

Disassemble the brake valve and clean and inspect all parts.

Park Brake Control Valve

Removal of Park Brake Control Valve

1. Chock the wheels and completely depressurize both systems.
2. Remove the hardware securing the front console cover and remove the cover.
3. Tag and disconnect the air lines connected to the park control valve. Tag and disconnect the electrical leads from the pressure switch screwed into the valve.
4. Remove mounting screws.
5. Unscrew pressure switch from the valve if new valve is to be installed.

Installation of Park Brake Control Valve

1. If removed, install the pressure switch in the valve port.
2. Install mounting screws.
3. Connect the air lines to the valve and the electrical leads to the pressure switch as per removal tags.
4. Install the front console cover and secure with the attaching hardware.

Operating and Leakage Check

NOTE: Replace malfunctioning or leaking parking brake valve.

1. Chock the wheels and pressurize the air system.
2. With the park brake valve plunger pulled out (exhaust position), coat the exhaust port and plunger stem with a soap solution. A 25 mm (1 in) bubble in five seconds is permissible. No leakage is permitted between the upper and lower body.
3. Push the park brake valve plunger in (applied position). A 25 mm (1 in) bubble in three seconds is permitted.
4. Reduce the air pressure and observe the park brake valve plunger. It should pop out when the air pressure drops to about 280 kPa (40 psi) exhausting the delivery line and engage the park brakes.

Preventive Maintenance of Park Brake Control Valve

Every 300 hours, 16,000 km (10,000 mi) or 3 months, perform the procedures under the Operating and Leakage Check noted above.

BRAKES

Description

NOTE: For more in depth information on Bendix system components go to the Bendix website and download the appropriate document.

Air Supply

The vehicle's compressor, see Air Compressor, page 8-22, takes in filtered air at an increased pressure from the intake manifold and compresses it. The compressed air is delivered to the air dryer where water and a small amount of oil is removed. The air then travels into the rear brake system reservoir and a front brake system reservoirr. For each system, the air pressurizes the reservoir and the air hoses all the way to the next control valve, where the air pressure remains, ready to be used.

A vehicle may use compressed air for many tasks. Some examples are: to provide force for braking, to deliver air to the air suspension system, and so forth.

Normal Braking

When the driver applies the foot brake, the air pressure is delivered to the rear and front brake systems. This air travels through the delivery (in this case signal) line to the relay valve. This closes the exhaust and opens the delivery of air to the brakes.

The pressure quickly increases in the brake chambers and applies force to the push rod, transferring the force to the S-Cam. When the brakes are released, the air in the brake chambers is able to be quickly released.

Vehicle Parking

Vehicles are parked using powerful springs, which are part of the spring brake assembly, to engage the brakes and hold the vehicle in position. When the driver prepares to move away and releases the parking brake, the spring force is countered by the introduction of air pressure. An anti-compounding valve in the system design helps prevent the application of both the spring and service brakes together.

Anti-lock Braking Systems (ABS)

This Grove crane uses an electronic Anti-lock Braking System (ABS) to help improve braking when excessive wheel slip, or wheel lock-up, is detected. Electronic Control Units (ECUs) monitor wheel speeds (on all wheels equipped with speed sensors) and use the ABS modulator valves to adjust or pulse the braking force being applied. These valves operate many times per second during an ABS event. ABS typically improves stability and steerability, and also reduces stopping distances on most surfaces.

In addition to the ABS features above, some advanced ECUs have a drag torque control feature which reduces driven-axle wheel slip (due to driveline inertia) by communicating with the engine's controller and increasing the engine torque.

NOTE: For information on the ABS speed sensors refer to Wheel Speed Sensor Replacement (Front), page 8-74 in this Manual.

Wheel Speed Sensor and Tone Ring

An ABS wheel speed sensor and tone ring (Figure 8-24) is mounted in each monitored wheel. As the wheel spins, the sensor sends a fluctuating signal to the ABS ECU, which the ECU interprets as wheel speed.

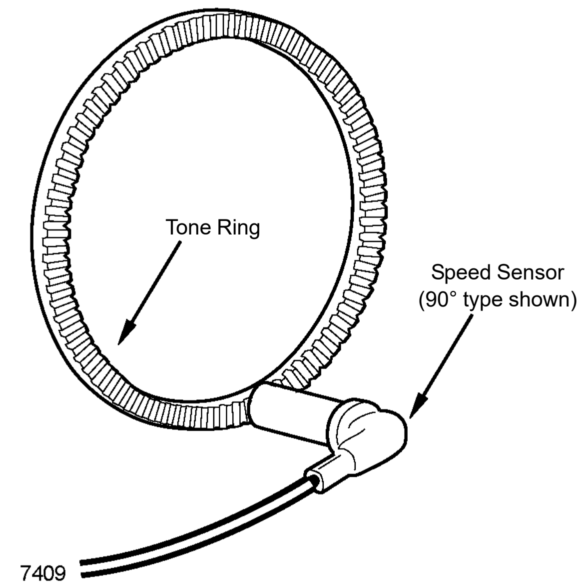


FIGURE 8-24

Automatic Traction Control

In addition to the ABS function, this crane provides an Automatic Traction Control (ATC) feature which can help improve vehicle stability and traction during vehicle acceleration at low speeds.

Emergency Braking

In emergency situations where the system air pressure is reduced or lost, the spring brake control valve actuates the parking brakes to bring the vehicle to a stop.

NON-ASBESTOS WARNING

Most brake linings no longer contain asbestos fibers. These fibers may be glass, mineral wool, aramid, ceramic, or carbon. Current regulations do not cover non-asbestos fibers. Medical experts do not agree about the possible long-term risks of working with and breathing non-asbestos fibers. But some experts think that long-term exposure to some non-asbestos fibers could cause pneumoconiosis, fibrosis, and cancer. Therefore, it is recommended that workers use caution to avoid dust when working on brakes.

- Whenever possible, work on brakes in a separate area away from other operations.

8

- Always wear a respirator approved by NIOSH or MSHA during all brake service procedures. Wear the respirator from removal of the wheels through assembly.
- NEVER use compressed air or dry brushing to clean brake parts or assemblies. OSHA recommends that you use cylinders that enclose the brake. These cylinders have vacuums with high efficiency (HEPA) filters. If such equipment is not available, carefully clean parts and assemblies in the open air.
- Clean brake parts and assemblies in the open air. During disassembly, carefully place all parts on the floor to avoid getting dust into the air. Use an industrial vacuum cleaner with a HEPA filter system to clean dust from the brake drums backing plates and other brake parts. After using the vacuum, remove any remaining dust with a rag soaked in water and wrung until nearly dry.
- Grinding or machining brake linings. If it is necessary to grind or machine brake linings, additional precautions should be taken because contact with fiber dust is higher during these operations. In addition to wearing an approved respirator, such work should be done in an area with exhaust ventilation.
- Cleaning the work area. NEVER use compressed air or dry sweeping to clean the work area. Use an industrial vacuum with a HEPA filter and rags soaked in water and wrung until nearly dry. Used rags should be disposed of with care to avoid getting dust into the air. Use an approved respirator when emptying vacuum cleaners and handling used rags.
- Worker clean-up. Workers should wash their hands before eating or drinking. Working clothes should not be worn home. They should be vacuumed after use and then should be laundered separately, without shaking, to prevent fiber dust from getting into the air.

FRONT BRAKES

Description

The front brakes are air actuated and cam operated. The brake shoes employ 19 mm (0.75 in) tapered block liners. The shoes are fabricated of steel and mounted on individual anchor pins which are supported by cast spiders. Automatic slack adjusters maintain proper push rod stroke and lining-to-drum clearance during normal service.

NOTE: For information on the ABS speed sensors refer to Wheel Speed Sensor Replacement (Front), page 8-74.

Maintenance

Troubleshooting the Brakes

SYMPTOM	PROBABLE CAUSE	SOLUTION
Brakes are poor or do not apply.	Insufficient air pressure.	Check for the correct air pressure at the compressor and brake air chambers.
	Restriction or leak in lines, valves, etc.	Check all lines, valves, etc., for leaks or restrictions.
	Brakes out of adjustment.	Adjust the brakes.
	Leaking diaphragm.	Replace the diaphragm.
Uneven braking or uneven lining wear.	Ruptured diaphragm.	Replace the diaphragm.
	Brakes out of adjustment.	Adjust the brakes.
	Grease on the lining.	Replace the lining.
	Glazed lining.	Replace the lining.
	Shoes installed backwards.	Reverse the shoes.
	Combination linings.	Remove the linings and replace with the correct style.

Disassembly of the Front Brakes

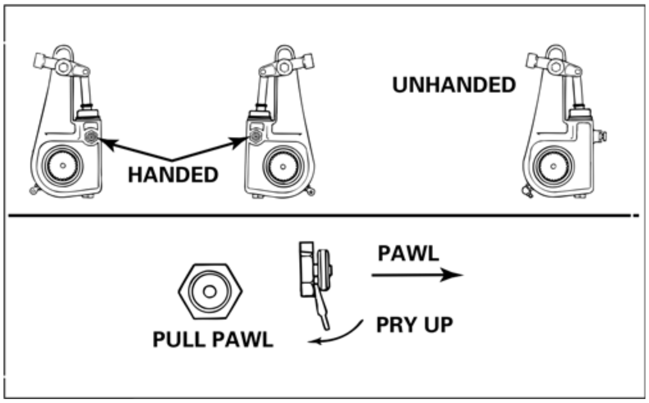
WARNING

Death or Injury Could Occur!

Do not work under a crane supported by only outrigger jacks. Use stands to support the carrier.

1. Set the parking brakes and block the wheels.
2. Raise the carrier so that the front wheels are off the ground.
3. Place jack stands under the frame where the wheels are to be removed.
4. Disengage the pull pawl. Pry the pull pawl at least 1/32-inch to disengage the teeth. See (Figure 8-25).

   NOTE: When the pry bar is removed, the pull pawl will re-engage automatically.



10073

FIGURE 8-25

5. Back off the automatic slack adjuster until the brake shoes are clear of the drum.
6. Remove the hub caps, lug nuts, washers, and wheel and tire assemblies.
7. To remove the drum, pull outboard while rocking from side to side.

CAUTION

Damage Could Occur!

Do not strike the axle shaft flange with a hammer. Do not use chisels or wedges to loosen the shaft or dowels.

CAUTION

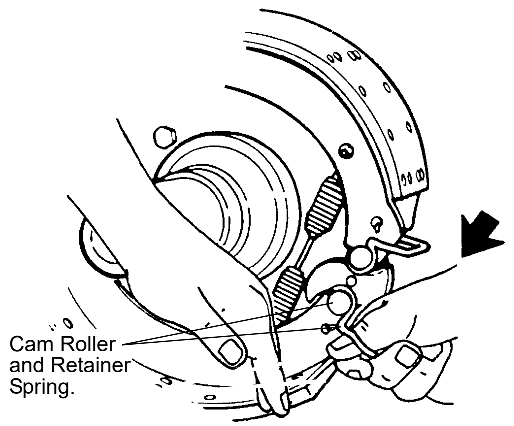
Damage Could Occur!

Do not force the drum. Excessive force may damage brake components.

Brake Shoe Removal

1. Push down on the bottom brake shoe and pull on the roller retaining clip to remove the bottom cam roller.

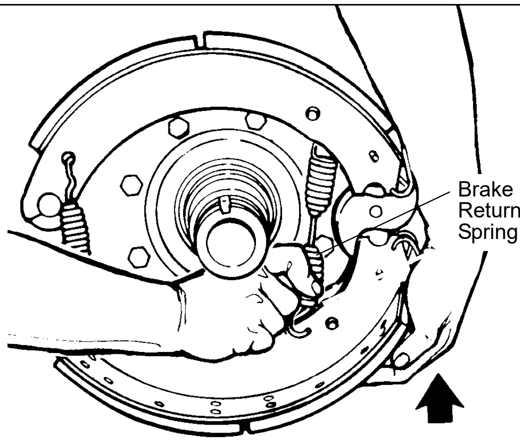
.



6861-1j

FIGURE 8-26

2. Lift the top brake shoe and pull on the roller retaining clip and remove the upper cam roller.
3. Lift the bottom brake shoe to release the tension on the brake return spring and remove the spring.
4. Rotate the bottom brake shoe to relieve tension on the retaining springs. Remove the springs and brake shoes.



6861-1k

FIGURE 8-27

5. Rotate the bottom brake shoe to relieve tension on the retaining springs. Remove the springs and brake shoes.

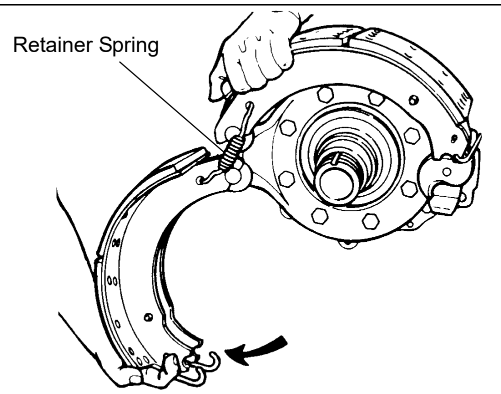


FIGURE 8-28

6. Remove the slack adjuster. Also refer to Automatic Slack Adjuster, page 8-40 in this Manual.
7. Remove the camshaft by grasping the camshaft head and pulling outboard.
8. Remove the bolts attaching the air chamber bracket to the spider and pull it away from the spider.
9. Remove spider-to-axle attaching nuts and bolts and remove the spider (Figure 8-29).

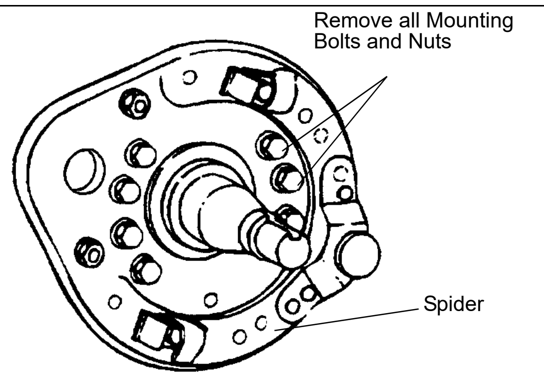


FIGURE 8-29

Cleaning Brakes

CAUTION

Damage Could Occur!

Oxidation and dirt on the outside of the brake drums acts as an insulator and may hinder heat dissipation. Remove oxidation and dirt with a wire brush.

---

1. Wire brush all parts of the brakes exposed to mud, road dirt, and salt, to include the spider, air chamber bracket, dust shield, and exterior of drum.
2. Following the recommendations at the beginning of this section, (*Brakes*, page 8-32) use a vacuum cleaner to remove brake dust from drums. Wipe the interior of the brake drums with a greaseless solvent to remove any spilled oil.
3. Clean all other brake parts thoroughly with a suitable shop solvent. Wipe dry with a clean, lint-free cloth.

Inspection of Brakes and Parts

NOTE: Refer to (Figure 8-30) for the brake components referenced in inspection.

CAUTION

Damage Could Occur!

Do not use drum if it exceeds maximum diameter or run-out specifications.

---

1. Check the spider for expanded anchor pin holes and cracks. Replace damaged spiders and anchor pin bushings.
2. Check the camshaft bracket for broken welds, cracks, and correct alignment.
3. Check anchor pins for corrosion and wear. Replace damaged anchor pins.
4. Check brake shoes for rust expanded rivet holes, broken welds, and correct alignment. Anchor pin holes must not exceed 26 mm (1.03 in) in diameter. The distance from the center of the anchor pin hole to the center of the roller hole must not exceed 327 mm (12.875 in).
5. Check the camshaft for cracks, wear, and corrosion. Check the cam head, bearing journals, and splines. Refer to Repair/Replacement of Camshaft, page 8-38 in this section.
6. Check the slack adjuster for the gap between the clevis and collar. If the gap exceeds 1.5 mm (0.060 in), replace the clevis. Check the clevis pins and bushing in the slack adjuster arm. Replace bushing if diameter exceeds 16.6 mm (0.65 in).
7. Rotate the slack adjuster adjusting nut through a 360 degree rotation (about 22 turns of the adjusting nut) with a torque wrench. Torque must be less than 2.8 N-m (25 lb-in) for a new or rebuilt slack adjuster.
8. Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting, and distortion.
9. Measure the inside diameter of the drum in several locations and replace if diameter exceeds manufacturers specifications.
10. Each time the brake shoes are removed, check the camshaft radial play as outlined in Step 10a thru 10e below and (Figure 8-31). Also, refer to Repair/ Replacement of Camshaft, page 8-38 in this Section.

a. Mount a dial indicator with the plunger on the cam head at the roller contact area.

b. Zero the dial indicator.

c. Move the cam head up and down and note the maximum reading.

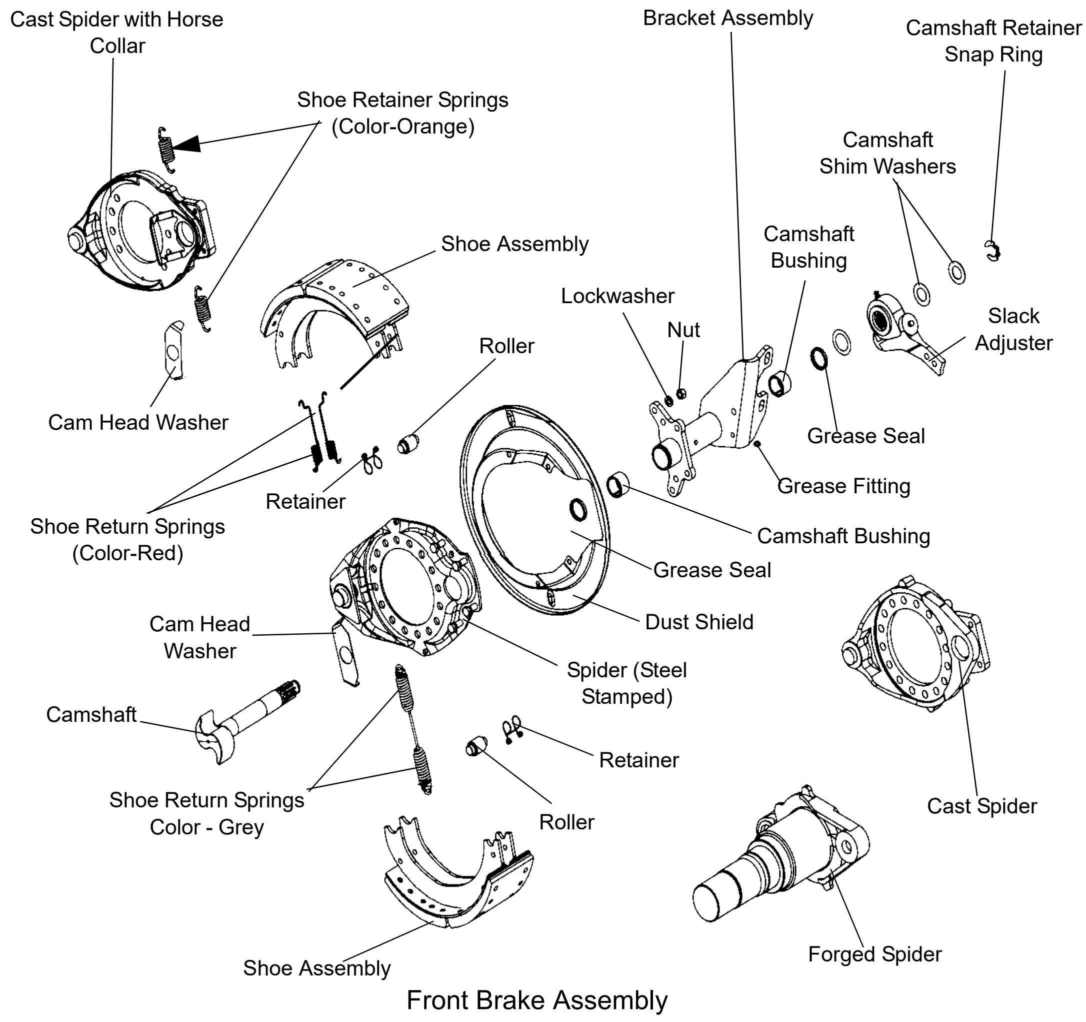
d. If play exceeds 0.030 in (.76 mm), re-bush the air chamber bracket and replace seals. Refer to *Repair/Replacement of Camshaft*, page 8-38 in this Section below.

e. After re-bushing, recheck radial play. Replace the camshaft if play is still excessive.

CAUTION

Damage Could Occur!

Do not use drum if it exceeds maximum diameter or run-out specifications.



Front Brake Assembly

FIGURE 8-30

.

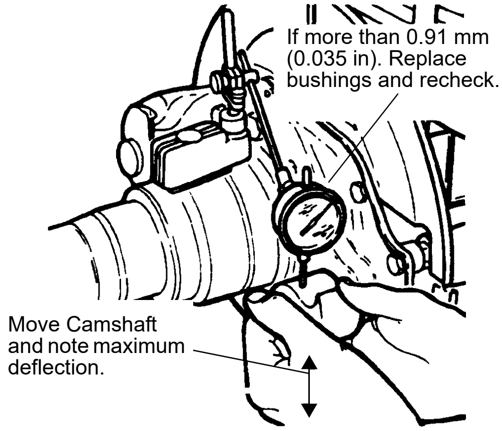


FIGURE 8-31

11. Check spline end of the camshaft for cracks and worn or deformed splines. Replace as necessary.
12. Check the camshaft bushing journals for wear or corrosion. If the camshaft shows visible wear or if roughness is felt in the journal, replace the camshaft.
13. Check the camshaft head for brineling, cracking or flat spots. Replace the camshaft if a ridge can be felt between the worn areas and surface of the cam head.

NOTE: The camshaft bushings and seals are mounted in the air chamber bracket assembly.

14. Check the camshaft bushings for deterioration or wear. The inner surface must be smooth. Replace the bushing if surface is rough or abrasive.
15. Check the grease seals and replace if nicked, cut, or distorted.
16. Check the air chamber bracket for a bent, broken, or cracked arm and welds. Replace as necessary.
17. Check the air chamber bracket mounting studs for looseness, damaged threads, or bent studs. Replace as necessary.
18. Check the air chamber for leaks, cracked housing, bent pushrod, loose clamp ring, clogged vent holes, or loose air fittings. Repair or replace as necessary.
19. If the air chamber is replaced or repaired, check the distance from the clevis pin hole centerline to the air chamber face. Reference *Automatic Slack Adjuster*, page 8-40 for adjustment.
20. If a new air chamber is installed, ensure that the cutoff pushrod does not project too far into the clevis. Minimum clearance from the clevis centerline to pushrod end is 22.2 mm (0.875 in).
21. Check air chamber clevis pin for cracks and wear.
22. Check the automatic slack adjuster. Reference *Automatic Slack Adjuster*, page 8-40.

Repair/Replacement of Camshaft

Routinely replace lower cost items such as springs, seals, bushings, and heavily worn parts. Damage caused by failure of worn parts is much more expensive than the cost of the parts.

Camshaft bushing and/or grease seal replacement is as follows:

1. Remove the air chamber bracket.
2. Drive out the old bushing and grease seal with a suitable driver.
3. Clean and inspect the air chamber bracket. Reference Inspection in this subsection.
4. Install the new bushings in the air chamber bracket with a piloted driver. Both bushings are nonmetallic and are labeled on one end. Install them with the labeled ends facing each other. The cam head end is recessed 7.1 mm (0.281 in) and the slack adjuster end is recessed 17.5 mm (0.688 in) from the ends of the tube (Figure 8-32).

.

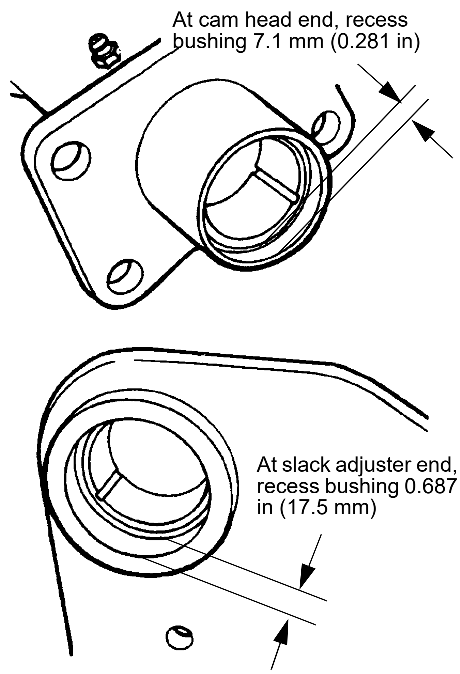


FIGURE 8-32

CAUTION

Damage Could Occur!

Seals must be installed with the lip side (spring side) of both seals facing toward the slack adjuster end of the bracket. Improperly oriented seals may allow grease to exit the camshaft head end of air chamber bracket and contaminate lining material.

5. Install new grease seals with a piloted driver so the seals are flush with the end of the air chamber bracket tube (Figure 8-33).

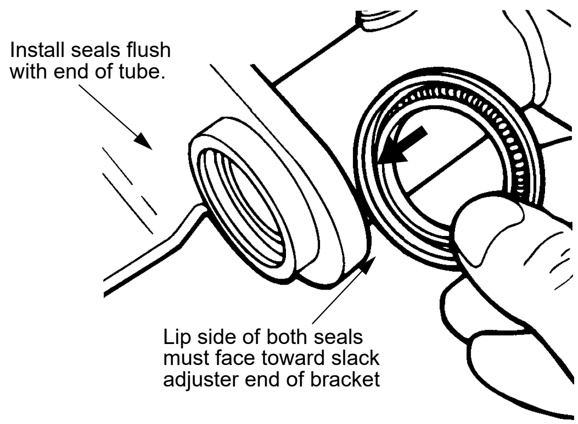
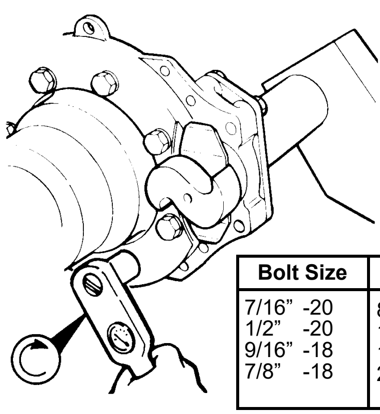


FIGURE 8-33

Camshaft Installation

1. Check all spider bolts for the correct torque as shown below.



Bolt Size	Nm	Pounds-Foot
7/16” -20	85 -102	60 -75
1/2” -20	115 -156	85 -115
9/16” -18	176 -224	130 -165
7/8” -18	244 -312	180 -230

FIGURE 8-34

2. Install new camshaft seals and, if required, bushings in both the spider and camshaft bracket. Use a seal driver to install the bushings.
3. If the camshaft bracket was removed, install the gasket and bracket to the spider. Torque to:

- 1/2”-13 Grade 8 - 122 to 163 N-m (90 to120 lb-ft).
- 1/2”-13 Grade 5 - 88 to 136 N-m (65 to 100 lb-ft).
- 5/8”-18 Plain Nut - 203 to 258 N-m (150 to 190 lb-ft).
- 5/8”-18 Lock Nut -176 to 224 N-m (130 to 165 lb-ft).

NOTE: Install both seals with lips toward slack adjuster.

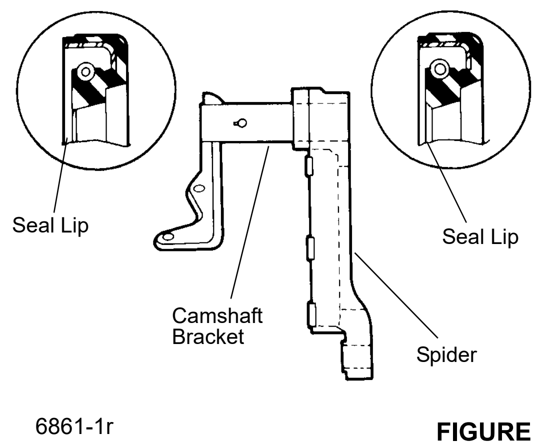


FIGURE 8-35

CAUTION

Damage Could Occur!

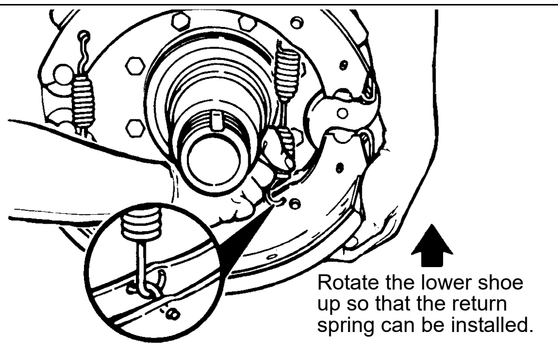
Do not get grease on cam head surface. The cam surface must be free of oil, grease, and other contaminates for efficient operation.

4. Put the cam head thrust washer on the camshaft. Apply O-617-A or B chassis grease to the camshaft bushings or needle bearings and to the camshaft journals. Install the camshaft through the spider and bracket so that the camshaft turns freely.
5. Install Slack Adjuster. Refer to Automatic Slack Adjuster, page 8-40 in this Section.

Brake Shoe Installation

1. Put the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and install the two new retainer springs.
2. Rotate the lower brake shoe forward and install a new brake shoe return spring.

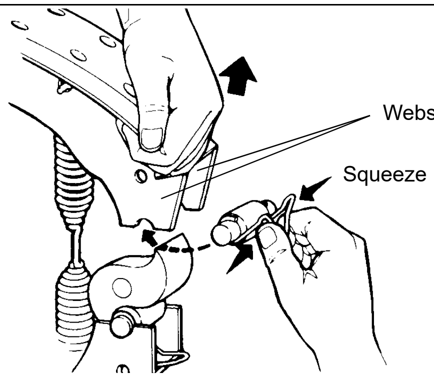
8



6861-1t

FIGURE 8-36

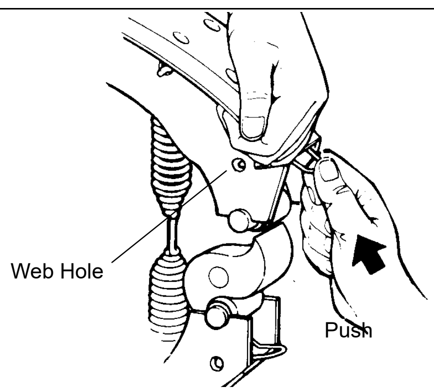
3. Pull each brake shoe away from the cam to permit enough space to install the cam rollers and retainers. Press the ears of the retainer together to permit the retainer to fit between the brake shoe webs.



6861-1u

FIGURE 8-37

4. Push the retainer into the brake shoe until its ears lock into the holes in the brake shoe webs.



6861-1v

FIGURE 8-38

5. Install the slack adjuster. Reference *Automatic Slack Adjuster*, page 8-40.

AUTOMATIC SLACK ADJUSTER

Description

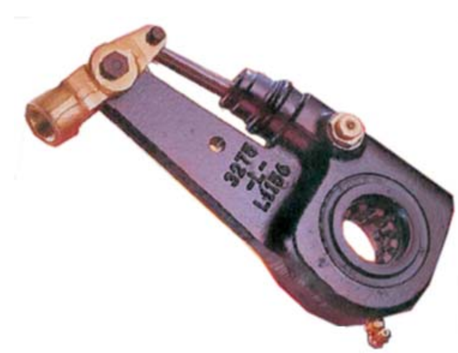
The automatic slack adjuster compensates for normal wear in the brake shoe linings by maintaining a nominal clearance between the lining and the drum.

When the brake is applied, the slack adjuster's rotation moves the brake shoes and linings into contact with the brake drum. This movement also lifts the actuation rod through a pre-set, free travel dimension that is normal lining to drum clearance. Continuing the brake application rotates a one-way clutch in its over-riding mode, and at the same time causes the large coil spring to deflect at a specific force. This spring deflection allows the worm to move axially. The clutch movement is restricted by a machine step. This movement fully disengages the drive clutch from the worm and prevents unwanted brake adjustment from occurring.

When the brake is released, the large coil spring resumes its original load and position, which allows the drive clutch to re-engage. Simultaneous to drive clutch re-engagement, if any lining wear has occurred, the actuation rod rotates the one-way adjuster clutch an amount proportional to lining wear. This motion rotates the worm, worm wheel, and the S-cam shaft resulting in adjustment of the brakes.

Maintenance of Slack Adjuster

NOTE: For the slack adjuster pictured in (Figure 8-39), perform the removal, installation, and adjustment procedures that follow.



7092-9

FIGURE 8-39

Removal of Slack Adjuster

CAUTION

Damage Could Occur!

You must disengage a pull pawl before rotating the manual adjusting nut, or you will damage the pawl teeth.

1. Disengage the pull pawl. Use a screwdriver or equivalent tool to pry the pull pawl at least 0.8 mm (0.0313 in) to disengage the teeth from the actuator.
2. Use a wrench to turn the manual adjusting nut clockwise until the brake shoes are fully retracted and the lining clears the drum.

CAUTION

Death or Injury Could Occur!

When you remove a clevis pin that has a spring, hold the spring with pliers. The spring can disengage from the clevis pin with enough force to cause serious personal injury.

CAUTION

Damage Could Occur!

Always replace used clevis pin retainer clips with new ones when you service an automatic slack adjuster. Do not reuse retainer clips. When you remove a retainer clip, it can bend out of shape and lose retention. Damage to components can result.

3. Remove both clevis pins and retainer clips or cotter pins.
4. Move the slack adjuster away from the clevis.
5. Discard the retainer clips and cotter pins and replace them with new ones.

CAUTION

Damage Could Occur!

Do not use a hammer to remove the slack adjuster. Damage to the slack adjuster and/or camshaft splines may result.

NOTE: Note the orientation of the slack adjuster with reference to the push rod before removal to make sure of proper orientation at installation.

6. Remove the slack adjuster with a suitable puller.

Installation of the Slack Adjuster

1. Verify that the push rod is fully retracted.
2. Install the inner washer on the camshaft. The inner washer has a larger hole.
3. Apply Anti-Seize type lubricant to the camshaft splines. Install the slack adjuster onto the camshaft with the adjusting shaft hex pointing away from the air brake chamber. Secure with outer shim washer(s) and snap ring.
4. Rotate the adjusting shaft hex nut clockwise until the slack adjuster arm and actuator rod holes line up with the clevis holes.
5. Install the clevis pins and the cotter pins.
6. Adjust the brakes by turning the adjusting shaft hex clockwise until the lining contacts the drum. Then rotate the adjusting shaft hex counterclockwise 1/2 turn.

Adjustment Procedures

Brake Applied Stroke Measurement

Make sure that the brake applied stroke is within the required values as outlined below.

1. Chock the wheels.
2. Charge air tanks. Refer to *Air System*, page 8-17.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures 621 to 689 kPa (90 to 100 psi). Refer to *Air System*, page 8-17.
5. With the service brakes released, measure the distance from the slack adjuster clevis pin to the chamber mounting face on each brake. Refer to Dimension “A” in (Figure 8-40).

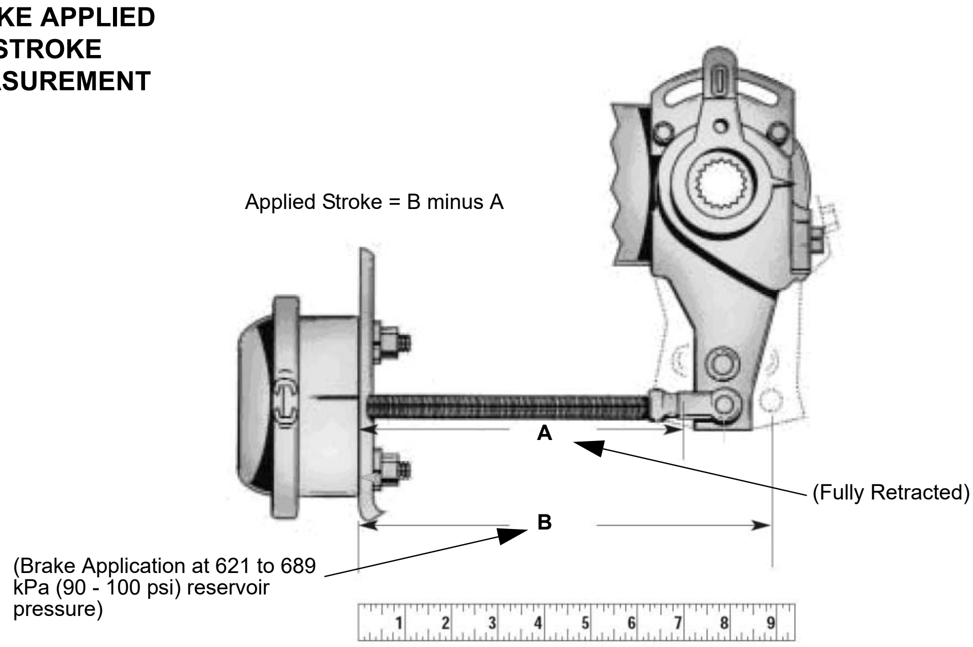


FIGURE 8-40

6. Starting with 621 to 689 kPa (90 to 100 psi) air tank pressure in both primary and secondary systems, fully apply service brakes and hold brakes on. Do not pump the brakes. Measure between the same points as in Step 5 on each brake. This is Dimension "B" in (Figure 8-40).
7. Subtract Dimension "A" from Dimension "B" for each brake position (Figure 8-40). Both front and rear brakes should be 6.3 cm (2.5 in). If measurement is outside this dimension, it may be necessary to repair or replace the automatic slack adjuster or other brake components. Contact your Grove Crane Distributor. The crane cannot be driven on public roads until repaired.

Brake Free Play Measurement

The following procedure is required to make sure that the free play of the brakes is within the required values.

WARNING

Death or Injury Could Occur!

There are no serviceable parts inside the spring brake chamber. Never attempt to disassemble the spring brake chamber as serious personal injury could result from the accidental sudden release of the high energy spring.

---

1. Chock the wheels and release the parking brakes.Measure the distance from the center of the large clevis to the air chamber mounting face with the brake fully released. This is dimension "X" in (Figure 8-41).

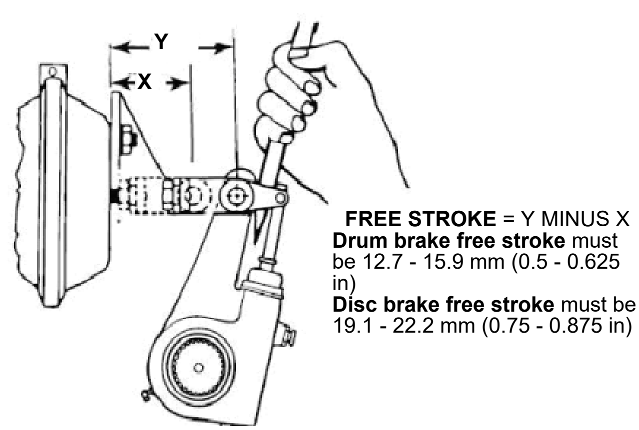


FIGURE 8-41

2. Using a pry bar, move the slack adjuster so that the linings contact the drum. Measure the distance between the same points as in Step 1. This dimension is "Y" in (Figure 8-41).
3. Subtract Dimension "X" from Dimension "Y" (Figure 8-41). The difference should be 12.7 to 15.9 mm (0.5 to 0.625 in). If the stroke falls outside these limits, it may be necessary to repair or replace the automatic slack adjuster or other brake components. Contact your

Grove Crane distributor. The crane cannot be driven on public roads until repaired.

REAR BRAKES

Description

Brakes

The rear brakes are air actuated and cam operated. Each brake shoe, which is steel fabricated, employs two 19 mm (0.75 in) tapered block liners. The brake shoes are mounted on individual anchor pins and supported by open type spiders. Automatic slack adjusters maintain proper adjustment of the push rod stroke and lining the drum clearance.

The brake actuator is a conventional brake air chamber with an emergency (parking) brake spring mechanism incorporated into the air brake chamber. The brake chamber has an aluminum body and pressure plate with a steel non-pressure plate that houses a service/emergency diaphragm, piston, and two springs.

Spring Brake Actuator

The spring brake actuator, which is the upper part of the air brake chamber, is spring applied and air released. When an air pressure of 482 kPa (70 psi) or more is applied against the piston, the spring is compressed and braking is done with the service brakes. When the air pressure is removed, the spring pushes against the piston and diaphragm plate to apply the brake. Internal venting works in conjunction with a one-way breather cap that allows system air to fill the vacuum behind the piston to keep out atmospheric air and contamination. The unit is equipped with a manual caging bolt to permit safe handling and service work.

Maintenance

Troubleshooting Rear Brakes

SYMPTOM	PROBABLE CAUSE	SOLUTION
Brakes are poor or do not apply.	Insufficient air pressure.	Check for correct pressure at compressor and brake chambers.
	Restriction or leak in lines, valves, etc.	Check all lines, valves, etc., for leaks or restrictions.
	Brakes are out of adjustment.	Adjust the brakes.
	Leaking diaphragm.	Replace diaphragm.
Uneven braking or lining wear.	Ruptured diaphragm.	Replace diaphragm.
	Brakes are out of adjustment.	Adjust brakes.
	Grease on the lining.	Replace lining.
	Glazed lining.	Replace lining.
	Shoes are installed backwards.	Reverse shoes.
	Combination linings.	Replace with correct style.
Automatic adjusters are not working.	Adjusting pawl installed backwards.	Remove and properly install pawl.
	Pawl is collapsed or missing.	Replace spring.
	Bolt is frozen in adjusting sleeve.	Free-up or replace the bolt.
	Detent is damaged allowing the bolt to rotate with sleeve.	Replace damaged detent.
	Double lip seals are not installed correctly.	Remove and correctly install seals.
Spring brake is not holding.	Power spring is not fully released. (uncaged).	Turn caging bolt fully counterclockwise until stop is reached.
	Brakes are out of adjustment.	Readjust the brakes.
	Hold-off air is not releasing fully.	Check for faulty air system components.
	Power spring is broken.	Replace spring brake actuator.
Brake is dragging.	Low spring brake hold-off air pressure 482 kPa (70 psi).	Check for minimum spring brake pressure 482 kPa (70 psi). Check for proper functioning of air system components.

SYMPTOM	PROBABLE CAUSE	SOLUTION
	Improper connection of the service line at spring brake.	Check and connect line to proper port.
	Leaking lines or spring brake seals.	Tighten connections on air lines or replace spring brake unit seals.

Spring Brake Actuator

The upper part of the brake air chamber containing the large spring is not serviceable; however, the lower part of the assembly is serviceable.

WARNING

Death or Injury Could Occur!

Spring brake unit is powerful enough to cause parts to fly apart with enough force to cause personal injury. The spring brake must be caged before removing or servicing brakes. Un-cage the spring brake before returning the crane to service.

Manually Caging the Spring Brake

1. Remove the caging bolt and washer from its storage hole on the outside of the brake chamber.
2. Remove the dust cap from the bolt hole in the top of the chamber.
3. Insert the head of the caging bolt through the opening and turn bolt 1/4-turn clockwise.
4. Thread the nut and washer on the bolt and turn the nut clockwise about 18 to 21 turns. Air pressure can be applied to the spring brake chamber through the parking port to compress the spring while the nut is being tightened.
5. Do not force the nut beyond its normal stop. A torque of 40.6 N-m (30 lb-ft) is the maximum that should be required. Reverse the procedure to uncage the spring.

Removal

WARNING

Death or Injury Could Occur!

Cage the spring brake before removal of the air brake chamber.

Disassembly of the Spring Brake

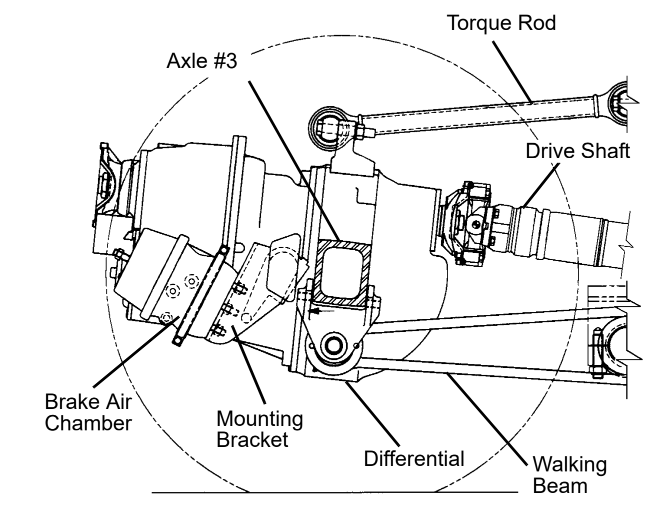


FIGURE 8-42

1. Cage the spring brake.
2. Tag, remove, and cap the air lines to the brake air chamber.
3. Remove the pin(s) connecting the clevis to the slack adjuster.
4. Mark the position of the clevis on the push rod so that the clevis can be reinstalled in the same position.
5. Unbolt the air brake chamber from the mounting bracket and remove the air brake chamber.

Installation of the Spring Brake

1. Bolt the air brake chamber to the mounting bracket.
2. Install the pin through the clevis and slack adjuster.
3. Check the brake adjustment.
4. Uncage the spring brake.

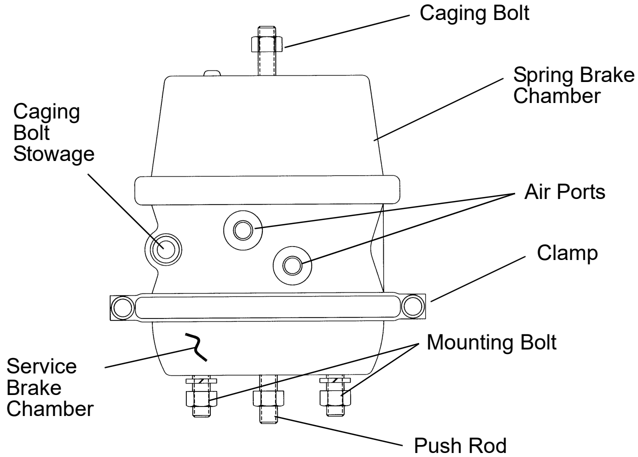


FIGURE 8-43

1. Remove the clamp securing the service brake chamber to the spring brake chamber.
2. Separate the lower cover from the spring brake chamber.
3. If the push rod or spring needs to be removed, mark the position of the clevis on the push rod. Remove the clevis and jam nut.
4. Remove the push rod.

Assembly of the Spring Brake

1. Insert the push rod through the spring and cover.
2. Screw on the jam nut and clevis as per removal marks.
3. Position the diaphragm over the push rod.
4. Push the lower cover assembly into the spring brake chamber and secure with the clamp.

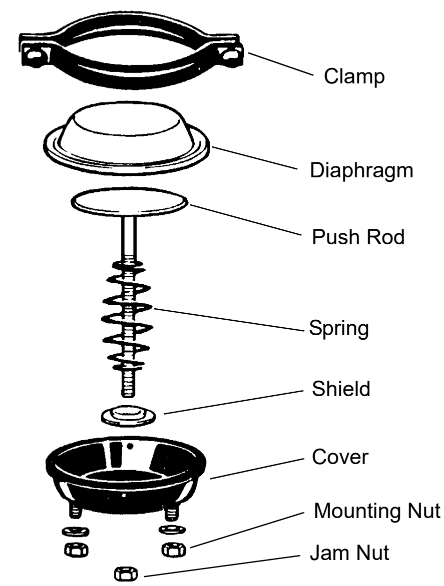


FIGURE 8-44

Adjustment Procedures

Brake Applied Stroke Measurement

Make sure that the brake applied stroke is within the required values as outlined below.

1. Chock the wheels.
2. Charge air tanks. Refer to *Air System*, page 8-17.
3. Release the parking brakes and shut down the engine.
4. Adjust the primary and secondary air tank pressures 621 to 689 kPa (90 to 100 psi). Refer to *Air System*, page 8-17.
5. With service brakes released, measure distance from slack adjuster clevis pin to chamber mounting face on each brake. Refer to Dimension “A” in (Figure 8-45).

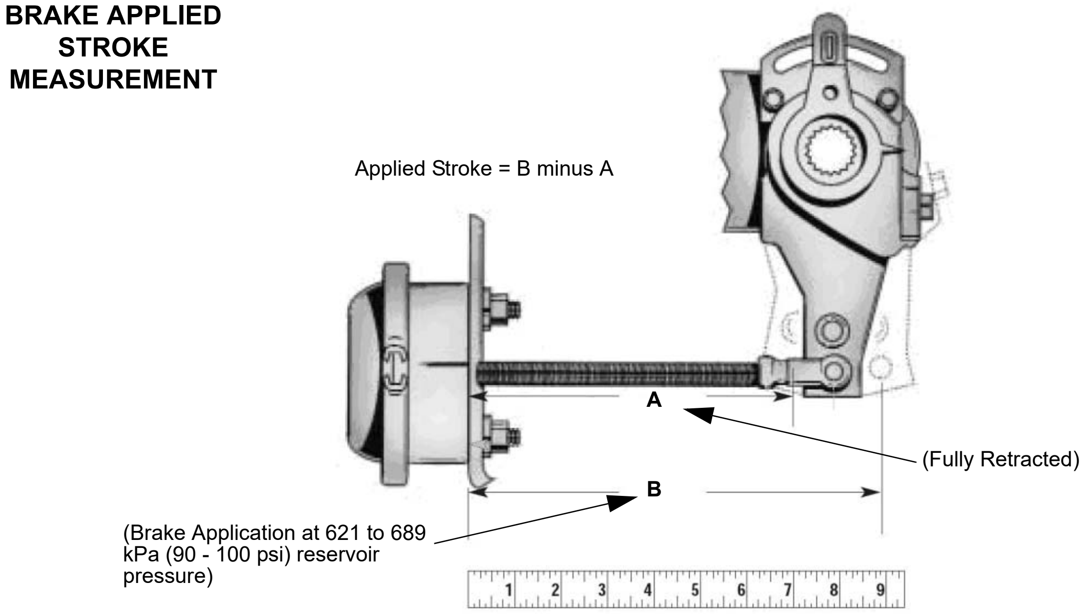


FIGURE 8-45

6. Starting with 621 to 689 kPa (90 to 100 psi) air tank pressure in both the primary and secondary systems, fully apply the service brakes and hold brakes on. Do not pump the brakes. Measure between the same points as in Step 5 on each brake. This is Dimension “B” in (Figure 8-45).
7. Subtract Dimension “A” from Dimension “B” for each brake position (Figure 8-45). This value cannot exceed 5 cm (2 in) on the front brakes or 6.3 cm (2.5 in) on the rear brakes.
8. If any brake exceeds values shown in Step 7 above, it may be necessary to repair or replace the automatic slack adjuster or other brake components. Contact your Grove Crane distributor. The crane cannot be driven on public roads until repaired.

Brake Free Play Measurement

The following procedure is required to make sure that the free play of the brakes is within the required values.

NOTE: If the brake is equipped with a spring-type parking chamber, the spring must be caged before taking measurements.

1. Chock the wheels and release the parking brakes.

NOTE: Do not use an impact wrench on the bolt.

For easier turning of the release bolt, apply 655 to 862 kPa (95 to 125 psi) air pressure to the air inlet port marked “Spring”. After caging, completely exhaust air from the spring chamber.

2. Turn the integral release bolt counterclockwise using a 3/4-inch socket wrench (Figure 8-46), until the power spring is fully caged or compressed. Full cage position requires approximately 22 to 23 turns for 76 mm (3.00 in) stroke units.

FIGURE 8-46

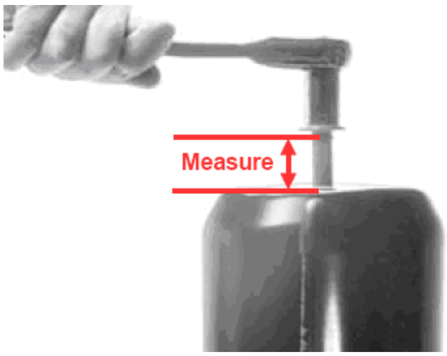
8

CAUTION

Damage Could Occur!

Do not exceed the length stated in Step 3 and do not exceed 68 N-m (50 lb) torque on the release bolt at any time or damage may occur which could prevent any further correct manual release of the spring brake chamber.

3. The dual thread release bolt, which reduces the travel of the release bolt by a factor of 2.4 in a 76 mm (3.00 in) stroke unit, for instance, the parking spring is fully caged when the release bolt is up approximately 33 mm (1.3 in) from the run position (Figure 8-47). After caging, completely exhaust air from the spring chamber.



7093-2

FIGURE 8-47

WARNING

Death or Injury Could Occur!

There are no serviceable parts inside the spring brake chamber. Never attempt to disassemble the spring brake chamber as serious personal injury could result from the accidental sudden release of the high energy spring.

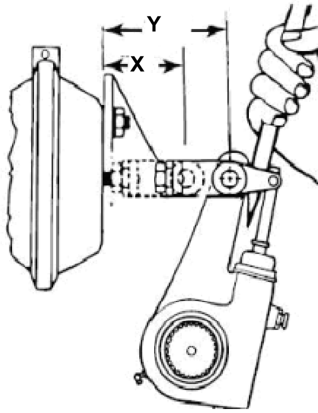
4. Measure the distance from the center of the large clevis to the air chamber mounting face with the brake fully released. This is Dimension “X” in (Figure 8-48).

5. Using a pry bar, move the slack adjuster so that the linings contact the drum. Measure the distance between the same points as in Step 4. This Dimension is “Y” in (Figure 8-48).

6. Subtract Dimension “X” from Dimension “Y”. The difference should be 12.7 to 15.9 mm (0.5 to 0.625 in). If the stroke falls outside these limits, it may be necessary to repair or replace the automatic slack adjuster or other brake components. Contact your Grove Crane distributor. The crane cannot be driven on public roads until repaired.

7. Uncage the spring brake, if so equipped.

MEASURE FREE STROKE



FREE STROKE = Y MINUS X
Drum brake free stroke must be 12.7 - 15.9 mm (0.5 - 0.625 in)
Disc brake free stroke must be 19.1 - 22.2 mm (0.75 - 0.875 in)

7092-7

FIGURE 8-48

Rear Brake Assembly

The rear brakes are air actuated and cam operated with two brake shoes. Each brake shoe is mounted on separate anchor pins and has open anchor pin ends for easy removal. There are two brake shoe retainer springs in addition to the brake shoe return springs.

NOTE: For information on the ABS speed sensors, refer to Wheel Speed Sensor, Replacement (Rear), page 8-75.

Disassemble Brakes

1. Raise the crane on outriggers so that the rear wheels are off the ground.

WARNING

Death or Injury Could Occur!

Do not attempt to do any type of work under a crane that is supported by only the outriggers or jacks.

2. Place jack stands under the frame where the wheels are to be removed.

3. Remove the tire and wheel assembly and brake drums.

4. Cage the spring brake with the caging bolt provided.

5. Fully release the slack adjuster so that the brake shoes retract allowing the drums to clear the linings. To retract the slack adjuster, do the following:

a. Remove the pawl assembly to keep the pawl teeth from being damaged.

b. Turn the manual adjusting nut until the brake shoe is fully retracted.

c. Install the pawl assembly into the slack adjuster.

6. Remove the brake drum.

Brake Shoe Removal

1. Push down on the bottom brake shoe and pull on the roller retaining clip to remove the bottom cam roller.

.

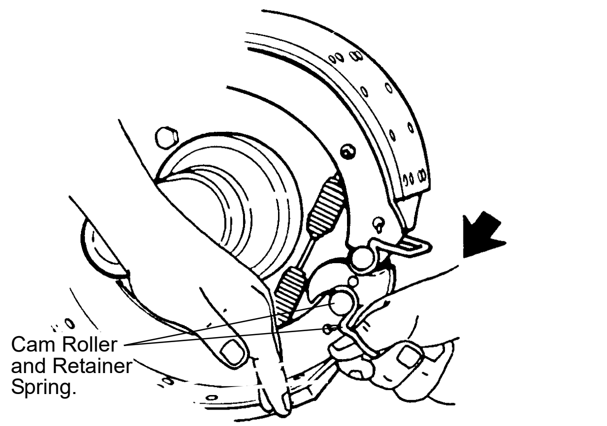


FIGURE 8-49

2. Lift the top brake shoe and pull on the roller retaining clip and remove the upper cam roller.

3. Lift the bottom brake shoe to release the tension on the brake return spring and remove the spring.

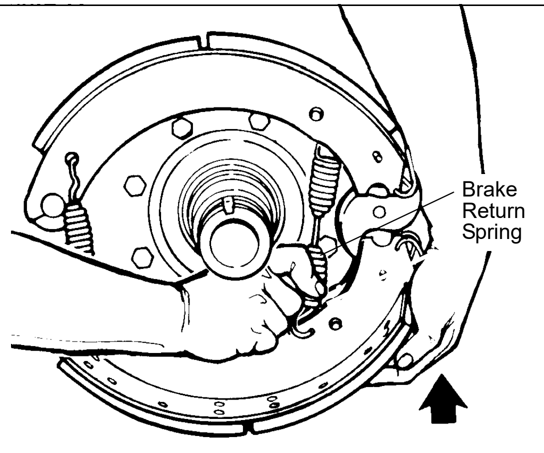


FIGURE 8-50

4. Rotate the bottom brake shoe to relieve tension on the retaining springs. Remove the springs and brake shoes.

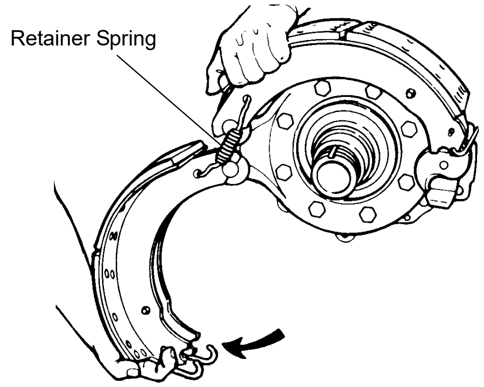


FIGURE 8-51

Clean and Inspect Parts

1. Clean all polished metal parts such as inner bore, gear, and worm with solvent cleaners.

WARNING

Death or Injury Could Occur!

Solvent cleaners can be flammable, poisonous, and cause burns.

2. Use soap and water to clean all nonmetallic parts. Dry all parts with soft clean paper or cloth.

CAUTION

Damage Could Occur!

Do not use solvent cleaners on nonmetallic parts.

3. Apply brake lubricant to all parts except the linings and drums to prevent rust.

Inspection of Brakes and Parts

1. Check the spider for expanded anchor pin holes and cracks. Replace damaged spiders and anchor pin bushings.

2. Check the camshaft bracket for broken welds, cracks, and correct alignment.

3. Check anchor pins for corrosion and wear. Replace damaged anchor pins.

4. Check brake shoes for rust expanded rivet holes, broken welds, and correct alignment. Anchor pin holes must not exceed 26 mm (1.03 in) in diameter. The distance from the center of the anchor pin hole to the center of the roller hole must not exceed 327 mm (12.875 in).

8

5. Check the camshaft for cracks, wear, and corrosion. Check the cam head, bearing journals, and splines. Refer to Repair/Replacement of Camshaft, page 8-38 in this section.

6. Check the slack adjuster for the gap between the clevis and collar. If the gap exceeds 1.5 mm (0.060 in), replace the clevis. Check the clevis pins and bushing in the slack adjuster arm. Replace bushing if diameter exceeds 16.6 mm (0.65 in).

7. Rotate the slack adjuster adjusting nut through a 360 degree rotation (about 22 turns of the adjusting nut) with a torque wrench. Torque must be less than 2.8 N-m (25 lb-in) for a new or rebuilt slack adjuster.

8. Check the brake drums for cracks, severe heat checking, heat spotting, scoring, pitting, and distortion.

9. Measure the inside diameter of the drum in several locations and replace if diameter exceeds manufacturers specifications.

10. Each time the brake shoes are removed, check the camshaft radial play as outlined in Step 7a thru 7e below and (Figure 8-32). Also, refer to Repair/Replacement of Camshaft, page 8-38 in this Section.

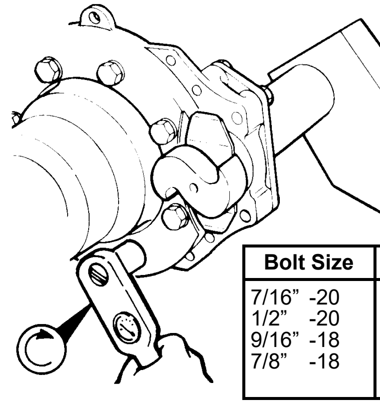
Assemble Brakes

Each time the brakes are relined, the following parts should also be replaced:

- Springs
- Rollers
- Anchor Pins
- Clevis Pins
- Camshaft Seals

Camshaft Installation

1. Check all spider bolts for the correct torque as shown below.



Bolt Size	Nm	Pounds-Foot
7/16” -20	85 -102	60 -75
1/2” -20	115 -156	85 -115
9/16” -18	176 -224	130 -165
7/8” -18	244 -312	180 -230

68612-2

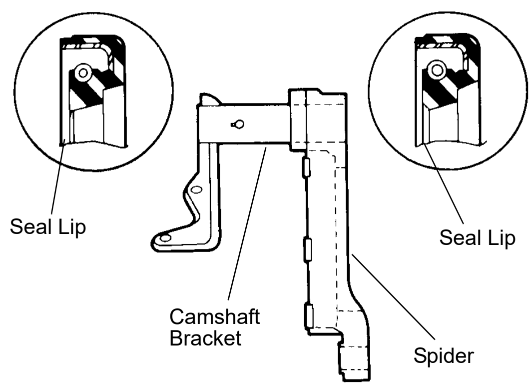
FIGURE 8-52

2. Install new camshaft seals and, if required, bushings in both the spider and camshaft bracket. Use a seal driver to install the bushings.

3. If the camshaft bracket was removed, install the gasket and bracket to the spider. Torque to:

- 1/2”-13 Grade 8 - 122 to 163 N-m (90 to120 lb-ft).
- 1/2”-13 Grade 5 - 88 to 136 N-m (65 to 100 lb-ft).
- 5/8”-18 Plain Nut - 203 to 258 N-m (150 to 190 lb-ft).
- 5/8”-18 Lock Nut -176 to 224 N-m (130 to 165 lb-ft).

NOTE: Install both seals with lips toward slack adjuster.



6862-3

FIGURE 8-53

CAUTION

Damage Could Occur!

Do not get grease on cam head surface. The cam surface must be free of oil, grease, and other contaminates for efficient operation.

4. Put the cam head thrust washer on the camshaft. Apply O-617-A or B chassis grease to the camshaft bushings or needle bearings and to the camshaft journals. Install the camshaft through the spider and bracket so that the camshaft turns freely.
5. Install Slack Adjuster. Refer to Automatic Slack Adjuster, page 8-40 in this Section.

Brake Shoe Installation

1. Put the upper brake shoe in position on the top anchor pin. Hold the lower brake shoe on the bottom anchor pin and install the two new retainer springs.
2. Rotate the lower brake shoe forward and install a new brake shoe return spring.

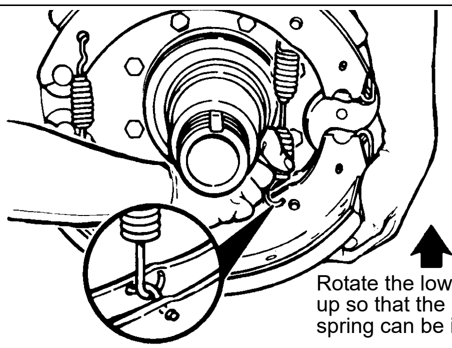


FIGURE 8-54

3. Pull each brake shoe away from the cam to permit enough space to install the cam rollers and retainers. Press the ears of the retainer together to permit the retainer to fit between the brake shoe webs.

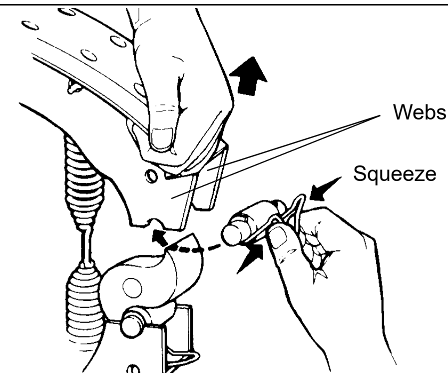


FIGURE 8-55

4. Push the retainer into the brake shoe until its ears lock into the holes in the brake shoe webs.

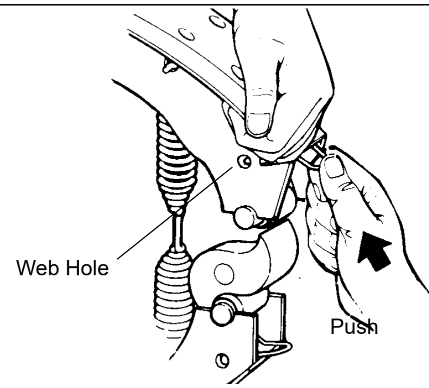


FIGURE 8-56

5. Install the slack adjuster and adjust brakes. Refer to following Sub-Section, Automatic Slack Adjuster, page 8-40.

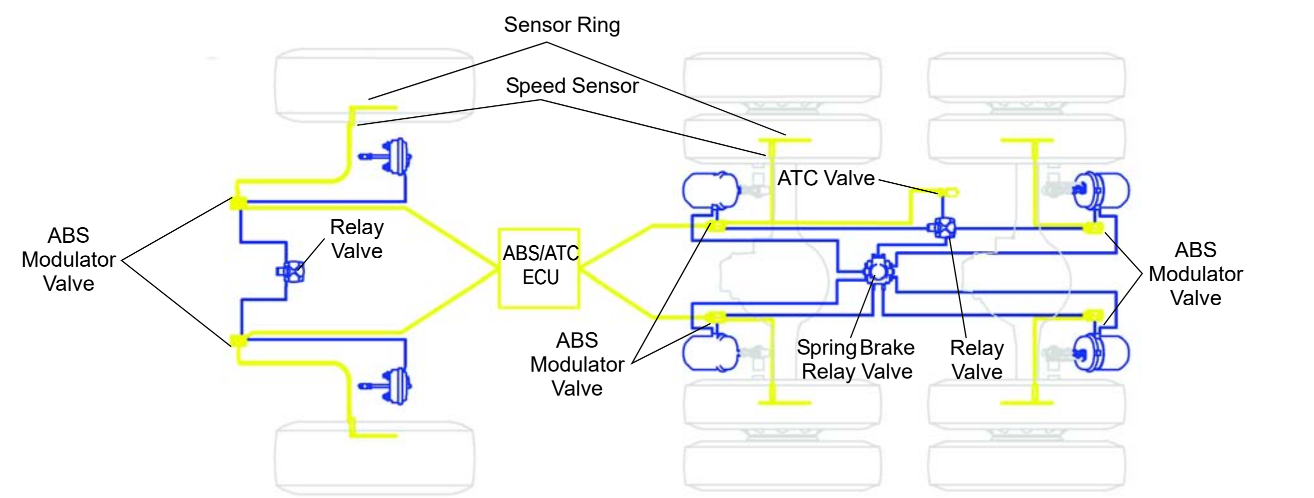
ANTI-LOCK BRAKE SYSTEM (ABS)/ AUTOMATIC TRACTION CONTROL (ATC)

ABS System Description

The Bendix Anti-Lock Braking System (ABS) (Figure 8-57) is an electronically controlled system that continually monitors wheel speed and controls wheel braking during extreme braking situations. The ABS is an important component of the foundation brake system. Its purpose is to prevent the wheels from locking up when the brakes are applied with great intensity under normal road conditions or when applied normally on slippery road surfaces.

The ABS works in conjunction with the standard vehicle braking system. The ABS monitors the vehicle wheel speed at all times and helps control braking during hard braking or slippery road conditions. The ABS improves the vehicle's stability and control by reducing wheel lock during braking.

The ABS electronically monitors the rotational speed of both front wheels and the wheels on the rear axle. The wheel rotation signals are sent to an Electronic Control Unit (ECU) which sends signals to the ABS modulator valves if it detects that a wheel has locked up or is about to lock up. The modulator valves control the pressure in the brake assembly air chambers.



Legend	
Air Components	(blue)
ABS/ATC Components	(yellow)

FIGURE 8-57

Wheel rotation is determined by an electronic sensor (1) (Figure 8-58) mounted in the brake spider. A signal is generated by the sensor as high spots on a tooth wheel (2) pass by the sensor. The tooth wheel is either mounted on or is part of the wheel hub.

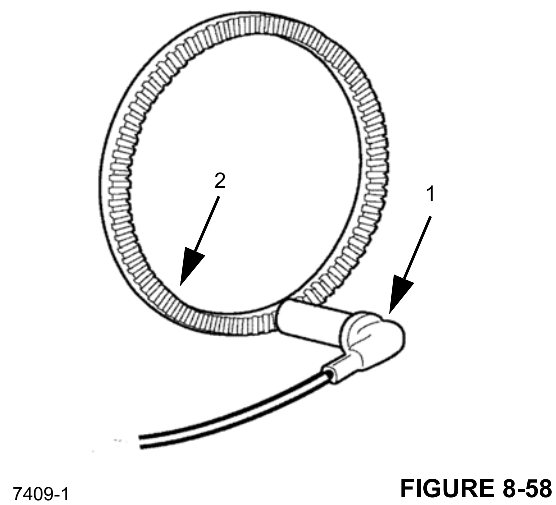


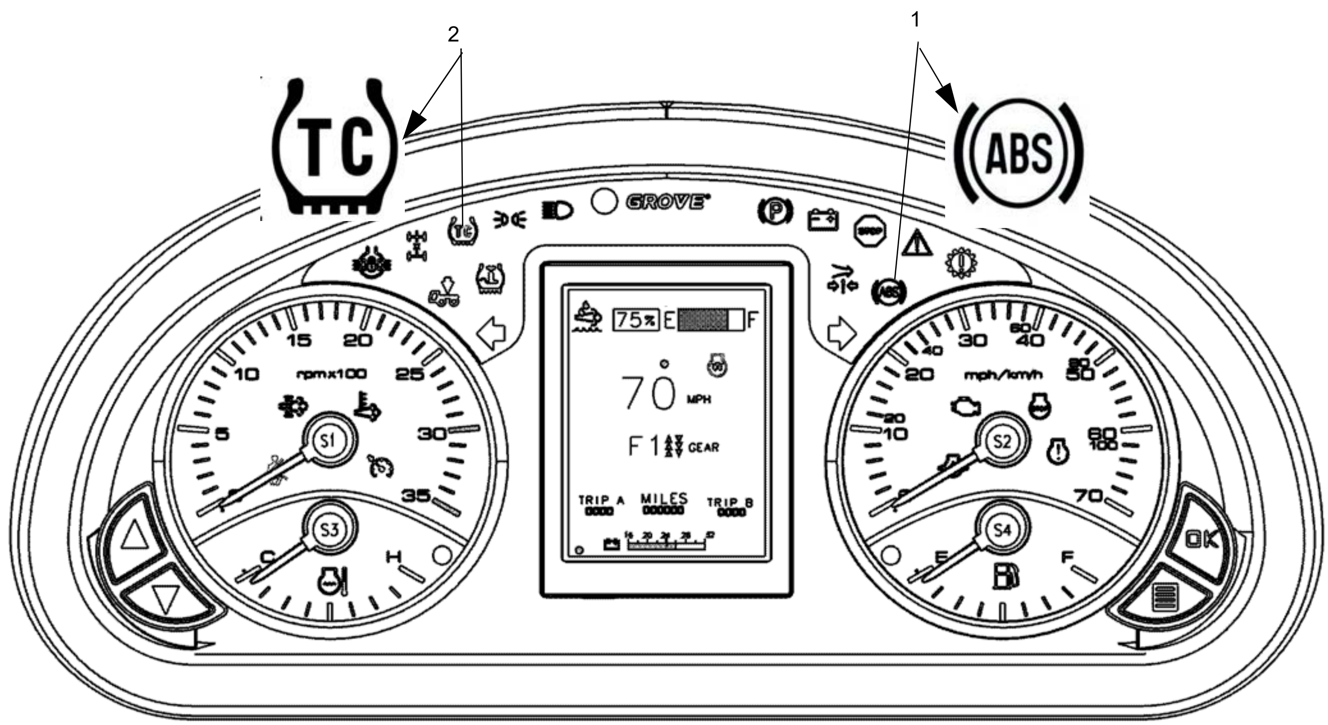
FIGURE 8-58

ABS Indicator

The ABS control unit contains a self-testing program that is engaged each time the ignition is turned on. The operator can verify the testing by listening for the ABS modulator valves actuating twice in series. To increase the sound, hold down the foot brake pedal when the ignition is turned on.

NOTE: The ECU will not perform the configuration test when the speed sensors detect that the vehicle is in motion.

If the indicator (1) (Figure 8-59) stays on, there is a problem with the ABS. If the ABS indicator lights during driving, the ABS self test has detected a fault in the system. The vehicle can still be driven with a problem in the ABS. However, the ABS will not be operating and standard air braking is in effect.



8861e

FIGURE 8-59

ATC System Description

Just as ABS improves vehicle stability during braking, ATC improves vehicle stability and traction during vehicle acceleration. The Electronic Control Unit (ECU) ATC function uses the same wheel speed information and modulator control as the ABS function. The ECU detects excessive drive wheel speed, compares the speed of the front, non-driven wheels, and reacts to help bring the wheel spin under control. The ECU is configured to use engine torque limiting and differential braking to control wheel spin. The ATC system is controlled by the ABS ECU. It helps improve traction on slippery or unstable driving surfaces by preventing excessive wheel spin. ATC also enhances vehicle stability by prevention of initial loss of traction.

ATC System Operation

During periods of wheel slip, the Electronic Control Unit enters an Automatic Traction Control mode. There are various modes of Automatic Traction Control.

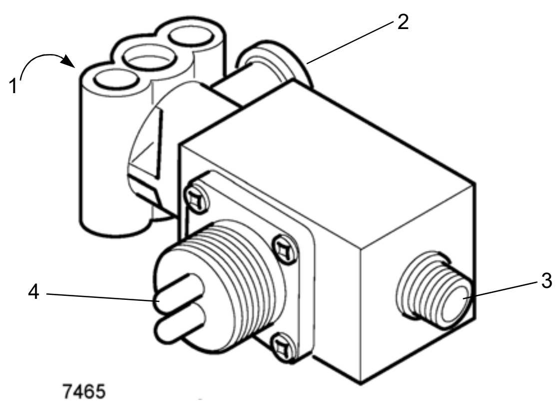
- At speeds above 40 km/h (25 mph), the engine is throttled back via the data link to control spin out.
- At speeds below 40 km/h (25 mph), both engine control and differential brake control are activated as required to control wheel slip. Once triggered, differential braking mode remains active regardless of vehicle speed.
- The off-road switch allows greater wheel spin (more torque) when activated. It is intended for adverse conditions, usually off-highway. The switch is programmed for momentary operation. ATC reverts to normal operation when the switch is cycled a second time and whenever the system goes through a power-up cycle.

ATC Valve

During normal operation, air is delivered to the ATC valve treadle port (3), (Figure 8-60) from the Brake Pedal Control Valve, which in turn supplies the air from the air delivery port (2), (Figure 8-60) to the Rear Service Brake Relay Valve.

When traction control is utilized, the ATC valve is activated, diverting supply tank air from the air supply port (1),(Figure 8-60) to the Modulator Valves on the drive axle(s) by way of the air delivery port (2), (Figure 8-60). The Electronic Control Unit then activates the appropriate solenoids in order to apply a brake force to the spinning wheel. The Automatic Traction Control System cannot increase traction to a particular wheel; it can only utilize the available traction.

8



Port	Designation
1	Air Supply Port
2	Air Delivery Port
3	Treadle Port
4	Electrical Connector

FIGURE 8-60

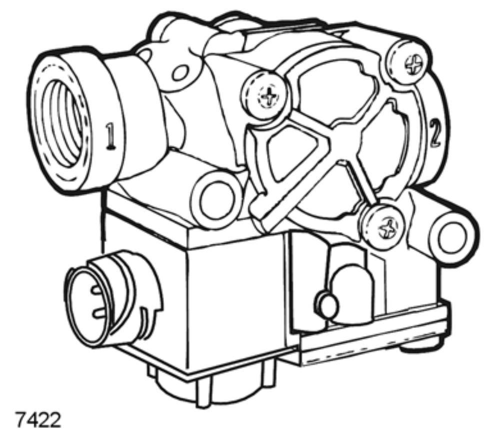
ATC Indicator

The ATC indicator (2), (Figure 8-59) is the primary indicator of the ATC status. The ATC indicator:

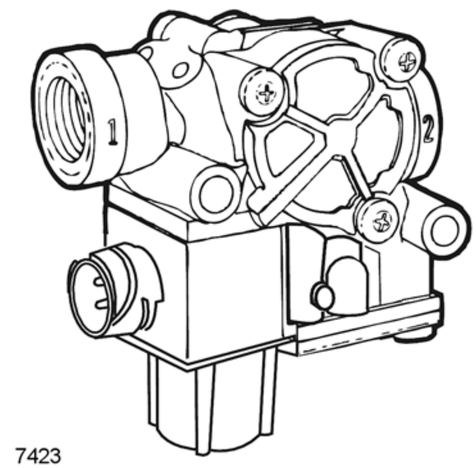
- Lights at key-ON and turns OFF after a two second lamp check. ATC is active after the lamp check.
- Flashes rapidly when ATC is operating.
- Flashes slowly when the off-road mode is selected and then flashes more rapidly when the automatic traction control system operates.
- Remains ON if an engine data link failure occurs.

Pressure Modulator Valves

Two types of ABS brake modulator valves are used with the Bendix Anti-Lock Brake System: the M-32 and the M-32QR (quick release) (Figure 8-61) anti-lock system modulators. This section includes general information on both valves.



M-32



M-32QR

FIGURE 8-61

The M-32 and M-32QR (quick release) anti-lock system modulators are high capacity, ON/OFF air valves that use a pair of electrical solenoids for control. The solenoids provide the electro-pneumatic interface between the anti-lock controller electronics and the air brake system. The modulator is used to control the braking function during anti-lock activity.

The modulator consists of a die cast aluminum body and a solenoid assembly which contains one normally open solenoid, one normally closed solenoid, and an inlet and exhaust diaphragm valve. A three–pin, weather resistant electrical connector is an integral part of the modulator solenoid assembly and serves to carry control commands from the anti-lock controller to the modulator. The supply, delivery and exhaust ports on both modulators are identified with a cast, embossed numeral for positive identification.

Acceptable Tire Sizes

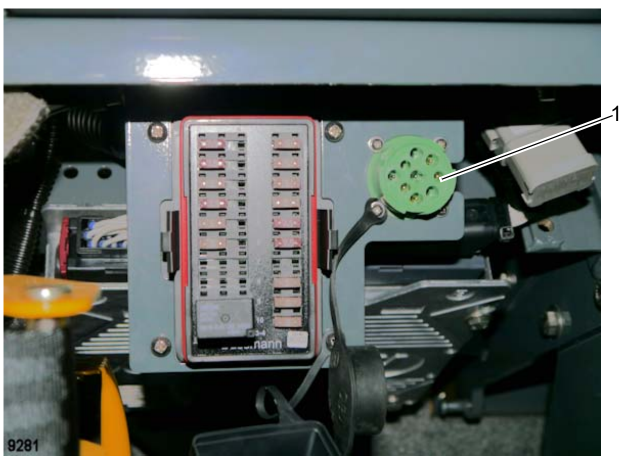
The speed calculation for an exciter ring with 100 teeth is based on a default tire size of 510 revolutions per mile. This figure is based on the actual rolling circumference of the tires, which varies with tire size, tire wear, tire pressure, vehicle loading, etc. The ABS response sensitivity is reduced when the actual rolling circumference is excessive on all wheels. For a 100 tooth exciter ring, the minimum number of tire revolutions per mile is 426, and the maximum is 567.

The ECU will set diagnostic trouble codes if the number of revolutions is out of this range. In addition, the size of the steer axle tires compared to the drive axle tires also has to be within the ABS system design. To avoid diagnostic trouble codes, the ratio of the effective rolling circumference of the steer axle, divided by the effective rolling circumference of the drive axle, must be between 0.85 to 1.15.

ABS Troubleshooting

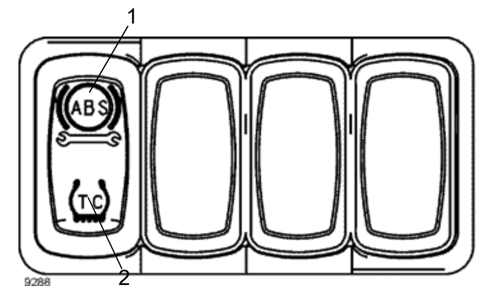
Diagnostic Connector and ABS Diagnostic Switch Location

The 9–pin on board diagnostic connector (1), (Figure 8-62) is located under the dashboard to the left of the steering column. The ABS diagnostic switch (1),(Figure 8-63) is located near the lower left of the control panel as shown in (Figure 8-63).



9281

FIGURE 8-62



9288

FIGURE 8-63

The ABS ECU is located at the rear of the cab behind the driver's seat. The ABS wiring harness is combined with the main cab and engine harness.

Troubleshooting: Blink Codes and Diagnostic Modes

The EC-60 controller (ECU) contains self-testing diagnostic circuitry that continuously checks for the normal operation of internal components and circuitry, as well as external ABS components and wiring.

ECU Diagnostics

Active Diagnostic Trouble Codes

When an erroneous system condition is detected, the EC-60 controller:

1. Illuminates the appropriate indicator lamp(s) and disengages part or all of the ABS and ATC functions.
2. Places the appropriate trouble code information in the ECU memory.
3. Communicates the appropriate trouble code information over the serial communications diagnostic link as required. Hand-held or PC-based diagnostic tools attach to the vehicle on-board diagnostic connector, located under the left-side dash as shown in (Figure 8-62).

NOTE: When using a hand-held device such as the Bendix RDU or Pro-Link, refer to the manual that came with the device.

Blink Codes

Blink codes allow a technician to troubleshoot ABS problems without using a hand-held or PC-based diagnostic tool. Instead, information about the ABS system is communicated by the ECU using the ABS indicator lamp to display sequences of blinks.

NOTE: The ECU will not enter the diagnostic blink code mode if the wheel speed sensors show that the vehicle is in motion. If the ECU is in the diagnostic blink code mode and then detects vehicle motion, it will exit the blink code mode.

In addition, by operating the blink code switch as described below, one of several diagnostic modes can be entered. Refer to the *Diagnostic Mode Selection*, page 8-56 in this Section.

Blink Code Switch Activation

When activating the blink code switch:

1. Wait at least two seconds after "ignition on." (When entering Reconfiguration Mode, refer to *Reconfigure ECU Mode*, page 8-57 in this Section.)
2. For the ECU to recognize that the switch is activated "ON," the technician must press the switch for at least 0.1 second, but less than five seconds. (**NOTE**: If the switch is held for more than five seconds, the ECU will register a malfunctioning switch.)
3. Any pauses between pressing the switch when a sequence is required, (e.g. when changing mode) must not be longer than two seconds.
4. After a pause of 3.5 seconds, the ECU will begin responding with output information blinks.

Blink Code Timing

The ECU responds with a sequence of blink codes. The overall blink code response from the ECU is called a "message." Each message includes, depending on the mode selected by the technician, a sequence of one or more groups of blinks. Simply record the number of blinks for each sequence and then use the *Active or Inactive Diagnostic Trouble Codes: Index*, page 8-58 of this Section for active or inactive trouble codes and you will be directed to the page that provides troubleshooting information.

Be aware of the following:

1. Sequences of blinks illuminate the ABS indicator lamp for half a second, with half-second pauses between them.
2. Pauses between blink code digits are 1.5 seconds.
3. Pauses between blink code messages are 2.5 seconds.
4. The lamp remains on for five seconds at the end of messages.

Once the ABS indicator lamp begins displaying a sequence of codes, it continues until all blink code messages have been displayed and then returns to the normal operating mode. During this time, the ECU will ignore any additional blink code switch activation sequences.

All trouble codes, with the exception of voltage and J1939 trouble codes, will remain in an active state for the remainder of the power cycle.

Voltage trouble codes will clear automatically when the voltage returns within the required limits. All ABS functions will be re-engaged.

J1939 trouble codes will clear automatically when communications are re-established.

Diagnostic Modes

In order to communicate with the ECU, the controller has several modes that the technician can select, allowing information to be retrieved, or other ECU functions to be accessed.

Diagnostic Mode Selection

To enter the various diagnostic modes:

Active Diagnostic Trouble Code Mode

For troubleshooting, typically the Active and Inactive Diagnostic Trouble Retrieval Modes are used. The technician presses the blink code switch once and the ABS indicator lamp flashes a first group of two codes, and if there are more trouble codes recorded, this is followed by a second set of codes, and so forth. (See *Reconfigure ECU Mode*, page 8-57 of this Section for a directory of these codes.) All active trouble codes may also be retrieved using a handheld or PC-based diagnostic tool.

To clear the active diagnostic trouble codes (as problems are fixed), simply clear (or "self-heal") by removing and re-applying ignition power. The only exception is for the wheel speed sensor trouble codes, which clear when power is removed, re-applied, and the ECU detects a valid wheel speed from the all-wheel speed sensors. Alternately, codes may be cleared by pressing the diagnostic blink code switch three times (to enter the clearing of the Active Diagnostic Trouble Code Mode) or by using a hand-held or a PC-based diagnostic tool.

NOTE: Hand-held or PC-based diagnostic tools are able to clear wheel speed sensor trouble codes without the vehicle being driven.

Inactive Diagnostic Trouble Code Mode

The ECU stores past trouble codes and comments (such as configuration changes) in its memory. This record is commonly referred to as "event history." When an active trouble code is cleared, the ECU stores it in the event history memory as an inactive trouble code.

Using blink codes, the technician may review all inactive trouble codes stored on the ECU. The ABS indicator lamp will display inactive diagnostic blink codes when the diagnostic blink code switch is depressed and released two times. See *Active or Inactive Diagnostic Trouble Codes: Index*, page 8-58 (this Section) for the index showing trouble codes and the troubleshooting guide page to read for help.

Inactive trouble codes, and event history, may be retrieved and cleared by using a hand-held or PC-based diagnostic tool.

Clearing Active Diagnostic Trouble Codes

The ECU will clear active trouble codes when the diagnostic blink code switch is depressed and released three times.

Dynamometer Test Mode

The Dynamometer Test Mode is used to disable the ATC when needed (for example, when performing any vehicle maintenance where the wheels are lifted off the ground and moving, including dyno testing). This mode is not reset by power OFF, power ON, or cycling. **NOTE:** Instead a hand-held or PC-based diagnostic tool must be used to change the setting. Alternatively, depressing and releasing the blink code switch three times will cause the ECU to exit the blink code mode.

Reconfigure ECU Mode

NOTE: To enter the Reconfiguration Mode, the blink code switch must be held in before the application of ignition power. Once the power is supplied, the switch is released and then pressed seven times.

System Configuration Check Mode

The ABS indicator lamp will display system configuration information when the diagnostic blink code switch is depressed and released four times. The lamp will blink out configuration information codes using the patterns listed in the System Configuration Check Table (shown below), shaded rows indicate proper code: “2-6-6-1-5-1”. In this mode the ECU tells the technician, by means of a series of six blink codes, the type of ABS system that the ECU has been set up to expect.

System Configuration Check	
1st Number	System Power
1	12 Volts
2	24 Volts
2nd Number	Wheel Speed Sensors
4	4 Sensors
6	6 Sensors
3rd Number	Pressure Modulator Valves
4	4 Modulators
5	5 Modulators
6	6 Modulators
4th Number	ABS Configuration
1	4S/4M or 6S/6M
2	6S/4M
3	6S/5M
5th Number	Traction Control Configuration
2	No ATC
3	ATC Engine Control Only
4	ATC Brake Control Only
5	Full ATC (Engine Control and Brake Control)
6th Number	Retarder Configuration
1	No Retarder
2	J1939 Retarder
3	Retarder Relay
4	J1939 Retarder, Retarder Relay

EC-60 Controller Wire Harness Connector Pin Assignments

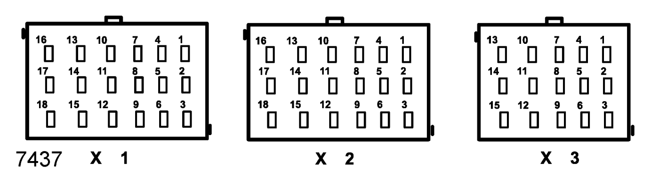


FIGURE 8-64

Conn. Designation	Number of Contacts	Deutsch Part Number
X1	17	DT16-15SA-K003
X2	18	DT16-18SB-K004
X3	15	DT16-18SC-K004

X1 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Ground	7	J1939 Low	13	SAE J1587 (B)
2	Trailer ABS Dash Indicator	8	J1939 High	14	SAE J1587 (A)
3	Ignition	9	Stop Lamp Switch Input	15	Not Used
4	Traction Control Valve - Common	10	Wheel Speed Sensor Drive Axle Right (+)	16	Battery
5	Traction Control Valve	11	Wheel Speed Sensor Drive Axle Right (-)	17	Retarder
6	ATC Dash Indicator/ ATC OFF-Road Switch	12	ABS Dash Indicator Ground	18	ABS Dash Indicator

X2 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	Modulator Valve Steer Axle Left - Hold	7	Modulator Valve Steer Axle Right - Release	13	Modulator Valve Drive Axle Right - Release
2	Modulator Valve Steer Axle Left - Release	8	Wheel Speed Sensor Steer Axle Left (-)	14	Wheel Speed Sensor Steer Axle Right (-)
3	Modulator Valve Steer Axle Left - Common	9	Modulator Valve Drive Axle Right - Common	15	Wheel Speed Sensor Drive Axle Left (+)
4	Modulator Valve Steer Axle Right - Hold	10	Modulator Valve Drive Axle Right - Hold	16	-Modulator Valve Drive Axle Left - Hold
5	Wheel Speed Sensor Steer Axle Left (+)	11	Wheel Speed Sensor Steer Axle Right (+)	17	Modulator Valve Drive Axle Left - Release
6	Modulator Valve Steer Axle Right - Common	12	Modulator Valve Drive Axle Left - Common	18	Wheel Speed Sensor Drive Axle Left (-)

X3 Connector Pin Assignments

Pin	Designation	Pin	Designation	Pin	Designation
1	ABS OFF-Road Switch	6	Modulator Valve Add. Axle Left - Common	11	Wheel Speed Sensor Add. Axle Left (+)
2	All Wheel Drive Diff. Lock Solenoid	7	Modulator Valve Add. Axle Left - Release	12	Wheel Speed Sensor Add. Axle Right (+)
3	All Wheel Drive Diff. Lock Solenoid - Common	8	Input/Output 3	13	Modulator Valve Add. Axle Right - Release
4	Modulator Valve Add. Axle Left - Hold	9	Modulator Valve Add. Axle Right - Common	14	Wheel Speed Sensor Add. Axle Left (-)
5	Input/Output	10	Modulator Valve Add. Axle Right - Hold	15	Wheel Speed Sensor Add. Axle Right (-)

Active or Inactive Diagnostic Trouble Codes: Index

How to interpret the first digit of messages received when Active or Inactive Diagnostic Trouble Code Mode is entered:

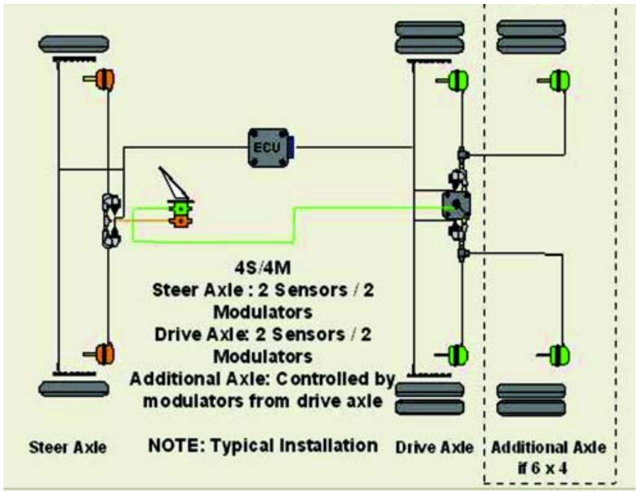
1st Blink Code Number	Troubleshooting Test Location	Refer to
1	No faults (Code 1, 1)	
2	Wheel Speed Sensors	page 8-59
3	Wheel Speed Sensors	page 8-59
4	Wheel Speed Sensors	page 8-59
5	Wheel Speed Sensors	page 8-59
6	Power Supply	page 8-64
7	Pressure Modulator Valves	page 8-61
8	Pressure Modulator Valves	page 8-61
9	Pressure Modulator Valves	page 8-61
10	Pressure Modulator Valves	page 8-61
11	J1939	page 8-65
12	Miscellaneous	page 8-66
14	Wheel Speed Sensors	page 8-59
15	Wheel Speed Sensors	page 8-59
16	Pressure Modulator Valves	page 8-61
17	Pressure Modulator Valves	page 8-61
18	Traction Control Valves	page 8-63

Example: For a message sequence of 3, 2 and 12, 4. For the first sequence (3, 2), go to Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors, page 8-59; the first code (3) indicates Right Steer Axle Sensor. The second code (2) indicates Output Low at Drive-off. The second sequence (12, 6), go to Troubleshooting Diagnostic Trouble Codes: Miscellaneous, page 8-66; the first code (12) indicates Miscellaneous and the second code (6) indicates ABS Indicator Lamp Circuit Fault.

Troubleshooting Diagnostic Trouble Codes: ECU

The 1st. Blink Code is 13, the 2nd. Blink Codes are 2-13. For all codes, check for damaged or corroded connectors. Check for damaged wiring. Clear trouble codes. If diagnostic trouble codes return, replace the ECU.

Troubleshooting Diagnostic Trouble Codes: Wheel Speed Sensors



7414-2b

FIGURE 8-65

1st Blink Code	Location
2	Left Steer Axle Sensor
3	Right Steer Axle Sensor
4	Left Drive Axle Sensor
5	Right Drive Axle Sensor

8

1st Blink Code	Location
14	Left Additional Axle Sensor
15	Right Additional Axle Sensor

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Excessive Air Gap	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
2	Output Low at Drive-OFF	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping.
3	Open or Shorted	Verify 1500-2500 ohms across sensor leads. Verify no continuity between sensor leads and ground or voltage. Verify no continuity between sensor leads and other sensors. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
4	Loss of Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
5	Wheel End	Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check mechanical function of brake. Check for kinked or restricted air lines.
6	Erratic Sensor Signal	Adjust sensor to contact exciter ring. Rotate wheel and verify a minimum of 0.25 VAC sensor output at ~0.5 RPS. Verify condition of sensor head. Verify mounting of exciter ring and condition of teeth. Verify proper bearing end play. Verify condition and retention of clamping sleeve. Verify sensor lead routing and clamping. Check for corroded/damaged wiring or connectors between the ECU and the wheel speed sensor.
7	Tire Size Calibration	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth.
8	Configuration Error	ECU is configured for four sensors, but has detected the presence of additional sensors. Verify sensor wiring and ECU configuration.

Speed Sensor Repair Tests

1. Take all measurements at ECU harness connector pins in order to check wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.
2. Wheel speed sensor measurements should read:

Location	Measurement
Sensor	1500 - 2500 Ohms.
Sensor to voltage or ground	Open Circuit (no continuity).
Sensor output voltage	0.25 of VAC sensor output at ~ 0.5 revs/sec.

3. Clear DTC after issue is corrected. The sensor DTC will remain until the power is cycled to the ABS ECU and the vehicle is driven above 15 MPH or DTC was cleared using either the diagnostic blink code switch or diagnostic tool.

ECU Wire Harness Connector: Speed Sensor Pins

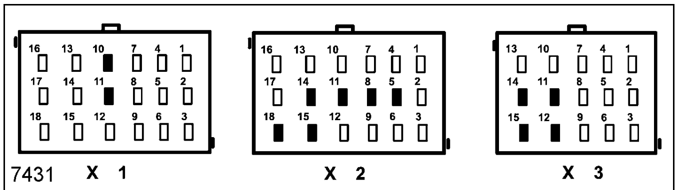


FIGURE 8-66

Connector	Pin	Wheel Speed Sensor Location
X1 17 Way	10	Right Drive Axle (+)
	11	Right Drive Axle (-)
X2 18 Way	5	Left Steer Axle (+)
	8	Left Steer Axle (-)
	11	Right Steer Axle (+)
	14	Right Steer Axle (-)
	15	Left Drive Axle (+)
	18	Left Drive Axle (-)
X3 15 Way	11	Left Additional Axle (+)
	14	Left Additional Axle (-)
	12	Right Additional Axle (+)
	15	Right Additional Axle (-)

Troubleshooting Diagnostic Trouble Codes: Pressure Modulator Valves

1st Blink Code	Location
7	Left Steer Axle
8	Right Steer Axle

1st Blink Code	Location
9	Left Drive Axle
10	Right Drive Axle
16	Left Additional Axle
17	Right Additional Axle

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Release Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
2	Release Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
3	Release Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
4	Hold Solenoid Shorted to Ground	Verify no continuity between PMV leads and ground. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
5	Hold Solenoid Shorted to Voltage	Verify no continuity between PMV leads and voltage. Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
6	Hold Solenoid Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
7	CMN Open Circuit	Verify 4.9 to 5.5 ohms from REL to CMN and HLD to CMN, and 9.8 to 11 ohms from REL to HLD. Check for corroded / damaged wiring or connectors between ECU and PMV.
8	Configuration Error	A mis-match exists between the ECU configuration and the modulator installation and wiring. Verify PMV wiring and installation. Verify ECU configuration.

Pressure Modulator Valve Repair Test

1. Take all measurements at the ECU harness connector pins in order to check the wire harness and the Pressure Modulator Valves (PMV). Probe the connector carefully so that the terminals are not damaged.
2. Pressure modulator resistance should read:

Location	Measurement
Release to Common	4.9 to 5.5 Ohms
Hold to Common	4.9 to 5.5 Ohms
Release to Hold	9.8 to 11.0 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

NOTE: When troubleshooting modulator trouble codes, check the inactive trouble codes and event history for over-voltage or excessive noise trouble codes. If one of these is found, troubleshoot these trouble codes first before the PMV.

ECU Wire Harness Connector: Pressure Modulator Valves Pins

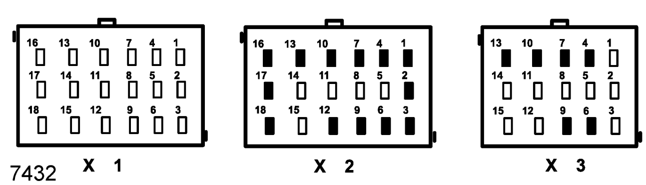
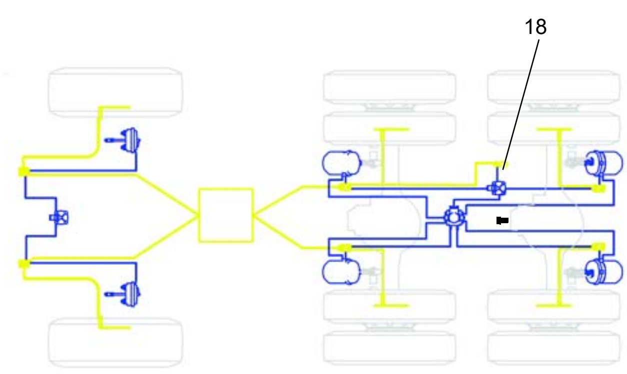


FIGURE 8-67

Connector	Pin	PMV Location
X2 18 Way	1	Left Steer Axle Hold
	2	Left Steer Axle Release
	3	Left Steer Axle Common
	4	Right Steer Axle Hold
	6	Right Steer Axle Common
	7	Right Steer Axle Release
	9	Right Drive Axle Common
	10	Right Drive Axle Hold
	13	Right Drive Axle Release
	12	Left Drive Axle Common
	16	Left Drive Axle Hold
	17	Left Drive Axle Release
X3 15 Way	4	Left Additional Axle Hold
	6	Left Additional Axle Common
	7	Left Additional Axle Release
	9	Right Additional Axle Common
	10	Right Additional Axle Hold
	13	Right Additional Axle Release

Troubleshooting Diagnostic Trouble Codes: Traction Control Valves



7414-ac

FIGURE 8-68

1st Blink Code	Location
18	Traction Control Valve

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	TCV Solenoid Shorted to Ground	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded / damaged wiring or connectors between ECU and TCV.
2	TCV Solenoid Shorted to Voltage	Verify 7 to 19 ohms between TCV and TCV common. Verify no continuity between TCV leads and ground. Check for corroded / damaged wiring or connectors between ECU and TCV.
3	TCV Solenoid Open Circuit	Verify 7 to 19 ohms between TCV and TCV common. Check for corroded / damaged wiring or connectors between ECU and TCV.

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
4	TCV Configuration Error	The ECU is not configured for TCV, but has detected the presence of a TCV. Verify TCV wiring. Inspect for the presence of a TCV. Verify ECU configuration.

Traction Control Valve Repair Tests

1. Take all measurements at the ECU harness connector pins in order to check the wire harness and traction control valve. Probe the connector carefully so that the terminals are not damaged.
2. Tractor Control Valve resistance measurements should read:

Connector	Pin	Traction Control Test
X1	4	Traction Control Valve Common
17 Way	5	Traction Control Valve

Location	Measurement
TCV to TCV Common	7 to 19 Ohms
Release, Hold, Common to Voltage or Ground	Open Circuit (no continuity)

ECU Wire Harness Connector: Traction Control Valve Pins

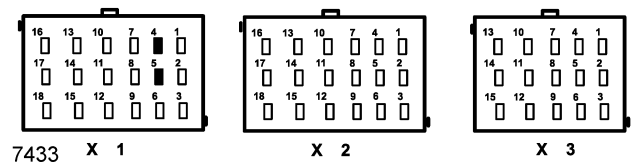


FIGURE 8-69

Troubleshooting Diagnostic Trouble Codes: Power Supply

1st Blink Code	Location
6	Power Supply

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Battery Voltage Too Low	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
2	Battery Voltage Too High	Measure battery voltage under load. Ensure that battery voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
3	Battery Voltage Too Low During ABS	Measure battery voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
4	Battery Voltage Open Circuit	Measure battery voltage under load. Check condition of fuse. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
5	Ignition Voltage Too Low	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections. Check condition of fuse.
6	Ignition Voltage Too High	Measure ignition voltage under load. Ensure that ignition voltage is correct for the model of ECU. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
7	Ignition Voltage Too Low During ABS	Measure ignition voltage under load. Check vehicle battery and associated components. Check for damaged wiring. Check for damaged or corroded connectors and connections.
8	Input Voltage has Excessive Noise (Temporary)	Check alternator output for excessive noise. Check for other devices causing excessive noise.
9	Input Voltage has Excessive Noise	Check alternator output for excessive noise. Check for other devices causing excessive noise.

Power Supply Tests

1. Take all measurements at the ECU harness connector.
2. Place a load (example: use an incandescence bulb 1157 stop lamp) across the battery or ignition and ground connection, measure ignition and battery voltage with the load. Ignition to ground and battery to ground should measure between 9 to 17 of 24-volt system. The values will change accordingly.
3. Check for damaged wiring, damaged or corroded connectors and connections.
4. Check the condition of the vehicle battery and associated components. Verify that the ground connection is good and tight.
5. Check the alternator output for excessive noise.

ECU Wire Harness Connector: Power Supply Pins

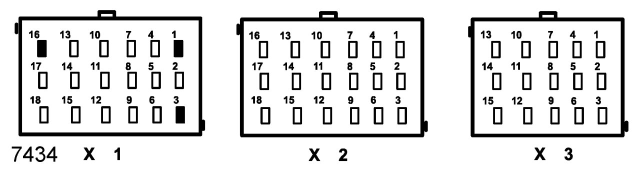


FIGURE 8-70

Connector	Pin	Traction Control Test
X1 17 Way	1	Ground
	3	Ignition
	16	Battery

Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications

J1939 Troubleshooting Tests

1. Take all measurements at the ECU harness connector.
2. Check for damaged or reversed J1939 wiring.

3. Check for corroded or damaged wiring connector problems such as opens or shorts to voltage or ground.
4. Check for other J1939 devices which may be loading down (inhibiting) J1939 communication.

1st Blink Code	Location
11	J1939

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	J1939 Serial link	Loss of communications between the E-60 controller and other devices connected to the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
2	J1939 Retarder	Loss of communications between the E-60 controller and other devices connected the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of retarder on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.
3	J1939 Engine Communications	Loss of communications between the E-60 controller and the engine ECU over the J1939 link. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors. Verify presence of engine ECU on the J1939 link. Verify ECU Configuration. Check for other devices inhibiting J1939 communications.

ECU Wire Harness Connector: J1939 Serial Communications Pins

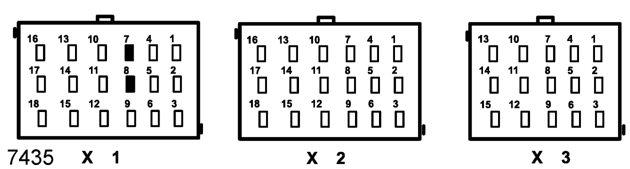


FIGURE 8-71

Connector	Pin	J1939
X1	7	J1939 Low
17 Way	8	J1939 High

Troubleshooting Diagnostic Trouble Codes: Miscellaneous

1st Blink Code	Location
12	Miscellaneous

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
1	Stop Lamp Switch Not Detected	ECU has not detected the presence of the stop lamp switch since ignition power was applied (note that stop lamp switch input may be applied to the E-60 controller using either hardwire input or J1939). Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.

2nd Blink Code	Diagnostic Trouble Code Description	Repair Information
2	Stop Lamp Switch Defective	Apply and release service brake. Check for brake switch input into ECU (see system wiring schematic). With service brake released, check for presence of the stop lamp bulb. With service brake applied, verify system voltage is now present at the stop lamp switch input to the ECU. Check for damaged wiring between ECU, stop lamp switch and bulb. Check for corroded or damaged connectors. Check for damaged or reversed J1939 wiring. Check for corroded or damaged connectors on J1939 link. Verify presence of engine ECU on the J1939 link. Verify ECU configuration.
3	Dynamometer Test Mode	ECU has been placed in the Dynamometer Test Mode by either the diagnostic blink code switch or a hand-held or PC-based diagnostic tool. ATC is disabled.
4	Retarder Relay Open Circuit or Shorted to Ground	Verify vehicle contains a retarder relay. Verify ECU configuration. Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of E-60 controller and ground. Verify condition and wiring of the retarder relay.
5	Retarder Relay Circuit Shorted to Voltage	Check wiring between ECU and retarder relay. Verify no continuity between retarder disable output of E-60 controller and voltage. Verify condition and wiring of the retarder relay.
6	ABS Indicator Lamp Circuit Fault	Check operation of diagnostic blink code switch. Check wiring of diagnostic blink code switch, ABS WL and ABS WL relay (frame ECUs only). Verify ABS WL ground input (cab ECUs only).
7	PMV Common Shorted to Ground	Verify no continuity between the CMN of all PMVs, TCV, and Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and CMN of all PMVs, TCV and Diff. Lock Solenoid.
8	PMV Common Shorted to Voltage	Verify no continuity between the CMN of all PMVs, TCV, and Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and CMN of all PMVs, TCV and Diff. Lock Solenoid.
9	ATC Disabled to Prevent Brake Fade	ATC is temporarily disabled to prevent excessive heating of the foundation brakes.
10	Tire Size Out of Range (Front to Rear)	Verify correct tire size as desired. Verify proper tire inflation. Verify correct number of exciter ring teeth. Verify that the ECU has the proper tire size settings.
11	Wheel Speed Sensors Reversed on an Axle	Sensors are reversed (left to right) on one of the axles. Verify proper installation, connection and wiring of the sensors.
12	Diff. Lock Solenoid Shorted to Ground or Open Circuit	Verify no continuity between the Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and Diff. Lock Solenoid.
13	Diff. Lock Solenoid Shorted to Voltage	Verify no continuity between the Diff. Lock Solenoid and ground. Check for corroded / damaged wiring or connectors between the ECU and Diff. Lock Solenoid.
23	I/O 2 or I/O 3 Shorted High	Check for short circuit condition between voltage and the I/O 2 and I/O 3 circuits.

Miscellaneous Troubleshooting

For all tests below, take all measurements at the ECU harness connector pins in order to check the wire harness and sensor. Probe the connector carefully so that the terminals are not damaged.

Stop Lamp Switch Test

1. With the service brake applied, measure the system voltage (9 to 17 VDC) stop lamp switch input to the ECU. **Note:** this is a 24-volt system.
2. Apply and release the service brake. Does the lamp extinguish?
3. Verify that the brake lamp switch is connected to the ECU via hard wire or J1939.

4. With the service brake released, check for presence of stop lamp bulb.

Dynamometer Test Mode (ATC Indicator Lamp Continuously Illuminated)

Clear the dynamometer test mode by depressing and releasing the blink code switch three times (or use an off-board diagnostic tool).

ABS Indicator Lamp

Verify that the diagnostic blink code switch is open when not activated.

Pressure Modulator Valves (MPV) Commons

Measure the resistance between any common (PMV, TCV and Diff.) and voltage or ground.

Test	Measurement
Any PMV, TCV or Diff. Common to Voltage or Ground	Open Circuit (no continuity)

Differential Lock Solenoid

Measure the resistance between Diff lock solenoid and voltage or ground.

Test	Measurement
Diff. Lock Solenoid to Voltage or Ground	Open Circuit (no continuity)

ECU Wire Harness Connector: Miscellaneous Pins

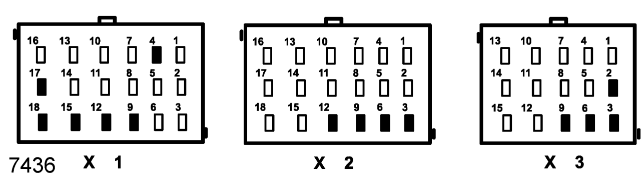


FIGURE 8-72

Connector	Pin	PMV Location
X1 17 Way	4	TCV Common
	9	Stop Lamp Switch
	12	ABS Dash Indicator Ground
	15	Not Used
	17	Retarder
	18	ABS Dash Indicator

Connector	Pin	PMV Location
X2 18 Way	3	PMV Left Steer Axle Common
	6	PMV Right Steer Axle Common
	9	PMV Right Drive Axle Common
	12	PMV Left Drive Axle Common
X3 15 Way	2	Diff. Lock Solenoid
	3	Diff. Lock Solenoid Common
	6	PMV Left Additional Axle Common
	9	PMV Right Additional Axle Common

Troubleshooting Wiring

CAUTION

All unused ECU connectors MUST be covered and receive proper environmental protection.

ABS/ATC Wiring

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.

CAB ECU Wiring Harness Connectors

The in-cab EC-60™ controllers are designed to interface with AMP MCP 2.8 connectors. Follow all AMP requirements for the repair of wire harnesses.

All wire harness connectors must be properly seated. The use of secondary locks is strongly advised.

ABS Wiring Requirements

As a matter of good practice and to make sure of maximum system robustness, always use the maximum size wire supported by the wire harness connectors for the battery, ignition, ground, PMV, TCV, Interaxle Differential Lock and indicator lamp circuits.

All sensor and serial communications circuits (J1587 and J1939) must use twisted pair wiring (one to two twists per inch). See the appropriate SAE document for additional details.

It is recommended that wires be routed straight out of a connector for a minimum of three inches before the wire is allowed to bend. The battery and ground wires should be kept to a minimum length.

If convoluted tubing is used, its I.D. must match the size of the wire bundle as closely as possible.

CAUTION

All wires must be carefully routed to avoid contact with rotating elements. Wiring must be properly secured approximately every 6 to 12 inches using UV stabilized, non-metallic hose clamps or bow-tie cable ties to prevent pinching, binding or fraying.

Wire harness lengths MUST be carefully selected for the vehicle. Harnesses that are too long increase the possibility of electrical interference and wire damage. Excess lengths of wire are not to be wound to form coils, instead re-route, repair or replace wire harnesses. DO NOT attempt to stretch harnesses that are too short, since mechanical strain can result in wire breakage.

ABS/ATC Cab Wiring Schematic

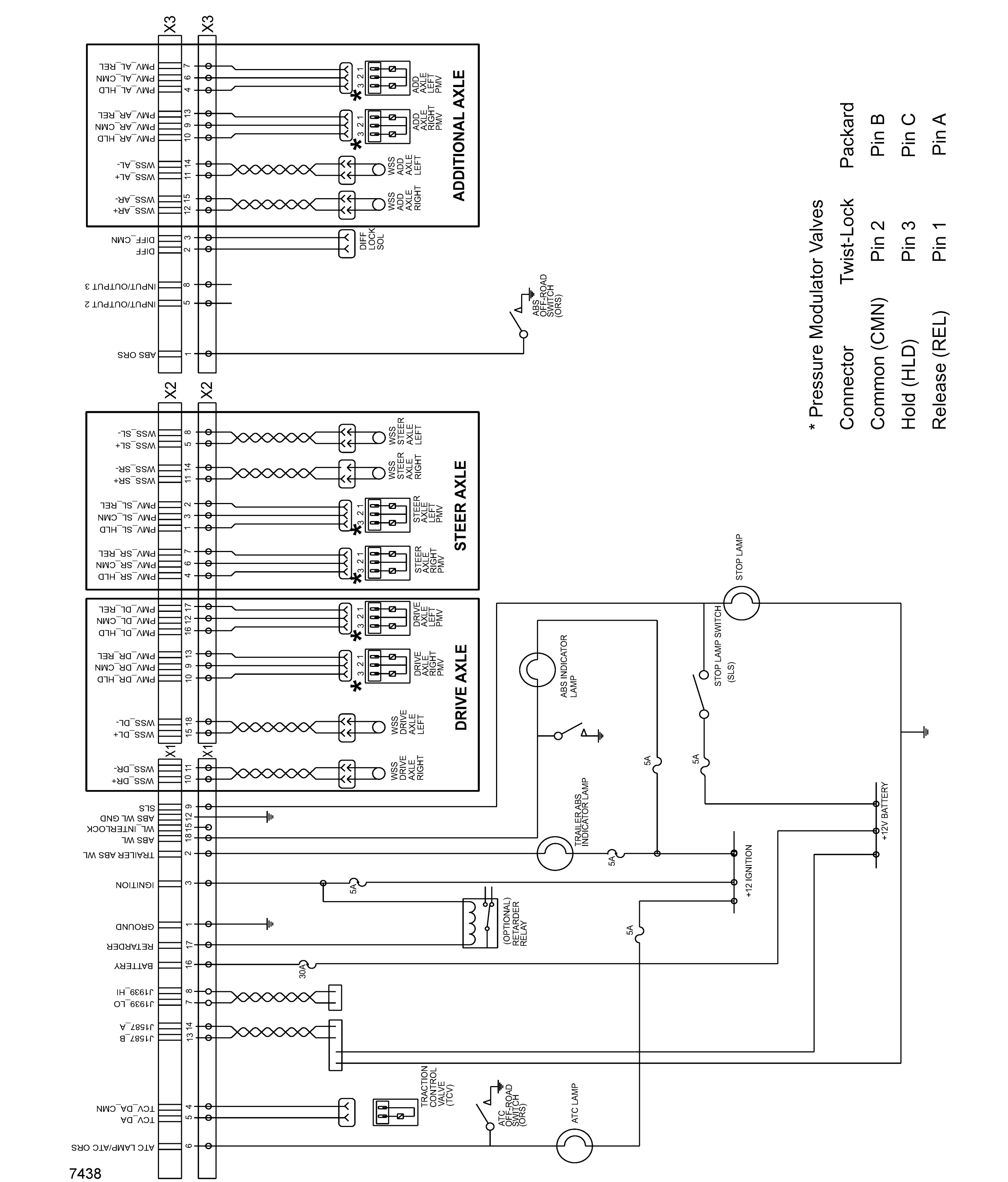


FIGURE 8-73

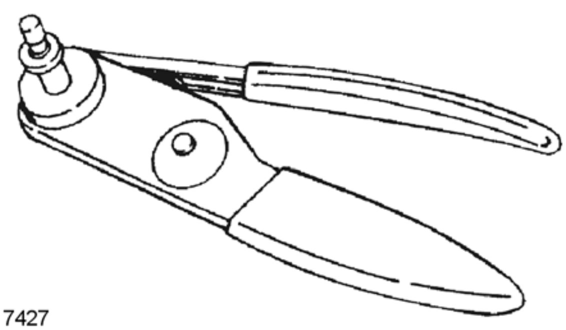
SPECIAL TOOLS

The following tools are recommended for use in the procedures described in this manual. In some cases, use of the tool is necessary to carry out the troubleshooting / repair procedure. The following tools are recommended for use in the procedures described in this manual.

Description	Deutsch P/N	Grove P/N
Extraction Tools		
18-20 gauge wire	0411-240-1605	9-999-102084-RED
16 gauge wire	0411-310-1605	9-999-100195-BLUE
12 gauge wire	114010	9-999-100194-YELLOW
8-10 gauge wire	114008	7-902-0000-12-GREEN
4-6 gauge wire	114009	7-902-000009-WHITE

Description	Deutsch P/N	Grove P/N
Crimping Tools		
16 gauge wire	HDT - 16-00	9-999-100193
12 gauge wire	HDT - 12-00	9-999-100192
8-10 gauge wire	CONSULT FACTORY	CONSULT TFACTORY
4-6 gauge wire	CONSULT FACTORY	CONSULT FACTORY

Deutsch Universal Hand Crimp Tool



7427

FIGURE 8-74

Deutsch Heavy-duty Contact Removal Kit

7428

FIGURE 8-75

Tests, Repair and Adjustment

ABS EC-60 Controller

Installing a New ABS EC-60 Controller

NOTE: When replacing the EC-60 controller, verify that the unit you are installing has the correct default settings. Failure to do so could result in a loss of features, such as ATC and PLC, or noncompliance with U.S. regulations such as FMVSS 121. It is recommended to use only the correct replacement part number. Verify the correct operation of the EC-

60 controller system and indicator lamps prior to putting the vehicle back into service. Towing vehicles manufactured after March 1, 2001 must support the trailer ABS indicator lamp located on the dash. For further information, contact either your authorized Manitowoc Cranes distributor or Manitowoc Crane Care.

1. Position and secure the EC-60 controller in the original mounting orientation using the mounting bolts retained during removal.
2. Torque the mounting bolts for frame-mounted units to 7.5 to 9 N-m (66-80 in-lb). Over tightening the mounting hardware can cause damage to the EC-60 controller.
3. Reconnect the electrical connectors to the EC-60 controller.
4. Apply power and monitor the EC-60 controller power-up sequence to verify proper system operation.

Reconfiguring EC-60 Controllers

The EC-60 controller is programmed for features specific to this Grove crane. Contact your Manitowoc Cranes distributor or Manitowoc Crane Care if reconfiguring the controller is necessary.

ATC Valve

Follow the steps listed below to locate and correct ATC problems:

1. Access active diagnostic trouble code(s) using either the*Active Diagnostic Trouble Codes*, page 8-55, or the *Troubleshooting: Blink Codes and Diagnostic Modes*, page 8-55 of this manual.
2. Lookup the code description, the possible causes and the repair procedures provided in this section.
3. Perform the recommended repair procedures.
4. After the repairs are completed, clear all codes and check for any additional codes.

ABS Modulator Valves

1. Remove any accumulated contaminants and visually inspect the exterior for excessive corrosion and physical damage.
2. Inspect all air lines and wire harnesses connected to the modulator for signs of wear or physical damage. Replace as necessary.
3. Test air line fittings for leakage and tighten or replace as necessary.
4. Perform the *Operating and Leakage Checks*, page 8-29 and the *Leakage Test: Traction Control Valve*, page 8-74 described in this manual.

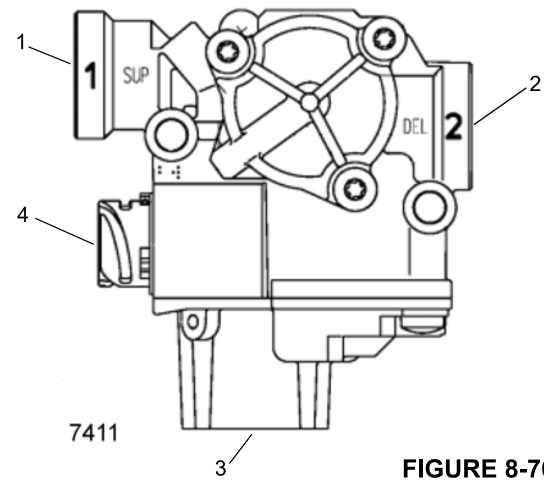
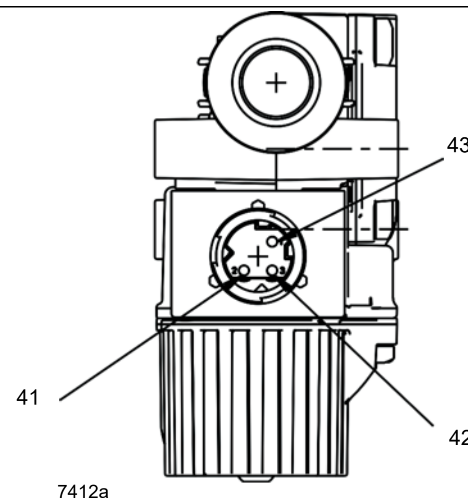


FIGURE 8-76

Port	Designation
1	Air Supply Port
2	Air Delivery Port
3	Air Exhaust Port
4	Elec. Connector-Twist Lock



Electrical Connector	Pin Values
41	Source
42	Hold
43	Exhaust

FIGURE 8-77

Leakage Test: M-32 and M-32QR Modulator Valves

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to full pressure.
2. Turn the engine OFF and make four or five brake applications and note that the service brakes apply and release promptly.
3. Build system pressure to governor cut-out and turn the engine OFF.
4. After determining the pressure loss with the brakes released (2 psi/minute allowed), make and hold a full service brake application. Allow the pressure to stabilize for one minute.
5. Begin timing pressure loss for two minutes while watching the dash gauges for a pressure drop. The leakage rate for the service reservoirs should not exceed 3 psi/ minute.
6. If either circuit exceeds the recommended 2 psi / minute, apply soap solution to the exhaust port of the modulator and any other components in the respective circuit.
7. The leakage at the exhaust port of most Bendix components, including M-32 modulators, should not exceed a 25 mm (one-inch) bubble in three seconds. If leakage at the modulator is determined to exceed the maximum limits, replace the modulator.

Operation Test: M-32 and M-32QR Modulator Valves

To properly test the function of the modulator will require two service technicians.

1. Park the vehicle on a level surface and block or chock the wheels. Release the parking brakes and build the air system to governor cut out.
2. Turn the engine ignition key to the “OFF” position then make and hold a full brake application.
3. With the brake application held, and one (1) service technician posted at one (1) of the modulators, turn the vehicle ignition key to the “ON” position. One or two short bursts of air pressure should be noted at the modulator exhaust. Repeat the test for each modulator on the vehicle. If at least a single burst of exhaust is not noted or the exhaust of air is prolonged and not short, sharp and well defined, perform the Electrical Tests.

Electrical Tests: Modulator Valves

NOTE: Before testing the solenoid assembly of a suspect modulator, its location on the vehicle should be confirmed using the Troubleshooting or Start Up procedure for the specific anti-lock controller in use. (See the Service Data Sheet for the anti-lock controller for this procedure at the Bendix website.

Proceed to the modulator in question and inspect its wiring connector. Disconnect the connector and test the resistance between the pins on the modulator. Refer to (Figure 8-77);

- Hold to Source (41-42): Read 4.9 to 5.5 ohms.
- Exhaust to Source (43-41): Read 4.9 to 5.5 ohms.
- Exhaust to Hold (43-42): Read 9.8 to 11.0 ohms.

Individually test the resistance of each pin to vehicle ground and note there is no continuity. If the resistance readings are as shown, the wire harness leading to the modulator may require repair or replacement. Before attempting repair or replacement of the wire harness, refer to the test procedures specified for the anti-lock controller in use for possible further testing that may be required to substantiate the wire harness problem. If the resistance values are not as stated, replace the modulator.

ABS Sensor Troubleshooting

1. To check wheel speed sensor resistance, refer to.Troubleshooting: Blink Codes and Diagnostic Modes, page 8-55 and Troubleshooting Diagnostic Trouble Codes: J1939 Serial Communications, page 8-65.

Component Removal and Installation

WARNING

Before working on a vehicle, set the parking brakes, place the transmission in neutral and block the wheels.

DO NOT work under a vehicle supported only by jacks. Always use jack stands under the vehicle.

Stop the engine and remove ignition key when working under or around the vehicle.

If the work is being performed on the vehicle’s air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning any work on the vehicle.

Failure to follow these warnings can cause serious personal injury or death.

Prior to returning the vehicle to service, make certain that all components and systems are restored to their proper operating condition.

For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON, see Dynamometer Test Mode, page 8-57) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.

ATC Valve

Removal of ATC Valve

1. Disconnect the wiring connector (4), (Figure 8-60) from the ATC valve.
2. Disconnect the air lines from the supply (1) and delivery port (2) and treadle port (3) of the ATC valve (Figure 8-60).
3. Disconnect the valve mounting fasteners, and remove the valve.

Installation of ATC Valve

1. Install the ATC valve. Torque fasteners to manufacturers specification.Refer to the Torque Tables in Section 1 of this manual.
2. Connect the air lines to the supply port (1), delivery port (2) and treadle port (3) of the ATC valve as shown in (Figure 8-60).
3. Install the wiring connector to the ATC valve.
4. Test the installation.

Leakage Test: Traction Control Valve

Make and hold brake application. No audible air leaks are permitted.

Traction Control Valve Component Test with Hand-Held Diagnostic Tool

1. Select Traction Control Valve.
2. Verify traction control light operation.
3. Drive the vehicle and verify ABS indicator lamp operates properly.

WARNING

Do not start and engage the transmission with one wheel raised from the floor. With ATC, power will go to the wheel on the floor and cause the vehicle to move which can injure personnel or damage the machine.

See Dynamometer Test Mode, page 8-57 to disable ATC for dyno testing.

Modulator Valves M-32, M-32QR

Removal

1. Locate the modulator that will be replaced and clean the exterior.
2. Identify and mark or label all air lines and their respective connections on the valve to facilitate ease of installation.
3. Disconnect all air lines and the electrical connector.
4. Remove all air line fittings and plugs. These fittings will be re-used in the replacement modulator.

Installation

1. Install all air line fittings and plugs, making certain thread sealing material does not enter the valve.
2. Install the assembled valve on the vehicle.
3. Reconnect all air lines to the valve using the identification made during removal.
4. Reconnect the electrical connector to the modulator.
5. After installing the valve, test all air fittings for excessive leakage and tighten as needed.

Wheel Speed Sensor Replacement (Front)

Removal

1. Park the vehicle on a level surface. Apply the parking brake, place the transmission in neutral and block the rear wheels. Make sure vehicle ignition is in the “OFF” position.

NOTE: DO NOT pull on the sensor cable to remove it, as this may permanently damage the sensor. DO NOT use any device to pry the sensor from its mounting block, as this may damage the steel casing on the sensor and can void any existing warranty.

2. Cut the tie straps along the sensor cable. Using a slight twisting motion, remove the sensor from its mounting block. Use extreme care not to damage the tooth wheel or the sensor.
3. Disconnect any fasteners that hold the sensor cable and the hose clamp to other components.
4. Disconnect the sensor from the vehicle wiring at the connector closest to the sensor.

Installation

1. Install the sensor cable around the S-cam tube and bracket, up the brake chamber airline, and route the cable along the frame rail.
2. Connect the sensor cable connector.
3. Install the sensor into the spider assembly.
4. Fasten the sensor cable to the brake air line using a tie strap.

NOTE: DO NOT use a screwdriver or sharp instrument to adjust the sensor. Use of a sharp instrument could permanently damage the sensor.

DO NOT use a hammer to drive the sensor into position. Hammering the sensor could permanently damage it.

5. Verify proper sensor operation by driving the vehicle. This allows the ABS to perform a self test. Once the vehicle reaches approximately 11 km/h (7 mph), the ABS warning lamp will go out if the sensor is working properly.

Wheel Speed Sensor, Replacement (Rear)

Removal

1. Park the vehicle on a level surface. Apply the parking brake, place the transmission in neutral, and block the rear wheels. Make sure vehicle ignition is in the “OFF” position.

NOTE: DO NOT pull on the sensor cable to remove it, as this may permanently damage the sensor. DO NOT use any device to pry the sensor from its mounting block, as this may damage the steel casing on the sensor and can void any existing warranty.

2. Cut the tie straps along the sensor cable. Using a slight twisting motion, remove the sensor from its mounting block. Use extreme care not to damage the tooth wheel or the sensor.
3. Disconnect any fasteners that hold the sensor cablee to other components.
4. Disconnect the sensor from the vehicle wiring at the connector closest to the sensor.

Installation

NOTE:

5. Install the sensor cable around the S-cam tube and bracket, up the brake chamber airline, and route the cable along the frame rail.
6. Connect the sensor cable connector.
7. Install the sensor into the spider assembly.
8. Fasten the sensor cable to the brake air line using a tie strap.

NOTE: DO NOT use a screwdriver or sharp instrument to adjust the sensor. Use of a sharp instrument could permanently damage the sensor.

DO NOT use a hammer to drive the sensor into position. Hammering the sensor could permanently damage it.

9. Verify proper sensor operation by driving the vehicle. This allows the ABS to perform a self test. Once the vehicle reaches approximately 11 km/h (7 mph), the ABS warning lamp will go out if the sensor is working properly.

OUTRIGGERS

Description

The outriggers, when properly extended and set, provide a rigid four point platform which is capable of supporting the crane and its maximum load capacity. The outriggers consist of inverted jack cylinders with single-stage outrigger beams to allow for fully retracted, partial extension and fully extended operation. A center front jack is provided for stabilization during over the front lifting. The front outrigger box is mounted behind the front axles while the rear outrigger box is mounted behind the rear axles. The center front jack is mounted on the center of a cross member at the front of the crane.

The outrigger beam assembly retracts into the outrigger boxes. The beam assembly contains the extension cylinder with integral encoders and the jack cylinder, which is mounted in a tube at the end of the beam. The encoder integral to each extension cylinder is part of the Outrigger Monitoring System (OMS).The OMS indicates the horizontal position for the beams’ position—fully retracted, mid-extend, or fully extended.

The outrigger circuit consists of an outrigger selector valve, four extension cylinders, five jack cylinders, a relief valve, a pressure switch, and check valves. The five jack cylinders have pilot operated check valves threaded into their port blocks. The pressure switch is mounted in a port on the center front jack cylinder.

There are three outrigger control panels on the crane. One outrigger control panel is located in the superstructure cab which is integrated into the ODM. There is also a control panel on either side of the crane behind the front outriggers. Also, the outriggers can be controlled with the O/R remote (separate from the remote controller).

A sight bubble level is mounted on the right side console in the cab and near each of the side control panels. The sight bubble level provides the operator with a visual indication of crane level attitude.

Theory of Operation

When the outrigger extension cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. When the jack cylinder extends and makes contact with the ground through an outrigger pad, the jack cylinder applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

Outriggers are extended and retracted from the Operator Display Module (ODM) in the Superstructure Cab.The Outrigger Control Panels, located on either side of the crane, have the Extension/Jack switches. Depressing one of the outrigger selector switches causes a solenoid valve (located on the integrated outrigger valve) to open. As the selector switch is moved, the selector valve shifts, allowing flow to either the extend or retract line, as applicable. If the selector switch is in the EXTEND position, the flow continues through the open solenoid valve to the barrel side of the cylinder. If a jack is to be extended, the flow first unseats the check valve then extends the cylinder. The oil from the rod end flows to the selector valve and through the swing bank on the way to the reservoir.

When the selector switch is in the RETRACT position, the flow through the selector valve is to the rod side of the cylinder. The oil in the barrel side flows through the open solenoid back to the selector valve and through the swing bank on the way to the reservoir.

The front jack functions similar to any of the other outrigger cylinders. A pressure switch is used to sense pressure in the barrel end of the cylinder after extension. When the pressure reaches 206.8 bar (3000 PSI) the switch causes a red light to be illuminated on the ODM. This alerts the operator that the center jack is approaching an overloaded condition.

The in line relief valve prevents over pressurization of the center front jack cylinder. The valve is installed in line between the solenoid valve and the cylinder, and is set at 13.8 bar (200 PSI).

Maintenance

Troubleshooting Outriggers

SYMPTOM	PROBABLE CAUSE	SOLUTION
Slow or erratic operation of outrigger extension cylinders.	Damaged relief valves.	Remove relief valve, clean or replace.
	Low hydraulic oil.	Replenish oil to proper level.
	Sticking solenoid valve spool.	Repair or replace valve spool.
	Solenoid improperly grounded.	Ground properly.
	Damaged O-Rings and swivel.	Remove swivel and replace O-Rings.
	Directional selector switch sticking.	Replace switch.
	Damaged wiring to solenoid switch.	Replace wiring.
	Damaged extension cylinder (internal parts).	Remove extension cylinder and repair as necessary.
	Bent cylinder rod.	Replace piston rod and seals.
	Excessive material on outrigger beams.	Clean outrigger beams.
	Binding outrigger beam.	Repair or replace outrigger beam.
	Damaged outrigger valve.	Repair or replace valve.
	Damaged valve coil.	Replace coil.
	Main hydraulic pump cavitation.	Replace or tighten hose or fittings.
	Partially shifted hydraulic selector spool or over-tightened cartridge.	Disassemble, clean, and polish spool and valve housing with very fine emery cloth. Do not over-tighten cartridge.
	Insufficient voltage for operation of solenoid valve.	Solenoids require a minimum of 24 volts to energize.
	Damaged piston seals.	Replace all cylinder seals.

Manitowoc Crane Care

SYMPTOM	PROBABLE CAUSE	SOLUTION
	Worn or damaged hydraulic pump section.	Repair or replace pump section.
	Scored cylinder barrel.	Repair or replace barrel.
	Cracked or damaged piston.	Replace piston and all cylinder seals.
	Piston loose on piston rod.	Replace all cylinder seals and torque piston locknut.
Sticking spool.	Dirt in system.	Change oil and flush system.
	Flow in excess of valve rating.	Limit flow through valve to that recommended. Check pump output.
	Pressure in excess of valve rating.	Check relief valve setting or pump compensation and adjust or replace as necessary.
	Electrical failure.	Check wiring and solenoids.
External leakage.	Damaged O-Rings or quad rings.	Check for chipped packings and replace.
	Damaged solenoid.	Replace damaged parts.
Solenoid failure.	No current.	Check power source of at least 85% of coil rating.
	Damaged solenoid assembly.	Replace solenoid.
	Short in solenoid.	Replace coil.
Outrigger vertical jack cylinder slow or erratic.	Low in hydraulic oil.	Replenish oil to proper level.
	Damaged main relief valve.	Repair or replace valve.
	Damaged holding valve seals.	Replace holding valve seals.
	Bent cylinder rod.	Replace cylinder rod and seals.
	Bent outrigger housing.	Repair or replace outrigger housing.
	Damaged O-Rings in swivel.	Replace O-Rings.
	Sticking solenoid valve spool.	Repair or replace valve spool.
	Damaged wiring to solenoid.	Repair or replace wiring.
	Directional selector switch sticking.	Clean or replace switch.
	Main hydraulic pump cavitation.	Replace or tighten hose and fittings.

8

SYMPTOM	PROBABLE CAUSE	SOLUTION
	Worn or damaged hydraulic pump section.	Repair or replace pump section.
Jack cylinder retracts under load.	Damaged piston seals.	Replace all cylinder seals.
	Damaged holding valve seals.	Replace valve assembly.
	Damaged holding valve.	Replace valve assembly.
	Scored cylinder barrel.	Repair or replace cylinder.
	Cracked or damaged piston.	Replace piston and all cylinder seals.
Jack cylinder extends while machine is traveling.	Damaged piston seals.	Replace all cylinder seals.
	Scored cylinder barrel.	Replace jack cylinder.
	Cracked or damaged piston.	Replace piston and seals.
	Piston loose on cylinder rod.	Replace seal and re-torque.
Outrigger system will not activate (from stowed or extended and down position).	Hydraulic oil low.	Replenish oil to proper level.
	Loose or broken wire on switch.	Repair or replace wiring.
	Clogged, broken, or loose lines or fittings.	Clean, tighten, or replace lines or fittings.
	Damaged relief valve or damaged control valve.	Repair or replace valve.
Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	Clogged, broken, or loose hydraulic lines or fittings.	Clean, tighten, or replace lines or fittings.
	Loose or broken wire on control switch or solenoid valve.	Repair or replace wiring.
	Damaged solenoid valve.	Repair or replace valve.
	Damaged control switch.	Replace switch.
	Damaged hydraulic cylinder.	Repair or replace cylinder.
Outrigger will not lift the machine.	Improper sequence of button activation OR damaged relief valve.	Activate individual control switch; then activate system control switch OR Replace damaged valve.
Two outriggers activate from single control switch.	Damaged solenoid valves.	Repair or replace damaged parts.

SYMPTOM	PROBABLE CAUSE	SOLUTION
One/two outriggers will not stow.	Hydraulic lock.	Recycle individual outrigger(s).
Individual outrigger will not set or stow.	Damaged piston seals. Damaged check valve.	Replace seals. Repair or replace valve.

Outrigger Beam (with Adjustable Wear Pads)

Inspection of Outrigger Beams Before Removal

1. Activate the hydraulic system; extend and retract the outrigger beams.
2. Observe the operation of the outrigger beams.
3. Inspect the hoses, couplings, and end fittings for cracks, chafing, cuts, or other damage.
4. Check the hydraulic connections for any evidence of leakage.
5. Inspect the outrigger beams for evidence of cracks or other damage.
6. Make sure that the Outrigger Monitoring System (OMS) functions properly.

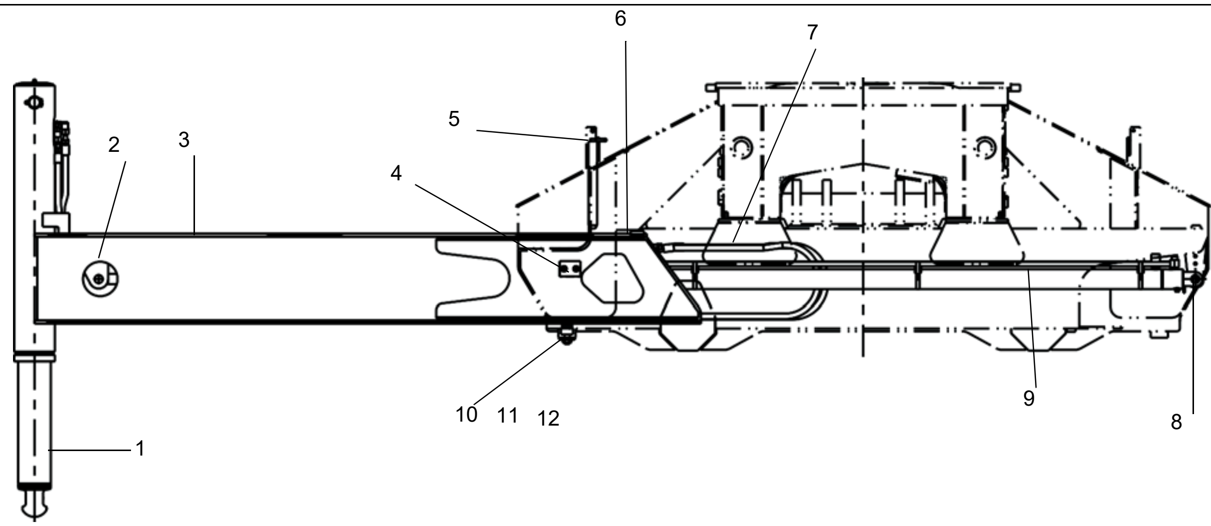
Removal of Outrigger Beam

1. Remove the rear cover of the outrigger box.
2. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
3. From the opposite side of the outrigger box, remove the end cover.
4. Tag and disconnect the OMS sensor cable.
5. Tag and disconnect the hydraulic lines to the cylinder end of the extension cylinder. Cap all lines and fittings.
6. Loosen the wear pad jam nut on the bottom adjustable wear pad and back wear pad away from the beam. (Figure 8-78).
7. Remove the cotter pin and clevis pin securing the rod of the extension cylinder to the outrigger beam.
8. After attaching a suitable lifting device of straps or belts, instead of chains to prevent damage to the bottom edges of the outrigger beam, pull the outrigger beam out of the outrigger box, re-adjusting the lifting attachment to prevent the beam from tipping.

WARNING

Death or Injury Could Occur!

Make sure that any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.



1. Jack Cylinder
2. Extension Cylinder Clevis Pin
3. Outrigger Beam
4. Wear Pad
5. Mid Extend Lock Pin
6. Wear Pad
7. Jack Cylinder Hose Assembly
8. Extension Cylinder Clevis Pin
9. Extension Cylinder
10. Wear Pad
11. Wear Pad Jam Nut
12) Plate

FIGURE 8-78

NOTE: The outrigger beam assembly weighs approximately 338 kg (745 lb).

9. Position the outrigger beam on the blocking material.

10. If necessary, remove the wear pads from the bottom of the outrigger box.

NOTE: Do not allow the end of the extension cylinder to fall when the cylinder barrel lugs are removed from the brackets. Use blocking to limit the drop or an adequate soft support to cushion any distance the cylinder will drop.

WARNING

Death or Injury Could Occur!

Make sure that any blocking material used is capable of supporting the weight of the outrigger beam. Do not allow it to tilt or slide.

Inspection of Outrigger Beams After Removal

1. Inspect the hoses, couplings, and end fittings for cracks, chafing, cuts, or other damage.
2. Check the hydraulic connections for any evidence of leakage.
3. Inspect the outrigger beams for evidence of cracks or other damage.

Installation of Outrigger Beams

1. Apply grease (EPMPG) to the top and bottom of the outrigger beam assembly contact area.
2. Install the bottom wear pads with approximately 3.2 mm (0.125 in) protruding. This will prevent the beam side plates from riding on the bottom of the box.
3. Attach a suitable lifting device of straps or belts instead of chains to prevent damage to the bottom edges of the outrigger beam.
4. Slide the beam into the outrigger box and align the cylinder rod with the mounting hole.
5. Secure the cylinder rod to the housing with the clevis pin and cotter pin.

CAUTION

Damage Could Occur!

Make sure that the piston side of all outrigger cylinders is connected to the solenoid valve bank. Reversal of port connections could result in damage to the cylinders as very high pressure intensification will occur.

During initial start-up and checking of the outrigger operation, each control switch must be operated before operating the selector valve. If hydraulic lines are reversed to one or more cylinders, this will prevent damage to the cylinders.

6. Connect the hydraulic lines as tagged prior to removal.
7. Adjust the wear pads, refer to *Wear Pad Adjustment on Outrigger Beams*, page 8-81 (in this Section).
8. Connect the electrical connection to the extend cylinder for Outrigger Monitoring System (OMS).
9. Install the rear cover of the outrigger box.

NOTE: At installation, be sure that the outrigger jack cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

Wear Pad Adjustment on Outrigger Beams

NOTE: When adjusting wear pads, refer to (Figure 8-79).

1. Adjust the outrigger box bottom wear pads until a gap of 2.0 mm (0.08 in) is obtained at the tightest point during full extension. Through-out the travel of the beam assembly (extend/retract), the beam assembly must not jam or have excessive play within the outrigger box.
2. Tighten the wear pad jam nut to lock wear pad adjustment.

8

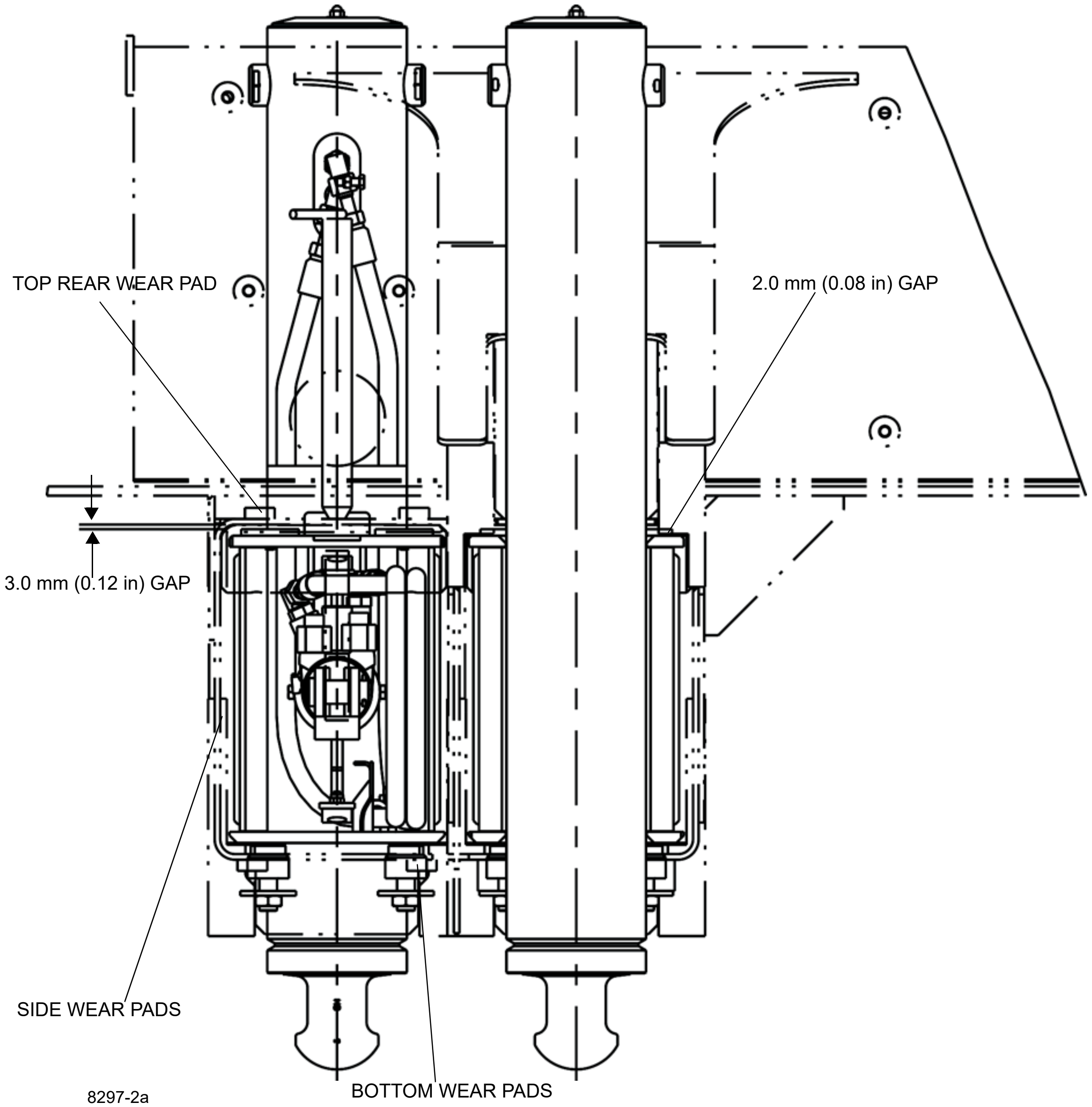

TOP REAR WEAR PAD
2.0 mm (0.08 in) GAP
3.0 mm (0.12 in) GAP
SIDE WEAR PADS
8297-2a
BOTTOM WEAR PADS

FIGURE 8-79

Extension Cylinder

Description

The extension cylinder is installed in the outrigger beam. The cylinder has a single stage. The rod end attaches to the outrigger beam while the barrel anchors to the outrigger box.

The cylinder has a 6.35 cm (2.50 in) diameter bore. Internal seals are used to prevent internal and external leakage. A wiper ring is mounted to the front of the barrel to wipe dirt from the rod as it is retracted.

The retracted length of the cylinder from the hole in the barrel to the hole in the rod is 218.14 cm (85.88 in).The extended length of the cylinder from the hole in the rod is 403.56 cm (158.88 in). Its stroke is 185.42 cm (73 in).

Each cylinder weighs approximately 32.5 kg (71.67 lb).

Maintenance for Extension Cylinder

Removal of Extension Cylinder

1. Remove the outrigger beam. Refer to *Removal of Outrigger Beam*, page 8-79 in this Section.
2. Remove the cotter pin and clevis pin securing the rod end of the extension cylinder to the outrigger beam.
3. Pull the extension cylinder from the outrigger beam until the hydraulic hoses on the rod end of the cylinder can be accessed. Tag and disconnect the hoses from the rod end of the cylinder. Cap or plug all openings.
4. Remove the cylinder.

Installation of the Extension Cylinder

1. Install the extension cylinder into the outrigger beam.

CAUTION

Damage Could Occur!

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

---

2. Connect the lines to the jack cylinder as marked during disassembly.
3. Secure the hoses in place with the bolts, pipe clamps and bolt inserts.
4. Install the shaft securing the rod end of the extension cylinder to the outrigger beam.
5. Install the outrigger beam. Refer to paragraph *Outrigger Beam (with Adjustable Wear Pads)*, page 8-79 in this Section.

Functional Check for Extension Cylinder

1. Activate the hydraulic system; extend and retract the outrigger.
2. Observe the operation of the outrigger beam.
3. Check the hydraulic connections for any evidence of leakage.
4. Make sure that the Outrigger Monitoring System (OMS) functions properly.

OUTRIGGER JACK CYLINDERS

Description

The jack cylinders have 10.16 cm (4.0 in) diameter bores and are the double-acting type. The cylinders are pinned into tubes welded onto the end of the outrigger beams. A port block is welded to the end of the cylinder rod and a pilot-operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

The retracted length of the cylinder from the end of the ball on the barrel to the hole in the rod is 105.72 cm (41.62 in). The extended length of the cylinder from the end of the ball on the barrel to the hole in the rod is 152.71 cm (60.12 in). Its stroke is 47 cm (18.5 in).

Each cylinder weighs approximately 56.9 kg (125.5 lb).

Maintenance for Jack Cylinders

Removal of Jack Cylinders

1. Extend the outrigger beam slightly for improved access to the jack cylinder. Shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.
5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin.
6. Jack the cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

CAUTION

Damage Could Occur!

Use a nylon strap to remove the cylinder to make sure that the retaining pin is not damaged.

7. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

Installation of Jack Cylinders

1. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under the paragraph *Removal of Jack Cylinders*, page 8-83 of this Section, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
2. Apply grease (EPMPG) to the ID of the jack cylinder support tube.
3. Remove the retaining pin and cotter pins from the cylinder.
4. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam. Secure the cylinder in place with the retaining pin and cotter pins.
5. Install the cylinder cap.

CAUTION

Damage Could Occur!

Be sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

6. Connect the hydraulic hoses to the jack cylinder as marked during disassembly.

Functional Check of Jack Cylinders

1. Activate the hydraulic system.
2. Extend and retract the jack cylinder.
3. Check for smooth operation of the cylinder.
4. Check all hydraulic connections and hoses for evidence of leakage.

CENTER FRONT JACK CYLINDER

Description

The retracted length of the cylinder (Figure 8-80) from the end of the ball on the barrel to the hole in the rod is 115.6 cm (45.50 in). The extended length of the cylinder from the end of the ball on the barrel to the hole in the rod is 179.1 cm (70.5 in). Its stroke is 63.5 cm (25 in).

The cylinder weighs approximately 42.5 kg (93.70 lb).

Maintenance for Center Front Jack Cylinder

Removal of Center Front Jack Cylinder

1. Remove the screws, washers, flatwashers, and hex nuts securing the plate. Remove plate.
2. Remove the bolts, bushings, flatwashers and locknuts securing the outrigger pad to the cylinder ball and remove the outrigger pad.
3. Remove the washers and nuts securing the cylinder cap.
4. Tag, disconnect, and cap the hydraulic lines to the cylinder.
5. Remove the pressure switch prior to cylinder removal. Cap the pressure switch port.
6. 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.
7. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin and cylinder cap retaining bracket.
8. Jack the cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

CAUTION

Damage Could Occur!

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

9. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube.
10. Remove the Wear Ring from the groove of the cylinder. Remove the Wear Ring from the groove in the bottom of the tube.

Installation of Center Front Jack Cylinder

1. Apply grease (EPMPG) to the ID of the jack cylinder support tube.
2. If removed, install Wear Ring in groove in bottom of support tube and in groove at top on jack cylinder.
3. Place a jack beneath the cylinder tube. Using the same method as described under Removal, lower the jack cylinder into the cylinder tube until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.
4. Remove the retaining pin and cotter pins from the cylinder.

CAUTION

Damage Could Occur!

When installing cylinder retaining pin, orient it so that when cotter pins are installed they will be horizontal.

5. Lower the jack until the holes in the cylinder rod align with the holes in the tube. Apply anti-seize to the retaining pin. Secure the cylinder and cylinder cap retaining bracket in place with the retaining pin and cotter pins.
6. Install the hydraulic lines as tagged prior to removal.
7. Install the pressure switch.
8. Install the cylinder cap and secure with the washers and nuts.
9. Position the outrigger pad on the cylinder ball and secure with bolts, bushings, flatwashers and locknuts. Thread nut on bolt until washer contacts pad. Do not tighten any further. Apply medium strengths Loctite to screws before installing.
10. Position the plate on the mounting bracket and secure with the screws, washers, flatwashers, and nuts.

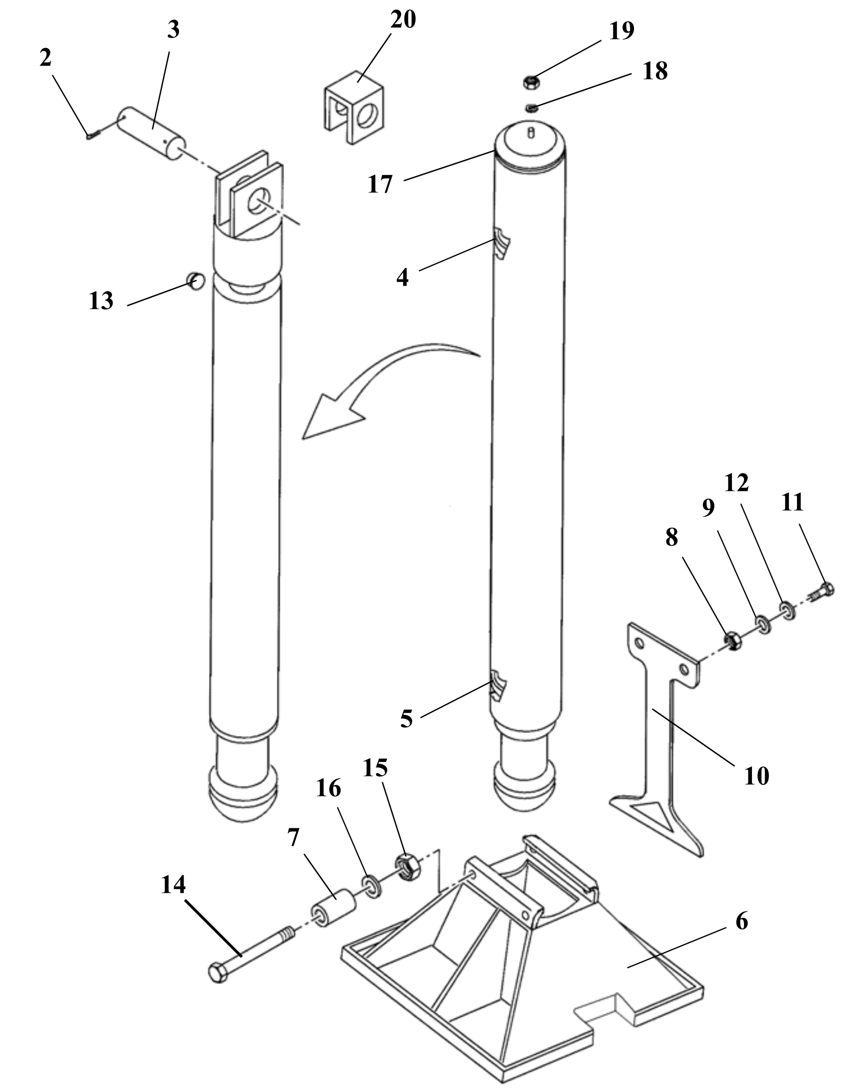
Functional Check of Center Front Jack Cylinder

CAUTION

Damage Could Occur!

Extend and set the four main outriggers before extending the center front jack.

1. Extend and set the outriggers.
2. Activate the hydraulic system; extend and retract the center front jack.
3. Observe for proper operation of the cylinder.
4. Check the hydraulic connections for evidence of leakage.



6512

1.	Cylinder	10.	Plate
2.	Pin	11.	Capscrew
3.	Cotter Pin	12.	Flatwasher
4.	Cylinder Head Wear Ring	13.	Plug
5.	Piston Wear Ring	14.	Capscrew
6.	Outrigger Pad	15.	Locknut
7.	Bushing	16.	Flatwasher
8.	Hex Nut	17.	Cap
9.	Lockwasher	18.	Washer
		19.	Acorn Nut
		20.	Cap Bracket

FIGURE 8-80

OUTRIGGER MONITORING SYSTEM

Description

The Outrigger Monitoring System (OMS) aids the operator in accurately programming the Rated Capacity Limiter (RCL) by automatically identifying the position of each outrigger beam. The OMS uses four sensors, one per outrigger beam, to indicate when an outrigger beam is positioned to one of three pre-defined locations, including fully retracted, mid-extend, and fully extended.

The Outrigger setup is the same for cranes equipped with the OMS; refer to Setting the Outriggers from the Superstructure Cab, page 4-27 of the Operators Manual.

If the crane is setup on outriggers and “On Outriggers” is selected when programming the RCL, then the OMS indicates to the RCL the horizontal position of each of the four outrigger beams. If the outrigger beam configuration programmed by the operator does not match that which is detected by the Outrigger Monitoring System, an outrigger beam over-ride warning screen will appear (refer to Overriding the Outrigger Monitoring System, page 4-87 of the Operator Manual). The RCL does not lock-out the crane or select a different load chart based on the outrigger beam position that is identified by the OMS. The operator must confirm the outrigger positions and rigging code. Refer to the *Operator Manual* for additional information.

OMS Linear Position Sensors

Removal

1. Remove the rear access cover plate from outrigger box.
2. Rotate the gnarled bayonet portion of the connector in order to pull the harness from the sensor.

NOTE: Avoid free-release of cable to prevent damage to OMS linear potentiometer.

3. Tag and disconnect the electrical connector and secure to avoid damage.

Repeat steps 1 through 3 for the other linear potentiometer, if necessary.

Installation

1. Connect the tagged OMS Connector of the harness to the sensor on the cylinder.

NOTE: Avoid free-release of cable to prevent damage to the OMS branch of the harness.

2. Install access cover plate to outrigger box.

THIS PAGE BLANK

SECTION 9
LUBRICATION

SECTION CONTENTS

GENERAL 9-1
Environmental Protection 9-1
Cummins Oil Registration List. 9-1
Standard Lubricants 9-2
Arctic Lubricants and Conditions 9-4
Cylinder Rod Surface Protection 9-6
Wire Rope Lubrication 9-6
Lubrication Points 9-6
Drivetrain Lubrication 9-8
Steering Lubrication 9-12
Axle Lubrication 9-13
Outrigger Lubrication 9-17
Miscellaneous Lubrication 9-18
Turntable & Cab Platform Lubrication 9-19
Hoist Lubrication 9-21
Turntable Central Lubrication 9-22
Boom Lubrication. 9-24
Monthly Lubrication Work 9-29
Carwell® Rust Inhibitor. 9-30
Protecting Cranes From Corrosion 9-30
Cleaning Procedures 9-30
Inspection and Repair 9-31
Application 9-31
Areas of Application. 9-31

GENERAL

Following the designated lubrication procedures is important in ensuring maximum crane lifetime and utilization. The procedures and lubrication charts in this section include information on the types of lubricants used, the location of the lubrication points, the frequency of lubrication, and other information.

The service intervals specified are for normal operation where moderate temperature, humidity, and atmospheric conditions prevail. In areas of extreme conditions, the service periods and lubrication specifications should be altered to meet existing conditions. For information on extreme condition lubrication, contact your local Grove Cranes distributor or Manitowoc Crane Care.

CAUTION

Possible Equipment Damage!

Chassis grease lubricants must not be applied with air pressure devices as this lubricant is used on sealed fittings.

The multipurpose grease installed during manufacture is of a lithium base. Use of a non-compatible grease could result in damage to equipment.

Environmental Protection

Dispose of waste properly! Improperly disposing of waste can threaten the environment.

Potentially harmful waste used in Grove cranes includes — but is not limited to — oil, fuel, grease, coolant, air conditioning refrigerant, filters, batteries, and cloths which have come into contact with these environmentally harmful substances.

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

When filling and draining crane components, observe the following:

- Do not pour waste fluids onto the ground, down any drain, or into any source of water.
- Always drain waste fluids into leak proof containers that are clearly marked with what they contain.
- Always fill or add fluids with a funnel or a filling pump.
- Immediately clean up any spills.

Cummins Oil Registration List

Cummins has a program that lists engine oils that it has tested to meet its engineering specifications. Listing of recommended oils is on QuickServe® Online. Log on to quickserve.cummins.com and login with a current user name and password or create a new account by selecting “Create an Account” under information, choose Limited Owners Plan and register. Once logged in, click on the “Service” Tab in the top red bar, “Service Tools” mini-tab and “Oil Registration Lists” link within the Service Tools list. This will load a list of the different Cummins Engineering Specification numbers. Select the one that applies to your engine to view the registered oils.

Standard Lubricants

Standard lubricants are used on all Grove cranes unless the crane is ordered with a cold weather package. These standard lubricants are effective in ambient temperatures down to -9°C (15°F). Refer to TABLE 9-1: for a list of the recommended standard lubricants.

TABLE 9-1: Standard Lubricants/Fluids [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec. #	Lube Spec.	Recommended Lubricant Type	Grade	Classification
Extreme Pressure 3% Moly Grease	6829015304	M	Citgo: Lithoplex CM2 Mobil: Mobilgrease CM-P Ipiranga: IPIFLEX LI-COMP MOLY 2	NLGI Grade 2	
Synthetic Gear Lube SAE 40	80078954	E	Emgard MTF 7000 (BASF) Phillips 66 Triton Synthetic MTF Kendall SHP Synthetic MTF	SAE 40	
Gear Lubricant (GL-5)	6829012964	B	Century Unigear Semi-synthetic SAE 80W-90 Gear Lubricant, Product Code No. 324094 Texaco Multigear SS 80W-90 Chevron DELO Gear Lubricant 80W-90	80W-90	
Engine Oil SAE	6829104182	F	Conoco Fleet Supreme EC Mobil Delvac 1300 Super Mobil Delvac MX ESP	15W-40	CJ-4
Hydraulic Oil	6829006444	K	Exxon Mobil 424 Phillips 66 PowerTran XP	ISO grade 46/68	Must Meet John Deere Std. JDM J20c
Extreme Pressure Gear Lube	6829100213	H	Mobil: 600XP 150 Gear Oil Texaco: Meropa 150		
Extreme Pressure Multipurpose Grease	6829003477	A	Citgo: Lithoplex Red MP Grease Chevron: Starplex EP 2 Phillips 66: Multiplex Red Mobil: Mobilgrease XHP 222 Ipiranga: IPIFLEX LI-COMP EP 2	NLGI 2	
Open Gear Lube	6829102971	G	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Anti-Seize Compound (ASC)	6829003689	N	Jet Lube Kopr Kote Loctite C5-A Compound		
Fully Formulated Antifreeze Coolant	6829101130	C	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Compleat EG	Mix 50/50	

TABLE 9-1: Standard Lubricants/Fluids [Down to -9°C (15°F)]

Lubricant/Fluid	Grove Spec. #	Lube Spec.	Recommended Lubricant		
			Type	Grade	Classification
Liquid Coolant Conditioner	6829012858	D	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Exhaust Fluid (DEF)	80019225	L	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		

Arctic Lubricants and Conditions

Temperatures Below -9°C (15°F)

Regions with ambient temperatures below -9°C (15°F) are considered arctic. In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results in these temperatures. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, may not be compatible with hydraulic system seals and wear bands. Therefore, always check with an authorized Grove distributor or Manitowoc Crane Care if in doubt of the suitability of a specific fluid or lubricant.

When operating in cold weather and regardless of the oil viscosity of the crane's lubricants, always follow the cold weather start-up and operating procedures described in this *Operator Manual* to adequate lubrication during system warm-up and proper operation of all crane functions.

Cold Weather Lubricants

Cold weather lubricants are used on all Grove cranes when the crane is ordered with a cold weather package. The optional lubricants are effective in ambient temperatures down to -29°C (-20°F). Refer to TABLE 9-2: for a list of the recommended optional lubricants.

TABLE 9-2: Optional Lubricants/Fluids [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Lube Spec.	Recommended Lubricant		
			Type	Grade	Classification
Extreme Pressure 3% Moly Grease	6829104275	M	Mobil: Mobilith SHC 220 Petro-Canada; Precision Synthetic EP1	No. 2	
Synthetic Gear Lube SAE40	80078954	E	Emgard MTF 7000 (BASF)		
Extended Service Interval Gear Lubricant (GL-5)	6829014058	B	CITGO, Syntetic Gear Lube 75W-90 Eaton, Roadranger EP75W-90 Mobil, Mobilube SHC 75W-90 Shell, Spirax® S 75W-90 Sunoco®, Duragear EP75W-90 Petro-Canada, Traxon E Synthetic 75W-90	75W-90	
Engine Oil	80056036	F	Shell Rotella® T6 0W-40 Mobil Delvac 1 ESP 0W-40 Caterpillar Cat DE0-ULS Cold Weather	0W-40	CJ-4
Hydraulic Fluid	6829006993	K	Exxon Mobil Univis HVI 26		
Extreme Pressure Gear Lube	6829103636	H	Mobil SHC629 Petro-Canada; Enduratex Synthetic EP 150		AGMA No. 4 EP
Extreme Pressure Multipurpose Grease	6829104275	A	Mobil: Mobilith SHC 220 Petro-Canada; Precision Synthetic EP1	NLGI 2	
Open Gear Lube	6829102971	G	Fuchs Ceplattyn 300 Spray	NLGI 1-2	
Anti-Seize Compound (ASC)	6829003689	N	Jet Lube Kopr Kote Loctite C5-A Compound		

TABLE 9-2: Optional Lubricants/Fluids [Down to -29°C (-20°F)]

Lubricant/Fluid	Grove Spec.	Lube Spec.	Recommended Lubricant		
			Type	Grade	Classification
Fully Formulated Antifreeze Coolant	6829101130	C	Old World Industries, Inc. Fleet Charge SCA Caterpillar DEAC Fleetguard Complete EG	Mix 50/50	
Liquid Coolant Conditioner	6829012858	D	Fleetguard DCA4 Fleetguard DCA2 Penray Pencool 3000		
Diesel Exhaust Fluid (DEF)	80019225	L	Fleetguard StableGuard™ Urea 32 Premix AdBlue® TerraCair Ultrapure® DEF		

CYLINDER ROD SURFACE PROTECTION

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

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

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

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* in *Section 1 - Introduction* of the *Service Manual*.

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 coverage of lube points that will receive attention based on their readings. Other lubrication requirements must be made on a timely basis, such as weekly or monthly.

All oil levels are to be checked with the crane parked on a level surface in transport position, and while the oil is cold, unless otherwise specified.

On plug type check points, the oil levels are to be at the bottom edge of the check port.

On all hoists with a check plug in the drum, the fill plug shall be directly on top of the hoist, and the check plug level.

All grease fittings are SAE STANDARD unless otherwise indicated. Grease non-sealed fittings until grease is seen extruding from the fitting. 1 oz (0.28 kg) of EP-MPG equals one pump on a standard 1 lb (0.45 kg) grease gun.

Over lubrication on non-sealed fittings will not harm the fittings or components, but under lubrication will definitely lead to a shorter lifetime.

On sealed U-joints, care must be exercised to prevent rupturing seals. Fill only until expansion of the seals first becomes visible.

Unless otherwise indicated, items not equipped with grease fittings, such as linkages, pins, or levers should be lubricated with oil once a week. Motor oil, applied sparingly, will provide the necessary lubrication and help prevent the formation of rust. An Anti-Seize compound may be used if rust has not formed, otherwise the component must be cleaned first.

Grease fittings that are worn and will not hold the grease gun, or those that have a stuck check ball, must be replaced.

Where wear pads are used, cycle the components and relubricate to complete lubrication of the entire wear area.

CAUTION

The following lube intervals are to be used as a guideline only. Actual lube intervals should be formulated by the operator to correspond to actual service conditions such as continuous duty cycles and/or hazardous environments.

Notes Listed in the Following Tables

1.Final fluid levels shall be adjusted to indicating arrows, dipstick markings, or to filler plugs.

a.Caution: axle fluid levels shall be adjusted to “bottom of fill plug threads”. Check with crane on level ground, at normal ride height, cold or room temperature oil only!

2.Change filter when changing gear oil.

3.Capacities indicated are for a fully formulated mixture of 50% AFC and 50% water.

4.Brush lubricant on top and bottom of outrigger beams contact area.

5.The hydraulic oil shall meet or exceed ISO 4406 class 17/14 cleanliness level (ref SAE J1165).

6.Brush lubrication on I.D. of jack cylinder support tubes and wear bands before installing jack cylinders.

7.Fill radiator to bottom of filler neck per engineering specification 80029046. Run engine through (2) thermal cycles. Check level and refill as required.

8.Fill through dipstick opening.

9.Check fluid level using sight gauge on the side of the tank with boom retracted and in boom rest and all outrigger cylinders retracted.

10.Engine shall be running during lubrication to ensure equal distribution of grease.

11.Clean magnetic drain plug when changing lubricant.

12.Air conditioner - refer to applicable air conditioner manual.

13.See operator's manual when ambient temperatures are expected between +4°C (+40°F) and -62°C (-80°F).

14.Generously coat the wheel pilot or hub pads with lubricant. Do not lubricate the face of the wheel or the hub.

15.Apply lubricant during assembly and reapply lubricant whenever wheels are removed for service.

16.Clean coolant strainer after first 100 hours of use and at 2000 hrs/1 yr intervals thereafter.

17.Replace air cleaner element when indicator shows red (25" H2O).

18.Change filter at first 200 hours. Thereafter, at normal intervals. Drain with oil temperature at 65°C - 95°C (150°F - 200°F).

19.Change filter when changing gear oil.

20.Drain water trap every ten hours or daily.

21.Only use on ISL9 engine machines.

22.Service hours:

a.500 (0-55 PPM sulfur fuel)

b.400 (500-5000 _PPM sulfur fuel)

c.250 (<5000 -PPM sulfur fuel. Not recommended.)

23.Extend boom for access through holes.

24.Spread grease on bottom plates. Top plates and side plates of boom in area that the wear pads move on.

25.One fitting per sheave.

26.Fill turntable gearbox until oil level is at middle to top of sight gauge.27.Replace the hydraulic filter element when the restriction indicator gauge on the filter head is in the red with the oil at a minimum of 100°F. When replacing the filter also replace the breather.

28. Operator must monitor the DEF level gauge and refill as necessary/indicated. Actual use rate depends on engine loading but won't be faster than fuel usage/topping off can be done at normal fueling intervals.

29. Change the oil after the first 250 hours of operation, then every 2000 hours of operation.

30. Top off when topping off fuel tank.

31. Cleanliness, environment, and usage will dictate when and if the suction strainer requires service. High vacuum pressures on the suction line may indicate that there is debris in the strainer.

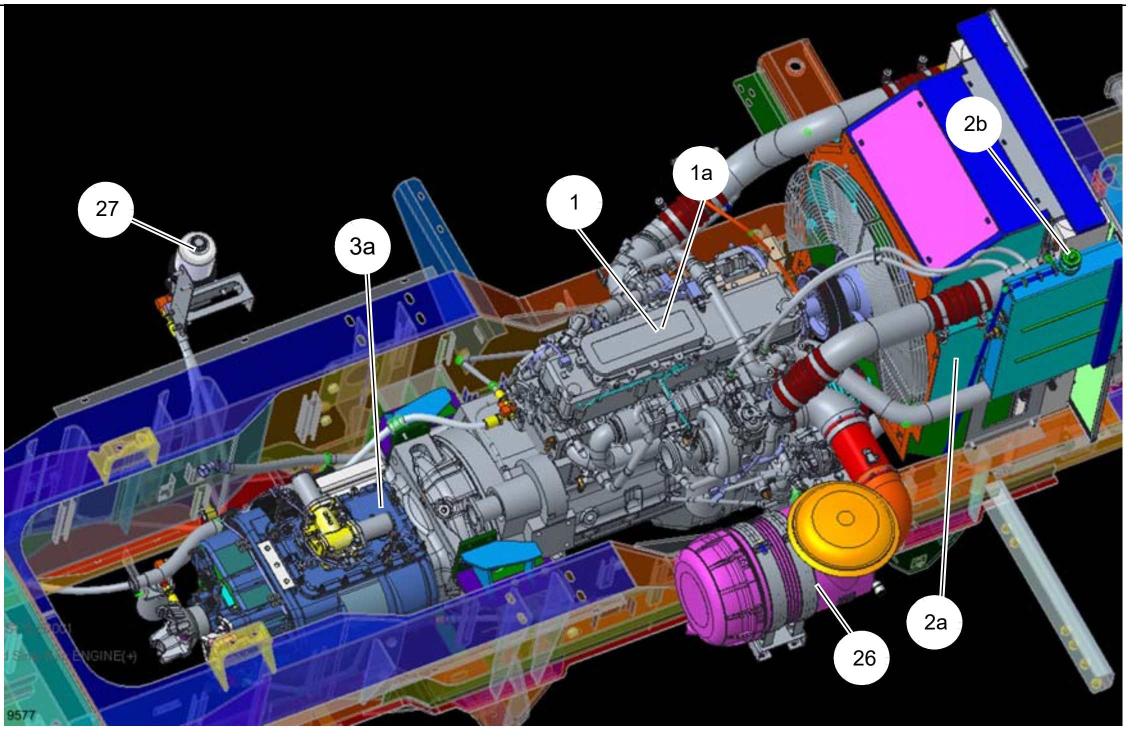
32. Drain and fill initially at 250 hours; thereafter, drain and fill every 500 hours.

The following describes the lubrication points and gives the lube type, lube interval, lube amount and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown in the following figures.

9

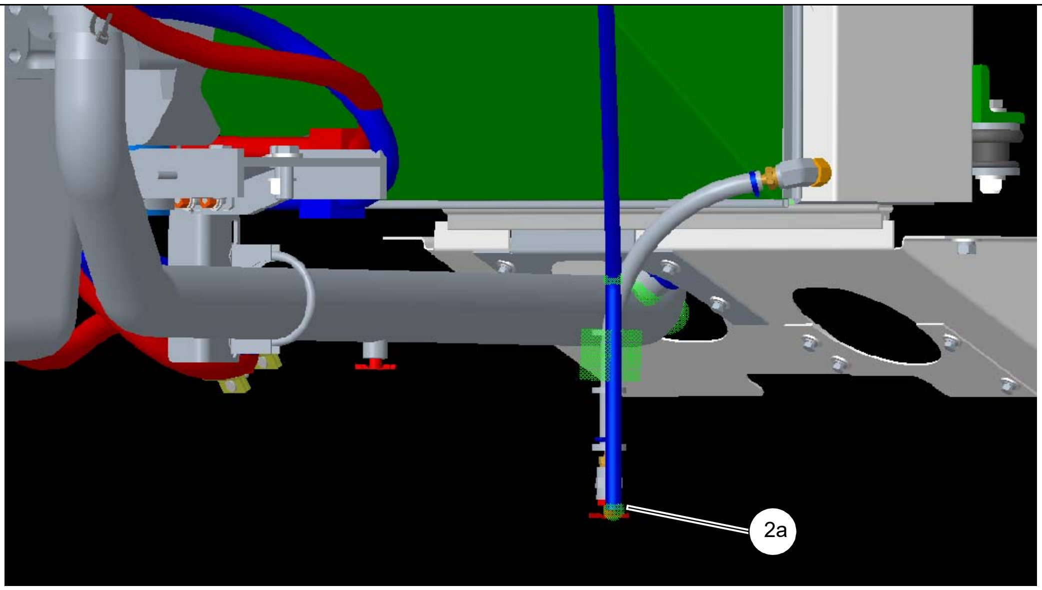
Drivetrain Lubrication

ITEM NUMBER	LOCATION NAME	APPROXIMATE CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
1	ENGINE CRANKCASE L9	---------------	F	, 1	1	CHECK & FILL	10 HRS/DAILY
	WITH FILTER	5.0 GAL	F	1	1	DRAIN & FILL	500 HRS/6 MONTHS
1a	CRANKCASE BREATHER ELEMENT	---------------	---------------	------------	1A	CHANGE	60,000 MILES/2000 HRS/ 2 YEARS
2a	ENGINE COOLING SYSTEM	--------------	C	3, 7	1	CHECK &FILL	500 HRS/6 MONTHS
	ENGINE COOLING SYSTEM - L9	67L (17.7 GAL)	C	3, 7	1	DRAIN & FILL (IF CONTAMIN ATED DURING CHECK)	S1000 HRS/1 YEAR
2b	ENGINE COOLING SYSTEM - L9	AS REQUIRED	D		1	TEST AND ADD	ENGINE 500 HRS/750 HRS
2c	COOLANT STRAINER	---------------	-----------------	16	1	CLEAN STRAINER	2000 HRS/ 1 YR SEE NOTE 16
NOTE: Close shutoff valves. Remove hex plug. Clean strainer plug.Open shutoff valves.							
3a	TRANSMISSION - AUTOMATED MANUAL	--------------	E	1	1	CHECK & FILL	500 HRS/9000 MI/6 MONTHS/
		16.1 L (17 QT)	E		1	DRAIN & FILL	50000 MI/2 YRS
3b	TRANSMISSION FILTER	--------------	--------------	1, 18	1	CHANGE FILTER	3000 HRS
4a	PUMP DRIVE SHAFT U-JOINTS	---------------	A		2	LUBE	250 HRS
4b	PUMP DRIVE SHAFT SPLINE	-------------	A		1	LUBE	500 HRS
5	CLUTCH THROW-OUT BEARING AND SHAFT	---------------	A	10	1	LUBE	250 HRS
8	DRIVELINE SLIP	---------------	A		2	LUBE	500HRS/10000 MI
26	AIR CLEANER FILTER	---------------	---------------	17	1	CHANGE FILTER	SEE NOTE 17
27	FUEL FILTER - PRIMARY	---------------	---------------	20	1	CHANGE FILTER	1000 HRS/6 MONTHS



9577

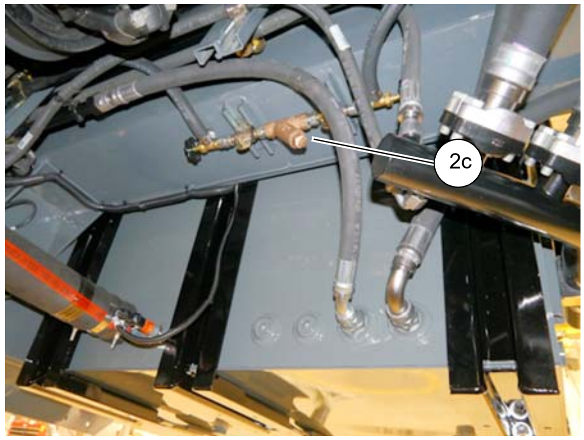
FIGURE 9-1



9577-a

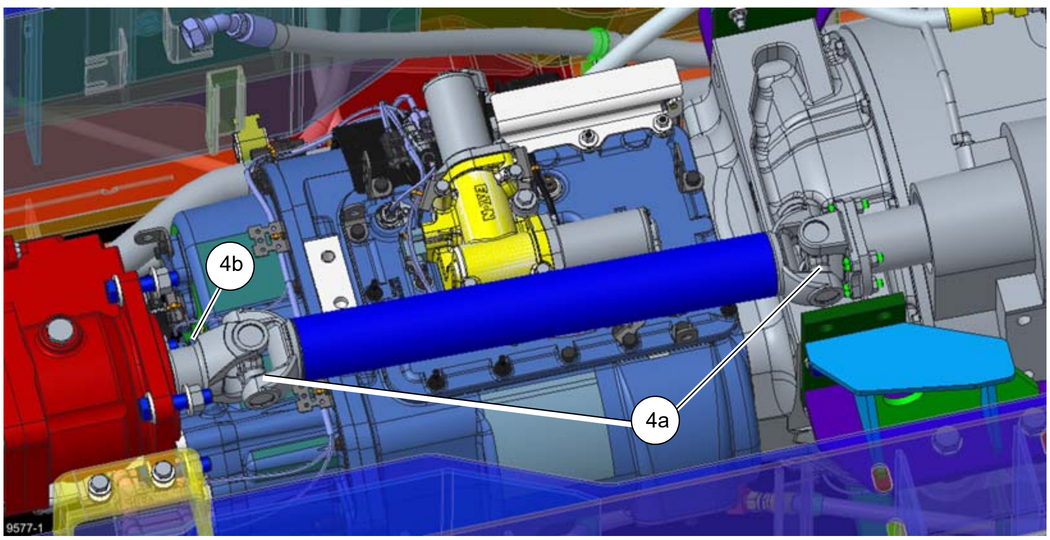
FIGURE 9-2

9



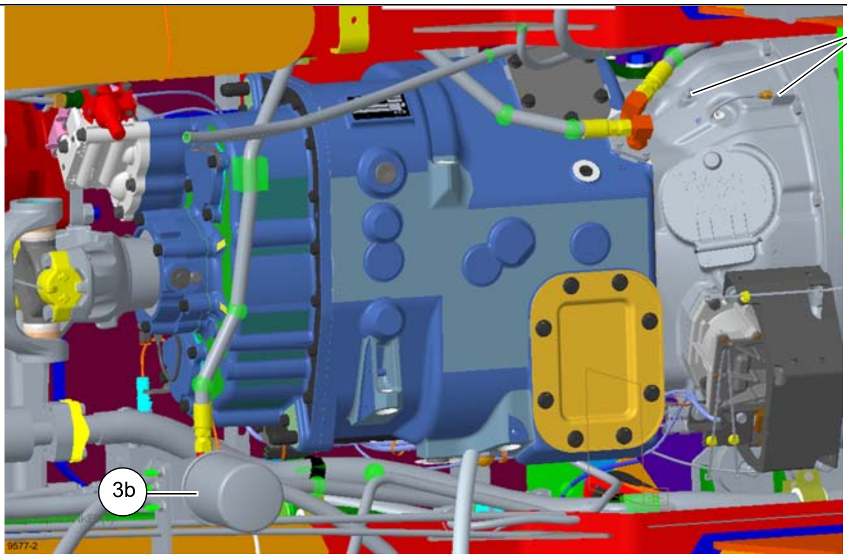
9834

FIGURE 9-3

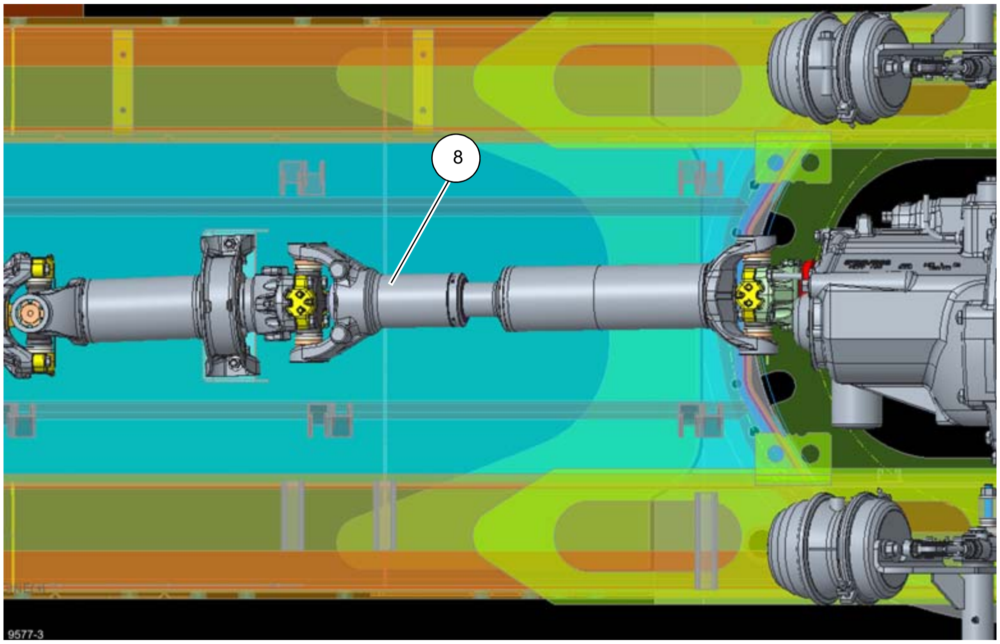


9577-1

FIGURE 9-4



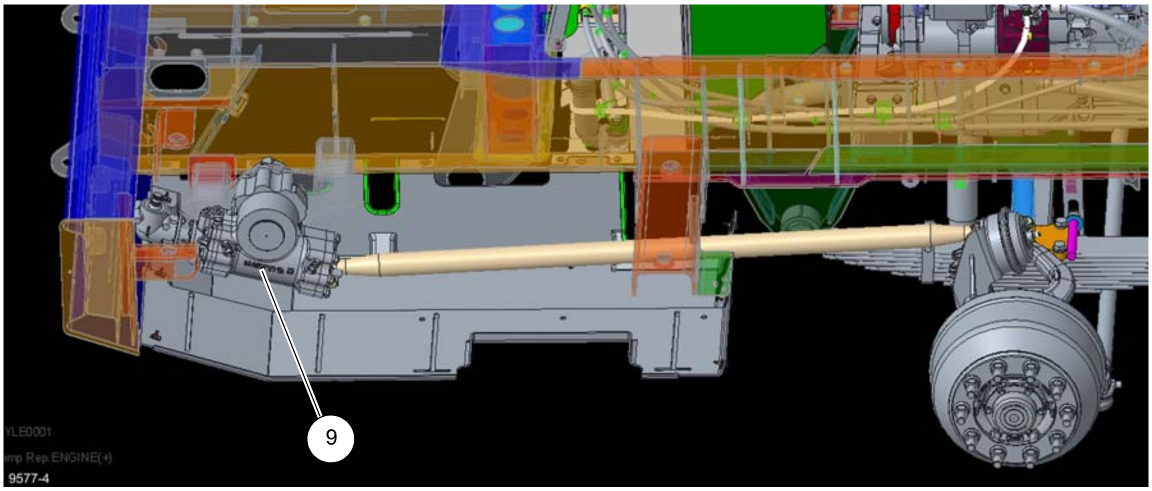
9577-2
FIGURE 9-5



9577-3
FIGURE 9-6

Steering Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
9	POWER STEERING GEARBOX	---------------	A		1	LUBE	1000 HRS

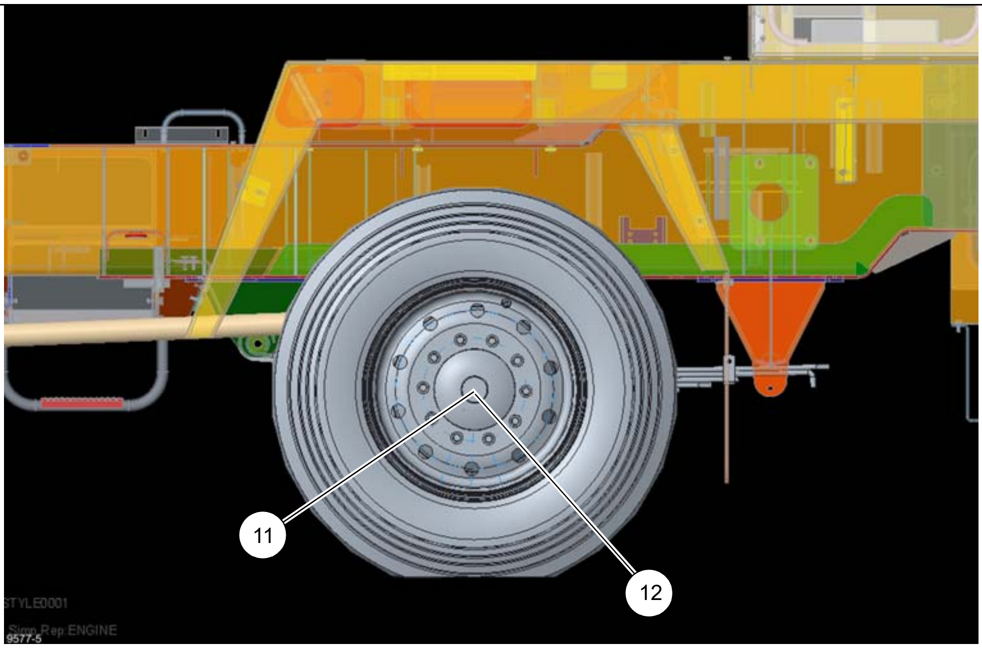


9577-4

FIGURE 9-7

Axle Lubrication

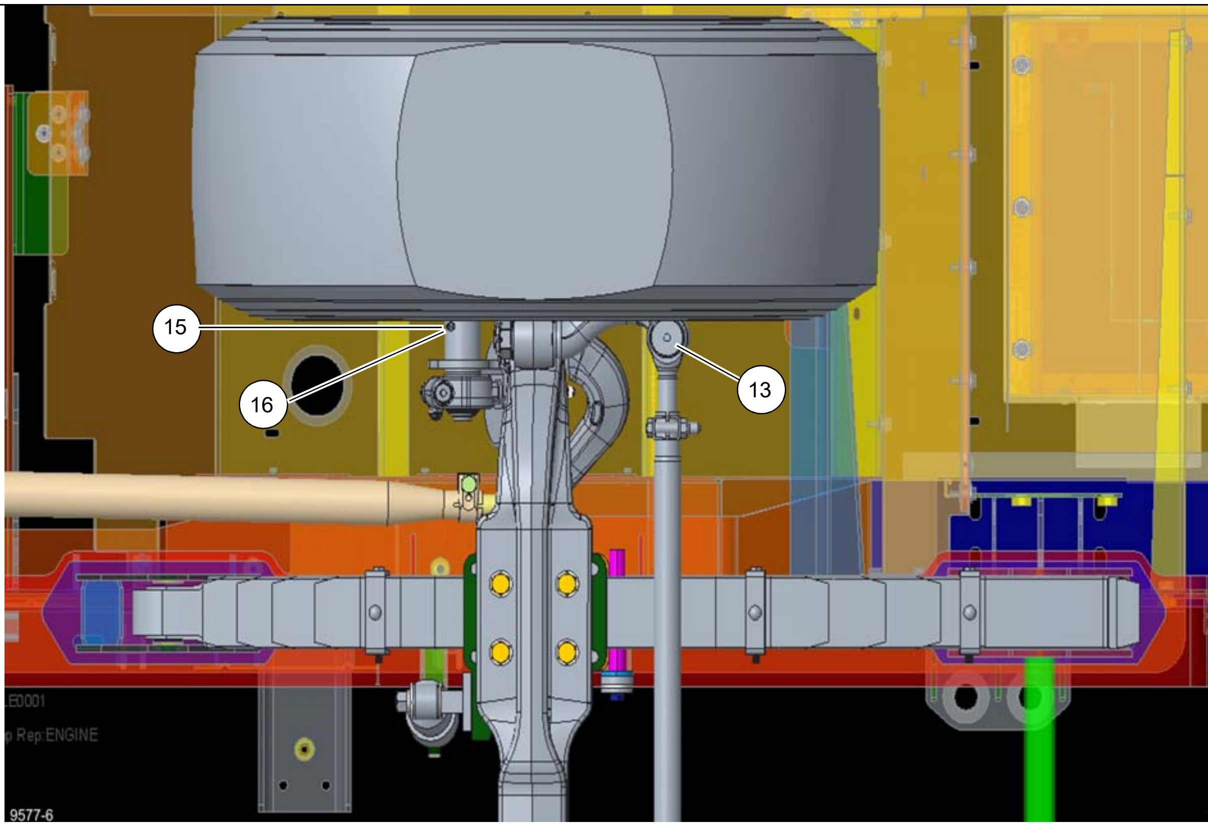
ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
11	FRONT WHEEL PILOTS	---------------	N	14	2	BRUSH ON	SEE NOTE 15
12	FRONT AXLE HUBS	0.57 L (1.2 PT) EACH	B	1	2	CHECK & FILL	250 HRS
13	FRONT AXLE TIE ROD ENDS	---------------	A		2	LUBE	1000 HRS
14	FRONT AXLE KING PINS	---------------	A		4	LUBE	1000 HRS
15	FRONT AXLE BRAKE SLACK ADJUSTERS	---------------	A		2	LUBE	1000 HRS
16	FRONT AXLE BRAKE CAMSHAFTS	---------------	A		2	LUBE	1000 HRS



9577-5

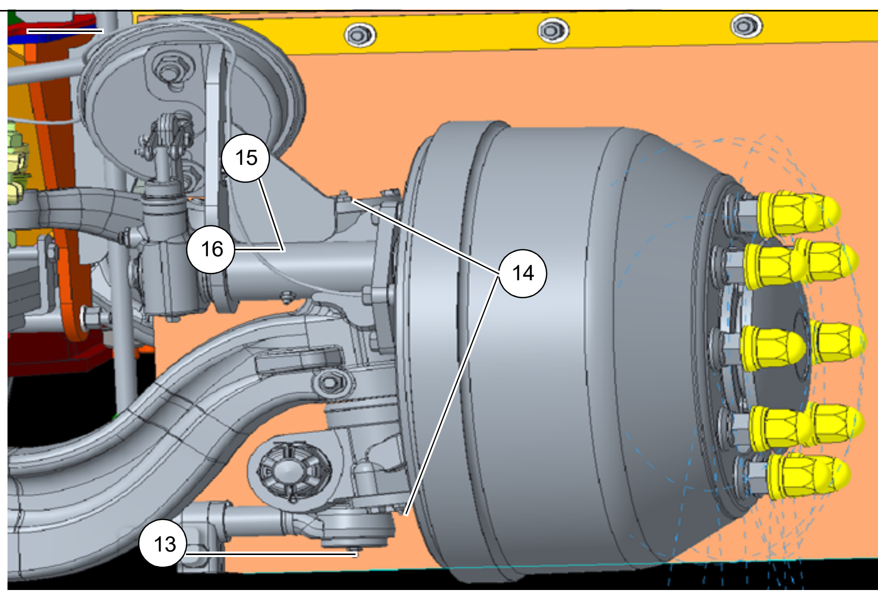
FIGURE 9-8

9



9577-6

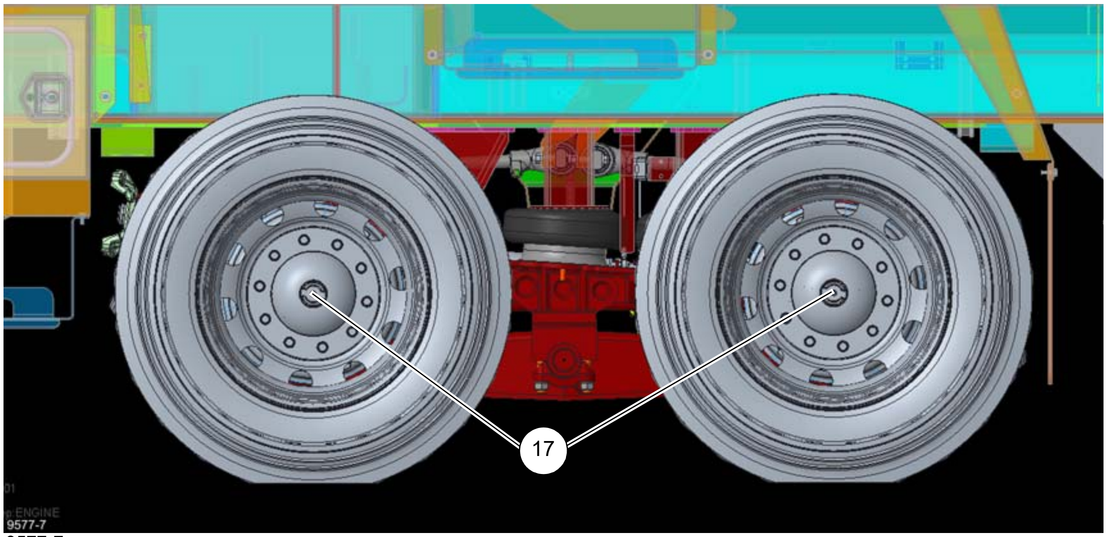
FIGURE 9-9



9577-22

FIGURE 9-10

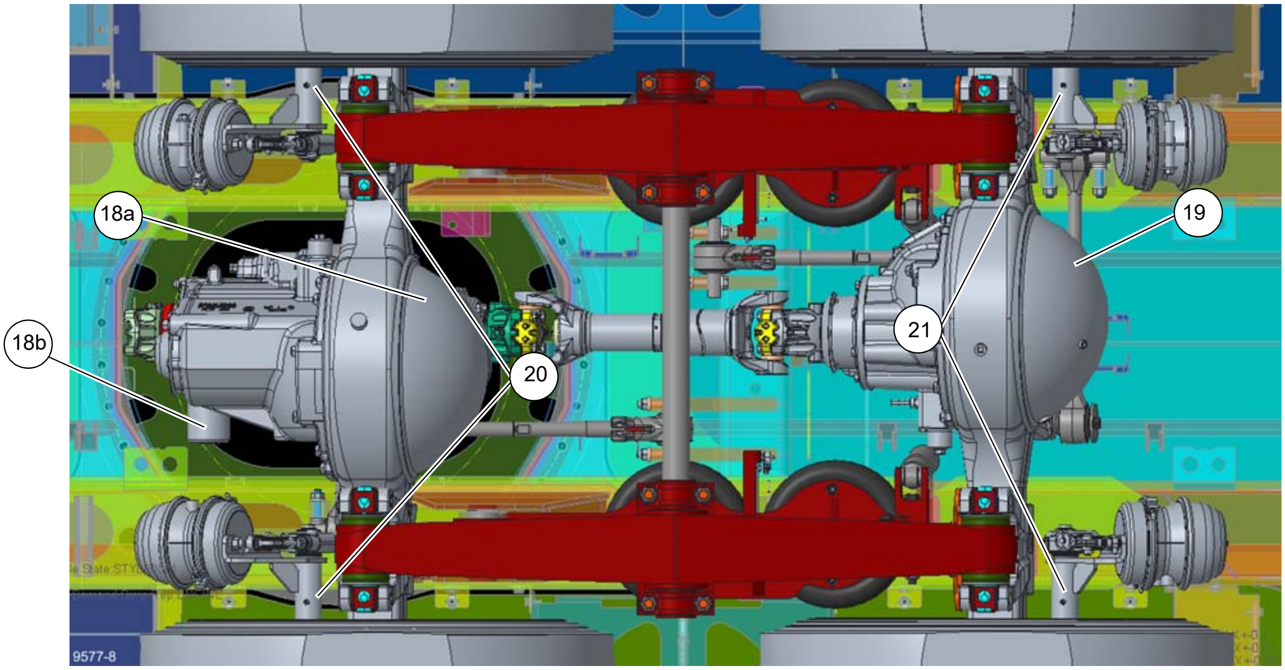
ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
17	REAR WHEEL PILOTS	---------------	N	14	4	BRUSH ON	SEE NOTE 15
18a	FRONT REAR AXLE BOWL	---------------	B	1	1	CHECK & FILL	250 HRS
		18.5 L (19.5 QTS)	B	1, 2, 11	1	DRAIN & FILL	50000 MI/2 YRS
18b	DIFFERENTIAL FILTER	---------------	---------------	19	1	CHANGE FILTER	50000 MI/2 YRS
19	REAR, REAR AXLE BOWL	---------------	B	1	1	CHECK & FILL	250 HRS
		16.3 L (17.2 QTS)	B	1, 2, 11	1	DRAIN & FILL	50000 MI/2 YRS
20	REAR AXLE BRAKE SLACK ADJUSTERS	---------------	A		4	LUBE	1000 HRS
21	REAR AXLE BRAKE CAMSHAFTS	---------------	A		4	LUBE	1000 HRS



9577-7

FIGURE 9-11

9

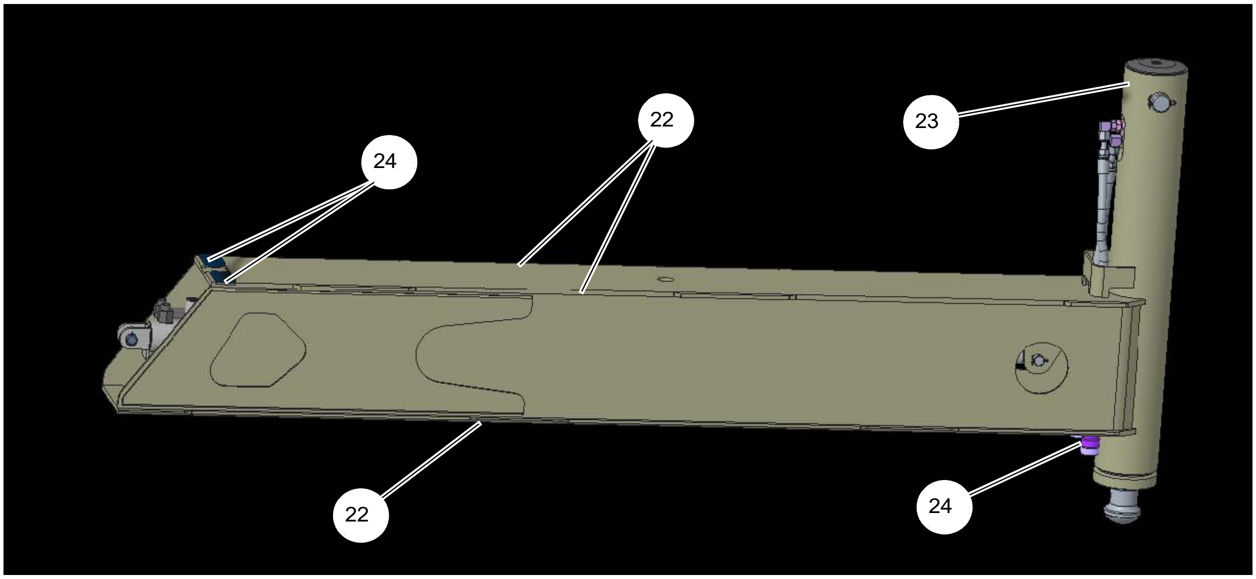


9577-8

FIGURE 9-12

Outrigger Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
22	O/R BEAMS	---------------	M	4	8	BRUSH ON	50 HRS/1 WEEK
23	JACK CYLINDER SUPPORT TUBES	---------------	M	6	5	BRUSH ON	SEE NOTE 6
24	WEAR PADS	---------------	M		24	BRUSH ON (Top & Bottom of Wear Pads)	50 HRS/1 WEEK



8885-25

FIGURE 9-13

Miscellaneous Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
25	HYDRAULIC RESERVOIR	405 L (107 GAL) () (TANK ONLY)	K	5, 9	1	CHECK & FILL	10 HRS/DAILY
95	HYDRAULIC FILTER & BREATHER	---------------	---------------	27	1	CHANGE FILTER & BREATHER	SEE NOTE 27
28	DEF SUPPLY MODULE FILTER	---------------	---------------	---------------	1	CHANGE FILTER	6500 HRS/ 300000 MI
29	DIESEL EXHAUST FLUID TANK	37.9 L (10 GAL) (TANK ONLY)	L	30	1	CHECK & FILL	SEE NOTE 30
30	DEF TANK STRAINER	---------------	---------------	31	1	CHECK FILTER	SEE NOTE 31

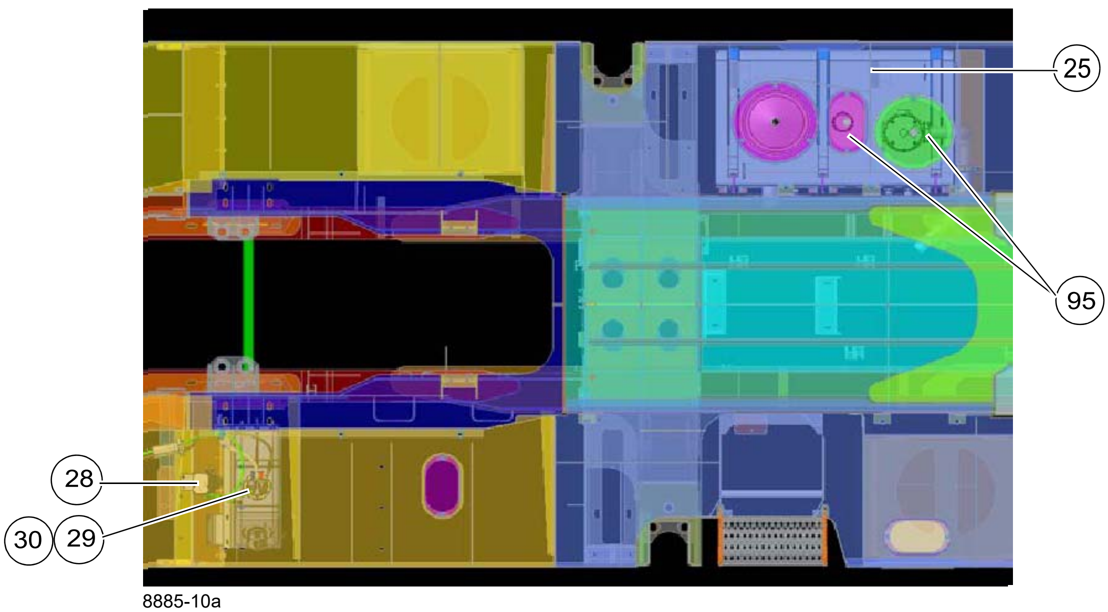
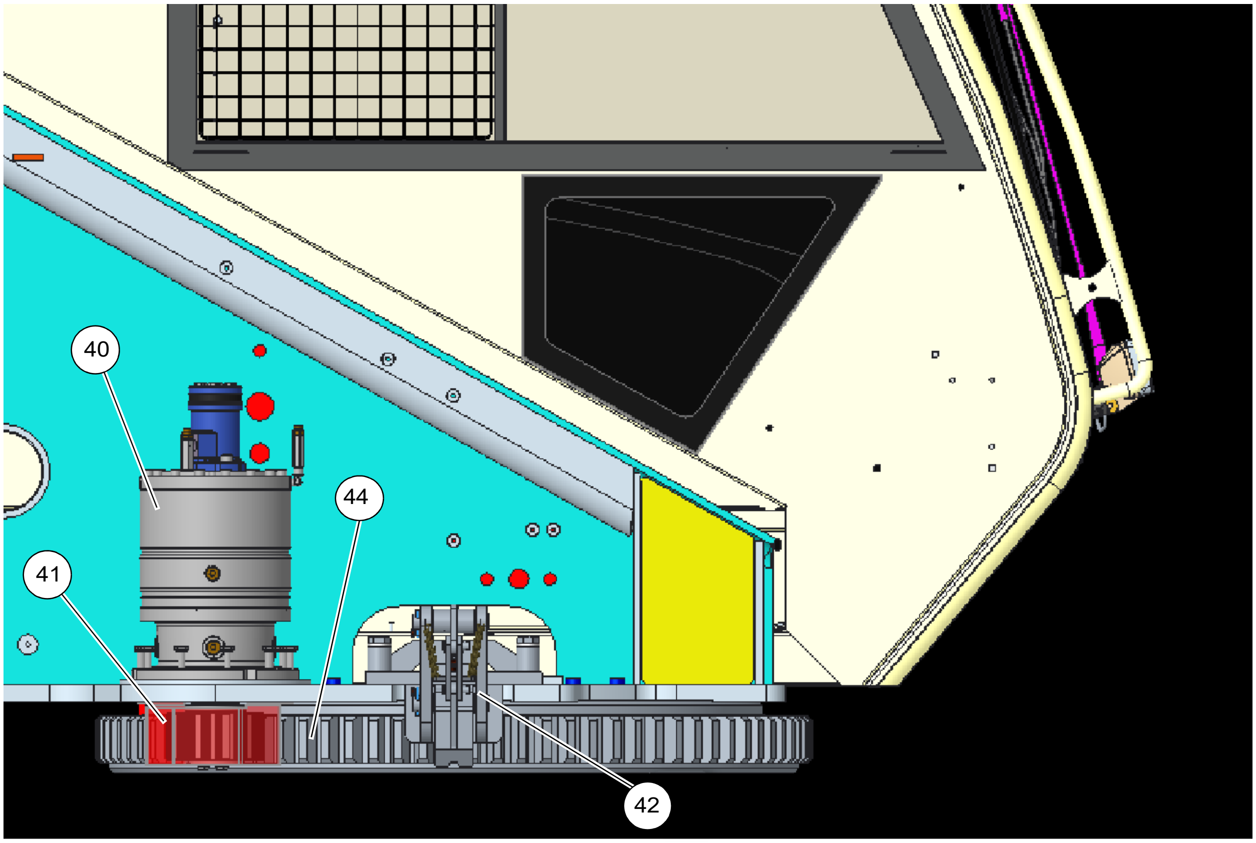


FIGURE 9-14

Turntable & Cab Platform Lubrication

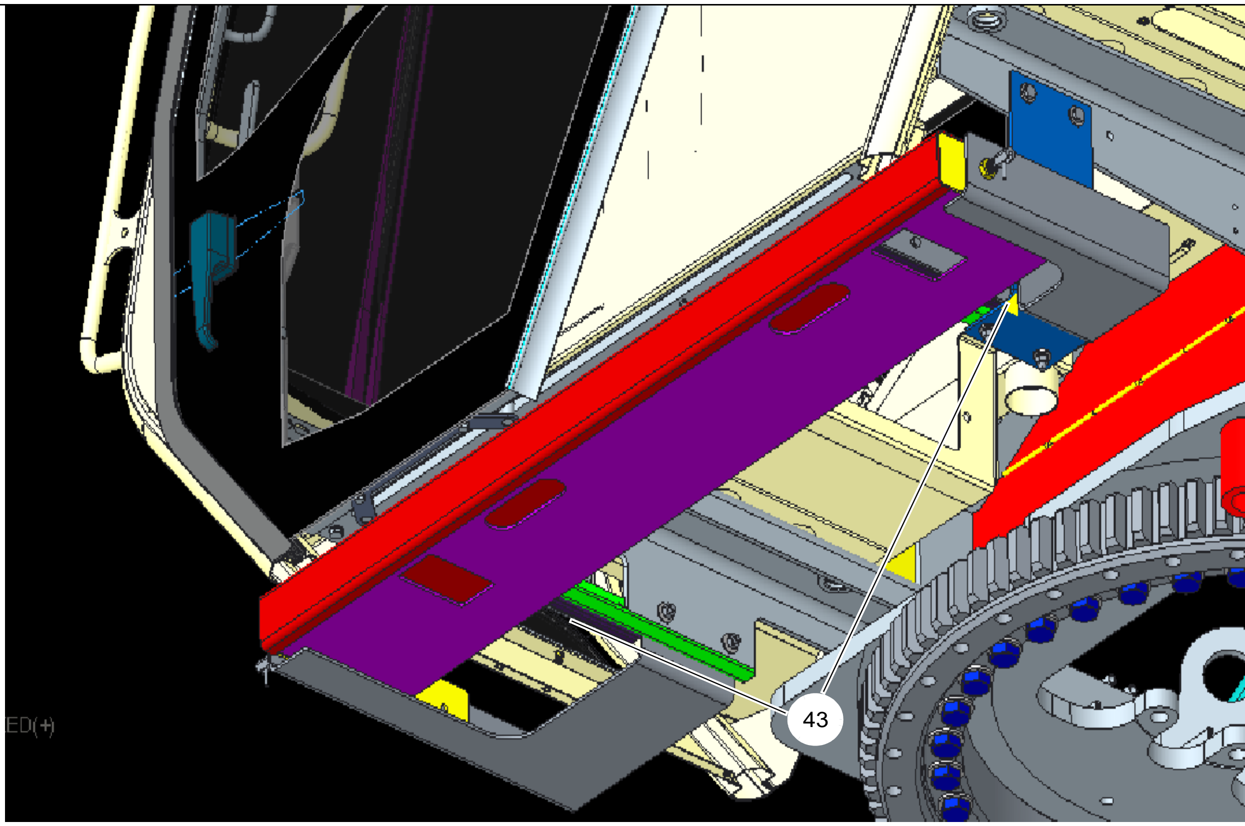
ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
40	TURNTABLE GEAR BOX	4.0 L (4.25 QT)	H	1	1	CHECK & FILL	50 HRS/1 WEEK
		4.0 L (4.25 QT)	H	32	1	DRAIN & FILL	SEE NOTE 32
41	TURNTABLE GEAR & DRIVE PINION	---------------	G		1	SPRAY ON	500 HRS/6 MONTHS
42	TURNTABLE SWIVEL LOCK	---------------	G	1, 14	1	SPRAY ON	500 HRS/6 MONTHS
43	CAB TRACK & ROLLERS	---------------	LIGHT OIL				
44	TURNTABLE BEARING INNER RACE	---------------	A	1	2	LUBE	500 HRS/6 MONTHS



8885-26

FIGURE 9-15

9



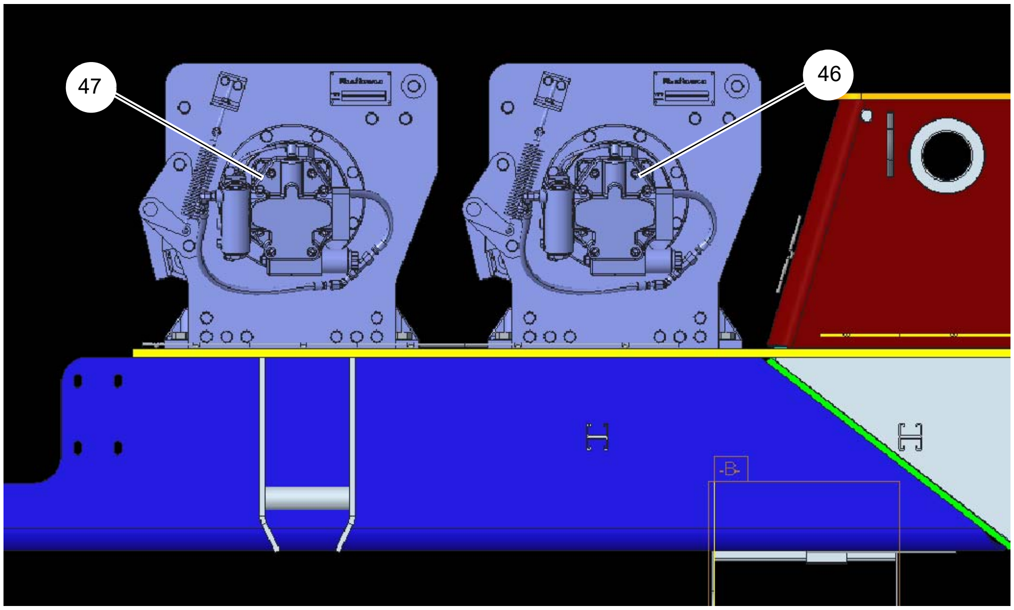
8885-27

FIGURE 9-16

Hoist Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
46	MAIN HOIST - GEARBOX	---------------	H	2, 14	1	CHECK & FILL	50 HRS / WEEKLY
		5.2 L (5.5 QTS)	H	32	1	DRAIN & FILL	SEE NOTE 32
						SAMPLE OIL	500 HRS / 6 MONTHS
47	AUX HOIST -- GEARBOX	---------------	H	2, 14	1	CHECK & FILL	50 HRS / WEEKLY
		5.2 L (5.5 QTS)	H	32	1	DRAIN & FILL	SEE NOTE 32
						SAMPLE OIL	500 HRS / 6 MONTHS

NOTE: Line up the Fill/Drain Plug with the top cutout hole. Verify hoist is level side to side. Place a level along the tie rod and confirm the bubble is centered. Let hoist sit idle for 20 minutes for an accurate reading. Oil should be visible in sight glass. Level of oil is acceptable if it is at least 1.6 mm (1/16 in) down from top or up 1.6 mm (1/16 in) from the bottom of the sight glass. Hoist and oil temperature should be in the 21°C ± 7°C (70°F ± 20°F) range. If oil temperature is outside this range, allow for a higher oil level reading if hotter or a lower oil level reading if colder. Oil escaping from vent plug is an indication the hoist may be overfilled. If hoist is over filled, move the Fill/Drain Plug to the lower cutout hole and drain until oil level falls within the sight glass.



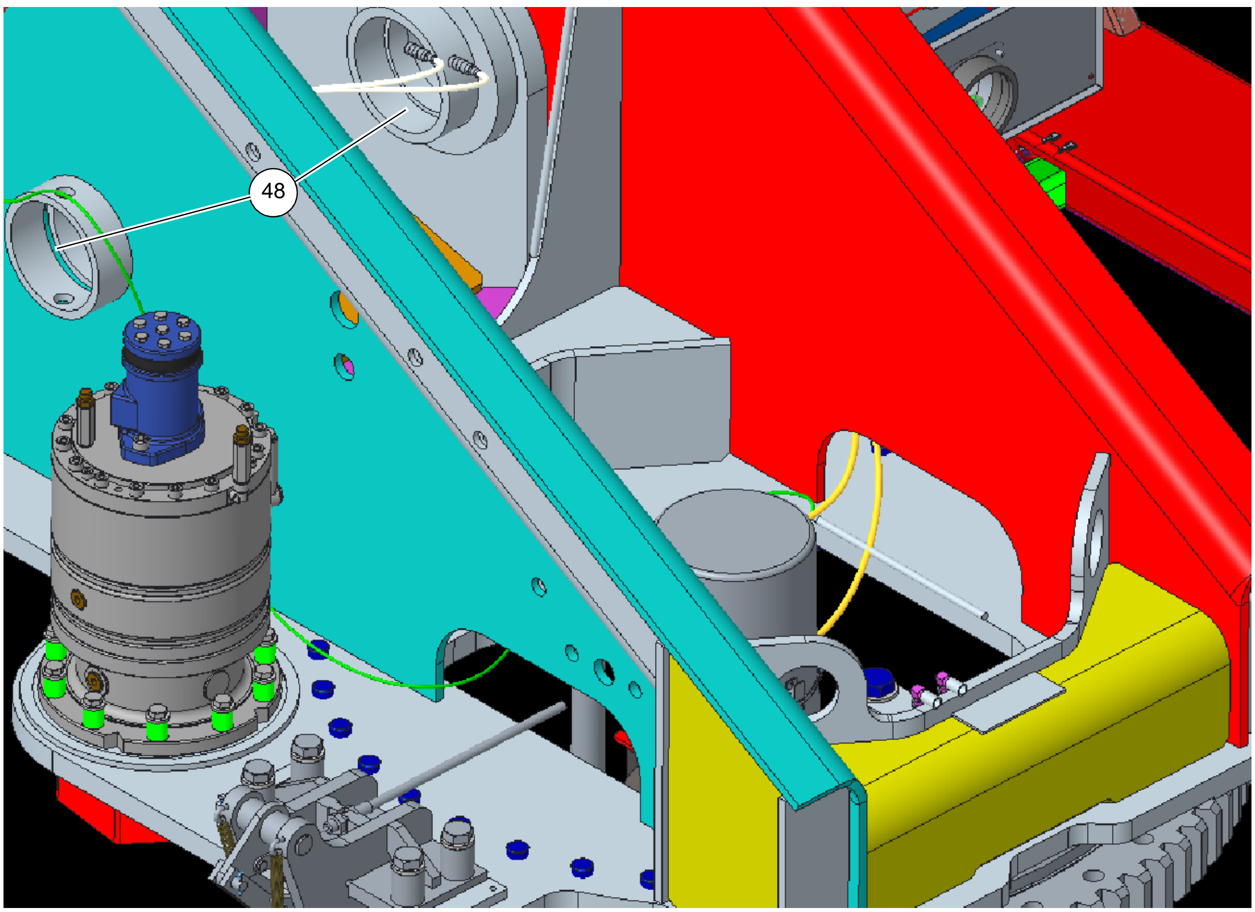
8885-28

FIGURE 9-17

9

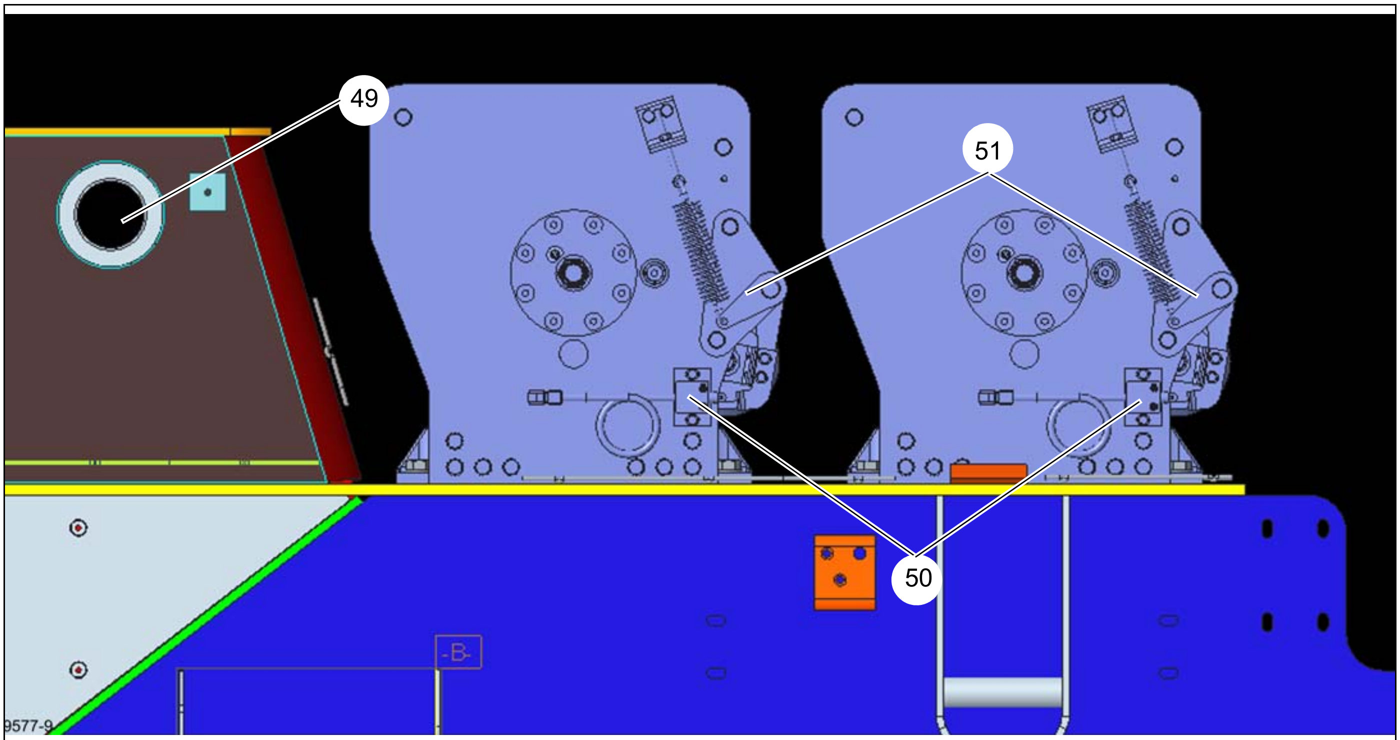
Turntable Central Lubrication

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
			HOIST				
48	LIFT CYLINDER	--------------	M	------------	2	LUBE	500 HRS / 3 MONTHS
49	BOOM PIVOT PIN	---------------	M		2	LUBE	250 HRS / 3 MONTHS
50	HOIST LOWER LIMIT SWITCH (Optional)	---------------	A		2	SPRAY ON	250 HRS / 3 MONTHS
51	CABLE FOLLOWER (ARMS)		G		2	SPRAY ON	250 HRS / 3 MONTHS



9577-10a

FIGURE 9-18



9577-10a

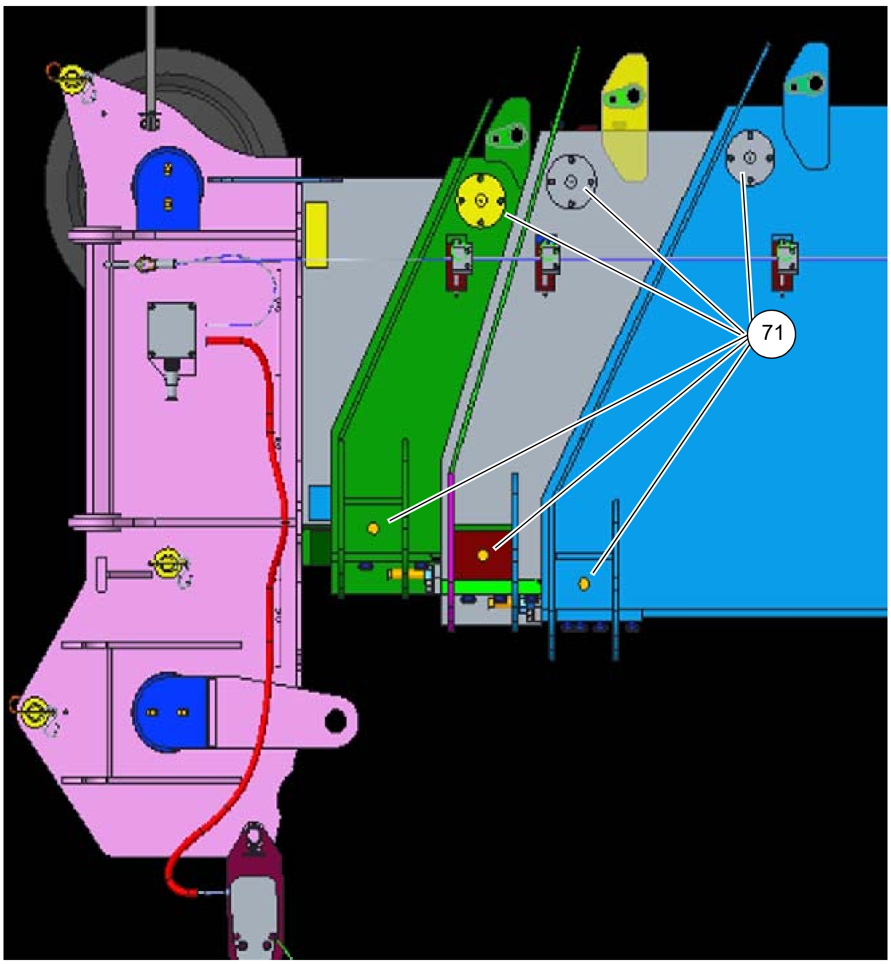
FIGURE 9-19

Boom Lubrication

For Crane Setup:

- Machine to be set up on firm level surface with fully extended outriggers and a minimum of 8,500LBS counterweight installed. Ensure that the crane is level.
- It is recommended to have the boom position be directly over the front and the house lock engaged.
- Set boom angle at zero degrees.
- Disable the swing function to engage the swing brakes, and engage the 360-swing lock, if applicable.
- Extend the boom until grease zerks appear in access holes. Refer to load chart for 0 degree telescoping capability.

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
71	BOOM SIDE WEAR PADS	---------------	A	14, 26, 27, 29	12	BRUSH ON	250 HRS / 3 MONTHS

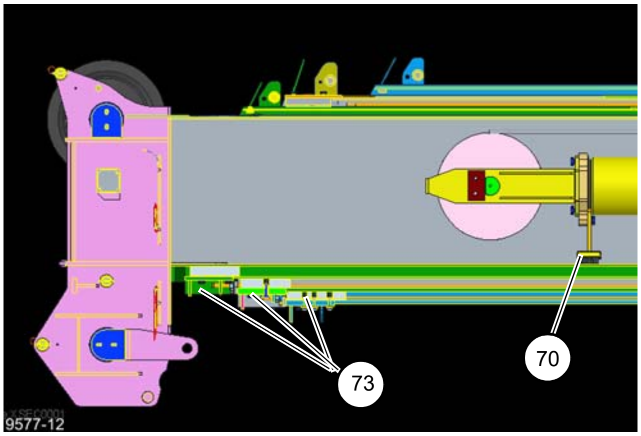


9577-11a

FIGURE 9-20

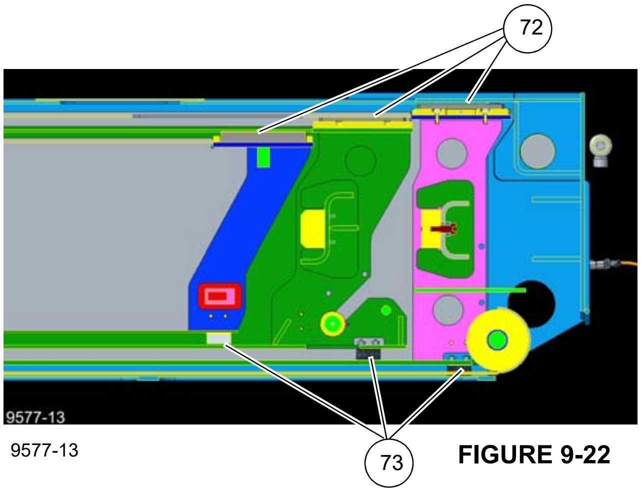
.

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
70	TELE CYL WEAR PADS	---------------	A	14, 26, 27, 29	2	BRUSH ON	125 HRS / 3 MONTHS
72	BOOM UPPER WEAR PADS	---------------	A	14, 26, 27, 29	6	BRUSH ON	50 HRS / 1 WEEK
73	BOOM LOWER WEAR PADS	---------------	A	14, 26, 27, 29	6	BRUSH ON	50 HRS / 1 WEEK



9577-12

FIGURE 9-21



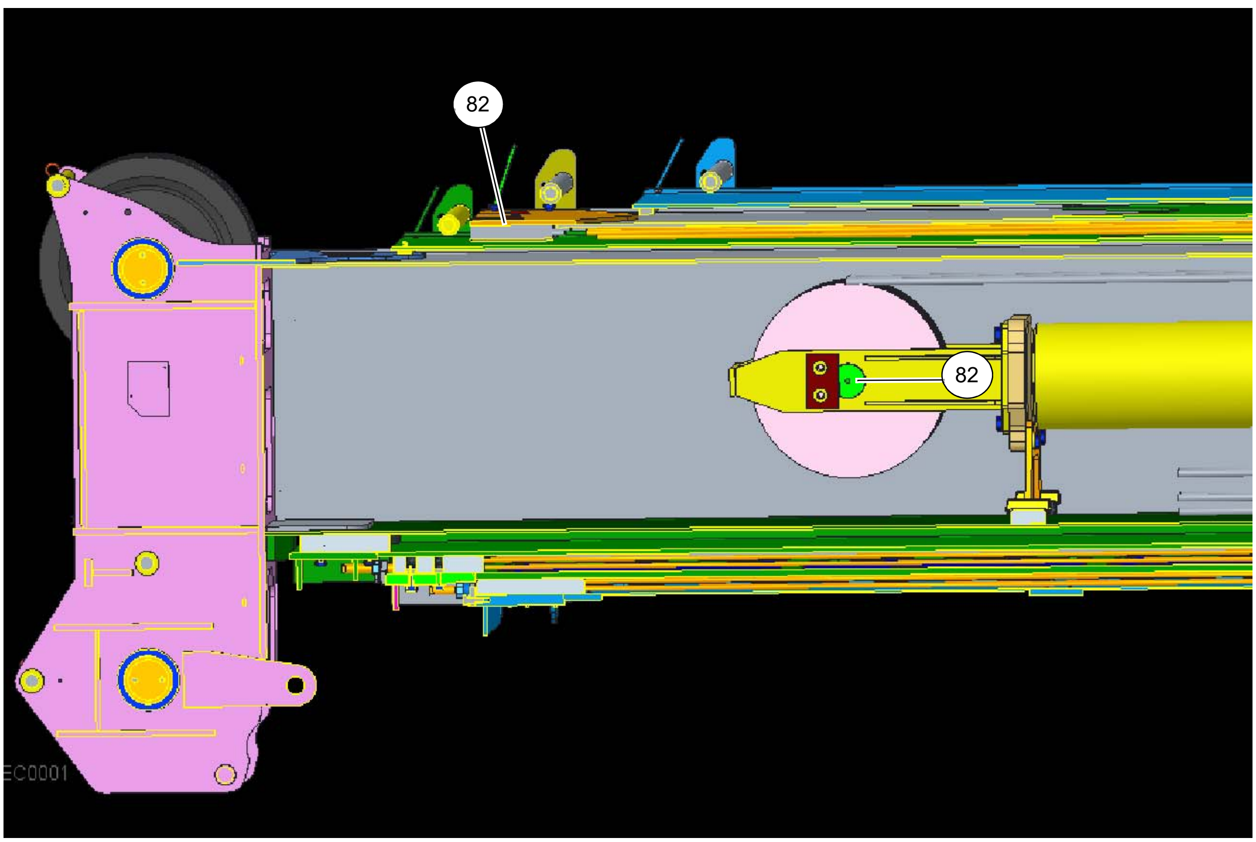
9577-13

FIGURE 9-22

9

.

ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
BOOM							
82	EXTEND CABLE SHEAVES	---------------	A	1, 8, 14, 26	1	LUBE	250 HRS / 3 MONTHS
83	RETRACT CABLE SHEAVES	---------------	A	1, 8, 14, 26	1	LUBE	250 HRS / 3 MONTHS
84	BOOM EXTENSION SHEAVE	---------------	A	1, 8, 14	1	LUBE	250 HRS / 3 MONTHS
85	MAST SHEAVE	---------------	A	14, 28	1	LUBE	500 HRS / 12 MONTHS
86	BOOM NOSE SHEAVES (2 upper sheaves and 4 lower sheaves) Applies to 95' and 102' Booms.	---------------	A	1, 8, 14, 28	2	LUBE	250 HRS / 3 MONTHS
87	AUX BOOM NOSE SHEAVE	---------------	A	1, 8, 14	1	LUBE	250 HRS / 3 MONTHS
88	BOOM EXTENSION ROLLER	---------------	A	1, 8, 14	1	LUBE	250 HRS / 3 MONTHS



9577-21

FIGURE 9-23

NOTE: The Boom will need to be extended to line up the Exterior Access Holes.

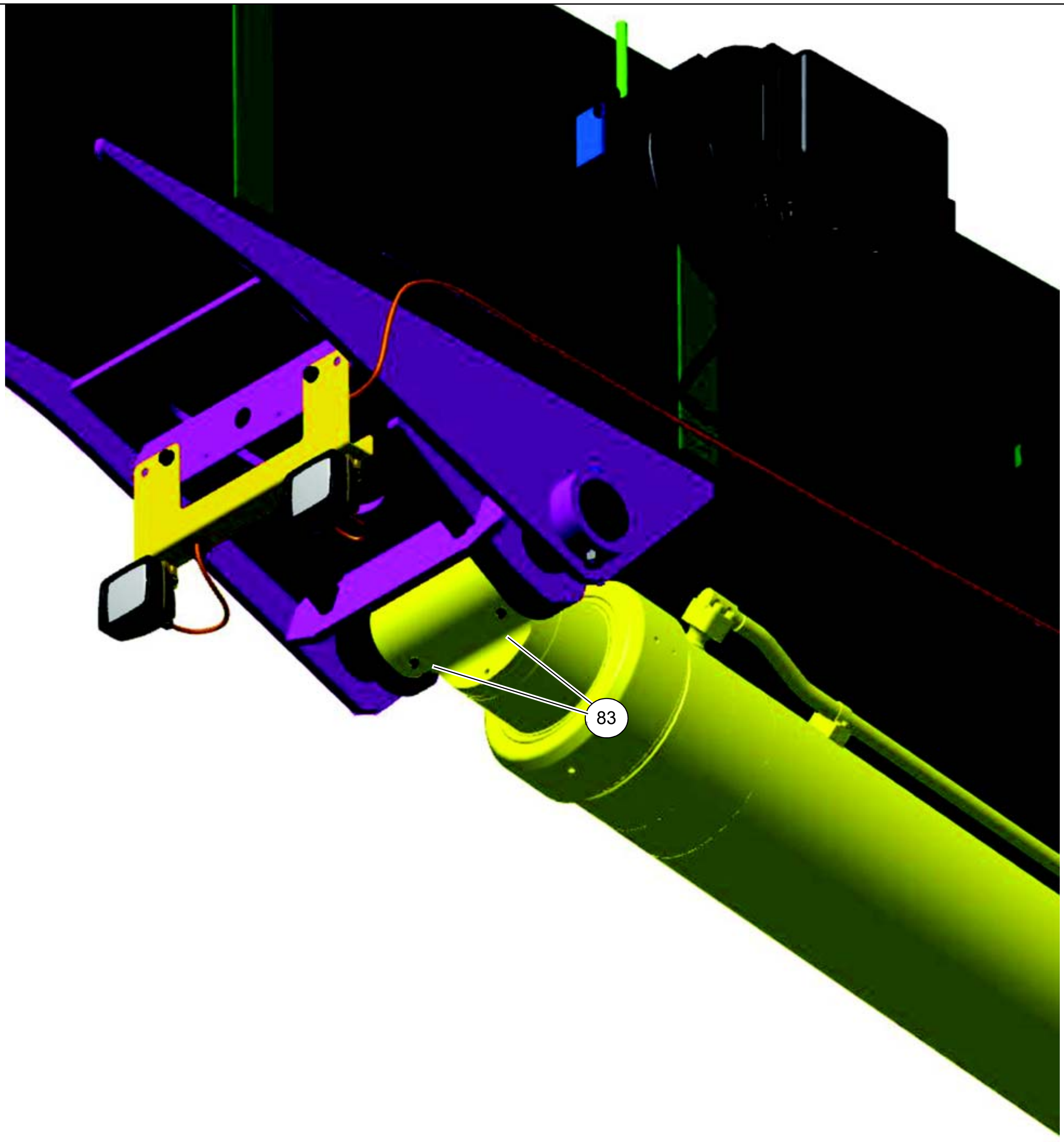
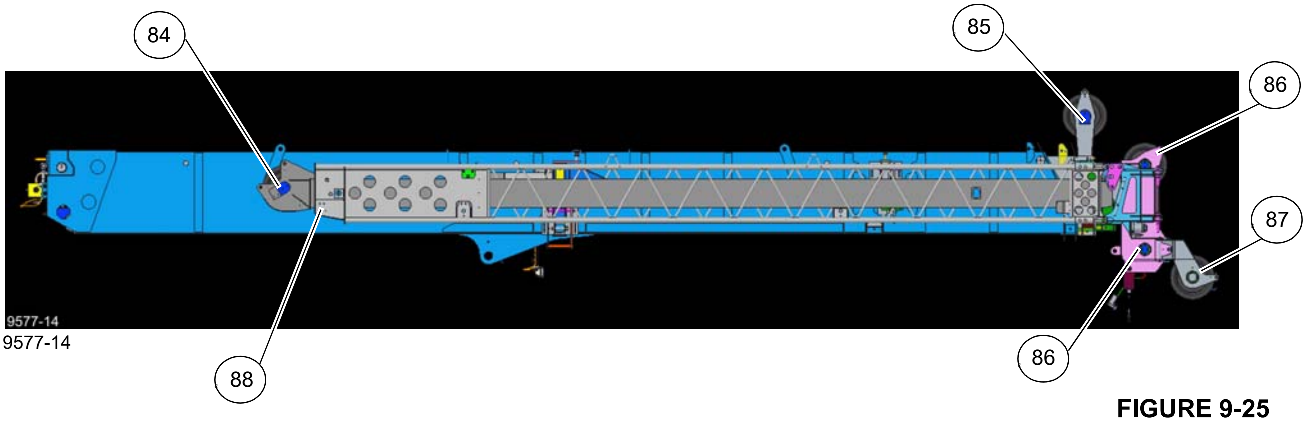


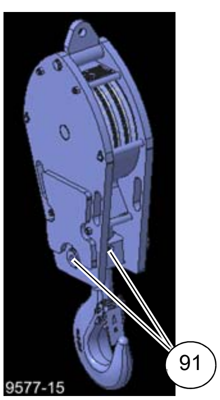
FIGURE 9-24



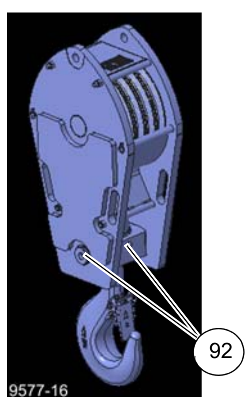
9577-14

FIGURE 9-25

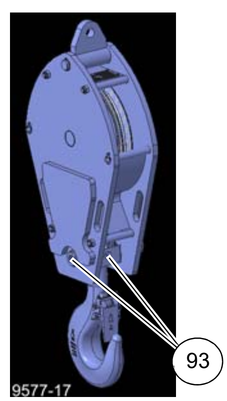
ITEM NUMBER	LOCATION NAME	APPROX. CAPACITY	LUBE SPEC	NOTES	SERVICE POINTS	SERVICE	SERVICE HOURS
91	HOOK BLOCK - 33 TON (3 SHEAVE) SWIVEL BEARING	---------------	A	8, 14	3	LUBE	250 HRS / 3 MONTHS
92	HOOK BLOCK - 40 TON (4 SHEAVE) SWIVEL BEARING	---------------	A	8, 14	3	LUBE	250 HRS / 3 MONTHS
93	HOOK BLOCK - 20 TON (1 SHEAVE) SWIVEL BEARING	---------------	A	8, 14	3	LUBE	250 HRS / 3 MONTHS
94	OVERHAUL BALL - SWIVEL	---------------	A	8, 14	1	LUBE	250 HRS / 3 MONTHS



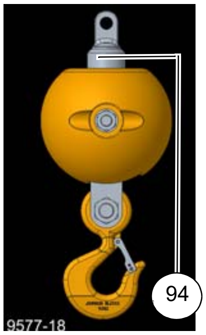
9577-15



9577-16



9577-17



9577-18

FIGURE 9-26

Monthly Lubrication Work

Pins

Lubricate the following items on a monthly basis:

- the pins for the pin connection on the lattice extension,
- the retaining pins on the return pulleys,
- the retaining pins used for fastening the lattice extension sections for transport,

NOTE: The lubrication interval applies to average operation. Also, lubricate the pins after high-pressure cleaning and generally at an interval that will prevent them getting dry.

CARWELL® RUST INHIBITOR

Protecting Cranes From Corrosion

Manitowoc Crane Group's cranes are manufactured to high quality standards, including the type of paint finish demanded by today's industry. In partnership with our paint supplier, we are also doing our part to help prevent premature corrosion of cranes.

Grove cranes will be treated with a rust inhibitor called Carwell T32-CP-90. While a rust inhibitor cannot guarantee that a machine will never rust, this product will help protect against corrosion on Grove cranes that are treated with this product.

Carwell is a treatment, not a coating. It contains no silicones, solvents, CFCs or anything that would be classified as hazardous under OSHA Regulation 29CFR1910.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly “oily” residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, Grove crane owners must provide proper maintenance and care to help long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on Grove cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleaning if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions, 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's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments such as islands, coastal regions, industrial areas, and/or areas where winter road salt is regularly used, reapplication of treatment is recommended sooner than 12 months, for instance, repeat treatment in 6-9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

NOTE: Unit must be completely dry before applying treatment.

- Do not allow product to puddle or build-up on weather stripping or rubber gaskets. Unit should not have puddles or runs evident anywhere.
- To proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

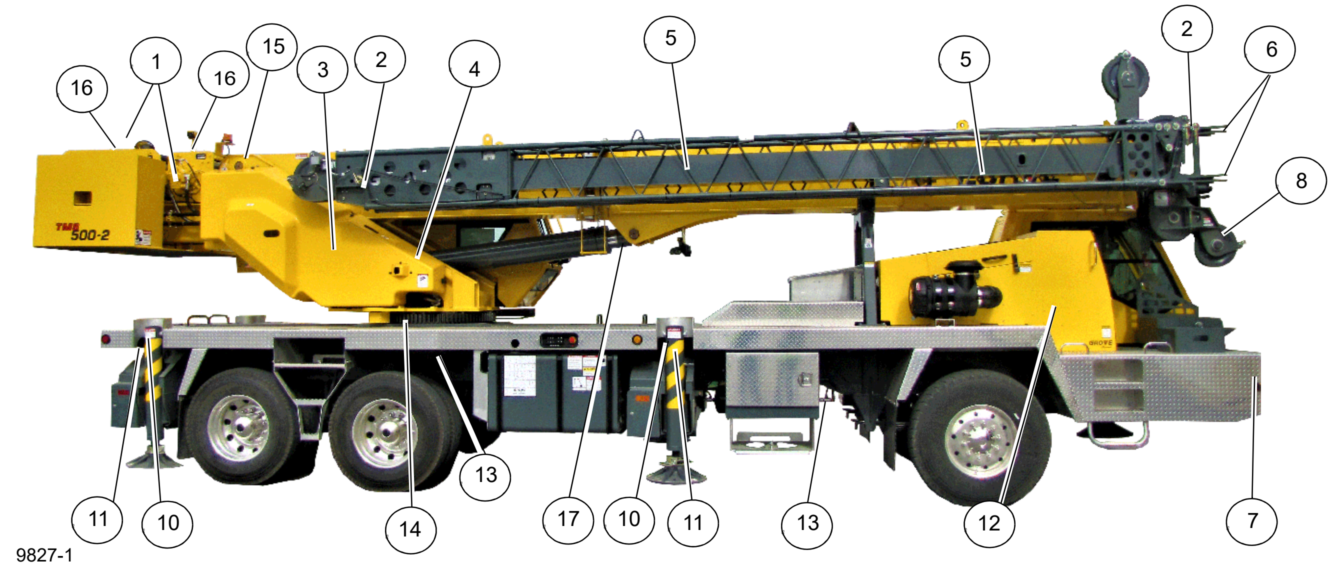
Areas of Application

Reference Figure 9-27.

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; valves, hose ends and fittings, swivel, pumps, axles, drivelines, transmission, swing bearing fasteners and all interior surfaces of the frame.
- Frame application areas are; hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoists, roller tensioning springs on hoists,

all unpainted fasteners and hardware, valves, swing bearing fasteners and all bare metal surfaces.

- Boom applications areas are; pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, overhaul ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.


16
1
16
15
3
2
4
5
5
2
6
8
11
10
14
13
17
10
11
13
12
7
9827-1


6
15
8
17
9
14
9
10
7
13
11
18
9826

FIGURE 9-27

Item	Description	Item	Description
1	Hoist Hose Connections	10	O/R Hose Connections
2	Boom Extension Pins, Clips	11	All Hardware, Clips, Pins, Hose Connections not painted O/R Pins, Clips
3	Valve Bank	12	Power train Hardware Inside Compartment
4	Hose Connections Inside Turntable	13	Entire Underside of Unit
5	Boom Extension Hanger Hardware	14	Turntable Bearing Fasteners
6	Boom Nose Pins, Clips	15	Wire Rope
7	Hook Block Tie-down Cable	16	Tension Springs
8	Overhaul Ball / Hook Block	17	Pivot Shaft
9	Mirror Mounting Hardware	18	Outrigger Beam Wear Pad Adjustment Hardware

THIS PAGE BLANK

Alphabetical Index

After-treatment Diesel Exhaust Fluid (DEF) 7-17
Air Intake System. . . . 7-11
Air System 8-17
Anti-Lock Brake System (ABS)/Automatic Traction Control (ATC) 8-51
Automatic Slack Adjuster. . . . 8-40
Axles 8-1
Batteries. . . . 3-1
Boom Assembly Procedure 4-23
Boom Extension Removal (Optional). . . . 4-9
Boom Extension Sequence 4-2
Boom Maintenance 4-43
Boom Nose Sheaves. . . . 4-20
Boom Removal 4-10
Boom Retract Sequence 4-4
Boom System Components 4-2
Brake Test Procedure 5-6
Brakes 8-32
Camera System (Optional) 3-9
Carrier Power Panel and Fuse Panels 3-2
Carrier Valves 2-17
Carwell® Rust Inhibitor 9-30
Center Front Jack Cylinder 8-84
Computer Modules 3-28
Counterweight Removal 5-13
Counterweights 5-13
Cylinder Rod Surface Protection 9-6
Cylinders 2-31
Description. . . . 2-1
Drive Train 7-26
Electronic Clutch Actuator (ECA). . . . 7-28
Engine Control System 7-6
Engine 7-1
Exhaust System. . . . 7-15
Extension and Retraction Cable Maintenance. . . . 4-44
Final Boom installation. . . . 4-40
Front Brakes 8-34
Fuel System. . . . 7-9
General Maintenance Notes 4-8
General Maintenance 1-11
GENERAL 9-1
Hoist Drum Rotation Indicator System. . . . 5-11
Hoist Maintenance and Inspection. . . . 5-4
Hoist to Boom Alignment 5-7
Hydraulic Pumps 2-11
Idler Drum and Cable Follower 5-9
Introduction 6-1
Jump Starting Hazard 3-11
Lift Circuit Troubleshooting 4-7
Lift Circuit. . . . 4-6
Lift Cylinder Maintenance 4-46
List Of Specifications 1-3
Lubrication Points 9-6
Maintenance 2-8

Non-Asbestos Warning. 8-33
Outrigger Control Manifold 2-21
Outrigger Jack Cylinders 8-83
Outrigger Monitoring System 8-87
Outrigger Selector Manifold Valve 2-19
Outriggers. 8-75
Pilot Operated Check Valve 2-26
Piston Motor and Control Valve 5-8
Pressure Setting Procedures 2-33
Preventive Maintenance and Oil Sampling. 5-5
Pump/PTO Assembly 7-30
Radios (Optional) 3-9
Rear Brakes 8-43
Remote Controller (Optional) 3-28
Return Hydraulic Filter Assembly 2-9
Safety Messages 1-2
Special Tools 8-71
Steering Gearbox 8-16
Steering System 8-13
Superstructure Cab Fuse and Relay Panels 3-7
Superstructure Hydraulic system 2-31
Superstructure Wiper Assembly 3-23
Supply Pressure and Return Circuit 2-5
Swing Bearing 6-8
Swing Gearbox and Brake 6-7
Swing Motor 6-6
Swingaway Extension Installation (Optional) 4-41
Switch Replacement. 3-19
Swivels 6-14
Telescope Circuit Troubleshooting 4-5
Telescope Circuit 4-4
Tensioning the Boom Extend and Retract Cables 4-35
Theory of Operation 5-1
Transmission 7-28
Troubleshooting Accessories 3-14
Troubleshooting 3-11
Using the Operator Display Module (ODM) 3-28
Using The Service Manual 1-1
Water Cooling System 7-20
Wheels and Tires 8-12
Windshield Washer Assembly Replacement 3-23
Windshield Wiper Assembly Replacement - Carrier Cab 3-20
Windshield Wiper Assembly Replacement - Superstructure Cab 3-24
Wire Rope Lubrication 9-6