National Crane 500E2

Service Manual

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Grove Manitowoc National Crane Potain

Manitowoc

WARNING

California Proposition 65

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

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

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

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

California Spark Arrestor

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

The original language of this publication is English.

NATIONAL CRANE
by Manitowoc

SERVICE MANUAL

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

500E2

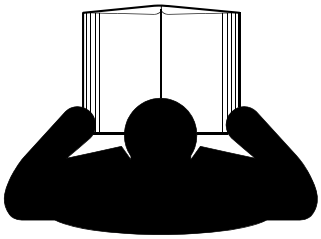
This Manual is Divided into the following Sections:

SECTION 1	**INTRODUCTION**
SECTION 2	**HYDRAULIC SYSTEM**
SECTION 3	**ELECTRICAL SYSTEM**
SECTION 4	**BOOM**
SECTION 5	**HOIST**
SECTION 6	**SWING**
SECTION 7	**LUBRICATION**
SECTION 8	**TROUBLESHOOTING**
SECTION 9	**CRANE INSTALLATION**
SECTION 10	**SCHEMATICS**

NOTICE

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

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



⚠DANGER

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

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

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TABLE OF CONTENTS

SECTION 1 . . . . . Introduction

General 1-1
- Supplemental Information 1-1
- New Owner 1-2
- Basic Nomenclature 1-2

General Maintenance 1-2
- Cleanliness 1-3
- Removal and Installation 1-3
- Disassembly And Assembly 1-3
- Pressing Parts 1-3
- Locks 1-3
- Shims 1-3
- Bearings 1-3
- Gaskets 1-4
- Hydraulic Systems 1-4

Electrical 1-5
- Batteries 1-5
- Jump Starting Hazard 1-5
- Charging the Batteries 1-5
- Connectors, Harnesses, Wires, and Connectors 1-5
- Dielectric Grease 1-6

Fatigue Of Welded Structures 1-6
Loctite 1-7
Fasteners and Torque Values 1-7
Weld Studs 1-20
- Torque Wrenches 1-20
- Using Torque Wrench Extensions 1-20

Wire Rope 1-21
- General 1-21
- Keeping Records 1-21
- Environmental Conditions 1-22
- Dynamic Shock Loads 1-22
- Lubrication 1-22
- Precautions and Recommendations During Inspection 1-22
- Inspection 1-23
- Wire Rope Replacement 1-23
- Care of Wire Rope 1-24
- Boom Extension and Retraction Cables 1-24
- Wire Rope Replacement (All Wire Rope) 1-25
- Seizing Wire Rope 1-25

SECTION 2 . . . . . Hydraulic System

Hydraulic System Description 2-1
General Adjustment And Repair Procedures 2-1
- Hydraulic System Maintenance Precautions 2-2
- Label Parts When Disassembling 2-2
- Welding Precautions 2-2
- Hydraulic Oil Recommendations 2-2
- Draining and Flushing 2-2
- Removing Air From the Hydraulic System 2-3

Parts Replacement. 2-4
Maintenance Records 2-4
Hydraulic Oil Reservoir 2-4
Hydraulic Filter 2-4
Oil Cooler Service & Maintenance (Optional) 2-4
Servicing The Control Valves 2-5
Disassembly And Reassembly Of Control Valves To Replace Seals 2-5
Replacing Spool Seals 2-5
Unloader Valve Service 2-6
Control Valve Relief Adjustment 2-7

SECTION 3 . . . . . Electric System
Anti-two Block System Description 3-1
Anti-two Block Operation 3-1
Anti-two Block Internal Wire Repair 3-2
Three Section Boom ATB Wire Repair 3-2
Alternative #1 3-2
Alternative #2 3-3
Hydraulic Capacity Alert System. 3-4
HCA Maintenance & Repair 3-4
HCA System Adjustment 3-4
Jib Load Limiting Device 3-5
Single Character Display 3-5
Jib Load Limiting Device Troubleshooting 3-6
Outrigger Monitoring System (OMS) (Optional—Standard in North America) 3-6
Operation 3-6
Maintenance. 3-6
Remote Control. 3-9
Safety 3-9
Danger Remote Start Hazard. 3-9
Operation 3-9
Hydraulic System Description 3-10
Service and Maintenance. 3-10
Troubleshooting, Repair and Replacement 3-10
Installation 3-11
Radio Remote Controls. 3-11
Safety 3-11
Operation 3-11
Service and Maintenance. 3-11
Quick Test for Receiver Antenna and Cable 3-12
Troubleshooting 3-12
Specifications 3-13
Installation 3-13

SECTION 4 . . . . . Boom
Three Section Boom Operation 4-2
Special Boom Inspection 4-2
Three Section Boom Maintenance 4-2
Three Section Cable Tensioning 4-2
Hoist Removal. 4-3
Boom Removal 4-4
Boom Disassembly 4-4
Boom Disassembly Alternative #1 4-4

Boom Disassembly Alternative #2 4-5
Additional Maintenance, Disassembled Boom 4-6
Three Section Boom Assembly 4-6
Three Section Top/Bottom Pad Replacement (Assembled Boom) 4-8
Top Rear Pad Replacement 4-8
Front Bottom Pad Replacement 4-8
Inner Wear Pad Calibration 4-8
Cable Tensioning 4-10
Tensioning Setup Procedure 4-10
Cable Tension Sequence 4-10
3- Section Boom w/ 1 Stage Cylinder Cable Positioning 4-11
Cable Retention 4-12
Lift Cylinder Repair 4-13
Lift Cylinder Disassembly 4-13
Extend Cylinder Repair 4-14
Extend Cylinder Disassembly 4-14
Extend Cylinder Assembly 4-15
Jib Installation and Adjustment 4-15
Jib Jack Service and Maintenance 4-17
Adding Oil 4-17
Changing Oil 4-17
Lubrication 4-17
Rust Prevention 4-17

SECTION 5 . . . . . Hoist
Hoist Removal 5-1
Hoist Installation 5-1

SECTION 6 . . . . . Swing
Swing Gearbox And Brake 6-1
Disassembly & Assembly Instructions 6-1
Swing Drive Disassembly 6-1
Tulsa Swing Drive Assembly Procedure 6-4
Rotation Stop-mechanical 6-5
Rotation Stop Adjustment 6-5
Maintenance 6-6
General 6-6
Torquing Swing Bearing Bolts 6-6
General 6-6
Swing Bearing Bolts 6-7
Torque Values 6-9
Bearing Clearance 6-9
Bearing Replacement 6-11
Removal 6-11
Installation 6-11
Testing 6-12

SECTION 7 . . . . . Lubrication
Lubrication General 7-1
Environmental Protection 7-1
Lubricants 7-1

Arctic Conditions Below -9°C (15°F) 7-2
Chassis Grease 7-2
Low Temperature Grease 7-2
Extreme Pressure Multipurpose Gear Lubricant (EPGL) 7-2
Open Gear Lubricant 7-2
Antifreeze/Coolant (for Cab Heater) 7-2
Anti-wear Additives 7-2
Hydraulic Oil 7-2
Standard Hydraulic Oil 7-2
Arctic Hydraulic Oil 7-3
Hydraulic Oil Inspection 7-3
Surface Protection for Cylinder Rods 7-3
Lubrication 7-3
Lubrication Chart 7-5
Internal Cable Sheave Lubrication 7-6
Inner Boom Pad Lubrication 7-7
Side and Bottom Boom Wear Pad Lubrication 7-7
Hoist Gearbox Oil 7-7
Hoist Brake Oil 7-8
Swing Gearbox and Brake Oil 7-9
Hydraulic Oil Reservoir Level 7-9
Wire Rope Lubrication 7-9
Carwell© Rust Inhibitor 7-10
Protecting Cranes From Corrosion 7-10
Cleaning Procedures 7-10
Inspection and Repair 7-11
Application 7-11
Areas of Application 7-12

SECTION 8 . . . . . Troubleshooting
Hydraulic System Troubleshooting Chart 8-1
Jib Load Limiting Device Troubleshooting 8-4
Jib Jack Troubleshooting 8-5
Systematic Troubleshooting 8-5
HCA Troubleshooting Flow Chart 8-6

SECTION 9 . . . . . Crane Installation
Crane to Truck Installation 9-1
Minimum Truck Requirements 9-2
Mounting Configurations 9-2
Configuration 1 - 571E2 9-3
Configuration 2 - 571E2 9-4
Configuration 3 - 560E2 9-5
Configuration 4 - 560E2 And Shorter Booms 9-6
PTO Horsepower Requirements 9-7
Direct Mount Pump to PTO 9-7
Pump Rotation 9-7
Truck Frame Strength 9-8
Section Modulus Tables 9-9
Channel (Table A) 9-9
Channel Reinforcement (Table A) 9-9
Angle Reinforcement (Table B) 9-9
Fish Plate Reinforcement (Table C) 9-9

Angle Under Reinforcement (Table D) 9-9
Requirements For Optional Single Front Outrigger 9-14
Truck Frame Section Modulus Tables 9-15
Truck Preparation 9-18
Welding Precautions 9-18
Positioning Crane On Truck 9-18
PTO Installation 9-18
Hydraulic Pump Installation 9-18
Reinforcing/after Frame Extension 9-19
After Frame Modification 9-22
Crane Mounting Procedure 9-22
Crane Component Installation Sequence 9-22
Torsion Box and ASH Stabilizer Installation 9-22
Install Torsion Box 9-22
Mount the Turret and Torsion Box to the Frame Assembly 9-22
Turret Mounting 9-22
Torsion Box Mounting 9-23
Mount the Outrigger Box 9-24
ASH to Torsion Box Mounting 9-25
Assemble the Outriggers 9-26
Hydraulic Reservoir Installation 9-26
Boom Installation 9-27
Lift Cylinder Installation 9-27
Wire Rope Installation 9-28
Hoist to Truck Cab Clearance 9-29
Painting 9-29
Pin Bearing Inspection And Installation Procedure 9-29
Pin Inspection 9-29
Bearing Installation 9-29
Trunnion Inspection 9-29
Bearing Inspection 9-29
Counterweighting 9-29
Counterweighting Determination Example 9-30
Counterweighting Methods 9-31
Concrete poured in the bed measures: 9-33
Boom Rest Requirements 9-34
CAN Bus System Setup 9-35
Required Equipment 9-35
CAN Bus System using Software 9-35
CAN Bus System using Programming Button 9-36
Initial Crane Run In Procedure 9-37
Stability Check 9-37
Specifications 9-39
Hydraulic Pump 9-39
Hydraulic System 9-39
Reservoir 9-39
HCA 9-39
Hoist Speed and Pull 9-39
Crane Operating Speeds 9-39

SECTION 10 . . . . . Schematics

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1

SECTION 1
INTRODUCTION

SECTION CONTENTS

General 1-1
Supplemental Information 1-1
New Owner 1-2
Basic Nomenclature 1-2
General Maintenance 1-2
Cleanliness 1-3
Removal and Installation 1-3
Disassembly And Assembly 1-3
Pressing Parts 1-3
Locks 1-3
Shims 1-3
Bearings 1-3
Gaskets 1-4
Hydraulic Systems 1-4
Electrical 1-5
Batteries 1-5
Jump Starting Hazard 1-5
Charging the Batteries 1-5
Connectors, Harnesses, Wires, and Connectors 1-5
Dielectric Grease 1-6
Fatigue Of Welded Structures 1-6
Loctite 1-7
Fasteners and Torque Values 1-7
Weld Studs 1-20
Torque Wrenches 1-20
Using Torque Wrench Extensions 1-20
Wire Rope 1-21
General 1-21
Keeping Records 1-21
Environmental Conditions 1-22
Dynamic Shock Loads 1-22
Lubrication 1-22
Precautions and Recommendations During Inspection 1-22
Inspection 1-23
Wire Rope Replacement 1-23
Care of Wire Rope 1-24
Boom Extension and Retraction Cables 1-24
Wire Rope Replacement (All Wire Rope) 1-25
Seizing Wire Rope 1-25

GENERAL

This manual has been compiled to assist you in properly operating and maintaining your Model 500E2 Series National Crane.

Before placing the crane in to service, all operators and persons working around the crane must thoroughly read and understand the contents of the Operators Handbook pertaining to ***Safety, Operation and Maintenance.*** Before moving a vehicle equipped with the crane, information relating to transporting the vehicle must be read and observed.

This manual must be retained with the machine for use by subsequent operating personnel.

Information this manual does not replace federal, state or local regulations, safety codes or insurance requirements

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

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

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

Supplemental Information

Supplemental Information regarding Safety & Operation, Specifications, Service & Maintenance, Installation, and parts for options such as remote controls, augers, varying control configurations, baskets, grapples, etc. is included in separate sections of this manual, if applicable.

Whenever a question arises regarding your National Crane product or this publication, please consult your National Crane distributor for the latest information. Your National Crane distributor is equipped with the proper tools, necessary parts, and trained personnel to properly maintain and service your equipment.

A Safety Compact Disc or a USB flash drive which includes sections on Operation, Service and a Safety Video for National Crane operators and owners is supplied when the equipment is purchased new. Additional copies are available from your local distributor.

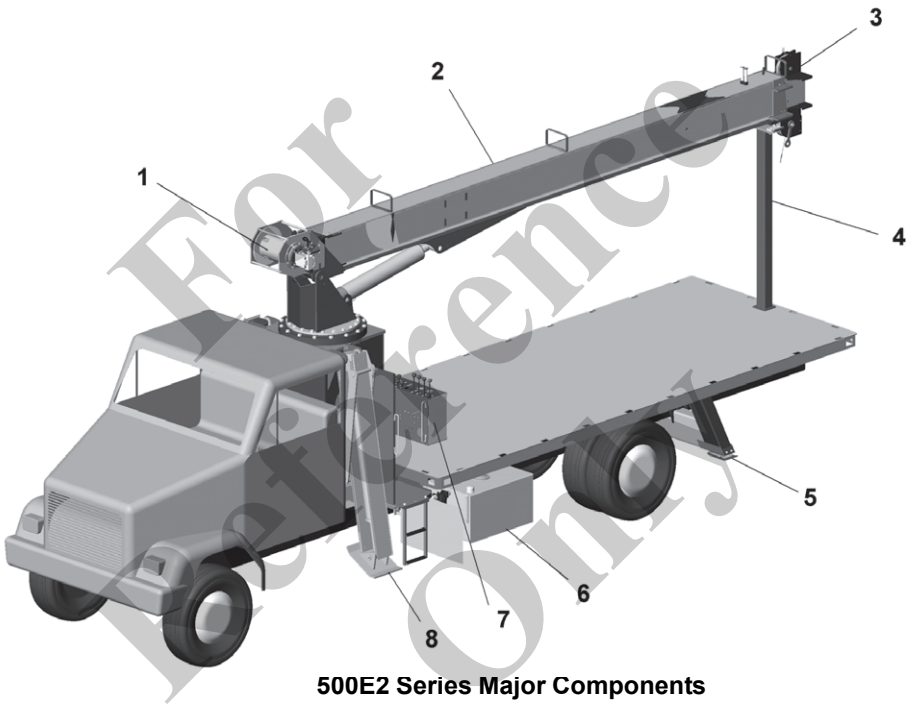
New Owner

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

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

Basic Nomenclature

The nomenclature used to describe parts of a National Crane are described in the figure below. This nomenclature is used throughout this manual.



500E2 Series Major Components

Item	Component
1	Winch
2	Boom
3	Sheaves
4	Boom Rest

Item	Component
5	Stabilizers
6	Hydraulic Reservoir
7	Control Console
8	Outriggers

GENERAL MAINTENANCE

The suggestions listed below are helpful in analyzing and correcting problems:

- Determine the problem.
- List possible causes.
- Devise checks.
- Conduct checks in a logical order to determine the cause.
- Consider the remaining service life of components against the cost of parts and labor to replace them.
- Make the repair.
- Test the equipment to ensure the problem is fixed.

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

Cleanliness

Cleanliness is important in preserving the life of the machine. Keep dirt out of working parts and compartments. Keep filters and seals clean. Whenever hydraulic, fuel, lubricating oil lines, or air lines are disconnected, clean the adjacent area as well as the point of disconnect. Cap and plug each line or opening to prevent entry of foreign material.

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

Do not attempt to manually lift heavy parts that require hoisting equipment. Do not put heavy parts in an unstable position.

When raising a portion or a complete crane, ensure the weight is supported by blocks rather than by lifting equipment.

When using hoisting equipment, follow the winch manufacturers recommendations. Use lifting devices that achieve the proper balance of the assemblies being lifted. Unless otherwise specified, use an adjustable lifting attachment for all removals requiring hoisting equipment. Some removals require the use of lifting fixtures to obtain proper balance.

All supporting members (chains and cables) need to 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.

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

Disassembly And Assembly

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

Pressing Parts

When one part is pressed 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

Lock washers, flat metal locks, or cotter pins are used to lock nuts and bolts. For flat metal locks, bend one end of the lock around the edge of the part and the other end against one flat surface of the nut or bolt head.

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

Use a steel flat washer between aluminum housings and lock washers.

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 is shortened if not properly lubricated. Dirt can cause an antifriction bearing to lock and result 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 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 preloading. When installing a bearing, spacer, or washer against a shoulder on a shaft, be sure the chamfered side is toward the shoulder.

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

Preload

Preload is an initial load placed on the bearing at the time of assembly. Consult the disassembly and assembly instructions to determine if the bearing can be preloaded.

Be careful in applying preload to bearings requiring end clearance. Otherwise, bearing failure may result.

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.

Hydraulic Systems

DANGER

Pressurized hydraulic fluid can cause serious injury. Depressurize the hydraulic system before loosening fittings.

Visual Inspection

Do a visual inspection daily on all hydraulic components for missing hose clamps, shields, guards, excessive dirt build up, and leaks. Do a monthly or 250 hour inspection for the items listed in the inspection procedure below.

Valves and Manifolds

Inspect valves and manifolds for leaking ports or sections.

Hoses and Fittings

Inspect all hoses and fittings for the following:

- Cut, kinked, crushed, flattened, or twisted hoses.
- Leaking hoses or fittings.
- Cracked, blistered, or hoses charred by heat.
- Damaged or corroded fittings.
- Fitting slippage on hoses.

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

The climate in which the crane operates affects the service life of the hydraulic components. The climate zones are defined in the table on page 1-6. Recommended replacement of hoses is as follows:

- Climate zone C after 8,000 hours of service.
- Climate zones A and C with high ambient temperatures and duty cycles after 4000 to 5000 hours of service.
- Climate zones D and E after 4000 to 5000 hours of service.

Cleanliness

Contaminants in a hydraulic system affects operation and results in serious damage to the system components.

Keep The System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

When disconnecting hoses, tag each one to ensure proper identification during assembly.

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

Due to manufacturing methods there is a natural curvature to a hydraulic hose. Reinstall the hose so any bend is with this curvature.

ELECTRICAL

Batteries

Clean the batteries with a solution of baking soda and water. Rinse with clear water and dry. Clean the battery terminals with fine sandpaper and coat the terminals dielectric grease. Do not use a non-dielectric grease.

Remove the batteries If the machine is not used for an extended period of time. Store the batteries in a warm, 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.

CAUTION

Disconnect batteries prior to working on the electrical system.

When disconnecting wires, tag each one to ensure proper identification during reassembly.

Jump Starting Hazard

Do not attempt to jump start the crane.

CAUTION

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

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

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries. Refer to *Charging the Batteries*, page 1-5.

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.

Connectors, Harnesses, Wires, and Connectors

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

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

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

The climate in which the crane operates affects the service life of the electrical components. The climate zones are defined in the table on page 1-6. Recommended replacement of harness and cables is as follows:

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

Climate Zone Classification

Zone	Classification
A (Tropical Moist)	Latitude 15° - 25° North and South (All months average above 64° F [18° C])
B (Dry or Arid)	Latitude 20° - 35° North and South (Deficient of precipitation most of the year)
C (Moist Mid-Latitude)	Latitude 30° - 50° North and South (Temperate with mild winters)
D (Moist Mid-Latitude)	Latitude 50° - 70° North and South (Cold winters)
E (Polar)	Latitude 60° - 75° North and South (Extremely cold winters and summers)

Dielectric Grease

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

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

Excluded Connections

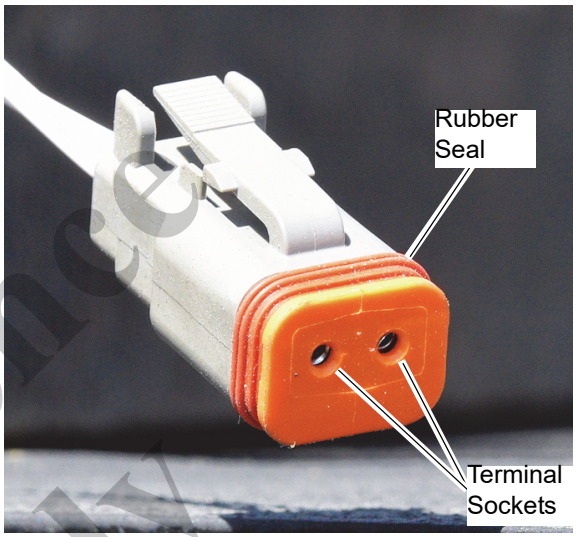
Do not apply dielectric grease to the following connections:

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

Applying Dielectric Grease to an Electrical Connector

Use the following procedure to apply dielectric grease to an electrical connection. Grease should be applied immediately prior to securing the connector. Ensure that grease is applied to all terminal sockets (Figure 1-1).

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



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Example. For illustration purposes only. Your connector may differ. **FIGURE 1-1**

4. Use a clean towel to remove excess grease from the surface of the connector, and wipe grease into the terminal sockets (Figure 1-1).
5. Ensure grease is applied to each terminal socket. The towel with excess grease can be used to fill empty terminal sockets (Figure 1-1).
6. Ensure grease is applied to the entire surface of the connector's rubber seal (Figure 1-1).

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

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

FATIGUE OF WELDED STRUCTURES

Highly stressed welded structures are subject to cracking (fatigue) when repeatedly subjected to varying stresses caused by twisting, shock, bending, and overloads. Inspect equipment periodically for weld fatigue. The frequency of

inspections depends on the age of the equipment, the severity of the application, and the experience of the operators and the maintenance personnel. The following are known high stress areas and should be inspected as part of a preventive maintenance program:

- Hydraulic cylinder and boom pivot attaching points.
- Outrigger pads, beams, boxes and attachment structures.
- On the frame in the area of doubler plates and crossmembers.
- Turntable bearing connection (where bearing is welded to the crane turret).
- Counterweight support structures (were applicable).
- Hydraulic cylinder end connections.

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

LOCTITE

DANGER

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

Follow the directions on the Loctite container. There are different Loctite types for different applications. The following types of Loctite brand adhesives are available from the parts department of the local National Crane 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).

NOTE: Ensure the threaded surface, both male and female, is clean of contaminants and free of dirt and oil. Adhesive/Sealant Application

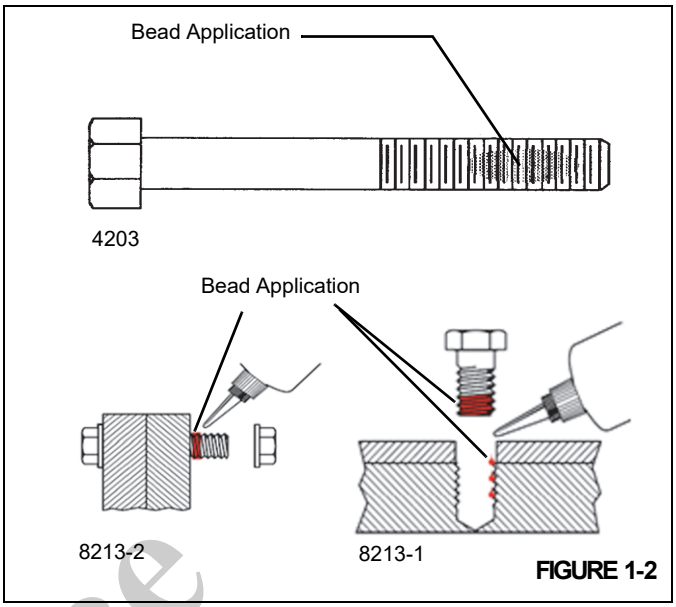


FIGURE 1-2

1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-1).
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. Time required to achieve full strength is 24 hours.

FASTENERS AND TORQUE VALUES

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

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

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

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

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

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

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

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

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

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

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

Torque Wrenches

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

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

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

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

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

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

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

Torque Values

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

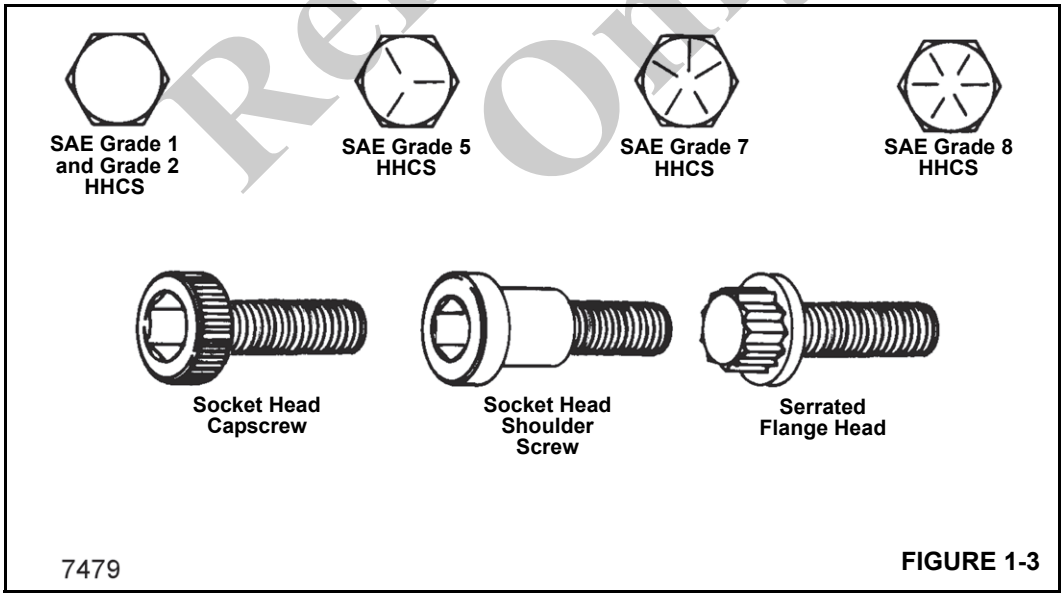


FIGURE 1-3

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

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

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

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28 UNF	5	7.5	7.3	7.1
	8	10.6	10.4	10.1

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

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

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

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

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

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

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

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

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

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

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

Nominal Size, Threads per millimeter, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M20x1	8.8	405.7	395.5	385.4
	10.9	577.8	563.3	548.9
	12.9	676.1	659.2	642.3
M20x1.5	8.8	386.0	376.3	366.7
	10.9	549.7	535.9	522.2
	12.9	643.3	627.2	611.1
M22x1.5	8.8	520.8	507.8	494.8
	10.9	741.7	723.2	704.7
	12.9	868.0	846.3	824.6
M24x2	8.8	655.8	639.4	623.0
	10.9	934.0	910.6	887.3
	12.9	1092.9	1065.6	1038.3
M27x2	8.8	951.4	927.6	903.8
	10.9	1355.0	1321.1	1287.2
	12.9	1585.6	1546.0	1506.3
M30x1.5	8.8	1369.2	1334.9	1300.7
	10.9	1950.0	1901.3	1852.5
	12.9	2281.9	2224.9	2167.8
M30x2	8.8	1324.6	1291.5	1258.4
	10.9	1886.6	1839.4	1792.2
	12.9	2207.7	2152.5	2097.3
M33x2	8.8	1784.5	1739.9	1695.3
	10.9	2541.6	2478.0	2414.5
	12.9	2974.2	2899.8	2825.4
M36x2	8.8	2340.1	2281.6	2223.1
	10.9	3332.8	3249.5	3166.2
	12.9	3900.2	3802.6	3705.1

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

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

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

Size	Torque (Nm)
M8x1.25	13
M10x1.5	27

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

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

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

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

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

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

Table 1-7 Inch Series Bearing Bolts – Untreated (black finish)

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

Table 1-8 Metric Series Bearing Bolts– Untreated (black finish)

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

Table 1-9 Inch Series with Coarse Threads (UNC) – Untreated (black finish)

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

Table 1-10 Inch Series with Fine Threads (UNF) – Untreated (black finish)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28	5	10	9.5	9
	8	14.5	14	13.5

Table 1-10 Inch Series with Fine Threads (UNF) – Untreated (black finish) (Continued)

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

Table 1-11 Metric Series with Coarse Threads – Untreated (black finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	8.8	3.1	2.9	2.8
	10.9	4.5	4.3	4.1
	12.9	5.4	5.2	4.9

Table 1-11 Metric Series with Coarse Threads – Untreated (black finish) (Continued)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M5x0.8	8.8	6.5	6.2	5.9
	10.9	9.2	8.9	8.5
	12.9	11	10.5	10
M6x1	8.8	11	10.5	10
	10.9	16	15	14
	12.9	19	18	17
M8x1.25	8.8	27	26	25
	10.9	38	36.5	35
	12.9	45	43.5	42
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144
M14x2	8.8	148	142	136
	10.9	212	203.5	195
	12.9	248	238	228
M16x2	8.8	230	221	212
	10.9	322	310	298
	12.9	387	372	357
M18x2.5	8.8	319	306.5	294
	10.9	455	436.5	418
	12.9	532	511	490
M20x2.5	8.8	447	430	413
	10.9	629	605	581
	12.9	756	727	698
M22x2.5	8.8	608	585	562
	10.9	856	823	790
	12.9	1029	989	949
M24x3	8.8	774	744	714
	10.9	1089	1047	1005
	12.9	1306	1256	1206
M27x3	8.8	1134	1090	1046
	10.9	1591	1530	1469
	12.9	1910	1836.5	1763

Table 1-11 Metric Series with Coarse Threads – Untreated (black finish) (Continued)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M30x3.5	8.8	1538	1479	1420
	10.9	2163	2080	1997
	12.9	2595	2495	2395
M36x4	8.8	2681	2578.5	2476
	10.9	3964	3812	3660
	12.9	4639	4461	4283

Table 1-12 Metric Series with Fine Threads – Untreated (black finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1	8.8	29	28	27
	10.9	41	39.5	38
	12.9	49	47	45
M10x0.75	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M10x1.25	8.8	57	55	53
	10.9	81	78	75
	12.9	96	93	90
M12x1	8.8	101	97.5	94
	10.9	150	144	138
	12.9	175	168	161
M12X1.25	8.8	100	96	92
	10.9	147	141.5	136
	12.9	172	165.5	159
M12x1.5*	8.8	100	96	92
	10.9	140	135	130
	12.9	168	162	156
M14x1.5	8.8	160	153.5	147
	10.9	229	220	211
	12.9	268	257	246
M16x1.5	8.8	248	238.5	229
	10.9	348	335	322
	12.9	418	402	386

Table 1-12 Metric Series with Fine Threads – Untreated (black finish) (Continued)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M18x1.5	8.8	345	331.5	318
	10.9	491	471	451
	12.9	575	552	529
M20X1	8.8	471	453	435
	10.9	694	667.5	641
	12.9	812	781	750
M20x1.5	8.8	483	464.5	446
	10.9	679	653	627
	12.9	816	785	754
M22x1.5	8.8	657	632	607
	10.9	924	888.5	853
	12.9	1111	1068	1025
M24x2	8.8	836	803.5	771
	10.9	1176	1130.5	1085
	12.9	1410	1356	1302
M27x2	8.8	1225	1171.5	1130
	10.9	1718	1652.5	1587
	12.9	2063	1983.5	1904
M30x1.5	8.8	1530	1471.5	1413
	10.9	2253	2166.5	2080
	12.9	2637	2536	2435
M30x2	8.8	1661	1597.5	1534
	10.9	2336	2246.5	2157
	12.9	2800	2695	2590
M33x2	8.8	2141	2059	1977
	10.9	3155	3034	2913
	12.9	3692	3550.5	3409
M36x2	8.8	2795	2688	2581
	10.9	4118	3960	3802
	12.9	4818	4634	4450

WELD STUDS

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

Table 1-13: Weld Stud Torque Values

T-2-4

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

Torque Wrenches

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 overstressed or damaged, it should immediately be removed from service until re-calibrated. 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.

NOTE: Torque values are in foot pounds (Nm). Torque values apply to plain finish and zinc plated fasteners. Torque values specified are dry with as received residual oils. Special lubricants are not recommended.

Torque values for bolts listed above are not affected with the use of Loctite.

Loctite should not be used on rotation bearing fasteners. Hardened washers should be used with Grade 8 fasteners

Using Torque Wrench Extensions

1. Torque wrench extensions are designed to extend the range or versatility of torque wrenches. Torque wrench scale readings or limit settings shall be computed with the following formulas when an extension handle is employed. The sketch below shows which formula is to be used, adding “A” or subtracting “A” when calculating the torque wrench setting.
2. If the offset C/L is not in line with the torque wrench C/L, then you must measure the distance from the C/L of the torque wrench to the C/L of the offset by using a square. Then apply this dimension to the torque wrench setting formula. See sketch below.
3. If offset is positioned at right angles to the torque wrench, then the offset will not change the effective length. Therefore, TW-wrench setting and Ta-applied torque, will be the same value as if no offset were used.

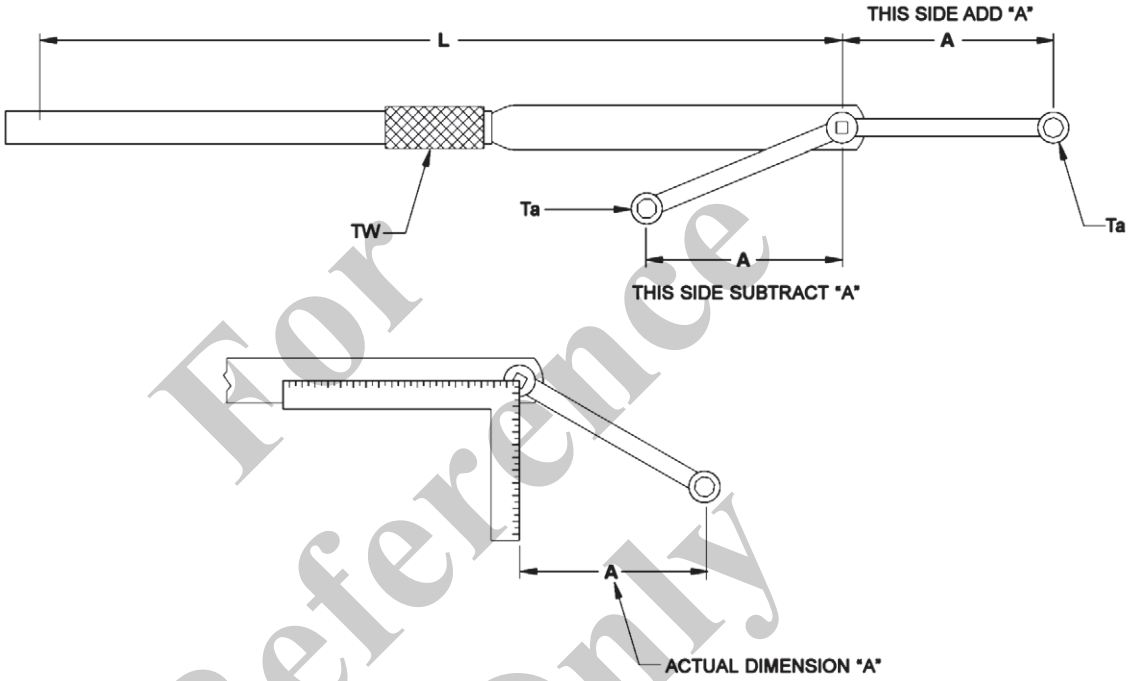
$$TW = \frac{Ta \times L}{L + A} \text{ or } \frac{Ta \times L}{L - A}$$

Ta = Torque required (specified)

TW = Wrench scale reading or limit setting of torque wrench

L = Length of torque wrench in inches (center of drive tang to handle pivot pin or center of hand grip extension handles are considered part of wrench length, when used).

A = Length of adapter extensions in inches



WIRE ROPE

General

The following information includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and National Crane specifications. The inspection interval shall be determined by a qualified person and shall be based on expected rope life as determined by experience, severity of environment, percentage of capacity lifts, frequency 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 information contains inspection and maintenance procedures for wire ropes used on National products as load lines, hoisting cables, boom extension and retraction cables, pendant cables, and hook block tie down cables.

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

Keeping Records

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

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

Environmental Conditions

The life expectancy of wire rope may vary due to the degree of environmental hostility. Variation in temperature, continuous excessive moisture levels, exposure to corrosive chemicals or vapors, or subjecting the wire rope to abrasive material can shorten wire rope life. Frequent inspections and maintenance of the wire rope is recommended for preventing premature wear and to insure long-term performance.

Dynamic Shock Loads

Subjecting wire rope to abnormal loads shortens the ropes life expectancy. Examples of this type of loading are as follows:

- High velocity movement followed by abrupt stops (hoisting or swinging of a load).
- Suspending loads while traveling over irregular surfaces such as railroad tracks, potholes, and rough terrain.
- Moving a load that is beyond the cranes rated capacity.

Lubrication

The object of rope lubrication is to reduce internal friction and to prevent corrosion. New lubricant needs be added throughout the life of the rope. It is important that lubricant applied needs to be compatible with the original lubricant. Consult the rope manufacturer for proper lubricant. The lubricant applied shall be of the type which does not hinder visual inspection. Those sections of rope which are located over sheaves or otherwise hidden during inspection require special attention when lubricating rope.

During fabrication, ropes receive lubrication which provides the rope with protection for a reasonable time if stored under proper conditions. After the rope is put into service, periodic applications of a suitable rope lubricant are required. The wire rope lubricant should have the following characteristics:

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

Remove dirt from the rope before applying lubrication. Use a stiff wire brush and solvent, compressed air, or live steam to clean the rope. Lubricate the rope immediately after cleaning. Methods of lubrication are bath, dripping, pouring, swabbing, painting, or pressure spray (Figure 1-4). Apply the lubricant at the top bend in the rope because at that point the strands are spread and more easily penetrated. Do not lubricate a loaded rope. The service life of wire rope is directly proportional to the amount of lubricant reaching the working parts of the rope.

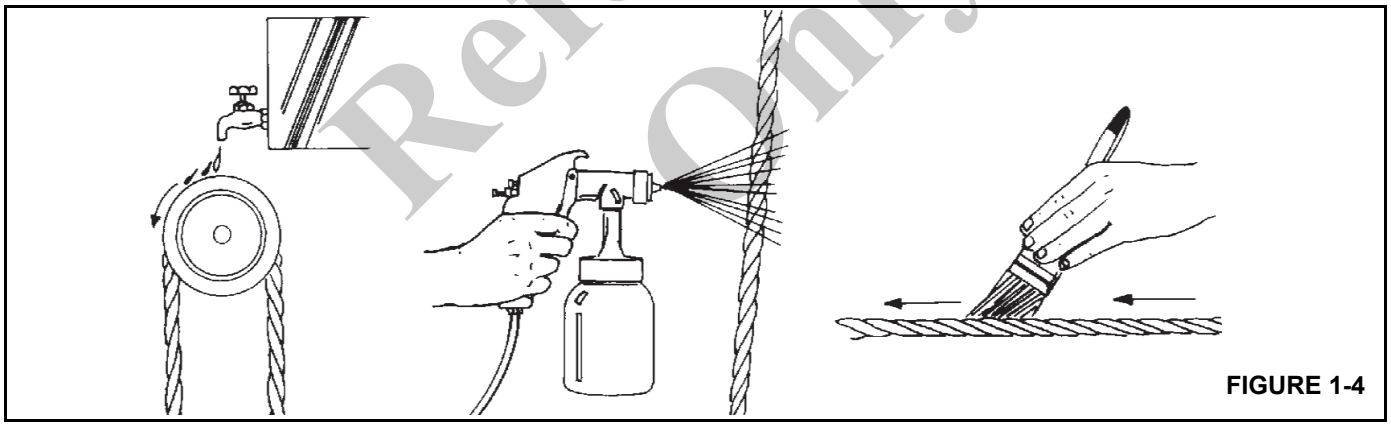


FIGURE 1-4

Precautions and Recommendations During Inspection

- Always use safety glasses for eye protection.
- Wear protective clothing, gloves, and safety shoes as appropriate.
- Measure the rope's diameter across crowns of the strands when determining if rope has become damaged, refer to Figure 1-5.

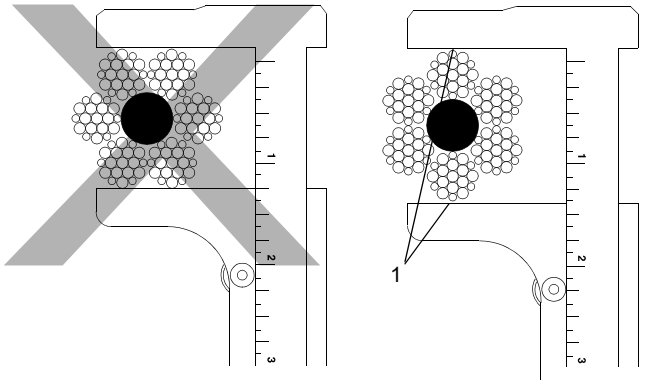


FIGURE 1-5

Inspection

All hoist cable in service needs to be inspected on a daily, monthly, and quarterly basis. Cable which has been idle for a period of a month or more must be given a thorough inspection before it is placed in service. These inspections should cover all types of deterioration including:

- Distortion such as kinking, crushing, un-stranding, bird caging, main strand displacement or core protrusion.
- Loss of cable diameter in a short cable length or unevenness of outer strands indicates the cable needs to be replaced.
- Significant corrosion.
- Broken or cut strands.
- Number, distribution and type of visible broken wires.
- Core failure in rotation resistant ropes.
- Prior electrical contact with a power line or other electric arc damage.
- Significantly corroded, cracked, bent, or worn end connections.

Only inspect the outer surface of a cable. Never attempt to open the cable.

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

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

Daily Inspections

All cable in continuous service must be inspected at the beginning of each work day. Inspect the eye end and length of cable that is used in daily operation. The end should be inspected for abrasion, corrosion, broken wires, and loose or broken servings. Inspect the remainder of the cable length used for daily operations for points showing kinks, sharp bends, or any other evidences of damage or excessive wear.

Monthly Inspections

Inspect the eye end and length of cable normally used in daily operations. Examine the rest of the cable for kinked, crushed or otherwise damaged points.

Periodic Inspections

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. Periodic inspection should include all previous items listed under Inspection, plus the following:

- Inspect for severely corroded or broken wires at 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/extension 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.

Inspect the eye end of the cable for greater wear than the rest of the cable. If the cable is in good condition, reverse the cable on the drum so that the wear is equalized along the total length of the cable.

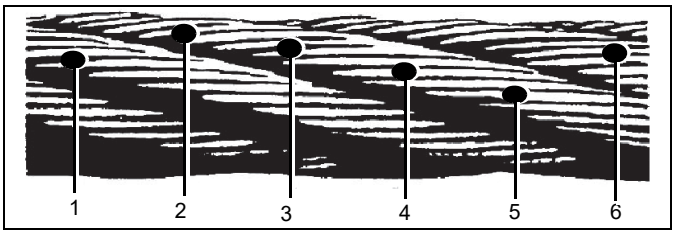
Wire Rope Replacement

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.

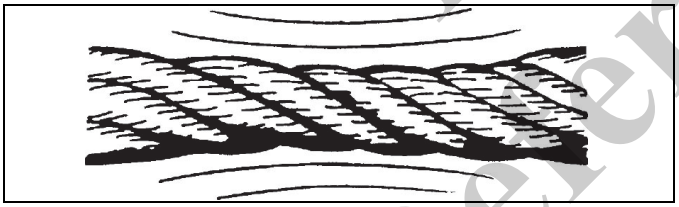
Wire rope replacement should be determined by the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies and as recommended by National Crane. All wire rope will eventually deteriorate to a point where it is no longer usable.

Wire rope shall be taken out of service when any of the following conditions exist:

- Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay. The rope is unsafe for further use if there are either three broken wires in one strand (Breaks 2, 3, 4) or a total of six broken wires in all strands in any one lay.



- In rotation resistant ropes: two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters
- Wear of one-third the original diameter of outside individual wires. Worn rope, usually indicated by flat spots on the outer wires is unsafe for further use when less than two-thirds the thickness of the outer wire remains.
- Necking down of the rope indicates core failure.



- Kinking, crushing, bird caging, or any other damage resulting in distortion of the rope structure.
- Evidence of heat damage.
- Reductions from nominal diameter of more than 5%.
- One outer wire broken at its point of contact with the core of the rope which has worked its way out of, and protrudes or loops out from the rope structure.

Care of Wire Rope

Handle wire rope with care to prevent damage to the individual wires which affect the overall strength and performance of the rope. Do not allow the formation of kinks, because this displaces the strands of wire from their original position and relation to each other causing severe bending and unequal tensions in the strands. This distortion and wire displacement cannot be corrected even under high tension and a permanent weak point remains in the rope. Displaced or raised wires indicate a previous kink, but does not show the damaged condition of the inner rope wires.

Never pull wire rope over a non-rotating support such as a spindle bar, a pin, or an inoperative sheave. This practice causes severe abrasion to the outer strand wires. A properly operating sheave or snatch block is essential to safety and long service life of the rope.

Do not use worn sheaves or sheaves with flat grooves because they do not provide sufficient support to prevent the distortion and flattening of the rope. Sheaves with nicked or broken flanges can cut or otherwise damage the rope.

An even distribution of rope coils over the hoist drum is essential to smooth operation. This prevents the rope from cutting down through or crushing other coils on the drum resulting in damage to and difficulty in unwinding the rope.

Boom Extension and Retraction Cables

Periodic Inspection

It is recommended that inspection of all boom extension and retraction cables be performed in conjunction with boom lubrication or quarterly using the following guidelines.The inspection shall cover all visible areas of the extension and retraction cables of an assembled boom. Note that extending and/or retracting the boom may be required to access visual inspection holes.

The inspection shall cover the entire length of the extension and retraction cables of a disassembled boom prior to reassembly.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:

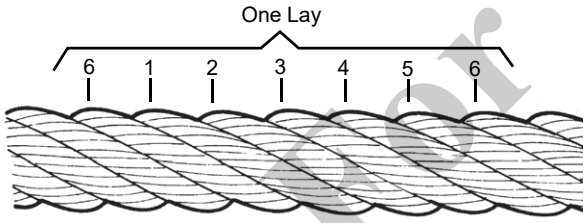
- reduction of rope diameter below nominal diameter.
- severely corroded or broken wires at end connections.
- severely corroded, cracked, bent, worn, or improperly applied end connections.
- deterioration in areas such as:
  - sections in contact with saddles, equalizer sheaves, or other sheaves where 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.
- damaged or wobbly boom extension and retraction sheaves which can cause rapid deterioration of wire rope.
- unusual cable sag/stretch. 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 a more thorough inspection to determine and correct the cause.

Wire Rope Replacement (All Wire Rope)

No precise rules can be applied to wire rope replacement because of the variables involved. Determining the condition of the wire rope depends largely upon the judgment of a qualified person.

The information below is excerpted from a National Consensus Standard as referenced by Federal Government Agencies and Manitowoc Crane Care recommendations to help determine when wire rope needs to be replaced. 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 (Figure 1-6).



One lay is parallel to the rope center-line and is the distance for one strand to make a complete spiral around the rope.

FIGURE 1-6

- 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.
- 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 heat damage from any cause.
- Reductions from nominal diameter of more than 5%.
- Severe corrosion evidenced by pitting.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- National Crane recommends that for cable extended booms, a single damaged wire rope assembly shall require replacement of the complete set of extension cables.
- National Crane recommends 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 need to 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 methods for seizing wire ropes are described below.

Method 1

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

The two ends of the annealed wire should be twisted together tightly. Cut off the excess wire and pound the twist flat against the wire rope (Figure 1-7).

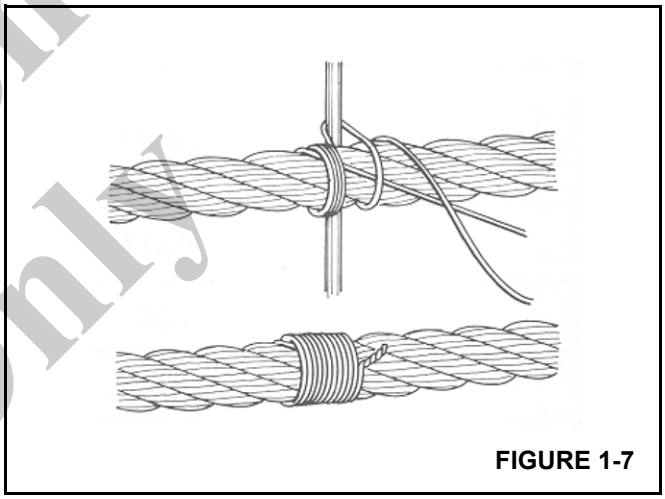


FIGURE 1-7

Method 2

Wind a length of soft annealed wire around the wire rope at least seven times. Twist the two ends 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 (Figure 1-8).

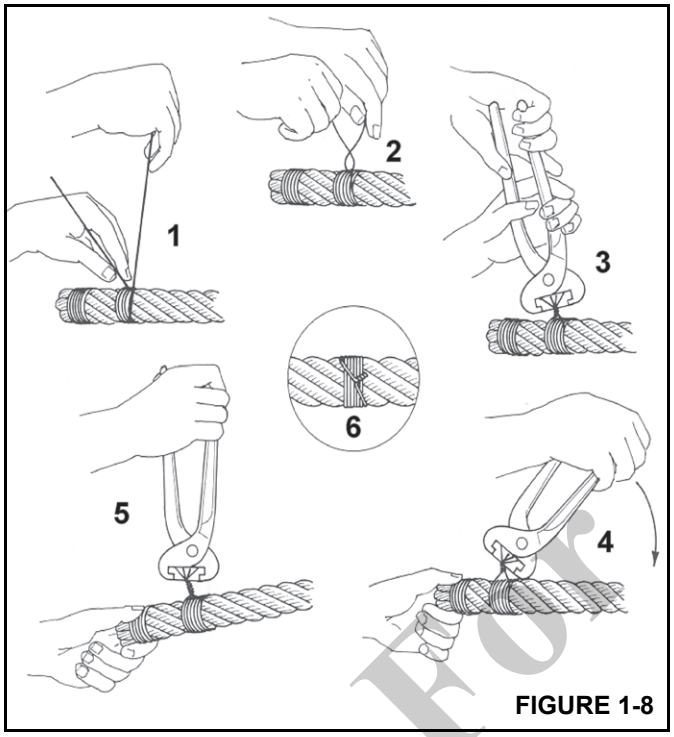


FIGURE 1-8

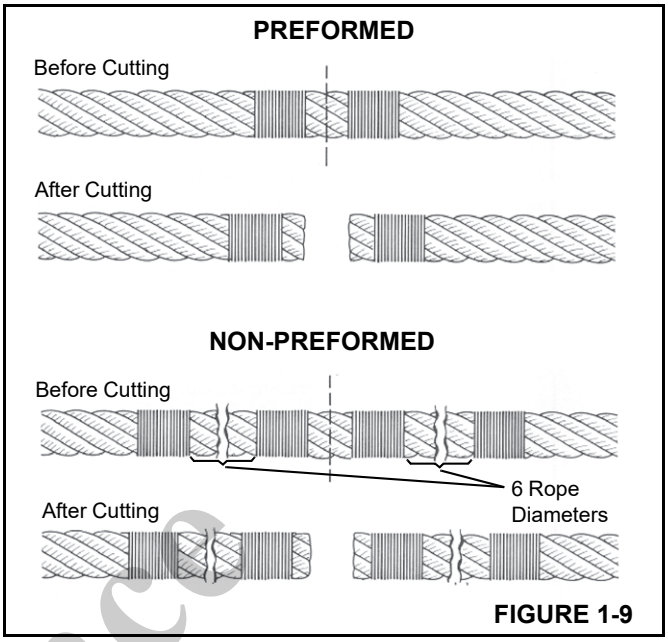


FIGURE 1-9

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

SECTION 2
HYDRAULIC SYSTEM

SECTION CONTENTS

Hydraulic System Description. 2-1
General Adjustment And Repair Procedures. . . . 2-1
Hydraulic System Maintenance Precautions 2-2
Label Parts When Disassembling. 2-2
Welding Precautions. 2-2
Hydraulic Oil Recommendations. 2-2
Draining and Flushing. 2-2
Removing Air From the Hydraulic System 2-3
Parts Replacement. 2-4
Maintenance Records 2-4
Hydraulic Oil Reservoir 2-4
Hydraulic Filter. 2-4
Oil Cooler Service & Maintenance (Optional) 2-4
Servicing The Control Valves. 2-5
Disassembly And Reassembly Of Control Valves To Replace Seals. 2-5
Replacing Spool Seals. 2-5
Unloader Valve Service. 2-6
Control Valve Relief Adjustment 2-7

HYDRAULIC SYSTEM DESCRIPTION

The hydraulic system of this machine is an open center type consisting of a fixed displacement three section high pressure pump which supplies oil to a main control valve and a winch control valve. The main control valve is equipped with a main inlet and a mid inlet. The main inlet supplies oil to the turn function, the mid inlet supplies the remainder of the crane function requirements. The main control valves contain inlet section reliefs or port reliefs which limit pressure in the hydraulic system to acceptable levels and control crane movements. See Specification Section for pressure settings.

The large single section control valve supplies oil to winch up and down. The inlet section contains a screw adjustable main relief. The first work section of the multi-section main control valve controls turn right and left.This work section is supplied oil by the main inlet section which contains a screw adjustable relief valve. The remaining work sections are boom telescope, boom lift, and outrigger functions in that order. The oil to these sections is supplied by the mid inlet section which also contains a main relief valve. The winch and the main circuits are all connected through shuttles to a pressure gage located on the control console.

The hydraulic oil is supplied by a truck frame mounted oil reservoir, which is equipped with a replaceable canister type return oil filter. The truck power take off driven hydraulic pump is sized to supply 34 GPM (129 Lpm) to the winch circuit, 18 GPM (68 Lpm) to the boom lift and telescope circuits and 10 GPM (38 Lpm) to the turn function at 2500 rpm pump shaft speed. Higher pump speeds may result in excessive heat generation in the hydraulic system. The pump is not bidirectional and can only be used when the shaft rotates only in the proper direction. If you need to verify or change pump rotation, contact your National Crane distributor or National Crane Product Support.

The crane hydraulic system includes a hydraulic capacity alert system. This system is a hydraulically operated, maximum capacity sensing device that monitors lift cylinder pressure. As pressure in the lift cylinder approaches its maximum predetermined level, which can be monitored on the console mounted range gages, a hydraulic pressure switch activates an integral hydraulic dump circuit in the main control valve, disabling the crane functions which increase the over capacity condition.

All load bearing cylinders on this machine are protected from inadvertent movement or collapse due to hose failure by pilot operated check valves or by pilot operated counterbalance valves if overhung loads must be controlled.

The standard swing gearbox is locked in place by an integrally mounted spring applied brake and a dual counterbalance motor holding valve. The swing brake and counterbalances are piloted open and closed by operating swing left or right and are automatically reapplied by ceasing the swing function. Maximum swing speed can be limited using the swing speed adjustment valve.

GENERAL ADJUSTMENT AND REPAIR PROCEDURES

Before adjustments and repairs are started on a crane, the following precautions shall be taken as applicable:

- Place a warning tag in a conspicuous place at the controls stating that the machine requires adjustment or repair before it can be operated.

- Park the crane it causes the least interference with other equipment or operations in the area.
- Place all controls at the off position and secure all operating features from inadvertent motion by brakes or other means.
- Disable all methods used to start the truck's engine.
- Power plant stopped or disconnected at take-off.
- Boom lowered to the ground or otherwise secured against dropping.
- Load block lowered to ground or otherwise secured against dropping.
- Relieve hydraulic oil pressure from all hydraulic circuits before loosening or removing hydraulic components.

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

Adjustments and repairs shall be done only by designated personnel who are properly trained. Use only National Crane supplied parts to repair the crane.

Hydraulic System Maintenance Precautions

Contaminants in a hydraulic system affect operation and can result in serious damage to the system components. 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. Lubricate all components to aid in assembly.

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

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

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

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

Label Parts When Disassembling

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

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

Welding Precautions

Sensitive truck computer system and crane's jib load limiting device computer system components may be damaged by welding on the truck or crane. The following precautions should be taken:

- Disconnect truck battery cables (positive and negative)
- Attach welding ground lead as close as possible to area to be welded.
- Remove the jib from the crane before welding on the crane or remove the jib sheave case assembly from the jib before welding on the jib.

Hydraulic Oil Recommendations

For the hydraulic oil specifications, Reference *Lubrication*, page 7-1.

Draining and Flushing

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

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

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

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

5. Disconnect the return line from the lift cylinder and raise the boom to maximum elevation.

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

CAUTION

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

10. Disconnect the return lines from a pair of outrigger jack cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger jack cylinders to the stowed position. Replenish the reservoir hydraulic oil level as necessary.
12. Repeat Steps 10 and 11 for the remaining two outrigger cylinders.
13. Disconnect the return line from the telescope cylinder and fully extend the boom.
14. Connect the return line and retract the boom. Replenish the reservoir hydraulic oil level as necessary.
15. Disconnect the return lines from steer cylinders and turn the wheels to the extreme right.
16. Connect the return lines and turn the wheels to the extreme left and then back to center. Replenish the reservoir hydraulic oil level as necessary.
17. Raise the crane on outriggers.
18. Disconnect the return line from the main hoist motor and fully hoist up the hoist.
19. Connect the return line to the main hoist motor and fully hoist down the hoist, then hoist up again. Replenish the reservoir hydraulic oil level as necessary.
20. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
21. Connect the line to the swing motor, then drive the swing motor in the opposite direction until the boom is centered and forward. Replenish the reservoir hydraulic oil level as necessary.

CAUTION

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

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

Removing Air From the Hydraulic System

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

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

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

CAUTION

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

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

CAUTION

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

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

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

Parts Replacement

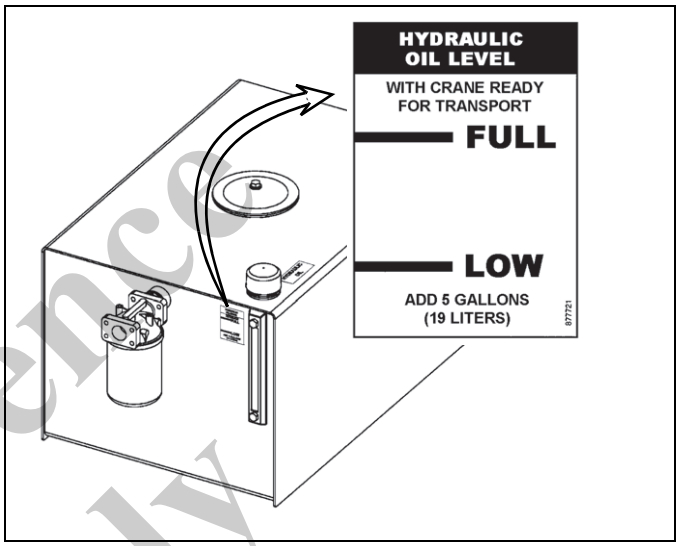
Parts found damaged or out of tolerance when maintenance is being performed should be replaced. Refer to the National Crane Parts Catalog for proper replacement parts.

Maintenance Records

Dated records must be kept for inspection of critical components such as, brakes, crane hooks, wire ropes, hydraulic cylinders and relief valve pressure settings. These records must be kept where they can be easily obtained and reviewed.

Hydraulic Oil Reservoir

The hydraulic oil reservoir has a sight gauge located on the side of the reservoir. This sight gauge has a decal beside it that indicates a “full” level and an “add oil” level. The oil required to bring it from the “add” line to the “full” line is 5 gallons. Do not fill the reservoir above the “full” line. The oil level should be checked with the crane parked on a level surface, in the transport condition (all cylinders retracted and boom stowed) and the oil cold.



Hydraulic Filter

Return oil filtration has been designed to handle the maximum system flow and to protect the hydraulic system components.

The filter is mounted on the oil reservoir, and is a replaceable canister type return oil filter. The filter must be serviced with National Crane replacement elements at recommended intervals to assure the warranty remains in force.

Oil Cooler Service & Maintenance (Optional)

The heat exchanger must be kept clean to allow for efficient operation of the cooler system. Frequent washing of the heat exchanger core will eliminate oil film, road dirt and other foreign object buildup on the heat exchanger fins which reduces cooling efficiency.

Frequent inspection and tightening of hose clamp line connections will eliminate the possibility of end connection failure due to back pressure from cold startup.

If cooler system fails to provide adequate performance, reduced air or oil flow through the heat exchanger is the probable cause. The cooling fan should be inspected for proper operation. Any obstructions to air flow should be

corrected (cooler too close to other truck components, foreign matter in heat exchanger fins, etc.). All hydraulic lines should be periodically checked for obstructions, hose kinks or other flow restrictions.

SERVICING THE CONTROL VALVES

Disassembly And Reassembly Of Control Valves To Replace Seals

NOTE: For clarification, the inlet cover containing the main relief is called the left side of the valve assembly.

1. Before disassembly, numerically mark each valve for correct reassembly.
2. Remove three stud nuts from the end section.
3. Remove valve sections by sliding from assembly studs.
4. If valve sections are to be added or removed, use the proper length stud.

NOTE: Use assembly nuts, three required, with all assembly studs. No lockwashers! All studs are stress-proof material and should be replaced only with original equipment replacement parts.

5. Thoroughly clean o-ring counterbores and ground surfaces of each section.
6. Replace the four o-rings for crane valve, the three o-rings for the winch valve, and seals. There are two seals per section. Buna-N seals are standard.
7. Replace the valve sections on assembly studs in the same order in which they were removed.

NOTE: Use care in replacing valve sections to avoid dislodging o-rings from counterbores.

8. When all valve sections are positioned on assembly studs, replace stud nuts and tighten evenly to 32 ft-lb (43 N.m) torque for crane valve and 25 ft-lb (34 N.m) torque for winch valve.

NOTE: If stud nuts are not tightened to the proper torque, valve spools may bind or stick, or cause section seals to extrude.

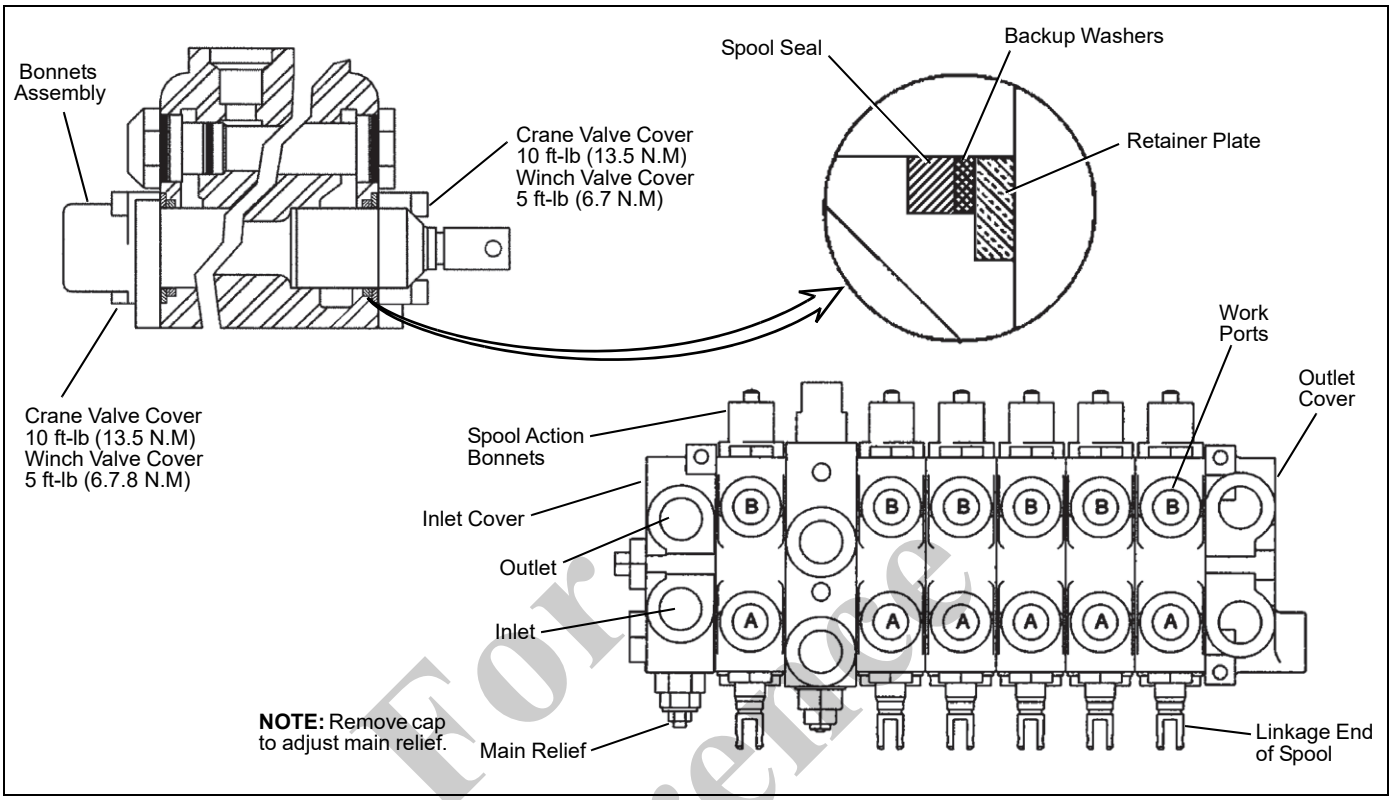
Replacing Spool Seals

Valve sections and covers are identified by numbers cast into the body.

1. Remove bonnet assembly parts from back of valves and keep in order of disassembly.
2. Remove all parts connected to the spool on the front of the valve.

NOTE: Do not remove the spool because the seals can be replaced externally. To prevent the spool from turning, insert a screw driver through clevis slot. Do not hold the spool with a wrench. This will destroy the finish.

3. Remove retainer plate, retainer plate washers, back-up washers, and spool seals.
4. Thoroughly clean counterbore.
5. Lightly oil new seals. Slide over valve spool and insert in seal counterbore.



Unloader Valve Service

Refer to ATB System Diagnosis if an electrical problem has occurred.

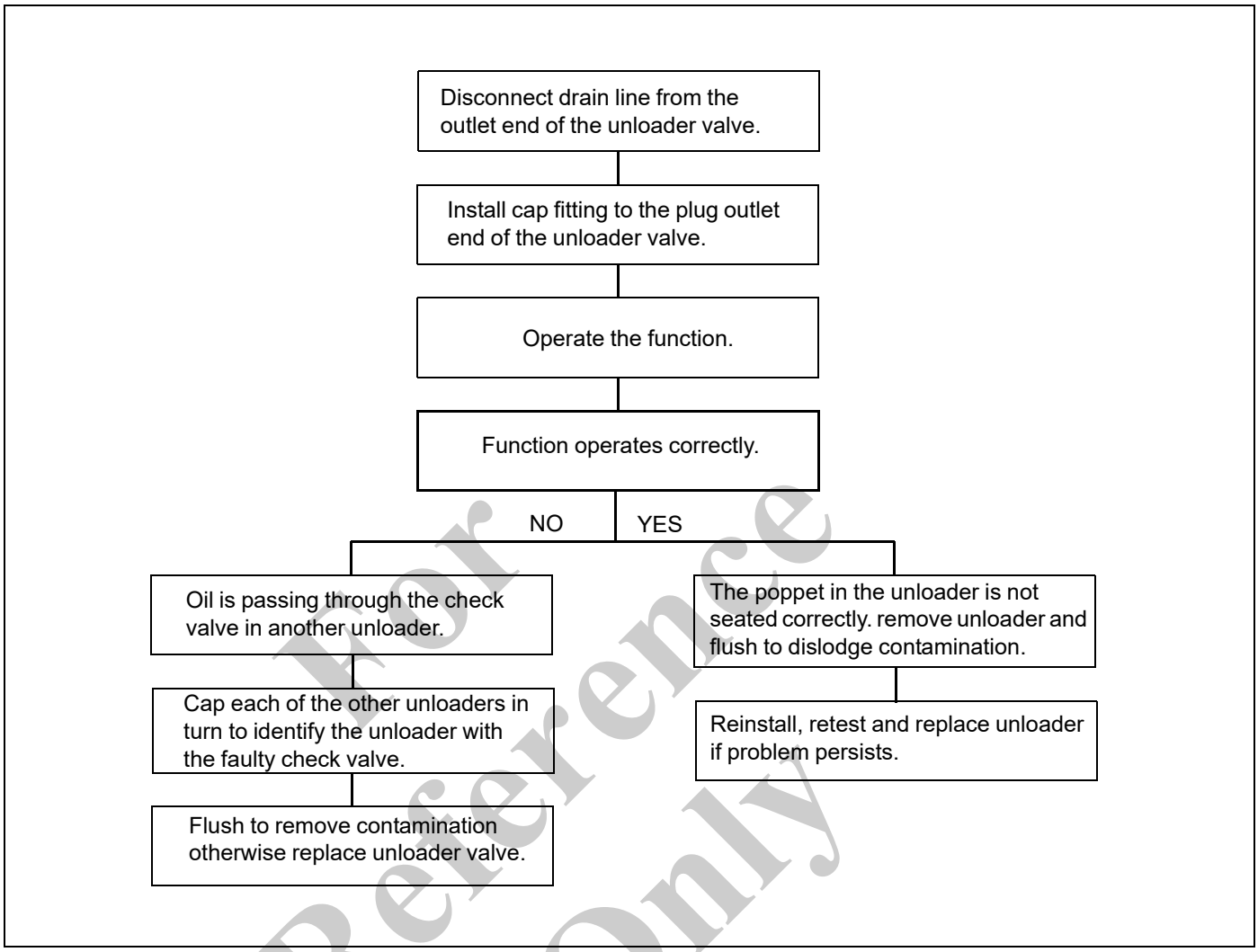
This crane has three work sections equipped with unloader (dump) valves. The functions connected to the unloader valves are winch up, boom down and boom extend. The purpose of these unloaders is to stop control oil from reaching the functions in the event of a two-block occurrence or overload condition. Hydraulic lines extend between the unloader valve on each of these sections to a single solenoid (dump) valve. The hydraulic oil in these lines can drain out over a period of time, when the pump is not engaged, or may be lost during servicing the unit. Air may enter these lines at such a time. If the unloader hydraulic lines have air in them, these three functions may not operate or may exhibit a delay in their operation.

NOTE: Internal parts of the unloader valves are not serviceable.

In the event that one of these three functions do not operate or operates with a delay and the crane is not overloaded or two-blocked, the following air purging procedure should be followed. If no improvement is seen after completing the following procedure twice, follow the troubleshooting steps outlined for checking and inspecting the solenoid valve and unloaders in this hydraulic circuit outlined below.

1. Purposely trip the ATB switch to open the solenoid (dump) valve.
2. Operate winch up, boom down and boom extend separately for about a minute, longer if the oil is cold.
3. Operate all three functions simultaneously.
4. Release the ATB switch.
5. Check the operation of each function.
6. Repeat procedure if necessary.

In the event that one of these three functions will not operate and the crane is not overloaded or two- blocked, the following procedure is used to diagnose the problem.



CONTROL VALVE RELIEF ADJUSTMENT

The control valves supplied on this crane are equipped with adjustable relief valves. After some time of use, it may be necessary to make some adjustment in pressure because of spring weakening, etc. The relief valves are adjustable only through a specific pressure range.

Both the inlet and mid-inlet of the main control valve and inlet of the winch valve have screw adjustable main relief valves. Turning the relief in increases pressure relief setting; turning the relief out decreases pressure relief setting.

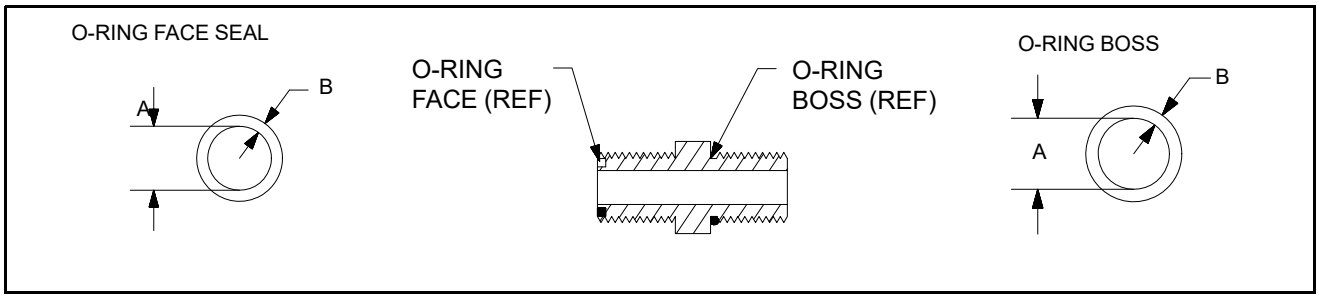
The turn circuit pressure can be checked by plugging a port on the turn motor with a pressure gage. The pressure on the main control valve stack should be checked by booming the lift cylinder down against the end of the cylinder stroke. The winch circuit pressure can be checked by plugging a port on the winch motor with a pressure gage.

Some valve sections include work port reliefs. The work port reliefs are shim adjustable. Adjustment is made by adding or taking out shims. Adding a 0.010 shim will increase pressure 100 psi (0.68 MPa). See “Specifications” section for correct pressure settings.

Never set pressure above recommendations.

WARNING

If the machine does not perform properly at these pressures, the problem is not the relief valve and no attempt should be made to readjust the setting. It the relief valves are set to higher pressures than those listed above, the warranty on the machine is void. Also the machine could operate in a manner such as to endanger personnel safety.



O-RING FACE SEAL			FITTING SIZE		O-RING BOSS		
THREAD SIZE	B inches (mm)	A inches (mm)	TUBE O. D.	MFGR 'S SIZE CODE	A inches (mm)	B inches (mm)	THREAD SIZE
9/16-18	0.07 (1.78)	0.301 (7.64)	0.250	4	0.351 (8.92)	0.072 (1.83)	7/16-20
11/16-16	0.07 (1.78)	0.364 (9.24)	0.375	6	0.458 (11.63)	0.078 (1.98)	9/16-18
13/16-16	0.07 (1.78)	0.489(12.42)	0.500	8	0.644 (16.36)	0.087 (2.21)	3/4-16
1-14	0.07 (1.78)	0.614 (15.60)	0.625	10	0.755 (19.18)	0.097 (2.46)	7/8-14
1 3/16-12	0.07 (1.78)	0.739 (18.77)	0.750	12	0.924 (23.47)	0.116 (2.95)	1 1/16-12
1 7/16-12	0.07 (1.78)	0.926 (23.52)	1.000	16	1.171 (29.74)	0.116 (2.95)	1 5/16-12
1 11/16-12	0.07 (1.78)	1.176 (29.87)	1.250	20	1.475 (37.46)	0.118 (3.00)	1 5/8-12
2-12	0.07 (1.78)	1.489 (37.82)	1.500	24	1.720 (43.69)	0.118 (3.00)	1 7/8-12
NOTE: Contact your National Crane Distributor or Manitowoc Crane Care for O-Ring boss seal kits.							

SECTION 3
ELECTRIC SYSTEM

SECTION CONTENTS

Anti-two Block System Description 3-1
Anti-two Block Operation 3-1
Anti-two Block Internal Wire Repair 3-2
Three Section Boom ATB Wire Repair 3-2
Alternative #1 3-2
Alternative #2 3-3
Hydraulic Capacity Alert System 3-4
HCA Maintenance & Repair 3-4
HCA System Adjustment 3-4
Jib Load Limiting Device 3-5
Single Character Display 3-5
Jib Load Limiting Device Troubleshooting 3-6
Outrigger Monitoring System (OMS) (Optional—Standard in North America) 3-6
Operation 3-6
Maintenance 3-6
Remote Control 3-9
Safety 3-9
Danger Remote Start Hazard 3-9
Operation 3-9
Hydraulic System Description 3-10
Service and Maintenance 3-10
Troubleshooting, Repair and Replacement 3-10
Installation 3-11
Radio Remote Controls 3-11
Safety 3-11
Operation 3-11
Service and Maintenance 3-11
Quick Test for Receiver Antenna and Cable 3-12
Troubleshooting 3-12
Specifications 3-13
Installation 3-13

ANTI-TWO BLOCK SYSTEM DESCRIPTION

The anti-two-block system provided on your National Crane can help prevent cable damage by sensing the position of the hoist cable end attachments with respect to the sheave case and disabling the functions that can cause a two block condition.

The anti-two-block system consists of normally open, work port unloader valves in the main and hoist control valves. When the cartridge solenoid is energized, the crane functions normally, when de-energized, the oil to the boom extend, boom down, and hoist up crane functions are diverted to tank. These solenoids are controlled by a limit switch, which is attached to the boom or jib sheave case. This switch is held in the closed position by a chain suspended weight. The weight, which is looped around the hoist cable, causes the contacts to remain closed until the hoist cable end attachments contact the weight and release the tension on the switch. At this point the contacts in the switch open, breaking electrical continuity through the circuit provided by the internal anti-two-block cord routed through the boom. When this continuity is broken, the unloader cartridges de-energize and divert the function oil to tank. An indicator light is provided on the control console to alert the operator when a two-block condition is detected.

On machines equipped with an optional Rated Capacity Limiter (RCL) System, the anti-two-block system is integral with the RCL wiring and display. An audible, visual warning of the two block condition is provided in the display console. See RCL Operators Handbook for additional information.

Normal functioning is restored by hoisting down (or retracting boom) until the weight is once again suspended freely. Occasionally if the hoist up and boom extend functions are operated at maximum speed in the dump mode, the back pressure induced in the circuit will cause the hoist up or boom extend functions to creep slightly (with no load on the hook). Such a condition is not cause for alarm, as the back pressure is not of sufficient magnitude to damage the cable or end connections.

Anti-two Block Operation

The internal anti-two-block wire is routed from the control console to the hoist mount end of the boom, following the path of the extend cables to the rear of the 3rd section boom. This is the length of the wire that proportions in and out with the boom length, similar to the route of the extend cables. At this point at the rear of the 3rd section, the wire loops around and anchors at the anti-two-block cable clamp on the extend cable anchor. The anti-two-block wire, now attached at the rear of the 3rd, runs the length of the section and attaches to

the 3rd section sheave case. The wire then loops around the clamp arrangement on the sheave case and routes through access holes in the side plate of the boom. The wire terminates at a quick connect three conductor plug designed for anti-two-block switch or jib interface.

ANTI-TWO BLOCK INTERNAL WIRE REPAIR

In the event of a break in continuity of the anti-two-block wire routed internally in the boom, the anti-two-block hydraulic system will sense a problem and make certain crane functions inoperative. Before repair or replacement of internal wire, check for continuity loss at the anti-two-block switch, damaged, missing, or corroded connectors and overall system condition. Due to the environmental exposure of the system, a thorough check of the circuit should be performed.

The procedure for removal and reinstallation of the anti-two-block wire can be accomplished using two different methods depending on the severity of the damage. Alternative #1 should be used if the wire has experienced a continuity failure in one or both of the conductors, but the rubber jacket of the wire is still intact. Alternative #2 is to be used if the wire has been completely cut or either end of the wire is inaccessible.

THREE SECTION BOOM ATB WIRE REPAIR

WARNING

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations

Alternative #1

This procedure pulls the replacement wire through the boom, following the path of the defective wire.

Special tools or equipment:

- Two end-to-end electrical butt connectors
- Shrink tube or electrical tape

Proceed as Follows:

1. Retract boom completely.
2. Loosen and remove capscrew and cable clamp arrangement from sheave case attachment point of anti-two-block wire. Remove quick connect plug on anti-two-block wire by unscrewing base of plug and disconnecting individual wires from connections. Note pigtail length at this time and wire / terminal number location for proper reassembly.
3. Pull end of anti-two-block wire through side plates of 3rd section boom to gain in-line wire path.
4. Attach replacement anti-two-block wire to damaged wire with a temporary splice, securing the conductors with end to end butt connectors and shrink tube or electrical tape. This connection must be secured well enough to pull the new wire through the boom.
5. At the hoist mount end, reach into the rear of the boom and loosen the capscrew on the anti-two-block cable clamp enough to let the cable run around it with minimal effort. This clamp is located on the extend cable anchor.
6. Disassemble spade bolt anchor attaching anti-two-block wire to the extend cable plate on the hoist mount end of the boom.
7. Pull wire from hoist mount end. Replacement wire temporary splice may need assistance reeving around anti-two-block cable clamp in rear of 3rd section. If excessive force is needed to pull wire through, observe wire routing and make adjustments as needed to avoid breaking temporary splice. If splice fails at this point, wire routing Alternative #2 should be used.
8. Pull wire through boom, leaving enough wire on sheave case end to properly attach and terminate wire.
9. Tighten anti-two-block wire clamp located in rear of 3rd section.
10. Route sheave case end of anti-two-block wire around clamp in sheave case, and through holes in side plates. Pulling on this end will tension the static length of anti-two-block wire clamped in the 3rd. Approximately 15-25 lb (6-11 kg) will be sufficient to provide proper operation. Tighten sheave case anti-two-block wire clamp.
11. Reassemble quick disconnect plug to anti-two-block wire. Proper wire attachment is critical for proper anti-two-block system operation.Consult electrical schematic in this book for proper connector wiring.
12. Temporary splice should now be approximately 10 feet (3 m) past the hoist mount end of the boom. Break splices and slide strain relief/cord grip onto wire, into approximate position inside the boom.
13. Assemble spring and spade bolt to cord grip and reassemble anchor components to extend cable anchor plate on the hoist mount. Slide cord grip up anti-two-block wire into boom to increase spring tension on moving length of anti-two-block wire. Approximately 2" (50 mm) of spring extension tension should be adequate for proper operation.
14. Visually inspect interior routing of anti-two-block wire for excess slack in wire, inaccurate routing of wire, etc. correct any problems before boom operation.

Alternative #2

This procedure is to be used for anti-two-block wire replacement in the event of a complete separation of the wire, or the inability to access one or both of the ends outside the boom assembly. This procedure routes a new anti-two-block wire through the boom without having an existing wire to pull it through (Alternative #1).

Special tools or equipment:

- Electrical tape
- Installation tool

To route the wire the entire length of the boom, a long tube, to be used as a installation tool, must be utilized to transport the end of the anti-two-block wire from one end of the boom assembly to the other. A telescopic grease applicator for the boom, hydraulic tubing or electrical conduit are all possibilities for an installation tool. The installation tool should be at a minimum 2' (61cm) longer than the retracted boom assembly.

1. Retract boom completely.
2. Loosen and remove anti-two-block cable clamp arrangements from sheave case and 3rd section extend anchor. Remove spade bolt anchor from extend cable anchor plate in the hoist mount end of boom.
3. Remove quick disconnect plug on anti-two-block wire by unscrewing base of plug and disconnecting individual wires from connections. Note pigtail length at this time, and wire/terminal number location for proper reassembly.
4. Pull anti-two-block wire out of boom assembly. Visually inspect boom interior from both ends to verify all the cable has been removed from the boom. Visually inspect center sheave on extend cylinder for damage.
5. Start installation of replacement wire on the sheave case end of the boom assembly. Using electrical tape, attach one end of replacement wire to the end of the installation tool.
6. Insert installation tool and wire into sheave case in the center open area between the sheave case side plates. Visually guide the wire and installation tool over the center sheave on the extend cylinder sheave case.
7. Push installation tool and wire through boom until it appears at the hoist mount end, detach wire from installation tool, route wire through open top of hoist mount and temporarily tie off to a convenient anchor point. Pull installation tool out sheave case end of boom.
8. From sheave case end of boom, attach other end of replacement wire to installation tool with electrical tape. Insert installation tool and wire into the boom sheave case, in the open area between the sheave case side plates. Visually guide this end under the center sheave on the extend cylinder sheave case.
9. Push installation tool and wire through boom until it appears at the hoist mount end. Do not detach wire from installation tool.
10. From hoist mount end of boom, locate installation tool and attached wire, and pull the wire out of the boom section, removing the slack loop from the sheave case end of the boom. This will place the wire close to, if not on the center sheave of the extend cylinder.
11. Move to the sheave case end of the boom. Visually determine if the wire has properly located itself onto the sheave. If not, manipulate the wire placement through the end of the boom and place the wire on the sheave. A 5' (1.50 m) long access tool (hook end) will simplify this procedure greatly.
12. From the hoist mount end of the boom, assemble the anti-two-block wire clamp on the extend cable anchor in the rear of the 3rd section. Loop anti-two-block wire around clamp and lightly tighten capscrew holding clamp together. Keeping a slight amount of tension on the wire at this point will keep the wire properly located on the sheave.
13. From the sheave case end, pull the installation tool and wire end out of the boom. The route of the anti-two-block wire in the boom is now complete.
14. Pull wire at either end of boom to adjust length of wire on sheave case end to properly attach and terminate wire.
15. Tighten anti-two-block wire clamp located in rear of 3rd section.
16. Route sheave case end of anti-two-block wire around clamp in sheave case and through holes in side plates. Pulling on this end will tension the static length of anti-two-block wire clamped in the 3rd. Approximately 15-25 lb (7-11 kg) will be sufficient to provide proper operation. Tighten sheave case anti-two-block wire clamp.
17. Reassemble quick disconnect plug to anti-two-block wire. Proper wire attachment is critical for proper anti-two-block system operation. Consult electrical schematic in this book for proper connector wiring
18. From hoist mount end of boom, slide strain relief/cord grip onto wire, into approximately position inside the boom.
19. Assemble spring and spade bolt to cord grip and reassemble anchor components to extend cable anchor plate on the hoist mount. Slide cord grip up anti-two-block wire into boom to increase spring tension on moving length of anti-two-block wire. Approximately 2" (50 mm) of spring extension tension should be adequate for proper operation.

20. Visually inspect interior routing of anti-two-block wire for excess slack in wire, inaccurate routing of wire, etc. Correct any problems before boom operation.

HYDRAULIC CAPACITY ALERT SYSTEM

This hydraulic capacity alert system uses the work port unloader solenoids in the anti-two-block system as the hydraulic system dump circuit.

The hydraulic capacity alert system has an override switch and button located on the operator's console that momentarily overrides the hydraulic capacity alert and anti-two-block systems and restores power to crane functions.

When trip pressure is reached, the pressure sensing switch breaks electrical continuity to the work port unloader solenoid in the main control valve.When power is removed from this solenoid, the unloader valves allow the oil flowing to hoist up, telescope out and boom down to flow to tank. This path to tank will prevent further operation of these functions. When the overload condition is corrected by hoisting down, retracting the boom, or raising the boom, the pressure sensing switch allows the work port unloader solenoids to be powered thereby allowing the crane to function normally.

HCA Maintenance & Repair

The following step-by-step analysis will be helpful in isolating and correcting almost every service problem if followed in a step-by-step systematic manner. Use this information with the Hydraulic Schematic and the Illustrated Parts Catalog to identify parts and follow flow paths. Start at top box and work downward step by step. Do not try to start in the middle or skip steps.

1. Refer to Hydraulic Schematic and System Description to gain a thorough understanding of the capacity alert system before proceeding with any maintenance.
2. System adjustment must be checked every three months for accuracy. Refer to the preceding section on System Adjustment.
3. Always be sure the boom is adequately supported and no hydraulic pressure remains in the lines before the pilot pressure line fittings are loosened.

HCA System Adjustment

The hydraulic capacity alert system should be checked for proper adjustment during initial crane start-up and quarterly thereafter. The procedure for proper adjustment should be performed as follows:

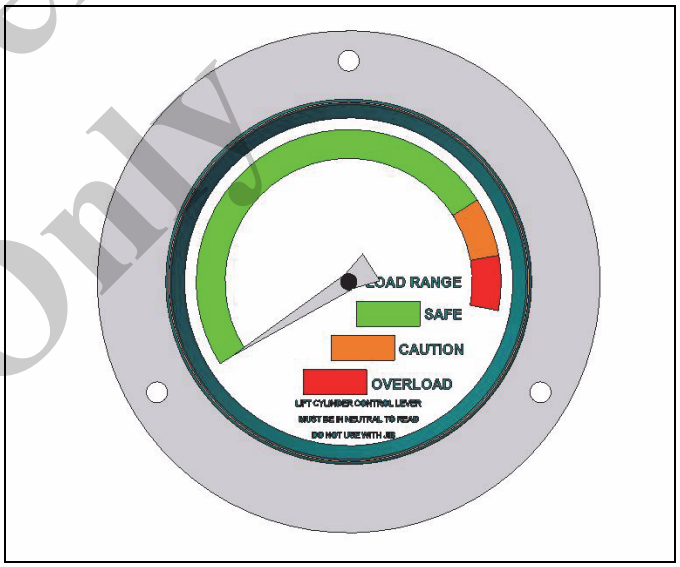
NOTE: Trapped air must be bled from the system before adjustments are made.

1. Remove the console cover on the operators console.

WARNING

Before loosening any fittings, support the boom.

2. Start the truck and set the crane up for operation as prescribed in the Operators Manual.
3. Select a test weight that is equal to crane capacity at an intermediate boom length and radius.
4. Work with loads which have loaded boom angles near 30°. Starting with the boom at the chosen reference angle and a radius less than the chosen radius, pick the weight up with the hoist and begin extending the boom.
5. As the boom is extending, lower the load with the hoist to keep the load near the ground.
6. Monitor the load range gage located in the console as the boom is extending. The gage is plumbed directly into the lift cylinder pilot line and the pressure reading should increase to what is defined as capacity load pressure as the selected intermediate boom length and radius is reached.



7. The intermediate boom length is determined by a line and corresponding dimension decal on the side of the second section boom. The chosen radius is measured from the centerline of rotation to the loadline.
8. If the gage reading does not increase while extending, lower the load to the ground and check the system plumbing according to the hydraulic schematic. Re-plumb the system according to the schematic and illustrated parts page or replace faulty pressure gage.

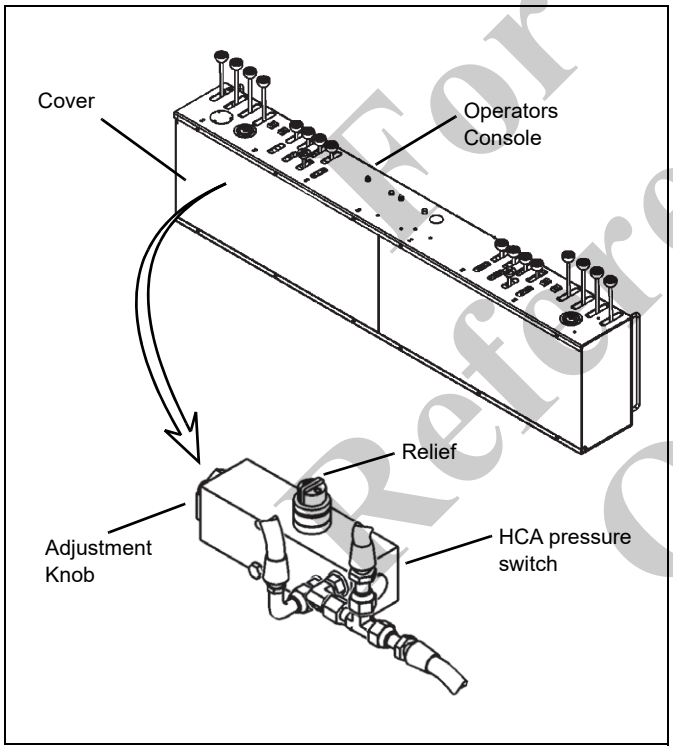
.

WARNING

Before loosening any fittings, support the boom.

9. When the pressure reaches capacity load pressure, the overload system should activate and boom extension will stop. This is defined as trip pressure. This point should be at or very close to the red/yellow color change on the load range gage.

10. Trip pressure should be reached as the boom extension reaches the chosen radius. If the overload system trips before the chosen radius is reached or allows extension beyond the chosen radius, adjustment is required. If the system is activated before trip pressure is reached, lower the load and turn the knurled collar on the HCA pressure switch clockwise to increase trip pressure.



11. When the gage reaches trip pressure, turn the setscrew counterclockwise until the system solenoid is deactivated and tighten the locking nut.

12. Retract the boom until the pilot pressure is reduced enough to reactivate the system solenoid. The hydraulic capacity alert indicator light will go out when the solenoid is reactivated.

13. Check the trip pressure setting by extending the load until the chosen radius is reached. As the chosen radius is reached, the system solenoid should be deactivated and the indicator light should come on. Readjust switch head if trip pressure is not correct.

14. Once proper adjustment is verified, return the boom to a firmly supported position, stop the truck engine and replace covers.

JIB LOAD LIMITING DEVICE

The jib load limiting device is an electromechanical maximum capacity sensing system that stops normal crane functions which cause an overload condition when the maximum capacity of the jib is exceeded. In the event that an over capacity condition occurs, the jib load limiting device is actuated by a load cell which causes the boom down, extend out, and hoist up functions to become inoperative. On jibs with a manually extendable section, a configuration switch operated by the extension retaining pin distinguishes between an extended jib and a retracted jib. This system allows for continued operation of the hoist down, boom up, and boom retract. This allows the operator to bring the load to a shorter operating radius or set the load down in order to eliminate an overload condition. Once the overload has been reduced, normal operation can be resumed. This system uses the work port unloader solenoid in the anti-two-block system as the hydraulic system dump circuit.

When trip force is reached, the jib load limiting device breaks electrical continuity to the work port unloader solenoid in the main control valve. When power is removed from this solenoid, the unloader valves allow the oil flowing to hoist up, telescope out and boom down to flow to tank. This path to tank will prevent further operation of these functions. When the overload condition is corrected by hoisting down, retracting the boom, or raising the boom, the jib load limiting device allows the work port unloader solenoid to be powered thereby allowing the crane to function normally.

During operation at near capacity loads, care must be taken to operate the controls smoothly or the system may be shocked into the dump mode prematurely.

Single Character Display

The electronics box of the jib load limiting devices equipped with a single character display that provides the following information:

- startup codes
- table number selected
- current load reading
- current limit value
- error codes
- current angle reading.

On power-up, the unit first displays the startup codes. The startup codes can be a sequence of up to four single digits, but is usually be only one digit which is a "2". Each number is displayed for 1/2 second. The codes are:

- (1) Indicates the unit is being initialized. This only happens the first time the unit is powered up after it is programmed.
- (2) Indicates that the previously stored table is being erased. This is displayed when the unit is powered on and the switches are not set for the new table numbers.
- (3) This is displayed only before a new table number is stored. The “2” is displayed first.
- (8) The switches are set up with the new table number and the old number is erased. On the next power on, the new table number is read in and stored.

After the startup codes, the table number is displayed in the form of three sequential single digits. The first digit is always zero. The digits are be displayed for about 1 second each.

After the table number is displayed, the display starts to sequence through the following information. After reaching the end of the sequence, the display starts again at the current load reading.

- Current load reading (lbs.):
  - 4 digits, decimal point on
- Current limit value (lbs.):
  - 4 digits, decimal point flashing
- Error codes (only if an error exists):
  - 4 digits, first and last digits are blanks.
  - 0-invalid table number,
  - 1-load readings higher than the limit.
- Current angle reading:
  - 4 digits, decimal point off, displays in tenths of degrees.

Jib Load Limiting Device Troubleshooting

See chart in Section 8 of this manual.

OUTRIGGER MONITORING SYSTEM (OMS) (OPTIONAL—STANDARD IN NORTH AMERICA)

Operation

The Outrigger Monitoring System (OMS) aids the operator in ensuring that the crane is properly setup on outriggers and stabilizers. The OMS utilizes one sensor in each outrigger and one proximity switch in each horizontally extending stabilizer to identify when the outriggers and stabilizer beams are extended to a point in which they provide maximum stability.

Maintenance

Outrigger Cylinder Length Sensor (Version 1)

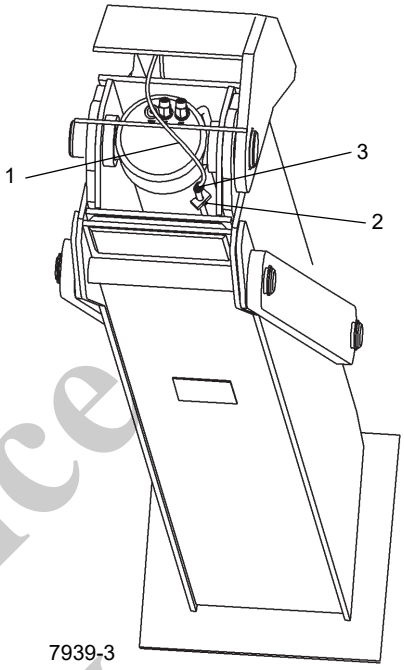


FIGURE 3-1

Remove

1. Fully retract outriggers.
2. Disconnect electrical connector (1, Figure 3-1) at sensor.
3. Remove setscrews (2, Figure 3-1) securing sensor holding plate.
4. Slide sensor (3, Figure 3-1) out of sensor holding bracket.

Install

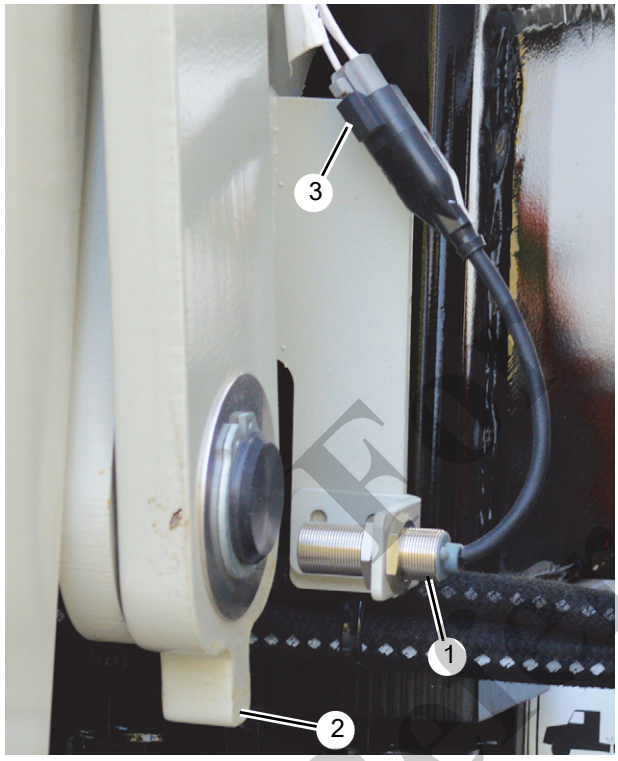
1. Fully retract outriggers.
2. Slide sensor (3, Figure 3-1) into holding bracket.
3. Using the two setscrews (2, Figure 3-1) and sensor holding bracket, secure sensor to the hydraulic cylinder.
4. Connect electrical connector (1, Figure 3-1) to sensor.
5. Calibrate sensor; refer to *Calibrate*, page 3-6.

Calibrate

Calibrating the cylinder length sensor requires a laptop equipped with the HED Conductor software and a USB cable connector (p/n 80009992). Contact your National Crane distributor for further assistance.

Outrigger Proximity Switch (Version 2)

On newer versions of the crane, the OMS and RCL use proximity switches to determine if the outriggers are fully extended. The switches are located between the operator's cab and A-frame outriggers. The proximity switch (1, Figure 3-2) uses a tab (2) on the outrigger arm to determine when the outrigger is fully extended.



9365
For illustration purposes only.
Your crane may differ.

FIGURE 3-2

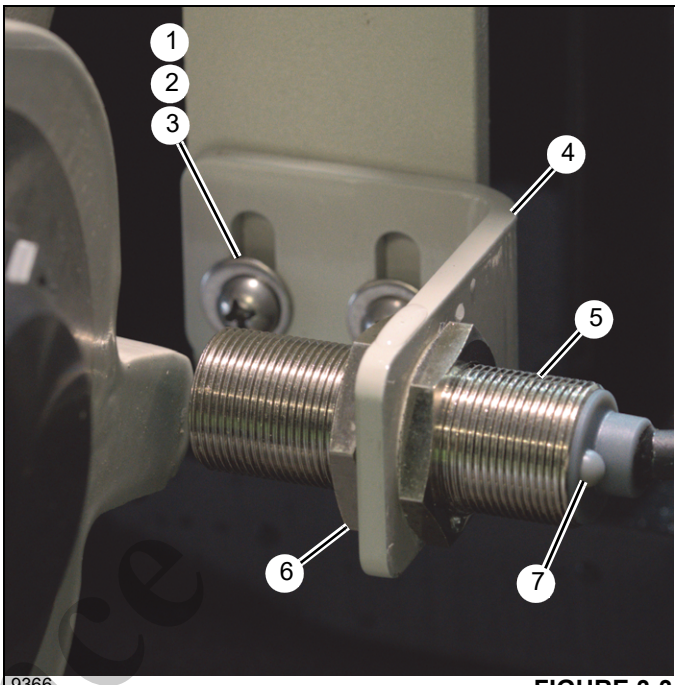


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FIGURE 3-3

Remove

1. Fully retract the outriggers.
2. Disconnect the proximity switch (1, Figure 3-2) and sensor plug (3).
3. Remove capscrews (1, Figure 3-3), lockwashers (2), and nuts (3) to remove plate (4) and proximity switch (5) from chassis.
4. Loosen jam nuts (6) and remove proximity switch (5) from plate (4).

Install

1. Fully retract the outriggers.
2. Install proximity switch (5) on plate (4) using two jam nuts (6).
3. Install switch (5) and plate (4) on chassis using capscrews (1), lockwashers (2), and nuts (3).
4. Connect proximity switch (Figure 3-2) to sensor plug.

NOTE: The proximity switch should be a maximum of 6.4 mm (0.25 in.) from the outrigger tab.

5. With power on, fully extend the outriggers. When active, the LED light (7) on the proximity switch illuminates constant yellow. Depending on how the vehicle is equipped, verify that the proximity switch output is working as follows:

   - If equipped with Outrigger Monitoring (OMS) and HCA systems, make sure the outrigger status indicator on the operator's console turns from

constant red to constant green when the outrigger is fully extended.

or

- If equipped with an RCL and OMS systems, outrigger status is shown on the QScale monitor. Make sure all outrigger status symbols turn from red to green when the outriggers are fully extended.

Stabilizer Proximity Switch (Version 1)

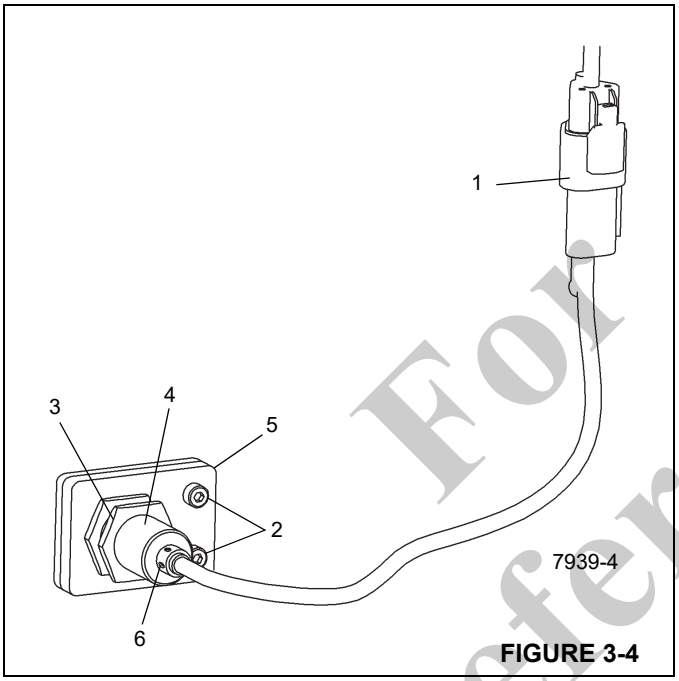


FIGURE 3-4

Remove

1. Disconnect electrical connector (1, Figure 3-4) at switch.
2. Remove the two screws (2, Figure 3-4) securing the mounting bracket/switch assembly to the stabilizer box.
3. Loosen jam nut (3, Figure 3-4) securing switch (4) to mounting bracket; remove switch.

Install

1. Fully extend stabilizer beam.
2. Thread switch (4, Figure 3-4) into mounting bracket (5) so that face of switch protrudes 10 mm through bracket.
3. Using two screws (2, Figure 3-4), secure mounting bracket/switch assembly to stabilizer box.
4. Tighten jam nut (3, Figure 3-4) on switch.
5. Connect electrical connector (1, Figure 3-4) to switch.
6. With power on and stabilizer beam fully extended, ensure LED (6, Figure 3-4) on proximity switch illuminates; retract stabilizer beam and ensure LED is not illuminated.

Stabilizer Proximity Switch (Version 2)

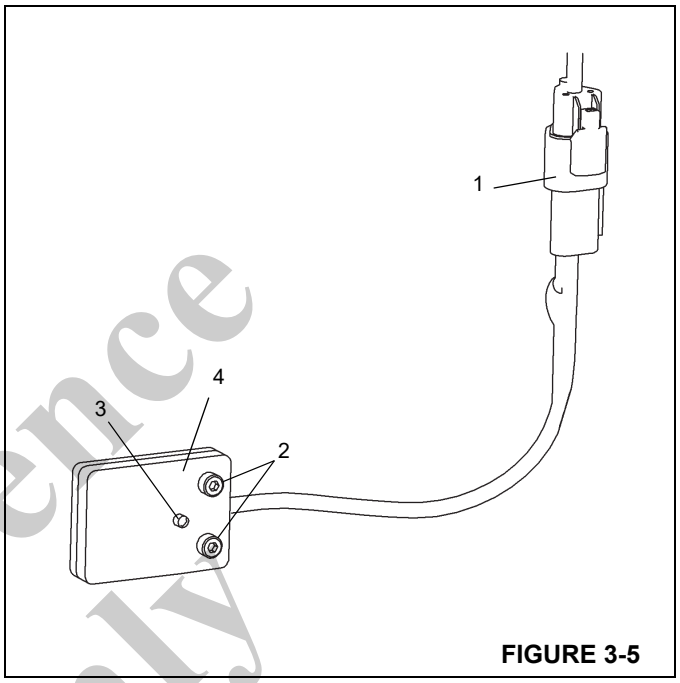


FIGURE 3-5

Remove

1. Disconnect electrical connector (1, Figure 3-5) at switch.
2. Remove the two screws (2, Figure 3-5) securing the switch (4) to the stabilizer box; remove switch.

Install

1. Fully extend stabilizer beam (horizontally).
2. Using two screws (2, Figure 3-5), secure the switch (4) to stabilizer box.
3. Connect electrical connector (1, Figure 3-5) to switch.
4. With power on and stabilizer beam fully extended, ensure LED (3, Figure 3-5) on proximity switch illuminates; retract stabilizer beam and ensure LED is not illuminated.

REMOTE CONTROL

Safety

DANGER

This crane is not insulated. The remote control provides no protection against the electrocution hazard. Do not operate near live electrical power lines. All warnings in the Safety and Operation Section of this manual and on the crane relative to operating and safety procedures and power line clearances must be observed when using the crane remote control.

The remote control system offers an excellent solution to safety, speed and ease of use, less downtime, and overall maneuverability. Like any device, there are precautions and common sense that work hand in hand to assure safe and reliable operations.

Never allow any operation until the operator has read all instructions and has become completely familiar with the total system. Should **anything** happen unexplained, unpredicted, or incorrect operation, immediately shut down the complete system and investigate! This includes shutting down all electronics, hydraulics, power take-offs, and engines. **Never** resume operation until the problem has been corrected!

Danger Remote Start Hazard

DANGER

Starting truck engine with drive train engaged will cause unexpected movement of the truck resulting in death or serious injury.

Do not install remote start relay on any chassis that can be started while transmission is in gear.

Before a remote start relay can be installed, the chassis must be equipped with a switch that prevents the engine from starting while the transmission is in gear.

The remote start relay has been intentionally supplied separately from the rest of the remote engine compartment wiring. Before installing the remote start relay on any chassis, the installer must verify that the chassis can not be started while the transmission is in gear. The remote start relay is only to be installed on a chassis that is equipped with a switch (neutral safety switch) that prevents the engine from starting while the transmission is in gear. A chassis not equipped with or that can not be equipped with a neutral safety switch will not have the start relay installed and therefore can not be started with the radio transmitter only.

DANGER

Starting truck engine with drive train engaged will cause death or serious injury.

Do not start truck engine unless drive train is in neutral.

Before attempting to start truck with remote control make sure the drive train is in neutral.

When not using the remote control, disconnect power to the remote control system with the selector switch installed in the truck cab. This will prevent inadvertent operation of the crane if the hand control is operated. Protect and monitor the hand control unit to prevent damage and unplanned operation.

Operation

1. Position crane at job site, set park brake, and shift transmission to neutral.
2. Start truck from inside truck cab.
3. Engage P.T.O.
4. Set outriggers.
5. Stop truck engine.
6. Connect hand control cord to receptacle on crane. (If equipped with hard wire remotes).
7. Turn Hydraulic Capacity Alert/RCL and Remotes/SLP power switches ON - in truck cab.
8. Starting truck for remote operation:

- If truck is equipped with the remote start relay (see warning before installing start relay), then activate ignition/start switch on hand control to start truck.
- If truck is not equipped with remote start relay; then activate ignition/start switch on hand control to the ON position and start truck with the ignition switch in the truck cab.

9. Set engine throttle control if not equipped with automatic throttle advance.
10. Actuate desired crane function switch.
11. Slowly squeeze speed trigger to increase crane operating speed.
12. Slowly release speed trigger to decrease crane operating speed.
13. Release crane function switch.
14. Stow crane and shut off hand control ignition/start switch.
15. Turn Hydraulic Capacity Alert/RCL and Remotes/SLP power switches OFF - in truck cab.

16. Disconnect hand control and store in truck, (If equipped with hard wire remotes).
17. Start truck from inside of cab.
18. Stow outriggers.
19. Disengage P.T.O.

Hydraulic System Description

Solenoid Valve Assembly

Flow Control Valve in Inlet Section

1. Electrically controlled priority flow control valve which can be remotely actuated to control the amount of oil flow from the inlet to the bypass or the regulated ports.
   a. Oil supply of 5 - 18 GPM is pumped to inlet port.
   b. With electrical voltage up to 2 volts on the valve coil, 0 GPM of inlet oil is directed to the solenoid valve sections and the remaining oil goes through the bypass port and into the manual control valve, then back to tank.
   c. As voltage increases linearly from 2 to 9 volts, there is a resulting linear increase of oil flow to the solenoid sections to 18 GPM maximum. Any remaining oil is directed back to tank through the bypass port.

Solenoid Valve Sections

2. An electrically actuated directional control valve which receives oil from the regulated port of the flow control valve and directs it to the various crane functions.
   a. When 12 VDC power is applied to any of the electro-magnetic coils on the valve, the resulting force pushes a spring centered spool from its neutral position to allow oil flow out the work port opposite the energized coil.
   b. Oil flow through the solenoid valve is then increased and decreased at the flow control valve to get desired crane operating speeds.
3. Pressure relief valve (part of solenoid valve) in inlet section.
   a. Protects remote control hydraulic circuit from over pressurization. Must be set to match crane manual system pressure.

Shuttle Valve

Biased shuttle valves are located in the turn and hoist functions on units equipped with remote hoist operation. They block the open oil path through the main control valve during remote operation.

Service and Maintenance

Follow the procedures outlined in the Service and Maintenance Section of the *Owner Manual* to maintain proper crane operation. The following procedure and intervals represent additional required maintenance for a crane equipped with a remote control option.

Initial Start Up

The return line oil filter cartridge should be changed after four hours of operation and then again at 12 hours of operation. After this initial break in period, normal maintenance procedures found in the crane Service and Maintenance Section of this book can be followed.

Troubleshooting, Repair and Replacement

A few of the remote control components can be repaired, all can be replaced. The following is a list of these items and recommended method of repair or replacement.

Circuit Breaker

There are two automatic resetting breakers in the system, one 15 amp under the hood that protects the entire system and a 10 amp on the frame that protects the hand control. If a breaker is opening, it is an indication that there is a short circuit somewhere in the system. It will generally stay open from 30-60 seconds.

Relays

Three 12 VDC, normally open, automotive type relays are installed under the truck hood on the ignition start and throttle advance circuits. One automotive type relay is installed in the control console on the HCA-RCL override circuit. They are used so that current through the hand control does not become excessive. These relays will occasionally fail from physical damage, corrosion or excessive current through the relay. Failure is evident when the relay will not close as power is applied to the pilot terminal or will not open when power is removed from the pilot terminal. These relays cannot be repaired and must be replaced.

Solenoid Valve

If the solenoid valve is inoperative, it is generally because of:

- Contamination in the valve.
- Not enough electrical power to operate solenoids.

The valve can be disassembled and cleaned when contamination is suspected. If voltage drops below 10.5 V at the solenoid coil, the solenoids may not operate. Defective electrical equipment on the truck will generally cause this low voltage condition. Check the truck battery, voltage regulator and generator (alternator) in this case.

Installation

1. Install the crane on the truck by following the procedures in the Installation Section of this manual.
2. The Electrical and Hydraulic Schematics show the typical connections of the remote control system.
   a. The Pump pressure line is connected to the pressure port of the solenoid valve.
   b. Install all electrical components and wires using the parts pages and electric schematic as reference for this installation. This machine is wired at the factory for a 12 VDC, negative ground electrical system. When used on other than 12 VDC systems, a suitable 12 VDC source must be provided to power the remote control. This remote control is not intended for use with positive ground systems.
   c. Mount relay assembly in engine compartment in a convenient location and connect the appropriate wires to the terminal block as shown in wiring schematic. Only install remote start relay on a chassis equipped with a switch that prevents the engine from starting while the transmission is in gear.
   d. Adjust throttle actuator so it advances engine speed to approximately 80% maximum manual operating speed.

DANGER

Starting truck engine with drive train engaged will cause unexpected movement of the truck resulting in death or serious injury.

Do not install remote start relay on any chassis that can be started while transmission is in gear.

Before a remote start relay can be installed, the chassis must be equipped with a switch that prevents the engine from starting while the transmission is in gear.

RADIO REMOTE CONTROLS

Safety

The radio remote control system offers an excellent solution to safety, speed and ease of use, less downtime, and overall maneuverability. Like any device, there are precautions and common sense that work hand in hand to assure safe and reliable operations.

Never allow any operation until the operator has read all instructions and has become completely familiar with the total system. Should **anything** happen unexplained, unpredicted, or incorrect operation, immediately shut down the complete system and investigate! This includes shutting down all electronics, hydraulics, power take-offs, and engines. **Never** resume operation until the problem has been corrected!

DANGER

Starting truck engine with drive train engaged will cause death or serious injury.

Do not start truck engine unless drive train is in neutral.

Before attempting to start truck with remote control make sure the drive train is in neutral.

When not using the remote control, disconnect power to the remote control system with the selector switch installed in the truck cab. This will prevent inadvertent operation of the crane if the hand control is operated. Protect and monitor the hand control unit to prevent damage and unplanned operation.

Always turn the truck ignition off and start the unit using the remote hand control. This will allow the truck engine to be turned off with the remote hand control. If the truck ignition is on, the stop and emergency stop functions will not function.

Operation

For operation instructions, see the *Operator Manual*.

Service and Maintenance

A premium quality 9 volt alkaline non-rechargeable battery is recommended. These batteries have a current rating of 600 milli-amps. When transmitting, current draw is 25 milli-amps. Most of the current draw when transmitting is used by the radio frequency transmitting function. The current draw for the rest of the electronics in the transmitter is in the micro-amp range. For instance, when the transmitter power switch is on and the unit is not being used, the current draw is less than one milli-amp. This means that leaving the power switch in the ON position over night will not necessarily mean that the 9 volt battery will be dead. The system requires a battery that has a minimum voltage of 7.2 volts for satisfactory operation. Rechargeable batteries are not recommended because of their poor charge memory. Their ability to take a charge tends to degrade over time.

To install the 9 volt battery, remove the battery cover on the rear of the transmitter. Removal of the battery cover is easily achieved by releasing the latch clip. Care should be taken not to use excessive force to prevent damage to the cover. Insert the battery making sure the polarity of the terminals are correct.

Transmitter

As with any electronic device, care should be taken not to subject the transmitter to excessive abuse. The radio transmitter is a very rugged instrument and will withstand normal use. The transmitter housing is made of a durable material and will serve many years of use. The toggle

switches are industrial grade, self-cleaning, environmental sealed switches. To remove dirt, grease, oil, etc., wipe with a cloth soaked with soap and water.

For those hard stains, a light alcohol based cleaner should be used. Should moisture build up inside the housing, remove the cover and allow to air dry. This process may be sped up using a blow dryer set on a low heat range.

Quick Test for Receiver Antenna and Cable

Test the antenna harness with points A, B, C, D.

- Test Point A — Inner Conductor of Connector
- Test Point B — Outer Connector Housing
- Test Point C — Larger Ring Terminal
- Test Point D — Small Ring Terminal

Using an ohmmeter set at the minimum resistance scale, make the following measurements with the antenna cable disconnected from the receiver. With one meter test lead on “A” and the other on “B”, there should be no continuity (Maximum resistance reading). Next, attach one meter lead to “A” and the other to “D”. There should be minimum resistance (near 0 ohms). The same will be true at points “B” and “C”. To do these last tests, another wire may have to be used to extend the leads.

Troubleshooting

1. Begin the process of elimination by always checking the fuse in the receiver first and then checking all wiring and connectors **(Look for dead shorts in wiring and connections).**
2. If the transmitting range drops or intermittent movement occurs when activating a function, read the following:
   - **a.** Make sure the 9 volt battery is good in the transmitter.
   - **b.** Be sure the antenna is free of vertical metal obstruction (minimum 2 feet).
   - **c.** Any excess antenna cable should not be coiled together.
   - **d.** Check antenna cable connector at the receiver. Be certain the antenna is properly installed and that there is nothing touching the bare portion of wires at the antenna connection. **(Be sure antenna is installed properly.)**
3. If a unit fails completely or if just one or two outputs are not working, check the following:
   - **a.** Remove cover on the receiver and refer to the “Receiver Printed Circuit Board” drawing, Figure 3-6, in the installation instructions.
   - **b.** With power to the receiver, the Power Indicator LED will be on. Turn transmitter power on. At this time the receiver’s RF Indicator LED will be on for 10 seconds and you will hear the power relay engage. (Anytime after transmitter power is on, a function may be activated.) To verify that the power relay is engaged and that the transmitter is transmitting, activate the emergency stop on the transmitter. This will disable the power relay and the transmitter will transmit for 10 seconds.The RF and Power Indicator LED’s will be on. During this time any toggle switch activated will only send the emergency stop signal. To reset the receiver and transmitter, turn the transmitter power off and back on. At this time the receiver’s RF Indicator LED will be on for 10 seconds (without activating a toggle on the transmitter) and you will hear the power relay engage.
     1. When a function is activated on the transmitter, two or three LED’s are turned on in the receiver: (1) RF Indicator LED, (2) Output Status Indicator LED, (3) Master Control LED (may or may not be utilized on the equipment).
     2. With power relay engaged, check each function by activating each toggle. Make sure that each of the receivers Output Status Indicator LED’s turn on. Suppose the appropriate Output Status Indicator LED doesn’t come on, read ahead through 4.
     3. If the power relay doesn’t engage, there is a possibility that the address codes are not matching. Compare the 12 position address switches in both transmitter and receiver and then repeat step 3B. If they both match and still the power relay doesn’t engage, set all 12 of the dip switches to the OFF position in both the receiver and transmitter and then repeat step 3B. At this point if the radio controller works or not, call the factory to either be assigned a new address code or to have the controller shipped back to the factory for repair.
     4. With a function activated and all three indicator LED’s ON and there is no voltage registering on the voltmeter, check the output fuse. There is a 7.5 amp fast blow fuse on each output. There is an extra fuse and clip on the PC board. Remove and replace blown fuse. If fuse repeatedly fails, you may have a dead short in your wiring harness or the electric coil or relay is failing. Do not use anything other than the recommended fuse furnished on the receiver PC board.
   - **c.** If the transmitter face plate has been removed and replaced, then three problems could have been introduced. Troubleshoot as follows:

1. Remove faceplate from transmitter. Make sure that leads to each lead screw on toggles are secure and will not be at an angle where it would be touching anything when replacing the faceplate.
2. Disconnect wiring harness from PC board and then reconnect the same way. Be sure that no wires are loose at connector and that connector is secure on connector pins. The wiring harness should be positioned between toggle housings or where it is not hanging down creating a bind when replacing the faceplate.
3. Refer to 3B.

Example to follow on existing equipment

4. Activate a function (boom up) on the transmitter, at this time the receiver's RF Indicator LED and the appropriate Output Status Indicator LED will be on. And if the function activated, such as the boom up motion does not occur, check the following:
   a. Be sure that the appropriate orange connector pin matches the Output Status Indicator LED. There should be 12 or 24 volts DC to that output, depending on the power supplied from the vehicle. If it is determined there is power to the output, then the wiring and hydraulic system should be checked.
   b. If the appropriate Output Status Indicator LED is turned on and there is no power to the orange connector pin, this indicates that a circuit failure has occurred and the radio controller must be repaired at the factory.
5. If crane function occurs when function switch is activated and before trigger is pulled, readjust the low end proportional potentiometer in the receiver. See Installation Section for correct procedure.

Specifications

Transmitter	Description
Material	Composite plastic (high impact plastic material)
Seal	Water resistant enclosure
Color	Light gray
Switch Type	Industrial environmentally sealed toggle
Dimension	9" L x 5-3/4" W x 4-3/4" D (including handle)
Approximate Weight	2.5 lb
Power Source	9 volt battery (disposable, not rechargeable)

Transmitter	Description
Antenna	External 6: (Rubber Ducky)
Operating Temperature	-20°C to +50°C (-4°F to +122°F)
Frequency	49 MHz Band
Address Codes	>20,000 combinations including RF bands

Receiver	Description
Material	18 gauge aluminum housing
Color	Light gray
Dimension	9" L x 7" W x 2" D
Approximate Weight	3 lb
Number Outputs	1 to 17
Control Voltage Range	10 - 24 VDC
Power Supply Operation	10 - 24 VDC
Connector	Cage-Clamp style connection
Temperature Range	-20°C to +50°C (-4°F to +122°F)
Fused Outputs	7.5 Amp fast blow fuse

Installation

Transmitter

Each unit's address code has been preset by the factory. (We advise not to change codes without first consulting factory.)

Receiver Mounting

The receiver should be mounted on the crane console. If installed in a tool box or compartment, care should be taken in routing cable and wires so when tools and supplies are inserted or removed they do not snag or pull on the cabling.

If mounting on a vertical plane, ideal mounting would be to place the connectors pointing down. Adequate planning is required so wire routing can be accomplished. You must keep in mind that the unit comes standard with 20 feet of antenna cable. Use the mounting holes on the receiver for securing the system. Once mounted, remove the cover to inspect the Status Indicators. (Refer to the Receiver Printed Circuit Board drawing, Figure 3-6, in the following steps.)

Connector Instructions

Strip all wires to be inserted into the 20 pin connector, to a length of 3/8 to 1/2 inch (10 mm to 13 mm). Solder the loose wire strands into one solid wire. Insert a small straight blade screwdriver into the square hole of the desired pin. Prying towards the face (lid) of the receiver, insert the appropriate stripped wire into the round hole directly below the

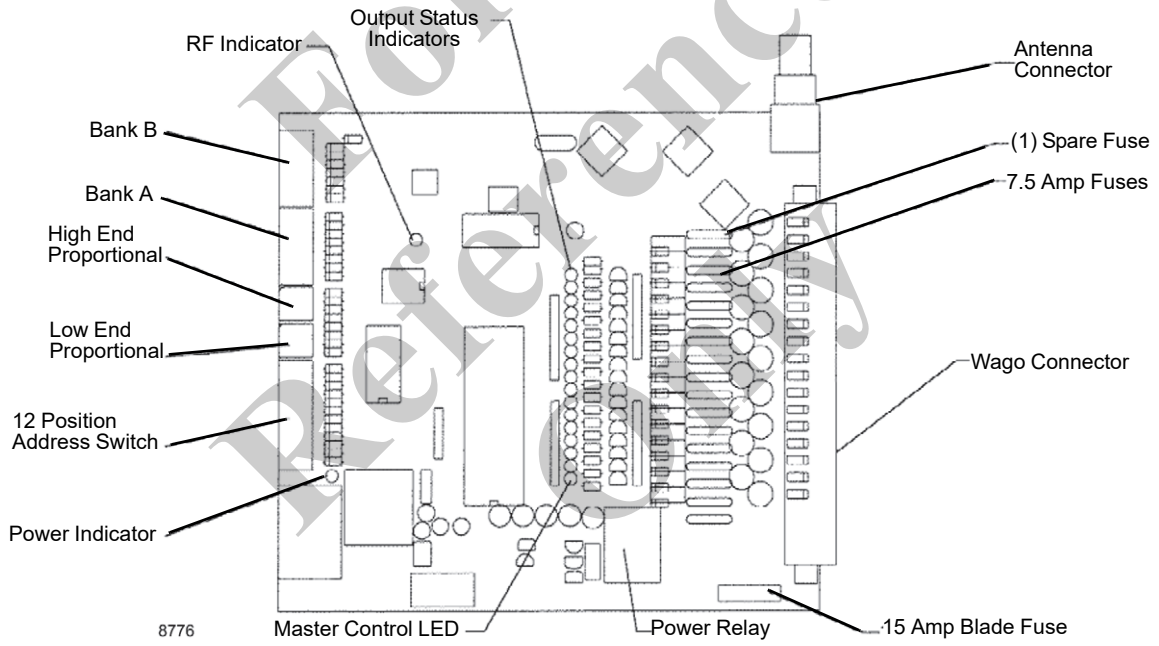
screwdriver. Release the screwdriver and the connection is complete. This connector will accept wire sizes from 14 gauge to 22 gauge wire.

When connecting the individual wires, be sure that the connector clamps onto the bare stripped wire only! If any wire insulation gets into the connector, this may cause a poor connection and cause intermittent or complete failure.

Receiver Input and Output

Each unit comes with a connector chart (Chart C) with the appropriate input and output instruction for your unit. There are three (3) inputs to the receiver: (A) BNC connector, (B) Positive DC current, (C) Negative ground. The unit derives power from a 10 to 24 volt DC power system that is negative ground. It is required to install a power switch for the receiver in series (in-line) with the DC power system (battery). Refer to the Receiver Printed Circuit Board drawing, Figure 3-6.

1. When power is supplied to the receiver the Power Indicator LED will come on. If not, verify correct polarity of power and condition of fuse.
2. Turn on the power to the transmitter. At this time the transmitter will send out a 10 second signal to the receiver to initialize the system.
   a. At this time, the RF Indicator LED and the on-board relay will be energized. Once the initial 10 seconds have lapsed, the RF Indicator LED will illuminate each time the transmitter is activated.
   If only the RF Indicator LED illuminates when the transmitter is activated but does not energize the relay, verify that the 12 position address switches on the receiver match those inside the transmitter.
3. Activate each function with the transmitter and notice that the appropriate output Status Indicator LED illuminates inside the receiver. (The LED's parallel to the orange connector.)

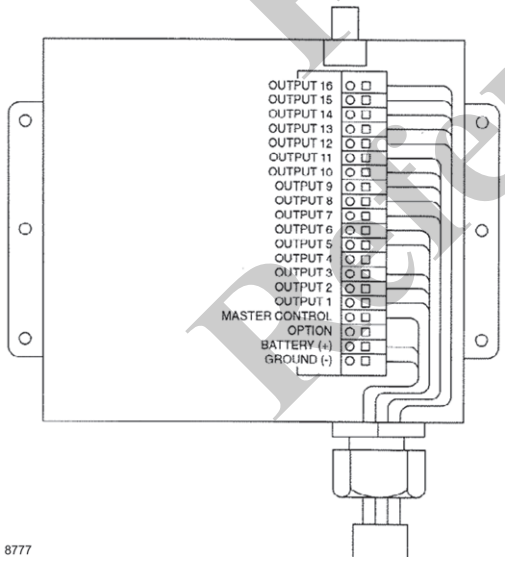


Receiver Printed Circuit Board

FIGURE 3-6

Description	Output Label	NCC Cord Wire Color	5 Conductor Cord Wire Color
N/A	Output 16		
HCA - RCL Override	Output 15	Blu/Red	
Turn RH	Output 14	Org/Blk	
Turn LH	Output 13	Bwn/Blk	
Boom Up	Output 12	Red/Blk	
Boom Down	Output 11	Yel/Blk	

Description	Output Label	NCC Cord Wire Color	5 Conductor Cord Wire Color
N/A	Output 10		
N/A	Output 9		
Tele Retract	Output 8	Blu	
Tele Extend	Output 7	Org	
Hoist Up	Output 6	Red	
Hoist Down	Output 5	Brn	
N/A	Output 4		
Throttle	Output 3	Red/Blu	Blk
Start	Output 2	Blk/Blu	Org
Ignition	Output 1	Blu/Blk	Yel
Proportional	Master Control	Bwn/Red	
N/A	Option		
Battery V+	Battery (+)	Blk	Red
Ground	Ground (-)	Yel	Blu



Insert a small straight blade screwdriver into the square hole of the desired pin. Prying towards the face (lid) of the receiver, insert the appropriate stripped wire into the round hole directly below the screwdriver. Release the screwdriver and the connection is complete.

FIGURE 3-7

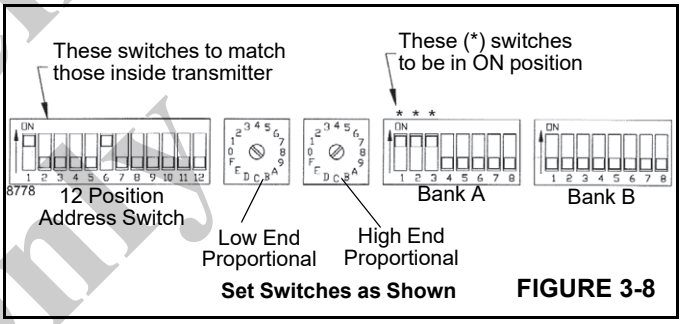


FIGURE 3-8

Setup Procedure for the Proportional Channel

Not all proportional valves are ideal. That is, they do not all begin to operate at exactly the same voltage nor do they all reach their full travel at exactly the same voltage. Many proportional valves work in a narrow “window” of voltage span. Therefore, a method has been designed to allow the installer to configure the proportional output to conform to the proportional valves’ characteristics. This allows the transmitter proportional potentiometer to control the proportional valve through its entire range of travel.

Once the receiver is installed properly, the following steps should allow the installer to quickly match the receiver’s proportional output to the proportional valve. Please refer to the Receiver Printed Circuit Board drawing, Figure 3-6.

- Low End Proportional — 0 Least Trigger Setting, F Highest Trigger Setting
- This pot is used to set starting movement on the trigger.

- High End Proportional — 0 Highest Trigger Setting, F Least Trigger Setting
    1. Set The potentiometer on the transmitter to minimum, This is done by releasing trigger.
    2. Set the “Low End Proportional” hex switch in the receiver to 0.
    3. With the receiver powered, activate the transmitter and depress the desired function to control (i.e. boom up, boom down, extend out, etc.)
    4. While maintaining Transmission, slowly increment the Low End Proportional hex switch until movement of the activated function begins. No movement is desired when activating a function at minimum potentiometer setting; therefore, back up one step on the hex switch. Activate each function switch to assure that no function moves when the switch is on. Occasionally, a machine will not move even when the low end potentiometer is at its maximum setting F. If this occurs, leave the low end proportional set at F.
    5. Now set the potentiometer on the transmitter to maximum. This is done by fully pulling trigger.
    6. Set the High End Proportional to 0.
    7. Again activate the desired function. Be careful since now the function activated will be at full speed!
    8. While maintaining transmission, slowly increment the High End Proportional hex switch until a noticeable decrease in function speed is noticed. Now back up the High End Proportional hex switch 1 to 2 settings.
    9. Failure to properly set the high end pot will result in a decrease in the motion range of the trigger when proportioning a function.

The procedure is now complete and proportional control will function through the complete range of the transmitter potentiometer.

Antenna Mounting

Care should be taken in installing the antenna. When mounting antenna, keep in mind that the unit comes standard with 20 feet (6.1 m) of antenna cable. If driving an electric over hydraulic pump or any type of electric motor, mount the antenna away from the motor since that may emit spurious interference. This will reduce the possibility of electrical interference. For best operation, mount antenna on underside of boom. Otherwise pick a location that has the best visibility and a ground plane with a diameter that is at least twice the height of the antenna. (Note: it is important that you do not wrap any excess antenna cable in loops.) The connector on the end of the cable will hook up to antenna connector on receiver. See Figure 3-6.

NOTE: Regarding Antenna Placement; Place antenna in an open area, at least 18 inches (45.7 cm) from any vertical metal. The position of a “Boom” (over or around) can effect the antenna’s ability to receive a signal, creating “Dead Spots”.

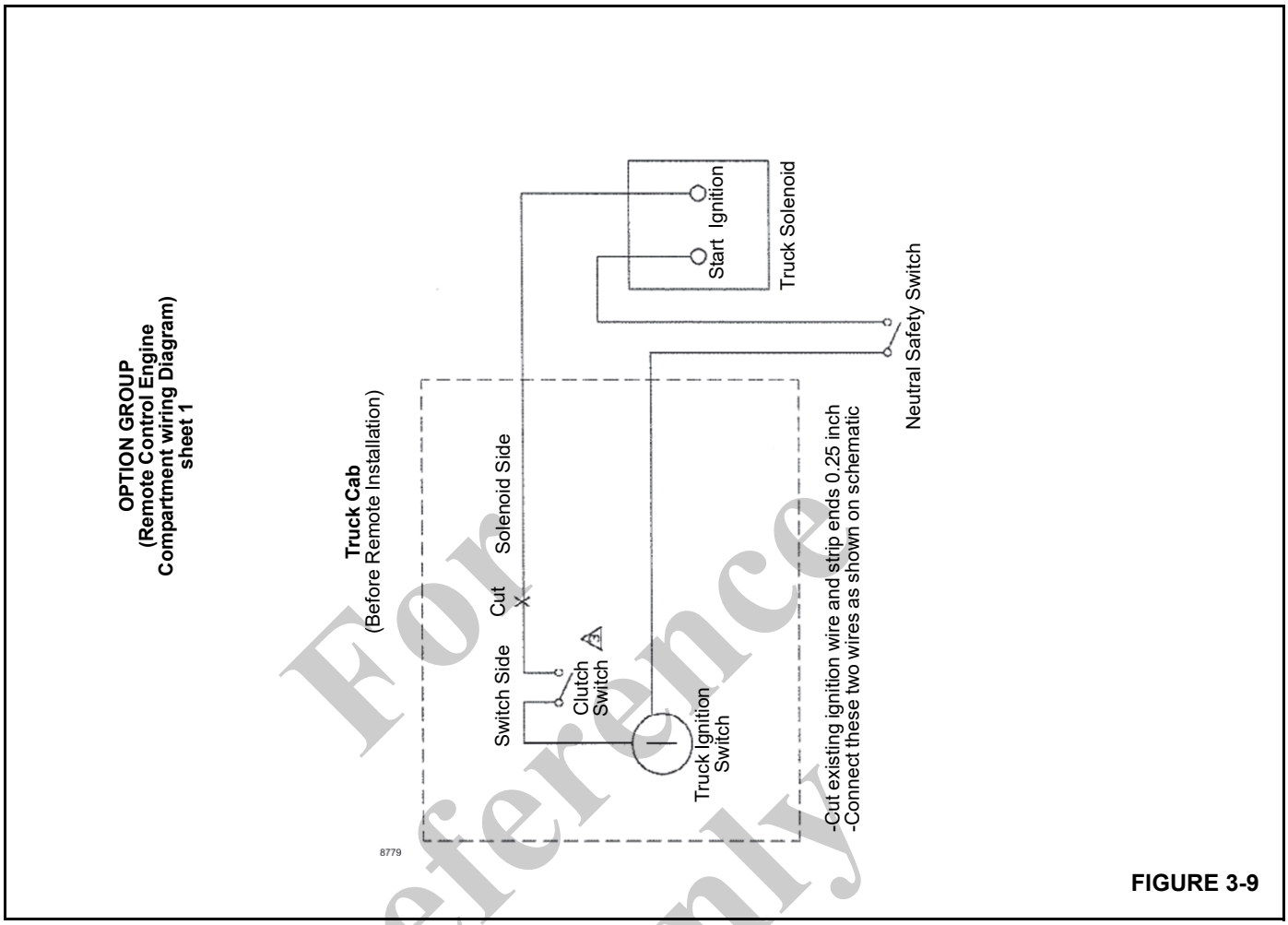


FIGURE 3-9

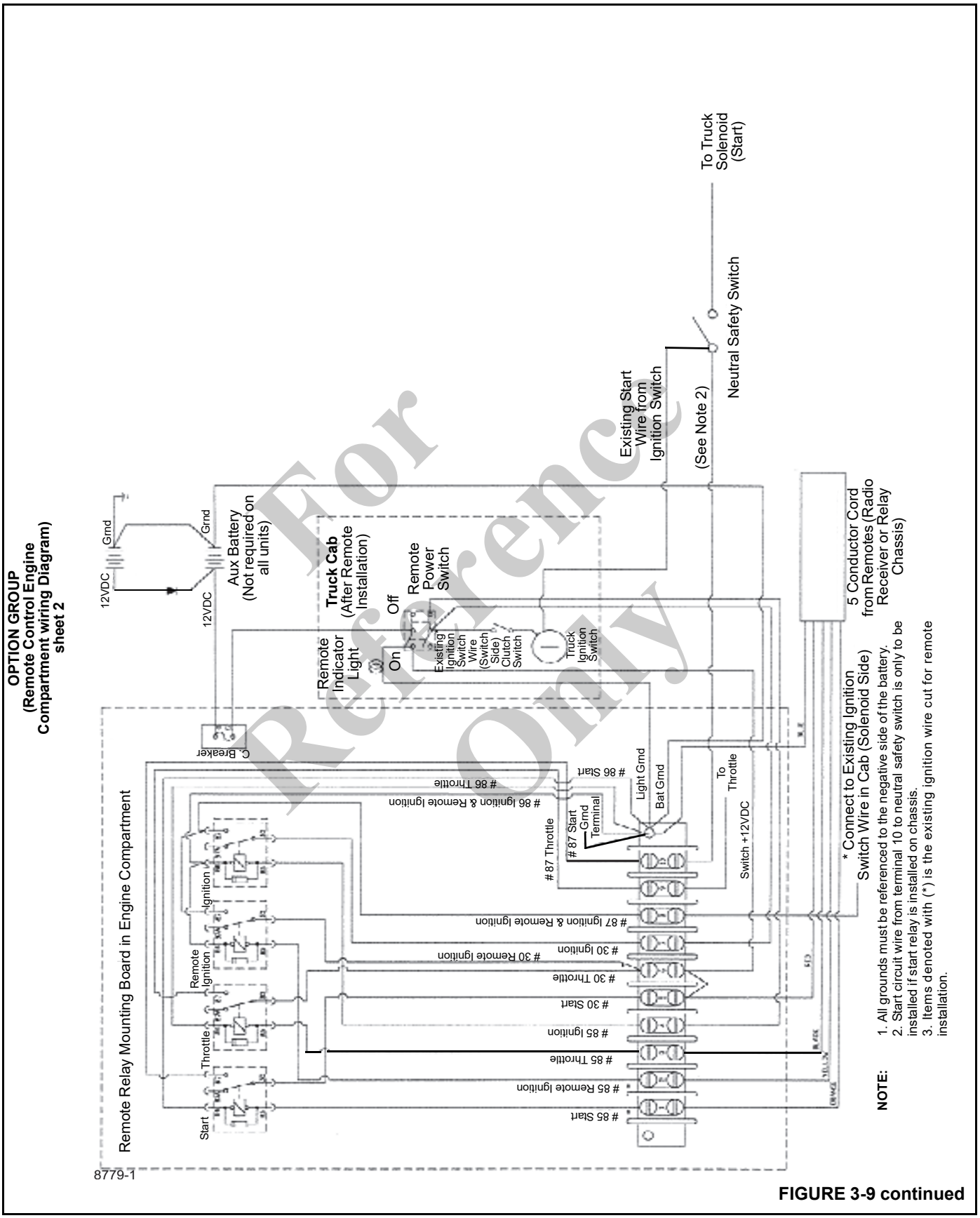


FIGURE 3-9 continued

OPTION GROUP
(R4 Remote Control Hydraulic Diagram)

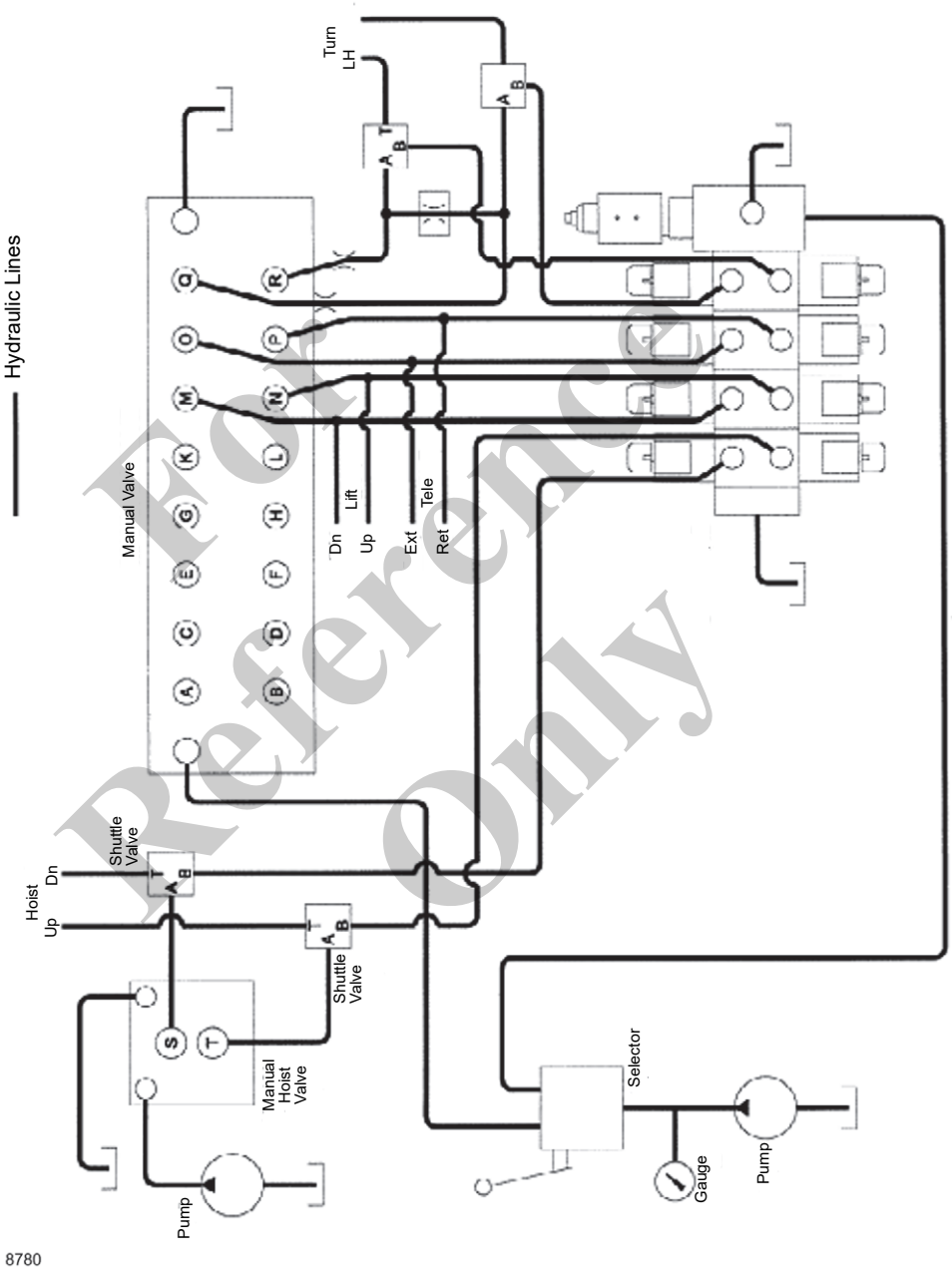


FIGURE 3-10

OPTION GROUP
(R4 Radio Remote Electrical Schematic)

Receiver Box Assembly

Solenoid Terminal	20 Cond. NCC Cord Wire Color	Function	5 Cond. Cord Wire Color
2	Brn/Blk	Turn LH	
1	Org/Blk	Turn RH	
4	Org	Tele Extend	
3	Blu	Tele Retract	
6	Yel/Blk	Lift Down	
5	Red/Blk	Lift Up	
8	Brn	Hoist Down	
7	Red	Hoist Up	
9	Brn/Red	Flow Regulator	
10	Blu/Red	HCA - RCL Override	
	Yel	Power - Ground	Blu
	Blk	Power - Positive	Red
	Blu/Blk	Remote Ignition	Yel
	Blk/Blu	Start	Org
	Red/Blu	Throttle	Blk

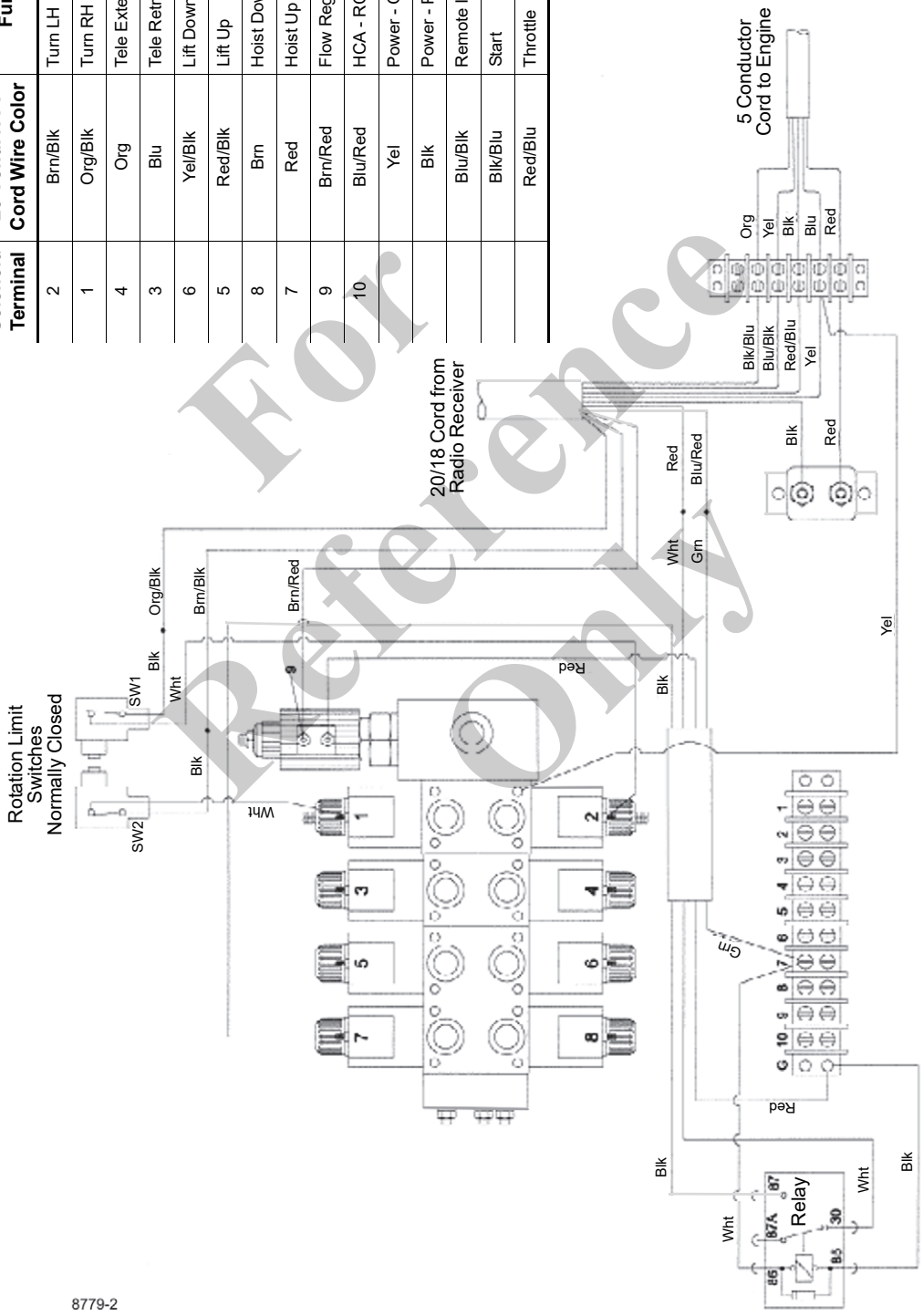
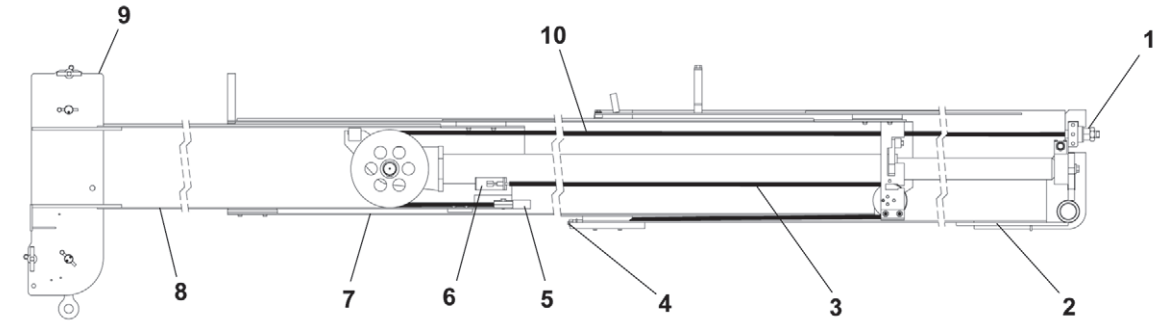


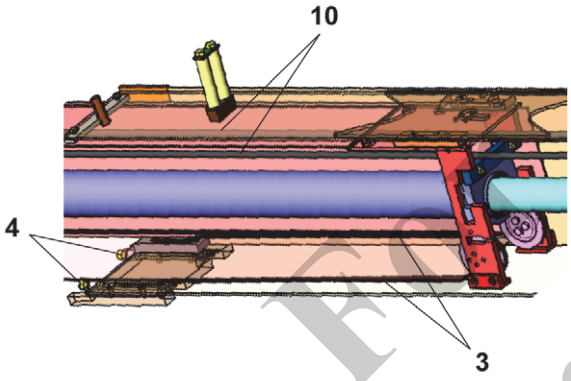
FIGURE 3-11

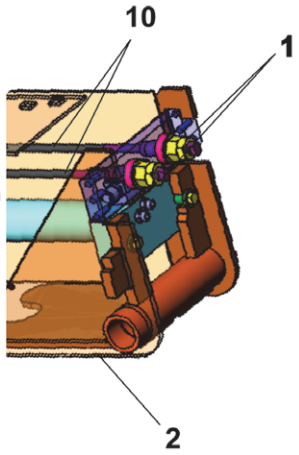
SECTION 4
BOOM

SECTION CONTENTS

Three Section Boom Operation 4-2
Special Boom Inspection 4-2
Three Section Boom Maintenance 4-2
Three Section Cable Tensioning. 4-2
Hoist Removal. 4-3
Boom Removal 4-4
Boom Disassembly 4-4
Boom Disassembly Alternative #1 4-4
Boom Disassembly Alternative #2 4-5
Additional Maintenance, Disassembled Boom . . . 4-6
Three Section Boom Assembly. 4-6
Three Section Top/Bottom Pad Replacement (Assembled Boom) 4-8
Top Rear Pad Replacement 4-8
Front Bottom Pad Replacement 4-8
Inner Wear Pad Calibration 4-8
Cable Tensioning. 4-10
Tensioning Setup Procedure 4-10
Cable Tension Sequence 4-10
3- Section Boom w/ 1 Stage Cylinder Cable Positioning 4-11
Cable Retention 4-12
Lift Cylinder Repair 4-13
Lift Cylinder Disassembly 4-13
Extend Cylinder Repair. 4-14
Extend Cylinder Disassembly 4-14
Extend Cylinder Assembly. 4-15
Jib Installation and Adjustment 4-15
Jib Jack Service and Maintenance 4-17
Adding Oil 4-17
Changing Oil 4-17
Lubrication 4-17
Rust Prevention 4-17







Item	Component
1	Extend Cable Adjustment
2	Section 1
3	Retract Cable
4	Retract Cable Adjustment

Item	Component
5	Extend Cable Anchor
6	Retract Anchor
7	Section 2
8	Section 3
9	Tip

THREE SECTION BOOM OPERATION

A rod-fed, double-acting cylinder, attached to the 1st and 2nd boom sections, supports and propels the 2nd boom section. The extend cables attach to the base end of the 1st boom section, are reeved around sheaves attached to the cylinder, and attach to the base end of the 3rd boom section, providing support and extension the 3rd boom section.

The retract cables attach to the tip end of the 1st boom section, are reeved around sheaves attached to the 2nd boom section, and attach to the base end of the 3rd boom section, therefore providing retraction of the 3rd boom section. This type of boom operation provides that the 2nd and 3rd section booms extend and retract equally. Proper service and maintenance is required to insure smooth and proper operation.

Special Boom Inspection

If the boom has not been disassembled and inspected in the last five years or 3,000 hours of use, the boom is to be completely torn down to allow a thorough inspection of the extend and retract cables, sheaves, and pins.

THREE SECTION BOOM MAINTENANCE

Three Section Cable Tensioning

After boom reassembly or from time to time if interior proportioning cables appear loose, cable tensioning may be required. Tensioning must be done with the boom horizontal.

1. Slightly tighten all cables. Then cycle the boom approximately 4 feet (120 cm) out and in a few times to equalize the extend and retract cable/ boom section sequence positioning.
2. Fully retract boom. Do not induce and hold hydraulic pressure. At full retraction, observing through the hoist mount end of the boom, the second section should be bottomed on the extend cylinder butt plate, and the third section should be bottomed on the thick vertical side plates welded to the inside of the second section.

NOTE: It is important to achieve these boom postitions before torquing.

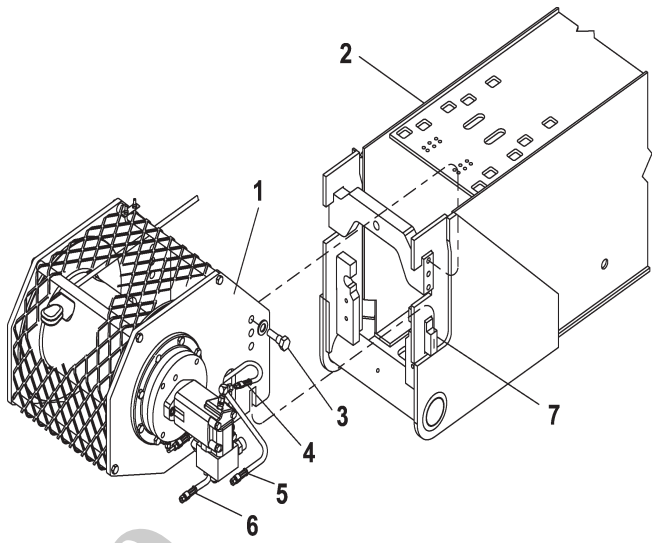
3. If the boom sections do not bottom out as specified (boom is out of sequence), adjust cables to achieve proper section positioning.
4. Torque retract cables to 6 ft-lb (8.13 Nm). Cable adjustment point is located at the sheave case end of the boom, on the bottom of the 1st section. Use the flats at the front of the cable ends to keep the cables from turning while torquing retainer nuts.
5. Torque extend cables to 20 ft-lb (27.11 Nm). Cable adjustment point is located at the rear of the boom on the cable anchor bar going through the hoist mount.
6. Repeat Steps 4 and 5.
7. Torque the retract cables to 12 ft-lb (16.26 Nm).
8. Torque the extend cables to 30 ft-lb (40.67 Nm).
9. Cycle the boom fully, check that all cables are torqued properly and that all sections are retracted completely, then add jam nuts to all cables. All threaded cable ends must be equipped with retainer nuts and jam nuts.

HOIST REMOVAL

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

1. Extend and set the outriggers.
2. Fully retract the boom and place in a horizontal position.



Item	Component
1	Winch
2	Boom
3	Capscrew (6 plcs)
4	Hyd Hose 1
5	Winch Down Hose 2
6	Winch Up Hose 3
7	Winch Alignment Ears

3. Remove hook block or downhaul weight. Wind up rope on hoist drum and stow wedge socket on pegs provided on 1st section. Shut down truck engine.
4. Tag and remove the hydraulic hoses (the inside hose “up” and the outside “down”). Cap all hoses.
5. Pull hydraulic hoses through the access hole towards turret.

CAUTION

The combined weight of the hoist and 325 ft. of wire rope is 660 lbs (300 kg).

6. Remove Rope Guard mesh and attach suitable lifting device to hoist and take up the slack.
7. Remove 6 mounting capscrews and washers (3 on each side).
8. Lift hoist clear of boom and secure to a suitable holder.

BOOM REMOVAL

Boom Length	Boom Weight	Cg From Pivot Point
71 ft (21.6 m)	5145 lb (2334 kg)	140 in (3.56 m)
60 ft (18.2 m)	4660 lb (2113 kg)	118.8 in (3.02m)

1. Extend and set machine outriggers. Boom must be completely retracted and stowed in the boom rest.
2. If equipped, remove swing around jib. See Section 4 Operator's Handbook, Section 4.
3. Remove hook block or downhaul weight. Wind up rope on hoist drum and stow wedge socket on pegs provided on 1st section. Shut down truck engine.
4. Attach a lifting device to rod end of lift cylinder, remove boom lift cylinder pin keeper and pin from bottom of the 1st section boom. Lower lift cylinder to a suitable support.
5. Tag and disconnect extend cylinder lines and hoist hydraulic lines. Cap all open lines and ports.
6. Attach a lifting device to provide even weight distribution and raise the boom until weight is removed from the boom pivot pin. Remove boom pivot pin keeper and boom pivot pin. Lift boom free of turret.

Boom Disassembly

The 500E2 Service Manual boom can be disassembled by using two different methods. Alternative #1 disassembles the boom in the conventional manner. Alternative #2 removes the extend cylinder from the rear of the boom, after removal of the hoist. This feature facilitates cylinder service without complete boom teardown.

For reference, the front of the boom refers to the sheave case end, the rear of the boom is the hoist mount end. Left and right are viewed from front to rear.

If the boom is to be unpinned from the turret of the crane structure, please refer to the Boom Removal Procedure section in this book. If the required service procedure is to be performed on the boom while still pinned to the turret, please follow these directions.

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

Boom Disassembly Alternative #1

1. Gaining access through rear of boom, loosen capscrews retaining the extend cable anchor in the rear of the 3rd section as well as the capscrew on the anti-two-block wire clamp on the anchor assembly.
2. Extend boom 24 inches (60 cm). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Remove nut from anti-two-block spade bolt. Tag and disconnect hydraulic lines to the extend cylinder.
3. Drape extend cables and anti-two-block cable inside boom, and slide cable anchor plate out of the side of the hoist mount if hoist has been removed from boom.
4. Loosen and remove two capscrews, lockwashers and spacers which anchor the extend cylinder rod butt plate to the rear of the 1st section.
5. Loosen and remove two capscrews and lockwashers securing spacer bar to the inside top of the front of the 1st section. Remove spacer bar.
6. Loosen and remove four capscrews securing wear pads to the bottom of the 1st section. Removal of side wear pads is optional. Adequate clearance exists between adjoining section side pads for boom disassembly. If side pad removal is required, tag all pads, shims, and corresponding locations for proper reassembly.
7. Support 2nd 3rd assembly at the front with an appropriate lifting method. Raise the 2nd 3rd assembly inside the 1st section to allow for front bottom pad removal. Remove bottom wear pads.
8. With the 2nd & 3rd assembly supported, slide assembly out of the 1st. Relocation of the sling point on the 2nd & 3rd assembly will be necessary for proper balancing of the assembly as it slides out of the 1st section. Keep tension on retract cables as the assembly is pulled out of the 1st, to minimize the chance of retract cable damage.
9. Place 2nd & 3rd assembly on a suitable horizontal surface. Take care not to pinch or crush retract cables while lifting or supporting assembly.
10. Remove top rear wear pads on the 2nd section. They will lift off the cam plates easily. Do not remove or loosen the capscrews holding the cam plates to the section. This will affect side clearance during re-assembly.
11. Loosen and remove four capscrews securing the rear bottom wear pads on the 2nd section. This pad serves as a bottom and side pad as well as the retract cable keeper under the retract sheaves. Removal of this pad will allow the retract cables to uncoil off the retract

sheaves. Place retract cable ends in a location to minimize the possibility of damage.

12. Loosen and remove six capscrews securing retract sheave pin and retract sheaves to 2nd section. Remove sheaves and pins.

13. Loosen and remove two capscrews functioning as upper retract cable keepers.

14. Loosen and remove two capscrews securing lock bar to the extend cylinder collar. This bar constrains the vertical movement of the extend cylinder. Remove bar.

15. Loosen capscrews retaining extend cable anchor to back of the 3rd section. Total removal of the capscrews will allow the cable anchor to be completely disassembled, backing capscrews out approximately 0.50 inch (12 mm) will allow the anchor assembly to slide rearward out of the section as the extend cylinder is removed.

16. Support extend cylinder with an appropriate lifting device and pull the extend cylinder out of the boom while keeping the extend cables and anti-two-block wire tensioned slightly by hand to minimize the possibility of damage to the cables. Pull cylinder to within 3 feet (91 cm) of complete removal from the boom sections.

17. Reach into the rear of the 3rd section and loosen and remove the anti-two-block cable clamp on the extend cable anchor. Pull the extend cable anchor out from its retaining pocket on the bottom of the 3rd section. A slight angle applied to the anchor as it is being pulled to the rear will permit easier removal through the 2nd section.

18. Remove the extend cylinder from the boom.

- **a.** Do not allow sheaves to fall off the pin on th end of th extend cylinder.
- **b.** Remove extend cables. Place cylinder and cables in suitable area to prevent possible damage.

19. Remove retract cables from the back of the 3rd section by manipulating cable end through the slot in the anchor. Place cables in location to prevent possible damage.

20. Anti-two-block wire can be removed if necessary by disassembly of the clamp arrangement at the sheave case and pulling wire through boom.

21. Loosen and remove two capscrews, cable guide, wear pad and spacer bar from the front top of the second section.

22. Loosen and remove four capscrews attaching the bottom pad plate to the second section. Slightly lift third section, and remove pad plate.

23. Slide 3rd section out of 2nd section. Removal of side pads is optional, as the side pads have adequate clearance for boom disassembly. If removal of side pads is required, tag all shims, pads and corresponding locations for proper re-assembly.

24. Loosen and remove all remaining capscrews and wear pads from boom sections.

Boom Disassembly Alternative #2

The 500E2 Service Manual boom design allows for removal of the extend cylinder from the rear of the boom without complete disassembly of the boom sections. This procedure allows quick access to the cylinder, retract cables, and various internal boom components for service or replacement.

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

1. Remove hoist. Please refer to the hoist removal section in this book.

2. Gaining access through rear of boom, loosen capscrews retaining the extend cable anchor in the rear of the 3rd section as well as the anti-two-block wire clamp on the anchor assembly. Loosen and remove two capscrews retaining lock bar to extend cylinder. Remove lock bar

3. Extend boom 24 inches (61 cm). Loosen and remove the nuts which secure the extend cables to the cable anchor plate. Remove nut from anti-two-block spade bolt.

4. Drape extend cables and anti-two-block wire inside boom, and slide cable anchor plate out of the side of the winch mount.

5. Loosen and remove two capscrews, lockwashers and spacers which anchor the extend cylinder rod butt plate to the rear of the 1st section.

6. Using appropriate lifting device, lift extend cylinder up and out of retaining slot on rear of 2nd section. Retracting cylinder with an external hydraulic power source during this step may be necessary.

7. Pull cylinder out through rear of boom assembly approximately one-half the length of the cylinder. Turning of the butt plate and rod 90 degrees may aid in sliding cylinder through winch mount area. Keep extend cables tight to minimize the possibility of damage.

8. Lift extend cylinder up until it contacts inside of boom section. Remove anti-two-block wire clamp from extend cable anchor. Remove anchor by pulling anchor and cables out rear of boom. A slight angle applied to the

anchor as it is being pulled to the rear will permit easier removal.

9. Continue to pull extend cylinder and cables out of rear of boom. Remove extend cables and store in an area to minimize the possibility of damage.

Additional Maintenance, Disassembled Boom

1. Clean all boom sections and inspect for wear, dents, bent or bowed boom sections, gouged metal, broken welds or any abnormal conditions. Repair or replace as required.
2. Inspect all sheaves for excessive groove wear or abnormal rim wear. Replace as required.
3. Inspect all sheave bearings for excessive wear or cut liner material. If installed bearing diameter is 0.015 inch (0.38 mm) larger than the pin diameter, bearing must be replaced. Any cut or gouge which causes the bearing liner to be distorted is cause for bearing replacement.
4. Clean and inspect all cable assemblies according to the wire rope inspection procedures in this section. Pay particular attention to any wire breakage within 6 feet (180 cm) of the end connections. Replace cable assemblies as required. Lubricate all cable assemblies before reinstalling them in the boom.
5. Inspect all sheave pins for nicks, gouges or pitting due to rust in the bearing surface area. Replace if any damage is evident.
6. Inspect all grease fittings and grease paths in pins to ensure proper grease flow. Clean and replace as required.
7. Inspect all wear pads for excessive wear, gouges, or abnormal conditions. Clean and replace as required.

THREE SECTION BOOM ASSEMBLY

NOTE: Do not use Loctite on any cable threaded ends. Always use the locknut and nut provided.

When initially assembling threaded ends of cables, thread the first nut on past the flat in the cables so adjustment can be made later.

Refer to Inner Wear Pad Calibration on page 4-8 of this section to determine Wear Pad shim thickness.

1. Assemble sheaves into 3rd section sheave case. Top sheave is to be installed to the left hand side of the boom with the spacer to the right hand side.
2. Attach rear wear pads on bottom of 3rd section. Using Loctite 243 blue, Loctite all wear pad mounting capscrews.
3. Install 3rd section boom into 2nd section. Slide together approximately 5 feet (150 cm).
4. Assemble bottom front wear pads for 2nd section and Teflon plugs. Attach pads to pad plate.
5. Using appropriate lifting device, lift 3rd section to allow for wear pad/pad plate installation in front of 2nd. Install wear pad/pad plate assembly. Slide sections together within 12 inches (30 cm) of full retraction.
6. Install front side wear pads with appropriate shims, between 3rd and 2nd sections. If boom has been disassembled, and no sections have been replaced, use same shim quantity and location as was previously used.
7. Route anti-two-block wire through 3rd section, keeping bulk of wire at the rear of the boom sections. Routing can be accomplished using an installation tool, such as a telescopic boom grease applicator, electrical conduit, or hydraulic tubing. Route anti-two-block wire between sheave case side plates. If locations are in question, refer to Shim Calibration Section in this manual.
8. Uncoil retract cable assemblies, and insert button end into anchors in back of the 3rd section. Place uncoiled cable in area that will minimize the potential for damage.
9. Assemble retract sheaves and retract sheave pins in rear of 2nd section. Coat surfaces of bearings with grease before assembly.
10. Place retract cables over top of retract sheaves. Install keeper capscrew above sheave to hold retract cables in place.
11. Reeve cables over retract sheave and install keeper/wear pad to bottom rear of 2nd section. This pad acts as a side pad, bottom pad, and a cable retainer.
12. Assemble exterior extend cylinder components. Install and center sheave pin into butt plate of extend cylinder. Install bearings into extend cable sheaves. Coat surface of bearings with grease and assemble extend sheaves on sheave pin.
13. Wrap approximately 10 feet (300 cm) of each 5/8 inch (15.88 mm) diameter extend cable around extend sheaves and install extend cable anchor. Do not tighten capscrews clamping anchor together completely. These capscrews if tightened completely will not allow cable anchor to install into 3rd section. Route anti-two-block cable over center sheave on extend cylinder.
14. Install wear pad over extend cylinder sheave side plates. This serves as a wear pad to keep the end of the extend cylinder centered in the boom, as well as an extend cable retainer.

15. Slide extend cylinder /extend cables into 2nd/3rd boom assembly enough to assemble extend cable anchor into bottom rear of 3rd section. Route anti-two-block cable over extend cable anchor as anchor slides into 3rd section. Be aware of extend and anti-two-block cable location when inserting cylinder into boom sections, inadvertent crushing or other damage to cables will warrant replacement.

16. Tighten capscrews clamping extend anchor together. These capscrews will protrude through the 3rd section bottom plate, locking the anchor in position.

17. Loop anti-two-block cable at the extend cable anchor in the 3rd and install anti-two-block cable clamp. Do not completely tighten clamp capscrew.

18. Assemble anti-two-block clamp in the sheave case. Reeve anti-two-block cable around anchor and through holes in side plate of sheave case. Pull approximately 2 feet (60 cm) of cable out the end of the boom for proper routing and termination.

19. Tighten anti-two-block clamp on the extend cable anchor in the rear of the boom. Tension anti-two-block cable from the sheave case end of the boom, and tighten anti-two-block clamp located in sheave case.

20. Visually verify that the extend and anti-two-block cables are properly routed on their sheaves and continue to slide the extend cylinder and cables into the boom sections. Keep extend and anti-two-block cables supported and slightly tensioned during insertion of cylinder, to maintain proper cable placement.

21. As the extend cylinder keeper plate nears the 2nd section, adjust the height of the cylinder to allow the cylinder to access the cylinder keeper cutouts in the doubler plates on the sides of the 2nd section.

22. Drop the cylinder down into the vertical cutouts in the doubler plates on the sides of the 2nd section.

23. Install lock bar and capscrews to the extend cylinder.

24. Position 2nd/3rd/ cylinder assembly in position to be inserted into 1st section. Lay retract cables out under 2nd/3rd/ cylinder to allow easy installation as the booms are assembled.

25. Slide 2nd/3rd/ cylinder assembly into 1st section boom approximately 2 feet (60 cm). Use caution during this step to keep retract cables straight and on the correct side of the boom assembly as the sections are assembled.

26. Continue to slide 2nd/3rd/cylinder assembly into 1st until it is approximately halfway into 1st.

27. Assemble bottom front wear pads in 1st section, trapping ends of retract cables in slots on bottom of 1st section. Lift 2nd/3rd/cylinder assembly up to ease installation.

28. Slide boom together to within 12 inches (30 cm) of complete retraction. Install upper front spacer bar in 1st section and upper front wear bar and cable guide assembly to 2nd.

29. Retract boom completely, using proper hardware and spacers, connect extend cylinder butt plate to the winch mount. Hydraulic power source can be utilized at this time if slight cylinder length adjustment is necessary.

30. Slide extend cable anchor into position in winch mount. Push threaded ends of 5/8 inch (15.88 mm) extend cables through holes in anchor and assemble hex nuts onto threaded ends.

31. Assemble top/rear wear pads to the top of the 2nd and 3rd boom sections with the cam plates.. Wear pads can be inserted from the winch mount end of the boom. Install capscrews through holes in outer boom sections.

32. The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16” (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06" (1.5 mm) off center in the plate and 0.03" (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.

    a. Adjust pads until they are within 0.03” (0.8mm) off center in the were pad. Various combinations of rotation of these parts allows the adjustment.

    b. Torque retainer capscrews to 110 ft-lb (149 N-m). Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.

33. Approximately 10 feet (300 cm) of anti-two-block cable will be available on the winch mount end of the boom to route and hookup to the control console wiring. Find the end of this cable and slide the cord grip/strain relief hookup onto it and slide it up the cable into approximate position inside the boom.

34. Assemble the extension spring and spade bolt to the cord grip. Assemble the spade bolt through the extend cylinder anchor with a hex nut. Adjust tension on anti-two-block cable by sliding cord grip down cable into the boom. Approximately 2 inches (5 cm) of spring extension should be adequate for proper boom operation.

35. Visually check each end of boom for proper extend, retract and anti-two-block cable routing and placement.

Make certain anti-two-block cable is correctly on sheave. Inspect from sheave case end.

36. Adjust slack out of extend and retract cables at hex nut adjustment points. Slowly cycle boom in and out several times. Torque cables per procedure located elsewhere in this book.

Three Section Top/Bottom Pad Replacement (Assembled Boom)

NOTE: Refer to Inner Wear Pad Calibration on page 4-8 of this section to determine Wear Pad shim thickness.

Inspect top and bottom wear pads periodically for signs of abrasion or excessive wear. Excessive is defined as:

- 3/16 of an inch (4.76 mm) from the original pad thickness.
- Top rear pad thickness 0.75 inch (19.05 mm).
- Bottom front 1st section 1 inch (25.4 mm).
- Bottom front 2nd section 0.50 inch (12.7 mm).
- Uneven pad wear of 3/32 inch (2.38 mm) from side to side on the wear pad.

If any of these conditions exist, the top and bottom pads can be replaced without complete disassembly of the boom.

Top Rear Pad Replacement

NOTE: Refer to Inner Wear Pad Calibration on page 4-8 of this section to determine Wear Pad shim thickness.

1. Retract boom completely.

2. Remove capscrews through access holes on top rear of sections.

3. Remove wear pads and cam plates from the rear of the boom through open winch mount end.

4. Note all pad locations and tag accordingly.

5. Inspect pads for wear using previously mentioned inspection criteria.

6. Assemble top/rear wear pads to the top of the 2nd and 3rd boom sections with the cam plates.. Wear pads can be inserted from the winch mount end of the boom. Install capscrews through holes in outer boom sections.

7. The wear pad on each side at the top/rear of the boom can be adjusted over a range of 3/16” (4.8 mm) by rotating, end for end, the wear pad and plate or the wear pads and plate independently. This is possible because the holes in these parts are offset from the center. The holes are 0.06" (1.5 mm) off center in the plate and 0.03" (0.8 mm) off center in the wear pad. Various combinations of rotation of these parts allow the adjustment.

a. Adjust pads until they are within 0.03” (.8mm) off center in the were pad. Various combinations of rotation of these parts allows the adjustment.

b. Torque retainer capscrews to 110 ft-lb (149 N-m). Failure to properly torque capscrews will cause loss of preload and cause excessive side clearance between sections.

Front Bottom Pad Replacement

NOTE: Refer to Inner Wear Pad Calibration on page 4-8 of this section to determine Wear Pad shim thickness.

1. Extend boom approximately 4 feet (120 cm) out.

2. Using an appropriate lifting device, sling around the 3rd section boom and lift it up until weight is removed from the bottom pads in the front of the 2nd and 1st boom sections.

3. Loosen and remove the four capscrews holding the pad doubler plate in between the 3rd and 2nd sections, remove plate, remove pads from this plate. Note all pad locations and tag accordingly.

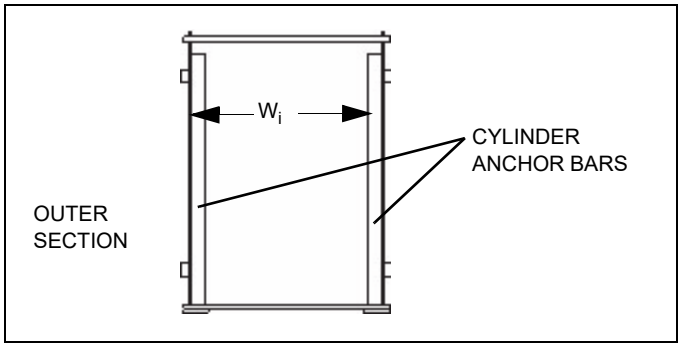
4. Loosen and remove the four capscrews holding the bottom front wear pads to the 1st section, remove pads. Retract cable adjustment ends may have to be loosened during this step. Note all pad locations and tag accordingly.

5. If disassembly of cables was required:

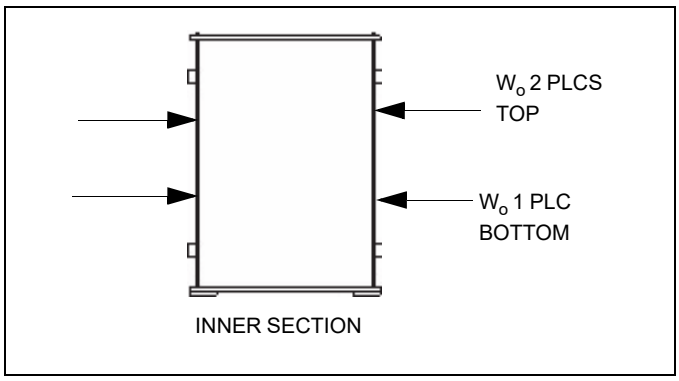
- Replace all wear pads.
- Wear pad plate.
- Re-torque retract cables.

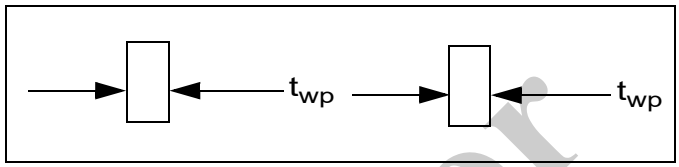
INNER WEAR PAD CALIBRATION

1. With a pair of inside/outside calipers, measure the inside width of the outer section (Wi) at the front and back of the boom and record the smallest measurement. If the section has cylinder anchor bars, take a measurement directly in front of these bars

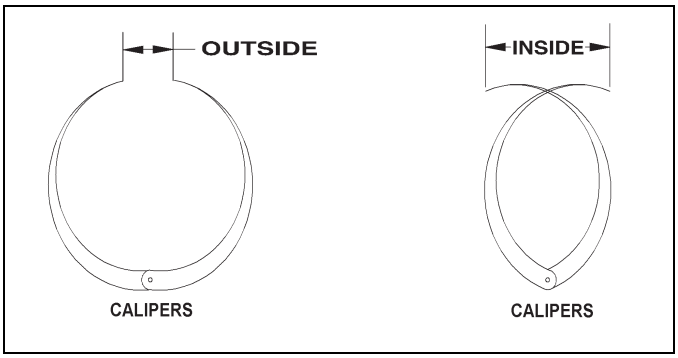


2. With the inside/outside calipers, measure the outside width of the inner section (W0) at each side pad location. Record the largest measurement.





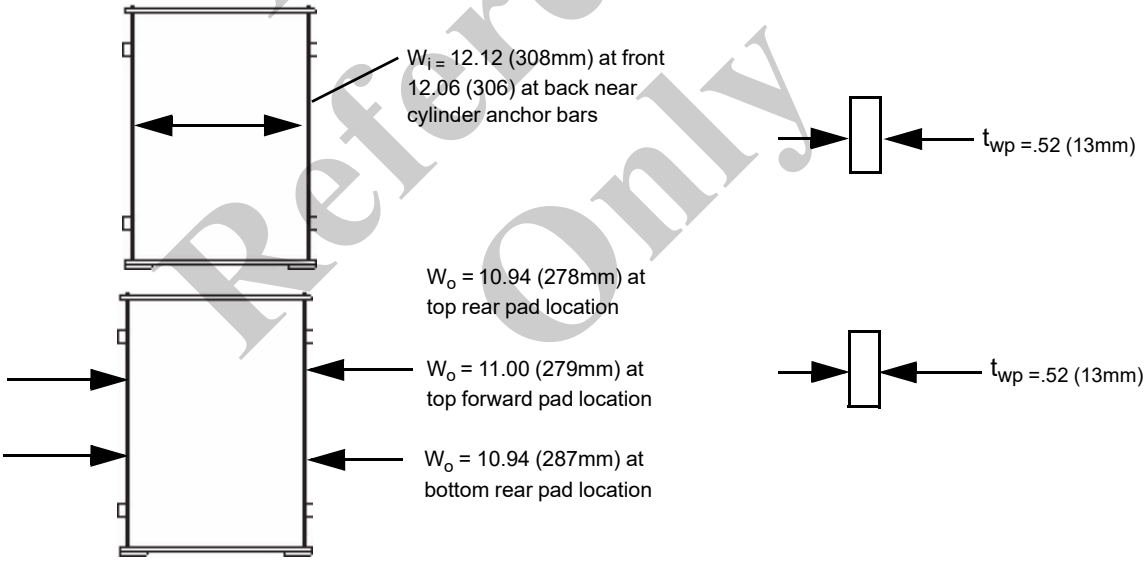
3. Measure the thickness of the wear pads and record (twp).



4. Subtract the largest outside width (W0) of the inner section and the thickness of the two pads (t_{wp}) from the inside width of the outer section (Wi). Add shims as required [each shim is 0.03 inches (0.8 mm) thick) to tighten the pads so that there is 0.03 inch – 0.09 inch (0.8 mm – 2.3 mm) clearance between the widest part of the inner boom and the most narrow part of the outer boom when shims and pads are installed. In some cases it will be necessary to have an unequal number of shims behind the pads at the top and bottom side pad locations. See example.

4

Shim Calculation for Wear Pads (Example)



	Top Rear	Bottom Rear
W_i =	12.06 (306 mm)	12.06 (306) mm
$-W_o$ =	-10.94 (-278 mm)	-10.94 (-278 mm)
$-t_{wp}$ =	-0.52 (-13 mm)	-0.52 (-13 mm)
$-t_{wp}$ =	-0.52 (-13 mm)	-0.52 (-13 mm)
Clearance Before Shims =	0.008 (2 mm)	0.08 (2 mm)
Left Side Shim =	-0.03 (-0.8 mm)	-0.03 (-0.8mm)
Final Clearance =	0.05 (1.2 mm)	0.05 (1.2 mm)

CABLE TENSIONING

A boom assembly is considered properly timed when telescoping sections extend equally relative to each other and bottom out simultaneously at full retraction and do not spring back out after retract pressure is returned to neutral.

Hydraulic extend cylinder construction will dictate which extendable section will be the driver that the other extend sections will need to be adjusted to utilizing cable adjustment.

A single stage cylinder will control first extendable section.

A dual stage cylinder will control second extendable section.

Timing sequence of cables will depend on number of sections and the extend cylinder construction.

Design intent of the cable tensioning is to balance the preload of extend and retract cables for each extendable section. In addition, sequencing of the sections during retraction requires retract cables of every section to be indexed relative to each other.

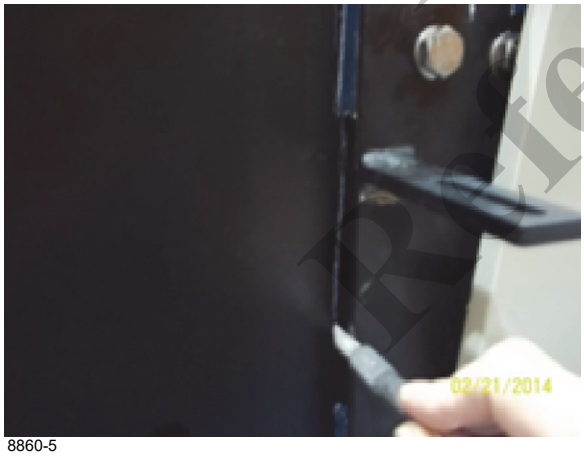
Tensioning Setup Procedure

Tensioning must be done with the boom in the horizontal position.

When tightening/loosening the first (adjustment) nuts on cables, secure cable using the wrench flats at the front of the cable ends to prevent cable twist. Excess twisting of cables can cause premature failure.

Ensure boom is completely assembled and fully retracted.

1. Mark the front of each section with a chalk line as indicated in Figure 4-1.
2. Extend and retract boom several times to establish working state of cables.
3. Extend boom so scribed lines are exposed by approximately 12 inches.
4. Measure the extension gaps between each boom section and scribed line and note values.
5. Retract boom so that the scribed lines are exposed by approximately 6 inches.
6. Measure the retraction gaps between each boom section and scribed line and note values.
7. Extend and retract the boom a few times and then repeat measuring the extension gaps.
8. Adjust all corresponding cables according to Three Section Cable Tensioning instructions.



8860-5


8860-6

FIGURE 4-1

Cable Tension Sequence

Three section boom with one stage cylinder.

Cable tensioning to be in the following order:

1. 123 extend cables.
2. 321 retract cables.

3- Section Boom w/ 1 Stage Cylinder Cable Positioning

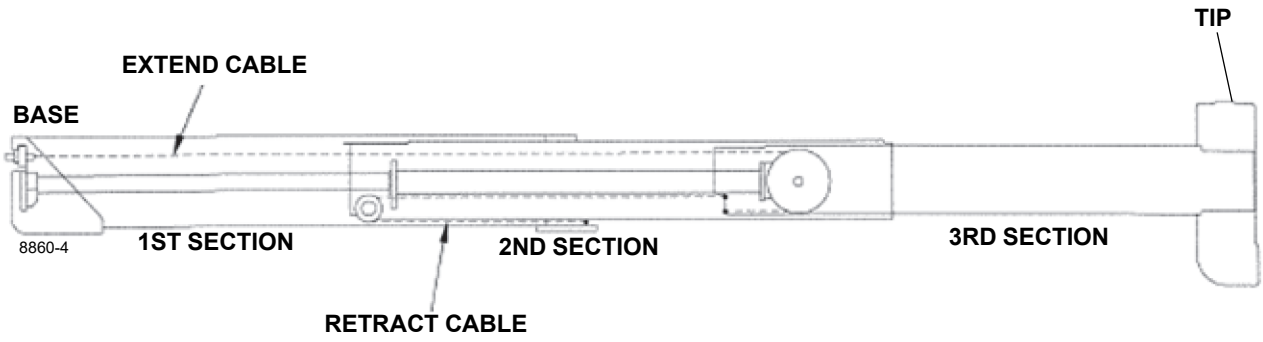


FIGURE 4-2

Cable Tightening Sequence 3 Section Boom with (1) Stage Extend Cylinder

Boom must be in horizontal position when adjusting cable tension (See Figure 4-2.) Retract boom fully ensuring sections are bottomed out on section stops. Ensure all sections are fully bottomed out and do not spring back.(Reference Tensioning Setup Procedure)

321 and 123 cable balancing

Extension

1. Measure the extension gaps between the first and second section and the second and third section.

If the extension gap between second and third section is less than the extension gap between the first and second section.

2. Tighten **123** extend cable located at the back top of the base section the difference in the extension gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the extension gaps.

   The third section should have moved out.
4. Tightening until the extension gap between the first and second section and the extension gap between the second and the third are equal.

Retraction

1. Measure the retraction gaps between the first and second section and the second and third section.

   If the retraction gap is greater between the second and third section than the retraction gap between the first and second section;
2. Tighten the **321** retract cable located at the front bottom of the base section the difference in the retraction gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

   The third section should have moved in.
4. Tightening until the retraction gap between the first and second section and the retraction gap between the second and the third are equal.

   At this time the all extendable sections should extend and retract equally and bottom out against the stops simultaneously.

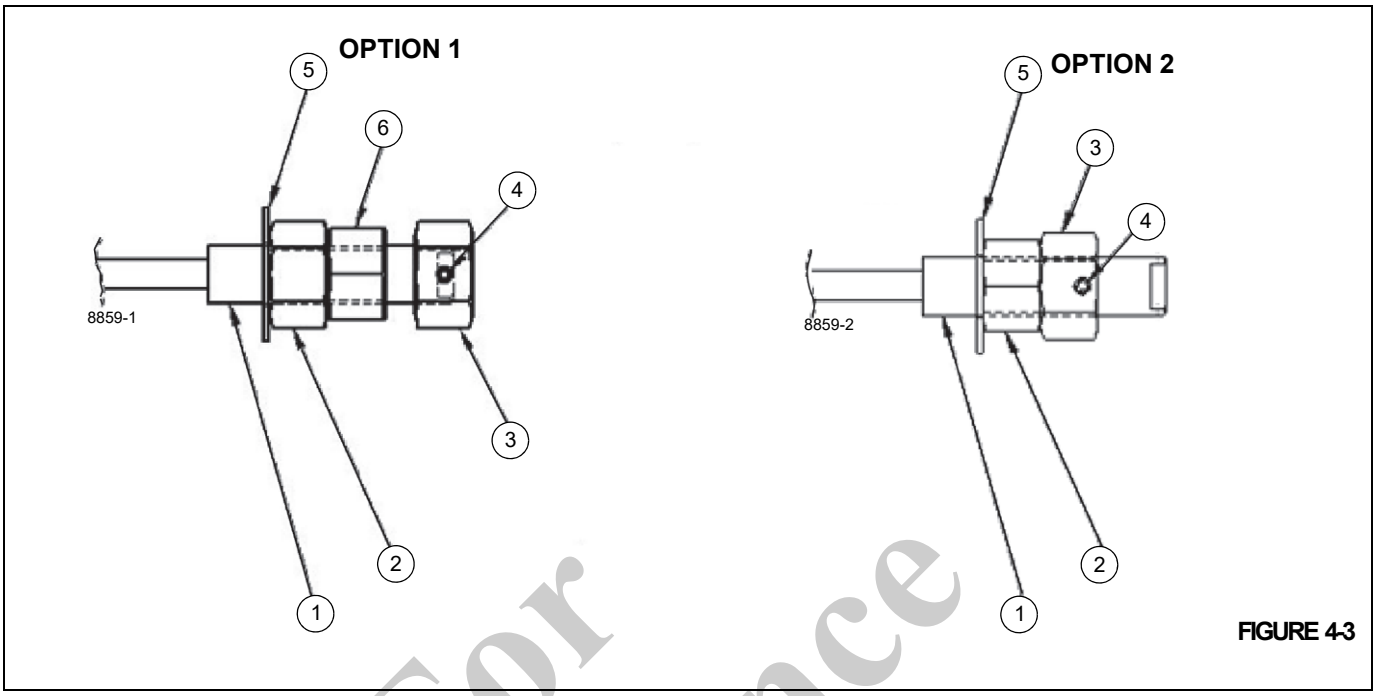


FIGURE 4-3

Cable Retention

Cable Retention Hardware

Item	Description
1	Threaded Cable End
2	Nut (Adjustment)
3	Nut (Positive Lock)
4	Setscrew
5	Washer
6	Nut (Torqued)

Nut configuration (see Figure 4-3) will be First Nut (ADJUSTMENT) and Second Nut (TORQUED).

NOTE: (**OPTION 2**) method used ONLY when space constraints prevent **OPTION 1** usage.

When tightening/loosening the first (adjustment) nuts on cables, secure cable using the wrench flats at the front of the cable ends to prevent cable twist.

After the cable adjustment procedure is completed for the entire boom assembly. The second (torqued) nut must be installed on all retract and extend cables.

The second nut should be hand tightened until it comes in contact with the back of the first nut.

Hold the first (adjustment) nut stationary and a torque wrench to tighten the second (torqued) nut against the first (adjustment) nut to the values indicated in TORQUE VALUES for Second Nut:

Third (positive lock) nut installation is to be placed on each of the extend cables. The retract cables do not require the third (positive lock) nut.

The third nut should be hand tightened until the tapped hole for the set screw is tangent to the end face of the wrench flat.

Install set screw into Third nut and tighten.

(**OPTION 2**) method used ONLY when space constraints prevent **OPTION 1** usage (see Figure 4-3).

TORQUE VALUES for Second Nut:

Inch Series with Coarse Threads (UNC)

Cable end Thread Size	Minimum Nut Strength GRADE	Nut Type	TORQUE ft lbf
1/2-13	SAE 2	Hex Jam (HALF)	12
5/8-11	SAE 2	Hex Jam (HALF)	31
3/4-10	SAE 2	Hex Jam (HALF)	47
7/8-9	SAE 2	Hex Jam (HALF)	63
1-8	SAE 2	Hex Jam (HALF)	199
1 ¼-7	SAE 2	Hex Jam (HALF)	203
1 ½-6	SAE 5	Hex Jam (FULL)	250
1 ¾-5	ASTM B	Hex Jam (FULL)	250

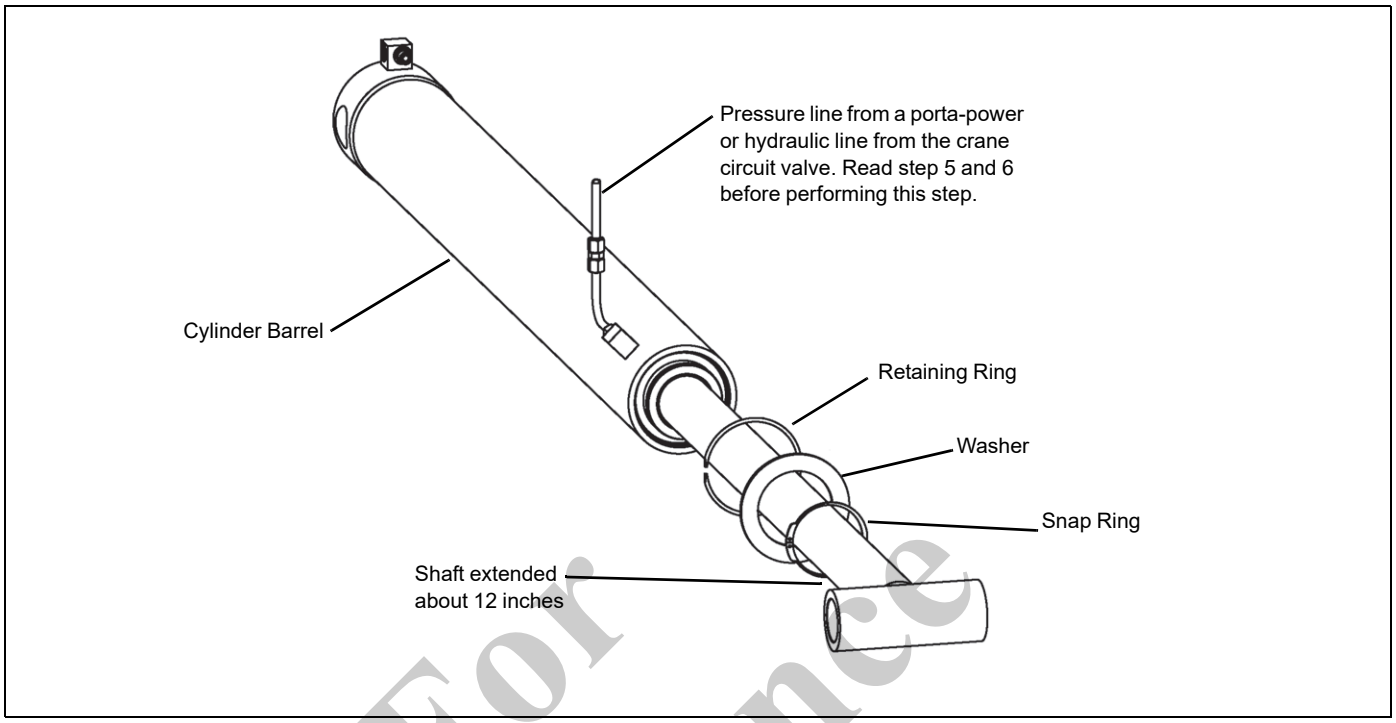
Metric Series with Coarse Threads

Cable end Thread Size	Minimum Nut Property Class	Nut Type	TORQUE Nm
M16x2	5	Hex Jam (THIN)	26
M20x2.5	5	Hex Jam (THIN)	66

LIFT CYLINDER REPAIR

Lift Cylinder Disassembly

1. Disconnect shaft end of cylinder from machine.
2. Retract cylinder shaft with oil from the hydraulic system until about 12 inches (30 cm) of shaft is extended. The barrel must be filled with oil to prevent a compressed air chamber being formed which could result in injury at disassembly.
3. Remove the cylinder from the machine and place on supports with an oil pan directly beneath the cylinder head area.
4. Using the proper size of external snap ring pliers, expand the snap ring completely and remove from groove. Slide large washer forward to gain access to the packing gland.
5. Using a special drive tool, drive the packing gland into the barrel assembly to expose the round cross section retaining ring. Then use a small needle nose locking plier to clamp the round cross section retaining ring to prevent it from rotating in the groove. Use two straight blade screw drivers: one to pry the end of the ring out of the groove and the other to pry the ring out of the barrel assembly.
6. Attach a porta-power hand pump or hydraulic line from crane circuit valve to the shaft end of the cylinder. De-burr ring groove edge. Failure to do so will damage barrel or packing gland.
7. Operate hand pump or crane circuit valve, preferably the boom telescope circuit, to force packing gland out of barrel.
8. Remove holding valve from cylinder to allow removal of shaft and piston assembly. Remove the shaft and piston assembly by hand.
9. Disassemble the piston set by removing nut, replace worn or damaged parts. Note: Loctite 680 is used during original assembly to secure nut to shaft. If necessary, heat nut to 400-500° F (204-260°C) to facilitate removal. If heat is necessary for removal, discard nut and replace with new equivalent nut as well as worn or damaged parts.
10. Wipe and inspect all cylinder internal and external surfaces for damage.
11. Remove seals and bearings from packing gland and piston. Replace all seals and bearings.
12. Reassemble shaft and piston set assembly in the proper order with external snap ring, large washer, internal round section ring, assembled packing gland, stop tube, piston to shaft O.-ring, assembled piston, and locknut. Loctite locknut onto shaft using type 680 according to Loctite recommendations. Torque locknut to 600 ft-lbs (813 Nm).
13. Grease piston assembly and install the shaft assembly with piston, O.-ring, stop tube, packing gland, internal round ring, large washer, and external snap ring into barrel assembly.

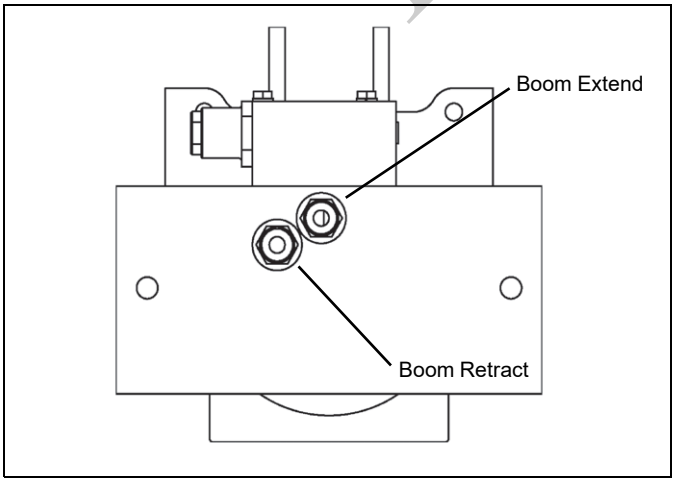


14. Using special drive tool, drive the packing gland into the barrel assembly.

15. Insert one end of round ring into groove in barrel assembly and spiral the ring into groove with straight blade screw driver.

16. Slide large washer into position on end of packing gland and retain with the external snap ring being sure that snap ring contracts completely and properly into the snap ring gland groove.

EXTEND CYLINDER REPAIR



Extend Cylinder Disassembly

1. After cylinder has been removed from boom, place on supports and place drain pan under holding valve and cylinder head area.

2. Retract cylinder shaft with oil from the hydraulic system until about 12 inches (30 cm) of shaft is extended. The barrel must be filled with oil to prevent a compressed air chamber being formed which could result in injury at disassembly. Relieve any trapped hydraulic pressure which might remain in the cylinder.

3. Remove any plug or fitting that is in the retract port in the cylinder butt plate. Using a special drive tool, drive the packing gland into the barrel assembly to expose the round cross section retaining ring. Then use a small needle nose locking plier to clamp the round cross section retaining ring to prevent it from rotating in the groove. Use two straight blade screw drivers: one to pry the end of the ring out of the groove and the other to pry the ring out of the barrel assembly.

4. De-burr ring groove edge after removing round ring. Failure to do so will damage packing gland and or barrel assembly when packing gland is removed.

5. Plug retract port in the cylinder butt plate with SAE #8 O.-Ring boss plug and pull on the rod assembly to force packing gland out of the barrel assembly.

6. If step 5 fails to break packing gland loose from the barrel assembly, remove the plug from the retract port and plug the extend port in the cylinder butt plate (SAE #8 O.-Ring boss). Apply retract pressure to cylinder to

break packing gland loose. Remove holding valve and extend and retract plugs from butt plate and pull packing gland out by hand.

7. As soon as the packing gland is sufficiently loosened, properly support the rod assembly and carefully remove it by hand. Place rod assembly on supports. Exercise caution in the support and removal of the rod assembly as damage to the chrome surface requires rod assembly replacement.

8. Disassemble the piston set by removing nut, replace worn or damaged parts.

NOTE: Note: Loctite 680 is used during original assembly to secure nut to shaft.

9. If necessary, heat nut to 400-500° F (204-260°C) to facilitate removal. If heat is necessary for removal, discard nut and replace with new equivalent nut as well as worn or damaged parts.

10. Wipe and inspect all cylinder internal and external surfaces for damage.

11. Remove seals and bearings from packing gland and piston. Replace all seals and bearings.

12. Inspect wear pad on barrel assembly and replace as required.

Extend Cylinder Assembly

1. Reassemble shaft and piston set assembly in the proper order with internal round section ring, assembled packing gland, stop tube, piston to shaft o-rings, assembled piston, and locknut. Loctite locknut onto shaft using type 680 according to Loctite recommendations. Torque locknut to 300 ft-lbs (407Nm).

2. De-burr ring groove edge in barrel assembly and inspect all internal and external surfaces for damage.. Failure to do so will damage packing gland and or barrel assembly when packing gland is installed.

3. Grease piston assembly and install the shaft assembly with piston, o-ring, stop tube, packing gland, internal round ring into barrel assembly.

4. Using special drive tool, drive the packing gland into the barrel assembly.

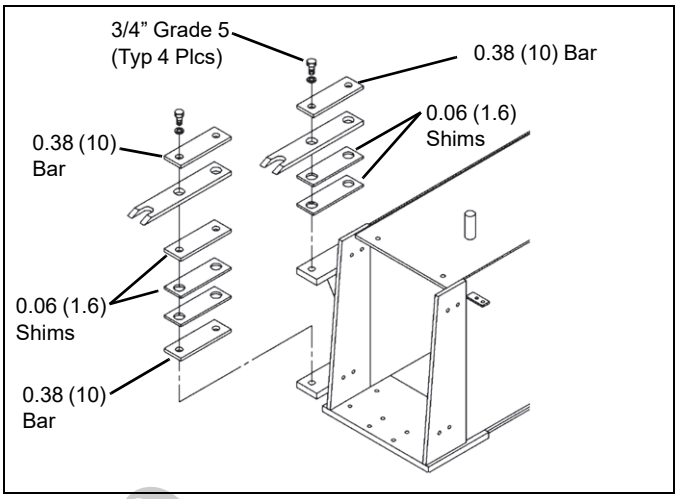
5. Insert one end of round ring into groove in barrel assembly and spiral the ring into groove with straight blade screw driver.

6. Cycle test cylinder to ensure no leaks exist. Support end of cylinder as it extends and retracts.

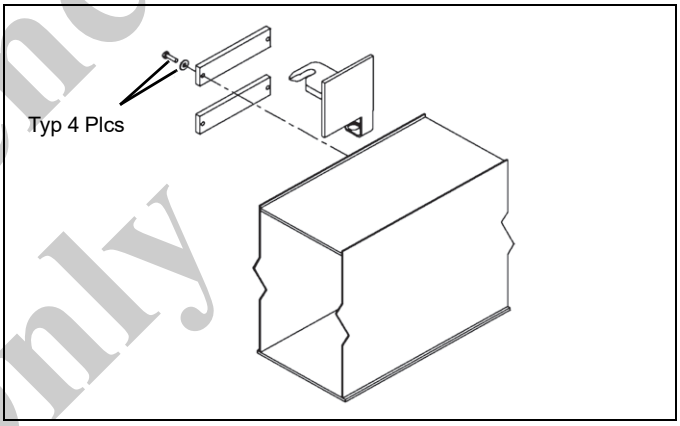
JIB INSTALLATION AND ADJUSTMENT

1. Loosely bolt the two ear assemblies with shims and bars as shown to the side of the first boom section.

NOTE: Note: All measurements are in inches (mm).

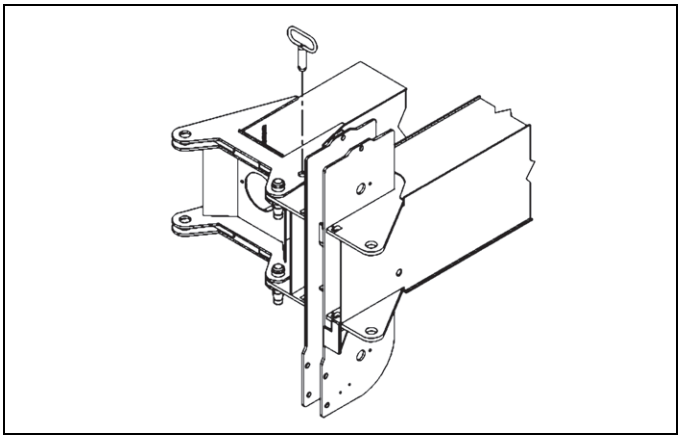


2. Loosely bolt the hook assembly to the side of the first boom section.



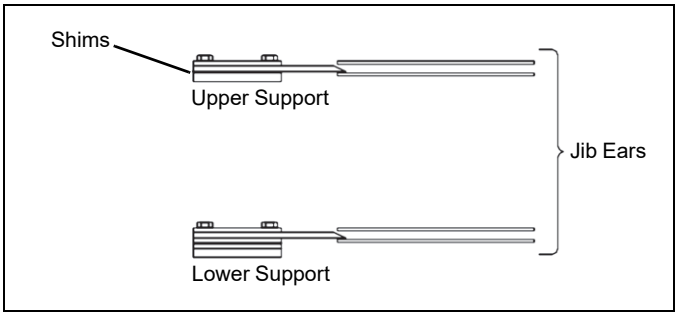
3. Extend the boom approximately one foot (300 mm).

4. Using an overhead hoist, lift the jib assembly and align and pin the jib to the boom sheave head.

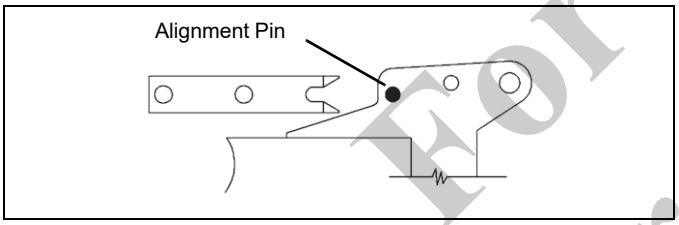


5. With jib pinned to the sheave head, swing the jib parallel to the boom and install the pin which keeps the jib from

swinging (the pin is attached by cable to the end of the jib).

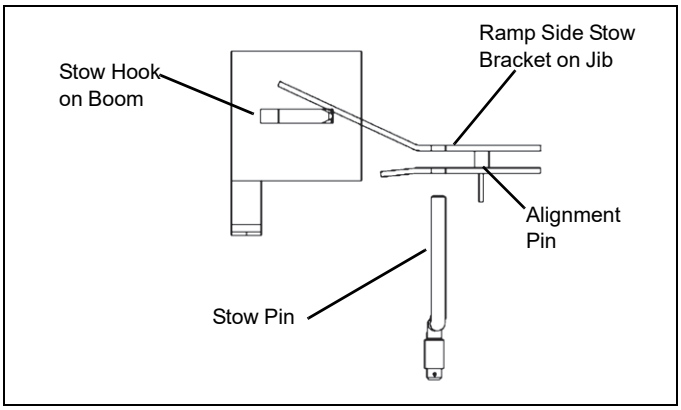


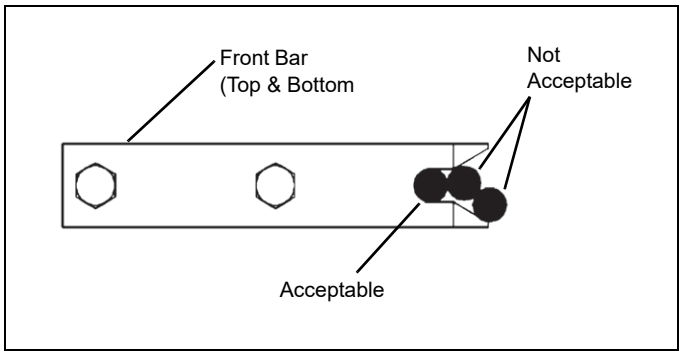
6. Slowly retract the boom until the jib ears are within 0.50 inch (13 mm) of the ear assemblies on the first section. Observe the vertical alignment of the jib ears and ear assemblies and add or remove shims until the jib is supported by the jib ears. The jib will typically rest only on the upper support.



7. Observe the horizontal alignment of the slot in the ear assemblies and the alignment pin in the jib. Horizontal adjustment of the stow ears is provided by oversize bolt holes in the stow ear. Move the ears in or out to achieve proper alignment. Position the top ear so it holds the top of the jib in toward the boom and the bottom ear so that it holds the bottom of the jib away from the bottom of the boom.

8. Retract the boom slowly. Observe the stow hook and side stow bracket assembly alignment as the boom is retracted (View AA and BB below).





CAUTION

Make sure ramp slides up to the stow hook and does not hit the end of the ramp.

9. When the boom is fully retracted, the jib must be bottomed out securely in the ear assemblies. If the alignment pins are not aligned properly, the hook assembly and front bars will have to be positioned as shown so the jib cannot slide forward or backward as the boom is elevated.

10. Try to remove the jib pins. If the pins are too tight, the stow hook assembly or front bars will have to be adjusted.

11. Torque all capscrews to their specified torque value (see “Fasteners and Torque Values Table in Section 2. Install stow pin in lock assembly and remove the jib pins.

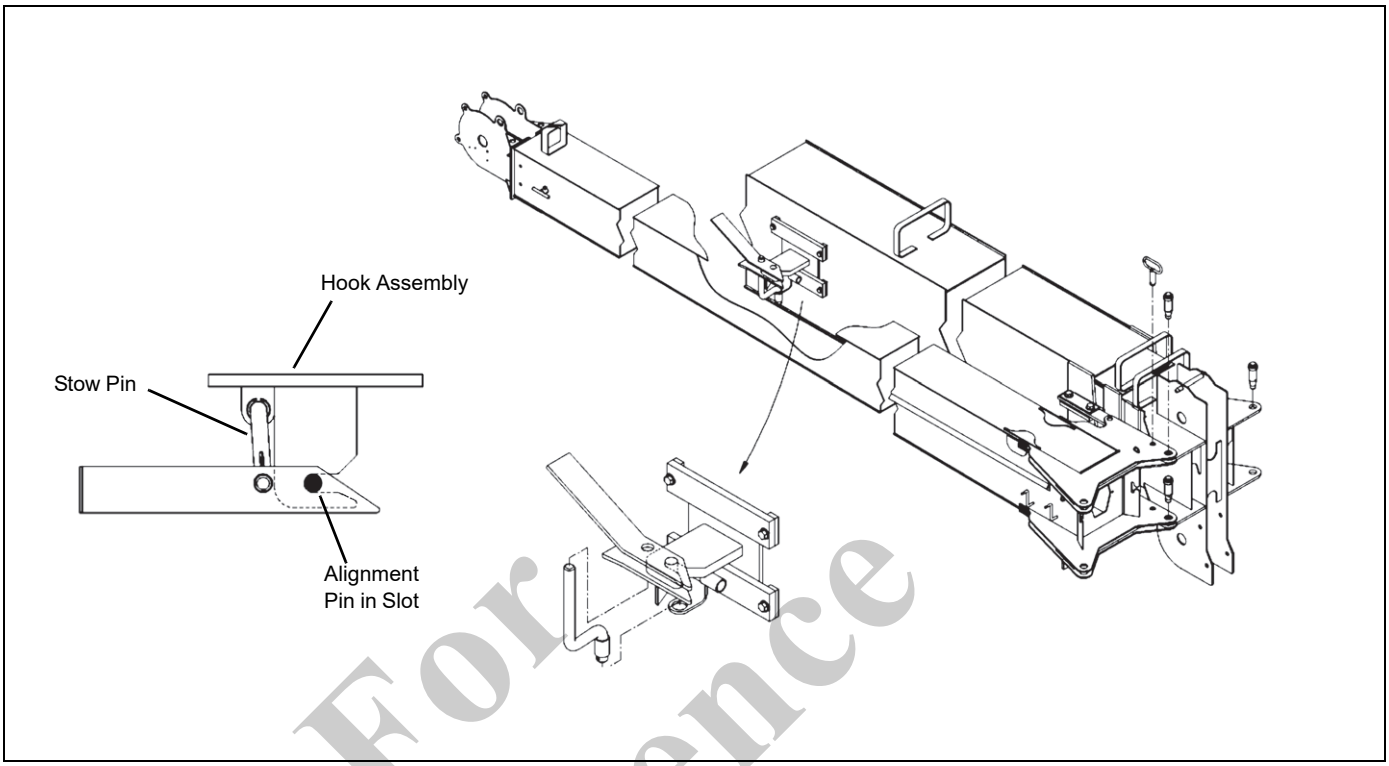
12. Extend and retract boom to insure proper alignment of jib pins.

13. Install jib pins and remove the stow pins.

14. Extend and retract the boom and jib to ensure proper alignment of jib stow brackets.

15. Install jib stow pins and remove jib pins.

16. Always save shims to allow future adjustment of jib stow if required



JIB JACK SERVICE AND MAINTENANCE

Important: Use only a good grade hydraulic jack oil, transmission oil, or turbine oil. Avoid mixing types of oil. Do not use brake fluid, alcohol, glycerin, detergent motor oil, or dirty oil. Improper fluid can cause serious Internal damage to the jack rendering it inoperative.

Adding Oil

1. With saddle fully lowered and piston depressed, set jack in upright level position and remove oil filler plug.
2. Fill until oil is level with filler plug hole.

Changing Oil

1. For best performance and longest life, replace the complete oil supply at least once a year.
2. To drain the oil, remove the filler plug.
3. Lay the jack on its side and drain the oil into a suitable drain pin. The oil will run slowly because air must enter as oil drains out.
4. Be careful to prevent dirt or foreign matter from entering the system.
5. Replace with proper oil as described above.

Lubrication

Add proper lubrication oil to all pivoting sections every three months.

Rust Prevention

Check ram every three months for any sign of rust or corrosion. Clean as needed and wipe with an oil saturated cloth.

NOTE: When the jack is not in use, always leave the saddle and ram all the way down.

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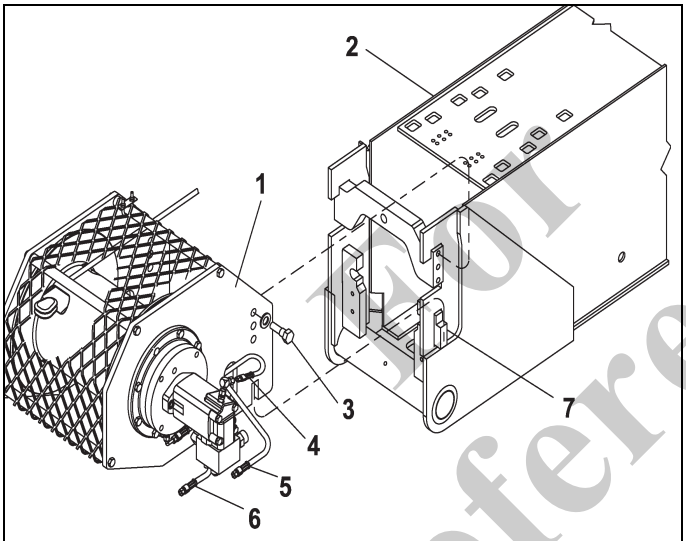
SECTION 5
HOIST

SECTION CONTENTS

Hoist Removal **5-1**
Hoist Installation **5-1**

HOIST REMOVAL



Item	Component
1	Hoist
2	Boom
3	Capscrew (6 plcs)
4	Case Drain
5	Hoist Down Hose
6	Hoist Up Hose
7	Hoist Alignment Ears

1. Extend and set the outriggers.
2. Fully retract the boom and place in a horizontal position.
3. Remove hook block or downhaul weight. Shut down truck engine.
4. Remove and cap hydraulic hoses.

NOTE: Tag hydraulic hoses to avoid confusion during re-assembly (the inside hose “up” and the outside is “down”).

CAUTION

The combined weight of the hoist and 325 ft. of wire rope is 660 lbs (300 kg).

5. Remove rope Mesh Guard.
6. Attach suitable lifting device to hoist and take up the slack.
7. Remove 6 mounting capscrews and washers (3 on each side).
8. Lift which clear of boom and secure to a suitable holder

HOIST INSTALLATION

1. Remove rope Mesh Guard from hoist.
2. Lift hoist with suitable lifting device.
3. Lower hoist onto the alignment ears.
4. Install Mesh Guard.
5. Install 6 capscrews and washers. Torque capscrews to 220 ± 20 ft lb (300 ± 30 N.m.).
6. Inspect hydraulic hoses and anti chafing sleeve for wear or damage. Replace as required.
7. Route hoses with anti chafing sleeve installed through access hole in turret assembly.
8. Install hoist **up** hydraulic hose to lower **inside** fitting on hoist motor.
9. Install hoist **down** hydraulic hose to **outside** fitting on hoist motor.

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SECTION 6
SWING

SECTION CONTENTS

Swing Gearbox And Brake. 6-1
Disassembly & Assembly Instructions 6-1
Swing Drive Disassembly 6-1
Tulsa Swing Drive Assembly Procedure. 6-4
Rotation Stop-mechanical 6-5
Rotation Stop Adjustment 6-5
Maintenance 6-6
General 6-6
Torquing Swing Bearing Bolts 6-6
General 6-6
Swing Bearing Bolts. 6-7
Torque Values 6-9
Bearing Clearance 6-9
Bearing Replacement 6-11
Removal. 6-11
Installation 6-11
Testing 6-12

6

SWING GEARBOX AND BRAKE

Disassembly & Assembly Instructions

This section describes the disassembly and assembly procedures for the swing gearbox. Item numbers shown in parentheses throughout this procedure, refer to the exploded parts breakdown drawing.

Swing Drive Disassembly

1. Remove drive from vehicle and drain gearbox lubricant by removing the drain plug (26).
2. Remove the motor from the motor adapter (3).
3. Remove the brake assembly from the gear housing assembly (1) by removing six socket head capscrews (27).

NOTE: The position of the brake port in conjunction with the drain and fill holes in the housing for reassembly.

4. Separate the motor adapter assembly (3) from the brake housing (2) by removing six capscrews (28).

NOTE: Notice the position of the motor mounting hole in relation to the brake release port for reassembly.

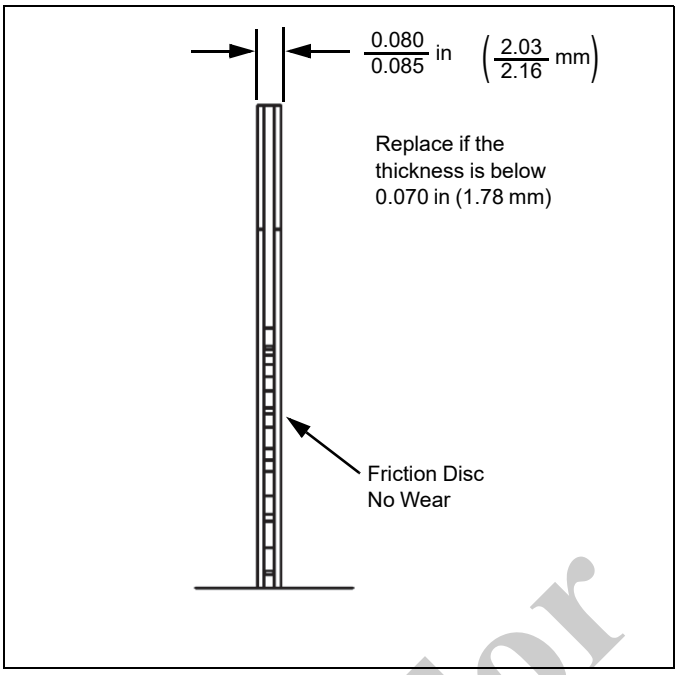
CAUTION

The motor adapter is spring loaded and the capscrews should be loosened in a sequence that will allow an even load distribution on the motor adapter.

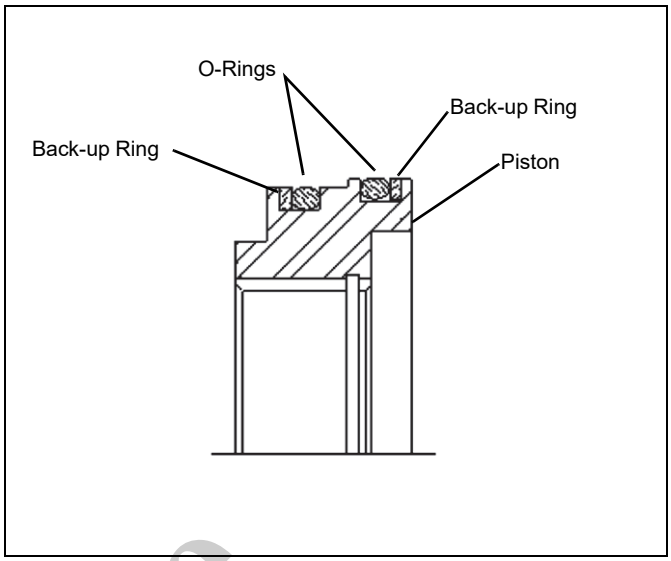
5. Inspect the motor adapter o-ring (24) for wear. Replace if necessary.
6. Remove the six springs (15) and the brake driver (8) from the brake housing (2).
7. Remove retaining ring (37) from the brake piston (5).
8. Remove the stator plates (16) and friction discs (17) from the brake piston (5). Inspect stator plates for excessive grooving or burn spots. Also, inspect friction discs for wear. Replace as required.
9. Remove the piston (5) from the brake housing (2).

NOTE: Notice the position of the dowel pin hole in piston with the brake release port for reassembly.

A port-a-power can be used to assist in removal of piston by slowly pressurizing the brake release port until piston clears the top of the housing.



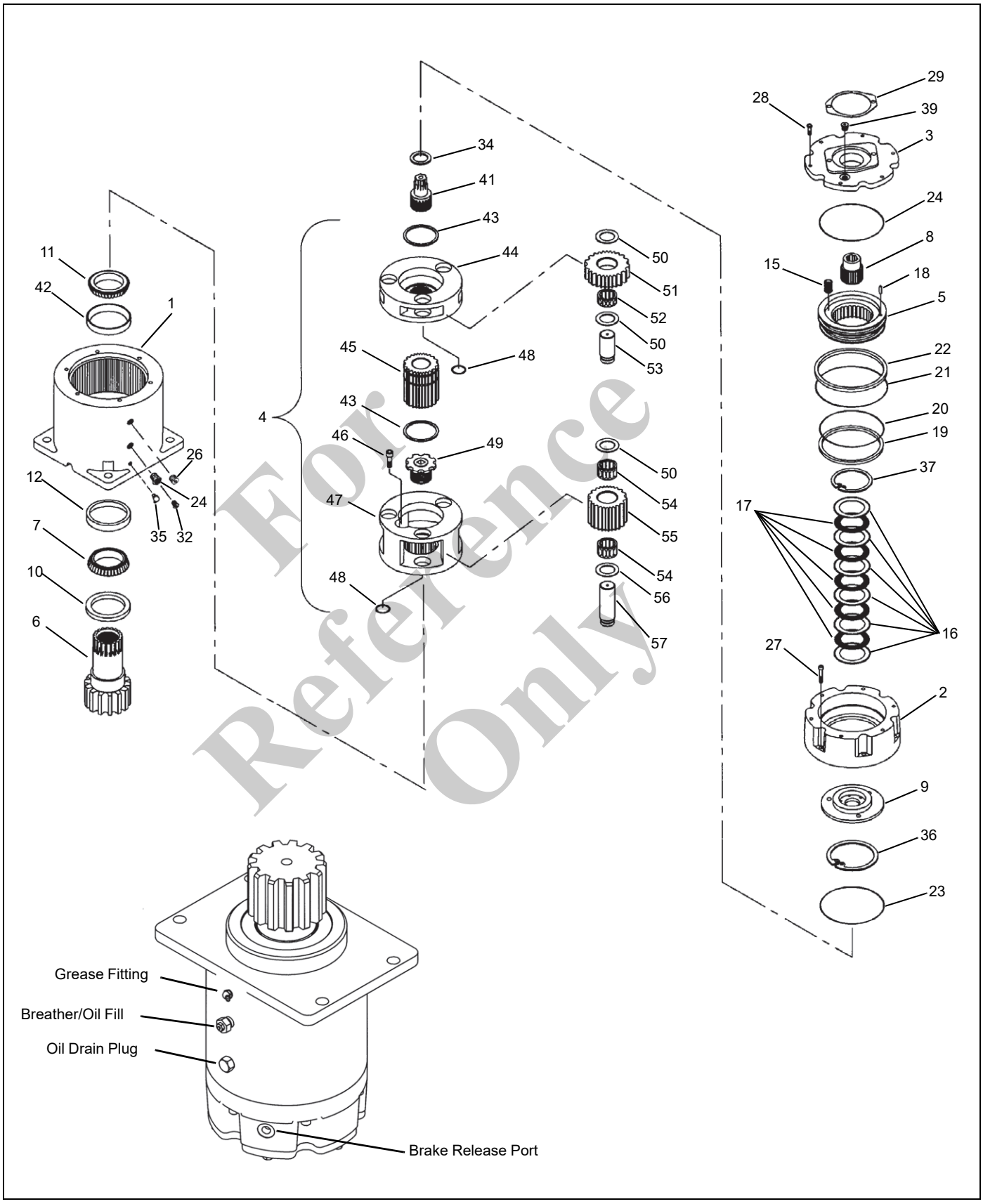
10. Inspect the piston 0-rings (20 &21)and the back up rings (19 & 22) for damage, replace if necessary.



11. Inspect the thrust plate (9) for excessive grooving and replace if necessary by removing snap ring (36).

12. Remove the brass thrust washer (34) and sun gear (41).

13. Remove input planet set (3, part of gear set 4) from gear housing (1) by pulling straight up and out of the housing.



Item	Component
1	Gear Housing
2	Brake Housing
3	Motor Adapter
4	Gear Set
5	Brake Piston
6	Pinion Shaft
7	Outboard Bearing
8	Brake Driver
9	Thrust Plate
10	Seal
11	Inboard Bearing
12	Bearing Cup
15	Spring

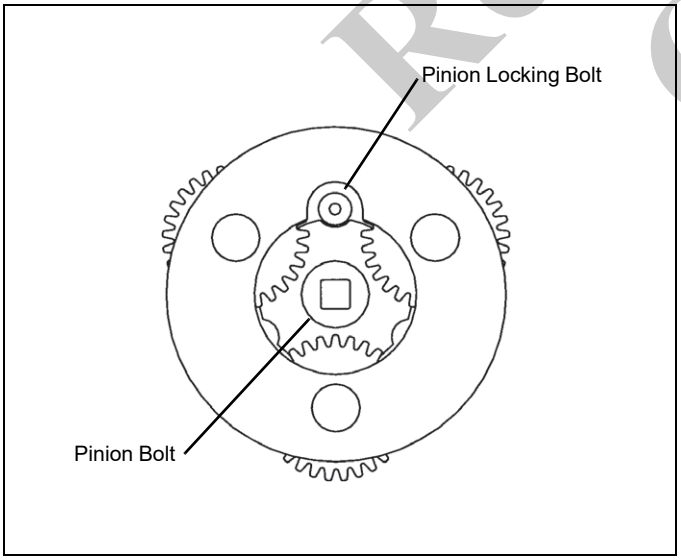
Item	Component
16	Stator Plates
17	Friction Plates
19	Back-up Ring
20	O-ring
21	O-ring
22	Back-up Ring
23	O-ring
24	Fill Plug
26	Drain Plug
27	Socket Head Capscrew
28	Socket Head Capscrew
32	Breather
34	Thrust Washer
35	Grease Fitting

Item	Component
36	Snap Ring
37	Retaining Ring
41	Sun Gear
43	Retaining Ring
44	Input Carrier
45	Sun Gear
46	Locking Bolt
47	Output Planet Carrier
48	Retaining Rings
49	Pinion Bolt
51	Planet Gear
52	Needle Bearings
53	Planet Pin

14. Remove the retaining ring (43) from the input carrier (44), remove the output sun gear (45), and inspect for wear and replace as necessary.

15. Remove retaining rings (48), press out the planet pin (53), remove the planet gear (51), and needle bearings (52), inspect for unusual wear. Replace as required.

16. Remove the pinion locking bolt (46) from the out put planet carrier (47). Loosen the pinion bolt (49).



17. Remove the retaining rings (48). Lift output planet set out of the housing (1). Press out the planet pin (57); remove the planet gear (55) and needle bearings (54). Inspect for unusual wear. Replace as required.

18. Remove the inboard bearing (11) and inspect for wear.

19. Remove the pinion shaft (6) from the housing (1) and inspect the pinion shaft, seal, and bearing for wear.

20. Remove outboard bearing (7) and seal (10). Inspect for wear and replace if necessary.

Tulsa Swing Drive Assembly Procedure

1. Press the inboard and outboard bearing cup (12) into the gear housing (1) if replaced.

2. Grease pack the bearing cones items (7) with EP 2 before installation.

3. Install the outboard cone (7) into the outboard cup (12). Press the seal (10) into the gear housing (1) from the outboard side.

4. Slide the output pinion (6) into the housing (1) from the outside.

5. Install the inboard bearing cone (11).

6. Separate the gear set (4) into sections.

7. Apply Loctite to the threads of the pinion bolt (49). Install the output carrier (47) into the gear housing (1).

a. Tighten the pinion bolt halfway, check the alignment of the output carrier (47) with the spline on the pinion shaft (6), and then tighten the pinion bolt the rest of the way.

b. Torque the pinion bolt to 50 ft-lb (68 Nm), loosen and re-torque until the pinion locking bolt aligns with

the slot on the nut portion of the pinion bolt at 25 ft-lb (34 Nm) If the pinion bolt is between slots always tighten to the next slot.

NOTE: Install a 1/2-13 bolt into the end of the pinion shaft on the outboard side and check the rolling torque. Preload of the bearing rolling torque should be 35-50 ft-lb (47-68 Nm). Apply Loctite to the pinion locking bolt (46) and torque to 20 ft-lb (27 Nm).

8. Install the input carrier section (44) with Sun gear (45) attached with retaining ring (43).

9. Install the sun gear (41) and thrust washer (34)

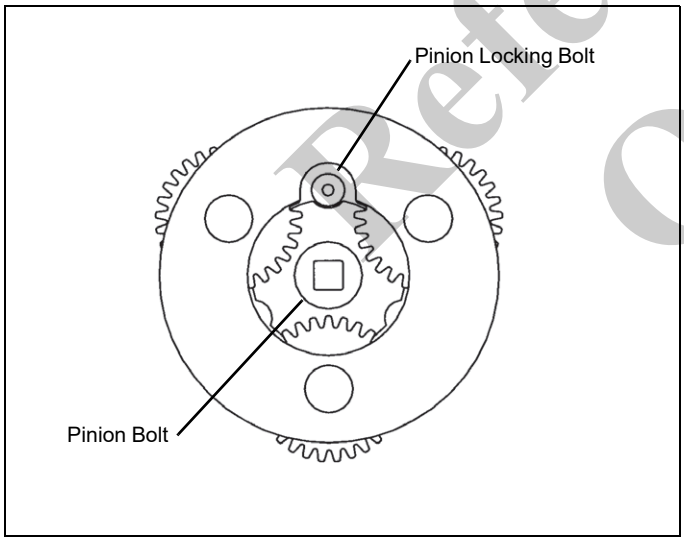
10. Assemble the brake section by first installing the O-ring (23) on the brake housing (2). Install six capscrews (27) to the brake housing (2) and torque to 10 ft-lb (13 Nm). Notice the position of the brake port in conjunction with the drain and fill holes in the housing.

11. Install the O-ring (20) and back-up ring (19) on the small step of the piston (5).

12. Install one back-up ring (22) and one 0-ring (21) on the large step of the piston (5). Apply a slight film of oil on the O-rings and back-up rings before installing.

13. Carefully press the assembled piston (5) into the brake housing (2), taking care not to damage the rings.

NOTE: The position of the dowel pinhole in piston with the brake release port for correct assembly.



14. Insert the brake driver (8) into the assembled brake housing (2) and piston (5).

15. Install the stator plates (16) and friction disks (17) starting with one stator plate and alternating between friction disk and stator plate until six stator plates and five friction disks are used.

NOTE: Soak friction disk in EP-90 for 24 hrs. before installation.

16. Reinstall the retaining ring (37) into the piston.

17. Install six springs (15) into the holes in the motor adapter (3).

18. Mount the motor adapter (3) to the brake housing (2) with six capscrews (28) checking to make sure the roll pin (18) is in line with the dowel hole in piston (5).

NOTE: Notice the position of the motor mounting hole in relation to the brake release port for correct reassembly.

19. Fill the gearbox to desired level with EP-90 gear lube.

ROTATION STOP-MECHANICAL

The rotation stop system is designed to stop crane rotation beyond 375 degrees in the clockwise or counterclockwise directions. This is accomplished by mechanically returning the control valve to the centered position as full rotation is approached. The operator will feel the control lever begin to pull in the opposite direction as full rotation is approached.

The operator should not resist this counteracting force, but permit the rotation stop system to return the lever to neutral.

If a load cannot be reached or placed due to the available rotation, the crane must be re-positioned.

DANGER

Attempting to override the rotation stop system will result in damage to the crane and possible injury to the operator.

Rotation Stop Adjustment

There are two methods that can be used for adjusting the rotation stop system.

Method 1

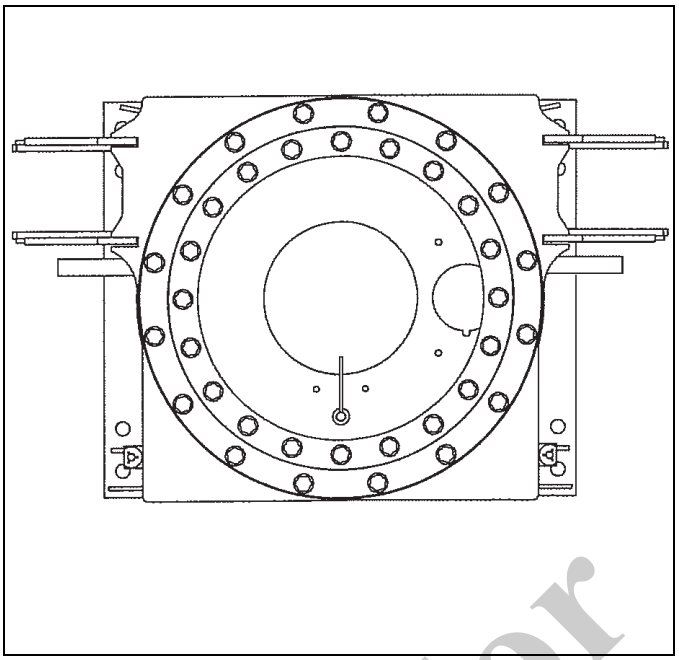
1. From inside of the frame, rotate the flag rod until it is centered between the two stop pins on either side of the flag.

2. Make certain that the turn lever is vertically aligned. If not, adjust the lever at the clevis connecting it to the control valve.

3. With the turn lever vertically adjusted, verify that the spacer is centered in the turn control rod tab.

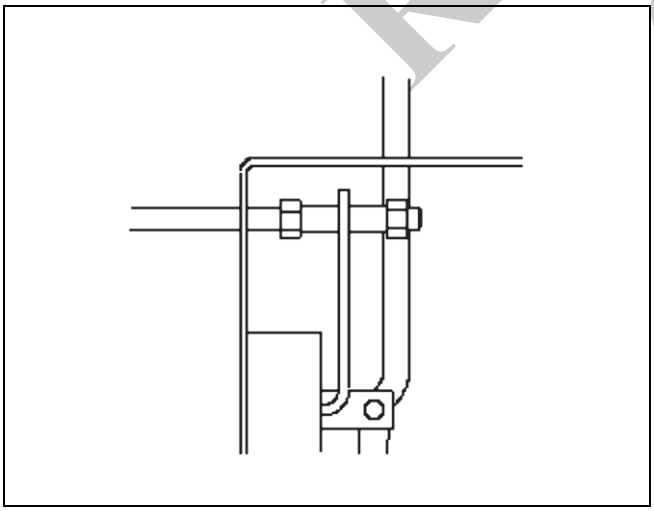
4. If it is not centered, loosen the two nuts, one on either side of the spacer. Turn the nuts in the same direction until the spacer is centered. Tighten the nuts against the ends of the spacer to secure it in place.

5. Verify that the flag is sill centered between the stop pins.



Method 2

1. Follow the crane set-up procedures in this manual to set outriggers and stabilizers and level the ma chine.
2. With the crane properly set-up, raise the boom to near full boom angle (75-80 degrees). This must be done with the boom fully retracted and with no load attached to the loadline.
3. Slowly rotate the boom until is directly over the front of the truck (behind cab mounting). With the boom directly over the front, place a mark at the top of the frame aligned with the center of the lift cylinder.



4. Rotate the crane clockwise, or counterclockwise until the rotation stop system centers the control lever.
5. Again make a mark at the crane frame aligned with the center of the lift cylinder.
6. Now rotate the crane in the opposite direction until the rotation stop system centers the control lever.
7. Make another mark on the crane frame aligned with the center of the lift cylinder.
8. If the rotation stop system is properly adjusted, the distance should be the same from the first mark made to the second mark, as it is from the first mark to the third mark.
9. If not, loosen the nut on either side of the spacer on the flag rod actuator rod and adjust the position of the spacer. Tighten the two nuts and repeat steps 3 through 7 above until proper adjustment is achieved.

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 turret and frame. Therefore, proper care of the bearing and periodic maintenance of the turret-to-bearing attach bolts IS A MUST to ensure safe and efficient operation.

TORQUING SWING BEARING BOLTS

General

⚠ DANGER

It is mandatory that swing bearing and T-box attaching bolts be inspected and re-torqued after the first 300 hours of crane operation and every 500 hours thereafter. The bolts may loosen and cause the crane to separate from the carrier which will result in damage to the crane and possible injury or death 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 turret from the frame.

CAUTION

Repeated re-torquing may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and

plating that will cause variation from dry torque values. When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification. Torque the capscrews to recommended values, refer to *Fasteners and Torque Values*, page 1-7.

NOTE: Zinc flake coated bearing bolt heads are stamped with the suffix “ZF” as a visual identifier.

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

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

Torque wrenches are precision instruments and must be handled with care. To ensure accuracy, calibrations must be made on a scheduled basis. Whenever there is a possibility that a torque wrench may have been either overstressed or damaged, it should immediately be removed from service until re-calibrated. 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 swing bearing bolts must be inspected for looseness and re-torqued to specifications.

Torque the swing bearing bolts according to the procedures outlined in this section.

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

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

Swing Bearing Bolts

The inner race of the bearing is secured to the turret by 26 capscrews (Figure 6-1). The outer race of the bearing is secured to the frame by 24 capscrews (Figure 6-1).

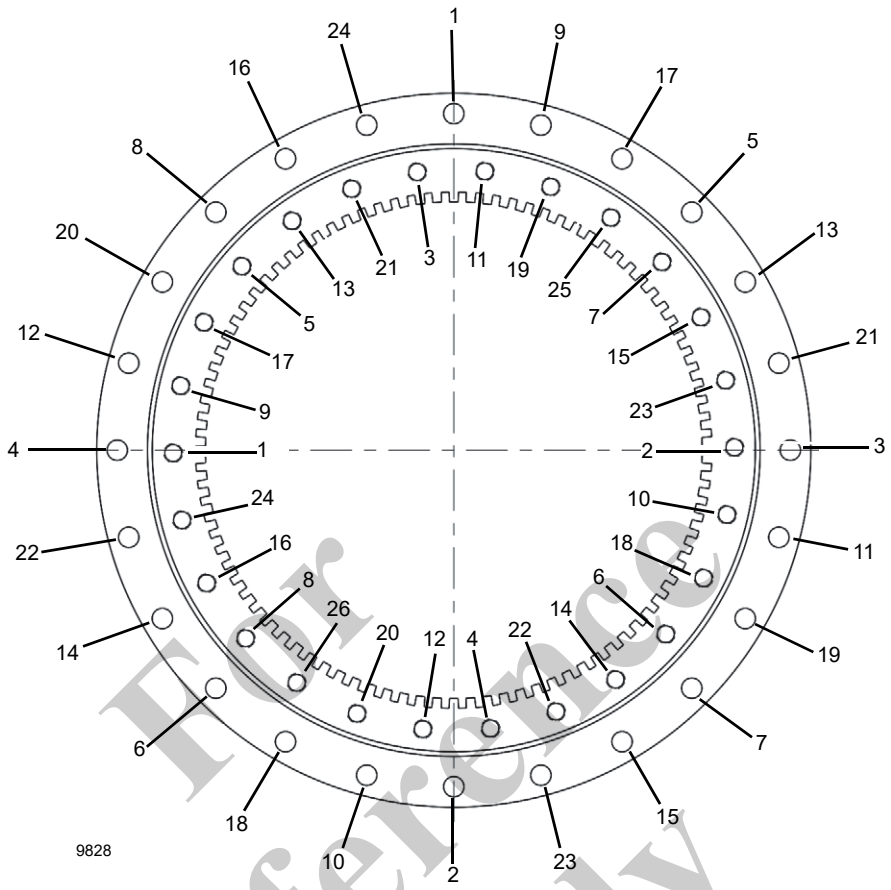


FIGURE 6-1

FIGURE 6-2

Torque Values

Torque all swing bearing bolts to a final torque. Refer to “Fasteners and Torque Values” on page 1-7.

Inner Race Torquing

The inner race bearing bolts are located on top of the inner race (Figure 6-2).

1. Extend and set the outriggers.
2. Fully elevate the boom.
3. Torque all bolts to 80% of the specified torque value following a star pattern sequence as shown in Figure 6-1 starting with bolt number 1. Refer to “Fasteners and Torque Values” on page 1-7.

Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.

4. Return to bolt 1 and torque all bolts using the same star pattern sequence to the final torque value specified. The same tools are used as in step 3.

Outer Race Torquing

The outer race bearing bolts are located on top of the outer race (Figure 6-2).

1. Extend and set the outriggers.
2. Fully elevate the boom.
3. Torque all bolts to 80% of the specified torque value following star pattern sequence as shown in Figure 6-1 starting with bolt number 1. Refer to “Fasteners and Torque Values” on page 1-7.

Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.

4. Return to bolt 1 and torque all bolts using the same star pattern sequence to the final torque value specified. The same tools are used as in step 3.

BEARING CLEARANCE

If a swing bearing exhibits the following symptoms, it may have reached the end of its useful life.

- metal particles in the grease
- increased drive power required
- noise
- rough operation
- acceleration in the increase in bearing clearance

Measure the internal clearance of the swing bearing to determine if it needs to be replaced. (Reference National Crane Technical Support Information TSI #10)

1. Place the boom in the boom rest and set the outriggers.
2. Put a magnetic base dial indicator opposite the boom on the top of the frame (Figure 6-3).
3. Place the dial on the top of the swing bearing (Figure 6-3).
4. Power the boom down onto the boom rest.
5. Set the dial indicator at zero.
6. Raise the boom about 3 in above the boom rest.
7. Record the deflection indicated on the dial.
8. Repeat steps 4 through 7 three times and average the readings.
9. If the average is greater than 0.090 in, replace the bearing.
10. If the average is less than 0.090 in, repeat the measurement at every 45° around the total working area of the crane (Figure 6-4).
    a. Measure the deflection at positions 2, 3, 7, and 8 for 180° rotation and positions 2 and 8 for 360° rotation.
    b. Use another crane to support the end of the boom when the boom is powered down.
    c. Locate the dial indicator opposite the boom.
    d. Set the dial indicator to zero.
    e. Raise the boom about 3 in.
    f. Record the reading on the dial indicator.
    g. Repeat steps d through f three times.
    h. Average the readings.
    i. If the averages is greater than 0.090 in at any position, replace the bearing.

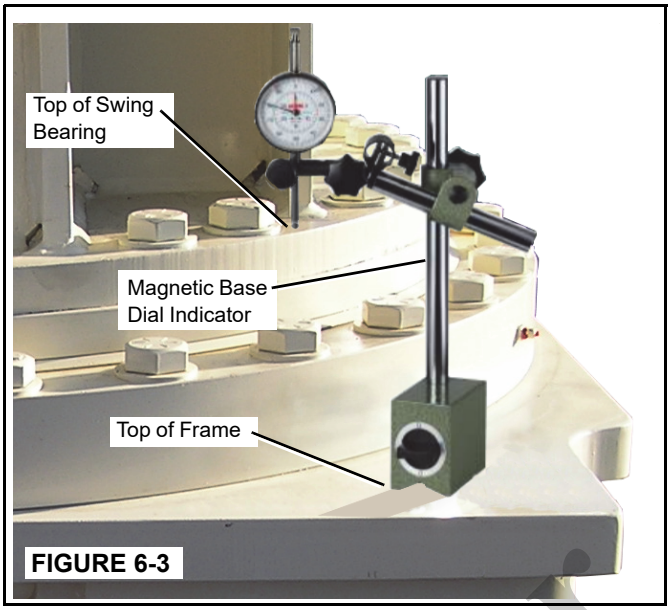


FIGURE 6-3

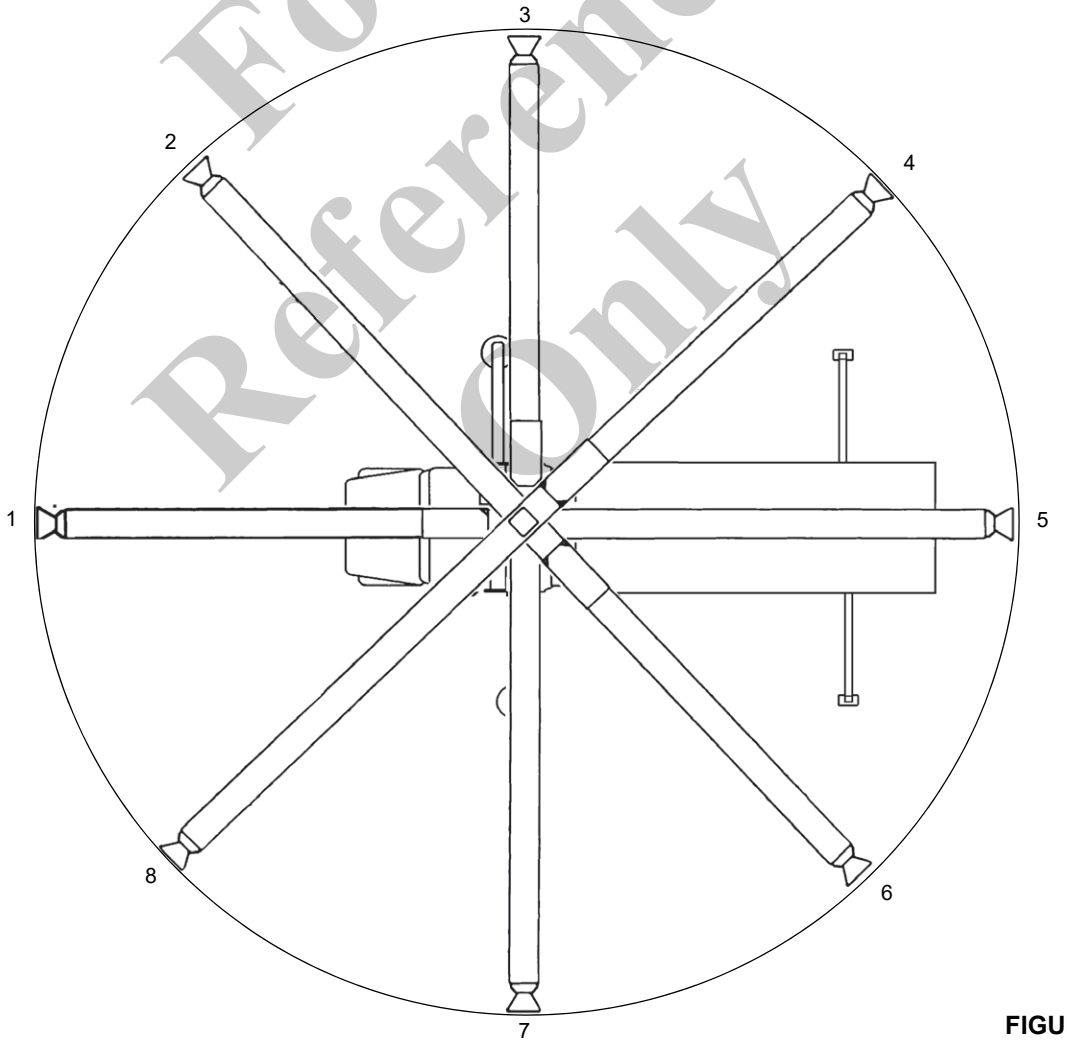


FIGURE 6-4

BEARING REPLACEMENT

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. Rotate the boom to about 10° off the rear position so that the boom is clear of the boom rest.

NOTE: The lift cylinder pins need to be accessible from the truck deck.

3. Elevate the boom slightly and shut down the engine.
4. Tag and disconnect the battery cables.
5. Remove the boom and lift cylinder following the procedures outlined in “Boom Removal” on page 4-3.

NOTE: If equipped with a swivel, tag and disconnect all hydraulic lines from the swivel on the carrier side. Cap or plug all lines and openings. The swivel is removed with the turret.

6. Attach a suitable lifting device to the turret. Remove any slack in the sling. Do not pull up on the turret.

DANGER

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

7. Remove all bolts and washers from the outer race of the swing bearing.

DANGER

Ensure blocking material can support the turret.

8. Carefully lift the turret with bearing off the truck and set it on blocking that will not allow the turret to tilt or shift. Leave the lifting device attached.

NOTE: If the current bearing is to be reinstalled, mark the position of the bearing on the turret before removal.

9. Remove all bolts from the inner race of the swing bearing.
10. Lift the turret off the swing bearing and set on blocking.

NOTE: The bearing weighs about 415 lb (188.2 kg).

Check the bearing teeth for chipping or cracking. If any evidence of these is found, replace the bearing. Ensure the bolt holes are free of dirt, oil, or foreign material.

Installation

DANGER

Do not reuse the swing bearing bolts. The swing bearing is torqued to the applied torque of the grade 8 bolts. New bolts ensure proper torque and bolt strength for securing the swing bearing and turret to the frame.

NOTE: If the current bearing is reinstalled, align the marked teeth on the swing drive pinion shaft with the marked teeth on the bearing.

1. Using an appropriate lifting device, set the turret on the swing bearing. If the same bearing is being used, position it as marked prior to removal.
2. Install new bolts and washers securing the bearing to the turret. Refer to “Inner Race Torquing” on page 6-9.
3. Using an appropriate lifting device, align the turret over the frame at the same position that it was before removal.
4. Carefully lower the turret into position on the bearing plate.

NOTE: If equipped, be careful not to damage the swivel assembly.

5. Install all bolts and washers to secure the outer race of the swing bearing to the T-box frame. Refer to “Outer Race Torquing” on page 6-9.

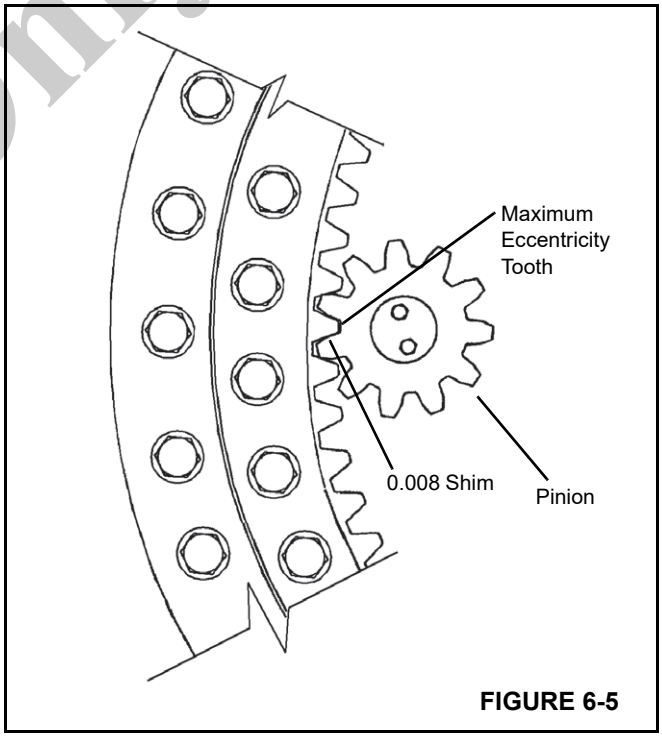


FIGURE 6-5

NOTE: If a new bearing is installed, a new pinion gear must also be used.

6. Install the swing drive pinion so that the high point (maximum eccentricity) is aligned with the turret bearing high point. Check the backlash with a (0.008 in) 0.203 mm thick shim (Figure 6-5). If the pinion must be moved to achieve proper backlash, contact your local National Crane distributor.

NOTE: If equipped with a swivel, reconnect the hydraulic lines as per removal tags.

7. Install the boom and lift cylinder following the procedures outlined in Section 4- BOOM.

8. Reconnect the batteries.

Testing

Activate the crane and check for proper function.

NOTE: If the turret does not turn freely after bearing and pinion replacement, contact your local distributor.

SECTION 7
LUBRICATION

SECTION CONTENTS

Lubrication General 7-1

Environmental Protection 7-1
- Lubricants 7-1
- Arctic Conditions Below -9°C (15°F) 7-2
- Chassis Grease 7-2
- Low Temperature Grease 7-2
- Extreme Pressure Multipurpose Gear Lubricant (EPGL) 7-2
- Open Gear Lubricant 7-2
- Antifreeze/Coolant (for Cab Heater) 7-2
- Anti-wear Additives 7-2
- Hydraulic Oil 7-2
- Standard Hydraulic Oil 7-2
- Arctic Hydraulic Oil 7-3
- Hydraulic Oil Inspection 7-3
- Surface Protection for Cylinder Rods 7-3

Lubrication 7-3

Lubrication Chart 7-5
- Internal Cable Sheave Lubrication 7-6
- Inner Boom Pad Lubrication 7-7
- Side and Bottom Boom Wear Pad Lubrication . . . 7-7
- Hoist Gearbox Oil 7-7
- Hoist Brake Oil 7-8
- Swing Gearbox and Brake Oil 7-9

Hydraulic Oil Reservoir Level 7-9

Wire Rope Lubrication 7-9

Carwell© Rust Inhibitor 7-10
- Protecting Cranes From Corrosion 7-10
- Cleaning Procedures 7-10
- Inspection and Repair 7-11
- Application 7-11
- Areas of Application 7-12

LUBRICATION GENERAL

Following a designated lubrication procedure is important to ensure a maximum crane life. 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. This section does not include lubrication requirements for the truck chassis. Refer to truck service manual for this 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 National Crane Distributor or Manitowoc Crane Care.

ENVIRONMENTAL PROTECTION

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

Potentially harmful waste used in National 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.

Lubricants

Specific recommendations of brand and grade of lubricants are not made here due to regional availability, operating conditions, and the continual development of improved products. Where questions arise, contact your National Crane Distributor or Manitowoc Crane Care.

Arctic Conditions Below -9°C (15°F)

In general, petroleum based fluids developed especially for low temperature service may be used with satisfactory results. However, certain fluids, such as halogenated hydrocarbons, nitro hydrocarbons, and phosphate ester hydraulic fluids, might not be compatible with hydraulic system seals and wear bands. If you are in doubt about the suitability of a specific fluid, check with your authorized National Crane distributor or Manitowoc Crane Care.

NOTE: All fluids and lubricants may be purchased by contacting the Manitowoc Crane Care Parts Department.

Regardless of temperature and oil viscosity, always use suitable start-up procedures to ensure adequate lubrication during system warm-up.

Chassis Grease

CAUTION

Do not use air pressure devices to apply chassis grease otherwise damage to sealed fittings may result.

Lubricating grease of proper consistency is to be applied periodically at relatively frequent intervals with grease guns through grease fittings. Minimum apparent viscosity of 300 SUS (Saybolt Universal Seconds) at 38°C (100°F) is recommended.

CAUTION

The multipurpose grease installed during manufacture is of a lithium base. Use of a non-compatible grease could result in damage to equipment.

Low Temperature Grease

This special grease for low temperature remains plastic at -51° C (-60° F) with melting point of 138°C (280°F). The grease is a heavy duty extreme pressure type lubricant (Lubricate Low Temp or equal).

Extreme Pressure Multipurpose Gear Lubricant (EPGL)

This gear lubricant is compounded to achieve high load carrying capacity and meet the requirements of either API-GL-5 or MIL-L-2105C. Unless otherwise specified, SAE 80W-90 viscosity may be used for year round service. Low temperature usage is restricted as follows:

SAE Viscosity Number	Minimum Ambient Temperature C (F)	
75W	-40°C	(-40°F)
80W	-26°C	(-15°F)
85	-12°C	(+10°F)
90	-7°C	(+20°F)
140	+5°C	(+40°F)
250	+10°C	(+50°F)

Open Gear Lubricant

This is a special high-graphite adhesive lubricant that helps to eliminate fretting corrosion, is water resistant, and forms a dry lubrication film which does not attract dust. Lubricant meets NLGI Class 1-2 specifications.

Antifreeze/Coolant (for Cab Heater)

The standard antifreeze/coolant filled from the factory is intended to provide protection against freeze-up down to -36° C (-34° F) and boil-over up to 129° C (265° F) using a 15 psi pressure cap.

Anti-wear Additives

Excessive wear in the system may cause a loss in volumetric efficiency and cause shutdowns for maintenance. An efficient anti-wear oil protects the components against rusting, resists oxidation and helps prevent wear.

Hydraulic Oil

Oil in a hydraulic system serves as the power transmission medium, system lubricant and coolant. Selection of the proper oil is essential to ensure satisfactory system performance and life. The most important factors in selecting an oil for hydraulic service are viscosity and anti-wear additives.

CAUTION

Operation of the crane with incorrect hydraulic oil in sub freezing temperature (below 0° C, 32° F) can cause damage to the extend cylinder.

NOTE: When operating the crane in temperatures -9°C (15°F) and below, follow the procedures in the section titled “Arctic Conditions Below -9°C (15°F)” on page 7-2.

Standard Hydraulic Oil

Temperature Above -9°C (15°F)

The factory fill standard hydraulic oil is ISO grade 46/68 Hydraulic Oil. This fluid is acceptable for operating temperatures above -9°C (15°F).

NOTE: On units equipped with self-leveling platforms, low temperature service oils are necessary to provide

proper boom functions at temperatures below -9°C (15°F).

CAUTION

Operation of the crane with incorrect hydraulic oil in sub freezing temperature below 0°C (32°F) can cause damage to the extend cylinder.

Arctic Hydraulic Oil

Temperature Down to -9°C (15°F) to -29°C (-20°F)

For colder operating conditions, the standard fluid may be replaced with a petroleum based fluid developed especially for colder environments.

Temperature Down to -40°C (-40°F) and Below

Petroleum based fluids developed especially for low temperature service may be used with satisfactory results. However, certain fluids, such as hologenated hydrocarbons, nitro hydrocabons and phosphate ester hydraulic fluids might not be compatible with hydraulic system seals and wear bands. Arctic hydraulic oil is not recommended for service in ambient temperatures above 0°C (32°F).

If you are in doubt about the suitability of a specific fluid, check with your authorized National Crane distributor or Manitowoc Crane Care.

NOTE: All fluids and lubricants may be purchased by contacting the Manitowoc Crane Care Parts Department.

Hydraulic Oil Inspection

Environmental and other conditions can dramatically affect the condition of hydraulic oil and filters. Therefore, specific intervals for servicing/changing hydraulic oil, filters and hydraulic tank breathers cannot be set. However, it is imperative for the continued satisfactory performance that inspections be performed on the basis of how and where each crane is used. Air borne and ingested contaminants can significantly reduce the life of oil and the condition of hydraulic oil filters and tank breathers.

Under normal operating conditions, it is recommended that hydraulic oil, filter and breathers be inspected at least every three to six months and more frequently for severe operating conditions. The inspections should be for air borne and/or ingested particles and water that deteriorate and contaminate the oil. For example, if oil appears “milky” or no longer has a transparent clear to amber color. The return filter by-pass indicator should be observed daily to determine if contaminant content is high. If the indicator reaches the red zone or indicates a by-pass condition, the hydraulic oil must be sampled. The hydraulic tank breather should also be inspected to assure that it is not restricting air flow into and out of the reservoir.

To inspect the hydraulic oil, fill a small glass container with a sample of the reservoir oil and another glass container with fresh oil. Let the samples stand, undisturbed, for one or two hours. Then, compare the samples. If the reservoir oil is heavily contaminated with water, the sample will appear “milky” with only a small layer of transparent oil on top. If the “milky” appearance is due to air foaming, it will dissipate and the oil should closely match the fresh oil. Remember, replacement oil must meet ISO 17/14 or better cleanliness level and must meet John Deere Standard JDM J20C. Contact your National Crane distributor or Manitowoc Crane Care if you have any questions.

Surface Protection for Cylinder Rods

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

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

NOTE: Cylinder operation and inclement weather will remove the Boeshield protectant. Inspect machines once a week and reapply Boeshield to unprotected rods.

LUBRICATION

A regular frequency of lubrication must be established based on component operating time. The most efficient method of keeping track of lube requirements is to maintain a job log of crane usage.

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

CAUTION

Lubrication intervals are to be used only as a guide. Actual intervals should be formulated by the operator to correspond accordingly to conditions such as continuous duty cycles and/or hazardous environments.

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 fill port.

Over lubrication of non-sealed fittings will not harm the fittings or components, but under lubrication shortens lifetime.

Worn grease fittings that do not hold a grease gun, or those that have a stuck check ball, must be replaced.

When wear pads or rotation bearings are lubricated, cycle the components and lubricate again to ensure complete lubrication of the entire wear area.

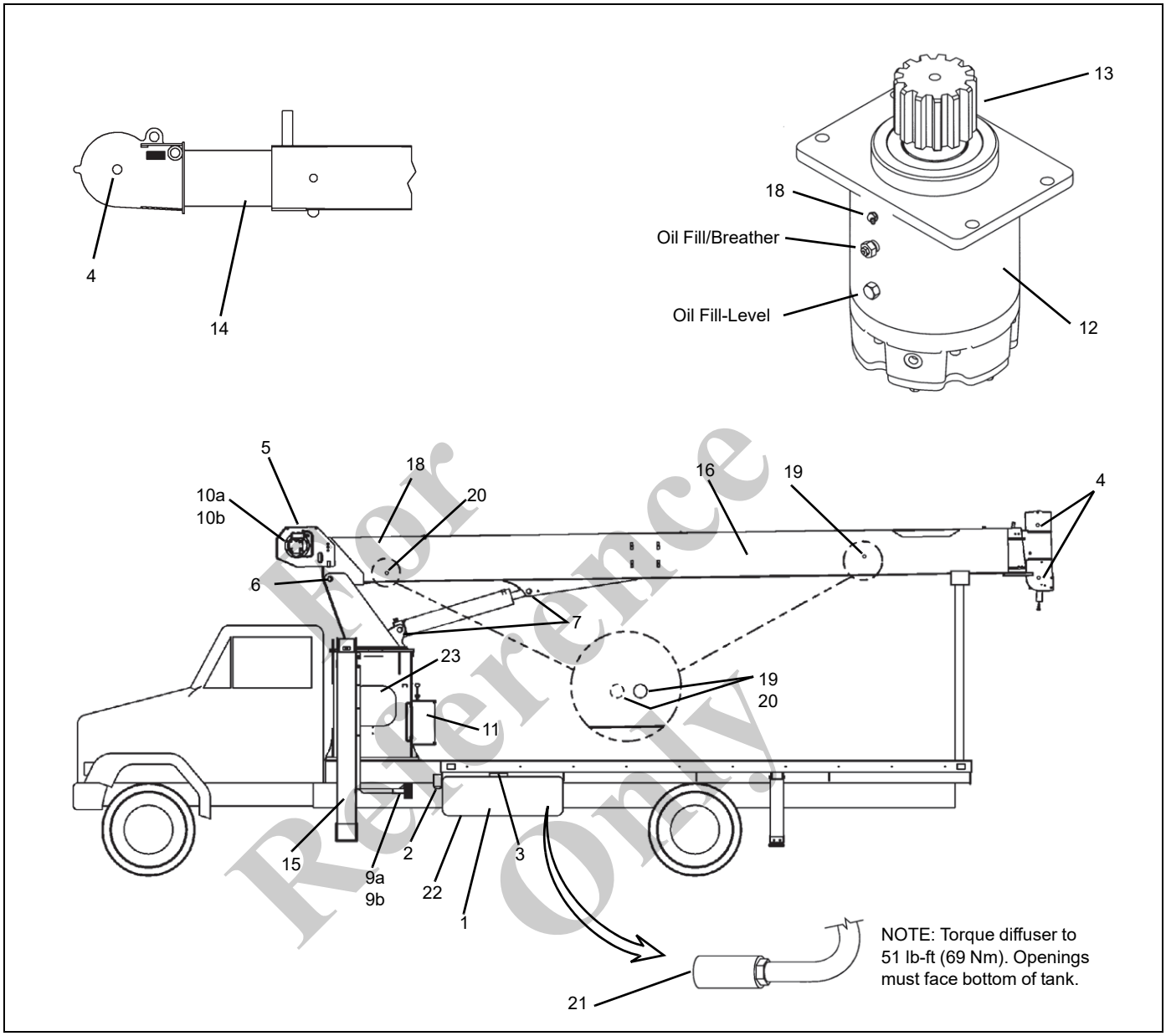
CAUTION

Lubrication intervals are to be used only as a guide. Actual intervals should be formulated by the operator to correspond accordingly to conditions such as continuous duty cycles and/or hazardous environments.

The following describe the lubrication points and gives the lube type, lube interval, lube amount, and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown in “Lubrication Chart” on page 7-5. Lube description and symbols are found in tables below.

Symbol	Description	National Crane Lube Specification
EP-MPG	Extreme Pressure Multipurpose Grease - Lithium Soap Base, NLGI Grade 2.	A6-829-003477
EP-3MG	Extreme Pressure Moly Grease	A6-829-015304
GL-5	Extended Service Interval Gear Lubricant - SAE Grade 80W-90	A6-829-012964
AFC - 50/50	50/50 Blended Fully Formulated Antifreeze/Coolant, SAE J1941, ASTM D6210	A6-829-101130
HYDO	Hydraulic Oil - Must meet ISO 4406 cleanliness level 17/14	A6-829-006444
EO-15W/40	Engine Oil - SAE 15W-40, API Service Classification CI-4 or better	A6-829-003483
EP-OGL	Open Gear Lubricant, CEPLATTYN 300 Spray, NLGI Grade 1-2	A6-829-102971
AGMA EP-4	Extreme Pressure Gear Lubricant.	A6-829-100213
WRL	Wire Rope Lubricant	A6-829-015236
LTG	Low Temperature Grease, NLGI Grade 1	A6-829-225828

LUBRICATION CHART



Item	Application	Recommended Lubricant	Procedure	Frequency
1	Hydraulic oil reservoir	HYDO	Check and Fill Change	Check and Fill: Weekly, Fill as required Change: Semi-annually
2	Oil filter, magnetic plug, hydraulic oil reservoir		Change or clean	After first 40 hrs. as indicated by gauge thereafter.
3	Breather, hydraulic oil reservoir		Clean	Monthly
4	Sheave pins: boom (3 plcs), jib (1 pl)	EP-MPG	Grease gun	Weekly
5	Wire rope (loadline)	EP-OGL	Brush or spray	Semi-Annually
6	Boom pivot pin	EP-MPG	Grease gun	Monthly
7	Lift cylinder pins - 2 ea.	EP-MPG	Grease gun	Monthly
8	Swing bearing (turret) (not shown)	EP-MPG	Grease gun	Weekly

Item	Application	Recommended Lubricant	Procedure	Frequency
9a	Pump drive U-Joint 2 ea.	EP-MPG	Grease gun	Monthly
9b	Pump spline shaft (direct mount)	EP-MPG	Remove pump and apply to shaft or grease gun	Semi-Annually
10a	Hoist gearbox.	SAE 90 EP	Check and Fill	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks.
			Change	Change: Every 1000 hours or 6 months.
10b	Hoist brake	HYDO	Check and Fill	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks.
			Change	Change: Every 1000 hours or 6 months.
11	Control linkage	EO-15W/40	Oil Can	As Required
12	Swing drive gearbox	GL-5	Check and Fill	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks.
			Change	Change: After first 50 operating hours, and every 500 operating hours thereafter.
13	Swing gear teeth	EP-OGL	Spray Can	Monthly
14	Boom extension	LTG	Brush, roller or grease gun	Monthly or as required
15	Outrigger beams, bottom, sides	LTG	Brush or roller	Monthly or as required
16	Extension cables (not shown)	WRL	Spray or brush	Any time boom is disassembled or 5 years.
17	Boom Wear Pads (not shown)	EP-MPG	Brush or roller	Monthly or as required
18	Swing Motor Pinion Bearing	EP-MPG	Grease gun	Sparingly every 50 hours
19	Extend Sheaves	EP-3MG	Grease gun	Weekly
20	Retract Sheaves: Extend the boom until the retract sheave grease holes are visible through the access holes along side of boom.	EP-3MG	Grease gun	Weekly
21	Diffuser strainer, Hydraulic oil reservoir		Clean	Semi-Annually with oil change
22	Magnetic plug, hydraulic oil reservoir		Clean	At oil filter service interval
23	Continuous rotation swivel (optional)	EP-MPG	Grease gun	Monthly

Internal Cable Sheave Lubrication

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations

The lubrication points on the internal sheaves require a grease gun adapter because there are no grease fittings on the sheaves.

Special Tools: Nozzle or needle grease gun fitting:

- 0.25 inch (6.35 mm) diameter nozzle grease gun tip (National Crane P/N 955047).
- Contact the Manitowoc Crane Care to obtain this nozzle tip.

NOTE: To determine the amount of grease required, visually inspect the sheaves. From the front of the boom, look back through the sheave case at the extend sheaves. From the back of the boom, look up through the hoist mount at the retract sheaves. A small amount of grease extrusion around the pin is adequate.

The extend sheaves are located on the boom tip end of the extend cylinder, and the retract sheaves are located on the inside rear of the 2nd section. Lubrication is as follows:

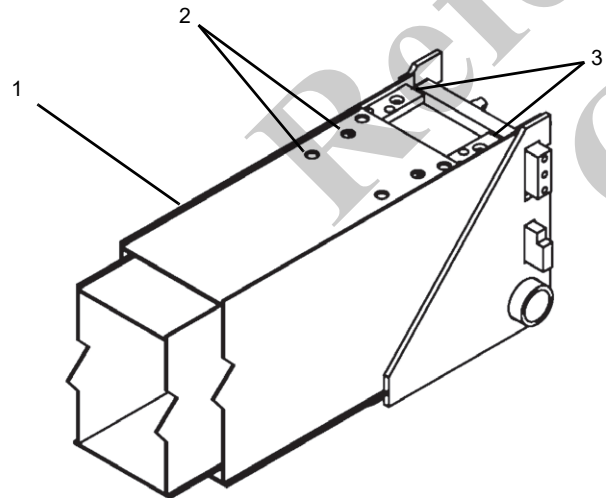
1. Extend boom until grease access hole (Item 19 on the Lubrication Points diagram) becomes visible on side of 2nd section.

2. Check alignment between the 2nd section access hole and the 3rd section access holes. When these holes become aligned, the end of the extend cable sheave pin is visible and accessible for lubrication.
3. This boom position also aligns the access holes at the rear of the 1st section for lubrication of the retract sheaves.

Inner Boom Pad Lubrication

1. With the boom fully retracted, apply grease to the wear pads on the top of second boom section with a small paint brush or a grease gun.
2. Extend boom to position the wear pad access holes directly above the wear pads on the third boom section, apply grease to the pads using the brush or gun.
3. Extend boom to position the wear pad access holes directly above the wear pads on the fourth boom section, apply grease to the pads using the brush or gun.
4. After grease is applied to all wear pads raise the boom to the maximum angle and slowly extend the boom to full extension and slowly retract completely.
5. Repeat steps 1 - 4 three times to ensure the boom is fully lubricated.

Side and Bottom Boom Wear Pad Lubrication



Item	Component
1	First Section of Boom
2	Wear Pad Access Holes
3	Third Section Wear Pads

1. Fully extend and set the outriggers.
2. Lower the boom to horizontal.
3. Fully extend the boom and apply grease to the side and bottom of the 2nd and 3rd sections with a brush.
4. Raise the boom to about 75° and retract the boom
5. Extend and retract the boom several times until the grease is evenly spread.
6. Repeat steps 1-3 as necessary to ensure the boom is fully lubricated.

Hoist Gearbox Oil

Use the following procedures to change the hoist gearbox oil (Figure 7-1).

NOTE: Hoist gear and brake lubricants are satisfactory for operation in temperatures from -10°F to +110°F (-23°C to 43°C). For operation outside this range, contact Manitowoc Crane Care for recommendations.

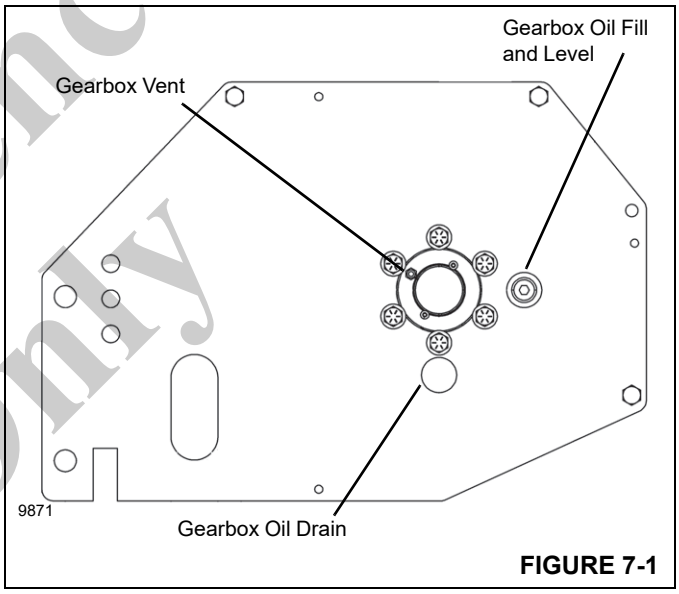


FIGURE 7-1

Hoist Gearbox Oil Change

To change the hoist gearbox oil, rotate the drum so that the plug is visible through the lower hole in the side plate (See 33, Figure 7-2, *view 1*). Screw in a piece of 1 inch pipe in the gearbox oil drain to allow the oil to drain. Remove the gearbox vent (30, Figure 7-2, *view 1*), then with a hex wrench remove the drain plug located inside of the 1 inch pipe (See Figure 7-2, *view 2*). Examine the used oil for signs of significant metal deposits and then dispose of it in a proper manner. Remove the 1 inch pipe.

Rotate the drum so that the port is visible through the gearbox oil fill and level hole in the side plate (Figure 7-1). Install a 1 inch pipe with elbow into the upper hole in the side plate (*See* Figure 7-2*, view 3*). Fill the gearbox with

1.42 liters (1.50 quarts) of oil. Remove the pipe and elbow, then replace the plug.

For information about changing hoist brake oil, see *"Drain / Add New Hoist Brake Oil" on page 7-8.* See *"Lubrication Chart" on page 7-5* for recommended oil type and grade for your application.

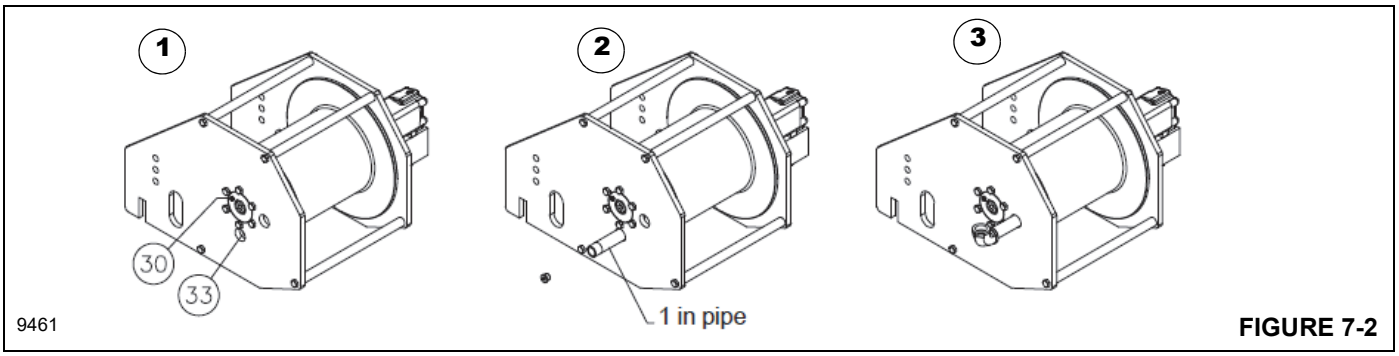


FIGURE 7-2

Hoist Brake Oil

DANGER

Do not, under any circumstances, work at an elevated height without using proper fall protection as required by local, state or federal regulations.

Check Hoist Brake Oil

CAUTION

The maximum fill capacity for the hoist brake is 0.23 liter (0.25 quart). Over-filling the hoist brake can cause damage to the hoist.

To check the hoist brake oil, remove the vent and fill plug (Figure 7-3) and visually inspect the oil level. The maximum fill capacity for the hoist brake is 0.23 liter (0.25 quart). See "Lubrication Chart" on page 7-5 for recommended oil type.

Drain /Add New Hoist Brake Oil

To drain and add new oil, remove the brake vent/fill plug and brake drain plug (Figure 7-3) and drain the brake oil. Examine the oil for metallic particles or burning. Reinstall drain plug and add fluid at the brake vent/fill hole. The hoist brake fill capacity is 0.23 liter (0.25 quart). Reinstall the brake vent/fill plug.

NOTE: Brake lubricants are satisfactory for operation in temperatures from -23° C to 66° C (-10° F to +150° F). For operation outside this range, contact Manitowoc Crane Care for recommendations.

DANGER

Do not use EP type gear lubes in the brake section. This may prevent proper operation and cause the load to fall resulting in serious injury or death.

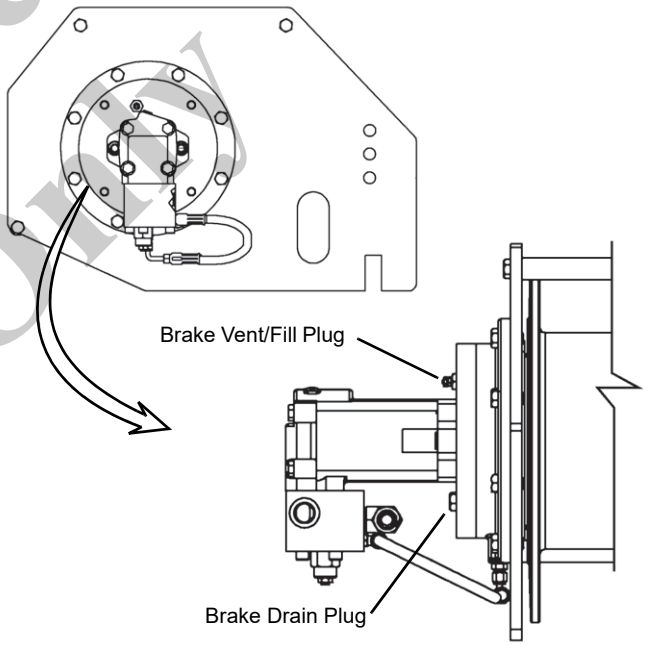


FIGURE 7-3

Swing Gearbox and Brake Oil

Check Swing Gearbox oil level:

The oil in the gearbox and brake sections is recommended to be changed after first 50 hours of operation and every 500 hours of operation.

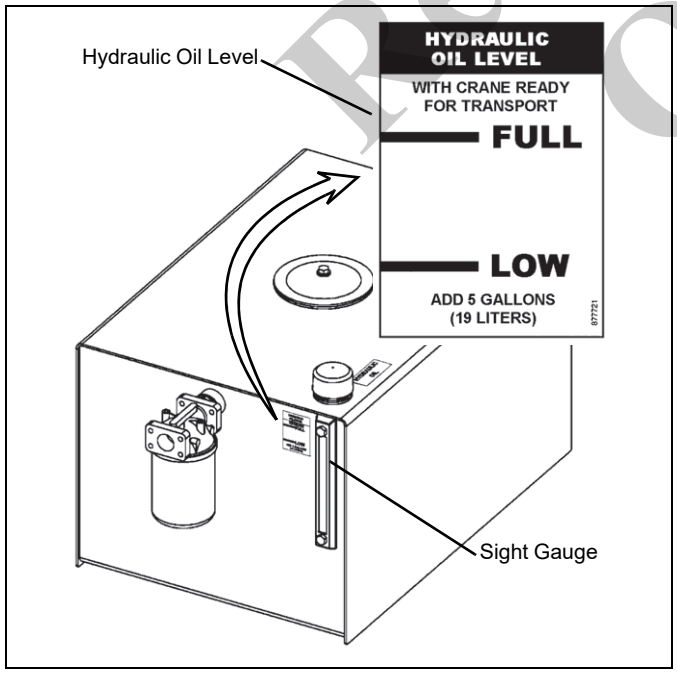
1. Examine the used oil for signs of significant metal deposits.
2. Fill the swing gearbox with the appropriate amount and type of oil and then replace plug and vent. *See "Lubrication Chart" on page 7-5.*

To inspect the Swing gearbox oil level, remove the gearbox fill/vent plug and visually inspecting the oil level. Maximum oil level is to be 1" below the port for this gearbox with of gear lube oil.

Gearbox lubricants are satisfactory for standard operation in temperatures from -23° C to 82° C (-10° F to +180° F). For operation outside this range, contact Manitowoc Crane Care for recommendations.

HYDRAULIC OIL RESERVOIR LEVEL

The hydraulic oil reservoir has a sight gauge located on the side of the reservoir. This sight gauge has a decal beside it that indicates a "full" level and an "low oil" level. The oil required to bring it from the "low" line to the "full" line is 5 gallons. Do not fill the reservoir above the "full" line. The oil level should be checked with the crane parked on a level surface in the transport condition (all cylinders retracted and boom stowed) and the oil cold.



WIRE ROPE LUBRICATION

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

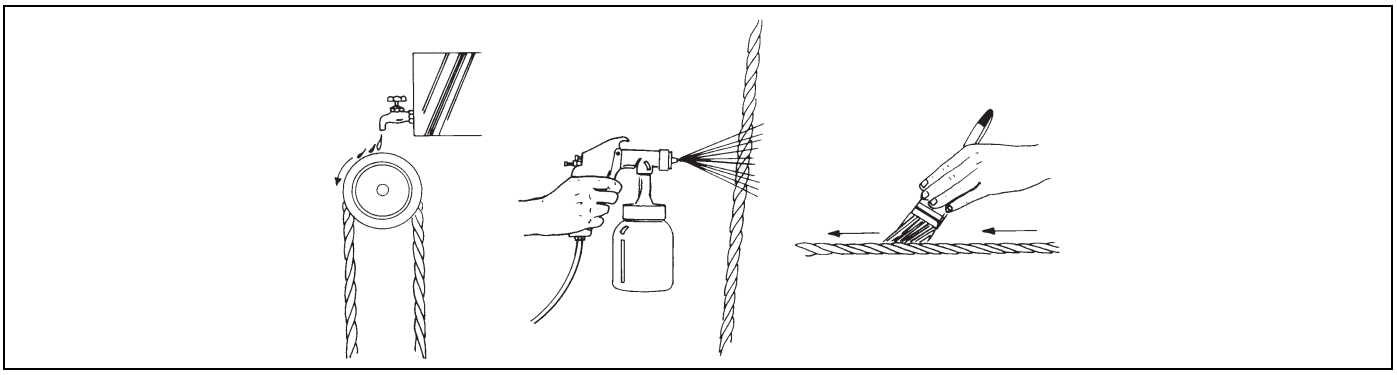
During fabrication, ropes receive lubrication; the kind and amount depends on the rope's size, type, and anticipated use. This in-process treatment will provide the finished rope with ample protection for a reasonable time if it is stored under proper conditions. But, when the rope is put into service,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

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

1. It should be free from acids and alkalis.
2. It should have sufficient adhesive strength to remain on the ropes.
3. It should be of a viscosity capable of penetrating the interstices between wires and strands.
4. It should not be soluble in the medium surrounding it under the actual operating conditions (i.e. Water).
5. It should have a high film strength.
6. 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; bath, dripping, pouring, swabbing, painting, pressure spray.

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.



CARWELL© RUST INHIBITOR

Protecting Cranes From Corrosion

National 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.

National 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 National 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 29 CFR 19 10.1200. The product is a liquid blend of petroleum derivatives, rust inhibitors, water-repelling and water-displacing agents.

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, Carwell T32-CP-90 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.

Carwell 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 Carwell coating, National Crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and guidelines to help maintain the paint finish on National 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, cased by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

While the surfaces of the crane that are easily seen have the biggest impact on the appearance of the crane, particular attention should be given to the undercarriage of the crane to minimize the harmful effects of corrosion.

Exercise special care and increase the frequency of cleanings if the crane is operated:

- on roads where large quantities of salt or calcium are applied to treat icy and snowy road surfaces;
- in areas that use dust control chemicals;
- anywhere there are increased levels of wetness - especially near salt water;
- during prolonged periods of exposure to damp conditions (e.g., moisture held in mud), where certain crane parts may become corroded even though other parts remain dry; or
- in high humidity, or when temperatures are just above the freezing point.

Cleaning Procedures

To help protect against corrosion of National Cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleanings may be needed when operating in harsh

environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

NOTE: Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:

NOTE: Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.

CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

- For scratches and marks in highly visible areas:
- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat 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 Carwell T32-CP-90 be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of Carwell T32-CP-90 is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primered and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying Carwell.

NOTE: Unit must be completely dry before applying Carwell.

- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of Carwell, the product needs to be fogged on the unit.
- Use of pressure pots to apply the Carwell to the unit being processed is recommended.
- Carwell T32-CP-90 is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the Carwell 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

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; Valves, hose end and fittings, Swivel, pumps, axles, drivelines, transmission, 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 alarms.
- Superstructure applications are; hose end and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring, all bare metal surfaces.
- Boom applications areas are; pivot pins, hose end and fittings, jib pins and shafts, all bare metal surfaces, downhaul weight / hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have Carwell applied.

7650-43

7650-42

Item	Description
1	Boom Nose Pins, Clips
2	Wire Rope
3	All Hardware, Clips, Pi ns, Hose Connections not painted O/R Pins, Clips
4	Pivot Shaft
5	Hoist Plumbing Connections
6	Mirror Mounting Hardware
7	O/R Hose Connections

Item	Description
8	O/R Pins, Clips
9	Power Train Hardware
10	Valve Bank, Hose Connections Inside Turntable
11	Entire underside of unit
12	Hook Block/Downhaul Weight
13	Turntable Bearing Fasteners
14	Pins, Clips for Jib (Not Shown)
15	Hanger Hardware for Jib (Not Shown)

SECTION 8
TROUBLESHOOTING

SECTION CONTENTS

Hydraulic System Troubleshooting Chart 8-1
Jib Load Limiting Device Troubleshooting 8-4
Jib Jack Troubleshooting 8-5
Systematic Troubleshooting 8-5
HCA Troubleshooting Flow Chart 8-6

HYDRAULIC SYSTEM TROUBLESHOOTING CHART

Condition	Possible Cause	Possible Solution
Oil Leakage	Hose fittings loose, worn or damaged. Oil seal rings deteriorated by excess heat.	Check & replace damaged fittings or "O" Rings. Torque to manufacturers specifications. Replace oil seal rings by disassembling Pump unit.
	Bolt loose or its sealing area deteriorated by corrosion.	(a) Loosen then tighten single bolt to torque specification. (b) Replace bolt.
	Shaft seal worn or damaged.	Remove seal carrier from pump. - Remove damaged seal from seal carrier.
		If shaft is worn, install new seal in the inner position. Reinstall seal carrier.
No Flow from Pump (If pump does not prime in 30 seconds STOP!)	Pump not installed correctly.	Check proper drive rotation. Make sure pump shaft is turning (i.e. drive coupling is engaged). Check for sources of suction leaks, inlet flange tight? Pinched o-rings?
	Pump not getting oil.	Make sure reservoir is full of oil.
	Can't Build Any Pressure Flow has an unrestricted path.	Is it an open circuit to the reservoir.
	Internal leakage in cylinders, valves, motors or pumps.	Repair component.
No response to control	Overload system inoperative.	Insure overload system is working properly and Anti-Two-Block/Overload solenoid is powered.
	Load too heavy.	Check Capacity Chart.
	PTO not engaged.	Engage PTO.
	Low hydraulic fluid supply.	Check and fill as required.
	Suction line blocked.	Drain tank and hose and remove blockage.
	Broken hydraulic pressure line.	Replace as required.
	Defective hydraulic pump.	See Pump Service Manual.
	Incorrect relief valve setting.	Adjust relief.
	Relief valve sticking.	Clean relief.

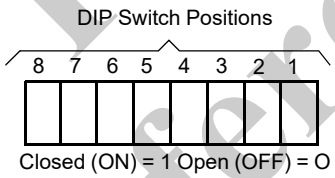
HYDRAULIC SYSTEM TROUBLESHOOTING CHART

Condition	Possible Cause	Possible Solution
Poor hydraulic system performance	Pump not operating at proper speed.	Check PTO ratio, pump size and engine speed for proper oil flow
	Low hydraulic fluid supply.	Check and fill as required.
	Relief valve sticking.	Remove and clean.
	Relief setting too low.	Readjust to proper setting.
	Worn pump, motor or cylinder.	Replace bad part.
	Plugged filter.	Change filter.
	Valve spools not fully open.	Adjust linkage so valve has full throw.
	Boom holding valves out of adjustment.	Adjust or clean as required.
	Oil temperature too high.	Reduce engine speed, slow cycle time to cool oil or add oil cooler option.
	Hydraulic oil too cold or dirty.	Warm oil or use less viscous oil.
	Line restricted.	Check lines; clean and repair as necessary.
	Internal control valve crack.	Replace valve.
	Load too heavy.	Check Capacity Chart and reduce load.
Swing moves erratic or loosely (Standard system)	Loose turntable bearing.	Torque bearing mounting bolts.
	Loose swing gearbox mounting bolts.	Tighten bolts.
	Worn gears or bearing.	Replace worn parts or adjust gearbox spacing.
	Operator control of lever too erratic.	Operate controls smoothly.
	Motor counterbalance valves dirty or not set properly.	Clean or replace counterbalance valves not set at 600 psi.
	Brake not holding properly.	Replace worn brake parts or shim brake to proper torque. Replace worn brake parts or shim brake to proper torque
	Brake releasing at wrong time or erratically.	Bleed air from brake with bleed screw on side of brake.
	Swing speed adjustment set too low.	Adjust valve on turn motor.
Swing will not turn (Standard System)	Turn circuit relief valves sticking.	Clean and check circuit pressure.
	Turntable bearing drag.	Lubricate thoroughly as rotating boom.
	Brake not releasing properly.	Check for 200 + PSI brake pilot pressure. Clean pilot line or adjust motor counterbalance valves.
		Adjust or clean brake for proper release.
	Swing speed adjustment set too low.	Adjust valve on turn motor.

HYDRAULIC SYSTEM TROUBLESHOOTING CHART

Condition	Possible Cause	Possible Solution
Excessive pump noise during operation	Excessive pump speed.	Adjust foot throttle or check for too high PTO ratio.
	Low oil temperature.	Allow unit to warm up.
	Low hydraulic oil supply.	Check and fill.
	Suction line kinked, collapsed or blocked.	Clear blockage.
	Pump Cavitation	Check for loose clamps.
	Hydraulic oil too thick.	Warm oil or use oil more applicable to environment.
	Relief valve chattering.	Dirt in relief valve or damaged relief.
	Hydraulic tubing vibration.	Check for loose tubing.
	Tank breather plugged.	Clean breather.
Cylinders drift	Not getting oil to cylinders.	Clean and replace as required.
	Worn or damaged piston seals.	Replace as required.
	Air in hydraulic oil.	Cycle operate crane cylinder to remove air.
	Loose holding valve.	Tighten valve.
	Dirt in holding or check valve.	Clean valve.
Hoist will not lift or hold load	Load too heavy.	Check load and change to applicable multipart reeving.
	Relief valve setting too low.	Check and adjust if required.
	Motor worn excessively.	Replace motor.
	Counterbalance valve defective or leaking.	Clean and replace as necessary.
	Anti-two-block system defective.	Repair anti-two-block system.
	Brake worn out.	Repair or replace brake.
Hoist gearbox heats	Gearbox grease low.	Check and fill as required.
	Duty cycle too high.	Reduce cycle time or speed of hoist.
Boom chatters during extension/retraction or doesn't proportion properly	Boom sections need lubrication.	Grease boom.
	Wear pads not shimmed correctly.	Re-shim as described in boom assembly section.
	Worn wear pads.	Replace pads.
	Extension cables out of adjustment.	Readjust cables and tension properly.
	Extend or retract cables broken.	Disassemble and inspect and replace cables.
Boom will not extend	Proportioning cables not attached.	Reconnect, replace and/or adjust cables.
	Anti-two-block system shut down.	Lower hook, and extend load.
	Defective anti-two-block system	Check anti-two-block system; repair if defective.

HYDRAULIC SYSTEM TROUBLESHOOTING CHART

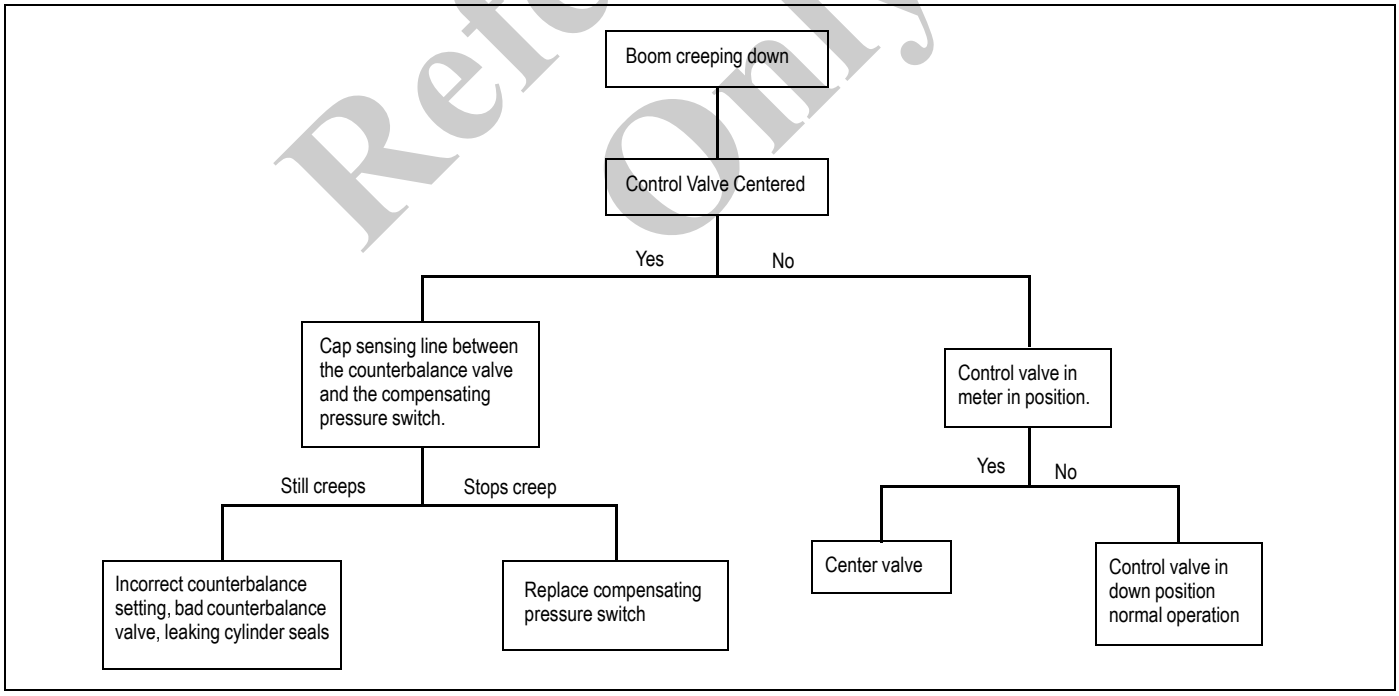
Condition	Possible Cause	Possible Solution
JIB LOAD LIMITING DEVICE TROUBLESHOOTING		
System is in a state of constant cut-out	Loose or incorrect wiring.	Carefully check the integrity of all circuits external to the electronics box, from the jib tip to the console. Compare to electrical schematic.
	Blown fuse.	Check fuse at crane console. Replace if necessary. Remove electronics box from jib, remove electronics from housing, and check a fuse on board. Replace if necessary.
	ATB switch open.	Ensure that ATB switch is closed.
	No table selected. Crane Table Switch Settings: • 560E2 = 00101000 • 571E2 = 10101000	Set the unit for the proper table. • Power down the unit, set the DIP switch to 10101010, and power up the unit. • Power down the unit and set the DIP switch for the appropriate table. Power up the unit.
	Load cell not calibrated 	To set the zero point, remove all force from the load cell. Power down the unit. Set switch position 8 to ON. Power the system. Do not turn off power until both the zero point and the gain have been set. To set the zero point, press the button on the board. To set the gain, set switch position 8 to OFF. Set the switch to the correct code that matches the load cell gain. This code can be found on the tag that accompanies the load cell. Press the button.
System cuts out too early or too late	Wrong table selected.	See no table selected above.
	Angle sensor not zeroed.	Ensure that the electronics box is tightly mounted to the jib. Zero the angle sensor using the following procedure: • Place the level indicator on the jib over the electronics box and level the jib. • Power up the unit, unplug the connector to the ATB switch, and jump pin 1 to ground. • Remove the jumper wire, re-connect the ATB connector, and power down the unit.
	Configuration switch stuck open or closed (two section jibs only).	Configuration switch must be closed when the jib is retracted and open when the jib is extended. Adjust or replace switch As necessary.
	Pivot pin not free to move.	Ensure that pivot pin is free, well lubricated, and allows the jib head to pivot freely. Inspect and replace bearings in jib head assembly as required.
	Foreign object stuck between jib head assembly and jib. The only contacts between the jib head assembly and the jib are to be the load cell and the pivot pin.	Remove any foreign objects which interfere with jib head assembly operation.

HYDRAULIC SYSTEM TROUBLESHOOTING CHART

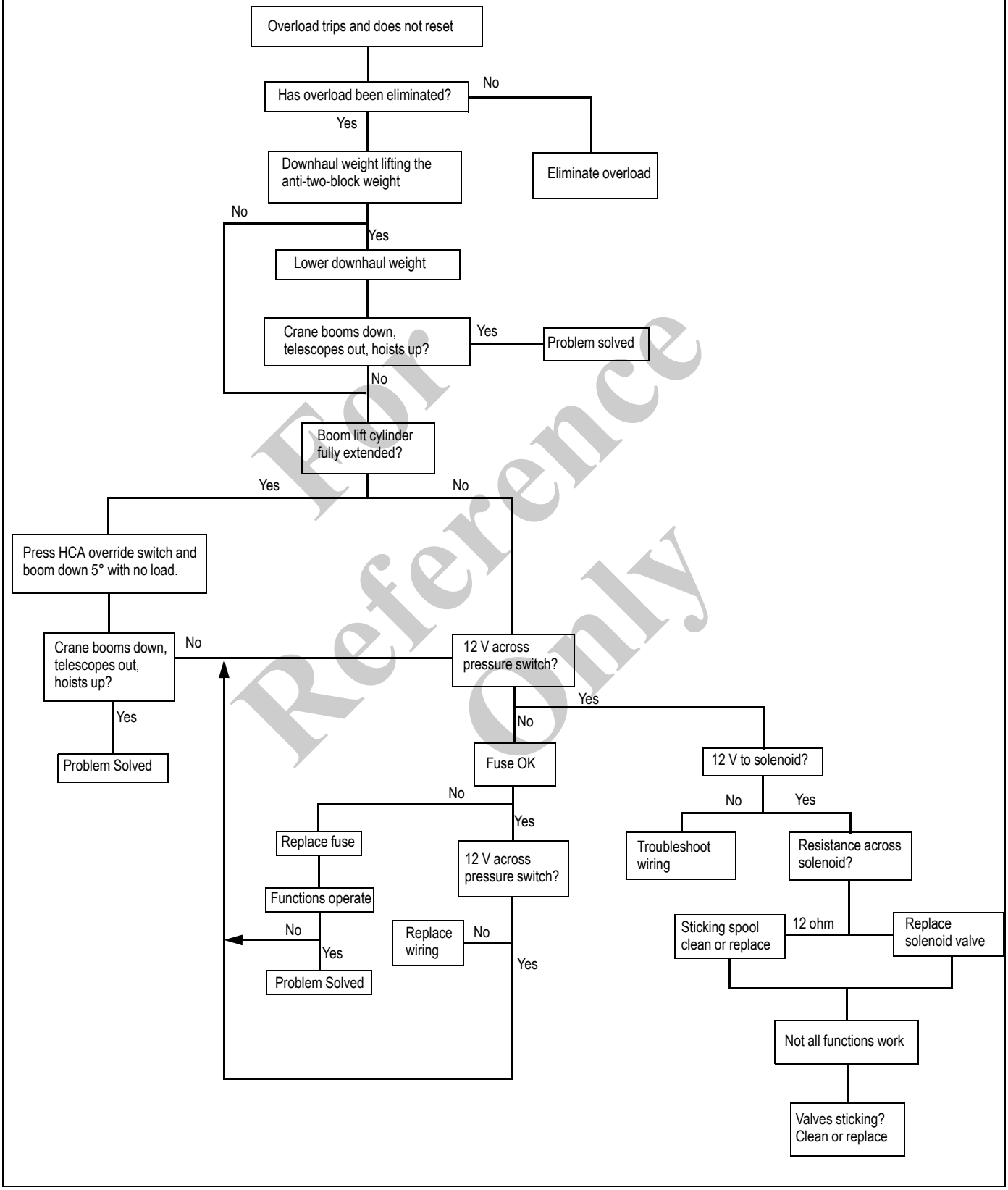
Condition	Possible Cause	Possible Solution
JIB JACK TROUBLESHOOTING		
Does not lift load	No oil in system Release valve not closed	Add oil to reservoir tank through oil filler hole Turn handle clockwise tightly
Lifts load only part way	Oil level low	Add oil to reservoir tank through oil filler hole
Lifts load but does not hold	The following valve or valves leaking a. Suction valve b. Delivery valve c. Release valve	Replace jack
	Packings worn or damaged	Replace jack
Jack does not lower	Release valve stuck, probably dirt or foreign matter	Transfer load then replace dirty oil, flush oil reservoir with kerosene
Poor lifting	Dirty oil Air in hydraulic system	Change hydraulic oil Purge air from system
Poor pumping action	Oil seal for pump unit worn out or damaged	Replace jack

Systematic Troubleshooting

The following step-by-step analysis will be helpful in isolating and correcting almost every service problem if followed in a step by step systematic manner. Use this information with the Hydraulic Schematic and the Illustrated Parts Catalog to identify parts and flow paths. Start at the top box and work downward step-by-step. Do not try to start in the middle or skip steps.



HCA TROUBLESHOOTING FLOW CHART



SECTION 9
CRANE INSTALLATION

SECTION CONTENTS

Crane to Truck Installation 9-1
Minimum Truck Requirements 9-2
Mounting Configurations 9-2
Configuration 1 - 571E2 9-3
Configuration 2 - 571E2 9-4
Configuration 3 - 560E2 9-5
Configuration 4 - 560E2 And Shorter Booms 9-6
PTO Horsepower Requirements 9-7
Direct Mount Pump to PTO 9-7
Pump Rotation 9-7
Truck Frame Strength 9-8
Section Modulus Tables 9-9
Channel (Table A) 9-9
Channel Reinforcement (Table A) 9-9
Angle Reinforcement (Table B) 9-9
Fish Plate Reinforcement (Table C) 9-9
Angle Under Reinforcement (Table D) 9-9
Requirements For Optional Single Front Outrigger 9-14
Truck Frame Section Modulus Tables 9-15
Truck Preparation 9-18
Welding Precautions 9-18
Positioning Crane On Truck 9-18
PTO Installation 9-18
Hydraulic Pump Installation 9-18
Reinforcing/after Frame Extension 9-19
After Frame Modification 9-22
Crane Mounting Procedure 9-22
Crane Component Installation Sequence 9-22
Torsion Box and ASH Stabilizer Installation 9-22
Install Torsion Box 9-22
Mount the Turret and Torsion Box to the Frame Assembly 9-22
Turret Mounting 9-22
Torsion Box Mounting 9-23
Mount the Outrigger Box 9-24
ASH to Torsion Box Mounting 9-25
Assemble the Outriggers 9-26
Hydraulic Reservoir Installation 9-26
Boom Installation 9-27
Lift Cylinder Installation 9-27
Wire Rope Installation 9-28
Hoist to Truck Cab Clearance 9-29
Painting 9-29
Pin Bearing Inspection And Installation Procedure 9-29
Pin Inspection 9-29
Bearing Installation 9-29
Trunnion Inspection 9-29
Bearing Inspection 9-29
Counterweighting 9-29
Counterweighting Determination Example 9-30
Counterweighting Methods 9-31
Concrete poured in the bed measures: 9-33
Boom Rest Requirements 9-34
CAN Bus System Setup 9-35
Required Equipment 9-35
CAN Bus System using Software 9-35
CAN Bus System using Programming Button 9-36
Initial Crane Run In Procedure 9-37
Stability Check 9-37
Specifications 9-39
Hydraulic Pump 9-39
Hydraulic System 9-39
Reservoir 9-39
HCA 9-39
Hoist Speed and Pull 9-39
Crane Operating Speeds 9-39

CRANE TO TRUCK INSTALLATION

The installation section contains information for mounting and initial check out of the crane. Proper mounting is required for long lasting crane performance. Improper mounting can cause permanent damage to the truck, i.e. frame or transmission, and the crane, i.e. pump or nonstability. Also Federal Department of Transportation Laws relating to vehicle manufacture and modification such as lights, brakes and axle loads must be met as well as State

vehicle laws relating to weights and dimensional restrictions such as overall length, overhang, etc.

This section is organized by first presenting detailed information relating to truck requirements and mounting configurations followed by a step-by-step installation procedure including PTO selection, Pump rotation selection, reinforcement, crane and stabilizer installation, counterweighting, boom rests and stability testing.

The final manufacturer of the vehicle must certify that the axle ratings have not been exceeded with all permanently attached equipment including a full load of fuel and men [at 200 lb (90 kg) each].

National Cranes need to meet ASME/ANSI B30.5 (latest) when completed as cranes and ASME/ANSI B30.23 (latest) when completed as a personnel lifting system. These standards require welds to meet AWS D14.3 or AWS D1.1 respectively. Any work done in mounting must be done in compliance with these codes.

NOTE: Before installation, verify that the serial number on the plates located on the major components match the main serial number on the crane frame. If the serial numbers do not match, contact the factory before proceeding. Matching the serial numbers insure that accurate warranty information is recorded at the factory and aids in dispensing service bulletins and other pertinent information.

MINIMUM TRUCK REQUIREMENTS

Many factors must be considered in the selection of a proper truck for a boom truck crane. Items which must be considered are:

- **Axle Rating -** Axle ratings are determined by the axles, tires, rims, springs, brakes, steering and frame strength of the truck. If any one of these components is below the required rating, the gross axle rating is reduced to its weakest component value.
- **Wheelbase, Cab-to-Axle (CA) -** The wheelbase and CA required are in part determined by the mounting configuration but also by the boom length and the platform length of the particular unit. Match the platform length to the retracted boom length so that the boom doesn't overhang the rear of the bed by more than that required by legal regulations where the unit will be operated. The truck cab-to-axle dimension is then determined by the length of the bed (the bed should be approximately centered over the rear axle) and the mounting space that the crane frame takes up between the cab and the bed.
- **Truck Frame -** Try to select a truck frame that will minimize or eliminate frame reinforcement or extension of the after frame (AF). Many frames are available that have the necessary after frame (AF) section modulus (S.M.) and resistance to bending moment (RBM) so that reinforcing is not required. The front hydraulic jack is used for a 360 degree working range around the truck. The frame under the cab through the front suspension must have the minimum S.M. and RBM because reinforcing through the front suspension is often difficult because of engine, radiator mounts and steering mechanics. See “Truck Requirements” and “Frame Strength.” pages for the necessary section modulus and resistance to bending moment values.
- **Additional Equipment -** In addition to the axle ratings, wheelbase, cab-to-axle requirements and frame, it is recommended that the truck is equipped with electronic engine control, increased cooling and a transmission with a PTO opening available with an extra heavy duty PTO. See “PTO Selection” pages. A conventional cab truck should be used for standard crane mounts.
- **Neutral Start Switch -** If the crane is equipped with optional remote operator controls, the chassis must be equipped with an engine anti-start switch that prevents remote start-up operation of the engine starter when the transmission is engaged in gear.

MOUNTING CONFIGURATIONS

The National Crane is a versatile machine and its versatility can be enhanced by the manner in which it is mounted. Following is a brief description of the mounting configurations and the advantages of each. The minimum weights listed below the front and rear axles for each configuration are estimated minimum front and rear axle weights for an 85% stability factor before the crane, stabilizers and sub-base, if required, are installed on the chassis. The minimum weights listed below the front and rear axles for the New York City approved configurations are estimated front and rear axle weights for 75% stability factor before the crane stabilizers and sub-base are installed on the chassis.

NOTE: These weights include the permanently attached equipment on the chassis, such as pumps, PTO's, reinforcing, chassis mounted options, bed and counterweight.

Before placing this unit in service, a final stability check as outlined in this section must be performed.

The maximum weights listed below the front and rear axles for each configuration are estimated maximum front and rear axle weights for not exceeding axle capacities before the crane, stabilizers, and sub-base, if required, are installed on the chassis.

Configuration 1 - 571E2

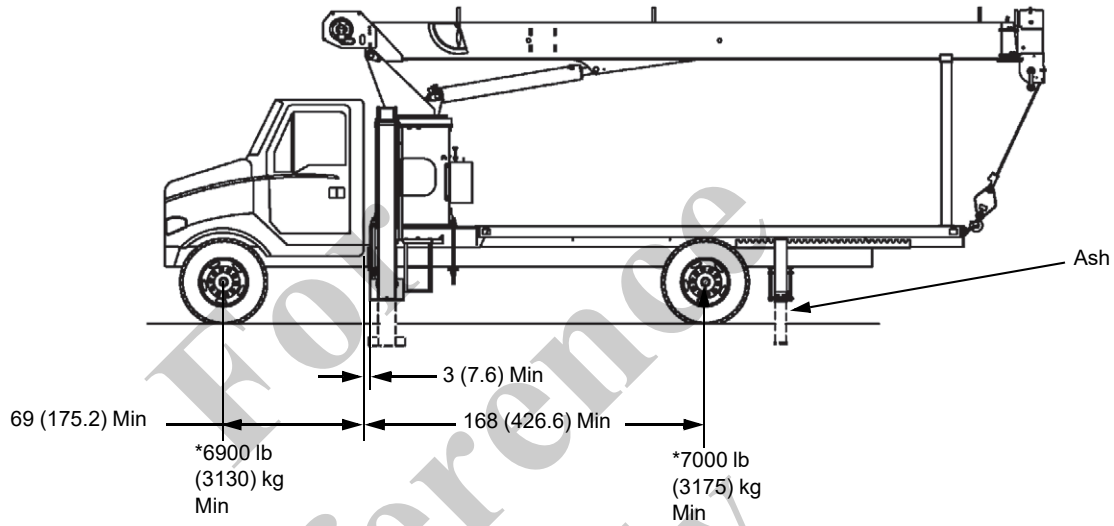
This configuration allows the installation of the Series 571E on a chassis with a small frame by using the standard sub-base for 20 ft bed. In most cases, the chassis will not require reinforcing and the amount of counterweight required as minimized increasing payload capabilities.

Requires 12,000 (5443 kg) GAWRF, 21,000 (9525 kg) GAWRR, 33,000 (14,968 kg) GVWR, ASH rear stabilizers and sub-base for 20 ft bed.

Full capacity work area is rear 180° of vehicle from outrigger to outrigger.

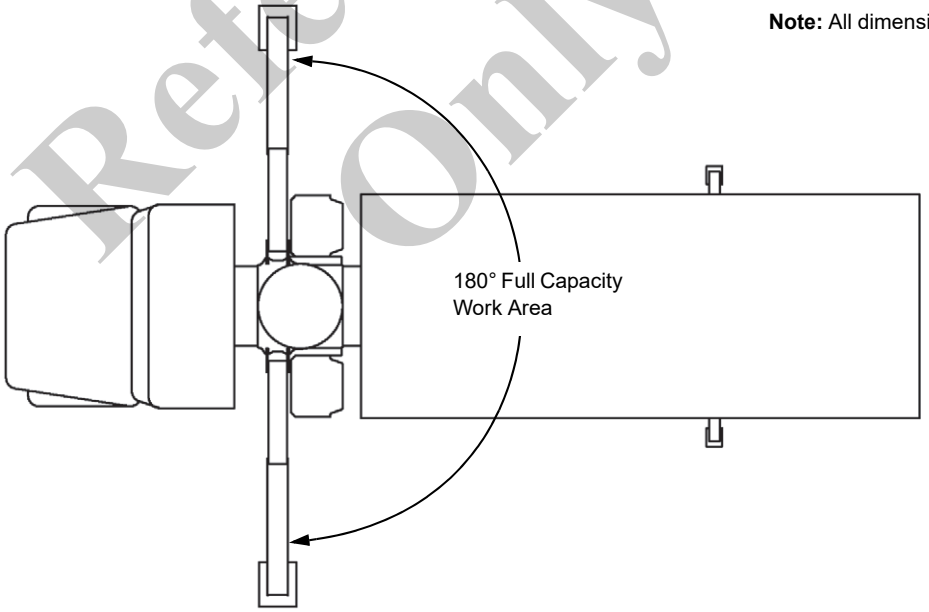
Tandem axle trucks may be used for hauling larger payloads.

Truck frame must have or be capable of being reinforced to 15.9 in^3 S.M. (261cm^3) and 1,749,000 in-lb (197,610 N-m) RBM under the crane, spring hanger to spring hanger.



* Actual scale weights prior to installation of crane, sub-base, and stabilizers

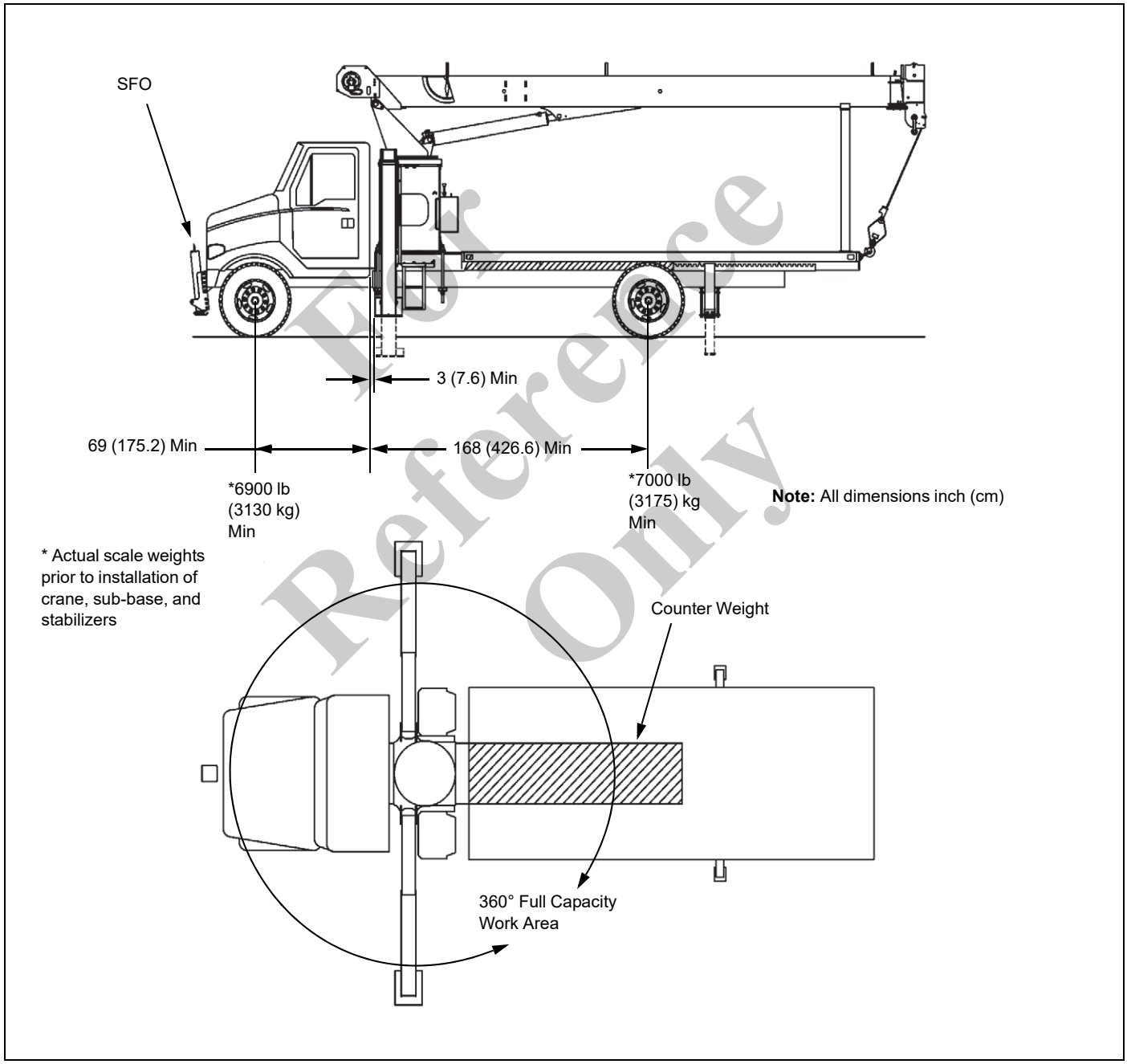
Note: All dimensions inch (cm)



Configuration 2 - 571E2

This mount requires single front outrigger (SFO) and additional counterweight in the underside of the bed for full capacity 360× around the truck. The SFO gives the machine a solid base helping the operator control loads.

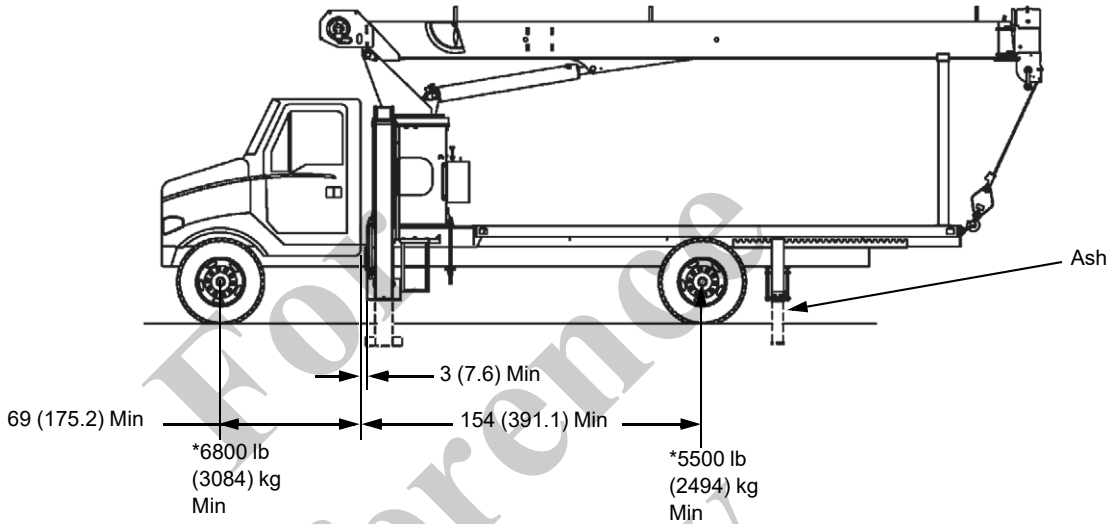
Requires 12,000 pound (5443 kg) GAWRF, 21,000 (9,525 kg) GAWRR, 33,000 (14,968 kg) GVWR, standard sub-base for 20 ft bed, SFO and ASH rear stabilizers and usually requires concrete counterweight in the torsion box between the crane and the ASH. Counterweighting in this manner reduces the loading induced on the SFO when lifting over the front. Truck must have 15.9 in^3 (261 cm^3) section modulus and 1,749,000 in-lb (197,610 N-m) RBM or be capable of being reinforced to this strength under the crane frame through to the front suspension. Normally a tapered frame cannot be reinforced to this requirement. The frame strength requirements for the remainder of the truck frame are the same as in Configuration 1. Tandem axle trucks may be used for hauling larger payloads.



Configuration 3 - 560E2

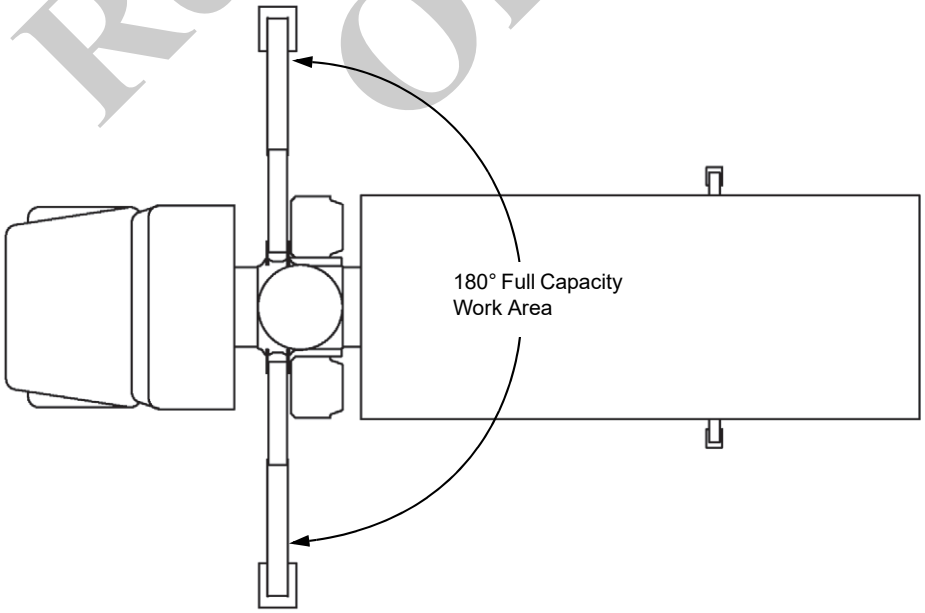
This configuration allows the installation of the Series 560E on a chassis with a small frame by using the standard sub-base for 18' bed. In most cases, the chassis will not require reinforcing and the amount of counterweight required as minimized increasing payload capabilities.

Requires 12,000 (5443 kg) GAWRF, 21,000 (9525 kg) GAWRR, 33,000 (14,968 kg) GVWR, ASH rear stabilizers and sub-base for 18' bed. Full capacity work area is rear 180× of vehicle from outrigger to outrigger. Tandem axle trucks may be used for hauling larger payloads. Truck frame must have or be capable of being reinforced to 15.9 in.3 S.M. (218 cm^3) and 1,749,000 in-lb (197,610 N-m) RBM under the crane, spring hanger to spring hanger.



* Actual scale weights prior to installation of crane, sub-base, and stabilizers

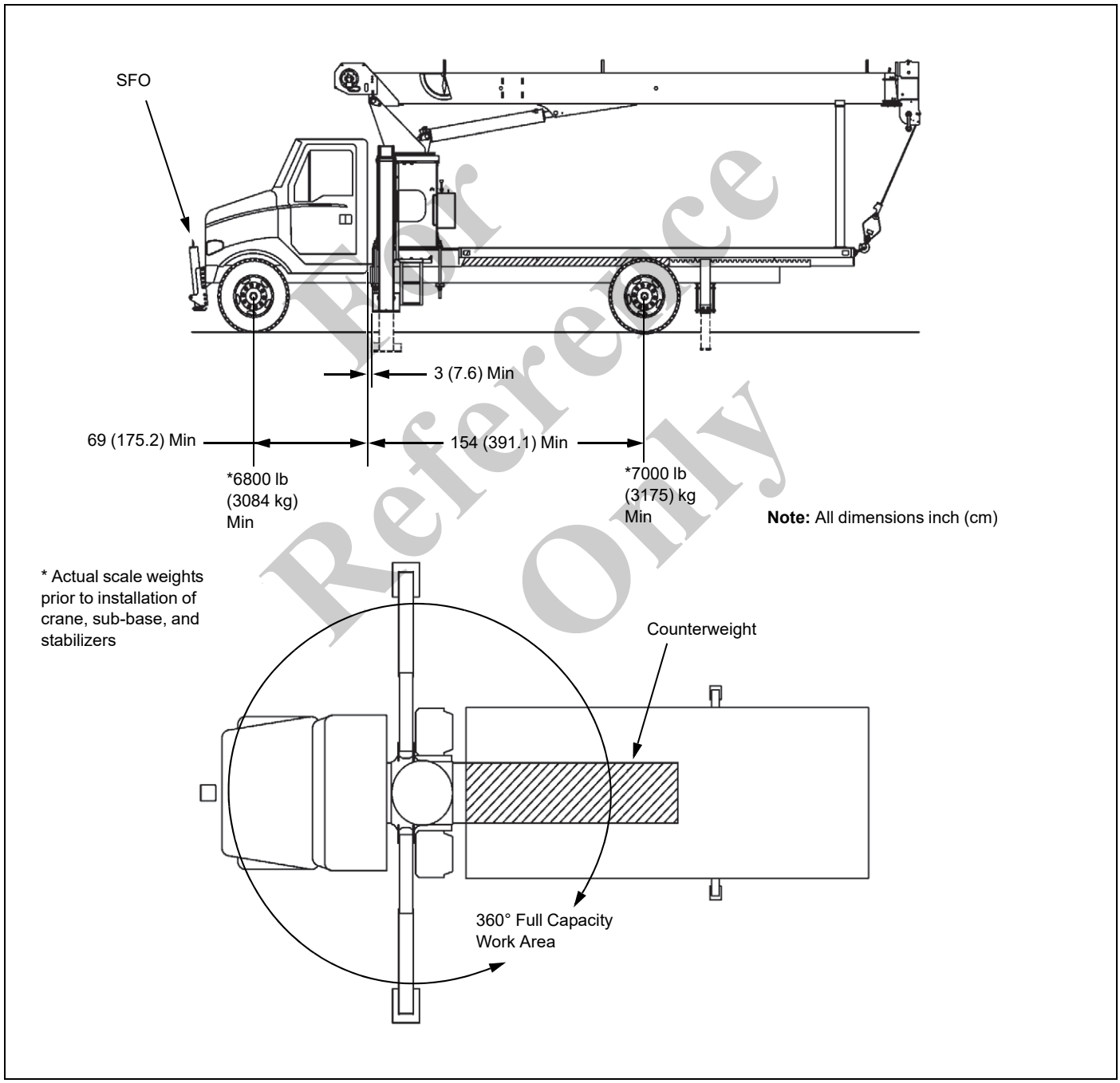
Note: All dimensions inch (cm)



Configuration 4 - 560E2 And Shorter Booms

This mount requires single front outrigger (SFO) and additional counterweight in the underside of the bed for full capacity 360° around the truck. The SFO gives the machine a solid base helping the operator control loads.

Requires 12,000 pound (5443 kg) GAWRF, 21,000 (9,525 kg) GAWRR, 33,000 (14,968 kg) GVWR, standard sub-base for 18' bed, Single Front Outrigger (SFO) and Angle Stabilizer Hydraulic (ASH) rear stabilizers and usually requires concrete counterweight in the torsion box between the crane and the ASH. Counterweighting in this manner reduces the loading induced on the SFO when lifting over the front. Truck must have 15.9 in.3 (261 cm3) section modulus and 1,749,000 in-lb (197,610 N-m) RBM or be capable of being reinforced to this strength under the crane frame through to the front suspension. Normally a tapered frame cannot be reinforced to this requirement. The frame strength requirements for the remainder of the truck frame are the same as in Configuration 3. Tandem axle trucks may be used for hauling larger payloads.



PTO HORSEPOWER REQUIREMENTS

The unit is equipped with a three section pump that supplies 34 GPM (129 LPM) to the hoist, 18 GPM (68 LPM) to the boom and outriggers, and 10 GPM (38 LPM) to the swing (turn) circuit. To provide these flows, the pump shaft must turn at 2500 RPM. The PTO requirement is a torque rating of at least 200 ft-lb (271 Nm) or 40 HP (30 KW) per 1000 RPM of PTO shaft speed.

Direct Mount Pump to PTO

Most pump installations can be direct mounted to the PTO using adapter assemblies available from the PTO supplier. If the pump is direct mounted, its weight should be supported by a strap between the pump and the transmission. The splined shaft coupling in a direct mount pump installation requires lubrication. #200S Silver Streak Special Multi-Lube (Medium) needs to be applied to the shaft during original installation and re-applied to the shaft or zerk provided on PTO housing shaft semi-annually thereafter.

Pump Rotation

It is imperative that the three section hydraulic pump installed in a 500E2 Service Manual application be the correct pump rotation configuration for the truck drive train/ power take off rotation direction. Make certain which direction the power take off output shaft rotates before selecting a clockwise (cw) or counter-clockwise (ccw) rotation hydraulic pump. Either cw or ccw rotation pumps are available, and are marked clearly with a directional arrow on the pump housing.

CAUTION

To avoid pump failure, do not turn the pump in the opposite direction of the indicating arrow on the pump housing.

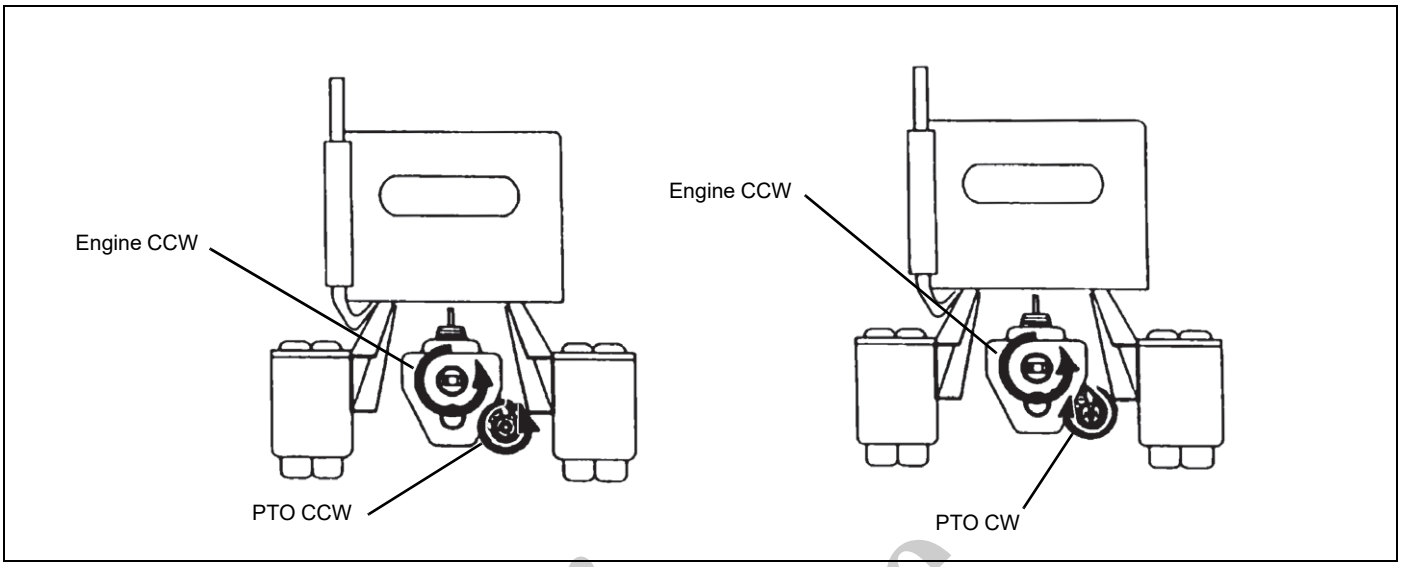
Do not confuse engine crankshaft rotation with power take off rotation. If the power take off shaft rotates opposite the engine crankshaft, it is turning in a clockwise (cw) direction when viewed from the rear of the truck and if the power take off shaft rotates the same as the engine crankshaft it is turning counter-clockwise (ccw).

Operating speeds and performance of the crane are based on proper pump outputs to the hoist, lift, telescope and swing circuits. A triple pump system is standard equipment on the 600D. This pump supplies 34 (129), 18 (68) and 10 (38) GPM (LPM) to the appropriate crane circuits when operating at 2500 RPM.

The speeds shown below are optimum operating speeds. The engine must be operated at a speed such that the horsepower developed is adequate to pull the pumps under pressure.

See pump rotation section to determine correct pump for your application.

	ENGINE SPEED (RPM)	PTO RATIO 2400 RPM PUMP
Gasoline Engine Optimum Speed Range	2900	86%
	2800	89%
	2600	96%
	2500	100%
Diesel Engine Optimum Speed Range	2400	104%
	2200	114%
	2000	125%
	1800	139%
	1600	156%
	1500	167%



TRUCK FRAME STRENGTH

In order for a truck frame to be suitable for accepting a Series 500E2 Service Manual size crane, the truck frame must have a requirement for rigidity so as not to allow excessive boom movement due to truck frame deflection, and it must be strong enough to resist the loading induced by the crane so as not to permanently bend or deform. Section Modulus (S.M.) is a measurement of the area of the truck frame and determines the rigidity of the frame. Resistance to bending moment (RBM) is a measurement of strength and is determined by multiplying the section modulus of each frame rail by the yield strength of the rail material.

For a standard, behind-the-cab mount, 180° stability, the Series 500E2 Service Manual crane requires a minimum of 1,749,000 in-lb (1197,610 N-m) RBM and 15.9 in^3 (261 cm^3) S.M. under the crane frame between the front and rear springs with 1,430,000 in-lb (161,590 N-m) RBM and 13 in^3 (213 cm3) S.M. through suspension to rear stabilizers on each truck frame rail. For 360° stability, the truck frame must have a 15.9 in^3 (261 cm^3) section modulus [1,749,000 in-lb (197,610 N-m) RBM] minimum at the crane frame between the front and rear springs with 1,430,000 in-lb (161,590 N-m) RBM and 13 $in.^3$ (213 cm^3) S.M. through suspension to rear stabilizers on each truck frame rail. Listed below is a table showing the commonly used truck frame and reinforcing materials and the section modulus required for each material to ensure adequate strength and rigidity. In all cases, the minimum requirements for section modulus and RBM must be met.

REQUIRED FRAME STRENGTH

	Truck Frame or Reinforcing Material	Minimum Section Modulus Under Crane	Minimum Section Modulus Through Rear Suspension	RBM Under Crane	Rmb Through Suspension
360° Stability	110,000 PSI (758 MPa)	15.9 in^3 (261 cm^3)	13.3 in^3 (218 cm^3)	1,749,000 in-lb (197,637 Nm)	1463,000 in-lb (161,570 Nm)
	50,000 PSI (345 MPa)	33.0 in^3 (541 cm^3)	18.0 in^3 (295 cm^3)	1,650,000 in-lb (186,425 Nm)	850,000 in-lb (96,050 N-rn)
180° Stability	110,000 PSI (758 MPa)	15.9 in^3 (261 cm^3)	13.3 in^3 (218cm^3)	1,749,000 in-lb (197,637 Nm)	1,463,000 in-lb (161,570 Nm)
	50,000 PSI (345 MPa)	33.0 in^3 (541 cm^3)	18.0 in^3 (295 cm^3)	1,650,000 in-lb (186,425 Nm)	850,000 in-lb (96,050 N-m)

SECTION MODULUS TABLES

The following tables will determine the section modulus of the truck frame. Always measure the truck frame and check the tables to be sure that any truck factory listed section modulus is correct.

Channel (Table A)

Table A provides the section modulus of channel frames in thicknesses of 3/16 inch (4.76 mm), 1/4 inch (6.35 mm), 5/16 inch (7.94 mm), and 3/8 inch (9.52 mm) with each grouping a flange width and web depth column. When the depth of frame channel and flange width is known, the point at which these two lines intersect is the section modulus from that particular channel.

If the section modulus of the channel does not meet the requirements, the channel should be reinforced in the most applicable method following.

Channel Reinforcement (Table A)

In order to provide more strength, a channel of suitable thickness can be added to the existing frame. The depth and flange width of this channel should be chosen so it fits over the existing frame. The section modulus of the needed channel is obtained from Table A and should be added to the section modulus obtained from the truck frame.

Angle Reinforcement (Table B)

If the truck is reinforced with an angle, refer to Table B for the data on the added strength provided by the angle.

Add this to the section modulus of the channel obtained from Table A.

Fish Plate Reinforcement (Table C)

The frame can be strengthened by adding a fish plate of suitable thickness and depth equal to the frame. The section modulus of the fish plate can be obtained from Table C and this must be added to the section modulus of the frame to obtain the total section modulus.

Angle Under Reinforcement (Table D)

This table lists the section modulus of an angle with the flange under the truck frame that is added to a frame with an angle reinforcement already added. Add the section modulus from Table D to the section modulus obtained from tables A and B to determine total section modulus.

The edges of the reinforcing angles or channels are to be flush with the edges of the frame.

Welding. Two rows of 1 inch (25.4 mm) diameter plug welds are to be placed in a staggered pattern of the web; the rows to be spaced 5 inches (127 mm) apart with welds at an interval of 4 inches (102 mm). Do not weld on the flanges.

Where thickness, depth or flange width vary, interpolation between tables or variables within a given table will provide the strength for the section.

If you have any questions concerning frame strength or reinforcing, contact National Crane before proceeding.

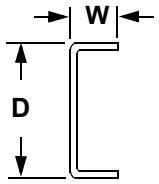


TABLE A
Section Modulus in^3 (cm^3)

Thickness 3/16 in. (4.76 mm)					
D in. (mm)	W in. (mm)				
	2.5 (64)	3 (76)	3.5 (89)	4 (102)	
8 (203)	5.3 (87)	6.0 (98)	6.7 (110)	7.5 (123)	in^3 (cm^3)
9 (229)	6.3 (103)	7.1 (116)	7.9 (130)	8.7 (143)	
10 (254)	7.3 (120)	8.2 (134)	9.1 (149)	10.0 (164)	
11 (279)	8.4 (138)	9.4 (154)	10.4 (170)	11.4 (187)	
12 (305)	9.5 (156)	10.6 (174)	11.7 (192)	12.8 (210)	
13 (330)	10.8 (177)	11.9 (195)	13.1 (215)	14.3 (234)	
14 (356)	12.0 (197)	13.3 (218)	14.6 (239)	15.9 (261)	
15 (381)	13.4 (220)	14.7 (241)	16.1 (264)	17.5 (287)	

Thickness 1/4 in. (6.35 mm)					
D in. (mm)	W in. (mm)				
	2.5 (64)	3 (76)	3.5 (89)	4 (102)	
8 (203)	6.9 (113)	7.8 (128)	8.8 (144)	9.7 (159)	in^3 (cm^3)
9 (229)	8.2 (134)	9.2 (151)	10.3 (169)	11.4 (187)	
10 (254)	9.5 (156)	10.7 (175)	11.9 (195)	13.1 (215)	
11 (279)	11.0 (180)	12.3 (202)	13.6 (223)	14.9 (244)	
12 (305)	12.5 (205)	13.9 (228)	15.3 (251)	16.8 (275)	
13 (330)	14.1 (231)	15.6 (256)	17.2 (282)	18.8 (308)	
14 (356)	15.8 (259)	17.5 (287)	19.1 (313)	20.8 (341)	
15 (381)	17.5 (287)	19.3 (316)	21.2 (348)	23.0 (377)	

Thickness 5/16 in. (7.94 mm)					
D in. (mm)	W in. (mm)				
	2.5 (64)	3 (76)	3.5 (89)	4 (102)	
8 (203)	8.4 (138)	9.5 (156)	10.7 (175)	11.9 (195)	in^3 (cm^3)
9 (229)	10.0 (164)	11.3 (185)	12.6 (206)	13.9 (228)	
10 (254)	11.6 (190)	13.1 (215)	14.6 (239)	16.0 (262)	
11 (279)	13.4 (220)	15.0 (246)	16.6 (272)	18.3 (300)	
12 (305)	15.3 (251)	17.1 (280)	18.8 (308)	20.6 (338)	
13 (330)	17.3 (284)	19.2 (315)	21.1 (346)	23.1 (379)	
14 (356)	19.4 (318)	21.4 (351)	23.5 (385)	25.6 (420)	
15 (381)	21.6 (354)	23.8 (390)	26.0 (426)	28.3 (464)	

Thickness 3/8 in. (9.52 mm)					
D in. (mm)	W in. (mm)				
	2.5 (64)	3 (76)	3.5 (89)	4 (102)	
8 (203)	9.8 (161)	11.2 (184)	12.5 (205)	13.9 (228)	in^3 (cm^3)
9 (229)	11.7 (192)	13.2 (216)	14.8 (243)	16.3 (267)	
10 (254)	13.6 (223)	15.4 (252)	17.1 (280)	18.8 (308)	
11 (279)	15.7 (257)	17.7 (290)	19.6 (321)	21.5 (352)	
12 (305)	18.0 (295)	20.1 (329)	22.2 (364)	24.3 (398)	
13 (330)	20.3 (333)	22.6 (370)	24.9 (408)	27.2 (446)	
14 (356)	22.8 (374)	25.3 (415)	27.8 (456)	30.3 (497)	
15(381)	25.4 (416)	28.1 (461)	30.8 (505)	35.5 (582)	

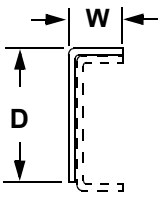


TABLE B
Section Modulus in^3 (cm^3)

Thickness 3/16 in. (4.76 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
7.5 (191)	2.2 (36)	2.3 (38)	2.3 (38)	2.4 (39)	in^3 (cm^3)
8.5 (216)	2.8 (46)	2.9 (48)	3.0 (49)	3.0 (49)	
9.5 (241)	3.4 (56)	3.5 (57)	3.6 (59)	3.7 (61)	
10.5 (267)	4.1 (67)	4.3 (70)	4.4 (72)	4.5 (74)	
11.5 (292)	4.9 (80)	5.1 (84)	5.2 (85)	5.4 (88)	
12.5 (318)	5.8 (95)	6.0 (98)	6.1 (100)	6.3 (103)	
13.5 (343)	6.7 (110)	6.9 (113)	7.1 (116)	7.3 (120)	
14.5 (368)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)	

Thickness 1/4 in. (6.35 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
7.5 (191)	2.9 (48)	3.0 (49)	3.1 (51)	3.2 (52)	in^3 (cm^3)
8.5 (216)	3.7 (61)	3.8 (62)	3.9 (64)	4.0 (66)	
9.5 (241)	4.5 (74)	4.7 (77)	4.8 (79)	5.0 (82)	
10.5 (267)	5.5 (90)	5.7 (93)	5.8 (95)	6.0 (98)	
11.5 (292)	6.5 (106)	6.7 (110)	6.9 (113)	7.1 (116)	
12.5 (318)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)	
13.5 (343)	8.8 (144)	9.1 (149)	9.4 (154)	9.6 (157)	
14.5 (368)	10.1 (166)	10.5 (172)	10.7 (175)	11.0 (180)	

Thickness 5/16 in. (7.94 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
7.5 (191)	3.6 (59)	3.7 (61)	3.9 (64)	4.0 (66)	in^3 (cm^3)
8.5 (216)	4.6 (75)	4.7 (77)	4.9 (80)	5.0 (82)	
9.5 (241)	5.6 (92)	5.8 (95)	6.0 (98)	6.2 (102)	
10.5 (267)	6.8 (111)	7.1 (116)	7.3 (120)	7.5 (123)	
11.5 (292)	8.1 (133)	8.4 (138)	8.6 (141)	8.9 (146)	
12.5 (318)	9.5 (156)	9.8 (161)	10.1 (166)	10.4 (170)	
13.5 (343)	11.0 (180)	11.4 (187)	11.7 (192)	12.0 (197)	
14.5 (368)	12.6 (206)	13.0 (213)	13.4 (220)	13.7 (224)	

Thickness 3/8 in. (9.52 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
7.5 (191)	4.3 (70)	4.5 (74)	4.6 (75)	4.8 (79)	in^3 (cm^3)
8.5 (216)	5.5 (90)	5.7 (93)	5.9 (97)	6.0 (98)	
9.5 (241)	6.7 (110)	7.0 (115)	7.2 (118)	7.4 (121)	
10.5 (267)	8.1 (133)	8.4 (138)	8.7 (143)	8.9 (146)	
11.5 (292)	9.7 (159)	10.0 (164)	10.3 (169)	10.6 (174)	
12.5 (318)	11.3 (185)	11.7 (192)	12.1 (198)	12.4 (203)	
13.5 (343)	13.1 (215)	13.6 (223)	14.0 (229)	14.3 (234)	
14.5 (368)	15.1 (247)	15.5 (254)	16.0 (262)	16.4 (269)	

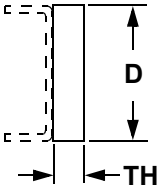


TABLE C
Section Modulus in^3 (cm^3)

TH in. (mm)	D in. (mm)									
	8 (203)	9 (229)	10 (254)	11 (279)	12 (305)	13 (330)	14 (356)	15 (381)	16 (406)	
3/16 (4.76)	2.0 (33)	2.51 (41)	3.10 (51)	3.75 (61)	4.46 (73)	5.24 (86)	6.08 (100)	6.98 (114)	7.94 (130)	in^3 (cm^3)
1/4 (6.35)	2.66 (44)	3.37 (55)	4.16 (68)	5.03 (82)	5.99 (98)	7.03 (115)	8.15 (134)	9.36 (153)	10.5 (172)	
5/16 (7.94)	3.33 (55)	4.21 (69)	5.20 (85)	6.29 (103)	7.49 (123)	8.79 (144)	10.19 (167)	11.7 (192)	13.31 (218)	
3/8 (9.52)	4.0 (66)	5.06 (83)	6.25 (102)	7.56 (124)	9.00 (148)	10.56 (173)	12.25 (201)	14.06 (230)	16.0 (262)	
7/16 (11.11)	4.67 (76)	5.9 (97)	7.29 (119)	8.82 (144)	10.5 (172)	12.32 (202)	14.29 (234)	16.4 (269)	18.66 (306)	

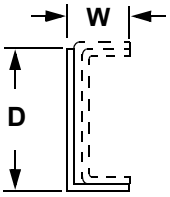


TABLE D
Section Modulus in^3 (cm^3)

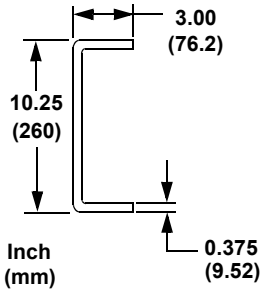
Thickness 3/16 in. (4.76 mm)					
D in. (mm)	W in. (mm)				
	3 (76)	3.5 (89)	4 (102)	4.5 (114)	
8.5 (216)	5.7 (93)	6.4 (105)	7.0 (115)	7.7 (126)	in^3 (cm^3)
9.5 (241)	6.7 (110)	7.4 (121)	8.1 (133)	8.9 (146)	
10.5 (267)	7.7 (126)	8.5 (139)	9.3 (152)	10.1 (166)	
11.5 (292)	8.8 (144)	9.7 (159)	10.6 (174)	11.4 (187)	
12.5 (318)	10.0 (164)	10.9 (179)	11.9 (195)	12.8 (210)	
13.5 (343)	11.2 (184)	12.2 (200)	13.2 (216)	14.3 (234)	
14.5 (368)	12.5 (205)	13.6 (223)	14.6 (239)	15.7 (257)	
15.5 (394)	13.8 (226)	15.0 (246)	16.1 (264)	17.3 (284)	

Thickness 1/4 in. (6.35 mm)					
D in. (mm)	W in. (mm)				
	3 (76)	3.5 (89)	4 (102)	4.5 (114)	
8.5 (216)	7.7 (126)	8.6 (141)	9.4 (154)	10.3 (169)	in^3 (cm^3)
9.5 (241)	9.1 (149)	10.0 (164)	10.9 (179)	11.9 (195)	
10.5 (267)	10.5 (172)	11.5 (188)	12.5 (205)	13.6 (223)	
11.5 (292)	11.9 (195)	13.1 (215)	14.2 (233)	15.4 (252)	
12.5 (318)	13.5 (221)	14.7 (241)	16.0 (262)	17.2 (282)	
13.5 (343)	15.2 (249)	16.5 (270)	17.8 (292)	19.2 (315)	
14.5 (368)	16.9 (277)	18.3 (300)	19.7 (323)	21.2 (347)	
15.5 (394)	18.7 (306)	20.2 (331)	21.7 (356)	23.3 (382)	

Thickness 5/16 in. (7.94 mm)					
D in. (mm)	W in. (mm)				
	3 (76)	3.5 (89)	4 (102)	4.5 (114)	
8.5 (216)	9.8 (161)	10.8 (177)	11.9 (195)	12.9 (211)	in^3 (cm^3)
9.5 (241)	11.5 (188)	12.6 (206)	13.8 (226)	15.0 (246)	
10.5 (267)	13.3 (218)	14.5 (238)	15.8 (259)	17.1 (280)	
11.5 (292)	15.1 (247)	16.5 (271)	18.0 (295)	19.4 (318)	
12.5 (318)	17.1 (280)	18.6 (305)	20.2 (331)	21.7 (356)	
13.5 (343)	19.2 (315)	20.8 (341)	22.5 (369)	24.2 (397)	
14.5 (368)	21.4 (351)	23.1 (379)	24.9 (408)	26.7 (438)	
15.5 (394)	23.7 (388)	25.5 (418)	27.4 (449)	29.4 (482)	

Thickness 3/8 in. (9.52 mm)					
D in. (mm)	W in. (mm)				
	3 (76)	3.5 (89)	4 (102)	4.5 (114)	
8.5 (216)	11.9 (195)	13.2 (216)	14.4 (236)	15.6 (256)	in^3 (cm^3)
9.5 (241)	14.0 (229)	15.3 (251)	16.7 (274)	18.1 (297)	
10.5 (267)	16.2 (266)	17.7 (290)	19.2 (315)	20.7 (339)	
11.5 (292)	18.4 (302)	20.1 (329)	21.8 (357)	23.5 (385)	
12.5 (318)	20.9 (342)	22.6 (370)	24.5 (402)	26.3 (431)	
13.5 (343)	23.4 (384)	25.3 (415)	27.3 (447)	29.3 (480)	
14.5 (368)	26.0 (426)	28.1 (461)	30.2 (495)	32.4 (531)	
15.5 (394)	28.8 (472)	31.0 (508)	33.3 (546)	35.6 (583)	

Example:



A truck frame of 110,000 psi (758 MPa) yield strength steel has the following dimensions: 3/8 in. (9.52 mm) thick, 3 in. (76.2 mm) flanges and is 10.25 in. (260 mm) deep. To find the frame section modulus:

1. From Table A, 3/8 in. (9.52 mm) thickness,

- W (width) = 3 in. (76.2 mm),
- D (depth) = 10 in. (254 mm)
- section modulus = 15.4 in.3 (252 cm3.

2. From Table A, 3/8 in. (9.52 mm) thickness,

- W = 3 in. (76.2 mm),
- D = 11 in. (279 mm),
- Section Modulus = 17.7 in.3 (290 cm3).

3. Interpolating between the two values:

- 10 in. (254 mm) deep channel = 15.4 in.3 (252 cm3)
- 11 in. (279 mm) deep channel = 17.7 in.3 (290 cm3)
- 10.5 in. (267 mm) deep channel

$$= \frac{15.4\ \text{in.}^3 \div 17.7\ \text{in.}^3}{2} = 16.55\ \text{in.}^3$$

$$= \frac{252\ \text{cm}^3 \div 290\ \text{cm}^3}{2} = 271\ \text{cm}^3$$

4. Now interpolate between a 10 in. (254 mm) deep channel and a 10.5 in. (267 mm) deep channel to get the section modulus of a 10.25 in. (260 mm) deep channel.

- 10 in. (254 mm) deep channel = 15.4 in.^3 (252 cm^3)
- 10.5 in. (267 mm) deep channel = 16.55 in.^3 (271 cm^3)
- 10.25 in. (260 mm) deep channel

$$= \frac{15.4\ \text{in.}^3 \div 16.55\ \text{in.}^3}{2} = 15.98\ \text{in.}^3$$

$$= \frac{252\ \text{cm}^3 \div 271\ \text{cm}^3}{2} = 262\ \text{cm}^3$$

5. A 3/8 in. (9.52 mm) x 3 in. (76.2 mm) x 10.25 in. (260 mm) truck frame has a 15.98 in.^3 (262 cm^3) Section Modulus and RBM of 110,000 psi x 15.98 in.^3 = 1,757,800 in. lbs. (758 MPa x 262 cm^3 = 198,596 N.m)

- 10.5 in. (267 mm) deep channel = 16.55 in.^3 (271 cm^3)
- 10.25 in. (260 mm) deep channel I

$$= \frac{15.4\ \text{in.}^3 \div 16.55\ \text{in.}^3}{2} = 15.98\ \text{in.}^3$$

$$= \frac{252\ \text{cm}^3 \div 271\ \text{cm}^3}{2} = 262\ \text{cm}^3$$

6. 15.98 in.3 (262 cm3) Section Modulus, 110,000 psi (758 MPa) steel is adequate for a standard mount with a torsion box.

REQUIREMENTS FOR OPTIONAL SINGLE FRONT OUTRIGGER

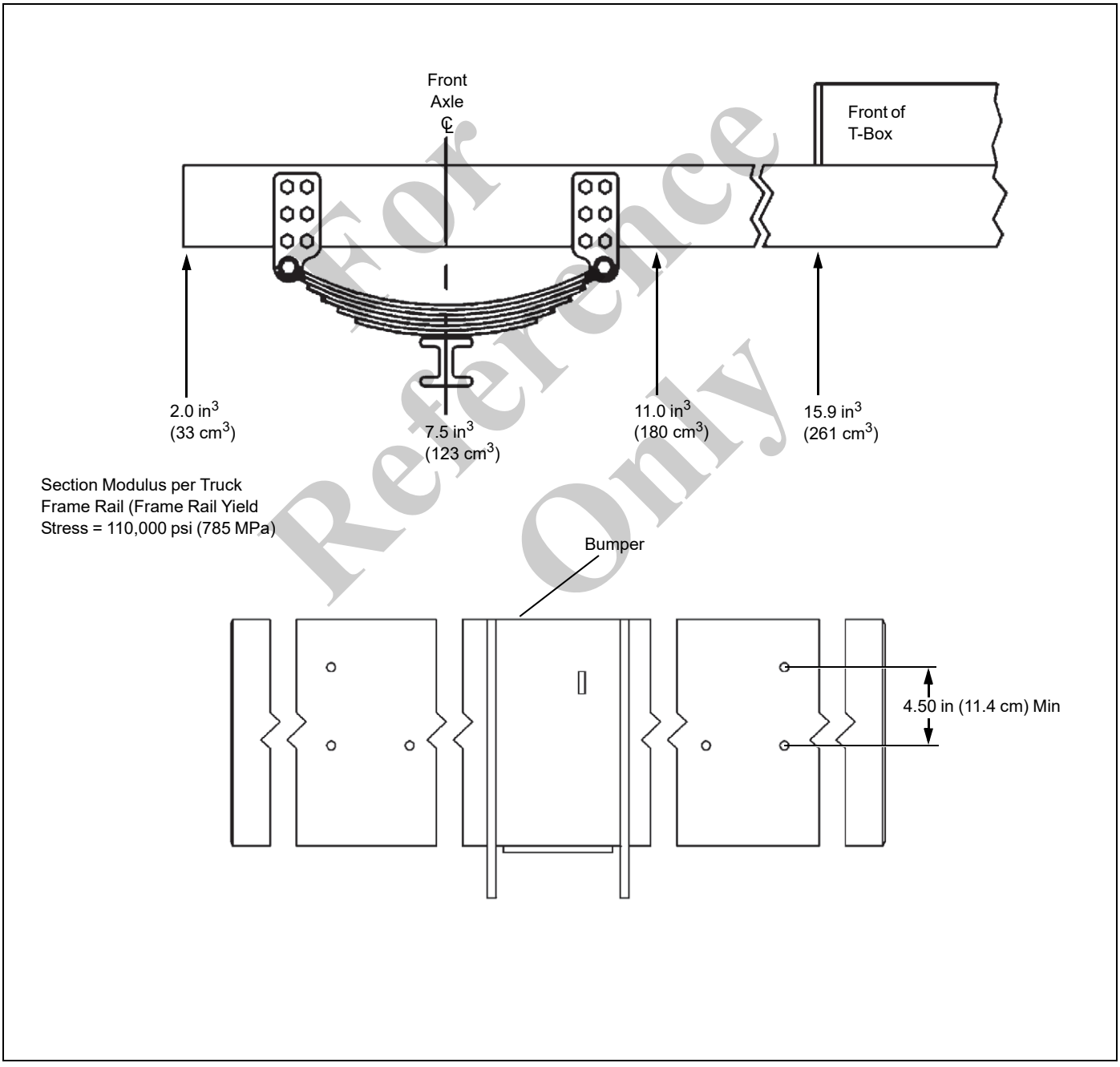
The truck frame must have adequate strength from under the crane frame through the front suspension to the bumper assembly for single front outrigger (SFO) installation. A truck frame yield strength of 110,000 psi (758 MPa) is required.

The following diagram shows the required section modulus at various stations along the front end of the truck frame for a standard behind-the-cab mount with torsion box.

In order to safely mount a SFO in place of the normal front bumper, a minimum bolt pattern as shown is required. The bracket must be capable of supporting 0.50 inch (12.7 mm) DIA. Grade 8 bolts to their nominal breaking strength. Torque the mounting bolts supplied with the SFO to 110 ft-lb (149 N·m).

Do not use spacers between the bumper bracket and the SFO bumper assembly.

If the bumper bracket and front of the truck frame do not meet these specifications, an extended frame truck must be used. Contact factory for details. Details for mounting an SFO on an extended frame truck are included in that installation instruction. However, the Section Modulus requirements outlined below do apply.



TRUCK FRAME SECTION MODULUS TABLES

Use Table E and Table F below along with Tables A through D in the preceding section of this manual for determining the section modulus of the truck frame.

Always measure the truck frame and check the tables to be sure that any truck factory listed section modulus is correct. It is also necessary to measure the frame and check the section modulus wherever the depth and/or flange width changes.

Channel (Table E). Table E supplements Table A for narrower truck frame flanges. Use the width of the narrow flanges for "W" to find the section modulus from Table E.

Angle (Table F). Use Table F for an angle section such as when a flange and part of the web of a truck frame channel is removed.

Where thickness, depth or flange width vary, interpolation between tables or variables within a given table will provide the strength for the section.

If you have any questions concerning frame strength or reinforcing, contact National Crane before proceeding.

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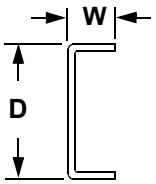


TABLE E
Section Modulus in^3 (cm^3)

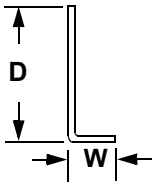
Thickness 3/16 in. (4.76 mm)				
D in. (mm)	W in. (mm)			
	1 (25)	1.53 (38)	2 (51)	
8 (203)	3.2 (52)	3.9 (64)	4.6 (75)	in^3 (cm^3)
9 (229)	3.8 (62)	4.7 (77)	5.5 (90)	
10 (254)	4.6 (75)	5.5 (90)	6.4 (105)	
11 (279)	5.4 (88)	6.4 (105)	7.4 (121)	
12 (305)	6.3 (103)	7.4 (121)	8.5 (139)	
13 (330)	7.2 (118)	8.4 (138)	9.6 (157)	
14 (356)	8.2 (134)	9.5 (156)	10.8 (177)	
15 (381)	9.3 (152)	10.6 (174)	12.0 (197)	

Thickness 1/4 in. (6.35 mm)				
D in. (mm)	W in. (mm)			
	1 (25)	1.53 (38)	2 (51)	
8 (203)	4.1 (67)	5.0 (82)	5.9 (97)	in^3 (cm^3)
9 (229)	5.0 (82)	6.0 (98)	7.1 (116)	
10 (254)	5.9 (97)	7.1 (116)	8.3 (136)	
11 (279)	7.0 (115)	8.3 (136)	9.6 (157)	
12 (305)	8.2 (134)	9.6 (157)	11.0 (180)	
13 (330)	9.4 (154)	10.9 (179)	12.5 (205)	
14 (356)	10.7 (175)	12.4 (203)	14.1 (231)	
15 (381)	12.1 (198)	13.9 (228)	15.7 (257)	

Thickness 5/16 in. (7.94 mm)				
D in. (mm)	W in. (mm)			
	1 (25)	1.53 (38)	2 (51)	
8 (203)	4.9 (80)	6.1 (100)	7.2 (118)	in^3 (cm^3)
9 (229)	6.0 (98)	7.3 (120)	8.6 (141)	
10 (254)	7.2 (118)	8.7 (142)	10.1 (166)	
11 (279)	8.5 (139)	10.1 (166)	11.8 (193)	
12 (305)	9.9 (162)	11.7 (192)	13.5 (221)	
13 (330)	11.5 (188)	13.4 (220)	15.3 (251)	
14 (356)	13.1 (215)	15.2 (249)	17.3 (284)	
15 (381)	14.8 (242)	17.1 (280)	19.3 (316)	

Thickness 3/8 in. (9.52 mm)				
D in. (mm)	W in. (mm)			
	1 (25)	1.53 (38)	2 (51)	
8 (203)	5.7 (93)	7.1 (116)	8.4 (138)	in^3 (cm^3)
9 (229)	7.0 (115)	8.6 (141)	10.1 (166)	
10 (254)	8.4 (138)	10.2 (167)	12.0 (197)	
11 (279)	10.0 (164)	11.9 (195)	13.8 (226)	
12 (305)	11.6 (190)	13.8 (226)	15.9 (261)	
13 (330)	13.4 (220)	15.7 (257)	18.0 (295)	
14 (356)	15.4 (252)	17.8 (292)	20.3 (333)	
15 (381)	17.4 (285)	20.1 (329)	22.8 (374)	

TABLE F
Section Modulus in^3 (cm^3)



Thickness 3/16 in. (4.76 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
3.5 (89)	0.6 (10)	0.6 (10)	0.6 (10)	0.6 (10)	in^3 (cm^3)
4.5 (114)	0.9 (15)	1.0 (16)	1.0 (16)	1.0 (16)	
5.5 (140)	1.4 (23)	1.4 (23)	1.4 (23)	1.5 (25)	
6.5 (165)	1.8 (30)	1.9 (31)	2.0 (33)	2.0 (33)	
7.5 (191)	2.2 (36)	2.3 (38)	2.3 (38)	2.4 (39)	
8.5 (216)	2.8 (46)	2.9 (48)	3.0 (49)	3.0 (49)	
9.5 (241)	3.4 (56)	3.5 (57)	3.6 (59)	3.7 (61)	
10.5 (267)	4.1 (67)	4.3 (70)	4.4 (72)	4.5 (74)	
11.5 (292)	4.9 (80)	5.1 (84)	5.2 (85)	5.4 (88)	
12.5 (318)	5.8 (95)	6.0 (98)	6.1 (100)	6.3 (103)	
13.5 (343)	6.7 (110)	6.9 (113)	7.1 (116)	7.3 (120)	
14.5 (368)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)	

Thickness 1/4 in. (6.35 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
3.5 (89)	0.8 (13)	0.8 (13)	0.8 (13)	0.8 (13)	in^3 (cm^3)
4.5 (114)	1.2 (20)	1.3 (21)	1.3 (21)	1.3 (21)	
5.5 (140)	1.8 (30)	1.8 (30)	1.9 (31)	1.9 (31)	
6.5 (165)	2.4 (39)	2.5 (41)	2.6 (43)	2.6 (43)	
7.5 (191)	2.9 (48)	3.0 (49)	3.1 (51)	3.2 (52)	
8.5 (216)	3.7 (61)	3.8 (62)	3.9 (64)	4.0 (66)	
9.5 (241)	4.5 (74)	4.7 (77)	4.8 (79)	5.0 (82)	
10.5 (267)	5.5 (90)	5.7 (93)	5.8 (95)	6.0 (98)	
11.5 (292)	6.5 (106)	6.7 (110)	6.9 (113)	7.1 (116)	
12.5 (318)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)	
13.5 (343)	8.8 (144)	9.1 (149)	9.4 (154)	9.6 (157)	
14.5 (368)	10.1 (166)	10.5 (172)	10.7 (175)	11.0 (180)	

Thickness 5/16 in. (7.94 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
3.5 (89)	0.9 (15)	1.0 (16)	1.0 (16)	1.0 (16)	in^3 (cm^3)
4.5 (114)	1.5 (25)	1.5 (25)	1.6 (26)	1.6 (26)	
5.5 (140)	2.2 (36)	2.3 (38)	2.3 (38)	2.4 (39)	
6.5 (165)	3.0 (49)	3.1 (51)	3.2 (52)	3.2 (52)	
7.5 (191)	3.6 (59)	3.7 (61)	3.9 (64)	4.0 (66)	
8.5 (216)	4.6 (75)	4.7 (77)	4.9 (80)	5.0 (82)	
9.5 (241)	5.6 (92)	5.8 (95)	6.0 (98)	6.2 (102)	
10.5 (267)	6.8 (111)	7.1 (116)	7.3 (120)	7.5 (123)	
11.5 (292)	8.1 (133)	8.4 (138)	8.6 (141)	8.9(146)	
12.5 (318)	9.5 (156)	9.8 (161)	10.1 (166)	10.4 (170)	
13.5 (343)	11.0 (180)	11.4 (187)	11.7 (192)	12.0 (197)	
14.5 (368)	12.6 (206)	13.0 (213)	13.4 (220)	13.7 (224)	

Thickness 3/8 in. (9.52 mm)					
D in. (mm)	W in. (mm)				
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)	
3.5 (89)	1.1 (18)	1.1 (18)	1.1 (18)	1.2 (20)	in^3 (cm^3)
4.5 (114)	1.8 (30)	1.8 (30)	1.9 (31)	1.9 (31)	
5.5 (140)	2.6 (43)	2.7 (44)	2.7 (44)	2.8 (46)	
6.5 (165)	3.5 (57)	3.7 (61)	3.8 (62)	3.8 (62)	
7.5 (191)	4.3 (70)	4.5 (74)	4.6 (75)	4.8 (79)	
8.5 (216)	5.5 (90)	5.7 (93)	5.9 (97)	6.0 (98)	
9.5 (241)	6.7 (110)	7.0 (115)	7.2 (118)	7.4 (121)	
10.5 (267)	8.1 (133)	8.4 (138)	8.7 (143)	8.9 (146)	
11.5 (292)	9.7 (159)	10.0 (164)	10.3 (169)	10.6 (174)	
12.5 (318)	11.3 (185)	11.7 (192)	12.1 (198)	12.4 (203)	
13.5 (343)	13.1 (215)	13.6 (223)	14.0 (229)	14.3 (234)	
14.5 (368)	15.1 (247)	15.5 (254)	16.0 (262)	16.4 (269)	

Example:

Refer to the sample truck frame cross sections in Table E. Truck frame yield strength is I I 0,000 psi (758 MPa) with the following dimensions at the front axle location: 3/8 in. (9.52 mm) thick, 1.50 in. (38.1 mm) top flange, 3 in. (76.2 mm) bottom flange, 10.25 in. (260 mm) deep. To find the frame section modulus:

1. Use a channel with 1.50 (38.1 mm) flanges since I.50 in. (38.1 mm) is the smaller flange width.

2. From Table E, 3/8 in. (9.52 mm) thickness:

- W (width) = 1.50 in. (38.1 mm)
- D (depth) = 10.0 in. (254 mm)
- Section Modulus = 10.2 in^3 (167 cm^3)

3. From Table E, 3/8 in. (9.52 mm) thickness

- W = 1.50 in. (38.1 mm),
- D = 11.0 in. (279 mm)
- Section Modulus = I I.9 $in.^3$ (195 cm^3)

4. Interpolate between the two values:

- 10 in.(254mm) deep channel = 10.2 $in.^3$ (167cm^3)
- 11 in.(279mm) deep channel = 11.9 $in.^3$ (195cm^3)
- 10.5 in.(267 mm) deep channel

$$= \frac{10.2\ in.^3 + 11.9\ in.^3}{2} = 11.0\ in.^3$$

$$= \frac{167\ cm^3 + 195\ cm^3}{2} = 181\ cm^3$$

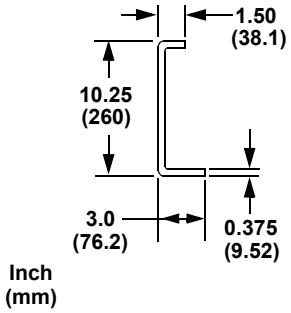
5. Now interpolate between a 10.0 in. (254 mm) deep channel and a 10.5 in. (267 mm) deep channel to get the section modulus of a 10.25 in. (260 mm) deep channel.

- 10.0 in. (254 mm) deep channel = 10.2 $in.^3$ (167cm^3)
- 10.5 in. (267 mm) deep channel = 11.0 $in.^3$ (181cm^3)
- 10.25 in. (260 mm) deep channel

$$= \frac{10.2\ in.^3 + 11.0\ in.^3}{2} = 10.6\ in.^3$$

$$= \frac{167\ cm^3 + 181\ cm^3}{2} = 174\ cm^3$$

Frame Section Modulus at the front axle location is 10.6 $in.^3$ (174 cm^3). This is greater than the 7.5 $in.^3$ (123 $in.^3$) required so the truck frame is strong enough at this location.



TRUCK PREPARATION

Plan installation completely before any work is done. Plan the location of the crane for the final front and rear axle weights and boom overhang. Check final weight (see Counterweighting Section to verify that final truck weight with crane, reinforcement, counterweight and options such as jib, etc. complies with the appropriate laws).

Welding Precautions

- Sensitive truck computer system and crane's RCL or jib load limiting device computer system components may be damaged by welding on the truck or crane. The following precautions should be taken:
- Disconnect truck battery cables (positive and negative)
- Attach welding ground lead as close as possible to area to be welded.
- Remove the jib from the crane before welding on the crane or remove the jib sheave case assembly from the jib before welding on the jib.

POSITIONING CRANE ON TRUCK

The final user of the crane must be aware of all state axle and length laws in force at the time of crane mounting and position the crane on the truck accordingly. Following are items which must be considered.

1. Overall Length: Most states have a maximum straight truck length limit of 40 feet (12.19 m). Using too long a WB truck could cause the unit to exceed this limit.
2. Axle Weights: All states allow 20,000 lb (9072 kg) single axle weight and 34,000 lb (15,422 kg) tandem axle weights on primary roads, however, some states restrict axle weight to less on secondary roads or at certain times throughout the year. Be aware of your state's axle laws and the roads the machine will operate on for weight restrictions due to secondary roads, bridges, winter driving conditions, etc.
3. Overhang: The most restrictive overhang laws call for a maximum of 3 feet (0.91 m) in front of the truck. Many states have a maximum of 4 feet (122 cm) overhang in back of the truck. Check on your state requirements.
4. Federal Bridge Law: The Federal Bridge Law in effect currently states that in order to carry 54,000 pounds (24,494 kg) on a three axle truck, the extremes of any group of axles must be at least 23.5 feet (7.16 m) apart. This equates to a truck with a wheelbase of at least 258 inches (655 cm) with a minimum length of 24 inches (60.96 cm) from the center of tandems to the center of the rear axle.

PTO INSTALLATION

Select the PTO according to the PTO Selection pages shown earlier in this section. PTO's are not furnished by the factory.

Hydraulic Pump Installation

1. Install the PTO and PTO shifting mechanism according to the PTO manufacturer's instructions. If PTO has a reverse gear, it must be blocked out. Pump must not run backwards.

CAUTION

To avoid pump failure, do not turn the pump in the opposite direction of the indicating arrow on the pump housing.

2. If PTO integral mount flanges are to be used, the pump can be mounted directly to the PTO. Be sure adequate clearance exists for this type of pump mount. Sometimes the pump is powered through a drive line with the pump located no more than 42 inches (107 cm) from the PTO. The drive line should not exceed a 7° angle. The drive line U-joint yokes on both ends of the drive shaft must be parallel with each other. Drive lines should be sized so they can safely carry the maximum pump horsepower requirements. See “PTO Selection” pages. Drive lines are not furnished by the factory.
3. Plan the location of the pump mounting bracket and drive line, if used, so that ample clearance is maintained between pump and truck drive shaft or exhaust system. Pump should be situated so that hydraulic lines can be connected without sharp bends especially the large suction line from the reservoir. Pump mounting brackets may be attached to existing frame crossmembers or a 6 inch (15 cm) channel crossmember can be made and installed.
4. Install pump mounting bracket (driveline driven pumps only) securely to the truck frame. Attach pump to pump mounting plate or directly to the PTO using capscrews provided.
   a. Install the pump support bar at the rear of the pump and bolt or weld the upper end to a crossmember if the pump is driven by a driveline.
   b. For a direct mounted PTO bolt to transmission.
   c. The rear of the pump must be supported regardless of the mounting method.
5. The splines of the pump shaft and the drive coupling need Lubrication. If the gearbox is a wet drive then no grease is required because the gearbox oil will lubricate the splines. If the gearbox coupling is sealed then the splines needs to be greased with Heavy Lithium Grease covering all the Splines

6. For a wet mount, a gasket is required for the mounting flange to PTO gearbox interface. Dry mount does not require a gasket.

7. Torque the mounting flange nuts to 50 ft. lbs (222 Nm).

NOTE: Some of the pipe fittings used are sealed by means of two threaded tapered sections, one male and one female. When these two tapers meet, you will note a sudden increase in the force required to screw the fittings together. This is true of all tapered pipe threads. Further tightening will not only fail to increase the pressure tightness of the joint, but may ruin the connections and make correct assembly impossible.

Other fittings are of the o-ring boss type. These are installed by first screwing the lock nut flush to the upper thread land and installing fitting into port until the nut contacts the surface of the port. Adjust fitting to desired direction. Tighten locknut.

Most pressure fittings are the O-ring face seal types. A small O-ring is compressed between the male and the female fittings of the joint. Be sure the O-ring is present on the fitting and seated properly in its groove before the fittings are tightened.

8. Remove the dust covers from the pump inlet and outlet and make sure that the suction and pressure sides of the pump are correct.

NOTE: An arrow is cast into the rear of the pump housing to identify rotation. Make sure the rotation is correct.

Rotate the pump in the direction as the PTO. Rotate the pump in the direction as the PTO. Rotate the pump in the mounting bracket so suction side is toward the reservoir suction port.

REINFORCING/AFTER FRAME EXTENSION

1. Refer to “Truck Frame Strength” and “Section Modulus” tables. Determine section modulus by actual measurement of the truck frame. If reinforcing is required, always use at least 100,000 psi (758 MPa) steel to minimize the amount of reinforcing required. Use Grade 90 weld material for any welding to be done.

2. Strip the frame of obstructions in the area to be reinforced or extended, one side at a time. If the truck frame cross members are bolted in, remove the bolts. Do not attempt to remove any rivets.

3. Place the reinforcing on the truck frame and clamp in place. Mark the location of any rivets by striking the outside of the reinforcing over the rivet area so that the rivets make an impression on the inside of the reinforcing. Mark the approximate location of the crane mounting anchors so that no obstructions exist. Remove the reinforcing and drill or torch cut clearance holes for bolts or rivets. See Figure A.

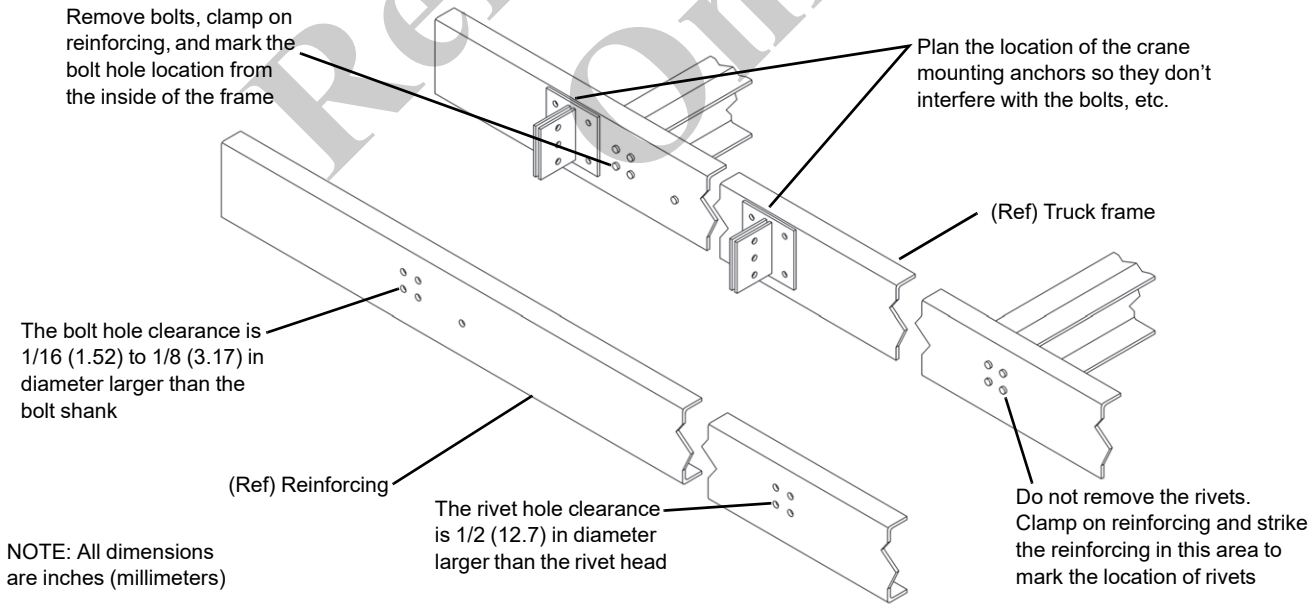


Figure A

4. If reinforcing is to be welded on, torch cut hole pattern in reinforcing being careful to clear crane mounting anchors. Install reinforcing, clamp in place, install any crossmember bolts that were previously removed and weld to truck frame as shown in Figure B.

In some cases, because of customer stipulation or truck manufacturer voiding their warranty, bolt-on reinforcing is required. In these cases, install the reinforcing, clamp in place, install any crossmember bolts that were previously removed, then drill through reinforcing and truck frame being careful to clear crane mounting anchors and bolt reinforcing in place. See Figure C for recommended drilling and bolting procedure. Use 5/8, Grade 8 bolts, drill holes to 39/64 diameter, drive fit bolts and torque according to "Torque Values For Grade 5 and 8 Bolts" table in Section 2.

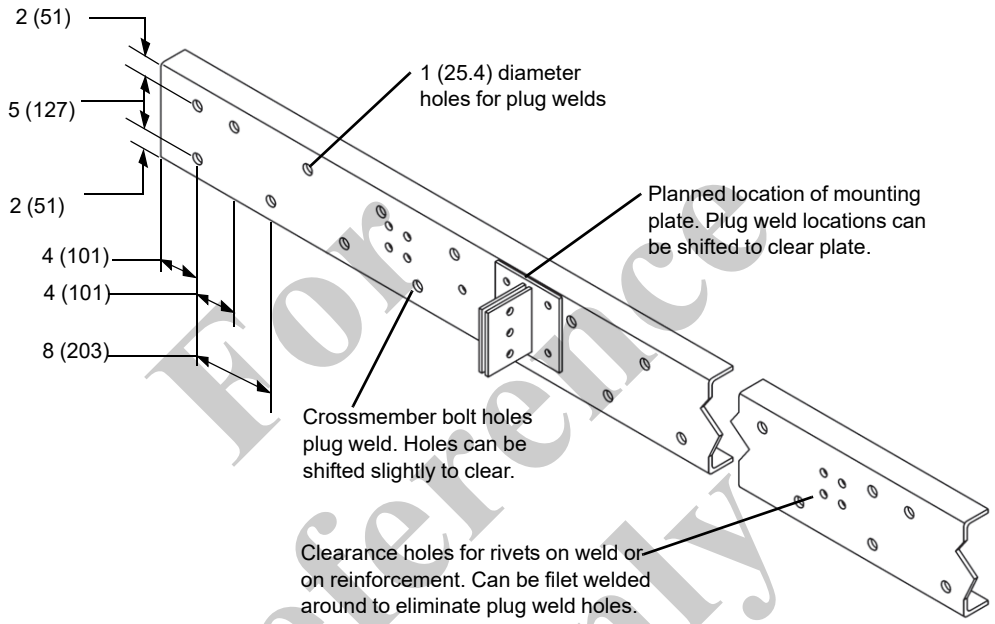


Figure B

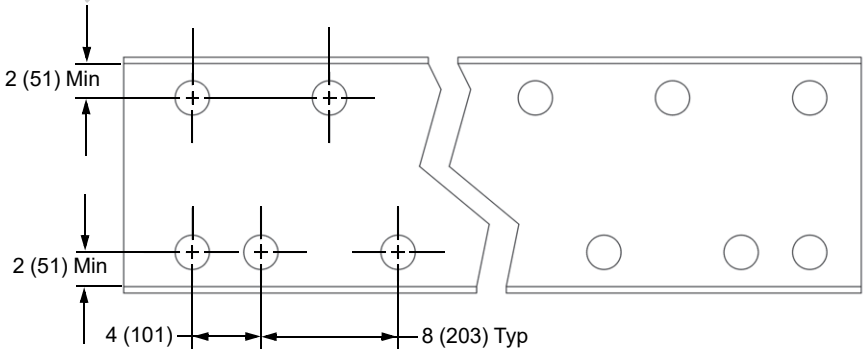
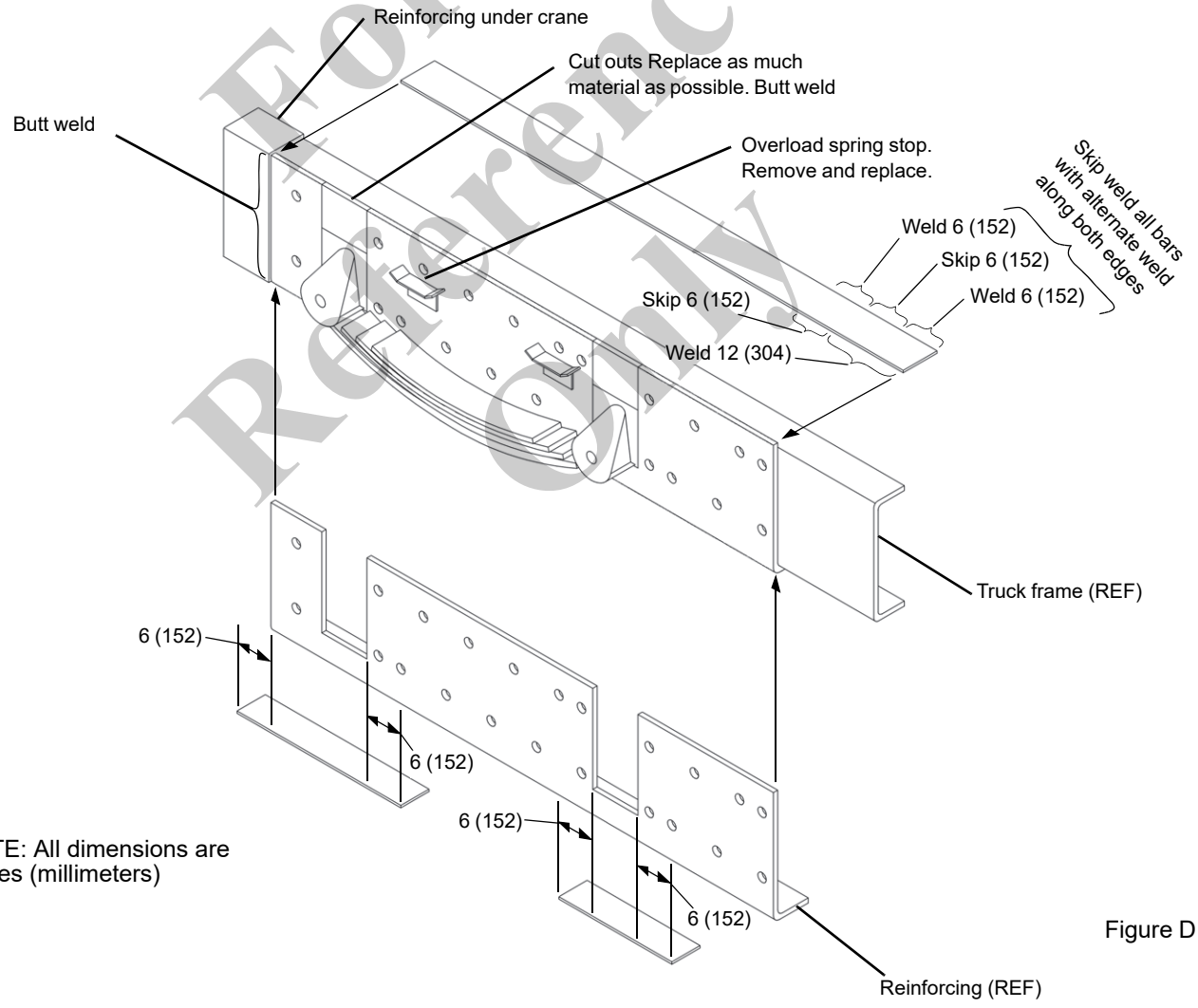


Figure C

NOTE: All dimensions are inches (millimeters)

5. If the frame through the rear suspension doesn't meet minimum specifications for RBM and section modulus as shown on “Truck Frame Strength” table, it can be reinforced by adding an angle type of reinforcing as in Figure D. See “Section Modulus tables, Table B” for the required size of reinforcing. Strip all easily removable equipment from the frame through the suspension such as spring stops, etc. Butt the reinforcing angle up against the reinforcing forward of the suspension and mark the areas that will require cutting so that the angle will slide up around the spring hangers and against the existing truck frame and forward reinforcing. Torch out the marked areas in the long leg of the angle deep enough so that the lip of the angle can be slid up from the underneath the frame to contact either existing truck frame or spring hanger brackets (if they extend down below the existing truck frame). If reinforcing angle is to be welded to truck frame, cut out plug weld hole pattern as in Figure B. Slide the reinforcing angle up from the bottom, butt it to existing forward reinforcing and weld rear suspension reinforcing to forward reinforcing. Replace as much of the spring hanger cut out areas as possible and butt weld these pieces in.

If reinforcing angle is to be bolted on, drill hole pattern and install bolts according to Figure C. Reinforce spring hanger cut outs and the weld area, suspension reinforcing to forward reinforcing by adding bars under these areas. The bars should be of the same thickness, width and yield strength as the reinforcing angle lip, and should be long enough to extend at least 6 inches (152 mm) beyond either side of the weld or cut out areas. Weld these reinforcing bars to the underside of the reinforcing with length-wise welds. **Do Not Weld Across The Flanges**. Replace any equipment that had been removed.



NOTE: All dimensions are inches (millimeters)

Figure D

AFTER FRAME MODIFICATION

If additional suspension reinforcing is required, as may be the case with a truck frame that tapers down to approximately 6 inches (15.24 cm) deep through the suspension, a channel may be fabricated through the suspension for additional strength. To do this, install the angle as described in the previous step, making sure that the long leg of the angle extends to the top of the truck frame. A bar of the same material strength, thickness, length and flange width as the reinforcing angle is then added to the top of the truck frame. The bar is butt welded to the top of the forward reinforcing, then skip-welded with 6 inches (15.24 cm) of weld, 6 inches (15.24 cm) no weld, etc., along both edges of the bar, front to back. Length of after frame (AF) may have to be modified for crane installation. If AF is too long, cut off excess and remove any crossmembers from back of truck frame. If AF is too short, the frame will have to be lengthened. Use channels fabricated from 100,000 psi (758 MPa) yield material that are the same size as the truck frame. Weld these channels to the ends of the existing truck frame channels. Bevel the ends of the channels to get 100% weld joints with Grade 90 weld material. Fabricate an inner channel of the same thickness as the truck frame channels to span the weld joint for at least 12 inches (30 cm) on each side of joint. Plug weld this channel to the inside of the truck frame, then skip weld the inside edge of the top and bottom flanges to the truck frame flanges

CRANE MOUNTING PROCEDURE

The following is a suggested sequence of steps required to successfully mount the crane on the truck. This is only one of several possible ways to mount the crane and is offered as an aid to planning the mounting of the crane.

Crane Component Installation Sequence

- Position Torsion Box and mark frame locations for Hydraulic Reservoir and ASH
- Remove Torsion Box
- Install hydraulic pump
- Locate and drill holes for Hydraulic Reservoir
- Install Hydraulic Reservoir
- Install pump lines to Reservoir
- Position Torsion Box
- Install ASH
- Install Truck Bed
- Install Frame Assembly
- Install Outriggers
- Route and connect hydraulic hoses to Reservoir and Main Control Valve
- Install Boom
- Install hoist cable
- Fill hydraulic reservoir

Torsion Box and ASH Stabilizer Installation

1. Determine installation position for the crane considering the operating area of the crane, space for saddle tanks, truck frame crossmembers, or anything that might affect installation and be sure the frame is clear of any obstructions that might interfere with proper installation.
2. Center the subbase on chassis at the proper location.
3. If subbase does not fit tightly on truck frame at all locations, do not force them together to remove gaps since they will not affect the units stiffness or strength. Add spacers as required to level truck bed before attaching it to the torsion box.

Install Torsion Box

Install outriggers on crane frame as shown in illustrated parts pages. Attach the appropriate hoses to the outrigger cylinders. Cycle the outriggers to fill with oil completely and install the latch plate to hold outriggers in place during travel.

Mount the Turret and Torsion Box to the Frame Assembly

Position the turret assembly and the torsion box on the frame assembly so that the mounting bolts can be attached through the plates attaching the assemblies to the frame (Figure 9-1).

Turret Mounting

1. If not already applied, apply channel molding (15, Figure 9-1) to both holes where the turret assembly will sit. Tap molding until snug. Trim excess molding as needed.
2. Position the turret assembly.
3. Install the standard SAE washer (4) against the head of the 1-1/4 inch bolt (3).
4. Install the Direct Tension Indicator (DTI) crush washer (7) with the bumps facing away from the SAE washer (4), facing toward the hardened washer (14).

NOTE: Do not allow the DTI crush washer to turn during tightening of fastener or damage may occur to the bumps on DTI crush washer causing improper tension.

NOTE: The DTI crush washer cannot be re-used and must be replaced if the studs become loose or are removed.

5. Install the DTI hardened washers (14).

6. Assemble and install the bolt and washer assembly through the holes in plate (5) and install plate on outer surface of the truck chassis.
7. Install crush plate (6) to the inside of chassis frame channel. Ensure the crush plate is machined to properly fit to the inside the frame channel of the truck chassis conforming to the frame rail.

NOTE: Cut the plate and machine as necessary to fit inside the truck frame.

8. Align and install bolt (3) passing through mounting holes in crush plate (6) and aligning through inner mounting holes in the turret.
9. Install the washer (4) and nuts (8) on top side of the turret and snug tight.
10. Install the outer bolt and washer assembly in the outer turret assembly mounting holes.

WARNING

When tightening nuts keep the plate parallel to truck frame. Failure to do so causes uneven edge loading and stud failure.

11. Snug all bolts arrays in a star pattern.
12. Tighten evenly in a star pattern until the direct tension indicator (DTI) crush washer (7) compresses and the silicone indicator is visible between the washers.

NOTE: The DTI crush washer cannot be re-used and must be replaced if the studs are removed.

NOTE: Tighten the bolt assembly only until the DTI crush washer (7) is adequately compressed and the silicone indicator is visible regardless of the tension value being applied.

Tension should be verified by inserting 0.127mm (0.005 in) feeler gauge between the hardened washer and the DTI crush washer in between each bump of the DTI crush washer. An example of the acceptable tension would be when the feeler gauge will not enter half of the available places right in the bolt shank. If it does, then the bolt assembly will need to be tightened slightly more.

WARNING

Crushing Hazard!

It is mandatory that T-box attaching bolts be inspected and re-tightened after the first 300 hours of crane operation and every 500 hours thereafter. The bolts may loosen and cause the crane to separate from the carrier which will result in damage to the crane and possible injury or death to personnel.

Maintaining proper tension 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 turret from the frame.

CAUTION

Repeated re-tightening may cause bolts to stretch. If bolts keep working loose, they must be replaced with new bolts and DTI of the proper grade and size.

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), the service technician must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry tightening values. When a high strength bolt is removed, or un-tightened, the bolt must be replaced with a new bolt of the same classification.

Torsion Box Mounting

1. Position the torsion box assembly onto the chassis frame (Figure 9-1).
2. Attach the torsion box to frame using the bolt and plate assembly procedure as referenced in *Turret Mounting* on page 9-22.

WARNING

When tightening bottom nuts keep the plate parallel to truck frame. Failure to do so causes uneven edge loading and stud failure.

3. Install plate, rear light (10) to rear of the torsion box using attaching hardware capscrew (11), washer (12), and locknut (13).

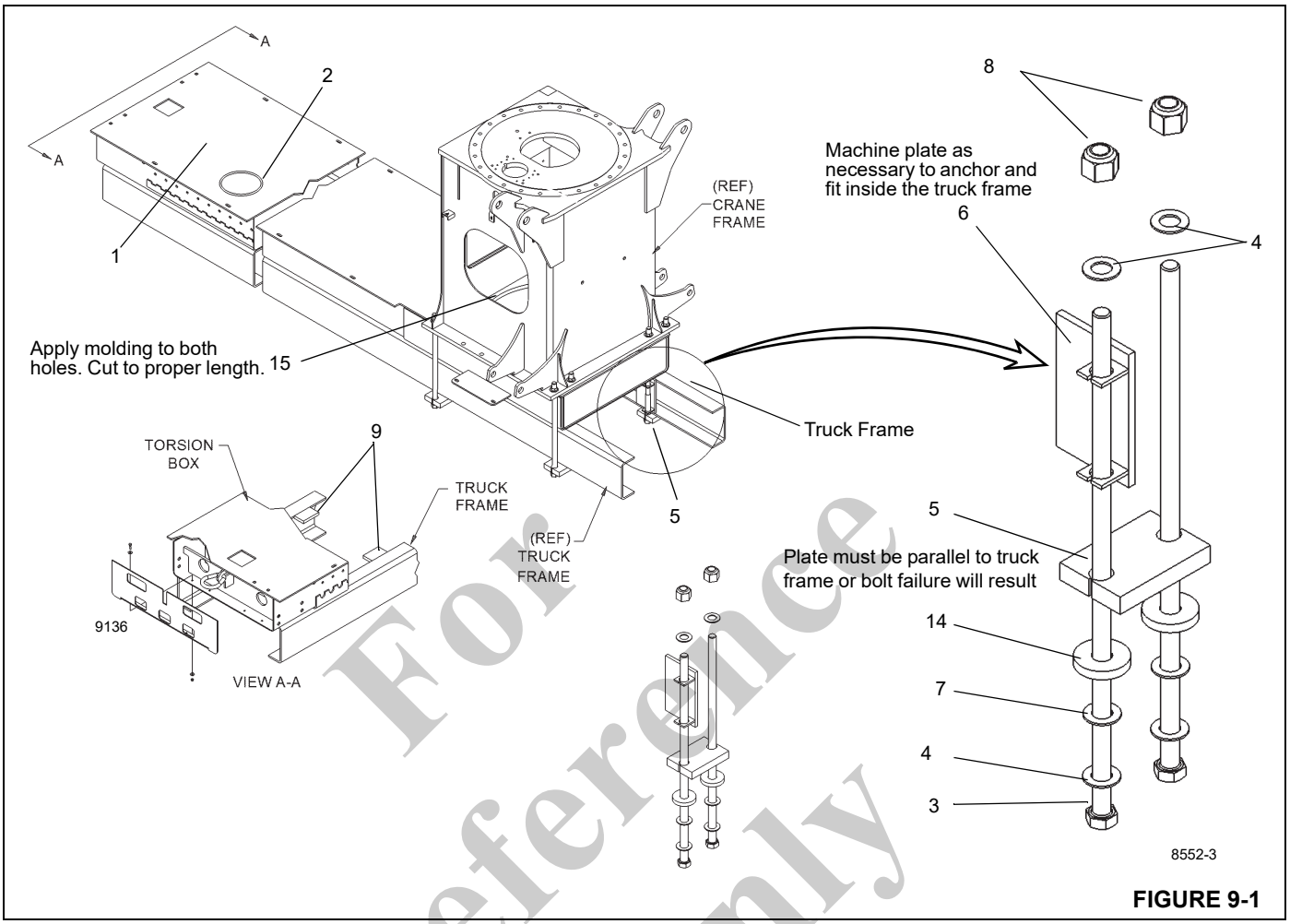


FIGURE 9-1

Table 9-1

Item	Description
1	Torsion Box
2	Protector
3	Bolt - 1 1/4 X 30
4	1-1/4 Washer, Hardened
5	Clamp Plate
6	Crush Plate
7	1-1/4 DTI Crush Washer
8	Locknut - 1 1/4
9	Bar
10	Plate - Rear Light
11	Bolt - 3/8

Item	Description
12	Washer - 3/8
13	Locknut - 3/8
14	Washer - 1 1/4
15	Channel Molding

Mount the Outrigger Box

Position the front outriggers on the T-Box and bolt to the truck frame with the anchor bolts and brackets, Reference (Figure 9-2).

Position the rear outriggers on the T-Box and bolt to the truck frame with the anchor bolts brackets.

NOTE: The front outrigger boxes are integral to the T-box on cranes where the operators station is mounted behind the truck cab.

ASH TO TORSION BOX MOUNTING

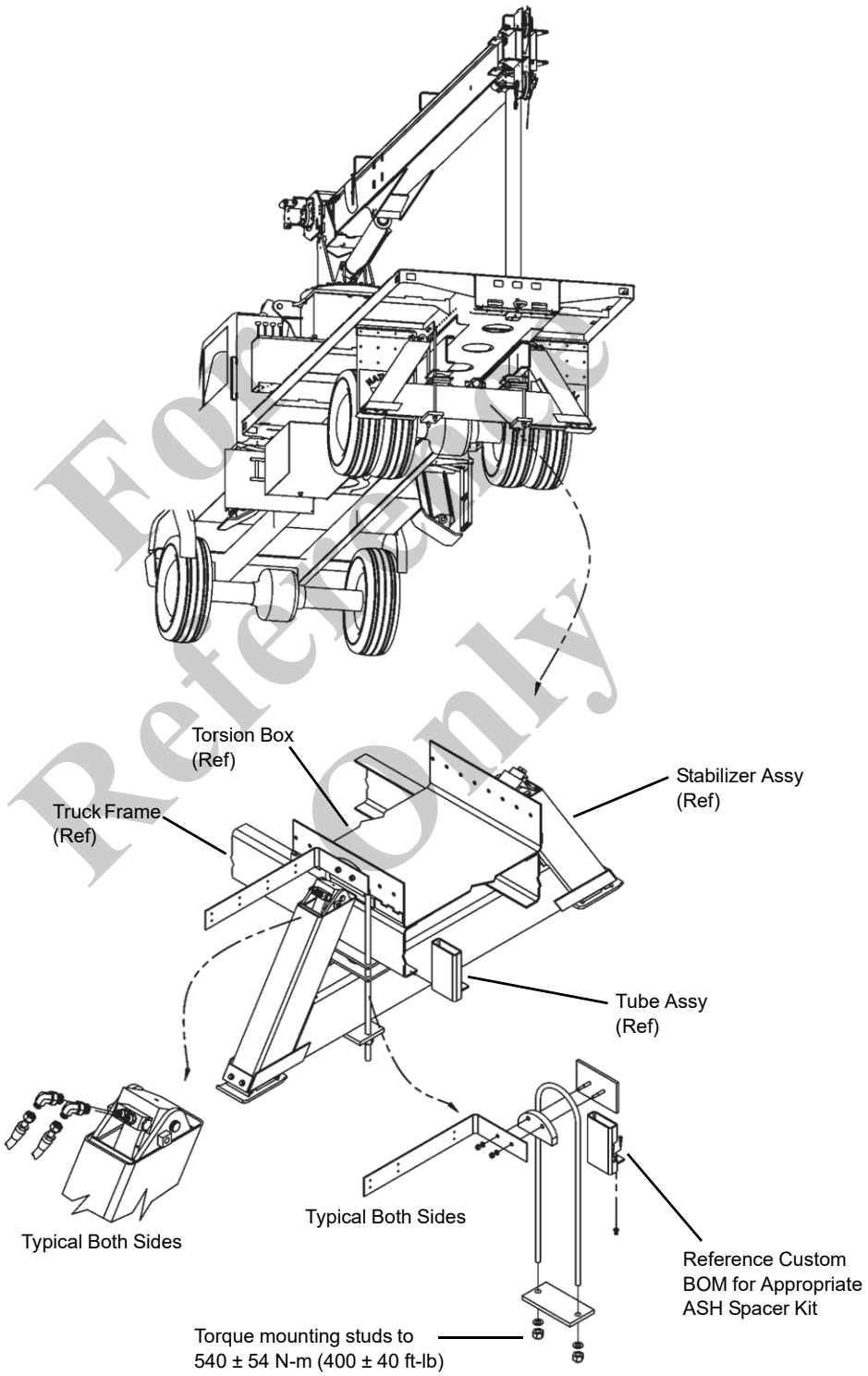


FIGURE 9-2

Assemble the Outriggers

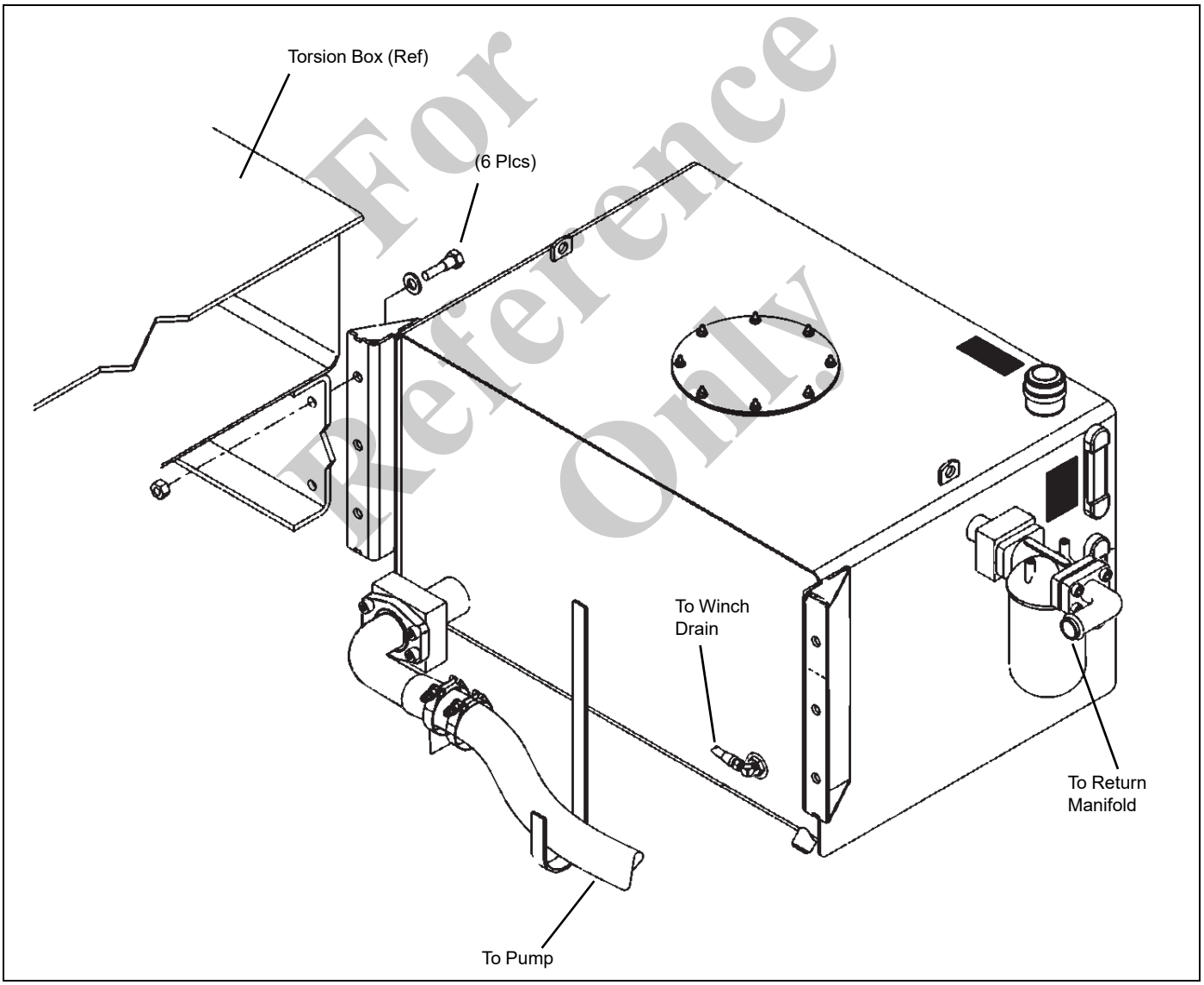
1. Assemble the outriggers as shown in the parts manual and connect the hydraulics as per hydraulic schematics. Connect the solenoids to the outrigger selector switch on the control panel.

   Alternate between studs at each corner during the tightening process to insure studs are straight and bottom clamp plate is kept parallel with truck frame. Failure to keep clamp plate parallel with truck frame will cause uneven edge loading and cause premature stud failure.

Hydraulic Reservoir Installation

1. Find a location for and install hydraulic oil reservoir. Mounting brackets may be bolted to the truck frame. Before placing reservoir in service, remove cleanout cover and inspect to ensure proper installation of diffuser.
2. Connect manifold return, hoist drain, and pump suction to couplings on reservoir before filling with oil.
3. Install the return line from the crane frame to the filter on the side of the reservoir.

NOTE: The weight of suction and return hose and plumbing must be supported to prevent damage to the reservoir. Install support brackets and clamp or tie hoses up to eliminate strain on reservoir connections.

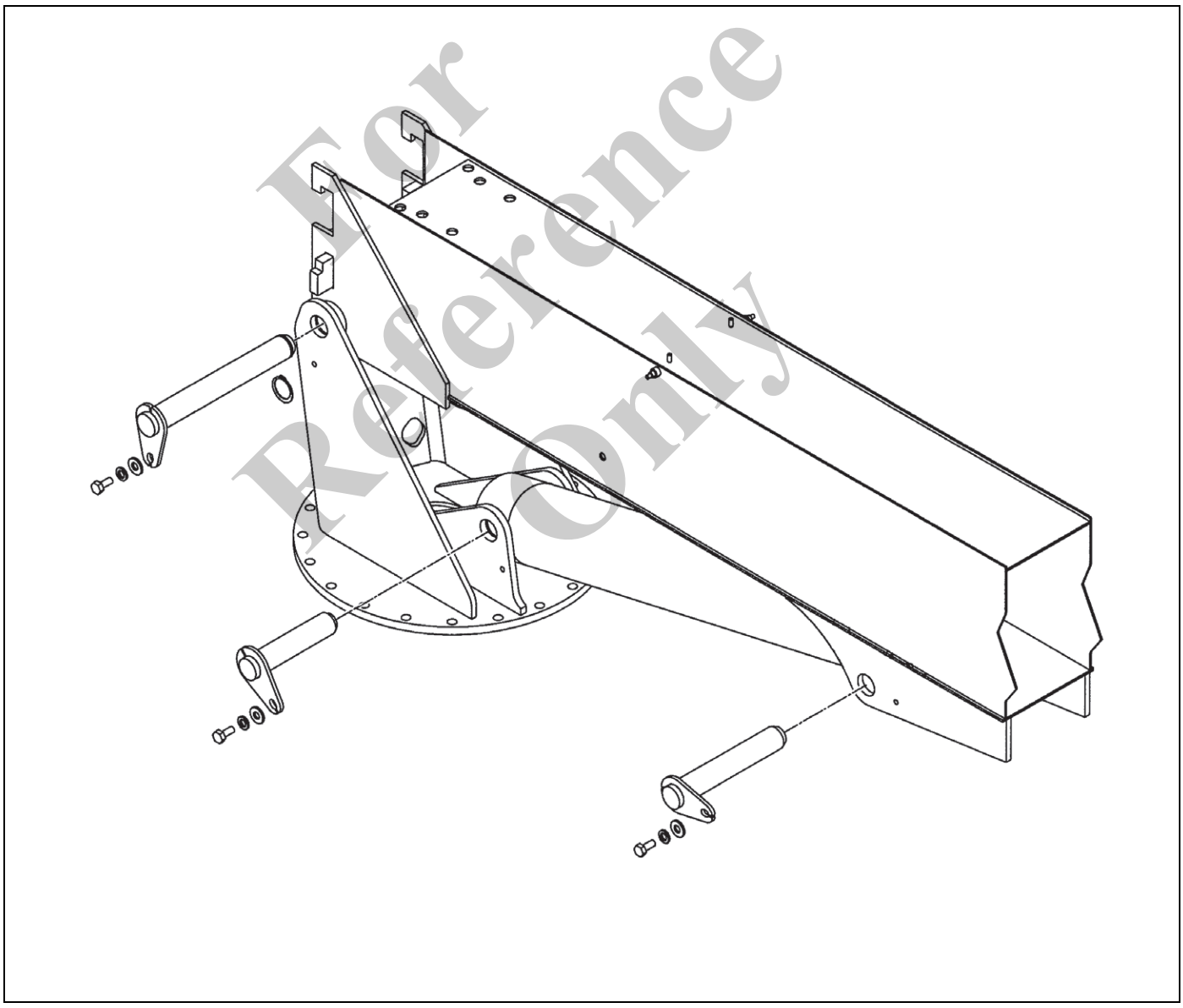


BOOM INSTALLATION

Lift Cylinder Installation

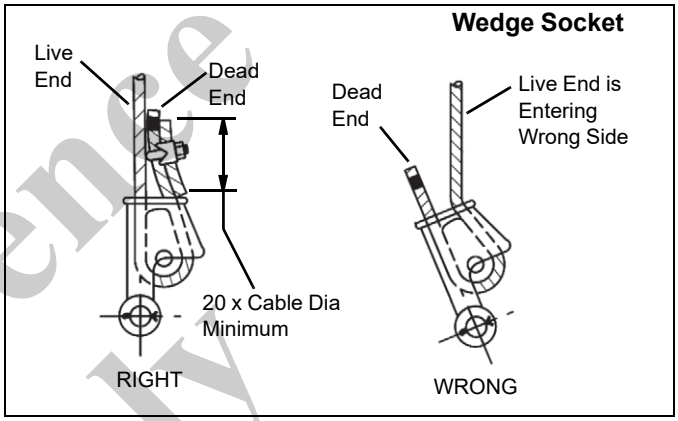
NOTE: Before attempting to assemble the boom and lift cylinder to the frame, see Pin Bearing Inspection and Installation pages in this section. Before connecting hoses, boom must be opposite (180°) the rotation stop to minimize hose twist.

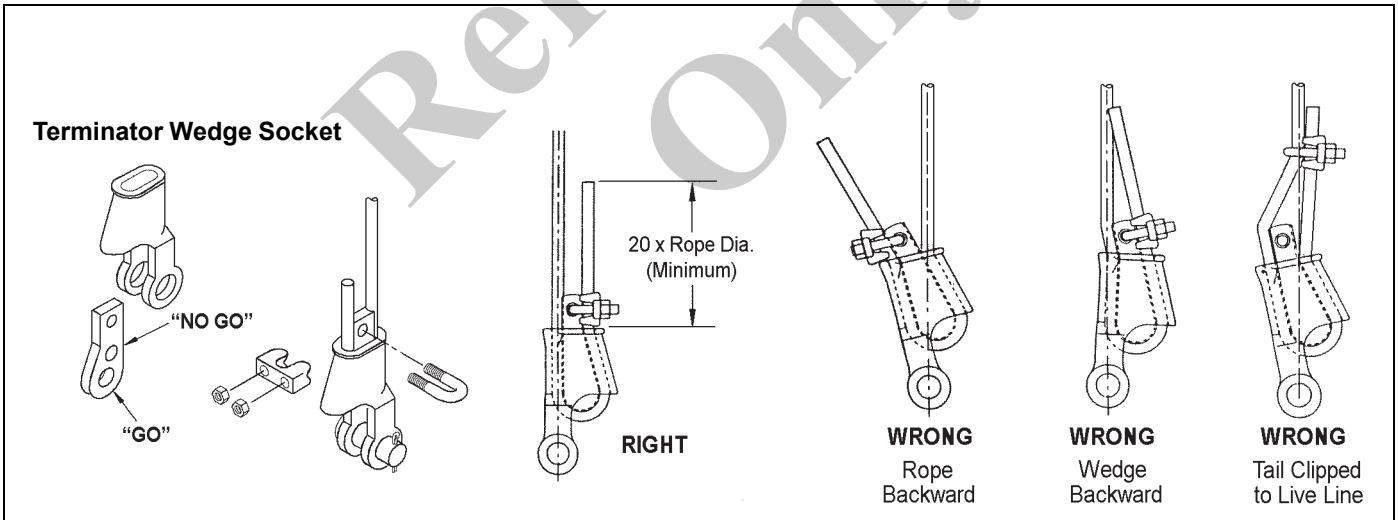
1. Pin lift cylinder barrel in position in the turret.
2. Pin boom pivot to turret. (It will be necessary to use an overhead hoist for lifting boom and lift cylinder.)
3. Connect the 1/2 inch R12 hoses to the lift cylinder.
4. Support outer end of boom securely and use the overhead hoist to position the lift cylinder with the control valve to pin the cylinder to the boom ears. Torque pin keeper capscrews to proper torque.
5. Grease the three pin joints with gun grease and operate the boom and lift cylinder through several complete cycles before placing machine in operation.
6. Route the 1/2 inch R12 telescope hoses over the turret back plate and to the back side of the boom. Connect the telescope cylinder connections at the back of the boom.
7. Route the 3/4 inch R12 hoist hoses and the 1/4 inch R1 hoist drain hose through the turret then through the holes in the side of the hoist side plates and connect to the hoist fittings.



Wire Rope Installation

1. Unspool approximately 15 feet (8 m) of cable and route the cable through the boom cable guides from the front of the boom to the hoist.
2. Install one end of the loadline cable into the hoist drum using the wedge socket provided.
3. Remove the cable keeper T-handle pin from the sheave case and lay the cable over the top sheave. Replace the top cable keeper pin.
4. Unspool the remainder of the cable out from the back of the truck being sure the cable is straight and without kinks. Attach downhaul weight, wedge socket, hook and cable clamp to the end of cable as shown in Loadline Section. Torque cable clamp (clip) to 95 ft-lb (128 N·m). This torque must be rechecked after initial operation of the crane. Be sure cable clamp is attached to the free end of the cable only. If equipped with optional 2/3 part block, omit downhaul weight and assemble as shown in Loadline Section. Special care should be taken to reeve the cable through the wedge socket as shown below.
5. Spool the loadline onto the hoist drum while maintaining approximately 500 pounds (250 kg) of tension on the cable (attaching a small vehicle to the end of the loadline with another person lightly riding the vehicle brakes while the cable is spooling on the drum will accomplish this). While the first half of the hoist bare drum is filling, it will be necessary to force the cable to wrap tightly against the preceding wrap by pounding the cable against the preceding wrap with a rubber mallet until at least half of the drum is full. The remaining half of the drum should wrap tightly because the fleet angle of the cable will tend to pull the cable to the center of the drum thus wrapping tightly.
6. Continue winding the cable on the second, third and fourth layer of the drum. Keep the cable paying in straight to the boom to avoid side loading the boom. The preceding layers will wrap smoothly guided by the first layer wrapping.
7. After cable is completely wrapped on drum, replace remaining cable keeper bolts on the sheave case. Attach wedge socket and cable clip to end of cable per illustration in Loadline Section of parts manual and torque cable clip bolts to 95 ft-lb (128 N·m) for 9/16 inch cable.





Torque Value Table

Cable Size (inches)	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1	1-1/8	1-1/4
Torque ft/lbs	45	65	65	95	95	130	225	225	225	360
Torque values shown are based upon clean dry threads free of lubrication.										

Hoist to Truck Cab Clearance

Check for hoist mount tail swing clearance at top of cab. Any equipment that extends above the truck cab such as exhaust stacks or air horns may interfere with the hoist mount when the boom is elevated and rotated. Shorten exhaust stacks or move air horns, etc. to ensure clearance.

Painting

If crane is to be repainted, mask all decals prior to final paint or install all new decals in accordance with location drawings and illustrated parts catalog over final paint.

PIN BEARING INSPECTION AND INSTALLATION PROCEDURE

Pin Inspection

1. Remove the protective covering from pins and inspect each pin for nicks, gouges or deep wide scratches. A small nick or gouge up to 1/8 inch (3 mm) diameter can be repaired by dressing the edges of the imperfection with a file so that no metal protrudes above the circular surface of the pin.
2. A circular scratch of up to 1/16 inch (1.5 mm) wide or deep can be repaired as in 1 above.
3. A lengthwise scratch on the pin of up to 1/32 inch (0.8 mm) wide or deep can be repaired as in 1 above.
4. Pins with defects larger than those listed in 1, 2 or 3 should be replaced.

Bearing Installation

1. The bearings furnished with this machine are made up of a tough epoxy impregnated wound glass backing shell with a thin inner layer of filament wound bearing material. The outer bearing material should be visually checked for imperfections. Bearings with cracks or gouges larger than 1/4 inch (6 mm) diameter on the outside diameter should be replaced.
2. Inspect the inner diameter surface of the bearing. any scratches, cut or gouges which have penetrated through the inner liner may cause premature failure of the bearing. The bearing should be replaced.

Trunnion Inspection

The trunnion bore should either have a machined step or have a spring spacer installed to prevent inward movement of the bearing. If equipped with a spring spacer, check to make sure the opening is positioned over the grease hole.

Bearing Inspection

1. Two bearings are to be installed in the boom pivot trunnion located directly below the hoist and the remaining four bearings are to be installed in the lift cylinder, two at each side of the rod end of the cylinder and two at each side of the butt end of the cylinder.
2. The bearings should be started in their respective bores by rotating the bearing while applying inward pressure with the hand. Once the bearing has been started squarely into its bore, it can be driven to its full counterbored depth by tapping lightly with a rubber mallet. The head diameter of the mallet should exceed the outside diameter of the bearing to ensure that the bearing is not damaged during assembly into the bore.
3. If the bearing appears to be loose in the bore (if it can be pushed in with hand pressure alone), it is permissible to tighten the bearing by center punching the bore diameter in approximately 50 places around and throughout the 2 inch (51mm) deep bored area. Center punching will raise the metal around the edge of the punch mark and this raised metal will hold the bearing firmly in place during machine operation.
4. After all bearings have been installed and before attempting to assemble the machine, insert the pins through both bearings in each end of the lift cylinder and through the boom pivot bearings to insure alignment and fit are correct. Also check the two sets of pin holes in the turret and the pin holes in the boom ears to ensure that the pins will slide freely through the leading hole and start in the opposite hole. If a pin starts to bind through the leading hole, do not force the pin any further to avoid damaging the pin surface finish. Remove the pin and clean any corrosion of burrs out of the holes with a round file or emery cloth.
5. When pinning the boom to the turret, and the lift cylinder to the turret and boom, use a round smooth bar of approximately 1-1/2 inch (38 mm) diameter as a pry bar to align the pin holes. A pry bar with a sharp edge, such as a crowbar, can gouge or cut bearing and this may lead to premature bearing failure.

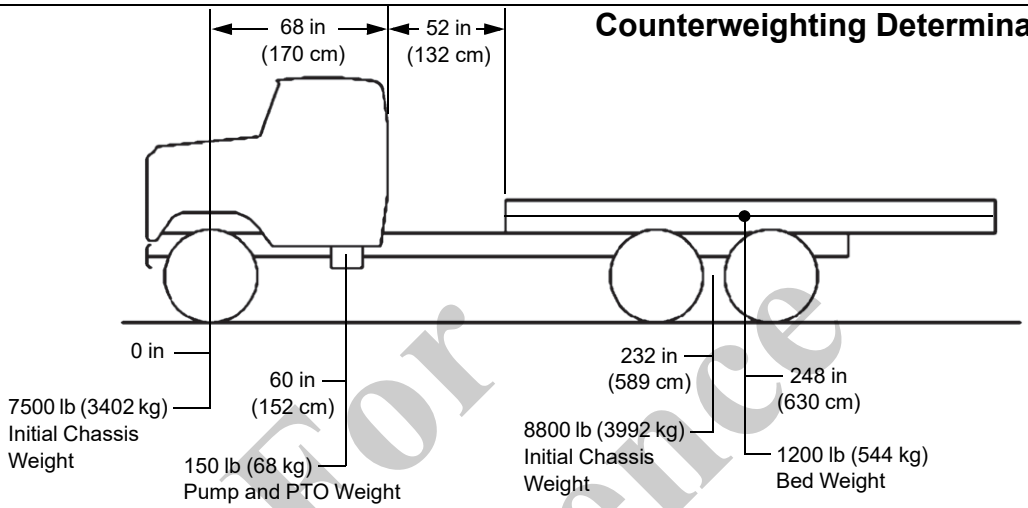
COUNTERWEIGHTING

Refer to Mounting Configuration pages in this section. The amount of counterweight and its location is dependent upon the stability working area (180 x behind the truck or 360 x around the truck), the weight of the truck and all permanently attached equipment. Permanently attached equipment which can be considered as counterweight includes the bed, reinforcing, PTO and pumps, tool boxes, etc. The torsion resisting subbase and rear stabilizers are considered part of this crane and not part of the counterweight. Additional counterweight is usually added to the underside of the bed and/or to the torsion resisting subbase. On some trucks, a heavy front bumper may also be required for stability around the rear.

The 85% tipping factor as outlined in OSHA and ANSI specifications means that when lifting the full capacity loads most likely to cause the truck (with outriggers and stabilizer set) to overturn, the unit is at 85% of tipping over. Increasing this full capacity load by 117.6% (overloading) will cause the unit to tip over.

In order to determine the amount of counterweight required, it is necessary to add up the weight that each permanently attached piece of equipment will place on the front and rear axles of the truck along with the initial truck chassis weight and then compare the total front and rear axle weights with the weights listed on the "Mounting Configuration" (Installation Section) pages to determine the amount and location of counterweight required.

Counterweighting Determination Example



$$\frac{\text{(Wt) x (Dist from Front Axle)}}{\text{Wheel Base}} = \text{Rear Axle Wt} \qquad \text{Wt - Rear Axle Wt} = \text{Front Axle Wt}$$

	Rear		Front	
Initial Front Axle Weight	Rear Axle Weight $\frac{(7500) \times 0}{232} = 0$ lb	$\frac{(3402) \times 0}{589} = 0$ kg	Front Axle Weight 7500 - 0 = 7500 lb	3402 - 0 = 3402 kg
Pump and PTO Weight	$\frac{(150) \times 60}{232} = 39$ lb	$\frac{(68) \times 152}{589} = 18$ kg	150 - 39 = 111 lb	68 - 18 = 50 kg
Initial Rear Axle Weight	$\frac{(8800) \times 232}{232} = 8800$ lb	$\frac{(3922) \times 589}{589} = 3922$ kg	8800 - 8800 = 0 lb	3922 - 3922 = 0 kg
Bed Weight	$\frac{(1200) \times 248}{232} = 1283$ lb	$\frac{(544) \times 630}{589} = 582$ kg	1200 - 1283 = -83 lb	544 - 582 = -38 kg
Add the front and rear axle weights	10122 lb	4592 kg	7528 lb	3414 kg
Compare with weight required for this type of mount from Mounting Configuration 1	10500 lb	4763 kg	8000 lb	3629 kg
Difference	**378 lb**	**171 kg**	**472 lb**	**215 kg**

Counterweighting Methods

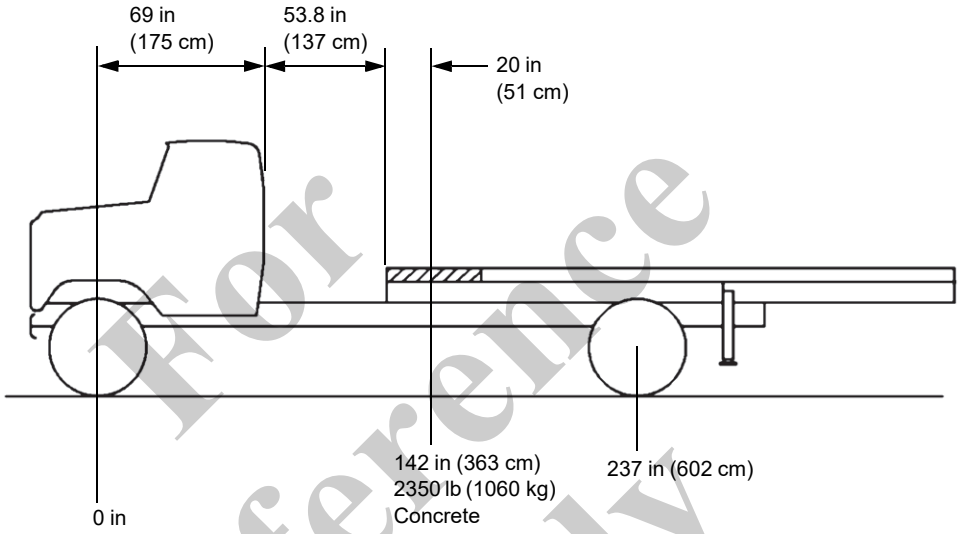
Two methods of counterweighting may be used:

a. a heavy front bumper and concrete in the bed or

b. concrete in the bed only.

The easiest and most economical method is usually concrete in bed only. The amount of counterweight required will be 1132 + 918 = 2050 pounds (513 + 417 = 930 kg). Use 2350 pounds (1066 kg) of concrete poured in the front of the bed. See “Counterweighting for 180° Stability” in this section

Determine axle weights added by the counterweight by using the same method as used before. Figure the center of the counterweight to determine where the weight acts. If the counterweight is oddly shaped, figure the center and weight of each regular shape. Weights ahead of the front axle require using a negative (-) distance in calculations.



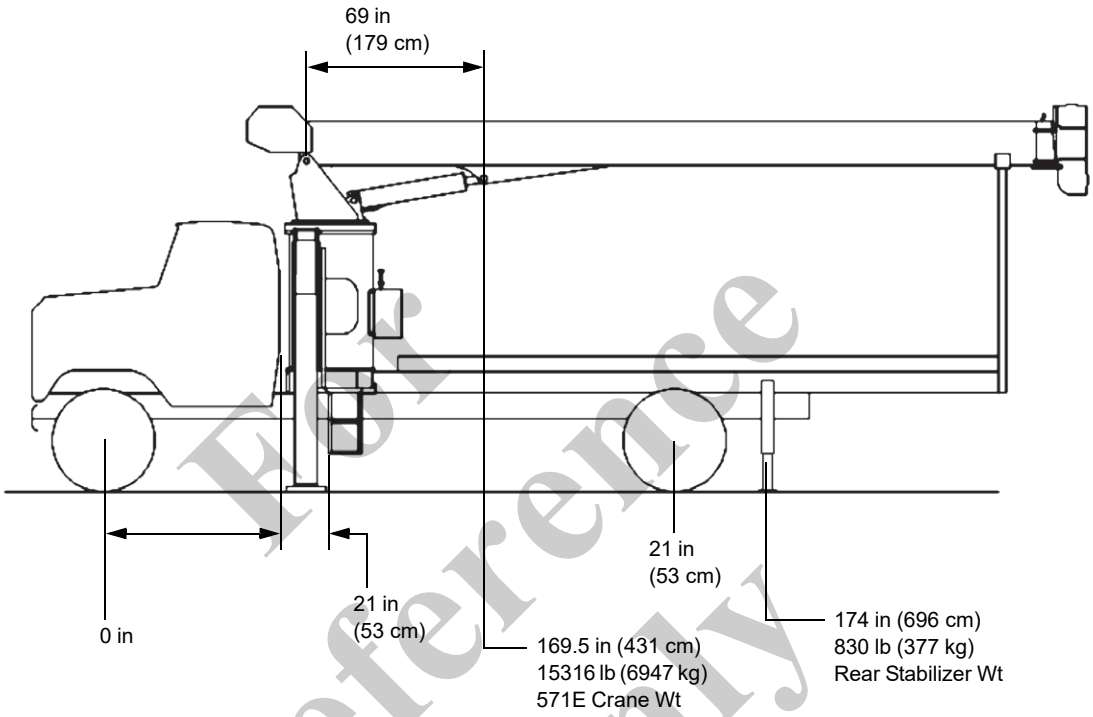
	Rear Axle Weight	Front Axle Weight
1150 lb (520 kg) Bed Concrete	$\frac{(2350) \times 142.8}{237}$ = 1416 lb	(2350) - 1416 = 934 lb
	$\frac{(1066) \times 363}{602}$ = 634 kg	(1066) - 643 = 423 lb
Required Counterweight	1132 lb 513 kg	918 lb 417 kg
Difference	**284 lb** **130 kg**	**16 lb** **6 kg**

The rear axle weight is 284 lbs (130 kg) heavier than required and the front axle weight is 16 lbs (6 kg) heavier than required.

Check the final weight of the unit with crane installed. See “Specifications Section” for weight of 571E and center of gravity. Note that this weight does not include weight of rear ASH stabilizers [830 pounds (377 kg)]. Use 4” set back (Cab to Torsion Box).

Check the final unit weight with a full load of diesel (7.3 lbs per gal) (0.87 kg per liter) and men (200 lbs per man) (90 kg per man) to ensure that the axle ratings have not been exceeded so that DOT certifications requirements can be met.

After the unit is completely assembled, the stability test must be run in accordance with the Stability Test Procedure at the end of this section to verify crane stability.



	Rear Axle Weight	Front Axle Weight
Base Unit	4968 lb 2254 kg	5982 lb 2713 kg
Counterweight	1416 lb 643 kg	934 lb 423 kg
Add Crane Weight	$\frac{(15136) \times 169.5}{237}$ = 10954 lb	(15136) - 10954 = 4326 lb
	$\frac{(6947) \times 431}{602}$ = 4974 kg	(6947) - 14974 = 1973 kg
Rear Stabilizer Weight	$\frac{(830) \times 274}{237}$ = 960 lb	(830) - 960 = -130 lb
	$\frac{(377) \times 696}{602}$ = 436 kg	(377 - 436 = -59 kg
Total	**18298 lb 8307 kg**	**11148 lb 5050 kg**

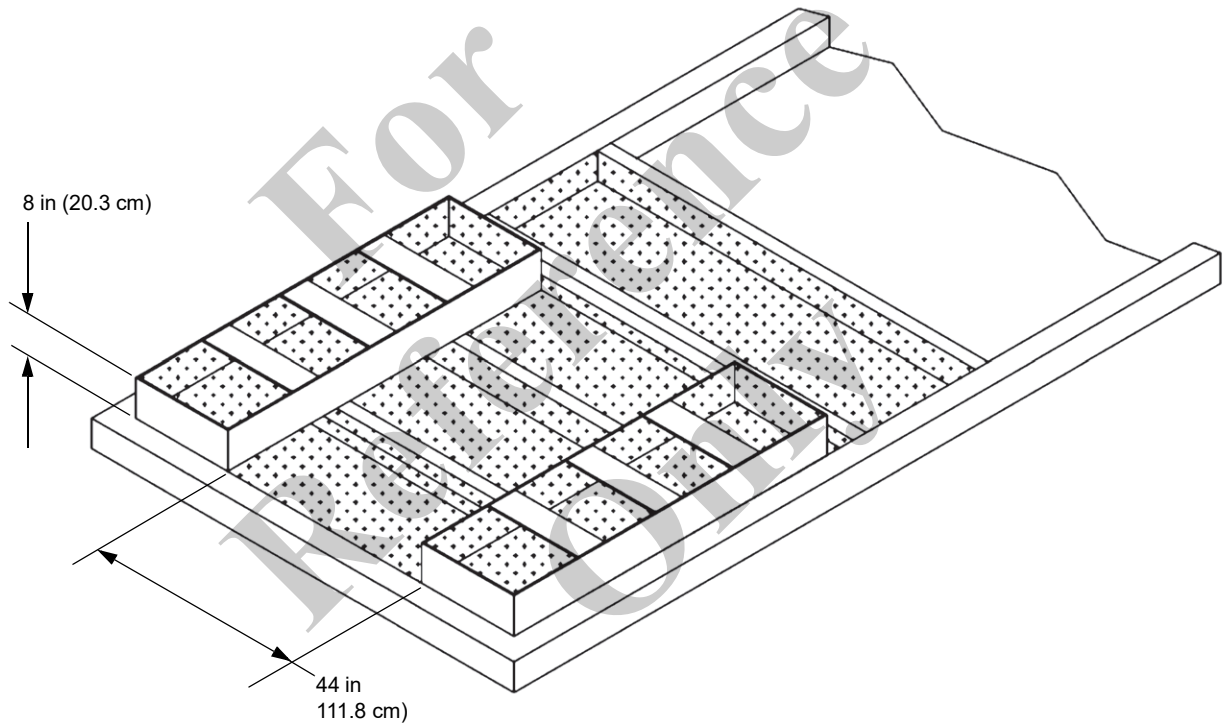
The method shown below can be used to shift more weight to the front of the crane than the previous methods. When using this method, check for interference with hydraulic reservoir and truck tires. Bed attachment to truck should be planned in advance. If the bed is attached to the torsion box by bolting through the slots in torsion box, leave an open area in concrete counterweight for hardware access. The weight of the concrete can be determined by multiplying the volume in cubic inches by 0.083 lb per cubic inch.

Example

Concrete poured in the bed measures:

- 4 inches (10.16 cm) deep
- 86 inches (218.44 cm) wide
- 70 inches (177.80 cm) long.

The weight of the concrete is 4 x 86 x 70 x0.083 = 2000 lb. (907 kg). The center of this weight is in the center of the concrete slab.



BOOM REST REQUIREMENTS

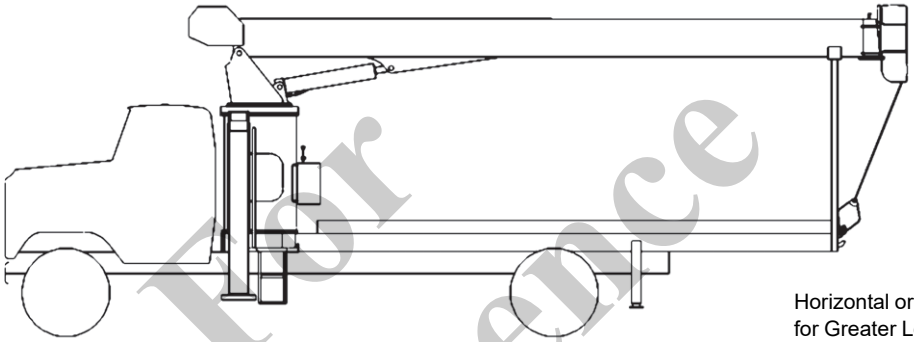
Before the mounting of a crane is complete, a boom rest must be installed. A rest must be supplied for transport to reduce vibratory stress on the crane and truck and protect rotation system from transient damage.

Below are shown typical configuration designed to meet boom support requirements. These Boom Rests are available at your National Crane distributor.

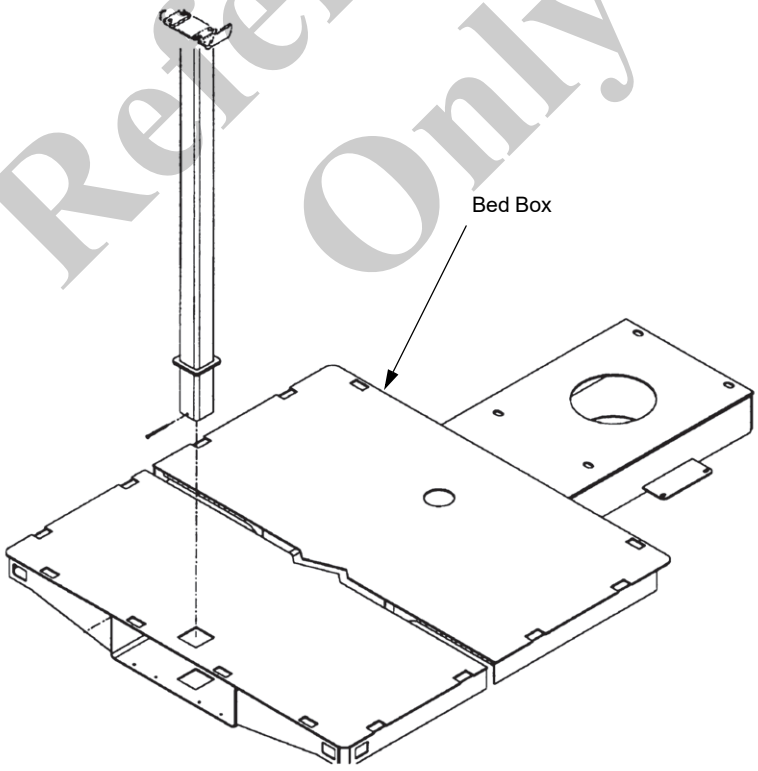
The loadline shall be hooked to some point on the bed, truck frame, etc. to secure the hook weight during transport. Install tie down point low enough to allow room for anti-two-block weight. Do not shorten chain.

The boom rest should be positioned to support the 1st section boom. Be careful to avoid contacting the boom at or near the end where the retract cables are located. Contact with these cables will result in costly repairs.

The boom rest saddle provided is designed to support the 1st section boom. It will be necessary to modify the saddle to make it narrower and reposition the support cushions under the boom side plates if the boom is extended to reach the boom rest.



Horizontal or Removable Mount for Greater Load Space.



CAN BUS SYSTEM SETUP

Before the engine is started from the crane for the first time, the CAN bus system must be set up. The following information must be entered to initialize the CAN bus system:

- Select the make of the truck engine.
- Calibrate the throttle pedals.

The throttle pedals also must be calibrated if a pedal is replaced.

Use one of the following methods to initialize the CAN bus system:

- CAN bus system software. See *CAN Bus System using Software*, page 9-35.
- Programming button method. *CAN Bus System using Programming Button*, page 9-36.

Required Equipment

NOTE: Only maintenance personnel who have attended the New Technology training course can purchase the software and cable. Contact Manitowoc Crane Care for more information.

Table 9-2 shows the equipment needed when setting up the CAN bus system using HED software.

Table 9-2 Required Equipment

Item	Example
Laptop PC	
CAN bus system software, such as HED Orchestra Suite	
Diagnostics T-Harness Cable	 9829

Table 9-2 Required Equipment (Continued)

Item	Example
CAN to USB Adapter Cable	 9830
Software Key	 9835

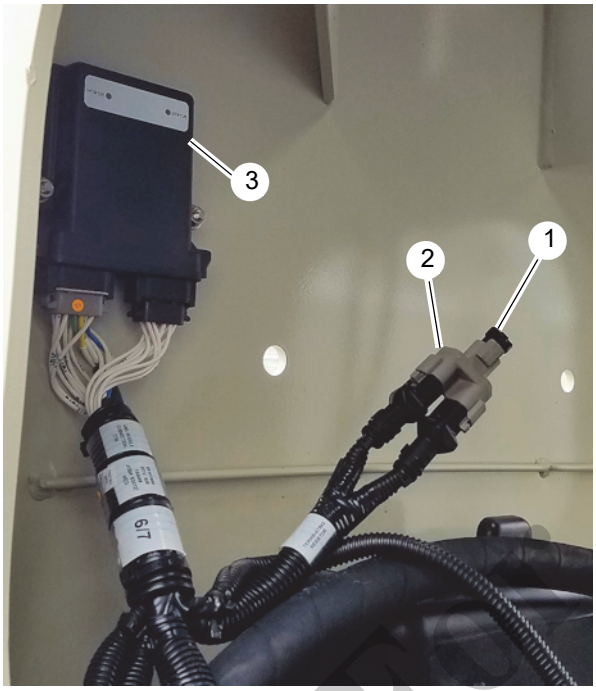
CAN Bus System using Software

NOTE: Refer to the A-Frame Crane Software Specification and Configuration specification for detailed instructions to calibrate or troubleshoot using the OMS software.

Use the following procedures to calibrate the CAN bus system using HED software.

Connecting Cables and Adapters

1. Locate the terminating resistor (1, Figure 9-3) and Deutsch splitter (2) near the OMS throttle module (3) on the driver's side of the crane frame.



9831

FIGURE 9-3

2. Remove the terminating resistor from the Deutsch splitter (Figure 9-4).
3. Install the terminating resistor in to the diagnostics cable.
4. Connect the diagnostic cable to the splitter.
5. Connect the serial port to the CAN to USB adapter cable.
6. Connect the USB adapter cable to the laptop.
7. Engage the PTO.
8. Turn the crane ignition switch to the RUN position. Do not start the engine.

Setting Up the CAN Bus System

1. Start the laptop and launch the CAN bus system software.
2. Use the HED software to set EEPROMs for engine type, throttle calibration, and OMS setup.
3. Use the software debug feature to verify that the setup is complete.
4. Disconnect and close the CAN bus system software application.
5. Disconnect the diagnostic cable from the laptop and crane. Install the terminating resistor in the splitter.
6. Disengage the PTO.

CAN Bus System using Programming Button

The programming button is located on the driver's side console behind the sliding door above the override key switch.

CAUTION

Only trained personnel should use the programming button to initialize the CAN bus system. Incorrect setup of the CAN bus system can cause the throttle pedals to be inoperable.

Refer to the *A-Frame Crane Software Specification and Configuration* specification for detailed instructions about using the push button method of initializing the CAN bus system.

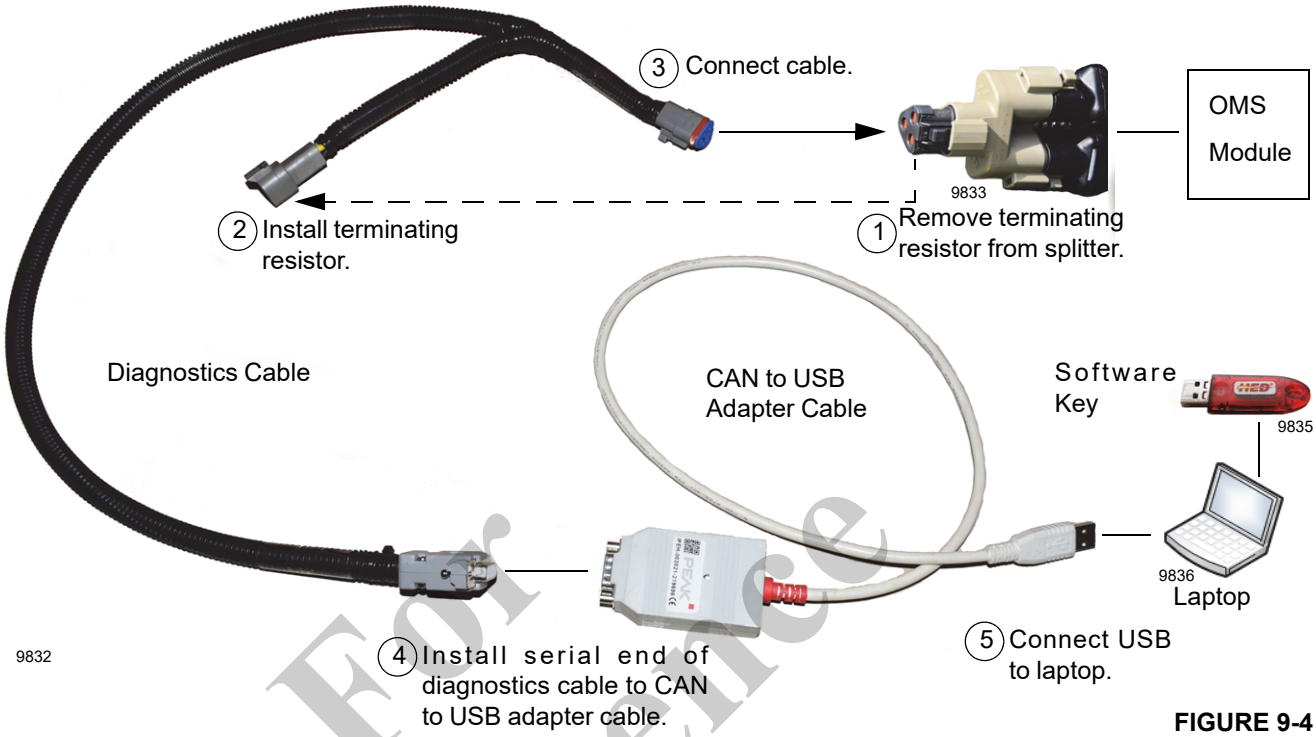


FIGURE 9-4

INITIAL CRANE RUN IN PROCEDURE

1. Engage the PTO and run the truck engine at idle to activate the pump (approximately 600 rpm). Turn the crane power switch on and operate the crane and outriggers though all of their functions at least six (6) times to purge cylinders of air. Operate the control valves slowly with the truck engine at idle and cycle each cylinder through its complete stroke each time. Check to see that movement of outriggers and boom correspond with direction indicated on switches and levers. Refer to hydraulic or electrical schematic and parts pages to correct any problems.

NOTE: Add oil to reservoir as required to keep air from reentering the system.

2. Set throttle according to engine RPM and PTO ratio to get 2400 RPM pump shaft speed.
3. When all cylinders have operated through complete cycles, stow crane and place the outriggers in the up position. The oil level should be visible near the top of the sight gage. Lift and stability test must now be performed on the unit. Hoist and crane tests should be conducted to insure proper performance.
4. After testing is completed, all cable clamp bolts should be re-torqued to specifications. Inspect the T-box and frame mounting bolts for proper tension.
5. Upon completion, overall height of crane vehicle combination must be measured and posted inside of cab informing driver of overall height.

STABILITY CHECK

The chassis weight, before the crane is mounted, is intended for use only as a guideline in determining the total weight required for the unit to be stable with an 85% tipping factor (i.e. when lifting capacity load, the unit is at 85% of tipping or less).

In order to ensure the stability of the unit with an 85% tipping factor, a live load stability test must be performed on each completed unit. Proceed as follows:

1. Test the unit for stability on a firm level surface.
2. A Series 500E2 Service Manual crane requires rear stabilizers for stability. With the boom stowed, set the unit up level on the outriggers and stabilizers.
3. When stability testing this unit, select the load from the capacity chart that is listed at the longest boom extension and approximately 30° of boom elevation.

Model	Boom Length	Loaded Angle	Loaded Radius
560E2	60' (18.28 m)	34.5°	50' (15.24 m)
571E2	71' (21.64 m)	32°	60' (18.29 m)

The stability test load will be 1.18 times the load chosen from the load rating area of the capacity chart.

Example for 571E2

- Boom Length: 71' (21.64 m)
- Loaded Radius: 60' (18.29 m)
- Load Rating: 2200 lb (998 kg)
- Stability Test Load: 1.18 x 2200 lb (998 kg) = 2596 lb (1178 kg) (Includes weights of slings and downhaul blocks.)

Be sure the stability test weight is accurate. A 1% increase in stability test weight will mean up to a 10% increase in counterweight. Extend the boom to the maximum boom length and hoist the stability load off the ground. Slowly boom the load down so the load will swing out, until the loaded radius is reached. As the boom is lowered keep hoisting the load up to keep it about 6 inches off the ground.

NOTE: Do not exceed loaded radius.

Slowly rotate the boom throughout the work area. As the boom is rotated, the boom will have to be raised and/or lowered to maintain the loaded radius because of subbase flexure.

On units not equipped with single front outriggers, tipping from stabilizer support to front wheel support will occur as the load or boom is swung around the front. Do not attempt to lift rated loads around the front of the truck unless the unit is equipped with a SFO.

NOTE: Weights of accessories installed on the boom or loadline (including downhaul weight) must be deducted from the calculated load when checking stability.

4. If slight tipping occurs, but load can be kept from coming in contact with ground by hoisting the load up, unit is stable. If not, counterweighting will have to be added to get unit in a stable condition or decal must be added to define areas of full stability and areas of reduced capacity because of stability. If the unit is equipped with a jib, the stability test should be repeated. Use the fully extended jib capacity multiplied times 1.18 at the lowest angle that the jib is rated fully extended.
5. When adding counterweight to the vehicle, it is usually most effective when added as close to the crane as possible. After adding counterweight, the above procedure must be repeated to insure the added counterweight is adequate.

SPECIFICATIONS

Hydraulic Pump

Pump Speed ..... 2500 RPM

Displacements:

Section P1 ..... 18 GPM (68.1 LPM) at 3900 psi +100/-000 (26.89 MPa)

Section P2 ..... 34 GPM (128.7 LPM) at 3300 psi +100/-000 (22.75 MPa)

Section P3 ..... 10 GPM (37.8 LPM) at 2350 psi +100/-000 (16.20 MPa)

Hydraulic System

Requirements:

Boom and Outrigger System ..... 18 GPM (68 LPM), 3900 psi +100/-000 (26.89 MPa)

Boom Extend ..... 18 GPM (68 LPM), 2800 psi +50/50 (19.31 MPa)

Boom Retract ..... 18 GPM (68 LPM), 2900 psi +100/-000 (20.00 MPa)

Hoist System ..... 34 GPM (129 LPM), 3300 psi +100/-000 (22.75 MPa)

Turn ..... 10 GPM (38 LPM), 2350 psi +100/-000 (16.20 MPa)

Reservoir

Capacity ..... 66 Gallons (250 L)

Filtration ..... 10 Micron Return

Flow rates listed are at free flow condition (approx. 100 psi/ 1 MPa)

HCA

Load charts are based on 2650 psi (18.27 MPa) Constant Pressure (2800 psi (19.31 MPa) Trip Pressure on HCA)

Hoist System Wire Rope ..... Standard 325 ft (99 m) of 9/16 “(14.3 mm) diameter,

Rotation Resistant Nominal Breaking Strength ..... 38,500 lb (17,463 kg) 325 ft (99 m) of 9/16 “(14.3 mm) diameter

Hoist Speed and Pull

Layer	Hoist Pull		Hoist Speed		BOS Hoist Speed		Rope Capacity	
	lbs	(kg)	fpm	(mpm)	fpm	(mpm)	ft	(m)
1	10,200	(4627)	111	(34)	157	(48)	64	19
2	9,200	(4173)	123	(38)	173	(53)	136	41
3	8,400	(3810)	135	(42)	191	(59)	215	65
4	7,700	(3493)	147	(45)	207	(64)	301	91
5	7,100	(3221)	159	(49)	220	(68)	394	120

NOTE: All ratings based on 34 GPM at 3300 psi (128.7 LPM at 22.75 MPa)- Burst of Speed maximum pull = 3000 lb (1361 kg)

Crane Operating Speeds

Rotation, 375° ..... 35 sec ± 5 sec

Boom up -10° to 80° ..... 25 sec ± 5 sec

Boom Down 80° to -10° ..... 20 sec ± 5 sec

Boom Extend/Retract Three Section 27 - 71 ft

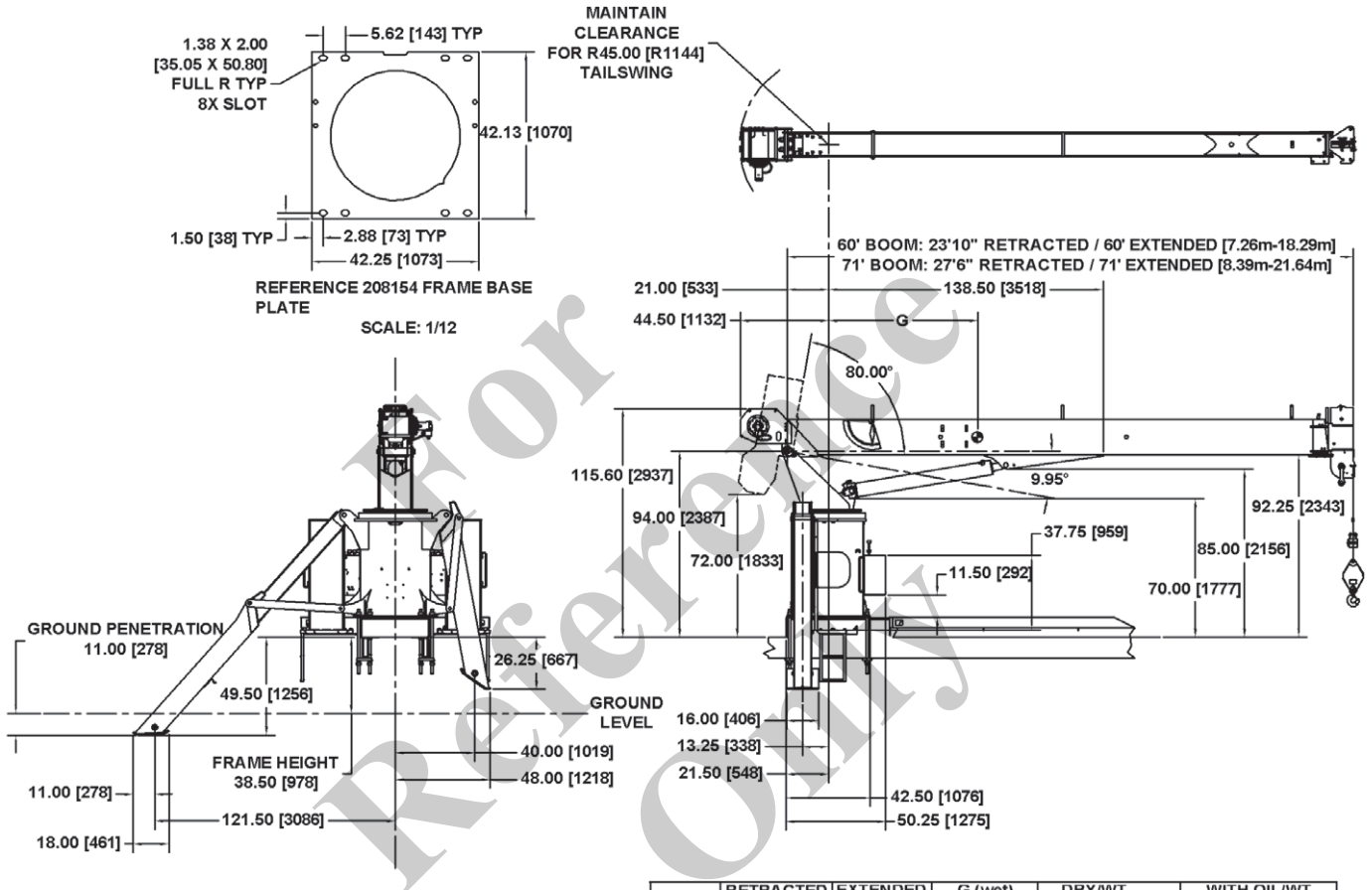
Extend ..... 55 sec ± 5 sec

Retract ..... 50 sec ± 5 sec

Boom Extend/Retract Three Section 24 - 60 ft

Extend ..... 45 sec ± 5 sec

Retract ..... 40 sec ± 5 sec



SERIES	RETRACTED LENGTH	EXTENDED LENGTH	G (wet) Inches (m)	DRY/WT lb (kg)	WITH OIL/WT lb (kg)
560E2	23'10"	60'	63 (1.60)	13,528 (6,136)*	14,123 (6,406)*
571E2	27'6"	71'	75 (1.91)	14,721 (6,677)**	15,316 (6,947)**
571E2	27'6"	71'	78 (1.98)	15,851 (7,190)***	16,446 (7,460)***

*INCLUDES STANDARD 18' SUBBASE
**INCLUDES STANDARD 20' SUBBASE
***INCLUDES 20' INTEGRAL BED/T-BOX

NOTES:
1. DIMENSIONS ARE IN INCHES [mm] UNLESS OTHERWISE SPECIFIED.

SECTION 10
SCHEMATICS

For your convenience, the latest version of schematics available at the time of printing are placed in this section.

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Alphabetical Index

After Frame Modification 9-22
Anti-two Block Internal Wire Repair 3-2
Anti-two Block System Description 3-1
ASH to Torsion Box Mounting 9-25
Bearing Clearance 6-9
Bearing Replacement 6-11
Boom Installation 9-27
Boom Removal 4-4
Boom Rest Requirements 9-34
Cable Tensioning 4-10
CAN Bus System Setup 9-35
Carwell© Rust Inhibitor 7-10
Concrete poured in the bed measures: 9-33
Control Valve Relief Adjustment 2-7
Counterweighting 9-29
Crane Mounting Procedure 9-22
Crane to Truck Installation 9-1
Electrical 1-5
Environmental Protection 7-1
Extend Cylinder Repair 4-14
Fasteners and Torque Values 1-7
Fatigue Of Welded Structures 1-6
General Adjustment And Repair Procedures 2-1
General Maintenance 1-2
General 1-1
HCA Troubleshooting Flow Chart 8-6
Hoist Installation 5-1
Hoist Removal 4-3
Hoist Removal 5-1
Hydraulic Capacity Alert System 3-4
Hydraulic Oil Reservoir Level 7-9
Hydraulic System Description 2-1
Hydraulic System Troubleshooting Chart 8-1
Initial Crane Run In Procedure 9-37
Inner Wear Pad Calibration 4-8
Jib Installation and Adjustment 4-15
Jib Jack Service and Maintenance 4-17
Jib Jack Troubleshooting 8-5
Jib Load Limiting Device 3-5
Jib Load Limiting Device Troubleshooting 8-4
Lift Cylinder Repair 4-13
Loctite 1-7
Lubrication Chart 7-5
Lubrication General 7-1
Lubrication 7-3
Maintenance 6-6
Minimum Truck Requirements 9-2
Mounting Configurations 9-2
Outrigger Monitoring System (OMS) (Optional—Standard in North America) 3-6
Pin Bearing Inspection And Installation Procedure 9-29
Positioning Crane On Truck 9-18
PTO Horsepower Requirements 9-7
PTO Installation 9-18
Radio Remote Controls 3-11
Reinforcing/after Frame Extension 9-19

Remote Control 3-9
Requirements For Optional Single Front Outrigger 9-14
Rotation Stop-mechanical 6-5
Section Modulus Tables 9-9
Servicing The Control Valves 2-5
Specifications 9-39
Stability Check 9-37
Swing Gearbox And Brake 6-1
Three Section Boom Assembly 4-6
Three Section Boom ATB Wire Repair 3-2
Three Section Boom Maintenance 4-2
Three Section Boom Operation 4-2
Torquing Swing Bearing Bolts 6-6
Truck Frame Section Modulus Tables 9-15
Truck Frame Strength 9-8
Truck Preparation 9-18
Weld Studs 1-20
Wire Rope Lubrication 7-9
Wire Rope 1-21