

# National Crane NBT60L

## Service Manual



9695



## **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](http://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](http://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.

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The original language of this publication is English.

# SERVICE MANUAL

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

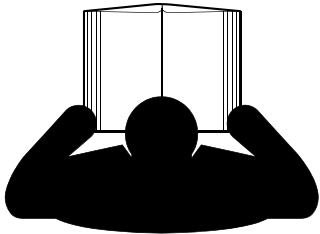

## NBT60L Cranes

This manual is divided into the following sections:

SECTION 1	INTRODUCTION
SECTION 2	HYDRAULIC SYSTEM
SECTION 3	ELECTRIC SYSTEM
SECTION 4	BOOM MAINTENANCE
SECTION 5	HOIST AND COUNTERWEIGHT
SECTION 6	SWING
SECTION 7	OUTRIGGERS
SECTION 8	LUBRICATION
SECTION 9	CRANE INSTALLATION
SECTION 10	SCHEMATICS

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.

	<h2> DANGER</h2> <p><b>An untrained operator subjects himself and others to death or serious injury. Do not operate this crane unless:</b></p> <ul style="list-style-type: none"><li>• You are trained in the safe operation of this crane. National Crane is not responsible for qualifying personnel.</li><li>• 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.</li><li>• You are sure that all safety signs, guards, and other safety features are in place and in proper condition.</li><li>• The Operator Manual and Load Chart are in the holder provided on crane.</li></ul>
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**For  
Reference  
Only**

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## SECTION 1 INTRODUCTION

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### SERVICE MANUAL DESCRIPTION

This manual has been compiled to assist you in properly operating and maintaining your Model NBT60L National Crane (Figure 1-1).

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

Information this manual does not replace federal, state or local regulations, safety codes or insurance requirements. For detailed information concerning the operation and maintenance of the Rated Capacity Limiter (RCL) system installed on the equipment, see the manufacturer's manual supplied with the equipment. Manufacturers of rated capacity limiters may refer to them in their manuals as a load moment indicator (LMI), a hydraulic capacity alert system (HCAS); National Crane refers to these systems as a Rated Capacity Limiter (RCL) throughout its Operator and Service Manuals.

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

National Crane reserves the right to make specification and equipment changes without notice because of product improvements.

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 for options, such as remote controls, augers, varying control configurations, baskets, grapples, is included in separate manuals.

Whenever a question arises regarding your National Crane or this publication, please consult your National Crane distributor for the latest information. Your National Crane distributor is equipped with the proper tools, necessary

National Crane parts, and trained service personnel to maintain and service your crane.

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](https://www.manitowoccranes.com/en/Parts_Services/ServiceAndSupport/ChangeOfOwnershipForm) and complete the form.

### Basic Nomenclature

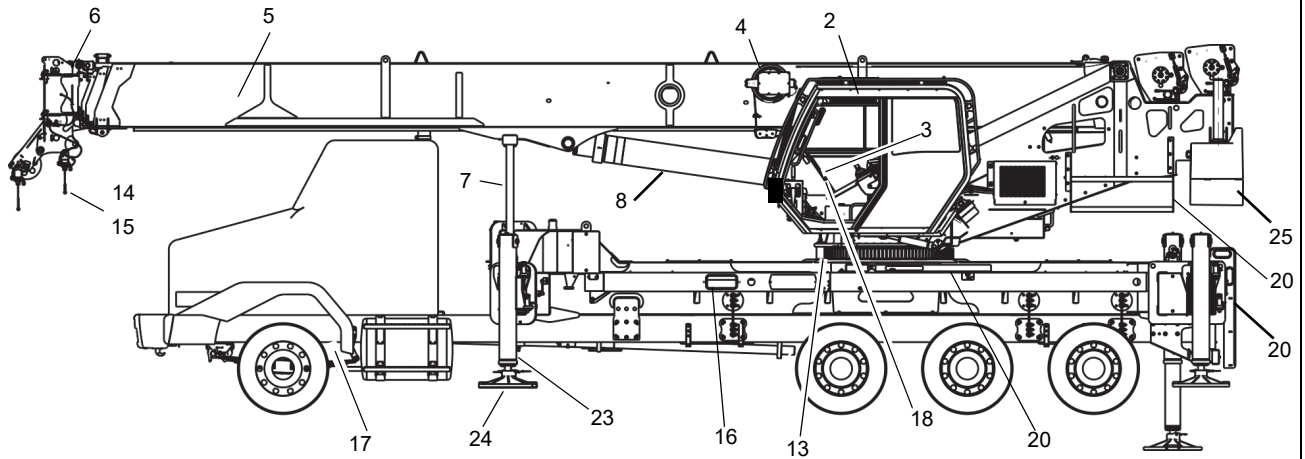
The nomenclature used to describe parts of a National Crane are described in Figure 1-2. This nomenclature is used throughout this manual.



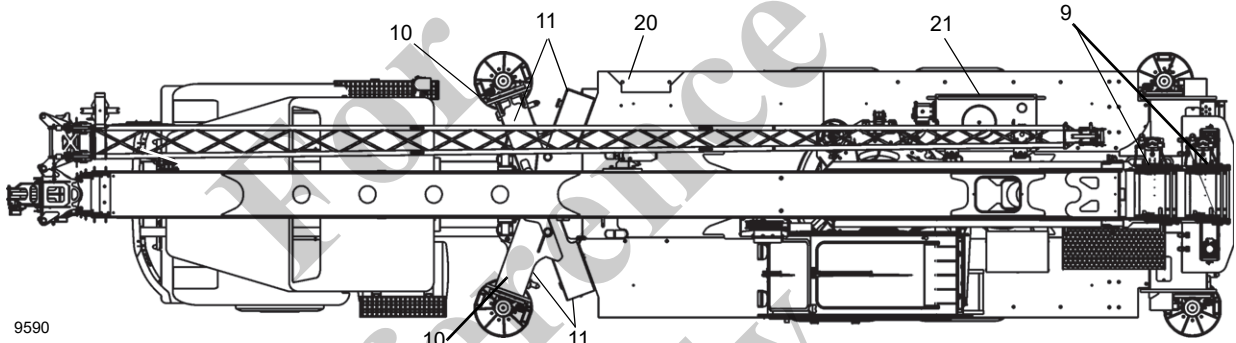
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NBT60L Shown. Your crane may differ.

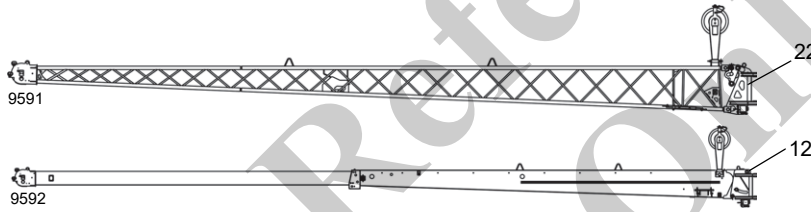
**FIGURE 1-1**



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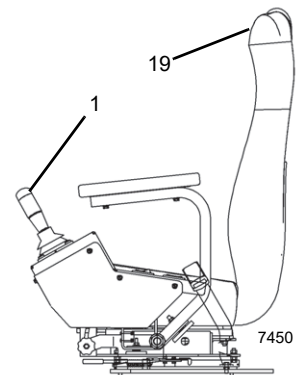


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FIGURE 1-2

Item	Component
1	Cab Crane Controls
2	Cab
3	RCL, Display Screen
4	Rated Capacity Limiter (RCL) Reel
5	Boom
6	Sheave Case
7	Boom Rest
8	Lift Cylinder
9	Main (front) and Auxiliary Hoist (rear)
10	Outrigger Beam
11	Outrigger Box
12	Telescoping Jib
13	Turret
14	Hook Block (Not Shown)
15	Hoist Cable, Wire Rope (Not Shown)

Item	Component
16	Ground Outrigger Control
17	Hydraulic Pump
18	Cab Outrigger Control
19	Cab Seat
20	Access Steps
21	Hydraulic Tank
22	Lattice Jib
23	Outrigger Jack
24	Outrigger Float
25	Counterweight(s)

## 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 hoist 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.

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### 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.

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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 of 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 B 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-rings, 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.

**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 18° C [64° F])
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)



## 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 plate is welded to the crane turret).
- Counterweight support structures (where 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 the entire crane is recommended.

## 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.

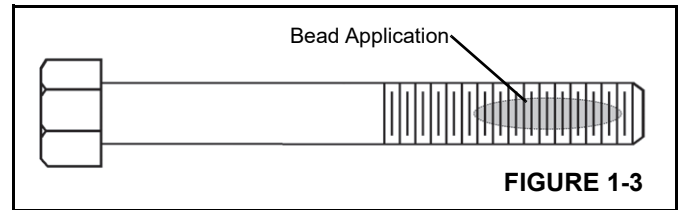
### **Application of Medium Strength Loctite®**

**NOTE:** The fastener can be re-used and the adhesive can 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).

Clean dirt and oil from the threaded surfaces, both male and female.

## Adhesive/Sealant Application



1. Apply a bead several threads wide in the approximate area of threaded contact (Figure 1-3).
2. In a blind hole application, apply several drops of adhesive in the bottom of the hole so that the adhesive is forced up when the bolt is installed.
3. After installation, fixturing occurs within thirty (30) minutes.
4. The 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 torquing can seriously affect performance and reliability.

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

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

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

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

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

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

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

**Torque Wrenches**

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

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

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

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

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

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

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

**Torque Values**

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

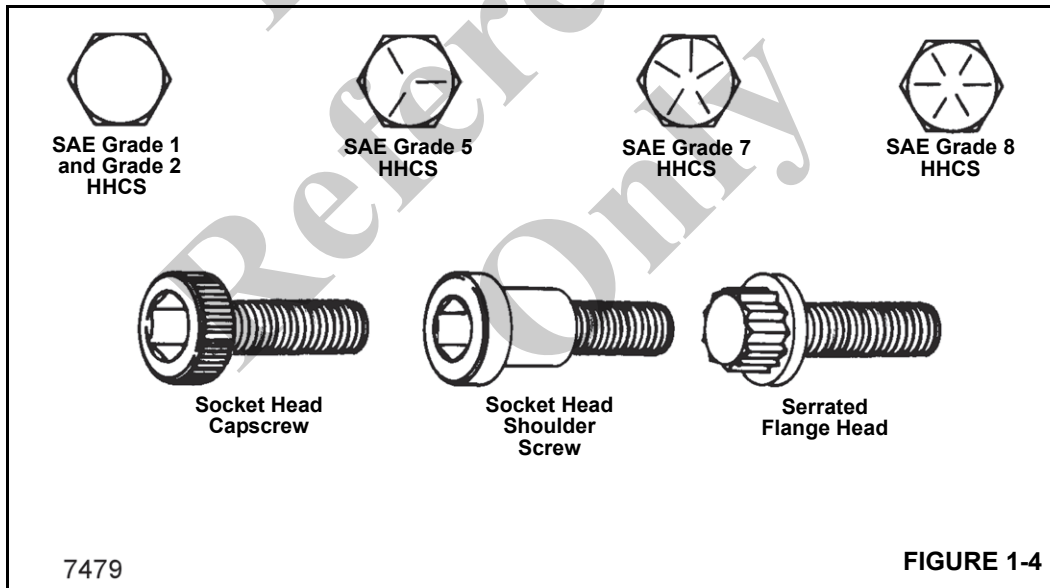


Table 1-1Inch Series with Coarse Threads (UNC) – Zinc Flake Coated

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**Table 1-7 Inch Series 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



Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
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 1-8 Inch Series with Fine Threads (UNF) – Untreated (black finish)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-28	5	10	9.5	9
	8	14.5	14	13.5
5/16-24	5	21	20	19
	8	26	25	24
3/8-24	5	36	35	34
	8	53	51	49
7/16-20	5	57	55	53
	8	85	82	79
1/2-20	5	88	84.5	81
	8	125	120	115
9/16-18	5	126	121	116
	8	177	170	163
5/8-18	5	182	174.5	167
	8	250	240	230
3/4-16	5	312	299.5	287
	8	425	409	393

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
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 1-9 Metric Series with Coarse Threads – Untreated (black finish)

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M4x0.7	8.8	3.1	2.9	2.8
	10.9	4.5	4.3	4.1
	12.9	5.4	5.2	4.9
M5x0.8	8.8	6.5	6.2	5.9
	10.9	9.2	8.9	8.5
	12.9	11	10.5	10
M6x1	8.8	11	10.5	10
	10.9	16	15	14
	12.9	19	18	17
M8x1.25	8.8	27	26	25
	10.9	38	36.5	35
	12.9	45	43.5	42
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
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
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 1-10 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

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

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
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 1-11  
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

**HYDRAULIC FITTING**

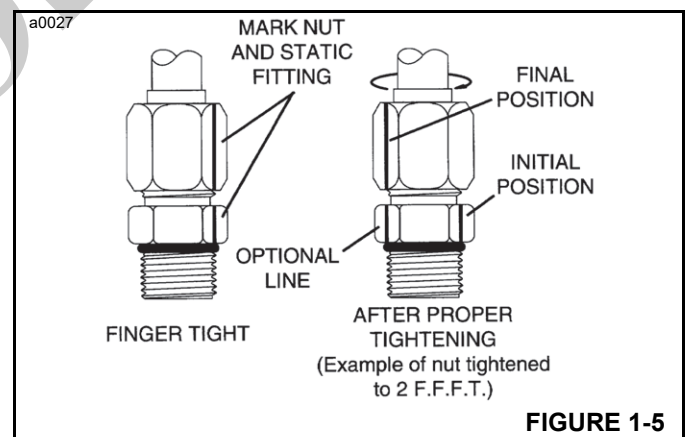
**F.F.F.T. METHOD (Flats from Finger Tight)**

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

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

Follow these steps when tightening all fitting connections:

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



5. Tighten the joint by the number of flats (F.F.F.T.) as specified in Table 1-12 and 1-13 for size and type of fitting.
6. Optional for future tightening of the same connection.) Extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-5).

**37° Flared Steel Fitting - Tube or Hose to Fitting**

1. Follow F.F.F.T. method, see F.F.F.T. METHOD (Flats from Finger Tight).

Table 1-12

T-2-5

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

**Adjustable Straight**

Table 1-13 Adjustable Straight Thread O-ring

T-2-6

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

**Thread O-ring Fitting — Fitting to Port (Table 1-13)**

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

**Nonadjustable Straight Thread O-ring Fitting — Fitting to Port (Table 1-14)**

1. Make sure both threads and sealing surfaces are free of burrs, nicks, scratches or any foreign particles.
2. Lubricate O-ring with clean oil (Figure 1-7).
3. Turn fitting until finger tight.
4. Using the assembly torque method, tighten to given torque for size from Table 1-14.

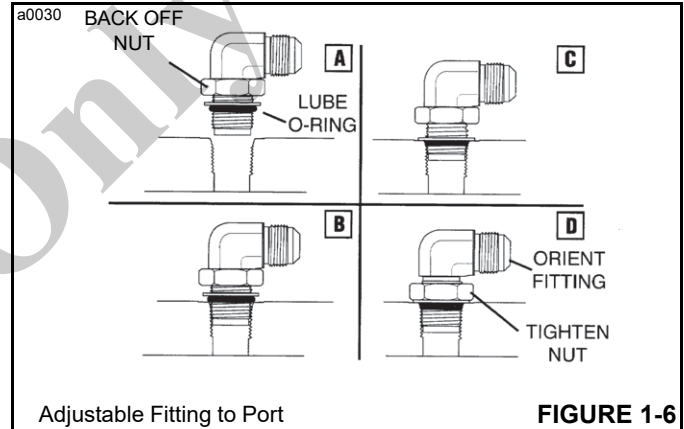
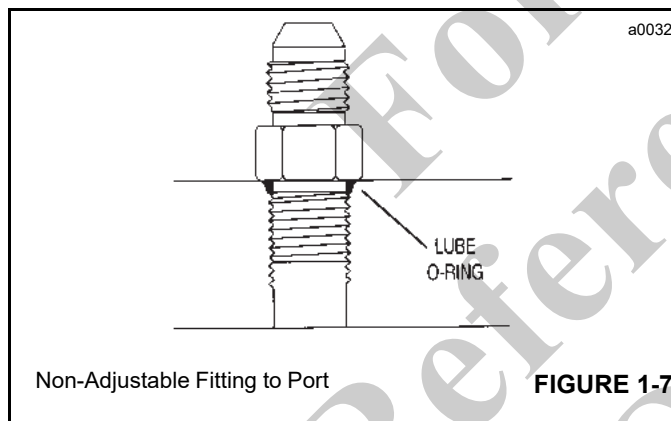


Table 1-14

T-2-7

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



**⚠ WARNING**  
**Worn or Damaged Equipment Hazard!**  
 Never use a worn or damaged hoist rope. Death or serious injury could result from using worn or damaged hoist rope.

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

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

**Keeping Records**

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

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

**HOIST CABLE INSPECTION AND MAINTENANCE**

**Hoist Rope**

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

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

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

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

**WIRE ROPE**

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 Crane products as load lines, hoisting cables, boom extension and retraction cables, pendant cables, and hook block tie down cables.

## 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 objective 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 1-8). 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.

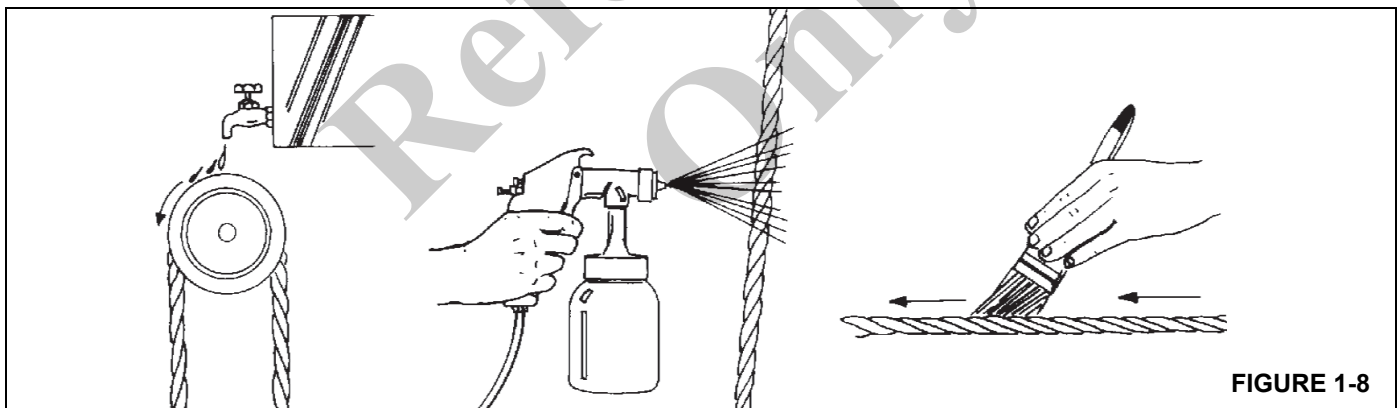


FIGURE 1-8

## Recommendations for Servicing Wire Rope

- Lock out equipment power when removing or installing wire rope assemblies.
- Use safety glasses for eye protection.
- Wear protective clothing, gloves, and safety shoes.
- Use supports and clamps to prevent uncontrolled movement of wire rope, parts, and equipment.

- When replacing fixed length cable assemblies (e.g. pendants) having permanently attached end fittings, use only pre-assembled lengths of wire rope as supplied from Manitowoc Crane Care. Do not build lengths from individual components.
- Replace an entire wire rope assembly. Do not attempt to rework damaged wire rope or wire rope ends.
- Never electroplate wire rope assemblies.
- Do not weld wire rope assemblies or components unless recommended by the wire rope manufacturer.



- Do not allow welding spatter to come in contact with the wire rope or wire rope ends.
- Do not allow the wire rope to become an electrical path during other welding operations.
- Wire ropes are manufactured from special steels. If the wire rope is heated, discard the entire length of rope.
- Wire rope sets must be replaced as a set.
- Do not paint or coat wire ropes with any substance except approved lubricants.
- sections at or near terminal ends where corroded or broken wires may protrude.
- sections in contact with stationary surfaces where abrasion or chafing may take place as a result of equipment vibration.
- boom nose sheaves, hook block sheaves, boom jib sheaves, auxiliary boom nose sheaves, and hoist drums for wear. Damaged sheaves or hoist drums can accelerate wear and cause rapid deterioration of the wire rope.

## Wire Rope Inspection

Inspect wire rope in accordance with the following information excerpted from a National Consensus Standard as referenced by Federal Government Agencies. Recommended inspection intervals depend on the machine, environmental conditions, frequency of lifts, and exposure to shock loads. The inspection intervals may also be predetermined by state and local regulatory agencies.

**NOTE:** Wire rope is available from Manitowoc Crane Care.

Record any deterioration of the wire rope in the equipment inspection log. Determination of wire rope replacement must be made by a qualified person.

### Daily Inspection

A daily visual inspection is recommended for all ropes in service. Use the daily inspection to monitor progressive degradation and to identify damages that require wire rope replacement such as:

- Distortion, kinking, crushing, un-stranding, bird caging, reduction of diameter, etc.
- General corrosion.
- Broken or cut strands.

### Yearly Inspection

Inspect the total length of wire rope annually or more often if necessitated by adverse conditions. Only inspect the outer surface of the wire rope. Do not attempt to open the strands of the rope. Items to include in the yearly inspection are items listed in the daily inspection plus the following:

- 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.
- areas subjected to rapid deterioration such as:
  - sections in contact with saddles, equalizer sheaves, or other sheaves where wire rope travel is limited.

## 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. This inspection shall cover all visible areas of the extension and retraction cables of an assembled boom.

**NOTE:** Note that extending and retracting the boom may be required to access visual inspection holes.

This inspection shall cover the entire length of the extension and retraction cables of a disassembled boom prior to reassembly. Use this inspection to monitor degradation and identify damage that requires wire rope replacement or equipment repair. Inspect the rope using the following guidelines for:

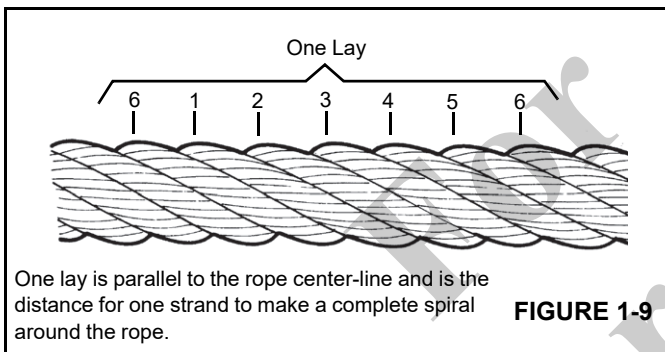
- reduction of rope diameter below nominal diameter.
- severely corroded or broken wires at end connections.
- severely corroded, cracked, bent, worn, or improperly applied end connections.
- deterioration in areas such as:
  - sections in contact with saddles, equalizer sheaves, or other sheaves where 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 1-9).



- 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.
- Reductions from nominal diameter of more than 5%:
  - 0.4 mm (0.0156 in) for rope diameters to 8 mm (0.313 in)
  - 0.8 mm (0.031) for rope diameters 9.5 mm (0.375 in) to 0.50 in (12.7 mm)
  - 1.2 mm (0.047 in) for rope diameters 14.3 mm (0.561 in) to 19.1 mm (0.75 in)
  - 1.6 mm (0.063) for rope diameters 22.2 mm (0.875 in) to 28.6 mm (1.125 in).
- 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.

- 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.
- 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.

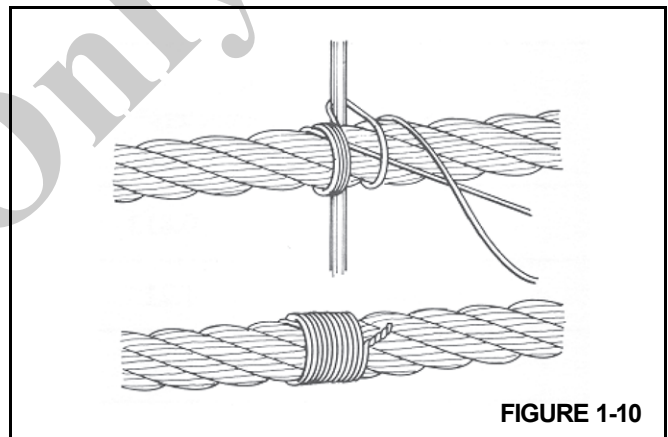
**Seizing Wire Rope**

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**

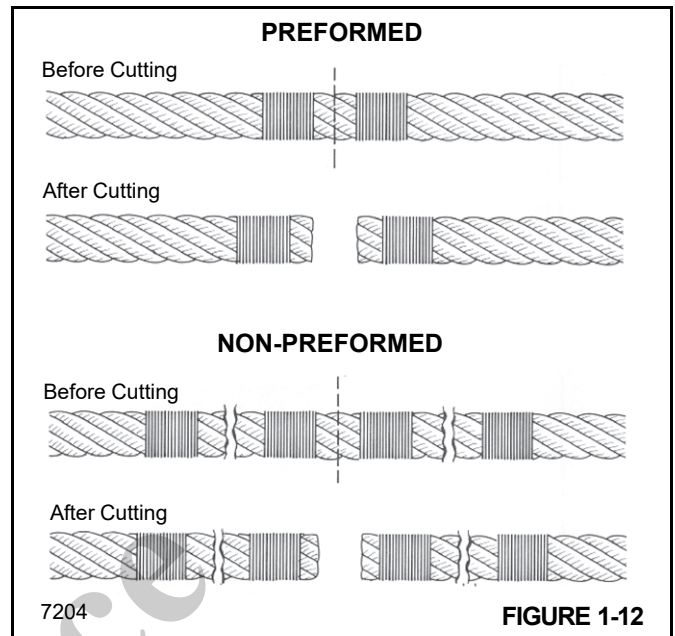
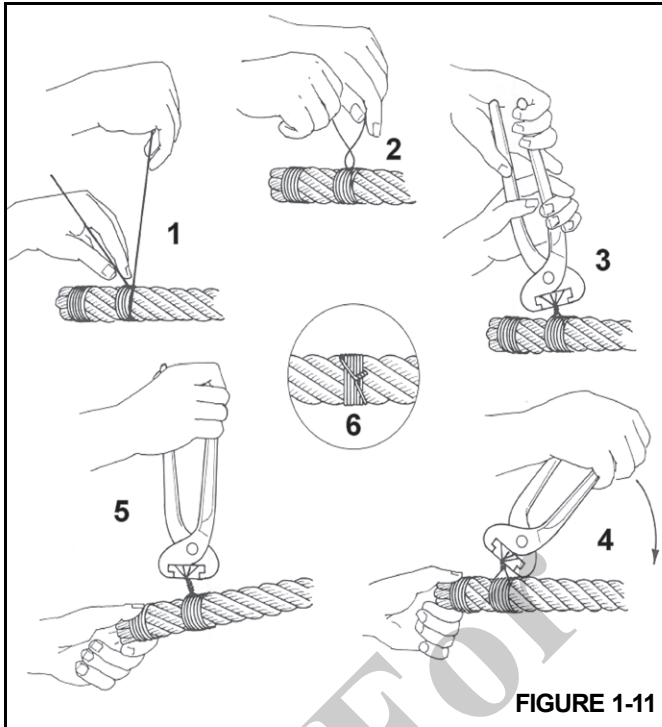
Using a length of soft annealed wire, place one end in the groove between two strands of the wire rope. Turn the long end of the annealed wire at right angles to the wire and wrap it tightly over the portion in the groove.

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 1-10).



**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 1-11).



**NOTE:** Non-preformed wire rope should have two seizings located on each side of the cut (Figure 1-12).

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**SECTION 2  
HYDRAULIC SYSTEM**



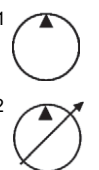
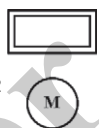
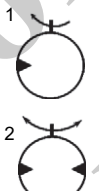






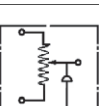
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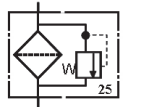







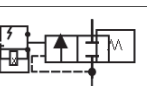
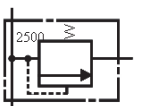
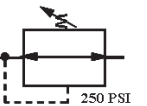
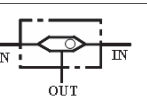
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This section describes the hydraulic system, the components which make up the hydraulic system, and the components dependent upon the hydraulic system for their operation. This includes descriptions of the supply pressure and return circuit, pumps, valves, and cylinders. Detailed

descriptions and operation of individual hydraulic circuits are discussed within their individual sections as applicable. *HYDRAULIC SYMBOLS*, page 2-2 contains all hydraulic symbols used in the hydraulic schematics contained in this manual.

HYDRAULIC SYMBOLS

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

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

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

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

## HYDRAULIC SYSTEM MAINTENANCE

Before adjustments and repairs begin on a crane, the following precautions must be taken as applicable:

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

After adjustments and repairs have been made, do not return the crane to service until all guards have been reinstalled, trapped air has been removed from the hydraulic system if required, safety devices have been reactivated, and maintenance equipment and all warning tags have been 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 result in serious damage to the system components. Dirty hydraulic systems are a major cause of component failures.

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

Disassemble and reassemble hydraulic components on a clean surface.

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

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

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

the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

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

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

### Label Parts when Disassembling

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

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

### Welding Precautions

Sensitive truck computer systems and crane's electrical system may be damaged by welding on the truck or crane. The following precautions should be taken:

- Disconnect the truck battery cables.
- Attach the welding ground lead as close as possible to the area to be welded.

## PARTS REPLACEMENT

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

## SERVICE

### Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to Section 8 — Lubrication.

### 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 shut down the engine.



4. Remove the reservoir drain plug and drain the reservoir. Clean and install the drain plug and fill the reservoir with clean hydraulic oil.

---

### CAUTION

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

**NOTE:** Connect a drain hose in place of a disconnected return line so that the hydraulic oil can be drained in a container for proper disposal.

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 line from the hoist motor and fully hoist up.
16. Raise the boom as necessary. Connect the return line to the hoist motor and fully hoist down and back up again. Replenish the reservoir hydraulic oil level as necessary.
17. Disconnect one of the lines from the swing motor and drive the motor in the direction it will go.
18. 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

Hydraulic oils must be of the same specifications or discoloration (miliness) may occur.

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, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

### Removing Air from Hydraulic System

Air entering the hydraulic oil is normally removed by baffles in the hydraulic reservoir. If a component has been replaced, the reservoir oil level is too low, or a leak develops in the suction line to the pump, air can enter the system. Air can cause noisy operation of the swing and hoist hydraulic motors. Check the level of the hydraulic reservoir first if noisy operation occurs. 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 - 0.276 bar (2 - 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 by the internal baffles.

---

### DANGER

Extending the boom at low angles greatly increases the risk of tipping. Locate the crane on a firm surface and position the boom over the front on outriggers.

- 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 still trapped, lower the boom to below horizontal, extend the telescope cylinders as far as

practical, and allow the boom to remain in this position overnight. This should allow trapped 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.

**⚠ DANGER**

Pressurized hydraulic fluid can cause serious injury. Be careful when removing plugs or restrictions from pressurized hydraulic systems suspected to have entrapped air.

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

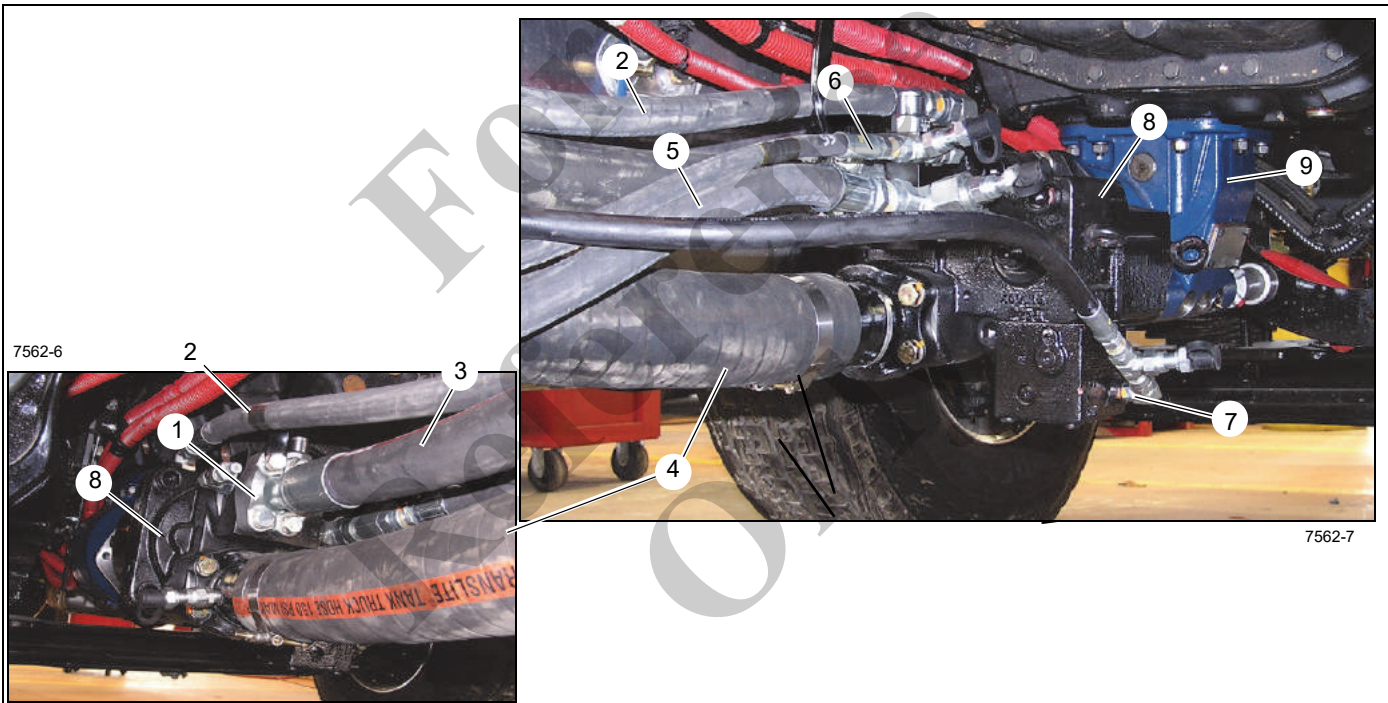
**⚠ DANGER**

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

- If the above procedures fail to eliminate trapped air, contact your authorized National Crane Distributor.

**SYSTEM DESCRIPTION**

**Hydraulic Pump**



Item	Description	To
1	Pump Manifold	
2	Hose, 3/4" ID	Swivel Port 1, Case Drain
3	Hose 1-1/4" ID	Swivel Port 4, DC Valve
4	Hose, 3" ID	Swivel, Hydraulic Tank
5	Hose Assembly 3/4" ID	Front Outrigger, Port P

Item	Description	To
6	Hose, 3/8" ID	Front Outrigger, Port T
7	Hose, 3/8" ID	Front Outrigger, Port LS
8	Piston Pump	Mounted to Truck PTO
9	Power Take Off (PTO)	On truck Engine

FIGURE 2-1

The hydraulic system pressure is supplied from an axial piston pump mounted on the truck power take off (PTO) Figure 2-1.

The axial piston hydraulic pump (1, Figure 2-18) converts input torque into hydraulic power. Rotational force is transmitted through an input shaft to a cylinder block. The spinning cylinder block contains nine reciprocating pistons. Each piston has a brass slipper connected at one end by a ball joint. The reciprocating movement of the pistons occurs as the slippers slide against an inclined swashplate during rotation. One half of the cylinder block is connected to pump inlet and the other half to pump outlet. As each piston cycles in and out of its bore, fluid is drawn from the inlet and displaced to the outlet to supply power into the system circuit. A small amount of fluid is allowed to “leak” from the cylinder block/valve plate and slipper/swashplate interfaces for lubrication and cooling. Case drain ports are provided to return this fluid to the reservoir.

The volume of fluid displaced into the system circuit is controlled by the angle of the swashplate. The swashplate is forced into an inclined position (into stroke) by the bias piston and spring. The servo piston opposes the action of the bias piston and spring forcing the swashplate out of stroke when hydraulic pressure in the control circuit rises above the spring force.

## Directional Control Valve (DCV)

The DCV controls the hoist, swing, lift cylinder, telescope cylinder and options when installed. The valve is located on the outside, off-cab side of the turntable.

### Inspection

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

### Valve Leakage

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

A component functioning at reduced efficiency may indicate that the valve section in the DCV for that component is leaking internally. If preliminary check-out reveals that adequate volume is being supplied to the affected valve

bank, relief valves are properly adjusted, and the component is not at fault, check the valve for scored or worn parts. Scoring is usually a sign of contamination (external contamination by dust or internal contamination by debris from deteriorating components or oxidized hydraulic oil). Scored or severely worn valve components must be replaced.

Check valves in the DCV are designed to permit a flow of hydraulic oil in one direction only. If a piece of dirt or rust has worked its way into the check valve and lodges between the poppet and seat, it will keep the valve open and allow a return flow of hydraulic oil. Clean the valve and check that the hydraulic system filter is still serviceable.

### Binding Spools

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

Warping occurs when mounting plates are not level or they become distorted from machine damage. The valve can be shimmed level to correct this problem.

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

### Visual Inspection of Hoses and Fittings

#### CAUTION

Ensure that the hydraulic hose is depressurized before loosening the connections.

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

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

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

If any of these conditions exist, address them appropriately.

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

**Table 2-1 Operational Climate Zones**

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

**Supply Pressure and Return Circuit**

The supply pressure and return circuit is made up of several circuits which route hydraulic oil from the hydraulic pump to the directional control valves for the individual operating circuits. The supply pressure and return circuit consists of the reservoir and integral filter, the hydraulic pump, and a hydraulic oil cooler. Refer to *Hydraulic Pump*, page 2-25 for a description and maintenance instructions for the hydraulic pump. The supply pressure and return circuit routes hydraulic oil from the hydraulic pump to the directional control valve for the individual operating circuits. The supply and return circuit consists of the reservoir and spin-on filter, hydraulic pump, and hydraulic oil cooler.

**Outrigger Manifolds**

The outrigger functions are controlled by two manifolds located near the front and rear outrigger boxes. The front manifold contains the extend/retract valve for front and rear outriggers, front outrigger component valves, and the optional front jack valve. The rear outrigger manifold contains the outrigger component valves for the rear outriggers. The valves are operated by solenoids that are controlled by keypads on each side of the crane and in the cab.

**Hydraulic Reservoir and Filter**

The reservoir (Figure 2-2) is attached on the outside, off-cab side of the turret. The all-steel reservoir has a breather-filter, a suction filter and also a return line filter. Internal baffles help cool the hydraulic oil and prevent foaming.

Hydraulic oil flows through the suction line of the reservoir to the hydraulic swivel. Return lines or case drain lines for the oil cooler, pump, and hoist (Figure 2-2) go directly into the reservoir instead of through the filter.

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

A filter (19, Figure 2-3) is located on the top, inside the hydraulic reservoir to help protect the pump from contamination and a suction strainer with integral suction shut off is connected to the main suction line in the front of reservoir.

The breather/filler cap (4, Figure 2-2) on the top of the reservoir is for filling the reservoir. The filler cap includes a strainer for catching contaminants and gaskets to prevent leaking. The breather cap, (vent) which is part of the filler cap, allows air to enter or leave the reservoir. The breather must be kept clean to prevent damage to the reservoir.

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

The large access cover (5, Figure 2-2) on the top of the reservoir provides access for cleaning. The cover is secured to the top of the reservoir with a single bolt and has a gasket to prevent leaking. The access hole can also be used to fill the reservoir after it has been completely drained at the magnetic drain plug on the bottom of the reservoir (11, Figure 2-2).

**NOTE:** When removing the access cover, do not loosen the nut completely from the bolt. Loosen only enough to remove the cover assembly from the tank. Loosening the nut completely will allow the cover and spider assembly to fall into the tank.

### **Pump Distribution**

The pump input port receives fluid directly from the hydraulic reservoir. The output of the pump directs flow to the load sensing Directional Control Valve (DCV) and to the outrigger manifolds. The DCV directs fluid to the hydraulic components in the system. The speed of the hydraulic components in the system depends on the volume of fluid being provided by the pump.

### **Hydraulic Filter Replacement**

The filter must be serviced with National Crane replacement elements at recommended intervals to assure the warranty remains in effect.

The hydraulic oil suction filter (Figure 2-2) is located on the front of the reservoir and contains a replaceable filter element.

The filter can be changed without emptying the reservoir by closing the shutoff valve. The shutoff valve is controlled by the hand wheel on the filter cover. There is an anti-start safety switch to avoid accidental start up when valve is closed.

### **Element Removal**



Ensure that hydraulic system is shut down and the pressure is relieved or personnel injury could result.

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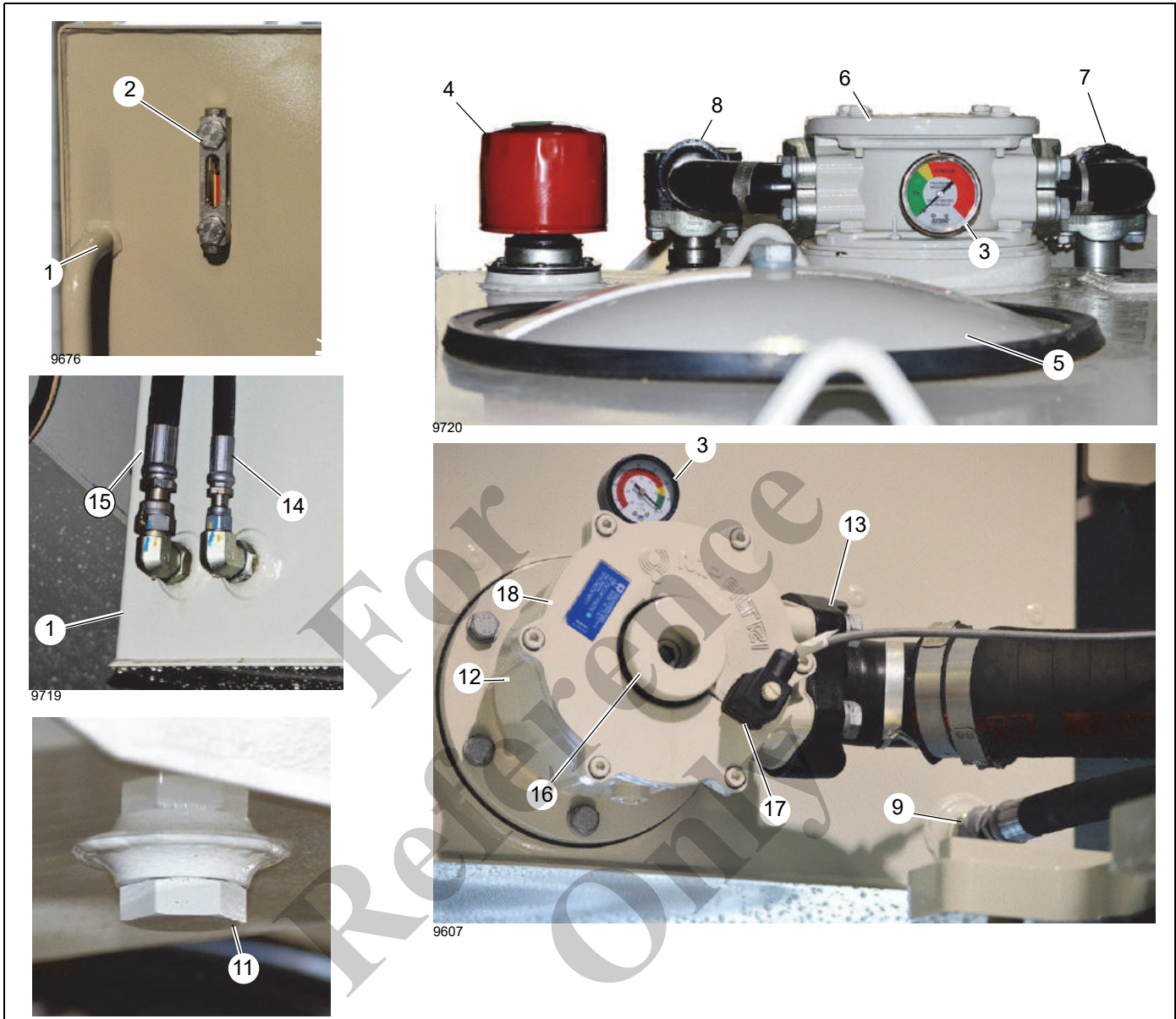
1. Shut down the flow of oil from the hydraulic tank to the suction filter body by turning the hand wheel on the oil filter counterclockwise until shutoff valve is closed. Closing the valve will activate the anti-start safety switch preventing start-up and prompting a warning to be displayed on cab.
- 

### **CAUTION**

Do not overtighten the hand wheel. Damage to the shutoff valve may occur. Stop turning the handwheel when slight resistance is felt.

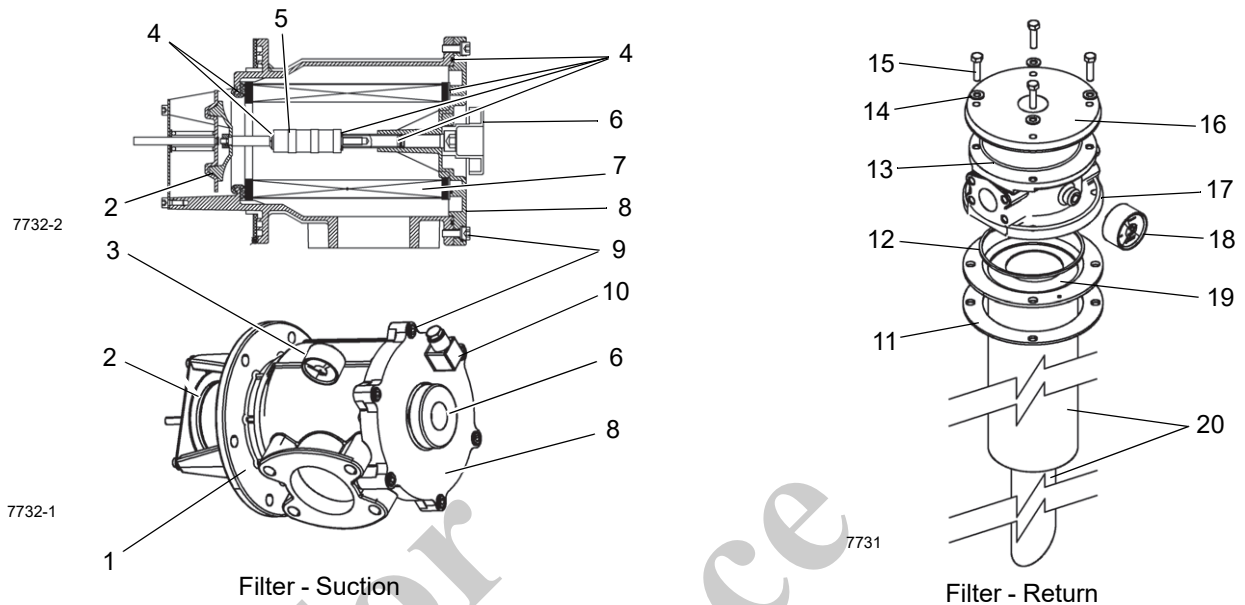
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2. Wipe any dirt from the filter head.
3. Place a container under the filter to catch spilled oil.
4. Remove (6) screws and remove the filter cover and seal.
5. Remove the used filter.
6. Install new filter element and new seal.
7. Re-install filter cover and screws.
8. Open filter shutoff valve to provide oil flow to hydraulic system by turning hand wheel clockwise.
9. Properly discard the used filter and oil. Closing the valve will activate the anti-start safety switch preventing start-up and prompting a warning to be displayed on cab console monitor.



Item	Component	Item	Component
1	Hydraulic Reservoir	10	Thermometer-Temperature
2	Hydraulic Oil Level Gauge-Sight	11	Magnetic Tank Drain-
3	Pressure Gauge (Vacuum)	12	Oil Suction Filter
4	Breather-Filler Cap	13	Pump Suction Hose (to Swivel)
5	Access Cover	14	Manifold Drain Hose (to DVC)
6	Filter-Return	15	Pump Case Drain Hose (to Swivel)
7	Cooler Return Hose - Oil Cooler	16	Shut-off Hand Wheel
8	Return Hose - Bypass from Valve	17	Safety Switch - Anti Start
9	Hoist Case Drain	18	Filter Cover

FIGURE 2-2



Item	Component	Item	Component
1	Body - Filter	11	Gasket
2	Valve - Shutoff	12	O-ring
3	Gauge	13	O-ring
4	Seal	14	Washer
5	Magnet	15	Capscrew
6	Hand wheel - Shutoff Assembly	16	Cover
7	Filter Element	17	Head - Filter
8	Cover	18	Gauge
9	Screw	19	Filter Element
10	Safety Switch - Anti Start	20	Body-Filter

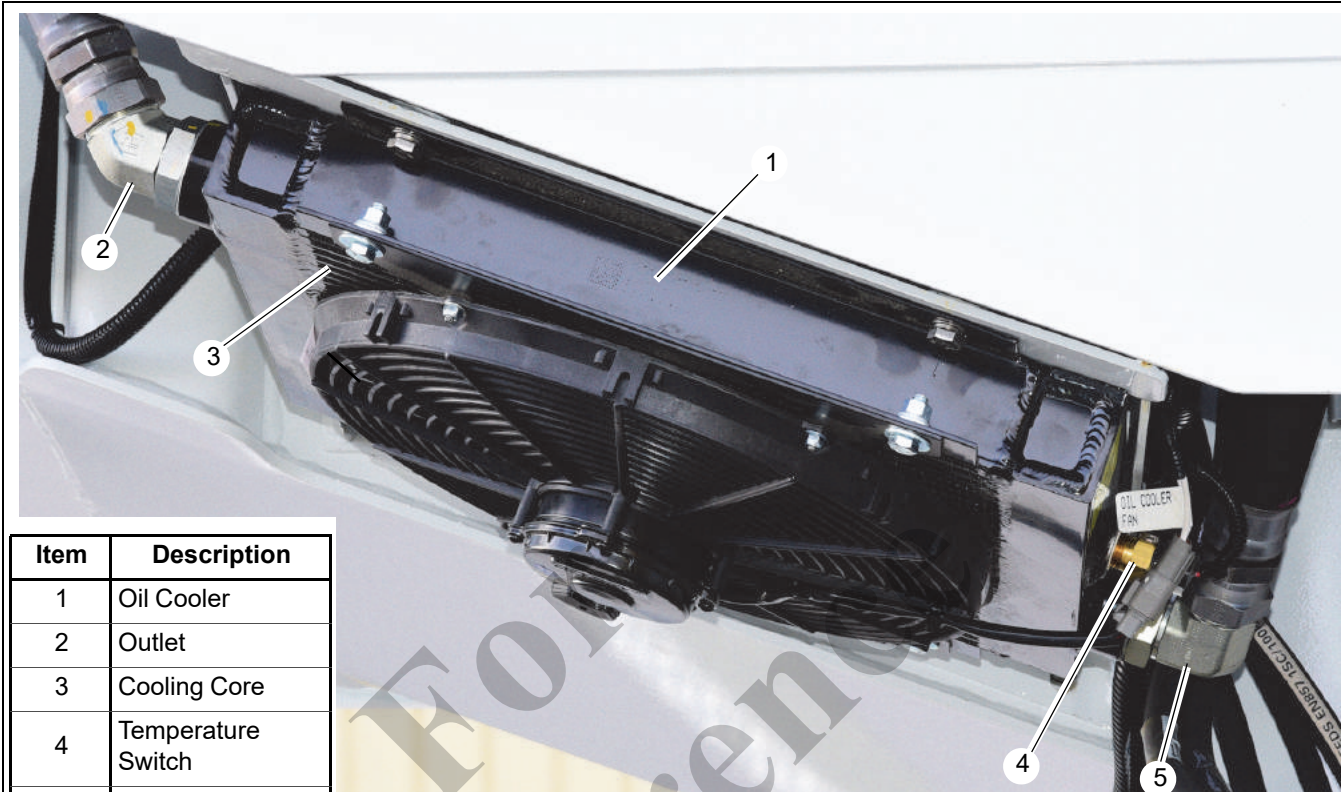
FIGURE 2-3

**Hydraulic Oil Cooler**

The hydraulic oil cooler is installed below the directional control valve (DCV) on the turret frame (Figure 2-4). The oil cooler return circuit is in parallel with the reservoir return circuit and a 206 kPa (30 psi) integral check valve regulates flow through the oil cooler. When the hydraulic oil is cold, most of the return oil goes directly to the tank. As the oil

warms up and becomes thinner, more oil goes through the cooler.

A temperature switch located in the cooling core and a resistive temperature device (RTD) located internally to the directional control valve provide inputs to the control system modules, which then energize the fan relay when the oil temperature reaches 48.8° C (120° F).



Item	Description
1	Oil Cooler
2	Outlet
3	Cooling Core
4	Temperature Switch
5	Inlet

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FIGURE 2-4

**Oil Cooler Service and Maintenance**

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 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.

**HYDRAULIC VALVES**

This subsection provides descriptive information for all the hydraulic control valves used on this crane. For a listing of all valves, the circuit they are used in, and their physical location, refer to Table 2-2. The description of each valve given here is for the valve itself. For information for how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

**Table 2-2 Directional Control Valve**

Valve Name	Circuit Used In	Physical Location
Directional Control Valve (DCV)	Boom Lift, Telescope, Hoist(s) and Swing	Mounted outside on off-cab side of turret
Electric Control Valves	Boom Lift, Telescope, Hoist(s) and Swing	Mounted to DCV outside on off-cab side of turret
Holding Valves	Boom Lift, and Telescope	Port block on cylinder, hoist, outrigger
Hoist Motor Counter Balance Valve	Hoist	On hoist motor
Front Outrigger Selector and Control Manifold	Outrigger	Inside T-box frame (front)



Table 2-2 Directional Control Valve (Continued)

Valve Name	Circuit Used In	Physical Location
Rear Outrigger Control Manifold	Outrigger	Inside T-box frame (rear)
Pilot Operated Check valve	Outriggers	Port block of each jack cylinder (4)
Swing Speed Flow Valves	Swing	On swing motor
High Speed Hoist Control Solenoid	Hoist	On hoist motor
Single Front Outrigger relief valve (optional)	Outrigger	On single front outrigger (SFO)
Counterweight Removal and Tilt Cab Valve	Counterweight cylinders and Tilt Cab	Mounted inside the turret at rear under hoists

The Directional Control Valve (DCV) (1, Figure 2-5) is located on the passenger side of the superstructure frame.

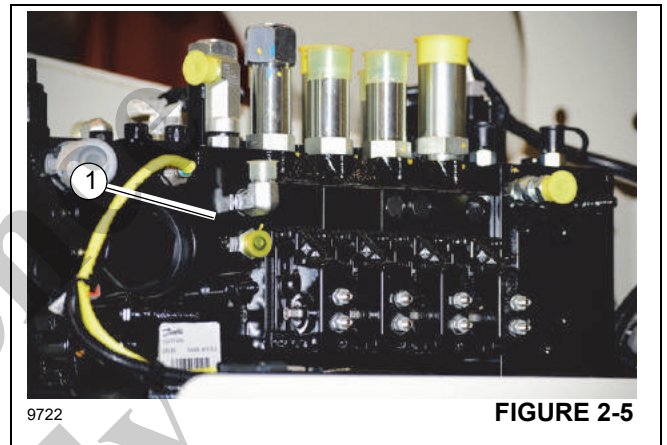
The ports and valves used on the directional control valve are identified in Figure 2-6.

Cab controls and radio remotes control the crane functions through solenoid controlled proportional valves that are integral to the DCV and control pilot pressure to the main function valves on the DCV.

When the crane function power switch is turned on the pilot pressure enable solenoid on the DCV (Figure 2-6) is energized.

Energizing the proportional solenoid valves opens pilot pressure to the valve sections. With the solenoid valves on each valve section shifted, pilot pressure is allowed to build for crane operation.

If an overload condition is sensed, the RCL system disables the control of boom down, telescope out, and hoist up (main and auxiliary) on both the cab and radio remote controls.

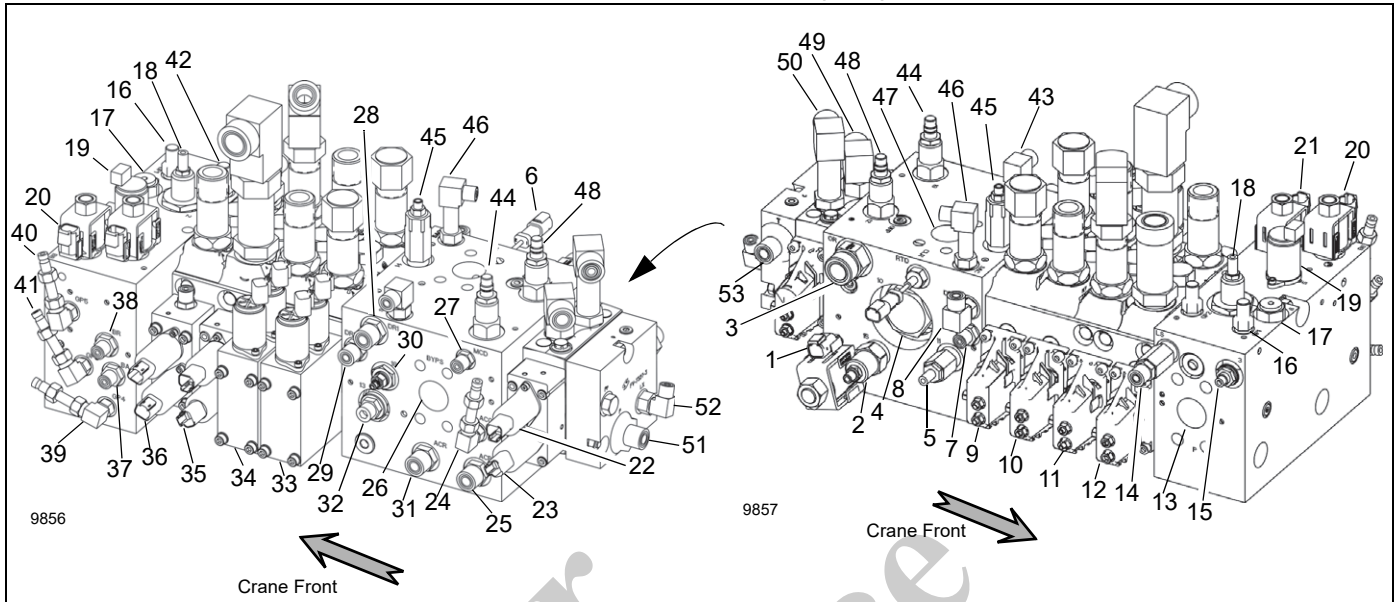


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FIGURE 2-5

Reference Only

Directional Control Valve (DCV)



Item	Description
1	A/C Enable Solenoid Valve
2	FDCB-LAN
3	Lower Return Check Valve
4	Oil Cooler Check Valve
5	Swing - Anti-Cav Supercharge Valve
6	Resistive Temperature Device (RTD)
7	Lift Cylinder HV Drain
8	Gearbox Coolant Drain
9	Auxiliary Hoist B-port section (with manual)
10	Main Hoist B-port section (with manual override)
11	Telescope B-port section (with manual override)
12	Boom B-port section (with manual override)
13	Port P
14	Load Sense Shuttle Valve (LS)
15	Pilot Pressure/Brake Release
16	GP1 Port Pump Inlet
17	Pilot Supply Filter
18	Main Relief Valve
19	Brake Apply Valve
20	Pilot Supply Valve
21	Brake Release Valve
22	Swing Solenoid A
23	Swing Solenoid B
24	ACG Port - A/C Gauge
25	ACP Port - A/C Pressure
26	BYPS Port - Cooler Bypass
27	MCD Port - Motor Case Drain
28	DR1 Port - Reservoir Drain

Item	Description
29	DR2 Port - A/C Case Drain
30	Gearbox Coolant Flow
31	ACR Port - A/C Return
32	Gearbox Coolant Supply
33	Auxiliary Hoist Solenoid B
34	Main Hoist Solenoid B
35	Telescope Solenoid B
36	Boom Solenoid B
37	BA Port - Apply Brake
38	BR Port - Brake Release
39	Swing A work port (No gauge port)
40	GP5 Port - Pilot Supply
41	GP3 Port - Brake Supply
42	GP2 Port - (Load Sense)
43	SGC Port - Swing Gearbox Coolant Supply
44	A/C Relief Valve
45	Load Sense Relief
46	SAC Port - Swing Anti-Cavitation
47	CLR Port - Cooler Supply
48	GP1 Swing Back Pressure Check Valve
49	Swing A Workport
50	Swing B Workport
51	Counterweight Removal Pressure Port
52	LX Port Counterweight Removal, (Load Sense)
53	T Port Tank (Not used)

FIGURE 2-6

**REMOVAL**

1. Tag and disconnect the hydraulic and electrical lines from the valve.
2. Plug the lines and cap ports.
3. Loosen and remove the valve mounting bolts and remove the control valve.

**Installation**

1. Bolt the directional control valve to the enclosure.
2. Reinstall the hydraulic and electrical lines as per removal tags.

**Functional Check**

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

**COUNTERWEIGHT REMOVAL CYLINDER AND TILT CAB VALVE**

Figure 2-8 shows the counterweight removal and tilt cab valve. Located in the superstructure under the hoists, this valve regulates the operation of the counterweight removal and tilt cab cylinders.

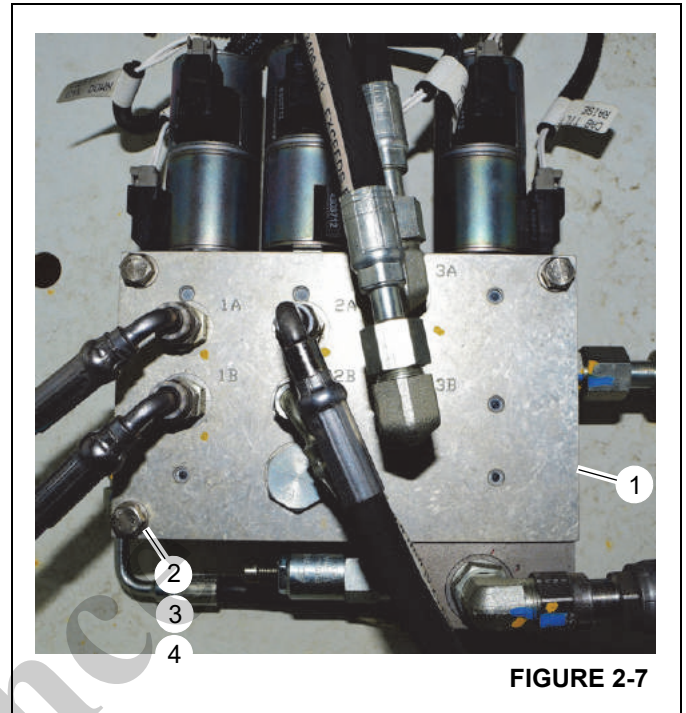
The counterweight and tilt cab valve features the ports shown in Table 2-3.

**Table 2-3 CWT Removal and Tilt Cab Valve Ports**

ID	Description
1A	CWT Removal Left Cylinder Extend
1B	CWT Removal Left Cylinder Retract
2A	CWT Removal Right Cylinder Extend
2B	CWT Removal Right Cylinder Retract
3A	Tilt Cab Extend
3B	Tilt Cab Retract
LS	Load Sense
P	Pressure from DCV
T	Tank (Return)

**Removal**

Use the following procedure to remove the counterweight removal and tilt cab valve (1, Figure 2-7).



**FIGURE 2-7**

1. Tag and disconnect the hydraulic hoses and electrical connectors from the valve.
2. Plug the lines and cap the ports.
3. Remove capscrews (2), washers (3), lockwashers (4), and the valve (1).

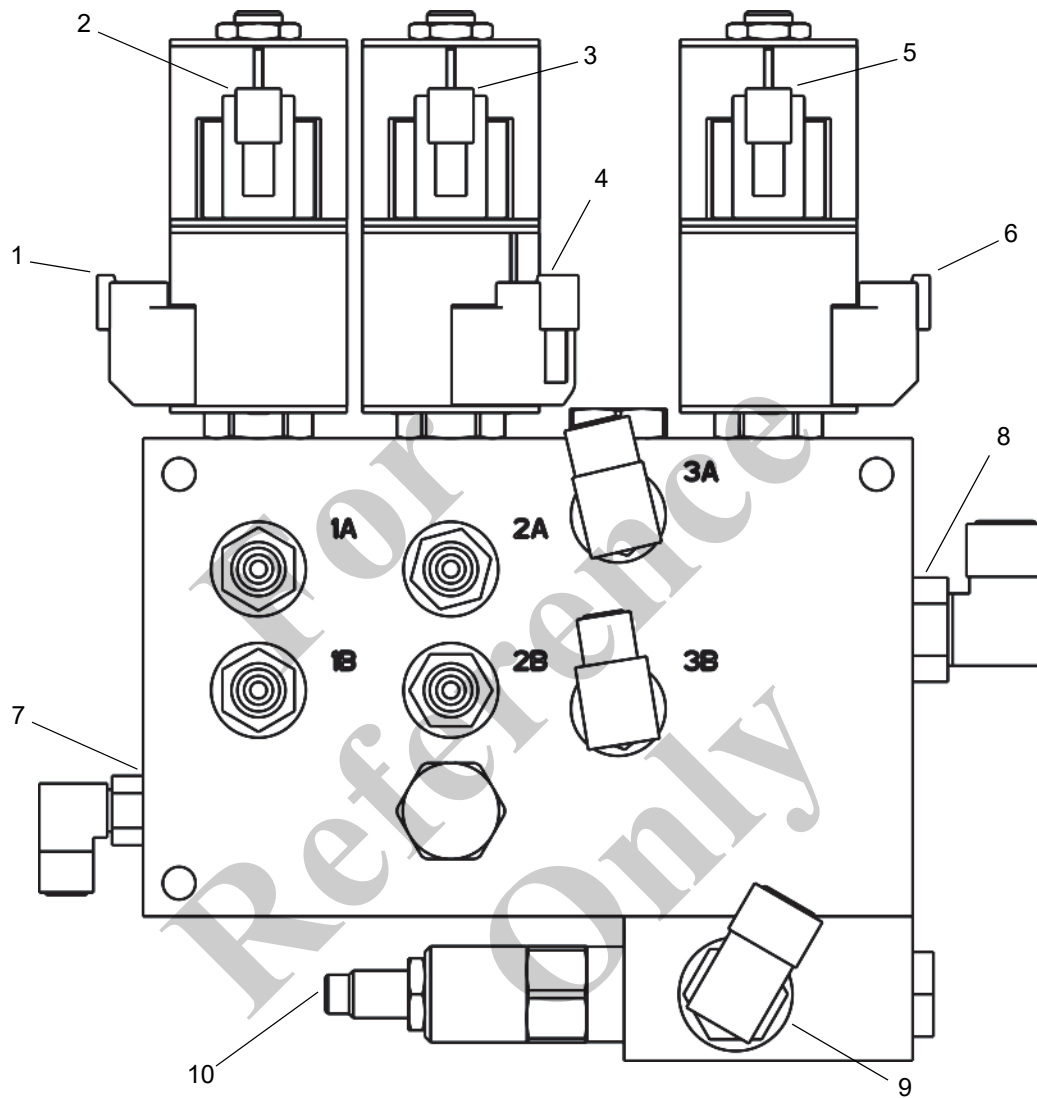
**Installation**

Use the following procedure to install the counterweight removal and tilt cab valve (1, Figure 2-7).

1. Install the valve (1) with lockwashers (4), washers (3), and capscrews (2).
2. Reinstall hydraulic and electrical connections per removal tags.

**Functional Check**

1. Start the engine and run it at normal speed.
2. Operate the counterweight cylinders. Check for smooth operation of cylinders and motors.
3. Operate the tilt cab. Check for smooth operation of cylinders and motors.
4. Check the valve and lines for leakage. Make repairs as needed.



Item	Description
1	Counterweight Left Cylinder Extend
2	Counterweight Left Cylinder Retract
3	Counterweight Right Cylinder Extend
4	Counterweight Right Cylinder Retract
5	Cab Tilt Retract

Item	Description
6	Cab Tilt Extend
7	LS Port
8	T Port
9	P Port
10	Reducing Valve

FIGURE 2-8

HYDRAULIC SYSTEM SETUP PROCEDURE

Table 2-4 Pressure Settings

Hydraulic Circuit	Pressure bar (PSI)	Tolerance bar (PSI)	1: Gauge Port Label (GPX) 2: Location 3: Figure Number
Hoist(s)	310.3 (4500)	-0/+3.5 (-0/+50)	<b>GP2</b> @ Directional Control Valve Load Sense Relief Valve Figure 2-12
Boom Up	310.6 (4351)	-3.5./+48.3 (-50/+700) (LSRV Setting)	<b>None</b> Directional Control Valve, Non-adjustable Figure 2-12
Boom Down	140 (2031)	-3/+23 (-50/+330)	<b>None</b> Directional Control Valve, Non-adjustable Figure 2-12
Telescope - Retract	209.9 (3045)	-3/+23 (-50/+330)	<b>None</b> Directional Control Valve, Non-adjustable Figure 2-12
Telescope - Extend	125 (1813)	-3.5/+28 (-50/+400)	<b>None</b> Directional Control Valve, Non-adjustable Figure 2-12
Swing Clockwise	206.8 (3000)	-3.5/+3 (-50/+50)	<b>GPA</b> @ Swing Manifold Directional Control Valve, Adjustable LSRV Valve Figure 2-12 and Figure 2-11
Swing Counter Clockwise	206.8 (3000)	-3.5/+3 (-50/+50)	<b>GPB</b> @ Swing Manifold Directional Control Valve, Adjustable LSRV Valve Figure 2-12 and Figure 2-11
Swing Backpressure	28 (400)	-0/+3.5 (-0/+50)	<b>GP1</b> @ Directional Control Valve Swing Backpressure Relief Valve Figure 2-12
Pilot Supply	21 (300)	-0/+3.5 (-0/+50)	<b>GP5</b> @ Directional Control Valve Pilot Relief Valve Figure 2-12
Swing Brake Release	21 (300)	-0/+3.5 (-0/+50)	<b>GP4</b> @ Directional Control Valve Pilot Relief Valve Figure 2-12

2

Table 2-4 Pressure Settings (Continued)

Hydraulic Circuit	Pressure bar (PSI)	Tolerance bar (PSI)	1: Gauge Port Label (GPX) 2: Location 3: Figure Number
Swing Brake Apply	26 (375)	-0/+3.5 (-0/+50)	<b>GP3</b> @ Directional Control Valve None - Solenoid Controlled (Current, mA) Figure 2-12
Air Conditioning- S/S Cab	100 (1450)	-0/+3.5 (-0/+50)	<b>ACG</b> @ Directional Control Valve A/C - Relief Valve Figure 2-12
Gearbox Coolant	4 (60)	-0/+2 (-0/+25)	<b>None</b> Coolant Reducing Valve Figure 2-12
Outrigger - Extend	206.8 (3000)	-0/+3 (-0/+50)	<b>GPB</b> @ Front Outrigger Manifold Pump Manifold Relief Valve Figure 2-13 and Figure 2-14
Outrigger - Retract	127.6 (1850)	-0/+13.8 (-0/+200)	<b>GPA</b> @ Front Outrigger Manifold Pump Manifold Relief Valve Figure 2-14
Counterweight Removal and Tilt Cab Manifold			
Counterweight Removal Cylinder(s)	138.0 (2000)	-0/+3.5 (-0/+50)	<b>GP2</b> @ Main Control Valve CWT Manifold Inlet Figure 2-15
Tilt Cab Cylinder	138.0 (2000)	-6.9/+6.9 (-100/+100)	<b>GP2</b> @ Main Control Valve Cab Tilt Valve Figure 2-17

**A. Getting Started**

1. Before checking any pressure for the work functions, the following settings must be set/verified:
  - a. Pump Margin Pressure (Standby)
  - b. Pump Max Pressure (Pmax)
  - c. Load Sense Relief Valve Pressure (LSRV)
  - d. Reference the *A. Pump Startup Procedure*, page 2-26 for how to set and verify these settings.
2. Valve sections that have relief valves installed (called "shock valves" by the manufacturer) have a fixed adjustment and cannot be changed, shimmed, etc.

3. If the shock valve is suspected of being incorrect, it can be inspected using a 13mm socket to remove the outer casing that retains the shock valve assembly.
  - a. For the Boom, Telescope, and Hoist sections reference Figure 2-9. These sections have shock valves on each side of the valve section - directly opposite of each other, with shock valves facing horizontally.
  - b. For the Swing function, reference Figure 2-10 of the generic valve section cutaway. There are shock valves on each side of the valve section located adjacent to each workport (vertical).
4. The setting of the shock valve in "bar" is stamped on each assembly and can be seen when removed.

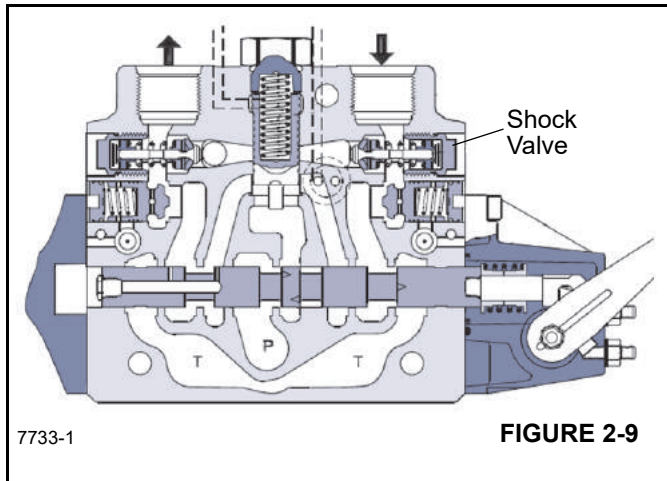


FIGURE 2-9

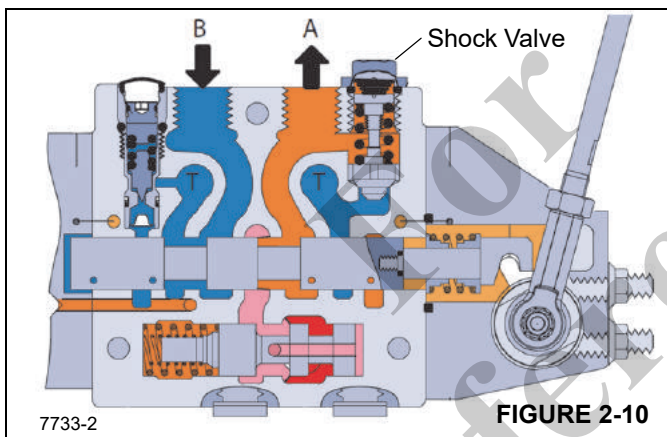


FIGURE 2-10

## B. Hoists

These functions are limited by the maximum load sense relief valve (LSRV) setting.

Reference the *A. Pump Startup Procedure*, page 2-26 for how to set and verify these settings

## C. Boom Up

Boom Up has a single shock valve in the valve section that has a fixed adjustment as shown in Figure 2-12 and Table 2-4.

This cannot be changed, shimmed, etc. Reference comments in Section A (page 2-18) about checking this setting on the physical shock valve assembly.

- To check this setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the extend hose at the cylinder connection.
  - b. Bottom out lift cylinder (full extension) or actuate the function with plugged hoses if no cylinder is present.
  - c. Move joystick to full shift and monitor pressure reading at gauge.

- d. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
- e. Uninstall gauge and re-torque all connections.

## D. Boom Down

Boom Down has a single shock valve in the valve section that has a fixed adjustment as shown in Figure 2-12 and Table 2-4.

This cannot be changed, shimmed, etc. Reference comments in Section A (page 2-18) about checking this setting on the physical shock valve assembly.

- To check this setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the retract hose at the cylinder connection.
  - b. Bottom out lift cylinder (full retraction) or actuate the function with plugged hoses if no cylinder is present.
  - c. Move joystick to full shift and monitor pressure reading at gauge.
  - d. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
  - e. Uninstall gauge and re-torque all connections.

## E. Telescope Extend

The Telescope Extend function has dual shock valves in the valve section that each have a fixed adjustment as shown in Figure 2-12 and Table 2-4.

This cannot be changed, shimmed, etc. Reference comments in *A. Getting Started*, page 2-18 about checking this setting on the physical shock valve assembly

- To check this setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the extend hose at the cylinder connection.
  - b. Bottom out telescope cylinder (full extension) or actuate the function with plugged hoses if no cylinder is present.
  - c. Move joystick to full shift and monitor pressure reading at gauge.
  - d. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
  - e. Uninstall gauge and re-torque all connections.

## F. Telescope Retract

The Telescope Retract function has dual shock valves in the valve section that each have a fixed adjustment as shown in Figure 2-12 and Table 2-4.

This cannot be changed, shimmed, etc. Reference comments in Section A (page 2-18) about checking this setting on the physical shock valve assembly

- To check this setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the retract hose at the cylinder connection.
  - b. Bottom out telescope cylinder (full retraction) or actuate the function with plugged hoses if no cylinder is present.
  - c. Move joystick to full shift and monitor pressure reading at gauge.'
  - d. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.'
  - e. Uninstall gauge and re-torque all connections.

### G. Swing Clockwise/Counter Clockwise

Swing clockwise/counter clockwise each have a single shock valve in the valve section that has a fixed adjustment as shown in Figure 2-12 and Table 2-4. This cannot be changed, shimmed, etc. Reference comments in Section A about checking this setting on the physical shock valve assembly if suspect.

The swing setting should be set by the load sense relief valve (LSRV) for each direction as it is adjustable up to the shock valve setting mentioned above. These LSRV's are located under the rounded black plastic plugs located on each side of the section adjacent to the shock valves as shown in Figure 2-10 and Figure 2-12.

- To set the swing settings:
  - a. Install a 345 bar (5000 psi) minimum gauge in the GA or GB gauge port on the hydraulic motor manifold Figure 2-11.

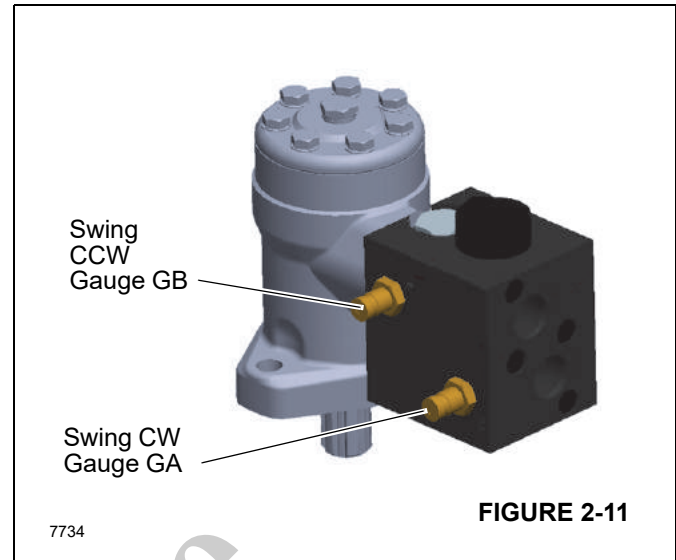


FIGURE 2-11

- b. Method #1: Using mechanical override
 

With the swing brake locked, actuate the valve using a 9mm box-end wrench on the spool's cam Figure 2-12. Pulling up on the wrench is swing counter clockwise, pushing down is swing CW.
- c. Method #2: Using swing brake
 

Actuate the swing CW or counter clockwise with the swing brake released (with Brake Release solenoid unplugged - Wire#50).
- d. Move joystick/override to full shift and monitor pressure reading at gauge.
- e. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance for LSRV valve(s).
- f. Uninstall gauge and re-torque all connections.

### H. Swing Backpressure

1. This back pressure should have been set at pump startup.
2. Reference the *A. Pump Startup Procedure*, page 2-26 for how to set and verify this setting.



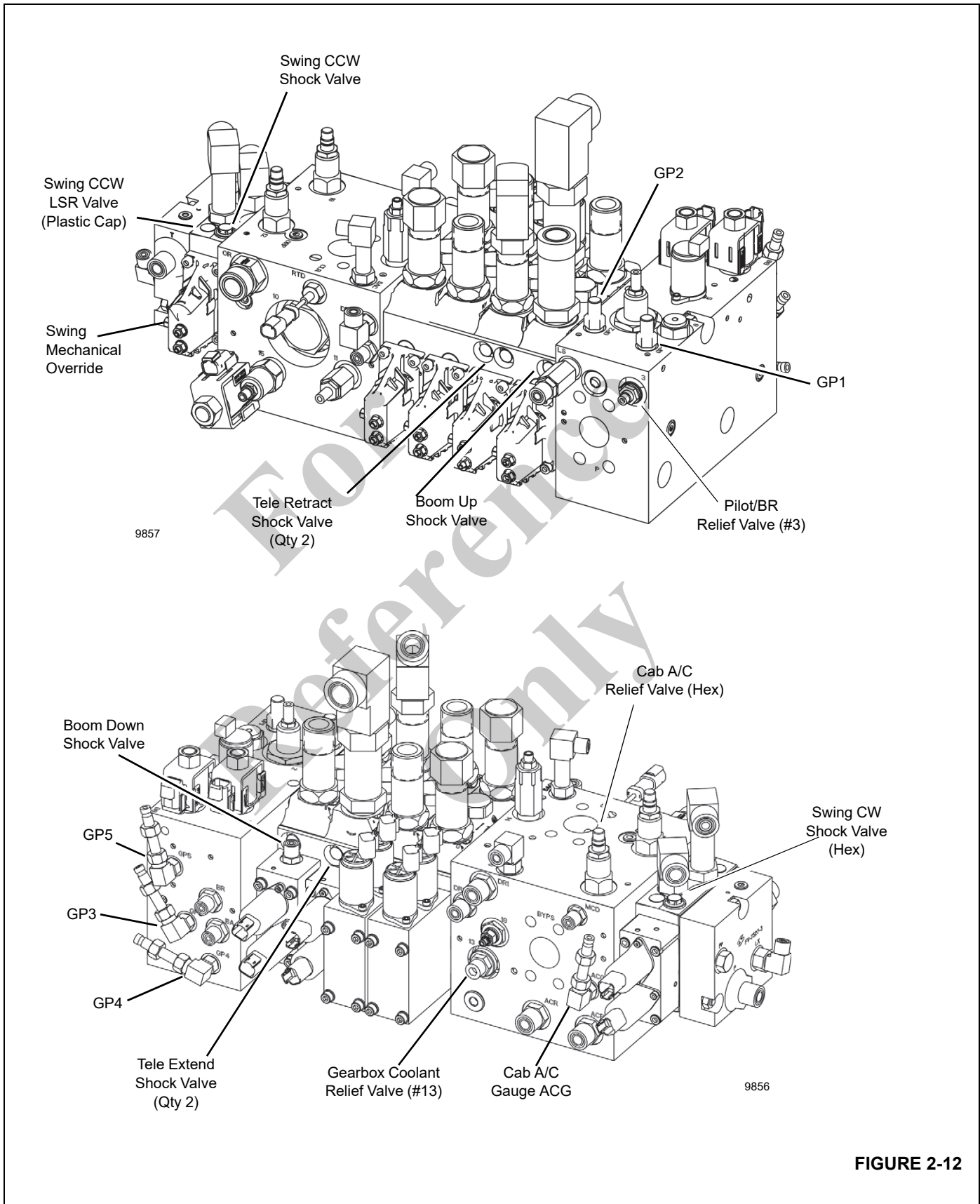


FIGURE 2-12

## I. Cab A/C

The Cab A/C circuit has a single relief valve in the directional control valve mid-inlet manifold with a setting as shown in Figure 2-12 and Table 2-4.

This can be adjusted by loosening the 3/4 in. locknut and using a 1/4 in. allen wrench to adjust the setting. Clockwise rotation increases the setting and each turn gains 40 bar (573 PSI). Be sure to re-tighten the 3/4 in. locknut to 5 N·m (4 lb-ft) when setting is correct.

- To check this setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the ACG gauge port on the control valve mid-inlet manifold Figure 2-12.
  - b. Install a plug in the A/C pressure hose at the compressor box located behind the crane cab.
  - c. Turn Cab A/C ON using the cab control knob and monitor pressure reading at gauge.
  - d. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
  - e. Uninstall gauge and re-torque all connections.

## J. Pilot Supply

### (Shared Relief with Swing Brake Release)

The Pilot Supply circuit has a single relief valve in the directional control valve inlet manifold with a setting as shown in Figure 2-12 and Table 2-4.

This can be adjusted by loosening the 11/16 in. locknut and using a 3/16 in. allen wrench to adjust the setting. Be sure to re-tighten the 11/16 in. locknut to 5.4 Nm (4) lb-ft when setting is correct.

- To check this setting:
  - a. Install a 69 bar (1000 psi) minimum gauge in the GP5 gauge port on the control valve inlet manifold Figure 2-12.
  - b. Turn Crane Power Switch ON using the cab control switch and monitor pressure reading at gauge
  - c. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
  - d. Uninstall gauge and re-torque all connections.

## K. Swing Brake Release

### (Shared Relief with Pilot Supply)

The Swing Brake Release circuit has a single relief valve in the directional control valve inlet manifold with a setting as shown in Figure 2-12 and Table 2-4.

This can be adjusted by loosening the 11/16 in. locknut and using a 3/16 in. allen wrench to adjust the setting. Be sure to re-tighten the 11/16 in. locknut to 5 N·m (4 lb-ft) when setting is correct.

3. To check this setting:
  - a. Install a 69 bar (1000 psi) minimum gauge in the GP4 gauge port on the control valve inlet manifold Figure 2-12.
  - b. Turn Crane Power Switch and Swing Brake Release switch ON using the cab control switches and monitor pressure reading at gauge.
  - c. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
  - d. Uninstall gauge and re-torque all connections.

## L. Swing Brake Apply

1. The Swing Brake Apply circuit is controlled through a proportional solenoid valve shown in Figure 2-12 and Table 2-4 and cannot be adjusted.
2. In order to check this setting:
  - a. Install a 69 bar (1000 psi) minimum gauge in the GP3 gauge port on the control valve inlet manifold. See Figure 2-12.
  - b. Turn Crane Power Switch and Swing Brake Release switch ON using the cab control switches. Fully depress the swing brake pedal on cab floor and monitor pressure reading at gauge.
  - c. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
  - d. If above or below tolerance, the amount of current (mA) available to this proportional valve may need to be adjusted. Reference "Crane Software Configuration" specification for instructions on adjusting and checking this current, contact Manitowoc Crane Care.
  - e. Uninstall gauge and re-torque all connections.

## M. Gearbox Coolant

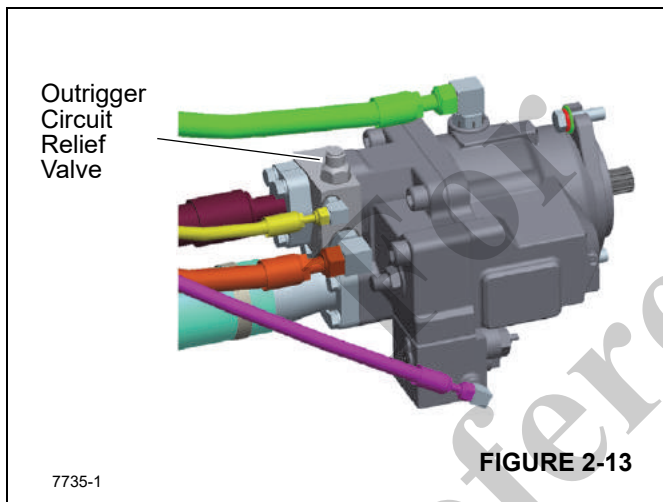
1. The Gearbox Coolant circuit has a single reducing valve in the directional control valve mid-inlet manifold with a setting as shown in Figure 2-12 (Gearbox Coolant Relief Valve #13).
2. This can be adjusted by loosening the 3/4 in. locknut and using a 5/16 in. allen wrench to adjust the setting. CW rotation increases the setting and each turn gains 29 bar (420 PSI). Be sure to re-tighten the 3/4 in. locknut to 5 N·m (4 lb-ft) when setting is correct.
3. In order to check this setting:

- a. Install a 69 bar (1000 psi) minimum gauge in the gearbox coolant hose at the swing gearbox with the hose removed from the gearbox port.
- b. With the hydraulic system operating, monitor pressure reading at gauge.
- c. Use Table 2-4 on page 2-17 to verify nominal setting and allowable tolerance.
- d. Uninstall gauge and re-torque all connections.

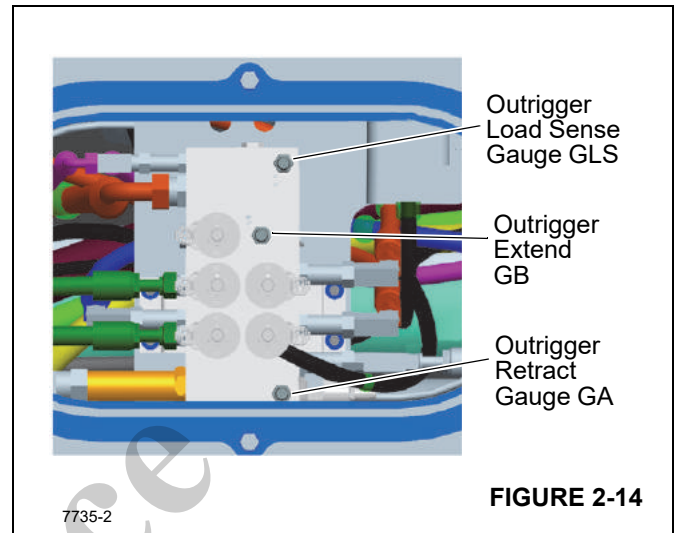
- c. Use to verify nominal setting and allowable tolerance.
- d. Uninstall gauge and re-torque all connections.

**N. Outrigger Extend**

- 1. The outrigger circuit has a single relief valve in the pump manifold with a setting as shown in Figure 2-13 and Table 2-4.



**FIGURE 2-13**



**FIGURE 2-14**

- 2. This can be adjusted by first removing the adjustment cover plug using a 5/16 in. allen wrench and using a 3/16 in. allen wrench to adjust the setting. Clockwise rotation increases the setting and each turn gains 61 bar (884 PSI). Be sure to re-tighten the adjustment cover to 5 N·m (4 lb-ft) when setting is correct.
- 3. In order to check setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the GB gauge port on the front outrigger manifold. See Figure 2-14.
  - b. Turn Crane Power Switch ON using the cab control switch. Fully extend an outrigger beam or jack and continue to hold function switch while monitoring pressure reading at gauge.

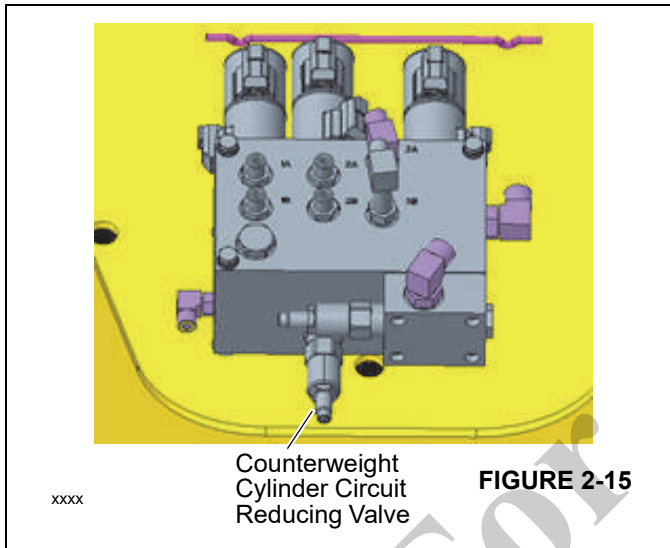
**Outrigger Retract**

The O/R Retract circuit has a single relief valve in the Front O/R Valve with a setting as shown in Figure 2-14 and Table 2-4.

- 1. This can be adjusted by first loosening the 3/4" jam-nut and using a 1/4" Allen to adjust the setting. CW rotation increases the setting and each turn gains 370 PSI. Be sure to re-tighten the adjustment cover to 6 lb-ft when setting is correct.
- 2. In order to check setting:
  - a. Install a 5000 PSI minimum gauge in the GA gauge port on the front O/R manifold (See Table 2-4).
  - b. Turn Crane Power Switch ON using the cab control switch. Fully retract an O/R beam or jack and continue to hold function switch while monitoring pressure reading at gauge.
  - c. Use Table 2-4 to verify nominal setting and allowable tolerance.
  - d. Uninstall gauge and re-torque all connections.

## P. Counterweight Removal Cylinders

1. The Counterweight Cylinder circuit has a single reducing valve in the counterweight removal manifold with a setting as shown in Figure 2-15 and Table 2-4.



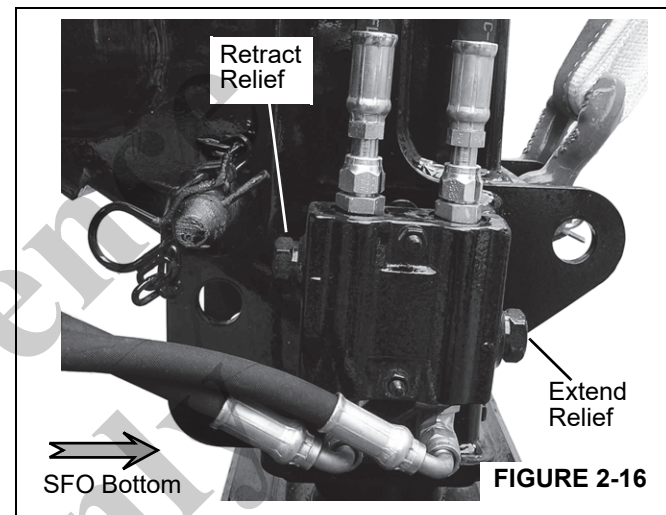
2. This can be adjusted by loosening the  $\frac{3}{4}$ " locknut and using a  $\frac{1}{4}$ " allen wrench to adjust the setting. Clockwise rotation increases the setting and each turn gains 7.5 bar (110 PSI). Be sure to re-tighten the  $\frac{3}{4}$ " locknut to 5 N·m (6 lb-ft) when setting is correct.
3. In order to check this setting:
  - a. Install a 345 bar (5000 psi) minimum gauge in the GP2 gauge port on the directional control valve Figure 2-12.
  - b. Fully retract (or extend) one of the counterweight removal cylinders and hold button.
  - c. Use Table 2-4 to verify nominal setting and allowable tolerance.
  - d. Uninstall gauge and re-torque all connections.

### Single Front Outrigger (Optional)

1. Disconnect the single front outrigger (SFO) extend and retract lines (Figure 2-16). Cap the retract line and install a gauge in the extend line.

**NOTE:** Install a gauge in each line and set the extend and retract pressures as described below with extend/retract switch.

2. Start engine and set at governed RPM.
3. Depress the front outrigger extend/retract switch to extend.
4. Adjust the extend relief valve on the front jack port block to 34 bar (500 psi) +6.89 / -0 bar (+100/-0 psi).
5. Shut down the engine.
6. Remove the gauge from the extend line and install in the retract line. Cap the extend line.
7. Adjust the retract relief valve on the front jack port block to 121 bar (1750 psi) -0/+6.89 bar (-0/+100 psi).
8. Shutdown the engine, remove the gauge and cap, and reconnect the SFO hydraulic lines.

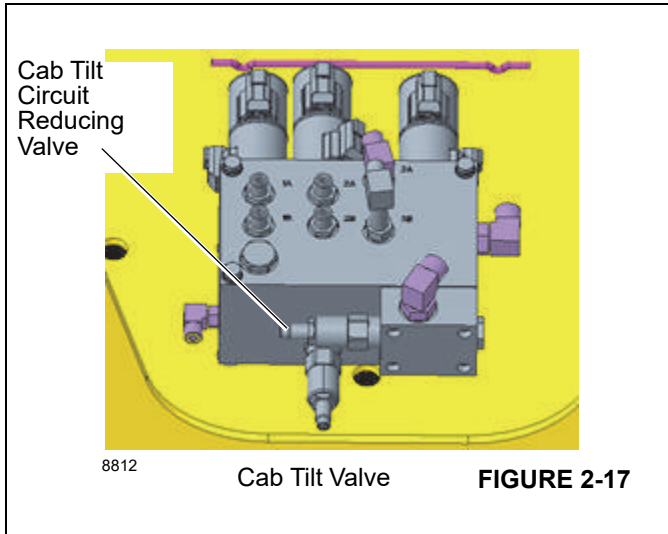


### Tilt Cab Valve

The tilt cab circuit is controlled by a single reducing valve (Figure 2-17 and Table 2-4) located inside the turret near the manifold valve with a setting of 138 bar (2000 psi). The valve is operated by a solenoid controlled by a switch on the right side armrest of the crane cab seat.

In order to check this setting:

1. Install a 5000 psi minimum gauge in the GP2 gauge port on the directional control valve. See Figure 2-17.
2. Fully retract the cab tilt cylinder (lower cab) and hold switch.
3. Verify nominal setting and allowable tolerance.
4. Uninstall gauge and re-torque all connections.



Cab Tilt Valve **FIGURE 2-17**

**Holding Valves**

Pilot operated check valves located in the valve block on each cylinder act as holding valves to keep the cylinder from collapse due to hose failure. Do not remove a valve block unless the cylinder is completely retracted.

Do not try to repair or set the valve pressure. If a holding valve is suspect, replace it with a new valve before putting the crane in service.

**Load Sense Control**

The Load Sense (LS) standby control (2, Figure 2-18) matches pump flow with system demand. The LS control senses the flow demand of the system as a pressure drop across an External Control Valve (ECV). As the ECV opens and closes, the pressure delta across the valve changes. Opening the ECV decreases the delta and closing the ECV increases the delta. The LS control then increases or decreases pump flow to the system until the pressure delta becomes equal to the LS setting. The advantage of the load sense control system is only the amount of flow required to do work is pumped through the system. This increases efficiency and reduces system temperature.

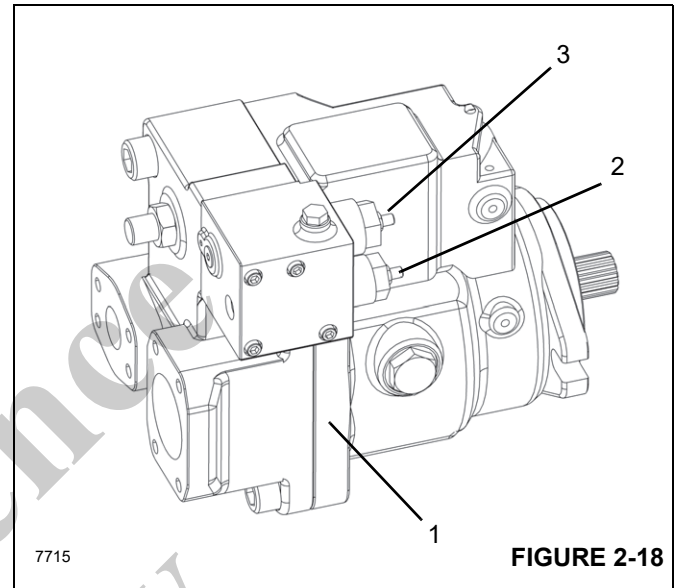
**HYDRAULIC PUMP**

The pump input receives fluid directly from the hydraulic reservoir. The output of the pump directs flow to the load sensing Directional Control Valve (DCV). The DCV directs fluid to the hydraulic components in the system. The speed of the hydraulic components in the system depends on the volume of fluid being provided by the pump. The operating pressure varies depending on the hydraulic component load, but is limited to:

- An adjustable maximum setting by the Pressure Compensator (PC) [3], Figure 2-18 section of the pump control.

- A system relief valve integrated into the side module of the directional control valve.

The position of the DCV spool sets the demand for flow in the system and communicates this to the pump control by means of a hydraulic signal (load sense signal). The pump provides as much flow to the system as it demands while limiting the maximum pressure. Therefore flow and pressure in the system are compensated to meet requirements.



7715 **FIGURE 2-18**

**Removal**

Replace the hydraulic fluid if pump replacement is required to make sure the system is free of contaminants.

1. Drain the hydraulic tank.
2. Tag and disconnect the hydraulic lines from the pump.
3. Remove the bolts from the pump rear mounting strap.
4. Remove the bolts from the pump mounting flange and slide the pump out of the PTO drive coupling.

**Installation**

1. Lubricate the splines on the pump and PTO drive shaft coupling with heavy lithium grease.
2. Line up the splines on the PTO drive shaft coupling with the pump drive shaft and slide the pump drive shaft into the coupling.
3. Bolt the pump to the PTO with the pump mounting flange.
4. Bolt the pump rear mounting bracket to the truck mounting strap.
5. Reconnect the hydraulic lines per removal tags.
6. Fill the hydraulic tank to the full mark with hydraulic oil.

## A. Pump Startup Procedure

If the pump is removed for maintenance or replacement, the following start up procedure should be followed to prevent damage to the pump or other components in the hydraulic system.

1. Connect the pump to the PTO. Ensure pump is properly aligned to the PTO shaft.
2. Fill the reservoir with hydraulic fluid.
3. Turn the shut-off valve on the suction line of the reservoir clockwise until the handwheel is fully open in order to achieve maximum oil flow. Check the line for properly tightened fittings, and be sure the line is free of restrictions and air leaks.
4. Fill the pump housing with hydraulic fluid. Pour the oil directly into the upper most case drain port Figure 2-20.
5. Fill the inlet line from the pump to the reservoir.
6. Check the suction line for properly tightened fittings and be certain it is free of any restrictions. Check for potential air leaks.
7. Inspect the case drainline for leaks or restrictions.
8. Install a gauge at the pump pressure gauge port (GP1) on the Directional Control Valve (DCV) Figure 2-19.
9. Start the engine and engage the PTO while monitoring the gauge. Idle the engine about 2 to 3 minutes until the gauge registers pressure. Do not operate any hydraulic functions. If the pump does not build up pressure, shut down the engine, and take corrective action.

### CAUTION

The supply line shut-off valve must be open to allow flow to the pump to prevent pump damage.

**NOTE:** The anti-start safety switch will prevent start-up if filter shutoff valve is even partially closed.

**NOTE:** Pressure at idle should be in the 52 to 55 bar (750 to 800 psi) range.

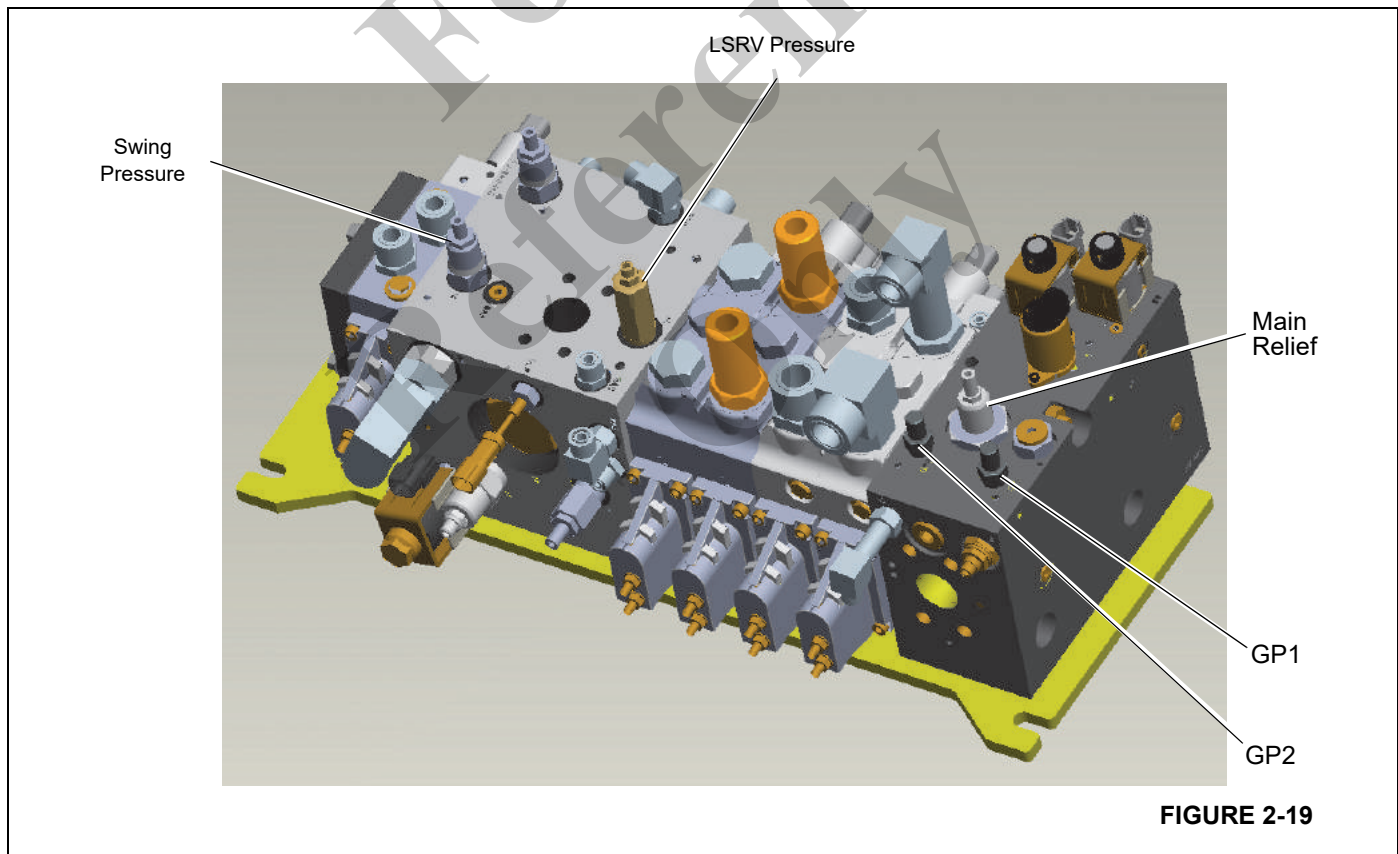


FIGURE 2-19

10. Operate the system under a light load for 5 to 10 minutes.
11. Check/adjust pump margin pressure. See Table 2-5.
12. Check/adjust main relief valve pressure. See Table 2-5.
13. Check/adjust maximum pump pressure. See Table 2-5.
14. Check/adjust valve load sense relief valve pressure. See Table 2-5.

- Remove pressure gauge, check hydraulic oil level in reservoir and fill if needed.

Table 2-5

Pump Margin Pressure (psi) [Read @ GP1]	Main Relief Pressure (psi) Read @ GP1	Max. Pump Pressure (psi) Read @ GP1	Load Sense Relief Valve Pressure (psi) Read @ GP2
25 bar ± 1.7 (363 psi ± 25) Gauge reading = 52.6 bar ± 1.7 (763 psi ±25)	345 bar -0 +3.4 (5000 psi -0 + 50)	335.3 bar -0 +3.4 (4863 psi -0 +50)	310.3 bar -0 +3.4 (4500 psi -0 +50)

### B. Pump Margin Pressure Setting

Use to verify nominal setting and allowable tolerance.

To check the margin pressure, there are two pressures that will be set as the crane's swing circuit requires 28 bar (400 psi) of back pressure all the time. This means that when a gauge is installed in the load sense port (GP2 in Figure 2-19), the pressure will read the relief that is present in the swing circuit. Therefore, the swing back pressure must be verified first.

After the swing back-pressure and pump margin settings are completed, the pump outlet gauge (GP1 in Figure 2-19) should be as follows:

$$\text{Gauge reading for Margin Pressure} = \text{Pump Margin } 25 \text{ bar (363 psi)} + \text{Swing Back-Pressure } 28 \text{ bar (400 psi)} = 53 \text{ bar } \pm 1.72 \text{ bar (763 psi } \pm 25 \text{ psi) [Table 2-5].}$$

#### Swing Back-Pressure Setting

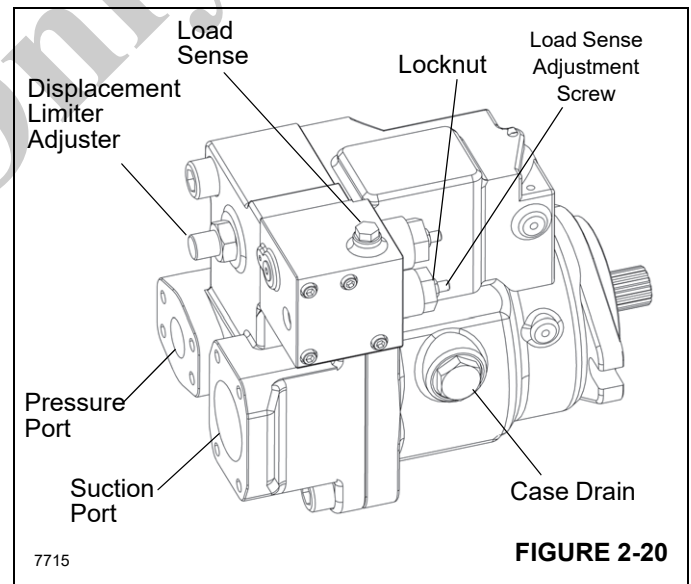
- Install a gauge at the pump pressure gauge port (GP2) on the DCV (Figure 2-19).
- Idle engine with PTO engaged and do not operate any functions.
- Verify swing pressure is 28 bar -0 +3.4 (400 psi - 0 + 50).
- If swing pressure is not correct, adjust Main Relief (Figure 2-20) as follows: Loosen 1/2 in locknut and use 4 mm allen wrench to adjust setting. Turning clockwise increases the setting. Each turn gains 11 bar (153 psi). Be sure to tighten the locknut to 5.4 Nm (4 ft-lb) to secure the setting.

#### Pump Margin Pressure Setting

- Install a gauge at the pump pressure gauge port (GP1) on the DCV (Figure 2-19).
- Idle engine with PTO engaged and do not operate any functions.

Total margin pressure measured should be 53 bar (763 psi ±25), which equals the pump margin pressure of 25 bar ±1.7 bar (363 psi ±25) + the swing back-pressure of 28 bar -0 +3.4 (400 psi -0 + 50).

- Adjust the LS adjusting screw (Figure 2-20) on the pump until the Pump Margin Pressure setting is correct. Turning clockwise increases the setting and each turn gains 19 bar (275 psi). When the setting is correct, tighten the M8 locknut to 16.3 Nm (12 ft-lb).



### C. Main Relief Pressure Setting

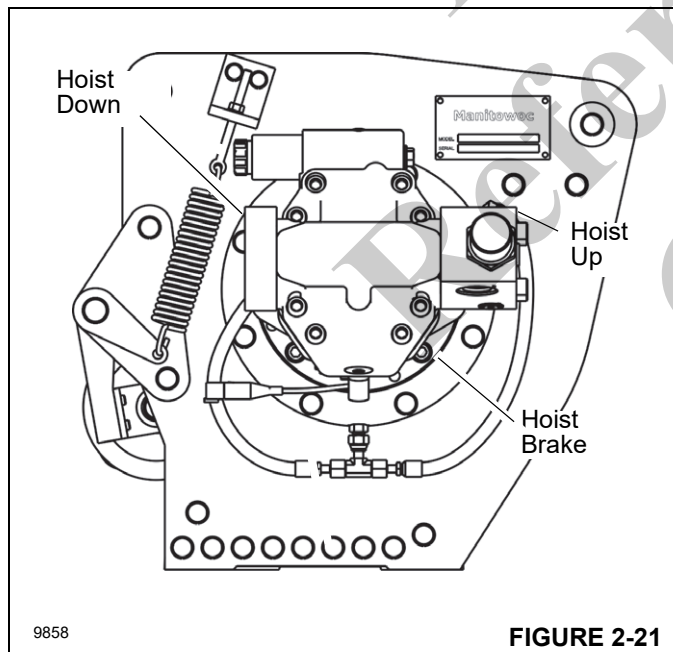
Use to verify nominal setting and allowable tolerance.

In order to set the maximum pump pressure, the load sense relief valve (LSRV) setting must be raised to a value higher

than the desired setting of the maximum pump pressure. To do this, raise the LSRV setting (Figure 2-19) by loosening the locknut (1/2 in. hex) and turning the adjustment hex (4 mm) clockwise until bottomed out. This should result in a setting shown in Table 2-5.

**NOTE:** There are two methods for setting the main relief pressure.

- Method #1: Leave the main hoist up/down hoses connected to the motor and cap the main hoist brake line at the hoist down block on the hoist with a #4 JIC Cap. Using this method, activate the hoist down function to develop maximum pressure (Figure 2-21).
  - Method #2: Disconnect and cap the main hoist up/down hoses. Refer to Figure 2-21. Using this method, activate the hoist up or hoist down function to develop maximum pressure.
1. Start the engine and idle with PTO engaged. Activate hoist joystick. Refer to table for correct Maximum Pump Pressure reading (Table 2-5). The pressure reading at GP1 should be the value of the Maximum Pump Pressure as this is now the lowest pressure in the system.
  2. Install a 414 bar (6000 psi) minimum gauge in the pump gauge port GP1 (Figure 2-19).

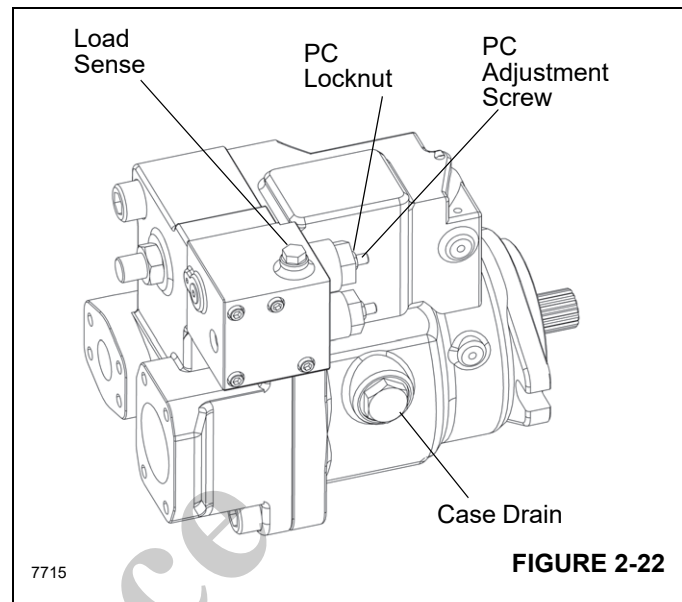


**FIGURE 2-21**

### Setting Main Relief Pressure

1. Idle machine with PTO engaged. Use method #1 or #2 above and hold the joystick. The pressure reading at GP1 should be the value of the Maximum Pump

Pressure (Table 2-5) as this is now the lowest pressure in the system.



**FIGURE 2-22**

2. If the pressure reading is less than the Maximum Pump Pressure setting, raise the pump pressure compensating (PC) adjusting screw as shown in (Figure 2-22). Loosen M8 locknut and use a 4mm Allen wrench to adjust the setting. Turning clockwise increases the setting and each turn gains 100 bar (1450 psi).
3. Increase the pressure compensator (PC) setting until Main Relief Pressure (Table 2-5) is reached on the gauge. There should be an audible hiss at the main relief and the return line back to the hydraulic tank should feel as if there is a large oil flow to tank. This means that the main relief setting has been reached.
4. If the Main Relief Pressure setting (Table 2-5) cannot be reached on the gauge, the main relief valve setting must be increased (Figure 2-19). This can be adjusted by loosening the 3/4 in. locknut and using a 3/16 in. allen wrench to adjust the setting. Turning clockwise increases the setting and each turn gains 91 bar (1315 psi). Be sure to re-tighten the 3/4 in. locknut to 8 Nm (6 lb-ft) when setting is correct.
5. After the desired main relief setting is reached, the pump pressure compensator (PC) setting must be returned to the value from Table 2-5. See "D. Setting Maximum Pump Pressure, page 2-28."

### D. Setting Maximum Pump Pressure

After the desired main relief setting is reached, the pump pressure compensator (PC) setting must be returned to the value shown in Table 2-5.



1. Install 414 bar (6000 psi) gauge at the pump pressure gauge port (GP1) on the DCV Figure 2-19.

**NOTE:** There are two methods for setting the Maximum Pump Pressure.

Method #1: Leave the main hoist up/down hoses connected to the motor and cap the main hoist brake line at the hoist down block on the hoist with a #4 JIC Cap (Figure 2-21). Using this method, activate the hoist down function to develop maximum pressure.

Method #2: Disconnect and cap the main hoist up/down hoses (Figure 2-21). Using this method, activate the hoist up or hoist down function to develop maximum pressure.

2. Start the engine and activate hoist joystick. Adjust pressure compensator (PC) Adjusting Valve (Figure 2-22) counter clockwise to attain correct pressure. Refer to Table 2-5 for correct Maximum Pump Pressure reading.
3. Reset the LSRV setting to the value shown in (Table 2-5). See *E. Load Sense Relief Valve (LSRV) Pressure Setting (Directional Control Valve)*, page 2-29.

**E. Load Sense Relief Valve (LSRV) Pressure Setting (Directional Control Valve)**

This procedure should be used when resetting the LSRV after setting the pump's maximum pressure setting or when desiring to verify the LSRV setting alone.

**Troubleshooting Chart**

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Excessive Noise and/or Vibration	Check fluid level in reservoir.	Insufficient hydraulic fluid causes cavitation.	Fill the reservoir to proper level.
	Check for air in system.	Air in system causes noisy, erratic control.	Purge air and tighten fittings. Check inlet for leaks.
	Check pump inlet pressure/vacuum.	Improper inlet conditions cause erratic behavior and low output flow.	Correct pump inlet pressure / vacuum conditions.
	Inspect shaft couplings.	A loose or incorrect shaft coupling causes excessive noise and/or vibration.	Repair or replace coupling and ensure that correct coupling is used.
	Check shaft alignment.	Misaligned shafts create excessive noise and/or vibration.	Correct shaft misalignment.
	Hydraulic fluid viscosity above acceptable limits.	Hydraulic fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures.

**NOTE:** There are two methods for setting the LSRV pressure.

Method #1: Leave the main hoist up/down hoses connected to the motor and cap the main hoist brake line at the hoist down block on the hoist with a #4 JIC Cap. See Figure 2-21. Using this method, activate the hoist down function to develop pressure.

Method #2: Disconnect and cap the main hoist up/down hoses. Using this method, activate the hoist up or hoist down function to develop pressure.

**To Set the LSRV Pressure**

1. Install a 345 bar (5000 psi) gauge at the pump pressure gauge port (GP2) on the DCV (Figure 2-19).
2. Idle engine with PTO engaged. Use method #1 or #2 above and hold the joystick. Verify LSRV pressure is at correct setting (Table 2-5).

If the LSRV pressure is not correct, adjust the LSRV adjusting screw as shown in Figure 2-19.

**HYDRAULIC SYSTEM TROUBLESHOOTING**

The following chart lists malfunctions which may occur during operation, the possible cause, and the possible solution. These are not all inclusive but are designed to help isolate the problem and should be checked before calling Manitowoc Crane Care.



Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Actuator Response is Sluggish	Check external system relief valve setting.	Low external relief valve setting slows down system.	Adjust external relief valve setting following manufacturer's recommendations. External relief setting must be above pressure compensator setting to operate properly.
	Check Pressure Compensator and load sense control setting.	Low pressure compensator setting prevents the pump from achieving full stroke. Low load sense setting limits output flow.	Adjust pressure compensator and load sense setting.
	Check load sense control signal pressures.	Incorrect load sense signal will not allow pump to operate correctly.	Inspect system to ensure that proper load sense signal is transmitted to pump.
	Internal system leaks.	Worn internal parts don't allow the pump to operate properly.	Refer to Authorized Service Center for required repair.
	Hydraulic fluid viscosity above acceptable limits.	Hydraulic fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operation or use fluid with the appropriate viscosity grade for expected operating temperatures.
	Check external system valving.	Malfunctioning valving may not allow system to respond properly.	Repair or replace system valving as required.
	Check pump case pressure.	High case pressure causes the system to be sluggish.	Correct case drain line restrictions.
System Operating Hot	Check pump inlet pressure/vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.
	Check fluid level in reservoir.	Insufficient volume of hydraulic fluid will not meet cooling demands of system.	Fill reservoir to proper level. Verify proper size of reservoir.
	Inspect heat exchanger. Check air flow and input air temperature for the heat exchanger.	Insufficient air flow, high input air temperature, or undersized heat exchanges will not meet cooling demands of the system.	Clean, repair, or replace heat exchanger as required. Verify proper size of heat exchanger.
	Check external system relief valve setting.	Fluid passing through relief valve adds heat to system.	Adjust external system relief valve setting following manufacturer's recommendations. External relief valve setting must be above pressure compensator setting for proper operation.
	Check pump inlet pressure/vacuum.	High inlet vacuum adds heat to system.	Correct inlet pressure/vacuum conditions.

Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
Low Pump Output Flow	Check fluid level in reservoir.	Insufficient hydraulic fluid will limit output flow and cause internal damage to pump.	Fill the reservoir to proper level.
	Hydraulic fluid viscosity above acceptable limits.	Fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures.
	Check external system relief valve setting.	External relief valve set below pressure compensator setting causes low output flow.	Adjust external relief valve following manufacturer's recommendation. External relief valve setting must be above pressure compensator setting to operate properly.
	Check pressure compensator and load sense control setting.	Low pressure compensator setting prevents the pump from achieving full stroke.	Adjust pressure compensator and load sense setting.
	Check pump inlet pressure/vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.
	Check input speed.	Low input speeds decrease flow.	Adjust input speed.
	Check pump rotation.	Incorrect rotational configuration causes low flow.	Use pump with appropriate rotational configuration.
Pressure or Flow Instability	Check for air in system.	Air in system causes erratic operation.	Activate pressure compensator allowing system to bleed air. Check inlet line for leaks and eliminate source of air ingress.
	Check control spools.	Sticking control spools cause erratic operation.	Inspect spools for free movement in bore. Clean or replace.
	Check load sense setting.	Low load sense setting may cause instability.	Adjust load sense setting to proper level.
	Check load sense signal line.	Blocked load sense signal line interferes with proper load sense operation.	Remove blockage.
	Check load sense shuttle valve (14, Figure 2-7).	Blocked valve causes erratic functionality.	Repair or replace the load sense shuttle valve.
	Check external relief valve and pressure compensator setting.	Insufficient pressure differential between pressure compensator setting and external relief valve.	Adjust external relief valve or pressure compensator control settings to appropriate level. Relief valve setting must be above pressure compensator setting to operate properly.
	Check external relief valve.	Chattering external relief valve may cause unstable feedback to pump control.	Adjust or replace relief valve.

Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	CORRECTIVE ACTION
System Pressure not Reaching Pressure Compensator Setting	Check pressure compensator control setting.	System pressure will not rise above pressure compensator setting.	Adjust pressure compensator to appropriate setting.
	Check external relief valve.	External relief valve setting below pressure compensator setting presets pressure compensation.	Adjust external relief valve according to manufacturer's recommendations. External relief valve must be set above pressure compensator setting to operate properly.
	Inspect pressure compensator control spring.	Broken, damaged, or missing spring will cause erratic operation.	Replace the spring as required.
	Inspect pressure compensator spool for wear.	Wear of pressure compensator spool causes internal leakage in the control.	Replace the spool as required.
	Inspect pressure compensator spool for proper orientation.	Improper orientation results in poor operation.	Correct orientation of spool.
	Check pressure compensator control for contamination.	Contamination may interfere with movement of the pressure compensator spool.	Clean pressure compensator control components, take appropriate action to eliminate contamination.
High inlet Vacuum <b>Caution</b> High Inlet Vacuum Causes Cavitation which can Damage Internal Pump Components.	Check fluid temperature.	Low temperature increases viscosity. High fluid viscosity causes high inlet vacuum.	Allow system to warm up before operating.
	Inspect inlet screen.	Blocked or restricted inlet strainer screen causes high inlet vacuum.	Clean screen/remove blockage.
	Check inlet piping.	Kinked or obstruction in inlet hose.	Remove kink or obstruction.
	Hydraulic fluid viscosity above acceptable limits.	High fluid viscosity causes high inlet vacuum.	Select fluid with appropriate viscosity for expected operating temperature.

## SECTION 3 ELECTRIC SYSTEM

### SECTION CONTENTS

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### ELECTRICAL SYSTEM DESCRIPTION

The truck electrical system is a standard 12 volt DC automotive type system and supplies power for all crane functions. The wire harness is routed through the truck frame and contains the wiring interface between the truck and the crane.

#### Jump Starting Hazard

Do not attempt to jump start the crane.

### CAUTION

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

This crane has multiple computer systems (crane control, RCL, engine and transmission control) that are highly

susceptible to voltage/amperage surges in the electrical system.

The batteries should be completely disconnected from the crane electrical system and charged using a battery charger of appropriate voltage level or replace the batteries with fully charged batteries. Refer to *Charging the Batteries*, page 3-2.

### Charging the Batteries

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

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

### WELDING PRECAUTIONS

Sensitive truck computer system and crane's electrical system 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.

### ELECTRICAL SYSTEM MAINTENANCE

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



**DANGER**

When metal jewelry, rings, or watches come in contact with live circuits, serious burns can result. Remove all metal jewelry, rings, and watches before working on live circuits.

### General Troubleshooting

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

1. Use reported symptoms to identify a problem or a suspect component.
2. Use a multimeter to test for circuit continuity if you suspect an open circuit or for voltage if you suspect a power problem. Check the electrical schematic for the most accurate wiring information.
3. Replace faulty components and wiring.
4. Test the repaired circuit and verify that the circuit works properly.

### Troubleshooting the Electrical Swivel

The electrical swivel is located in the turret under the cab. The swivel features multiple electrical connections. Troubles common to the swivel are improper mounting, foreign material between the brushes and slip rings, worn brushes, improper spring tension on the brush assembly, and loose setscrews on the slip ring assembly. Refer to the electrical schematic and wiring diagram for slip ring connections and amperages.

### Connector Troubleshooting

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

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

### Ignition Switch

There are two ignition switches on the crane. One is in the truck cab and the other one is in the crane cab. Only one switch at a time can be energized.

**NOTE:** If one switch does not engage the truck starter, check and make sure the other switch is OFF.

In order to start the crane from the crane cab, the following conditions must be met:

- Both of the Outrigger Control ESTOPS must be off.

- The ESTOP in the crane cab must be off.
- The truck Ignition Switch must be turned to off.
- The PTO switch must be on.
- The hydraulic suction valve at the filter must be closed.

## 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. See "Excluded Connections" on page 3-3.

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

### Excluded Connections

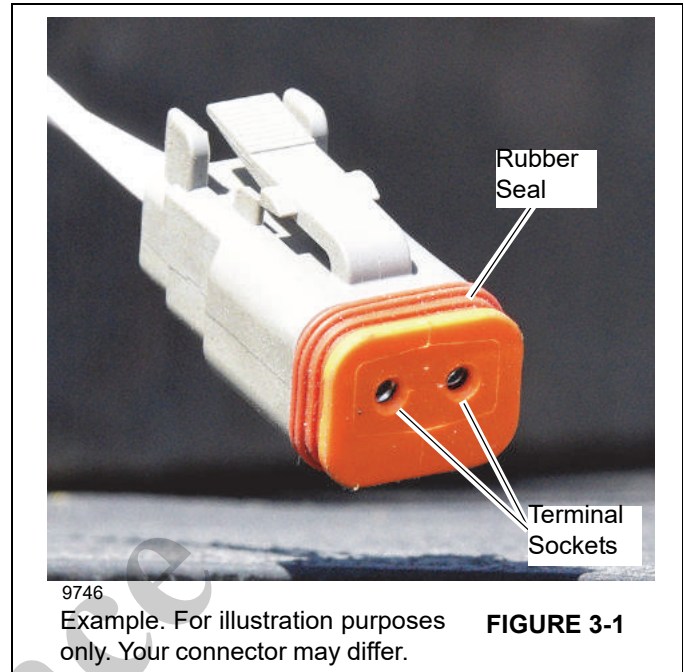
Do not apply dielectric grease to the following connections:

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

### Applying Dielectric Grease to an Electrical Connector

Use the following procedure to apply dielectric grease to an electrical connection. Grease should be applied immediately prior to securing the connector. Ensure that grease is applied to all terminal sockets (Figure 3-1).

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.



9746  
Example. For illustration purposes only. Your connector may differ. **FIGURE 3-1**

4. Use a clean towel to remove excess grease from the surface of the connector, and wipe grease into the terminal sockets (Figure 3-1).
  5. Ensure grease is applied to each terminal socket. The towel with excess grease can be used to fill empty terminal sockets (Figure 3-1).
  6. Ensure grease is applied to the entire surface of the connector's rubber seal (Figure 3-1).
- 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.

## CAB MODULE, FUSE, RELAY PANEL

The cab and superstructure fuse/relay panel (9, Figure 3-4) is located behind the operator seat. Remove the two thumbscrews securing the access panel to gain access to the fuse blocks, relays, crane master module, cab modules, and interface connectors.

The fuse panel (6, Figure 3-4) contains the fuses that protect the circuits as indicated in Figure 3-2.

**NOTE:** The cab control modules are not serviceable. Contact Manitowoc Crane Care Customer Service with any service or repair questions about the modules.

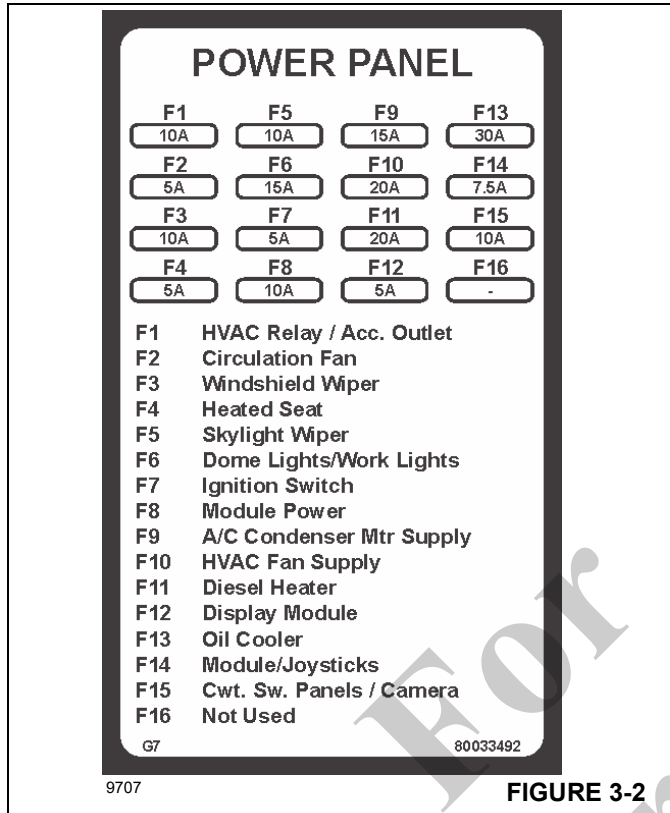


FIGURE 3-2

### SUPERSTRUCTURE SERVER MODULE

The superstructure server module (11, Figure 3-4) is located inside the crane cab attached to the back side of the fuse panel.

This module acts as the main crane server module. It monitors and supports the operation and functions of the

crane operating system including: swing, main and auxiliary hoist, oil cooler, boom extend, boom lift, boom down, hydraulic suction and remote modules.

The superstructure main harness assembly is connect to the module and to each of the system components.

It can also be used as a diagnostic tool when accessed though the diagnostic plug.

**NOTE:** This module is not serviceable. Contact Manitowoc Crane Care Customer Service with any service or repair questions about the module.

### DIRECTIONAL CONTROL VALVE

All crane functions are controlled by the directional control valve (1, Figure 3-3) located in the turret. The solenoid valves are identified in Figure 3-5.

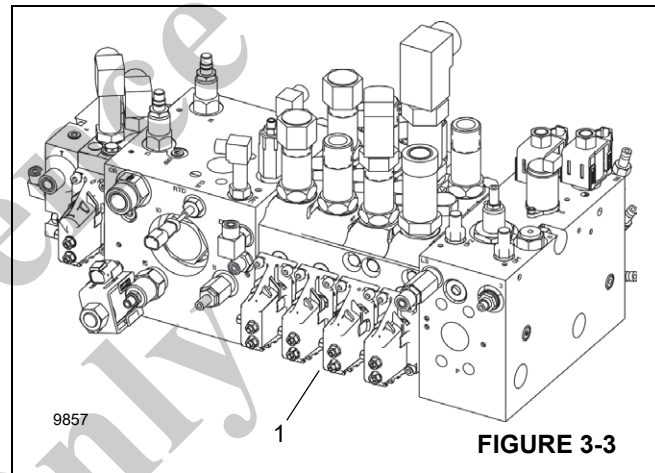
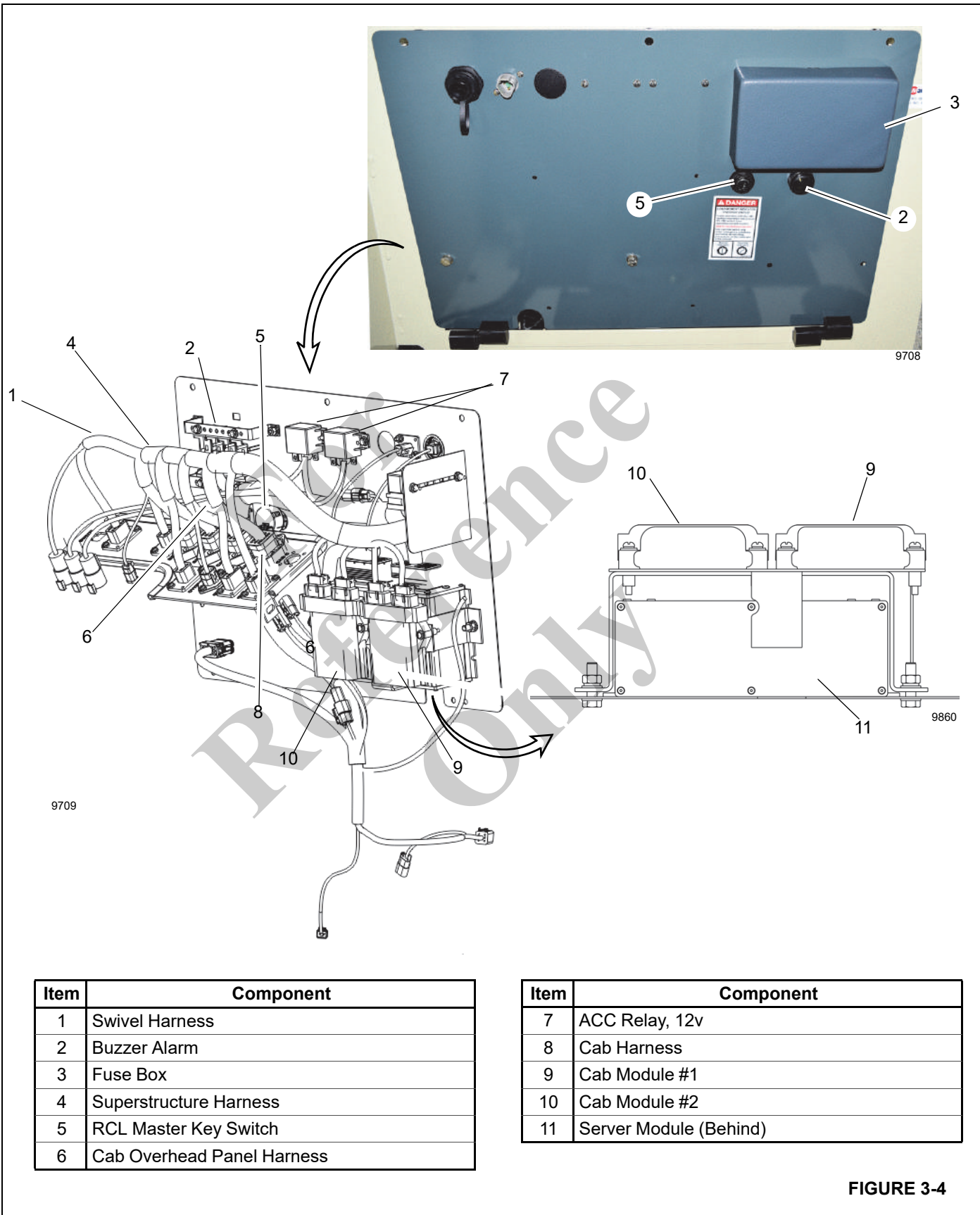


FIGURE 3-3





Item	Component
1	Swivel Harness
2	Buzzer Alarm
3	Fuse Box
4	Superstructure Harness
5	RCL Master Key Switch
6	Cab Overhead Panel Harness

Item	Component
7	ACC Relay, 12v
8	Cab Harness
9	Cab Module #1
10	Cab Module #2
11	Server Module (Behind)

FIGURE 3-4

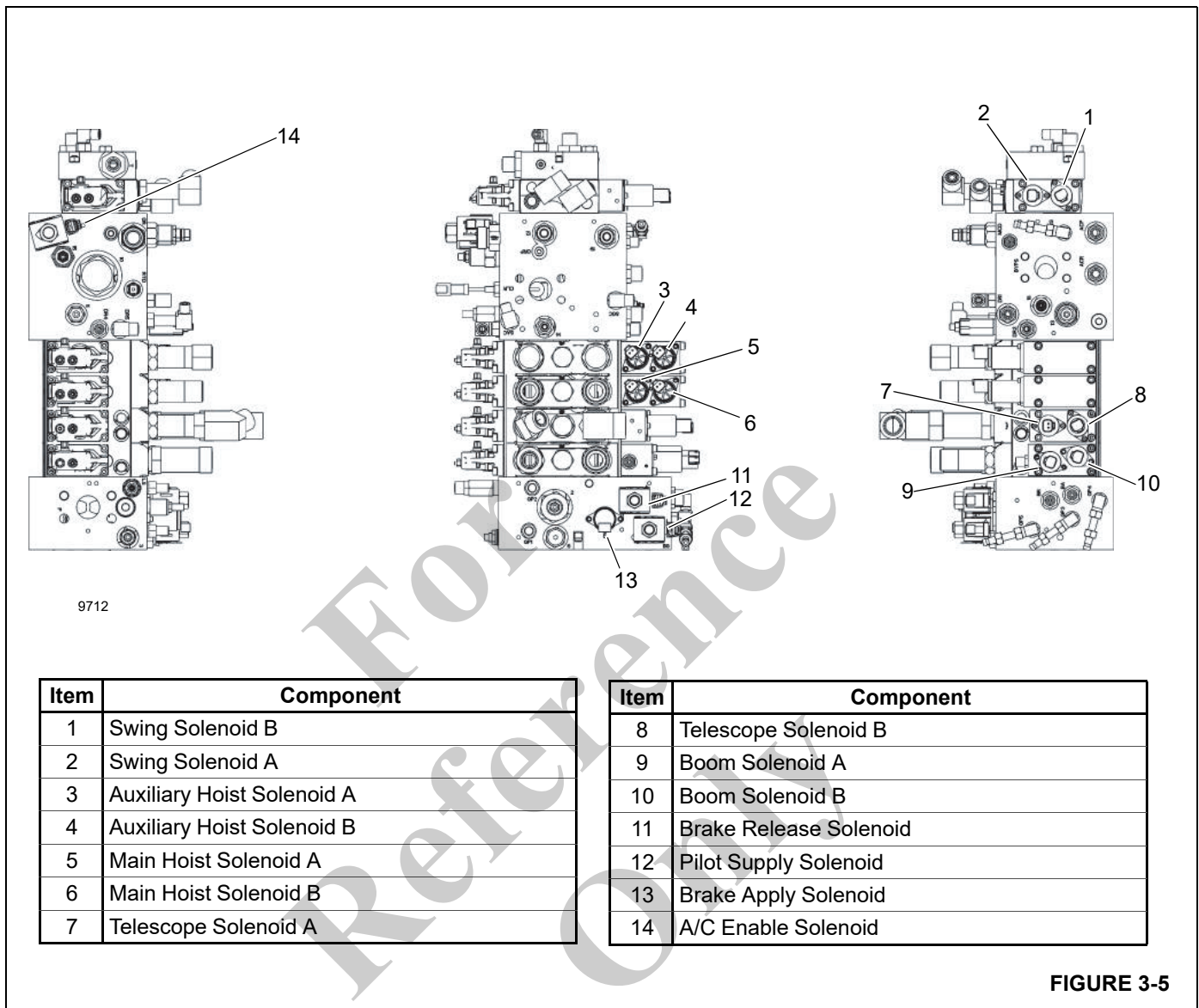


FIGURE 3-5

## DIRECTIONAL CONTROL VALVE (DCV) SOLENOIDS

The solenoids on the directional control valve are used to control the mode of operation of the associated valve. The swing, hoist(s), telescope, and boom solenoids all directly control the crane functions and are proportional valves. Of the remaining solenoids on the DCV, the swing brake apply solenoid is the only other proportional valve because it operates in conjunction with the swing brake apply footpedal. The brake release, pilot supply, and A/C enable solenoids are On/Off solenoids.

## OUTRIGGER MANIFOLDS

There are two outrigger manifolds located on the crane t-box frame. The front outrigger manifold is mounted in the center of the crane frame between the cab and front outrigger box (Figure 3-6).

The rear outrigger manifold is mounted in the center of the crane frame between the rear of the superstructure cab and rear outrigger box (Figure 3-7).

To access either of the outrigger manifolds, the manifold cover plate will need to be removed.

**NOTE:** The front outrigger modules (Figure 3-6 and Figure 3-7) are not serviceable; contact Manitowoc Crane Care Customer Service with any service or repair questions about the module.

### Front Outrigger Manifold

The solenoids on the front outrigger manifold (Figure 3-6) control the selection of the front outrigger components, the optional single front outrigger (SFO) (if equipped) and the extend and retract functions of front outrigger components.

When the crane function power switch in the operator cab is turned ON, all outrigger functions are disabled from the lower controls.

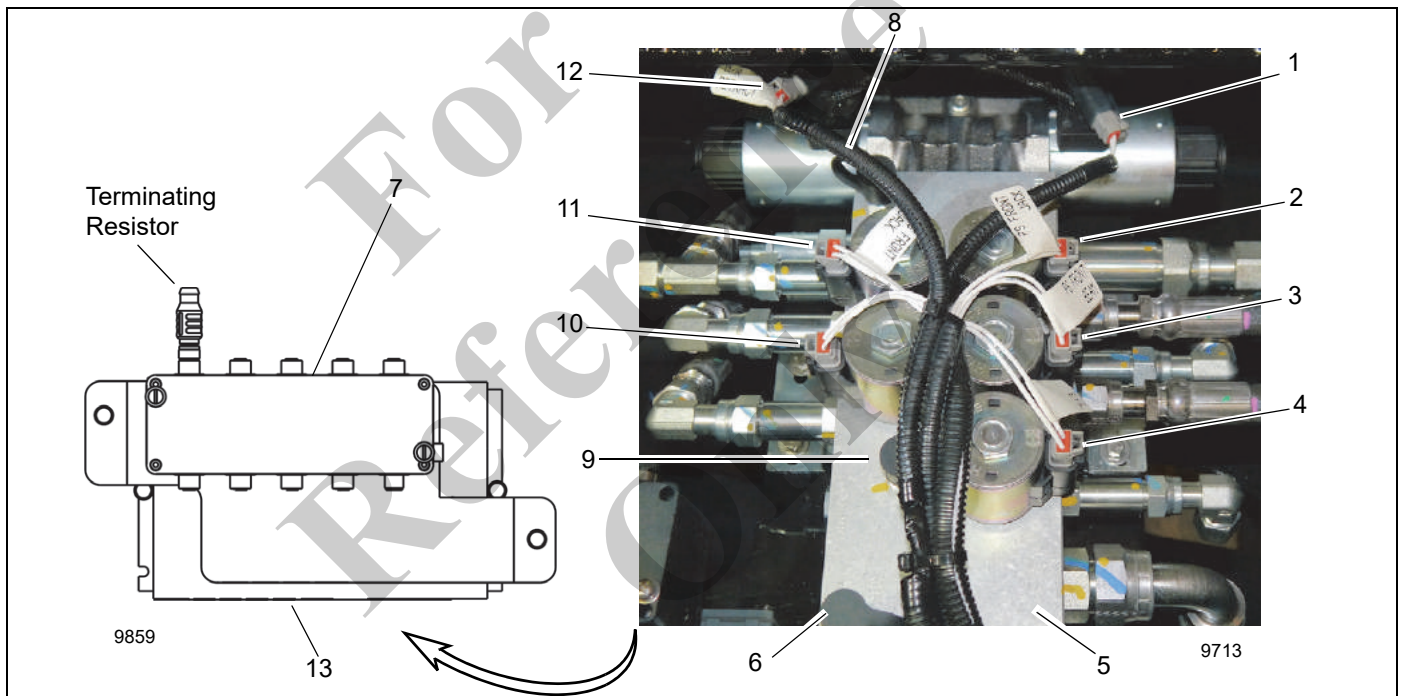
The solenoids on the front outrigger manifold provide the following functions:

**NOTE:**

- The single front outrigger (SFO) solenoid (4) extends or retracts the SFO when energized. Any time the retract switch on the outrigger control is depressed, the SFO is the first to retract.

- The extend solenoid (12) controls the extend functions for all outrigger components.
- The retract solenoid (1) controls the retract functions for all outrigger components.
- Solenoids (2), (3), and (10), (11) control the front outrigger components. See Figure 3-6 for solenoid identification.
- The front module (13) is mounted with a CAN bus junction box (7) and connected to the lower frame main wiring harness (8) providing outrigger function data to the main server module.

If disconnecting the main wiring harness (8) from the CAN bus junction box, note the position of the connectors; these connectors must be reconnected in the same position.



Item	Description
1	Solenoid, Outrigger Retract
2	Solenoid, Right Front Outrigger Jack Cylinder
3	Solenoid, Right Front Outrigger Beam
4	Solenoid, Single Front Outrigger (SFO) (optional)
5	Outrigger Manifold
6	Outrigger Load Sense Gauge Port (GLS)

Item	Description
7	CAN Bus Junction
8	Frame Main Wiring Harness
9	Outrigger Extend Gauge Port (GB)
10	Solenoid, Left Front Outrigger Beam
11	Solenoid, Left Front Outrigger Jack Cylinder
12	Solenoid, Outrigger Extend
13	Front Module

FIGURE 3-6

## Rear Outrigger Manifold

The solenoids on the rear outrigger manifold control the rear outrigger functions. The lower front module controls the rear solenoids. See Figure 3-7 for solenoid identification.

- Solenoids (1), (2), (3), and (4) control the rear outrigger components.

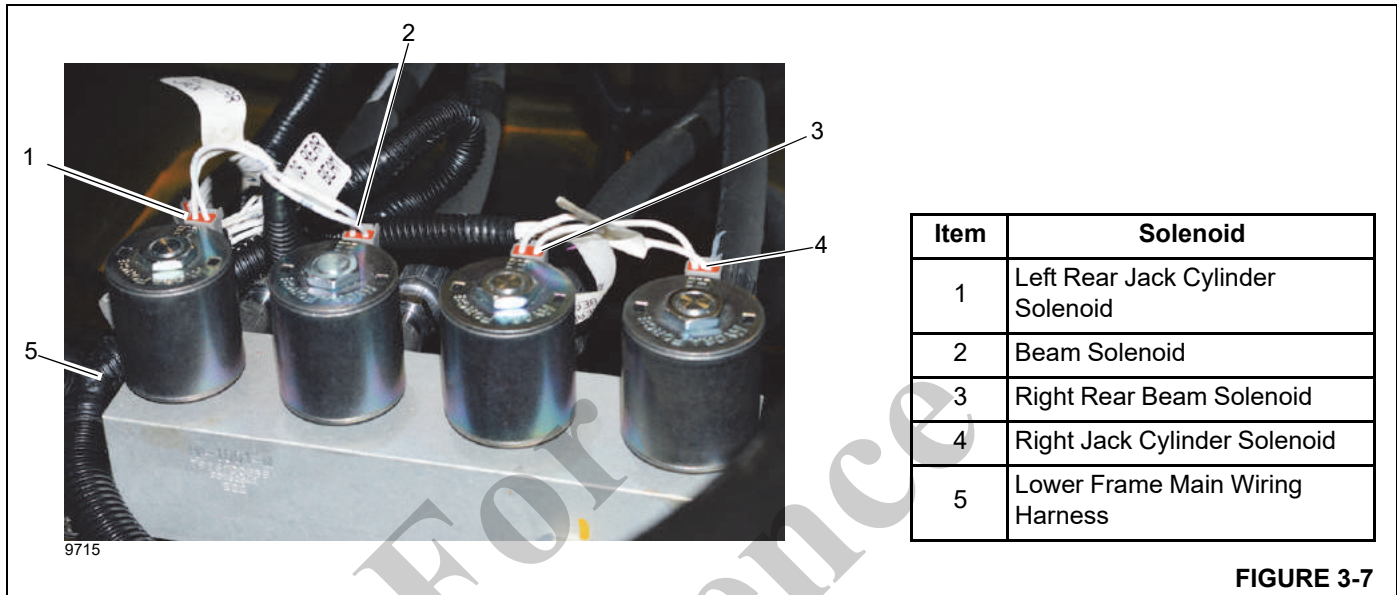


FIGURE 3-7

## HYDRAULIC OIL COOLER

The cooler electrical system is made up of the following:

- Electric Fan
- Temperature Sensor

The temperature sensor is located in the cooling core and a resistive temperature device (RTD) located internally to the directional control valve provide inputs to the control system modules, which then energizes the fan relay when the hydraulic oil reaches 48.8° C (120° F). If the fan is not running and the oil temperature warning is displayed on the RCL screen, check the fan temperature sensor and fan motor.

## WIND SPEED SENSOR (OPTIONAL)

An optional wind speed sensor is mounted at the end of the boom. Data from the wind speed indicator appear on the RCL screen. When the crane is not in operation or traveling, the wind speed indicator is stored in the crane cab. For more information about the optional wind speed indicator, see the *Operator Manual*.

If maintenance is required on your wind speed indicator, contact your local National Cranes distributor or Manitowoc Crane Care.

## CAMERA SYSTEM (OPTIONAL)

An optional camera system can be installed on NBT60L cranes. When installed, the cameras are located on the boom facing the hoists and the rear of the superstructure behind for rear-facing views. The camera video is output to a monitor in the operator cab. For more information, see the *Operator Manual*.

If maintenance is required on your camera system, contact your local National Crane distributor or Manitowoc Crane Care.

## RATED CAPACITY LIMITER (RCL) SYSTEM DESCRIPTION

The Rated Capacity Limiter (RCL) monitors crane operation and alerts the operator of stability or structural limits based on the load chart. The crane functions that worsen the condition (hoist up, boom down, telescope out) are disabled. The RCL override key on the operator display panel temporarily overrides the RCL system as long as the key is turned. The RCL override key switch located behind the operator's seat continuously overrides the RCL system. For more information, see the *Operator Manual*.

## RCL and Anti-two Block (A2B) System Description

The anti-two-block system (A2B) is part of the RCL system that helps prevent damage to the hoist cable by sensing

when the lower block is near the boom tip and disables the functions that cause a two block condition.

Normal functioning is restored by hoisting down or retracting boom until the A2B weight is suspended freely. The A2B system is incorporated into the crane RCL system.

**! WARNING**

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

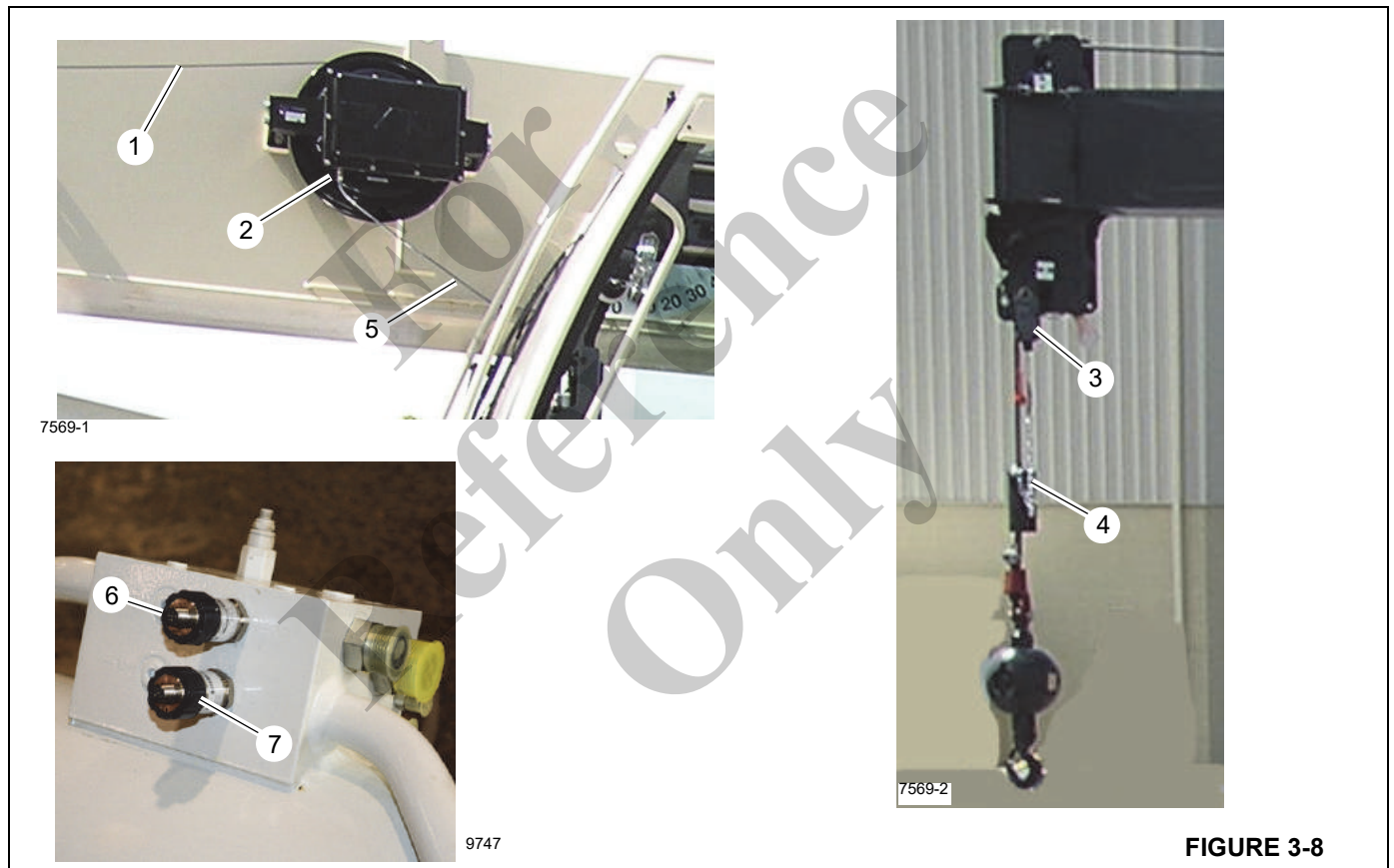
The boom A2B cable (1, Figure 3-8) runs from the A2B reel inside the boom to the A2B switch assembly (3). The A2B

switch assembly cable is attached to the anti-two block weight.

To replace the A2B cable:

1. Retract the boom.
2. Route the cable from the RCL reel to the turnaround sheave assembly and into the boom.
3. Secure the A2B cable to the boom tip.

The CAN bus cable (5) runs from the bottom of the reel to the rear of the boom, then down through the CAN bus junction box, located on the outside of the turret behind the crane cab.



**FIGURE 3-8**

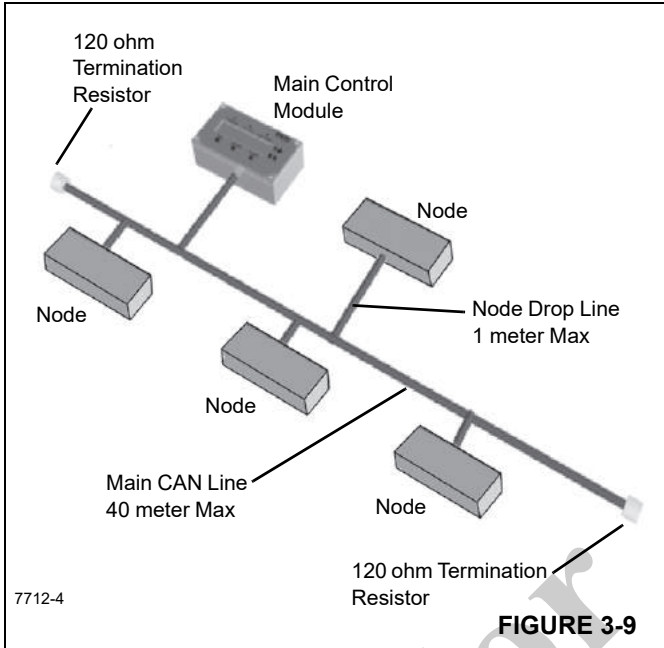
**RCL Communication Overview**

The RCL needs to communicate with the various sensors, switches, and transducers on the crane in order to perform the RCL functions. The RCL uses Controlled Area Network (CAN) bus communications.

Each device on the CAN network is capable of digital communications. This enables many devices to communicate quickly over a single twisted pair of wires.

Each device on the CAN bus sends and/or receives messages on the network in a predefined format called a protocol. A device is called a node and one of the nodes is defined as the control module.

The transmission of messages is broadcast over the network to all nodes. Only the node or nodes to which the message is intended responds to the transmission. All other nodes ignore the message.



Advantages to a CAN bus system are:

- Reliability
- Self diagnostics
- Ease of Installation
- Elimination of a large bundle of wires
- Downloading to a laptop computer
- Protected safety interlocks
- EMI/RFI tolerant

**Tools For Troubleshooting**

This machine uses a CAN bus Multiplex system. The RCL system features the following troubleshooting features, including a full suite of on-board diagnostics tools. For more information, see “Diagnostics” on page 3-20. Definitions for error codes are available in the Manitowoc Diagnostics Code Application. For more information, see “About the Manitowoc Diagnostic Code Application” on page 3-23.

System software and a Windows-based personal computer can also be used to troubleshoot the RCL system. You will need CAN-Link service software, and a connection cable. The CAN-link service software and connection cable are available through Manitowoc Crane Care to service technicians who have attended the Manitowoc New Technology training course.

Manitowoc Crane Care recommends you have as part of your service tool kit inventory the Orchestra (CAN-Link) service tool kit for the NBT60L. The software enables you to see in real time the status of all inputs and outputs signals on the system, and it will allow you to detect any errors on input

or output. The Orchestra (CAN-Link) service software and hardware are available through Crane Care to those service technicians who have successfully completed the Orchestra level training course.

**About System Configuration**

Use the following procedure to access the System Configuration Menu. The System Configuration menu is where the functions shown in Table 3-1 can be accessed.

**Table 3-1 System Configuration Menu Icons**

Icon	Description
	<b>Sensor Calibration Menu</b> — Select this icon to calibrate crane sensors. This icon appears red if sensors need to be calibrated. For more information, see “Calibrating RCL Sensors” on page 3-13.
	<b>Crane Configuration</b>
	<b>Enable Chart Loading</b> — Select this icon to upload a new load chart. For more information, see “Uploading the Load Chart” on page 3-11.
	<b>Software Update</b> — Select this icon to load software updates. For more information, see “Uploading the RCL Display Software” on page 3-12.
	<b>Crane Function Configuration</b>
	<b>Truck/Engine Configuration</b>
	<b>Component Addressing</b> —Select this icon to update or add a CAN bus address to a component. This icon appears red when components need to be addressed. For more information, see “Component Addressing” on page 3-17.
	<b>Real-Time Clock Configuration</b> — Select this icon to update the RCL system time and date information. For more information, see the <i>Operator Manual</i> .

**Accessing the System Configuration Menu**

Use the following procedure to access the System Configuration menu. The password 12331 is required to continue to the System Configuration Menu.

1. In the main menu, select the Tools icon.  
The Tools menu appears.

- In the Tools menu, select the System Configuration icon



- Enter the password 12331 to continue to the System Configuration menu. For more information, see “Entering the System Configuration Password” on page 3-11.

### Entering the System Configuration Password

A 5-digit password is required to access the system configuration screen. After three failed attempts, there is a three second timeout before the user can re-enter the password. After all numbers are entered, the Select button turns green.

The up and down indicator in the time and password boxes correspond to button (4) “OK” to modify selection.

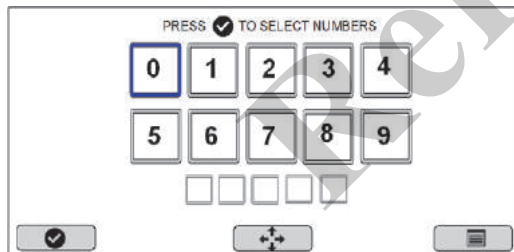
Use the Delete functional key to remove all entries.

The System Configuration screen is where you calibrate the sensors, upload the RCL software, and load charts.

To enter the calibration password:

- Access the Sensor Calibration Menu.
- Select the sensor you want to calibrate.

The Password screen appears.



- Enter the following. Use the directional arrow key, highlight the number, then press to populate the field.

1, 2, 3, 3, 1

- After all numbers are entered, press the green Select function key to submit the password.

### Uploading the Load Chart

Use the following procedure to upload updated load charts to the RCL system. Connect a laptop computer to the crane control system through the Diagnostic Connector in the

operator’s cab control panel. Contact Manitowoc Crane Care or the National Crane distributor for the required software and cables for the crane interface.



**DANGER**  
Incorrectly installed RCL software could prevent the RCL from working properly. Overloading the crane could occur resulting in tip over or structural failure. Death or serious injury could occur.

- Connect the laptop to the Diagnostic Connector with the interface cable.
- If the RCL is in the start up mode and at the Main Menu screen, select function key 2, Tools.

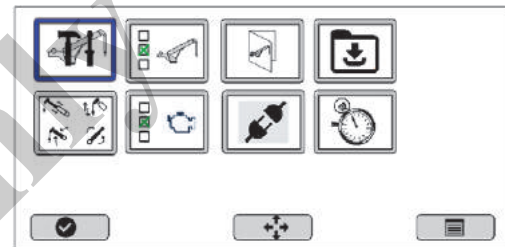
The Tools screen appears.

- Press highlight the Calibration icon and press the OK function key.

The Password screen appears.

- Enter the password: 12331 and press OK function key. For more information, see “Entering the System Configuration Password” on page 3-11.

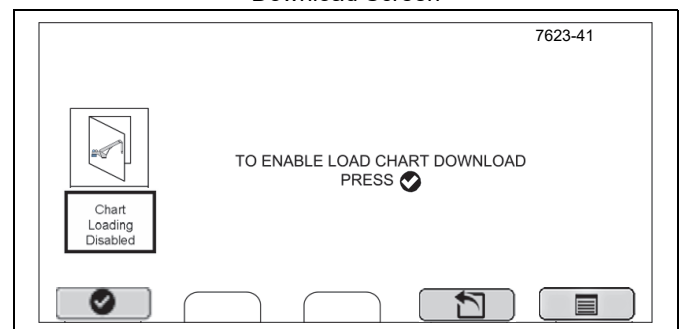
The System Configuration screen appears.



- Highlight key 3 (use directional arrow key to scroll) and press the OK function key.

The Chart Download screen appears.

Download Screen



- At the Download Screen, select OK  to start the download from the laptop.

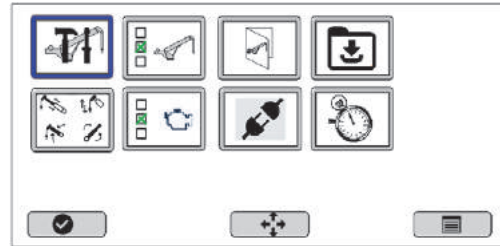
After enabled, the display returns to the sensor calibration menu.

- Enter the password: 12331 and press OK  function key. For more information, see “Entering the System Configuration Password” on page 3-11.

The system configuration menu appears.

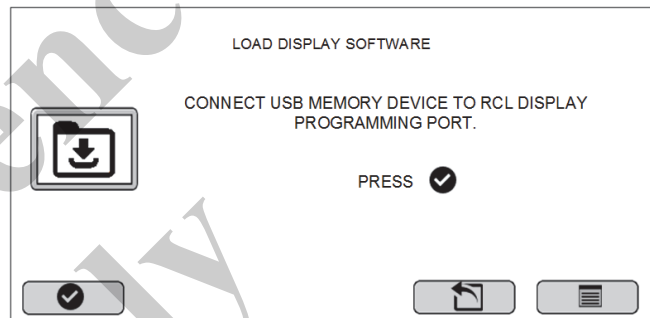
### Uploading the RCL Display Software

Use the following procedure to update the RCL display software. After the software is installed, the RCL system reboots. Contact Manitowoc Crane Care or the National Crane distributor for the required software.



- Highlight the software download icon using the directional arrow key and press the OK  function key.

The Load Display Software screen appears.



- Press the OK  function key to start the software upload.

### Setting System Date and Time

Use the following procedure to set the RCL system Date and Time. Table 3-2 shows the functional keys available in the Time Set screen.

Table 3-2 Time Set Functional Keys

Icon	Description
	Use this button to set changes to a field.
	Use this button to cycle (tab) through the fields that can be changed.
	Use this button to increase and decrease the value in the selected field.
	Use this button to return to the System Configuration screen without saving changes.
	Use this button to return to the main menu.

### DANGER

Incorrectly installed RCL software could prevent the RCL from working properly. Overloading the crane could occur resulting in tip over or structural failure. Death or serious injury could occur.

- If not already done, flash the updated RCL software on to a USB flash drive.
- Insert the USB flash drive in the RCL Software port (1, Figure 3-10).




FIGURE 3-10

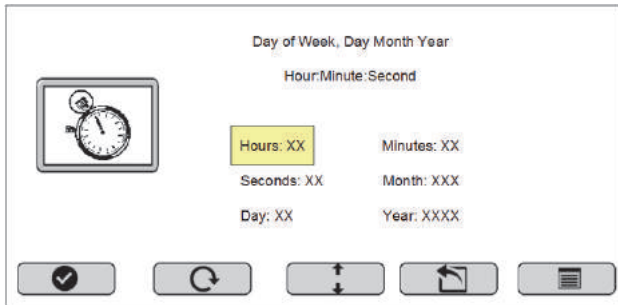
- From the main menu, press Tools.
- Highlight the Calibration icon and press the OK  function key.




The Password entry screen appears.



1. In the System Configuration menu, select the Time Set icon .

The Time Set screen appears.



2. Do the following to update the field(s):
  - Use the cycle button  as needed to tab through the fields available to update.
  - Use the Increment/decrement button  as needed to increase or decrease the value in the highlighted field.
3. Press the Select button  to save changes.

### CALIBRATING RCL SENSORS


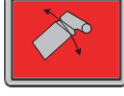




The RCL sensors are located throughout the crane and are used to monitor the lifting parameters set by the crane operator.


When a sensor requires calibration, the icon appears with a RED background in the RCL. Table 3-3 shows the Sensor Calibration warning icons. The sensors are calibrated at the factory before the crane is delivered, but need to be calibrated in the following circumstances:

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

**NOTE:** Calibration warnings do not appear for all instances when a sensor needs to be calibrated. For example, if a sensor is replaced, moved, or damaged, the sensor should be calibrated, but no warning icon will appear.

Table 3-3 Sensor Calibration Warnings

Icon	Description
	<b>Slew Angle</b> — Indicates that the slew sensor needs to be calibrated.
	<b>Boom Angle</b> — Indicates that the boom angle sensor needs to be calibrated.
	<b>Boom Length</b> — Indicates that the boom length sensor needs to be calibrated.
	<b>Lift Cylinder Rod Pressure Transducer</b> — Indicates that the rod side transducer located on the lift cylinder needs to be calibrated.
	<b>Lift Cylinder Base Pressure Transducer</b> — Indicates that the base side transducer located on the lift cylinder needs to be calibrated.
	<b>Outrigger Sensor</b> — Indicates that the sensors on the outriggers needs to be calibrated.

The calibration reset button  resets all calibrations while in the Calibration screen.

Main Sensor Calibration Menu

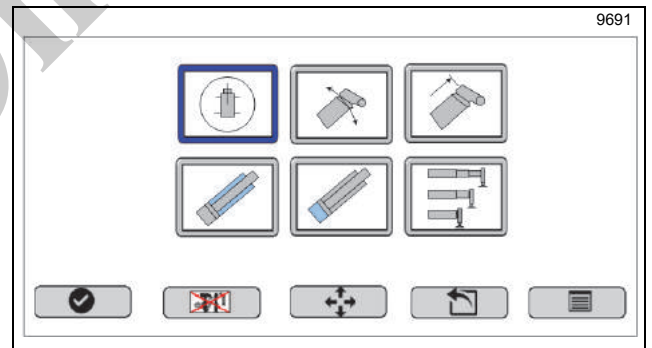


Table 3-4 Sensor Calibration Options

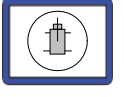
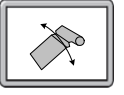
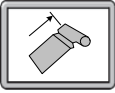
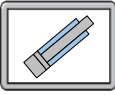
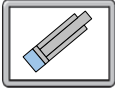
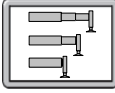
Icon	Description
	<b>Slew Angle</b> — Use this option to calibrate the slew sensor. For more information, see “Calibrating the Slew Sensor” on page 3-14.
	<b>Boom Angle</b> — Use this option to calibrate the boom angle sensor. For more information, see “Calibrating the Boom Angle” on page 3-14.

Table 3-4 Sensor Calibration Options (Continued)

Icon	Description
	<b>Boom Length</b> — Use this option to calibrate the boom length sensor. For more information, see “Calibrating the Boom Length” on page 3-15.
	<b>Lift Cylinder Rod Pressure Transducer</b> — Use this option to calibrate the rod side transducer located on the lift cylinder. For more information, see “Calibrating the Rod and Base Side Pressure Transducers” on page 3-15.
	<b>Lift Cylinder Base Pressure Transducer</b> — Use this option to calibrate the base side transducer located on the lift cylinder. For more information, see “Calibrating the Rod and Base Side Pressure Transducers” on page 3-15.
	<b>Outrigger Sensor</b> — Use this option to calibrate the sensors on the outriggers. For more information, see “Calibrating the Outrigger Span/Length” on page 3-16.




Use the right arrow key to move to the function keys.

Select ESC button  to return to the System Configuration menu screen without deleting any limit values.

A password is required to calibrate a sensor. For more information, see “Entering the System Configuration Password” on page 3-11.

## Accessing the Sensor Calibration Menu

To access the sensor calibration menu:

1. Select key 2, Tools on the Main Menu.  
The Tools Screen appears.
2. Highlight the  icon and press the OK  function key.
3. Enter the System Configuration screen password. For more information, see “Entering the System Configuration Password” on page 3-11.  
The System Configuration screen appears.
4. In the System Configuration menu, highlight and select the Sensor Calibration Menu icon .  
The Sensor Calibration menu appears.

## Calibrating the Slew Sensor

The slew sensor requires calibration in the following circumstances:

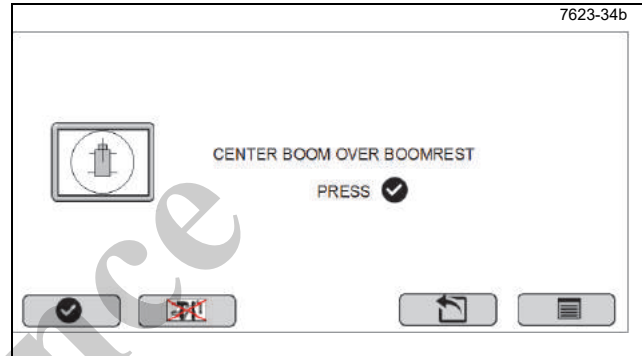
- The slew sensor is repaired or replaced
- The swivel is repaired or replaced
- The RCL display is replaced
- The RCL software is updated


To calibrate the slew sensor:

1. Select 1 from the Main Sensor Calibration Menu screen to begin the slew angle calibration.

The Slew Sensor Calibration screen appears.

### Slew Sensor Calibration



2. Swing the turret with mounted counterweight until the counterweight aligns with the stowage pins on the lower frame.
3. Select the OK  function key from the Slew Sensor Calibration screen.

## Calibrating the Boom Angle

Use the following procedure to calibrate the boom angle. The boom angle sensor requires calibration in the following circumstances:

- Boom angle sensor is repaired or replaced
- Cable is adjusted on the reel
- Cable reel is repaired or replaced
- Boom is repaired or replaced
- The RCL display is replaced
- The RCL software is updated

**NOTE:** The boom angle sensor calibration is not required if the lift cylinder is modified.

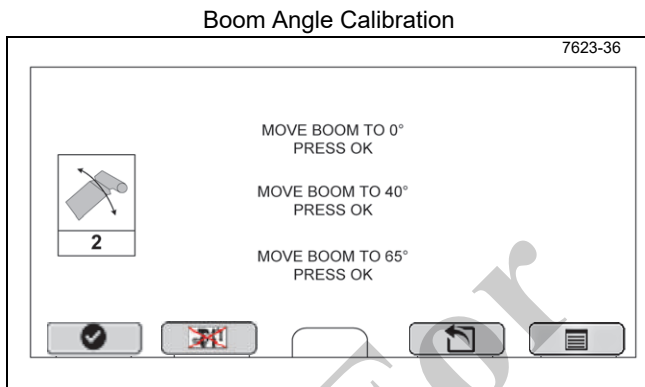
Level and set the truck on outriggers before starting the boom angle calibrate procedure. The boom angle needs to be measured accurately with an inclinometer to do an accurate calibration.

Three calibration positions are shown one at a time starting with the 0° position on the Boom Angle Calibration screen. After OK is pressed for the 0° position, the 40° is activated, and then the 65° boom angle.

If the RCL system determines the sensor is not within the established zero range, an error screen appears. The sensor must then be mechanically zeroed internal to the length angle reel.

1. Level and set the crane on the outriggers.
2. Select 2 on the Main Sensor Calibration Menu screen to start the boom angle calibration.

The Boom Angle Calibration screen appears.



3. Move the boom to the 0° position.
4. Click the OK  function key.
5. Move the boom to the 40° position.
6. Click the OK  function key.
7. Move the boom to the 65° position.
8. Click the OK  function key.

### Calibrating the Boom Length

Use the following procedure to calibrate the boom length sensor. The boom length sensors require calibration in the following circumstances:

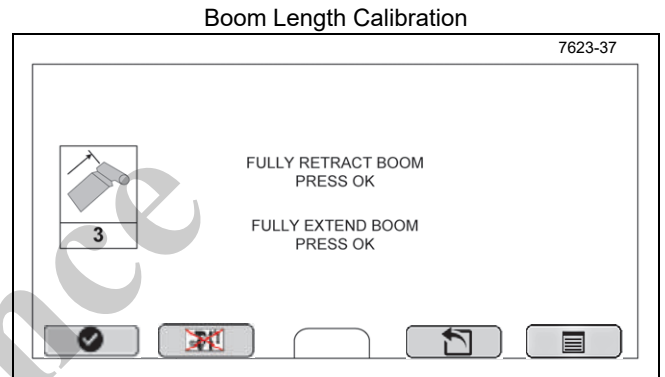
- Boom length sensor is repaired or replaced
- Cable is adjusted on the reel
- Cable reel is repaired or replaced
- Boom is repaired or replaced
- The RCL display is replaced
- The RCL software is updated

**NOTE:** The boom length sensor recalibration is not required if the lift cylinder is modified.

Two calibration positions are shown one at a time starting with the fully retracted position on the Boom Length Calibration screen. After OK is pressed for the fully retracted position, the fully extended position is activated and appears.

1. Level and set the crane on the outriggers.
2. Select 3 from the Main Sensor Calibration Menu screen (13) to start the boom length calibration.

The boom length calibration screen appears.



3. Fully retract the boom.
4. Press the OK  function key.
5. Fully extend the boom.
6. Press the OK  function key.

### Calibrating the Rod and Base Side Pressure Transducers

The following sections describe how to calibrate the rod and base side pressure transducers. The rod and base side pressure transducers are located on the lift cylinder manifold (Figure 3-11). Each transducer must be calibrated to the zero position separately.

The transducers require calibration in the following circumstances:

- When a transducer is replaced
- The RCL display is replaced
- The RCL software is updated



FIGURE 3-11

**Calibrating Rod Side Pressure Transducer**

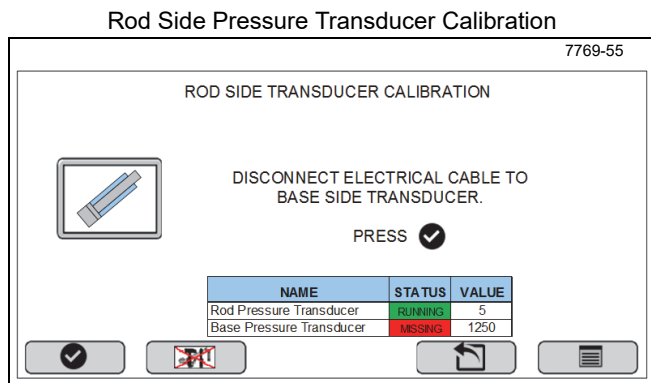
Use the following procedure to calibrate the rod side pressure transducer. To zero the rod side transducer, the base transducer electrical cable must be disconnected.

**NOTE:** There is no need to bleed the pressure at each transducer. Simply follow the instructions and disconnect the appropriate electrical cables as indicated.

To calibrate the rod side pressure transducer:

1. In the Main Sensor Calibration Menu screen, highlight the rod side pressure transducer icon.
2. Press the OK  function key.

The Rod Side Transducer Calibration screen appears.



3. Disconnect the base side transducer (RCL 1).

4. Press the OK  function key to send a signal to the transducer to re-program and power down.
5. When prompted, reconnect the base transducer to the manifold and press OK to return to the Main Sensor Calibration Menu screen (13).

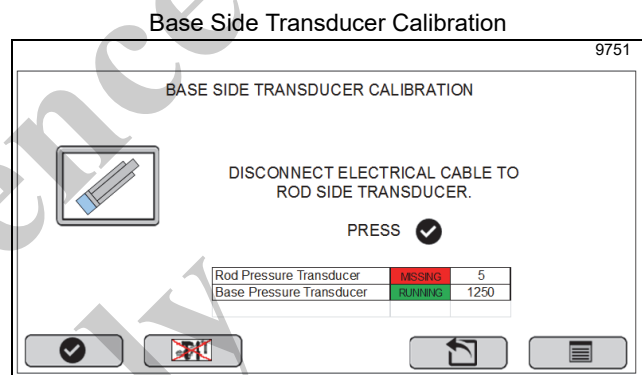
**Calibrating the Base Side Pressure Transducer**

Use the following procedure to calibrate the base side pressure transducer.

To calibrate the base side pressure transducer:

1. In the Main Sensor Calibration Menu screen, highlight the base side pressure transducer icon.
2. Press the OK  function key.

The Base Side Transducer Calibration screen appears.



3. Disconnect the rod side transducer (RCL 2 port).
4. Press the OK  function key to send a signal to the transducer to re-program and power down.
5. When prompted, reconnect the rod side transducer to the lift cylinder manifold.
6. Press the OK  to return to the main sensor calibration screen (13).

**Calibrating the Outrigger Span/Length**

Use the following procedure to calibrate the outrigger span and length. The outrigger sensors require calibration in the following circumstances:

- A sensor is replaced
- An outrigger beam is removed for service
- There is a spooling issue in the potentiometer reel
- The RCL display is replaced
- The RCL software is updated


Calibration positions are shown on the Outrigger Length Sensor Calibration screen one at a time starting with the Fully Retract position. Pressing OK at the activated position automatically activates the next position.

If an error screen appears after OK is pressed, the outrigger sensor for that screen should be checked for proper function and wiring.

See the new error screen to communicate which sensor or sensors need investigation. For more information, see "Viewing the Fault Codes List" on page 3-23.

For information about setting the outriggers, see "Outrigger Setup" in the Operator Guide.





To calibrate the outrigger span/length:

1. In the main sensor screen, highlight the outrigger calibration icon.
2. Press the OK  function key.

The Outrigger Length Sensor Calibration screen appears.

Outrigger Length Sensor Calibration



3. Fully retract (0% position) the outrigger beams.
4. Press the OK  function key.
5. Set the outrigger beams to 50% position (midspan).
6. Press the OK  function key.
7. NTC60L cranes only: extend the outrigger beams to the 75% position.
8. NTC60L cranes only: Press the OK  function key.
9. Fully extend (100% position) the outrigger beams.
10. Press the OK  function key.




### Calibrating the Wind Speed Indicator (If Equipped)

The wind speed indicator is an optional feature and is calibrated at the factory prior to shipment. If calibration is needed, contact Manitowoc Crane Care or your local National Crane distributor.

### COMPONENT ADDRESSING




Table 3-5 shows the component addressing warning icons. These icons may appear after a component is replaced.

Table 3-5 Component Addressing Warnings

Icon	Description
	Outrigger Control Panel(s)—Indicates that the outrigger control panel(s) need a CAN bus address.
	Counterweight Control Panel(s)—Indicates that the counterweight control panel(s) need a CAN bus address.
	Hoist Module(s)—Indicates that the hoist module(s) need a CAN bus address.

Use the following procedures to address the components shown in Table 3-6.



Table 3-6 Component Addressing

Icon	Description
	Outrigger switches
	Counterweight Switches
	Hoist Modules

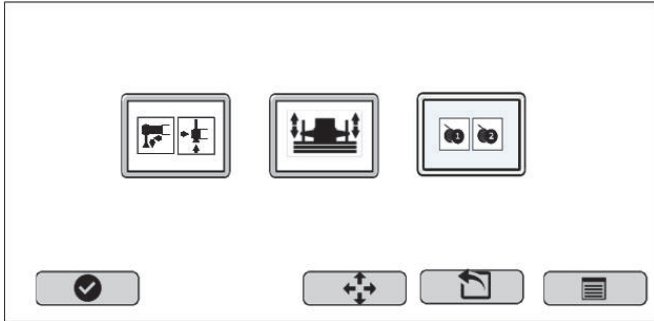
These procedures assign an ID in the CAN bus system for that component. When a component needs a CAN bus address, usually after replacement of a part, the component icon is highlighted in red.

### Accessing the Component Addressing Screen

Use the following procedure to access the Component Addressing screen.



1. Access the System Configuration screen.
2. Highlight the Component Addressing icon  and press the OK  function key.

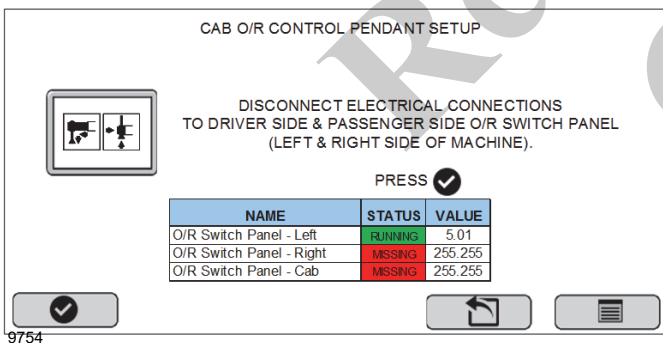
The Component Addressing Screen appears.







### Assigning CAN Bus ID to Outrigger Control Panels

Use the following procedure to assigning a CAN bus address to the outrigger control panels located in the crane cab and left and right sides of the decking. This procedure is required any time an outrigger control panel is replaced.

1. Access the Component Addressing screen.  
The Component Addressing screen appears.
2. Highlight the Outrigger control panel keypad icon  and press the OK  function key.  
The Outrigger Control Panel screen appears.



3. When prompted, disconnect the electrical connections to the driver and passenger side outrigger control panels. Press the OK  function key.
4. Reconnect the passenger side (right) outrigger control panel. press the OK  function key.
5. Reconnect the driver side (left) outrigger control panel. press the OK  function key.
6. Press the OK  function key to complete the procedure.

### Assigning CAN Bus ID to Counterweight Control Panels

The following sections describe how to calibrate the Counterweight (CWT) control panels.

The left (driver side) CWT control panel is located on the superstructure above the air conditioner (Figure 3-12). Access the control panel electrical connectors through the superstructure gusset.

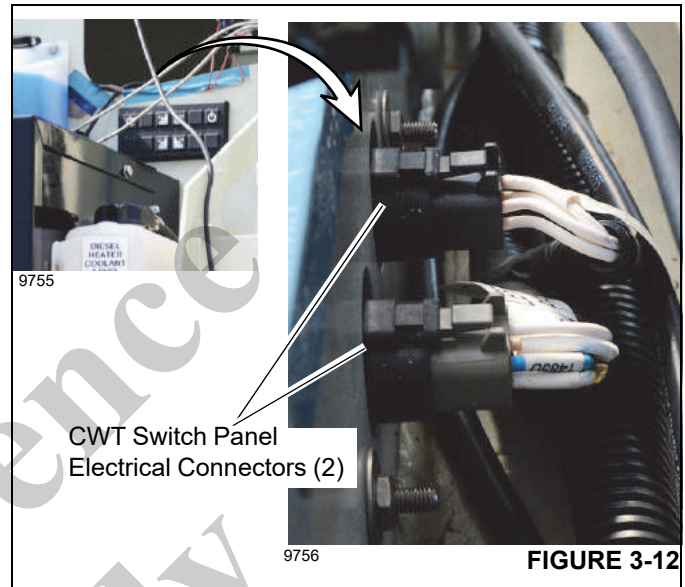


FIGURE 3-12

The right side (passenger's side) CWT control panel is located on the valve cover behind the hydraulic tank (Figure 3-13). The valve cover must be removed to access and disconnect the CWT control panel.

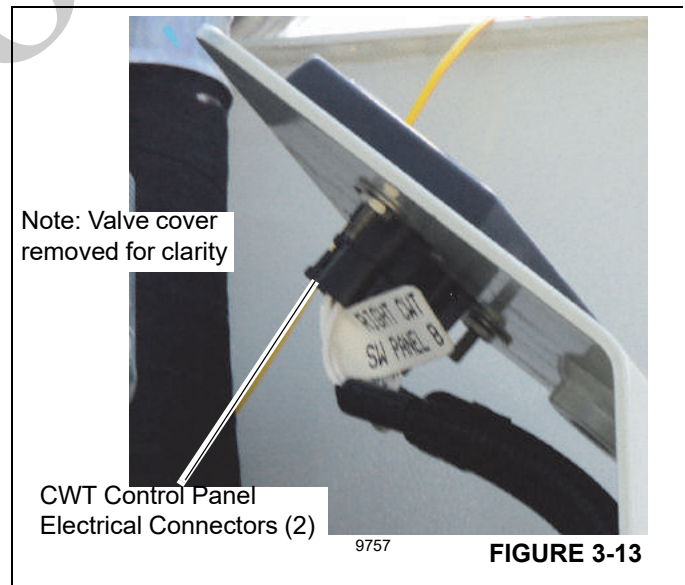
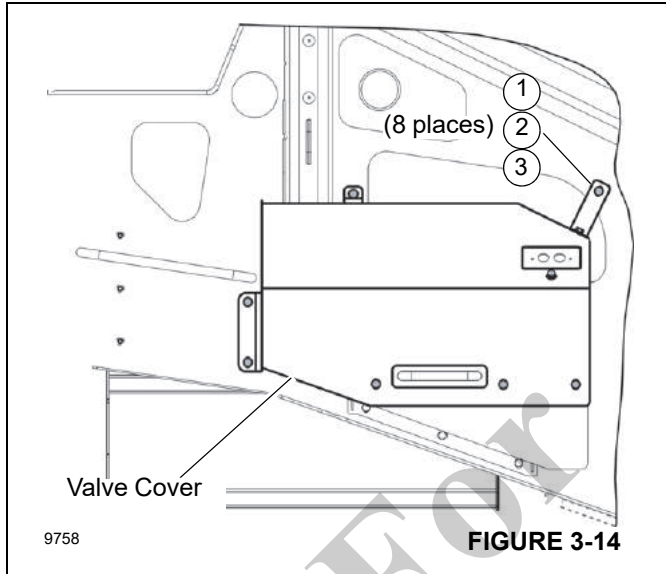


FIGURE 3-13

To calibrate the CWT control panels:



**NOTE:** The valve cover weights approximately 6.8 kg (15 lbs).

1. Remove capscrews (1, Figure 3-14), lock washers (2), washers (3), and the valve cover.

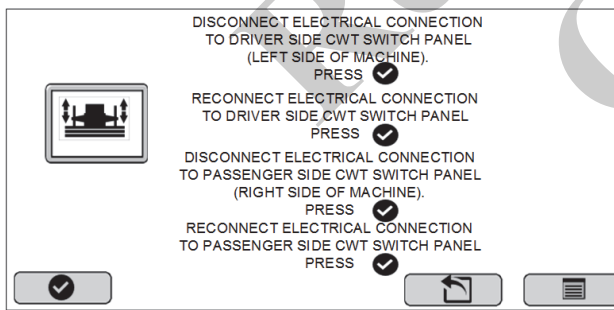


2. Access the Component Addressing screen. For more information, see “Accessing the Component Addressing Screen” on page 3-17.

The Component Addressing screen appears.

3. Highlight the Counterweight control panel icon  and press the OK  function key.

The Counterweight Control Panel screen appears.

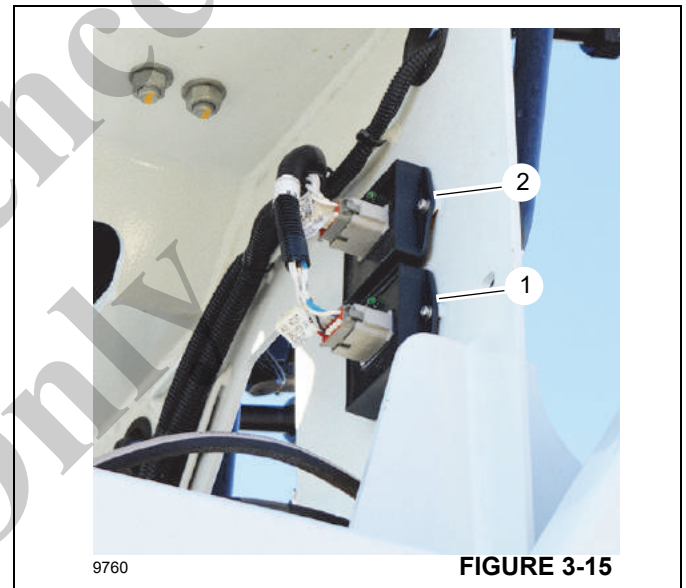


4. Confirm that you have disconnected the proper electrical connections and follow the instructions as they appear on the screen.
5. When calibration is complete, install the valve cover using washers (3, Figure 3-14), lockwashers (2), and capscrews (1).

### Assigning CAN Bus ID to Hoist Module(s)

Use the following procedure to assign a CAN bus ID to the hoist module(s). If equipped, the auxiliary hoist module (1, Figure 3-15) must be disconnected before the main hoist module (2) can be assigned a CAN bus ID. Similarly, the main hoist module must be disconnected before an address is assigned to the auxiliary hoist, if equipped.

The hoist module connectors are located inside the superstructure below the hoists. The rear cover of the superstructure should be removed to access the hoist modules.



You will need to recalibrate the hoist module(s) after a hoist is replaced.

**NOTE:** The auxiliary hoist is displayed only if equipped.

To assign a CAN bus ID to the hoist module(s):

1. Remove capscrews (1, Figure 3-16), lockwashers (2), washers (3), retaining nuts (4), and the superstructure rear cover (5).

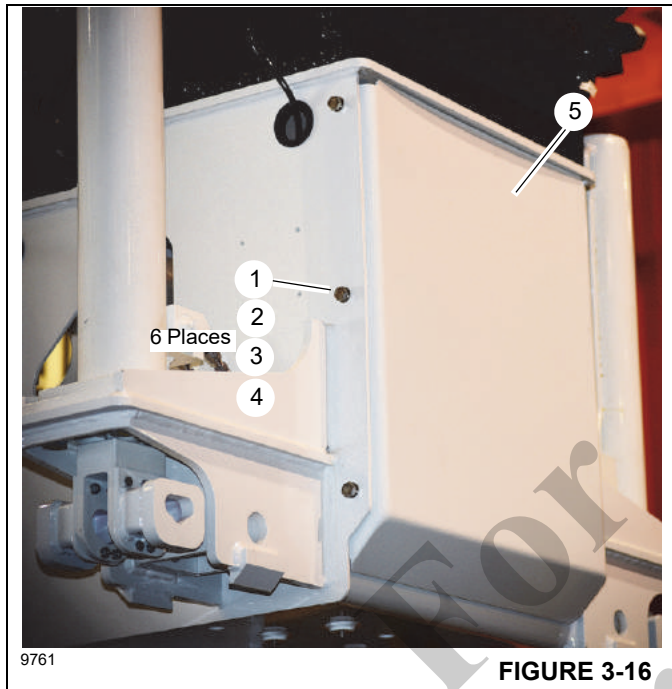




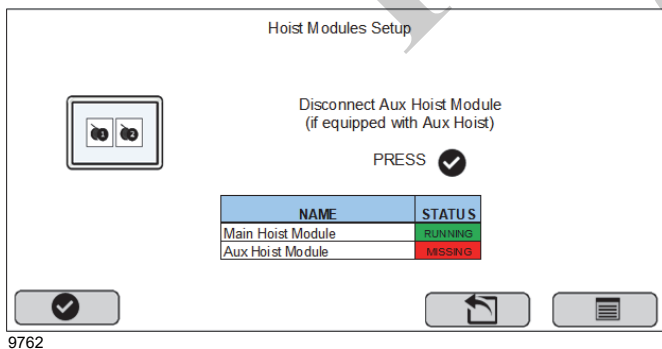
FIGURE 3-16



2. Access the Component Addressing screen. For more information, see “Accessing the Component Addressing Screen” on page 3-17.


The Component Addressing screen appears.

3. Highlight the hoist module icon  and press the OK  function key.

The Hoist Modules Setup screen appears.



4. If equipped, disconnect the auxiliary hoist module (1, Figure 3-15) and press the OK  function key.
5. If equipped with an auxiliary hoist, connect the auxiliary hoist (1) and disconnect the main hoist module (2).
6. Press the OK  function key.

7. When complete, press the OK  function key to return to the component addressing screen.
8. Reconnect the main hoist module (2).
9. Install the superstructure rear cover (5, Figure 3-16) using capscrews (1), lockwashers (2), washer (3), and retaining nuts (4).

## DIAGNOSTICS

The Diagnostics Menu screen contains crane and truck operating information and warnings, an hour meter, and fault code displays.

### About the Diagnostics Screen

Machine information/warnings display in upper left hand corner of the Diagnostics Menu screen.

Table 3-7 shows the navigation buttons on the bottom of the Diagnostics screen. Use the function key to use the appropriate function key to navigate to the next screen.

Table 3-7 Diagnostics Navigation Keys





Icon	Key	Description
	Button #1	Navigates to Diagnostic Screen 2 (Fault Codes) when pressed.
	Button #2	Navigates to real-time Input/Output (I/O) screen when pressed.
	Button #4	Appears only when a valid crane configuration has been entered and navigates to RCL Operating Mode Screen.
	Button #5	Navigates to Main Screen when pressed.

Table 3-8 describes the icons and data that populate the Diagnostics screen.

Table 3-8 Diagnostics Screen Icons



	<b>Truck Engine RPM</b> — Shows the current engine RPM.
	<b>Truck Diesel Fuel Level</b> — The truck diesel fuel level is displayed as a percentage of maximum fuel level. If the truck diesel fuel level drops below 20% of maximum capacity, the general warning light is shown on the operating mode screen and the truck diesel fuel level icon is highlighted YELLOW on the diagnostics screen. GRAY if not supported.



Table 3-8 Diagnostics Screen Icons (Continued)

	<b>Hydraulic Oil Temp</b> — If the hydraulic oil temperature rises above 180°F, the general warning light is shown on the operating mode screen and this icon is highlighted RED. Fahrenheit is default value.
	<b>Crane Hour Meter</b> — Real-time clock is on anytime the crane is operating. The time is saved when crane is shutdown.
	<b>Battery Voltage</b> — If the truck battery voltage drops below 10.5 Volts, the general warning light is shown on the operating mode screen and the truck battery voltage icon is highlighted RED on the diagnostics screen.
	<b>Engine Water Temperature</b> — If the engine water temperature rises above 220°F the general warning light is shown on the operating mode screen and this icon is highlighted RED. Fahrenheit is default value.
	<b>Engine Stop Lamp</b> — If an engine error is detected the icon is highlighted RED.
	<b>Engine Warning Lamp</b> — If an engine warning is detected the icon is highlighted YELLOW.
	<b>Truck Regeneration Needed</b> — When the truck is in need of regeneration (first stage and all subsequent stages), the general warning light is shown on the operating mode screen and the truck diesel particulate filter icon is highlighted YELLOW on the diagnostics screen. Gray if not supported.
	<b>Module Fault</b> — Turns RED when any lower module is missing.
	<b>Engine Oil Pressure Warning</b> — If the truck engine oil pressure drops below 5 psi, the general warning light is shown on the operating mode screen and the truck engine oil pressure icon is highlighted RED on the diagnostics screen.

Table 3-8 Diagnostics Screen Icons (Continued)

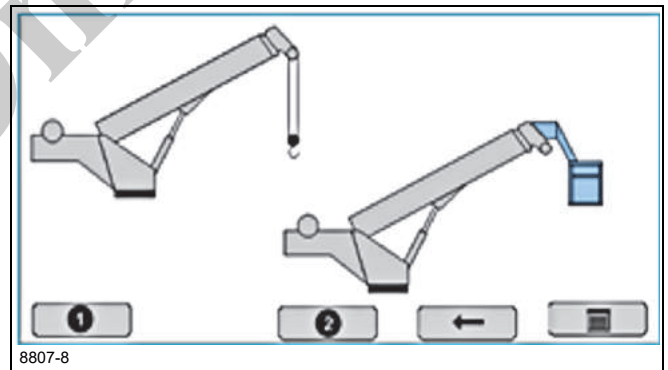
	<b>Engine Oil Temperature</b> — If the truck engine oil temperature rises above 250°F, the general warning light is shown on the operating mode screen and the truck engine oil temperature icon is highlighted RED on the diagnostics screen. Temperature is displayed in degrees Fahrenheit (default value).
	<b>Hydraulic Filter Reminder Warning</b> — If the hydraulic filter reminder limit has been reached, the general warning light is shown on the operating mode screen and the hydraulic filter reminder icon is highlighted RED on the diagnostics screen.  The hydraulic filter time reminder can be configured. For more information, see <i>Setting up the Hydraulic Filter Reminder</i> in the Operator Manual.
	<b>Suction Shut-off Valve is Closed</b> — Turns RED when valve closes Crane cannot function = ESTOP


3

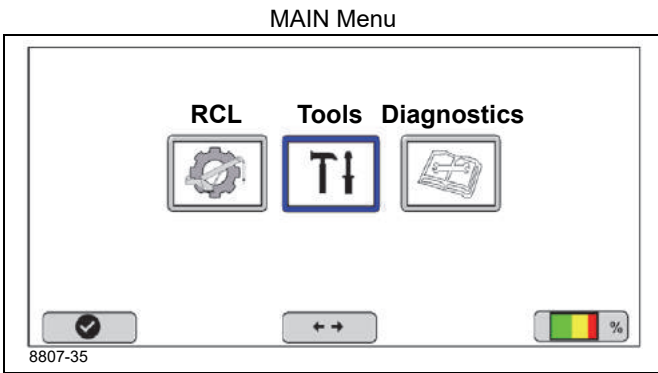
**Accessing the Diagnostics Menu**

To get to the Diagnostics Menu screen, turn on the crane ignition switch and use the following screens.

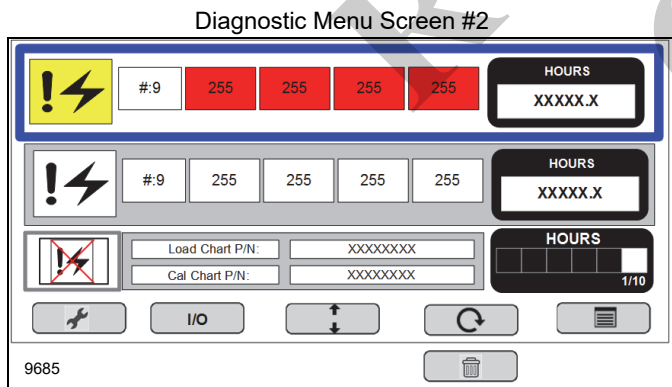
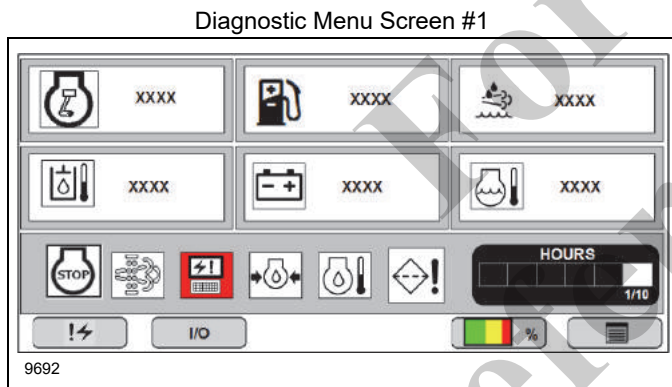
Screen 1



1. Select function key 5: the Main Menu function key  takes you to the Main Menu.



2. Select function key, Diagnostics.  
The Diagnostics menu appears.



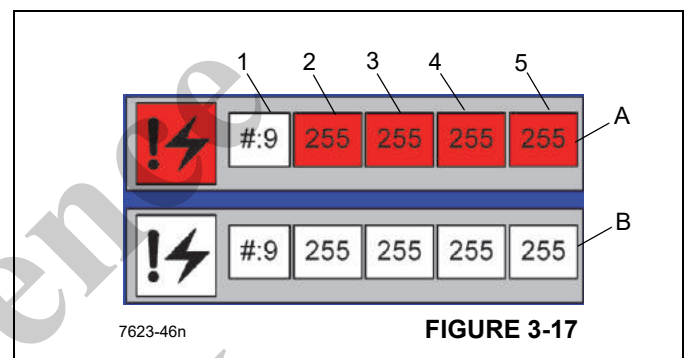
**About Faults and Real-Time I/O Diagnostics**

Figure 3-17 shows active and logged faults. The crane control system displays up to 20 of the most recent logged faults or errors in the crane and RCL control system(s). The

circular arrows can be used to scroll through the active faults. This series of numbers corresponds to a specific fault for a specific module, connector, and pin. To clear the logged fault codes, the button with the fault code icon and red “X” can be pressed.

Definitions of fault codes are available on the Manitowoc Diagnostics Code Application. Enter the fault code in the application to retrieve the definition. For more information, see “About the Manitowoc Diagnostic Code Application” on page 3-23.

The real-time I/O Diagnostics screens feature detailed information about the status of crane components. For more information, see “Viewing Real-Time I/O Diagnostics Screens” on page 3-23.









**FIGURE 3-17**

The following describes the fault code screen (Figure 3-17):

- Active Fault Box (Red, A, Figure 3-17) — The crane control system displays up to 20 active faults or errors in the crane and RCL control system(s). Fault numbers show only when the fault occurs and clears when fault is corrected. The three digit numbers correspond to a specific fault for a specific module, connector, and pin. The following data make up the fault code:
  - 1 — # Block — Indicates the number of the active fault already in the control system, use the arrow keys to scroll. Numbers are 1 through 20 with maximum of 20 faults.
  - 2 — Device Number
  - 3 — Group Number
  - 4 — Index
  - 5 — Error Number
- Logged Fault Box (B, Figure 3-17) — Logged faults are not currently active. Use the up/down arrows to scroll through the codes.

Table 3-9 shows the navigation icons on the active alerts screen.


**Table 3-9 Fault Screen Navigation Buttons**

Icon	Description
	Press the UP/Down button to highlight the Logged Fault Code Box.
	Press the circular arrow button (#3) to scroll through the faults for either the “Active” or “Logged” faults.
	Button #4 changes to “delete” when the clear log icon is selected.
	Button #2 navigates to real-time I/O screen when pressed.
	Press button (#5) to navigate to the Main Menu.
	Press button (#1) to navigate to the Diagnostic Screen #1.

**Viewing the Fault Codes List**

Access the list of fault codes (diagnostics screen #2) from the Diagnostics menu. Use the directional button to scroll through the list of faults.

To access the fault codes menu:

1. Press the  function key.
2. Use the directional key as needed to scroll through the fault codes.


**Viewing Real-Time I/O Diagnostics Screens**

Use the following procedure to view the real-time Input/Output (I/O) diagnostics screens. Use the directional button to scroll through the following I/O status screens:

- Module Status
- CAN Status
- ESTOP Status

- RCL Status
- RCL Master Inputs
- RCL Master Outputs
- RCL Display Inputs
- RCL Display Outputs
- Remotes Module
- Throttle Module Outputs

To view real-time I/O diagnostics:

1. Navigate to the Diagnostics Menu. See “Accessing the Diagnostics Menu” on page 3-21.
2. Press the I/O  function key.  
The Real-time Diagnostics screen appears.
3. Use the directional button to scroll through the real-time I/O screens.

**About the Manitowoc Diagnostic Code Application**

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

**NOTE:** The Manitowoc Diagnostic Code Application is updated regularly. Some of the screens shown in this section may appear different in the application.

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

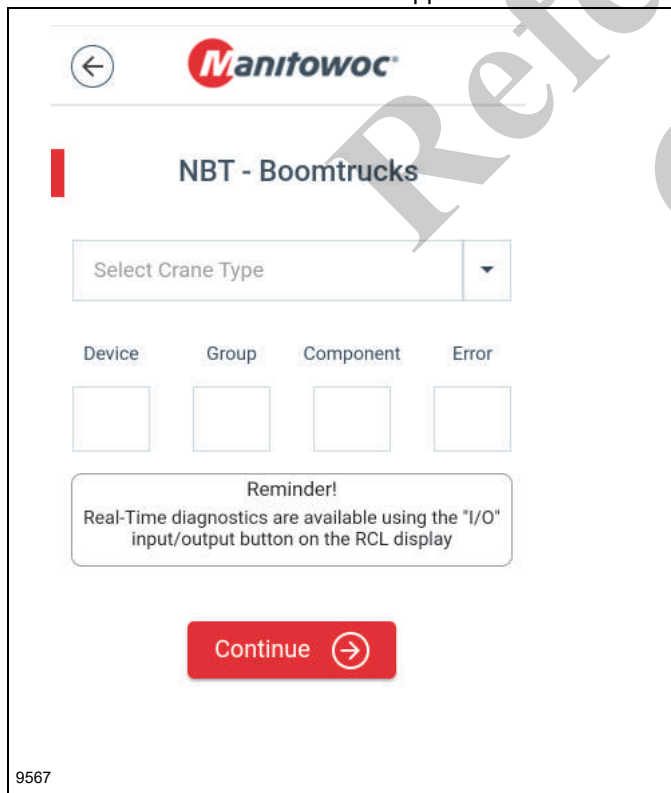
1. Find the fault code you want to research in the RCL diagnostics screen. For more information, see “About Faults and Real-Time I/O Diagnostics” on page 3-22.
2. Open the Manitowoc Diagnostics Code Application on your smart device.

The Diagnostic Code Application splash screen appears.



3. Click NBT.

The NBT - Boomtrucks screen appears.

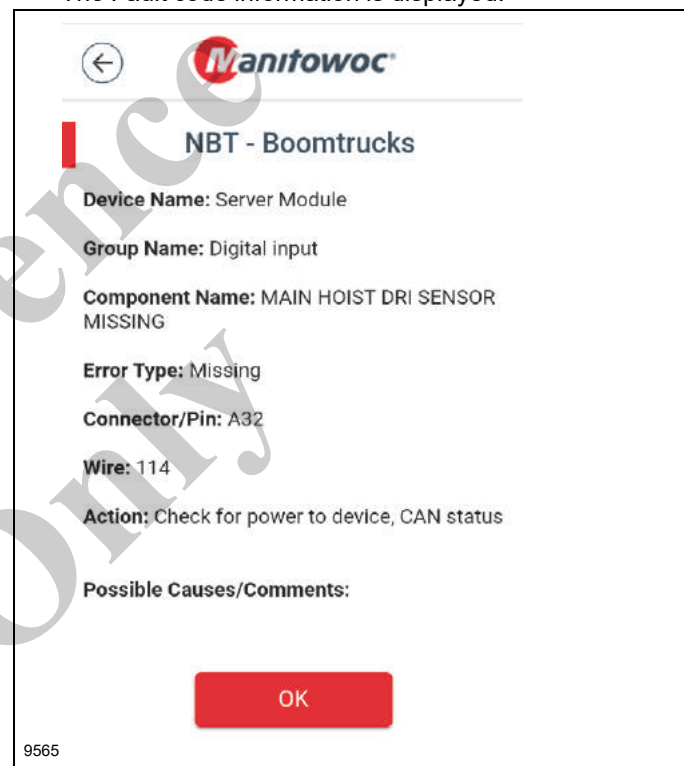


4. Complete the following using information from the error code displayed on the RCL:

- Select Crane Type—Select the NBT crane type from the dropdown list.
- Device—Enter the device number from the fault code.
- Group—Enter the group information from the fault code.
- Component—Enter the component information from the fault code.
- Error—Enter the number information from the fault code.

5. Click Continue.

The Fault code information is displayed.



6. Click OK to return to the main screen.

## SECTION 4 BOOM MAINTENANCE

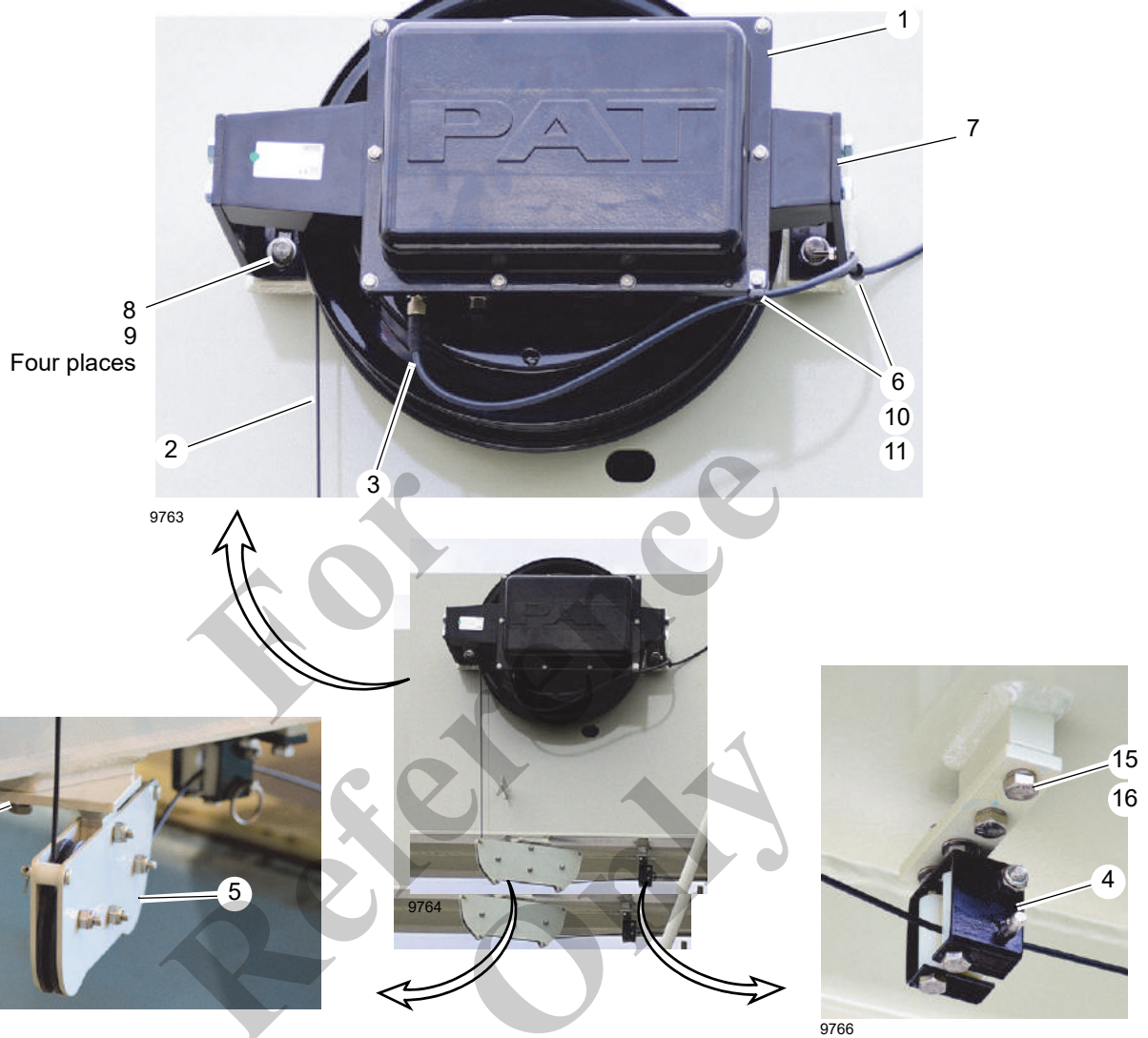
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### RCL CABLE REEL

The RCL cable reel (1, Figure 4-1) is located on the left side of the boom. The reel cable (2) connects the reel to the A2B switch at the end of the boom. The cable is routed through

the inside and runs the length of the boom. The reel assembly connects to the crane CAN Bus network through a connector (3) on the bottom of the reel assembly.



Item	Description
1	RCL Cable Reel
2	Reel Cable
3	CAN Bus Connector
4	Small Roller Guide
5	Sheave Case
6	Clamp
7	Reel Bracket
8	Capscrew

Item	Description
9	Washer
10	Capscrew
11	Washer
12	Washer
13	Lockwasher
14	Capscrew
15	Lockwasher
16	Capscrew

FIGURE 4-1

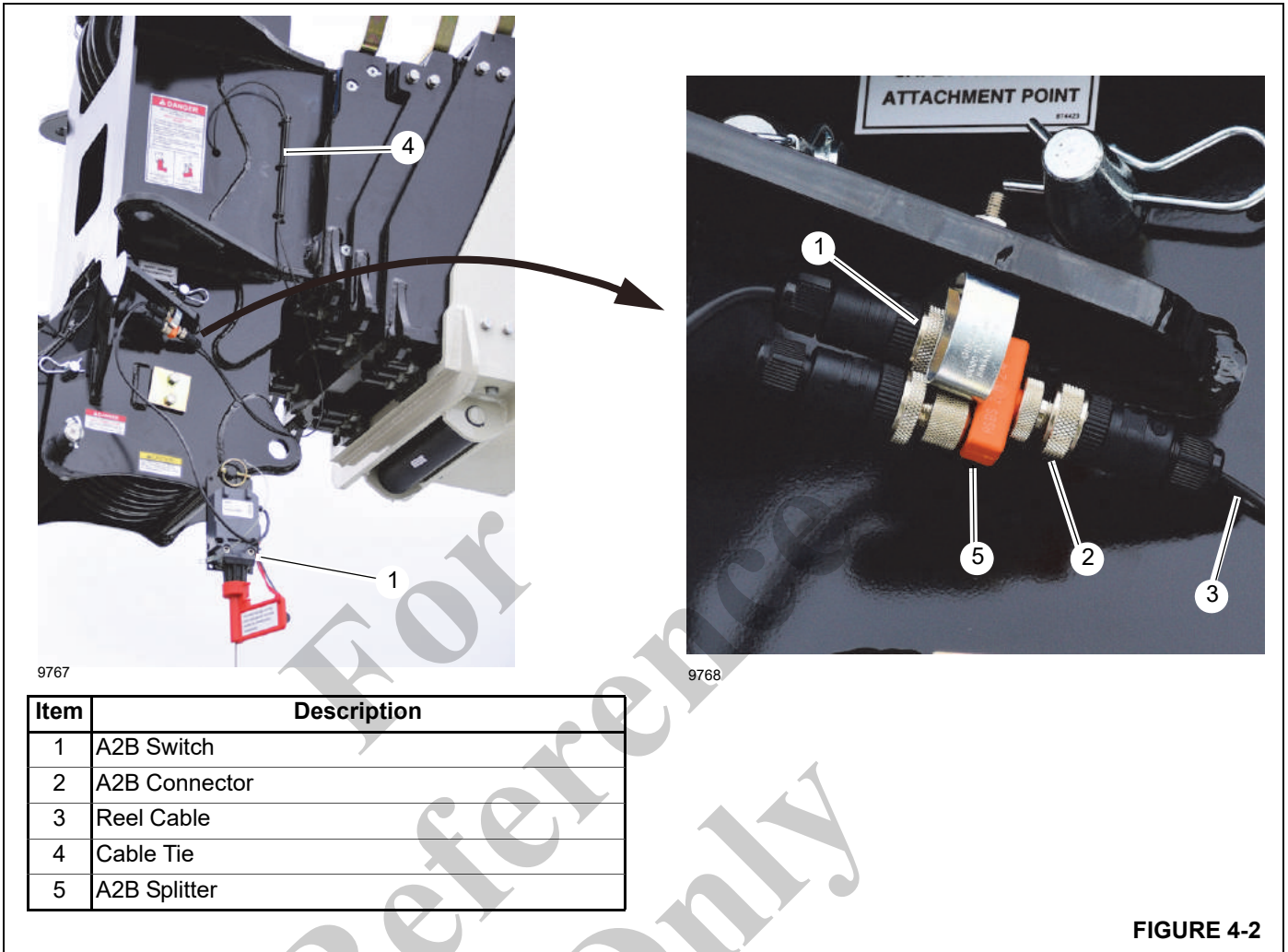


FIGURE 4-2

**Removing the RCL Cable Reel**

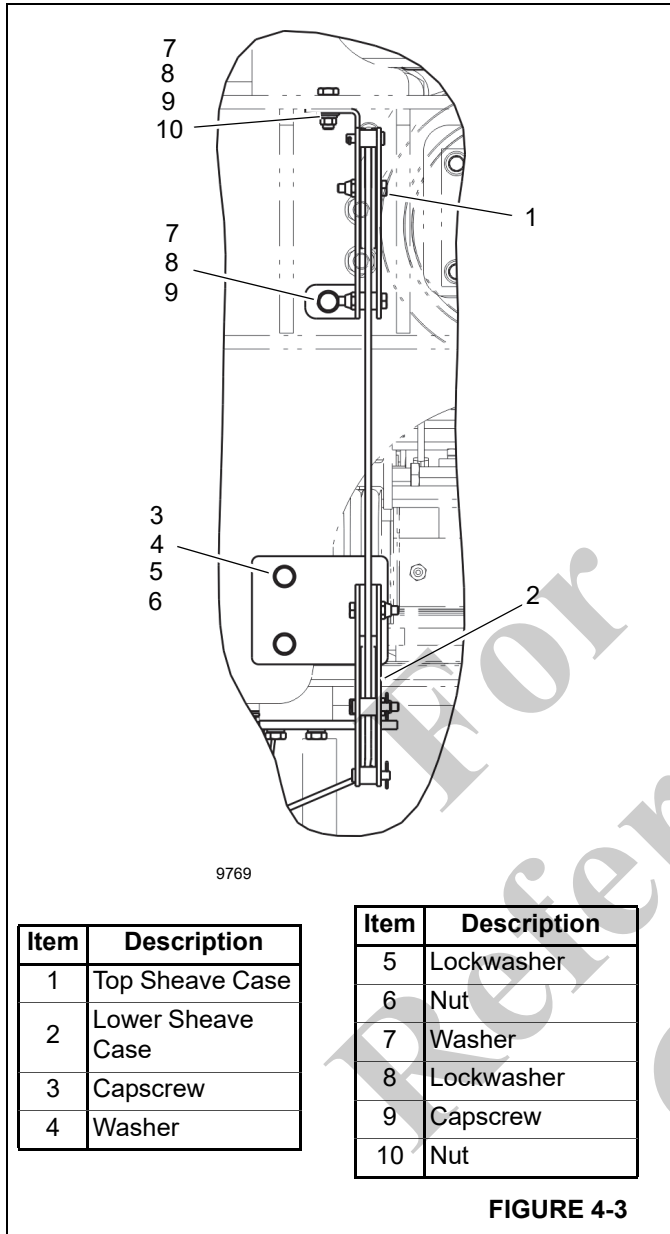
Use the following procedure to remove the reel cable and reel from the boom.

1. If necessary, remove the jib from the boom tip. See the *Operator Manual* for instructions.
2. Disconnect and remove the A2B switch (1, Figure 4-2).
3. Disconnect the cable reel A2B connection (2) from the A2B splitter assembly (5) at the boom tip.
4. Remove the A2B connector from the reel cable (3). Removing the connector from the cable reel enables the reel cable to be retracted through the boom.

5. Remove cable ties (3) that secure the cable to the boom tip.
6. Remove the cable clamp, thimble, spacer, washers, and capscrew inside the boom tip.

**NOTE:** If necessary, remove top access panels to access the reel cable.

7. Remove the reel cable from the boom, including the sheave assemblies. If necessary, gently pull the cable through the hole in the rear of the boom. Allow the cable to fully retract on the cable reel.



### Installing the RCL Cable Reel

Use the following procedure to install the RCL cable and reel on the boom.

1. Install the RCL cable reel (1, Figure 4-1) to the boom using capscrews (8) and washers (9).
2. Connect the RCL CAN Bus connector (3) to the cable reel assembly (1).
3. Secure the RCL CAN Bus cable to the reel bracket using clamps (6), capscrews (10), and washers (11).
4. Install sheave assembly (5) using washers (12), lockwashers (13), and capscrews (14).
5. Install small roller guide assembly (4) using lockwashers (15) and capscrews (16).
6. Install lower sheave assembly (2, Figure 4-3) on the rear of the boom using capscrews (3), washers (4), lockwashers (5), and nuts (6).
7. Install the upper sheave assembly (1) on the rear of the boom using washers (7), lockwashers (8), capscrews (9), and nut (10).
8. Reeve the reel cable through sheaves (5, Figure 4-1 and 1 and 2, Figure 4-3) and roller (4, Figure 4-1) to the rear of the boom.

**NOTE:** If necessary, remove top access panels to access the RCL cable.

9. Attach the end of the reel cable to an extender rod. Insert the cable and extender rod through the hole in the rear of the boom. Push the reel cable through the length of the boom, adding extender rods as needed. Pull the reel cable through the holes in the boom tip until the cable reaches A2B connector.
10. Add the A2B connector (2, Figure 4-2) to the end of the reel cable (3).
11. Connect the reel cable connector (2) to the A2B splitter assembly (5).
12. Secure the cable with the clamp inside the boom tip using spacer, flat washer, thimble, flat washer, and capscrew.
13. Secure the reel cable to the boom with cable ties (4).
14. Calibrate the boom in the RCL software. For more information, see "Calibrating RCL Sensors" on page 3-13.

8. Remove the top sheave case assembly (1, Figure 4-3) at the rear of the boom.
9. Remove the lower sheave case assembly (2) from the rear of the boom.
10. Remove the roller guide assembly (4, Figure 4-1).
11. Remove the sheave case (5).
12. Disconnect the CAN Bus cable (3) from the cable reel.
13. Remove the clamps (6) that secure the CAN Bus cable to the reel bracket (7).
14. Remove capscrews (8), washers (9), and the RCL cable reel assembly (1).

### FIVE SECTION BOOM

The following sections describe the components of the 5 section boom. Figure 4-4 shows an overview of the extend and retract cables in the five section boom.



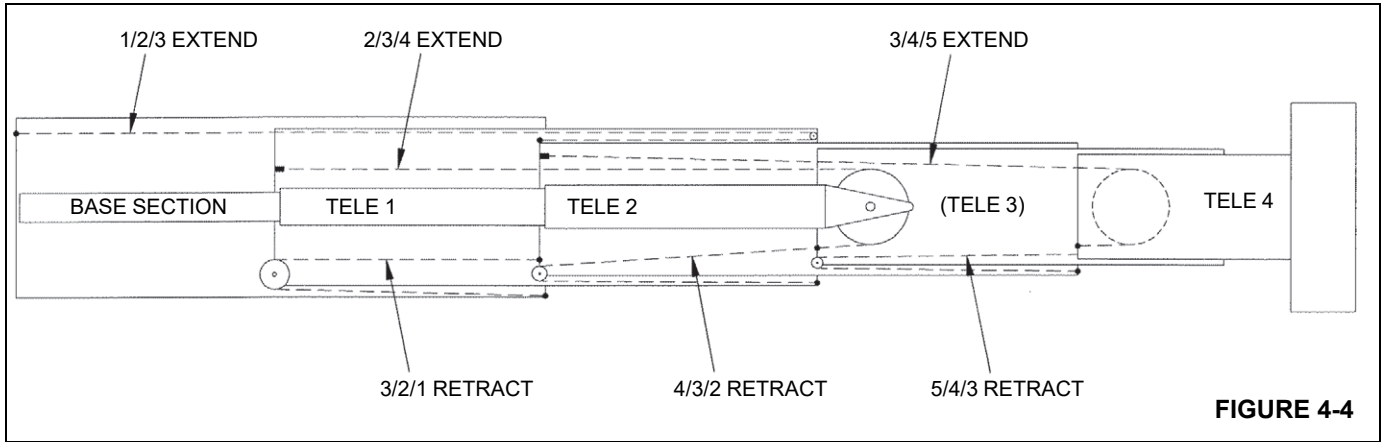


FIGURE 4-4

**Telescope Cylinder**

A two-stage, rod fed, double-acting cylinder (Figure 4-7) supports the Base, Tele 1, and Tele 2 boom sections. The telescope cylinder is attached to the Tele 1 and Tele 2 section booms. The 2/3/4 extend cables are anchored to the Tele 1 and Tele 3 section booms.

**3/4/5 Extend Cables**

The 3/4/5 extend cables (Figure 4-5) attach to the base of the Tele 2 section boom, are reeved around sheaves at the tip of the Tele 3 section boom and attach to the base of the Tele 4 section and support the Tele 4 section boom.

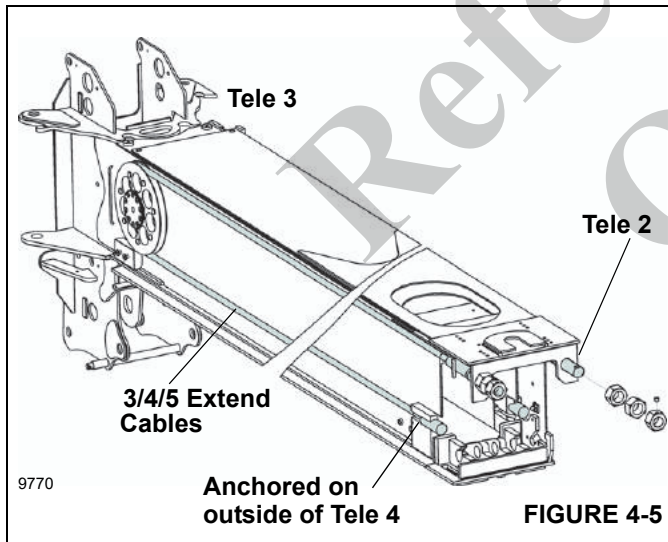


FIGURE 4-5

**5/4/3 Retract Cables**

The 5/4/3 retract cables (Figure 4-6) are attached to the base of the Tele 4 section boom, are reeved around sheaves at the base of the Tele 3 section boom and attach to the tip of the Tele 2 section boom.

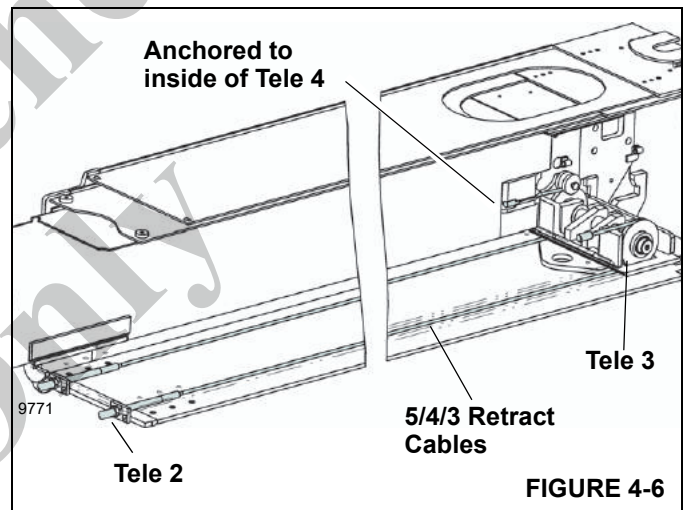
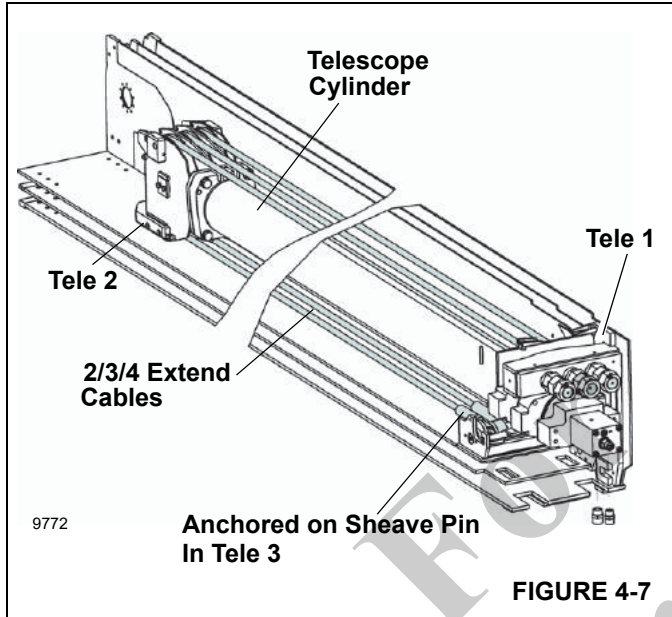


FIGURE 4-6

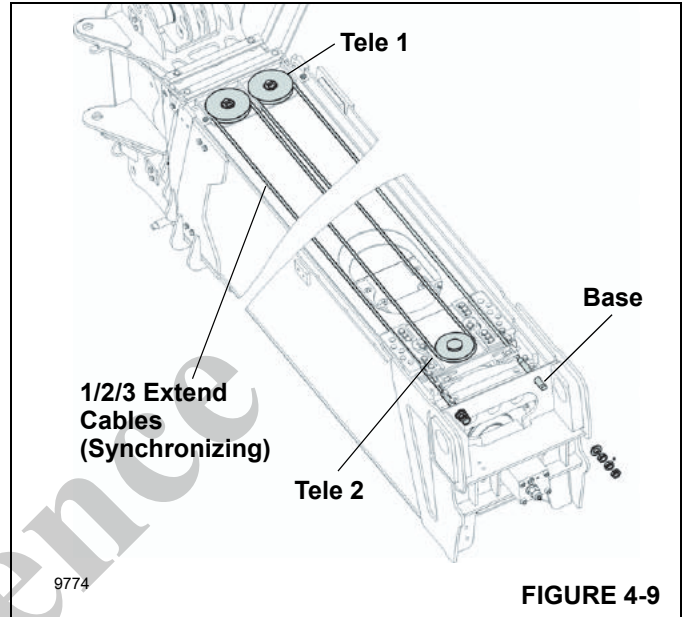
**2/3/4 Extend Cables**

The 2/3/4 extend cables (Figure 4-7) attach to the base of the Tele 1 section boom, are reeved around sheaves at the tip of the Telescope cylinder and attach to the base and support the Tele 3 section boom.



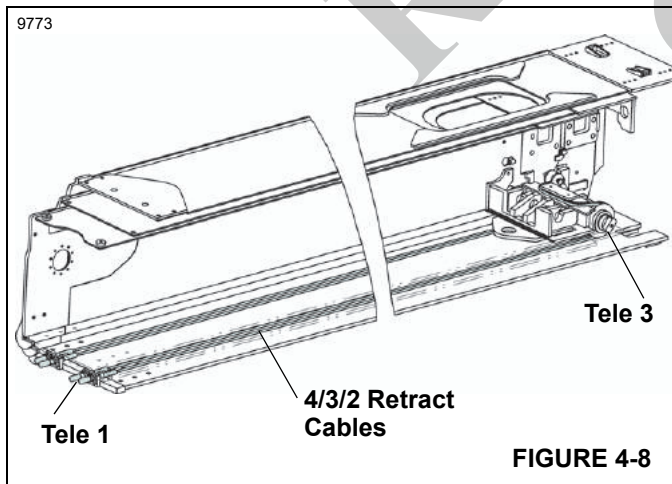
**1/2/3 Extend Cables (Synchronizing Cables)**

The 1/2/3 extend cables (synchronizing cables) (Figure 4-9) attach to the rear of the Base section boom, are reeved around sheaves at the tip of the Tele 1 section boom, and attach to the rear of Tele 2 section boom.



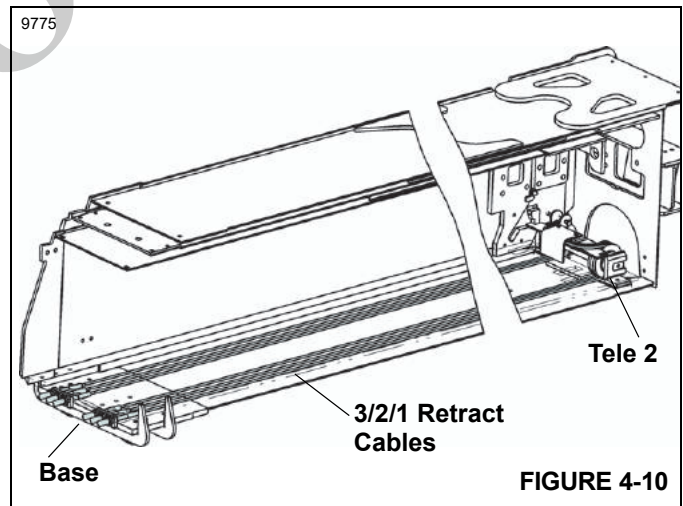
**4/3/2 Retract Cables**

The 4/3/2 retract cables (Figure 4-8) are attached to the base of the Tele 3 section boom, are reeved around sheaves at the base of the Tele 2 section boom and attach to the tip of the Tele 1 section boom.



**3/2/1 Retract Cables**

The 3/2/1 retract cables (Figure 4-10) attach to the rear of the Tele 2 section boom, are reeved around sheaves at the rear of the Tele 1 section boom and attach to the tip of the Base section boom.



The 3/2/1 retract cables (Figure 4-10) directly oppose the synchronizing cables (Figure 4-9) to ensure that the Tele 1 and Tele 2 section booms extend and retract equally at all times.

The 4/3/2 retract cables (Figure 4-8) directly oppose the 2/3/4 extend cables (Figure 4-7) to ensure that the Tele 2 and Tele 3 section booms extend and retract equally at all times.

The 5/4/3 retract cables (Figure 4-6) directly oppose the 3/4/5 extend cables (Figure 4-5) to ensure that the Tele 3 and Tele 4 section booms extend and retract equally at all times.

## Removing the Boom

For Boom weight, see "Specifications" on page 9-39 of this manual.

1. Extend and set machine outriggers and optional single front outrigger, if equipped. Boom must be completely retracted and stowed in boom rest over front of truck.
2. If equipped, remove the boom extension according to procedures outlined in the Set-Up Section of the *Operator Manual*.
3. Remove hook block or downhaul weight, wind up rope on hoist drum and stow wedge socket. Shut down the truck engine.
4. Remove the counterweight(s). Refer to the counterweight removal instructions in the *Operator Manual*.

5. Attach a lifting device to rod end of lift cylinder, remove boom lift cylinder pin keeper and pin from bottom of Base section boom. Lower lift cylinder rod end to the deck.
6. Tag and disconnect extend cylinder lines and hoist hydraulic and electric lines. Cap all openings.
7. Unplug anti-two-block/RCL cord from receptacle in turret.
8. Attach a lifting device to provide even weight distribution and raise the boom until weight is removed from the boom pivot pins. Remove bolts, washers, boom pivot pin keeper and boom pivot pins. Lift boom free of turret.

## Disassembling the Five Section Boom

*For reference, front (tip) is sheave case end, rear (base) is boom pivot end, left and right are viewed from rear to front.*

**NOTE:** All wear pads must be tagged, inspected, and reassembled exactly as they have been removed unless doing a complete overhaul.

**NOTE:** For complete parts breakdown, including part numbers, see the *Manitowoc Crane Care Parts Manual*.

Steps 1 through 3 apply to a boom that is to be disassembled with the Base section (1, Figure 4-11) and jib (if equipped) left on crane.

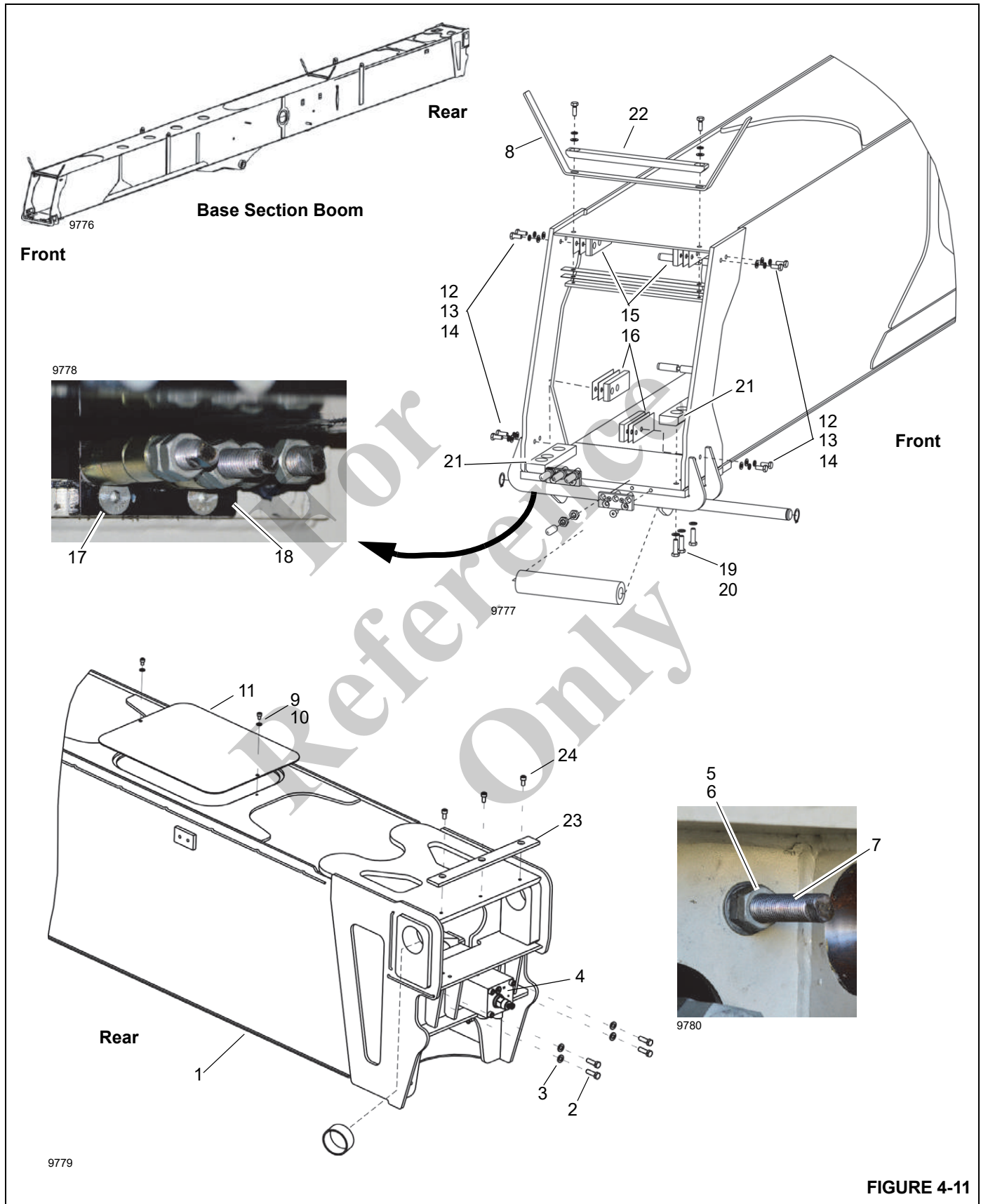


FIGURE 4-11

Table 4-1 Base Section Boom Figure 4-11 Item List

Item	Description
1	Base Section Boom
2	Capscrew
3	Washer
4	Telescope Extend Cylinder
5	Nut
6	Washer
7	Synchronizing Cable
8	Cable Guide
9	Capscrew
10	Washer
11	Access Cover
12	Capscrew
13	Washer
14	Lockwasher
15	Shim
16	Wear Pad
17	Capscrew
18	3/2/1 Retract Cable Anchor
19	Capscrew
20	Washer
21	Wear Pad
22	Wear Pad
23	Wear Pad
24	Capscrew

1. Extend and set the outriggers and optional SFO, if installed.
2. Completely retract the boom and place it in a horizontal position.
3. Tag and disconnect the hydraulic lines to the telescope cylinder. Cap all lines and openings.
4. Remove the RCL reel assembly and sheaves. For more information, see "Removing the RCL Cable Reel" on page 4-3.
5. Remove capscrews (2, Figure 4-11) and washers (3) that attach the telescope extend cylinder (4) to the base section boom (1).
6. Remove nuts (5) and washers (6) from synchronizing cables (7) at the rear of the Base section (1). Mark the

locations of the nuts and washers. Mark and tag the cables while leaving the cable ends draped inside the boom.

7. Remove the attaching hardware, wear pads, and cable guides (8) from the top of all boom sections and store in a secure place.
8. Remove capscrews (9), washers (10), and access cover (11) from the top of the Base section (1).
9. Attach a sling or chain to the tip of the Base section boom and pull the Tele 1 section boom (with the Tele 2, Tele 3, and Tele 4 sections) out approximately 304 mm (12 in) or until the inspection hole on all of the boom sections align to the top wear pad assemblies for all of the boom sections.

**NOTE:** All top wear pads must be tagged, inspected, and reassembled exactly as they have been removed.

10. Through the access hole in the top rear of the Base section boom, remove adjustment screws (56, Figure 4-12) and nuts (57) from the top of Tele 1 section. Remove capscrews (54), washers (55), mounting plates (52), and wear pads (53).
11. Remove and tag capscrews (12, Figure 4-11), washers (13), lockwashers (14), shims (15), and wear pads (16) from the sides of Base section boom (1).
12. Remove four capscrews (17) that retain the 3/2/1 retract cable anchors (18) to the bottom tip of the Base section boom (1).
13. Remove and tag capscrews (19), washers (20), and wear pads (21) from bottom tip of Base section boom. Pull the retract cable anchors (18) out and keep retract cables taut while pulling Tele 1 (with Tele 2, Tele 3, Tele 4) section out of Base section (1). Support the base end of the Tele 1 section as it exits the Base section boom.
14. Place the Tele 1 (with Tele 2, Tele 3 and Tele 4) section on a suitable horizontal surface.

**NOTE:** Use caution not to pinch or crush 3/2/1 retract cables while lifting or supporting Tele 1 section boom.

**Removing Boom Tele Section 1 from Tele Sections 2, 3, and 4**

Use the instructions in this section to the remove Tele 2, 3, and 4 boom sections from Tele 1 section boom (1, Figure 4-12).

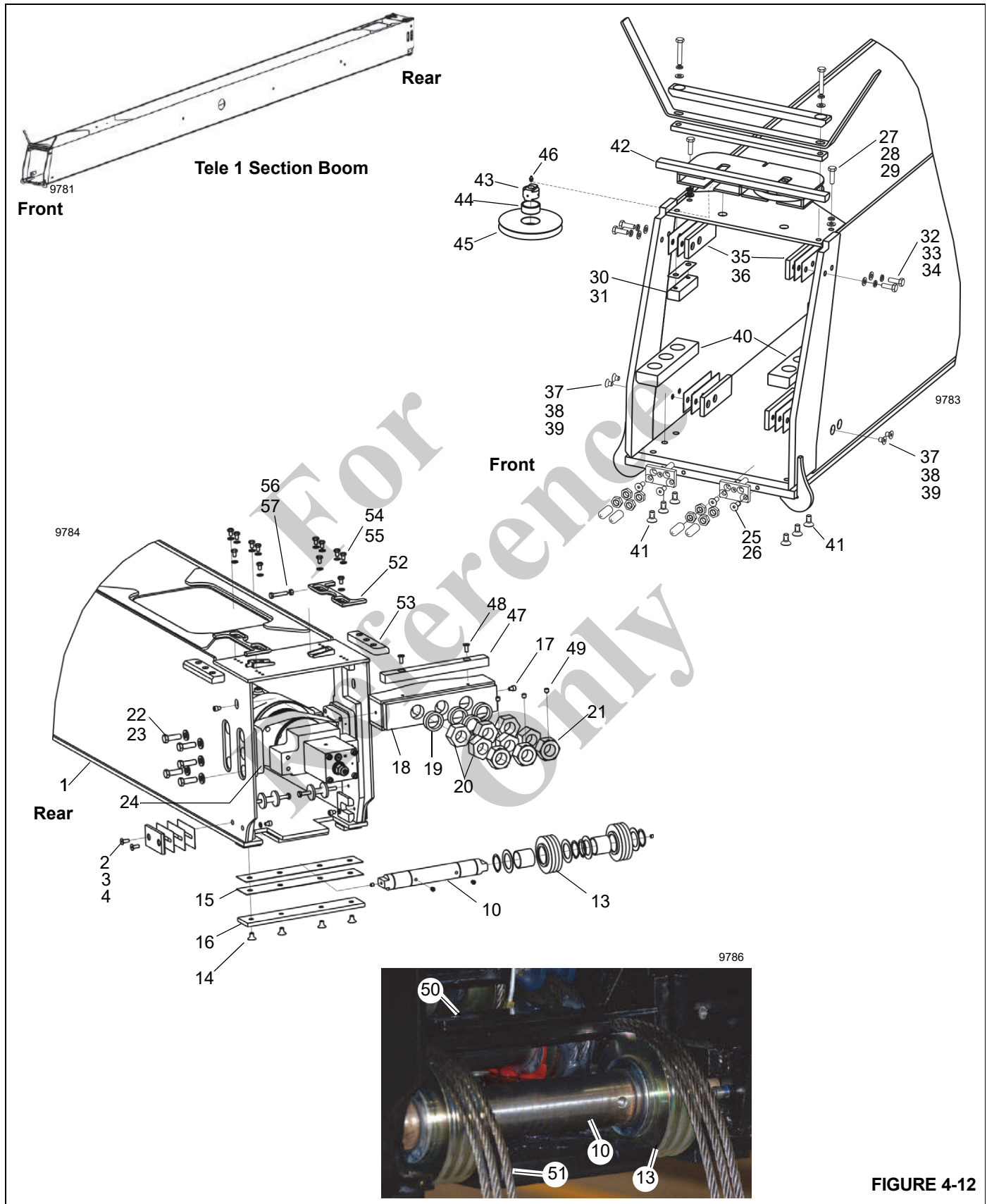
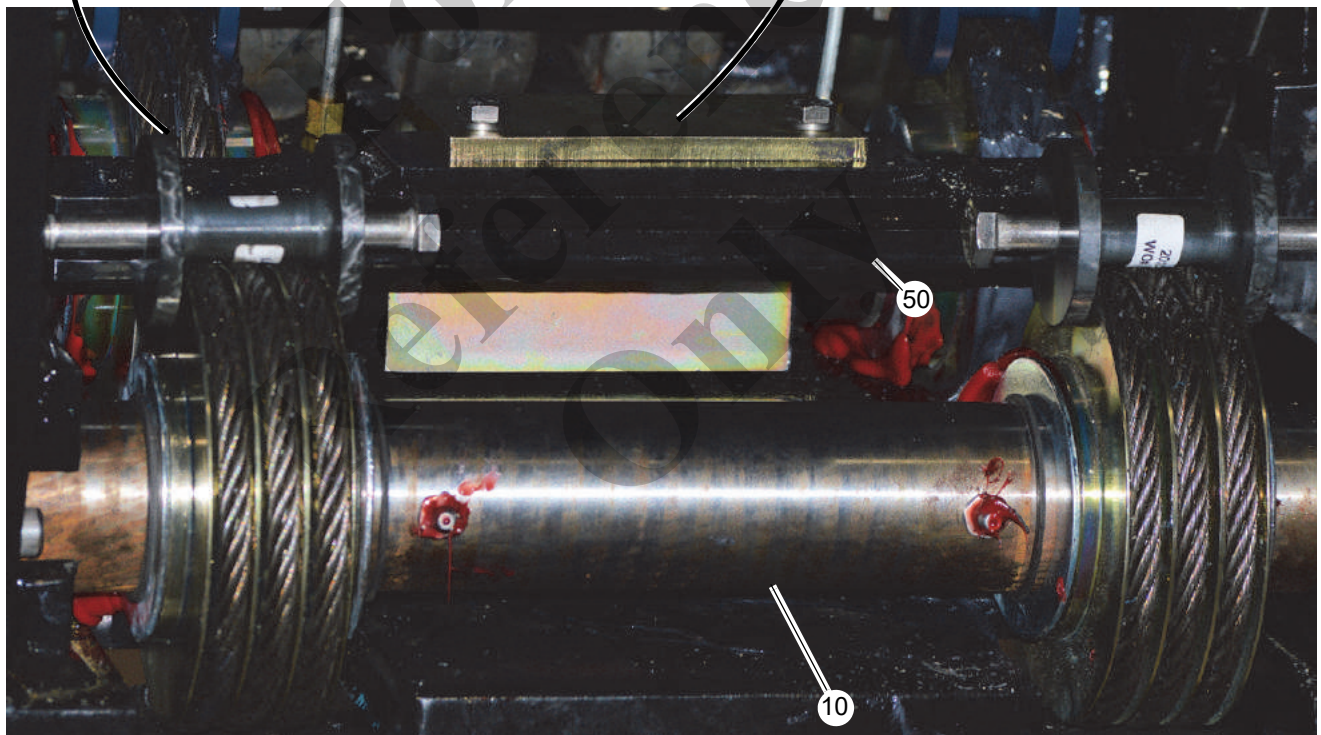
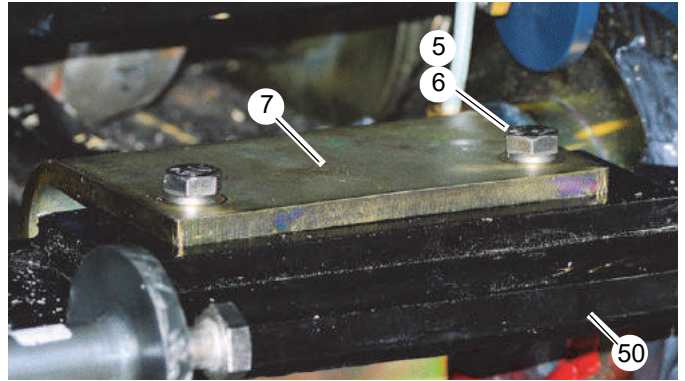
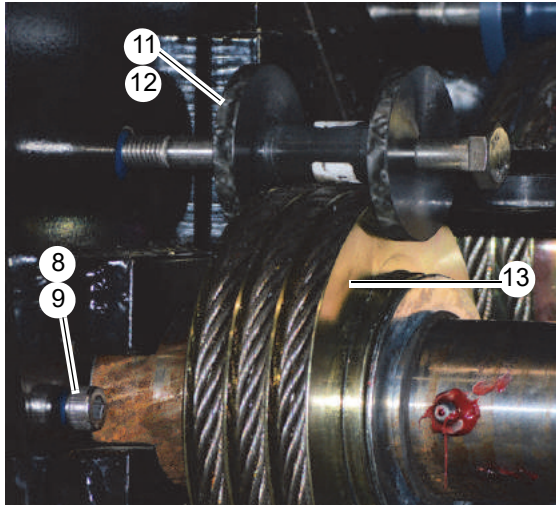


FIGURE 4-12



For illustrations purposes only.  
Your crane may differ.

FIGURE 4-12 continued

Table 4-2 Tele 1 Section Boom Figure 4-12 Item List

Item	Description
1	Tele 1 Section Boom
2	Capscrew
3	Shim
4	Wear Pad
5	Capscrew
6	Lockwasher
7	Cable Retainer Bracket
8	Jam Nut
9	Lockwasher
10	3/2/1 Retract Cable Sheave Pin
11	Capscrew
12	Cable Guide
13	3/2/1 Retract Cable Sheave
14	Capscrew
15	Shim
16	Wear Pad
17	Capscrew
18	Extend Cable Anchor
19	Spacer
20	Hex Nut
21	Nut
22	Capscrew
23	Washer
24	Trunnion Plate
25	Capscrew
26	4/3/2 Retract Cable Retainer
27	Capscrew
28	Washer
29	Lockwasher
30	Shim
31	Wear Pad
32	Capscrew
33	Washer
34	Lockwasher

Table 4-2 Tele 1 Section Boom Figure 4-12 Item List

Item	Description
35	Shim
36	Wear Pad
37	Capscrew
38	Shim
39	Wear Pad
40	Capscrew
41	Wear Pad
42	Synchronizing Cable Sheave Case
43	Sheave Pin
44	Bearing
45	Sheave
46	Grease Fitting
47	Wear Pad
48	Capscrew
49	Set Screw
50	3/2/1 Retract Cable Anchor
51	3/2/1 Retract Cables
52	Mounting Plate
53	Wear Pad
54	Capscrew
55	Washer
56	Adjustment Capscrew
57	Nut

1. Tag and remove capscrews (2), shims (3), and wear pads (4) from the base of Tele 1 section boom (1).
2. Remove two capscrews (5), lockwashers (6), and cable bracket (7).
3. Remove two jam nuts (8) and lockwashers (9) that secure the 3/2/1 retract cable sheave pin (10).
4. Remove capscrews (11) and cable guides (12) from 3/2/1 retract cable sheaves (13).
5. Remove 3/2/1 retract cable anchor (50) with the 3/2/1 retract cable pin (with sheaves) (10) and 3/2/1 retract cables from the rear of the Tele 1 section boom (1).



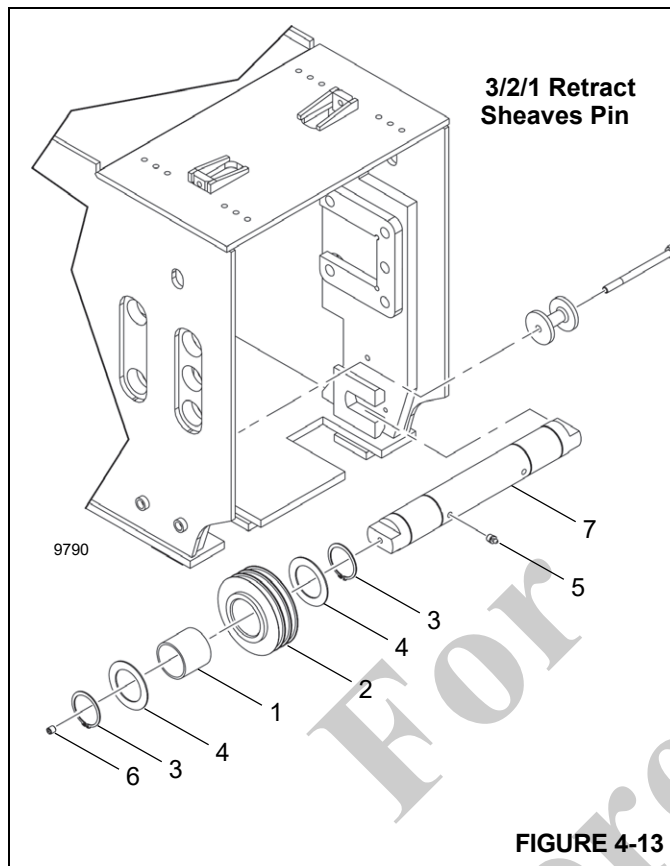


FIGURE 4-13

6. Disassemble the 3/2/1 retract cable pin (7, Figure 4-13) as follows:
  - a. Remove snap rings (3) and washers (4).
  - b. Remove 3/2/1 retract sheaves (2).
  - c. Remove bearings (1) from 3/2/1 retract sheaves.
  - d. Remove plugs (6).
  - e. Remove grease fittings (5).
7. Remove four capscrews (14, Figure 4-12), two shims (15), and wear pad (16) from bottom of Tele 1 section boom (1).
8. Remove sockethead capscrews (17) and extend cable anchor (18). Mark the location of the nuts that secure the 2/3/4 extend cables to the Tele 1 section boom base.
9. Remove nuts (21), hex nuts (20), spacers (19), set screws (49), and extend cable anchor assembly (18) from 2/3/4 extend cables.
10. Remove capscrews (22), washers (23), and trunnion plates (24).
11. Remove capscrews (25) and 4/3/2 retract cable anchors (26) from the front tip of Tele 1 section boom (1).

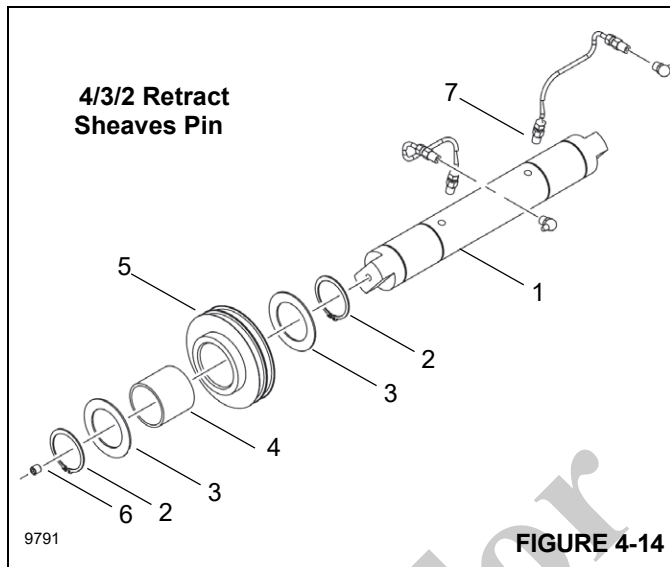
12. Attach a sling or chain to the tip of the Tele 2 section boom. Pull the Tele 2 section boom (with Tele 3 and Tele 4) out approximately 304 mm (12 in).
13. Remove and tag capscrews (27), washers (28), lockwashers (29), shims (30), and wear pads (31) from the top front of the Tele 1 boom section (1).
14. Remove and tag capscrews (32), washers (33), lockwashers (34), shims (35), and wear pads (36) from inside of the front sides of the Tele 1 section boom (1).
15. Remove and tag capscrews (37), shims (38), and wear pads (39) from inside of the front sides of the Tele 1 section boom (1).
16. Remove and tag capscrews (40) and wear pads (41) from inside of the front sides of the Tele 1 boom section (1).
17. Pull the synchronizing cable sheave case assembly (42) out from the top tip of the Tele 1 section boom (1) and let the sheave case and cables rest on the top of Tele 2 section boom.
18. Remove boom sections Tele 2, Tele 3, and Tele 4 from the Tele 1 boom section. Be careful not to damage 4/3/2 retract cables.
19. Place the Tele 2, Tele 3, and Tele 4 section booms on a suitable horizontal surface. Take care not the pinch or crush the retract and extend cables while lifting or supporting the Tele 2 section boom.
20. Remove the synchronizing cable from top of Tele 2 section boom. Slide the center top base sheave (36, Figure 4-16) back and remove. Pull the cable loop forward and remove from sheave keeper. Cable is now free at the rear of boom. Push the two sheaves forward and remove them from the synchronizing cable sheave case (42, Figure 4-12) atop the Tele 2 section boom. The cable loops may now be pulled back out of the sheave case and the synchronizing cable is free. Smooth out any burrs that may be present on the flat ends of the pins to eliminate sheave bearing damage and remove pins from tip sheaves (45).

### Removing Tele 2 Section Boom and Telescope Cylinder

Use the instructions in this section to remove the Tele 2 (1, Figure 4-16) and telescope cylinder (1, Figure 4-17) from Tele 3 and Tele 4.

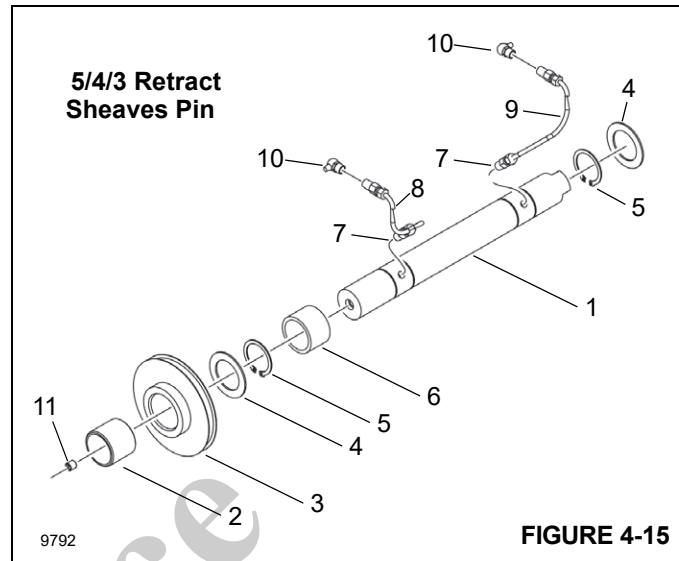
1. Remove capscrews (2, Figure 4-16) and two cable roller guides (3).
2. Remove lubrication tubes (4) and grease fittings (5) from 4/3/2 sheave pin (6) and brackets (7).
3. Remove capscrews (8), shims (9), and wear pads (10) from the bottom of Tele 2 section boom (1).

4. Remove capscrews (11) and wear pad (12).
5. Remove 4/3/2 retract cable retainer (13), sheave pin (with sheaves) (6), and retract cables.



6. Disassemble the 4/3/2 retract sheave pin (1, Figure 4-14) as follows:
  - a. Remove retaining rings (2) and washers (3).
  - b. Remove 4/3/2 retract sheave pins (5)
  - c. Remove bearings (4) from sheaves (3).
  - d. Remove remaining retaining rings (2) and washers (3).
  - e. Remove plugs (6).
  - f. Remove grease fittings (7) as necessary.
7. Remove nuts (16, Figure 4-16), set screws (15), hex nuts (45), and 3/4/5 extend cables (14).
8. Remove capscrews (17) and 5/4/3 retract cable anchors (18) from the front of the Tele 2 section boom.
9. Remove capscrews (38, Figure 4-18) and roller guides (39) from 5/4/3 retract-2/3/4 extend pin sheaves.
10. Remove tubes (19, Figure 4-16) and grease fittings (20) from 5/4/3 retract cable sheave pin (21) and 90-degree grease fittings (22).
11. Remove setscrews (22, Figure 4-19) and disconnect button and 5/4/3 retract cable (12) from anchor inside the Tele 4 section boom.
12. Remove the 5/4/3 retract cable sheave pin (21, Figure 4-16) (with 3/4/5 extend cable eyelets and 5/4/3 sheaves) from the mounting bracket in the Tele 2 section boom (1). Drape the sheave pin (with 3/4/5 extend cable eyelets and 5/4/3 sheaves) out of the bottom of the Tele 2 section boom.

13. Remove 5/4/3 retract cable (23) from the 5/4/3 retract cable sheave pin (21).



14. Disassemble the 5/4/3 retract sheave pin (1, Figure 4-15) as follows:
  - a. Remove bearings (2) and 5/4/3 sheaves (3).
  - b. Remove bearings (2) from sheaves (3).
  - c. Remove washers (4), retaining rings (5), and spacers (6).
15. Remove the 2/3/4 extend cables from the 5/4/3 retract-2/3/4 extend pin (21, Figure 4-16).
16. Use a suitable lifting device to support the end of the telescope cylinder.
17. Remove capscrews (25), washers (26), and trunnion plates (27) from sides of Tele 2 section boom. The telescope cylinder (1, Figure 4-17) is now detached from the boom section.
18. Using a lifting device to support the end of the telescope cylinder, remove the telescope cylinder from the rear of the assembly of Tele 2, 3, and 4 section booms. Ensure that any attached cables are taut during removal. As the telescope cylinder is removed, use an additional support. Ensure that the telescope cylinder is balanced when lifting.
19. Place the telescope cylinder on a suitably supported work area.
20. Use the following steps to disassemble the telescope cylinder sheave case (8, Figure 4-17) if necessary:
  - a. Remove capscrews (6, Figure 4-17) and top wear pads (7) from telescope cylinder sheave case (8).
  - b. Remove capscrews (9) and bottom wear pad (10) from telescope cylinder sheave case (8).

- c. Remove capscrews (2), retaining pins (3), capscrews (4), and plate (5) as needed to remove the 2/3/4 extend cables (20) from telescope cylinder tip. Store cables and extend cylinder in an area where they will not be damaged during further boom disassembly.

**NOTE:** The telescope cylinder sheave case weighs approximately 16.8 kg (37 lbs).

- d. Remove capscrews (11), washers (12), nuts (13), and telescope cylinder sheave case (8) from the front of the telescope cylinder (1). Place sheave case on a suitable work surface.
- e. Remove capscrews (14), washers (15), keeper (16), sheave pin (17), and sheaves (18) from telescope cylinder sheave case (8).
- f. Inspect sheaves (18) for wear and damage. Remove bearings (19) from sheaves (18) as needed. Replace sheaves if worn or damaged.

**NOTE:** All top wear pads must be tagged, inspected, and reassembled exactly as they have been removed.

- 21. Remove and tag capscrews (56, Figure 4-16), washers (55), and cam plates (48) from the top of the Tele 2 section boom (1).

- 22. Remove and tag capscrews (58), washers (57), wear pad mounting plates (46), and wear pads (47) from top of Tele 2 section boom (1).

- 23. Remove and tag capscrews (28), washers (29), shims (30), and wear pads (31) from inside the front of the Tele 2 section boom.

- 24. Remove and tag capscrews (32), shims (52), and wear pads (33) from inside the front of the Tele 2 section boom.

- 25. Remove and tag capscrews (34) and wear pads (35) from the bottom front of the Tele 2 section boom.

- 26. Attach a sling or chain to the tip of the Tele 3 section boom and pull Tele 3 section boom (with the Tele 4 section boom) out approximately 609 mm (2 ft). Remove Tele 2 section boom from Tele 3 and Tele 4 boom sections. Pull the retract cable anchors out and keep retract cables taut while pulling Tele 3 section boom (with Tele 4 section boom) out of Tele 2 section boom.

- 27. Place the Tele 3 and Tele 4 section booms on a suitable horizontal surface.

**NOTE:** Use caution not to pinch or crush the retract and extend cables while lifting or supporting the Tele 3 section boom.

Reference Only

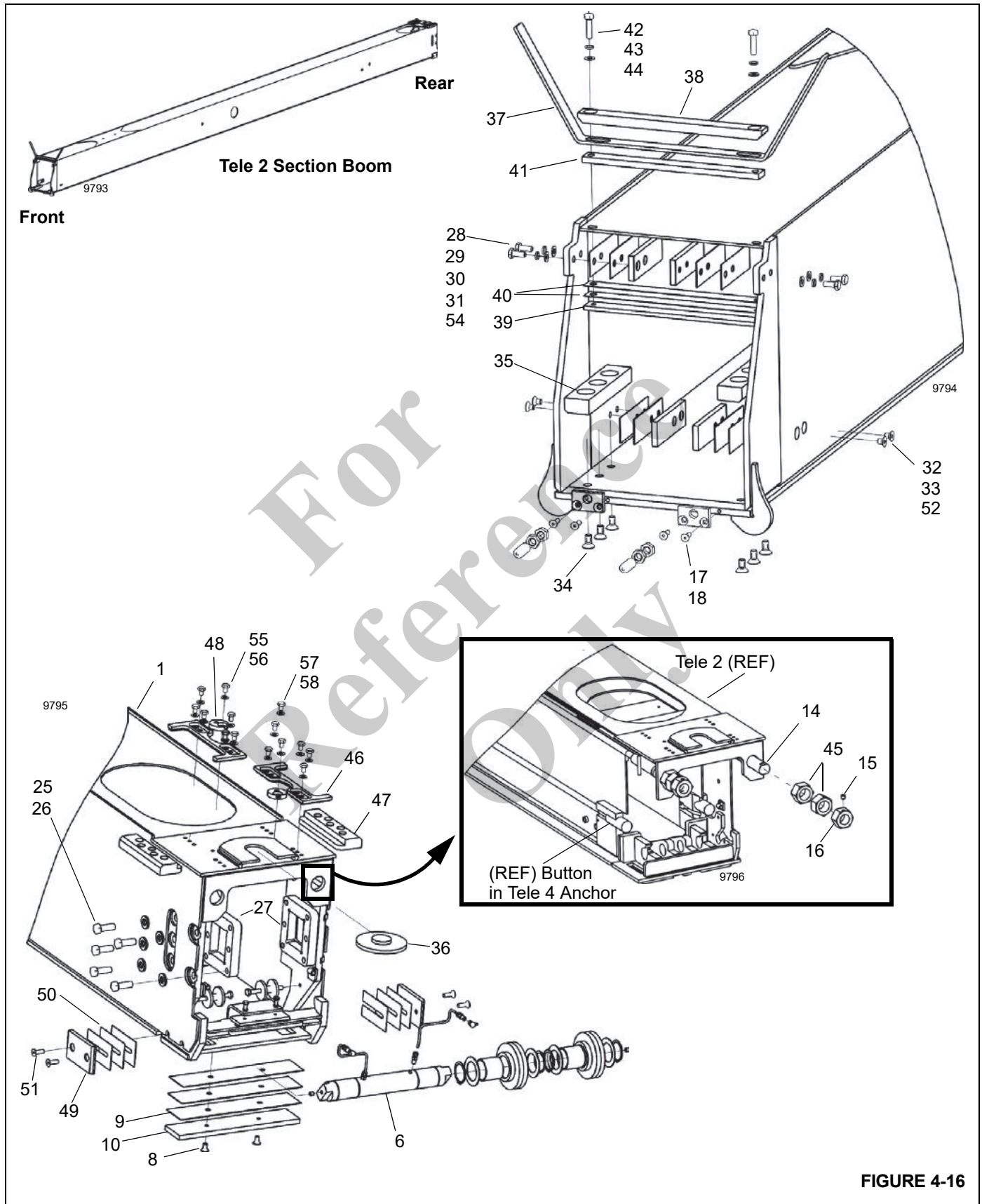
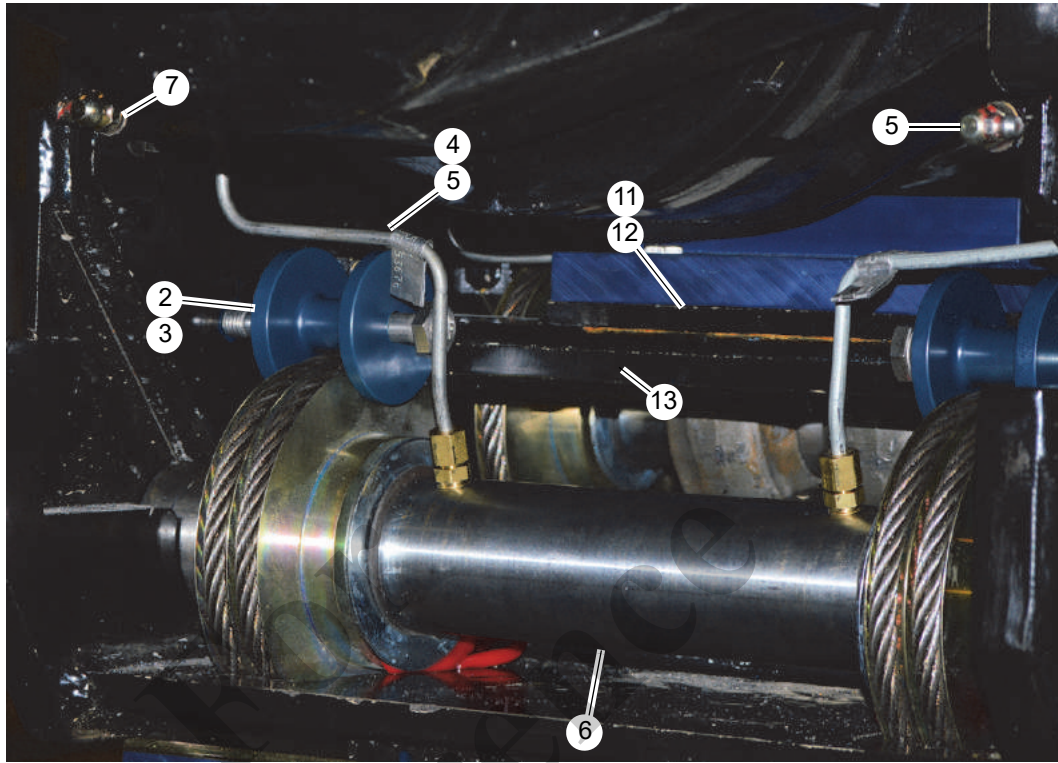


FIGURE 4-16



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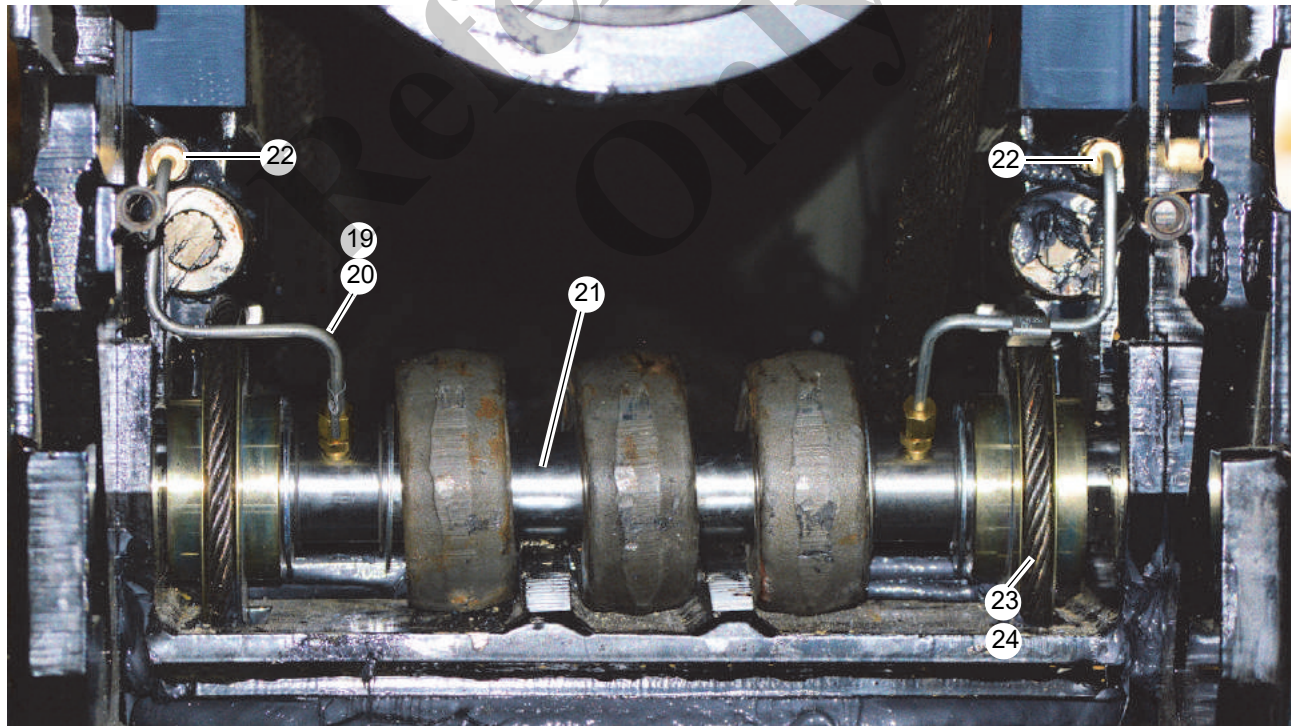


FIGURE 4-16 continued

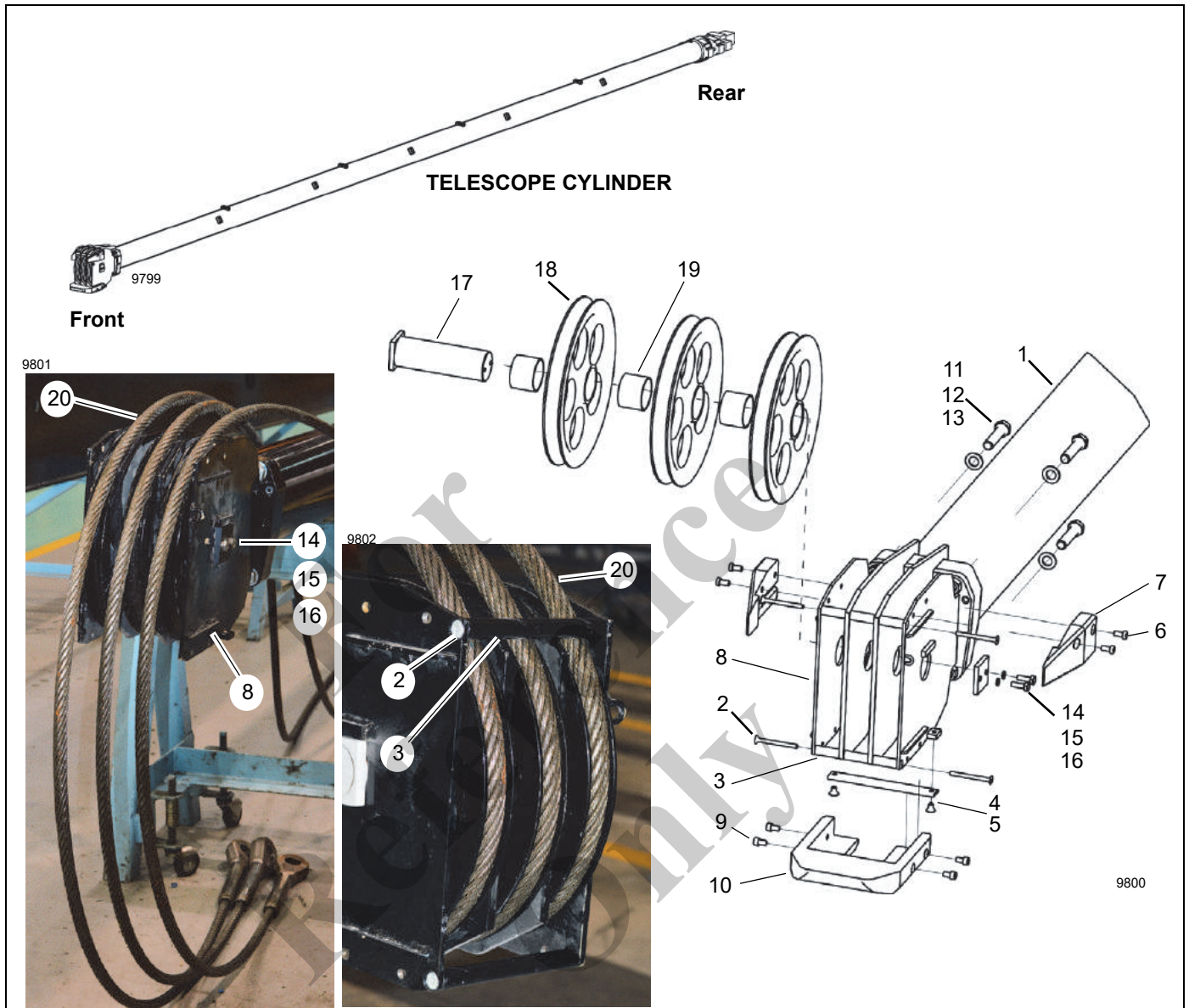
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Table 4-3 Tele 2 Figure 4-16 Item List

Item	Description
1	Tele 2 Section Boom
2	Capscrew
3	Cable Roller Guide
4	Lubrication Tube
5	Grease Fitting
6	4/3/2 Sheave Pin
7	Bracket
8	Capscrew
9	Shim
10	Wear Pad
11	Capscrew
12	Wear Pad
13	4/3/2 Retract Cable Retainer
14	3/4/5 Extend Cable
15	Set Screw
16	3/4/5 Extend Cable Nut
17	Capscrew
18	5/4/3 Retract Cable Anchor
19	Lubrication Tube
20	Grease Fitting
21	5/4/3 Retract Cable Sheave Pin
22	90-degree Grease Fitting
23	5/4/3 Retract Cable
24	Sheave
25	Capscrew
26	Washer
27	Trunnion
28	Capscrew
29	Washer

Table 4-3 Tele 2 Figure 4-16 Item List (Continued)

Item	Description
30	Shim
31	Wear Pad
32	Capscrew
33	Wear Pad
34	Capscrew
35	Wear Pad
36	Sheave
37	Rope Guide
38	Wear Pad
39	Plate
40	Shim
41	Wear Pad
42	Capscrew
43	Washer
44	Lockwasher
45	Hex Nut
46	Mounting Plate
47	Wear Pad
48	Cam Plate
49	Wear Pad
50	Shim
51	Capscrew
52	Shim
53	Nut
54	Lockwasher
55	Washer
56	Capscrew
57	Washer
58	Capscrew



Item	Description
1	Telescope Cylinder
2	Capscrew
3	Retaining Pin
4	Capscrew
5	Plate
6	Capscrew
7	Top Wear Pad
8	Telescope Cylinder Sheave Case
9	Capscrew
10	Bottom Wear Pad

Item	Description
11	Capscrew
12	Washer
13	Nut
14	Capscrew
15	Washer
16	Keeper
17	Sheave Pin
18	Sheave
19	Bearing
20	3/4/5 Extend Cable

FIGURE 4-17

### Removing Tele 3 Section Boom

Use the following procedure to disassemble and remove Tele 4 section boom from the Tele 3 section boom (1, Figure 4-18).

1. Remove and tag capscrews (2), shims (3), and wear pads (4) from the sides of the Tele 3 section boom (1).
2. Remove and tag capscrews (5), shims (6), and wear pad (7) from the bottom of the rear of the Tele 3 section boom (1).
3. Remove and tag nuts (8), washers (9), capscrews (10), and wear pads (11) from inside the Tele 3 section boom (1).
4. Remove and tag capscrews (12), washers (13), and rear wear pad cam plates (14) as needed from the Tele 3 section boom (1).

**NOTE:** All top wear pads must be tagged, inspected, and reassembled exactly as they have been removed.

5. Remove capscrews (15), washers (16), wear pad plate weldment (17), and wear pad (18) as needed from the Tele 3 section boom (1).
6. Attach a sling or chain to the tip of the Tele 4 section boom (1, Figure 4-19) and pull Tele 4 section boom out approximately 1828 mm (6 ft).
7. Remove and tag side capscrews (19, Figure 4-18), shims (20), and wear pads (21) from the tip of the Tele 3 section boom (1).
8. Remove and tag capscrews (22) and bottom wear pads (23) from the tip of the Tele 3 section boom (1).
9. Remove and tag capscrews (24), shims (25), and wear pads (26) from the top of the Tele 3 section boom (1).

10. Remove sockethead capscrews (27) from 3/4/5 extend sheave pins (28) and remove 3/4/5 extend sheave pins while removing 3/4/5 extend sheaves (29).

11. Pull the Tele 4 section boom out of the Tele 3 section boom while keeping extend cables taut.

12. Place the Tele 4 section boom on a suitable horizontal surface. Take care not to pinch or crush extend cables while lifting or supporting Tele 4 section boom.

13. If necessary, tag and remove wear pads (3, Figure 4-19) and shims (2) from the rear of the Tele 4 section boom.

14. If necessary, tag and remove capscrews (23), wear pads (5), and shims (4) from the rear of the Tele 4 section boom.

**NOTE:** All top wear pads must be tagged, inspected, and reassembled exactly as they have been removed.

15. If necessary, tag and remove capscrews (6) and rear wear pad cam plates (7) from the top rear of the Tele 4 section boom (1).

16. If necessary, tag and remove capscrews (8), wear pad plate weldment (9), and wear pads (10) from top rear of the Tele 4 section boom.

17. Remove 3/4/5 extend cables (11) from the anchor plates at the bottom base of the Tele 4 section boom and store in an area where they will not be damaged during further boom disassembly.

18. Remove loadline sheaves (14) if desired, by removing capscrews (15), lockwashers (16) and the keeper (17) from the sheave pins (18) and lightly tapping the pin while removing sheaves (14) and spacers (19) until all sheaves are removed from boom tip.



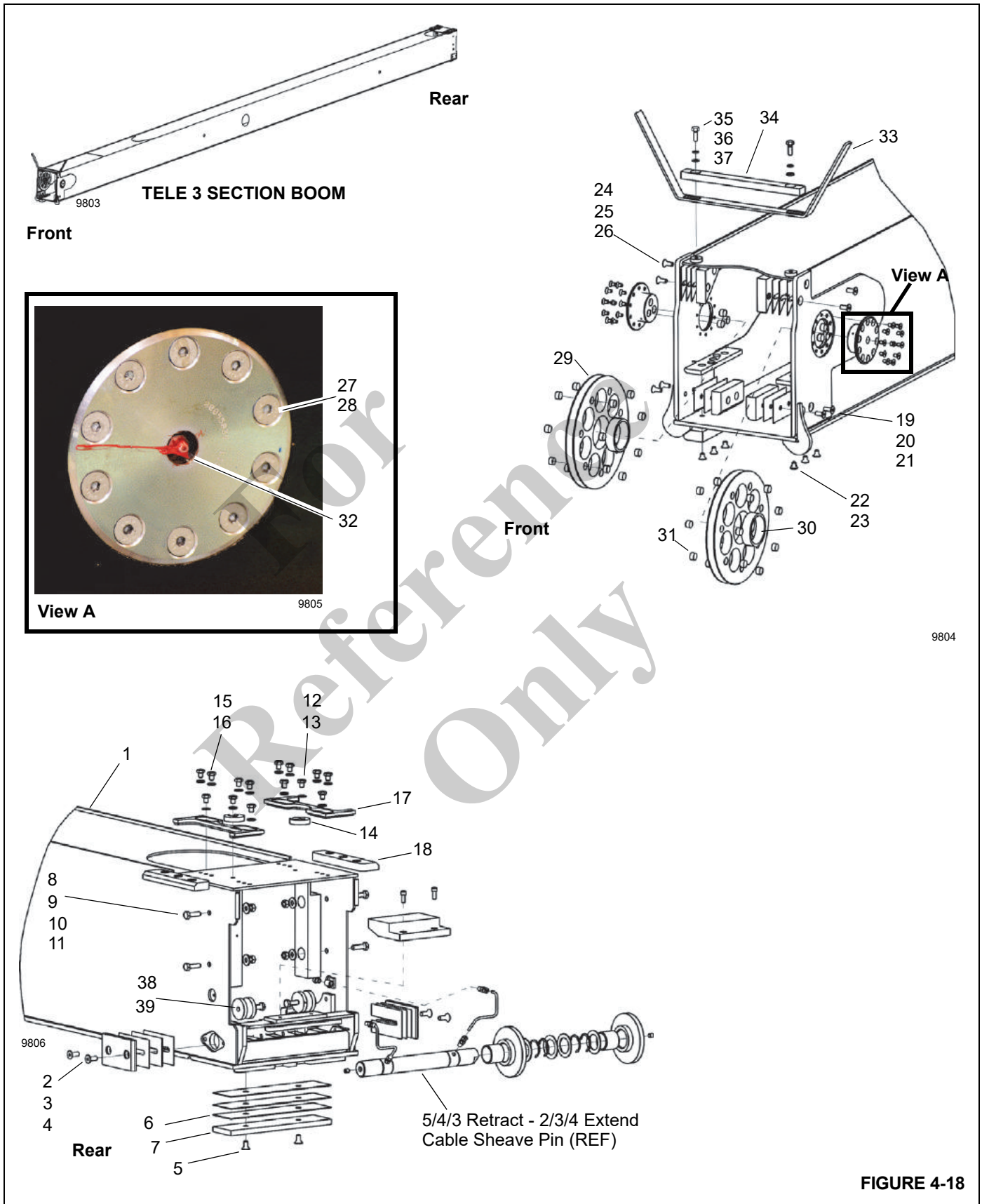


FIGURE 4-18

Table 4-4 Tele 3 Section Boom Figure 4-18 Item List

Item	Description
1	Tele 3 Section Boom
2	Capscrew
3	Shim
4	Wear Pad
5	Capscrew
6	Shim
7	Wear Pad
8	Nut
9	Washer
10	Capscrew
11	Wear Pad
12	Capscrew
13	Washer
14	Cam Plates
15	Capscrew
16	Washer
17	Wear Pad Mounting Plate
18	Wear Pad
19	Capscrew

Table 4-4 Tele 3 Section Boom Figure 4-18 Item List

Item	Description
20	Shim
21	Wear Pad
22	Capscrew
23	Wear Pad
24	Capscrew
25	Shim
26	Wear Pad
27	Capscrew
28	3/4/5 Extend Sheave Pin
29	Sheave
30	Bearing
31	Wear Plug
32	Grease Fitting
33	Cable Guide
34	Wear Pad
35	Capscrew
36	Washer
37	Lockwasher
38	Capscrew
39	Roller Guide

For Reference Only

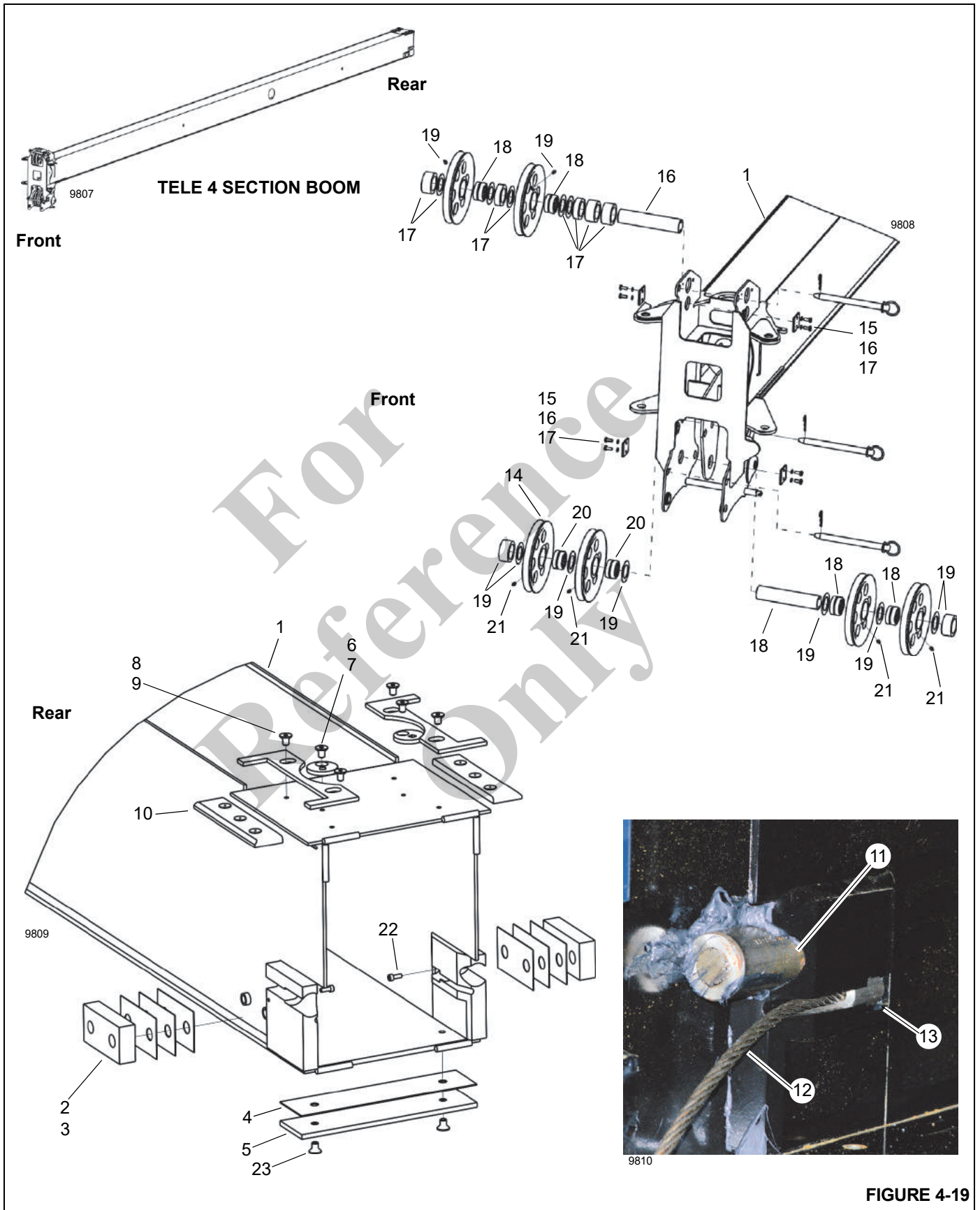


FIGURE 4-19

Table 4-5 Tele 4 Section Boom Figure 4-19 Item List

Item	Description
1	Tele 4 Section Boom
2	Shim
3	Wear Pad
4	Shim
5	Wear Pad
6	Capscrew
7	Cam Plate
8	Capscrew
9	Wear Pad Plate
10	Wear Pad
11	3/4/5 Extend Cable
12	5/4/3 Retract Cable
13	5/4/3 Retract Cable Button End
14	Sheave
15	Capscrew
16	Lockwasher
17	Keeper
18	Sheave Pin
19	Spacer
20	Bearing
21	Grease Fitting
22	Set Screw
23	Capscrew

### Additional Maintenance, Disassembled Boom

1. Clean all boom sections and inspect for wear, dents, bent or crooked 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 inner liner material. If installed bearing diameter is 0.015 in larger than pin diameter, bearing must be replaced. Any cut or gouge which causes the bearing liner to lose strands is cause for bearing replacement.
4. Clean and inspect all cable assemblies according to wire rope inspection procedures in this section. Pay particular attention to any wire breakage at the end connections. Replace cable assemblies as required. Lubricate all cable assemblies as required. Lubricate all cable assemblies before reinstalling them in 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. Replace all lubricating plugs in all wear pads.

### Assembling the Five Section Boom

**NOTE:** Torque all hardware to their specified torque value. For more information, see "Fasteners and Torque Values" on page 1-7.

**NOTE:** Apply medium-strength thread locking adhesive/sealant using Loctite™ type 243 (according to Loctite recommendations) to all hardware and torque.

**NOTE:** All wear pads must be tagged, inspected, and reassembled exactly as they have been removed unless doing a complete overhaul.

**NOTE:** Install cables in their natural untwisted condition. Do not twist cables. Twisting cable will result in damage or failure of the cable. When initially assembling threaded ends of cables, thread the first nut on past the flat so adjustment can be made later.

**NOTE:** Apply multipurpose grease (MPG) to all wear pads and contact surfaces.

**NOTE:** Do not use Loctite® on any cable threaded ends. Always use the jam nuts and/or nuts provided.

**NOTE:** For complete parts breakdown, including part numbers, see the *Manitowoc Crane Care Parts Manual*.

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

*For reference, front (tip) is sheave case end, rear (base) is boom pivot end, left and right are viewed from rear to front.*

### Assembling Tele 4 Section Boom in Tele 3 Section Boom

1. Assemble and then install sheaves (14, Figure 4-19) and bearings (20) into the boom nose sheave case.

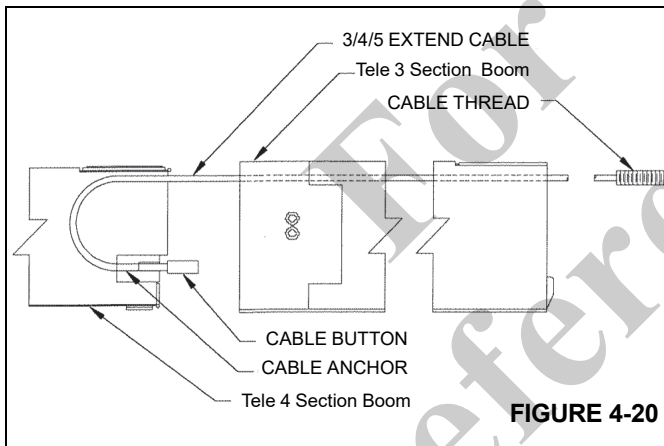
Sheaves (14) must be installed with the grease fittings (21) facing the nearest side plates to allow for greasing.

Install spacers (19) between sheaves (14) and between sheaves and side plates. Top sheaves (14) are to be installed to the left hand side of the boom nose with the spacers (19) to the right hand side.

2. Install top wear pad mounting plates (9), wear pads (10), and cam plates (7), and bottom wear pad (5) and shims

- (4) onto the base of the Tele 4 section boom. Install two side wear pads (3) and shims (2) onto the base of the Tele 4 section boom. Use equal number of shims on each side.
3. Raise and support the Tele 4 section boom in front of the Tele 3 section boom. Route threaded end of 3/4/5 extend cables (11) through the tip of the Tele 3 section boom and out of the base of the Tele 3 section boom. Loop the button end of 3/4/5 extend cables back beyond the cable anchor on the Tele 4 section boom and install the button end of the 3/4/5 extend cables into anchor plates at the base of the Tele 4 section boom (1) and pull taut. Loop of 3/4/5 extend cables will be laying on bottom plate lip of Tele 4 section boom. Install Tele 4 section boom into Tele 3 section boom approximately 3 m (10 ft).

**NOTE:** Use caution not to damage 3/4/5 extend cables.



**FIGURE 4-20**

4. Raise the Tele 4 section boom against top of the Tele 3 section boom and install wear pads (23, Figure 4-18) and capscrews (22) into the bottom tip of the Tele 3 section boom. Lower the Tele 4 section boom onto wear pads in the Tele 3 section boom.

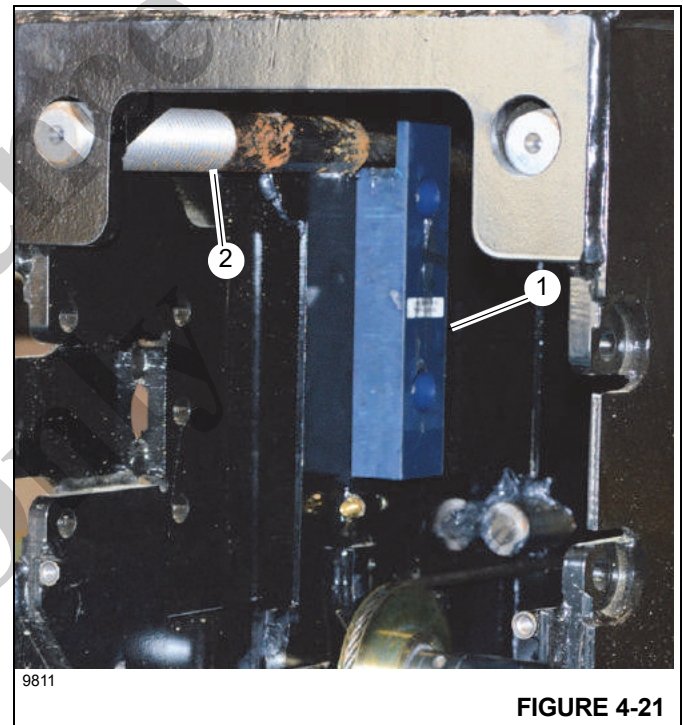
**NOTE:** Apply multipurpose grease (MPG) to all wear pads and contact surfaces.

**Assembling Tele 3 Section Boom**

1. Install 3/4/5 extend sheave pins (28) and bearings (30) into 3/4/5 extend sheaves (29). Install wear plugs (31) into holes on each side of extend sheaves. Loop 3/4/5 extend cables (11, Figure 4-19) around 3/4/5 extend sheaves (29, Figure 4-18) and install 3/4/5 extend sheaves into the Tele 3 section boom. Install retaining capscrews (27) into 3/4/5 extend sheave pins (28) and torque. Install grease fittings (32) into the center of the 3/4/5 extend sheave pins (28).
2. Install upper side wear pads (26) with shims (25) and capscrews (24). Install the lower side wear pads (21) with shims (20) and capscrews (19) on front inside of the Tele 3 section boom.

3. Install the cable guide (33) with wear pad (34) and related hardware (35, 36, and 37) on the top front of the Tele 3 section boom. Push Tele 4 section boom into the Tele 3 section boom until top wear pads on base of Tele 4 section boom (10, Figure 4-19) are accessible through the access hole in the rear of the Tele 3 section boom. Center the Tele 4 section boom within the Tele 3 section boom, then adjust the top wear pads according to the calibration instructions in this section. Push the Tele 4 section boom completely into the Tele 3 section boom keeping 3/4/5 extend cables taut and scribe a mark in the tip of the Tele 4 section boom in front of side wear pads on the Tele 3 section boom for retract sequencing (Figure 4-31).

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.



**FIGURE 4-21**

4. Install 3/4/5 extend cable retaining wear pads (11, Figure 4-18 and 1, Figure 4-21) inside the base of the Tele 3 section boom using capscrews (10, Figure 4-18), washers (9), and nuts (8). Keep 3/4/5 extend cables (2, Figure 4-21) between opening of the pad and the side plate of the Tele 3 section boom with the threaded end of 3/4/5 extend cable beyond base of Tele 3 section boom and the cable retaining pad.
5. Push button ends of 5/4/3 retract cables (12, Figure 4-19) through openings in the bottom base of the Tele 3 section boom and drape button ends out of the back of the Tele 3 section. Pull threaded ends of 5/4/3 retract cable (12) towards tip of boom. Install 5/4/3 retract-2/3/4 extend pin (21, Figure 4-16) into retainer at

base of Tele 3 section boom. Loop 5/4/3 retract cables (12, Figure 4-19) over pin (21, Figure 4-16) and install button end of 5/4/3 retract cables (13, Figure 4-19) into anchor plates at the bottom base of the Tele 4 section boom. Secure with setscrews (22).

### Assembling Tele 2 Section Boom and Telescope Cylinder

1. Install two top wear pad mounting plates (17, Figure 4-18), top wear pads (18), and cam plates (14), and one bottom wear pad (7) and shims (6) onto the base of the Tele 3 section boom. Install two side wear pads (4) and shims (3) onto the base of the Tele 3 section boom.

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

2. Raise and support Tele 3/Tele 4 section booms and install into Tele 2 section boom approximately 15 ft.

**NOTE:** Use caution to keep 5/4/3 retract cables (12, Figure 4-19) taut, not crossing cables and keeping all cables clear of pinch points created by slings and bottom pads.

3. Raise Tele 3/Tele 4 section booms against top of Tele 2 section boom and install wear pads (35, Figure 4-16) into the bottom tip of the Tele 2 section boom using capscrews (34). Lower Tele 3/Tele 4 section booms onto wear pads in the Tele 2 section boom. Push Tele 3/Tele 4 section booms into Tele 2 section boom leaving approximately 4 ft of Tele 3/Tele 4 section booms left out of Tele 2 section boom.
4. Assemble 5/4/3 retract cable keepers (18) onto 5/4/3 retract cables (12, Figure 4-19), double nut just beyond flat at threaded end of retract cables and assemble at bottom tip of Tele 2 section boom.
5. Install lower side wear pads (33, Figure 4-16) with shims (52) and capscrews (32) on front inside of the Tele 2 section boom.

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

6. Install upper side wear pads (31) and shims (30) with washers (29), lockwashers (54), and capscrews (28).

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

7. Install rope guide assembly (37), wear pads (38, 41), shims (40), and plate (39) using washers (43), lockwashers (44), and capscrews (42) on front inside of Tele 2 section boom (1). Shim according to calibration instructions in this section.
8. Push Tele 3/Tele 4 section boom into the Tele 2 section boom until top wear pads on base of Tele 3 section boom are accessible through the access hole in the base of the Tele 2 section boom. Center the Tele 3/Tele 4 section booms within the Tele 2 section boom, then adjust the top wear pads according to the calibration instructions in this section. Push the Tele 3/Tele 4 section booms completely into Tele 2 section boom and scribe a mark in the tip of the Tele 3 section boom in front of the side wear pad on the Tele 2 section for retract sequencing (Figure 4-31). Keep 3/4/5 extend cables and 5/4/3 retract cables taut while guiding 3/4/5 extend cables into anchor plates at upper base of Tele 2 section boom. Thread nuts onto 3/4/5 extend cables just beyond flats.
9. Remove 5/4/3 retract cables from anchor plate at the bottom base of the Tele 4 section boom and loop cables back away from base of boom.
10. Pull Tele 4 section boom out of Tele 3 section boom approximately 304 mm (12 in).
11. If needed, install bearings (19, Figure 4-17) into 2/3/4 telescope cylinder sheaves (18). Coat bearing with chassis grease and install 2/3/4 extend sheaves (18) into telescope cylinder.
12. If needed, install the telescope cylinder sheave case (8) on the end of telescope cylinder using capscrews (11), washers (12), and nuts (13).
13. Remove 5/4/3 retract-2/3/4 extend pin (21, Figure 4-16) from the retainer at the base of the Tele 3 section boom.
14. Reeve 2/3/4 extend cables (20, Figure 4-17) over 2/3/4 telescope cylinder sheaves (18), install retaining pins (3) at top and bottom of telescope cylinder sheave case. Install wear pads (7) on front tip of telescope cylinder.
15. Install 2/3/4 cable eyelets onto 5/4/3 retract-2/3/4 telescope pin (1, Figure 4-15). Install washers (4), retaining rings (5), grease fittings (7) and plugs (11) into 5/4/3 retract-2/3/4 extend pin (1). Install bearings (2) into 5/4/3 retract sheaves (3) and brush with chassis grease. Install spacers (6), retaining rings (5), washers (4) and 5/4/3 retract sheaves (3) onto 5/4/3 retract-2/3/4 extend pin (1).

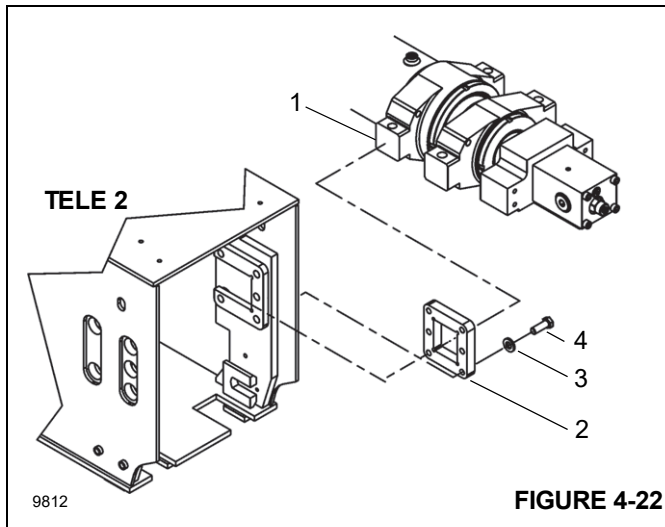
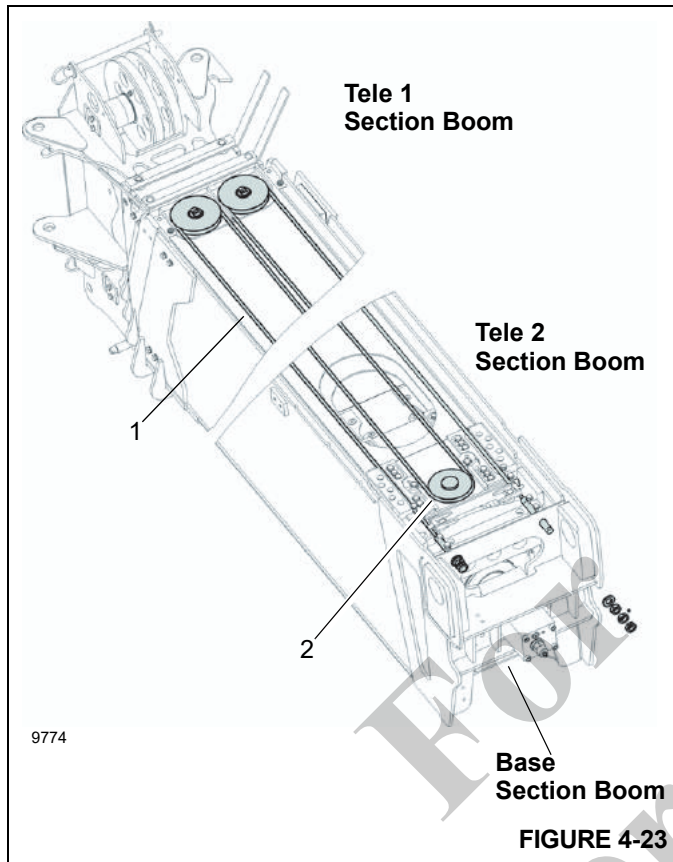


FIGURE 4-22

16. Install trunnions (2, Figure 4-22) loosely on telescope cylinder forward flanges (1). Support and install the telescope cylinder approximately 3 m (10 ft) into the base of the Tele 4 section boom. It may be necessary to raise and lower the outer end of the cylinder to insert the cylinder into the boom section. Push the Tele 4 section boom completely into the Tele 3 section boom and raise the telescope cylinder to top of Tele 2 section boom.
17. Install 5/4/3 retract-2/3/4 extend pin (21, Figure 4-16) into anchor plates at the base of the Tele 3 section boom with grease fittings (20, Figure 4-16) toward base of boom. Roll 5/4/3 retract cables (23) onto 5/4/3 retract sheaves (24).
18. Install retract cable roller guides (39, Figure 4-18) with capscrews (38) into the base of the Tele 3 section boom.
19. Install 90 degree grease fittings (22, Figure 4-16) in bracket on sides of Tele 2 section boom. Install lubrication tubes (19) and fittings (20) on 5/4/3 retract-2/3/4 extend pin. Connect grease tube fittings to 90 degree grease fittings (22).
20. Lower extend cylinder and push into Tele 2 section boom keeping cables taut to approximately 304 mm (12 in) behind cylinder anchors in the Tele 2 section boom. Raise base of extend cylinder to top of Tele 2 section boom.
21. Install wear pad (12, Figure 4-16) and 4/3/2 retract cables onto 4/3/2 retract cable retainer (13). Install 4/3/2 retract cable retainer (13) into anchor plates at the base of the Tele 3 section boom and route threaded ends of 4/3/2 retract cables down through the opening in the base of the Tele 2 section boom and pull threaded ends of 4/3/2 retract cables toward tip of boom.
22. Install bearings (4, Figure 4-14) into 4/3/2 retract sheaves (5) and brush with chassis grease. Install snap rings (2), washers (3), 4/3/2 retract sheaves (5), grease fittings (7), and plugs (8) onto 4/3/2 retract pin (1). Loop 4/3/2 retract cables around 4/3/2 retract sheaves (5). Install the assembled 4/3/2 retract pin (1) into anchor plates at the base of the Tele 2 section boom.
23. Install lubrication tubes (4, Figure 4-16) and grease fittings (5) on 4/3/2 retract sheave pin (6). Connect lubrication tubes (4) to 90 degree grease fitting (5) in bracket (7) on sides of Tele 2 section boom.
24. Install retract cable roller guides (3) using capscrews (2) into the base of the Tele 2 section boom.
25. Lower the telescope cylinder as needed to align the trunnions (2, Figure 4-22) and mounting holes on the sides of the Tele 2 section boom. Install telescope cylinder in Tele 2 section boom using capscrews (4), washers (3) and trunnions (2). (See also 25, 26, 27 in Figure 4-16.)
26. Install two top wear pad mounting plates (46, Figure 4-16), wear pads (47), and cam plates (48) using washers (55 and 57) and capscrews (56 and 58).
27. Install one bottom wear pad (10) and shims (9) onto the base of the Tele 2 section boom using capscrews (8). Shim according to calibration instructions in this section or as pads were originally removed and tagged.
28. Install two side wear pads (49) and shims (50) onto the base of the Tele 2 section boom using capscrews (51).

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.



29. Stretch 3/8 diameter, synchronizing cable (1, Figure 4-23) out, then bring threaded ends back together to form a loop and find the center of cable length. Slide this center loop from front to back through the cable anchor slot at base, top of the Tele 2 section boom. Slide the keeper sheave (2) into this slot from back to front so raised portion of sheave slides into slot of cable anchor plate. Pull this loop of cable forward to lock synchronizing cable (1) to Tele 2 section boom. Place the sheave case assembly (42, Figure 4-12) on top front of Tele 2 section boom with its top bar up and forward. Loop both threaded ends of cable toward back of boom to form two loops, left and right, at front of boom. Slide left and right loops into left and right sides of sheave case assembly.

30. Install bearings (44) in sheaves (45), brush with chassis grease, install flattened end pins (43) in sheaves with grease fittings toward the back of the boom and slide pins (with sheaves) into slots in front of sheave case assembly. Pull threaded cable ends toward base of boom and loop over base of boom.

#### Assembling Tele 1 Section Boom

1. Ensure Tele 1 section telescope cylinder flanges are horizontal. Raise and support Tele 2/Tele 3/Tele 4 section booms and install into Tele 1 section boom approximately 4.5 m (15 ft).

**NOTE:** Use caution to keep 4/3/2 retract cables taut, not crossing cables and keeping all cables clear of pinch points created by slings and bottom pads.

2. Raise Tele 2/Tele 3/Tele 4 section booms against the top of the Tele 1 section boom and install wear pads (41, Figure 4-12) and capscrews (40) into the bottom tip of the Tele 1 section boom. Lower Tele 2/Tele 3/Tele 4 section booms onto wear pads in the Tele 1 section boom. Install Tele 2/Tele 3/Tele 4 section booms into Tele 1 section boom leaving approximately 1.21 m (4 ft) of Tele 2/Tele 3/Tele 4 section booms left out of Tele 1 section boom.

3. Assemble 4/3/2 retract cable keeper retainer assemblies (26) onto 4/3/2 retract cables, double nut just beyond flat on 4/3/2 retract cables and assemble at bottom tip of Tele 1 section boom.

**NOTE:** Use caution not to cross cables.

4. Install lower side wear pads (39) with shims (38) on front inside of Tele 1 section boom using capscrews (37).

5. Install upper wear pad (31) with shims (30) using lockwashers (29), washers (28), and capscrews (27).

6. Install upper side wear pads (36) and shims (35) with capscrews (32), washers (33), and lockwashers (34) on the top front of Tele 1 section boom.

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

7. Loosely install trunnion plates (2, Figure 4-24) on telescope cylinder flanges (1).



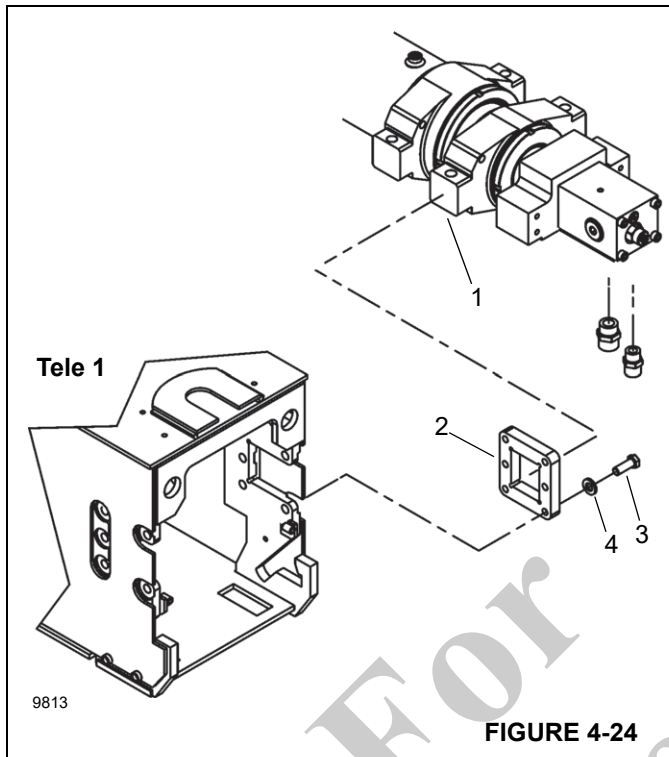


FIGURE 4-24

8. Slide the synchronizing cable sheave case assembly (which is on the top tip of the Tele 2 section boom) into position in the Tele 1 section boom. Install grease fittings (46, Figure 4-12) into synchronizing cable sheave pins (43).
9. Push Tele 2/Tele 3/Tele 4 section boom into the Tele 1 section boom until top wear pads on base of Tele 2 section boom are accessible through the access hole in the base of the Tele 1 section boom. Center the Tele 2/ Tele 3/Tele 4 section booms within the Tele 1 section boom, then adjust the top wear pads according to the calibration instructions in this section. Push Tele 2/Tele 3/Tele 4 section booms into Tele 1 section boom until it bottoms out against cylinder flanges and scribe a mark in the tip of the Tele 2 section boom in front of the side wear pad on the Tele 1 section for retract sequencing (Figure 4-31).
10. Install cap screws (3, Figure 4-24), washers (4), and trunnion plates (2) to secure the telescope cylinder to the Tele 1 section boom.
11. Install wear pad (47, Figure 4-12) on top of 2/3/4 extend cable anchor assembly (18) using cap screws (48), then install 2/3/4 extend cable anchor assembly in slots at base top of Tele 1 section boom while guiding 2/3/4 extend cables into anchor assembly. Install spacers (19), nuts (21), hex nuts (20), and set screws (49) on threaded ends of 2/3/4 extend cables. Lock cable anchor assembly (18) in place with cap screws (17) through the top back side plates of the Tele 1 section boom. Tighten nuts (21), hex nuts (20), and set screws (49) according to "Cable Retention" on page 4-33. Be sure synchronizing cables (1, Figure 4-23) are threaded over the top of the 2/3/4 extend cable anchor (18, Figure 4-12).
12. Install 3/2/1 retract cables onto 3/2/1 retract cable anchor (50, Figure 4-12) and install into anchor plates at base of Tele 2 section boom with 3/2/1 retract cables draped out behind boom. Install 3/2/1 retract cable retainer bracket (7) using lockwashers (6) and cap screws (5) onto 3/2/1 retract cable anchor (50).
13. Install bearings (1, Figure 4-13) into 3/2/1 retract sheaves (2) and brush with chassis grease. Install retaining rings (3), washers (4), 3/2/1 retract sheaves (2), grease fittings (5) and plugs (6) onto 3/2/1 retract pin (7).
14. Loop 3/2/1 retract cables (51, Figure 4-12) around 3/2/1 retract sheaves (13). Install 3/2/1 retract pin (10) into anchor plates at the base of the Tele 1 section boom, pulling threaded ends of 3/2/1 retract cables (51) towards tip of boom. Install lockwashers (9) and 3/2/1 retract pin retainer jam nuts (8) that secure the retract pin (10).
15. Install cap screws (11) and retract cable roller guides (12) into the base of the Tele 1 section boom.
16. Install two top wear pad mounting plates (52) and wear pads (53) using cap screws (54) and washers (55).
17. Install bottom wear pad (16) and shims (15) onto the base of the Tele 1 section boom using cap screws (14). Make sure the 3/2/1 retract cables (1, Figure 4-25) between the bottom of the Tele 1 section boom and the bottom wear pad shims (2).

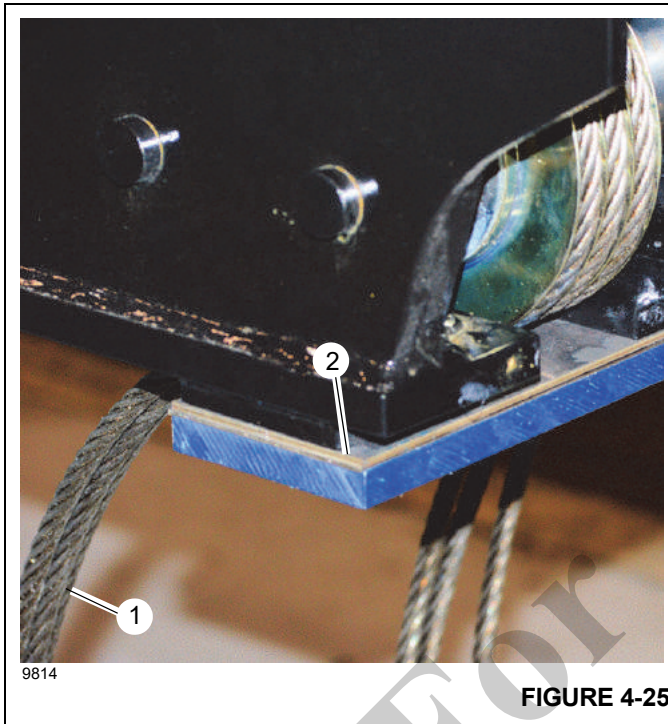


FIGURE 4-25

18. Install adjustment capscrews (56, Figure 4-12) and nuts (57).
19. Install two side wear pads (4) and shims (3) onto the base of the Tele 1 section boom using capscrews (2).

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

### Assembling Base Section Boom

1. Raise and support Tele 1/Tele 2/Tele 3/Tele 4 section booms and install into Base section boom approximately 4.6 m (15 ft).

**NOTE:** Use caution to keep 3/2/1 retract cables taut, not crossing cables and keeping all cables clear of pinch points created by slings and bottom pads.

2. Raise Tele 1/Tele 2/Tele 3/Tele 4 section booms against top of Base section boom and install wear pads (21, Figure 4-11) into the bottom tip of the Base section boom using washers (20) and capscrews (19). Lower Tele 1/Tele 2/Tele 3/Tele 4 section booms onto wear pads in Base section boom. Push Tele 1/Tele 2/Tele 3/Tele 4 section booms into Base section booms leaving approximately 1.2 m (4 ft) of Tele 1/Tele 2/Tele 3/Tele 4 section booms sticking out of Base section boom.
3. Assemble 3/2/1 retract cable anchors (18) onto 3/2/1 retract cables, double nut just beyond flat on 3/2/1 retract cables. Install anchors using capscrews (17) at bottom tip of Base section boom.

**NOTE:** Use caution not to let the cross cables.

4. Install upper side wear pads (16) and shims (15) using lockwashers (14), washers (13), and capscrews (12).

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

5. Install lower side wear pads (16) and shims (15) using lockwashers (14), washers (13), and capscrews (12).

**NOTE:** Shim according to calibration instructions in this section or as pads were originally removed and tagged.

6. Install cable guide (8) with wear pad (22) and related hardware on the top front of Base section boom.

7. Push Tele 1/Tele 2/Tele 3/Tele 4 section boom into the Base section boom until top wear pads on base of Tele 1 section boom are accessible through the access hole in the base of the Base section boom. Center the Tele 1/Tele 2/Tele 3/Tele 4 section booms within the Base section boom, then adjust the top wear pads according to the calibration instructions in this section. Push Tele 1/Tele 2/Tele 3/Tele 4 section booms completely into Base section boom keeping 3/2/1 retract cables taut and scribe a mark in the tip of the Tele 1 section boom in front of the side wear pad on the Base section for retract sequencing (Figure 4-31).

8. It is important in this step to have the nuts loose on the 3/2/1 retract cables at the bottom tip of the Base section boom (1, Figure 4-11). Install the synchronizing cables (7) into the holes at the base of the Base section boom, double nut with washers (6) and nuts (5) just beyond flats.

9. Secure the telescope cylinder (4) to the rear of the Base section using capscrews (2) and washers (3).

10. Install wear pad (23) to the top rear of the Base section using capscrews (24).

11. Install access cover (11) to top of Base section using washers (10) and capscrews (9).

12. Torque cables per "Boom Cable Tensioning" on page 4-30".

13. Install the RCL reel cable. For more information, see "Installing the RCL Cable Reel" on page 4-4.

14. Install the assembled boom on the crane.

15. Calibrate the boom RCL sensors. For more information, see "Calibrating RCL Sensors" on page 3-13.

## BOOM 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.

### Five Section Cable Tensioning

#### Tensioning Setup Procedure

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. Proceed as follows:

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 4-26.
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 "Cable Tension Sequence" on page 4-31.



FIGURE 4-26

### Cable Tension Sequence

#### Five section boom with two stage cylinder.

Cable tensioning (See Figure 4-4) to be in the following order:

1. 321 retract cables
2. 123 extend (synchronizing) cables.
3. 234 extend cables
4. 432 retract cables.
5. 345 extend cables

6. 543 retract cables.

### 5 - Section Boom w/ 2 Stage Cylinder Cable Positioning

#### Cable Tightening Sequence 5 Section Boom with Two Stage Extend Cylinder

Boom must be in horizontal position when adjusting cable tension (See Figure 4-4) Retract boom fully ensuring sections are bottomed out on section stops 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 first and second section is less than the extension gap between the second and third section;

2. Tighten **321** retract cable located at the front bottom 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 second 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.

If when tightening the **321** retract cable the third section starts to go out with the second section the **123** synchronizing cable located at the top back of the base section may need to be loosened.

**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 first and second section than the retraction gap between the second and third section;

2. Tighten the **123** synchronizing cable located at the back 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 out.

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 second and first extendable sections should extend and retract equally and bottom out against the stops simultaneously.

**234 and 432 cable balancing****Extension**

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

If the extension gap between third and fourth section is less than the extension gap between the second and third section;

2. Tighten the **234** extend cable located at the back top of the second 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 fourth section should have moved out.

4. Tightening until the extension gap between the third and fourth section is equal to the extension gap between the second and third section.

**Retraction**

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

If the retraction gap is greater between the third and fourth section than the retraction gap between the second and third section;

2. Tighten the **432** retract cable located at the front bottom of the second 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 fourth section should have moved in.

4. Tightening until the retraction gap between the third and fourth section is equal to the retraction gap between the second and third section.

At this time the third, second and first extendable sections should extend and retract equally and bottom out against the stops simultaneously.

**345 and 543 cable balancing****Extension**

1. Measure the extension gaps between the fourth and fifth section and the third and fourth section.

If the extension gap between fourth and fifth section is less than the extension gap between the third and fourth section;

2. Tighten the **345** extend cable located at the back top of the third 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 fifth section should move outward.

4. Tightening until the extension gap between the fifth and fourth section is equal to the extension gap between the fourth and third section.

**Retraction**

1. Measure the retraction gaps between the fourth and fifth section and the third and fourth section.

If the retraction gap is greater between the fourth and fifth section than the retraction gap between the third and fourth section;

2. Tighten the **543** retract cable located at the front bottom of the third section the difference in the retraction gap measurements.

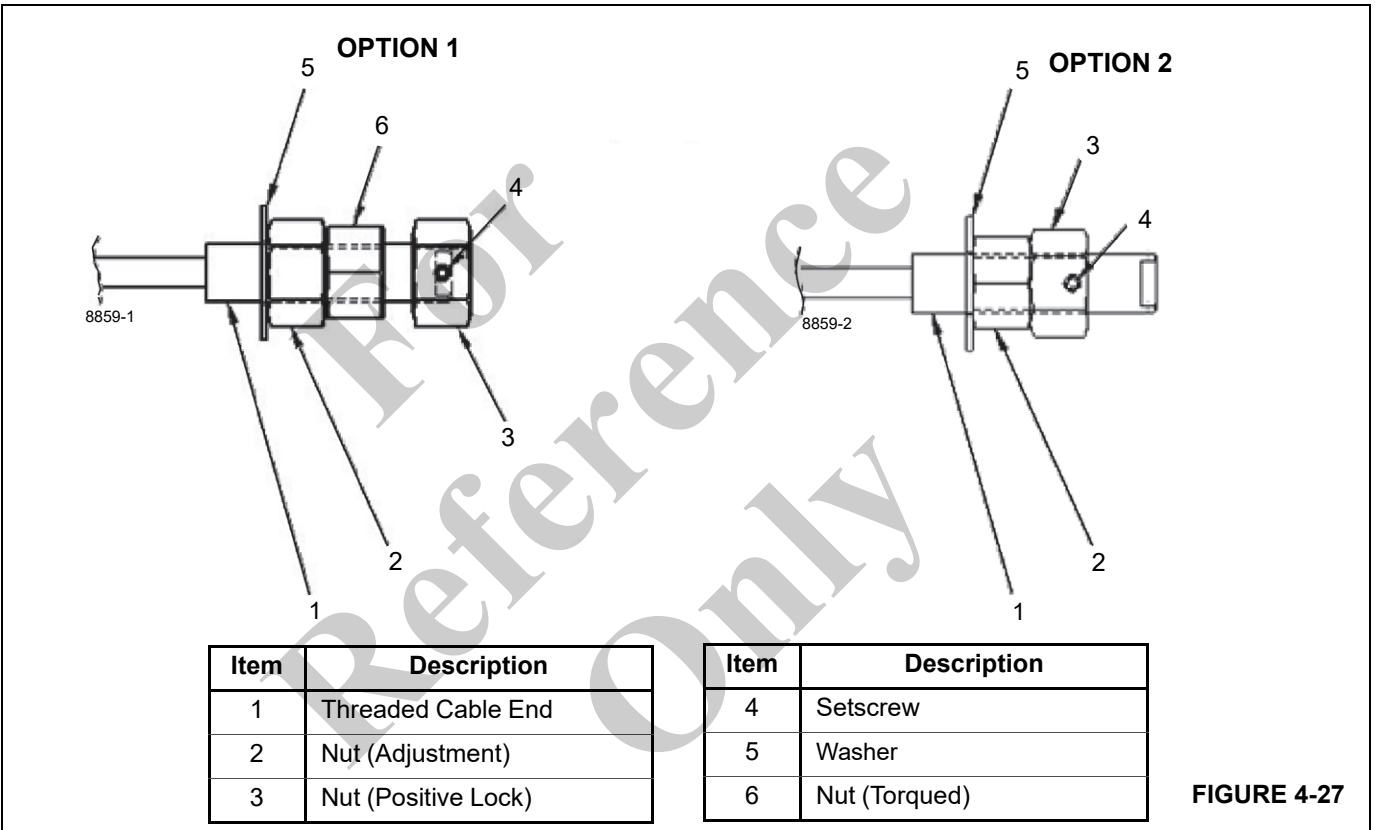
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

The fifth section should have moved in.

4. Tightening until the retraction gap between the fifth and fourth section is equal to the retraction gap between the fourth and third section.

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

**Cable Retention**



Nut configuration (see Figure 4-27) 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 4-27).

**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

**Five Section Top/Bottom Pad Replacement, Assembled Boom**

Inspect top and bottom wear pads periodically for signs of abrasion or excessive wear.

Excessive wear is wear in excess of 4.7 mm (3/16 in) from original thickness (Base, Tele 1, and Tele 2 section bottom pads are 29.7 mm (1.17 in) thick, Tele 3 section bottom pads are 11.6 mm (0.46 in) thick, Tele 1 and Tele 3 section top pads are 19 mm (0.75 in) thick, Tele 2 section top pads are 25.4 mm (1.00 in) thick, Tele 4 section top pads are 11.6 mm (0.46 in) thick or uneven wear such as the outside edge of the pad worn in excess of 2.38 mm (3/32 in) deeper than the inside edge of the pad. If any of these conditions are found, the top and bottom pads may be replaced without disassembly of the boom.

**Replacing the Top Pads**

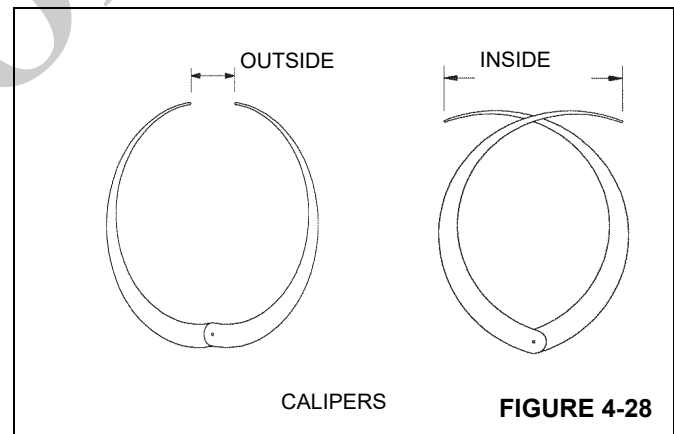
1. Remove the access cover from the rear of the Base section boom.
2. Extend/retract boom until the top wear pads of each boom section is accessible through the access hole in the Base section boom. Refer to Figure 4-4.
3. Remove the cam plates, adjustment plates, and wear pads from any boom section that requires changing.

4. Install new wear pads and original adjustment plates and cam plates. Adjust the top wear pads according to the calibration instructions in this section.

**Bottom Pad Replacement**

1. Lower the boom until the boom lift cylinder is bottomed out and extend the boom approximately eight ft out (two ft per section).
2. Raise the Tele 4 section boom tip, until weight is removed from the bottom pads in the Tele 3, Tele 2, Tele 1, and Base section booms.
3. Remove the capscrews (three in each pad) which retain the Tele 3, Tele 1, and Base section boom bottom wear pads and remove and replace pads. Reinstall capscrews, Loctite ® and torque to proper tightness.
4. Mark the location of the nuts which retain the 5/4/3 retract cables to the bottom tip of the Tele 2 section boom. Loosen (to remove tension) the nuts on the 5/4/3 retract cables. Remove capscrews from 5/4/3 retract cable retainers and move retainers and cables towards center of boom.
5. Remove the capscrews (two in each pad) which retain the Tele 2 section boom's bottom wear pads and remove and replace pads. Reinstall capscrews, Loctite ® and torque to proper tightness.
6. Reinstall 5/4/3 retract cable retainers and 5/4/3 retract cables into bottom tip of the Tele 2 section boom. Tighten 5/4/3 retract cables to their original location previously marked on the threaded cable ends.

**CALIBRATING THE BOOM**



**Top, Rear Wear Pads**

1. With a pair of inside/outside calipers, measure the inside width of the outer section ( $W_i$ ) within 50 mm (2 in) of the top plate 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 those bars.

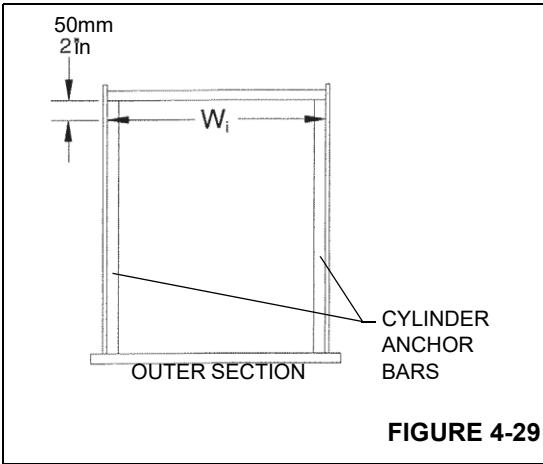


FIGURE 4-29

- The top rear wear pads also act as the top side pads. Each pad is held in position by a retainer plate which is adjusted by way of a cam plate. The retainer plates and cam plates attach to the inner boom top plate. Adjust the left and right cam plates to obtain a total of 2.00 mm (0.08 in) clearance between these wear pads ( $W_o$ ) and inside width ( $W_i$ ) of outer section; adjust the left and right wear pads such that they extend past the inner boom side plates equally.

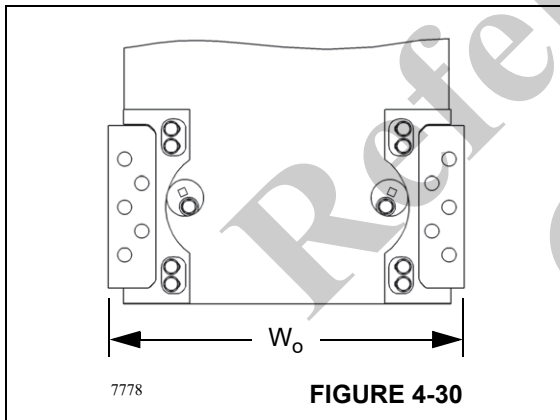


FIGURE 4-30

**Inner Side Pads**

- With a pair of inside/outside calipers, measure the inside width of the outer section ( $W_i$ ) at the front and back of the boom within 3 in of the bottom plate and record the smallest measurement. If the section has cylinder anchor bars, take a measurement directly in front of these bars.

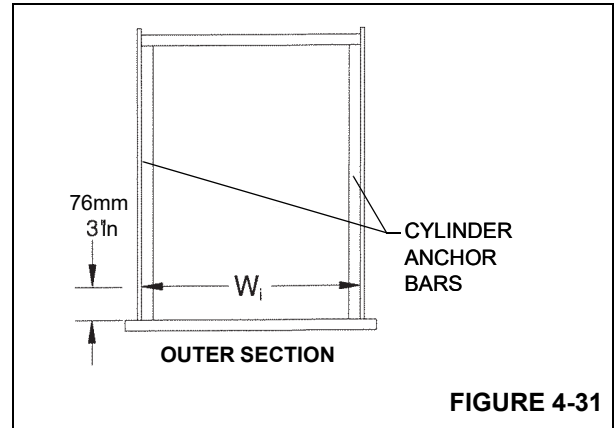


FIGURE 4-31

- With the inside/outside calipers, measure the outside width of the inner section ( $W_o$ ) at the rear, lower side pad location. Record the largest measurement.

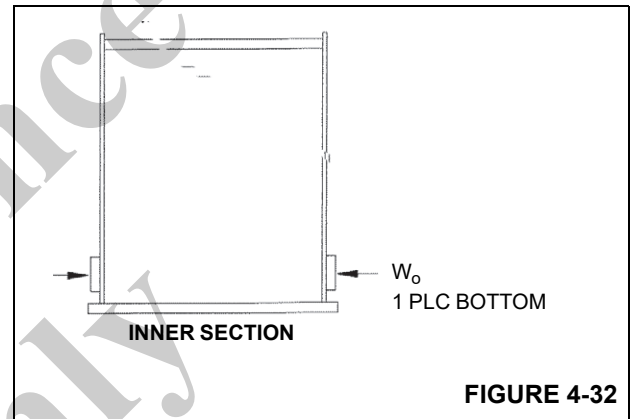


FIGURE 4-32

- Measure the thickness of the wear pads and record ( $t_{wp}$ ).

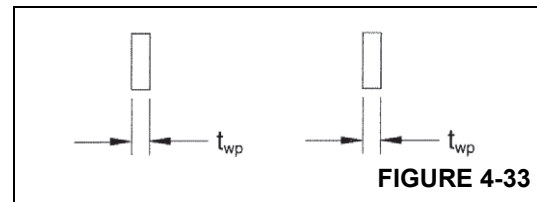


FIGURE 4-33

- Subtract the outside width ( $W_o$ ) of the inner section and the thickness of the two pads ( $t_{wp}$ ) from the inside width of the outer section ( $W_i$ ). Add shims as required (each shim is 0.7 mm (0.03) thick) to tighten the pads so that there is 0.00 - 0.06 in clearance between the inner boom rear lower wear pads and the most narrow part of the outer boom when shims are installed.

**Bottom Rear Pads**

- With a tape measure, measure the inside height of the outer section ( $H_i$ ) 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.

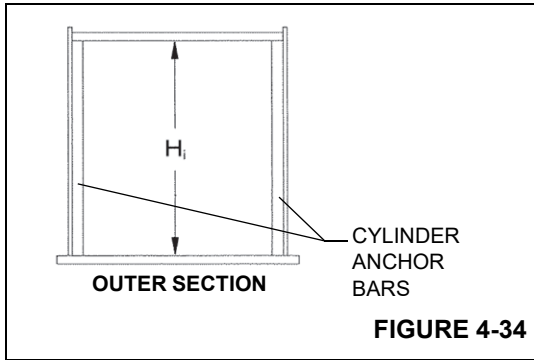


FIGURE 4-34

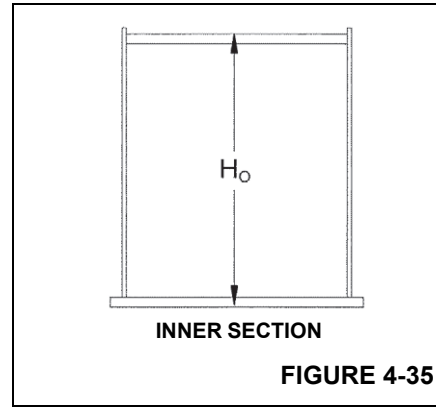


FIGURE 4-35

2. With the tape measure, measure the outside height of the inner section ( $H_o$ ) at bottom, rear pad location. Record the largest measurement.

3. Measure the thickness of the top wear pads and record ( $t_{wp}$ ).

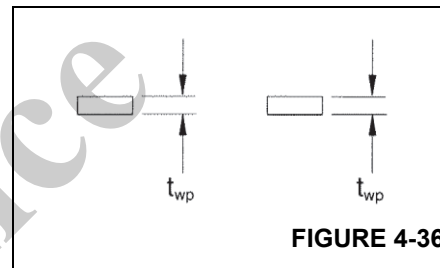


FIGURE 4-36

EXAMPLE

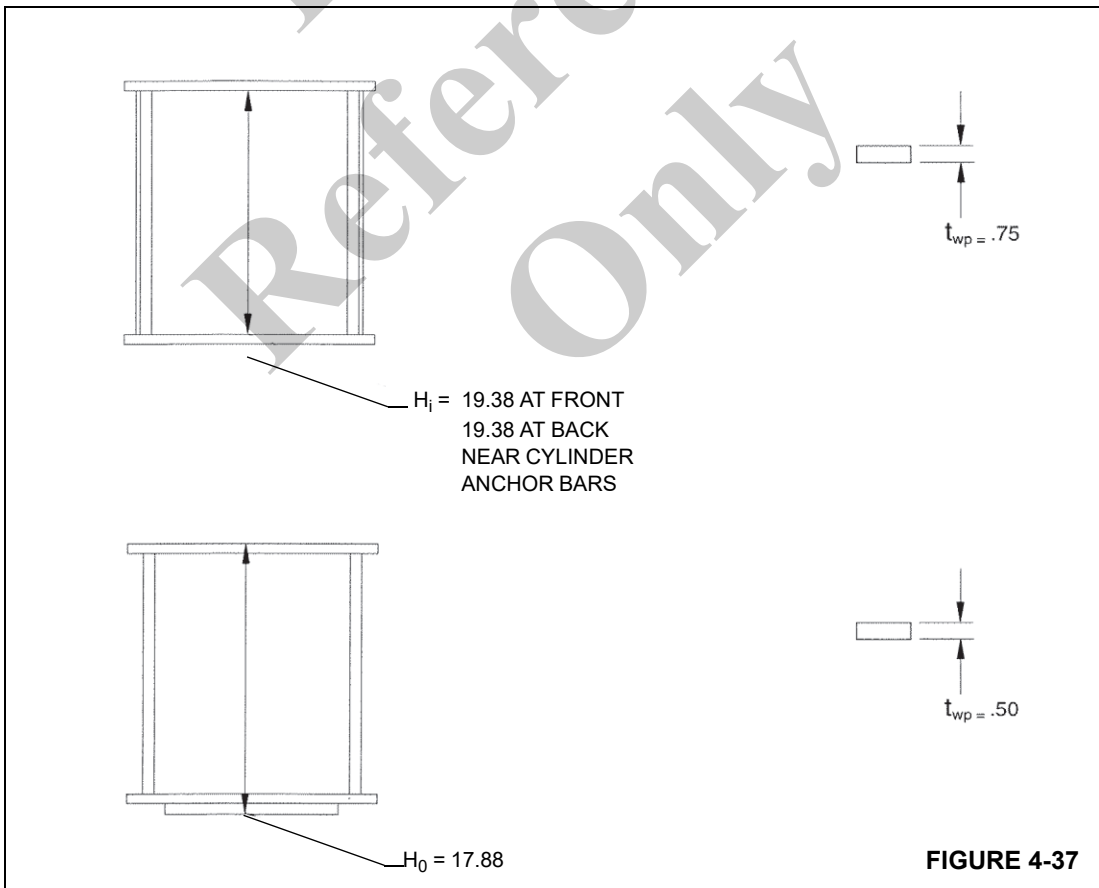


FIGURE 4-37



H <sub>i</sub>	=	19.38
-H <sub>o</sub>	=	-17.88
-twp	=	-0.75
-twp	=	<u>-0.50</u>
Clearance	=	0.25
Bottom shims	=	<u>-0.19</u>
<b>Final Clearance</b>	=	<b>0.06</b>

**TELESCOPE CYLINDER**

The telescope cylinder is located inside the boom assembly. If the telescope cylinder requires maintenance, contact your local National Crane distributor or Manitowoc Crane Care.

**JIB**

The following sections describe maintenance procedures for telescoping and lattice jibs.

**General Warnings**



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



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

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



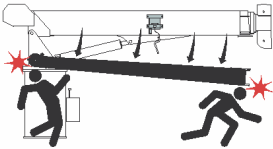
Before attempting to erect or stow the jib, read and strictly adhere to all danger decals installed on the boom/boom nose, jib, and stowage brackets.

**CAUTION**

- Boom tip attachment can contact jib in stowed position when boom is fully retracted.
- Contact can cause damage to boom extension system and jib stow system.
- Boom must be left extended .5 ft (.2 m) to prevent contact.
- Boom attachment must be removed for retracted boom lifting operations.

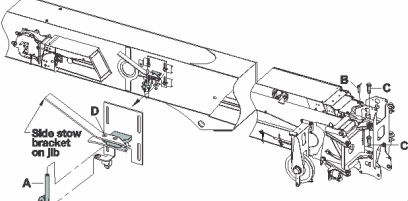
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**⚠ DANGER**



**A FREE FALLING JIB WILL RESULT IN DEATH OR SERIOUS INJURY**

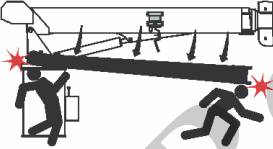
Before operating the crane check that jib is properly secured. You must follow proper jib erection and stowing procedures. See crane manufacturer's manual.



- Before removing pins (C) when stowing jib, boom must be level and fully retracted, and stow pin (A) must be properly located in the side stow bracket through hole (D).
- Do not extend boom after removing jib swing pin (B) until boom is in level position.
- When stowing or erecting jib, boom must be in level position.

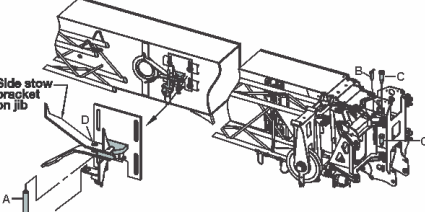
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**⚠ DANGER**



**A FREE FALLING JIB WILL RESULT IN DEATH OR SERIOUS INJURY**

Before operating the crane check that jib is properly secured. You must follow proper jib erection and stowing procedures. See crane manufacturer's manual.



- Before removing pins (C) when stowing jib, boom must be level and fully retracted, and stow pin (A) must be properly located in the side stow bracket through hole (D).
- Do not extend boom after removing jib swing pin (B) until boom is in level position.
- When stowing or erecting jib, boom must be in level position.

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## Replacing Jib Stowage Brackets

Use the following procedures to remove and install the jib stowage brackets. The jib stowage brackets are located on the base boom section.

### Removing the Front Jib Bracket Assembly

1. If not already done, remove the jib from the boom. For more information, see the *Operator Manual*.

**NOTE:** The front jib bracket weighs approximately 24 kg (53 lbs).

2. Loosen hex nut (1, Figure 4-38) and capscrew (2).
3. Remove nuts (3) from captive capscrews (4).
4. Remove nuts (5), washers (6), capscrews (7), and pins (8) from the front bracket assembly (9).
5. Remove capscrews (10), washers (11), and front bracket assembly (9) from the boom base section.

### Installing the Front Jib Bracket Assembly

1. Install the front bracket assembly (9, Figure 4-38) using washers (11) and capscrews (10).
2. Install pins (8) on the front mounting bracket (9) using capscrews (7), washers (6), and nuts (5).
3. Install nuts (3) on captive capscrews (4).
4. Tighten nut (1) and capscrews (2) as necessary.
5. Adjust the front jib stowage bracket as needed. For more information, see "Adjusting the Telescoping Jib Stowage Bracket" on page 4-39.

### Removing the Rear Jib Mount Assembly

1. If not already done, remove the jib from the boom base section. For more information, see the *Operator Manual*.
2. If necessary, remove the spring clip (18, Figure 4-38) from stow pin (19). Install the spring clip and stow pin in the stowed position for ease of removal.
3. Loosen capscrew (12) and nut (13).
4. Remove capscrews (14), washers (15), plate (16), and rear jib mount assembly (17).

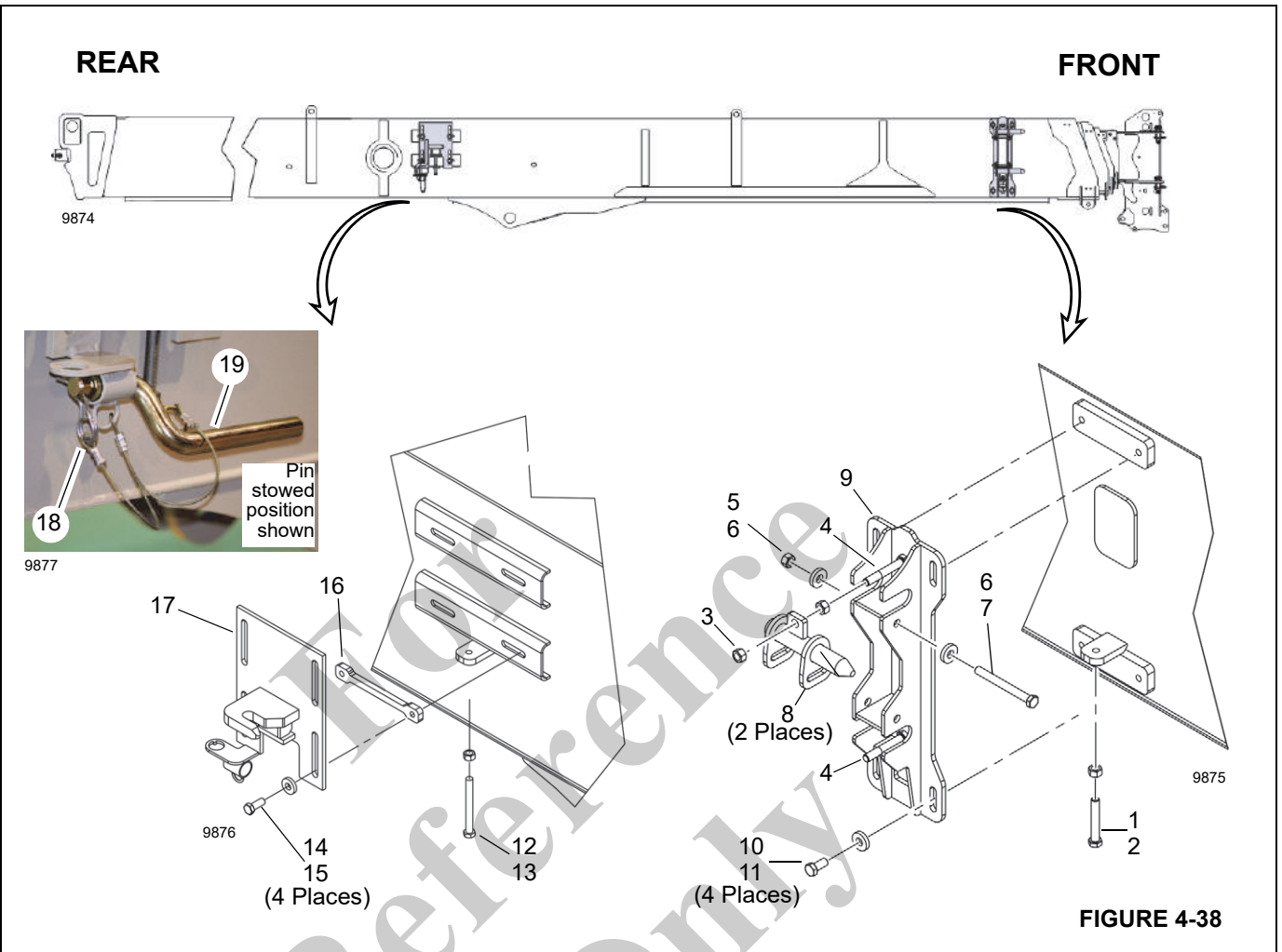


FIGURE 4-38

**Installing the Rear Jib Mount Assembly**

1. If necessary, remove the spring clip (18, Figure 4-38) from pin (19). Install the spring clip and stow pin in the stowed position for ease of installation.
2. Install the plate (16) and rear jib mount assembly (17) using washers (15) and capscrews (14).
3. Tighten capscrew (12) and nut (13) as necessary.
4. Adjust the jib stowage bracket position. For more information, see “Adjusting the Telescoping Jib Stowage Bracket” on page 4-39.

**Adjusting the Telescoping Jib Stowage Bracket**

**NOTE:** The following procedure applies to the lattice and telescoping jibs.

Use the following procedure to make adjustments to the jib stowage brackets.

Before beginning this procedure read and understand the DANGER decals in “General Warnings” on page 4-37. Also review and understand the *Operator Manual Set-Up* section 4 for jib safety, stowing, and deployment instructions.

1. Do one of the following:
  - **If the boom is stowed on the boom rest:**

**CAUTION**

When stowing to the lattice jib, do not extend the boom more than 25 cm (10 in). Stowing the lattice jib when the boom is extended more than 25 cm (10 in) will result in damage to the lattice jib.

- a. With the boom in the boom rest, extend the boom as follows for the type of jib being stowed:
  - Telescoping jib: approximately 30 cm (12 in)
  - Lattice jib: no more than 25 cm (10 in)
- b. Proceed to step 2.

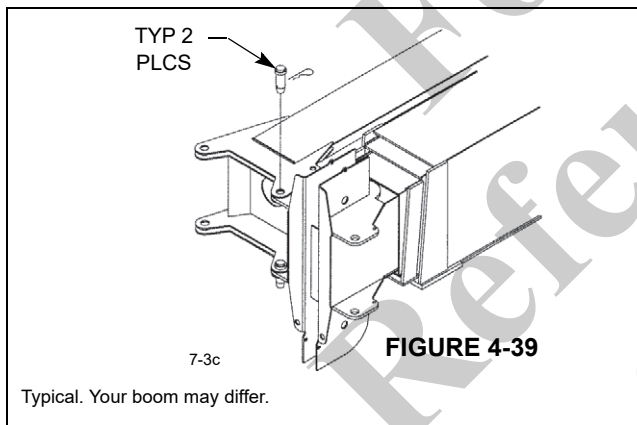
—or—

- **If the superstructure must be rotated to access the mounting brackets:**
  - a. Set the crane for operation. For more information, see the *Operator Manual*.
  - b. Raise the boom to a horizontal position.

### CAUTION

When stowing to the lattice jib, do not extend the boom more than 25 cm (10 in). Stowing the lattice jib when the boom is extended more than 25 cm (10 in) will result in damage to the lattice jib.

- c. Extend the boom as follows for the type of jib being stowed:
    - Telescoping jib: approximately 30 cm (12 in)
    - Lattice jib: no more than 25 cm (10 in)
  - d. Proceed to step 2.
2. Using a suitable assist crane, lift the jib assembly and align and pin the jib to the boom sheave head, Figure 4-39.

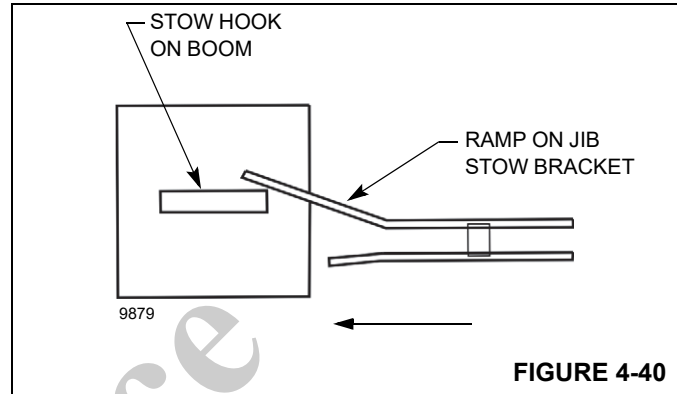


3. With the jib pinned to the sheave head, swing the jib parallel to the boom using a tag line. Observe the alignment of the rear jib mount assembly and the jib stowage bracket (Figure 4-40). If necessary, adjust the vertical position of the rear jib mount bracket on the base boom section as follows:

**NOTE:** The rear jib mount bracket on the base of the boom should be approximately 1 inch higher than the center of the stowage bracket on the jib to enable

the ramp on the job stow bracket to engage when the jib is mounted (Figure 4-40).

- a. Loosen capscrews (14, Figure 4-38).
- b. Adjust capscrew (12) and nut (13) as necessary to adjust the height of the bracket.
- c. Tighten capscrews (14).



4. Observe the alignment of the front jib mounting bracket on the base boom section and the mounting slots on the jib. If necessary, adjust the vertical and horizontal positions of the front jib mounting bracket as follows:

To adjust the vertical position of the bracket:

- a. Loosen capscrews (10, Figure 4-38).
- b. Adjust capscrew (2) and nut (1) as necessary to adjust the height of the bracket.
- c. Tighten capscrews (10).

To adjust the horizontal position of the bracket:

- a. Loosen nuts (5, Figure 4-38).
- b. Adjust nuts (3) as necessary to adjust the horizontal position of the bracket pin (8).
- c. Tighten nuts (5).

5. Slowly retract the boom until jib mounting brackets seats on the rear base boom section. Install the stow pin (Figure 4-41). Make sure the stow pin is aligned and properly seated in the stow hook on the rear jib mounting bracket. Adjust the rear and front jib mounting brackets as necessary for proper alignment.

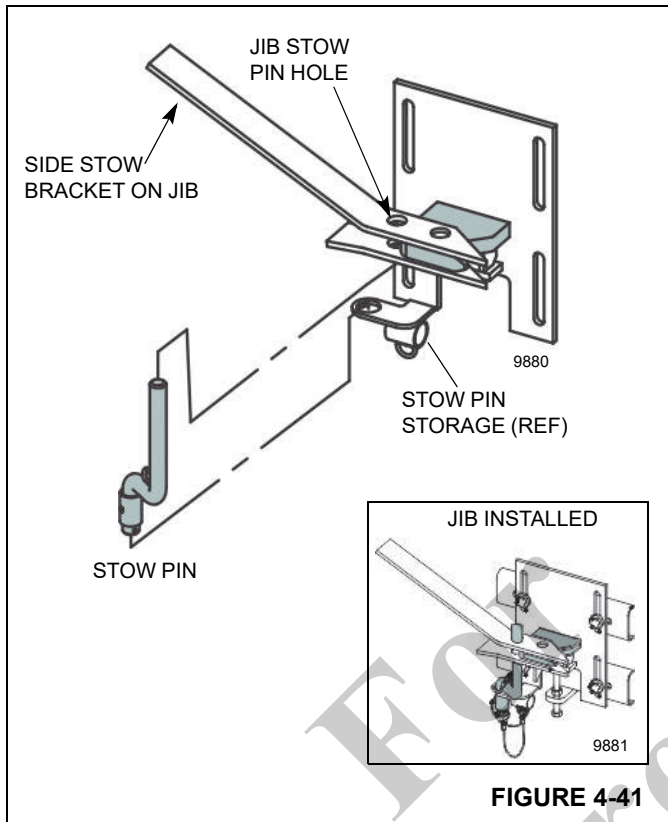


FIGURE 4-41

**! DANGER**

Make sure the jib is securely seated on the rear jib mounting bracket with the stow pin (Figure 4-41) properly installed before removing the jib pins (Figure 4-39). Failure to properly secure the jib during stowing and erecting may allow the jib to fall. Serious personal injury or death could result.

6. Try to remove the jib pins (Figure 4-39). If the pins are too tight, adjust as necessary the vertical and horizontal positions of the front job mounting bracket as described in step 4.
7. Torque all capscrews on the front and rear jib mounting brackets to their specified torque value. See "Fasteners and Torque Values" on page 1-7.
8. Remove the jib pins from the boom sheave head.
9. Remove the assist crane.

10. Extend and retract boom to insure proper alignment of jib ears. The jib ears should align with the boom jib flanges (Figure 4-42).

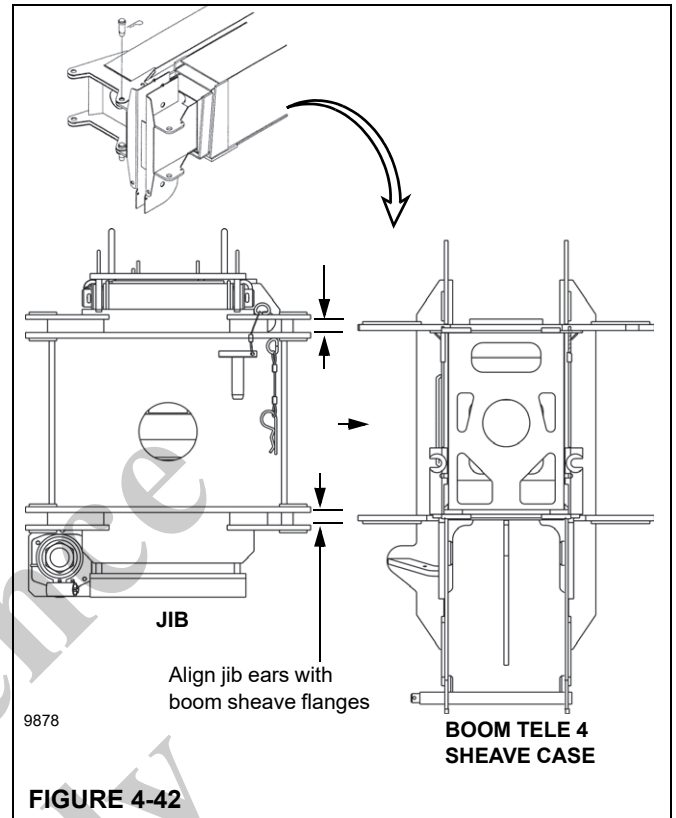


FIGURE 4-42

**! DANGER**

Make sure the jib pins are securely installed in the upper and lower jib holes on the boom tip (Figure 4-39) before removing the stow pin from the rear jib mounting bracket (Figure 4-41). Failure to properly secure the jib during stowing and erecting may allow the jib to fall. Serious personal injury or death could result.

11. Install front jib pins and remove the stow pin from rear bracket.
12. Extend and retract the boom and jib to ensure proper alignment of jib stow brackets.
13. Slowly retract the boom until jib mounting brackets seats on the rear base boom section. Install the stow pin (Figure 4-41). Make sure the stow pin is aligned and properly seated in the stow hook on the rear jib mounting bracket.

**⚠ DANGER**

Make sure the jib is securely seated on the rear jib mounting bracket with the stow pin (Figure 4-41) properly installed before removing the jib pins (Figure 4-39). Failure to properly secure the jib during stowing and erecting may allow the jib to fall. Serious personal injury or death could result.

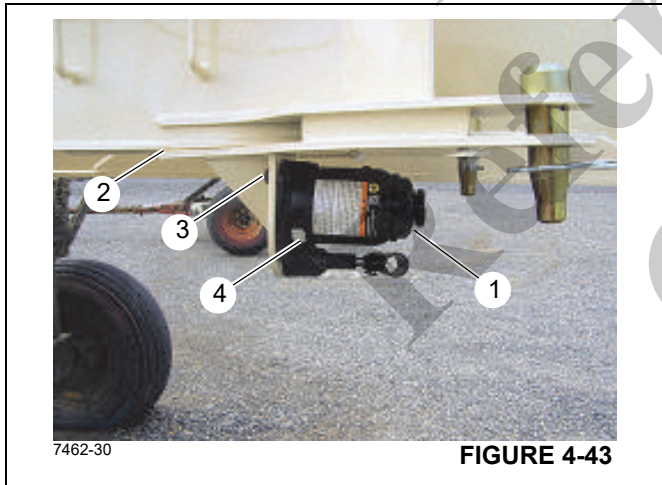
14. Install jib stow pin in rear jib mount bracket and remove front jib pins.

**Jib Jack Service and Maintenance**

**NOTE:** 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.

**NOTE:** The following procedures applies to the jib jack on the telescoping and lattice jibs.

Remove the jack (1, Figure 4-29) from the jib boom (2) by removing three bolts and flatwashers (3, Figure 4-29).



**FIGURE 4-43**

**Adding Oil**

1. With saddle fully lowered and piston depressed, set jack in its upright level position and remove oil filler plug. (4, Figure 4-43).
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 (4, Figure 4-43).
3. Lay the jack on its side and allow the oil to run out into suitable drain pan. 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 not in use, always leave the saddle and ram all the way down.

**Troubleshooting**

Symptom	Possible Cause(s)	Solution
Will not lift load	<ol style="list-style-type: none"> <li>1. No oil in system</li> <li>2. Release valve not closed</li> </ol>	<ol style="list-style-type: none"> <li>1. Add oil to reservoir tank through oil filler hole</li> <li>2. Turn handle clockwise tightly</li> </ol>
Will lift load only part way	Oil level low	Add oil to reservoir tank through oil filler hole
Will lift load but will not hold	<ol style="list-style-type: none"> <li>1. The following valve or valves leaking:                             <ol style="list-style-type: none"> <li>a. Suction valve</li> <li>b. Delivery valve</li> <li>c. Release valve</li> </ol> </li> <li>2. Packings worn out or defective</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace jack</li> <li>2. Replace jack</li> </ol>

Symptom	Possible Cause(s)	Solution
Jack will not lower	Release valve stuck, probably dirt or foreign matter	Transfer load then replace dirty oil, flush oil reservoir with kerosene
Poor lifting	1. Dirty oil 2. Air in hydraulic system	1. Change hydraulic oil 2. Purge air from system
Poor pumping action	Oil seal for pump unit worn out or defective	Replace jack

**LIFT CIRCUIT**

The boom lift circuit consists of the lift hydraulic remote controller, lift directional control valve, holding valve, and the lift cylinder. These components enable the boom to be raised or lowered to various degrees of elevation ranging from -8 to +80 degrees from horizontal.

The lift directional control valve is the closed spool type.

The double acting lift cylinder has a 22.86 cm (9.0 in) bore. Dirt and other foreign material is prevented from entering the cylinder and causing internal damage during rod retraction by the use of a wiper seal. Oil seals on both the piston and cylinder head prevent internal and external hydraulic oil leakage.

The holding valve is a balanced poppet type hydraulic valve. It is threaded into the port block which is an integral portion of the lift cylinder barrel. The holding valve functions when

booming up (cylinder rod extended), booming down (cylinder rod retracted), or holding (cylinder rod stationary).

**Theory of Operation**

The directional control valve bank housing is supplied by flow from the hydraulic pump.

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

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

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

**Maintenance**



Symptom	Probable Cause	Corrective Action
1. Boom raises erratically.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine RPM.	b. Increase engine RPM to recommended setting.
	c. Main relief valve damaged.	c. Replace relief valve.
	d. Air in cylinder rod.	d. Bleed cylinder rod.
	e. Bent boom pivot shaft.	e. Replace pivot shaft.
2. Boom lowers erratically.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine RPM.	b. Increase engine RPM to recommended level.
	c. Circuit and/or relief valve inoperative.	c. Repair or replace relief valve.
	d. Air in hydraulic cylinder.	d. Bleed air from cylinder.
	e. Damaged hydraulic pump section.	e. Repair or replace pump section.

Symptom	Probable Cause	Corrective Action
3. Boom raises slowly.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine RPM.	b. Increase and maintain engine RPM.
	c. Damaged relief valve.	c. Repair or replace relief valve.
	d. Extremely cold hydraulic oil.	d. Operate unit to bring oil to operating temperature.
	e. Improper hose or fittings, installed.	e. Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	f. Operating two functions with in the same control valve bank assembly.	f. Feather controls to obtain desired speed of both functions.
	g. Restriction in return hose.	g. Replace return hose.
	h. Cylinder piston seals leaking.	h. Replace all cylinder seals.
	i. Scored cylinder barrel.	i. Hone or replace barrel.
	j. Worn hydraulic pump section.	j. Repair or replace pump section.
4. Boom lowers slowly.	a. Low hydraulic oil level.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Low engine RPM.	b. Increase RPM to recommended level.
	c. Damaged relief valve.	c. Repair or replace relief valve.
	d. Operating two functions within the same control valve bank assembly.	d. Feather controls to obtain desired speed of both functions.
	e. Extremely cold hydraulic oil.	e. Operate unit to bring oil to operating temperature.
	f. Improper hose or fittings installed.	f. Replace hose or fittings. (Refer to Manitowoc Crane Care Parts Manual).
	g. Restriction in return hose.	g. Replace return hose.
	h. Cylinder piston seals worn.	h. Replace all cylinder seals.
	i. Scored cylinder barrel.	i. Hone or replace barrel.
	j. Worn hydraulic pump section.	j. Repair or replace pump section.
	k. Piston rod broken (loose from piston).	k. Replace piston rod and all cylinder seals.



Symptom	Probable Cause	Corrective Action
5. Boom will not raise.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Main relief valve or circuit relief valve damaged.	b. Repair or replace relief valve.
	c. Excessive load.	c. Reduce load as required.
	d. Worn or damaged hydraulic pump section.	d. Repair or replace pump section.
	e. Broken pump shaft.	e. Replace pump shaft and seals.
	f. Broken pump drive coupling.	f. Replace drive coupling.
	g. Broken control valve spool.	g. Replace control valve.
6. Boom will not lower.	a. Low hydraulic oil.	a. Check system for leaks. Make repairs as needed. Fill reservoir.
	b. Main relief valve or circuit relief valve damaged.	b. Repair or replace relief valve.
	c. Worn or damaged hydraulic pump section.	c. Repair or replace pump section.
	d. Broken pump shaft.	d. Replace pump shaft and seals.
	e. Broken pump drive coupling.	e. Replace drive coupling.
	f. Broken control valve spool.	f. Replace control valve.

For Reference Only

Symptom	Probable Cause	Corrective Action
<p>7. The rod side calibration warning icon appears in the RCL screen.</p> <p><b>Note:</b> Refer to the Manitowoc Diagnostic Code application for details about RCL error codes. For more information, see “About the Manitowoc Diagnostic Code Application” on page 3-23.</p> 	<p>a. Lift cylinder rod side transducer needs to be calibrated.</p>	<p>a. Calibrate the rod side transducer in the RCL. For more information, “Calibrating the Rod and Base Side Pressure Transducers” on page 3-15.</p>
<p>8. The base side calibration warning icon appears in the RCL screen.</p> <p><b>Note:</b> Refer to the Manitowoc Diagnostic Code application for details about RCL error codes. For more information, see “About the Manitowoc Diagnostic Code Application” on page 3-23.</p> 	<p>a. Lift cylinder base side transducer needs to be calibrated.</p>	<p>a. Calibrate the rod side transducer in the RCL. For more information, “Calibrating the Rod and Base Side Pressure Transducers” on page 3-15.</p>

**NOTE:** Contact Manitowoc Crane Care for lift cylinder disassembly and assembly procedures. Maintenance not requiring removal of the cylinder barrels, such as packing, may be performed without removing the cylinders from the turntable. However, all disassembly and assembly should be conducted in a clean dust-free area.

**NOTE:** The lift cylinder weighs approximately 750 kg (1653.47 lb).

### Removing the Lift Cylinder

Use the following procedure to install the lift cylinder (1, Figure 4-44).

1. Extend and set the outriggers and level the crane.
2. Elevate the boom slightly so that the lift cylinder is extended approximately 0.3 m (1 ft).

3. Ensure the boom is fully supported by placing blocking or cribbing under the boom. Rest the boom on the blocking or cribbing.
4. Attach an adequate lifting/supporting device to the lift cylinder.
5. Remove the capscrew (11) and lock nut (12) securing the lift cylinder upper pivot shaft (10) to the boom.
6. Remove the capscrew (8), washers (6 and 9) that secure the lift cylinder lower pivot shaft (3) to the turntable.
7. Remove capscrews (7), washers (5), and pin retainer plate (2).
8. Remove the upper pivot shaft (10) and any attached thrust washers (13 and 14). Activate the hydraulic system and retract the lift cylinder (1) enough to clear the upper attach point.
9. Tag and disconnect all the hydraulic lines to the cylinder. Cap or plug all openings with high pressure fittings.



**DANGER**

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury could result if the lifting device cannot support the load.

10. Tag and disconnect the pressure transducers (4).
11. Pull the lower lift cylinder pivot shaft (3) and any attached washers out far enough to remove the cylinder.
12. Move the lift cylinder to a clean work area.

### Installing the Lift Cylinder

Use the following procedure to install the lift cylinder (1, Figure 4-44).

1. Attach an adequate lifting device to the lift cylinder (1) and position the cylinder over the attach fitting on the turntable.

**NOTE:** The lift cylinder weighs approximately 750 kg (1653.47 lb).

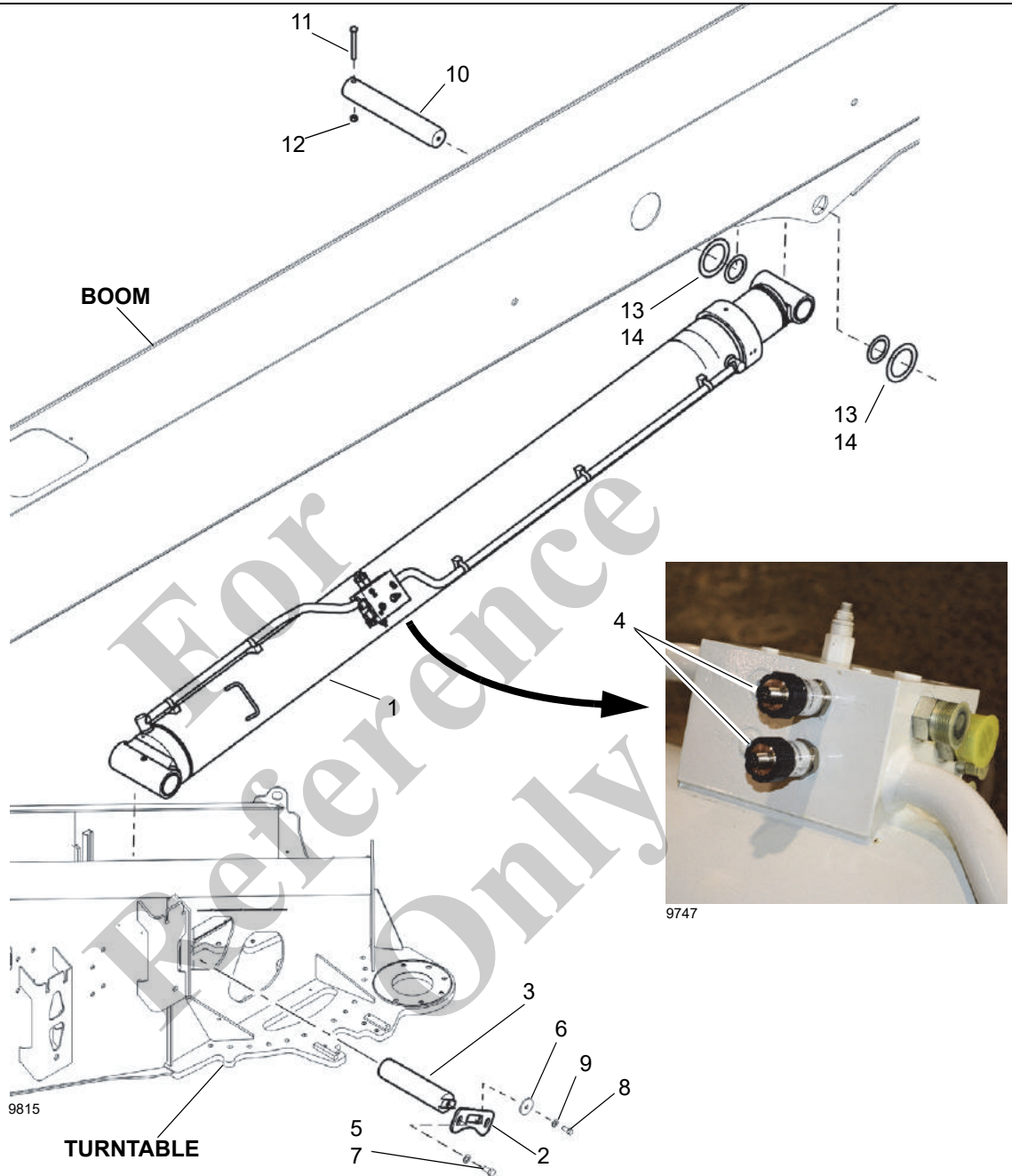
2. Lower the lift cylinder into the attach fittings on the turntable and align the lift cylinder bushing with the attach fitting holes.

**NOTE:** Install pivot shaft with tapped hole on the right side of the crane, side opposite the cab.

3. Install the pin retainer plate (2) using capscrews (5) and washers (7).
4. Install the lift cylinder lower pivot shaft (3). Secure the shaft (3) with capscrew (8) and washer (6).
5. Connect the extend and retract hoses to the lift cylinder.

6. Connect the pressure transducers (4) to the appropriate cable.
7. Apply anti-seize compound to upper pivot shaft (10) per specification 6829003689.
8. Activate the crane's hydraulic system and align the lift cylinder rod end with the attach point on the boom. Install the upper pivot shaft and any attached thrust washers through the cylinder and boom attach points. Shut down the engine.
9. Shim pivot shaft (10), as needed, using thrust washer(s) (13 and 14) on each side. If possible, install the identical number of thrust washers on each side of the pivot shaft (10).
10. Secure the upper pivot shaft (10) with the capscrew (11) and locknut (12).
11. Remove the lifting and supporting devices from the boom and lift cylinder. Activate the hydraulic system and check the lift cylinder for proper operation and any leaks.
12. Lubricate the pivot shafts using grease fittings on cylinder. See *Lubrication*, page 8-1.
13. Calibrate the lift circuits if needed. For more information, see "Calibrating the Rod and Base Side Pressure Transducers" on page 3-15.

For Reference Only



Item	Description
1	Lift Cylinder
2	Pin Retainer Plate
3	Lower Lift Cylinder Pin
4	Pressure Transducer
5	Washer
6	Washer
7	Capscrew-M20×40

Item	Description
8	Capscrew-5/8-18U
9	Washer Plate
10	Pivot Shaft
11	Capscrew-M16×150
12	Lock Nut
13	Thrust Washer
14	Thrust Washer

FIGURE 4-44

## SECTION 5 HOIST AND COUNTERWEIGHT

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### HOIST DESCRIPTION

The NBT60L hoist is composed of motor control valve, a dual displacement hydraulic motor, multiple disc brakes, and a pair of planetary gear sets.

The multiple disc brake is spring applied and hydraulically released through a port in the brake housing. An overrunning clutch allows the hoist to be raised without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down.

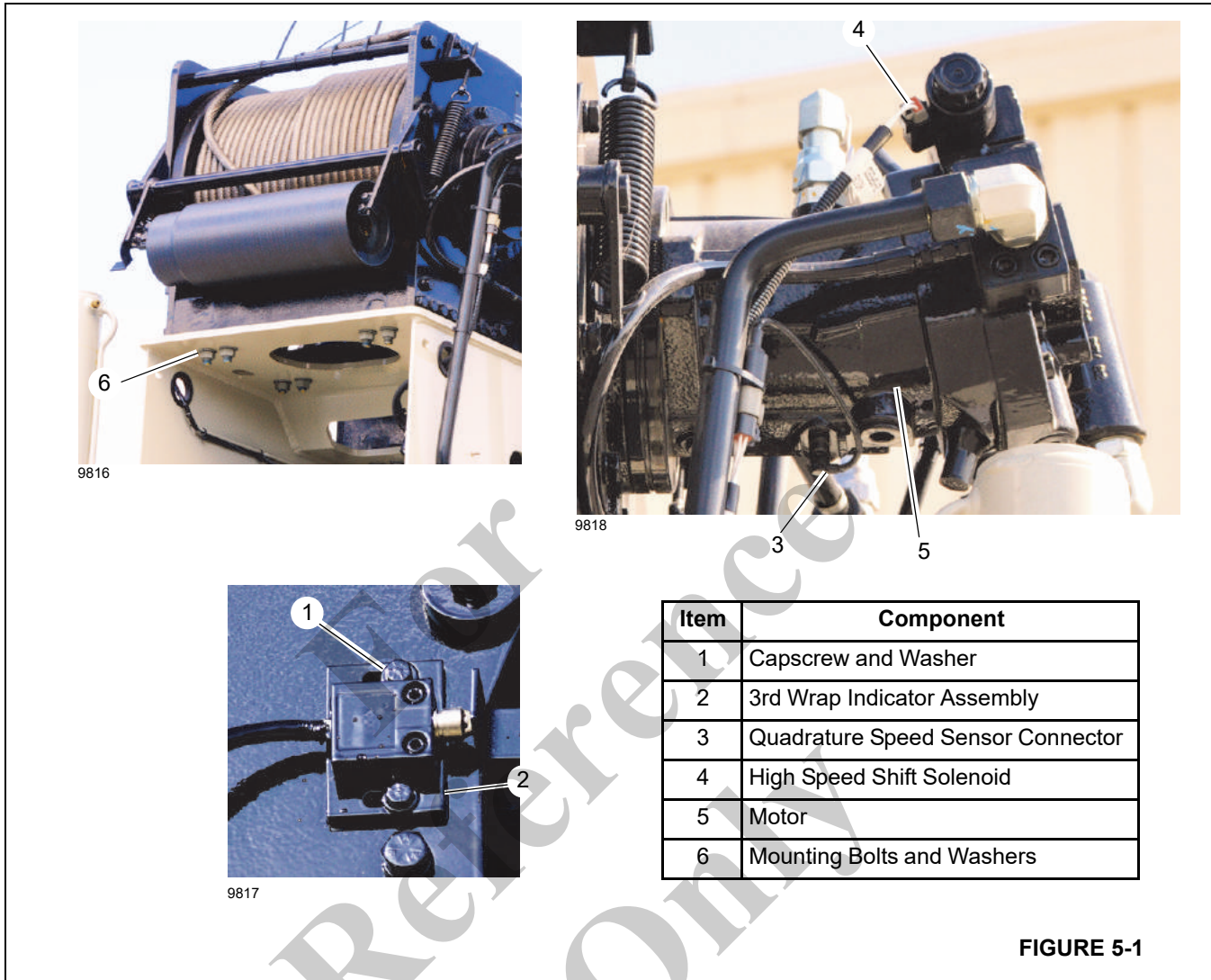


FIGURE 5-1

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.

**⚠ DANGER**

Pressurized hydraulic fluid can cause serious injury. Be careful when removing hoses from pressurized hydraulic systems suspected to have entrapped air.

**⚠ CAUTION**

The combined weight of the hoist and 137.6 m (450 ft) of wire rope is 499 kg (1100 lbs).

1. Turn Off the truck engine.
2. Remove the wire rope from the cable drum and align the drain hole in the drum with a hole in the support side plate before removing the hoses and mounting bolts. After the hoist is removed from its mounting, thoroughly clean the outside surfaces.
3. Remove two capscrews (1, Figure 5-1) and remove the 3rd Wrap Indicator assembly (2) from the hoist.
4. Disconnect the high speed shift solenoid (4) and quadrature speed sensor (3) connectors from the hoist.

5. Tag and disconnect the hoist hydraulic lines. Cap and plug all hoist hydraulic hose and motor openings.
6. Attach a lifting device to hoist and take up the slack.
7. Remove the mounting bolts and washers (6) from the hoist.
8. Remove the hoist from the crane with the lifting device.

### Hydraulic Hose

Inspect the hydraulic hoses for wear and damage. Replace hoses or hose connectors as needed.

### Hoist Installation

1. Attach a lifting device to the hoist.
2. Lift the hoist with a lifting device onto the turret.
3. Align the hoist with the boom.
4. Install mounting bolts and washers (6).
5. Remove the lifting device.
6. Reinstall the hydraulic hoses as per removal tags.
7. Connect the high speed shift solenoid (4) and quadrature speed sensor (3) connectors to the hoist.
8. Install the 3rd wrap assembly (2) on the hoist with capscrews and washers (1).

### Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential if ambient temperature is below 4°C (+40°F). Run the crane at idle with the hoist control lever in neutral and allow sufficient time for the hydraulic system to warm up. Operate the hoist at low speeds, forward and reverse, several times to prime all lines with warm hydraulic oil and circulate lubricant through the planetary gear sets.

### 3rd Wrap Indicator

The 3rd Wrap Indicator is integrated in to the RCL system. The 3rd wrap indicator assembly (Figure 5-2) is located on the bearing support (left) side of the crane hoist. The 3rd Wrap Indicator is designed to notify the operator when three wraps of wire or synthetic rope remain on the hoist drum.

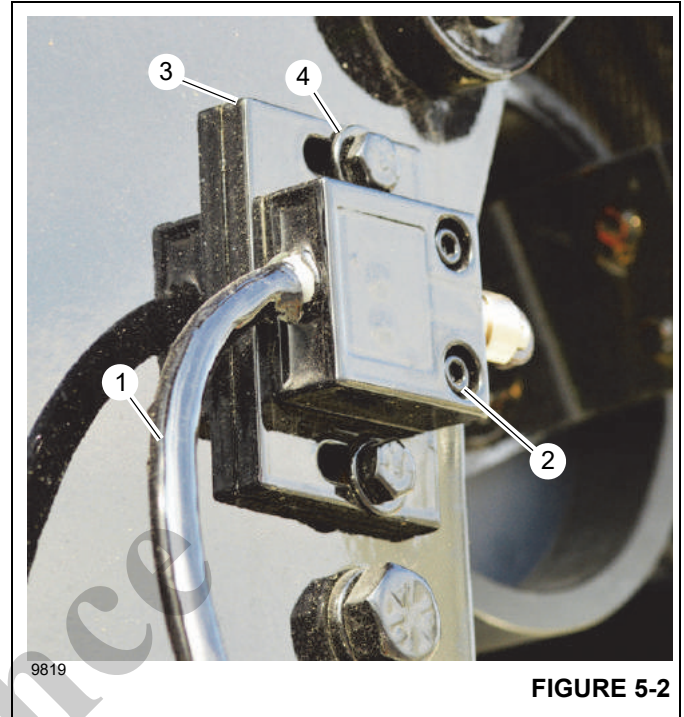


FIGURE 5-2

#### Removal

1. Disconnect the 3rd wrap cable (1, Figure 5-2) from the 3rd wrap indicator connector located inside the hoist frame.
2. Remove capscrews (2) and remove the 3rd wrap indicator assembly from the plate (3).
3. Remove capscrews and washers (4) and remove the 3rd wrap indicator plate (3) from the hoist.

#### Installation

1. Install the plate (3) on the hoist using washers and capscrews (4).
2. Install the 3rd wrap indicator assembly on the plate (3) using capscrews (2).
3. Route the 3rd wrap indicator wire (1) through the gusset in the hoist frame. Connect the wire to 3rd wrap indicator connector inside the hoist frame.

**NOTE:** The 3rd wrap indicator sensor should be 0.25 inches from the switch bracket on the roller assembly with one layer of rope on the drum.

4. Adjust the 3rd wrap indicator sensor as needed, then tighten capscrews and washers (4).

### Drum Rotation Indicator (DRI) Display

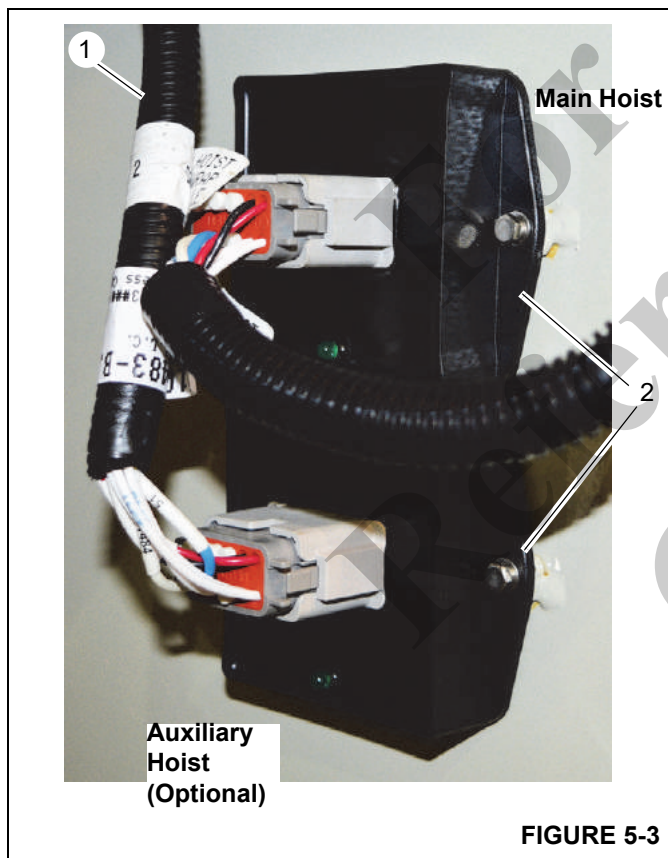
The DRI Display appears in the RCL display as an icon that indicates the hoist(s) are rotating. The DRI system also provides the operator with a touch indication of drum rotation

so the operator will know if and at what speed the hoist drum is rotating, even under the most distracting conditions. Refer to *Drum Rotation Indicator*, page 5-4.

## DRUM ROTATION INDICATOR

The Drum Rotation Indicator (DRI) is integrated in to the RCL system. The DRI wiring harness connects to the 2- and 4-speed connectors on the hoist motor and is connected to the hoist DRI module located on the right side of the hoist inside the frame.

**NOTE:** If a DRI module (2) is replaced, the new module's component ID must be assigned in the RCL system. For more information, see *Assigning CAN Bus ID to Hoist Module(s)*, page 3-19.



## Removal

1. Disconnect the DRI wiring harness (1, Figure 5-3) from the appropriate DRI module (2) located inside the hoist frame.
2. Disconnect the 2-speed (3, Figure 5-1) and 4-speed (4) connectors from the hoist motor.
3. Remove the DRI wiring harness (1). Remove tie wraps as needed.

## Installation

To connect the DRI wiring harness to a hoist, use the following procedure:

1. Route the DRI wiring harness (1, Figure 5-3) through the gusset in the hoist frame. Connect the DRI connector to the appropriate hoist DRI module (2) located on the inside of the hoist frame.
2. Connect the 2-speed (3, Figure 5-1) and 4-speed (4) wires to their connectors on the hoist motor.
3. Secure the DRI wiring harness to piping as needed using cable wraps.



## HOIST REPAIR

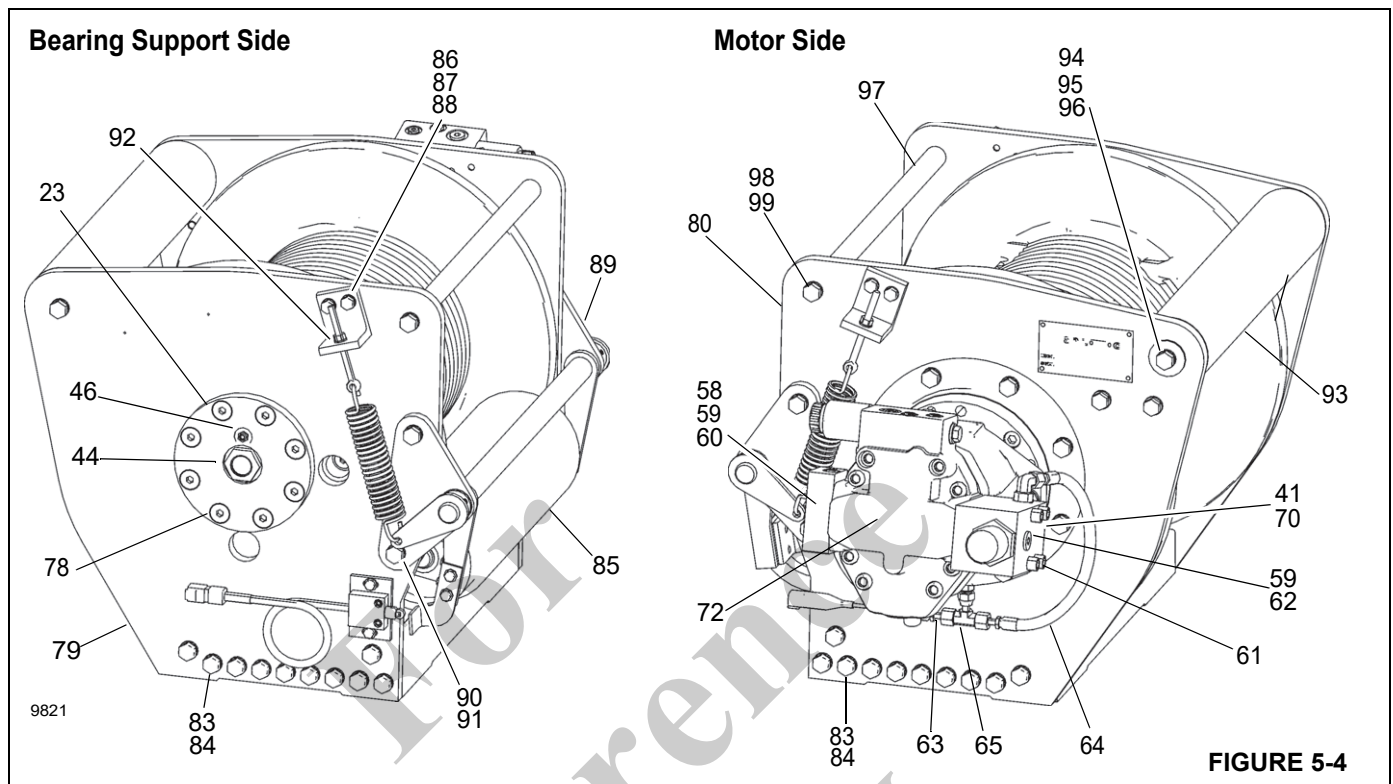


FIGURE 5-4

**Disassembling the Hoist**

Refer to Figure 5-5 and Figure 5-5 and the Hoist Parts List on page 5-8 to disassemble the hoist.

1. If not already done, remove the hoist from the crane. For more information, see *Hoist Removal*, page 5-2.
2. Drain the oil from the hoist gearbox and brake sections using the instructions in the *Operator Manual*.
3. Remove the roller assembly (85, Figure 5-4). For more information, *Roller Assembly*, page 5-10.
4. Remove the 3rd wrap indicator assembly. For more information, see *3rd Wrap Indicator*, page 5-3.
5. Remove the oil level sight gauge (44).
6. Remove the vent plug (46).
7. Stand the hoist on its end with the motor pointing up.
8. Tag and remove the hydraulic hoses (63 and 64) that connect the brake valve (62) and manifold (60) to the brake cylinder (1).
9. Remove the capscrews (70) and lockwashers (41) securing the motor (72), and lift the motor off of the hoist. Remove and discard the O-ring (33) installed on the pilot of the motor.
10. Tag and remove the hoses (63 and 64) and fittings (65) from the brake cylinder release port.
11. Remove the brake clutch assembly (56, Figure 5-5) from the motor support (32). Refer to *Brake Clutch*, page 5-12 for additional information.
12. Remove the motor support capscrews (42) and lockwashers (41) and install two capscrews and a short piece of chain into the motor mounting bolt holes. Using the chain as a handle, lift the motor support out of the brake cylinder being careful to avoid damaging the sealing surfaces. Remove and discard the O-ring (47) and backup ring (48) from the motor support (32). Refer to *Brake Cylinder*, page 5-10 for additional information. Note the location of the brake release port in relation to hoist prior to removing the brake cylinder.
13. Remove the brake cylinder capscrews (40) and lockwashers (41) and install two capscrews and a short piece of chain into the motor support mounting bolt holes. Using the chain as a handle, lift the brake cylinder (1) out of the drum and base, being careful to avoid damaging the sealing or bearing surfaces. Refer to *Brake Cylinder*, page 5-10 for additional information.
14. Remove the motor end side plate (80).
15. Using two heel type pry bars placed between the primary planet carrier and the drum closure, pry upward

to remove the drum closure (25). Remove and discard the O-ring (28) from the outside of the drum closure (25). Some drum closures have 3/8-16 tapped lifting eye holes that may be used in place of the heel bars.

16. Remove the seal (29) and bearing (26) from inside of closure.
17. Remove the primary sun gear (35) and thrust washer (31) from the primary planet carrier (10).
18. Remove the primary planet carrier (10) from the drum. Refer to *Planetary Set*, page 5-11 for additional information.
19. Remove the output sun gear (34) and thrust washer (43) from the output planet carrier (16).
20. Remove the output planet carrier (16) from the drum. Refer to *Planetary Set*, page 5-11 for additional information.
21. Stand hoist on motor end with bearing support up. Remove eight bearing support capscrews (78, Figure 5-4) and bearing support (23, Figure 5-4 and Figure 5-5) being careful to avoid damaging the sealing or bearing surfaces.
22. Slide drum out of base onto a work bench and remove seal (27) and bearing (26) from support end.
23. Thoroughly clean and inspect drum and base. Check ring gear (machined into inside surface of drum) teeth for nicks, spalling or excessive wear. Replace if wear is greater than 0.015 in. (0.4 mm) when compared to unworn area of teeth.

### Assembling the Hoist

Refer to Figure 5-4 and Figure 5-5 and the Hoist Parts List on page 5-8 to disassemble the hoist.

#### CAUTION

Use special shoulder capscrews to fasten side plates to the base plate. DO NOT use standard capscrews in their place.

1. Place hoist base on side with bearing support end up.
2. Install a new bearing (26) in the drum if replacement is necessary. Apply a non-hardening sealant on the outside diameter of the new seal (27). Install the spring side of the seal next to the bearing, then press into the drum, using a flat plate to avoid distortion. Be sure drain plug is installed securely.

#### CAUTION

Make certain the snap ring (30) is installed on the bearing support (23). This snap ring will keep the output planet carrier correctly positioned in the hoist. Gear train damage may occur if this snap ring is omitted.

3. Center the drum in the opening of the base. Lubricate the bearing support (23) with petroleum jelly or gear oil and install in base and drum.

#### CAUTION

Be sure the vent plug (46) is located above the horizontal centerline for the intended application. Oil leakage may occur if vent is positioned incorrectly.

4. Tighten the bearing support capscrews (78) to the recommended torque.
5. Stand hoist on bearing support end. Install the output sun gear (34) and thrust washer (43) into output planet carrier (16).
6. Install the output planet carrier (16) into the drum while meshing the planet gears with the ring gear and the planet housing with the bearing support.
7. Install the primary sun gear (35) and thrust washer (31) into the primary planet carrier (10).
8. Install the primary planet carrier (10), meshing the planet gears with the ring gear and the planet housing with the output sun gear (34).
9. Install a new bearing (26) in the drum closure (25) as required. Use sealant on the outside surface of the oil seal. Install with spring side of the seal toward bearing, using a flat plate to avoid distortion. Install a new O-ring (28) in the groove on the outer diameter of the drum closure (25).
10. Lubricate the O-ring (28) and drum opening with petroleum jelly or gear oil and install the drum closure (25) into the drum.
11. Lubricate the pilot, oil seal and bearing surfaces of the brake cylinder (1) and carefully install brake cylinder into base and drum. Locate the brake release port toward the lower rear corner of the base. Tighten brake cylinder capscrews (40) and lockwashers (41) to recommended torque.

12. Install the brake clutch assembly (56) with the short end of the inner race toward the motor.

When installed correctly, the inner race (50) should turn freely in the opposite direction the drum turns to pull wire rope in. An easy way to check the rotation is to hold the outer race (49) in one hand, and rotate the inner race.

If the clutch free wheels in the wrong direction, disassemble the clutch and reverse the inner race (50). Refer to *Brake Clutch*, page 5-12 for additional information.

13. If the brake discs are misaligned, preventing the installation of the clutch, then with a hand pump, apply 750-1000 psi to the brake release port. The brake discs will move freely with the brake released, permitting alignment of the discs, brake clutch, and input sun gear.

### CAUTION

Be certain the snap ring (53) is seated in the groove in the splined bore of the inner race (50). This snap ring will keep the brake clutch assembly (56) correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.

14. Install the hoses (63, 64, Figure 5-4) and fittings (65) to the brake cylinder release port.
15. Install a new O-ring on the motor pilot, then lubricate with petroleum jelly or gear oil.

### CAUTION

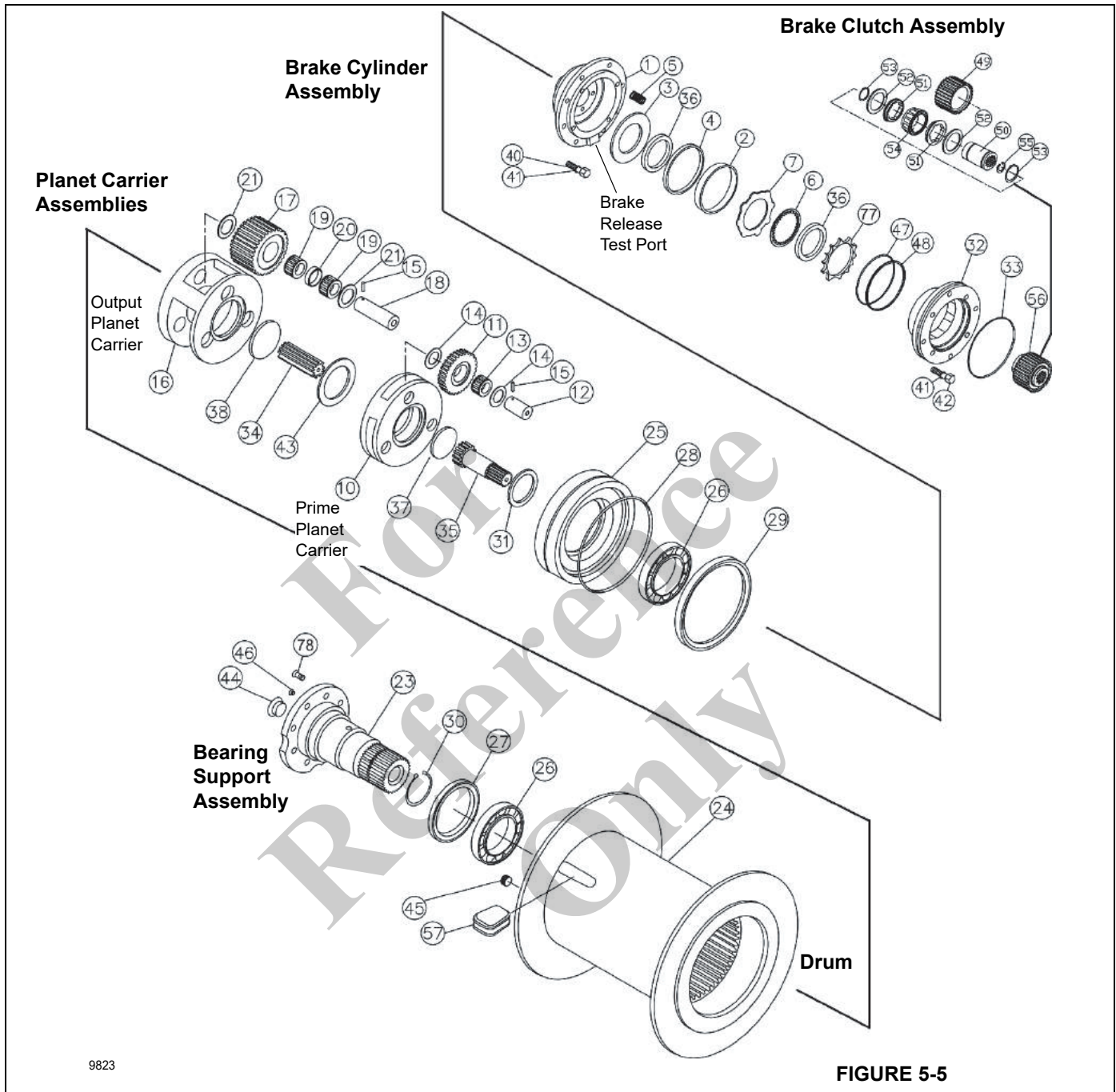
Care must be taken to assure the primary thrust plate remains properly located in its counterbore when the motor is installed for the first time, or is being reinstalled on the hoist. It is possible for the primary thrust plate to drop out of its counterbore and become wedged between the planet gears and the planet carrier. If the hoist is operated with the primary thrust plate wedged between primary gears and the planet carrier, or with a thrust washer out of position, severe damage to internal hoist components could result.

Measure the distance from the motor mounting surface to the inner brake race. With all components properly

installed, this distance should be 11/16 in. (17.5 mm) to 3/4 in. (19.1 mm). If this distance is less than 9/16 in. (14.3 mm), the primary spacer may be positioned as shown below and should be checked.

The Primary Thrust Plate is shown wedged between the planet gears and the planet carrier. Note that the Primary Sun Gear (35) and the entire Brake Clutch Assembly (56) have moved to the right (toward the hydraulic motor).

16. Engage the motor shaft with the brake clutch inner race and lower motor into place. Tighten capscrews (70) and lockwashers (41) to recommended torque.
17. Install the hoses (63, 64, Figure 5-4) that connect the manifold (60) and brake valve (62) to the brake cylinder (1).
18. Install the roller assembly (85). For more information, see *Roller Assembly*, page 5-10.
19. Install the 3rd wrap indicator assembly. Adjust as needed. For more information, see *3rd Wrap Indicator*, page 5-3.
20. Install the oil level sight gauge (44).
21. Install the vent plug (46).
22. After the hoist assembly is complete, check all capscrews and fittings to make certain they have been tightened correctly.
23. Refill the hoist with the recommended oil and install the oil level plug. For more information, see *Operator Manual*.



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FIGURE 5-5

Table 5-1 Hoist Item List (Figure 5-5)

ITEM NO	DESCRIPTION
001	Brake cylinder
002	Seal
003	Pressure plate
004	Piston backup ring

Table 5-1 Hoist Item List (Figure 5-5) (Continued)

ITEM NO	DESCRIPTION
005	Die spring
006	Friction Disc
007	Brake Disc
010	Primary planet carrier
011	Primary planet gear

Table 5-1 Hoist Item List (Figure 5-5) (Continued)

ITEM NO	DESCRIPTION
012	Primary planet gear shaft
013	Roller bearing
014	Thrust washer
015	Spirol pin
016	Planet carrier
017	Planet gear
018	Planet gear shaft
019	Roller bearing
020	Bearing spacer
021	Thrust washer
022	Base
023	Bearing support
025	Cable drum closure
026	Ball bearing
027	Oil seal
028	O-ring
029	Seal, oil
030	Retaining ring, external
031	Thrust washer
032	Motor support
033	O-ring
034	Output sun gear
035	Primary sun gear
036	Spacer
037	Spacer, primary
038	Spacer, output
039	Spacer
040	Capscrew
041	Lockwasher
042	Capscrew
043	Thrust washer
044	16166-16 O-ring plug, hex head
045	16496-8 plug, O-ring flush
046	Relief valve 7.5-15 PSI
047	O-ring
048	Backup ring
049	Outer brake race

Table 5-1 Hoist Item List (Figure 5-5) (Continued)

ITEM NO	DESCRIPTION
050	Inner brake race
051	Sprag bearing
052	Thrust bearing
053	21-B3-1 snap ring
054	Sprag clutch
055	Retaining ring
056	Brake Clutch Assembly
057	Cable wedge
058	Manifold
059	O-ring
060	Capscrew
061	Capscrew
062	Brake Valve Assembly
063	Hose assembly
064	Hose assembly
065	Adapter
066	2685008 elbow TBG fitting
067	Swivel tee
068	Elbow fitting
069	Reducer elbow
070	Capscrew
071	Hose assembly
072	Hydraulic motor, gear
077	Spring Spacer
078	Capscrew
079	Side plate support end
080	Side plate motor end
083	Capscrew
084	Lockwasher
085	Roller Assembly
086	Capscrew
087	Lockwasher
088	Roller Bracket
089	Roller Plate
090	Capscrew
091	Lockwasher
092	Roller Adjustment Nut

Table 5-1 Hoist Item List (Figure 5-5) (Continued)

ITEM NO	DESCRIPTION
093	Roller Idler
094	Capscrew
095	Lockwasher
096	Dowel Pin
097	Space Bar
098	Capscrew
099	Lockwasher

## ROLLER ASSEMBLY

The following sections describe how to remove, install, and adjust the hoist roller assembly.

### Removing the Roller Assembly

1. Loosen roller adjustment (92) as necessary to unload tension from roller spring.
2. Remove capscrews (86, Figure 5-4) and washers (87) from the roller brackets (88) on the motor and bearing sides of the hoist.
3. Remove capscrews (90) and washers (91) from the roller plates (89) on the motor and bearing sides of the hoist.
4. Remove the roller assembly (85).

### Installing the Roller Assembly

1. Install roller plates (89, Figure 5-4) to the motor and bearing sides of the hoist using capscrews (90) and washers (91).
2. Install roller brackets (88) to the motor and bearing sides of the hoist using capscrews (86) and washers (87).
3. Torque the capscrews (86).
4. Adjust the roller assembly (85) as needed. For more information, see *Adjusting the Roller Assembly*, page 5-10.
5. Adjust the 3rd wrap indicator assembly as needed. For more information, see *3rd Wrap Indicator*, page 5-3.

### Adjusting the Roller Assembly

Use the following procedure to adjust both sides of the roller assembly.

1. Make sure that the roller is resting against the hoist drum.
2. Tighten the nut (92, Figure 5-4) to remove slack.

3. Turn the nut (92) five times to preload the roller assembly (85).

## BRAKE CYLINDER

### Brake Cylinder Disassembly

1. After removing the motor support (32, Figure 5-5) and brake clutch assembly (56), continue brake cylinder disassembly by removing the spacers (36 and 77), friction brake discs (6), and steel brake discs (7).
2. Remove the piston backup ring (4) and pressure plate (3).
3. Remove the brake springs (5).

### Clean and Inspect

1. Thoroughly clean and inspect all parts at this time. Check brake piston sealing surfaces on brake cylinder and motor support. Be sure brake release port is free of contamination.
2. Check oil seal and bearing surfaces on brake cylinder for damage or wear.
3. Place friction brake disc (6) on flat surface and check for distortion with a straight edge. Friction material should appear even across entire surface with groove pattern visible. Replace friction disc if splines are worn to a point, disc is distorted, friction material is worn unevenly, or groove pattern is worn away.
4. Place steel brake disc (7) on flat surface and check for distortion with a straight edge. Check surface for signs of material transfer or heat. Replace steel disc if splines are worn to a point, disc is distorted or heat discolored.

### CAUTION

Failure to replace brake springs (5) as a set may result in uneven brake application pressure and repeated brake spring failure.

5. Check brake spring free length; minimum free length is 1 3/16 in. (30.2 mm). Check springs for any sign of cracking or failure. If a brake spring must be replaced for any reason, then ALL brake springs must be replaced.

### Brake Cylinder Assembly

1. Begin assembly by placing motor support on workbench with motor mounting surface down. Install new O-ring (47) and backup ring (48) as shown.
2. Insert first, a steel brake disc (7) against the spacer (36) followed by a friction brake disc (6) then alternate steel and friction discs until seven friction and eight steel discs have been installed. Finish with a steel brake disc (7) on top.

**NOTE:** It is a good practice to pre-lubricate the discs in hydraulic oil prior to assembly.

3. Install the brake spacer (36) on top of the last steel brake disc (7).
4. To check brake stack height, place pressure plate (3) on top of brake spacer (36). Hold pressure plate down firmly by hand and measure clearance in three places between motor support (32) and pressure plate (3). Average gap must measure between 0.153 in. (4 mm) maximum and 0.080 in. (2 mm) minimum. If the gap exceeds the maximum limit, there are too many brake discs in stack-up or the discs are distorted. If the gap is less than the minimum, there are too few discs in stack-up or the discs are worn out. When stack height is correct, remove pressure plate and continue assembly.
5. Lubricate the brake piston seal (2) and motor support sealing surface with petroleum jelly or hydraulic oil. Install new piston seal to motor support, seal lip down.
6. Install the spring spacer (77), then the brake springs.
7. Install pressure plate (3) into brake cylinder (1) followed by the piston backup ring (4). The close-fitting piston backup ring may be depressed slightly to one side to lodge the backup ring (4) in the brake cylinder (1) bore and temporarily hold the pressure plate and springs (5) in place while you lower the brake cylinder over the motor support.
8. Apply petroleum jelly to the entire sealing surface of the brake cylinder (1) and to the piston seal (2). Install the brake cylinder over the motor support (32) being careful to avoid damaging the piston seal (2) or motor support O-ring (33). (A press may be necessary to avoid cocking the brake cylinder during installation.)
9. Install motor support capscrews (42) and lockwashers (41) and evenly tighten to recommended torque.

### DANGER

Always use the molded spring spacer (77) with the new brake cylinder. The brake springs (5) must be properly positioned by the spring spacer (77). Failure to install the spring spacer may allow the springs to contact each other and become damaged. This could result in loss of load control, property damage, injury or death.

### Brake Cylinder Pressure Test

1. Install the -4 JIC fitting into the brake release port. Connect a hand pump with accurate 0-2000 psi (0-13,800 kPa) gauge and shut-off valve to this fitting. Apply 1000 psi (6,900 kPa) to the brake. Close shut-off valve and let stand for five minutes. If there is any loss of pressure in five minutes, the brake cylinder should be

disassembled for inspection of the sealing surfaces and brake piston.

2. WHILE PRESSURE IS APPLIED AND THE BRAKE RELEASED, install the brake clutch assembly (56) in the brake pack, short end of the inner race toward motor. Turn the clutch back and forth as you align the outer race splines with the brake disc splines.
3. Release the pressure on the brake cylinder, then remove the brake clutch assembly (56). The brake cylinder assembly is now complete and ready to be installed in the hoist.

### PLANETARY SET

Use the following procedures to service the output (16, Figure 5-5) and primary (10) planet carrier assemblies. The procedures for the output and primary planets carriers are the same except the following:

- The primary planet carrier (10) has only one bearing (13) for each gear. The output carrier (16) has two bearings (19).
- The primary planet carrier (10) has no bearing spacer.

### Planet Carrier Disassembly

1. Remove the planet gears (17 or 11, Figure 5-5) by driving the roll pins (15) into the center of the planet shafts (12 or 18).
2. Use a punch to drive the roll pins (15) from the planet shafts (12 or 18). Do not reuse the roll pins.
3. Now you can remove the planet shafts (12 or 18), bearings (19 or 13), spacer (20), thrust washers (21 or 14), and gears (17 or 11). Thoroughly clean all parts and inspect for damage and wear. The bearing rollers should exhibit no irregularities. If the rollers show any sign of spalling, corrosion, discoloration, material displacement or abnormal wear, the bearing should be replaced. Likewise, the cage should be inspected for unusual wear or deformation, particularly the cage bars. If there is any damage that will impair the cage's ability to separate, retain and guide the rollers properly, the bearing should be replaced. The thrust washer contact areas should be free from any surface irregularities that may cause abrasions or friction. The gears and shafts should be inspected for abnormal wear or pitting. Replace if necessary.

### Planet Carrier Assembly

1. Place the output planet carrier on workbench with splined coupling side down. Install output thrust plate in center of carrier.
2. For the output planet carrier, insert two bearings (19) and a bearing spacer (20) into a gear with the spacer

between the bearings. Place a thrust washer (21 or 14) on each side of the gear and position in a carrier opening. Slide the shaft through the carrier (16 or 10), thrust washer (21 or 14), bearing-gear sub-assembly and remaining thrust washer (21 or 14). Be careful to avoid damaging thrust washers when installing planet shafts.

**NOTE:** For the primary planet carrier, there is only one bearing per gear and no spacer. Refer to Figure 5-5.

3. Carefully align the pin hole in the carrier with the hole in the planet gear shaft and drive the roll pin (15) into place. Always use NEW roll pins.
4. Note that the roll pin (15) is recessed approximately 1/16 in. (0.06 mm) in the carrier when properly installed. With a center punch, stake the carrier next to the pin hole as shown. This will distort the hole so the pin will not back out. Repeat these steps for each of the three planet gears.

## BRAKE CLUTCH

Use the following procedures to service the brake clutch assembly (56).

### Brake Clutch Disassembly

1. Remove the snap ring (53) and thrust bearing (52) from one end only.
2. Pull the inner race out (50). Examine the race for scoring, wear, or indentations caused by the sprag cams. Inspect retaining ring (55) and replace as necessary.
3. Remove the sprag bearing (51) from one end of the outer race (49). There are four special cut-outs in the sprag bearing (51) to help in removing the bearing. Be careful not to damage the bearing inside surface. If a bearing's inside surface is damaged or shows wear, replace it.
4. Next, slide the sprag clutch (54) out. Inspect the sprag clutch closely for abnormal wear, cracks, pitting or corrosion. Check small clips for breakage or bright spots; the signs of excessive wear. Unless the outer race or remaining sprag bearing is damaged or shows excessive wear, there is no need for further disassembly. If disassembly is necessary, remove the bearing according to the procedure covered in step

number 3. All brake clutch assembly parts should be thoroughly cleaned and inspected before assembly.

## Brake Clutch Assembly

### DANGER

The polished surfaces of the races and sprag cams must be perfectly smooth to insure positive engagement of the clutch. The slightest defect may reduce brake clutch effectiveness, which may lead to loss of load control and result in property damage, personal injury or death. It is generally recommended to replace the entire brake clutch assembly if any component is defective.

1. Press a sprag bearing (51) into the outer race (49), using a mechanical or hydraulic press. A flat plate of approximately the same diameter as the bearing flange outside diameter should be placed between the press and bearing during assembly to protect the bearing. Be certain the bearing flange is against the shoulder in the outer race (49).
2. Turn the assembly over and install the sprag clutch (54) in the bore of the outer race (49).
3. Press the remaining bearing into the race. Again, make sure the bushing is against the shoulder.
4. Install a thrust bearing (52), then a snap ring (53) on the inner race (50). Be sure the snap ring is seated in the snap ring groove.
5. Slide the inner race (50) through the bearings and sprag clutch (54) (the race will have to be rotated in the free-wheeling direction to start it through the sprag clutch). If the inner race will not go through the bearings, the bearings have probably been damaged and should be replaced.
6. Turn the assembly over with the snap ring down. Install the second thrust bearing (52) and snap ring (53). Make certain the snap ring is seated in the groove properly.

### CAUTION

Be certain the snap ring (53) is seated in the groove in the splined bore of the inner race. This snap ring will keep the brake clutch assembly correctly positioned in the center of the friction brake pack. Binding of the brake or brake failure may occur if this snap ring is omitted.



HOIST TROUBLESHOOTING

Problem	Cause	Solution
<p style="text-align: center;"><b>A</b></p> <p>The hoist will not lower the load or not lower the load smoothly.</p>	<p>1. The problem could be a plugged or loose pilot orifice. The pilot orifice is a small pipe plug with a hole drilled through it, located behind the pilot port fitting on the brake valve. If it becomes plugged, it will prevent the pilot pressure, from the manifold, from opening the brake valve. If it becomes loose, it will allow an unregulated amount of oil in to operate the brake valve which cause erratic brake valve operation.</p> <p>2. The friction brake may not be releasing as a result of a defective brake cylinder seal.</p> <p>NOTE: If the brake cylinder seal is defective you will usually find oil leaking from the hoist vent plug.</p> <p>3. Friction brake will not release as a result of damaged brake discs.</p>	<p>1. Remove pilot hose and fitting from brake valve, then use a 5/32 inch Allen wrench to remove pilot orifice. The diameter of the orifice is approximately 0.020 inches. Clean and install pilot orifice tightly in the brake valve.</p> <p>2. Check brake cylinder seal as follows:</p> <p>a. Disconnect the swivel tee from the brake release port. Connect a hand pump with accurate 0-2000 psi gauge and shut-off valve to the -4 J.I.C. fitting in the brake release port.</p> <p>b. Apply 1000 PSI (6,900 kPa) to the brake. Close shut-off valve and let stand for five (5) minutes.</p> <p>c. If there is any loss of pressure in five (5) minutes, the brake cylinder should be disassembled for inspection of the sealing surfaces and replacement of the seals. Refer to <i>Brake Cylinder</i>, page 5-10.</p> <p>3. Disassemble brake to inspect brake discs. Check stack-up height as described in <i>Brake Cylinder</i>, page 5-10.</p>
<p style="text-align: center;"><b>B</b></p> <p>Oil leaks from vent plug.</p>	<p>1. Same as Cause A2.</p> <p>2. Motor seal may be defective as a result of high system back pressure or contaminated oil.</p> <p>a. Vent positioned below oil level.</p> <p>b. Oil expansion due to overheating.</p>	<p>1. Same as Solution A2.</p> <p>2. System back pressure must not exceed 150 PSI (1,035 kPa). Inspect hydraulic system for a restriction in the return line from the control valve to the reservoir. Be sure control valve and plumbing is properly sized to hoist motor.</p> <p>3. Oil analysis may indicate contamination has worn motor shaft and seal. Thoroughly flush entire hydraulic system and install new filters and oil. In- stall new motor seal.</p>


HOIST TROUBLESHOOTING

Problem	Cause	Solution
<p style="text-align: center;"><b>C</b></p> <p>The brake will not hold a load with the control lever in neutral.</p>	<ol style="list-style-type: none"> <li>1. Excessive system back pressure acting on the brake release port.</li> <li>2. Friction brake will not hold due to worn or damaged brake discs.</li> <li>3. Brake clutch is slipping.</li> </ol>	<ol style="list-style-type: none"> <li>1. Same as Solution B2.</li> <li>2. Same as Solution A3.</li> <li>3. Brake Clutch Slipping:                             <ol style="list-style-type: none"> <li>a. Improper planetary gear oil may cause the brake clutch to slip. Drain old gear oil and flush hoist with solvent. Thoroughly drain solvent and refill hoist with recommended planetary gear oil.</li> <li>b. Brake clutch may be damaged or worn. Disassemble and inspect brake clutch as described in <i>Brake Clutch</i>, page 5-12.</li> </ol> </li> </ol>
<p style="text-align: center;"><b>D</b></p> <p>The hoist will not hoist the rated load.</p>	<ol style="list-style-type: none"> <li>1. The hoist may be mounted on an uneven or flexible surface which causes distortion of the hoist base and binding of the gear train. Binding in the gear train will absorb horsepower needed to hoist the rated load and cause heat.</li> <li>2. System relief valve may be set too low. Relief valve needs adjustment or repair.</li> <li>3. Be certain hydraulic system temperature is not more than 180 degrees F. Excessive hydraulic oil temperatures increase motor internal leakage and reduce motor performance.</li> <li>4. Hoist line pull rating is based on 1st layer of wire rope.</li> <li>5. Rigging and sheaves not operating efficiently.</li> </ol>	<ol style="list-style-type: none"> <li>1. Mounting Surface:                             <ol style="list-style-type: none"> <li>a. If necessary, use shim stock to level hoist. Refer to <i>Hoist Repair</i>, page 5-5.</li> <li>b. First loosen, then evenly retighten all hoist mounting bolts to recommended torque.</li> </ol> </li> <li>2. Check relief pressure as follows:                             <ol style="list-style-type: none"> <li>a. Install an accurate 0-4000 psi (27,580 kPa) gauge into the inlet port of the brake valve.</li> <li>b. Apply a stall pull load on the hoist while monitoring pressure.</li> <li>c. Compare gauge reading to hoist specifications. Adjust relief valve as required.</li> </ol> <p>NOTE: If pressure does not increase in proportion to adjustment, relief valve may be contaminated or worn out. In either case, the relief valve may require disassembly or replacement.</p> </li> <li>3. Temperature:                             <ol style="list-style-type: none"> <li>a. Same as solutions for CAUSE D1 and D2.</li> <li>b. Same as solutions for CAUSE E2.</li> </ol> </li> <li>4. Refer to hoist performance charts for additional information.</li> <li>5. Perform rigging service as recommended by crane manufacturer.</li> </ol>

HOIST TROUBLESHOOTING

Problem	Cause	Solution
<p style="text-align: center;"><b>E</b></p> <p>The hoist runs hot.</p>	<p>1. Same as CAUSE D1.</p> <p>2. Be certain that the hydraulic system temperature is not more than 180 degrees F. Excessive hydraulic oil temperatures may be caused by:</p> <p>2a. Plugged heat exchanger.</p> <p>2b. Too low or too high oil level in hydraulic reservoir.</p> <p>2c. Same as D2.</p> <p>2d. Hydraulic pump not operating efficiently.</p> <p>3. Excessively worn or damaged internal hoist parts.</p>	<p>1. Same as Solution D1.</p> <p>2a. Thoroughly clean heat exchanger exterior and flush interior.</p> <p>2b. Fill/drain to proper level.</p> <p>2c. Same as Solution D2</p> <p>2d. HYDRAULIC Pump:</p> <p>d1. Same as Solution D2.</p> <p>d2. Prime mover low on horsepower or R.P.M. Tune/adjust prime mover.</p> <p>d3. Check suction line for damage.</p> <p>d4. If pump is belt driven, belts are slipping. Replace/tighten belts.</p> <p>d5. Pump worn. Replace pump.</p> <p>3. Disassemble hoist to inspect/replace worn parts.</p>
<p style="text-align: center;"><b>F</b></p> <p>Hoist "chatters" while raising rated load.</p>	<p>1. Same PROBABLE CAUSE as D2.</p> <p>2. Hydraulic oil flow to motor may be too low.</p> <p>3. Controls being operated too quickly.</p>	<p>1. Same as Solution for D2.</p> <p>2. Same as Solution for E2.</p> <p>3. Conduct operator training as required.</p>

HOIST TROUBLESHOOTING

Problem	Cause	Solution
<p style="text-align: center;"><b>G</b></p> <p>The wire rope does not spool smoothly on the drum.</p>	<ol style="list-style-type: none"> <li>1. The hoist may be mounted too close to the main sheave, causing the fleet angle to be more than 1-1/2 degrees.</li> <li>2. The hoist may not be mounted perpendicular to an imaginary line between the center of the cable drum and the first sheave.</li> <li>3. Could possibly be using the wrong lay rope. There is a distinct advantage in applying rope of the proper direction of lay. When the load is slacked off, the several coils on the drum will stay closer together and maintain an even layer. If rope of improper lay is used, the coils will spread apart each time the load is removed. Then, when winding is resumed, the rope has a tendency to crisscross and overlap on the drum. The result is apt to be a flattened and crushed rope.</li> <li>4. The hoist may have been overloaded, causing permanent set in the wire rope.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check mounting distance and fleet angle. Reposition hoist as required.</li> <li>2. Refer to "Hoist Installation".</li> <li>3. Consult wire rope manufacturer for recommendation of wire rope that best suits your application.</li> <li>4. Replace wire rope and conduct operator/rigger training as required.</li> </ol>
<p style="text-align: center;"><b>H</b></p> <p>Hoist component addressing warning icon appears on RCL screen.</p> <p><b>Note:</b> Refer to the Manitowoc Diagnostic Code application for details about RCL error codes. For more information, see <i>About the Manitowoc Diagnostic Code Application</i>, page 3-23.</p> 	<p>The hoist DRI module(s) lacks a component ID on the CAN Bus system.</p>	<p>Add the hoist component ID to the CAN Bus system. For more information, see <i>Assigning CAN Bus ID to Hoist Module(s)</i>, page 3-19.</p>

**COUNTERWEIGHT CYLINDER**

**Removal**

1. Stow the counterweight. Refer to *Stowing the Counterweight* in *Section 4* of your *Operator Manual*.
2. Fully retract the counterweight cylinder (1, Figure 5-6).
3. Tag and disconnect the two hydraulic hoses at the cylinder. Cap and plug all openings.

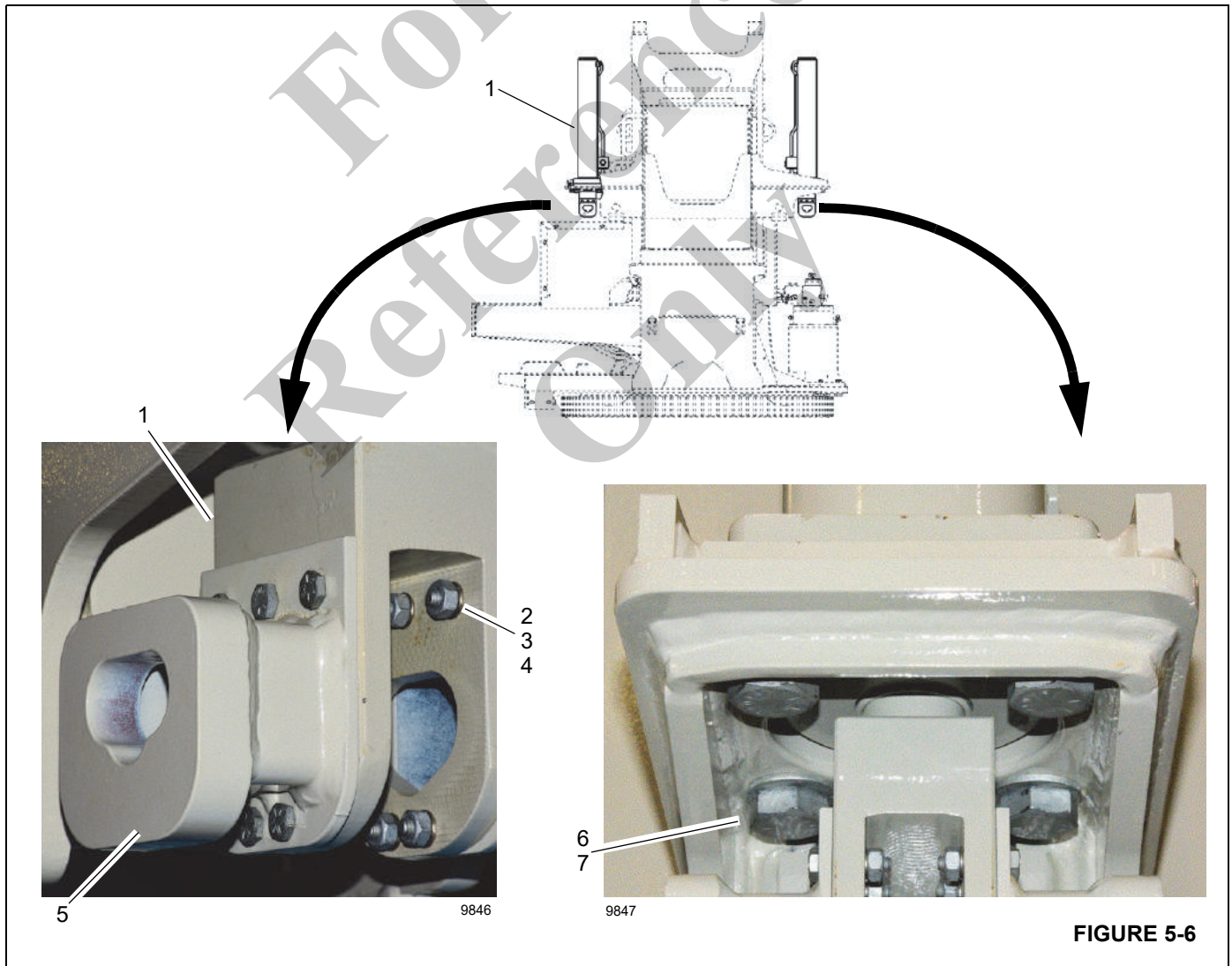
**NOTE:** Counterweight cylinder weighs 38.5 kg (85 lb).

4. Attach an adequate lifting device and sling to the cylinder. Remove the slack from the sling.
5. Remove nuts (2), washers (3), capscrews (4), and lugs (5) from the bottoms of the cylinders (1).
6. Remove the capscrews (6) and washers (7) that secure the cylinder to the superstructure and remove the cylinder (1).

**Installation**

**NOTE:** Counterweight cylinder weighs 38.5 kg (85 lb).

1. Using an adequate lifting device and sling, lift and position the cylinder on top of the superstructure. Make sure the steel hydraulic tube on the side of the cylinder is facing toward the superstructure.
2. Secure cylinder to superstructure with washers (7) and capscrews (6) after applying thread locking compound (Specification 6829012418) to the bolts' threads. Torque bolts. Refer to *Fasteners and Torque Values*, page 1-7 for proper torque value.
3. Install lugs (5) using capscrews (4), washers (3), and nuts (2).
4. Connect the two hydraulic hoses to cylinder as tagged during removal.
5. Extend and retract the cylinder to make sure it operates properly and there are no leaks.



**FIGURE 5-6**

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For  
Reference  
Only

## SECTION 6 SWING

### SECTION CONTENTS

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### SWING SYSTEM DESCRIPTION

The purpose of the swing system is to allow the crane turret to rotate atop the carrier frame. The NBT60L swing system provides full 360 degree rotation in both directions and is equipped with free swing capabilities. With free swing and the swing brake switch in the OFF position, the turret swings freely after the swing control lever is released and coasts to a stop.

**NOTE:** When equipped with a radio remote control, the swing brake is automatically applied whenever the swing control lever is in the neutral position.

The swing system consists of a electronic joystick in the operator cab, directional control valve, swing drive gearbox, swing motor, swing brake, and swing brake pedal. The swing control lever is used to slow and stop the swing by moving the control lever to the opposite direction of the swing. The swing brake pedal is used to keep the turret parked in position.

### SWING SYSTEM THEORY OF OPERATION

#### Swing Drive

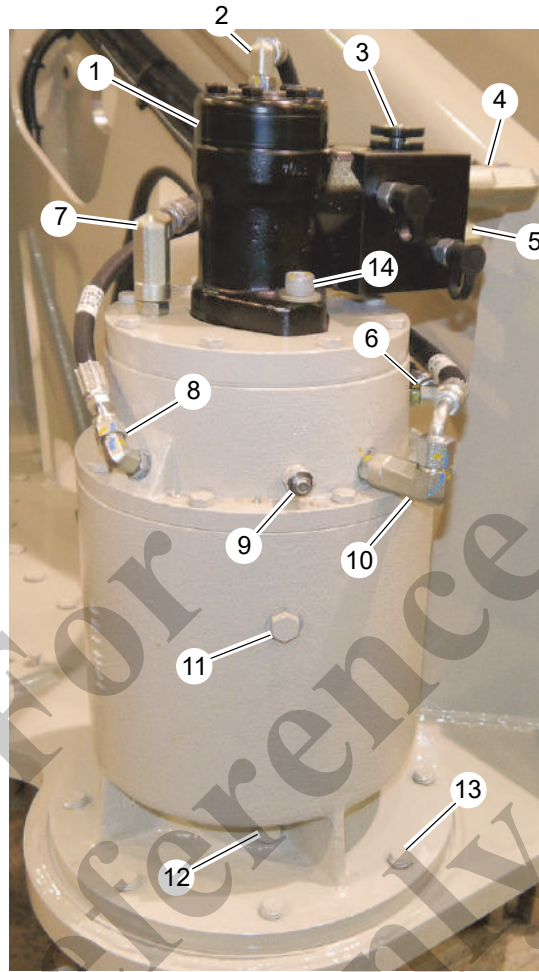
The hydraulic power for the swing drive (Figure 6-1) is supplied by the PTO driven axial piston hydraulic pump. Oil flows from the pump, through swivel port #3, to the directional control valve.

When the electronic joystick in the operator cab is positioned to select right or left swing, the flow through the control valve is directed to the swing motor. If the swing brake selector switch is in the OFF position, the turret rotates in the desired direction. Shifting the control to neutral allows the turret to coast to a stop. Shifting the control to the opposite directions powers the turret to a stop. Depressing the swing brake pedal holds the turret in position.

#### Swing Brake

Hydraulic power for the swing brake control is supplied by the directional control valve and swing brake pedal. Pressing the Swing Brake Release Switch activates a solenoid and releases the spring applied swing brake and permits the crane to swing. The swing brake is applied dynamically using the electronic foot pedal on the cab floor. The brake can also be applied using the swing brake control switch. Refer to the *Operator Manual* for a description of the brake release switch.





9705

Item	Description	Item	Description
1	Motor	8	Brake Apply
2	Case Drain	9	Breather
3	Adjustable Speed Valve	10	Coolant In
4	Control Counter-Clockwise	11	Oil Fill
5	Control Clockwise	12	Oil Drain
6	Brake Release	13	Screw and Flatwasher, 3/4"
7	Coolant Out	14	Screw and Lockwasher, 1/2"

FIGURE 6-1



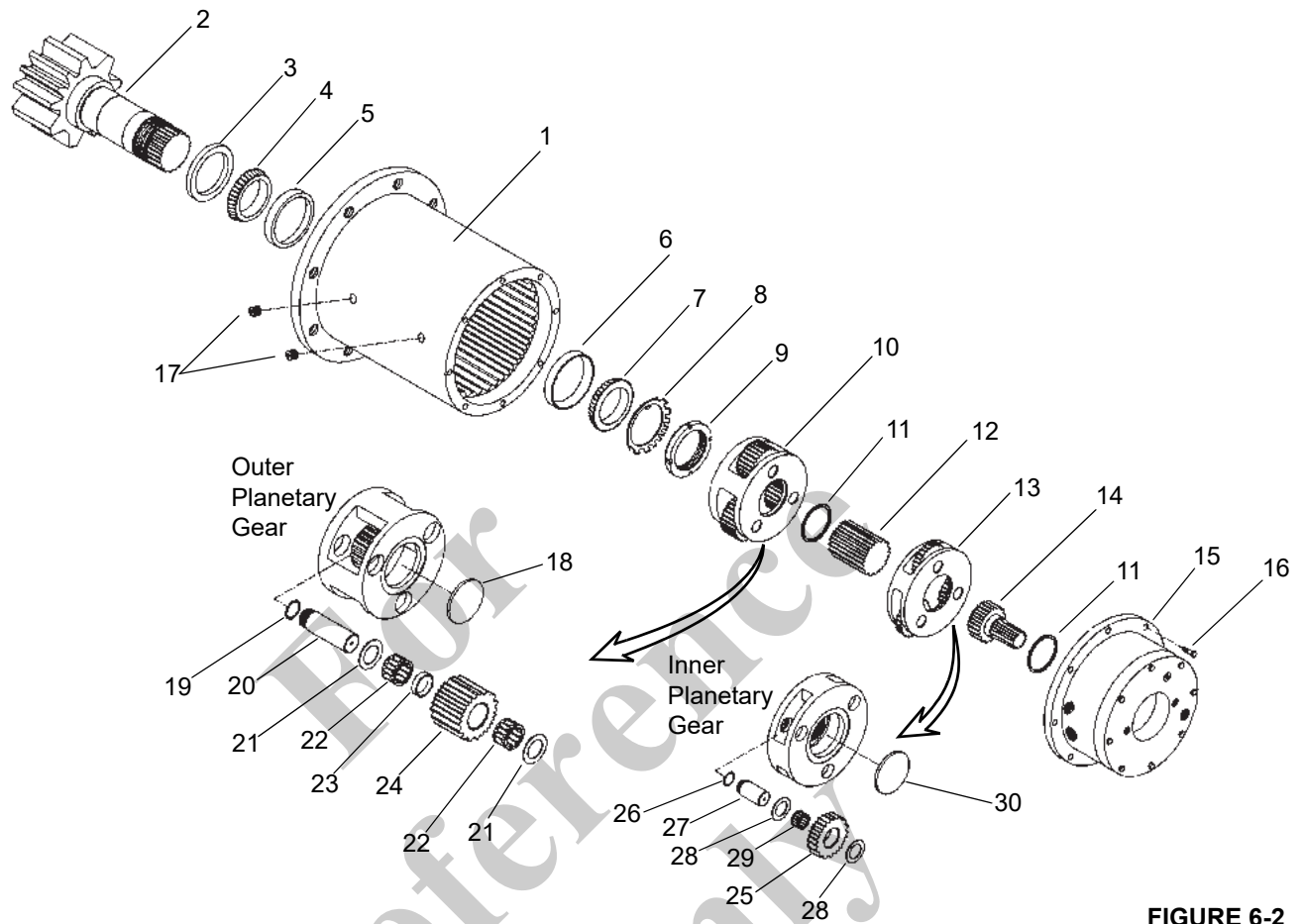


FIGURE 6-2

Item	Component
1	Housing
2	Output Shaft
3	Seal
4	Lower Bearing
5	Lower Bearing Race
6	Upper Bering Race
7	Upper Bearing
8	Lock Washer
9	Locknut
10	Output Planetary Assembly
11	Thrust Washer
12	Output Sun Gear
13	Input Planetary Assembly
14	Input Sun Gear
15	Brake Assembly

Item	Component
16	Cap Screw (8)
17	Drain Plugs
18	Plate
19	Retaining Washer
20	Output Planetary Pin
21	Washer
22	Needle Bearing
23	Spacer
24	Output Planet Gear
25	Input Planet Gear
26	Retaining Washer
27	Input Planetary Pin
28	Washer
29	Needle Bearing
30	Plate

## SWING GEARBOX AND BRAKE

The rotation drive is a double planetary gear reducer with an integral brake. The gear reducer is designed to give long life in heavy duty applications such as crane rotation. The gearbox incorporates tapered roller bearings on the output shaft and heavy duty bearings in the planet gears.

**NOTE:** Motor and cartridge valves are not serviceable in the field. Return them to an authorized distributor for service.

### Disassembly and Assembly Instructions

If the rotation drive needs to be repaired, use the following procedure for disassembly. (See Figure 6-1)

1. Remove the gearbox from the crane by securing the boom.
2. Tag and disconnect hydraulic hoses connecting the gearbox to the crane.
3. Removing the mounting bolts.

**NOTE:** The weight of the rotation gearbox with integral brake and a hydraulic motor bolted on the input end of the assembly is approximately 124 kg (275 lbs).

### Tools Required

- Scribe or small punch
- Oil drain pan
- Eye bolts, 1/4 in
- Retaining ring pliers
- Gear puller
- Ratchet wrench (1/2 in drive)
- 9/16 in socket (1/2 in drive)
- Socket for pinion nut (Whittet-Higgins P/N BAS-14)
- Soft hammer (brass or plastic)
- Press
- Drift rod 6.3 mm to 9.5 mm (1/4 to 3/8 in diameter)
- Torque wrench [1/2 in drive - approximately 135 Nm (100 ft-lb)]

### Parts Required to Rebuild

- Seals
- O-rings
- Back-up rings
- Parts to replace damaged or worn parts
- Locknut (9) and lockwasher (8)

### Disassembly

(See Figure 6-2 for reference (#) numbers.)

1. With a scribe or small punch make a set of marks on the brake assembly flange (15) and the top edge of the gear housing (1) to aid in reassembly.
2. Remove both drain plugs (17) and drain the oil from the unit. Drainage is facilitated when the oil is warm.
3. Remove the eight capscrews (16) holding the brake assembly (15) onto the gear housing (1).
4. Lift the brake assembly (15) off of the gearbox. If necessary, screw the hydraulic motor bolts into the brake assembly for use as handles.
5. Remove the thrust washer (11) and input sun gear (14) from the input planetary assembly (13).
6. Install three 1/4 in eyebolts into the three planet pins of the input planetary assembly (13) and with a small chain pull the planet set (13) from the gear housing.
7. Remove the output sun gear (12) and thrust washer (11) from the output planetary assembly (10).
8. Using the eyebolt/chain method outlined in step 6, remove the output planetary assembly (10) from the gear housing.
9. To remove the output shaft (2) from the gear housing (1), bend the tab on the lockwasher (8) out of the slot in the locknut (9). Loosen and remove the locknut (9) from the output shaft (2).

### CAUTION

The locknut is no longer retaining the output shaft. Care should be taken when moving the gear housing because the output shaft can fall out.

10. Output shaft removal. Place the gear housing (1) on a plate or table with a hole that allows the output shaft (2) to extend through the hole. Press the output shaft out the bottom of the case by applying a minimal load to the threaded end of the output shaft until it passes through the upper shaft bearing (6, 7).

The unit is now disassembled into groups of parts. The area(s) requiring repair should be identified by thorough inspection of the parts after they have been washed in solvent, then refer to the appropriate group repair section.

### Input Planetary Repair

(See Figure 6-2 for reference (#) numbers.)

1. Remove the retaining washers (26) from the planet pins.
2. Use a press to remove the planet pins (27) from the carrier. Support the input carrier (13) to remove the planet pins (27).

3. Slide planet gears (25) and races (28) out of the input carrier (13).
4. Remove the plate (30) from the input carrier (13).
5. If needle bearings (29) must be replaced, they may now be removed out of the input planet gears (25).
6. Rebuild input gear set in reverse order using any required new parts.
7. Before reassembly, be sure to insert the plate (30) into the input carrier (13).
8. To reassemble, be careful to line up the planet pins (27) with the races (28) and the bearings (29) and then press the knurled part of the planet pin (27) into the input carrier (13). If the planet pins (27) are not lined up properly, the races (28) can be shattered during the pressing process. Reinstall the retaining washers (26) onto the planet pins.

### Output Planetary Repair

(See Figure 6-2 for reference (#) numbers.)

Repair for the output planetary gear set is the same as the input planetary gear set with one exception. The output planetary gear set has two needle bearings (22) per planetary pin (20) with a spacer (23) between the bearings.

### Shaft Repair

(See Figure 6-2 (#) for reference numbers.)

1. Tapered bearing (4) may be removed from output shaft (2) using a gear puller.
2. Remove old seal (3) and discard. Grease pack the lower bearing (4) with lithium grease or EP lube and install into the bearing race (5) in the gear housing (1). The old bearing (4) may be reused only if it was removed to replace the seal and was not the cause of the seal failure. Use a press fixture or a hammer and a large flat-ended bar or rod to press the new seal (3) into the gear housing (1) until the seal is flush.

**NOTE:** If the bearing (4) is replaced, the bearing race (5) must also be replaced.

3. Install the output shaft (2) into gear housing (1) Be careful not to damage seal (3) in gear housing.

### Case Assembly Repair

(See Figure 6-2 for reference numbers.)

1. Remove the bearing race (6) and replace if required.
2. Clean all foreign material from case.

### Unit Assembly

(See Figure 6-2 for reference numbers.)

1. Place the gear housing (1) on a table with the gear end of the output shaft (2) on the table surface.

#### CAUTION

The output shaft and case are not retained together at this point. Move the unit so that the output shaft and gear do not separate.

2. Hold the gear of output shaft (2) and rotate the gear housing (1) to be sure it moves freely. The slight resistance is due to seal load on the output shaft (2).
3. Grease pack the upper bearing (7) with lithium grease or EP lube. Slide the bearing (7) over the threaded end of output shaft (2) with the small end down. Press the bearing (7) on slowly until it is just seated.

Hold the output shaft (2) and rotate the gear housing (1) when installing the bearing (7). The bearing is seated when all rollers are rotating evenly.

**NOTE:** If bearing (7) is replaced, bearing race (6) must also be replaced.

4. Slide the lockwasher (8) down the threaded end of the output shaft (2) until it reaches the end of the bearing (7).
5. Thread the locknut (9) down the threads of the output shaft (2) and tighten until it is snug.
6. Set the bearing preload by tightening locknut (9) onto output shaft (2) to 135 N·m (100 ft-lb). Proper bearing preload is determined by the rolling torque method. This method involves increasing press load on the bearings (4 and 7) until drag or rolling resistance of 8.4 - 9.6 N·m (75 - 85 in-lb) is achieved when rotating the case.

This includes bearing as well as seal drag. The torque is equal to a force of 8.4 - 9.6 N·m (75 - 85 in-lb) on a bolt screwed into one of the brake assembly mounting holes to rotate the case. Bend tang of lockwasher (8) into place on locknut (9).

7. Place the gear housing (1) on a table with the gear end of the output shaft (2) on the table surface.
8. Lower the output gear set (10) into the gear housing (1) until the planet gears engage the teeth in the gear housing. Lower the output gear set (10) until the planet gears engage the teeth on the output shaft (2). Rotate the output gear set (10) or the output shaft (2) until the gear set (10) slides down to allow full contact between the two sets of gear teeth.
9. Firmly hold the pinion end of the output shaft (2) and slowly rotate the gearbox assembly to ensure free rotation of installed gear sets.

10. Install the thrust washer (11) and the output sun gear (12) in the end of the output gear set (10).
11. Lower the input gear set (13) into the gear housing (1) until the planet gears engage the teeth on the input end of the output sun gear (12).
12. Rotate the input gear set (13) or the output shaft (2) until the input gear set (13) slides down to allow full contact between the two sets of gear teeth.
13. Firmly hold the pinion end of the output shaft (2) and slowly rotate the gearbox assembly to ensure free rotation of installed gear sets.
14. Install thrust washer (11) and the input sun gear (14) into the input gear set (13).
15. Lubricate a new O-ring (3-brake) and install in the groove in the top of the gear housing (1).
16. Place the brake assembly (15) onto the top of the gear housing (1). The marks made during the disassembly process will aid in properly lining up the brake assembly (15) on the gear housing (1).
17. Install the eight capscrews (16) in the brake assembly (15) and torque to 40 N·m (30 ft-lb).
18. Put pipe sealant on one of the pipe plugs (17) and install the plug in the lower hole of the gear housing (1).
19. Fill the gear housing (1) with 1 gallon (3.8 L) of EP 80-90 gear grease.
20. Put pipe sealant on the other pipe plug (17) and install the plug in the top hole in the gear housing (1).

## SWING BRAKE

The brake is manufactured for two specific types of holding torque requirements. The brake has a "park" mode and is also set up to operate in a "glide-swing" mode. The brake is in the park mode until pressure is applied to one side of the piston in the brake assembly. As the pressure increases the spring force keeping the brake applied is overcome and the brake is released. Once the brake is released, the crane is free to rotate. Rotation is controlled by applying pressure on

the dynamic brake piston which reapplies pressure to the brake discs.

## Disassembly

(See Figure 6-3 for item number identification.)

1. With a scribe or punch make a pair of marks on the edge of the brake cover (23) and the top of the brake housing (3) to aid in reassembly.
2. Remove the hydraulic motor from the brake assembly.
3. Alternately loosen the eight capscrews (24) one turn at a time until all internal spring force is relieved.

### DANGER

Do not clamp or otherwise restrain cover while removing capscrews because the brake is under high compressive spring load.

4. Lift the brake cover and remove from the brake housing.
  5. Remove the brake springs (21) from the assembly.
  6. Apply low hydraulic pressure 0.14 MPa (20 psi) to brake release port while holding one hand on top of the brake piston (20). The pressure will force the brake piston out of the brake housing.
  7. Remove the friction discs (15) and the stator plates (14) from the brake housing.
- NOTE:** Record the order in which the friction discs are removed because they must be reinstalled in the same order.
8. Remove the brake driver (12) from the brake housing.
  9. If necessary, remove the two retaining rings (11 and 13) from the inside of the brake driver.
  10. Apply low hydraulic pressure 0.14 MPa (20 psi) to dynamic brake port to push dynamic brake piston (10) out of the brake housing.
  11. Remove the bearing (5) and the oil seal (4) from the brake housing.

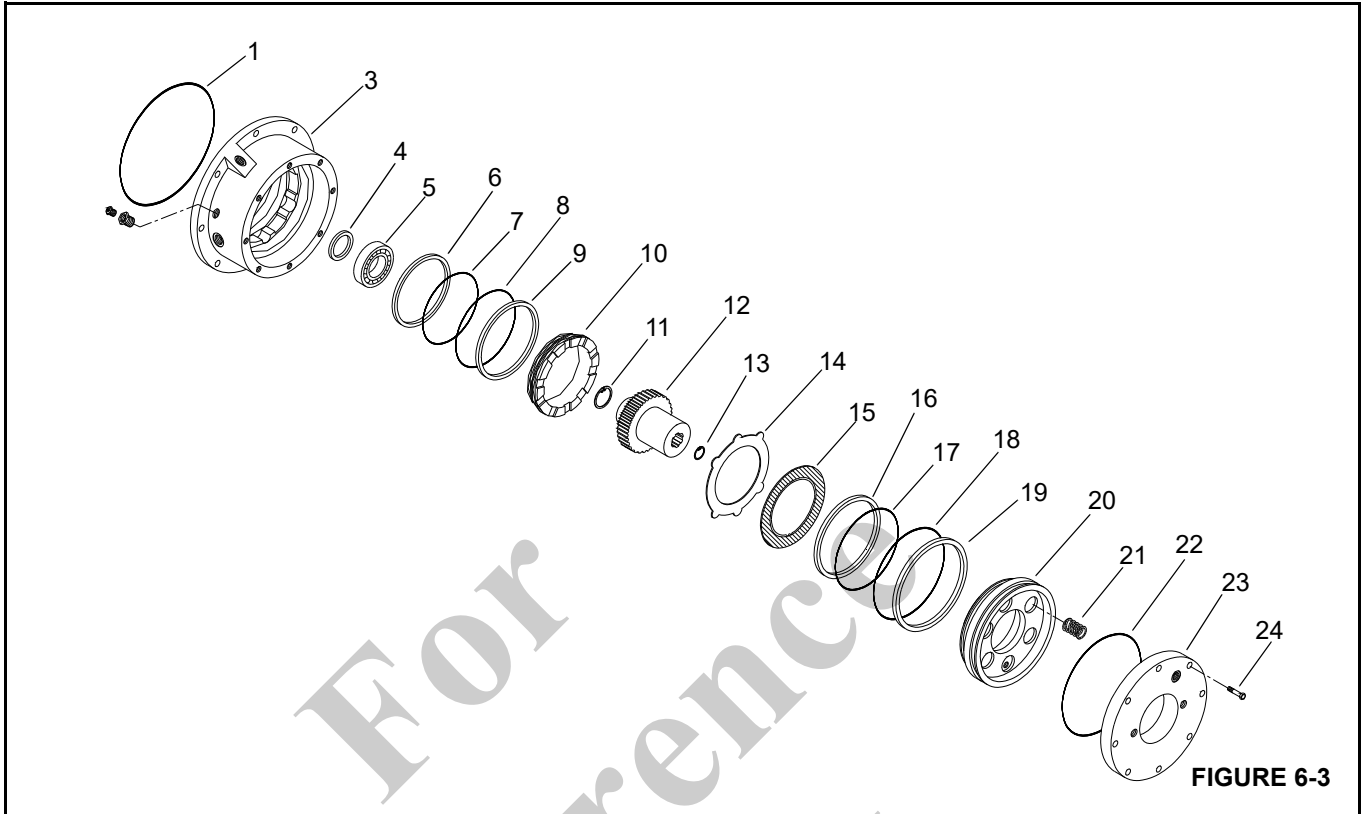


FIGURE 6-3

Item	Component
1	O-ring
3	Housing
4	Seal
5	Bearing
6	Backup Ring
7	O-ring
8	O-ring
9	Backup Ring
10	Brake Piston
11	Retaining Ring
12	Brake Driver
13	Retaining Ring

Item	Component
14	Stator Plates
15	Friction Discs
16	Backup Ring
17	O-ring
18	O-ring
19	Backup Ring
20	Park Brake Piston
21	Springs
22	O-ring
23	Cover
24	Capscrews (8)

## Assembly

(See Figure 6-3 for reference numbers.)

Assembly is in reverse order of disassembly with the following additional instructions.

1. Lubricate the sealing lip of the oil seal (4) with the same type of hydraulic oil that the crane uses. Press the oil seal into the brake housing (3) with the open side of the seal facing the hydraulic motor end of the brake assembly. Install the bearing (5) into the brake housing.
2. If replacing the dynamic brake O-rings (7 and 8), be sure to install the O-rings and their backup rings (6 and 9) in the same order in which they were removed. Lubricate with hydraulic oil to aid assembly.
3. Gently slide the brake piston (10) into the brake housing. Press down on the piston with the heel of both hands to squeeze the O-rings into the housing. Push the piston completely down into the housing.
4. Install the brake driver (12) into the brake housing by pushing down until the bearing shoulder on the driver is seated against the bearing. Be sure that retaining rings (11 and 13) are installed in the driver.
5. Install stator plates and the friction discs into the brake housing in exactly the same order that they were removed. Note that two stator plates are stacked together in the center of the stack. Be careful not to contaminate the friction surfaces with dirt, grease or fluid media other than what is specified for your brake. Note: If installing new friction discs, soak all discs in specified fluid media for approximately 10 minutes before installation.
6. Pour fluid media into the brake housing (3) until it is level with the top of the brake discs and stator plates.
7. If replacing the brake piston O-rings (17 and 18) be sure to reinstall the O-rings and their backup rings (16 and 19) in the same order in which they were removed. Lubricate O-rings and backup rings with hydraulic oil to aid in their assembly.
8. Gently slide the park brake piston (20) into the brake housing. Press down on the brake piston using the heel of both hands. This will squeeze the O-rings into the case and set the brake piston against the stator plates.
9. Insert the brake springs (21) into the brake piston.
10. Lubricate the O-ring (22) with hydraulic oil and install on the brake cover (23).
11. Carefully set the brake cover on top of the piston springs so they remain upright on the brake piston.

Start the eight capscrews (24) into the brake housing by hand. Alternately tighten the capscrews one turn at a time

until the cover is tight against the brake housing. Torque the capscrew to 41 to 47 N·m (30 to 35 ft-lb).

## SWING BEARING

### Description

The swing bearing is an anti-friction roller bearing that mates the turret to the carrier. The bearing inner race is bolted to the turret and the outer race is bolted to the Carrier. The inner race contains two grease fittings for lubrication of the bearing. The outer race incorporates gear teeth that mesh with the pinion gear of the swing gearbox to provide rotation.

## SWING BEARING MAINTENANCE

### General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the turret and carrier. 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

#### 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 the 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 carrier. Refer to *Fasteners and Torque Values*, page 1-7 for information on the use of a torque wrench and torque values for fasteners.

#### 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), service personnel 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. 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.

When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.

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.

### Swing Bearing Bolts

The inner race of the bearing is secured to the turret by 42, M24 × 150mm, Grade 10.9 bolts (Figure 6-4). The outer race of the bearing is secured to the carrier frame by 42, M24 × 150mm, Grade 10.9 bolts (Figure 6-4).

### Inner Race Torquing

The inner race bearing bolts are located on top of the inner race (Figure 6-5).

1. Extend and set the outriggers.
2. Fully elevate the boom.

3. Torque all bolts to 80% of the full torque value of 790 Nm ±35 Nm (582.7 lb-ft ± 26 lb-ft) following a star pattern sequence as shown in Figure 6-4 starting with bolt number 1.

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

4. Return to bolt 1 and torque all bolts using the same star pattern sequence to the final torque of 790 Nm ±47 Nm (582.7 lb-ft ± 35 lb-ft). 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 6-5).

1. Extend and set the outriggers.
2. Fully elevate the boom.
3. Torque all bolts to 80% of the full torque value of 790 Nm ±35 Nm (582.7 lb-ft ± 26 lb-ft) following star pattern sequence as shown in Figure 6-4 starting with bolt number 1.

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

4. Return to bolt 1 and torque all bolts using the same star pattern sequence to the final torque of 790 Nm ±47 Nm (582.7 lb-ft ± 35 lb-ft). The same tools are used as in step 3.

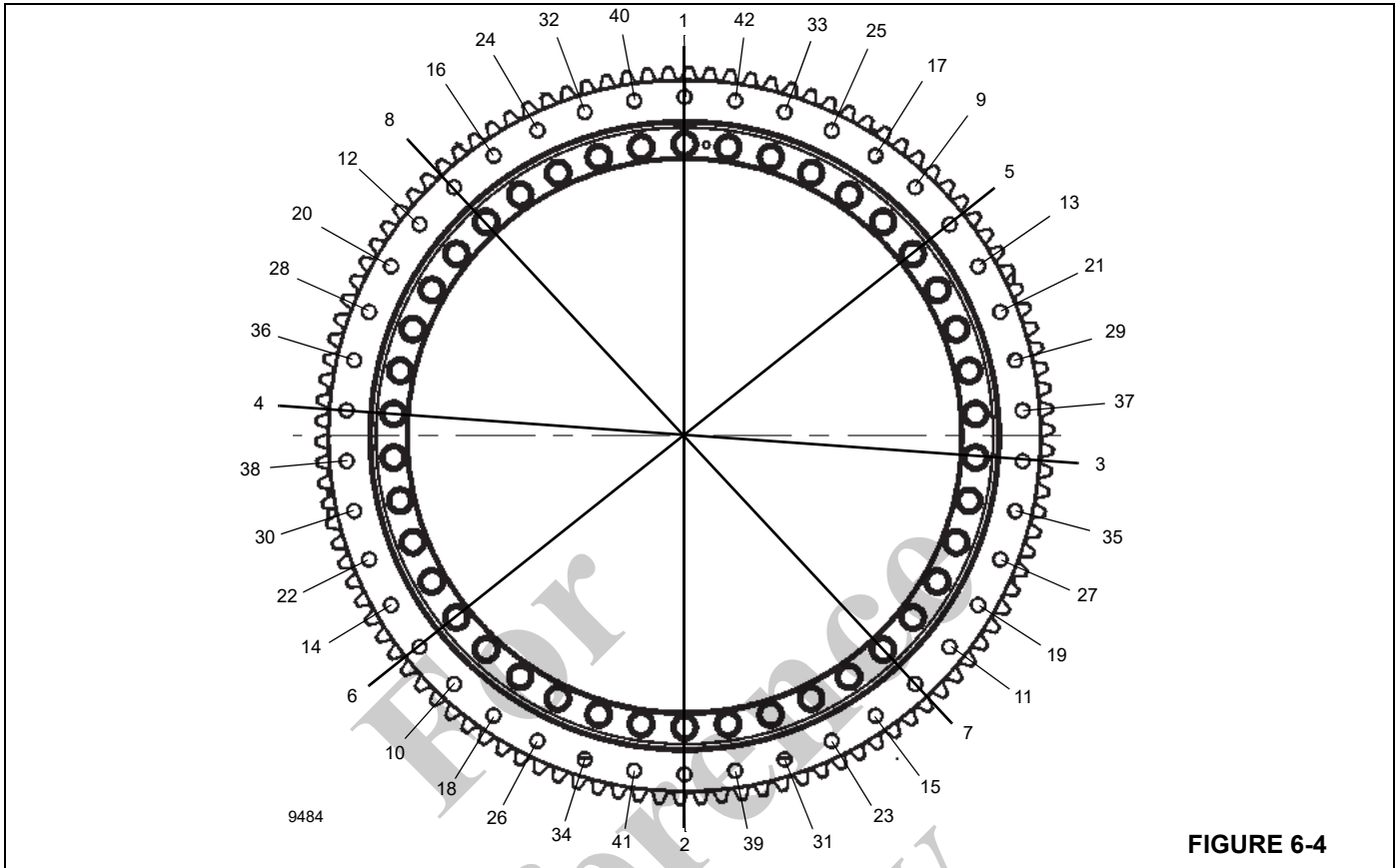


FIGURE 6-4

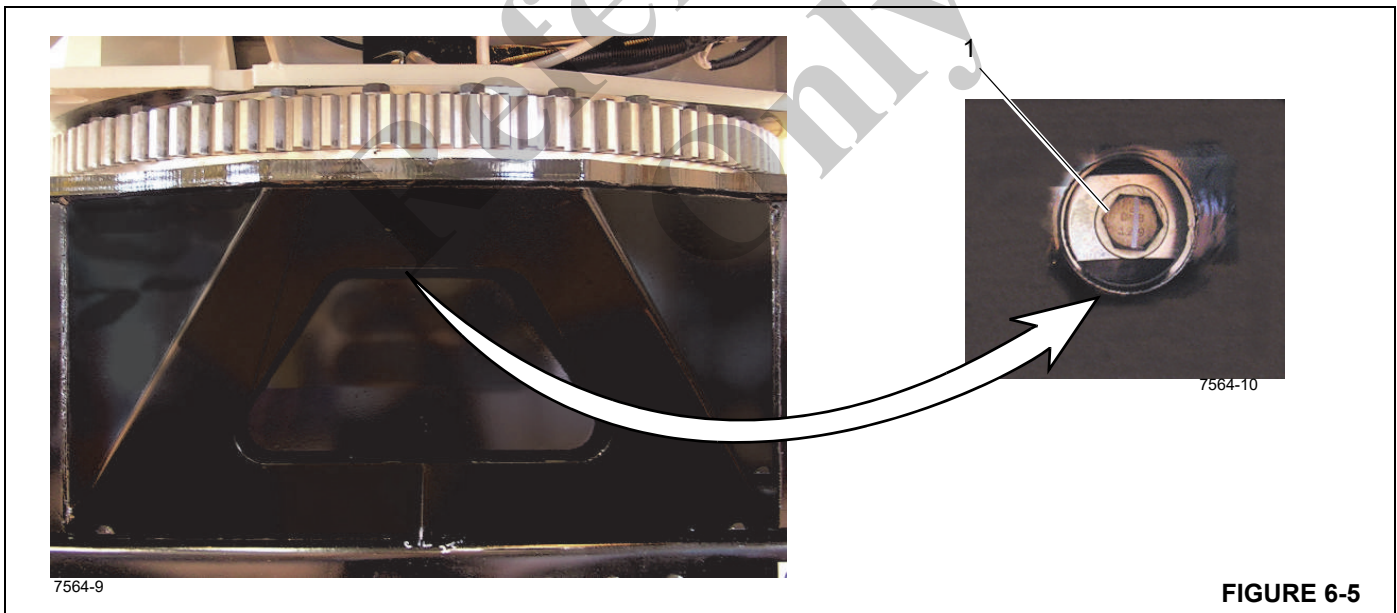


FIGURE 6-5



## 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 of normal wear 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 over the front and set the outriggers.
2. Put a dial indicator (2, Figure 6-6) opposite the boom on the T-box frame (3).
3. Place the dial on the top of the turret bearing plate (1, Figure 6-6).
4. Power the boom down onto the boom rest.
5. Set the dial indicator at zero.
6. Raise the boom about 76 mm (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 2 mm (0.090 in), replace the bearing.
10. If the average is less than 2 mm (0.090 in), repeat the measurement at every 45° around the total working area of the crane (Figure 6-7).

- 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 76 mm (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 2 mm (0.090 in) at any position, replace the bearing.

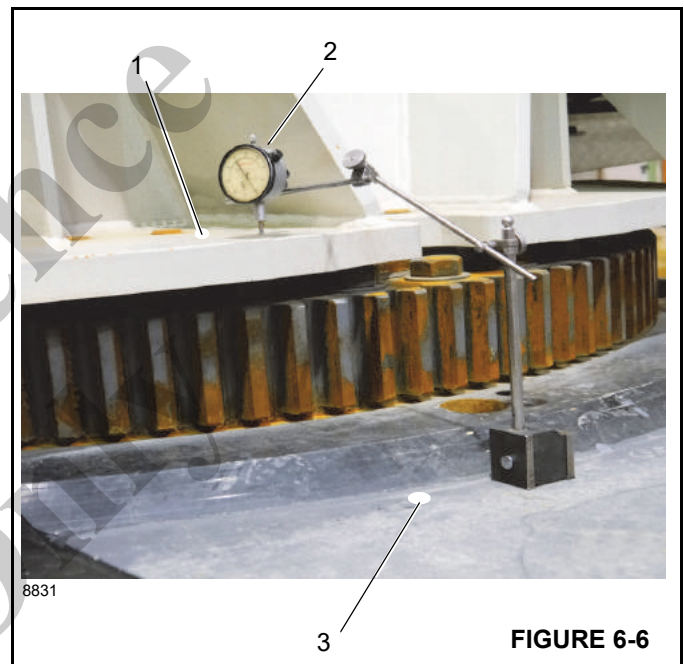


FIGURE 6-6

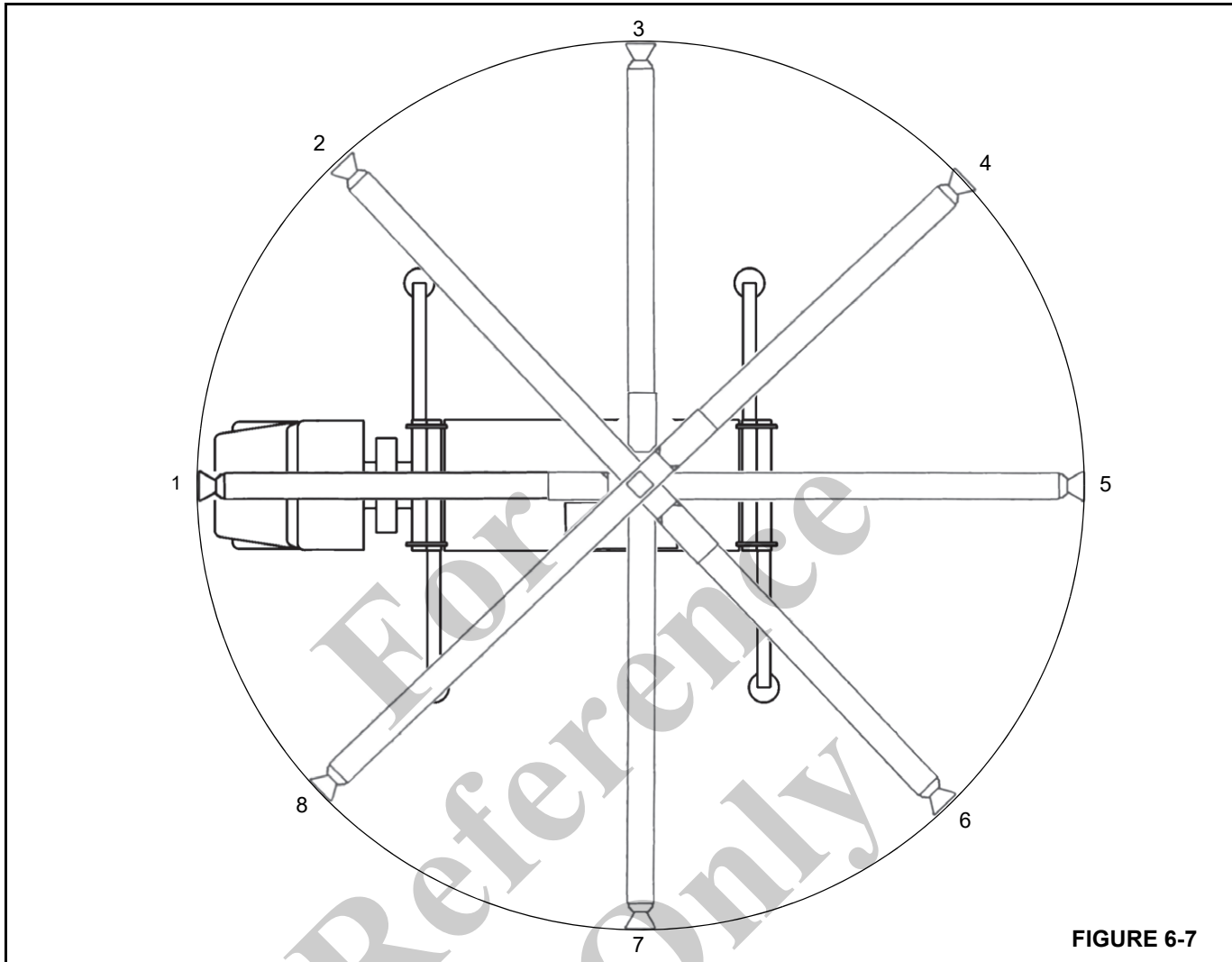


FIGURE 6-7

## 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 20° off the front position so that the boom is clear of the truck cab.

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

3. Mark the position of the swing motor. The bolts underneath the swing motor need to be removed before any other bearing bolts are removed.
4. Rotate the boom back to the front and remove the turntable bolts between the marks in step 3.

5. Slowly rotate the boom back to 20° off front position.
  6. Elevate the boom slightly and shut down the engine.
  7. Tag and disconnect the battery cables.
  8. Remove the boom and lift cylinder following the procedures outlined in *Boom Maintenance*, page 4-1.
  9. Tag and disconnect all hydraulic lines from the swivel on the carrier side. Cap or plug all lines and openings.
  10. Disconnect the wiring harness connectors from the carrier side of the swivel.
  11. Coil the wiring harness and secure it to the swivel to prevent damage to the harness during turret removal.
- NOTE:** The swivel is removed with the turret.
12. 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.

- Remove the remaining bolts and washers securing the swing bearing outer race to the carrier.

**⚠ DANGER**

Ensure blocking material can support the turret.

- Carefully lift the turret 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.

- Remove the 42 bolts from the inner race of the turret bearing.

- Lift the turret off the swing bearing and set on blocking.

**NOTE:** The bearing weighs about 504 kg (1111 lb).

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**

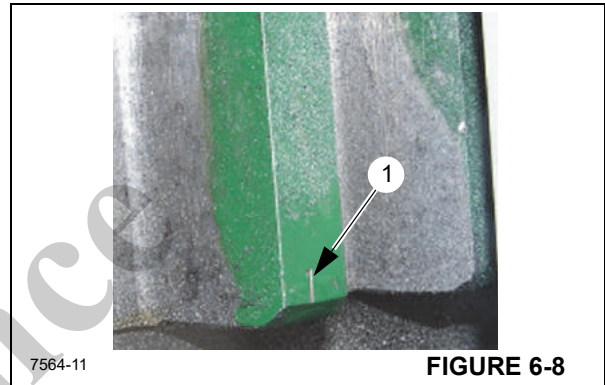
Do not reuse the swing bearing bolts. The swing bearing is torqued to the applied torque of the class 12.9 bolts. New bolts ensure proper torque and bolt strength for securing the swing bearing and turret to the carrier.

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

- 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.
- Install 42 new bolts and washers securing the bearing to the turret. Refer to Torquing Swing Bearing Bolts.
- Using an appropriate lifting device, align the turret over the carrier same position that it was before removal.
- Carefully lower the turret into position on the bearing plate. Be careful not to damage the swivel assembly.
- Install all bolts and washers that are not covered by the swing motor. Refer to Outer Race Torquing on page 6-9.

- Install the swing drive pinion (1) (Figure 6-9) so that the drive pinion gear teeth are aligned with the high point (maximum eccentricity) teeth (2) on the turret bearing (3).

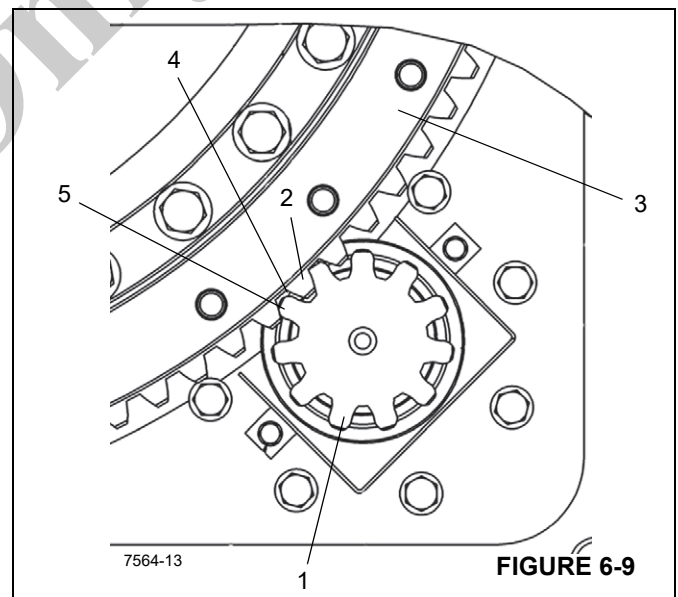
The high point or maximum eccentricity of the turret bearing is identified at the factory using three gear teeth in a row on the turret bearing as the high point. Tooth one and three are steel stamped (1, Figure 6-8) with a dash mark at the top and bottom of the gear teeth. Use these three gear teeth when installing the swing drive and checking the backlash shown in Figure 6-9.



**FIGURE 6-8**

- Check the backlash (4, Figure 6-9) with a 0.203 mm (0.008 in) thick shim between the drive pinion gear teeth (5) and the high point (maximum eccentricity) gear teeth (2) on the turret bearing.

If the pinion must be moved to achieve proper backlash 0.40 mm (0.016 in), contact your local distributor.



**FIGURE 6-9**

**NOTE:** If a new bearing (3) (Figure 6-9) is installed, a new pinion gear (1) must also be used.

- Plug the swivel wiring harness connectors into the carrier receptacles.

9. Reconnect the hydraulic lines as per removal tags.
10. Install the boom and lift cylinder following the procedures outlined in SECTION 4 - *Boom Maintenance*, page 4-1.
11. Reconnect the batteries.
12. Carefully swing the turret so that the bolt holes that were covered by the swing motor are accessible.
13. Install the remaining swing bearing bolts.
14. Check the slew potentiometer in the electrical swivel for proper orientation as described below.

### Slew Encoder

#### Adjustment

There is no mechanical adjustment for the slew encoder (Figure 6-10). Refer to the *Calibrating RCL Sensors*, page 3-13 for calibration instructions.



## SECTION 7 OUTRIGGERS

### SECTION CONTENTS

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### OUTRIGGER DESCRIPTION

The outriggers, when properly extended and set, provide a rigid four point platform which is capable of supporting the crane and its maximum load capacity. The outriggers consist of inverted jack cylinders with outrigger beams to allow for fully retracted, mid (50%) extension, three quarters (75%) extension (optional), and fully (100%) extended operation. An optional single front outrigger (SFO) is available for added stabilization, if needed for unique truck chassis applications only. The outriggers are fully hydraulic. The front outrigger box is mounted behind the front axles while the rear outrigger box is mounted behind the rear axles. The optional SFO is mounted on the center of a crossmember at the front of the crane or to the front frame of the truck chassis.

The beam assembly (see Figure 7-1) contains the bore extension cylinder and the jack cylinder which is mounted in a tube at the end of the beam.

The outrigger circuit consists of an integrated outrigger selector manifold, two outrigger manifold valves, four extension cylinders, four jack cylinders, a relief valve, and (pilot operated) check valves. The two front extension cylinders are mounted in the front outrigger beams and the two rear extension cylinders are mounted in the rear outrigger beams. The front and rear outrigger cylinders are mounted on their respective outrigger boxes; in turn the outrigger tubes are mounted on the end of each outrigger beam. The optional SFO is mounted to the front of the truck chassis to a crossmember of frame brackets. Each cylinder has an integral pilot operated valve.

There are three outrigger control panels on the crane. One outrigger control panel is located on the console in the superstructure cab. There is also a standard control panel on either side of the crane near the outriggers.

A sight bubble level is mounted on the right side of the cab console and at each standard control panel on the left and right sides of the crane. The sight bubble level provides the operator with a visual indication of crane level attitude.



## OUTRIGGER THEORY OF OPERATION

When the outrigger extension cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This sequence of events provides for lifting and stabilizing the crane for operation.

The outrigger extend or retract momentary switch must be used in conjunction with the outrigger selector switch to control the operation of the jack and extension cylinders. Push the desired switch to select the extend or retract mode.

The integrated outrigger valve spool shifts allowing flow to either the extend or retract line as applicable. If the switch is pushed to extend, flow continues through the open solenoid valve to the piston side of the cylinder. If the jack is to be extended, the flow first unseats the cylinder check valve then extends the cylinder. The oil from the rod end flows through the integrated outrigger valve, and then to the reservoir.

When the outrigger retract button is depressed, the flow through the selector valve is directed to the rod side of the cylinder. The oil in the piston side flows through the open solenoid back to the integrated outrigger valve. If a jack cylinder is to be retracted, then pilot pressure from the pressurized retract line unseats the cylinder check valve allowing oil to flow from the piston side through the open solenoid valve to the integrated outrigger valve. The integrated outrigger valve directs the flow to the reservoir.

The optional (if equipped) single front outrigger (SFO) functions similar to any of the other outrigger cylinders. The SFO will retract when the outrigger retract button is positioned to the retract position. After operating the main outrigger control, the SFO must be reset before operating the crane. An inline relief valve prevents over pressurization of the SFO as the cylinder is being extended. The valve is installed in line between the solenoid valve and the cylinder, and is set at 3447 kPa (500 psi).

For  
Reference  
Only

**MAINTENANCE**

**Troubleshooting**

Symptom	Probable Cause	Solution
1. Outrigger beam extension cylinder slow or erratic.	a. Low hydraulic oil level.	a. Check for leaks. Make any needed repairs. Fill reservoir to proper level.
	b. Damaged relief valve.	b. Remove relief valve; clean or replace.
	c. Sticking solenoid valve spool.	c. Repair or replace valve spool.
	d. Improper ground to base of solenoid.	d. Ground properly.
	e. Damaged O-rings and swivel.	e. Remove swivel and replace O-rings.
	f. Directional selector switch sticking.	f. Clean or replace switch.
	g. Collector ring dirty or glazed.	g. Clean and deglaze collector ring.
	h. Damaged wiring to solenoid.	h. Replace wiring.
	i. Weak brush springs on collector ring.	i. Replace brush springs.
	j. Damaged extension cylinder (internal parts).	j. Remove extension cylinder and repair as necessary.
	k. Bent cylinder rods.	k. Replace piston rods and seals.
	l. Excessive material on outrigger beams.	l. Clean outrigger beams.
	m. Binding outrigger beam.	m. Adjust the wearpads, or repair or replace outrigger beam.
	n. Damaged outrigger valve.	n. Repair or replace valve.
	o. Damaged valve coil.	o. Replace coil.
	p. Main hydraulic pump cavitation.	p. Replace or tighten hose or fitting.
	q. Partially shifted hydraulic spool in selector valve or manifolds.	q. Disassemble, clean, and polish spool and valve housing with very fine emery cloth (water paper).
	r. Insufficient voltage for operation of solenoid valve.	r. Solenoids require a minimum of 9.5 volts to energize. Check outrigger wiring and electrical coupling collector rings.
s. Damaged piston seals.	s. Replace all cylinder seals.	
t. Worn or damaged hydraulic pump section.	t. Repair or replace pump section.	
u. Scored cylinder barrel.	u. Repair or replace extension cylinder.	

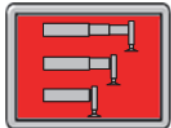

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Symptom	Probable Cause	Solution
Slow or erratic operation of outrigger extension cylinders. (continued)	<b>v.</b> Cracked or damaged piston.	<b>v.</b> Replace rod weld and all cylinder seals.
	<b>w.</b> Piston loose on piston rod	<b>w.</b> Replace all cylinder seals and torque piston locknut.
<b>2.</b> Sticking spool.	<b>a.</b> Dirt in the system.	<b>a.</b> Change oil and flush system.
	<b>b.</b> Distortion caused by sectional tie bolts being overtorqued.	<b>b.</b> Retorque sectional tie bolts.
	<b>c.</b> Flow in excess of valve rating.	<b>c.</b> Limit flow through valve to recommended. Check pump output and cylinder ratio.
	<b>d.</b> Pressure in excess of valve rating.	<b>d.</b> Check relief valve setting or pump compensation recommended values.
	<b>e.</b> Electrical failure.	<b>e.</b> Check wiring and solenoids.
<b>3.</b> External leakage.	<b>a.</b> Damaged O-ring or quad rings.	<b>a.</b> Check for chipped packings and replace.
	<b>b.</b> Loose sectional tie bolts.	<b>b.</b> Retorque sectional tie bolts.
	<b>c.</b> Damaged solenoid.	<b>c.</b> Replace damaged parts.
<b>4.</b> Solenoid failure.	<b>a.</b> No current.	<b>a.</b> Check power source.
	<b>b.</b> Damaged solenoid assembly.	<b>b.</b> Replace solenoid.
	<b>c.</b> Short in solenoid.	<b>c.</b> Replace coil.
	<b>d.</b> Loss of solenoid force.	<b>d.</b> Decrease time of solenoid energization, decrease cycle rate.
<b>5.</b> Outrigger vertical jack cylinder slow or erratic.	<b>a.</b> Low hydraulic oil level.	<b>a.</b> Check for leaks. Make any needed repairs. Fill reservoir to proper level.
	<b>b.</b> Damaged main relief valve.	<b>b.</b> Repair or replace valve.
	<b>c.</b> Damaged holding valve seals.	<b>c.</b> Replace holding valve seals.
	<b>d.</b> Bent cylinder rod.	<b>d.</b> Replace cylinder rod and seals.
	<b>e.</b> Bent outrigger housing.	<b>e.</b> Repair or replace outrigger housing.
	<b>f.</b> Damaged O-rings in swivel.	<b>f.</b> Replace O-rings.
	<b>g.</b> Excessive material on beams.	<b>g.</b> Clean outrigger beams.
	<b>h.</b> Sticking solenoid valve spool.	<b>h.</b> Repair or replace valve spool.
	<b>i.</b> Damaged wiring to solenoid.	<b>i.</b> Repair or replace wiring.
	<b>j.</b> Weak brush springs on collector rings.	<b>j.</b> Replace brush springs.
	<b>k.</b> Collector ring dirty or glazed.	<b>k.</b> Clean or deglaze collector ring.
<b>l.</b> Directional selector switch sticking.	<b>l.</b> Clean or replace switch.	



Symptom	Probable Cause	Solution
Outrigger vertical jack cylinder slow or erratic. (continued)	<b>m.</b> Main hydraulic pump cavitation.	<b>m.</b> Replace or tighten hose and fittings.
	<b>n.</b> Worn or damaged hydraulic pump section.	<b>n.</b> Repair or replace pump section.
<b>6.</b> Outrigger jack cylinder retracts under load.	<b>a.</b> Damaged piston seals.	<b>a.</b> Replace all cylinder seals.
	<b>b.</b> Damaged holding valve seals.	<b>b.</b> Replace seals.
	<b>c.</b> Damaged holding valve.	<b>c.</b> Replace valve assembly.
	<b>d.</b> Scored cylinder barrel.	<b>d.</b> Repair or replace cylinder.
	<b>e.</b> Cracked or damaged piston.	<b>e.</b> Replace piston and all cylinder seals.
<b>7.</b> Jack cylinder extends while machine is traveling.	<b>a.</b> Damaged piston seals.	<b>a.</b> Replace all cylinder seals.
	<b>b.</b> Scored cylinder barrel.	<b>b.</b> Replace jack cylinder.
	<b>c.</b> Cracked or damaged piston.	<b>c.</b> Replace piston and seals.
	<b>d.</b> Piston loose on cylinder rod.	<b>d.</b> Replace seal and retorque.
<b>8.</b> Outrigger system will not activate (from stowed or extended and down position).	<b>a.</b> Hydraulic oil low.	<b>a.</b> Replenish system.
	<b>b.</b> Loose or broken wire on keypad.	<b>b.</b> Repair or replace wiring.
	<b>c.</b> Clogged, broken, or loose lines or fittings.	<b>c.</b> Clean, tighten, or replace lines or fittings.
	<b>d.</b> Damaged relief valve or damaged control valve.	<b>d.</b> Repair or replace valve.
<b>9.</b> Outrigger system activates, but selected outrigger will not stow or extend and lower as desired.	<b>a.</b> Clogged, broken, or loose hydraulic lines or fittings.	<b>a.</b> Clean, tighten, or replace lines or fittings.
	<b>b.</b> Loose or broken wire on control switch or solenoid valve.	<b>b.</b> Repair or replace wiring.
	<b>c.</b> Damaged solenoid valve.	<b>c.</b> Repair or replace valve.
	<b>d.</b> Damaged control switch.	<b>d.</b> Replace switch.
	<b>e.</b> Damaged hydraulic cylinder.	<b>e.</b> Repair or replace cylinder.
	<b>f.</b> Damaged relief valve.	<b>f.</b> Repair or replace relief valve.
<b>10.</b> Outriggers will not set.	<b>a.</b> Improper sequence of activation.	<b>a.</b> Activate individual control switch; then activate system control switch.
<b>11.</b> Two outriggers activate from single control switch.	<b>a.</b> Improper wiring.	<b>a.</b> Troubleshoot wiring from modules
<b>12.</b> One/two outriggers will not stow.	<b>a.</b> Pressure may be too low.	<b>a.</b> Check pressures to ensure the right value is being sent to activate the cylinders



Symptom	Probable Cause	Solution
<p>13. Individual outrigger will not set or stow.</p>	a. Damaged piston seals.	a. Replace seals.
	b. Damaged check valve.	b. Repair or replace valve.
	c. Loosen or broken wire on control switch or solenoid valve.	c. Repair or replace wiring.
	d. Damaged solenoid valve.	d. Repair or replace valve.
<p>14. The outrigger calibration warning icon appears in the RCL.</p> <p><b>NOTE:</b> Refer to the Manitowoc Diagnostic Code application for details about RCL error codes. For more information, see "About the Manitowoc Diagnostic Code Application" on page 3-23.</p> 	<p>a. One of the following:</p> <ul style="list-style-type: none"> <li>- A sensor has been replaced.</li> <li>- An outrigger beam has been removed for service.</li> <li>- The RCL display has been replaced.</li> <li>- The RCL software has been updated.</li> </ul>	a. Calibrate the outriggers in the RCL. For more information, see "Calibrating the Outrigger Span/Length" on page 3-16.
	<p>b. There is a spooling issue in the potentiometer reel.</p>	b. Correct the spooling error, then recalibrate the outrigger in the RCL. For maintenance information, see "Outrigger Maintenance" on page 7-7. For information about calibrating the outrigger in the RCL, see "Calibrating the Outrigger Span/Length" on page 3-16.
<p>15. The outrigger keypad component address warning icon appears in the RCL.</p> <p><b>NOTE:</b> Refer to the Manitowoc Diagnostic Code application for details about RCL error codes. For more information, see "About the Manitowoc Diagnostic Code Application" on page 3-23.</p> 	An outrigger keypad has been replaced.	Assign the CAN Bus ID to the outrigger control panel. For more information, see "Assigning CAN Bus ID to Outrigger Control Panels" on page 3-18.

**OUTRIGGER BEAM**

The outrigger beam assembly (see Figure 7-1) consists of an outrigger beam, a jack cylinder, a outrigger extension cylinder, and the required hoses and mounting hardware.

**Theory of Operation**

When the outrigger extension cylinder is activated, it extends or retracts the outrigger beam within the outrigger box. The jack cylinder is mounted to the end of the beam. The jack cylinder applies force to the outrigger beam vertically. This provides for lifting and stabilizing the crane for operation.

## Outrigger Maintenance

See Figure 7-1 for outrigger assembly breakdown.

### Outrigger Removal

1. Extend the outrigger slightly to facilitate attaching a lifting device to the outrigger beam.
2. Remove the bolts, washers, and lock washers securing the shim plates to the ends of the outrigger box and mid beam.
3. From the opposite side of the outrigger housing, remove the end cover.
4. Tag and disconnect the three hydraulic hoses from the hydraulic tubes entering the outrigger box housing. Cap or plug all openings.



### CAUTION

Cable is under spring tension. Do not free-release. This could result in injury and damage to the sensor.

5. Disconnect the outrigger string potentiometer (quick clip) cable from the jack beam.
6. Disconnect electrical connection from the potentiometer.
7. Remove the pipe clamp, bolt insert, and bolt from each of the three hydraulic tubes entering the outrigger housing.
8. Tag, disconnect, and remove the three hydraulic tubes to the cylinder end of the extension cylinder. Cap or plug all openings.
9. On the side of the outrigger housing, remove the setscrews from the adjustable wear pads and back off the wear pads from the housing.
10. Remove the cotter pin and clevis pin securing the rod of the extension cylinder to the outrigger housing.
11. After attaching a suitable lifting device of straps or belts (instead of chains) to prevent nicking the bottom edges of the outrigger beam, pull the outrigger beam out of the

outrigger box, re-adjusting the lifting attachment to prevent the beam from tipping.

**NOTE:** The outrigger beam assembly weighs approximately 759 kg (1673 lb).

12. Position the outrigger beam on the blocking material.
13. If necessary, remove the wear pad from the inside bottom of the outrigger box.

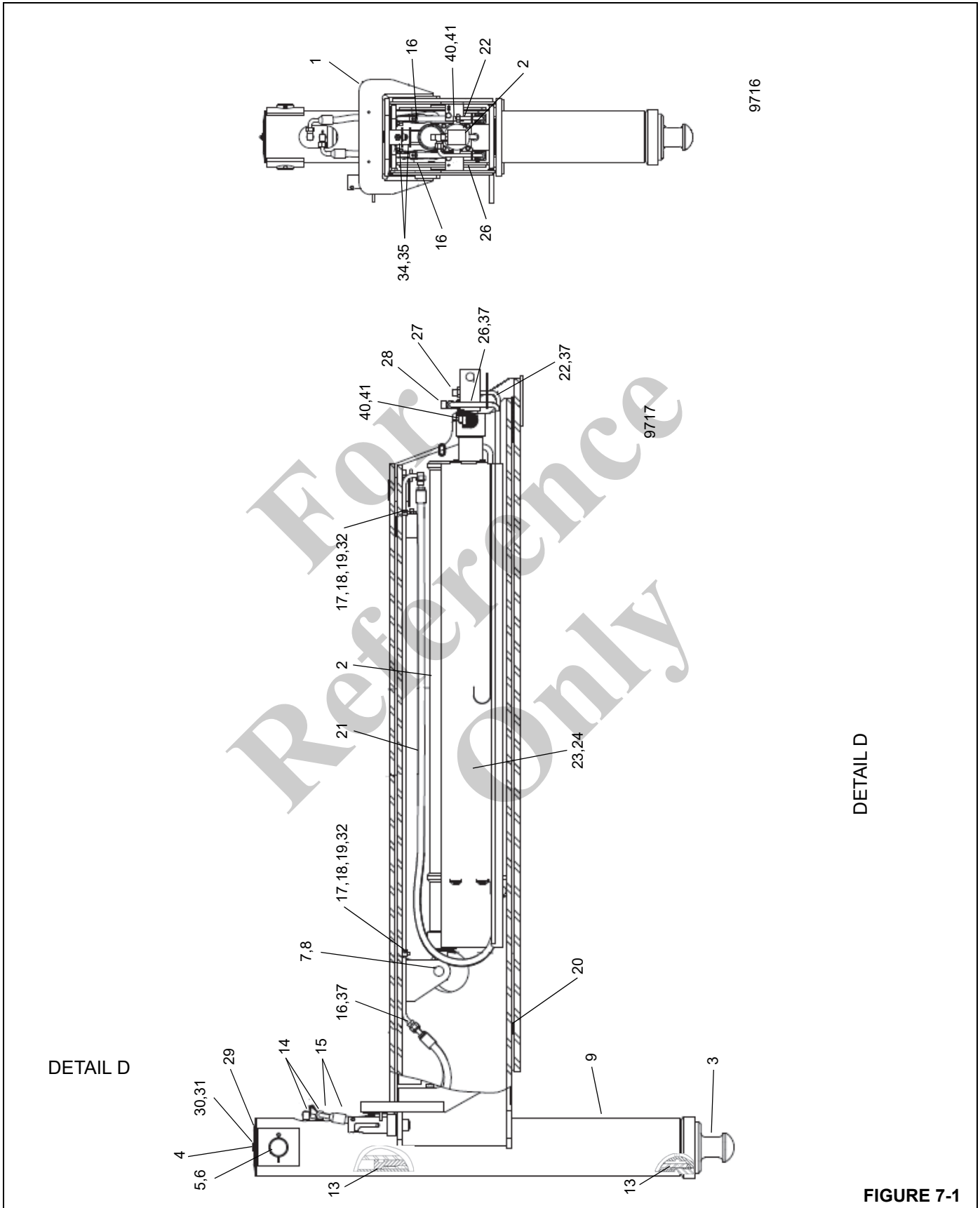
### Outrigger Disassembly

1. Remove the four bolts and lock washers securing the extension cylinder barrel lugs to the brackets on the mid beam.
2. Attach a suitable lifting device of straps or belts to the outrigger jack beam. Partially pull the outrigger jack beam out of the outrigger mid beam, re-adjusting the lifting attachment to prevent the beam from tipping.

**NOTE:** Do not use chains to prevent nicking the bottom edges of the outrigger beam,

**NOTE:** The outrigger jack beam assembly weighs approximately 453 kg (999 lb).

3. Position the outrigger jack beam on the blocking material.
4. Remove the wear pad and wedge from the pocket in the top of the mid beam.
5. Remove the wear pad from the pocket in the bottom of the mid beam.
6. Remove the wear pad and wedge from the pocket in the top of the jack beam.
7. Remove the extension cylinder. See Extension Cylinder on page 7-11.
8. Remove the jack cylinder. See Outrigger Jack Cylinder on page 7-12.
9. Remove the two clamps, washers, lock washers, and nuts securing each tube and hose assembly to the inside top of the jack beam. Remove the tube and hose assemblies.



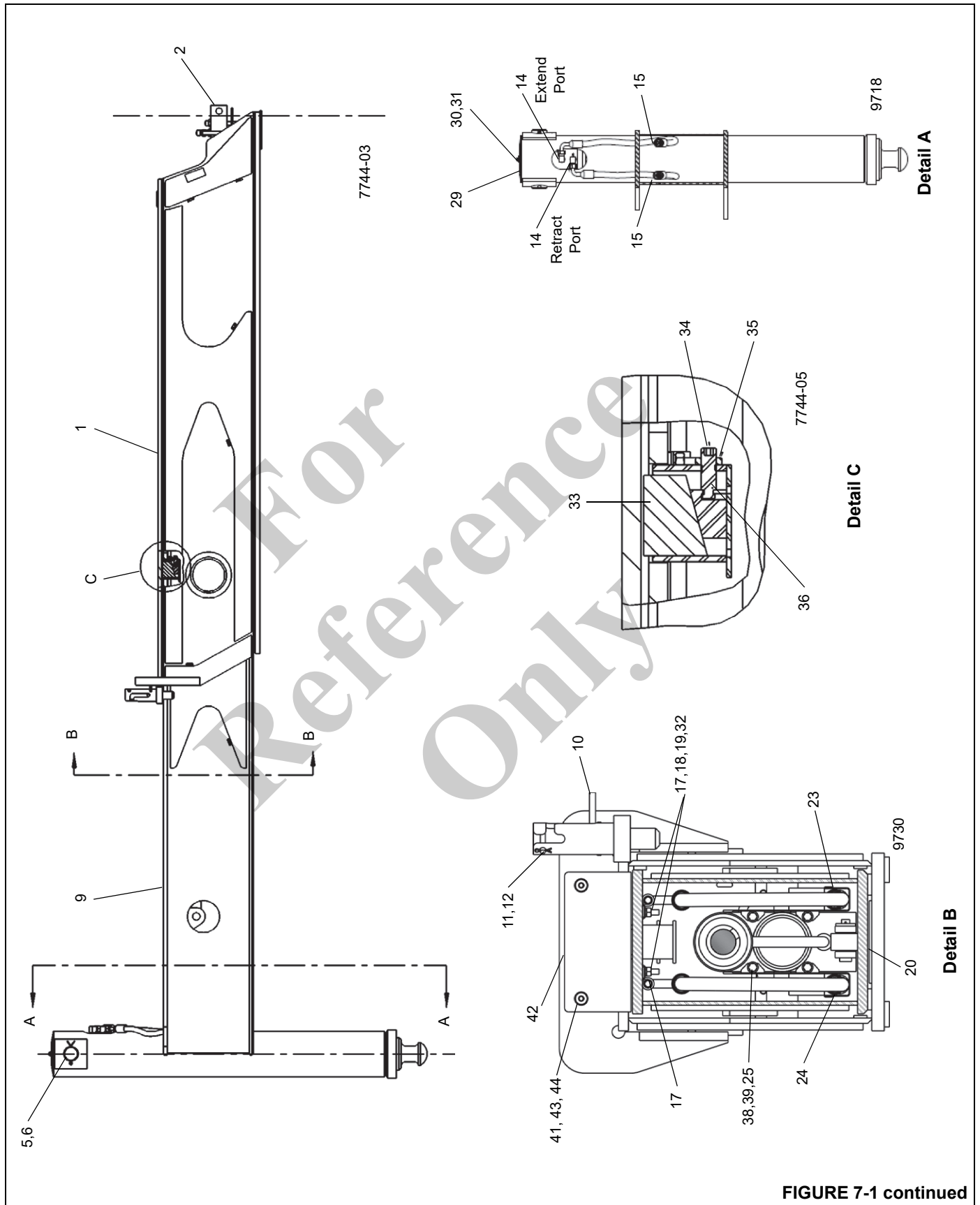


FIGURE 7-1 continued

Item	Description
1	Outrigger Mid Beam
2	Cylinder Assembly-2.50 Outrigger Extend
3	Cylinder Assembly-5.50 Jack
4	Cap Bracket
5	Pin
6	Cotter Pin 0.25x3" St
7	Clevis Pin 1x2.5" Hard
8	Cotter Pin 0.19x1.75" St
9	Outrigger Jack Beam
10	Pin
11	Clevis Pin 0.31x2.13" St
12	Cotter Pin 0.09x0.75" St
13	6.50" Wear Ring
14	90 deg Elbow
15	Hose Assembly - 0.5" Abrasion
16	Tube, Outrigger Jack Line
17	Tubing Clamp 1/2" I.D.
18	F Washer 8 -St ISO 7089
19	L Washer 8 -HRHRXC44-51 DIN 798
20	Wear Pad, Outrigger (Nylon)
21	Hose Assembly 133/16-16 x 1/2 ID x 76
22	Tube Assembly Outrigger Jack Cylinder
23	Tray L.H.
24	Tray R.H.
25	HHCS 1/4-20UNC x 0.5 G5
26	Tube Assembly Outrigger Jack Cylinder
27	Str Adapter
28	Run Tee
29	Cap - Jack Cyl Tube
30	F Washer 0.38x0.90x0.06"
31	Acorn Nut 5/16-18UNC SAE-2
32	Hex Nut M8 8 ISO 4032
33	Wear Pad
34	SSS - Special M12x40
35	Hex Jam Nut M12 04 ISO 4035

Item	Description
36	Wedge
37	O-ring
38	F Washer 1/4" Nar MS
39	L Washer 1/4" Reg HRC44-51
40	HHCS M10x35 10.9 ISO 4017
41	L Washer 10 -HRC44-51 DIN 7980
42	Shim, L-shape
43	SBHCS M10x25 8.8 FLZN ISO 7380
44	Flat Washer 10 -ST ISO 7089

**Inspection**

1. Inspect the hoses, couplings, and end fittings for cracks, chafing, cuts, or other damage.
2. Inspect the outrigger beams for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder or damaged hydraulic line.

**Assembly**

1. Route the tube and hose assemblies through the jack beam. Attach the tubes to the inside top of the jack beam using the four clamps, washers, lock washers, and nuts; do not tighten the clamps at this time.
2. Install the jack cylinder in the jack beam. Refer to Outrigger Jack Cylinder - Installation in this Section.
3. Install the outrigger extension cylinder in the jack beam. Refer to Extension Cylinder - Installation in this Section.
4. Position the wedge and wear pad in the pocket in the top of the jack beam. Coat the wear pad with grease.
5. Position the wear pad in the pocket in the bottom of the mid beam. Coat the wear pad with grease.
6. Position the wedge and wear pad in the pocket in the top of the mid beam. Coat the wear pad with grease.
7. Attach a suitable lifting device of straps or belts to the outrigger jack beam. Slide the jack beam into the outrigger mid beam.

**NOTE:** Do not use chains to prevent nicking the bottom edges of the outrigger beam,

**NOTE:** The outrigger jack beam assembly weighs approximately 453 kg (999 lb).

8. Place the extension cylinder barrel lugs in the brackets of the mid beam and secure with four bolts and lock washers.

**Installation**

1. Install the wear pad in the inside bottom of the outrigger housing. This will prevent the beam side plates from riding on the bottom of the box.
2. Apply grease (EP-MPG) to the bottom of the outrigger beam assembly.
3. Attach a suitable lifting device of straps or belts and slide the beam into the outrigger housing and align the cylinder rod with the mounting hole.

**NOTE:** Do not use chains to prevent nicking the bottom edges of the outrigger beam,

**NOTE:** The outrigger beam assembly weighs approximately 759 kg (1673 lb).

4. Secure the cylinder rod to the housing with the clevis pin and cotter pin.
5. Connect the three hydraulic tubes to the cylinder end as tagged during removal.
6. Secure the three hydraulic tubes to the outside of the outrigger housing using the pipe clamps, bolt inserts, and bolts.
7. Connect the outrigger string potentiometer (quick clip) cable to the jack beam.
8. Connect the three hydraulic hoses to the hydraulic tubes as tagged prior to removal.

**CAUTION**

Make sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.

**CAUTION**

During initial start-up and checking of the outrigger operation, each control switch must be operated before operating the selector valve. If hydraulic lines are reversed to one or more cylinders, this will prevent damage to the cylinders.

9. Install the shim plates on the ends of the outrigger housing and the mid beam using the bolts, washers, and lock washers.
10. Adjust the wear pads. Refer to Wear Pad Adjustment.
11. Install the end cover.

**NOTE:** At installation, be sure that the outrigger jack cylinder hydraulic hoses are not trapped against the outrigger box when the beam is fully retracted.

Calibrate the outrigger RCL sensors. For more information, see "Calibrating the Outrigger Span/Length" on page 3-16

**Wear Pad Adjustment**

**NOTE:** When adjusting wear pads, refer to Figure 7-1.

1. Adjust the top wear pads until a gap of 2.0 mm (0.07 in) is obtained at the tightest point during full extension. Install and lock setscrews against wear pads.
2. Adjust outrigger box side wear pads until a gap of 2.0 mm (0.07 in) is obtained at the tightest point during full extension. Install and lock setscrews against wear pads.

**EXTENSION CYLINDER****Description**

The outrigger beam extension cylinder is a combination unit with two rods, one for extending each beam section. Each "half" of the cylinder is a double-acting type cylinder. The barrel end is attached to the mid beam. The lower rod is attached to the outrigger box and the upper rod is attached to the jack beam.

Each barrel has a 6.4 cm (2.50 in) diameter bore. Internal seals are used to prevent internal and external leakage.

**Removal**

1. Remove the outrigger beam. Refer to Outrigger Beam - Removal in this section.
2. Remove the cotter pin and clevis pin securing the cylinder rod to the jack beam.
3. Loosen the two clamps securing each hydraulic tube to the inside top of the jack beam. Slide the tubes out of the jack beam enough to remove the hoses from them. Tag and remove the hoses from the tubes. Cap or plug all openings.
4. Slide the extension cylinder from the jack beam being careful not to damage the two hydraulic tubes mounted to the inside top of the jack beam.

**NOTE:** The extension cylinder weighs approximately 70.3 kg (155 lb).

5. Disconnect the tube from the extension cylinder port.
6. Pull the tube and hose assemblies from the tube trays.
7. Remove the bolts, washers, and lockwashers securing the trays to the extension cylinder and remove the trays.

**Installation**

**NOTE:** The extension cylinder weighs approximately 70.3 kg (155 lb).

1. Coat the inside of the tube trays with Never-Seeze. Attach the trays to the extension cylinder with bolts, washers, and lockwashers.
2. With the extension cylinder sitting with the roller down, rotate the rod end that is closest to the jack cylinder so that the centerline through the clevis pin hole is horizontal to the ground.
3. Install the tube and hose assemblies in the trays.
4. Insert the extension cylinder three-quarters of the way in the end of the jack beam.
5. Connect the hoses to the tubes in the top of the jack beam as marked during disassembly. Ensure the top and bottom portions of the curved hoses are in vertical alignment with each other or else the hoses will be damaged during cylinder extension and retraction.
6. Connect the tube to the extension cylinder port.
7. Slide the tubes that are attached to the inside top of the jack beam into the jack beam until their ends are flush with the top plate of the jack beam, then tighten the four clamps.
8. Secure the extension cylinder rod to the jack beam ears using the clevis pin and a cotter pin.
9. Assemble the jack beam into the mid beam. Refer to Outrigger Beam - Assembly in this section.

**Functional Check**

1. Extend and retract the outrigger.
2. Observe the operation of the outrigger beam.
3. Check the hydraulic connections for any evidence of leakage.

**OUTRIGGER JACK CYLINDER****Description**

The jack cylinders are the double-acting type. The cylinders are pinned into tubes welded onto the end of the outrigger beams. A port block is welded to the end of the cylinder rod and a pilot-operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

**Maintenance****Removal**

1. Extend the outrigger beam slightly for improved access to the jack cylinder. Shut down the engine.
2. Tag and disconnect the hydraulic hoses from the jack cylinder. Remove the fittings from the cylinder.
3. Remove the cylinder cap.
4. Place a jack capable of supporting the weight of the jack cylinder at the base of the cylinder barrel. Jack up the cylinder just enough to relieve any pressure on the cylinder retaining pin.

**NOTE:** The outrigger jack cylinder weighs approximately 105.4 kg (232.5 lb).

5. Remove the cotter pins securing the cylinder retaining pin and remove the cylinder retaining pin.
6. Remove the cap bracket from the top of the cylinder.
7. Raise the jack cylinder up just enough to insert the retaining pin back into the cylinder. Insert the retaining pin into the lugs on the cylinder and secure in place with the cotter pins.

**CAUTION**

Use a nylon strap to remove the cylinder. This will ensure the retaining pin is not damaged.

8. Fasten a nylon strap onto the cylinder retaining pin and use an adequate lifting device to lift the jack cylinder out of the tube on the beam assembly.

**Installation**

1. Apply grease to the grooves at the top of the jack cylinder and inside the bottom of the jack cylinder tube. Install a wear ring around the top of the jack cylinder and the inside of the cylinder tube. Apply grease to the wear rings.
2. Place a jack beneath the cylinder tube on the outrigger beam. Using the same method as described under Removal, lower the jack cylinder into the cylinder tube on the outrigger beam until the retaining pin is just above the tube. Position the jack so that it will support the cylinder in this position. Remove the lifting device from the cylinder.

**NOTE:** The outrigger jack cylinder weighs approximately 105.4 kg (232.5 lb).

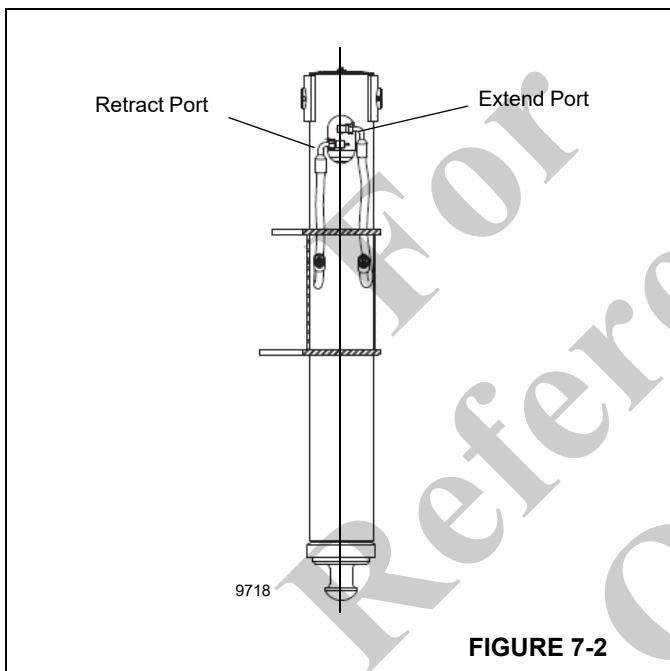
3. Remove the retaining pin and cotter pins from the cylinder.



4. Lower the jack until the holes in the cylinder rod align with the holes in the outrigger beam. Install the cap bracket on top of the cylinder. Secure the cylinder in place with the retaining pin and cotter pins.
5. Install the cylinder cap.

**! CAUTION**

Make sure that the piston side of all outrigger cylinders are connected to the solenoid valve bank. Reversal of port connection of the rod and piston sides could result in severe damage to the cylinders as very high pressure intensification will occur.



6. Install the fittings in the cylinder, then connect the hydraulic hoses to the jack cylinder as marked prior to disassembly.

**Functional Check**

1. Extend and retract the jack cylinder.
2. Check for smooth operation of the cylinder.
3. Check all hydraulic connections and hoses for evidence of leakage.

**Outrigger Jack Cylinder Internal Leak Test**

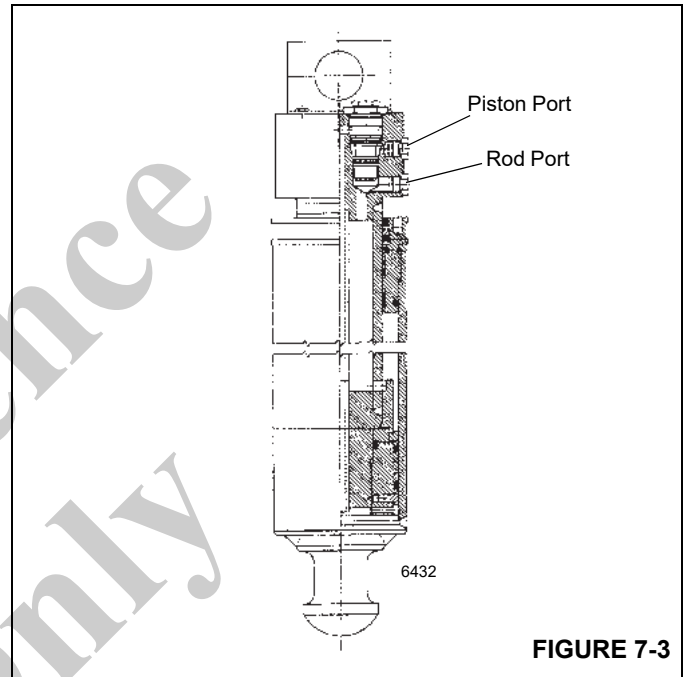
Use the following procedure to troubleshoot and diagnose an internal leak, a leaking pilot operated check valve or a thermal contraction on an outrigger jack cylinder.

**! DANGER**

Perform the following procedures with the crane positioned on a firm level surface with outriggers fully extended and set, and the crane in the travel position. Remove hoses from one cylinder at a time.

**Checking Cylinder For Internal Piston Seal Leak**

1. Fully extend and set the outriggers.



**! CAUTION**

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

2. Remove the rod side cylinder hose from the suspected leaking jack cylinder (see Figure 7-3). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the rod side port.

Check for the following conditions:

- a. If oil stops flowing, the cylinder's internal piston seal is sealing properly.
- b. If oil continues to flow out the rod port, the cylinder's internal piston seal is leaking.

- After determining the condition of the cylinders internal piston seal, keep the rod side hose disconnected and continue to test the pilot operated check valve.

### Testing Pilot Operated Check Valve For Leakage

- Fully extend and set the outriggers.



### CAUTION

When performing step number 2, remove hose to adapter connection slowly. Trapped pressure may exit between the outrigger cylinder and the work port pilot operated check valves in the outrigger selector valve.

- Remove the piston side cylinder hose from the suspected leaking jack cylinder (see Figure 7-3). Oil will flow until the cavity in the cylinder port block empties. Once the port block cavity empties, oil should stop flowing from the piston side port.
  - If oil stops flowing, the cylinder's pilot operated check valve is sealing properly.
  - If oil continues to flow out the piston port, the cylinder's pilot operated check valve is leaking.

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

## OUTRIGGER SYSTEM VALVES

### Description

There are four valve assemblies responsible for controlling the outrigger system: the pressure reducing valve, the front outrigger control manifold, the rear outrigger control manifold, and the pilot operated check valves. Trucks equipped with an optional single front outrigger (SFO) have an additional relief valve.

**NOTE:** For a more detailed DESCRIPTION and MAINTENANCE of the valves, refer to VALVES in Section 2 - HYDRAULIC SYSTEM.

### Pressure Reducing Valve

The pressure reducing valve is located on the pump manifold and reduces the system pressure in the outrigger circuit.

### Front Outrigger Control Manifold

The front outrigger control manifold is located behind the front outrigger boxes and inside the T-box frame. The manifold consists of a three position four way solenoid directional control valve that controls outrigger extend and retract functions. Additionally, five solenoid control valves on the manifold operate the front outrigger beam extension and

jack cylinders as well as the optional single front outrigger (SFO) cylinder. The manifold also contains a relief valve that protects the cylinders from damage due to thermal expansion.

### Rear Outrigger Control Manifold

The rear outrigger control manifold is located in front of the rear outrigger boxes and inside the T-box frame. The rear manifold consists of four solenoid control valves that operate the rear outrigger extension and jack cylinders.

### Pilot Operated Check Valve

A pilot operated check valve is located in each outrigger jack port block. The check valve prevents the jack cylinder from retracting if a hose fails.

### Single Front Outrigger (SFO) Circuit Relief Valve

The single front outrigger (SFO) - if equipped, circuit relief valve is mounted to the side of the front jack tube and prevents over pressurization of the front jack circuit when fully extended or retracted.

## SINGLE FRONT OUTRIGGER (SFO) CYLINDER (OPTIONAL)

The optional single front outrigger cylinder is the double acting type. The cylinder is bolted to a tube which is mounted onto a special crossmember or using custom mounting brackets attached to the front end of the carrier frame. A port block is bolted to the end of the cylinder rod and a pilot operated check valve is threaded into the port block. Internal seals are used within the cylinder to prevent internal and external leakage. A wiper ring is mounted to the front of the cylinder barrel to wipe dirt from the rod as it is retracted.

## Maintenance

### Removal

See Figure 7-4 for cylinder breakdown.

- Tag and disconnect the two hoses coming from the truck to the relief valve on the side of the jack cylinder support tube. Cap or plug all openings.
- Remove the two pins securing the SFO assembly to the front chassis. Remove the jack assembly.

**NOTE:** The front jack cylinder assembly weighs approximately 78.9 kg (174 lb).

- Tag and disconnect the two hoses to the check valve block on top of the cylinder. Cap or plug all openings.
- Remove the two bolts securing the check valve block to the cylinder port block. Remove the check valve block.
- Slide the cylinder out of the cylinder support tube.

**Installation**

1. Apply grease (EP-MPG) to the inside of the jack cylinder support tube.
2. Slide the cylinder into the cylinder support tube.
3. Install the check valve block on the cylinder port block using the two bolts.
4. Connect the hoses to the check valve block as tagged prior to removal.
5. Install the jack assembly on the front chassis using the two pins. Ensure there is a ground clearance of 14 to 19 in under the jack cylinder.
6. Connect the hoses coming from the truck to the relief valve on the side of the jack cylinder support tube as tagged prior to removal.

**Functional Check**



Extend and set the four main outriggers before extending the single front outrigger.

1. Extend and set the outriggers.
2. Extend and retract the front jack cylinder.
3. Observe for proper operation of the cylinder.
4. Check the hydraulic connections for evidence of leakage.

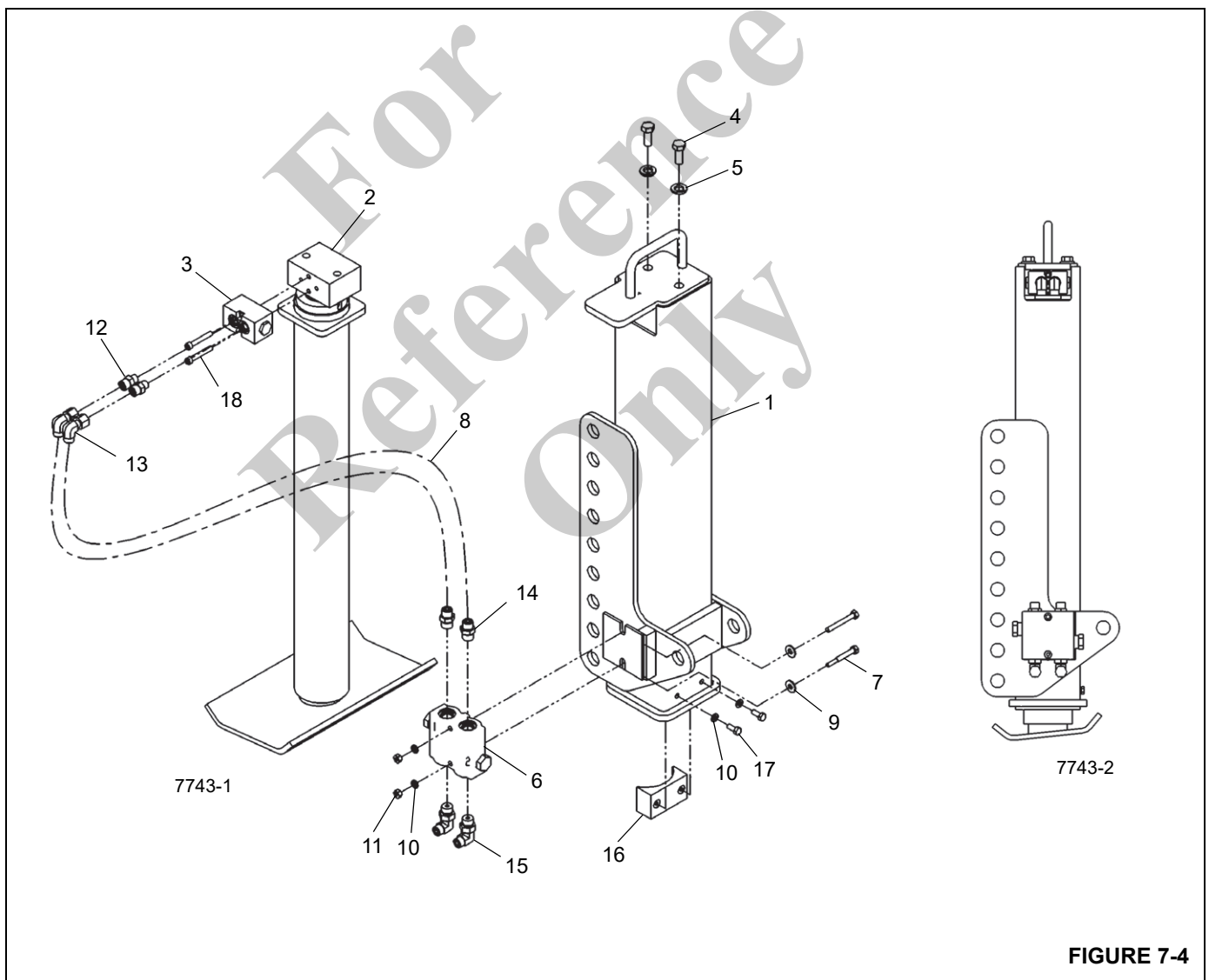


FIGURE 7-4

Item	Description
1	Single Front Outrigger Leg
2	Cylinder Assembly
3	Check Valve
4	HHCS 1/2-13UNCx1.25 G5
5	L Washer 1/2" Reg HRC45-51
6	Relief Valve
7	HHCS 5/16-18UNCx2.5 G5
8	3/8" I.D. Hydr Hose Assy Str B
9	F Washer 5/16" Wide MS

Item	Description
10	L Washer 5/16" Reg HRC44-51
11	Hex Nut 5/16-18UNC SAE-2
12	Straight Thread Adapter
13	90 Deg Elbow - Male ORS Thd To
14	Str Thread Adapter
15	90 Deg Elbow
16	Wear Pad
17	HHCS-L 5/16-18UNCx0.75 G5
18	SHCS 5/16-18UNCx2 A574

For  
Reference  
Only

## SECTION 8 LUBRICATION

### SECTION CONTENTS

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### LUBRICATION DESCRIPTION

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 Cranes 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 is intended to provide protection against freeze-up down to -40° C (-40° F) and overheat temperature shutdown of 105° C (221° F).

## 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 8-1.

## 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 halogenated hydrocarbons, nitro hydrocarbons 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.

## LUBRICATION POINTS

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.

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 (page 8-4) 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 on the Lubrication Chart (Figure 8-1). Lube description and symbols are found in tables below.

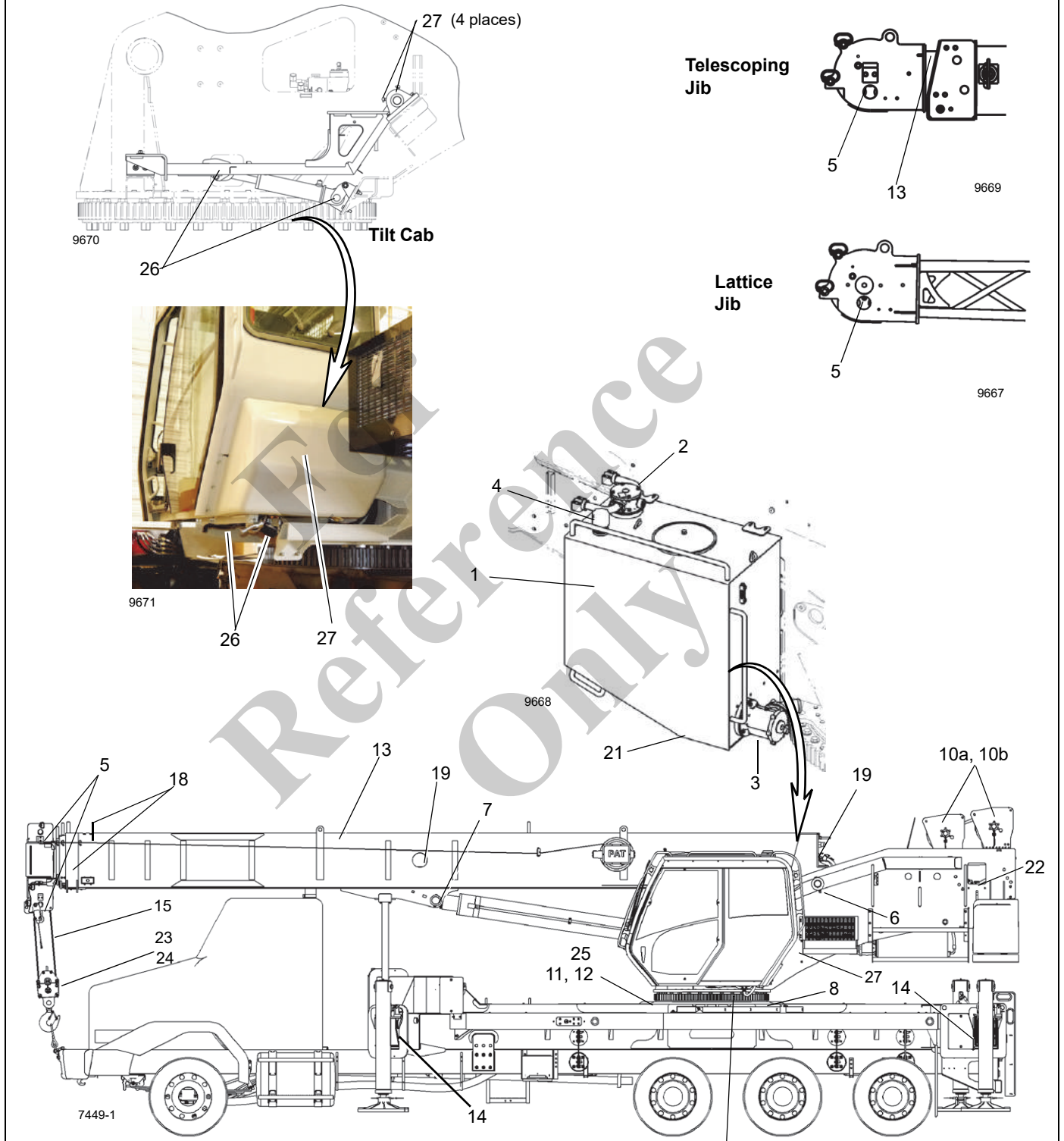
Symbol	Description	National Crane Lube Specification	
		Standard	Cold Weather -40°C (-40°F)
AFC	Antifreeze/Coolant (for Cab Heater)	6829101130	6829104212
EP-MPG	Extreme Pressure Multipurpose Grease	6829003477	6829104275
GL-5	GL-5 Gear Lubricant	6829012964	6829014058
HYDO	Hydraulic Oil	6829006444	6829006993
EP-OGL	Open Gear Lubricant, CEPLATTYN 300 Spray, NLGI Grade 1-2	6829102971	6829102971
AGMA EP-4	Extreme Pressure Gear Lubricant.	6829100213	6829103636
WRL	Wire Rope Lubricant	6829015236	6829010993
EO-20W-20	Engine Oil (Light non-EP Oil), Mil-L-46152	6829005570	-
TES 295	TES295 Compliant Fluid	-	6829101690

**NOTE:** Cold weather lubricants are not sufficient for temperatures below -40° C (-40° F). Use hydraulic tank heaters and insulate where appropriate.

For  
Reference  
Only



Lubrication Points



Illustrations for reference only.  
Your crane may be different.

FIGURE 8-1

Item	Application	Recommended Lubricant	Procedure	Frequency
1	Hydraulic oil tank reservoir	HYDO	Check and Fill Change	Weekly, Fill as required Semi-Annually
2	Hydraulic tank Oil filter		Change or clean	After first 40 Hrs, Quarterly thereafter.
3	Hydraulic tank suction filter		Change or clean	After first 40 Hrs, Quarterly thereafter.
4	Breather, Hydraulic oil reservoir		Clean	Monthly
5	Sheave pins: boom (5 plcs), jib (1 pl), block (1 pl), rooster sheave (1 pl)	EP-MPG	Grease gun	Weekly
6	Boom pivot pin	EP-MPG	Grease gun	Monthly
7	Lift cylinder pins - 2 ea.	EP-MPG	Grease gun	Monthly
8	Swing bearing	EP-MPG	Grease gun	Weekly
10	Hoist gearbox and brake	GL-5	Check and Fill  Change	Check and Fill: Every 500 operating hours, or 3 months. Change: After first 100 hours, then every 1000 hours or 6 months thereafter. For more information, see "Hoist Gearbox and Brake Oil" on page 8-8.
11	Swing drive gearbox	GL-5	Check and Fill  Change	Check and Fill: As part of daily crane inspection, check the gearbox for visible leaks. Change: After first 50 hours of operation, every 500 hours thereafter. For more information, see "Swing Gearbox Oil" on page 8-9.
12	Swing gear teeth	EP-OGL	Spray Can	Monthly
13	Boom Inner, Side and Bottom Wear Pads	LTG	See page 8-7	Monthly or as required
14	Outrigger beams, bottom, sides	LTG	Brush or roller spray can	Monthly or as required
15	Wire rope (loadline)	EP-OGL	Brush or spray	Semi-Annually
17	Swing Motor Pinion Bearing	EP-MPG	Grease Gun	Springly every 50 hours
18a	Synchronizing Sheaves: Top of 2nd Section	EP-MPG	Grease Gun	Weekly
18b	Extend Sheaves: Side of 4th Section	EP-MPG	Grease Gun	Weekly
18c	Extend Sheaves: Opening on tele 1	EP-MPG	Grease Gun	Weekly
19	Retract Sheaves, Rear of sections 2, 3, and 4: Fully retract the booms until the retract sheave grease fittings can be accessed from the rear of the Booms or extend the booms until the fittings are visible through the access holes at the center of boom.	EP-MPG	Grease Gun	Weekly
20	Extension Cables (Not Shown)	WRL	Spray or Brush	Any Time Boom is Disassembled or 7 Years

Item	Application	Recommended Lubricant	Procedure	Frequency
21	Hydraulic tank magnetic plug (tank bottom)		Clean	When servicing hydraulic tank, item 1
22	Cab Heater Reservoir	AFC	Check and Fill Change	Check and Fill: Weekly, Fill As Required Change: Semi-Annually
23	Hook Block Swivel Bearing	EP-MPG	Grease gun	Monthly
24	Hook Block Sheaves	EP-MPG	Grease gun	Monthly
25	Turntable Swing Lockpin	EP-MPG	Spray	Monthly
26	Cab Tilt Cylinder Pivot Pins	EP-MPG	Grease gun	Every 500 hours or 3 months
27	Cab Pillow Block	EP-MPG	Grease gun	Every 500 hours or 3 months

**NOTE:** Lubricate items more frequently than interval indicated in table if environmental conditions and/or operating conditions necessitate.

### Internal Cable Sheave Lubrication



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

A grease gun adapter is required to lubricate the internal sheaves. The required needle grease gun fitting is:

- A 0.25 in (6.35 mm) diameter nozzle grease gun tip (National P/N 955045).
- Contact Manitowoc Crane Care to obtain this tip.

Lubrication of the extend and retract sheaves is as follows:

1. Locate the fittings as listed in the table above.
2. Lubricate the sheave pins until a small amount of grease extrudes from the sheave pin.

### Side and Bottom Boom Wear Pad Lubrication

#### WARNING

- The boom cannot be fully extended at 0° under any circumstances.
- Follow all load charts when greasing the boom.

Recommended lubricant is EP-3MG grease.

1. Fully extend and set the outriggers.
2. Lower the boom to horizontal.  
Extend the boom and apply grease to the side and bottom of the Tele 2, Tele 3, Tele 4, and Tele 5 sections with a brush.
3. Raise the boom to 75° and retract the boom.
4. Extend and retract the boom several times until the grease is evenly spread.
5. Repeat as necessary.

### Outrigger Beam Lubrication



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

Recommended lubricant is EP-3MG grease.

1. Fully extend and set the outriggers. Refer to (Figure 8-2).
2. Apply grease to all wear pads and contact surfaces at the side and bottom of all beam sections and lower surface of the stabilizer/jacks with a suitable brush or putty knife.
3. Extend and retract the outriggers several times until the grease is evenly spread.
4. Repeat as necessary.

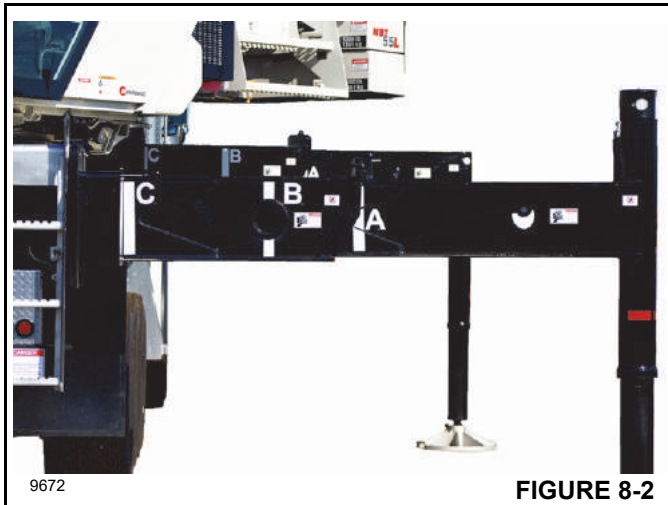


FIGURE 8-2

## Hoist Gearbox and 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.

**NOTE:** The NBT60L crane can feature two hoists: Main and if equipped, Auxiliary. Use the inspection and oil change procedures below for each hoist.

The hoist(s) share(s) oil between the gearbox and brake. The hoist gearbox and brake oil should be checked through the sight glass every 500 hours of operation, or every three months. The oil should be changed after the first 100 hours of operation, and every 1,000 hours or 3 months thereafter. The hoist oil capacity is 5.44 liters (11.5 pints). See "Lubrication Points" on page 8-3 for oil type and maintenance intervals.

**NOTE:** Hoist 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.

### **Inspect the Oil Level**

Check the oil level in the sight glass (1, Figure 8-3) on the hoist. When cool and not in operation, check the oil level in the sight glass. The oil should be approximately half-way up in the sight glass. The hoist gearbox and brake holds a maximum of 5.44 liters (11.5 pints) of oil.

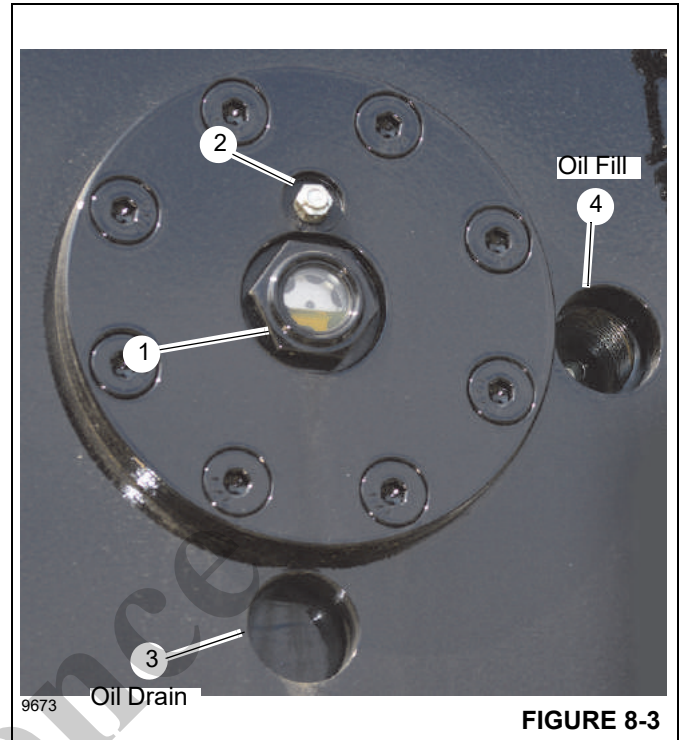


FIGURE 8-3

### **Replace the Hoist Oil**

The hoist oil drain and fill plug is located on the drum. The plug can be accessed through one of two access holes. The bottom (6 o'clock position) access hole (3, Figure 8-3) is used when draining the oil. The access hole on the side (3 o'clock position) is used when filling the hoist with oil (4).

When draining the hoist oil, use a short, 1 inch pipe with standard 1-11.5 NPSM thread. The pipe is installed in the larger, outer threads around the drain and fill plug and will serve as a drain for the oil. The pipe can also be used as needed when filling the hoist with oil.

The vent plug (2) is a one-way vent. It must be clean and unobstructed. Do not paint over the vent plug for replace it with a solid plug.

### **Drain the Gearbox and Brake Oil**

1. Remove the vent plug (2, Figure 8-3). Clean with solvent as needed. Set aside for later use.
2. Rotate the hoist drum so the drain and fill plug (Figure 8-4) is aligned with the oil drain access hole at the 6 o'clock position (3, Figure 8-3).

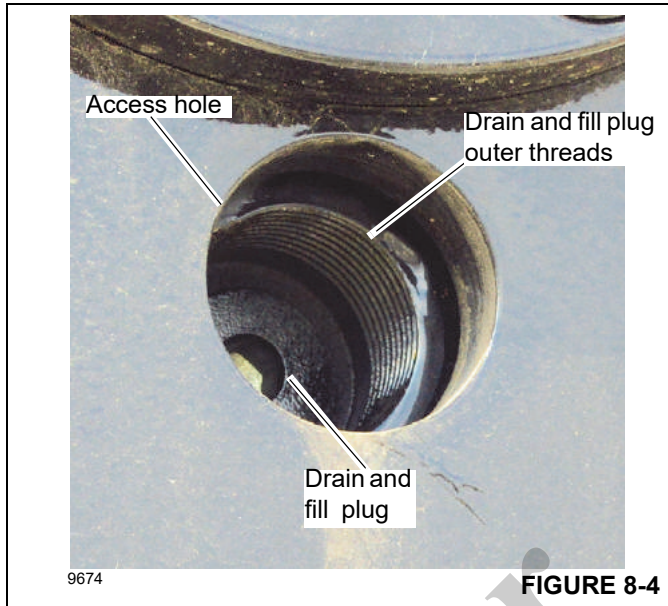


FIGURE 8-4

3. Install a short 1 inch (25 mm) pipe in the outer threads around the drain and fill plug (Figure 8-4).

**NOTE:** Place an oil pan or other receptacle under the drain pipe as needed.

4. Using a 5/16 inch (8 mm) Allen wrench, remove the drain and fill plug through the drain pipe. Allow the oil to drain from the hoist completely.
5. Inspect the O-ring on the drain and fill plug. Replace as needed.
6. Install the drain and fill plug through the 1 inch (25 mm) drain pipe using a 5/16 inch (8 mm) Allen wrench. Torque the fill and drain plug to 67.8 Nm (50 ft-lb).
7. Remove the 1 inch (25 mm) drain pipe from access hole.
8. Coat the vent plug (2, Figure 8-3) threads with oil and install the vent plug.

### Fill the Gearbox and Brake Oil

1. Rotate the hoist drum so the plug aligns with the oil fill access hole at the 3 o'clock position (4, Figure 8-3).
2. Using a 5/16 inch (8 mm) Allen wrench, remove the drain and fill plug (Figure 8-4).

### CAUTION

The hoist gearbox and brake holds a maximum of 5.44 liters (11.5 pints) of oil. Under- or over-filling the hoist can lead to damage of equipment.

3. Fill the hoist gearbox and brake with oil. See "Lubrication Points" on page 8-3 for specific lubricants.
4. Visually inspect the oil level through the sight glass (1, Figure 8-3). When done filling, the oil level should be approximately half-way up in the sight glass.
5. Using a 5/16 inch (8 mm) Allen wrench, install and tighten the drain and fill plug (4, Figure 8-4). Torque the drain and fill plug to 67.8 Nm (50 ft-lb).

### Swing Gearbox Oil

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

1. Remove the drain plug (1, Figure 8-5) and vent plug (2) to drain the gearbox oil.
2. Examine the used oil for signs of significant metal deposits and then dispose of it in a proper manner.
3. Replace the drain plug (1). Inspect and replace the o-ring as needed.
4. Remove the oil level/fill plug (3). Fill the swing gearbox with 2.4 l (2.5 qt) of the appropriate type of oil, and then replace the vent plug (2) and level/fill plug (3). Inspect and replace the o-rings as needed. See "Lubrication Points" on page 8-3 of this manual.
5. Inspect the outside of the swing gearbox daily for any visible leaks. The maximum oil capacity for this gearbox is 2.4 l (2.5 qt) 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.

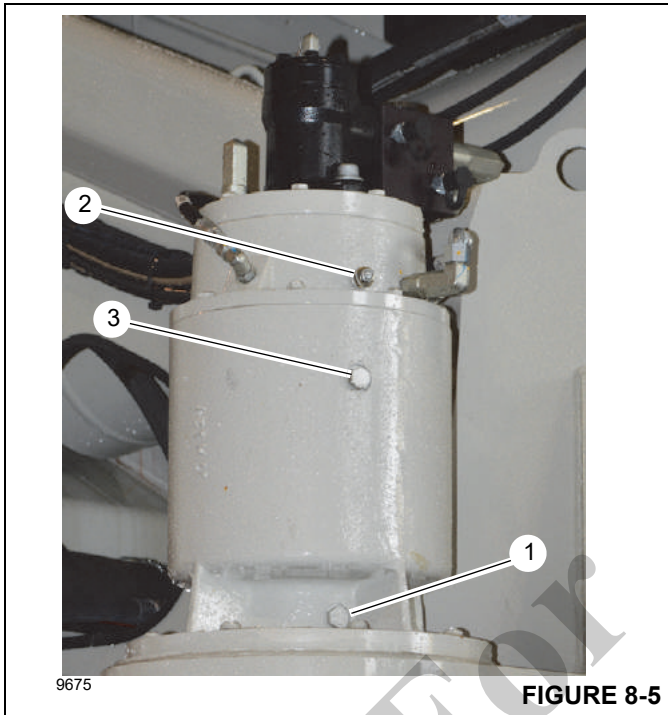


FIGURE 8-5

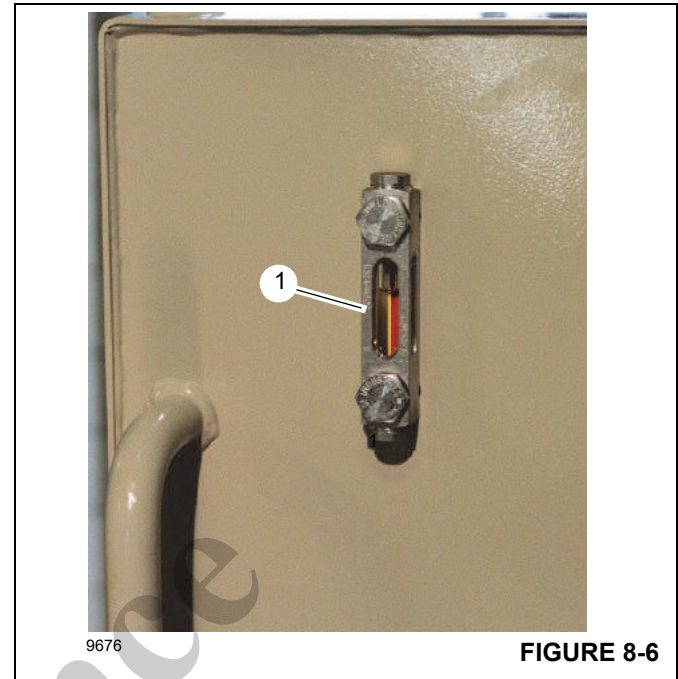


FIGURE 8-6

### Hydraulic Oil Reservoir Level

The hydraulic oil reservoir has a sight gauge (1, Figure 8-6) located on the side of the reservoir. The oil in the hydraulic reservoir is sufficient when the level is between the High and Low marks on the sight gauge with the crane parked on a level surface in the transport position and the oil cold.

If the oil level is too low, add the recommended hydraulic oil until the oil level is even with the upper mark. If the oil level is high, drain oil until the oil level is even with the upper mark.

### 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.

## WIRE ROPE LUBRICATION

Wire rope is lubricated during manufacture and the lubricant applied does not last the life of the rope. The wire rope must be lubricated as part of a regularly scheduled maintenance program. The lubricant applied must be compatible with the original lubricant and not hinder visual inspection of the rope. Consult the rope manufacturer for proper lubricant. The sections of rope which are located over sheaves or otherwise hidden during inspection and maintenance procedures require special attention.

The object of rope lubrication is to reduce internal friction and to prevent corrosion. The type and amount of lubrication applied during manufacture depends on the rope size, type, and anticipated use. This lubrication provides the finished rope with protection for a reasonable time if the rope is stored under proper conditions. When the rope is put into service, periodic applications of a suitable rope lubricant are necessary. Characteristics of a good wire rope lubricant are that it should be:

- free from acids and alkalis.
- have sufficient adhesive strength to remain on the rope.
- 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 (example: Water).
- have a high film strength.
- resistant to oxidation.

Before applying lubrication, accumulations of dirt or other abrasive material should be removed from the rope. Clean with a stiff wire brush and solvent, compressed air, or live steam. Lubricate the rope immediately after the rope is cleaned. Techniques that can be used include:

- 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. The service life of wire rope is directly proportional to the effectiveness of the method used and amount of lubricant that reaches the working parts of the rope.

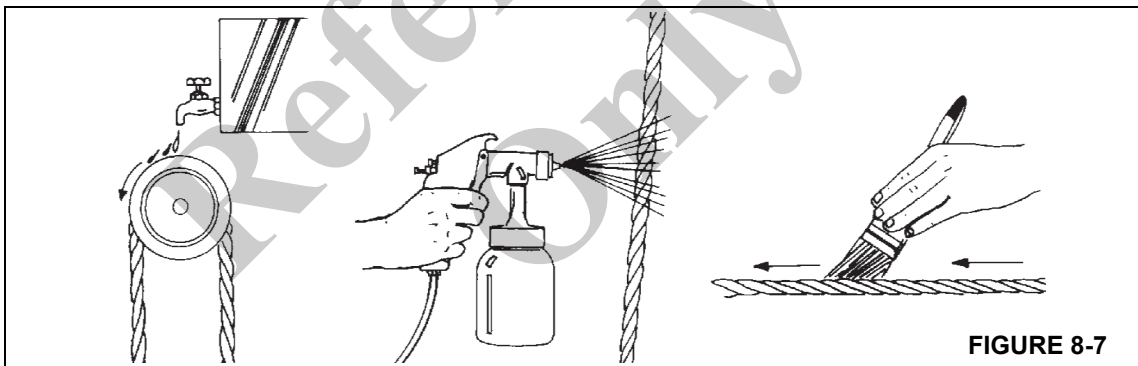


FIGURE 8-7

## CARWELL® RUST INHIBITOR

### Protecting Cranes From Rusting

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

Special equipment is used to spray a light film onto the entire undercarriage and various other areas of each new crane prior to shipment. When applied the product has a red tint to

allow applicators to view coverage during application. This red tint will turn clear on its own within approximately 24 hours after application.

Once applied, treatment can appear to leave a slightly “oily” residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it must be removed using standard steam-cleaning techniques.

This treatment works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied treatment, 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, caused by minor incidents or moving components;
- Damage caused by personal abuse, such as using the decks to transport rigging gear, tools, or cribbing; and
- Exposure to harsh environmental hazards such as alkaline, acids, or other chemicals that can attack the crane's paint finish.

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

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

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

## Cleaning Procedures

To help protect against corrosion of National cranes, Manitowoc Crane Care recommends washing the crane at least monthly to remove all foreign matter. More frequent cleaning may be needed when operating in harsh environmental conditions. To clean the crane, follow these guidelines:

- High pressure water or steam is effective for cleaning the crane's undercarriage and wheel housings. Keeping these areas clean will not only help retard the effects of corrosion, but will also improve the ability to identify potential issues before they grow into larger problems.

### CAUTION

High pressure water can be forced into spaces and infiltrate beyond seals. Avoid pressure washing in the vicinity of electrical controls, panels, wiring, sensors, hydraulic hoses and fittings, or anything that can be damaged by high pressure cleaning/spraying.

- Rinse the dirt and dust off before washing the crane. Dirt can scratch the crane's finish during washing/cleaning.
- Hard to clean spots caused by road tar or bugs should be treated and cleaned after rinsing and prior to washing. Do not use solvents or gasoline.
- Wash using only soaps and detergents recommended for automotive paint finishes.
- Rinse all surfaces thoroughly to prevent streaking caused by soap residue.
- Allow the crane to dry thoroughly. You can accelerate drying by using compressed air to remove excess water.

**NOTE:** Polishing and waxing (using an automotive-type wax) is recommended to maintain the original paint finish.

## Inspection and Repair

- Immediately following cleaning, Manitowoc Crane Care recommends an inspection to detect areas that may have become damaged by stone chips or minor mishaps. A minor scratch (one that has not penetrated to the substrate surface) can be buffed with an automotive-type scratch remover. It is recommended that a good coat of automotive wax be applied to this area afterwards.
- All identified spots and/or areas that have been scratched through to the metal should be touched up and repaired as soon as possible to prevent flash rusting. To repair a major scratch (down to bare metal) or minor damage, follow these procedures:



**NOTE:** Manitowoc Crane Care recommends that a qualified body repairman prepare, prime and paint any major scratch(es) or minor damage.



### CAUTION

To the extent any damage is structural in nature, Manitowoc Crane Care must be contacted and consulted as to what repairs may be required.

For scratches and marks in highly visible areas:

- Sand to remove the scratch and feather outward from the mark to blend the repair into the original surface. Body putty may be applied as necessary to hide the defect; then sand smooth.
- Cover all bare metal with a primer that is compatible with the original paint finish and allow to dry thoroughly.
- Prepare the surface prior to applying the finish coat of paint.
- Apply a finish coat paint using accepted blending techniques. Use of original paint colors is recommended to ensure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.

Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

### Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that the treatment be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of treatment is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently primed and painted areas for at least 48 hours after paint is properly dried and cured. For minor touch up areas a 24 hour period is needed for cure time before applying treatment.

**NOTE:** Unit must be completely dry before applying treatment.

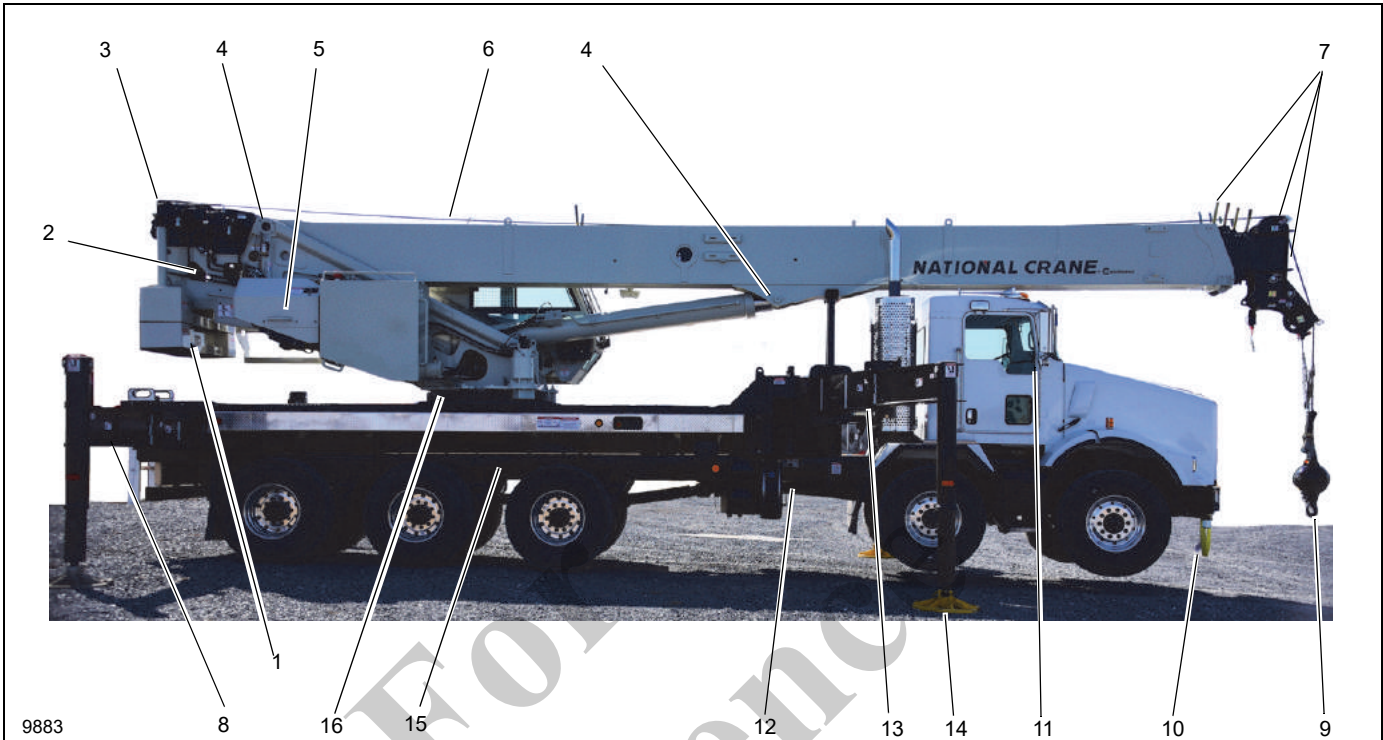
- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of treatment, the product needs to be fogged on the unit.
- Use of pressure pots to apply the treatment to the unit being processed is recommended.
- Carwell treatment is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of the treatment is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

### Areas of Application

Refer to Figure 8-8

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include: Valves, hose ends and fittings, swivel, pumps, axles, drivelines, transmission, slew ring fasteners and all interior surfaces of the frame.
- Frame application areas are: hose ends and fittings, all unpainted fasteners and hardware, all bare metal surfaces, outrigger pads, and back up alarm hardware.
- Superstructure applications are; hose ends and fittings, wire rope on hoist roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring fasteners and all bare metal surfaces.
- Boom applications areas are: pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, downhaul ball pins/ hook block pins and fasteners.
- All hardware, clips, pins, hose connections not painted will have treatment applied.



Illustrations for reference only.  
Your crane may be different.

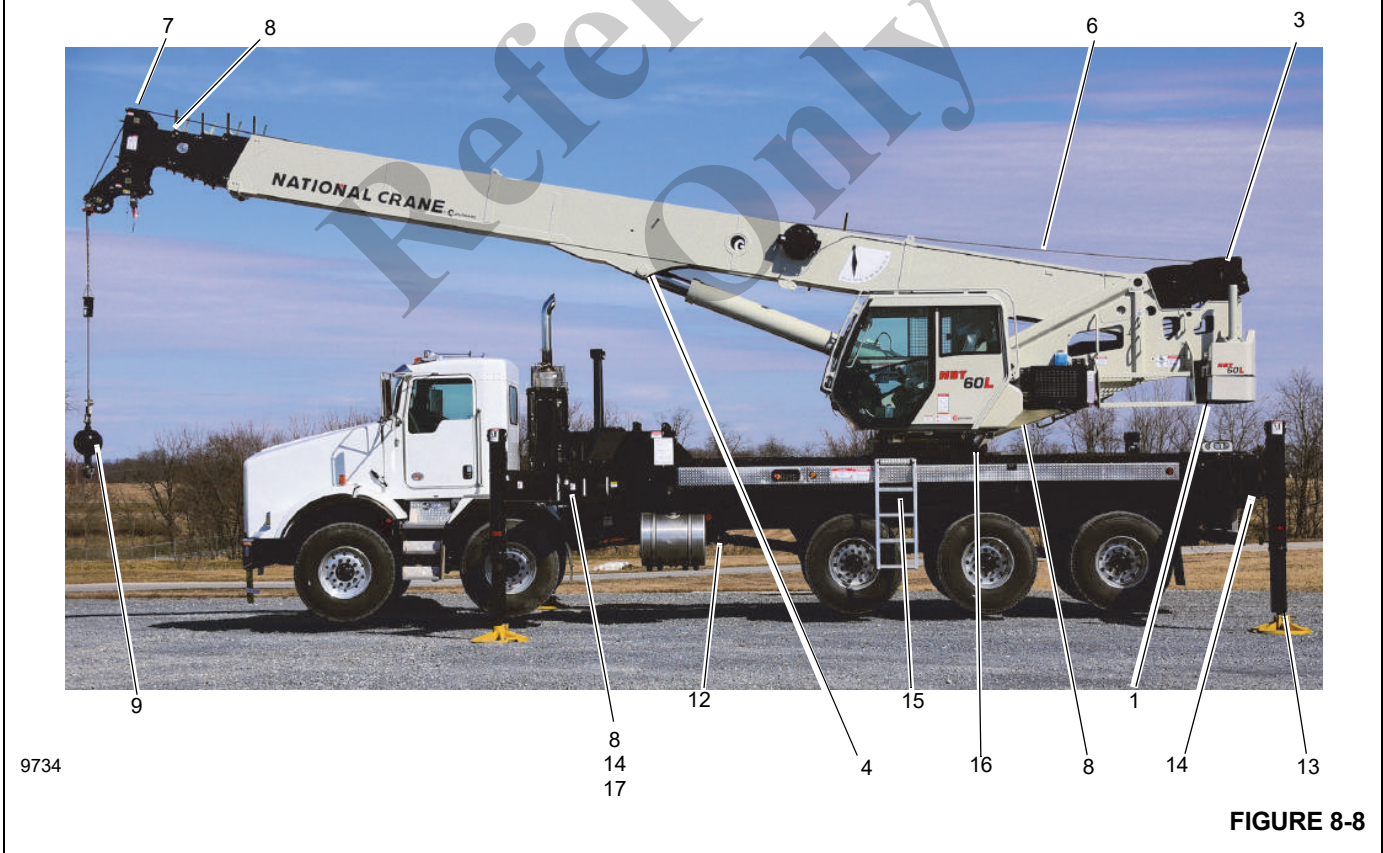


FIGURE 8-8

Item	Description
1	Counterweight Pins
2	Hoist Plumbing Connections
3	Tension Spring
4	Pivot Shaft
5	Valve bank, Hose Connections inside turntable
6	Wire Rope
7	Boom Nose Pins, Clips
8	All Hardware, Clips, Pins, Hose Connections not painted Outrigger Pins, Clips
9	Downhaul Weight/Hook block

Item	Description
10	Downhaul Weight/Hook Block Tiedown
11	Mirror Mounting Hardware
12	Powertrain Hardware
13	Outrigger Hose Connections
14	Outrigger Pins, Clips
15	Entire underside of unit
16	Turntable Bearing Fasteners
17	Outrigger Beam Hardware
18	Boom Extension Hardware (Optional)

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## SECTION 9 CRANE INSTALLATION

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This section provides information for proper mounting and initial checkout of the crane. Improper mounting can result in damage to the truck frame, drive train, and hydraulic pump, and cause crane instability. The 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 and overhang.

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 90 kg [200 lb] each).

National Cranes must meet ASME/ANSI B30.5 (in effect) when completed as cranes and ASME/ANSI B30.23 (in effect) when completed as a personnel lifting system. When equipped with the dual-rating option from the factory, the equipment is compliant with ASME B30.5 (in effect) and ANSI/SAIA A92.2 (in effect). 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.

### MINIMUM TRUCK REQUIREMENTS

Many factors must be considered in the selection of a proper truck for a NBT60L crane. The following items must be considered.

- **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 (WB), Cab-to-Trunnion (CT) and Bare Chassis Weight**
  - Mounting Configuration
  - Boom Length
  - Bed Length

The wheelbase (WB), cab-to-trunnion (CT), and chassis weights shown meet technical axle ratings and stability requirements. The dimensions given assume the sub-base is installed properly behind the truck cab. If exhaust stacks, transmission protrusions, etc. do not

allow a close installation to the cab, the WB and CT dimensions must be increased. See the mounting configuration pages for additional information.

- **Axle Weight Limits**—Individual states vary on the permissible loads that a three-axle or four-axle truck may carry on state highways. Some states allow 11,340 kg (25,000 lb) on the steering axle and 20,412 kg (45,000 lb) on the tandem axle if the unit is designated as a truck-mounted crane.

All states must use the federal bridge law requirements for trucks operating on the interstate highway system. The federal bridge law formula must be used to determine allowable axle weights for every individual axle and axle group.

- **Truck Frame**—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 AF section modulus (SM) and resistance to bending moment (RBM) so that reinforcing is not required. The single front outrigger (SFO) is used for a 360-degree working area around the truck. The frame

under the cab through the front suspension must have the minimum SM and RBM because reinforcing through the front suspension is often difficult because of engine, radiator mounts, and steering mechanics. See Minimum Truck Requirements and Truck Frame Strength pages for the necessary SM and resistance to RBM 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 Requirements pages for more information. A conventional cab truck should be used for standard crane mounts.
- **Neutral Start Switch**—The chassis must be equipped with a switch that prevents operation of the engine starter when the transmission is in gear.
- **Serial Number Identification**—Figure 9-1 shows the typical serial number locations for the main components of the crane.

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Typical Serial Number Locations

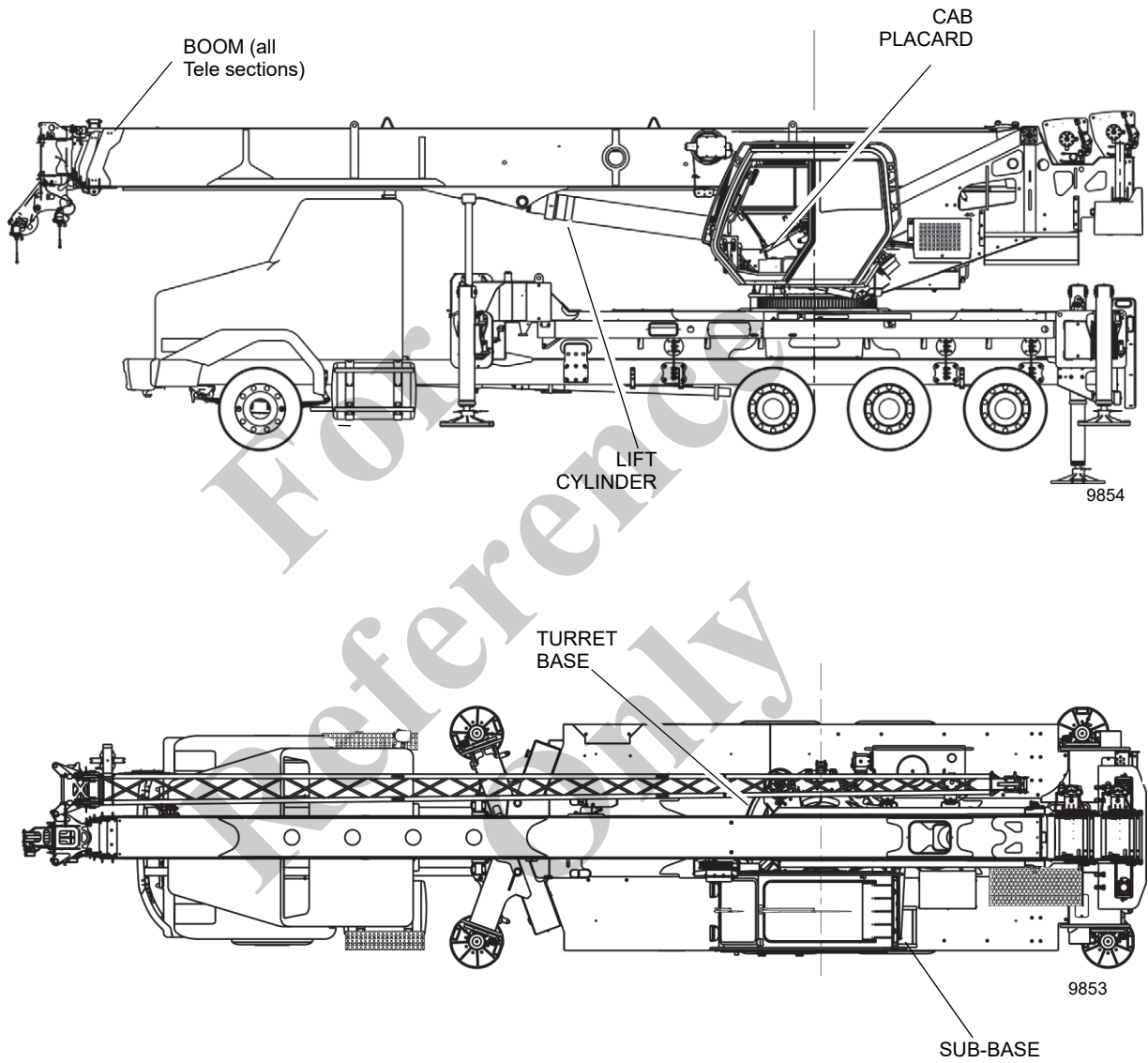


FIGURE 9-1

## MOUNTING CONFIGURATIONS

Table 9-1 Weight and Center of Gravity (CG) Data

Weight and CG Estimates (See Notes)				
Standard NBT Configuration	Horizontal CG mm (in)	Weight with Fluids kg (lb)	CWT Pinned (No. Slabs)	CWT Stowed (No. Slabs)
NBT60L	20	54800	2	0
NBT60L	36	54800	1	1
NBT60L	51	54800	0	2

**Weight and CG Estimate Notes:**

- Information is for reference only
- Weight and CG data is applicable for a standard crane:  
151 ft boom  
No Jib  
2/3 part lineblock included  
Main hoist only (No auxiliary hoist)  
STD decking with fixed access ladder  
No extension equipped  
No Auxiliary nose or optional hook blocks.

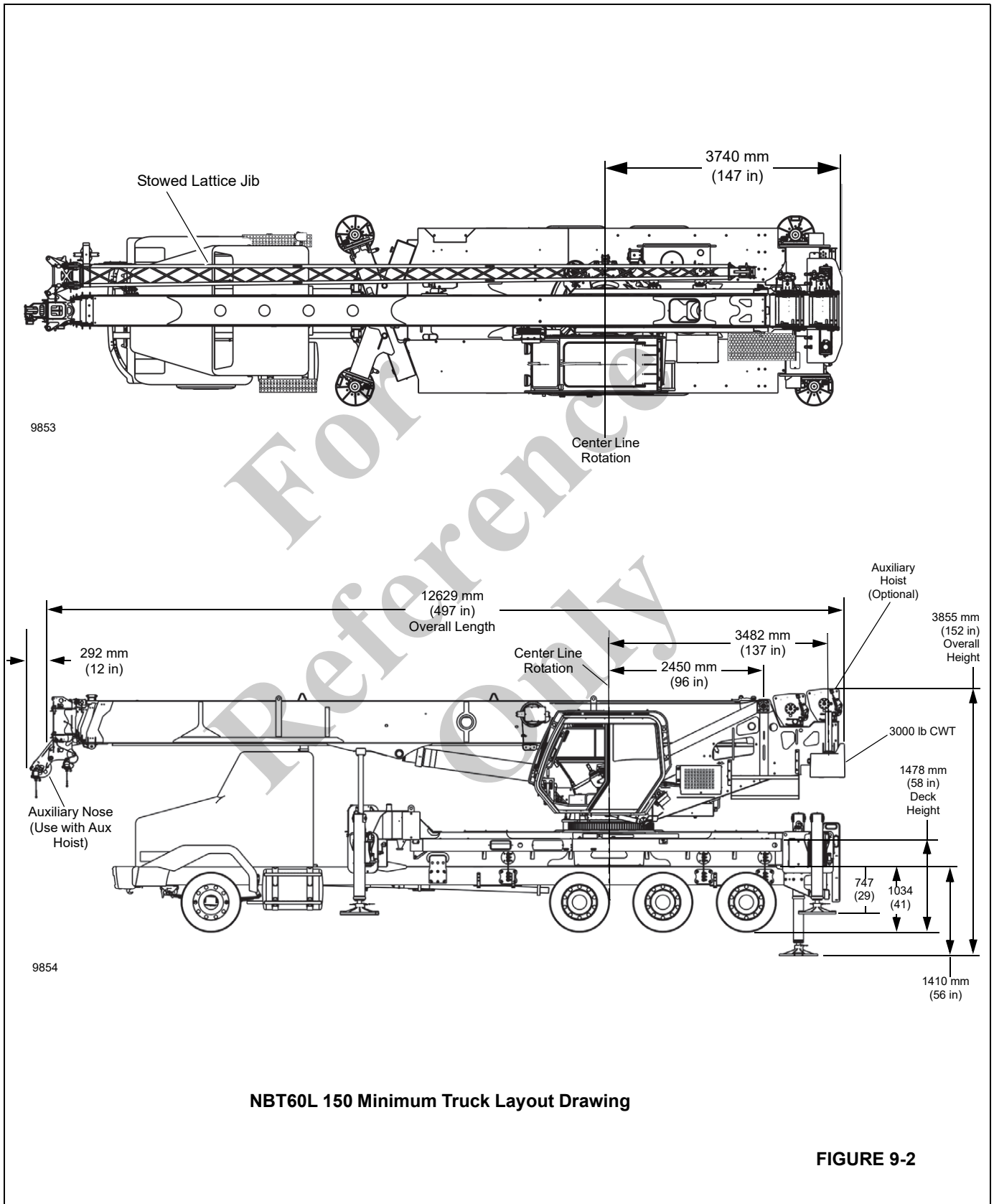
- All counterweight configurations are shown in table:  
Pinned = attached to cylinders and turret (in use)  
Stowed = attached to torsion box (not in use)  
"2" = Top and bottom slabs  
"1" = Top or bottom slab only

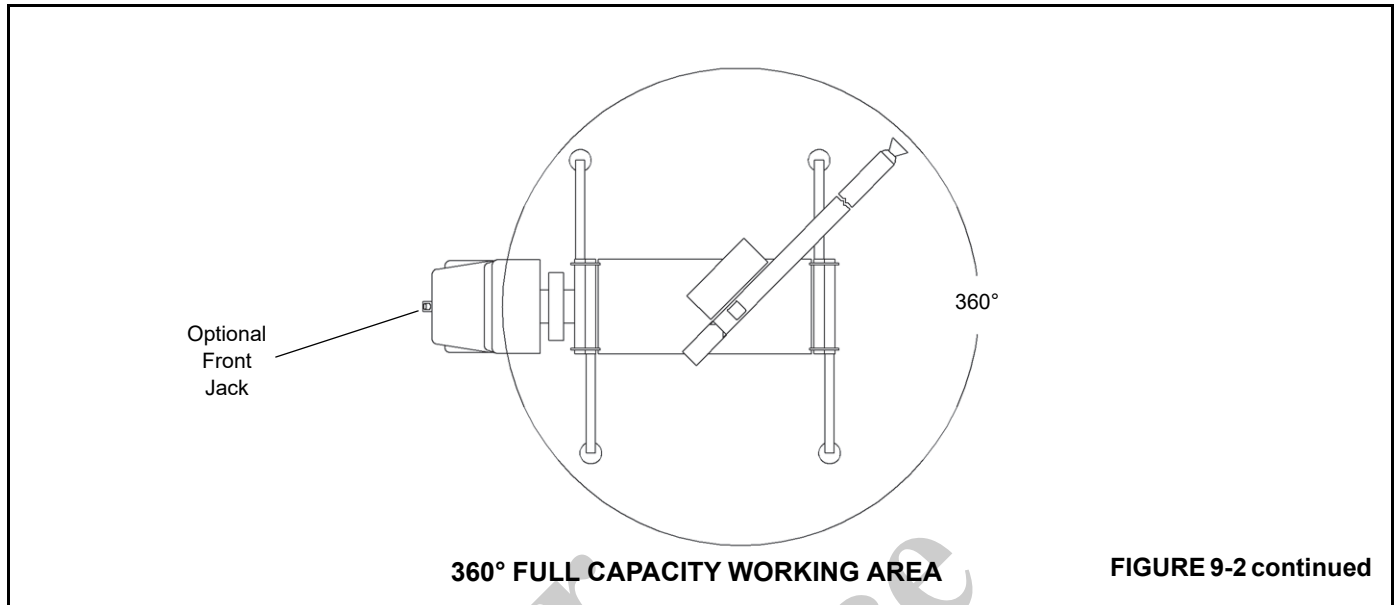
If both stowed and pinned columns are "0" the counterweight is physically removed from the crane. IPO counterweight is also assumed removed in this case (if no auxiliary hoist is equipped).

For more information contact Manitowoc Crane Care or your local National Crane distributor.



Configuration (151 ft) Boom





The mounting configuration shown is based on an 85% stability factor.

The complete unit must be installed on the truck in accordance with factory requirements, and a test performed to determine actual stability and counterweight requirements, since individual truck chassis vary.

If bare truck weights are not met, counterweight will be required.

A summary of mounting and truck requirements are as follows:

- Working area 360°
- Gross Axle Weight Rating (GAWR), front 9072 kg (20,000 lb)
- Gross Axle Weight Rating (GAWR), rear 18,144 kg (40,000 lb)
- Gross Lift Axle Weight Rating (Pusher or Tag) 4536 kg (10,000 lb) minimum
- Gross Vehicle Weight Rating 27,216 kg (60,000 lb)
- Gross Tag Axle Rating 4536 kg (10,000 lb) (min)
- Wheelbase (WB) 6.5 m (256 in)
- Cab to Centerline of Tandem 4.88 m (192 in)

- Cab to end of frame 804 m (331 in).
- Frame Section Modulus (SM), front axle to end of after frame (AF), 409.66 cm<sup>3</sup> (25 in<sup>3</sup>).

Figure 9-2 shows the 360° working area. The SFO is needed when extending the boom and lifting loads over the front of the truck. See *Truck Frame Strength*, page 9-7 for truck frame strength required for mounting crane and the optional SFO.

Gross Vehicle Weight Rating (GVWR) is dependent on all components of the vehicle (axles, tires, springs, frame, etc.) meeting manufacturers' recommendations; always specify GVWR when purchasing trucks.

Diesel engines require a variable speed governor and energize-to-run fuel solenoid for smooth crane operation; electronic fuel injection is required.

All mounting data is based on a National Crane NBT60L with sub-base and an 85 percent stability factor.

The complete unit must be installed in accordance with factory requirements, and a test performed to determine actual stability and counterweight requirements; contact the factory for details.

Transmission neutral safety interlock switch is required.

**PTO REQUIREMENTS**

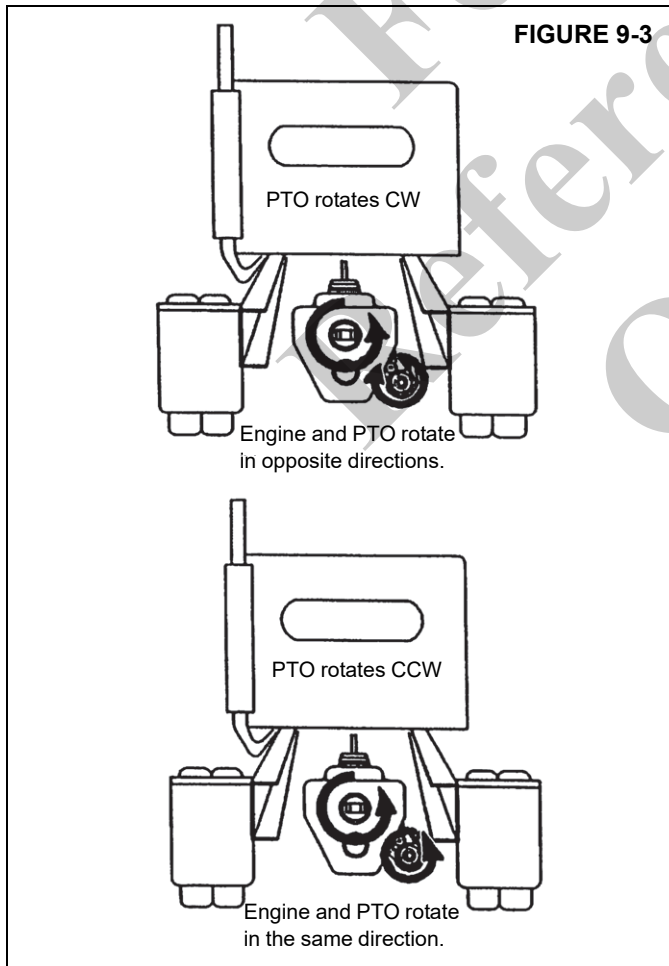
**Pump Rotation**

The hydraulic pump must be installed so that the pump rotates the same direction as the arrow on the pump housing. 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**

Rotating the pump in the wrong direction damages the pump.

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 CW direction when viewed from the rear of the truck. If the power take off shaft rotates the same as the engine crankshaft, it is turning in a CCW direction when viewed from the rear of the truck. See Figure 9-3.



**PTO Ratio**

Pump shaft speed is determined by truck engine RPM and PTO ratio:

$$\text{Pump Shaft Speed} = \text{Truck Engine RPM} \times \text{PTO Ratio}$$

The following PTO ratio - engine speed combinations will provide 2200 rpm pump shaft speed which is the recommended maximum speed for the NBT60L pump:

ENGINE SPEED (RPM)	PTO RATIO
2900	76%
2800	79%
2600	85%
2400	92%
2200	100%
2000	110%
1800	122%
1600	138%
1500	147%
1400	157%

The speeds shown above 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 and flow requirements.

**PTO Horsepower Requirements**

In order to operate the NBT60L pump at full flow and full pump pressure, a PTO capable of delivering 100 HP per 1000 rpm of shaft speed with 475 lb-ft torque rating is required. This is an extra heavy duty rated PTO usually an 8 bolt mount.

If it is desirable to integrally mount the pump to the PTO, most PTO's can be supplied with integral pump mounting brackets so that the standard pump may be integrally mounted. The back end of the pump must be supported because of pump weight. Use the support bars provided to do this.

The splined shaft coupling in a direct mount pump installation requires lubrication. #200S Silver Streak Special Multi-Lube (Medium) should be applied to the shaft during original installation and reapplied to the shaft or zerk provided on PTO housing shaft semi-annually thereafter.

**TRUCK FRAME STRENGTH**

For a truck frame to be suitable for a NBT60L crane, the truck frame must:

- Be rigid enough to allow excessive boom movement due to truck frame deflection when lifting over the front of the unit
- Be strong enough to resist the loading induced by the crane
- Not permanently bend or deform

The section modulus (SM), which determines the rigidity of the frame, is a measurement of the cross-sectional area of the truck frame. Resistance to bending moment (RBM) is a measurement of strength and is determined by multiplying the SM of each frame rail by the yield strength of the rail material.

The NBT60L cranes require a minimum of 372,850 Nm (3,300,000 in-lb) RBM and 426 cm<sup>3</sup> (30 in<sup>3</sup>) SM from the rear of the truck frame to the front of the front outrigger boxes.

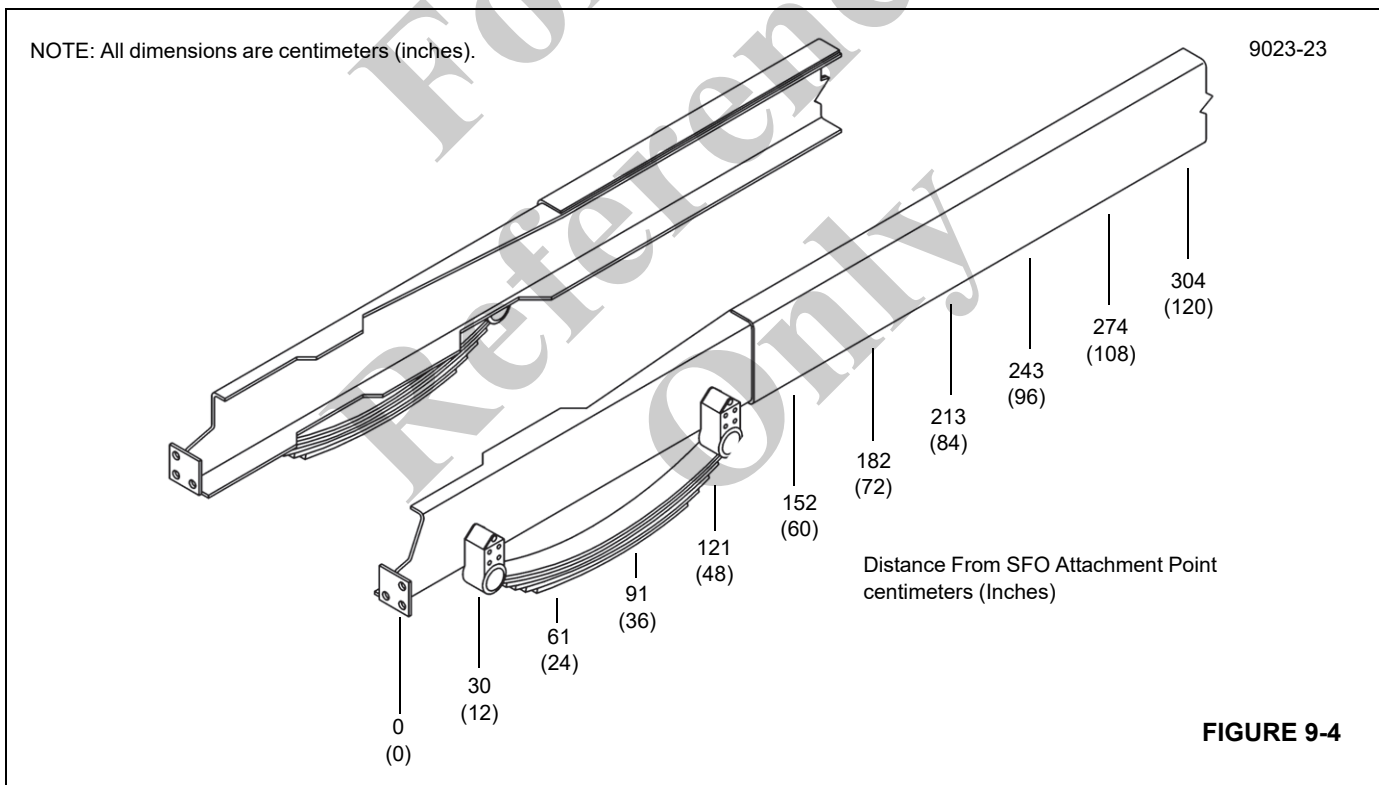
The truck frame strength required from the front of the outrigger boxes to the single front outrigger (SFO) attachment point is variable and is listed in the table below.

Most truck frames have reduced section properties through the front suspension due to truck frame cut-outs or because outer channel reinforcement stops short of the front suspension. In these cases it is imperative that the truck frame is measured and the SM is calculated and compared to the table below to ensure adequate strength exists for front stabilizer loading.

The distances listed in Table 9-2 are shown in Figure 9-4.

Table 9-2

Distance From SFO Attachment cm (In)		Section Modulus (SM) Per Rail cm <sup>3</sup> (in <sup>3</sup> )	
0 - 30	(0 - 12)	44	(2.7)
30 - 61	(12 - 24)	90	(5.5)
61 - 91	(24 - 36)	134	(8.2)
91 - 121	(36 - 48)	180	(11.0)
121 - 152	(48 - 60)	224	(13.7)
152 - 182	(60 - 72)	270	(16.5)
182 - 213	(72 - 84)	315	(19.2)
213 - 243	(84 - 96)	359	(21.9)
243 - 274	(96 - 108)	405	(24.7)
274 - 304	(108 - 120)	449	(27.4)
304 +	(120 +)	492	(30.0)



**Section Modulus Tables**

The following tables (TABLE A, TABLE B, TABLE C, TABLE D) determine the section modulus (SM) of the truck frame. Always measure the truck frame and check the tables to be sure that the truck factory listed SM is correct.

- Channel** (TABLE A, page 9-9)—Table A shows the SM of channel frames in thicknesses of 3/16 in (4.76 mm), 1/4 in (6.35 mm), 5/16 in (7.94 mm), and 3/8 in (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 SM from that particular channel.

If the SM of the channel does not meet the requirements, the channel should be reinforced in the most applicable method following.

- **Channel Reinforcement** (TABLE A, page 9-9)—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 SM of the needed channel is obtained from TABLE A and should be added to the SM obtained from the truck frame. Add this to the SM of the channel obtained from TABLE A.

- **Angle Reinforcement** (TABLE B, page 9-10)—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 SM of the channel obtained from TABLE A.
- **Fish Plate Reinforcement** (TABLE C, page 9-10)—The frame can be strengthened by adding a fish plate of suitable thickness and depth equal to the frame. The SM of the fish plate can be obtained from table C and this

must be added to the SM of the frame to obtain the total SM.

- **Angle Under Reinforcement** (TABLE D, page 9-11)—This table lists the SM of an angle with the flange under the truck frame that is added to a frame with an angle reinforcement already added. Add the SM from TABLE D to the SM obtained from TABLE A and TABLE B to determine total SM.

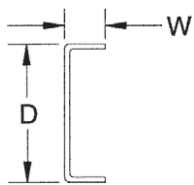
The edges of the reinforcing angles or channels are to be flush with the edges of the frame.

**Welding** - Two rows of 1 in (25.4 mm) diameter plug welds should be placed in a staggered pattern of the web. The rows should be spaced 5 in (127 mm) apart with welds at an interval of 4 in (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<sup>3</sup> (cm<sup>3</sup>)**



	THICKNESS 3/16 in (4.76 mm)				THICKNESS 1/4 in (6.35 mm)				
	2½ (64)	3 (76)	3½ (89)	4 (102)	2½ (64)	3 (76)	3½ (89)	4 (102)	
8 (203)	5.3 (87)	6.0 (98)	6.7 (110)	7.5 (123)	8 (203)	6.9 (113)	7.8 (128)	8.8 (144)	9.7 (159)
9 (229)	6.3 (103)	7.1 (116)	7.9 (130)	8.7 (143)	9 (229)	8.2 (134)	9.2 (151)	10.3 (169)	11.4 (187)
10 (254)	7.3 (120)	8.2 (134)	9.1 (149)	10.0 (164)	10 (254)	9.5 (156)	10.7 (175)	11.9 (195)	13.1 (215)
11 (279)	8.4 (138)	9.4 (154)	10.4 (170)	11.4 (187)	11 (279)	11.0 (180)	12.3 (202)	13.6 (223)	14.9 (244)
12 (305)	9.5 (156)	10.6 (174)	11.7 (192)	12.8 (210)	12 (305)	12.5 (205)	13.9 (228)	15.3 (251)	16.8 (275)
13 (330)	10.8 (177)	11.9 (195)	13.1 (215)	14.3 (234)	13 (330)	14.1 (231)	15.6 (256)	17.2 (282)	18.8 (308)
14 (356)	12.0 (197)	13.3 (218)	14.6 (239)	15.9 (261)	14 (356)	15.8 (259)	17.5 (287)	19.1 (313)	20.8 (341)
15 (381)	13.4 (220)	14.7 (241)	16.1 (264)	17.5 (287)	15 (381)	17.5 (287)	19.3 (316)	21.2 (348)	23.0 (377)

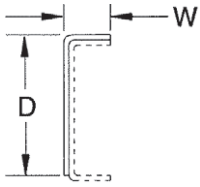
  

	THICKNESS 5/16 in (7.94 mm)				THICKNESS 3/8 in (9.52 mm)				
	2½ (64)	3 (76)	3½ (89)	4 (102)	2½ (64)	3 (76)	3½ (89)	4 (102)	
8 (203)	8.4 (138)	9.5 (156)	10.7 (175)	11.9 (195)	8 (203)	9.8 (161)	11.2 (184)	12.5 (205)	13.9 (228)
9 (229)	10.0 (164)	11.3 (185)	12.6 (206)	13.9 (228)	9 (229)	11.7 (192)	13.2 (216)	14.8 (243)	16.3 (267)
10 (254)	11.6 (190)	13.1 (215)	14.6 (239)	16.0 (262)	10 (254)	13.6 (223)	15.4 (252)	17.1 (280)	18.8 (308)
11 (279)	13.4 (220)	15.0 (246)	16.6 (272)	18.3 (300)	11 (279)	15.7 (257)	17.7 (290)	19.6 (321)	21.5 (352)
12 (305)	15.3 (251)	17.1 (280)	18.8 (308)	20.6 (338)	12 (305)	18.0 (295)	20.1 (329)	22.2 (364)	24.3 (398)
13 (330)	17.3 (284)	19.2 (315)	21.1 (346)	23.1 (379)	13 (330)	20.3 (333)	22.6 (370)	24.9 (408)	27.2 (446)
14 (356)	19.4 (318)	21.4 (351)	23.5 (385)	25.6 (420)	14 (356)	22.8 (374)	25.3 (415)	27.8 (456)	30.3 (497)
15 (381)	21.6 (354)	23.8 (390)	26.0 (426)	28.3 (464)	15 (381)	25.4 (416)	28.1 (461)	30.8 (505)	35.5 (582)



TABLE B

Section Modulus in<sup>3</sup> (cm<sup>3</sup>)



THICKNESS 3/16 in (4.76 mm)

	2¼ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	2.2 (36)	2.3 (38)	2.3 (38)	2.4 (39)
8½ (216)	2.8 (46)	2.9 (48)	3.0 (49)	3.0 (49)
9½ (241)	3.4 (56)	3.5 (57)	3.6 (59)	3.7 (61)
10½ (267)	4.1 (67)	4.3 (70)	4.4 (72)	4.5 (74)
11½ (292)	4.9 (80)	5.1 (84)	5.2 (85)	5.4 (88)
12½ (318)	5.8 (95)	6.0 (98)	6.1 (100)	6.3 (103)
13½ (343)	6.7 (110)	6.9 (113)	7.1 (116)	7.3 (120)
14½ (368)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)

THICKNESS 1/4 in (6.35 mm)

	2¼ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	2.9 (48)	3.0 (49)	3.1 (51)	3.2 (52)
8½ (216)	3.7 (61)	3.8 (62)	3.9 (64)	4.0 (66)
9½ (241)	4.5 (74)	4.7 (77)	4.8 (79)	5.0 (82)
10½ (267)	5.5 (90)	5.7 (93)	5.8 (95)	6.0 (98)
11½ (292)	6.5 (106)	6.7 (110)	6.9 (113)	7.1 (116)
12½ (318)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)
13½ (343)	8.8 (144)	9.1 (149)	9.4 (154)	9.6 (157)
14½ (368)	10.1 (166)	10.5 (172)	10.7 (175)	11.0 (180)

THICKNESS 5/16 in (7.94 mm)

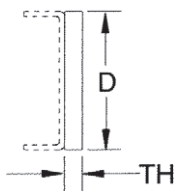
	2¼ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	3.6 (59)	3.7 (61)	3.9 (64)	4.0 (66)
8½ (216)	4.6 (75)	4.7 (77)	4.9 (80)	5.0 (82)
9½ (241)	5.6 (92)	5.8 (95)	6.0 (98)	6.2 (102)
10½ (267)	6.8 (111)	7.1 (116)	7.3 (120)	7.5 (123)
11½ (292)	8.1 (133)	8.4 (138)	8.6 (141)	8.9 (146)
12½ (318)	9.5 (156)	9.8 (161)	10.1 (166)	10.4 (170)
13½ (343)	11.0 (180)	11.4 (187)	11.7 (192)	12.0 (197)
14½ (368)	12.6 (206)	13.0 (213)	13.4 (220)	13.7 (224)

THICKNESS 3/8 in (9.52 mm)

	2¼ (70)	3¼ (83)	3¾ (95)	4¼ (108)
7½ (191)	4.3 (70)	4.5 (74)	4.6 (75)	4.8 (79)
8½ (216)	5.5 (90)	5.7 (93)	5.9 (97)	6.0 (98)
9½ (241)	6.7 (110)	7.0 (115)	7.2 (118)	7.4 (121)
10½ (267)	8.1 (133)	8.4 (138)	8.7 (143)	8.9 (146)
11½ (292)	9.7 (159)	10.0 (164)	10.3 (169)	10.6 (174)
12½ (318)	11.3 (185)	11.7 (192)	12.1 (198)	12.4 (203)
13½ (343)	13.1 (215)	13.6 (223)	14.0 (229)	14.3 (234)
14½ (368)	15.1 (247)	15.5 (254)	16.0 (262)	16.4 (269)

TABLE C

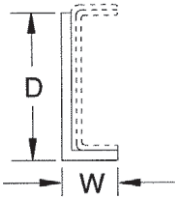
Section Modulus in<sup>3</sup> (cm<sup>3</sup>)



	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)
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<sup>3</sup> (cm<sup>3</sup>)



THICKNESS 3/16 in (4.76 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	5.7 (93)	6.4 (105)	7.0 (115)	7.7 (126)
9 1/2 (241)	6.7 (110)	7.4 (121)	8.1 (133)	8.9 (146)
10 1/2 (267)	7.7 (126)	8.5 (139)	9.3 (152)	10.1 (166)
11 1/2 (292)	8.8 (144)	9.7 (159)	10.6 (174)	11.4 (187)
12 1/2 (318)	10.0 (164)	10.9 (179)	11.9 (195)	12.8 (210)
13 1/2 (343)	11.2 (184)	12.2 (200)	13.2 (216)	14.3 (234)
14 1/2 (368)	12.5 (205)	13.6 (223)	14.6 (239)	15.7 (257)
15 1/2 (394)	13.8 (226)	15.0 (246)	16.1 (264)	17.3 (284)

THICKNESS 3/8 in (9.52 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	11.9 (195)	13.2 (216)	14.4 (236)	15.6 (256)
9 1/2 (241)	14.0 (229)	15.3 (251)	16.7 (274)	18.1 (297)
10 1/2 (267)	16.2 (266)	17.7 (290)	19.2 (315)	20.7 (339)
11 1/2 (292)	18.4 (302)	20.1 (329)	21.8 (357)	23.5 (385)
12 1/2 (318)	20.9 (342)	22.6 (370)	24.5 (402)	26.3 (431)
13 1/2 (343)	23.4 (384)	25.3 (415)	27.3 (447)	29.3 (480)
14 1/2 (368)	26.0 (426)	28.1 (461)	30.2 (495)	32.4 (531)
15 1/2 (394)	28.8 (472)	31.0 (508)	33.3 (546)	35.6 (583)

THICKNESS 5/16 in (7.94 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	9.8 (161)	10.8 (177)	11.9 (195)	12.9 (211)
9 1/2 (241)	11.5 (188)	12.6 (206)	13.8 (226)	15.0 (246)
10 1/2 (267)	13.3 (218)	14.5 (238)	15.8 (259)	17.1 (280)
11 1/2 (292)	15.1 (247)	16.5 (271)	18.0 (295)	19.4 (318)
12 1/2 (318)	17.1 (280)	18.6 (305)	20.2 (331)	21.7 (356)
13 1/2 (343)	19.2 (315)	20.8 (341)	22.5 (369)	24.2 (397)
14 1/2 (368)	21.4 (351)	23.1 (379)	24.9 (408)	26.7 (438)
15 1/2 (394)	23.7 (388)	25.5 (418)	27.4 (449)	29.4 (482)

THICKNESS 1/4 in (6.35 mm)

	3 (76)	3 1/2 (89)	4 (102)	4 1/2 (114)
8 1/2 (216)	7.7 (126)	8.6 (141)	9.4 (154)	10.3 (169)
9 1/2 (241)	9.1 (149)	10.0 (164)	10.9 (179)	11.9 (195)
10 1/2 (267)	10.5 (172)	11.5 (188)	12.5 (205)	13.6 (223)
11 1/2 (292)	11.9 (195)	13.1 (215)	14.2 (233)	15.4 (252)
12 1/2 (318)	13.5 (221)	14.7 (241)	16.0 (262)	17.2 (282)
13 1/2 (343)	15.2 (249)	16.5 (270)	17.8 (292)	19.2 (315)
14 1/2 (368)	16.9 (277)	18.3 (300)	19.7 (323)	21.2 (347)
15 1/2 (394)	18.7 (306)	20.2 (331)	21.7 (356)	23.3 (382)

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 the final weight to verify that final truck weight with crane, reinforcement, counterweight and options, such as the jib, complies with the appropriate laws.

Welding Precautions

Sensitive truck computer system and crane's RCL 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.

Positioning Crane on Truck

The installer of the crane must be familiar with state axle and length laws in force at the time the crane is mounted on the truck. The following items must be considered.

- **Overall Length**—Most states have a maximum straight truck length limit of 12 m (40 ft). Using too long a WB truck could cause the unit to exceed this limit.
- **Axle Weights**—Most states allow 9,072 kg (20,000 lb) single axle weight and 15,422 kg (34,000 lb) tandem axle weights on primary roads. However, some states restrict the axle weight to less on secondary roads or at

certain times throughout the year. Be aware of your state's axle laws for weight restrictions.

- **Overhang**—Some states restrict front overhang to 914.4 mm (36 inches). Check your state requirements.
- **Federal Bridge Law**—The Federal Bridge Law in effect currently states that in order to carry 26,308 kg (58,000 lb) on a four-axle truck, the extremes of any group of axles must be at least 732 cm (24 ft) apart.

## PTO, Pump, Reservoir

1. Select the PTO according to the PTO Selection pages shown earlier in this section. PTO's are not furnished by the factory.
2. 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

Rotating the pump in the wrong direction damages the pump.

3. If PTO integral mount flanges are being used, the pump can be mounted directly to the PTO. Make sure there is adequate clearance for this type of pump mount. Sometimes space is limited and the pump is powered through a driveline. The maximum length and angle of the driveline should not exceed the manufacturers recommendations. The U-joint yokes on both ends of the driveline must be parallel with each other. Drivelines should be sized so they can safely carry the maximum pump horsepower requirements. See "PTO Requirements" on page 9-7. National Crane does not furnish drivelines.
4. Plan the location of the pump mounting bracket and driveline, 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 152.4 mm (6 in) channel crossmember can be made and installed.
5. 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. 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, or attach to a transmission bolt if the pump is direct mounted to the

PTO. The rear of the pump must be supported regardless of the mounting method.

**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.

6. Remove the dust covers from the pump inlet and outlet and determine that the suction and pressure sides of the pump are correct while rotating the pump in the same direction as the PTO. Rotate the pump in the mounting bracket so suction side is toward the reservoir suction port. An arrow is cast into the rear pump housing to identify rotation.
7. If using a drive shaft type of mount, connect PTO drive shaft to pump and PTO. Drill a 0.31 in dia. x 0.12 in deep hole on the flat of the hex shaft at the fixed yoke end of the drive shaft to engage the yoke set screw. A small flat area should be ground in the O.D. of the splined pump shaft to engage the pump yoke set screw. Apply Loctite® and tighten the shaft setscrews. Grease the PTO universal joints.

## 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 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 crossmembers are bolted in, remove the bolts. Do not attempt to remove any rivets.

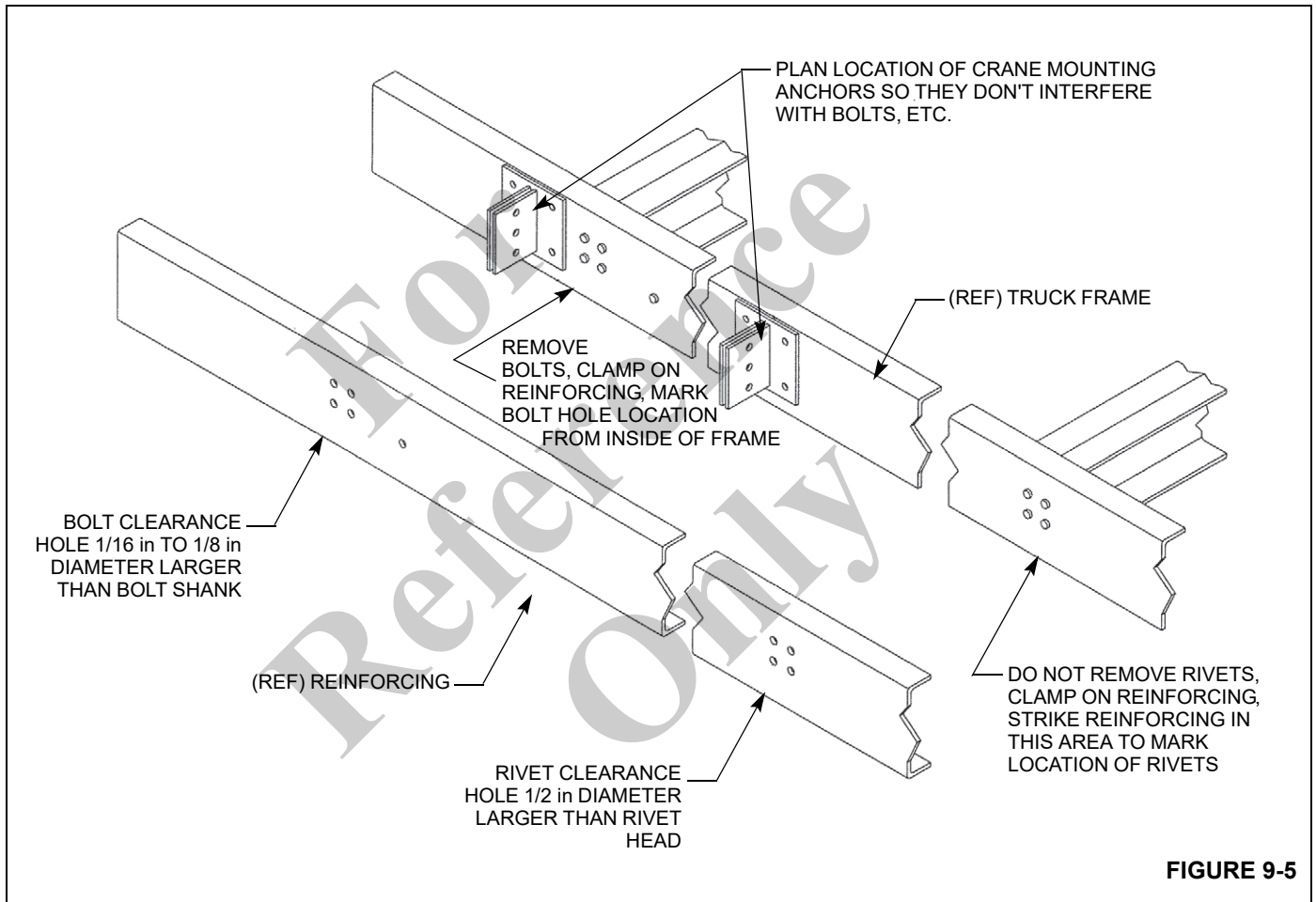


3. If rivets are used to secure truck frame cross members. Place the reinforcing on the truck frame and clamp in place. See Figure 9-5.

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 9-5.



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 9-6.

5. If bolt-on reinforcing is required, 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 9-7 for recommended drilling and bolting procedure. Use 5/8, Grade 8 bolts, drill holes to 39/64 diameter, drive fit bolts and properly tighten accordingly. See "Fasteners and Torque Values" on page 1-7.

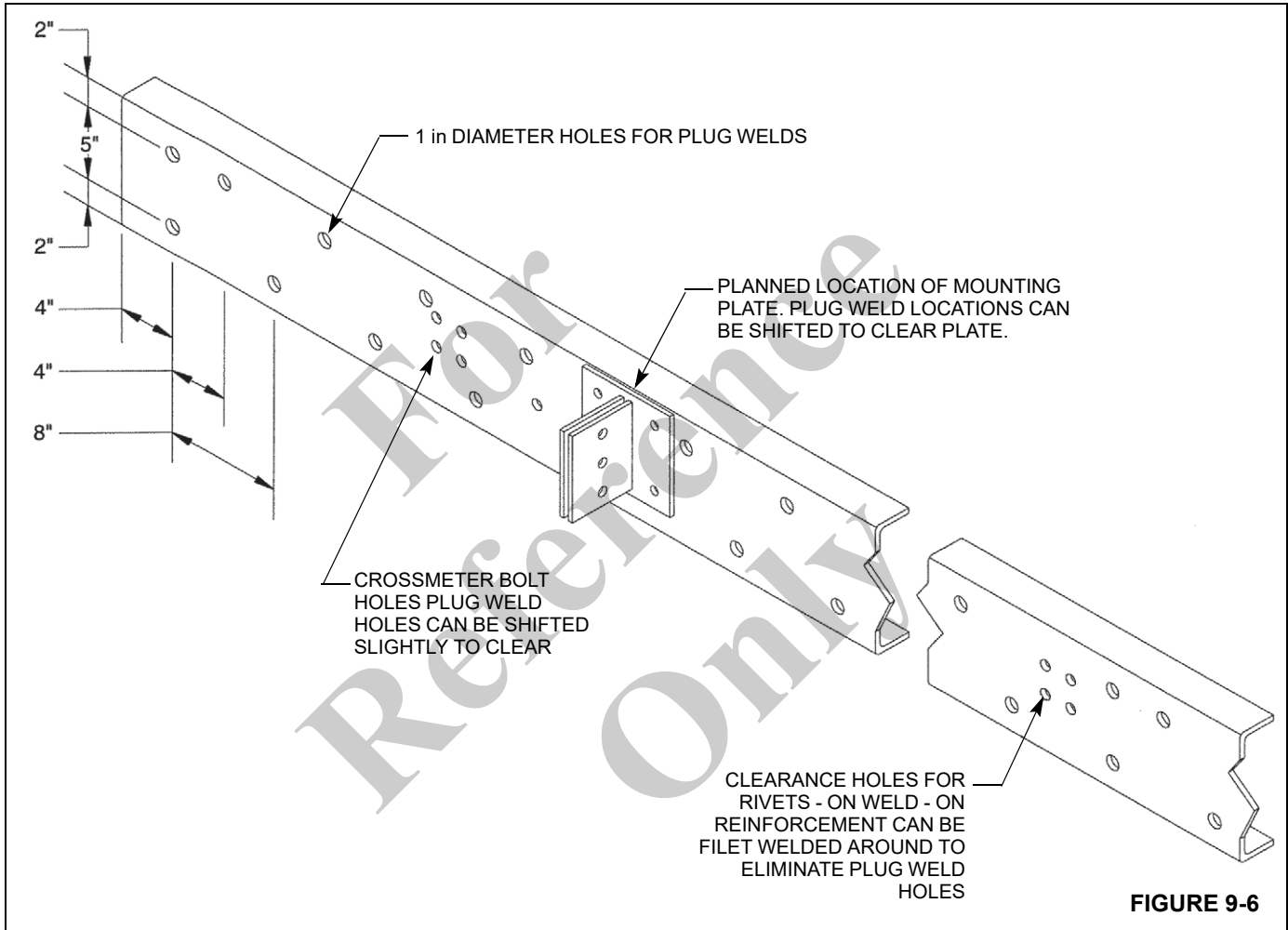


FIGURE 9-6

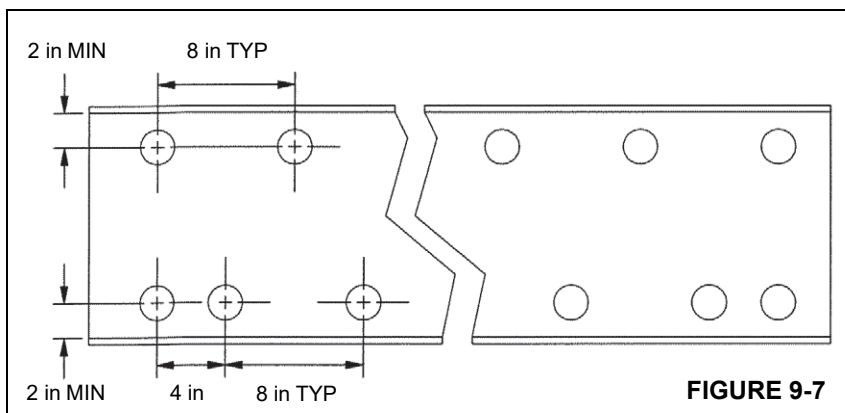


FIGURE 9-7

6. If the frame through the rear suspension doesn't meet minimum specifications for RBM and section modulus as shown on *Truck Frame Strength*, page 9-7 table, it can be reinforced by adding an angle type of reinforcing as in Figure 9-8.

See "Section Modulus Tables" on page 9-8, 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 underneath the frame to contact either existing truck frame or spring hanger brackets (if they extend down below the existing truck frame).

7. If reinforcing angle is to be welded to truck frame, cut out plug weld hole pattern as in Figure 9-6.

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.

8. If reinforcing angle is to be bolted on, drill hole pattern and install bolts according to Figure 9-7. 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 in beyond either side of the weld or cut out areas. Weld these reinforcing bars to the underside of the reinforcing with length-wise welds.

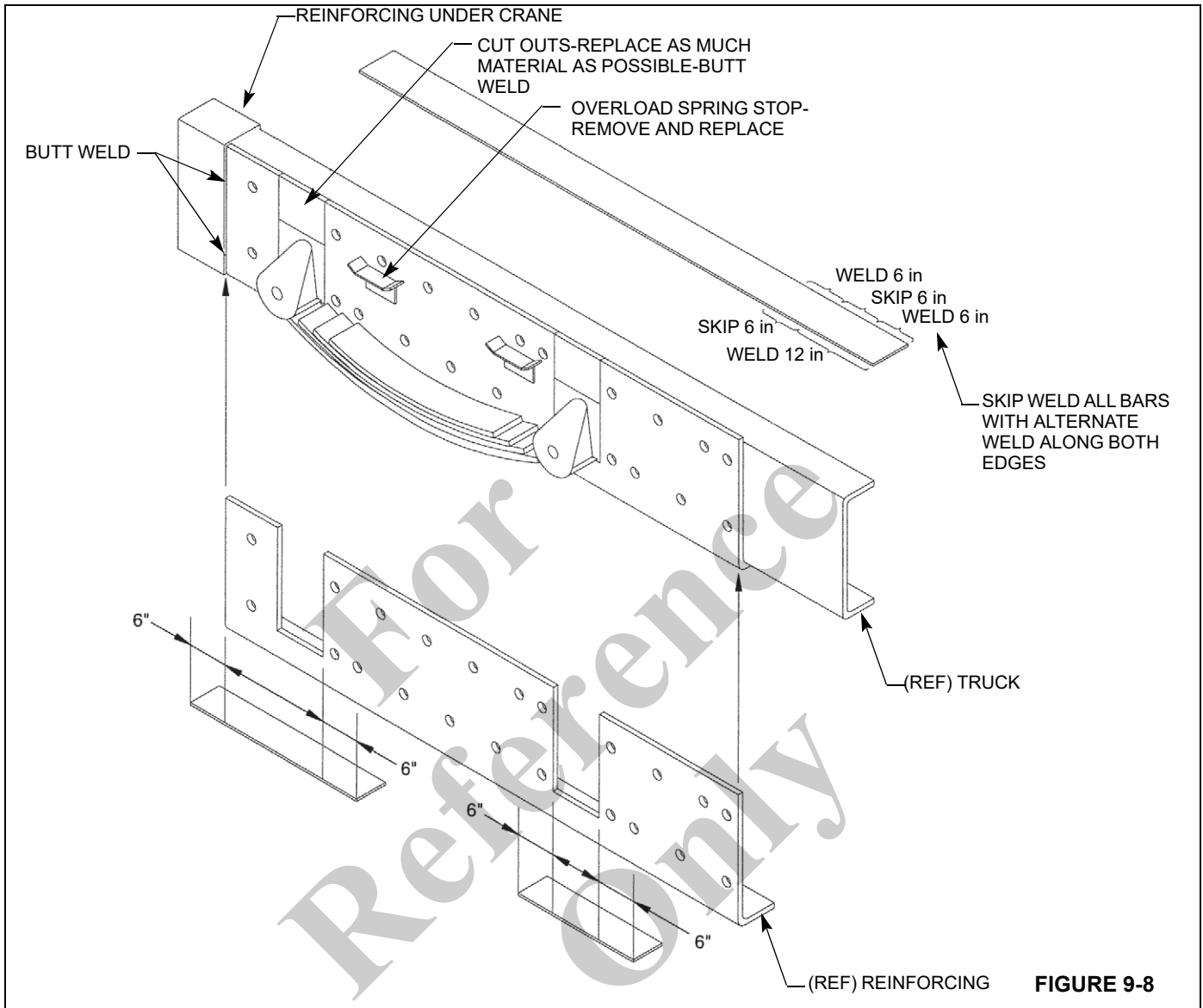
**Do not weld across the flanges.**

Replace any equipment that had been removed.

9. Figure 9-9 shows the afterframe specifications for the NBT60L for a tridem or tag axle.

Calculate the weight distribution of the complete machine in order to determine where the crane center of rotation will be in relationship to the center of the rear axles. The afterframe must extend a minimum of the dimensions shown in Figure 9-9 behind the centerline of crane rotation. 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 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 304.8 mm (12 in) 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.



## MOUNTING THE CRANE

### T-Box Installation

#### 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.

Make sure the truck has been configured to meet the minimum truck, PTO, and frame strength requirements as described previously in this section. Use the following procedures and refer to Figure 9-9 when installing the T-box to the truck frame.

**NOTE:** All welds used to secure the crane to the truck frame must be grade 90 or better.

**NOTE:** See "Fasteners and Torque Values" on page 1-7 for the proper torque value when tightening any fasteners.

1. Place the crane assembly on the truck frame as determined by the information contained in the section titled *Positioning Crane on Truck* on page 9-11.
2. Locate the six mounting plates (12) and spacer plates (11) on the truck frame (18) and clamp in place (Details A and D). Be sure the hole pattern of the mounting plates (12) and spacer plates (11) is centered vertically to the frame rails. Also, be sure the left and right side mounting plates are aligned across from each other.

Drill 16 mm holes through the truck frame (18) using the existing holes in the mounting plates (12) and spacer plates (11) as templates.

Bolt the six mounting plates (12) and spacer plates (11) to the truck frame (18) using the bolts, flat washers, and nuts.

3. Bolt one anchor bar (13) to each of the six mounting plates (12) that are attached to the truck frame (18) (Details A and D).

4. Bolt a mounting plate (12) to each anchor bar (13) finger tight; clamp the mounting plates flush against the T-box frame (19) (Details A and D).

5. Weld the six upper mounting plates (12) to the T-box frame (19). See Detail D for weld requirements.

6. Starting on the passenger side, locate the front strap plate (8) and spacer plate (10) on the truck frame (18); clamp in place (Details A and B). Be sure the hole pattern of the front strap plate (8) is centered vertically to the frame rail. Align the driver side front strap plate (8) and spacer plate (10) directly across from the passenger side strap plate and spacer plate; clamp in place.

Drill 16 mm holes through the truck frame (18) using the existing holes in the front strap plates (8) and spacer plates (10) as templates.

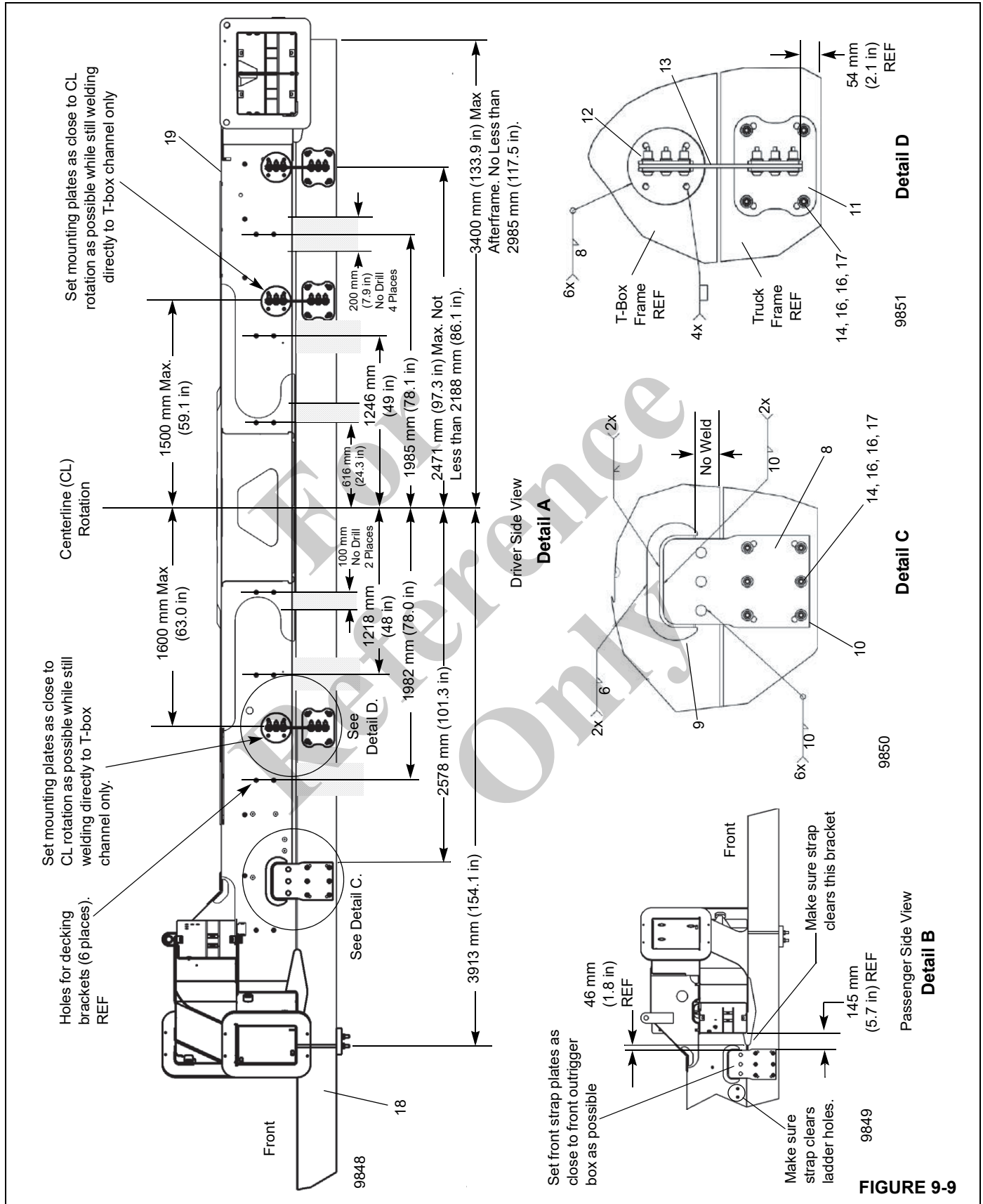
Bolt the front strap plates and spacer plates to the truck frame using the 16x75 mm bolts, flat washers and nuts.

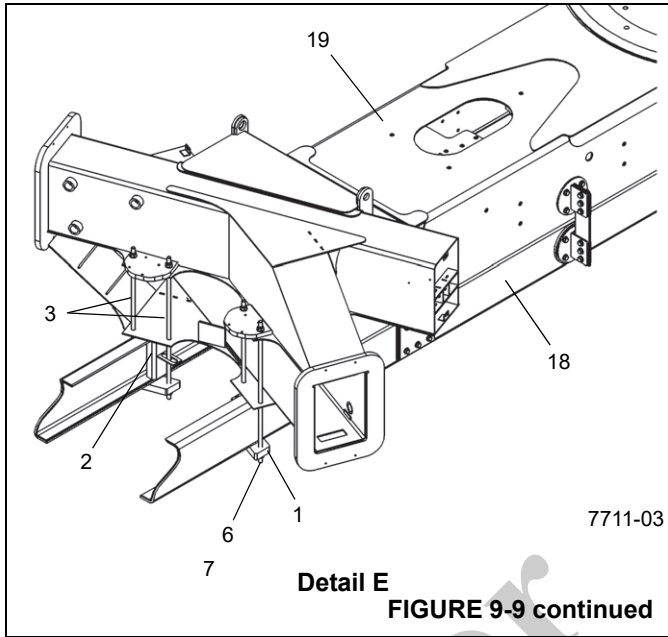
7. Position the two collar plates (9) above the front strap plates (8) on the T-box frame (19); clamp in place. Weld the front strap plates (8) and collar plates (9) to the T-box frame (19). See Detail C for locator dimensions and weld requirements.

8. If necessary, cut the two channel assemblies (2) to fit inside the truck frame (18) at a location immediately in front of the front outrigger box. Install the two channel assemblies (2) inside the truck frame (Detail E).

9. Install a locknut and flat washer onto one end of the four 20x900 mm studs (3). Working at the front of the outrigger box on top of the T-box frame (19), insert the four studs (3) down through the existing holes in the T-box frame (19), ensuring the studs (3) on the inside of the truck frame rails pass through the slotted holes in the channel assemblies (2) (Detail E).

Install clamp plates (1) onto the studs (3) and slide up against the bottom of the truck frame (18), then secure with lock washers and nuts.





### Rear Bumper and Light Installation

Use the following procedures and refer to Figure 9-10 when installing the rear bumper and lights.

1. Position the left and right bumper mounting brackets (4, 5) against their respective frame rail (15); clamp in place. See Detail A.

Using the bumper mounting brackets as templates, drill five 17 mm holes through each mounting bracket and truck frame (15). Use the bumper mounting bracket's wide hole pattern on a truck with a long frame rail (Detail A) or the narrow hole pattern on a truck with a short frame rail (Detail B). Bolt the mounting brackets to the truck frame.

2. Mount the light plate (2) and the bumper (3) to the left and right bumper mounting brackets (4, 5). See Details A and D.
3. Mount the light cover plate (1) to the top of the T-box frame as shown in Detail D.

Item	Description
1	Clamp Plate
2	Channel Assembly
3	Stud M20x900 10.9
4	Hex Lock Nut M20 8 ISO 7040
5	F Washer 20-HRC38 ANSI B18.22M
6	L Washer 20-HRC44-51 DIN 7980
7	Hex Nut M20 8 ISO 4032
8	Plate
9	Plate
10	Plate, Shear Plate Spacer
11	Plate, Flex Plate Spacer
12	Anchor ASM
13	Bar
14	HHCS M16x75 10.9 ISO 4014
15	HHCS M16x55 10.9 ISO 4014
16	F Washer 5/8" Hard ASTM F-436
17	Hex Nut M16 10 ISO 4032
18	Truck Frame
19	T-box Frame

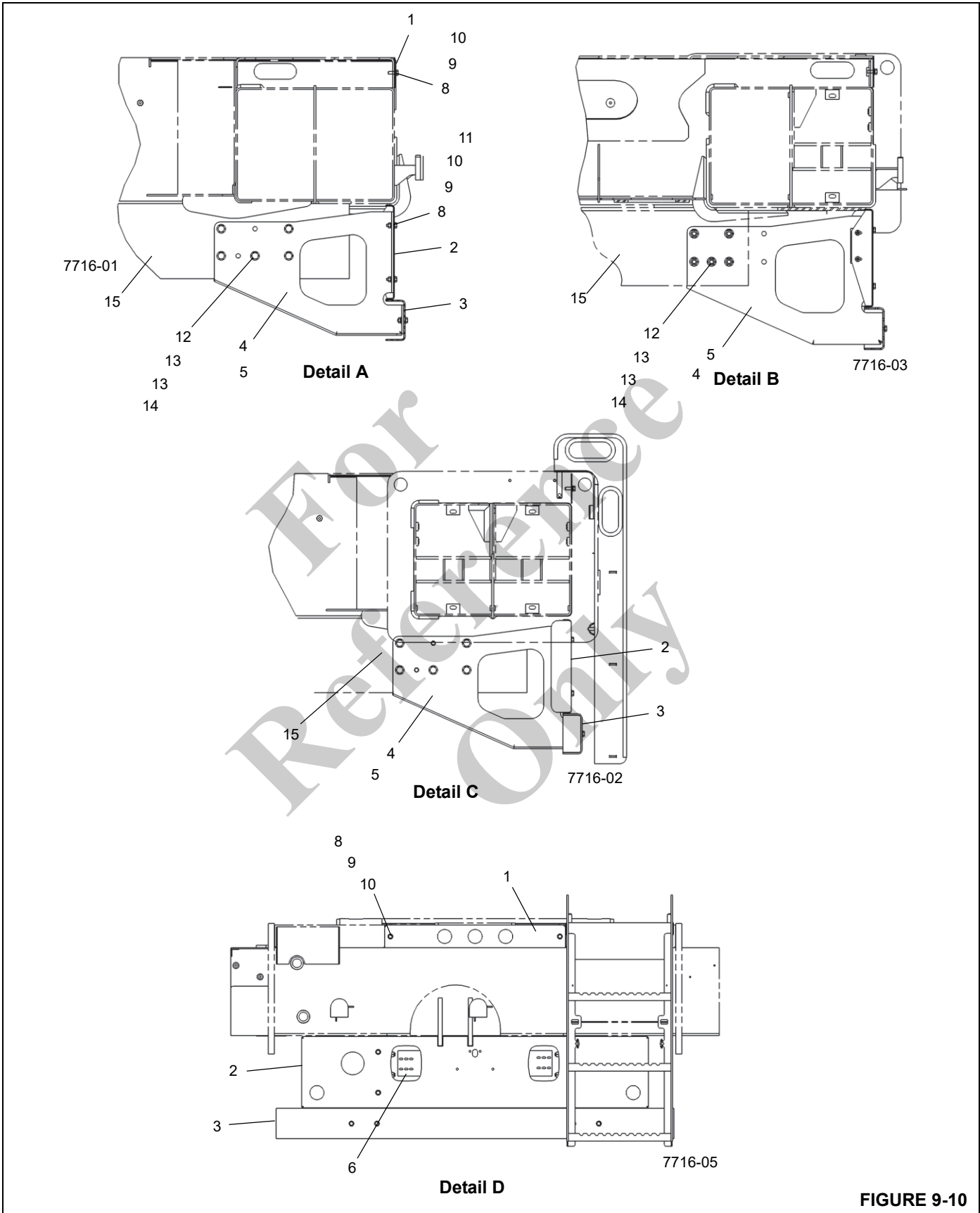


FIGURE 9-10



Item	Description
1	Light Cover Plate
2	Light Plate
3	Bumper
4	Bumper Mounting Bracket LH
5	Bumper Mounting Bracket RH
6	Plate
7	Ladder Assembly
8	HHCS M10x30 SS ISO 4014
9	F Washer 3/8" Wide MS
10	L Washer 10-HRC44-51 DIN 7980
11	Hex Nut M10 8 ISO 4032
12	HHCS M16x55 10.9 ISO 4014
13	F Washer 5/8" Hard ASTM F-436
14	Hex Nut M16 10 ISO 4032
15	Truck Frame

**Decking and Ladder Installation**

Use the following procedures and refer to Figure 9-11 through Figure 9-13 when installing the decking and ladder.

1. Install the mounting brackets (5, 6, 8, 9, 43, 44) on the T-box frame in the locations indicated. Add Loctite ® 243 to all mounting hardware.
2. Install the driver side front and rear fender (1, 3) and the passenger side front and rear fender (2, 4). Secure the fender to one another and also to the T-box frame using the angled mounting brackets (7) and the supplied hardware. Add Loctite ® 290 to all mounting hardware.
3. Install the front and rear outrigger covers (14, 15) on the outrigger boxes.
4. Install the outrigger cover (16) on the front outrigger.
5. Install a mud flap plate (20) on the left and right side rear fender (1, 2), then attach a mud flap (22) on each mud flap plate (20) using a bracket (21).
6. Install cover panel plates (17) on the top front and rear portions of the T-box frame. Install cover plates (18) on top of the left and right rear outrigger boxes.
7. Install decal plates (46) on the sides of the driver and passenger side front fender (3, 4).
8. Measure and cut the trim strip (24) to fit around the openings in the sides of the driver and passenger side front fender (3, 4).
9. Attach the ladder (10) to the passenger side front fender (4), then secure the ladder (10) to the T-box frame with the ladder support (11). Install a handle (12) on each side of the ladder (10). Add Loctite ® 243 to all mounting hardware.
10. Mount the bracket hold down (19) to the top of the driver side rear fender (1); add Loctite ® to mounting hardware. Measure and cut the trim strip (24) to fit around the opening in the handle of the ladder assembly (13). Attach the ladder assembly to the top of the driver side rear fender using the shoulder bolt, flat washers, nylon washer and nut (37, 38, 39, 40, 41, 42). Make sure the leg of the ladder assembly (13) engages the bracket hold down (19), then secure in place with the lock pin (23).
11. Install the ladder catches (61) to the sides of the driver side front and rear fender (1, 3).
12. Install the level adjustment plate (57), with the flat side down, and level (56) on the driver and passenger side front fender (3, 4).  
Once the outriggers are operational, each level (56) must be calibrated by doing the following:
  - a. Place a level on a machined surface of the T-box frame, such as the bearing plate. Do not use the outrigger box or decking.
  - b. Using the outrigger controls, level the crane both laterally and longitudinally.
  - c. Adjust the level adjustment plate (57) until the bubble inside the level (56) is within the circle.
  - d. Repeat Step 12c for level on opposite side of the crane.

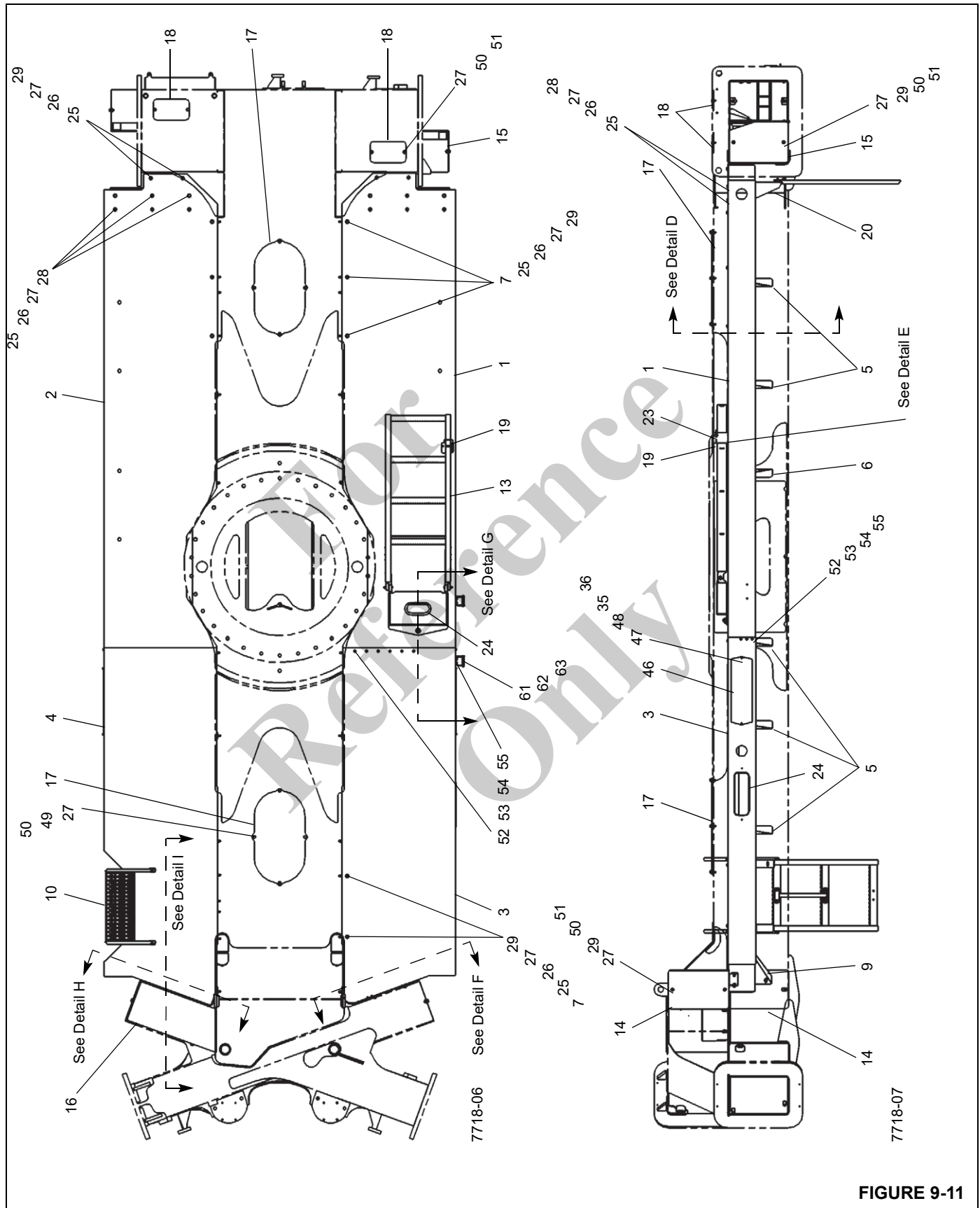


FIGURE 9-11

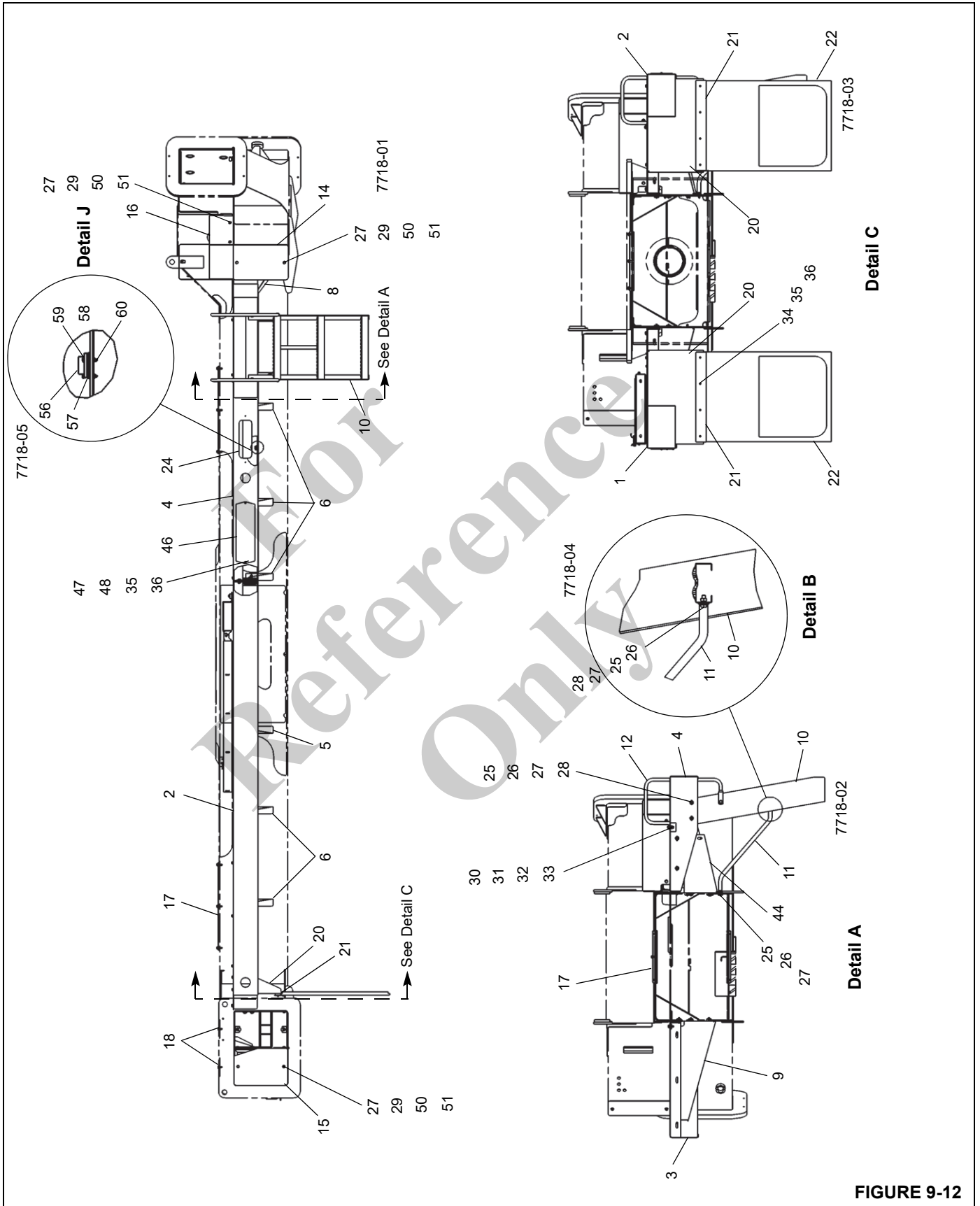


FIGURE 9-12



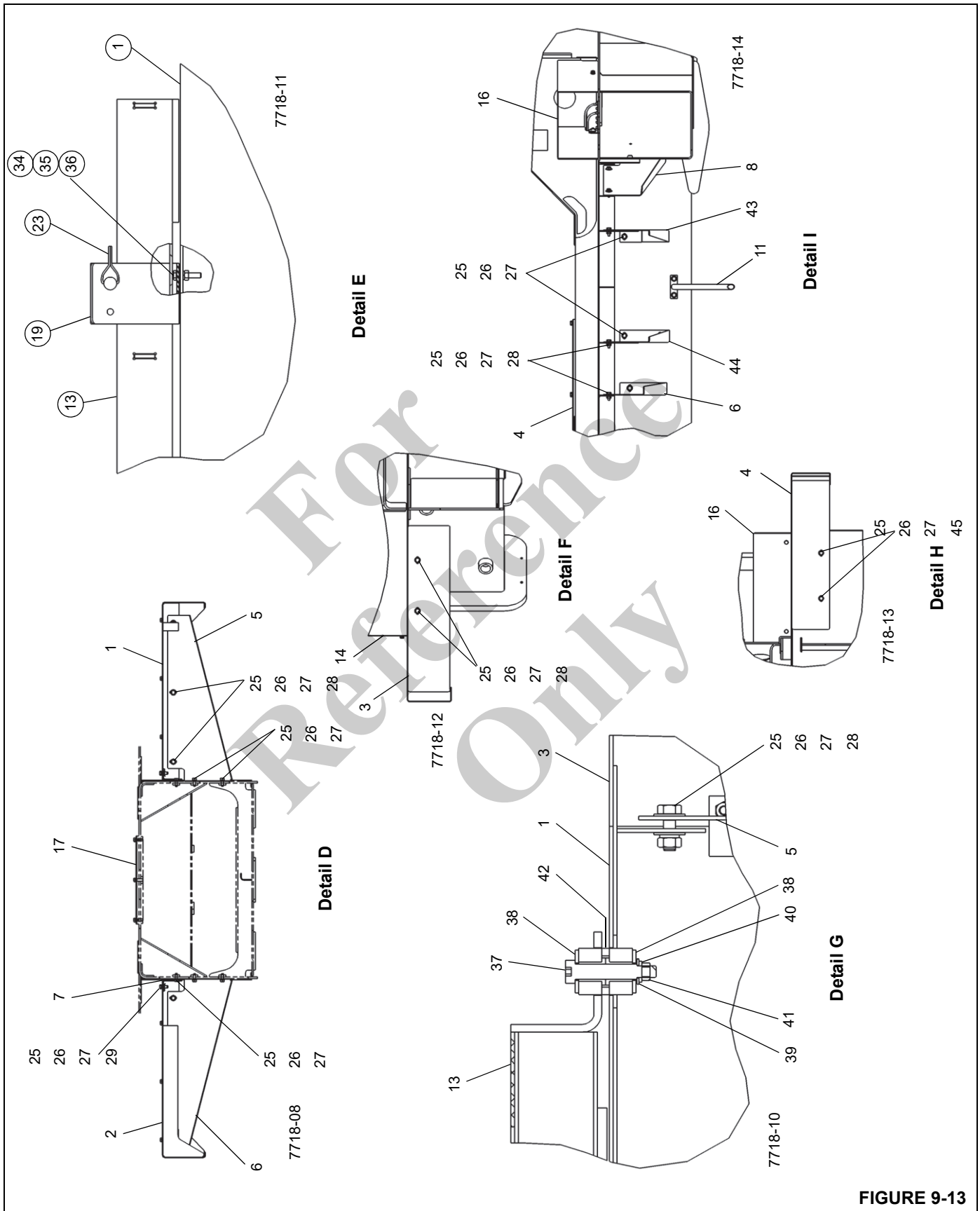


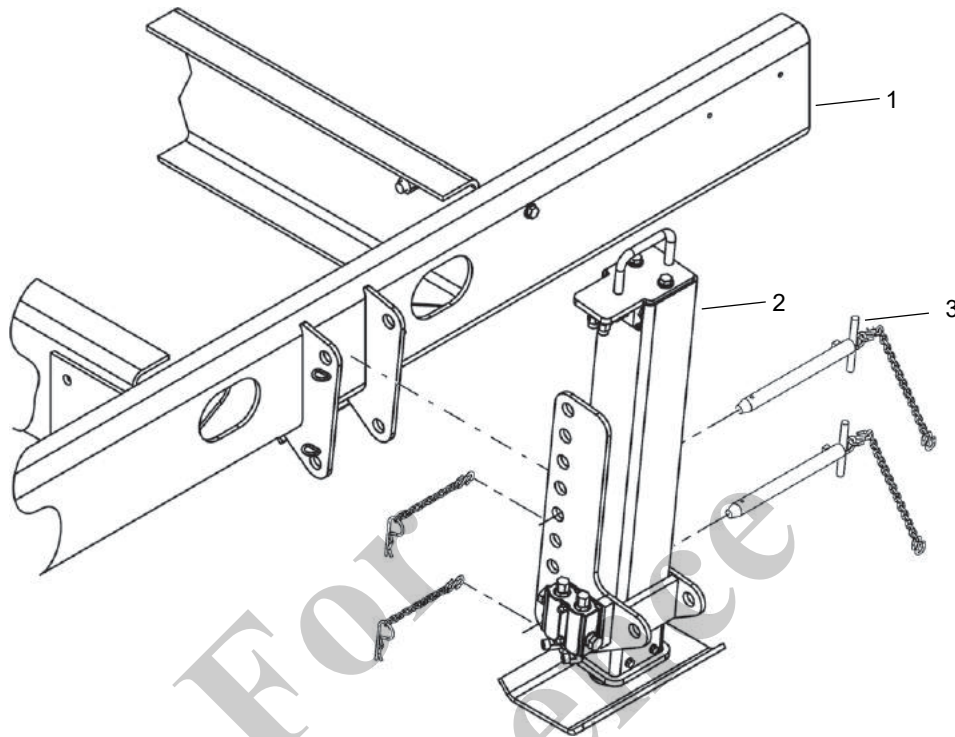
FIGURE 9-13

Item	Description
1	DS Rear Fender
2	PS Rear Fender
3	DS Fender
4	PS Front Fender
5	Mounting Bracket
6	Mounting Bracket
7	Angle
8	Mounting Bracket Angled
9	Mounting Bracket Angled
10	Step
11	Support Ladder
12	Step Handle
13	Ladder (Asm)
14	Front Outrigger Cover
15	Rear Outrigger Cover
16	Outrigger Cover
17	Plate, Cover Panel
18	Cover Plate
19	Bracket hold Down
20	Mud Flap Plate
21	Bracket
22	Mud Flap
23	Lock pin 3/8x2.25"
24	Trim Strip
25	HHCS M10x30 SS ISO 4014
26	F Washer 3/8" Wide MS
27	L Washer 10-HRC44-51 DIN 7980
28	Hex Nut M10 ISO 4032
29	Retaining Nut M10
30	HHCS M12x30 SS ISO 4017
31	F Washer 12-St ISO 7089
32	L Washer 12-HRC44-51 DIN 7980
33	Hex Nut M12 8 ISO 4032
34	HHCS M6x30 8.8 ISO 4014
35	L Washer 6-HRC44-51 DIN7980

Item	Description
36	Hex Nut M6 8 ISO 4032
37	Shoulder Bolt
38	F Washer 1/2" Wide MS
39	F Washer 3/8" Nar MS
40	L Washer 3/8" Reg HRC44-51
41	Hex Nut 3/8-16UNC SAE-2
42	F Washer 7/8" Nylon
43	Mounting Bracket
44	Mounting Bracket
45	HHCS M10x20 SS ISO 4017
46	Decal Plate
47	HHCS M6x25 8.8 ISO 4017
48	F Washer 6 -St ISO 7089
49	HHCS M10x35 SS ISO 4014
50	F Washer 3/8" Nar MS
51	HHCS M10x25 SS ISO 4014
52	HHCS M8x25 8.8 ISO 4014
53	F Washer 8 -St ISO 7089
54	Hex Nut M8 8 ISO 4032
55	L Washer 8-HRC44-51 DIN 798
56	Level
57	Plate-Level Adjusting
58	Slot PMS M3x20 SS ISO 1580
59	F Washer 3 -St ISO 7089
60	Hex Nut M3 8 ISO 4032
61	Ladder Catch
62	Clevis Pin 0.5x3" St
63	Cotter Pin 0.09x0.75" St

**Single Front Outrigger Installation (SFO) - Optional**

Figure 9-14 and Figure 9-15 show common examples of SFO bumper bracket kits. Bumper bracket kits are available from National Crane to mount a SFO to a particular manufacturer's truck. If more information about your truck model is needed, contact your National Crane distributor or Manitowoc Crane Care.



9862

Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Assembly
3	Pin

Before installing the single front outrigger (SFO), ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-7.

1. Remove the existing bumper.
2. Install replacement bumper (1) using existing hardware.
3. Using the two pins (3), attach the SFO (2) to the bumper (1). Make sure that there is a ground clearance between 355 to 482 mm (14 to 19 in) under the SFO.

FIGURE 9-14

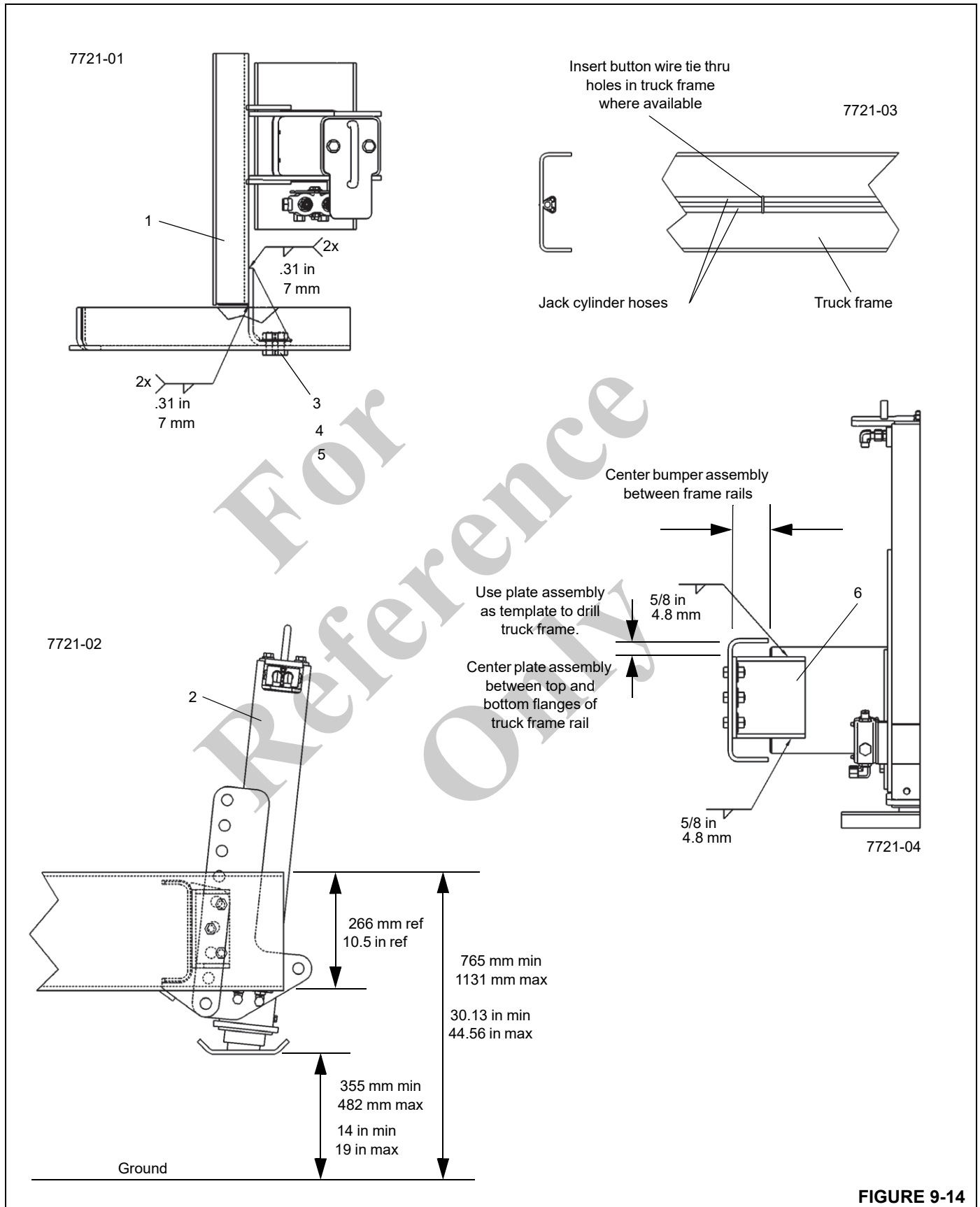


FIGURE 9-14

Item	Description
1	Bumper
2	Single Front Outrigger (SFO) Cylinder Assembly
3	Hex Nut 5/8-11UNC SAE-8
4	Flat Washer 5/8" Hard St
5	Hex Head Capscrew 5/8-11UNCx2 G8
6	Plate
7	Installation Drawing
8	Pin
9	Decal-Danger Outrigger Crush Hazard

Before installing the single front outrigger (SFO) jack, ensure the truck frame and bumper mounting brackets meet the structural requirements as defined in the sub-section titled *Truck Frame Strength*, page 9-7 and that the top of the truck frame has a ground clearance between 765 to 1131 mm (30.13 to 44.56 in).

1. Remove the existing bumper.
2. Center the mounting plates (6) between the top and bottom flanges of the truck frame rails. Clamp plates in place, then drill six 15.5 mm (5/8 in) holes (three per side) through the truck frame using the mounting plates as templates.
3. Attach the mounting plates (6) to the truck frame rails.
4. Center the bumper (1) between the frame rails such that there is a ground clearance of between 355 to 482 mm (14 to 19 in) under the front outrigger jack, then tack weld to the mounting plates.
5. Remove the mounting plate/bumper assembly from the truck, then finish welding the mounting plates (6) to the bumper (1) following the weld requirements found on the drawing in Figure 9-14; all welds to be grade 70.
6. Attach the mounting plate/bumper assembly to the truck frame using the supplied hardware (3, 4, 5).
7. Attach the outrigger jack (2) to the bumper (1) using the two attaching pins (8).

**FIGURE 9-14 continued**

### **Single Front Outrigger (SFO) Hydraulic Connection**

Using the hydraulic hoses provided, connect the single front outrigger (SFO) to the front outrigger control manifold as shown in Figure 9-15. Route hydraulic hoses without sharp bends and with clearance or protection between hoses and

stationary or moving parts which could wear against the hose. Connect the piston side of the jack to port "3" of the front outrigger control manifold; using a T-fitting, connect the rod side of the jack to the "A" port of the front outrigger control manifold.



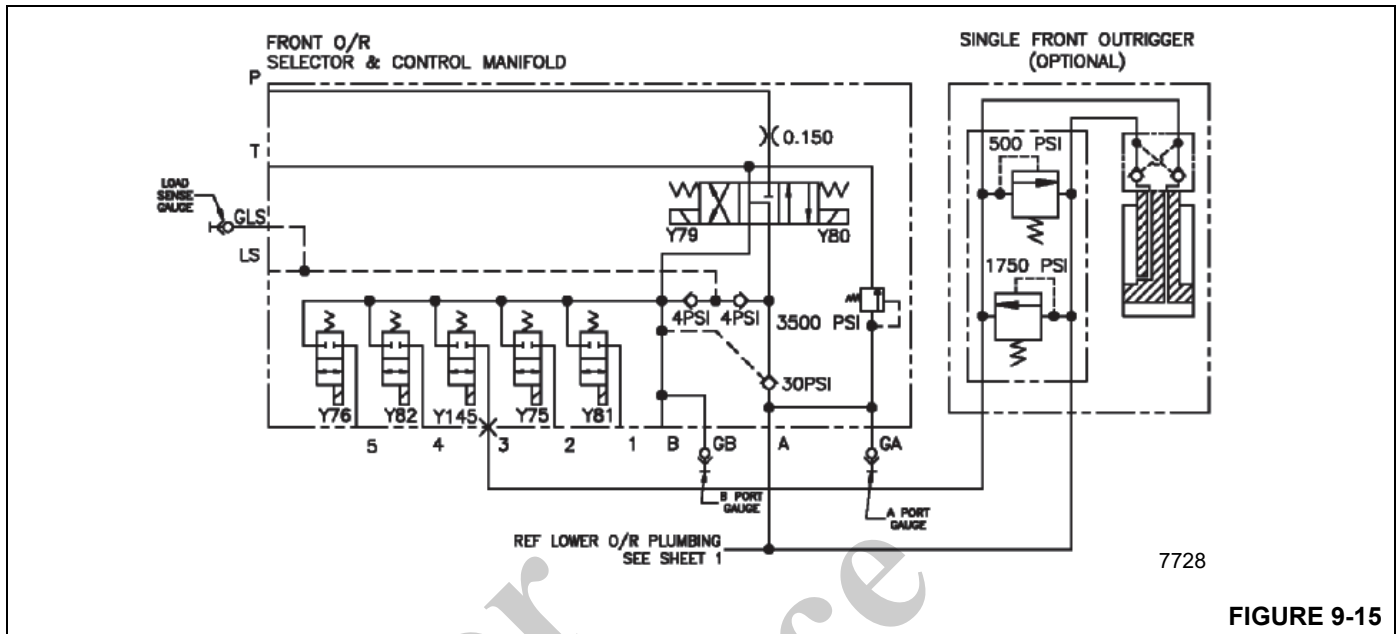


FIGURE 9-15

### Truck Interface Electrical Connection

Make the electrical connection between the crane and truck using the following procedures and information in Figure 9-16.

1. Working at the rear of the truck, install the five red marker lights (8) in the light cover plate and light plate (Detail B), then connect the marker lights to the main wire harness (1).
2. Install the original truck taillights to the truck wire harness using the integral brackets in the light plate.
3. Install the license plate light assembly (9) in the light plate using the supplied hardware (10, 11, 12, 16) (Detail B), then connect the light assembly to the main wire harness (1).
4. If equipped, install the backup/motion alarm (13) and grommet (14) in the light plate (Detail B), then connect the alarm to the main wire harness (1).
5. Install the red marker lights (8) in the driver and passenger side rear fender (Detail C), then connect the marker lights to the main wire harness (1).
6. Install the yellow marker lights (7) in the driver and passenger side front fender (Detail C), then connect the marker lights to the main wire harness (1).

7. Install the left and right remote outrigger control panels (left -2, right - 3) in their respective front fender using the supplied hardware (4, 5, 6) (Detail C), then connect the control panels to the main wire harness (1).
8. Using the two butt connectors (15), splice the #396 wire of the main wire harness (1) into the truck's PTO indicator wire (Detail A and E).
9. Route the breakout wires #52 (crane start signal), #112 (truck acc signal), and #901 (crane ign signal) of the main wire harness (1) through the truck's firewall and into the dashboard (Detail A). Connect the wires to the keyswitch.

**NOTE:** The crane is equipped with a terminating resistor for the J1939 network which is located at the master module on the fuse and relay panel in the operator's cab. This resistor must be removed if the truck's resistor is used.

10. Make the wire connections to the truck ECM and set the engine type using the RCL. For more information, see *Configuring the Truck Engine Type in the RCL*, page 9-30.
11. Connect the #7 wire and three fuse holders (one 60 amp and two 40 amp) of the main wire harness (1) to the positive terminal of the battery. Connect the two #51 wires of the main wire harness (1) to the negative terminal of the battery (Detail D).

### Configuring the Truck Engine Type in the RCL

**NOTE:** This procedure is not necessary for National Cranes mounted on trucks at the factory. This procedure is needed only if the crane is shipped without a truck and mounted on a truck at a customer site.

Use this procedure to configure the engine type through the RCL.

The Engine Type Selection screen is where the **Engine Type** is entered. Table 9-3 shows the options for engine type selection. *1: Cummins* is the default value. In most cases, the **J1939 Tx Address** field updates automatically to the default setting for the Engine Type selected. In the cases of Mercedes, Mack, and International (J1939) engines, the J1939 Tx Address can be edited.

**Table 9-3 Engine Type Selection Options**

ENGINE MAKE	ENGINE SELECT	J1939 TX ADDR
CAT	0	003
CUMMINS (Default)	1	023
MERCEDES	2	023 or 051
DETROIT DIESEL ENGINES (Needs to be entered manually)	2	231
MACK	3	003 or 023
ANALOG THROTTLE	4	023
CUMMINS (EXPORT ENGINES)	5	023
INTERNATIONAL (J1939)	6	033 or 023
PACCAR MX (EARLIER THAN 2018)	7	033
PACCAR MX 2018	8	033
PACCAR MX 2018 AND LATER-VECU	9	007
CUMMINS TSC1	10	007
THROTTLE DISABLED (Used when throttle is not connected to the truck ECU, Will disable truck/J1939 related errors.)	255	023

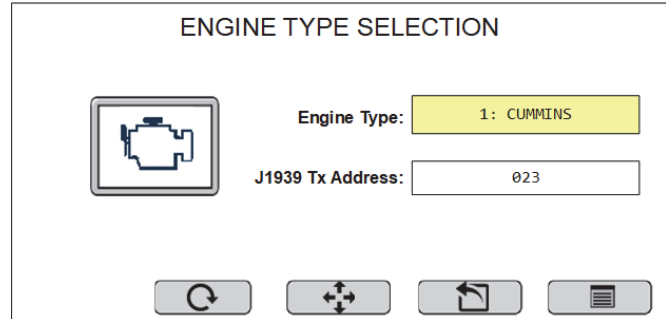
The J1939 Fuel Level Source Address Selection screen is where the **J939 Fuel Level Source Address** is entered. You can scan for the correct address or enter the value manually.

The engine type and fuel level source address information can also be configured using a laptop and software. For more information, contact your National Crane distributor or Manitowoc Crane Care.

**To configure the engine type and throttle:**

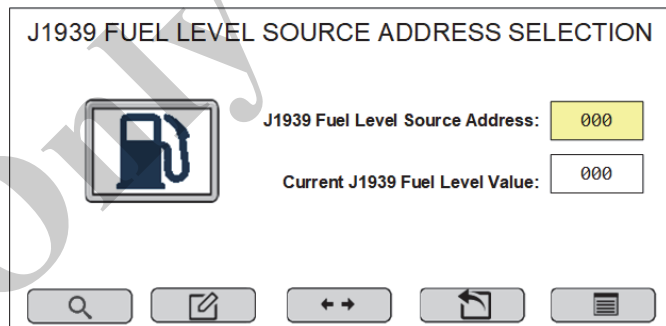
1. From the Main Menu, select the Tools icon.  
The Tools screen appears.

2. Select the Configuration icon.
3. Enter the password (12331).
4. Click the Engine Configuration icon.  
The Engine Configuration screen appears.



5. In the **Engine Type** field, use the up/down arrow icon to select your engine type. *1: Cummins* is the default value.
6. If necessary, use the Advance icon to move to the **J1939 Tx Address** field. Edit the field as needed.
7. Select the Set icon.

The J1939 Fuel Level Source Address Selection screen appears.



8. Do one of the following:
  - (Recommended) Click the Search icon to perform an automated scan of the Source Address.
  - or
  - Select the Edit icon and use the + and - soft keys to enter the source address manually.
9. Select the Set icon.  
The truck engine type is configured.

Illustrations for reference only.  
Your crane may be different.

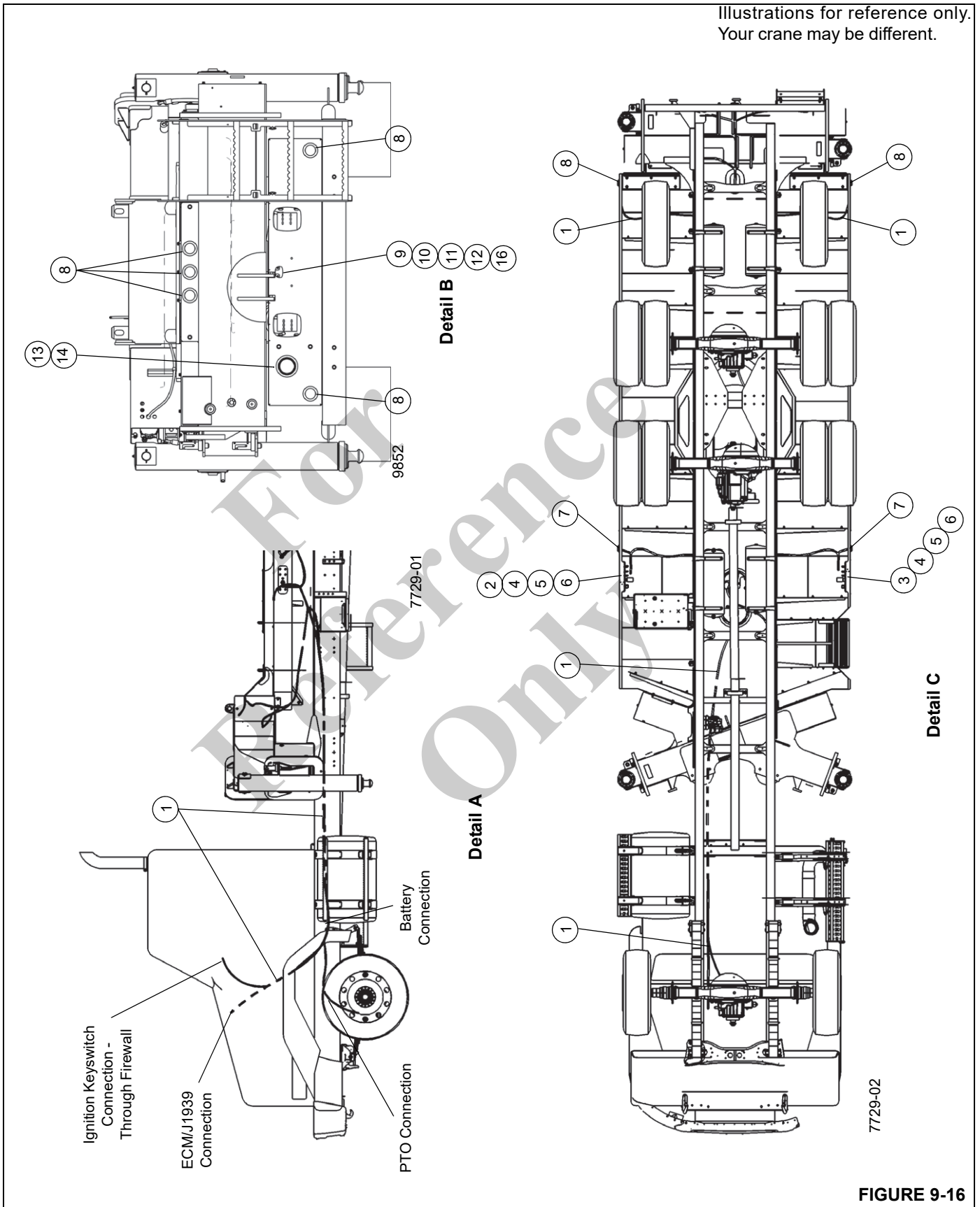


FIGURE 9-16

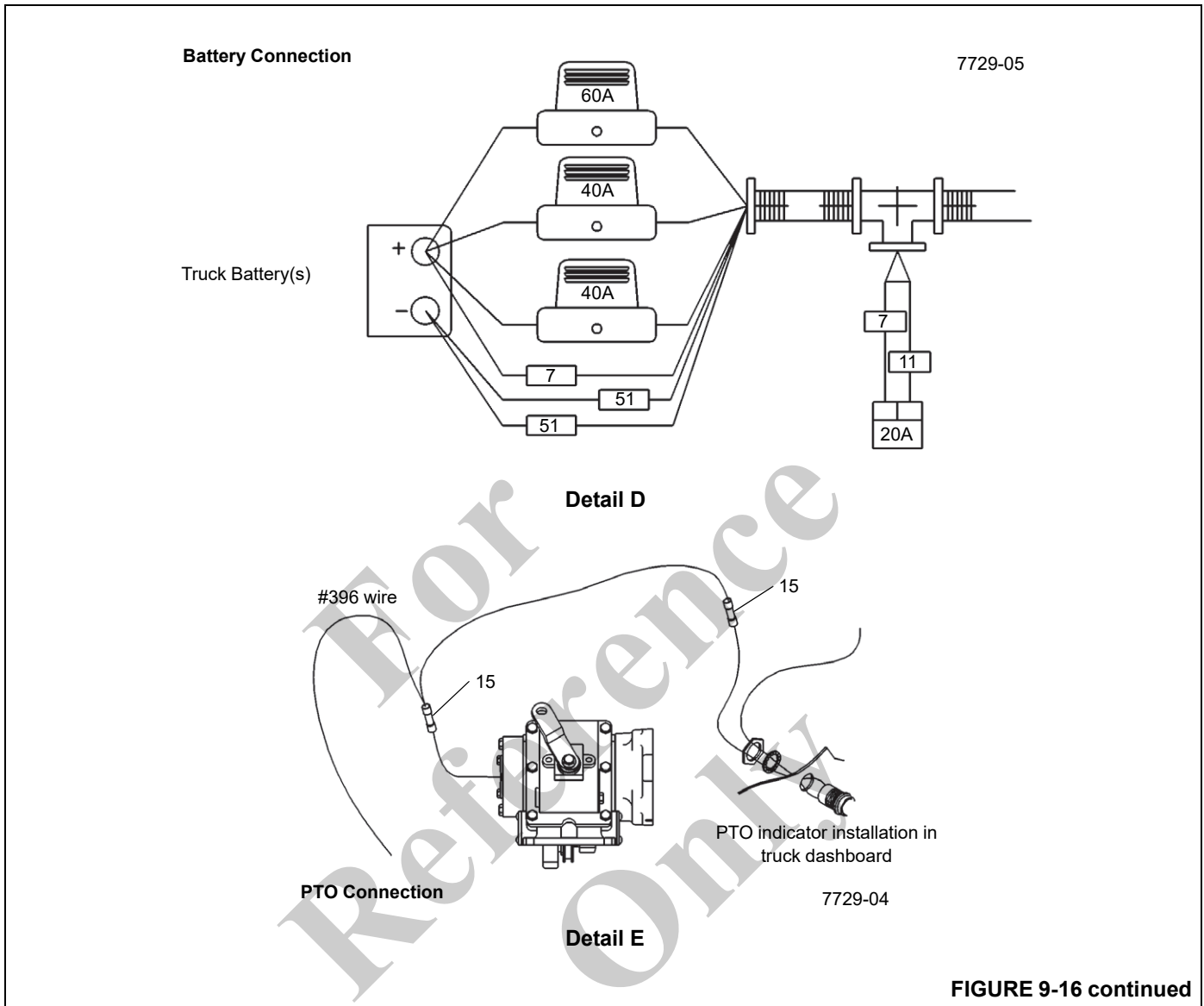
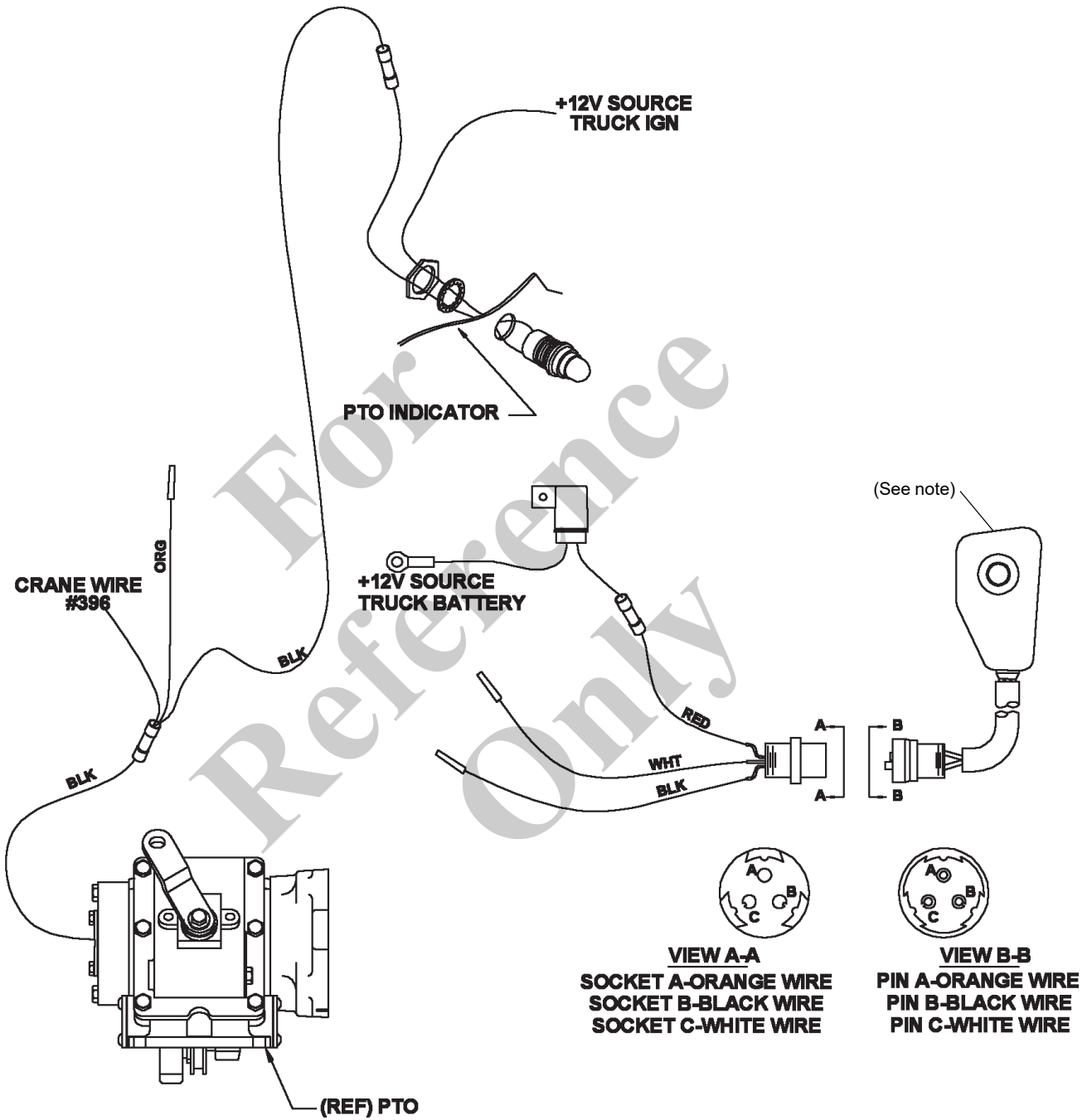


FIGURE 9-16 continued

Item	Description
1	Lower Wire Harness
2	Panel Assy-Left Hand Remote Outrigger Control
3	Panel Assy-Right Hand Remote Outrigger Control
4	Hex Head Capscrew M6x25 8.8 ISO 4017
5	Flat Washer 6 -St ISO 7089
6	Retaining Nut M6
7	Yellow LED Marker Light w/Grommet
8	Red LED Marker Light w/Grommet

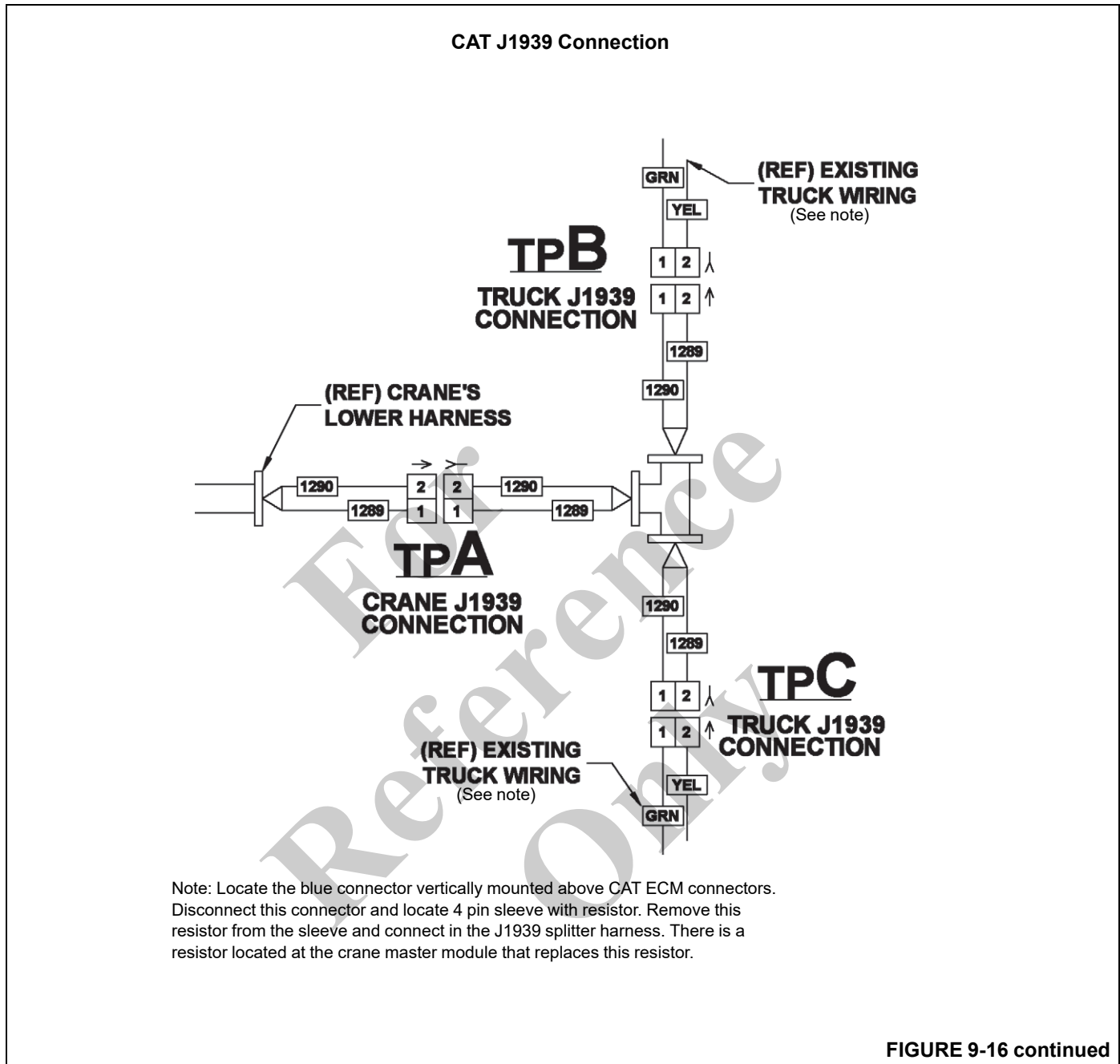
Item	Description
9	License Plate Light Assem
10	Slot PMS #8-32UNCx0.75 G1
11	Lock Washer #8 Reg HRC44-51
12	Hex Nut #8-32UNC Sae-2
13	Dual Tone Backup Alarm
14	Grommet
15	22-16 Ga Butt Conn Ins Melt
16	Flat Washer #8 Nar MS

CAT - PTO and Throttle Sensor Wire



Note: CAT throttle sensor is used only to send the ECM a valid idle signal all the time. Sensor can be tie strapped to the truck wiring in the engine compartment.

FIGURE 9-16 continued



**Hydraulic Pump Connection**

**CAUTION**

Make sure the gate valve on the return line is open before starting the engine and engaging the pump or damage to the pump could result.

See Figure 9-17 for the following steps.

The hydraulic system pressure is supplied by a hydraulic pump (1, Figure 9-17) mounted on the truck power take-off (PTO) (8).

For initial pump installation, use the following procedure:

1. The hydraulic pump has integral mounting flanges and can be bolted directly to the PTO. Be sure adequate clearance exists for this type of pump mount.
2. If the hydraulic pump is powered through a driveline, a pump mount must be installed or bolt the pump to an existing frame crossmember.

3. A mounting bracket needs to be installed so that the rear mounting bracket on the pump can be secured.
4. Make sure the driveline meets the minimum requirements for maximum pump horsepower. See "Specifications" on page 9-39.
5. Do not locate the hydraulic pump more than 107 cm (42 in) from the PTO. Do not exceed a 7° driveline angle, and make sure the U-joints on both ends of the drive shaft are parallel with each other.
6. Plan the location of the hydraulic pump mount and driveline for adequate clearance between the hydraulic pump and truck drive shaft or exhaust system.
7. Position the pump so that hydraulic lines can be connected without sharp bends, especially the large suction line from the reservoir.
8. For drive line installation, install the hydraulic pump mount to the truck frame.
9. Lubricate the splines on the hydraulic pump shaft. See "Lubrication" on page 8-1 for more information.

10. If using the configuration shown in Figure 9-17 be sure to position the case drain port (2) at the highest point above ground level.
  11. Attach the pump mounting flange to the PTO or to the hydraulic pump mount on the truck.
  12. Tighten the mounting flange nuts to a torque of 222 Nm (50 ft-lb).
  13. Install the hydraulic pump rear mounting bracket to the truck mounting bracket.
- NOTE:** O-ring boss fittings are used for sealing hydraulic line connections. Make sure the O-ring is in its groove before tightening.
14. Remove the dust covers from the hydraulic pump inlet and outlet ports and install the hydraulic fittings and lines as shown in Figure 9-17.

**NOTE:** Figure 9-17, View A, shows the left (driver's) side of the hydraulic pump installation and View B shows the right (passenger) side of the hydraulic pump installation.

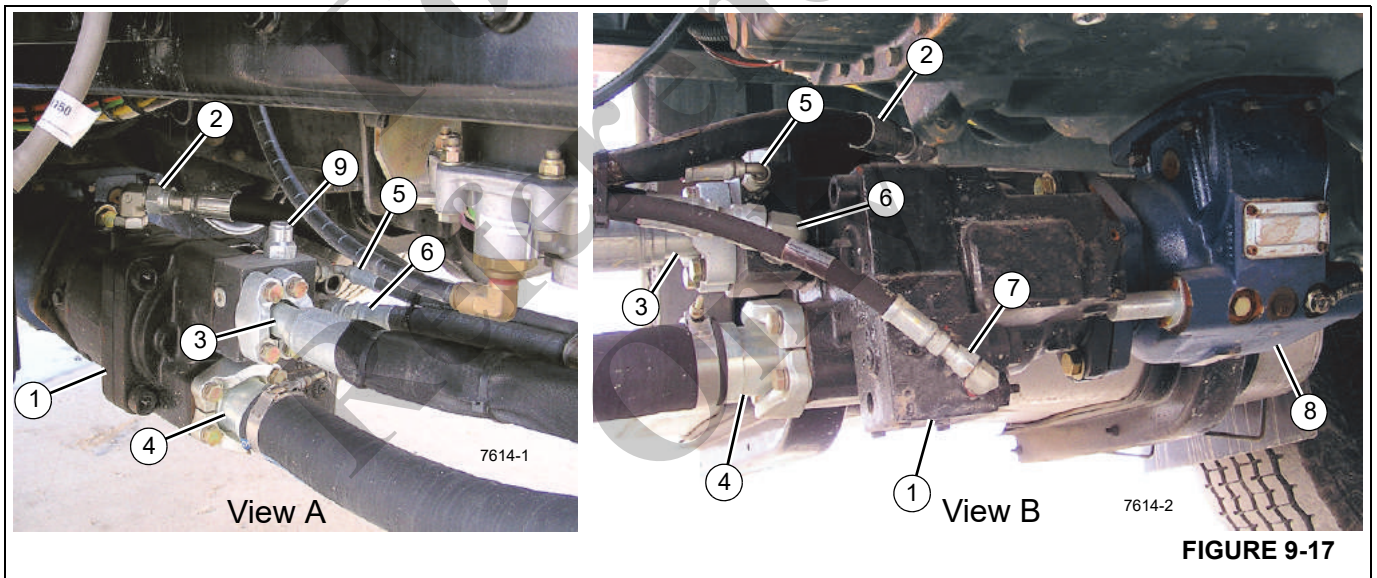


FIGURE 9-17

Item	Description
1	Hydraulic Pump
2	Case Drain Port
3	Hose - Swivel Port 3
4	Hose - Hydraulic Tank
5	Hose - Front O/R Valve, Port T
6	Hose - Front O/R Valve, Port P
7	Hose - Front O/R Valve, Port LS

Item	Description
8	Truck PTO
9	Outrigger Pressure-reducing Valve

**Initial Pump Start-up**

1. Fill the reservoir with the proper hydraulic oil to the high level mark on the reservoir sight gauge.
2. Verify that inlet valves are open to prevent cavitation or aeration of the hydraulic pump.
3. Pour hydraulic oil into the case drain port to fill the hydraulic pump housing. Reinstall the fitting and reconnect the case drain hose.

4. Fill the inlet line from the reservoir to the hydraulic pump. Check the line for properly tightened fittings to prevent air leaks.
5. Inspect the case drain hose for leaks.
6. Install a pressure gauge in the pressure port of the directional control valve (DCV).
7. While watching the pressure gauge, start the truck engine and idle until the gauge registers the pressure. System pressure must be within 51.7 bar to 55.1 bar (750 psi to 800 psi). If the hydraulic pump does not build pressure within this range, shut down the engine, and determine the cause.
8. If the system pressure is OK, operate the system under a light load five to ten minutes.
9. Verify or set the margin pressures. See “B. Pump Margin Pressure Setting” on page 2-27.
10. Verify or set the maximum system pressure. See “D. Setting Maximum Pump Pressure” on page 2-28.
11. Verify or set the load sense relief valve pressure. See “E. Load Sense Relief Valve (LSRV) Pressure Setting (Directional Control Valve)” on page 2-29.
12. Shut down the engine, relieve all hydraulic pressure, and remove the pressure gauge. Check the hydraulic oil level in the reservoir and fill if needed.

**INITIAL CRANE RUN IN PROCEDURE**

1. With the unit in an open area for testing that will permit full operation of all its functions, engage the PTO, start the truck from the crane cab, and program the RCL. Turn the crane power switch on and operate the crane and outriggers through 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 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 2200 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.
4. Lift and stability test must now be performed on the unit. (See “Stability Test” on page 9-36.) Hoist and crane tests should be conducted to ensure proper performance.

5. After testing is completed, the mounting bolts and all cable clamp bolts should be retorqued to specifications.
6. Upon completion, overall height of crane vehicle combination must be measured and posted inside of cab informing driver of overall height.

**STABILITY TEST**

The chassis weight before the crane is mounted is included for use only as a guide in determining the total weight required for the unit to be stable with an 85% tipping factor (i.e. when lifting capacity load, the crane 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 on a firm level surface. Provide cribbing under outrigger pads if they tend to sink when loaded.
2. With the boom in the rest, raise and level the machine up on the outriggers with all tires clear of the ground according to procedures outlined in the Operation Section. Set the single front outrigger (if equipped).
3. To determine if the machine is capable of lifting all stability loads with an 85% tipping factor, it is necessary to lift 1.176 times the rated load at the boom lengths and radii shown in Table 9-4, Table 9-5, and Table 9-6.

**NOTE:** Two test loads are required to ensure the crane is stable over both the sides and rear of the machine.

**NOTE:** Special care must be taken in performing the stability test if the crane is equipped with a jib extension. The stability test can be performed with or without the jib stowed on the side of the main boom.

Be sure to select the correct load capacity chart; the charts are titled—with stowed extension or without extension.

**Table 9-4 360° Full Span Stability Cases, No Jib**

Model	Boom Length meters (feet)	Loaded Radius meters (feet)
NBT60L w/151 ft Boom (w/ 0 lb CWT)	21.9 m (72 ft)	18.3 m (60 ft)
	32.91 m (108 ft)	16.8 m (55 ft)
	43.9 m (144 ft)	32.0 m (105 ft)
NBT60L w/151 ft Boom (w/ 3000 lb CWT)	21.9 m (72 ft)	18.3 m (60 ft)
	32.91 m (108 ft)	19.8 m (65 ft)
	40.2 m (132 ft)	33.5 m (110 ft)



Table 9-4 360° Full Span Stability Cases, No Jib

Model	Boom Length meters (feet)	Loaded Radius meters (feet)
NBT60L w/151 ft Boom (w/ 6000 lb CWT)	25.6 m (84 ft)	21.3 m (70 ft)
	36.6 m (120 ft)	27.4 m (90 ft)
	46.0 m (151 ft)	30.5 m (100 ft)
Note: Loads are all 360° load cases Cwt = Counterweight		

Table 9-5 Over the Rear, Full Span, No Jib

Model	Boom Length meters (feet)	Loaded Radius meters (feet)
NBT60L w/151 ft Boom (w/ 0 lb CWT)	25.6 m (84 ft)	21.3 m (70 ft)
	36.6 m (120 ft)	32.0 m (105 ft)
	45.7 m (150 ft)	29.0 m (95 ft)
NBT60L w/151 ft Boom (w/ 3000 lb CWT)	25.6 m (84 ft)	21.3 m (70 ft)
	32.91 m (120 ft)	32.0 m (105 ft)
	45.7 m (150 ft)	28.0 m (95 ft)
NBT60L w/151 ft Boom (w/ 6000 lb CWT)	25.6 m (84 ft)	21.3 m (70 ft)
	35.6 m (120 ft)	32.0 m (105 ft)
	45.7 m (150 ft)	38.1 m (125 ft)
Note: Loads are all 360° load cases Cwt = Counterweight		

Table 9-6 360°, Full Span Stability Cases with Jib

Model	Jib Length meters (feet)	Jib Offset	Boom Length meters (feet)	Loaded Radius meters (feet)
NBT60L w/151 ft Boom (w/ 6000 lb CWT and Lattice Jib)	11.3 m (37 ft)	0°	46.0 m (151 ft)	33.5 m (110 ft)
	11.3 m (37 ft)	30°	40.2 m (132 ft)	41.1 m (135 ft)
NBT60L w/151 ft Boom (w/ 6000 lb CWT and Tele Jib)	7.9 m (26 ft)	0°	46.0 m (151 ft)	29.0 m (95 ft)
	13.7 m (45 ft)	30°	46.0 m (151 ft)	442.7 m (140 ft)
Note: Loads are all 360° load cases Cwt = Counterweight				



Stability test conditions represents overloads at crane positions where boom weight and CG location make up a large portion of the overturning moment. Great care should be taken to control boom position and keep hook load close to the ground. Test loads should not be allowed to swing out past rated radius. If overturning caused by the load is allowed to start, and boom angle gets too low, boom weight may cause the unit to upset.

**NOTE:** Make sure the weights lifted are accurate. A 1% increase in load weight can result in a 10% increase in stability test weight required.

**NOTE:** The following stability test examples show boom length, radius and lift capacities; these numbers should be used for the following example stability test only. They are not meant to be and should not be used for this machine's stability test.

Always see the load capacity chart provided with your machine for boom length, radius, and capacity.

**NOTE:** If the NBT60L crane is equipped with a 11.3 m (37 ft) lattice jib or a 7.9–13.7 m (26 – 45 ft) telescopic jib, refer to the appropriate "jib stowed" load chart to get the rated 85% stability load and adjust by 1.176 as indicated.

**Example 1: NBT60L Without Jib**

- NBT60L 151 ft boom without jib, 6000 lb counterweights, Outriggers fully extended, capacity at:
  - Boom Length: 46.0 m (151 ft)
  - Radius: 30.5 m (100 ft)
  - Load: 1787.2 kg (3940 lb) per capacity chart
- Stability test load:
  - $1787.2 \text{ kg} \times 1.176 = 2101.7 \text{ kg}$  ( $3940 \text{ lb} \times 1.176 = 4633.4 \text{ lb}$ )

**Example 2: NBT60L Without Jib Over the Rear**

- NBT60L 151 ft boom without jib, 6000 lb counterweights, Outriggers fully extended, capacity at:
  - Boom Length: 65.3 m (144 ft)
  - Radius: 56.7 m (125 ft)
  - Load: 1179.3 kg (2600 lb) per capacity chart

- Stability test load:
  - $1179.3 \text{ kg} \times 1.176 = 1386.9 \text{ kg}$  ( $2600.0 \text{ lb} \times 1.176 = 3057.6 \text{ lb}$ )

### Example 3: NBT60L With Jib

- NBT60L 151 ft boom with lattice jib, 6000 lb counterweight, Outriggers fully extended, capacity at:
  - Boom Length: 40.2 m (132 ft)
  - Jib length: 11.3 m (37 ft)
  - Jib offset: 30°
  - Radius: 41.1 m (135 ft)
  - Load: 694.0 kg (1530 lb) per capacity chart
- Stability test load:
  - $694.0 \text{ kg} \times 1.176 = 816.1 \text{ kg}$  ( $1530 \text{ lb} \times 1.176 = 1799.3 \text{ lb}$ )

#### 4. Over the side:

- Assemble the first or third stability test load as described above near the crane.
- Measure the load radius from the center of rotation directly to one side of the machine.
- Extend the boom to the specified boom length.
- Lift the stability test load just slightly off the ground (not over 0.3 m [1 ft]).
- Slowly boom down while hoisting up to move the load out to the load radius.
- Move the load very slowly when approaching the load radius so the stability test load does not swing

out past the load radius. If the stability test load can be kept from contacting the ground at the load radius, the unit is stable over the side tested.

- Slowly rotate the load 360 degrees to ensure that the stability test load is stable directly over both sides, the back, and the front.

#### 5. Over the rear:

- Assemble the second or third stability test load as described above near the crane.
- Measure the load radius from the center of rotation directly to the rear of the machine.
- Extend the boom to the specified boom length and lift the stability test load just slightly off the ground (not over 0.3 m [1 ft]).
- Boom down while hoisting up to move the stability test load out to the load radius.
- Move the load very slowly when approaching the load radius so the stability test load does not swing out past the load radius. If the stability test load can be kept from contacting the ground at the load radius, the unit is stable over the rear of the unit.
- Slowly rotate the stability test load 360 degrees to ensure that the load is stable directly over both sides, the back, and the front.

#### 6. If the unit is unstable, the counterweight needs to be added.

- Add weight at the front bumper or at the front of the sub-base, if the crane is unstable over the rear.
- Add weight close to the centerline of rotation if the crane is unstable over the side.

**SPECIFICATIONS**

**Hydraulic**

Hydraulic Pump .....	286 l/min (75.5 gpm) at 2200 rpm, Variable displacement, axial piston with load sense
Pump Displacement .....	130 cc/rev (7.93 in <sup>3</sup> /rev)
Pump Max Pressure .....	338 bar (4900 psi)
Load Sense Relief Valve .....	332 bar ±3.45 (4663 psi ±50)
Pump Load Sense Margin .....	25 bar ±1.72 (363 psi ±25)
Required PTO Rating .....	156.5 kw (210 hp) at 2200 rpm
Boom Up .....	227.12 l/min at 296.5 bar (60 gpm at 4300 psi)
Boom Down .....	71.92 l/min at 172.4 bar (19 gpm at 2500 psi)
Outrigger Extend .....	206.84 bar (3000 psi)
Outrigger Retract .....	206.84 bar (3000 psi)
Telescope Extend .....	189.3 l/min at 124.11 bar (50 gpm at 1800 psi)
Telescope Retract .....	57.8 l/min at 206.84 bar (15 gpm at 3000 psi)
Swing .....	87 l/min at 210 bar (23 gpm at 3045 psi)
Swing Park Brake .....	Hydraulic released disc, released at 12 bar (175 psi)
Cab Air Conditioner .....	3.780 lpm at 259.9 bar (13 gpm at 3770 max psi)
Reservoir Capacity .....	598.1 l (158 gal)
Reservoir Return Filter .....	5 micron
Pump Suction Filter .....	250 micron
Cab Tilt Cylinder	
Operating Pressure (Maximum) .....	137.9 bar (2000 psi)
Single Front Outrigger (SFO) (if equipped)	
Operating Pressure (Maximum) .....	206.84 bar (3000 psi)

**Air Conditioner**

Air Conditioner Hydraulic System .....	3770 psi
Minimum Evacuation Time .....	30 minutes
Refrigerant Charge Levels .....	2.0 pounds (+/- 0.5 ounce)
Additional PAG Oil Required Above 6 ounces in Compressor	4.0 ounces

**Hoist System**

Wire Rope:	
Length .....	152 m (498.7 ft)
Diameter (Rotation Resistant) .....	16 mm (5/8 in)
Nominal Breaking Strength .....	25,592 kg (56,420 lb)
Maximum Line Pull (First Layer) .....	5240 kg (11,250 lb)
Synthetic Rope:	
Length .....	152 m (498.7 ft)
Diameter .....	18 mm (0.70 in)
Minimum Breaking Strength .....	28893.8 kg (63,700 lb)
Maximum Operating Pressure .....	310.2 bar (4500 psi)
Maximum Flow .....	132.5 l/min (35 gpm)
Gearbox Oil Capacity .....	5.44 l (5.75 qt)
Brake Oil Capacity .....	Shared with gearbox

Maximum Line Pull per Layer @ 310.2 bar (4500 psi)	
Layer	Low Speed KG (lb)
1	7824 (17250)
2	7008 (15450)
3	6350 (14000)
4	5801 (12790)
5	5343 (11780)

**Swing Gearbox**

Output Torque.....	6779.1 Nm (60,000 in-lbs)
Brake Release Pressure .....	12.1 bar (175 psi)
Brake Torque (Static and dynamic).....	350.3 Nm (3100 in-lbs)
Gearbox oil capacity .....	2.4 l (2.5 qt)

**Crane Operating Speeds**

(Performance based on full governed RPM and 100° F (37.8° C) hydraulic reservoir temperature.)

Rotation 360° .....	30 ±5 sec (1.8 ± 0.2 rpm) Adjustment Knob Closed
Boom up -10° to 80° .....	42 ±10 sec
Boom Down 80° to -10° .....	38 ±10 sec
Boom Extend/Retract Five Section	
Extend (Angle 60°) .....	180 ±30 sec
Retract (Angle 60°) .....	120 ±20 sec
Outrigger Beam Extend .....	10 ±3 sec
Outrigger Beam Retract .....	10 ±3 sec
Outrigger Jack Extend .....	10 ±3 sec
Outrigger Jack Retract .....	10 ±3 sec

**Counterweights**

**NBT60L/NTC60L**

Weight #1 .....	1,360 kg (3,000 lb)
Weight #2 .....	1,360 kg (3,000 lb)
Weight - Combined.....	2,720 kg (6,000 lb)

**Anemometer (Optional)**

Measurement Range .....	0 to 241.4 kph (0 to 150 mph)
Radio Range (clear line of sight) .....	1402.1 m (4600 ft)
Radio Frequency (FCC) .....	902 to 928 MHz
Battery	
Type .....	D Cell Lithium 3.6V or Alkaline 1.5V
Lithium Battery Life (Installed).....	4 years for 40 hr/week or 20 months for continuous use
Alkaline Battery Life .....	1 year for 40 hr/week or 6 months for continuous use
Gateway Router (Crane Cab)	
Frequency (FCC) .....	915 MHz

**Camera (Optional)**

**Monitor (Crane Cab)**

Input Voltage.....	12 volts to 60 volts (±10%)
Size .....	17.78 cm (7 inches)
Resolution .....	WVGA 800 x RGB x 480 Pixels

**Cameras (Hoist and Rear View)**

Power Input .....	12 to 24 V/DC
Video Signal .....	NTSC 720 (Hor) x 480 (Vert), 60 fields per second
View Angle (Hoist Camera) .....	80° (Horizontal)
View Angle (Rear View Camera) .....	170° (Horizontal)

**General**

Capacity NBT60L/NTC60L .....	54.4 metric tons (60 tons) at 1.8 m (6 ft) radius
Overall Length .....	12.6 m (41.42 ft)
Overall Width .....	2.6 m (101.6 in)
Overall Height.....	3.95 m (155.5 in)
Boom Length, 151 ft, 5 section .....	Retracted 11.3 m (37 ft), Extended 46.0 m (151 ft)
Jib Length (Telescoping 4-plate Construction).....	Retracted 7.9 m (26 ft), Extended 13.7 m (45 ft)
Jib Length (Fixed Length Lattice) .....	11.1 m (36.5 ft)
Jib Offset (Telescoping).....	0° and 30°
Jib Offset (Lattice) .....	0°, 15°, and 30°
Machine Weight (without Chassis/Jib) NBT60L/NTC60L .....	25,038.3 kg (55,200 lb)

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## 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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