

National Crane 900H

Service/Maintenance Manual



Grove

Manitowoc

National Crane

Potain





WARNING

California Proposition 65

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

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

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

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

California Spark Arrestor

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

The original language of this publication is English.

SERVICE MANUAL

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

900H

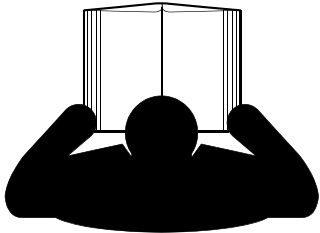
This Manual is Divided into the following Sections:

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

NOTICE

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

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



DANGER

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

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

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**For
Reference
Only**

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**SECTION 1
INTRODUCTION**

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GENERAL

This manual has been compiled to assist you in properly operating and maintaining your Model 900H Series 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.

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

Information in 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 RCL system installed on the crane, see the manufacturer’s manual supplied with the crane. Manufacturers of rated capacity limiters may refer to them in their manuals as a load moment indicator (LMI) or a hydraulic capacity alert system (HCAS); National Crane refers to these systems as a rated capacity limiter (RCL) throughout its *Operator* and *Service Manuals*.)

This 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.



FIGURE 1-1

National Crane and our Dealer Network want to ensure your satisfaction with our products and customer support. Your local dealer 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 dealer's service management to coordinate the contact on your behalf.

Service and Repair

Service and repairs to the crane must only be performed by a qualified person. All service and repairs must be performed in accordance with manufacturer's recommendations, this manual, and the Operator Manual for this machine. All replacement parts must be approved by Manitowoc Crane Care.

Any modification, alteration, or change to a crane which affects its original design and is not authorized and approved by Manitowoc Crane Care is **STRICTLY PROHIBITED**. Such action invalidates all warranties and makes the owner/user liable for any resultant accidents.

Before performing any maintenance, service or repairs on the crane:

- The boom should be fully retracted and lowered and the load placed on the ground.
- Stop the engine and disconnect the battery.
- Controls should be properly tagged-out. Never operate the crane if it is tagged-out nor attempt to do so until it is restored to proper operating condition and all tags have been removed by the person(s) who installed them.

Recognize and avoid pinch-points while performing maintenance. Stay clear of sheave wheels and holes in crane booms.

After maintenance or repairs:

- Replace all guards and covers that have been removed.
- Remove all tags, connect the battery, and perform a function check of all operating controls.
- Perform load tests when a structural or lifting member is involved in a repair.

Supplemental Information

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

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

A 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 crane is purchased new. Additional copies are available from your National Crane distributor.

New Owner

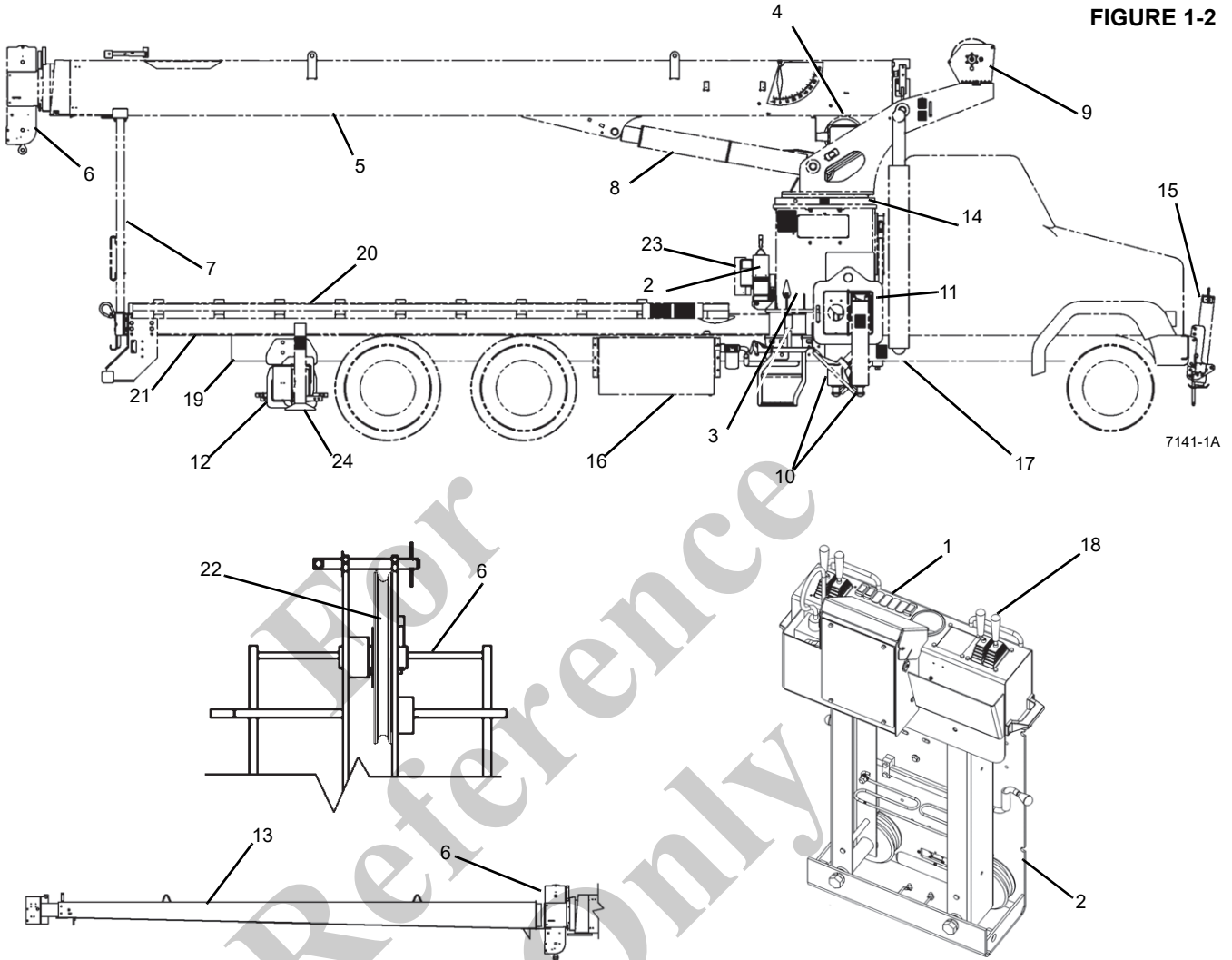
If you are the new owner of a National crane, please register it with Manitowoc Crane Care so we have the ability to contact you if the need arises.

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

Basic Nomenclature

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

FIGURE 1-2



Item	Component
1	Operator's Console
2	EasyReach™ Pedestal
3	Operators Station
4	Load Moment Indicator (RCL) Reel
5	Boom
6	Boom Nose
7	Boom Rest
8	Lift Cylinder
9	Hoist
10	Outrigger Beam
11	Outrigger Box
12	Rear Stabilizer Out and Down (RSOD)
13	Extension
14	Turret
15	Stabilizer Front Outrigger (SFO), Front Outrigger Jack

Item	Component
16	Hydraulic Tank
17	Hydraulic Pump
18	Hydraulic Remote Controller (HRC)
19	Truck Frame
20	Truck Bed
21	Torsion Box, T-Box
22	Sheave
23	Bulkhead
24	RSOD Foot

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.

CAUTION

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

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

Disassembly and Assembly

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

Pressing Parts

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

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

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

Locks

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

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

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

Shims

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

Hoses and Tubes

⚠ DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Inspection

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

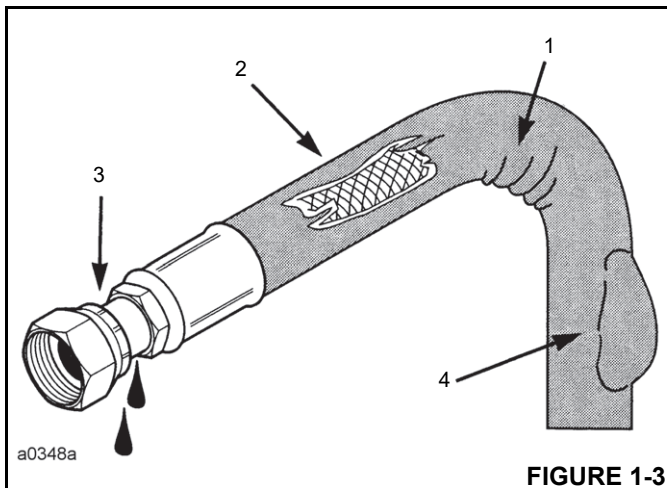
Tighten all connections to recommended torque.

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

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

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

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



Installation

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

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

Bearings

Antifriction Bearings

When an 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 show signs of heat damage. If the bearing is serviceable, coat it with oil and wrap it in clean waxed paper. Do not unwrap new bearings until time of installation. The life of an antifriction bearing will be shortened if not properly lubricated. Dirt in an antifriction bearing can cause the bearing to lock resulting in the shaft turning in the inner race or the outer race turning within the cage.

Double Row, Tapered Roller

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

Heating Bearings

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

Installation

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

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

Preload

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

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

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

Sleeve Bearings

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

Gaskets

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

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

Batteries

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

If the machine is to be stored or not used for an extended period of time, the batteries should be removed. Store the

batteries in a cool (not subfreezing), dry place, preferably on wooden shelves. Never store on concrete. A small charge should be introduced periodically to keep the specific gravity rating at recommended level.

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 1-6.

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.

Hydraulic Systems

DANGER

High Pressure/Temperature Hazard!

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

Hydraulic oil is hot, it can cause severe burns.

Pressurized hydraulic oil can cause death or serious injury.

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

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

Cleanliness

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

Keep the System Clean

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

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

Disassemble and assemble hydraulic components on a clean surface.

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

Sealing Elements

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

Hydraulic Lines

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

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

Visual Inspection of Hoses and Fittings

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

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

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

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

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

If any of these conditions exist, address them appropriately.

3. All hydraulic hose assemblies are recommended to be replaced after 8000 hours of service life.

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

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

6. Hydraulic hose assemblies operating in climate zones "D" and "E" should expect a degradation of mechanical properties such as elasticity, therefore, it is recommended these hoses be inspected and addressed accordingly.

Hydraulic Fittings

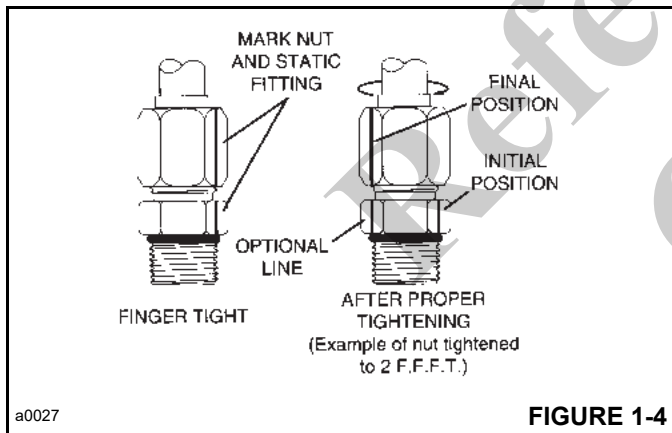
Flats from Finger Tight (F.F.F.T.) Method

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 over-tightening.

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

Follow these steps when tightening all fitting connections:

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



5. Tighten the joint by the number of flats as specified in Table 1-1 and 1-2 for size and type of fitting.
6. Optionally for future tightening of the same connection: extend the line from the nut at its new location onto the hex of the static fitting or port (Figure 1-4).

37° Flared Steel Fitting: Tube or Hose to Fitting

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

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

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

T-2-5

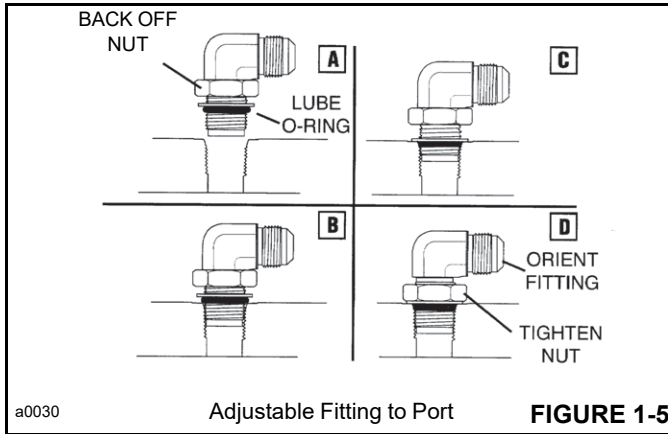
Adjustable Straight Thread O-ring Fittings

Refer to Figure 1-5 and Table 1-2 for the following procedure.

Table 1-2: Adjustable Straight Thread O-ring Fittings

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

1-2-6

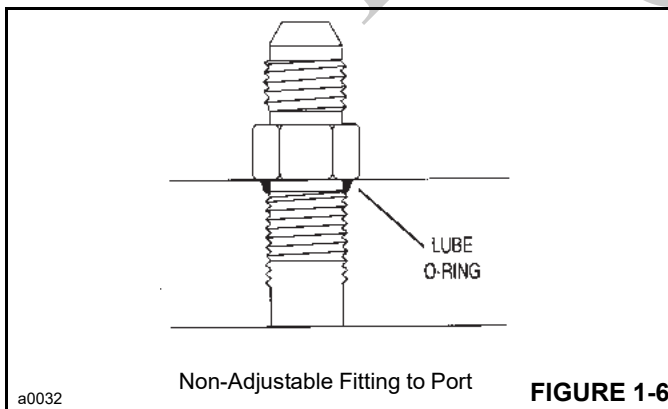


1. Inspect both mating parts for burrs, nicks, scratches, or foreign particles.
2. Lubricate O-ring with a light coat of clean oil.
3. Back off locknut as far as possible (A).
4. Screw the fitting into port by hand until the backup washer contacts the face of the port and is pushed all the way towards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

Nonadjustable Straight Thread O-ring Fitting: Fitting to Port

Refer to Table 1-3 for the following procedure.

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



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

Table 1-3: Straight Thread Fittings

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

Electrical System

Harnesses, Wires, and Connectors

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

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

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

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

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

Dielectric Grease

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

- All Deutsch Connectors

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

Excluded Connections

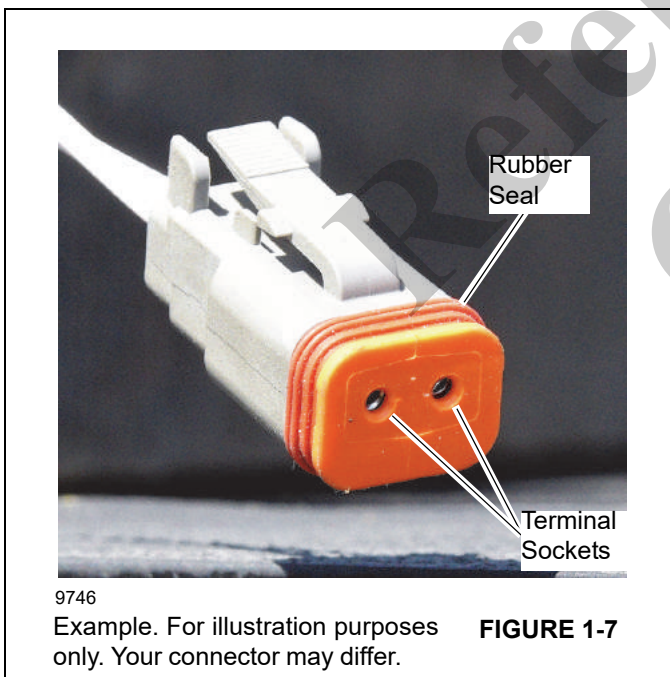
Do not apply dielectric grease to the following connections:

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

Applying Dielectric Grease to an Electrical Connector

Use the following procedure to apply dielectric grease to an electrical connection. Grease should be applied immediately prior to securing the connector. Ensure that grease is applied to all terminal sockets (Figure 1-7).

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.



4. Use a clean towel to remove excess grease from the surface of the connector, and wipe grease into the terminal sockets (Figure 1-7).

5. Ensure grease is applied to each terminal socket. The towel with excess grease can be used to fill empty terminal sockets (Figure 1-7).

6. Ensure grease is applied to the entire surface of the connector's rubber seal (Figure 1-7).

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

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

8. Secure the connector when complete.

Fatigue of Welded Structures

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

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

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

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

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

Loctite

⚠ CAUTION

Skin and/or Eye Hazard!

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

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

Application of Medium Strength Loctite

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

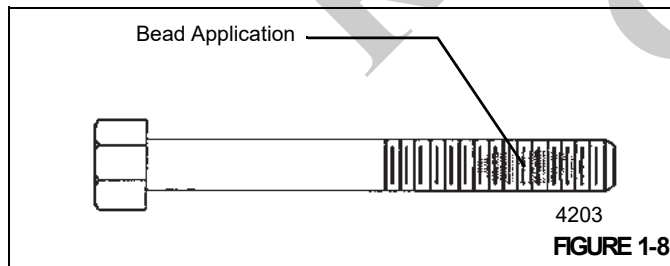
The following procedure covers the proper application and curing method for medium strength Loctite adhesive/sealant (Loctite #242) and primer (Loctite Primer T7471).

Primer Application

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

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

Adhesive/Sealant Application



1. Apply a bead perpendicular to the thread, several threads wide, in the approximate area of threaded engagement (see Figure 1-1).
2. In a blind hole application, a bead of several drops of adhesive should be applied into the bottom of the hole to be hydraulically forced up during engagement.
3. After application and engagement of mated threads, fixturing will occur within five (5) minutes if primed prior to engagement. Fixturing may take up to 30 minutes on unprimed parts.

4. Time required to achieve full strength is 24 hours. Maximum ultimate strength is achieved using no primer with this specific threadlocking adhesive.

Fasteners and Torque Values

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

Torque values should correspond to the type 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.

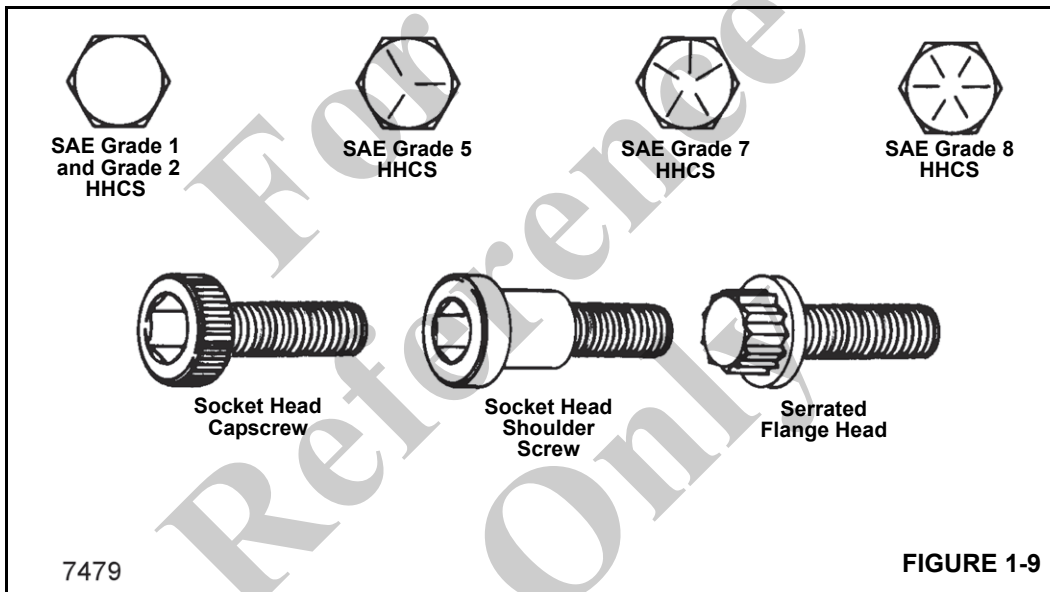


Table 1-4 Inch Series with Coarse Threads (UNC) – Zinc Flake Coated

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
1/4-20 UNC	5	6.6	6.4	6.2
	8	9.3	9.0	8.8
5/16-18 UNC	5	13.5	13.2	12.8
	8	19.1	18.6	18.1
3/8-16 UNC	5	24.0	23.4	22.8
	8	33.9	33.1	32.2
7/16-14 UNC	5	38.4	37.4	36.5
	8	54.3	52.9	51.5

Table 1-4 Inch Series with Coarse Threads (UNC) – Zinc Flake Coated (Continued)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
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 1-5 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

Table 1-5 Inch Series with Fine Threads (UNF) – Zinc Flake Coated (Continued)

Nominal Size, Threads per Inch, and Series Designation	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
5/8-18 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 1-6 Metric Series with Coarse Threads – Zinc Flake Coated

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

Table 1-6 Metric Series with Coarse Threads – Zinc Flake Coated (Continued)

Nominal Size, Threads per millimeter, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
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
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 1-7 Metric Series with Fine Threads – Zinc Flake Coated

Nominal Size, Threads per millimeter, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M8x1.0	8.8	21.6	21.1	20.5
	10.9	31.7	30.9	30.1
	12.9	37.1	36.2	35.3

Table 1-7 Metric Series with Fine Threads – Zinc Flake Coated (Continued)

Nominal Size, Threads per millimeter, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
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
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

Table 1-7 Metric Series with Fine Threads – Zinc Flake Coated (Continued)

Nominal Size, Threads per millimeter, and Series Designation	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
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 1-8 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 1-9 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	-

Table 1-9 Inch Series Screws of STAINLESS STEEL 300 (18-8) with Coarse Threads (Continued)

Size	Torque	
	lb-in	lb-ft
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 1-10 Inch Series Bearing Bolts – Untreated (black finish)

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

Table 1-11 Metric Series Bearing Bolts– Untreated (black finish)

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

Table 1-12 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

Table 1-12 Inch Series with Coarse Threads (UNC) – Untreated (black finish) (Continued)

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

Table 1-13 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

Table 1-13 Inch Series with Fine Threads (UNF) – Untreated (black finish) (Continued)

Size	Grade	Torque (ft/lb)		
		Maximum	Nominal	Minimum
9/16-18	5	126	121	116
	8	177	170	163
5/8-18	5	182	174.5	167
	8	250	240	230
3/4-16	5	312	299.5	287
	8	425	409	393
7/8-14	5	458	439.5	421
	8	672	646	620
1-12	5	658	632	606
	8	1009	970	931
1-14	5	670	644.5	619
	8	945	908.5	872
1 1/8-12	5	882	848	814
	8	1500	1440	1380
1 1/4-12	5	1251	1203	1155
	8	2092	2008.5	1925
1 3/8-12	5	1704	1638	1572
	8	2833	2719	2605
1 1/2-12	5	2288	2196.5	2105
	8	3640	3500	3360

Table 1-14 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

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

Size	Property Class	Torque (Nm)		
		Maximum	Nominal	Minimum
M10x1.5	8.8	53	51	49
	10.9	75	72	69
	12.9	89	86	83
M12x1.75	8.8	93	89	85
	10.9	130	125	120
	12.9	156	150	144
M14x2	8.8	148	142	136
	10.9	212	203.5	195
	12.9	248	238	228
M16x2	8.8	230	221	212
	10.9	322	310	298
	12.9	387	372	357
M18x2.5	8.8	319	306.5	294
	10.9	455	436.5	418
	12.9	532	511	490
M20x2.5	8.8	447	430	413
	10.9	629	605	581
	12.9	756	727	698
M22x2.5	8.8	608	585	562
	10.9	856	823	790
	12.9	1029	989	949
M24x3	8.8	774	744	714
	10.9	1089	1047	1005
	12.9	1306	1256	1206
M27x3	8.8	1134	1090	1046
	10.9	1591	1530	1469
	12.9	1910	1836.5	1763
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 1-15 Metric Series with Fine Threads – Untreated (black finish)

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

Table 1-15 Metric Series with Fine Threads – Untreated (black finish) (Continued)

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

Weld Studs

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

Table 1-16: Weld Stud Torque Values

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

T-2-4

WIRE ROPE

General

The following information includes inspection, replacement, and maintenance guidelines for wire rope as established by ANSI/ASME B30.5, federal regulations, and National Crane specifications. The inspection interval shall be determined by a qualified person and shall be based on expected rope life as determined by experience, severity of environment, percentage of capacity lifts, frequency of operation, and

exposure to shock loads. Periodic inspections need not be at equal calendar intervals and should be performed at shorter time intervals as the wire rope approaches the end of its useful life. A periodic inspection shall be performed at least once a year. The following information contains inspection and maintenance procedures for wire ropes used on National products as load lines, hoisting cables, boom extension and retraction cables, pendant cables, and hook block tie down cables.

Environmental Conditions

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

Dynamic Shock Loads

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

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

Lubrication

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

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

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

Remove dirt from the rope before applying lubrication. Use a stiff wire brush and solvent, compressed air, or live steam to clean the rope. Lubricate the rope immediately after cleaning. Methods of lubrication are bath, dripping, pouring, swabbing, painting, or pressure spray (Figure 1-10). 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.

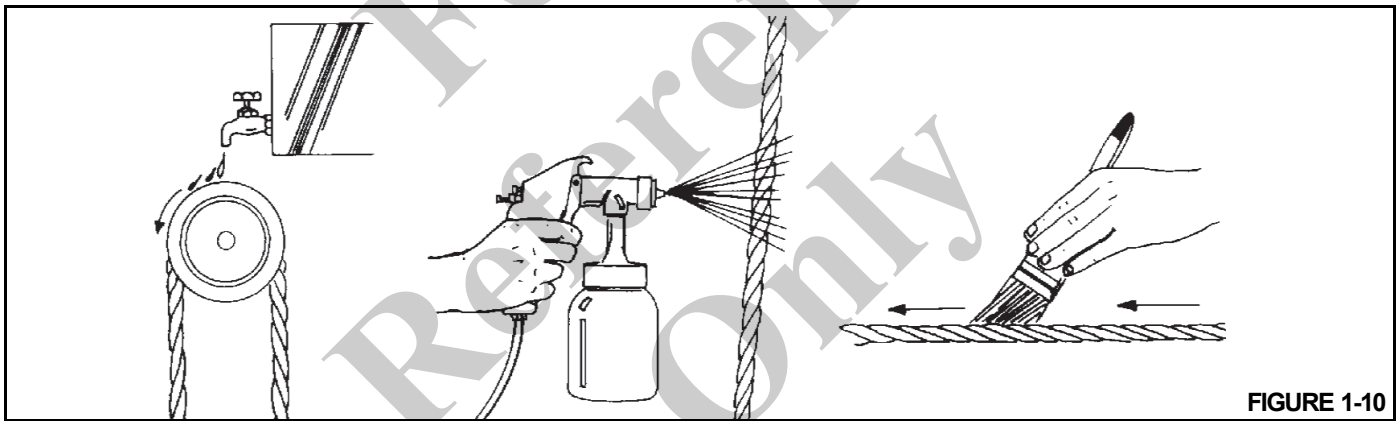


FIGURE 1-10

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.

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.
- Significant corrosion.
- Broken or cut strands.
- Number, distribution and type of broken wires.
- Evidence of core failure.
- Significantly corroded, cracked, bent, or worn end connections.
- Improperly applied end connections.

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.
 - 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 Extension sheaves, auxiliary boom nose sheaves, and hoist drums for wear. Damaged sheaves or hoist drums can accelerate wear and cause rapid deterioration of the wire rope.

Boom Extension and Retraction Cables

Periodic Inspection

Do a periodic inspection of the total length of all boom extension and retraction cables. Use this inspection to monitor degradation and identify damage that requires wire rope replacement or equipment repair. Inspect the rope 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 1-11).

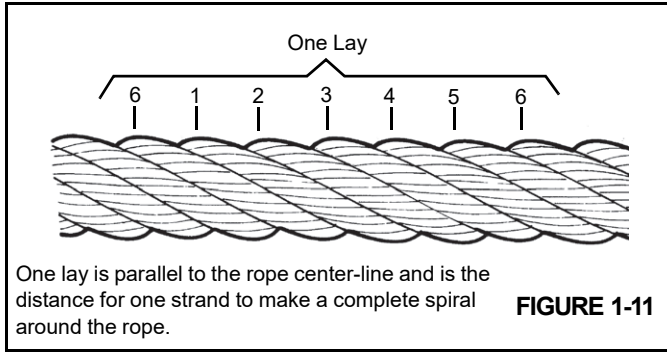


FIGURE 1-11

- 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.
- Severe corrosion as evidenced by pitting.
- Reductions from nominal diameter of more than 5%.
- In standing ropes, more than two broken wires in one lay in sections beyond end connections or more than one broken wire at an end connection.
- In rotation resistant rope, two randomly distributed broken wires in six rope diameters or four randomly distributed broken wires in 30 rope diameters.
- 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 1-12).

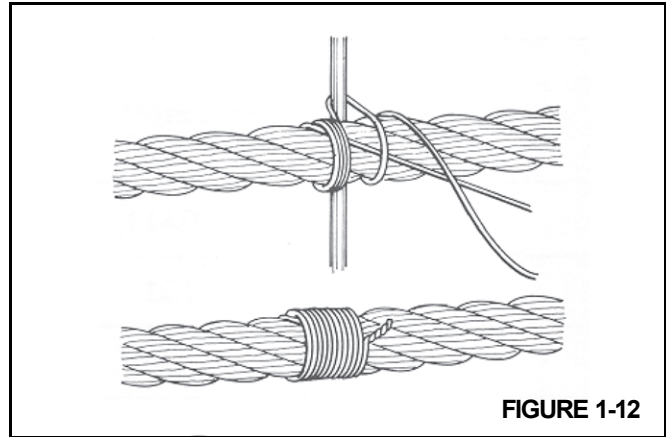


FIGURE 1-12

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 1-13).

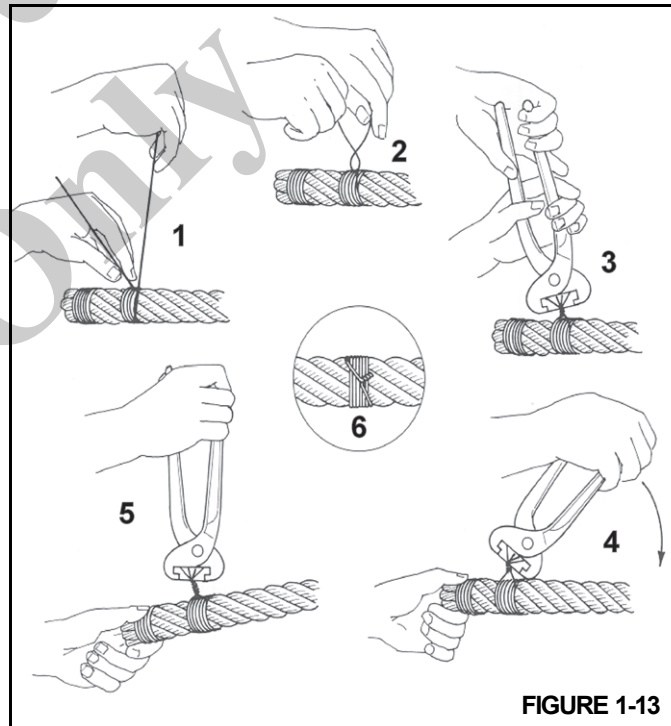


FIGURE 1-13

NOTE: Non-preformed wire rope should have two seizings located on each side of the cut (Figure 1-14).

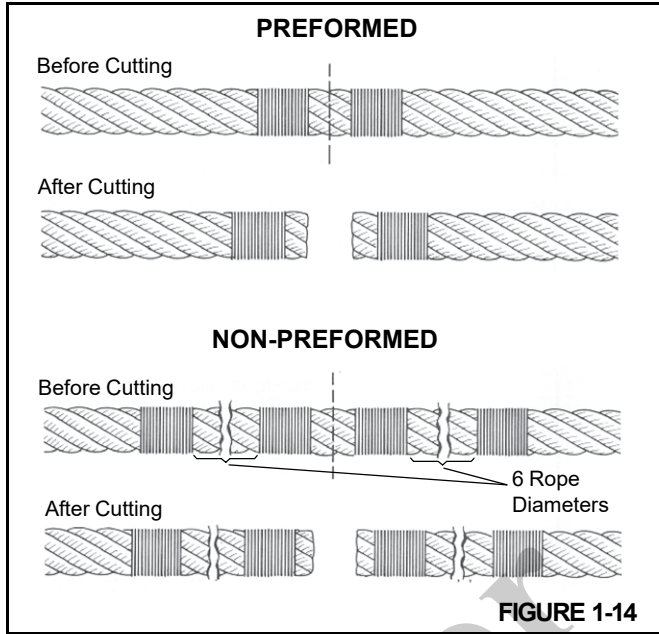


FIGURE 1-14

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SECTION 2 HYDRAULIC SYSTEM

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INTRODUCTION

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

Hydraulic System General Overview

A hydraulic system uses liquid to make a transfer of force. Any force on a confined liquid is applied to any point in the system that the liquid reaches. Oil is used as the hydraulic liquid for this system because the liquid must be a lubricant for the components of the system.

There are several main components in a hydraulic system. Each component has a specific function in the system.

The **pump** moves the oil through the system. It is important to remember that the pump causes the flow, not the pressure in the system. Pressure is caused by resistance to the flow. This resistance can be **external** (for example, a load on a

cylinder or motor), or **internal** (the resistance of the components of the system). Pressure increases as the resistance to the flow increases. The pump will continue to push more oil into the system until the resistance is overcome or the relief valve opens (fixed displacement pumps) or the pump compensator setting is reached (variable displacement pumps).

Valves are used to control the flow, pressure, direction, and volume of the oil in the system. There are many different types of valves. An explanation of the different valves used on this machine is given in the description of each circuit.

Filters remove dirt and particles of foreign materials from the oil in the system. The oil in the system must be kept clean to inhibit damage to the pumps, cylinders, valves, and other components of the system.

Motors and Cylinders are the actuators or working tools of the system. In the motors and cylinders, hydraulic energy is changed into mechanical force (rotary or straight line movement).

The **Hydraulic Oil Tank** has three important functions: storage, cooling, and supply of oil to the pumps. Because piston rods take space in the cylinders, the level of the oil in the tank will be higher when all the cylinders are retracted.

To understand how a hydraulic system works, it is important to understand the following words:

Flow - The flow through the system is caused by the pump. The amount of fluid which is sent to a circuit or actuator generally controls the speed of that function. The flow is measured in gallons per minute (gpm) or liters per minute (L/min).

Pressure - is caused by any resistance to the flow of the oil. Pressure is normally measured in pounds per square inch (psi) or kilopascals (kPa). There are four general types of pressure.

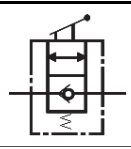
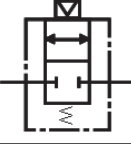
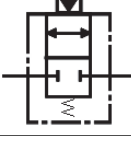
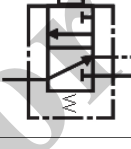
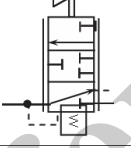
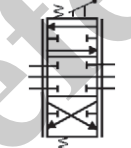
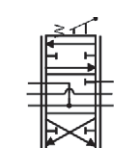
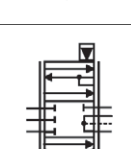
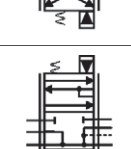
1. **High Pressure**, which is normally the result of an external load on the system.
2. **Low Pressure**, normally the result of the internal resistance of the components in the system.
3. **Static Pressure**, where the oil is closed in a circuit between two components. There is no movement of the oil, but there is pressure on the oil, normally because there is an external load on the circuit.
4. **Series Pressure**, which is found where oil is confined between two components in a series arrangement, for example when the rod port of one cylinder is connected to the base port of another cylinder. Movement of either cylinder will cause movement in the other cylinder.


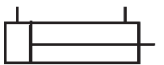
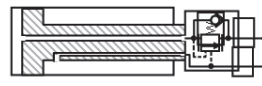
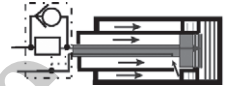

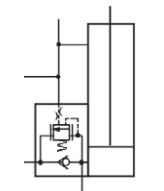
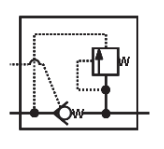
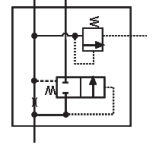
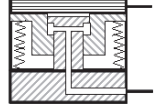
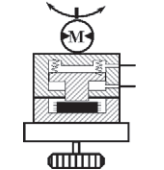
HYDRAULIC SYMBOLS

The following pages show basic hydraulic symbols as used on the schematics.

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 Stabilizer - Extends the barrel down to raise the crane off the ground.	
Holding Valve - Keeps boom lift cylinder from collapse if hydraulic pressure failure occurs (i.e. hose rupture).	
Pilot Operated Check Valve (with thermal relief) - Requires pilot pressure to unseat the one way check (nonadjustable).	
Flow Divider Valve - Regulates flow to a selected circuit.	
Hoist Brake - Holds load after control is returned to neutral (spring applied and hydraulically released).	
Swing Brake - Spring applied hydraulically brake holds superstructure in place.	

MAINTENANCE

Preparation

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

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

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

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

Maintenance, adjustments and repairs shall be done only by designated personnel who are properly trained. Use only 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 hoses so they do not rub the machine or another hose and has a minimum of bending and twisting. Tighten bolts in both couplings.

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

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

Label Parts when Disassembling

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

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

Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to *Lubrication*, page 8-1.

Parts Replacement

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

Visual Inspection of Hoses and Fittings

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

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

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

If any of these conditions exist, address them appropriately.

3. Hydraulic hose assemblies operating in climate zone are recommended to be replaced after 8000 hours of service life.
4. Hydraulic hose assemblies operating in climate zones "A" or "B" with high ambient temperatures, could see hose service life reduced by 40% - 50%. Therefore, it is recommended to replace these hoses after 4000 - 5000 hours of service life.
5. Hydraulic hoses assemblies operating in climate zones "D" and "E" cold climates should expect a degrade of mechanical properties such as elasticity. Therefore it is recommended that these hoses be inspected and address correctly.

Table 2-1 Climate Zones

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

Troubleshooting Aids

1. **Hydraulic schematics** - an exact illustration of the arrangement of the system. The schematic shows all the components in relation to the system. The ability to understand the schematic is important to good troubleshooting. The schematic can be found at the end of this section.
2. **Flowmeter** - an instrument that can be connected into the system to measure the flow of the oil in the system. The flow is measured in gallons per minute (gpm) or liters per minute (Lpm). Normally, the flowmeter is used to check the output of the pump. The flow meter can also

be used to find the location of leakage or restriction in the system. Instructions for installation of the flow meter and the use of the flowmeter are normally included with the flowmeter.

3. **Pressure Gauge** - an instrument for measurement of the pressure in the system. This indication is normally given in pounds per square inch (psi) or kilopascals (kPa). On this machine, quick couplers are installed in the pressure lines from the pumps. Pressure taken at these locations will give an indication of operating pressure or relief pressure.

Troubleshooting Procedures

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

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

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

Remember:

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

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

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

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

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

General Hydraulic System Troubleshooting

Table 2-2

Symptom	Possible Cause	Remedy
Noise (above normal)	Air in system. Low oil supply. Restriction in pump inlet line. Dirty oil. Loose clamps, vibration of hydraulic lines. Dirt or foreign material in a relief valve. Broken control valve spool. Pump bearings worn.	With engine at low rpm, operate all control functions several times to return the air to atmosphere through the tank breather. Add recommended oil. Remove and clean inlet line to pump. Change oil and filters. See Section 3. Check and tighten. Clean or replace the relief valve. Replace the control valve section. Replace the bearings or pump.
Slow operating speeds (All functions)	Low engine rpm. Air leak in pump inlet line. Air in oil (foam in tank). Leakage in the load sense relief valve. Improper load sense relief valve setting. Leakage in hydraulic swivel. Control valve not fully actuated. Improper primary pump pressure. Faulty pump.	Increase engine rpm. Tighten pump inlet line. Replace O-ring inlet flange. Check oil level, look for leaks in the system. Remove and clean or replace the relief valve. Check and adjust relief valve setting. See "Hydraulic Pump" on page 2-11. Replace seals on swivel shaft. Check spool travel. Check and adjust pump pressure settings. See "Hydraulic Pump" on page 2-11. Overhaul or replace pump.
No movement when system is first started.	Low oil level. Air or restriction in inlet line to pump. Cold oil or wrong weight of oil.	Check and add oil. Check and tighten inlet line. Clear restriction. Use correct oil, follow manual warming procedure.
Loss of movement during operation.	Low oil level. Vacuum in hydraulic tank. Restriction or leakage in the relief valve. Broken hydraulic line. Bad seal in hydraulic swivel. Broken gear or shaft in pump.	Check and add oil. Clean tank filler/breather cap. Clean or replace the relief valve. Replace. Replace seals. Overhaul or replace.



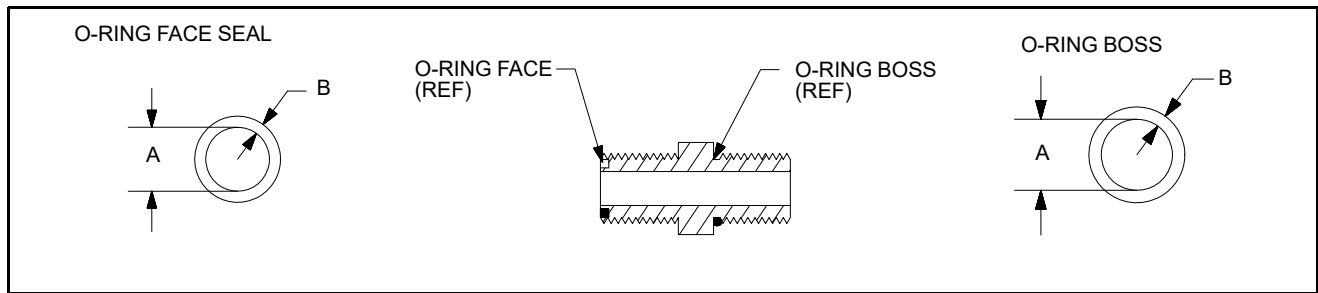
Symptom	Possible Cause	Remedy
Overheating of hydraulic oil	Wrong operation (running over the load sense relief pressure setting for long periods). Dirty filters. Oil too light. Low oil level. Dirty oil.	Change procedure of operation. Change filter. See Section 3. Use correct oil. Check and add oil. Change oil and filters. See Section 3.
Foam in hydraulic tank	Leak in system. Wrong type of oil. Low oil level. Bad seal in pump, motor or cylinder.	Check O-ring on pump inlet. Check for leak in system and correct. Use correct oil. Check and add oil. Overhaul or replace.
Short life of pump bearings, shafts, etc.	Dirt in oil. Wrong type of oil.	Change oil and filter more frequently. Use correct oil.
Pump leakage (external)	Bad seal pump shaft. Bad seals between pump sections (Swing & Steering).	Replace shaft seal. Replace seals.
Difficult to engage valve spools	Restriction in pilot lines. Dirt or foreign material between valve spool and valve bore. Pilot pressure too low. Broken spring (spool return). Distortion or damage to valve spool.	Check and correct. Remove and clean valve spool and bore. Faulty pressure reducing valve. Replace. Replace spring. Replace valve section.

Reference Only!

PARTS REPLACEMENT

Manitowoc Crane Care Parts Catalog for proper replacement parts.

Parts found damaged or out of tolerance when maintenance is being performed need to be replaced. Refer to the



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

NOTE: Contact your National Crane Distributor or Manitowoc Crane Care for O-Ring boss seal kits.

SERVICE

Hydraulic Oil Recommendations

For the hydraulic oil specifications, refer to Section 9 - 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 stabilizer cylinders and activate the cylinders to their maximum down positions.
11. Connect the return lines and raise the outrigger stabilizer 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. 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 (milkiness) may occur.

When hydraulic oils are changed, recheck the reservoir hydraulic oil level after brief system operation and add hydraulic oil as required. Working reservoir capacity (capacity to full mark) is 73 U.S. gallons (276 liters). Ensure the crane is level and in the travel mode of operation when the hydraulic system is being filled. The system must be filled

with all cylinders retracted. Fill the reservoir to the full mark on the reservoir sight gauge. After the reservoir is filled, operate all circuits and recheck the reservoir sight gauge. Add hydraulic oil as required.

Removing Air from the Hydraulic System

Air entering the hydraulic oil is normally removed by baffles in the hydraulic reservoir. If a component has been replaced, the reservoir 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 2 - 4 psi (13.8 - 27.6 kPa) 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.

WARNING

Tipping Hazard!

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 a cylinder.

**WARNING****High Pressure Hazard!**

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

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

- 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.

**WARNING****High Pressure Hazard!**

Do not attempt to loosen fittings in pressurized lines or while the hydraulic pumps are in operation. Serious injury or death may result

- In the event that trapped air persists, bleed off the air by loosening various clamp and screw type fittings.
- If the above procedures fail to eliminate trapped air, contact your authorized National Crane Distributor.

HYDRAULIC PUMP

The axial piston hydraulic pump 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.

Load Sense Control

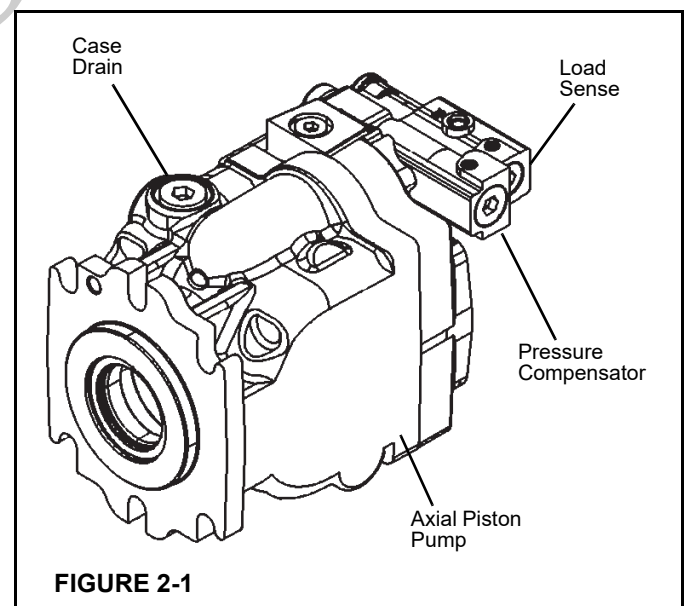
The Load Sense (LS) control matches pump flow with system demand. The LS control senses the flow demand of the system as a pressure drop across an External Control Valve (ECV). As the ECV opens and closes, the pressure delta across the valve changes. Opening the ECV decreases the delta and closing the 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.

System Circuit Flow

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) in the EasyReach pedestal. 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) 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.

**FIGURE 2-1**

VALVES

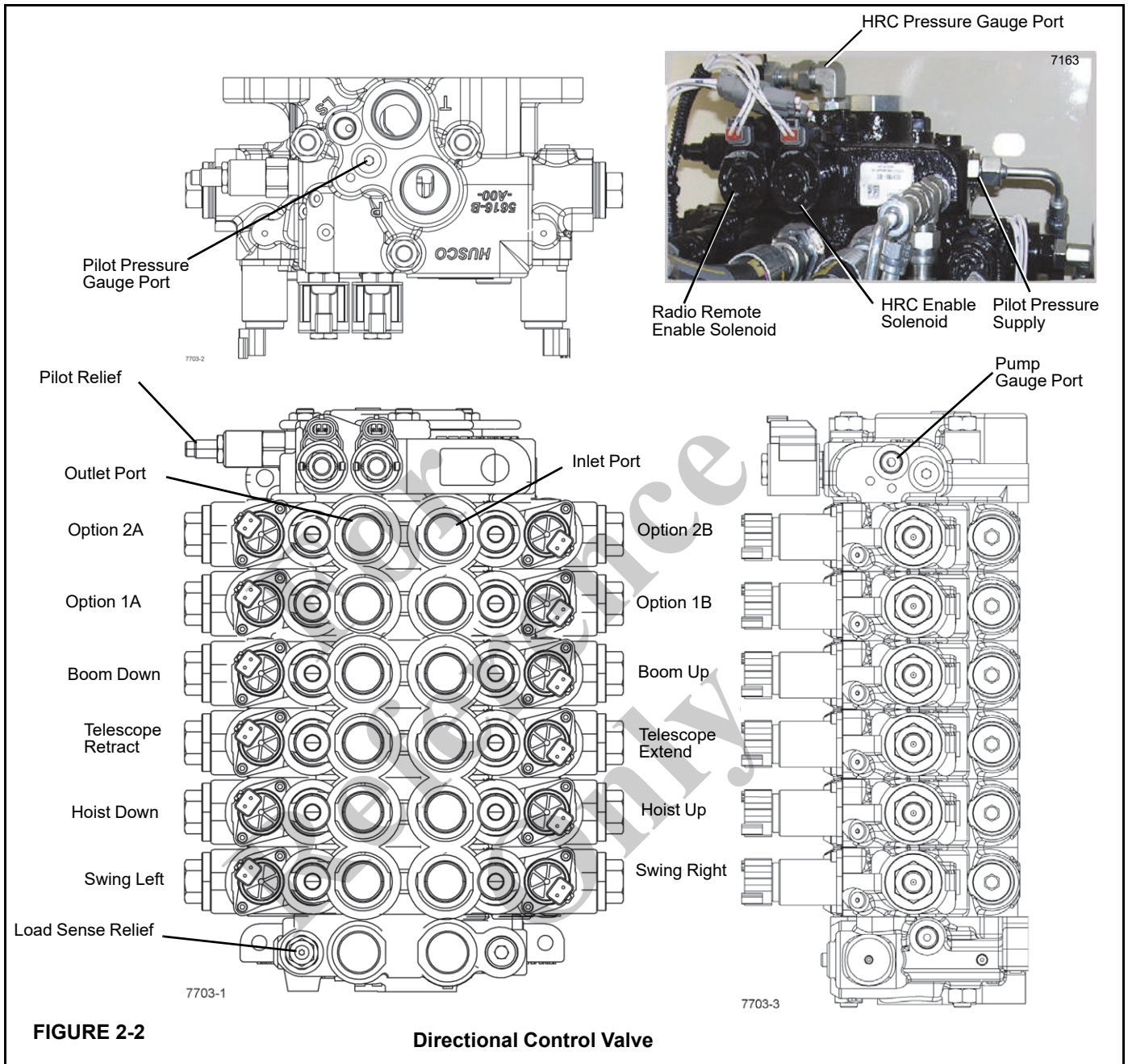
General

This subsection provides descriptive information for all the hydraulic valves used on this crane. For a listing of all valves,

the circuit they are used in, and their physical location, refer to the table on page 2-12. The description of each valve given here is for the valve itself. For information on how each valve functions in the individual circuits, refer to the description and operation procedures of that circuit.

Valve Name	Circuit Used In	Physical Location
Directional Control Valve	Boom Lift, Telescope, and Swing	Mounted on back of EasyReach pedestal.
Hydraulic Remote Controllers (HRC)	Boom Lift, Telescope, Hoist(s) and Swing	EasyReach Console
Holding Valves	Boom Lift, Telescope, Hoist and Outriggers	Port block on cylinder
Hoist Motor Counter Balance Valve	Hoist	On hoist motor
Front Outrigger Selector and Control Manifold	Outrigger	Manifold on front outrigger box.
RSOD Control Manifold	Outrigger	Manifold above rear outrigger box.
Pilot Operated Check valve	Outriggers	Port block of each stabilizer cylinder (4)
Swing Counterbalance and Speed Flow Valves	Swing	On swing motor
High Speed Hoist Control Solenoid	Hoist	On hoist motor
Front center stabilizer relief valve	Outrigger	On SFO

For Reference Only



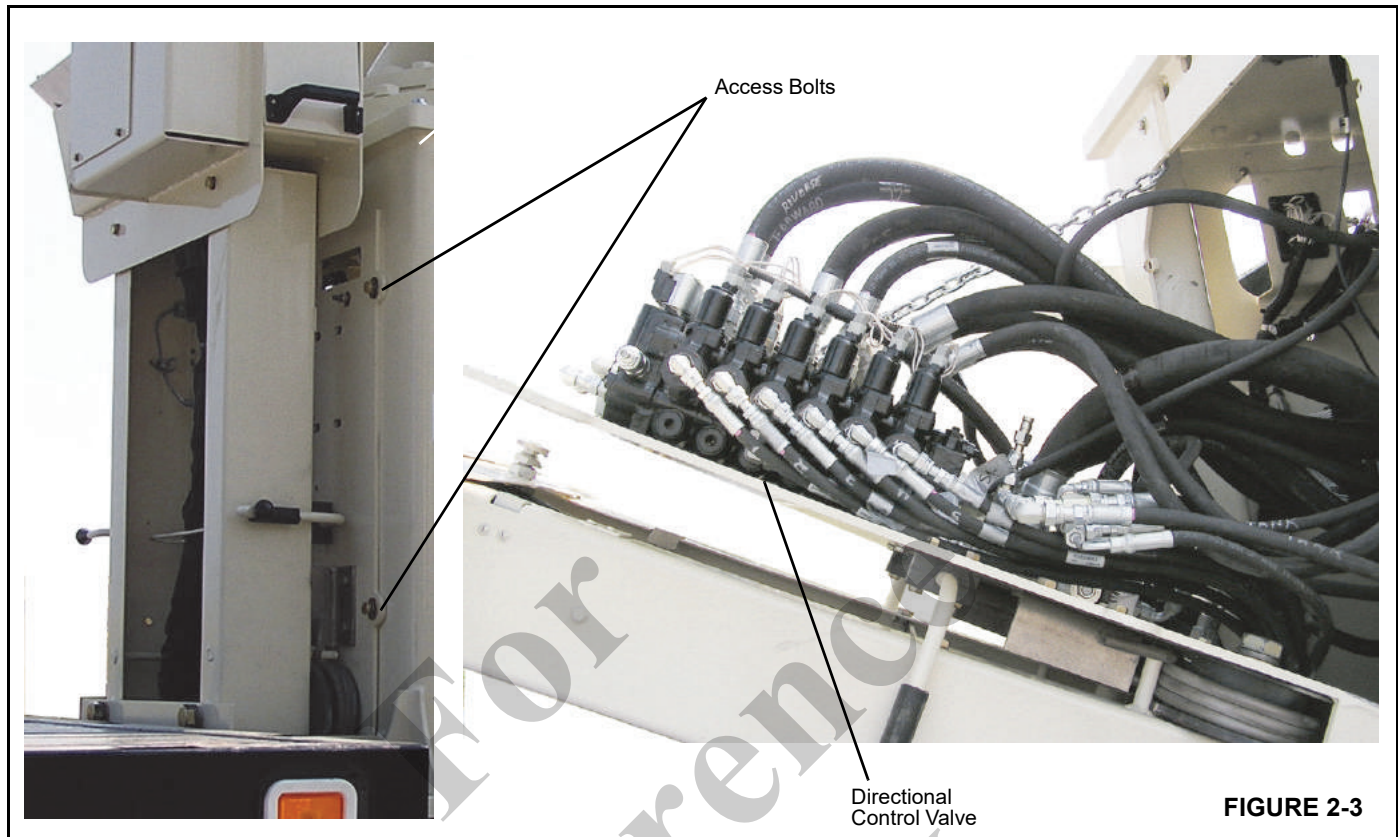


FIGURE 2-3

DIRECTIONAL CONTROL VALVE

Description

The directional control valve (Figure 2-2 and 2-3) is located in the crane frame behind the EasyReach pedestal. To gain access to the directional control valve, remove the access bolts and lower the EasyReach pedestal.

Control of crane functions is accomplished with pilot pressure from Hydraulic Remote Controllers (HRC) or radio remotes with control solenoids that are integral to the valve.

When the crane function power switch is turned on:

- the HRC enable solenoid on the directional control valve (Figure 2-2) is energized.
- all solenoid valves on each valve section are energized. This closes the solenoid valves.

NOTE: The normal (de-energized) position of the solenoid valves on the valve sections is open. If crane power is lost, the solenoid valves open and control of crane functions with the HRC's is disabled.

Energizing the HRC enable solenoid opens pilot pressure to the valve sections. With the solenoid valves on each valve section closed, pilot pressure is allowed to build for HRC operation.

When the Radio Remote switch is turned on:

- the radio remote enable solenoid is energized.
- all solenoid valves on each section act as proportional control valves.

This allows control of crane functions with the radio remote transmitter.

NOTE: 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 HRC and radio remote controls.

RELIEF PRESSURES

Description

Relief valves protect hydraulic systems from over pressurization and ensure the components get the proper pressure and flow. The relief valves for the swing and telescope circuits are integral to the directional control valve and are not adjustable. The hoist and lift circuits are set to the load sense relief valve pressure.

All relief valves are preset at the factory. Certain relief valves can be adjusted and certain valves are not adjustable, see the following table for pressure settings and adjustability.

Maintenance

Relief pressures are checked by causing a given circuit to reach its pressure limit (stall). At the stall point the relief valve opens and the hydraulic oil is returned to the reservoir. Hydraulic circuits can be stalled by plugging the work hoses to the motor or cylinder prior to actuating the control valve. A pressure gauge placed in the proper line shows the pressure that the relief valve opens. Release the control lever after taking each reading.

It is only necessary to hold hydraulic pressure long enough (usually a few seconds) in the circuit to gain an accurate reading. Do not overload the hydraulic circuits for long periods of time.

Use an accurate 0 to 5000 psi (0 to 34,500 kPa) pressure gauge when adjusting relief valves. To adjust a relief valve, turn the adjustment screw (in to increase or out to decrease) until the proper setting is reached. Reservoir oil temperature is to be 140° - 160°F (60° - 71°C).



Hydraulic Circuit	Pressure PSI (MPa)	Tolerance PSI (kPa)	Location
Telescope In Relief (Not Adjustable)	2975 (20.5)	+100/-50 (±344)	Directional Control Valve (Preset)
Telescope Out Relief (Not Adjustable)	2850 (19.65)	+100/-50 (±344)	Directional Control Valve (Preset)
Hydraulic Remote Controller Pilot	360 (2.48)	+100/-0 (+689/-0)	Directional Control Valve
Outrigger Circuit Maximum Pressure	3000 (20.68)	±50 (±344)	Relief Valve On Pump
Outrigger Circuit Beam Extension	1000 (6.89)	±50 (±344)	Front Outrigger Control Manifold
Swing Circuit (Not Adjustable)	2975 (20.5)	+100/-50 (±344)	Directional Control Valve (Preset)
Load Sense Relief	3650 (25.17)	±25 (±172)	Relief Valve On Pump
Load Sense Standby	360 (2.48)	±25 (±172)	Relief Valve On Pump
Boom Down Circuit	3000 (20.68)	±50 (±344)	Relief Valve On Pump

CHECKING RELIEF PRESSURE

CAUTION

Do not hold the relief valve open for more than one minute at a time. Damage to the hydraulic system may result.

Preparation

- Start and warm up the engine until the hydraulic oil temperature reaches a minimum of 140° - 160°F (60° - 71°C).
- Shut down the engine.



WARNING

High Pressure Hazard!

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

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

Hoist and Boom Lift

Relief pressure for both the hoist and boom lift hydraulic circuits is controlled by the load sense relief valve located on

the directional control valve (Figure 2-2); this relief valve is not adjustable.

The load sense relief and maximum pressure can be check by performing the following steps.

1. Install a hydraulic pressure gauge to the pump gauge port on the directional control valve (Figure 2-2).
2. Idle machine with PTO engaged. Bottom out the lift cylinder so that boom is at -10°. With the cylinder at full retraction, continue to hold the lever in the boom down position, verify that the maximum pump pressure is at the correct setting (see table above).
3. If maximum pressure is not correct; adjust the pressure compensating control on the piston pump (see Figure 2-17).
4. Shut down the engine.
5. Remove the pressure gauge and plug the pump gauge port.

Telescope In and Telescope Out Reliefs

The telescope relief pressures are preset and not adjustable. To check the telescope relief pressures do the following:

1. Remove the extend and retract (work port) hoses from the telescope cylinder (Figure 2-4) and cap the telescope adapters.

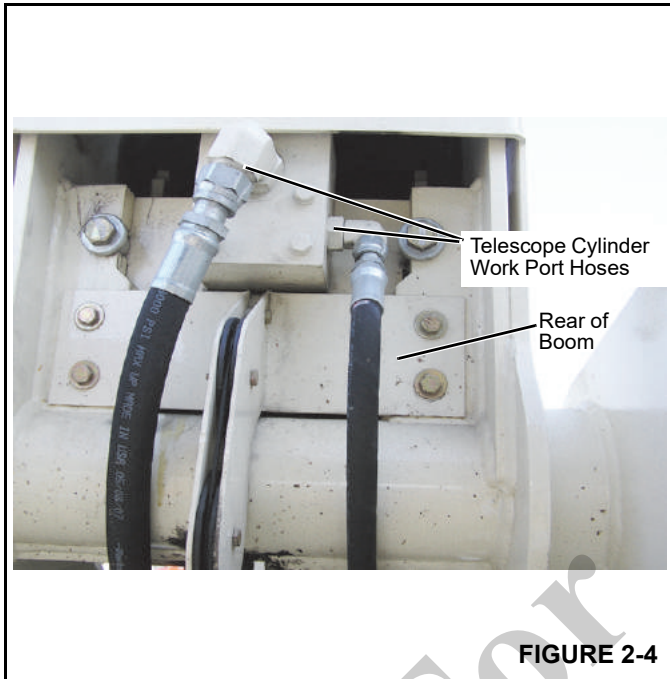


FIGURE 2-4

2. Attach a pressure gauge to the telescope extend hose and plug the telescope retract hose.

NOTE: Install a gauge in each line, in turn, and check the extend and retract pressures as described below with telescope control lever.

3. Start the engine and set the throttle to governed rpm.
4. Push the telescope control lever to extend.
5. Relief pressure should be 2850 psi (19.65 MPa).
6. Shut down the engine.
7. Move the gauge to the retract line and plug the extend line.
8. Start the engine.
9. Pull the telescope control lever to retract.
10. Relief pressure should be 2975 psi (20.5 MPa).
11. Shut down the engine.
12. Remove the pressure gauge and plug from the hoses.
13. Reconnect the telescope cylinder hoses.

Swing

The swing relief is preset and not adjustable. To check the swing relief pressure do the following:

1. Disconnect the work port hoses at the swing motor.
2. Connect a pressure gauge to one line and plug the other.

3. Start the engine and set to governed rpm.
4. Activate the swing control lever. The relief should read 2975 psi (+100/-50 psi) (20511 kPa (+689/-344 kPa)).
5. The relief valves are in the directional control valve and are preset.

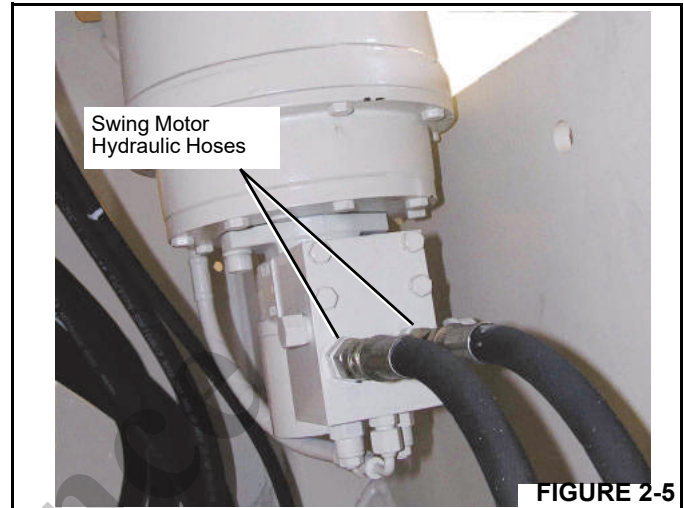


FIGURE 2-5

Outriggers Maximum Pressure

1. Select a front outrigger and remove the retract line from the outrigger extend cylinder.
2. Install a pressure gauge in the retract line (Figure 2-8).
3. Start the engine and set the throttle to governed rpm.
4. Activate the retract function for the selected outrigger. Adjust the relief pressure to 3000 (+100/-0) psi (20684 +689/-0 kPa). The relief valve for the outrigger circuit is located on the pump manifold (Figure 2-6).

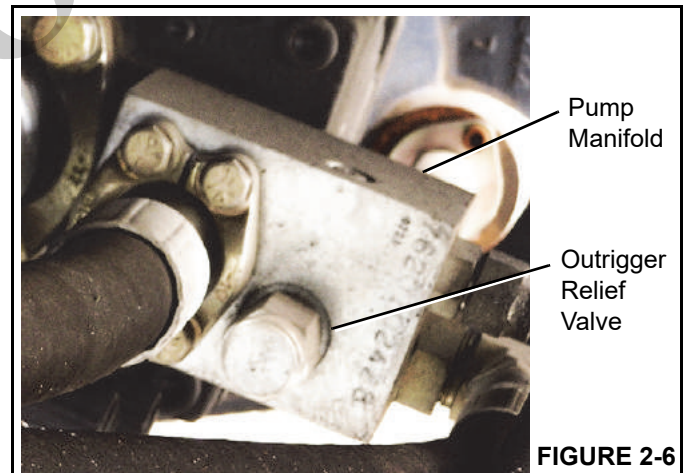


FIGURE 2-6

5. Shutdown the engine and disconnect the pressure gauge and reconnect the stabilizer retract line.

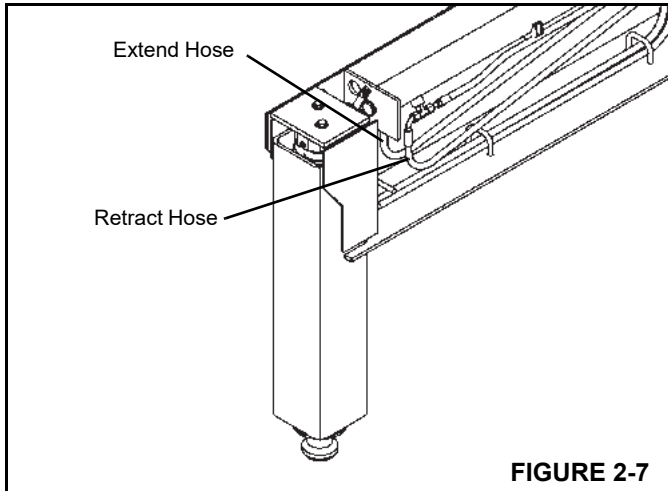


FIGURE 2-7

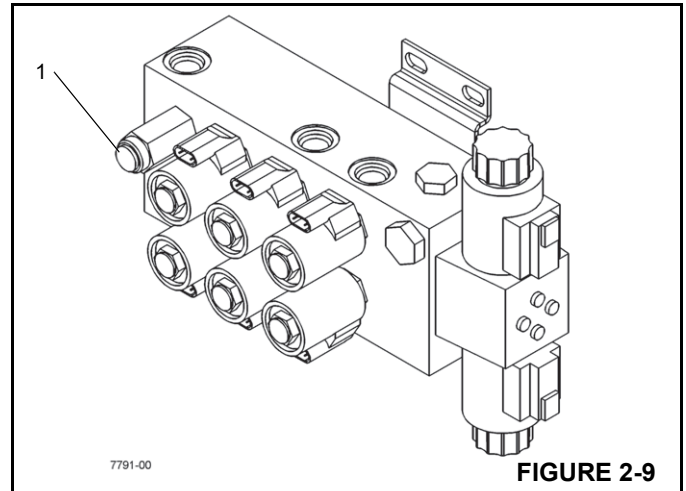


FIGURE 2-9

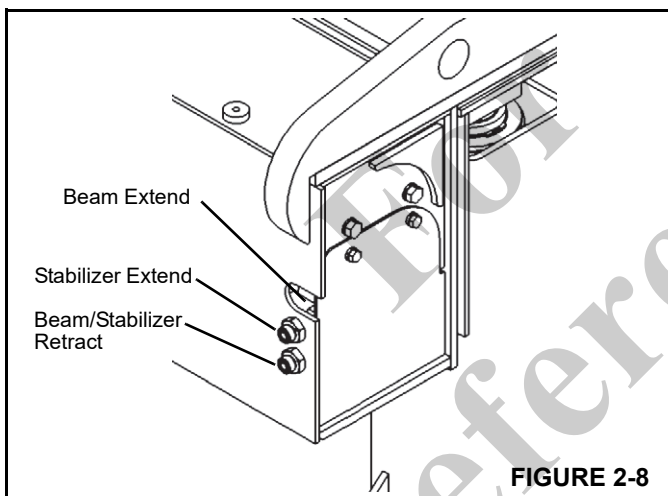


FIGURE 2-8

Single Front Outrigger (SFO)

1. Disconnect the single front outrigger extend and retract lines (Figure 2-10). Cap the retract line and install a gauge in the extend line.
2. Start engine and set at governed rpm.
3. Depress the SFO extend/retract switch to extend.
4. Adjust the extend relief valve on the SFO port block to 500 psi +100/-0 (3447 kPa +689/-0).
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 SFO port block to 1750 psi +100/-0 (12065 kPa +689/-0)
8. Shutdown the engine, remove the gauge and cap, and reconnect the SFO hydraulic lines.

Outriggers Beam Extend

1. Select an outrigger and remove the extend line from the outrigger extend cylinder.
2. Install a pressure gauge in the extend line (Figure 2-8).
3. Start the engine and set the throttle to governed rpm.
4. Activate the extend function for the selected outrigger. Verify the relief pressure is 1000 (+50/-0) psi (6895 +345/-0 kPa). The relief valve (1) for the outrigger circuit is located on the front outrigger control manifold, Figure 2-9. Remove the cap on the relief valve to access the adjustment screw.
5. Shutdown the engine and disconnect the pressure gauge and reconnect the stabilizer extend line.

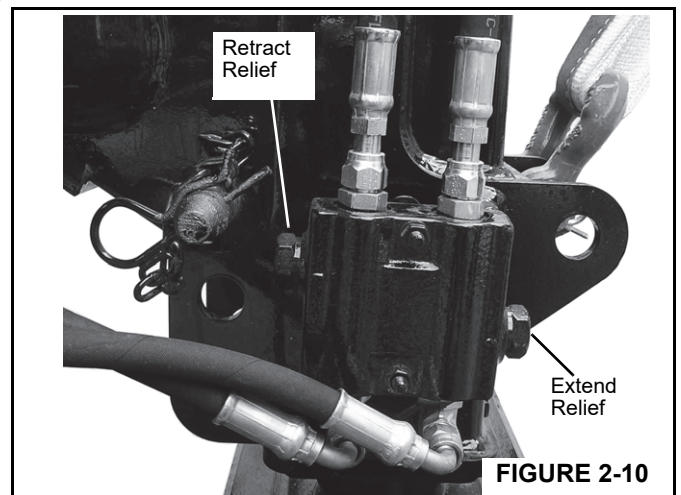


FIGURE 2-10

Hydraulic Remote Control Pressure Setting

Check the hydraulic remote control (HRC) pressure with the crane function power switch and the optional radio remote switch off. To check the pressure do the following:

1. Connect a pressure gauge to the HRC gauge port on the DCV.
2. Start the truck engine from the crane.
3. Check the pressure reading on the gauge.
4. Adjust the HRC relief valve.

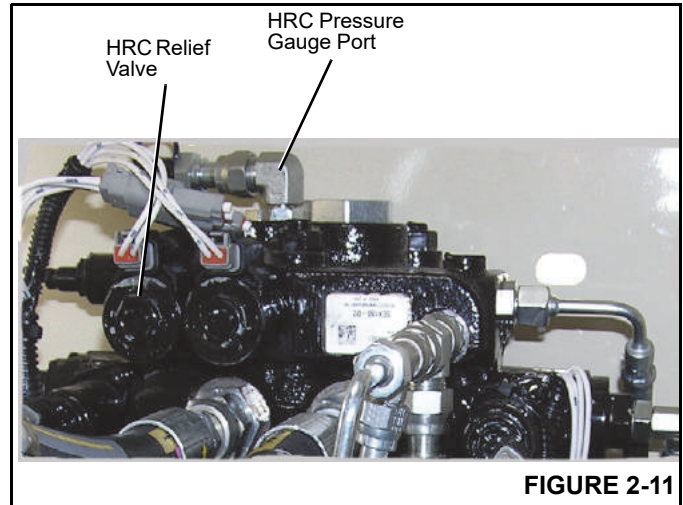


FIGURE 2-11

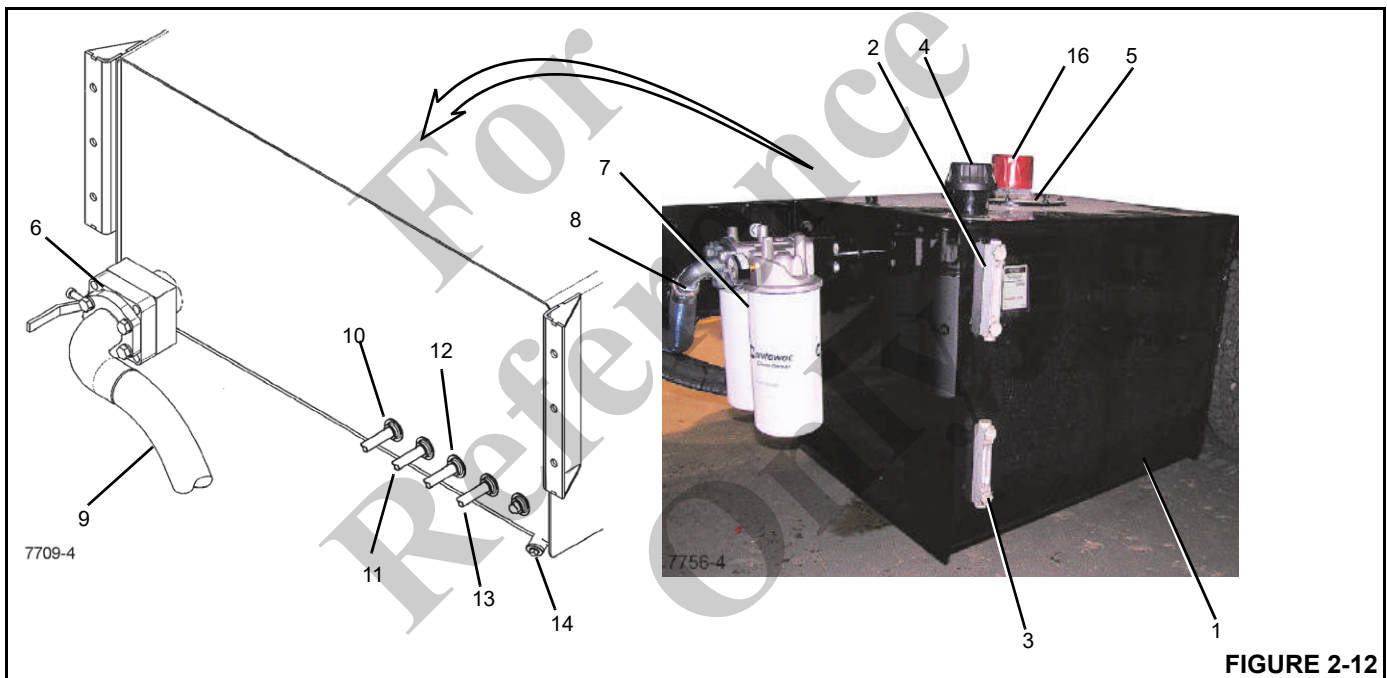


FIGURE 2-12

Item	Component
1	Hydraulic Reservoir
2	Hydraulic Oil Level Gauge
3	Hydraulic Temperature Gauge
4	Fill Cap
5	Access Cover
6	Shutoff Valve
7	Spin-on Filters
8	Return Line

Item	Component
9	Suction Line
10	Sump Line from Directional Control Valve
11	Pump Manifold Case Drain
12	Outrigger Return
13	Case Drain from Pump
14	Drain Plug
15	Temperature Sensor
16	Breather

SUPPLY CIRCUIT

Description

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 optional hydraulic oil cooler.

Hydraulic Reservoir and Filter

The reservoir, (Figure 2-12) is attached to the left side of the truck underneath the bed and has a capacity of 73 U.S. gallons (276.3 liters) to the full mark. The all-steel reservoir has two spin-on full flow filter mounted on the front of the tank. Internal baffles help cool the hydraulic oil and prevent foaming.

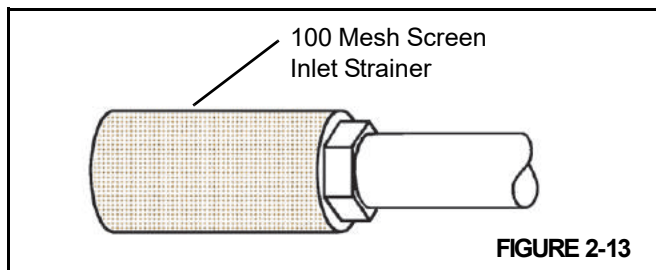
Hydraulic oil flows through the suction line at the lower rear of the reservoir to the hydraulic pump. Most of the return flow goes through the spin-on filter at the front of the reservoir. Return lines (10,11,12,13 Figure 2-12) go directly into the reservoir instead of through the filter.

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

A 100 mesh screen inlet strainer (Figure 2-13) is located in the hydraulic tank to help protect the pump from contamination.

A filler cap on the top of the reservoir is for filling the reservoir. The filler cap includes a strainer for catching contaminants and gaskets to prevent leaking. The breather (vent) 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 side of the reservoir to indicate hydraulic oil level.



A large access cover on the top of the reservoir provides access for cleaning. The cover is secured to the top of the reservoir with screws and has a gasket to prevent leaking. The access hole can also be used to fill the reservoir after it has been completely drained.

The dual spin-on hydraulic oil filters (Figure 2-12) are located on the front of the reservoir and are replaceable.

Hydraulic Filter Replacement

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

Element Removal

WARNING

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

1. Shut down the hydraulic system.
2. Wipe any dirt from the filter head.
3. Place a container underneath the filters to catch spilled oil, unscrew and remove each filter.
4. Install the new filters.
5. Properly discard the used filters.

Hydraulic Oil Cooler (Option)

An optional hydraulic oil cooler can be installed at the rear of the frame (Figure 2-14). The oil cooler return circuit is in parallel with the reservoir return circuit and a 30 psi (206 kPa) 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.

The oil cooler is energized by R3 relay and is in line with fuse F5. The relay and fuse are located in the micro fuse box in the crane frame. A temperature switch located in the cooling core energizes the fan relay when the oil temperature reaches 120°F (48.8 °C).

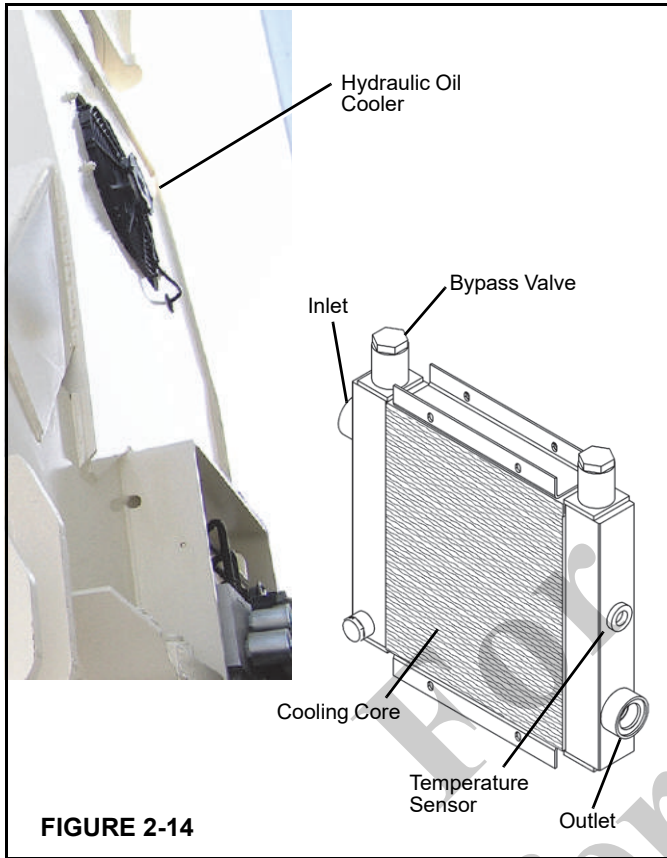


FIGURE 2-14

Oil Cooler Service & 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 and tightening of hose clamp line connections will eliminate the possibility of end connection failure due to back pressure from cold startup.

If cooler system fails to provide adequate performance, reduced air or oil flow through the heat exchanger is the probable cause. The cooling fan should be inspected for proper operation. Any obstructions to air flow should be corrected (cooler too close to other truck components, foreign matter in heat exchanger fins, etc.). All hydraulic lines should be periodically checked for obstructions, hose kinks or other flow restrictions.

Hydraulic Valves

Directional Control Valve Manifold

The Directional Control Valve Manifold (DCV) controls the hoist, swing, lift cylinder, telescope cylinder and options, when installed. The valve is located behind the EasyReach pedestal.

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 a check 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 such adjustments are needed.

Directional Control Valve Manifold

Removal

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

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. Check for smooth operation of cylinders and motors.
3. Check the valve bank and lines for leakage. Make repairs as needed.

Hydraulic Remote Controllers

The crane functions are controlled by hydraulic remote controllers (HRC) on the operator's console. The hand controllers operate from a low pressure pilot circuit which is generated and controlled by the directional control valve (DCV). Low pressure is applied to the bonnets on each side of the control valve spools to shift the spool in the required direction.

Outrigger Manifolds

The outrigger circuits are controlled by two manifolds located at 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 switches on the outrigger control box.

Holding Valves

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

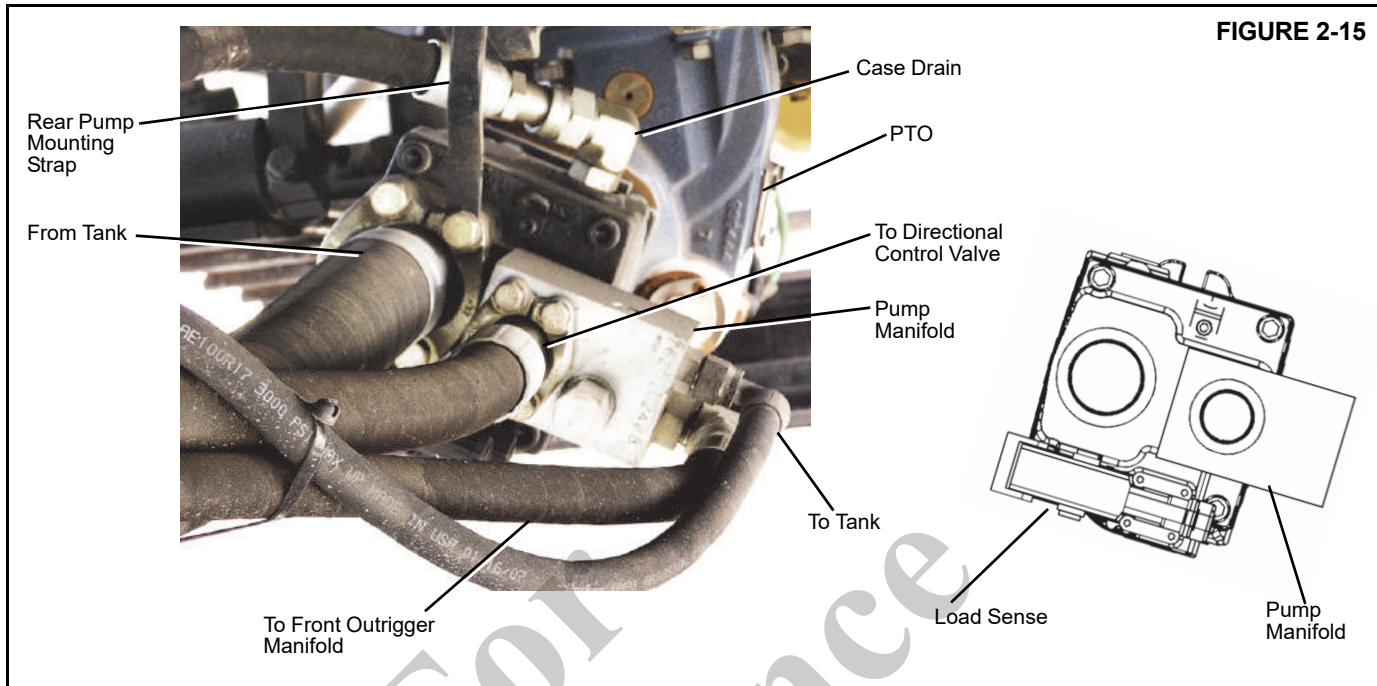
Do not try to repair or set the valve pressure. If a holding valve is suspect, replace it with a new valve.

Swing Gearbox

The swing gearbox is mounted inside the frame and rotates the boom. The swing gearbox has an integrally mounted brake that is automatically applied when the swing control lever is in the neutral position to prevent boom rotation. The swing brake is spring applied and hydraulically released. As the controller is moved off center, hydraulic pressure is automatically applied to release the brake.

Crane Function Power Switch

The crane function power switch is located on the operator's console and activates the controllers on the console. The EasyReach pedestal must be lowered to the operating position before the controllers can be activated.



HYDRAULIC PUMP SERVICE

Description

The hydraulic system pressure is supplied from a axial piston pump mounted on the truck power take off (PTO). The hydraulic gear pump requires a PTO rating of 210 hp at (156.5 kw) 1800 rpm.

Removal

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

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 mounting flange.
4. Bolt the pump rear mounting bracket to the rear mounting strap.
5. Reconnect the hydraulic lines as per removal tags.
6. Fill the hydraulic tank to the full mark with hydraulic oil.

Pump Startup

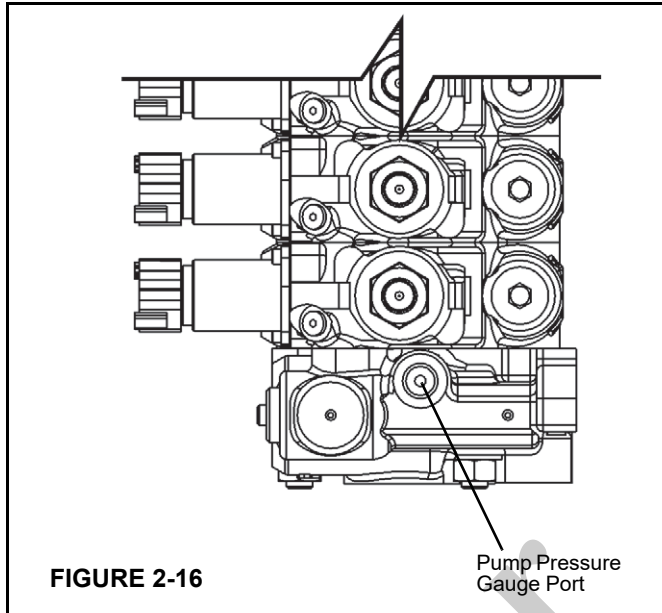
The pump startup procedure is as follows:

1. Fill the pump housing with hydraulic fluid. Pour the oil directly into the upper most case drain port.
2. Open the shut-off valve on the inlet line from the pump to the reservoir. Check the line for properly tightened fittings, and be sure the line is free of restrictions and air leaks.

CAUTION

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

3. Inspect the case drain line for leaks and restrictions.
4. Start the truck engine and engage the PTO. Turn off the truck engine.



5. Install a gauge at the pump pressure gauge port on the DCV (Figure 2-16).
6. Start the truck engine from the crane while monitoring the gauge and idle the engine about 2 to 3 minutes until the gauge registers pressure. Do not operate any hydraulic levers. Pressure at idle should be in the 200 to 300 psi (1379 to 2068 kPa) range.

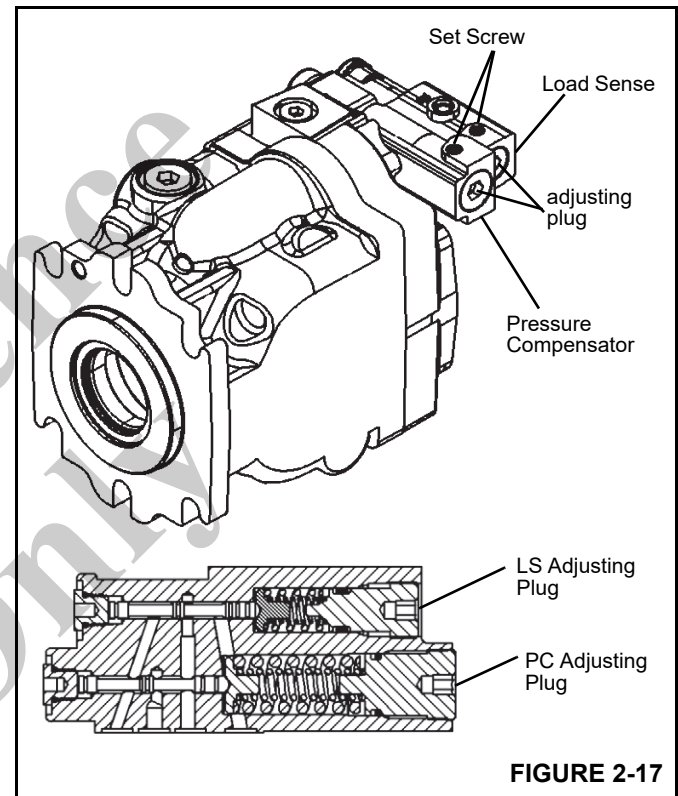
NOTE: If the pump does not build up pressure, shut down the engine and take corrective action.

7. Operate the system under a light load for 5 to 10 minutes.

NOTE: The standby pressure is the system pressure with no hydraulic component operating.

8. Check standby pressure and adjust as necessary.
 - a. Install a gauge at the pump pressure gauge port on the DCV (Figure 2-16)
 - b. Adjust the LS adjusting plug (Figure 2-17) on the pump until the standby pressure is at 350 psi (2413 kPa).
9. Check the maximum pump pressure and adjust as necessary.

- a. Install a gauge at the pump pressure gauge port on the DCV (Figure 2-16)
- b. Start the engine at idle. Bottom out the lift cylinder so that the boom is at a -10° angle.
- c. Hold the boom control lever in the down position and check the maximum pump pressure. The pressure should be 4000 psi (27579 kPa).
- d. If necessary, adjust the maximum pump pressure with the Pressure Compensator adjusting plug (Figure 2-17). While holding the boom lever in the down position, loosen the set screw then make adjustment, retighten the set screw.



Trouble Diagnosis

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

CONDITION	ITEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
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 operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures.
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 compensation setting to operate properly.
	Check pressure compensation and load sense control setting.	Low pressure compensation setting prevents the pump from achieving full stroke. Low load sense setting limits output flow.	Adjust pressure compensation and load sense settings.
	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 the pump.
	Internal system leaks.	Worn internal parts don't allow the pump to operate properly.	Refer to local distributor 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 controls 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 valve(s) may not allow system to respond properly.	Repair or replace system valve(s), as required.
	Check pump case pressure.	High case pressure causes the system to be sluggish.	Correct case drain line restrictions.
	Check pump inlet pressure/ vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.

Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
System Operating Hot	Check fluid level in reservoir.	Insufficient volume of hydraulic fluid will not meet cooling demands of system.	Fill reservoir to proper level.
	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.
	Check external system relief valve setting.	Fluid passing through relief valve adds heat to system.	Adjust external system relief valve setting. External relief valve setting must be above pressure compensation setting for proper operation.
	Check pump inlet pressure/vacuum.	High inlet vacuum adds heat to system.	Correct inlet pressure/vacuum conditions.
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 the controls 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 compensation setting causes low output flow.	Adjust external relief valve following manufacturer's recommendation. External relief valve setting must be above pressure compensation setting to operate properly.
	Check pressure compensation and load sense control setting.	Low pressure compensation setting prevents the pump from achieving full stroke.	Adjust pressure compensation 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.	



Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
Pressure or Flow Instability	Check for air in system.	Air in system causes erratic operation.	Activate pressure compensation 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 external relief valve and pressure compensation setting.	Insufficient pressure differential between pressure compensation setting and external relief valve.	Adjust external relief valve or pressure compensation control settings to appropriate level. Relief valve setting must be above pressure compensation setting to operate properly.
	Check external relief valve.	Chattering external relief valve may cause unstable feedback to pump control.	Adjust or replace relief valve.
System Pressure not Reaching pressure compensation setting	Check pressure compensation control setting.	System pressure will not rise above pressure compensation setting.	Adjust pressure compensation to appropriate setting.
	Check external relief valve.	External relief valve setting below pressure compensation setting presents pressure compensation.	Adjust external relief valve according to manufacturer's recommendations. External relief valve must be set above pressure compensation setting to operate properly.
	Inspect pressure compensation control spring.	Broken, damaged, or missing spring will cause erratic operation.	Replace the spring as required.
	Inspect pressure compensation spool for wear.	Wear of pressure compensation spool causes internal leakage in the control.	Replace the spool as required.
	Inspect pressure compensation spool for proper orientation.	Improper orientation results in poor operation.	Correct orientation of spool.
Check pressure compensation control for contamination.	Contamination may interfere with movement of the pressure compensation spool.	Clean pressure compensation control components, take appropriate action to eliminate contamination.	

Troubleshooting Chart (Continued)

CONDITION	ITEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
High inlet Vacuum Caution 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.

2

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SECTION 3 ELECTRIC SYSTEM

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DESCRIPTION

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

MAINTENANCE

General Electrical Understanding

To aid in the understanding and troubleshooting of an electrical system, review the terms and information that follows.

CAUTION

Know the electrical circuit before connecting or disconnecting an electrical component. A wrong connection can cause personal injury or damage to the component and/or system.

Electrical Energy - power which comes from the movement of electrons. Electrons are particles with a negative charge. Electrons will collect around particles with a positive charge, called protons, until an electrical imbalance occurs.

Amperage - rate of flow of electrons (Current), measured in amperes.

Voltage - the electromotive force (EMF) which causes electrons to move through an electrical circuit, measured in volts.

Resistance - any resistance to flow of electrons in an electrical circuit, measured in Ohms.

Ohm's Law - Electric current increases in direct relation to the voltage and decreases in relation to the amount of resistance in any circuit.

To Find:

- **EMF (Voltage)** - Multiply CURRENT (amps) by RESISTANCE (Ohms).
- **RESISTANCE (Ohms)** - Divide EMF (voltage) by CURRENT (amps).
- **CURRENT (Amps)** - Divide EMF (voltage) by RESISTANCE (Ohms).

Consider the following when trying to find trouble in an electrical system:

1. Current always flows from (+) positive to (-) negative, or from the point of highest voltage.
2. Because the system used on this machine is a negative ground system, current flows from the positive battery terminal and returns to the negative battery terminal.
3. In series circuit arrangements, the voltage is completely used in the circuit when the current is flowing. In parallel circuit arrangements, the voltage is constant.
4. When the voltage is constant, resistance controls the rate of current (amps) in the circuit. Refer to Ohm's Law.

Comparing Electrical System to a Hydraulic System

The electrical system is in many ways similar to a hydraulic system. Both systems need a "pump" to cause the flow which generates the energy. Each system needs a complete circuit so the flow can return to storage or supply. Both systems need "valves" to control the flow through the system. See Table 3-1.

Table 3-1: Comparing Electrical System and Hydraulic System

ELECTRICAL SYSTEM	HYDRAULIC SYSTEM
Alternator	Pump
Battery	Reservoir
Switches	Valves
Wires and Cables	Tubes and Hoses
Diodes	Check Valves
Volts	PSI or kPa
Amps	gpm or L/min
Ohms	Resistance

General Maintenance Introduction

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

⚠ CAUTION
Burn Hazard!

When possible, ensure the battery is disconnected before performing any maintenance on an electrical circuit which is not fused.

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

⚠ CAUTION
Electrical Fire or Equipment Damage Hazard!

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

General Troubleshooting

⚠ CAUTION
Electrical Shock Hazard!

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

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

1. First, use reported symptoms to identify a problem or a suspect component.
2. Using a multimeter, test the circuit for continuity if you suspect a broken circuit or for voltage if you suspect a power problem. Check the electrical schematic and wiring diagram for most accurate wiring information.
3. If the component proves faulty, replace it with a known working component. If wiring proves faulty, replace it with wiring of equal gauge.
4. After troubleshooting, test and repair the repaired circuit. Verify the circuit works properly.

Connector Troubleshooting

The cause of an electrical problem may be a loose or corroded connection in the pin or socket connectors. Check the connectors to ensure that the pins and sockets are properly seated and engaged. If the pins and sockets show any signs of corrosion, use a good quality electrical contact

cleaner or fine sandpaper to clean them. When the pins or sockets show signs of arcing or burning, it will probably be necessary to replace them.

Refer to (Table 3-2) and (Table 3-3) for listing of tools necessary for connector maintenance.

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.

Table 3-2
Deutsch Extraction Tool Table

Description	Deutsch Part Number	Grove Part Number
12 gauge wire	114010	9999100194
16 gauge wire	0411-204-1605	9999100195
8-10 gauge wire	114008	7902000012
4-6 gauge wire	114009	7902000009
20-24 gauge wire	0411-240-2005	9999102084

Table 3-3
Deutsch Crimping Tool Table

Description	Deutsch Part Number	Grove Part Number
12, 14, 16, 18, 20, 22, 24 gauge wire	HDT-48-00	9999100808
4, 6, 8, 10 gauge wire	HDT04-08	9999100842

Troubleshooting Electrical System

Finding a problem in the electrical system is not difficult if you know basic electricity and understand the arrangement of the electrical system. Use your electrical schematic.

Accurate testing equipment is also necessary. The instruments normally used are a voltmeter, ammeter, ohmmeter and test light.

Many times the problem can be found by visual inspection of the components in the circuit. Corrosion on terminals, loose connections or bad wiring are the causes of many problems.

Each circuit in the system has a fuse for protection against overloads. Remember that a burnt fuse is an indication of an overload or **SHORT** circuit, not an **OPEN** circuit.

If you did not find the cause of the problem during the visual inspection, use a voltmeter to check the voltage at several points in the circuit, or measure voltage drop across the component. Normally, the best method is to start at the furthest component in the circuit and move backwards toward the power supply. An ohmmeter can be used to measure the resistance in any component.

NOTE: Remember to disconnect the component from the power supply before you connect the ohmmeter.



Ignition Switch

There are two ignition switches on the crane. One is in the truck cab and the other one is on the EasyReach console. 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.

When the crane ignition switch at the operators station is set to RUN and the PTO engaged, the throttle pedal in the operators station overrides the truck cab throttle, the RCL system is powered, and the crane functions can be activated. The outrigger controls are disabled when the crane function power switch is ON.



EasyReach Proximity Switch

A proximity switch located in the EasyReach pedestal prevents the crane from being started unless the EasyReach pedestal is in the operating position. Check the proximity switch if the EasyReach pedestal is down and the crane ignition does not work.



FIGURE 3-1

Proximity Switch

RCL SYSTEM DESCRIPTION

The 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. A RCL override key switch is located behind an access panel on the crane frame. Turn the key switch ON to override the RCL. The RCL memory always has power supplied by the truck battery even when the truck ignition is in the OFF position.

NOTE: Consult the RCL manual in the event of an RCL malfunction.

ANTI-TWO-BLOCK SYSTEM DESCRIPTION

The anti-two-block system (A2B) helps prevent cable damage by sensing when the end of the hoist cable is near the boom tip and disables the functions that cause a two block condition. Normal functioning is restored by hoisting down or retracting the boom until the A2B weight is suspended freely. The A2B system is incorporated into the crane RCL system.

A2B Cable Repair



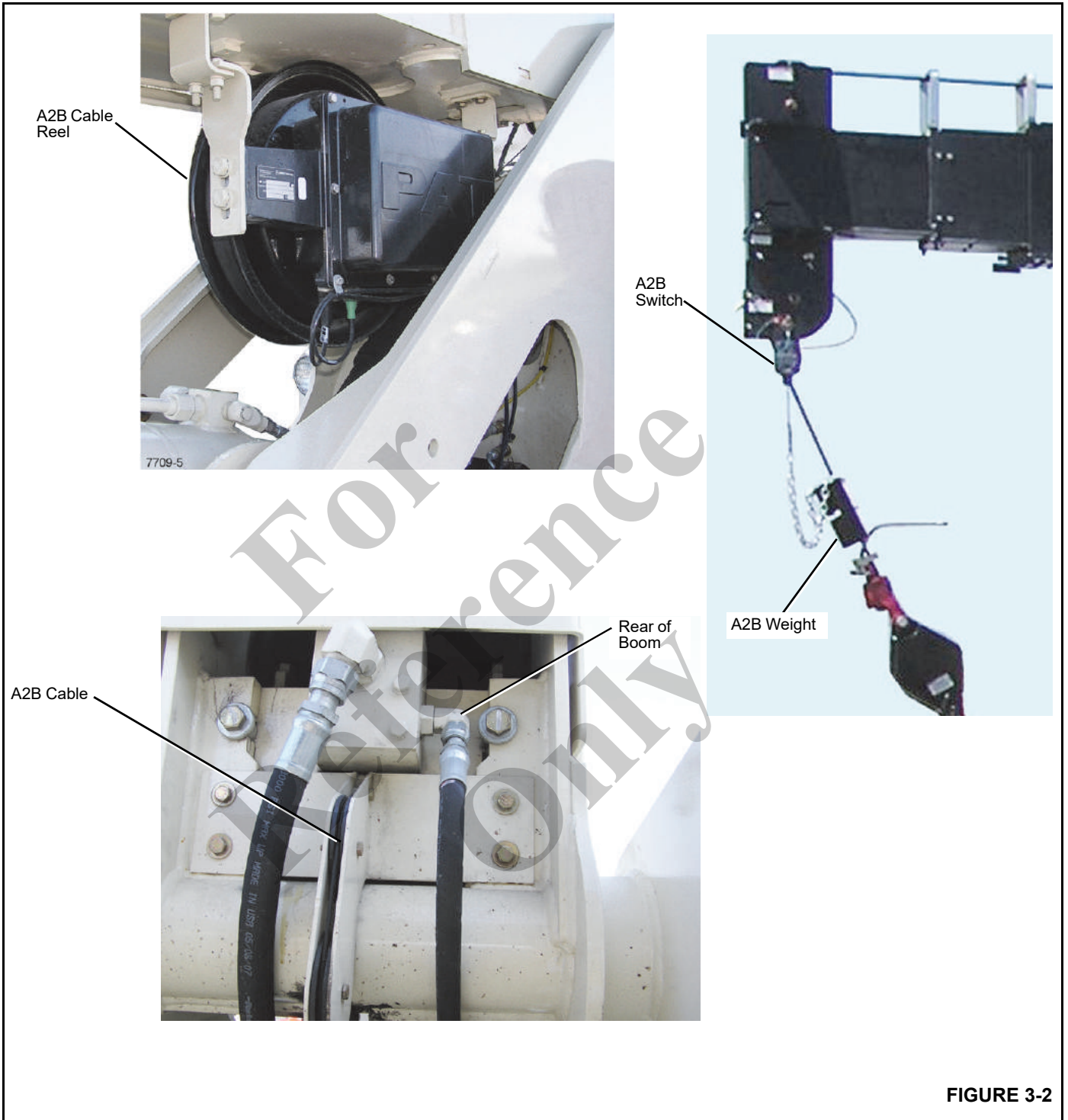
WARNING

Fall Hazard!

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

The A2B cable runs from the A2B reel through the boom to the boom tip (Figure 3-2). To replace the A2B cable:

- Retract the boom.
- Run a small diameter rod from the front of the boom to the back.
- Attach the cable to the rod and pull the cable through the boom and secure the A2B cable to the boom tip.



3

FIGURE 3-2

MICRO RELAY/FUSE BLOCK

There is one relay/fuse block located in the fuse compartment (Figure 3-3) on the left side of the frame.

Loosen the four wing nuts and remove the access panel to gain access to the fuse compartment, control module, interface connector and the RCL override keyswitch.

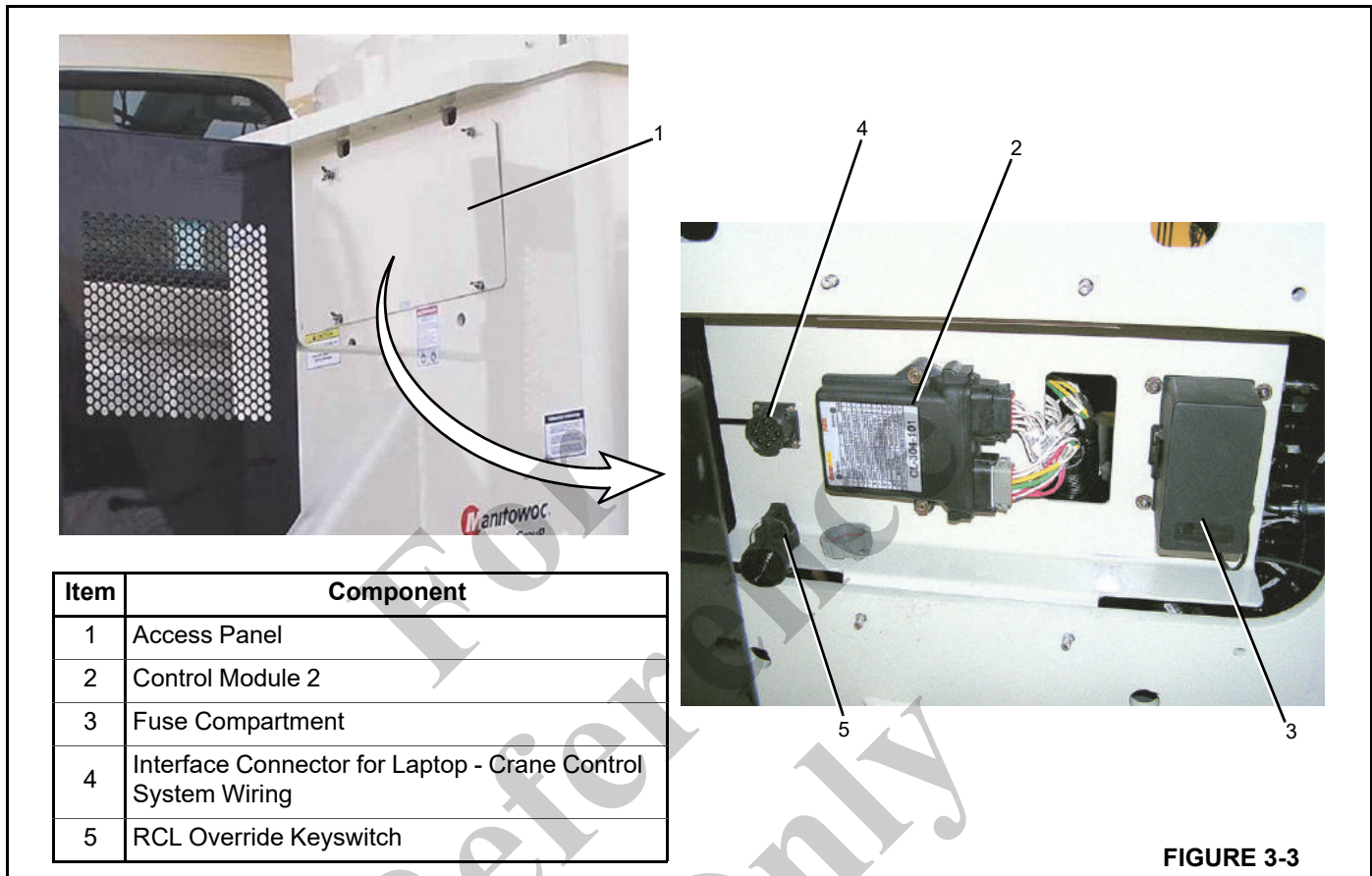


FIGURE 3-3

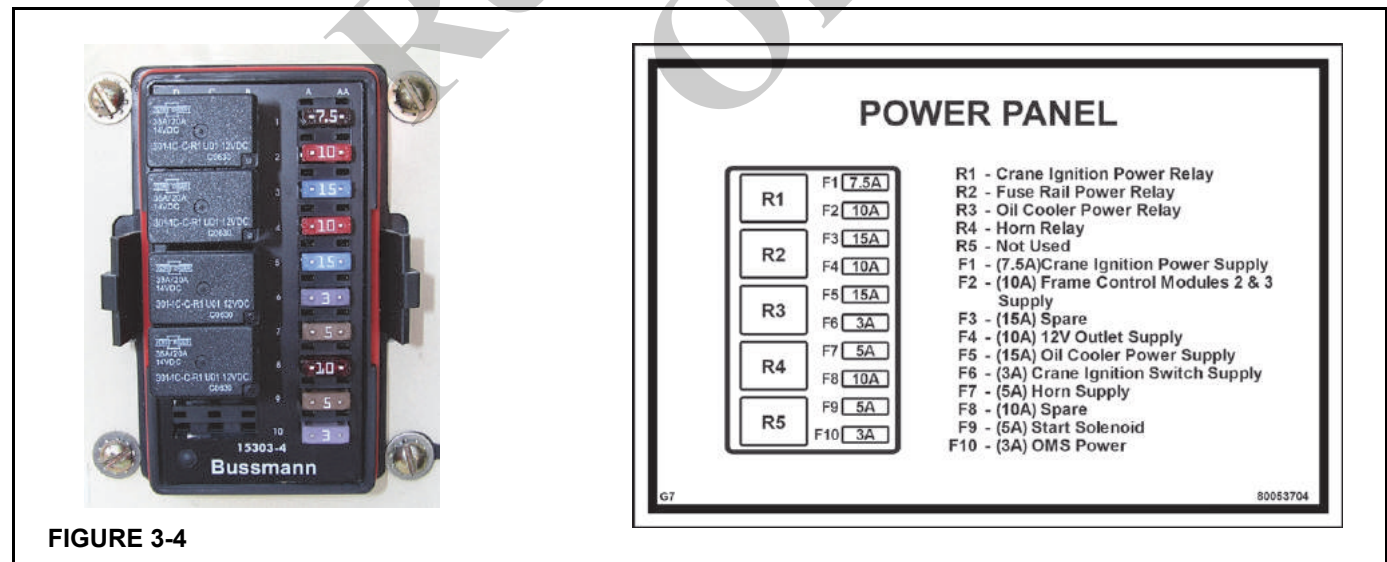


FIGURE 3-4

DIRECTIONAL CONTROL VALVE SOLENOIDS

The solenoids on the directional control valve (DCV) manifold are used to control the mode of operation of the valve.

There are two modes of operation for the valve:

- Hydraulic Remote Controllers (HRC) control mode.
- Radio remote control mode.

The Crane function power switch energizes the HRC enable solenoid and the Radio Remote switch energizes the radio remote enable solenoid. See *Directional Control Valve*, page 2-14 for a description of the DCV operation.

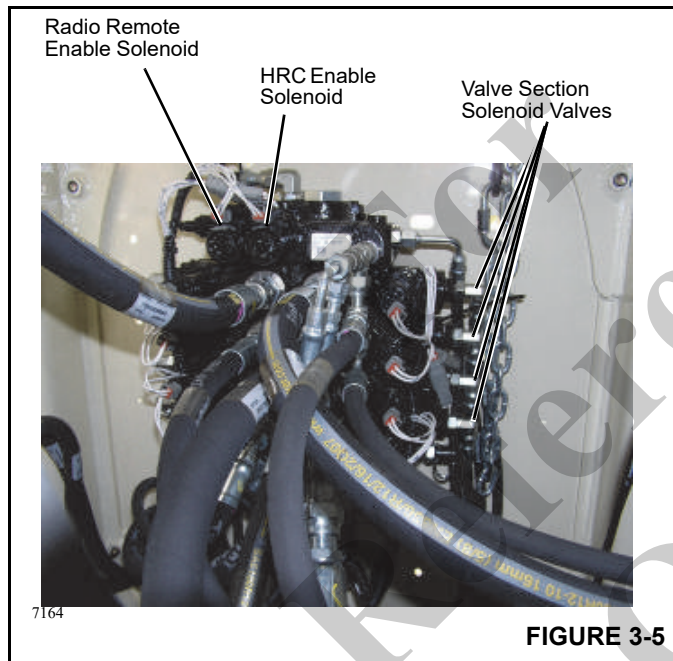


FIGURE 3-5

HOIST JOG SWITCH

A hoist jog switch (Figure 3-6) at the rear of the truck aids the operator in stowing the hook block. The switch activates the hoist for a two second interval to take up or let out the load line.

NOTE: The crane function power switch and remote power switch must be off.

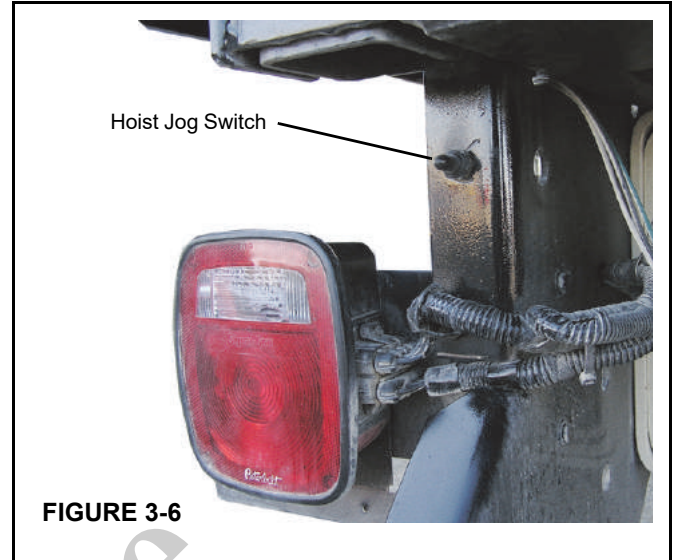


FIGURE 3-6

OUTRIGGER MANIFOLDS

There are two outrigger manifolds located on the crane. The front outrigger manifold is mounted on the center of the front outrigger box (Figure 3-7) and the rear outrigger manifold is mounted on the rear outrigger box (Figure 3-8).

Front Outrigger Manifold

The solenoids on the front outrigger manifold (Figure 3-7) control the selection of the front outrigger components, front center jack (SFO), the extend and retract functions of all outrigger components.

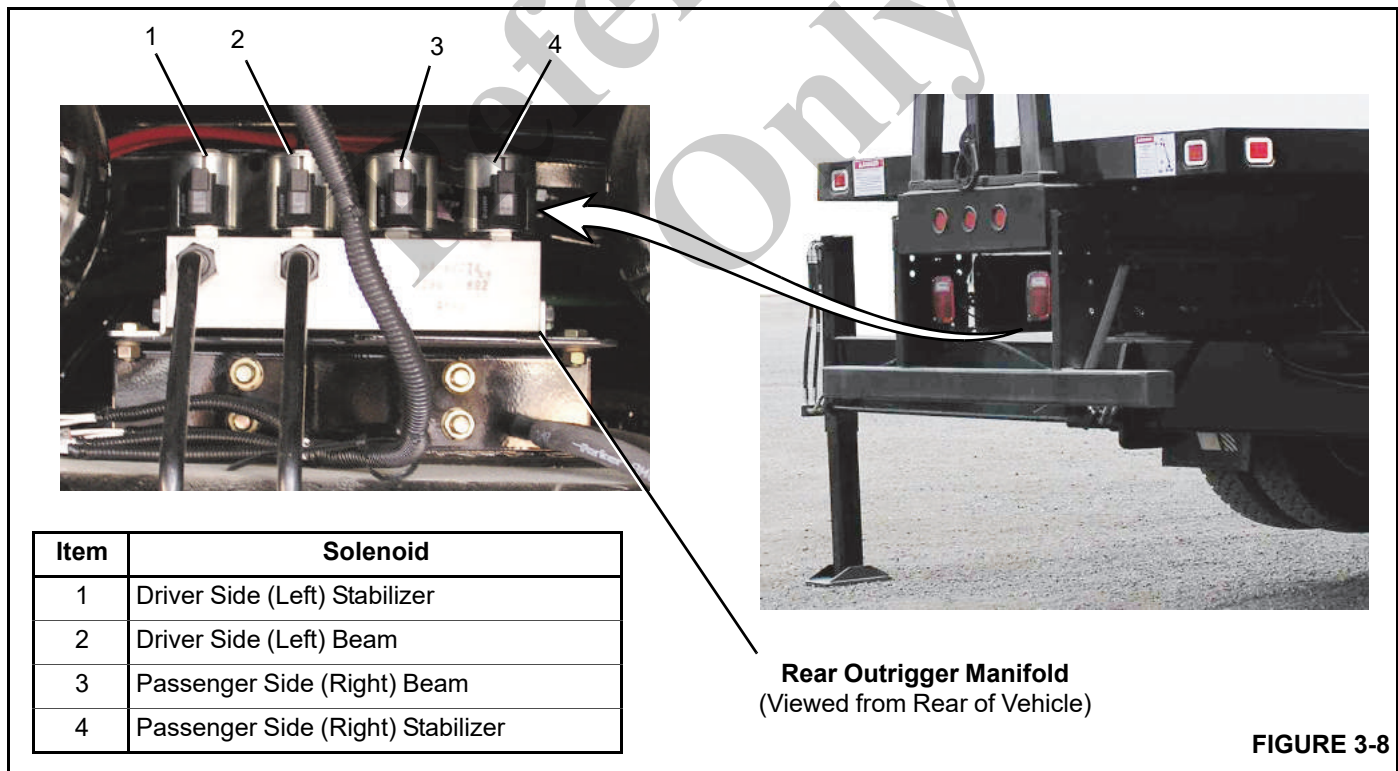
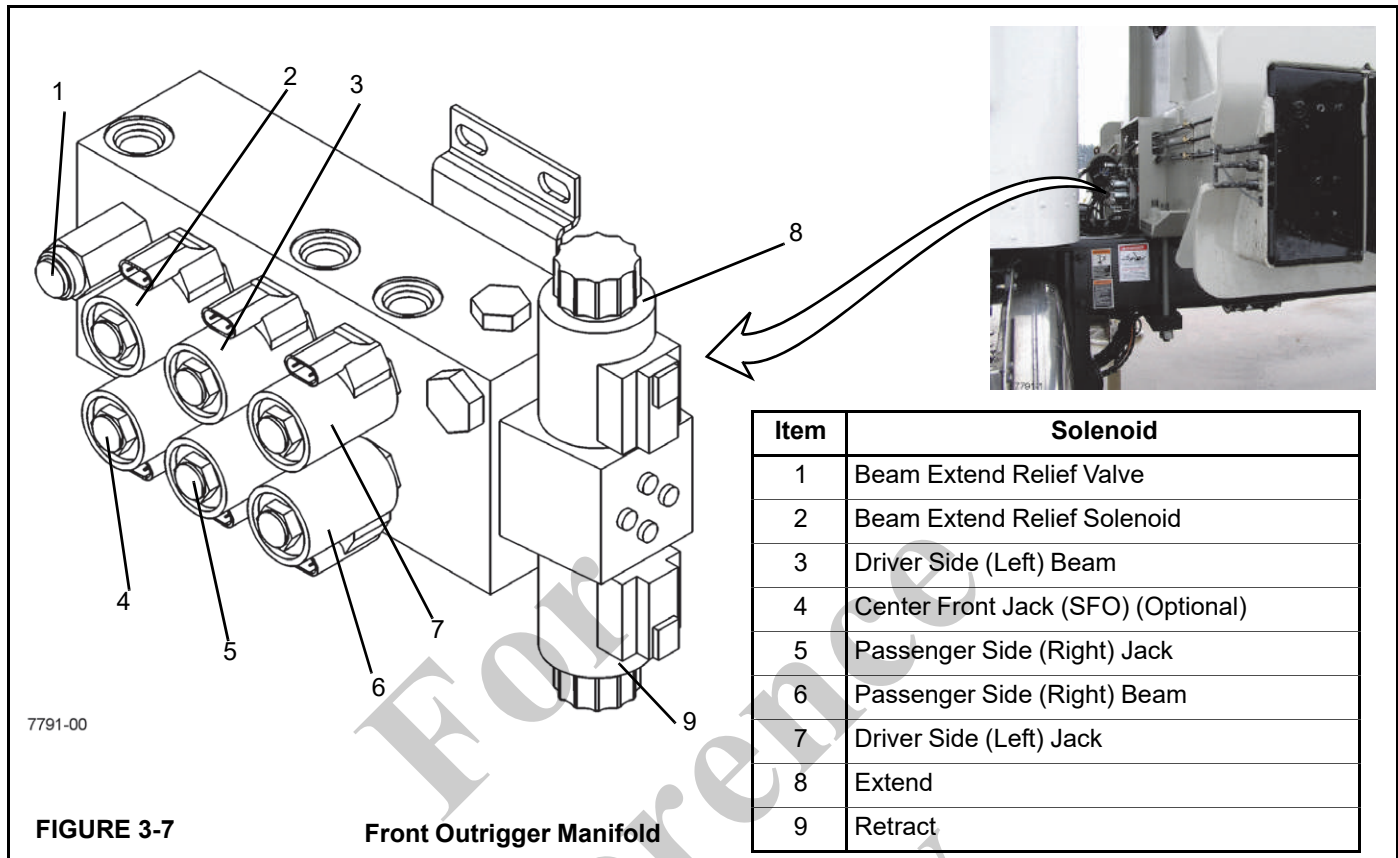
The solenoids on the front outrigger manifold provide the following functions:

NOTE: When the crane function power switch on the operator console is turned ON, all outrigger functions are disabled.

- The center front jack (4) solenoid extends or retracts the SFO when energized. Any time the retract switch on the outrigger control is depressed, the SFO is retracted first.
- The extend solenoid (8) controls the extend functions for all outrigger components.
- The retract solenoid (9) controls the retract functions for all outrigger components.
- Solenoids (3) (5) and (6) (7) control the front outrigger components. See Figure 3-7 for solenoid identification.

CAUTION

The CAN Bus system overrides the A2B switch when the hoist jog switch is activated. Be careful not to cause a two-block condition when hoisting up the hook block.



Rear Outrigger Manifold

The solenoids on the rear outrigger manifold control the rear outrigger components. See Figure 3-8 for solenoid identification.

HYDRAULIC OIL COOLER OPTION

The optional hydraulic oil cooler (Figure 3-9) is mounted in front of the frame. An electric fan in the crane frame, circulates air over the cooling core when the hydraulic oil in the cooling core reaches 120° F (48.8° C).

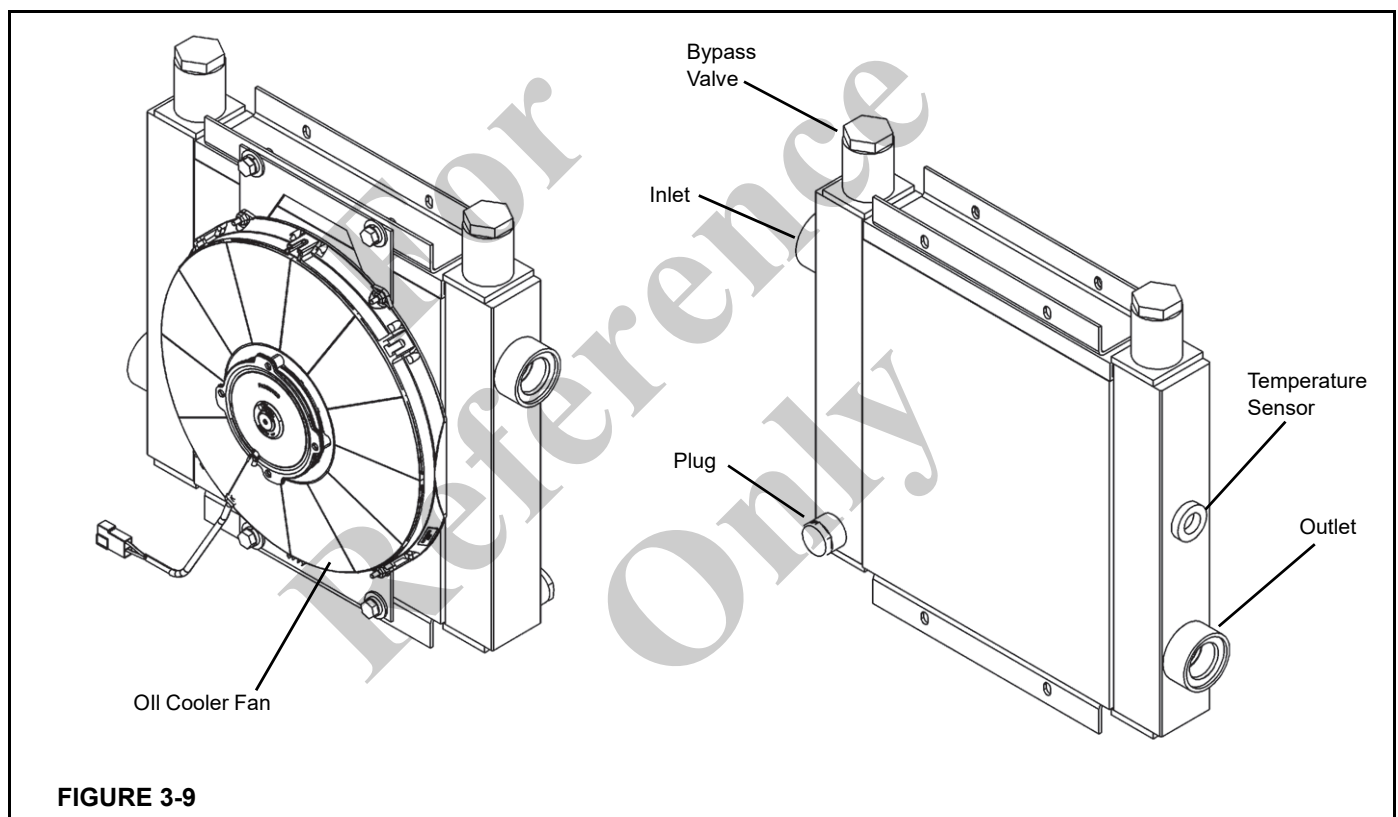
Not all return flow is routed through the oil cooler. A 35 psi (206 kPa) check valve in the oil cooler limits the flow through the cooler. Since hydraulic oil is thicker when it is cold, less

oil is routed through the cooler when it is cold than when it is hot.

The cooler electrical system is made up of the following:

- Electric Fan
- Fan Relay
- Temperature Sensor

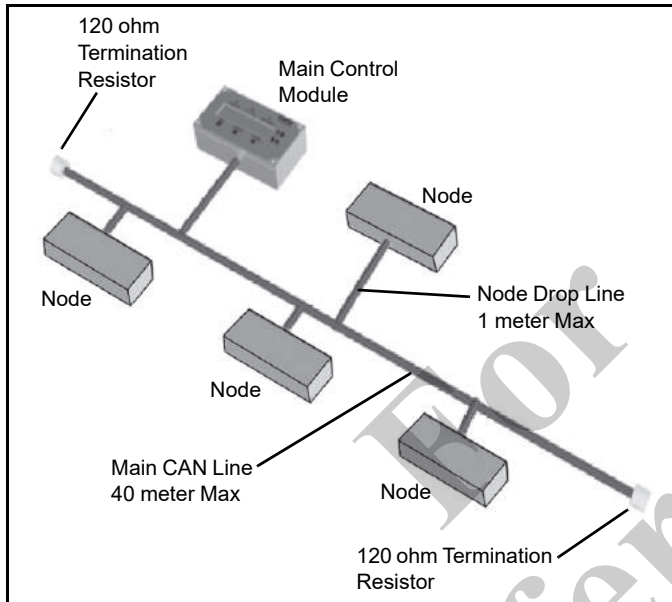
The temperature sensor is located in the cooling core and energizes the fan relay when the hydraulic oil reaches 120° F (48.8° C). The fan relay (R3) is located in the micro relay/fuse box and turns the fan on when energized (Figure 3-4). If the fan is not running and the oil temperature warning is displayed on the RCL screen, check the fan temperature sensor, relay, and fan motor.



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 CANbus 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.

Information is sent over a main CAN line which has a maximum length of 40 meters. Each node has a drop line off the main CAN line and the maximum length of the drop line is about 3.28 ft (1 m).

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 CANbus system are:

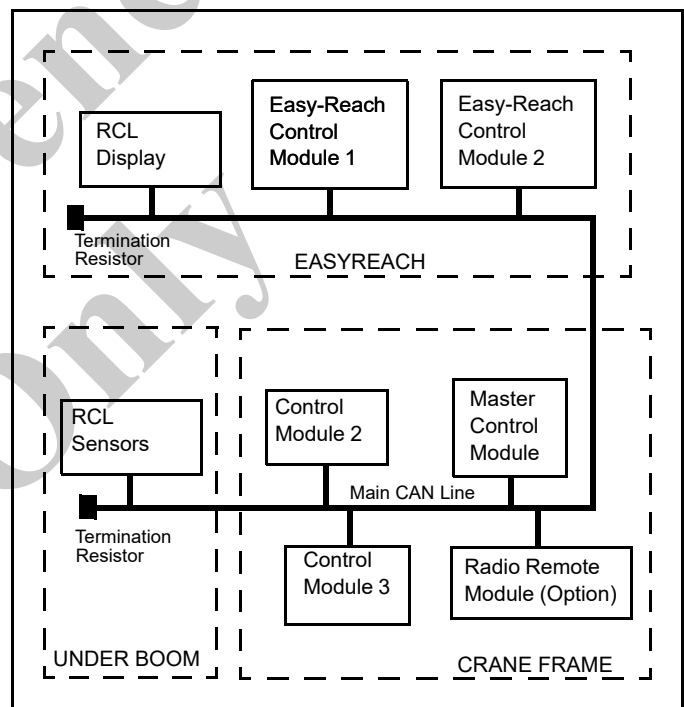
- Reliability
- Self diagnostics
- Ease of Installation

- Elimination of a large bundle of wires
- Down loading to a laptop computer
- Protected safety interlocks
- EMI/RFI tolerant

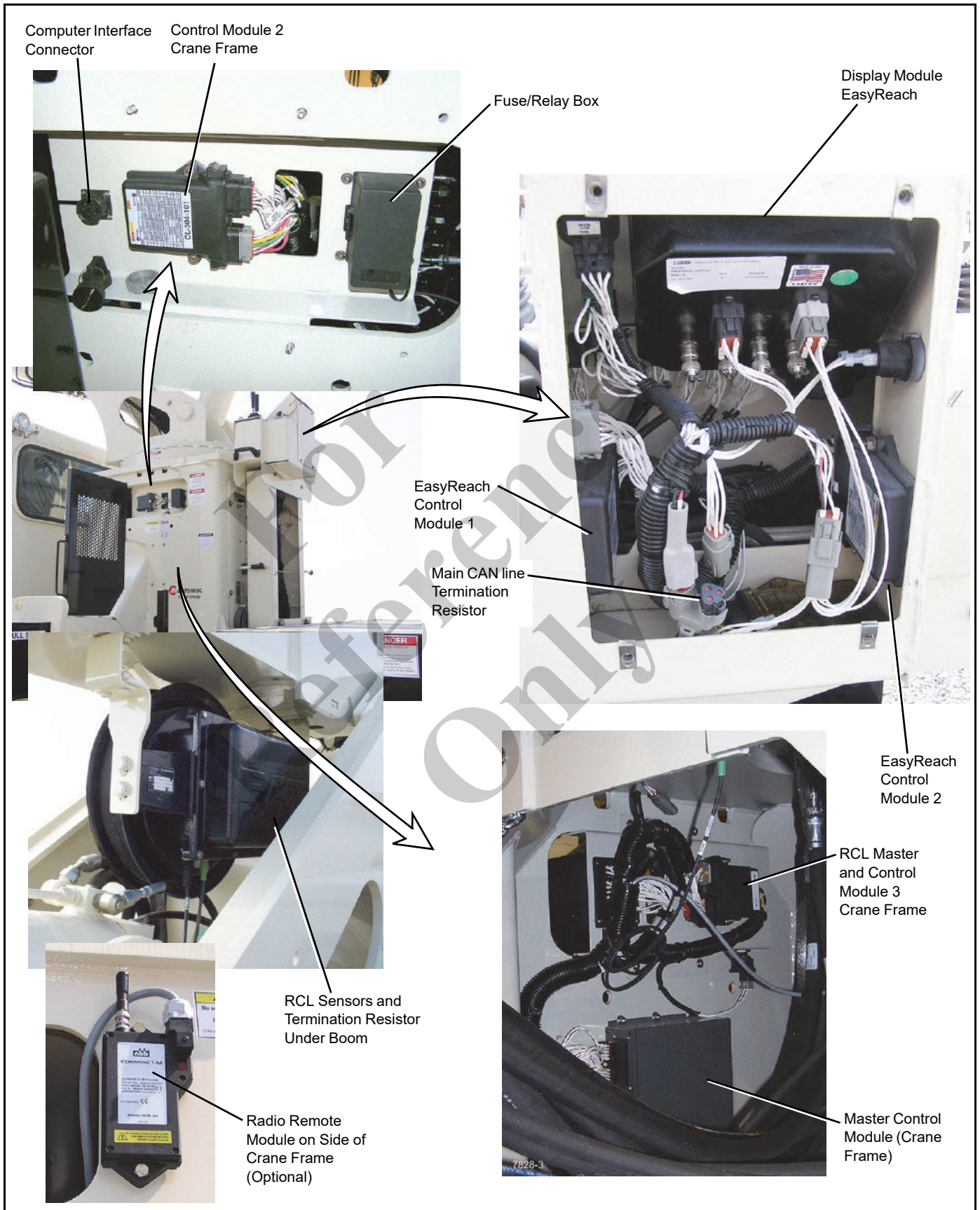
900H RCL CANBUS

The RCL has the following Nodes on the CANbus:

- Master Control Module
- RCL Sensor Modules
- Control Module 2
- Radio Remote Module (Optional)
- Control Module 3
- EasyReach Control Module 1
- EasyReach Control Module 2
- EasyReach Display Module



All nodes on the RCL CANbus both receive and transmit messages. There is 120 ohm termination resistor on each end of the main CAN line. The resistors are in parallel and when the main CAN line is measured across the terminals the resistance should read 60 ohms.



Troubleshooting

This machine incorporates a CANbus Multiplex system. In order to effectively troubleshoot the electrical system, you need a Windows-based PC, CAN-link service software (9999102409), and a connection cable (9999102296). The CAN-link service software and connection cable may be ordered from CraneCARE.

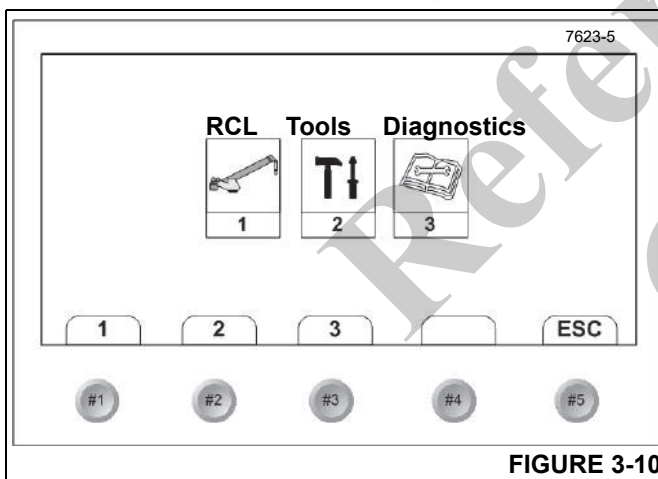
NOTE: The software and cable can only be purchased by technicians that have attended the Grove New Technology training course.


Refer to the 900H CAN control specification and the 900H CAN RCL specification for detailed instructions to program or troubleshoot using the control and RCL software.

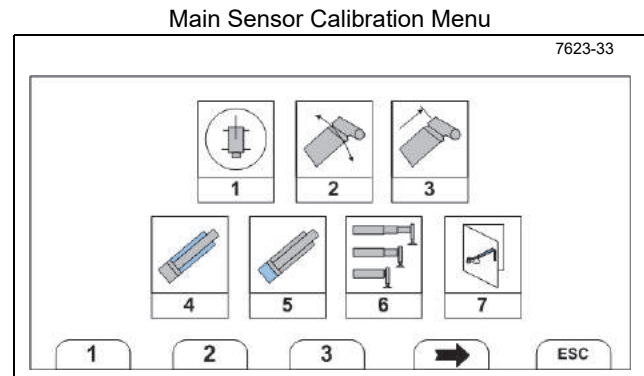
RCL SENSOR CALIBRATION (LEGACY RCL VERSION)

The RCL sensors are located throughout the crane and are used to monitor the lifting parameters set by the crane operator. To be sure the sensors are working correctly it is necessary to verify the calibration of each RCL sensor to perform this calibration:

Select key #2, Tools on the Main Menu, Figure 3-10.



The Tools Screen will appear, select the  icon, the Main Sensor Calibration Menu will appear.



The sensors are displayed in the above Sensor Calibration Menu screen.

NOTE: The five digit pass code, 12331, is required to perform a sensor calibration. Use the 1, 2, and 3 keys then select OK.

Choices are:

1. Slew Angle
2. Boom Angle
3. Boom Length
4. Lift Cylinder Rod Pressure
5. Lift Cylinder Piston Pressure
6. Outrigger Length
7. Load Chart Upload

Use the right arrow key to move to the function keys 4,5,6,7.

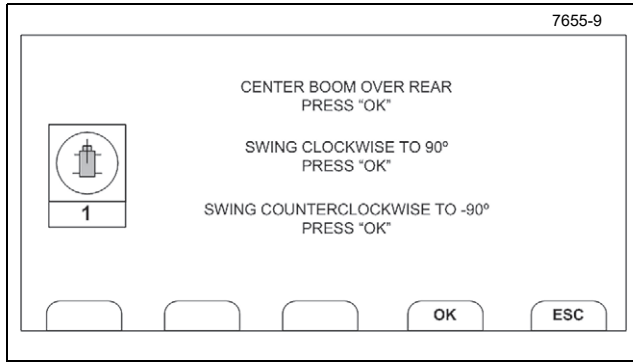
Select ESC goes back to the Main Limits menu screen.

Slew Potentiometer Calibration

NOTE: The slew sensor is a 10-turn potentiometer. Before calibrating the slew potentiometer, make sure the center of the potentiometer is approximately 2500 mV when the boom is over the rear of the crane.

1. Level and set the truck on outriggers before starting the slew potentiometer calibration procedure.
2. Select 1 from the Main Sensor Calibration Menu screen to begin the slew angle calibration.

Slew Sensor Calibration

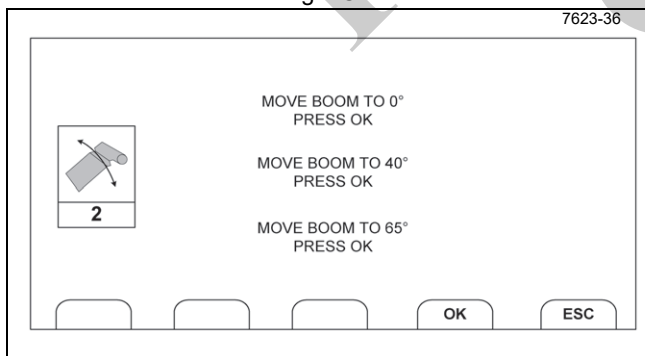


3. Three calibration positions are described one at a time on the Slew Sensor Calibration screen starting with Center Boom Over Rear. After the superstructure is positioned and OK is pressed the next calibration position will be activated.
 - Place the superstructure at the Center Boom Over Rear position then press OK.
 - Place the superstructure at the Swing Clockwise To 90° position then press OK.
 - Place the superstructure at the Swing Counter Clockwise To 90° position then press OK.

Boom Angle Calibration

1. Select 2 on the Main Sensor Calibration Menu screen to start the boom angle calibration.
2. Set up the truck on outriggers and level before starting the boom angle calibration procedure. The boom angle needs to be measured accurately with an inclinometer to do an accurate calibration.

Boom Angle Calibration



3. Three calibration positions are shown one at a time on the Boom Angle Calibration screen starting with the 0°

position. Once the boom is positioned and OK is pressed the next calibration position will be activated.

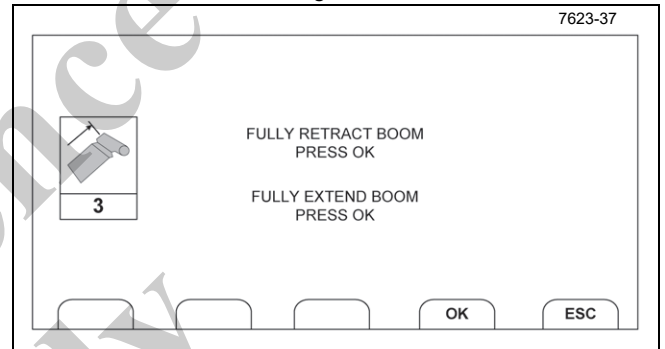
- Move boom to 0° position then press OK.
- Move boom to 40° position then press OK.
- Move boom to 65° position then press OK.

If the RCL system determines the sensor is not within the established zero range, an error screen will appear. The sensor will then have to be mechanically zeroed.

Boom Length Calibration

1. Level and set the truck on outriggers before starting the boom length calibration procedure.
2. Select 3 from the Main Sensor Calibration Menu screen to start the boom length calibration.

Boom Length Calibration



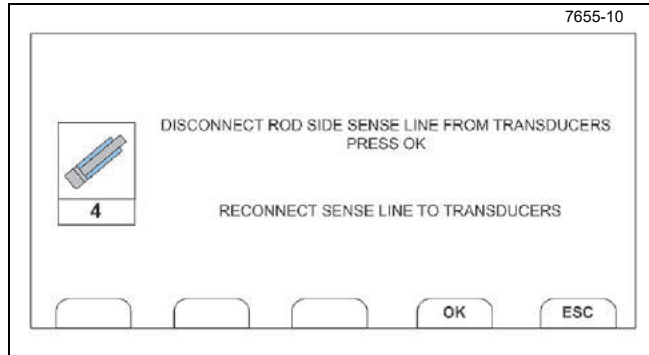
3. Two calibration positions are described one at a time, starting with the fully retracted position on the Boom Length Calibration screen.
4. After OK is pressed for fully retracted position the fully extended position is activated and will appear. Fully extend the boom and select OK.

Rod Side Pressure Sensor Calibration

The lift cylinder rod side transducer must be calibrated to zero before the crane is used to lift any load. Use the following instructions and screen to calibrate.

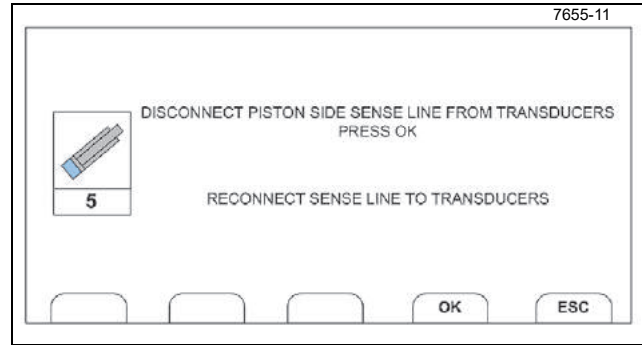
1. Level and set the truck on outriggers before starting the pressure sensor calibration procedure.
2. Lower the lift cylinder until it is fully retracted. The crane power can be shut off at this time.
3. Select 4 from the Main Sensor Calibration Menu screen to start the lift cylinder rod side pressure calibration.

Rod Side Pressure Sensor Calibration



4. Disconnect rod side sense line from the transducer.
5. Press OK.
6. Reconnect the sense line to the transducer.
7. Press OK.

Base Side Pressure Sensor Calibration



4. Disconnect the piston side sense line from transducer.
5. Press OK.
6. Reconnect the sense line to the transducer.
7. Press OK.

DANGER

High Pressure Hazard!

Pressurized hydraulic fluid can cause serious injury. Be careful when removing plugs or restrictions from pressurized hydraulic systems suspected to have entrapped air. Fluid injected into skin must be surgically removed within a few hours by a doctor familiar with this type of injury or gangrene will result.

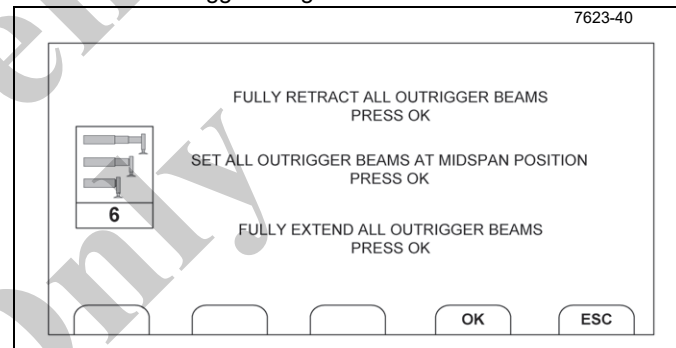
CAUTION

Make sure there is no hydraulic pressure in the hydraulic line when disconnecting the pressure lines from transducers. Pressurized hydraulic fluid can cause personal injury.

Outrigger Span/Length

1. Select 6 from the Main Sensor Calibration Menu screen (12) to start the outrigger length sensor calibration.

Outrigger Length Sensor Calibration



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

If the screen fails to advance, an error with one of the values has occurred. Calibrating through the service tool will be necessary.

After calibrating in the fully retracted position, extend the outriggers to the midspan position and complete the calibration procedure.

Load Chart and Calibration Chart Download

The Main Load Chart Calibration and the Calibration Chart are downloaded to the RCL system using a laptop computer connected to the crane control system through the Diagnostic Connector (1, Figure 3-11). Contact Manitowoc Crane Care for the required software and cables for the crane interface.

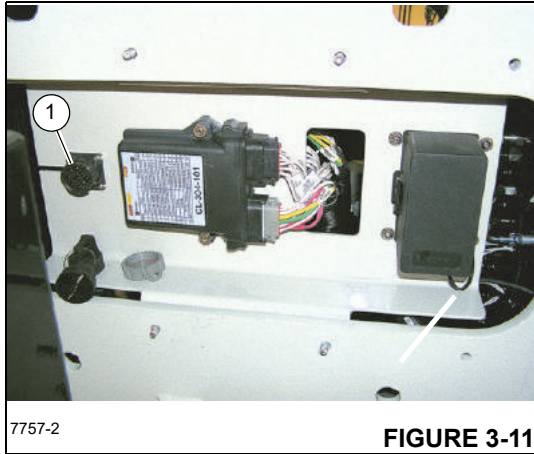


FIGURE 3-11

1. Connect the laptop to the Diagnostic Connector (1, Figure 3-11) with the interface cable.
2. If the RCL is in the start up mode and at the Main Menu screen (Figure 3-12), select function key 2, Tools.

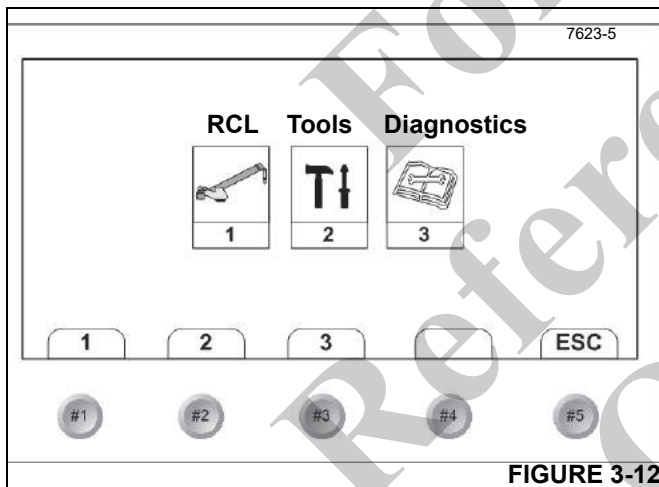
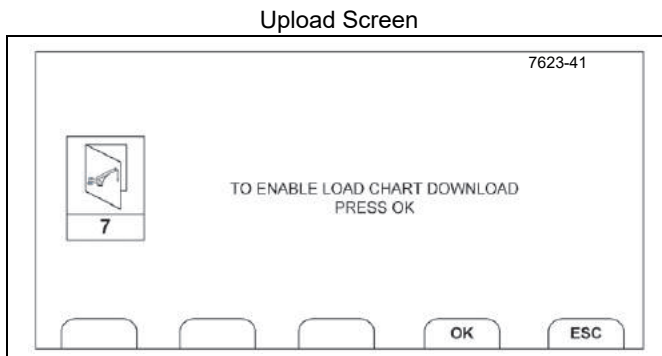


FIGURE 3-12

3. After entering the pass code to enter the System Configuration Menu, select function key 7 (use arrow keys to scroll).



4. At the Download Screen, Select OK to start the download from the laptop.

5. Once enabled, the display will return to the sensor calibration menu.

SYSTEM CONFIGURATION (CURRENT RCL VERSION)

Use the following procedure to access the System Configuration Menu. The System Configuration menu is where the functions shown in Table 3-4 can be accessed.

Table 3-4 System Configuration Menu Icons

Icon	Description
	Sensor Calibration Menu — Select this icon to calibrate crane sensors. This icon appears red if sensors need to be calibrated. For more information, see <i>RCL Sensor Calibration (Current RCL Version)</i> , page 3-18.
	Enable Chart Loading — Select this icon to upload a new load chart. For more information, see <i>Uploading Charts</i> , page 3-16.
	RCL Display Software Update — Select this icon to load software updates. For more information, see <i>Downloading the RCL Display Software</i> , page 3-16.
	Real-Time Clock Configuration — Select this icon to update the RCL system time and date information. For more information, see <i>Setting System Date and Time</i> , page 3-17.


Accessing the System Configuration Menu

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

1. In the main menu, select the Tools icon.
The Tools menu appears.
2. In the Tools menu, select the System Configuration icon
3. Enter the pass code 12331 to continue to the System Configuration menu. For more information, see *Entering the System Configuration Pass Code*, page 3-15.

Entering the System Configuration Pass Code

A 5-digit pass code 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 pass code. After all numbers are entered, the Select button turns green.

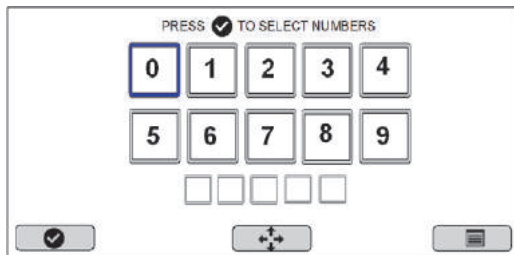
Use the Delete functional key  to remove all entries and start the pass code process again.


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

To enter the calibration pass code:


1. Access the System Configuration Menu.

The pass code screen appears.



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

1, 2, 3, 3, 1

3. After all numbers are entered, press the green  select function key to submit the pass code.

Uploading Charts



Use the following procedure to upload charts to the RCL system. Connect a laptop computer to the crane control system. Contact Manitowoc Crane Care or your 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.

1. Connect the laptop to the Diagnostic Connector with the interface cable.
2. If the RCL is at the Main Menu screen, select Tools Menu.

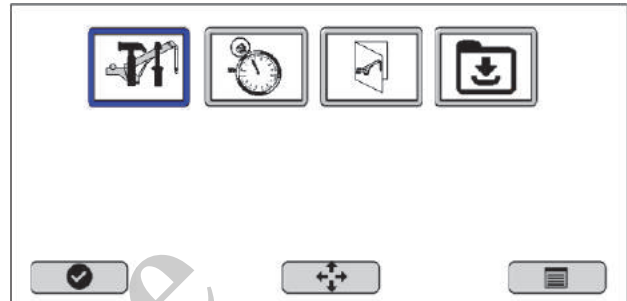
The Tools screen appears.



3. Press highlight the System Configuration icon  and press the OK  function key.

The pass code screen appears.

4. Enter the pass code: 12331 and press OK  function key. For more information, see *Entering the System Configuration Pass Code*, page 3-15.

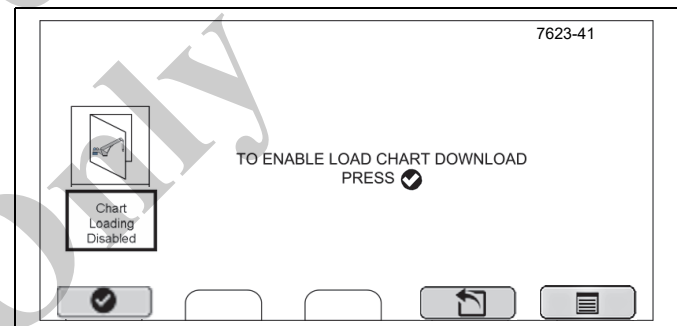
The System Configuration screen appears.




5. Select  (use the navigational keypad to highlight the Upload Charts icon) and press the OK  function key.

The Chart Download screen appears.

Download Screen



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

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

Downloading the RCL Display Software

NOTE: If a major release or a release that re-defines EEPROMs is needed, this process cannot be used.

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

⚠ 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.

1. If not already done, copy the updated RCL software onto a USB flash drive.
2. Remove capscrews (1, Figure 3-13) and lockwashers (2) holding the display access cover plate (3) to access the RCL USB port.
3. Insert the USB flash drive with the new RCL software version in the RCL Software port (4, Figure 3-13).

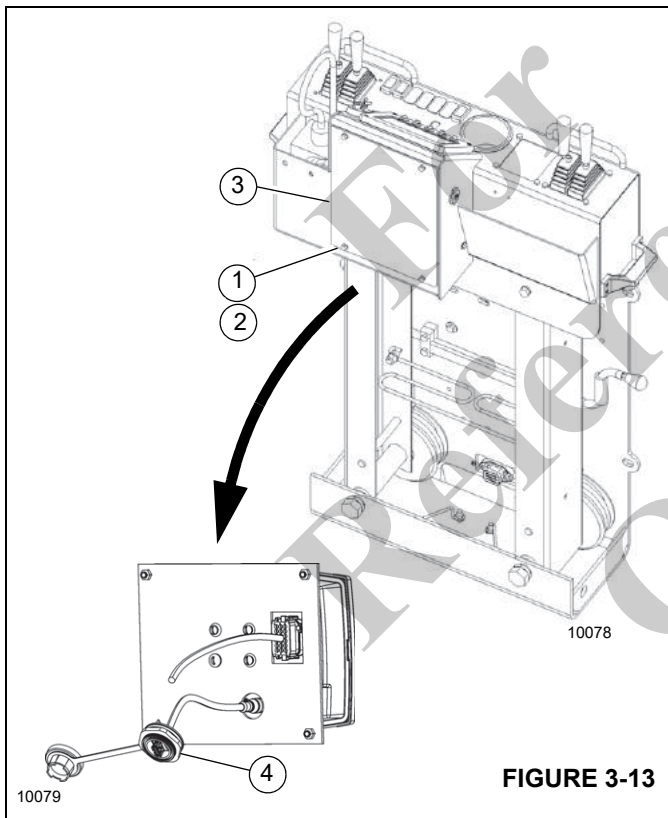



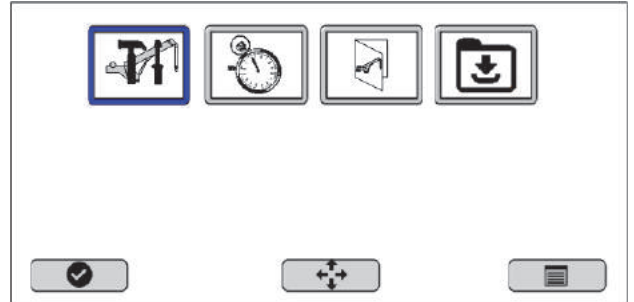




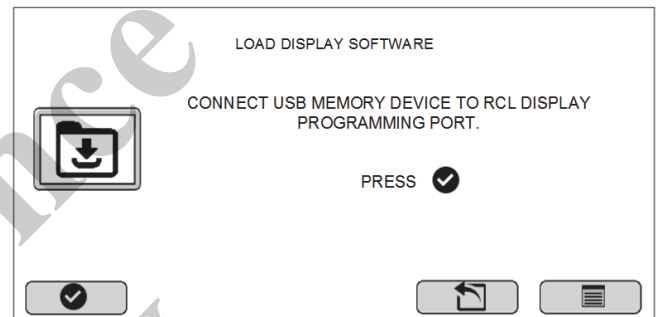
FIGURE 3-13


4. From the main menu, press Tools.
5. Highlight the System Configuration icon  and press the OK  function key. The pass code entry screen appears.
6. Enter the pass code: 12331 and press OK  function key. For more information, see *Entering the System Configuration Pass Code*, page 3-15. The system configuration menu appears.



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

The Load Display Software screen appears.









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

Setting System Date and Time

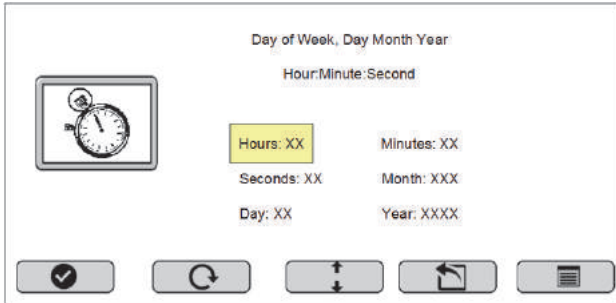
Use the following procedure to set the RCL system Date and Time. Table 3-5 shows the functional keys available in the Time Set screen.




Table 3-5 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.

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.

RCL SENSOR CALIBRATION (CURRENT RCL VERSION)


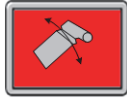




The RCL sensors are located throughout the crane and are used to monitor the lifting parameters set by the crane operator.


When a sensor requires calibration, the icon appears with a RED background in the RCL. Table 3-6 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 individual sensor(s) readings are inaccurate (individual sensor(s) only must be calibrated)
- The sensor(s) or component(s) being measured (such as the boom, lift cylinder, outriggers, etc.) is replaced, adjusted, removed, or reinstalled (individual sensor(s) 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 3-6 Sensor Calibration Warnings

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

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

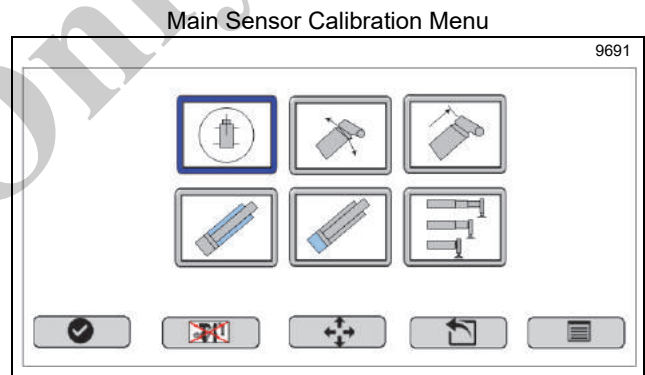


Table 3-7 Sensor Calibration Options

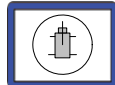
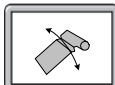
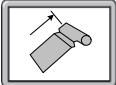
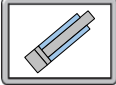
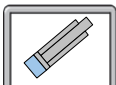
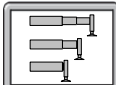

Icon	Description
	Slew Angle — Use this option to calibrate the slew sensor. For more information, see <i>Calibrating the Slew Sensor</i> , page 3-19.
	Boom Angle — Use this option to calibrate the boom angle sensor. For more information, see <i>Calibrating the Boom Angle</i> , page 3-19.

Table 3-7 Sensor Calibration Options (Continued)

Icon	Description
	Boom Length — Use this option to calibrate the boom length sensor. For more information, see <i>Boom Length Calibration</i> , page 3-13.
	Lift Cylinder Rod Pressure Transducer — Use this option to calibrate the rod side transducer located on the lift cylinder. For more information, see <i>Calibrating the Rod and Base Side Pressure Transducers</i> , page 3-20.
	Lift Cylinder Base Pressure Transducer — Use this option to calibrate the base side transducer located on the lift cylinder. For more information, see <i>Calibrating the Rod and Base Side Pressure Transducers</i> , page 3-20.
	Outrigger Sensor — Use this option to calibrate the sensors on the outriggers. For more information, see <i>Calibrating the Outrigger Span/Length</i> , page 3-22.





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

Select ESC button  to return to the System Configuration menu screen.

A pass code is required to calibrate a sensor. For more information, see *Entering the System Configuration Pass Code*, page 3-15.

Accessing the Sensor Calibration Menu

To access the sensor calibration menu:


- Navigate to the Tools icon with the navigation keypad and OK .
The Tools Screen appears.
- Highlight the System Configuration icon  and press the OK .
- Enter the System Configuration screen pass code. For more information, see *Entering the System Configuration Pass Code*, page 3-15.
The System Configuration screen appears.
- In the System Configuration menu, highlight and select the Sensor Calibration Menu icon .
The Sensor Calibration menu appears.

Calibrating the Slew Sensor

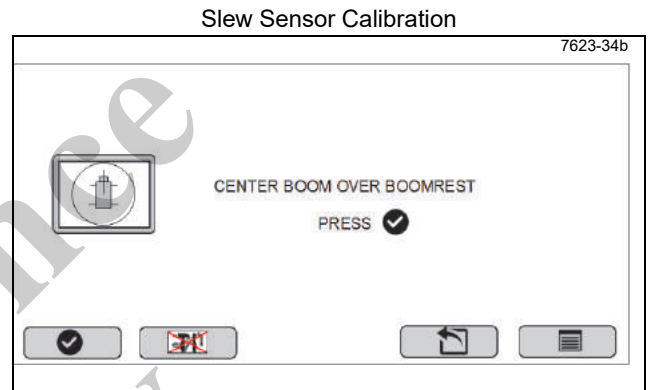
The slew sensor requires calibration in the following circumstances:


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

To calibrate the slew sensor:

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

The Slew Sensor Calibration screen appears.



- Center the boom over the boom rest.
- Select the OK  function key from the Slew Sensor Calibration screen.
- Follow the prompts on the screen to swing the boom over each side to complete the calibration.

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 module is replaced
- The RCL software is updated

NOTE: The boom angle sensor calibration is not required if the lift cylinder is repaired or replaced.

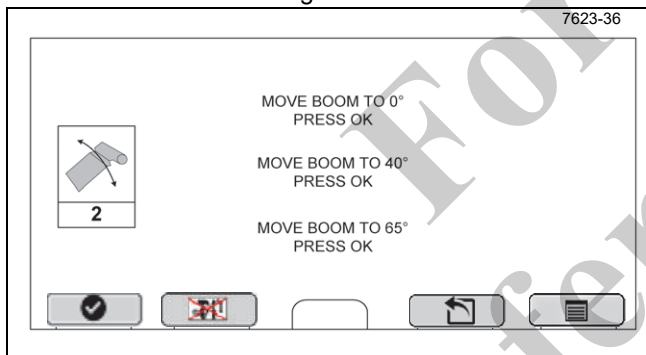
Level and set the truck on outriggers before starting the boom angle calibration procedure. The boom angle needs to be measured accurately with an inclinometer to complete an accurate calibration.

Four 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, then the 65° boom angle and then approximately 80°.

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. Similarly, after the calibration of a boom angle, an error message may appear until the boom is moved within $\pm 1^\circ$ of the next angle to be calibrated. If the error message persists, the service tool needs to be used to update the angle values.

1. Level and set the crane on the outriggers.
2. Navigate to the Boom Angle icon in the Main Sensor Calibration Menu screen and press the OK  function key to start the boom angle calibration.

The Boom Angle Calibration screen appears.
Boom Angle Calibration



3. Follow the prompts as necessary to complete the calibration.

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 module is replaced
- The RCL software is updated

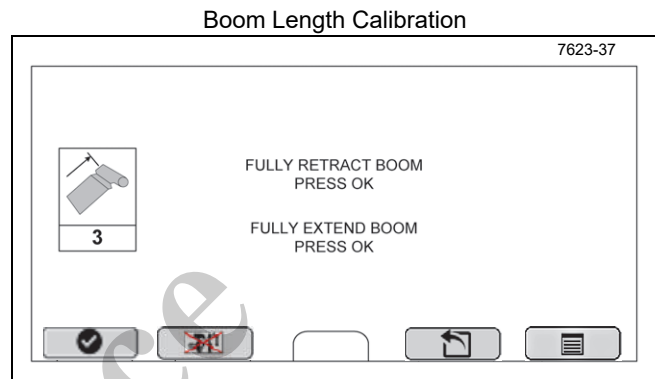
NOTE: The boom length sensor recalibration is not required if the lift cylinder is repaired or replaced.



Two calibration positions are described, 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. Navigate to the Boom Length icon on the Main Sensor Calibration Menu screen and press the OK  function key 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 transducer block is located on the rear of the turret (3, Figure 3-14). Each transducer must be calibrated separately.


The transducers require calibration in the following circumstances:

- When the transducer block is replaced
- The lift cylinder is replaced
- The RCL module is replaced
- The RCL software is updated

Calibrating Rod Side Pressure Transducer

Use the following procedure to calibrate the rod side pressure transducer (1, Figure 3-14). To zero the rod side transducer, the hydraulic line to the rod side (1) must be disconnected.

To calibrate the rod side pressure transducer:

1. In the Main Sensor Calibration Menu screen, highlight the rod side pressure transducer icon (lower left of the Sensor Calibration icon group).
2. Press the OK  function key.
The Rod Side Transducer Calibration screen appears.

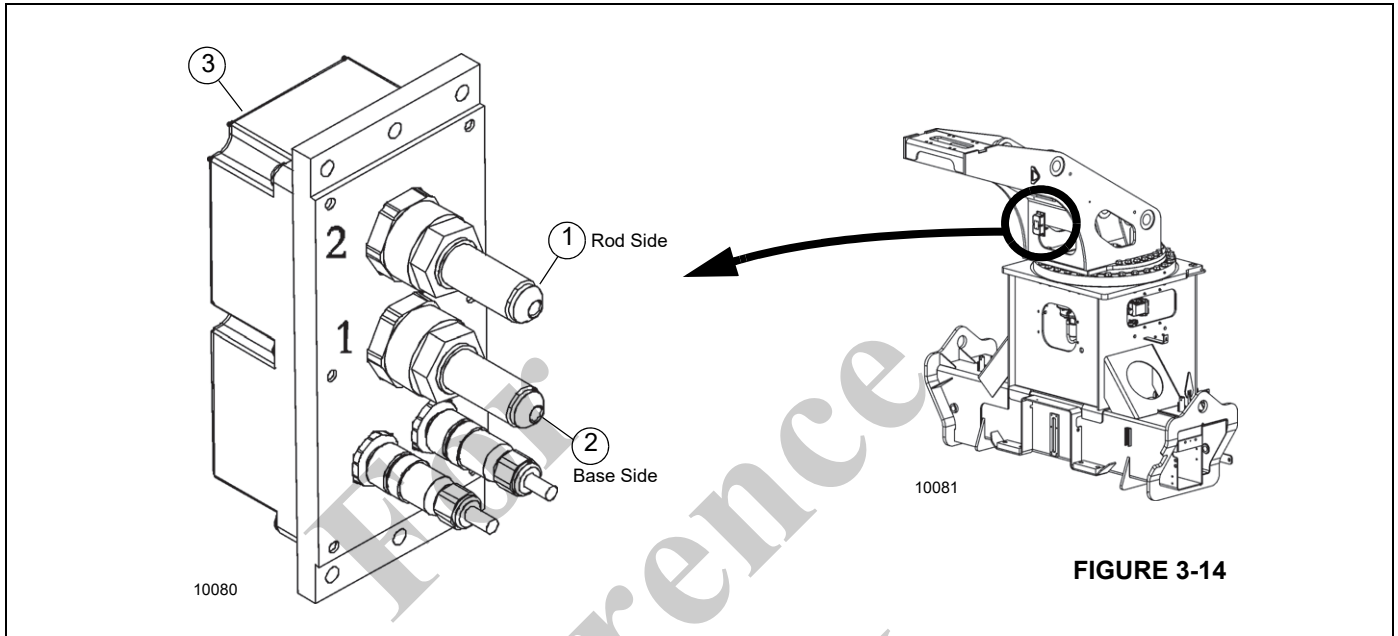
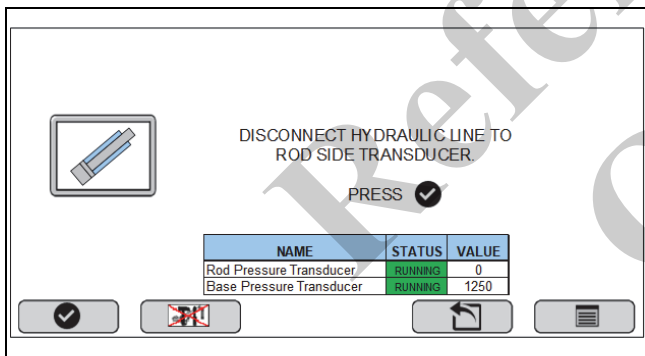




FIGURE 3-14

Rod Side Pressure Transducer Calibration




3. Disconnect the hydraulic line from the rod side (5) on the transducer block (3).
4. Press the OK  function key.
5. When prompted, reconnect the rod side hydraulic line to the fitting on the transducer block (3).
6. Press OK  to return to the Main Sensor Calibration Menu screen.

Calibrating the Base Side Pressure Transducer

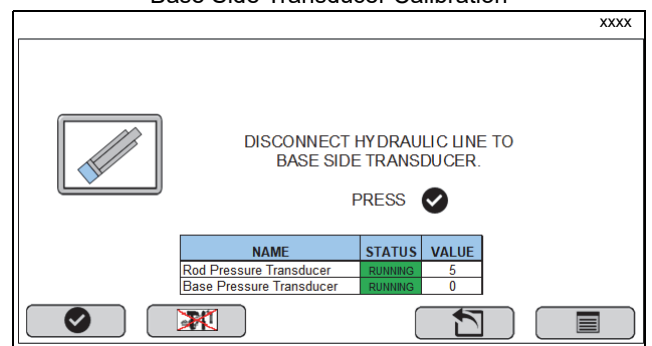
Use the following procedure to calibrate the base side pressure transducer (2, Figure 3-14).

To calibrate the base side pressure transducer:



1. In the Main Sensor Calibration Menu screen, highlight the base side pressure transducer icon (lower middle in the Sensor Calibration icon group).
2. Press the OK  function key.

The Base Side Transducer Calibration screen appears.

Base Side Transducer Calibration



3. Disconnect the hydraulic line on the base side (2) of the transducer block (3).

4. Press the OK  function key.
5. When prompted, reconnect the base side hydraulic line (2) on the transducer block (3).
6. Press the OK  to return to the main sensor calibration screen.

Calibrating the Outrigger Span/Length

DANGER

Tipping Hazard!

All four outriggers must either be fully retracted, at the mid-extend, or fully extended positions, and the RCL set to the correct position. Failure to do so creates a tipping hazard.

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
- The RCL module is replaced
- The RCL software is updated


Starting with the fully retracted position, calibration positions are shown on the Outrigger Length Sensor Calibration screen. 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 appear red in a high level view. The

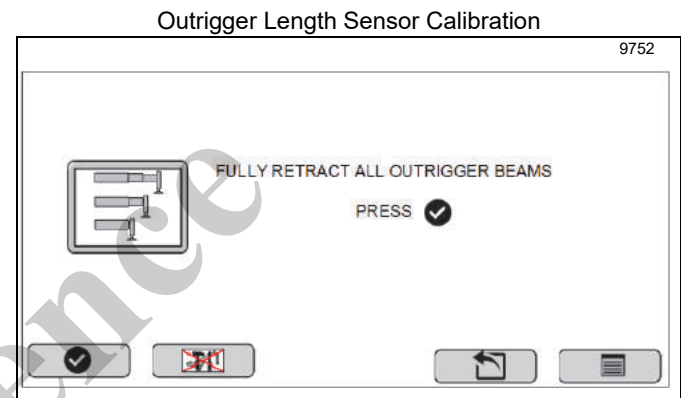
sensor corresponding beam should be checked for proper function and wiring.




For information about setting the outriggers, see “Outrigger Setup” in the Operator Manual.

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.



3. Fully retract (0% position) and lock the outrigger beams.
4. Press the OK  function key.
5. Set and lock the outrigger beams to 50% position (midspan).
6. Press the OK  function key.
7. Fully extend (100% position) the outrigger beams.
8. Press the OK  function key.

SECTION 4 BOOM MAINTENANCE

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THEORY OF OPERATION

The boom is a four section boom that uses a hydraulic telescope cylinder and internal cables to extend and retract the boom. A lift cylinder located under the boom is used to raise and lower the boom.

The telescope cylinder is two-stage, double acting, and attached to and extends the 1st, 2nd, and 3rd boom sections. Extend cables are used to extend the 4th boom section (Figure 4-1). The telescope cylinder retracts the 1st and 2nd boom sections. Retract cables are used to retract the 3rd and 4th boom sections. The extend cables for the 4th section are attached to the rear of the 2nd boom section, reeved around sheaves on the front of the telescope cylinder and attached to the rear of the 4th boom section.

The retract cables for the 4th boom section are attached to the front of the 2nd boom section, reeved around sheaves on the rear of the 3rd boom section, and attached to the rear of the 4th boom section. The retract cables for the 3rd boom section are attached to the front of the 1st boom section, reeved around sheaves at the rear of the 2nd boom section, and attached to the rear of the 3rd boom section.

A proportioning cable is attached to the rear of the 1st boom section, reeved around a sheave at the front of the 2nd section, and attached to the rear of the 3rd section. This cable maintains proper telescope cylinder proportion and equal boom section extension.

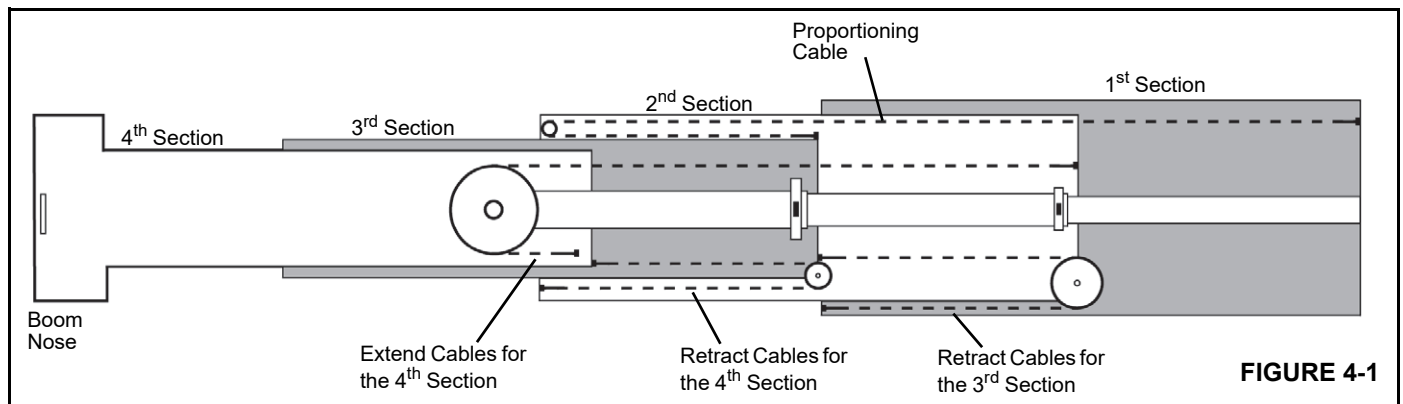
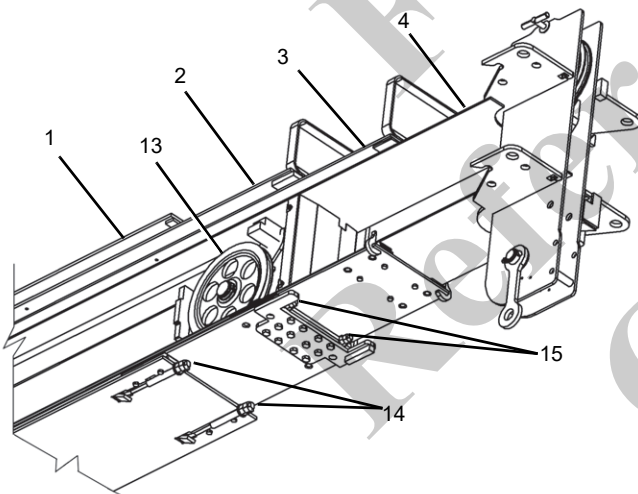
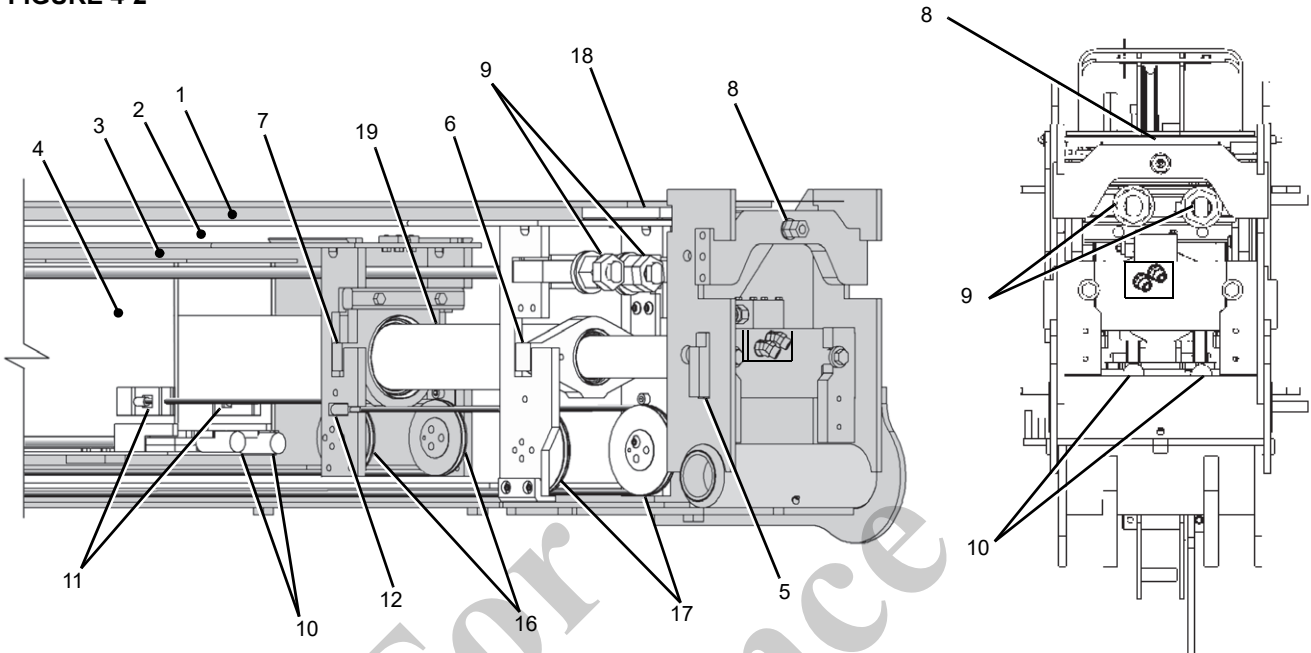


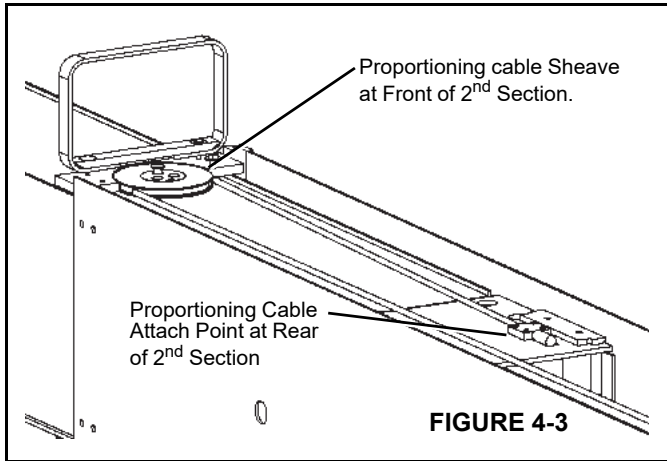
FIGURE 4-1

FIGURE 4-2



Item	Component
1	1 st boom section
2	2 nd boom section
3	3 rd boom section
4	4 th boom section
5	Telescope cylinder rod attach point at the 1 st boom section.
6	Telescope cylinder attach point for the 2 nd boom section.

Item	Component
7	Telescope cylinder attach point for the 3 rd boom section.
8	Proportioning cable attach point.
9	Attach point at the rear of the 2 nd boom section for the 4 th boom section extend cables.
10	Attach point at the rear of the 4 th boom section for the 4 th boom section extend cables.
11	Attach point at the rear of the 4 th boom section for the 4 th boom section retract cables.
12	Attach point at the rear of the 3 rd boom section for the 3 rd boom section retract cables.
13	Extend sheaves at the front of the telescope cylinder.
14	Attach point at the front of the 1 st boom section for the 3 rd boom section retract cables.
15	Attach point at the front of the 2 nd boom section for the 4 th boom section retract cables.
16	Retract sheaves at the rear of the 3 rd section for the 4 st section retract cables.
17	Retract sheaves at the rear of the 2 nd section for the 3 rd section retract cables.
18	Upper Wear Pad
19	Extend Cylinder

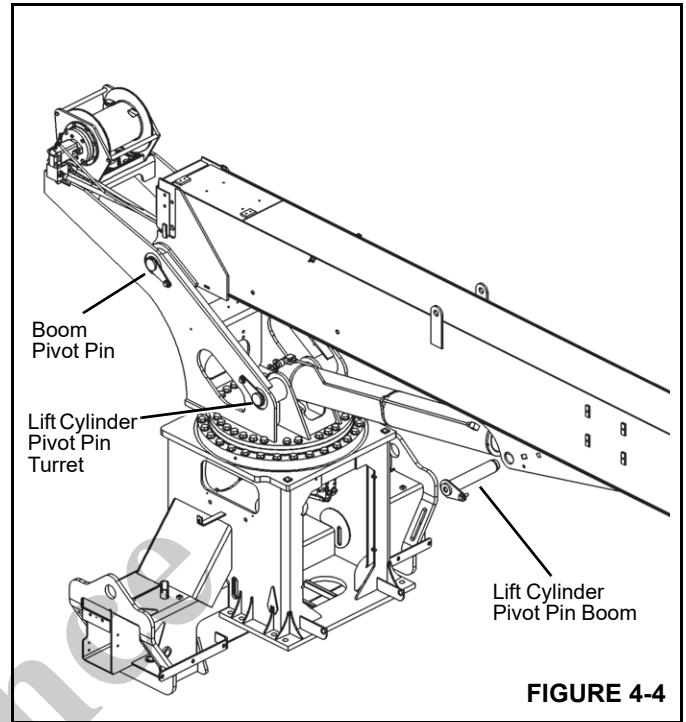


BOOM REMOVAL FROM TRUCK

The boom and hoist are removed from the truck as one assembly.

Boom Length	Boom Weight*
969	7220 lb (3275 kg)
995	8910 lb (4041 kg)
9105	9600 lb (4354 kg)

* Includes single hoist



5. Lower lift cylinder to a suitable support.
6. Tag and disconnect the hydraulic lines boom telescope cylinder. Cap all lines and ports.

CAUTION
Fall Hazard!

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

1. Extend and set the outriggers. The boom must be completely retracted and stowed in the boom rest.
2. If equipped, remove swing around jib according to "Section 4, Setup" of the Operator Manual.
3. Remove the hook block or downhaul weight and wind up the rope on hoist drum. Shut down the truck engine.
4. Attach a lifting device to the rod end of the lift cylinder and remove the boom lift cylinder pin keeper and pin from bottom of the 1st section boom (Figure 4-4).

WARNING
Crushing Hazard!

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

7. Attach a lifting device at the boom CG and raise the boom until the weight is removed from the boom pivot pin. Remove boom pivot pin keeper and pin (Figure 4-4) and lift boom off the turret.

Lift Cylinder Removal

This procedure assumes the boom has been removed.

1. Tag and disconnect the hydraulic lines attached to the lift cylinder.
2. Attach a lifting device to the lift cylinder.
3. Remove the lift cylinder pivot pin at the turret.
4. Lift the cylinder off the truck.

BOOM DISASSEMBLY

The front of the boom is the sheave case end and the rear of the boom is the hoist mount end. Left and right are viewed from the rear to the front.

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 hoist can be removed to facilitate disassembly, but it is not required.

2nd, 3rd, 4th Boom Section Removal

To remove the 2nd, 3rd, 4th sections from the 1st section as an assembly, use the following procedure:

1. Remove the left and right upper wear pads in the rear between the 1st and 2nd boom sections (Figure 4-5).

NOTE: The lower wear pads are not removed at this time. They are left in to aid in protecting the extend cables during removal of the 2nd, 3rd, 4th boom sections.

2. Loosen and remove the two capscrews, lockwashers and spacers that anchor the extend cylinder rod butt plate to the rear of the 1st section.
3. Attach a suitable lifting device to the 2nd, 3rd, 4th boom section assemblies.
4. Slide the 2nd, 3rd, 4th boom section assemblies out about 2 feet.
5. Tag and remove the top and side wear pads, shims, and wear plates. Leave the bottom wear pads in.
6. With the 2nd, 3rd, 4th boom section assembly supported, slide the assembly out of the 1st section until the assembly is just ready to drop out of 1st section. Relocate the sling on the 2nd, 3rd, 4th boom assembly so that the assembly is balanced as it slides out of the 1st section.

NOTE: Keep the retract cables tensioned slightly by hand as the assembly is pulled out of the 1st section to prevent damage to cable assemblies.

7. Loosen and remove the two capscrews and lockwashers securing the spacer bar to the inside top front of the 1st section. Remove the spacer bar.
8. Loosen and remove four capscrews securing wear pads to the bottom of the 1st section.
9. Raise the 2nd, 3rd, 4th boom assembly inside the 1st section to allow for front bottom pad removal. Tag and remove the bottom wear pads.

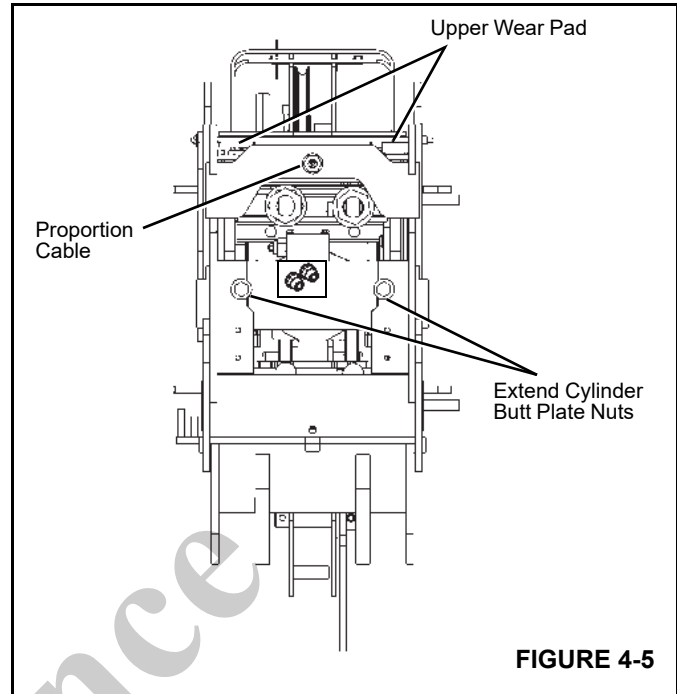


FIGURE 4-5

10. After the wear pads have been removed, slide the 2nd, 3rd, 4th assembly out of the 1st section and place on a suitable horizontal surface. Take care not to pinch or crush the retract cables while lifting or supporting the assembly.

Disassembly of 2nd, 3rd, 4th Boom Sections

1. Loosen and remove the four capscrews securing the two top rear wear pads on the 2nd section. Tag and remove the wear pads, shims, and plates.

NOTE: Keep all parts for each wear pad together so that the correct shims are in place for reassembly.

2. Loosen and remove the four capscrews securing the rear bottom wear pads on the 2nd section.

NOTE: Removal of these pads allow the retract cables to uncoil off the retract sheaves.

3. Place the retract cable ends in a location to minimize the possibility of damage.
4. Loosen and remove the six capscrews securing the retract sheave pin and retract sheaves to the 2nd section. Remove the sheaves and pins.
5. Loosen and remove the two capscrews functioning as the upper retract cable keepers. Remove the retract cables.
6. Loosen and remove the two capscrews securing the lock bar to the extend cylinder collar. Remove the bar.

NOTE: The lock bar constrains the vertical movement of the extend cylinder.

7. Loosen the capscrews that secure the extend cable anchor to the rear of the 4th section.
 - a. Total removal of the capscrews allow the cable anchor to be completely disassembled.
 - b. Back the capscrews out about 0.50 inch (12 mm) to allow the anchor assembly to slide back out of the section as the telescope cylinder is removed.
8. Support the telescope cylinder with an appropriate lifting device and pull the telescope cylinder out of the boom to within 3 feet (91 cm) of complete removal from the boom sections.

NOTE: Keep the extend cables tensioned slightly by hand to minimize the possibility of damage to the cables.

9. Reach into the rear of the 4th section and pull the extend cable anchor out from its retaining pocket on the bottom of the 4th section. A slight angle applied to the anchor as it's being pulled to the rear permits easier removal through the 2nd and 3rd sections.
10. Remove the telescope cylinder and cables from the boom. Place cylinder and cables in a safe place to keep them from being damaged.
11. Loosen and remove the two capscrews, wear pad, and cable guide from the front top of the 2nd section.
12. Loosen and remove the capscrews attaching the bottom cable retainer plate to the 2nd section. Slightly lift the 3rd section and remove the retainer plate.
13. Slide the 3rd section out of the 2nd section. The side pads may need to be removed. Tag and remove the side pads and shims if required.
14. Loosen and remove the two capscrews, cable guide, wear pad, and spacer bar from the front top of the 3rd section.
15. Loosen and remove the four capscrews attaching the bottom pad plate to the 3rd section. Slightly lift the 4th section and remove the pad plate.

16. Slide the 4th section out of the 2nd section. The side pads may need to be removed. Tag and remove the side pads and shims if required.

17. Loosen and remove all remaining capscrews and wear pads.

Additional Maintenance, Disassembled Boom

1. Clean all boom sections and inspect for wear, dents, bent or crooked 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 the bearing diameter is 0.015 inch (0.38 mm) larger than pin diameter, the bearing must be replaced. Any deep cut or gouge in the bearing liner is cause for replacement.
4. Clean and inspect all cable assemblies and replace as required. Lubricate all cable assemblies before reinstalling 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.

BOOM ASSEMBLY

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

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

1. Assemble the sheaves into the 4th section sheave case. The top sheave is to be installed to the left hand side of the boom with the spacer to the right hand side (Figure 4-6).

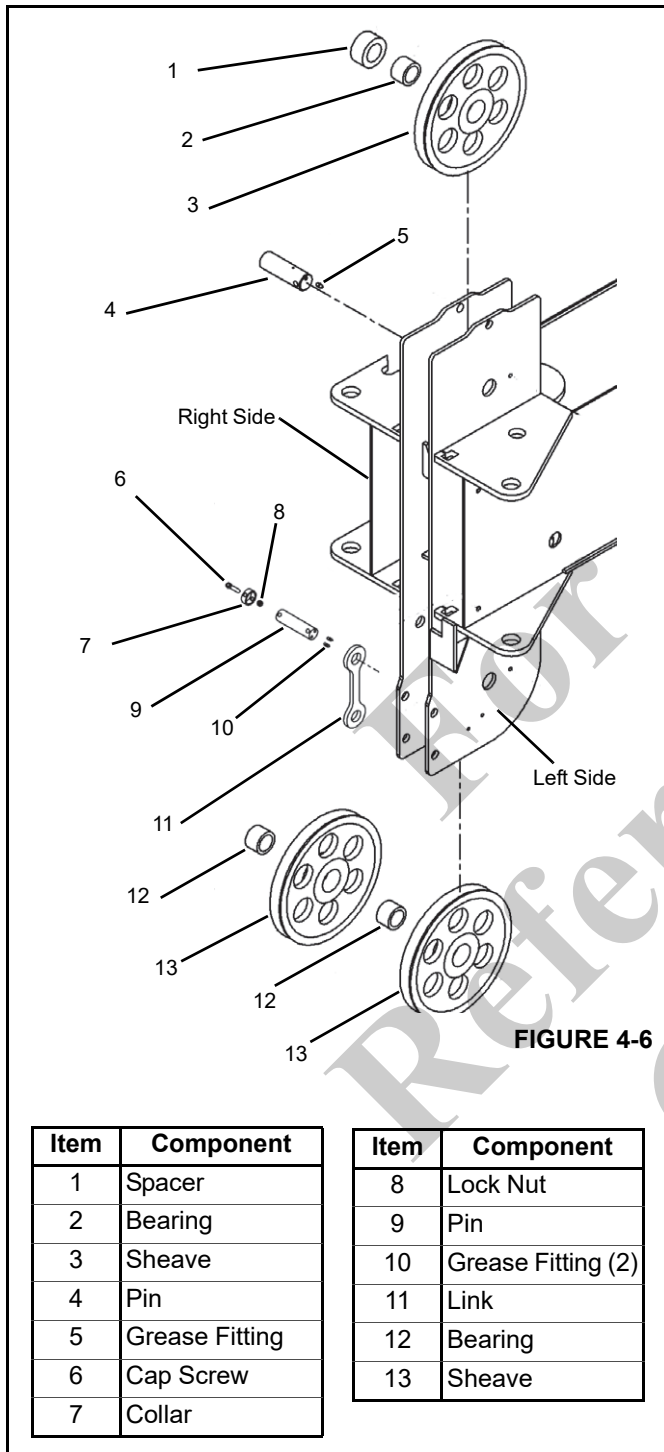


FIGURE 4-6

2. Attach the rear wear pads on bottom of the 4th section as per removal tags. Use Loctite 243 blue on all wear pad mounting capscrews (Figure 4-7).

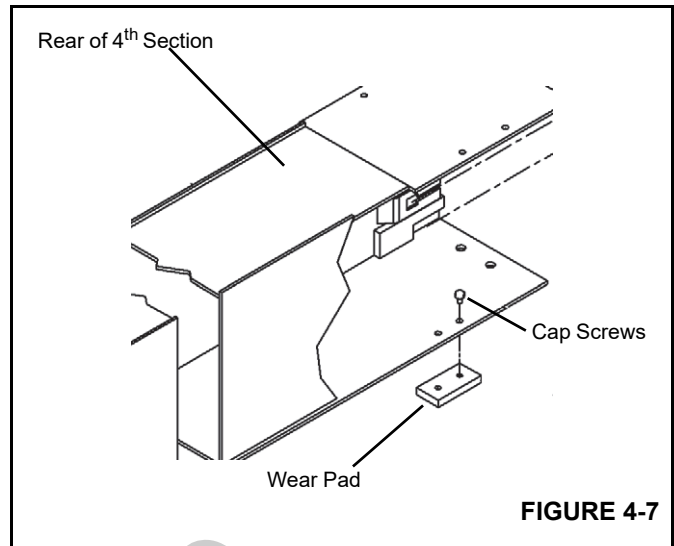


FIGURE 4-7

3. Install the 4th section boom into the 3rd section. Slide in until about 5 feet (150 cm) of the 4th section extends from the 3rd section.

4. Assemble the bottom front wear pads for the 3rd section as per removal tags and attach to the pad plate (Figure 4-8).

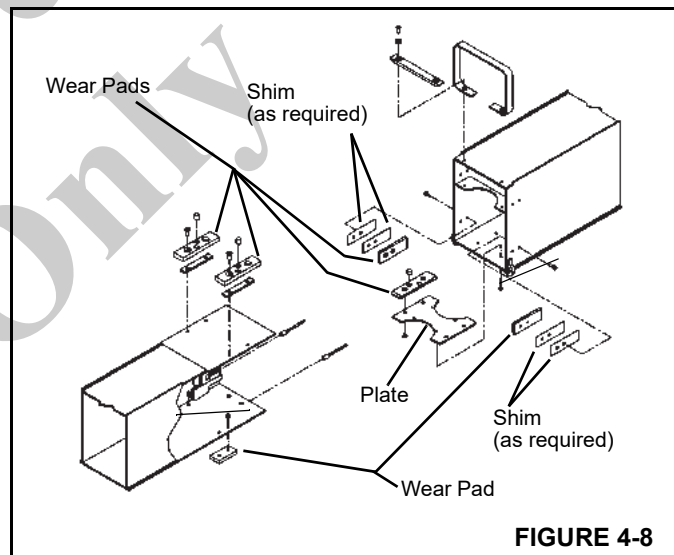


FIGURE 4-8

5. Using an appropriate lifting device, lift the 4th section to allow for wear pad/pad plate installation in front of the 3rd section.

6. Install the wear pad/pad plate assembly and slide the sections together within 12 inches (30 cm) of full retraction.

7. Install the cable guide and upper spacer to the front of the 3rd section.

8. Install the front side wear pads and shims between the 4th and 3rd sections.

NOTE: For boom reassembly with no new sections, reinstall shims per removal tags. For new boom section, shim calibration may be necessary.

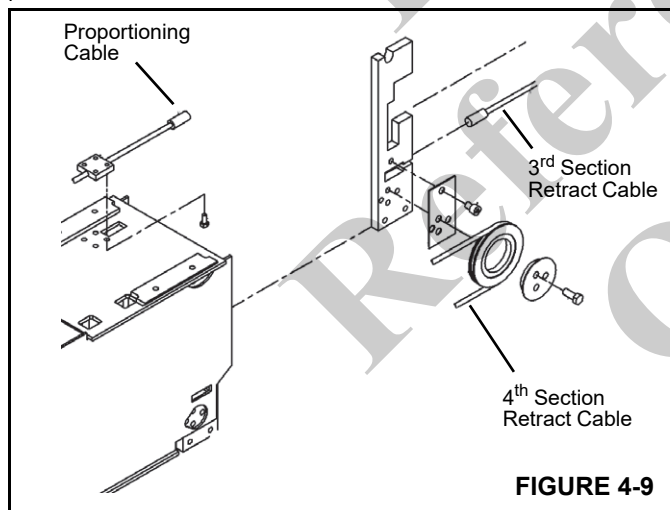
9. Slide boom sections completely together.
10. Assemble the top rear wear pads to the 4th boom section with the cam plates and install through the hoist mount end of the boom. Install the capscrew through holes in the outer boom sections.

NOTE: To adjust the wear pads on each side at the top/rear of the boom, rotate the wear pad and plate or the wear pads and plate independently. The adjustment range is 0.187 in (4.8 mm).

Offset holes (0.06 in (1.5 mm) in the plate and 0.03 in (0.8 mm) the wear pad) allow for adjustment.

Extend/Retract Cable Installation

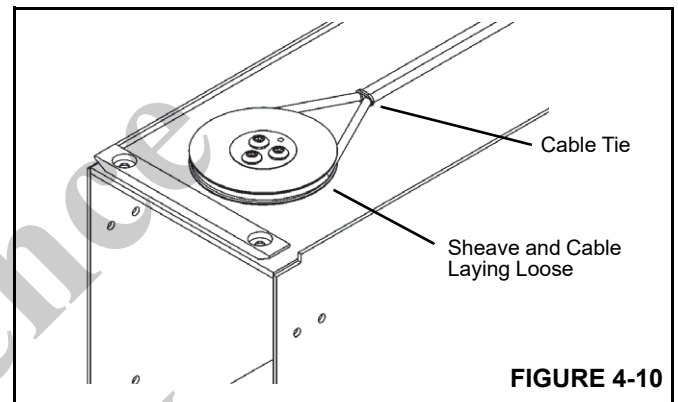
NOTE: Five cables to be installed in this part of the boom assembly (two are added later). The cables installed now are four retract cables and one proportioning cable.



1. Uncoil 3rd section retract cable assemblies and insert the button end into the cable anchor pockets in the rear of the 3rd section. Install the keeper plate over the cable end (Figure 4-9).
2. Install the cable sheave onto anchor plate. Coat the surfaces of the bearings and keeper plates with grease before assembly.
 - a. Install the sheave retainer cap with the three cap screws.
 - b. Reeve the 4th section retract cable around cable sheave.

- c. Install the cable retainer pin into the anchor plate.
- d. Place the uncoiled cable in a safe area to prevent damage (Figure 4-9).

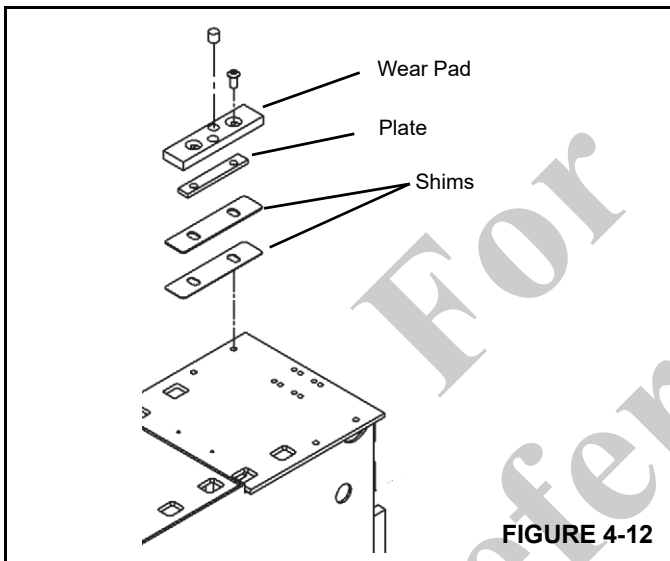
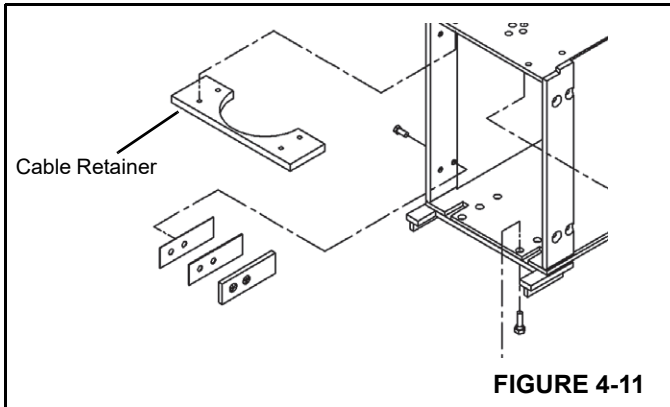
3. Place the retract cables anchored to the 4th section over the top of the retract sheaves on the 3rd section. Install the keeper capscrew above the sheave to the hold retract cables in place.
4. Reeve the cables over the retract sheave and install the keeper/wear pad to the bottom rear of the 3rd section. This pad acts as a side pad, bottom pad, and a cable retainer. Loctite all wear pad mounting screws with Loctite 243 blue.



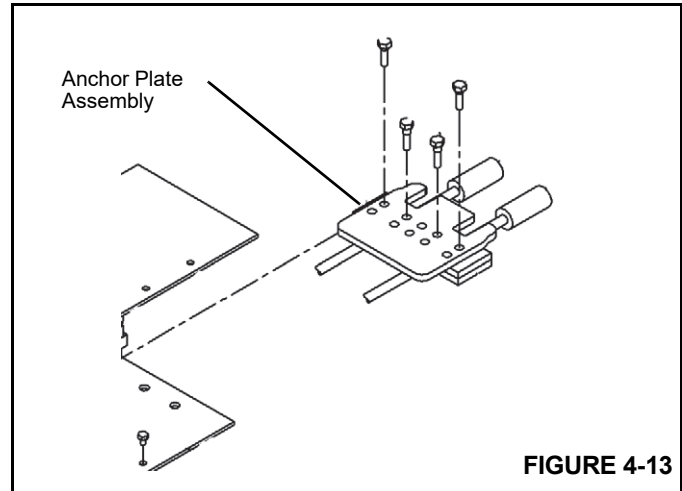
5. Loop the proportion cable around the cable sheave and place it on the top of the 3rd section. (this assembly is attached to the 2nd section later). Tie the two cables together as shown in Figure 4-10.

NOTE: The loop end must be towards the front. The threaded and button end must be towards the rear.

6. Slide the 4th/3rd section assembly into the 2nd section. Leave this assembly hanging out of the 2nd section about 4 to 5 ft (1.2 to 1/5 m).
7. On the tip end of the 2nd section install the bottom wear pad, plate, capscrews and washers.
8. On the tip end of the 2nd section install the bottom side wear pads and shim as required.
9. Remove the cable tie installed in step 15.
10. Slide the 4th/3th section assembly into the 2nd section about 2 ft (.6 m).
11. Install the proportion cable and sheave to the top plate of the 2nd section.
12. Install the cable retainer to the top plate of the 2nd section (Figure 4-11).

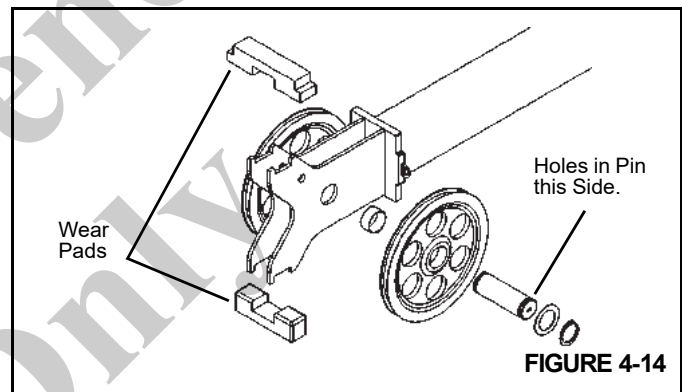


13. On the base end of the 2nd section install the upper wear pad and plate (Figure 4-12).
14. Extend the 4th section 4 to 5 in (101 to 127 mm).
15. Extend the 3rd section 4 to 5 in (101 to 127 mm) or until the anchor plate is accessible.
16. Install the anchor assembly, plate and extend cable (Figure 4-13).



Telescope Cylinder Installation

1. Install the sheave wheels on the telescope cylinder. The holes in the end of the pin must be located as shown in (Figure 4-14).



2. Reeve the retract cables around the telescope cylinder sheaves.
 3. Install the wear pads on the telescope cylinder.
- NOTE:** Ensure the top wear pads do not fall off during cylinder installation (Figure 4-14).
4. Insert the telescope cylinder assembly $\frac{1}{2}$ to $\frac{3}{4}$ of the way into the 2nd section.
 5. At the base end of the 4th section (Figure 4-15) install the anchor assembly in the following order:
 - a. Plate
 - b. Extend cable button ends
 - c. Anchor assembly and cap screws

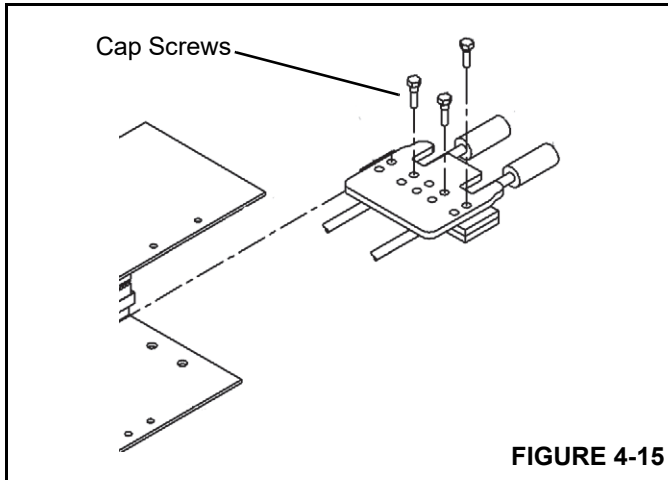


FIGURE 4-15

6. Install the telescope cylinder the rest of the way into the boom assembly.
7. Insert the extend cable anchor assembly into the base end of the 2nd section (Figure 4-16).
8. Thread the extend cable through the extend cable anchor assembly.
9. Install the following onto the extend cable in the following order:
 - a. Spacer
 - b. Round washer
 - c. Hex nut
 - d. Jam nut
 - e. Cable protector
 - f. Retainer plate
 - g. Two cap screws

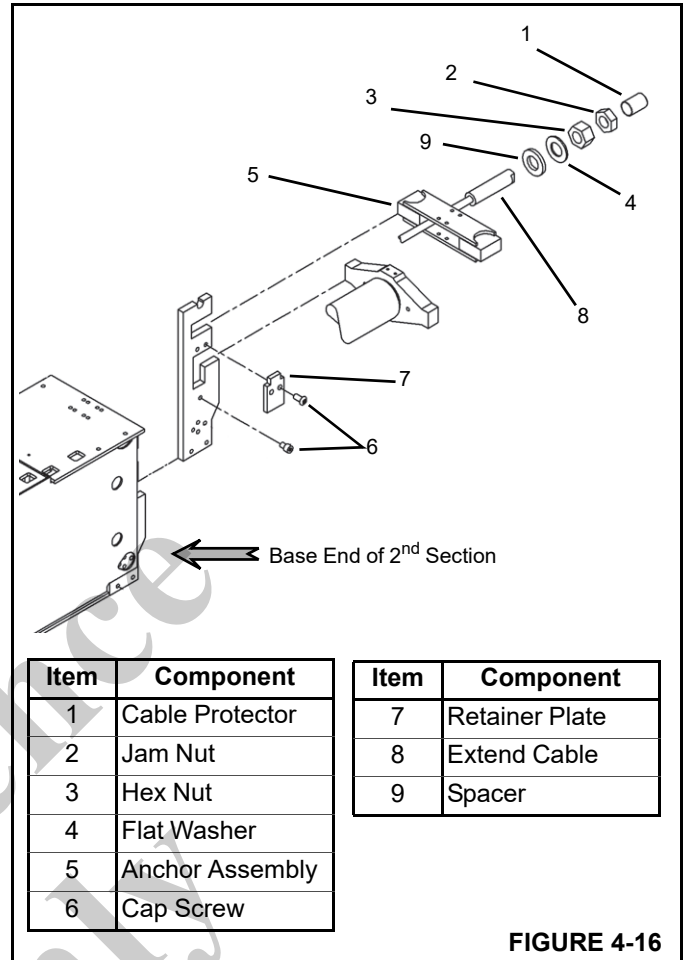


FIGURE 4-16

2nd/3rd/4th BOOM SECTION INSTALLATION

1. Slide the 2nd/3rd/4th section assemblies into the 1st section until 4 to 5 ft (1.2 to 1.5 m) of the assembly is left.
2. Install the lower wear pads at the front end of the 1st section and secure with cap screws (Figure 4-17).
3. Install the side wear pads and shims as required. Secure with cap screws
4. Install the upper wear pad and secure with a flat washer and cap screws.

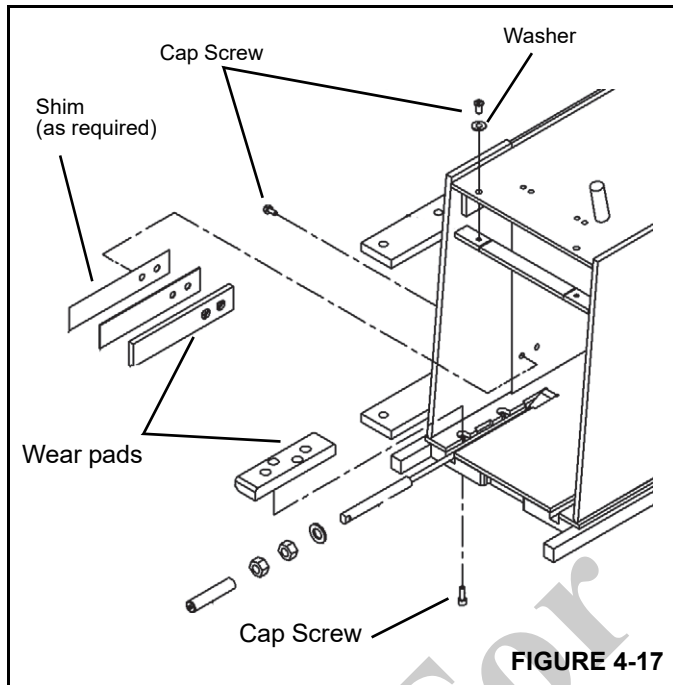


FIGURE 4-17

5. Slide the completed 2/3/4 assembly all the way into the base section.
6. Install the spacers and cap screws through the telescope cylinder anchor plates.
7. Thread the proportioning cable through the anchor plate and install the anchor plate (Figure 4-18) in the following order:
 - a. Washer
 - b. Hex nut
 - c. Cable protector

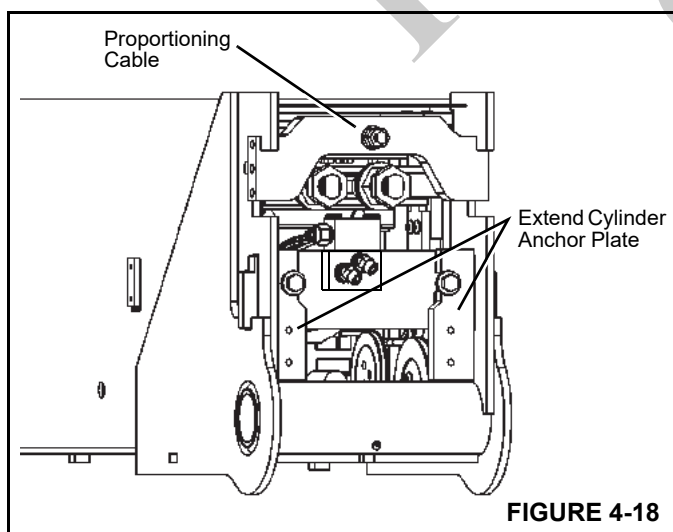


FIGURE 4-18

CABLE TENSIONING

NOTE: The boom must be horizontal to get proper tension on the cables.

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

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

A single stage cylinder will control first extendable section.

A dual stage cylinder will control second extendable section.

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

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

Tensioning Setup Procedure

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

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

Ensure boom is completely assembled and fully retracted.

1. Mark the front of each section with a chalk line as indicated in Figure 4-19.
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 Tightening Sequence** instructions.



Cable Tension Sequence

Four section boom with two stage cylinder.

Cable tensioning to be in the following order:

1. 321 retract cables
2. 123 extend (synchronizing) cables.
3. 234 extend cables

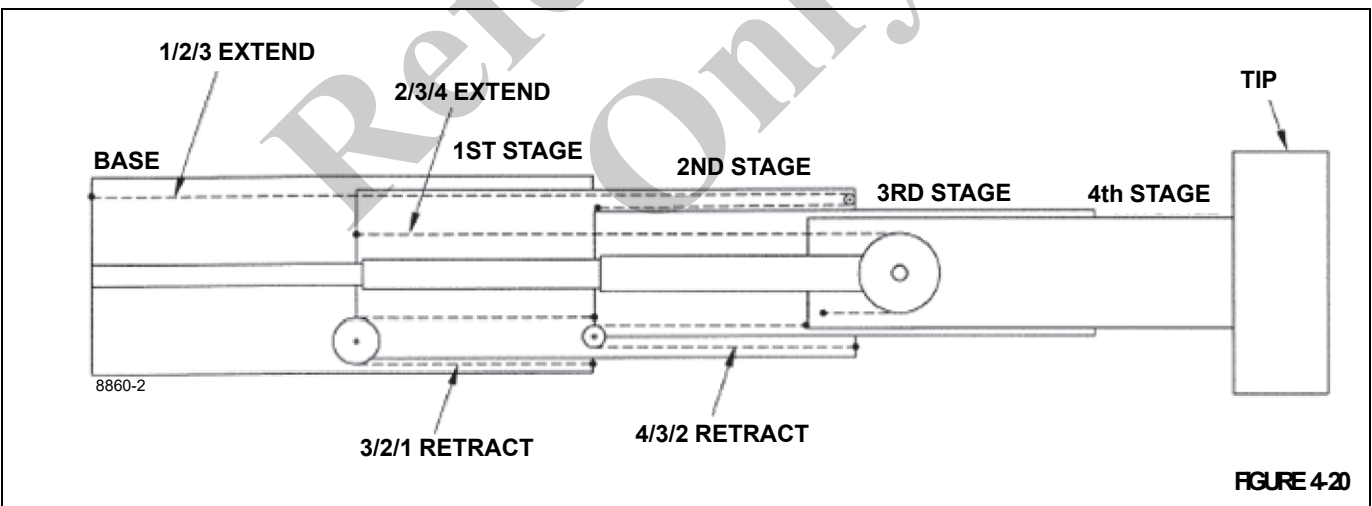
4. 432 retract cables.

Four section boom with one stage cylinder.

Cable tensioning to be in the following order:

1. 123 extend cables.
2. 321 retract cables.
3. 234 extend cables.
4. 432 retract cables.

4- Section Boom w/ 2 Stage Cylinder Cable Positioning



Cable Tightening Sequence 4 Section Boom with Two Stage Extend Cylinder

Boom must be in horizontal position when adjusting cable tension (See Figure 4-20.) Retract boom fully ensuring sections are bottomed out on section stops. Ensure all sections are fully bottomed out and do not spring back.(Reference Tensioning Setup Procedure)

321 and 123 cable balancing

Extension

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

If the extension gap between 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;

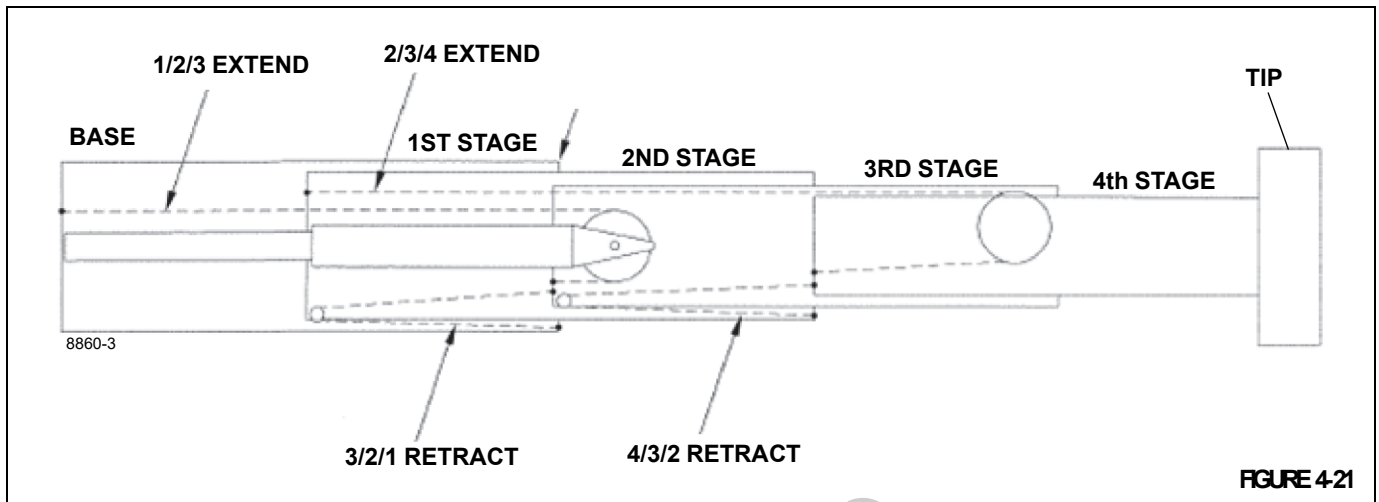
2. Tighten the **432** retract cable located at the front bottom of the second section the difference in the retraction gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

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

4- Section Boom w/ 1 Stage Cylinder Cable Positioning



Cable Tightening Sequence 4 Section Boom with (1) Stage Extend Cylinder

Boom must be in horizontal position when adjusting cable tension (See Figure 4-21.) Retract boom fully ensuring sections are bottomed out on section stops. Ensure all sections are fully bottomed out and do not spring back. (Reference Tensioning Setup Procedure)

321 and 123 cable balancing

Extension

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

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

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

The third section should have moved out.

4. Tightening until the extension gap between the first and second section and the extension gap between the second and the third are equal.

Retraction

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

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

2. Tighten the **321** retract cable located at the front bottom of the base section the difference in the retraction gap measurements.
3. Extend and retract the boom a few times and then repeat measuring the retraction gaps.

The third section should have moved in.

4. Tightening until the retraction gap between the first and second section and the retraction gap between the second and the third are equal.

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

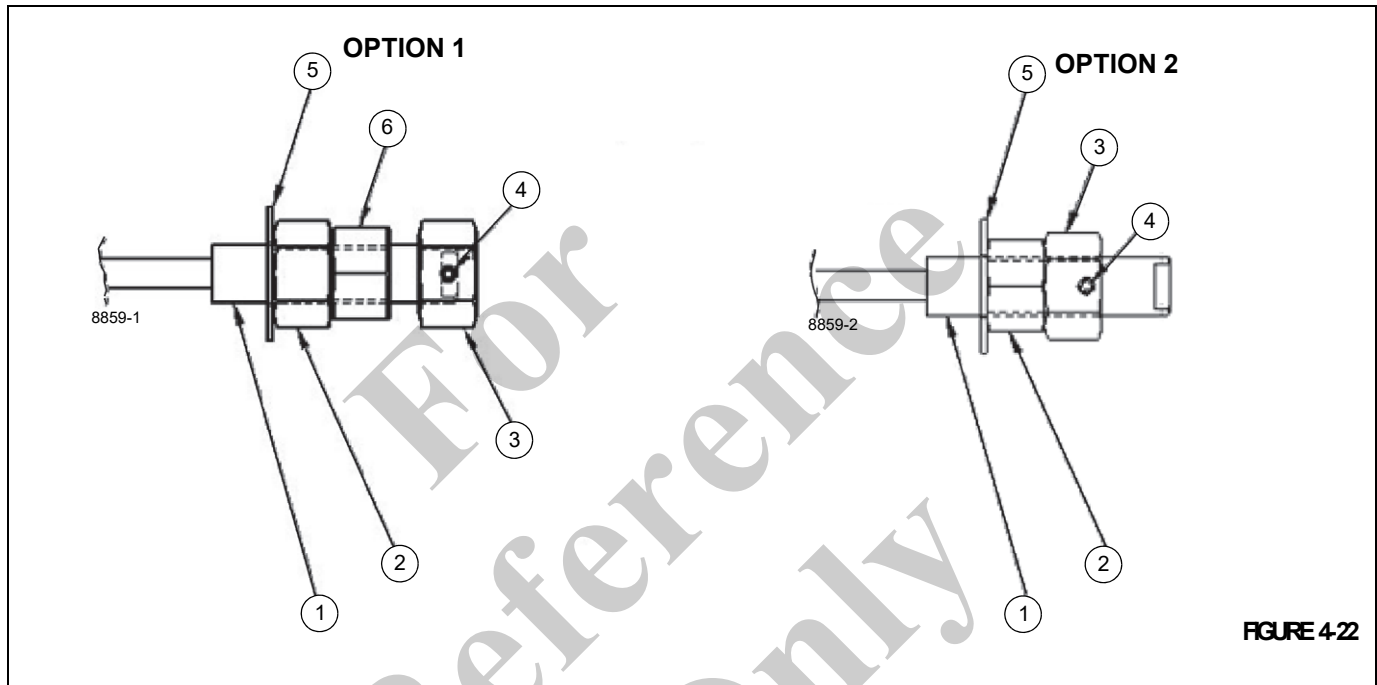


FIGURE 4-22

Cable Retention

Cable Retention Hardware

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

Nut configuration (see Figure 4-22) 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 4-22).

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 1/4-7	SAE 2	Hex Jam (HALF)	203
1 1/2-6	SAE 5	Hex Jam (FULL)	250
1 3/4-5	ASTM B	Hex Jam (FULL)	250

Metric Series with Coarse Threads

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

BOOM INSTALLATION ON THE TRUCK



Fall Hazard!

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

1. Extend and set the outriggers.
2. Attach a lifting device at the boom center of gravity and lift the boom on the truck and lower to the boom rest.
3. Line up the boom with the attach point on the turret.
4. Install the boom pivot pin (Figure 4-4).
5. Attach a lifting device to the rod end of the lift cylinder raise the lift cylinder so that the pivot pin can be installed (Figure 4-4).
6. Install the lift cylinder pivot pin in the bottom of the 1st boom section.
7. Reinstall telescope cylinder hydraulic lines as per removal tags.



Crushing Hazard!

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury may result.

LIFT CYLINDER INSTALLATION

1. Attach a lifting device to the lift cylinder.
2. Raise the lift cylinder to the truck bed under the boom.
3. Line up the lift cylinder with the attach point on the turret and install the pivot pin (Figure 4-4).
4. Raise the rod end of the lift cylinder to the attach point under the boom and install the pivot pin.



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*For
Reference
Only*

**SECTION 5
HOIST**

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DESCRIPTION

The 900H hoist is composed of motor control valve, a fixed displacement hydraulic motor, a multiple disc brake, 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 raise the load without releasing the brake while at the same time holding the load until there is sufficient pressure to release the brake when hoisting down.

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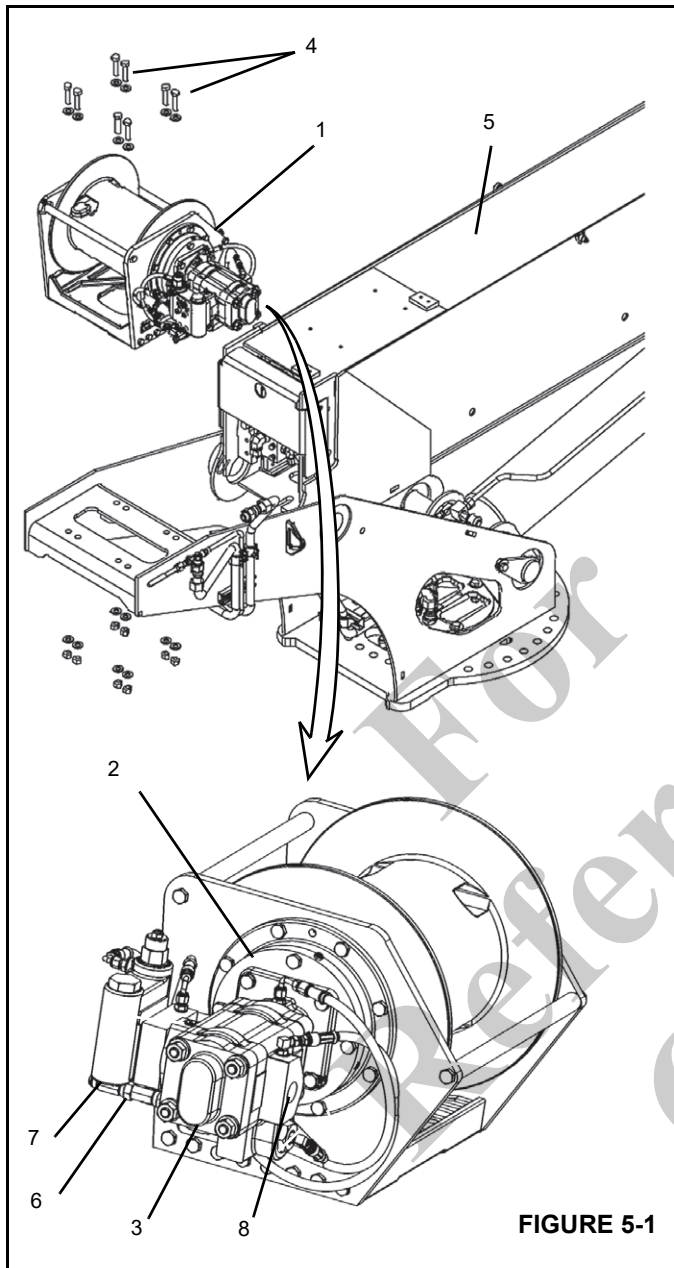


FIGURE 5-1

Item	Component
1	Hoist
2	Brake
3	Motor
4	Mounting Bolts (8 places)
5	Boom
6	Case Drain
7	Pressure Port to Raise
8	Pressure Port to Lower

MAINTENANCE

Inspect the hoist daily for oil leaks, loose bolts, and worn hoist cable. Check the gearbox and brake oil every 500 hours. Do an oil change every 1000 hours. Refer to *Lubrication*, page 8-1. Inspect the hoist from the deck of the crane. Do not stand on the turret.

WARNING

Fall Hazard!

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

Warm-up Procedure

A warm-up procedure is recommended at each start-up and is essential if ambient temperature is below +40°F (4°C). 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.

Removal

WARNING

Crushing Hazard!

The combined weight of the hoist and 390 ft of wire rope is 730 lbs (331 kg). Death or serious injury may result.

NOTE: See Figure 5-1 for item identification.

1. Remove the cable from the hoist drum.
2. Tag and disconnect the hoist hydraulic lines. Cap and plug all hydraulic openings.
3. Attach a lifting device to the hoist and take up the slack.
4. Remove the mounting bolts from the hoist.
5. Remove the hoist from the crane with the lifting device.

Hydraulic Hoses

Inspect the hydraulic hoses and replace as required.

Hoist Installation

1. Attach a lifting device to the hoist.
2. Lift the hoist with a lifting device onto the turret.
3. Install mounting bolts and washers.
4. Remove the lifting device.

- Reinstall the hydraulic hoses as per removal tags.

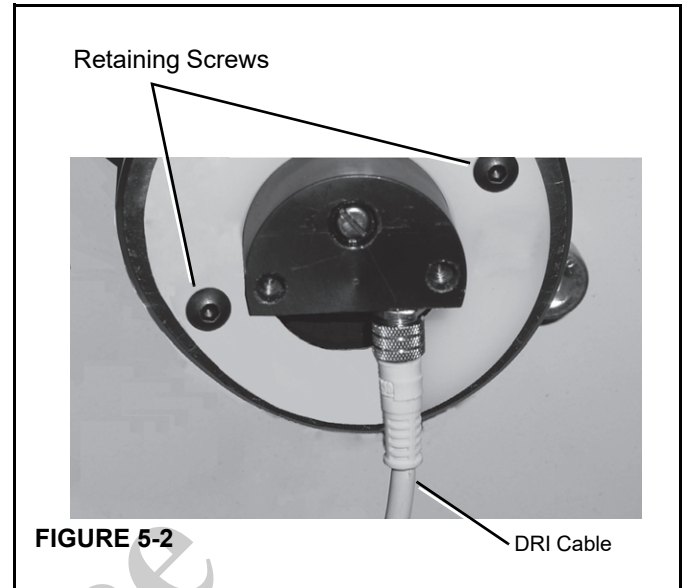
DRUM ROTATION INDICATOR

The drum rotation indicator (DRI) is located on the left side of the hoist and transmits a rotation signal to a solenoid (thumb thumper) located in the hoist control lever on the operator's control panel.

The DRI transducer may have an optional integral 3rd wrap indicator which is programmed to notify the operator when there are three wraps of cable left on the drum.

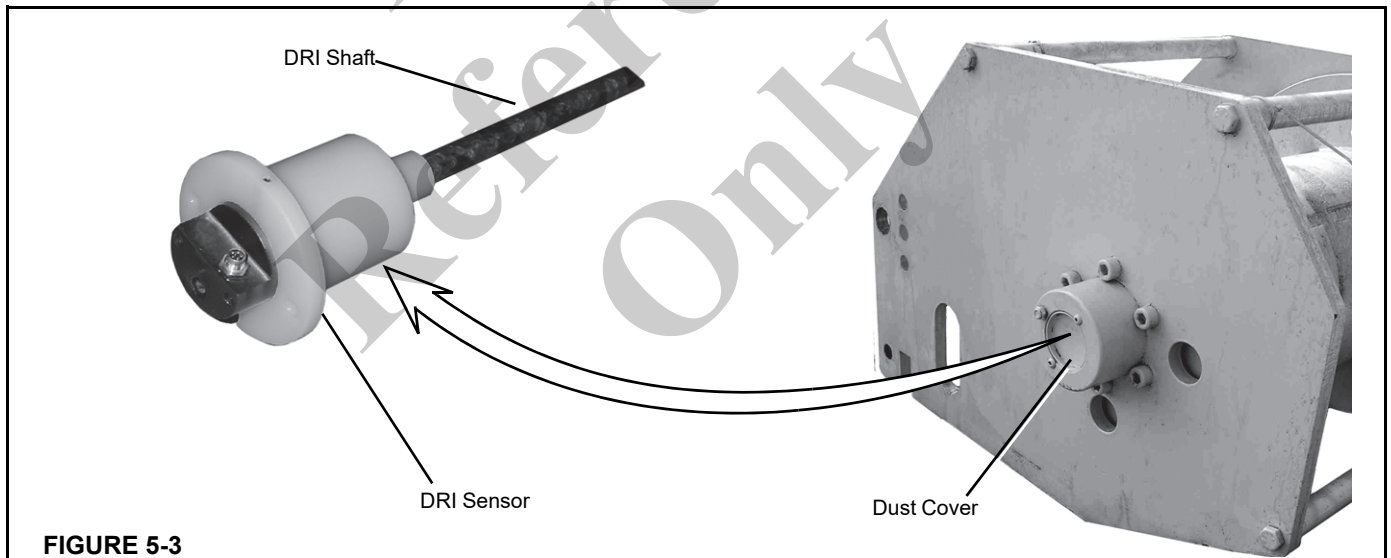
Removal

- Loosen the collar on the connector and unplug the DRI cable.
- Remove the two retaining screws.
- Remove the DRI unit from the hoist.



Installation

The DRI is installed on the left side of the drum. For initial installations, remove the dust cover from the center of the drum.



To install the DRI, use the following procedure:

- Insert the DRI into the drum. Rotate the DRI so that the DRI shaft engages the drive inside the drum.
- Push the DRI into the drum so that the notch is lined up with the breather, refer to Figure 5-4.

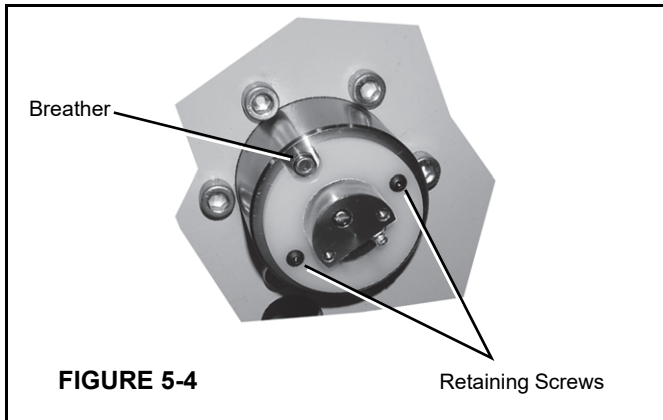


FIGURE 5-4

Retaining Screws

3. Secure the DRI with the retaining screws.
4. Loosen the set screw on the bottom of the DRI flange (Figure 5-5).
5. Use a spanner wrench and rotate the DRI so that the connector is pointed down.
6. Tighten the set screw after the DRI is positioned.
7. Plug in the DRI cable and tighten the collar to secure the connector.

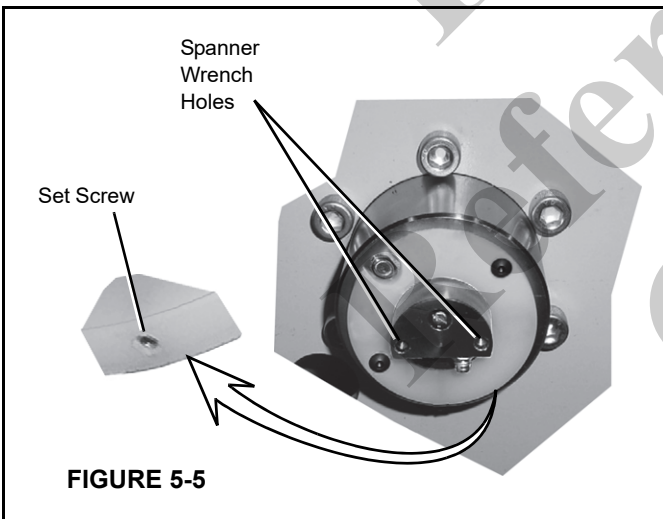


FIGURE 5-5

Programming the 3rd Wrap Indicator (Optional)

The 3rd Wrap Indicator needs to be programmed to alert the operator when the cable is down to the third wrap. To program the 3rd wrap indicator:

1. Run the hoist to the third wrap.
2. Remove the programming screw on the DRI as shown in Figure 5-6.
3. Remove power from the 3rd wrap indicator by disconnecting the DRI cable.

4. With a ballpoint pen or small punch, push and hold the learn button (Figure 5-6) and return power to the 3rd wrap indicator by reconnecting the DRI cable.
5. Release the DRI learn button.
6. Run the hoist to the start of the second layer.
7. Press and hold the learn button for a few seconds.
8. Replace the 3rd wrap indicator programming screw.

NOTE: Failure to replace the programming screw could effect the operation of the 3rd wrap indicator.

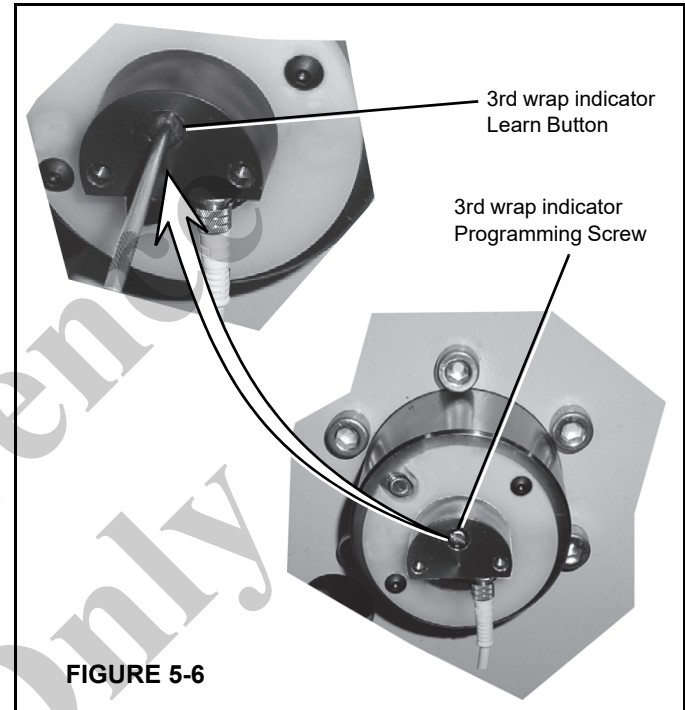


FIGURE 5-6

HOIST REPAIR

Disassembly

The following steps describe how to disassemble the hoist. Inspect and replace all worn parts.

1. Stand the hoist on its end with the motor pointing up. Place blocking under the side plate so the hoist is not sitting on the shaft (Figure 5-7).

NOTE: See Figure 5-9 for item number identification.

2. Remove the brake hose (46) from the straight adapter (45).
3. Remove the motor and counterbalance assembly from the hoist by removing two capscrews (47) and two lockwashers holding the motor (44) to the brake cover (20). See *Motor*, page 5-9 for motor and counterbalance valve disassembly.

4. Remove the brake sub-assembly from the hoist by removing the eight capscrews (9) holding the brake housing to the side plate (41). Re-install two of these capscrews into the two extra tapped holes and tighten them evenly until the brake housing is loose from the side plate. Take note of the vent (30) location for reassembly. See *Brake*, page 5-6 for brake repair.

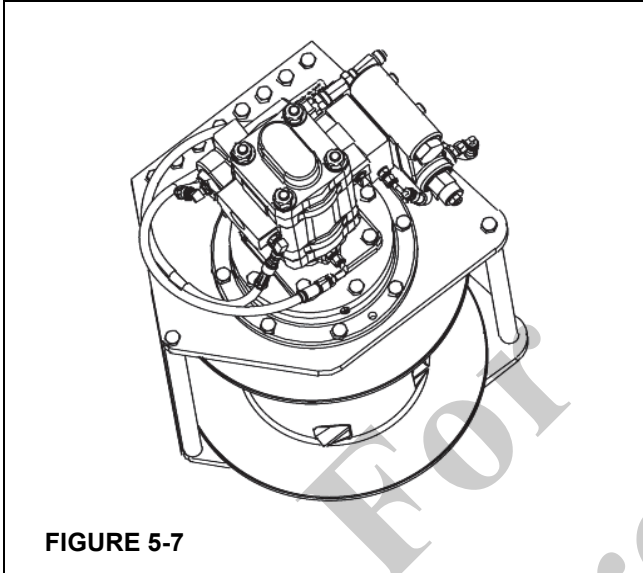


FIGURE 5-7

5. Remove the side plate (41) by removing the three capscrews (1).
6. Lift the bearing carrier (26) from the drum. If necessary remove and replace the bearing (28) and seal (306).
7. Remove the input sun gear (8) and thrust washer (6) from the input planet assembly (36).
8. Remove the input planet set (36) from the drum. Inspect the planet set for wear. See *Servicing The Planetary Set* section for disassembly and repair.
9. Remove the output sun gear (16) and thrust washer (6) from the output planet assembly (4).
10. Remove the output planet set (4) from the cable drum. Inspect the planet set for wear. See *Servicing The Planetary Set* section for disassembly and repair.
11. Remove the cable drum (5) and inspect the gear teeth for excessive wear. Remove and replace the bearing (28) and seal (306) located in the drum.
12. Inspect retaining ring (48) to insure it is still in groove and is not bent over.
13. If necessary remove output shaft (32) from side plate (29) by removing six capscrews (3) holding sideplate (29) to shaft (32). Take note of vent (30) location for reassembly.

Reassembly

NOTE: See Figure 5-9 for item number identification.

1. Thoroughly clean all parts. Replace those that show wear or damage.
2. Inspect the cable drum (5) for structural integrity and replace if necessary.
3. Attach the shaft (32) to the side plate (29) using the six capscrews (3). Make sure the vent (30) is oriented properly. Torque the capscrews to recommended values, refer to *Fasteners and Torque Values*, page 1-11.
4. Install retaining the ring (48) onto the shaft (32)
5. Lay the unit down with the rods (2) pointing up. Support the side plate (29) with blocking (Figure 5-7) so that the hoist is not setting on shaft (32).
6. Set cable drum (5) onto shaft (32) and seat drum on bearing (28). Be careful not to damage seal (306).
7. Install the output planet set (4).
8. Install the output sun gear (16) into the output planet set.
9. Install the thrust washer (6) into the output planet set.
10. Install the input planet set (36) into the drum. Make sure that it fits over the output sun gear (16).
11. Install the input sun gear (8) and thrust washer (6) into the input planet set.
12. Install the thrust washer (6) into the input planet set.
13. Install a new O-ring (304) and if necessary bearing (28) & seal (306) into the bearing carrier (26). Grease the O-ring and seal then install the bearing carrier into the drum.
14. Position the side plate (1) over cable drum on rods (43). Secure the side plate with the three capscrews (2). Tighten capscrews to 80 to 90 lb-ft (109 to 122 Nm).
15. Install the brake sub-assembly into the side plate (1). Make sure that the pilot of the brake housing aligns with the bore in the bearing and that the bolt holes for the motor and vent are oriented properly. Install the eight capscrews (2). Tighten the capscrews evenly to 80 to 90 lb-ft (109 to 122 Nm).
16. Install a new O-ring (305) onto the face of the motor and reinstall the motor/counterbalance valve assembly. Reconnect the hose (70).
17. Fill both the gearbox and the brake section with the proper amount and type of lubricants. See *Lubrication*, page 8-1.

HOIST SERVICE

Brake

NOTE: See Figure 5-9 for item number identification.

1. Evenly remove the four capscrews (11) holding the brake cover (20) in place. Spring pressure will raise the cover up as the capscrews are loosened. Remove the cover from the brake housing.
2. Remove the springs (24) from the piston and check the springs for free height. Each spring should measure at least 1.20 in (30.5 mm) with no force.
3. To remove the brake piston (10), install two pieces of all-thread (3/8-16NC) in the bottom of two spring pockets.
4. Using jam nuts, screw the all-thread pieces in evenly until the piston is clear of the housing. An alternate way of removing the piston is to use shop air to slowly pressurize the brake cavity until the piston is out of the bore.
5. Grasp the brake driver/clutch assembly (Items 38, 13, 23, 14, 15 & 17) and remove it from the brake housing.
6. Remove the stator plates (19) and friction discs (18) from the brake housing and check for excessive wear. Be sure to check the top stator plate for scoring caused by the removal tools and polish if necessary. Friction discs should measure no less than 0.055 in (1.397 mm) thickness and stator plates should measure no less than 0.068 in (1.727 mm) thickness.
7. With a hook wire or pry bar, remove the seal.
8. Examine the bushing (39) in the brake housing for wear and replace if necessary.
9. If brake housing (21) is removed from the hoist, examine the journal on the brake housing, where the seal (304) fits, for wear. If severely worn, replace the brake housing.
10. Carefully disassemble the brake driver/clutch assembly noting the direction of lockup for the clutch (34). The clutch assembly must be re-assembled with the arrow pointing in the proper direction for the hoist to function properly. Inspect the outside diameter on the input driver (38) and inside diameter of the brake driver (13) where the clutch (34) runs. If there is any pitting or spalling (flakes of a material that are broken off) on the driver then it and the clutch must be replaced.
11. Re-assemble the driver/clutch assembly, making sure that the clutch is installed properly.
12. Install a new seal into the brake housing. If the brake housing is removed from the hoist temporarily install the input sun gear into the brake housing, and slide the driver/clutch assembly onto the sun gear spline.

13. Install the stator plates (19) and friction discs (18) into the brake housing starting with a stator and alternating friction discs and stator plates. There is one more stator plate than friction disc so the last item installed is a stator plate.
14. After installation, check the brake stackup to make sure that the dimensions are within the tolerance shown in Figure 5-8. If your measurement is greater than shown, either some friction discs and stator plates have been left out, or the friction discs are worn beyond acceptable tolerances. If your measurement is less than shown, too many plates or discs have been inserted or they are not seated properly.
15. Coat the new backup rings and O-rings with light oil and install onto the piston (10) with the backup rings toward the outside of the piston. See Figure 5-8 for proper O-ring and backup ring installation.

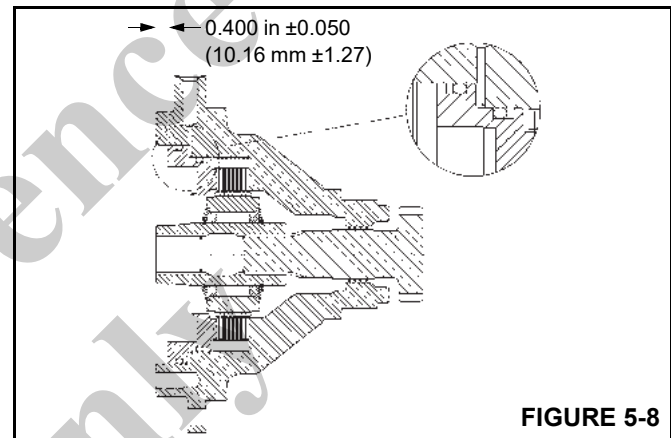
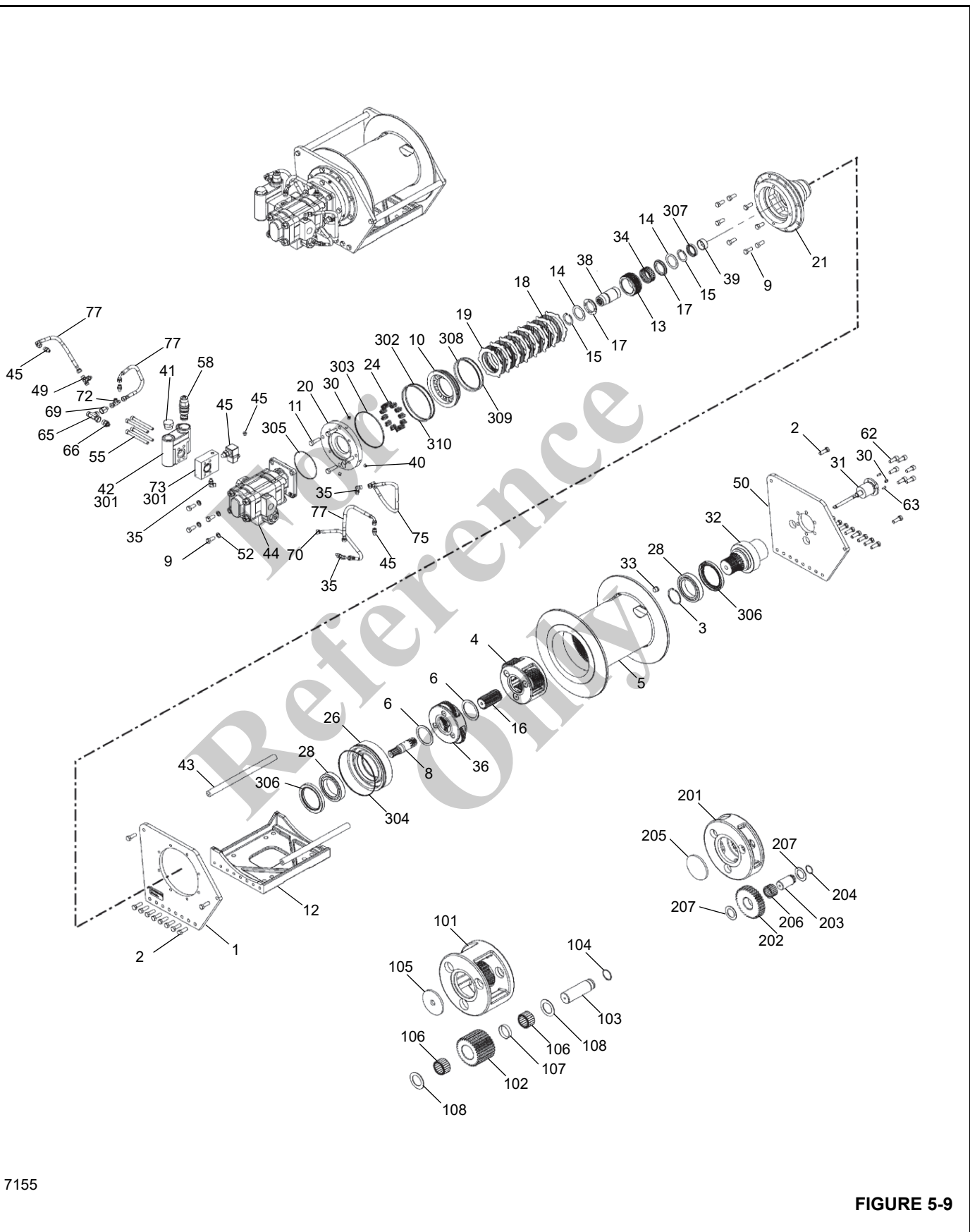


FIGURE 5-8

16. Carefully install the piston into the brake housing and gently tap it down until it is seated.
17. Install the springs (24) into the spring pockets of the piston. If working in a horizontal position, coat the bottom of each spring with chassis lube to keep it in position.
18. Coat the new O-ring with light oil and install into the groove on the brake cover (20).
19. Install the cover (20) onto the brake housing (21) and tighten it evenly, alternating between opposite capscrews. Make sure that the cover is aligned properly with the brake housing to orient the motor and vent as they should be.
20. Check the brake release with a portable hydraulic pump. Full release should be obtained at 250 psi ± 20 psi (1724 kPa ± 138 kPa). Also, check the brake for proper operation by applying 155 psi (1069 kPa) to the brake port and adapting a torque wrench to the input shaft. The torque in the hoist-down, or payout, direction should be 95 to 115 lb-ft (120 to 156 Nm).



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FIGURE 5-9

Item	Quantity	Description
1	1	Plate, Side
2	20	Capscrew
3	1	Snap Ring
4	1	Gear Set
5	1	Drum Housing
6	2	Race, Bearing
8	1	Gear, Input Sun
9	12	Capscrew
10	1	Brake Piston
11	4	Screw
12	1	Base Plate
13	1	Brake Driver
14	2	Race
15	2	Snap Ring
16	1	Gear, Sun Output
17	2	Bushing
18	7	Friction Disc
19	8	Plate, Stator
20	1	Cover, Brake
21	1	Brake Housing
24	12	Brake Spring
26	1	Carrier, Bearing
28	2	Bearing
30	2	Breather
31	1	Sender, DRI/LLI
32	1	Shaft, Output
33	1	Plug, O-ring
34	1	Clutch
35	3	Fitting, 90 deg
36	1	Input Gear Set - 201 thru 207
38	1	Driver, Input
39	1	Bushing
40	2	Plug
41	1	Plug, Flush
42	1	Counterbalance Block
43	2	Support Rod
44	1	Motor Assy
45	4	Fitting, Adapter
49	1	Fitting, Tee
50	1	Plate, Side
52	4	Lockwasher, 1/2 ID
55	4	Capscrew
58	4	Counterbalance Valve

Item	Quantity	Description
61	4	NCC Label
62	6	Capscrew
63	2	Screw, Buttonhead
64	1	Cord Set
65	1	Fitting, Tee
66	1	Fitting, Straight Adapter
69	1	Fitting, Reducer
70	1	Hose Assy
72	1	Fitting, Tee Adapter
73	1	Manifold Block
74	1	Valve, Cart. Solenoid
75	1	Hose Assy
77	3	Hose Assy
80	1	O-ring
81	1	Cord Set Rotation
82	1	Shaft DRI
101	1	Housing, Carrier
102	3	Gear, Planet
103	3	Pin
104	3	Retainer
105	1	Plate
106	6	Bearing
107	3	Spacer
108	6	Race, Bearing
201	1	Housing, Carrier
202	3	Gear, Planet
203	3	Pin
204	3	Retainer
205	1	Plate
206	3	Bearing
207	6	Race, Bearing
301	2	O-ring
302	1	O-ring
303	1	O-ring
304	1	O-ring
305	1	O-ring
306	2	Seal, Oil
307	1	Seal, Oil
308	1	O-ring
309	1	Ring, Back-up
310	1	Ring, Back-up
315	1	Kit, Seal

Planetary Set

NOTE: See Figure 5-9 for item number identification.

1. Remove the spiral retaining rings from the planet pins.
2. Remove the pins from the carrier by carefully tapping them out.
3. Remove the planet gears, thrust washers and bearings from the carriers.
4. Inspect the pins, bearings, and gear bores for evidence of wear and replace if necessary.
5. On output planet sets, note that two bearings with a spacer between them are used.
6. Before reassembly, be sure to insert the round plates into the carriers.
7. To re-assemble, be careful to line up the planet pins with the thrust washers and bearings and then press the knurled part of the pin into the carrier.

CAUTION

Possible Equipment Damage!

If the pins are not lined up properly, the thrust washers can be shattered during the pressing operation.

Motor

1. Remove the hose and the counterbalance block (42) from the motor assembly.
2. To remove the counterbalance block (42), loosen and remove the 4 capscrews (55).
3. Remove the counterbalance valve (58) from the counterbalance block and inspect the small metering hole located on the side of the cartridge valve to make sure it is not obstructed (Figure 5-10). Also inspect the O-rings to insure that they are not cut or flattened.
4. Motors and cartridge valves are not serviceable in the field. Return them to an authorized dealer for service.

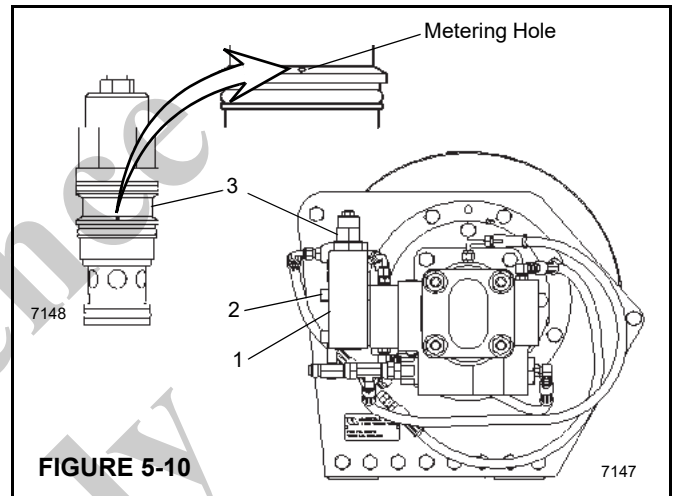


FIGURE 5-10

TROUBLESHOOTING

Problem	Cause	Solution
Hoist does not hold load	Excessive back pressure in the system. Brake discs are worn out. Hoist clutch is slipping.	Check the system for restrictions and reduce the back pressure. Replace brake discs. Inspect the clutch and driver for wear and replace worn parts.
The hoist does not raise the load it should.	Relief valve setting may be too low to allow proper lifting. Load being lifted may be more than the hoist's rating.	Increase relief valve pressure setting. Reduce the load or re-rig to increase mechanical advantage.
The hoist does not lower the load.	The brake valve was connected improperly after being disconnected. The cartridge in the brake valve may have a plugged metering hole.	Check plumbing and connect lines properly. Remove the cartridge and clean it if necessary.
Oil leaks from the vent on the motor side of the hoist.	The motor shaft seal may have failed. Brake piston seals may have failed.	Replace this seal and reduce back pressure if high pressure caused the shaft seal to fail. Service the brake section and replace worn parts.

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SECTION 6 SWING

SECTION CONTENTS

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DESCRIPTION

The purpose of the swing system is to allow the crane turret to rotate on top of the frame. The 900H swing system provides 410 degree rotation.

The swing system consists of a hydraulic remote controller, directional control valve, swing drive gearbox, swing motor, and swing brake. The maximum rotation is 2.0 rpm. The swing brake is automatically applied when the control lever is moved to the neutral position.

THEORY OF OPERATION

Swing Drive

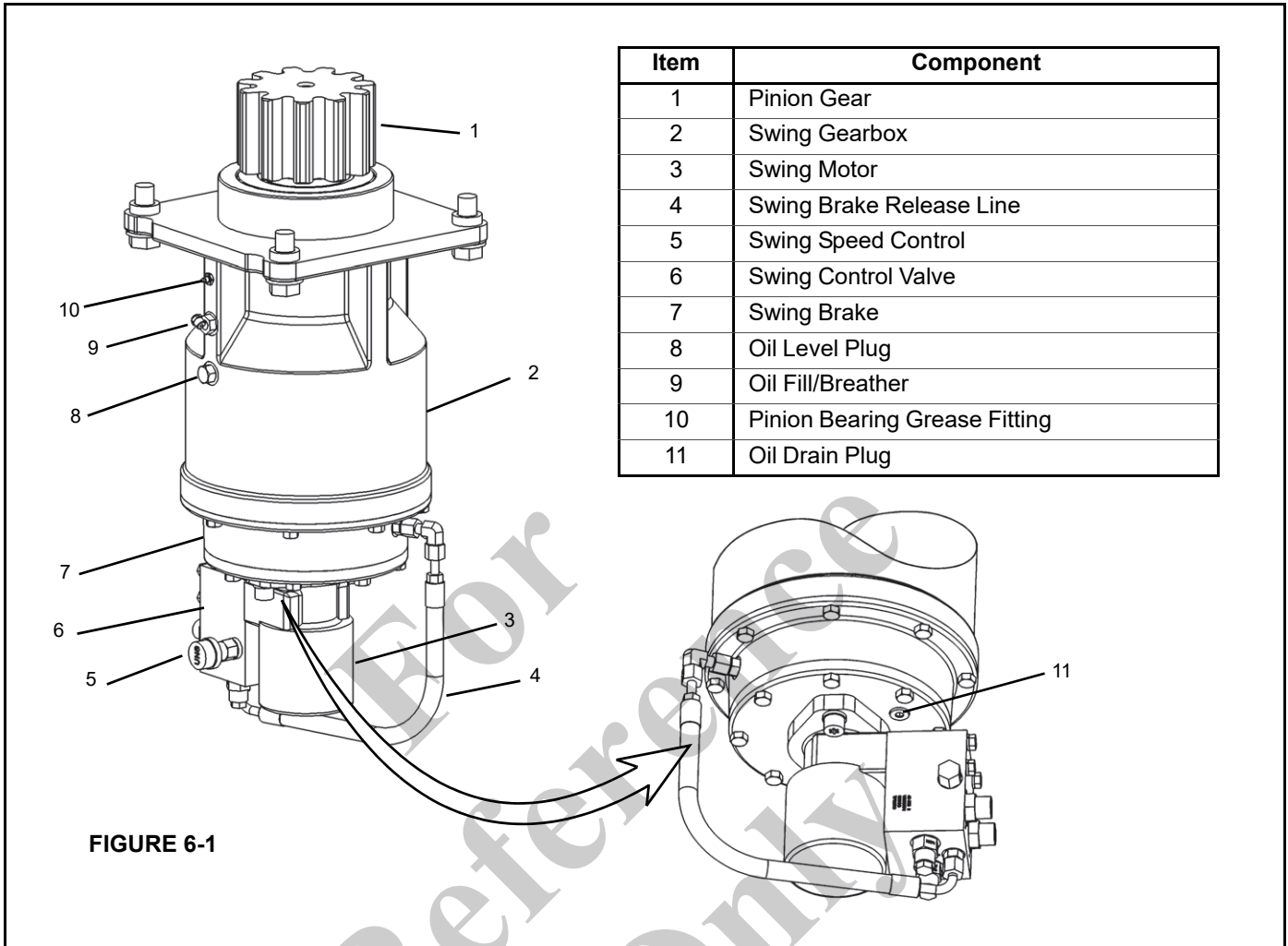
The hydraulic power for the swing drive (Figure 6-1) is supplied by the hydraulic piston pump. Oil flows from the pump to the main directional control valve.

When the hydraulic remote control is positioned to either right or left swing, the flow through the control valve is directed to the swing motor and the turret rotates in the desired direction. Shifting the control to neutral applies the brake stopping the turret.

Swing Brake

The swing brake is spring applied and hydraulically released. Hydraulic pressure for the swing brake control is supplied by the swing control valve. Moving the swing control lever off neutral releases the swing brake and starts the swing motor. Moving the swing control lever back to the neutral position stops the swing motor and engages the swing brake.





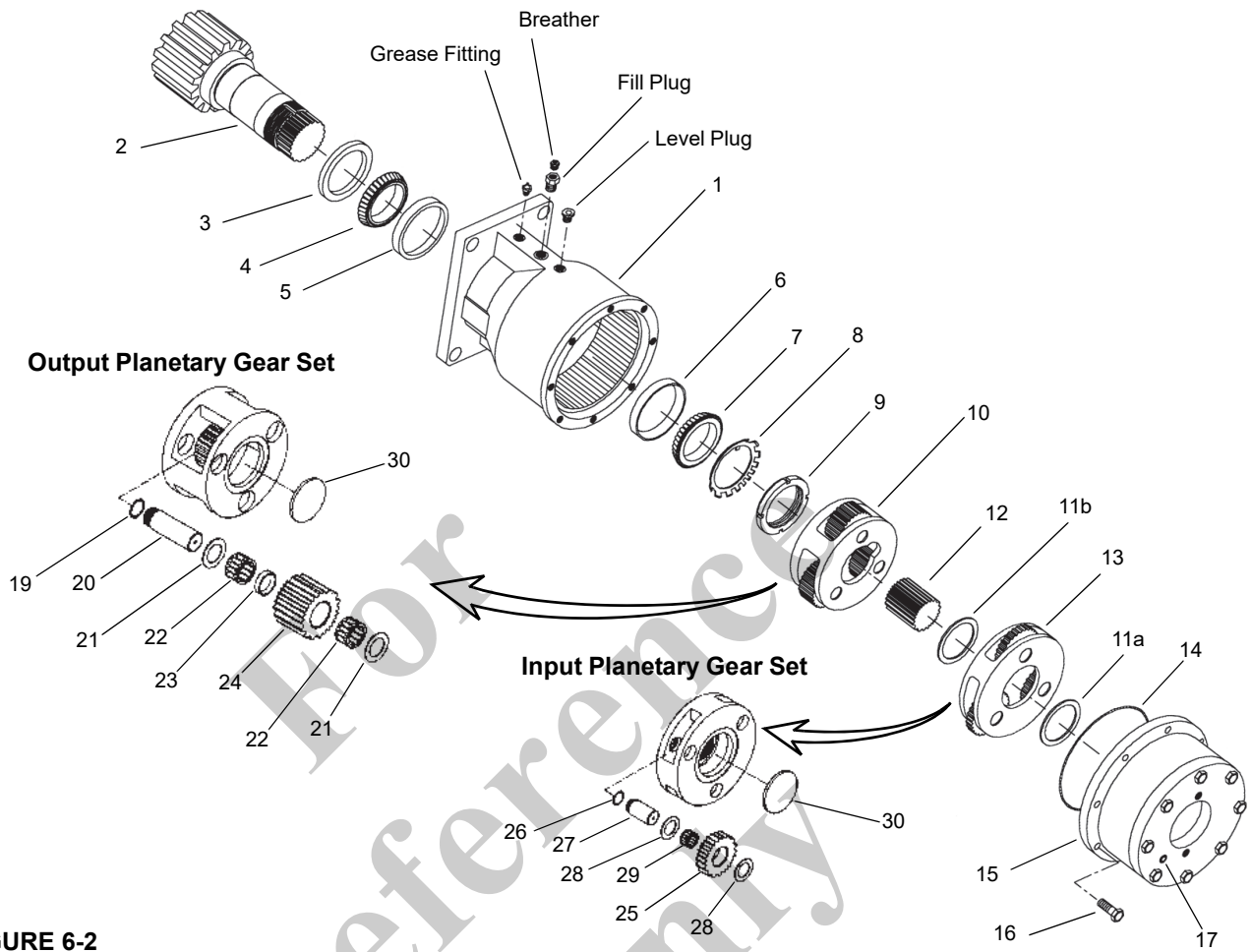


FIGURE 6-2

Item	Component
1	Gearbox Housing
2	Pinion Shaft
3	Outboard Seal
4	Outboard Bearing
5	Outboard Bearing Race
6	Inboard Bering Race
7	Inboard Bearing
8	Lock Washer
9	Locknut
10	Output Planetary Assembly
11a	Race (Input Planetary Gear)
11b	Race (Output Planetary Gear)
12	Output Sun Gear
13	Input Planetary Assembly
14	Brake Housing O-Ring
15	Brake Assembly

Item	Component
16	Brake Mounting Capscrews (8)
17	Drain Plug
Output Planetary Gear Set	
19	Retaining Washer
20	Output Planetary Pin
21	Washer
22	Needle Bearing
23	Spacer
24	Output Planet Gear
Input Planetary Gear Set	
25	Input Planet Gear
26	Retaining Washer
27	Input Planetary Pin
28	Washer
29	Needle Bearing
30	Plate

SWING GEARBOX AND BRAKE

The swing drive is a double planetary gear set with an integral brake. The swing drive is designed to give long life in heavy duty applications such as crane rotation.

NOTE: Motor and cartridge valves are not serviceable in the field. Return them to an authorized dealer for service.

Disassembly and Assembly Instructions

Use the following procedure for swing drive disassembly.

NOTE: The weight of the rotation gearbox with integral brake and a hydraulic motor bolted on the input end of the assembly is approximately 275 lbs (124 kg).

Tools Required

- Scribe or small punch
- Oil drain pan
- Eye bolts 1/4"
- Retaining ring pliers
- Gear puller
- Ratchet wrench (1/2" drive)
- 9/16" socket (1/2" drive)
- Socket for pinion nut (Whittet-Higgins P/N BAS-14)
- Soft hammer (brass or plastic)
- Press
- Drift rod (0.25 in to 0.375 in (6 to 10 mm) diameter)
- Torque wrench [1/2" drive - approximately 100 ft-lb (135 N·m)]

Gearbox Disassembly

(See Figure 6-2 for reference numbers.)

1. Remove the swing drive from the crane and remove the swing motor from the swing drive.
2. Drain the oil from the gearbox by removing the drain plug (17).
3. Scribe a mark on the brake assembly flange (15) and the top edge of the gear housing (1) to aid in reassembly.
4. Remove the eight capscrews (16) holding the brake assembly (15) onto the gear housing (1).
5. Lift the brake assembly (15) off of the gear housing (1).
6. Inspect the brake housing O-ring (14) and replace if necessary.

7. Remove the race (11a) from the input planetary assembly (13).
8. Install three 1/4" eyebolts into the three planet pins of the input planetary assembly (13) and with a small chain pull the planet set from the gear housing.
9. Remove the output sun gear (12) and race (11b) from the output planetary assembly (10).
10. Using the eyebolt/chain method outlined in step 6, remove the output planetary assembly (10) from the gear housing.
11. Remove the lockwasher (8) and locknut (9).
12. Remove the pinion shaft (2) from the housing (1).

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 number identification.)

1. Remove the retaining washers (26) from the planet pins.
2. Press the planet pins (27) out of the carrier (13).
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 number identification.)

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.

Pinion Shaft Repair

(See Figure 6-2 for reference numbers.)

1. Remove the outboard race (5) and bearing (4) from the pinion shaft (2).
2. Remove the outboard seal (3) and discard.
3. Pack the outboard bearing (4) with lithium grease or EP lube and install into the outboard bearing race (5) in the gearbox 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.
4. 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.

5. Install the pinion shaft (2) into gear housing (1). Be careful not to damage the seal (3) in the gear housing.

Case Assembly Repair

(See Figure 6-2 for reference numbers.)

1. Remove the inner bearing race (6) and replace if required.
2. Clean all foreign material from case.

Gearbox Assembly

(See Figure 6-2 for reference numbers.)

1. Place the gear housing (1) on a table with the gear end of the pinion shaft (2) on the table surface.
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. Pack the upper bearing (7) with lithium grease or EP lube. Slide the bearing (7) over the threaded end of the pinion shaft (2) with the small end down. Press the bearing (7) on slowly until it is just seated.

Hold the pinion shaft (2) and rotate the gearbox 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 pinion shaft (2) to 100 ft-lb (135 N·m). 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 75 to 85 in-lb (8.4 to 9.6 Nm) is achieved when rotating the case.

This includes bearing as well as seal drag. The torque is equal to a force of 75 to 85 in-lb (8.4 to 9.6 Nm) 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 gearbox housing (1) on a work bench with the gear end of the pinion shaft (2) on the table surface.
8. Lower the output planet gear set (10) into the gearbox housing (1) until the planet gears engage the teeth in the gearbox housing. Line up the gear teeth and slide the output planet gear (10) down until the planet gears engage the teeth on the pinion shaft (2). Rotate the output gear set (10) or the pinion shaft (2) until the gear set (10) slides down to allow full contact between the two sets of gear teeth.
9. Firmly hold the gear end of the pinion 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 planet gear set (10).
11. Lower the input planet gear set (13) into the gear housing (1) until the gears engage the teeth on the output sun gear (12).
12. Rotate the input planet gear set (13) or the pinion shaft (2) until the input planet gear set (13) slides down to allow full contact between the two sets of gear teeth.
13. Firmly hold the gear end of the pinion shaft (2) and slowly rotate the gearbox assembly to ensure free rotation of installed gear sets.
14. Install thrust washer (11b) and the input sun gear (12) into the input planet gear set (13).
15. Lubricate a new O-ring (14) 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) as per removal scribe marks.
17. Install the eight capscrews (16) in the brake assembly (15) and torque to recommended values, refer to *Fasteners and Torque Values*, page 1-11.
18. Install the drain plug (17).
19. Reinstall the swing motor and fill the swing gearbox with EP 80-90 oil until the oil is level with the fill hole.
20. Reinstall the level plug and breather/fill plug.

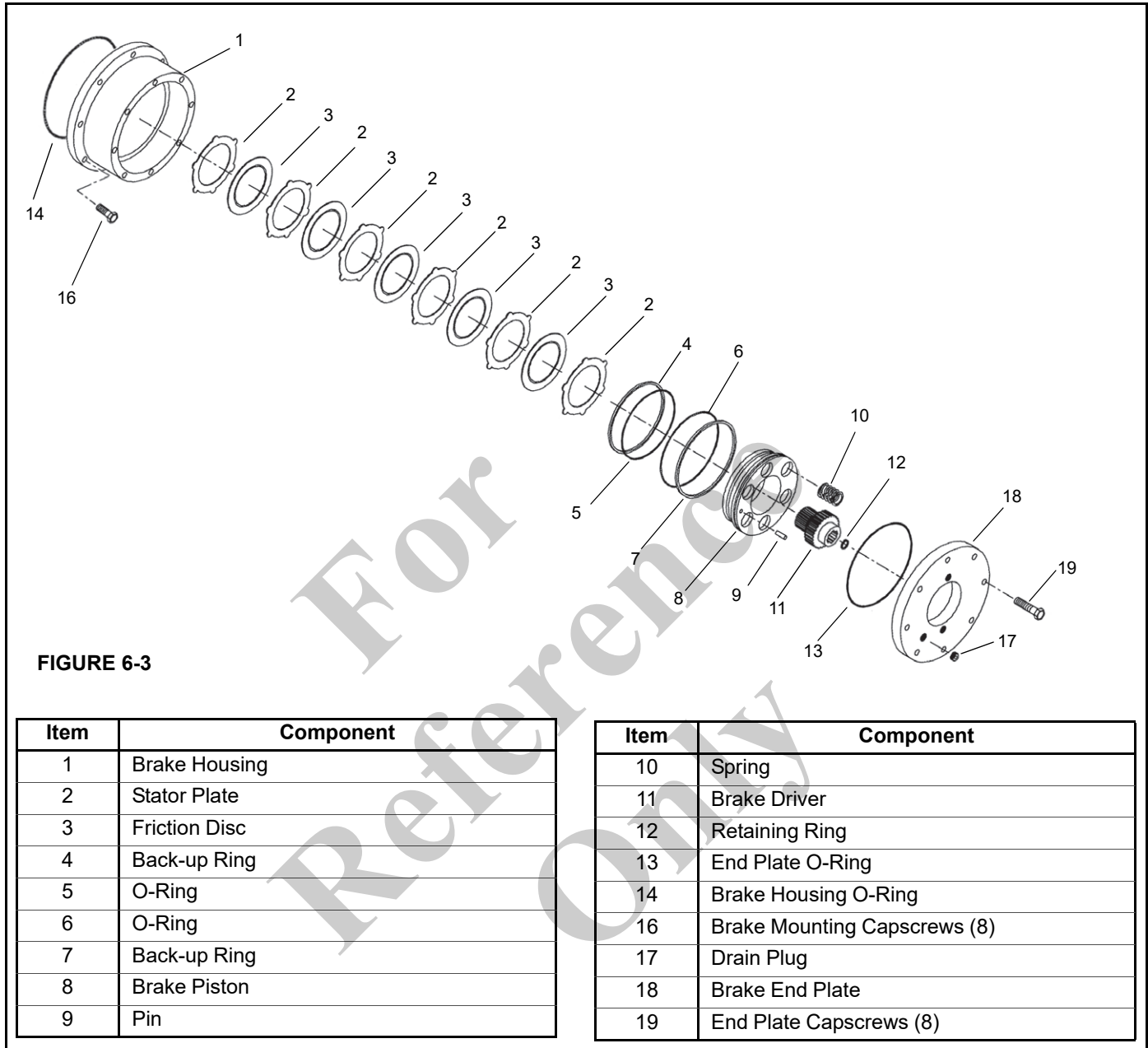


FIGURE 6-3

Item	Component
1	Brake Housing
2	Stator Plate
3	Friction Disc
4	Back-up Ring
5	O-Ring
6	O-Ring
7	Back-up Ring
8	Brake Piston
9	Pin

Item	Component
10	Spring
11	Brake Driver
12	Retaining Ring
13	End Plate O-Ring
14	Brake Housing O-Ring
16	Brake Mounting Capscrews (8)
17	Drain Plug
18	Brake End Plate
19	End Plate Capscrews (8)

SWING BRAKE

See "Gearbox Disassembly" on page 6-4 for gearbox removal from the crane. Use the following procedure for swing drive disassembly.

Disassembly

(See Figure 6-3 for item number identification.)

1. Scribe a mark on the edge of the brake end plate (18) and the top of the brake housing (1) to aid in reassembly.

NOTE: The brake end plate (18) is spring loaded and needs to be loosened so that the pressure on the end plate is distributed evenly.

2. Alternately loosen the eight cap screws (19) one turn at a time until all internal spring force is relieved.
3. Remove the brake end plate (18) from the brake housing (1).
4. Inspect the brake end plate O-Ring (13) and replace if necessary.
5. Remove the brake springs (10) from the assembly.

6. Connect a port-a-power or other hydraulic pressure source to the brake release port and slowly apply pressure until the brake piston (8) clears the brake housing (1).

NOTE: Note the position of the dowel-pin hole with respect to the brake release port for reassembly.

7. Inspect the piston O-rings (5, 6) and backup rings (4, 7). Replace if necessary.

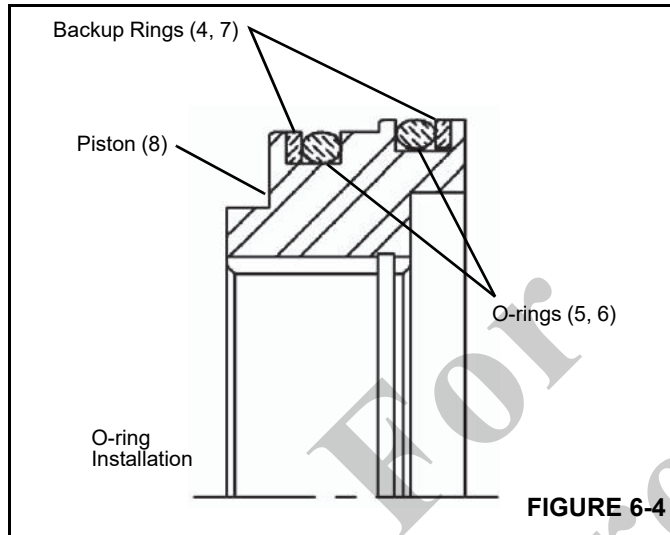


FIGURE 6-4

8. Remove the brake driver (11) from the brake housing (1).
9. Remove the friction discs (3) and the stator plates (2) from the brake housing.

NOTE: Record the order in which the friction discs are removed and reinstall in the same order.

10. Inspect the friction discs for wear and the stator plates for excessive grooving or burn spots. Check the friction disc thickness (Figure 6-5).

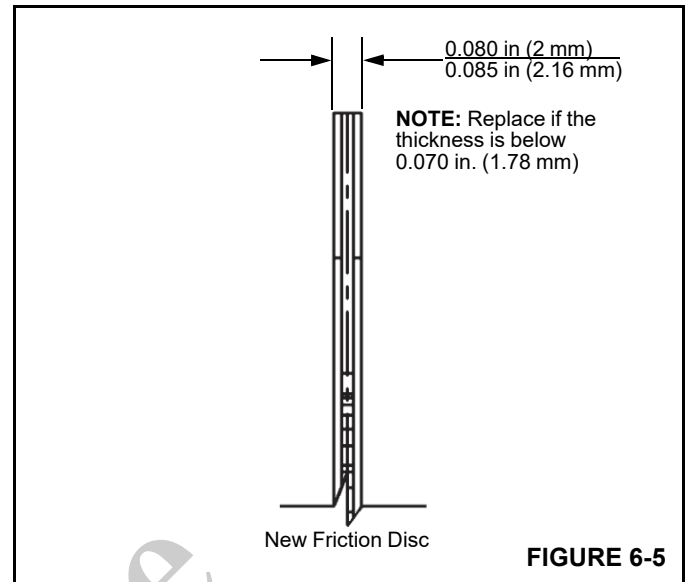


FIGURE 6-5

Assembly

(See Figure 6-3 for reference number identification.)

Assembly of the swing brake is as follows:

1. Install the O-ring (14) in brake housing (1) and bolt the brake housing to the swing gearbox with the capscrews (16). Torque the capscrews to recommended values, refer to *Fasteners and Torque Values*, page 1-11.

NOTE: Position the brake housing on the gearbox housing as per removal scribe mark.

2. Start with a stator plate and install the stator plates and friction discs into the brake housing in the same order that they were removed.

NOTE: Soak the friction discs in EP-90 oil before installation.

3. Gently slide the brake piston (8) 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.

NOTE: Apply a film of oil to the O-rings and backup rings to aid in assembly.

4. Install the brake driver (11) into the brake housing. Be sure that retaining ring (12) is installed in the driver.
5. Install the springs (10) into the holes in the brake piston (8).
6. Lubricate the O-ring (13) with hydraulic oil and install on the brake end plate (18).
7. Carefully set the brake end plate (18) on top of the piston springs (10) so that the springs remain upright on the brake piston.

8. Bolt the brake end plate (18) to the brake housing (1) with the capscrews (19). Alternately tighten the capscrews one turn at a time until the cover is tight against the brake housing.

NOTE: This keeps the pressure on the end plate distributed evenly. Torque the capscrews to recommended values, refer to *Fasteners and Torque Values*, page 1-11.

SWING BEARING

Description

The swing bearing is an anti-friction roller bearing that mates the turret to the frame. The bearing inner race is bolted to the turret and the outer race is bolted to the frame. The outer race contains four grease fittings for lubrication of the bearing. The inner race incorporates gear teeth that mesh with the pinion gear of the swing gearbox to provide rotation.

MAINTENANCE

General

The swing bearing is the most critical maintenance point of the crane. It is here, at the centerline of rotation, that stresses of loads are concentrated. In addition, the bearing provides the only attachment between the turret and frame. Therefore, proper care of the bearing and periodic maintenance of the turret-to-bearing attachment bolts IS A MUST to ensure safe and efficient operation.

TORQUING SWING BEARING BOLTS

General



WARNING

Crushing Hazard!

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

Maintaining proper torque value for bolts is extremely important for structural strength, performance, and reliability of the crane. Variations in torque can cause distortion, binding, or complete separation of the turret from the frame.

CAUTION

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

Proper identification of bolt grade is important. When marked as a high strength bolt (grade 8), the serviceman must be aware of bolt classifications and that he is installing a high strength heat-treated tempered component and the bolt must be installed according to specifications. Special attention should be given to the existence of lubricant and plating that will cause variation from dry torque values. When a high strength bolt is removed, or un-torqued, the bolt must be replaced with a new bolt of the same classification.

Before performing the following procedure refer to *Torque Wrenches*, page 1-11 on the proper use of a torque wrench.

Swing Bearing Bolts

The inner race of the bearing is secured to the turret by 30, one inch, Grade 8 bolts (Figure 6-6). The outer race of the bearing is secured to the frame by 30, one inch, Grade 8 bolts (Figure 6-6).

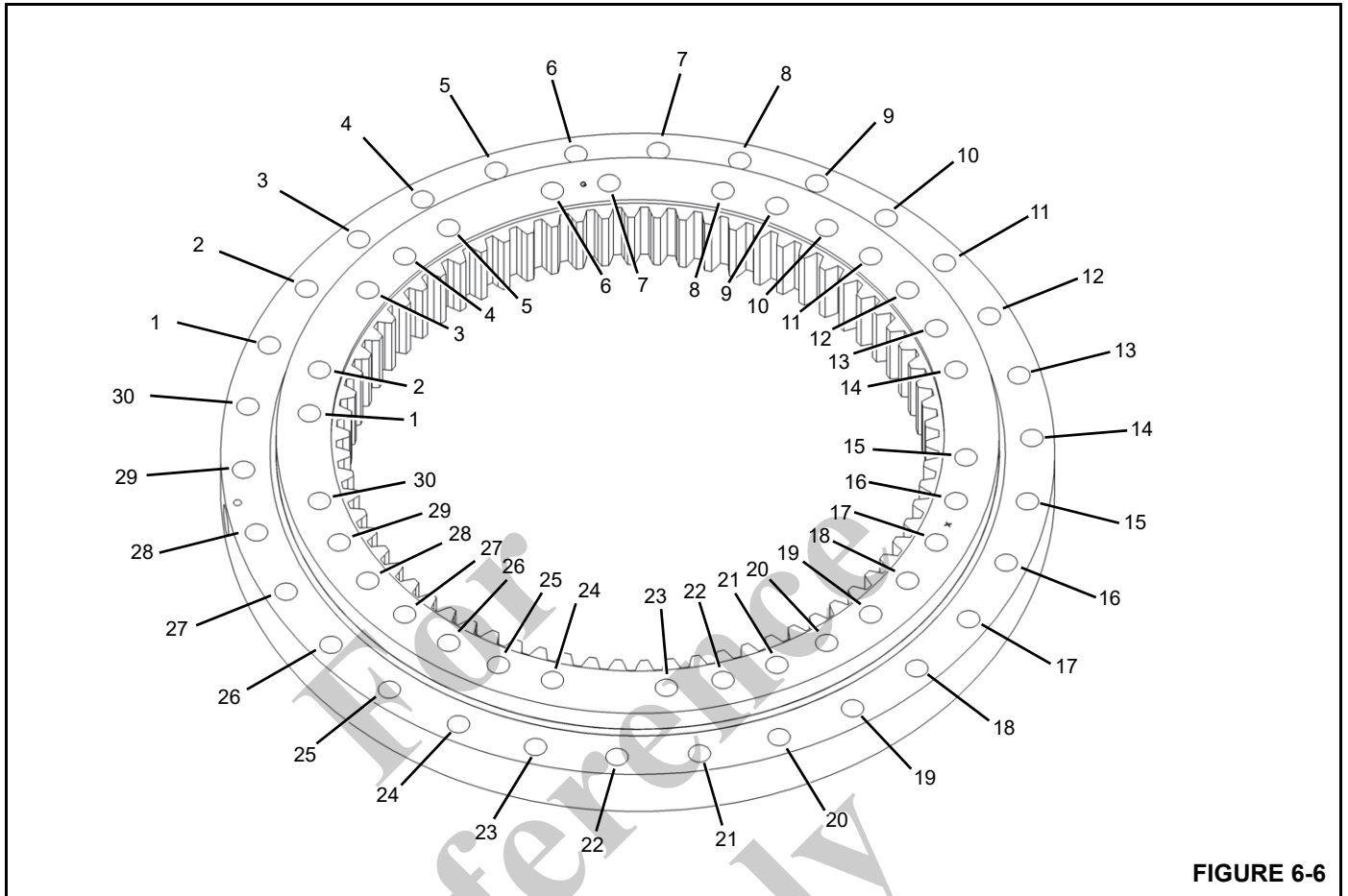


FIGURE 6-6

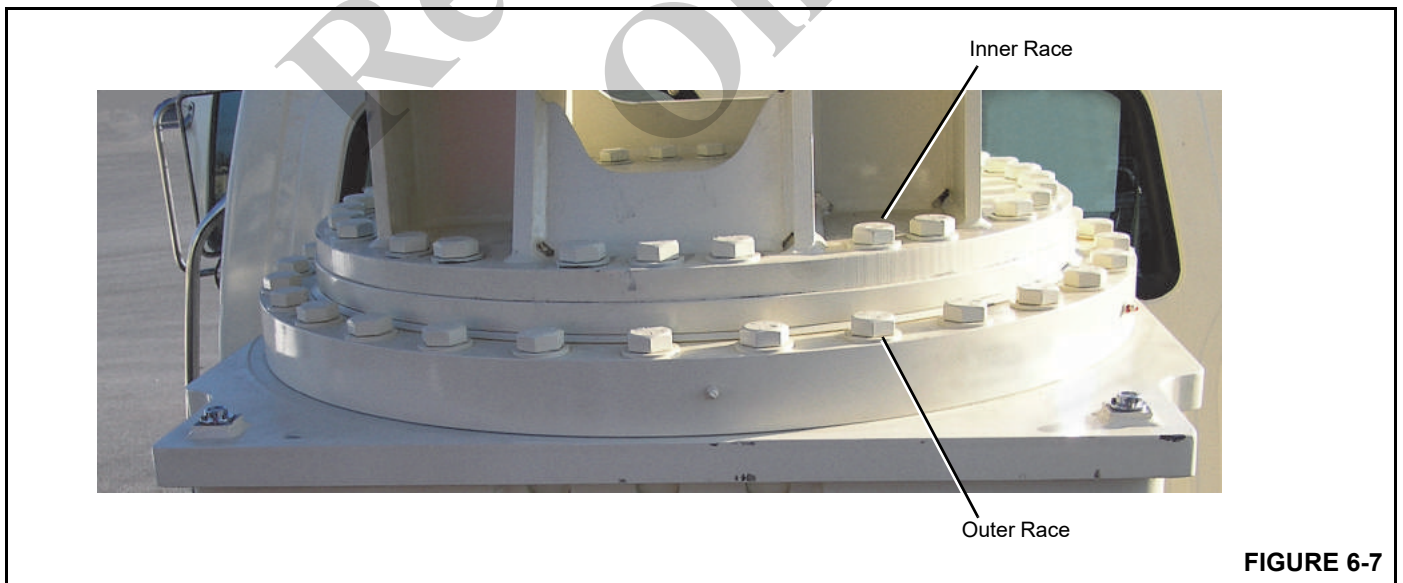


FIGURE 6-7

6

Torque Values

Torque all swing bearing bolts to a final torque of 600 lb-ft \pm 60 lb-ft (813 Nm \pm 81 Nm).

Inner Race Torquing

The inner race bearing bolts are located on top of the inner race (Figure 6-7).

1. Extend and set the outriggers. Fully elevate the boom.
2. Torque eight bolts (Figure 6-6) to 670 lb-ft \pm 26 lb-ft (908 Nm \pm 35 Nm) using the following sequence pattern; 1, 19, 10, 28, 6, 23, and 15. Tools used are the socket, multiplier, backlash adapter, necessary extensions, and torque wrench.
3. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to the final torque of 895 lb-ft \pm 35 lb-ft (1213 Nm \pm 47 Nm). The same tools are used as in step 1.

Outer Race Torquing

The outer race bearing bolts are located on top of the outer race (Figure 6-7).

1. Extend and set the outriggers. Fully elevate the boom.
Torque eight bolts (Figure 6-6) to 670 lb-ft \pm 26 lb-ft (908 Nm \pm 35 Nm) using the following sequence pattern; 1, 17, 9, 25, 4, 20, 12, and 28.
2. Return to bolt 1 and torque all bolts sequentially in a clockwise direction to 895 lb-ft \pm 35 lb-ft (1213 Nm \pm 47 Nm). The same tools are used as in step 1.

BEARING CLEARANCE

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

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

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

1. Place the boom in the boom rest and set the outriggers.
2. Put a magnetic base dial indicator opposite the boom on the top of the frame (Figure 6-8).

3. Place the dial on the top of the swing bearing (Figure 6-8).
4. Power the boom down onto the boom rest.
5. Set the dial indicator at zero.
6. Raise the boom about 3 inches above the boom rest.
7. Record the deflection indicated on the dial.
8. Repeat steps 4 through 7 three times and average the readings.
9. If the average is greater than 0.090 in (2.3 mm), replace the bearing.
10. If the average is less than 0.090 in (2.3 mm), repeat the measurement at every 45° around the total working area of the crane (Figure 6-9).
 - a. Measure the deflection at positions 2,3,7, and 8 for 180° rotation and positions 2 and 8 for 360° rotation.
 - b. Use another crane to support the end of the boom when the boom is powered down.
 - c. Locate the dial indicator opposite the boom.
 - d. Set the dial indicator to zero.
 - e. Raise the boom about 3 in (76 mm).
 - f. Record the reading on the dial indicator.
 - g. Repeat steps d through f three times.
 - h. Average the readings.
 - i. If the average is greater than 0.090 in (2.3 mm) at any position, replace the bearing.

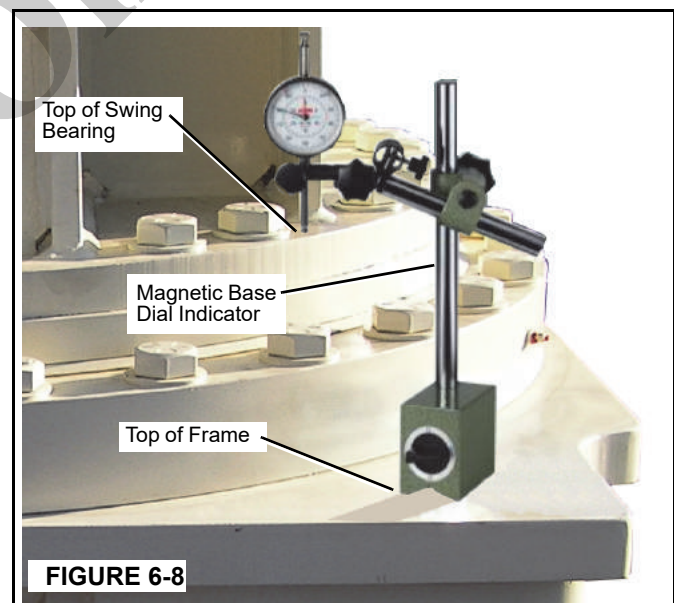


FIGURE 6-8

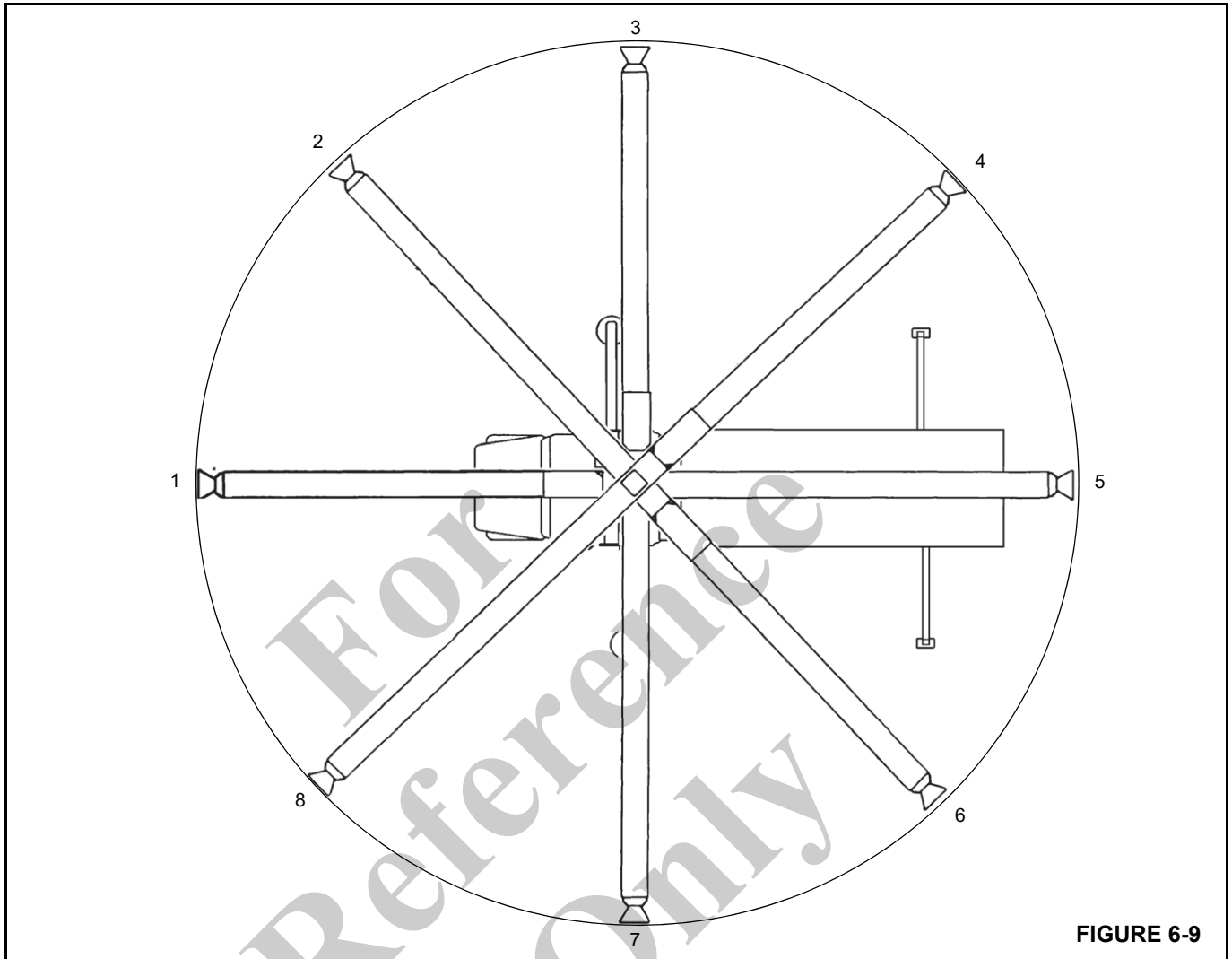


FIGURE 6-9

BEARING REPLACEMENT

Removal

1. Fully extend and set the outriggers enough to take up the slack in the pads.

NOTE: Do not raise the machine on the outriggers.

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

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

3. Elevate the boom slightly and shut down the engine.
4. Tag and disconnect the battery cables.
5. Remove the boom and lift cylinder following the procedures outlined in *Boom Removal from Truck*, page 4-3.

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

DANGER

Crushing Hazard!

Ensure the lifting device is capable of supporting the boom assembly. Death or serious injury may result.

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

WARNING

Crushing Hazard!

Ensure blocking material can support the turret. Serious injury or damage to the turret may result.

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

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

9. Remove all bolts from the inner race of the swing bearing.

10. Lift the turret off the swing bearing and set on blocking.

NOTE: The bearing weighs about 625 lb (284 kg).

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

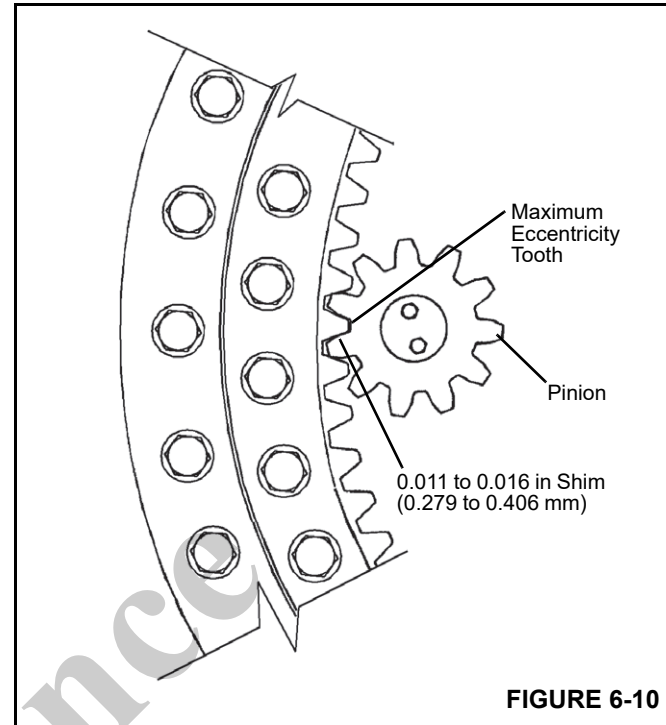
Installation

CAUTION

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

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

1. Using an appropriate lifting device, set the turret on the swing bearing. If the same bearing is being used, position it as marked prior to removal.
2. Install new bolts and washers securing the bearing to the turret. Refer to *Inner Race Torquing*, page 6-10.
3. Using an appropriate lifting device, align the turret over the frame at the same position that it was before removal.
4. Carefully lower the turret into position on the bearing plate.
5. Install all bolts and washers to secure the outer race of the swing bearing to the T-box frame. Refer to *Outer Race Torquing*, page 6-10.



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

6. Install the swing drive pinion so that the high point (maximum eccentricity) is aligned with the turret bearing high point. Check the backlash with a 0.011 to 0.016 in (0.279 to 0.406 mm) thick shim (Figure 6-10). If the pinion must be moved to achieve proper backlash, contact your local dealer.
7. Install the boom and lift cylinder following the procedures outlined in *Boom Maintenance*, page 4-1.
8. Reconnect the batteries.
9. Check the slew potentiometer for proper orientation as described below.

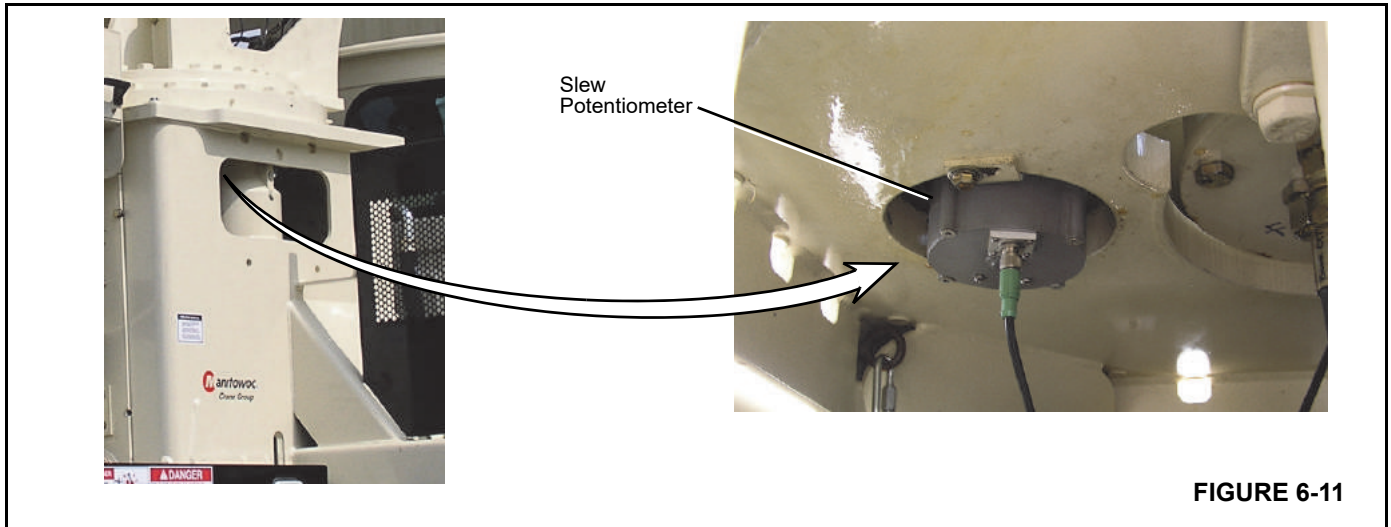


FIGURE 6-11

Slew Potentiometer Calibration

The slew potentiometer (slew pot) located inside the turret, is used by the RCL to determine swing position and limits the swing to 410°—205° left and 205° right. The slew pot needs to be oriented to 0° ($\pm 5^\circ$) before the RCL can be calibrated for the swing parameters.

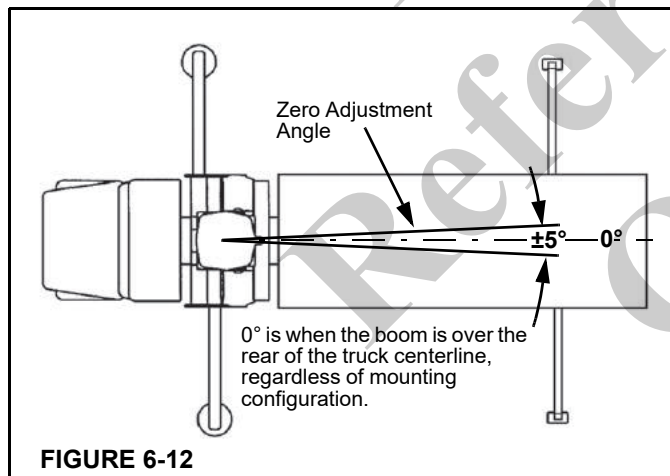


FIGURE 6-12

The following procedure is to mechanically adjust the slew pot to zero when the slew pot is out of the $\pm 5^\circ$ specified by the RCL. This procedure can also be used for installing a new slew pot.

1. Place the boom at 0° over the truck centerline.
2. Remove the slew pot from the turret.
3. Make sure the slew pot is plugged into the RCL connector and turn the RCL on.

4. Go to the RCL slew angle calibrate screen as described in the RCL service manual.
5. Rotate the slew pot gear until the reading on the RCL is 0° ($\pm 5^\circ$). This reading must be within $\pm 5^\circ$ of 0° or the RCL will not calibrate the swing position correctly.
6. Reinstall the slew potentiometer in the turret.
7. Slide the slew pot forward to make sure the slew pot gear is meshed with the swing bearing teeth.
8. Back off the slew pot gear slightly so that there is a 0.125 to 0.188 inch (3.1 to 4.7 mm) gap between the slew pot gear teeth and the swing bearing gear teeth.

CAUTION

There must be 0.125 to 0.188 inch (3.1 to 4.7 mm) gap between the slew pot gear teeth the swing bearing gear teeth to keep from damaging the slew pot gear shaft.

9. Tighten the bolts on the slew pot bracket.
 10. Calibrate the slew angle with the RCL.
- NOTE:** When verifying the slew angle calibration in step 11, refer to your slew angle calibrate screen.
11. Verify the slew angle calibration by swinging the boom 180° to the right and left according to instructions on the slew angle calibrate screen.
 12. If the readings are not correct, recalibrate the slew angle with the RCL.

For Reference Only
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SECTION 7 OUTRIGGERS

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DESCRIPTION

There are two sets of outriggers on the crane. The front outriggers are just behind the cab and the rear outriggers are located behind the rear tandem wheels. The rear outriggers (RSOD) are described on page 7-6.

Cranes equipped with Outrigger Monitoring System (OMS) (Optional—Standard in North America) have a string potentiometer mounted inside each outrigger box. The potentiometer is connected to the outrigger beam to monitor the extension of the beam—retracted, mid-extended and full extended.

The front outriggers are the main support because they are located under the frame. The front outriggers can be used in the fully retracted, at the mid-extended position, or the fully extended position.

The outriggers are controlled with the hand held outrigger control box located in a compartment on the EasyReach

pedestal. When the outrigger extension is activated, it extends or retracts the selected outrigger beam or stabilizer.

The outriggers can be extended to the mid-extend position by allowing the lock pin to ride on the top of the beam while it's extending. The lock pin drops into the hole when the beam reaches the mid-extend position.

FRONT OUTRIGGER ASSEMBLY

The front outrigger assembly (Figure 7-1) consists of the following:

- outrigger beams
- stabilizer, or jack, cylinders
- required hoses and mounting hardware
- OMS potentiometer and associated hardware (if equipped)



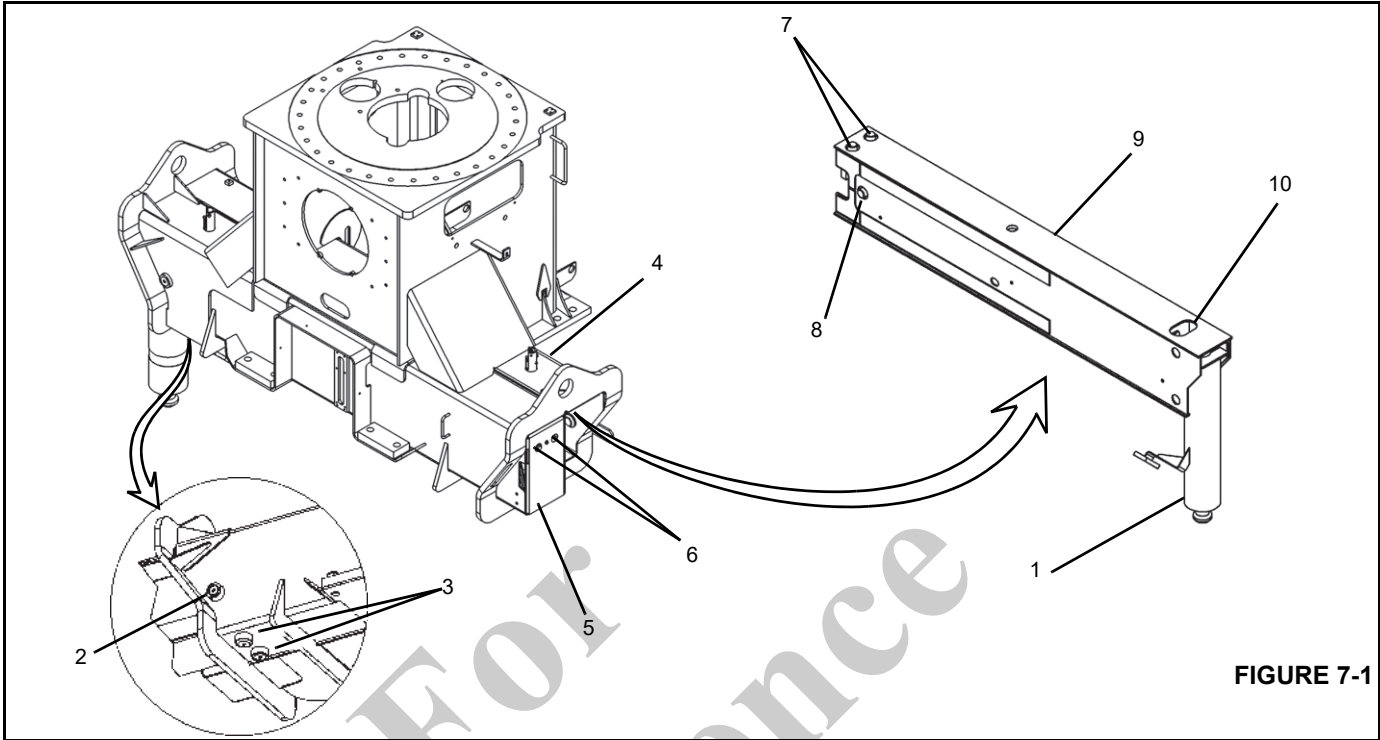


FIGURE 7-1

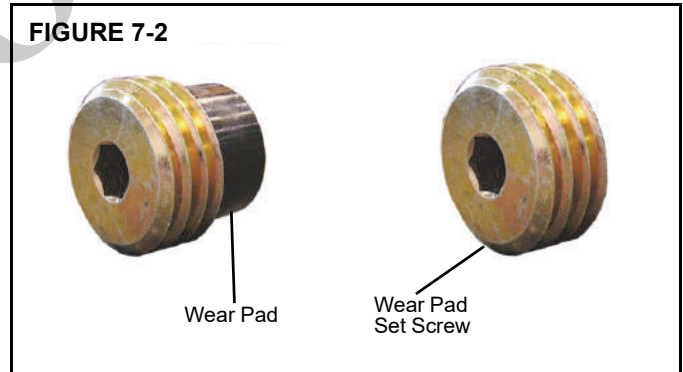
Item	Component
1	Stabilizer Cylinder
2	Outrigger Box Side Wear Pad (One Side)
3	Outrigger Box Bottom Wear Pads
4	Outrigger Box
5	Outrigger End Plate (Outrigger Box)

Item	Component
6	Extension Cylinder Bolts
7	Outrigger Beam Top Wear Pads
8	Outrigger Beam Side Wear Pad (Both Sides)
9	Outrigger Beam
10	Access Hole (Outrigger Beam)

Outrigger Beam Removal

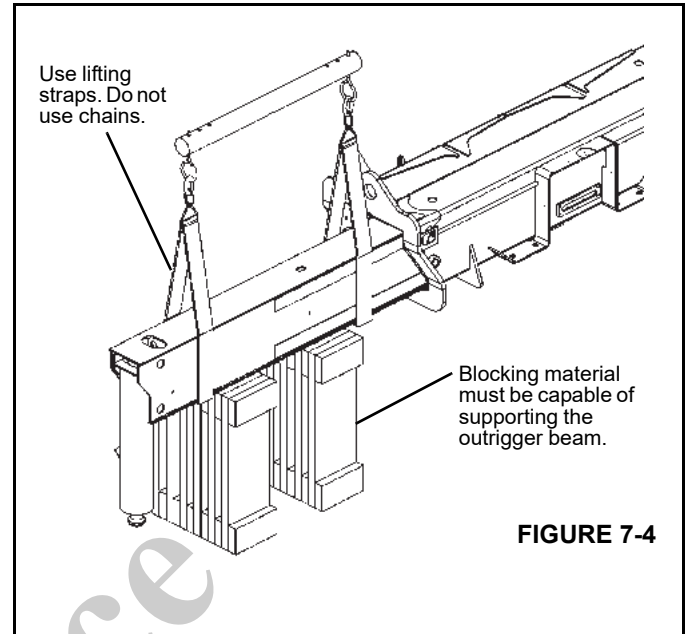
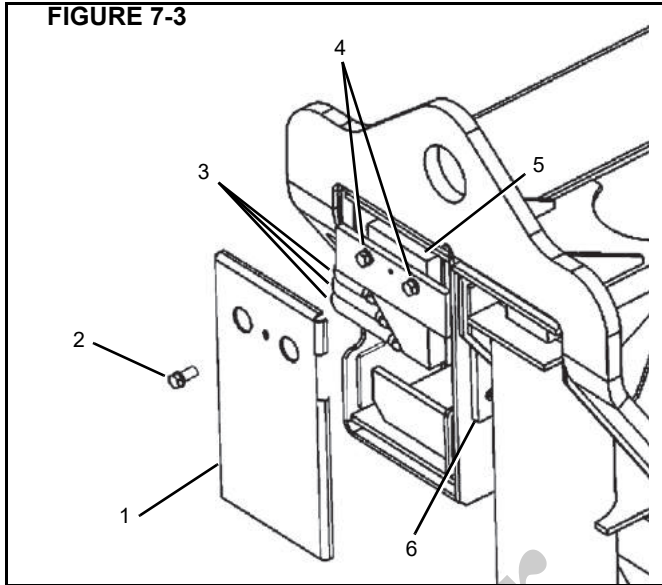
1. Check that the stabilizer cylinder is fully retracted and the float removed.
2. On the stabilizer cylinder end of the beam, remove the side wear pad set screw (Figure 7-2) in the outrigger box and back off the side wear pad (Figure 7-2).

FIGURE 7-2



3. Extend the outrigger beam slightly so that a lifting strap (Figure 7-4) can be attached to the outrigger beam.

NOTE: To prevent nicks and gouges to the bottom of the outrigger beam, do not attach chains to the outrigger beam.



Item	Component
1	Outrigger End Plate
2	End Plate Bolt
3	Outrigger Hydraulic Tubes
4	Extension Cylinder Bolts
5	Barrel End of Extension Cylinder
6	Nonadjustable Wear Pad

4. Unbolt and remove the end plate.
5. Tag and remove the hydraulic tubes at the end of the outrigger box (Figure 7-3).
6. Remove the extension cylinder bolts and lower the base of the extension cylinder to the bottom of the outrigger beam.
7. Remove the wear pad set screws in the top of the outrigger beam and back off the top wear pads (7) (Figure 7-1).
8. Place blocking material under the outrigger beam (Figure 7-4).

⚠ DANGER
Crushing Hazard!

Blocking material must be able to support the outrigger beam and not allow the beam to tilt or slide.

9. Pull the outrigger beam out of the outrigger box with the lifting device.
10. Position the outrigger beam on the blocking material.

Inspection

Inspect the outrigger beam for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder, loose connection, or damaged hydraulic line.

Installation

1. Apply grease (EP-MPG) to the bottom of the outrigger beam.
2. Apply anti-seize to wear pad and set screw threads.
3. Adjust the bottom wear pads on the outrigger box until about 0.25 in (6.4 mm) is protruding. This keeps the beam off of the bottom of the outrigger box.
4. Slide the beam into the outrigger box.
5. Align the base of the extension cylinder barrel with the holes in the end of the outrigger box.
6. Bolt the extension cylinder to the end of the outrigger box with the two bolts.
7. Reconnect the hydraulic lines as per removal tags.

- 8. Adjust the wear pads as described in *Wear Pad Adjustment*, page 7-5.
- 9. Retract the outrigger after wear pad adjustment.

Extension Cylinder

The purpose of the extension cylinder is to extend and retract the outrigger beam.

Removal

- 1. Remove the outrigger beam assembly as described in *Outrigger Beam Removal*, page 7-2.
- 2. Remove the keeper (6, Figure 7-5) from the keyhole.

- 3. Remove the rod end of the extension cylinder (5) from the keyhole on the stabilizer end of the outrigger beam.
- 4. Slide the extension cylinder out from the outrigger beam. Be careful not to drop the cylinder.

NOTE: The hydraulic hoses for the stabilizer cylinder are removed with the extension cylinder. Be careful not to damage the hydraulic hoses.

- 5. Tag and disconnect the hydraulic hoses for the stabilizer cylinder at the base of the extend cylinder.

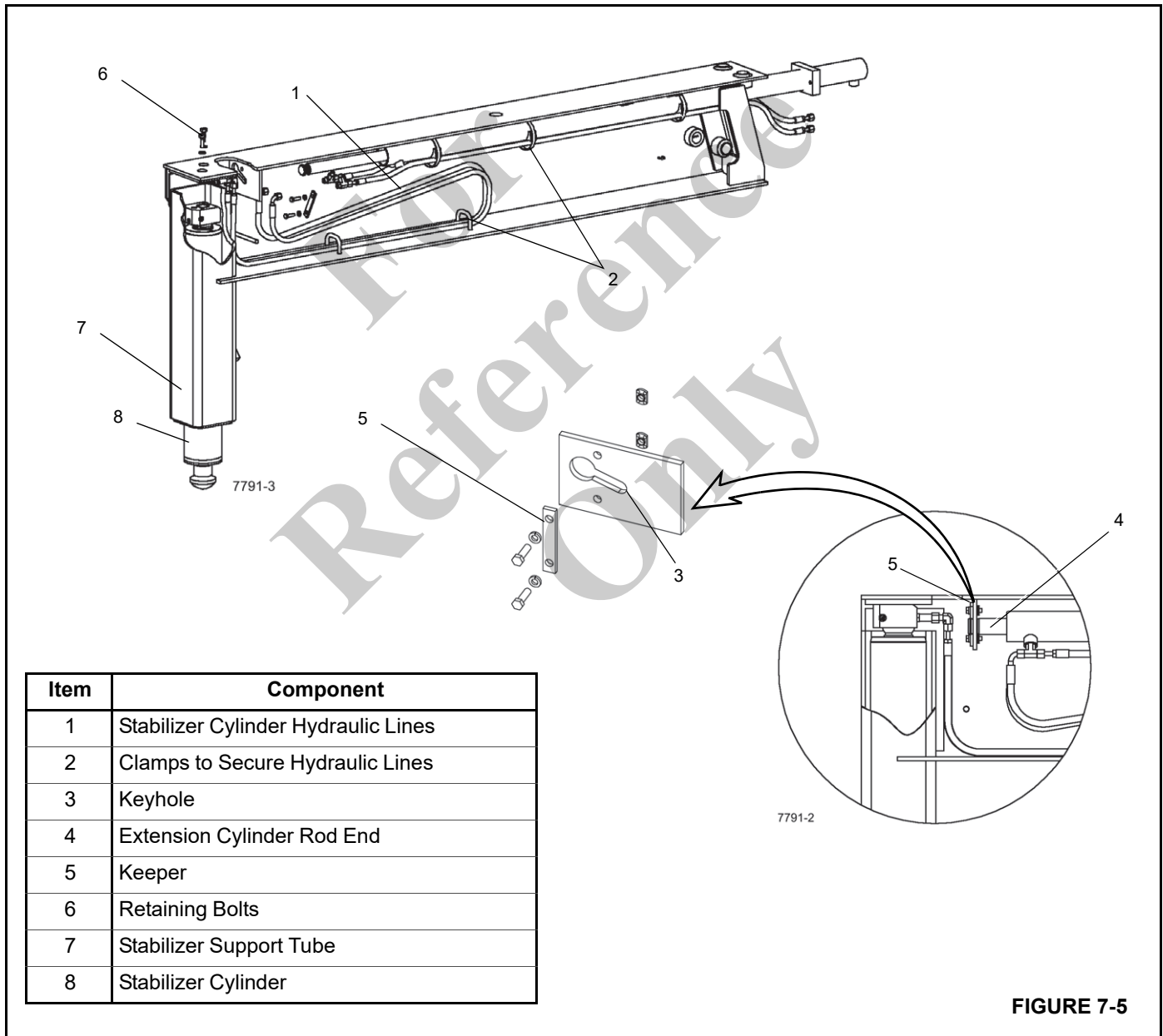


FIGURE 7-5

Installation

1. Reconnect the hydraulic hoses for the stabilizer cylinder to the base of the extension cylinder per removal tags.
2. Secure the stabilizer hydraulic hoses to the extend cylinder with the clamps as shown in Figure 7-5.
3. Slide the extension cylinder into the outrigger beam. Make sure the stabilizer hydraulic hoses are routed as shown in Figure 7-5.
4. Insert the rod end of the extension cylinder into the keyhole to secure the end of the rod.
5. Reinstall the keeper in the keyhole.
6. Reinstall the outrigger beam as described in Outrigger Beam Removal on page 7-1.

Stabilizer Cylinder

The stabilizer or jack cylinders extend down to provide stability for crane operation. The cylinder barrel extends down out of the stabilizer support tube. This protects the cylinder rod and reduces problems caused by dirt and mud.

Removal

1. With a lifting device, raise the truck until there is enough clearance to remove the stabilizer cylinder (8, Figure 7-5) from the stabilizer support tube (7).
2. Extend the outrigger beam until the access hole on top of the outrigger beam is accessible.
3. Tag and disconnect the hydraulic hoses to the stabilizer cylinder.
4. Unbolt the retaining bolts (6) for the stabilizer cylinder.
5. Slide the stabilizer cylinder (8) out of the stabilizer support tube (7).

Installation

1. Apply grease (EP-MPG) to the ID of the stabilizer support tube.
2. Place the stabilizer cylinder under the stabilizer support tube and insert the stabilizer cylinder into the support tube.
3. Bolt the stabilizer cylinder in the top of the support tube with the retaining bolts.
4. Reconnect the hydraulic hoses as per removal tags.

Wear Pad Adjustment

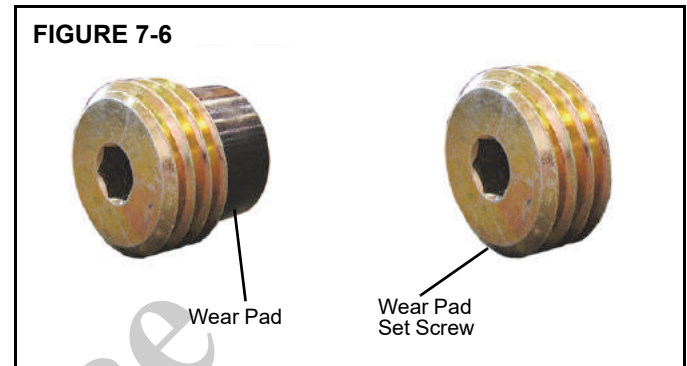
There are seven adjustable wear pads on each outrigger. Three wear pads are on the outrigger box and can be accessed from the outside. Four wear pads are on the

outrigger beam and are adjusted from inside the outrigger box.

Outrigger Beam Wear Pad Adjustment

Wear pad adjustment is as follows:

1. Remove the end plate from the outrigger box. This should provide access to the wear pads.



2. Remove the wear pad set screw from the adjustable wear pad (Figure 7-6).
 3. Apply anti-seize to wear pad and set screw threads.
 4. Reinstall the wear pad set screw to keep the wear pad in place.
 5. Screw the wear pad in until it stops and back off 1/2 turn to maintain 3.3mm (0.13 inch) gap in retracted position.
- NOTE:** Each 1/2 turn moves the wear pad about 3.3 mm (1/8 inch) laterally.
6. Repeat for all wear pads on the outrigger beam.

Outrigger Box Wear Pad Adjustment

1. With the outrigger fully retracted, attach the float to the jack and extend the jack until the outrigger beam contacts the top of the outrigger box.
 2. Apply anti-seize to wear pad and set screw threads.
 3. Screw the bottom wear pads on the outrigger box (Figure 7-1) in and back off about 1/2 turn to maintain 3.3mm (.13 inch) gap.
- NOTE:** Each 1/2 turn moves the wear pad about 3.3 mm (1/8 inch) laterally.
4. Screw the side wear pads on the outrigger box (Figure 7-1) in and back off about 1/2 turn.

Nonadjustable Wear Pad

Check the nonadjustable side wear pad on the outrigger box (Figure 7-3). There should be a 1.5 mm (0.06 in) gap between the outrigger box and wear pad. To correct the gap, add or remove shims to the wear pad.

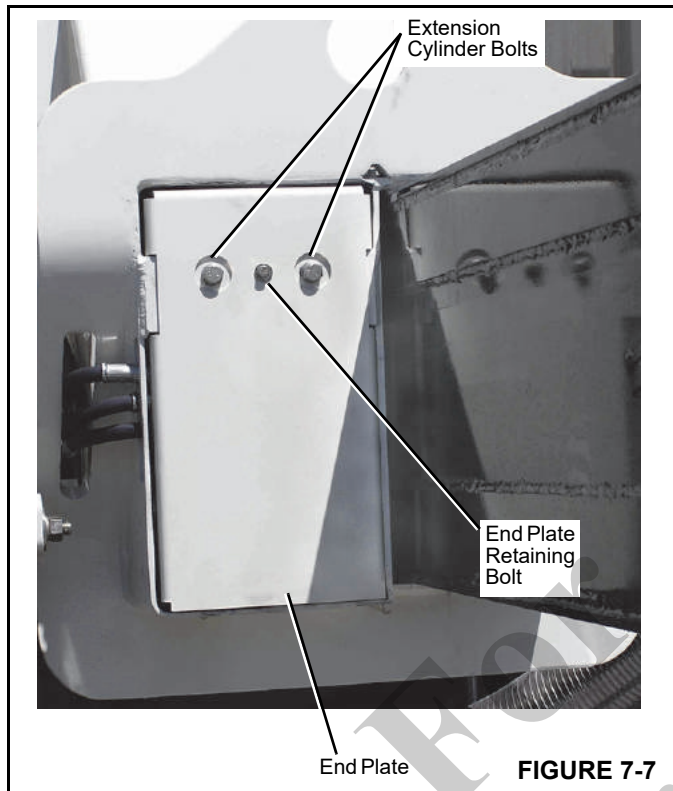


FIGURE 7-7

REAR OUTRIGGERS (RSOD)

The Rear Stabilizer Out and Down (RSOD) (Figure 7-8) is located behind the rear wheels and provides added stability for the crane. The RSOD can be used in the fully retracted, at the mid-extended, or the fully extended positions.

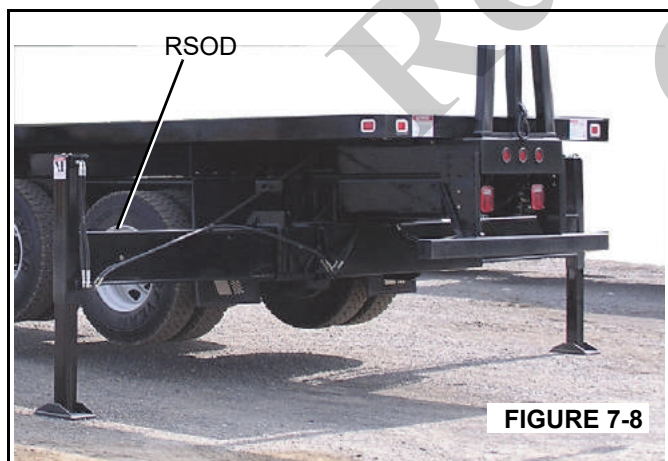


FIGURE 7-8

The RSOD is controlled with the hand held outrigger control box located in a compartment on front of the EasyReach

pedestal. When the outrigger extension is activated the selected beam or stabilizer is extended or retracted.

RSOD Assembly

The RSOD assembly consists of the following:

- outrigger beams
- stabilizers
- required hoses and mounting hardware
- OMS potentiometer and associated hardware (if equipped)

Removal

1. Check that the stabilizer is fully retracted.
2. Extend the outrigger beam slightly so that a lifting strap (Figure 7-4) can be attached to the outrigger beam.

NOTE: To prevent damage to the bottom of the outrigger beam, do not attach chains to the outrigger beam.

3. Tag and remove the hydraulic hoses connected to the extension (5, Figure 7-9) and stabilizer (7) cylinders.
4. Remove the bolts (1) that attach the extension cylinder barrel to the outrigger box.
5. Pull the outrigger beam out of the outrigger box with the lifting device.
6. Position the outrigger beam on blocking material (Figure 7-4).

! DANGER

Crushing Hazard!

Blocking material must be able to support the outrigger beam and not allow the beam to tilt or slide.

Inspection

Inspect the outrigger beam for bends, evidence of cracks, or other damage. Check the outrigger beam internally for hydraulic fluid, which may indicate a leaking cylinder, loose connection, or damaged hydraulic line.

Installation

1. Apply grease (EP-MPG) to the bottom of the outrigger beam.
2. Slide the beam into the outrigger box.
3. Bolt the extension cylinder to the end of the outrigger box.

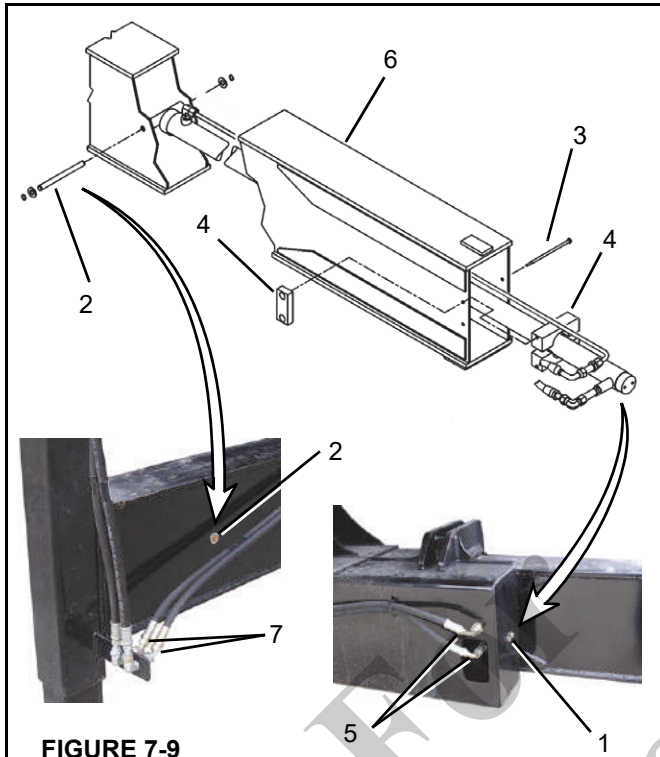


FIGURE 7-9

Item	Component
1	Extension Cylinder Anchor Bolts
2	Cylinder Rod Pin
3	Wear Pad Bolts
4	Wear Pad
5	Extension Cylinder Hydraulic Hoses
6	Outrigger Beam
7	Stabilizer Cylinder Hydraulic Hoses

Extension Cylinder

The purpose of the extension cylinder is to extend and retract the outrigger beam.

Removal

1. Remove the cylinder rod pin (2, Figure 7-9).
2. Remove the bolts (3) from the cylinder wear pads (4).

3. Remove the extension cylinder from the outrigger beam.

Installation

1. Slide the extension cylinder into the outrigger beam.
2. Install the extension cylinder wear pads.
3. Install the cylinder rod pin.

RSOD Stabilizers

The RSOD stabilizers extend down to provide stability for crane operation. The stabilizer cylinder is enclosed in the stabilizer support tube (4) and can be removed for replacement or repair.

Removal

1. With a jack, raise the truck until there is enough clearance to remove the stabilizer cylinder (3) and foot (4) from the stabilizer support tube (7).
2. Tag and disconnect the stabilizer cylinder hydraulic hoses (6).
3. Remove the check valve (2) from the stabilizer cylinder.
4. Remove the bolts on top of the stabilizer support tube and lower the stabilizer cylinder and foot out of the support tube.
5. Remove the bolt on the bottom of the stabilizer foot and remove the stabilizer cylinder from the foot.

Installation

1. Place the stabilizer cylinder in the stabilizer foot and bolt the bottom of the foot to the cylinder.
2. Apply grease (EP-MPG) to the outside of the stabilizer foot.
3. Place the stabilizer foot under the stabilizer support tube and jack up the foot until the stabilizer cylinder can be bolted to the top of the stabilizer support tube.
4. Bolt the stabilizer cylinder to the stabilizer support tube.
5. Reinstall the check valve.
6. Reconnect the hydraulic hoses as per removal tags.

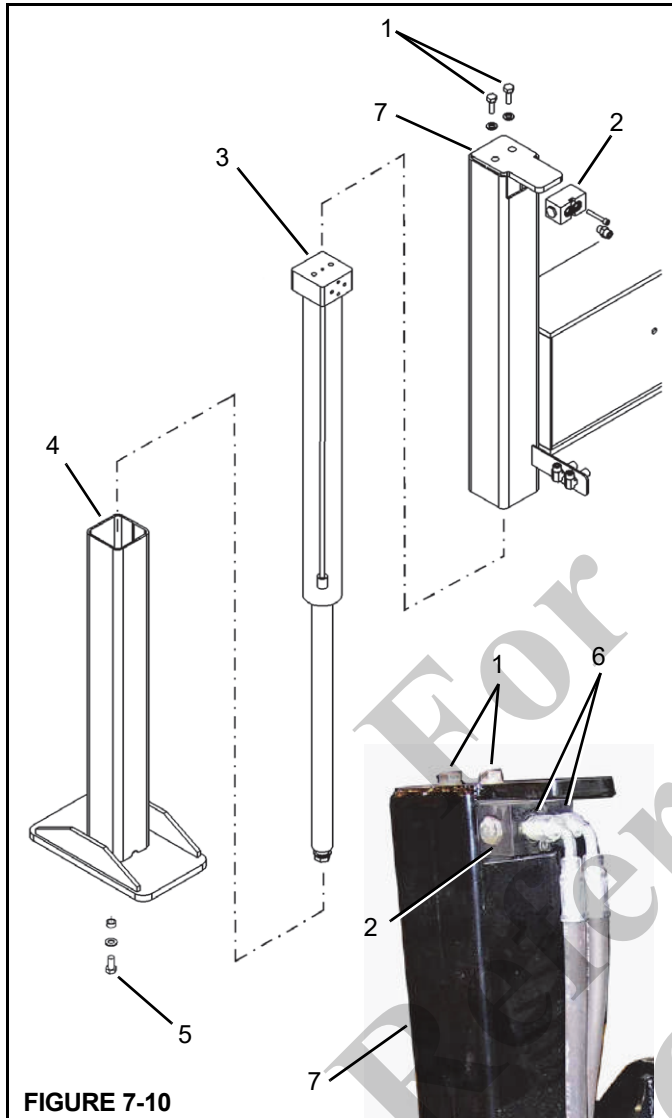


FIGURE 7-10

Item	Component
1	Stabilizer Cylinder Bolts
2	Check Valve
3	Stabilizer Cylinder
4	Stabilizer Foot
5	Stabilizer Foot Bolt
6	Stabilizer Cylinder Hydraulic Hoses
7	Stabilizer Support Tube

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

Description

The outrigger monitoring system (OMS) utilizes string potentiometers to monitor the outrigger's extension beam positions together with the RCL. Four monitoring string potentiometers are used on the crane, one at the end of each outrigger extension beam to monitor if beams are at full, mid or retracted positions. The default is to the lowest possible load chart after sensing all outrigger positions, for example, if three outriggers are fully extended and one is retracted, the RCL defaults to the retracted chart.

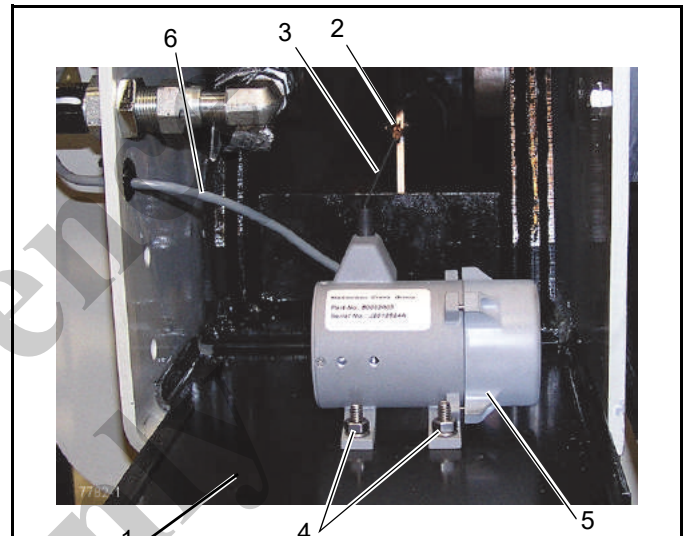


FIGURE 7-11

Item	Component
1	Outrigger Cover Plate
2	Cable Clip
3	Cable
4	Mounting Hardware (4)
5	String Potentiometer
6	Electrical Cable

Removal

1. Extend the outrigger beam slightly and shut down the engine.
2. Remove the hardware that secures the outrigger cover plate (1, Figure 7-11) and remove the cover plate.
3. Remove the OMS string potentiometer connector (2) from the attaching point on the outrigger beam.

NOTE: To prevent damage to the OMS string potentiometer, do not allow the cable (3) to retract freely.

4. Disconnect the electrical cable (6) connector and secure to avoid damage.
5. Completely remove the mounting hardware (4) for the string potentiometer.
6. Remove the OMS string potentiometer (5) from the outrigger cover plate.

Installation

1. Install the string potentiometer (5) on the inside of the outrigger cover plate (1).
2. Connect the electrical cable (6) to the OMS string potentiometer.

3. Attach the OMS string potentiometer connector (2) to the attaching point on the outrigger beam.

NOTE: To prevent damage to the OMS string potentiometer, do not allow the cable to retract freely.

4. Install the outrigger cover plate to the outrigger box and secure with the hardware.
5. Calibrate string potentiometer; refer to *Calibration*, page 7-9

Calibration

Calibrating the string potentiometer is done through the crane's RCL. Refer to *RCL Sensor Calibration (Legacy RCL Version)*, page 3-12.

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SECTION 8 LUBRICATION

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GENERAL

To ensure maximum crane life, follow a designated lubrication procedure. 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. Lubrication requirements for the truck chassis are not included here. Refer to appropriate truck manufacturer's manual for this information.

The service intervals specified are for normal operation with moderate temperature, humidity, and atmospheric conditions. In areas of extreme conditions, the service periods and lubrication specifications need to be altered for 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)

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

Open Gear Lubricant

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

Antifreeze/Coolant (for Cab Heater)

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

Anti-wear Additives

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

Hydraulic Oil

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

CAUTION

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

NOTE: When operating the crane in temperatures -9°C (15°F) and below, follow the procedures in the section titled "Arctic Conditions Below -9°C (15°F)" on page 8-2.

Standard Hydraulic Oil

Temperature Above -9°C (15°F)

The factory fill standard hydraulic oil is SAE grade 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 hydrogenated 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 bypass condition, the hydraulic oil must be sampled. The hydraulic tank breather should also be

inspected to assure that it is not restricting air flow into and out of the reservoir.

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

Surface Protection for Cylinder Rods

Steel cylinder rods have 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 allow hydraulic oil to warm and penetrate the cracks. If machines are operated daily the rods are protected. 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 by applying a protectant. Unless the machine is operated daily, exposed rod surfaces will corrode. Some cylinders 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.

Exposed cylinder rods need to 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 removes the Boeshield protectant. Inspect machines once a week and reapply Boeshield to unprotected rods.

The lubrication points, type, interval, amount, and application methods are describe in the table on page 8-5. 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 listed in tables below.

LUBRICATION

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

 **DANGER**

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

CAUTION

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

All oil levels are to be checked with the crane parked on a level surface in transport position, and while the oil is cold, unless otherwise specified. On plug type check points, the oil levels are to be at the bottom edge of the fill port.

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

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

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

CAUTION

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

The following describe the lubrication points and gives the lube type, lube interval, lube amount, and application of each. Each lubrication point is numbered, and this number corresponds to the index number shown 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°F (-40°C)
EP-MPG	Extreme Pressure Multipurpose Grease	A6-829-003477	A6-829-104275
GL-5	Extended Service Interval Gear Lubricant	A6-829-012964	A6-829-014058
HYDO	Hydraulic Oil	A6-829-006444	A6-829-101559
EP-OGL	Open Gear Lubricant, CEPLATTYN 300 Spray, NLGI Grade 1-2	A6-829-102971	Standard
AGMA EP-4	Extreme Pressure Gear Lubricant	A6-829-100213	A6-2829-103636
WRL	Wire Rope Lubricant	A6-829-015236	Standard

NOTE: Cold weather lubricants are not sufficient for temperatures below -40°F (40°C). Use hydraulic tank heaters and insulate where appropriate.

Lubrication Points

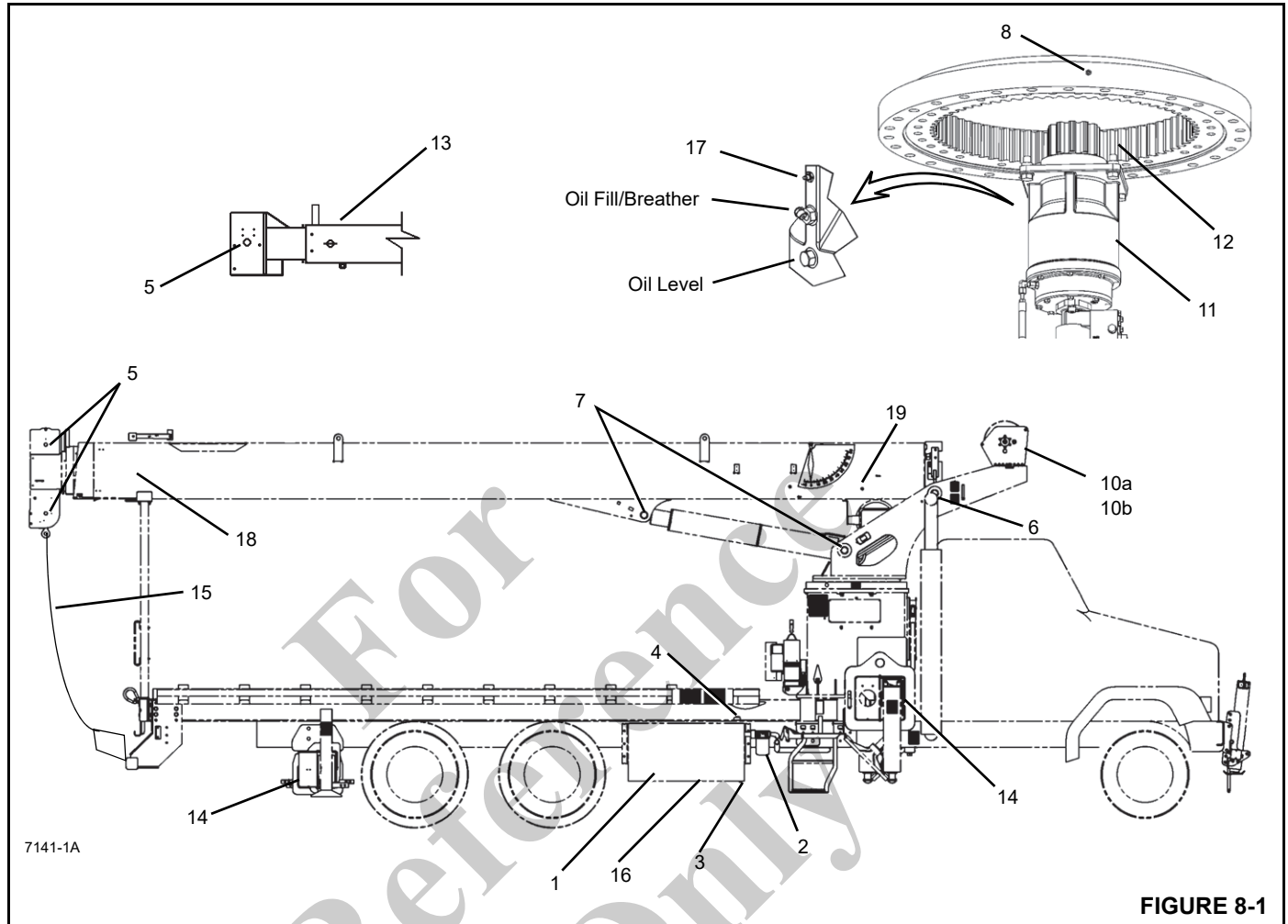


FIGURE 8-1

Table 8-1: Lubrication Intervals

Item	Application	Recommended Lubricant	Procedure	Frequency
1	Hydraulic oil reservoir	HYDO	Check fill change	Weekly As Required Semi-Annually
2	Oil filter, Hydraulic oil reservoir		Change or clean	After first 40 Hrs. Quarterly thereafter.
3	Magnetic Plug, Hydraulic oil reservoir		Clean	At oil filter service interval.
4	Breather, Hydraulic oil reservoir		Clean	Monthly
5	Sheave pins: boom (5 plcs), Extension (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
10a	Hoist gearbox.	SAE 90 EP	Change/check & fill	Every 1000 hours or 6 months
10b	Hoist brake	HYDO	Change/check & fill	Every 1000 hours or 6 months
11	Swing drive gearbox	GL-5	Change	After 100 operating hours

Table 8-1: Lubrication Intervals

Item	Application	Recommended Lubricant	Procedure	Frequency
12	Swing gear teeth	EP-OGL or EP-MPG	Spray Can or brush	Monthly
13	Boom extension	LTG	Brush, roller or grease gun spray can	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
16	Diffuser strainer, Hydraulic oil reservoir		Clean	Semi-Annually with Oil Change
17	Swing Drive Pinion Bearing	EP-MPG	Grease Gun	Sparingly every 50 hours
18	Extend Sheaves	EP-3MG	Grease Gun	Weekly
19	Retract Sheaves: Extend the boom until the retract sheave grease holes are visible through the access holes along side of boom.	EP-3MG	Grease Gun	Weekly
20	Extension Cables (Not Shown)	WRL	Spray or Brush	Any Time Boom is Disassembled or 5 Years

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 inch (6.35 mm) diameter nozzle grease gun tip (National Crane P/N 955045).
- Contact Manitowoc Crane Care to obtain this tip.

Lubrication of the extend and retract sheaves is as follows:

1. Extend the boom until the grease access holes on the side of the 2nd and 3rd sections are lined up.
2. Lubricate the pin for the extend cable sheaves (18) (Figure 8-1) until a small amount of grease extrudes from the pin. From in front of the boom, look back through the sheave case at the pin to determine the amount of grease.
3. This position also aligns the access holes in the rear of the 1st and 2nd sections for lubrication.
4. Lubricate the pins for the retract sheaves until a small amount of grease extrudes from the sheave pins. From in back of the boom, look up through the hoist mount at the pins to determine the amount of grease.

Inner Boom Wear Pad Lubrication

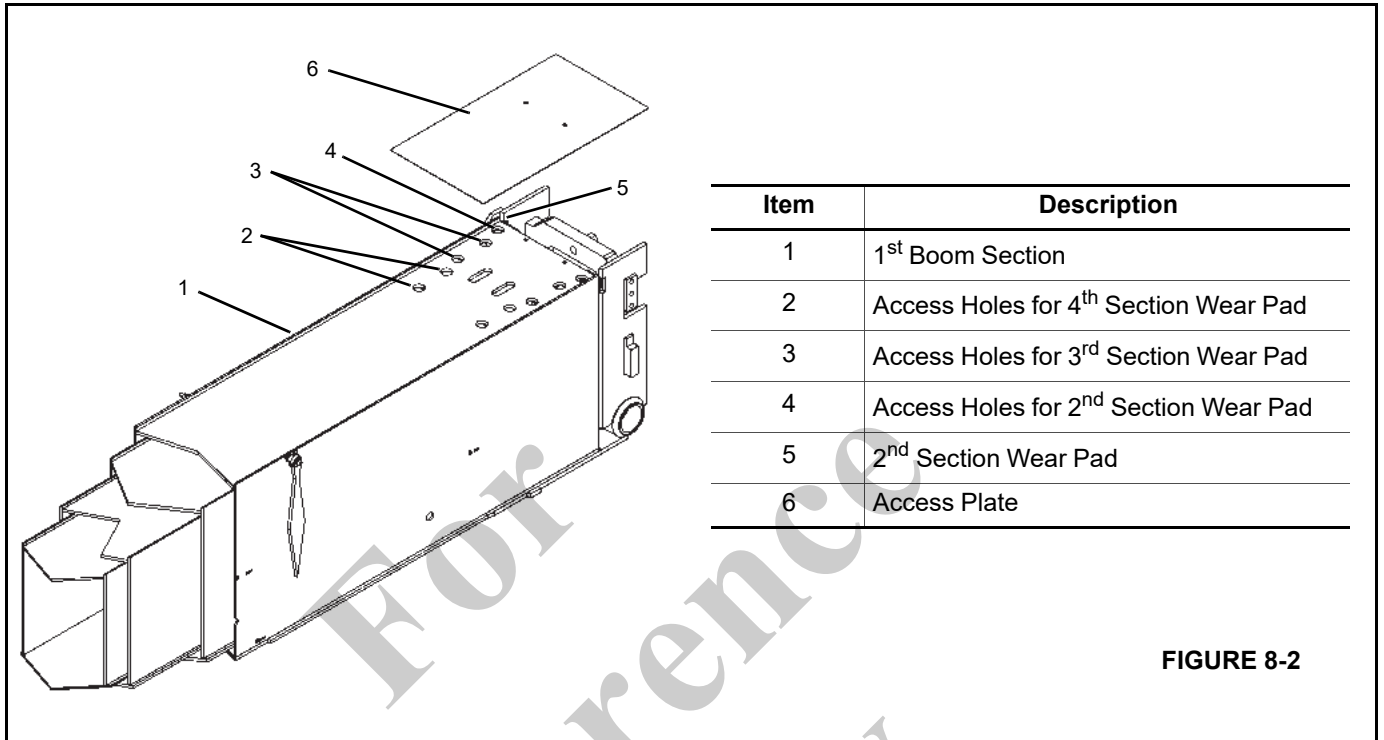
1. Fully extend and set the outriggers.
2. With the boom fully retracted, remove the access plate (6) located on the top rear of the 1st section (Figure 8-2).
3. Apply grease to the wear pads on the top of the 2nd section through the access holes (4) in the 1st section with a grease gun (Figure 8-2).
4. Extend the boom to line up the access holes on the 2nd section (3) with the wear pads on the 3rd section. Apply grease to the 3rd section wear pads with a grease gun.
5. Extend the boom to line up the access holes (2) on the 3rd section with the wear pads on the 4th section. Apply grease to the 4th section wear pads with a grease gun.
6. Raise the boom to at least 75°.
7. Extend the boom about 1/3 and retract to spread the grease.
8. Repeat steps 3 - 6. Extend the boom about 2/3 and retract to spread the grease.
9. Repeat steps 3 - 5. Fully extend and retract the boom to spread the grease.

Side and Bottom Boom Wear Pad Lubrication

Recommended lubricant is EP-3MG grease.

1. Fully extend and set the outriggers.
2. Lower the boom to horizontal.
3. Fully extend the boom and apply grease to the side and bottom of the 2nd, 3rd, and 4th sections with a brush.

4. Raise the boom to 75° and retract the boom.
5. Extend and retract the boom several times until the grease is evenly spread.
6. Repeat as necessary.



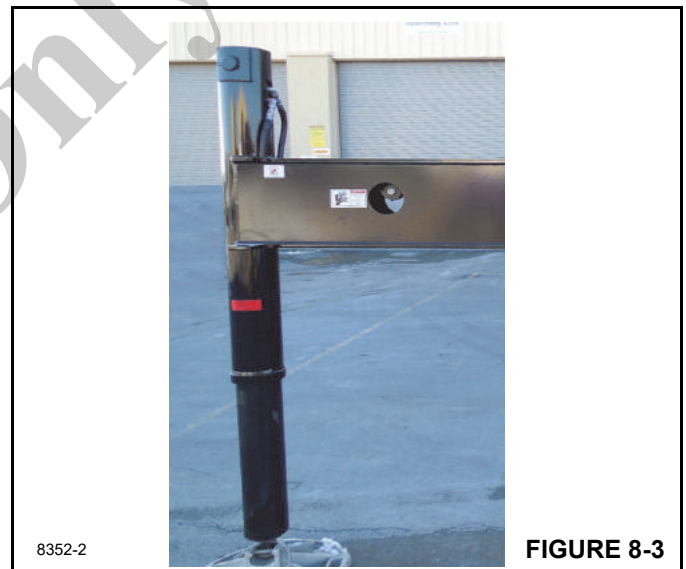
Outrigger Beam Lubrication



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 8-3.)
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.



Hoist Brake Oil

Check Hoist Brake Oil

To check the hoist brake oil, remove the inspection plug (Figure 8-4) and visually inspect the oil level. The fluid

should be visible within the bottom of the inspection hole. If more fluid is needed, add through the brake oil vent and fill plug hole until oil is at the bottom level of the inspection hole.

Drain /Add New Hoist Brake Oil

To drain and add new oil, remove the drain plug (Figure 8-4), inspection plug and vent plug and drain the brake oil. Reinstall drain plug and add fluid at the brake oil vent hole until oil is at the bottom level of the inspection hole. Install the inspection plug and the oil vent and fill plug. See "Lubrication Points" on page 8-5. The hoist brake fill capacity is 0.23 liter (.25 quart).

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

⚠ DANGER

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

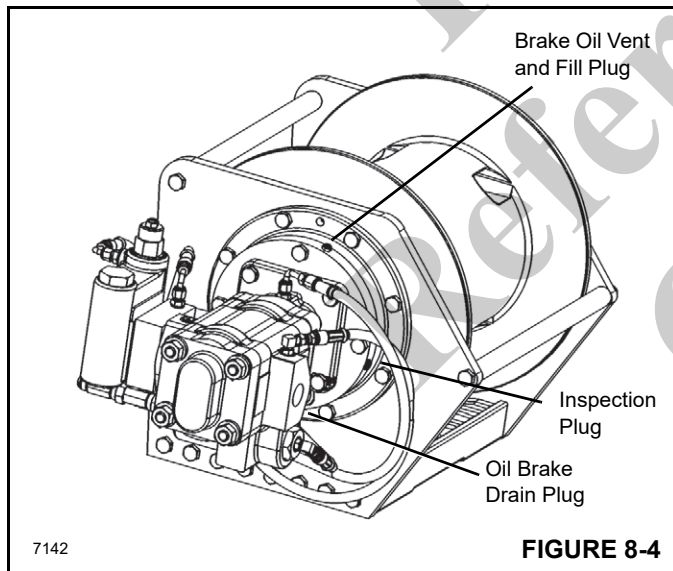


FIGURE 8-4

Hoist Gearbox Oil Level Check

To check the hoist gearbox oil level:

- Rotate the drum until the oil fill/drain plug is level with the oil level/fill inspection hole (Figure 8-5).
- Remove the oil fill/drain plug and visually inspect the level. The oil should be level with the bottom of the inspection hole. If more oil is needed, add SAE 90 EP gear lube.

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

Hoist Gearbox Oil Change

Oil Drain

1. Rotate the drum until the oil/fill plug is level with the drain hole (Figure 8-5).
2. Screw a 1" black pipe nipple into the drain hole so that the oil can be drained into an approved container.
3. Remove the drain/fill plug with a 3/8" hex wrench.
4. Remove the breather.

Oil Fill

1. Remove the 1" pipe nipple from the drain hole.
2. Rotate the drum until the drain/fill hole is level with the fill hole.
3. Install a 1" pipe nipple with elbow in the drain/fill hole.
4. Fill the gearbox with 1.5 quarts of new gear lube. The lube should be level with the bottom of the fill hole.
5. Remove the fill pipe.
6. Check that the breather is not clogged. Replace if necessary.
7. Install the drain/fill plug and breather.

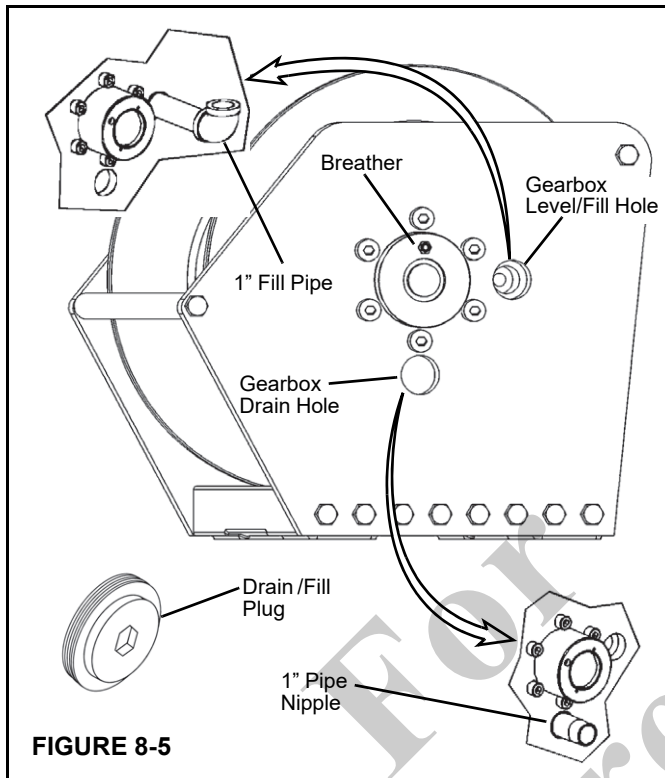


FIGURE 8-5

900H Hydraulic Oil Reservoir Level

The hydraulic oil reservoir has a sight gauge located on the side of the reservoir (Figure 8-6). The oil in the hydraulic reservoir is sufficient when the level is between the upper and lower marks on the decal 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.

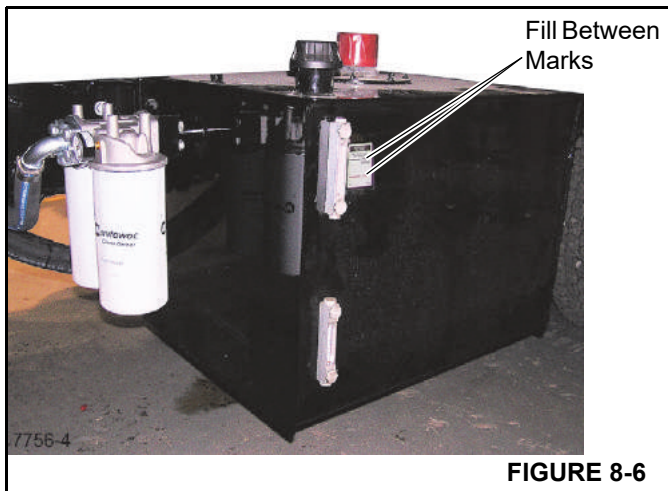


FIGURE 8-6

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 (i.e. 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.

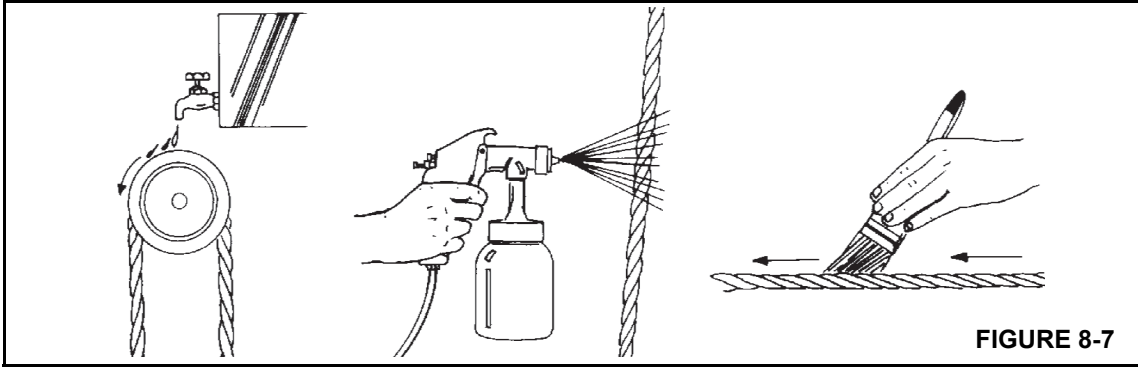


FIGURE 8-7

CARWELL® RUST INHIBITOR

Protecting Cranes From Corrosion

National 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 Crane 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 T32-CP-90 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, Carwell T32-CP-90 can appear to leave a slightly "oily" residue on painted surfaces and until the red tinting fades could initially be mistaken for a hydraulic oil leak. While the product is not harmful to painted surfaces, glass, plastic or rubber, it can be removed using standard steam-cleaning techniques.

Carwell works in various ways: (1) it eliminates the moisture containing salt, dirt and other pollutants by lifting and removing them from the metal surface; (2) the film creates a barrier to repel further moisture from coming in contact with the metal; and (3) it penetrates crevices.

In addition to the factory-applied Carwell coating, National crane owners must provide proper maintenance and care to help ensure long-term protection of their crane against corrosion. This procedure provides information and

guidelines to help maintain the paint finish on National Cranes.

The most common causes of corrosion include the following:

- Road salts, chemicals, dirt, and moisture trapped in the hard-to-reach areas;
- Chipping or wear of paint, 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 your National Crane, 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 of paint using accepted blending techniques. Use of original paint colors is recommended to insure the best color match possible.

For scratches and marks in areas of low visibility:

- Consider touching up the spots with a brush technique to cover the bare metal. This will retard the effects of corrosion and enable you to do the repair at a later time during a normal maintenance interval.
- Spots should be touched up with quality paint. Primers tend to be porous; using a single coat of primer only will allow air and water to penetrate the repair over time.

Application

Depending upon the environment in which a crane is used and/or stored, the initial factory application of Carwell T32-CP-90 should help inhibit corrosion for up to approximately 12 months.

It is recommended that Carwell T32-CP-90 be periodically reapplied by the crane owner after that time to help continue to protect against corrosion of the crane and its components.

However, if a crane is used and/or stored in harsh environments (such as islands, coastal regions, industrial areas, areas where winter road salt is regularly used, etc.), reapplication of Carwell T32-CP-90 is recommended sooner than 12 months, e.g., repeat treatment in 6-9 months.

- Do not apply to recently 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 Carwell.

NOTE: Unit must be completely dry before applying Carwell.

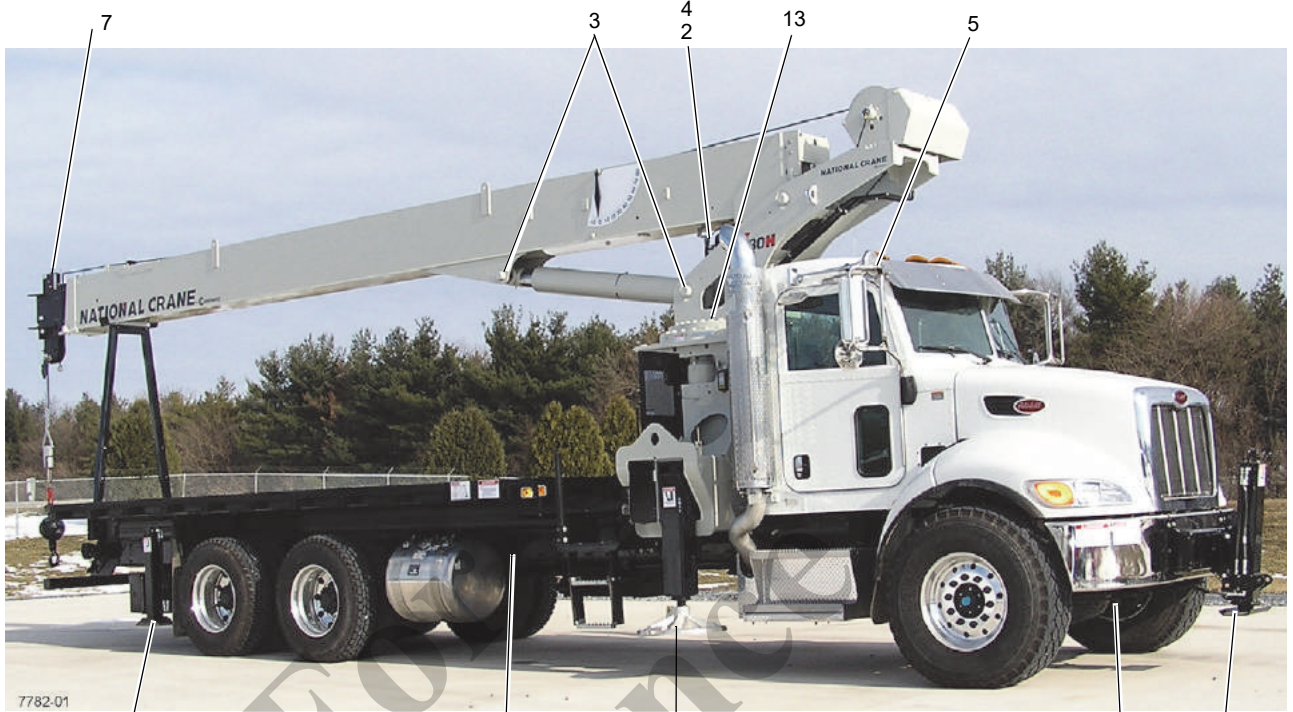
- Do not allow product to puddle or build-up on weather stripping, rubber gaskets, etc. Unit should not have puddles or runs evident anywhere.
- To ensure proper coverage of Carwell, the product needs to be fogged on the unit.
- Use of pressure pots to apply the Carwell to the unit being processed is recommended.
- Carwell T32-CP-90 is available in 16 ounce spray bottles from Manitowoc Crane Care (order part number 8898904099).
- After application of Carwell is complete, wash or clean film residue from lights, windshield, grab handles, ladders/steps and all access areas to crane, as necessary.

Please contact Manitowoc Crane Care should you have any questions.

Areas of Application

- The underside of the unit will have full coverage of the rust inhibitor. These are the only areas that a full coat of the rust inhibitor is acceptable on the painted surfaces. Areas include; valves, hose ends and fittings, swivel, pumps, axles, drive lines, transmission 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 alarms.
- Superstructure applications are: hose ends and fittings, wire rope on hoist, roller tensioning springs on hoists, all unpainted fasteners and hardware, valves, slew ring, all bare metal surfaces.
- Boom applications areas are: pivot pins, hose ends and fittings, jib pins and shafts, all bare metal surfaces, overhaul weight/ hookblock pins and fasteners.
- All hardware, clips, pins, hose connections that are not painted will have Carwell applied.

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Item	Description
1	Hoist Plumbing Connections
2	All Hardware, Clips, Pins, Unpainted Hose Connections
3	Pivot Shaft
4	Hose Connections
5	Mirror Mounting Hardware
6	Wire Rope
7	Boom Nose Pins, Clips

Item	Description
8	Hook Block/Overhaul Weight
9	O/R Hose Connections
10	O/R Pins, Clips
11	Power Train Hardware
12	Entire Underside of Unit
13	Turntable Bearing Fasteners, Pins
14	Valve Bank, Hose Connections
15	Clips for Optional Jib
16	Hanger Hardware for Optional Jib

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SECTION 9 CRANE INSTALLATION

SECTION CONTENTS

<p>General 9-1</p> <p>Minimum Truck Requirements 9-1</p> <p>Extension protection Schematic 9-1</p> <p>Mounting Configuration 9-4</p> <p>PTO and Hydraulic Pump 9-6</p> <p style="padding-left: 20px;">Horsepower 9-6</p> <p style="padding-left: 20px;">Direct PTO Mount 9-6</p> <p style="padding-left: 20px;">PTO Ratio 9-6</p> <p style="padding-left: 20px;">Pump Rotation 9-6</p> <p>Truck Frame Strength 9-7</p> <p>Truck Preparation 9-11</p> <p style="padding-left: 20px;">Welding Precautions 9-11</p> <p style="padding-left: 20px;">Positioning the Crane On the Truck 9-11</p> <p>Reinforcing After Frame Extension 9-12</p> <p>Mounting the Crane 9-16</p> <p style="padding-left: 20px;">Mount the T-Box 9-16</p> <p style="padding-left: 20px;">Attach the RSOD 9-18</p> <p style="padding-left: 20px;">Mount the Frame Assembly 9-19</p> <p style="padding-left: 20px;">Install the Front Outriggers 9-19</p> <p style="padding-left: 20px;">Install the Boom Rest 9-20</p>	<p style="padding-left: 20px;">Install the Rear Bumper 9-20</p> <p style="padding-left: 20px;">Mount the Operator Platforms and Install the Foot Throttles 9-21</p> <p style="padding-left: 20px;">Install the Boom, Lift Cylinder, and Hoist 9-22</p> <p style="padding-left: 20px;">Install the RCL Reel 9-22</p> <p style="padding-left: 20px;">Connect the Slew Potentiometer 9-23</p> <p style="padding-left: 20px;">Connect the Electrical Interface 9-23</p> <p style="padding-left: 20px;">Install the Hydraulic System 9-24</p> <p style="padding-left: 20px;">Front Outrigger Hydraulic Line Connections 9-26</p> <p style="padding-left: 20px;">RSOD Hydraulic Line Connections 9-27</p> <p>CAN Bus System Setup 9-28</p> <p>Initial Crane Run In Procedure 9-28</p> <p>RCL Calibration 9-28</p> <p>Stability Test 9-28</p> <p>Specifications 9-30</p> <p style="padding-left: 20px;">Hydraulic Pump 9-30</p> <p style="padding-left: 20px;">Hydraulic System 9-30</p> <p style="padding-left: 20px;">Reservoir 9-30</p> <p style="padding-left: 20px;">Hoist System 9-30</p> <p style="padding-left: 20px;">Outrigger Speeds 9-31</p>
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GENERAL

This section provides information for proper mounting and initial check out of the crane. Improper mounting can result in damage to the truck frame and drive train, the 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, overhang, etc.

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 personnel [at 200 lb (90 kg) each].

National Cranes must meet ASME/ANSI B30.5 (latest) when completed as cranes and ASME/ANSI B30.23 (latest) when completed as a personnel lifting system. These standards require welds to meet AWS D14.3 or AWS D1.1 respectively.

Any work done in mounting must be done in compliance with these codes.

NOTE: Verify that the number on the serial number plates on the major components match the main serial number located on the crane frame (Figure 9-1). If the serial numbers do not match, contact the factory before proceeding. Matching serial numbers insure that accurate information is recorded at the factory.

MINIMUM TRUCK REQUIREMENTS

The minimum truck requirements for mounting the 900H series cranes are as follows:

- **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 Cab-to-Axle (CA)** - The WB, CT and CA requirements are determined by:

- Mounting Configuration
- Boom Length
- Bed Length

The WB and CT shown in Figure 9-2 are required so the basic 900H can be legally driven in all states and meet 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. Refer to Mounting Configuration on page 9-4 for additional information.

- **Truck Frame** - Select a truck frame that minimizes or eliminates 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 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 Truck Frame Strength on page 9-7 for the necessary section modulus and resistance to bending moment values.

- **Additional Equipment**

Additional equipment recommendations are as follows:

- electronic engine control system
- increased cooling system
- extra heavy duty PTO. See page 9-6 for PTO and Hydraulic Pump.

A conventional truck cab 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.

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Typical Location of Serial Number Identification Tags

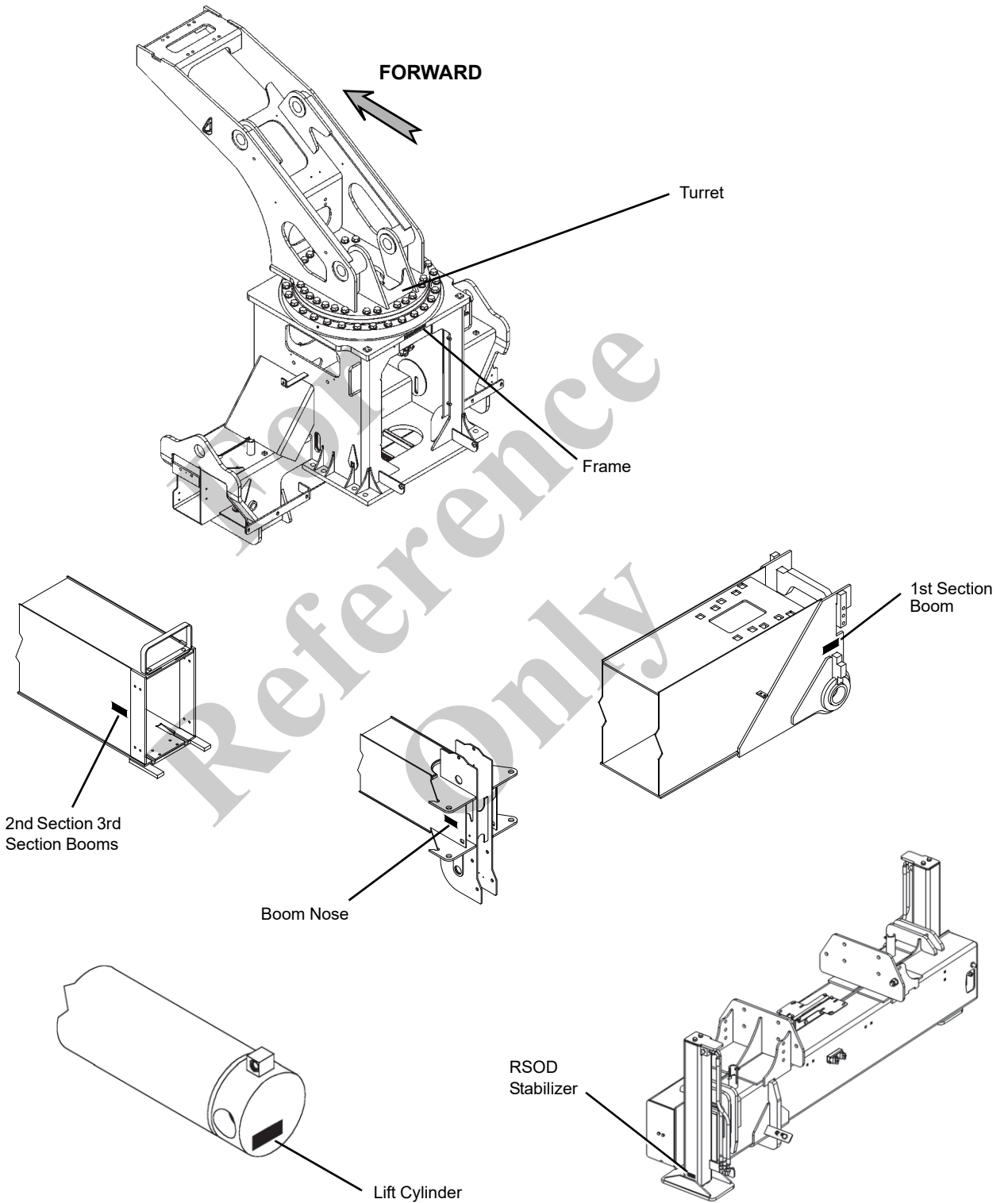


FIGURE 9-1

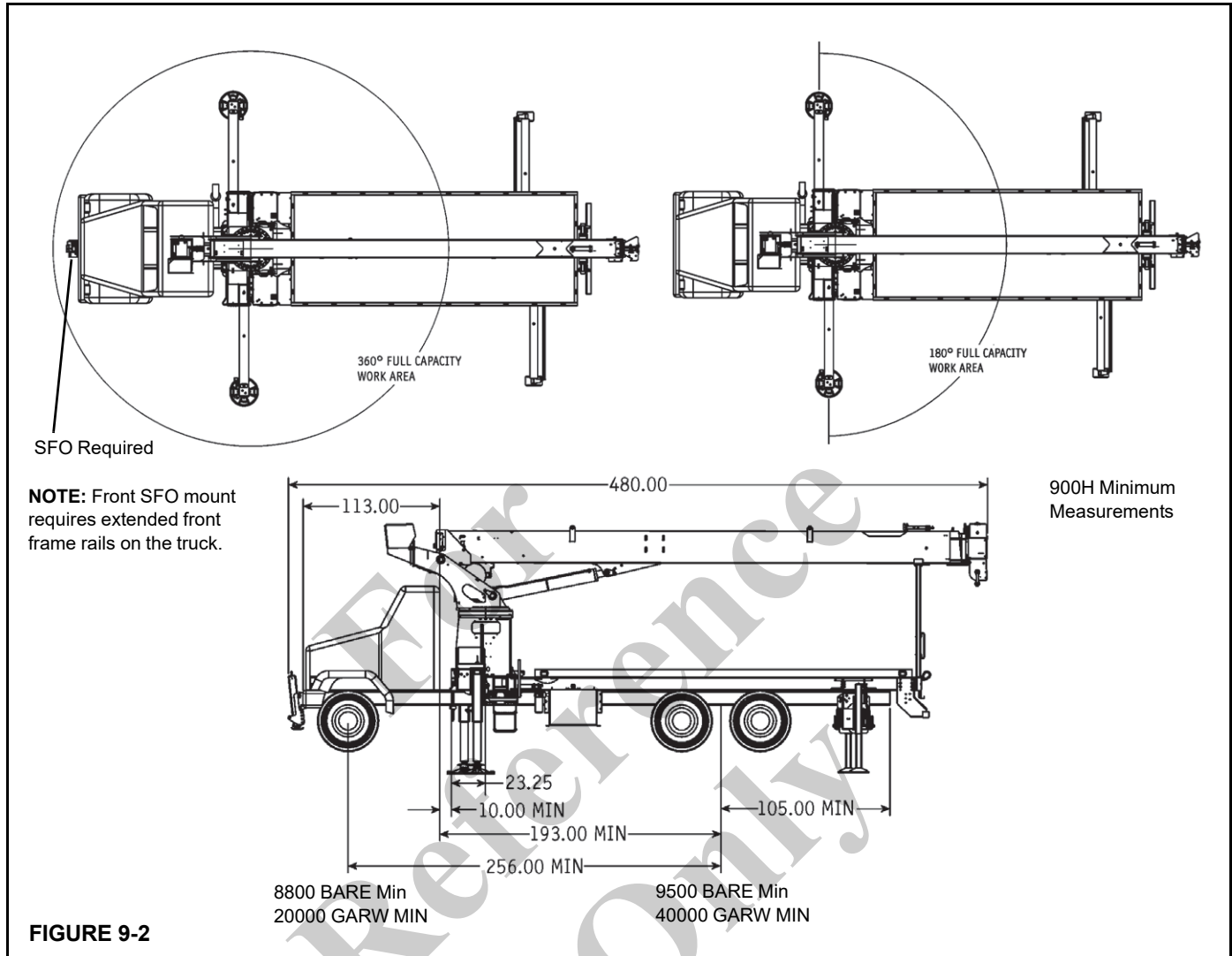


FIGURE 9-2

MOUNTING CONFIGURATION

The mounting configuration shown in Figure 9-2 is based on an 85% stability factor. The crane must be installed on the truck in accordance with factory requirements and a test performed to determine the stability and counterweight requirements. If the bare truck weights are not met, a counterweight is required. A summary of mounting and truck requirements are:

- Working area - 360° (SFO Required)
- Working area - Limited to 180° with no SFO.
- Gross Axle Weight Rating (GAWR) front - 20,000 lb (9071 kg)
- Gross Axle Weight Rating (GAWR) rear - 40,000 lb (18143 kg)
- Gross Vehicle Weight Rating - 60,000 lb (27215.54 kg)

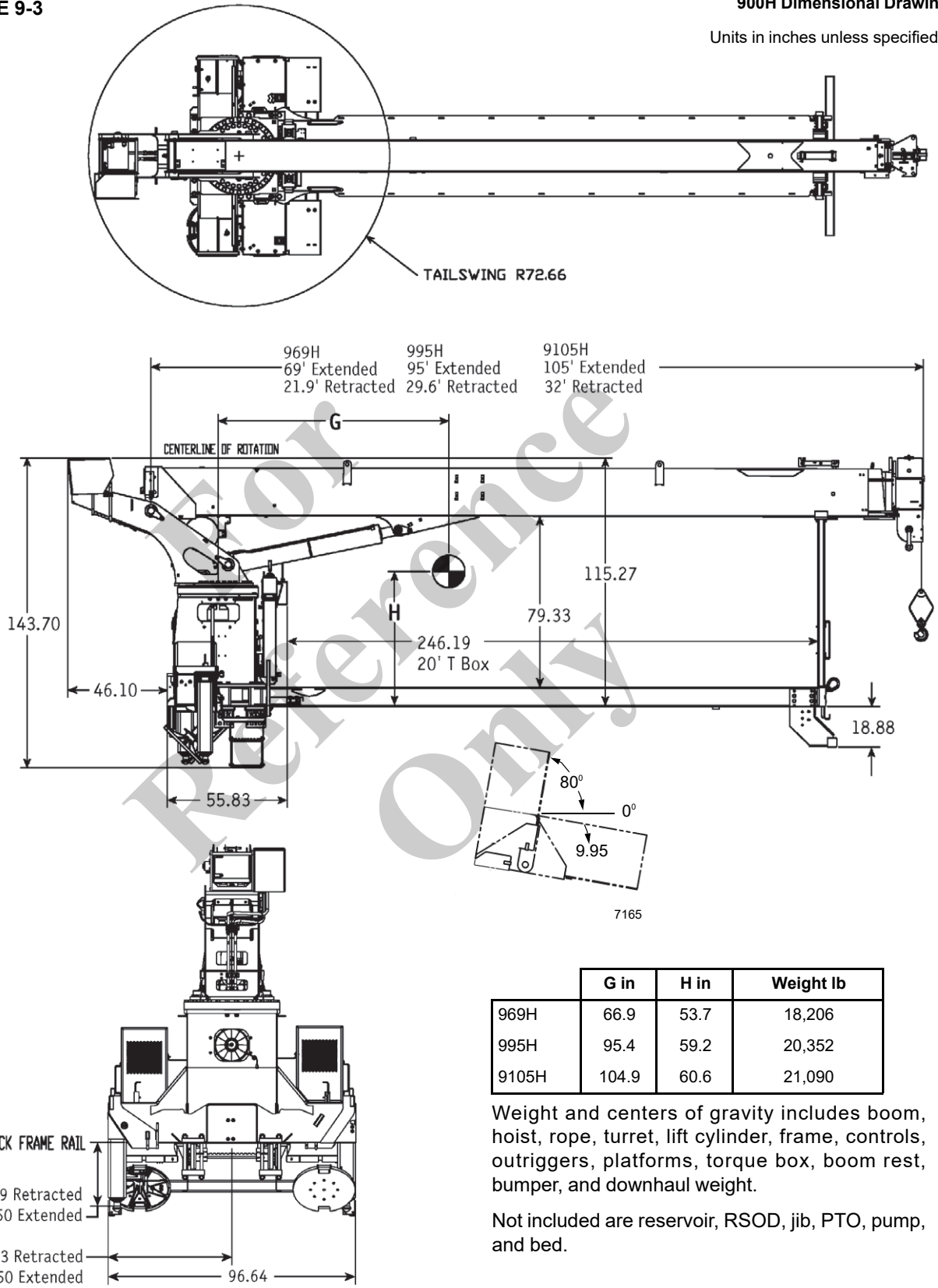
NOTE: Gross Vehicle Weight Rating (GVWR) is dependent on all components of the vehicle (axles, tires, springs, frame, etc.) meeting manufacturer's recommendation. Always specify GVWR when purchasing trucks.

- Wheelbase (WB) - 256 in (650 cm)
- Cab to Axle Trunnion (CT) - 193 in (490 cm)
- After Frame (AF) - 105 in (266 cm)
- Frame Section Modulus (SM) front axle to end of afterframe - 110,000 psi (759 MPa) 30 in³ (See *Truck Frame Strength*, page 9-7)
- The estimated bare chassis weights required for stability prior to installation of crane or accessories are:
 - Front 8800 lb (3991 kg)
 - Rear 9500 lb (4309 kg)

FIGURE 9-3

900H Dimensional Drawing

Units in inches unless specified



Weight and centers of gravity includes boom, hoist, rope, turret, lift cylinder, frame, controls, outriggers, platforms, torque box, boom rest, bumper, and downhaul weight.

Not included are reservoir, RSOD, jib, PTO, pump, and bed.

PTO AND HYDRAULIC PUMP

Horsepower

An axial piston pump is furnished with this crane. The pump uses a load sense system to supply flow to the crane hydraulics. With load sense, only the systems that are working are supplied with flow. To provide these flows, the pump shaft must turn at 2400 RPM. The PTO requirement is 210 HP (156.5 kW).

Direct PTO Mount

In most installations the pump can be mounted directly to the PTO using adapter assemblies available from the PTO supplier. If the pump is direct mounted, its weight should be supported by a strap between the pump and the transmission. The splined shaft coupling in a direct mount pump installation requires lubrication. #200S Silver Streak Special Multi-Lube (Medium) is applied to the shaft during original installation and reapplied to the shaft or grease fitting provided on PTO housing shaft semi-annually thereafter.

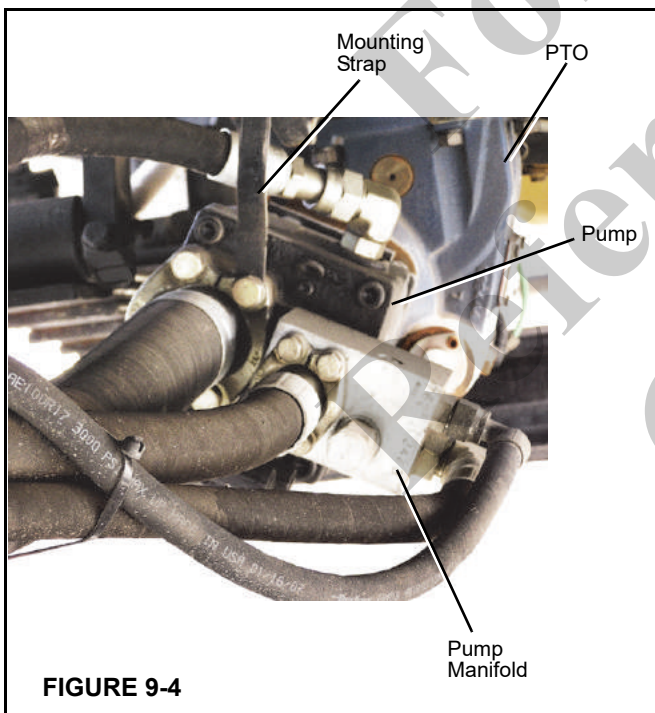


FIGURE 9-4

PTO Ratio

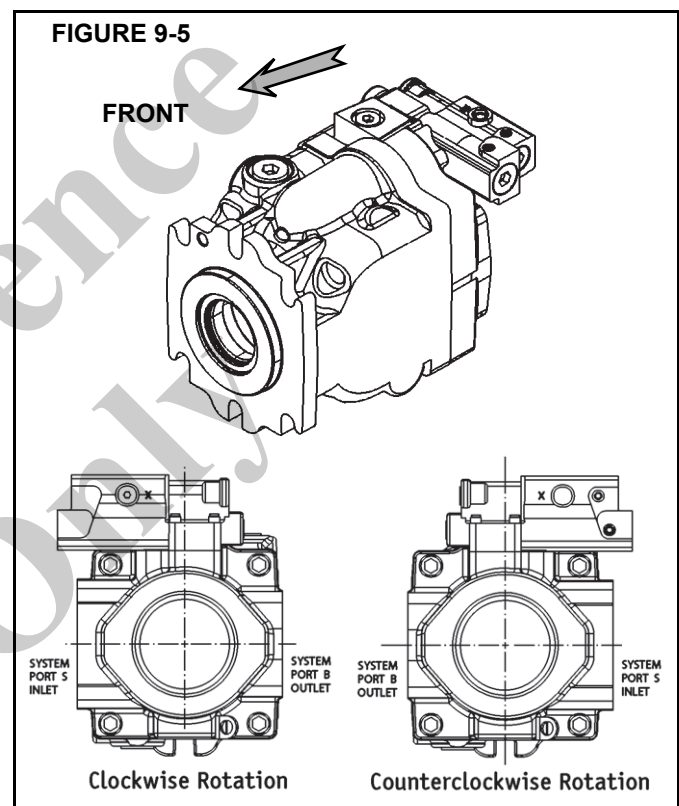
Pump shaft speed is determined by truck engine RPM and PTO ratio:

$$\text{Pump Shaft Speed} = \text{Truck Engine RPM} \times \text{PTO Ratio}$$

The following PTO ratio and engine speed combinations provide proper pump shaft speed which is the recommended maximum speed for the 900H pump.

The engine must be operated at a speed such that the horsepower developed is adequate to run the pump under pressure and provide the required flow.

Diesel Engine Optimum Speed Range (RPM)	PTO Ratio 2400 RPM PUMP
2400	100%
2200	109%
2000	120%
1800	133%
1600	150%
1500	160%



Pump Rotation

The hydraulic pump that is installed in a 900H application must be the correct pump rotation configuration for the PTO. Verify the direction the PTO output shaft rotates before selecting a clockwise (CW) or counter-clockwise (CCW) rotation hydraulic pump (Figure 9-5). Both CW or CCW rotation pumps are available.

CAUTION

Rotating the pump in the wrong direction damages the pump.

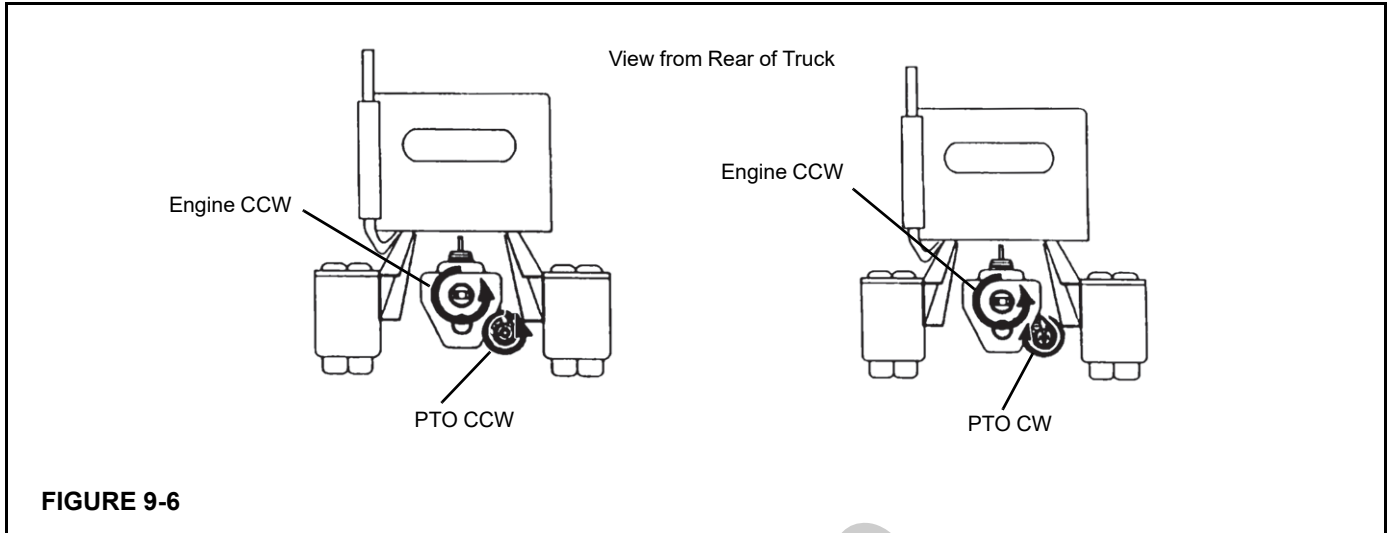


FIGURE 9-6

TRUCK FRAME STRENGTH

For a truck frame to be suitable for a Series 900H crane, the truck frame must:

- be rigid enough to prevent 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.

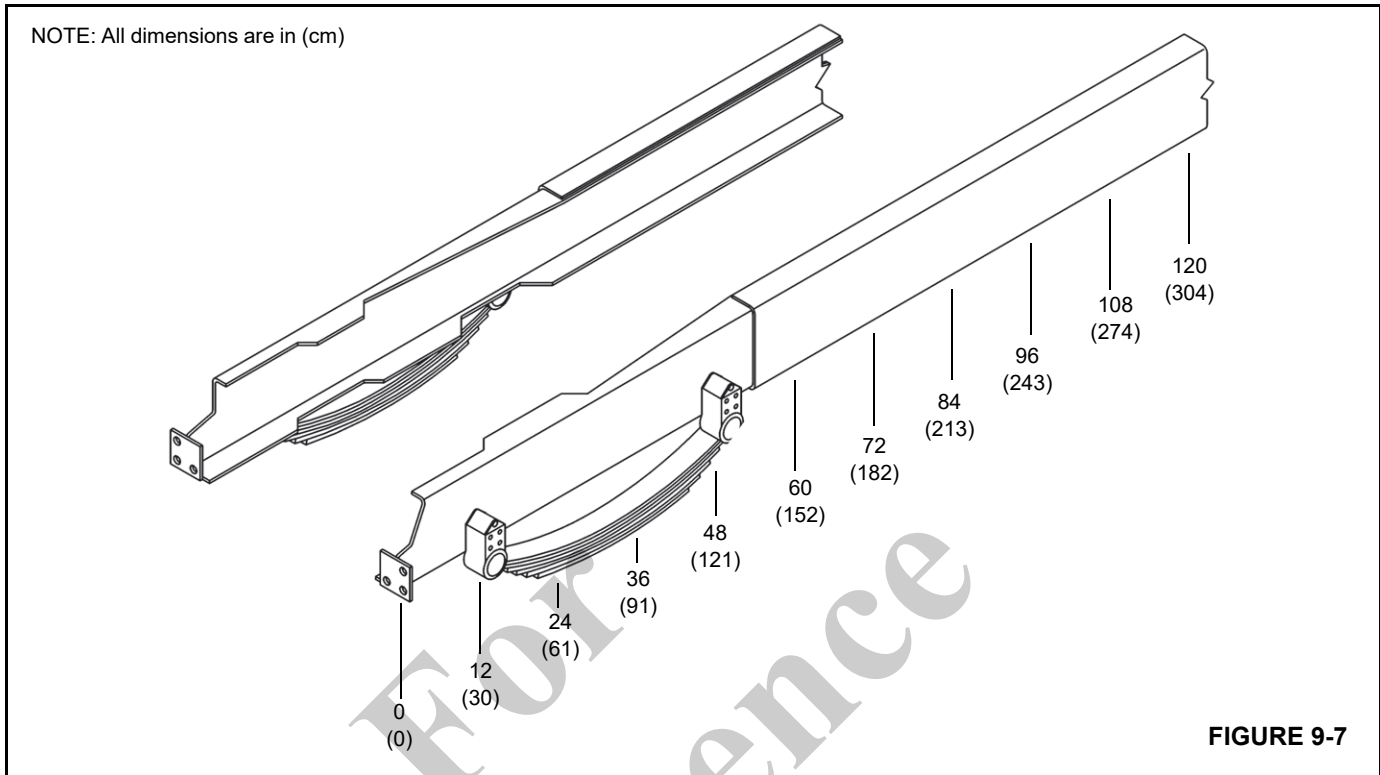
The Section Modulus (S.M.), which determines the rigidity of the frame, is a measurement of the area of the truck frame. Resistance to bending moment (RBM) is a measurement of strength and is determined by multiplying the section modulus of each frame rail by the yield strength of the rail material.

For a standard, behind-the-cab mount, the Series 900H crane requires a minimum of 2,200,000 in-lb (248,566 N.m) RBM and 20.0 in³ (327 S.M. under the crane frame between the front and rear springs with 1,650,000 in-lb (186,424 N.m) RBM and 15 in³ (295 cm³) SM. through suspension to stabilizers on each truck frame rail.

For 360° stability the truck frame must have a 20.0 in³ (327 cm³) section modulus [2,200,000 in-lb (197,610 N.m) RBM] minimum under the crane frame, 15 in³ (245 cm³)

section modulus [1,650,000 in-lb [186,424 N.m] RBM) at the front spring rear hanger, 10 in³ (163 cm³) section modulus [1,100,000 in-lb (124,283 N.m) RBM] through the front spring and 3 in³ (49 cm³) section modulus [330,000 lb (37,284 N.m) RBM] at the stabilizer attachment point on each truck frame rail. Listed below is a table showing the commonly used truck frame and reinforcing materials and the section modulus required for each material to ensure adequate strength and rigidity. In all cases, the minimum requirements for section modulus and RBM must be met.

Distance From Stabilizer Attachment in (cm)	Section Modulus Per Rail in. ³ (cm ³)
0 - 12 (0 - 30)	2.7 (44)
12 - 24 (30 - 61)	5.5 (90)
24 - 36 (61 - 91)	8.2 (134)
36 - 48 (91 - 121)	11.0 (180)
48 - 60 (121 - 152)	13.7 (224)
60 - 72 (152 - 182)	16.5 (270)
72 - 84 (182 - 213)	19.2 (315)
84 - 96 (213 - 243)	21.9 (359)
96 - 108 (243 - 274)	24.7 (405)
108 - 120 (274 - 304)	27.4 (449)
120+ (304 +)	30.0 (492)



The following tables determine the section modulus of the truck frame. Measure the truck frame and check the tables to be sure that the truck factory listed section modulus is correct.

- **Channel** (Table A page 9-9) - Table A provides the section modulus 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 section modulus from that particular channel.

If the section modulus of the channel does not meet the requirements, the channel should be reinforced in the most applicable method following.

- **Channel Reinforcement** (Table A) - In order to provide more strength, a channel of suitable thickness can be added to the existing frame. The depth and flange width of this channel should be chosen so it fits over the existing frame. The section modulus of the needed channel is obtained from Table A and should be added to the section modulus obtained from the truck frame. Add this to the section modulus 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 section modulus 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 section modulus of the fish plate can be obtained from Table C and this must be added to the section modulus of the frame to obtain the total section modulus.
- **Angle Under Reinforcement** (Table D page 9-11) - This table lists the section modulus of an angle with the flange under the truck frame that is added to a frame with an angle reinforcement already added. Add the section modulus from Table D to the section modulus obtained from tables A and B to determine total section modulus.

The edges of the reinforcing angles or channels are to be flush with the edges of the frame.

Welding - Two rows of 1 in (25.4 mm) diameter plug welds are to be placed in a staggered pattern of the web; the rows to 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.

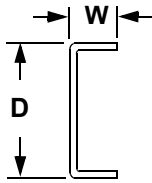


TABLE A
Section Modulus in³ (cm³)

Thickness 3/16 in. (4.76 mm)				
D in. (mm)	W in. (mm)			
	2.5 (64)	3 (76)	3.5 (89)	4 (102)
8 (203)	5.3 (87)	6.0 (98)	6.7 (110)	7.5 (123)
9 (229)	6.3 (103)	7.1 (116)	7.9 (130)	8.7 (143)
10 (254)	7.3 (120)	8.2 (134)	9.1 (149)	10.0 (164)
11 (279)	8.4 (138)	9.4 (154)	10.4 (170)	11.4 (187)
12 (305)	9.5 (156)	10.6 (174)	11.7 (192)	12.8 (210)
13 (330)	10.8 (177)	11.9 (195)	13.1 (215)	14.3 (234)
14 (356)	12.0 (197)	13.3 (218)	14.6 (239)	15.9 (261)
15 (381)	13.4 (220)	14.7 (241)	16.1 (264)	17.5 (287)

Thickness 1/4 in. (6.35 mm)				
D in. (mm)	W in. (mm)			
	2.5 (64)	3 (76)	3.5 (89)	4 (102)
8 (203)	6.9 (113)	7.8 (128)	8.8 (144)	9.7 (159)
9 (229)	8.2 (134)	9.2 (151)	10.3 (169)	11.4 (187)
10 (254)	9.5 (156)	10.7 (175)	11.9 (195)	13.1 (215)
11 (279)	11.0 (180)	12.3 (202)	13.6 (223)	14.9 (244)
12 (305)	12.5 (205)	13.9 (228)	15.3 (251)	16.8 (275)
13 (330)	14.1 (231)	15.6 (256)	17.2 (282)	18.8 (308)
14 (356)	15.8 (259)	17.5 (287)	19.1 (313)	20.8 (341)
15 (381)	17.5 (287)	19.3 (316)	21.2 (348)	23.0 (377)

Thickness 5/16 in. (7.94 mm)				
D in. (mm)	W in. (mm)			
	2.5 (64)	3 (76)	3.5 (89)	4 (102)
8 (203)	8.4 (138)	9.5 (156)	10.7 (175)	11.9 (195)
9 (229)	10.0 (164)	11.3 (185)	12.6 (206)	13.9 (228)
10 (254)	11.6 (190)	13.1 (215)	14.6 (239)	16.0 (262)
11 (279)	13.4 (220)	15.0 (246)	16.6 (272)	18.3 (300)
12 (305)	15.3 (251)	17.1 (280)	18.8 (308)	20.6 (338)
13 (330)	17.3 (284)	19.2 (315)	21.1 (346)	23.1 (379)
14 (356)	19.4 (318)	21.4 (351)	23.5 (385)	25.6 (420)
15 (381)	21.6 (354)	23.8 (390)	26.0 (426)	28.3 (464)

Thickness 3/8 in. (9.52 mm)				
D in. (mm)	W in. (mm)			
	2.5 (64)	3 (76)	3.5 (89)	4 (102)
8 (203)	9.8 (161)	11.2 (184)	12.5 (205)	13.9 (228)
9 (229)	11.7 (192)	13.2 (216)	14.8 (243)	16.3 (267)
10 (254)	13.6 (223)	15.4 (252)	17.1 (280)	18.8 (308)
11 (279)	15.7 (257)	17.7 (290)	19.6 (321)	21.5 (352)
12 (305)	18.0 (295)	20.1 (329)	22.2 (364)	24.3 (398)
13 (330)	20.3 (333)	22.6 (370)	24.9 (408)	27.2 (446)
14 (356)	22.8 (374)	25.3 (415)	27.8 (456)	30.3 (497)
15 (381)	25.4 (416)	28.1 (461)	30.8 (505)	35.5 (582)

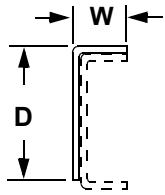


TABLE B
Section Modulus in³ (cm³)

Thickness 3/16 in. (4.76 mm)				
D in. (mm)	W in. (mm)			
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)
7.5 (191)	2.2 (36)	2.3 (38)	2.3 (38)	2.4 (39)
8.5 (216)	2.8 (46)	2.9 (48)	3.0 (49)	3.0 (49)
9.5 (241)	3.4 (56)	3.5 (57)	3.6 (59)	3.7 (61)
10.5 (267)	4.1 (67)	4.3 (70)	4.4 (72)	4.5 (74)
11.5 (292)	4.9 (80)	5.1 (84)	5.2 (85)	5.4 (88)
12.5 (318)	5.8 (95)	6.0 (98)	6.1 (100)	6.3 (103)
13.5 (343)	6.7 (110)	6.9 (113)	7.1 (116)	7.3 (120)
14.5 (368)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)

Thickness 1/4 in. (6.35 mm)				
D in. (mm)	W in. (mm)			
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)
7.5 (191)	2.9 (48)	3.0 (49)	3.1 (51)	3.2 (52)
8.5 (216)	3.7 (61)	3.8 (62)	3.9 (64)	4.0 (66)
9.5 (241)	4.5 (74)	4.7 (77)	4.8 (79)	5.0 (82)
10.5 (267)	5.5 (90)	5.7 (93)	5.8 (95)	6.0 (98)
11.5 (292)	6.5 (106)	6.7 (110)	6.9 (113)	7.1 (116)
12.5 (318)	7.6 (124)	7.9 (129)	8.1 (133)	8.3 (136)
13.5 (343)	8.8 (144)	9.1 (149)	9.4 (154)	9.6 (157)
14.5 (368)	10.1 (166)	10.5 (172)	10.7 (175)	11.0 (180)

Thickness 5/16 in. (7.94 mm)				
D in. (mm)	W in. (mm)			
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)
7.5 (191)	3.6 (59)	3.7 (61)	3.9 (64)	4.0 (66)
8.5 (216)	4.6 (75)	4.7 (77)	4.9 (80)	5.0 (82)
9.5 (241)	5.6 (92)	5.8 (95)	6.0 (98)	6.2 (102)
10.5 (267)	6.8 (111)	7.1 (116)	7.3 (120)	7.5 (123)
11.5 (292)	8.1 (133)	8.4 (138)	8.6 (141)	8.9 (146)
12.5 (318)	9.5 (156)	9.8 (161)	10.1 (166)	10.4 (170)
13.5 (343)	11.0 (180)	11.4 (187)	11.7 (192)	12.0 (197)
14.5 (368)	12.6 (206)	13.0 (213)	13.4 (220)	13.7 (224)

Thickness 3/8 in. (9.52 mm)				
D in. (mm)	W in. (mm)			
	2.75 (70)	3.25 (83)	3.75 (95)	4.25 (108)
7.5 (191)	4.3 (70)	4.5 (74)	4.6 (75)	4.8 (79)
8.5 (216)	5.5 (90)	5.7 (93)	5.9 (97)	6.0 (98)
9.5 (241)	6.7 (110)	7.0 (115)	7.2 (118)	7.4 (121)
10.5 (267)	8.1 (133)	8.4 (138)	8.7 (143)	8.9 (146)
11.5 (292)	9.7 (159)	10.0 (164)	10.3 (169)	10.6 (174)
12.5 (318)	11.3 (185)	11.7 (192)	12.1 (198)	12.4 (203)
13.5 (343)	13.1 (215)	13.6 (223)	14.0 (229)	14.3 (234)
14.5 (368)	15.1 (247)	15.5 (254)	16.0 (262)	16.4 (269)

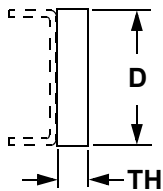


TABLE C
Section Modulus in³ (cm³)

TH in. (mm)	D in. (mm)								
	8 (203)	9 (229)	10 (254)	11 (279)	12 (305)	13 (330)	14 (356)	15 (381)	16 (406)
3/16 (4.76)	2.0 (33)	2.51 (41)	3.10 (51)	3.75 (61)	4.46 (73)	5.24 (86)	6.08 (100)	6.98 (114)	7.94 (130)
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)

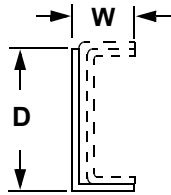


TABLE D
Section Modulus in³ (cm³)

Thickness 3/16 in. (4.76 mm)				
D in. (mm)	W in. (mm)			
	3 (76)	3.5 (89)	4 (102)	4.5 (114)
8.5 (216)	5.7 (93)	6.4 (105)	7.0 (115)	7.7 (126)
9.5 (241)	6.7 (110)	7.4 (121)	8.1 (133)	8.9 (146)
10.5 (267)	7.7 (126)	8.5 (139)	9.3 (152)	10.1 (166)
11.5 (292)	8.8 (144)	9.7 (159)	10.6 (174)	11.4 (187)
12.5 (318)	10.0 (164)	10.9 (179)	11.9 (195)	12.8 (210)
13.5 (343)	11.2 (184)	12.2 (200)	13.2 (216)	14.3 (234)
14.5 (368)	12.5 (205)	13.6 (223)	14.6 (239)	15.7 (257)
15.5 (394)	13.8 (226)	15.0 (246)	16.1 (264)	17.3 (284)

Thickness 1/4 in. (6.35 mm)				
D in. (mm)	W in. (mm)			
	3 (76)	3.5 (89)	4 (102)	4.5 (114)
8.5 (216)	7.7 (126)	8.6 (141)	9.4 (154)	10.3 (169)
9.5 (241)	9.1 (149)	10.0 (164)	10.9 (179)	11.9 (195)
10.5 (267)	10.5 (172)	11.5 (188)	12.5 (205)	13.6 (223)
11.5 (292)	11.9 (195)	13.1 (215)	14.2 (233)	15.4 (252)
12.5 (318)	13.5 (221)	14.7 (241)	16.0 (262)	17.2 (282)
13.5 (343)	15.2 (249)	16.5 (270)	17.8 (292)	19.2 (315)
14.5 (368)	16.9 (277)	18.3 (300)	19.7 (323)	21.2 (347)
15.5 (394)	18.7 (306)	20.2 (331)	21.7 (356)	23.3 (382)

Thickness 5/16 in. (7.94 mm)				
D in. (mm)	W in. (mm)			
	3 (76)	3.5 (89)	4 (102)	4.5 (114)
8.5 (216)	9.8 (161)	10.8 (177)	11.9 (195)	12.9 (211)
9.5 (241)	11.5 (188)	12.6 (206)	13.8 (226)	15.0 (246)
10.5 (267)	13.3 (218)	14.5 (238)	15.8 (259)	17.1 (280)
11.5 (292)	15.1 (247)	16.5 (271)	18.0 (295)	19.4 (318)
12.5 (318)	17.1 (280)	18.6 (305)	20.2 (331)	21.7 (356)
13.5 (343)	19.2 (315)	20.8 (341)	22.5 (369)	24.2 (397)
14.5 (368)	21.4 (351)	23.1 (379)	24.9 (408)	26.7 (438)
15.5 (394)	23.7 (388)	25.5 (418)	27.4 (449)	29.4 (482)

Thickness 3/8 in. (9.52 mm)				
D in. (mm)	W in. (mm)			
	3 (76)	3.5 (89)	4 (102)	4.5 (114)
8.5 (216)	11.9 (195)	13.2 (216)	14.4 (236)	15.6 (256)
9.5 (241)	14.0 (229)	15.3 (251)	16.7 (274)	18.1 (297)
10.5 (267)	16.2 (266)	17.7 (290)	19.2 (315)	20.7 (339)
11.5 (292)	18.4 (302)	20.1 (329)	21.8 (357)	23.5 (385)
12.5 (318)	20.9 (342)	22.6 (370)	24.5 (402)	26.3 (431)
13.5 (343)	23.4 (384)	25.3 (415)	27.3 (447)	29.3 (480)
14.5 (368)	26.0 (426)	28.1 (461)	30.2 (495)	32.4 (531)
15.5 (394)	28.8 (472)	31.0 (508)	33.3 (546)	35.6 (583)

TRUCK PREPARATION

Plan the installation of the crane location for:

- the front axle weight.
- the rear axle weight.
- the boom overhang.

Check the final weight to verify that final truck weight with crane, reinforcement, counterweight and options such as jib, etc. complies with the appropriate laws.

Welding Precautions

Sensitive truck computer and crane RCL system components can be damaged by welding on the truck or crane. The following precautions must be taken:

- Disconnect both positive and negative battery cables.

- Attach welding ground lead as close as possible to area to be welded.

Positioning the Crane On the Truck

The final user of the crane must be familiar with state axle and length laws in force at the time the crane is mounted on the truck. Following are items which must be considered.

- **Overall Length** - Most states have a maximum straight truck length limit of 40 ft (12.19 m). Using a truck that has a too long WB may exceed this limit.
- **Axle Weights** - All states allow 20,000 lb (9,072 kg) single axle weight and 34,000 lb (15,422 kg) 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** - The amount of overhang allowed varies from state to state. Check on your state requirements.
- **Federal Bridge Law** - The Federal Bridge Law in effect currently states that in order to carry 54,000 lb (24,493 kg) on a three axle truck, the extremes of any group of axles must be at least 23.5 ft (7.16 m) apart. This equates to a truck with a wheelbase of at least 258 in (655 cm) with a minimum length of 24 in (61 cm) from the center of tandems to the center of the rear axle.

PTO, PUMP, AND RESERVOIR

1. Select the PTO as outlined in the section titled *PTO and Hydraulic Pump*, page 9-6. PTO's are not furnished by National Crane.
2. Install the PTO and PTO shifting mechanism according to the PTO manufacturer's instructions. If the PTO has a reverse gear, it must be blocked out. The pump cannot run backwards (Figure 9-5).

CAUTION

Rotating the pump in the wrong direction damages the pump.

3. If mounting flanges integral to the PTO are used, the pump can be mounted directly to the PTO. Be sure adequate clearance exists for this type of pump mount.
4. If a drive line is used, locate the pump no more than 42 in (106 cm) from the PTO. Do not exceed a 15° angle on the drive line. The drive line U-joint yokes on both ends of the drive shaft must be parallel with each other. The drive lines need be sized so they can safely carry the maximum pump horsepower requirements. Drive lines are not normally furnished by the factory.
5. Plan the location of the pump mounting bracket and drive line so that ample clearance is maintained between pump and truck drive shaft or exhaust system. Position the Pump so that the hydraulic lines can be connected without sharp bends especially the large suction line. The pump mounting brackets can be attached to existing frame crossmembers or a 6 in (15.25 cm) channel crossmember be installed.
6. Install the pump mounting bracket (driveline driven pumps only) securely to the truck frame. Attach the pump to the pump mounting plate or directly to the PTO using the capscrews provided. Install a pump support bar at the rear of the pump and, if the pump is driven by a driveline, bolt or weld the upper end to a crossmember. If the pump is mounted on the PTO, the rear mounting bar can be attached to a transmission bolt. The rear of

the pump must be supported regardless of the mounting method.

NOTE: Some of the pipe fittings 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. Further tightening does not increase the seal of the joint and can ruin the connection. Use pipe thread sealant on tapered pipe fittings.

Other fittings are of the O-ring boss type. To install this fitting, screw the lock nut in to the upper thread land. Insert the fitting into the port until the nut contacts the surface of the port. Adjust the fitting to the desired direction and tighten the locknut

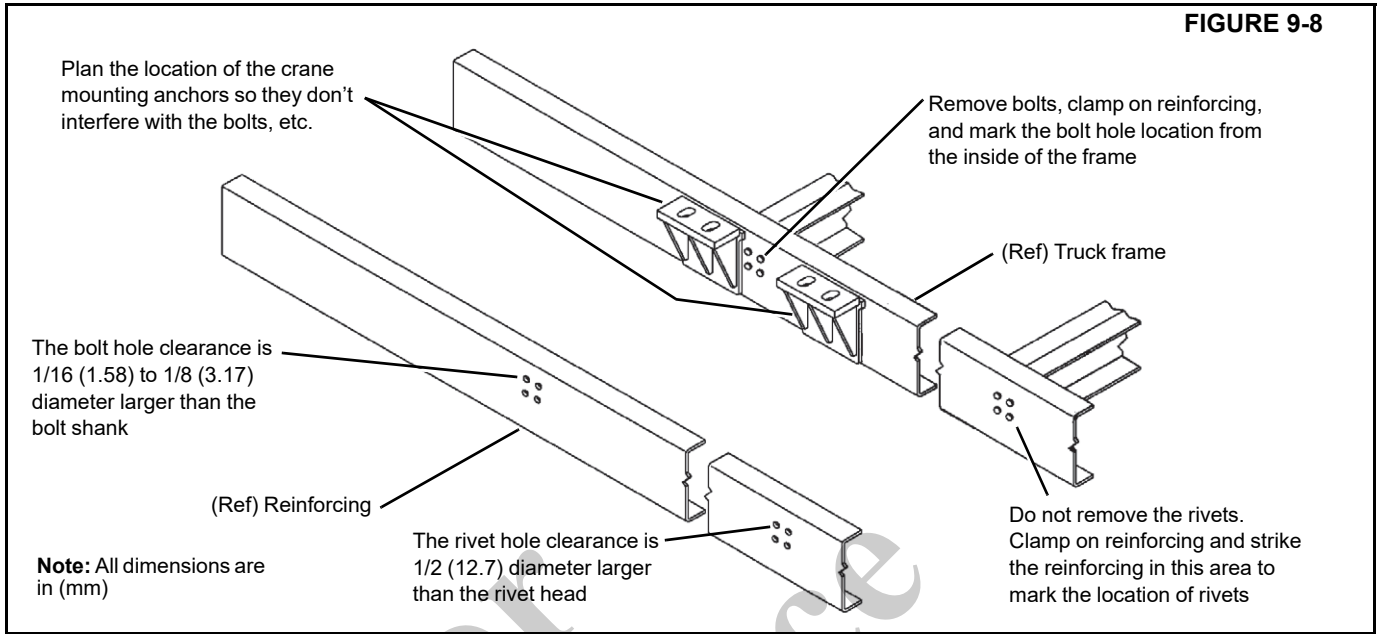
Most pressure fittings are the O-ring face seal types. A small O-ring is compressed between the male and female fittings of the joint. Be sure the O-ring is present on the fitting and seated properly in its groove before the fittings are tightened.

- Remove the dust covers from the pump inlet and outlet ports. Verify 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. Refer to Pump Manual for information on how to rotate pump ports and how to convert pump rotation.
- 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 (7.87 mm x 3 mm) 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 and grease the PTO universal joints.

REINFORCING AFTER FRAME EXTENSION

1. Measure the truck frame and use the Section Modulus Tables to determine the section modulus of the frame. If reinforcing is required, 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 remove rivets.

FIGURE 9-8



3. Place the reinforcing on the truck frame and clamp in place. Mark the location of 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 cut clearance holes for the rivets (Figure 9-8).
4. If reinforcing is to be welded to the frame, remove the crossmember bolts, mark, and cut the hole pattern in the reinforcing. Be sure to clear the crane mounting anchors. Clamp the reinforcing in place, install

crossmember bolts that were previously removed, and weld to truck frame as shown in Figure 9-9.

If bolt-on reinforcing is required, clamp the reinforcing in place and install crossmember bolts that were previously removed. Drill through the reinforcing and truck frame. Be sure to clear crane mounting anchors and bolt reinforcing in place. See Figure 9-10 for recommended drilling and bolting procedure. Use 5/8 in, Grade 8 bolts, drill holes to 39/64 in (15.5mm) diameter, drive fit bolts and torque according to Torque Chart in the Maintenance Section.

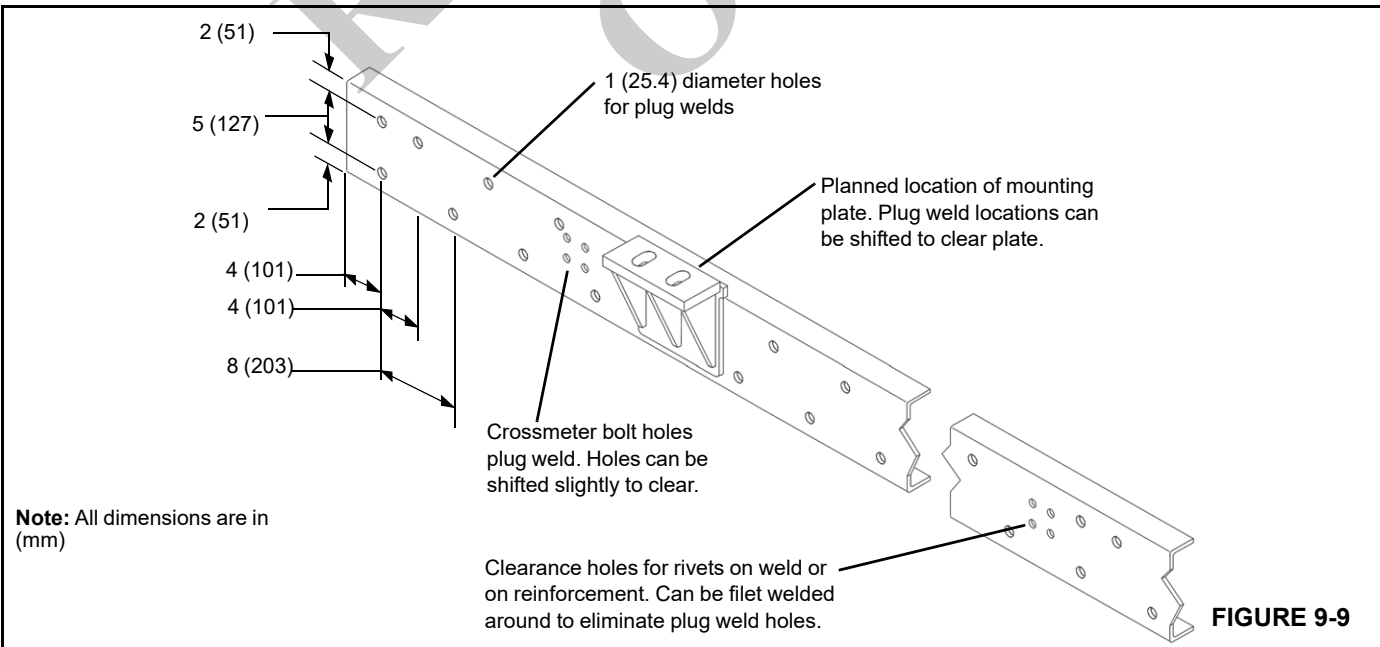
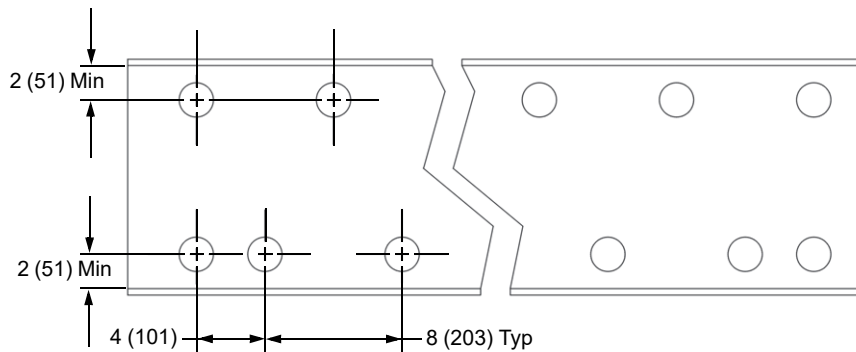


FIGURE 9-9



Note: All dimensions are in (mm)

FIGURE 9-10

5. If the frame through the rear suspension does not meet the minimum specifications for RBM and section modulus, it can be reinforced by adding a reinforcing angle as shown in Figure 9-11. See Section Modulus Table B on page 9-10 for the required size of reinforcing. Strip all easily removable equipment from the frame through the suspension such as spring stops, etc. Butt the reinforcing angle up against the reinforcing forward of the suspension and mark the areas that will require cutting so that the angle will slide up around the spring hangers and against the existing truck frame and forward reinforcing. Torch out the marked areas in the long leg of the angle deep enough so that the lip of the angle can be slid up from the underneath the frame to contact either existing truck frame or spring hanger brackets (if they extend down below the existing truck frame). If reinforcing angle is to be welded to truck frame, cut out plug weld hole pattern as in Figure 9-9.

Slide the reinforcing angle up from the bottom, butt it to existing forward reinforcing and weld rear suspension reinforcing to forward reinforcing. Replace as much of the spring hanger cut out areas as possible and butt weld these pieces in.

If reinforcing angle is to be bolted on, drill hole pattern and install bolts according to Figure 9-10. 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 (152mm) 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.

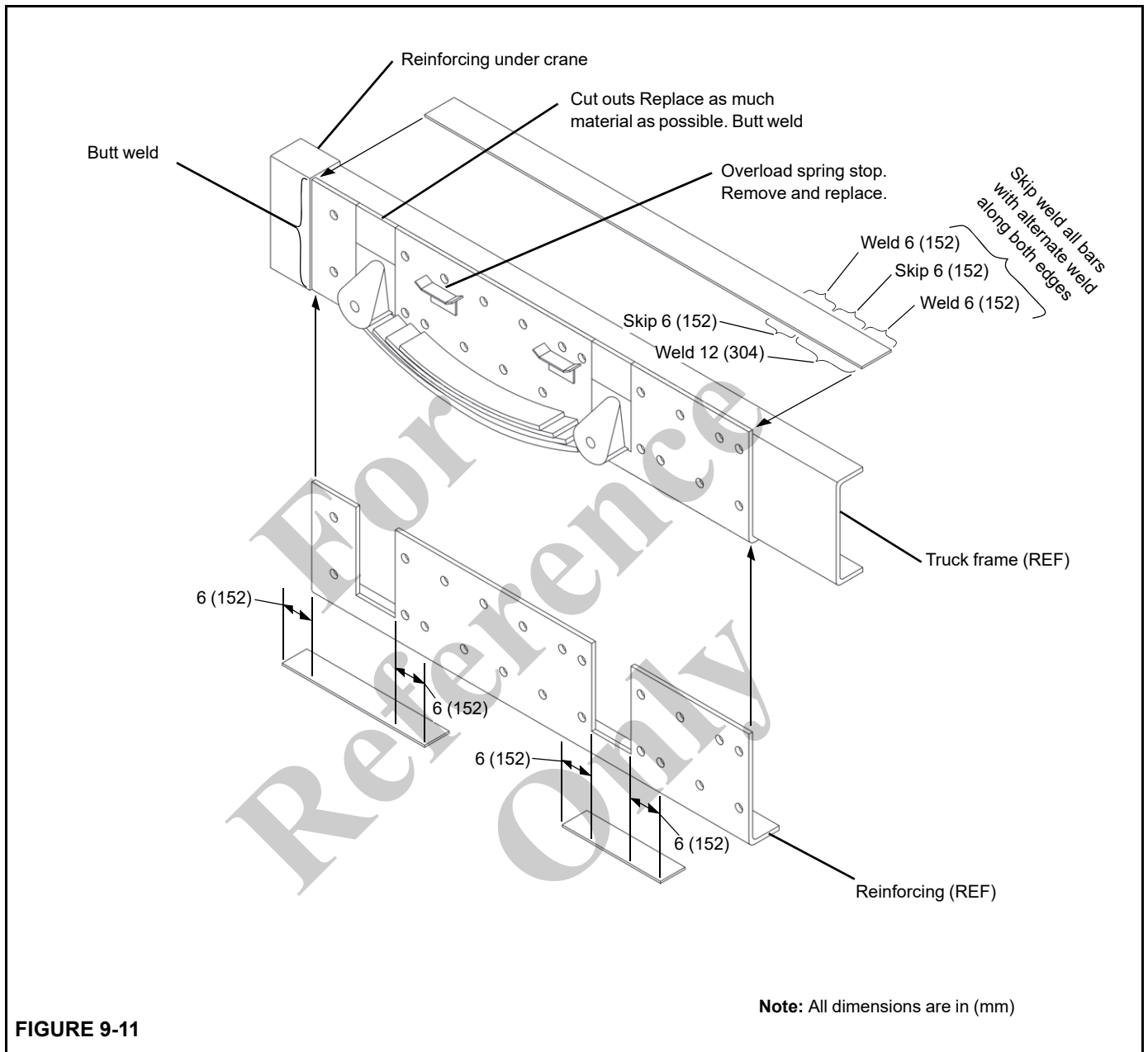


FIGURE 9-11

6. 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 12 in (30 cm) on each side of joint. Plug weld this channel to the inside of the truck frame, then skip weld the inside edge of the top and bottom flanges to the truck frame flanges.

MOUNTING THE CRANE

DANGER

It is mandatory that swing bearing and crane anchor 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 on page 9-1 through page 9-16. Mounting the crane to the truck frame is as follows:

- Mount the torsion box (T-box) on the truck frame (9-16).
- Attach the RSOD to the truck frame and T-box (9-18).
- Mount the frame assembly on the T-box (9-19).
- Install the front outriggers (9-19).
- Install the boom rest on the T-box and rear bumper on the truck frame (9-20).
- Mount the operator stations and install the foot throttles (9-21).
- Install the boom, lift cylinder, and hoist (9-22).
- Install the RCL reel under the boom (9-22).
- Connect the slew potentiometer 9-23.

- Connect the electrical interface (9-23).
- Install the hydraulic system (9-24).
- Complete the initial crane run in procedure (9-28).
- Calibrate the RCL and do the stability test (9-28).

Mount the T-Box

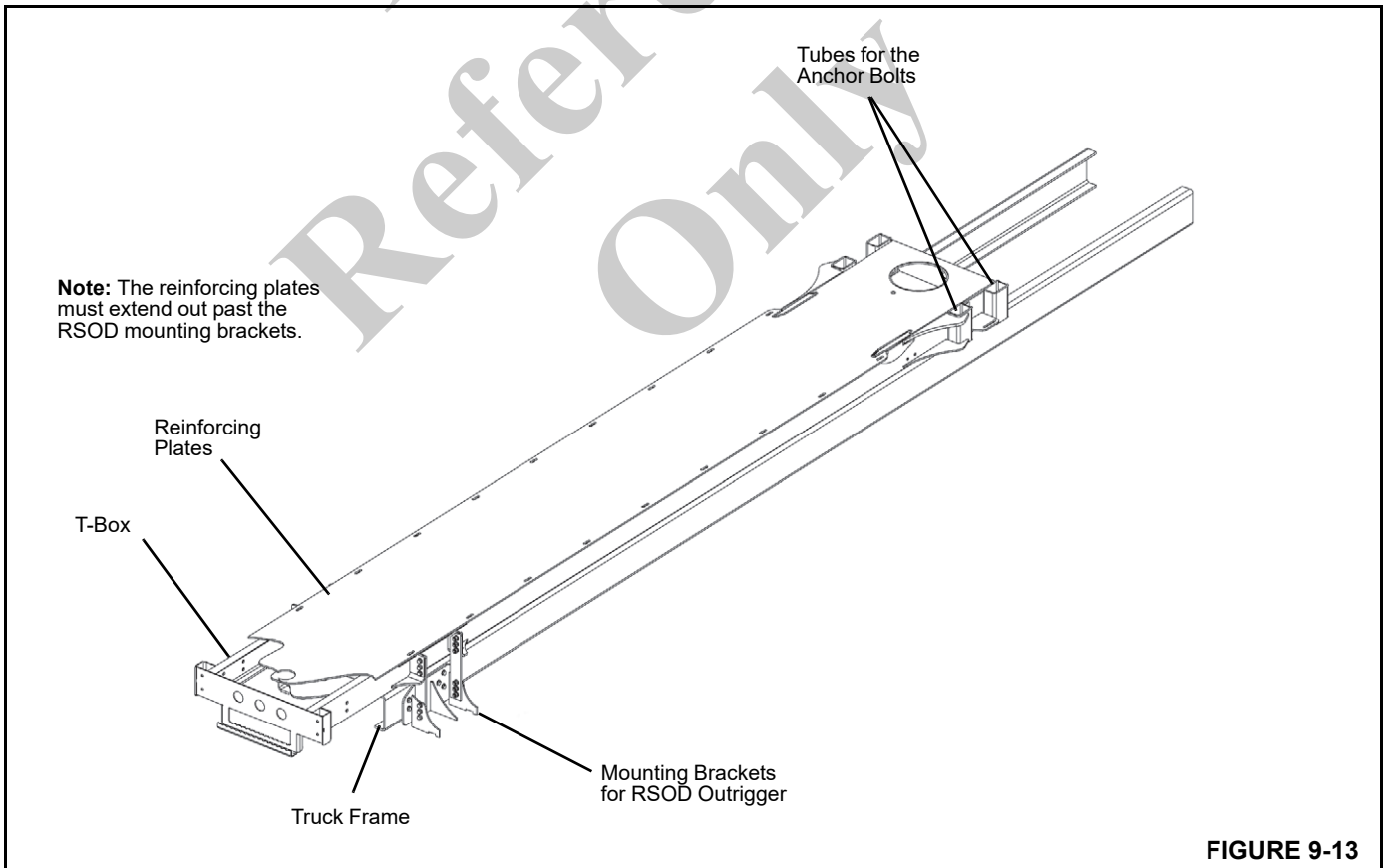
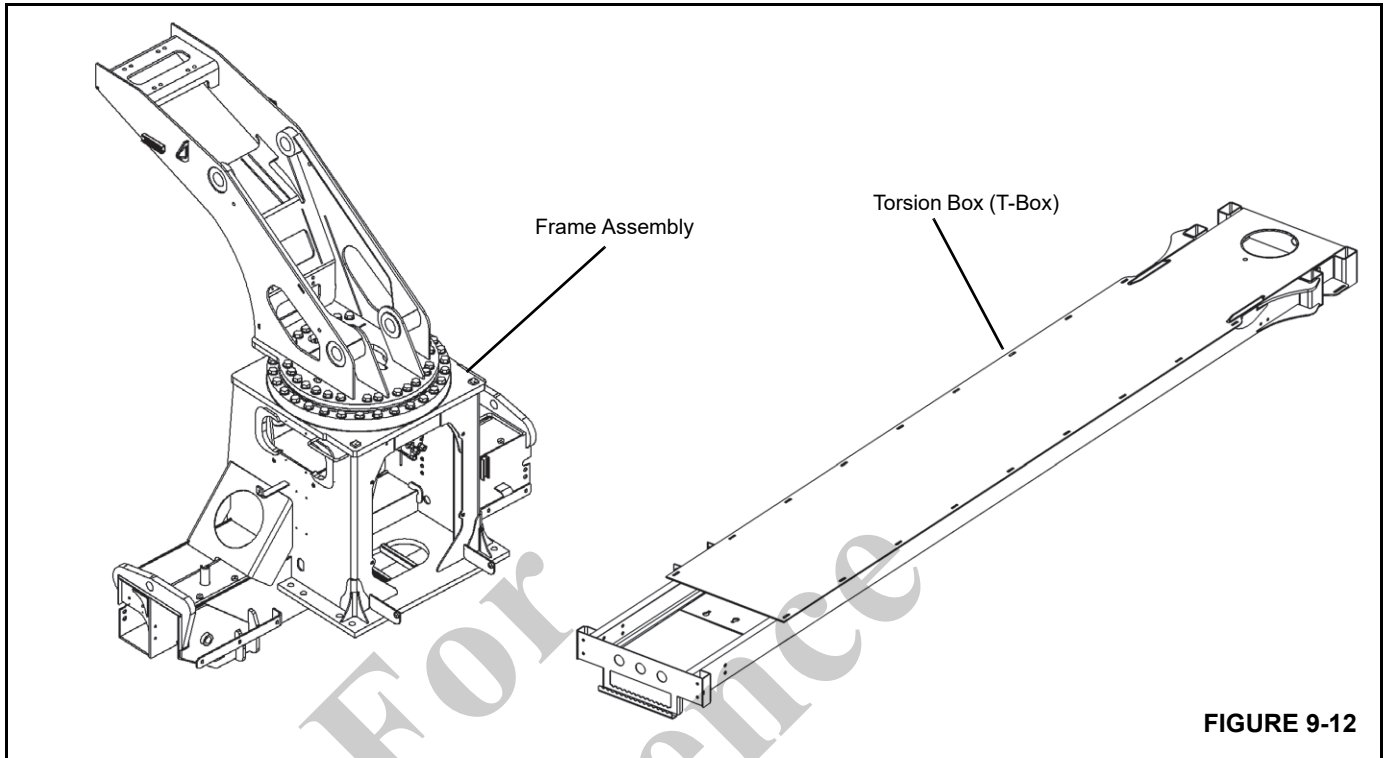
1. Position the truck so that the truck frame is level.
2. Place the T-box on the truck frame as determined by the information contained in the section titled Positioning the Crane On the Truck on page 9-11.

NOTE: The top and bottom T-box reinforcing plates must extend past the RSOD mounting position (Figure 9-13). If this cannot be accomplished because of a long cab to tandem (CT) dimension, contact the factory.

3. Clamp the anchor brackets on the truck frame so that the holes for the anchor bolts line up with the tubes for the anchor bolts (Figure 9-13). Check for interference with truck frame crossmembers.

NOTE: If the T-box does not fit tightly against the truck frame, clamp the T-box and truck frame together to remove the gaps.

4. Drill four 3/4 in holes in the truck frame for each crane anchor bracket.
5. Bolt the anchor brackets to the truck frame as shown in Figure 9-14. Torque refer to *Fasteners and Torque Values*, page 1-11.



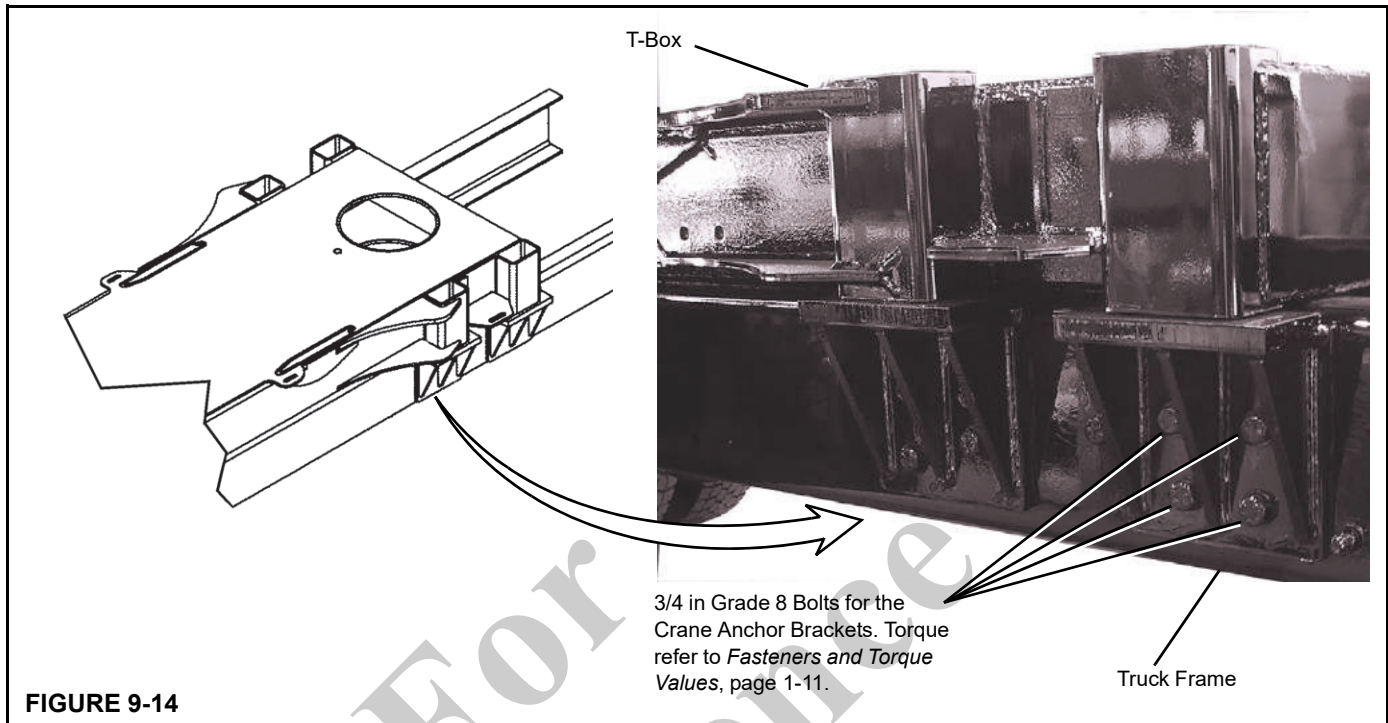
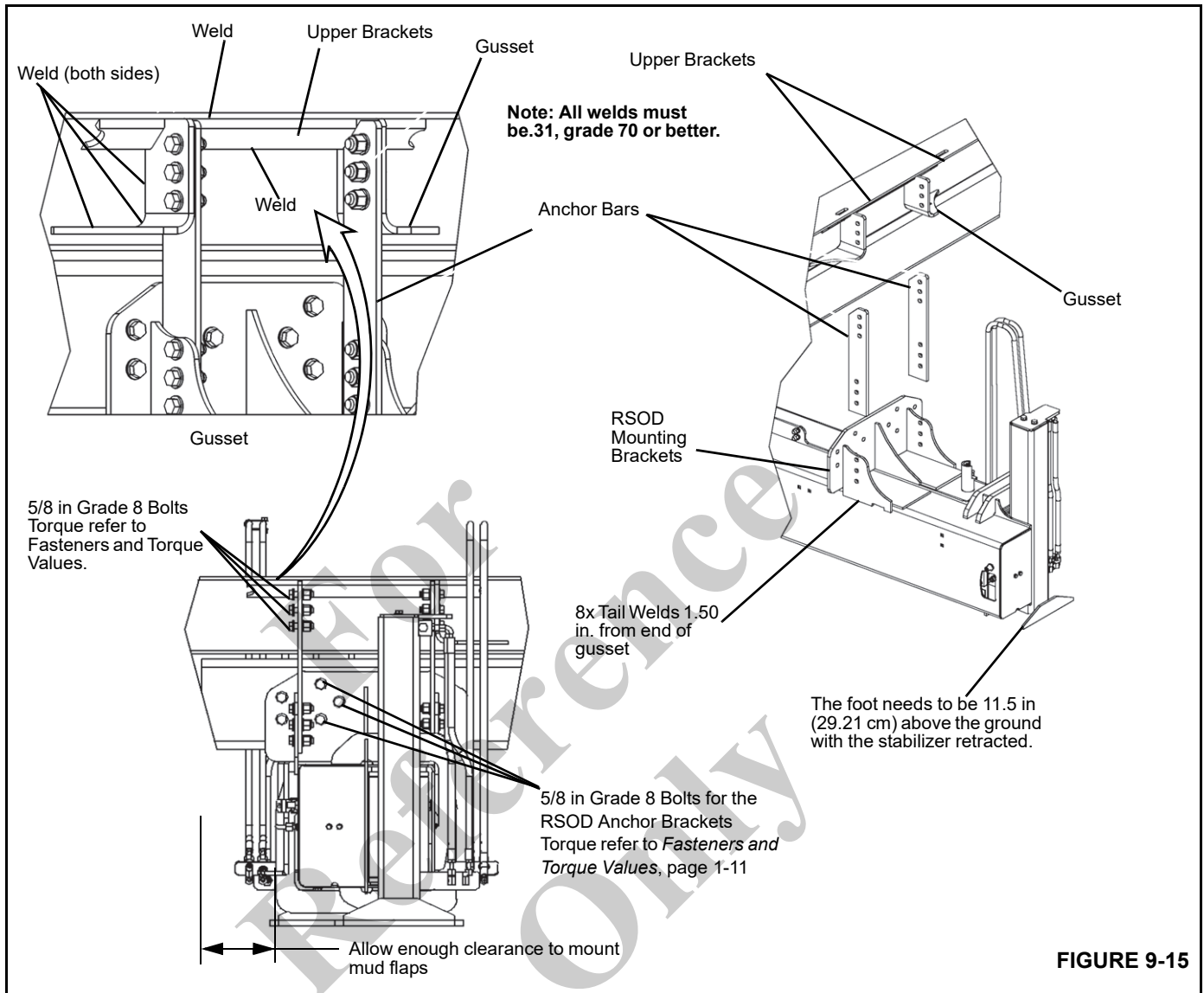


FIGURE 9-14

Attach the RSOD

1. Position the RSOD on the truck frame so that there is about 12 in (30.4 cm) between the rear tire to the front of the RSOD Figure 9-15. This should be enough clearance for mounting the mud flaps.
2. Check for interference with truck frame rivets or bolt holes.
3. Make sure that the RSOD stabilizer is vertical and the foot is 11 in (27.9 cm) above the ground.
4. Use the RSOD brackets as a template and drill six 3/4 in holes in the truck frame for each bracket.
5. Bolt the RSOD brackets to the truck frame with the 3/4 x 2-1/2 in grade 8 bolts. Torque refer to *Fasteners and Torque Values*, page 1-11.
6. Clamp the anchor bars to the RSOD mounting bracket.
7. Use the holes in the brackets as a template and drill three 5/8 in holes in each anchor bar.
8. Loosely bolt the anchor bars to the to the RSOD mounting bracket.
9. Clamp the upper brackets to the anchor bars.
10. Position the upper brackets on the T-box and tack weld in place.
11. Dill three holes in the anchor bar using the upper bracket holes as a template.
12. Remove the anchor bars and weld the upper brackets and gussets in place.
13. Bolt the anchor bars to the RSOD brackets and upper brackets with the 5/8 in grade 8 mounting bolts. Properly torque bolts by referring to *Fasteners and Torque Values*, page 1-11.
14. Refer to page 9-27 for RSOD hydraulic line hookup.



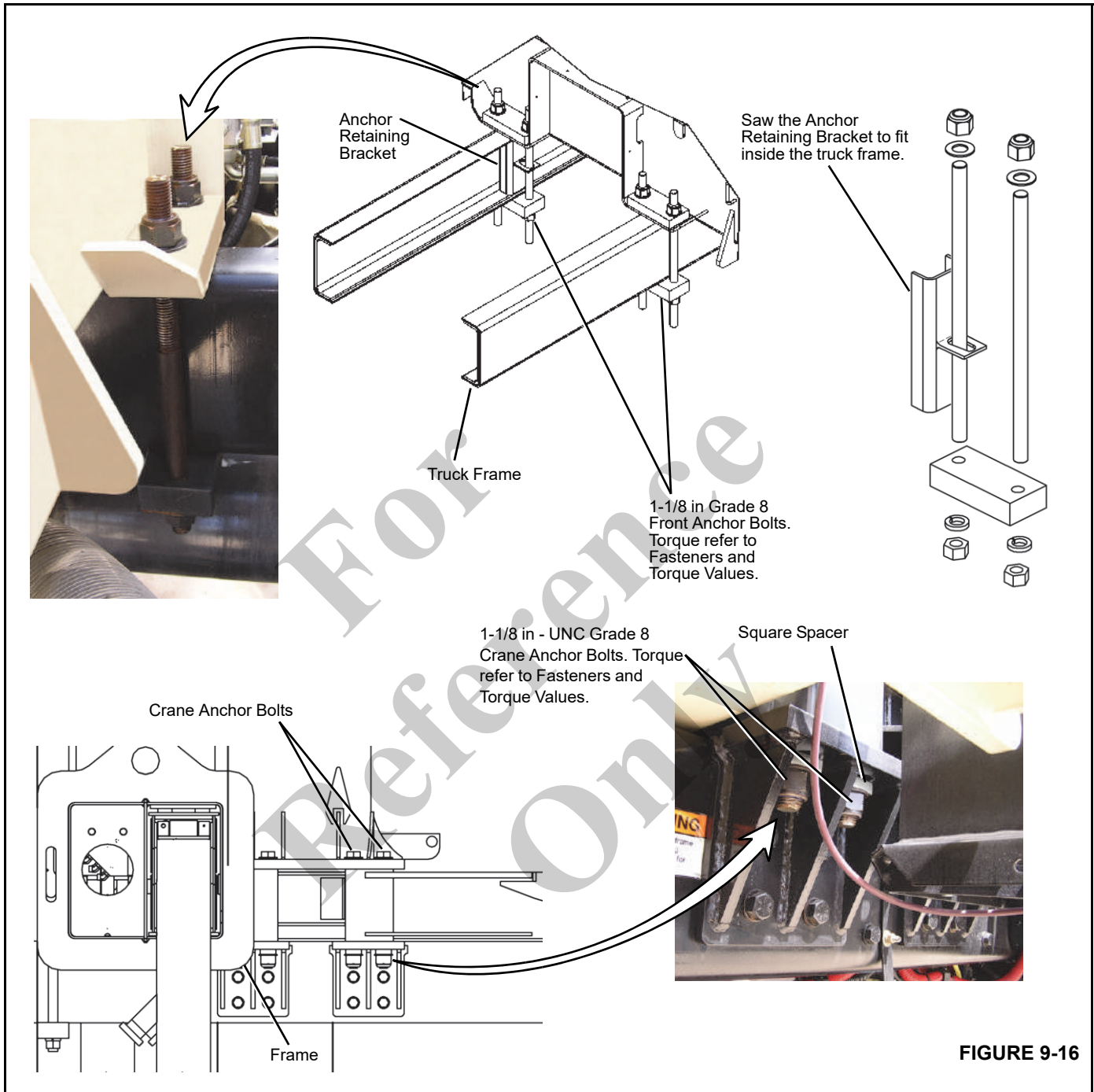
Mount the Frame Assembly

1. Position the frame assembly on the T-box so that the mounting bolts can be routed through the tubes on the T-box.
2. Bolt the frame to the anchor brackets on the truck frame with the 1-1/8 in grade 8 bolts (Figure 9-16). Torque the bolts to refer to *Fasteners and Torque Values*, page 1-11.

3. Cut the anchor retaining bracket for the front anchor to fit inside the truck frame.
4. Install the front anchor brackets and torque the bolts to refer to *Fasteners and Torque Values*, page 1-11.

Install the Front Outriggers

Install the front outriggers in the frame as described in SECTION 7 under *Installation*, page 7-3. See page 9-27 for outrigger hydraulic connections



Install the Boom Rest

Insert the boom rest into the brackets on back of the T-box and secure with the 5/8 in grade 5 bolts (Figure 9-16).

Install the Rear Bumper

Bolt the rear bumper to the truck frame with the 3/4 in grade 5 bolts (Figure 9-16). Ground clearance should be from 20 - 23 in (50.5 - 58.4 cm).

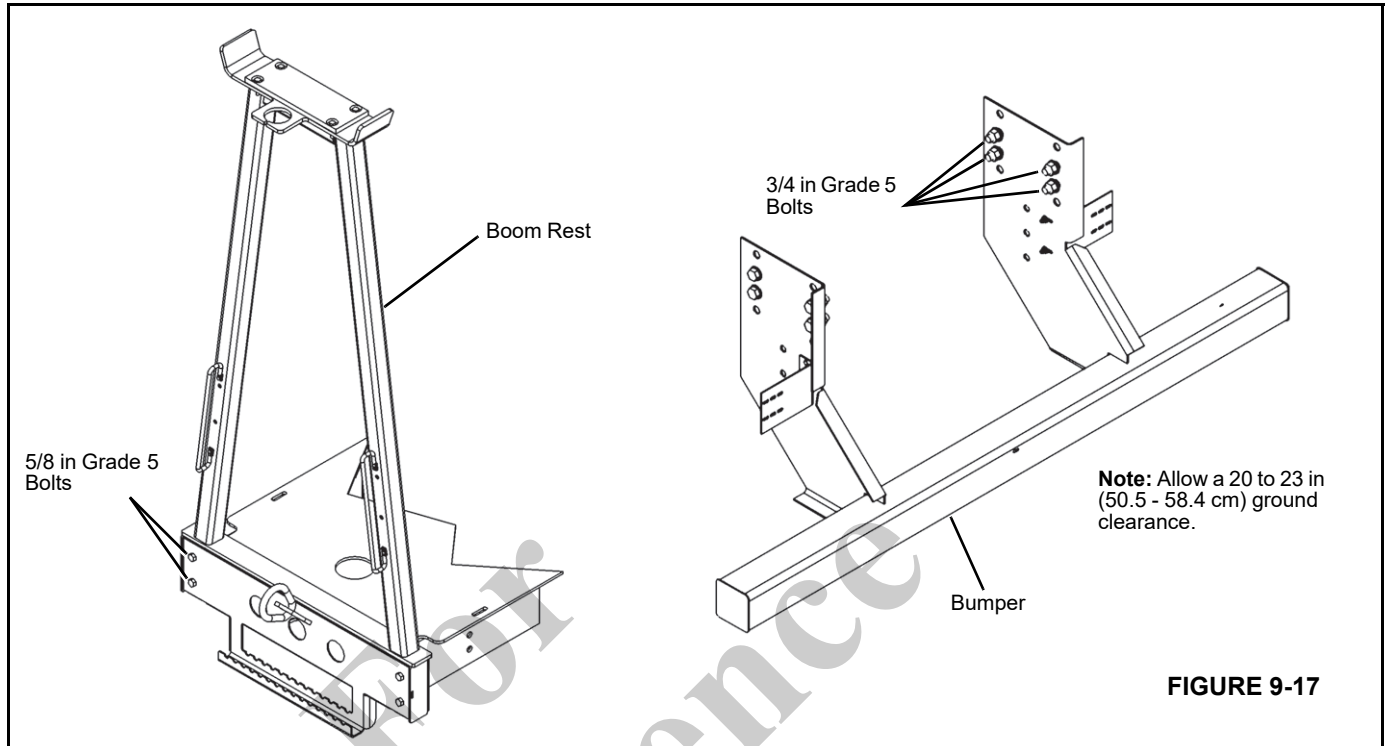


FIGURE 9-17

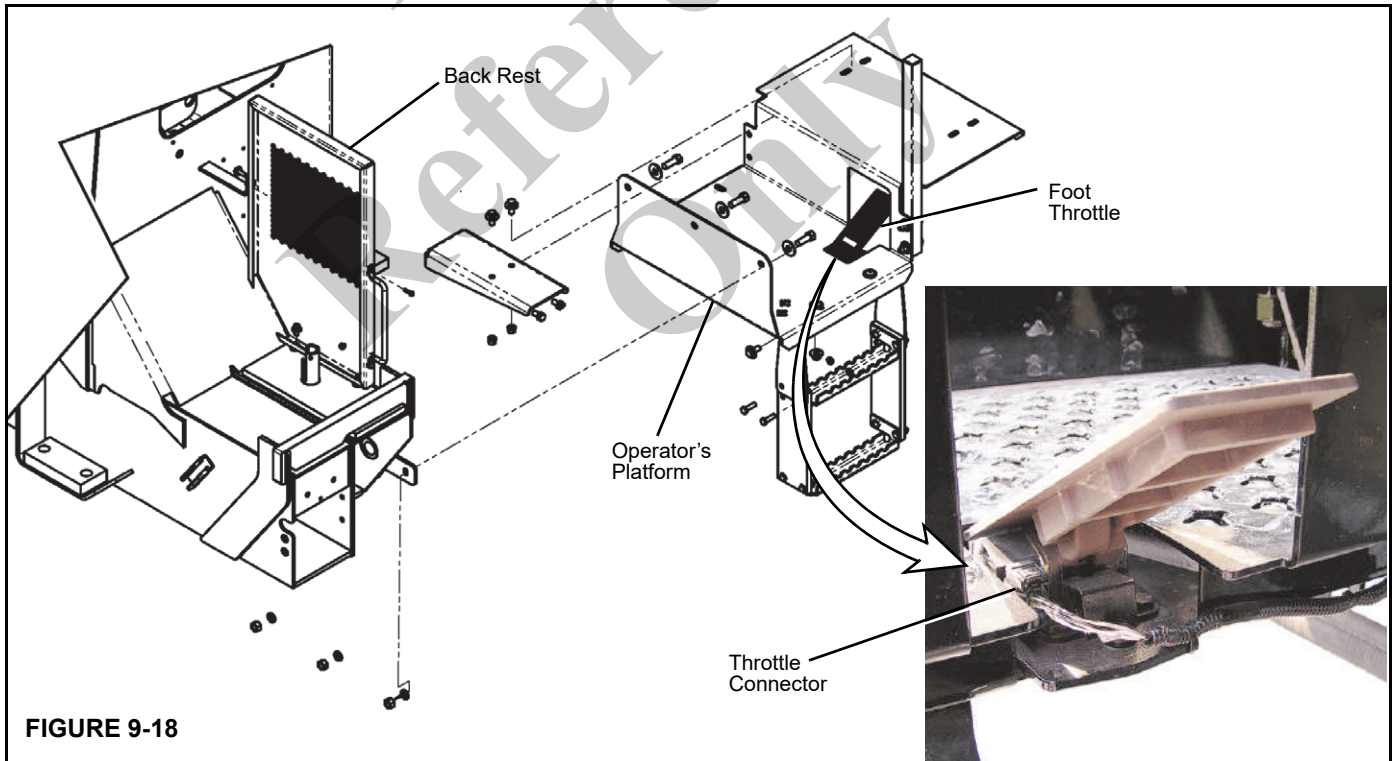


FIGURE 9-18

Mount the Operator Platforms and Install the Foot Throttles

the frame as shown in Figure 9-18. Assemble and mount the foot throttles (Figure 9-18).

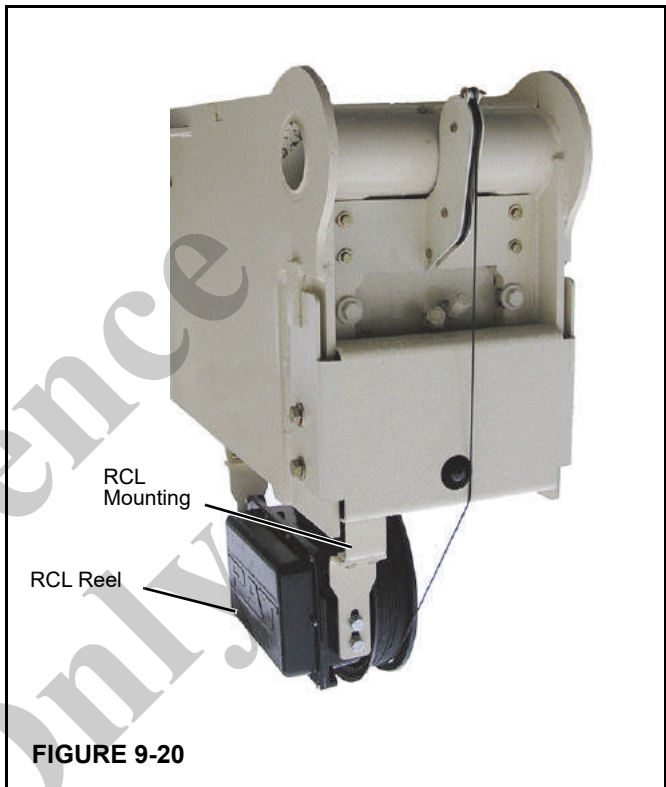
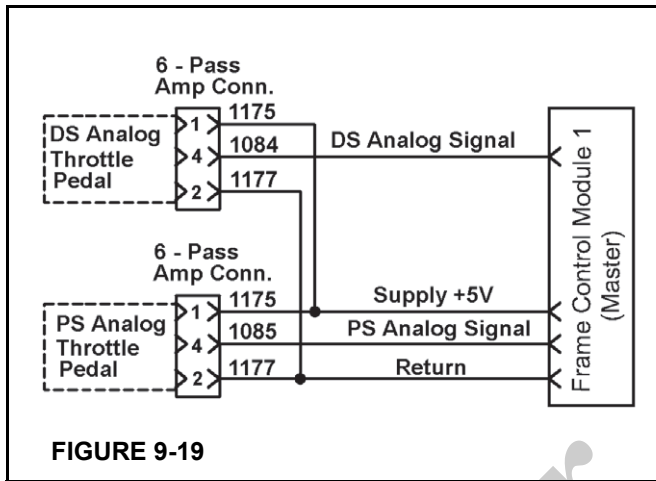
Install the backrest and operator's platform on both sides of

Mount the throttle pedal on the platform as shown in (Figure 9-18). Plug the connector on the wiring harness into the throttle pedal.

NOTE: The RCL must be mounted as shown to get the proper clearance.

CAUTION

Make sure there is adequate clearance between the RCL reel and adjacent components so that the RCL reel does not come in contact with and damage the components when the boom is fully lowered.



Install the Boom, Lift Cylinder, and Hoist

Install the boom and lift cylinder as described in Section 4. Install the hoist as described in Section 5. For hoist cable and wedge socket installation, see Section 4 of the Operators Manual.

Install the RCL Reel

The crane is shipped with the RCL reel temporarily attached to the top of the boom (Figure 9-20). To mount the reel:

1. Remove the RCL reel and mounting brackets from the top of the boom (Figure 9-20).
2. Bolt the C-brackets to the bottom of the boom.
3. Attach the mounting brackets to the RCL reel and mount the RCL to the boom as shown in Figure 9-21.

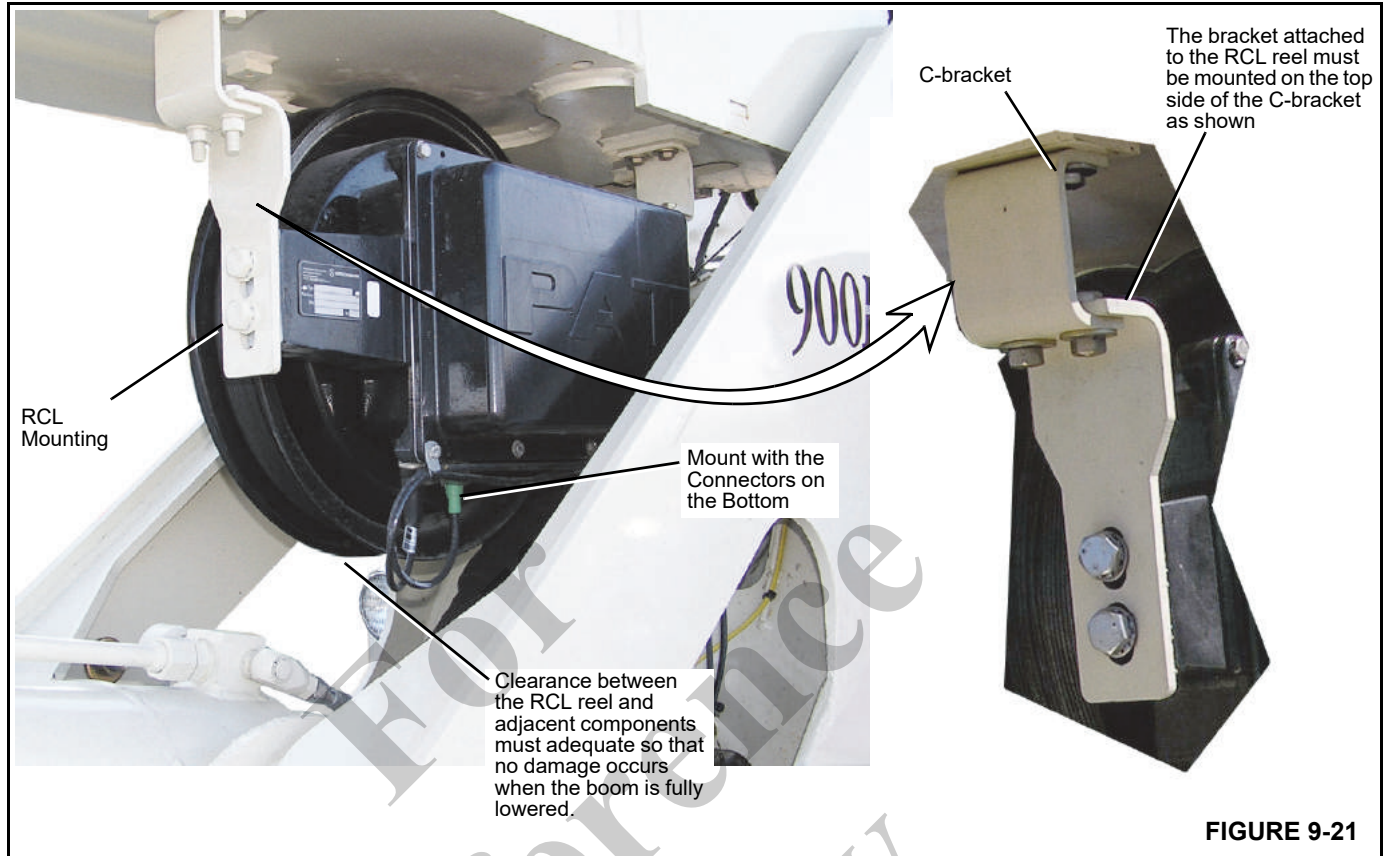


FIGURE 9-21

Connect the Slew Potentiometer

Connect the cable (green connector) from the slew potentiometer located in the turret (Figure 9-22) to the RCL system. See page 6-13 for a detailed description of the slew potentiometer.

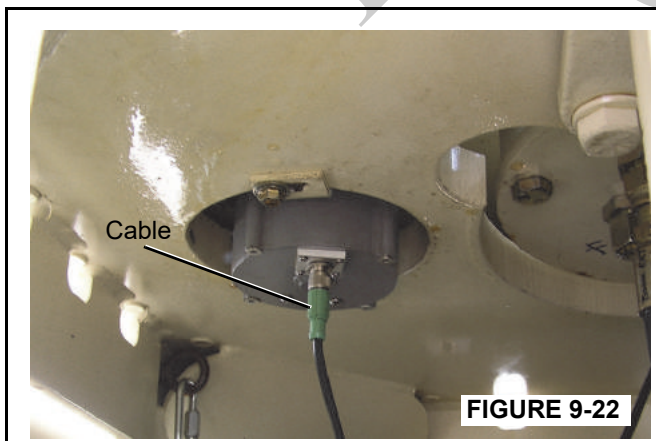


FIGURE 9-22

Connect the Electrical Interface

Connections to the truck electrical system is as follows:

- Run the T-box interface harness to the truck cab and secure.

NOTE: Keep the harness away from the drive line and exhaust system.

- Connect the truck interface harness as shown in Figure 9-23.

NOTE: If there are two truck ignition wires, tie into both wires. Connect the start wire to the start solenoid in the engine compartment. Do not connect the start wire to the truck ignition switch.

- Run the battery harness to the truck battery and connect as shown in Figure 9-23.

- Install the hoist bump switch at the back bumper as shown on page 3-7.

Truck Battery Harness	
Wire	Truck Function
51	(-) Ground
5	(+) Positive

Truck Interface Harness	
Wire #	Truck Function
112	From Truck Ignition
901A	To Truck Ignition
52	To Truck Start
396	PTO Mode Enable
1159	Remote Throttle
1592	Remote Throttle
1593	Remote Throttle
1289 (H) & 1290 (L)	J1939 Interface Connector

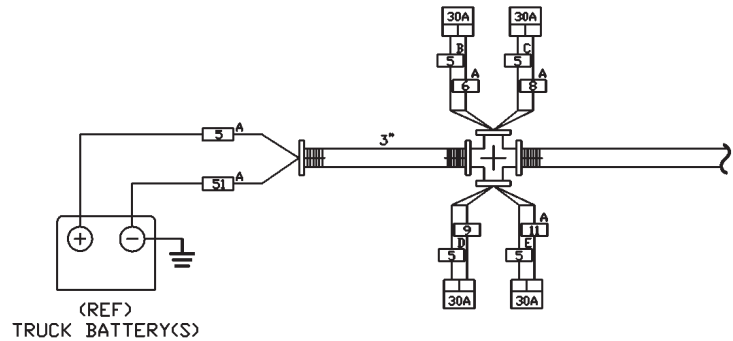


FIGURE 9-23

Install the Hydraulic System

The hydraulic system pressure is supplied an axial piston pump mounted on the truck power take off (PTO). See *PTO and Hydraulic Pump*, page 9-6 for pump installation. For hydraulic pump startup, see *Hydraulic Pump*, page 2-11.

See *Hydraulic Reservoir and Filter*, page 2-19 for hydraulic reservoir installation. Connect the hydraulic hoses to the pump sections as marked.

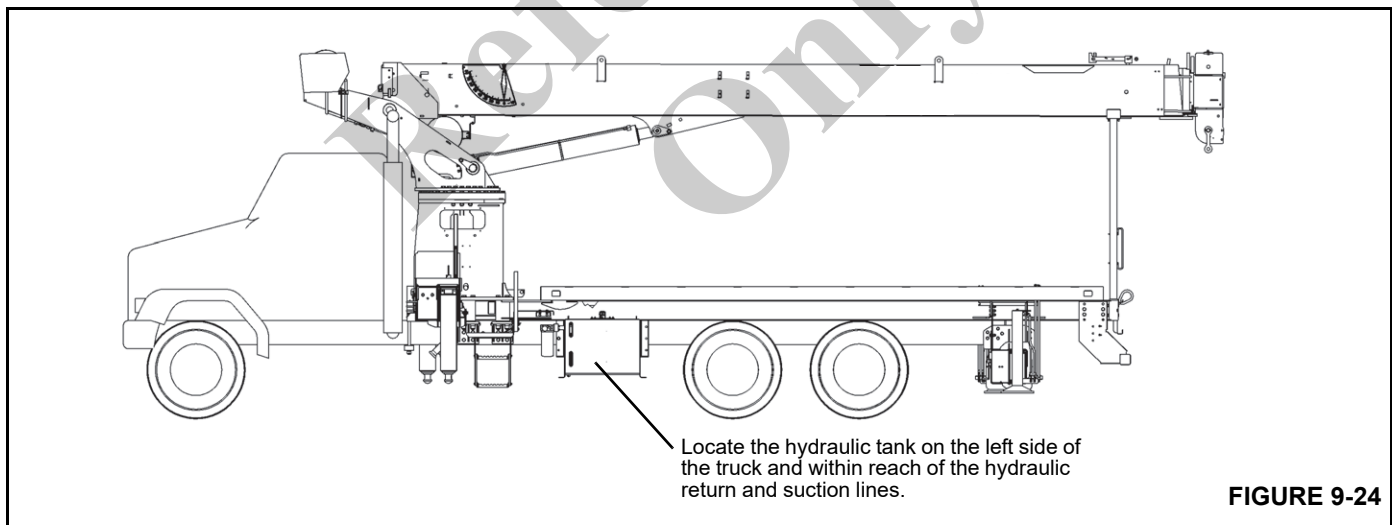


FIGURE 9-24

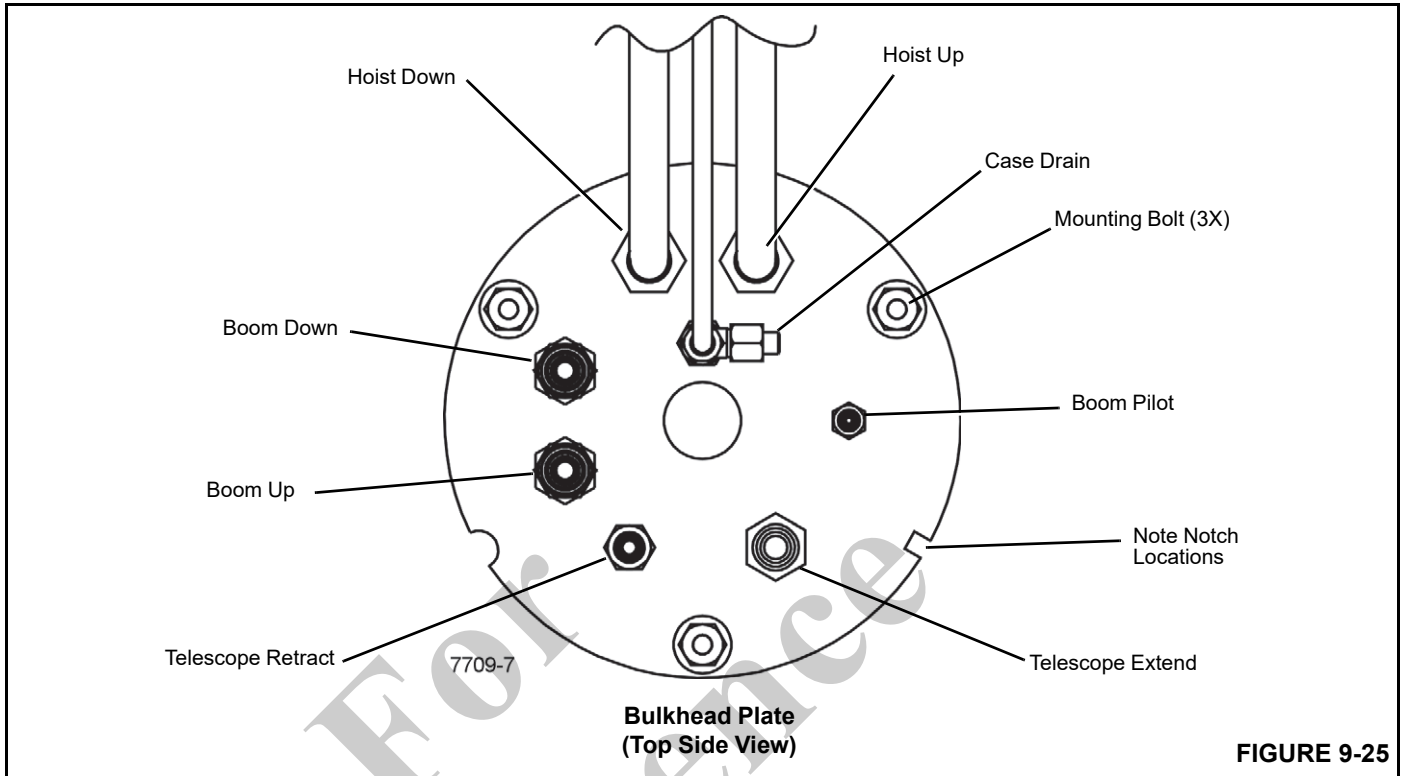


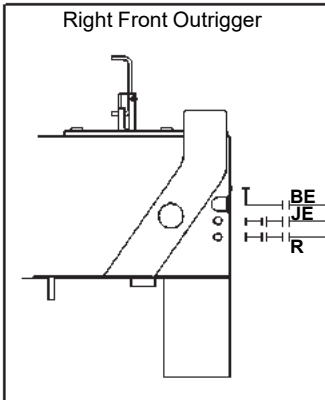
FIGURE 9-25

For Reference Only

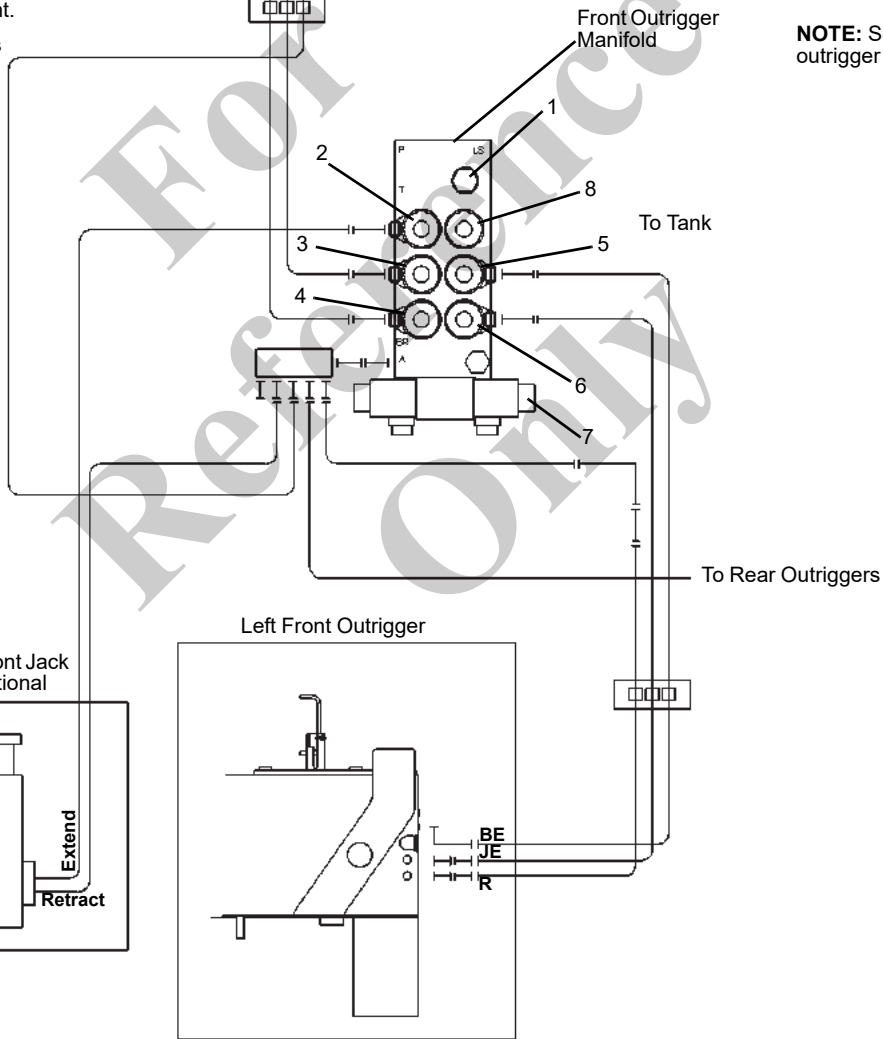
Front Outrigger Hydraulic Line Connections

R = Retract
 JE = Jack Extend
 BE = Beam Extend

Item	Solenoid
1	Outrigger Enable
2	Center Front Jack (SFO) (Optional)
3	Passenger Side Stabilizer (Right)
4	Passenger Side Beam (Right)
5	Driver Side Beam (Left)
6	Driver Side Stabilizer (Left)
7	Extend/Retract
8	Beam Extend Relief



- Outrigger beam and stabilizer are on the right.
- Hydraulic line hookup is on the left side.



NOTE: See page 3-7 for front outrigger manifold detail.

7816

- Outrigger beam and stabilizer are on the left.
- Hydraulic line hookup is on the right side.

FIGURE 9-26

RSOD Hydraulic Line Connections

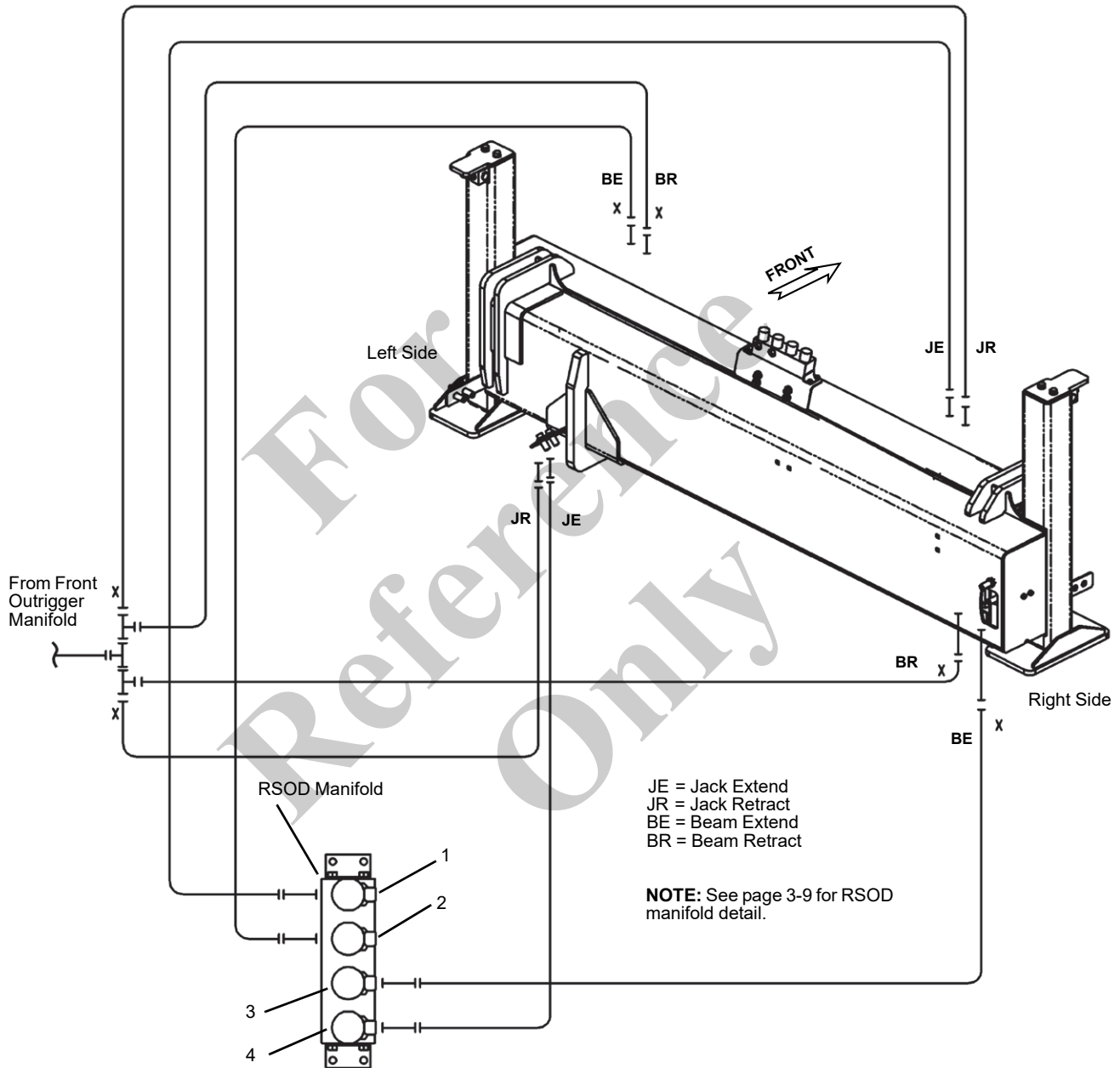


FIGURE 9-27

Item	Solenoid
1	Driver Side Stabilizer (Left)
2	Driver Side Beam (Left)
3	Passenger Side Beam (Right)
4	Passenger Side Stabilizer (Right)

CAN BUS SYSTEM SETUP

Before the engine is started from the crane for the first time, the CAN Bus system needs to be initialized. Interface to the CAN Bus system is through the 9-pin RS232 port on a laptop. To access the CAN Bus system connector, remove the access panel on the side of the crane frame and plug the cable into the CAN Bus system connector (Figure 9-28).

NOTE: The software and cable can only be purchased by technicians that have attended the Grove New Technology training course.

Refer to the 900H CAN control specification and the 900H CAN RCL specification for detailed instructions to program or troubleshoot using the control and RCL software.

- Turn the crane ignition switch to the ON position. Do not try and start the engine.
- Boot up the laptop and launch the CAN Bus system software.
- Follow the screen prompts to input:
 - make of truck engine.
 - throttle adjustment.

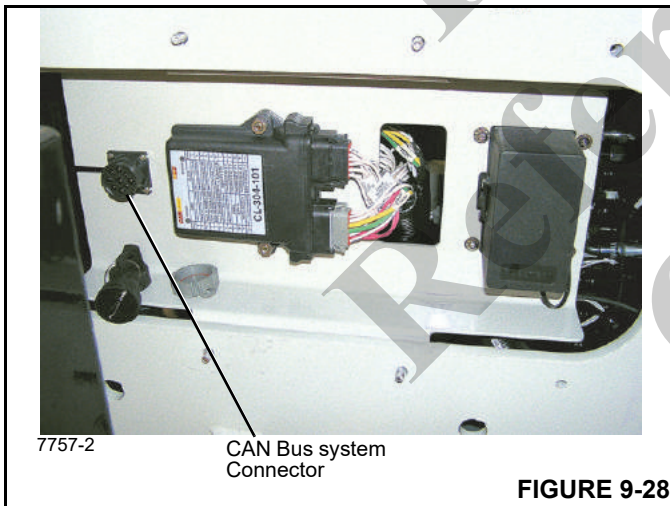


FIGURE 9-28

INITIAL CRANE RUN IN PROCEDURE

1. Place the crane in an area that allows for full operation of all its functions.

NOTE: Make sure the hydraulic tank is full and the butterfly valve in the suction line is on.

2. Engage the PTO, start the truck from the crane cab.
3. Program the RCL as outlined in the RCL manual.
4. Run the truck engine at idle and turn the crane power switch on.

5. Operate all crane functions and outriggers slowly at least six (6) times to purge cylinders of air. Check that the movement of the outriggers, boom, and hoist correspond with direction indicated on the control levers. Refer to the appropriate sections in this manual to correct any problems.

NOTE: Add oil to reservoir as required to keep air out of the system.

6. Adjust the throttle for the engine RPM and PTO ratio to get proper pump shaft speed.
7. After all cylinders have been cycled, stow the crane and place the outriggers in the up position. The oil level should be visible near the top of the sight gage.
8. Lift and stability test must now be performed on the unit. Hoist and crane tests need to be conducted to insure proper performance.
9. After the stability test is complete, check the T-box and frame mounting bolts for proper torque.
10. Measure the overall height of the crane and truck. Post the overall height measurement inside the truck cab to inform the driver of the overall height.

RCL CALIBRATION

After the crane has been installed and all electrical and hydraulic connections are completed, calibrate the RCL. Calibrate the RCL as described in the RCL manual titled Calibration/Service Manual.

STABILITY TEST

DANGER

The loads used for stability tests put the crane at the tipping point. Keep the hook load close to the ground. Control of the boom position is critical. Do not allow the test loads to swing out past the rated radius. If the crane starts to overturn and the boom angle is too low the crane will upset.

The chassis weight, before the crane is mounted, is intended for use only as a guideline in determining the total weight required for the unit to be stable with an 85% tipping factor (i.e. when lifting capacity load, the unit is at 85% of tipping or less).

In order to ensure the stability of the unit with an 85% tipping factor, a live load stability test must be performed on each completed unit. Proceed as follows:

1. Test the unit for stability on a firm level surface.
2. Set the unit up on a firm level surface with outriggers extended and set. Level the unit with the outriggers.

- For the stability test, select the load from the capacity chart that is listed at the longest boom extension and matches the radius listed below.

Model	Boom Length	Loaded Angle	Loaded Radius
9105H	23 m (76 ft)	42.0°	16.7 (55 ft)
9105H	27 m (90 ft)	32.2°	22.8 (75 ft)
9105H	32 m (105 ft)	40.3°	24.3 (80 ft)
9105H With Jib	13 m (44 ft)	62.8°	22.8 (75 ft)
995H	25 m (82 ft)	42.1°	18.2 (60 ft)
995H	25 m (82 ft)	29.4°	21.3 (70 ft)
995H	29 m (95 ft)	42.4°	21.3 (70 ft)
995H With Jib	13 m (44 ft)	58.4°	24.3 (80 ft)
995H With Auger	29 m (95 ft)	24.7°	25.9 (85 ft)
995H With Auger	25 m (82 ft)	20.4°	22.8 (75 ft)

Example: 9105H

- Boom Length: 105
- Loaded Radius: 90' (27.4 m)
- Load Rating: 650 lbs (294.8 kg)
- Stability Test Load:
 $1.18 \times 650 \text{ lb} = 767 \text{ lb} (349.7 \text{ kg})$ Includes weights of slings and downhaul blocks.

Be sure the stability test weight is accurate. A 1% increase in stability test weight requires up to a 10% increase in

counterweight. Extend the boom to the maximum boom length and hoist the stability load off the ground. Slowly boom the load down so the load will swing out, until the loaded radius is reached. As the boom is lowered, hoist the load up to keep it about 6 in off the ground.

Do not exceed loaded radius

Slowly rotate the boom throughout the work area. As the boom is rotated, the boom may need to be raised and/or lowered slightly to maintain the loaded radius because of T-box flexing.

On front mount configuration cranes that are not equipped with single front outriggers, tipping from outrigger support to front wheel support will occur as the load or boom is swung around the front. Do not attempt to lift rated loads around the front of the truck unless the unit is equipped with a single front outrigger. This applies to front mount configuration cranes only. Rear mount configuration cranes are not affected.

NOTE: Weights of accessories installed on the boom or loadline (including downhaul weight) must be deducted from the calculated load when checking stability.

- If slight tipping occurs, but load can be kept from coming in contact with ground by hoisting the load up, unit is stable. If not, counterweighting will have to be added to get unit in a stable condition or decal must be added to define areas of full stability and areas of reduced capacity because of stability. If the unit is equipped with a jib, the stability test should be repeated. Use the fully extended jib capacity multiplied times 1.18 at the lowest angle that the jib is rated fully extended.
- When adding counterweight to the vehicle, it is usually most effective when added as close to the crane as possible. After adding counterweight, the above procedure must be repeated to insure the added counterweight is adequate.

SPECIFICATIONS

Hydraulic Pump

Type Variable displacement, axial piston with load sense
 Total Flow 46.6 GPM (176.4 LPM) at 2400 RPM

Hydraulic System

Requirements:

Outrigger System 14 gpm (52.9 lpm)
 Boom Up 21 gpm (79.5 lpm)
 Boom Down 13 gpm (49.2 lpm)
 Telescope Extend 42 gpm (158.9 lpm)
 Telescope Retract 15 gpm (56.7 lpm)
 Hoist System 21 gpm (79.5 lpm)
 Swing 12 gpm (45.4 lpm)

Reservoir

Capacity 73 gal (276 L) at full mark
 System capacity 98 gal (370.9 L)
 Filtration 3 Micron Return

Hoist System

Wire Rope:

Length 390 ft (118.9 m)
 Diameter (Rotation Resistant) 9/16 in (14.3 mm)
 Nominal Breaking Strength 38,500 lb (17,463 kg)

Low Speed Hoist Performance (1 part line)				
Layer	Hoist Pull			
	lbs	(kg)	fpm	(mpm)
1	10,520.7	(4772.1)	113.8	(34.6)
2	9,485.9	(4302.7)	126.2	(38.4)
3	8,636.4	(3917.4)	138.6	(42.2)
4	7,926.6	(3595.4)	151.0	(46.0)
5	7,324.6	(3322.3)	163.4	(49.8)

NOTE: All ratings based on 25 gpm at 3500 psi (94.6 lpm at 24.1 MPa)

High Speed Hoist Performance (1 part line)				
Layer	Hoist Pull			
	lbs	(kg)	fpm	(mpm)
1	5,260.3	(2386.0)	227.6	(69.3)
2	4,742.9	(2151.3)	252.4	(76.9)
3	4,318.2	(1958.7)	277.3	(84.5)
4	3,963.3	(1797.7)	302.1	(92.0)
5	3,662.3	(1661.2)	326.9	(99.6)

NOTE: All ratings based on 25 gpm at 3500 psi (94.6 lpm at 24.1 MPa)

Crane Operating Speeds

Rotation 375°	48 ± 5 sec (1.2 ± 0.2 rpm) Adjustment Knob Closed
Boom up -10° to 80°	30 ± 5 sec
Boom Down 80° to -10°	30 sec ± 5 sec
Boom Extend/Retract Four Section	
Extend 30 ft to 95 ft (Angle 60°)	50 sec (±10 sec)
Extend 32 ft to 105 ft (Angle 60°)	60 sec (±10 sec)
Retract 30 ft to 95 ft (Angle 60°)	70 sec (±10 sec)
Retract 32 ft to 105 ft (Angle 60°)	80 sec (±10 sec)

Outrigger Speeds

Beam Extend	7 sec ±3 sec
Beam Retract.....	5 sec ±3 sec
Stabilizer Extend.....	8 sec ±3 sec
Stabilizer Retract	6 sec ±3 sec

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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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